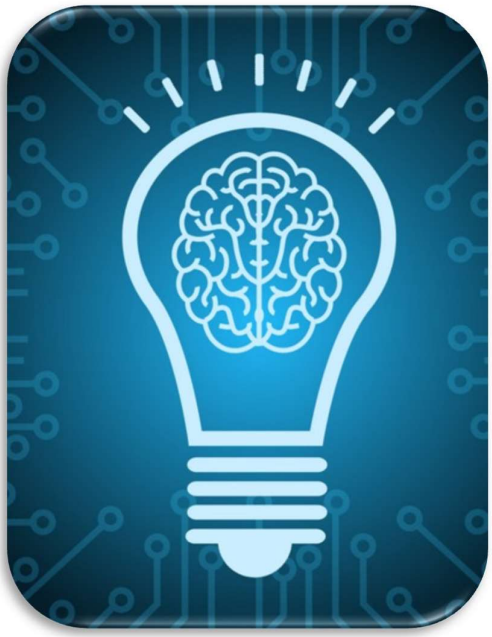

BEES Magazine

February 2016

K S R Institute for Engineering and Technology

Department of Electrical and Electronics Engineering

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Together We Make Difference

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Contents

Editorial Board

Swarm Robotics

MATHAN G
IV year EEE

MAKESH KANNAN P
IV year EEE

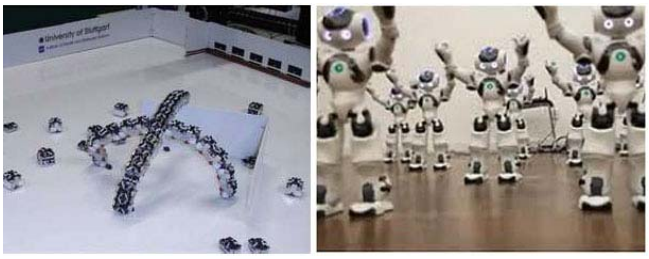
Introduction

"When everybody thinks alike, nobody is thinking much", is so rightly said. Think out-of-the-box and you potent some innovation or maybe an invention; credits to your gamut. To speak in line with the concept here, swarming population; not always, is a bad idea.

Swarm Robotics

How about rescuing some disaster hit zone with swarming intelligent population or maintaining a warehouse with moving, self-operational shelves?? A great idea indeed. Well, this is all about a seemingly new concept of **Swarm Robotics**. Everybody, in active adolescence or passive maturity may be, must have noticed the movement of ants or similar insects. It is awesomely coordinated and aligned with respect to each other. They accomplish their task collectively by keeping an eye on each other's movement. This type of coordinated movement in insects is termed as "**Swarm**" and when this movement is performed by some group of robots then in technical terms it is called as "**Swarm Robotics**" inspired by colonies of ants and swarms of bees. Simply put, Swarm Robotics is a multi robot system which consists of a large number of simple, physical autonomous robots. It was first coined by Gerardo Beni; professor at University of California and Jing Wang in 1989 in order to impart a notion of swarm intelligence to cellular robotic systems.

Like any other robot, a **swarm robot** has two main organs; hardware and software. Software is the brain of the system. It gives a simulation environment to the functioning of the robot. In essence, it is the brain of the system. The hardware brings into action, directions simulated by the software. When many such inter-communicable robots are brought to work together, swarming action comes to force.



Swarm Robotics in Action

Introduction to Swarm Intelligence

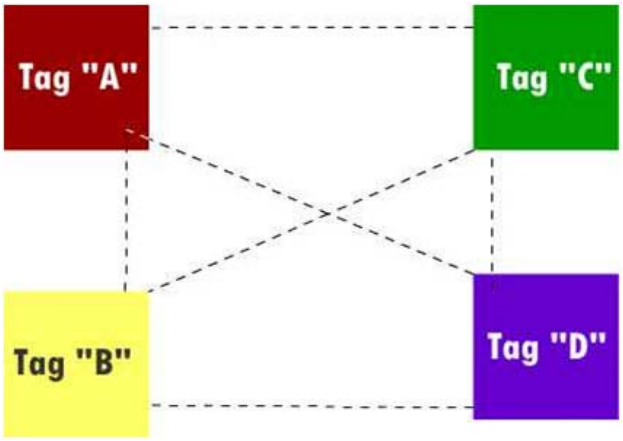
Swarm Intelligence is a property of a system or group of systems wherein the members of the group interact locally with each other and the environment in a decentralized manner thereby attaining the desired goal via self-organization. By self-organization we mean the emergence of a global, complex pattern by local level interaction between low-level, simple but autonomous components of the system. The **application of swarm intelligence** to robotics has conceived to the very idea of swarm robotics. Studies of self-organization in biological species like insects had

acted as the biggest inspiration for swarm robotics. Some of the legendary examples are ant colonies, birds flocking, food foraging, schooling of fishes, etc. Let's have a good look at one of these to find the crux.

***Foraging of food by ant colonies*:** Ants are social insects that do not have eyes or ears. Ants communicate by touch and smell. It sniffs with its antennae to discover whether an intruder is a friend or a foe. They usually set out of their nests in groups for food foraging. Before they leave the nest each day, foragers normally wait for early morning patrollers to return. As the patrollers return and enter their nest, they touch their antennas shortly with the foragers'. Taking this signal as a trigger, the foragers set out for foraging. But not just one contact does the job, foragers require several contacts not more than ten seconds apart before it go out. Foragers use the rate of their encounters with patrollers to tell if it's safe to go out. So, this is how swarm intelligence works, each ant works on its own using local information and without any centralized control. Even if one or two members accidentally run out of the group, the group dynamics remain unaltered and it goes on.

Intercommunication between Robots

With multiple robots working simultaneously in a decentralized environment, the primary factor that keeps them bind as a team is inter-communication. Communication between robots can multiply their capabilities and increase their efficiencies. Communication works differently in different robotic systems depending on various factors like type of environment, size of robot, range of transmission/reception, communication area, etc. It is to be noted that the communication or sensing in swarm robotics is limited to local sensing so that the control or coordination among the robots remains distributed (decentralized). Let us first have a general idea for communication using tags. This could be resolved by having tags over each robot. This tags can be anything like for robot one it is "A" then for second robot it is "B" and so on. In practical world these tags are some binary digits or codes given to each robot. These tags acts as their address and to perform action in coordination, they interact individually through tags. The below figure gives a quick idea of detection—



Detection of Intercommunication Between Robots

Now if robot with tag "A" gets some fault, other robots can detect the error and will quickly fill up the redundant space. Similarly for different type of usage like robot "C" is getting out of the area, then other robots can address it to be in the particular area. This is how a swarm robot works now there could different ways of utilizing the tagging and detection depending upon the idea and purpose.

Swarm intelligence works under two types of communication namely,

Implicit Communication (Stigmergy) - It is a method of communication through the environment or by changing the environment. During foraging, in order to find the shortest path to target/nest or for some other task, ants change the environment by placing a chemical substance called pheromone on

the way. However, fabricating virtual pheromone in practical swarm robotics does sound non-pragmatic.

Explicit Communication - Explicit communication is that mode of communication in which the robots directly pass messages to each other. The most common technologies for sending messages from robot to robot in swarms are Bluetooth, wireless LAN or infrared. All of the techniques are unique in some sense and share some trade-offs.

IR Communication -Infrared technology for communication is suited for micro-robots as it consumes quite less power. In addition to communication, IR transmitters and receivers can also be used for proximity sensing, obstacle detection and distance measurement at the same time. The IR technique is most suitable for small distance and Line of Sight (LoS) communication. However, it is not suited for long distance communication and is prone to interference from sunlight and other light source. Infrared communication technology is based on a set of standard rules and regulations (protocols) namely IrDA. IrDA (Infrared Data Association) provides a complete set of protocol specifications for IR communication.

RF Communication- It is needless to mention the hold of RF in the wireless market. RF is used as a synonym for wireless communication. Its range may vary from few metres to thousands of kilometers. It can cross as many obstacles as required and is not limited to line of sight communication. Bluetooth, Radios, Cell phones, Satellite etc are all examples of RF communication. Bluetooth can be used in case of medium-sized robots. Zigbee is a widely accepted protocol for RF communication.

The communication technique only gives the basic conditions for direct inter-robot communication. The message or data to be sent needs to be assigned some specific ID. These messages should be distributed as intelligent as possible through the swarm and therefore a more or less simple routing protocol should be used.

Algorithms

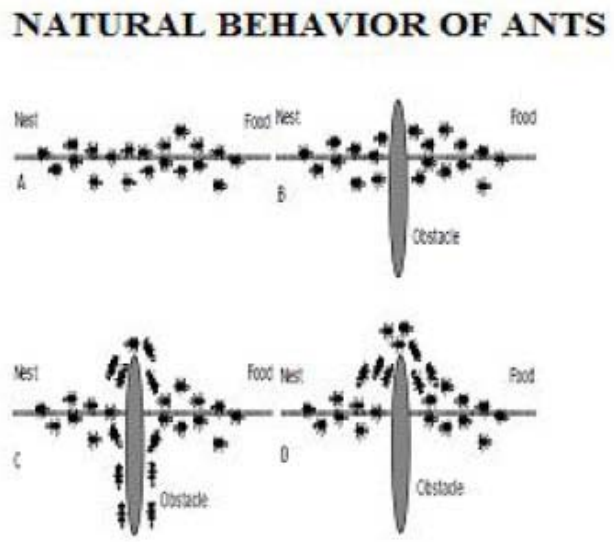
Swarm Robotics Algorithms

So far, we have witnessed some quintessential notions of swarm robotics. In order to implement the notion of decentralization, self-organization, flocking and many others, a lot of research has been done and some control algorithms had been designed, both for real and simulated robots. Some of these algorithms are discussed below:

1. Flocking Algorithm (FA) - A flock can be defined as an aggregation of thousands of individuals/birds in an elegant and organized manner. The FA was given by Craig Reynolds. The algorithm is based on three basic rules simulating which a much organized flock is obtainable. Before taking up the rules let us also consider the prerequisites for its application. The FA is applied for limited computational power and only minimalist swarm robot equipment. Such basic equipment is a set of distance sensors, which are usually used for collision avoidance. Each robot in the swarm emits IR pulses periodically. The first rule in FA is called the *collision avoidance rule.* Here, the front sensor's active IR response is checked for obstacle detection. If the recorded observation exceeds the threshold, the robot takes a random turn. If not, then the passive values of all the other sensors are checked for threshold. In case any of the sensors is found to exceed the threshold limit, the robot takes a turn presuming another robot close to it. This rule is called *separation rule.*

The third rule in flocking algorithms is usually the alignment rule which generates the common direction of movement in a flock.

2. Ant Colony Optimization (ACO) - ACO is a very popular algorithm proposed by Marco Dorigo in 1992 in his PhD Thesis. Inspired by the self-organization of ant colony ACO was modeled as a class of optimization algorithm. ACO methods are useful in problems that need to find paths to goals. It is developed from studies of ant behavior when foraging for food, wherein they find the shortest path to and from the source despite the availability of multiple trails. The idea of Stigmergy is undertaken in ACO. The ACO has been successfully applied to Travelling Salesman Problem (TSP).



Ant Colony Optimization Algorithm

Many other popular and successful algorithms have been coined such as Particle Swarm Optimization (PSO), Dispersion in indoor environments, Distributed localization and mapping, Mobile formation, Cooperative hole avoidance and many more.

Applications and Promising future

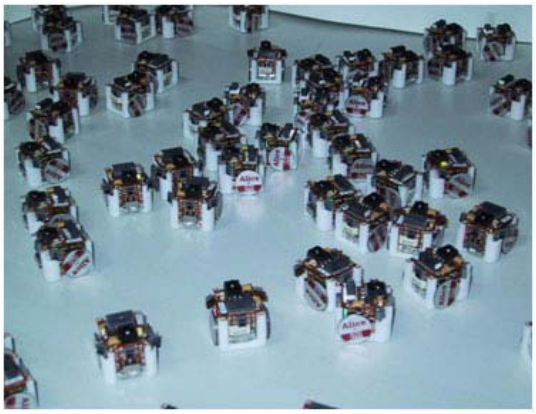
Roboticists say the swarms of robots could prove more adaptable and smarter than individual, self-contained ones. Swarm robotics has many applications in numerous domains. Swarm robots can be deployed in areas which are spread in space such as environmental monitoring of lake. The distributed sensing ability of swarm robotic system can provide surveillance for immediate detection of hazardous events, such as the accidental leakage of a chemical. Here is a brief mention to some of the featured swarmbots:

Swarmanoid- Swarmanoid is a heterogeneous swarm robotic system capable of operating in a fully 3-dimensional environment. Swarmanoid comprises of heterogeneous, dynamically connected, autonomous robots of three types; eye-bots, foot-bots and hand-bots. Eye-bots are specialized in sensing and analyzing the environment from a high position to provide an overview to the rest. Hand-bots are specialized in moving and acting in a space zone between the one covered by the foot-bots (the ground) and the one covered by the eye-bots. Foot-bots are specialized in moving on rough terrain and transporting either objects or other robots.

Swarmanoid Robotic System

Alice micro robot swarm- Alice is swarm robot developed by Gilles Caprari at the Autonomous Systems Lab. These cubical swarm robots form a bit huge army of 90 robots working together. Its

simulation was done in WeBots simulator. Alice has an IR based proximity sensor to detect obstacle, it also has IR remote to control them manually. Other complexities have been added to this swarm systems like linear camera, Grip modules etc to increase their capabilities.



Micro Robot Swarm System

Kiva Systems- ***An inspiring analogy to swarm robotics***

Kiva systems is a company which uses mobile robots for warehouse automation. It fulfills its orders by making inventory items come close to the warehouse workers rather than vice versa. A computer cluster keeps track of all robots and racks on the floor, and resource-allocation algorithms efficiently orchestrate their movement. This system helps Kiva in completing their orders at a faster pace. It is an innovation, indeed a revolution in the warehouse distribution system. This idea of using mobile robots for inventory management was conceived by Mick Mountz, a graduate from MIT and Harvard.

Mobile Robots for Warehouse Automation

Warehouse floors at Kiva are laid with two-dimensional barcodes in a grid at a distance of 1 meter. Robots navigate the warehouse by pointing cameras at the floor. The robots relay the encoded information wirelessly to a computer cluster that functions both as a dispatcher and a traffic controller.

Well with so many proven advantages and many more to come, swarm robotics offers us a very promising future. Swarm of robots could one day be exploring space or doing dangerous jobs on earth. Researchers say, with swarm robots life would be much easier to just design simple robots and allow them to organize themselves.

Soft Starter

RAMADAS K
III year EEE

SARAVANARAJ M
III year EEE

Introduction

A soft starter is any device which controls the acceleration of an electric motor by means of controlling the applied voltage.

An Induction motor has the ability to self start owing to the interaction between the rotating magnetic field flux and the rotor winding flux, causing a high rotor current as torque is increased. As a result the stator draws high current and by the time the motor reaches to full speed, a large amount of current (greater than the rated current) is drawn and this can cause heating up of the motor, eventually damaging it. To prevent this, motor starters are needed.

Motor starting can be in 3 ways

- Applying full load voltage at intervals of time: Direct On Line Starting
- Applying reduced voltage gradually : Star Delta Starter and Soft starter
- Applying part winding starting: Autotransformer starter

Defining Soft Starting

Now let us shift our particular attention to soft starting. In technical terms, a soft starter is any device which reduces the torque applied to the electric motor. It generally consists of solid state devices like thyristors to control the application of supply voltage to the motor. The starter works on the fact that the torque is proportional to the square of the starting current, which in turn is proportional to the applied voltage. Thus the torque and the current can be adjusted by reducing the voltage at the time of starting the motor.

Open Control:

A start voltage is applied with time, irrespective of the current drawn or the speed of the motor. For each phase two SCRs are connected back to back and the SCRs are conducted initially at a delay of 180 degrees during the respective half wave cycles (for which each SCR conducts). This delay is reduced gradually with time until the applied voltage ramps up to the full supply voltage. This is also known as Time Voltage Ramp System. This method is not relevant as it doesn't actually control the motor acceleration.

Closed Loop Control:

Any of the motor output characteristics like the current drawn or the speed is monitored and the starting voltage is modified accordingly to get the required response. The current in each phase is monitored and if it exceeds a certain set point, the time voltage ramp is halted. Thus basic principle of soft starter is by controlling the conduction angle of the SCRs the application of supply voltage can be controlled.

2 Components of a basic soft starter

- **Power switches** like SCRs which need to be phase controlled such that they are applied for each part of the cycle. For a 3 phase motor, two SCRs are connected back to back for each phase. The switching devices need to be rated at least three times more than the line voltage.
- **Control Logic** using PID controllers or Microcontrollers or any other logic to control the application of gate voltage to the SCR, i.e. to control the firing angle of SCRs in order to make

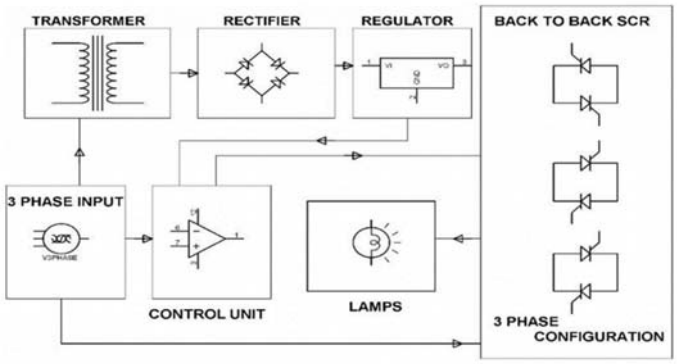
the SCR conduct at the required part of the supply voltage cycle.

Example of Electronic Soft Start System

The system consists of the following components.

- Two back to back SCRs for each phase, i.e. 6 SCRs in total.
- Control Logic circuitry in form of two comparators- LM324 and LM339 to produce the level and the ramp voltage and an opto-isolator to control the application of gate voltage to the each SCR in each phase.

A power supply circuitry to provide the required dc supply voltage.



Block Diagram showing Electronic Soft Start System for 3 phase Induction Motor by *Edgefx Kits*

The level voltage is generated using the comparator LM324 whose inverting terminal is fed using a fixed voltage source and the non inverting terminal is fed through a capacitor connected to the collector of an NPN transistor. The charging and discharging of the capacitor causes the output of the comparator to change accordingly and the voltage level to change from high to low. This output level voltage is applied to the non inverting terminal of another comparator LM339 whose inverting terminal is fed using a ramp voltage. This ramp voltage is produced using another comparator LM339 which compares the pulsating DC voltage applied at its inverting terminal to the pure DC voltage at its non inverting terminal and generates a zero voltage reference signal which is converted to a ramp signal by the charging and discharging of a electrolyte capacitor. The 3rd comparator LM339 produces a High pulse width signal for every high level voltage, which decreases gradually as the level voltage reduces. This signal is inverted and applied to the Opto isolator, which provides gate pulses to the SCRs. As voltage level falls, the pulse width of the Opto isolator increases and more the pulse width, lesser is the delay and gradually the SCR is triggered without any delay. Thus by controlling the duration between the pulses or delay between applications of pulses, the firing angle of SCR is controlled and the application of supply current is controlled, thus controlling the motor output torque.

The whole process is actually an open loop control system where the time of application of gate triggering pulses to each SCR is controlled based on the how earlier the ramp voltage decreases from the level voltage.

Advantages of Soft Start

Now that we have learnt about how an electronic soft start system works, let us recollect few reasons why it is preferred over other methods.

- **Improved Efficiency**: The efficiency of soft starter system using solid state switches is more owing to the low on state voltage.
- **Controlled startup**: The starting current can be controlled smoothly by easily altering the starting voltage and this ensures smooth starting of the motor without any jerks.
- **Controlled acceleration**: Motor acceleration is controlled smoothly.
- **Low Cost and size**: This is ensured with the use of solid state switches.

Night Vision Technology

PRABHU C
IV year EEE

GOKULRAJ M
IV year EEE

Introduction

Night vision is a spy or action movie you've seen, in which someone straps on a pair of night-vision goggles to find someone else in a dark building on a moonless night. With the proper night-vision equipment, you can see a person standing over 200 yards (183 m) away on a moonless, cloudy night. Night vision can work in two very different ways, depending on the technology used.

" **Image enhancement** - This works by collecting the tiny amounts of light, including the lower portion of the infrared light spectrum, that are present but may be imperceptible to our eyes, and amplifying it to the point that we can easily observe the image.

" **Thermal imaging** - This technology operates by capturing the upper portion of the infrared light spectrum, which is emitted as heat by objects instead of simply reflected as light. Hotter objects, such as warm bodies, emit more of this light than cooler objects like trees or buildings.

To study about night vision technology we should first know about light.

The amount of energy in a light wave is related to its wavelength: Shorter wavelengths have higher energy. Of visible light, violet has the most energy, and red has the least. Just next to the visible light spectrum is the infrared spectrum.

Night vision technology consists of two major types: light amplification (or intensification) and thermal (infrared).

Most consumer night vision products are light amplifying devices. All ITT Night Vision products use light-amplifying technology.

This technology takes the small amount of light that's in the surrounding area (such as moonlight or starlight), and converts the light energy (scientists call it photons) into electrical energy (electrons).

These electrons pass through a thin disk that's about the size of a quarter and contains more than 10 million channels. As the electrons go through the channels, they strike the channel walls and thousands more electrons are released. These multiplied electrons then bounce off of a phosphor screen which converts the electrons back into photons and lets you see an impressive nighttime view even when it's really dark.

In night vision, thermal imaging takes advantage of this infrared emission.

Thermal imaging works as

1. A special lens focuses the infrared light emitted by all of the objects in view.
2. The focused light is scanned by a phased array of infrared-detector elements. The detector elements create a very detailed temperature pattern called a thermogram. It only takes about one-thirtieth of a second for the detector array to obtain the temperature information to make the thermogram.

This information is obtained from several thousand points in the field of view of the detector array.

3. The thermogram created by the detector elements is translated into electric impulses.

4. The impulses are sent to a signal-processing unit, a circuit board with a dedicated chip that translates the information from the elements into data for the display.

5. The signal-processing unit sends the information to the display, where it appears as various colors depending on the intensity of the infrared emission. The combination of all the impulses from all of the elements creates the image.

Types of Thermal Imaging Devices

Most thermal-imaging devices scan at a rate of 30 times per second. They can sense temperatures ranging from -4 degrees Fahrenheit (-20 degrees Celsius) to 3,600 F (2,000 C), and can normally detect changes in temperature of about 0.4 F (0.2 C).

There are two common types of thermal-imaging devices:

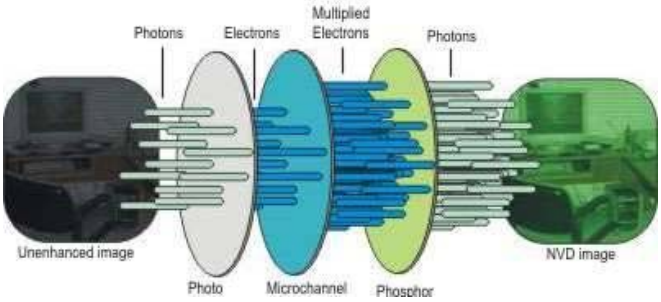
• **Un-cooled -** This is the most common type of thermal-imaging device. The infrared-detector elements are contained in a unit that operates at room temperature. This type of system is completely quiet, activates immediately and has the battery built right in.

• **Cryogenically cooled -** More expensive and more susceptible to damage from rugged use, these systems have the elements sealed inside a container that cools them to below 32 F (zero C). The advantage of such a system is the incredible resolution and sensitivity that result from cooling the elements. Cryogenically-cooled systems can "see" a difference as small as 0.2 F (0.1 C) from more than 1,000 ft (300 m) away, which is enough to tell if a person is holding a gun at that distance!

While thermal imaging is great for detecting people or working in near-absolute darkness, most night-vision equipment uses image-enhancement technology.

IMAGE ENHANCEMENT

Image enhancement technique is used in night vision technology. In fact, image-enhancement systems are normally called night-vision devices (NVDs). NVDs rely on a special tube, called an image-intensifier tube, to collect and amplify infrared and visible light.



The image-intensifier tube changes photons to electrons and back again.

Here's how image enhancement works:

1. A conventional lens, called the objective lens captures ambient light and some near-infrared light.

2. The gathered light is sent to the image-intensifier tube. In most NVDs, the power supply for thimage-intensifier tube receives power from two N-Cell or two "AA" batteries. The tube outputs a high voltage, about 5,000 volts, to the image-tube components.

3. The image-intensifier tube has a photo cathode, which is used to convert the photons of light energy into electrons.

4. As the electrons pass through the tube, similar electrons are released from atoms in the tube, multiplying the original number of electrons by a factor of thousands through the use of a micro channel plate (MCP) in the tube.

An MCP is a tiny, glass disc that has millions of microscopic holes (micro channels) in it, made using fiber-optic technology. The MCP is contained in a vacuum and has metal electrodes on either side of the disc. Each channel is about 45 times longer than it is wide, and it works as an electron multiplier. When the electrons from the photo cathode hit the first electrode of the MCP, they are accelerated into the glass microchannels by the 5,000-V bursts being sent between the electrode pair.

As electrons pass through the microchannels, they cause thousands of other electrons to be released in each channel using a process called cascaded secondary emission. Basically, the original electrons collide with the side of the channel, exciting atoms and causing other electrons to be released. These new electrons also collide with other atoms, creating a chain reaction that results in thousands of electrons leaving the channel where only a few entered. An interesting fact is that the microchannels in the MCP are created at a slight angle (about a 5-degree to 8-degree bias) to encourage electron collisions and reduce both ion and direct-light feedback from the phosphors on the output side.

5. At the end of the image-intensifier tube, the electrons hit a screen coated with phosphors. These electrons maintain their position in relation to the channel they passed through, which provides a perfect image since the electrons stay in the same alignment as the original photons. The energy of the electrons causes the phosphors to reach an excited state and release photons. These phosphors create the green image on the screen that has come to characterize night vision.

6. The green phosphor image is viewed through another lens, called the ocular lens, which allows you to magnify and focus the image. The NVD may be connected to an electronic display, such as a monitor, or the image may be viewed directly through the ocular lens.

Electric Traction

ARAVINDHAN B
II year EEE

HARIRAMU R
II year EEE

Introduction

The evaluation of electric motor design and electrification technologies have not only led to the design of high-speed locomotives (Metros and suburban railways), but also have raised the overall energy efficiency.

A driving force that causes propulsion of a vehicle is referred to as a traction system. The traction system is of two different types: non electric traction system and electric traction system.

Non-Electric Traction System

The traction system that doesn't use electricity at any stage of a vehicle movement is referred to as a non-electric traction system. Such a traction system is used in steam locomotives, IC engines, and in the maglev trains (high -speed trains).

Electric Traction System

The traction system that uses electricity in all stages or some stages of a vehicle movement is referred to as an electric traction system.

Electric Vs Non electric traction

In an electric traction system the driving force to pull a train is generated by the traction motors. The electric traction system can be broadly divided into two groups: one is self-powered and the other one is third-rail system.

The self-powered systems include diesel electric drives and battery electric drives that can generate their own power to pull the train; whereas, the third-rail or overhead-wire systems use the power from an external distribution network or grids, and the examples include tramways, trolley buses and locomotives driven from overhead electric lines.

Types of Track Electrification Systems

The track electrification refers to the type of source supply system that is used while powering the electric locomotive systems. It can be AC or DC or a composite supply.

Selecting the type of electrification depends on several factors like availability of supply, type of an application area, or on the services like urban, suburban and main line services, etc.

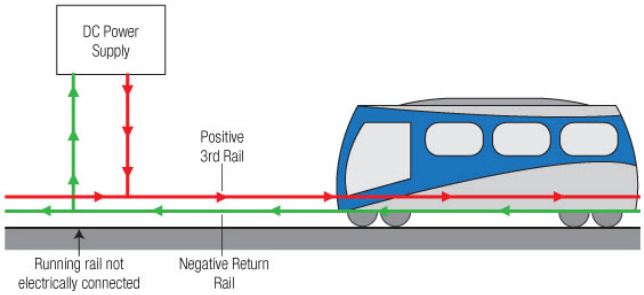
The three main types of electric traction systems that exist are as follows:

1. Direct Current (DC) electrification system
2. Alternating Current (AC) electrification system
3. Composite system.

Direct Current (DC) electrification system

The choice of selecting DC electrification system encompasses many advantages, such as space and weight considerations, rapid acceleration and braking of DC electric motors, less cost compared to AC systems, less energy consumption and so on.

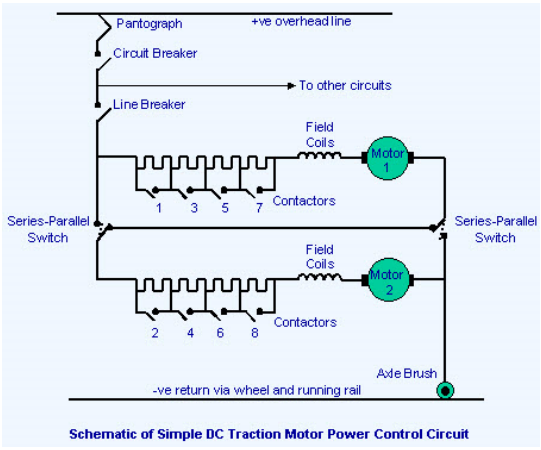
In this type of system, three-phase power received from the power grids is de-escalated to low voltage and converted into DC by the rectifiers and power-electronic converters.



3rd rail system

This type of DC supply is supplied to the vehicle through two different ways: the first way is through the 3rd rail system (side running and under running electrified track and providing return path through running rails), and the second way is through the overhead line DC system. This DC is fed to the traction motor like the DC series or compound motors to drive the locomotive, as shown in the above figure.

The supply systems of DC electrification include 300-500V supply for the special systems like battery systems (600-1200V) for urban railways like tramways and light metros, and the 1500-3000V for suburban and mainline services like light metros and heavy metro trains. The 3rd (conductor rail) and 4th rail systems operate at low voltages (600-1200V) and high currents, whereas the overhead rail systems use high voltages (1500-3000V) and low currents.



DC electrification system

Due to high starting torque and moderate speed control, the DC series motors are extensively employed in the DC traction systems. They provide high torque at low speeds and low torque at high speeds.

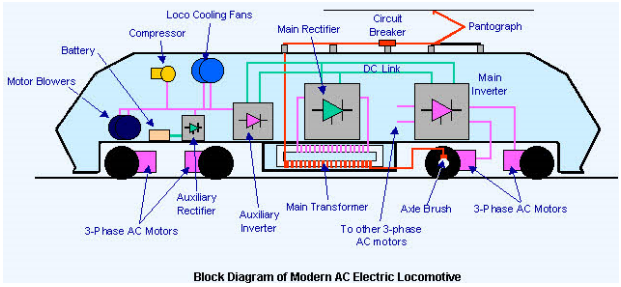
An electric motor speed controller is used by varying the voltage applied to it. The Special drive systems that are used to control these electric motors include tap changer, thyristor control, chopper control and micro processor control drives. The disadvantages of this system include difficulty in interruption of currents at high voltages when fault condition is raised, and the need for locating DC substations between short distances.

Alternating Current (AC) electrification system

An AC traction system has become very popular nowadays, and it is more often used in most of the traction systems due to several advantages, such as quick availability and generation of AC that can be easily stepped up or down, easy controlling of AC motors, less number of substations requirement, and the presence of light overhead catenaries that transfer low currents at high voltages, and so on.

The supply systems of AC electrification include single, three phase, and composite systems. The Single phase systems consist of 11 to 15 KV supply at 16.7Hz, and 25Hz to facilitate variable speed to AC commutation motors. It uses step down transformer and frequency converters to convert from the high voltages and fixed industrial frequency.

The Single phase 25KV at 50Hz is the most commonly used configuration for AC electrification. It is used for heavy haul systems and main line services since it doesn't require frequency conversion. This is one of the widely used types of composite systems wherein the supply is converted to DC to drive DC traction motors.



Block Diagram of Modern AC Electric Locomotive

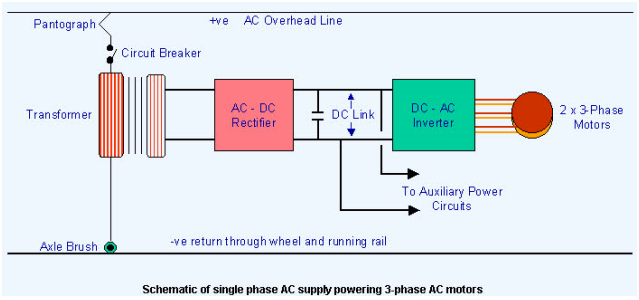
AC electrification system

Three phase system uses three phase induction motor to drive the locomotive, and it is rated at 3.3.KV, 16.7Hz. The high-voltage distribution system at 50 Hz supply is converted to this electric motor rating by transformers and frequency converters. This system employs two overhead lines, and the track rail forms another phase, but this raises many problems at crossings and junctions.

The above figure shows AC electric locomotive operation wherein the catenary system receives single-phase power from the overhead system. The supply is stepped up by the transformer, and then converted to DC by a rectifier. A smoothening reactor or a DC link, filters and smoothens DC to reduce the ripples, and then the DC is converted to AC by an inverter that varies frequency to get variable speed of the traction motor (similar to VFD).

Composite system

This system incorporates the advantages of both DC and AC systems. These systems are of mainly two types: a single phase to three phases or Kando system, and the other single phase to DC system.



Schematic of single phase AC supply powering 3-phase AC motors

Single phase to three phase or Kando system

In a Kando system, a single overhead line carries the single-phase supply of 16KV, 50Hz. This high voltage is stepped down and converted to three-phase supply of same frequency in the locomotive itself through the transformer and converters.

This three-phase supply is further supplied to the three-phase induction motor that drives the locomotive. Since the two-overhead line system of the three-phase system is replaced by a single overhead line by this system, it is economical.

As we have already discussed in the AC electrification that a single-phase to DC system is highly popular, it is the most economical way of single overhead line and has wide variety of DC series motor characteristics.

In this particular system, a single-phase 25KV, 50Hz supply of overhead line system is stepped down by transformer inside the locomotive, and then converted to DC by rectifiers. The DC is fed to the DC-drive system to drive the series motor and to control its speed and braking systems.

This is all about the electric locomotive systems. And, we hope that we have given you ample and relevant information about the various supply systems used in the traction systems.

Biochip

MURUGAN G
IV year EEE

VIGNESH R
IV year EEE

Introduction

The current, in use, biochip implant system is actually a fairly simple device. Today's, biochip implant is basically a small (micro) computer chip, inserted under the skin, for identification purposes. The biochip system is radio frequency identification (RFID) system , using low-frequency radio signals to communicate between the biochip and reader. The reading range or activation range, between reader and biochip is small, normally between 2 and 12 inches

Size

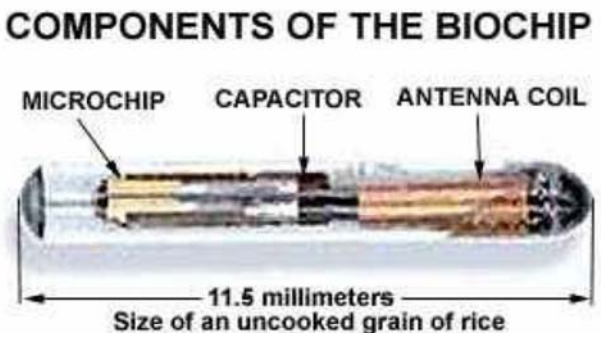
The size of Biochip is of a size of an uncooked rice grain size. It ranges from 2inches to 12inches.

Components of the Biochip

The biochip implant system consists of mainly two components the transponder and reader

The Transponder

The transponder is the actual biochip implant. It is a passive transponder, meaning it contains no battery or energy of its own. In comparison, an active transponder would provide its own energy source, normally a small battery. Because the passive biochip contains no battery, or nothing to wear out, it has a very long life, up to 99 years, and no maintenance. Being passive, it's inactive until the reader activates it by sending it a low-power electrical charge. The reader "reads" or "scans" the implanted biochip and receives back data (in this case an identification number) from the biochip. The communication between biochip and reader is via low-frequency radio waves.



The biochip transponder consists of four parts:

(i) Computer Microchip:

The microchip stores a unique identification number from 10 to 15 digits long. The storage capacity of the current microchips is limited, capable of storing only a single ID number. AVID (American Veterinary Identification Devices), claims their chips, using an nnnnnn-nnn format, has the capability of over 70 trillion unique numbers. The unique ID number is "etched" or encoded via a laser onto the surface of the microchip before assembly.

(ii) Antenna Coil:

This is normally a simple, coil of copper wire around a ferrite or iron core. This tiny, primitive, radio antenna "receives and sends" signals from the reader or scanner.

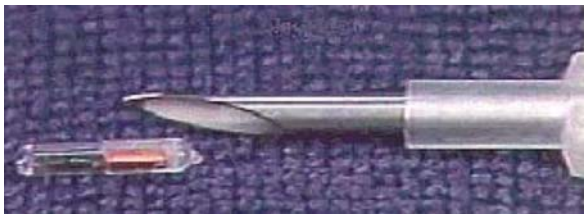
(iii) Tuning Capacitor:

The capacitor stores the small electrical charge (less than 1/1000 of a watt) sent by the reader or scanner, which activates the transponder. This "activation" allows the transponder to send back the ID number encoded in the computer chip. Because "radio waves" are utilized to communicate between the transponder and reader, the capacitor is "tuned" to the same frequency as the reader.

(iv) Glass Capsule:

The glass capsule "houses" the microchip, antenna coil and capacitor. It is a small capsule, the smallest measuring 11 mm in length and 2 mm in diameter, about the size of an uncooked grain of rice. The capsule is made of biocompatible material such as soda lime glass. After assembly, the capsule is hermetically (air-tight) sealed, so no bodily fluids can touch the electronics inside. Because the glass is very smooth and susceptible to movement, a material such as a polypropylene polymer sheath is attached to one end of the capsule. This sheath provides a compatible surface, which the bodily tissue fibers bond or interconnect, resulting in a permanent placement of the biochip.

The biochip is inserted into the subject with a hypodermic syringe. Injection is safe and simple, comparable to common vaccines. Anesthesia is not required nor recommended. In dogs and cats, the biochip is usually injected behind the neck between the shoulder blades. Trovan, Ltd., markets an implant, featuring a patented "zip quill", which you simply press in, no syringe is needed. According to AVID "Once implanted, the identity tag is virtually impossible to retrieve . . . The number can never be altered."

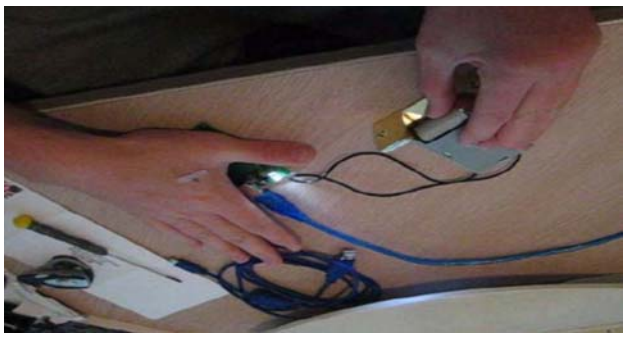


The reader

The reader consists of an "exciter" coil which creates an electromagnetic field that, via radio signals, provides the necessary energy (less than 1/1000 of a watt) to "excite" or "activate" the implanted biochip. The reader also carries a receiving coil that receives the transmitted code or ID number sent back from the "activated" implanted biochip. This all takes place very fast, in milliseconds. The reader also contains the software and components to decode the received code and display the result in an LCD display. The reader can include a RS-232 port to attach a computer .

Working of a Biochip

The reader generates a low-power, electromagnetic field, in this case via radio signals, which "activates" the implanted biochip. This "activation" enables the biochip to send the ID code back to the reader via radio signals. The reader amplifies the received code, converts it to digital format, decodes and displays the ID number on the reader's LCD display. The reader must normally be between 2 and 12 inches near the biochip to communicate. The reader and biochip can communicate through most materials, except metal.



Applications of a Biochip

A. With a biochip tracing of a person/animal, anywhere in the world is possible:

Once the reader is connected to the Internet, satellite and a centralized database is maintained about the biochipped creatures, it is always possible to trace out the personality intended [8].

B. A biochip can store and update financial, medical, demographic data, basically everything about a person:

An implanted biochip can be scanned to pay for groceries, obtain medical procedures, and conduct financial transactions. Currently, the in use, implanted biochips only store one 10 to 15 digits. If biochips are designed to accommodate with more ROM & RAM there is definitely an opportunity [8].

C. A biochip leads to a secured E-Commerce systems:

It's a fact; the world is very quickly going to a digital or E-economy, through the Internet. It is expected that by 2012, 60% of the Business transactions will be performed through the Internet. The E-money future, however, isn't necessarily secure. The Internet wasn't built to be Fort Knox. In the wrong hands, this powerful tool can turn dangerous. Hackers have already broken into bank files that were 100% secure. A biochip is the possible solution to the "identification and security" dilemma faced by the digital economy. This type of new bio-security device is capable of accurately tracking information regarding what users are doing, and who are to accurately track information regarding what users are doing, and who is actually doing it [8].

Conclusion

A chip implanted somewhere in human bodies might serve as a combination of credit card, passport, driver's license, personal diary. No longer would it be needed to worry about losing the credit cards while traveling. A chip inserted into human bodies might also give us extra mental power.

The really fascinating idea is under fast track research "but we're close." The day in which we have chips embedded in our skins is not too far from now. "This is science fiction stuff." ,"This is a true example to prove science really starts with fiction".

Big Data Visualization Techniques

DEEPIKAA SRI M
IV year EEE

SUGANYA D
IV year EEE

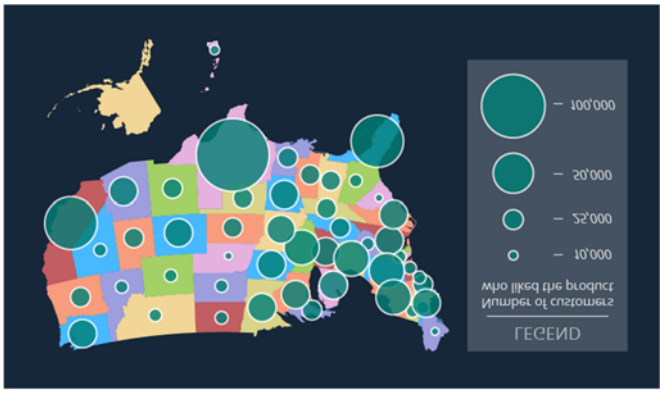
Introduction:

For traditional business intelligence, data visualization is very helpful: instead of looking through a report with hundreds of lines, a business user can just glance at a graph. For big data, visualization is not just a convenient feature, rather it's a must. Otherwise, how can a user grasp the data that is big and ever increasing by definition? Our visualization team shares an overview of big data visualization techniques, which can be both specific and non-specific. Let's take a closer look at them.

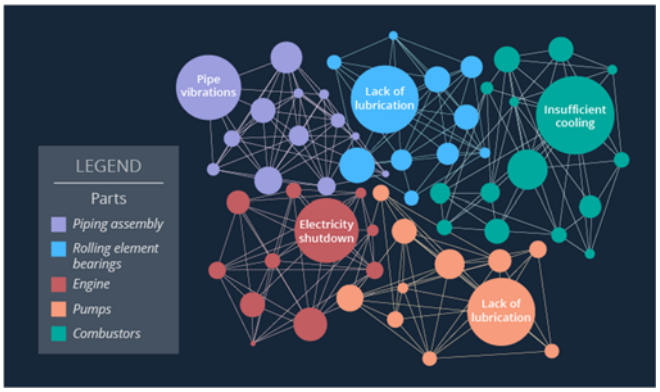
Dedicated big data visualization techniques

Word clouds give companies the idea of how often a word is used. The words in the cloud are of different sizes. The more the size – the higher the frequency. This technique may be helpful, for example, for sentiment analysis of the customers' social media posts.

Symbol maps are maps with symbols on them. The symbols differ in size, which makes them easy to compare. Imagine a US manufacturer who has launched a new brand recently. The manufacturer is interested to know which regions liked the brand particularly. To achieve this, they can use a map with symbols representing the number of customers who liked the product (left a positive comment on the internet, marked a new product high in a customer survey, etc.)



Connectivity charts show the links between phenomena or events. The chart below, for example, shows the connections between machinery failures and their triggers, as well as the strength of these connections.

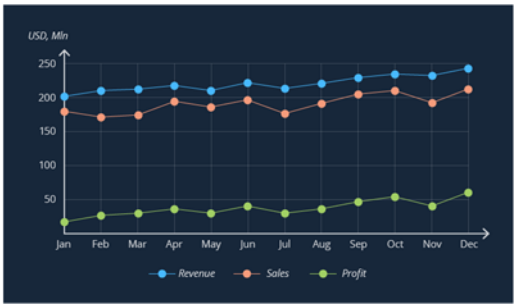


For more examples on how big data visualization can make a difference, visit this article.

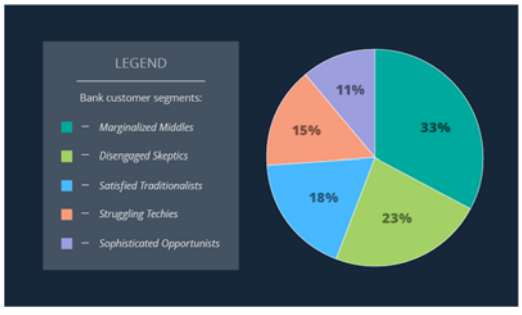
Visualization techniques that work for both traditional and big data

Some of traditional data visualization techniques suit big data as well.

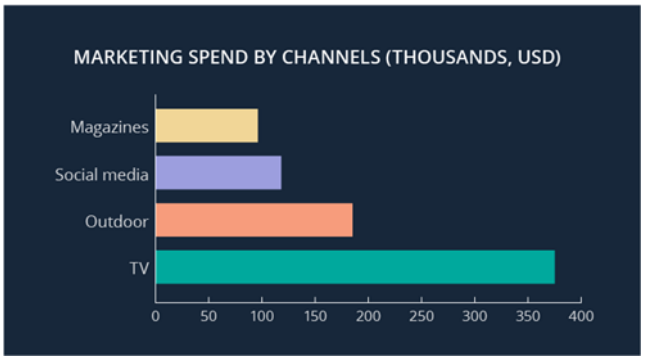
Line charts allow looking at the behavior of one or several variables over time and identifying the trends. In traditional BI, line charts can show sales, profit and revenue development for the last 12 months. When working with big data, companies can use this visualization technique to track total application clicks by weeks, the average number of complaints to the call center by months, etc.



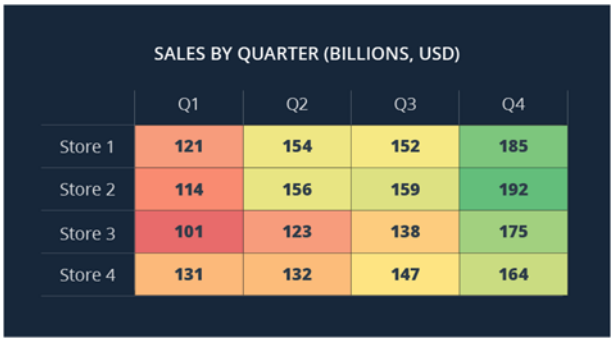
Pie charts show the components of the whole. Companies that work with both traditional and big data may use this technique to look at customer segments or market shares. The difference lies in the sources from which these companies take raw data for the analysis.



Bar charts allow comparing the values of different variables. In traditional BI, companies can analyse their sales by category, the costs of marketing promotions by channels, etc. When analysing big data, companies can look at the visitors' engagement with their website's multiple pages, at the most frequent pre-failure cases recognized by sensors and more.



Heat maps use colors to represent data. A user may encounter a heat map in Excel that highlights sales in the best performing store with green and in the worst performing – with red. If a retailer is interested to know the most frequently visited aisles in the store, they will also use a heat map of their sales floor. In this case, the retailer will analyze big data – such as the data from a video surveillance system.



	Q1	Q2	Q3	Q4
Store 1	121	154	152	185
Store 2	114	156	159	192
Store 3	101	123	138	175
Store 4	131	132	147	164

Conclusion

Big data can use both special and traditional visualization techniques. No matter the approach, it must make data analysis results easily readable and understandable for business users. So, choose big data visualization techniques wisely taking into account your particular business requirements. You may also involve big data practitioners

HART Technology

GOVARTHANAN E
III year EEE

MOHANRAJ K
III year EEE

Introduction

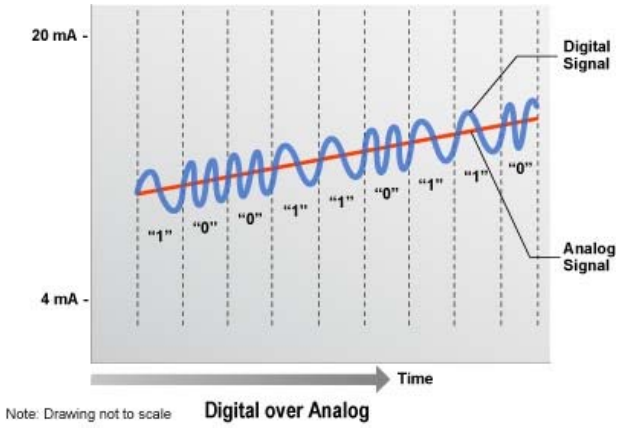
HART technology is easy to use and very reliable when used for commissioning and calibration of smart devices as well as for continuous online diagnostics. If you've ever used a land-line telephone and noticed the Caller ID display to take note of who is calling, you already know half of what the HART Protocol does—it tells "who" is calling.

In an industrial automation network "who" is a microprocessor-based smart field device. In addition to letting such smart field devices "phone home," HART Communication lets a host system send data to the smart instrument.

HART emerged in the late1980s based on the same technology that brought Caller ID to analog telephony. It has undergone continued development, up to and including automation products now shipping with built-in *Wireless* HART Communication.

How HART Works

"HART" is an acronym for Highway Addressable Remote Transducer. The HART Protocol makes use of the Bell 202 Frequency Shift Keying (FSK) standard to superimpose digital communication signals at a low level on top of the 4-20mA.



Frequency Shift Keying

The HART communication protocol is based on the Bell 202 telephone communication standard and operates using the frequency shift keying (FSK) principle. The digital signal is made up of two frequencies— 1,200 Hz and 2,200 Hz representing bits 1 and 0, respectively. Sine waves of these two frequencies are superimposed on the direct current (dc) analog signal cables to provide simultaneous analog and digital communications. Because the average value of the FSK signal is always zero, the 4–20 mA analog signal is not affected. The digital communication signal has a response time of approximately 2–3 data updates per second without interrupting the analog signal. A minimum loop impedance of 230 W is required for communication.

This enables two-way field communication to take place and makes it possible for additional information beyond just the normal process variable to be communicated to/from a smart field instrument. The HART Protocol communicates at

1200 bps without interrupting the 4-20mA signal and allows a host application (master) to get two or more digital updates per second from a smart field device. As the digital FSK signal is phase continuous, there is no interference with the 4-20mA signal.

HART technology is a master/slave protocol, which means that a smart field (slave) device only speaks when spoken to by a master. The HART Protocol can be used in various modes such as point-to-point or multidrop for communicating information to/from smart field instruments and central control or monitoring systems.

HART Communication occurs between two HART-enabled devices, typically a smart field device and a control or monitoring system. Communication occurs using standard instrumentation grade wire and using standard wiring and termination practices.

The HART Protocol provides two simultaneous communication channels: the 4-20mA analog signal and a digital signal. The 4-20mA signal communicates the primary measured value (in the case of a field instrument) using the 4-20mA current loop – the fastest and most reliable industry standard. Additional device information is communicated using a digital signal that is superimposed on the analog signal.

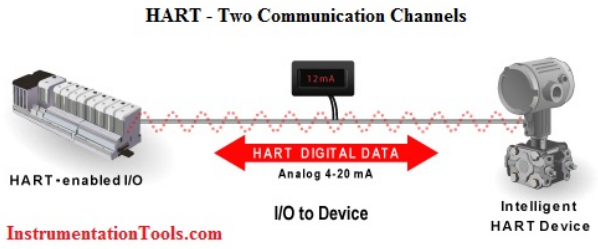
The digital signal contains information from the device including device status, diagnostics, additional measured or calculated values, etc. Together, the two communication channels provide a low-cost and very robust complete field communication solution that is easy to use and configure.

HART Networks

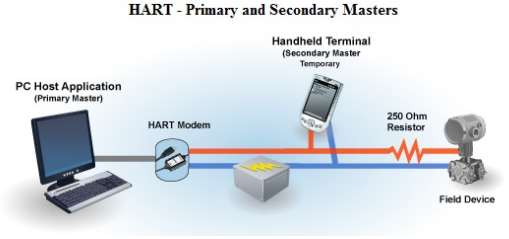
HART devices can operate in one of two network configurations—point-topoint or multidrop.

POINT-TO-POINT

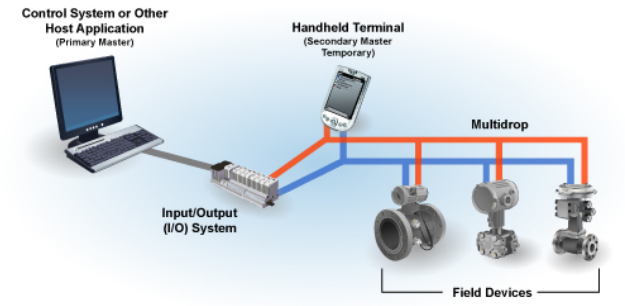
In point-to-point mode, the traditional 4–20 mA signal is used to communicate one process variable, while additional process variables, configuration parameters, and other device data are transferred digitally using the HART protocol (Figure 2). The 4–20 mA analog signal is not affected by the HART signal and can be used for control in the normal way. The HART communication digital signal gives access to secondary variables and other data that can be used for operations, commissioning, maintenance, and diagnostic purposes.



The HART Protocol provides for up to two masters (primary and secondary). This allows secondary masters such as handheld communicators to be used without interfering with communications to/from the primary master, i.e. control/monitoring system.



The HART Protocol permits all digital communication with field devices in either point-to-point or multidrop network configurations:



Two Masters

Multidrop Configuration

There is also an optional "burst" communication mode where a single slave device can continuously broadcast a standard HART reply message. Higher update rates are possible with this optional burst communication mode and use is normally restricted to point-to-point configuration.

The multidrop mode of operation requires only a single pair of wires and, if applicable, safety barriers and an auxiliary power supply for up to 15 field devices. All process values are transmitted digitally. In multidrop mode, all field device polling addresses are >0, and the current through each device is fixed to a minimum value (typically 4 mA).

Communication Modes

1. Master Slave Mode

HART is a master-slave communication protocol, which means that during normal operation, each slave (field device) communication is initiated by a master communication device. Two masters can connect to each HART loop. The primary master is generally a distributed control system (DCS), programmable logic controller (PLC), or a personal computer (PC). The secondary master can be a handheld terminal or another PC. Slave devices include transmitters, actuators, and controllers that respond to commands from the primary or secondary master

2. Burst Mode

Some HART devices support the optional burst communication mode. Burst mode enables faster communication (3–4 data updates per second). In burst mode, the master instructs the slave device to continuously broadcast a standard HART reply message (e.g., the value of the process variable). The master receives the message at the higher rate until it instructs the slave to stop bursting.

Device Description

Some HART host applications use device descriptions (DD) to obtain information about the variables and functions contained in a HART field device. The DD includes all of the information needed by a host application to fully communicate with the field device. HART Device Description Language (DDL) is used to write the DD, that combines all of the information needed by the host application into a single structured file. The DD identifies which common practice commands are supported as well as the format and structure of all device-specific commands. A DD for a HART field device is roughly equivalent to a printer driver for a computer. DDs eliminate the need for host suppliers to develop and support custom interfaces and drivers.

A DD provides a picture of all parameters and functions of a device in a standardized language. HART suppliers have the option of supplying a

DD for their HART field product. If they choose to supply one, the DD will provide information for a DD-enabled host application to read and write data according to each device's procedures.

DD source files for HART devices resemble files written in the C programming language. DD files are submitted to the HCF for registration in the HCF DD Library. Quality checks are performed on each DD submitted to ensure specification compliance, to verify that there are no conflicts with DDs already registered, and to verify operation with standard HART hosts. The HCF DD Library is the central location for management and distribution of all HART DDs to facilitate use in host applications such as PCs and handheld terminals.

Benefits of Using HART

Engineers operating in analog automation environments no longer need utter the words "if only" as in "if only I could get the device information without going into the field" or "if only I could get *this* configuration information from *that* pressure transmitter into my PC."

Users worldwide who have realized the benefits of HART Communication know that they can gain quick, easy visibility to devices in the field when using HART-enabled handheld test, calibration devices and portable computers. In fact, device testing, diagnostics and configuration has never been easier!

However, many have yet to realize HART technology's greatest benefits which come from full-time connections with real-time asset management and/or control systems.

HART technology can help you:

- Leverage the capabilities of a full set of intelligent device data for operational improvements.
- Gain early warnings to variances in device, product or process performance.
- Speed the troubleshooting time between the identification and resolution of problems.
- Continuously validate the integrity of loops and control/automation system strategies.
- Increase asset productivity and system availability.

Increase Plant Availability

- Integrate devices and systems for detection of previously undetectable problems.
- Detect device and/or process connection problems real time.
- Minimize the impact of deviations by gaining new, early warnings.
- Avoid the high cost of unscheduled shutdowns or process disruptions.

Reduce Maintenance Costs

- Quickly verify and validate control loop and device configuration.
- Use remote diagnostics to reduce unnecessary field checks.
- Capture performance trend data for predictive maintenance diagnostics.
- Reduce spares inventory and device management costs.

Improve regulatory compliance

- Enable automated record keeping of compliance data.

- Facilitates automated safety shutdown testing.
- Raise SIL/safety integrity level with advanced diagnostics.
- Take advantage of intelligent multivariable devices for more thorough, accurate reporting.

The standard features of HART technology range from simple compatibility with existing 4-20mA analog networks to a broad product selection:

- Compatibility with standard 4-20mA wiring
- Simultaneous transmission of digital data
- Simplicity through intuitive menu-driven interfaces
- Risk reduction through a highly accurate and robust protocol
- Ease of implementation for maximum "up-front" cost effectiveness

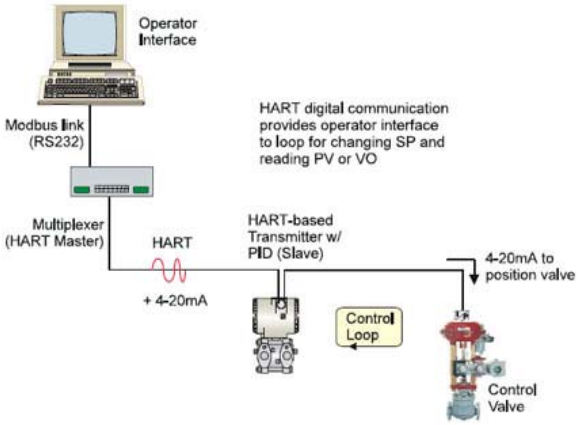
HART Protocol Specifications

The HART Protocol was developed in the late 1980's and transferred to the HART Foundation in the early 1990's. Since then it has been updated several times. When the protocol is updated, it is updated in a way that ensures backward compatibility with previous versions. The current version of the HART Protocol is revision 7.3. The "7" denotes the major revision level and the "3" denotes the minor revision level.

The HART Protocol implements layers 1,2, 3, 4 and 7 of the Open System Interconnection (OSI) 7-layer protocol model:

Advanced HART Application

The power of the HART protocol is evident in the control diagram of Below Figure. This innovative application uses the inherent feature of the HART protocol that both 4-20 mA analog and digital communication signals are transmitted simultaneously over the same wiring.



In this application, the HART-compatible transmitter has an internal PID control capability. The device is configured such that the 4-20 mA loop current is proportional to the control output of the PID algorithm executing in the device (not the measured variable as in most transmitter applications). Since the 4-20 mA loop current is regulated by the PID control output, it is used to drive the valve position directly.

The control loop executes entirely in the field between the transmitter (with PID) and the control valve. The control action is continuous as the traditional 4-20 mA analog signal drives the valve. HART digital communication links the operator with the control loop to change set point, and read the primary variable, or valve position output. Substantial savings are possible in applications where this innovative control architecture is appropriate.

HDMI

PRIYANKA M
II year EEE

SANGAVI K
II year EEE

Introduction

An industry-leading technology **HDMI** is an acronym for **High-Definition Multimedia Interface** and is a de-facto standard for connections between high-definition (HD) digital equipment, e.g., HDTVs, personal computers, cameras, camcorders, gaming consoles, tablets, Blu-ray players, smart phones, and many others supporting HD signals. HDMI is the first industry-supported, uncompressed all-digital audio/video interface. To interface any audio/video source (for e.g. Set-top Box, DVD Player, etc.) and an audio/video monitor (Digital TVs), HDMI is being used and is the technology of future.

HDMI technology dramatically simplifies cabling and provides customers with the highest-quality HD experience. HDMI delivers all contents- digital audio, video as well as control signals via a single cable. HDMI has support for standard, enhanced or high definition video as well as multichannel video on a single cable. It transmits all HDTV standards and supports 8-channel, uncompressed digital audio and all presently-available compressed formats. In addition, it has spare bandwidth to accommodate future upgrades.

HDMI Cables

Typical HDMI interface on Digital equipment

Compared to its predecessors (Component Video, S-Video and Composite Video, which were all analog interfaces), HDMI interface is all digital interface and carry uncompressed signals.

HDMI – Brief Background

HDMI was founded by seven leading consumer electronics manufacturers which include Panasonic Corporation, Philips, Hitachi, Sony, Toshiba, Technicolor, and Silicon Image. HDMI is also supported by producers of motion pictures including Universal, Fox, Warner Bros. and Disney. Many system operators including DirecTV, EchoStar (Dish Network) and Cable Labs also support HDMI.

HDMI specifications and compliance are imposed by an organization called HDMI LLC, which is governed by the seven founding companies. So far, HDMI Specifications have been adopted by over 1200 largest consumer electronics, personal computers and cellphone manufacturers.

HDMI is a standard feature in over 1 billion consumer products.

In 2011, HDMI Forum was created by the HDMI Founders with an objective to nurture future development of the technology, to enable companies to contribute in the growth of the HDMI Specification. Approximately sixty of the largest consumer electronics, personal computers and semiconductor companies have joined their hands to make HDMI Specification better and widely adopted.

HDMI – Specifications

Audio

HDMI supports 8-channel of audio with resolution of 24 bits and sampling rates up to 192 KHz, thereby supporting uncompressed digital audio and all presently-available compressed formats. HDMI also supports audio streams such Dolby TrueHD and DTS-HD Master Audio which are lossless and compressed. HDMI also provides Audio Return Channel (ARC).

Video

HDMI supports existing HD video formats (720p, 1080p and 1080i). It has got the flexibility to support enhanced video formats as well as NTSC and PAL (standard definition formats).

Video data can use pixel sizes of 24, 30, 36 or 48 bits. Color depths greater than 24 bits are defined to be "Deep Color" modes. Encoding of video pixels can be done in either RGB, YCBCR 4:2:2 or YCBCR 4:4:4 formats.

HDMI 1.0 - 1.2a uses the EIA/CEA (Electronic Industries Alliance/Consumer Electronic Association)-861-B video standard, HDMI 1.3 employs the CEA-861-D video standard, whereas HDMI 1.4 employs the CEA-861-E video standard. HDMI 1.4 provides additional colors to support digital still cameras.

Cables

HDMI cable looks like a USB cable but is able to support high bandwidth of 5 Gbps which is more than sufficient to transport multichannel audio and video. Standard HDMI cables (or "category 1"): These cables have been tested for their performance at speeds of 75 MHz. High Speed (or "category 2") HDMI cables: These cables have been tested for performance at speeds of 340 MHz; this is the maximum bandwidth currently achievable over an HDMI cable. High-Speed cables also support higher resolution displays (resolution upto 2560 x 1600).

Communication Channels

HDMI integrates data link (TMDS), status link (CEC), control link (DDC) and configuration protocols in a single miniature connector. The data link is unidirectional and low speed whereas control and status links are bidirectional and of high speed.

The HDMI cable and connectors have 4 differential channels; three of them are for audio, video and auxiliary data while one of them is used for TMDS clock.

HDMI carries an I2C specification based VESA DDC (Display Data channel). The DDC is utilized for configuration and status exchange between a single transmitter and a single receiver. The DDC is used by the transmitter to read the

receiver's Enhanced Extended Display Identification Data (E-EDID) in order to discover the receiver's configuration and capabilities.

The optional CEC protocol is used for providing control functions between various audio and/or video products.

Data Security

Along with HDCP (HD Content Protection), HDMI offers a safe audio/ video interface meeting security specifications of system operators and content providers.

Compatibility with DVI

HDMI has full backward compatibility with DVI for digital TVs. HDMI DTVs display video received from DVI equipped products and DVI equipped TVs, (equipped with HDCP decoding) display video from HDMI sources.

Advantages of HDMI

Quality:

Being a digital interface, HDMI ensures all digital rendering of highest, crispest quality video by avoiding losses associated with analog interfaces such as Component Video or S-Video.

Ease-of-use:

HDMI integrates multiple channel audio and video in one single cable, reducing the complexity, involved in variety of different A/V cables currently used in A/V systems. Single cable offers advantage during system upgrades/modification. Single cable also results in cost reduction.

Intelligence:

HDMI allows bidirectional communication between the DTV and the video source (such as a DVD player), enabling new functionality such as one-touch play and automatic configuration. HDMI also allows devices to automatically select and deliver the best according to the display that it is connected to.

Support for multiple formats

Not only does it provide the functionality and the quality of a digital interface, HDMI supports uncompressed video formats along with multiple audio formats (standard/ multi-channel /stereo / surround sound).

Conclusion

HDMI is replacing all analog interfaces which used to be there in PCs and TVs. HDMI are available in almost all consumer electronics like digital cameras and camcorders, HD DVD players, Blu-ray disc, and mobiles and also on Personal computers and Tablets.

In times to come, jungle of all audio and video cables is likely to disappear and will be replaced by HDMI cables. HDMI is likely to become a standard on all CEs and PCs.

Program Outcomes (POs)

PO1	**Engineering Knowledge:** Apply the knowledge of mathematics, science, and engineering fundamentals to solve the complex electrical engineering problems.
PO2	**Problem Analysis:** Identify, formulate, review research literature, and analyze complex Electrical and Electronics Engineering problems enabling attainment of conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions:** Design solutions, components or process for complex Electrical Engineering problems to meet the specified needs considering public health, safety and environmental considerations.
PO4	**Conduct Investigations of complex problems:** Exercise research knowledge and technical methodology for design, analysis and interpretation of data to converge to a suitable solution.
PO5	**Modern Tool Usage**: Use modern engineering tools, softwares and equipments to predict, analyze and model engineering problems.
PO6	**The Engineer & Society:** Apply reasoning skills to assess societal, health, safety, legal and cultural issues relevant to the professional engineering practice and take consequent responsibilities in the society
PO7	**Environment and Sustainability:** Realize the impact of the professional engineering solutions and demonstrate the knowledge for sustainable development in environmental context
PO8	**Ethics:** Apply and realize the professional ethics and responsibilities in Electrical engineering practice.
PO9	**Individual and Team Work:** Exhibit Individuality, Leadership and Team spirit in multidisciplinary settings.
PO10	**Communication:** Communicate, comprehend, write reports, design documentation and presentation effectively on complex engineering activities
PO11	**Project Management & Finance:** Demonstrate the Electrical engineering and management principles adhering to financial strategies to manage projects as a member or leader in a team
PO12	**Life Long Learning:** Inculcate independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs)

PSO 1: Electrical drives and control: Graduates will Analyze, design and provide Engineering solutions in the field of Power Electronics and Drives

PSO 2: Embedded system: Graduates will Simulate, experiment and solve complex problems in Embedded System.

KSR INSTITUTE FOR ENGINEERING AND TECHNOLOGY

VISION

To become a globally recognized Institution in Engineering Education, Research and Entrepreneurship.

MISSION

- Accomplish quality education through improved teaching learning process.
- Enrich technical skills with state of the art laboratories and facilities.
- Enhance research and entrepreneurship activities to meet the industrial and societal needs.

Department of EEE

VISION

To produce world class Electrical and Electronics Technocrats and Entrepreneurs with social responsibilities.

MISSION

- Impart quality education in the field of Electrical and Electronics Engineering through state of the art learning ambience.
- Enrich interdisciplinary skills and promote research through continuous learning.
- Enhance professional ethics, entrepreneurship skills and social responsibilities to serve the nation.

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