# Multi Channel Wireless PLC for DC Motor Protection

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## Abstract

*The Wireless Programmable Logic Controller is one of the recent applications where a perfect combination of communication technique with embedded system for achieving a efficient protection. The Protection System is the heart of any design and has a wide application in the industry to protect different devices against different fault condition or abnormal condition .The interface of the communication technique makes the system concentric and networked for easy monitoring. This system basically consisting of two parts one is a Programmable logic Controller and located at the plant site to indicate and protect the device against faults, the other part is a base station which receives the fault information through a communication network.All the equipments, those are required to be protected are connected with a fault detector or sensor and a conditioning circuit. The fault detector will generate a TTL compatible logic high state when fault occurs on the specific device.*



## 1. Introduction

In the present scenario of technological revolution it has been observed that every application products are imported with multiple functions. The designs are also moving forwards the miniature architecture, all this properties can be achieved in a product by using programmable device. The embedded technology is now a days very much popular and most of the product are developed with Microcontroller based embedded technology. Though electrical systems are quit reliable and cheaper, it has certain disadvantages. The electro mechanical protection relays are too bulky and needs regular maintenance. The multifunctional is out of question. Recently, the technical revolution made embedded technology cheaper, so that it can be applied to all the fields. The pioneer manufactures of switchgear and protection system such as SIMENS, LARSON & TUBRO, and CUTLER HAMPER etc. manufacturing protection relays based on embedded technology. Now a days the protective devices and developed with Rs485 compatible and also multiple protections are integrated in a small and economical package. This technology is very fast so controlling of multiple parameters is possible also the parameters are field programmable by the user.

The PLC designed here is basically for monitoring the different parameters of a AC motor and protect the AC motor against the fault. If there is any fault the protective relay trip protective relay.

## 2. Design and operation principle.

In this paper there are two basic sections one is programmable Logic controller with a FM Transmitter. This is designed with a motherboard , the other part is a base station consisting of a FM receiver with a motherboard.

This system is developed on an micro controller. The system accepts logic signals as a fault condition from the sensor devices and can be programmed to function accordingly. The present paper has four channels that is this system can monitor 4- Channels for fault, once a fault occurs at any device the fault detection circuit will generate a TTL compatible logic level or pulse. That pulse is considered as a fault condition, by the controller. The controller protect the device with activating a protection relay and at the same time the controller sends switching signal to the Dual Tone Multi Frequency (DTMF)encoder the encoder generates a particular DTMF signal respective to a fault. There are twelve DTMF signals can be generated by this method adopted in this project. The DTMF signal has frequency components in the audio frequency range. This signal is feed to a FM Transmitter having a carrier frequency approximately between 90MHz to 102MHz. The transmitted signal can be send to a distance approximately 100 meter in this project. This can further improved to approximately 1 Km by using proper antenna. The receiver part of this project tuned to receive the same signal, which is transmitted by the transmitter. The receiver remove the carrier signal and sends the DTMF signal to the DTMF Decoder, which decodes the signal and produce a unique BCD code at its output.

Power supply is positive. In this Transformer (0-12)Vac, 1A,integrated circuits, diodes, LED & resistors. Here 230V, 50 Hz ac signal is given as input to the primary of the transformer and the secondary of the transformer is given to the bridge rectification diode. The o/p of the diode is given as i/p to the IC regulator (7805 &7812) through capacitor (1000mf/35v). The o/p of the IC regulator is given to the LED through resistors. The series of three-terminal positive regulators packages and several fixed output voltages, with a wide range of applications. These regulators can provide local on-card regulation, eliminating the distribution problems associated with single point regulation. Each type employs internal current limiting, thermal shut-down and safe area protection, making it essentially indestructible. If adequate heat sinking is provided, they can deliver over 1 A output current. Although designed primarily as fixed voltage regulators, these devices can be used with external components to obtain adjustable voltage and currents.

Output current to 1.5 A, Output voltages of 5; 6; 8; 8.5; 9; 12; 15; 18; 24 V. Thermal overload protection. Short circuit protection. Output transition SOA protection.

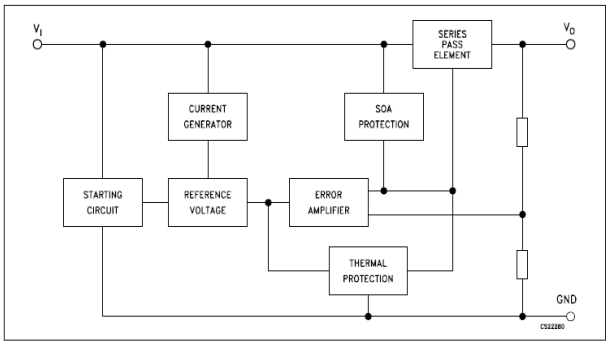


Figure-1 Block diagram

## 3.Circuit description:

The motherboard is a core compatible micro controller. The motherboard is designed on a printed circuit board, compatible for the micro controller. This board is consisting of a socket for micro controller, input/output pull-up registers; oscillator section and auto reset circuit. The memory types are illustrated in the following graphic. They are: On-Chip Memory, External Code Memory, and External RAM.

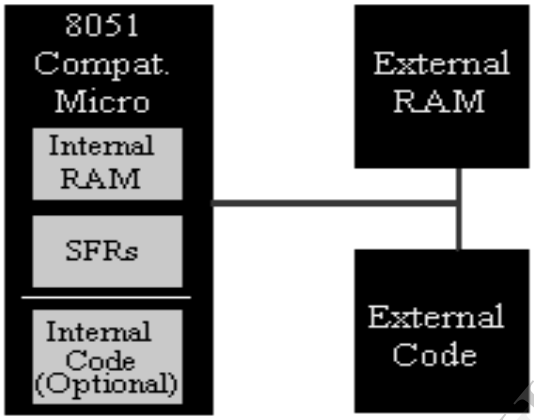


Figure-2 Internal structure

On-Chip Memory refers to any memory Code, RAM that physically exists on the Microcontroller itself. On-chip memory can be of several types, but we'll get into that shortly. External Code Memory is code or program memory that resides off-chip. This is often in the form of an external EPROM. External RAM is RAM memory that resides off-chip. This is often in the form of standard static RAM or flash RAM. Code memory is the memory that holds the actual 8051 program that is to be run. This memory is limited to 64K and comes in many shapes and sizes. Code memory may be found *on-chip*, either burned into the Microcontroller as ROM or EPROM. Code may also be stored completely *off-chip* in an external ROM or, more commonly, an external EPROM. Flash RAM is also another popular method of storing a program. Various combinations of these memory types may also be used. It is possible to have 4K of code memory *on-chip* and 64k of code memory *off-chip* in an EPROM.

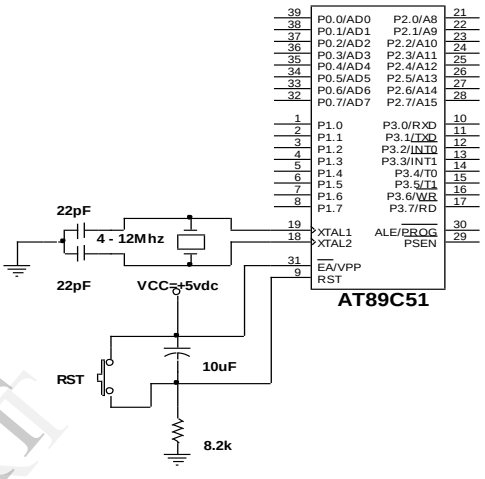


Figure-3 Microcontroller

The auto reset circuit is a RC network in the mother board circuit. A capacitor is connected in series with a resister the R-C junction is connected to the micro controller pin 9 which is reset pin. The reset pin is one when ever kept high logic 1 the program counter resets to 0000h so the processor starts executing the programmed from that location. Whenever the system is switched ON the mother board gets power and the capacitor acts as short circuit and the entire voltage appears across the resistor, so the reset pin get a logic 1 and the system get reset, whenever it is being switched ON.

In Pull-up resister PORT0 and PORT2 of the architecture is of open collector type so on writing logic 0 the pins are providing a perfect ground potential. Whereas on writing logic1the port pins behaves as high impedance

condition so putting a pull-up resister enables the port to provides +5volt logic1. Port1 and Port3 are provided with internal pull-up. A pull-up resister is normally a 10K resistance connected from the port pin to the Vcc +5volt.

The 8051 family microcontroller contains an inbuilt crystal oscillator, but the crystal has to be connected externally. This family of microcontroller can support 0 to 24MHz crystal and two numbers of decoupling capacitors are connected. These capacitor decouples the charges developed on the crystal surface due to piezoelectric effect. These decoupling capacitors are normally between 20pf to 30pf.

### 4. Led indicator:

The indicator section consists of a light emitting diode and its driver circuit is designed on the basis of current required to glow the light emitting diode. The Microcontroller cannot provide adequate current for LED. The LEDs require a current between 10mA to 20mA of current to glow. The driver circuit provides current to the load from a separate source, so the load current used not pass through the Microcontroller. The driver circuit activates the load on receipt of a logic signal from the Microcontroller and the load in the absence of the signal as the current requirement is very less to glow a LED a single stage driver is sufficient to drive the load. The driver circuit is a perfect transistor switch. The driver transistor goes in to saturation on receipt of base signal and drives into cut-off region, in absence of base signal.

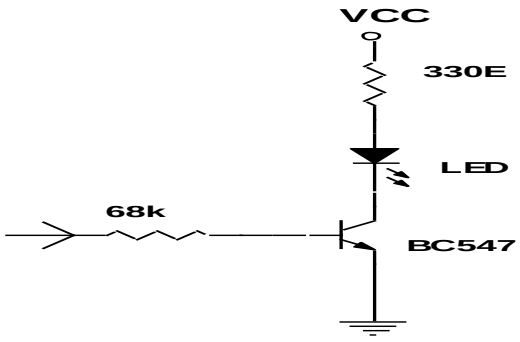


Figure- 4 Ledindicator.

The relay used here having the specification as Coil resistance =400ohm Coil, 12Vdc, Contact capacity=230V, 7A.

### 5.Overvoltage / Undervoltage.

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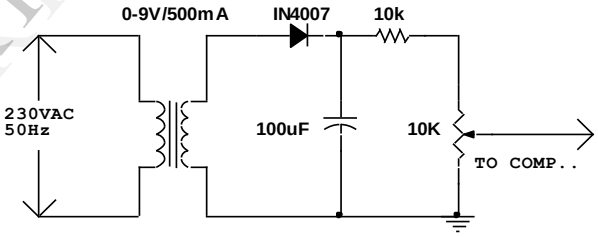


Figure-5 Line voltage signalling circuit.

The line voltage coming from the main is to step down that voltage with the help of a step down transformer. If the line voltage varies, the step down voltage also varies in accordance with the input voltage. Due to the mutual induction of the transformer the primary winding of the transformer voltage is more the flux induced is more and the secondary voltage is more. Similarly, if the primary winding of the transformer voltage is less the flux induced is less and the secondary voltage is less. In this way under/over voltage occurs. A half-wave rectifier used, in which it will converts ac to dc voltage. The output of the signal sampling voltage goes to the input of both of the comparator. In the first comparator set the voltage say3.5Vto the non-

inverting terminal. In this case non-inverting terminal is greater than the inverting terminal. That means output of the first comparator is low. Under temperature has to be done as set point has been changed which is connected to the inverting terminal of that comparator. Similarly,for the second comparator. In this case inverting terminal is greater than the non-inverting terminal that means output of the second comparator is high.

If the temperature increases, the corresponding voltage will increase.That voltage goes to the input of both of the comparator. In the first comparator set voltage to the non-inverting terminal. In this case inverting terminal is greater than the non-inverting terminal. That means output of the first comparator is high which means that over temperature has occurred. Similarly, for the second comparator .

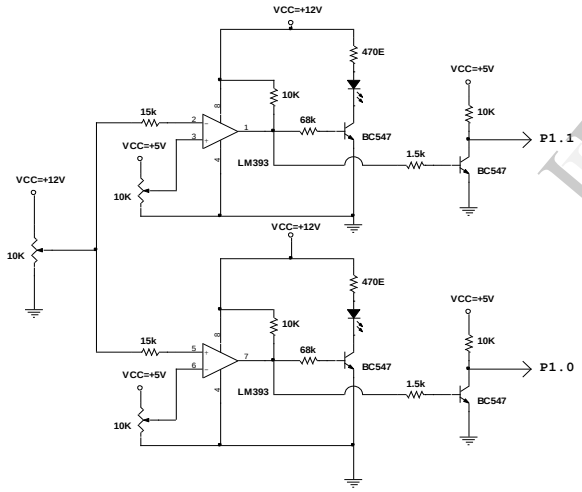


Figure- 6 Over voltage/ under voltage circuit

## 6.Overtemperature

In this section aim is to detect under and over temperature . For that a temperature sensor is needed as thermister for sensing the temperature and for comparing the temperature a comparator is required which compares the two input voltages and give the corresponding output according to the temperature. The temperature sensor is a circuit that converts temperature to the corresponding voltage. One end of the terminal of the thermister is connected to a Vcc and the other end terminal is connected to the GND through a series connected resistances, which form a voltage divider network. At constant room temperature, the corresponding voltage will be available at the output. If the temperature increases the corresponding voltage will increase according to the increase in temperature. That output signal is given to the comparator for comparing the voltage. If the comparator input is connected to the inverting terminal (+) reference value is greater than the non-inverting terminal (-), the comparator output is high i.e. ON condition. Similarly, if the comparator input is connected to the non-inverting terminal (-) then reference value is greater than the inverting terminal (+), the comparator output is low i.e. OFF condition. But, here inverting and non-inverting of both of the comparator is connected to the temperature sensor and the values input set in through a variable resistance . That output signal is given to the LED indicator section for indication purpose for the availability of the signal at the output of the comparator.

That output signal is compatible with the controller because the current will flow from the collector of the transistor whenever the base voltage is high due to the transistor action. Similarly the output is low in the absence of the input signal to the signal conditioning circuit from the comparators

For over speed Tacho generator is required. DC Motor Generator is a set of two PMDC motors. One out of these runs as motor and other as generator. The motor shaft is coupled with the armature of the generator so the mechanical energy is converted into electrical power. The emf generated by the generator is

linearly varies with the RPM of the motor shaft. In PMDC motor:

$$E_b \alpha N$$

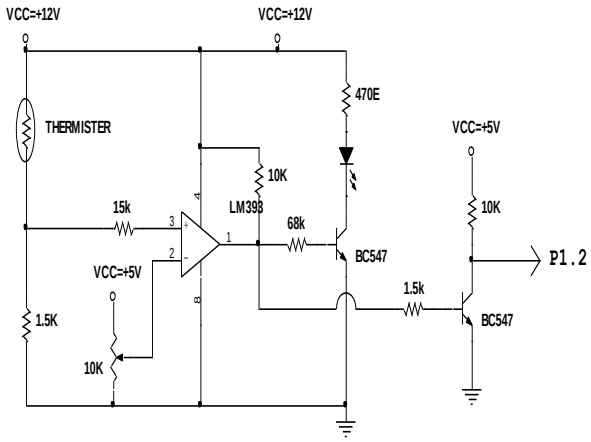


Figure-7 Over temperature circuit

The value of $E_b$ saturates at certain point, which is very much associated with the geometry of the motor and pole structure. The DC value generated by the generator is compared with a reference value set at the comparator. The comparator output becomes high when the speed of the PMDC motor is above the set value. In the normal condition the comparator output is low.

## 8.Over Current.

In this section the line voltage is varying with current. The line voltage coming from the mains is given to the one end of primary of the current transformer and another end through a load of 1kw to neutral. That current/voltage is step down at the secondary winding of the current transformer due to the mutual induction. If the load varies, the step down voltage also varies in accordance with the input voltage. Due to the mutual induction of the transformer, if the primary winding of the transformer voltage is more the flux induced is more and the secondary voltage is more. Similarly, if the primary winding of the transformer voltage is less the flux induced is less and the secondary voltage is less. In this way under/over voltage occurs. At present we can't vary the line voltage manually. For that we need to vary the load manually. But in our project we can vary the current/voltage by converting it to AC to DC voltage. A half-wave rectifier is used in which it will convert ac to dc voltage, vary the voltage with the variable load resistance which can make under/over voltage manually; otherwise the line voltage may vary. That output signal is compatible with the controller because the current will flow from the collector of the transistor whenever the base voltage is high due to the transistor action. Similarly the output is low in the absence of the input signal to the signal conditioning circuit comparators.

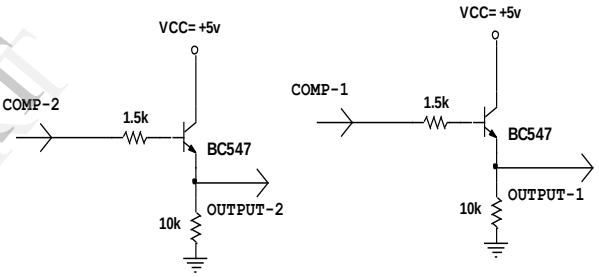


Figure-8 Signal conditioning

DTMF, there is no base band multiplexing done on DTMF signals. The signal generated by a DTMF encoder is a direct algebraic summation, in real time, of the amplitudes of two sine (cosine) waves of different frequencies which will send a tone made by adding to the other end of the line. The touch tone system uses pairs of tones to represent the various keys. There is a "low tone" and a "high tone" associated with each button. The low tones vary accordingly to what horizontal row is in, while the high tones correspond to the vertical column of the tone button

When the 4 buttons are pressed, then tones are sent together from the DTMF encoder. The DTMF decoder decodes the tone and generates the equivalent of the key number at the output. The tone frequencies were

designed to avoid harmonics and other problems that could arise when two tones are sent and received. Accurate transmission from the encoder and accurate decoding on the decoder is important. They may sound rather musical when dialed .The tones should all be +/- 1.5% of nominal. The high frequency tone should be at least as loud, and preferably louder than the low frequency. It may be as much as 4 db louder. This factor is referred to as "twist." If a Touchtone signal has +3db of twist, then the high frequency is 3 db louder than the low frequency. Negative twist is when the low frequency is louder.

DTMF encoders in many ways to be generated as DTMF tone. Using oscillator and filter array are one of the methods. The Integrated IC version is having one key board section. On receiving proper row column section the tone generator section generates DTMF tone output

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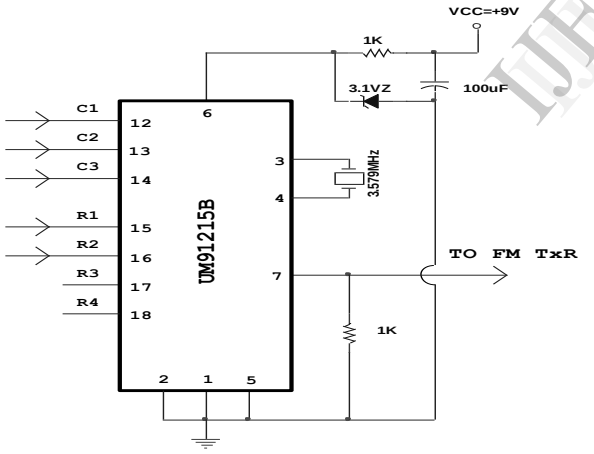


Figure- 9 DTMF Encoder.

An eight sharp-tuned filter combined with detection circuits. The IC's do not require more than one 3.58 MHz resonator and the power circuitry is 4 bit binary strobe.

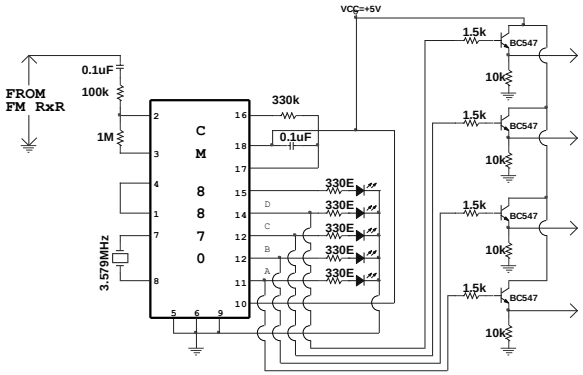


Figure-10 DTMF Decoder.

## 9.FM transmitter

Frequency Modulation is a method of varying a carrier waves frequency proportionally to the frequency of another signal. This compares to the other most common transmission method, Amplitude Modulation, which broadcasts may vary the amplitude of the carrier wave according to an input signal. Standard FM broadcasts are based in the 88 - 108 MHz range; otherwise known as Radio Frequency range. However, they can be in any range, as long as a receiver has been tuned to demodulate them. Thus the Radio frequency carrier wave and the input signal can't do much by themselves, they must be modulated. If broadcast of 100MHz signal and tune a radio into that frequency then nothing is heard. That 100MHz signal has locked or captured that spot and simply produces a DC value. Now to move the incoming signal +/- 100KHz in either direction at a frequency of 1000Hz, then a 1000Hz signal heard on the radio. If only moved +/-10Khz then the sound from the radio would be 1/10th the original in loudness. Thus the rate of frequency at which change the carrier which produces the audible frequency that can be heard, and further from the main radio frequency carrier, then the output will be louder. This is the basis of all FM transmitters. It is also

important to note that the Federal Communications Commission (FCC) have very strict rules regarding broadcasting in these ranges. It is important that you check FCC regulations before attempting to build this circuit or any similar circuits.

## 10.FM receiver

It is easily being noticed that this is the receiver with inter-frequency amplifier. By adding integrated circuit multiple enhancements are performed. Huge input resistance, the oscillatory circuit is not choked, resulting in better selectivity. The sensitivity of the device is extremely increased since this integrated circuit has big amplification and the automatic amplification regulation is also accomplished, making the usage of this device easier and comfortable. It is very important to obtain the necessary value of the DC voltage for its proper operation. The receiver is set to some weaker station, the sound volume is made very low with potentiometer, and the slider of the is carefully moved until the best reception is made. If that doesn't work, changing the value of resistor is an alternative, to be done also if the supply voltage being used . In case of voltage on the pin being much bigger than 1.3 V, and cannot be reduced. The voltage stabilizer with isn't needed if the receiver is supplied from the 6V battery. The receiver needs input circuit to be 100% complete. That can be an independent input circuit amplifier that are described. If the former circuit is used, station tuning is being accomplished. . However, the receiver is tested .DC voltage setting on pin 1 is done with the trimmer. Its slider is put in mid position, the receiver is tuned to some weaker station close to the upper bound of the bandwidth. While making the reproduction very quiet, the trimmer slider is moved until reaching optimum reception. After that the trimmer is disconnected, its resistance measured and the ordinary resistor of similar value is put into circuit. The device operates nicely with the outside antenna made of a piece of wire measuring only half metre in length. The reception would certainly become better if an input circuit would be added.

## 11.Signal conditioning:

The output from the input signal from decoder or any other circuit must be compatible with the µ -controller, because the µ -controller can takes 5V as input voltage and gives a 5V as output voltage. That for ne a signal conditioning circuit is needed.

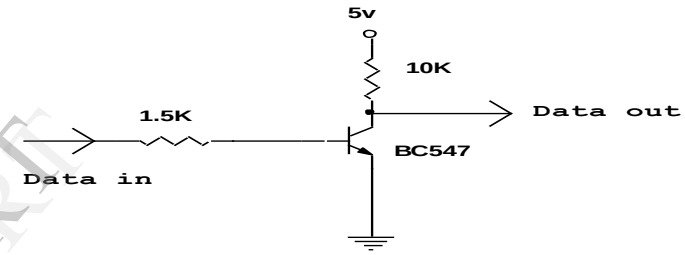


Figure-11 Signal conditioning.

whenever the base voltage is high the transistor comes to saturation condition i.e. the emitter current flows to the collector which gives a low voltage at the output corresponding to GND. The output is taken from the collector junction through a current limiting resistance and the output signal is given to the µ - controller or any other circuit which needs a compatible voltage. Similarly, whenever the base voltage is low the collector current flows from the collector junction of the transistor, which gives a high voltage at the output corresponding to Vcc. The output is taken from the emitter junction through a current limiting resistance and the output signal is given to the µ - controller or any other circuit which needs a compatible voltage. The application of the transistors is

not limited solely to the amplification of the signals. Through proper design transistors can be used as switches for computers and control applications. Buzzer drivers interfaces one audible piezoelectric buzzer with the controller. The controller activates the buzzer whenever there is any fault appears in any of the channel. piezoelectric buzzer is a device that converts electrical signal to an audible sound signal. The Microcontroller cannot drive directly to the buzzer, because the Microcontroller cannot give sufficient current to drive the buzzer for that needs a driver transistor, which will give sufficient current to the buzzer. Whenever a signal received to the base of the transistor through a base resistance high, the transistor comes to saturation condition i.e. ON condition thus the buzzer comes to on condition with a audible sound. Similarly, whenever the signal is not received to the base of the transistor, thus the transistor is in cut-off state i.e. is in OFF state thus the buzzer does not gets activated. This project is concluded with the above mentioned facilities, due to cost and time factors. The following expansion can be incorporated in this project.The transmission media used here is a FM link, which is analog communication technique. The further improvement in this technique can be achieved by adopting digital communication techniques.

## 12. Conclusion.

In this paper there is only one Transmitter and one receiver section but this can be further developed by using a networking communication method i.e. having multiple transmitters and single receiver. This paper is working satisfactorily in the laboratory test condition and indicating the faults at the computer perfectly. Hence, we can conclude that the microcontroller is quite efficiently able to protect the device by operating the protective relays with the PLC section along with the computer information sections operation becomes faster. Resulting with less operational error and the system is quite stable under test conditions.

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