TEGA© Panel Health Monitoring System

World's 1st Screen deck wear monitoring system
With world's only mobile app monitor.

TOTAL : Solution™

Introduction

-" There is no such thing as impossible, it's just a matter of figuring out how"

" The difficult takes time and the impossible takes a little longer".

Haruhiko Tanahashi Chief Engineer- Lexus Motors

In the field of extractive metallurgy, mineral processing is the process of separating commercially valuable minerals from their ores. The classification of mineral particles on the basis of particle size is an important process in the mineral benefaction industry and it is of great importance to keep mineral sizes within certain tolerance limits in order to maintain optimum efficiency of downstream extraction processes carried out on those mineral particles. Therefore, there exists a need for a technology to help industries keep a close check on the size of particles during classification. The current project aims to develop such a system.

Industrial Screening

Screening is the practice of taking crushed material and separating it into multiple grades on the basis of particle size. Industrial screening is extensively used for size separations from 300mm down to around 40µm. Screening tends to serve the following purposes:

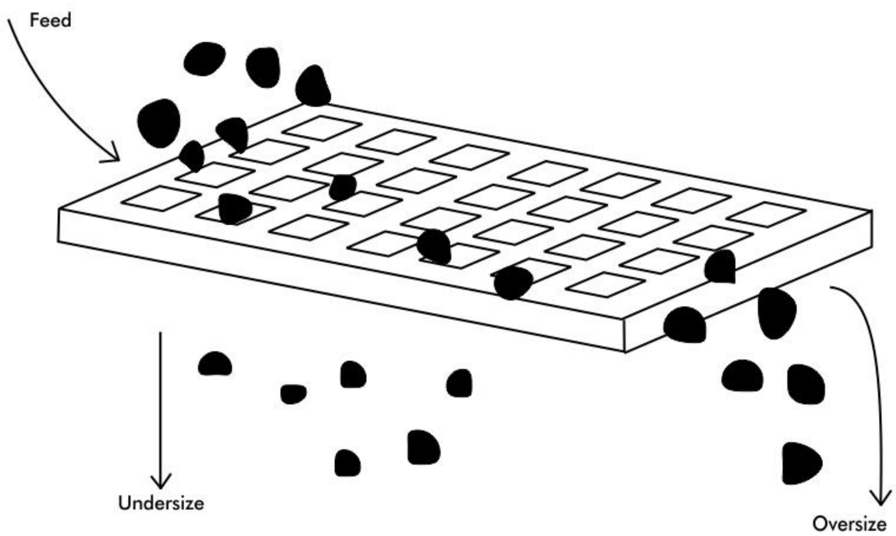
Sizing or Classification, to separate particles by size usually to provide a downstream unit process with particles having size range suited to that unit operation;
Grading, to prepare a number of products within specified size ranges. This is important in quarrying and iron ore, where the final product size is an important part of the specification;
Dewatering, to drain free moisture from a wet sand slurry;
Desliming, to remove fine material (called *fines)*, generally below 0.5mm from a wet or dry feed.

The screening process comprises of passing the mineral particles through a surface, called *screening media,* having apertures, or holes, of uniform dimensions. Particles of size greater than the aperture dimensions, called the *oversize*, are carried away while the particles of size smaller than the aperture dimensions, called the *undersize*, are allowed to pass through the surface, thus separating the oversize from the undersize.

The mining and mineral processing industry uses screening for a variety of processing applications. For example, after mining the minerals, the material is transported to a primary crusher. Before crushing, large boulders are scalped on a shaker with 0.25 in (6.4 mm) thick shielding screening. Further downstream after crushing the material can pass through screens with openings that continue to become smaller. Finally, screening is used to make a final separation to produce salable product based on a grade or a size range.

Screening Media

Screening media consists of a surface having many apertures, or holes, of a given size fixed to a support structure known as a *screen deck* or a *screen box*. Particles passing over that surface will either pass through or be retained, depending upon whether the particles are smaller or larger than the dimensions of the aperture. Screens are usually imparted a vibratory motion and are inclined at an angle (~ 15°)to prevent clogging of screen apertures and to facilitate easy movement of the particles.



Many types of screening surfaces are nowadays available. The selection of the material, shape and size of the apertures, proportion of open area will depend on the natures of the material being separated. Screening surfaces are usually manufactured from steel, rubber or polyurethane, and can be classified according to how they are fixed to the screen:

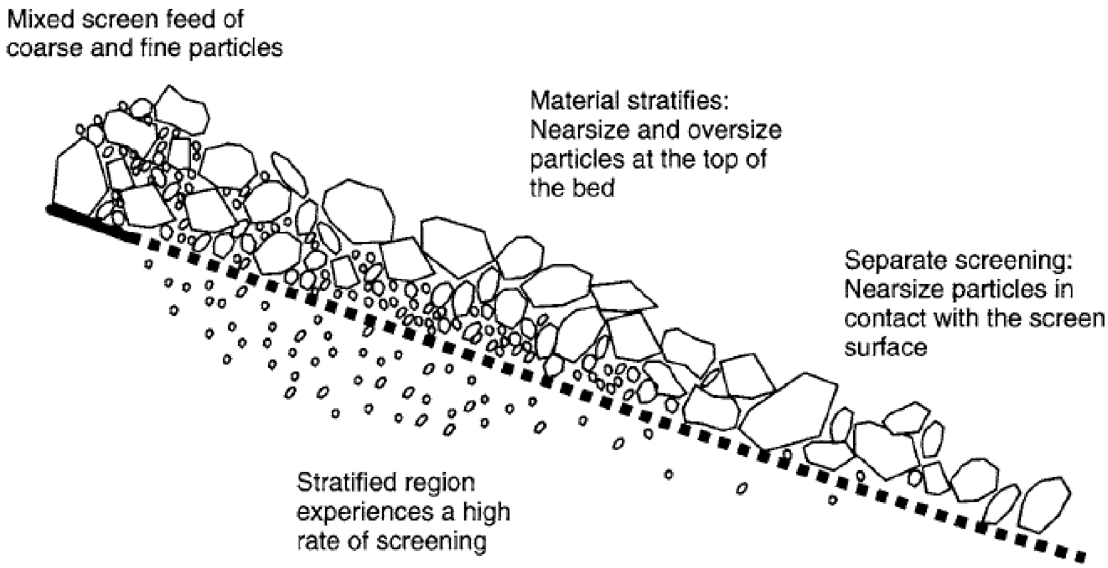
Bolt-in screening surfaces Screening surfaces used for particles larger than around 50m frequently consist of large sheets of punched, laser cut or plasma cut steel plate, often sandwiched with a polyurethane or rubber wear surface to maximize wear life. The screens are rigid and are bolted to the screen.

Tensioned screening surfaces Tensioned screen surfaces consist of membranes that are stretched taut, either between the sides of the screen (cross tensioned) or along the length of the screen (end tensioned).

Modular screening surfaces The most popular screening surfaces in harsh screening duties are polyurethane and rubber screen decks, usually assembled in modules or panels that are fixed onto a sub-frame (called *bucker-up frame*). Both materials offer exceptional resistant to abrasion. Rubber also has excellent impact resistance, and is therefore used in applications where top size can be greater than 50mm. The major advantage of modular polyurethane panels is the exceptional wear resistance in most applications; often 10 times the wear life is reported over traditional wire-mesh screens. Modular screens do not require tensioning and re-tensioning and damaged sections of the screen can be replaced *in situ.* Also, they are quieter and the more flexible apertures reduce blinding compared to steel wire meshes.

Screening Efficiency

The efficiency of screening operation is determined by the degree of perfection of separation of the material into size fractions above or below the aperture size.



Factors affecting screen performance

From the figure below, it is seen that as the size of the particle approaches that of the aperture, the probability of it going into oversize increases rapidly. Particles having size approaching that of the screen aperture, known as *near-mesh particles*, are mainly responsible for causing clogging of the apertures.

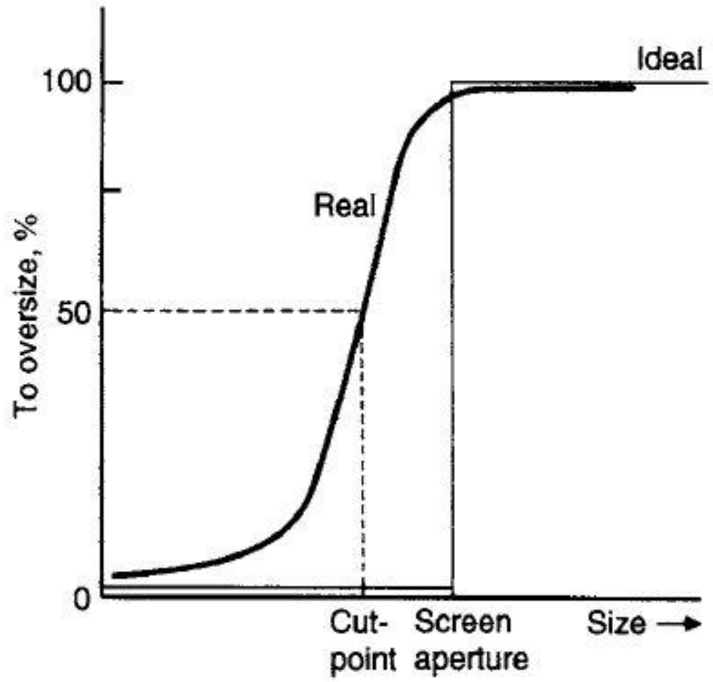
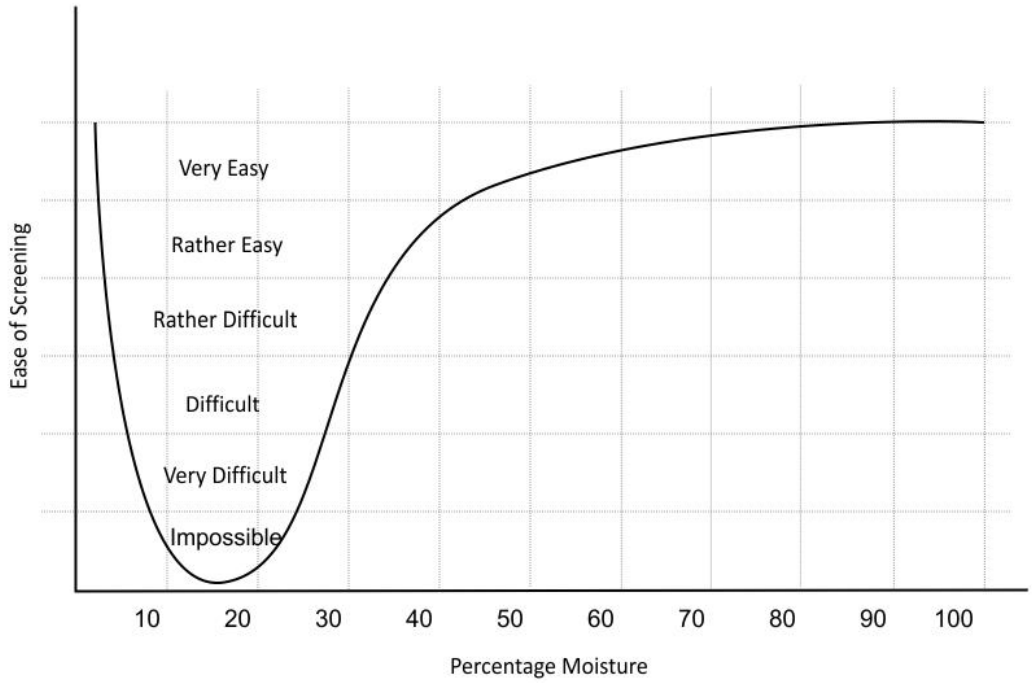


Fig: Partition Curve

The chief factors that affect the efficiency of the panels are as follows:

1. **Feed rate**: In industrial screening practice, economics dictate that relatively high feed rates be used. At these high feed rates, a thick bed of material is formed on the screen, and fines must travel to the bottom of the particle bed before they have an opportunity to pass through the screen surface. High capacity and high efficiency are, therefore, opposing requirements of any separation process.
2. **Screen angle**: The slope of the screening surface affects the angle at which particles are presented to the screen apertures. The screen angle also affects the speed at which particles are conveyed along the screen, and therefore, the dwell time on the screen and the number of opportunities particles have of passing the screen surface.
3. **Vibration**: Screens are vibrated in orders facilitate stratification of particles, which allow the fines to move through the layer of particles, at the same time causing larger particles to rise to the top. Also, vibration helps to prevent clogging of the apertures.
4. **Moisture**: The amount of surface moisture present in the feed has a marked effect on the screening efficiency, as does the presence of clays and other sticky materials. Damp feeds screen very poorly as they tend to agglomerate and clog the screen apertures.



5. **Actual screen aperture size and thickness** : With constant operation over a long period of time, due to abrasive wear of the screening media, the dimensions of screening apertures tend to increase, while the thickness of the panels decrease. With passage of time, therefore, the cut-point begins to deviate from the actual required cut point.

The Problem

"We can't solve problems by using the same kind of thinking we used when we created them."

- Albert Einstein

Conventionally, punched steel plates or wire-mesh were used as screening media, as these were easy to manufacture. However, these suffered from one major drawback – *low life*. Mineral particles are highly abrasive and they cause heavy wear and tear of wire-mesh and punched-hole screens, due to which the screens were reported to either fail regularly or their aperture sizes increased above the desired cut-point. Due to this problem, the customer suffers a loss not only due to frequent down-times of the plant for maintenance, but also due to inefficient separation of mineral particles, causing reduction in quality of products of the plants.

It was to solve this problem that polyurethane and hardened-rubber screening panels were developed. Tega Industries has been a premier in introducing this new product in the Indian market. Polyurethane is highly abrasion resistant, and replacement of conventional wire-mesh screens by polyurethane screens were reported to increase the life of panels by as much as 10 times.

However, even polyurethane panels are not absolutely abrasion resistant and need replacement from time to time. The replacement time may vary from plant to plant depending upon the abrasiveness of the mineral and total runtime. Therefore, we need a system that would be able to constantly monitor aperture size of the screens and inform the plant operator beforehand when the panels need replacement.

Purpose of the Project - The Problem Statement

The problem statement as given by the R&D team was as follows :

“Design a system to *measure wear* and *aperture size* of screens and to *wirelessly transmit* this data. “

Challenges of the Project

The technology required to solve the given problem posed a number of challenges before the working team. These challenges were required to be overcome in order to find a feasible solution to the given problem. Some of these were as follows:

1. *Operability in rough working conditions*: During operation, screens are imparted vibratory motion and are exposed to a very dusty environment, where periodic human access is usually difficult. Particles of various sizes usually fall with great impact on the panels, which require that the proposed device should be able to bear the vibrations as well as the huge impact.
2. *Capability of measurement during runtime*: It is but impractical to stop the operation of the plant to monitor the condition of the screens. Increase in down times obviously has direct impact in the form of reduction in the output of the plant which incurs a loss to the plant.
3. *Elimination of human involvement/ automation of the measurement process*: It is impractical for a human attendant to keep a check on the wear-rate of screen every now and then, chiefly because it is not possible to stop a working plant frequently. Also, there are usually a large number of panels in a single plant and it is difficult and dangerous to gain access to the screens, being usually covered from all sides.
4. *Accurate measurement*: Certain application might demand very small variations in particle size, and therefore the wear measurement technique has to be precise enough to detect wear as small as a millimeter.
5. *Cost effectiveness*: No customer would want to obtain this technology unless it is available at an affordable cost. Therefore, we do not want this device to be an “unnecessary luxury” for our customers.

The Ideation Process

"Any intelligent fool can make things bigger, more complex, and more violent. It takes a touch of genius—and a lot of courage—to move in the opposite direction."

- Albert Einstein

The process to finding a solution for the given problem was divided into several phases where the team looked into various aspects of the problem, part by part, finding solutions for each aspect and for the time being, not caring whether or not they were completely feasible for the present problem or not, and then putting together all the ideas gathered to form one final solution. The problem was divided into 'part-problems' on the basis of the specific requirements of the problem-statement:

1. Continuous/Discontinuous Measurement Methods
2. Online/Offline Measurement Methods
3. Remote/Near Measurement Methods

Continuous/Discontinuous Measurement 'Continuous' measurement here refers to a measurement process in which any amount of wear can be determined very precisely. 'Discontinuous' measurement, on the other hand, refers to a measurement process which can indicate only certain levels of wear.

Online/Offline Measurement Methods As emphasized beforehand, there exists a need to make measurements during running of the screens. Such methods shall be referred to as 'online' methods hence forth, and other methods that require operation of the screen to be stopped shall be referred to as 'offline' methods.

Remote/Near Measurement Methods Online measurement would require that the measurement be made from a remote location, not very close to the screen to save the equipment from damage by the harsh environment near the screen. Such methods have been referred to as 'remote' measurement methods here, while techniques which require the device to be situated in close proximity to the screen have been referred to as 'near' measurement methods.

With these requirements in mind, we zeroed in on the following possible methods which could lead to an effective wear measurement process:

1. Image Processing Method;
2. Thin Layer Activation Method;
3. Ultrasonic Measurement, and;
4. Embedded Wire Method.

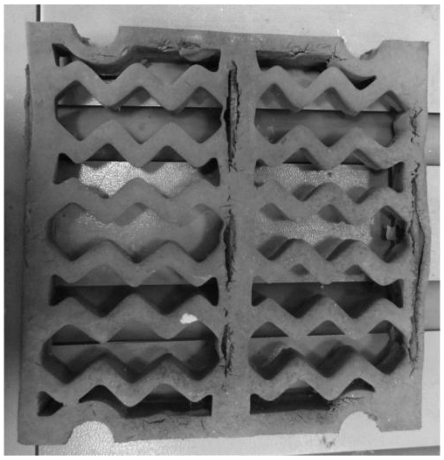
A brief description of each of these techniques is now presented below.

Image Processing

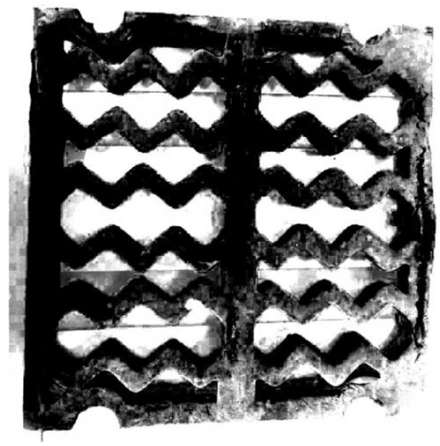
Image Processing is a form of signal processing for which the input data is an image, such as a photograph or a video frame, which is processed by some computer algorithms. By using a properly calibrated camera, it is possible to make several inferences from the image, like size and of objects, comparison between size of two objects and detection of specific motion of objects. Problems solved using image processing methods include artificial vision for artificial-intelligence robots, in monitoring of traffic and large crowds, motion-sensing video games and many more.

For the current problem, it is possible to monitor aperture dimensions by taking images of a screen at scheduled intervals and processing the image by a computer. By suitably calibrating the camera and having appropriate lighting conditions, it is possible to measure the dimensions of the apertures.

However a number of problems are encountered while proceeding with this method. Due to the flow of particles over the panels during operation, it is not possible to obtain a direct visual of the apertures, not to mention the large vibrations of the screen and a very dusty environment, which make it very difficult to take clear images of the screen during runtime.



Before : Raw, straight-out-of-camera image.



After: Image after processing by computer algorithms. Note that the apertures can now be clearly distinguished from the panel surface.

Also, in order that good images be obtained, it is important to have very controlled lighting conditions, which is not possible in a plant. Further, installation of camera on-site poses another problem.

Thin Layer Activation Method

In this method, a thin layer of radioactive material is deposited on the surface of the screens. The method makes use of the phenomenon that as the screens wear out slowly, the radioactive material deposited on the panels wear out too, which can be detected in the form of a decrease in radioactivity of the panels. Thin Layer Activation (TLA) method has the advantage of being able to measure even small amounts of wear, and hence is a continuous method. However, a lot of downsides exist with the current method. Firstly, TLA does not given a quantitative estimation of the level of wear in thickness and aperture size. An average wear can be estimated, which has contributions from both, decrease in thickness of panels as well as increase in aperture sizes. Thus, applications where aperture sizes are critical, this method cannot be used. Also, production of such panels would need a separate and very expensive infrastructure of its own.

Ultrasonic Thickness Measurement Method

Ultrasonic measurement is being employed extensively in industries where detection of internal holes, cracks etc is required. The methods involves primarily sending an ultrasonic wave through the material whose properties are to be known and by analyzing the reflected wave, suitable inferences about its thickness, presence of holes, etc. can be made.

Though quite accurate, ultrasonic measurement requires the sensors to be placed in close contact with the material being inspected. This makes employment of this method for the current problem difficult. Also, the current method can only provide information regarding the thickness of the panel, rendering it unsuitable for our project.

Embedded Wire Method

The month long ideation process led us to a unique method for measurement of wear of panels, which we called the *Embedded Wire Method.* The method simply involves laying out a wire-loop within the panel, strategically placed at a desired distance from the aperture circumference and at a desired depth from the surface of the panel. With continuous wear, the wire gets cut which can be detected by suitable electronic means. Since the wire was laid out at a known location, the level of wear of the panel can be easily inferred. This method was deemed by the team to be the cheapest and easiest method of determining wear-levels accurately, and hence was preferred over the other methods mentioned above. The pages that follow give an detailed description fn the *Tega Panel Health Monitoring System* (TPHMS), the proposed product by us.

The Proposed Solution

"The solution of one problem is another problem."

- Johann Wolfgang von Goethe

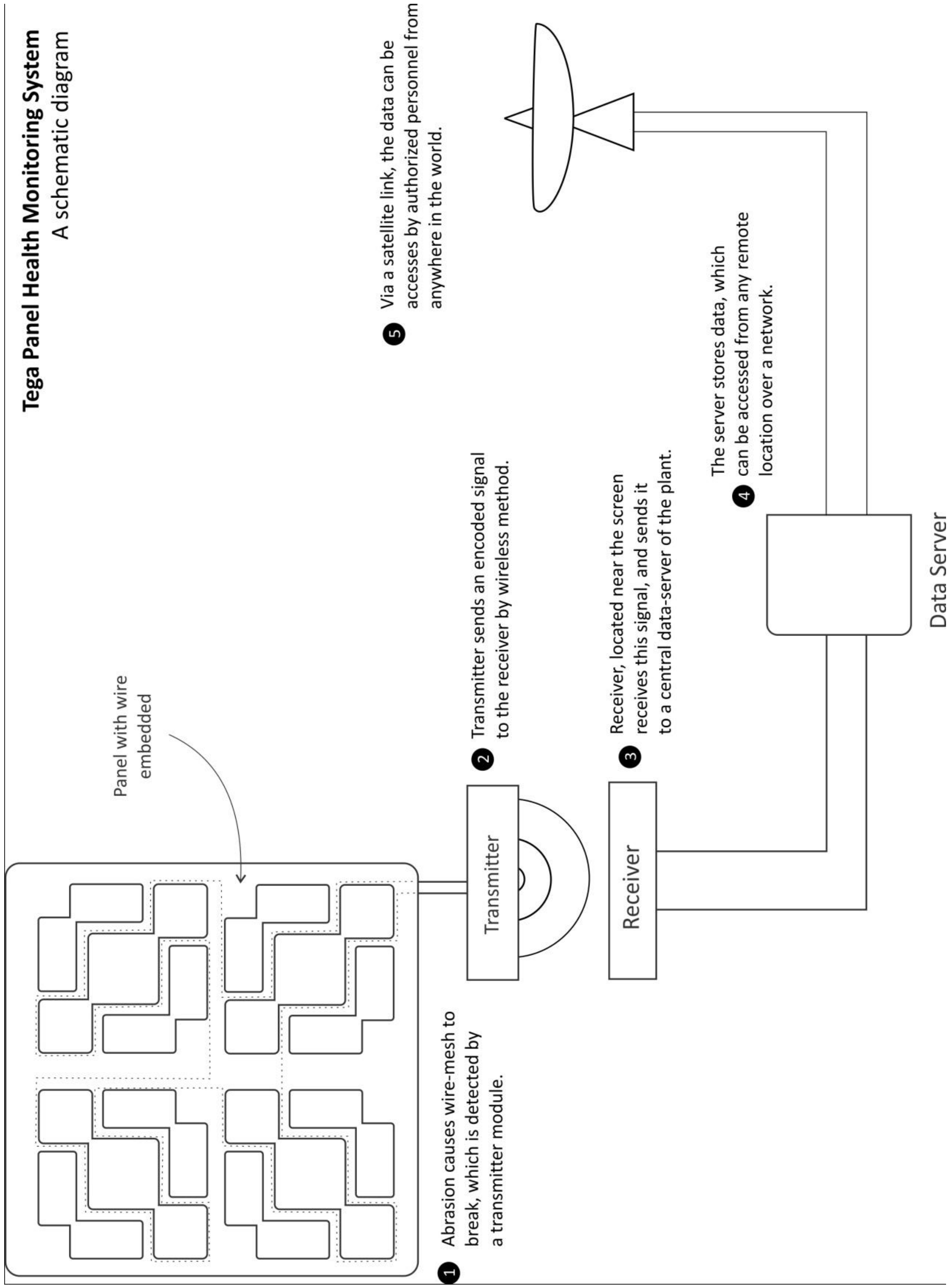
The ideation process, which lasted for around a month, gave rise to a solution which was deemed to be the most feasible out of the various possibilities considered. The following sections contain a detailed description of the system proposed to solve the problem of detection of wear of screen panels. An attempt to clearly explain the idea and the rationale behind each decision has been made by making use of a suitable data and a number of illustrations.

The Tega Panel Health Monitoring System (TPHMS)

The final solution proposed, named as the *Tega Panel Health Monitoring System or the TPHMS*, works on the simple principal that abrasion can cause a thin, conducting wire embedded within the polyurethane panel to break, causing disruption in electrical connectivity of a circuit. This interruption can be detected by some suitable means and would be indicative of impending failure of the panel. Here failure refers to the increase in aperture of the panel above a specified tolerance level. A schematic diagram showing the basic working of TPHMS is show in the next page.

Wire Layout

The wire loop should be placed in such a way that it should pass through all critical areas of the panel. The two parameters that decide the sensitivity of EWAS are the lateral distance of the wire from the apertures and its depth from the top-surface of the panel. On the basis of whether a



single wire or multiple wires are used, the wire-meshes can be classified to be either single-wire system or differential-wire system.

Single Wire System A single wire system is the classic system as described above. It consists of a single loop of wire that passes through critical areas of the panel. Single wire systems are however, a little impractical from the point of manufacturing as different applications might have different tolerances on the changes in aperture sizes. Therefore, several different types of panels would need to be manufactured depending on the various possible applications. This calls for a bigger manufacturing infrastructure, which is not desirable. It is to solve this problem of variability of customer demand that the *Differential Wire System* has been proposed.

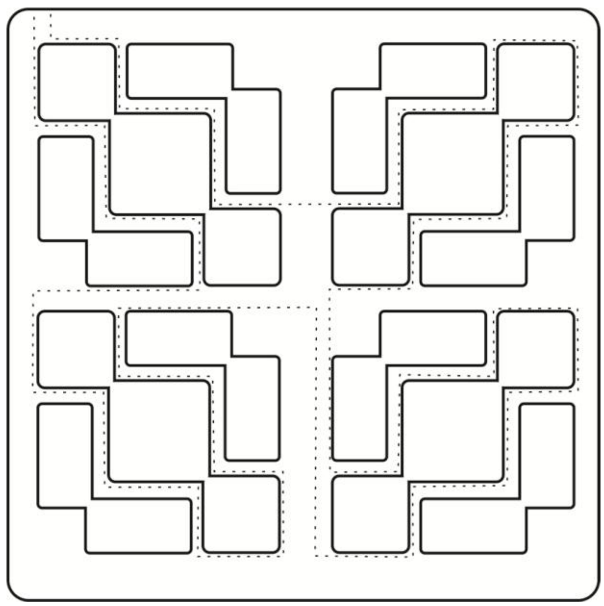


Figure: Single Wire System

Differential Wire System The Differential Wire System is a variant of the Single Wire System, with the modification that instead of a single wire, a number of wires are laid down at different heights and distances from the apertures. Failure of each wire generates a unique signal, which is indicative of the various levels of wear of the panel in terms of aperture size and thickness. Such a wire-layout system can, therefore, single handedly cater to the needs of a large number of applications.

Transmitter Unit

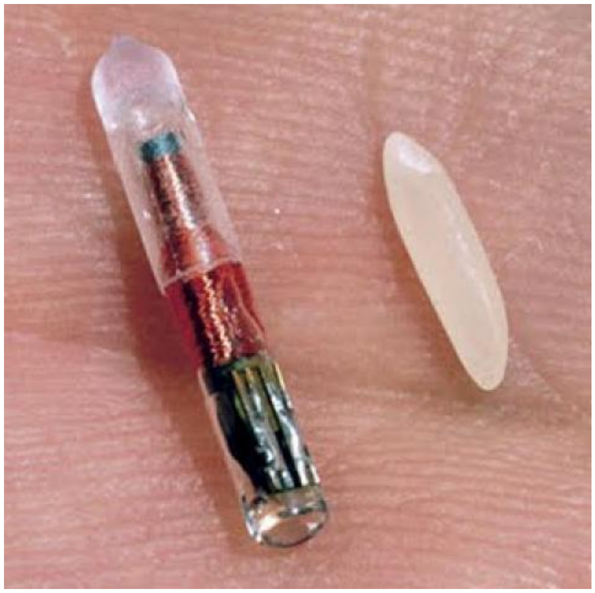
The transmitter unit represents a small module embedded within the panel that is responsible for detecting the breakage of the wires and transmitting this information to a data unit. This data may be transmitted by wired or wireless means, although wireless methods are preferred as it saves us the labor and intricacy of laying out wires for each panel. Various alternatives exist for wireless methods:

RF Modules An RF module consists of a transmitter circuit (called *Tx*) and a receiver circuit (called *Rx*). These can be connected to any microcontroller capable of RS-232 communication, after which wireless communication between the microcontrollers can be easily established. Although easy to implement, these are bigger in size and need an external power source for operation.

Transmitter (Tx) Circuit   Receiver(Rx) Circuit

Figure : A typical 434 MHz RF Module

RFID Tags Radio Frequency Identification or RFID is a surveillance system employed mainly to keep track of inventories and top prevent shoplifting in shopping-malls and stores. Perhaps the biggest advantage of RFID is that it does not require any battery as a power-source, which enables heavy miniaturization in its size. This feature makes RFID tags particularly attractive for the present problem, as the problem of embedding these tags in the panels is very easy.



RFID tags can be made extremely small! : RFID chip next to a grain of rice. This chip contains a radio-frequency electromagnetic field coil that modulates an external magnetic field to transfer a coded identification number when queried by a reader device. This small type is incorporated in consumer products, and even implanted in pets, for identification.

Receiver Unit

The receiver unit is the first point where data from the beacons is received. The data, preferably digital, can then be relayed to a central server of the plant. This data can be displayed on a computer screen in a suitable form, through which the health status of the panels can be continuously monitored. The type of receiver used depends solely on the type of transmitter employed.

Prototyping

"...durch planmässiges Tattonieren."

("...through systematic, palpable experimentation.")

- Carl Friedrich Gauss, when asked how he came upon his theorems

A prototype of TPHMS was built using 434MHz RF transmitter and receiver modules. RFID, although a promising solution, could not be employed for prototyping, mainly because of non-availability in small numbers for experimentation and requirement of a very expensive reader (> INR 1,00,00,000).

The prototype developed in this project consisted of the following parts:

1. A Rapid-O-Byta screen panel with wire inlay;
2. An RF Transmitter Module;
3. An RF Receiver Module.

The purpose of this prototype was to:

1. Access the performance of RF signals in transmitting through polyurethane panels;
2. Understand design requirements for the transmitter module;
3. And, understand intricacies of the wire inlaying process.

Construction

The Transmitter Module

The Transmitter module consisted of an ATMEGA8L microcontroller unit (MCU) by ATMEL Corporation connected to a Tx module operating at 434MHz. The reasons for the choice of the microcontroller were as follow:

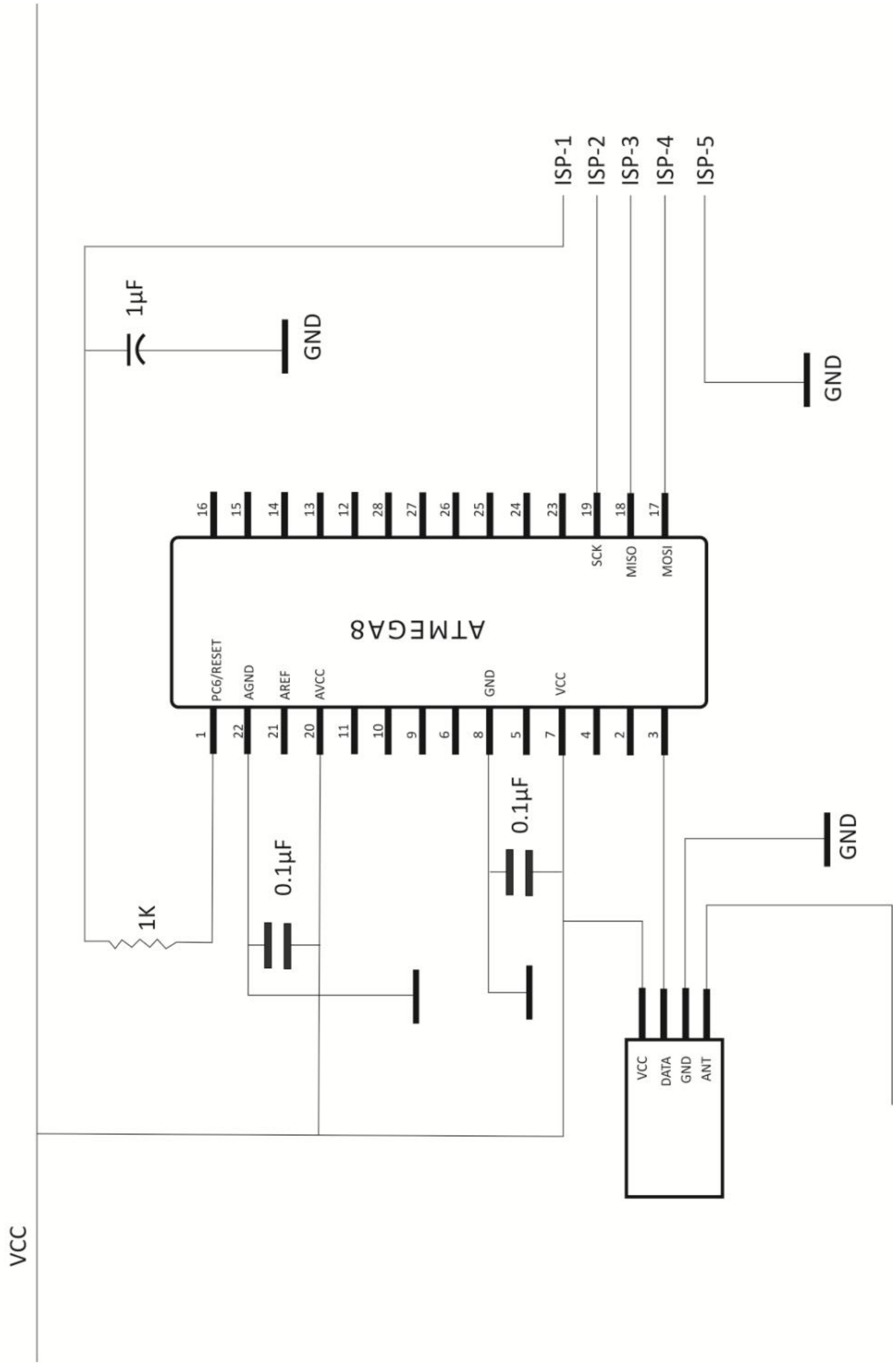
1. It is easy to program and the team had previous experience in using this IC. Thus considerable time could be saved which otherwise would have been lost in learning to use a new microcontroller. Also, it is reprogrammable and so there was a lot of scope for experimentation;
2. ATMEGA8L has an operating temperature of -55oC to +125oC, which makes it suitable for bearing the high temperature faced during moulding;
3. Programming is possible in C or Assembly Language. C, being more user-friendly, was the preferred choice.

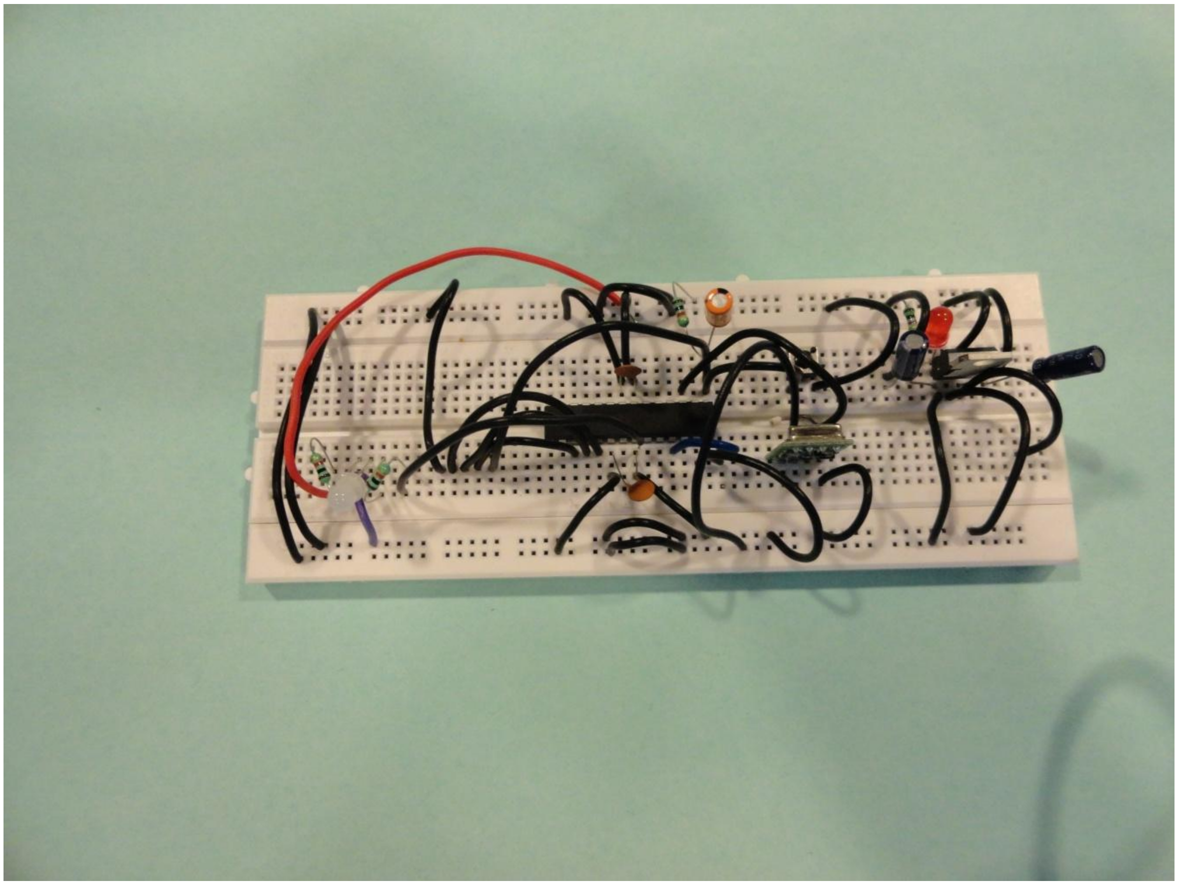
However, there exist smaller MCUs like ATtiny series by ATMEL Corporation which may be used for further miniaturization of the circuit. The MCU was programmed to send a signal when the wire-layout in the panel was broken, which caused an LED on the receiver to turn from GREEN to RED. The module was first assembled, programmed and tested on a breadboard, after which it was soldered to a printed-circuit board. Post soldering, the circuit measured 6cm x 4cm x 1cm.

Power Source for Transmitter

In the current prototype, power was provided to the transmitter unit by a 5V DC adapter circuit built using a 12V/1A DC adapter and a 7805 voltage regulator IC. However, Li-ion batteries are proposed to be used for in actual implementations as they can have a long life of 3-5 years.

Transmitter Circuit

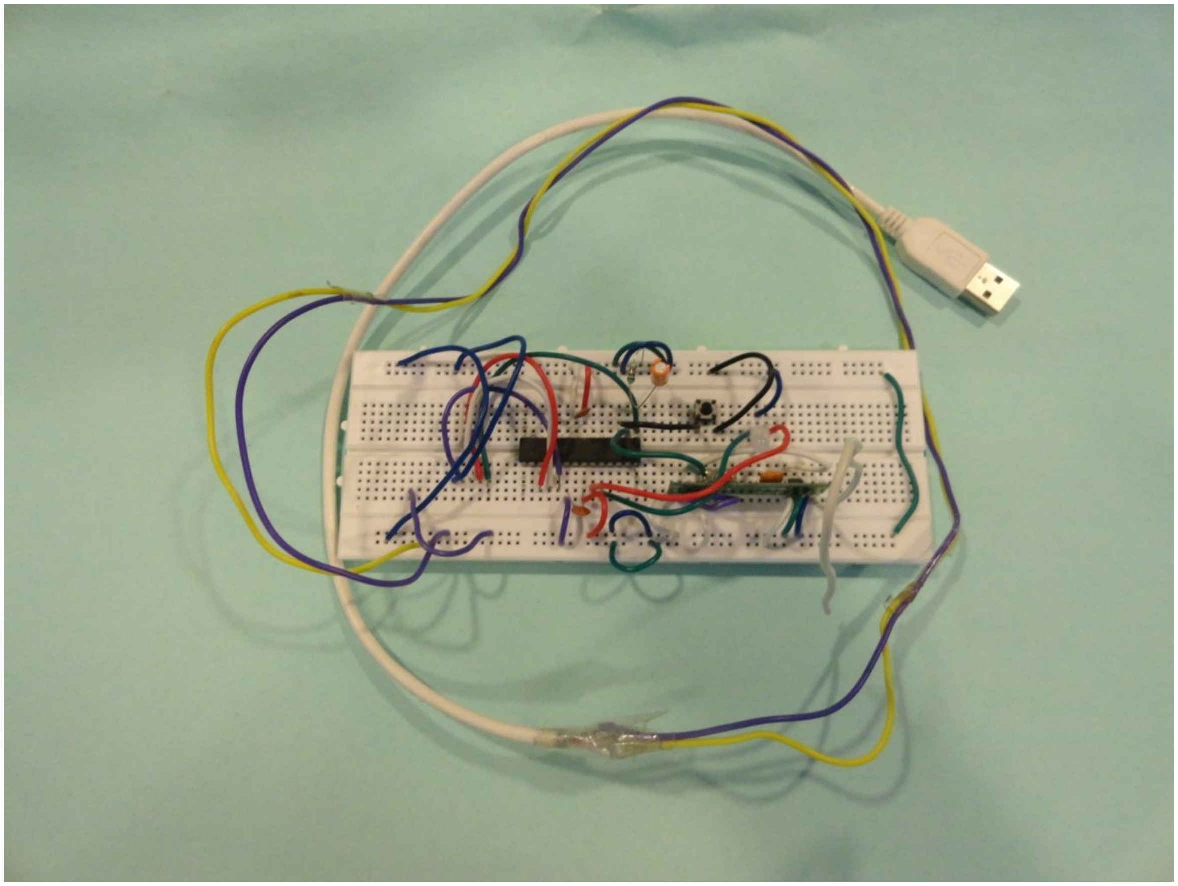




Picture : Transmitter when assembled on a breadboard

Receiver Module

The Receiver Module consisted of an ATMEGA8L microcontroller connected to a Rx module operating at 434MHz and a red-green LED. The microcontroller was programmed to turn the LED from GREEN to RED when an appropriate signal is received from the transmitter module. The circuit was assembled on a breadboard and tested and programmed there only.



Picture : Receiver circuit, when assembled on a breadboard

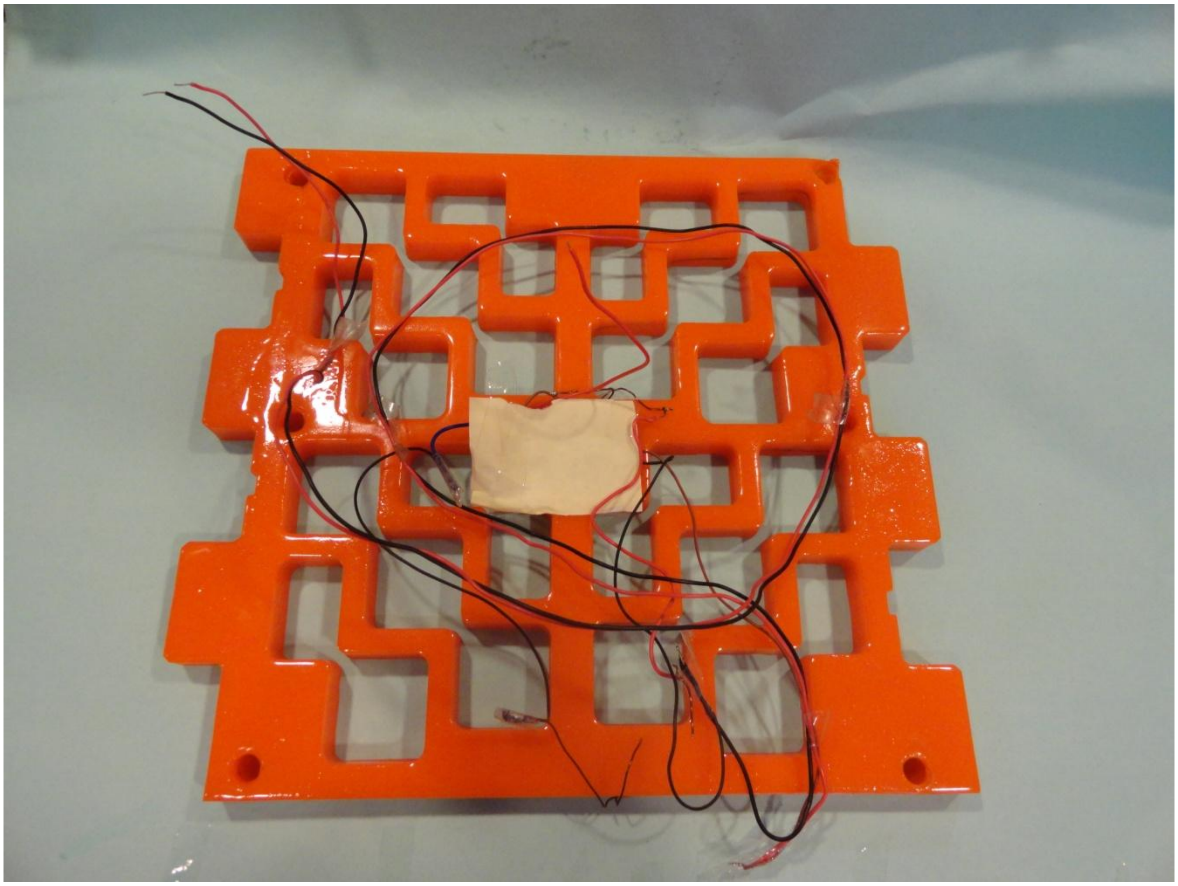
Wire Inlay in Rapid-o-Byta Screen Panel

A 0.8mm copper wire was embedded at a depth of 2mm from the top-surface of the panel. The lateral distance of the wires from the apertures could not be precisely controlled because the wire-mesh was made using crude handmade methods. Copper was chosen as a wire-material as,

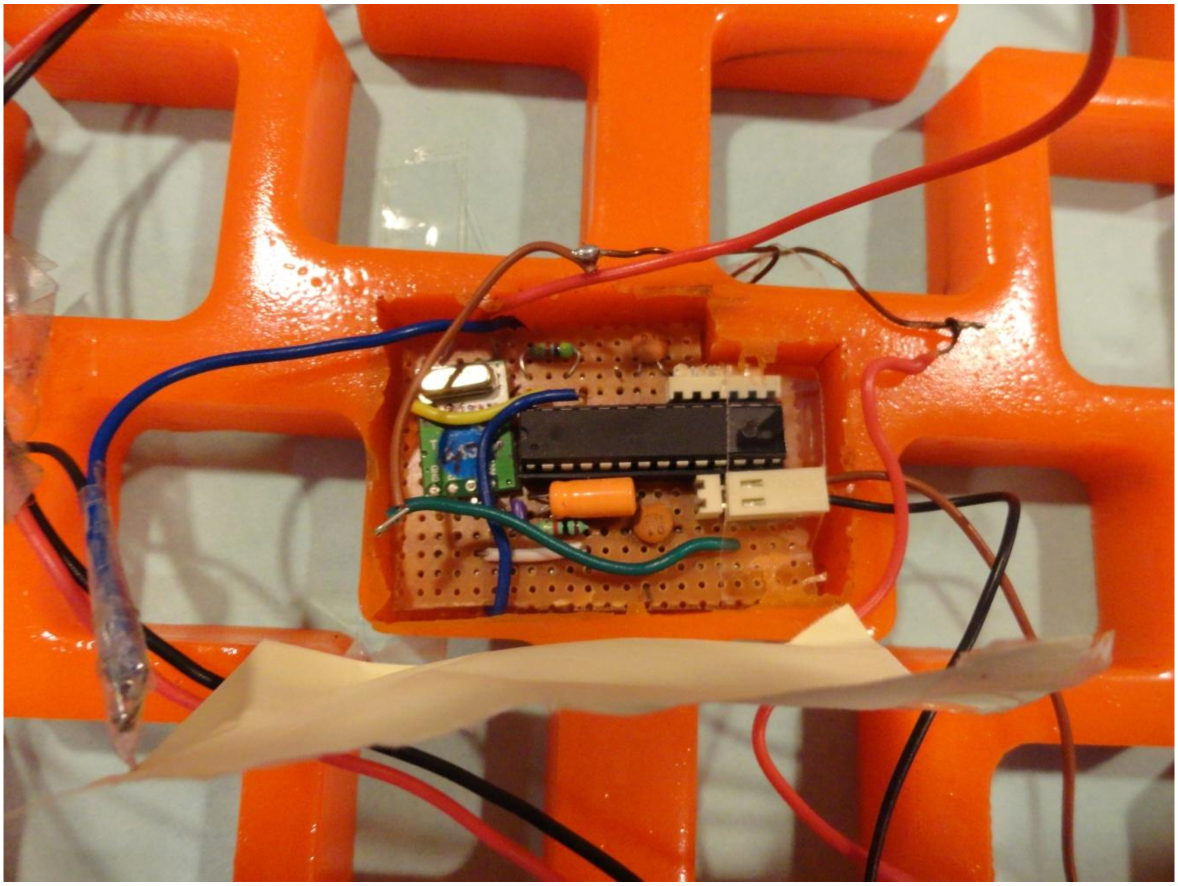
Conducting The material should be highly conducting with as low-internal resistance as possible.

Low-resilience Low resilience was a necessary requirement for the wire material as it was required that the wire should stay in the form given to it for long periods of time, as any deformation before or during the moulding process might give rise to erroneous placement of the wire, giving an altogether inaccuracy to the measurement of wear of the screen panel.

Cheap The material of the wire should be cheap enough to not raise the price of the panel by a large margin.



Picture : The final prototype. The screen used for prototyping was a Rapid-o-Byta™ screen panel. A mesh of copper wire was embedded within its polyurethane body. In the center is the embedded transmitter module.

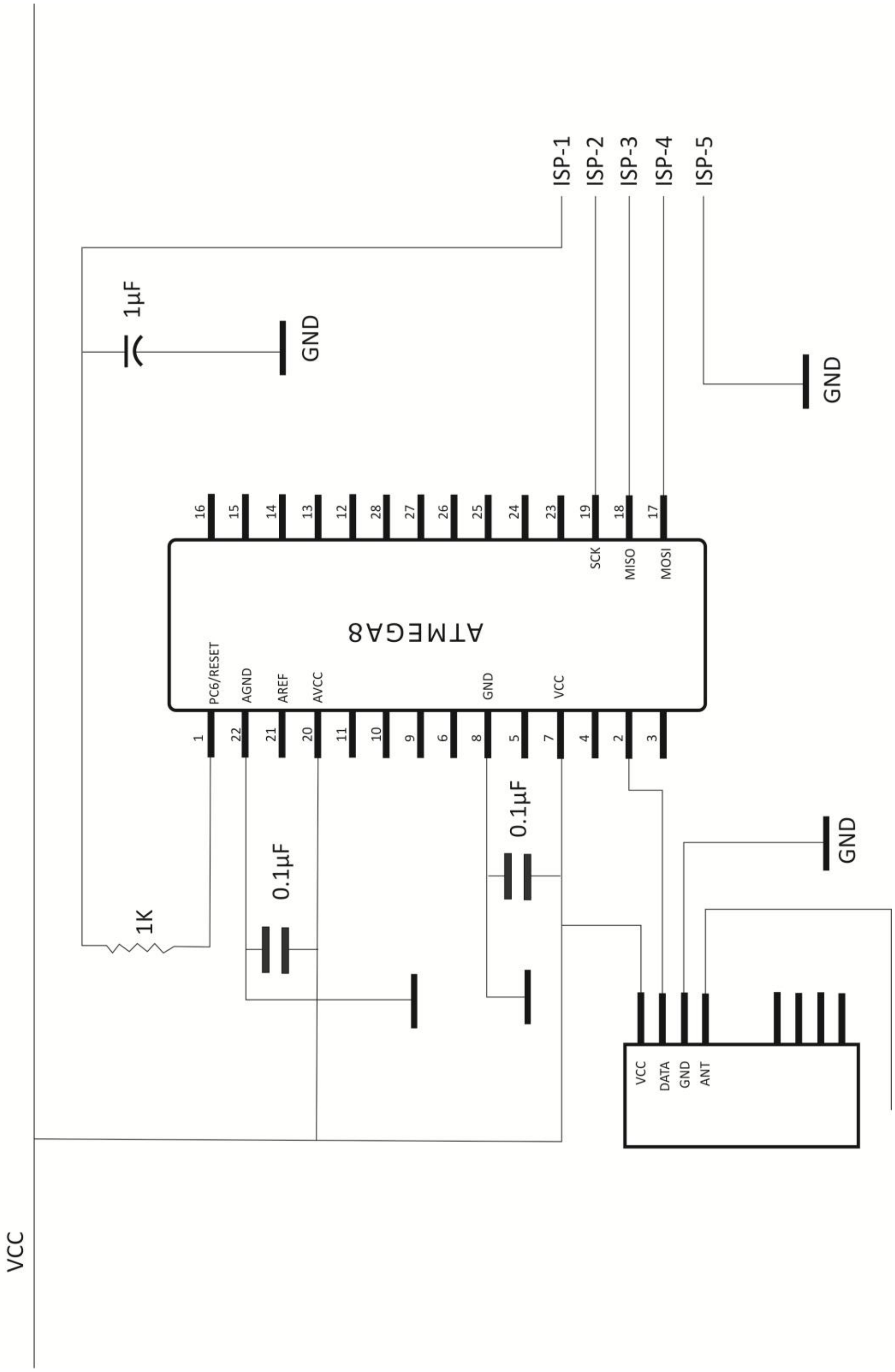


Picture: Close-up of embedded transmitter.

Explanation of basic working

When the aperture wears to the threshold level, the conducting wire-mesh gets cut, sending a signal to the transmitter module embedded within the panel. The transmitter transmits this information wirelessly to a receiver situated close to the panel, which is then relayed to a central station. From here, the status of the screen-panel can be monitored via a graphical user-interface. Also this data can be transmitted over a network to the manufacturing company, which can accordingly keep adequate stock ready for timely availability to the customer.

Receiver Circuit



Tests and Results

The Transmitter module needed to be tested for its detection range. Experiments yielded the following results:

Condition	**Approximate Maximum Range**
In air, with antenna on both transmitter and receiver.	10 feet
In air, with antenna on transmitter only	100 feet
In air, with antenna on both transmitter and receiver	100 feet
Transmitter in polyurethane without antenna and receiver in air with antenna	15 feet
Transmitter in polyurethane with antenna and receiver in air with antenna	30 feet

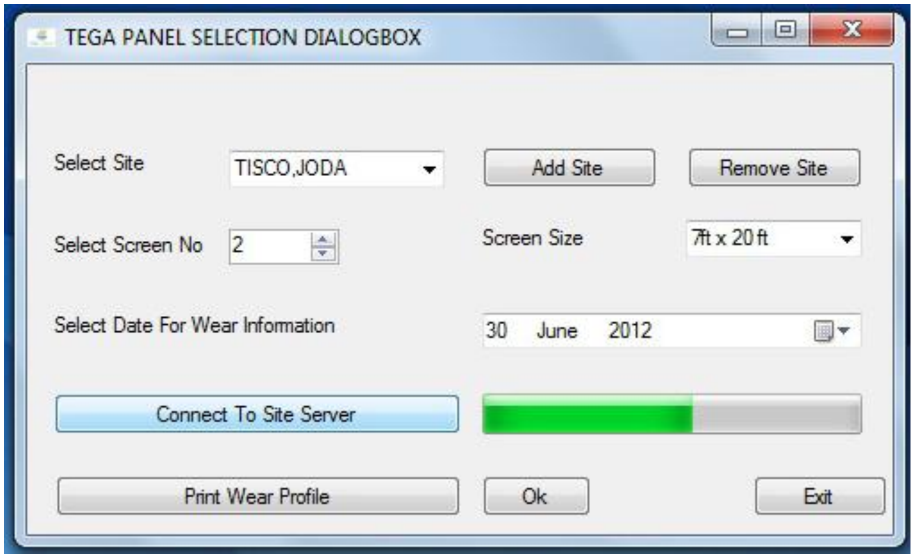
Note : *A wire antenna of length one-fourth of the operating wavelength, i.e. 17 centimeters, was found to be to be the most effect in transmission and reception of signals and hence, was used for both the transmitter and the receiver.*

The above results show that a satisfactory range of 30 feet can be obtained from a 434MHz RF transmitter without using any voltage amplifiers. By using appropriate voltage amplifiers, the range of the transmitter may be further extended.

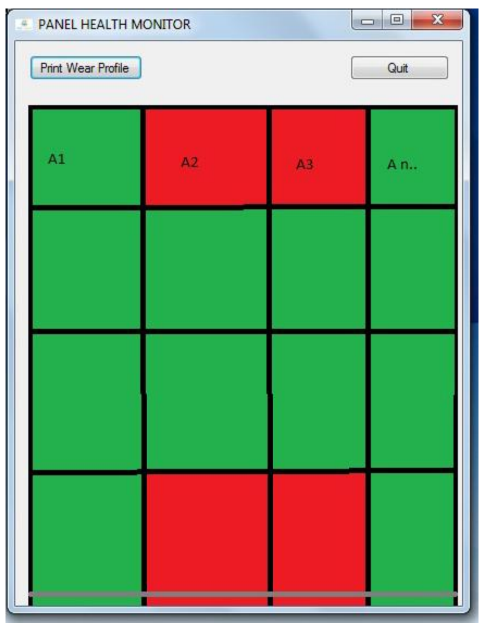
Software Interface

Representing the data captured in a suitable form was deemed necessary and hence a dummy software interface was also developed by the team to display the power of EWAS. The software was written in Visual Basic in Microsoft Visual Studio. The software interface allows any authorized personnel to login into a server and fetch the screen wear-data for any specific screen of any location desired. To be able to visually assess the condition of the screens, working screens were represented by green color while faulty screens were represented by green. When differential wire meshes are used, it would be possible to use multiple colors to indicate various levels of wear of the screen.

Login Panel: Screenshot showing login window which restricts data access to authorized personnel only.



Screen-selection window: This window allows any particular screen to be selected from a list of locations available.



Panel Health Display Window: The health of the panel is represented by its color. A red square means a damaged panel, while a green square represents a healthy panel.

Scope for Improvement

"Every day, in every way, I am getting better and better."

- Emile Coue

-

The current work is just a beginning into solving the problem of timely detection of wear of screen-panels. A number of problems still need to be solved before the current prototype can turn in a full-fledged commercial product. The areas in which further improvements can be made in the current invention are as follows:

1. Increase in range of the transmitter by the use of amplifiers and better antenna design;
2. Further miniaturization of the circuit;
3. Carrying out prototyping using RFID tags.

TABLE OF CONTENTS

INTRODUCTION

In the field of extractive metallurgy, mineral processing is the process of separating commercially valuable minerals from their ores. The classification of mineral particles on the basis of particle size is an important process in the mineral benefaction industry and it is of great importance to keep mineral sizes within certain tolerance limits in order to maintain optimum efficiency of downstream extraction processes carried out on those mineral particles. Therefore, there exists a need for a technology to help industries keep a close check on the size of particles during classification. The current project aims to develop such a system.

Industrial Screening

Screening is the practice of taking crushed material and separating it into multiple grades on the basis of particle size. Industrial screening is extensively used for size separations from 300mm down to around 40µm.Screening tends to serve the following purposes:

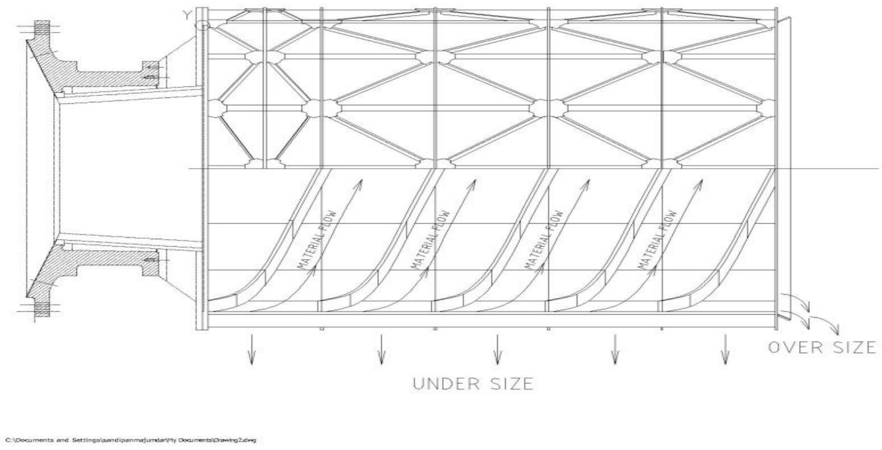
Sizing or Classification, to separate particles by size usually to provide a downstream unit process with particles having size range suited to that unit operation; *Grading,* to prepare a number of products within specified size ranges. This is important in quarrying and iron ore, where the final product size is an important part of the specification;
Dewatering, to drain free moisture from wet sand slurry;
Desliming, to remove fine material (called *fines)*, generally below 0.5mm from a wet or dry feed.

The screening process comprises of passing the mineral particles through a surface, called *screening media,* having apertures, or holes, of uniform dimensions. Particles of size greater than the aperture dimensions, called the *oversize*, are carried away while the particles of size smaller than the aperture dimensions, called the *undersize*, are allowed to pass through the surface, thus separating the oversize from the undersize.

The mining and mineral processing industry uses screening for a variety of processing applications. For example, after mining the minerals, the material is transported to a primary crusher. Before crushing, large boulders are scalped on a shaker with 0.25 in (6.4 mm) thick shielding screening. Further downstream after crushing the material can pass through screens with openings that continue to become smaller. Finally, screening is used to make a final separation to produce salable product based on a grade or a size range.

Trommel is a cantilever type rotating structure connected to mill discharge end, it provides support to the perforated rubber/ PU screen panels. Trommel is used to segregate the underground, oversize materials; pebble and impurities; broken ball of ball mills from the mill discharges.

Below cut size particle and slurry will be flown out of the trommel through the aperture and over size will be pushed out by the spiral for the subsequent handling. Spiral maintains the balance of slurry velocity. So there is no significant mismatch between drop out velocity and axial velocity. Which eventually result in perfect slurry discharge as trommel undersize.



Parameters determining size

- Ore specific gravity
- Feed (t/hr)
- Circulating load
- Surge factor
- Volumetric flow rate (m3/hr)
- Maximum particle size
- Mill feed
- Mill discharge
- Discharge % of solids

Advantages:

- Long life
- Cost economic.
- Optimum Trommel size.
- Wide range of apertures (PU & RBR)
- Scrolls of different heights & pitches.
- Easy to fit & remove.
- Finite Element Analysis (FEA) of the Trommel Structure results in high safety.

THE PROBLEM

Conventionally, punched steel plates or wire-mesh were used as screening media, as these were easy to manufacture. However, these suffered from one major drawback – *low life*. Mineral particles are highly abrasive and they cause heavy wear and tear of wire-mesh and punched-hole screens, due to which the screens were reported to either fail regularly or their aperture sizes increased above the desired cut-point. Due to this problem, the customer suffers a loss not only due to frequent down-times of the plant for maintenance, but also due to inefficient separation of mineral particles, causing reduction in quality of products of the plants. Also, the efficiency of the processing down the line decreases and sometimes even the machines are damaged due to clogging or other issues because of oversized particles.

It was to solve this problem that polyurethane and hardened-rubber screening panels were developed. Tega Industries has been a premier in introducing this new product in the Indian market. Polyurethane is highly abrasion resistant, and replacement of conventional wire-mesh screens by polyurethane screens were reported to increase the life of panels by as much as 10 times.

However, even polyurethane and rubber panels are not absolutely abrasion resistant and need replacement from time to time. The replacement time may vary from plant to plant depending upon the abrasiveness of the mineral and total runtime. Therefore, we need a system that would be able to constantly monitor aperture size and the threshold height wear of the screens and inform the control room beforehand when the panels need replacement, so they can order the next set in time and do the replacement in a suitable maintenance or downtime.

Purpose of the Project - The Problem Statement

"Design an autonomous monitoring System to Indicate failure of panels. "

Here, failure of panel includes both the wear of threshold height of screen and the increase of the size of apertures.

Challenges of the Project

The technology required to solve the given problem posed a number of challenges before the working team. These challenges were required to be overcome in order to find a feasible solution to the given problem. Some of these were as follows:

6. *Operability in rough working conditions*: Trommel is a continuously rotating machine which has high slurry levels (around 50-60%) and the inside is completely dark. Human access within the Trommel is very difficult and is generally not done for purposes other than panel replacement. Particles of various sizes usually fall with great impact on the panels, requiring that the proposed device should be able to bear the vibrations as well as the huge impact.
7. *Capability of measurement during runtime*: It is but impractical to stop the operation of the plant to monitor the condition of the screens. Increase in down times obviously has direct impact in the form of reduction in the output of the plant which incurs a loss to the plant. In some plants, losses of non-productivity of mill and trommel are to the tune of $50,000. Thus, the problem statement resorts to providing solution to such customers who are willing to adapt new technologies as some initial expense but want to maintain or increase their productivity by cutting down down-time losses.
8. *Elimination of human involvement/ automation of the measurement process*: It is impractical for a human attendant to keep a check on the wear-rate of screen every now and then, chiefly because it is not possible to stop a working plant frequently. Also, there are usually a large number of panels in a single plant and it is difficult and

dangerous to gain access to the screens inside the Trommel. Also, measurement of aperture size using measurement tools inside a Trommel having multiple number of screens with multiple number of apertures arranged in a rotating cylinder is a daunting task.

9. *Accurate measurement*: Certain application might demand very small variations in particle size, and therefore the wear measurement technique has to be precise enough to detect wear as small as a millimeter.
10. *Cost effectiveness*: No customer would want to obtain this technology unless it is available at an affordable cost. Therefore, we do not want this device to be an “unnecessary luxury” for our customers.

THE IDEATION PROCESS

The process to finding a solution for the given problem was divided into several phases where the team looked into various aspects of the problem, part by part, finding solutions for each aspect and for the time being, not caring whether or not they were completely feasible for the present problem or not, and then putting together all the ideas gathered to form one final solution. The problem was divided into ‘part-problems’ on the basis of the specific requirements of the problem-statement:

4. Continuous/Discontinuous Measurement Methods
5. Online/Offline Measurement Methods
6. Remote/Near Measurement Methods

Continuous/Discontinuous Measurement: ‘Continuous’ measurement here refers to a measurement process in which any amount of wear can be determined very precisely. ‘Discontinuous’ measurement, on the other hand, refers to a measurement process which can indicate only certain levels of wear. This can also be referred to as ‘Discrete Level’ measurement.

Online/Offline Measurement Methods: As emphasized beforehand, there exists a need to make measurements during running of the Trommel. Such methods shall be referred to as ‘online’ methods hence forth, and other methods that require operation of the screen to be stopped shall be referred to as ‘offline’ methods.

Remote/Near Measurement Methods: Online measurement would require that the measurement be made from a remote location, not very close to the Trommel to save the equipment from damage by the harsh environment inside the Trommel. Such methods have been referred to as ‘remote’ measurement methods here, while techniques which require the device to be situated in close proximity to the screen have been referred to as ‘near’ measurement methods.

With these requirements in mind, we zeroed in on the following possible methods which could lead to an effective wear measurement process:

5. Strobe Light and Image Processing
6. Fluid Channel Embedded in Screen
7. Flexible PCB Implant in Screen
8. Screen Wear Thickness Measurement- Thevenin Concept
9. Glowing Element Detection
10. Ultrasonic Thickness Measurement

A brief description of each of these techniques is now presented below.

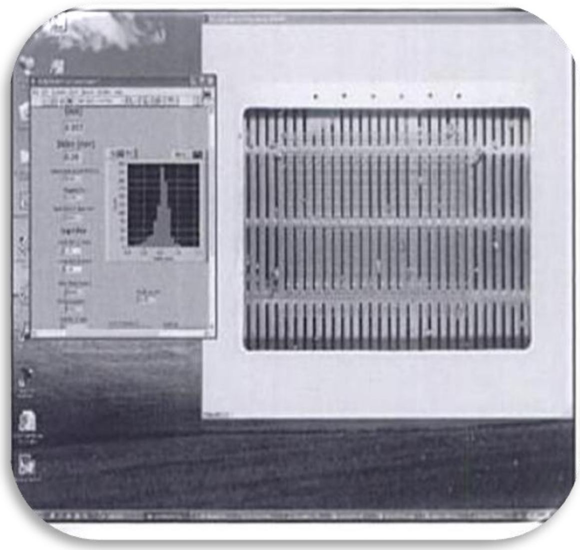
Image Processing

Image Processing is a form of signal processing for which the input data is an image, such as a photograph or a video frame, which is processed by some computer algorithms. By using a properly calibrated camera, it is possible to make several inferences from the image, like size and of objects, comparison between size of two objects and detection of specific motion of objects. Problems solved using image processing methods include artificial vision for artificial-intelligence robots, in monitoring of traffic and large crowds, motion-sensing video games and many more.

For the current problem, it is possible to monitor aperture dimensions by taking images of a screen at scheduled intervals and processing the image by a computer. By suitably calibrating the camera and having appropriate lighting conditions, it is possible to measure the dimensions of the apertures.

However a number of problems are encountered while proceeding with this method. Due to the flow of particles over the panels during operation and the rotation of the Trommel, it is not possible to obtain a direct visual of the apertures, not to mention the Slurry filling the inside of the Trommel, the impact caused by the falling particles and the extremely harsh environment, which make it very difficult to take clear images of the screen during runtime as well as to safely mount the imaging camera and strobe light inside the Trommel. The rotation of the Trommel poses a problem in the form of being able to capture high quality pictures of the Screens in order to measure the aperture dimensions.

Using highly specialized camera, high quality images are captured which are then used in further processing.



After: Image after processing by computer algorithms. Software are coded so as to detect the dimensions of the apertures as well as produce any desired output such as Standard Deviation of aperture size and other such data.

Also, in order that good images be obtained, it is important to have very controlled lighting conditions, which is not possible in a plant. Further, installation of camera on-site poses another problem.

Glowing Element Detection

In this method, a thin layer of glowing material is coated between two layers of screen at the threshold height. The method makes use of the phenomenon that as the screens wear out slowly, the glowing element layer is exposed which can be detected in the form of visual inspection or by using a light source and a camera. This method can be implemented at various heights with different color of glowing property but this is limited as a discrete level measurement solution. However, a lot of downsides exist with this method. Firstly, this method is difficult to implement for remote monitoring as mounting the camera and the light source inside the trommel is a problem. Secondly, this method is also indicatory of failure but cannot predict failure, i.e., it only indicates after the failure has happened.

Ultrasonic Thickness Measurement Method

Ultrasonic measurement is being employed extensively in industries where detection of internal holes, cracks etc is required. The methods involves primarily sending an ultrasonic wave through the material whose properties are to be known and by analyzing the reflected wave, suitable inferences about its thickness, presence of holes, etc. can be made.

Though quite accurate, ultrasonic measurement requires the sensors to be placed in close contact with the material being inspected. This makes employment of this method for the current problem difficult. Also, the current method can only provide information regarding the thickness of the panel, rendering it unsuitable for our project.

Flexible PCB Implant

One of the ideas that was developed during this internship, which we proceeded with prototyping is the "Flexible PCB Implant". In this idea, we have used Flexible PCB material and printed a circuit on that which is a conductive lining covering the perimeter of each of the apertures. Any breakage of circuit aperture will result of cutting off of the copper lining in the circuit and hence our controller system will detect this failure and send this message to the controller unit on the receiving end. This data is now displayed on the serial port of the computer in the control room. The height of the placement of the PCB is decided depending on the wear requirement of the particular screen and hence the aperture size of the tapered insert is computed by linear interpolation. The PCB aperture threshold size is hence suitably decided keeping in mind the consumer's requirement of the largest allowable ore size. This idea is selected as one of the very feasible ideas for panel failure indication and hence the prototype manufacturing was pursued and testing was done which is discussed later in greater detail.

Fluid Channel Embedded in Screen

"Fluid Channel Embedded in Screen" is an idea that was conceptualized midway during the internship and was prototyped and tested as a perfectly working concept. This idea comprises of a Fluid channel made to cover the perimeter of all the apertures. The fluid channel for the prototype was made of 4 mm tubing and some readily available connectors for this tubing. The concept behind this idea is that the fluid channel is embedded in the Screen material and pressurized conducting fluid is filled in the channel. As long as the channel contains fluid the indication is transmitted to the controller unit that the panel is OK. When the aperture size increases, the fluid channel begins to wear. At the threshold wear value, the fluid pipe ruptures causing the pressurized fluid to come out. This drop in pressure and fluid level can be monitored using pressure sensors or using fluid level measurement. For the purpose of the prototype, level sensing was done of Soapy saline water which will be discussed in detail later.

Screen Wear Thickness Measurement- Thevenin Concept

In order to obtain the thickness of wear of the screen, apart from having an aperture wear circuit, we needed another mechanism to predict the wear height of the screen. For this, after intensive patent mining and preparation of patent tree, the concept of Thevenin Voltage and resistance measurement was chosen to be implemented for its easy application and implementation. The basic concept is to place Resistance at different discrete thickness thresholds and to measure voltage across these resistances. As the screen wears off up to the threshold values, the resistances also begin to wear off and break out of the circuit. This causes the Thevenin voltage value to change which is easily measured by the controller unit. The controller unit now converts these values of voltages into useful information in the form of wear height by comparison operators and then transmits this data towards the controller unit at the receiving end. The receiving controller unit takes this data and presents it on the serial port of the control room. An interface then displays this data in user friendly format.

The Proposed Solution

The ideation process, which lasted for around a month, gave rise to solutions which were deemed to be the most feasible out of the various possibilities considered. In this section we gave a detailed description of the systems proposed to solve the problem of detection of wear and aperture damage of trommel panels. Finalizing the idea depends on various factors like ease to manufacture, life, accuracy, cost, availability etc. We proposed **three solutions** for the problem. All are explained below in detail:

Trommel Panel Wear Monitoring System

SOLUTION 1

"Fluid channel embedded in screen"

It works on the simple principle of detecting leakage or pressure drop in the channel. A fluid channel is embedded at the threshold point of the panel so that whenever aperture damage or wear occurs the fluid will leak and that can be detected from level measurement, pressure drop, conductivity loss.

FLUID CHANNEL:

Design of fluid channel depends on the dimensions of aperture and the threshold limit required for a particular panel. The fluid channel has an input and output.

Selection of Tubing Material depends on various factors:

- Wear rate should be same as panel.
- Low cost
- Availability
- Size

Hence we compared the properties of various materials of the tubing in order to come up with a choice which is the most suitable for our purpose. The materials analyzed for characteristic properties were:

1. PVC Tubing
2. Polyurethane Tubing
3. Nylon Tubing

4. Fluor polymer Tubing (PTFE)
5. Rubber Tubing (Viton, Latex, Hytrel)
6. Silicone Tubing

Material	Characteristics	Advantages	Disadvantages
PVC	**Heat shrinkable PVC tubing:** • Quickly shrinks to half of its original diameter. Operating Temp -30° to 105°C. **Non-heat shrinkable PVC Tubing:** • Operating Temp -68° to 105°C depending on compound.	Relatively Low Cost	Little/No Flexibility
Polyurethane	• Very flexible and extremely tough. • Offers great abrasion, fatigue, tear, and kink resistance for demanding applications • Two basic types of polyurethane tubing • Ester-based : Better chemical resistance to fuels and lubricants • Ether-based: More resistant to moisture • Operating Temperature: -68 to 100 C	Wear characteristics match PU panel material.	Compression characteristics poor
Nylon	• Abrasion Resistance • Extreme Temperature Resistance • Excellent High-Pressure Resistance • Great Impact Strength • Semi-Rigid • Operating Temperatures: -85° to 100°	Temperature and Pressure Resistant	Expensive Material

Silicone	• Resists High/Low Temperatures • Good Electrical Properties • High Purity Grades Available for Medical Applications • Operating Temperature: -73° to 260°C	High Temperature Resistance	Too Compressible
Rubber	• Chemically Inert • Resilient Materials (Resistant to Flex Fatigue and Tear) • Extremely Compressible • Operating temperatures: -73° to 260°	High Temperature Resistance	Too Compressible
Fluor polymer (PTFE)	• Excellent Resistance to chemicals. • Resistance to elevated temperatures • Low friction • Non-adhesive by nature.	Temperature and Pressure Resistant	Expensive Material

After analyzing all these properties and relating these to the constraints and the requirements of our project, we selected Polyurethane (PU) as the material of our choice and proceeded with procurement of samples and subject those to quality testing.

Hence the multiple samples we obtained were then subjected to Quality Testing where small moulds are made with the rubber and PU and these cylindrical quality testing products can then be subjected to be used directly into the abrasion testing machine. First, to understand the Temperature and Pressure sustaining characteristics of the Tubing Material in the Rubber Molding process, quality samples were made.Rubber Molding Process in quality samples:

- Molding Temperature- 170 C
- Curing Time- 30min

When the results of the quality testing was observed, it became evident that the use of PU tubing in Rubber samples was not possible because the high pressure and temperature of the moulding process had complete collapsed the tubing. Also, materials that could sustain higher amounts of pressure were thought upon but due the limitation of having similar wear rates as our base material, the use of this particular idea in the case of Rubber had to be dropped.

The PU tubing would not be able to sustain the pressure because the hardness was low and the operating temperature was exceeded although melting issue was negligible in the results. To use tubing, pressurized fluid filled tubing can be tested. Some issues include:

- Fluid with high boiling temperature is required and salt water can't be used as its boiling point is exceeded.
- Pressured fluid while moulding is difficult to supply and can be dangerous as the fluid is hot and pressurized.

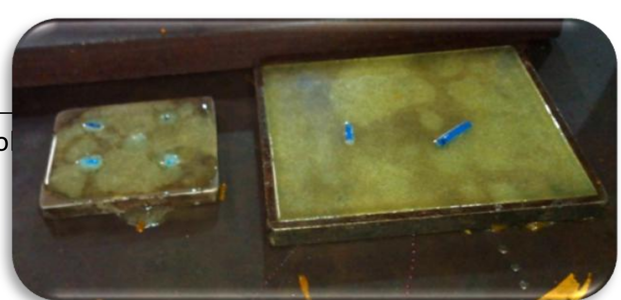
In the later stages of the project an idea was found wherein the idea can be implemented I the case of rubber. Hence it was put up as a suggestion for the possibility of implementing this idea for rubber.

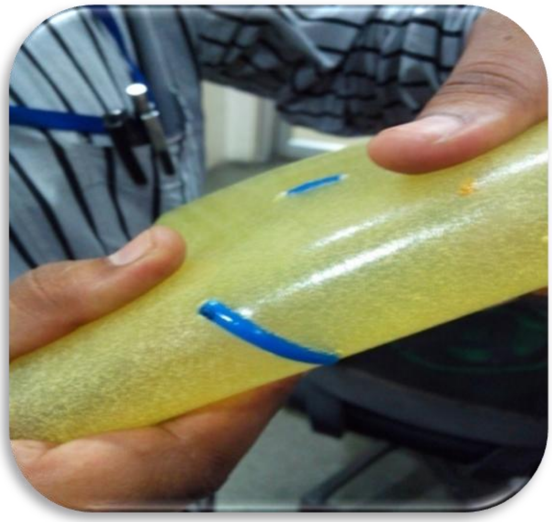
1. Injection Molding can be done to produce Tubing covered in rubber at a lower pressure and temperature.
2. This can be inserted in the actual Mold in the form of the water channel with rubber covering.

Quality Testing- PU

Quality Testing was done to understand the Temperature and Floatation sustaining characteristics of the Tubing Material in PU.
Quality Moulding Process for PU:

- Mould Temperature- 100-110 C
- Poured PU Temperature- 80 C
- Curing Time- 15 min





Testing results:

- Abrasion Testing Weight Reduction Values indicated similar Wearing Rates for both Tubing and PU Sample.
- The samples floated on top of PU because of presence of air reducing average density. Thus, Water channel has to be secured inside the Screen, for e.g., with the reinforcement.
- There was some amount of bonding between the tubing and the PU.

So we selected the PU pipes for making fluid channel based on the following observations and properties.

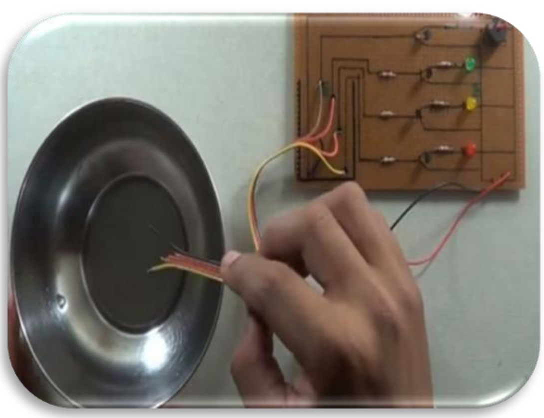
Next stage is to detect leakage for this also we searched various leak detection methods:

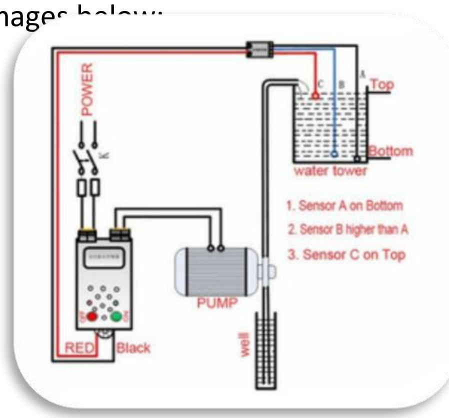
1. Float Method
2. Capacitance, Resistance or Induction Method
3. Differential Pressure Measurement
4. Ultrasonic, Microwave or other EM Waves
5. Electrical Probes

But we have some limitations on leak detection method:

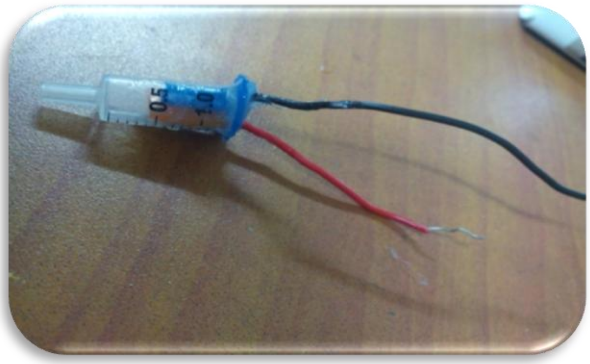
1. Easy to Manufacture
2. Accurate Indication
3. Output easy to transmit
4. Work at Trommel rpm
5. Small in size

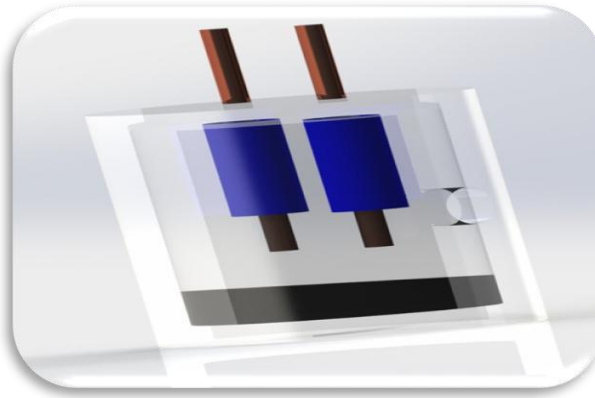
After understanding all these constraints that we had regarding the dynamic application of leak sensing in our case, we decided to use Electrical probes as the output is in the easiest form possible and the method is easy and accurate. The concept behind our selection came from the application of it in the case of Automatic level sensing in our houses where the level of water is sensed and the motor is automatically started and turned off as and when required. This concept is displayed in the images below:





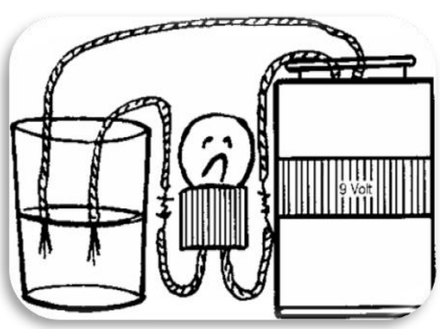
After testing this we made a small capsule like device to sense the fluid level drop. We used small syringe to make the capsule. The capsule consist of two separate wires which can be connected to the circuit whenever the capsule will be filled with the conducting fluid, two separate wires comes into contact and starts conducting and whenever the level drops due to wear or any damage the fluid will come out and the level in the capsule will drop which will disconnect the circuit and we can detect this.

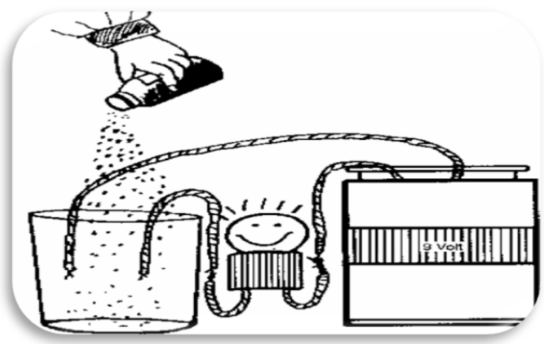




Now we searched what fluid should be used which will sever our purpose. We have few limitations on the fluid to be used:

1. Fluid must be Conducting
2. Surface Tension must be low
3. Viscosity must be low
4. Boiling Point must be more than 50 C.





In order to add conductivity to water, we took the elementary step of adding common salt to the water. In order to obtain the concentration of salt to be added for good conductivity, we studied the NaCl concentration V/s conductivity values as depicted in the table below.

TABLE OF CONDUCTIVITY VS CONCENTRATION FOR COMMON SOLUTIONS
Conductivity (G) in microsiemen/centimetre (micromho/cm) at 25°C (77°F)

Weight %	ppm mg/litre	Sodium Chloride, NaCl	Sodium Hydroxide, NaOH	Hydrochloric Acid, HCl	Sulfuric Acid, H_2SO_4	Nitric Acid, HNO_3	Hydrofluoric Acid, HF	Acetic Acid (a), CH_3COOH
0.0001	1	2.2	6.2	11.7	8.8	6.8	10	4.2
0.0003	3	6.5	18.4	35.0	26.1	20	30	7.4
0.001	10	21.4	61.1	116	85.6	67	99	15.5
0.003	30	64	182	340	251	199	290	30.6
0.01	100	210	603	1 140	805	657	630	63
0.03	300	617	1 780	3 390	2 180	1 950	1 490	114
0.1	1 000	1 990	5 820	11 100	6 350	6 380	2 420	209
0.3	3 000	5 690	16 200	32 200	15 800	18 900	5 100	368
1.0	10 000	17 600	53 200	103 000	48 500	60 000	11 700	640
3.0	Rarely Used	48 600	144 000	283 000	141 000	172 000	34 700	1 120
5.0	Rarely Used	78 300	223 000	432 000	237 000	275 000	62 000	1 230
10.0	Rarely Used	140 000	358 000	709 000	427 000	498 000	118 000	1 530
20.0	Rarely Used	226 000	414 000	850 000	709 000	763 000	232 300	1 600
30.0	Rarely Used	Saturated	292 000	732 000	828 000	861 000	390 000	1 405
40.0	Rarely Used	Saturated	191 000	Saturated	770 000	820 000	N/A	1 080
50.0	Rarely Used	Saturated	150 000	Saturated	620 000	717 000	N/A	740
75.0	Rarely Used	Saturated	Saturated	Saturated	182 000	340 000	7.8 (0°C)	168
100.0	Rarely Used	Saturated	Saturated	Saturated	10 000	50 000	4 (0°C)	< 1
Point of Maximum Solubility	---	26%	About 50%	37%	---	---	---	---
Point(s) of Maximum Conductivity	---	26%	16%	18.5%	31% 92.5%	31%	About 35%	19%
Maximum Conductivity	---	244 000	412 000	852 000	830 000 139 000	862 000	N/A	1 600

So, based on the above table, we decided to use salt concentration to be approximately 20-30 % .

For surface tension and viscosity to be low we used soap solution. Earlier we tried with salt solution but due to its high surface tension proper leakage didn't happen and capillary action caused water to stay in the tubing instead of flowing out of the leak, making the level sensing difficult. So, we used soap solution as the addition of soap in water reduces the surface tension to around 1/3rd of water. Now as we have to use conductive fluid so we added salt so finally our solution becomes "**SOAPY SALINE WATER**". Using this we are able to sense the required level drop in the capsule.

So the entire system can be explained as a fluid channel embedded in the panel and placed at the waer thresholds in terms of the screen height as well as the apertures, which contains pressurized soapy salt solution such that whenever wear or any damage occurs the fluid channel gets worn at that point and leakage occurs which can be sensed by a level sensing capsule which is connected to the controller unit which encodes this damage data into signals and transmits it to the controller system.

Now, in order to transmit this failure data from the rotating trommel screen to the control room which can be very distant from the trommel, we had to look into solutions where accurate data transmission can be done and received on the outside.

On studying about transmission options, many different ideas and technologies came up utilizing either a wired or wireless communication. But since our environment is dynamic so we concluded to use wireless communication as using wired means become very difficult and costly.

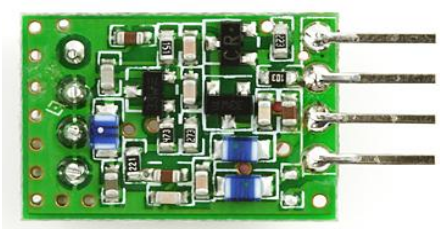
For using wireless communication we studied many choices like:

- Bluetooth
- Wi-Fi
- RF Modules

After this we identified our constraints in order to be able to further streamline our choice:

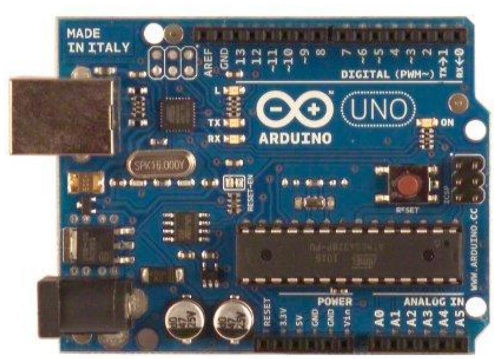
1. Should work easily in a dynamic environment as trommel is always rotating.
2. Low Price
3. High Reliability
4. Legal Frequency range
5. Workability should be easy
6. Small size Modules
7. High range

So keeping these constraints in mind we concluded to use "**434 MHz Modules**" for prototyping.



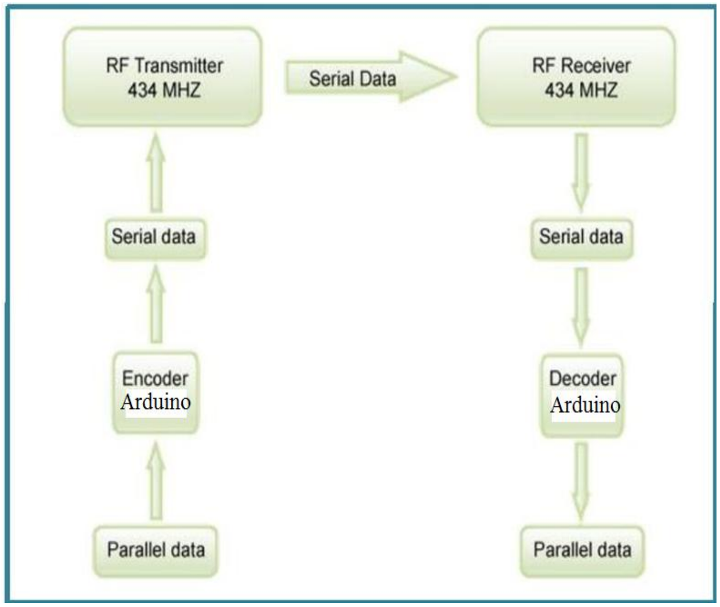
Transmitter

Receiver

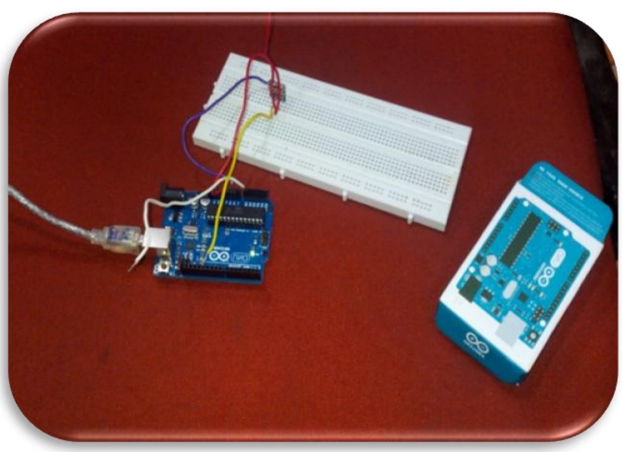


Arduino Uno- Coding and RX-TX

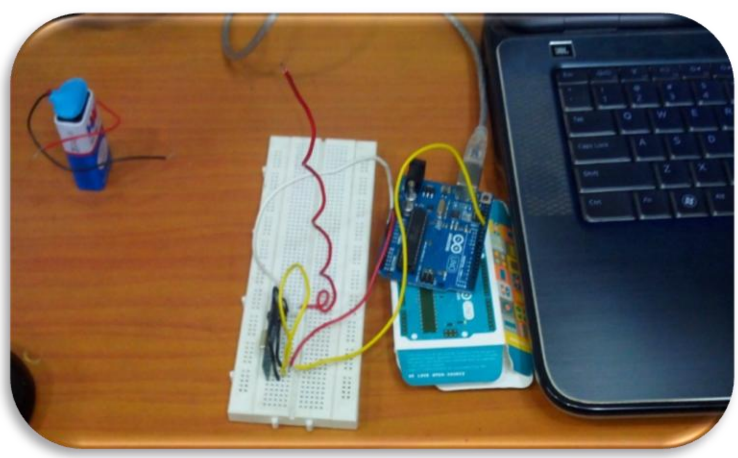
Flow chart of the system:



In the flow chart describes the working principle of our system. At first the parallel data, i.e., the leakage detection data is sent to the Arduino board which will act as an encoder and send the encoded data to the RF Transmitter. Then this data is received by the RF Receiver which will be transferred to the second Arduino board which acts as a decoder and converts the data into useful wear data and displays this data on the serial port of the computer in the control room. For making these circuit we used bread boards for the easy of use. Circuitry components used are RF modules, Arduino board, wires, LED's, resistors, batteries, connectors etc.



Transmitter circuit



Receiver circuit

We used Arduino board as it is a developer board and is generally used for prototyping. It is open source based and hence many sample codes and pre-fabricated libraries are available making it easier to focus on the functionality required and easily implement any required change. The coding is also user friendly and has a very easy learning curve. The codes were written in the Arduino software and various trials were done to achieve accuracy.

Another concern for us was the ability of the transmitters and receivers to have a good range and to be able to transmit through the Trommel steel structure without any hindrance or loss of consistency of data. Hence testing was done to measure the range of the transmitter through steel. For doing this we placed the receiver in an iron casing equivalent to real situation and transmitter far from this in an iron casing and the observed range was fine around 40-50 meters even if we required more range then we can use amplifier to amplify the signal and receive it at the required place. The transmission and reception codes that have been written for leakage detection, transmission and data reception are shown below:

Trommel_Panel_Failure_Warning_System_Transmitter_Updated | Arduino 1.0.1

File Edit Sketch Tools Help

Trommel_Panel_Failure_Warning_System_Transmitter_Updated §

```
#include <VirtualWire.h>
int ledl = 8;
int vl=0;

void setup()
{

    pinMode(ledl, OUTPUT);
    pinMode(13,OUTPUT);

    Serial.begin(9600);   // Debugging only
    Serial.println("setup");

    // Initialise the IO and ISR
    vw_set_ptt_inverted(true); // Required for DR3100
    vw_setup(200);       // Bits per sec
}
void loop()
{  vl=1023;
  while(vl>300)
  {
  digitalWrite(ledl, LOW);
    // turn the LED off by making the voltage LOW
  delay(500);               // wait for a second
  digitalWrite(ledl, HIGH);
  // turn the LED on (HIGH is the voltage level)

  vl=analogRead(A0);
  if(vl>570){

  Serial.print("  PANEL1 OK ");
  }
   if(vl<700){
  // Transmission Begins
    Serial.print(" PANEL1 Failure ");
    const char *msg = "fail";
    digitalWrite(13, true); // Flash a light to show transmitting
    vw_send((uint8_t *)msg, strlen(msg));
    vw_wait_tx(); // Wait until the whole message is gone
    digitalWrite(13, false);
    delay(200);
}
    delay(200);
}
  }
```

Trommel_Panel_Failure_Warning_System_Receiver | Arduino 1.0.1

File Edit Sketch Tools Help

Trommel_Panel_Failure_Warning_System_Receiver §

```
#include <VirtualWire.h>

void setup()
{
    Serial.begin(9600); // Debugging only
    Serial.println("setup");
    pinMode(13,OUTPUT);

    // Initialise the IO and ISR
    vw_set_ptt_inverted(true); // Required for DR3100
    vw_setup(2000);      // Bits per sec

    vw_rx_start();       // Start the receiver PLL running
}

void loop()
{
    uint8_t buf[VW_MAX_MESSAGE_LEN];
    uint8_t buflen = VW_MAX_MESSAGE_LEN;


    if (vw_get_message(buf, &buflen)) // Non-blocking
    {
        int i;
        char c;

        digitalWrite(13, true); // Flash a light to show received good message
        // Message with a good checksum received, dump it.
        //Serial.print("Got:");

        for (i = 0; i < buflen; i++)
        {
            //Serial.print(buf[i], HEX);
        c= buf[i];
        Serial.print(c);
        Serial.print(" ");
        }
        Serial.println("");
        digitalWrite(13, false);
    }
}
```

Blinking codes has been used to:

- Using Blinking code to blink Voltage drop in the Arduino Output and pass this through the Fluid Capsule and detect Output through the other end.
- This saves battery by not continuously using power.

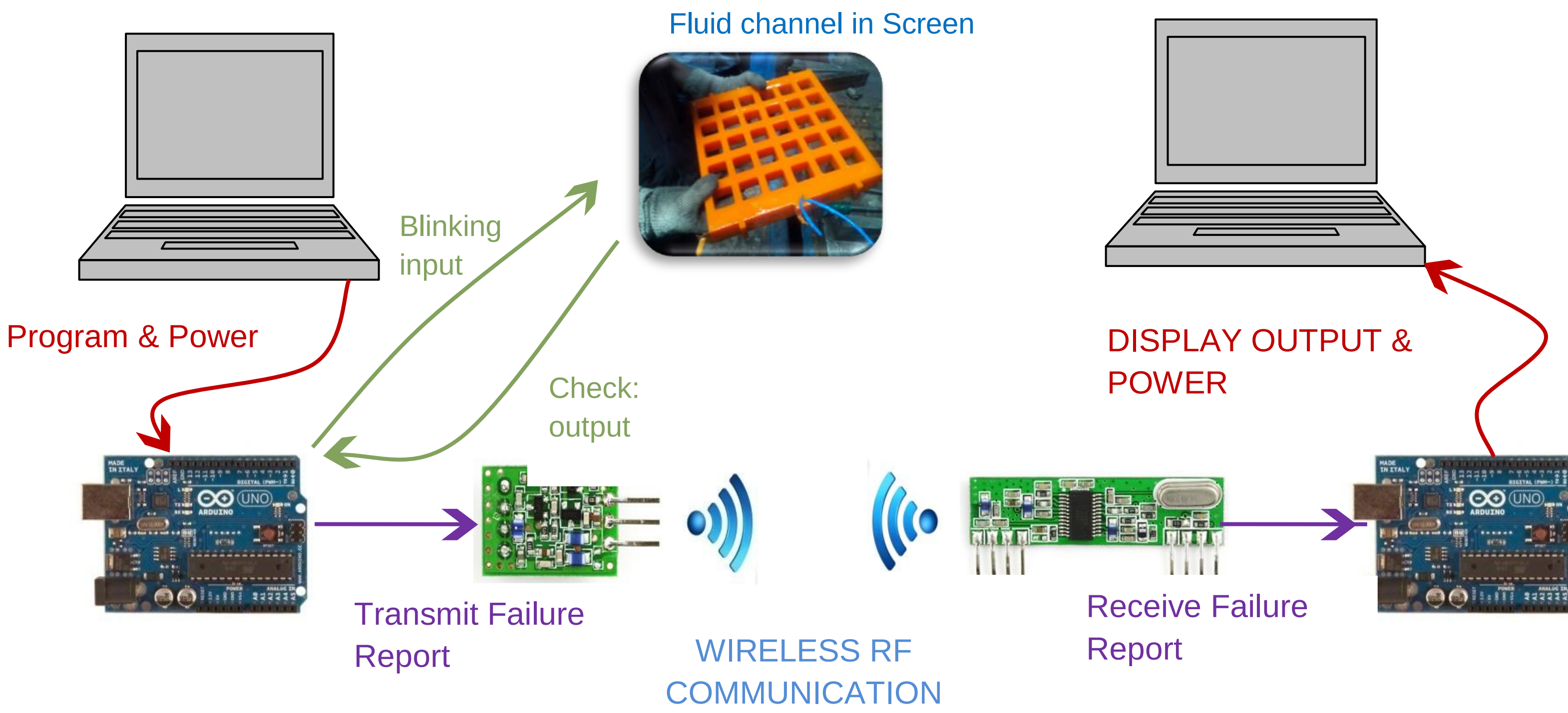
Manufacturing the Prototype:

Now after preparing with the selected materials for the channel and also preparing the detection, transmission and reception modules, we started to manufacture the panel implementing this idea. So at first we raised the FSO then we collected the reinforcement of the required dimension. After placing the reinforcement in the mould we marked the threshold points on the reinforcement so that we can attach the fluid channel on the reinforcement at the marked place. In order to attach the fluid channel to the reinforcement , many options were considered including wrapping by copper wire, making fasteners, etc. but for the prototype, we used Fevi-quick for the ease of its application.

After making the channel we allowed the reinforcement to heat for some time then PU is poured slowly into the mould and air bubbles were removed using heat. After manufacturing we did testing to validate the idea. We connected the capsule with the panel and soapy saline water is filled into it. Then we cut the PU pipes there was a sufficient voltage drop across the LED which can be sensed and converted into useful data. After doing the testing we came to the conclusions that:

- The idea and the concept can be successfully used.
- Thresholding has to be done properly.
- Floatation issue has to be resolved by proper fastening.
- Input and output of the channel has to be provided from the back of the screen
- Smaller connectors (preferably inside the tube connectors) have to be used.
- AutoCAD drawing for the channel can be provided along the Mould, reinforcement and product drawing.
- Connectors design can be modified by making pin and lock type method for maintaining the threshold. This will reduce manufacturing time and difficulty.

FLOW CHART OF THE CONCEPT



SOLUTION 2

"Flexible PCB Implant in the panel"

Our second idea is to implant a flexible printed circuit board at the threshold of the panel. The PCB contains a single conductivity such that it covers all apertures. It works on the principle that whenever any aperture or damage occurs the conductive lining got damage and it will break the conductivity which can be sensed using sensors.

Flexible PCB types:

- Single-sided flex circuits:
  - Single conductor layer made of either a metal or conductive (metal filled) polymer on a flexible dielectric film.
- Double access flex circuits:
  - Conductor layer made on either side of the PCB base material. Both sided can be used separately.
- Multilayer flex circuits :
  - Multiple Layers of the conductor layers are there on a single side of the PCB isolated from each other.

Among these available PCB's we have chosen single sided PCB as our requirement is to detect any damage and wear. So we can work with this PCB and for more accuracy we can implant multiple layer of PCB to sense the wear rate accurately.

Flexible Circuit Base Materials:

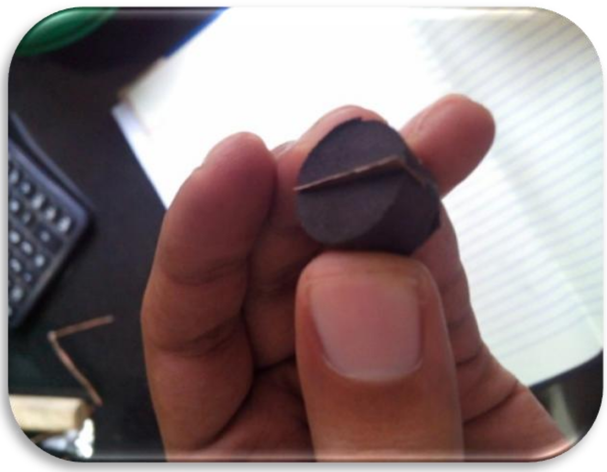
- Properties:
  - Flexible polymer film is foundation for the laminate
  - Provides most primary physical and electrical properties of the flexible circuit.
- Examples:
  - Polyimide (PI)
  - Polyester (PET)
  - Polyethylene Napthalate (PEN)
  - Polyetherimide (PEI)
  - Fluoropolymer (FEP)
  - FR-4

- Among all these available materials we have chosen **FR-4 with a copper base** as heat sink.

- FR-4 is a composite material composed of woven fiberglass cloth with an epoxy resin binder that is flame resistant.

After manufacturing of the PCB we did quality testing with rubber mould.

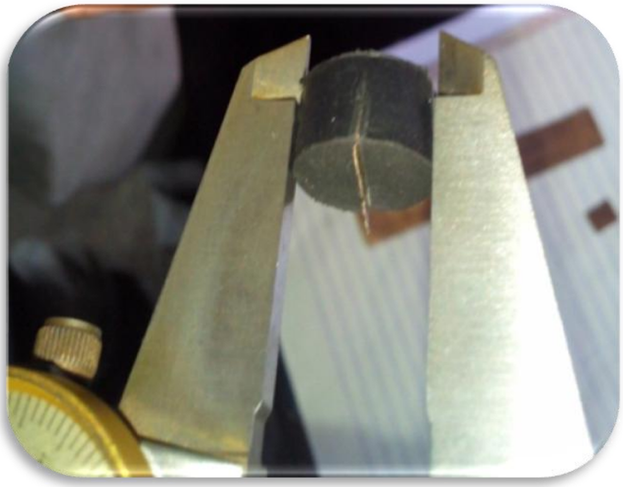
- Quality Testing was done to understand the Temperature and Pressure sustaining characteristics of the PCB Material in the Rubber Moulding Process.
- Quality Moulding Process:
  - Moulding Temperature- 170 C
  - Curing Time- 30min

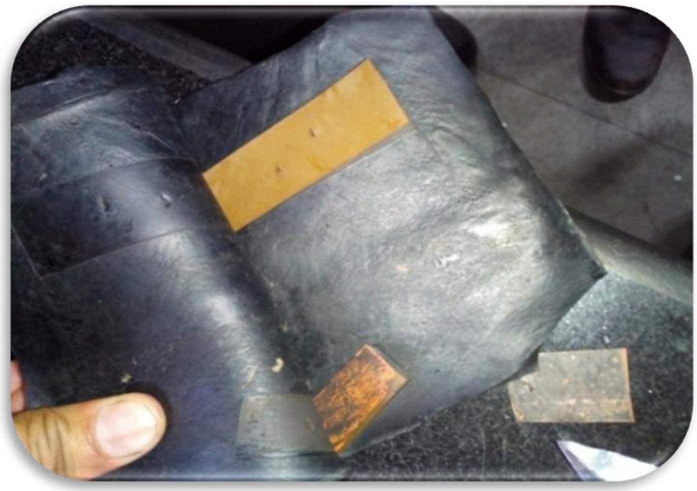


Testing results:

- Elongation or other deformations were not observed. Bending of rubber sample did not damage the PCB inside.
- Wearing of both the Flexible PCB material (FR-4 with Copper Base) and the rubber were found to be similar on the Abrasion Testing Machine because wear heights were similar for both.
- Quality Moulding Process:
  - Moulding Temperature- 170 C

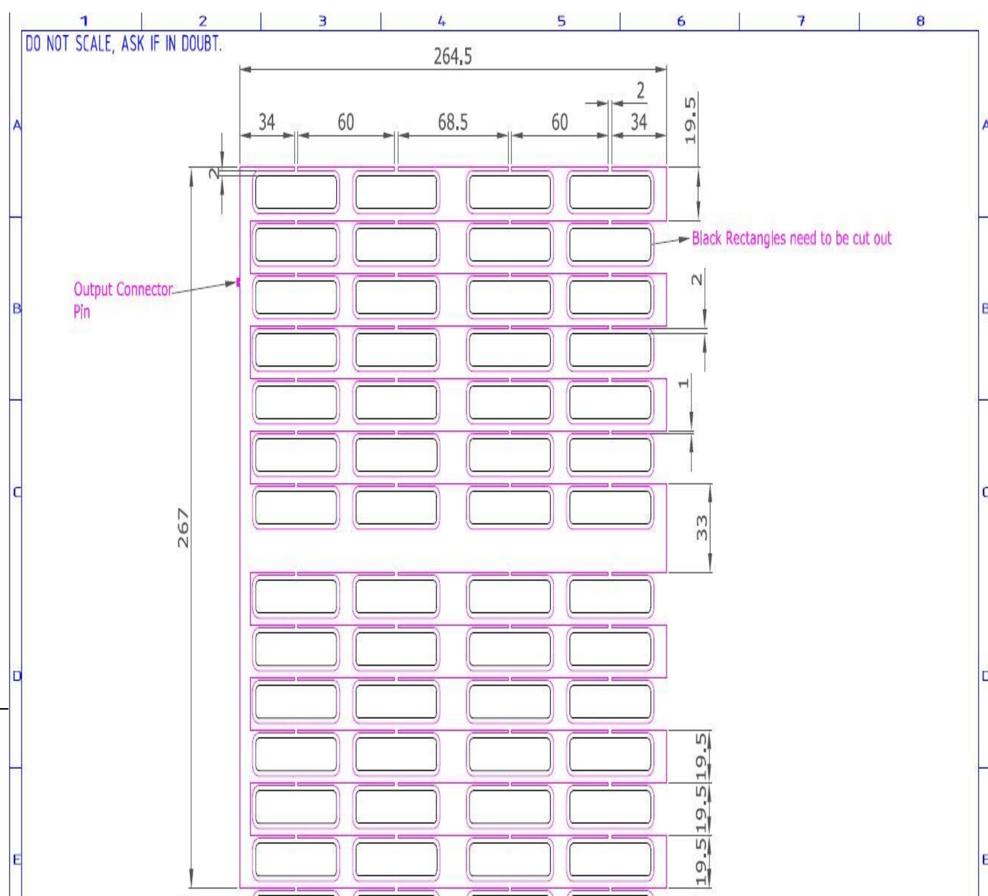
- Curing Time- 30min





PCB Design for prototype:

Now for manufacturing the panel we have to design the PCB considering the required thresholding so we selected a panel design with size 1ft*1ft and aperture size 12*50 mm and for prototyping we have chosen 2 mm thresholding so according to this we designed the PCB circuit such that it has a single conductive lining and it covers all aperture. For designing the circuit we have used AutoCAD software then converted the design into monochrome format and given to the manufacturer for printing.



PCB procured from manufacturer:

Without Thermal Coating

With Thermal Coating

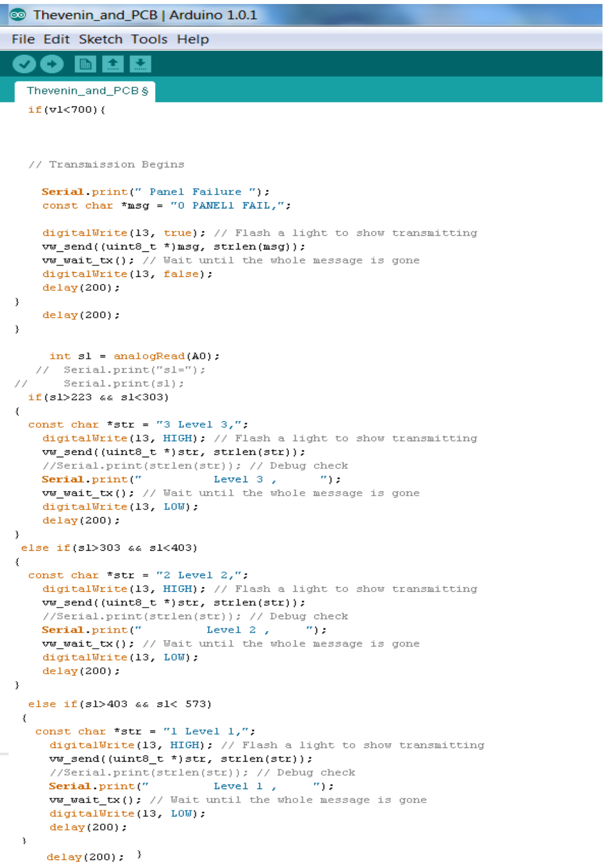
Now for getting the output data of PCB breakage we have used similar method used for Fluid channel method same RF modules have been used with same range. But for this the codes are different as we are now detecting the breakage of circuit instead of voltage drop. So in the same software codes were written and testing had been done to check the working of the system.

Thevenin_and_PCB | Arduino 1.0.1

File Edit Sketch Tools Help

Thevenin_and_PCB §

```
#include <VirtualWire.h>

int ledl = 8;
int vl=0;

void setup()
{
    Serial.begin(9600);   // Debugging only
    Serial.println("setup");
     pinMode(13,OUTPUT);

    pinMode(ledl, OUTPUT);


    // Initialise the IO and ISR
    vw_set_ptt_inverted(true); // Required for DR3100
    vw_setup(2000);      // Bits per sec
}

void loop()
{
int i=0;
//const char *str;//const char *msg;
     // read the input on analog pin 0:

vl=1023;`
  {
  digitalWrite(ledl, LOW);
    // turn the LED off by making the voltage LOW
  delay(500);              // wait for a second
  digitalWrite(ledl, HIGH);
  // turn the LED on (HIGH is the voltage level)

  vl=analogRead(A1);
  if(vl>700){

  Serial.print("  Panel OK  ,");
   const char *msg = "9 PANEL1 OK,";

    digitalWrite(13, true); // Flash a light to show transmitting
    vw_send((uint8_t *)msg, strlen(msg));
    vw_wait_tx(); // Wait until the whole message is gone
    digitalWrite(13, false);
    delay(200);

  }
```



Thevenin_and_PCB | Arduino 1.0.1

File Edit Sketch Tools Help

Thevenin_and_PCB §

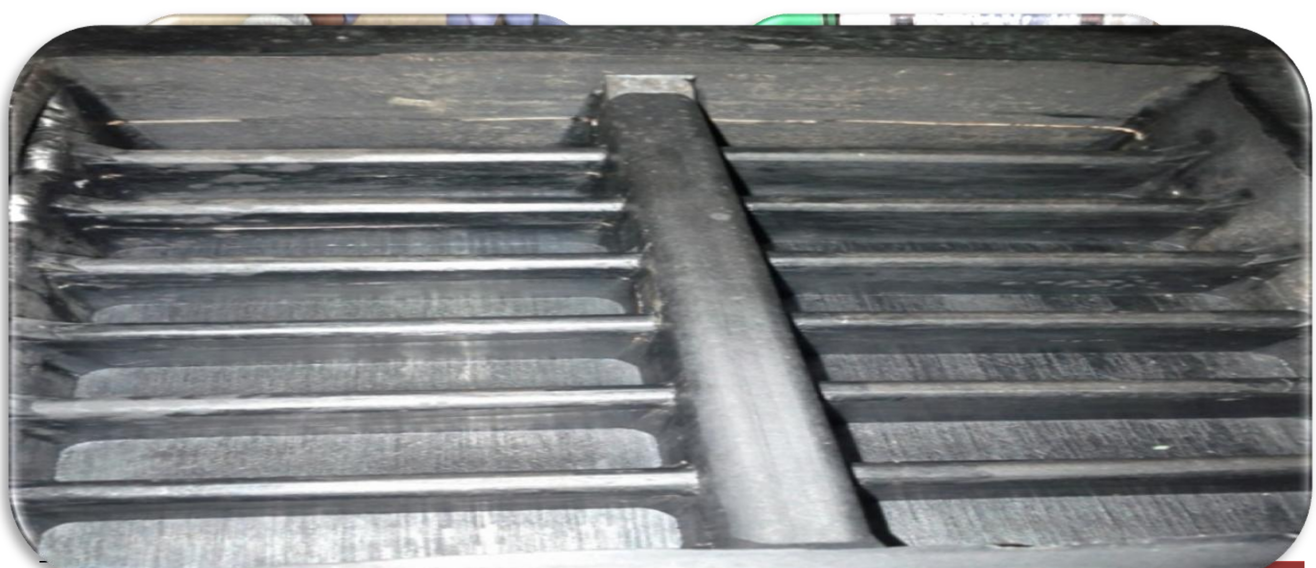
```
  if(vl<700){


  // Transmission Begins

    Serial.print(" Panel Failure ");
    const char *msg = "0 PANEL1 FAIL,";

    digitalWrite(13, true); // Flash a light to show transmitting
    vw_send((uint8_t *)msg, strlen(msg));
    vw_wait_tx(); // Wait until the whole message is gone
    digitalWrite(13, false);
    delay(200);
}
    delay(200);
}

     int sl = analogRead(A0);
   //  Serial.print("sl=");
//     Serial.print(sl);
  if(sl>223 && sl<303)
{
  const char *str = "3 Level 3,";
    digitalWrite(13, HIGH); // Flash a light to show transmitting
    vw_send((uint8_t *)str, strlen(str));
    //Serial.print(strlen(str)); // Debug check
    Serial.print("          Level 3 ,      ");
    vw_wait_tx(); // Wait until the whole message is gone
    digitalWrite(13, LOW);
    delay(200);
}
 else if(sl>303 && sl<403)
{
  const char *str = "2 Level 2,";
    digitalWrite(13, HIGH); // Flash a light to show transmitting
    vw_send((uint8_t *)str, strlen(str));
    //Serial.print(strlen(str)); // Debug check
    Serial.print("         Level 2 ,     ");
    vw_wait_tx(); // Wait until the whole message is gone
    digitalWrite(13, LOW);
    delay(200);
}
  else if(sl>403 && sl< 573)
 {
   const char *str = "1 Level 1,";
     digitalWrite(13, HIGH); // Flash a light to show transmitting
     vw_send((uint8_t *)str, strlen(str));
     //Serial.print(strlen(str)); // Debug check
     Serial.print("         Level 1 ,     ");
     vw_wait_tx(); // Wait until the whole message is gone
     digitalWrite(13, LOW);
     delay(200);
 }
     delay(200);  }
```

Manufacturing of Rubber Panel:

At first manufacturing of rubber panel without reinforcement was done to check the feasibility of implanting PCB in the panel. For this PCB was divided into two halves and two outputs are taken. The PCB was inserted into the mould. After charging the mould we observed one side of the PCB was completely damaged and the second half is showing the conductivity. But as reinforcement hadn't been used so due to this the entire PCB got tilted and comes at the bottom of the screen the main reason behind this was the inflow of rubber as PCB was of accurate dimensions and inserts are tapered so when the PCB was placed on insert at the bottom there was no filling of uncured rubber because of that when mould was charged the high pressurized rubber flow forces the PCB to bent. It also damaged the PCB and tilted it.

From this testing we observed proper support from the back has to be provided, have to provide proper tolerances, and some holes to be made on the PCB for providing inflow of rubber.

So during making the second prototype all these constraints were taken care. A same sized uncured rubber had been used in which apertures had been cut so that it can be fixed in the insert below the PCB to provide support. The setup was like at the bottom some uncured rubber had been placed then reinforcement, and above it the PCB structured uncured rubber had been placed to provide proper support. This time proper holes had been made on the PCB for the inflow of the rubber.



This time thresholding was almost correct, no damage in the PCB, no conductivity loss. Testing of the product had been done with the written codes. So the conclusion was that it can be used but it increase the manufacturing time so some manufacturing techniques needs to be changed for saving time:

- AutoCAD design of uncured rubber cut
- Using die punch for cutting rubber
- Mould design need to be modified by using complimentary inserts on the top part of the mould.

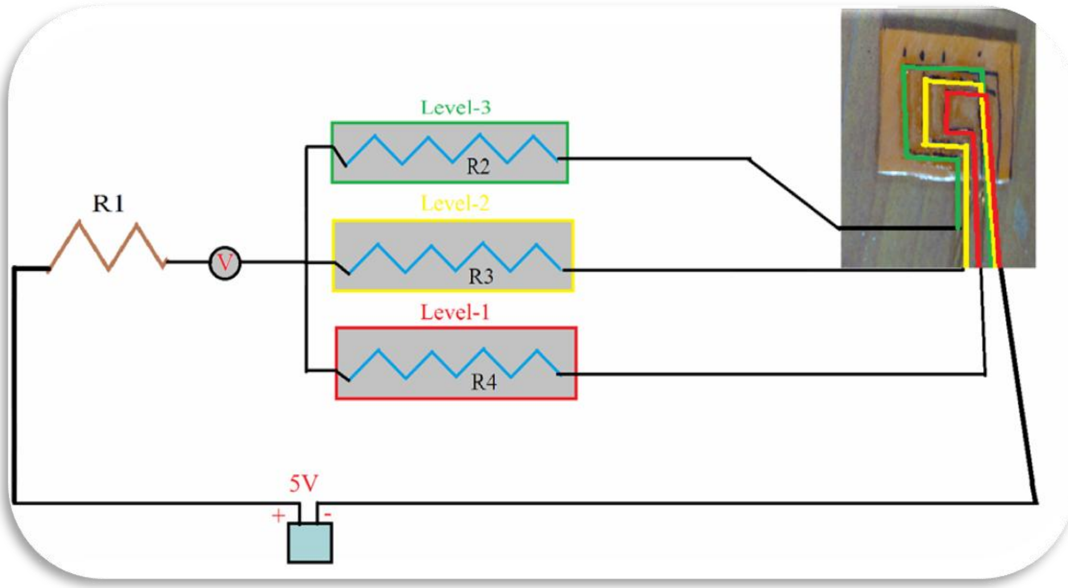
SOLUTION 3

"Thevenin Height Wear Measurement"

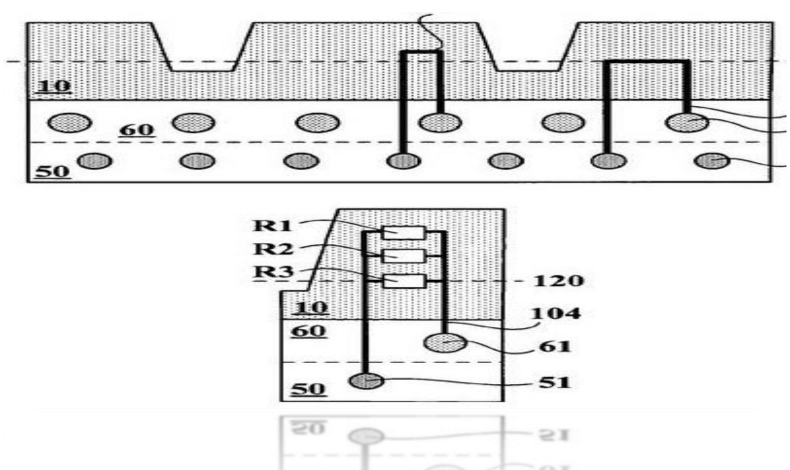
In this particular idea, we utilized the concept of Thevenin resistance and voltage in a unique way to be able to indicate the height wear of the screen at discrete levels. The image below shows the existence of wires at 3 different height levels, which have been colour coded as green for the third level, yellow for the second level and red for the lower most level. Each of these levels are connected to the corresponding resistors and as the wires get worn off along with that height of the screen, the resistance is disconnected from the system and thus, we get an apparent drop in the value of voltage across the voltmeter. Hence, using this voltage value we are able to predict the value of voltage and height the discrete height. We can have multiple levels depending upon requirement and hence have many discrete levels, making our sensitivity low or high as per requirement.

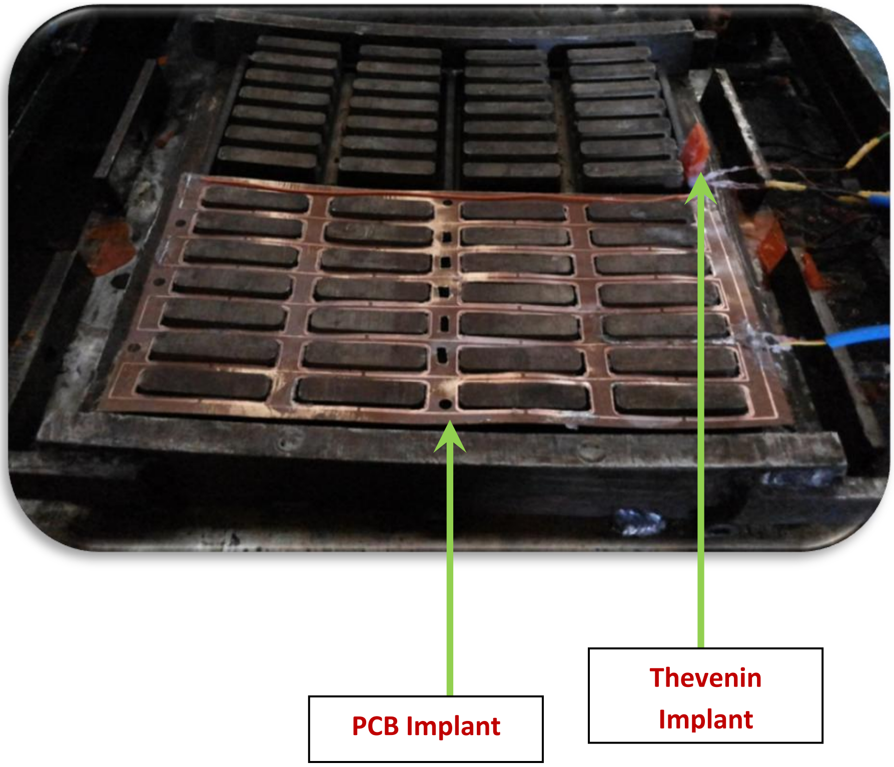
Arduino board's analog read ports have been used to detect the analog value of the supplied 5V on a 0-1023 analog board in comparison to ground. Hence, the value obtained in that particular scale is converted into and equivalent voltage. Comparisons can then be made between calculated Thevenin Voltage values and the obtained voltage value from the analog-Read.

The implant for the prototype was made inhouse using a piece of PU cut-out but for the manufacturing, the Flexible PCB manufacturer should be given the job to manufacture the implant on FR4 material for accuracy and repeatability.



Now that we have the means to measure both the height wear of the screen and the wear of the apertures, we can now combine both concepts to obtain a complete wear measurement device. This is henceforth called as "Trommel Panel Wear Monitoring System". This system is described as the system having both the concepts of aperture measurement by the "Embedded Fluid Channel" concept or the "PCB Implant in Screen" concept, combined with the height measurement by the "Thevenin Wear Height Measurement Implant".





For the 3 level height as well as PCB failure measurement, the following code was written and was demonstrated:

SIZE REDUCTION OF ARDUINO UNO

The normal size of arduino uno generally is quite large and is also expensive. The cost of an arduino uno board is roughly around Rs 1500. In addition power consumption of arduino uno is also very high. All these factors create hassles when used in a project. My task for the last 3weeks has basically been to reduce the arduino uno size as small as possible and yet be able to do the task of whatever is required in the project.

BAREBONES ARDUINO
After searching for various techniques on size reduction of arduino uno, the most obvious choice was creating your barebones arduino with minimum peripherals as this would significantly reduce the power consumption and well as reduce the size of arduino uno. If proper soldering can be done the size can be reduced to less then half of original arduino uno. This gave me the base idea of starting my project.

BILL OF MATERIALS

First I had to procure all the basic necessary items for making my barebones arduino. Here is the list of the items I procured.

Total Items: 24 Weight: 310 grams Amount: Rs.1,012.00

2 x0.01uF Capacitor Pack - 10 Nos.(103) Rs.5.00/unit Total cost Rs.10.00

4 x22pF Capacitor Pack - 10 Nos. Rs.5.00/unit Total cost Rs.20.00

2 x22 uF/50V Radial Electrolytic Capacitor Rs.15.00/unit Total Cost Rs.30.00

2 x28 Pin - DIP IC Socket/Base (Narrow) Rs 22.00/unit Total Cost Rs.44.00

2x 16 Mhz - Standard Frequency Crystals Rs.8.00/unit Total Cost Rs.16.00

2 x Pushbutton Switch (2 pin Tactile) Rs 25.00/unit Total Cost Rs.50.00

2 x 1K ohm Resistance Pack-1/4 Watt Rs.4.00/unit Total Cost Rs.8.00

2 x LM7805 - 5V Positive Voltage Regulator Rs.12.00/unit Total Cost Rs.24.00

2 x ATmega328P Microcontroller with Arduino UNO Bootloader Rs.325.00/unit Total cost Rs.650.00

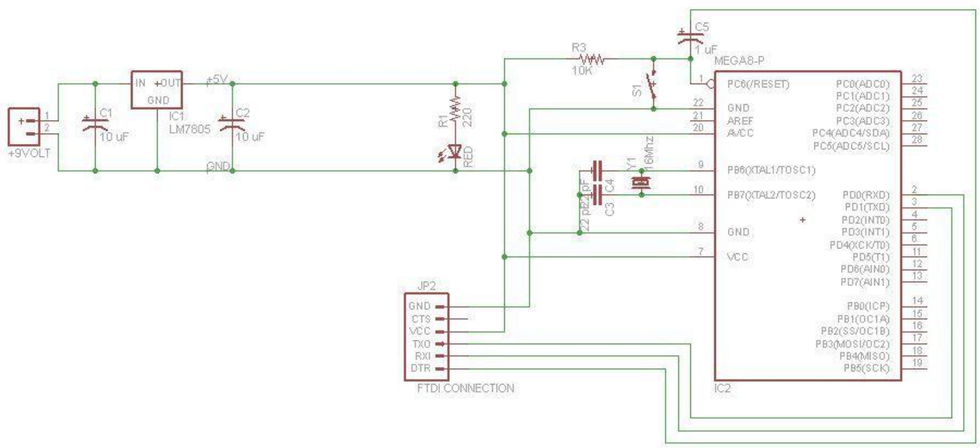
2 x General Purpose/Perforated boards PCB Rs.35.00/unit Total cost Rs.70.00

2 x Wire Stripper & Cutter Rs.45.00/unit Total cost Rs.90.00

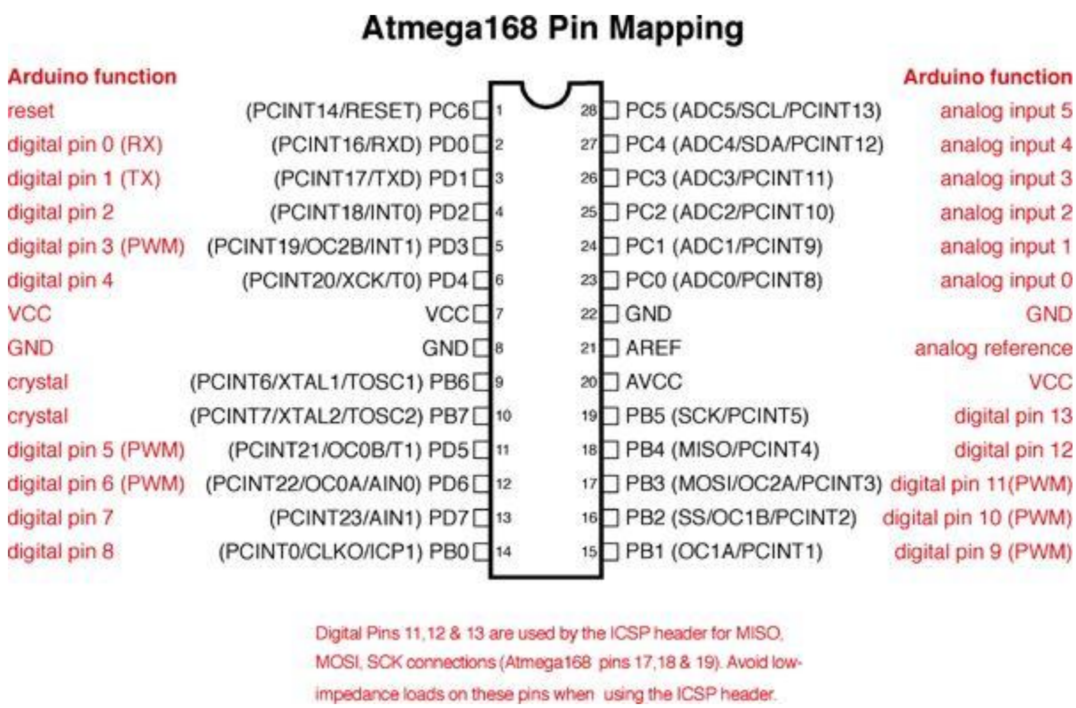
Sub-Total: Rs.1,012.00

This Bill of material is for two sets. An individual set would cost around Rs 506.00. As can been seen that the price has been greatly reduced from Rs 1500 to Rs 506.

SCHEMATIC DIAGRAM



This is the schematic digram I used to make circuit design on the breadboard. I have not used FTDI circuit.



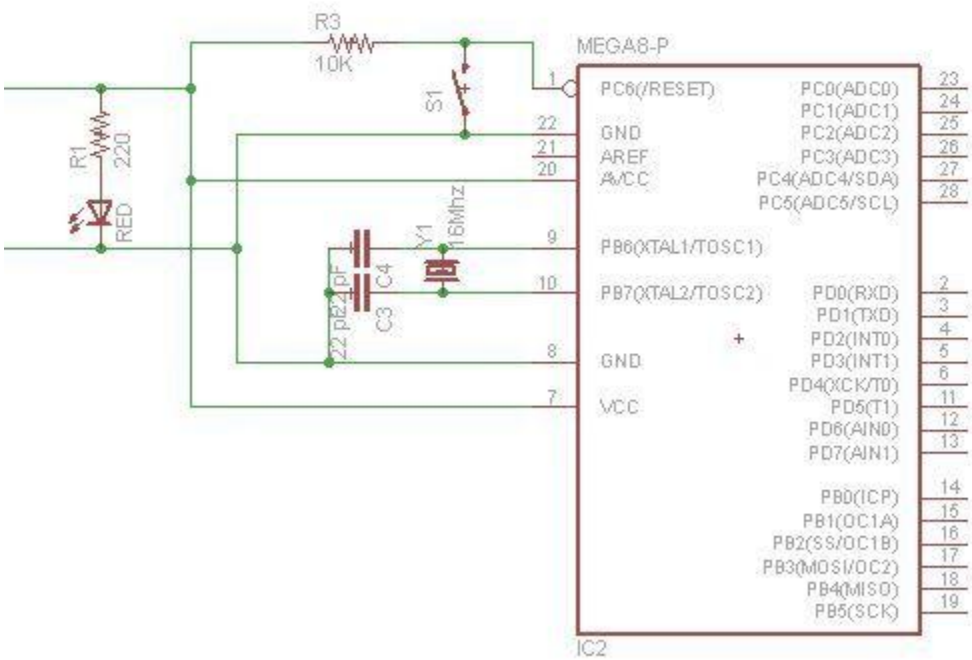
This is the pin configuration diagram of the ATMEGA168/328P.

POWER CIRCUIT

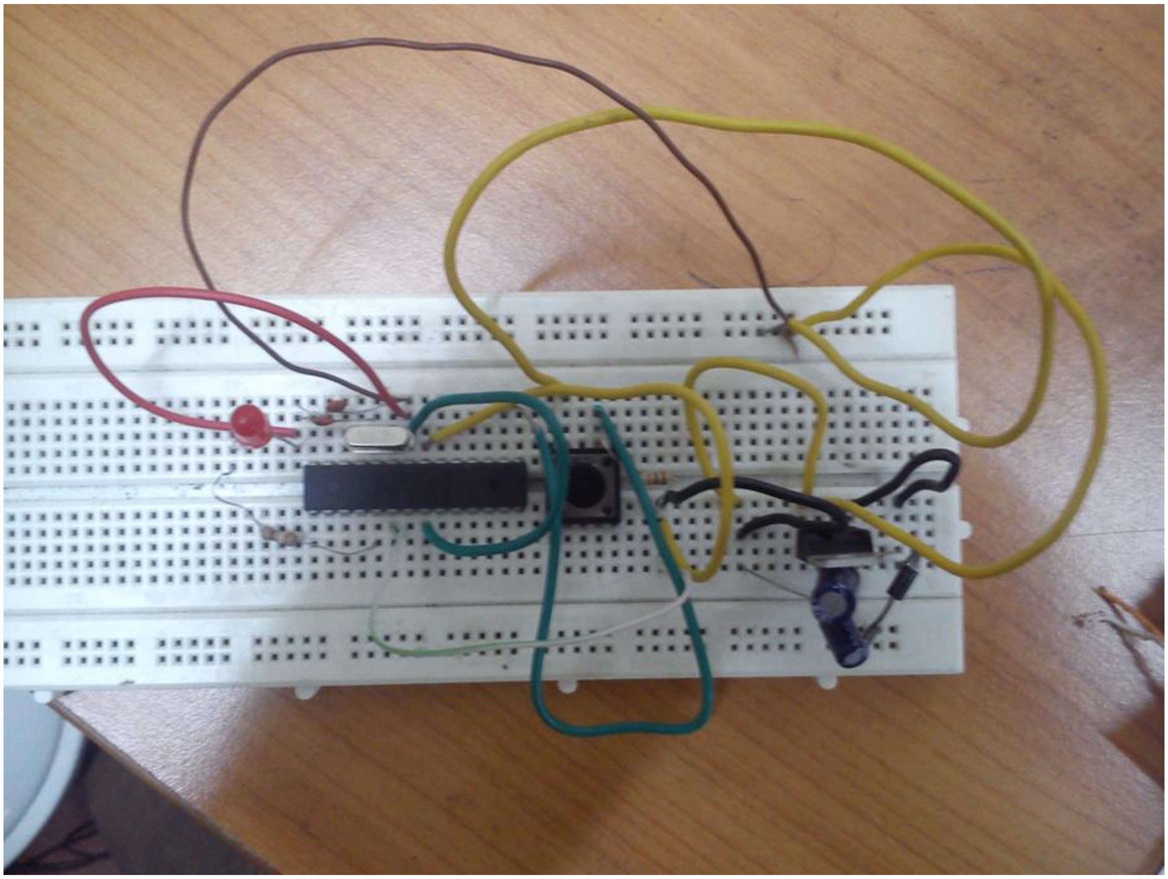
Now moving on the the circuit design. For any any electronic circuit design a power circuit is required so first I designed a power circuit. I used LM7805 - 5V Positive Voltage Regulator. The task of voltage regulator is that it regulates voltage. In this case Battery source would be 9V. So a regulator would regulate the 9V down to 5V which is a decent voltage for arduino to work on. I connected two capacitors of value 100micro Farads and 10micro farads across the input to ground and ground to output respectively of the regulator. They are used to condition the input and output power to each of the Voltage Regulators. I also added a diode which is not mentioned in the schematic just as a safety issue. The diode only allows current to pass in one direction.

REST OF DESIGN

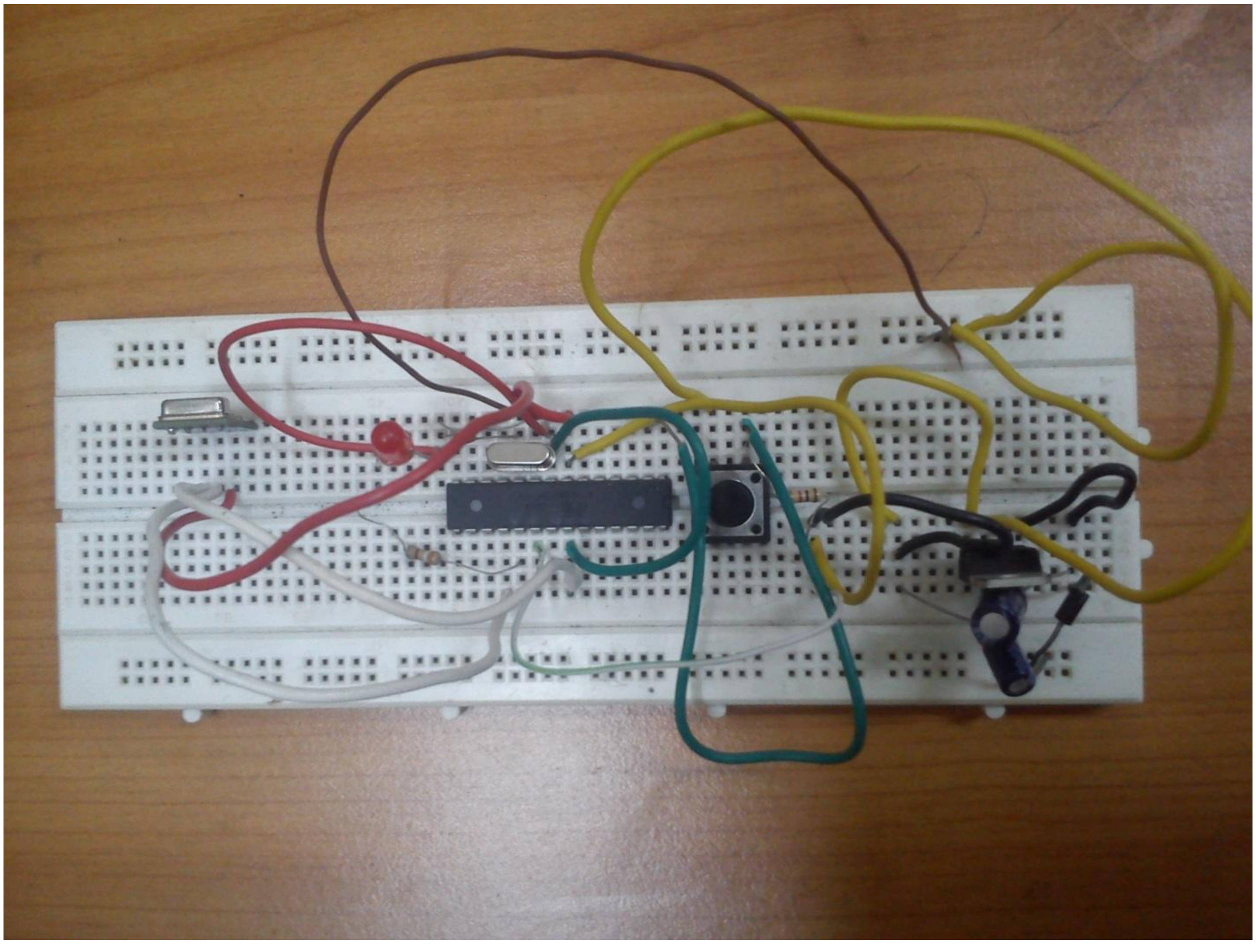
I did not follow exactly the schematic diagram the way it is, I made some modifications to suit my own comfort. However I placed the chip on the arduino uno and pretty much followed the steps as mentioned in the schematic diagram. The main thing to keep in mind was that pin number 7 was Vcc and pin number 8 was Gnd so it becomes easier to connect the rest of components. I connected the LED in a slightly different way then what is mentioned in the diagram but like I said that was to suit my comfort zone. The clock is the main component to the timing system. It is required for the processor to operate correctly with the Arduino programmer. I connected two two 22pFarads just to make the timing more efficient and more accurate. Below is the continuation schematic diagram of the rest of circuit.



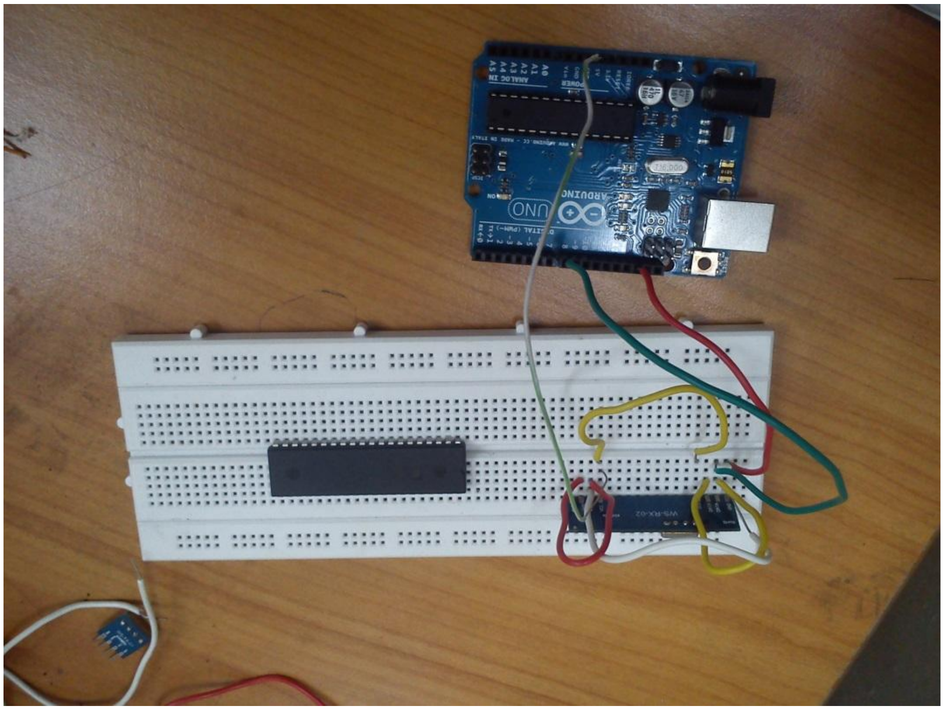
I connected a resistor between the 5 volt power and the bottom left pin of the switch and the bottom right pin of switch straight to ground. Then connect the same top left pin of your switch to pin 1 of your chip (the reset pin). Then connect the bottom left pin of the switch to ground. The setup will allow to reset the program by momentarily pressing the button. I made sure to check the   continuity of pins in the switch to know which two pins are having continuity before placing it in the breadboard. Below are the snaps of my bread bone arduino.



The next step was to bootload the atmega 328p with the transmitter code. I removed the atmega 328p chip from the arduino uno board which already had the transmitter code burned in it and inserted the blank atmega 328p and then I successfully bootloaded the code in the atmega 328P. The next step was to interface the RF transmitter in my breadboard design. I connected Ground of Transmitter to ground of one of the peripherals of the atmega 328P, Vcc to Vcc of atmega 328p and Data pin to the pin which I had set on the code. I gave it a power source and it was transmitting successfully. Below is the snap of the breadboard arduino with the RF transmitter.



On the receiving side I connected RF module Rx with the arduino uno. Just shorted all the grounds together and connected one wire from the ground to ground of arduino uno. Shorted all the Vccs together and connected a wire to Vcc pin of arduino and connected data pin of Rx to pin port set according to the code. Below is the snap.



The basic design is all set, some modifications need to be make which I am currently working on. After this setup is complete my next step would be to shoulder the same design in PCB completely minimizing the size.

Thevenin_and_PCB | Arduino 1.0.1

File Edit Sketch Tools Help

Thevenin_and_PCB §

```
#include <VirtualWire.h>

int led1 = 8;
int v1=0;

void setup()
{
    Serial.begin(9600);   // Debugging only
    Serial.println("setup");
     pinMode(13,OUTPUT);

    pinMode(led1, OUTPUT);


    // Initialise the IO and ISR
    vw_set_ptt_inverted(true); // Required for DR3100
    vw_setup(2000);      // Bits per sec
}

void loop()
{
int i=0;
//const char *str;//const char *msg;
     // read the input on analog pin 0:

v1=1023;
  {
  digitalWrite(led1, LOW);
    // turn the LED off by making the voltage LOW
  delay(500);               // wait for a second
  digitalWrite(led1, HIGH);
  // turn the LED on (HIGH is the voltage level)

  v1=analogRead(A1);
  if(v1>700){

  Serial.print("  Panel OK  ,");
   const char *msg = "9 PANEL1 OK,";

    digitalWrite(13, true); // Flash a light to show transmitting
    vw_send((uint8_t *)msg, strlen(msg));
    vw_wait_tx(); // Wait until the whole message is gone
    digitalWrite(13, false);
    delay(200);

  }
```

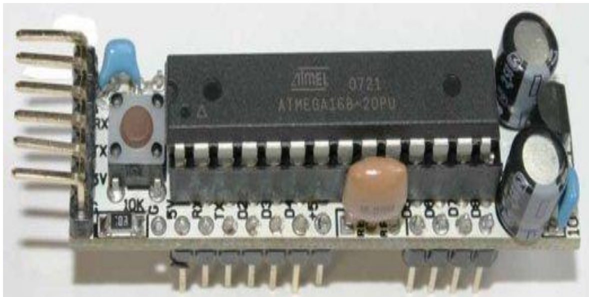
Thevenin_and_PCB | Arduino 1.0.1

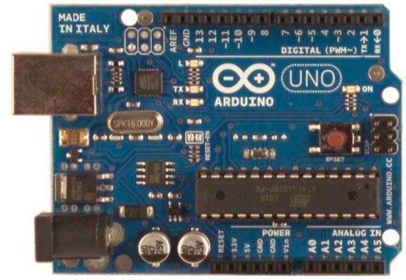
File Edit Sketch Tools Help

Thevenin_and_PCB §

```
  if(v1<700){



  // Transmission Begins

    Serial.print(" Panel Failure ");
    const char *msg = "0 PANEL1 FAIL,";

    digitalWrite(13, true); // Flash a light to show transmitting
    vw_send((uint8_t *)msg, strlen(msg));
    vw_wait_tx(); // Wait until the whole message is gone
    digitalWrite(13, false);
    delay(200);
}
    delay(200);
}

     int s1 = analogRead(A0);
   //  Serial.print("s1=");
//     Serial.print(s1);
  if(s1>223 && s1<303)
{
  const char *str = "3 Level 3,";
    digitalWrite(13, HIGH); // Flash a light to show transmitting
    vw_send((uint8_t *)str, strlen(str));
    //Serial.print(strlen(str)); // Debug check
    Serial.print("        Level 3 ,      ");
    vw_wait_tx(); // Wait until the whole message is gone
    digitalWrite(13, LOW);
    delay(200);
}
 else if(s1>303 && s1<403)
{
  const char *str = "2 Level 2,";
    digitalWrite(13, HIGH); // Flash a light to show transmitting
    vw_send((uint8_t *)str, strlen(str));
    //Serial.print(strlen(str)); // Debug check
    Serial.print("       Level 2 ,     ");
    vw_wait_tx(); // Wait until the whole message is gone
    digitalWrite(13, LOW);
    delay(200);
}
  else if(s1>403 && s1< 573)
 {
   const char *str = "1 Level 1,";
     digitalWrite(13, HIGH); // Flash a light to show transmitting
     vw_send((uint8_t *)str, strlen(str));
     //Serial.print(strlen(str)); // Debug check
     Serial.print("        Level 1 ,     ");
     vw_wait_tx(); // Wait until the whole message is gone
     digitalWrite(13, LOW);
     delay(200);
 }
     delay(200); }
```

LIFE OF BATTERY CALCULATIONS





1. Barebones Arduino is suggested to be employed for the industrial application instead of the Arduino Uno used in the Prototyping as the codes are not required to be changed again and the USB interface is also not required. The power consumption for this particular chip is very less in comparison to the Uno takes around 6mA (instead of 15mA) when running in normal conditions.

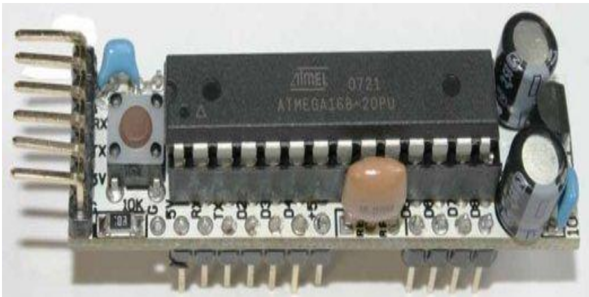
2. The use of Arduino Library called "JeeLib" is suggested for the code. It has inbuilt function called "Sleepy" which makes the Arduino run in low power mode for specified time and reduces power consumption substantially.

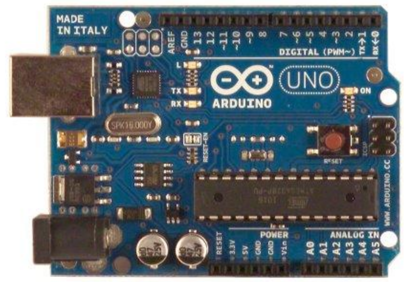
   Below, we present some of the calculations made for the system along with the assumptions:

- Assuming 6mA current for blinking circuit for 1 minutes in every 30 minutes.
- Average current = (6mA*1*0.5+16uA*30)/32 min = 0. 248mA
- Battery time = 450mAh/0.248mA = 1814hrs = Around 76 days (2.52 months)

Hence, connecting 2* 450 mAh batteries in parallel we can get a life of over 5 months. More batteries can be attached depending on required life.

COST CALCULATIONS





Cost Per Panel:

- PCB= **Rs 200/-** (estimate) (1 Ft* 1Ft)

- Barebones Arduino= Rs 900
  - Divided by 6 Panels= 900/6 = **Rs 150/-** (approx)

- Transmitter= Rs 140/-
  - Divided by 6 Panels=/6 =**Rs 25/-**

- Battery= **Rs 25/-**

Total Cost per panel= Rs 200+150+25+25= Rs 400/-

Current Prototype:

As the above ideas of PCB and the pipes weren't that much effective the idea for wiremesh was selected for the final prototype

With reference to the embodiments of the present invention there exist a system of wear detection which comprises of a simple circuitry and method of working. There exists predetermined threshold or a plurality of thresholds which can be in the form of an electrical conductor. The threshold is directly or indirectly coupled with the controller system (**1**). The controller system (**1**) comprises of a transmitter(which may or may not include an antenna) in circuit with a microcontroller unit (MCU) or Controller unit which generates a pulse of electrical signals which passes through the conductor(**2**) put at a threshold distance inside the panel, thus there exist an electrical conductivity in the threshold conductors(**2**) which in turns drives the MCU unit to transmit a certain packets of data wirelessly or through wire ,the transmitter module which can be of any type infra-red transmitter, RF module ,ultrasonic transmitters, wired communicator and other types of transmitter units which is embedded inside the panel (**3**) at a suitable location, the transmitter unit may or may not include antenna or a plurality of antennas depending on the area of coverage. The transmitter module if wireless transmits radio signals on one or more carrier frequencies. Several carrier frequencies are commonly used in commercially-available transmitter units, including 433.92MHz, 315MHz, 868MHz, 915 MHz and other carrier frequencies. These frequencies are used because of national and international regulations governing the use of radio for communication. (Citation needed).

In a certain embodiment the transmitter unit can be a unified transmitter and receiver unit which can perform bi-directional communication with other units capable of doing so and can also relay signals to other repeater units for more coverage.

The present invention works on the principle of circuit break, the embedded conductor(**2**) is laid out in the form of threshold; there can be plurality of thresholds put in a strategic manner so as to cover the most strategic portions of the screen panels where most wear is likely to occur. Plurality of threshold can work as multiple levels of wear detection. The conductor(**2**) in turn are resistant to certain amount of heat and comes out of the enclosure through suitable connectors and as said earlier is put around the aperture at a particular threshold , the threshold can be single threshold or multi threshold means made up of one or more conductor(**2**) looped around the aperture. As the resilient materials of the screen panels wears out due to abrasion, impact and other types of actions exposing the threshold conductor(**2**), the conductor(**2**) also begins to wear out and finally breaks out and the electrical conductivity which existed in it loses. As the conductivity loses the circuit breaks and becomes an open one and thus the signals that were being transmitted gets interrupted and the receiver on the other side which consists of suitable components to catch the incoming signals from the transmitter and process it further, doesn't get the signal as per requirement and switches modes to give warning in the form of visual, audio visual and other kinds of warnings through an interface system which is installed on the site indicating the wear on the panels , the receiver can be connected to the interface through wired or wireless connections, also the connection between transmitter and the receiver units can be either wired or wireless. The MCU unit/Controller unit also processes the signal for desired packets of data and decodes the encrypted packets of data for desired results which is matched to show the wear profile on the user interface.

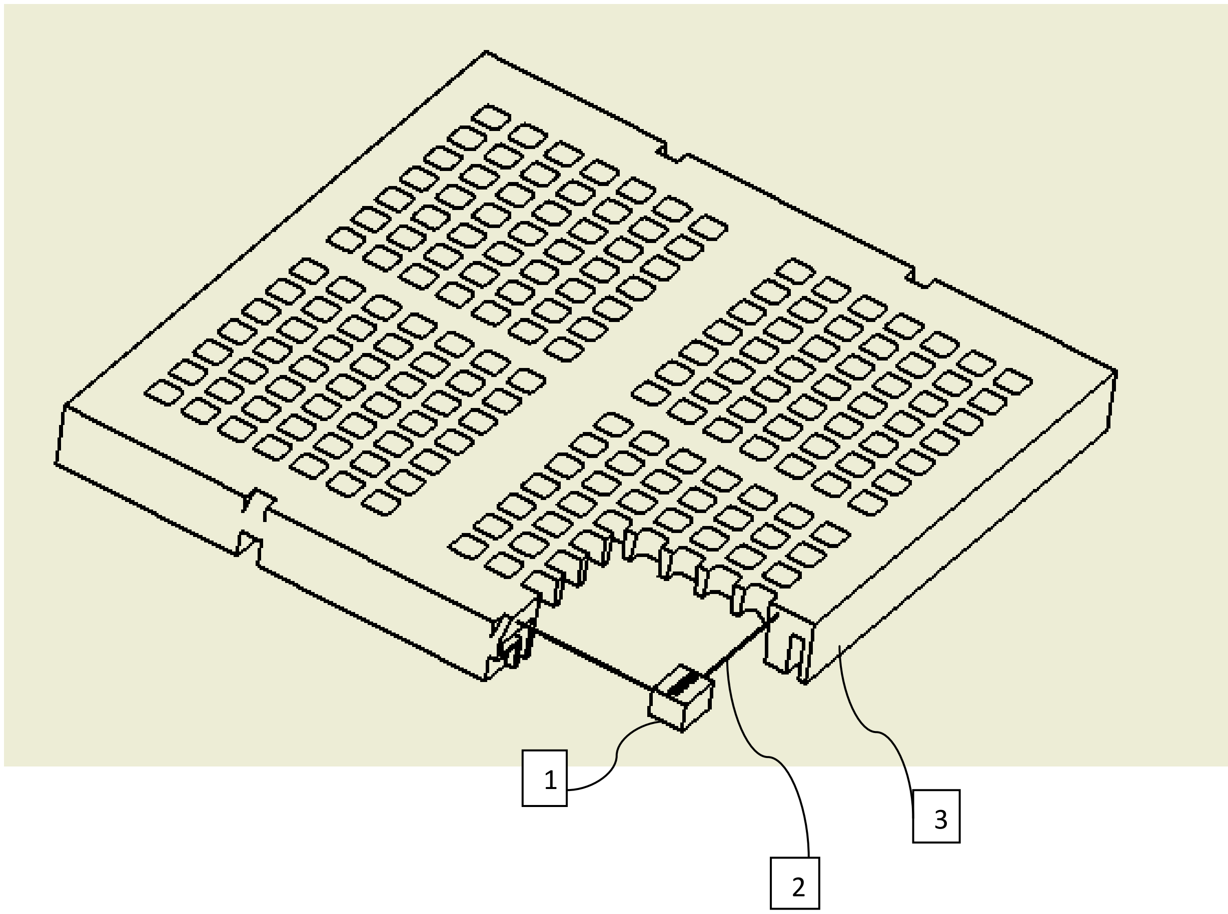
A separate part of the system that is the receiver unit(in case of wired transmitter system the receiver is also a device for sensing electrical signal through wired communication) or circuit breaker data acquisition system comprises of a radio wave receiver unit along with other integrated circuitry for suitably decoding the signals into desired information and/or electrical signals, this receiver unit operates at a suitable frequency and is in range with the transmitter unit so as to catch the signals sent by the panels transmitter unit; the signals can be further amplified using amplifiers which can be radio wave amplifiers, Wi-Fi routers, Wi-Fi access points, networked signal boosters and other kinds of signal boosters, relay units etc, which can be connected to a network as well as the internet so as to provide an accessibility for the client as well as other users to get the wear information on the first hand. The receiver unit can be mounted on the vibrating screen machine frames and/or trommel structures or can also be mounted on stands and frames away from the screening unit but within the range of the transmitter on the panels at a suitable location and can be powered by suitable methods like battery, solar power, internally or externally generated power from different suitable power sources. The receiver unit can also be housed inside a protective casing to protect it from adverse conditions at the plant site.

The screen deck consists of a plurality of screen panel (**3**) which can be made of resilient materials like polyurethane, rubber etc. In this embodiment the screen panel (**3**) is modular in nature and is fitted in numbers to form the screen deck bed of the screen, the screen panel/panels (**3**) along with the circuit breaker signaling system (transmitter along with Controller Unit) which can be powered internally or externally using external and internal power sources which can be of any form like solar panels, batteries, externally generated power. The panels (**3**) which are placed side by side of each other can be interconnected using specially developed connection interfaces or connectors which are less prone to vibrations from the screen machines, the embedded conductors (**2**) lead out to the connectors, in a particular embodiment the connectors can be male and female type parts which can interconnect and provide a steady electrical connectivity, the connector may also have provision for replacement when they have worn out or have damaged. The connectors can be made of any electricity conducting material like brass, copper, etc or can be readily available socket and plug system along with other connection mechanisms and wirings. The whole system can be kept in a vibration and temperature resistant enclosure and embedded inside the panels (**3**) so as to protect the system from damage, there may or may not be provision for removal/replacement of the system from the conductors in case any of the components of the system fails or is damaged, the provision of removal/replacement is also provided so that it can be reused after the panel has worn out but the system circuitry comprising of the transmitter ,controller unit and/or power source are intact and operational.

The whole system can be embedded at the middle of the panel and the conductors can be looped around the aperture, the placements of the system depends on aperture size, shape, and open area of the panel, thickness of the panel and the edges of the panel, the threshold limits and the number of thresholds needed.

In this embodiment of the present invention the receiver is connected to a computer system (through suitable connection which may be wired or wireless and can comprise of different connection systems Ethernet, Serial Communication using RS-232, RS-422, RS-423, RS-428 ports etc, Parallel Communication using LPT1,LPT2,LPT3 ports, USB, Bluetooth, Wi-Fi and other connection methods)on which a software comprising the user interface is installed, the client's computer/server in turn is connected to the internet. The client's computer/server is configured with IP (Internet Protocol) address and is used as an access point and the client side information can be accessed through internet using a similar front end software interface.

In another embodiment of the present invention the receiver unit can be connected to a standalone interface which may or may not be connected to networks or internet, and can consists of a switches embedded circuits, power sources, connectors, wires, LCD/LED or other kinds of display unit that displays the wear profile or the status of panel through different color codes or glowing of LED's and/or display of numbers on the display unit directly or indirectly depicting the panel layout arrangement on the screening system.



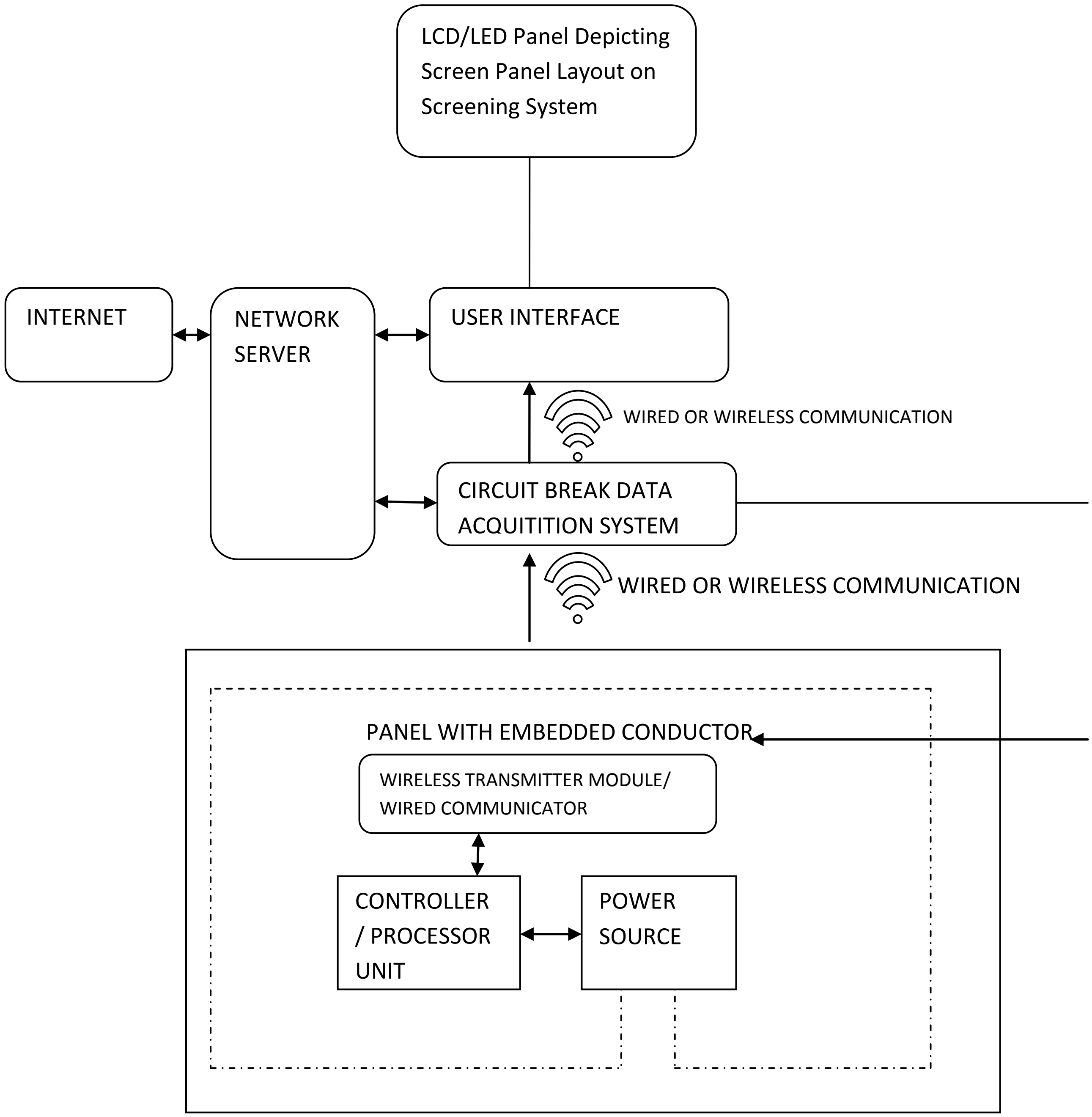

LCD/LED Panel Depicting
Screen Panel Layout on
Screening System
INTERNET
NETWORK
SERVER
USER INTERFACE
WIRED OR WIRELESS COMMUNICATION
CIRCUIT BREAK DATA
ACQUITITION SYSTEM
WIRED OR WIRELESS COMMUNICATION
PANEL WITH EMBEDDED CONDUCTOR
WIRELESS TRANSMITTER MODULE/
WIRED COMMUNICATOR
CONTROLLER
/ PROCESSOR
UNIT
POWER
SOURCE

FIG 2

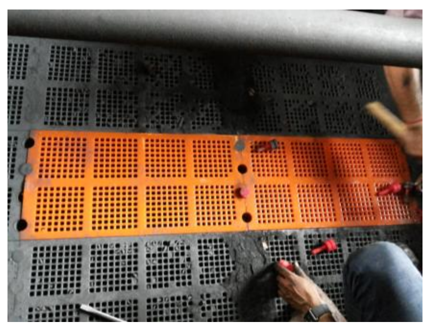
Wireless Receiver

Model No	SIM5216E
How to?	Simcom Module Tutorial
Category	3G Module
Manufacturer	Simcom
Form Factor	Board-to-Board Connector
Dimensions	36 x 26 x 4.7 mm
Technologies	GSM,GPRS(Class 12),EDGE,UMTS,HSDPA
Dload Speed	3.6 Mbps
Upload Speed	384 kbps
Freq bands	
GPRS/EDGE	850/900/1800 MHz

WCDMA	900/2100 MHz
Temperature	-30 º C to 80 º C
Certifications	CE, GCF, RoHS
Interfaces	UART, GPIOs, ADC/DAC, USB, SPI, I2C
Voice Support	None
GPS Support	No

The Receiver is a 3G module of the above specification attached onboard the Arduino board which is programmed using the Arduino IDE software to put AT Commands though the serial port and thus making it to work for basic functionality as in to connect to the server and upload the data that is being received by the ASK 433 Mhz receiver unit.

Installation Of Panels With Tphms @ Tata Steel

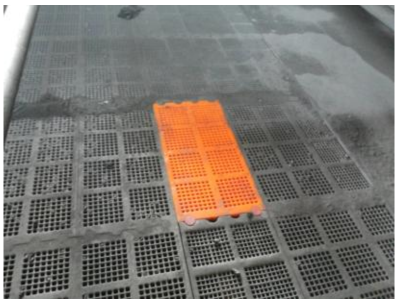


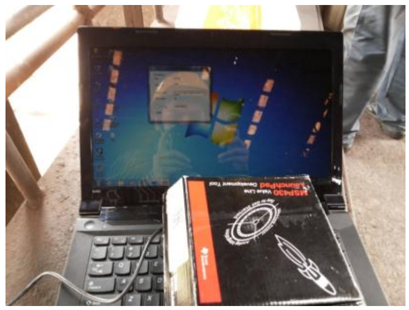
4 Nos of panels were installed at the site & tested but after fixing which was difficult due to the uneven planes on the panel. Two panels stopped working due to vibration.

Test data from previous test with Anaren Transmitter

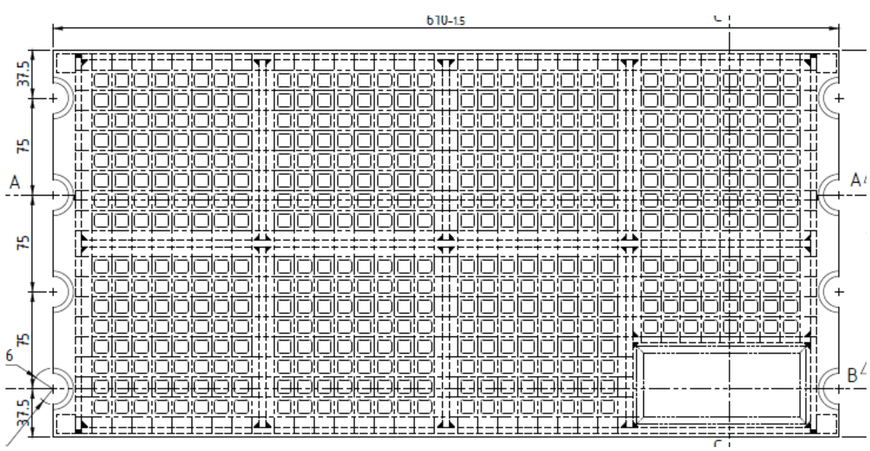
Test data collected with 1sec pulse

```
!d:00,00,3BC0,01,0000,02,0000,03,0000
!d:01,00,3400,01,0000,02,0000,03,0000 !s:00,D700,01,D500
!d:00,00,3BC0,01,0000,02,0000,03,0000
!d:01,00,3400,01,0000,02,0000,03,0000 !s:00,D700,01,D500
!d:00,00,3BC0,01,0000,02,0000,03,0000
!d:01,00,3400,01,0000,02,0000,03,0000 !s:00,D700,01,D500
!d:00,00,3B80,01,0000,02,0000,03,0000
!d:01,00,33C0,01,0000,02,0000,03,0000 !s:00,D700,01,D500
!d:00,00,3BC0,01,0000,02,0000,03,0000
```

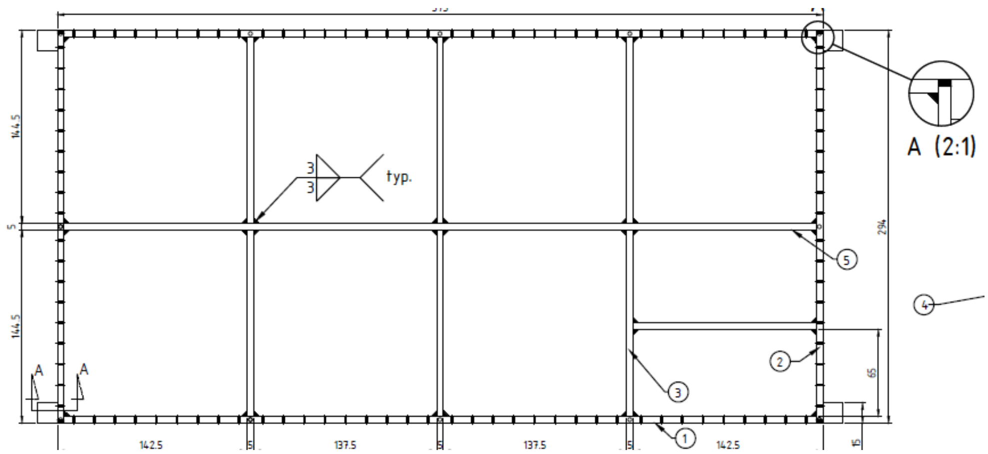




New Design of the panels to support our transmitters as well as Anaren transmitters



New Reinforcement with two row of apertures blocked



TOTAL : Solution™

Issues & possible solutions

Issues	Solutions
Space constraint	Smaller transmitter Have talked with Anaren for custom transmitters but pricing and amount pending issues.
Proper wiring & Connections	Embedding plastic or PU pipes for better connections.
Durable batteries & life	More efficient program to utilize proper battery. Durable battery.
Proper packing of the transmitter and battery.	Should be sealed.

TOTAL : Solution™

tega

Alternative Options

- The LM7805 voltage regulator/step down voltage needs to get removed. As it is consuming a lot of current. That would enhace the battery life and chip life.

- Using AA/AAA pencil batteries of three sets of 1.5V each. So total of 4.5Volts. However the issue with using three sets of AAA batteries is that it wont be able to fit in battery slot on the panels.

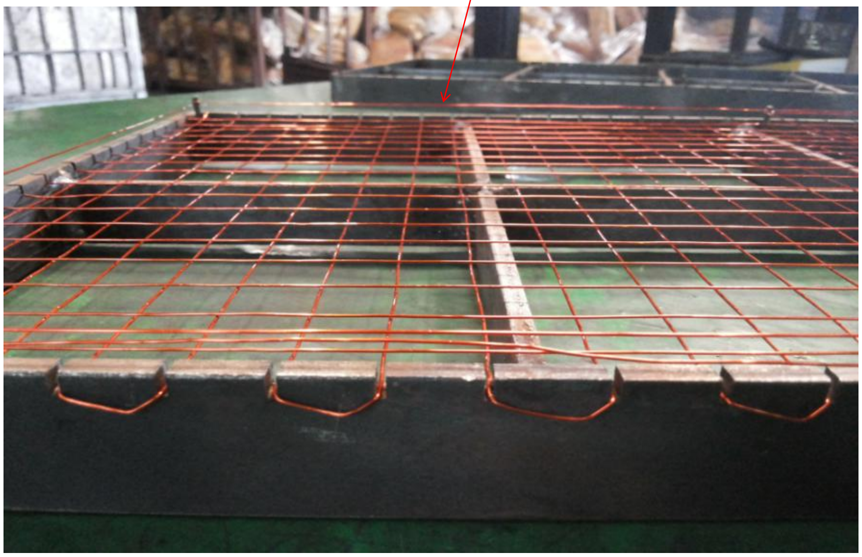
Regulator

TOTAL : Solution™

tega

Reinforcements with the Wire Meshing Done and The thickness threshold done.

Threshold wire



Panel With Wire Mesh Embedded

Turn table for wiremesh weaving

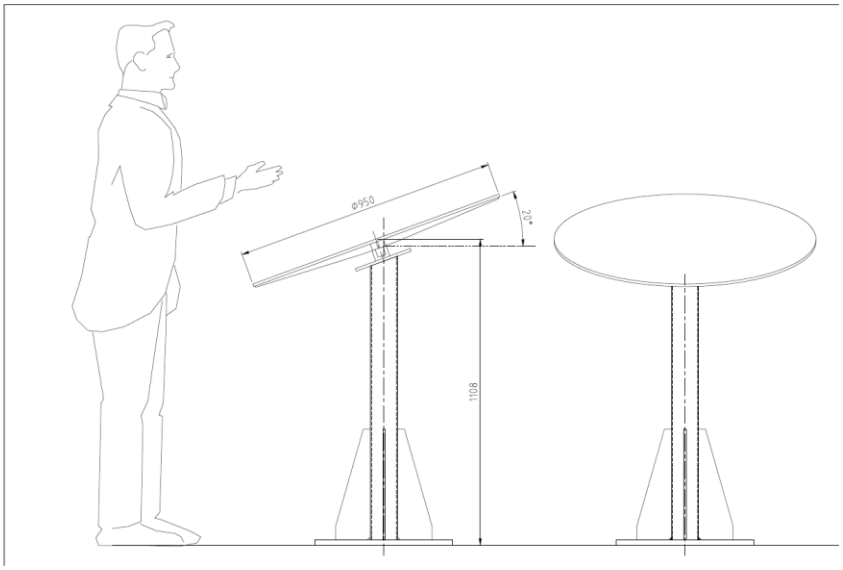


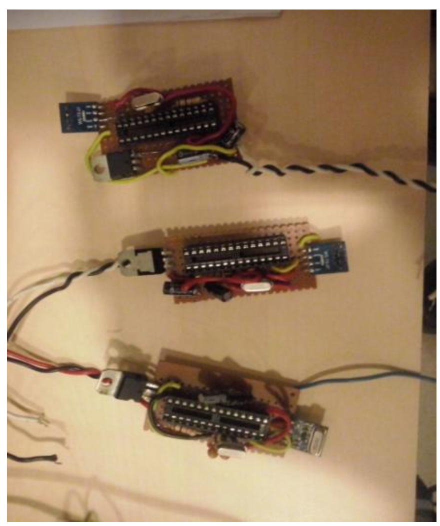
TABLE FOR FAST WEAVING OF WIRE MESH

TOTAL : Solution™

tega

Tega© Panel Health Monitoring System			
Pending			**Remarks**
Activity	**Start date**	**End Date**	
Making of 5 more panels	20-Apr-14	30-Apr-14	3 panels have been made.
Putting the transmitters inside the panels	20-Apr-14	30-Apr-14	8 transmitter modules made but 2 of them not working so need to be remade
Making of the turn table for wire weaving	1-Apr-14	30-May-14	Drawings made, awaiting procurement.
Testing of panels at site	5-May-14	30-May-14	
Steamlining the manufacturing	30-Aug-14	30-Dec-14	Will have to streamline the manufacturing as the process is cumbersome and in accqurate.

FINAL CHIP PROTOTYPE



5 RF Transmitter Measurements tests

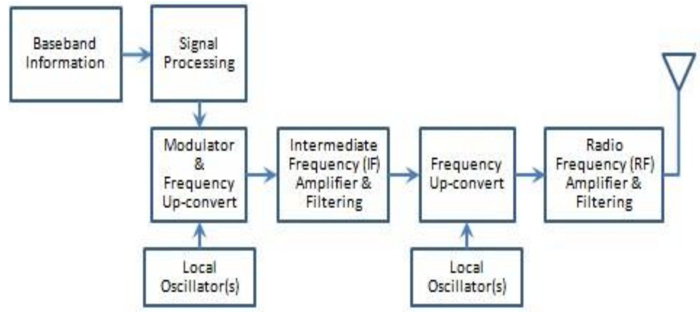


Figure 1. The block diagram of a generic RF transmitter shows baseband information conditioned with signal processing, and then modulated and converted to an intermediate frequency before the final conversion to RF for transmission.
Operating parameters, cost, and design considerations impact RF transmitter performance and, subsequently, the RF signal quality. Consequently, ensuring the RF transmitter meets specification is essential in quality RF communications. Across various implementations of RF transmitters there are standard tests that are essential to ensuring proper operation. This paper explores five essential measurements frequently performed on RF transmitters.

1. Output Power- RF power measurements take many forms, depending on the RF transmitter design and application. The RF output may be a simple continuous wave (CW) signal, a pulse, an analog modulated signal, or a complex digitally modulated transmission, such as an IQ or orthogonal frequency division multiplexing (OFDM) waveform. Among the types of RF power measurements, the steady state RF power of a CW tone is perhaps the simplest.

2. Power in a Band- One measurement is the integrated power across the assigned channel, often called the occupied bandwidth (OBW), power-in-band, or channel power. Here the power is integrated across the channel from the assigned start to the assigned stop frequency.

3. Unwanted Signals- With a perfect RF transmitter, the only signal transmitted would be the signal of interest. However, unwanted signals are a consequence of real-world transmitter design trade-offs. Cost, performance, and other requirements influence the final product. These unwanted signals fall within three broad categories: harmonic, intermodulation, and spurious (spurs).

4. Phase Noise- Perhaps one of the most competitive specifications for an RF transmitter is phase noise. RF transmitters, and receivers for that matter, typically consist of several frequency conversion stages.

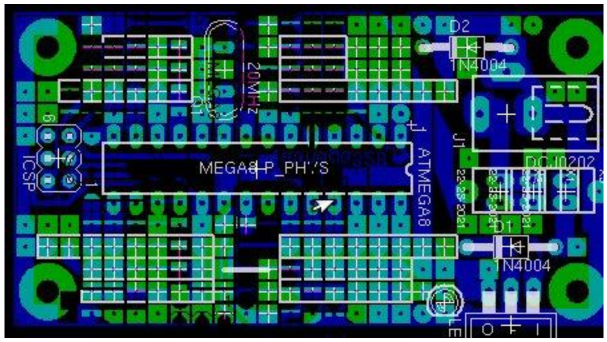
5. Modulation Quality- RF transmitters encode information on one or more CW carriers with modulation. Evaluating the quality of the modulated signal provides insight into the health of the entire transmitter chain from baseband to RF output. Some tests are specific to a given modulation scheme, but others are widely used. For example, with AM and FM analog modulation, modulation index and depth are generally measured.

New Alternative Transceiver unit for better transmission

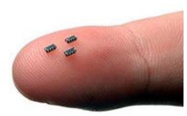
Feature:

- 2.4Ghz lisence-free ISM band
- Highest data speed 2Mbps，high efficient GFSK modulation, anti-interfere, specially suit for indutrial control
- 125 channel, can reach different point or jump frequency communication needs
- Integrated hardware 8/16 bytes CRC confirmation and point to mutiple points communication adress control, combine TDMA – CMDA – FDMA working principle, enable wireless communication.
- Low power comunpiton 1.9 – 3.6V ，Standby mode only need 1uA ；
- Module can set address by software, only output data when receive own device address(display interruption), can directly connect to any single chip, easy to program.
- Send and receive interruption signal, send 28 bytes maximally each time.
- Integrated special voltage regulator, use any kind of power including DC/DC power can have better communication effort.
- Standard DIP jack, easy for embedded system application.
- CLK，DATA，DR three wires connection，easy to program。
- Two channels data receive, embedded circular antennas, communication distance is 20-30 meters in open and no interferes environment.
- Dimension: 34mm * 17mm * 1mm（PCB embedded antennas）

PCB DESIGN



SMT Components



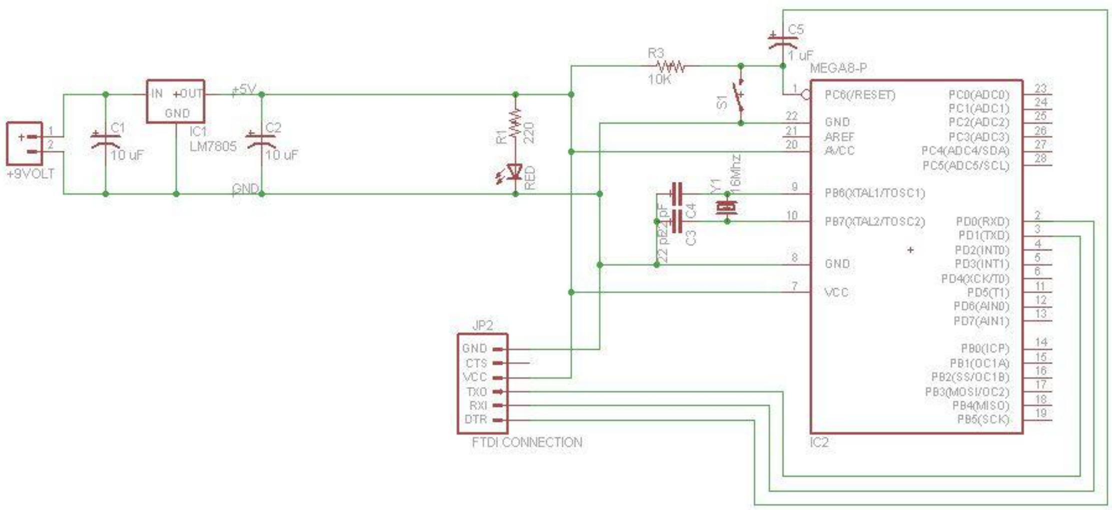
• The new SMD components make the circuits more stable and smaller in size.

• A surface mounted technology (SMT) is defined as a methodology for attaching packages to one side of a printed circuit board (PCB) by way of a solder joint. These solder joints attach the leads of a package to the PCB right on the surface. Prior to the implementation of SMT, the type of attachments used comprised of one main type: through-hole technology (THT).

• Testing :

1. Thermal cycling
2. Power cycling
3. Vibrational- Vibrational testing with regards to SMTs is basically the testing of how SMTs react to vibrations over 150 Hz while in use

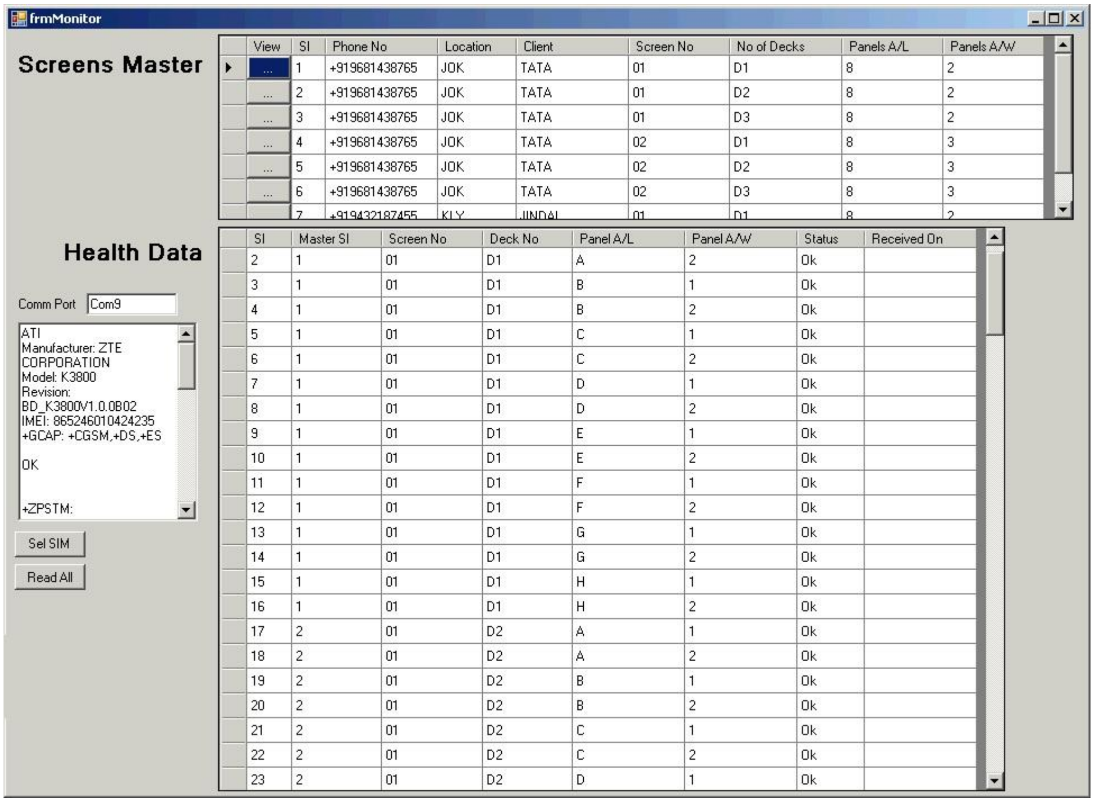
DESIGN OF PCB LAYOUT



COST PER PCB

ITEMS	COST per item
ATMEGA 328p with UNO bootloader	Rs 290
RF 433Mhz modoules	Rs 100
SMD 16Mhz crystal Oscillator	Rs 15
SMD 10microfarads Capacitor	Rs 4.90
SMD 22Pf capacitor	Rs 1.1
10K resistor	Rs 0.7
SMD 7805 Voltage regulator	Rs 12.50
Atmega chip case	Rs 5
9V Volt battery	Rs 12.60
Manufactering Cost	Rs 250
	Total Cost Rs 691.8/ US dollars $11.673

New SMS based Screen Master Program



View	Sl	Phone No	Location	Client	Screen No	No of Decks	Panels A/L	Panels A/W
...	1	+919681438765	JOK	TATA	01	D1	8	2
...	2	+919681438765	JOK	TATA	01	D2	8	2
...	3	+919681438765	JOK	TATA	01	D3	8	2
...	4	+919681438765	JOK	TATA	02	D1	8	3
...	5	+919681438765	JOK	TATA	02	D2	8	3
...	6	+919681438765	JOK	TATA	02	D3	8	3
	7	+919432187455	KLY	JINDAL	01	D1	8	2

Sl	Master Sl	Screen No	Deck No	Panel A/L	Panel A/W	Status	Received On
2	1	01	D1	A	2	Ok	
3	1	01	D1	B	1	Ok	
4	1	01	D1	B	2	Ok	
5	1	01	D1	C	1	Ok	
6	1	01	D1	C	2	Ok	
7	1	01	D1	D	1	Ok	
8	1	01	D1	D	2	Ok	
9	1	01	D1	E	1	Ok	
10	1	01	D1	E	2	Ok	
11	1	01	D1	F	1	Ok	
12	1	01	D1	F	2	Ok	
13	1	01	D1	G	1	Ok	
14	1	01	D1	G	2	Ok	
15	1	01	D1	H	1	Ok	
16	1	01	D1	H	2	Ok	
17	2	01	D2	A	1	Ok	
18	2	01	D2	A	2	Ok	
19	2	01	D2	B	1	Ok	
20	2	01	D2	B	2	Ok	
21	2	01	D2	C	1	Ok	
22	2	01	D2	C	2	Ok	
23	2	01	D2	D	1	Ok	

CODES AND PROGRAMS

SMS:

```
#include <SoftwareSerial.h>

SoftwareSerial SIM900(5,6);


void setup()

{

  SIM900.begin(115200);

  SIM900power();

  delay(20000);  // give time to log on to network.

}


void SIM900power()

// software equivalent of pressing the GSM shield "power" button

{

  digitalWrite(8, HIGH);

  delay(1000);

  digitalWrite(8, LOW);

  delay(5000);

}


void sendSMS()

{

  SIM900.print("AT+CMGF=1\r");                                    // AT command to send SMS message

  delay(100);
```

```
  SIM900.println("AT+CMGS=\"8902608479\"");                              // recipient's mobile number, in
international format
  delay(100);
  SIM900.println("Hello, world. This is a text message from an Arduino Uno.");       // message to send
  delay(100);
  SIM900.println((char)26);                    // End AT command with a ^Z, ASCII code 26
  delay(100);
  SIM900.println();
  delay(5000);                              // give module time to send SMS
  SIM900power();                              // turn off module
}

void loop()
{
  sendSMS();
  do {} while (1);
}
```

NUMBER DAILING USING SOFT SERIAL:

```
#include <SoftwareSerial.h>
SoftwareSerial SIM900(5,6); // configure software serial port

void setup()
{
  Serial.begin(115200);
  SIM900.begin(115200);
  SIM900power();
```

```
  delay(20000);  // give time to log on to network.
}

void SIM900power()
// software equivalent of pressing the GSM shield "power" button
{
  digitalWrite(8, HIGH);
  delay(1000);
  digitalWrite(8, LOW);
  delay(5000);
}

void callSomeone()
{
  SIM900.print("ATD8902608479;\r");
  delay(100);
  SIM900.println();
  delay(30000);           // wait for 30 seconds...
  SIM900.println("ATH");   // hang up
}

void loop()
{
  callSomeone(); // call someone
  SIM900power();   // power off GSM shield
  do {} while (1); // do nothing
```

```
}
```

WEBSERVER

```
/*
  Web Server

 A simple web server that shows the value of the analog input pins.
 using an Arduino Wiznet Ethernet shield.

 Circuit:
 * Ethernet shield attached to pins 10, 11, 12, 13
 * Analog inputs attached to pins A0 through A5 (optional)

 Created By Tanmay Moharana

 */

#include <SPI.h>
#include <Ethernet.h>

// Enter a MAC address and IP address for your controller below.
// The IP address will be dependent on your local network:
byte mac[] = {
  0xDE, 0xAD, 0xBE, 0xEF, 0xFE, 0xED };
IPAddress ip(192,168,10,66);

// Initialize the Ethernet server library
```

```
// with the IP address and port you want to use
// (port 80 is default for HTTP):
EthernetServer server(80);

void setup() {
 // Open serial communications and wait for port to open:
  Serial.begin(9600);
   while (!Serial) {
    ; // wait for serial port to connect. Needed for Leonardo only
  }


  // start the Ethernet connection and the server:
  Ethernet.begin(mac, ip);
  server.begin();
  Serial.print("server is at ");
  Serial.println(Ethernet.localIP());
}


void loop() {
  // listen for incoming clients
  EthernetClient client = server.available();
  if (client) {
    Serial.println("new client");
    // an http request ends with a blank line
```

```
  boolean currentLineIsBlank = true;
  while (client.connected()) {
   if (client.available()) {
    char c = client.read();
    Serial.write(c);
    // if you've gotten to the end of the line (received a newline
    // character) and the line is blank, the http request has ended,
    // so you can send a reply
    if (c == '\n' && currentLineIsBlank) {
     // send a standard http response header
     client.println("HTTP/1.1 200 OK");
     client.println("Content-Type: text/html");
     client.println("Connection: close");  // the connection will be closed after completion of the
response
          client.println("Refresh: 5");  // refresh the page automatically every 5 sec
     client.println();
     client.println("<!DOCTYPE HTML>");
     client.println("<html>");
     // output the value of each analog input pin
     for (int analogChannel = 0; analogChannel < 6; analogChannel++) {
      int sensorReading = analogRead(analogChannel);
      client.print("analog input ");
      client.print(analogChannel);
      client.print(" is ");
      client.print(sensorReading);
      client.println("<br />");
     }
```

```
          client.println("</html>");
          break;
        }
        if (c == '\n') {
          // you're starting a new line
          currentLineIsBlank = true;
        }
        else if (c != '\r') {
          // you've gotten a character on the current line
          currentLineIsBlank = false;
        }
      }
    }
    // give the web browser time to receive the data
    delay(1);
    // close the connection:
    client.stop();
    Serial.println("client disconnected");
  }
}
```

FTP SERVER FOR RECEIVER:

```
#include <VirtualWire.h>

string c;

void setup()

{

 Serial.begin(115200);

 vw_set_ptt_inverted(true); // Required for DR3100

 vw_setup(2400);          // Bits per sec

  vw_set_rx_pin(6);

  vw_rx_start();      // Start the receiver PLL running

  uint8_t buf[VW_MAX_MESSAGE_LEN];

  uint8_t buflen = VW_MAX_MESSAGE_LEN;


  Serial.println("AT+CFTPSERV=\"tegascreen.comxa.com\"");

 delay(2000);

 Serial.println("AT+CFTPPORT=21");

 delay(2000);

 Serial.println("AT+CFTPMODE=1");

 delay(2000);

 Serial.println("AT+CFTPUN=\"a6803377\"");

 delay(2000);

 Serial.println("AT+CFTPPW=\"computer2007\"");
```

```
delay(2000);

Serial.println("AT+CFTPPUT=\"/public_html/test/paneltest.txt\"\r");

 delay(60000);

  while(c="")

 {



 if (vw_get_message(buf, &buflen)) // Non-blocking

 {

        int i;



    digitalWrite(13, true); // Flash a light to show received good message

        // Message with a good checksum received, dump it.

        // Serial.print("Got:");


        for (i = 0; i < buflen; i++)

        {

           //Serial.print(buf[i], HEX);

        c= buf[i];

    Serial.print(c);

    Serial.print(" ");

        }

        Serial.println("");

    digitalWrite(13, false);

 }
```

```
}
 delay(5000);
  Serial.write((byte)0x1A);
}


 void loop()
 {



 }
```

RECEIVER CODE:

```
#include <VirtualWire.h>


void setup()

{

  Serial.begin(9600);    // Debugging only

  Serial.println("setup");


  // Initialise the IO and ISR


  vw_set_ptt_inverted(true); // Required for DR3100


  vw_setup(2400);        // Bits per sec


  vw_rx_start();      // Start the receiver PLL running


  uint8_t buf[VW_MAX_MESSAGE_LEN];

  uint8_t buflen = VW_MAX_MESSAGE_LEN;
```

```
}

void loop()
{
  uint8_t buf[VW_MAX_MESSAGE_LEN];
  uint8_t buflen = VW_MAX_MESSAGE_LEN;


  if (vw_get_message(buf, &buflen)) // Non-blocking
  {
        int i;
    char c;

    digitalWrite(13, true); // Flash a light to show received good message
        // Message with a good checksum received, dump it.
        // Serial.print("Got:");

        for (i = 0; i < buflen; i++)
        {
          //Serial.print(buf[i], HEX);
        c= buf[i];
    Serial.print(c);
    Serial.print(" ");
        }
        Serial.println("");
```

```
        digitalWrite(13, false);
    }
}
```

TCP WEBSERVER

```
char data[1024];
int data_size;
int led = 13;
int onModulePin = 8;        // the pin to switch on the module (without press on button)

int x = 0;

char server[ ]="www.google.com";
char port[ ]="80";
void switchModule(){
    digitalWrite(onModulePin,HIGH);
    delay(2000);
    digitalWrite(onModulePin,LOW);
}
```

```
void setup(){

  Serial.begin(115200);              // UART baud rate
  delay(2000);
  pinMode(led, OUTPUT);
  pinMode(onModulePin, OUTPUT);
  switchModule();                    // switches the module ON

  for (int i=0;i< 5;i++){
    delay(5000);
  }



  delay(8000);

  Serial.println("AT+CREG=2");
  delay(8000);
  Serial.println("AT+CGAUTH=1,1,\"\",\"\"");
  delay(5000);
  Serial.println("AT+NETOPEN=\"TCP\",6000");
  delay(5000);
  Serial.println("AT+CGSOCKCONT=1,\"IP\",\"SMARTNET\""); // my apn is internet (tango lu)
  delay(5000);
  Serial.println("AT+SERVERSTART");
  delay(5000);
```

```
  Serial.flush();

  Serial.println("AT+IPADDR");

  Serial.println(Serial.read());


  Serial.flush();

  while(Serial.read()!='K');


}


void loop()

{


  Serial.print("AT+CHTTPACT=\""); //Connects with the HTTP server

 Serial.print(server);

 Serial.print("\",");

 Serial.println(port);

  Serial.flush();

  x=0;

  do{

    while(Serial.available()==0);

    data[x]=Serial.read();

    x++;

  }while(!(data[x-1]=='T'&&data[x-2]=='S'));       //waits for response "REQUEST"


  Serial.println("GET /index.html HTTP/1.1");

 Serial.println("Host: www.google.com");
```

```
 Serial.println("Content-Length: 0");
 Serial.write(0x1A);      //sends ++
  Serial.write(0x0D);
  Serial.write(0x0A);

 while(Serial.read()!='K');
 while(Serial.read()!=' ');

 data_size=0;
 do{
  data_size*=10;
  data_size=data_size+(Serial.read()-0x30);
 }while(Serial.peek()!=0x0D);

 for(x=0;x< data_size;x++){
  data[x]=Serial.read();
 }

 Serial.print(data);

  while(1);

}
```

GSM XIVELY CLIENT

```
/*
 GSM Xively client

 This sketch connects an analog sensor to Xively (http://www.xively.com)
 using a Telefonica GSM/GPRS shield.

 This example has been updated to use version 2.0 of the Xively.com API.
 To make it work, create a feed with a datastream, and give it the ID
 sensor1. Or change the code below to match your feed.

 Circuit:
 * Analog sensor attached to analog in 0
```

```
 * GSM shield attached to an Arduino

 * SIM card with a data plan


 created 4 March 2012

 by Tanmay Moharana

 This code is in the public domain.


 http://arduino.cc/en/Tutorial/GSMExamplesXivelyClient


 */


// libraries

#include <GSM.h>


// Xively Client data

#define APIKEY         "ZFZNMnwFJzUvQMzAdkxb6dadVYmCLmH91wzTTHxWA4ETBwbD"  // replace
your xively api key here

#define FEEDID         1893442342                 // replace your feed ID

#define USERAGENT      "My Project"             // user agent is the project name


// PIN Number

#define PINNUMBER ""


// APN data

#define GPRS_APN       "SMARTNET"  // replace your GPRS APN

#define GPRS_LOGIN     ""     // replace with your GPRS login

#define GPRS_PASSWORD  ""  // replace with your GPRS password
```

```
// initialize the library instance:
GSMClient client;
GPRS gprs;
GSM gsmAccess;

// if you don't want to use DNS (and reduce your sketch size)
// use the numeric IP instead of the name for the server:
// IPAddress server(216,52,233,121);    // numeric IP for api.xively.com
char server[] = "api.xively.com";      // name address for xively API

unsigned long lastConnectionTime = 0;        // last time you connected to the server, in milliseconds
boolean lastConnected = false;                // state of the connection last time through the main loop
const unsigned long postingInterval = 10*1000;  //delay between updates to Xively.com

void setup()
{
  // initialize serial communications and wait for port to open:
  Serial.begin(9600);
  while (!Serial) {
    ; // wait for serial port to connect. Needed for Leonardo only
  }

  // connection state
  boolean notConnected = true;
```

```
  // After starting the modem with GSM.begin()
  // attach the shield to the GPRS network with the APN, login and password
  while (notConnected)
  {
    if ((gsmAccess.begin(PINNUMBER) == GSM_READY) &
        (gprs.attachGPRS(GPRS_APN, GPRS_LOGIN, GPRS_PASSWORD) == GPRS_READY))
      notConnected = false;
    else
    {
      Serial.println("Not connected");
      delay(1000);
    }
  }
}


void loop()
{
  // read the analog sensor:
  int sensorReading = analogRead(A0);


  // if there's incoming data from the net connection.
  // send it out the serial port.  This is for debugging
  // purposes only:
  if (client.available())
  {
    char c = client.read();
```

```
    Serial.print(c);
  }

  // if there's no net connection, but there was one last time
  // through the loop, then stop the client:
  if (!client.connected() && lastConnected)
  {
    client.stop();
  }

  // if you're not connected, and ten seconds have passed since
  // your last connection, then connect again and send data:
  if (!client.connected() && ((millis() - lastConnectionTime) > postingInterval))
  {
    sendData(sensorReading);
  }

  // store the state of the connection for next time through
  // the loop:
  lastConnected = client.connected();
}

/*
  This method makes a HTTP connection to the server.
*/
void sendData(int thisData)
```

```
{
 // if there's a successful connection:
 if (client.connect(server, 80))
 {
  Serial.println("connecting...");

  // send the HTTP PUT request:
  client.print("PUT /v2/feeds/");
  client.print(FEEDID);
  client.println(".csv HTTP/1.1");
  client.println("Host: api.xively.com");
  client.print("X-ApiKey: ");
  client.println(APIKEY);
  client.print("User-Agent: ");
  client.println(USERAGENT);
  client.print("Content-Length: ");

  // calculate the length of the sensor reading in bytes:
  // 8 bytes for "sensor1," + number of digits of the data:
  int thisLength = 8 + getLength(thisData);
  client.println(thisLength);

  // last pieces of the HTTP PUT request:
  client.println("Content-Type: text/csv");
  client.println("Connection: close");
  client.println();
```

```
    // here's the actual content of the PUT request:
    client.print("sensor1,");
    client.println(thisData);
  }
  else
  {
    // if you couldn't make a connection:
    Serial.println("connection failed");
    Serial.println();
    Serial.println("disconnecting.");
    client.stop();
  }
  // note the time that the connection was made or attempted
  lastConnectionTime = millis();
}


/*
  This method calculates the number of digits in the
  sensor reading.  Since each digit of the ASCII decimal
  representation is a byte, the number of digits equals
  the number of bytes.
*/
int getLength(int someValue)
{
  // there's at least one byte:
```

```
  int digits = 1;

  // continually divide the value by ten,
  // adding one to the digit count for each
  // time you divide, until you're at 0:
  int dividend = someValue / 10;
  while (dividend > 0)
  {
    dividend = dividend / 10;
    digits++;
  }

  // return the number of digits:
  return digits;
}
```

TESTED CODE FOR JAMSHEDPUR:

```
#include <JeeLib.h>
#include <Ports.h>

#include <VirtualWire.h>

 ISR(WDT_vect) { Sleepy::watchdogEvent(); }
```

```
int led1 = 8;

int v1=0;


int j=0;

void setup()

{

  Serial.begin(9600);	// Debugging only

  Serial.println("setup");

  Serial.println("Site: TATA STEEL JAMSHEDPUR, COKE SCREEN PLANT 1");

  pinMode(13,OUTPUT);


  pinMode(led1, OUTPUT);






  // Initialise the IO and ISR

  vw_set_ptt_inverted(true); // Required for DR3100

  vw_setup(2400);	 // Bits per sec

  vw_set_tx_pin(7);

  digitalWrite(13,true);

  Serial.println("TATA:JSR:COKE-PLANT-1");

  delay(200);
```

```
}



void loop()
{
 if(j%11==0){
int i=0;
//const char *str;//const char *msg;
   // read the input on analog pin 0:

v1=1023;

 {
 digitalWrite(led1, LOW);
  // turn the LED off by making the voltage LOW
 delay(500);              // wait for a second
 digitalWrite(led1, HIGH);
 // turn the LED on (HIGH is the voltage level)

 v1=analogRead(A1);
 if(v1>700){

 Serial.print("  Panel1 OK  ,");
  const char *msg = "9 PANEL1 OK,SCREENER NO:1";

  digitalWrite(13, true); // Flash a light to show transmitting
```

```
 vw_send((uint8_t *)msg, strlen(msg));

 vw_wait_tx(); // Wait until the whole message is gone

 const char *msg2 =("TATA:JSR:COKE-PLANT-1");

 vw_send((uint8_t *)msg2, strlen(msg2));

 vw_wait_tx();

 for (byte i = 0; i < 3; ++i)

  Sleepy::loseSomeTime(600);



 digitalWrite(13, false);

 delay(200);


}


if(v1<700){




// Transmission Begins


 Serial.print(" Panel Failure ");

 const char *msg = "0 PANEL1 FAIL,SCREENER NO:1";


 digitalWrite(13, true); // Flash a light to show transmitting

 vw_send((uint8_t *)msg, strlen(msg));

 vw_wait_tx();
```

```
   for (byte i = 0; i < 5; ++i)
     Sleepy::loseSomeTime(60000);; // Wait until the whole message is gone
   digitalWrite(13, false);
   delay(200);
}
   delay(200);
}

    int s1 = analogRead(A0);
  //  Serial.print("s1=");
//    Serial.print(s1);




 if(s1>200 && s1< 1023)
{
  const char *str = "1 Level 1,";
   digitalWrite(13, HIGH); // Flash a light to show transmitting
   vw_send((uint8_t *)str, strlen(str));
   //Serial.print(strlen(str)); // Debug check
   Serial.print("        Level 1 ,     ");
   vw_wait_tx(); // Wait until the whole message is gone
   for (byte i = 0; i < 3; ++i)
     Sleepy::loseSomeTime(60000);
   digitalWrite(13, LOW);
```

```
    delay(200);

}

    delay(200);
  }
else

j++;
}
```