



1-1410

P-1410



**APPLICATION OF EMBEDDED TECHNIQUE IN CORROSION  
CONTROL FOR THE UNDERGROUND PIPELINE**

By

**K.EZHIL MEENAKSHI**  
Register No. : 71203415004



of

**KUMARAGURU COLLEGE OF TECHNOLOGY  
COIMBATORE – 641 006**

**A PROJECT REPORT**

Submitted to the

**FACULTY OF ELECTRICAL ENGINEERING**

*In partial fulfillment of the requirements  
for the award of the degree  
of*

**MASTER OF ENGINEERING**

**IN**

**POWER ELECTRONICS & DRIVES**

*June, 2005*

Certified that this project report titled "Application of embedded technique in corrosion control for the underground pipeline" is the bonafide work of Ms. K. Ezhil meeankshi who carried out the research under my supervision. Certified further, that to the best of my knowledge the work reported herein does not form part of any other project report or dissertation on the basis of which a degree or award was conferred on an earlier occasion on this or any other candidate.

*K.Ragupathy subramaniam*

**(Countersigned by the HOD)**

**Mr.K.Ragupathy subramaniam**

Department of Electrical Engineering,  
Kumaraguru College of Technology,  
Coimbatore – 641 006.

*Dr.T.M.Kameswaran*

**(Signature of the Supervisor)**

**Dr.T.M.Kameswaran**

**Dean of EEE,**

Department of Electrical Engineering,  
Kumaraguru College of Technology,  
Coimbatore – 641 006.

The candidate with university no : 71203415004 was examined by us in the project Viva-voce examination held on: 23.06.2005

*K.Ragupathy subramaniam*  
**INTERNAL EXAMINAR**

*Dr.T.M.Kameswaran*  
**EXTERNAL EXAMINAR**

## ABSTRACT

Corrosion control is one of the most essential processes in many industries. Corrosion takes many forms and has various names, such as oxidation, rust, chemical ie, electrolytic action and bacteria action. Corrosion protection can be achieved when one or more reactions of the corrosion cell are prevented: the anodic, the cathodic or the electrolytic. These mean, that either no humidity and/or no oxygen and/or no carbon dioxide and/or no chloride ions may arrive at the steel surface.Objective of the engineer: Redundant, reliable and durable corrosion protection system.

The corrosion of submerged metallic structures which takes place due to electrolytic action. The increment of corrosion beyond the reference value causes the problems like high power wastage and it also reduce the life of the components. So, it's very significant to maintain the corrosion value within the safe limit.

This corrosion problem can be prevented by counter acting the galvanic corrosion currents by means of superimposed DC currents using external DC currents using an external DC source. Thus, when direct current is applied to a submerged/underground structure with a polarity, which opposes the natural galvanic current and is of sufficient magnitude so as to polarize all the anodic area, corrosion is prevented. However, the current required to provide complete protection depends on various conditions in which the structure operates. This helps to improve the productivity of the unit and the quality of the product.

with respect to reference electrolyte continuously adjusting the impressed current to maintain the structure to soil potential at a present optimum value. The amount of current so impressed has bearing on the degree of protection to the structure. This potential is kept constant under varying conditions of soil/water, temperature stray currents etc., thus providing suitable protection to structure. If the current impressed is higher than the required value, the structure would be partially protected.

Galvanic corrosion rectifiers are already in use but those system has disadvantages which are inconsistent, frequent maintenance is required, it is costly, not user friendly and auto mode change was not possible. But in this estimated system, we have following advantages that are very compact, single chip solution and has got added features like auto mode change continuous display of DC voltage, DC current, reference feedback are present.

This describes the significance of our project in industrial environment; the reliability of the existing system is very low that it cannot adopt itself to the ever-growing demand. So, we utilize most advanced technique to control the corrosion in underground pipeline. Accurate automatic control of current in the underground leads to efficient usage of unit and improves the industry's economy also automates the entire plant, thus avoiding errors in critical location.

## ACKNOWLEDGEMENT

I wish to express our gratitude to Thiru.**Dr. N. Mahalingam B.Sc., F.I.E.**, honorable chairman of our college and our beloved correspondent **Prof. K. Arumugam B.E (Hons), M.S.(U.S.A). , M.I.E.**,

I would like to express the affectionate thanks to the Principal **Dr. A. Padmanabhan M.Tech (IIT-kgp), PhD (IIT-kgp)** of our esteemed institution in guiding and supporting my project.

I take immense pleasure to express sincere thanks to Head of the department **Mr. K. Ragupathy Subramaniam B.E (HONS), MSC, MIEEE, IES.**

I wish to convey my regards to Dean.**Dr.T.M.Kameswaran Ph.D., F.I.E.** of EEE department for giving his valuable suggestions and support during the course of our project work.

Addendly I would like to pay my deep gratitude to **BRIGHT ELECTRO CONTROL EQUIPMENTS (P) LTD**, Coimbatore, for the encouragement and moral support by sponsoring this project.

I feel that it is my duty to acknowledge the help extended to us by all other teaching and non-teaching staff of the Department during the course of my project work.

# CONTENTS

<b>BONAFIDE CERTIFICATE</b>		ii
<b>ABSTRACT</b>		iii
<b>ACKNOWLEDGEMENT</b>		v
<b>CONTENTS</b>		vi
<b>LIST OF TABLES</b>		viii
<b>LIST OF FIGURES</b>		ix
<b>CHAPTER 1</b>	<b>INTRODUCTION</b>	<b>1</b>
	1.1 Problem of statement	2
<b>CHAPTER 2</b>	<b>CORROSION PROTECTION</b>	<b>3</b>
	2.1 Cause of corrosion	3
	2.2 Consequences of corrosion	6
	2.3 Requirement of corrosion	7
	2.4 Parameter of soil corrosion	7
<b>CHAPTER 3</b>	<b>CONTROL SCHEME</b>	<b>10</b>
	3.1 Operation of the unit	11
	3.2 Process control systems	12
	3.3 Specification of the unit	16
<b>CHAPTER 4</b>	<b>CATHODIC PROTECTION SCHEME</b>	<b>18</b>
	4.1 Impressed current method	19
<b>CHAPTER 5</b>	<b>HARDWARE IMPLEMENTATION</b>	<b>24</b>
	5.1 PIC Microcontroller	24
	5.2 Memory organization	29
	5.3 Opto coupler	33

<b>CHAPTER 6</b>	<b>RESULTS AND IMPLEMENTATION</b>	45
6.1	Output results of the scheme	45
6.2	Output waveform	46
<b>CHAPTER 7</b>	<b>CONCLUSION AND FUTURE EXTENSION</b>	47
		46
<b>APPENDICES</b>		49
<b>REFERENCES</b>		64

## LIST OF TABLES

<b>TABLE NUMBER</b>	<b>DESCRIPTION</b>	<b>PAGE NO.</b>
2.1	Soil potential and corrosion	8
2.2	Resistivity and corrosion	9
5.1	OPTION-REG register bit transmission rating	40
6.1	Output results of the scheme	45

## LIST OF FIGURES

<b>FIGURE NUMBER</b>	<b>DESCRIPTION</b>	<b>PAGE NO.</b>
2.1	Corrosion affecting the structures	4
2.2	Electro chemical reaction in one corrosion cell	5
2.3	Path of electric current between corrosion cells	5
3.1	Circuit diagram for control circuit	10
3.2	Main Block Diagram Of Corrosion Protection System	12
3.3	Block Diagram Of Process Control System	13
3.4	Block diagram of power supply	14
3.5	Circuit diagram of power supply	15
4.1	Protection of buried pipe by impressed current rectifier method	21
4.2	Overview structure of cathodic protection scheme in underground pipeline	22
4.3	Structural arrangement of impulse current scheme	23
5.1	Block diagram of ALU	25
5.2	PIC Architecture	28
5.3	Microcontroller outline with its basic elements and internal connections	29
5.4	Optotriac circuit diagram	33
5.5	Example of optocoupler on an input line	34
5.6	Example of optocoupler on output line	35
5.7	ADC diagram	36
6.1	Output waveform	46

## CHAPTER 1

### INTRODUCTION

Now a day the technology has been developing in all aspects, especially in industrial field. In these fields the industries have been modernizing to achieve quality and quantity end product. The corrosion control is one of the main process taking places in the industry.

There are many techniques available for controlling the corrosion like electrochemical process, microprocessor, microcontroller etc, rather than this; PIC controller is the latest one. The advantage of PIC over the others is precised corrosion control.

Corrosion of steel embedded in soil can generally be explained in terms of long cell action arising from differential aeration. The significant factors to promote corrosion are soil potential, resistivity and draining characteristics. Permeability of the rate of draining of water i.e. rate of saturation. Corrosive nature of soil is not absolute but depends on its water content and on the state of surrounding soil. Corrosive activity is most vigorous when a soil is partially drained .i.e. when it contains 50 to 95 percent of water needed for saturation and oxygen plays a dominant role in this as a cathodic reactant.

soil, climatic condition, quality of fluid material flowing through pipe etc., The effect of corrosion in the form of reduction in soil thickness, pitting, scaling etc., starts showing its effect on the material of pipeline and is the function of age of pipeline, which may results sometimes in bursting of pipeline at some critical locations.

The aim of our project is control of corrosion using embedded technology. We have chosen to implement the protection of unit with the help of PIC micro controller technique. This system has PIC micro controller with other control devices. The entire operation depends on the C software coding in PIC. This ensures unauthorized person cannot change the set parameter. The data present in the devices can be viewed with the help of 7segment display using embedded technique.

## **1.1 PROBLEM STATEMENT**

The objective of our project is to control the corrosion level within the predefined value and also monitor the voltage fluctuation as well as the output of unit involved in the packing process. For minimizing the rusting process in underground pipeline, the remedial measures in the form of 'Cathodic Protection Scheme'.

This system consists of PIC micro controller, sensing devices and optotriac with other control devices. PIC controls the entire system by acting as master. According to the software coding in the PIC, corrosion will be maintained within the prescribed limit. Also the parameters like current, voltage and number of outcome of the devices are stored in device for every predefined duration.

## CHAPTER 2

### CORROSION PROTECTION

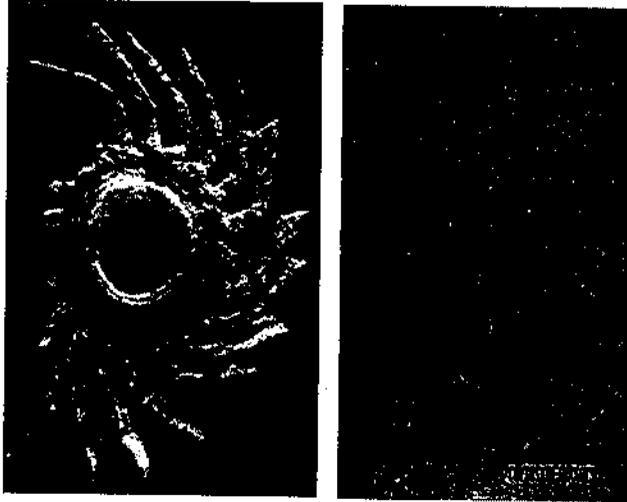
#### 2.1 CAUSE OF CORROSION

Corrosion is the term used to designate the deterioration of a metal by chemical or electrochemical reaction with its environment. Most commonly used metals are produced by extraction from their oxides. Therefore, the refined metal is in a thermodynamically less stable state than that of its natural oxide form and under appropriate conditions will revert to oxides, i.e. it corrodes. When corrosion inhibiting constraints are lacking the metal will react with oxygen and water to form oxides and/or hydroxides. The process by which corrosion occurs is generally recognized to be electrochemical in nature, i.e. a galvanic cell is developed. The term galvanic corrosion is used, in a broad sense, to denote corrosion occurring from dissimilar adjacent surface conditions of a metal, differences in oxygen concentrations or differences in environmental conditions.

Corrosion is simply the loss of material resulting from current leaving a metal; flowing through a medium, and returning to the metal at a different point. Galvanic corrosion (also called 'dissimilar metal corrosion' or wrongly 'electrolysis') refers to corrosion damage induced when two dissimilar materials are coupled in a corrosive electrolyte. It occurs when two (or more) dissimilar metals are brought into electrical contact under water. When a galvanic couple forms, one of the metals in the couple becomes the anode and corrodes faster than it would all by itself, while the other becomes the cathode and corrodes slower than it would alone. The driving force for corrosion is a potential difference between the different materials.

corrosion rates will change.

- Corrosion of the anode will accelerate
- Corrosion of the cathode will decelerate or even stop.



**Figure 2.1 Corrosion affecting the structures**

A difference of potential is setup between two parts of the submerged under ground metallic structure due to varying conditions of electrolyte like difference in temperature, soil content, oxygen availability, moisture etc., This difference of potential acting between different parts of structure sets up a flow of galvanic current between these parts. The current setup this way causes corrosion.

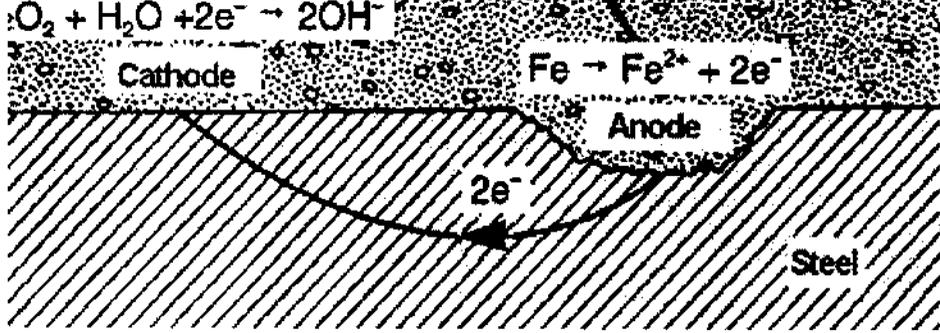


Figure 2.2 Electro-chemical reaction in one corrosion cell

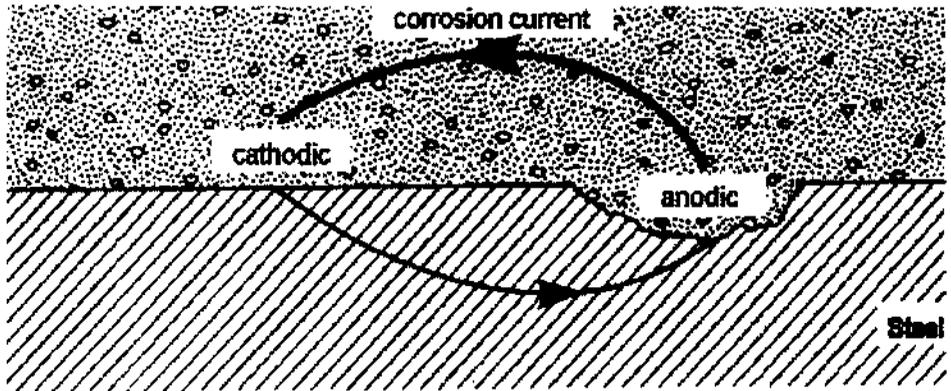


Figure 2.3 Path of electric current between corrosion cells

At this points at which these galvanic currents emanate, the metallic ions react and get dissolved into the electrolyte, leaving pits and causing leaks on the surface of the metal. Corrosion is a very important factor in any process plant. It makes all the difference between a trouble free operation and a costly shut-down.

The rate of corrosion is related to the ratio of the anodic region to the cathodic region. Increasing this ratio by decreasing the cathodic area results in a reduced current flow which denotes a decrease in the corrosion rate. Increasing the cathodic area (or decreasing the anodic area) decreases this ratio resulting in an increased corrosion rate.

When passivation occurs it reduces the corrosion rate to a very low level or completely halt the corrosion process. Obviously, when ions are present that destroy the passivation film the corrosion rate will be greatly accelerated.

The electrical conductivity of the electrolyte (the concrete) is an important parameter in the rate of corrosion, the higher the conductivity the grater the rate of corrosion. Conductivity is a function of temperature, moisture and ionic content, since the corrosion current flows through the electrolyte by ionic conduction.

## **2.2 CONSEQUENCES OF CORROSION**

The economic and social consequences of corrosion include

- Plant shutdown due to failure.
- Replacement of corroded equipment.
- Preventive maintenance (such as painting).
- Necessity for over design to allow for corrosion.
- Loss of efficiency.
- Contamination or loss of the product (e.g. from a corroded container).
- Safety (e.g. from fire hazard or explosion).
- Health hazard.

The corrosion protection element and system must meet some fundamental requirements:

- i. No advance effect on the strength and /or during of the structural elements.
- ii. Compatibility to each other with respect to their physical and chemical characteristics.
- iii. Resistance to the possible influences during service  
e.g. mechanical, thermal, UV radiation.
- iv. No adverse effect to the environment.
- v. Durability for the required life or replacability without jeopardizing the stability and durability of the structure.
- vi. Practical and easy applicability.
- vii. Controllability.
- viii. Economical during construction maintenance.
- ix. Particular requirements to special characteristics, e.g. bond to steel and concrete.

## **2.4 PARAMETER OF SOIL CORROSION**

Corrosion in soil(Microbiological corrosion)

Soil as a corrosive medium can be regarded as a porous substance consisting of more or less solid, partly colloidal, soluble and hygroscopic constituents and living organisms. The pores of the soil contain air and water. Above the ground-water level the finest capillary tubes are filled with water whereas the greater pores contain air. For corrosion in soils certain moisture is necessary and, generally oxygen. Nevertheless, steel can corrode under anaerobic conditions as well. The most common form of microbiological attack comes from the metabolic processes of sulfate

ions, which react with the metal allowing dissolution of the anodic region of the corrosion cell to result in metal sulfide.

### **i. SOIL POTENTIAL**

The potential difference between a buried pipe and soil is of greater importance, either in determining the corrosivity or in evaluating the extent of cathodic protection being applied for industrial scheme.

IS: 8062 (part-I) 1976 has given following guidelines for potential values.

**Table No 2.1 Soil Potential and corrosion**

Potential(-ve) in mv	Nature of corrosion
Less than -850mv	No corrosion
-850 to -400mv	Very low rate of corrosion
-400 to -100mv	Higher rate of corrosion

### **ii. SOIL RESISTIVITY**

It is measured in terms of conductivity of soil which is nothing but the measure of the concentration of soluble salts in the soil and which in turn is a measure of its corrosive action.

The IS: 8062 (part-I) 1976 has recommended following values as a general indication of the nature of corrosivity w.r.to resistivity.

**Table No 2.2 Resistivity and Corrosion**

Resistivity (ohm-cm)	Corrosivity
Upto 500	Very high
501 to 1000	High
1001 to1500	Higher rate of corrosion
1501 to 5000	Normal

## CHAPTER 3

### CONTROL SCHEME

Principle is based on the principle of transfer of the potential of metal to a specific transfer of the potential of the metal to a specific suitable protection potential so as to avoid corrosion. Thus in this method, the negative ions which are responsible for corrosion are automatically get repelled reducing corrosion to a significant level.

The operation of the unit in this mode will be fully automatic which is controlled by reference electrode feedback. The unit will automatically maintain reference voltage within +15mv or -15mv under all condition.

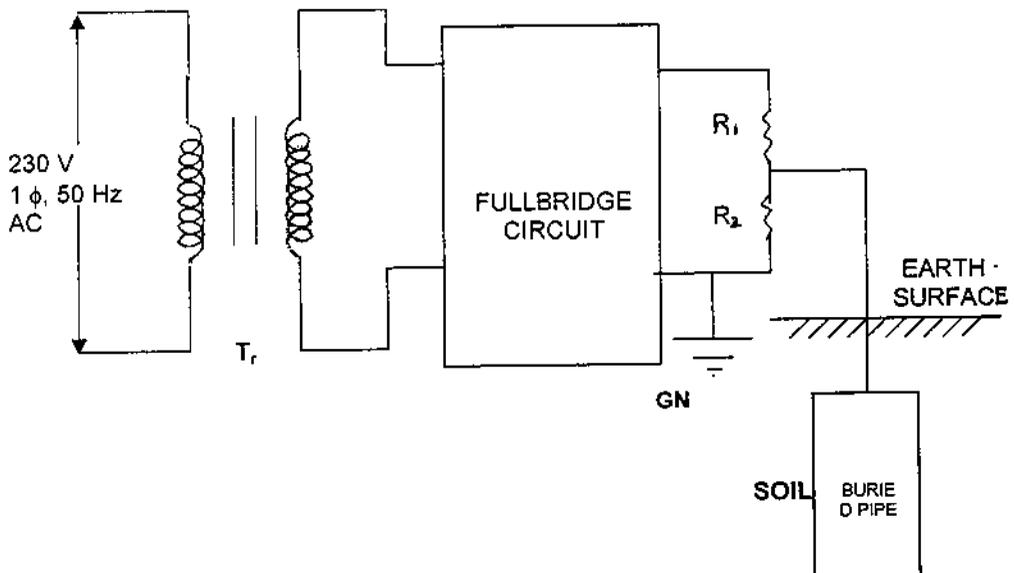


Figure 3.1 Circuit diagram for control circuit

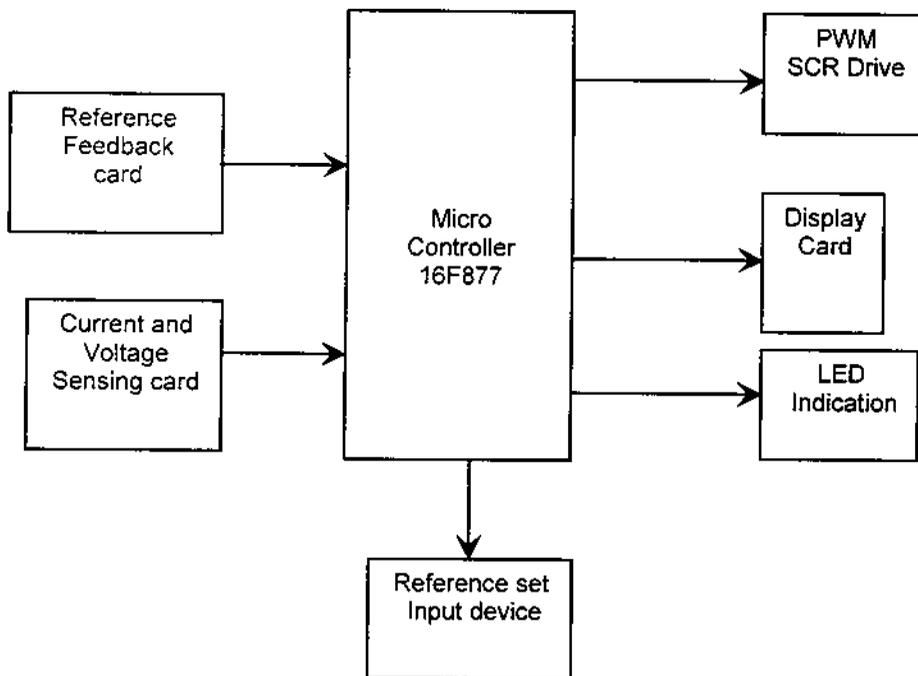
external source e.g. D.C. supply, thus resulting into the flow of current from the earth to the pipeline which nullifies the current avoiding corrosion. The design and installation of an impressed current system calls for specialized knowledge and considerable experience in this field. The system self-corrects for the voltage shift between the land-based drainage point and the location where protection is applied.

### 3.1 OPERATION OF THE UNIT

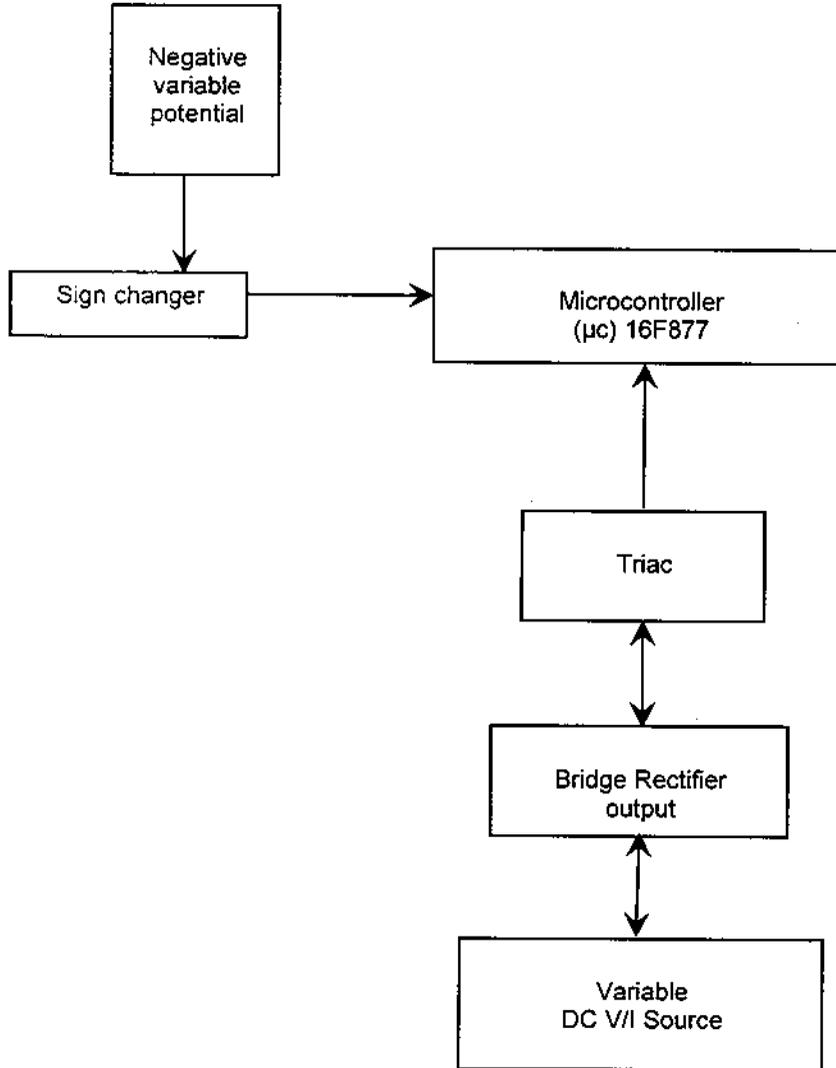
Unit can be operated as Automatic voltage current control mode (Avcc mode). This ensures 100% reliable protection of the structure irrespective of various environmental condition of varying earth resistance, salinity, moisture, velocity of free water, temperature, stray currents etc., The unit can be operated in AVCC mode is called AVCC (Automatic voltage current control) mode as the unit can automatically control the set DC voltage and current in AVCC mode position. In this mode, the reference feedback is removed and DC output voltage feedback is provided through potential divider and chain of resistances R1 & R2 .The output voltage of the unit can be set anywhere from zero volts to the rated value by means of the PRESET ADJUSTER. The unit then maintains this voltage within  $\pm 0.2\text{V}$  of the set value for full change in O/P load changes in mains input voltage within the specified limits. The current limit can also be set anywhere from zero to rated current value by means of the PRESET ADJUSTER. Whenever the load current tries to exceed the set limit , the unit automatically goes from constant voltage mode to constant current mode and maintains the current within  $\pm 0.5\text{A}$  or  $-0.5\text{A}$  of the set value under all conditions. The indication for current limit operation is provided by means of the LED.



Process Control Systems is used for maintaining the rate of rust within the permissible limit and also monitoring the voltage and number of out coming devices of the unit. PIC is used as the heart of the system and reference feedback card, current & voltage sensing card, isolated PWM SCR drive.i.e, Optotriac and 7segment display are the supporting components. Information that microcontroller needs in order to be able to function. Software can not have any errors if we want the program and a device to function properly. Software can be written in different languages such as: Basic C, Pascal or assembler.

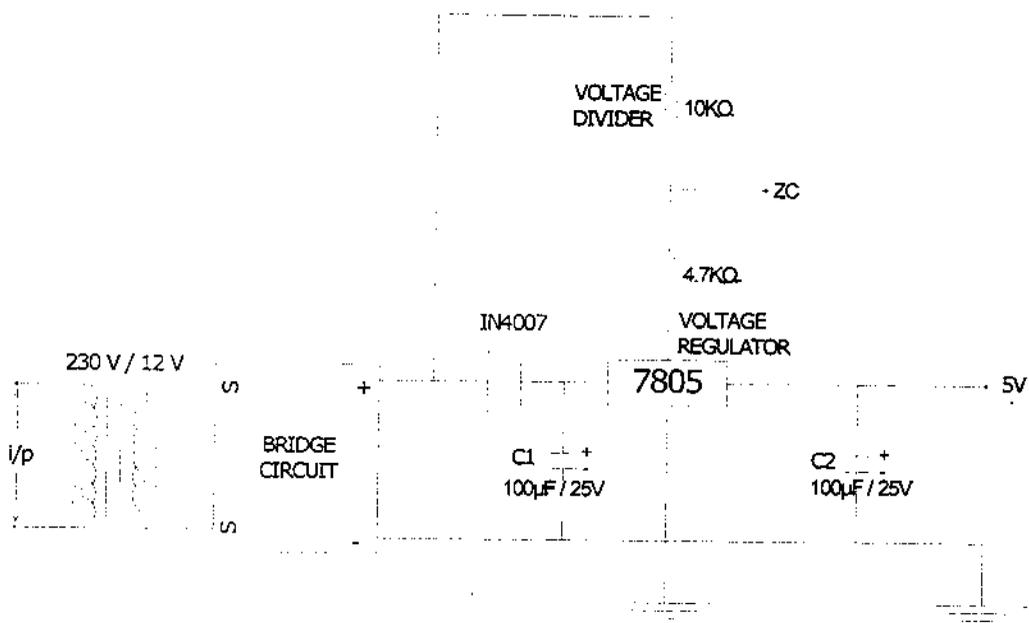


**Figure 3.2 Main Block Diagram Of Corrosion Protection System**



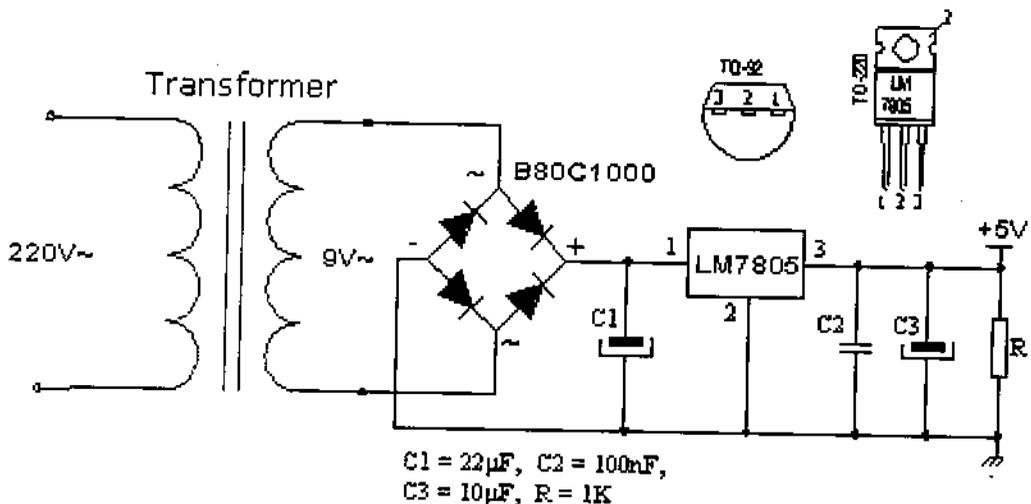
**Figure 3.3 Block Diagram Of Process Control System**

A major challenge faced by transmission line operations and maintenance departments is the detection, prevention and repair of corrosion on steel components at or below the ground line. The accurate voltage supply is of utmost importance for the proper functioning of the microcontroller system. For a proper function of any microcontroller, it is necessary to provide a stable source of supply. According to technical specifications by the manufacturer of PIC microcontroller, supply voltage should move between 2.0V to 6.0V in all versions. Voltage divider function is to provide different dc voltages needed by different circuits. It has a number of resistors connected in series across the output terminals of the voltage regulator. The simplest solution to the source of supply is using the voltage stabilizer LM7805 which gives stable +5V on its output. One such source is shown in the picture below.



**Figure 3.4 Block diagram of power supply**

output (pin 3), input voltage on pin 1 of LM7805 should be between 7V through 24V. Depending on current consumption of device we will use the appropriate type of voltage stabilizer LM7805. There are several versions of LM7805. For current consumption of up to 1A, the applied input voltage of the unit is monitored in order to determine the maximum fluctuation within the specified time duration. Potential divider circuit is used for this purpose. Potential divider circuit produces input voltage as output. The applied voltage is reduced using step down transformer and this voltage is converted into DC by means of diode bridge rectifier. This DC voltage is applied to potential divider. The output of potential divider is in analog form and is fed to PIC which is converted to digital value. The change in digital value with respect to analog value depends on potential divider ratio. Potential divider is a circuit, which divides the given input voltage. The input (230V) is applied to the potential divider circuit .it will produce the half of the input as the output. The output of the potential divider is given to the PIC for performing further operation.



**Figure 3.5 Circuit diagram of power supply**

will be changed with the help of PIC i.e., 16f877PIC. Opto triac provides pulse to the PIC from underground pipeline. PIC sends these potential to sensing devices i.e., reference feedback card & I/V sensing card for comparing the potential with reference value. Required rating of potential will send to PIC. The rate of potential is changed into analog signal by means of signal conditioning device and it's given to PIC. PIC has an inbuilt analog to digital converter. It converts analog voltage to digital value and compares the digital value with the reference value. If it exceeds reference value, automatically microcontroller controls the voltage. It will give high rate of DC current to the structure of pipeline depending upon potential condition of corroded pipe. Seven segment displays represent the potential of corrosion continuously.

### 3.3 SPECIFICATIONS OF THE UNIT

- PIC microcontroller chip: PIC 16F877
- Potential transformer : 230V/12V
- Current transformer 5:1
- SCR Device No: DYN604
- BT139 (TRIAC)
- MOC 3021
- W06 Bridge
- Power supply
- Diode device: IN4007
- Resistor range : 4.7K $\Omega$ , 1K $\Omega$
- Voltage divider : 10K $\Omega$
- Voltage regulator device : LM7805
- Typical value of load regulation: 15mV.
- Preset limiter : 4.7K $\Omega$
- Capacitor range : 100 $\mu$ F/25V

- RMC connectors
- Crystal range : 4MHZ
- A.C.Input voltage:230v
- Peak voltage rating:60v
- D.C.output voltage:40v
- RMS current rating:4A
- Average current rating:2.5A
- Gate current value:50mA
- Holding current value:30mA

## CHAPTER 4

### CATHODIC PROTECTION SCHEME

Cathodic protection is the use of an impressed or galvanic current to reduce or prevent corrosion of a metal in an electrolyte by making the metal to be protected by the cathode of a corrosion cell. The source of the protective current is immaterial, and it may be derived from zinc or magnesium anodes or external sources of power, i.e., a rectifier. Whenever corrosion takes place at the surface of steel in contact with an electrolyte, it can be controlled by cathodic protection. It is not always the most economical method since other more corrosion-resistant materials may be applied. However, after careful study of all the factors, cathodic control of corrosion by itself or in conjunction with protective coatings will often prove to be the most efficient means of protecting buried or submerged metals. Cathodic protection is not considered a practical means for protecting the interior surfaces of smaller diameter pipelines. In each structure, protection is a specific problem and has to be handled as such in cathodic protection installations.

Cathodic protection is the electrical solution to the corrosion problem. Cathodic protection is the process of forcing a metal to be more negative (cathodic) than the natural state. If the metal is forced negative enough, then corrosion will stop. Using cathodic protection, corrosion of steel piles can be monitored with high reliability.

cathodic protection problems.

- One is from a pipeline crossing a lake.
- Another is a pipeline in very rocky soil.
- The third is a well casing in dry clay.

If the rate of corrosion exceeds the safer limit, it enables the pin for control process. Protection of Dc current can be implemented using 16f877PIC. This corrosion problem can be prevented by counter acting the galvanic corrosion currents by means of superimposed external DC currents using an external DC source. Thus, when direct current is applied to submerged/underground structure with a polarity, which opposes the natural galvanic current and is of sufficient magnitude so as to polarize all the anodic area, corrosion is prevented. This forms the basis of impressed current cathodic protection system. However, the current required to provide complete protection depends on various conditions in which the structure operates.

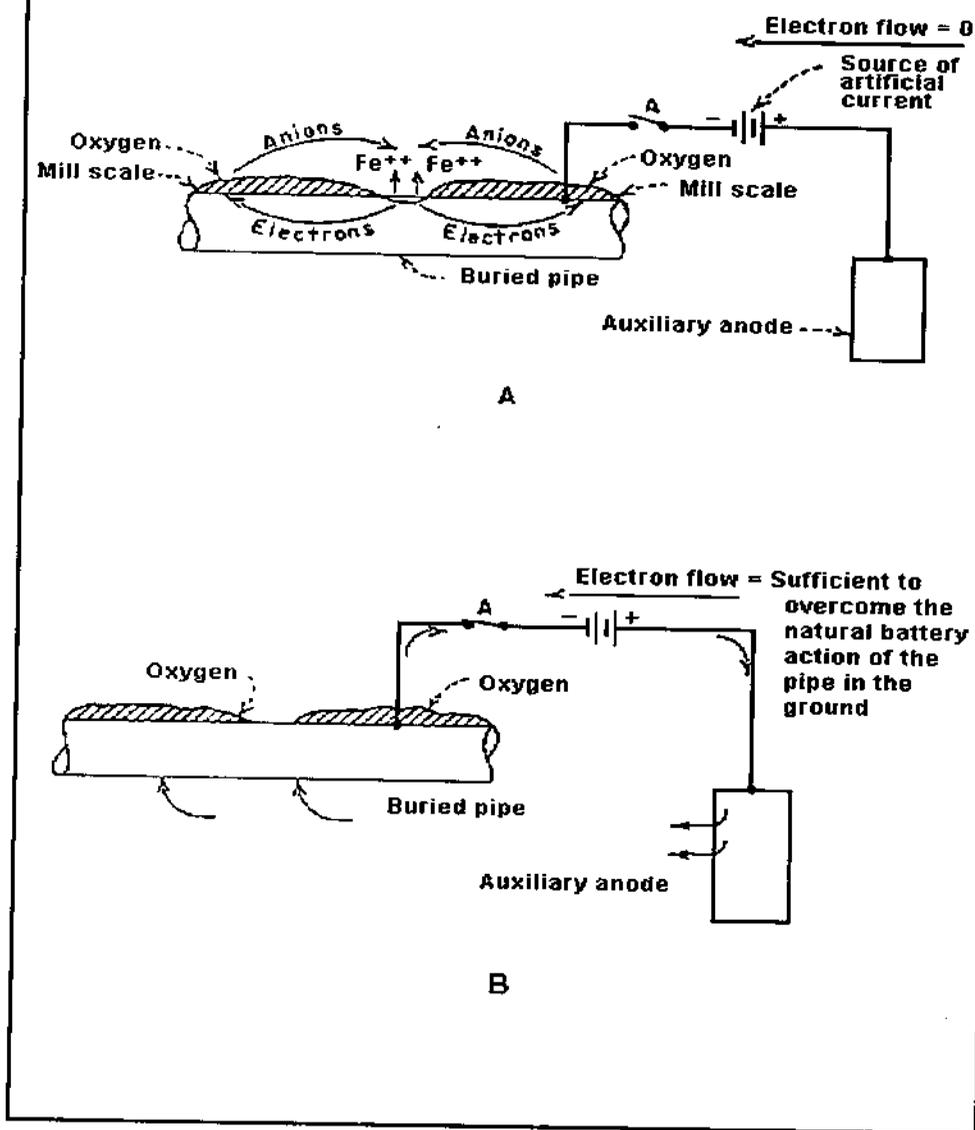
#### **4.1 IMPRESSED CURRENT METHOD**

A cathodic protection has inherent personnel protection systems are typically designed to drive the potential to about 11v negative. Potentials more negative than 2.5v can be damaging the coatings. The corrosion situation depicted in figure 4.1 may also be solved by cathodic protection using an impressed current or rectifier system.

First consequence, the galvanic potential of the anode is no longer relevant, and almost any electrode material may be used. Scrap iron, abandoned structures, driven steel anodes, etc., among sacrificial materials will suffice; or nonsacrificial materials, such as high silicon iron, graphite, or platinum, may be selected as anodes.

because the artificial current source makes available higher voltages and currents which can be manipulated to advantage. For instance, anodes can be located considerable distances from a pipeline and sufficient current supplied to protect the lines for as much as an 80.5-km (50-mi) length. Also, high enough voltages can be obtained to supply necessary currents for protection in high-resistance soils where sacrificial anodes are ineffective.

Third, the power potential in a rectifier system carries with it the danger that at excessive current densities, coatings on the structure may be damaged or destroyed or that accidental reversal of the polarity of the impressed current source may cause highly-accelerated corrosion of the structure instead of protecting it.



Electrochemical reaction on structure of pipeline

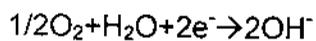
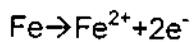
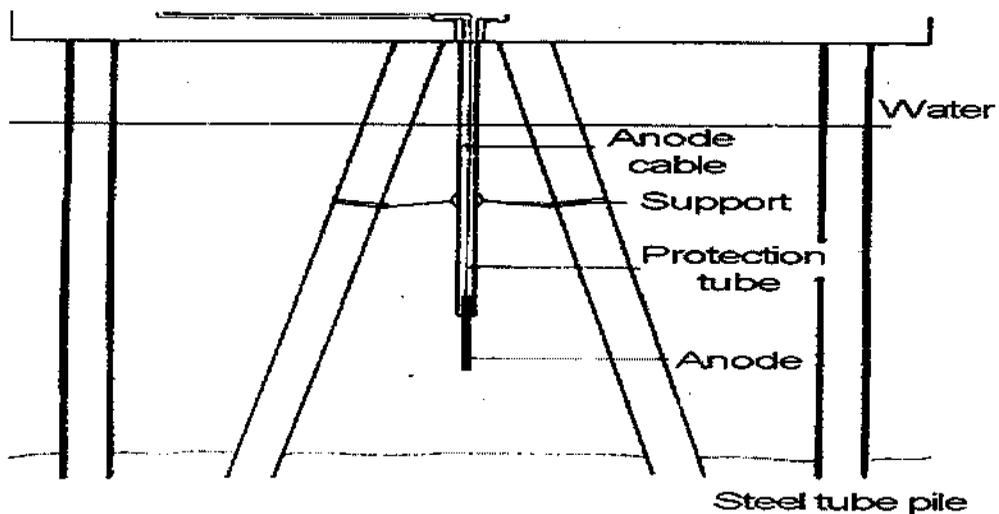


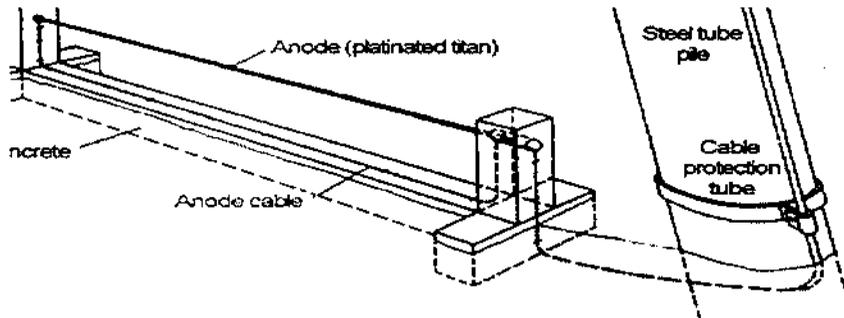
Figure 4.1 Protection of buried pipe by impressed current rectifier method.

resistance path to ground ( $<2\Omega$ ). This provides an adequate path for dissipation of current in a faulty condition. Cathodic protection can be also applied if the metal to be protected is coupled to the negative pole of a direct current (DC) source), while the positive pole is coupled to an auxiliary anode. Since the driving voltage is provided by the DC source there is no need for the anode to be more active than the structure to be protected. For example, a ship may play with different drafts in water of varying salinity and temperatures with varying speeds in different seawater velocity. Thus the current value to protect such ships has to be varied continuously. Cathodic protection with electric current applied to steel piles in water and anodes rigidly mounted in protection tubes between piles as shown in figure 4.2.



**Figure 4.2 Overview structure of cathodic protection scheme in underground pipeline**

protection to the structure. If the current impressed is higher than the required value, the structure would be partially protected. Arrangement of anodes for cathodic protection with electric current applied to steel piles in water and anode mounted in a support on the sea or soil bottom as shown in figure 4.3.



**Figure 4.3 Structural arrangement of impulse current scheme**

Automatic cathodic Protection rectifier has to accomplish this by monitoring the structure to electrolyte potential (cathode to electrolyte-pipe to soil) with respect to reference electrolyte continuously adjusting the impressed current to maintain the structure to soil potential at a present optimum value. This potential is kept constant under varying conditions of soil/water, temperature stray currents etc., thus providing protection to structure. This helps to improve the productivity of the unit and the quality of the product.

## CHAPTER 5

### HARDWARE IMPLEMENTATION

#### 5.1 PIC MICROCONTROLLER

Micro controller is the tiny chip. It has inbuilt memory, timer, ports and other additional features. There are several companies, manufacturing the micro controllers like Intel, Motorola and Microchip. PIC is the product of microchip. The following are the special characteristics of PIC,

##### Features of PIC

- Long Word Instructions
- Single Word Instructions
- Instruction Pipeline
- Single Cycle Instruction
- Reduced Instruction Set
- Register File Architecture
- Orthogonal (Symmetric) Instructions
- Instruction Flow/Pipelining

##### PIC Registers

##### Arithmetic Logical Unit (ALU)

PIC Micro controllers contain an 8-bit ALU and an 8-bit working register. The ALU is a general-purpose arithmetic and logical unit. It performs

and any register file.

The ALU is 8-bits wide and is capable of addition, subtraction, shift and logical operations. Unless otherwise mentioned, arithmetic operations are two's complement in nature. In two-operand instructions, typically one operand is the working register (W register). The other operand is a file register or an immediate constant. In single operand instructions, the operand is either the W register or a file register. The W register is an 8-bit working Register used for ALU operations. It is not an addressable register. Figure 5.1 shows the block diagram of ALU.

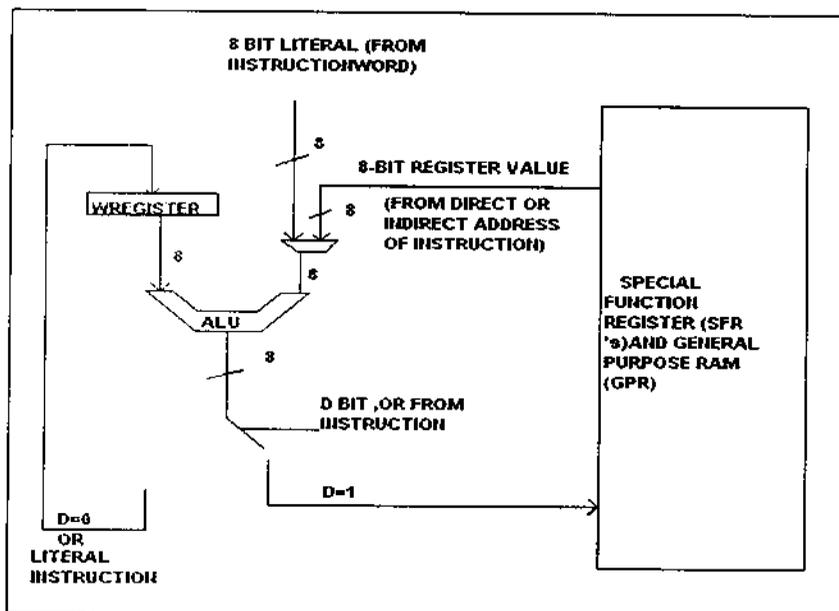


Figure 5.1 Block diagram of ALU

The STATUS register contains the arithmetic status of the ALU, the RESET status and the bank select bits for data memory. Since this register controls the selection of the Data Memory banks, it is required to be present in every bank. Also, this register is in the same relative position (offset) in each bank.

The STATUS register can be the destination for any instruction, as with any other register. If the STATUS register is the destination for an instruction that affects the Z, DC or C bits, then the write to these three bits is disabled. These bits are set or cleared according to the device logic. Furthermore, the TO and PD bits are not writable. Therefore, the result of an instruction with the STATUS registers, as destination may be different than intended. For example, CLRF STATUS will clear the upper-three bits and set the Z bit. This leaves the STATUS register as 000u u1uu (where u=unchanged).

It is recommended therefore, that only BCF, BSF, SWAPF and MOVWF instructions be used to alter the STATUS register because these instructions do not affect the Z, C or DC bits from the STATUS register. For other instructions not affecting any status bits.

R/W-0 R/W-0 R/W-0 R-1 R-1 R/W-X R/W-X R/W-X

IRP	RP1	RP0	T0	PD	Z	DC	C
Bit 7							Bit 0

Bit 7 **IRP** : Register Bank Select bit (used for indirect addressing)

1 = Bank 2, 3 (100h - 1FFh)

0 = Bank 0, 1 (00h - FFh)

always maintain this bit clear.

**Bit 6:5 RP1 : RP0:** Register Bank Select bits (used for direct addressing)

11 = Bank 3 (180h - 1FFh)

10 = Bank 2 (100h - 17Fh)

01 = Bank 1 (80h - FFh)

00 = Bank 0 (00h - 7Fh)

Each bank is 128 bytes. For devices with only Bank0 and Bank1 the IRP bit is reserved, always maintain this bit clear.

**Bit 4 TO:** Time-out bit

1 = After power-up, CLRWDT instruction, or SLEEP instruction

0 = A WDT time-out occurred

**Bit 3 PD:** Power-down bit

1 = After power-up or by the CLRWDT instruction

0 = By execution of the SLEEP instruction

**Bit2 Z:** Zero bit

1 = The result of an arithmetic or logic operation is zero

0 = The result of an arithmetic or logic operation is not zero

**Bit 1 DC:** Digit carry/borrow bit (ADDWF, ADDLW, SUBLW, SUBWF instructions) (for borrow the polarity is reversed)

1 = A carry-out from the 4th low order bit of the result occurred

0 = No carry-out from the 4th low order bit of the result

**Bit 0 C:** Carry/borrow bit (ADDWF, ADDLW, SUBLW, SUBWF instructions)

Device	Program FLASH	Data Memory	Data EEPROM
PIC16F874	4K	192 Bytes	128 Bytes
PIC16F877	8K	368 Bytes	256 Bytes

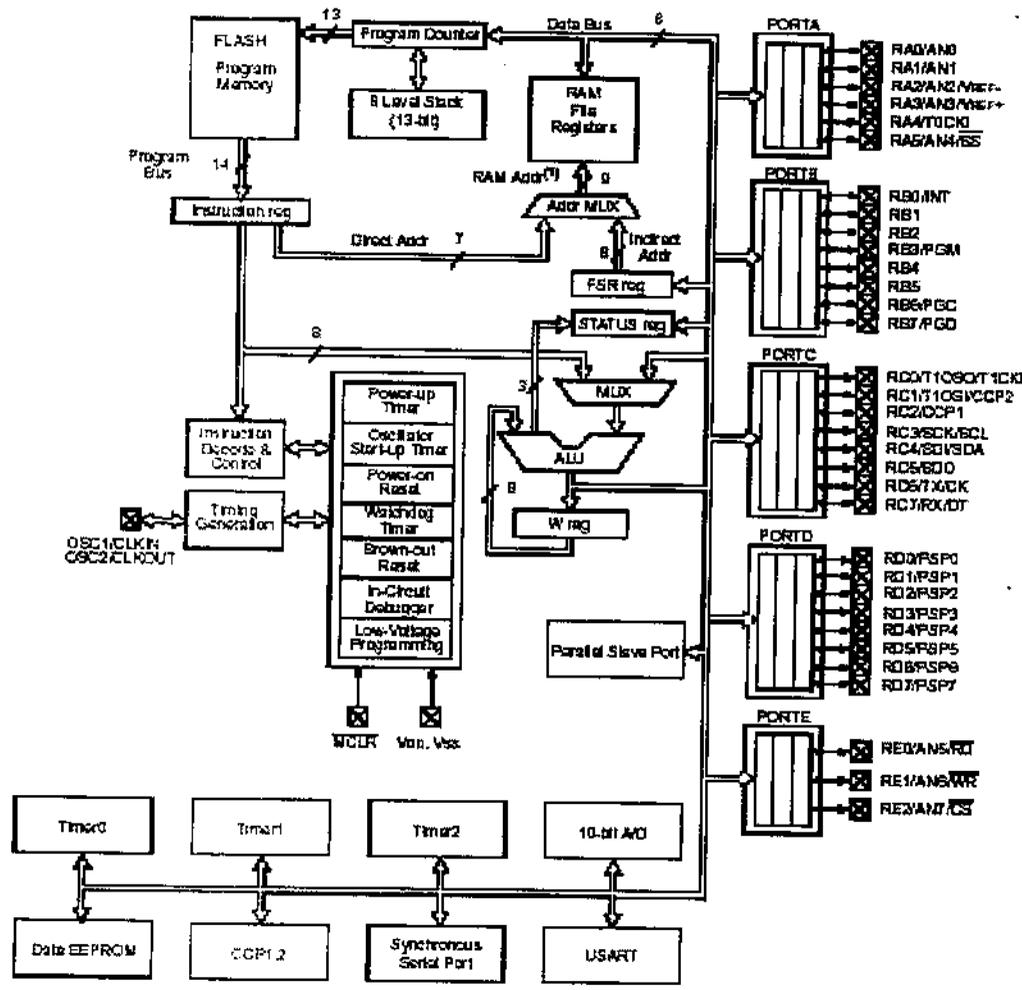


Figure 5.2 PIC Architecture

## 5.2 MEMORY ORGANIZATION

There are two-memory blocks

1. Program memory
2. Data memory.

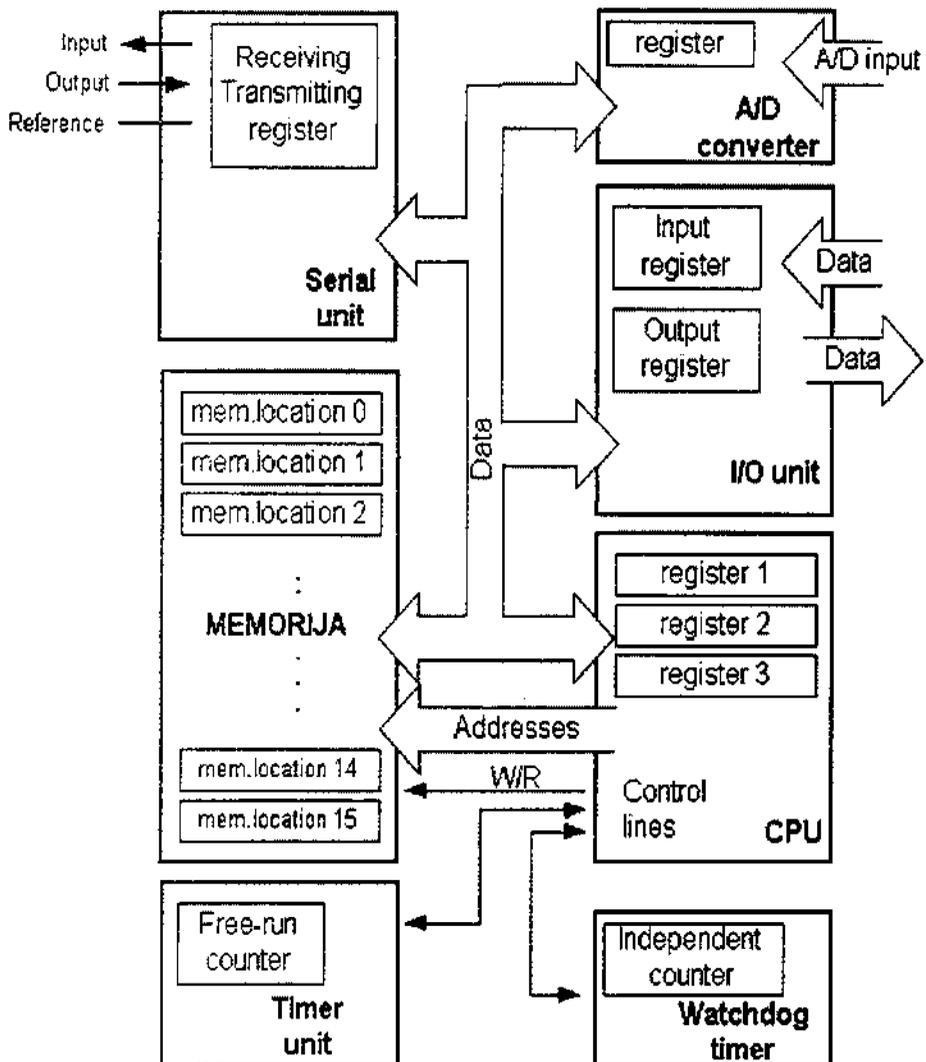


Figure 5.3 Microcontroller outline with its basic elements and internal connections

occur during the same oscillator cycle. The data memory can further be broken down into

General Purpose RAM.

Special Function Register (SFRs).

## **Program Memory Organization**

Mid-Range MCU devices have a 13-bit program counter capable of addressing an 8K x 14 program memory space. The width of the program memory bus (instruction word) is 14-bits. Since all instructions are a single word, a device with an 8K x 14 program memory has space for 8K of instructions. This makes it much easier to determine if a device has sufficient program memory for a desired application.

## **Program Counter (Pc)**

The program counter (PC) specifies the address of the instruction to fetch for execution. The PC is 13-bits wide. The low byte is called the PCL register. This register is readable and writable. The high byte is called the PCH register. This register contains the PC<12:8> bits and is not directly readable or writable. All updates to the PCH register go through the PCLATH register.

## **Stack**

The stack allows a combination of up to 8 program calls and interrupts to occur. The stack contains the return address from this branch in program execution. Mid-Range MCU devices have an 8-level deep x 13-bit wide hardware stack. The stack space is not part of either program or data space and the stack pointer is not readable or writable. The PC is PUSH onto the stack when a CALL instruction is executed or an interrupt causes a

POP.

## **Data Memory Organization**

Data memory is made up of the Special Function Registers (SFR) area, and the General Purpose Registers (GPR) area. The SFRs control the operation of the device, while GPRs are the general area for data storage and scratch pad operations. The data memory is banked for both the GPR and SFR areas. The GPR area is banked to allow greater than 96 bytes of general purpose RAM to be addressed. SFRs are for the registers that control the peripheral and core functions.

Banking requires the use of control bits for bank selection. These control bits are located in the STATUS Register (STATUS<7:5>). To move values from one register to another register, the value must pass through the W register. This means that for all register-to-register moves, two instruction cycles are required. The entire data memory can be accessed either directly or indirectly. Direct addressing may require the use of the RP1:RP0 bits. Indirect addressing requires the use of the File Select Register (FSR). Indirect addressing uses the Indirect Register Pointer (IRP) bit of the STATUS register for accesses into the Bank0 / Bank1 or the Bank2 / Bank3 areas of data memory.

## **Special Function Registers (SFR)**

The CPU and Peripheral Modules use the SFRs for controlling the desired operation of the device. These registers are implemented as static RAM. The SFRs can be classified into two sets, those associated with the "core" function and those related to the peripheral functions. Switching between these banks requires the RP0 and RP1 bits in the STATUS register

initialize some SFRs, while other SFRs are unaffected.

## **Port Control registers**

### **Port A and Tris A Register**

The RA4 pin is a Schmitt Trigger input and an open drain output. All other RA port pins have TTL input levels and full CMOS output drivers. All pins have data direction bits (TRIS registers), which can configure these pins as output or input.

Setting a TRISA register bit puts the corresponding output driver in a hi-impedance mode. Clearing a bit in the TRISA register puts the contents of the output latch on the selected pin(s).

### **Port b and Tris b Register**

PORTB is an 8-bit wide bi-directional port. The corresponding data direction register is TRISB. Setting a bit in the TRISB register puts the corresponding output driver in a high-impedance input mode. Clearing a bit in the TRISB register puts the contents of the output latch on the selected pin(s).

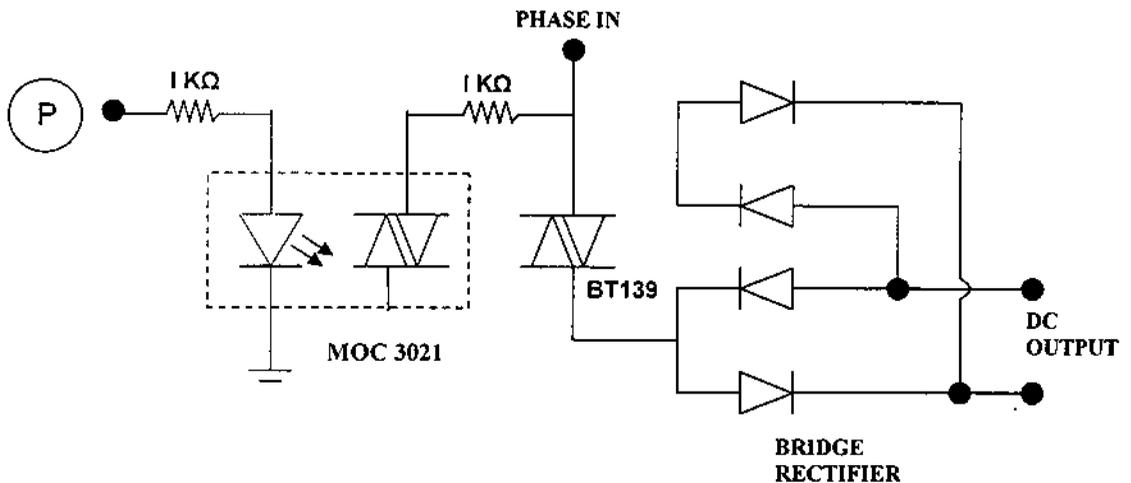
### **Port c and Tris c Register**

PORTC is an 8-bit bi-directional port. Each pin is individually configurable as an input or output through the TRISC register. PORTC pins have Schmitt Trigger input buffers. When enabling peripheral functions, care should be taken in defining TRIS bits for each PORTC pin. Some peripherals

override.

### 5.3 OPTOCOUPLER

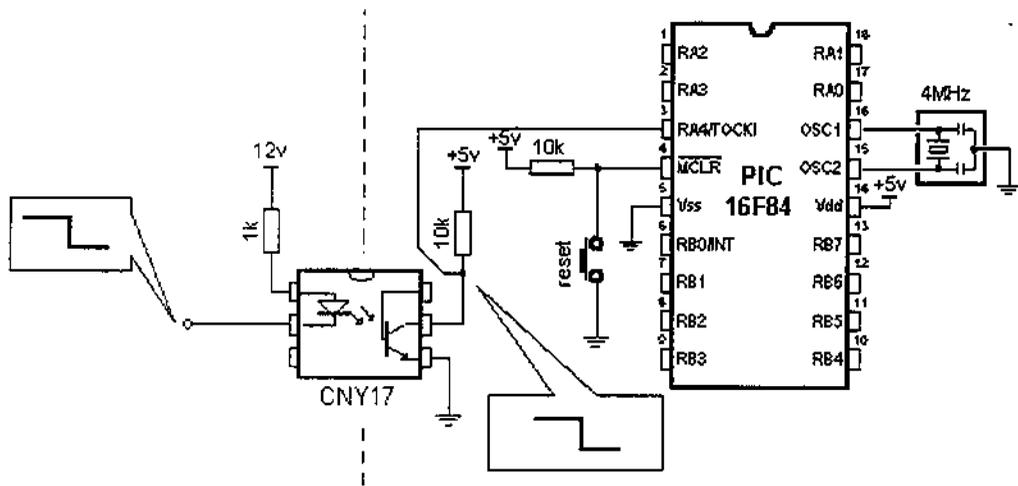
Optocouplers were discovered right after photo-transistors (like any other transistor, except it is stimulated by light), by combining a LED and photo-transistor or triac in the same case. The purpose of an optocoupler is to separate two parts of a circuit.



**Figure 5.4 Optotriac circuit diagram**

Optocouplers come as a single unit or in groups of two or more in one casing. Each optocoupler needs two supplies in order to function. They can be used with one supply, but the voltage isolation feature, which is their primary purpose, is lost.

When a signal arrives, the LED within the optocoupler is turned on, and it illuminates the base of a photo-transistor within the same case. When the transistor is activated, the voltage between collector and emitter falls to 0.7V or less and the microcontroller sees this as a logic zero on its RA4 pin. LED in turn will 'send' a signal by means of photo-transistor or triac to a microcontroller input RA4 (TOCKI). Current status of the counter is displayed on PORTB LEDs.



**Figure 5.5 Example of optocoupler on an input line**

### **OPTOCOUPLER ON AN OUTPUTLINE**

An Optocoupler can be also used to separate the output signals. If optocoupler LED is connected to microcontroller pin, logical zero on pin will activate optocoupler LED, thus activating the transistor. This will consequently switch on LED in the part of device working on 12V. Layout of this connection is shown below.



The ADCON1 register configures the functions of the port pins. The I/O pins can be configured as analog inputs (one I/O can also be a voltage reference) or as digital I/O. Figure 5.7 shows the ADC diagram.

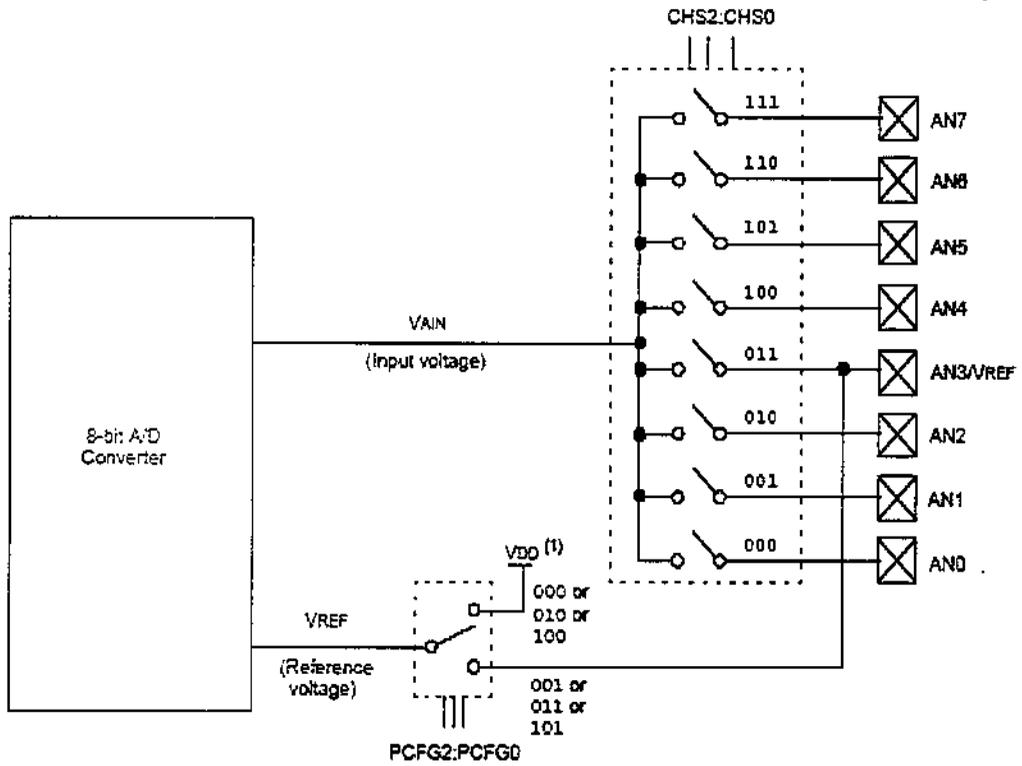


Figure 5.7 ADC diagram

## ADCON0 Register

ADCS1	ADCS0	CHS2	CHS1	CHS0	GO/DONE	Resv	ADON
Bit 7						Bit 0	

Bit 7:6    **ADCS1 : ADCS0:** A/D Conversion Clock Select bits

00= FOSC/2

01= FOSC/8

10= FOSC/32

11= FRC (clock derived from the internal A/D RC oscillator)

Bit 5:3    **CHS2 : CHS0:** Analog Channel Select bits

000= channel 0, (AN0)

001= channel 1, (AN1)

010= channel 2, (AN2)

011= channel 3, (AN3)

100= channel 4, (AN4)

101= channel 5, (AN5)

110= channel 6, (AN6)

111= channel 7, (AN7)

### Note:

For devices that do not implement the full 8 A/D channels, the unimplemented selections are reserved. Do not select any unimplemented channels.

When ADON = 1

1 = A/D conversion in progress

(Setting this bit starts the A/D conversion. This bit is automatically cleared by hardware when the A/D conversion is complete)

0 = A/D conversion not in progress

Bit 1 **Reserved** : Always maintain this bit cleared.

Bit 0 **ADON: A/D On bit**

1 = A/D converter module is operating

0 = A/D converter module is shutoff and consumes no operating current

### ADCON1 Register

--	--	--	--	--	PCFG2	PCFG1	PCFG0
----	----	----	----	----	-------	-------	-------

Bit 7

Bit 0

Bit 7:3 **Unimplemented**: Read as '0'

Bit 2:0 **PCFG2:PCFG0: A/D Port Configuration Control bits**

PCFG2:PCFG0	AN7	AN6	AN5	AN4	AN3	AN2	AN1	AN0
000	A	A	A	A	A	A	A	A
001	A	A	A	A	VREF	A	A	A
010	D	D	D	A	A	A	A	A
011	D	D	A	A	VREF	A	A	A
100	D	D	D	D	A	D	A	A
101	D	D	D	D	VREF	D	A	A
11x	D	D	D	D	D	D	D	D

A = Analog input

D = Digital I/O

- RA0 is set to one to make it as input.
- Sending the data 0x80 to this register configures ADCON1; in this register the bit ADFM is set.
- Sending the data 0x81 to this register configures ADCON 0, in this register ADON bit is set to enable conversion and also ADCS1 is set to select the frequency of conversion.
- Delay subroutine is called (10micro sec).
- ADGO bit is set to one.
- ADGO bit is checked to know either the A TO D conversion is completed or not.
  - ADGO is zero --- Conversion has done
  - ADGO is one --- Conversion hasn't done.

## Digital Output

$$(ADRESH * 256) + ADRESL$$

## 5.5 CONTROLLING REGISTER

### Control Register

The OPTION\_REG register is a readable and writable register, which contains various control bits to configure the TMR0/WDT prescaler, the External INT Interrupt, TMR0, and the weak pull-ups on PORTB.

### OPTION\_REG Register

To achieve a 1:1 prescaler assignment for the TMR0 register, assign the prescaler to the Watchdog Timer.

1 = Weak pull-ups are disabled

0 = Weak pull-ups are enabled by individual port latch values

**Bit 6 INTEDG:** Interrupt Edge Select bit  
1 = Interrupt on rising edge of INT pin  
0 = Interrupt on falling edge of INT pin

**Bit 5 T0CS:** TMR0 Clock Source Select bit  
1 = Transition on T0CKI pin  
0 = Internal instruction cycle clock (CLKOUT)

**Bit 4 T0SE:** TMR0 Source Edge Select bit  
1 = Increment on high-to-low transition on T0CKI pin  
0 = Increment on low-to-high transition on T0CKI pin

**Bit 3 PSA:** Prescaler Assignment bit  
1 = Prescaler is assigned to the WDT  
0 = Prescaler is assigned to the Timer0 module

**Bit 2:0 PS2:PS0:** Prescaler Rate Select bits

**Table No: 5.1 OPTION-REG register Bit transmission rating**

Bit Value	TMRO Rate	WDT Rate
000	1 : 2	1 : 1
001	1 : 4	1 : 2
010	1 : 8	1 : 2
011	1 : 16	1 : 8
100	1 : 32	1 : 16
101	1 : 64	1 : 32
110	1 : 128	1 : 64
111	1 : 256	1 : 128

Depending on the number of peripheral interrupt sources, there may be multiple Peripheral Interrupt Flag registers (PIR1, PIR2). These registers contain the individual flag bits for the peripheral interrupts. These registers will be generically referred to as PIR. Although, the PIR bits have a general bit location within each register, future devices may not be able to be consistent with that. It is recommended that you use the supplied Microchip Include files for the symbolic use of these bits. This will allow the Assembler/Compiler to automatically take care of the placement of these bits within the specified register. Interrupt flag bits get set when an interrupt condition occurs regardless of the state of its corresponding enable bit or the global enable bit.

**TMR1IF:** TMR1 Overflow Interrupt Flag bit

1 = TMR1 register overflowed (must be cleared in software)

0 = TMR1 register did not overflow bit

**TMR2IF:** TMR2 to PR2 Match Interrupt Flag bit

1 = TMR2 to PR2 match occurred (must be cleared in software)

0 = No TMR2 to PR2 match occurred bit

**CCP1IF:** CCP1 Interrupt Flag bit

Capture Mode

1 = A TMR1 register capture occurred (must be cleared in software)

0 = No TMR1 register capture occurred

Compare Mode

1 = A TMR1 register compare match occurred (must be cleared in software)

0 = No TMR1 register compare match occurred

Unused in this mode bit

**CCP2IF: CCP2 Interrupt Flag bit**

Capture Mode

1 = A TMR1 register capture occurred (must be cleared in software)

0 = No TMR1 register capture occurred

Compare Mode

1 = A TMR1 register compare match occurred (must be cleared in software)

0 = No TMR1 register compare match occurred

PWM Mode

Unused in this mode bit

**SSPIF: Synchronous Serial Port Interrupt Flag bit**

1 = the transmission/reception is complete

0 = Waiting to transmit/receive bit

**RCIF: USART Receive Interrupt Flag bit**

1 = The USART receive buffer, RCREG, is full (cleared when RCREG is read)

0 = The USART receive buffer is empty bit

**TXIF: USART Transmit Interrupt Flag bit**

1 = The USART transmit buffer, TXREG, is empty (cleared when TXREG is written)

0 = The USART transmit buffer is full bit

**ADIF: A/D Converter Interrupt Flag bit**

1 = An A/D conversion completed (must be cleared in software)

0 = The A/D conversion is not complete

The INTCON Register is a readable and writable register, which contains various enable and flag bits.

GIE	PEIE	TOIE	INTE	RBIE	TOIF	INTF	RBIF
-----	------	------	------	------	------	------	------

Bit 7

Bit 0

- Bit 7**      **GIE:** Global Interrupt Enable bit  
1 = Enables all un-masked interrupts  
0 = Disables all interrupts
- Bit 6**      **PEIE:** Peripheral Interrupt Enable bit  
1 = Enables all un-masked peripheral interrupts  
0 = Disables all peripheral interrupts
- Bit 5**      **TOIE:** TMR0 Overflow Interrupt Enable bit  
1 = Enables the TMR0 overflow interrupt  
0 = Disables the TMR0 overflow interrupt
- Bit 4**      **INTE:**INT External Interrupt Enable bit  
1 = Enables the INT external interrupt  
0 = Disables the INT external interrupt
- Bit 3**      **RBIE (1):** RB Port Change Interrupt Enable bit  
1 = Enables the RB port change interrupt  
0 = Disables the RB port change interrupt
- Bit 2**      **TOIF:** TMR0 Overflow Interrupt Flag bit  
1 = TMR0 register has overflowed (must be cleared in software)  
0 = TMR0 register did not overflow

Bit 1

**INTF:**INT External Interrupt Flag bit

1 = The INT external interrupt occurred (must be cleared in software)

0 = The INT external interrupt did not occur

Bit 0

**RBIF (1):** RB Port Change Interrupt Flag bit

1 = At least one of the RB7:RB4 pins changed state (must be cleared in software)

0 = none of the RB7:RB4 pins have changed state.

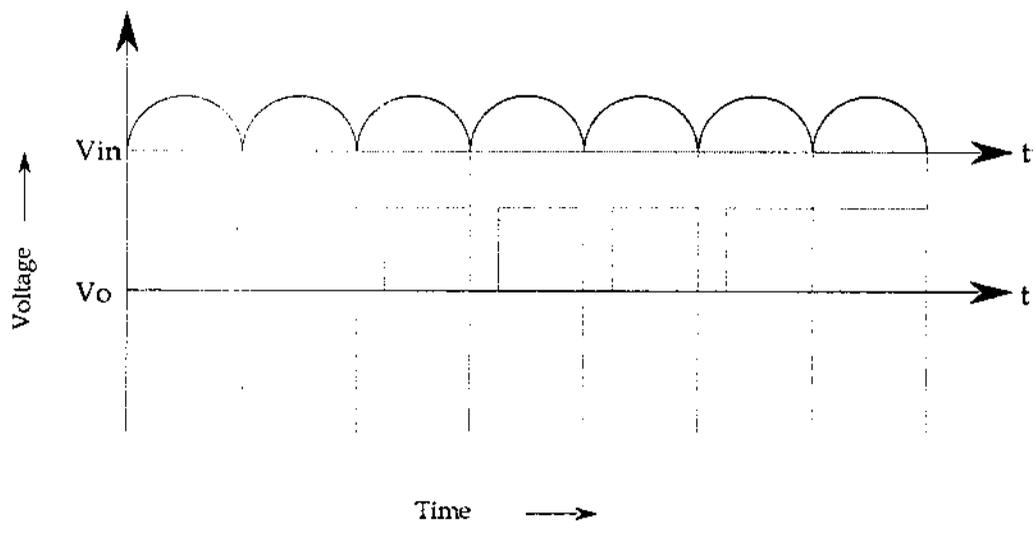
## CHAPTER 6

### RESULTS AND IMPLEMENTATION

#### 6.1 OUTPUT RESULTS OF THE SCHEME

Table 6.1 Output Results

S.No:	Reference Voltage(0 to 20V),V	Ground Potential(0 to20V),V	Input current(0 to 50A), I	Input voltage(0 to rated voltage), V	Voltmeter range(0 to 1000V)DC voltage,V
I	18	2	48	240	23
		8	46	239	25
		11	46	239	46
		18	45	238	171
		20	45	237	180
II	10	4	50	148	65
		9	49	146	143
		10	49	145	145
		15	48	145	186
		20	48	145	190



**Figure 6.1 output waveform**

## CHAPTER 7

### CONCLUSION AND FUTURE EXTENSION

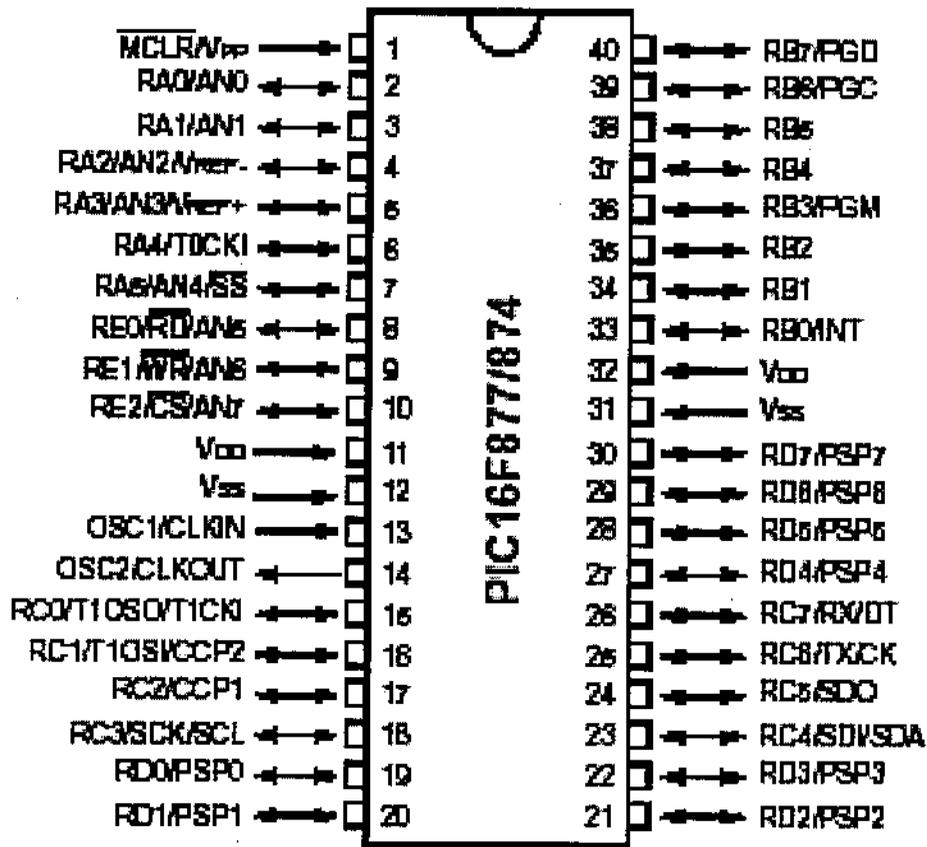
Trends in corrosion research have changed rapidly over the years. It has started with simple galvanic measurements and has now come to the use of potential/galvanostatic sophisticated instrumentation and the revolution in computer technology make the possibility of on-line monitoring of corrosion.

A proper protection of the ordinary reinforcing steel and the prestressing steel against corrosion is a great challenge for the engineers. Advanced corrosion protection methods and advanced corrosion protected systems can be applied to produce structures with the required durability.

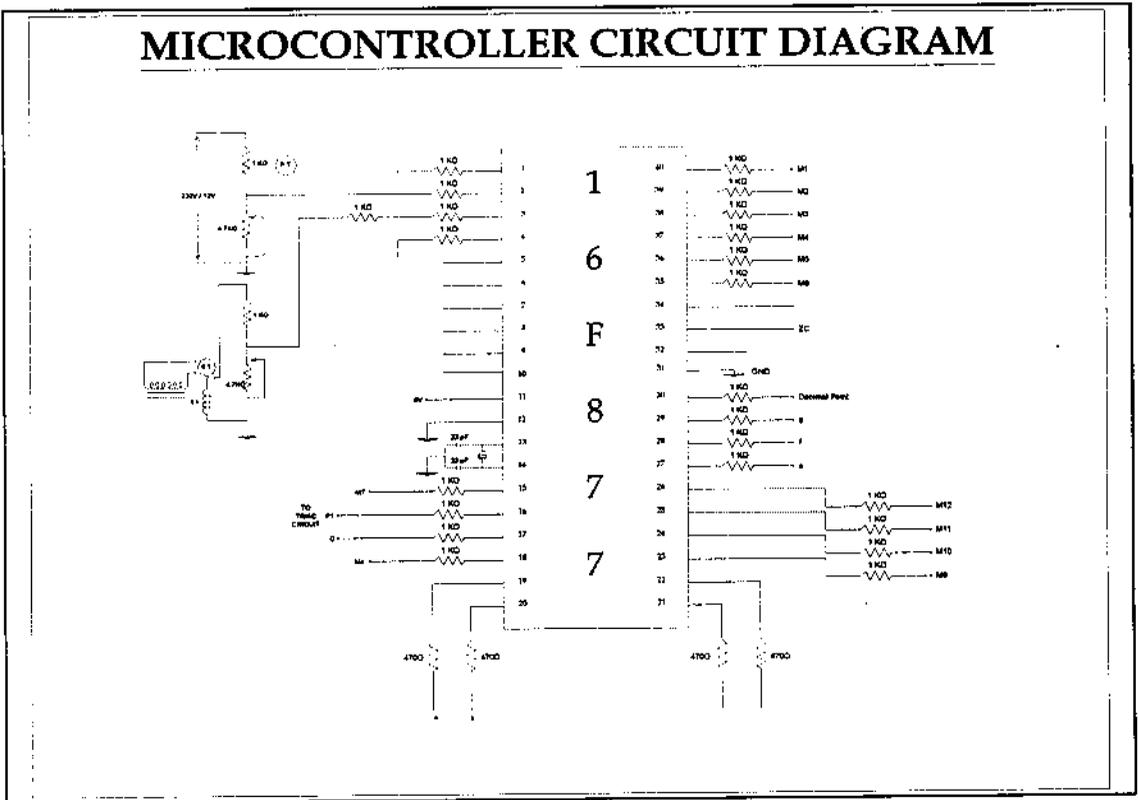
The system automatically corrects the corrosion rate by comparing it with the preset value. This is an industry-oriented system. The latest advancements are updated in this project to differentiate this from the existing system. The methodology used, is most comfortable for remote monitoring of industrial parameters. Many industries will adapt to this system, since it is economical, fast, and reliable.

The project can be extended with real time clock. This system helps to determine the time at which the rating of corrosion exceeds the set value and maximum voltage fluctuation. Specified amount of DC current should be applied on the structure of the pipeline, it will limit the rating of corrosion.

This will make the system more efficient. This user efficient system can be installed in all units to achieve long life of the pipeline structure. From the cost analysis, it can be concluded that cathodic protection system is to be applied right at the stage of laying the pipeline to protect the buried structure. This technique will be widely used for industrial application.



OVERALL CIRCUIT DIAGRAM





**APPENDIX III**

**HARDWARE PHOTOCOPY**



## PROGRAM

```

/*-----*/
                phase control
/*-----*/
#include<pic.h>
/*-----*/
                variable declaration
/*-----*/
const char
lookup[]={0x3f,0x06,0x5b,0x4f,0x66,0x6d,0x7d,0x07,0x7f,0x6f,0x40};
char
times,come,j,i,dcome,seg1,seg2,seg3,seg4,seg5,seg6,seg7,seg8,seg9,seg10,s
eg11,seg12;
char ycm,ycome,bcm,bcome,rerror,yerror,berror,yentry=0,bentry=0;
char seg;

int result,result1,rvolt,yvolt,bvolt,doad,mcome,buffer,rduty,yduty,bduty,sevolt=0;
/*-----*/
                main routine
/*-----*/
main()
{
TRISA=0xff;
TRISB=0X01;
TRISD=0X00;
TRISC=0X00;
PORTD=0X00;
PORTB=0X00;
PORTC=0X00;
PORTA=0X00;
INTCON=0XC0;
INTE=1;
OPTION=0x85;
TMR0=200;
T0CS=1;
T0IE=1;
come=0;
T2CON=0X25;
PR2=130;
TMR2IE=1;
while(1)
{

```

```

setvoltage();
}
}
acvoltage()
{
result=0;
doad=0;
for(doad=0;doad<1200;doad++)
{
ADCON1=0X80;
ADCON0=0X89;
for(j=0;j<10;j++);
ADGO=1;
while(ADGO);
result1=(ADRESH*256+ADRESL);
if(result1>result)
result=result1;
}
result=result/4;

seg1=result/100;
buffer=result%100;
seg2=buffer/10;
seg3=buffer%10;
}

```

```

accurrent()
{
result=0;
doad=0;
for(doad=0;doad<1200;doad++)
{
ADCON1=0X80;
ADCON0=0X81;
for(j=0;j<10;j++);
ADGO=1;
while(ADGO);
result1=(ADRESH*256+ADRESL);
if(result1>result)
result=result1;
}
result=result/4;

seg4=result/100;
buffer=result%100;
seg5=buffer/10;

```

```

{
result=0;
doad=0;
for(doad=0;doad<1200;doad++)
{
ADCON1=0X80;
ADCON0=0X91;
for(j=0;j<10;j++);
ADGO=1;
while(ADGO);
result1=(ADRESH*256+ADRESL);
if(result1>result)
result=result1;
}
result=result/50;
setvoltage=result;
seg7=result/100;
buffer=result%100;
seg8=buffer/10;
seg9=buffer%10;
}

/*-----*/
/*-----*/
main routine
/*-----*/
/*-----*/
dcvoltage()
{
result=0;
doad=0;
for(doad=0;doad<1200;doad++)
{
ADCON1=0X80;
ADCON0=0X99;
result1=(ADRESH*256+ADRESL);
if(result1>result)
for(j=0;j<10;j++);
ADGO=1;
while(ADGO);
result=result1;
}
result=result/50;
rvoltage=result;
seg10=result/100;
buffer=result%100;
seg11=buffer/10;
seg12=buffer%10;
}

```

```
rerror=setvolt-result;  
rduty=189-(rerror*10);  
if(rduty<100)  
rduty=100;  
}
```

```
if(rvolt>setvolt)  
{  
error=result-setvolt;  
rduty=189+(rerror*10);  
if(rduty>254)  
rduty=254;  
}  
}
```

```
/*-----*/
```

interrupt service routine

```
/*-----*/
```

```
static void interrupt  
isr()  
{
```

```
if(T0IF==1)  
{  
T0IF=0;  
RC1=1;  
T0CS=1;  
}
```

```
    if(INTF==1)  
    {  
        INTF=0;  
        RC1=0;  
        TMR0=rduty;  
        T0CS=0;  
    }
```

```
if(TMR2IF==1)
```

```
{  
TMR2IF=0;  
seg++;  
if(seg==13)  
seg=1;  
if(seg==1)  
{  
PORTB=0;
```

```
RC0=0;
RC3=0;
RC7=0;
PORTD=lookup[seg1];
RC6=1;
}
if(seg==2)
{
PORTB=0;
RC5=0;
RC4=0;
RC6=0;
RC0=0;
RC3=0;
RC7=0;
PORTD=lookup[seg2];
RC5=1;
}
if(seg==3)
{
PORTB=0;
RC5=0;
RC4=0;
RC6=0;
RC0=0;
RC3=0;
RC7=0;
PORTD=lookup[seg3];
RC4=1;
}
if(seg==4)
{
PORTB=0;
RC5=0;
RC4=0;
RC6=0;
RC0=0;
RC3=0;
RC7=0;
PORTD=lookup[seg4];
RC0=1;
}
if(seg==5)
{
PORTB=0;
RC5=0;
```

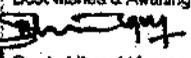
```
RC3=0;
RC7=0;
PORTD=lookup[seg5];
RC3=1;
}
if(seg==6)
{
PORTB=0;
RC5=0;
RC4=0;
RC6=0;
RC0=0;
RC3=0;
RC7=0;
PORTD=lookup[seg6];
RC7=1;
}
if(seg==7)
{
PORTB=0;
RC5=0;
RC4=0;
RC6=0;
RC0=0;
RC3=0;
RC7=0;
PORTD=lookup[seg7];
RB2=1;
}
if(seg==8)
{
PORTB=0;
RC5=0;
RC4=0;
RC6=0;
RC0=0;
RC3=0;
RC7=0;
PORTD=lookup[seg8];
RB3=1;
}
if(seg==9)
{
PORTB=0;
RC5=0;
RC4=0;
```

```
RC7=0;
PORTD=lookup[seg9];
RB4=1;
}
if(seg==10)
{
PORTB=0;
RC5=0;
RC4=0;
RC6=0;
RC0=0;
RC3=0;
RC7=0;
PORTD=lookup[seg10];
RB5=1;
}
if(seg==11)
{
PORTB=0;
RC5=0;
RC4=0;
RC6=0;
RC0=0;
RC3=0;
RC7=0;
PORTD=lookup[seg11];
RB6=1;
}
if(seg==12)
{
PORTB=0;
RC5=0;
RC4=0;
RC6=0;
RC0=0;
RC3=0;
RC7=0;
PORTD=lookup[seg12];
RB7=1;
}
}
}
}
```

 <p><b>NATIONAL CONFERENCE</b> on <b>CUTTING EDGE TECHNOLOGIES IN POWER CONVERSION AND INDUSTRIAL DRIVES</b> (PCID – 2005)</p>  <p>Department of Electrical &amp; Electronics Engineering (Accredited by NBA) Bannari Amman Institute of Technology Sathyamangalam – 638 401, Tamilnadu</p> <p>March 25 – 26, 2005</p>	
<p><b>Organizing Committee</b></p> <p>Patron Sri S.V. Balasubramaniam Managing Trustee, BIT</p> <p>Chairman Dr. A. Shanmugam Principal, BIT</p> <p>Vice Chairman Dr. G. Gurusamy Dean/EEE, BIT</p> <p>Convener Dr. A. Nirmal Kumar HOD/EEE, BIT</p> <p><b>Organizing Secretaries</b> Prof. R. Senthilkumar Mr. R. Bharanikumar</p> <p><b>Joint Secretaries</b> Mr. J. Charles Arokiaraj Mr. P.S. Mayurapprian</p>	<p style="text-align: right;">Date: 28-01-2005</p> <p>Dear Sir / Madam</p> <p>Congratulations, I am pleased to inform you that the extended summary of the paper submitted by you (and your co-authors) has been provisionally accepted for presentation at PCID – 2005. Kindly send the full paper (with soft copy) in IEEE format * along with Registration Fees * in the form of Demand Draft drawn in favour of The Principal, Bannari Amman Institute of Technology payable at Sathyamangalam and two passport size photographs of authors to Mr.R.Bharanikumar, Organising secretary-PCID2005, Bannari Amman Institute of Technology Sathyamangalam 638 401.</p> <p>The letter of acceptance will be sent on receipt of the full paper along with the Registration fees on or before 20.02.2005.</p> <p>Accommodation will be provided inside our campus. Please feel free to send your queries to <a href="mailto:pcid2005@rediffmail.com">pcid2005@rediffmail.com</a>. For further details, please visit our website <a href="http://www.bitsathy.ac.in/PCID2005">www.bitsathy.ac.in/PCID2005</a>.</p> <p>With regards and best wishes,</p> <p>Dr. A. Nirmal Kumar, Convener, PCID – 2005, Bannari Amman Institute of Technology, Sathyamangalam, Tamilnadu.</p> <p>* - Details available in website</p>
<p>Bannari Amman Institute of Technology, Sathyamangalam – 638 401, Erode Dt. Tamilnadu Tel: 04295 – 221289. Ext.522. Fax: (91 – 4295) 223775; E – mail: <a href="mailto:pcid2005@rediffmail.com">pcid2005@rediffmail.com</a>, Website: <a href="http://bitsathy.ac.in/PCID2005">bitsathy.ac.in/PCID2005</a></p>	

Department of Electrical & Electronics Engineering  
Bannari Amman Institute of Technology  
Sathyamangalam - 638 401, Tamilnadu

March 25 - 26, 2005

<p><b>Organizing Committee</b></p> <p><b>Patron</b> Sri S.V. Balasubramanian Managing Trustee, BIT</p> <p><b>Chairman</b> Dr. A. Shanmugam Principal, BIT</p> <p><b>Vice Chairman</b> Dr. G. Gurusamy Dean/EEE, BIT</p> <p><b>Convenor</b> Dr. A. Nirmal Kumar HOD/EEE, BIT</p> <p><b>Organizing Secretaries</b> Prof. R. Senthilkumar Mr. R. Bharanikumar</p> <p><b>Joint Secretaries</b> Mr. J. Charles Arulkumar Mr. P.S. Mayurappriyan</p>	<p>To Ms. K.Ezhi Meenakshi PG Student / EEE Kumaraguru College of Technology Coimbatore</p> <p>Date: 21-02-2005</p> <p>Title of paper : Application of Embedded Technique in Galvanic Corrosion for underground Pipeline</p> <p>Dear Ms. K.Ezhi Meenakshi</p> <p>Congratulations! Thank you for your interest in PCID 2005. We acknowledge with thanks the receipt of your full paper along with the registration fees. Your paper has been accepted for oral presentation in PCID 2005. The list of accepted papers uploaded in the website: <a href="http://www.bitsathy.ac.in">www.bitsathy.ac.in</a> is being updated periodically.</p> <p>This is a pro-author Conference and your personal participation is absolutely essential. Kindly confirm your participation for PCID 2005 by return mail on or before 7<sup>th</sup> March 2005.</p> <p>We will provide free boarding and lodging for all the participants within our campus. To serve you better, we would request you to furnish the following details as soon as possible.</p> <ul style="list-style-type: none"> <li>• Name of participant(s) - Specify Male or Female</li> <li>• Date of arrival</li> <li>• Lodging requirement</li> </ul> <p>We are personally anxious to see you here at Sathyamangalam during the Conference. Please treat this letter as an official document for all conference related activities. The schedule for presentation will be informed at the time of registration. Your presentation would be for 15 minutes. You may present your paper with the help of OHP transparencies or with power point slides. Best paper in each session will be rewarded. Please feel free to write to us in case you have any query. Best wishes &amp; Awaiting your active participation in PCID 2005</p> <p> Dr. A. Nirmal Kumar Convenor, PCID - 2005, Bannari Amman Institute of Technology, Sathyamangalam, Tamilnadu * - Details available in website</p>
--	--

Bannari Amman Institute of Technology, Sathyamangalam - 638 401, Erode Dt, Tamilnadu  
Tel: 04295 - 221289, Ext:522, Fax: (91 - 4295) 223775.  
E - mail: [pcid2005@rediffmail.com](mailto:pcid2005@rediffmail.com); Website: [bitsathy.ac.in/PCID2005](http://bitsathy.ac.in/PCID2005)



# BANNARI AMMAN INSTITUTE OF TECHNOLOGY

Sathyamangalam - 638 401 Erode Dt. Tamil Nadu



FIRST NATIONAL CONFERENCE ON  
"CUTTING EDGE TECHNOLOGIES IN POWER CONVERSION AND INDUSTRIAL DRIVES"

PCID-2005

Organised by : Department of Electrical & Electronics Engineering  
(Accredited by NBA,AICTE New Delhi)

Sponsored by : Council of Scientific and Industrial Research(CSIR), New Delhi

## THIS CERTIFIES THAT

Prof./Dr./Mr./Ms. K. EZHIL MEENAKSHI

has participated in the NATIONAL CONFERENCE on "POWER CONVERSION AND INDUSTRIAL DRIVES",

PCID-2005 held during 25 - 26 March 2005 and has presented a paper titled Application of Embedded  
Technique in Inverter Control for Underground Pipeline

in the session PS-2 of the conference.

Dr. A. Nirmal Kumar  
Convener PCID-2005

Session Chair  
PCID-2005

Dr. G. Gurusamy  
Dean EEE

Dr. A. Shanmugam  
Principal



## Bright Electro Control Equipments (P) Ltd

Manufacturers of Electronic & Electrical Equipments

GRASS HILL ROAD, SF No.162, KAMADENU NAGAR,

AVARAMPALAYAM, COIMBATORE 641 006, INDIA

TEL : 0422 - 2560116, 2567249

FAX : 0422 - 2562973



Date : 16 - 05 - 05

### PROJECT CERTIFICATE

This is to certify that

Miss. K. Ezhil Meenakshi M. E.

Student of Kumara guru College of Technology, Coimbatore have successfully completed her Project "APPLICATION OF EMBEDDED TECHNIQUE IN GALVANIC CORROSION CONTROL FOR UNDERGROUND PIPELINE" in our company.

During this period her conduct and behavior was good.

Her interest towards work and sincerity is appreciated.

We wish her all success in the future.

For BRIGHT ELECTRO CONTROL EQUIPMENTS ( P ) LTD

Authorised Signatory.

## REFERENCES

- [1] DAVID E.Simon 'An software primer', Pearron Educational Aria 2001.
- [2] John.B.Peatman 'Design with PIC Microcontroller', Pearson Educational Aria 2000.
- [3] FUJIMOTO.S, SHIBATA.T, MATSU MOTO.N 'Improvement of localized corrosion resistance of austenitic stainless steel by N, Cr and Mo ion implantation', Ion Implantation Technology Proceedings, 1998 International Conference on, Volume: 2, 22-26 June 1998.
- [4] HOPE.F, J, BASU.S.P, ROGERS.G.E 'Design, installation and field experience with real -time cathodic protection monitoring of pipe type cable systems', Underground syst.Inc.Armonk.N.Y.USA, Transmission and Distribution Conference, 1996.Proceedings. 1996, IEEE.
- [5] SARFI.R.J, SALAMA.M.M.A, GEBO TVS.C, CHIKHANI.A.Y 'Optimal design of cathodic protection schemes: a power engineering applications', Electrical and Computer Engineering, 1993, Canadian Conference.
- [6] DIKMAROVA.L, NICHOGA.V, DUB.P 'Underground pipeline in problems of remote testing of corrosion protection', Instrumentation and measurement, IEEE Transactions.
- [7] QAMARUZZAMAN, PURWADI.A, DAHONO.P.A 'A DC high-current Low-voltage power generating system', Power systems Technology, 2002 proceedings power con.2002, International conference.
- [8] V.D.Patil, P.S.Phulari,'Cathodic protection system for underground M.S.Pipeline of water supply project', Indian.j.Environmental health.vol.45, No: 1, P.11-14, January 2003.
- [9] Paper presentation, 'Application of embedded technology in galvanic corrosion for underground pipeline', presented in National conference on Cutting edge technologies in power conversion and industrial Drives(PCID-2005),Bannari Amman Institute Of Technology, Sathyamangalam, Erode Dt(T.N).

- [11] Easy PIC by Mykepredko.
- [12] Midrange manual-Microchip.
- [13] [www.microchip.com](http://www.microchip.com)
- [14] [www.sensors.com](http://www.sensors.com)
- [15] [www.google.com](http://www.google.com)
- [16] [www.ieee.org](http://www.ieee.org)

