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Editorial

Due to technical reasons we weren't able to publish some of the issues of the hydel and this issue bridges that huge gap. Kindly accept my apoligies for the delay. The 'Power Scenario" all over the world, especially in our country's in panic. All are wishing for a paradigm shift from our conventional energy conversion ways and let us hope it happen soon. It seemed it would emerge from the Nano world, but is still to happen. The hopes are still alive. In this issue we are discussing the environmental blocade which are dampening the Indian Power Scenenrio, we are looking back a little into the history as well the current trends in the technical world. So happy reaidng.

Jins K.D.
Editor, Hydel

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Photoplethysmography and its Applications

by SHAIJA P. J., M.Tech., Assistant Professor, Electrical & Electronics Dept., Model Engineering College, Ernakulam

Photoplethysmography (PPG) is a simple and inexpensive optical technique that can be used to detect blood volume changes in the micro vascular bed of tissues. With the advancement in optical technology, noninvasive assessment of cardiovascular functions by the peripheral arterial pulse has gained substantial research and clinical interest and PPG is one such technique which has gained popularity during recent decades.

Photoplethymographic signal characteristics have been studied to identify vascular diseases. There has been a rebirth of interest in the technique in recent years, driven by the demand for low cost, simple and portable technology for the primary care and community based clinical settings and the wide availability of low cost and small semiconductor components, and the advancement of computer-based pulse wave analysis techniques. The PPG technology has been used in a wide range of commercially available medical devices for measuring oxygen saturation, blood pressure and cardiac output, assessing autonomic function and also detecting peripheral vascular diseases. PPG being a noninvasive technique has its own attraction when compared to other expensive invasive methodologies used for cardio-vascular diagnostics.

THE PHOTOPLETHYSMOGRAPHY WAVEFORM

The PPG waveform comprises of a pulsatile ('AC') physiological waveform attributed to cardiac synchronous changes in the blood volume with each heart beat, and is superimposed on a slowly varying ('DC') baseline with various lower frequency components attributed to respiration, sympathetic nervous system activity and thermoregulation. The pulsatile component of the PPG waveform is often called the 'AC' component and usually has its fundamental frequency, typically around 1 Hz, depending on heart rate (figure 1). This AC component is superimposed onto a large quasi-DC component that relates to the tissues and to the average blood volume. These characteristics are also body site dependent. With suitable electronic filtering and amplification both the AC and DC can be extracted for subsequent pulse wave analysis. The pulsatile part has two components – a systolic component and a diastolic component and a prominent dip (in the case of normal subjects) called the dicrotic notch.

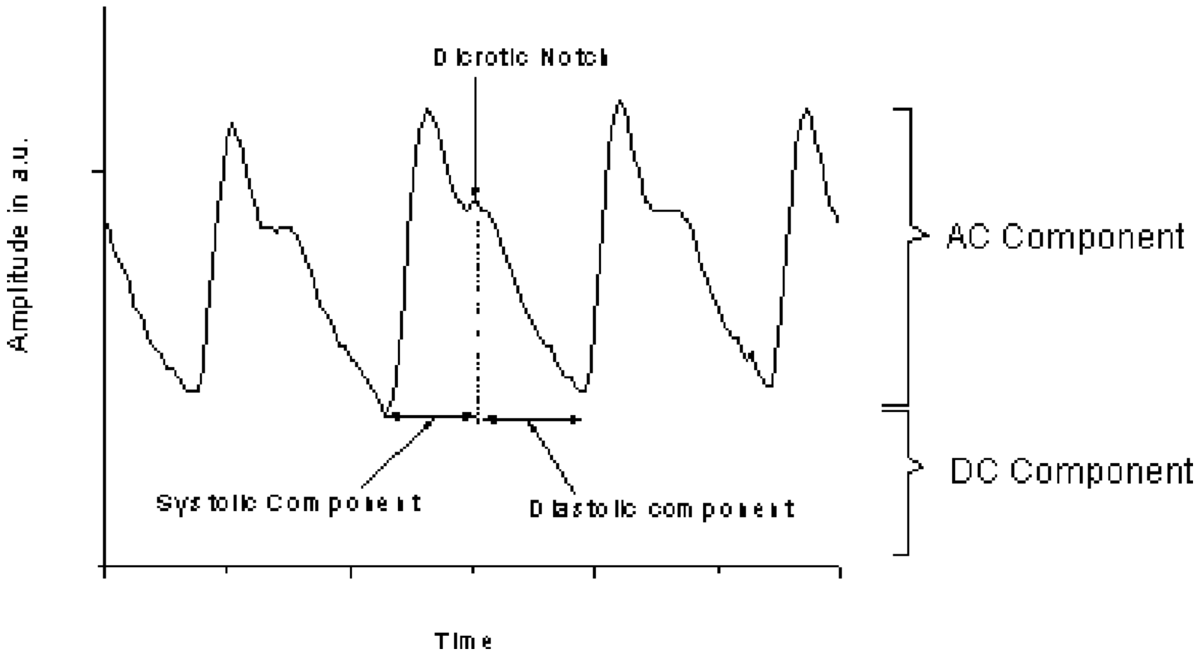

Fig 1: Typical PPG waveform showing the 'AC' and 'DC' components

PHOTOPLETHYSMOGRAPHY INSTRUMENTATION

Modern PPG sensors often utilize low cost semiconductor technology with LED and matched photodetector devices working at the red and/or near infrared wavelengths. The choice of light source is important. LEDs convert electrical energy into light energy and have a narrow single bandwidth (typically 50 nm). They are compact, have a very long operating life (>105 h), operate over a wide temperature range with small shifts in the peak-emitted wavelength, and are mechanically robust and reliable. The averaged intensity of the LED should be constant and preferably be sufficiently low to minimize excessive local tissue heating and also reduce the risk of a non-ionizing radiation hazard. The choice of photodetector is also important. Its spectral characteristics are chosen to match that of the light source. A photodetector converts light energy into an electrical current. They are compact, low-cost, sensitive, and have fast response time. Near infrared devices can be encased with daylight filters. The photodetector connects to low noise electronic circuitry that includes a transimpedance amplifier and filtering circuitry. A high pass filter reduces the size of the dominant DC component and enables the pulsatile AC component to be boosted to a nominal 1 V peak-to-peak level. Carefully chosen filtering circuitry is also needed to remove the unwanted higher frequency noise such as electrical pick up from (50 Hz) mains electricity frequency interference. Figure 2(a) shows a transimpedance amplifier design and figure 2(b) shows the signal conditioning stages surrounding this, including low pass filtering, high pass filtering and further amplification, signal inversion and signal interface. The choice of high pass filter cut-off frequency is particularly important and is often a design compromise; excessive filtering can distort the pulse shape but too little filtering can result in the quasi-DC component dominating over the AC pulse. This example system shows a constant current driver stage for the PPG probe LED.

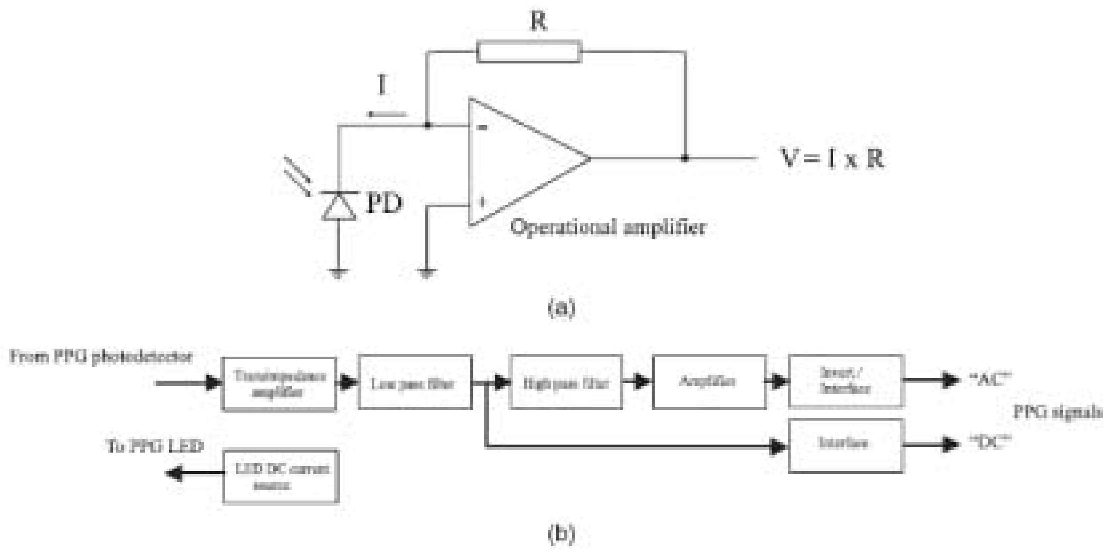

Figure 2. Electronic building blocks used in a typical PPG measurement system. (a) A transimpedance (current-to-voltage) amplifier stage that converts light intensity at the photodiode (PD) to an amplifier output voltage (V = I × R, transimpedance gain proportional to feedback resistor value R). (b) The signal conditioning stages surrounding the transimpedance amplifier which include low pass filtering, high pass filtering and further amplification, inversion and signal interfaces. The AC component and a measure of the DC component are available for pulse wave analysis. A constant current driver stage for the PPG LED is also shown.

REFLECTION MODE PPG VS TRANSMISSION MODE PPG

There are two operational configurations of PPG: transmission ('trans-illumination') mode operation where the tissue sample (e.g. fingertip) is placed between the source and detector, and reflection ('adjacent') mode operation where the LED and detector are placed side-by-side. Clearly, transmission mode PPG imposes more restrictions than the reflection mode PPG on the body locations available for study. Transmission mode PPG is limited to areas such as the finger, ear lobe or toe while reflection mode allows measurements on virtually any skin area. The intensity of the transmitted or reflected light, which reaches the photodetector, is measured and the variations in the photodetector current are assumed to be related to blood volume changes underneath the probe. These variations are electronically amplified and recorded as a voltage signal called the photoplethysmograph. The arrangement used in the transmission method and reflection method of photoelectric plethysmography is shown in fig.3(a). and fig.3(b) respectively.

In the transmission method, a light-emitting diode (LED) and a photodiode or phototransistor are mounted in an enclosure that fits over the tip of the subject's finger or toe. Light is transmitted through the finger tip and the photocurrent is determined by the amount of light reaching it. With each contraction of the heart, blood is forced to the extremities and the amount of blood in the finger increases. It alters the optical density with the result that the light transmission through the finger reduces and it causes a variation in photocurrent. This photocurrent is converted to voltage by a transimpedance

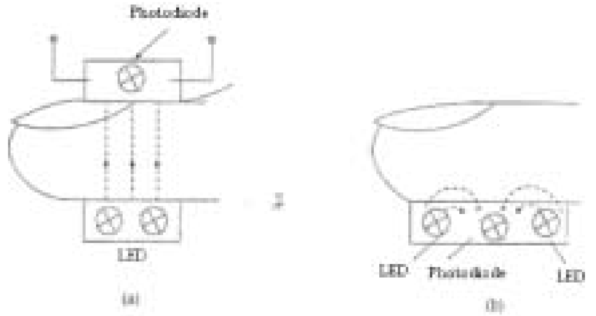

Figure 3. Arrangement of photodiode and LED in a PPG probe (a) Transmission method (b) Reflection method.

amplifier. This voltage that closely follows the pressure pulse and its wave shape can be displayed on an oscilloscope or recorded on a strip-chart recorder.

In the reflection method of photoelectric plethysmography, the photodiode is placed adjacent to the LED. A part of the light rays emitted by the LED is reflected from the skin and the tissues and falls on the photodiode. The quantity of light reflected is determined by the blood saturation of the capillaries and, therefore, the output of photodiode will vary in proportion to the volume changes of the blood vessels.

The PPG probe should be held securely in place to minimize probe-tissue movement artefact. There are other sources of artefact that need to be considered in the measurement technology. For example, artefact can arise from ambient light interference but can be reduced in several ways: by suitable probe attachment to the skin (e.g. using a dark Velcro wrap), by further shading of the study site area and performing measurements in subdued lighting, and by electronic filtering (e.g. light modulation filtering). Careful placement and application of the device is essential in order to prevent movement artefacts due to mechanical distortion of the skin.

CLINICAL APPLICATIONS

PPG has been applied in many different clinical settings, including clinical physiological monitoring (blood oxygen saturation, heart rate, blood pressure, cardiac output and respiration), vascular assessment (arterial disease, arterial compliance and ageing, endothelial function, venous assessment, vasospastic conditions, e.g. Raynaud's phenomenon, microvascular blood flowand tissue viability) and autonomic function (vasomotor function and thermoregulation, blood pressure and heart rate variability, orthostatic intolerance, neurology and other cardiovascular variability assessments).

PPG measurements can be used to determine arterial blood oxygen saturation by shining red and then near infrared light through the vascular tissue with rapid switching between the wavelengths. The AC component of the PPG signal is synchronous with the beating heart and therefore it will be a source of heart rate information. Arterial blood pressure is a very important clinical parameter to measure. Several approaches to noninvasive PPG based blood pressure measurements have been described. Physiological monitoring of breathing interval (respiratory rate) is important in many clinical settings, including critical and neonatal care, sleep study assessment and anaesthetics. Respiration causes variation in the peripheral circulation, making it possible to monitor breathing using a PPG sensor attached to the skin. PPG signals have also been widely used in vascular assessment, studies related to arterial compliance, age and endothelial dysfunction. ●

Environmental Roadblock

Power projects hit a rough patch as MoEF clamps down
by Shubhra Pari

It was never easy, but procuring an environmental clearance for power projects has now become a Herculean task. Many projects have been awaiting this crucial clearance for over a year now while some others have received an unequivocal refusal. But perhaps the worst off are those projects that had begun construction work having obtained the clearance, and are now held up for re-evaluation by the Ministry of Environment and Forests (MoEF). In this scenario, it is small wonder that the Ministry of Power has cited delays in obtaining environment and forest clearance as being the key reason for generation capacity addition not being up to speed...

What has added to the disquiet of power developers is a recent joint study by the MoEF and the coal ministry (see box 1) on nine major coal mining areas, which has concluded that almost 35 per cent of the coal blocks are located in no - go zones, where there is dense forest cover and mining is prohibited. About 43 coal blocks allotted to private power companies have been found to be located in these regions. All coal blocks have now been cancelled by the environment ministry and the projects are now stranded.

Says I.C.P. Keshari, joint secretary, Ministry of Power, "About 55 projects amounting to 50,000 MW including two ultra mega power projects (UMPPs) have been impacted. Besides, the existing projects will also be affected as they will receive lesser coal than their requirements." He believes that environmental concerns should balance developmental imperation. "Leaving aside the densely forested areas, the MoEF should clear as many mines as possible for development. Non-availability of mines will only lead to higher costs of power for the final consumer and put a question mark on the country's GDP", he adds. The Prime Minister's Office has reportedly intervened to sort out the crucial issues.

The study apart, the MoEF has of late been tightening its controls in light of the growing environmental awareness and increasing public scrutiny. Effluents and gases from thermal projects, water displacement caused by hydro projects, and the degradation of flora and fauna due to coal mining cause irreparable damage to the environment. So, the MoEF has been clamping down strongly whenever a project is proposed close to a tiger reserve, in a thick forest area or a sensitive ecological system. It also takes into account local community and NGO concerns, and seeks expert and legal opinion wherever required. In some cases, fresh investigations and studies have necessitated a relook at the clearance. All this has led to major delays in the clearance process.

While the MoEF's concern is justified for sustainable development and safeguarding the environment, it is proving to be a major issue for both the coal and power ministries which are anxious to get their projects off the ground. Power projects based on captive coal mining blocks are suffering the most as they need separate forest and environmental clearances for the mining projects as well.

The process of obtaining a clearance itself is quite cumbersome. It involves applications, finalisation of terms of reference (TOR), a series of state clearances and approvals, an environment impact assessment (EIA) report, multiple stages of appraisals and public hearings, etc. (see box 2). On an average, an environmental clearance takes between 12 and 18 months while a forest clearance may take up to two years. The processes and paperwork required for both the clearances are separate.

The delays are also attributed to the ongoing reforms in the MoEF. These reforms are aimed at streamlining, decentralising as well as improving transparency and stakeholder contribution. For instance, the ministry now seeks a comprehensive EIA report, asks for more technical data and ensures proper public hearings - all of which result in more groundwork for the project developers.

According to the MoEF's website, as on March 31, 2010, a total of 28 thermal and hydro projects were awaiting environmental clearance, of which five had been pending for over nine months. Seven projects were awaiting forest clearances, of which four had been pending for over nine months. Besides, eight transmission line projects were also awaiting clearances.

"No go" mining area

The future of some of the UMPPs has become uncertain. The MoEF has identified the Hasdeo coal block in Chhattisgarh - allotted by the coal ministry for the 4,000 MW Sarguja UMPP - as being a no-go area. Preliminary bids for the project have been invested but the last date for submission has been extended due to the objections raised by the MoEF.

The Bedabhal UMPP in Orissa has met a similar fate. Two of the three coal blocks associated with the UMPP - Minakshi B and the dipside of Minakshi - fall in no-go areas. Both these projects, which were ironically intended to be on a fast track, now face long delays, if not cancellation.

A number of other power projects have been hit hard due to the joint study.

Essar Power's proposed 1,200 MW Mahan I project was to source coal from the Mahan coal block in Madhya Pradesh, which has now been declared a no-go area. The Sayang coal block allotted for AES's 1,200 MW project in Chhattisgarh has also failed to obtain forest clearances. IFFCO Chhattisgarh Power's 2 x 660 MW coal-fired power project has also been put on hold. The Wardha Power Company's 1,800 MW project in Chhattisgarh has been stranded since the Morga II coal block in Chhattisgarh could not obtain forest clearance. Several other projects in which the developers had invested significantly are now similarly stranded.

Hydro projects under greater public scrutiny

Hydro projects have been a subject of much debate right from the 1980s, when the Narmada dam project drew flak from environmentalists and the local community. The Tehri Dam project in Uttarakhand and the Maheshwar hydro project in Madhya Pradesh have both been embroiled in controversies over issues of submergence of large areas and rehabilitation and resettlement (R & R) of the displaced people. In May this year, the centre lifted a ban on construction work at Maheshwar's project site, imposed by the MoEF due to non-completion of R & R work b the project authorities.

Recently, two hydro projects on the Bhagirathi river have been scrapped by the environment ministry. These are Uttarakhand Jal Vidyut Nigam's 480 MW Pala Maneri and 381 MW Bhaironghati projects. However, work on NTPC's Loharinag Pala has been allowed to continue on the river as substantial work on the project had already been completed. A number of environmental groups have opposed the projects on the grounds that they would create a negative impact on the river's ecology. A high-level environmental committee set up to assess the ecological impact of hydel projects on the Bhagirathi had recommended to the MoEF that it was necessary to maintain at least 4 cubes of water flow during the lean season. This would not have been possible if more projects were constructed on the river.

There are fresh reports indicating that the Forest Advisory Committee (FAC) has withheld forest clearances for many of the proposed projects in Uttarkhand until the National Ganga River Basis Authority conducts a cumulative impact assessment study of all the proposed dams. This has impacted more than 50 proposed public and private hydro projects in the state.

Ecologically fragile areas

Ecologically sensitive areas (estuaries, mangroves, virgin forest reserves, wild-life reserves, coastal areas) such as the Western Ghats and the Gulf of Kutch have generated a lot of attention in recent times. Issues related to the preservation of important ecosystems have come to the forefront in the wake of an increasing civic consciousness.

Adani Power has failed to receive environmental clearance for its 3,300 MW Tiroda project since the Lohara mines allocated for the project are located close to the Tadoba-Andhari forest reserve which is home to tiger populations and mining activities may upset the region's ecological balance. The MoEF has said that the coal ministry should have consulted it before allocating the mines. Though Adani Power has asked for alternative coal mine allocation, the present law does not have such a provision in the event of environmental clearance being denied.

Meanwhile, several proposed power projects in Ratnagiri - the horticulture zone known

Box 1: Environment and forest clearance process

Environmental and forest clearances are accorded by the Ministry of Environment and forests (MoEF), and are based on the Environment Protection Act, 1986, the Forest Conservation Act, 1980 and the Wildlife Protection Act, 1972.

Environmental clearance

- As per the Environmental Impact Assessment (EIA) Notification, 2006, if the project falls under Category A, it is cleared by the MoEF, while a Category B project requires the state government's approval. Thermal power projects under 500 MW are termed as Category B projects and need to obtain the state government's permission. Over 500 MW projects, whether new or expansion, need to approach the MoEF. Category B projects are further dividend into B1 and B2. B2 projects do not require an EIA or a public hearing.
- After the initial application, a pre-feasibility report and a draft terms of reference (TOR) are prepared by the project proponent. The TOR helps to plan and design the EIA report. (The Environment Advisory Committee or the State Expert Appraisal Committee finalises the TOR for preparing the EIA report.)
- A no objection certificate (NOC) by the State Pollution Control Board (SPCB) and the State Forest Department (if the location involves the use of forest land) is needed. A public consultation is conducted by the SPCB to ascertain the projects impact on the local populace through hearings at the site or responses on the website, etc. The public hearing is presided over by the local district magistrate.
- The application form is submitted along with the EIA report, details of the public hearing and an NOC from the state regulators, Category B projects are appraised at the state level by the State Environmental Impact Assessment Authority (SEIAA) constituted by the ministry in consultation with the respective state governments. Currently, 22 SEIAAs have been constituted.
- After the initial scrutiny, projects are placed before sector-specific expert appraisal committees constituted by the ministry for looking into the Category A projects. These sectoral committees are for industrial, thermal power and coal mining, non-coal mining, river valley, infrastructure and coastal regulation zones, and construction projects.
- In the case of certain very special/controversial projects, the committee may also arrange for public hearings. Announcements for such hearings are to be made at least 30 days in advance through newspapers. The appraisal committees make public their recommendations for the approval or rejection of particular projects.
- This is followed by the MoEF's final decision.

Forest clearance

Environmental clearance is granted to the project proponent while forest clearance is granted to the government of the state in which the projects is to come up. Forest clearances are given by the centre after the cases have been examined by the state government concerned. Normally, the projects that are not located in large/dense forest areas or in important wildlife conservation regions are favourably considered for diversion. However, regions with more than 40 hectares of forest area, those having a high tree density and those located in important wildlife areas are examined in detail by the Forest Advisory Committee, and are cleared or rejected as appropriate. In the case of forest clearances involving national parks and sanctuaries, the proposal first needs to be cleared by the State Board for Wildlife and finally by the Supreme Court of India. The case is then processed under the Forest (Conservation) Act, 1980. It is a two-stage approval process.

- Stage I: After a prima facie review, the proposal is either accepted or rejected. If approved, the project authority is required to deposit an amount as compensation for the opportunity cost of the forest (net present value, compensatory afforestation, additional expenses towards mitigating the probable environmental damage, etc.)
- Stage II: Following the deposit, the land is handed over to the project authorities, provided they have obtained all the other requisite clearances.

for growing Alphonso mangoes and fish-breeding - are being carefully evaluated. JSW's 1,200 MW project in Ratnagiri was given a green signal on the condition that it take mitigation measures to desulphurise emissions, provide dense plantations and fully utilise the fly ash it generates. The project was cleared by the MoEF in 2007 but a high court order has now asked the environment ministry to relook at the project.

Other causes for delays

The MoEF claims that the reforms undertaken by it have expedited the process of obtaining clearances and made it less cumbersome. Its website now provides real-time information on the exact status of projects that are awaiting clearances.

However, the ministry has pointed out several inadequacies on the part of the project developers that hold up the clearance process. To begin with, the applications do not furnish all the required details. Also, the prefeasibility report is found wanting. Recently, the environment ministry returned the prefeasibility reports of four atomic projects proposed by the Nuclear Power Corporation of India as important issues involving land use details and land use maps, the sites' environmental setting and details of the township component were not mentioned. Sometimes, the ministry finds that the TORs are not adhered to, or that by the time of TOR is issued and the EIA report presented, significant changes with regard to project size or land usage have already taken place.

At the times, the protect-affected people complain that public hearings have not been conducted in a proper manner or that they have not been adequately compensated. The ministry has to intervene in such cases. Sometimes the developers begin work on the project without obtaining environmental clearance, simply assuming that it is bound to come later on. One such case is that of Jindal Power's Raigargh project in Chhattisgarh. The ministry has revoked the TOR of this expansion project claiming that it had started work without the requisite clearance, and had also kept the ministry in the dark about its change in location. In its defence, Jindal Power has stated that it has only optimised land use for the project as advised in the final TOR, and that the construction was for the existing unit and not the new one.

Another cause for the delays is that several fragile regions have reached their carrying capacity limit owing to a project-by-project clearance approach. What is needed is landscape-wide or basin-based approached to project development.

Developer concerns

The developers contend that too much effort goes into obtaining clearances. According to them, a disproprotionate amount of details are sought in the application and technical issues are reopened at every stage of appraisal. The multiplicity of agencies involved at the centre and the state level also make it a time-consuming proposition. "Despite improving the systems and transparency, there is still an element of adhocism and arbitrariness in the entire approach", says a disgruntled developer.

"The streamlining measures should continue and proper systems should be put in place. Otherwise, only some developers suffer. Also, the ministry can't undo everything that has been done in the past. Projects that have received the clearance, even if not deserving, should not be stopped", notes another developer, whose project in Chhattisgarh now falls in the prohibited area.

Box 2: MoEF's latest salove - To mine of not to mine

Triggering panic among power project promoters, a joint study by the coal ministry and the MoEF has identified mines that fall in go-go areas. Undertaken in nine blocks of Coal India Limited, the study has categorised the blocks into A and B. Coal blocks that are situated in large, densely forested areas, or form a part of an unbroken landscape or are located in important wildlife parks and sanctuaries fail under Category a, while the rest fall under Category B where applications under the Forest Conservation Act (FCA), 1980 are processed. However, the Category B blocks would be open to mining only if the area does not form a part of any national park and wildlife sanctuary or any important wildlife corridor and is not an island of disturbance in an unbroken landscape. Under Category A, the study has identified 30 mines in North Karapur (Jharkhand), 24 mines in to Valley (Orissa), 11 mines in West Bokaro (Jharkhand), 20 mines in Hasdeo (Chhattisgarh) and 22 mines in Shogpur. Overall, 35 per cent of the mining area fails in Category. A while 65 per cent of the mines fail under Category B. In the case of the Hasdeo-Arand coal-filed, the interministerial team has suggested that it should be cleared under the FCA but with a lot of mitigative measures, compensatory afforestation and long-term independent monitoring. A similar exercise is now expected to be taken up in Coal India Limited's other coal blocks.

Power project promoters with captive coal blocks say that the sudden decision to declare some areas as no-go zones has put a spanner in their works. They say that the coal ministry should have sought forest clearance for these blocks before allotting the captive mines in 2008. "The absence of time-bound accordance of these clearances creates a significant amount of uncertainty with regard to the project development schedule", says a promoter. "On the other hand, the developer faces the risk of cancellation of bank guarantees and mine allotments if clearances are not obtained in a time-bound manner as specified in the allotment letter."

Conclusion

Clearly, with environmental security becoming a top priority, procuring environment and forest clearances is getting increasingly difficult. While the MoEF does its job, project promoters can ensure expeditious clearance of their projects by carefully preparing the requisite documents and reports, and observing good practices and self-compliance. The government, meanwhile, must ensure proper coordination between the coal, power and environment ministries so that promoters and projects do not suffer unjustly.

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Substation Automation

by C. V. Usha, Deputy Chief Engineer (Retd.), KSEB

Power transmission networks are used for transmission of supply from Generating Stations to different parts of our country. In order to reduce the high transmission loss high voltage transmission system are used in our country.Distribution networks are used for distribution of supply to the consumers and this is done at lower level of voltage. Due to lack of intelligent automation systems in the field of electrical power transmission/distribution, power losses and accidents are not uncommon in our country. It is too late to modernize these networks with advanced automation tools like PLC and SCADA. Our project is to integrate complete operations of the electrical substation to the SCADA installed in a computer. The SCADA communicate with the PLC and control is done through PLC. The operations in a substation can be broadly classified to

1. Monitoring of different parameters and data logging
2. Safety interlocks
3. Control of different feeders from single computer.

SUBSTATION AUTOMATION FUNDAMENTALS

Levels of Substation Automation - Substation integration and automation can be broken down into five levels. The lowest level is the power system equipment, such as transformers and circuit breakers. The middle three levels are Intelligent Electronic Device (IED) implementation, IED integration, and substation automation applications. All electric utilities are implementing IEDs in their substations. The focus today is on the integration of the IEDs. Once this is done, the focus can be shifted to what automation applications should run at the substation level. The highest level is the utility enterprise, and there are multiple functional data paths from the substation to the utility enterprise.

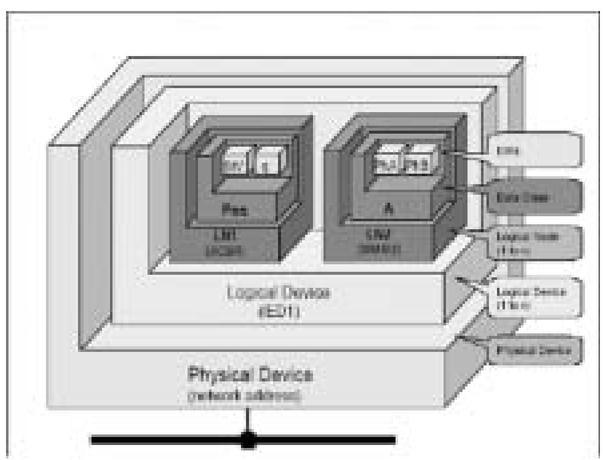


Fig. 1. Devices, nodes, classes and data

Architecture Functional Data Paths - There are three primary functional data paths from the substation to the utility enterprise: operational data to SCADA systems, non-operational data to data warehouse, remote access to IED. The most common data path is conveying the operational data (e.g., volts, amps) to the utility's SCADA system every 2 to 4 hours. This information is critical for the utility's dispatchers to monitor and control the power system. The most challenging data path is conveying the non-operational data to the utility's data warehouse.

Substation Integration and Automation System Functional Architecture - The functional architecture includes three functional data paths from the substation to the utility enterprise, as well as the SCADA system and the data warehouse - Data Concentrator, SCADA interface, Router. The operational data path to the SCADA system utilizes the communication protocol presently supported by the SCADA system. The non-operational data path to the data warehouse conveys the IED non-operational data from the substation automation (SA) system to the data warehouse, either being pulled by a data warehouse application from the SA system or being pushed from the SA system to the data ware house based on an event trigger or time.

Equipment Condition Monitoring - Many electric utilities have employed ECM to maintain electric equipment in top operating condition while minimizing the number of interruptions. With ECM, equipment-operating parameters are automatically tracked to detect the emergence of various abnormal operating conditions. This allows substation operators to take timely action when needed to improve reliability and extend equipment life. This approach is applied most frequently to substation transformers and high voltage electric supply circuit breakers to minimize the maintenance costs of these devices, as well as improve their availability and extend their useful life.

Different Levels in substation automation.

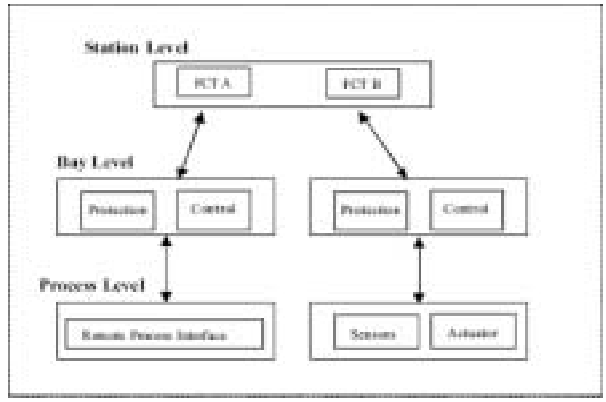


Fig.2. Levels defined in IEC-61850

Process Level functions

Process level function extracts the information from sensors/transducers in the substation and to send them to upper level device, called bay level device. The other major task of process level function is to receive the control command from bay level device and execute it at the appropriate switch level.

Bay Level Functions

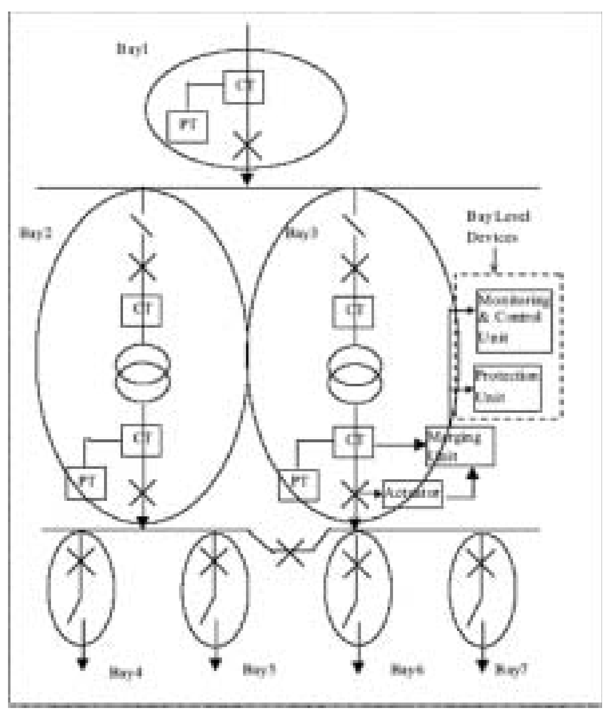


Fig.3. Bay level functions

Bay level functions acquire the data from the bay and then mainly act on the primary (power circuit) equipment of the bay. The different conceptual subparts of a substation are encircled by dotted line in following figure. These subparts are called bays and designated by Bay1 to Bay7. For example, a transformer with its related switchgear between the two busbars representing the two voltage levels forms one bay, designated by Bay3. The Current Transformer (CT) and Potential Transformer (PT) are an integral part of Bay3 for monitoring, control and protection of the transformer. The CT, PT and actuator are connected to protection and control unit via merging unit. Merging unit is a device to collect the instantaneous values of current and voltage from CT and PT, sample the same and send them to the protection and controls unit. Protection unit and Control unit are bay level devices. Bay level devices collect data from the same bay and/or from different bays and perform actions on the primary equipment in its own bay.

Station Level Functions

Station level functions are of two types.

1. Process related functions
2. Interface related functions

Process related functions

Process related functions act on the data from multiple bays or substation level database. These functions are used to submit the control commands for the primary equipment (Circuit breakers) and collect the substation data like voltage, current, power factor etc. from the bay level devices. As described above, each bay includes one primary equipment such as transformers, feeders etc.

Interface related functions

Interface related functionsenable interactive interface of the substation automation system to the local station operator HMI (Human Machine Interface), to a remote control centre TCI (Tele Control Interface) or to the remote monitoring centre for monitoring and maintaining TMI (Tele Monitoring Interface).

Intelligent Electronic Devices

Intelligent electronic devices (IEDs) being implemented in substations today contain valuable information, both operational and non-operational, needed by many user groups within the utility. An IED is any device that incorporates one or more processors with the capability to receive or send data/control from or to an external source (e.g., electronic multifunction meters, digital relays, controllers, PLCs,). IED technology can help utilities improve reliability, gain operational efficiencies, and enable asset management programs including predictive maintenance, life extensions and improved planning.

IEDs are a key component of substation integration and automation technology. Substation integration involves integrating protection, control, and data acquisition functions into a minimal number of platforms to reduce capital and operating costs, reduce panel and control room space, and eliminate redundant equipment and databases. Automation involves the deployment of substation and feeder operating functions and applications ranging from supervisory control and data acquisition (SCADA) and alarm processing to integrated volt/var control in order to optimize the management of capital assets and enhance operation and maintenance efficiencies with minimal human intervention.

IEDs facilitate the exchange of both operational and non-operational data. Operational data, also called supervisory control and data acquisition (SCADA) data, are instantaneous values of power system analog and status points such as volts, amps, MW, MVAR, circuit breaker status, switch position. This data is time critical and is used to monitor and control the power system (e.g., opening circuit breakers, changing tap settings, equipment failure indication, etc.). Non-operational data consists of files and waveforms such as event summaries, oscillographic event reports, or sequential events records, in addition to SCADA-like points (e.g., status and analog points) that have a logical state or a numerical value. This data is not needed by the SCADA dispatchers to monitor and control the power system.

BLOCK DIAGRAM

Substation automation block diagram

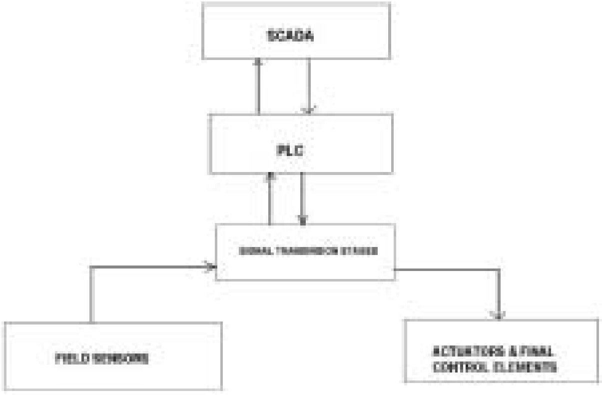


Fig.4. Substation block diagram for SCADA

FIELD SENSORS

Current Transformers

Current Transformers can be installed on either or both sides of the circuit-breakers and at the ends of outgoing circuits.

Voltage Transformer

Voltage Transformers can be installed anywhere on the substation.

Push Button Switches

Push button switches are mainly two types- NO type and NC type. NO type push button switches are used for energizing feeder ACB or contactor and NC type are used for de energizing. An Emergency stop button is used for system shut down during alert conditions.

Temperature measurement

The temperature of transformers and other equipments can be monitored using Resistance Temperature Detector (RTD) and temperature transmitter. The output of temperature transmitter is 4 – 20 mA corresponding to the temperature. The ADC inside PLC will convert this signal to 16 bit digital signal.

Frequency transmitter

Supply frequency in each feeder can be monitored using frequency transmitters connected in corresponding feeder. High speed data acquisition systems are used for frequency measurement. Normally the output is in the range of 0 to 10 V or 4 to 20 mA.

Power factor measurement

Power factor regulation is the most important and complicated process in electrical distribution networks. The power factor in the line depends on the inductive or capacitive load connected in the feeder. Pf measuring digital circuits produce a retransmission output which can be connected to PLC and monitored using SCADA. Power factor can be regulated using capacitor banks connected in binary order.

FINAL CONTROL ELEMENTS

Contactors

Contactors are used for switching up to 450 A. Contactors are mainly 3 Pole type or 4 Pole with extra NO / NC auxiliary contacts. The coil voltage may vary from 24 V DC to 440 V AC. For higher current carrying capacity ACBs are used.

Fig.5. AC contactor

Air Circuit Breaker

Air circuit breakers are used for high capacity feeders. In high current feeders the arching is common. Air Circuit Breakers are specially designed to reduce the arching.

Fig.6. Air Circuit Breaker

PROGRAMABLE CONTROL LOGIC (PLC)

Control engineering has evolved over time. Manual controlis the main method for controlling a system. More recently electricity has been used for control and early electrical control was based on relays. These relays allow power to be switched on and off without a mechanical switch. It is common to use relays to make simple logical control decisions. The development of low cost computer has brought the most recent revolution the Programmable Logic Controller (PLC). The advent of the PLC began in the 1970s, and has become the most common choice for manufacturing controls. PLCs have been gaining popularity on the factory floor and will probably remain predominant for some time to come. Most of this is because of the advantages they offer.

- Cost effective for controlling complex systems.
- Flexible and can be reapplied to control other systems quickly and easily.

- Computational abilities allow more sophisticated control.
- Trouble shooting aids make programming easier and reduce downtime.
- Reliable components make these likely to operate for years before failure.

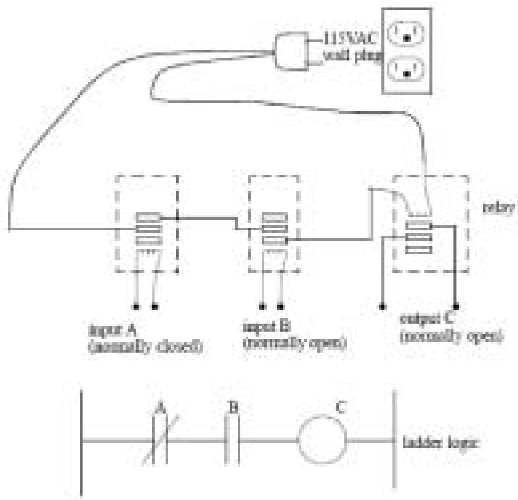


Fig.7. A simple relay controller

The following figure shows the comparison of relay logic system with PLC. In relay logic system we are using a number of relays to accomplish one control sequence. In relays, the no. of poles is limited to three so that more relays are to be used if same input is coming in many places.

In the Figure 7 it is clear that the wiring is very less and all functions of relays are replaced by single PLC.

Ladder logic is the programming language used for programming PLCs. It is similar to relay wiring diagram so that technicians can easily understand the working of each part.

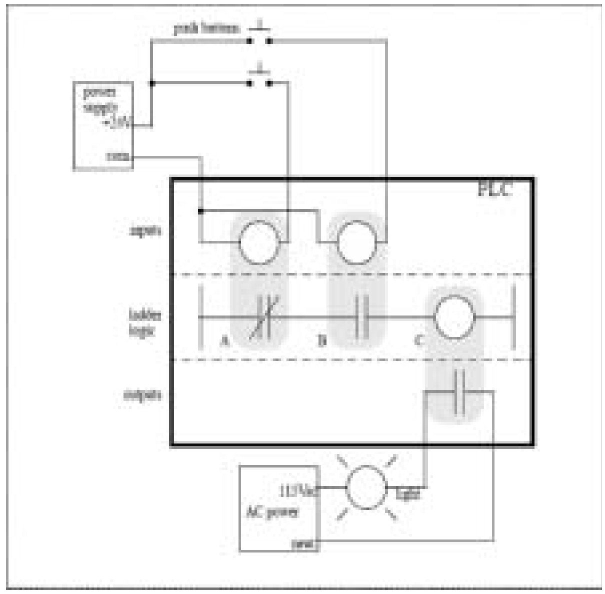


Fig.8. A PLC illustrated with relays

PLC Architecture

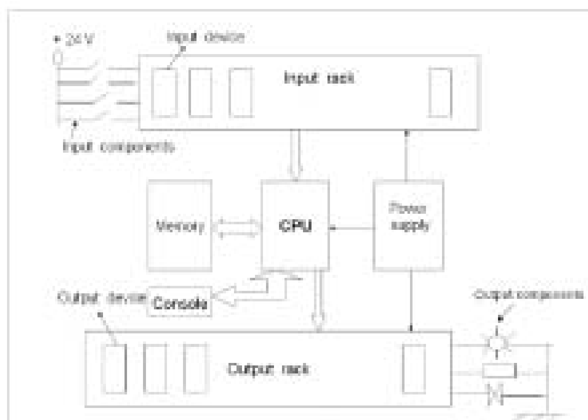


Fig.9. PLC Architecture

Description of PLC components

Central Processing Unit

The CPU performs data handling execution and self-diagnostics. It first checks what and what the values of inputs are. Then the CPU processes these inputs according to the program loaded and decides the instantaneous values of outputs. CPU sends the output values to the corresponding devices.

The CPU manufacturing is done based on different technologies like Transistor Transistor Logic (TTL), CMOS, or microprocessor.

Input module

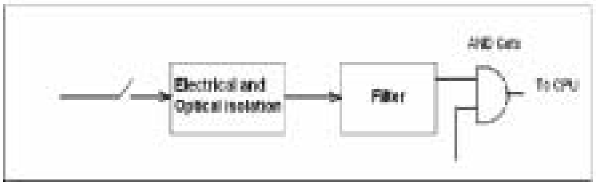


Fig. 10. Input module

The input module consists of the channels to the input registers. Generally PLCs are manufactured having 8, 16 or 32 input channels as a standard. Miniature type of PLCs might be having only 8 inputs. Higher type of models might be having 16 or 32 channels.

Each input channel consists of an electrical isolator (switch), filter and an AND gate switching section. The isolator will be a relay. It may be an electromagnetic relay or a transistor switch etc. It is expected to give a digital signal of 24 volts. The filter eliminates any type of voltage spikes in the input channel. Then the AND gate is connected. The AND gate will be supplied with other inputs like enabling signal etc. Thus the corresponding input will be lead to the input register.

There are PLCs that use 5, 12, and 24 volts also. Moreover there are systems using even ac voltage. But at present as a standard 24V dc is used in almost all PLCs.

Note: - An input module is used for converting physical inputs to digital inputs which can be interpreted by CPU.

Output module

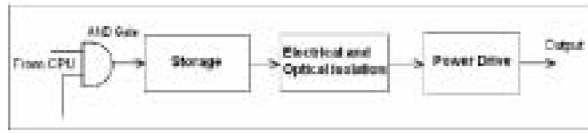


Fig. 11. Output module

Output module also consists of 8, 16 or 32 channels emerging from the processor module. The outputs from CPU are first stored in the memory. Then they are taken from the memory to the output pins. There will be an optical or electrical isolator. This isolator provides with the digital output signal of 24 volts. This signals works as the power driving signals of the outputs. They can drive the output devices like motors, solenoids, lights etc. if proper power supply is there.

Note: - An output module is used for converting digital inputs from CPU to physical inputs, which can energize the outputs.

Power supplies

PLCs are having power supplies for the working of inputs and outputs. Generally +24V DC is used for driving inputs and outputs. Some PLCs are having internal power supplies and some have provision for connecting external power supplies.

Input and output components

Input and output components are the components, which assist the PLC to give and take inputs and outputs properly. The generally used input components include Toggle switches, Limit switches, Push button switches, Centrifugal switches, Level switches, etc. and the output components are motors, relays, coils, meters etc.

Memory

Typically there are registers assigned to simply store data. They are usually used as temporary storage for math or data manipulation. They can also typically be used to store data when power is removed from the PLC. The data includes the program, input, output values and internal relay values. Memory is the Library where the application programs & executive programs are stored. Upon power-up they will still have the same contents as before power was removed. Semiconductor memories are used for storing data and programs.

Programmer Units (Console)

The programmer unit provides interface between the PLC & the user. The programmer could enter the program and load the program to the PLC using the programmer unit. Earlier days Small hand held units were available for this purpose. It could provide complete documentation, I/O status, and on-line & off-line programming ability. Nowadays personal computers are used as programmer units. Ladder diagrams or text programs can be used for programming.

PLC Operation

A PLC works by continually scanning a program. This scan cycle consists of 3 important steps.

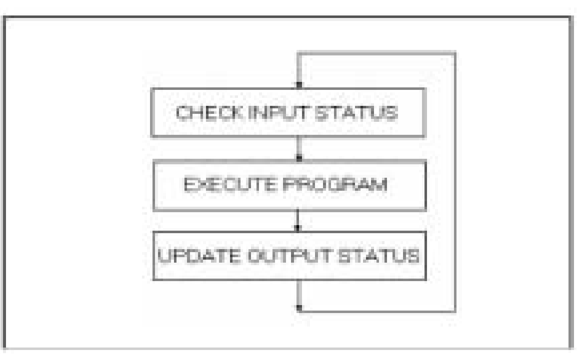


Fig. 12. Block diagram of PLC operation

Step 1 - Check Input Status-First the PLC takes a look at each input to determine if it is on or off. In other words, it checks whether the sensor connected to the input on.

Step 2 - Execute Program-Next the PLC executes the program one instruction at a time. Maybe the program said that if the first input was on then it should turn on the first output. Since it already knows which inputs are on/off from the previous step it will be able to decide whether the first output should be turned on based on the state of the first input. It will store the execution results for use later during the next step.

Step 3 - Update Output Status-Finally the PLC updates the status of the outputs. It updates the outputs based on which inputs were on during the first step and the results of executing your program during the second step.

After the third step the PLC goes back to step one and repeats the steps continuously. One scan time is defined as the time it takes to execute the 3 steps listed above.

PLC input output modules

Discrete inputs and outputs

Inputs to, and outputs from, a PLC are necessary to monitor and control a process. Both inputs and outputs can be categorized into two basic types: logical or continuous. Consider the example of a light bulb. If it can only be turned on or off, it is logical control. If the light can be dimmed to different levels, it is continuous. Continuous values seem more intuitive, but logical values are preferred because they allow more certainty, and simplify control. As a result most controls applications (and PLCs) use logical inputs and outputs for most applications. Hence, we will discuss logical I/O and leave continuous I/O for later. Outputs to actuators allow a PLC to cause something to happen in a process.

Outputs from PLCs are often relays, but they can also be solid state electronics such as transistors for DC outputs or Triacs for AC outputs. Continuous outputs require special output cards with digital to analog converters. Inputs come from sensors that translate physical phenomena into electrical signals. Inputs for a PLC come in a few basic varieties, the simplest are AC and DC inputs.

Sourcing and sinking inputs are also popular. This output method dictates that a device does not supply any power. Instead, the device only switches current on or off, like a simple switch.

Sinking (NPN) -When active the output allows current to flow to a common ground. This is best selected when different voltages are supplied.

Sourcing (PNP) - When active, current flows from a supply, through the output device and to ground. This method is best used when all devices use a single supply voltage.

Inputs

In smaller PLCs the inputs are normally built in and are specified when purchasing the PLC. For larger PLCs the inputs are purchased as modules, or cards, with 8 or 16 inputs of the same type on each card. For discussion purposes we will discuss all inputs as if they have been purchased as cards. PLC input cards rarely supply power, this means that an external power supply is needed to supply power for the inputs and sensors. The example in Figure 13 shows how to connect an AC input card.

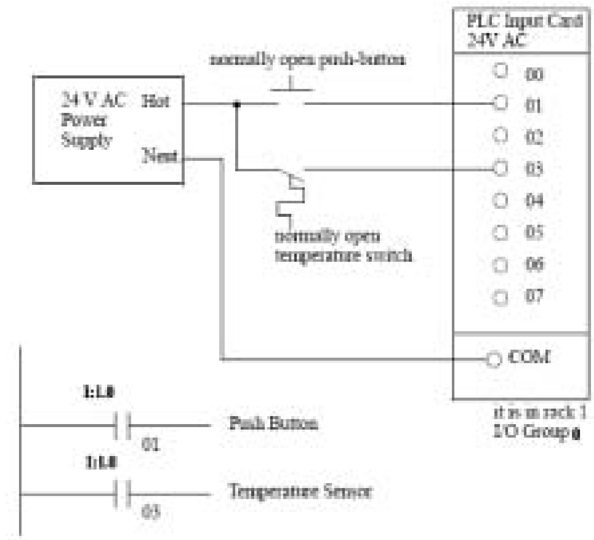


Fig.13. Connection of ac input card

An important concept is the common. Here the neutral on the power supply is the common, or reference voltage. In effect we have chosen this to be our 0V reference, and all other voltages are measured relative to it. If we had a second power supply, we would also need to connect the neutral so that both neutrals would be connected to the same common. Often common and ground will be confused. The common is a reference, or datum voltage that is used for 0V, but the ground is used to prevent shocks and damage to equipment. The ground is connected under a building to a metal pipe or grid in the ground. This is connected to the electrical system of a building, to the power outlets, where the metal cases of electrical equipment are connected. When power flows through the ground it is bad. Unfortunately many engineers and manufacturers mix up ground and common. It is very common to find a power supply with the ground and common mislabeled.

One final concept that tends to trap beginners is that each input card is isolated.

This means that if you have connected a common to only one card, then the other cards are not connected. When this happens the other cards will not work properly. You must connect a common for each of the output cards.

Why Use a Programmable Logic Controller?

- Vacant rack and module space to add non-vital relays was constraining for the magnitude of the modification for this particular project.
- The ease to familiarize oneself with the programming of a PLC.
- Off-the-shelf PLCs were very attractive from the cost perspective
- The agreed upon exit prohibit algorithm required a complex logic arrangements including counters and timers that would challenge all relay logic to the extent that the hardware requirement would quickly become cost prohibitive.
- The simplicity of the installation of a PLC.
- PLCs are specially made for industrial applications so that they are more reliable compared to micro controllers.

SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA)

SCADA is the short form for Supervisory Control and Data Acquisition. It the most commonly used automation software for monitoring and controlling different process in a plant. SCADA can communicate with many automation products through Remote Terminal Unit (RTU).

WonderwareInTouch SCADA package

Intouch is world's leading supervisory control and data acquisition software. The InTouch software package consists of Tags (Memory + I/O). The package is available in 64, 256, 1000 and 64,000 Tags with the two options

1. Development + Runtime + Network (DRN)
2. Runtime + network (RN).

With DRN package you can develop as well as run the application but in case of RN you cannot develop/modify the application. The application can be developed by using DRN package and can be installed on RN package.

Wonderware has a package, Factory suite, which can be used for monitoring the process. It's a Runtime software with no control i.e. output from the factory focus software to hardware/external devices is not possible.

Application Development InInTouch Involves

1. Creating new application
2. Creating windows / MIMIC page
3. Tag definition
4. Drawing objects
5. Animation properties
6. Writing scripts
7. Real-time Trends
8. Historical Trends
9. Alarms and Events

SCADA in the project

SCADA is the important part of the project for the supervisory control of power distribution system. We can create a better user interface with different features in SCADA. A SCADA interface can be developed so as to control supply to different feeders and also main feeder. An emergency stop button can be used for stopping the whole system during accidents.

The most important feature is that a user can set the timing for load shedding in different feeders. The feeder is automatically charged after the load-shedding period. The system can be operated both in Auto and Manual modes. User can control the distribution of power to different feeders by single mouse click in computer.

Thus with PLC communication SCADA project can be implemented in any power distribution networks for computerized monitoring and control.

APPLICATIONS

This project is of great applications in industries and domestic areas. The project can be implemented for substations for automation and thus the required manpower can be reduced.

In BMS (Building Management systems) the power distribution to different flats are from a single control room. This project can be implemented in any BMS system utilizing SCADA for and data logging and computer based control of power distribution.

In motor control centers the operation of different motors can be controlled from a single terminal with the aid of this project. Different motors can be switched on and switched off with a mouse click from a computer.

DISADVANTAGES

1. The system is very costly
2. Proper use of automation system requires skilled workers.
3. Mistakes in the operator can cause great accidents in the distribution networks.
4. Losses in transmission data cause malfunctioning.

FUTURE DEVELOPMENTS

Programmable power distribution system

In this system the load shedding time can be set by a user. When the system time become the programmed time the supply will be automatically disconnected and after the preset time the supply is again charged to the feeder.

1. Energy monitoring and data logging system
2. Supply to different feeders can be monitored and logged in convenient formats so that the energy consumption in each feeder can be analyzed for future use. ●

"We have to remember that what we observe is not nature herself, but nature exposed to our method of questioning"

– Werner Karl Heisenberg

Electronic Noses Sniff Success

E-Noses will soon be ubiqutious, thanks to printed organic semiconductors
by Josephine B. Chang & Vivek Subramanian

Several hundred years ago, village doctors in rural China diagnosed diabetes by the characteristically sweet smell of a patient's breath. Today hospitals use a battery of blood tests and laboratory analyses to make that same diagnosis, but doctors may soon be sniffing their patients' breath again. This time the doctors will have electronic noses small and cheap enough to carry in their pockets.

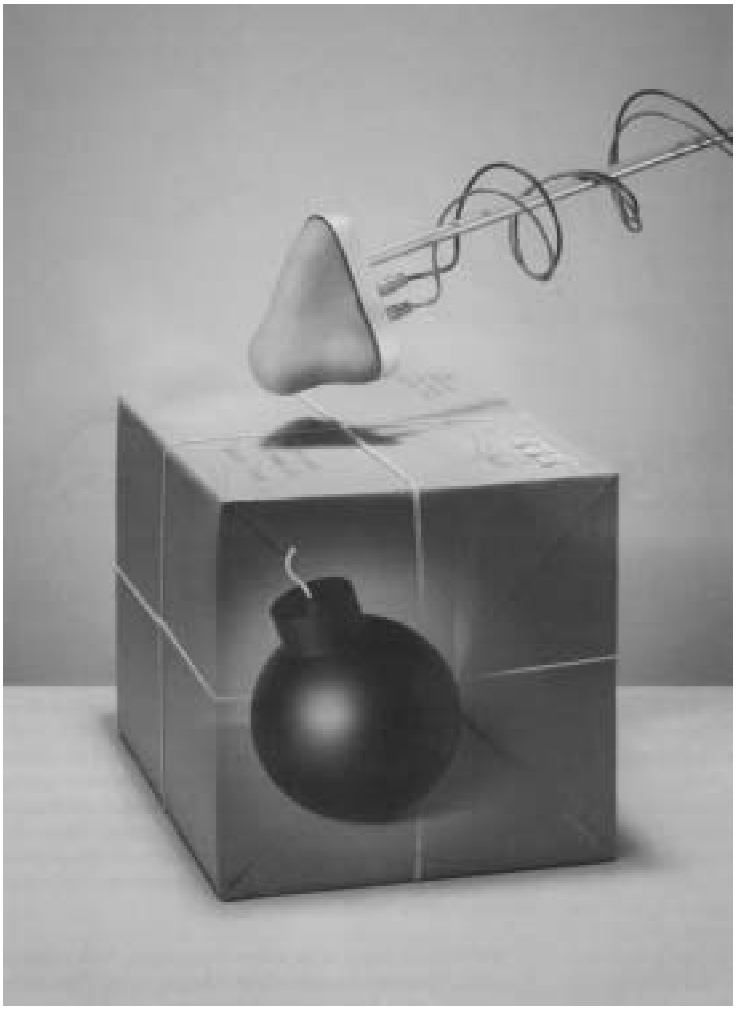
This e-nose will be the culmination of decades of work at countless laboratories, where researchers have sought to create a tiny, cheap, automatic sniffer that would let wine bottles monitor the aging of their contents, allow meat packages to flag spoilage, and enable mailboxes to check for bombs. Imagine barroom coasters that double as Breathanalyzers, bumper stickers that monitor car emissions. Until now, it's been just so much sci-fi.

E-nose technology has quietly advanced during the past two decades. Commercial models equipped with sensor arrays came to market in the mid-1990s, and today they're used to distinguish wines, analyze food flavours, and sort lumber. Benchtop systems are also used in the pharmaceutical, food, cosmetics, and packaging industries, while smaller, portable units are used to monitor air quality.

But these noses cost in the range of US $5000 to $100000. A coming convergence between e-nose technology and advances in printed electronics will finally bring the price down - way down. Within a decade we'll see e-noses that cost tens of dollars and appear in smart packaging for high-end items like pharmaceuticals or as part of intelligent or interactive appliances - picture a refrigerator that knows when milk has gone bad. Prices could easily drop to under a dollar by 2020.

The secret? Conducting polymers. Developers of both electronic noses and printed electronics are exploiting these materials, which can be sensitive to the chemicals that make up odors and are also capable of producing electrical signals. E-nose developers are concentrating on honing the sensing properties of conducting polymers, while the printed - electronics people are investigating ways of using these materials to fabricate ultralow-cost electronics. Combining the fruits of these two separate efforts will finally bring e-noses into our supermarkets, homes, and daily life.

The human nose is an astounding organ, with millions of odor sensors of hundreds of different types. They let an average adult detect 10000 different odors, which are usually a complex mixture if vapors, or what



chemists call volatile organic compounds. Some arise from chemical concentrations in air down in the parts-perptrillion range. A normally functioning person can tell the difference between fresh milk and milk that's bonebad.

Volatile organic compounds shape the aroma and taste of most foods and can act as keen indicators of freshnes and quality. But a fresh-cut orange, say, or a piece of Swiss cheese may release hundreds of these chemicals. As far back as the 1950s, researchers built sensors that could detect and quantify the sprawling assortment of chemical components of an odor. But these sensors were difficutt to design and had limited use. Even today, most of these basic chemical sensors operate on a lock-and-key strategy, in which a targeted sensing mechanism picks out one specific kind of molecule from the dozens or more in an odor.

In 1982, Krishna persaud and George Dodd at the Unviersity of Warwick, in Coventry, England, put together the first sensor array for odor recognition - that is, a collection of electronic sensors, each of which responded in different ways to a range of volatile chemicals. Persaud and Dodd used oscillating semi-conducting transducers that changed frequency when they detected certain compounds.

In 1988, Julian Gardner, also at the University of Warwick, dubbed this approach the electronic nose. Rather than cataloging the chemical compounds of an odor, an e-nose identifies complex odors by using pattern recognition strategies similar to those of the human olfactory system, albeit with diffferent sensing mechanisms. Given a glass of wine, the average person knows from the smell alone what the liquid is. But only a serious oenophile might be able to break the odor down into its constituent parts: alcohols, acids and esters. The human nose has hundreds of different types of odor sensors, whose response patterns are processed by the brain, which then searchers its memory for matches to stored response patterns. An electronic nose uses far fewer sensors; commerical systems have around 10 to 50 sensing elements.

Your typical e-nose consists of a sampling system, a gas-sensor array, and a signal processor coupled to a pattern-recognition system of some sort. The sampling system brings vapor-laden air into the sensor array; in a laboratory setup it might have a fan that blows air across the array in an action reminiscent of human sniffing. The nose might allow a vial of air to be released inside it; perfume makers capture samples this way. Or it might work passively, simply because the array is exposed, like the sensor in a smoke detector.

In the sensor array, each of the sensors responds to a broad range of gases, with much duplication; multiple sensors will respond to the same gas, but not in the same way, and not to all the same gases. To identify specific odors requires the signal processor to analyze the array response with pattern-recognition algorithms; in today's expensive electronic noses, a micro-processor uses a large set of stored algorithms to sort through patterns. In the future, however, single-purpose noses looking for a simple change - food gone bad, for example - could use application-specific integrated circuits for analysis.

Much like that of the human nose, this type of odor recognition is more flexible and more powerful than what is possible with a lock-and-key sensor, which can detect only a single compound, say, carbon monoxide. Such a sensor would have a hard time telling the difference between Grandma's apple pie and Mom's. But it may be possible to train an array-type e-nose to discriminate between them and all other apple pies.

And unlike systems based on lock-andp-key sensors, electronic noses can be enormously flexible. Rather than developing one nose for wine monitoring and a different one to detect bad fish, the same piece of hardware could be trained separately for different tasks. Imagine an electronic-nose system shipped with standard pattern-recog nition libraries. Load up one for the refrigerator and the system will sniff for spoiling foodstuffs; load up a different one for the garden and the system searchers instead for the telltale odors of snails and other pests. And what if you want the e-nose to learn the difference between Grandma's apple pie and Mom's? Well, chances are the manufacturers will have never met Grandma or Mom or sampled the output of their ovens. But they may have included software for generating new pattern-recognition libraries. If so, you would hook up the nose to the training system, introduce it to one apple pie at a time and find out if the pies generate distiguishable responses in the array. If they do, they generate a new library, load it up, and you've got a personalized apple-pie connoisseur.

In training a nose, it is not necessary to fully understand the chemical differences between good wine and bad wine or between two pies; it is enough that the nose knows. So to teach a nose, developer simply presents, say, to samples of wine gone bad and to samples of good wine and asks the system to find a pattern that represents the difference and to use that to distinguish good from bad in the future.

In 1998, the University of Warwick's Gardner along with Philip Bartlett, of the University of Southampton, predicted that "the next decade should see the cost of electronic noses fall dramatically" and that they would “be used not ony in industry but also in everday life.” It didn’t happen. Today commercial prices for electronic noses are the same as they were in 1998, typically about $10000. even simple consumer products like handheld Breathanalyzers and carbon monoxide monitors, which usually target only a single compound and are therefore much simpler, sell for $50 and up.

Electronic noses have been expensive up to now because they use different technologies - electroic circuitry for signal processing and pattern recognition along with multiple chemical sensors that have to be separately wired together - and so can’t easily be mass-produced. In many cases, a personal computer runs the signal-processing software, the sensing apparatus is simply plugged into it. These patched-together systems have limited uses and aren’t suited for high-volume, low-cost consumer markets.

Researchers have tried to integrate the sensors into the circuitry-that is, to make them on a single chip with traditional semi-conductor-manufacturing techniques typically using the CMOS process. This is theoretically possible, as sensors are normally made out of metal oxides like tin, copper, nickel, or cobalt oxide; these can be deposited on a wafer. However, a typical CMOS chip has 20 to 40 layers, add in 50 sensors, each with a slightly different composition requiring separate deposition steps, and you’ve doubled the complexity. In addition to the cost of these extra steps, each layer also introduces defects that hurt yield and therefore raise the cost of each device. And you couldn’t manufacture these chips in multipurpose factory: introducing exotic materials into that environment could hurt yeilds of traditional chips made on the same line, so you’d have to build your own very expensive manufacturing line. the hurdles for a CMOS e-nose, therefore, are not readily surmountable and have stalled the progress of low-cost electronic noses for years.

Advances over the past few decades in the capabilities of conducting polymers, however, have given e-nose researchers new hope. These materials can be deposited from a solution, enabling them to be cheaply and easily painted or printed onto substrates.

These are organic polymers, which are long molecules with carbon backbones. Carbon, with its four valence electrons, has an enormous capacity for chemical interactions with other materials. This capacity makes organic polymers ideal for sensing applications because they can be designed to internet in many different ways with many different vapor molecules. Most orgaic polymers are electrically insulating, but by tweaking the structure, designers can produce some electrically conductive polymers by making it easy for charge to travel along the carbon backbone of the molecule.

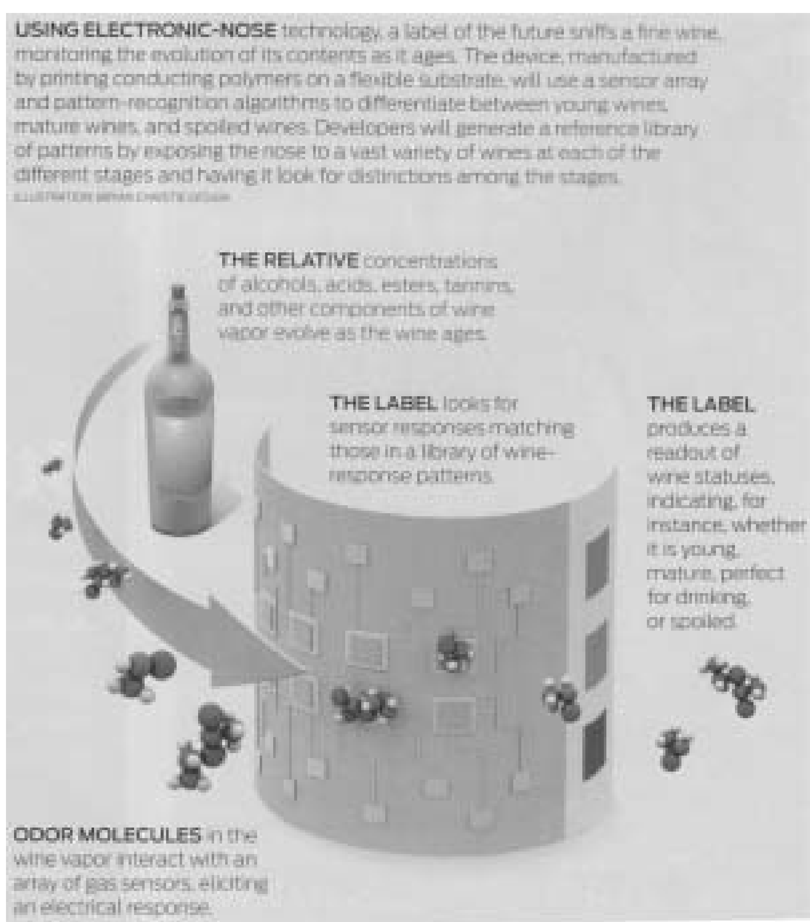
For a gas sensor to actually “sense” an odor, it must translate a response - which is often a subtle chemical interaction between the sensor and the odor-into an output that can be easily interpreted, such as colour change. Conducting polymers excel at this translation because the chemical interaction between an orgnanic polymer with a vapor molecule can change the polymer’s electrical characteristics, resulting in an electrical response that is cheap and easy to detect.

In the early 1990s, scientists first

demonstrated that a variety of conducting polymers, each with different electrical characteristics, could be integrated on a single substrate using a process called serial electrode position. In this process, the manufacturer repeatedly dips a substrate into a chemical solution containing the chemical building blocks of the sensing polymers. Then an electrical bias is applied, which induces the molecules to polymerize. Polymerization is the process by which many identical small chemical building blocks, called monomers, come together to from long chains.

By slipping low concentrations of different chemicals into the mix during polymerization, scientists can modify the characteristics of the final polymer. Using this method, only one type of material can be deposited at once, so manufactures must repeat the process multiple times to get different polymers onto the same substrate.

While conducting polymers are potentially soluble, the majority of conducting polymers used for sensing today are not. The advantage of going to soluble polymers is that manufacturers already have tools for laying soluble polymers on a substrate cheaply, reliably, and quickly. They print them the same way an inkjet printer quickly deposits various coloured inks to make color printouts. Printing allows the placement of many types of different materials next to one another on the same substrate. In printed sensors, then additional sensor materials can be incorporated by adding extra print heads; additional process steps are not required. Processes like these have jump-started the emerging field of printed electronics, with the first new porudcts, like-books by Sony and Amazon, just now reaching consumers. Also, printing is compatible with roll-tol-roll processing, in which sheets of substrate are continuously processed, as opposed to producesses such as electrodeposition, in which small samples of the substrate must be dipped individually into different batches of solution. The roll-to-roll method speeds up manufacturing considerably, which brings down the cost.



USING ELECTRONIC-NOSE technology, a label of the future sniffs a fine wine, monitoring the evolution of its contents as it ages. The device, manufactured by printing conducting polymers on a flexible substrate, will use a sensor array and pattern-recognition algorithms to differentiate between young wines, mature wines, and spoiled wines. Developers will generate a reference library of patterns by exposing the nose to a vast variety of wines at each of the different stages and having it look for distinctions among the stages.

Printing polymers doesn't completely solve the manufacturing problem for e-noses, however. It is very rare to find the properties of conductivity, sensitivity to vapors, and solubility in a single organic polymer material. To get around this, researchers can incorporate conductive non-sensing materials into a soluble, sensing - but non-conductive-polymer. Visualize a pudding with raisins in it. Conductive raisins are suspended in a pudding that swells in the presence of certain odors. At a sufficiently high raisin density, randomly adjacent raisins would begin to form complete paths through the pudding to allow charges to percolate through. Carefully adjust the raisin density to rest near this threshold and you can expect any expansion or contraction of the pudding to strongly affect the number of percolation paths through the pudding.

There are two different types of "raisins" that developers use to form these soluble, conductive polymer composites. One is carbon black, which is made up of conductive carbon particles small enough to suspend easily in a soluble polymer solution. The other is polypyrrole, a common soluble conductive polymer.

Researchers are testing methods of using these polymer composites to print sensor arrays along with support circuitry on an integrated circuit chip. Electronics manufacturers have been developing techniques for printing organic electronics for a decade at least, focusing on printed displays, memories, batteries, organic thin-film transistors, and photovoltaics. Printed electronics in some of these applications are nearing their last stages of development before commercialization. Although many of the organic condcutive materials used in these applications are similar to those used in e-nose research, no developer has yet reported printing organic electronics for low-cost gas-sensor arrays.

In 2006, researchers at the University of California, Berkeley, reproted using an array of integrated printable organic semiconductors to differentiate between basic classes of odors, such as acids, alcohols, amines, and thiols; for example, this sensor array was able to distinguish wine from vinegar. In October 2007, researchers at MIT announced that they had successfully printed barium carbonate, which can detect a range of gases, onto a silicon chip. This is yet another printable sensing material that could enable printed gas-sensor arrays, though it has yet to become part of a working e-nose system.

The main hurdles to wide commercial use of these organic polymers involve their instability and short lifetimes. For odor sensing, a stronger chemical interaction between the sensor and the vapor improves the sensitivity of the sensor. However, the stronger the interaction, the more likely that the interaction will not be completely reversible. Put another way, the complete reversibility of the sensing interaction prolongs sensor lifetime, because the sensor is not permanently changed by the odors.

The most stable organic materials are the ones that do not interact with the environment at all. But no interaction means no sensing, of course. So gas sensors based on organic electronics must balance chemical sensitivity with resistance to degradation. Fortunately, there are a multitude of ways to tweak the properties of organic electronic materials to find the balance. Because the carbon atoms in the backbone of these substances bond easily with other materials, researchers can tack on or take off atoms of oxygen, nitrogen, or sulfur, for example, and change the shape, electrical response, or other properties of the polymer.

Making such changes has let researchers build electronic circuits that are sensitive to various gases. "Chemiresistors" change resistance in response to certain vapors, "chemicapacitors" change capacitance, and "chemitransitors" exhibit a variety of electrical changes in response to a particular vapor. As designers can also create standard resistors, capacitors, and transistors using organic electronics, they could incorporate sensing and signal processing into a complete e-nose package that could be manufactured cheaply.

It will take perhaps a decade more to increase the perfromance, yield, and reliability of organic electronics in order to make a cheap electronic nose a reality. Sensitivity, selectivity, and reproductibility of printable sensors all need improvement. Applications with lower cost margins, such as monitoring perishable items at the grocery stores, will require aggressive refinement of ultralow-cost printing techniques. More critical applications, like disease diagnosis, would require stringent improvements in accuracy and reliability as well as rigorous field testing. But once the technology is ready, printed electronics could do for e-noses what the printing press did for books: it could allow them to go from rare to ubiquitous in the blink of an eye...or the sniff of a nose. ●

Which is more important, the guru or you?
You are more important than I,
more important than any teacher, any savior, any slogan,
any belief, because you can find truth only through yourself,
not through another. When you repeat the truth of
another it is a lie.

– Jiddu Krishnamoorthi

The Silicon Dioxide Solution

How physicist Jean Hoerni built the bridge from the transistor to the integrated circuit by MICHAEL RIORDAN

Not plastic bags, nor metal screws, nor cigarette butts, No, the commonest human artifact today is the transistor - invented 60 years ago by Bell Labs physicists John Bardeen and Walter Brattain. Millions of these subminiature switches populate computers, cell phones, toys, domestic appliances, and anything else that carries a microchip. Exactly how many transistors are around is hard to know, but several years ago Gordon Moore, a founder of Intel Corp. and author of the famed Moore's Law, made an educated guess: more than 10^{18}-that's one quintillion - transistors are produced annually. "We make more transistors per year than the number of printed characters in all the newspapers, magazines, books, photocopies, and computer printouts," Moore told me recently. "And we sell these transistors for less than the cost of a character in the Sunday New York Times."

Behind the explosive growth that transistor production has seen since 1960 is a major technological achievement. Today, chipmakers essentially print transistors on silicon wafers. It's a manufacturing method rooted in the mechanical printing process originated by Johannes Gutenberg more than 500 years ago - though far more complex, of course. Moore himself played a lead role in developing transistor-fabrication technology during the 1960s when he was research director at Fairchild Semiconductor Corp., in Palo Alto, Calif. But much of the credit for that revolutionary advance belongs to a lesser-known semiconductor pioneer and Fairchild confounder. The unsung hero of this pivotal chapter in the history of electronics - the invention of the planar transistor-is Jean Hoerni.

A Swiss-born theoretical physicist, Hoerni, along with seven other determined, like-minded rebels-Moore, Robert Noyce, Jay Last, Sheldon Roberts, Eugene Kleiner, Julius Blank, and Victor Grinich-founded Fairchild in 1957. They all contributed, directly or indirectly, to the new technology, but mone so much as Hoerni [see photo, "Practical Theorist"]. Fifty years ago, sitting alone in his office, he elaborated a radically new kind of transistor; a more compact, flatter device whose sensitive parts were protected beneath a thin layer silicon dioxide. Hoerni's brilliant idea, more than any other single factor, allowed the fledging firm to begin printing transistors on silicon. Planar transistors would prove to be much more reliable and perform far better than other designs, in effect rendering the competition's offerings obsolete.

The planar process also made it easy to interconnect neighbouring transistors on a wafer, paving the way to another Fairchild achievement: the first commercial integrated circuits. As other companies realized the great advantages of planar technology and began adopting it on their own production lines. Hoerni's elegant idea helped to establish Silicon Valley as the micro-electronics epicenter of the world.

The final months of 1957 were a time of anticipation at Fairchild as the founders organized the new firm's labs and production lines in a group of buildings at 844 Charleston Road in Palo Alto. In September of that year, the eight scientists and engineers had resigned en masse from Shockley Semiconductor Laboratory, in Mountain View, about 2 kilometers away. They were rankled by the heavy-handed management style of its founder, transistor pioneer William shockley, and his pursuit of difficult R & D projects at the expense of useful, salable products. So they persuaded the Fairchild Camera and Instrument Corp. of Syosset, N.Y., a firm looking to diversify its business, to found Fairchild Semiconductor. The eight founders planned to use the silicon processing techniques they'd learned under Shockley to make and sell advanced, high-speed transistors.

Their timing could not have been better. On 4 October 1957, the Soviet Union launched Sputnik I into orbit, igniting a frenzied space race with the United States. Millions worldwide gazed sky-ward to watch the awesome, undeniable evidence that the Soviets had a big head start. Meanwhile, Senator Lyndon B. Johnson (D-Texas) spearheaded congressional investigations into how the Eisenhower administration could ever have permitted such a "missile gap" to arise. With the USSR holding a major advantage in the greater thrust of its missiles, the U.S. aerospace industry sought every imaginable way to reduce the size and weight of its payloads and satellites. "There was a great deal of talk about the packing density of electronic functions in the late 1950s," Noyce recalled in a 1975 interview, which is archived in the IEEE History Center. "It was the Missile Age, and transportation costs from here to Russia were very high." The need for small, ultralight electronic circuits based on reliable silicon transistors made these devices a promising market for Fairchild.

That fall, the Fairchild founders worked feverishly to get everything up and running. Moore set up diffusion furnaces designed to impregnate silicon wafers with micrometers - thin layers of impurities - chemical elements such as boron, phosphorus, or aluminum that alter silicon's electrical characteristics to from a transistor's building blocks. Metallurgist Sheldon Robers took on the task of growing high-purity silicon crystals from which the wafers could be sliced. Noyce and Last developed methods to do photolightography and oxide masking, by which they could define precise openings in a thin silicon - dioxide layer on the wafer surface; the impurities would diffuse through these openings into the underlying silicon. Other cofounders dug into manufacturing, testing, and selling the high-tech devices to aerospace customers.

And then there was Hoerni. A theorist with not one but two doctorates, from the Universities of Cambridge and Geneva, he had come to the United State to pursue postdoctoral studies at Caltech. In 1956, Shockley lured the 32-year-old physicist away from academia and assigned him to do theoretical calculations of diffusion rates. At first, Hoerni was cloistered in a separate office, but he kept coming around and snooping in the lab in the main building - which gave him valuable insights into solid-state diffusion. Later, at Fairchild, while the others worked on building or installing equipment, he mostly sat in his office and "scribbled in his notebook", Moore told me.

On 1 December 1957, Hoerni grabbed his crisp new lab notebook and began writing an entry titled "Method of protecting exposed p-n junctions at the surface of silicon transistors by oxide masking techniques." In a loose, fluid scrawl interspersed with three simple drawings, he described a revolutionary new way to fabricate transistors - unlike anything ever before attempted.

The most advanced silicon transistors at that time were called mesa transistors because they resembled the plateaus of the American Southwest, the impurity layers running laterally like the colorful rock strata. These transistors basically consisted of three impurity layers piled up vertically, each rich in either electrons (n-type) or electron deficiencies, better known as holes (p-type). The main drawback of the mesa structure is that its p-n junctions, the interfaces between layers where the transistor's electrical activity occurs, are exposed at the edges. Bits of dust or drops of moisture can contaminate the sensitive interfaces and disrupt their normal electrical behavior.

Hoerni's was to protect the p-n junctions by keeping the oxide layer in place upon the silicon after the diffusion process; the standard practice at the time was to etch that layer away, baring the junctions. "the oxide layer so obtained is an integrant [sic] part of the device," he wrote in his notebook that December day, "and will protect the otherwise exposed junctions from contamination and possible electrical leakage due to subsequent handling, cleaning, and canning of the device."

It was a brilliant conception but too far ahead of its time, Hoerni's approach would require additional fabrication steps, and making mesa transistors was already at the limits of the possible. Bell Labs and Western Electric had produced prototypes of mesas, but no company had sold one on the open market.

In early 1958, Fairchild secured its first purchase order for silicon transistors from IBM's Federal Systems Division, which planned to use them in the onboard computer it was designing for the B-70 bomber. Fairchild, which didn't even have prototypes, faced the formidable challenge of delivering real working devices. To maximize the chances of success, the cofounders decided to develop two different kinds of mesa transistors. A group under Moore pursued the n-p-n transistors, which were thought to be easier to fabricate, while Hoerni formed another group to delve into the p-n-p versions.

Crucial to both efforts was the work Last and Noyce were doing on the optical methods needs to transfer the patterns defining a transistor's features onto the silicon wafer. On a trip to San Francisco, they purchased three 36-millimeter lenses from a camera store and used them to fashion a step-and-repeat camera, a contraption that produced rectangular arrays of tiny, identical images on photographic plates, called masks. Workers shone light through the masks onto a special photosensitive resin that had been deposited on the wafer in a powerful acid, it etched the illuminated areas away, exposing the silicon beneath them. Thin layers of impurities were then diffused into the silicon through the resulting openings. Using such techniques, Fairchild could batch-process hundreds of identical transistors on a single wafer.

Another breakthrough was the use of a single metal to make the electrical connections to both n-type and p-type silicon, an approach that greatly simplified the manufacturing process. Moore had been struggling with this issue, trying many different metals, when Noyce happened by his lab early one day and suggested aluminum. As a p-type impurity, aluminum easily bonds to p-type silicon but often sets up a current-blocking p-n junction when it is deposited on n-type silicon. Moore found a way round this problem by starting with n-type silicon that had more impurities than usual. Moore's group got its n-p-n transistors into production in May 1958, well ahead of Hoerni's team, which had opted to use silver for electrical contacts.

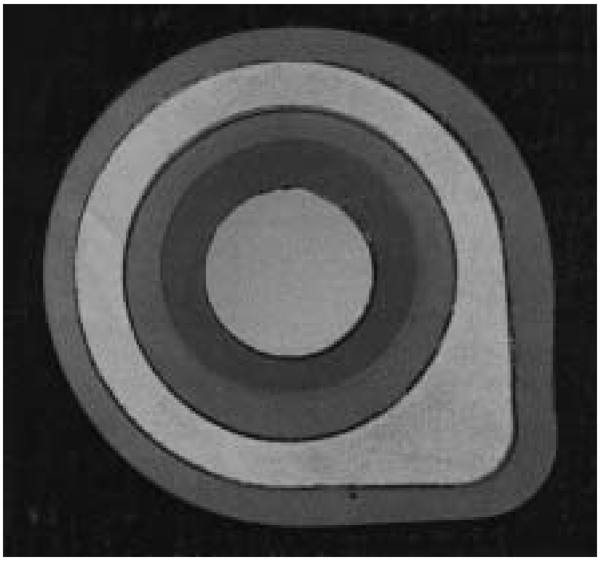
To protect the mesa's sensitive junctions, each transistor was packaged into a pea-size bermetically sealed metal can and then tested. Fairchild shipped the first hundred of them to IBM on schedule that July, billed at US $150 apiece. The next month, at the WESCON electronics trade show, the founders discovered to their delight that they were the only ones with silicon mesa transistors on the market. "We scooped the industry!" Noyce said, exulting at a Fairchild meeting a few days later.

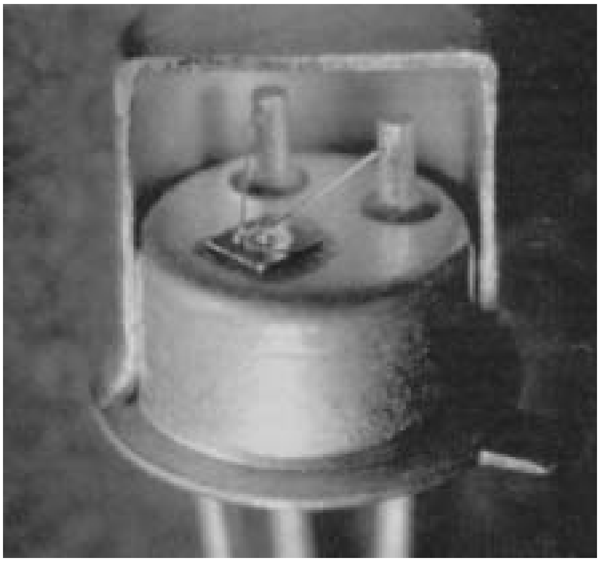
About the only person at Fairchild not celebrating was Hoerni. A proud, charming, but irascible and often volatile man, the scion of a Swiss banking family, he was miffed that his p-n-p approach had been passed over. But he was also a hardheaded contrarian whose creative fires were stocked by adversity. Hoerni not only didn't give up he set out to develop an even better transistor. Later that year, he returned to the ideas written down in the opening pages of his notebook. Could the oxide layer in fact be used to protect the sensitive p-n junctions? There were indications it might. That spring, reports had come in from Bell Labs that the oxide layer indeed protected the silicon underneath. Why not the junctions, too?

With a doctorate in crystal physics, Hoerni realized that the impurity atoms coming through the tiny openings in the oxide layer would diffuse sideways nearly as well as downward into silicon's crystal structure. Which meant that the junction interfaces would curl up under the oxide layer surrounding an opening, just micrometers farther out from its edges. If left in place instead of being etched away, he figured, the oxide layer could protect those junctions.

But the device Hoerni envisioned would not only be more difficult to fabricate, its structure flew in the face of conventional wisdom Especially at Bell Labs and Western Electric, the oxide layer was considered "dirty" - filled with impurities after the diffusion process - and thus had to be removed.

Meanwhile, serious concerns began to emerge in late 1958 and early 1959 about the mesa transistors Fairchild was selling. Some of the devices were experiencing amplification instabilities, and others were malfunc-



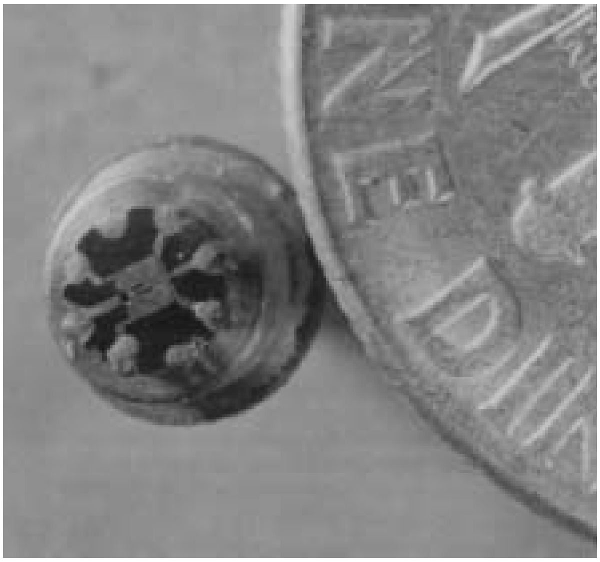


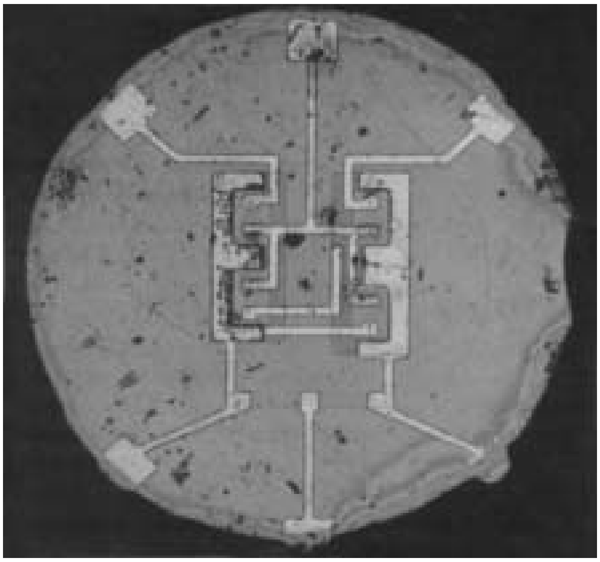
tioning. One important customer reported that a transistor had suddenly stopped working altogether. A Fairchild technician eventually traced the failures to tiny dust particles and solder fragments trapped inside the cans. The specks were attracted to the junctions by the strong electric fields there. In a subsequent quality-control procedure that became known as the tap test, workers would tap on the can with pencil erasers, trying to dislodge any bits that might short out the junctions. If that happened, the transistor was discarded. Those were anxious days for the brash young firm, for such failures in its only product threatened its very existence.

Hoerni's single-minded pursuit of a more reliable transistor proved timely indeed. In what Moore described to me as a "kludge experiment" intended to assess Hoerni's ideas, a technician deliberately left the oxide layer on top of one of the p-n junctions in a mesa transistor. When tested, it had substantially better amplification stability - suggesting that Hoerni was truly onto something. On 14 January 1959, he had two of his notebook pages typed up as a formal disclosure and sent to John Ralls, Fairchild's patent attorney. Other than a few minor corrections and better drawings, it was identical to the notebook entry he had written more than a year earlier.

One problem with Hoerni's approach - and part of the reason nobody attempted it at first - was that his transistor structure was more complex than the mesa's, requiring a fourth photo-lithographic mask to fabricate it. Last and Noyce's step-and-repeat camera could accommodate only three masks. But that February, Last "july-rigged a fourth mask" for this purpose, he recalled in a recent telephone interview. On a March, Hoerni wrote another entry in his notebook titled "A method of manufacture of PNP transistors with oxide protected junctions." In two more pages of text and drawings, he indicated specifically how to fabricate such a device, though still stubbornly using silver for the electrical contacts on the top side. By then, his technicians were already transforming his novel ideas into actual fabrication processes.

But all that progress came at a time of upheaval at Fairchild. The same week that Hoerni was jotting down his fabrication





Silicon flatland: Above from left, an early prototype planer transistor made by Fairchild in the spring 1959, a cutaway model of the company's first commercial planar transistor, the 2N1613, initially markted in April 1960, one of the first inegrated circuits made by Jay Last's development team in the spring of 1960; and a prototype planar flip-flop circuit fabricated in the fall of 1960.

ideas, Edward Baldwin, who had been hired from Hughes Electronics Corp. to serve as Fairchild's general manager, departed abruptly to found Rheem Semiconductor in Mountain View, taking with him five key people from the manufacturing division. After persistent urging by the other Fairchild confounders. Noyce stepped up to replace him, and Moore took over Noyce's position as research director.

The following week, Hoerni invited several colleagues to watch a demonstration of his new prototype transistor. Under a microscope it appeared unlike any other Fairchild device. Less than a mullimeter across, it was completely flat - no mesa protruded in the middle. All that was visible was a circular metallic dot with a metal ring around it, plus the oxide surface layer between them. It resembled a bull's - eye target with a portion of it pulled out like a teardrop, making it easier to attach a wire [see photos, "Silicon Flatland"].

What happened next is unclear. Some observers have claimed that Hoerni suddenly spat on his transistor, to demonstrate that such outrageous abuse had no ill effects on the oxide-protected junctions. But Last and Moore don't recall him actually spitting, and Moore points out that saliva would have shorted out the metal wires on the device. Even so, the demonstration was dramatic and convincing. Last tome me. "Gee, it's too bad Baldwin had to leave last week", he recalls joking afterward.

Things moved swiftly after that. It was obvious that Hoerni's creation was far more rugged and reliable than the mesas. And it also proved to have much lower leakage currents - small, wrong-way trickles that can seriously degrade transistor performance. In a Fairchild report released the following year.

Hoerni observed that the leakage currents in his device were usually less than a nonoamphere, or as little as 1 percent of those in mesa transistors.

The nagging questions on everyone's mind was, Can we manufacture these transistors in quantity? Initially, the planar process yielded only a few working transistors in every too-much worse than the mesa process. But as various problems, such as pinholes in the oxide layer, were resolved, yields rose and doubts evaporated. In April 1960, Fairchild sold its first planar transistor, the 2N1613 - a metal cylinder about half a centimeter in diameter and almost as high, with three little metal legs sticking out beneath it.

A few months later, Noyce and Moore decreed that hence-forth all the company's transistors would be planar. While other semiconductor firms such as Rheem, Motorola, and Texas Instruments had begun churning out competitively priced mesa transistors, Fairchild boldly struck out in a promising new direction. soon avionics manufacturers began to demand planar transistors because of their unmatched reliability. The Autonetics division of North American Aviation, for example, insisted on using Fairchild's planar transistors in the guidance and control systems for the Minutemanmissile.

Fairchild eventually licensed the planaer process to other transistor makers - even Bell Labs and Western Electric. Either the other firms followed Fairchild's lead or they exited the industry.

Well before Fairchild succeeded in commercializing Hoernil's device, Noyce had begun thinking about what else the company could do with the planar approach. In his 1975 interview, he credited patent attorney Ralls with challenging the Fairchild team to consider other applications that could arise from the new way of making transistors. Noyce relized that by leaving the oxide layer in place, "the surface fo the silicon then had one of the best insulators known to man covering it." Which meant that the electrical connections could be made by depositing strips of metal - such as the aluminum contacts Moore's group had perfected - on top of the oxide layer. The strips would be automatically insulated from the components underneath.

On 23 January 1959, not long after Hoerni had his patent disclosure typed up. Noyce penned an entry in his own noebook: "In many applications now it would be desirable to make multiple device on a single piece of silicon in order to be able to make interconnections between devices as part of the manufacturing process, and thus reduce size, weight, etc., as well as cost per active element." His entry went on for another four pages and included the crucial idea of using the oxide layer as an insulator underneath the connections. He also described a way to isolate the circuit elements - not just transistors but also resistors, capacitors, and diodes - from one another by inserting between them extra p-n junctions, which permit current flow in only one direction.

Did Noyce recognize the significance of these ideas at first? In those days, researchers at Bell Labs, Fairchild, and elsewhere often had a colleague immediately witness and sign important, potentially patentable ideas. Noyce, for instance, had witnessed nobody witness Noyce's entry, suggestinng that he did not consider it all that important when he wrote it.

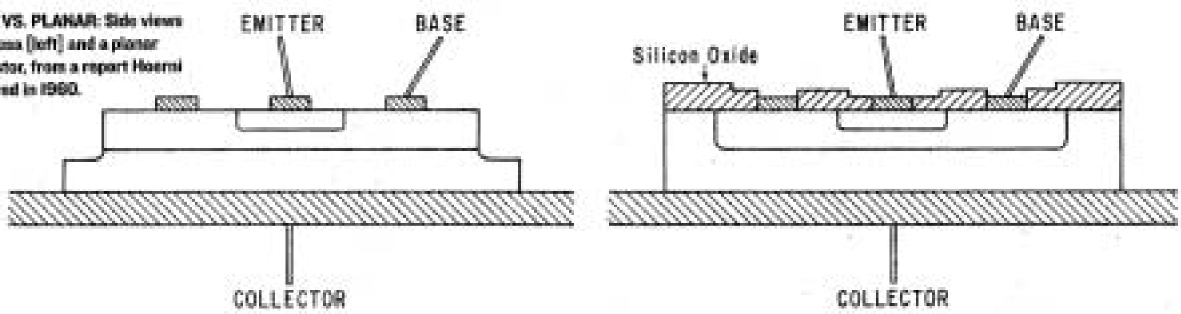
Around that time, the "monolithic idea" of fabricating complete, rugged electronic circuits in a single chunk of silicon, germanium, or other semiconductor was becoming fashionable. The U.S. Army, Navy and Air Force were each promoting their own pet approahces and funding R & D contracts in industry. Monolithic integration was considered a way to overcome the "tyranny of numbers" bemoaned by Bell Labs Vice President Jack Morton. He had warned that as the number of circuit components increased, so did the likelihood of circuit failure. But what if you farbicated reliable components and interconnected them in a single semiconductor chip? Then your odds of building successful complex ciricuits might be much higher.

In August 1958, Jack Kilby at Texas Instruments had conceived a way to make such integrated circuits in silicon. He even built a prototype oscillator based on the idea, using germanium mesa transistors, which were then readily available at deposited on an oxide layer, Kilby's device used "flying wires" to make the electrical connections. TI publicly announced this break through on 6 March 1959 at a gathering of the institute of Radio Engineers in New York city. TI President Mark Shepherd boasted that it was "the most significiant development by Texas Instruments since we digulted the commercial availability of the silicon transistor."

News of TI's achievement reached Fairchild just as its management turmoil was winding down and Hoerni was about to demonstrate his new transistor. Later that month, Noyce called a meeting to discuss how to respond to TI and revealed his thoughts about how to interconnect multiple device in silicon. By then it was becoming obvious that Hoerni's planar process offered major advantages in fashioning suuch integrated circuits. Hoerni, Last Moore, and the other cofounders discussed that possibility extensively, with the emphasis on the pragmatic. "Any one of us could think of ten things we might do, but then we'd rule out nine or even ten of them as impractical," Last said in a recent phone conversation. "We were focused on making things that worked."

Out of this creative stew emerged another crucial concept, which historians have so far overlooked. With the planar transistor, it was noe easy to put all these electrical contracts - to the emitter, base, and collection - on one side of the silicon wafer. At first glance, it might seem just a merginal improvement, but this feature, plus the fact that a single metal such as aluminum could be bsed to form the connections meant that Fairchild could now, in effect, print electrical circuits - transistors and all - on silicon. Like the typographic patterns of ink impressed onto paper by a printing press, the patterns of the individual semiconductor devices and metal interconnections could now be imposed photolithographically on a single side of a wafer.

Horni was the first to public the concept of putting all the electrical contacts on one side. In his patent application for a "Method of Manufacturing Semiconductor Devices", filed on 1 May 1959, he presented the idea almost as an aside, after revealing a structure closer to that of the mesa, with contacts on both sides of the wafer. In Noyce's much more famous patent, "Semiconductor Device and Lead Structure", filed three months later, the single - side feature is a fundamental as-



MESA VS. PLANAR: Side views of a mesa [left] and a planar transistor, from a report Hoerni prepared in 1960.

pect of his planar integrated - circuit structure. But neither man's lab notebook mentions the idea - suggesting that it probably emerged from the fertile give-and take discussions that spring and was later added to the patent applications.

In any event, that special feature of the planar process gave Fairchild a tremendous advantage in realizing the monolithic idea.

To implement this new technology

Last formed a group in the fall of 1959, aiming to manufacture integrated circuits based on Hoerni's planar process. It took another 19 months before the first commercial microchips, Fairchild's Micrologic series, reached the market. But Fairchild still came out with its microchip more than six months ahead of TI, which succeeded only after it began using the planar technology it had licensed from fairchild.

To achieve this goal, Last's team had to overcome several significant obstacles. Tolerances were a lot tigher on positioning the physical features of these chips - which meant the various masks had to be aligned more precisely. Finding a way to isolate their components electrically was also a thorny problem. Noyce's idea of inserting back-back p-n junctions between individual components proved an effective solution, opening the door to commercialization in March 1961.

But Hoerni and Last were not around to share in the celebrations. They had become disenchanted with the increasingly stratified Fairchild hierarchy and the worsening relations with its New York parent. They also felt that Fairchild's marketing department opposed microchips because they'd compete directly with the company's principal products - transistors and diodes. So Hoerni and Last departed to start yet another semiconductor operation, the Amelco division of Teledyne, with hte goal of producing integrated circuits.

Close friends since their days at Shockley Lab, the two often spent their weekends together hiking in the deserts and mountains of the Southwest. Last remembers that Hoerni had incredible stamina and could hike for house on little food or water. To lighten his load, he carried only a skimpy old sleeping bag. When termperatures got too cold, he'd stuff it with newspapers - once claiming that *The Wall Street Journal* provided the most extra warmth.

In two years, however, Hoerni began to have problems with the new company. In the midst of a cash crunch in April 1963, Teledyne executives siuggested that he be reassigned from general manager of

Amelco to director of research as a cost-cutting measure. The moody Swiss physicist did not warm to the idea. Instead, he decided to leave the firm and began casting around for other business alternatives.

Although their relationship was "rather frosty" after Hoerni's decision. Last says, they still headed out that spring for a 3000 meter climb in the Inya Mountains east of the Sierra Nevadas. Exhausted, they reached the summit at dusk, just before a cold front pushed through and temperatures plummeted. Despite their differences, the two huddled together the rest of the night to keep from freezing. "We climbed down the next morning, drove back to the Bay Area, and continued our frosty business discussions", Last recalled years later, during a memorial service for his friend.

While Last remained with Teledyne until the late 1970s, Hoerni went to wrok for Union Carbide, setting up its semi-conductor division. In 1967 he ventured out in yet another direction, founding Intersil Corp., with European investors, to make microchips for digital watches; it was the first company to produce such low-voltage, low-power circuits based on CMOS (complementary metal-oxide-semiconductor) technology. They following year Moore and Noyce abandoned Fairchild to launch Intel in Santa Clara, Calif., at the heart of what soon became known as Silincon Valley.

For the next three decades, Hoerni remained active as an investor and consultant in the semiconductor industry. He also became involved in philanthropic initiatives and continued trekking throughout the world. He died in Seattle on 12 January 1997, the year the transistor turned 50. Although often overlooked in semiconductor history, he should be remembered as the person who engineered the all-important bridge from this revolutionary solid-state device to the integrated circuit, which has become so ubiquitous today. ●

Only two things are infinite:

The universe and human stupidity

(and I am not sure about the universe!)

– Albert Einstein

Effective Evacuation

Transmission plans for NER hydro projects
by Swarna Kesavan

There are big plans to boost the Northeast's hydro generation capacity. A key issue, however, is the need for a robust transmission system to evacuate power from these projects, including those in Sikkim and Bhutan. This is a challenge given the terrain of the region and the fact that the entire power from the region has to come through the Siliguri corridor, known as the "chicken neck". This is a narrow stretch of land (only 21 to 40 km. in width), connecting the north-eastern states with the rest of India, and with Nepal and Bangladesh, lying on either side of the corridor.

The Central Transmission Utility (CTU), Power Grid Corporation of India Limited (PGCIL), has been gearing up to take on the challenge. Currently, there are only three interregional transmission links between the north-eastern region (NER) and eastern region at the 400 kV and the 220 kV levels, with a total transfer capacity of around 2,00 MW. However, PGCIL is planning to build four high capacity ± 800 kV high voltage direct current (HVDC) bipole lines, each with 6,000 MW of capacity. The first of these lines is already under construction and is known as the North East-Northern/Western Interconnector-I (NER-NR/WR Interconnector-1). The CTU has reserved the corridor for three other high capacity lines, which it plans to construct as and when the generation projects in the JER, Sikkim and Bhutan commence operation.

PGCIL is confident of being able to evacuate 28,000-30,000 MW of power between the four high capacity corridors and the existing corridors/lines in the next 15-20 years, during which time most of the planned projects are expected to come online. The CTU is justified in planning the development of these corridors as and when the proposed generation projects make progress, since each of these high capacity corridors entails huge investments of about Rs. 150 - Rs. 200 billion.

Developing hydro projects in the region is not an easy task. The terrain is difficult and

Power Potential in NER and Sikkim

The north eastern region of India is endowed with huge hydro power resources, which need to be developed and evacuated expeditiously. This potential could wipe out a significant portion of the country's peak deficits, particularly in the northern and western regions. Over 40 per cent of India's total hydro potential lies in Sikkim and the seven north-eastern states (predominantly Arunachal Pradesh). The aggregation to 63.257 MW according to the CEA.

So far, the north-eastern states have exploited just about 2 per cent of their identified 58,971 MW capacity, while Sikkim, which has an identified potential of 4,286 MW, has been able to develop 13.86 per cent of its potential. Seven schemes aggregating 4,533 MW and 41 schemes aggregating 15,956 MW have been planned for commissioning respectively, according to Eleventh and Twelfth Plan documents.

In Arunachal Pradesh alone, a potential of 57,755 MW has been identified. Of this, 104 schemes aggregating 29,526 MW have been allotted to public and private players for commissioning between the Eleventh (2007-12) and the Fourteenth Plan 2022-27) periods. This includes 99 schemes aggregating 23,796 MW, to be developed by the private sector. Meanwhile, Sikkim plans to exploit most of its potential by the end of the Twelfth Plan period, during which 12 schemes aggregating 2,455 MW have been planned, in the Eleventh Plan period, three schemes aggregating 1,809 MW have been scheduled for commissioning.

there are social and security concerns, which often lead to time and cost overruns. Locking huge investments without any revenue coming in is not economically prudent.

Evacuation plan

For the NER-NR/WR Interconnector-I, which will facilitate power evacuation from the first few projects. PGCIL's board approved an investment of Rs. 111.3 billion in February 2009. The transmission project is expected to be complete by August 2013. The time to complete construction of the transmission system in the NER ranges from 48 to 54 months, mainly due to the region's geographical and political conditions, in addition to rehabilitation and resettlement issues.

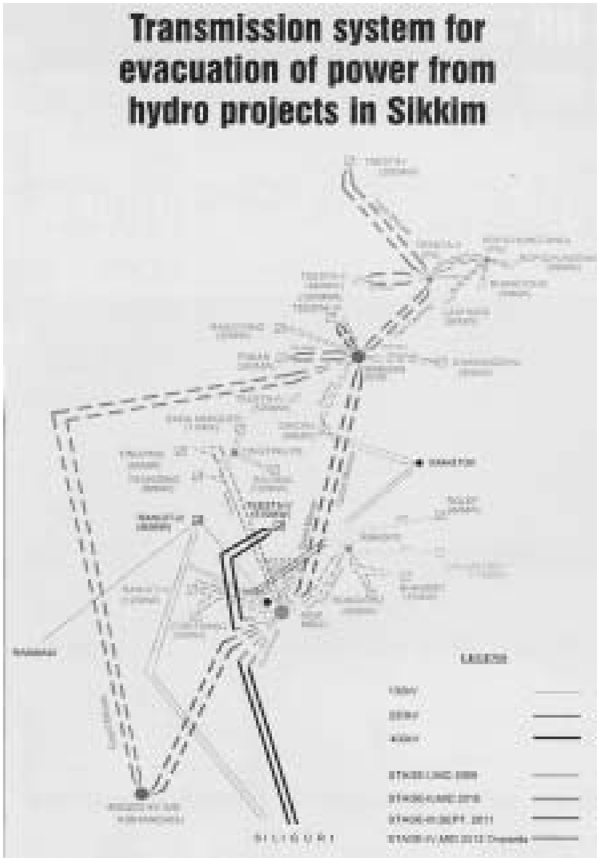
The NER-NR/WR Interconnector-I scheme comprises a 6,000 MW + 800 kV HVDC bipole line connecting a pooling point in Arunachal Pradesh (Bishwanath Chariyali) with the northern region (Agra in Uttar Pradesh). Two 3,000 MW HVDC converter stations will also be set up at Bhishwanath Chariyali and Agra. PGCIL is in the process of acquiring land for the Bishwanath Chariyali station, and has awarded a few packages of the transmission line tenders. It is currently undertaking technical evaluation of the bids received for the HVDC terminal station at Bishwanath Chariyali.

To begin with, he transmission corridor will facilitate power evacuation from two key projects in Arunachal Pradesh - the 2,000 MW Lower Subansiri hydro-electric project (HEP) and the 600 MW Kameng HEP - which are expected to be commissioned in 2012-13. Separate lines and substation extensions

Table 1: Scope of work for NER/NR/WR Interconnector-I

Part A: North East Northern/Western Interconnector-I to be completed by August 2013	
Transmission lines	
Bishwanath Chariyali Agra 800 kV, 6,000 MW HVDC bipole line	1.815 km.
Balipara-Bishwanath Chariyali 400 kV D/C line	73 km.
LILO of Ranganadi-Balipara 400 kV D/C line of Bishwanath Chariyali	52 km.
LILO of Depota-Gohpur 132 kV SIC line at Bishwanath Chariyali	22 km.
Substations	
400/132 kV pooling station at Bishwanath Chariyali with 2 x 200 MVA; 400/132/33 kV transformers along with associated bays	
HVDC rectifier module of 3,00 MW Bishwanath Chariyali and inverter module of 3,000 MW at Agra.	
Augmentation of 300 kV Agra substation by 3 x 167.5 MVA, 400/220/33 kV transformer along with associated bays.	
Extension of 300 kV line bays at Balipara substation.	
Parts B and C: Transmission system for immediate power evacuation from Kameng and Lower Subansiri HEP̄s to be completed by February 2013.	
Transmission lines	
Kameng-Balipara 400 kV D/C line	65 km.
Balipara-Bongaigaon 400 kV D/C line (quad conductor) with 30 per cent fixed series compensation at the Balipara end	300 km.
Lower Subansiri-Bishwanath Chariyali 400 kV 2 x D/C line with twin lapwing conductors	350 km
Substations	
Second 315 MVA, 400/220 kV ICT at Misa	
Extension of 300 kV line bays at Bongaigaon and Balipara substations	
Extension of 400 kV line bays at Bishwanath Chariyali pooling substation	
Source: CEA	

have been planned for power evacuation from these projects up to the pooling point at Bishwanath Chariyali, which will coincide with the commissioning of the generation project. While 35 per cent of the power from these two projects has tentatively been allocated to the NER and 50 per cent has been allocated to the northern and western regions, the remaining 15 per cent unallocated power has been reserved for the NER to begin with. In the medium term, the transmission scheme will help in the evacuation of power from the upcoming hydro projects aggregating around 4,000 MW in the NER.



In order to utilise the entire HVDC line capacity and optimise the utilisation of right of way (RoW), PGCIL plans to build another 3,000 MW terminal at Alipurduar in West Bengal, along with loop-in and loop-out (LILO) of the HVDC bipole line at this terminal. This would facilitate the evacuation of power from upcoming projects aggregating around 2,400 MW in Sikkim, and about 1,200 MW (through the Punatsangchu-I HEP) in Bhuttan, to the northern and western regions. The plan is to ramp up the Bishwanath Chariyali station to 6,000 MW as and when more projects come online in Arunachal Pradesh. Simultaneously, the Alipurduar station could also be ramped up to 6,000 MW, with more projects coming up in Bhutan. One of the reserved corridors could also be utilised by PGCIL to build a separate 6,000 MW + 800 kV HVDC line from Alipurduar.

For now, the evacuation system for the initial projects in Sikkim and Bhutan mentioned above has been divided into three parts. The first part will comprise power evacuation from two projects in Sikkim - the 99 MW Chuzachen and the 1,200 MW Teesta III - by 2011-12. The second part would enable evacuation of another 1,100 MW in the state by 2012-13. Power from projects coming up during 2011-13 in Sikkim will be first brought to the 400/220 kV Kishanganj pooling station in Bihar, through the pooling stations at Jarethang and Rangpo in Sikkim. From Kishanganj station, the power would be further transferred through AC lines including LILO of the Siliguri-Purnea 400 kV double circuit (D/C) lines at Kishanganj as well as the Kishanganj-Patna 400 kV D/C lines.

The final part, in additional to allowing evacuation of power from the Punatsangchu-I project in Bhutan, would also provide the corridor towards the northern and western regions with adequate reliability and security for the hydro protects in Sikkim. This part would also allow the initial evacuation of power from future hydro projects in Bhuttan, including the 990 MW Punatsangchu-II and the 720 MW Mangdechu, both of which are expected to be commissioned in 2016.

Transmission charges for the first two parts of this scheme would be initially borne by the developers of the generation project while charges for the final part would be borne by the beneficiaries of Bhutan Power,

Table 2: Transmission System for Sikkim and Bhutan projects

Part A: To be completed by 2011-12 for evacuation of 1,300 MW from Sikkim

- Establishment of a new 2 x 315 MVA, 400/220 kV substation at Kishanganj.
- LILO of Siliguri (existing) Purnea 400 kV D/C line (quad) at new Kishanganj poling station.
- LILO of Siliguri (existing-Purnea 400 kV D/c line at Kishanganj with high capacity, high temperature, low sag conductor.
- LILO of Siliguri-Dalkhola 220 kV D/C line at new Kishanganj pooling station.
- LILO of Gangtok-Melli 132 kV S/C line up to Rangpo, where the Chuzachen-Rangpo 132 kV D/c line would be connected so as to from Chuzachen-Gangtok and Chuzachen-Melli 132 kV/SC lines.

Part B: To be completed by 2012-13 for evacuation of an additional 1,100 MW from Sikkim

- Establishment of 220/132 kV, c 2 100 MVA gas-insulated switchgear (GIS) substation at Rangpo.
- Establishment of 10 x 167 MVA, single phase, 300/220 kV GIS at New Melli
- LILO of Teesta III-Kishanganj 400 kV D/C line at New Melli.
- Rangpo-New Melli 220 kV D/C line with twin moose conductor)
- LILO of Gangtok-Rangit 132 kV S/C line at Rangpo and termination of Gangtok-Rangpo and Melli-Rangpo 132 kV lines at Rangpo.
- LILO of Teesta V-Siliguri 300 kV D/C line at New Melli
- Kishanganj-Patna 400 kV D/c (quad) line

Part C: To be completed by 2014-15 for evacuation of 1,200 MW from Punatsangchu-I in Bhutan and transfer of power from Sikkim/Bhutan to NR/WR

- New 400 kV AC and HVDC substation with + 800 kV, 3,000 MW converter module at new Alipurduar pooling station.
- Extension of + 800 kV HVDC station with 3,000 MW inverter module at Agra
- LILO of Bishwanath Chariyali Agra HVDC line at new Alipurduar pooling station for parallel operation of the HVDC station.
- LILO of Bongaigaon-Siliguri 400 kV D/C line at new Alipurduar pooling station.
- LILO of Tala-Siliguri 400 kV D/C line at new Alipurduar pooling station.
- LILO of Birpara-Salakati 220 kV D/C line at new Alipurduar pooling station.
- Punatsangchu-I-Alipurduar 400 kV D/C with quad conductor.

Source: CEA

subject to the allocation of power. For power evacuation from future projects in Bhutan, including the 4,060 MW Sankosh and the 900 MW Wangtoo projects, the Central Electricity Authority (CEA) has pointed out that a separate HVDC line would be required to be installed. However, since these projects are still in the pipeline, it has been decided to finalise the transmission system proposal only after getting a firm schedule from the Bhutanese authorities.

Key challenges

The chicken-neck area would involve the bunching of transmission lines; this raises the technical risk of systemic collapse as the tripping of one line could impact the entire grid. As more lines come up through this area, PGCIL would need to address this issue adequately.

While PGCIL, along with the CEA, is putting in efforts to ensure that transmission planning is undertaken in a dynamic manner to optimise RoW and investments for power evacuation from the generation projects through the chicken neck area, the actual implementation of generation and transmission projects in the NER continues to be an area of concern. Opposition from environmentalists and local populations regarding land acquisition issues, along with the difficulty in obtaining environmental clearances, may lead to project delays. Geological surprises could also play a significant role. It would be important, therefore to involve the local people and streamline the process for developers. ●

We are just an advanced breed of monkeys on a minor planet of a very average star. But we can understand the universe. That makes us something very special.

– Stephen Hawking

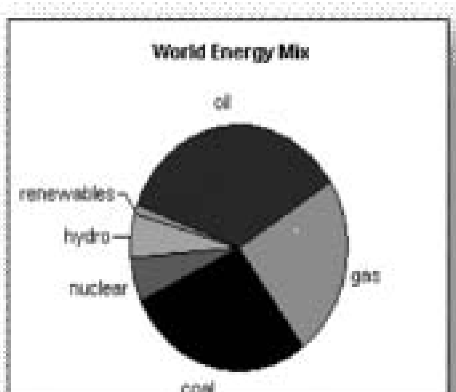
Energy Conservation - Role of an Electrical Engineer

Thomas Cherian, S4, Electrical & Electronics, MA College of Engineering, Kothamangalam

Energy is the greatest resource mankind ever found. A life without energy and energy transformations is nearly impossible now. Thus conservation of such a valued resource is the need of the hour, especially when most of the non-renewable energy resources are running out. If the records stating that coal and petroleum reserves will end almost by 2060, that would certainly slow down the pace of growth in all fields in a global level. Being engineers we definitely have a commitment to bring an end to such a crisis. That's exactly what I aim with this paper.

The main causes:

Take a look at the pie chart showing the world energy mix; it's very clear that we only use less than 3% of energy from renewable energy resources. This is the main cause of the energy crisis. As time passes by these resources vanishes and thus makes energy crisis a grave issue.



The second main reason which I feel is the increasing population growth. As the population increases the energy needs also increase.The final reason which I like to point is the enegy losses. No system is 100% efficient Any system will have an energy loss assosciated with. For example iron losses or copper losses. Large energy is wasted this way. We must ty to increase the efficiency with the help of modern technology.

Solutions or Remedies

So what we really need to do now is to find the solutions or remedies. In my perspective I have classified it into 4.They are:

- **Ideas**
- **Innovation**
- **Invention**
- **Change**

Ideas:

Idea could be just a personal view that takes birth in our mind. But these are those things that help us to change the face of the world. For example the idea of the telephone by Alexander Graham Bell in the late 18th century paved the way for the modern communication system. Likewise we need great ideas to bring an end to energy crisis. Regarding the energy conservation the few ideas are the following. Production of electricity from gyms, utilization of wind energy from a fast moving train or buses to charge mobiles, recycling of waste water, harnessing energy from sound are the few things. The energy produced from each of these sources will be really less, still remember every single drop conserved, means it lasts longer.

Innovation:

Innovation technically means to improve something, which makes it better than how it was before. Now I would like to introduce a topic called the wind shield defogger. A small innovation done on the existing system .It is a cost efficient method to eliminate windshield fog has been proposed. Instead of the existing method of using air conditioner to prevent windshield fogging this device uses the heat produced in the engine due to internal combustion.

Objective: To device a simple mechanism to eliminate windshield fog in cars by bringing down the temperature difference between the windshield and the air in the car.

Application: To remove windshield fog, herby providing the driver with better visibility in cold conditions. This will help to bring down a fair share of accidents.

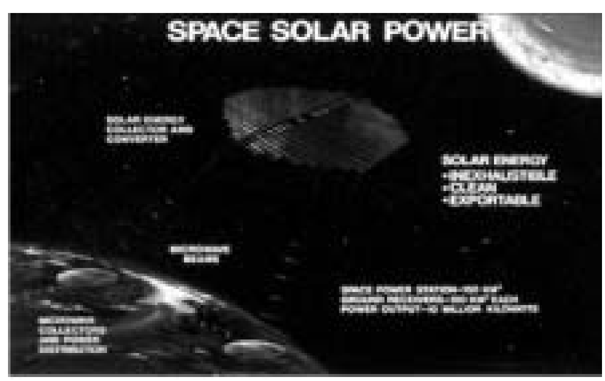
Theory: For a given temperature there is a maximum pressure of water the air can withstand. If the pressure exceeds this limit then the water starts condensing. This withholding capacity increases with the rise in temperature. For every 10 c rise in the temperature the moisture holding capacity doubles.

Working principle: This new device works on the principle that hot air can hold more moisture. The coolant which comes from the engine is hot. As the coolant carrying the tube comes in contact with the windshield temperature rises. The formation of the windshield fog is due to the cooling of air when it comes in contact with the cold windshield. But with this modification the temperature of the windshield will be increased which would prevent the condensation of water vapor.

Conclusion: From the above discussion it is clear that the modification is a cost effective method to avoid windshield fog.

Merits: The present method of windshield defogging is highly fuel consuming. As we know fuel is something the world is fighting for. The method that I have devised does not require any fuel. So having a method which is literally free and does not cause any pollution is something which we need in this present scenario.

Invention:



Invention means creating something totally new. And when the energy crisis is at our door steps what we really need to do now is to promote something that's totally new that would help us to bring an end to the energy crisis. The wireless power transmission is the ideal pick without a second thought. It is more efficient and energy losses are less. Wireless energy transfer or wireless power is the transmission of electrical energy from a power source to an electrical load without interconnecting conductors. Also a great technological innovation taking place within the witricity called the SPS that is solar power satellite program could soon one day bring an end to the question of energy crisis. This was aimed to provide energy to earth's increasing energy need. This efficiently make use of renewable energy i.e., solar energy.SPS would be placed in geostationary orbits. Each SPS would have millions of photocells. Using rectenna/photovoltaic cell, the energy is converted to electrical energy. Efficiency exceeds 95% if microwave is used. This will be transmitted to earth in the form of microwaves/ LASER.

Now this great technology will not be accepted by many telling such a great project is nearly impossible by putting forward a number of practical difficulties. But the fact is this will be really work out one day. A word called impossible is totally impossible in technology. We dreamt to fly like a bird, many told that is impossible, then technology invented an aero plane, we wished to swim like a fish, many told its impossible technology made submarine and now ultimately when few people are thinking SPS is not possible all I have to say is keep your fingers crossed and eagerly look forward to the most futuristic technology mankind will ever witness in this century because technology would definitely make this a reality with the next 2 decades, and this will end the issue of energy crisis then and there forever.

Change:

Leo Tolstoy once said, everyone thinks of changing the world, but no one thinks of changing himself. This is the exact story in the 21st century. Now I don't think anyone can have ideas, or bring out an innovation or an invention, but definitely we can bring a change in our attitude. That's what we really need to do now. All these things given below are something which I know, something which u know, yet something which everyone fail to do. Let's try to make all these part of our healthy habit.

- ✓ Spreading awareness.
- ✓ Use of various sensors that could save more energy.
- ✓ Use of more renewable energy.
- ✓ Use energy efficient electric appliances
- ✓ Use an energy efficient computer. Buy a laptop instead of a desktop. It consumes five times less electricity.
- ✓ Drive less
- ✓ Walk, bike, carpool or take public transport. You'll save 1.5 kg of carbon dioxide for every 5km you don't drive.
- ✓ Turn off electronic devices-Simply turning off your television, stereo, computer, fans, lights when you are not using them will save you thousands of kilograms of carbon dioxide a year. I don't think we should be an electric engineer to switch of an unnecessary light. Isn't it?!?
- ✓ Reduce, reuse & recycle - Recycling and re-using products like paper and bottles will help protect the environment. Use recycled paper. Recycle your office and household waste.

Conclusion

There is little doubt that the supply of energy must be increased dramatically in coming decades. Furthermore, it appears almost certain that there will be a shift toward renewable sources and that solar will be a major contributor. While the option of Space Solar Power may seem futuristic at present, it is technologically feasible and, given appropriate conditions, can become economically viable. From these researches and discoveries it can be said that wireless power transmission is going to be a major field of interest for scientists and for people. The facts that the power can be transmitted from space to earth will revolutionize the field of satellites. Since the uses of wireless power transmission are many, from easy installation, neatness, easy maintenance to multi-equipment working are amazing, the area for researchers on this field seems very interesting. Rather concentrating on the false beliefs, the concentration should be put on advantages of witricity for further increasing the efficiency of wireless power transmission with more safety measures. It is a rocking technology provided the researches continue to move in same speeding direction.

Witricity, if successful will definitely change the way we live. Imagine cell phones, laptops, digital camera's getting self-charged! Wow! Let's hope the researchers will be able to come up with the commercial system soon. Till then, we wait in anticipation!

Always remember mother earth has given everything for everyone's need but not for their greed. Guys don't be mean but be green. There is no planet B. All we have is one earth. Our planet needs us now. Act like we belong here. Let's join our hands, spread awareness and hope this could spread light to make our earth a better place to live in. ●

Males are a brreding experiment run by females -
a proving ground from which females cull winning genes.

– John Hartung

SMS in Indian Languages – Where are we and Why

Babu Narayanan, CEWiT **

The Indian telecom sector has been experiencing tremendous growth over the past few years with the number of connections growing at an average rate of several millions per month. The total number of wireless connections (GSM and CDMA combined) in India is on the threshold of reaching one billion. That is some achievement for a developing country.

Following the global trend, voice and SMS are two most widely used services in India. According to industry estimates, Value Added Services (VAS) generates almost 10% of the operators revenue, of which nearly half comes from SMS. On an average, an Indian subscriber sends 30 to 35 short messages per month. However, the usage varies across different types of service areas, as shown in Figure 1. In B and C circles, SMS usage is quite low compared to Metro and A Circles. Government data indicates that this gap is larger in case of prepaid subscribers, who incidentally constitute a majority of subscribers. Note that these B and C service areas comprise small towns and cities as well as large swathes of rural areas. English literacy in these areas is lower compared to Metro and A Circles and hence there is a need for enabling Indian language SMS. However, lack of good support for Indic SMS currently means that the access of users in these areas to SMS service is quite limited.

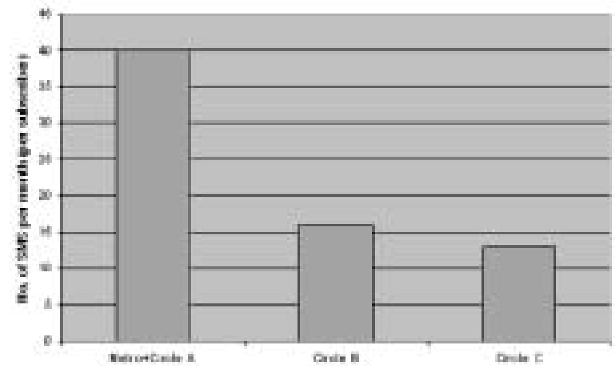


Figure 1: SMS usage in different service areas

It must also be pointed out that number of subscribers in rural areas is also growing rapidly. An obvious implication of this trend will be greater demand for SMS in Indian languages as the use of local languages in rural areas is more widespread and English literacy levels are quite low.

Another important point to be noted here is that SMS is not just about person-to-person (P2P) messaging. Application-to-person (A2P) SMS provides an effective way to disseminate information to a large segment of the population. The enterprise, government, social and political organisations are increasingly using A2P SMS to push all kinds of information to users such as news, cricket alerts, stock alerts, travel and weather updates, commodity prices, bank transactions details, health advice, job postings, election canvassing, jokes and other entertainment content, advertisements, directory services etc. Such content has to be provided in local languages, only then it will become useful.

Technical Challenges

SMS in Indian languages has been available for the past few years and several operators are providing this service. However, this service has not really taken off for several reasons. In order to understand the Indic SMS challenges, a holistic view of the issue is needed. The figure below shows a high-level end-to-end view of the process of sending a short message (for the sake of simplicity, network elements, such as SMSC, are not displayed here).

At the sender side, there are two basic processes involved. The end user enters a sequence of characters which make up the message. These characters are represented in binary form using an appropriate encoding and the resulting byte-string is inserted into the SMS payload. The message traverses through the originating and terminating networks and finally reaches the intended recipient where the payload is decoded using the same character encoding that was used at the sending side. The message is then displayed to the user. This is essentially the typical set of operations that take place in the sending/receiving devices.

In the case of English, the entire process is highly standardised. In particular, all devices have English keypads with the same layout, defined in ITU and ETSI specifications. Furthermore, the 7-bit default GSM encoding for English SMS is supported by all handsets. Finally, a wide range of efficient and scalable fonts are also available. The same is not true for SMS in Indian languages. No standard approach is in place in any of the three key areas, viz. input entry, encoding and display, and this has given rise to issues related to inter-operability, usability, complexity etc.

Need for Efficient Standard-based Encoding

SMS usage in India is quite low compared to other countries in the region. For instance, China with a market size similar to India's, averages 100 messages per month. In Philippines, often dubbed as the 'SMS capital of the world', subscribers send 750 messages per month.

There are several reasons behind this gap. It is often said that one of the key drivers for high SMS usage in Philippines was that initially this

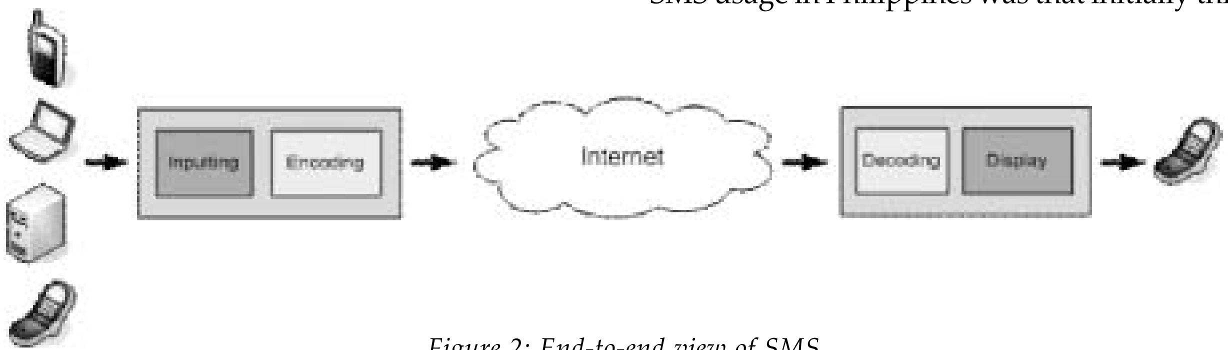


Figure 2: End-to-end view of SMS

service was offered for free by mobile operators. However, growth has continued even after this initial period, despite the fact that this service is no longer free. Hence, the importance of technical challenges in ensuring a wider acceptance of SMS cannot be underestimated. In particular, the lack of a standards-based, scalable, inter-operable, cost-effective and user-friendly Indian language SMS solution has been a major barrier towards widespread adoption of SMS in India.

One of the technical issues is the encoding used for Indian language SMS. Until recently, the 3GPP specification for SMS provided the option of 2-byte encoding for Indian languages, as per the UCS-2 standard. It is true that handsets that implement the optional UCS-2 character set can provide standards-based inter-operable solution for SMS in Indian languages (or any language, for that matter). However, this approach, apart from being optional in the standard, requires 16 bits per character, limiting the SMS payload size to 70 characters, as opposed to the 160 characters possible in English. Given the nature of Indian languages, this limits the message to only seven or eight words. This is too short, forcing the user to send multiple messages, increasing the cost and making it cumbersome.

In the case of Philippines, the local language uses Roman script. This allows the same SMS solution which is used globally for English to be deployed for sending short messages in the local language. In other words, the telecom network and end devices have in-built support for SMS in the local language.

Usability Requirements

Most of the Indian language implementations on mobile phones have adopted an "English" centric approach. The intention was to provide the same level of simplicity of use as for English. However, since Indian languages are inherently very different from English, this approach has ironically complicated the usage of Indian languages on mobile phones rather than simplifying it. The table below in an indication of the radically different nature of Indian languages compared to English.

Feature	**English**	**Indic Scripts**
No. Of Characters	26	>50
Nature of Script	Linear	Non-Linear
Conjuncts	Non-Existent	Backbone
Case Handling	Lower & Upper	Non-Existent

Therefore, the usability challenge with respect to Indian language SMS also needs to be addressed in a way that takes into account the characteristics of Indian languages, particularly with respect to text entry and display / rendering.

** *Acknowledgements:*

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Professionalism

Fr. Thomas Njarackel VC, MSW, MBA

Profession and Professionalism:- Profession is a line of business or occupation or career or living. There are certain elements essential for an occupation to become a standard profession. They are 1) Knowledge and skill in the specialized area, 2) Training in a specialized area 3) A professional is an expert in a specific field. 4) A high standard of professional ethics 5) Reasonable work morale and motivation. 6) Membership in a professional body and relationship with colleagues 7) Professional Attire.

Professionalism is an attitude, a culture and style of activity. Professionalism is the proper attitude and conduct of a person or organization. Professionalism is defined as "meticulous adherence to undeviating courtesy, honesty, and responsibility in one's dealings with customers and associates, plus a level of excellence that goes over and above the commercial considerations and legal requirements." Educational consultant James Stenson describes professionalism as "a set of internalized character strengths and values directed toward high-quality service to others through one's work."

Traits of Professionalism:- There are a number of characteristics of a professional. Acting in a professional manner means treating colleagues with respect, listening to their views with interest and taking onboard opinions or suggestions. As a professional, you must be industrious, motivated and reliable, delivering results on time and to the highest possible standard. Sincerity, integrity, good reputation, sense of responsibility, rational approach, commitment to the occupation, good communication abilities and a set of good manners are the traits of Professionalism. It involves being thorough in your work, taking pride in what you do and endeavoring to carry out your responsibilities to the best of your ability.

Impact of Professionalism:- If you demonstrate a high level of professiona-lism, you will instill confidence in your colleagues and your managers, who will be impressed by your outlook. Ultimate result of professionalism is good climate for your work place and good reputation for your firm. Professionalism has tremendous impact on any enterprise or business you are taking up. For a business to succeed, all of its employees need to demonstrate a high level of professionalism. All the works are to be completed with high standard, delivered to the customer rising up to their expectations and with assurance of after sale service. Diligent in all activities is important on an individual basis, as it boosts reputation and enables you to get noticed in the workplace. If you act in a professional manner, being motivated and efficient, then those around you will learn from your example and react in the same way.

Professionalism in the Office:- The office, as a workplace is highly competitive and continuously changing; therefore, the knowledge and use of business manners are essential. Today's administrative professionals are given greater responsibilities than ever before such as writing, organizing, and maintaining data; interacting with clients, vendors, and the general public; supervising office and staff; handling purchases and training others. With these additional responsibilities ever present, professionalism in the office is vital, and with a better understanding of how to maintain this professionalism in the office, you can easily enhance your business prospective.

To become successful within any business, it is imperative to learn and practice the principles of work behavior - competence, conduct, accountability, and interest conflict. Competence includes the knowledge and application of new techniques and ideas. Those with competence generally possess the ability to multi-task rather easily and make use of a variety of skills, including superior time management. These individuals maintain respect for and are willing to use appropriate resources within the office environment. Business etiquette is essential part of that climate. The proper conduct includes the both knowledge and use of basic etiquette guidelines.

Everyone should be accountable for his or her own action. Accountability includes the warranty of work, staying with problems until they are resolved, and being both available and reliable. The final principle of work behavior is interest conflict. Within every office there should be specific practices employed in order to avoid future conflicts. These include safeguarding all confidential information, honoring copyright restrictions, and complying with licenses and agreements.

Customer Relations:- Work behavior greatly affects a business's clientele. Good interpersonal and customer service skills are essential. The character of a business is often judged by the quality of performance and efficiency of performers. Therefore, a lack of appropriate manners can result in the loss of clientele. The basics of business etiquette can help to avoid any future losses, however. Etiquette basics include appearance, which should be conservative and neat; courtesy, and respect; and the practice of both telephone and electronic etiquette guidelines. When you practice professionalism in the office, you are ultimately maximizing your overall value to your employer/firm.

Continuous Improvement:- There are other ways to maximize your value within the workplace. This means keeping yourself informed of technological changes and becoming proficient with an array of innovative systems. It also helps to enhance or gain new skills by pursuing higher education, becoming certified, attending business-related workshops, and improving both written and verbal communication skills. Volunteering your time can also prove to be worthwhile. Practice leadership abilities offering to train others on improving workplace manners. Become familiar with techniques for managing confrontation such as difficult customers and unpleasant office situations. Practice researching skills. Today's office professional often helps with research and managing projects from start to finish; therefore, this is a good skill to have.

Another important area to become familiar with is office equipment. Learn about the different types and use them correctly. The office workplace is constantly changing and administrative professionals are given more responsibilities as a result.

Professionalism in the Office - Tips:- Create and maintain a high level of professionalism in your workplace by applying some simple, yet important guidelines given by Mary Beth Magee (2004).

(1)Business Etiquette Begins at the Top; Model the desired behavior from the highest position in the company to the lowest ones. Foster excellence by displaying it. Establish a clear-cut set of expectations through employee handbooks, in-service training and timely feedback.

(2) Professionalism Assessment: - More than doing a Job demonstrate professionalism at any level of employment by the attitude you bring. Answer the following and take the next step.

Ask yourself if you can answer "True" to these statements:

1. I do the job to my best ability.
2. I take pride in the job I do.
3. People appreciate the way I do my job; I make a difference.
4. I start my workday neat and clean.
5. I report for work on time and stay for my entire shift or workday.
6. I honestly earn my pay.
7. I treat my customers, clients and coworkers with respect and dignity.
8. I employ good manners in my interactions with others.
9. I keep my mind on the job at hand.
10. I respect my work and myself.
11. I take care of my tools and supplies, whatever their cost.
12. Add these statements for management-level positions:
13. I set an example of proper performance for my staff.
14. I regularly acknowledge and reward excellence among my staff.
15. I give meaningful feedback when I see a problem developing.
16. I enforce company guidelines evenly across my staff.
17. I provide a "measuring stick" of what I expect from my staff.
18. I supply appropriate tools to enable my staff to perform their work.

Answer "no" is spotting a potential problem in your company's culture.

(3) A Professional Appearance is Key:- Many clichés come to mind when you think about how to become a professional, including, "the value of a good first impression" or "dressing for the job you want, not the job you have" or, simply, "dress for success." As is the case with most clichés, there is some truth to them: you can take the first step to becoming a professional by having a polished, conservative, and meticulous appearance.

1. Be well groomed, clean and pressed, head to toe, everyday.
2. If you have a moment's doubt about whether something is appropriate to wear in the workplace, don't wear it.
3. Avoid clothes that are too tight or revealing.
4. Use restraint with cologne and perfume.

(4) Professionalism and Ethics:- Ethics and professionalism are closely related. Set high ethical standards for employee behavior. Support those standards with training, communication and an atmosphere of trust, advises consultant Shawn Smith (2008). Ethical "problems can add up to significant legal exposure and loss of competitive advantage in the marketplace," she writes. "The employers that best avoid these difficulties are not necessarily the ones with the fanciest ethics policies, but those that most effectively provide their workforce with the framework to identify and address ethical issues as they arise."

(5) A Good Character is a Professional Character:- To be successful at your job, you always need the skills and knowledge to perform your duties and responsibilities. In addition to intelligence, expertise, and education, employers value the willingness of an employee who goes above and beyond simply completing the assigned tasks. Displaying a strong character and integrity is crucial to your growth and success as you walk the path to become a professional. Be honest, reliable, positive, true to yourself and see your job as an extension of who you are.

(6) Effective Communication is Essential for Success:- Intelligent, effective communication in the workplace is the driving force to any successful business. Knowing how to speak and write clearly and concisely and being an active listener are invaluable skills if you want to become a professional.

1. Speak clearly and in a light, friendly manner.
2. Pay attention to others and what goes on around you.
3. Communicate honestly and directly but always with tact and respect.
4. Express your beliefs even if you don't agree, but remain positive and supportive to the organization.
5. Communicate with care via telephone and email since that is often the first contact others make with you and your company.
6. See the big picture and make connections between people and events.

(7) Represent the Organization:- An important thing to know is that whether you are on the job or at the grocery store, your employer considers you a representative of the organization at all times and your behavior reflects on that organization. Conduct yourself at every moment with thought, care and dignity to become a professional that others will want to emulate.

1. Demonstrate a vested interest and commitment to your organization.
2. Clearly and accurately articulate your company's mission.
3. Take pride in your work.

(8) Professional Relationships Require Emotional Intelligence:- One of the greatest challenges of any workplace is developing work relationships with co-workers, customers or clients. You may find yourself working with people that have different backgrounds, opinions, viewpoints, politics, religions or work styles than you and that can be difficult. Relationships are bound to rouse some emotion at some point. To become a professional you must handle your emotions with grace and intelligence.

1. It is natural to feel angry with others, even on the job, however it is never appropriate to act out on anger.
2. Take responsibility for your actions.
3. Develop solid working relationships by showing kindness and respect to all.
4. There can be incidents on the job or co-workers that may cause you unhappiness or harm. Figure out how to promptly and calmly this with the concerned party, avoiding drama and tattling.
5. Avoid gossip.

(9) Care About Yourself, Care About Your Job:- In our country we are a busy group; striving to look good, have fun, enjoy families and career satisfaction, yet in many ways our own health can get lost in the shuffle - and what could be more important? Being healthy means taking care of your body as well as your mind and spirit. The more strong and healthy you are in all of those ways, the better you will be at anything and everything in your life, not just your job. To become a professional is to become a strong and whole person.

1. Eat and sleep well. If you don't know how to do that, there's no better time than the present to learn!
2. Know yourself. Take the time to slow down and reflect on your strengths and weaknesses, triumphs and mistakes, developing a realistic, non-judgmental and non-egotistical view of yourself.
3. Look for the lessons in every experience, positive or negative.
4. Slow down. It is difficult to have a sense of your well-being if you are never still.
5. Exercise for improved overall health, energy and happiness. Enjoy looking good as the by-product, not the goal.
6. Healthy people who know how to take care of themselves are attractive people and that quality gets noticed. If you care about yourself, you will be better able to care about your job and that will impress any employer.

How to Bring Professionalism:- Here are a few simple points to keep in mind that can help you to climb the ladder to reach the higher levels of the Profession.

A job is what you make it. If you look at your function as only a job (show up, fill a desk, answer a phone, and pass on a report), that's what it will be. But if you recognize the time you spend in your early, entry or junior position as a process of career building, then that's what you will have: a career.

If you handle your position as just a job (or as just a paycheck) then what you do (even if you do it well) can probably be done by a lot of other people. But if you handle it as a *position*, your value will be recognized.

Know your company and its business, who the officers are and who the competition is.

Don't be intimidated by senior people. Remember, they also started somewhere, and if they are purposely intimidating you, they can't be very secure themselves.

Don't, however, confuse intimidation with respect. Even if you don't agree with a senior person, they have earned and deserve their due for what they have achieved in the organization. (And remember, there's always the chance you'll surpass them someday!) Play your role with dignity, looking for ways to learn from it.

If you are typing a document, understand what it says. If you're unsure, don't be afraid to ask. If you are sitting in on a meeting (even in a note-taking or other non-speaking role), be aware of the results of the meeting and see what requires follow-up.

You may not be asked to speak, but that doesn't mean that you can't have an opinion, which can be offered to someone more senior at the appropriate time.

Never be afraid to give an opinion or idea. Just make sure you believe in it before you do. Conversely, don't get depressed if that opinion or idea isn't always met with applause. The fact that you are interested will be noticed.

Juniors probably make the most mistakes. After all, they are learning and they don't make the rules! Mistakes are really teachers—they are only a problem if they happen again. Learn from your mistakes.

Most important; *listen* to the assignment and carry out what has been asked. Again, remember that you are the one directed, not the director, at this point in your career. You may not like the assignment, but do it with the same enthusiasm that you show for those projects you do like. Pencils must be sharpened, and everyone (even the CEO) has taken his turn.

When you *earn* your way in business, it truly is yours. Even if you leave your position, the growth you achieve and the respect you have gained can't be taken away. It goes wherever you go.

Professionalism for Everyone;- These are professionalism tips in the workplace arena, where we spend a major part of our lives and strive to make ourselves useful and find ourselves. Through each one of these professionalism tips, I hope to paint the image of a thorough 'Professional'!

1) *Excellence is Thy Goal*
2) *Get Your Basics Right*
3) *Take Your Job Seriously*
4) Switch Off Personal Problems
5) *When at the Workplace, Focus on Thy Work*
6) *Be Willing to Learn*
7) *Earn your Salary & your Respect*
8) *Be a Team Player*
9) *Handle difficult people at work*
10) *Enjoy what you do*

Professional or Amateur: - Are you a professional or amateur? The first step to making yourself a professional is to decide you are a professional. The following check list from L. Ron Hubbard will help you to develop a professional frame of mind and bring you to a privileged level of Professionalism.

"You can miss 15% of the driving-test answers and still get a driver license. 'Just getting by' is an attitude many people accept. But it is the attitude of amateurs. *Don't ever do anything as though you were an amateur.* Anything you do, do it as a Professional with Professional standards.

Develop the frame of mind that whatever you do, you are doing it as a professional and move up to professional standards in it.

Professionals see situations and they handle what they see. They are not amateur doers.

A professional learns every aspect of the job. An amateur skips the learning process whenever possible.

A professional carefully discovers what is needed and wanted. An amateur assumes what others need and want.

A professional looks, speaks and dresses like a professional. An amateur is sloppy in appearance and speech.

A professional keeps his or her work area clean and orderly. An amateur has a messy, confused or dirty work area.

A professional is focused and clear-headed. An amateur is confused and distracted.

A professional does not let mistakes slide by. An amateur ignores or hides mistakes.

A professional jumps into difficult assignments. An amateur tries to get out of difficult work.

A professional completes projects as soon as possible. An amateur is surrounded by unfinished work piled on top of unfinished work.

A professional remains level-headed and optimistic. An amateur gets upset and assumes the worst.

A professional handles money and accounts very carefully. An amateur is sloppy with money or accounts.

A professional uses higher emotional tones: Enthusiasm, cheerfulness, interest, contentment. An amateur uses lower emotional tones: anger, hostility, resentment, fear, victim.

A professional persists until the objective is achieved. An amateur gives up at the first opportunity.

A professional produces more than expected. An amateur produces just enough to get by.

A professional produces a high-quality product or service. An amateur produces a medium-to-low quality product or service.

A professional earns high pay. An amateur earns low pay and feels it's unfair.

A professional has a promising future. An amateur has an uncertain future."

"Anything You Do, Do it as a Professional with Professional Standards."

Good Luck

Global Warming

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The prediction of climate change due to human activities began with a prediction made by the Swedish chemist, Svante Arrhenius, in 1896. Arrhenius took note of the industrial revolution then getting underway and realized that the amount of carbon dioxide being released into the atmosphere was increasing. Moreover, he believed carbon dioxide concentrations would continue to increase as the world's consumption of fossil fuels, particularly coal, increased ever more rapidly. His understanding of the role of carbon dioxide in heating Earth, even at that early date, led him to predict that if atmospheric carbon dioxide doubled, Earth would become several degrees warmer. However, little attention was paid to what must have been seen to be a rather far-out prediction that had no apparent consequence for people living at that time. Arrhenius was referring to a potential modification of what we now call the greenhouse effect.

Short wave solar radiation can pass through the clear atmosphere relatively unimpeded, but long wave infrared radiation emitted by the warm surface of the Earth is absorbed partially and then re emitted by a number of trace gases - particularly water vapor and carbon dioxide - in the cooler atmosphere above. Because, on average, the outgoing infrared radiation balances the incoming solar radiation, both the atmosphere and the surface will be warmer than they would be without the greenhouse gases. One should distinguish between the "natural" and a possible "enhanced" greenhouse effect. The natural greenhouse effect causes the mean temperature of the Earth's surface to be about 33°C warmer than it would be if natural greenhouse gases were not present. This is fortunate, for the natural greenhouse effect creates a climate in which life can thrive and humankind can live under relatively benign conditions. Otherwise, the Earth would be a very frigid and inhospitable place. On the other hand, an enhanced greenhouse effect refers to the possible raising of the mean temperature of the Earth's surface above that occurring due to the natural greenhouse effect because of an increase in the concentrations of greenhouse gases due to human activities. Such a global warming would probably bring other, sometimes deleterious, changes in climate; for example, changes in precipitation, storm patterns, and the level of the oceans. The word "enhanced" is usually omitted, but it should not be forgotten in discussions of the greenhouse effect.

Nearly 100 years after the Arrhenius prediction, we are now aware that carbon dioxide in the atmosphere is increasing, with the possibility that it will double by the middle of the next century from the levels at the time of Arrhenius. Post-World War II industrialization has caused a dramatic jump in the amount of carbon dioxide in the atmosphere. As the prospect of considerable change in the atmosphere becomes more real and threatening, new computer models are being applied to the problem. These models take into account the natural processes that must be part of the whole picture to understand what could happen to Earth's climate as carbon dioxide increases.

An important aspect of the newer models is their treatment of the "amplifier" or feedback effect, in which further changes in the atmosphere occur in response to the warming initiated by the change in carbon dioxide. In addition to moisture and cloud processes, the newer models are beginning to take into account the role of vegetation, forests, grasslands, and crops in controlling the amount of carbon dioxide that actually will be in the atmosphere. Along with their role as "sinks" for carbon dioxide, the various types of vegetation in the biosphere have further effects on climate. Plants heat or cool the air around them (through the reflection and absorption of solar radiation and the evaporation (process), remove momentum from surface winds, and take up and release moisture into the air (thus contributing to alterations in the hydrologic cycle). In turn changes in climate will affect the patterns of vegetation growth. For instance, forest stands that require relatively cool conditions may not be able to adjust to the relatively rapid warming that is being predicted for the interiors of continents. Other feedback effects at work also must be considered. In normal conditions, plant leaves take in carbon dioxide from the air and release moisture to the air as part of the photosynthesis process. The release of moisture through evapo-transpiration causes the air to cool. With increasing atmospheric carbon dioxide, one can expect to see a change in plant carbon exchange rates and water relations. This may result in reduced evaporation rates, thus amplifying the summer continental warming. Without plants, the ground and air would become warmer, exacerbating the problem. To predict climate change, one must model the climate. One test of the validity of predictions is the ability of the climate models to reproduce the climate as we see it today. Elements of the models such as the physics and chemistry of the processes that we know - or think we know - are essential to represent in the models.

Therefore, the models have to embody the characteristics of the land and the oceans that serve as boundaries of the atmosphere represented in the models. Models also have to take into account the radiative characteristics of the gases that make up the atmosphere, including the key radiative gas, water vapor, that is so variable throughout the atmosphere.

Global records of surface temperature over the last 100 years show a rise in global temperatures (about 0.5° C overall), but the rise is marked by periods when the temperature has dropped as well. If the models cannot explain these marked variations from the trend, then we cannot be completely certain that we can believe in their predictions of changes to come. For example, in the early 1970's, because temperatures had been decreasing for about 25 to 30 years, people began predicting the approach of an ice age! For the last 15 to 20 years, we have been seeing a fairly steady rise in temperatures, giving some assurance that we are now in a global warming phase. The major gases in the atmosphere, nitrogen and oxygen, are transparent to both the radiation incoming from the sun and the radiation outgoing from the Earth, so they have little or no effect on the greenhouse warming. The gases that are not transparent are water vapor, ozone, carbon dioxide, methane, nitrous oxide, and the chlorofluorocarbons (CFCs). These are the greenhouse gases. There has been about a 25% increase in carbon dioxide in the atmosphere from 270 or 280 parts per million 250 years ago, to approximately 360 parts per million today. The record of carbon dioxide in the atmosphere shows a variation as seasons change. This variation is more pronounced in the northern hemisphere, with its greater land area, than in the southern hemisphere because of interactions in the atmosphere caused by vegetation. In the growing season, during daylight, vegetation takes in carbon dioxide; at night and in the senescent season, vegetation releases carbon dioxide. The effect is more pronounced in the northern hemisphere because most of the land on Earth is located there.

Modeling to understand and predict climate change, the following types of models are needed:

- Socio-economic models that predict future fossil fuel consumption and utilization of alternative fuels. These models depend upon technology, e.g., industrial production methods, energy efficiency, new materials, etc.; public policy and social attitudes, e.g., concern for the environment; and economic development, standard of living and reliance on energy and chemical-based products.
- Chemical-physical-biophysical models of the Earth System that tell us what happens to gases released into the atmosphere, e.g., how much carbon dioxide is taken up by the oceans and the biosphere, and how industrial and agricultural uses of chemicals and natural processes on Earth's surface affect the release of methane, nitrogen oxides, and other greenhouse gases into the atmosphere.
- Coupled ocean-atmosphere models that tell us how the climate system, e.g., temperatures, humidity, clouds, and rainfall, responds to changes in the chemical composition of the atmosphere.

Getting reliable predictions from models is difficult because many of the secondary processes are not understood. For example, when temperatures start to warm because of the direct radiative effect of increasing carbon dioxide, will clouds increase or decrease? Will they let in less radiation from the sun, or more?

These secondary processes are important. The direct radiative effect of doubling carbon dioxide is relatively small, and there is not much disagreement on this point among models. Where models conflict is in regard to the secondary, or feedback effects. Models that predict a very large warming from carbon dioxide show cloud cover changes that greatly amplify the warming effects, while models that predict more modest warming show that clouds have a small or even damping effect on the warming. Can we match the observation of temperature trends with the model predictions? The temperature record of the past hundred years does show a warming trend, by approximately 0.5°C. However, the observed warming trend is not entirely consistent with the carbon dioxide change. Most of the temperature increase occurred before 1940, after which Earth started to cool until the early seventies, when warming resumed. Carbon dioxide, on the other hand, has been increasing steadily throughout the past century. Other factors that could have affected climate during this period include the possible change in the solar energy reaching Earth, the cooling effects of volcanic aerosols, and the possibility that sulfur dioxide and other pollutants might be affecting the amount of solar radiation that is reflected back to space. Some of these effects can cause a cooling that could counteract the warming due to carbon dioxide and other greenhouse gases. All of these effects would have to be taken into account and appropriately modeled in order to predict the changes that one might expect in the next century. An important need in the further development and verification of climate models is the acquisition, assembly, and analysis of reliable climate data. Highly accurate, self-consistent, and long-term data sets are to be designed to fulfill that need.

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