

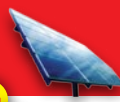
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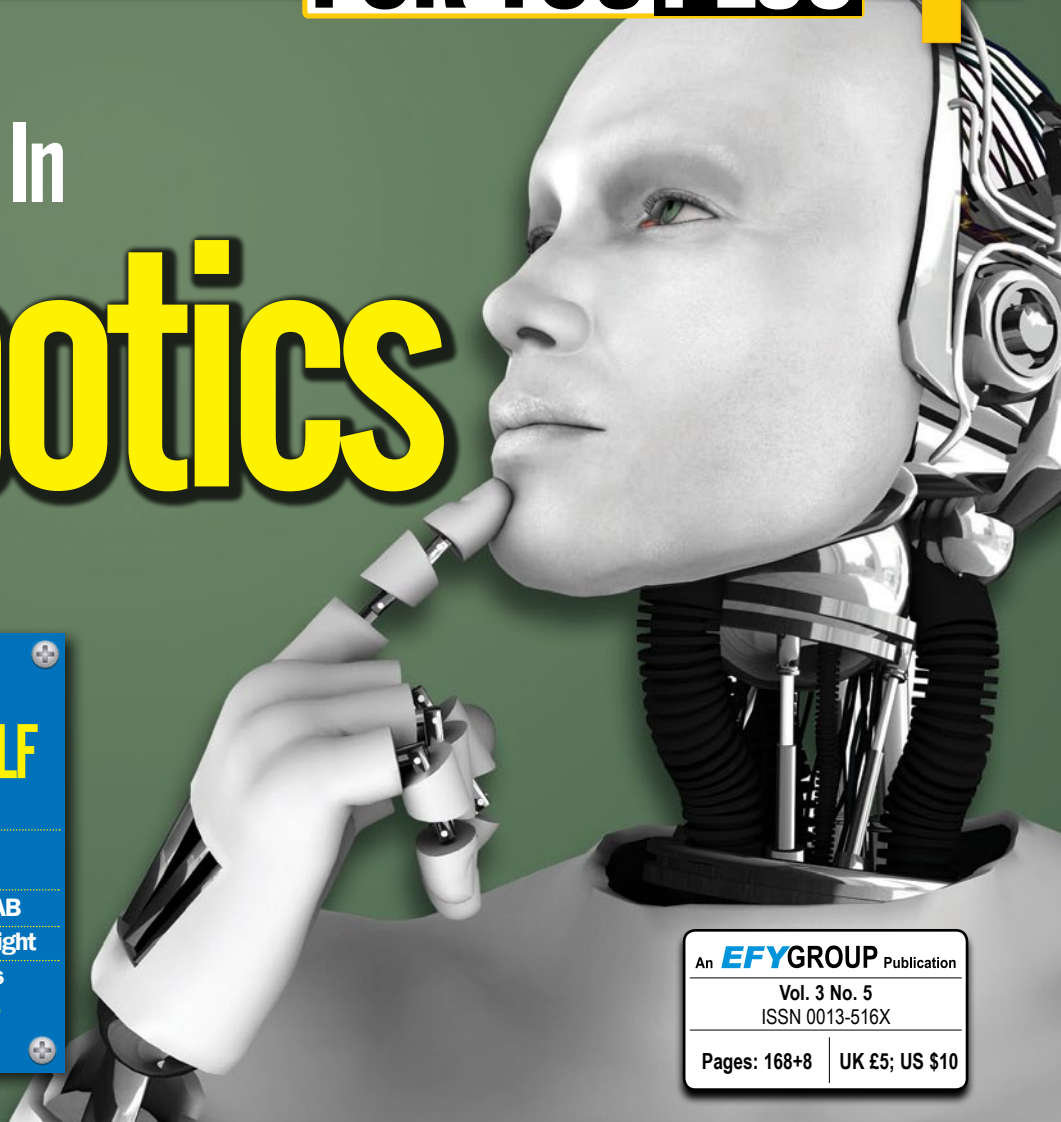
Electronics In

Robotics

TOP 5 DO-IT YOURSELF

- > XBee-Controlled Aircraft
- > Surveillance Using Raspberry Pi Camera
- > Face Counter Using MATLAB
- > Desktop LED Emergency Light
- > Running Linux on Windows

Plus, many more make your own projects inside



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DesignSpark: For All Your PCB Designing Needs VI

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• Educational & Training Products

• Development Boards (Microcontroller based)

Lava's Music Android Smartphone

For music lovers, at an affordable price

Lava's popular IRIS series has got a new entry, Lava IRIS 360 Music, which mainly targets music lovers at a very affordable price. It sports 8.9cm (3.5-inch) HVGA display, dual front-facing speakers, Android 4.2, 1GHz dual-core processor, 512MB of RAM, 1400mAh battery, 4GB internal storage, microSD card slot, 3G connectivity and all the usual set of connectivity options. It also features a 3MP rear camera with LED flash and 0.3MP front camera. The handset is available in black, white and grey colour options.

Price: ₹ 3849



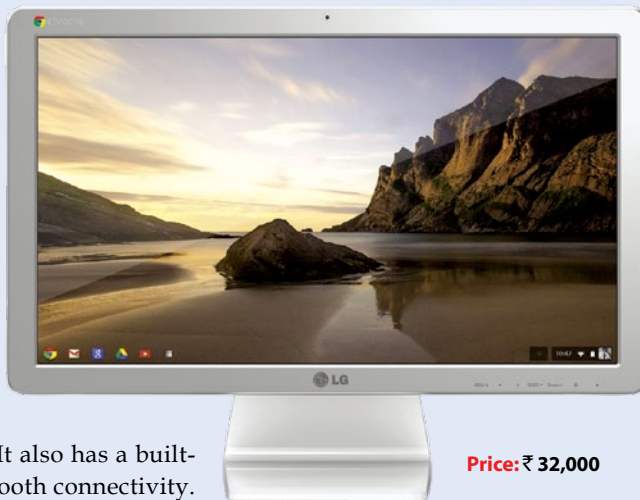
Chromosome Desktop Launched by LG

For an interrupted high definition display

LG has launched a new all-in-one desktop running Google's Chrome OS. The LG Chromosome 22CV241 has a 54.6cm (21.5-inch), 1920×1080 full HD display resolution and is powered by a fourth-generation Intel Celeron Haswell processor. It has a 2GB RAM and 16GB SSD storage. It also provides HDMI inputs for using the display with other devices.

The desktop is enabled with Ethernet, three USB 2.0 ports and one USB 3.0 port. It also has a built-in Wi-Fi and Bluetooth connectivity.

It features a 1.3MP camera with dual 5W speakers and good-quality microphone. The desktop comes with a keyboard, mouse, cable organiser and 100GB Google Drive space.



Price: ₹ 32,000

Windows Tablets from Croma

Running Windows 8.1 on 1.3GHz quad-core Intel Atom processor

Croma has launched two new tablets which run Windows 8.1 on a 1.3GHz quad-core Intel Atom processor. The 30.3cm (8-inch) Croma 1179 and 25.7cm (10.1-inch) Croma 1177 have 2GB RAM and both have built-in 32GB storage. Other common features and specifications include a display resolution of 1280×800 pixels, dual cameras with 2MP rear and 2MP front. Each

has a USB host, enabled with Wi-Fi and Bluetooth connectivity. Croma 1179 weighs 390 grams and comes with a 5000mAh battery whereas Croma 1177 weighs 600 grams and has a 7900mAh battery. Croma 1177 comes with a keyboard case and it also supports Huawei's Ultra Stick for 3G access.

**Price: Croma 1179: ₹ 13,990
Croma 1177: ₹ 21,990**





GizMo ByTes

India's First Anonymous Social Network App

Vavia Technologies has introduced a one-of-its-kind social networking app for the Android platform that lets you interact and communicate with your near and dear ones anonymously. Notably, Confess is the first such app to be launched in India. It is essentially an anonymous social network that will allow users to share their secret confessions with only their connections and groups without the fear of prying eyes. A user can post confessions on this application which will then appear on all his/her connections alone using the app. Comments/likes on the confession in the aftermath will also be visible to the user/their connections alone. Further, no identities are revealed during the entire process.

SBI Launches 'State Bank Anywhere' in Hindi

State Bank of India has launched Hindi version of 'State Bank Anywhere' mobile app for SBI retail Internet banking users, released for Android and iOS smartphones. As the name suggests, customers can do banking from anywhere, anytime using their mobile phones. The Hindi version will make the usage easier and comfortable for a larger number of customers.

India's first digital parenting application

Delhi-based technology start-up, Certus Technologies, has launched eKAVACH, India's most comprehensive digital parenting application as a service that is designed specially to increase parental awareness about their kid's activity online and in the social media. eKAVACH is a unique mobile application for parents which offers families comprehensive safety in the online world. It offers sufficient parental supervision and control over a child's activities across various digital media to ensure focused learning outcomes and appropriate usage of social media. eKAVACH offers unique insights about the behaviour and activities of kids, when they are online and on the move, which can help parents to make better and more informed decisions about their children.

Logitech's Bluetooth Audio Adaptor

Turns wired speakers into a wireless system for gadgets

Logitech has unveiled its new Bluetooth audio adaptor that turns the wired speakers into a wireless sound system for smartphones and tablets. It has Multipoint Bluetooth connectivity that enables one-touch pairing for up to two devices.

Connecting to two devices simultaneously, this multipoint Bluetooth adaptor helps in streaming the audio with just a push of a button. If the speakers are out of range, the adaptor automatically re-pairs to other nearby devices so that the music experience doesn't get hindered at all.

The adaptor is attached to the speakers using a standard analogue RCA or 3.5mm cable, helping one to control the speakers with a reliable direct line-of-sight connection from up to 15 metres.

Price: ₹ 1995



Garmin Launches Fitness Band

Can be synced with smartphone, laptop or PC

Garmin has launched a new fitness-centric wrist band in India. Called Vivofit (veevo-fit), it is available on Flipkart. It is a light device, weighing 25.5gm, and its curved structure fits easily. Its screen displays time, date and month besides total steps taken throughout the day, step target for the day, total kilome-

tres of walking and also the number of burnt calories.

The device can be synced with your smartphone, laptop or PC. Three weeks of 24/7 data can be stored in it. Vivofit is always awake to monitor whether we had proper sleep. It is waterproof up to 50 metres under water.



Price: ₹ 9990

Smartphone Cameras: It's All About What Clicks

If you thought checking the megapixels of a smartphone's camera is enough, think again! There's more to it...

PRASID BANERJEE AND DIKSHA GUPTA

A lot of people select a smartphone based on its camera's quality. For them the smartphone serves as a replacement for their camera, while also allowing them to use the phone. From measly VGA cameras, these devices have now come up to almost DSLR quality, and the quality is improving further day by day. Remember the time when a 5-megapixel camera on a mobile phone used to be a big thing? Well, today a 5-megapixel camera is either a front camera or a budget smartphone's camera.

When buying a smartphone for its camera, you would naturally be looking at the megapixel count. While this gives an idea of picture quality, two cameras with the same megapixel count may produce different picture qualities. Take the case of 16-megapixel cameras in Samsung Galaxy S5 and Micromax Canvas

Knight; Galaxy S5 produces much better pictures than Canvas Knight.

Features to look for

Smartphone cameras' quality depends on more than just megapixels. Of course the megapixels do make a difference to the quality of the pictures you want to click, but this is surely not the only thing to look for. Megapixels just indicate how sharp an image you can take with the camera. It also gives an idea of how much you can enlarge the image without pixelation. But there are other important features to look out for.

Image sensor. An image sensor is where the light falls through the lens to form picture. If image sensor size is big, the picture will be more detailed. So, if you have a camera with higher number of megapixels but a smaller image sensor, the quality of image may get compromised.

ISO or sensitivity of the camera. This is yet another detail that buyers

ignore while buying a camera-enabled phone. High ISO setting means you can take clear images even in low light-situation without any hassle. With high ISO, the camera electrically stimulates the sensor to brighten the image.

Aperture. Aperture refers to size of lens-opening that allows light to fall on the sensor. So, if your smartphone promises awesome photography in low light, remember that it has nothing to do with megapixels, but the aperture of your camera. An aperture of f2.2 or f1.8 is a common standard these days.

Let us now take a look at the kind of devices available in India.

Budget range

Let us consider smartphones priced at ₹ 10,000 to ₹ 15,000, as phones that boast of 12- megapixel plus camera are usually not available at a price below this. The Micromax Canvas Magnus and Canvas Turbo are two good examples of phones

SMARTPHONE CAMERAS TO CHOOSE FROM

	Xiaomi Mi 3	Karbbon Titanium Octane Plus	Micromax Canvas Turbo 250	Lenovo S850	Micromax Canvas Gold	Micromax Canvas Knight A 350	HTC Desire 816	Samsung Galaxy K Zoom
								
Price	₹ 13,999	₹ 14,999	₹ 14,729	₹ 14,890	₹ 19,730	₹ 18,990	₹ 23,399	₹ 29,999
Camera	13-megapixel	16-megapixel	13-megapixel	13-megapixel	16-megapixel	16-megapixel	13-megapixel	20.7-megapixel

	Sony Xperia Z1 Compact	Nokia Lumia 1520	Samsung Galaxy Note 3	Nokia Lumia 1020	LG G3	HTC One (M8)	Sony Xperia Z2	Samsung Galaxy S5
								
Price	₹ 28,990	₹ 36,990	₹ 37,499	₹ 43,390	₹ 43,999	₹ 39,600	₹ 41,990	₹ 33,500
Camera	20.7-megapixel	20-megapixel	13-megapixel	41-megapixel	13-megapixel	4-Ultrapixel	20 MP	16-megapixel

The prices mentioned here are from various e-commerce portals and are subject to change.

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Output Contact	# SPDT (1 C/O) # DPDT (2 C/O)
Contact Rating	5A @ 230VAC/ 24VDC
Supply Voltage	110VAC, 230VAC, 415VAC, 24VAC/DC, 20-240VAC, 12-240VDC

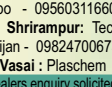
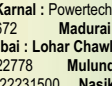
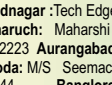


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Flasher	With Flasher / Without Flasher
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Volume Control	Yes, 10 to 100%
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in this range with 13-megapixel rear cameras. But the problem with both is that, their picture-quality is nowhere close to that obtained with some higher-priced phones. In fact, Canvas Turbo's 13-megapixel camera is unlikely to give as good pictures as even Samsung Galaxy Note 2's 8-megapixel camera.

So, buy a smartphone in this range only if you are on a tight budget and the camera's quality is not so important for you. Spending ₹ 14,000 on a Moto G phone would be a very good idea otherwise.

Mid-range

Smartphones priced at ₹ 15,000 to ₹ 25,000 are available in abundance. Micromax Canvas Knight lies in this range, as does the Karbonn Titanium Octane smartphone. Both Canvas Knight and Titanium Octane though are more about the processors than the camera. While both click decent pictures, as with the Canvas Turbo, there are better options available. But these do come closer to satisfaction than their budget-range counterparts.

There are other options too, and you would do well to consider the 13-megapixel cameras on Sony Xperia T2 Ultra and Lenovo K900. Both these take decent pictures, with Sony's device taking the cake with its better overall camera technology. Perhaps the best in this range comes from Samsung Galaxy S4 Zoom, which has 16-megapixel camera and is pretty far ahead of its competitors. Of course, some of Apple's iPhones are also available in this range. While these devices do not have the megapixel count that we have been talking about, Apple's superior camera technology has repeatedly proven to be a good choice.

So, the conclusion that we arrive at is that, this range is for the budget-conscious to look at. While below ₹ 15,000 phones provide poor-to-average image quality, this range provides average-to-good image quality, providing value for money.

High-end

This is the above ₹ 30,000 range, which is usually reserved for the flagship products from each company. The high-end

phones are really the ones that have been revolutionising cell-phone cameras for some time now. Nokia's PureView technology and its 41-megapixel camera on Lumia 1020 can arguably work as well as a professional DSLR camera. Similarly, the slightly toned down 20.7-megapixel camera on Lumia 1520 can also take excellent pictures.

Sony has started putting its award-winning G Lens along with an EXMOR RS sensor in its flagship devices in Xperia range. Both Xperia Z1 and its successor Xperia Z2 have this technology alongside a 20.7-megapixel camera. Though Xperia phones tend to take somewhat dull pictures, the camera is undoubtedly one of the best ones available.

Samsung Galaxy S5 and the HTC One (M8) smartphones are both low on megapixel count, yet 16-megapixel camera in the S5 and 4-Ultrapixel camera on the M8 can easily give the other phones a run for their money. While Samsung's new camera on the S5 has often been touted to be the best in market, HTC's Ultrapixel technology has turned quite a few heads. The company took things a step ahead with the M8 by adding the duo-lens that adds a variety of features, like shoot first focus later, to the phone.

Most of these phones are priced at above ₹ 40,000, which automatically makes this a very niche range. Still, with the benefits of buying devices on EMIs available now, these are way more accessible than ever before.

Conclusion

Camera technology is one of the main selling points of smartphones today. Manufacturers are working hard to provide better cameras with each new and more expensive device. A smartphone with a 12-megapixel plus camera is available for ₹ 10,000 to ₹ 50,000, and more. Your decision would therefore very much depend on your budget. ●

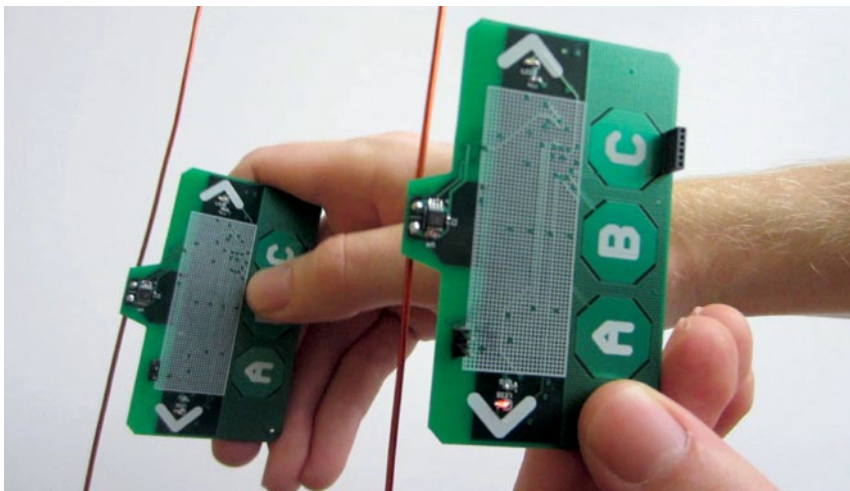
Diksha Gupta is senior assistant editor at EFY, while Prasad Banerjee was working with EFY as a correspondent till recently

Turn your dumb TV into a smartTV

If you do not want to spend money on a new smartTV, there are ways to turn your present TV into one. For instance, WD TV Live Hub and iOmega ScreenPlay DX HD are two set-top box type media players for TV that are ideal for accessing web services like TuneIn, YouTube and Flickr. These have a nice software interface and a hard drive of 1TB size. WD TV Live Hub is available for ₹ 12,500 while iOmega ScreenPlay DX HD is available for ₹ 12,000.

Amketto offers EvoTV series of devices, costing ₹ 5500 to ₹ 10,500. This set-top box runs on Google's Android OS, which is an advantage because you can access Google's apps using Play Store. There is also an option to attach USB keyboard to make the experience more interactive. Another option, Apple TV, is a network media player that you can connect to TV for streaming pictures, music and videos from iPhone or iPad. Apple lets users subscribe to channels using iTunes.

Google's Chromecast is an easy-to-use HDMI device through which you can connect to Wi-Fi network, or link it to a laptop or mobile device to stream the content from these devices on TV. Chromecast also provides an option to stream YouTube videos on TV screen. Users can subscribe to services like BigFlix, NexGTV, Spuul and BoxTV to



Using ambient backscatter, these devices can interact with users and communicate with each other without using batteries. They exchange information by reflecting or absorbing pre-existing radio signals

stream their shows on TV. It is available on online stores for ₹ 3999. One can insert it in HDMI port of TV and even connect its microUSB port to TV's USB port for alternative source.

Technology to connect battery-free devices to Wi-Fi

A new technology will help connect battery-free devices to Wi-Fi and also allow the devices to store information about our daily activities, but everything will be done without any battery. The new communication system developed by researchers at the University of Washington uses radio frequency signals as a power source. Existing Wi-Fi infrastructure is being reused to provide Internet to all these devices. Embedded sensors will help in monitoring and tracking everything ranging from safety measures at bridges and health factors.

Providing Wi-Fi connectivity to the devices is not an easy job as conventional, low-power Wi-Fi re-

quires more power than usual. Hence an ultra-low-power tag prototype associated with an antenna and circuit has been developed by the researchers. This particular technology helps in communication with Wi-Fi enabled laptops or smartphones using a very negligible amount of power.

Wi-Fi signals moving between the router and a laptop or a smartphone help in activation of these tags. The data is encoded by these tags, and sometimes Wi-Fi routers' signals get reflected and sometimes they don't. As a result, the wireless signals get slightly changed. Laptops and smartphones, which are equipped with Wi-Fi, are able to detect these changes and data is received from the tag.

Efficient spray-on solar cells developed

Researchers from the University of Sheffield, led by Prof. David Lidzey, have found a new method of tapping solar energy. They used a crystalline organometal called Perovskite to make cheap and efficient solar cells. Perovskite, made of calcium titanate, is cheaper as compared to silicon. Silicon needs a layer of minimum 180 micro-



iOmega ScreenPlay DX HD

BINAY - Lighting Up The Future



BINAY LED-based HIGH, MEDIUM and LOW Intensity Aviation Obstruction Light Beacons

As per International Civil Aviation Organisation (ICAO) requirements Available in Low Intensity, Medium Intensity and High Intensity versions (as per International Civil Aviation Organization guidelines), BINAY's patented LED Aviation Lights come with 5-year/3-year warranties

LED Obstruction Lighting for:

- Industrial chimneys and smokestacks
- Transmission, microwave and cellular towers
- Radio, TV and similar structural towers
- High-rise buildings and structures
- Airports and airfields

The BINAY LED Aviation Obstruction Light offers the following advantages:

- Fit-and-forget maintenance-free operation
- A long life of 100,000 hours (20 years at 12 hours daily burning)
- Pays for itself within a short period of operation in the form of reduced installation, maintenance and servicing costs
- Quick Installation; Reliable operation 365 days per year
- Shock-proof and vibration-resistant
- Over-Designed Intensity to allow for natural LED intensity degradation over its operating lifetime



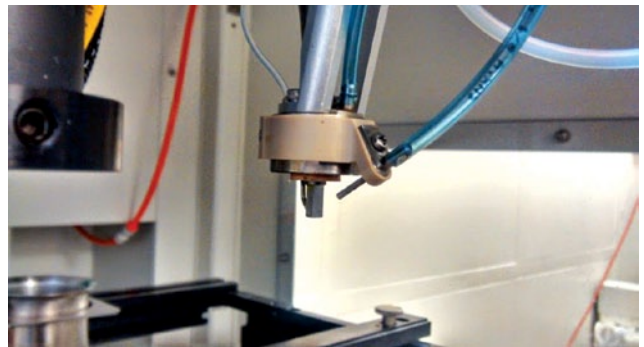
THE BINAY LED OBSTRUCTION LIGHT IS UNDER ACCEPTED PATENT, AND AS SUCH IS A PROPRIETARY PRODUCT



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POWERING LED TECHNOLOGIES WORLDWIDE SINCE 1983



Spray-on Perovskite solar cells (Courtesy: www.extremetech.com)

metres to absorb light, whereas Perovskite can be sprayed in one micrometre thick layer.

The prototype built by this method has 11 per cent efficiency. However, the conventional silicon cells have higher 25 per cent efficiency and Perovskite cells have efficiency of 19 per cent. The team used same conventional structure to build the cell using Perovskite. They just replaced silicon layer with spray-painted Perovskite layer.

Perovskite absorbs light energy from any surface. In future, we can coat Perovskite on any surface like mobile phones or cars. The technology can be scaled down to build small spray nozzles to coat on any tiny surface.

Design a tiny inverter and win a million

IEEE and Google have jointly started a competition titled 'Little Box Challenge' to design a power inverter with power density of more than 50 watts/cube inch. The successful designer designing this kW-scale inverter will be rewarded with prize money of US\$ 1 million.

Google is aiming to scale down current size of inverters. If innovators succeed in shrinking size of inverter to as small as laptop or tablet, solar inverters can power all appliances in homes.

Registration ends on 30th September while submissions by participants can be made up to July 22, 2015. Google and IEEE will pick up 18 finalists, who will have to bring their inverters to the testing facility in the USA in person. Specifications of the inverter and other details can be checked at www.littleboxchallenge.com

TouchPico turns any surface into touchscreen

Yes, it's possible now to turn any surface of up to 203cm (80-inch) into a touchscreen. TouchPico is a small Android PC with an in-built projector that converts any surface into an interactive touchscreen. Stylus can be used to interact with the touchscreen and apps on the surface. The project is up for funds on the popular crowd funding website Indigogo.

This device is powered by Android 4.0 and comes with Google Play Store to serve all app-related needs of the user. Users can use the same Android apps that are available on any Android device on large screen. TouchPico can be used

in corporate world for presentations, drawings, etc. It can also be used in classrooms as learning tool for students and teachers.

The lamp used in projector emits output of 80 lumens. The device comes with HDMI input as well as Internet streaming feature. It is powered by 1.6GHz dual-core ARM Cortex A9 processor coupled with 1GB RAM. It comes with wireless mouse and audio output too. The device has memory card slot.

New display technology to end reading glasses

Researchers from MIT's Media Lab, Berkeley and University of California are working together with Microsoft on a display which corrects vision defects. This technology uses algorithm to anticipate how human eye distorts the image and makes adjustments beforehand to bypass the function of corrective lenses. It works on pixel level to create a sharp image on the retina. This technique can assist people with hypermetropia (long sightedness) and circumvents serious vision defects such as spherical aberration that cannot be corrected through glasses.

The concept has been tried out before but the new approach produces sharper and higher contrast image. The research used a Canon DSLR camera with focus set to simulate a poor vision. The image was rendered on an iPod Touch which was fixed with plastic screen pierced with thousands of tiny and evenly spaced holes, which displayed sharper image.

There are some hindrances, however. For instance, the screen is customised for certain focal length and requires eye to be still, but researchers say that it can be solved in coming years. This technology fails to help myopic patients who suffer near sightedness.

3D chocolate printer made in India

Students of Massachusetts Institute of Technology (MIT) in USA recently gained fame by developing 3D ice-cream printer. Now, students from Manipal Institute of Technology (MIT) in India have developed a 3D chocolate printer, called Chocobot.



3D food printer 'Pramaan' (Courtesy: <http://microfabricator.com>)

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POWERING LED TECHNOLOGIES WORLDWIDE SINCE 1983

The students have launched a start-up company named Global3dlabs, according to whose director, Gopal Krishna, 3D printing of food could be the next big thing. The company launched their first 3D food printer called 'Pramaan' priced at ₹ 75,000 in April with the help of a local bakery.

In USA, NASA has funded a project of 3D printing pizza for astronauts. Famous chocolate maker company Hershey has made a deal with a company from South Carolina to build 3D chocolate printer. The food industry seems to be adopting the idea of digital food.

Technology to look behind solid walls

A new technology allows robots to see through solid walls using Wi-Fi signals. University of California based scientists have been working on this project which provides X-ray vision to these robots, and they are able to look at objects and humans at the other side of thick walls by using radio frequency signals.

With this technology, the robots can not only look at the objects behind the walls but can also calculate their actual position and geometry, without any kind of previous knowledge of that area. Moreover, the robots can also identify the materials of which the objects are made of and classify them as human, metal or wood.

If a situation arises where human access is risky, the technology built

into robots can be of great help. The technology is also applicable for Wi-Fi enabled gadgets or any Wi-Fi network. When used in an existing network, it can help monitor presence and location of objects and people. This kind of monitoring helps keep a check on trespassers and even catch them.

Tattoo based bio-battery turns sweat to power

Looks like sweating it out during a daily workout has an all new meaning now, serving a dual purpose: quite useful in a multi-tasking world of ours. Pretty soon, a rigorous workout will make you fit and power your phone or other portable devices in close proximity at the same time.

A team of researchers at the University of California have successfully created a unique bio-sensor that takes the form of a temporary tattoo and uses your body sweat to monitor exercise process, all the while generating a weak electrical current. The sensor detects and interacts with lactate in sweat, a conjugate base of lactic acid that is produced by the human body via a process called glycolysis. The events gradually unfold during exercise.

Up until now, the process of monitoring and measuring the amount of lactate produced in sweat was a rather tedious process which involved taking multiple blood samples during a workout. The sensor in question is able to do away with the same, and yet is able to deliver a little



A tattoo biosensor (enlarged above) detects lactate levels during exercise; a bio-battery using the technology could power electronics (Courtesy: Joseph Wang, UCSD)

extra: generate electrical current as a by-product.

Charge your phone with background noise

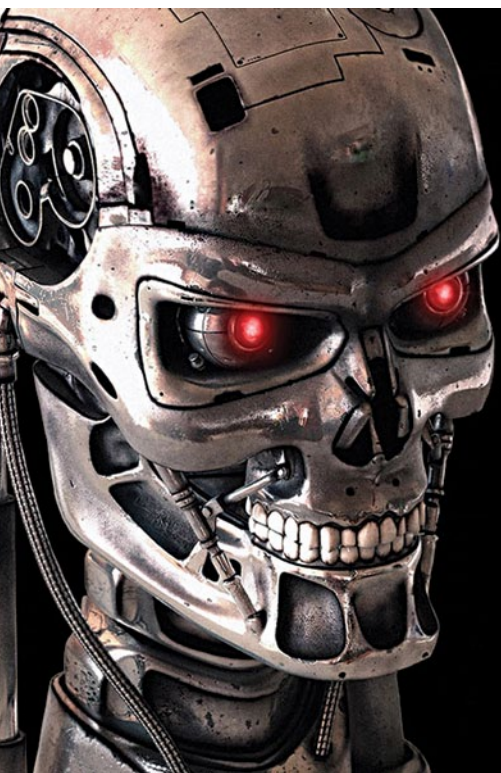
Cell-phone charging will not require a charger and a socket any more. Traffic noise, music, cheering sounds from a sports ground and even your own voice can charge your phone. This innovation has been made possible by scientists from Queen Mary University of London and Nokia, who have created a prototype nanogenerator which can be used for cell-phone charging through background noises.

This energy-harvesting prototype consists of zinc oxide in the form of nanorods, which converts energy from motion into electrical energy and creates a voltage. The nanorods are coated on surfaces which make the energy harvesting process more resourceful. As soon as this surface is stretched or squashed, a high voltage is generated from the nanorods. The vibration created by any kind of sound, like our voice, catches a response from these nanorods and electrical contacts on both sides are used to harvest the voltage in order to charge a phone.



Scientists at the University of California, Santa Barbara have been working to provide X-ray vision to enable robots to see objects and humans behind thick walls through the use of radio frequency signals (Courtesy: <http://ibnlive.in.com>)

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The Robots' Guide To World Domination

Going by the effort being put in to make robots smarter, we would be seeing 'intelligent' robots in no time. This article points to some latest technologies that are being developed which could take over this world

DILIN ANAND AND ANAGHA P.

Only five countries in the world actually voted in favour of banning autonomous (a.k.a smart) killer robots at a recent UN convention. This could mean that there are a lot of countries that are already building their own autonomous robots or are in favour of building them soon. In fact, Russia announced that autonomous robots that will gun down trespassers, no questions asked, would soon man their ballistic missile bases.

Of course it is not all about battles and war. Japan's Prime Minister Shinzo Abe was reported by *Jiji Press* as saying, "In 2020, I would like to gather all of the world's robots and aim to hold an Olympics where they compete in technical skill." It would

be an understatement to say that the future will have a lot of autonomous robots. They are already here, being designed and manufactured around the world. And perhaps, they have already left the industry shop-floor and are on their way to your living room.

Step one to world domination: infiltrate homes

ABI Research says 1.8 million home automation systems will ship this year, and it will increase to 12 million in the next five years. What's more, seemingly unobtrusive electronics like small domestic-lighting bulbs, home heating and cooling, smoke sensors and electronic door-locks would be collecting usage data which the other machines could also make use of.

Companies are aggregating previously-available technologies and putting them into small devices that are

affordable and can be used in domestic scenarios to make life easier at home. Cisco has brought out its Control4 technology which pairs up with Zigbee for home automation. Verizon has its own automation service that is powered by Motorola's technology that it got through its acquisition of 4Home.

While useless individually, big data analytics conducted on accumulated data from the bots in your home lets outside machines and their users gain considerable insight on the behaviour of the people living in your home. These machines can understand when you come home, and also whether you go for a bath immediately or you have food or exercise first. Over a long term, it can understand whether you have other people at home, or if it is time to 'ask' an autonomous vacuum cleaner to clean up your place. It can even determine the best time to break into your house while you are sleeping!

US-based Droplet Robotics has introduced a data-analytics powered system that can identify the soil and plant types to precisely disperse required amount of water for an optimal growth of each plant. It also provides the user with analytics data like how much water goes to each type of plant, tree or lawn. They use cloud computing, connected services and machine-to-machine communication (M2M) to analyse situations and identify events. They also use the information to make intelligent decisions that are then implemented through robots that they control.

Remember Robovacs? These are those intelligent and autonomous cleaning systems of yesteryear that have the capability to analyse their surroundings and use the data to implement the most efficient cleaning process. Things have changed a lot since the introduction of these robots though.

The latest Robovacs like the Roomba 800 series from iRobot have advanced their robots' 'smartness factor' by enabling them to make the most of a whole lot of sensors that come with the bot. The newer robots can detect cliffs and steps before they fall down, know how to fol-

low walls rather than bouncing of them, and negotiate around items cluttering the floor. These can even escape if caught in a particularly difficult nook under a table.

The next generation of housekeeping robots promise to be a lot smarter. A robot designed to demonstrate cognitive systems that self-understand and self-extend (CogX) is one such example. This robot is equipped with probabilistic reasoning and planning capability to exploit facts or pieces of knowledge that it detects. For instance, if you ask this robot to find a pack of cornflakes, it will exploit the knowledge that there is a greater probability that someone has left it in the kitchen and start its search from there.

Technology like this can make robots far more intelligent than they are now, and more efficient in cases like the one mentioned above.

Step two: understanding emotions

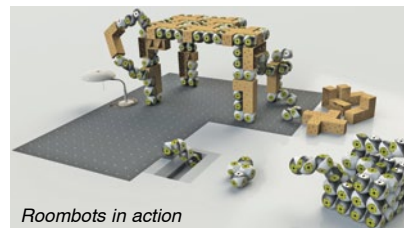
We finally have the technology to ensure that even if your spouse doesn't understand your feelings, you can count on your robot. Computer Expression Recognition Toolbox (CERT) is a complete system for fully automated facial expression recognition. The CERT system helps detect spontaneous facial expressions, including automated discrimination of posed vs genuine expressions of pain, automated detection of driver drowsiness, adaptive tutoring systems and intervention for children with autism.

CERT also has its successor technology in the market, called FACET Vision by Emotient. Emotient API provides the ability to analyse emotional response of users, detecting everything from joy, surprise and anger to complex ones like frustration and confusion. It can even identify blends of two or more emotions. It does this by using Emotient API Facial Action Units (AUs). These action units are essentially elementary facial muscle movements that are detected and monitored by the robot or application to identify what kind of expression is being shown by the human being. Emotient AUs are factors used to detect over 28 human actions, from raising an eyebrow to a jaw drop. Emotient

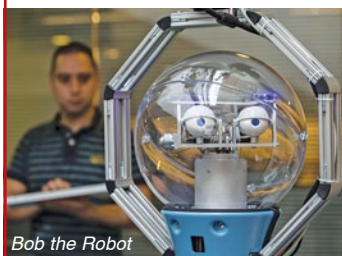
Home automation gets a body

Social robots. The winner of this year's Oracle IoT Developer global challenge, BOT-SO, is an interesting robot for home security. Developed by Kolkata-based EdifiXio India, it can send photos, videos and other data as direct messages to its users via Twitter. The first prototype was made from easily-available components like Raspberry Pi Model B, camera module, micro servomotor, temperature sensor, motion detector and USB soundcard. "BOT-SO is in its very early stages, and would act as an open source reference platform for developing an intelligent robot," says Debraj of EdifiXio. The name BOT-SO is derived from the words 'social robot,' since it communicates through social media.

Furniture that changes shape. Roombots are mobile, adaptive, self-assembling, self-reconfigurable modular robots that could roll out and change their shape to a chair or table or box, or even disassemble, depending on user's instructions. Each Roombot comes with two connected spheres and four motors; like Lego bricks, it connects to other Roombots (on their own, unlike Lego bricks) to create the furniture you desire.



Roombots in action



Bob the Robot

Environment aware. Developed by the University of Birmingham, Bob is a tall robot that builds a 3D image of a room by using 3D sensors to scan. This robot then compares it with the previous image of the same room to detect any changes. If the settings of the room have changed (like a door being opened, or change in position of furniture), it immediately informs the concerned authorities. Bob also asks for help when stuck at a place. It charges itself when battery is low.

recently raised over six million US dollars for its facial recognition technology.

Affectiva, a company that grew out of MIT's Media Lab, develops Affdex, another emotion measurement technology that competes with FACET Vision. Affdex SDK enables any connected device, even a smartphone, to be able to read emotions and expressions. The data for such systems is gained through 3D cameras mounted on the robots, and through the use of sensor arrays on the robots' bodies. One example of a much-hyped idea for a successful application of this technology is to create robotic pets that help you in times of mental difficulty. In short, a robot can be your friend in need.

Step three: replace their animals

Robotics is not always about humanoid form-factors. Some robot concepts and designs that came up recently were inspired by fishes, birds and animals. Jayakrishnan of Asimov Robotics finds



JIBO helping in the kitchen

these models inspired by nature very intriguing. These robotic pets are also known as companion robots. They might be an emotional companion to some, or a utility companion to others.

PARO is one such high-tech interactive robot developed by AIST, a Japanese industrial automation company. It allows the benefits of animal therapy to be administered to people in environments where live animals present treatment or logistical difficulties. Think of it as your Tamagotchi (a hand-held digital pet created in Japan) with a body. Robotic pets use interactive and adaptive computing technology to use the input gained from their sensors to simulate

Robotic animals are already here

Arti'fish'ial intelligence. A joint project by University of Essex and Strathclyde, the Tyndall National Institute and Thales Safare (TSFR), this 152cm (five feet) long robot swims like real fish and is fitted with sensors that collect samples and determine the pollution level in water bodies. This robo-fish can detect and avoid obstacles, communicate with each other, send data to shore station up to 1km away and return on its own to base when the 8-hour long battery runs low.

Ready to run. Boston Dynamics has developed WildCat robot which runs at a speed of over 29mph (faster than Usain Bolt!) and has set a new land-speed record for legged robots. The design of Wildcat and its predecessor Cheetah are inspired by locomotion of animals: an articulated back that flexes back and forth on each step, thereby increasing stride and running speed.

Snakes. A 1.2cm (half inch) in diameter snake-robot named MiRoR (Miniaturised Robotic systems for holistic in-situ Repair and maintenance) works in restrained and hazardous environments to allow engine experts to remotely and quickly find faults in large, complex machines like aircraft. Apart from UV laser to perform welding and grinder to sand down and smoothen damaged parts, this robot is also equipped with self-positioning, reasoning, planning and adaptation capabilities. MiRoR is a joint project of Rolls-Royce, University of Nottingham, Fraunhofer IPA, IK4 Tekniker, ETH Zurich, Acciona Infrastructure and OMV Petrom.



some biological characteristics of the animal it is pretending to be.

For example, PARO has five kinds of sensors: tactile, light, audition, temperature and posture. It processes data from these sensors to collect information with which it can perceive people and its environment. With the light sensor, the robot can recognise light and its intensity. It feels being stroked and beaten by tactile sensors, or being held by posture sensor. It can also recognise the direction of voice and words such as its name, greetings and praise with its audio sensor.

Researchers at National Sun Yat-sen University have developed a framework that employs a neural network-based approach to construct behavior primitives and arbitrators for robots. This neural network-based architecture could allow these researchers to build a robot that learns or evolves its behavior based on how the human interacts with it, or based on the data it gets from its sensors. They believe that it will be far easier to implement through this architecture, compared to traditional solutions.

PhD student Mriganka Biswas says in an article in *ScienceDaily*, "Cognitive biases make humans what they are, fashioning characteristics and personality, complete with errors and imperfections. Therefore introducing cogni-

tive biases in a robot's characteristics makes the robot imperfect by nature, but also more human-like. Based on human interactions and relationships, we will introduce characteristics and personalities to the robot. If we can explain how human-to-human long-term relationships begin and develop, it would be easier to plan the human-robot relationship."

Step four: takeover their vehicles

OEMs have taken autonomous cars seriously, and Land Rover has taken its first step towards self-driving, cloud-connected, augmented-reality based vehicles. Discovery Vision is Land

Rover's all new SUV concept expected to hit roads in a few years. BMW and Audi are coming out with their own versions, although none have reached the levels of Transformer robots yet.

NVIDIA's Tegra K1 mobile processor is currently the processor of choice for Audi, as the German automaker tips its toes into autonomous vehicles. The K1 processor is powered by a 192-core graphics processing unit (GPU) which is the heart of Audi's entire automotive infotainment system. This gives an idea of the level of computing required for an automotive robot to function properly.

Of course, you need some very sophisticated software to ensure that your car doesn't end up jumping over a bridge with you inside. Bosch is developing an Automatic Park Assist technology that will be out next year, which allows a car to be parked remotely using just a smartphone app. Another technology, Traffic Jam Assistant, will step in when the vehicle is moving at low speeds. Google is already trying to make fully automated driving a reality. Bosch's autonomous technology gathers data using an array of sensors, including radar and video cameras, as well as a roof-mounted laser scanner (LIDAR) that generates a detailed 3D map of the environment.

While most of these technologies can be connected to those used in other autonomous robots, safety is critical for the automotive robots, so these have lot more policies and regulations to

Robots that can understand humans

Feeling low? Take Pepper. Aldebaran Robotics and Softbank have unveiled Pepper, a cute affectionate robot that studies your expressions, gestures and speech tone to read your mood, cracks jokes and sings songs for you when you are feeling low. It comes with a multitude of sensors, 3D cameras, four microphones and advanced voice-recognition hardware and software. Pepper could serve as an emotional companion and an understanding friend.

The mind reader. Remember Rosie, the robot maid from the cartoon series *The Jetsons*? You do not have to wait too long for a real-life robot like Rosie that can tend to your needs. Developed by Personal Robotics Lab at Cornell University, this clever robot can be trained to be a wait staff and predict your actions with surprising accuracy. It performs functions like refilling your tea cup or opening the door without you needing to ask for it.

Prison-guard robot. Robo-guard is a South Korean correction service robot that observes inmates in a prison using embedded 3D cameras, detects changes in behaviour of inmates with the help of special software, and raises an alarm if anything suspicious is detected. It is an autonomous robot that can also be controlled by iPad.

Family robots. Brainchild of MIT professor Dr Cynthia Breazeal, JIBO project has received incredible welcome and crowd-funding in Indiegogo community. It is a small robot that can see, hear, speak, recognise emotions, adapt to situations and possibly perform many other activities. Since it is based on open source platform, the skills of JIBO would only improve with time.

A bot to replace me

A company called Narrative Science has launched a software product that can write newspaper stories about sports games directly from the games' statistics. It uses special algorithms to turn all the information it collects into attractive articles.

The same software can also be used to write an overview of a company's business performance using information available from analysts or even the web! I plan on buying one to outsource all my writing work to it, so that I can focus on the more important things in life—like reading a good book.

—Dilin Anand

consider while operating. This also applies to the ruggedness of the electronics that they use. The fact that electronics in vehicles has increased a lot over the years is an obvious point now that cars were some of the hottest attractions at the International Consumer Electronics Show (CES) 2014.

Sensors that empower self-driving cars have started showing up in mid-range cars for limited uses, like ultrasonic systems and front-mounted radar for adaptive cruise control. Automakers are making the most of this by using the concept of sensor fusion to combine data from different sensor systems and cameras to enable the car to make a decision before the driver even knows what's happening.

In a report on CNN, Dr Werner Huber, BMW project manager driver, spoke about how the car is now becoming a driving and moving robot. And the Federal Bureau of Investigation (FBI) feels that driverless cars could be used as lethal weapons, as per a report released by their Strategic Issues Group.

Step five to world domination: replace humans

What the industrial revolution did to manual labourers in the last century is being done to knowledge-workers (like you and me) now. Medical industry is also witnessing breakthrough innovations powered by robotics. "Most of the intelligent systems introduced in medical industry are still under trial and not certified yet to be used widespread," says Satish Mohanram of NI, "but the applica-

Your driver is inside the hood

No driving license? Not a problem. The self-driving car is a hot topic these days. The smartness of these devices is increasing at an incredible rate. Previous version of Google self-driving cars had a steering wheel and control for humans to take over, just in case the machine was not able to understand and perform properly. But the current version has no steering wheel, drives on its own, identifies hand signals of cyclists, spots pedestrians from behind and slows down when required. Though the level of dependency on such cars is debatable, continuous researches are going on, many of which have been successful, to bring out the perfect self-driving connected car ecosystem.

No pilot's licence? Still not a problem. Lockheed Martin and Kaman Aerospace Corp announced in the last week of July that their Kanan K-MAX autonomous helicopter is back from its successful test deployment in Afghanistan. It can deliver cargo and people to remote locations by flying through night and day. It can even tackle hazardous conditions like mountains, which even human pilots might find intimidating.

Still want someone in the driver's seat? Valkyrie (R5) humanoid robot has been designed by National Aeronautics and Space Administration (NASA) for Defense Advanced Research Projects Agency's (DARPA's) international DARPA Robotic Challenge. Designed to aid disaster-relief efforts, its roles include cutting through the wall, cleaning debris and driving vehicles.



Major contributors to the story

- Biju Varkey, owner, DPD Robotics
- Debraj Dutta, director, Edifixio India Pvt Ltd
- Jayakrishnan T., CEO, ASIMOV Robotics Pvt Ltd
- Satish Mohanram, technical marketing manager, National Instruments, India

tions in these fields are huge." One such possibility is a system that can diagnose a medical condition and prescribe remedies for the situation. It could potentially perform telemedicine on its own.

Not all robots that replace humans are humanoid though. A human sperm-shaped, tiny (322µm long, 5.2µm wide and 42µm thick), swimming microbot with a magnetic head is a competitor with the most senior of doctors for performing surgery. Armed with a 200nm cobalt-nickel layer, this little fellow creates a dipole moment that allows this flexible structure to align along weak oscillating magnetic field lines, and hence generate a propulsion mechanism. This robot, named as MagnetoSperm, could assist targeted drug delivery, in-vitro fertilisation and even perform minimally invasive surgeries.

It is not just doctors that could get replaced, robots can affect even gourmet chefs. San Francisco-based Momentum Machines has a robot that occupies just 155 square centimetre (24 square inch) space. This robot takes customised orders and produces

around 360 gourmet burgers per hour. Since the burgers are produced entirely by the machine and untouched by human hands, it is more sanitary. Higher productivity, lower cost (except the initial investment) and consistency are some other features of this machine.

What the future holds

At this rate, we are soon approaching the retro-future depicted in The Jetsons and WALL E. Robots taking up human jobs could mean not only faster, better and cheaper services but, perhaps, also unemployment and lower wages for existing employees. Well we are facing a question very similar to what we did when computers were first introduced into the mainstream.

Perhaps it is time to think of the possibilities for working in a world where robots perform major tasks and are even judged as being better than humans. After all, they don't have emotional problems, criminal tendencies or try to understand the meaning of life. Yet. ●

Dilin Anand is a senior assistant editor and Anagha P. is a technical correspondent at EFY

Robots That 'Grow Up'

Programming devices—and robots—to do stuff is no longer exciting. The next thing on the wish list is robots that learn how to behave and do things autonomously, just like humans and animals learn as they grow up

JANANI GOPALAKRISHNAN VIKRAM

Shape-shifting robots, 3D printed ones, those with facial recognition and social skills too are evolving in robotics labs across the world, but there is something more interesting brewing! Scientists are now working to develop robots that can learn to do things and react to situations like humans do. Just as a baby learns to be and do, by observing, assimilating, experimenting and adapting, robots of the future can be taught, or will even learn naturally like we do, without being programmed to do everything. Here, we look at some research and early examples.

Hi Jimmy!

You need to 3D print some parts, fix in other non-printable parts including an Intel Edison processor, and voila, your robot buddy is ready! And, according to Intel, you do not need a PhD to program Jimmy, their open source robot, which will be on sale by end of this year.

When first launched, Jimmy walked up on stage, introduced himself, danced and then sat down to watch the rest of the proceedings. A short trip to Intel's website and you can see Jimmy solving the Rubik's cube, cheering for his favourite team at a match, and making a public appearance with Intel CEO. Once you make your own

Jimmy (or whatever you call it), it can send tweets on your behalf, sing or dance with you, bring you food, and more.

Led by Brian David Johnson, Intel's robotics lab ultimately aims to build an easy-to-make and easy-to-use, completely open source robot that is extremely social, friendly, and able to dream, feel and think. While it seems awesome and impossible that you can make your own robot and also make it do whatever you want, Johnson

explains that it is just akin to a smartphone with customisable apps.

The company is also betting big on the open source model, because when you have a smart and social robot like Jimmy, it needs to constantly evolve, and what better way to do it than have the whole world contribute apps and ideas?

Please, Monica...

Do you remember walking into your dad's office, to be greeted by his personal assistant, who politely seated you, offered your favourite beverage and book, chatted friendlily and then subtly broke the news that your father was out of office for a meeting? Do you remember her trying to step in and solve small problems when dad was overworked, booking tickets, paying bills and helping out with professional and personal tasks that could be shared? Where did they go? Why aren't today's smartphones and laptops as efficient as those reliable personal secretaries in reducing your stress? Well, perhaps it is because these inanimate objects cannot think, feel or even actually realise how tired or stressed you are!

You would not feel this way if you had a couple of digital assistants like Eric Horvitz's. Horvitz, managing director of Microsoft Research Redmond, is deeply involved in the Situational Interaction project to enable



Intel's vision of tomorrow's robot—Jimmy (Courtesy: Intel)

India's #1 Website For Electronics Engineers Working Across The Globe

Established: 1998
Registered Users: 300,000+



Monthly Statistics

Page Impressions:
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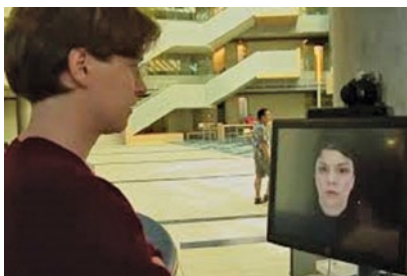
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Digital Assistants at Microsoft Research
(Courtesy: Microsoft Research)

many forms of complex, layered interaction between machines and humans.

People who visit Horvitz at his Redmond office are often pleasantly surprised by the practical results of the research. When you get to his office floor, a cute little robot would greet you, give you directions with proper hand movements, and let Horvitz's virtual assistant Monica know that you have arrived. Monica, an onscreen personality, greets you in her unmistakable British accent. In the background, she does a quick calculation about the costs and benefits of an unplanned interruption, taking into consideration Horvitz's current desktop activity, calendar and past behaviour. When she is convinced that a short interruption is okay, she lets you in. Monica is smarter than this; she can access Horvitz's online calendar, detect his presence in office, predict when he will finish a task, infer how busy he is, when he will return to office after a meeting and even when he will read and reply to emails, and even predict, quite well, when he will conclude a phone conversation based on her 'observation' of his past behaviour!

Machines that are part of this project have situational awareness and can take into account the physical aspects of an interaction including people's gait, gestures, etc, which helps understand the tone of an interaction better. The project integrates machine vision, natural language processing, machine learning, automated planning, speech recognition, acoustical analysis, sociolinguistics, etc, to help robots and computers better understand multi-party interaction. The team has tried to endow systems with short-term and long-term memory so they can use past

experiences also to decide how to react in a particular situation. In a Microsoft Research article, Horvitz comments that, "Interactions with the system, especially when we integrate new competencies, seem magical, with the magic emerging from a rich symphony of perception, reasoning and decision-making that's running all the time."

Help me, haathi

An elephant is one of the most intelligent creatures on our planet, and undoubtedly its trunk is one of nature's smartest creations. It features tens of thousands of muscles working in tandem to deftly break a small nut as beautifully as it can uproot a large tree! This versatility of the elephant's trunk has long inspired robotics scientists, and ultimately a few months ago, scientists of German engineering firm Festo managed to develop a bionic elephant trunk that can learn and work just like an elephant's.

The trunk is made of 3D-printed segments and is controlled by a system of pneumatic muscles. Instead of using regular precision control software, the team has used a method called 'goal babbling' or trial-and-error learning, inspired by how infants learn to use their muscles. When the robot works, it records the tiny pressure adjustments made in the pneumatic tubes operating the artificial muscles. It then creates a map that relays the trunk's exact position, to calibrate the pressure in each tube.

The trunk can be trained by manually manipulating it into required positions. While it might resist the movement at first, the trunk slowly yields and follows the movement. It then 'learns' it. So, the next time you start pushing it to the same position, it moves easily and naturally. They call this ability of the trunk to remember its past movements as muscle memory.

The company hopes that this muscle memory together with the trunk's dexterity will enable its use in industrial environments and for jobs like changing road lights, picking apples, etc.

To the rescue, MacGyver

Inspired by the famous fictional secret agent Angus MacGyver, known for his troubleshooting skills, Georgia Tech submitted a research paper titled *Robots Using Environment Objects as Tools: The 'MacGyver' Paradigm for Mobile Manipulation* at the IEEE International Conference on Robotics and Automation (ICRA 2014). The MacGyver robots proposed in the paper stand out from the current generation in their skill to make use of environmental objects to solve problems, rather than be intimidated by unpredictable environments.

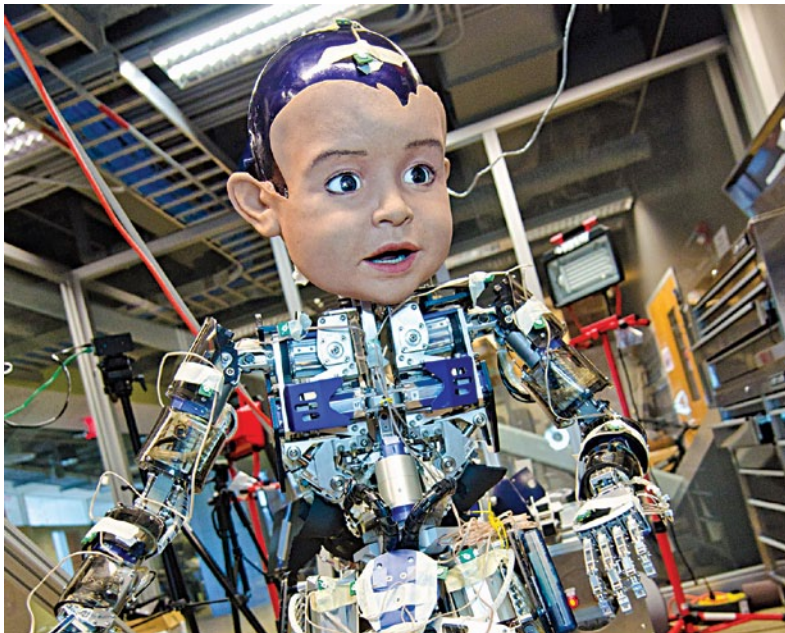
In a demonstration of the concept, the team designed a complete rescue scenario with a 100kg brick object blocking entry to a room and another 100kg loaded cart. Here is how Georgia Tech's Golem Krang robot used the myriad stuff around it to complete the task. They noted, "Interestingly, the loaded cart becomes a fulcrum for an arbitrary board to topple the bricks. Then the bricks, which were initially an obstacle, are used as a fulcrum for a lever to pry the door open. Finally, the robot uses a wider board to create a bridge and perform the simulated rescue."

Another team from Georgia Tech presented a second paper at the same conference detailing how a humanoid robot can be taught to traverse a gap by finding and using an object in its environment. This team achieves such behaviour using a concept that they call Environment Aware Planning (ETAP), which lets the robot evaluate and use resources in its environment to assist its locomotion capabilities, to achieve its goal.

In the demonstration, an HRP-2 robot was made to cross a rather large

gap. The robot, guided by an ETAP-based planning system, picked up a board in its environment and dropped it across the gap, resting on the two platforms on either side. To do this, it evaluated several boards and picked one that was larger than the gap to be crossed.

These researches show that it is



Diego-san, a boy-like humanoid teaching robot being developed at the University of California, San Diego (Courtesy: University of California, San Diego)

possible for robots of the future to understand their environment and react to it intelligently, enabling fully autonomous movement.

Teach me, crowd!

We have been speaking of robots that are aware of their environment and learn from it. But, that would mean their knowledge is only as good as what they see around them, and the people whom they learn from. If the behaviour or methods around them are flawed, their learning would be flawed too.

For example, if a robot is assigned the task of making something using building blocks, its construction would be only as good as the explanation or design it learns from the people around it, which may or may not be the best way of building the object. Instead, if a service like Amazon's Mechanical Turk could be used to

crowd-source designs for building the required object, and the robot could use machine learning to analyse these and choose the best way?

This was the technique that a team from the University of Washington proposed at a recent conference. They described their technique as a goal-based imitation learning framework

that utilises crowd-sourcing as a major source of human demonstration data. They demonstrated their approach by making a robot build models with basic building blocks using knowledge gained from people around it as well as online crowd sources.

They also showed how such a technique could support human-robot collaboration tasks such as goal inference through object-part classification and missing-part prediction.

It is obvious that machine learning is making huge strides. Demonstrations of autonomous cars, intelligent industrial systems, smart drones, and even context-aware apps, are all signs of advancement of artificial intelligence—all of which is reflected in robotics too, albeit at much higher levels. There is no end to the examples we can give. Diego-San, a boy-like robot developed at the University of California, San Diego; user-friendly machine intelligence tools like PredictionIO that help develop self-learning robots and devices; Pepper, the chatty Japanese android that can understand people's emotions and around 70 to 80 per cent of their spontaneous conversation. The list will go on and on, till we arrive at the day when robots pass the Turing test with ease! ●

The author is a technically-qualified freelance writer, editor and hands-on mom based in Chennai

A Combo Connectivity Chipset for IoT Applications

This award-winning ultra-low-power product integrates multiple connectivity methods and is designed in India (though the company offering it is in the USA) exclusively for Internet of Things paradigm

ANAGHA P.

The Internet of Things (IoT) is basically the connection and communication of diverse devices to each other and to the Internet. The back-end of any IoT device consists of elements like microcontrollers, integrated chips and sensors, while the front end is where the communication and connectivity options come, forming the digital side of device.

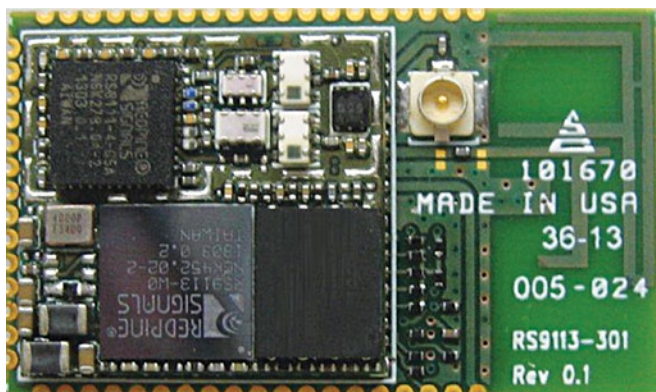


Image of actual SoC

While designing an IoT device, a designer has different connectivity options to choose from, depending on several factors like the range of communication and power consumption with some examples being Zigbee, Bluetooth 4.0 and Wi-Fi. However, the communication backbone is the IP based network, and there is a need for gateway devices to bridge data across these protocols. The RS9113 M2MCombo chipset provides this functionality of a gateway device in the most integrated manner in the industry today – resulting in lower cost, greater energy efficiency and higher quality of service (QoS) than others.

This product was designed

and developed by a team of over 70 Indian engineers under N. Venkatesh, senior vice president of advanced technologies at Redpine Signals. Based in San Jose California, Redpine Signals is a wireless systems company founded in 2001. They specialise in chipset and system level products for wireless applications.

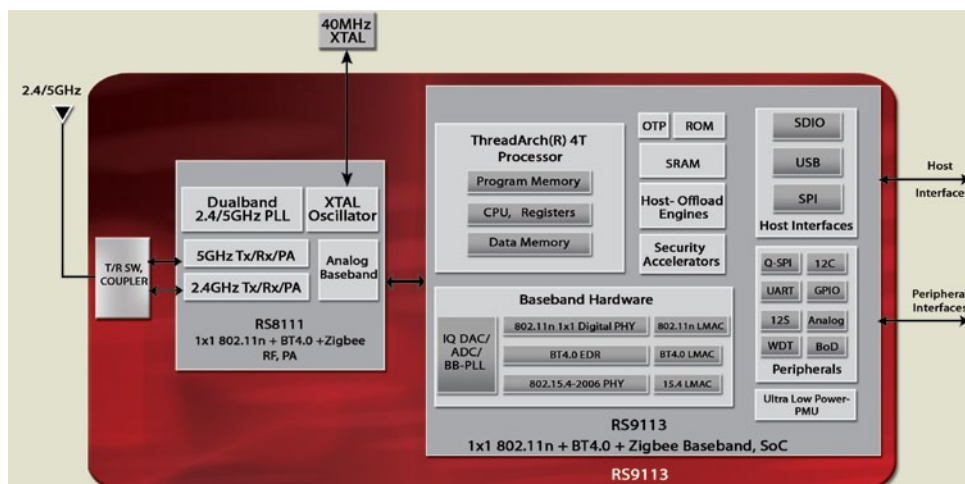
What is it?

The RS9113 is an ultra-low-power, single spatial stream, system on a chip (SoC) that brings together multiple wireless connectivity methods which include 1 Tx-1 Rx dual-band 802.11n Wi-Fi, dual-mode Bluetooth 4.0 and ZigBee (802.15.4-2006) – all these functionalities into a single module. The chipset is a fully self-contained solution, and does not require any part of the protocols it supports to run on a host processor.

This device is basically a complementary metal-oxide-semiconductor (CMOS) chipset that contains a four-threaded processor with on-chip ROM (read-only memory) and RAM (random access memory).

It has integrated baseband digital signal processing, analogue front-end, analogue peripherals, support for digital peripherals, crystal oscillator, dual-band RF transceiver, dual-band high power amplifiers, calibration memory, baluns, diplexers, diversity switch and Quad-SPI Flash.

The processor in the device runs MAC protocol as well as network protocol, enabling the integration of wireless interfaces to embedded systems



Block diagram of SoC

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A bundle of connectivity

RS9113 chipset comes with the following features that help the user design a machine to machine (M2M) device easily: Wi-Fi 2.4 GHz, Wi-Fi 5.8 GHz, Bluetooth 2.1+EDR (enhanced data rate), BT 3.0, BT 4.0 (also known as Bluetooth Smart, Bluetooth Low Energy or Bluetooth LE), ZigBee, calculation power on internal MCU for your application, a large number of diverse peripheral interfaces like I²C (Inter-Integrated Circuit), I²S (Integrated Interchip Sound), SPI (Serial Peripheral Interface), QSPI (Quad Serial Peripheral Interface), UART (Universal Asynchronous Receiver/Transmitter), GPIO (General-Purpose Input/Output), JTAG (Joint Test Action Group) and analogue input/output.

with small host controllers. With the multi-threaded processor and on-chip ROM and RAM, this chipset enables integration into zero host-load applications with the capability to run the Wi-Fi security supplicant and TCP/IP on the chip itself.

What's special about it?

The device can simultaneously maintain connection on some or all of the interfaces, providing multi-protocol gateway for users. It has an antenna and a U.FL connector (a miniature RF connector) for external antenna integrated on it with an option to select either one of them. What's also interesting is that all wireless transceivers inside the chipset will end in a single antenna.

The innovative technology implemented by Redpine will ensure that Wi-Fi, classic Bluetooth, Bluetooth LE and ZigBee on 2400 MHz will not interfere. This new coexistent algorithm helps system design engineers to solve the problems often encountered when trying to co-locate multiple wireless protocols in current multi-chip solutions.

For example, an RS9113 chipset-based gateway device could communicate with a medical sensor via Bluetooth, smartphone via Bluetooth or Wi-Fi, or in-house display device via ZigBee functionality, without the need for using multiple connectivity modules from various vendors.

Redpine offers this product to customers in the form of chips or as ready-to-use wireless modules that can be easily integrated into embedded system designs. They provide a complete reference design and development environment for creating applications using the new chip, and offer an easy-to-use development kit SDIO, SPI,

UART, and USB2.0 interfaces.

The RS9113 solution comes with Redpine's OneBox embedded software framework which supports common API-based base transceiver station, access-point, dual-mode BT 4.0, Wi-Fi Direct, ZigBee and SEP2.0 (Smart Energy Profile 2.0) functions on diverse host platforms and embedded operating systems. Software package includes firmware, reference drivers, application profiles and configuration GUI (graphic user interface) for Windows, Linux and Android operating systems.

This chipset can be used to enable wireless connectivity to a variety of electronic systems like healthcare, industrial and home automation, and in several other devices like VoWiFi (Voice over Wi-Fi) phones, serial to Wi-Fi interface, wireless sensors, smart meters, in-home devices like thermostats and displays, wireless RTLS (real-time locating system) tags and other mobile and M2M communication implementations.

Challenge of developing this SoC

Engineering a complex SoC like this requires careful consideration of factors like meeting power consumption goals, data throughputs, device size factor, and performance. These were a major challenge while developing this product, says N Venkatesh of Redpine Signals, Inc. RF and power amplifier design in CMOS is complex. Developing a protocol compliant firmware that is able to run within limited embedded resources was also another challenge faced by the team. It took approximately two years to get this product idea from inception to fruition. ●

The author is a technical correspondent at Efy

Part 1 of 2

An Introduction to Wireless Sensor Networks

Wireless sensor networks (WSNs) have seen explosive growth in recent years because of their independent sensing capabilities. Study of WSNs requires knowledge of many subjects. First part of his article gives basics of the technologies used in WSNs. The next part will cover network protocols

DR J.D. JAIN

A wireless sensor network (WSN) is a communication system which senses and gathers information from a certain area and sends it to different places of its choice. In other words, WSN connects physical world to virtual world. In such networks the communication system requires networking protocols that are efficient, reliable, scalable and secure.

WSNs can be very useful for target detection and identification by military, and for environmental applications like agricultural farm monitoring and forest fire monitoring. Sensors integrated into structures, machinery and the environment, coupled with efficient delivery of sensed information, could provide tremendous benefits to society, such as fewer catastrophic failures, conservation of natural resources and improved manufacturing productivity.

These applications require a good quality of service (QoS) from sensor networks, such as, minimum percentage of sensor coverage in the required area, continuous service during required time slot with minimum (or limited) resources (like sensor energy and channel bandwidth) and minimum outside intervention. The sensors may vary from miniature in-built sensors to external sensors like video cameras and position sensors.

WSNs have witnessed tremendous growth recently because of their location-independent sensing capabilities even in inaccessible and dangerous

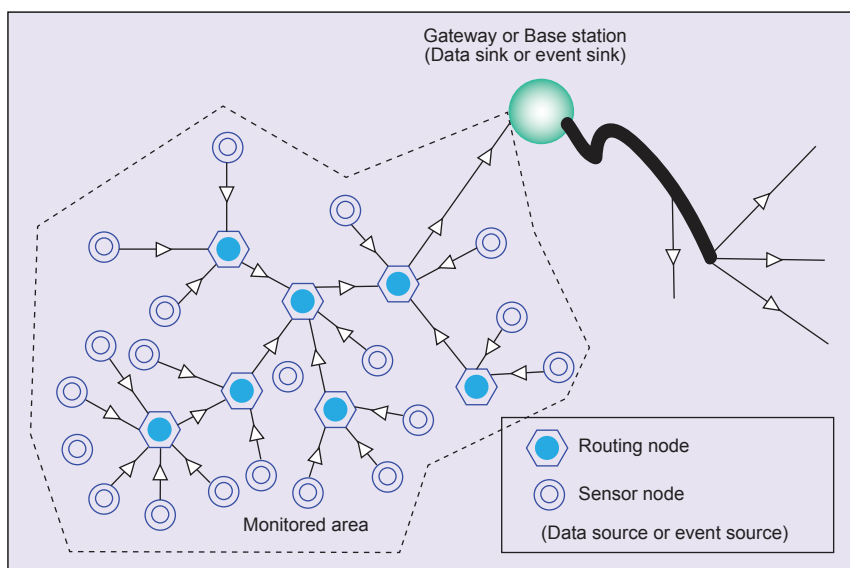


Fig. 1: Monitored area with WSN network

regions, low cost of sensors and long life of power supply because of low power consumption.

The WSN is a variant of ad-hoc networks and differs from ad-hoc networks because of its constraints and unique features. Ad-hoc network means each sensor supports a multi-hop routine algorithm (several nodes may forward data packets to the base station). The WSN lifetime is dependent on the available energy, so energy routing protocol is desired, which can significantly prolong the life-time of WSN. A WSN requires collaboration among multiple types of sensors with different specifications, thus forming a heterogeneous WSN.

Wireless technologies aim at achieving ambient intelligence. Mobile devices embedded in homes, offices and public

places enable ubiquitous sensing, computing and communication. Mobility also implies that limited size and restriction on power consumption, seamless connectivity with other devices and fixed networks, and increased data rates are the bare minimum necessities for intelligent systems.

Features of WSNs

Following are some unique features of WSNs:

1. Sensor nodes are typically immobile
2. WSNs may be deployed in harsh environments, so failures may be quite common
3. The WSNs may be very small, thereby requiring smaller batteries which are bound to have short life-time.

So WSNs may have less computational power and less memory

4. Location information only

5. Communication is typically data-centric rather than address-centric, meaning routing may be aggregated/compressed/prioritised, even dropped, depending on the contents of the data

6. Communication in WSN takes place in very short packets to reduce overheads

7. Sensor networks have many-to-one traffic pattern, which may create hot-spot problems

Incorporating and taking care of the above features plays a tremendous role in designing protocols for efficient utilisation of the limited resources. Sensor networks operate under light load and suddenly become active in response to events like fire outbreak, earthquake or enemy movement.

WSN architecture

WSNs are a type of wireless networks that have three main components: large number of arbitrarily distributed sensor nodes, sink nodes (also known as base station or gateway) and software (see Fig. 1). Each node has a single omnidirectional antenna. Two sensors are neighbours if they are in transmission range of each other and can directly communicate with certain reliability. The gateway is located at the boundary of the monitored area, where it is reachable by at least some sensors and connects the micro-sensor network to the outside.

We refer to each micro-sensor as a data source or an event source and the gateway as a data sink or an event sink. The data is collected at the wireless sensor node, compressed and transmitted to the gateway directly or, if required, uses other wireless sensor nodes to forward data to the gateway. The transmitted data is then presented to the system by the gateway connection. The architecture of a micro-sensor contains four components: sensing circuitry, digital processing, power supply and radio transceiver.

Sensing circuitry. A wireless sensor node contains sensing and analogue-to-digital circuitry, which senses the surrounding environment and transforms it

into electrical signals. The sensed data may be about the behaviour of moving objects or static information like temperature, pressure and humidity. The position of the individual sensors cannot be predetermined. For example, the monitoring fields could be hostile or dangerous and may not be accessible in case of forest fire, chemical pollution, ongoing battle, etc.

A sensor network contains thousands of sensors, which are randomly and densely deployed (10 to 20 sensors per square metre). The sensors' range is not always a perfect circle, it could be an elliptical or some other shape. The sensing strength could vary with distance from the sensor. The development of sensor nodes equipped with Flash memory is giving a new direction in designing and deploying energy-efficient WSNs.

Sensor nodes can be imagined as small computers having limited computational power and limited memory. They consist of processing unit with sensors, designed to compute, calculate and distribute to communication device (transceiver or optical) power source).

The sink is a powerful workstation with plentiful resources whereas sensor nodes are low-power devices which have limited resources, memory space, computational capability and communication bandwidth. Desirable functions for sensor nodes include: ease of installation, self-identification, self-diagnosis, reliability, time awareness for coordination with other nodes, some software functions and digital signal processing (DSP), and standard control protocols and network interfaces. IEEE 1451 is the set of smart transducer interface standards developed by the Institute of Electrical and Electronics Engineers (IEEE) which meets these requirements.

As mentioned earlier, high degree of quality of service (QoS) or fidelity is important for sensor networks. QoS may be measured as percentage of the environment that is actually covered by active sensors. In a typical surveillance application, at least one sensor must remain active within one sub-region

of the network so that the intruder may be detected with high degree of probability. Since the main function of data sinks is acquiring the description of the environment rather than receiving all raw data collected by individual nodes, the throughput is less meaningful. This means, during operation, delay may be either much more or much less important.

Digital processing. The sensed data is fed to the processing unit, which usually has a small storage unit, for processing before transmission. This is referred to as 'in-network processing' during which redundant, useless and spurious data are deleted and observations from different sources are combined and aggregated. In-network data processing is a must to decrease the large volume of raw observations per sensor and to reduce the number of broadcasts. The data processing and storage capacity of the sensor node is limited.

Radio transceiver. A transceiver sends collected data via radio transmitter to sink node either directly or through intermediate sensor nodes. Sensor networks have short transmission range (up to 10 metres) and low data rate (several bytes). They may not have a globally unique ID.

Radio transceiver is the dominant power consumer. Digital radio transceivers for cellular communication backhaul and ground terminal transceivers for very small apertures terminals (VSATs) already employ m-band MMICs. Most VSATs operate in Ku band (12GHz to 18GHz) but, in the future, will be moving to Ka band (26GHz to 40GHz). However, most of the excitement lies in E-band (60GHz to 90GHz) which is meant for point-to-point WLANs and broadband Internet access. Point-to-point wireless can replace fiber-optic communication. Active antenna arrays and radar transmitters at W-Band, especially 94GHz, offer superior performance through clouds, fog and smoke.

Collision and congestion

If more than two nodes attempt to send data to the same destination at the same time, the destination node may fail to receive the data. This is called congestion.

tion. Congestion in wireless networks is of two types: radio collision and buffer overflow. Congestion is very dangerous for WSNs. Collision has the following drawbacks:

1. Increases energy dissipation rates of sensor nodes
2. Causes a lot of packet loss which in turn diminishes the network throughput
3. Hinders fair event detections and reliable data transmissions

Inter symbol interferences (ISI)

Multi-path, cross-antenna interference and multi-user interference (MUI) are the major vulnerabilities of wireless communication systems. To avoid these, a system uses multi-carrier modulation, which is very effective in avoiding MUIs and providing multiple access simultaneously.

Recent developments of orthogonal frequency division multiplexing (OFDM) and interleaved division multiple access (IDMA) have proved that OFDM suppresses the inter symbol interference (ISI) induced by multi-path channels and IDMA avoids MUIs. The drawbacks of code division multiple access (CDMA) are overcome by OFDM-IDMA techniques. In CDMA, interleaver is used for coding gain while in IDMA, the interleavers are used for separating the users. The basic function of IDMA is to use specific interleaver to differentiate the users. However, it is imperative that the interleaver between the transmitter and receiver should be identical. The WSN life-time is dependent on the available energy, so energy routing protocol is desired and can significantly prolong the life-time of WSN.

Routers

Since a distributed network has multiple nodes and services many messages, and each node can be a shared resource, many decisions must be made. There may be multiple paths from the source to the destination, so the message routing is an important task. Routers are a specific type of measurement nodes that one can use to extend WSN working distance or its reliability. Here it is the necessity of

designing dedicated routing protocols which consumes resources like energy and bandwidth very effectively.

Routing methods can be fixed (that is, pre-planned), adaptive, centralised, distributed, broadcast, etc. Routing tables are provided in the fixed routing schemes, where they dictate the next node to be routed to, given the current message location and the destination node. Routing algorithms can be based on various network analysis and graph theoretic concepts in computer science (for example, A-star tree-search, or in operations research including shortest route, maximal-flow and minimum-span problems). Routing is closely associated with dynamic programming and the optimal control problem in feedback control theory

Important design issues for routing are: network model, node deployment, node/link heterogeneity (different types of data to be routed in the same network), data reporting model, energy consumption without losing accuracy, network dynamics (for example, mobility of sensor nodes is necessary, fault tolerance, connectivity, coverage, QoS, data aggregation, transmission media and security).

Resource-aware routing

Different approaches have been developed which consider sensors' resources (such as energy) when making routing decisions. These routers can be of different types, such as:

Distributed activation based on predetermined routes (DAPR). It considers the importance of a node to the sensing application. Here, a node first finds the sub-region within its region of coverage that is the most poorly covered. The cost assigned to that node is related to the combined energy of all nodes capable of redundantly covering this poorly-covered region.

Data-centering routing. In data-centering routing, the end nodes, the sensors themselves, are less important than the data. Thus, queries are posed for specific data rather than for data from a particular sensor, and routing is performed using knowledge that it

is the aggregate data rather than any individual data item that is important.

Sensor protocol for information via negotiation (SPIN)

Because of blind flooding or gossiping data dissemination, SPIN avoids three costly problems: implosion, overlap and resource blindness.

Implosions occur in highly-connected networks that employ flooding and thus each sensor receives many redundant copies of the data. For large data messages, this wastes considerable energy.

Overlap occurs if two sensors send some common data, causing redundancy in data transmission and thus energy waste. SPIN solves this problem by naming data so that sensors only request the data or parts of data they are interested in receiving

Resource blindness is a mechanism whereby a node that is running low on energy will not advertise its data in order to save its low energy resources.

To perform a sensing task, a querying node creates an interest, which is named according to the attributes of data or events to be sensed. When an interest is created, it is injected into the network by the sink node by broadcasting an interest message containing the interest type, duration and an initial reporting rate to all neighbours. Interests are diffused throughout the network toward the sink node using a forwarding technique.

Classification of WSNs

Network based. These are based on mobility, network type and type of communication. Their mobility can be static or dynamic. The network can be flat or cluster-type. The flat type is data-centric and all the nodes in the network are treated equally.

Clustering type. Different nodes are grouped to form clusters and data from nodes belonging to a single cluster can be combined (aggregated). The node with highest available network resources is selected as a cluster head.

Communication based. The routing protocols based on communication are classified as unicast, multicast and

broadcast. When data transmission is directly from sensor node to sink node it is called unicast.

Protocol operation based. These can be route-discovery based, data-delivery mode based, node-location based and QoS based. Route-discovery based protocols are classified as proactive, reactive and hybrid. Data-delivery based routing protocols are classified as continuous, event based and query based. Node-location based protocols are classified as flooding and greeding. The QoS based classification depends on network conditions, traffic classes and real-time streaming.

Application based. A routing protocol selected for one kind of application will not be suitable for other types.

Coverage based. Coverage can be considered a quality of service (QoS) which guarantees that all points in the region of interest (RoI) are covered at least by one sensor. The coverage can be further classified as: (a) area coverage, (b) barrier coverage, whose main objective is to detect the intrusion of any object in the RoI and to minimise the probability of undetected intrusion of an object, (c) point coverage, when the goal is to cover set of points in the RoI, and (d) path coverage, to cover a particular path that an object follows to reach from one point to another.

Connectivity and coverage problems are caused by the limited communication and sensing range. There are basically three main reasons that cause coverage problems: random deployment, limited sensing range and not enough sensors to cover the whole RoI. Strategies used in solving the coverage problem can be divided into three categories: force based, grid based and computational-geometry based.

Ratio of area covered to the area of RoI is called coverage percentage. Coverage is estimated as ratio of grid points covered to total number of grid points in RoI. Computational geometry is based on coverage optimisation.

Hardware presentation: ZigBee, XBee, SquidBee

ZigBee is a standard wireless network

protocol designed for low-rate control networks. Its applications include automation networks, security systems, industrial control networks, remote meter reading and PC peripherals connectivity. ZigBee is the name of a specification for a suite of high-level communication protocols using small, low-power digital radios based on IEEE 802.15.4 standard for wireless personal area networks (WPANs), such as wireless headphones connected to cell phones via short-range radio.

ZigBee has a much wider range as compared to Bluetooth. It covers the network layer, application framework and application profiles, which guarantees interoperability between equipment from different vendors. In addition, the ZigBee network layer specification defines networking topologies like peer-to-peer, cluster or mesh network configurations. The cluster and mesh networks are also known as multi-hop networks, whereas star network is called single-hop network. ZigBee network can activate (go from sleep to active mode) in 30 milliseconds or less, the latency can be very low and devices can be very responsive. Because ZigBee can 'sleep' most of the time, average power consumption can be very low.

ZigBee's use of IEEE 802.15.4 PHY & MAC standards allows networks to handle any number of devices. ZigBee's protocol code stack is estimated to be about one-fourth of Bluetooth's or 802.11's. ZigBee may secure messages transmitted over a single hop using secured MAC data frames, but for multi-hop messaging it relies upon upper layers (such as NWK layer) for security. The ZigBee alliance is not pushing a technology, rather it is providing a standardised base set of solutions for sensors and control systems.

There are several WSN hardware platforms available. One of them could be to base an Arduino board and XBee module. Arduino boards are available with ATmega 8, 16....328, and are equipped with a library for interfacing with ZigBee/XBee modules for dealing with analogue or digital

inputs and outputs. These are modules for easy programming (in C) of the microcontroller. This module can be interfaced with a PC using Visual Basic so that the parameters can be monitored.

Another WSN platform developed is SquidBee, which is an open source device in which each SquidBee Mote takes environmental parameters like temperature and humidity with its sensors and sends them wirelessly through the SquidBee network using ZigBee protocol.

ZigBee arrived in 2.4GHz band 50 years ago, joining the well-established Bluetooth and Wi-Fi technologies. Inseteon combines wired power line and wireless communication to form mesh networks for the devices to communicate when in proximity. If one device fails the others can take over.

XBee and XBee PRO ZB are the most advanced ZigBee modules available, and are ideal for deployment in ZigBee networks. XBee-embedded RF modules share a common hardware footprint and are modelled after a common software application programming interface (API). Once deployed in an application, an original equipment manufacturer (OEM) can rapidly change from one protocol to another with minimal time and development risk.

With advanced mesh networking functionality, XBee PRO ZB modules improve data traffic management, allow for greater node density and provide OEMs with the ability to change firmware remotely with over-the-air updates. XBee-embedded modules are available with different protocols to suit a variety of applications and network topologies. Supported protocols include IEEE 802.15.4, the Zigbee PRO feature set, proprietary long range and Digimesh.

There are many simulatory softwares for WSN including NS-2, SENSE, NETSIM, OPNET and OMNeT+ which can be used to analyse data packet delivery, probability of packet being discarded and other parameters.

To be continued next month

The author is director (R&D), Global Institute of Technology, Jaipur

Part 1 of 3

The Electronics Behind Big Guns

This article reveals the evolution, degree of penetration and the resultant capabilities of the present-day sophisticated canons and tanks. This part deals mainly with crew protection systems

B. KAMALNATH

From the birth of the gunpowder-warfare era, soldiers have been incrementally striving for bigger, more powerful and more accurate guns. Their quest has resulted in the present-day big guns, such as tanks and artillery guns. These big guns – the ‘noisy giant cousins’ of rifles – have the capability to win battles by shattering and scaring the enemy.

The big guns entered the battlefield as state-of-the-art machines during the First World War and played havoc during the Second World War. But they were just like the shaky grandfathers of today’s big guns. This is because electronics has virtually penetrated all the subsystems of today’s big guns. This penetration has made these guns enormously more capable than their shaky ancestors.

What these guns actually do and how

Though tanks and artillery guns are big and possess long barrels, these are not the same. These are brothers with different purposes. Artillery guns, epitomised by stationary field guns, have longer barrels than the tanks. But here, just for the sake of fair comparison, let us see the electronics present in their track-wheeled brothers – the self-propelled guns (SPGs), which are chiefly area-strike weapons.

A group of such guns, called batteries, is used to bombard an area rather



Fig. 1: German Panzer Haubitze 2000 self-propelled gun with its long barrel (Photograph credit: Quistnix, through Wikimedia commons)

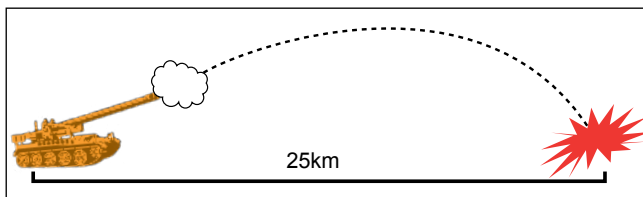


Fig. 2: Typical firing of SPG



Fig. 3: American M1A1 Abrams tank with its shorter barrel (Photograph credit: US Navy, through Wikipedia)

than a single target. With their huge explosive shells, they can bombard a target area situated as far as 30 km away. This is called artillery barrage. An artillery barrage is the most scary and devastating aspect in the battlefield and can flatten structures, vehicles and men. Artillery barrage is the most lethal form of firepower next only to bombing from aircraft. Skilled gunners can engage a single target even as small as a car from as far as 20 km. But the intrigu-

ing aspect is that the gunners do not ‘see’ their target.

In military parlance, the common saying is that “you can’t fire at what you don’t see!” But perhaps these guns are one of the very few exceptions as they don’t see their targets. They simply look at the sky and shoot the shells and shatter the targets into smithereens. When these guns face the sky and fire the shells, the shells obey gravity and ballistics, like a stone thrown upwards. The shells fly in a parabolic trajectory and land on the target area.

These guns are deployed 30 to 40 km behind the frontlines and fired. A trooper employed as forward observer, operating along with the frontline troops, is the key. When enemy forces try to overwhelm the frontline troops, commander calls for artillery support in the form of barrage. The observer sees and selects the target, directs the firing of these guns and reports the impact. The guns

can fire even over a hill to neutralise the enemy in support of frontline troops, in what is called ‘indirect fire support.’

For the shells to land accurately on the target area, the gun’s elevation and azimuth to be maintained are calculated through trigonometry. The accuracy of the calculation determines the accuracy of a shot! Firing these guns requires a complex alignment process and use of instruments like sextants and clinometers. Simply put, it is more

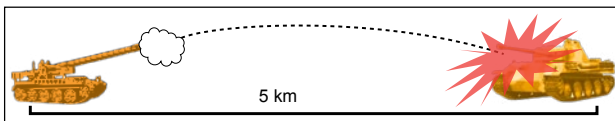


Fig. 4: Typical tank firing



Fig. 5: American AGM-114 Hellfire laser-guided missile on predator drone. Missile's front tip is the eye (Photograph credit: US Department of Defense, through Wikipedia)



Fig. 6: American BGM-71 tube-launched optically-tracked wire commanded data link guided missile with the wire trailing behind the missile (Photograph credit: US Army, through Wikipedia)

of an engineering process than a firing process.

During the First World War, in the Battle of the Somme, a strange-looking beastly armoured metallic vehicle making 'clang clink clang' noises crawled into the battlefield like a caterpillar. It was a British invention that was conspicuously named as 'tank' to conceal its real purpose of crossing trenches. As the trench warfare of the WW-I went out of favour of the militaries, tanks got a new job. That job was to be the spearhead of an advancing force.

Germans exploited this aspect through their blitzkrieg campaigns in WW-II and tanks came to prominence.

Unlike the artillery guns, tanks see their targets and shatter them. During an advance, typically, the tank will put its crosshairs on anything that annoys the advance and blow it into smithereens. If a bunker is annoying the infantry the tank will put it in its crosshairs and shatter it, in what is called 'direct fire support.' The shells fired by tanks exit the gun in a flat trajectory at a speed of around 1525 m/s (5000 ft/s) whereas the shells fired from SPGs exit the gun in a parabolic trajectory at a speed of around 305 m/s (1000 ft/s).

The basic differences between a tank and an SPG make them to complement each other. In an armoured thrust deep inside the enemy territory, the tanks form

frontline and proceed shattering what they see. The SPGs follow the frontline at a distance of 20 km, giving indirect fire support as and when required. With this background let us embark on a virtual tour to see the electronic systems present in these big guns—the defensive, offensive and command & control systems.

Crew protection systems

Losing a well-trained crew is more unacceptable for an army than losing a tank or self-propelled gun. So these big

guns have armour around them. As the self-propelled guns are not operated on the frontlines, these have minimum armour. This armour can protect the crew only from bullets and splinters, but not from an enemy tank's shell. On the other hand, as the tanks form the spearhead of an invasion force, they require enormous protection that is usually provided by its mightily heavy armour.

The tank's heavy armour, through its bulk and tensile strength, protects the crew to a greater extent even from the enemy shells. This armour itself became an iconic representation of tanks within a few years of tanks' introduction into battlefield. Army units centred on tanks got named as armoured divisions, armoured corps, etc, and now form the core of the offensive formations all over the world.

Introduction of active protection systems (APS) for crew has made the armour just the last line of defence. The APS protect the tank from anti-tank missiles and rockets. Hard-kill APS (HK-APS) destroy the projectiles while soft-kill APS (SK-APS) spoofs and diverts them.

Soft-kill active protection systems

SK-APS are used against laser-homing and wire-guided anti-tank missiles. Laser-homing missiles look for laser reflections from the targeted tank to home in and attack. For this, a laser designator is focussed on the targeted tank by another entity. The designator continuously emits pulse-coded IR laser beam which gets meagrely reflected by the tank. After the missile is launched, while it is flying, it looks for these meagre reflections from the targeted tank, spots them, and flies towards the reflection (tank) to destroy it.

A wire-guided anti-tank missile is launched from a command-launcher console. The missile uncoils a thin wire while flying, throughout its range. The command-launcher console sends guidance signal to the missile through this wire. The operator just keeps the target on the crosshairs of the command-launcher console. A computer

inside the console understands the orientation of the command-launcher console. The missile has a small IR beacon on its rear whose emissions the command-launcher console continuously tracks. From these two parameters, the command-launcher console understands the missile's trajectory and the target's position. It then calculates the trajectory that the missile should follow. Accordingly, it sends the guidance signals through the uncoiled wire.

The probability of a tank being engaged by any of these two types of missiles is very high. So the SK-APS must be capable of tackling both these types. A typical SK-APS is based on a control computer taking input from laser sensors (situated at strategic locations on the tank's body) and controlling an electro-optical jammer and grenade launchers, which are situated on the sides of the tank.

To tackle laser-guided missiles, the SK-APS computer continuously looks for any laser emissions in the tank's vicinity through its laser sensors. Once the control computer detects a pattern of laser emissions, it activates the grenade launchers present in the direction from where the missile is arriving. Grenade launchers fire smoke grenades that dispense a thick aerosol cloud at a distance from the tank and effectively erect a smoke screen. This cloud is opaque for the lasers from the designators to penetrate. So the laser gets reflected and the missile mistakes the cloud as a target. But unknown to the missile, the tank moves to a different position and escapes from the killer missile.

To defeat wire-guided missiles, the SK-APS, uses a jammer. The jammer is a powerful IR flashlight that can also pulsate. The command-launcher console tracks the IR beacon of the missile to find the position of the missile. When the missile starts approaching the tank, the SK-APS computer activates the electro-optical jammers that start emitting IR pulses. The command-launcher console mistakes the jammer for missile's IR beacon. Since jammer is an integral

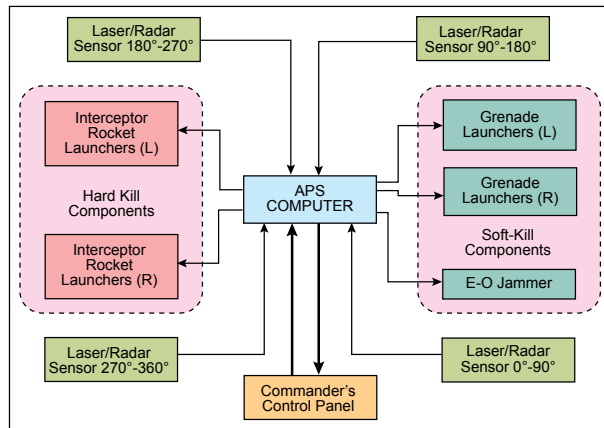


Fig. 7: Block diagram of a typical active protection system showing both hard and soft kill components



Fig. 8: Shtora with jammers active; note the lit red flashlights (Internet photo)

part of the tank, the command-launcher thinks that the missile is exactly on course, but in fact the missile is now off course. The missile therefore crashes somewhere other than the tank.

American AN/VLQ-6 missile countermeasures device, German multi-functional self-protection system and Russian Shtora are some of the predominant SK-APS systems in use.

Hard-kill active protection systems

A major handicap of an SK-APS is its inability to defeat anti-tank rockets. An anti-tank rocket, called rocket propelled grenade (RPG), is a dumb weapon without any electronic guidance system. So it cannot be confused. It just travels in a straight line like a bullet. Though dumb and cheap, it can effectively destroy millions of dollars worth tank. Hence it has become the favourite weapon of terrorists.

The changing geopolitics has led the battles to be fought in cities against terrorists and insurgents rather than

in open terrains. This requires the tanks to prowling the streets, an unfavourable ground for tanks. Even a minimally trained person can take out a tank with an RPG from a roof-top. So narrow streets and gullies have now become tank-killing grounds. This has necessitated hard-kill systems to destroy these rockets. So far only Russia and Israel have had to fight intensely inside cities and faced the wrath of the RPGs. Forced by these conditions, only they have successfully deployed such systems to defeat the RPG menace. Developmental efforts are going on all over the world to develop such systems.

The HK-APS is a fully-automatic system providing a very high degree of protection for the tank in all climatic and terrain conditions. It can protect the tank from anti-tank rockets and missiles, and treats them the same way. It uses radar for detecting the incoming projectile missile or rocket. Then it uses interceptor rocket launchers instead of grenade launchers and jammers.

Multi-directional radar mounted on roof of the tank acts as eyes of the HK-APS and constantly scans for an approaching rocket. Depending on the type and design of the HK-APS, separate radars scanning different sectors may replace this multi-directional radar. The HK-APS computer filters the resultant radar echoes and culls out the echoes matching that of these RPGs.

Once the echo of an RPG is filtered and identified, the radar switches to the target-tracking mode. In this mode, it stops looking elsewhere and continuously looks at the projectile to derive the direction and bearing (trajectory) of the incoming RPG. This trajectory

data is fed into the APS computer of the HK-APS.

If the computer finds that the trajectory of the projectile is towards the tank, it calculates the right time and angle to destroy the RPG. Once the RPG has reached the right area, the control computer activates the rocket launcher to fire a short-range interceptor rocket. This rocket, after reaching the proximity of the RPG, explodes and releases many fragments that in turn destroy the RPG. The same methodology applies for anti-tank missiles also.

The reaction time of these hard-kill active protection systems is generally in milliseconds after an RPG is detected. The RPG is intercepted within a blink of an eye. After destroying an RPG, the system gets ready to destroy the next projectile within half a second. In a separate interactive display, the tank commander sets the modes of operation and monitors status of the system. Even if a projectile passes without harming the tank, through this display the HK-APS indicates to the tank commander the direction from where it was fired. The tank commander may, in turn, attack that source of attack.

The design of these APS is such that they do not respond to decoys. The modern Russian HK-APS systems are rumoured to be even capable of working in a group with the APS of the adjacent tanks. But further details are kept as highly classified information. In general, how the APS distinguishes between different types of missiles and accordingly fixes its *modus operandi* are not revealed in the open domains.

German AMAP-ADS, Swedish LEDS-150 and American Quick Kill are some of the HK-APS systems in pre-induction phases, while Israeli Iron Fist and Trophy and Russian Arena are fully operational. The only disadvantage of HK-APS is that it is dangerous for the infantry to be within 20-30 metres of the tank during joint infantry-armour operations. A tank can either have SK-APS or HK-APS, not both.

But APS cannot offer protection against the high-speed anti-tank shells fired by other tanks. Because of the



Fig. 9: An Iraqi soldier with Russian rocket-propelled grenade-7 (RPG-7) (Photograph credit: US Marines, through Wikipedia)



Fig. 11: Interceptor launcher of Israeli 'Iron Fist' APS (Photograph credit: Ereshkigal1 through Wikipedia)

speed (1.5 km/s) at which these shells travel, it is impossible for any system to intercept them. The best way to avoid these shells is through better tactics so as to avoid getting shot at. But in spite of the tactics if a tank is shot, the armour is the last line of defence. Notwithstanding the armour's strength, electronics has penetrated these armours. So, now smart armours are being developed to replace the traditional armours.

Smart armour

The armour explained below, though still in research phase in the UK, is likely to enter the battlefield in the next decade. This explosive reactive armour (ERA) uses layers of highly explosive material sandwiched between armour plates. When a projectile hits the ERA, the hit detonates the explosive layers. The resulting explosion pushes the outer steel plates on to the warhead and disrupts its flow. All this happens in milliseconds. This counter explosion

reduces the force of impact greatly and saves the tank crew. This armour is presently used in the form of ERA tiles fitted over the existing tank's armour. The ERA tiles have to be replaced after a hit.

The 'smart' concept has been extended to the ERA. In future, the ERA will be formed as small ERA blocks instead of ERA tiles and their detonation will be controlled by a computer. Pressure sensors will be embedded into the ERA blocks. On a shell's hitting the armour, the computer through the pressure sensors would sense the location, velocity and diameter of the shell from the impact. Accordingly, the computer would detonate only the relevant explosive elements.

Through this 'Smart ERA' concept, minimum force will be used to destroy the shell. Further, the need to change an entire ERA tile would be eliminated. The smaller damaged explosive blocks would be easily replaced at a later time. Since there is only one-in-a-million chance of two shells hitting at the same point, the tank will be safe even without an immediate ERA replacement.

To sum up, electronic tank protection systems have become the tank's first line of defence, pushing the armour to be the last resort. Army strategists, due to these APS, foresee the reduction of armour weight. Such reduction will make the tanks light, fuel-efficient and agile.

Electronic systems to defend tanks are fine but what about the electronic systems for offensive capabilities? For that the electronic fire control system comes into the play, which will be described in the next part.

To be continued next month

The author has contributed several articles in the past as well

FTTH and Passive Optical Networks

Depending on the termination point, fibre access networks have different configurations, such as fibre-to-the-home, fibre-to-the-premise, fibre-to-the-building, fibre-to-the-curb, or fibre-to-the-node. Let us have a look

DR RAJIV KUMAR SINGH

Since long back, telecommunication service providers have dreamed of an all-fibre network and for good reasons. A fibre provides substantially more bandwidth, carries signals farther, is more reliable and secure, and has a longer life span. Additionally, providers view fibre's bandwidth capacity as a competitive weapon, particularly in the access network.

Fibre is seen as the pre-eminent long-term alternative to today's broadband access technologies. One that not only allows providers to generate new services but also provides them with significant and sustainable reductions in operating expenses, and shifts their capital spend-

ing from older technologies to newer, less costly technologies. The single greatest driver for fibre in the access network is multi-play services, the opportunity to offer subscribers high-speed data, voice and video as one of a variety of potential bundled services.

Today, fibre networks come in many varieties, and telecommunication service providers consider a variety of FTTx architectures (here 'x' stands for the termination point) for delivering fibre to their subscribers. Depending on the termination point, FTTx is classified as fibre-to-the-premise (FTTP), fibre-to-the-home (FTTH), fibre-to-the-building (FTTB), fibre-to-the-curb (FTTC) or fibre-to-the-node (FTTN), each having different configurations and characteristics.

Currently, there is no one-size-solves-all architecture, so providers must make a series of technology decisions based on their service goals. A primary consideration for providers is to decide whether to deploy an active (point-to-point) or passive (point-to-multipoint) fibre network.

Configurations

FTTx configurations depend on how the optical fibre is used in the last-mile access network.

FTTH. It is a method of installing optical fibre cable to the home. FTTH is the final configuration of access networks using optical fibre cable. It consists of a single optical fibre cable from the telecom service provider's central office, or base station, to the subscriber's home. An OLT optical line terminal (OLT) at central office connects optical network unit (ONU) residing at subscriber's home through a dedicated fibre. The optical-to-electrical signal conversion is done through a modem and connection to the user's computer is established via an Ethernet card (Fig. 1).

FTTB. In this configuration, optical fibre cable is run from the telecom service provider's central office (OLT/central terminal) or base station to the building's termination point (ONU/remote terminal). A local area network (LAN), or existing telephone metallic cable, is then used to connect the user (Fig. 2).

FTTC. It is a method of installing optical fibre cable by the curb near the user's home. An optical communications system is then used for the remote (optical or electrical) signal conversion unit installed outside (near the curb or on a telephone pole) the installation centre. Finally, metallic

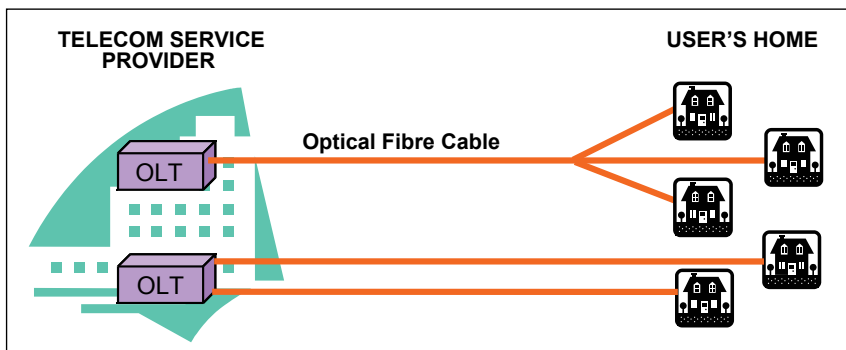


Fig. 1: FTTH configuration

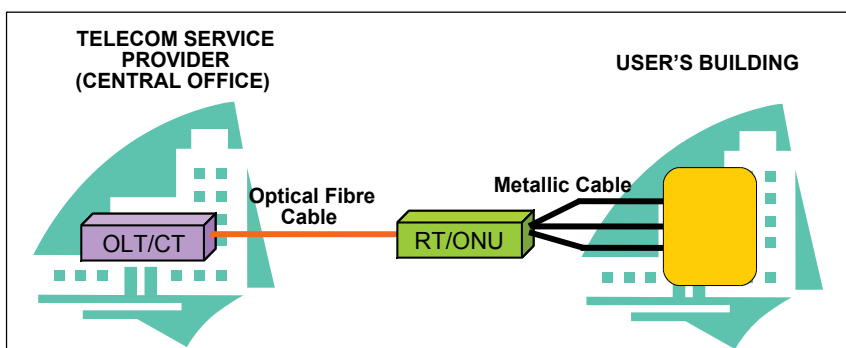


Fig. 2: FTTB configuration

telephone cable, coaxial cable or other similar cable is used between the remote unit and user (Fig. 3).

Architectures

Selection of network architecture to be implemented is a very important criterion for providing telecom services to the consumers. A telecom service provider considers aspects such as network location, the cost of deploying the network, subscriber density, existing outside plant, the return on investment (ROI) and many more things.

Basically, two types of architectures are available, namely, active and passive. Active architectures are sometimes referred to as home-run fibre and/or active star Ethernet. On the other hand, passive architectures,

which include passive optical networks (PONs), are the current choices. Each has its own pros and cons, and the final selection depends on the provider's unique requirements.

Active optical networks (AONs)

Home-run fibre (point-to-point). As the name suggests, active optical networks employ active or powered devices. A home-run fibre architecture is one in which a dedicated fibre from an optical line terminal (OLT) located in the central office of the telecom service provider connects in a point-to-point fashion to an optical network terminal (ONT) residing at subscriber's premises. Both OLTs and ONTs are active, or powered, devices,

and each is equipped with an optical laser. Subscribers can be located as far away from the central office of the service provider as 80km, and each subscriber is provided a dedicated fibre that provides full bi-directional communication.

Home-run fibre is the most flexible architecture over the long term. However, it may be less attractive when the physical layer costs are considered. Since a dedicated fibre is deployed to each premise, home-run fibre requires installation of lot more fibres than other options, with each fibre running the entire distance between the subscriber and the central office. The fibre cost and size of the fibre bundle at the OLT can make this network expensive and inconvenient in many service areas.

Active star Ethernet (point-to-point). Active star Ethernet (ASE) architecture is a point-to-point architecture in which multiple premises share one feeder fibre through a remote node located between the central office and the served customer's premises (Fig. 4). Environmentally hardened optical Ethernet electronics—switches or broadband loop carriers—are installed at the remote node to provide fibre access aggregation. The remote node can be shared between four to a thousand homes via dedicated distribution links from the remote node.

Similar to the home-run fibre, subscribers can be located as far away from the remote node as 80km, and each subscriber is provided a dedicated fibre that provides full bidirectional bandwidth. ASE reduces the amount of fibre deployed, lowering costs through the sharing of fibre. ASE also offers the benefits of standard optical Ethernet technology, much simpler network topologies and supports a wide range of CPE solutions. And, most importantly, it provides broad flexibility for future growth.

Passive optical network (point-to-multipoint)

Passive optical network (PON) is essentially a cost-effective optical-fibre-based access system for providing multi-play services (voice, video, data, etc) to both

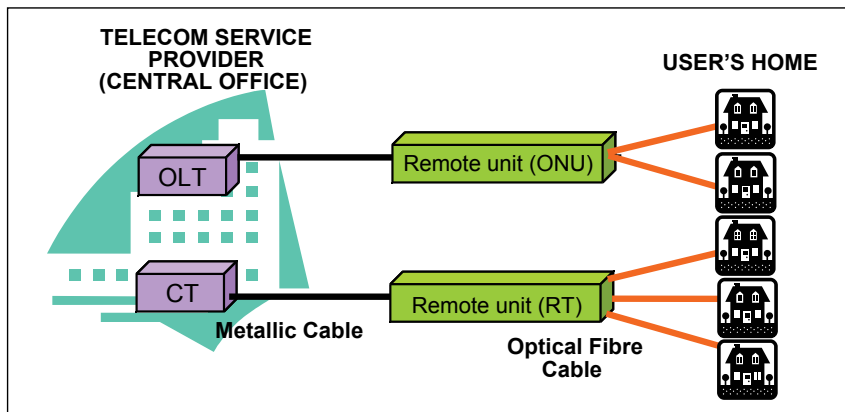


Fig. 3: FTTC configuration

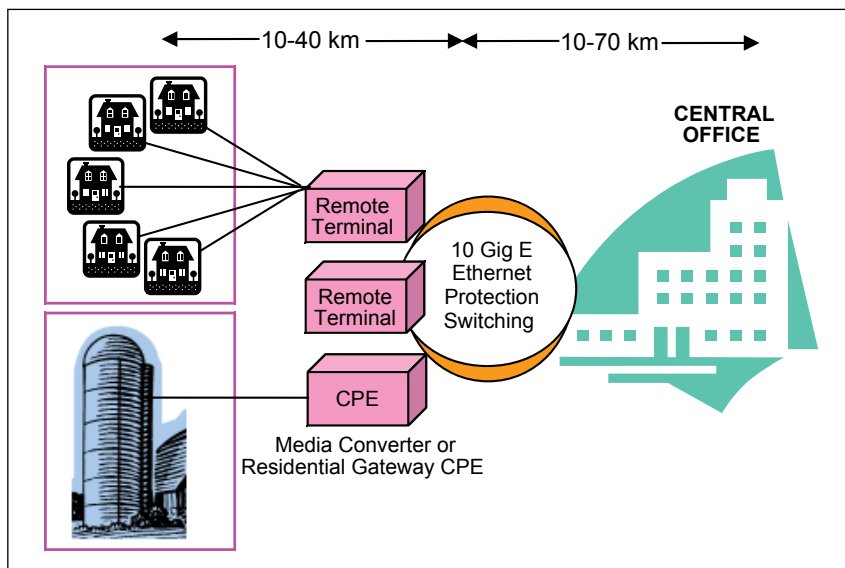


Fig. 4: Active star Ethernet architecture

business and residential customers. Passive optical networks use optical fibre and optical power splitters to connect the OLT at the local exchange to the ONU at subscriber's premises (Fig. 5). No electrical or electronic components are used between these points, all being passive components.

This approach greatly simplifies network operation and maintenance, and reduces the cost. PON, being a point-to-multipoint architecture, requires much lesser fibres as compared to point-to-point topologies. The key network elements of a PON system are OLT, ONU, optical splitter and network management system (NMS).

OLT resides in the telecom service provider's central office and provides traffic aggregation and switching functionality between the core network and PON interfaces. OLT devices support management functions and can manage up to 128 downstream links. In practice, it is common for only 8 to 32 ports to be linked to a single OLT in the central office. Thus, one OLT serves multiple ONUs/ONTs.

The access node installed within user premises for network termination is termed as ONT. Access node installed at any other location, such as curb/cabinet/building, is known as ONU. ONU/ONT provides access to

the users and interfaces to uplink local traffic towards OLT.

Passive optical splitters/combiners provide connectivity between OLT and several ONUs/ONTs. These splitters (distributed or single staged) are available in several options like 1:4, 1:8, 1:16, 1:32 and 1:64.

Network management functions are performed from OLT through the NMS. Time division multiplexed (TDM) data is sent downstream from the OLT towards each ONU where the appropriate portion is extracted for local use. In the upstream direction, a time domain multiple access (TDMA) protocol allocates slots for data transmitted from each ONU to communicate back to the OLT without any contention between different subscribers. Typical distance between OLT and ONU can be up to 35 kms.

Based on Ethernet technology to create a passive optical infrastructure, PON is classified as Ethernet-PON (EPON) and gigabit Ethernet-PON (GPON). The key features of various PONs are summarised in Table I.

PON requires fewer fibres because subscribers are connected via dedicated distribution fibres to the site, and they share the optical distribution network (ODN) trunk fibre back to the central office. Fig. 6 shows the lesser fibre requirement for PON (EPON and GPON) as compared to the topologies of point-to-point (P2P) and point-to-multipoint (P2M) switched Ethernet.

Point-to-point Ethernet might use either N or 2N fibres, and would have 2N optical transceivers. Point-to-multipoint switched Ethernet uses one or two trunk fibres and thus would save fibres and space in the telecom service provider's central office (CO). But it would use 2N+2 optical transceivers and would require electrical power in the field.

PON also uses only one trunk fibre and thus minimises fibres and space in the CO, and it also uses only N+1 optical transceivers. Most importantly, it requires no electrical power in the field. The drop throughput can be up to the line rate on the trunk link. EPON can

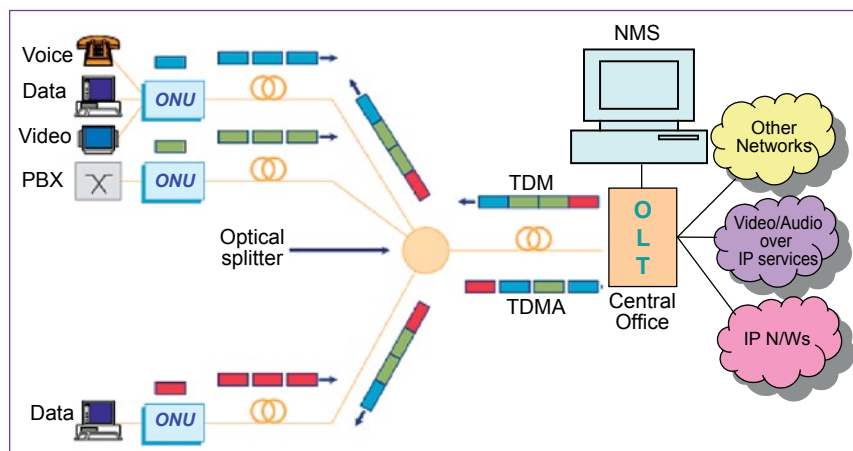


Fig. 5: Passive optical network architecture

Key Features of Various PON Standards

Features	BPON	EPON	GPON
Standard	FSAN & ITU-T SG15 (G-983 series)	IEEE 802.3ah	FSAN & ITU-T SG15 (G-984 series)
Download	622Mbps	1.25Gbps	2.5Gbps
Upload	155.52Mbps	1.25Gbps	2.5Gbps
Downstream wavelength	1490nm & 1550nm	1490nm	1490nm and 1550nm
Upstream wavelength	1310nm	1310nm	1310nm
Layer-2 protocols	ATM	Ethernet	ATM, Ethernet, TDM over GEM
Frame	ATM	Ethernet	GPON encapsulation method
Max. distance (OLT to ONU)	20km	10km and 20km	20km (supports logical reach up to 60 Km)
Split ratio	1:16, 1:32 and 1:64	1:16 and 1:32	1:16, 1:32 and 1:64
Downstream security	AES: Advanced encryption standard 128-bit	Not defined	AES: Advanced encryption standard (counter mode)
Forward error correction	None	Yes	Yes
Protection switching	Support multiple protection configuration	None	Support multiple protection configuration

Conclusion

FTTx is a family of optical-fibre-based network system that is currently being widely adopted by several telcos to offer cost-effective, lightning high-speed telecom services to its customers through all-optical-fibre network. Technological improvement in the fibre optics domain has led to a new kind of passive optical network elements. EPON and GPON, being passive optical network systems, are very cost-effective for a variety of residential and business services like high-speed Internet, multi-play services, broadcast video, transparent LAN service, and many more. The fibre-optic technology is on the way for a series of technological innovations and developments that will continue to enable vast increases in offered bandwidth over long distances. ●

The author, currently with Lovely Professional University as assistant professor and previously associated with Bharat Sanchar Nigam Ltd, is PhD in electronics engineering from IIT (BHU), Varanasi and a recipient of senior research fellowship of UGC at Centre of Advanced Study (IT-BHU). His current research interests include wired and wireless technologies for high-speed telecom services

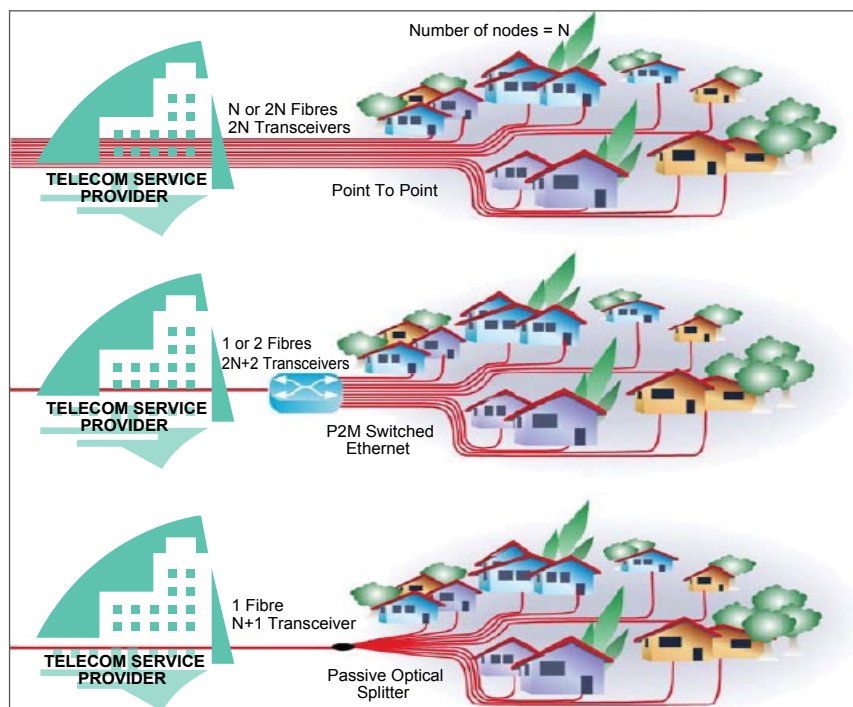


Fig. 6: P2P Ethernet, P2M switched Ethernet and PON

support downstream broadcast such as video. EPON is typically deployed as a

tree or tree-and-branch topology, using passive 1:N optical splitters.

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What's New in Software Design Tools for Embedded Systems

Embedded design tools have become as important as microcontrollers for designers. These tools are getting more powerful, intuitive and flexible, allowing for new and better designs to be completed much faster

PANKAJ V.

Since hardware designs are now being churned out in large numbers, it has become challenging for designers to increase the adoption rate and at the same time keep pace with new developments. But thanks to the software tools which are maturing at par with the hardware developments and helping the design engineers to overcome these challenges.

If we see the latest developments, Silicon Valley is getting equipped with a new generation of design tools which are easy to adopt, scalable to design, economical to build and help reduce time-to-market the new innovations. Almost all silicon vendors have taken up more integrated approach in terms of coming up with their own development environment and support.

On software side, emphasis has been on performance analysis and better utilisation of CPU cores, while hardware developments are getting assisted better with the help of more and more simplified and integrated IDE approaches.

From simple PCB designing to complex FPGA and embedded board designs, we have a variety of software tools available with rich sets of features to help design easy, simplified and optimised designs. Let us see how these tools have matured in recent times.

Performance analysis support

On software front, if we look at the new features, focus has been particularly on performance analysis. There have been various enhancements and developments in software for better utilisation of CPU cores and system memory, improving overall efficiency of the embedded design tools.



For instance, TI's code composer studio has been enhanced immensely to help analyse performance of DSP as well as CPU cores. Mentor Graphics also announced next-generation Sourcery CodeBench and Sourcery Analyzer products to allow developers accelerate system debugging, including concurrent Linux applications, by quick and easy visualisation and analysis of complex software systems.

Also, the latest version of Intel System Studio includes an all-new analyser which analyses system and

SOC events. The new GUI displays the hardware events with call stacks, and results can be seen in source or assembly without any instrumentation.

Virtual JTAG probes

Software applications can be tested against IDEs and the hardware can be developed for dedicated logics simulated on the design tools, and you can easily get all the bugs out. But when the entire system is put together, interacting with the processor, there occur system-level problems which are very hard to capture.

Arun Mulpur, industry marketing manager, MathWorks, says, "The most basic question while talking about hardware/software co-design/debug is, where do I start?"

Whether to start with hardware and then write software, or first software then hardware? But actually doing both at the same time in the same environment is the solution. Simulink embraces this approach as a system-level simulation and implementation platform for both hardware and software."

The latest embedded design suites are addressing these system-level problems with new capabilities where software breakpoints can trigger hardware data capture and vice-versa. You can execute instruction traces or have your hardware breakpoints to halt application debugs to easily find out system-level problems, saving time and costs.

Mentor's Embedded Sourcery Codebench Virtual Environment for

Static code analysis tools

Apart from the performance analysis integrated in the proprietary embedded tools, there are certain third-party tools which can be seamlessly integrated into your IDEs or your team's natural workflow and analyse your codes.

Static code analysis tools like Coverity and Klockwork have emerged with a great impact on the sales and product integrities. Experts believe that if there is a tool which could report the issue before it actually causes an outage, you should have that tool.

Dhaval Vasa, product manager, elfinfochips explains, "You can use these third-party tools as a part of your development environment, and then get things done. The static code analysis enables you to analyse your code before you actually combine it and make sure you remove all possible issues that exist in terms of security and second on the possible leakages that exist on the resource and the memory side. It is always a great help."

These tools can mirror how code is developed and find vulnerabilities on the run and thereby prevent any defects, as code is being written. You are thus enabled to take corrective actions immediately, before builds, and deliver more secure and reliable codes.

Tools are getting equipped with more and more coding standards, providing comprehensive defect coverage for various industries like automotive, embedded security, medical, aerospace and even gaming and mobile device developments.

software debug and Veloce Emulator allow hardware-software co-debug. You can use Veloche GUI to download hardware design and Sourcery Codebench Virtual Environment for software development and then debug through a virtual JTAG probe connected to the processor.

Embedded design suite from Xilinx also comes with the software/hardware cross feature, enabling software and hardware teams to debug in the same environment and allowing each team to capture both software and hardware data without having to use or learn separate tools.

Reduced bring-up time

For software validation in context of system hardware, methodologies like prototyping are widely used, and FPGA-based prototyping has surfaced with the solutions. But there are certain associated challenges.

The bring-up time to implement a design into an FPGA prototype has become a major challenge these days. It is not easy to make changes to the register-transfer level (RTL) design. Also, there hasn't been an easy transition available from an existing simulation or emulation environment to the prototype.

Same bring-up flow for emulation and rapid prototyping enables designers to switch seamlessly be-

tween two execution engines, which in-turn reduces the prototype bring-up time significantly as compared to traditional FPGA-based prototyping approaches.

The Protium platform from Cadence, based on Xilinx Virtex-7 2000T FPGAs and featuring an advanced implementation and debug software flow, addresses the above challenges. Common compile flow between Palladium emulation and Protium FPGA-based prototyping allow designers to have a quick and efficient transition from emulation to prototyping.

The platform supports up to 100 million gates, which is a 4X increase

in capacity compared to the first-generation Rapid Prototyping Platform. A fully automatic software flow enables fast prototype bring-up while additional user-driven performance optimisations assure highest possible speed, which is essential for early software development.

Power aware feature

This feature can be seen as a part of new performance analysis features that were mentioned earlier. In-depth analysis of performance and events of CPU and GPU activities allow identification of wake-up causes, timers triggered for different applications and various interrupts. Now you can maximise power efficiency of the silicon using functions provided in software tools.

Precision 32 from Silicon Labs enables developers to maximise power efficiency of embedded 32-bit designs. It features a power estimation view where the relative power profile of any given configuration can be seen and analysed. You can then make optimisations to the configuration using the tool and improve overall power consumption of the system.

Increasing hardware and software complexity in SoC designs has made low-power designing even more challenging. Juergen Jaeger, senior manager, product management and

IP builder for FPGAs

The concern for any FPGA designer is not only to run the code on the hardware but also to ensure the timing constraint, that is, whether it will run in the clock cycle supplied to the chip. Instead of using low-level hardware description languages, tools are giving us options to generate programs for FPGAs using simple languages like ANSI C or C++.

This helps separate the performance and space constraints from the code and allows any designer to focus only on performance of the code rather than other constraints.

Arun Veeramani from embedded systems segment, National Instruments, says, "For any designer, there are three main constraints which should be taken care of: performance, timing and resource constraints. The ideal situation would be to focus on performance and leave timing and resource constraints for the software to manage. There has been a lot of focus on high-level synthesis in last one year."

LabVIEW for FPGAs has introduced an IP builder feature for such high-level synthesis. It allows you to build almost anything and create an IP which will automatically optimise your FPGAs and achieve performance and resource utilisation goals.

Also, you can minimise code changes between your LabVIEW desktop and FPGA algorithm implementation, allowing a quick check for design trade-offs, without any need to change your algorithm.

marketing, Cadence Design Systems, Inc., explains, "The low-power requirements in many SoC devices (like mobile) exponentially increases hardware and software complexity in terms of clocking, power regions, etc, which in return requires cycle-accurate, yet high-performance tools to validate the system functionality."

Intel System Studio has come up with an all-new power profiler, Intel Energy Feature, which can analyse CPU core frequencies and events that wake up the processor at source code level. It also includes two support watches for Android systems: SoC Watch and WakeUp Watch. While SoC Watch monitors power states, frequencies and wake-up metrics that provide insight into the system's energy efficiency, WakeUp Watch traces and monitors system power states from the command line.

Dynamic Power Analysis in the Palladium XP II platform from Cadence is now integrated with veri-

Open source or proprietary?

This will always be a difficult question while selecting an EDA tool for your organisation. The trade-off will be between time and money. With open source tools you can save yourself the expense of buying a licence. You will be on the safer side even if this choice doesn't work for you.

While the proprietary tools are normally easy to implement, with support and training available from the vendor which saves a lot of time, you can lose money if you do not do it first-time right!

Open source software evolves through community cooperation with the sharing of experiences and ideas that can then be incorporated in future releases. This enables much faster development in open source software as compared to proprietary software. Also, the support provided by the community is amazing, because it is not one company but enthusiasts all over the world who are always happy to help.

fication and debug support for the IEEE 1801 standard for design and verification of low-power integrated circuits. With this, the Cadence System Development Suite now offers an integrated and consistent low-power flow for engineers using either of the power standards across the simulation and verification platforms, with common power plan and metrics, and integrated debug analysis.

These features will enable the

designers to address low-power requirements in SoC designs and further reduce time-to-market for the products, while at the same time improving product quality.

SQL Planner

The Internet of Things (IoT) is the next-generation field which almost everyone is talking about these days. Latest versions of almost all the development tools, including TI's Code Composer,

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Simplicity Studio from Silicon Labs, Design Suits from Xilinx and many others include support for the latest processors focusing on IoT developments and designs.

But apart from these applications, an all-new SQL Planner has been introduced to ease data analysis and management for intelligent devices. SQL Planner from ITTIA is included in its database engine which calculates critical data statistics efficiently with cost-based optimisations. It provides a smart query optimiser that determines the most efficient way to execute a given query by considering plausible query plans, thus accelerating SQL query execution and reducing the time to access data.

SQL Planner can be an important embedded data management tool to help devices gain intelligence in machine-to-machine (M2M) frameworks and thus IoT ecosystems. These devices are enabled to analyse data and determine when objects must be replaced, repaired or recalled.

Automatic NEON vectorisation

NEON is a single instruction multiple data (SIMD) architecture extension implemented as part of ARM processor. But it has its own execution pipelines and a distinct register bank. If you are working with applications based on ARM Cortex-A processors, especially with multimedia and signal processing applications, the support for NEON vectorisation becomes crucial.

IAR embedded workbench has

introduced the possibility to automatically vectorise code, enabling you to achieve faster application response time, improved application battery lifetime and the other requirements of low cost and low power.

Educational hardware

Low-cost target hardware platforms like Arduino, Raspberry Pi and others have become popular among designers as well as education community. This popularity has forced the design tools to have support for these interesting designing blocks. This new feature will not only help the designer community but the education sector as well.

Simulink, which offers block diagram environment for model-based design and simulation, now includes support for prototyping, testing and running models on such low-cost target hardware as Arduino, Lego Mindstorms NXT and Raspberry Pi in its latest version. The latest version also supports Samsung Galaxy Android devices.

For real-time applications

Also, Simulink product family now has a new member, Simulink Real-Time. It allows you to create real-time applications from different models and run them on dedicated as well as custom target computer hardware connected to your physical system.

With the existing support for real-time simulation and testing, rapid control prototyping, DSP and vision system prototyping, and hardware-in-the-loop (HIL) simulations, you can extend your

Simulink models with driver blocks, automatically generate real-time applications, define instrumentation, and perform interactive or automated runs on a dedicated target computer equipped with a real-time kernel, multicore CPU, I/O and protocol interfaces, and FPGAs.

EDA tools

With growing demand for compact and efficient systems, it is getting difficult to have everything fitted inside a box and at the same time maintain reasonable cost. The size constraint can be met with the help of rigid-flex PCB technology, though most tools do not include folding and fitting aspects of rigid-flex designs.

To eliminate these constraints and reduce manual work needed for designing rigid-flex PCBs, the latest version of Altium Designer is equipped with support for flex and rigid-flex designs, including schematic capture, 3D PCB layout, analysis and programmable design—all in a single unified platform. This allows smaller packaging of electronic designs, leading to lower cost of materials and production, and increased durability as well.

A single-layer-stack PCB tool cannot support rigid-flex designs, as both rigid and flex sections may use different sets of layers. The new enhanced layer stack management system supports the definition and naming of multiple stacks to support this design requirement. It allows definition and naming of primary and sub-stacks on a circuit board for use in a rigid-flex circuit design.

While Altium has enhanced its layer-stack management system for supporting rigid-flex designs, OrCAD has been updated with IDX (incremental data exchange) enhancements to support flex circuit definitions. Also, you can import flex circuit bend areas from MCAD in the latest version of OrCAD. ●

The author wrote this as a technical journalist at EFY. He recently opted and shifted to the hands-on training division of EFY

Incentives Restricting Solar Business In India

Indian industry needs a level-playing ground to be able to meet the challenges posed by some countries who seem to be dumping low-priced goods in the country. But should the industry keep getting incentives even when there is actually no need for them? Do such incentives help or hamper growth of the industry? Read on for the author's eye-opening views

P.S. DEODHAR

Since long, India's photo-voltaic (PV) solar industry has been driven by the Central and state governments by offering incentives. There is a need to look at market realities and the drastically reduced prices of PV modules. Grid parity, in real terms, is already achieved. Solar power costs less than a third of diesel power and yet our government offers subsidies!

Industries in India love subsidies and incentives. Even today, myth of PV solar power being more expensive than the power from the grid is being perpetuated. The new government will therefore do well to review and revamp this sector. Actually nothing more than reducing the capital cost of a solar plant and focussing on distributed use of solar energy is required.

Till three years ago, the cost of solar energy was high due to high cost of PV modules. But their prices per Wp have rapidly fallen from US\$ 3.75 in 2007 to mere US\$ 0.65 by 2014. Interestingly, the chart in Fig. 1 also makes it clear that even at the current price PV modules manufacturing industry is sustaining well, as reflected in the ever-growing volume of shipments. Those industries which were inefficient and not modern enough have already vanished from the scene.

Markets in the India's solar industry, however, continue to be incentive-driven. Not only this is unhealthy but also this incentive regime has vitiated the market with

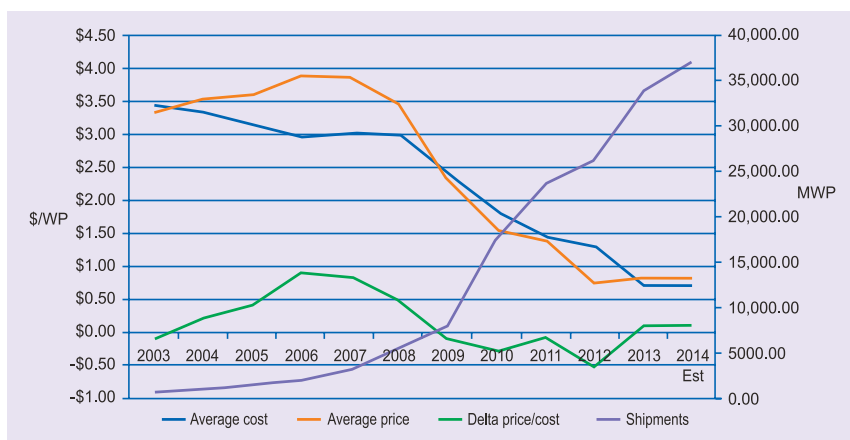


Fig. 1: Module ASPs, costs, shipments and the cost/price delta, 2003 through 2014

the Ministry of New and Renewable Energy (MNRE) taking the centre stage than the industry! Incentives and the associated bureaucratic rules and procedures have taken us back to the License Permit Raj. It has become a tool in the hands of government employees who seem to use it to line their pockets instead of promoting solar technology. Many of them have become rich. Related government offices at the Centre and the states are today surrounded by touts, many working for the *babus* inside.

Another reality is the government's complete failure in honouring its commitment to pay the promised subsidy. It is a shame that the solar energy industry is so dependent on the government for success. Crony capitalism rules in the renewable energy industry. As the cost of energy from fossil fuels continues its exponential rate of increase and solar technologies improve, the cost of solar energy is becoming progressively

competitive with energy derived from fossil fuels.

Need for off-grid systems

The emerging reality tells us clearly that, the most economical application of solar energy for India will be off-grid energy systems and micro-grids. May be rural homes need a capital subsidy, and that can be given 'cleanly' and efficiently through the nationalised banks. It is as important as the rural banking if not more. Biggest benefit in lighting our dark rural homes would be a sharp drop in highly-subsidised kerosene's use. Solar energy use in Sri Lanka hinges on this to reduce its fossil fuel imports.

NY State's Public Services Commission, in their April 2014 Reforming the Energy Vision (REV) document, proposes one new approach. It envisages a new mission for utilities, that of distributed services platform providers (DSPPs). "The DSPP will identify, plan, design, construct, operate and

maintain the needed modifications to existing distribution facilities to allow wide deployment of distributed energy resources." From grid-based electricity we are moving toward 'personal electricity,' or home-based electricity. India needs to wake up.

Very few are aware that currently, each day, our country wastes over 400MW of solar power out of 2GW that we feed into the grid because of 30% loss in transmission and distribution in our grid. That is 2000MWh of solar energy each day! Assuming energy need of average rural home is 200Wh, this lost energy could have brought light into ten million dark homes! One can't forget that the government uses our money to buy this lost energy at 10 to 12 rupees! How unjust and blind can one be!

I am disappointed that the solar energy industry is so focused on feeding into the grid. In case of hydropower or coal, electricity production has always been far away from where it could be used. Grid came up to aggregate power from such plants. God has provided a perfect distribution system for the Sun's energy. I consider that the grid is an alternative to energy storage in batteries. Grid storage demands efficient grid infrastructure, as in Germany, otherwise grid feed comes at a great price.

Unlike fossil fuel, solar energy is absolutely a free gift from the nature. Its kWh cost is essentially the apportioned cost from the plant-cost depreciation. If all scheduled banks are advised to lend the capital for a solar plant at 2%, everyone would want to go for a solar plant even in small towns and villages. Loan amount could be limited to ₹ 100 per Wp rating of solar modules used by grid-feed users and ₹ 130 per Wp for off-grid systems. Government can easily find a way to offer this incentive via banks and completely avoid corruption that is vitiating this business.

The incentive program therefore can be scrapped right away, except for lowering the interest on capital cost. After this adjustment, the solar energy will give full return for its current val-

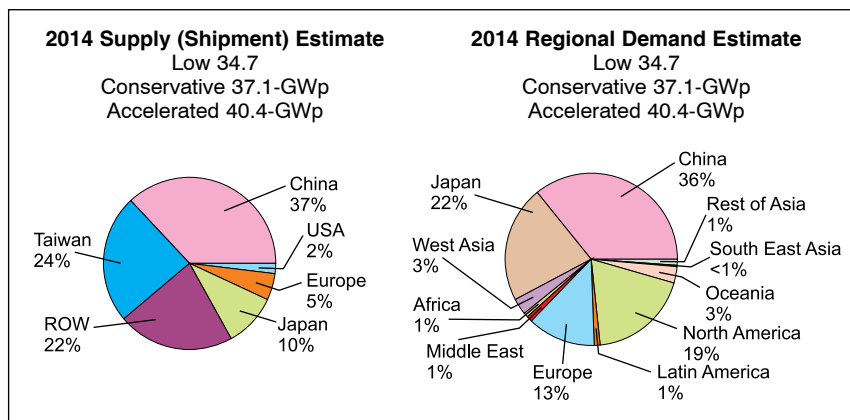


Fig. 2: Supply/demand expectations for 2014

ue. As it is, currently the cost per unit, kWh, is not more than ₹ 7 to 8. Cost of commercial power in most urban areas is 60 to 65% higher during the day time, when the Sun, ready to give away energy for free, is shining bright.

Since 80% of the investment is allowed to be written off, proper market promotion and low interest capital will make the urban institutions like schools and colleges, businesses, factories, malls and commercial shops and establishments to shift to this free and clean energy. The best way to stimulate this sector of potential solar users would be to allow 150% capital value write-off as depreciation same year. This will leave no scope for bribes.

Social cause

Solar energy has more to it than mere money. The solar energy does not run on hope so much as it runs on the basis that coal and gas are killing us, and we have to do something about it. Not everything is about money. Those who currently use it, even though it has not been the cheapest option for them, it is because of their concern for the future. The pie-chart in Fig. 2 reveals how insignificant we are in global projections, both in terms of supply and demand. This can change with micro-grids, and self-owned power by the people.

While we consider energy sector, one can see that the invisible (or better hidden or disguised) costs of fossil and nuclear are much higher. When UPA government was pitching for nuclear power to us as cheap, inexhaustible

energy, nobody talked about the fact that demolishing a nuclear power plant costs four times its construction, and that the solution for the nuclear waste disposal stands still unresolved in front of us. We have before us the 'occasional glitches' like Three Mile Island, Chernobyl and Fukushima. A report says that, cleaning Fukushima mess will cost the Japanese trillions of dollars besides the real human and environmental costs that nobody wants to talk about.

Once used, the oil is gone. Most of us do not worry since a generation or two later we would not be there to see the burden of the consequences. As the ancient Indian proverb says, "We do not inherit the earth from our ancestors; we borrow it from our children." So it is not only that we can still pay today for the use of fossil fuel, it is about should we use it to the extent that we do today?

While the current solar technology is for sure far from ideal, it offer a glimmer of hope that the coming generations can one day say: "At least some of us have tried hard to save the future." Unfortunately, all government policies these days are largely influenced to favour businesses and not the people at large. I hope current focus on rapid development will be steered to be inclusive in real terms. ●

The author was the chairman of the Electronics Commission in the eighties and advisor to late Prime Minister Rajiv Gandhi on electronics. He is founder of the APLAB Group of companies and a recipient of EFY's Lifetime Achievement Award. The views in this article are his personal

Solar-Powered Irrigation Systems

This article describes the different components of solar-powered irrigation systems, various specifications, different techniques used, the current scenario in India, the challenges faced by the consumers and the future scope of solar-powered irrigation systems

SANI THEO

Solar-powered water pumping systems can find application in town water supply, livestock watering and irrigation. Solar-powered irrigation system is an application of solar-powered water pumping system used in paddy fields, gardens for watering the plants, vegetables, etc. A typical example of solar-powered irrigation system is shown in Fig. 1.

Some advantages of a typical solar irrigation system are:

1. It makes irrigation possible in remote areas
2. Is environment friendly
3. No grid connection required
4. No electricity bills to be paid
5. No fuel required
6. Is durable, requiring minimal maintenance

Essential components

The actual components and hardware requirement depend on the type of irrigation system, such as surface irrigation where water is moved across the surface of agricultural lands, localised irrigation like spray or drip or trickle system (Fig. 2) where water is applied to each plant or adjacent to it, and sprinkler irrigation where water is piped to one or more central locations within the field and distributed by overhead high-pressure sprinklers or guns.

The major components of a typical solar-powered pumping system include a solar panel array that powers a bore-well pump or surface pump. The size of the complete system is dependent on size of the pump, the amount of water required per day and power available from the solar panels. The water is often pumped from a bore-

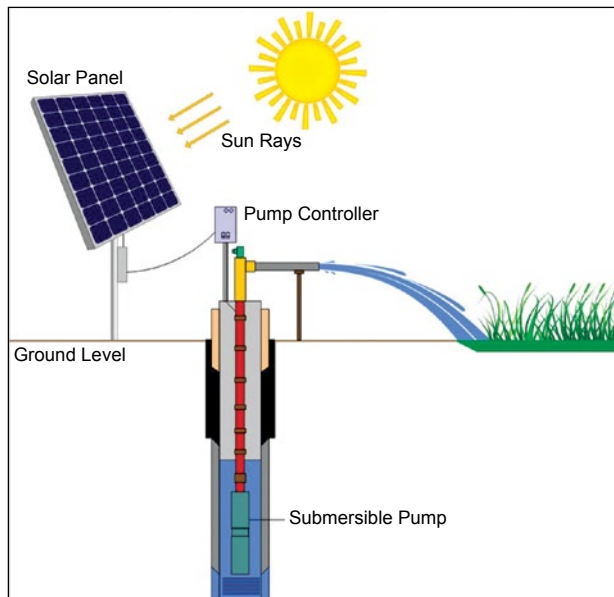


Fig. 1: A typical solar-powered irrigation system (Courtesy: www.taiyosolar.in)

well or stream into a storage tank or directly into the field. The solar-powered irrigation system has three main parts: motor pump, pump controller and solar panel.

Motor pump. The pump has a motor running on electricity generated by the solar panel. Depending on the type of motor (AC or DC), the voltage of the solar pump motor can be AC or DC. DC motors are mostly used for small to medium applications, such as garden fountains, landscaping, drinking-water for livestock, or small irrigation projects. Most DC pumps run at 24 volts rather than 12 volts. However, smaller systems for 12 volts do exist for light-duty applications, while systems running on 48 volts also exist for heavier applications. Power of a motor is specified in either watts or horsepower (HP).

Pump controller. There are two types of pump controllers: inverter and

variable frequency drive (VFD). If an AC solar pump is used, an inverter becomes necessary to change the DC from the solar panels into AC. The supported power range of a typical inverter extends from 0.15kW to 55kW, with the higher power inverter being used for larger irrigation systems.

The solar panel and inverter must be sized accordingly to accommodate the in-rush characteristic of

an AC motor. Since AC pump requires high power at the start, the inverter should be able to handle this extra start-up load. Sometimes a VFD controller is used to ensure that the pump motor gets proper voltage and current. Some typical specifications for various AC pumps and pump controllers are listed in Table I.

Many solar DC pumps require a special controller if they are to be powered directly by PV modules (without batteries). The controller or linear current booster (maximum power point tracker) enables the pump to start and run in low light conditions during a cloudy day, or early morning and evening. With a battery power source, the controller may not be required at all for a DC pump.

A special controller may also be employed for converting 12-volt battery power to higher voltage to run the pump at top speed. The DC pumps are

available from 12V to 48V with their initial torque varying from 12A to 96A. Typical specifications of various DC pumps and charge controllers available from a vendor are listed in Table II as an example.

Solar panel. The pumps are fitted with motors that receive energy from solar PV arrays. The nominal power of a solar module is expressed in peak



Fig. 2: Drip irrigation (Courtesy: <http://www.urbansustainableliving.com>)

wattage (Wp). The wattage of solar panels depends on the requirement and the motors used. In India, solar PV arrays having capacity in the range of 200W to 5kWp are recommended by the government. You may refer to information on solar PV arrays and motor pump sets for solar PV water pumping systems (2013-14) given by the Ministry of New and Renewable Energy, under Jawaharlal Nehru National Solar Mission, from the link: http://mnre.gov.in/file-manager/UserFiles/technical-specification_spwps_2013_14.pdf

Many vendors offer installation services at a cost. But if you are planning to install it yourself, you can refer many live video clips available on the Internet. One such link is available at <http://www.solarpumps.com/>

Types of motor pumps

Solar pumps fall into two major categories, surface and submersible, depending on their construction and applications.

Surface pump. Surface pump is usually installed above the water level which requires a suction lift. It is used to get discharge from an open well, pond or river where high flow and small head (height to which the water needs to be lifted to) are required. There are many different types of pumps available, and DC surface pumps with total lift up to 21m (70 feet) are easily available in India.

Submersible

pump. This pump is basically a hermetically sealed motor. The whole assembly of submersible pump is submerged in the water to be pumped up. It is generally used for pumping water from small-bore wells, and is designed to fit inside the drilled bore. The well may be anywhere from a few metres to 550 metres deep. But the deeper the well, the more powerful and expensive would be the system. The 0.25HP to 3HP pumps are easily available in the market. DC submersible pumps with total lift up to 92m are quite common in India.

Submersible pumps have the ability to lift water to a greater height. So these pumps are also used for water transfer applications from a canal to storage tanks or from an underground storage tank to an overhead tank.

Pump to buy

Before buying a pump you should know the depth at which water is available, daily water requirement and type of irrigation system to be installed. You may also need to know the water flow rate and the total head of the pump. You should buy a pump having the best efficiency. The best combination of head and flow rate at the least energy consumption gives the best pump efficiency.

The performance graph of 1.5HP motor pump available from a vendor is shown in Fig. 3 as an example. To interpret the graph and the table, let us say you have an input power of 400 watts from the PV array and you want to lift the water to a height of 40 metres at a flow rate of 12 litres per minute. As per Fig. 3, you would need a 1.5HP pump-set with pressure of 56.88psi or 392 kilopascals (392kPa).

Next step is to decide whether you should go for AC pump or DC pump. Though a DC pump can be run directly from a solar PV array, it has very limited range as compared to AC pump. The DC pump costs more than AC pump with the same category and the same head. But if a DC pump is available in your local market that meets your requirement it can be worth buy-

TABLE I
Typical AC Pump and Controller Specifications

AC pump HP	Volts	Controller	Solar panel (watt-peak)	Battery capacity
1HP	60	4kVA	1500Wp	100Ah - 5 Nos.
1.5HP	72	5kVA	1800Wp	100Ah - 6 Nos.
2HP	96	6kVA	2400Wp	100Ah - 8 Nos.
2.5HP	96	6kVA	2400Wp	120Ah - 8 Nos.

Courtesy: www.solarenergyproducts.co.in

TABLE II
DC Pumps with Charge Controllers

DC pump	0.125HP	0.25HP	0.5HP	1HP	2HP
Volts	24V	24V	24V	48V	48V
No-Load Current	2A	4A	8A	8A	16A
Full-Load Current	4A	8A	15A	16A	32A
Initial Torque	12A	24A	45A	48A	96A
Suction	1.83m (6 feet)	7.62m (25 feet)	16.46m (54 feet)	76.2m (250 feet)	152.4m (500 feet)
Delivery or Flow Rate (litres per hour or minute)	500-lph	8-lpm	24-lpm	35-lpm	70-lpm
Panel Capacity	200Wp	500Wp	800Wp	1500Wp	3000Wp
Battery Capacity	50Ah - 2 Nos.	150Ah - 2 Nos.	200Ah - 2 Nos.	200Ah - 4 Nos.	200Ah - 8 Nos.
Charge Controller Rating	24V, 40A	24V, 40A	24V, 40A	48V, 40A	48V, 40A -2 Nos.

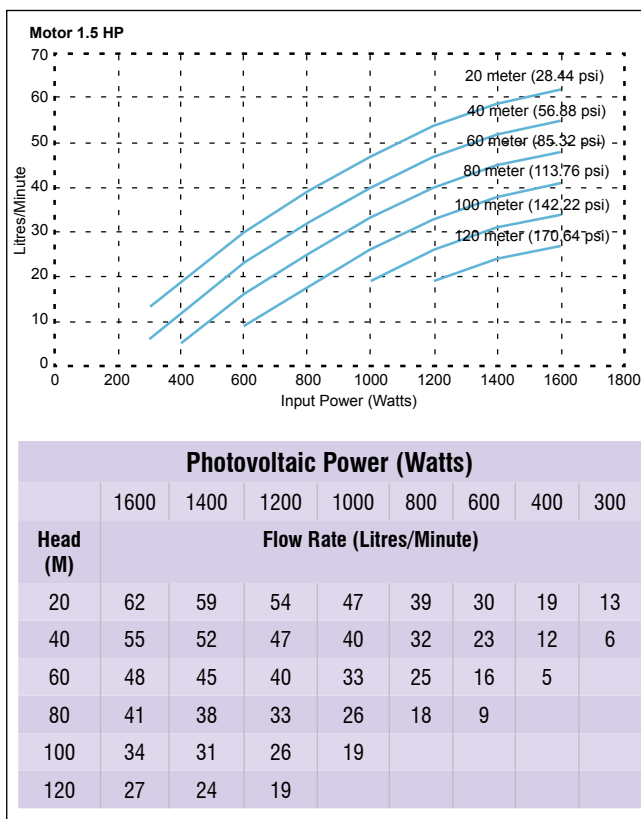


Fig. 3: 1.5HP motor pump performance

TABLE III
Capacities of DC Surface Pump and AC Submersible Pump

Type	Solar panel pump capacity		Head	Discharge rate/day (in litres)
DC Surface	900Wp	1HP	14m	75,000
	1800WP	2HP	14m	140,000
AC Submersible	1800WP	0.75HP	50m	50,000

ing. "One should buy AC submersible pump, because the maintenance for submersible is almost nil as compared to DC pump," says Hitesh Kapuriya, assistant manager, JJ PV Solar Pvt Ltd.

Indian manufacturers of pump-sets for various applications can be found at <http://www.pumpsindia.com> website. The type of motor pump, the wattage of the solar module, accessories, etc are some of the decisions you have to make. So before buying the system you should check the following:

1. *Solar water pump installation site.* You should first check whether it is to be installed near a pond, river, well or

complete system should be tested and certified by an authorised test centre to get the best performance and water discharge norms as specified by the ministry.

Various capacities of DC surface and AC submersible pumps available from a vendor are listed in Table III, just for information.

Current scenario in India

Nearly sixty percent of Indians work as farmers in the field of agriculture. But due to non-availability of electricity in remote areas, irrigation becomes difficult even if the land is fertile as it

somewhere else.

2. *Pump setting depth.* The accessories required for underground installation would be different and add to overall cost.

3. *Requirement of daily water.* If you need more water per day, you need heavier and powerful equipment.

4. *AC or DC pump.* For AC pump, you need solar panel, pump controller (inverter), module mounting assembly and accessories like cable, connectors and pipe. For DC pump, pump controller would not be required in case of direct connection with PV panel.

In addition, you may consider installing solar trackers and pump protection units. The complete

depends majorly on rainfall only. Solar energy can save not only electricity but also save Indian farmers (during drought and scanty rainfall) who are otherwise prone to suicide. Solar water pumping systems can make irrigation possible even in remote areas. The pumps are available for various types of irrigation, including paddy fields, horticulture farms, gardens, etc.

"The present scope of solar irrigation system in India is very good because there is support from nodal agencies in the states like Rajasthan, Bihar, etc. The Ministry of New and Renewable Energy, government of India, gives 30 per cent subsidy for a five horsepower solar water pump set," says Hitesh. Unfortunately, "Average cost of solar water pumping system is ₹ 450,000. Government policy for subsidy is having restriction up to 5HP solar pump only," adds Hitesh.

Besides the high cost of solar irrigation systems at present, another problem is the lack of awareness of the benefits amongst the farmers and consumers.

The future scope

With advancements in technology, the systems can be made more user-friendly. You can control the motor pump from a remote location using your mobile phone. You can get water level indication of the reservoir and overhead storage tank in your mobile phone. These technologies are already available in the market, though presently they are not so popular.

For further information on this subject you may refer to 'Irrigation Automation Opportunities in Rural Areas' article published in January 2012 issue. Also, you may refer to DIY articles on related topics, such as 'Cellphone-Based Remote Controller for Water Pump' published in January 2013 and 'GSM-Based Borewell Water-Level Monitor' published in May 2012 issues. ●

The author is a B.Tech (electronics & communication) from Punjab Technical University

Efficiently Harnessing Solar Power With Tracking System

Solar power holds a lot of promise for countries like India that are blessed with ample sunshine most of the time. But making solar power economically viable is a challenge that many are grappling with still. Here are some suggestions

SARANG GUPTA

India has enormous potential for solar power, as it receives 5000 trillion kWh worth of energy from the sun every year. The Jawaharlal Nehru National Solar Mission aims to promote solar power in India and help India achieve self-sufficiency in energy. Though the cost of solar power (Fig. 1) has been falling steadily, it is still more expensive than existing solutions. Hence it fulfils only a minor fraction of our ever-growing energy needs.

It is therefore imperative that, to

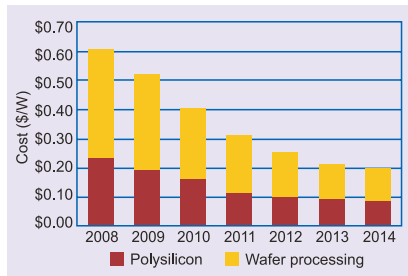


Fig. 1: The falling cost of solar power

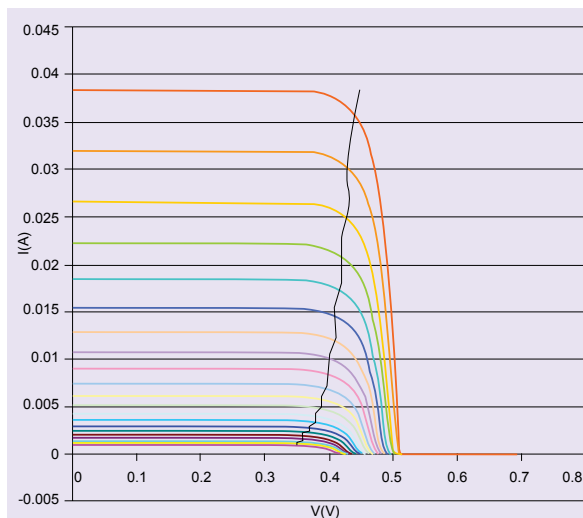


Fig. 2: Solar cell I-V curves in varying sunlight

increase production and decrease the cost per kilo watt hour, the currently installed solar power be used efficiently. This goal can be achieved with the help of maximum power point tracking (MPPT).

An MPPT system extracts maximum power output from a given solar cell. The power output of a solar cell is nonlinear and dependent on solar irradiation or intensity, ambient temperature and the load voltage. This power output can be seen with the help of a current-voltage (I-V) (Fig. 2) graph. Since power output is the product of current and voltage, it is signified by the area of the rectangle formed by a given point on the I-V curve and the origin. After finding voltage at which power output is highest, the MPPT system applies an appropriate load resistance to the solar panel, thus maximising the power output. Usually, the MPPT then uses a voltage converter (DC-DC/DC-AC) to output a voltage appropriate for the given load or to charge batteries.

Algorithms used in MPPT systems

MPPT can be implemented by a system in several ways. Each MPPT algorithm has its own advantages and drawbacks, and is hence suited for different conditions like:

Hill Climb or Perturb and Observe. Perturb and Observe

(P&O) is the most popular MPPT method due to its effectiveness and simplicity. It uses the characteristic I-V curve of a solar panel to determine the point of maximum power. The MPPT system increases the voltage of the panel such that the power obtained increases until there is no change in power. Since the power increases in the direction of voltage until a 'knee point' or a 'cliff' in the graph, this method is also called the Hill Climb method. This method may, though, produce oscillations in the output due to dynamic changes in voltage.

Incremental Conductance. Another popular method of maximum power point tracking is Incremental Conductance (IC) method. In IC method, MPPT controller uses the incremental conductance (given by dI/dV , which is approximately equal to $\Delta I/\Delta V$ for small changes in voltage and current) to find the voltage at which maximum power is delivered. This voltage is reached when the incremental conductance is equal to the conductance of the array. The process is repeated when the irradiance changes. A drawback of the IC method is that, the voltage oscillates due to the readjustment of MPPT voltage.

Constant Voltage. Constant Voltage method is the simplest of all methods but its simplicity comes at a cost to efficiency. The MPPT system interrupts load to the solar panel and measures the voltage known as the open circuit voltage (V_{oc}). The ratio of the MPPT voltage and the V_{oc} is a constant k ($k < 1$). The value of k is a characteristic of the given panel and is determined either by modelling the solar panel system

Comparison of PWM and MPPT Based Charging Systems

Feature	PWM	MPPT
Efficiency	Depends upon voltage matching of battery and array; 80-85% on average for a well matched system	Extracts 10-30% more power than comparable PWM systems (Fig. 4)
Array size	Array output voltage has to be more than battery voltage at all time for charging; panels must be wired for a specific voltage	Enables use of higher voltage panels/panels wired in series; voltage of battery need not be less than array voltage
Cost	Installation cost is cheaper than of MPPT based systems; expensive in the long run for larger installations due to low efficiency	Installation cost is higher than of PWM controllers; cheaper in the long term for moderate to large sized solar arrays
Battery service life	When properly implemented, PWM based controllers do not degrade battery service life	Battery service life in MPPT based systems is equal or better than that of comparable PWM systems
Design simplicity	Very simple to implement	Moderately complex to implement
Effect of environmental conditions on operating efficiency	Equivalent performance to MPPT based systems in higher temperature	Has a large efficiency gain when temperature is low due to higher panel voltage

and operating conditions or by experimentation. It is approximately equal to 0.76 for most panels. This method is extremely easy and cheap to implement as it can be implemented without a microcontroller. The value of k is static for the system and results in an approximation of the actual MPPT voltage.

Constant Current. Constant Current method is similar to the Constant Voltage method but is slightly more complicated due to addition of a switch and a load to measure the I_{sc} (short-circuit current). This also results in heat dissipation in the MPPT module. The constant k is taken as the ratio of MPPT current and I_{sc} . The method suffers from the same drawbacks as those faced by the Constant Voltage method.

Current Sweep. An MPPT system implementing the current sweep algorithm periodically measures all the possible current and voltage pairs for the solar panel. It then finds the voltage at which highest power is delivered and adjusts the load accordingly.

Implementation of MPPT in design

These days, there are many ICs available in the market to implement MPPT functionality in a single chip. They simplify MPPT design and usually have a large number of features. Systems built around such ICs are usually cheaper due to lower parts cost and count but cannot be customised to

specific conditions or needs.

Some ICs, such as BQ24650 by Texas Instruments and LT8490 by Linear Technologies, are fully integrated solutions with battery-charging capabilities, MPPT and switch mode voltage conversion in a single package. This drastically reduces parts cost and count. Others like the MPT612 from NXP Semiconductor (Fig. 3) are extremely powerful dedicated MPPT ICs with high-frequency RISC cores. The MPT612, in particular, uses a proprietary algorithm for implementation of MPPT and can be tailored to a particular application as it has memory for application software.

An MPPT system can also be built around microcontrollers like the PIC and AVR families that offer flexibility and a high degree of customisation. The firmware of such systems can be upgraded from time to time, allowing performance gains in existing systems. Higher-performance ARM microcontrollers can be used for systems requiring higher efficiencies and faster adjustment to changing conditions, but they are more complex and are often costlier. It is important to note, however, that MPPT systems built around microcontrollers require more external peripherals which are built in dedicated ICs and are hence costlier.



Fig. 3: MPT612 from NXP Semiconductor

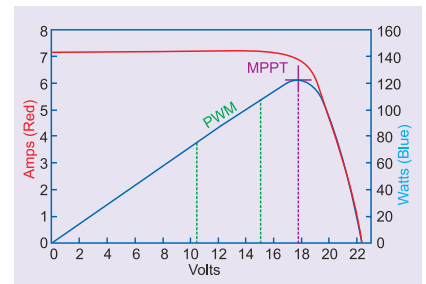


Fig. 4: PWM charging

Comparison of solar charging technologies

Currently, most solar charging systems are based on pulse width modulation (PWM) technology. Such charging systems charge the battery with varying amounts of current at various battery voltage intervals for higher battery life. The current is varied by connecting and disconnecting the solar panel to the battery very quickly for a fixed ratio of time, that is, by varying duty cycle of the power to the battery.

Conclusion

Solar power holds the key for India to end energy shortages and be self-sufficient in its energy demands. By increasing power output tremendously, MPPT is a technology that has the potential to fulfil this dream by making solar power cheaper and accessible to all. ●

The author is a student of class XII and has been building circuits since he was 12 years old. His interests include embedded electronic design, building robots and wireless communication. He is currently working on projects with the Raspberry Pi

Energy Education and Research Initiatives in India

Renewable energy sector is very important for a country like India for a faster growth. Realising its importance, the government of India and others working in this field have already taken some initiatives, which need to be highlighted. Here are some of them



Courtesy: <http://institute-of-solar-technology.blogspot.in>

SUBHRANSHU SEKHAR SAMAL, AMRITA SAMAL, ANANYA NAYAK

In 21st century energy has become a major concern in India. We are in dire need of alternate energy (renewable) sources like solar, wind, tidal and their combinations. Due to this serious concern, we need to educate our young generation about energy consciousness, energy research and energy education at various levels. Fortunately, realising this, the government of India and some others have already taken some initiatives in this direction. Here are some of them:

1. The government of India initiated solar energy research initiative (SERI) under Department of Science and Technology (DST) to facilitate and promote R&D activities in solar based

research in India in association with industries.

2. Ministry of New & Renewable Energy (MNRE) of the government extended its funding for energy research (solar, wind, tidal, hydrogen and hybrid) to academic institutes and research labs.

3. The Department of Science & Technology (DST) also recently encouraged industries and R&D centres to establish Technology, Information, Forecasting & Assessment Council - Centre of Relevance & Excellence (TIFAC-CORE) in the area of SPV technology.

4. MNRE introduced National Renewable Energy Fellowship (NREF) scheme for JRF/SRF/RA and post-doctoral Fellows working in the area of renewable energy.

5. Waste to energy scheme of the government is encouraging energy resources.

6. Jawaharlal Nehru National Solar Mission (JNNSM) set up by the government to enhance usage of solar energy.

7. Establishment of solar cell hub by DST-Technology Mission at IIST (formerly BESU), Kolkata.

8. Establishment of advanced centre for photo-voltaic by MNRE at IIST, Kolkata.

9. National Centre for Photovoltaic Research and Education (NCPRE) at IIT Bombay was launched in 2010 as part of the JNNSM.

10. Centre of excellence on Renewable Energy Systems at NIT, Rourkela (Odisha) funded by NPIU under TE-QIP, MHRD, New Delhi.

Besides, following premier institutions in India are offering courses in energy science, technology, engineering and management at undergraduate, postgraduate and doctoral levels (see table).

The Energy and Resources Institute, commonly known as TERI (formerly Tata Energy Research Institute), established in 1974, is a research institute based in New Delhi focusing its research activities in the fields of energy, environment and sustainable development. According to Think Tanks and Civil Societies Program (TTCSP) at the International Relations Program, University of Pennsylvania, TERI was ranked 20 in the list of top global think tanks on environment.

There are also some institutes under the MNRE, such as:

Energy Programmes Conducted by Various Institutions

Institutions	Programmes on energy
MANIT Bhopal	M.Tech (Renewable Energy) M.Tech (Green Technology)
NIT Calicut	M.Tech (Energy Engineering) M.Tech (Energy Management)
NIT Hamirpur	M.Tech (Energy Technology) PhD (Energy & Environment)
MNIT Jaipur	M.Tech (Renewable Energy)
NIT Kurukshetra	M.Tech (Renewable Energy System)
NIT Tiruchirappalli	M.Tech (Energy Engineering)
NIT Rourkela	PhD (Electrical Engineering-Renewable Energy)
IIT Delhi	M.Tech (Energy Studies) M.Tech (Energy and Environment Management) (For Working Executives Evening Program) PhD (Energy Studies)
IIT Bombay	M.Tech (Energy Systems Engineering) PhD (Energy Systems Engineering)
IIT Guwhati	PhD (Energy Studies)
Tezpur University, Tezpur, Assam	M.Tech (Energy Technology)
Central University of Jharkhand	PhD (Energy Engineering)
Pondichery University, Pondichery	M.Tech (Green Energy Technology) PhD (Green Energy Technology) PG Diploma in Green Energy Technology
University of Hyderabad (CVDL), Hyderabad	Post-Graduate Diploma in Energy Management (PGDENM)
Tezpur University (CODL), Tezpur, Assam	M.Tech (Energy Technology) PhD (Energy) PG Diploma in Renewable Energy & Energy Management
Devi Ahilya University, Indore	M.Tech (Energy Management)
University of Pune, Pune	M.Tech (Energy)
TERI University, New Delhi	M.Tech (Renewable Energy Engineering and Management) Advanced PG Diploma (Renewable Energy) PhD (Energy & Environment)
Jadavpur University, Jadavpur, West Bengal	M.Tech (Energy Science and Technology) PhD (Energy Science and Technology)
Anna University, Chennai	M.E (Solar Energy)
Gandhigram Rural University, Gandhigram, Tamil Nadu	M.Tech (Renewable Energy) M.Phil (Energy)
University of Rajasthan, Jaipur	M.Phil (Energy)
Lucknow University, Lucknow, UP	M.Sc (Renewable Energy)
University of Kota, Rajasthan	M.Sc (Physics-Energy Studies)
JNTU, Hyderabad	M.Tech (Energy System)
Bengal Engineering & Science University, Kolkata (Centre for Green Energy & Sensor systems)	M.Tech (Green Energy) PhD (Solar Materials)
Delhi Technological University (formerly DCE)	M.Tech (Renewable Energy Technology)
GERMI-Pandit Deendayal Petroleum University, Gandhinagar, Gujarat	M.Tech (Energy Systems & Technology – focused on Solar Energy) PhD (Solar)
University of Petroleum and Energy Studies (UPES), Dehradun	M.Tech (Renewal Energy Engineering)
PSG college of Technology, Coimbatore	M.Tech (Energy Engineering) M.S (Energy) PhD (Energy Engineering)
Amrita University, Kochi, Kerala	M.Tech (Nano Solar Materials) PhD (Nano Solar)
VIT University, Vellore, Tamil Nadu	M.Tech (Energy & Environmental Engineering)
Alternate Hydro Energy Centre (AHEC), IIT Roorkee, Uttarakhand	M.Tech (Alternate Hydro-Energy System) PhD (Alternate Hydro-Energy)
Academy of Scientific & Innovative Research (AcSIR) under CSIR, New Delhi: Structural Engineering Research Centre (SERC), Central Electronics Engineering Research Institute (CEERI), Central Electrochemical Research Institute (CECRI), Central Scientific Instruments Organisation (CSIO), National Environmental Engineering Research Institute (NEERI)	Integrated M.Tech-PhD Program (Renewable Energy)

1. National Institute of Solar Energy (formerly, Solar Energy Centre), Gurgaon

2. Centre for Wind Energy Technology (C-WET), Chennai

3. Sardar Swaran Singh National Institute of Renewable Energy (SSS-NIRE), Jalandhar

4. Alternate Hydro Energy Centre (AHEC), IIT Roorkee, Uttarakhand

5. Solar Energy Corporation of India (SECI), New Delhi

6. IREDA

And then there are some centres under DST in the area of energy, which include:

1. Centre for Solar Energy Materials, ARCI- Hyderabad

2. Centre for Fuel Cell Technology, ARCI- Hyderabad (based at Chennai)

3. Energy Research Unit, IACS, Kolkata

Some labs under DRDO in the area of energy are:

1. Solid State Physics Laboratory (SSPL), New Delhi

2. Defense Institute of Bio-Energy Research (DIBER) Haldwani, Uttarakhand

3. High Energy Materials Research Laboratory (HEMRL), Pune

Major professional bodies on energy are:

1. Solar Energy Society of India (SESI)

2. Indian Association of Hydrogen Energy and Advanced Materials (IAHEAM)

3. Indian Association of Energy Management Professionals (IAEMP)

Then there is a major event on energy conducted by International Congress on Renewable Energy in association with Solar Energy Society of India, besides many other events in India. ●

Subhranshu, an alumnus of NIT Rourkela and scientist in nanotechnology by profession, is recipient of Vidya Saraswati Award from Global Achievers Foundation for his contribution in the field of science and technology. Amrita, a postgraduate in computer application from Sambalpur University and having teaching experience at PG level, received award from KGC College of Technology, Chennai for commendable performance for the year 2012-2013. Ananya, pursuing B.Tech (EE) from VSSUT in Odisha, is interested in energy research and robotics

This Month's DVD Contents

This month's DVD brings to you the design and simulation software from National Instruments as well as DesignSpark PCB, along with Android SDK to help you develop your own Android app. Also included are some popular resources

DILIN ANAND

NI Circuit Design Suite

National Instruments' Circuit Design Suite 13.0.1 Education Edition includes NI Multisim 13.0 and NI Ultiboard 13.0. Multisim allows advanced mixed-mode simulation and validation with a library of components to easily build and validate circuit behaviour. Ultiboard is a flexible PCB layout and routing tool which also allows one to transfer the complete Multisim schematics to Ultiboard and layout, and then to route and export the completed designs for fabrication.

GCC ARM Embedded

GNU Compiler Collection (GCC) ARM Embedded contains a pre-built GNU toolchain for ARM Cortex-R (Cortex-R4/R5) and Cortex-M (Cortex-M0/M0/M3/M4) processors. It includes front ends for C, C++, Objective-C, Fortran, Java, Ada and Go, as well as libraries for these languages (libstdc++, libglibc,...).

DesignSpark PCB

DesignSpark PCB design software can significantly reduce your concept-to-production time. Its powerful software engine enables one to capture schematics and design PCB boards and layouts. It also

provides the simulation tool (LTSpice, Tina, etc) interface facility. Its built-in design calculator (track/via resistance, power dissipation, etc) enhances its usability.

DesignSpark Mechanical

DesignSpark Mechanical helps quickly design and change product concepts in 3D without having to learn complex traditional CAD software. It helps in producing a highly detailed dimensioned worksheet, remove bottlenecks, insert free, off-the-shelf component 3D models and create geometries with powerful and intuitive gesture based modelling.

KTechlab

KTechlab allows one to design and simulate the circuits related to PIC microcontroller and other electronics. It is an integrated environment for electronic design and automation (EDA) tasks. KTechlab features an extensive circuit designer that helps autorouting along with the simulation of logic elements and common electronic components.

Printed Circuit Board

Popularly known as PCB, it is an interactive printed circuit board editor that is used for all types of systems like Unix,

Linux, Windows and Mac. It can produce industry standard RS-274X, Excellon NC-Drill and centroid data (X-Y data) output format for use in board fabrication. It also provides photo-realistic and design-review images.

SZARP SCADA

SZARP is a full-featured, open source (GPL) SCADA system for Linux to perform human-machine interface visualisation tasks. Its latest version is compatible with 32-bit MS Windows (NT/2000/XP) and Linux. It has been mostly written in C++ with an average number of source code comments.

Engineering Calculator

Engineering Calculator is a lightweight yet handy math expression evaluation and unit conversion utility. Its portability allows the installation process to be bypassed easily and to be used on any PC by simply moving or copying the program files to a USB thumb drive or other storage device. The best part is that it will not update the Windows registry or hard drive with new entries without approval, and will leave no traces of it on the disk once removed.

Android SDK

Android SDK is a software stack for mobile devices, including an operating system, middleware and key applications, to help build, test and debug apps. If used properly, the SDK, together with Eclipse (the officially supported IDE) and JDK (Java Development Kit), can be state-of-the-art software for Android devices. Android SDK assumes that developers already have the Eclipse IDE installed, as well as JDK and the Android Development Tools plugin (not compulsory, although recommended,) as it includes only the basic utilities for Android app development. ●

Popular Resources

1. **7Zip.** 7Zip is an open source tool for compressing and decompressing files.
2. **JRE.** Java Runtime Environment, version 7 is used to run already developed Java programs.
3. **VLC Media Player.** VLC Media Player, version 2.1.3 is a highly portable multimedia player for various audio and video formats (MPEG-1, MPEG-2, MPEG-4, DivX, MP3, ogg, 3gp, etc) as well as DVDs, VCDs and various streaming protocols.
4. **Opera.** Opera web browser, version 23.0.1522.60 (latest version), developed by Opera Software runs on Microsoft Windows and OS X operating systems and uses the Blink layout engine.
5. **Free Download Manager.** Free Download Manager is an open source downloader which can increase download speeds up to 600%.
6. **Thunderbird.** Thunderbird, version 24.6.0 is a free email application that's easy to set up and customise, and is loaded with great features.
7. **Mozilla Firefox.** Mozilla Firefox, version 31.0b8 is a light and tidy open source web browser with simple and effective UI, fast speed and strong security capabilities.
8. **Apache Open Office.** Apache OpenOffice, version 4.1.0 is the leading open source office software suite for word processing, spreadsheets, presentations, graphics, databases and more.
9. **Protector Plus Internet Security.** Protector Plus antivirus software protects your computer against all types of malware like viruses, Trojans, worms and spyware.

NI Circuit Design Suite For All Your Circuit Designing Needs

The NI Circuit Design Suite combines NI Multisim and Ultiboard software for circuit design, simulation, validation and layout platform. In this month's DVD with EFY Plus, we present to you NI Circuit Design Suite 13.0, which can be used for 45 days for all your circuit designing needs

ABHISHEK A. MUTHA

National Instruments Circuit Design Suite is a suite of electronics design automation (EDA) tools having Multisim and Ultiboard, which can be installed from the accompanying DVD. Multisim is the schematic capture and simulation program designed for schematic entry, simulation and linkage to steps such as PCB layout. It also includes mixed analogue/digital simulation capability and microcontroller co-simulation. Ultiboard is for designing printed circuit boards, doing some basic mechanical CAD operations and preparing the PCBs for manufacture.

Features of Multisim

Let us take a look at the main features of Multisim.

Learn analogue circuits with circuit parameters. Circuit parameters provide the ability to define schematic-level variables that can then be easily modified to match homework, lab problems and other parametric analysis of a circuit. They allow us to highlight the key components and variables that characterise the response of analogue and power circuits. Prior to Multisim 13.0, the calculation of important variables and setting of related component values had to be done manually.

Variables embedded within a schematic can be based on theoretical calculation, which cascade to all applicable components. These variables

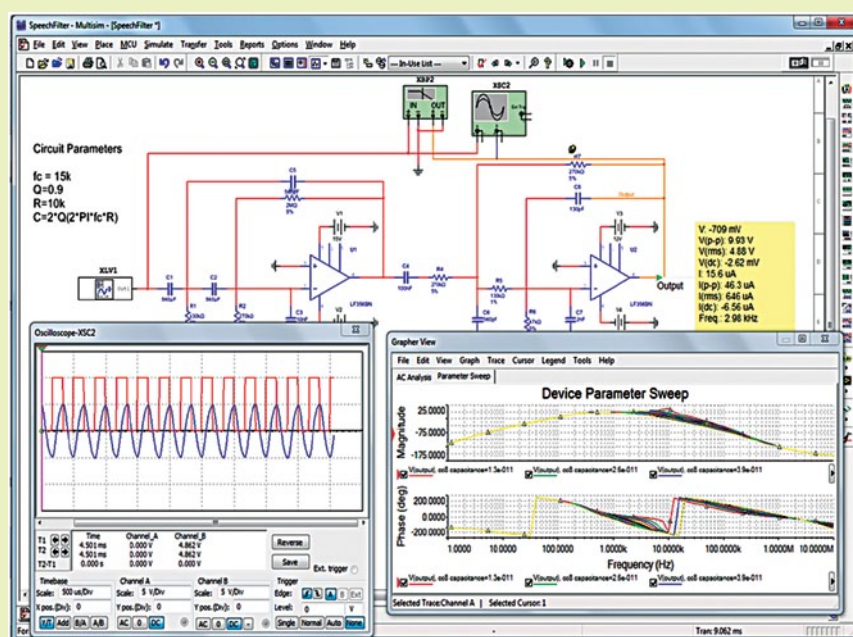


Fig. 1: Multisim simulation environment (Courtesy: www.ni.com)

Benefits of using NI Circuit Design Suite

You can:

- Capture and simulate circuit designs with NI Multisim software
- Easily design circuits with intuitive and cost-effective design tools
- Quickly improve circuit behaviour with interactive SPICE simulation
- Seamlessly transition to NI Ultiboard for PCB layout and routing
- Reduce design errors with leading analogue simulation capabilities

can also be used in expressions such that specific circuit characteristics can be determined dynamically, based on other component values within the schematic. This allows students and educators to bridge the gap between theory and practical, as well as opens up the possibility of far more advanced simulation analysis.

Better design performance with circuit parameters. Circuit parameters add sophistication to any simulation approach by allowing an engineer to easily explore different scenarios for various circuit structures and component values. The parameters also help in performing advanced analyses such as temperature sweep, parametric

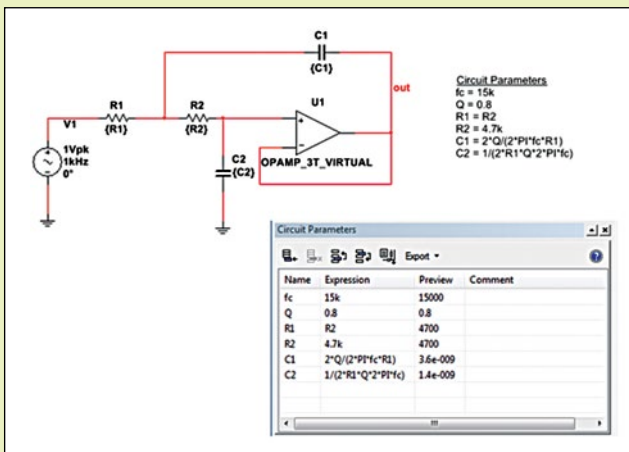


Fig. 2: An example with defined circuit parameters (Courtesy: www.ni.com)

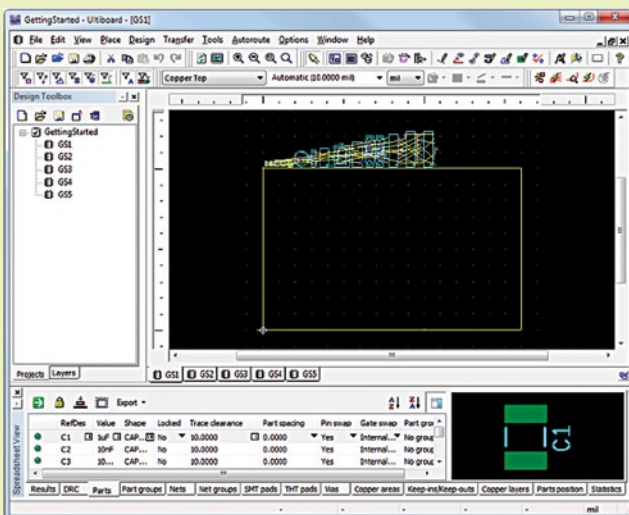


Fig. 3: User interface of NI Ultiboard

sweep and Monte Carlo analysis to validate design corner cases. The user can also sweep critical component parameters and iterate through parametric information in advanced simulations to optimise design performance.

Simulation enhancement with over 26,000 devices. Analogue designers rely heavily on datasheets provided by component manufacturers to design a circuit to specification. Although datasheets include critical information of individual components (and remain an indispensable resource), they lack information of how parts will behave within different design configurations. Devices from Maxim, Infineon, NXP, ON Semiconductor and Analog Devices have been added to the library of the latest SPICE models to evaluate design choices.

Rapid prototyping with user-definable templates. User-defined templates for circuit schematics and PCB layouts provide a comprehensive starting point to engineers to start designing their circuits and printed circuit boards. With a template, various elements such as connector placement, critical devices and board layout can be pre-configured to aid in the design process. These templates can save significant amounts of time spent on designs by collaborating with others, providing set constraints for adjacent

Power circuits' simulation with IGBT models and EPC devices. The powerful Multisim simulation enables the evaluation of power circuits of different ratings at an early design stage. To accurately model power electronics systems, you can use models for IGBT and MOSFET switches, electro-mechanical components, different active and passive components, and switching controllers. With the addition of new eGAN MOSFETs from market innovator Efficient Power Conversion Corporation (EPC), and a configurable thermal IGBT model, simulation of applications with greater accuracy can be achieved.

electronics or prototyping for hardware from National Instruments. You can also create, share and modify user-configurable templates to set critical spacing and layout settings to aid in prototyping.

Features of Ultiboard

Ultiboard, which can be easily integrated with Multisim, has some features which are special to it.

Easy-to-use design environment.

The NI Ultiboard interface enables efficient layout and routing of PCB designs. Tools such as spreadsheet view, toolbox and design wizards easily manage, control and define any board layout. Part placement and copper routes are optimised to allow full control for precise definition of critical parts or automation for quick design completion. The 3D preview renders a completed, populated board to gain a virtual perspective before production. Ultiboard exports and produces industry-standard formats, such as Gerber and DXF, to take a final, optimised board to prototype and manufacture.

Layout and routing. Ultiboard features intuitive tools for manual and automated part placement and routing. The flexible push-and-shove environment combined with placement processes ensures quick layout. Trace placement in Ultiboard offers flexibility to quickly and efficiently adjust, based on the degree of design complexity.

Integrated design. Seamless integration with NI Multisim allows easy transfer of schematics to layout, to quickly define a board for manufacture. Cross-probing ensures any land pattern can be selected at board level to simultaneously highlight the Multisim schematic counterpart. Forward and back annotation ensures that changes made at either the schematic or layout level are always reflected in

Post installation

If you go through the documentation provided with the software, it will take you through all the stages of circuit design flow, from schematic capture through simulation and analysis. After following the steps outlined in the documentation, you will have designed a circuit that samples a small analogue signal, amplifies it and then counts the cycles on a simple digital counter.

both versions of a design. The overall integrated experience is paramount in providing an easy and quick flow from design and validation in Multisim to final prototype with Ultiboard.

Installation

Double click on installation file in the DVD and unzip all the files; 537 files will be extracted. It will automatically open the file autorun.exe. Else you should do it manually. Click on 'Install NI Circuit Design Suite 13.0' and follow the steps indicated. Enter all the details and select the second option 'Install this product for evaluation.' Click Next. Choose the directory of installation and click on Next. You can select or deselect product notifications. Agree to both the agreements and click on Next. You will be prompted to install National Instruments ELVISmx software at the end of the installation. Click on Cancel and proceed. After the installation is complete, restart your computer before running any of this software. Post restart, launch the NI Launcher and use the required tool for your circuit designing needs.

You can extend the evaluation period from 7 days to 45 days, for which you will need an Internet connection. Double click NI Multisim 13.0; the tool prompts you information to extend the evaluation period. Click on Yes and proceed further. Fill in all your details and agree to the National Instruments privacy statement. In the next dialogue box, click on the link provided, copy the computer ID to clipboard and paste in the box on the website. Create your

System requirements

The following system requirements apply to all versions of NI Circuit Design Suite. To run NI Circuit Design Suite 13.0, your operating system must be one of:

- Windows XP, 32-bit edition
 - Windows Vista, 32-bit or 64-bit edition
 - Windows 7, 32-bit or 64-bit edition
 - Windows 8, 32-bit or 64-bit edition
 - Windows Server 2003 R2 (32-bit) or 2008 R2 (64-bit) edition
- NI Circuit Design Suite 13.0 does not support Windows NT/Me/98/95/2000, Windows XP x64, or the Windows Server non-R2 editions.

Your system must also meet or exceed the following:

- Pentium 4/M class microprocessor or equivalent
- 512MB of memory (256MB minimum)
- 2GB of free hard disk space
- SVGA resolution video adaptor with 800×600 video resolution minimum, 1024×768 or higher recommended

account at NI website if you do not have one. It is recommended that you create an account first, before extending the evaluation. After registering, you will get a 20-character evaluation code which needs to be pasted in the installation dialogue box. Restart the application and the evaluation period will be extended to 45 days. Perform the above steps for NI Ultiboard 13.0 to avail the same.

Top competing tools

Mentioned below are some other similar software tools:

KiCad. KiCad is an open source software suite for electronic design automation (EDA) for designing schematics of electronic circuits and printed circuit boards (PCBs).

TINA. TINA Design Suite is a powerful circuit simulation package for analysing, designing and real-time testing of analogue, digital, VHDL, MCU, SMPS, RF, communication,

optoelectronic and mixed electronic circuits and their PCB layouts.

EAGLE. EAGLE Layout Editor is an easy-to-use, yet powerful tool for designing printed circuit boards (PCBs). It has three main modules: Layout Editor, Schematic Editor and Auto Router.

Altium Designer. Altium Designer (currently, Winter '09 version) is an all-in-one software for PCB design. From schematic to PCB as well as FPGA programming, signal integrity check, mixed analogue/digital simulation, this software is what you need when it comes to PCB design.

Proteus PCB Design. It combines the ISIS schematic capture and ARES PCB layout programs to provide a powerful, integrated and easy-to-use suite of tools for professional PCB design. ●

The author is a senior technical correspondent at EFY. This article has inputs from white papers available at National Instruments website

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KTechlab: An Integrated Development Environment

Being an integrated development environment (IDE) for PIC microcontrollers and electronics, KTechlab essentially enables you to do design and simulation tasks. It is an open source software released under the terms of General Public License v2 (GNU GPL). Try out KTechlab included in this month's EFY Plus DVD

SNEHA AMBASTHA

KTechlab presents an integrated environment for electronic design and automation (EDA) tasks. It is considered to be an educational tool to design and simulate circuits related to PIC microcontrollers and other electronics. KTechlab features an extensive circuit designer that helps auto-routing along with simulation of logic elements and common electronic components.

KTechlab features include:

1. Allows auto-routing and supports real-time simulation and debugging
2. Enables use of C, Assembly and high-level programming languages
3. Provides a pictorial format for microcontroller programming

Many-in-one design tool

KTechlab has several components well integrated to help designers. Some of these are described below:

Circuit Simulator. It can simulate linear devices, non-linear devices and logics too. KTechlab can further be integrated with external simulators like gpsim so as to allow in-circuit simulation of PICs.

Editor. It can act as a schematic editor to provide a rich and real-time feedback of the simulation.

Visual Editor. It has a flowchart editor that allows KTechlab to construct PIC programs visually. This makes it easy to program a microcontroller. The editor provides a microcontroller with

all its ports defined as input or output. A designer can easily program that mi-

crocontroller by dragging arrows from those ports or by drawing a flowcode for those ports.

For example, let us program a PIC16F84 microcontroller to blink an LED. To do that, we will have to set any one port as output. Let us do that for PORTB,0 pin. The two ways in which it can be programmed are:

1. Click the arrow on the PORTB,0 pin and drag it to the left.

2. Click 'advanced' on the microcontroller and set PORTB,0 pin as output by resetting last bit of the tris register of port B. Then draw the flowcode and save it.

Compiler. KTechlab has a high-level pro-

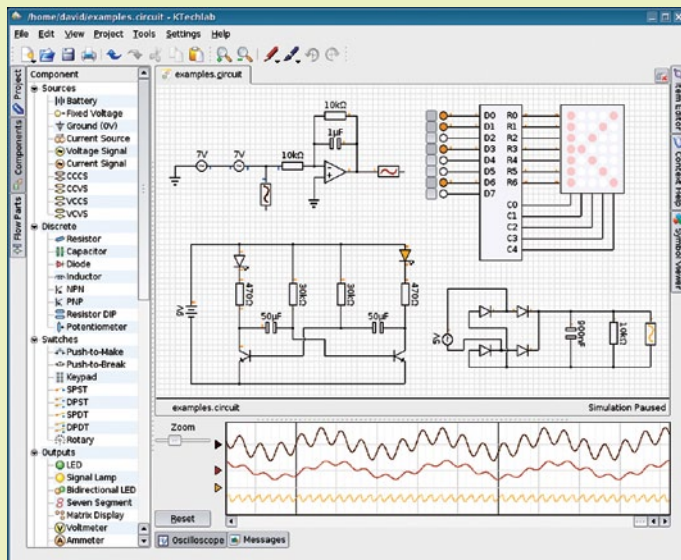


Fig. 1: KTechlab

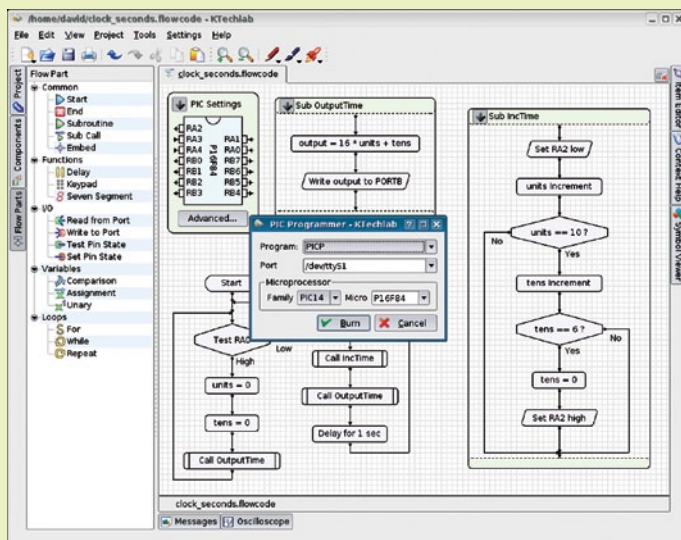


Fig. 2: Visual Editor

programming language called Microbe. It is basically a compiler for the PIC microcontrollers. Due to its similarity to Basic language, it is also called MicroBasic. It acts as a companion program to KTechlab. PIC16F84, PIC16F628, PIC16F627 and PIC16F877 are the microcontrollers' Microbe supports.

Assembler and disassembler. KTechlab can integrate both an assembler and a disassembler via gpasm and gpdasm.

What users think about this tool

Every designer reviews a tool before using it, in order to check if it would be of any use to him. No one can get a better review than from the users and the developers themselves. Following are the remarks from sourceforge.net, kde-apps.org and edaboard.com communities:

1. "This is terrific program. Comparable to MultiSim by National Instruments. I use it on Kubuntu 9.04 AMD64. I plan on installing it on my laptop with Kubuntu 10.4 to see how it works. Thanks for a great program. Keep up the good work."

2. "Great application that's a pleasure to use! It compiled and ran perfectly on SUSE 10.2. Now if we can just get PCB design support, that would be fantastic!"

How to install KTechlab

Following is the way to compile and then install KTechlab on Linux:

1. Use a terminal and navigate to the top-level source directory
2. Run the shell script:

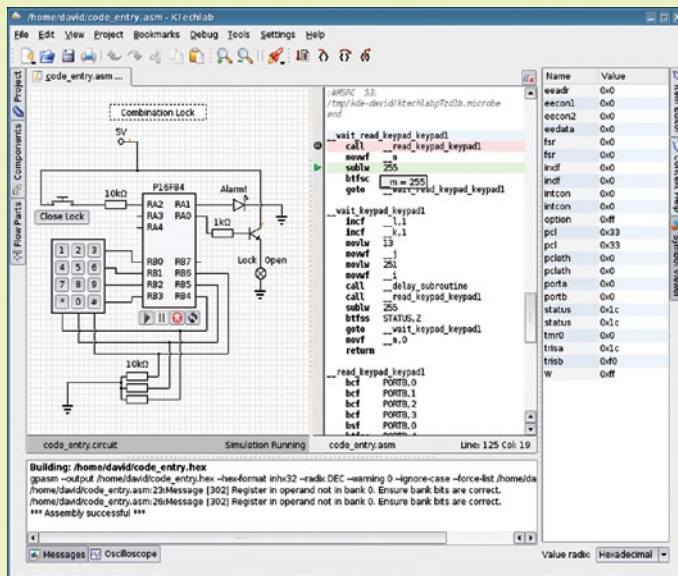


Fig. 3: Compilation and simulation side by side

```
simple-setup.sh
```

This command compiles KTechlab into the directory *simple-build*, installs it into the directory *simple-install* and sets up the user-specific settings (syscoca, mime database) for the current user.

```
sh simple-setup.sh
```

3. Launch KTechlab by running the script *simple-launch.sh*

```
sh simple-launch.sh
```

KTechLab should start running at this point.

Installing KTechlab on Ubuntu. We can also install this tool on the latest version of Ubuntu. However, we need to use the Debian version:

```
http://launchpadlibrarian.net/50881922/ktechlab_0.3.7-9ubuntu1_i386.deb
```

To download this package we have to install wget:

```
apt-get install wget
```

Then we can download ktechlab_0.3.7-9ubuntu1_i386.deb using the command:

```
wget-http://old.releases.ubuntu.com/ubuntu/pool/universe/k/ktechlab/ktechlab_0.3.7-9ubuntu1_i386.deb
```

Enter the following command to install ktechlab_0.3.7-9ubuntu1_i386.deb:

```
dpkg -i ktechlab_0.3.7-9ubuntu1_i386.deb
```

A claim of dependence will appear as libpopt0, but we can ignore it.

After the installation, exit the

System requirements

KTechlab does not have any special system requirements. It is compatible with operating systems like Linux, BSD and Unix, though it has following dependencies for better usage:

- Qt4 -dev
- cmake
- glib-dev

Then there are a few optional dependencies too:

- KDE4 libraries -dev
- KDevPlatform libraries -dev

Note. Only unit tests will get built without the above-listed components, and these are not useful for end users.

Users should install 'GPSim -dev' and 'Eigen2 -dev' (included in the DVD) to make full use of this tool.

➤ GPSim -dev; for microcontroller support

➤ Eigen2 -dev; for unit tests; generally it is not needed for builds targeted to end-users, but it is useful for development

Competitive tools

- MPLAB IDE
- PIC Simulator IDE
- Piklab

Then there are a few enterprise versions of the IDEs for PIC microcontroller:

- IAR Workbench IDE
- CCS' IDE
- Mikroelektronika's IDE

Ubuntu Lucid:

```
exit
```

Now, to run KTechlab enter the command:

```
schroot p KTechlab
```

Allowing multiple users on same build. An already compiled and installed version of KTechlab allows multiple-user access. In order to do this, run the script:

```
ktechlab-user-setup.sh
```

from the simple-install/bin/ directory:

```
sh simple/install/bin/ktechlab-user-setup.sh
```

Then you can launch KTechlab as usual:

```
sh simple-launch.sh
```

The author is a technical journalist at EFY. The article is based on the KTechlab documents available at sourceforge.net, space-kerala.org and github.com

DesignSpark: For All Your PCB Designing Needs

DesignSpark PCB is a schematic and layout design software. In this article we explore the capabilities of this software, highlight the new features that came in its latest version, and also shed light on DesignSpark Mechanical, which is another tool included in the DVD accompanying EFY Plus

ABHISHEK A. MUTHA

DesignSpark PCB is a powerful, professional and completely free schematic and layout design software. Ideal for use in professional design environment, it currently claims over 250,000 users worldwide. DesignSpark PCB is easy to learn and comes with an intuitive user interface. It features context-sensitive toolbars, context-sensitive help, customisable shortcuts, interaction bar, easy access

to all relevant commands and an online library of components—ModelSource—with some reference designs.

DesignSpark PCB also has online video and text tutorials to help users get started and a dedicated technical forum for technical clarifications. It improves itself based on community feedback, and further software development, enhancements and new features are derived from comments, design work and experiences shared by other members at DesignSpark's forum.

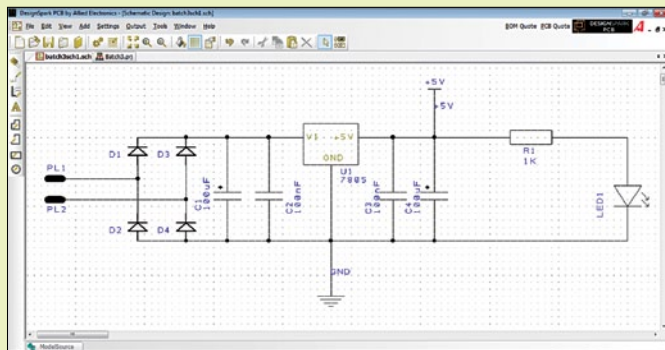


Fig. 1: User interface of DesignSpark PCB

sign and layout, generating impressive 3D view to visualise your design in real time and generate manufacturing files.

Compatibility

DesignSpark PCB supports importing of CadSoft Eagle PCB CAD design files, circuit diagrams and libraries. In addition to extensive libraries, sophisticated part-creation wizards make it easy to design new parts from scratch or by amending downloaded symbols and footprints. Bill of materials (BOM) report can also be generated at any time.

DesignSpark PCB is offered completely free of charge and fully featured. (There are no intentional restrictions on designs.) There are unlimited schematic sheets per project, up to one metre square of board size and no limits on layers—all of which allow you to get your creativity flowing without restraint. DesignSpark PCB circuit design software can be used for schematic capture, PCB board de-

sign and layout, generating impressive 3D view to visualise your design in real time and generate manufacturing files. DesignSpark PCB allows you to generate all the files required to take your project from circuit diagram to layout schematic to a circuit-board built project. Gerbers (extended RS-274-X), excellons and component position reports are available to make your design compatible with pick-and-place machines ready for automated PCB assembly (reflow oven process). Other output formats include DXF (import and export) and IDF for interfacing to mechanical CAD software tools.

Key features

Let us take a look at some of the key features of this tool:

Reference designs. DesignSpark PCB has reference designs for hardware evaluation modules and development kits with complete schematics, PCB files and detailed documentations. Designers can save a lot of their time by using these designs and modifying them according to their requirements.

Additions in version 6 (in this month's DVD)

- 1. Easy IDF export to DesignSpark Mechanical.** DesignSpark PCB version 6 has simplified IDF export to DesignSpark Mechanical by removing the need to do any configuration setting. Fully configurable IDF export is available to export in other MCAD tools.
- 2. Cross Probe.** The new Cross Probe (X-probe) functionality further speeds up the design process by allowing instant referencing between schematic and PCB design views within the software.
- 3. Custom Shortcuts.** DesignSpark Mechanical version 6 lets designers define their custom shortcuts in the software. This flexibility to designers speeds up the entire design process.
- 4. Start Page.** As soon as designers open DesignSpark PCB they see lists of useful electronics highlights, reference designs, getting started links and the handy list of recent projects/files.

The reference designs include, for instance, a chipKIT Max32 kit based on Microchip processor and motor control using Fairchild FNB41060.

ModelSource. ModelSource is an online library of PCB and schematic components with over 80,000 of them. Designers can add components in their designs from ModelSource library and, while doing so, they can see various parameters of the components, manufacturers' details, data sheets and components preview.

Simulation interface. The Simulation interface consists of Simulation Output, SPICE libraries and Simulation Netlist. For Simulation Output, DesignSpark PCB has built-in SPICE parameters that can be assigned to components so that a number of circuit elements could be output to a number of standard SPICE simulators. SPICE simulators supported in DesignSpark PCB are LsSpice, LTspice, B2spice and TINA.

SPICE libraries available contain commonly-used components and symbols, including circuit stimuli and probes to help designers quickly generate circuits to simulate. SPICE Netlists writes a description of the devices in the circuit using basic SPICE format.

Simulation interface lets designers analyse various simulation responses (like AC response, DC response, transient response) of their schematic in one of the above simulators. This saves a lot of time for designers as they need not make a schematic separately in the simulation tool.

Library creation and Components Wizard. DesignSpark PCB gives freedom to designers to create new schematic symbols, PCB footprints and join them to form components which can be added to the user-defined library. Also, since schematic symbols and PCB footprints are separate entities in DesignSpark PCB, by using Components Wizard designers can create new components by providing a few parameters to pre-defined schematic symbols and PCB footprint. Components Wizard also helps designers link multiple schematic symbols with different PCB

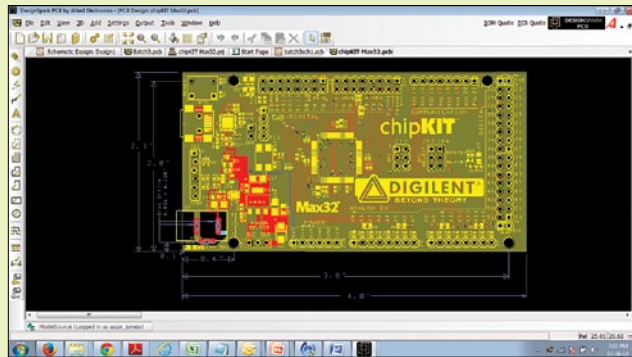


Fig. 2: ChipKit Max32 reference design

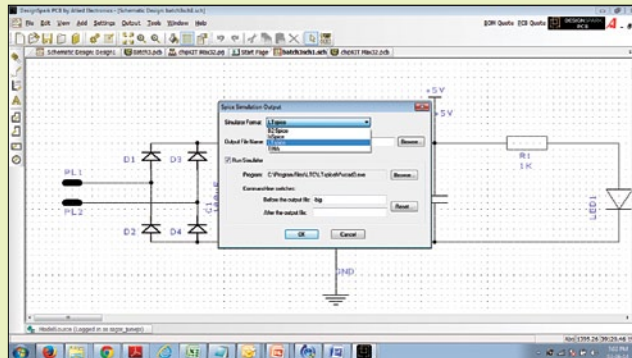


Fig. 3: Spice simulation output

DesignSpark Mechanical: For free and professional 3D model design

DesignSpark Mechanical is a gesture based modelling tool with an intuitive user interface which lets you create conceptual 3D designs with ease (no need to be a CAD expert). Once you are done with your conceptual 3D designs you can save them in the form of interactive 3D PDF to show it to your customers/clients, or you can even print them using 3D printers.

DesignSpark Mechanical gives a liberty to electronics designers to create conceptual 3D designs of their products themselves in very little time and with very little effort (reducing dependency on external 3D CAD designers). By simply importing their PCB design in DesignSpark Mechanical, designers can create a conceptual 3D design of their product enclosure with very easy-to-use commands and tools. To make it easier, DesignSpark Mechanical has a 3D library of over 38,000 components in various formats, which designers can import directly in their existing designs. There are lots of tutorials, videos and articles available at DesignSpark.com to get you started on DesignSpark Mechanical.

footprints and save the combinations as new components.

Design calculators. Track Width calculator lets designers calculate the minimum track width based on the current it carries and temperature rise when current is applied. Track Impedance calculator calculates the characteristic impedance of a unit length of PCB track for a set of common track

geometries. Via Resistance calculator calculates the resistance, voltage drop, power loss and thermal resistance of vias in a PCB design. Other design calculators available are for Heat Sink, RLCF and Conversion.

Design Rule Check. While designing a PCB, designers should keep in mind basic points like minimum track width, minimum annular ring, track-track clearance, track-pad clearance and pad-track clearance. Then there are other design rules related to nets, vias, drills and lot many things. When the Design Rule Check is run and errors found, textual error markers get added to the design with the appropriate code for that rule violation. This helps you identify and correct the error.

Auto-routing. DesignSpark PCB supports complete auto-routing, partial auto-routing and manual routing.

Using an auto-router to route even part of your PCB will give you a significant saving in time. And by combining the power of an auto-router with your experience in PCB layout, the resulting design can beat even the most labour-intensive manual layout results in terms of manufacturability, cost and even aesthetics.

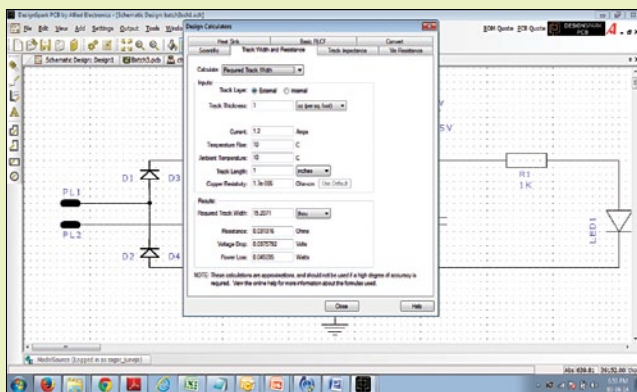


Fig. 4: Design Calculators

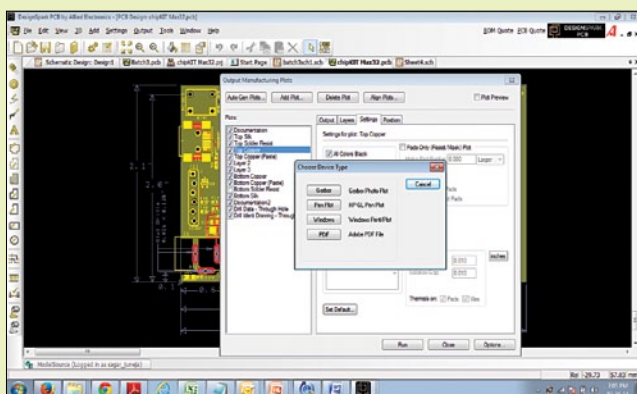


Fig. 5: Manufacturing plot

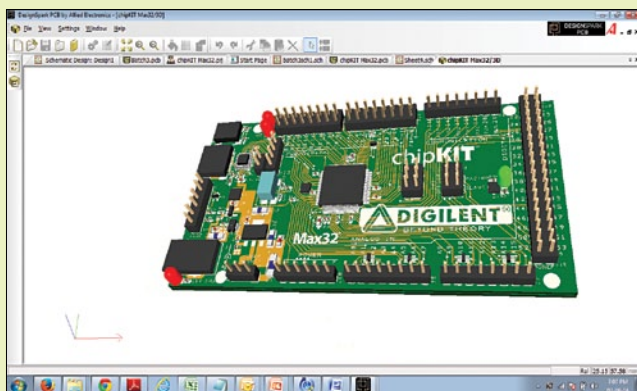


Fig. 6: 3D view

About DesignSpark PCB

Initial release: July 5, 2010

Stable release: Version 6.0 on January 21, 2014

Operating system: Windows, Linux

Type: Free EDA software

Licence: Proprietary software

Top competing tools

- Altium Designer
- EAGLE
- Fritzing
- gEDA Project
- KiCAD
- Ni Circuit Design Suite
- Proteus PCB Design
- TINA

Forward Design Change and Back Annotations.

After translating schematic to PCB, if any changes are made in schematic the same can be transferred to PCB layout using Forward Design Changes option. It works to achieve netlist synchronisation between related schematic sheets and PCB designs. Design changes (addition/deletion) that are pushed forward include Net name, Connection/Net, Net class, Component, Component values, Component groups, Package, Pin changes.

Back Annotations let designers make changes in the PCB design and then apply those changes back to the master or original schematic design.

Manufacturing plot (Auto-generating plot). Auto-generating plot lets designers

automatically generate manufacturing plot. Auto-generation of plots for a design depends on the type of design and the type of output device selected. Designers may choose one of the following device types: Gerber, Pen Plot, Windows, PDF. Once the device type is chosen, designers may select what their set of plots should cover.

3D Viewer, DXF and IDF export. DesignSpark PCB supports 3D view of the PCB, which lets designers actually analyse how their PCB would look

like physically. It uses a simple set of rules describing how each PCB symbol should be represented, together with various settings, like the thickness of the board, and uses the industry-standard OpenGL graphics toolkit to draw the 3D view.

In addition, designers can export their PCB in MCAD tool for designing product enclosure. DesignSpark PCB supports two MCAD export formats: DFX and IDF. DFX output generates an AutoCAD DXF format file containing the board outline shape and the requested drill holes. The IDF format is used as an alternative to DFX by some MCAD (mechanical CAD) vendors for importing into their own systems. IDF files are exported in IDF 3.0 format. The IDF format is used by DesignSpark Mechanical (free and professional 3D model design software sponsored by RS Components) for importing board and component data from PCB design.

Good tool with a good ecosystem

DesignSpark PCB has lots of technical resources available online to help designers easily learn and use the software. DesignSpark.com features video and text tutorials for designers to get started on DesignSpark PCB. There are also technical documentations on install and upgrade instructions, list of input/output file formats and lots of other information. A technical forum is also available on DesignSpark.com for specific technical clarifications and questions. Periodic releases of new versions of the software maximise designers' experience as new versions are released based on users' feedback and are available for free.

Whether you are a professional designer making money from your designs, an electronics education professional, a student or a hobbyist seeking an easy-to-use, professional but unrestricted schematic capture and PCB layout tool, DesignSpark PCB could be the right one for you. ●

The author is a senior technical correspondent at EFY

Today's Changing Instrumentation World

With the acceptance of computers and modular devices, virtual instrumentation has undoubtedly been universally embraced in test and measurement areas. But there are more changes happening in this field. Let us have a look at some of them very briefly

ABHISHEK A. MUTHA

Scientists, academia and especially engineering professionals seem to be driving virtual instrumentation. A major benefit of virtual instrumentation is accelerated project development (which in turn drives better control and design) and cost-effective solutions. However, virtual versus traditional instrumentation is a very subjective issue.

While virtual instruments provide flexibility through user-defined devices, traditional box instruments have fixed, vendor-defined functionality but are powerful. Virtual systems are modular and fast whereas box instruments are traditionally easy to use with all the knobs, buttons and screen displays that are now also available with touch-screen functionality.

Virtual instrumentation in box

Thinking out of the box is regarded as a positive trait but sometimes thinking inside the box could also set a trend. Test and measurement companies are using PXI (PXI stands for PCI eXtensions for Instrumentation) modules to create one-box testers for various wireless communication applications such as base station manufacturing test, power amp test, RF IC test and MIMO test. With advanced processors, easy-to-use software and improvements in technology, PXIs are becoming even more powerful and a better alternative.

A PXI system is typically used by manufacturers of cell phones and other cellular devices. It not only offers the manufacturers faster time-to-market by incorporating controllers, chassis and existing PXI modules but it can also



NI's VirtualBench

be upgraded easily by appending new instruments to it. Although every vendor is selling PXI modules separately, companies are pushing bundled solutions as they feel these solutions best demonstrate and represent customer and vendor advantages of using PXI-inside approach.

PXI is an open, PC-based platform with test, measurement and control capabilities in a low-cost, modular package. You can mix and match different open standard PXI modules to incorporate the exact control I/O and measurement required in each system. Triggering features and integrated timing in PXI backplane provide precise inter-module synchronisation. Vendors can easily pre-configure systems to match a customer's requirements and applications.

PXI Express multiplexers are capable of switching up to 300V DC or AC voltages and 2A current. They furnish around 152 channels for scanning multiple points to a common bus in 1-wire, 2-wire, or 4-wire configurations. The SMX-3276 3U PXI Express multiplexer from VTI Instruments gives ATE system designers the ability to switch

input signals with up to 34MHz bandwidth, while reducing crosstalk levels to as low as -70dB at 100kHz.

Another advantage that PXI has is the power of integration, which allows you to easily integrate another vendor's product into your instrument.

On the downside, especially in case of high-volume applications, PXI adds significant cost as compared to a custom-integrated solution. Also, industry experts believe that there is a lack of ruggedised PXI products for extreme environments. Commercial PXI products are typically not designed for harsh environments. Therefore, depending on the product, some kind of tweaking may be needed to modify the instrument, which could also add to cost. Some of these single-box PXI test devices look like traditional test-bench instruments.






Many instruments in one

"Today, a typical workspace of a typical design/test engineer includes an oscilloscope, a digital multimeter, a power supply and a function generator. Each instrument includes its own separate display and knobs/buttons,"

says Chinmay Anand Misra, certified LabVIEW developer, technical marketing engineer, National Instruments. He adds, "Because of these multiple redundant components, the instruments take up a lot of space, increase the cost of the set-up, and are in general cumbersome to work with if multiple of them are used at a time."

An upcoming trend, to solve the above issue, is integration of diverse instrumentation equipment, such as oscilloscope, function generator, multimeter and power supply in a single box using modular packages and providing a software for test and measurement. A user can interact with the instrument via software applications that run on PCs or iPads. This opens up new possibilities for design engineers, entrepreneurs and even academicians.

National Instruments recently announced its VirtualBench that has a lot of functionality within it. It incorporates a mixed-signal oscilloscope (2ch analogue, 32ch digital) having 100MHz bandwidth, 1G/s sampling rate and 8-bit), function generator (20MHz sine, 14-bit, 125 MS/s), digital multimeter (five-and-a-half digit, 300V and 10A max), DC power supply (+6V @ 1A, +25V @ 0.5A, -25V @ 0.5A) and digital

Five of the Latest Modular Instruments		
Product	Company	Best Features
 <p>U5309A 8-bit PCIe Gen2 high-speed digitiser</p>	Keysight	<ul style="list-style-type: none"> • 8-bit resolution and a DC to 500MHz frequency range • Up to 2GB DDR3 on-board memory and acquisition control using a Xilinx Virtex-6 FPGA • 2 channels up to 2GS/s or 8 channels up to 1GS/s • Includes a Xilinx Virtex-6 FPGA, allowing implementation of custom real-time processing algorithms using the available U5340A FPGA development kit
 <p>EMX-1434</p>	VTI Instruments	<ul style="list-style-type: none"> • 4-channel, 24-bit arbitrary waveform generator with dual-channel 1MHz counter/timers and four channels of digital I/O that plug into the PXI Express bus • Achieves a sampling rate of 204.8k/s per channel and provides a spurious-free dynamic range of -115dB • Output modes include sine, burst sine, chirp, burst random, and continuous random
 <p>BI-40</p>	Brilliant Instruments	<ul style="list-style-type: none"> • PXI-based clock generator card, available in 2.1GHz and 4.1GHz versions, generates square-wave clock signals with 20-digit resolution
 <p>PXIe-4139</p>	National Instruments	<ul style="list-style-type: none"> • A precision system source measure unit (SMU) that performs sample acquisitions at speeds of up to 1.8M/s • Up to 17 SMU channels in one 4U, 48.3cm (19-inch) PXI chassis, minimising overall test-system footprint
 <p>SMX-3276 3U PXI Express multiplexer</p>	VTI Instruments	<ul style="list-style-type: none"> • Switches up to 300V DC or AC and 2A • 152 channels for scanning multiple points to a common bus in 1-wire, 2-wire, or 4-wire configurations

I/O (8ch LVTTTL). Though it aims at simplifying circuit debugging and

validation with a diverse functionality, it costs US \$2000.

PXI modular hardware architecture maximises throughput

PXI is being used for testing wireless, multi-format devices. With today's advanced PXI modules, cellular devices can be tested for standards such as TD-SCDMA, W-CDMA, cdma2000, 1xEV-DO, GSM/EDGE-Evo and LTE-Advanced. Even devices with other connectivity formats, such as 802.11ac, Bluetooth, WiMAX and multi-satellite GNSS for navigation, can be tested.

Testing MIMO RF IC. For bring-up and design verification of MIMO RF IC chipsets used in mobile devices, PXI-based devices are equipped with 18-slot PXIe chassis powered by Core i5 processors. LitePoint's zSeries MIMO includes a perfect combination of hardware and software features for testing the latest generation of MIMO RF IC chipsets. It has powerful software for signal analysis, creating waveforms and performing tests such as SISO, direct mapped MIMO, asymmetric MIMO and true MIMO testing.

Multi-device testing. Keysight's E6640A EXM wireless test set has high-density PXI transmit and receive (TRX) modules that allow four transmit and receive channels within each unit. In sync with the latest cellular and WLAN chipsets, this test set is designed for multi-device testing with up to four TRXs.

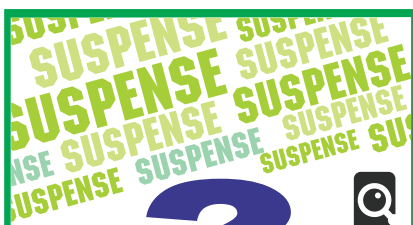
Field-testing and DAQ. A14-slot PXI card is incorporated inside the MTS-207 test box solution from Marvin for field-testing and data acquisition systems. The MTS-207 includes a 14-slot combination, shock-mounted PXI chassis with seven 3U slots and seven 6U slots. An internal heater keeps the modules stable at sub-zero temperatures, while the modules are carefully designed or selected to meet the +65°C requirement at the high end. Internal shock absorbers cushion the PXI modules, while conformal coating protects the modules against humidity and other harsh environments. Compact PCI, closely related to PXI, is also deployed.

Because of these advancements in PXIs, the latest trend today is to use modular devices and boards to create one-box testers (OBTs).

FPGAs for more power

Another interesting development is the concept of software-defined radio (SDR). Although SDR has been around for many years, it has become really viable only in the recent years. The main idea is to configure an FPGA within a PXI instrument exactly as per required test specifications. A software-defined virtual instrument makes available raw data from the hardware to the end users so they can define their own measurements and user interfaces. A combination of general-purpose, modular hardware and software-defined virtual instrumentation enables an end user to exploit the full flexibility and performance of the measurement software.

FPGAs allow implementation of custom real-time processing algorithms. Consider Keysight's PCIe



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Technology Drives Us

Apple to aim at electronics test solutions

You may be surprised, Apple is planning to come up with Mac Test, an engineering workstation in a laptop form for test engineers. Apart from USB and LAN, it will include PCI Express ports for interfacing with PXI or AXIe systems. But it is the software that has everybody talking. When an engineer transitions from Windows environment to Mac Test, the current engineering documents and test procedures would be converted to an Apple proprietary format, deleted from their current folders, and then loaded into iTunes, as reported in an article in *EDN*.

Digitizer U5309A. At the heart of the U5309A is a data processing unit (DPU) based on Xilinx Virtex-6 FPGA. Responsible for supervising the module functionality, data flow and real-time signal processing, this powerful FPGA allows data storage and reduction to be carried out at the digitiser level, speeding-up analysis and minimising transfer volumes.

An end user of an instrument with an 'open' FPGA can fully personalise the functionality of the instrument by adding application-specific measurements, custom triggering or the capability to use new digital protocols onto the system, to name a few. Essentially, the user can tweak firmware of the device to meet requirements—not just defining in software how the data should be used but also adding new functionalities that the instrument can perform. Using this approach boosts test speed.

The FPGA in Keysight's Digitizer is primarily intended to open the design of the FPGA to specific user requirements by providing a development framework that interfaces to the underlying hardware. It mainly looks to achieve multi GS/s real-time processing on a full digitiser framework by leveraging full density and speed of the FPGA. It also boosts the time-to-market with turn-key, easy-to-use development flow and debug.

Cloud-connected and voice-controlled instruments

Engineers have been transferring data between their devices using USB drives or a network, but now it is possible to do so with cloud technologies. Besides storing files in the cloud, some services host full applications in the cloud.

"Instrumentation that incorporates

network and cloud connectivity could provide these same benefits to engineers. Both the data and user interface could be accessed by multiple engineers from anywhere in the world," says Misra. He adds, "When debugging an issue with a colleague who is off site, rather than only sharing a static screenshot, engineers could interact with the instrument in real time to better understand the issue. Cloud technologies could greatly improve an engineering team's efficiency and productivity."

Also, context-aware computing is beginning to emerge and could fundamentally change how we interact with devices. This technology uses situational and environmental information to anticipate users' needs and deliver situation-aware content, features and experiences. A popular example of this is Siri, a feature found in recent Apple iOS devices.

Similar intelligence when combined with instrumentation could be game-changing. A common challenge that engineers face is attempting to make configuration changes to an instrument at the same time that their hands are tied up with probes. Misra says, "Voice control could not only provide hands-free interaction but also easier interaction with features. In addition, predictive intelligence could be used to highlight relevant or interesting data. An oscilloscope could automatically zoom and configure based on an interesting part of a signal, or it could add relevant measurements based on signal shape." "An instrument that leverages mobile devices could integrate and take advantage of context-aware computing as the technology is developed." ●

The author is a senior technical correspondent at EFY

Instrumentation Offers Most Jobs in Marketing and Software

An instrumentation engineer slips into a variety of roles, be it designing, developing, managing, installing or marketing, and is often employed across various industries. In India, the jobs available in instrumentation are more focused on sales and marketing as well as IT industry. Let us take a look at the scope for a career in instrumentation in India, the kind of opportunities available and the pay it offers

ABHISHEK A. MUTHA

We all know that instrumentation is the art and science of measurement, and control of process variables within a production or manufacturing area. Instrumentation engineering has been

extended as a separate area of focus from electrical and electronics branch of engineering.

Instrumentation is a multi-disciplinary stream and covers such areas as mechanical, computers, electronics, electrical and even chemical. So it can be said that, instrumentation engineer-

ing is a niche branch of electrical and electronics engineering that deals with automation, measurement and control of processes.

Job prospects

Typically, instrumentation engineers are employed in companies and organisations using heavy machinery to improve safety, stability and efficiency of automated processes. The main tasks of these engineers are to take care of maintenance or production, or design instrumentation systems used in manufacturing-related activities.

They work in an array of industrial sectors including thermal power plants, cement manufacturing, steel plants, R&D organisations and public and private sector firms. Apart from being hired by organisations that manufacture various instruments, these engineers are also hired by companies



(Courtesy: <http://vedavyasa.org>)

Popular skills for an instrumentation engineer

- Distributed control systems
- Programmable logic controllers (PLCs)
- Instrument control
- Engineering design

Some top instrumentation engineering organisations

- Larsen & Toubro
- Bosch
- Invensys
- National Instruments
- ABB
- GE
- Suzlon

making use of specialised instruments for their daily operations.

Instrumentation engineers and technicians are high-demand professionals who are needed across almost all areas of engineering, science and technology based industries. Requirements for this inter-disciplinary branch of engineers range across IT, engineering, manufacturing and continuously operating plants for their maintenance, instrumentation designing, sales and marketing, R&D and defence industries, to name a few.

The majority of jobs in this profession are located in the three big cities of Delhi, Mumbai and Bengaluru. So while there are ample opportunities, aspirants should be willing to relocate, if they reside elsewhere.

Instrumentation engineers are also hired by multinational companies for working in software and marketing domains. The most common designations they land up with are sales and marketing engineer, or software engineer, or that of an instrumentation engineer whose job responsibilities are a mix of both.

There is no doubt about availability of core jobs but these are considerably less. There are many entry-level roles in the field of instrumentation engineering. Prominent among them are sales engineer, application engineer, service engineer and marketing engineer or technician.

Qualifications for instrumentation engineer

To work in the instrumentation sector, of course an engineering degree (instrumentation, electronics, mechanical, electrical, or computers) is required. Based on your specialisation, you are assigned work in the particular vertical of instrumentation. Experts believe that one must also have a strong aptitude for mathematics and physics. Strong communication skills are a must for any discipline today, especially if you want to grow in your career, and it holds good for instrumentation as well.

Engineers must have the potential

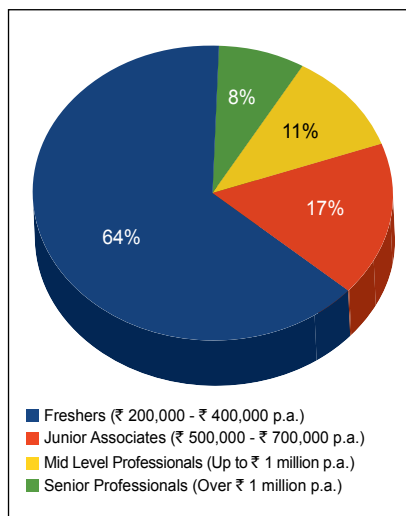


Fig. 1: Jobs and salary break up in instrumentation field (Data courtesy: TimesJobs.com)

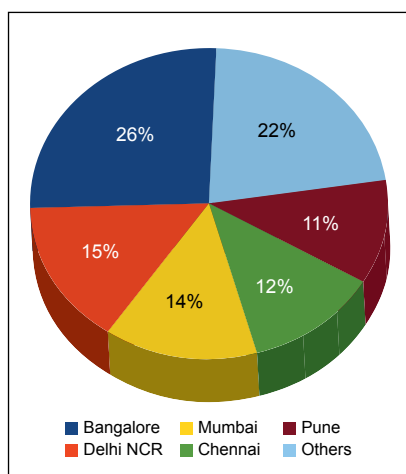


Fig. 2: Top locations for jobs in instrumentation (Data courtesy: TimesJobs.com)

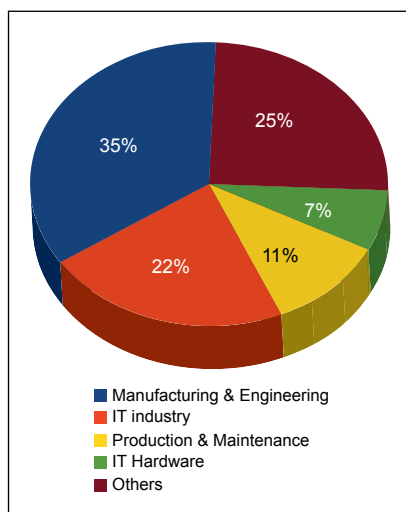


Fig. 3: Top industries hiring instrumentation professionals (Data courtesy: TimesJobs.com)

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Some notable institutes for instrumentation engineering

- IITs
- Netaji Subhas Institute of Technology, New Delhi
- NITs
- Madras Institute of Technology, Anna University, Chennai
- Birla Institute of Technology & Science
- JSS Academy of Technical Education, Bengaluru
- PES College of Engineering, Mandayal
- Indian Institute of Science, Bengaluru

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to express project requirements for the design and development of hardware suitable for the task. As instrumentation engineers usually find themselves called upon to solve uniquely challenging problems, they must possess essentials such as excellent problem-solving skills and an ability to think outside the box.

Those who are sound in fundamentals and have specific knowledge of measurement systems will find multiple career options within this industry.

Talking about technical skills, instrumentation engineers typically advance their skills in specific disciplines such as distributed control systems, programmable logic controllers, supervisory control and data acquisition (SCADA), and advanced process control. The use of these disciplines will depend on the exact nature of individual job roles.

Is the money worth it?

According to PayScale.com, an instrumentation engineer earns an average salary of ₹ 362,664 per year. The amount of experience strongly influences income for this job. The average starting salary for instrumen-

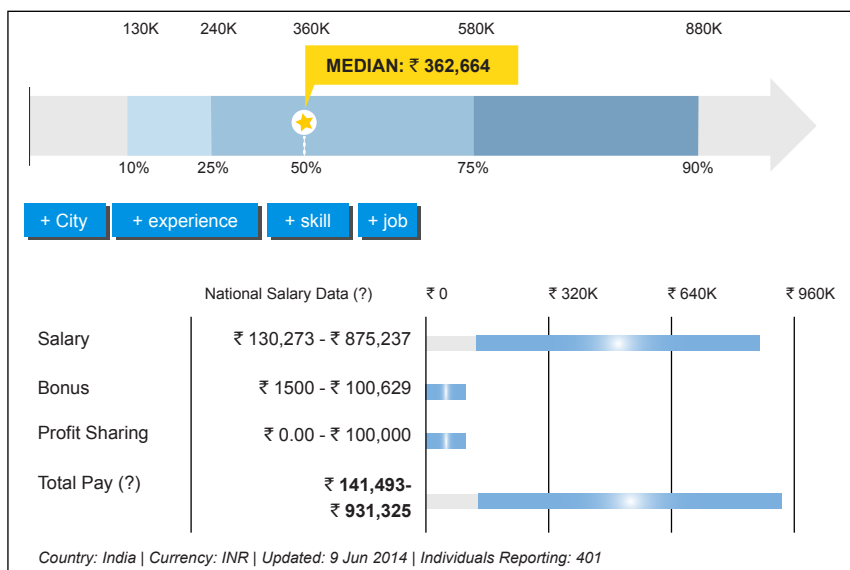


Fig. 4: Approximate pay range of instrumentation engineers (Data courtesy: Payscale.com)

tation engineers in India is ₹ 100,000 to ₹ 240,000 per year. Senior engineers can earn in the range of ₹ 350,000 to 600,000 per annum.

The skills that increase salaries for this job the most are engineering design, distributed control systems and instrument control. Most people move on to other jobs if they have more than ten years' experience in this field.

According to TimesJobs.com's statistics, 64% jobs are for fresh engineers who draw between ₹ 200,000 and ₹ 400,000 per annum. And 17% jobs are for junior associates who get anywhere between ₹ 500,000 and ₹ 700,000 per annum, whereas senior-level employees are paid up to or over ₹ 1,000,000 per annum.

Demand areas

As per data provided by TimesJobs.com, Bengaluru tops the list offering 26% of the jobs in instrumentation in India. Other cities offer: Delhi NCR-15%, Mumbai - 14%, Chennai - 12% and Pune - 11%. Remaining jobs are scattered all over other locations (refer pie chart).

The maximum number of professionals hired for working in instrumentation sector are in manufacturing and engineering industry with 35% share of jobs, which includes a majority of sales and marketing jobs. Next in line are IT

industry with 22% of jobs, production and maintenance industry with 11% and IT hardware with 7%.

Instrumentation engineering is available as B.Tech or B.E. programmes, entry to which is normally through an all-India entrance test or tests organised by state governments. Institutes like BITS Pilani offer instrumentation with electronics as BE (Hons) electronics and instrumentation.

Challenges

Industry experts believe instrumentation gives the pursuer an edge over mechanical or electrical engineers in terms of wider knowledge base. The pay is low initially but it gets better in later stages, once you develop the skills. It is also a highly responsible role as it includes a multitude and variety of tasks. On the other side, health could be affected due to high noise and temperature levels at manufacturing plants. You could also be required to work for longer hours. The jobs in sales, marketing and software are more as compared to core jobs.

There is hardly any area where instrumentation is not required. Hence, there is vast scope in this field. ●

The author is a senior technical correspondent at EFY

XBee-Controlled Aircraft

SOMNATH BERA

This is a remote-controlled aircraft project based on Arduino and XBee modules. The aircraft's movement is controlled through a brushless DC motor and three servo motors. It has an XBee-based remote control at the transmitter end and an Arduino-based aircraft at the receiver end. The aim of this project is to develop a 4-channel wireless remote control (RC) system with one XBee each in transmitter and receiver.

Circuit and working

Fig. 1 shows the circuit of XBee-controlled aircraft transmitter section and Fig. 2 shows its receiver section. The circuits are built around Arduino UNO (board1), a pair of XBee module (XB1

and XB2), electronic speed controller (ESC) module, three servo motors (M1-M3) and a BLDC motor (M4).

Transmitter section is driven by a 3.7V battery and receiver section by

an 11.1V LiPo battery. 11.1V is used to power the brushless DC motor (or BLDC motor) through ESC module. The Arduino board1 receives power supply from 11.1V battery at its Vin input pin.

The four potentiometers in transmitter section are used for sending different control signals to the receiver section through RF modules. Control signals received in the receiver are processed by micro-controller in the Arduino, which

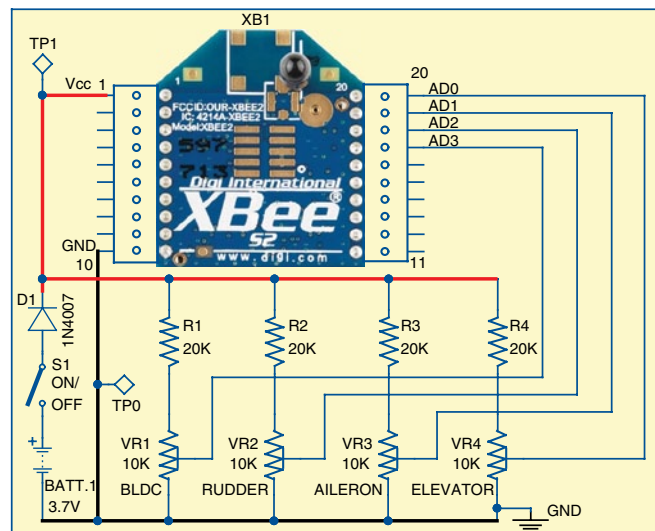


Fig. 1: Circuit of XBee-controlled aircraft (transmitter side)

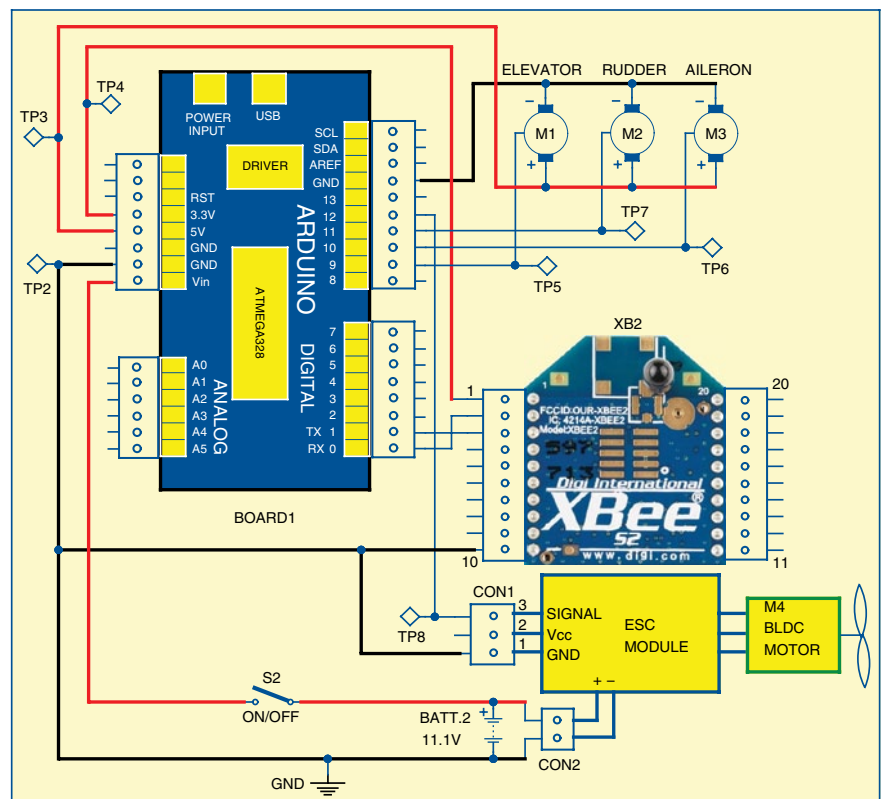


Fig. 2: Circuit of XBee-controlled aircraft (receiver side)

Test Points

Test point	Details
TP0	0V
TP1	3.1V (with respect to TP0)
TP2	0V
TP3	5V (with respect to TP2)
TP4	3.3V (with respect to TP2)
TP5	PWM signals for servo motor M1
TP6	PWM signals for servo motor M3
TP7	PWM signals for servo motor M2
TP8	PWM signals for BLDC motor M4

PARTS LIST

Semiconductors:

- Board1 - Arduino UNO board
- XB1, XB2 - XBee module
- ESC module

Resistors (all 1/4-watt, $\pm 5\%$ carbon):

- R1-R4 - 20-kilo-ohm
- VR1-VR4 - 10-kilo-ohm preset

Miscellaneous:

- CON1 - 3-pin connector
- CON2 - 2-pin terminal block connector
- BATT.1 - 3.7V battery
- BATT.2 - 11.1V LiPo battery
- M1-M3 - 5V servo motor
- M4 - BLDC motor
- S1, S2 - On/off switch
- Propeller blades
- Aircraft parts

in turn controls a BLDC motor and the servo motors for rudder, aileron and elevator of the aircraft.

Arduino Uno board. Arduino is an open source electronics prototyping platform based on flexible, easy-to-use hardware and software. It is intended for artists, designers, hobbyists and anyone interested in creating interactive objects or environments.

Arduino UNO is a board based on ATmega328 microcontroller. It consists of 14 digital input/output pins, six analogue inputs, a USB connection for programming the on-board microcontroller, power jack, an ICSP header and a reset button. It is operated with a 16MHz crystal oscillator and contains everything needed to support the microcontroller. It is very easy to use as the user simply needs to connect it to a computer with a USB cable or power it with an AC-to-DC adaptor or battery to get started. The microcontroller on the board is programmed using Arduino programming language and Arduino development environment.

XBee module. XBee is a small 2.4GHz transceiver with a small microcontroller on board. It is a communication protocol which is used in many other instruments too.

There are two types of XBee radio transceivers: series 1 and series 2. Each series has two varieties: normal and pro. While the normal has a range of 30 to 40 metres in indoor or urban situations, along the line of sight it works up to 100 or even 125 metres. The pro is effective up to 1.6km on line of sight. However, with a Yagi directional antenna, XBee pro can reach as long as 20km on line of sight.

While series 1 has eight digital I/O pins, series 2 has 11 pins. Series 2 is more advanced and can be made into mesh networks whose range can be extended to any length by putting router XBees in between.

Analogue input and XBee

XBee analogue input pins read 0V to 1.2V maximum. Any voltage above 1.2V is treated as maximum or 1. Since most XBees operate at 3.3V, we reduce

this voltage to 1.2V by adding a suitable resistor along the input device.

Suppose the analogue sensor is an LDR whose impedance varies from 0 to 10k, to drop 3.3V to 1.2V across the LDR we put a 20k resistor in series with the LDR, so that two-third voltage (of 3.3V) is dropped before reaching the LDR.



Fig. 3: XBee module



Fig. 4: BLDC motor

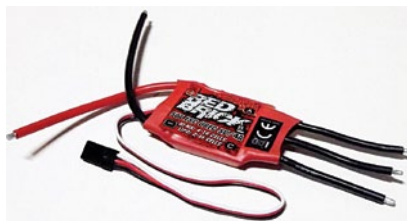


Fig. 5: ESC module

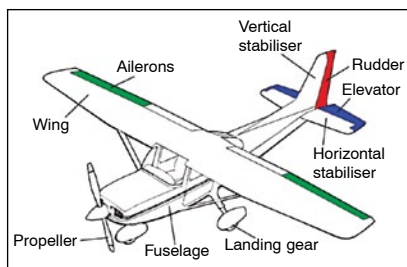


Fig. 6: Parts of RC aircraft (courtesy: dduino.blogspot.in)

Transmitter side. Pins 20 through 17 of XB1 are connected to four 10k presets (VR1 through VR4), which are used to control BLDC motor (refer Fig. 4), rudder, aileron and elevator, respectively.

Receiver side. Pins 0 and 1 of board1 are connected to pin 2 and 3 of XB2. Pins 9, 11, 10 and 12 of the board are connected to signal pins of M1 (elevator), M2 (rudder), M3 (aileron) servo motors and ESC module (refer Fig. 5), respectively. Main body parts of a typical RC aircraft are shown in Fig. 6.

BLDC motor is used for propeller of the aircraft. The propeller, or airscrew, converts rotary motion from motor to provide propulsive force. It is the most important part of the aircraft. The propeller is mounted on the front side of the aircraft and is generally made of two or more blades.

A rudder is used to steer the aircraft when it moves through the air, controlling the direction in which the aircraft is pointing. It is a flat sheet of material attached with hinges to the craft's stern, tail, or after end.

An aileron is a hinged flight control surface, usually attached to the trailing edge of each wing of an aircraft. Ailerons are used in pairs to control the aircraft in roll, or movement around the aircraft's longitudinal axis.

Elevators are flight control surfaces, usually at the rear end of an aircraft, which control the aircraft's longitudinal altitude. The position of the elevator controls whether the nose of the airplane is pointing up or down, and accordingly the plane moves up or down. The elevators are usually hinged to a fixed or adjustable rear surface.

Input supply wire of ESC is connected to 11.1V battery. Three output wires of ESC are connected to three-phase inputs of BLDC motor (M4).

Software

Arduino UNO is programmed using Arduino IDE software. ATmega328 on Arduino UNO comes with a boot loader that allows you to upload new

code to it without the use of an external hardware programmer. It communicates using the STK500 protocol.

You can bypass the boot loader and program the microcontroller through in-circuit serial programming (ICSP) header, but using boot loader programming is quick and easy. Select the correct board from 'Tools -> Board' menu in Arduino IDE 0022 and burn the program (sketch) through standard USB port in the computer.

We used Red Brick ESC module. If you use any other ESC module, you may have to modify delays in the code accordingly.

Programming an XBee

Several communication programs are available for programming an XBee, such as procontrol, xterm, pcu, X-CTU, even putty, but among these X-CTU is the easiest, Windows-based graphical program, though it takes longer time. But once you master X-CTU, you can quickly connect XBee to any other communication program and do the reprogramming of your XBee through short AT commands.

Download X-CTU from the Internet and install it on a Windows PC. Position the XBee on the Explorer board and connect it to the USB port of your PC. Fire up X-CTU and see whether it detects the device or not.

The two XBees can be made to communicate with each other freely and precisely through X-CTU software. The X-CTU has four tabbed windows: PC settings, Range test, Modem and Configuration. In PC settings window there are three sub-windows located at the bottom: Host setup, User COM ports and Network Interface. In case you have not found your right COM ports, you can click Network Interface and then Digi Device Discovery to find your device.

Press Test/Query button on right side of the same PC Settings window and see what XBee it discovers. Check Enable API box because we will use this feature in Coordinator Xbee (XB1). Now come to Configuration window where most of the settings need to be

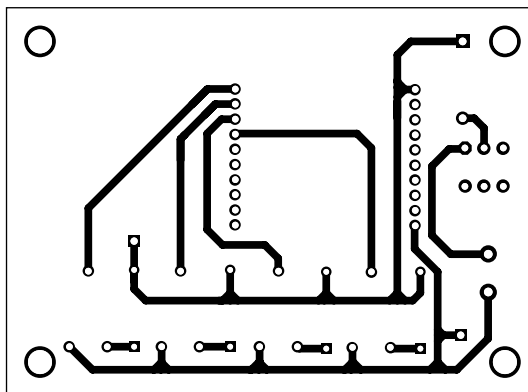


Fig. 7: An actual-size PCB pattern for XBee-controlled aircraft (transmitter side)

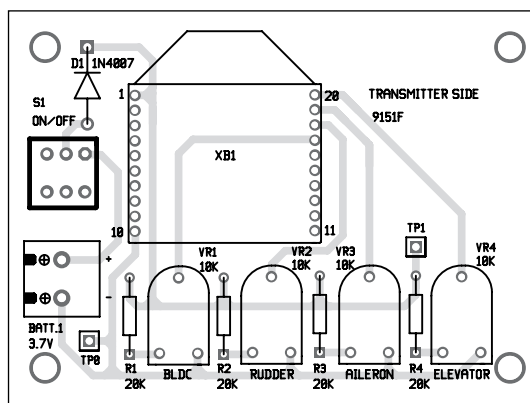


Fig. 8: Component layout for the PCB (transmitter side)

made.

In Configuration window, click on Read button and your screen will start showing lots of data. Do not get alarmed; you need to configure only a few parameters.

Click on Always Update Firmware, as this will keep the XBee updated with the latest software. In Function Set pull-down menu select XBee Coordinator API. In Version pull-down select the highest number. In Networking parameters window find the personal area network (PAN) parameter, and give it a 4-digit number, say, 7821. Do not give 1234 because most people use this number. In case another person is experimenting with XBee in your area, you both will collide in the air space for bandwidth.

For communication between two XBees, one has to be made Coordinator and the other a Router. Here we are preparing the Coordinator XBee (XB1).

Coming to the Addressing param-

eter at DH and DL, these are called the High and Low addresses. DH is a 32-bit address written on the XBee itself. Enter this parameter here. In most cases, it is the same number for all generic XBees: 0013A200 (find out yours to be sure). Just below this number you will find another 32-bit number inscribed on the XBee. This is the DL number.

The DL parameter is to be switched between the Coordinator and the Router; the Router number to be entered into the Coordinator and vice versa. After doing that check Write and the setup will be written in your Coordinator XBee. See the message below. You may need your Internet connection on now. When it is over, 'finished' message will appear at the bottom.

Pat yours back; you have set up the XBee Coordinator successfully! Now remove the Coordinator and insert

the other XBee (XB2) and open Configuration window. After checking Read, and getting the parameters shown on the middle window, go to the Function Set pull-down menu and select XBee Router API. In Version pull-down select the highest number. Find the PAN in the Networking parameter and enter 7821 (same as the Coordinator XBee). Set the JV parameter as 1, as it will set the Router to rejoin the coordinator on startup.

In Addressing parameter the DH shall be as written on the XBee and the DL shall be the DL number written on the Coordinator XBee. So far so good! Now come down further to IO Settings to set up analogue and digital data entry part of the router XBee.

In the IO Settings parameter, D0, D1, D2, D3 are the four analogue input pins through which we will send our 4-channel analogue data. By default these pins are disabled. To enable them, go to IO Settings and make D0,

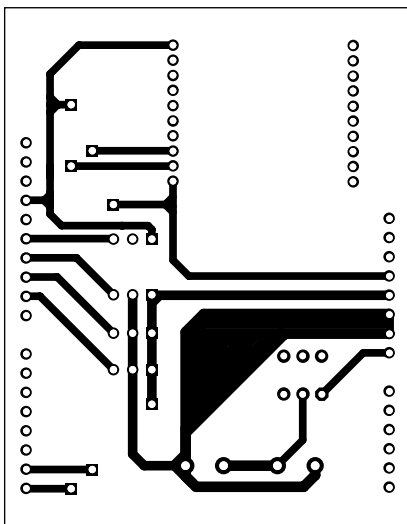


Fig. 9: An actual-size PCB pattern for XBee-controlled aircraft (receiver side)

D1, D2, D3 as 2 (as analogue data entry). However, these pins can be made digital data input or output pins also by simply changing to 3, 4 or 5. Set D5 to 4. This pin will be used as feedback signal from receiver XBee (XB2).

Now come to I/O Sampling section and set the IR sampling to 64, that is, 0X64. Once it is on 100-millisecond the feedback will be checked.

Check Write and let the configuration be written in XBee (XB2).

Construction and testing

An actual size, single-side PCB for the XBee-controlled aircraft transmitter circuit is shown in Fig. 7 its component layouts in Fig. 8. PCB for receiver circuit is shown in Fig. 9 and its component layout in Fig. 10.

PCB of receiver board1 is in the form of shield, so mount it on top of Arduino UNO board. Connect 3.7V

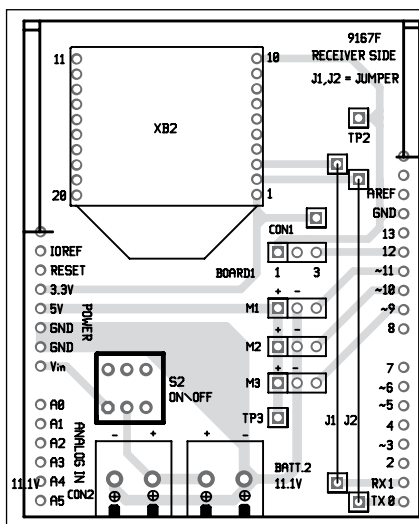


Fig. 10: Component layout for the PCB (receiver side)

battery to transmitter section and 11.1V battery to receiver section. Check working of BLDC motor by varying VR1, of servo motor M1 using VR4, of servo motor M2 using VR2 and of servo motor M3 using VR3. If there is any problem, verify voltages at test points given in the table.

Building an RC aircraft requires some basic skills and creativity. There are rich tutorials available on the Internet. Some useful information to build your own RC aircraft can be found from the links below:

<http://www.easyrc.com/airplanes/>

<http://rcvehicles.about.com/od/diyaircraft/>

<http://www.stenulson.net/rc-flight/rcflight.htm>

You can either build the body of the aircraft yourself or get it ready-made from an electronics spares shop.

EFY Note

The source code of this project is included in this month's EFY DVD and is also available for free download at source.efymag.com

The receiver PCB, along with the 11.1V battery, should be mounted firmly in the aircraft.

The RC aircraft can be launched by gathering speed on a long runway while some are launched by hand by literally throwing them into the air. In the first case, as soon as your plane builds up enough speed and catches wind, it will lift from the ground. But note that, if the runway surface is uneven (like grass-covered), your plane might not be able to gather the necessary speed for take-off. In that case you should opt for hand-launch.

Remember, the aircraft is controlled by a remote control which has a finite range. If your plane gets too far away from you (either vertically or horizontally), you might lose control and the plane would plummet back to the ground. The usual way to fly it is in circles above your head.

After assembling the complete project, switch on transmitter and receiver circuits. Slowly vary VR1 to increase the speed of the BLDC motor (propeller). Once the plane takes off and is stabilised above the ground, vary VR2, VR3 and VR4 one by one, gradually, and observe the effect on flight pattern. To return plane back to ground, reduce its speed using VR1. ●

The author is an avid user of open source software. Professionally, he is a thermal power expert and works as additional general manager at NTPC

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Celestial Weight Calculator

DR DARSHAN G. VYAS

Whether you are a science fiction fan, a space enthusiast or one of the millions who have watched astronauts gamboling about the moon's surface, you may have wondered how much you would weigh on other planets in the solar system. The weight depends on the gravitational forces acting on the object, which vary from planet to planet. The Newton's law of univer-

sal gravitation says that everything that has mass attracts every other thing that has mass, pulling with a force which is directly proportional to the product of the two masses of the objects and inversely propor-

tional to the square of the distance separating their centres. The mass and radius of different celestial bodies is mentioned in Table I.

The designed embedded system takes a weight on earth and shows the weights on other celestial bodies of our solar system. The device is designed and constructed using microcontroller AT89S52. It can give better understanding about gravity. The system calculates the mass and acceleration due to gravity (g) for other celestial bodies and displays the corresponding weight (force). Fig. 1 shows the author's prototype.

Suppose your weight on earth is 50.5 kg, your weight on other celestial bodies of our solar system would be as given in Table II.

Circuit and working

Fig. 2 shows circuit diagram of the celestial weight calculator. The circuit is built around microcontroller AT89S52 (IC1), 7-segment displays LTS542 (DIS1 through DIS8), and a few transistors and switches.

Microcontroller. AT89S52 is a low-power, high-performance CMOS 8-bit microcontroller. It provides 8k bytes of Flash, 256 bytes of RAM, 32 I/O lines, three 16-bit timer/counters, a six-vector two-level interrupt architecture, a full-duplex serial port, on-chip oscillator and clock circuitry. Power-on reset is provided by the combination of resistor R17 and capacitor C3. Switch S6 is used for manual reset. A 12MHz crystal along with two 33pF capacitors provides basic clock frequency to the microcontroller.

Port 0 and port 2 of IC1 are used for multiplexing the 7-segment displays

TABLE I
Mass and Radius of
Different Celestial Bodies

Celestial body	Mass (kg)	Radius (m)
Mercury	3.30×10^{23}	2,440,000
Venus	4.87×10^{24}	6,051,000
Earth	5.97×10^{24}	6,378,000
Moon	7.35×10^{22}	1,738,000
Mars	6.42×10^{23}	3,397,000
Jupiter	1.90×10^{27}	71,492,000
Saturn	5.69×10^{26}	60,268,000
Uranus	8.66×10^{25}	25,559,000
Neptune	1.03×10^{26}	24,764,000
Pluto	1.31×10^{22}	1,160,000
Sun	1.99×10^{30}	695,000,000

TABLE II
Weight of a 50.5kg
Substance on Different
Celestial Bodies

Celestial body	Weight (kg)
Sun	1367.1359
Mercury	19.088945
Venus	45.8035
Earth	50.5
Moon	8.3829994
Mars	19.038499
Jupiter	119.382
Saturn	54.54
Uranus	44.8945
Neptune	56.8125
Pluto	3.3835



Fig. 1: Author's prototype

PARTS LIST

Semiconductors:

- IC1 - AT89S52 microcontroller
- IC2 - 7805, 5V regulator
- BR1 - Bridge rectifier
- DIS1-DIS8 - LTS542 CA 7-segment display
- T1-T8 - BC557 pnp transistor

Resistors (all 1/4-watt, $\pm 5\%$ carbon):

- R1-R8, R17 - 10-kilo-ohm
- RNW1 - 10-kilo-ohm resistor network
- R9-R16 - 100-ohm

Capacitors:

- C1 - 470 μ F, 35V electrolytic
- C2 - 0.1 μ F ceramic
- C3 - 10 μ F, 16V electrolytic
- C4, C5 - 33pF ceramic

Miscellaneous:

- X1 - 230V primary to 15V, 500mA secondary transformer
- X_{TAL}1 - 12MHz crystal oscillator
- S1-S24 - Tactile switch

TABLE III
Port Pin Connections of Keyboard Matrix

Port pins	P3.7	P3.6	P3.5	P3.4	P3.3	P3.2
P1.7	7	8	9	SUN	PLUTO	JUPITER
P1.6	4	5	6	VENUS	SATURN	MERCURY
P1.5	1	2	3	MOON	URANUS	NEPTUNE
P1.4	0	00	•(DP)	MARS	EARTH	

•(DP): Decimal Point

(DIS1 through DIS8). The port 1 and port 3 are used for scanning the keyboard buttons, except switch S6. Transistors (T1 through T8) and resistors (R1 through R8) are used for digit selection. The 7-segment

displays used are LTS542, which are common-anode type. Eight current-limiting resistors (R9 to R16) of 100Ω each are used.

The pin connections between the matrix keyboard and IC1, with key

functions, are shown in Table III.

The multiplexing of eight 7-segment displays is done by using unconventional queer multiplexing technique. The even and odd segments are connected differently in this technique

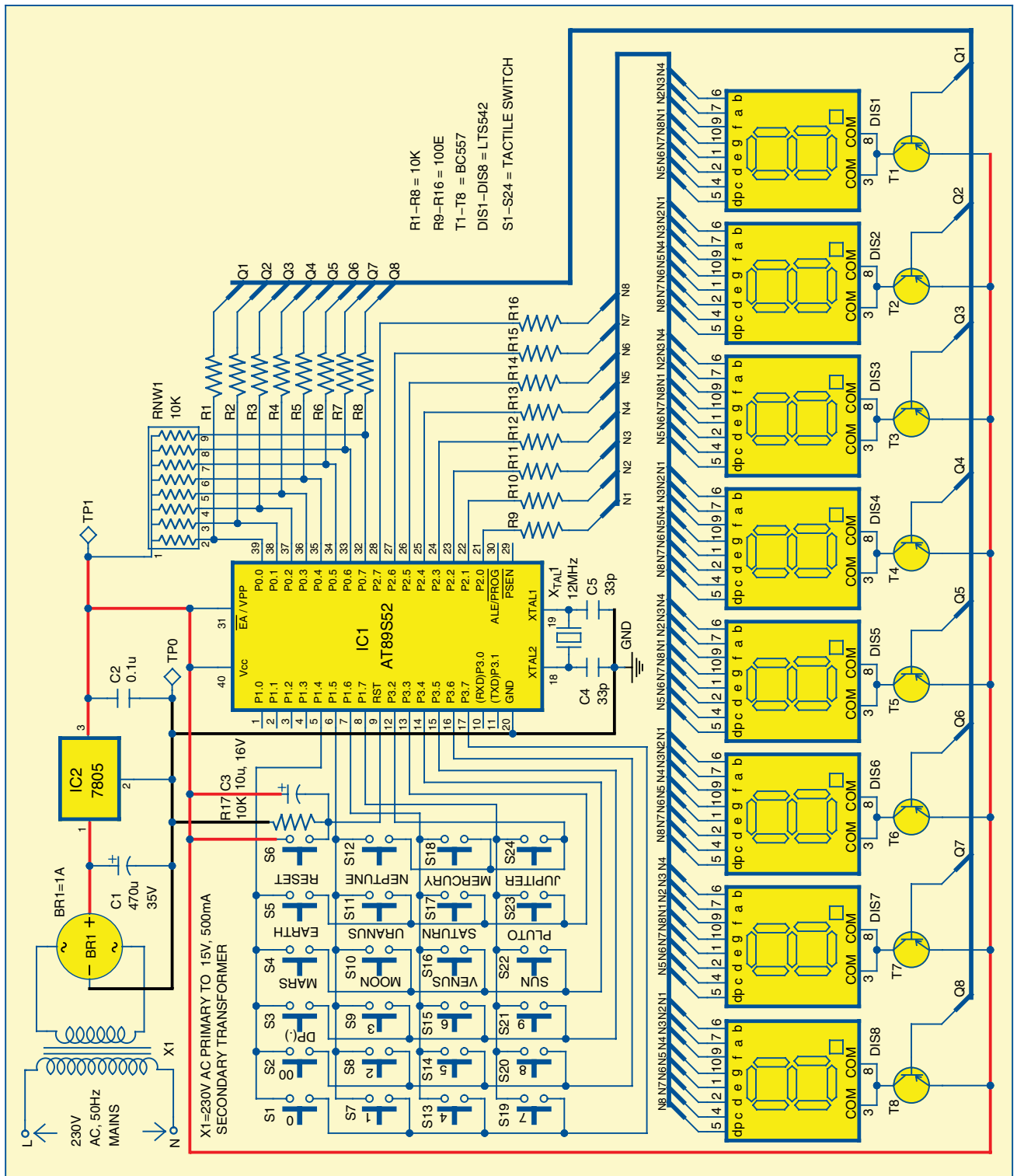


Fig. 2: Circuit diagram of the celestial weight calculator

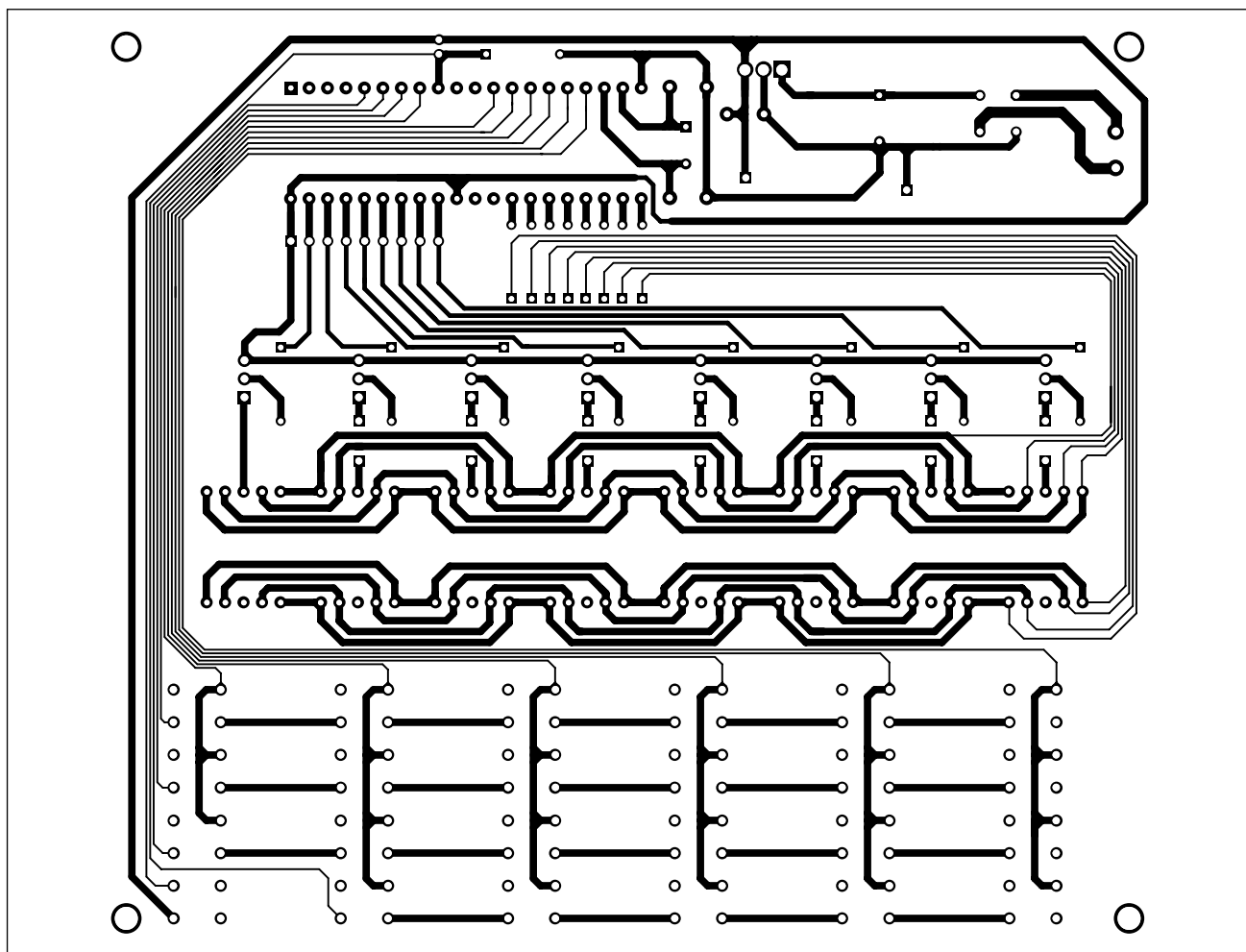


Fig. 3: An actual-size PCB layout for the celestial weight calculator

to make the PCB design simpler, as shown in Table IV.

The codes to display different numbers on even and odd 7-segment displays are shown in Table V.

The working of this device is very simple. Switch on the power supply and the device will display '0.' Enter

your weight on earth (either integer or real number). After entering weight press key for any celestial body and see the weight at that celestial body.

TABLE V
SSD Codes for Even and Odd SSDs

To see on SSD	Codes for even SSDs	Codes for odd SSDs
0	11H	88H
1	D7H	BEH
2	32H	C4H
3	92H	94H
4	D4H	B2H
5	98H	91H
6	18H	81H
7	D3H	BCH
8	10H	80H
9	90H	90H
BLANK	FFH	FFH

To enter a new weight on earth, press Reset key.

Software

The source program for the microcontroller is written in C language and compiled using Keil μ Vision4 compiler. The generated hex code is burnt

TABLE IV
Port Pin Connections with SSD Segments

Port pin	Even SSD	Odd SSD
P2.7	E	H(DP)
P2.6	D	C
P2.5	C	D
P2.4	H(DP)	E
P2.3	B	G
P2.2	A	F
P2.1	F	A
P2.0	G	B

TABLE VI
Test Points

Test point	Details
TP0	0V, GND
TP1	5V
S6 pressed	DIS1 shows 0

EFY Note

The source code of this project is included in this month's EFY DVD and is also available for free download at source.efymag.com

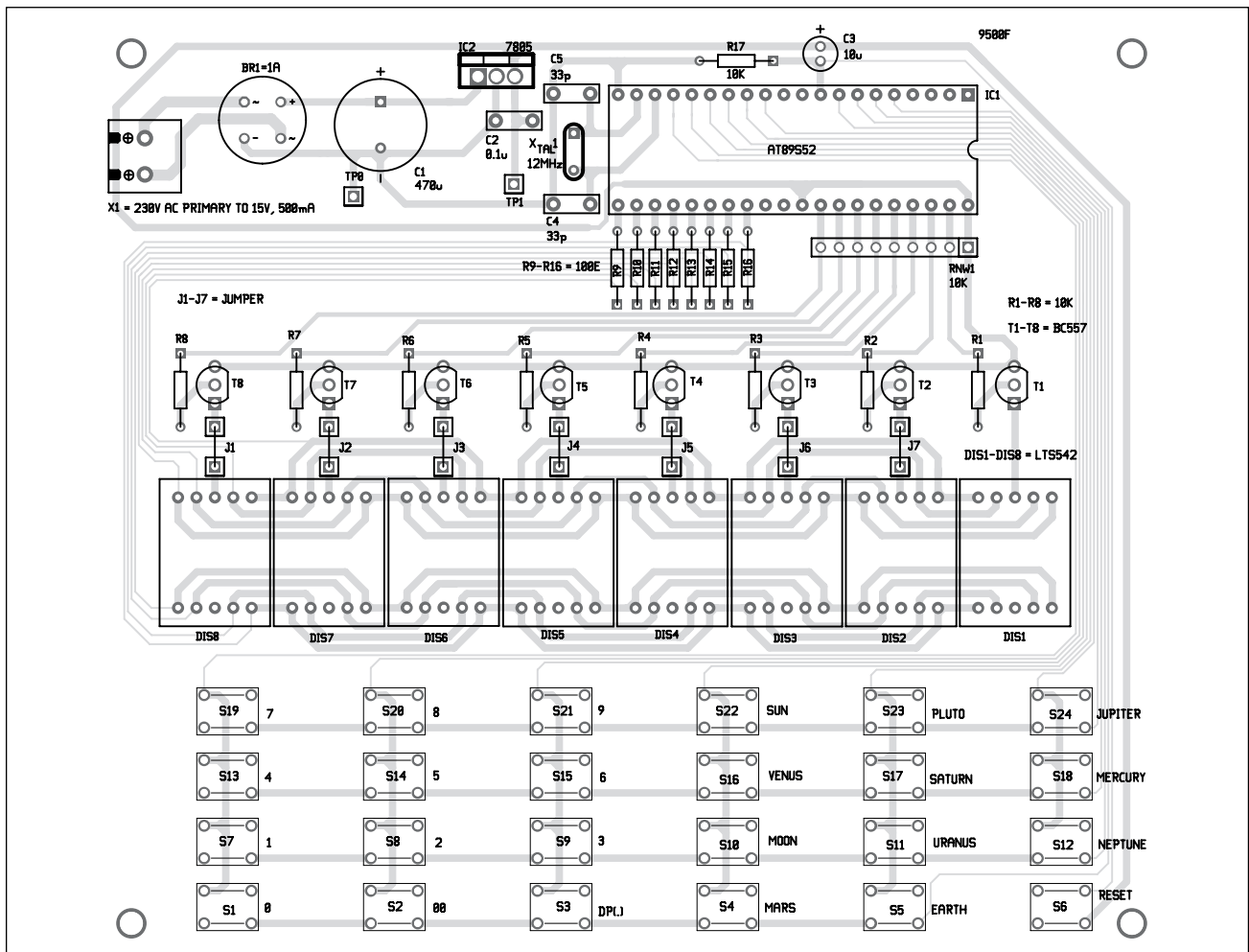


Fig. 4: Component layout for the PCB

into the microcontroller using a suitable programmer. On reset/power-on, the microcontroller executes the main function.

Construction and testing

An actual-size, single-side PCB for the

celestial weigh calculator is shown in Fig. 3 and its component layout in Fig. 4. Assemble the circuit on PCB to save time and minimize assembly errors. Carefully assemble the components and double-check for any overlooked error.

To test the circuit for proper functioning, verify correct 5V supply for the circuit at TP1 with respect to TP0. ●

The author works in the department of Physics, Hemchandracharya North Gujarat University, Patan, Gujarat

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Desktop LED Emergency Light

T.K. HAREENDRAN

You can make an ultra-simple desktop emergency light using 'discharged' batteries. You know that battery cells still have considerable energy left in them even when these become 'weak' for most



Fig. 1: Author's prototype of desktop LED emergency light



Fig. 2: 1W white LED

battery-powered devices. Here is a way to extract their leftover power for use in such applications as

Test Points

Test point	Details
TP0	0V
TP1	1.5V when S1 is on
Across TP2 and TP3	Around 5.1V when AC mains is available

emergency light.

The LED light described here can be powered off any 1.5V or even a drained 1.2V battery cell. Fig. 1 shows author's prototype and Fig. 2 shows the 1W white LED used.

Circuit and working

Fig. 3 shows the circuit diagram of desktop LED emergency light that comprises a combination of a joule thief circuit, a 1W white LED chip and a blackout detector section.

The front end of the circuit is a blackout detector for sensing the presence and absence of the grid power. Here, optocoupler PC817 (IC1) is connected to 230V AC mains supply through capacitor C1, diode D1, and resistors R1, R2 and R3.

PARTS LIST

Semiconductors:

- IC1 - PC817 optocoupler
- T1, T2 - BC548 npn transistor
- D1 - 1N4007 rectifier diode
- ZD1 - 5.1V, 0.5W zener diode

Resistors (all 1/4-watt, $\pm 5\%$ carbon):

- R1 - 470-kilo-ohm
- R2 - 100-ohm
- R3, R4 - 1-kilo-ohm

Capacitors:

- C1 - 100nF, 400V polyester
- C2 - 220 μ F, 16V electrolytic
- C3 - 10nF ceramic disk

Miscellaneous:

- X1 - 10mm ferrite core toroidal transformer
- S1 - On/off switch
- CON1, CON2 - 2-pin terminal connector
- CON3 - 2-pin connector
- 1.5V (used) battery
- 1W white LED

Voltage derived from AC mains is filtered by capacitor C2 and regulated by zener diode ZD1. This circuit section is used to control the switching of the joule thief circuit built around transistor T2, capacitor C3, resistor R4, and inductors L1 and L2. Resistor R4 limits the base current of transistor T2 and capacitor C3 improves the circuit efficacy.

When switch S1 is closed and the battery is connected at CON2 (and AC mains supply is not available), current flows into the base of transistor T2, the voltage across its base and emitter rises and the transistor is switched on. This means that a larger current can now flow through primary winding L1 of transformer X1 and then through the transistor. This collector current generates a magnetic field in the toroidal transformer in a direction opposite to the field created by the base current through its secondary winding L2.

As soon as the primary current becomes greater than the secondary current, the voltage on the secondary winding reverses which, in turn, switches off transistor T2. The magnetic field collapses and white LED is switched on. This allows the 1W white LED to be lit from a single 1.5V/1.2V battery, which otherwise required a 3.2V DC source or more.

Construction and testing

An actual-size, single-side PCB for the emergency light is shown in Fig. 4 and its component layout in Fig. 5. After assembling the circuit on PCB, enclose it in a suitable plastic box. When 230V AC

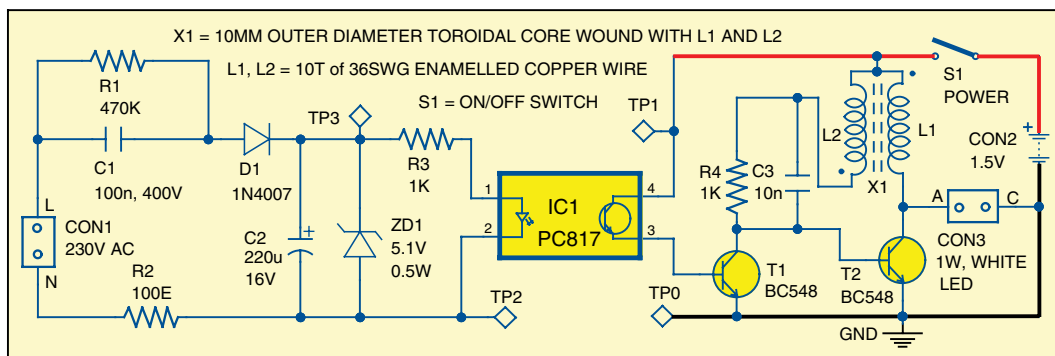


Fig. 3: Circuit diagram of the emergency light

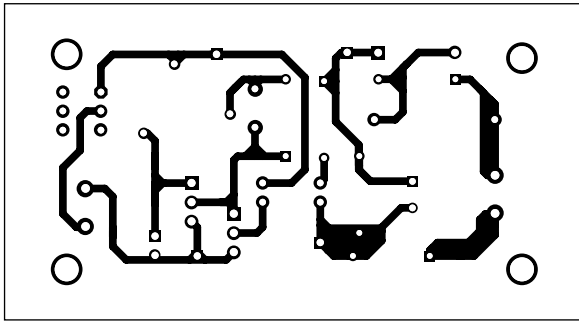


Fig. 4: An actual-size, single-side PCB for the circuit

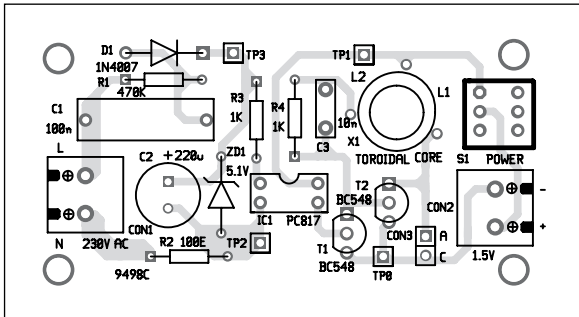


Fig. 5: Component layout for the PCB

mains supply is available, white LED is off—irrespective of the position of

dots in the circuit. Now join nearest ends of the coils together, as shown in

switch S1. When AC mains supply is off, switch S1 should be closed to make white LED glow and opened to switch it off.

For the winding on toroidal core, take a small toroidal core (for example, one with 10mm outer dia and 5mm height). Wrap a 36SWG enamelled copper wire around the toroidal core to make 10 turns. Repeat the winding with the second piece of 36SWG enamelled copper wire. The two windings (L1 and L2) should be in opposite directions. The polarities of the windings are shown by the

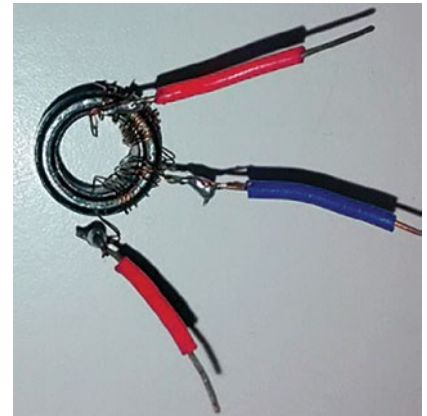


Fig. 6: Toroidal coil winding

Fig. 6. This forms the centre pole which is connected to positive terminal of the battery. Before using the circuit, verify the voltages are as per table.

Caution: The circuit operates off live 230V AC mains, so take all the necessary safety precautions while building and using this circuit to avoid any nasty electric shock. ●

The author is a freelance writer and circuits designer



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Simple Interface for Digital Sound Synthesis



PETRE TZV PETROV

You can make a digital sound synthesizer, for experimentation with sound equipment or with peripheral devices, using special integrated circuits or digital-to-analogue converters (DACs). But here is a simple 8-input digital sound-synthesis circuit for producing audio from digital codes that can be easily interfaced with microcontroller or microprocessor boards having up to eight TTL/CMOS-level digital output pins.

Circuit and working

Fig. 1 shows circuit diagram of the simple interface for digital sound synthesis. It is built around low-power audio amplifier LM386 (IC1), 9V voltage regulator 7809 (IC2) and a bridge rectifier (BR1).

The 8-bit digital code (representing audio signal) input is applied at connector CON4. Resistors R1 through R8 and potmeter VR1 work as a simple DAC circuit. The relationships to get approximate values of resistors in the DAC are:

$$R1 = 2R2 = 4R3 = 8R4 = 16R5 = 32R6 = 64R7 = 128R8$$

Value of VR1 can be from 10% of R8 to 20% of R8.

The minimum value of each resistor (R1 through R8) depends on digital output levels. Capacitors C14 and C15, with switches S1 and S2 closed, filter the sound signals, and can be omitted, if not needed.

The audio input is amplified by LM386 low-power amplifier. The gain is set to 200. With 9V power supply,

Test Points

Test point	Details
TP0	0V
TP1	12V to 18V DC
TP2	9V DC

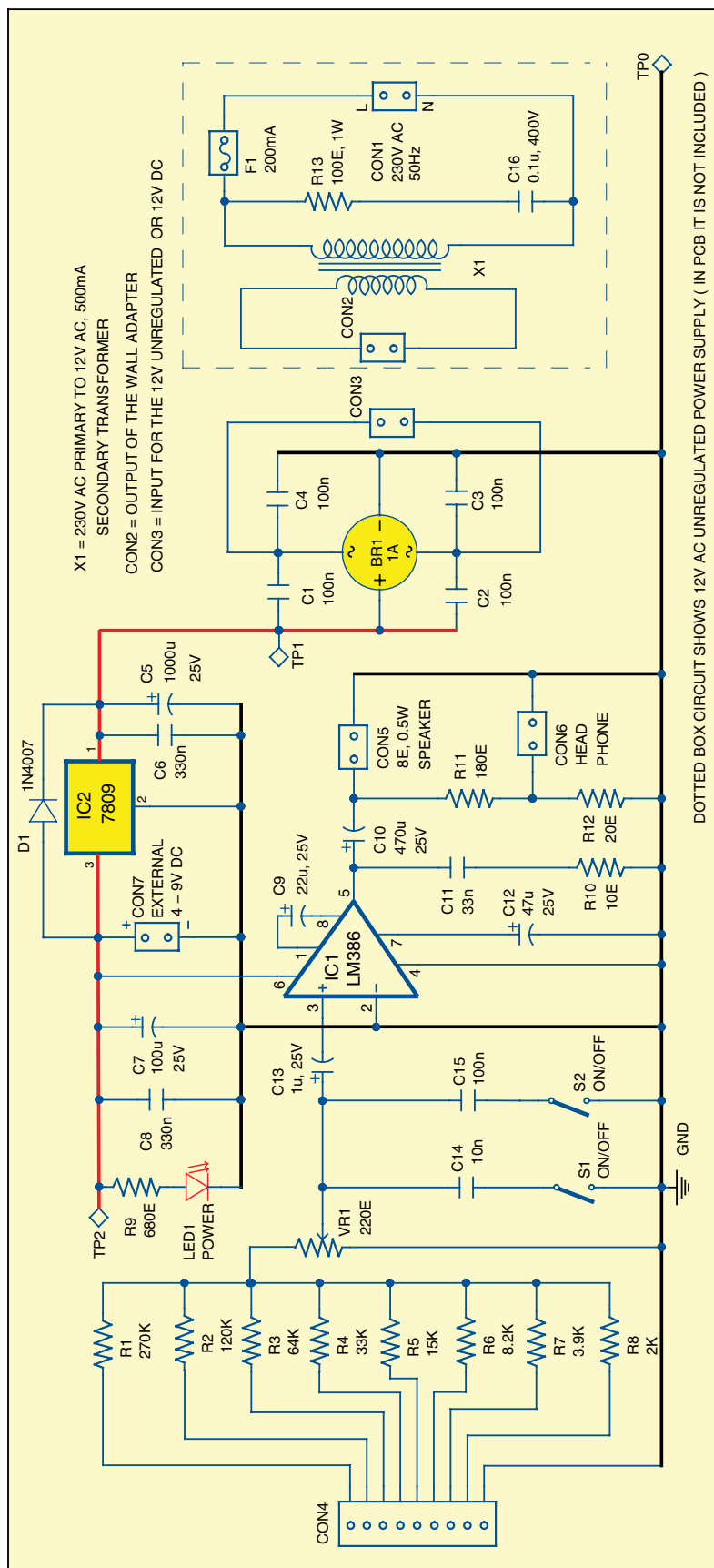


Fig. 1: Simple interface for digital sound synthesis

PARTS LIST*Semiconductors:*

IC1	- LM386 low-power audio amplifier
IC2	- LM7809, 9V voltage regulator
LED1	- 5mm LED
BR1	- 1A bridge rectifier module
D1	- 1N4007 rectifier diode

Resistors (all 1/4-watt, $\pm 5\%$ carbon, unless stated otherwise):

R1	- 270-kilo-ohm
R2	- 120-kilo-ohm
R3	- 64-kilo-ohm
R4	- 33-kilo-ohm
R5	- 15-kilo-ohm
R6	- 8.2-kilo-ohm
R7	- 3.9-kilo-ohm
R8	- 2-kilo-ohm
R9	- 680-ohm
R10	- 10-ohm
R11	- 180-ohm
R12	- 20-ohm
R13	- 100-ohm, 1W
VR1	- 220-ohm potmeter

Capacitors:

C1-C4, C15	- 100nF ceramic disk
C5	- 1000 μ F, 25V electrolytic
C6, C8	- 330nF ceramic disk
C7	- 100 μ F, 25V electrolytic
C9	- 22 μ F, 25V electrolytic
C10	- 470 μ F, 25V electrolytic
C11	- 33nF ceramic disk
C12	- 47 μ F, 25V electrolytic
C13	- 1 μ F, 25V electrolytic
C14	- 10nF ceramic disk
C16	- 0.1 μ F, 400V polyester

Miscellaneous:

S1, S2	- On/off switch
CON1, CON3	- 2-pin terminal connector
CON4	- 9-pin connector
CON2, CON5-CON7	- 2-pin connector
X1	- 230V AC primary to 12V AC, 500mA secondary transformer
F1	- 200mA fuse

the circuit outputs around 0.5W. The loudspeaker can be 4-ohm, but 8-ohm or higher is preferred to avoid overloading LM386.

The power supply is built around voltage regulator 7809 which gives a

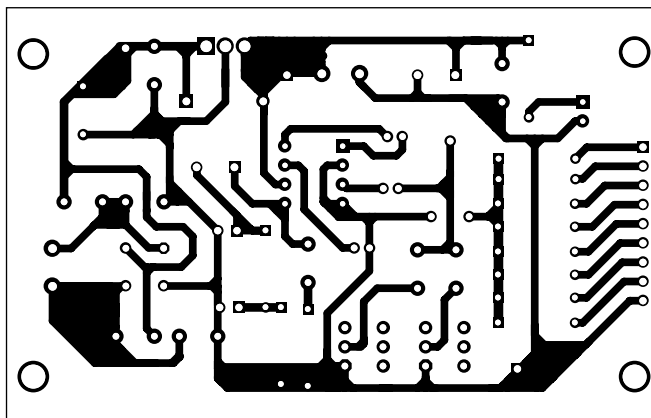


Fig. 2: An actual-size PCB layout for the circuit

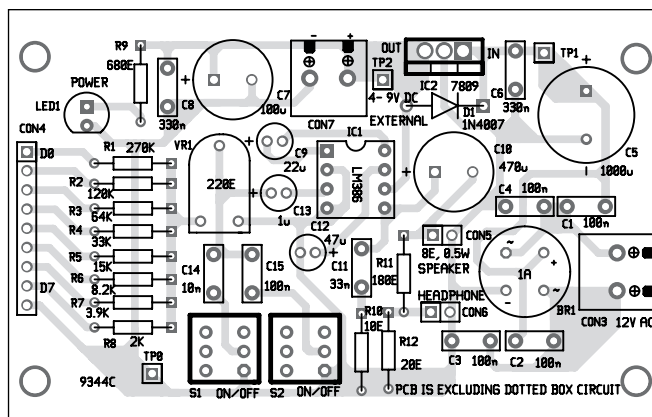


Fig. 3: Component layout for the PCB

9V regulated output. You can use 4-9V DC as external supply at CON7 input when 230V AC mains is not available.

Diode D1 is used for reverse protection of the regulator.

Construction and testing

An actual-size, single-side PCB for simple interface for digital sound synthesis (excluding the dotted box shown in the circuit) is shown in Fig. 2 and its component layout in Fig. 3.

After assembling the circuit on a PCB, enclose it in a suitable plastic box.

For testing, generate 1kHz square-wave signal and connect it to any input line of CON4 (D0 through D7). You will hear sound in the speaker connected at CON5.

You can write a simple software code, burn it into the microcontroller, connect its port pins to CON4 and check output from the speaker. You may change the code to various audio frequencies and check the output for experimentation.

You can also use this circuit as a simple audio signal mixer by applying the audio signals (including square-wave signals) at inputs D0 through D8.

Before using the circuit, do verify that voltages at test points are as per table. ●

The author was a researcher and assistant professor in Technical University of Sofia (Bulgaria) and expert-lecturer in OFPPT (Casablanca), Kingdom of Morocco. Now he is working as an electronics engineer in the private sector Bulgaria

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Tester for 555 Timer and 741 Op-amp ICs

PANKAJ A. RAUT

Sometimes you do not get proper output from a circuit due to faulty ICs. This circuit can test timer 555 and op-amp 741 ICs, which are commonly used in projects, to save you from this problem.

Circuit and working

Fig. 1 shows circuit diagram of the tester which is built around the very 555 timer (IC1) and the op-amp 741 (IC2) that are to be tested. IC1 is wired as astable multivibrator with output

frequency of around 1Hz. Resistors R1 and R2 and capacitor C1 are the timing components that decide output frequency. You can change 1Hz frequency by changing values of these components.

The 555 tester section is basically an LED flasher circuit. Square-wave output at pin 3 of IC1 drives LED1 and LED2 which glow alternately. That is, when pin 3 is low, LED1 glows and when pin 3 is high, LED2 glows. This indicates that the 555 timer under test is in good condition. If the 555 is faulty, both the LEDs may

remain off or glow dimly, or one or both of them may glow continuously.



PARTS LIST

Semiconductors:

- IC1 - 555 timer
- IC2 - 741 op-amp
- LED1-LED3 - 5mm LED

Resistors (all 1/4-watt, $\pm 5\%$ carbon):

- R1 - 68-kilo-ohm
- R2 - 39-kilo-ohm
- R3, R4, R7 - 1.2-kilo-ohm
- R5, R6 - 4.7-kilo-ohm

Capacitors:

- C1 - 10 μ F, 25V electrolytic
- C2 - 10nF ceramic disk

Miscellaneous:

- BATT.1 - 9V battery
- CON1 - 2-pin connector
- S1, S2 - On/off switch
- ZIF1, ZIF2 - 8-pin ZIF socket
- 2-pin terminal connector

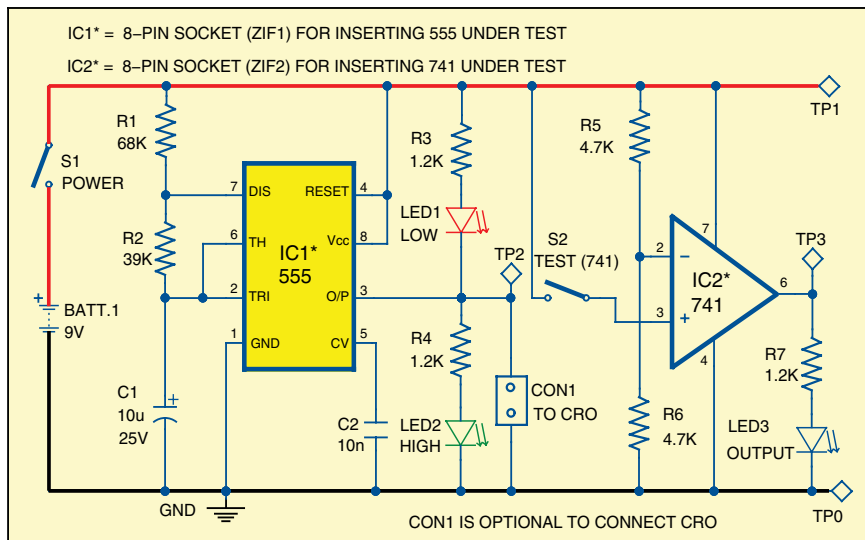


Fig. 1: Circuit diagram of 555 and 741 ICs tester

Test Points

Test point	Details
TP0	0V
Across TP0 and TP1	9V when switch S1 is closed
Across TP0 and TP2	Around 1Hz
Across TP0 and TP3	Around 8V when switch S2 is closed

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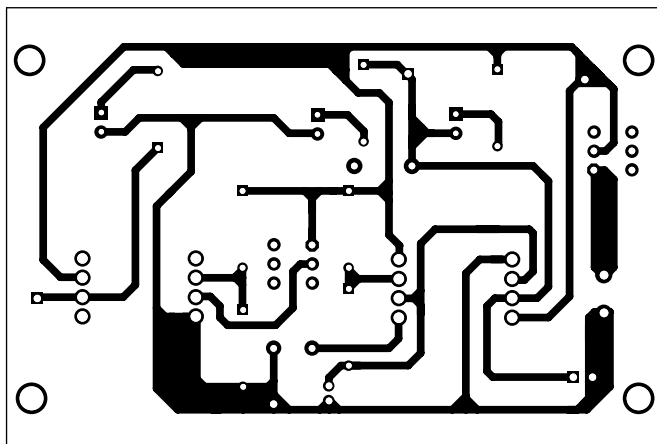


Fig. 2: An actual-size PCB for the testing circuit

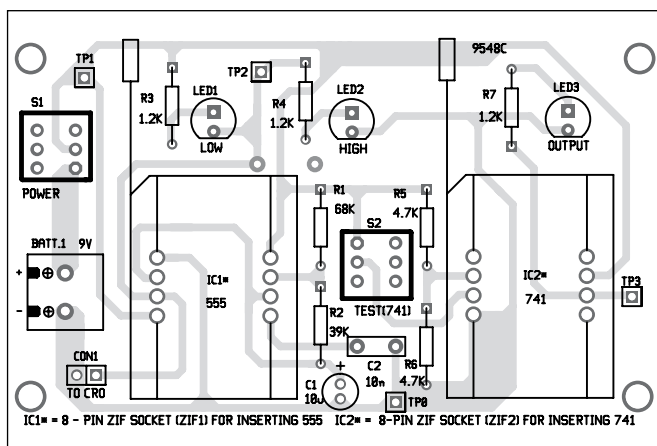


Fig. 3: Component layout for the PCB

Between pin 5 of IC1 and ground a 10nF ceramic capacitor (C2) is used to filter out any noise.

The 741 tester section is wired in a simple comparator mode. Around half of the supply voltage is produced through divider circuit comprising resistors R5 and R6 at inverting input pin 2 of IC2.

For testing 741, close switch S2, if LED3 glows properly the 741 is in good condition.

Construction and testing

An actual-size, single-side PCB for the 555 and 741 ICs testing circuit is shown in Fig. 2 and its component layout in Fig. 3. After assembling the circuit on a PCB, enclose it in a suitable plastic box. Solder two 8-pin ZIF sockets ZIF1 and ZIF2 on the PCB for 555 timer and 741 op-amp, respectively.

During testing, both the ICs should be inserted in their respective sockets. You can check frequency output of IC1 by connecting an oscilloscope's probes to CON1 in the PCB. In case of any problem, verify that voltages at test points are as per table. ●

The author is a B.Tech student (electronics and communication) of Jawaharlal Nehru Technological University, Hyderabad

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Lithium-Ion Battery Charger

EFY LAB

Like most people, you probably have some discarded devices like MP3 players and cell phones lying around that use lithium-ion batteries for power supply. Usually their electronics cannot be used for any other purpose, but their batteries can still be used, even for toys. Since electronics hobbyists tend to be an inventive lot, they will usually find a way to incorporate and recycle a battery. However, you need to charge these batteries.

Some original equipment includes charger circuit for the battery, most likely on a small part of the PCB. It is difficult to figure out which components form part of the charger circuit since no circuit diagram is normally available. In that case, we have to build our own lithium-ion charger as explained in this article.

Circuit and working

The charger circuit described here is built around lithium-ion charger IC MAX8677A (Fig. 1). This IC works completely autonomously, so there

is no need of a microcontroller (and hence no software). LEDs are used by the IC to indicate state of the charging process.

MAX8677A is very flexible and has three electronic switches to control the charge and load currents according to the situation. With an external power source, the IC can use the available power to both charge the battery and supply the load. If the load requires more power than the charger can deliver, MAX8677A can make the battery provide the extra current. When there is no external power source available, the load is powered solely by the battery.

The IC can be powered from a USB port via pins 15 and 16 (USB). In that case, the current drawn is limited to 500mA (the maximum for a USB 2.0 port). USB port pins are connected to ground if not used. The IC can also be powered from an adaptor via pins 2 and 3 (DC), where the current limit can be increased up to a maximum of 2A.

For the charger circuit, you can use the DC input, which gives us greater flexibility in setting various limits. Op-

erating voltage at the input is between 4.1V and 6.6V. If the voltage becomes too high, MAX8677A turns off the input to prevent it from overheating. The IC can survive voltage spikes up to a maximum of 14V. The charging status is indicated by the LEDs: the battery is being charged (LED3), the battery is fully charged (LED1), the battery is faulty (LED2).

Maximum charge current and maximum input current can be set with this IC; the second value should always be larger than the first. If this is not the case, the programmed maximum charge current can never be reached, as it cannot go higher than the maximum input current. Both these limits are set using a resistor.

Maximum charge current:

$$ICHGMAX = 3000 / R_{ISET} = 3000 / R_9 = 3000 / 5.6k\Omega = 535mA$$

Maximum input current:

$$IDCMAX = 3000 / R_{PSET} = 3000 / R_6 = 3000 / 3.3k\Omega = 909mA$$

PARTS LIST

Semiconductors:

- IC1 - MAX8677A charger
- LED1-LED3 - 5mm LED

Resistors (all 1/4-watt, $\pm 5\%$ carbon):

- R1, R2, R5 - 4.7-kilo-ohm
- R3, R4 - 560-kilo-ohm
- R6 - 3.3-kilo-ohm
- R7, R8 - 10-kilo-ohm
- R9 - 5.6-kilo-ohm

Capacitors:

- C1, C3 - 4.7 μ F, 16V electrolytic
- C2 - 0.1 μ F ceramic disk
- C4 - 0.068 μ F ceramic disk

Miscellaneous:

- CON1 - Mini USB connector
- CON2 - 2-pin terminal connector
- CON3, CON4 - 2-pin connector
- F1 - 500mA fuse
- 3.7V Li-ion battery

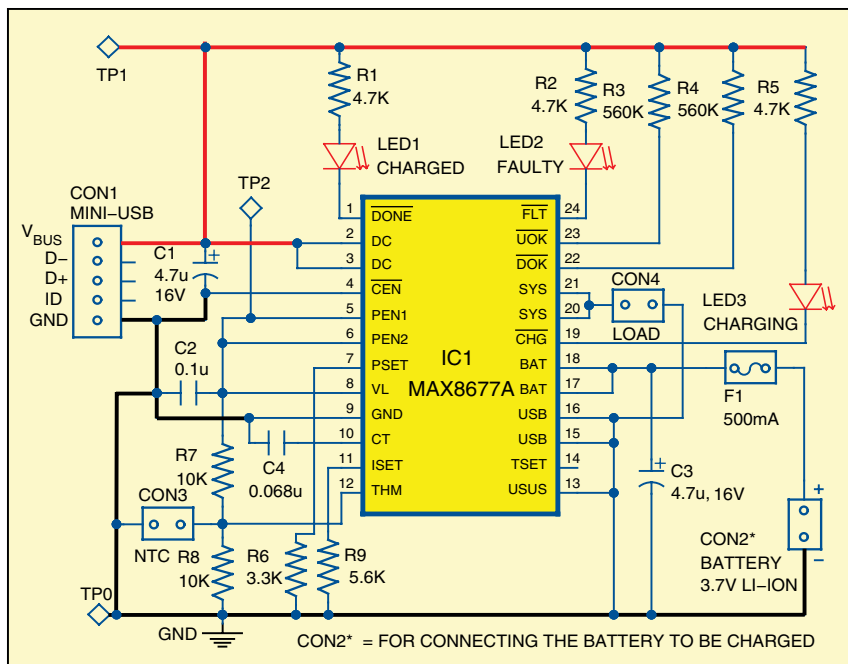


Fig. 1: Circuit diagram of the lithium-ion battery charger

Test Points

Test point	Details
TP0	0V
TP1	5V
TP2	3.3V

You can obviously select more suitable values depending on the power rating of the adaptor, the power consumption of the device and the desired load current. You can use a mini USB connector, which makes it easy to power the circuit with contemporary mains adaptors. This also ensures that we are using a 5V supply. The maximum input current should be adjusted according to the rating of the adaptor.

You can use an NTC thermistor at CON3. Batteries are often provided with a negative temperature coefficient (NTC) thermistor, which is used to prevent them from being charged at too high or too low temperatures. The lithium-ion battery therefore has three connections: a positive terminal (BAT+), a negative terminal (BAT-) and a connection for the NTC thermistor. Note that, some batteries with three connections have only a normal resistor inside, for identification. The value of the normal resistor will be constant and will not vary with temperature of the battery.

When an NTC thermistor is used, it should be connected between THM pin and ground (via BAT- connection). A resistor (R7) is also connected between THM pin and a reference voltage (VL), which creates a potential divider. The value of the resistor is chosen such that it has the same value as the NTC thermistor at a temperature of +25°C.

The voltage at THM pin at +25°C will be equal to 0.5 VL. When the temperature rises or falls, resistance of the thermistor falls or rises, as does the voltage at THM pin. The device will charge only when this voltage is between 0.28 VL and 0.74 VL. With contemporary NTC thermistors, this corresponds to a temperature between 0°C and 50°C. When no NTC

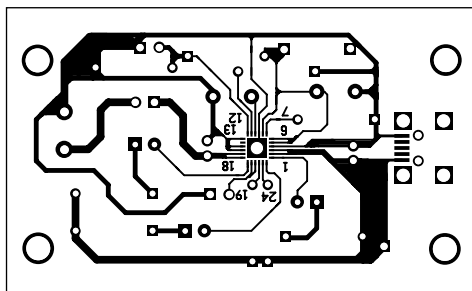


Fig. 2: Actual-size PCB layout for the battery charger

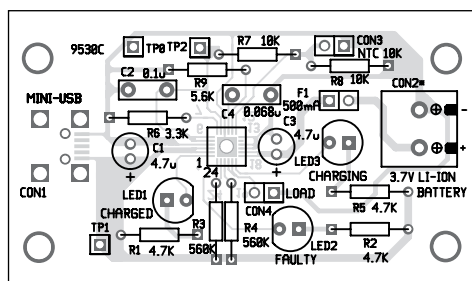


Fig. 3: Components layout of the PCB

thermistor is available, you should add R8, which causes the voltage at THM pin to be 0.5 VL. Remove R8 when NTC is available. CON4 is used for the system (load). A simple fuse (F1) offers sufficient protection from overloading.

Construction and testing

An actual-size, single-side PCB for the lithium-ion battery charger circuit is shown in Fig. 2 and its component layout in Fig. 3. After assembling the circuit on PCB, enclose it in a suitable plastic box. To mount SMDs you need some dexterity and soldering experience. For the TQFN-packaged MAX8677A, you should ideally use a reflow oven, since the pins and the exposed pad are on underside of the 4mm×4mm package. However, you can also solder the device by hand.

You need to make good electrical and thermal connections between the

exposed pad of the chip and the ground plane on the PCB. Mounting MAX8677A with a hot-air soldering iron is possible if you are experienced enough, though a reflow oven makes life much easier. The method described below explains how to use an ordinary soldering iron to mount the device.

Before etching the board, make sure that you make a 1.5mm dia hole in the PCB for connecting the exposed pad of the IC to the ground rail as well as providing thermal management solution to the chip. So the sequence of action for mounting the chip on the PCB should be as follows:

1. Drill a 1.5mm hole in the centre of the exposed pad
2. Position the chip on the PCB
3. Solder all contacts along the four sides of the chip. Use de-soldering litz wire to tidy everything up
4. Turn over the board and drop a few pieces of solder into the hole
5. Insert a solid copper wire into the 1.5mm hole and give a slight push to it till the wire touches the exposed pad. Heat the pad around the wire with soldering iron till the solder melts. When the copper wire makes proper contact with the exposed pad of the chip, trim the wire with a cutter and use a file to make the protruding end flat

6. Connect the extended exposed pad to the ground plane on solder side of the PCB

You will now have a good electrical and thermal connection between the exposed pad of the chip and the ground plane. Your lithium-ion battery charger is ready for use.

Note. This circuit is based on Maxim application notes. ●



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Surveillance Using Raspberry Pi Camera

ABHIJEET RAI

This surveillance system detects motion of any object within its camera's range, captures the image and stores it in Raspberry Pi. You can retrieve images from Rasp-



Fig. 1: Raspberry Pi and the camera

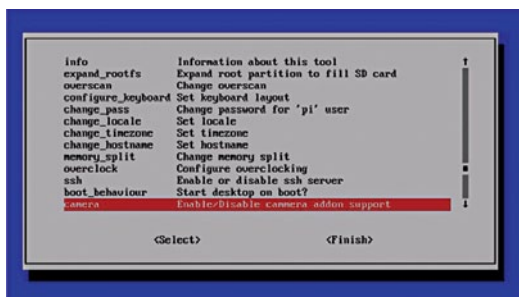


Fig. 2: Enabling the camera

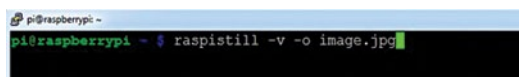


Fig. 3: Capturing an image

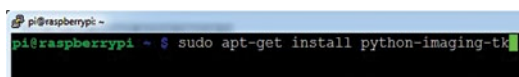


Fig. 4: Installing Python script

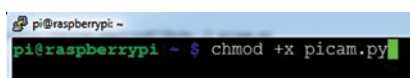


Fig. 5: Making the script executable

berry Pi any time.

Since Raspberry Pi camera is static-sensitive, take good grounding measures before you touch it. Connect the camera as shown in Fig. 1.

Installation of camera

Open Raspi config utility using the command:

```
$ sudo raspi-config
```

Now, enable the camera as shown in Fig. 2.

If your firmware is old, you need to update and upgrade it using the command mentioned below to see the camera enable option:

```
$ sudo apt-get update
```

```
$ sudo apt-get upgrade
```

After enabling and connecting the camera to Raspberry Pi, use following commands to check if it is working well. The first command is `raspistill`, which is used to take still pictures. For example, if you want to capture an image, type the following command (also see Fig. 3):

```
$ raspistill -v -o image.jpg
```

If red LED of the Raspberry Pi camera glows for some time, it shows that the image has been recorded. You may check the image under Home folder in Raspberry Pi to ensure that the camera is properly installed.

Capturing motion

We have two methods for motion detection. First method uses the light-weight motion detection Python script while the second method uses 'motion' software to detect motion and capture images.



Method 1: Using Python script.

Python script depends on Python Imaging Library, which is meant for analysing and manipulating images. So we have to install the library using the following command (also see Fig. 4):

```
$ sudo apt-get install python-imaging-tk
```

We can get the script from the link mentioned below:

<https://github.com/skl/raspberry-pi-cam/archive/master.zip>

Make the script executable by using the command (also see Fig. 5):

```
$ chmod +x picam.py
```

The script is designed to store images in a directory named `picam` under Home directory, so create it as shown below before executing the script:

```
$ mkdir ~/picam
```

We shall be ready to run the script after giving the following command:

```
$ ./picam.py
```

The script will turn on red LED of the Raspberry Pi camera and start taking low-resolution images. It will then compare them and look for movement by comparing the pixels in the images. If it detects any changes in the pixels, the script will capture a higher-resolution image.

The script is written in such a way that it stores only high-resolution images. All these images are saved in the `~/picam` folder which we had created. Note that, if the camera is placed in a windy area then set the threshold variable in config file to a higher value than the default.

For running the script during booting, we need an init script that runs the `picam.py` script and kills it before shutting down the Raspberry Pi. To get the script, issue the command given below:

```
$ wget http://pastebin.com/AfqbjQrb -O picam_init
```

Move the script into its correct

location using the command (also see Fig. 6):

```
$ sudo mv ~/picam_init /etc/init.d/picam
```

Next make the script executable using the command (also see Fig. 7):

```
$ sudo chmod +x /etc/init.d/picam
```

To make the script start during booting, type the command given below (also see Fig. 8):

```
pi@raspberrypi ~$ sudo mv ~/picam_init /etc/init.d/picam
```

Fig. 6: Moving the script to desired location

```
pi@raspberrypi ~$ sudo chmod +x /etc/init.d/picam
```

Fig. 7: Making the script executable

```
pi@raspberrypi ~$ sudo update-rc.d picam defaults
```

Fig. 8: Making the script start at boot time

```
pi@raspberrypi ~$ sudo apt-get install motion
```

Fig. 9: Installing motion software

```
pi@raspberrypi ~$ sudo apt-get install -y libjpeg62 libjpeg62-dev libavformat53 libavformat-dev libavcodec53 libavcodec-dev libavutil51 libavutil-dev libc6-dev zlib1g-dev libmysqlclient18 libmysqlclient-dev libpq5 libpq-dev
```

Fig. 10: Installing all the dependencies

```
pi@raspberrypi ~$ tar -zxvf motion-mmml.tar.gz
```

Fig. 11: Extracting the folder

```
pi@raspberrypi ~$ ./motion -n -c motion-mmmlcam.conf
```

Fig. 12: Running the motion application

```
$ sudo update-rc.d picam default
```

The script will now start and shut down along with the Raspberry Pi. We can also control it manually. That is, to stop the script, use the command:

```
/etc/init.d/picam stop
```

To start the script, use the command:

```
/etc/init.d/picam start
```

Method 2: Using motion software.

To install motion software, use the command below (also see Fig. 9):

```
$ sudo apt-get install motion
```

The standard motion packages do not yet work with Raspberry Pi camera. For that we have to install the special binary code known as motion-

mmal. So install following dependencies (also see Fig. 10):

```
$ sudo apt-get install -y libjpeg62 libjpeg62-dev libavformat53 libavformat-dev libavcodec53 libavcodec-dev libavutil51 libavutil-dev libc6-dev zlib1g-dev libmysqlclient18 libmysqlclient-dev libpq5 libpq-dev
```

After installing all the dependencies, download motion software from the link:

<https://www.dropbox.com/s/xdfoxcm5hu7ls97d/motion-mmml.tar.gz>

Extract it using the command (also see Fig. 11):

```
tar -zxvf motion-mmml.tar.gz
```

This will extract the motion application as well as a configuration file. Run the extracted motion application along with its configuration file using the command (also see Fig. 12):

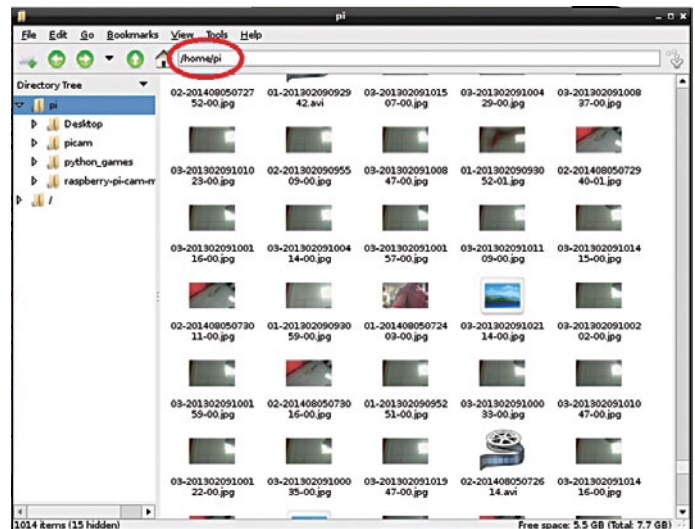


Fig. 14: Captured images stored in Raspberry Pi

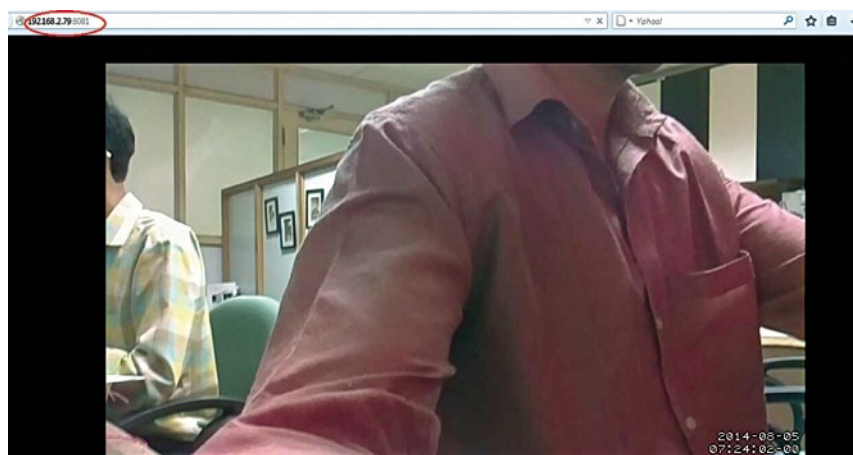


Fig. 13: Streaming video

```
./motion -n -c motion-mmmlcam.conf
```

While motion application is running, open the browser and type the IP address of your Raspberry Pi with the 8081 port (for example, 192.128.2.79:8081), as shown in Fig. 13, to see the live streaming video.

When camera detects the motion it will also capture the image and store it in Raspberry Pi Home folder, as shown in Fig. 14. ●

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Web Server Setup for WordPress on Raspberry Pi

POOJA JUYAL

WordPress is a PHP and MySQL based open source blogging platform and content management system. It is a popular blogging system and includes features like threaded comments, galleries, revision histories, trash, custom post types, thousands of themes, widgets and plug-ins. This article describes the setting up of a web server for WordPress on Raspberry Pi.

Apache web server installation

Apache, a web server application notable for playing a key role in the initial growth of the World Wide Web, is used to serve web pages. Follow the procedure given below to install it on Raspberry Pi.

1. Install apache2 package by executing the following command (also

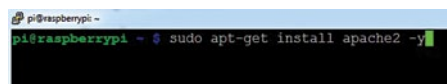


Fig. 1: Installing apache2 package

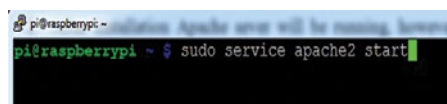


Fig. 2: Starting Apache server

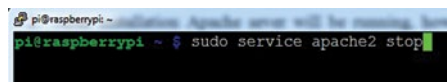


Fig. 3: Stopping Apache server



Fig. 4: Browser default HTML page



Fig. 5: Installation of all PHP packages

see Fig. 1):

```
$ sudo apt-get install apache2 -y
```

2. After this installation, Apache sever will be running. Thereafter you can start or stop it by running the following commands (also see Figs 2 and 3):

```
$ sudo service apache2 start
```

```
$ sudo service apache2 stop
```

3. Apache server by default creates a test HTML file in web folder. This can be served when `http://localhost/` is browsed on the Raspberry Pi or `http://192.168.2.104` (IP address of the Raspberry Pi in our case, but can be different in your case) from any other computer on the network.

Browse the default web page and you will see the message shown in Fig. 4 appear on the screen.

4. Change the default web page as per your requirement. The default web page is an HTML file on the file system and is located at `/var/www/index.html`. Execute the following command on terminal to navigate and have a look on the file:

```
$ cd /var/www
$ ls -al
```

You will see the following:

```
total 12
drwxr-xr-x 2 root root 4096 Mar 2
03:15 .
drwxr-xr-x 12 root root 4096 Mar 2
03:15 ..
-rw-r--r-- 1 root root 177 Mar 2
03:16 index.html
```

This shows that there is one file called `index.html` in `/var/www/`. The `''` (dot) at the end of line 2 refers to the directory itself `/var/www/` and the `..'` at the end of line 3 refers to the parent directory `/var/`.



Meaning of each column in the previous file is:

1. File or directory permissions
2. Number of files in the directory (1 in case of a file)
3. User who owns directory or file
4. Group which owns the directory or file
5. File size
6. Date and time of last modification

In order to edit the directory and file, you should log in as root user. Edit the `index.html` file using either of the following commands.

```
$ sudo chown pi: index.html
$ sudo nano index.html
```

Try editing/changing this file and refreshing the browser to see the web page changes.

Next step is to install PHP and MySQL, which are used to create your own site and publish your own content dynamically, without knowing how to program those pages.

PHP installation

Install PHP by executing the following command (also see Fig. 5):

```
$ sudo apt-get install php5 libap
ache-mod-php5 php5-intl php5-mcrypt
php5-curl php5-sqlite
```

To check whether PHP has been installed properly, move `index.html` file to `index.php` using following command (also see Fig. 6):

```
$ sudo mv index.html index.php
```

Now edit the file:

```
$ sudo nano index.php
```

Put following text in `index.php` after opening the nano editor:

```
<?php echo "hello world";
```

Save and then refresh the browser. You should see 'hello world' on your

browser. This is served by the PHP and is not dynamic. So let us try something dynamic like displaying date and time by giving following command:

```
<?php echo date('Y-m-d H:i:s');
```

Or you can show the PHP info by giving following command:

```
<?php phpinfo();
```

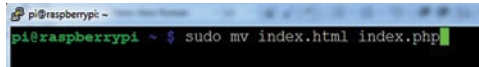


Fig. 6: Moving index.html file to index.php file

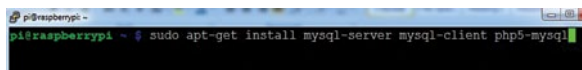


Fig. 7: Installing MySQL



Fig. 8: The wp-config.php file page

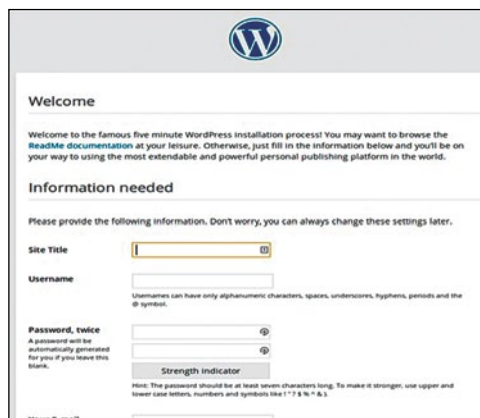


Fig. 9: Welcome screen on WordPress

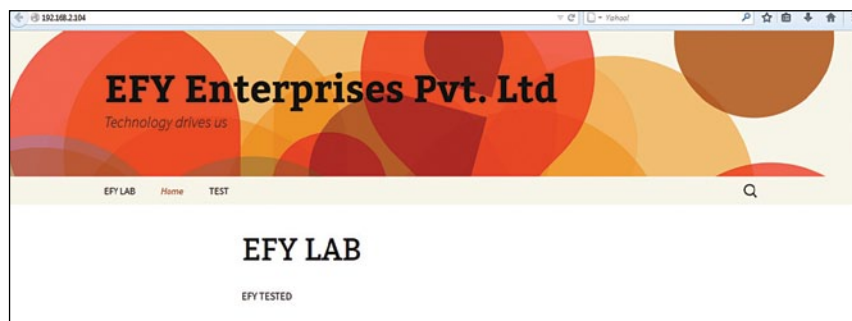


Fig. 10: WordPress hosted on Raspberry Pi

Installing MySQL database management system

Execute the following command to install MSQL (also see Fig. 7):

```
$ sudo apt-get install mysql-server mysql-client php5-mysql
```

Enter the password of your choice for the top-level MySQL user, who will be managing MySQL but is not root user of the Raspberry Pi operating system. Stop and start the apache2 server.

WordPress download

Download WordPress by running *wget* command on the terminal. You can find the latest version at wordpress.org/latest.tar.gz and wordpress.org/latest.zip

Download the WordPress to `/var/www/` location. You will have to empty the folder first. Now change the ownership of this folder to the Pi user using following command:

```
$ cd /var/www
$ chown pi:
$ rm *
$ wget http://wordpress.org/latest.tar.gz
```

Or you can download it directly from the link mentioned below:

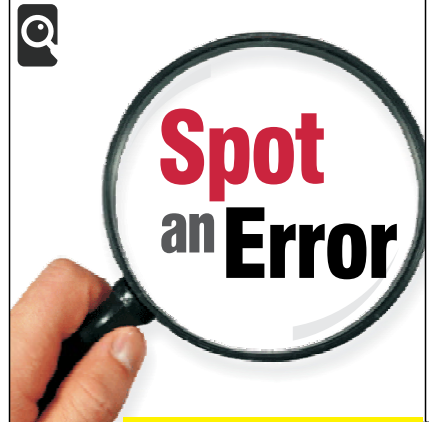
```
http://wordpress.org/latest.tar.gz
```

Extract the tarball using following command:

```
$ tar xzf wordpress-3.9.1.tar.gz
```

Move the contents of folder to the current directory.

```
$ sudo mv wordpress/*
```



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Remove the folder (which is now empty) and tarball to tidy up.

```
$ sudo rm -rf wordpress-3.9.1.tar.gz
```

To see the content of the WordPress project, run the `ls` or `tree-L1` command. You will see the project as given below. It is the source of a default WordPress installation.

```
— index.php
— license.txt
— readme.html
— wp-activate.php
— wp-admin
— wp-blog-header.php
— wp-comments-post.php
```

```
— wp-config-sample.php
— wp-content
— wp-cron.php
— wp-includes
— wp-links-opml.php
— wp-load.php
— wp-login.php
— wp-mail.php
— wp-settings.php
— wp-signup.php
— wp-trackback.php
— xmlrpc.php
```

The files for editing to customise installation is in the 'wp-content' folder.

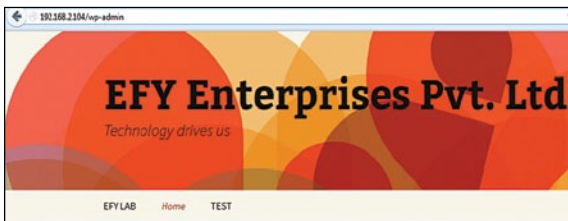


Fig. 11: Entering IP address for making changes

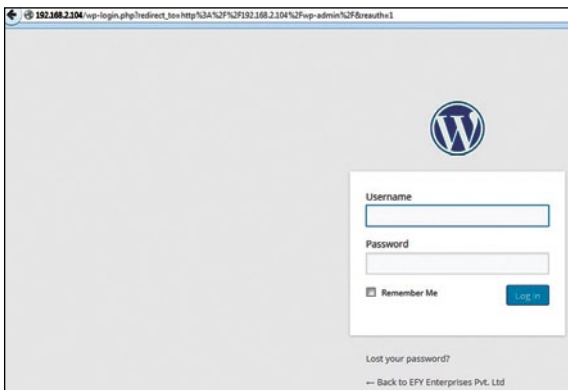


Fig. 12: Entering username and password

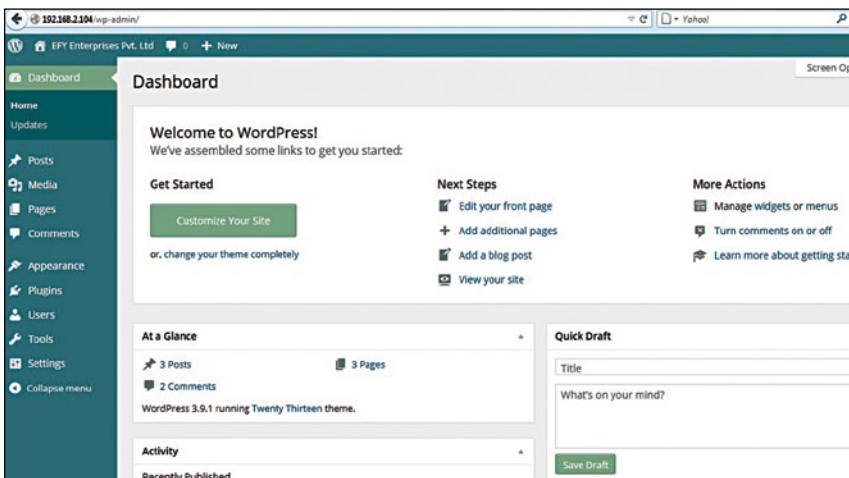


Fig. 13: Admin page to make changes on your web page

statement. After creating the database, you should see the following message:

```
Query OK, 1 row affected (0.00 sec)
```

Exit MySQL using Ctrl + D keys.

WordPress configuration

To access the Raspberry Pi in the browser, navigate to `http://192.168.2.104` (IP address of your Raspberry Pi). In case you do not know the IP, check it by running the command `hostname -I` on the terminal.

You should see the error page; this is good! Click the button marked as 'Create a Configuration File' followed by 'Let's go!' button on the next page.

Now, fill basic site information as mentioned below:

```
Database Name: wordpress
User Name: root
Password: <YOUR PASSWORD>
Database Host: localhost
Table Prefix: wp_
```

Upon successful database connection, you will get the contents of your `wp-config.php` file as shown in Fig. 8.

Copy this text. Then return to the Pi terminal and open the nano editor by running the command `nano wp-config.php`. Paste the copied text into the blank `wp-config.php` file. Save this file and exit the nano editor. Then come back to Fig. 8 and hit 'Run the install' button.

You should see a 'Welcome' screen as shown in Fig. 9. Fill in the required information shown in this window.

Now, you will get your web page on the screen. The web page with customised theme is shown in Fig. 10.

If you want to do some changes in your web page, write the IP address on the address bar as given below (also shown in Fig. 11):

```
192.168.2.104/wp-admin
```

A window will open on the screen for entering your username and password as shown in Fig. 12. Fill the information, give a title to your site and create username and password.

You can make changes in your web page from the admin web page as shown in Fig. 13. ●

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Face Counter Using MATLAB



VIVEK PANCHABHAIYA

This program helps count the number of persons present in a meeting hall or classroom at a time. The program logic can also be used in other applications, such as automatic temperature control which depends on the number of persons in a room. Video camera plays a very important role in this project.

If you try to count a large number of people in a hall, you may take time to count them and probably also make a mistake. With the help of this program, you can get the number of people instantly and more accurately using a camera and image processing.

Software program

A graphic user interface (GUI) allows users to perform tasks interactively through such controls as switches and sliders. You can create GUI and run it in MATLAB or as standalone application. The initial program output of this project is shown in Fig. 1 and its output after face detection is shown in Fig. 2.

Face detection algorithm.

There are different types of algorithms used in face detection. Here, we used Viola-Jones algorithm for face detection with MATLAB program.

The algorithm actually works in following steps:

1. Creates a detector object using Viola-Jones algorithm
2. Takes the image from the video
3. Detects the features
4. Annotates the detected features

MATLAB functions. The program (testing.m) has many functions. Do not edit the functions as these are linkers

and non-executable codes. First of all, you have to find the format supported by the camera and its device ID using the command given below (also shown in Fig. 3):

```
info = imagehwinfo('winvideo')
```

After knowing the device ID, you can change the device ID number in your source code.

We are having device ID as {1}, so have written '1' in the code, as mentioned below:

```
vid = videoinput('winvideo',1,'YUY2_640x480');
```

We also have other formats in MATLAB. You can check which format your camera supports by using commands below (also shown in Fig. 4):

```
info.DeviceInfo(1)
info.DeviceInfo.SupportedFormats
```

In Fig. 4, you can see that format 'YUY2_160x120' is the one which is

supported by the camera by default. But there are also other formats (resolutions) which your camera can support, as shown in last line in this screenshot. If you select another format and device number, you should make changes in the source code accordingly.

To detect a face or a particular feature on the faces of people, following steps are used in MATLAB program (testing.m):

1. Define and set up your cascade object detector using the constructor.

```
detector=vision.CascadeObjectDetector
```

It creates a system object detector that detects objects using the Viola-Jones algorithm. Its Classification Model property controls the type of object to detect. By default, the detector is configured to detect faces.

2. Call the step method with the input image I, the cascade object detector object, detector, points PTS and any optional properties. See the syntax below for using the step method. Use the step syntax with input image I, the selected cascade object detector object, and any optional properties to perform detection.

```
BBOX = step(detector, I)
```

It returns BBOX, an M-by-4 matrix defining M bounding boxes containing the detected objects. This method performs multi-scale object detection on the input image I. Each row of the output matrix BBOX contains a four-element vector (x, y, width and height) that specifies in pixels, the upper-left corner and size of a bounding box. Input image I must be a gray-scale or true colour (RGB) image.



Fig. 1: Face-counter program output

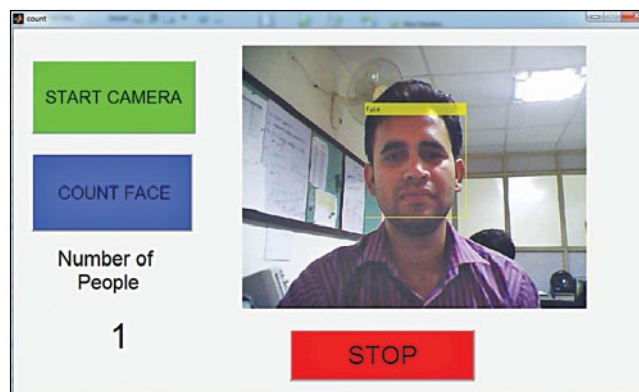


Fig. 2: Face counter using MATLAB

```

Command Window
>> info = imaqhwinfo('winvideo')

info =

    AdaptorDllName: [1x81 char]
    AdaptorDllVersion: '3.5 (R2010a)'
    AdaptorName: 'winvideo'
    DeviceIDs: {[1]}
    DeviceInfo: [1x1 struct]

```

Fig. 3: Checking the device ID

EFY Note

The source code of this project is included in this month's EFY DVD and is also available for free download at source.efymag.com

3. insertObjectAnnotation(I,'rectangle','Position,Label)

It inserts rectangles and corresponding labels at the location indicated by the position matrix. The position input must be an M-by-4 matrix, where each row (M) specifies a rectangle as a four-element vector (x, y, width and height). The elements x and y indicate the upper-left corner of the rectangle,

```

Command Window
>> info = imaqhwinfo('winvideo')

info =

    AdaptorDllName: [1x81 char]
    AdaptorDllVersion: '3.5 (R2010a)'
    AdaptorName: 'winvideo'
    DeviceIDs: {[1]}
    DeviceInfo: [1x1 struct]

>> info.DeviceInfo(1)

ans =

    DefaultFormat: 'YUY2_160x120'
    DeviceFileSupported: 0
    DeviceName: 'USB Video Device'
    DeviceID: 1
    ObjectConstructor: 'videoinput('winvideo', 1)'
    SupportedFormats: (1x5 cell)

>> info.DeviceInfo.SupportedFormats

ans =

    'YUY2_160x120'    'YUY2_176x144'    'YUY2_320x240'    'YUY2_352x288'    'YUY2_640x480'

```

Fig. 4: Formats supported by camera

and the width and height specify the size.

Testing

To test this program, follow the steps below:

1. Install MATLAB R2012a or higher version in your system. Launch it from desktop shortcut. You will see a blank command window.

2. Download the source folder either from EFY DVD, or from website, as given in EFY note.

3. Check the device ID, as shown in Fig. 3, and write that device ID number in the source code.

4. Run the program (count.m). A graphic user interface will appear,

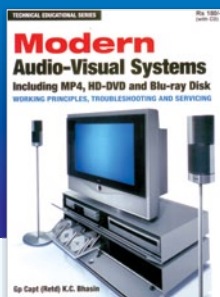
as shown in Fig. 1.

5. Click on Start Camera button to initialise camera settings.

6. Next click on Count Face button and the camera will start counting the faces.

7. To stop, click Stop button. ●

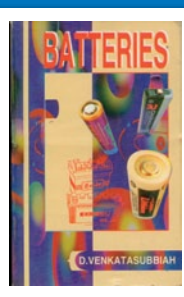
The author is a B.Tech in electronics and communication from SRCEM, Gwalior

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Getting Started With Kinect and OpenCV



SAMARTH SHAH

This article gives a brief introduction to Kinect sensor and explains how to install OpenCV libraries in Ubuntu operating system. The article also covers some useful commands at the end for connecting Kinect to your computer. It can serve as a base for developing complex computer vision applications using Kinect for Ubuntu operating system.

The Kinect

Kinect is a motion-sensing device developed by Microsoft for Xbox 360 video game console. Though initially invented for gaming, people have begun using it for different purposes. With Kinect you can control a television set without remote control, a computer without keyboard, a mouse icon or touch-screen and games without any controller in your hand.

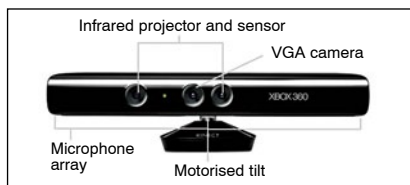


Fig. 1: Kinect showing the main parts

Kinect (see Fig. 1) has an array of sensors and specialised devices to pre-process the information received. Communication between Kinect and a game console, or Linux, is through a single USB cable. Its main features include:

Gesture recognition. Kinect can recognise gestures like hand movement based on inputs from an RGB camera and depth sensor.

Speech recognition. It can recognise spoken words and convert them into text, although accuracy strictly depends on the dictionary used. Input is from a microphone array.

The main components of Kinect are RGB camera, depth sensor and microphone array. The depth sensor combines an IR laser projector with a monochrome CMOS sensor to get 3D video data. Besides these, there is a motor to tilt the sensor array up and down for the best view of the scene, and an accelerometer to sense position.

To get the best out of Kinect, you should be familiar with two terms: natural user interface (NUI) and machine learning. NUI refers to close interaction between a user and the computer. It includes controlling the computer through gestures, or the

computer recognising the user's voice/face. Microsoft Surface, multi-touch and Kinect are a few examples of NUI.

Machine learning, according to Wikipedia, "...a branch of artificial intelligence, is a scientific discipline concerned with the design and development of algorithms that allow computers to evolve behaviour based on empirical data, such as from sensor data."

Open platforms. The OpenKinect community was founded by the developer of the Kinect open source driver. OpenKinect publishes its code under Apache 2.0 or GPL 2 licences. There is also another organisation, OpenNI, which publishes its work under different licences. There are mainly two open platforms or libraries, namely, libfreenect and OpenNI. These have been developed for almost the same purpose, and both support various languages like Python, C++, C#, JavaScript, Java JNI, Java JNA and ActionScript.

Kinect projects. Among some amazing things/projects that can be done with Kinect include gesture-controlled robot (EFY, January 2013), robot operating system (ROS), Kinect-controlled computers based on user gestures and/or speech recognition, scanning of 3D objects (Kinect enables robots to map 3D objects, resulting in detailed and precise models of people), medical applications like gesture-based control of surgical tools, and in education where writing and calculator applications have already been developed using it.

Programming with Kinect

For programming with Kinect, we need open source computer vision (OpenCV)—a library for real-time computer vision. We also need lib-

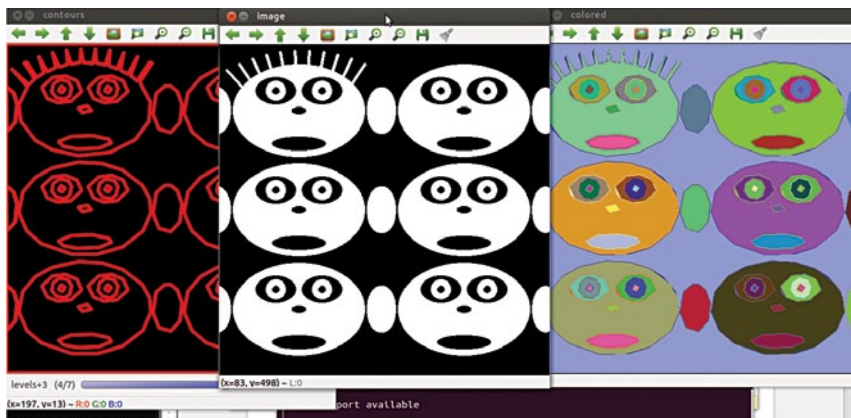


Fig. 2: OpenCV sample image



Fig. 3: Image captured by Kinect after running `glview` command

freenect library that can take the data (such as colour, depth and other information) from Kinect and convert it into a format that is readable by OpenCV library for further processing and developing complex algorithms like face recognition.

Installing OpenCV. For installing OpenCV in Ubuntu 12.04, use the following commands:

```
$ sudo apt-get install build-essential libtiff4-dev cmake git libgtk2.0-dev python-dev python-numpy libavcodec-dev libavformat-dev libswscale-dev libgstreamer0.10-dev libgstreamer-plugins-base0.10-dev libv4l-dev libjpeg-dev libjasper-dev libtiff4-dev libdc1394-22-dev libxine-dev
```

```
$ cd ~
```

Download `Opencv-2.4.7.tar.gz` from <http://sourceforge.net/projects/opencvlibrary/files/opencv-unix/2.4.7/opencv-2.4.7.tar.gz/download> and extract it to home folder.

```
$ cd OpenCV-2.4.7/
$ mkdir build
$ cd build
$ cmake -D WITH_XINE=ON -D WITH_OPENGL=ON -D BUILD-EXAMPLE=ON
$ make
$ sudo make install
```

```
$ sudo gedit /etc/ld.so.conf.d/opencv.conf
```

At the end of the file, add the following lines and save it:

```
gedit /etc/ld.so.conf
/usr/local/lib
```

And then configure dynamic linker run-time bindings:

```
$ sudo ldconfig
```

OpenCV-2.4.7 has been installed. Open another terminal to check some of the samples:

```
$ cd ~
$ cd opencv-2.4.7/samples/c
$ chmod +x build_all.sh
$ ./build_all.sh
```

To check any sample, go to that folder and run the sample. For example, in the 'c' folder, we have contours, so to run it, enter the command given below:

```
$ cd ~
$ cd opencv-2.4.7/samples/c
$ ./contours
```

You will get the output image as shown in Fig. 2.

Installing libfreenect. To install libfreenect, we need to first install some prerequisites for building it:

```
$ sudo apt-get install git-core
cmake freeglut3-dev pkg-config build-essential libxmu-dev libxi-dev
```

```
libusb-1.0-0-dev
```

Now download the clone from 'github':

```
$ git clone git://github.com/
OpenKinect/libfreenect.git
```

Change directory to 'libfreenect'

```
$ cd libfreenect
```

Make a directory named 'build' and change current directory to 'build'

```
$ mkdir build
```

```
$ cd build
```

CMake is used to control the software compilation process with simple platform and compiler-independent configuration files. CMake generates native make files and workspaces that can be used in the compiler environment of your choice.

```
$ cmake ..
```

The make program uses the make-file database and latest modifications of the files to decide which of the files need to be updated.

Sudo means superuser do. It allows a system administrator to give certain users the ability to run some commands as root while logging all commands and arguments.

```
$ make
$ sudo make install
$ sudo ldconfig /usr/local/lib64/
```

Run the sample project:

```
$ sudo glview
```

Fig. 3 shows the image captured by the system after using `glview` command.

Now we are done with complete environment set-up and can program OpenCV using libfreenect. To write your own code for OpenCV, add the `libfreenect.h` header to your code. ●

The author is a FOSS advocate and his areas of interest include Kinect, Linux, Arduino and Image Processing using OpenCV. This article is based on his articles published earlier in EFY's Linux For You (now Open Source For You) magazine

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Running Linux on Windows

One of the many reasons to run Linux on Windows would be to get the best of both the worlds. There are several methods for running Linux on Windows. The authors recommend Linux Integration Services, which has been made available by Microsoft. Read on to learn how to use LIS



VINAY PATKAR AND AVINASH BENDIGERI

Recent releases from Microsoft—Windows Server 2012 R2 and System Center 2012 R2—come with the ability to effectively host Linux and associated open source applications along with great management capabilities. Some of the improvements in Windows Server include faster live migration, dynamic memory support that can be used depending on workload, as well as the capability to dynamically resize VHDs and VHDXs. On the other hand, System Center provides a single interface for managing Windows, ESXi and Linux operating systems.

Microsoft's new feature from Windows Server 2012 R2 and System Center 2012 R2, called Data Center Abstraction Layer (DAL), based on CIM and WS-Man standards, has common management abstracts for managing all the resources of a data centre (including the physical and virtual environ-

ments). To support DAL, Microsoft has contributed Open Management Infrastructure (OMI) along with other providers to effectively manage Linux. OMI is well known for its smaller disk footprint.

This article will tell you how to use Windows Server 2012 R2 Hyper-V and Windows Hyper-V Server 2012 R2, and why installing Linux Integration Services is a best practice while running Linux as a guest OS.

Different ways of running Linux on Windows

Linux can be run on Windows in the following ways.

Virtual machines. Virtual machines (VMs) are some of the best ways of running any operating system. The advantages of a VM include better hardware utilisation, the ability to run multiple OSs and to install and run any application. On a Windows machine, one can install third-party virtualisa-

tion software like Virtual Box, VMware Player or Windows Hyper-V. Note that one can't install multiple virtualisation software on the same system.

The dual boot option. The dual boot option allows more than one operating system to reside on a single computer. In a dual boot, the Windows OS is stored on one volume/disk and the Linux OS on another volume/disk (assuming it is rarely used). The best use case would be to test a new OS without switching to it completely. This method is not the recommended way of running Linux alongside Windows, as the latter facilitates only partition-specific installation or on a logical partition (within an extended partition). The Microsoft recommendation is to install Windows on a primary partition. To dual boot a Windows machine, please refer to the link <https://help.ubuntu.com/community/Installation/FromUSBStick>

Live USB and live CDs. A live USB is a USB Flash drive or USB external hard drive containing the full operating system. It is the preferred way of running Linux when compared to a live CD, as data contained in the booting device can be changed and additional data can be stored in the USB. Refer to the link <https://help.ubuntu.com/community/Installation/FromUSBStick> to boot from a live USB.

Installing Ubuntu via Wubi. Windows-based Ubuntu Installer (Wubi) is a software installer for Ubuntu. Wubi creates a special file on your Windows partition and uses that file as your Ubuntu drive without the need for a separate partition. This means that you can install Ubuntu and use it without any partitioning, and you can uninstall Ubuntu from the Windows Control

Panel when your job is complete. Follow the link <http://www.howtogeek.com/howto/9142/easily-install-ubuntu-linux-with-windows-using-the-wubi-installer/> to install Ubuntu using Wubi.

Cygwin. Cygwin is a collection of tools that offer a Linux-like shell environment on Windows, but it's not a method of running a full Linux distro. Follow the link <http://x.cygwin.com/docs/ug/setup-cygwin-x-installing.html> for download and installation instructions for Cygwin.

Installing Hyper-V role on Windows. To install Hyper-V role on Windows, you first need to take the following steps.

Preparing the hardware. Before you get started with enabling Hyper-V on Windows, make sure virtualisation technology is enabled via BIOS--->Processor Settings--->Virtualization technology.

Preparing the platform. In our example, let's use Windows Server 2012 R2 Datacenter SKU on the host machine.

On Windows Server 2012 R2, go to Start, type Powershell ISE, and then type the following commands:

```
PS C:\Windows\system32> Import-Module ServerManager
PS C:\Windows\system32> Get-WindowsFeature
PS C:\Windows\system32> Install-WindowsFeature Hyper-V -Restart
```

However, the best practice for running Linux on Windows is to use Linux Integration Services.

Linux Integration Services

Microsoft developers have built drivers for Linux OSs and have released them through a package called Linux Integration Services (LISs), which are synthetic drivers for the network and disk that enhance I/O and networking performance.

To ensure compliance with the Linux community, the drivers have been reviewed by community and forum members, and have been checked into the main Linux kernel code base. Linux distribution vendors can now pull the drivers from the main Linux kernel and incorporate them into their respective distributions.

```
root@localhost:/media/RHEL63
File Edit View Search Terminal Help
[root@localhost ~]# mount /dev/cdrom /media/
mount: block device /dev/sr0 is write-protected, mounting read-only
[root@localhost ~]# cd /media/
[root@localhost media]# ls
RHEL55 RHEL56 RHEL57 RHEL58 RHEL6012 RHEL63
[root@localhost media]# cd RHEL63
```

Fig. 1: Run install.sh file

```
Change desktop appearance and behavior, get help, or log out
File Edit View Search Terminal Help
[root@localhost RHEL63]# ls
install.sh
kmod-microsoft-hyper-v-rhel63.3.5-20131212.i686.rpm      microsoft-hyper-v-rhel63.3.5-20131212.i686.rpm
kmod-microsoft-hyper-v-rhel63.3.5-20131212.x86_64.rpm    microsoft-hyper-v-rhel63.3.5-20131212.src.rpm
microsoft-hyper-v-debuginfo-rhel63.3.5-20131212.i686.rpm microsoft-hyper-v-rhel63.3.5-20131212.x86_64.rpm
microsoft-hyper-v-debuginfo-rhel63.3.5-20131212.x86_64.rpm
[root@localhost RHEL63]# ./install.sh
Installing the Linux Integration Services for Microsoft Hyper-V...
Preparing... [100%]
1:kmod-microsoft-hyper-v [100%]
Preparing... [100%]
1:microsoft-hyper-v [100%]
Saving old initramfs
Installing new initramfs
Adding KVP Daemon to Chkconfig...
Starting KVP Daemon...
Adding VSS Daemon to Chkconfig...
Starting VSS Daemon...
Linux Integration Services for Hyper-V has been installed. Please reboot your system.
[root@localhost RHEL63]# /sbin/modinfo hv_vmbus
filename: /lib/modules/2.6.32-279.el6.x86_64/extra/microsoft-hyper-v/hv_vmbus.ko
version:
license: GPL
srcversion: AC0A64859744D00E54C12
alias: acpi:*VMBUS*
alias: acpi:*VMBUS*
depends: 2.6.32-279.el6.x86_64 SMP mod_unload modversions
vermagic: 2.6.32-279.el6.x86_64 SMP mod_unload modversions
[root@localhost RHEL63]#
```

Fig. 2: The LIS version for hv_vmbus after installing LIS 3.5

Microsoft made LIS open source so that anyone can build from source and make changes to the code. The main Github page for Linux Integration Services is <https://github.com/LIS> and the latest LIS package is 3.5. The code (<https://github.com/LIS/LIS3.5>) for this has been released under the GNU Public Licence v2.

For more information on supported guest OSs on Windows OSs, please refer to the link <http://technet.microsoft.com/en-US/library/dn531026.aspx>

The following are some of the new features of LIS being introduced with Windows Server 2012 R2:

1. **Kdump/Kexec.** Just like physical machines running the Linux OS, Linux guests can also get crash dumps.

2. **Dynamic memory.** Based on the Linux guest OS' needs, memory can be automatically increased or decreased.

3. **Linux Synthetic Frame Buffer Drivers.** It provides enhanced graphics performance for Linux desktop users.

You can refer to the following link for a detailed LIS feature list from Microsoft's virtualisation blog <http://blogs.technet.com/b/virtualization/archive/2013/07/24/enabling-linux-support-on-windows-server-2012-r2-hyper-v.aspx>

The following example will show you how to install LIS 3.5 for RHEL 6.3 running on Windows Server 2012 R2.

Installing Linux Integration Services (LIS)

1. Create a Generation One virtual machine and install RHEL 6.3. Download LIS from <http://www.microsoft.com/en-us/download/details.aspx?id=41554>

2. Connect to the virtual machine, and from the menu go to Media--->DVD Drive --->Insert Disk and attach LIS3.5 ISO.

3. Open a terminal in the virtual machine running RHEL 6.3, and run the following commands as the root user to mount the

ISO and navigate to the directory relevant distribution (in this case, it is RHEL 6.3):

```
[root@localhost ~]# mount /dev/cdrom /media/
[root@localhost ~]# cd /media/
[root@localhost ~]# ls
[root@localhost ~]# cd RHEL63
```

4. Locate the install.sh file, in our case /media/RHEL63/, and run install.sh as shown in Fig. 1. It should show the 'Install successful' message. To check whether LIS is installed properly, run the following commands from a terminal:

```
[root@localhost ~]# /sbin/modinfo hv_vmbus
[root@localhost ~]# /sbin/modinfo hv_netvsc
[root@localhost ~]# /sbin/modinfo hv_storvsc
[root@localhost ~]# /sbin/modinfo hv_blkvsc
[root@localhost ~]# /sbin/modinfo hv_util
```

Fig. 2 shows the LIS version for 'hv_vmbus' after installing LIS 3.5. ●

Vinay and Avinash work as software development engineers at Dell India R&D Centre, Bengaluru. Vinay has close to two years' experience in automation, Windows Server OS and is interested in virtualisation and cloud computing technologies. Avinash is interested in the automation and system management domains. This article is a reprint of their article in June issue of EFY's Open Source For You magazine

Circuit and Project Ideas

New and innovative circuit and project ideas have always excited hobbyists and experimenters. This month we introduce to you some websites that host different ideas and schematics

NIRAJ SAHAY

electronicsforu.com

This portal serves as a storehouse of information for the electronics and technology industry. The latest news, information about new products and a web search covering not less than 50,000 electronics websites are some of the facilities this portal offers. It also includes the hugely popular EFY tested circuits and projects, reproduced from Electronics For You magazine.



<http://electronicsforu.com/newelectronics/lab/>



electroschematics.com

electroschematics.com discusses electronic circuit schematics, printed circuit board diagrams and electronics project diagrams. The website has a huge collection of electronic schematics: audio amplifiers, radio and IR transmitters, antennae, DIY kits and more. You can browse through a total of 1537 electronic project ideas.

<http://electroschematics.com/>

discovercircuits.com

The site was launched in 2002 and currently has 35,000+ electronic circuits or schematics carefully cross-referenced into 500+ categories. A one-stop resource for engineers, hobbyists, inventors and consultants, the site has a collection of information and offers quick solutions to electronic design problems. It is owned by David A. Johnson, P.E., an electronics engineer with over 30 years of practical experience in the areas of analogue and digital design, fibre optics and RFID.



<http://www.discovercircuits.com/DJ-Circuits/daj-main.htm>



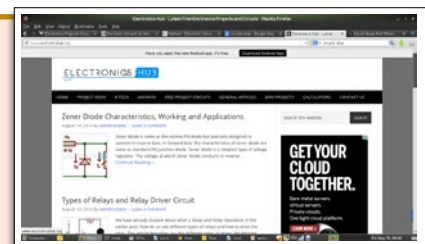
electronics-lab.com

The website has useful circuits with full description, diagrams and PCB layouts, electronics articles and many useful links. It also has online community which is dedicated to all electronics enthusiasts. The forum was created to provide a place where you can post your questions, ideas and projects concerning electronics.

<http://www.electronics-lab.com/>

electronicshub.org

The website is a real hub for circuit and project ideas. The free project ideas cover solar, embedded, robotics and similar topics. Apart from such ideas the site also has electrical/electronics calculator, how-to on different topics and list of electronics mini projects.



<http://www.electronicshub.org/>

Embedded World Offers Plethora of Jobs But With Low Starting Pay

The article discusses the tremendous career opportunities available in the embedded systems industry. It is based mostly on the advice and comments received from experts in the field

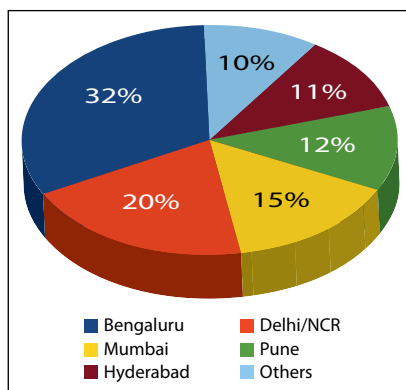
ABHISHEK A. MUTHA

Embedded systems are popular in healthcare, consumer goods, video security/surveillance, information technology (IT), telecommunication, Internet of Things (IoT), automotive and manufacturing industries, and now in the upcoming wearable electronics sector. With such pronounced existence, let us find out what a career in this field has to offer.

"Embedded design and development industry is so vast that it will consistently need core talented engineers with good hardware and software knowledge and, most importantly, out-of-the-box problem-solving skills," according to Amit Gohel, founder, Eleics Design.

Most electronics graduates are unaware of the abundant opportunities available in the field of embedded industry, believes Sakthivel K., chief executive officer, Caliber Embedded Technologies India (P) Ltd. He says, "According to the NASSCOM report, the total embedded system global business is expected to reach around \$90 billion by 2015, wherein India alone is expected to have a share of around \$16 billion."

On a similar note, Girija Vedi, senior marketing executive, VVDN Technologies also believes that career in the embedded domain is a worthy option available for electronics engineers today. She says, "As VVDN specialises in developing embedded systems for various segments, we are likely to hire around 500 engineers by 2014 year end, but shortage of candidates with the right talent is definitely one of the hurdles we are facing in achieving our goal."



Top five locations hiring professionals for embedded systems (Data courtesy: TimesJobs.com)

Hardware design or software testing option

Fresh electronics engineers having good knowledge and interest in digital and analogue electronics circuit design could choose board design as their field, advises Vinod D. Halappa, senior manager - business development, Dexcel Electronics Designs Pvt Ltd. He says, "With additional knowledge of VLSI/FPGA technology, design flow and HDL/System C, they can also get into ASIC/FPGA design/verification field." Fresh computer engineers with good basics of computer architecture, microprocessor/controller-based system design, embedded C, Linux (or any embedded OS) can go for embedded software as their field. He adds, "There are ample jobs in embedded software testing as well, for which they would need some specific training in state-of-the-art testing tools, methodologies and scripting languages for about three to six months."

With the recent initiatives of the government of India to promote local electronics system design and manufacturing (ESDM), announcements to

setup new semiconductor fabrications units and incentives to units being set up in various electronics clusters, local electronics manufacturing in India is poised for a major growth. Rajeev Tiwari, director, Tevatron Technologies says, "With this renewed emphasis on ESDM, engineers with skills in embedded systems, device drivers, firmware, hardware-software integration, PCB design, board design, graphics driver and real-time operating system would be most sought-after. At the same time, at product level, since a lot of innovation will start taking place in local market, product marketing engineers and managers will also get lot of attention."

With the rapid growth of electronics and consumer markets, plenty of smart devices are getting released within a short span of time. Undoubtedly, there is a shining future ahead for fresh candidates as well, informs Paramita Kapat, head - human resource, eInfochips. She says, "Compact embedded devices are playing a major role in the boom of various industries, especially smartphones, tablets and medical equipments. In nutshell, embedded systems field is the most diversified for electronics as well as computer science students."

Also, with the advancements in electronics, embedded systems field is becoming a niche segment and there is an influx of new products in market. Upendra Patel, CEO, Glide Technology Pvt Ltd says, "This is driving demand for both outsourcing projects as well as domestic products. Due to this, there is good demand for engineers in embedded systems industry." Although, he thinks, there is shortage of qualified and experienced resources.

Embedded systems industry offers great amount of career opportunities in various fields that are connected with product life-cycle and typical system architectures of current embedded products, informs Halappa. Basic requirement for a career aspirant in this field would be having specialisation in electronics, computers or any other related engineering. He says, "If we have to rank various fields by the number of opportunities generated by them, the list would be topped by embedded software design (~73%), followed by ASIC design (~15%), FPGA design (~4%), board design (~4%), CAD design (~2%), production services (1%) and sales and marketing (~1%)."

How freshers are placed

To design even a simple product, one has to study and know so many parameters and design requirements, which cannot be achieved without experience and cannot be taught at college, opines Gohel. He says, "Generally fresher engineers are considered to be 'too early' for embedded product design. So, for the initial few months, we put them under testing and validation of designs, and after they gather some experience, we let them develop customer applications under the supervision of senior engineers." "The semiconductor industry always comes up with new and improved components, so one has to keep updating with new technologies used and market's needs. This industry is only for the passionate people, and hence one cannot survive if s/he is not abreast with the latest happenings," he adds.

On the positive side, there is a good scope for fresh engineering talent in the industry, provided they meet the basic industry standards, informs Vedi. VVDN's selection process consists of basic-level (C/C++, electronics, aptitude) written entrance exam followed by an interview. She says, "Entry-level role is normally that of a trainee. They

Expectations from freshers

Technical skills

1. Basic electronics, logic design and microcontroller
2. Microprocessor and controller architecture, and Assembly language
3. Analogue circuits, linear electronics and digital electronics
4. Programming languages like C, C++, Java and HTML
5. Fundamentals of operation systems, real-time operating systems, inter-process communication, data structures
6. Computer networks

Personal skills

1. Basic aptitude
2. Good communication skills
3. Good analytical and problem-solving skills
4. Critical thinking towards field problems
5. Desire and passion to learn
6. Adaptation to new trends and technologies

are on probation for three months. Students need not go to specialised training centres after their graduation." She adds, "As a trainee, candidates get an opportunity to get involved in various roles, which include hardware development, software development and testing. Based upon the candidates' interest and performance during the probation, trainees are accredited as full-time employees and are given specialised designations based on their interest and company's requirement."

Talking about eInfochips, Kapat informs, "In product design projects, we prefer candidates to start as application engineers and then gradually, when they understand the product, they can dig into lower layers. Candidates who have good knowledge of programming languages and operating systems can directly start as firmware engineer where they get opportunity to learn about different systems on chips (SoCs)." She adds, "We also have well-defined on-the-job training programmes where a fresh candidate not only learns project-specific things but is assigned responsibilities to perform tasks."

Typical training period

Patel shares that it is very difficult to get experienced personnel, and the only way is to hire fresh engineering graduates and train them for the required technologies. He says, "As colleges are lacking qualified lecturers and infrastructure to cope up with new technology development, fresh engineers should start with a few

months of training on basics and devices/technologies used in current products. Once they spend about three to four months, they can be used as design engineers or firmware engineers under the supervision and guidance of senior engineers." He adds, "Even at entry level, they can prepare schematics, small board layouts and write application software modules."

Typically, entry-level engineers would be trainee engineers for three to six months, during which they get exposed to the company's work culture, product design life-cycle, design flow and methodology, standards/guidelines for design, coding, testing and safety, and quality compliance and IP protection policies. Halappa says, "After their tenure as trainee, based on individuals' performance in their earlier project tasks and their background experience, they would be assigned module-level design and/or testing tasks. But the kind of work and exposure that an individual gets may very well depend on the dynamics of ongoing projects and also individual's ability to grow with the challenges." He adds, "Typically, fresh engineers would mature as full-fledged design engineers in a span of three to five years, depending on their focus and ability."

Higher demand for software engineers

"With the rise of the Internet of Things, embedded systems have received a huge push forward and their complexity has led to a great demand for skilled professionals and technologists in this field. The majority of the roles are focussed in the IT software sector with Bengaluru, Delhi and Mumbai serving as the main hubs for companies engaged in employing these high-end programming skills. As with all niche specialisations, entry-level salaries quickly rise as the professional gains valuable on-the-job experience and deals with real-world scenarios," explains Vivek Madhukar, COO, Times Business Solutions Limited.

Apart from Bengaluru that features in the list of top locations for jobs in embedded field with 32%, figures indicate Delhi, Mumbai and Pune share 20%, 15% and 12% of the jobs, respectively. Remaining jobs are scattered in other locations.

Low pay initially

Talking about Tevatron, Anurag Gupta, director, Tevatron Technologies informs, "We recruit experienced and fresh engineers for embedded systems, firmware, VLSI design and chip design. The package varies from candidate to candidate, ranging from 300,000 to 2,000,000 rupees per annum, based on their experience level."

At Eleics Design, fresh graduates spend their initial months in training and learning, and hence they offer them a package of 100,000 rupees per annum. Solely based on their performance, pay is gradually incremented, informs Gohel. Talking about experienced professionals in embedded design, he says, "They will get a pay package of around 200,000 to 320,000 rupees per annum and, again based on performance, s/he will receive increments and other perks." He adds, "In some cases, we also pay on hourly basis to experts, and that amount varies as per his/her design specific expertise."

Vedi informs, "VVDN Technologies hires B. Tech/B.E. graduates from electronics, computer science, IT and electrical branches. For freshers, an approximate pay of 240,000 rupees is provided whereas for experienced professionals, it depends on their experience and knowledge."

At Caliber Embedded Technologies, Sakthivel says, "For fresh graduates we are offering between 125,000 and 175,000 rupees per annum and for experienced professionals we are offering 250,000 to 350,000 rupees per annum, based on the level of experience of the candidate."

On behalf of eInfochips, Kapat too affirms that they hire fresh engineers from engineering institutes all across the country. She says, "Depending on their qualification and institute, sal-

Do some institutes have a greater edge?

► "We recruit from IITs/NITs as well as other institutions. In particular, for freshers, we are looking for strong concepts and fundamentals rather than the college they come from." —**Anurag Gupta, director, Tevatron Technologies**

► "We need skilful engineers, we do not see IIT/NIT tags and sometimes we even do not see their mark sheets." —**Amit Gohel, founder, Eleics Design**

► "We are not restricted to IITs/NITs alone but do head hunting in other engineering institutions as well, as we believe that right talent is not restricted to premier institutions." —**Girija Vedi, senior marketing executive, VVDN Technologies**

► "We focus on good local engineering institutes and hire based on raw talent and train them for our needs. For small companies, it is difficult to get placement slots at IITs/NITs. There are several exceptional IITians I have engaged with in past and had great experience working with them. But, I have mostly come across research oriented and analytical IITians, who although intelligent and bright, were not able to tackle real life design problems. So, for normal engineering designs, our preference is for engineers from other institutes." —**Upendra Patel, CEO, Glide Technology Pvt Ltd**

► "We do not have any such reservations about the institutions, but it is true that being a small-scale company, we would do very stringent screening to ensure that people we recruit can ramp up quickly to our expectations and start delivering at the earliest. It is simply because we do not have much bandwidth to provide long trainings after the recruitment and bridge the gap." —**Vinod D. Halappa, senior manager - business development, Dexel Electronics Designs Pvt Ltd**

ary can be in the range of 200,000 to 300,000 rupees per annum."

At Glide Technology, Patel informs, "We have a mix of senior persons with freshers. Freshers' salaries range from 120,000 to 180,000 rupees and largely depend on the institution they had studied at and their college project. For experienced professionals, it is based on past experience, and there are no fixed criteria. We even hire freelance professionals with specialised skills on hourly rates for specific jobs."

Skills expectation

The industry expects basic knowledge and skills from the freshers but specific skills from the experienced. For the skills expected from a fresher, see the box titled 'Expectations from freshers,' which is based on views of the industry experts.

The skills expected from experienced candidates are much more specific, apart from the basics and soft skills of course. Tiwari says, "They should be equally conversant with hardware and software, particularly analogue IC, components and the digital counterparts, interfacing of I/O peripherals to microcontroller and building the embedded core programming logic from scratch." He adds, "They should be aware of the latest developments and emerging technologies like 32-bit ARM processor, Raspberry Pi, Arduino, Embedded

Linux, RTOS and interfacing Android apps to embedded hardware."

Speaking more specifically, Gohel says, "S/he must have worked on at least three MCU platforms such as Microchip PIC16/PIC18/PIC32, TI MSP430, Renesas RX62N and Atmel ATmega32 to list a few, and must be good at electronics and software development. S/he should have stabilised at least two or more products in the past and should also have a flair for PCB designing."

But when it comes to the experienced graduates, they are expected to carry product engineering/development knowledge for some specific domains like the consumer, defence, industrial automation, semiconductor, avionics or bio-medical sector, informs Halappa. He says, "In general, they must be strong in design aspects and considerations to meet the requirements for a product in a given domain in terms of performance, cost, quality and standard compliance. Specially quality and process compliance would be of great importance when it comes to defence, avionics and bio-medical products."

Experts' advice

Embedded systems, being so omnipresent and so inevitably embedded into our modern lifestyle, could be the single largest enabler that would play a significant and ever-growing role in shaping our future tools, gadgets,

machines and equipments in the fields ranging from agriculture to automobiles, infotainment to health, processing to construction industry and toys to aircrafts. Halappa says, "I would encourage fresh/experienced engineers to consider

this field as one of the top options as it offers highly challenging, learning and rewarding career for engineers with enthusiasm to be part of this futuristic industry."

"Mobile devices are driving the electronics development. Hence, the designs are miniaturised and have several challenges to be addressed. The engineers need to strengthen their knowledge on currently used devices, which are not taught in colleges, on their own by studying and experimenting with kits available in market," informs Patel. Halappa advises, "There are lot of low-cost development kits available in market to play with new processors and software architectures. Most of them share schematics, design files and firmware on the Internet, which can be a good way to learn embedded system design aspects to get entry in organisations."

Patel says, "There is lack of good-quality staff and infrastructure in many colleges. Knowledge of faculty in current technologies is also very limited. Therefore our advice to people looking for career in embedded systems will be to attend short-term courses in embedded systems or take an entry-level position in an organisation that specialises in embedded product design at low salary instead of taking up QA/testing/application development job at higher salary in traditional IT companies." On a similar note, Tiwari says, "Students need to invest their time in learning hands-on practical skills and concepts which are currently in demand. They should try to become industry-ready and only then they can get a job of choice in this market."

"Candidates need to develop right

skills and attitude. Apart from the technical knowledge and consistent academic performance, companies are in need of people having passion towards technology, who keep them abreast with the latest advancements in the technology, who take initiatives in their field and add value to their work," opines Vedi.

Can engineering institutes be blamed?

Nowadays, you get to hear quite often that engineering graduates are raw and unemployable. The blame, conveniently, is transferred to the institutions and the government, feels Vedi. She says, "I admit that it is the onus of the institutions and government to bring a change in the course curriculum and give an ideal environment to young students where they can learn and adopt necessary skills helpful for them to be employed in the industry." However, she adds, "I feel that students should take initiative and get involved in proactive measures to learn and develop skills which would help them in the long run. Internet and social media, groups and communities have made the information accessible to them in just one click. They should spend their time on enhancing their knowledge plus also work on improving their communication skills. After all, what companies require from a fresh graduate is just the basics plus good communication and, above all, right attitude."

Halappa agrees that the industry often complains that fresh graduates, coming out of regular institutions, are not ready for the industry. "It does not mean that the curriculum in these institutions is inferior, but in fact it is

somewhat over-ambitious and looks like super popular packages of all the latest technologies tailored to please every company that is coming for campus recruitment. So the real need is to ensure that the engineering colleges concentrate more on teaching better basics and providing practical orientation to contemporary subjects than dealing with every advanced and research area," he says.

Halappa believes that subjects need to be dealt in top-down approach rather than bottom-up approach. He cites, "The top-down approach would first give overall perspective of the subject, even before getting into the details of it. Unfortunately, the current and more prevalent bottom-up approach allows students to learn bits and pieces of the subject that may be easier to learn and score even without getting the overall perspective of the subject."

For this change to happen, Halappa feels the text books should be written with top-down approach. The teaching fraternity in the engineering institutions, who are the key players in this eco system, should be allowed, encouraged and even compelled to interact with industries on regular basis and gain insight to the product design life-cycle, design methodologies, standards and compliance, and the kind of job profiles available to engineers in the industry. "Only when a comprehensive system for training the trainer is established by the responsible and committed involvement of both industry and institutions, this gap can be minimised," according to Halappa. ●

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Solar Industry Expected to Grow Fast

In spite of a few challenges, the Indian solar industry is expected to grow substantially from 2600MW to 20,000MW by 2022 with the help of government and solar manufacturers' initiatives. We might soon see Indian cities turning into 'solar cities' in the near future

SNEHA AMBASTHA

The solar power industry is set to turn around quickly and establish its place amongst the topmost industries in India. With a total worldwide installed capacity of 136,697MW, this industry has recorded a growth of almost 35 per cent. And India has started contributing to it. Recently, the Renewable Energy Policy Network for the 21st Century (Ren21) ranked India amongst the top five nations worldwide for Concentrated Solar Power (CSP) technology capacity.

It is assumed that India would add a 50MW plant on a 1.27 million square metre floating platform by the end of this year. Currently, India's solar capacity is 2600MW only, but it is targeted to cross 20GW by 2022. It is said that India can generate 1.5 times the current electricity demand with just 1000GW of solar power. In order to build it, India needs just 0.5% of its land, or half the desert district of Barmher in Rajasthan.

The Commerce Ministry has recommended anti-dumping duty of US\$ 0.11 to US\$ 0.81 per watt to secure the market share of domestic manufacturers. A latest report by Powergrid suggests, "Market analysis has broad consensus that utility-scale solar photo-voltaic (PV) generation will achieve grid parity around 2016-17, based on the pace of reduction in cost of PV technology and rise in conventional energy prices."

The peculiar situation in India

India is in a similar situation as Japan when it comes to energy. Both these nations have very little land in places



Fig. 1: Solar power

where solar power plants need to be installed. This sounds very contradictory, specially when we see areas like Leh, Rajasthan, Gujarat and Madhya Pradesh. We have plenty of land available there.

Here is the twist to this statement: There is deficiency of power in places like Bihar, Uttar Pradesh, Nashik, Tamil Nadu and Kerala, which have limited land for the installation of huge solar power plants. These places also lack the transmission infrastructure. To this, Sandip Ghosh, EVP-solar products, Jakson Group says, "You cannot transmit power from Rajasthan to Tamil Nadu or to Bihar. The transmission and distribution losses will be close to 10%, and you will also require a huge investment for transmitting this type of power to the end consumer. So what is thought is instead of trying to get into captive power, you get into distributed power generation." He explains, "In places

like Bihar, where we have less cultivated land but abundant water bodies, floating plants are proposed." We have about 10MW of solar plants over canals now, and this number includes 1MW solar power plant that was put up in Gujarat about a year ago.

Sandip adds, "This has several benefits. It enables utilisation of water bodies where there is scarcity of land, reduces the evaporation of the water, and size of the water body below the plant remains cool, and its size does not get affected."

S.P. Gon Choudhury, chairman of Renewable Energy College says, "There are large stretches of water bodies in Kerala which NHPC (a local energy company) wants to harness for solar power. This floating solar power technology was developed by the Renewable Energy College and has been implemented in the city." He adds, "The first plant (a pilot project) is scheduled to be commissioned in

October this year. Each station would require around 300 square metres to generate 20kW power.” “There are many water bodies that could be used for solar power projects,” he says.

What is leading to this growth

Growth needs driving factors. Government of India is playing a major role in growth of the solar sector today. The Central government allows substantial concession or exemption of customs duty on import of equipment required to set up power projects.

Then there is rising demand for electricity, favourable government policies and high power tariffs that support the growth of solar industry.

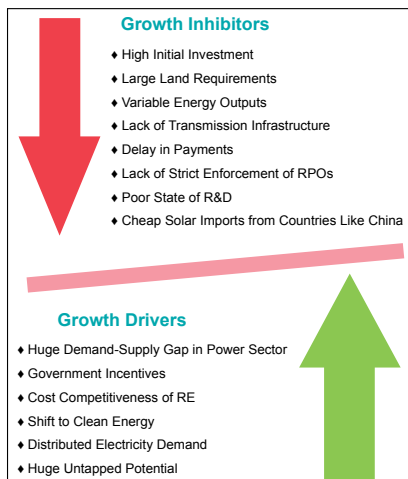


Fig. 2: Key growth drivers and inhibitors for solar energy market in India (Source: Novonous Insight)

The declaration of National Solar Mission (NSM) a few years ago has increased the hope of solar module manufacturers for growth in gross revenue. This has flooded the Indian market with cheaper imported modules and equipment.

One important attempt has been the release of funds by the Indian government to support the industry. S.K. Sharma, scientist D, Ministry of New and Renewable Energy (MNRE), in one of his reports says, “I am directed to convey sanction of the President for installation of 23,500 nos. (of) SPV power plants of 1kWp capacity each for domestic households in Rajasthan, Andhra Pradesh, Kerala, Tamilnadu, Chhattisgarh and other selected States with a financial support from NCEF of ₹ 148 crores (₹ 1480 million), in Rajasthan, Andhra Pradesh, Kerala, Tamil Nadu, Chhattisgarh and other selected States at a project cost of ₹ 493 crores (₹ 4930 million).”

Another factor supporting the growth is the heavy import duty imposed on the Chinese modules in the USA. This is acting as a motivational factor for the solar manufacturers in India to make their way into the lucrative US market.

The contribution of manufacturers in the solar industry has also been a big driving factor for the development of the solar electronics and the industry as a whole. For instance, Honeywell has

recently added its sixth manufacturing facility at Vadodra. It is stated that this unit will construct ten solar water-heater variants of galvanised iron and stainless steel (SS) that would deliver 100 to 300 litres per day for industrial, commercial and residential use. Then there is Schneider Electric’s Bengaluru plant, which has a capability to manufacture solar inverters that can raise nearly 1.4GW of energy a year.

Addition to the Indian solar team

The market is not a place for a single player. There are always new players that add up to the existing team to make the market grow. Solar industry in India needs many such players to evolve. Canadian Solar, a Chinese company and the world’s third-largest photovoltaic cell manufacturer, is aiming to set up its manufacturing base in India. But this is not all, it is also likely to take over Solar Semiconductor based in Hyderabad which is capable of producing about 195MW worth of modules. Then there are other solar companies like CNBN, Yingli, Trina and ReneSola from China that are also trying to set up their manufacturing base in India.

Su-kam Power Systems has joined hands with Dhampur Mills to sell solar products in the rural areas of Uttarakhand and Uttar Pradesh (UP) through ‘E-HAATS’. Dhananjay Sharma, general manager-solar networks, Su-Kam in one of his interview to *Electronics Bazaar* says, “Through this initiative, Su-Kam will sell technologically advanced solar products that offer people value for money, thereby helping them in both generating and saving energy through solar power usage.”

Indian market trend

Indian solar industry has built up quite interesting market trends through the solar power systems and other solar electronics products. Be it the Gujarat model or the new government schemes, all of them have acted as the pillars for growth of the solar market in India. Another pillar is the growing technology, where a portable, solar-powered mobile

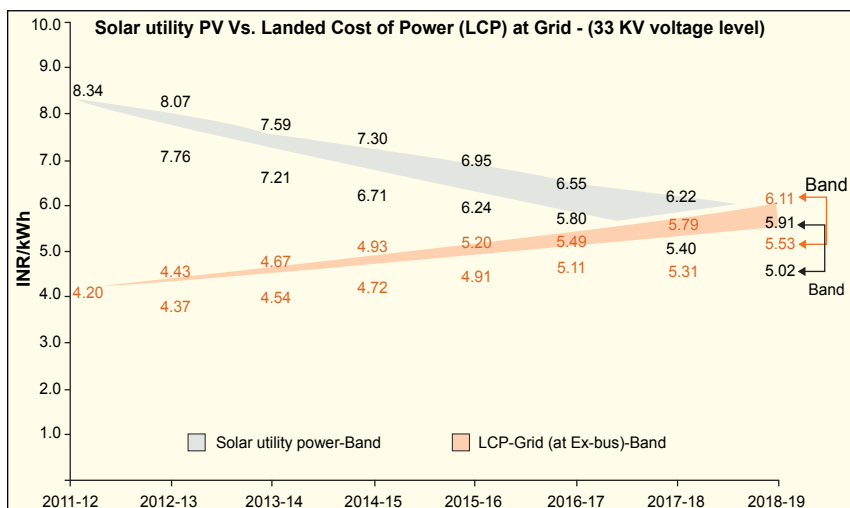


Fig. 3: Grid parity for solar power—utility level (Source: KPMG’s solar grid parity model)

phone charging system can charge about 1.2 million phones for people living off the grid.

Then there is a new micro-grid model that promises to deliver solar power to every village in India very soon. Brian Shaad, co-founder of Mera Gao Power, a micro-grid firm, elaborated in one of his meetings with Economics Times, "A customer would spend ₹ 160 a month for his mobile charging and kerosene for lamps. We charge him ₹ 100." He further said that, the model has grown fast and has been gaining 2000 subscribers per month.

There seems to be a lot of competition in the solar market currently, and the Delhi Metro Corporation (DMRC) does not want to be left out of it. They have recently inaugurated their first 500kWp roof-top solar power plant at Dwarka, sector 21. The Airports Authority of India (AAI) has signed an agreement with the Solar Energy Corporation of India (SECI) for installation of solar plants of 50MW cumulative capacity in phase one of its new initiative. This is supposed to increase to 150MW later.

Gujarat has a 'rent-a-roof' project where the locals rent their rooftops to the solar companies, which in turn pay them a sum of ₹ 3 for every unit of energy produced. Delhi government sent its team of experts and top officials to Gujarat to study it and now is all set to deploy this system in government schools and hospitals.

Even DLF is all set to install solar panels on the top of its official buildings in cities like Chennai, Gurgaon, Delhi and Kolkata. To start with, it has decided to install solar panels on the roof-tops of its commercial buildings. Companies like Aniron Solarcity (UK based) and Azure Power India have partnered up with DLF for this project to produce about 3MW of power. They will link this generated power to the main power supply to provide an uninterrupted power supply.

Government policies and initiatives

As per eftytimes.com, Piyush Goyal, the Union Energy Minister, met with



Fig. 4: Kochi power project

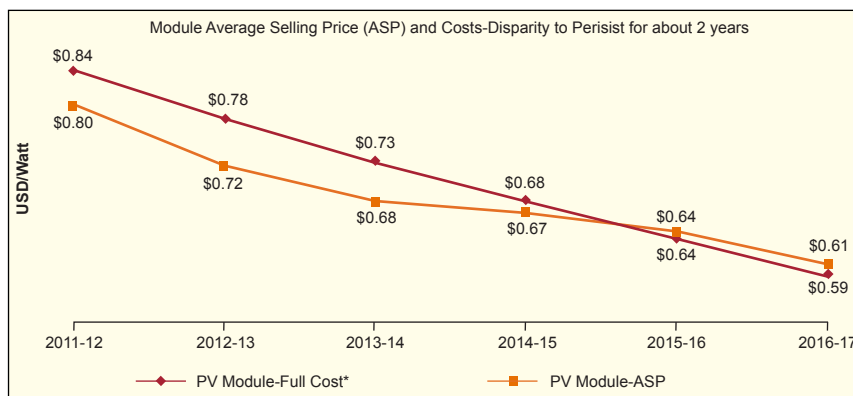


Fig. 5: Forecast of solar PV module costs

“NHPC had contacted us for offering technical know-how and installation assistance for their proposed 50MW plant” — S.P. Gon Choudhury, Renewable Energy College

officers from relevant departments recently, and asked them about the progress made on ongoing solar power projects. He also guided them for achieving greater targets in the following stage of the country's solar power mission. The ministry is planning to revamp the social system of the Jawaharlal Nehru National Solar Mission in order to auction 770MW of utility scale solar PV in financial year 2014-15, under the gap funding scheme. The Centre for Wind Energy Technology (C-WET), an independent research and development institution and a section of MNRE, has ratified an agreement with the ministry to act together and distribute critical information to match the objects related to the solar energy.

ETDC, Bengaluru, a branch of STQC, has been approved for certifying

solar inverters, street lights, home lights and lanterns. It also hints at possible amendment of the Electricity Act 2003 to encourage greater utilisation of renewable energy. This is also being supported by different cities. MNRE aims at developing 60 solar cities in India where solar energy would be used for garden lights, restaurants, hotels, street lights and administrative offices. Kochi already has a solar power plant under this scheme through which it is being turned into a solar city.

Through all this effort, the government wants to club all the solar and the conventional power sources and make renewable energy affordable to its people. Government also wants to tackle the delay in larger projects by eliminating roadblocks in the ongoing capacity addition programme

TABLE I
State-wise Solar RPO Targets

States	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
Andhra Pradesh	0.25%	0.25%	0.25%	0.25%	0.25%	0.25%					
Arunachal Pradesh	No regulation issued for RPO by the Power Department										
Assam	0.10%	0.15%	0.20%	0.25%							
Bihar	0.25%	0.25%	0.50%	0.75%	1.00%	1.25%	1.50%	1.75%	2.00%	2.50%	3.00%
Chhattisgarh	0.25%	0.50%									
Delhi	0.10%	0.15%	0.20%	0.25%	0.30%	0.35%					
JERC (Goa & UT)	0.30%	0.40%									
Gujarat	0.50%	1.00%									
Haryana	0.00%	0.05%	0.75%								
Himachal Pradesh	0.01%	0.25%	0.25%	0.25%	0.25%	0.25%	0.50%	0.75%	1.00%	2.00%	3.00%
Jammu and Kashmir	0.10%	0.25%									
Jharkhand	0.50%	1.00									
Karnataka	0.25%										
Kerala	0.25%	0.25%	0.25%	0.25%	0.25%	0.25%	0.25%	0.25%	0.25%	0.25%	0.25%
Madhya Pradesh	0.40%	0.60%	0.80%	1.00%							
Maharashtra	0.25%	0.25%	0.50%	0.50%	0.50%						
Manipur	0.25%	0.25%									
Mizoram	0.25%	0.25%									
Meghalaya	0.30%	0.40%									
Nagaland	0.25%	0.25%									
Orissa	0.10%	0.15%	0.20%	0.25%	0.30%						
Punjab	0.03%	0.07%	0.13%	0.19%							
Rajasthan	0.50%	0.75%	1.00%								
Sikkim	No regulation issued for RPO by the Power Department										
Tamil Nadu	0.05%										
Tripura	0.10%	0.10%									
Uttarakhand	0.03%	0.05%									
Uttar Pradesh	0.50%	1.00%									
West Bengal			0.25%	0.30%	0.40%	0.50%	0.60%				

Source: SERCs Order on RPO Regulations

for solar power. And to do all this, it has surveyed many cities and sites across the country, and has assessed the suitability and potential of solar power in India.

Anurag Garg, vice president-solar business, Schneider Electric India says, "Government has been amending its policies and incentives from time to time to attract investment in this sector, which have been well accepted by developers and in some states response has been very encouraging. However, as we move forward, it appears much more needs to be done to

reach the NSM targets of solar power by 2017 and 2022. Government needs to look into barriers and processes causing delay after award of project to developers and help developers with policies which can speed up the implementation of projects (for example, acquisition of land or allotment of land in solar parks, financing by Indian banks, evacuation issues for large projects). Also, some minimum guidelines for tariff should be issued and state policies should have similarities to promote solar across the country. The states with less solar irradiation and

higher demand for power should have additional incentives. While there have been differential tariffs for developers with and without accelerated depreciation, tariffs could also be differentiated by size of project, as larger projects have advantages of economies of scale vs small-size projects, and can help promote distributed energy through small-size projects."

Challenges faced and resolution

In its developing phase, every industry has many challenges to overcome,

and the solar industry too is passing through that stage. Some of these are:

Lack of skilled manpower. A major problem that India is likely to face in the future is, the shortage of skilled manpower. Sudeep Jain, chairman and managing director, Tamil Nadu Energy Development Agency (TEDA) says, "Finding good manpower for a few thousand installations every week is a major challenge, especially when TEDA is gearing up to install 300,00 home and 100,00 street solar lighting systems in the next five years." Experts think that solar-specific training in aspects like technical, detailed project reports, feasibility studies, design, technology selection and operation and maintenance is a requisite, although a B.Tech program in solar seems to be far fetched.

TEDA has planned to put up separate training sessions for the aspiring professionals in solar at its annual renewable energy event, Renergy, in Chennai. While GSES, a training organisation, has developed courses to cover various aspects of PV installation, the courses also cover sales, installation and maintenance of PV systems. One of their training course is 'Standalone Solar Power Supply Systems: Design and Installation' that is now offered in India. It covers all aspects of off-grid PV installation, including key issues in site assessment, quality and performance issues of solar PV modules, shadow analysis and planning and solar radiation.

Less number of retail products. Manufacturers state that although solar products like emergency lights, PV modules, lanterns and water heaters are available both in urban centres and villages at retail shops, their numbers are quite less. For instance, in Delhi, such products are available only at shops in the electrical market of Chandni Chowk. Solar shops like Akshay Urja (previously known as Aditya Solar Shops) that opened some time ago are either not doing good business or have shut down. Tarun Kapoor, joint secretary, MNRE, at a seminar recently said, "India's lack of retail outlets for solar

products is hampering sales to a large extent. We need to develop a mechanism wherein solar products are available in the open market so that consumers can buy these products easily."

"Since solar products do not get categorised as part of consumer electronics, we cannot expect them to be available at the typical consumer electronics shops. Although there are retail shops in cities and villages, their number is quite meagre. But with the demand rising, the number of such shops will grow," says Dr Satyendra Kumar, chairman, Saurya EnerTech. He adds, "Manufacturers are delivering their products to the market through their distributors, who are taking them to the retail shops. Retailers also approach the manufacturers directly for such products."

Until now it was the government alone that was boosting the growth of solar products, but now the scenario is changing. Seeing the demand for solar products grow in rural areas and in places with rampant power outage, manufacturers are either opening their own retail shops or tying with other retail outlets. Many other actions are also being taken care of, like Essmart Global has converted many of its kirana shops into retail shops for solar products. Anu Solar Pvt Ltd, Bengaluru-based solar product manufacturers and traders, have opened many retail shops for solar products. The store called Anu World has products like solar-powered calculators, caps with fans that run on solar

TABLE II
Solar Renewable Purchase Obligation by JNNSM

Year	Energy demand (MU)*	Solar RPO (%)	Solar energy requirement (MU) for RPO compliance	Solar capacity requirement for RPO compliance (MW)
	(A)	(B)	(A)X(B)	
2011-12	953,919	0.25	2385	1433
2012-13	1,022,287	0.25	2556	1536
2013-14	1,095,555	0.50	5478	3291
2014-15	1,174,074	0.75	8806	5291
2015-16	1,258,221	1.00	12,582	7560
2016-17	1,348,399	1.25	16,855	10,127
2017-18	1,443,326	1.75	25,258	15,176
2018-19	1,544,936	2.25	34,761	20,885
2019-20	1,653,700	2.50	41,343	24,839
2020-21	1,770,120	2.75	48,678	29,247
2021-22	1,894,736	3.00	56,842	34,152

Source: Novonous Insights

TABLE III
Solar PV Cost-Reduction Drivers

Module-Lever	2010	2012	2016
Wafer thickness (Micro meters)	200	180	125
Silver per cell (grams/cell)	0.3	0.23	0.1
Cell efficiency	14%	16.50%	20%
Glass absorption	4%	3%	1.75%
Glass reflection	0.98%	0.80%	0.55%
Glass thickness (mm)	3.2	3.2	2.85
Module to cell power ratio	97%	98.50%	100%

Source: International Technology Roadmap for Photovoltaic (ITRPV) and other estimates

power, solar water heaters and solar power based storage batteries and inverters. The significant matter to note is that, Anu World is a channel partner to MNRE and sells its products at subsidised rates.

Solar service providers, named Solar Basket, are all set to open roughly 150 stores across India by the end of this year. They claim to have about eight stores and 20 franchisees pan-India currently. So soon the cities like Guwahati, Vijayawada, Hyderabad, Itanagar, Chandigarh, Bilaspur, Surat, Panaji and Gurgaon will have solar stores too.

Not enough capital. Another im-

portant challenge faced by the solar industry in India is lack of money to invest. Piyush Goyal, power minister of the country said, "India's solar industry doesn't have enough capital to support the amount of manufacturing we are expecting from it. Hence we have requested Commerce and Finance ministries to review the proposal of imposing an anti-dumping duty on solar equipment. We expect to grow solar industry in India in the future. So, this is going to be a short-term review."

Power at a better price

The ultra mega power projects of 1000MW for solar, led by the government, have decreased the price of the solar power to ₹ 6.5 or ₹ 7 per unit in the last three years. An MNRE officer clarified that, "The bidding cost was slashed down to ₹ 8-10 per unit from ₹ 17 per unit after endless efforts of

NVVN." Sandip says, "To further decrease the power rates, we will have to bring down the tariffs on solar electronics products, increase the R&D efficiency and bring better quality products in market."

The Directorate General of Anti-Dumping (DGAD) has urged anti-dumping tariffs of up to US\$ 0.48 per watt of solar cells coming from the USA and US\$ 0.81 per watt from China. Meanwhile, it recommends duties of up to US\$ 0.62 per watt and US\$ 0.59 per watt for solar cells from Malaysia and Taiwan, respectively. DGAD has also recommended to the Finance Ministry that, India should impose dumping duty on international solar panels imported from the USA, Taiwan, China and Malaysia. Meanwhile, Tata Power Solar insists that the Finance Ministry should approve the same as soon as possible so as to save India's domestic solar manufacturing

sector from collapsing without the anti-dumping tariffs. Sandip feels that anti-dumping of the solar electronics might work, but would be effective only for a short term to sustain the price of the products, if the quality is not improved.

KPMG reports that an innovative lease model can further improve the market attractiveness for consumers by avoiding high upfront costs and reducing monthly power bills. They explain this with an example where a high-end residential consumer can install a 1kW solar PV system and reduce the marginal power consumption with a monthly EMI payment of around ₹ 2000 (without any down payment) for five years and avoid an average discounted monthly payment of around ₹ 1200 over the lifetime (25 years) of the grid. ●

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Electronics Development Fund expected soon

Central government's Electronics Manufacturing Policy proposed a fund of \$1641.49 million as Electronic Development Fund to boost the domestic electronic systems design and manufacturing (ESDM) capacity. The fund is now set to be rolled out within a couple of months. Government aims to promote innovation, intellectual property, research and development and nanoelectronics through this fund. The fund will also help to commercialise made In India products and focus on minimising imports.

A senior official associated with the ministry for Industry Promotion in ESDM sector said, "The secretary in the Department of Electronics and IT (DeitY) had forwarded the guidelines on the fund's corpus among others to the ministry and we expect cabinet approval soon." He added that a recent cabinet note on policy was influenced by market dynamics and ministry is keen on promoting this fund at least up to 2020.

The proposal for setting up this fund dates back to 2005 but it faced a lot of hurdles. The recent hurdle was created by Investment Promotion Cell (IPC) of IT ministry which said, "Adequate justification had not been provided to set up the venture capital fund for electronic ecosystem development."

DeitY proposed distribution of this fund for various activities. It expected 25 to 49 per cent of the fund for seed purpose, early growth stage activities in electronics and technology acquisition. Similarly, it proposed 25 per cent of the fund for development of electronic ecosystem and manufacturing.

However, IPC still believes that 100 percent government-supported venture capital fund cannot boost the private sector participation and wants

Manoj Verma joins NTL

Manoj Verma, having 32 years of experience with global leaders and MNCs, has taken over as the global president and director of NTL Lemnis. He will also be a member of the Advisory Board of NTL Electronics, the parent company. He started his career with Philips and after 17 years he moved to GE Lighting India to head their professional lighting business. He then worked with Osram India, Crompton Greaves and the CK Birla group as CEO of Orient Electric.

to include telecom department as one of its member of the funding board. DoT was a member of National Manufacturing Competitiveness Council and policy of DeitY has close link with manufacturing of telecom equipment.

Solar parks to host up to 20GW power

The government has plans to furnish low-cost loans and come up with solar power parks across the country to host about 20GW of capacity, which is ten times of what it has established to date. Speaking about the initiative, Tarun Kapoor, joint-secretary, Ministry of New and Renewable Energy said, "We are preparing a scheme for solar parks and it will be out after cabinet approval in about one month."

India is designing some of the world's largest photovoltaic plants as it attempts to bring the costs down and promote generation. It aims at producing power from about four ultra-mega projects at a peak of ₹ 5500 megawatt-hour, which is 32 per cent below the global average, as per the data accumulated by Bloomberg.

The parks will have large plants ranging between 500 to 1000MW power that will be affiliated to the grid. Government subsidies will maintain a very humble price of land within the parks, in order to control project costs, Kapoor said. State utilities will be asked to purchase at least 20 per cent of the power rendered at the parks. Project owners will be free to sell and send the balance to consumers elsewhere in the country.



Solar park

In Focus

Calendar of Forthcoming Electronics Fairs/Exhibitions/Seminars/Events

Name, Date and Venue	Topics to be covered	Contact address for details
EMMA Expo India September 11-13, 2014 Bangalore International Exhibition Centre, Bangalore	Electronics, machinery, auto parts & accessories	Claire Liu Phone: +886-2-2725-5200 #2864 E-mail: claireliu@taitra.org.tw
ELCINA-EFY Awards September 26, 2014 India Habitat Centre, New Delhi	Awards for excellence in electronics hardware manufacturing and services	EFY Enterprises Pvt Ltd Phone: 26810601/2/3, +91-8800094213 E-mail: efyexpo@efyindia.com
3rd Electronics Rocks 2014 October 10-11, 2014 Nimhans Convention & Exhibition Centre, Bengaluru	A platform for design engineers, R&D engineers, entrepreneurs, academicians, hackers and hobbyists including talks, workshops, discussions, product launches and design challenges	EFY Enterprises Pvt Ltd Phone: 26810601/2/3, +91-8800094213 E-mail: electronicsrocks@efyindia.com Web: www.electronicsocks.com/
ElectronicAsia October 13-16, 2014 Hong Kong Convention and Exhibition Center, Hong Kong	In conjunction with 'HKTDCC Hong Kong Electronics Fair (Autumn Edition)' highlights solar, displays and key components for smart devices	Hong Kong Trade Development Council (HKTDCC) Phone: (852) 2584 4333 E-mail: exhibitions@hktdcc.org Web: http://electronicasia.com/ex/05
OSI Days 2014 November 7-8, 2014 NIMHANS Convention Center Bengaluru	Open Source conference in Asia that aims to nurture and promote the open source ecosystem in the sub-continent	EFY Enterprises Pvt Ltd Phone: +91-088000 94211 E-mail: atul.goel@efyindia.com
Electronica/Productronica 2014 November 11-14, 2014 Munich, Germany	Electronic components, production equipment, systems and applications	MMI India Pvt Ltd, Mumbai Phone: (022) 42554700, 42554723 E-mail: Andrea.dsouza@mmi-india.in
Intersolar India November 18-20, 2014 Bombay Exhibition Centre, Mumbai	Exhibition and conference for the solar industry featuring photovoltaics, PV production technologies, energy storage and solar thermal technologies	MMI India Pvt Ltd Phone: (022) 42554700 E-mail: brijesh.nair@mmi-india.in
2nd EFY Expo- Western India Edition 2014 November 26-28, 2014 Bombay Convention & Exhibition Centre, Mumbai	For manufacturers, engineers and traders to source electronics components, products and services and to find latest offerings and dealers and distributors for products	EFY Enterprises Pvt Ltd Phone: 26810601/2/3, +91-8800094213 E-mail: efyexpo@efyindia.com Web: www.west.efyexpo.com
LED Expo 2014 December 5-7, 2014 Pragati Maidan, New Delhi	Exhibition and summit on LED lighting products and technology	MEX Exhibitions Pvt Ltd Phone: +91-9312285142 E-mail: info@themediexpo.com
2015 International CES January 6-7, 2015 Las Vegas Convention Center Las Vegas, USA	A mega consumer electronics event where new innovations and technologies are showcased	Consumer Electronics Association Phone: +1 703-907-7605 Web: www.cesweb.org
SPS Automation India February 5-7, 2015 Mahatma Mandir, Ahmedabad	Industrial control systems, sensor technology, ideal business platform	Messe Frankfurt Trade Fairs India Pvt Ltd Phone: +91 22 6144 5900 Web: www.in.messefrankfurt.com
Electronics For You Expo 2015 February 26-28, 2015 Hall 7 (A, B, C, D, E, F, G, H) Pragati Maidan, New Delhi	Covering complete electronics ecosystem, including innovation, manufacturing, design and sales	EFY Enterprises Pvt Ltd Phone: 26810601/2/3, E-mail: efyenq@efyindia.com Web: www.efyexpo.com
EFY Awards March 13, 2015 Bengaluru	To give recognition to the leading enterprises and individuals in the Indian electronics field	EFY Enterprises Pvt Ltd Phone: 26810601/2/3, +91-8800094213 E-mail: efyawards@efyindia.com Web: www.efyawards.com
International CES Asia, 2015 May 25-26, 2015 Shanghai New International Expo Center (SNIEC), China	Tech powerhouses to innovative startups, 3D printing, robotics, sensors, the Internet of Things and wearables	Shanghai New International Expo Center (SNIEC), Shanghai, China Phone: 703.907.7603 E-mail: afried@ce.org

Look up under 'Events' section in www.electronicsforu.com for a comprehensive list

Since this information is subject to change, all those interested are advised to ascertain the details from the organisers before making any commitment.

Apart from this, India plans to sell 1,500MW of photovoltaic capacity in its biggest bid to date. The final guidelines will be published soon and the first 750MW will be accoladed in bidding by the end of September, as stated by A.K. Maggu, general manager of state-run power trader NTPC Vidyut Vyapar Nigam Ltd. The company is supervising the procedure.

Andhra prepares to make it big in electronics sector

Electronics and IT sectors are going to be the main focus of the Andhra Pradesh government in the near future. Job creation is a main agenda on their list and around 500,000 people will be covered in this employment drive, according to Chief Minister N. Chandrababu Naidu.

A release from the state government quoted him as saying, "The new IT policy would emphasise on the need for mega infrastructure, quality human resources and good governance." Naidu would also focus on start-ups which are going to be a major part of new policies along with those companies which are using social media, mobile, analytics and cloud (SMAC) and IoT technologies.

Naidu is aiming to develop Andhra Pradesh as a knowledge hub which will be known globally for its focus on quality of citizens' lifestyles. This enhancement can be done only through high-quality education and more technology. Premier IT institutes will be established in the state with government support which will majorly focus on semiconductor industry, manufacturing of electronic goods and components. The CM also emphasised that to boost technical education, internship should be made compulsory in the final year of under-graduate courses in software, electronics and computer science.

Students and aspiring technical experts should engage in out-of-the-box thinking and reading study books will not be of much help. He said, "If students focus on skill development, India can rise to global standards

Snippets

Infosys awarded LEED 'Platinum' rating for building

The new M&C building of Infosys in Bengaluru has been awarded the Leadership in Energy and Environmental Design (LEED) India 'Platinum' rating by the India Green Building Council. The LEED Green Building Rating System is a globally accepted benchmark for design, construction and operation of high-performance green buildings. Platinum-certified buildings at Infosys now cover about 300,000 square metre of space.

Surya Group to invest in new LED products

Surya Group is planning to foray into the LED segment. The company will enter this market with 50 new products for which it will invest ₹ 250 million. A state-of-the-art technology has been adopted by Surya and they intend to come out with some of the best products in the LED lights segment.

and stay on par with China and the USA." Naidu aims to match the scale of China as a manufacturing hub as Indian resources have the potential to accomplish the same.

Bengaluru to nurture start ups

Karnataka government is keen to make Bengaluru's position stronger as the country's start-up capital and the government has started a partnership with Nasscom. This new collaboration will launch India's maiden hackcelerator which is expected to start functioning by November. Labs will also be set up in the new facility for projects related to IoT, mobility and design. These labs could get support from Cisco and Intel through equipment, technology and funds.

The Startup Warehouse presently houses 28 start ups and is built in an 800 square metre facility. An expansion up to 5,000 square metres is getting planned for 500 entrepreneurs. Srivatsa Krishna, the state's IT secretary, said, "We will invest 40 to 50 million rupees in the new facility. We are talking to three or four large private companies to become co-sponsors of the hackcelerator."

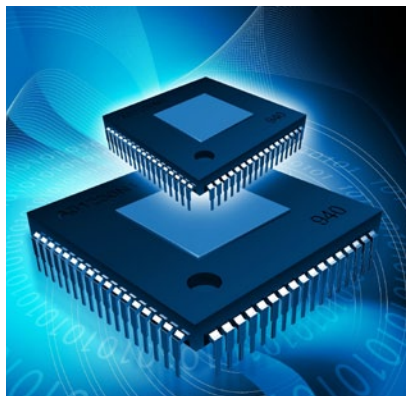
Nasscom Product Council's chairman, Ravi Gururaj, said, "The new facility can house over 100 start ups. Industry partners will mentor and nurture the start ups, execute skill development workshops, and assign executives-in-residence to provide specialised skills in areas of product

development, mobile and Internet of Things."

To promote entrepreneurship in tier-2 cities, new incubation centres were launched by the government in nine engineering colleges. IT minister S.R. Patil said, "These centres will receive state support of up to ₹ 4 million per college over a period of three years. All the incubation centres will be networked to exchange experiences and learn from one another."

West Bengal wants a chip design centre

Centre, which has plans to set up manufacturing units for semiconductors in the country, got a push from West Bengal government for the same. Chairman of West Bengal Electronics Industry Development, Hirak Sengupta said, "The West Bengal government will approach Centre for the investments." Talking to the reporters on the



Chips

sidelines of a seminar on electronics industry organised by Bengal Chamber, Sengupta informed that Centre had chalked out big plans involving huge investments in this plan.

He added that West Bengal also needs to pool money for the investment. "In order to capture the big chunk of this industry, the focus should be on semiconductors manufacturing centres." Presently, West Bengal contributes four percent share in Indian electronics market. This is the reason why government is laying stress on electronic systems design and manufacturing (ESDM), added Sengupta. He said that as mobile and TV market is up, this industry can be uplifted well.

RenGen Powertech to make solar inverters

Chennai-based ReGen Powertech, the wind turbine manufacturers, are planning to diversify into renewable energy sector in collaboration with their German partner Vensys. This new partnership will lead to creation of mega-watt solar inverters. Joint managing director, R. Sundaresh, told reporters, "The company would soon come out with hybrid inverters for wind and solar power generation." He continued, "The solar inverters will be made at the company's existing factories at Tada in Andhra Pradesh and Udaipur in Rajasthan."

Solar division's head, Anirudh Khemka, said that the company's focus will remain on large solar projects and the cost of the inverter will depend on the configuration required by the buyer. He said, "Going forward, ReGen would come out with hybrid inverters targeting the wind and solar power sectors."

Madhusudan Khemka, managing director, said, "No major additional investment is involved for the project as we will be making the product at the existing factories. The product is also largely similar to the inverters we make for wind power sector." ReGen plans to make 1MW, 1.5MW and 2MW solar inverters.

Check efytimes.com for more news, daily

NEW PRODUCTS

RECENTLY INTRODUCED IN INDIA, FROM NEAR AND FAR

COMPONENTS

Reed proximity sensor

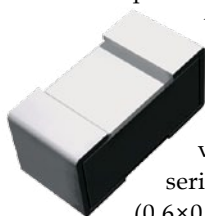
Standex-Meder Electronics announces its MK15-501 magnetically-operated reed proximity sensor for surface-mount device (SMD) mounting. It is ideal for position-detection in surface-mounted PCB assemblies, meter anti-tampering sensors and lid-detectors in household appliances, as well as heating, ventilation and air-conditioning due to its simple internal structure. It is available in two lead designs: straight leads for cutting and PCB slot mounting and bent SMD gull-wing leads used when the wire coming from a chip bends horizontally to make contact with a solder pad on a substrate.

With only 16×2.8×2.8mm size, the MK15-501 is excellent for low-power operations, requiring no external power for sensor operation. It is especially useful for magnetic systems requiring long operating distances with permanent magnets. Available in four operating sensitivities, it is also available for high-power switches. The sensors are supplied taped and reeled according to IEC 286-3, suitable for auto-placement. The magnetic pull-in sensitivity is divided into several AT classes at 5 AT steps each.

Standex Engraving India Pvt Ltd, Bengaluru
Phone: 08110415154
Website: kkasaragod@standexmeder.com

Low-value chip resistors

ROHM has developed low-ohmic chip resistors optimised for current detection applications in compact equipment such as smartphones and wearable devices. The UCR006 series of ultra-compact (0.6×0.3mm/0.2×0.1-inch) thick-film chip resistors is offered in resistances as low as 100mΩ, providing



greater energy savings. These are also the first 0603-size(mm)/0201-size(inch) resistors in the industry to ensure a temperature range of -55 to 155°C in the low-ohmic region, and feature twice the rated power compared with competitor products in the same size, enabling support for a wide range of applications. This higher power handling capability in a smaller size makes them ideal replacements for larger 1005-size(mm)/0402-size(inch) resistors, contributing to further miniaturisation.

ROHM's latest series utilises new materials and a new structure to achieve class-leading low resistance (100mΩ) in a 0603-size(mm), thick-film design. In addition, heat dissipation is improved, and rated power is increased to 0.1W—twice that of conventional products. Operating temperature range has also been expanded in the low-ohmic region to an industry-best of -55°C to 155°C, enabling compatibility with a greater variety of applications. And unique laser trimming technology makes it possible to achieve a resistance tolerance of ±1% (F Class), which has been traditionally difficult to realise at low resistances. These new products have adopted the reverse-mount design utilised in the existing series in order to minimise resistance variations during soldering and ensure a temperature coefficient of resistance (TCR) between 0 and 300ppm/°C, which reduces resistance fluctuations due to temperature changes. This provides high-accuracy current detection required by today's high-performance devices.

ROHM India Private Limited, Bengaluru
Phone: 080-4149290, 41250811
Website: www.rohm.com

LED driver

GlacialPower has launched dual-mode GP-LC7028 LED driver powering LED lighting of 7W to 20W. Featuring constant-current or constant-voltage operation, the LED driver mode and power

output can be adjusted to fit a variety of lighting and signage applications. Power input and output lines are connected via robust and easy-to-use clips.



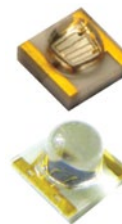
The GP-LC7028 is almost like two LED drivers in one, with DIP switch for either constant-current or constant-voltage mode for enhanced functionality. It can be customised to specific LED-lighting needs with eight modes of constant-current (from 250mA to 700mA) and constant-voltage (from 12V, 24V and 28V) operation. For constant-current mode, 1V to 10V dimming and push dimming can also be enabled with a dimmer.

GlacialPower, New Delhi
E-mail: sales@glaciallight.com

High-power LEDs

Taiwan Semiconductor Lighting Company has launched 65 degree products for unique applications like floodlights, bay lights and automotive applications. With a 125/65 degree silicone lens, the A3535L-xxx2 and A3535M-xNx2 LEDs feature high Tj 150, high brightness and efficiency, as well as a good lifetime.

Pine Valley, Bengaluru
Phone: 09871155223
E-mail: gopal@semileds.com
Website: www.tslc.com.tw



INFORMATION TECHNOLOGY

Development platform and Wi-Fi

Texas Instruments SimpleLink Wi-Fi CC3200 LaunchPad and CC3100 BoosterPack, a development platform and Wi-Fi device created for faster and easier implementation of solutions for the Internet of Things (IoT), is now available through element14.

The LaunchPad kit is the industry's first single-chip programmable microcontroller with built-in Wi-Fi connectivity suitable for applications in cloud connectivity, home automation, safety and security, health and fitness, and metering. It features on-board emulation using an FTDI device and has temperature sensors, a 3-axis accelerometer, LEDs and push-buttons. This SimpleLink-enabled wireless microcontroller, based on the high-performance ARM Cortex-M4, enables developers to create an entire application with a single IC. It comes with driver support and an SDK with over 40 applications for Wi-Fi protocols, Internet applications and microcontroller peripheral examples, together with user guides, design files and API guides.

One can add Wi-Fi to an external host microcontroller with the CC3100 BoosterPack, a next-generation SimpleLink Wi-Fi device, for easy implementation of Internet connectivity including security, quick connection and cloud support. This simplifies the creation of IoT solutions with advantages such as reduced development time, lower costs, space-saving, ease of certification and less need for RF expertise. Moreover, it can run on two AA batteries for over a year which, for the first time, brings embedded Wi-Fi capabilities to battery-operated end-equipment. In addition, advanced emulation accessory board CC31XXEMUBOOST is available for flashing updates to the CC3100BOOST, using the radio tool for RF performance evaluation and for advanced FTDI debugging.

element14 India Pvt Ltd

Phone: 1800 3000 3888 (toll free)

E-mail: in-sales@element14.com

POWER SUPPLIES

Inverter cards

Vidyut Systems has launched industrial-grade high-surge-capacity 3kVA and 5kVA, both 48V DC, inverter cards, code named VS 3048 and VS 5048, respectively. These are especially designed keeping in mind the Indian power conditions and changing requirements of industrial and



domestic consumers. The cards are best suited for high-torque motors, petrol pumps, compressors, deep freezers, air-conditioners, washing machines, microwave ovens, computers, laser printers and lighting, etc. These have high-efficiency, battery-friendly charging systems, which can charge the batteries very fast (max. charging current 25A) without heating them. Some other features are: in-built fault-diagnostic aids, user-settable system, black-box technology and modular design.

Vidyut Systems, New Delhi

Phone: 09971692678

E-mail: anil.vidyut@gmail.com

Website: www.vidyutsystems.com

TEST & MEASUREMENT

Digital clamp meter

MECO-G has introduced a new series of three-and-a-half-digit handheld clamp meters with backlit LCD display to measure AC and DC voltages, AC current, resistance, capacitance, temperature and frequency. Additional features like diode test, transistor check, continuity check, low-battery display, data hold and auto power-off are also available.



Full range of overload protection and unique design make these meters superior-performing instruments, according to the company. These meters are useful for various industries, manufacturing units and domestic purposes.

Goliya Instruments Pvt Ltd, Mumbai

Phone: 022-24149657, 24179467

E-mail: sales@goliyainstruments.com;

info@goliyainstruments.com

7-in-1 instrument

Scientech's Design Lab 7-in-1 instrument can make life easier for engineers, technicians and serious hobbyists by reducing mess on workbench. It incorporates 2-channel DSO, 16-channel

logic analyser, mixed signal oscilloscope (one analogue plus eight digital), synthesised function generator, pattern/word generator, programmable clock generator and variable power supply.



This compact instrument, having interactive virtual graphical interface, provides USB interface and saves the screenshots as images. User can see separate windows for each instrument. One has to just connect a laptop/PC for viewing the images on screen, or take printouts. No node locking, so the compatible software can be installed on various machines.

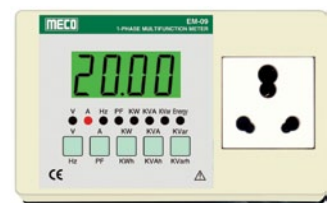
Scientech Technologies Pvt Ltd, Indore

Phone: 0731-42111100

E-mail: info@scientech.bz, vmantri@scientech.bz

Multifunction appliance meter

MECO offers single-phase multifunction appliance meter TRMS, model EM09 (1A, 5A and 20A). It measures 10 parameters on 10 display pages on a 20mm LCD display. It is equipped with five keys to view the parameters and program the meter.



The meter, ideal for HVAC industry, measures V, A, PF, Hz, kW, kVA, kVar, kWh, kVAh, kVAh and TRMS. It can be used for continuous monitoring, auto/manual scroll display (user-selectable) and microcontroller design. It is portable, easy to carry and simple to use. Has an LCD display with backlight, RS-485 port (5kV isolated) with MODBUS RTU protocol (optional) and Power Master software for MIS reports (optional). It can also be used for appliances and LED lights testing.

MECO Instruments Pvt Ltd, Navi Mumbai

Phone: 022-27673311-16, 27673300

E-mail: kishor.thakare@mecoinst.com

EFY Design Contest

Hello EFY! Let me start by saying this: "I am a big fan of EFY." I am an ECE, B.Tech 2014 pass out. In my college days I used to visit our library just to read EFY magazine.

You are the inspiration for doing 20+ projects in my academic years and to achieve merit prizes from NITs and big universities. You can see some of my projects at <http://www.waytoembedded.blogspot.in/>

I saw announcement about 'Electronics For You Design Contest' on your site some time ago. I want to exhibit two major projects for this competition: (1) Wireless Sensor Network Based Home Monitoring System and (2) Quad-copter for Live Streaming and Communication, which I hope to complete by November end.

M. Sundeep Goud
Hyderabad

EFY: The contest was announced last year and the winners were awarded during Electronics For You Expo held in February this year. The next contest has not yet been announced. But you also have the option of submitting your projects, which seem to be very interesting, for publication in EFY magazine.

Embedded Projects

I am an engineering student and I need to design a mega project on embedded systems. Can you please help me with some of the latest designs and descriptions of the projects?

Sangpriya Tiwari
Through e-mail

EFY: You will find quite a few projects in previous issues of EFY magazine. Also, we give hands-on training on some subjects through EFY Tech Centers (see efytechcenter.com).

Temperature Controller for Small Cooling Fans

The circuit in August issue drives a cooling fan (12V, 1.2W) and the negative temperature resistors are placed on hot items. These reduce in resist-

'Spot An Error' Award Winners

In 'Perfume Vaporiser Adaptor' circuit published in August issue, C1 (150nF) is used in the circuit diagram and also mentioned in parts list but is missing in the component layout for the PCB. It should be placed between the LED and diac DB3.

Akkanagamma S.M.

□ In 'Perfume Vaporiser Adaptor' circuit published in August issue, it is written that, "It is an inexpensive solid-state heat controlling circuit built around the commonly available triac BT139 (TRIAC1)." It should be BT136.

Somnath Biswas

□ In the eStyle First Look section in August issue, under 'Videocon Introduces VPhone,' the display is mentioned incorrectly as QVCA instead of QVGA display.

Siddharth Kaul

ance when the items get hot and the fan increases in speed. The fan takes 100mA when connected to the 12V supply. The whole circuit is over-designed and quite unnecessary.

First, what is the function of R8? The text says the voltage across this resistor will be up to 1.35V. But when 100mA flows, the maximum voltage will be 100mV. So why specify 1-watt resistor?

Second, what is the function of the 10-ohm resistors? The resistance (or impedance) of the fan is about 120 ohms. The NTC resistors will drop to 42 ohms when all are detecting 100°C. This makes the whole resistor network equal to about 10 ohms. If you remove the 10-ohm resistors, the NTC resistors only have to detect an additional 10°C to achieve the same overall resistance. Or you can use 330R NTC resistors.

Third, what is the function of diode D1; what is it protecting?

Fourth, what is the function of LED2? The fan will always be operating.

Colin Mitchell
Australia

The author, Petre Tzvetkov, replies:

The circuit was meant to illustrate the basic principles and for some educational value. One can apply or not apply the methods and the design principles listed below at own risk:

1. The circuit illustrates the simplest thermal controller with NTC or

PTC and a DC motor.

2. We connect several NTCs (NTC1 to NTC4) in parallel to reduce the self-heating effect and to have good accuracy of the controller.

3. We use equalisation resistors (R2 to R5) to reduce the differences between the NTCs (if needed).

4. The usage of series resistor is for measurement of the current of the DC motor. The value of the resistor (R8 = 1 ohm) is selected for fast and easy calculation of the current of the motor.

5. Usage of larger components is for easier and permanent attachment of the clips (connectors) of the measurement equipment. R8 is 1W resistor in that case. In case of blocking of the DC motor, or short circuit in the DC motor, that resistor will not burn immediately.

6. Usage of indicator LED2 is to show approximately the applied voltage over the DC motor and the speed of the DC motor.

7. Usage of resistor (R1) is to give some initial value of the current for the DC motor.

8. D1 protects the measurement and the on/off electronics for that circuit, and to some degree LED2.

9. The circuit is designed to resist blocking or short circuit of the DC motor, and some errors which could occur when it is implemented, especially when used for educational purpose or by non-experienced persons.



Q1. I am an engineering student and want to do a project on Linux platform. Please suggest.

Palu Patil
Through e-mail

A1. An interesting way to learn and build projects on Linux platform is to use Raspberry Pi. It is a wonderful ARM microcontroller-based development board that can run Raspbian, Risc OS, Arch, Raspbmc and Pidora Linux on it. With the availability of various GPIO pins, you can control any hardware and develop innovative applications. The Raspberry Pi Foundation recommends Python as a language for learners. However, any language which will compile for ARMv6 can be used with Raspberry Pi. So you can use Python, C, C++, Java, Scratch and Ruby, all of which come installed by default on Raspberry Pi. EFY is regularly publishing articles on Raspberry Pi since April 2013.

Q2. Thanks for answering our query on MATLAB colour detection in July issue. We have been able to detect colours. Can human face also be detected with the same algorithm?

Pooja
Through e-mail

A2. No, you will have to use different algorithm for that. Face detection has been regarded as one of the most complex and challenging problems in the field of computer vision due to large variations caused by differences in facial features, lighting and expression.

There are different types of algorithms that can be used for face detection. With MATLAB you can use Viola-Jones algorithm. Cascade-

ObjectDetector function in MATLAB uses Viola-Jones algorithm to detect human faces, noses, eyes, mouth or upper body. You can also use the trainCascadeObjectDetector function to train a custom classifier to use with this System object.

Q3. The solder I am using mentions 60/40 on its cover. What does it mean? What are the different types of solders available in the market?

Bhaskar Pandey
Through e-mail

A3. Solder is a metallic alloy that, when melted with a heated soldering iron, can join metallic sur-

same applies to solidification too. The third composition (62/36/2) is used for professional-grade products. For regular electronics works 63/37 is recommended.

These compositions are not used in European countries where lead-free soldering is a primary requirement. The European Union now requires all commercially-available electronics to use lead-free components, including solder. Lead is used to reduce the melting point of the alloy. With lead-free coming in, different metals need to be used.

Lead-free solders are a bit harder to use as these do not flow as nicely or at as low a temperature as lead-

TABLE I
Different Compositions

Type	Tin (Sn)	Lead (Pb)	Silver (Ag)	Melting temperature
60/40	60%	40%	0%	183-190°C
63/37	63%	37%	0%	183°C
62/36/2	62%	36%	2%	179°C

TABLE II
Lead-Free Solder Compositions

Sn96/Ag4
Sn96.5/Ag3.5
Sn93.6/Ag4.7/Cu1.7
Sn95.2/Ag4/Cu0.8
Sn95.2/Ag3.9/Cu0.9
Sn95.2/Ag3.8/Cu1
Sn95.5/Ag3.5/Cu1
Sn96.2/Ag3/Cu0.7
Sn96.5/Ag3/Cu0.5
Sn96.2/Ag2.5/Cu0.8/Sb0.5



Fig. 1: 60/40 solder wire

faces together. The most common solder compositions used for electronic circuits have tin (Sn), lead (Pb) and silver (Ag) elements. Table I shows different compositions and their melting temperatures.

The most widely used composition in India is 60/40 (refer Fig. 1). This composition doesn't melt at a specific temperature. It melts in a range of temperatures as shown in Table I. 63/37 is more modern, and it melts at a specific temperature. The

based solders. When lead-based solder is used, good joints can immediately be seen as these are shiny and convex shaped. And

with very little practice, you can master good soldering. However, in case of lead-free solder, good joints are not shiny, and it is very difficult to visually detect a bad joint. Table II shows some lead-free solder compositions.

Answers compiled by EFY technical editor, Ankit Gupta. Letters and questions for publication may be addressed to Editor, Electronics For You, D-87/1, Okhla Industrial Area, Phase 1, New Delhi 110020 (e-mail: editsec@efy.in) and should include name and address of the sender

“Each manufacturer has its own strategy on what to test and where”

Everybody uses mobile devices, but how many of us know the secrets of testing these? Lauri Antila, vice president-marketing and business development, JOT Automation spoke to EFY about the latest in mobile testing and the role of automation. JOT Automation, founded in 1988, develops test and production solutions for smart products, components and electronics



LAURI ANTILA
VICE PRESIDENT-MARKETING
AND BUSINESS DEVELOPMENT,
JOT AUTOMATION

Q: What are the most important parameters that should be tested in a mobile device?

The job starts from the board-level testing, i.e., testing the phones as PCBs and PCB-panels. In addition to electrical testing of the device, we should also take care of software flashing and RF-tuning. In other words, completely integrated and customised test solutions are needed. In the final testing phase, we simulate the use of smart phones using a variety of advanced sensor and robot technologies in a repeatable and reliable environment. In practice, our solutions test the proper functionality of microphones, loudspeakers, cameras, radios, dimensions, push buttons, signal lights and displays, touch-screens, and also the testing of all the physical connectors and interfaces, such as USB and audio plug.

Q: What would be an optimal method to test mobile devices, that allows minimum time to market?

The best solution would be one that is suitable for a variety of test strategies, processes, end products and applications, which makes them future-proof investments for manufacturers of smart devices. This ensures cost effectiveness for the test equipment. One of the key benefits of such a solution is that the very same test solution can be taken from R&D to production to secure efficient and swift production ramp up. The other key benefit of the solution is the modular system architecture, which enables it to easily adapt to production-volume variations during a product's life cycle, and also between the production lines and factories.

Q: How is the industry speeding up development cycles and overcoming capacity challenges?

Modularity and re-configurability is a must here. It is simply not possible to design manufacturing solutions from the scratch for new products. The answer for these kind of needs is platform(s) that can easily be adopted to new product variant or even totally new product. In practice you need only new test fixtures when changing product in production. This can be achieved in production testing both at board level and product level testing. Once verified and integrated to a customer's production testing processes, changing the products to be tested is rather simple. Even test fixtures are based on

standard components, so basically ramping up new products is about configuring new fixtures.

Q: How important is automation in production testing?

As a simple example, you would use automated solution, instead of operator's eye, to verify the functionality of the camera zoom. And to get exact automatically generated report about the quality of the process for each step and functionality. In general, this will put OEMs to better position.

Q: Are the test systems developing the way the industries want them to?

Smart phones get smarter and smarter and require even more testing than before. To keep the costs of testing on an acceptable level it is very important to have all the parties involved in development work. Many of the decisions regarding the efficiency of production testing are already made by chipset providers.

Q: What flaws are caused during manufacturing process?

During board assembly you can have problems with components or with the assembly process of components. In product assembly you don't necessarily get smart phone screen exactly placed where you want to. Or maybe the screen wasn't glued perfectly because of some dirt. Did we download the latest software release approved? A lot of things go wrong, and the sooner you detect the flaw the better. Product design and its quality is one thing, quality of the incoming components is another thing and quality of the manufacturing process as such is still another thing. However, everything is related and each manufacturer has its own strategy on what to test and where.

Q: Which features on a phone are the most challenging to test?

Many electromechanical features can be tricky. One example could be the exact functionality of push buttons. Human fingers are very sensitive but every finger is different. Automating that touch sensitiveness is pretty challenging. Another example of the challenging testing is the testing of antennae in production environment. ●

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