Simple Sensor Designs for Scientific and Technical Education

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ABSTRACT

Research finds ways to motivate and educate young children about the environment in which they live and suggests simple tools to observe and understand the environmental changes taking place every day. Better understanding means better chance of preserving the environment. Use of physical, chemical, technical and biological knowledge need to be beyond filling the brains with ideas, towards practical use of the knowledge in everyday life. This rapid change in the way we can take the research attitude from laboratory experiments to every house where each one of us can play a vital role in doing something good to preserve earth environment. The education system has to adopt new methods of teaching by experiments. Research organizations, their scientists and engineers need to develop simple methods that can be easily learnt and used by the young children at very early age. Those of us have knowledge also have responsibility to implement it. The greatest example is honorable Dr. Abdul Kalam the President of India, who does not mind talking to the children all about it. He is the first man in the country to visualize the need of it and makes sure that his every meeting with children gives them an idea to survive a bit better by the use of knowledge. This wave of new approach to education is very impotent and hence is the beginning of the research in this area.

1.0 INTRODUCTION

With rapid development of scientific and technical knowledge in the 20th century has created more challenges for the people to live in 21st century. Population of the world has significantly increased and the environment in which most of the population lives now faces more attacks from uncontrolled exploitation of technology and greater amount of generated waste that will continue to be a serious problem in future. We need to find ways and means to educate the younger generation such that they may find better solution to the problems that they may face by living into degraded environment of tomorrow.

The first step in the new approach to the scientific and technical education is to make people aware of the environmental changes. Students and researchers work hand in hand to discover simple ways to feel the environmental changes in every sphere of it that may affect the life system on earth. It is now well documented that biodiversity of the earth is essential for environmental sustainability of living system on earth. We need to preserve this system, which has been created by the nature in millions of years to give birth to life on earth. The basic idea of co-existence is essential to care about others. We live and let other also live on earth in an equally good environment. We have to shade of opportunistic attitude in order to make the system better for all. Our character is to be molded into the one very caring type and brotherhood.

Teachers need to use new methods of scientific tools and be a mentor to the children in their tiny research programs. Role of teachers is much greater in bringing success to this idea, as they are closest to the children for many years. Teachers can motivate children and can also help them with ideas.

In India education system is not well funded and hence, resources to the teaching system suffer a great deal. We can't blame teachers for this. In fact this is the responsibility of the society to pay reasonable to the teachers and to provide them with enough resources to let them do well to our own children. Government by itself does not understand anything and only people can influence it to act upon. All those of us with knowledge thus can play a positive role in bringing this change. Many of us have capability in bringing change in the life of thousands of our children. We with capability have to do it, as no one else is even aware of what is to be done.

1.1 CREATING RESPORCES

The very first step in the process is to create resources of knowledge. There it is needed to talk about it first, as we are doing it here today. We need to know, what is to be done and what is that we can do now and how we can work for the future programs. There need to be awareness groups who are vigilant and give us ideas all the time. From these ideas we can form the base of our education programs we talked about.

We then need the help of scientific and technical community to generate simple means to implement knowledge. We need gadgets for practical work, as we are no longer talking about theory alone. Highly scientific ideas in such a simple form that they become a toy play to the children and are safe for children. We need as many of these possible. We create scientific and technical exhibitions for learning ideas, tools to experiment in a class and in actual environment in the field areas. We also involve teachers and children in creating new practical ideas for their own use. Like every other safety program, we need to have a very seriously researched safety program for children such that do not get hurt accidentally by playing with scientific tools that may be dangerous to their health.

Having generated these physical resources, we also need trained teachers to implement the program. Our approach to generated better human resource of trained teachers is another essential step in the process. This needs drastic change in the education level of the teachers themselves. Most of them do not have the background, knowledge and training. Teaching the teachers thus becomes more essential. Even though it looks difficult, in fact it is not so. Teachers learn many ideas much faster and assimilate even from what their student do in their new activities. Hence, teachers become larger resource of knowledge by interaction with their students and other researchers. Teachers may join short training programs, workshops, seminars and conferences to get more ideas. They cam also get feedback on what they know or how they can approach to the new ideas that they may have come up during their teaching experience but find it hard to implement it on their own. They can look for support from other to solve their problems and find new easy solutions.

We finally need to have forum of evaluating and rewarding work of the new system such that, it has an incentive to motivate more in the area. Evaluation and feedback will strengthen the approach and will generate more ideas we talked about in the first step. Here after it is likely to become a self-sustainable perpetual system and perhaps it can take care of itself.

1.2 EXPERIMENTS NEED TO BE INTERESTING BY DESIGN

We are not talking about involving people into boring ideas. Hence, experiments need to be playful and highly interesting ideas. These experiments should create curiosity among children. They should feel to do it. While it may be possible at time to involve the children for days, it is not a good idea to make it a routine. Children have lot other things to do. Hence, time planning is equally essential to let their interest remain in this serious area along with their other normal activities. Some of the experiments can even support their normal activities.

Out door camps and visits to nature help a great deal. It is not a very good idea to take children to unhealthy areas where they may fall sick. Those areas are for the professionals to work on. We need to have clear distinction between the purpose of this awareness education program and actual serious problems. In no way, we should affect the health of the children during this program. We need to know the limits and teachers need to be vigilant and cautious.

Group activity often makes things interesting. Children play in a group to impress upon others. Similarly, the experimental activity can be a group activity. Each member of the group helps other member of the group and develops a friendly relationship by cooperation.

2.0 TEST EXPERIMENTS

There is no unique way to start and finish this program. It is an innovative process and an evolution in itself. One starts with whatever idea clicks at the first place and then one finds its utility for the group and then by learning from successful experience others may also involve in similar ideas in future.

Few simple ideas are listed here that can be taken only for reference and perhaps to start some activity and these ideas are not claimed to be the best guiding material by design.

2.1 BICYCLE TRACKING TO KNOW THE TERRINE OF THE PLACE

Students may like to do some terrine exploration on their bicycle. Teachers can provide the students simple technical tools like barometer for terrine height measurement by pressure change and thermometer for temperature recording. Students can collect data on the terrine height and temperature at each point and then it can be used for making greater study at the laboratory to draw the hills and valley map of the area. Electronic pressure sensors and temperature sensor are easy to obtain from market. Students can also connect a speedometer to their bicycles to know the speed of their travel at particular height or depth of the track. They can also collect the data electronically with time marked information to know how their experiment progressed in time.

It is also good to collect number of photographs of the area where students were during their experiments. They call recall the details of their experience using these photographs and can associate other experimental information to the details in the visual information.

In second phase, students can also collect water and soil sample in a zone. These can be laboratory tested. Students have to be taught proper way to collect samples such that maximum information is retained and data does not become erroneous.

Taking digital pictures of animals and plants may be of great interest to them. Collected information can be placed on the home pages of the students to be shared by other similar interest groups.

Information on people, structural design of their houses, old buildings and architectures of historical importance, water resources, hospital, education institutes, play ground, public utility facilities and markets will be excellent information. One can also collect information on water talk, ponds, sumps, rivers, canals, bore wells, village wells and can collect samples of water from these areas. One can also take interest in flora and fauna of the area. Interaction with people is also a good idea to know their education level, understanding power and reasoning against superstitions, interest in education, gender difference, health problems, average age of the villagers, food habits, resources and economic level etc.

2.2 WEATHER MONITORING STATION

Local weather monitoring station can be part of the activity at college where students can collect data on wind velocity, wind direction, air temperature, atmospheric pressure, ambient light intensity, rain etc. These gadgets are easily available or can be made by the teachers. Students can regularly watch the data pattern and compare these with the national data shown on the TV network or published in the newspapers. Institute can maintain the record of the data such that students can study changing pattern of the environment in a zone where the institute exists.

One can also monitor the visibility and fog condition, smog formation, smoke emission from industrial plants, smell from chemical waste dumped in air or water or soil, color of water, soil. Collection of information related to solar and wind power in the area. One can also record the changes in water levels in wells, ponds, and river for a year.

Effect of weather change on living system can also be studies as linked information that affects environment. Change in soil properties due to low of high amount of rain in the area and effect of over use of water resource can also be recorded.

3 GENERAL CLASSROM EXPERIEMNTS

Some of the experiments can be done in the classrooms and these can also help normal course studies of science and technology. Some of these experiments can be to design sensors, interfacing sensors with computer and using software to collect information. Even though these look like engineering ideas, they are rather simple technique that a high school student can easily understand and will like to experiment with.

Students should work with batteries of low power and low voltages and not with mains power which could be dangerous. Here I am listing few experiments that can be easily done.

3.1 UNDESTANDING BASICS OF ELECTRICITY

It is initially essential for the students to have some basic idea of the electricity. Flow of electrons is electric current and its closest simulated phenomenon is the flow of water. As water flows from high potential energy to the lower one, we can also explain the flow of current. As electrons have negative charge, the flow of current is just opposite to the flow of electrons. Perhaps teacher can also remind the students about how one can say that electrons have negative charge and do not have a positive charge on them. Only when deeper nuclear physics is understood then one can say that we have positrons as well that have positive charge and these are created by nuclear interaction of photon with nucleus but do not live longer. Having understood the role of electrons in making electricity, we can explain more about it using ohms law and can build a base on understanding conductors and insulators.

3.2 EXPERIMENTING WITH BATTERIES OR CELLS

We sure will need source of electricity for experimenting. Batteries and cells are easier to use and are safer than mains power that could hurt by giving shock. It is a good idea to show up as many types of batteries that are common in the market, how they are constructed and how they work.

Battery or cells having voltage in the range of 1.5V to 12V can be considered good for experiments. It is also to be known that batteries are storage of energy and hence if they are short circuited then they will generate quick heat and perhaps spark through metal where shorted. They may even explode. Hence, their safe usage practices need to be explained. Few important points are to be noted

1. Do not keep coin or metal parts where batteries are else they may short circuit
2. Do not place many batteries in pocket
3. Use insulated battery terminal shutters if they are available

While initially we can simply use the volt meter and current meters, we can explain about their design as well. We also may need bulb, LED, small DC motors to supplement our experiments.

INITIAL EXPERIMENT WITH BATTERIES:

Teacher can show that batteries can be used in combination to increase voltage or current capacity of the batteries. One can also have an idea of the power of the batteries and for how long they can deliver the power if used continuously. How one can increase power using many of them in parallel.

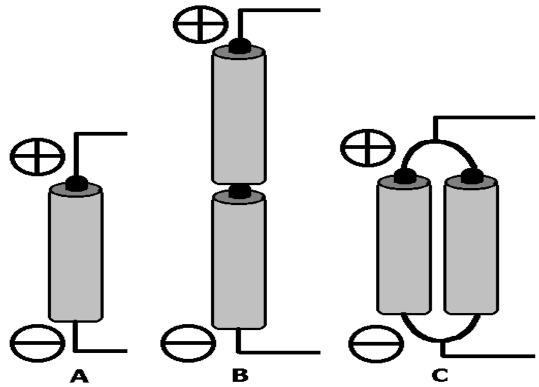

Figure 1: Batteries to be used in experiments; (A) single, (B) two in series to obtain double voltage, (C) two in parallel to obtain double current from same types.

Reversal of the polarity while in series makes the battery open, it is dangerous to make parallel of the reverse polarity of the batteries, as that is equivalent to short-circuiting of the two batteries in series. This combination is dangerous.

VOLTAGE AND CURRENT MEASUREMENT

Measurement of voltage and current using simple current-meter and voltmeter is easy to demonstrate. Alternative to current-meter and voltmeter is the digital multimeter, which can be shown with much greater flexibility. Teacher initially can show the proper use of the multimeter to the student and then student can use the meter easily. Multimeter also has capability to measure resistance, and hence is more that voltage and current measurement device.

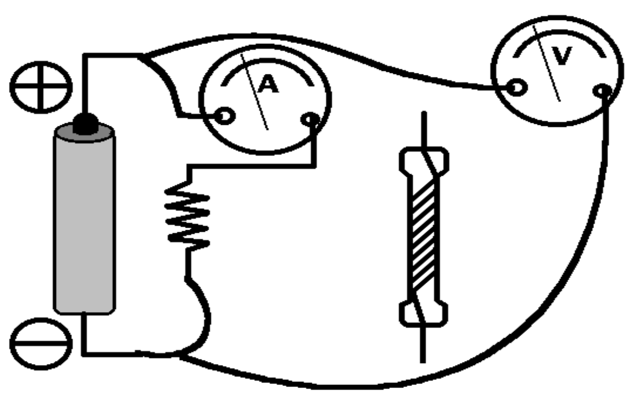

Figure 2: Simple experiment with battery, resistance, voltmeter and current meter. A resistance made using a resistive wire with many circular turns is also shown. Students can be asked to make their own resistance using wires of different lengths.

Measuring resistance using battery voltmeter and current meter needs basic idea of Ohms Law. Here one can combine theory and practical idea. Once this idea is formed, we can now go to field experiments.

FINDING CONDUCTORS AND INSULATORS

It is a fun to discover the electrical properties of various materials around us. Some may be good conductors and some may be bad or worst. Here we can also consider material of all types, like solid, liquid and gas (air is gas mixture). Once we have done these experiments, we now have an idea that there is this special property associated with materials that they may or may not allow flow of electricity.
Let us go to the next stage and discover if we can find material that may change its electrical property due to physical or chemical changes in the material.

EXPERIMENTING WITH WATER

Experiment in Figure 3 makes first sensor of impurity dissolved in water that makes it to pass electricity in a way that the concentration of the salt is related to the current flow. One this idea is formed it can used for further extension to see if water from river, well and pond has high concentration of salt. All it needs is a water sample and above setup shown in Figure 3. Students can now go in the field area to see where they find water samples in nature sources, which passes more electricity or has greater salt concentration.

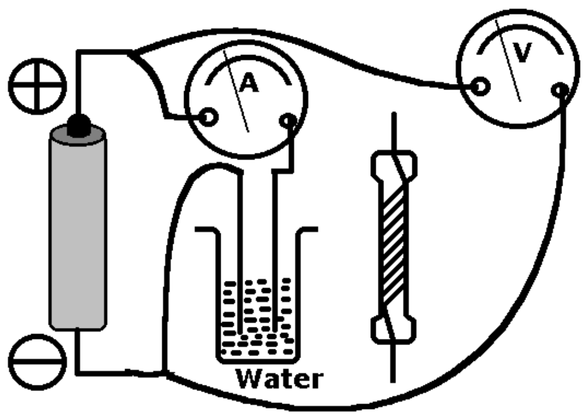

Figure 3: Experimenting with water. Initially distilled water is used and then it is made to contaminate with salt of different amount to see if electric current flow through water changes. A graph of concentration of salt vs. electric current will sure show some trend to give an idea that they are related.

In advanced classes we can discuss about ions and their conductivity in presence of electric field. We can also talk about ion deposition on electrodes we use to pass electricity through liquids. In advanced knowledge we can also stress about the AC and DC electric fields and unidirectional and bi-directional motion of ions and flow of electricity. Students can now visualize the need to have an AC voltage source and AC voltmeter and current-meter for measurement of electrical conductivity of the materials as it will inhibit electro-deposition of ions on electrodes.

3.3 DEVELOPMENT OF ADVANCED ELECTRONICS IDEAS

Let us now introduce some more electronics ideas such as computer Logic and use of Logic gates for our advantage. Simplest to use is the NOT gate which is also called an inverter Logic gate as it changes the state from “zero” to “one” and from “one” to “zero” if used with proper Logic level signals.

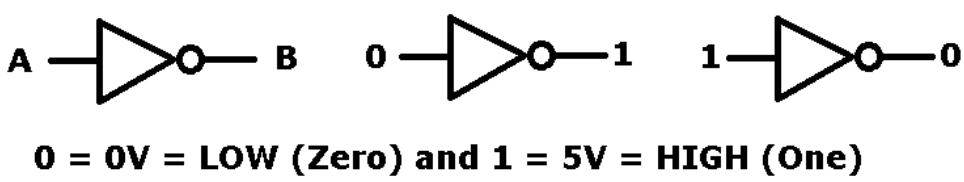

Figure 4: Logic gate NOT type changes digital signal state at the output.

We can now also build the idea of other passive components that students learn about other than resistance we discussed above. One most important component is the capacitor we often use in electronics. Capacitor can store energy and give back as we can fill water in a glass and can take out at our wish. This is a very important property of the capacitor. We can also see this property is charge storage batteries we use in digital camera and cell phones. Most of the students have used these devices and will feel comfortable about it.

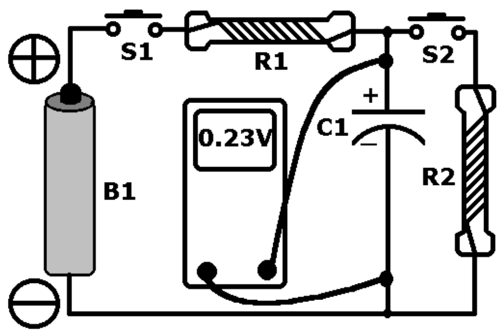

Figure 5: Capacitor charging and discharging through resistance give a waveform across capacitor. Voltage across capacitor changes in time and hence if continuously recorded then it produces time vs. voltage graph. Switches S1 and S2 are used to charge and discharge the capacitor. Quantity R1XC1 and R2XC2 is called the time constant.

DESIGNING AN OSCILLATOR CIRCUIT USING RESISTANCE AND CAPACITOR

It is great fun to design an oscillating waveform that will sustain by itself and needs no help from the designer to make it oscillating. The capacitor charges and discharges from the logic states of the NOT gate that change due to the charge on the capacitor.

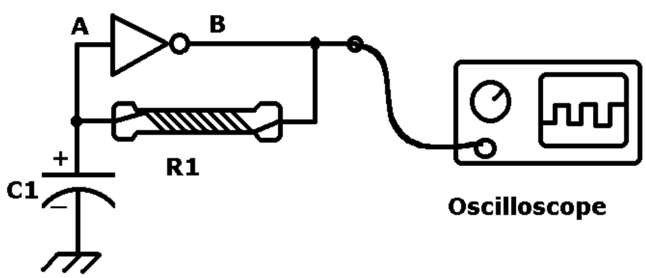

Figure 6: Designing an oscillator circuit using a NOT gate, capacitor and resistance. Oscillator frequency is inversely proportional to the R1XC1 time constant.

USING A FREQUENCY COUNTER

Frequency counter may also be a part of the multimeter or can be commercially obtained. One can also use PC parallel port along with software to measure frequency. In advanced designs one can use Microcontroller to count pulses for each second and report it as frequency.

Oscillator output has a time period, which is made of high and low level pulse widths. Reciprocal of the time period is called frequency.

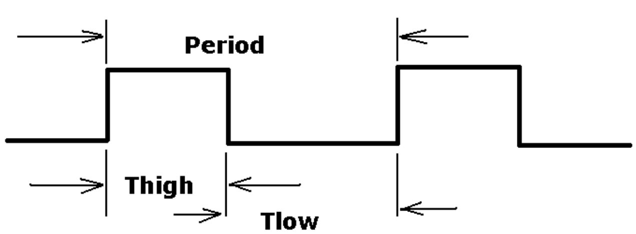

Figure 7: Oscillator period which is made of Thigh and Tlow pulse widths and 1/period is the oscillator frequency, which is measured in all discussed sensors that produce frequency as output signal.

We can now use the above property of the oscillator for measurement of the material properties. We can substitute either capacitor with unknown material or resistance with unknown material to see if our designed oscillator responds to it. Assuming that we replace the material with resistance, then the oscillator will oscillate with frequency that is through time constant of the material resistance and capacitor C1.

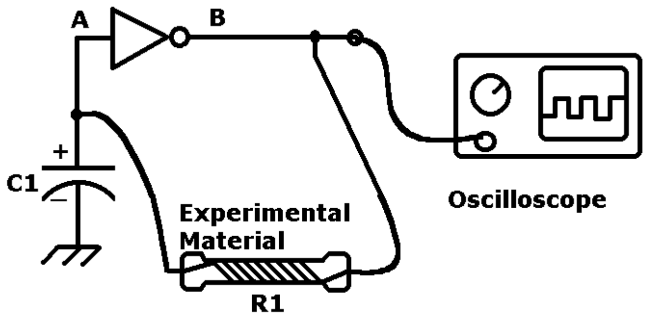

Figure 8: Making a sensor, which has frequency value due to the material resistance and can be related to its property in similar way we measured salt concentration in water.

MEASURING SOIL MOISTURE

One can measure soil moisture using above oscillator circuit and soil resistance with capacitor C1 forms the time constant for the oscillator. Oscillator frequency is proportional to 1 / (R1XC1) where R1 is the soil resistance. Greater is the moisture greater is the oscillator frequency.

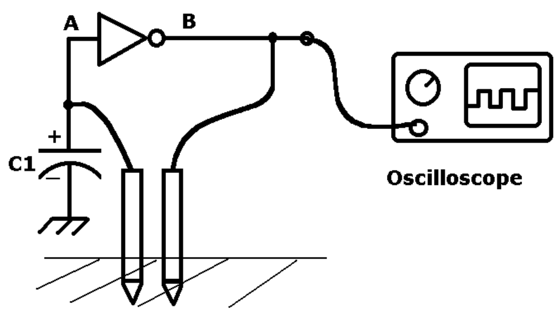

Figure 9: Soil moisture dependent oscillator frequency generator circuit. One can use this circuit to sense moisture of soil in flowerpot or in a garden.

Measuring ambient light

Light sensitive resistor changes resistance when light falls on it. More light means less resistance value. When this property is used in the RC oscillator design, we find that more light means greater frequency of the oscillator.

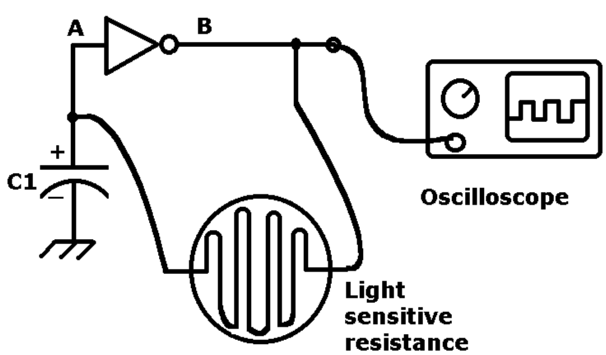

Figure 10: Measuring ambient light using a light sensitive resistor and RC oscillator.

CAPACITIVE MOISTURE SENSOR

It is also possible to use capacitor as moisture sensor if dielectric properties of the capacitor material change with moisture contents. One such sensor is HS1101 type made by Humirel France, which can be used to sense moisture. Capacitor value increases with moisture contents and hence the response curve is reciprocal type.

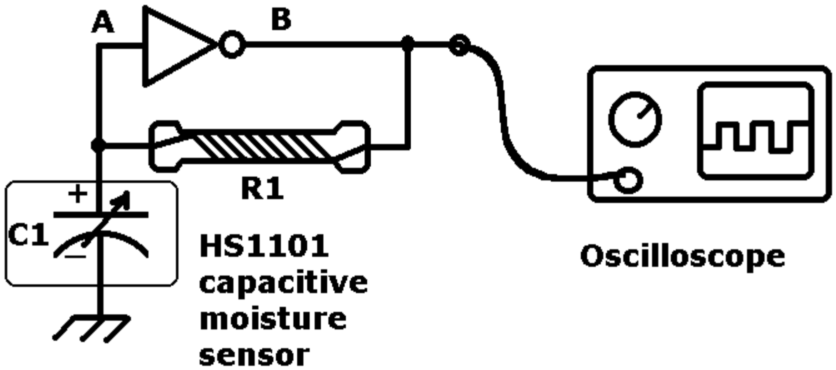

Figure 11: Moisture sensor uses a capacitive sensor HS1101 type.

SEEING IS THE OSCILLATOR OSCILLATIONS

It is fun to see oscillator oscillations and hence we will learn to convert electrical signal into light. We can either use small bulbs or light emitting diode (LED) to produce light from electric current.

We need to know that human vision perception is only limited to less than 20 Hz and hence greater oscillations will become unresolved by human eye and will look as if it is a continuous light. It is to be noted that LED needs minimum amount of voltage to glow and also is current direction sensitive and will not glow if polarity of the battery cell is reversed. LED is like rectifier diode, which allows current flow only in one direction. This problem is not there in bulb as it works on heating of the element and its temperature gives the light spectrum, which we also know the Plank's radiation from black body emission at particular temperature. All materials in thermodynamics are called black body and not just black looking materials as there is no perfect black body.

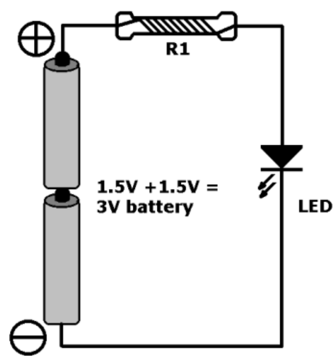

Figure 12: Using LED to generate light is simple and it needs only 10mA current to see good amount of light from LED.

In our new circuit with oscillator we replace the expensive oscilloscope with LED to see oscillations.

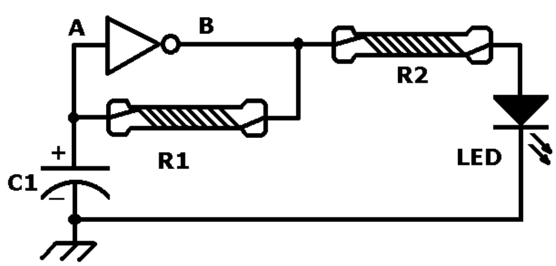

Figure 13: LED flashes ON and OFF with the oscillator frequency and now we can see the oscillations clearly from necked eye. Resistance R2 is to set the current to the LED to make it glow and within 10mA limit to a maximum value.

In above sensor circuit if we look at the waveform across a capacitor then it will show continuous charging discharging triangular waveform. We will need an oscilloscope to see this waveform.

MEASUREMENT OF TEMPERATURE

Temperature we measure using thermometer filled with mercury metal in liquid form in a glass tube. However, that is not a so good device for electronic temperature measurement. We can use temperature sensitive resistor to make an oscillator to sense temperature electronically.

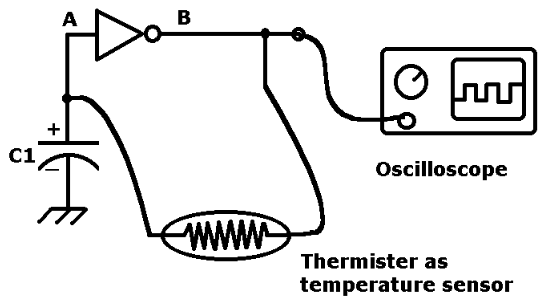

Figure 14: Using thermister for temperature sensing in RC oscillator. As temperature increases, the thermister resistance decreases and oscillator frequency goes up. Students can make a table of temperature vs. frequency of the oscillator.

EXPERIMENTING WITH ROBOTIC MOTORS

Robots are very interesting to experiments with. It is not very difficult to learn to build simple robots. Teachers can get robot parts from toys and then can make changes in them to drive the motors.

Robotic motors are generally DC gear motors and operate on low DC voltages and can change motor rotation direction on reversal of battery voltage polarity. These motors are used in toy cars and are also good for robotic experiments to make a good mobile robot. One needs two motors to make a robot mobile with capability to turn precisely. We call these left and right motors. Two separate battery connect to these motors and motor power is switch ON or OFF by a Logic to drive the robot.

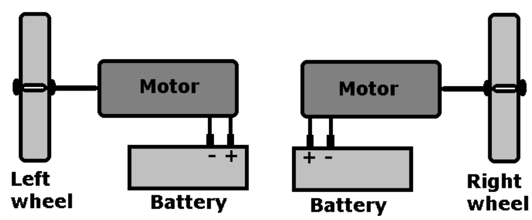

Figure 15: robot motors for left and right wheels. Two motors move in opposite direction to let the robot move either forward or reverse. If motors move same direction i.e. clockwise or anticlockwise then the robot takes a turn.

Changing the current through motor makes the motor to move fast or slow. This makes robot also to move accordingly. This kind of motor speed control is also called an open loop control where speed is not sensed and only anticipatory control is made, which may have some error in speed control.

ROBOT SPEED MEASUREMENT

Motor speed measurement is done through speedometer, which produces pulses per motor rotation. One can use either optical sensor or magnetic pickup sensors or a mechanical device to generate pulses per motor rotation. It is also possible to convert pulses per second or frequency into voltage signal and then it can be measured using a multimeter or voltmeter. More sophisticated electronics is required for precise motor speed control and is an engineering diploma or degree level education knowledge may be required.

COSMIC RAY EXPERIMENTS

Students can also be involved in simple nuclear experiments. However, care need to be taken as some of the experiments need high voltages (500V to 1000V) as this one given below.

Cosmic ray consists of high-energy particles and gamma rays that can easily ionize the atmosphere air. Geiger Muller (GM) tube is used to detect cosmic rays. When gas inside GM Tube is hit by cosmic ray, the gas filled inside the GM Tube gets ionized for a short duration and produces large amount of electrons and positively charges ions. Electrons are collected in static electric field using electrodes. The outcome of ionization is an impulse of electric charge pulse, which is then counted by an event counter. As cosmic rays are statistical in nature they produce random pulses. Number of pulses produced in proportion to the cosmic ray intensity.

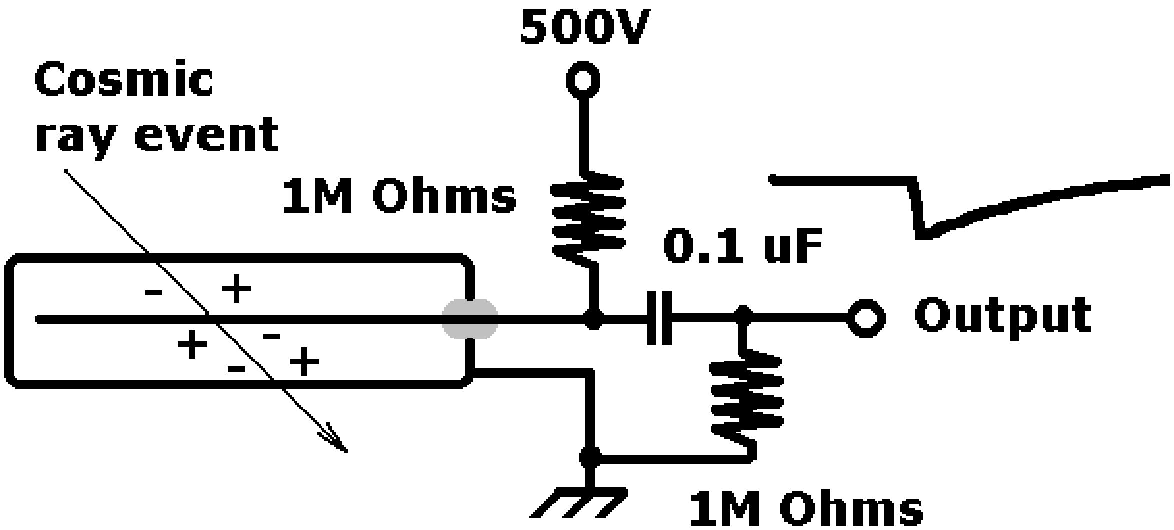

Figure 16: GM Tube cosmic ray event counting detector

GM counting detector can also be used to find the radiation level in natural salts, soil samples, mines, sand of rivers and sea. Ionizing radiation can be measured using GM detector. Ionizing radiation cause cancer and they are hazardous to human health. Ionizing radiation sources are both natural and manmade. Cosmic rays, radioactivity in soil, water, air, plants and animals are sources of different types of ionizing radiation in different intensities. Not all may be alarmingly dangerous. X-ray machines, reactor generated radiation sources and accelerator generated radiation sources are manmade. Radiation can also leak from nuclear accidents and nuclear wars to a very high level. Industries use radioactive sources for radiography and non-destructive testing. Radioactive sources are also used in medical treatment of cancer. Sometimes experiments are also done to find out flow of ground water using tracer radioactivity. Radioactive clods can travel across the boundaries of the countries.

3.4 MEASUREMENT USING MULTIMETER OR ADC

Simple measurements can be performed using multimeter or analog to digital converter with PC. These experiments can be in the following areas:

SENSING TEMPERATURE OF CANDLE OR FIRE USING THERMOCOUPLE

Thermocouples are made of two dissimilar metals and when one the metal junction is heated and other cooled, a thermo electromotive force (emf) develops, which makes flow of current in the thermocouple metal wires. The heat generated thermo electromotive force (emf). is measured using sensitive multimeter or ADC. As thermo electromotive force (emf) is a self-generated voltage, it does not require battery to measure it.

3.5 DAS-8 DATA ACQUISITION AND WIRELESS DATA LINK

Teachers can design simple to use data acquisition systems and wireless data communication links that can help student connect their sensors with computer. One such data acquisition system, which was designed for educational purpose is shown below. It has eight analog inputs and one frequency input to enable online recording of experimental data into computer.

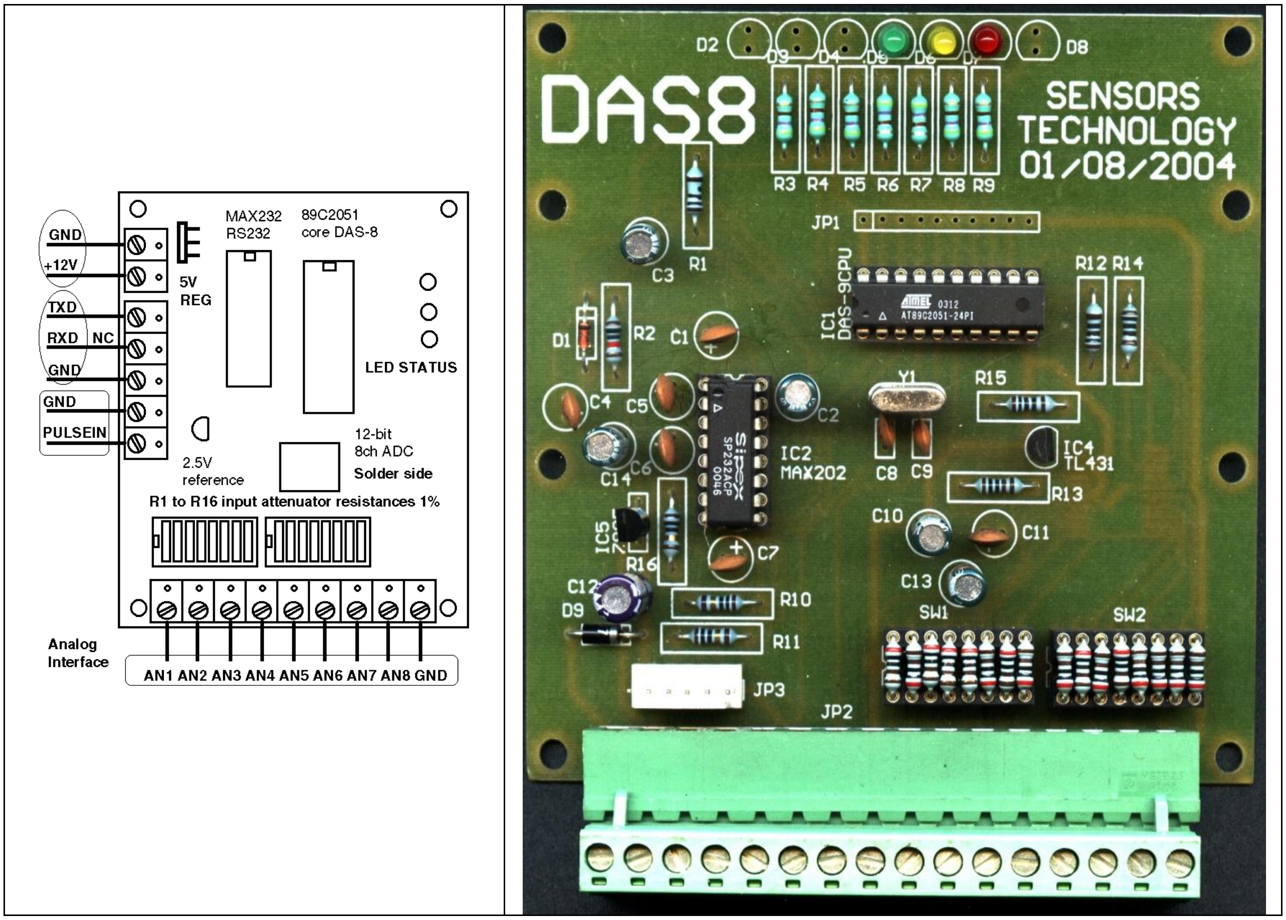

Figure 17: DAS8 At89C2051 Microcontroller based data acquisition system for educational purpose.

DAS-8 data acquisition system permits one to digitize 8 analog signals every second and the digital value is transmitted on wireless link at 1s intervals. We also have one extra channel of frequency signal of TTL level frequency source which is monitored and information is transmitted every second along with analog signals.

RS232 signals link the DAS8 board to wireless transmitter. Similarly RS232 signal link the receiver to PC. The data cable from PC to receiver connects all 9-lines on the COM1 port of PC one is to one bases. No other serial port can be used. Receiver requires 12V AC or DC power adopter for continuous operation, as internal 9V internal battery if used will last only for few hours.

WATER OPACITY MEASUREMENT

Presence of colloidal particles in water can make it opaque to light, which can be measured using a lamp or bulb and light-sensing resistor.

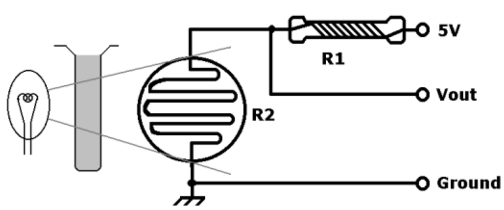

Figure 18: Water opacity measurement is essential for finding out the quality of water for human consumption as drinking water.

VISIBILITY AND SMOG MEASUREMENT

Sensor shown in Figure 17 is also used for visibility measurement in daytime on roads for traffic control and on airstrips for aircraft landing controls to avoid accidents.

SMOKE DETECTOR OF FIRE SENSING

Smoke from fire inside a building causes decrease in visibility and hence it is detected as fire signal in fire sensors using design shown in Figure 18.

4.0 TEACHER TRAINING PROGRAMS

Teachers require training in highly specialized teaching methods before they can teach or guide their students. Institutes thus have to have their own policy for getting their teachers trained at periodic intervals in suitable areas. Workshops can also be organized to get feedback from experts and to find new areas of understanding in concerned subjects. It s an essential ongoing processes that must remain active all time to improve education standard. It is not only hard but also nearly impossible for anyone to completely suggest the best way of education improvement program and is to be discovered in time by trial and error method and knowledge based feedback system.

5.0 CONCLUSIONS

Sensors Technology Private Limited conducted two national level conferences in 2004 (NCVSR-2004 March 1-5, 2004 and NCST-2004 December 27-28, 2004) and passed on its experience to the students and teachers. Author also developed few gadgets for educational program and these were shown to students and teachers to experiments with and have a feeling of these as new experience in life of understanding science and technology. It is a beginning and more such programs in future will be conducted in collaboration with interested institutions. These programs have created greater awareness in scientists, teachers, working engineers and students. Hopefully others will also take it seriously and may contribute for the greater cause.

REFERENCES:

Website of some of the organizations helping in education programs

Institute of Electrical and Electronics Engineers USA website http://www.ieee.org/
American Institute of Physics USA website http://www.iop.org/
American Chemical Society USA website http://www.acs.org/
NASA USA website http://www.nasa.gov/
NIST USA website http://www.nist.gov/
Sensors Technology India website http://www.sensorstechnology.com/

Electronics manufactures websites

LED and Light Sensors http://www.lumex.com/
ADC IC manufacturer http://www.ti.com/
Amplifier IC manufacturer http://maxim-ic.com/
Temperature sensor IC manufacturer http://www.national.com/
Industrial sensor manufacturer http://www.banner.com/
Radio frequency communication chip manufacturers http://www.radiometrix.com/