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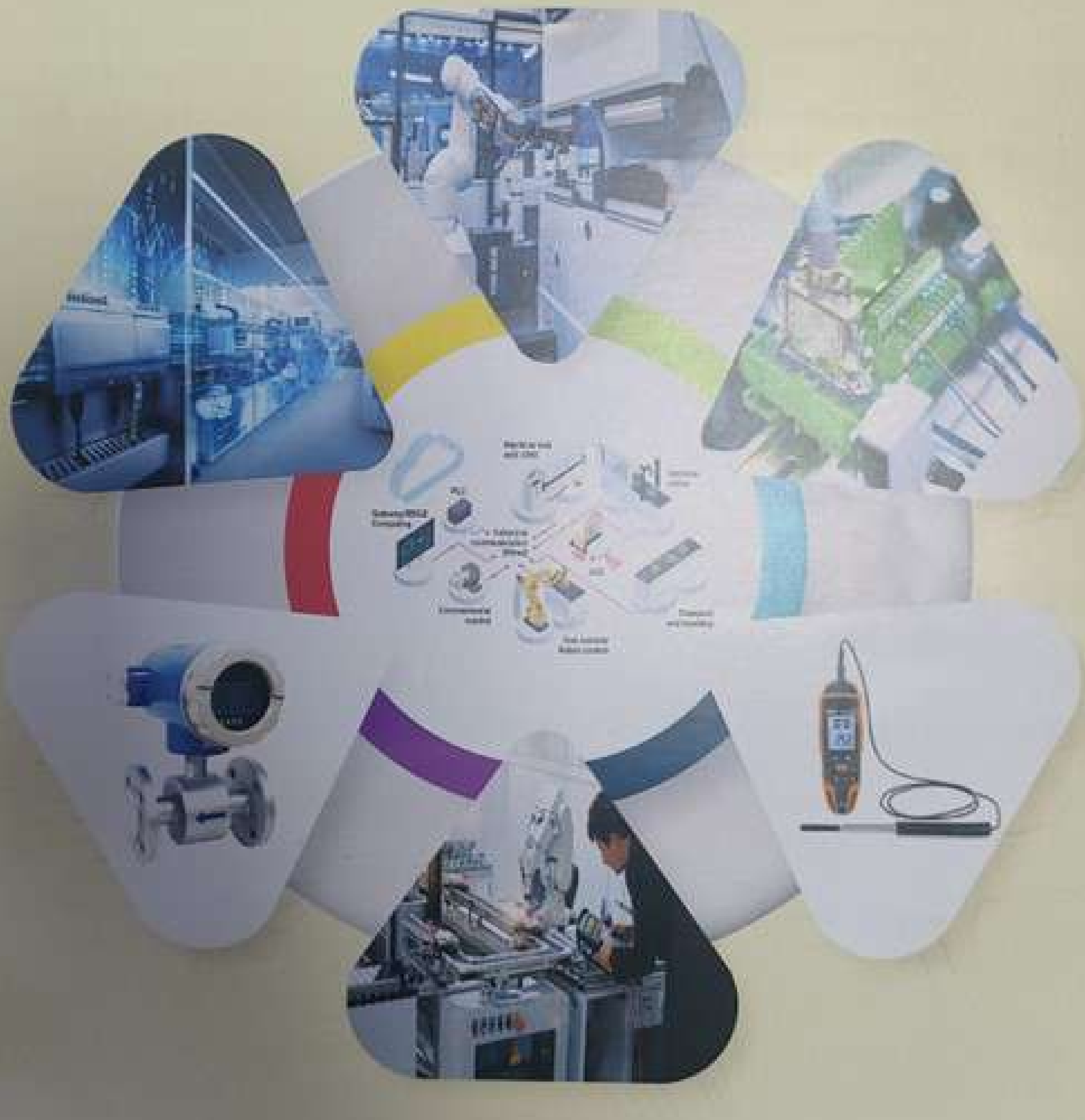
ICA-TECH



Department of

Electronics & Instrumentation Engineering

Instrumentation, Control & Automation **ICA-TECH**

Technical Magazine

Department of Electronics & Instrumentation Engineering

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STATES OF MATTER

N Naga Pranathi, III- EIE

We all are familiar with three states of matter. Solid, Liquid, Gas. But now, Do you know how many more states invented? Presently there are seven states of matter

1.Solid

2.Liquid

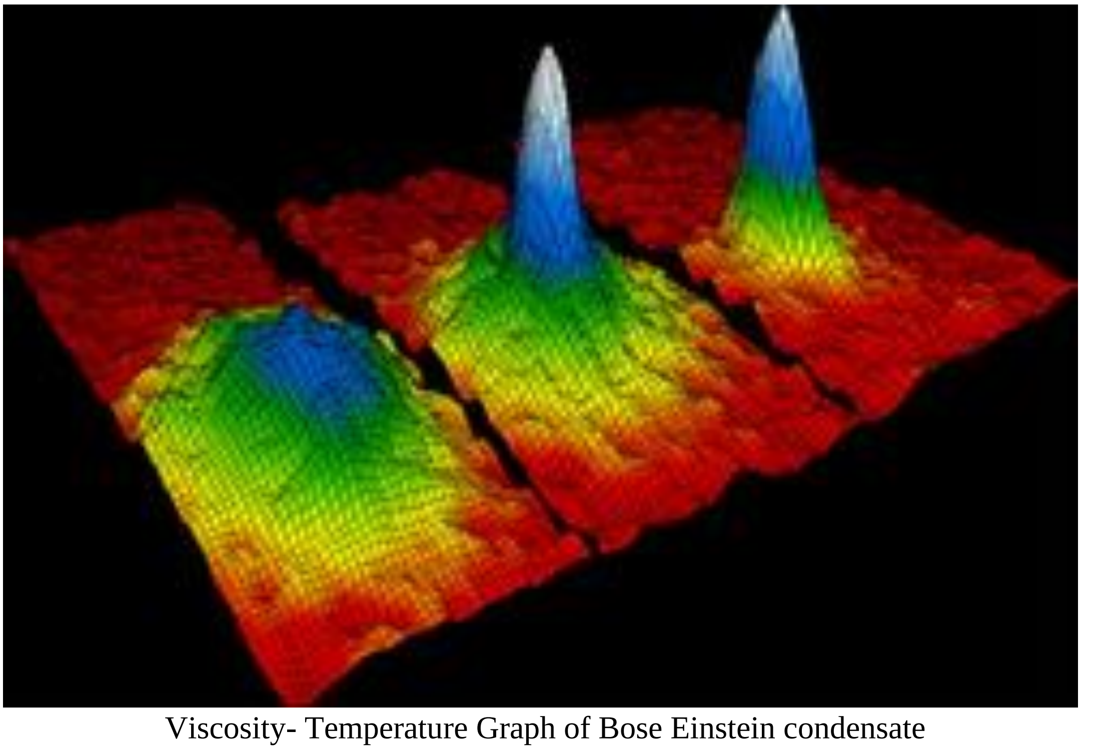
3.Gas

4.Plasma

5.Bose-Einstein Condensate

6.Fermionic Condensate

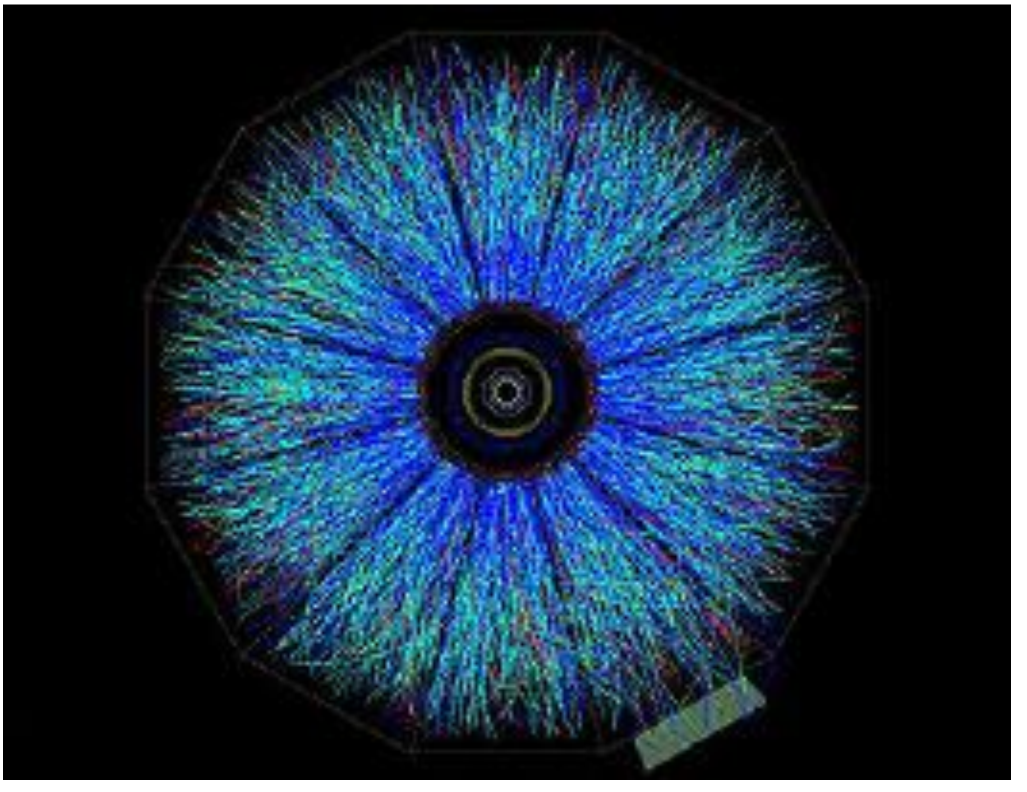
7.Quark-Gluon Plasma



Viscosity- Temperature Graph of Bose Einstein condensate

Most of us are familiar with the first 4 states of matter the remaining three are new in the group. It was first suggested by Sathendra Nath Bose &Albert Einstein. It is the state at which Bosons (they are subatomic particles having Integer spin) arrange together at same energy level (Quantum level) and this state of matter is called Bose- Einstein Condensate. Super fluidity and Super conductivity are the key features of these states of matter. Super fluidity means the fluid id free from gravity and viscosity. So it is not possible to keep the fluid in an open bottle as it free from gravity the matter will overflow by itself. Super conductivity is the property due to which the Bose-Einstein Condensate can conduct without any heat lose. This state of matter exists at very low temperature(4k).

Fermionic Condensate is somewhat similar to the Bose-Einstein Condensate but these state is formed by Fermions (Sub atomic particle having Fractional spin) eg:-Electron, Proton etc...Even though two electrons spinning in opposite direction, At very low temperature these form a cooper pair. In a sense they behave as it have the same energy level. Fermionic Condensate also have super fluidity, super conductivity. The seventh state of matter is Quark-Gluon Plasma. The concept was relatively new invented in 2001.Scientists still trying to make this concept a real one. The 5th and 6th states exists at very low temperature but the seventh state exist at extremely high temperature (4 Trillion degree celcious). Matter is formed by atoms and it is the subatomic particles that combines to form atoms Quarks are the basic material which combines to form electrons & protons etc. So, at high temperature the subatomic particles splits to form Quarks and this state is called Quark-Gluon Plasma



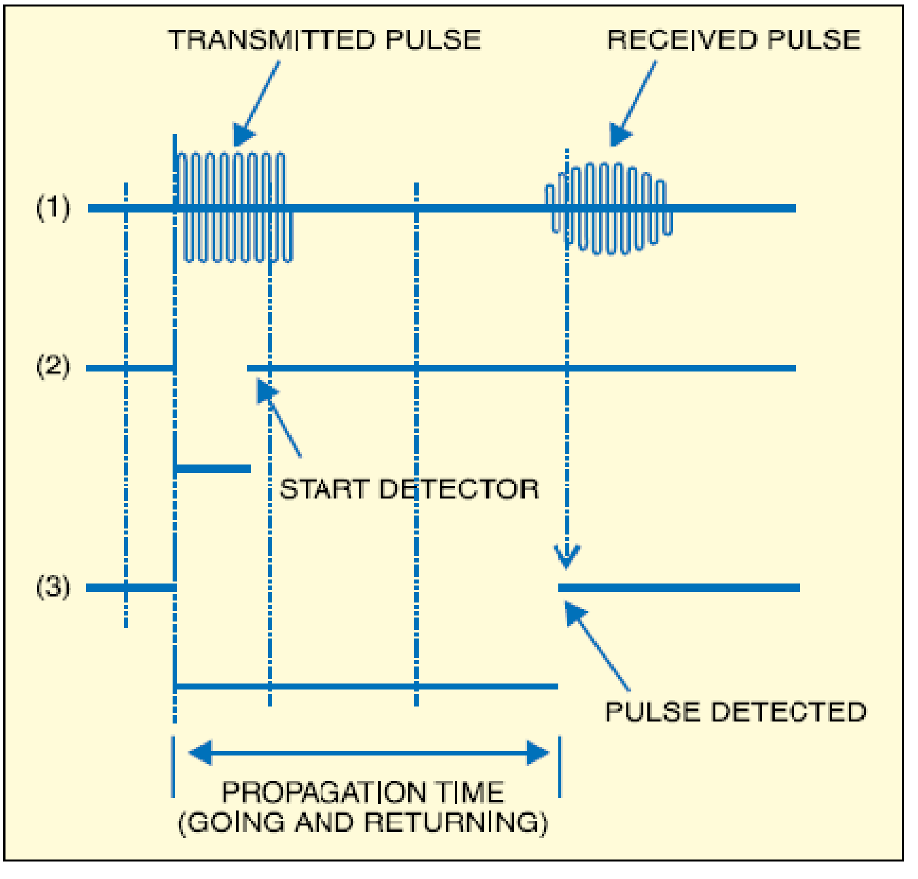
Ultrasonic Range Meter

A S Aiswarya Vallika, III-EIE

There are several ways to measure distance without contact. One way is to use ultrasonic waves at 40 kHz (for distance measurements). An ultrasonic range meter is used to measure the distance to targets from its set point in many areas like factories.

The working principle of the ultrasonic range meter is that it measures the amount of time taken for sound to travel to a particular surface and return as the reflected echo (velocity of ultrasonic wave is 343.2m/s).

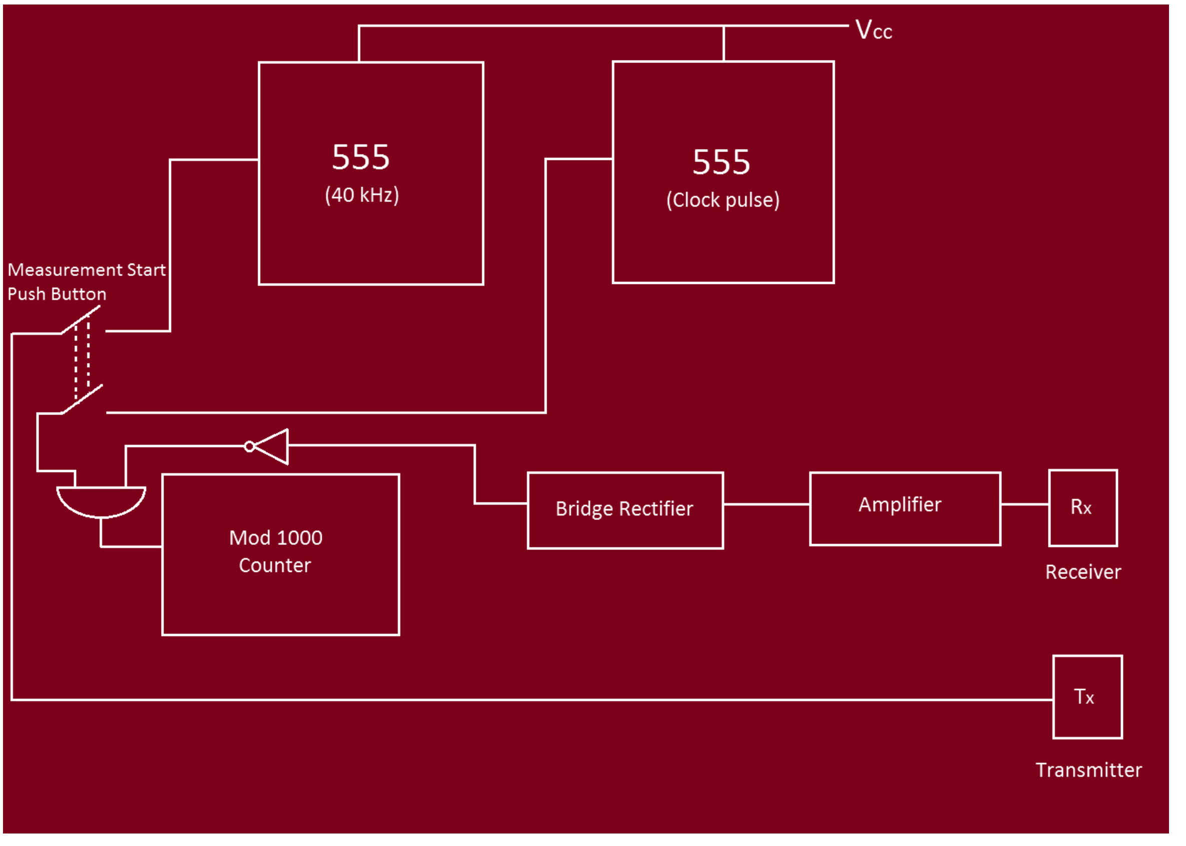
Ultrasonic range meter has following components two ultrasonic transducers (one transmitter & one receiver), two oscillators, one mod 1000 counter, one amplifier, one bridge rectifier, one AND gate, one NOT gate.



The ultrasonic pulse, echo signal and time measurement

Block Diagram of Ultrasonic range meter

Construction



We use an astable 555 IC as oscillator to generate 40 kHz square wave for transmission and another astable 555 IC to generate high frequency clock pulses for counting. The frequency of clock pulse is variable.

If we need a resolution of 1 metre the time period of clock pulse. Time Period, T = 1/343.2 = 2.9*10-3 seconds If we need a resolution of 1 centimetre the time period of clock pulse. Time Period, T = 1/34320 = 29*10-6 seconds

Therefore, the frequency of the clock pulse is set according to the distance to be measured. The receiver output will be in mili voltage hence should be amplified. A dc voltage is necessary to pulse the counter, hence we need a bridge rectifier. I

t is connected to an AND gate through the NOT gate. Working When we switch ON the circuit, both the counting and transmission begins. A 40 kHz oscillator based on 555 IC is activated as well as the oscillator for the clock pulse is also activated.

The signal will get transmitted. And the reflected echo from the target is received by the receiver. This is given to an amplifier of gain 100 for amplification. Bridge rectifier will convert it into rectangle pulse with time period that will last until the measurement start push button is depressed which is given to NOT gate followed by an AND gate.

The second input to AND gate is connected from the clock pulse. When the receiver is in state ‘1’, clock pulse will stop and thus the counting also stops. From this the count corresponding to the time difference can be calculated. Thus we can calculate the distance.

TIME BASED SPEED MANAGEMENT SYSTEM USING MSP430

K Sabarish, III-EIE

I. INTRODUCTION

We are fortunate to witness and enjoy the privileges provided by the computer era and the ever-developing technology around us. It is for us to use this technology for optimal and efficient utilisation of the resources available in the nature. A system is being presented here with this objective.

This system is intended to be used in trains, particularly in India, where considerable delays in train timings are quite usual. The speed of the train is being managed automatically in the proposed system. Distance to be travelled and the scheduled time of travel are entered at the start of travel, and the system automatically controls the speed in the course of travel, by considering the remaining distance and time at each instant.

This procedure is implemented using a microcontroller, distance monitoring system and suitable interface. The system can be interfaced with a PC at any time and can be tuned according to the user's requirements. Real-time display of the distance and time remaining to reach the destination are helpful information to the passengers of the train. Though it is explained for the case of the 'process' of running a train, this system can be modified to suit any industrial process.

SYSTEM MODEL

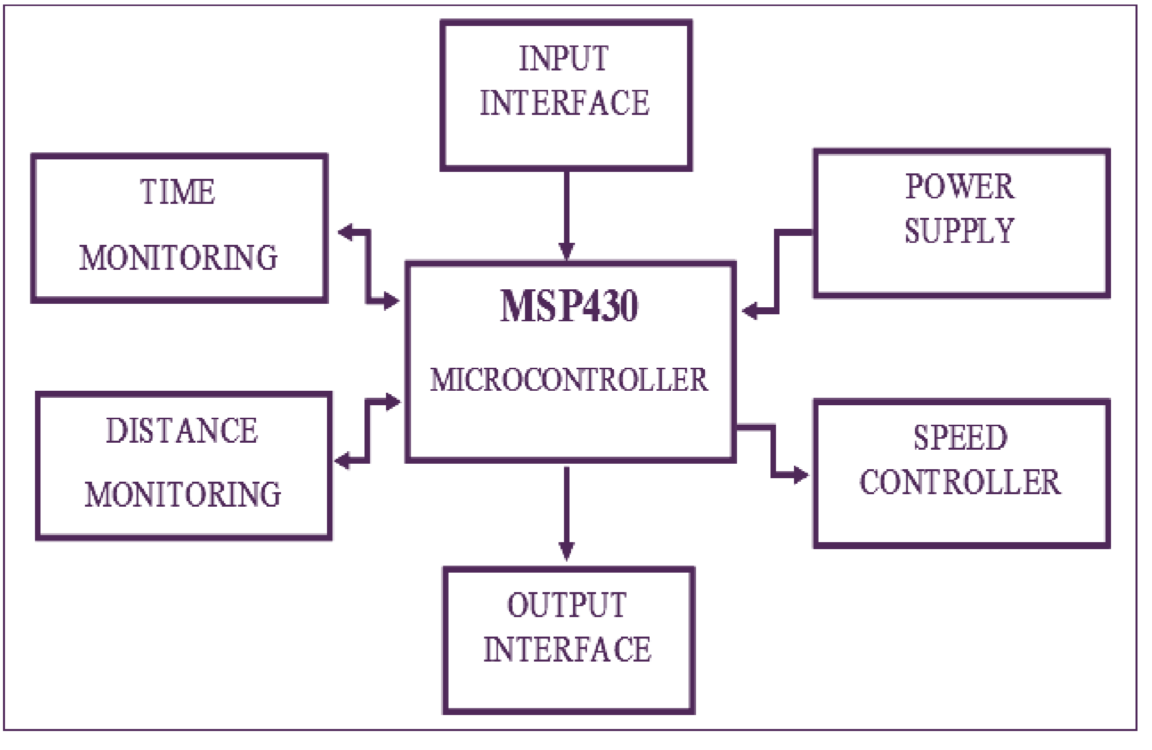


Fig. 1: System Model

The input interface is used to enter the time and used in trains, particularly in India, where considerable delays in train timings are quite usual. The speed of the train is being managed automatically in the proposed system. Distance to be travelled and the scheduled time of travel are entered at the start of travel, and the system automatically controls the speed in the course of travel, by considering the remaining distance and time at each instant.

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Separate batteries are used to power the microcontroller and the other peripherals. The output interface with the user is implemented using seven segment LED displays. The microcontroller is programmed to do the time monitoring. This is implemented by using a countdown timer that counts time from the value of time entered at start of travel.

The distance covered is monitored by counting number of rotations of a wheel of the vehicle using a suitable sensor. The distance and time generated at each instant is used by the microcontroller to calculate the required speed of the vehicle and a corresponding PWM signal is sent to the motor.

SUBSYSTEMS

There are four major subsystems in addition to the microcontroller. These are listed below.

- time monitoring system
- distance monitoring system
- speed controller
- input/output user interface

Time Monitoring System

Monitoring the time remaining for travel is central to the process. The microcontroller keeps decrementing the time field entered each second and when time goes to zero, the vehicle is made to stop.

Distance Monitoring System

An IR Tx-Rx pair is installed near a wheel of the vehicle, which gives one pulse for each rotation. Circumference of the wheel multiplied by the pulse count gives the distance covered.

Input/Output User Interface

Time and distance are given as input to the system through the keypad interface. The inputs are displayed using four numbers of seven-segment LED displays.

Speed Controlling System

Speed of motor is controlled by using PWM signal. Each instant, the velocity required is calculated and the corresponding PWM signal is sent to the motor.

MSP430 is a 16-bit microcontroller family from Texas Instruments. MSP is the acronym for 'Mixed Signal Processor', and '430' is a part number that has a curious origin. The legend is that 4/30 or April 30 is the date on which this microcontroller was first released. MSP430 is a 16-bit microcontroller at the price of an 8-bit processor.

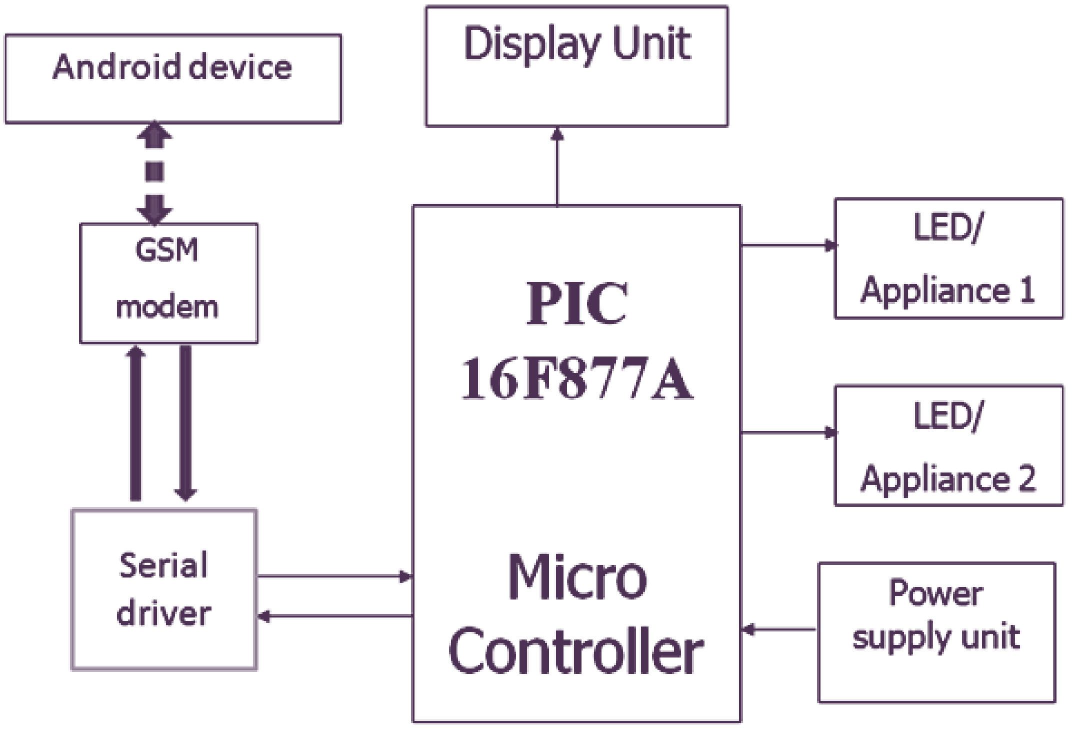
SMART HOME MANAGEMENT

D Teja Priyanka, II-EIE

Technology keeps advancing every day. Electronics finds applications in every minute of our life (or, is it every second!). We just include one more to the list of applications at your service. We are all too busy these days, and we don't find it too grave a mistake to forget switching off a device at home. You could be forgiven if your mistake causes only a hike in your electricity bill. What, if it leads to a calamity? Will it not be nice to have a handy device with you using which you can switch off a device at home? We have attempted something like that.

We use a microcontroller-based control module that receives its instructions and command from a cellular phone over the GSM network. The microcontroller then will then issue commands to do the required ON/OFF function, and then report the action back to the phone.

BLOCK DIAGRAM



IMPLEMENTATION AND CIRCUIT TESTING

An ANDROID Application for user interfacing was implemented to send SMS. LCD display and LEDs are used for demonstration. The PIC (16F877A) is coded to respond to a received message and to send a feedback SMS when the commanded function is done.

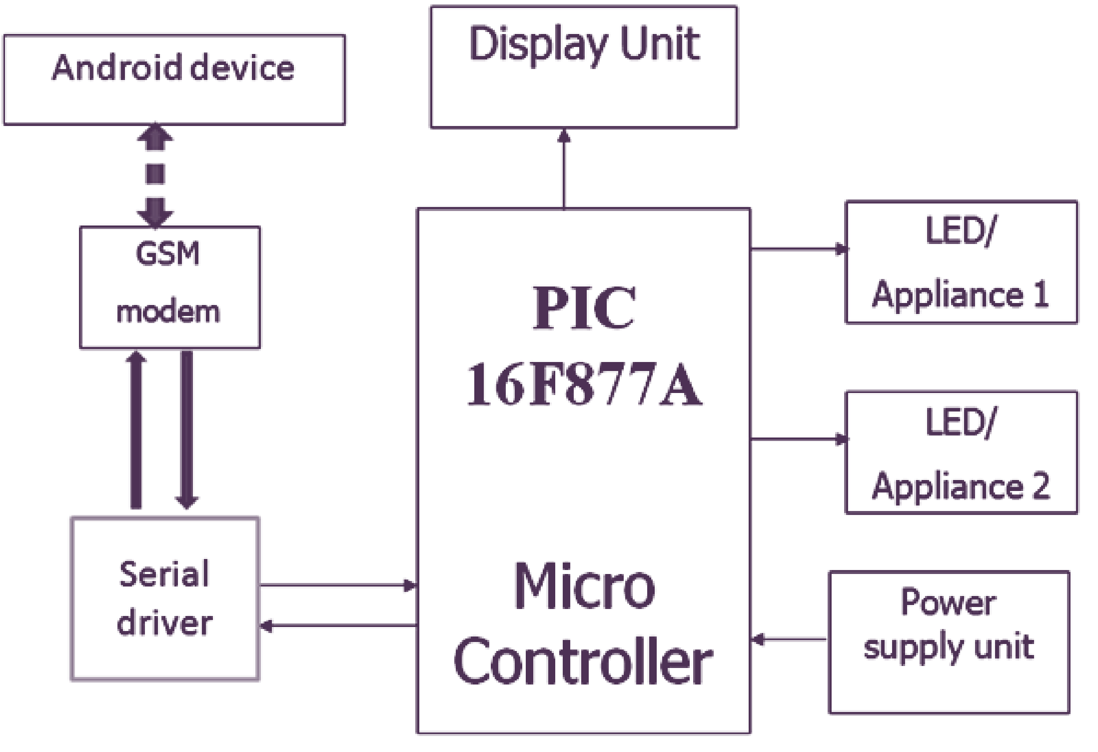
The circuit is tested by sending message to switch on an LED. GSM modem is connected to the circuit via RS232 cable. When the device is switched on the LCD displays “SYSTEM ON” and the PIC16F877A performs its basic functions to establish connection with GSM by sending AT (attention) commands by program. After the connection is established the LCD displays “GSM CONNECTED” and the user can send the SMS.

Android Application is used for sending SMS to the GSM for switching the appliance (LED for testing) ON or OFF. When the SMS is sent from the Android device, it is received at the GSM module and the

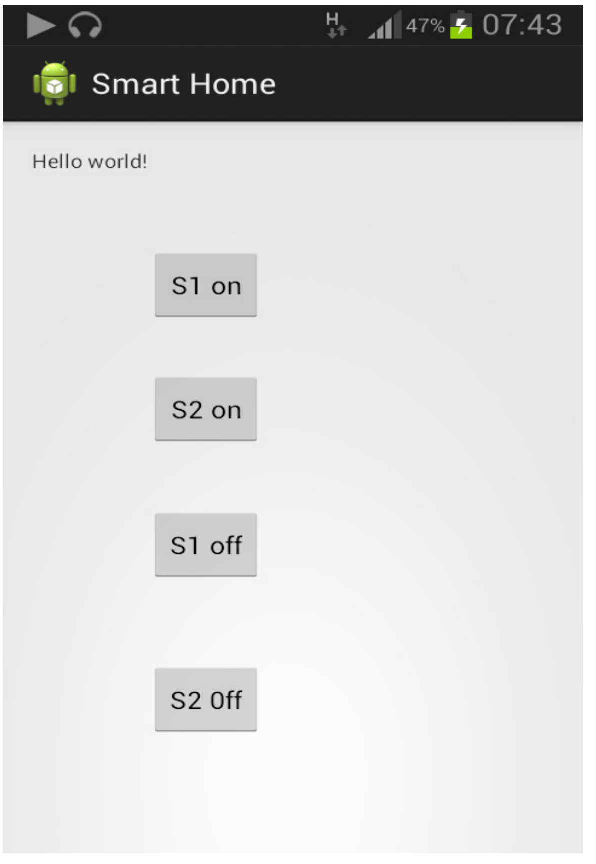
LCD displays "interrupt", and appliance (LED) gets switched ON/OFF. The system sends a feedback SMS to the user indicating that the particular appliance has been switched ON/OFF.

ANDROID INTERFACING

The software, Eclipse is used to develop the android application. Knowledge of basics of Java is required to develop the application. The Logic of implementation is simple. Four different messages should be sent from the android device, when two appliances are to be switched ON or OFF. One button is selected for each message. The code is developed such that:



•When Button S1 on is pressed an SMS with text "1" is sent to the SIM300 module.
•When Button S1 off is pressed an SMS with text "2" is sent to the SIM300 module.
•When Button S2 on is pressed an SMS with text "3" is sent to the SIM300 module.
•When Button S2 off is pressed an SMS with text "4" is sent to the SIM300 module.
The microcontroller is programmed in such a way that when texts like 1,2,3,4 are received the following happens:
•Upon reception of text message "1", appliance1 (LED1 for test) turns ON.
•Upon reception of text message "2", appliance 1 (LED1) turns OFF.
•Upon reception of text message "3", appliance 2 (LED2) turns ON.
•Upon reception of text message "4", appliance 2 (LED2) turns OFF.


47% 07:43
Smart Home
Hello world!
S1 on
S2 on
S1 off
S2 Off

Electro adhesive Gripper

P Akhil Sai, II-EIE

Traditionally, robots have had a hard time gripping objects because there are few good universal grippers. Most objects are very different from each other, with different textures, sizes, and physical properties. Stanford Research Institute (SRI) has come out with an excellent solution for this. The new technology is available for license. It allows electrically controlled reversible adhesion to most surfaces. It is called electro adhesion.

Using electro adhesion, grippers may be designed to pick up many more objects than previous robot grippers could. The grippers can even be used to give robots traction to climb up brick walls, glass windows, and a variety of other normally difficult surfaces.

By inducing charges on the surfaces, the electro adhesive gripper makes robotic hands ‘sticky’. Because this gripper uses electricity to run, it is more convenient for robot builders to use; there is no need for pneumatic vacuum pumps like many other universal grippers require.

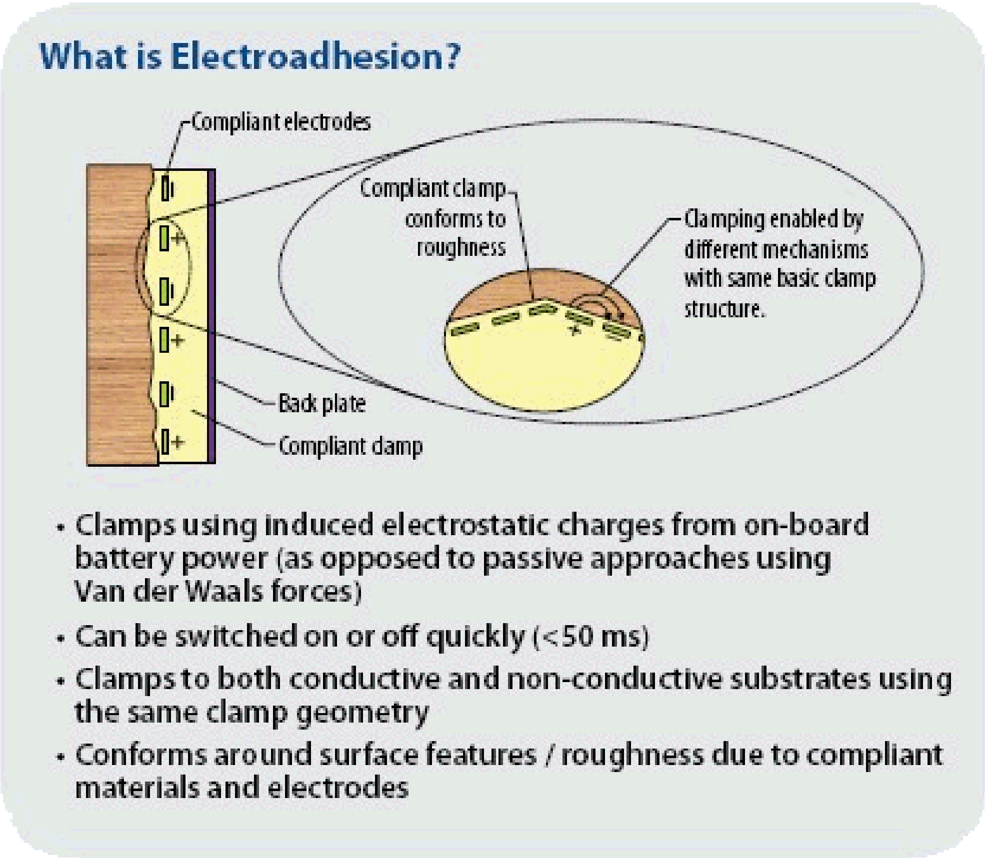
Electro adhesion is an electrically controllable adhesion technology. It involves inducing electrostatic charges on a wall substrate using a power supply connected to compliant pads situated on the robotic hand. SRI has demonstrated robust clamping to common building materials including glass, wood, metal, and concrete with clamping pressures in the range of 0.5 to 1.5 N per square cm of clamp.

The technology works on conductive and non-conductive substrates, smooth or rough materials, and through dust and debris. Unlike conventional adhesives or dry adhesives, the electro adhesion can be modulated or turned off for mobility or cleaning.

The technology uses a very small amount of power (on the order of 20 microwatts/Newton weight held) and shows the ability to repeatedly clamp to wall substrates that are heavily covered with dust or other debris.

Not for robotics alone!

What is Electroadhesion



adhesion can address a wide range of industrial, biomedical, military and consumer needs. Electro adhesion uses electrostatic forces between the substrate material (e.g., wall surface) and the electro adhesive surface.

Electro adhesive pads comprise of electrodes that are deposited on the surface of a polymer. When alternate positive and negative charges are induced on adjacent electrodes, the electric field sets up opposite charges on the substrate and thus causes electrostatic adhesion between the electrodes and the induced charges on the substrate.

The principle of operation is similar to electrostatic chucks used to hold silicon wafers or other specialized grippers for robotic handling of materials. The high compliance of the clamp is key to being able to adhere to a wide range of substrates. The technology also provides reversible adhesion to a number of surfaces with extremely low steady-state power consumption.

Blue Brain: A brain in a supercomputer

A Snehaja, III-EIE

The Blue Brain Project is an attempt to reverse engineer the human brain and recreate it at the cellular level inside a computer simulation. The project was founded in May 2005 by Henry Markram at the EPFL in Lausanne, Switzerland.

The goals of the project are to gain a complete understanding of the brain and to enable development of better and faster methods for treatment of brain diseases. The research involves studying slices of living brain tissues using microscopes and patch clamp electrodes.

Data is collected about all the many different neuron types. This data is used to build biologically realistic models of neurons and networks of neurons in the cerebral cortex. Simulations are carried out on a Blue Gene supercomputer built by IBM, hence the name "Blue Brain". The simulation software works around NEURON, together with other custom-built components. There are three main steps to building the virtual brain namely data acquisition, simulation and visualization of results.

Data acquisition involves taking brain slices, placing them under a microscope, and measuring the shape and electrical activity of individual neurons. This is how the different types of neurons are studied and catalogued. The neurons are typed by morphology (i.e. their shape), electro physiological behaviour, location within the cortex, and their population density.

These observations are translated into mathematical algorithms which describe the form, function and positioning of neurons. The algorithms are then used to generate biologically realistic virtual neurons ready for simulation.
The simulation step involves synthesizing virtual cells using the algorithms that were found to describe real neurons. The algorithms and parameters are adjusted for the age, species, and disease stage of the animal being simulated. Every single protein is simulated, and there are about a billion of these in one cell.

First a network skeleton is built from all the different kinds of synthesized neurons. Then the cells are connected together according to the rules that have been found experimentally. Finally, the neurons are functionalized and the simulation brought to life. The patterns of emergent behaviour are viewed with visualization software.

Progress

In November 2007, the project reported the end of the first phase, delivering a data driven process for creating, validating, and researching the neocortical column. The first artificial cellular neocortical column of 10000 cells was built by 2008. By July 2011 a cellular mesocircuit of 100 neocortical columns with a million cells in total was built. A cellular rat brain is planned for 2014 with 100 mesocircuits totalling a hundred million cells. Finally, a cellular human brain, equivalent to 1000 rat brains with a total of a hundred billion cells is predicted possible by 2023.

Applications of Blue Brain

• Gathering and Testing 100 years of data
• Cracking the neural code
• Understanding neocortical information processing
• A novel tool for drug discovery for brain disorders
• A foundation for whole brain simulations
• A foundation for molecular modeling of brain function

Advantages

• Remembering things with minimal effort.
• Taking decisions without the presence of a person.
• Using a person's intelligence even after his/her death.
• It would allow the deaf to hear via direct nerve stimulation.
• Contents of the brain saved in the computer can be used to treat mental illness.

Of course, there are objections raised, mainly by sociologists and religious quarters, against this research. That is quite normal. It has been so with many advanced biological research projects.

Ref: http://www.neuron.yale.edu/neuron/what_ is_neuron

Design of OpenCL Framework for Embedded Multi-core Processors

P Venkata Sushma, III-EIE

In modern mobile embedded systems, various energy-efficient hardware acceleration units are employed in addition to a multi-core CPU. Typically, mobile devices are equipped with a multi-core central processing unit (CPU), a multi-core graphics processing unit (GPU), digital signal processors (DSPs), image signal processors (ISPs) and video decoders. Since these processors have distinct hardware structures and instruction sets, compilers should generate the corresponding target binary codes to utilize them.

Once a certain binary code for a particular target is generated, the binary code can be executed only by the specific target device. Thus, it is not easy to fully utilize the various computing resources at runtime. Therefore, it is desirable to have a flexible and dynamically redistributable computing environment. By having such an environment, dynamic job assignment and load balancing become feasible, and better real-time responsiveness and reduction in the power consumption can be achieved.

Open Computing Language (OpenCL) was proposed to provide a framework that supports heterogeneous computing platforms. It is necessary to ensure that such an OpenCL framework can automatically generate binary codes for various computing devices. By using this framework, heterogeneous computing platforms can be utilized by a program written in one language, which is the key advantage of OpenCL.

OpenCL includes programming languages and application programming interfaces (APIs). OpenCL C is the programming language to write a parallel function code called the OpenCL kernel. When the kernel is compiled dynamically, it can be executed on various heterogeneous devices.

As the number of applications running simultaneously on an embedded device increase, the characteristics of the workload vary significantly. Therefore, it is highly desirable to have a flexible OpenCL framework that can redistribute workloads during runtime to fully utilize the available computing resources.

The compilation environment for both the host program and OpenCL kernels has been developed, to implement OpenCL framework. OpenCL libraries have also been implemented. OpenCL framework generates binary codes for a multi-core CPU by compiling the host program and kernel programs written in the OpenCL C language. The host program is the main program that is executed by the host, and the OpenCL kernel is a program that runs on an embedded multi-core processor.

Hence, both the compiler for the host program and the compiler for OpenCL kernels were implemented. Also, OpenCL libraries, which include built-in functions called the OpenCL kernel and OpenCL runtime, which are called by the host program, were implemented. In OpenCL framework, the platform, execution and memory models for the target CPU are properly defined in order to compose the execution environment that conforms to the OpenCL specification.

In the OpenCL specification, processors are called compute devices. An OpenCL compute device has one or more compute units (CUs), which are divided into one or more processing elements (PEs). The computation is carried out in a PE, and the different PEs can be executed in parallel. A kernel is built by the host program and is downloaded to a compute device.

The index space for OpenCL kernels is called 'NDRange', which stands for N-Dimensional Range. When the host program schedules a kernel execution, the index space gets defined. An instance of kernel executions is called a work-item, and work-items are grouped into a work-group. A work-item is executed by a PE at a point in the index space. The total number of work-items in the entire index space is called the global size.

Even though all work-items execute the same code, the data to be processed may be assigned differently for each work-item by changing the unique ID within a workgroup. This unique ID is called the global ID. Each work-item can access to distinct memory regions: global memory, constant memory, local memory and private memory. Global memory is a memory region which permits read and write accesses to all work-items in all workgroups. Constant memory is a global memory region for constants. Local memory is a memory region which is local to a workgroup. Local memory can be used to allocate objects which are shared by work-items in one workgroup. Private memory is a memory region which is private to a work-item, and this memory region is inaccessible to other work-items.

To execute the host program and a kernel program on an embedded multi-core processor, the binary codes should be generated by both the host program compiler and the kernel program compiler. The host program may be written in C, C++, or Java, and it describes the overall operation scenario of an application program.

The OpenCL kernel is a computationally intensive code that is executed on a compute device, and it is written in the OpenCL C language. The OpenCL kernel is a computationally intensive code that is executed on a compute device, and it is written in the OpenCL C language.

In OpenCL framework, the compilation environment is composed of a Linux-based mobile operating system (OS), the software development kit (SDK) and native development kit (NDK) for mobile platform, and LLVM. The proposed framework will be very useful in fully utilizing heterogeneous platforms, which is the original motivation of the OpenCL programming framework.

Cadence OrCAD PCB Design Suite16.6 - A Simple method for linear circuit analysis

J Priyanka, I-EIE

SPICE (Simulation Program for Integrated Circuits Emphasis) is a powerful general-purpose analog and mixed-mode circuit simulator that offers a total solution for code design tasks. It is used to verify circuit designs and to predict the circuit behaviour.

SPICE was originally developed at the Electronics Research Laboratory of the University of California, Berkeley (1975). PSpice is a PC version of SPICE. It is currently available from OrCAD Corp. of Cadence Design Systems, Inc.

PSpice overview

Once a design for simulation is prepared, OrCAD Capture generates a circuit file set. The circuit file set, containing the circuit net list and analysis commands, is read by PSpice for simulation. PSpice formulates these into meaningful graphical plots, which you can mark for display directly from your schematic page using markers.

What is PSpice?

OrCAD PSpice is a simulation program that models the behavior of a circuit containing analog devices. Used with OrCAD Capture for design entry, we can think of PSpice as a software-based breadboard of our circuit that we can use to test and refine our design before ever touching a piece of hardware.

Analyses that can run with PSpice

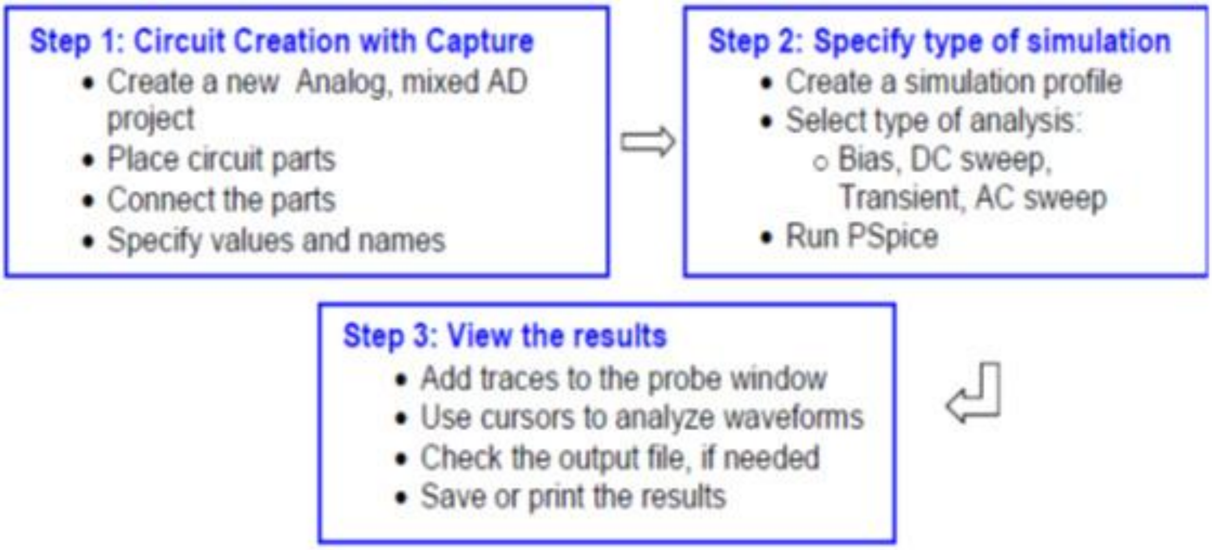
- Non-linear DC analysis: calculates the DC transfer curve.
- Non-linear transient: calculates the voltage and current as a function of time when a large signal is applied.
- Fourier analysis: Fourier analysis gives the frequency spectrum.
- Linear AC Analysis: calculates the output as a function of frequency. Then generates a bode plot.
- Also, Noise analysis, Parametric analysis and Monte Carlo Analysis can be carried out

In addition, PSpice has analog and digital libraries of standard components (such as NAND, NOR, flip-flops, MUXes, FPGA, PLDs and many more digital components,). This makes it a useful tool for a wide range of analog and digital applications.

Cadence OrCAD PCB Design Suite16.6

Capture is a user-friendly program that allows you to capture the schematic of the circuits and to specify the type of simulation. Capture is not only intended to generate the input for PSpice but also for PCB layout design programs.

The following figure summarizes the different steps involved in simulating a circuit with Capture and PSpice.


Step 1: Circuit Creation with Capture
• Create a new Analog, mixed AD project
• Place circuit parts
• Connect the parts
• Specify values and names
Step 2: Specify type of simulation
• Create a simulation profile
• Select type of analysis:
o Bias, DC sweep, Transient, AC sweep
• Run PSpice
Step 3: View the results
• Add traces to the probe window
• Use cursors to analyze waveforms
• Check the output file, if needed
• Save or print the results

Safety Instrumented Systems (SIS)

M Parthive, II-EIE

The operation of many industrial processes involves inherent risks due to the presence of dangerous materials like gases. SIS are specifically designed to protect personnel, equipment, and the environment by reducing the likelihood (frequency) or the impact severity of an identified emergency event.

Explosions and fires account for millions of dollars of loss in the chemical, and oil and gas industries each year. Since a great chance for loss exists, it is common to employ Safety instrumented systems (SIS) to provide safe isolation of flammable or potentially toxic materials in the event of a fire or accidental release of fluids. Safety levels can be arranged as layers described below.

The first layer is the Basic process control system (BPCS). The control system itself provides significant safety through proper design of process control. The next layer of protection is also provided by the control system and the system operators.

Automated shutdown sequences in the process control system combined with operator intervention to shut down the process form the next layer of safety. The third layer is SIS. It is a safety system independent of the process control system.

It has separate sensors, valves and logic systems. No process control is performed in this system; its only role is safety. The fourth layer is an active protection layer. This layer has valves or rupture disks designed to provide a relief point that prevents a rupture, large spill or other uncontrolled release that can cause an explosion or fire. The fifth layer is a passive protection layer.

It consists of a dike or passive barrier that serves to contain a fire or channel the energy of an explosion in a direction that minimizes the spread of damage.

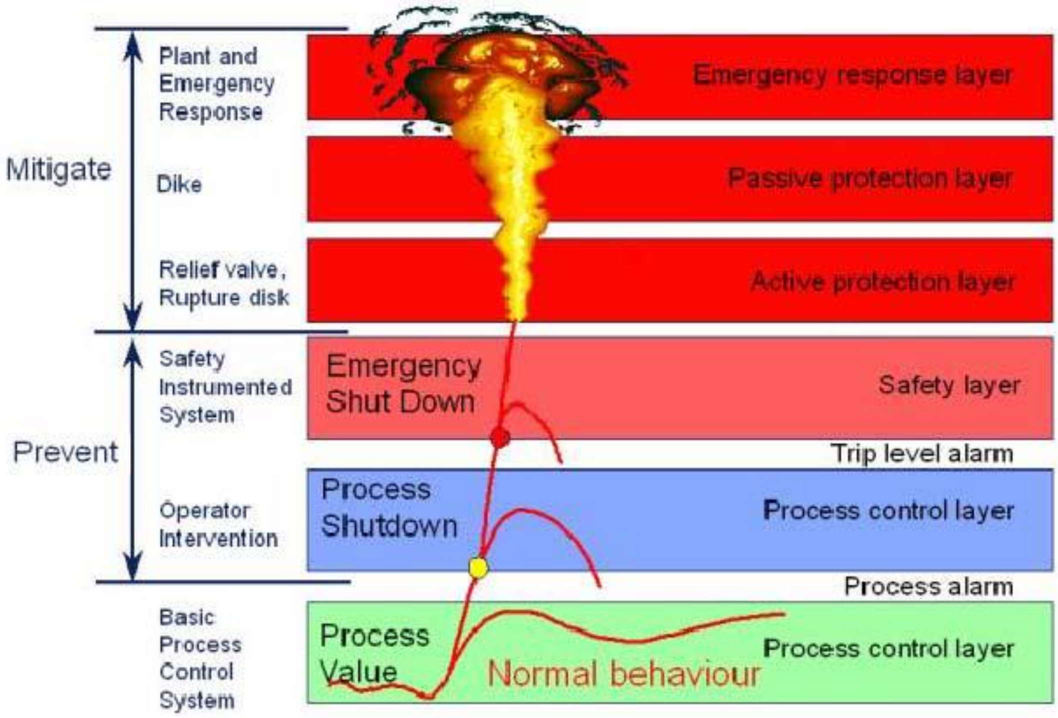
The final layer is plant and emergency response. If a large safety event occurs, this layer responds in a way that minimizes ongoing damage, injury or loss of life. It may include evacuation plans, fire fighting, etc. Overall safety is determined by how these layers work together.

The elements involved in safety instrumented system are:

A sensor, a logic solver and a final control element. The purpose of sensors is to help measurement of process parameters (e.g. temperature, pressure, flow, etc.) used to determine if the equipment or process is in a safe state. Sensor types range from simple pneumatic or electrical switches to smart transmitters with on-board diagnostics.
These sensors are dedicated to the SIS. Logic solver determines what action is to be taken based on the information gathered. Highly reliable logic solvers are used which provide both fail-safe and fault-tolerant operations.

It is typically a controller that reads signals from the sensors and executes pre-programmed actions to prevent a hazard by providing output to final control elements. Final Control Element implements the action decided by the logic system.

This final control element is typically a pneumatically actuated on-off system configured using solenoid valves. It is essential that all three elements of the SIS system function as designed in order to safely isolate the process plant in the event of an emergency.



Probability of Failure upon Demand (PFD)

There are two ways by which SIS could fail.
1) Commonly called a spurious trip which usually results in an unplanned but safe process shutdown. While there is no danger associated with this type of failure, the operational costs can be very high.

2) Here failure does not cause a process shutdown or trip, it remains undetected, and permits continued process operation in an unsafe or dangerous manner. If an emergency demand occurred, the SIS would be unable to respond properly.

These failures are known as covert or hidden failures. By understanding how components of SIS can fail, it is possible to calculate a probability of failure on demand (PFD).
In order to determine the PFD of each element, the analyst needs documented historic failure rate data for each element.
This failure rate is used in conjunction with the test interval (TI) term to calculate the PFD. It is the TI that accounts for the length of time before a hidden fault is discovered through testing. Increase in TI directly helps to improve chance of identification of potential failures.

Improving PID Controller Performance

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Proportional integral derivative (PID) control is the most commonly used control algorithm in the industry today. PID controller popularity can be attributed to the controller's effectiveness in a wide range of operation conditions, its functional simplicity, and the ease with which engineers can implement it using current computer technology.

PID controllers have some drawbacks that limit their effectiveness. They work best with systems that have only one input and output (single input, single output # SISO). With these systems, we have only one variable to control and only one actuation to apply. We also can control systems that have more inputs/outputs with PID controllers if we apply decoupling techniques to the different variables so the final overall control involves a number of SISO PID controllers.

This technique is not easily implementable because it depends heavily on how tight the correlation between the variables is. Quite a good amount of interest is there among researchers to model, design and implement new approaches to multivariable PID controllers.

[Ref: 1. Uduehi, D. et. al., Multivariable PID controller design using online generalised predictive control optimisation, Proceedings of the 2002 International Conference on Control Applications ; 2. Garcia, D, et. al., PID Controller Design for Multivariable Systems Using Gershgorin Bands, infoscience@epfl.ch.]

Another challenge for PID controllers (and for every control algorithm) is that the plant we need to control might not behave in a linear fashion. In other words, the output for a given input does not exhibit a linear response.

Some examples of nonlinearity are dead zones, saturation and hysteresis. Another challenge is that plant dynamics might also change over time. This can happen due to changes on the plant loads, normal wear and tear, or mechanical effectiveness in mechanical elements. To compensate for plant behaviour changing over time, we need expert users to recalibrate our PID gains, which drive up costs for both labour and downtime.

Lastly, when tuning PID controllers, we won't achieve optimal overall system performance because stability is a concern, and tuning for better performance might lead to losing control over the system.

There are several techniques to improve system performance and PID behaviour. A few of these are briefly discussed below.

1. Increased Loop Rate

With current technology, we can run PID loops up to 20 kHz using NI Compact Field Point controllers, 40 kHz with NI PXI technology, and up to 1 MHz with NI Compact RIO hardware when using PID functions based on field programmable gate arrays (FPGAs).

2. Gain Scheduling

To help cope with a system that exhibits high nonlinear behaviour, we can schedule the gain in different ranges differently to take care of the nonlinearity. One drawback with this technique is that PID gain tuning is required for the different operating ranges. Also, range transition might lead to instabilities if the PID controller is not designed to make smooth transitions.

3. Adaptive PID

We can use another advanced variant of PID controllers that involves gain change based on the dynamics of the system. While gain scheduling works only with the plant output to define the operating range, adaptive PID considers both inputs and outputs to fix the gains.

4. Analytical PID

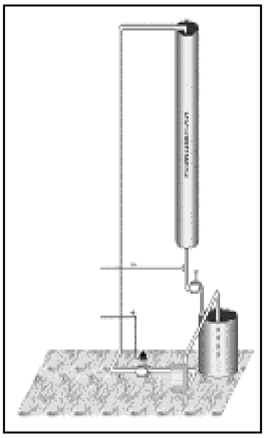
One of the difficulties being faced with PID controllers is with regard to gain tuning. Even with the implementation of auto tuning algorithms, service of an experienced operator cannot be totally eliminated, to ensure that the system remains stable through fine-tuning the controllers.

By using Analytical PID functionality, we can design PID gains. With the Analytical PID libraries included in the Lab VIEW Control Design and Simulation Module, we have the tools to find sets of PID gain values automatically for a given user model, which ensures system closed-loop stability. We can also input minimum gain and phase margin values to specify the optional performance constraints on the PID controller.

5. Optimal Controllers

Linear quadratic controllers are designed for optimal performance on the system based on design specification. They typically require us to control a model of the system so that control gains are calculated based on a cost algorithm.

This cost is user defined and can include time to reach stable output, amount of energy used, and so on. One of the main challenges of applying optimal controllers is finding a software model of the system.



Conclusion

PID control algorithms are popular and offer many benefits. Some PID implementations are examined along with means to improve system performance while replacing current PID controllers with other advanced algorithms.

Introduction to Field Bus

Field bus is a recent innovation in the area of computerised process control. It is a local area network (LAN) for instruments used in both process and automated manufacturing. It is an all-digital, serial, two-way communication system, interconnecting field devices such as sensors, actuators and controllers.

It has built-in capability to distribute the control application across the network. A sample architecture of field bus is shown in figure. It differs from any other communication protocol as it is designed to resolve process control applications, not for just transfer of data in a digital mode

Fieldbus can also be seen as the family of industrial communication protocols used for real-time distributed control, now standardized as IEC 61158.

Devices can be networked and configured according to the user needs. The system is fully scalable in the sense that it can be implemented for small plants to large plants.

Field Bus Signals

Fieldbus signals are encoded using the well-known Manchester Biphase-L technique. The clock information is embedded in the serial data stream, and so the signal is called synchronous serial.

Advantages of field bus

The field bus systems have many advantages compared to traditional DCS or PLC based controls in terms of reliability and intrinsic safety.

In addition, high resolution and distortion free characteristics of digital communication used in field bus enables improved control capability, leading to increased yield and quality.

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