In Phase

IIT Guwahati-Cepstrum Magazine

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Annual Issue 2009

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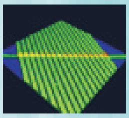

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From the editor...

In Phase has successfully entered into its third year of existence and I heartily congratulate all who have been nurturing it so hard from the last two years. With this issue, we bid farewell to our former Editor-in-chief Mr. Talla Vamsi. The new team promises to keep up the good work, to keep bringing to you the latest happenings in the field of Electronics & Communication.

In the latest issue of "In Phase" we take you with us on a walk down the memory lane revisiting previous issues and honoring some of their best articles. Also to share with you all the achievements of In Phase in these two years. In Phase has acquired a status of a reputed e-magazine worldwide and now planned to go on paper too.

This issue also features an article on recent economic crisis and its effects on electronic industry. Recession on a whole has affected one and all world wide and we as student and future industrialists, entrepreneur are bound to be curious about the same.

Also we have initiated a discussion on Memristor, the fourth circuit element along with resistors, capacitors and inductors. Its very interesting to study about its conceptualization and its final discovery.

We have also given the current Placement statistics of ECE department in our placement column. Along with a section featuring all the graduating B.Tech students of ECE department.

As this happens to be the annual issue most of the articles have been republished for our newly joined reader group. We thank you all for your support and co-operation and hope that you would continue to support us in future through your comments, views and constructive criticism.

Atul Sancheti
Editor-in-chief
(Third Year B.Tech)

Team In Phase

Faculty-in-charge:
Dr. Amit Kumar Mishra

Editor-in-chief:
Atul Sancheti

Members:
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Vishal Bhola
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Cartoonist:
Peter

Call for Articles

We are looking for technical as well as non technical and experience sharing articles from students, alumni, faculty members and industry professionals. Articles pertaining to completed/ongoing projects, views, discussions, topic introductions, applications and professional or educational experiences are most welcome. Articles must be 1500 - 3000 words in length and should be written keeping in mind the diverse range of targeted audience including people with little as well as extensive knowledge of electronics. Please email us at inphase@iitg.ernet.in for any clarifications or suggestions.

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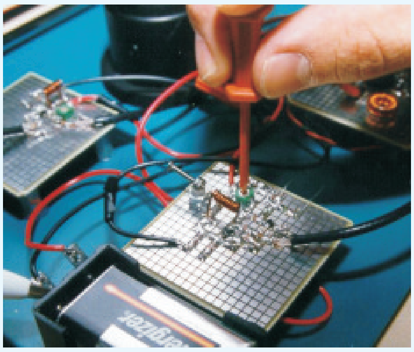
Is Analog a DEAD art??

Once upon a time, all electronics were analog. With passage of time analog electronics evolved into digital and as a result of its widespread application and tremendous popularity we live in a so called digital era. Over the past decade or so, though, the proportion of analog in an integrated-circuit design has been shrinking, until it now represents only about 20% to 25% of the design. In this article we attempt to examine the relevance of analog electronics in today's "digital" world. While this statement itself seems to suggest the demise of analog electronics, we would like to remain more skeptical regarding this issue. With the help of a couple of examples, we hope to demonstrate the (diminished) importance of analog electronics.

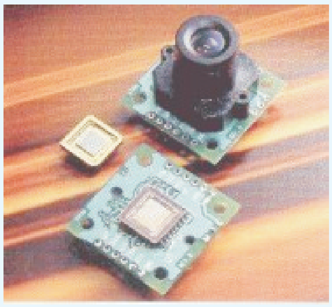
First of all, let us differentiate between analog and digital electronics. Analog Circuits are those which accept/output a continuously variable signal whereas digital Circuits, on the other hand, operate at a set of discrete levels, rather than over a continuous interval. If we look closely into digital electronics, the two discrete levels namely logic '1' and '0' are realized using analog voltage levels. Most commonly logic '1' is realized by analog voltage 5V and logic '0' by analog voltage 0V.(With some noise margin depending on TTL/CMOS technology). The most basic digital component NOT gate is realized using 2 MOS/BJT's. So, if we go by this realizations we can say that every digital component is analog in nature and hence we live in an analog world and hence the debate is over. But let's not jump the gun that easily!

Analog V/s Digital

Consider the advantages of digital systems over analog devices: noise levels and design difficulty being the primary ones. Noise is a broad term that refers to unwanted "noisy" signals being superimposed on the "good" signals being transmitted. The effects of noise can be quite easily



reduced in digital circuit because of the presence of discrete levels. For example in TTL input signal, high logic is realized between 5 to 2 V and low between 0 to .8 V. So, if the input signal is corrupted between this range the system is immune to the noise. The relatively low probability of such high levels of noise, together with better parity check mechanisms mean that noise plays a very small role in the design of digital systems. But since in analog circuits each analog voltage/current is an acceptable input, they are fraught with information losses and significant care has to be taken to prevent noise.



Design difficulty is another important factor in analog systems being phased out. When one compares a digital and an analog circuit that perform similar functions, the digital circuit will undoubtedly be simpler to design and debug.

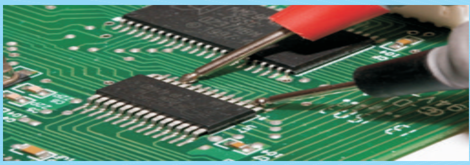
There are several other advantages that digital systems enjoy over their analog counterparts. Transmitting information digitally requires significantly less bandwidth than analog information transmission. A case in point is the newly introduced High Definition TV or HDTV for short. Early HDTV systems used analog broadcast formats, but all recent HDTV systems use digital transmission because of bandwidth considerations.

The SVGA Standard

Consider the introduction of the Super Video Graphics Array Standard, defined by the Video Electronics Standards Association (VESA), as a successor to the VGA Standard. We couldn't put it better than Wikipedia:

"Super VGA was first defined in 1989. In that first version, it called for a resolution of 800 × 600 4-bit pixels. Each pixel could therefore be any of 16 different colors…

Although the number of colors was defined in the original specification, this soon became irrelevant as the interface between the video card and the SVGA monitor uses simple analog voltages to indicate the desired color depth… In consequence, to increase the number of colors a Super VGA



“ Mixed-signal processing have helped designers realize the marketing requirements of the end product by integrating analog ICs, mixed-signal codecs and digital signal processors onto a common silicon device known as mixed-signal processor (MSP).”

display system can reproduce, no change at all is needed for the monitor, but the video card needs to handle much larger numbers and may well need to be redesigned from scratch...”

What is striking is the advantage of having made SVGA-rated monitors analog. When the limits of the digital technology were being pushed in the SVGA adapter chips, monitor vendors did not have to worry about their products becoming obsolete.

RF Circuits and Signal Processing

Another field in which digital electronics has had little impact is in RF Design. RF Circuits typically operate at a few Gigahertzes. Since digital processors that operate at such high frequencies have not yet been developed, signal processing and data analysis in this domain is typically in analog form.

Signal Processing is the analysis, interpretation and manipulation of signals. Signals generally need to be amplified before being used by any device. Such amplifiers are always “analog” devices. We could also perform various operations of signals like adding, subtracting, or multiplying two analog signals instantaneously. This would not be possible in digital circuits as the signal needs to be stored for a brief interval before processing. Similarly, filtering analog signals, like the output of a microphone, is simpler than doing them digitally. Having said this we cannot overlook the significant advantages provided by digital signal processing (DSP). DSP is highly cost effective due to the development of low cost of DSP core processors. To add to this in case of up gradation, we only need to upgrade the software which is very easy and efficient compared to hardware upgrade. Now, we all know that real time signals are analog in nature and before DSP core can process, it is transformed into digital domain using Analog to Digital converters (ADC) and once the processing is complete the signal is transformed back to analog using Digital to Analog converters (DAC). ADC and DAC are both analog devices and as we have seen, they are indispensable for digital signal processing.

In case telecommunications, modulation and demodulation of signals is one of the most significant operation which is also an analog “activity”.

Model AD – 256 released by Applied Dynamics Inc. with 256 amplifiers (Courtesy the Analog Computer Museum and History Center [3])

Hybrid Technology evolves: Importance of Analog electronics realized again!

So, we are attempting to say that although digital technology is definitely more convenient, analog electronics has not lost its importance. Now let us examine the middle path, or rather, the path that straddles both: the Analog-Digital Hybrid Computer.

The hybrid computer, in which a digital computer is combined with an analog computer, is used to obtain a very accurate but imprecise 'seed' value, using an analog computer front-end, which is then fed into a digital computer iterative process to achieve the final desired degree of precision. With a three or four digit, highly accurate numerical seed, the total digital computation time necessary to reach the desired precision is dramatically reduced, since many fewer iterations are required. In any case, the hybrid computer is usually substantially faster than a digital computer, but can supply a far more precise computation than an analog computer. It is useful for real-time applications requiring such a combination (e.g., the modeling of a weather system).

4. The World is Analog

We now broach a rather philosophical aspect: The realization that the world is analog. The following paragraphs detail this point of view.

Though we may find it convenient to work with digital technology, the world was, is and will be,

“After all, 25 years ago many said only low performance digital circuits were possible in CMOS and now we have high dynamic range CMOS radios and 10Gb/s clock and data recovery devices in production.”

exact amount of rainfall in Guwahati yesterday; it'll only give you a digital readout like 17.2 mm Digital technology thus is not in a position to convey the full extent of the information. By a digital device here, I don't just mean a logic circuit – a little reflection will convince you of the fact that even a foot rule is essentially a digital device. The read-out of every laboratory instrument is, in this sense digital, otherwise we wouldn't be told of “least counts”.

On the other hand, if the rain sensor were an analog device, something like two transformer coils within which rain water accumulates, and whose mutual inductance changes as a result of the rain water, the signal that would be propagated through the remainder of the analog circuit would technically have no least count, and we could get better results by simply changing the ADC Converter at the end of the chain, putting in an LCD Display with higher precision, and instead of seeing 17.2 on the LCD, you'd be seeing 17.25. Thus, getting higher precision would be a very simple matter really, and would just depend on the quality of your ADC Converter.

B5. ut Are Analog Computers Feasible?

An important point many proponents of digital tech would point out to be the flaw in the preceding argument is, and we have to concur, the suitability of analog devices to carry out such “least count less” arithmetic. While analog devices as such

possess no least count, noise, that analog designer's nightmare we talked about some time ago, itself provides (much) more in losses than the marginal percentage accuracy gained.

What struck me as interesting is the fact that we, as humans, accept our input digitally. Reflect on this, the time right now is 10/8/2007 20:13:36; my weight is 65 kilos; the length of the runway at the Bangalore Airport is 10657 feet.

Yes, we agree whole-heartedly that noise is an issue, design difficulty is an issue, and that we shouldn't allow such problems to get in the bigger picture. Thus, most modern computers are digital, and we support it. Nevertheless, it hasn't stopped a few enterprising folks who have built “small” analog electronic computers. The picture above shows one such computer.

Agreed, digital technology is more convenient in many fields, and in these fields, analog electronics seems to be getting phased out quickly. But there are fields in which analog electronics still retains a niche position, and other fields in which analog electronics brings, along with it, a few surprising advantages.

On a more serious note, it seems natural to reject any forecast of the demise of analog electronics; it is after all, an analog world.

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(Anurag Nilesh, Mukund R, Nipun Sehrawat, Sanjay Ahuja, Swagatika Prusty,

B Tech 6th Semester,

Computer Science and Engineering)

How to save Rs. 1 Lakh per month !!!

In a closed community environment like our IIT Guwahati, it is intriguing to see how small numbers add up to give a huge overall effect. Power consumption for example; single users might not consume large units but when we add it all up, the numbers give us a different picture! Here we present some interesting statistics on the power consumption in IIT Guwahati. After a detailed interview of the authorities at the engineering section, we compiled the following data and analyze where and by how much can we really save.

First some numbers on the electricity bill that IIT Guwahati pays. According to authorities in the engineering section, we pay roughly Rs. 50 lakhs per month in the summer and Rs. 35 lakhs per month in the winters. Apparently the major consumers are the air-conditioning plants, the New Academic Complex and the Administrative Building. And then comes hostels. Since our main purpose here is to present some kind of figure on the amount of power that we the students waste and consume, a break up of the energy ratings of various devices in our room is given in Table 1. Typical consumption statistics for computers are in Table 2.

Appliance	Power Consumption
Tube light	35 W
Fan	60 W
Bulb	60 W
Computers	100 W

Table 1

Model	Clock Speed (Ghz)	Power (W)	Speed:Power ratio (MHz/W)
Pentium 4-C	2.4	67.6	35.5
Core-Duo	1.6-2.16	31	51.6-70
Athlon 64 3200+	-	67	-

Table 2

(The link below can be followed for details on these and other statistics:
http://en.wikipedia.org/wiki/CPU_power_dissipation#Intel_Pentium_4)

There are various types of monitors out there so we will just give you an approximate figure. CRT monitors generally consume a lot of power, figures vary around 100 W. On the other hand LCD monitors are far more efficient, generally consuming about 40 W. Again we won't go into details for speakers (as they are not pertinent to our discussion here), but they also tend to consume about 30 W.

So let's get a conservative estimate for how much power we CAN save. Even with a screensaver or with the monitor off, more than 50 Watts of electricity is used up by the CPU. At least 100 Watts is used just for start up. Printers, speakers and other ancillary devices increase the total figure even more. This is pretty much what an average student is going to use during his stay in the hostel. Some people do use small heaters, mosquito repellants or irons, but we will assume that wastage due to these devices is small enough to be ignored. Now, many of us leave the fan or the lights on at sometime or the other and simply turning them off would be a great saving in itself. But since we are making a conservative estimate we will assume that people do have the habit of flicking the switches while leaving. However, the same cannot be said about computers. Almost all of us leave our computers on when we go to sleep or when we go for our classes. Now assuming that the average student sleeps for 6 hours and goes to classes for 4 hours, we arrive at a figure of 10 hours when we absolutely do not need to leave the computer on. So adding this and some wastage due to fans, bulbs, tube lights etc, it would be safe to say that we are wasting power at the rate of around 75 W for 10 hours. This translates into wastage of 0.75 kWhr per day. Taking into account the rate of electricity, that is Rs. 3.9 per kWhr, every student is wasting around Rs. 2.9 per day.

Doesn't seem like much, huh? Read on…

No. of students in IITG with computers – 1,200
(IIT Guwahati's total student strength is 2,126 as per the academic section website but since the first year students and some others generally don't have a computer, this is a rough estimate.)

Wastage per day – Rs. 2.9 * 1,200 = Rs. 3,510
No. of days in a month – 30
Wastage per month – Rs. 3,510 * 30 = Rs. 1,05,300

Thus even by a very conservative estimate, we are wasting more than a lakh of rupees per month. And this expenditure will rise as the number of students increase gradually year by year. We usually don't pay much attention to these things since WE don't have to pay. But simple measures like switching off your computer and the lights can help save money. And all of us are aware of the dismal power situation in India. Every bit helps. Saving energy doesn't just help us to save power and hence money, it also helps us save coal, petroleum and other fossil fuels which in the long run will help us save the environment. So let's start now – Don't forget to turn off your computers when you don't need it.

(If you can find some fault with the assumptions and facts, please do inform us.)

(Compiled by Rahul Sangwan,4th. yr. B. Tech,at Deptartment of Electronics & Communication Engineering, IIT Guwahati)

"MEMRISTOR"

Missing Fourth Electronic Circuit Element

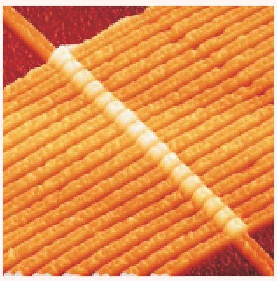
When you switch off your PC, the DRAM forgets what was there. So the next time you turn the power on you've got to sit there and wait while all of this stuff that you need to run your computer is loaded into the DRAM from the hard disk. With non-volatile RAM, that process would be instantaneous and your PC would be ready to serve you in a flash. So the question is how to get access to this non-volatile RAM? Its through the memory resistor.

In 1971, an engineer, Leon Chau, University of California, Berkeley, predicted that there should be a fourth element: a memory resistor, or memristor. Thirty-seven years later, a group of scientists from Hewlett-Packard Labs has finally built real working memristors, thus adding a fourth basic circuit element to electrical circuit theory, one that will join the three better-known ones (the capacitor, resistor and the inductor) and which could pave the way for applications both near- and far-term, from nonvolatile RAM to realistic neural networks.

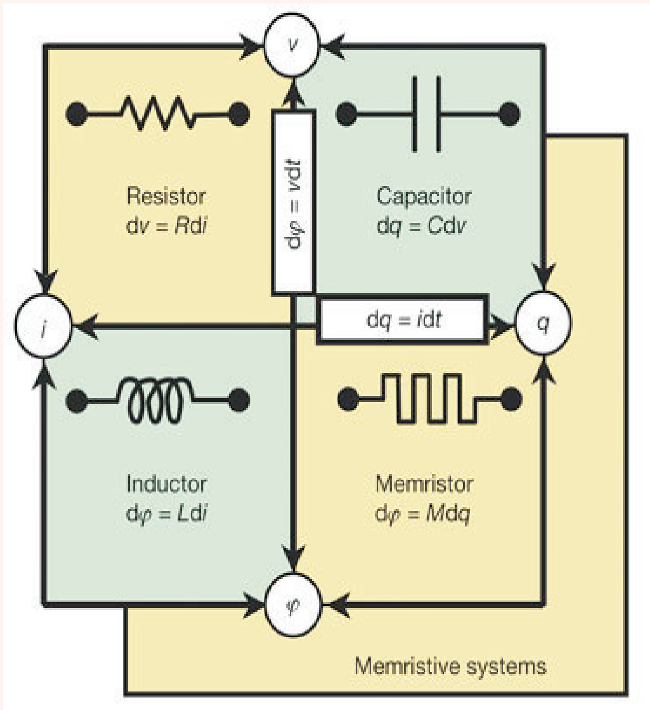
CHUA's VISION:

Such a device, Chua figured, would provide a similar relationship between magnetic flux and charge that a resistor gives between voltage and current. In practice, that would mean it acted like a resistor whose value could vary according to the current passing through it and which would remember that value even after the current disappeared!

Indeed, Chua's original idea was that the resistance of a memristor would depend upon how much charge has gone through the device. In other words, you can flow the charge in one direction and the resistance will increase. If you push the charge in the opposite direction it will decrease. Put simply, the resistance of the devices at any point in time is a function of history of the device –- or how much charge went through it either forwards or backwards. Such a mechanism could technically be replicated using transistors and capacitors, but, it would take a lot of transistors and capacitors to do the job of a single memristor. That simple idea, now that it has been proven, will have profound effect on computer industry.



Chua deduced the existence of memristors from the mathematical relationships between the circuit elements. The four circuit quantities (charge, current, voltage, and magnetic flux) can be related to each other in six ways. Two quantities are covered by basic physical laws dq = idt, and dΨ = Vdt and three are covered by known circuit elements resistor (dv=Rdi), Capacitor (dq = Cdv), and Inductor (dΨ = Ldi) It leaves one possible relation unaccounted for. Based on this realization, Chua proposed the memristor purely for the mathematical aesthetics of it, as a class of circuit element based on a relationship between charge and flux.

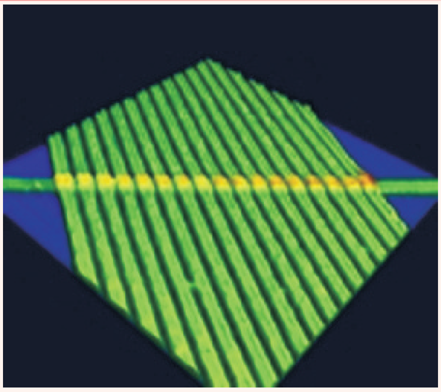


Why Memory:

The reason that the memristor is radically different from the other fundamental circuit elements is that, unlike them, it carries a memory of its past..

Potential Applications:

The first, as the name "memory resistor" implies, is for a type of non-volatile random access memory, or NVRAM. Such a memory would have very useful properties, in that it would not 'forget' the data that it stores when the power is turned off. We think that NVRAM made with the types of



memristor materials that are currently being studied by many groups around the world could be a strong competitor to the flash memory market in about five years. This functionality could play a significant role as "cloud computing" becomes more prevalent. Cloud computing requires an IT infrastructure of hundreds of thousands of servers and storage systems. The memory and storage systems used by today's cloud infrastructure require significant power to store, retrieve and protect the information of millions of web users worldwide. Memristor based memory and storage has the potential to lower power consumption and provide greater resiliency and reliability in the face of power interruptions to a data center.

Signal Processing with Memristors

One advantage of memristors to electronics is their ease of configurability. Since memristors can be switched between high and low resistances they may be used in a similar manner as fuses used to selectively open and close connections between electronic circuit components. However, in contrast to many conventional fuses the switching may be repeatedly reconfigured. In addition, when combined with nanowire crossbar interconnect technology previously developed by Hewlett Packard millions of memristor interconnects may be formed in a microscopic amount of space. One powerful application of such reconfigurability is in signal processing which may offer the potential to create electronic devices more capable of adapting to different situations and exhibiting a form of learning which may advance efforts in artificial intelligence.

Artificial Synapse

Another interesting application is as an 'artificial synapse' in a circuit designed for analog computation. Prof. Chua himself pointed out the connection between the properties of his proposed memristor and those of a synapse in his earliest papers, and he has performed a lot of research in the area of neural computing. We also think that this is a very interesting and potentially valuable research direction.

Arithmetic Processing with Memristors

Logic gates are formed from transistors and are subject to the ultimate limits of miniaturization which could eventually end Moore's law. Memristors could offer some solutions which may expand the capabilities of computation beyond traditional logic gates.

Improvement of recognition technology

Another potential application of memristor technology could be the development of computer systems that remember and associate series of events in a manner similar to the way a human brain recognizes patterns. This could substantially improve today's facial recognition technology, enable security and privacy features that recognize a complex set of biometric features of an authorized person to access personal information, or enable an appliance to learn from experience.

Pattern comparison with Memristors

Often logic gates called Exclusive NOR (XNOR) are used to perform individual bit comparisons to identify matching bits in a pattern. However, such logic gates can be inefficient when dealing with large array bit patterns associated with visual images, digitalized voice data, or other complex patterns since each bit comparison requires its own logic circuit. A variety of computer software tricks exist to make data comparisons more efficient but these tricks can have a detrimental effect on the overall speed of the pattern comparison. Memristor crossbar arrays offer the potential to bridge the gap between hardware solutions based on logic gates and software solutions based on computing power offering faster and more efficient pattern comparison operations.

You may never know what nature has in its store. Advent of new technologies like this is bound to boost the field of electronics to a great extent.

(Compiled by Sumeet Ungratwar & Pratik Patil 1st year students of ECE and EEE at IIT Guwahati)

Engineers, Entrepreneurs, and Economy: A Primer

- Amit Verma, Director - Sales, Aricent

Many of us strike upon great opportunities and business ideas but doubts, hurdles and questions come to mind every time we are faced with one. How do I start, how do I raise funds, which source of funding is good, how do I make a business plan, who is going to help me market the idea, how do I know if I have the right team, how do I manage a team of highly talented individuals, and the list goes on. This article does not cover all these questions in a lot of depth but touches upon many of them and highlights the importance of entrepreneurial thinking for today's engineers.

It is believed that entrepreneurs are good leaders, good managers of resources, problem solvers, passionate, and good risk managers. They are not necessarily among those who take risks overtly. Rather they are motivated to solve a problem and only take a calculated risk needed to solve that problem. Entrepreneurs play an important role in the growth of any economy and job creation, especially in a service and knowledge economy. While manufacturing economy favors large corporations, services economy lends itself to small businesses and continuous differentiation and hence the increased entrepreneurial activities.

Get Started

The first step towards becoming an entrepreneur is to start. Sometime it is the fear of failing and sometimes it is analysis-paralysis that comes in the way. While a good idea and thorough planning is important, there is no perfect plan and no silver bullet. A simple idea if well executed can provide better returns than a poorly executed brilliant idea. McDonald's and Subway are two great example of simple ideas that are extremely well executed.

Sometime the best way to start is to not wait for the next best idea but rather improve the existing ideas. Google did not invent internet search, but definitely improved it a great deal. Ideas are important and you want to make sure that there is something unique about what you are doing but it does not have to be completely new.

Does it address a real pain point in an economically viable fashion? That is the question you have to ask yourself.

Getting feedback on your idea is important. There is no point in keeping it to you. However, you may not get the best feedback by discussing your idea with just a closed circle of likeminded friends and family. They may not represent your end customer and hence their yes or no might not be very meaningful.

Ideation

Ideas evolve as you work on them and take input from your potential customers. Find ways to get early feedback. Prototyping, demos, and survey are some of very important ways to gain early feedback. Customer feedback may not support your original belief and may even prove that it is not a great idea – the pain point either does not exist or there is a better alternate method for solving it. Many young entrepreneurs shy away from seeking a broad feedback due to the fear of hearing back something other than what they believe. Such a fear could lead to unnecessary investment of time and capital into an idea that should have been killed or improved at the early stage. So, seek broad and early feedback to validate your idea.

Team Formation

Once you have a good idea it becomes very important to form a solid team. An experienced and talented team that adds direct value to your venture is central to the success of the venture. Starting a venture is not the best time to start pairing with your high-school buddies and start creating the "dream team" unless there are significant synergies. Most investors would like to know who all are in your team. Investors are generally more comfortable investing in people than ideas. There is a saying that the investors look at the last page of the Business Plan first. They want to know what is the background of the people in your team?, who are on your board?, who are on your advisory board?, etc.

Forming a solid team is obviously not an easy task, but perhaps the most important task. Look out for people that can add value to your idea and are passionate about it. It is no fun in working with people that don't share your passion. Make sure there is a fit and mutual respect. Once the core team of two or three is in place, then you start forming your advisory team and other functional team around that. In the early part of your venture, your best currency is your company equity so use it judicially. It should not be the case that four buddies from high-school are starting the venture and everyone is an equal member even though they may not add equal value. As you will move for funding, your team and the members that you are able to attract using equity as currency will represent the overall value of your company.

Funding Once your core team is in place, you need to start shaping the idea further and start looking for funding. Now there are three good resources for funding early on. Friends, Family, and Fools (three Fs). So reach out to them. Get them excited about the idea. The goal is to raise enough money to develop a proof of concept, if possible, and get some market validation. It is extremely important that your idea is not just a slideware. Now, it is perhaps possible to raise funds even with slideware, but in that case the bios of the team member become the central value proposition and you still may end up giving up significant part of the equity to raise small funds. So in general it is a good idea that you take your idea as far as possible and validate the idea with user community and gather some real feedback. It is good if you can get feedback and comments from actual customers. For most investors, testimonial are more important then the product details. Nothing succeeds like success and early success are good.

Other Options Now once you are ready for funding, you need to consider options. There is Angle money, there is VC money and there is money available from government and different large corporations. Each route has its own advantages or disadvantages. Angel money can be a good source of funding early on and can help you prove your idea and do market trial. Angel investors are individual investors and generally do not want too much control. They could be represented by a professional firm that screens Business Plans for them. They may move as a pack, so breaking into at least one of them is important.

There are also incubator funds. These funds are setup to provide seed level funding as well as also some logistic support such as space, access to VCs, talent etc. Incubators can add a lot of value to your venture and help de-risk the start. Logistical support can help you focus on developing the venture.

Venture Capital funds are more professionally managed, and hence can provide not only funding but guidance and market relationships well. Different Venture Capital focus on different stages of business (early stage, mid stage, later stage) and therefore you have to make sure you approach the right VC.

While money raising is critical to the success of your business, it is also important to know how much and when. Too much money is also not good, as it can distract you into doing things that may or may not be critical to success of your business. For example investing in a lavish office or hiring people you don't really need.

Large companies setup their own venture funds to promote innovation outside the typical corporate structure. This funding is available to both internal employees as well as external entrepreneurs. Similarly government agencies also set up funds to promote research and innovation in key areas. There may be some additional process/restrictions associated with government funding but it can also be a good source of funding.

Final Words Never fall too much in love with your product or idea. This is one of the mistakes many entrepreneurs especially engineers make. Because your idea will evolve and will change and has be suited to changing market needs. Focus should be on solving a real problem in an economically viable manner.

Exit strategy is just as important as the entry strategy. It is good to begin with an end in mind and especially the investor would like know the exit strategy. Rather it is important that partners have clear idea how each one of them would like to exit so that there is a strategic alignment. However don't start a business with intention of flipping it. It only leads to a very narrow and short-term vision and can curtail any strategic planning.

So in summary, as problem solvers, engineers have an important role to play in the economic growth of the country and in finding economically viable solutions to today's problems. Starting a venture is not easy but true entrepreneurial spirit combined with the knowledge of how to start, create, and run a business can lead to great personal success as well as social contribution.

Robotics: Thinking Beyond

One might be tempted to infer from the statement above that a few geeks are getting ready for their new venture, but is it really just that? In a matter of words, probably yes but it's surely not just some geeky science fiction, it is increasingly becoming Reality. That scientists round the globe are trying to develop robots is a well known fact, but what kind of robots? That is the question that we are skeptical about. RoboCup is one such attempt by robotics enthusiasts from the world over to organize and channel all their resources and to develop the next level humanoids capable of playing a game which involves not only the skills of kicking the ball but also reading the opponent, organizing oneself tactically and deploying a complex strategy difficult to predict. The goal of problems like RoboCup is to foster artificial intelligence and robotics research by providing a standard problem where a wide range of technologies can be examined and integrated. So is this article is all about robocup? Not at all, of course you have to read it through to know about it.

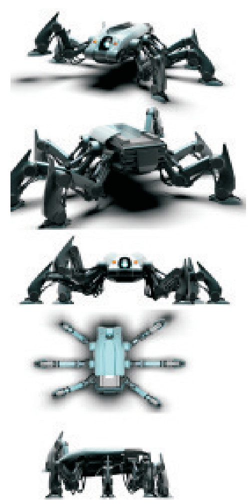
Today if we ask a person about his perception of a robot, the general answer will match to T1000 of Judgment Day or the NS-5 of I-Robot or maybe “weebo” from flubber. But that is far removed from the reality today. Even an imitation of human arm controlled by a computer or even manually with electronic control is something that can be referred to as a robot. Fundamentally thus, a robot is a mechanical system having a control unit, generally a computer, designed for a particular task or task set.

The hardware of the robot is not only what we see and feel when that mechanical devil is standing there, but a lot of other electronics and hydraulics and gears that we don't. It is the physical structure which is supposed to do work.

The first being the life of robot – a power system which one can generally think of as the famous internal combustion engines, or maybe electricity directly from the cables, or just the batteries. The kind of power system is generally decided based on the requirement. What is new in this field are the power cells, yeah not that powerful as that you saw in Rise of the Machines, but are under development and do have a capability to support a humanoid robot for days.

The second most important system of the robot is the hardware itself. From the immaculately sophisticated operating arm with multiple high torque motors or the small electromagnets to an elegant looking gyro stabilized biped, from massive big welding and cutting tools of industry for cutting through steel and concrete to small autonomous vacuum cleaners for home. Today the robots have a variety of applications defined for them and consequently there are various different mechanisms associated. Be it a complex surgery or be it a 'just for fun' environment, robots can be found anywhere and everywhere. They have started tracing the infinites of space to the minutes of human body. The hardware is one of the most challenging part in any kind of robot because of the versatility that has to be achieved.

The Third and yet another important system are the sensors. The sensors in a more crude term are the part of a robot which gathers the information about the surrounding, something similar to humans. Like we see and feel and smell and hear, we understand our environment and the basic task of our body is to get the raw data is by using them. The robots have various substitutes for our sense organs. To start with they have video camera, Infrared sensors, Ultrsonic sensors, Force and Pressure gauges (amazingly the development of substitute for human smelling capability is not that evident). Generally any single sensor is very easy to operate but the problem arises when a network is to be considered. A very simple example is a single LDR (Light Dependent Resistor) Vs Video camera; the former can be used to identify the color, but when a modern video camera is considered, it can be assumed to have millions of such LDR's (pixels) arranged in a rectangular fashion and compact manner. And it is very difficult is to extract a series of images to make a video taken into consideration of the high speed nature of our world. As the quality of video gets better, number of pixels increase and hence the need of compatible high speed to gather data from those LDR's to make a video of real world, i.e. greater usage of sensors means more complexity.



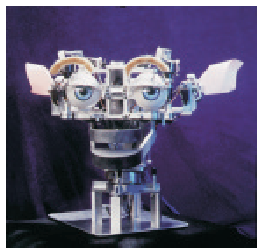
But what makes a machine different from its other counterparts, what really makes it a Robot. It is undoubtedly the intelligence associated with it, as you must have guessed by now. The fourth and most important component of any robot is the Artificial

Intelligence (AI); intelligence is the ability to decide and act according to the conditions available and artificial because it is not born with the machine but has to be embedded in it by programming. The buzzword of today is AI which is actually the method to utilize the capability of any kind of hardware machine that can be built by humans. The best example for this is the Asimo robot. It can walk and climb down the stairs without needing to be programmed every now and then. But intuition says it is pretty easy to walk if not to climb down the stairs! Just analyze, a 54 kg machine that is 4.25' high which has to be balanced on two rods (legs in our case). As soon as you lift one of them, the center of mass should be in forward direction and the robot should be toppling ahead and neither sideways nor backwards (else it will fall), which is very difficult to be ensured until and unless you have a computer powerful enough to calculate all the relevant mechanics calculations involved. When the robot is moving without any guidance, the computer also has to be moved and to know about the environment, whether to climb down the stairs or to walk, a video camera is placed in the head apart from various position sensors provided at the joints to know how much angle the motor has moved. It took nearly a decade to actually build Asimo, from a mere pair of walking legs to a fully autonomous humanoid. In effect, each step of this combined entity shows that what goes behind in our brain is by no means trivial but it is on the contrary, fairly complex and the intelligence that we show and assume easy is not that simple. We might teach a child how to walk easily but in the case of a robot we have to make them walk.

Is the AI limited to walking? Of course not, AI is not only about walking but also about every trivial looking thing, whether to negotiate a maze using a camera or even without it, just checking and avoiding any obstacle in front using a set of sensors which are used in your TV remote (which is called Lower Level Vision). What about all those fancy robots from Star Wars & Terminator series? Are robots made just to do menial work for humans and nothing else?

The questions above are not as easy as pie. A lot of intellectuals and scientists around the world are trying to answer them. In fact when in one part of the world a walking robot was being developed there was research going elsewhere to actually understand and implement human behavior. To begin with, we know there are various aspects of a human being viz., thinking about solutions to complex problems, learning multiple things, organizing various sensory data, managing himself and others, showing various kinds of emotions etc. Implementing these abstract things is difficult because one can behave in strikingly different manner for two seemingly same situations. Moreover learning, which is quite natural to us is not that ordinary for machine. The general notion that 'I am teaching the robot by programming it' is actually confusion.

Beginning with learning, when we were kid, we were taught how to hold a thing by someone elder. Initially giving a bigger toy to hold and slowly in a matter of weeks thinner and thinner toys, thereby slowly finessing our grip. But given a task that using the gripper of robot, program it to hold an object, standard programming will always end up in a fixed pattern no matter however sophisticated be the hardware. As a result, if you want a screw driver to be held will not be a problem, but then the same program might break a pencil. But if we program it with a method called Neural Networking, we will be able to teach the robot about how much force to put on holding a screw driver and pencil. In other words, the master program will learn the amount of force or pressure to be applied by the gripper, just like a small child. By making a robot being able to learn, a big problem of programming every possible scenario is reduced, and the robot only learns what it is going to face. One kind of such learning programmed robot is commercially available as AIBO by Sony, the famous robotic dog that you must have come across either through mass media or in reality. The robot when bought, acts like a puppy and later learns a lot of things as the master teaches, all by simple correlation of actions and word commands, like understanding when to kick the ball and when to fetch it.



But even apart from the objective of learning, robots can do a lot more; they can show anger or laugh at your joke and talk to you just like your friend. The researchers at Massachusetts Institute of Technology have designed one such robot called Kismet that can have realistic conversations with people and has seven different facial expressions and can vary the tone of its voice as per the statement it is making. The robot can also look up to the person to whom it is speaking to. The emotions are actually the results of in depth understanding of a linguistic statement or a situation. A set of situations can be tracked till a certain point to decide upon how to react to current situation, but to develop a system to understand language, it has to understand how we understand the language which

Asimov's Laws of Robotics:

Zeroth law

A robot may not harm humanity, or, by inaction, allow humanity to come to harm

First law

A robot may not injure a human being or, through inaction, allow a human being to come to harm except when it conflicts with the Zeroth law.

Second law

A robot must obey orders given to it by human beings except where such orders

is not as easy as it may seem. For a proof think how hard it is sometimes even for us, the human race who devised this urbane language, to infer the alternate intended meaning of any given statement.

This brings us to a very important aspect of human imitation: that of group psychology. It is the nature of humans to live and act in unison, in a complementary manner, managing and governing themselves, with a leader and followers accomplishing various tasks, forming different teams. But envisioning a group of robots operating similarly surely looks quite impossible to a common eye. I mean unless you yourself choose a leader and say to all the robots to follow it, you are just creating havoc. The robots must be able to identify whom to follow and whom not to, i.e. they should be able to choose their leader, make a choice whether or not to follow etc. And much of this has actually been done while research is going on the more subtle issues in this regard. This particular branch of robotics is commonly referred to as Multi Agent Systems, and have a sub-branch called swarm robotics which is getting popular nowadays as it has numerous utilities in areas such as defense and task completion. Understanding of Multi agent systems is thus very important for many applications like creating a workforce for heavy industry or exploration of space and other planets, where one robot alone is not sufficient but multiple are needed to be managed by themselves to a certain extent because of various issues. Entertainment events like Robocup etc. also need this kind of robots because they need to make a strategy, choose a leader and work in a coordinated manner which maybe quite intuitive to the eyes a of common man, but ask the person who has to implement it on the robots!

Even all this doesn't mean that AI is only associated with anthropomorphic and zoomorphic type of robots, It is also associated with many other kind of machines like cars, and other software like FICO which is used in the US to decide the credibility of a customer before giving loans to understand the payback capacity. So AI can help in creating robots which can actually talk, walk and behave like humans, robots which can think abstractly. A researcher from England has already made a robot which can paint like an artist, not the remakes of “Mona Lisa” but certainly original paintings which are abstract and artistic and a real work of art, admired by many in the line. That means one can create a lookalike of humans or maybe even better but shall robots be always governed by Issac Asimov's Laws of Robotics? If the robots are programmed to copy humans, they might theoretically be given the capacity to think like humans too. The objective ultimately is to create robots to do repetitive menial job, to work in unfavorable conditions for humans, and to simplify more complex tasks which will calls for a grater amount of thinking power from them. The ability to think can and will lead to the creation of an individuality of each seemingly similar robot. Each of them will start becoming unique, and they will become a part of the society. The term robots coined from Czech word robota meaning either a slave or worker doing heavy work, will start to be termed as equals. The humans will have a moral responsibility then to deal with what they have created. To some, this idea sounds comic and to some this is the bell of a great danger ahead, like the destruction attributed to Skynet in the Terminator series. And one view can be that they will be the next surviving fit species of Charles Darwin's theory who will continue to go on when even the entire human race vanishes from the earth.

Coming back to present times, there are already people working in the direction of development and formulation of moral code of conduct for dealing with robots with the capability of human intellect. But this idea brings forward a lot of questions. What exactly are we trying to achieve by incorporating intellect in these calculative machines? And if we will succeed, what are the chances that they won't start interfering with the very existence of human race? After making these kinds of machines, we will owe them a responsibility, are we willing to bear it? But above all are we trying to reinvent the wheel or are we trying to play the creator GOD?

Ah robotics, is this an engineering branch or a complete science in itself? Well that is something for you to decide.

(By Romesh Khaddar, an alumni of Batch'08 at Department of Electronics & Communication Engineering, IIT Guwahati.)

Document Authentication System

Preventing and Detecting Fraud of Paper Documents

HP Labs India has been established with the principal focus on creating new technologies for addressing the IT needs of the next billion customers for HP. A large majority of these new customers arise from rapidly growing markets such as India. Effectiveness of IT has been limited in these markets due to issues related to IT complexity, affordability and infrastructure. At HP Labs India, we derive our inspiration by being deeply immersed in the local customer environment and understanding major global technology trends. HP Labs India works at the intersection of deep technical research, direct impact on HP's business and solving hard and significant customer challenges.

Executive Summary

Paper documents are widely used to support business transactions. These include grade and degree certificates for obtaining employment, bank and financial statements for applying for loans and identity and address proofs for several requirements. Some of the reasons for the continued use of paper documents for these transactions include:

- the affordability of paper - paper is low cost
- the familiarity of paper - people are used to it
- the simplicity of paper - one does not require special equipment to write or read paper

Fraud and Forgery is an issue that plaques paper documents. Document fraud is a major concern for governments and enterprises around the world. For example, a KPMG study which polled senior managers across 1000 companies in India came up with the following findings:

- 39% of the respondents acknowledged that their enterprises had been subject to fraud in the last year
- Forged documents was among the top 3 reasons for fraud encountered by these companies
- 13% of the respondents identified forged documents as the major reason for fraud related losses in their business (in rupee terms)

Fraud prevention makes processes overly complex, increases the transaction costs, and makes due diligence of transactions cumbersome and time consuming. However incidents of forgery and fraud using paper documents has increased with the availability of cheaper printing and copying technologies.
So how can enterprises identify the authenticity of a given document given that manual verification of these documents is a tedious task, involving multiple levels of human interaction and is expensive and time consuming. Can we provide the same degree of security for paper documents that we can achieve in the electronic world?

We believe our technology innovation addresses these questions.

How do you Prevent Paper Fraud?

Traditionally, information on paper with a wet signature and a rubber stamp has been accepted as a reliable supporting document for all kinds of transactions. The strength of authentication using signatures is not very strong. Rubber stamps are also easy to replicate.

Determining the authenticity of the document is not just a technical challenge, but also a logistic one. In some countries there are as many as 20,000 authorities issuing birth certificates alone. Other agencies issue

Figure 1: A 2D Barcode

driver's licenses, degree certificates, etc. Tens of thousands of verifiers dealing with tens of thousands of issuing authorities is not a practical solution. Creating a dedicated online infrastructure for these agencies would be extremely expensive or in some cases even infeasible.

Existing authentication methods are complex, incur large transaction costs and are time consuming. Hence, the need for a system that can provide speedy, reliable and cost-effective verification of paper documents.

Our innovation addresses the problem by allowing enterprises to continue to use their existing methods of generating paper documents with the addition of machine readable data printed on them in the form of 2D barcodes. The Document Authentication System (DAS) we have created can be provided as a means to verify documents either issued by an enterprise or be a centralized system that can verify documents issued by a set of enterprises.

Document Authentication System

Machine readability of data from paper can be enabled through symbologies such as 2D Barcodes. 2D Barcodes are capable of storing multilingual information and images subject to size limitations. All such content can be recovered reliably on scanning and decoding of the barcode.

Why 2D barcodes?

- Can hold significant amount of data, typically of the order of 500 bytes per square inch.
- Can be printed on paper by normal printers and scanned by normal scanners.

The integrity of the document is validated using the content decoded from the barcode. The DAS incorporates security features to ensure that the contents of the barcode are not tampered with. The client side software prints out a verification statement which contains the information decoded from the barcode along

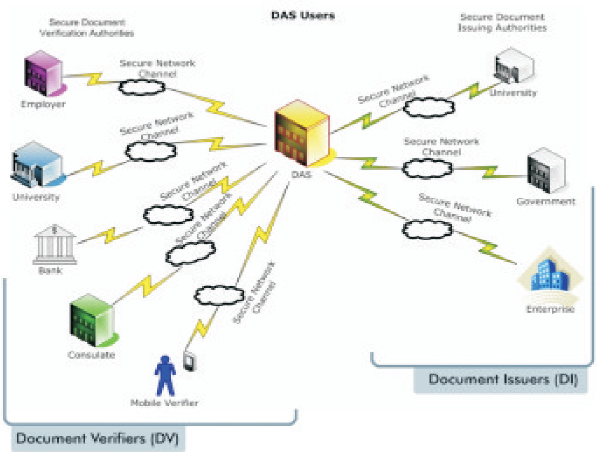


Figure 2: DAS system can serve multiple Document Issuers (DI) and Document Verifiers (DV)

with a statement from the server indicating that the barcode's contents are authentic. Comparison of this information with the

Figure 3: Educational Transcript of IIITB with 2D barcode printed at the back

information on the original document can be used to detect forgery or manipulation very early in an attempted fraud. The verification statement, containing full information, can be processed by itself without even comparing it with the original human-readable text. It is also often desirable that a centralized system should protect the privacy of the end users whose documents are being verified. The DAS system handles privacy protection too.

How a DAS can be used to Authenticate Documents? And example of Issue and Verification of Educational Transcripts

Lets take the example of transcripts that are issued by educational institutions that need to be verified by potential employers. This is based on a pilot we have running with the International Institute of Information Technology (http://www.iiitb.ac.in) where they have issued the grade transcripts for their students using our technology as a pilot.

The text of a transcript like the one given in Figure 3 can be presented as a 2D barcode and printed at the bottom or behind the page in a few square inches. This is done when it is issued by the authority, in this case an educational institute, whom we term as a *Document Issuer (DI).*

The centralized DAS systems created by HP Labs, India would accept information from many *Document Issuers (DIs*) and serve users on a network, which could be the Internet (see Figure 2).

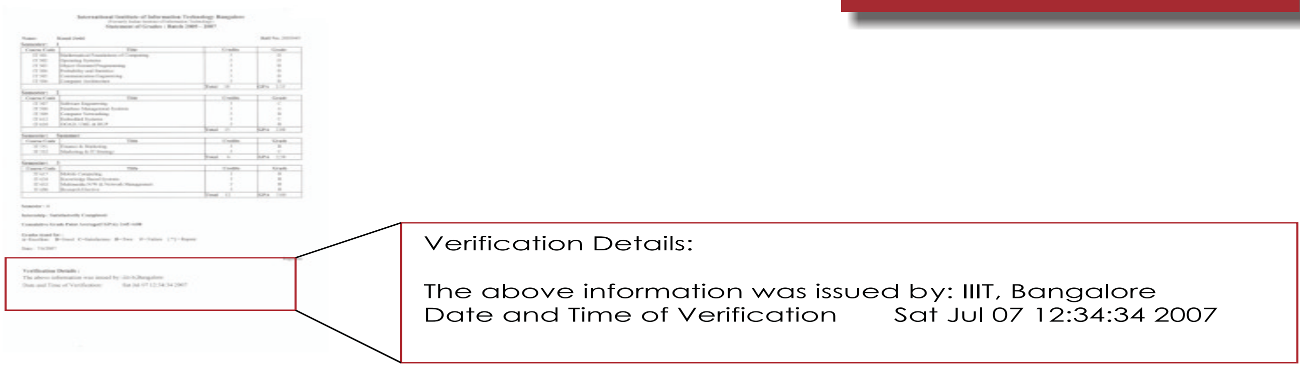


Figure 4: The verification statement for the IITB transcript

A barcoded document can be verified when presented as an authoritative document, for example, while applying for a job to an employer. The entity requesting the verification is a *Document Verifier (DV)* which in this case is a company. The barcode can be machine read using commonly available scanning devices and transmitted over a secure network.

The DAS would then verify that the content being held by a computer in the office of a *Document Verifier (DV)* was issued on the specified date and place by an authorized *Document Issuer (DI).* The DV would get a verification statement that contains the true authentic content of the document. Manual comparison of this with the document being verified would help determine the authenticity of the document.

The same method can be used to remotely issue documents and alleviate the need for a physical signature. This could be applicable in the context of government documents issued by kiosks.

Other Features of a DAS

Some of the other features of a DAS include:

a) The DAS itself will not hold content which can be misused by an agency/staff running it.
b) It does not compromise the privacy of the individuals concerned.
c) It incorporates error correction techniques, while enabling data to be extracted from even damaged barcodes.
d) It can deal suitably with documents issued prior to the creation of a DAS.

Advantages of a DAS

The advantages of a DAS include:

a) It is not expensive or complex to implement
b) It automates verification, thus reducing time and cost for transactions
c) It uses standard printing and scanning equipment without the need for any specialized devices

While enabling networked security for paper documents, DAS does not take away the positive aspects of the paper medium: low cost and user-friendliness. Adding a 2D barcode to the bottom or behind a printed document does not significantly increase the cost of generating such a paper document. The issuing institution will need to spend less time and resources in handling queries on the authenticity of a document it has issued, while the end users can be absolutely sure of the authenticity of the document in question.

About HP Labs India

HP Labs India has been established with the principal focus of creating new technologies for addressing the IT needs of the next billion users of IT. A large majority of these new customers arise from rapidly growing markets such as India, China, and other Asian countries. Effectiveness of IT has been limited in these markets due to issues related to IT complexity, affordability and infrastructure. At HP Labs India, we derive our inspiration by being deeply immersed in the local customer environment and understanding major global technology trends. HP Labs India works at the intersection of deep technical research, direct impact on HP's business and solving hard and significant customer challenges.

For More Information

HP Labs India, Bangalore
hplindia.info@hp.com
http://www.hpl.hp.com/india

Nomenclature of Ic's

Vishal Bhola

Every person who has ever been associated to Electronics would have come across “IC's”. Each IC has a unique designation, like 54S00, 74LS32 and so on. Have you ever wondered what exactly the numbers on an IC convey rather than just the logic operation that it performs?? If yes, then the following article will clarify all your doubts regarding nomenclature of an IC.

Upon simple observation, you will find that designation of an IC could be one of the many designations and these can be explained as follows: -

The first two digits, i.e., 74 or 54, indicate whether the part is a commercial version or a military version. The digits 74 imply a commercial version of the IC while the digits 54 imply a military version (The military version of the ICs provides the same functionality but has more stringent specifications and is guaranteed to work over a wider temperature range and can handle a larger voltage range, etc).

The middle letters, e.g., LS, S, etc., in the IC designation specify the technology and type of logic used in the manufacture of the IC. The widely used logic types are TTL (transistor-transistor logic) or CMOS (complementary metal-oxide-semiconductor), which specify the type of transistors used inside the chip. Following table lists most of the common types of digital IC's.

Nomenclature	**Characteristics**
74	Original TTL technology
74S	TTL employing Schottkey transistors
74LS	TTL employing Schottkey transistors. Less power consumption
74AS	Advanced Schottkey TTL. Twice as fast as the “S” series
74ALS	Advanced Schottkey TTL. Less power consumption
74F	Fast TTL (between 74AS and 74ALS)
74HC	Employs high-speed CMOS transistors. For use with CMOS-only circuits
74HCT	High-speed CMOS with TTL -compatible logic levels
74VHC	Very high-speed CMOS
74VHCT	Very high -speed CMOS with TTL compatibility

The ending of a 7400 series IC consists of two or three digits which indicate the number and functionality of the gates. The ending "00" indicates that there are four 2-input NAND gates in the IC. The ending "20" indicates that there are two 4-input NAND gates in the IC.

Thus, the IC number 74LS00 signifies that it is a commercial version of 2-input NAND gate IC, which employs low-power Schottkey technology.

(Vishal Bhola is a 3rd year student of B.Tech student at Deptartment of Electronics & Communication Engineering, IIT Guwahati)

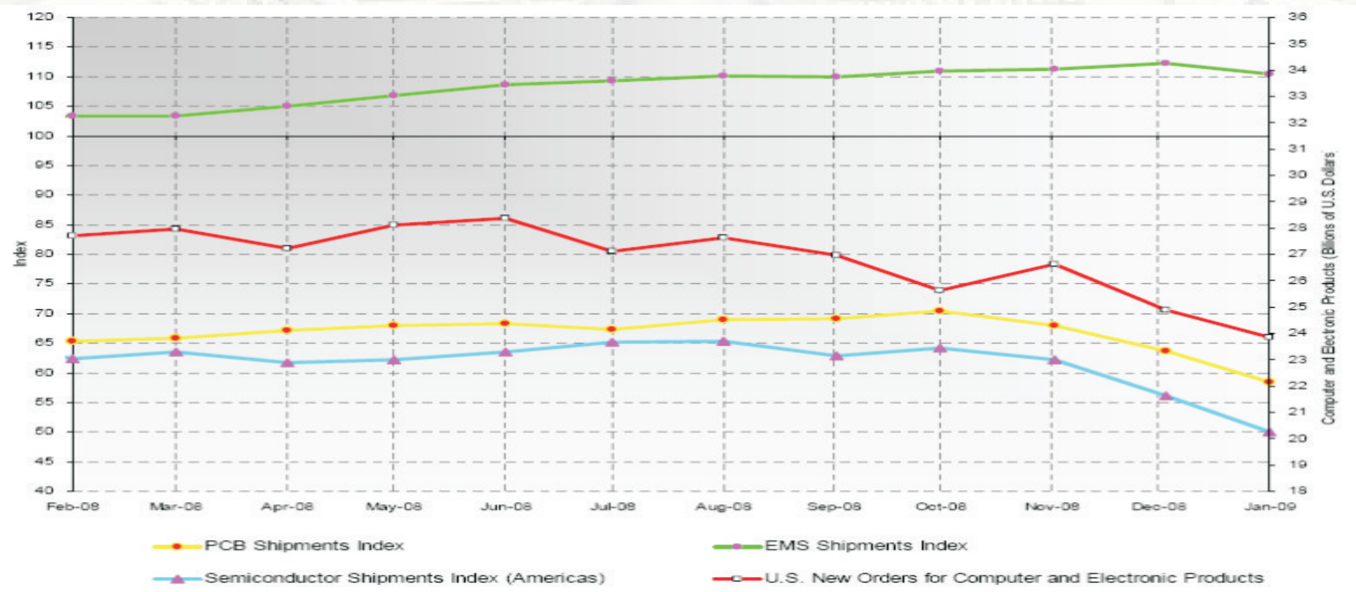
Recession
Effects on Electronics Industry

Historians will look back upon 2008 as a red letter year, as the 'Great Recession' shook the foundations of the world's economic order to the very core. The breadth and depth of the current economic crisis has left nothing and no one untouched. Initially some optimists hoped that the high tech electronics industry would remain relatively unaffected by the brewing storm in the financial sector. Sadly those hopes have proven to be dramatically unfounded.

In a poll conducted at the recent ESC Silicon Valley 2009 expo held in San Jose, California, 53 percent of respondents reported lay-offs at their companies and 52 percent reported wage and benefit reductions, unpaid time off, or other cost-saving measures. 11 percent of respondents reported having lost their job in the last six months. Nor is the problem confined to the West alone. In Taiwan's Hsinchu Science and Industrial Park, where a huge proportion of the world's notebooks and motherboards are made, about 75% of the 100,000+ workforce took at least one day of unpaid leave a week during the first two months of 2009. Clearly all is not well in the realm of electronic wizardry.

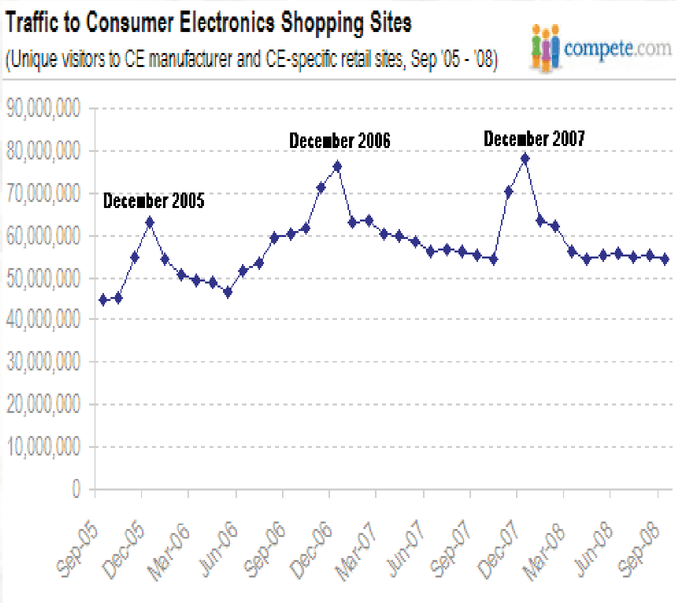
But how did all of this come to pass? After all, things were going fairly smoothly for the industry till recently. Moreover, the current crisis was triggered by Wall Street's arcane financial engineering that collapsed like a pack of cards when the US housing market tanked. The problem lay in the depth of the rot in the financial system as well the interconnectedness of the economy. This was the flip side of the seamlessness of the globalised economy.

Banks had bought billions of dollars worth of mortgage backed securities, often borrowing heavily to do so. This made the value of their assets dangerously dependant on the housing market. When the housing bubble finally burst, many of those assets became essentially worthless. Banks scrambled to repair the damage to their balance sheet by hoarding cash, which meant that they had to cut down dramatically on their lending. Since so many major financial institutions resorted to the same lending austerity, credit, the crucial grease that oils the wheels of commerce, simply dried up. The era of easy money had come to a definitive end.

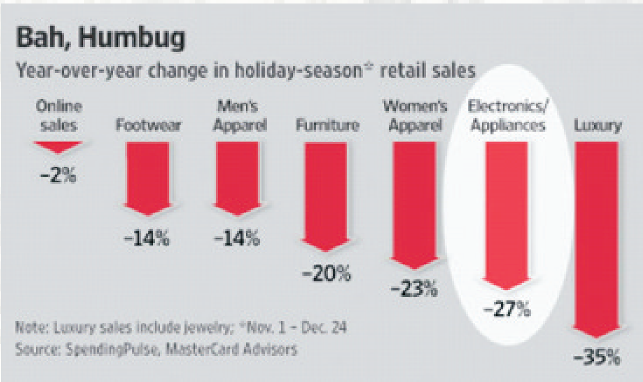


Trends in US computer and electronic products new orders vs North American sales indices of selected supplier industries December 2007 - November 2008

> **"When we were at peace, Democrats wanted to raise taxes. Now there's a war, so Democrats want to raise taxes. When there was a surplus, Democrats wanted to raise taxes. Now that there is a mild recession, Democrats want to raise taxes."**
>
> **Ann Coulter**

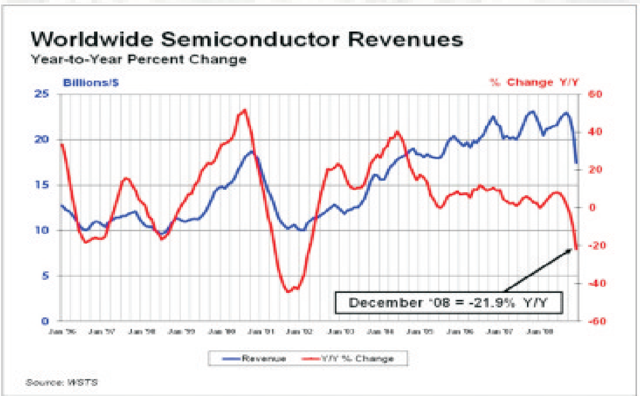


Furthermore, Western, and especially US consumers, watching the values of their assets (i.e. the price of their homes and stocks) plummet, stopped spending and started saving, en masse. Retail consumers for practically every industry simply became nonexistent, and the electronics industry was no exception. In addition, due to sagging demand and a gloomy economic outlook, most companies put all expansion plans on hold and began slashing costs. Capital costs, including the costs of purchasing equipment, were the first to face the axe. Hence sales to corporates, a once steady and lucrative stream of income for the electronics industry, dried up. Thus the industry faced a double whammy, as demand for its products took a free fall.



The credit crunch has hit the supply side as well. During the boom years, many companies expanded aggressively, often borrowing to fund acquisitions and new facilities. Now, as the payments come due, borrowers are finding it extraordinarily difficult to refinance those loans. Simply put, there simply aren't enough lenders willing to make a loan. At the other end of the supply chain, stores and retailers, already reeling from a lack of shoppers, are finding it difficult to optimize their inventories because of cramped lending. Stores sometimes stock their shelves with goods bought on short term credit, which is then repaid when those goods are sold. But with both lenders and buyers thin on the ground, retailers are being squeezed.

However, there does appear to be light at the end of the tunnel. It is felt that the world economy will pick up by 2010-11, with Asia perhaps recovering sooner. As consumers and



the electronics industry should recover. There might even be several silver linings to the dark clouds of the recession. Cash rich companies can look to make strategic buyouts or cherry pick acquisitions and technologies at low prices, and thus look to expand market share when the good times return, as the downturn winnows out the weaker companies. Also, as companies push back launches of new products due to sluggish demand, new technologies and ideas will have greater time to mature and develop, instead of being held hostage to markets and demands. As the job market softens, companies' wage bills (a high portion of their expenditure) should also come down. Thus those companies which survive the long winter of 2009, should emerge leaner, meaner and much more competitive entities.

Placement'08-09 Revisited

At the start of August last year, the term recession was just finding its way into the vocabulary of the hoi polloi, but nobody in the placement committee expected it to play too much of a significant role in this placement season. However, the collapse of Lehmann Brothers and other financial behemoths shattered that illusion. The subsequent worldwide financial squeeze meant that several of last year's recruiters refused to even fill the JAFs (Job Announcement Form). Then there were others that filled the JAF or gave the PPT (Pre-Placement Talk) but subsequently refused to participate. But the big shocker was reserved for “Day Zero”; Schlumberger arrived, sans its REMS division, the dream job of many ECE students. Microsoft also decided to go back on its decision to consider students from all branches, dashing the hopes of many non-CSE software enthusiasts.

The first 3-4 days saw our people land software profiles in companies like Fair Isaac, Oracle, Adobe and Cisco, as well as non-technical profiles in companies like iRunway and PWC. A few barren days followed, until the arrival of IBM (ISL) and Mu Sigma. MTE, visiting the campus for the first time, fulfilled the dreams of those craving a “core” profile, while US telecom giant Verizon sprang a pleasant surprise by recruiting in large numbers from our department. Meanwhile, Samsung (SISO) recruited just one person, a far cry from last year, when it was our largest recruiter.

That baton was passed on to C-DOT, which, in the process, outshone its more illustrious public sector counterparts like NTPC, BHEL, DRDO, HAL, etc. The revised pay packages and the second to none job security offered by PSUs is what has led to their resurgence in the placement scene of all IITs. Another noticeable change has been the heavy participation of various educational institutions.

On the whole, while the placement of CSE department has been fairly recession-proof, other departments have not been as lucky.

They have suffered due to the absence of both core companies as well as mass recruiters like Infosys, IBM, etc. As a result, only 85% B.Tech. students have been placed until now, while the corresponding figure for the M.Tech. students is a dismal 30%. Our own department is yet to achieve cent per cent placement for B.Tech. Even the average salary offered has declined from 6.8 lakhs to 6 lakhs. Lately, the situation has been exacerbated by issues like late joining dates, non-arrival of offer letters and worst of all, reduction of the package offered initially.

In such a grim scenario, it is advisable for next year's batch to explore options of MS/PhD/MBA. In fact, even a 6-month or year long internship could prove to be a good alternative. The placement committee, on its part, would have to work harder to bring more companies to campus. One can only hope that next year's placement report proves to be a more pleasant read.

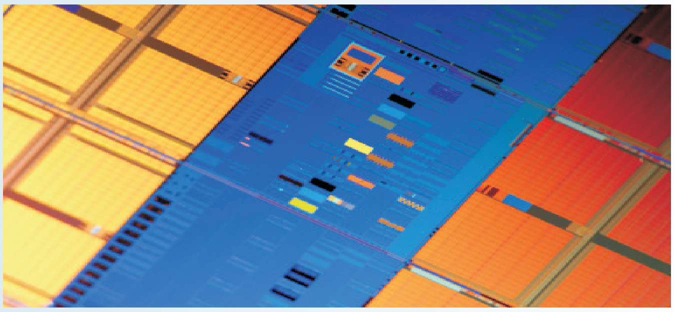
(By Nimish Kulshreshtha,a 4th year B.Tech student at Deptartment of Electronics & Communication Engineering, IIT Guwahati)

45 nm technology: What makes it so special?

Over the last 40 years, we have witnessed that the density of transistors on chips has been periodically doubling, as predicted by Moore's Law. Keeping up this trend Intel has launched the latest Core 2 microprocessors, code-named Penryn. The chips, based on the latest 45-nanometer CMOS process technology will have more transistors and run faster and cooler than microprocessors fabricated with the previous, 65-nm process generation. So what's so special about this technology if we have been following Moore's law for the last 40 years? Actually they are special because the chips would not have been possible without a major breakthrough in the way Intel construct a key component of the infinitesimal transistors on those chips, called the gate stack. This is the new revolution in this design and we will explore this further as to what problems Intel faced and how were they handled.

To keep on the Moore's Law curve, size of the transistors have to be halved every 24 months or so. The physics dictates that the smallest parts of those transistors have to be diminished by a factor of 0.7. But there's one critical part of the transistor that couldn't shrink anymore. It's the thin layer of silicon dioxide (SiO_2) insulation that electrically isolates the transistor's gate from the channel through which current flows when the transistor is on. That insulating layer has been slimmed and shrunk with each new generation, about tenfold since the mid-1990s alone. Two generations before Penryn, that insulation had become a scant five atoms thick.

Now, it wasn't possible to shave off even one more tenth of a nanometer—a single silicon atom is 0.26 nm in diameter. More important, at a thickness of five atoms, the insulation was already a problem, wasting power by letting electrons rain through it. Without a significant innovation, the semiconductor industry was in danger of encountering the dreaded "showstopper," the long-awaited insurmountable problem that ends the Moore's Law era of periodic exponential performance gains in memories, microprocessors, and other chips—and the very good times that have gone with it. The solution to this latest crisis involved thickening the insulator with more atoms, but of a different type, to give it better electrical properties. This new insulator works well enough to halt the power-sucking hail of electrons that's plagued advanced chips for the past four years. As difficult as finding the new insulator was, that was only half the battle. The point of the insulator is to separate the transistor's silicon gate from the rest of the device. The trouble is, a silicon gate didn't work with the new insulator material. The initial transistors made with them performed worse than older transistors. The answer was to add yet another new material to the mix, swapping the silicon gate for



Close-up of a 45nm SRAM Test Wafer

one made of metal.

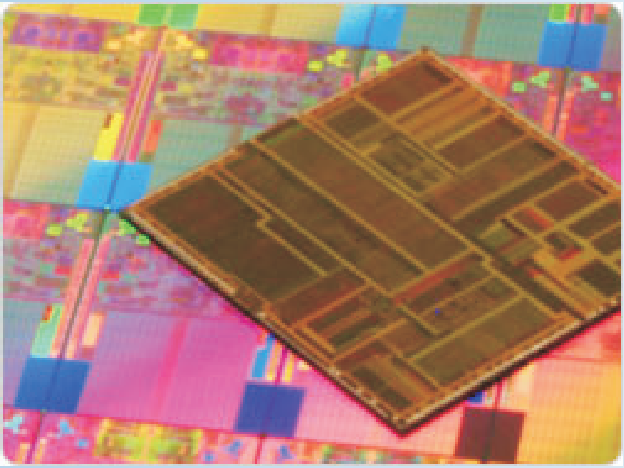
It may not seem like such a big deal to change the materials used in a transistor, but it was. A fundamental change to the composition of the transistor is pretty much unheard of. The combination of the gate and the insulator, the gate stack, hasn't changed significantly since Moore, Andrew S. Grove, and others .The problem, ultimately, is one of power. At five atoms, that sliver of SiO_2 insulation was so thin that it had begun to lose its insulating properties. Starting with the generation of chips fabricated in 2001, electrons had begun to trickle through it. In the processors made just two years later, that trickle became some 100 times as intense. All that current was a drain on power and a source of unwanted heat. The reason the gate oxide was shrunk no further is that it began to leak current. This leakage arises from quantum effects. At 1.2 nm, the quantum nature of particles starts to play a big role. The oxide layer is so narrow that the electron looks less like a ball and more like a wave. Specifically, it's a wave that defines the probability of finding the electron in a particular location. The trouble is that the wave is actually broader than the oxide layer, extending all the way to the other side and beyond. That means there is a distinct probability that an electron that should be on the gate side of the oxide can simply appear on the channel side, having "tunneled" through the energy barrier posed by the insulation rather than going over it.

The goal was to identify a gate dielectric material as a replacement for SiO_2 and also to demonstrate transistor prototypes that leaked less while at the same time driving plenty of current across the transistor channel. Intel needed a gate insulator that was thick enough to keep electrons from tunneling through it and yet permeable enough to let the gate's electric field into the channel so that it could turn on the transistor. In other words, the material had to be physically thick but electrically thin.

To overcome this problem, hafnium- and zirconium-based “high-k” dielectrics were used and to test capacitors were fabricated out of these. But the results were discouraging since it was found that charges got trapped at the interface between the gate electrode and the dielectric. This accumulated charge within the capacitor altered the voltage level needed to store the same amount of energy in the capacitor from one charge-discharge cycle to the next. But an innovative technology called atomic layer deposition was used for fabrication which smoothen the surface. This solved the problem of gaps and pockets in which charges could get stuck.

With two candidate materials identified, NMOS and PMOS transistors were fabricated out of them but they found some snags. For one thing, it took more voltage to turn them on than it should have—what's called Fermi-level pinning. For another, once the transistors were on, the charges moved sluggishly through them—slowing the device's switching speed. This problem is known as low charge-carrier mobility. The source of the trouble, ultimately, came down to the interaction between the polysilicon gate electrode and the new high-k dielectrics. They found out that metal gates solved the problem. Intel has not revealed it's identity due to competitiveness.

The new gate stack worked wonders in battling leakage through the gate, reducing it by more than a factor of 10. But the gate oxide is not the only source of transistor leakage chip makers have to worry about. The other significant leak is called source-to-drain or sub-threshold leakage. It's a trickle of current seen even when the transistor is intended to be in the “off” state. Making transistors smaller has also meant steadily lowering the amount of voltage needed to turn them on, the threshold voltage. Unfortunately, steadily lowering the threshold voltage lets more current slip through. For many years, each new generation of transistor would increase drive current (and improve performance) by about 30 percent but would pay the price of about a threefold increase in sub-threshold leakage. Leakage currents have reached levels high enough to be a noticeable portion of total microprocessor power consumption.



The Intel Xeon CPU Core

The industry is now in an era where power efficiency and low leakage are more important than raw speed increases. Compared with the previous 65-nm transistors, 45-nm high-k plus metal gate transistors provide either a 25 percent increase in drive current at the same subthreshold leakage or more than a fivefold reduction in leakage at the same drive current, or anywhere between those values. In January 2007, Intel made the first working 45-nm microprocessors using these revolutionary high-k plus metal gate transistors. One was the Penryn dual-core microprocessor, which has 410 million transistors. The quad-core version of this product will have 820 million transistors. Penryn was followed a few months later by Silverthorne, a single-core microprocessor with 47 million transistors. The invention of high-k plus metal gate transistors was an important breakthrough. Although Intel could have continued to shrink transistors to fit the dimensions needed for the 45-nm generation without this breakthrough, those transistors would not have worked much better than their predecessors, and they certainly would have expended more watts.

It is believed that this new transistor can be scaled further, and development is already well under way on the next-generation 32-nm transistors using an improved version of high-k plus metal gate technology. Whether this type of transistor structure will continue to scale to the next two generations—22 nm and 16 nm—is a question for the future. Will we need new materials and new structures again? Nobody knows for sure. But that is what makes integrated circuit research and development so exciting.

(By Talla Vamsi, a 4th yr. B. Tech student at Deptartment of Electronics & Communication Engineering, IIT Guwahati)

Math Blues !

Robert W. Lucky

(The following article has appeared in the reflections column of IEEE Spectrum, September 2007.)

I was browsing through some of the features of a popular computer program for doing Mathematics. Wow, I thought! What I would have given for this years ago!

But suddenly I was overcome with sadness. I don't need this anymore, I realized. In fact, it has been many years since I worked with "real" mathematics. I just never really thought about that loss before. It was as if my profession had slipped away when I wasn't looking.

I commiserated with several engineering friends. Two of them weren't concerned at all. That's what happens when you move along in your career, they said, and it doesn't make you ant less of an engineer. The other, a researcher like me, shared my nostalgia and pain. It made him think of what he had been- and was no more.

I wonder how many engineers use advanced math in their jobs and whether fewer do so, now that computers have consumed so much of our work. Has mathematics disappeared behind the screens of our monitors, as have so many other subjects since engineering began to centre increasingly on writing software?

Yet mathematics is a way of thought that binds us to our profession. Maxwell's equations are inscribed in the entrance foyer of the National Academy of Engineering as the very symbol of what we do. I look at them as the scripture of engineering-a concise and elegant description of the laws that govern electromagnetism. But I also wonder: How many engineers have actually used Maxwell's equation in their work? Alas, I've never had the pleasure myself.

Our journals are still full of mathematics. If you want to publish and have your work inscribed in stone for eternity, you must code your work in mathematical symbolism. If you want to parade among the elite of the profession, you must cloak yourself in mathematics. This is the way it has always been. Now, if math is disappearing from our practice, this would make me sad.

I remember the day well in high school algebra class when I was first introduced to imaginary numbers. The teacher said that since the square root of a negative number didn't exist, it was called, imaginary. That bothered me a lot. I asked, if it didn't exist, why give it a name and study it? Unfortunately the teacher had no answers to these questions.

As with much of the math we've all studied, understanding comes only much later. We've all had the experience of learning mathematical principles before we had any idea what they were good for. If I could go back to that day in high school, how would I have explained matters?

I can think of two approaches, although somehow I doubt that my younger self would have been happy with either. The first is to say that mathematics is beautiful in itself, a study of consistent rules of logic that can be appreciated as an art form, quite apart from any application it may have to everyday problems. The second is to note that the square root of minus one is actually useful (in problems that my younger self didn't know about yet). It opens the door to two dimensional thinking-a dimension that gets you off the line of real numbers. So whether or not this imaginary number exists in your world of arithmetic training, it's useful. In real world of problems, it works.

I'm reminded of a famous saying in physics, variously attributed to Paul Dirac and Richard Feynman: “Shut up and calculate”. It was a response to a class of problems in quantum mechanics in which Schrödinger wave equation often contradicts common perception, yet it always provides the right answers. So don't worry about it: quit complaining and just calculate. Like using the square root of minus one, it works.

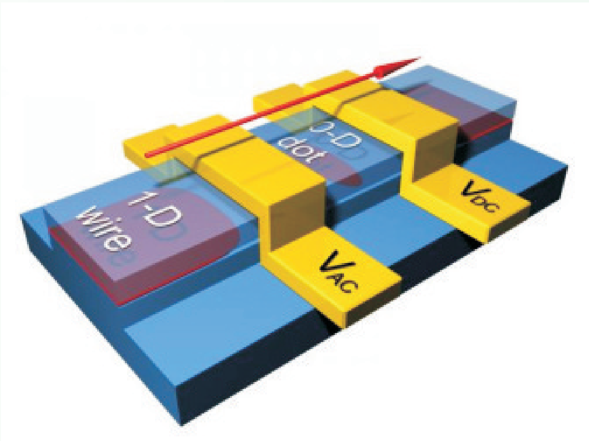
Since that first introduction to imaginary numbers, I've just about come full circle. I learned to appreciate math, and I found imaginary numbers useful. But now I'm thinking that, though the appreciation remains, the usefulness to me has faded.

The more I think about this as I write, the sadder I get. I'm going to go back and look at the features of this mathematics program again.

The author is a retired IEEE fellow. He was Vice President for applied research at Telcordia University.

Spintronics

Electron, as we know, is the driving force on which our whole technology flourishes. Be it whatever gadget or equipment, the electron will have a role to play in it. That's what that makes electrons so indispensible. It wouldn't come as a shocker if someone were to say to you that electronic research amounts for more than half the total research conducted throughout the world. It is a brainchild of this research that we have with us a new face of technology called Spintronics. It is fast, reliable, less error prone and more robust. Let's take a peek into the amazing future of the gadgets that are so hard to live without.

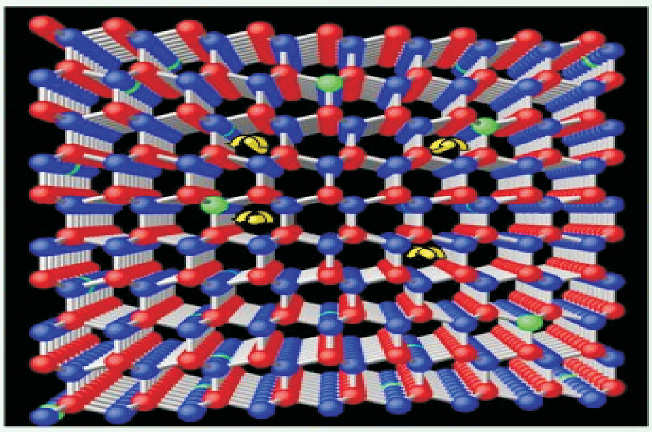


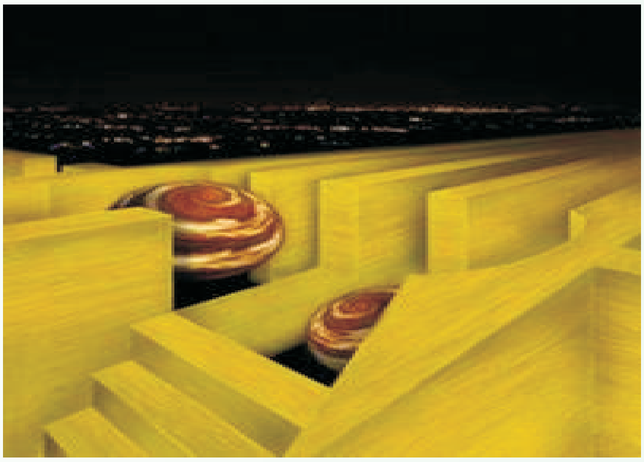
Spintronics, as the name suggests, deals with spin. But whose spin? It deals with electronic spin. Spintronics, or spin electronics, refers to the study of the role played by electron spin in solid state physics, and possible devices that mainly exploit spin properties instead of or in addition to charge degrees of freedom. In a more common language, it can be inferred that **spintronics**, also known as magneto electronics, is an emerging technology which exploits the intrinsic spin of electrons and its associated magnetic moment, in addition to its fundamental electronic charge, in solid-state devices.

It all started with Johnson and Silsbee in the year 1985, when while conducting experiments on spin-dependent electron transport phenomena in solid-state devices including the observation of spin-polarized electron injection from a ferromagnetic metal to a normal metal, the two observed that spin played a crucial part in the transport of information. If the spin could be exploited, amazing result could be achieved. Other notable contributors to this field include Albert Fert and Peter Grünberg who found a whiff of it while working on giant magneto resistance. The origins can be further traced back to ferromagnet/superconductor tunneling experiments pioneered by Meservey and Tedrow and initial experiments on magnetic tunnel junctions by Julliere in the 1970s. The use of semiconductors for spintronics can be traced back at least as far as the theoretical proposal of a spin field-effect-transistor by Datta and Das in 1990.

Spintronics makes use of the fact that electron have a distinct spin i.e. +1/2 or -1/2. They therefore constitute a two-state system with spin "up" and spin "down". The primary necessities to make a spintronic device are to have a system that can generate a current of spin polarized electrons comprising more of one spin species -- up or down -- than the other (called a spin injector), and a separate system that is sensitive to the spin polarization of the electrons (spin detector). In other words, we have a system that has electrons with up spin as well as down spin, however, the population of one of the types of the e^- is more than the other. On the other end of the system we have a sort of spin detector that is sensitive to the spin of the e^-. Electron spin during transport between injector and detector (especially in semiconductors) via spin precession can be manipulated using real external magnetic fields or effective fields caused by spin-orbit interaction. Thus this manipulation arms us with controlling the spin of the electron to our will.

The problem with the above mentioned technique is that it wouldn't work for non-





magnetic materials. Hence other methods are used to achieve results. Spin polarization in non-magnetic materials can be attained either through the Zeeman Effect in large magnetic fields and low temperatures, or by non-equilibrium methods. In the latter case, the non-equilibrium polarization will tend to decay over a timescale called the "spin lifetime". Spin lifetimes of conduction electrons in metals are relatively short but in semiconductors the lifetimes can be very long (probably lasting a few microseconds at low temperatures), especially when the electrons are isolated in local trapping potentials (for instance, at impurities, where lifetimes can be milliseconds).

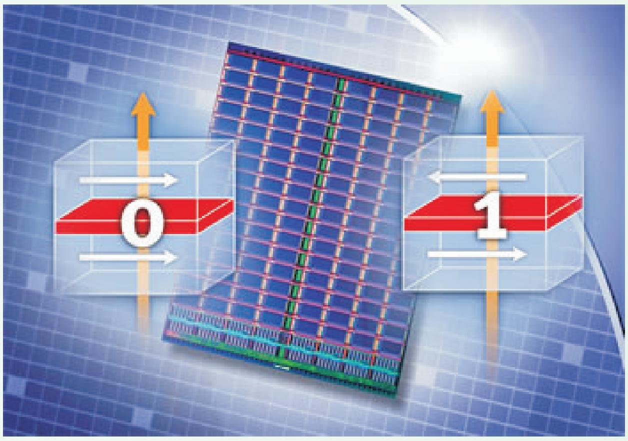
The spintronics field has numerous applications. To begin with, the storage density of hard drives is rapidly being increased along an exponential growth curve, courtesy spintronics, in part because the technique-enables devices like GMR (Giant Magneto Resistance) and TMR (Tunnel Magneto Resistance) sensors, in which it is used, to have an increase in the sensitivity of the read head which measures the magnetic state of small magnetic domains (bits) on the spinning platter. The doubling period for the areal density of information storage is twelve months, much shorter than Moore's Law, which observes that the number of transistors that can cheaply be incorporated in an integrated circuit doubles every two years.

MRAM, or Magnetic Random Access Memory, uses arrays of TMR or Spin torque transfer devices. MRAM is nonvolatile (unlike charge-based DRAM in today's computers) so information is stored even when power is turned off, potentially providing instant-on computing. Motorola has developed a 256 kb MRAM based on a single magnetic tunnel junction and a single transistor. This MRAM has a read/write cycle of under 50 nanoseconds. Another design in development, called Racetrac memory, encodes information in the direction of magnetization between domain walls of a ferromagnetic metal wire.

Advantages of semiconductor-based spintronics applications include potentially lower power use and a smaller footprint than electrical devices used for information processing. Also, applications such as semiconductor lasers using spin-polarized electrical injection have shown threshold current reduction and controllable circularly polarized coherent light output. Future applications may include a spin-based transistor having advantages over MOSFET devices such as steeper sub-threshold slope.

The other major application of spintronics is in Quantum Computing. A **quantum computer** is a device used for computation that makes direct use of quantum mechanical phenomena, such as superposition and entanglement, to perform operations on data. The basic principle behind quantum computation is that quantum properties can be used to represent data and perform operations on these data. In quantum computing, electronic spin represents a bit, called qubit, of information. The spin of the electron is exploited, instead of its charge and digitally used. If the electron is present on the surface, it is assigned “1” and if electron is not present, it is assigned “0”.

Due to its higher retaining time period, data storage seems to be the major area of interest in spintronics. Spintronics can also be used in

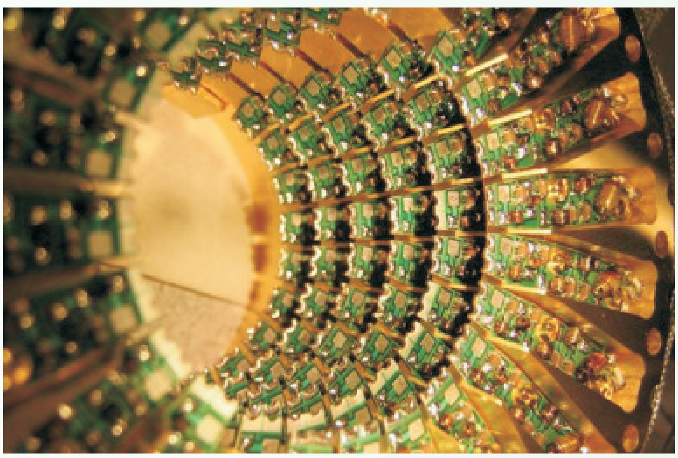


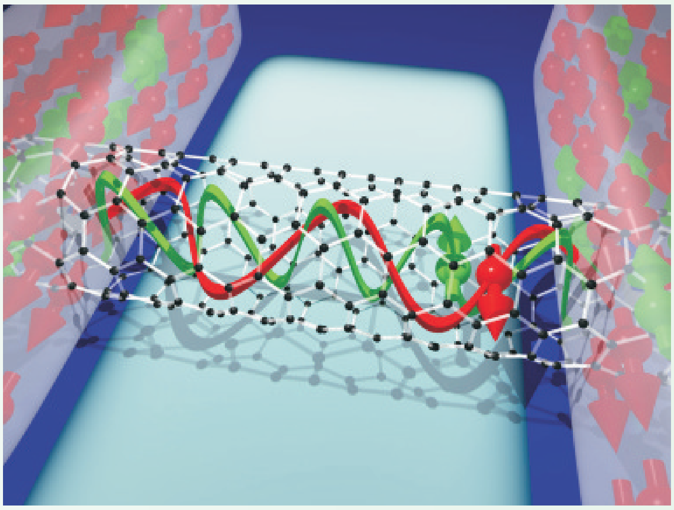
determining the magnitude of tunneling magneto resistance (TMR) in magnetic tunnel junctions (MTJ). Organic spintronics is also a field with upcoming promises. Research in the field of organic spintronics can lead to development in spintronics based organic memories, logic circuits, as well as improve efficiencies of organic light emitting diode (OLED)-based displays.

Silicon recently was found to prove as a haven for semiconductor spintronic researchers. The results mark another major steppingstone in the pioneering field of spintronics, which aims to use the intrinsic "spin" property of electrons versus solely their electrical charge for the cheaper, faster, lower-power processing and storage of data than present-day electronics can offer.

Spintronics, though seems to have endless uses, also has some shortcomings. The biggest one being that the efficiency can be improved only to a certain extent, not beyond a defined limit. Semiconductor spintronics is basically concentrated on problems like, coherent manipulation of electron spin at a given location, transporting spins between different locations within conventional semiconductor environment, all-electrical spin control via spin-orbit interactions, diluted magnetic semiconductors, and fixed or mobile spin qubits for quantum computing.

The key challenges of this field are the generation, manipulation and detection of spin in non-magnetic semiconductors. Various schemes have been proposed to tackle these challenges with different pros and cons. This can be taken of by studying the novel scheme of generation and control of spin current in semiconductors based on the discontinuity of





spin space in a spin heterostructure and the application of scheme in spintronic devices. Similar to the Josephson Effect, the equilibrium spin current is generated by the phase difference between the spin wave functions on the two sides of a junction. This problem is of important practical interest, because a spin current can be generated in a spin heterostructure without any external charge current and voltage and the approach has potential applications in low power spintronic devices.

In future, as we see, stress will be on achieving higher levels of efficiency and increasing the scope of spintronics. Currently, being in its infant stage, the technique is slated to become the next big thing. It is also supposed to replace electronics. Analyzing the pros and cons, this doesn't seem just a dream. Spintronics has helped create new levels of data storage and management. With a blend of spin and magnetic field, electrons, though being the tiniest indivisible part of the atom are set to shape the world that we live in. Big things do come in small packages.

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(By Harpreet Singh, a 3rd year B.Tech student at Deptartment of Electronics & Communication Engineering, IIT Guwahati)

eWASTE

Harsh Kumar

Over the last 50 years there has been a lot of improvement in the field of science and technology. There has been rapid growth of new technology and high tech equipments. The growth of the technology has been so fast that the rate at which devices of daily use become obsolete has increased exponentially. One sector of industry which has witnessed this trend in the most profound sense is the electronics sector. The pace of development has been tremendous. In the history of mankind, the pace of development has never been so great. The best example of this growth that we have all witnessed in our day to day life is the way we used to store data. It may be recalled that magnetic tapes were used to store data not very long ago. Then came floppy discs. They didn't lasted long and were replaced by CD's which are being phased out by DVD's. DVD's are also expected to die out soon with the introduction of newer storage devices like BluRay disc.

This is just a tiny part of the big picture. The rate at which things are changing has seen the everyday electronic item become obsolete at a great pace. The problem with this is not just waste of resources while buying new hardware but is related to the disposal of these old unwanted devices. Disposing this stuff is not as simple as disposing off our kitchen waste. Electronic waste or "Waste Electrical and Electronic Equipment (WEEE)" is of concern largely due to the toxicity and carcinogenicity of the substances which are part of it. Toxic substances in electronic waste may include lead, mercury, cadmium and a vast range of chemical substances which are dangerous for all living forms. Up to thirty-eight separate chemical elements are incorporated into electronic waste items.Landfilling e-waste, one of the most widely used methods of disposal, is prone to hazards because this releases toxins into the soil, air and groundwater. Older landfill sites and uncontrolled dumps pose a much greater danger of releasing hazardous emissions. Some electronic items contain hazardous compounds such as halogenated chlorides and bromides used as flame-retardants in plastics, which form persistent dioxins and furans on combustion at low temperatures (600-800°C). Copper, which is present in printed circuit boards and cables, acts a catalyst for dioxin formation when flame-retardants are incinerated. The PVC sheathing of wires is highly corrosive when burnt and also

induces the formation of dioxins. A study on burning printed wiring boards in India showed alarming concentrations of dioxins in the surroundings of open burning places reaching 30 times the Swiss guidance level.

The impact of these toxins on human body is dangerous. At high levels, the lead can have an adverse effect on various nerves, such as the motor nerves. This damage can result in the inability to maintain the hand or foot in a normal position due to weakness of muscle tone because of nerve damage ("wrist drop" or "foot drop"). The Center for Disease Control estimates that nearly two million American children under the age of six have at least low-level lead poisoning. The CDC also estimates that 10% of all children suffer from lead poisoning.

The first comprehensive study to estimate the annual generation of e-waste in India and answer the questions above is being undertaken up by the National WEEE taskforce. So far the preliminary estimates suggest that total WEEE generation in India is approximately 1,46,000 tonnes per year. The top states in order of highest contribution to WEEE include Maharastra, Andhra Pradesh, Tamil Nadu, Uttar Pradesh,West Bengal, Delhi, Karnataka, Gujarat, Madhya Pradesh and Punjab. The city wise ranking of largest WEEE generators is Mumbai, Delhi, Bangalore, Chennai, Kolkatta, Ahmedabad, Hyderabad, Pune, Surat and Nagpur.

An estimated 30,000 computers become obsolete every year from the IT industry in Bangalore alone. The reason – an extremely high obsolescence rate

"An estimated 30,000 computers become obsolete every year from the IT industry in Bangalore alone. The reason – an extremely high obsolescence rate of 30% per year."

of 30% per year.

The amount of old electronics, or e-waste, such as computers, phones and TVs being discarded every year is growing rapidly. In many countries it's the fastest growing type of waste as cheap prices mean replacing electronics is cheaper than fixing them, while low price often means low quality and very short life spans. The products are made cheap by companies by using low quality components which have low life. This is their way of increasing sales. Shorter life of product means that customers have to buy new products after very less time. The sales are also boosted by bringing out newer products and discontinuing support for old products, thus forcing obsolescence. The best example is whenever a newer version of the Windows operating system is released it requires a newer and faster hardware. This was seen with the recent release of Windows Vista. This ensures continuous revenue for both the software developers and hardware manufacturers.

As electronics increasingly become part of the throw away culture in many developed countries and some developing countries, amounts of e-waste have dramatically increased while solutions have often lagged far behind. Even in the European Union (EU) that has tighter regulation 75 percent of e-waste is unaccounted for. Of the estimated 8.7 million tonnes of e-waste created annually in the EU a massive 6.6 million tonnes of e-wastes do not get recycled.

In the US there is very little regulation of e-waste. Less than 20 percent of US e-waste is recovered for recycling. Worrying the recycling percentages for PCs (10 percent) and TVs (14 percent) are even lower. The imminent switch to digital TVs in the US and elsewhere will lead to a massive increase in the amount of redundant analogue TVs.

Another major concern for is the import of e-waste from developed countries into developing countries. A large quantity of e-waste is shipped into developing countries mainly India, China, Pakistan and a few African countries where laws and environmental standards are not strict. The scrap yards in the developing countries extract the valuable and required materials from the junk and

leave the rest. These workers have little or no expertise in recycling of e-waste and do their job in unprotected environment without proper equipments. Exporting e-waste from Europe is illegal but exporting old electronics for 'reuse' allows unscrupulous traders to profit from dumping old electronics in these countries. USA which is among the greatest producer of e-waste has no legislation that restricts the export of e-waste. Now the amount of domestic e-waste generated by these countries is growing fast. In India only one percent of e-waste is collected for authorized recycling.

The Basel Convention is an international treaty intended to restrict this sort of practice, but it has proven difficult to enforce and the United States has not yet ratified the agreement. Because the US has no domestic laws forbidding the export of toxic waste, the Basel Action Network estimates that about 80% of the e-waste directed to recycling in the US does not get recycled there at all but is put on container ships and sent to countries such as China.

The Solution

One clear solution for the problem is for the major electronics companies to eliminate the worst toxic chemicals from their products and improve their recycling programs. Having generated demand for the latest new mobile phone or sleek laptop and made vast profits from sales of electronics it should not be a problem the companies are allowed to ignore. In 2006 more than one billion mobile phones were shipped worldwide.

"In 2006 more than one billion mobile phones were shipped worldwide. However, Nokia (the market leader) recycles just 2 percent of the phones it sells."

However, Nokia (the market leader) recycles just 2 percent of the phones it sells. The major computer makers do little better, with currently an average recycling rate of just 9 percent. That means the major companies don't recycle over 90 percent of their old products. To address the rising tide of e-waste all manufactures must offer free and convenient recycling of their products to all their customers. While most companies accept responsibility for recycling their own products, and are improving their recycling programs for consumers, several TV companies are dragging their feet on recycling with the majority offering no recycling for old TVs in many countries. Of the TV companies, Philips stands out by publicly stating that recycling is the responsibility for the customer and government and consumers should pay for recycling, not the product makers.

Where companies are unwilling to do this tough legislation is need to ensure electronics are safely recycled. Japan has effective recycling legislation and Sony reports that it collects 53 percent of it's old products in Japan. That's five times better than the global average for major PC makers and shows that solutions are already available. There are several other legislations all over the world that encourage the recycling of e-waste and reducing the amount of hazardous chemicals in electronic products. The most notable of these legislations is the The **Directive on the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment** commonly referred to as the Restriction of Hazardous Substances Directive or RoHS. The directive was adopted in February 2003 by the European Union. The RoHS directive took effect on 1 July 2006, and is required to be enforced and become law in each member state. This directive restricts the use of six hazardous materials in the manufacture of various types of electronic and electrical equipment. RoHS is often referred to as the lead-free directive, but it restricts the use of the following six substances:

1. Lead
2. Mercury
3. Cadmium
4. Hexavalent chromium (Cr6+)
5. Polybrominated biphenyls (PBB)
6. Polybrominated diphenyl ether (PBDE)

The maximum permitted concentrations are 0.1% or 1000 ppm (except for cadmium, which is limited to 0.01% or 100 ppm) by weight of homogeneous material. Another notable legislation in this context is the The Electronic Waste Recycling Act of 2003 is a California law to reduce the use of certain hazardous substances in certain electronic products sold in the state. The act was signed into law September 2003. This also puts restriction on the maximum amount of hazardous chemicals in electronic devices. The Act also requires retailers to collect an Electronic Waste Recycling Fee (effective January 1, 2005) from consumers who purchase covered devices. Recycling fees are paid to the State of California.

In order to individually help make a difference, consumers can follow a number of steps to help with the recycling of electronics:

- Send your old computing equipment back to the electronic company from which you bought it.
- Dell, HP, and Apple are all willing to take back your old products when you buy a new one.
- When researching computer companies before your computer purchase, find out if they offer such recycling services.
- Don't throw your electronics away in the trash.
- Educate yourself! Read, research, and gain some knowledge about the harmful effects of recycling as well as the recycling laws.
- Don't burn any of the electronic items to get rid of them. It is best to send them to a recycling plant.
- Take initiative and join any of the NGO's which are concerned about this problem.
- Spread the word about the danger of e-waste.

Although the problem of e-waste pose a great amount of danger to our planet, several initiatives have been taken to bring this problem under control. A number of government and non-governmental agencies have been working to educate people and control this menace. As the public awareness increases, government and companies will be forced to take action and do their part of recycling the waste. Till then it is up to us, the residents of planet to save our mother earth.

(By Harsh Kumar, a 2nd year B.Tech student at Deptartment of Electronics & Communication Engineering, IIT Guwahati)

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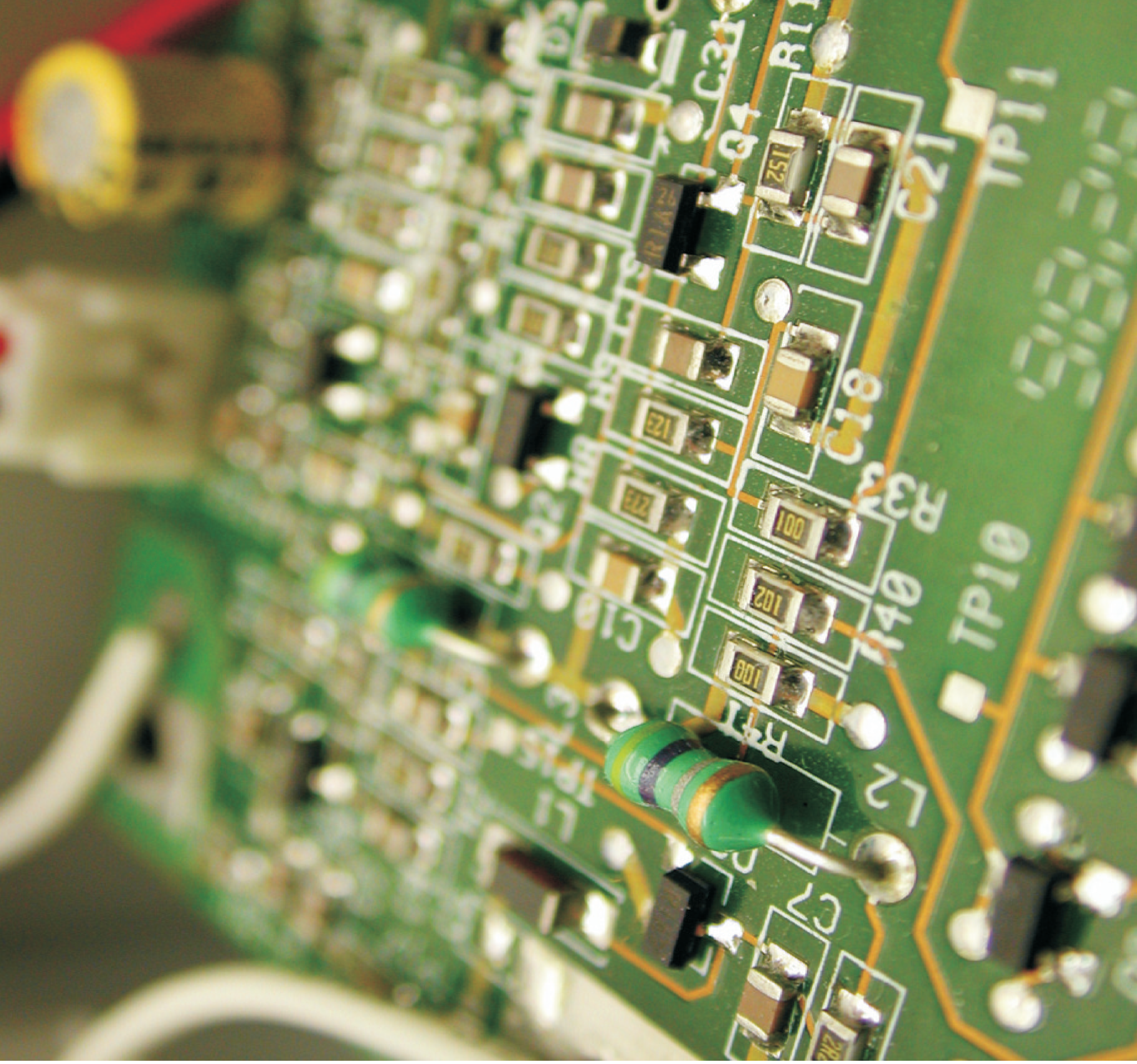

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