SIMULATION AND HARDWARE IMPLEMENTATION ON POWER FACTOR IMPROVEMENT FOR INDUCTION FURNACE

A Project Report

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BONAFIDE CERTIFICATE

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ABSTRACT

Power factor of the load in any industry or any Electrical system should be maintained nearer to unity. Our Project envisages for maintaining of Power factor around unity and also Providing Quality Power Supply to industries having Induction furnaces. By maintaing Power factor around unity the industry is benefited paying less charges to the Electricity Board and the supplier is also benefited having less line loss in network.

The Objectives of this project are two fold, one is eliminating the harmonics and another is improving the Power factor of the electrical system feeding Induction furnace by using power Electronic devices and controls.

This project provides the provision of measuring the Power factor of the system continuously for the Induction Furnaces and if the Power factor reduces below the required value a set of capacitor banks are arranged to be switched ON through a triac circuit automatically connected across the supply so as to improve Power factor.The Power factor of the load and required Power factor are compared using a software designed in the AT89C51 microcontroller unit based on the signal obtained from the Power factor sensing unit. Power factor of end is displayed in display unit continuously. Harmonics present in the supply is eliminated using a passive filter.

The Induction furnace requires a high frequency AC for which available 50 cycle AC supply is convered into DC and inverted to high frequency AC supply using Power electronic devices. This results in the Generation of harmonics. These harmonics are reduced to Maximum extent by using a Passive filter. The project has been completed based on a prototype mode l by converting Single phase AC supply to DC and inverted to high frequency AC around 70Hz.

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LIST OF SYMBOLS AND ABBREVIATIONS

	SYMBOLS	ABBREVIATIONS
1.	kW	Kilo Watt
2.	kVA	Kilo Volt Ampere
3.	kVAR	Kilo Volt Ampere Rating
4.	L,C	Inductance, Capacitance
5.	PFI	Power Factor Improvement
6.	EMI	Electro Magnetic Interface
7.	PFC	Power Factor Correction
8.	µH	Micro Henry
9.	µF	Micro Farad
10.	THD	Total Harmonic distortion
11.	ASD	Adjustable Speed Drives
12.	DC	Direct Current
13.	THDF	Transformer Harmonic Derating Factor
14.	RMS	Root Mean Square
15.	UPS	Uninterruptible Power Supply
16.	Ac	Alternating Current
17.	Scr	Silicon Controlled Rectifier
18.	MVA	Mega Volt Amperes
19.	VA	Volt Ampere
20.	E ,I	Voltage, Current
21.	Cos ?	Power Factor
22.	IC	Integrated Circuit
23.	Vi	Input Voltage
24.	GND	Ground
25.	+ Vsat	Positive Saturation Voltage
26.	- Vsat	Negative Saturation Voltage
27.	Vref	Reference Voltage
28.	XOR	Exclusive OR
29.	D	Diode

DEDICATED TO OUR BELOVED PARENTS

CHAPTER 1

INTRODUCTION

INTRODUCTION

1.1 Motivation for Selecting the Project

Coimbatore is an Industrial city well known for textile and small Engineering units. The Engineering units mostly employed in manufacturing of pumpsets, CNC lathes and Automobile spares and spares required for BHEL, Railways and major industries of government of India.

Most of the spares required are manufactured by steel of various grades.These steels are required to be melted, and to be made as a molten material for casting them in a required shape.

The Induction furnace is widely used in and around Coimbatore for steel casting. There are about Two hundred and more Induction furnaces of small,medium and lager sizes. They use the power by converting the available 50Hz power frequency to 700Hz using power electronic devices. These frequency conversion and power factor improvement and suppression of harmonics are designed and manufactured by M/s ABB and M/s SIEMENS companies and they are not ready to reveal their technology and software.

So we thought of fabricating indegenously the above unit with minimum cost, hence we have selected this project.

1.2 Statement of the Problem

Due to inductive load, the induction furnace will be consuming electricity with low lagging Power factor.

Due to the usage of inverters and converters, harmonics also will be present which will cause heating effect in the cores of transformers To eliminate these harmonics and to improve Power factor and thereby to have a quality Power supply, we proposed to fabricate "Power Factor Improvement For Induction Furnace Using Triac Switching Method".

1.3 Aim and Objective of the work

Our objective is to design and fabricate "Power Factor Improvement For Induction Furnace Using Triac Switching Method", of a prototype model as actual model will costing more it may not be affordable for us to take the actual fabrication for the real time induction furnace. Based on this Prototype model, the actual model may be fabricated for which we have also made a simulation study also,

We have used the ATMEL89C51 Microcontroller and developed a Software by ourself for controlling the Power electronic devices.

1.4 Organization of the Report

- **MATLAB Simulation**

This unit simulates the Single-Phase Power Factor Improvement For Inductive load. The detailed description of this unit is given in the chapter 3.

- **Power Factor Sensing Unit**

This unit measures the Power Factor of the supply by converting the voltage and the current from CT & PT in the form of pulses. The detailed description of this unit is given in the chapter 4.

- **Power Factor Control and Improvement Unit**

This unit with the help of the software tool designed checks the desired Power factor from the supply and gives an output signal for the operation of the triac. The triac part helps in including the capacitance from the capacitor bank across the supply. The detailed description is given in the chapter 5.

- **Induction Furnace**

It explains about the Induction Furnace and how to apply variable frequency supply to the Induction Furnace. We have also fabricated a passive filter consisting of capacitor and inductance and used in this circuit to suppress the harmonics. The description of this unit is given in the chapter 6.

CHAPTER 2
POWER FACTOR IMPROVEMENT TECHNIQUES

2. POWER FACTOR IMPROVEMENT TECHNIQUES

The Power factor which is determined by the load drawn by the industry, lags whenever the inductive load goes high and leads whenever the capacitive load goes high. The power used in KW by the industry is always less than the apparent power KVA.

Thus ,

KW/KVA=Power factor

To utilize most of the energy supplied to the industry, Power factor should be high .

The power factor can be increased by the following methods,

1.Use of Static Capacitors.

2.By Using Synchronous Compensators or Phase Modifiers.

3.By Using Phase Advancers

Among which the first two methods injects a leading current to neutralize the lagging current. The third method reduces the amount of lag but it does not neutralize it or cause a lead.

Thus the best method to improve the Power factor is to add optimal leading KVAR to the supply whenever the Power factor lags.This can done by including the capacitor bank to the supply line. Thus the Power factor is improved by the magnitude of the KVAR added. This is clear from the phasor diagram.

2.1 Working Principle

Our project injects a leading current (KVAR) to the supply whenever the Power factor lags below 0.9 lag. The Power factor is sensed and compared with the required limit and correspondingly the capacitor banks are included by switching on the triac connected to the capacitor bank.

The Power factor sensing unit senses the Power factor of the supply and gives to the microcontroller unit in the form of pulses. This unit compares and checks for the limit and gives an output to switch ON or OFF the triac. This triac activates the capacitor bank and includes it to the supply.

This procedure continuous repeatedly for all the 24 hours. The monitored Power factor is displayed continuously in the display unit and the Power factor is improved automatically whenever it lags.

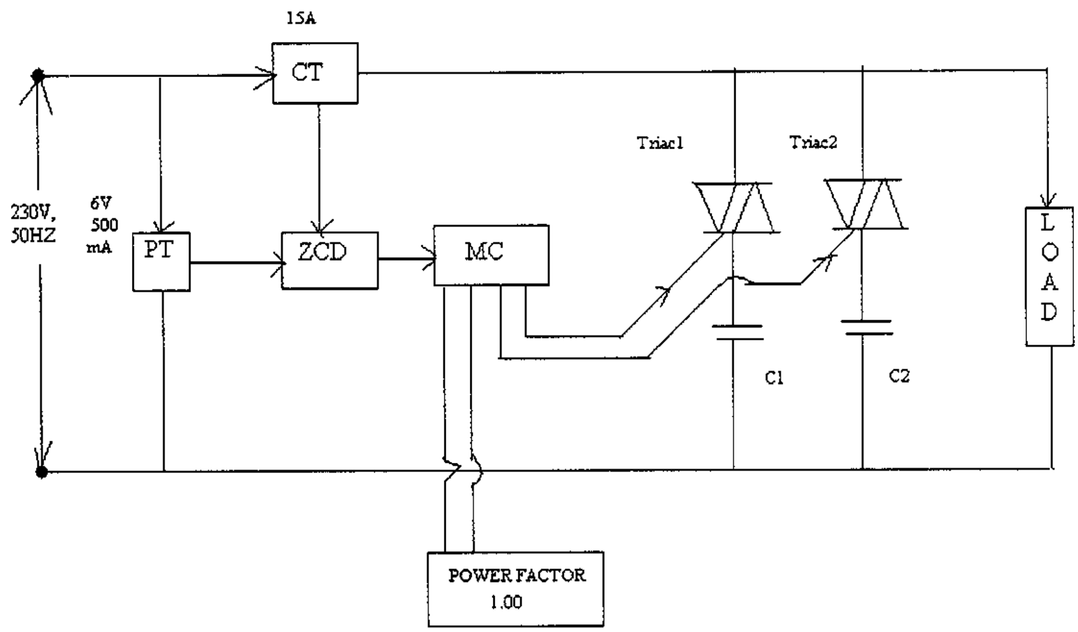


Fig 2.1 Schematic Block Diagram for Power Factor Unit

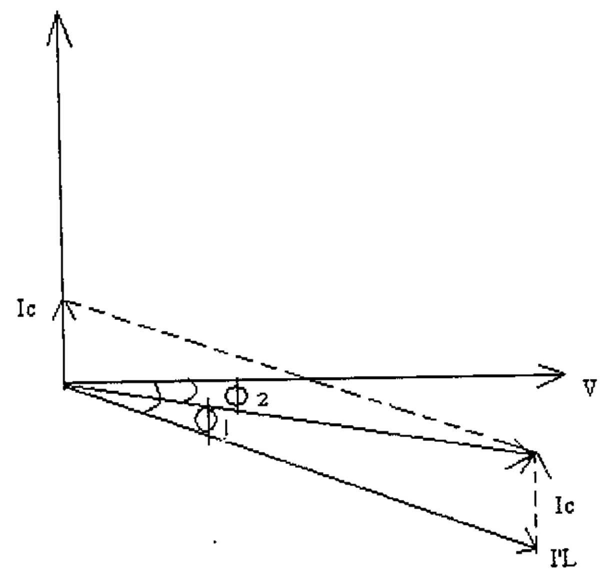


Fig 2.2 Phasor Diagram Showing the Capacitor Circuit and Power Factor Improvement.

ϕ_1 — Angle between Voltage and Load Circuit before Connecting Capacitor

ϕ_2 — Angle between Voltage and Load After Connecting Capacitor

CHAPTER 3

MATLAB SIMULATION

3. MATLAB SIMULATION

3.1. Introduction

The objective of this simulation is to get the unity Power Factor and Harmonics Reduction using Boost Mode Converter. The aim is to investigate the behavior of the Power Factor Correction boost converter under a conventional peak current-mode control. The converter is operated in continuous-conduction mode.The analysis performed by computer simulations reveals interesting effects of variation of some chosen parameters on the stability of the converter.

The basic practical requirement for power supplies is to regulate output voltage. Moreover, this requirement has to be combined with that of Power Factor Correction in the design of most practical power supplies. The Power Factor represents a useful measure of the overall quality level of satisfaction of power supplies and systems in such areas of performance as harmonic distortion and electromagnetic interference. Generally, any type of switching converters can be chosen as PFC stage. In practice, taking into account the current stress and efficiency, the boost converter has been a favorable and popular choice. The discontinuous conduction mode of operation has the obvious advantage of simplicity since no additional control is required. However, the PFC can be achieved even when the converter operates in continuous conduction.

3.2. Single-Phase Boost Converter

The circuit schematic of the PFC boost converter is presented in Fig 1. The basic circuit of the converter consists of inductor L, capacitor C, diode D, switch S and a load inductance R connected in parallel with the capacitor. The switch and the diode are always in complementary states during the continuous mode operation. Accordingly, two periodically toggling states can be identified during one switching cycle of period T_s.

The Single-Phase boost rectifier is used to obtain Unity Power Factor and to Reduce the Harmonic Distortion in the main supply

In this configuration, the inductor current i_L is chosen as the programming variable and is compared to the reference current i_{ref} in order to generate the switching signal for switch S. By turning on switch S at the beginning of the switching cycle, the inductor current i_L increases; when it reaches the reference value i_{ref}, the switch is turned off and remains off until the beginning of the next cycle. Thus, the average inductor current is programmed approximately by i_{ref}.

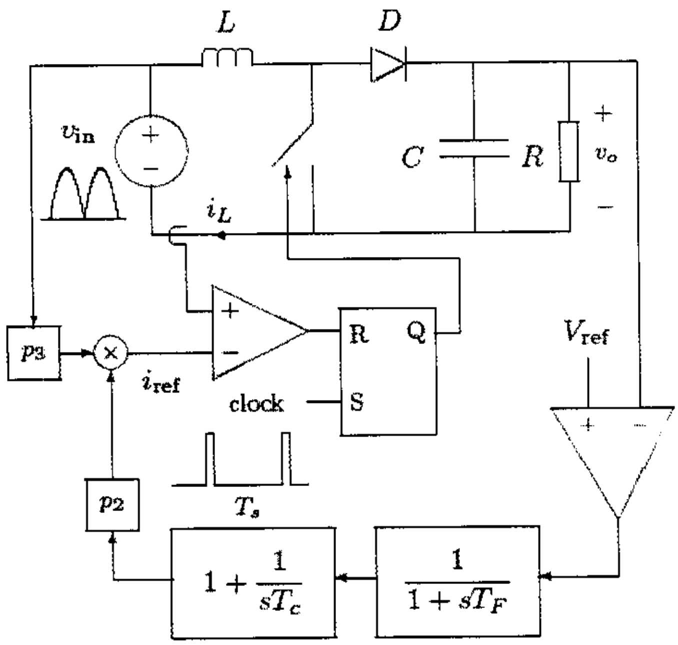


Fig 3.1 PFC Boost Converter

A Feedback loop comprising a first-order filter and a PI controller serves to control the output voltage v0 (vref is the reference steady-state output voltage) by adjusting the amplitude of iref, which is tracking the shape of the input voltage waveform vin(t). Thus, the input current iL is being directly programmed to follow the waveform of the input voltage. The result is a nearly Unity Power Factor.

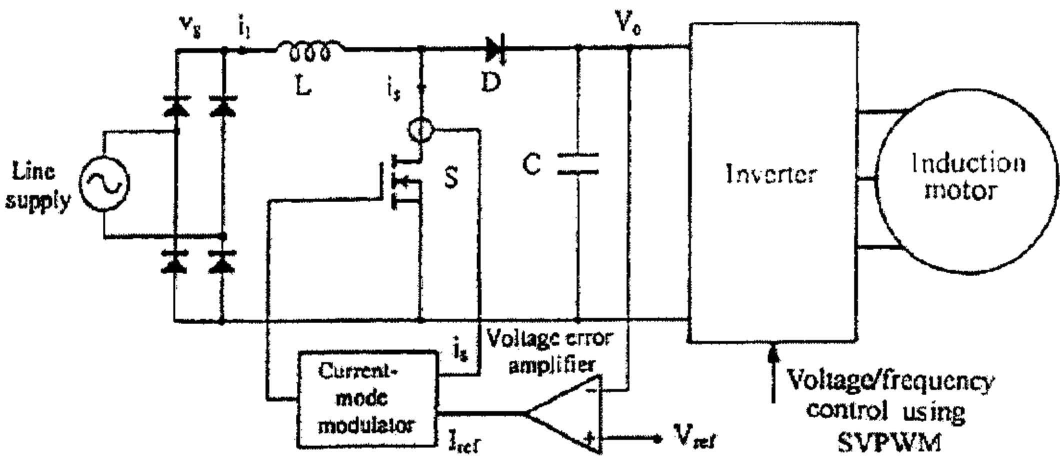


Fig 3.2 Block Diagram Of Converter-Inverter Drive System

The Variable Voltage Variable Frequency(VVVF) drives of small in industrial and household applications. The conventional induction drive systems employ a rectifier-inverter structure consisting of a diode or thyristor rectifier, dc bus filter and an inverter. The inverter has been the subject of improvements over past-years, however, most systems are still based on a diode or thyristor front-end rectifier, whose have many drawbacks such as, high harmonic distortions and deterioration of Power Factor in the main supply.

The current-mode pulse width modulator (PWM) is used to control the boost converter, as shown in Fig 3.2. The output dc voltage of the converter is regulated by voltage regulation loop, where an error amplifier is used as a proportional-integral (PI) regulator. The output of PI provides the reference current for the current control loop. The Mosfet switch (S) of the converter is turned on at the beginning of a switching cycle, and turned off when the switch current reaches the reference current, or when the switch

duty ratio reaches the maximum duty ratio. The peak reference current is varied slowly in the voltage regulation loop, and can be considered constant during a line cycle.

The current-mode modulator is clocked at a fixed switching frequency. The waveform is obtained by taking the average of the steady-state inductor current over a switching cycle.

The objective of the control scheme of the boost converters is to regulate the power flow ensuring tight output voltage regulation as well as Unity Power Factor. In this scheme, the output of the inverter voltage, limited to a safe value, forms the amplitude of input reference current. This reference amplitude is then multiplied to a template of input voltage to synchronize the reference with input voltage, as required for Unity Power Factor operation. The inductor current is forced to track its reference current using current controller, which generates appropriate gating signals for the active devices.

3.4. Pulse Width Modulation (PWM)

It is obvious from the timing analysis that the proposed on phase-shifting PWM for boost mode operation mandates two phases of PWM signals, which are phase-shifted by 180degree, and have a duty-cycle range from 0% to 100%. Unfortunately, no single PWM controller can fulfill these requirements of functionality.

One solution to the problem is presented in the block diagram for PWM control generation in boost mode in Fig 3.3. In this scheme, a pair of PWM controllers, PWM 2 and PWM 3, are synchronized with a pair of master clocks, which are out of phase, to ensure the 180degree phase difference. In reality, such a pair of clocks are readily available from PWM 1 for the buck mode operation.

As shown in Fig 3.3, S_5 and S_7 from PWM 1 are used to generate a pair of synchronization pulses, synchx and synchy, to feed into PWM 2 and PWM 3, respectively. Consequently, output S_x from PWM 2 and S_y from PWM 3 are synchronized and opposite in phase. A common average current regulation loop guarantees that S_x and S_y have roughly the same duty cycle. Certainly, the output bus voltage is also regulated at the level set by its reference V_{0_ref}.

3.5. Power Factor Calculation

The block represented in Fig 3.4. calculates the Active & Reactive Power from the product of voltage and current at the fundamental frequency.

The Power Factor is obtained from the ratio of Active & Reactive Power to the product of RMS signals of voltage and current.

3.6. Control Loop (with Feedback)

The block represented in Fig 3.5 shows the control loop for the Power Factor Correction . The reference voltage (Vref) is compared with the actual voltage (Vact) from the load.

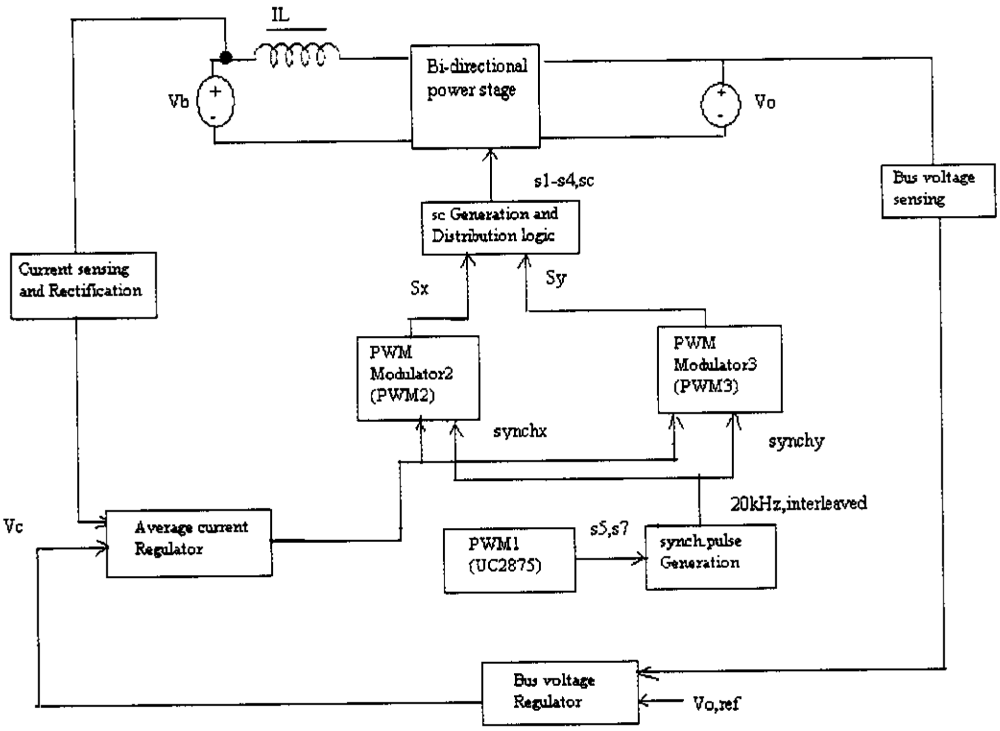
(Vref-Vact)

The signal divides into two modes, one is amplification mode and other is integrator-amplification mode. The two modes of signal are added and the output signal is multiplied with reference current (Iref).

The above value is compared with the input line current (iL). The output signal is amplified and compared to relational operator with repeating sequence.

The output pulse is given to S-R flip flop. The pulses are stored in this flip flop. The pulses are given as PWM signals.

The MOSFET switching speed is based on PWM pulses. Whenever the Mosfet is switched ON, the stored capacitor energy are given to the inverter. The inverter produce the AC power current and voltage phase difference as zero.



3.3 Block Diagram of PWM control in boost mode

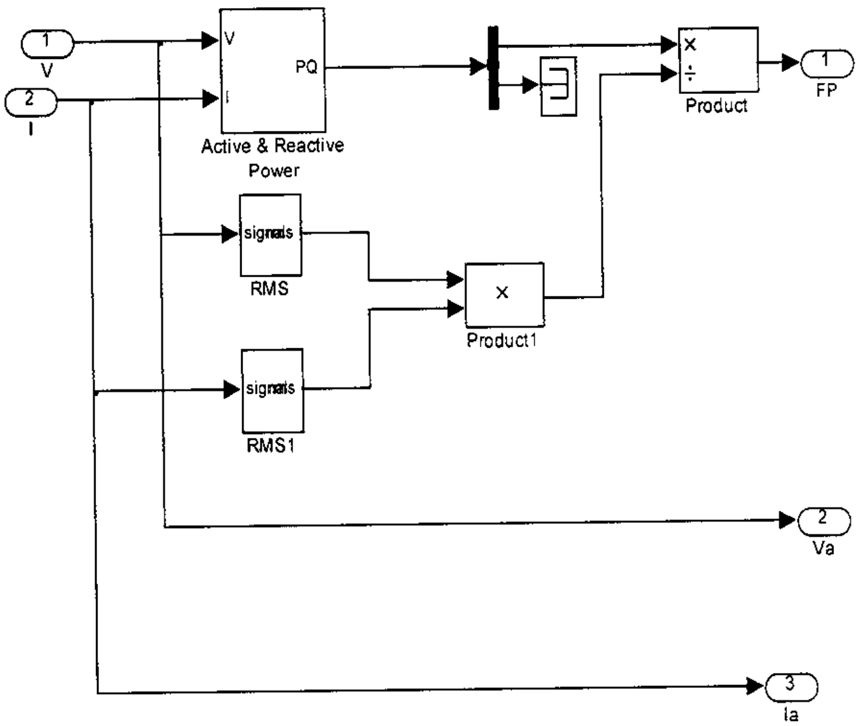


Fig 3.4 Power Factor Calculation

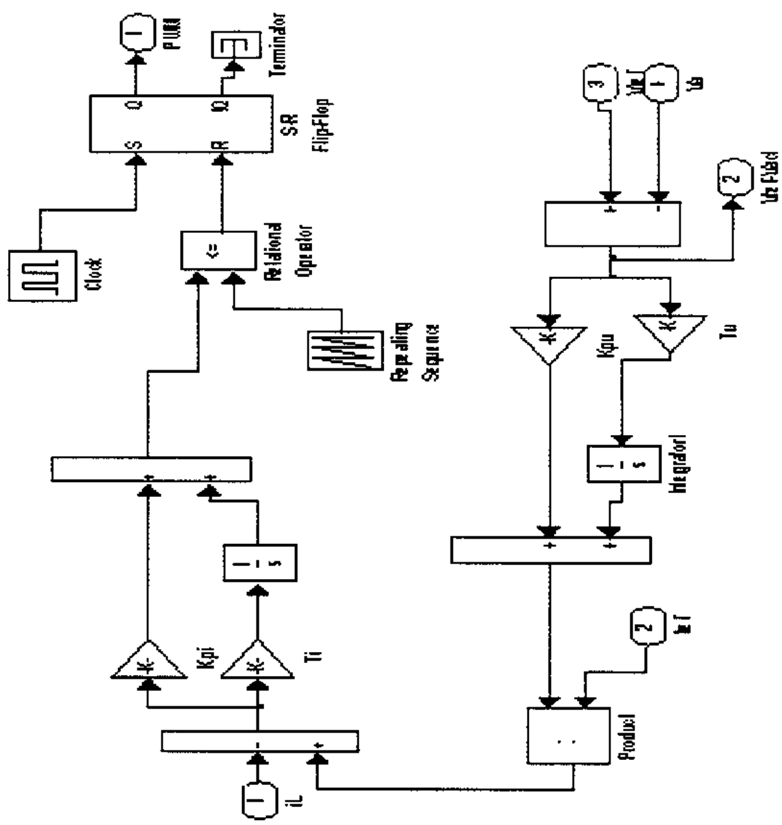


Fig 3.5 Control Loop for PFC

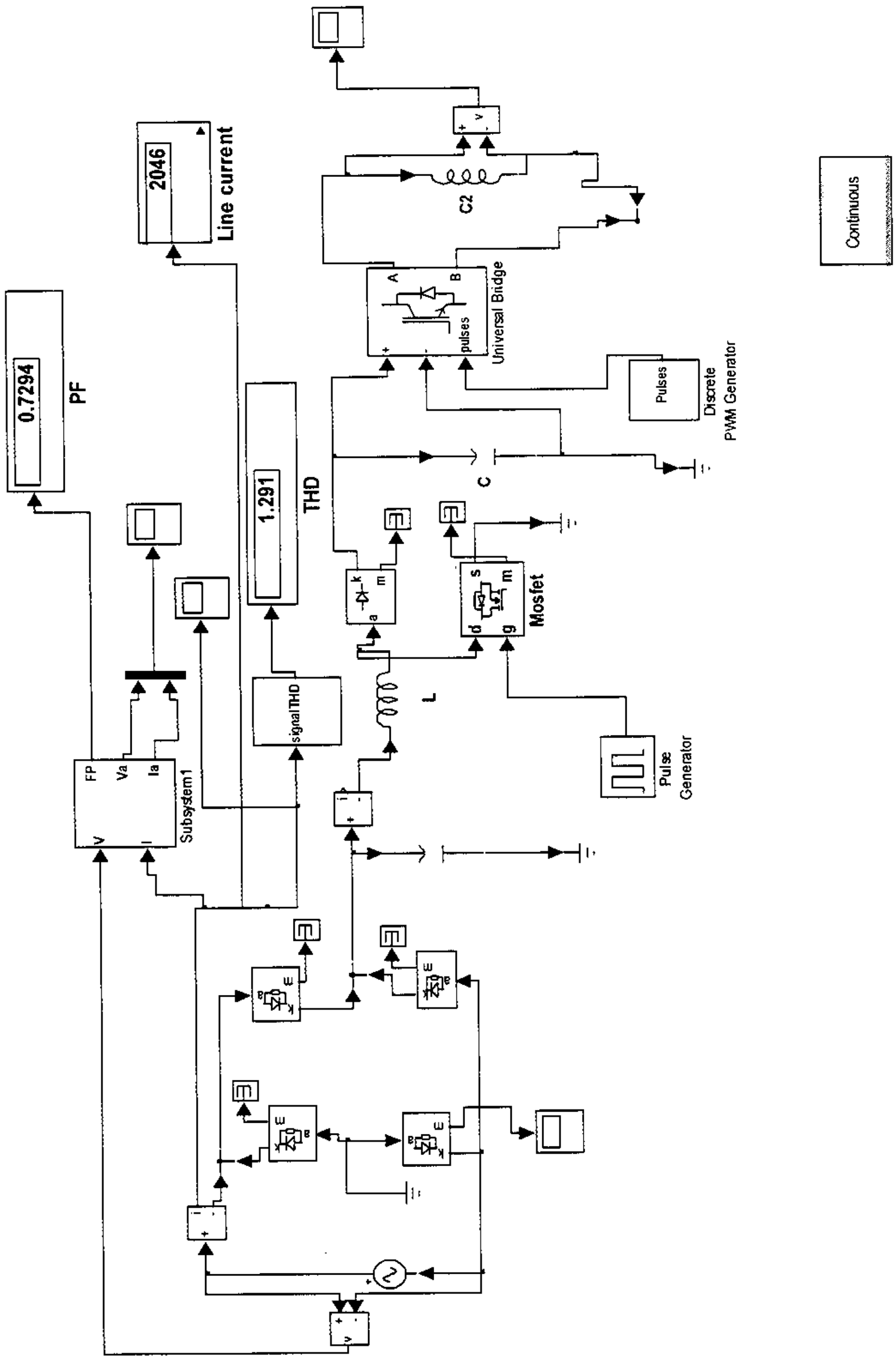


Fig 3.6 Power Factor without Feedback

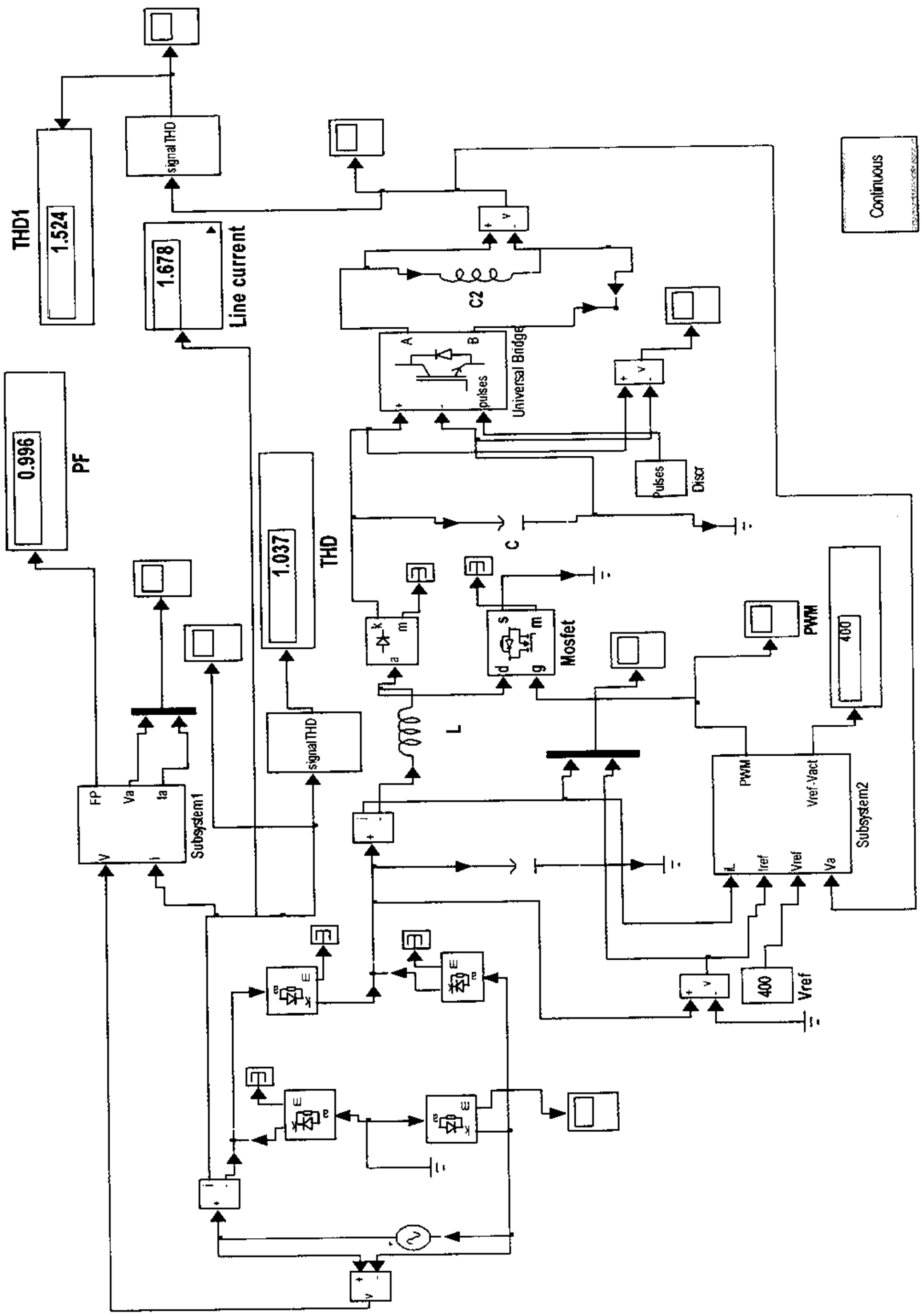


Fig 3.7 Power Factor Improvement Using Feedback Method

CHAPTER 4

POWER FACTOR SENSING UNIT

4. POWER FACTOR SENSING UNIT

4.1. POWER FACTOR

Power factor is the ratio between the KW (Kilo-Watts) and the KVA (Kilo-Volt Amperes) drawn by an electrical load where the KW is the actual load power and the KVA is the apparent load power. It is a measure of how effectively the current is being converted into useful work output and more particularly is a good indicator of the effect of the load current on the efficiency of the supply system.

All current flow will causes losses in the supply and distribution system. A load with a power factor of 1.0 results in the most efficient loading of the supply and a load with a power factor of 0.5 will result in much higher losses in the supply system.

A poor power factor can be the result of either a significant phase difference between the voltage and current at the load terminals, or it can be due to a high harmonic content or distorted/discontinuous current waveform.

Poor load current phase angle is generally the result of an inductive load such as an induction motor, power transformer, lighting ballasts, welder or induction furnace. A distorted current waveform can be the result of a rectifier, variable speed drive, switched mode power supply, discharge lighting or other electronic load.

A poor power factor due to an inductive load can be improved by the addition of power factor correction, but, a poor power factor due to a distorted current waveform requires an change in equipment design or expensive harmonic filters to gain an appreciable improvement.

4.1.1. Inductive Loads

Inductive loads include motors, transformers, and solenoids. In a purely inductive circuit, current lags behind voltage by 90°.Current and voltage are said to be "out of phase." Inductive circuits, however, have some amount of resistance. Depending on the amount of resistance and inductance, AC current will lag somewhere between a purely resistive circuit (0°) and a purely inductive circuit (90°). In a circuit where resistance and inductance are equal values, for example, current lags voltage by 45°.

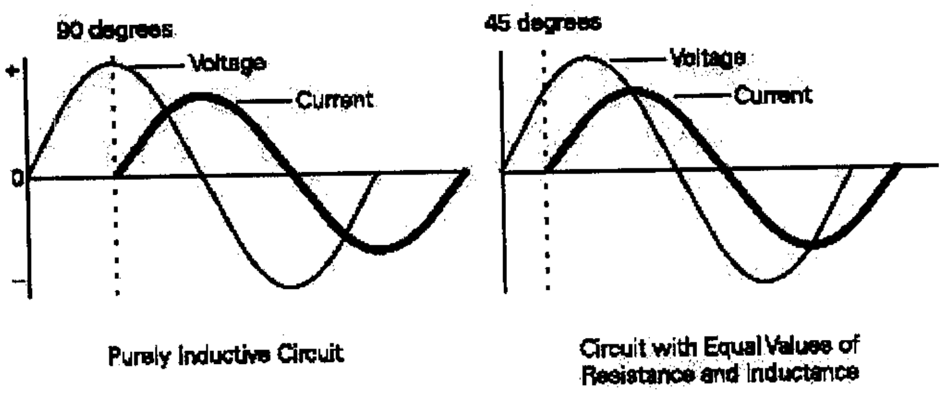


Fig 4.1 Inductive Waveform

4.1.2. Energy In Reactive Circuits

Energy in a reactive circuit does not produce work. This energy is used to charge a capacitor or produce a magnetic field around the coil of an inductor. Current in an AC circuit rises to peak values (positive and negative) and diminishes to zero many times a second. During the time, current is rising to a peak value, energy is stored in an inductor in the form of a magnetic field or as an electrical charge in the plates of a capacitor. This energy is returned to the system when the magnetic field collapses or when the capacitor is discharged.

4.1.3. Reactive Power

Power in an AC circuit is made up of three parts; true power, reactive power, and apparent power. We have already discussed true power. Reactive power is measured in volt-amps reactive(VAR). Reactive power represents the energy alternately stored and returned to the system by capacitors and/or inductors. Although reactive power does not produce useful work, it still needs to be generated and distributed to provide sufficient true power to enable electrical processes to run.

4.1.4. Apparent Power

Not all power in an AC circuit is reactive. We know that reactive power does not produce work; however, when a motor rotates work is produced. Inductive loads, such as motors, have some amount of resistance. Apparent power represents a load which includes reactive power (inductance) and true power(resistance). Apparent power is the vector sum of true power, which represents a purely resistive load, and reactive power, which represents a purely reactive load. A vector diagram can be used to show this relationship. The unit of measurement for apparent power is volt amps (VA). Larger values can be stated in kilovolt amps (KVA) or megavolt amps (MVA).

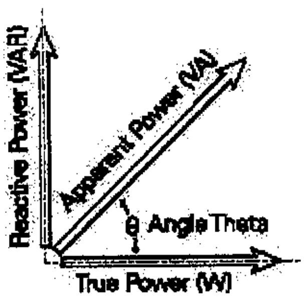


Fig 4.2 Power Diagram

4.1.5. Power And Power Factor in AC Circuit

Power consumed by a resistor is dissipated in heat and not returned to the source. This is true power. True power is the rate at which energy is used. The energy stored in the magnetic field of an inductor, or plates of a capacitor, is returned to the source when current changes direction. Power in an AC circuit is the vector sum of true power and reactive power. This is called apparent power. True power is equal to apparent power in a purely resistive circuit because voltage and current are in phase. Voltage and current are also in phase in a circuit containing equal values of inductive reactance and capacitive reactance. If voltage and current are 90 degrees out of phase, as would be in a purely capacitive or purely inductive circuit, the average value of true power is equal to zero.

There are high positive and negative peak values of power, but when added together the result is zero.

The formula for apparent power is:

P = EI

Apparent power is measured in volt-amps (VA).True power is calculated from another trigonometric function, the cosine of the phase angle (cos q). The formula for true power is:

P = EI cos q .True power is measured in watts.

In a purely resistive circuit, current and voltage are in phase .There is a zero degree angle displacement between current and voltage. The cosine of zero is one. Multiplying a value by one does not change the value. In a purely resistive circuit the cosine of the angle is ignored. In a purely reactive circuit, either inductive or capacitive, current and voltage are 90 degrees out of phase. The cosine of 90 is zero. Multiplying a value times zero results in a zero product. No power is consumed in a purely reactive circuit

4.2. Power Supply

The present chapter introduces the operation of power supply circuits built using filters, rectifiers, and then voltage regulators. Starting with an ac voltage, a steady dc voltage is obtained by rectifying the ac voltage, and finally, regulating to obtain a desired fixed dc voltage. The regulation is usually obtained from an IC voltage regulator unit, which takes a dc voltage and provides a somewhat lower dc voltage, which remains the same even if the input dc voltage varies, or the output load connected to the dc voltage changes.

A block diagram containing the parts of a typical power supply and the voltage at various points in the unit is shown in fig 4.3. The ac voltage, typically 120 V rms, is connected to a transformer, which steps that ac voltage down to the level for the desired dc output. This resulting dc voltage usually has some ripple or ac voltage variation. A regulator circuit can use this dc input to provide a dc voltage that not only has much less ripple voltage but also remains the same dc value even if the input dc voltage varies somewhat, or the load connected to the output dc voltage changes. This voltage regulation is usually obtained using one of a number of popular voltage regulator IC units.

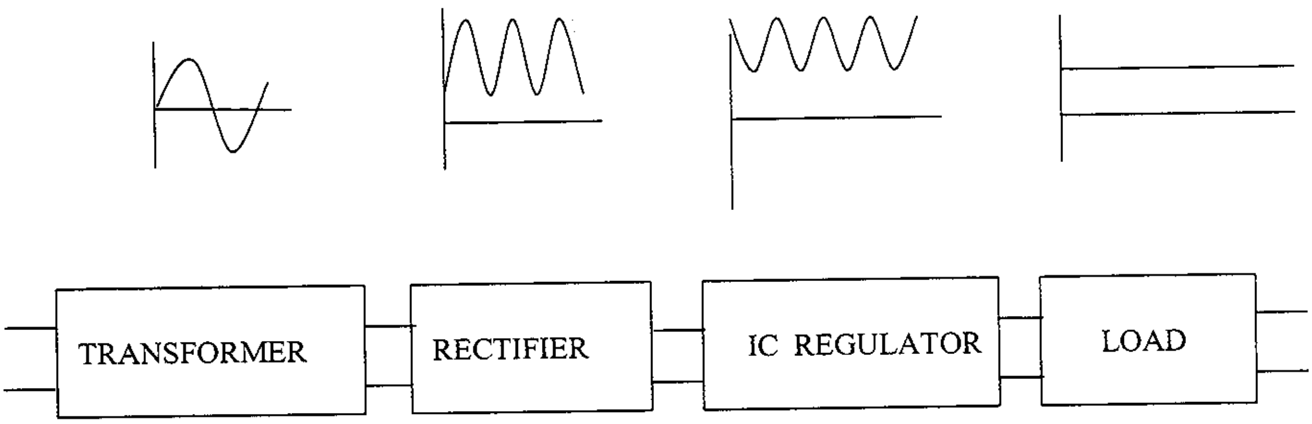


Fig 4.3 Power Supply Graph

4.2.1. IC Voltage Regulators

Voltage regulators comprise a class of widely used ICs. Regulator IC units contain the circuitry for reference source, comparator amplifier, control device, and overload protection all in a single IC. Although the internal construction of the IC is somewhat different from that described for discrete voltage regulator circuits, the external operation is much the same. IC units provide regulation of either a fixed positive voltage, a fixed negative voltage, or an adjustably set voltage.

A power supply can be built using a transformer connected to the ac supply line to step the ac voltage to a desired amplitude, then rectifying that ac voltage, filtering with a capacitor and RC filter, if desired, and finally regulating the dc voltage using an IC regulator. The regulators can be selected for operation with load currents from hundreds of milli amperes to tens of amperes, corresponding to power ratings from milliwatts to tens of watts.

4.3. Working Principle

4.3.1. Current Transformer

The current transformer is used with its primary winding connected in series with line carrying the current that is to be stepped down. Thus, the primary current is dependent upon the load connected to the system and is not determined by the load connected to the secondary of the current transformers. The primary winding consists of very few turns, and therefore there is no appreciable voltage drop across it. The secondary winding has larger number of turns, the exact number being determined by the turns ratio. Thus the stepped down current signals are obtained at the secondary.

The fig 4.4 gives the details about the connection of the current transformer to the supply and about the output terminals. The rating of the current transformer used here 75/15A.

4.3.2. Potential Transformer

The potential transformers are used to step down the supply voltage. The primary winding of the transformer is connected across the line carrying the voltage to be stepped down and the voltage circuit is connected across the secondary winding. The loading of a potential transformer is always small, sometimes only a few volt-ampere.

The fig 4.5 gives the details about the connection of the Potential transformer to the supply and about the output terminals. The rating of potential transformer used here is 230/6V.

4.3.3. Zero Crossing Detector

Next to the transformer section comes the conversion section which converts the incoming current and voltage signals to pulses. For this purpose the IC741 comparator is used to whose reference input is zero thus it acts as a zero crossing detector.

The IC741 is an operational amplifier. In this case it is operated in open loop configuration in a non-linear manner. In this mode it works as a comparator. A comparator is a circuit which compares a signal voltage applied at one point of an operational amplifier with a known reference voltage at the other input. It is basically an open loop operational amplifier with output +Vsat or –Vsat(Vcc).

There are basically 2 types of comparators,

1. Non-Inverting Comparator
2. Inverting Comparator

The type of comparator used here is the Non-Inverting comparator. The 10K ohms potentiometer is used to obtain the Vref practically. It is applied to the Non-Inverting terminal of the operational amplifier

Next to this conversion section the two outputs of the voltage and current waveforms in pulse form is given to the X-OR gate.

The IC has 4 X-OR gates within a single chip. Among which we use only one set. It has two input terminals to which pulses ranging within 5V are given. The output from the gate depends upon the inputs given. The Truth Table is as given .

F =XY'+X'Y

X	Y	F
L	L	L
L	H	H
H	L	H
H	H	L

Thus the output will be high whenever the two inputs are at opposite levels. Thus the Output of the X-OR gate will be the difference between the current and voltage pulses At its input. Thus the output pulse width from the X-OR gate is proportional to power factor.

Thus the pulse whose width is proportional to the power factor is the output of this whole section which is given as the input to the next section which is the Micro controller unit.

4.3.4. Bridge Rectifier

When four diodes are connected as shown in figure, the circuit is called as bridge rectifier. The input to the circuit is applied to the diagonally opposite corners of the network, and the output is taken from the remaining two corners.

Let us assume that the transformer is working properly and there is a positive potential, at point A and a negative potential at point B. the positive potential at point A will forward bias D3 and reverse bias D4.

The negative potential at point B will forward bias D1 and reverse D2. At this time D3 and D1 are forward biased and will allow current flow to pass through them; D4 and D2 are reverse biased and will block current flow.

The path for current flow is from point B through D1, up through RL, through D3, through the secondary of the transformer back to point B. this path is indicated by the solid arrows. Waveforms (1) and (2) can be observed across D1 and D3.

One-half cycle later the polarity across the secondary of the transformer reverse, forward biasing D2 and D4 and reverse biasing D1 and D3. Current flow will now be from point A through D4, up through RL, through D2, through the secondary of T1, and back to point A. This path is indicated by the broken arrows. Waveforms (3) and (4) can be observed across D2 and D4. The current flow through RL is always in the same direction. In flowing through RL this current develops a voltage corresponding to that shown waveform (5). Since current flows through the load (RL) during both half cycles of the applied voltage, this bridge rectifier is a full-wave rectifier.

One advantage of a bridge rectifier over a conventional full-wave rectifier is that with a given transformer the bridge rectifier produces a voltage output that is nearly twice that of the conventional full-wave circuit.

This may be shown by assigning values to some of the components shown in views A and B. assume that the same transformer is used in both circuits. The peak voltage developed between points X and y is 1000 volts in both circuits. In the conventional full-wave circuit shown—in view A, the peak voltage from the center tap to either X or Y is 500 volts. Since only one diode can conduct at any instant, the maximum voltage that can be rectified at any instant is 500 volts.

The maximum voltage that appears across the load resistor is nearly-but never exceeds-500 volts, as result of the small voltage drop across the diode. In the bridge rectifier shown in view B, the maximum voltage that can be rectified is the full secondary voltage, which is 1000 volts. Therefore, the peak output voltage across the load resistor is nearly 1000 volts. With both circuits using the same transformer, the bridge rectifier circuit produces a higher output voltage than the conventional full-wave rectifier circuit.

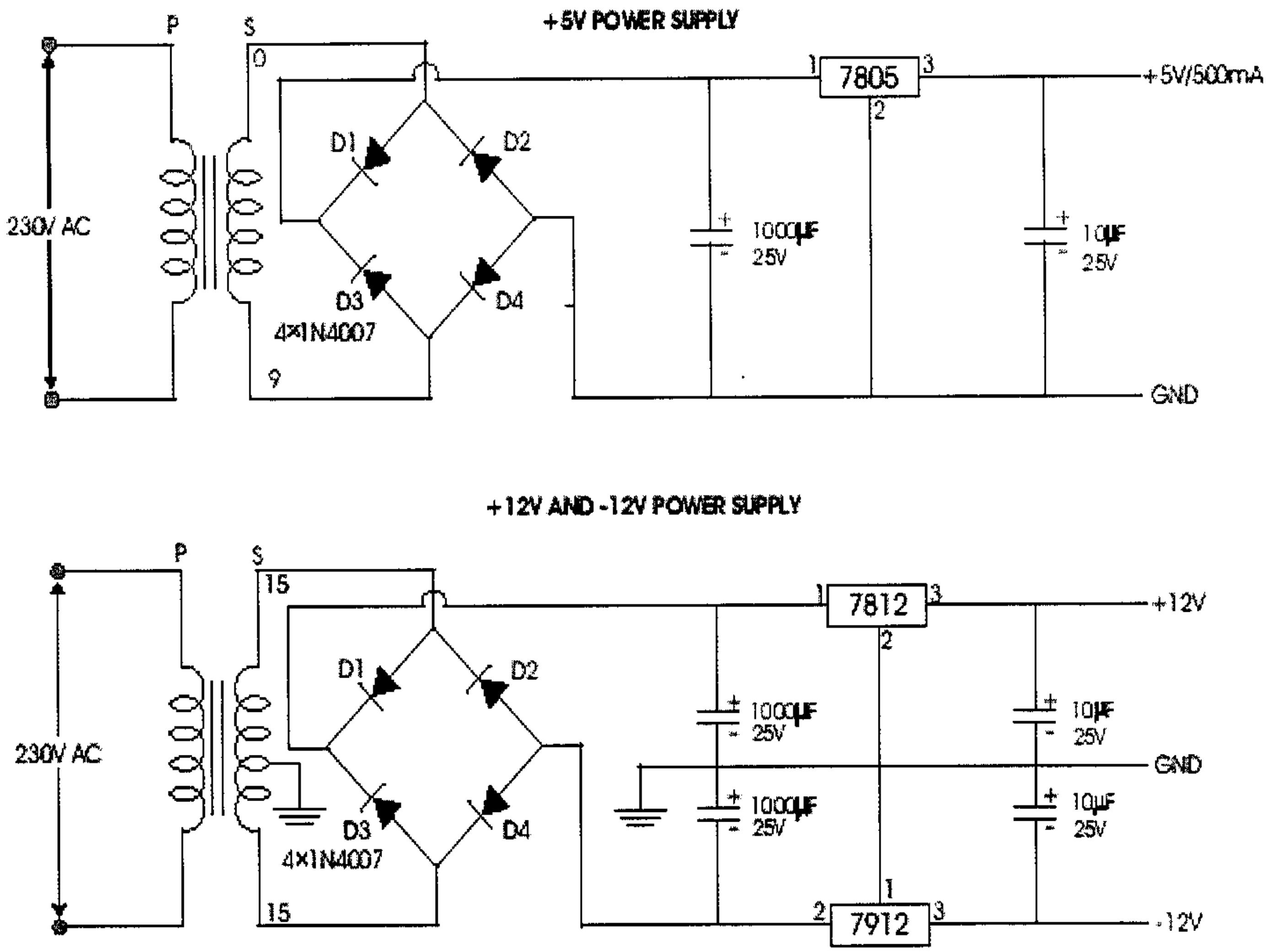


Figure 4.7 Circuit diagram (Power supply)

A fixed three-terminal voltage regulator has an unregulated dc input voltage, Vi, applied to one input terminal, a regulated dc output voltage, Vo, from a second terminal, with the third terminal connected to ground.

The series 78 regulators provide fixed positive regulated voltages from 5 to 24 volts. Similarly, the series 79 regulators provide fixed negative regulated voltages from 5 to 24 volts.

- For ICs, microcontroller, LCD --------- 5 volts
- For alarm circuit, op-amp, relay circuits ---------- 12 volts

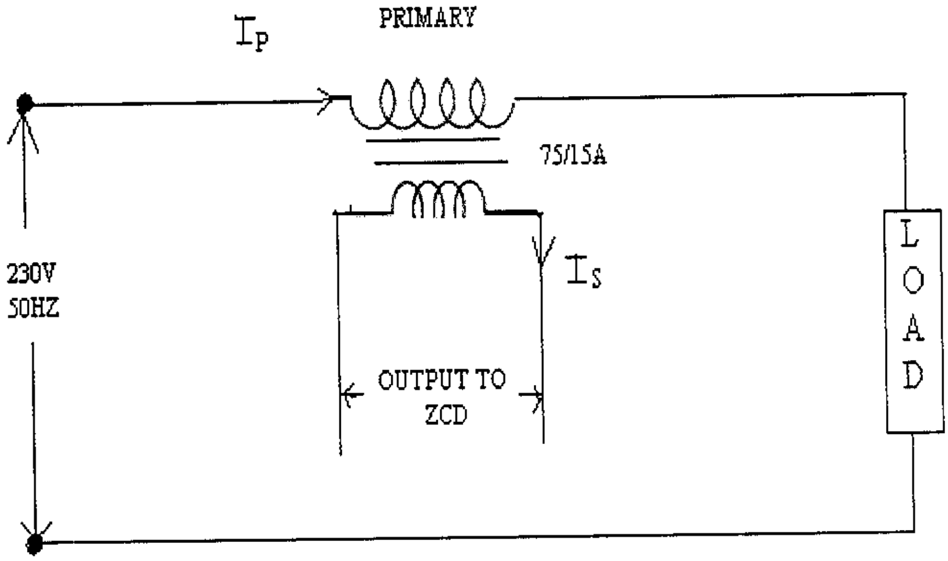


Fig 4.4 Connection of Current Transformer

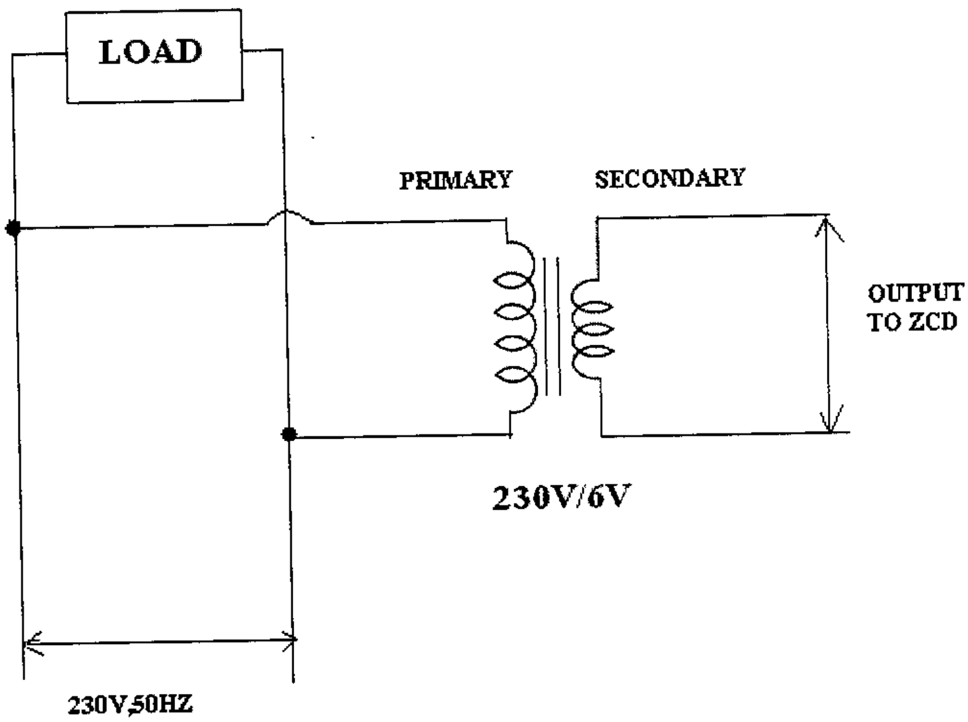


Fig 4.5 Connection of Potential Transformer

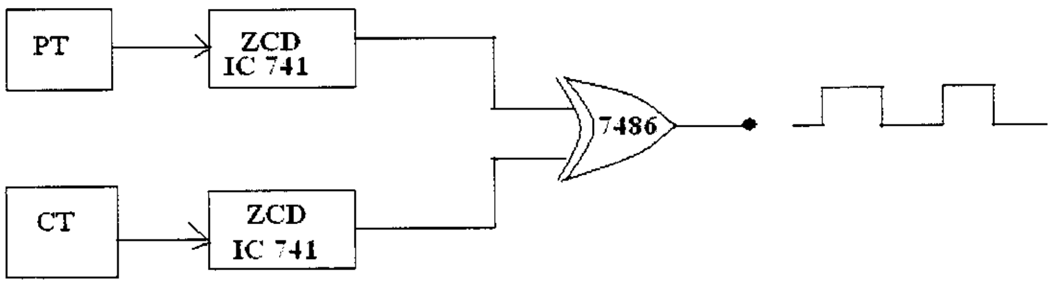


Fig 4.6 Pulse Producing Unit

PT – Potential Transformer

CT – Current Transformer

ZCD – Zero Crossing Detector

4.4. Current Measurement

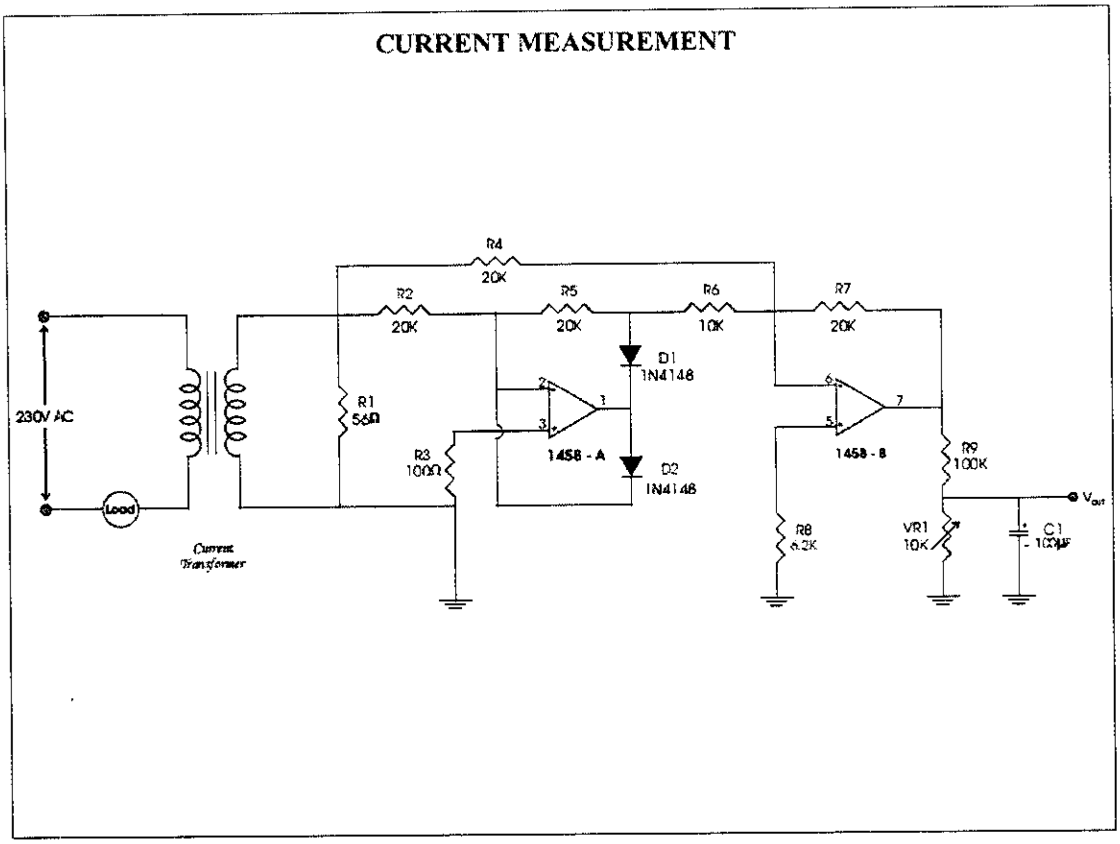


Fig 4.8 Current Measurement

The AC Current measurement can be done with the help of a current transformer across with a shunt resistor and rectifiers, which is based on diodes. When we use diode rectification to measure the current, we get only RMS value of the current. Normally in digital multimeters also we used to get RMS current only.

The current transformer will step down the high current to a lower value, that is if the input current is 15A output of the current transformer will be 5A, to convert from the current to voltage we are using a shunt resistor.

An absolute-value circuit, or full-wave precision rectifier, can be implemented by summing the output of a half-wave rectifier and its input with the proper phase and amplitude relations. Such a circuit in its basic form is shown. This circuit will be the starting point for a number of other absolute-valve circuits, which have evolved from this basic form.

4.5. Voltage Measurement

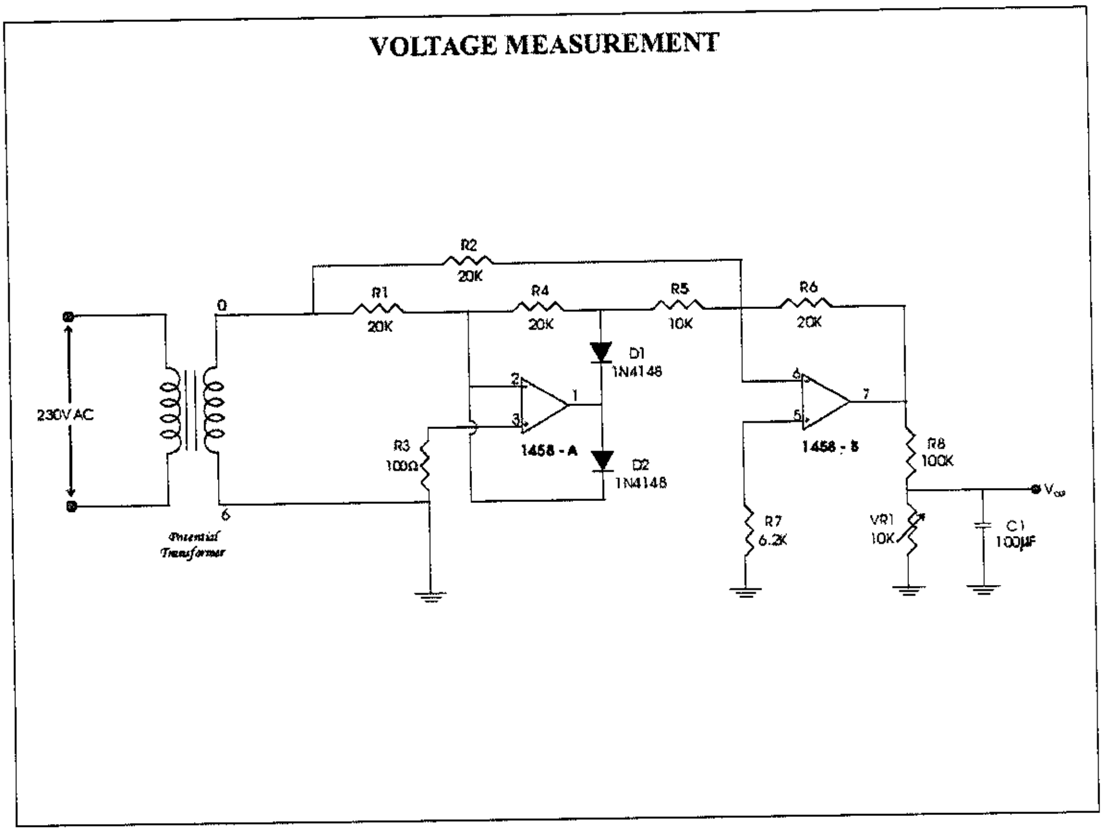


Fig 4.9

The AC voltage measurement is normally done with the help of rectifiers, which is based on diodes. When we use diode rectification to measure the voltage, we get only RMS voltage. Normally in digital multimeters also we used to get RMS Voltage only. But the measurement must be on the peak voltage, by using the precision rectifiers we can achieve this, the circuit and the description for precision rectifier as follows

An absolute-value circuit, or full-wave precision rectifier, can be implemented by summing the output of a half-wave rectifier and its input with the proper phase and amplitude relations. Such a circuit in its basic form is shown. This circuit will be the starting point for a number of other absolute-valve circuits, which have evolved from this basic form.

CHAPTER 5

POWER FACTOR CONTROL AND IMPROVEMENT UNIT

5. POWER FACTOR CONTROL AND IMPROVEMENT UNIT

5.1. Microcontroller

A Micro controller consists of a powerful CPU tightly coupled with memory RAM, ROM or EPROM), various I / O features such as Serial ports, Parallel Ports, Timer/Counters, Interrupt Controller, Data Acquisition interfaces-Analog to Digital Converter (ADC), Digital to Analog Converter (ADC), everything integrated onto a single Silicon Chip.

It does not mean that any micro controller should have all the above said features on chip, Depending on the need and area of application for which it is designed, The on chip features present in it may or may not include all the individual section said above. Any microcomputer system requires memory to store a sequence of instructions making up a program, parallel port or serial port for communicating with an external system, timer / counter for control purposes like generating time delays, Baud rate for the serial port, apart from the controlling unit called the Central Processing Unit.

5.1.1 Advantage of Microcontrollers

If a system is developed with a microprocessor, the designer has to go for external memory such as RAM, ROM or EPROM and peripherals and hence the size of the PCB will be large enough to hold all the required peripherals. But, the micro controller has got all these peripheral facilities on a single chip so development of a similar system with a micro controller reduces PCB size and cost of the design.

One of the major differences between a micro controller and a microprocessor is that a controller often deals with bits , not bytes as in the real world application, for example switch contacts can only be open or close, indicators should be lit or dark and motors can be either turned on or off and so forth.

5.1.2. Introduction to Atmel Microcontroller

SERIES: **89C51 Family,** TECHNOLOGY: **CMOS**

The major Features of 8-bit Micro controller **ATMEL 89C51**:

8 Bit CPU optimized for control applications

- Extensive Boolean processing (Single - bit Logic) Capabilities.
- On - Chip Flash Program Memory
- On - Chip Data RAM
- Bi-directional and Individually Addressable I/O Lines
- Multiple 16-Bit Timer/Counters
- Full Duplex UART
- Multiple Source / Vector / Priority Interrupt Structure
- On - Chip Oscillator and Clock circuitry.
- On - Chip EEPROM
- SPI Serial Bus Interface
- Watch Dog Timer

5.1.3. PROGRAM STATUS WORD

Program Status Word Register in Atmel Flash Micro controller

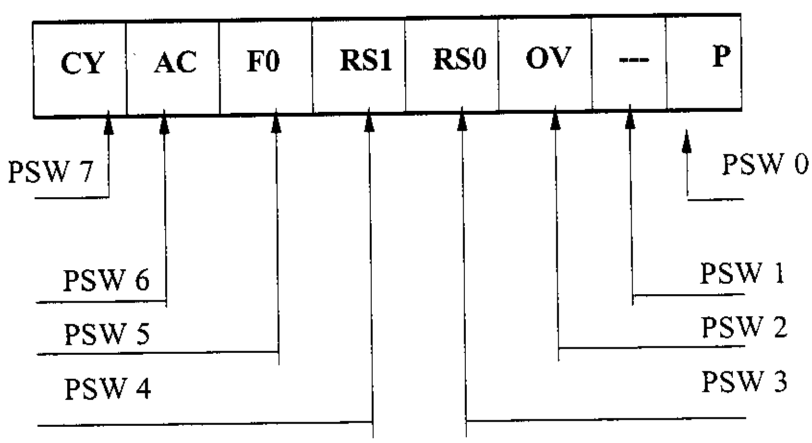


Fig 5.1 Register

PSW 0

Parity of Accumulator Set By Hardware To 1 if it contains an Odd number of 1s, Otherwise it is reset to 0.

PSW1

User Definable Flag

PSW2

Overflow Flag Set By Arithmetic Operations

PSW3

Register Bank Select

PSW4

Register Bank Select

PSW5

General Purpose Flag.

PSW6:

Auxiliary Carry Flag Receives Carry Out from
Bit 1 of Addition Operands

PSW7

Carry Flag Receives Carry Out From Bit 1 of ALU Operands.

The Program Status Word contains Status bits that refklect the current stae of the CPU. The PSW shown if Fig resides in SFR space. The PSW conrains the Carry Bit, The auxillary Carry (For BCD Operations) the two - register bank select bits, the Overflow flag, a Parity bit and two user Definable status Flags.

The Carry Bit, in addition to serving as a Carry bit in arithmetic operations also serves the as the "Accumulator" for a number of Boolean Operations .The bits RS0 and RS1 select one of the four register banks. A number of instructions register to these RAM locations as R0 through R7.The status of the RS0 and RS1 bits at execution time determines which of the four banks is selected.

The Parity bit reflect the Numer of 1s in the Accumulator .P=1 if the Accumulator conrains an even number of 1s, and P=0 if the Accumulator contains an even number of 1s. Thus, the number of 1s in the Accumulator plus P is always even. Two bits in the PSW are uncommitted and can eb used as general-purpose status flags.

5.1.4. Interrupts

The AT89C51 provides 5 interrupt sources: Two External interrupts, two-timer interrupts and a serial port interrupts. The External Interrupts INT0 and INT1 can each either level activated or transistion - activated, depending on bits IT0 and IT1 in Register TCON. The Flags that actually generate these interrupts are the IE0 and IE1 bits in TCON. When the service routine is vectored to hardware clears the flag that generated an external interrupt *only* if the interrupt WA transition - activated. If the interrupt was level - activated, then the external requesting source (rather than the on-chip hardware) controls the requested flag. Tf0 and Tf1 generate the Timer 0 and Timer 1 Interrupts, which are set by a rollover in their respective Timer/Counter Register (except for Timer 0 in Mode 3). When a timer interrupt is generated, the on-chip hardware clears the flag that generated it when the service routine is vectored to. The logical OR of RI and TI generate the Serial Port Interrupt. Neither of these floag is cleared by hardware when the service routine is vectored to. In fact, the service routine normally must determine whether RI or TI generated the interrupt an the bit must be cleared in software.

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- Input/ Output Ports

There are four I/O ports available in AT89C51. They are port 0, port 1, port 2, and port 3. All these ports are eight bit ports. All these ports can be controlled as eight-bit port or it can be controlled individually. One of the main feature of this micro controller is it can control the port pins individually. For example to control a LED we need to use one I/O line in Micro processor with 8255 we have to use an eight bit port. In micro controller we can use only. In 89C51 port 1 is available for users Port 3 is combined with interrupts. This can be used as interrupts (or) I/O ports, ports 2 & port 0 is combined with address bus & data bus.

All these port lines are available with internal pull-ups except port 0. If we want to use port 0 as I/O port we have to use pull up resistors. This Micro controller is working in a speed of maximum of 24MHz. This micro controller is available with inbuilt oscillator; just we have to connect the crystal to its terminal.

- Oscillator And Clock Circuit

XTAL1 and XTAL2 are the input and output respectively of an inverting amplifier which is intended for use as a crystal oscillator in the pioerce configuration, in the frequency range of 1.2 Mhz to 12 Mhz. XTAL2 also the input to the internal clock generator.

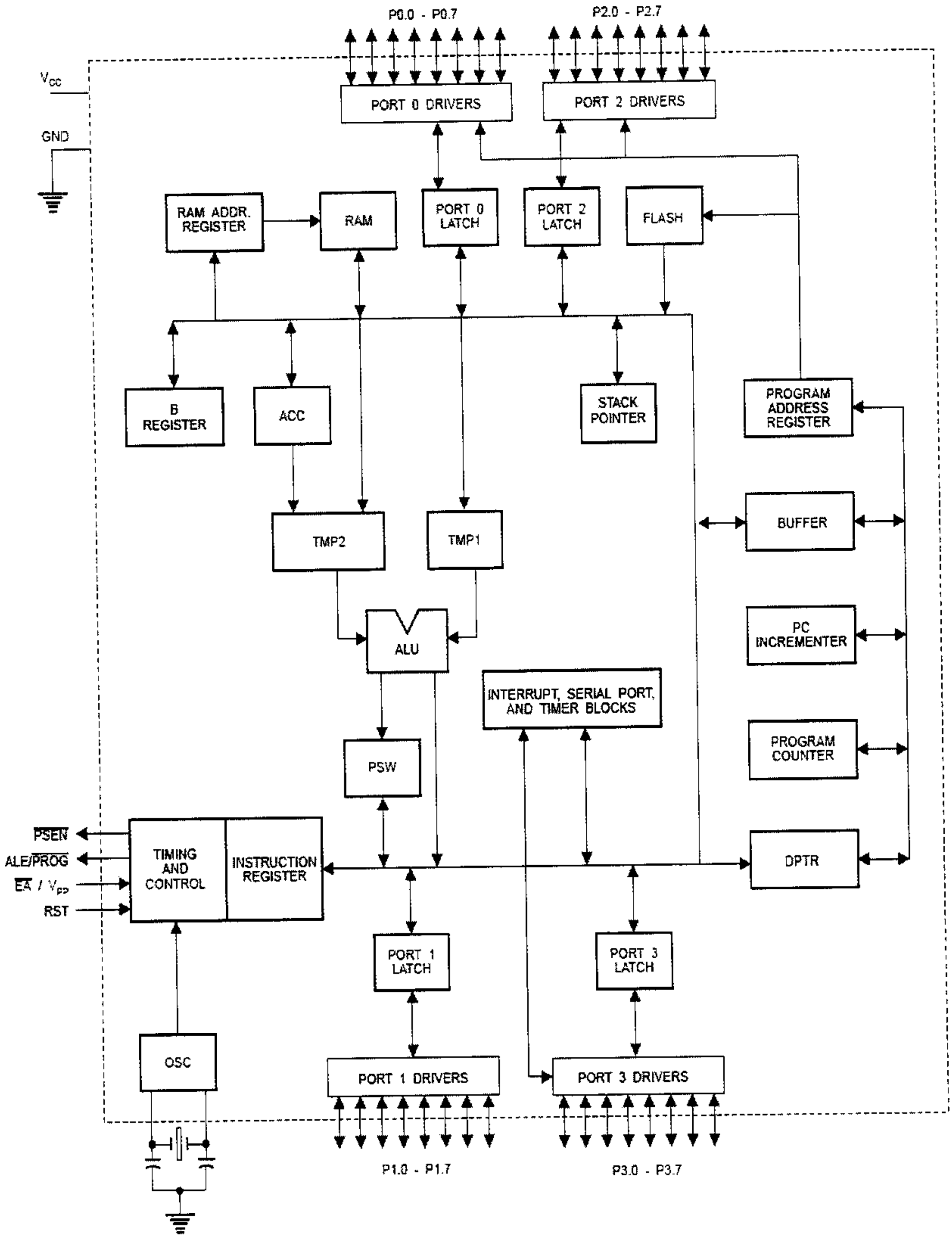
To drive the chip with an internal oscillator, one would ground XTAL1 and XTAL2. Since the input to the clock generator is divide by two filip flop there are no requirements on the duty cycle of the external oscillator signal. However, minimum high and low times must be observed.

The clock generator divides the oscillator frequency by 2 and provides a tow phase clock signal to the chip. The phase 1 signal is active during the first half to each clock period and the phase 2 signals are active during the second half of each clock period.

- CPU Timing

A machine cycle consists of 6 states. Each stare is divided into a phase / half, during which the phase 1 clock is active and phase 2 half. Arithmetic and Logical operations take place during phase1 and internal register - to register transfer take place during phase 2.

Block Diagram



5.2. LCD Display

5.2.1. Introduction

Liquid crystal displays (LCDs) have materials which combine the properties of both liquids and crystals. Rather than having a melting point, they have a temperature range within which the molecules are almost as mobile as they would be in a liquid, but are grouped together in an ordered form similar to a crystal.

An LCD consists of two glass panels, with the liquid crystal material sand witched in between them. The inner surface of the glass plates are coated with transparent electrodes which define the character, symbols or patterns to be displayed polymeric layers are present in between the electrodes and the liquid crystal, which makes the liquid crystal molecules to maintain a defined orientation angle.

One each polarisers are pasted outside the two glass panels. These polarisers would rotate the light rays passing through them to a definite angle, in a particular direction

When the LCD is in the off state, light rays are rotated by the two polarisers and the liquid crystal, such that the light rays come out of the LCD without any orientation, and hence the LCD appears transparent.

When sufficient voltage is applied to the electrodes, the liquid crystal molecules would be aligned in a specific direction. The light rays passing through the LCD would be rotated by the polarisers, which would result in activating / highlighting the desired characters.

The LCD's are lightweight with only a few millimeters thickness. Since the LCD's consume less power, they are compatible with low power electronic circuits, and can be powered for long durations.

The LCD's don't generate light and so light is needed to read the display. By using backlighting, reading is possible in the dark. The LCD's have long life and a wide operating temperature range.

Changing the display size or the layout size is relatively simple which makes the LCD's more customer friendly.

The LCDs used exclusively in watches, calculators and measuring instruments are the simple seven-segment displays, having a limited amount of numeric data. The recent advances in technology have resulted in better legibility, more information displaying capability and a wider temperature range. These have resulted in the LCDs being extensively used in telecommunications and entertainment electronics. The LCDs have even started replacing the cathode ray tubes (CRTs) used for the display of text and graphics, and also in small TV applications.

5.2.2. Interfacing the Microcontroller

The module, interfaced to the system, can be treated as RAM input/output, expanded or parallel I/O. Since there is no conventional chip select signal, developing a strobe signal for the enable signal (E) and applying appropriate signals to the register select (RS) and read/write (R/W) signals are important.

The module is selected by gating a decoded module – address with the host processor's read/write strobe. The resultant signal, applied to the LCDs enable (E) input, clocks in the data.

The 'E' signal must be a positive going digital strobe, which is active while data and control information are stable and true. The falling edge of the enable signal enables the data / instruction register of the controller. All module timings are referenced to specific edges of the 'E' signal. The 'E' signal is applied only when a specific module transaction is desired.

The read and write strobes of the host, which provides the 'E' signals, should not be linked to the module's R/W line. An address bit which sets up earlier in the host's machine cycle can be used as R/W.

When the host processor is so fast that the strobes are too narrow to serve as the 'E' pulse

a. Prolong these pulses by using the hosts 'Ready' input
b. Prolong the host by adding wait states
c. Decrease the Hosts Crystal frequency.

Inspite of doing the above mentioned, if the problem continues, latch both the data and control information and then activate the 'E' signal .When the controller is performing an internal operation he busy flag (BF) will set and will not accept any instruction. The user should check the busy flag or should provide a delay of approximately 2ms after each instruction.

The module presents no difficulties while interfacing slower MPUs. The liquid crystal display module can be interfaced, either to 4-bit or 8-bit MPUs. For 4-bit data interface, the bus lines DB4 to DB7 are used for data transfer, while DB0 to DB3 lines are disabled. The data transfer is complete when the 4-bit data has been transferred twice.

The busy flag must be checked after the 4-bit data has been transferred twice. Two more 4-bit operations then transfer the busy flag and address counter data. For 8-bit data interface, all eight-bus lines (DB0 to DB7) are used.

5.3. TRIAC Section

SCRs are unidirectional (one-way) current devices, making them useful for controlling DC only. If two SCRs are joined in back-to-back parallel fashion just like two Shockley diodes were joined together to form a diac, we have a new device known astriac

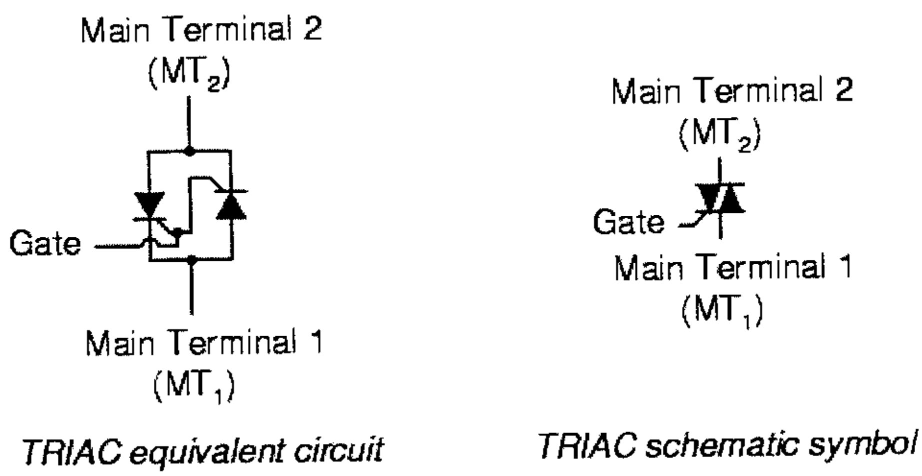


Fig 5.3 Triac Equivalent Circuit

When used to control AC power to a load, TRIACs are often accompanied by DIACs connected in series with their gate terminals. The DIAC helps the triac fire more symmetrically (more consistently from one polarity to another).

Because individual SCRs are more flexible to use in advanced control systems, they are more commonly seen in circuits like motor drives, while TRIACs are usually seen in simple, low-power applications like household dimmer switches.

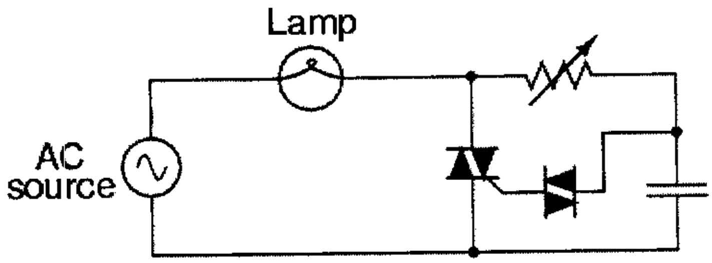


Fig 5.4 Triac Trigger Circuit

DIAC break over voltages tend to be much more symmetrical (the same in one polarity as the other) than TRIAC triggering voltage thresholds. Since the DIAC prevents any gate current until the triggering voltage has reached a certain, repeatable level in either direction, the firing point of the TRIAC from one half-cycle to the next tends to be more consistent, and the waveform more symmetrical above and below its centerline.

Practically all the characteristics and ratings of SCRs apply equally to TRIACs, except that TRIACs of course are bidirectional (can handle current in both directions). Not much more needs to be said about this device except for an important caveat concerning its terminal designations.

From the equivalent circuit diagram shown earlier, one might think that main terminals 1 and 2 were interchangeable. They are not! Although it is helpful to imagine the TRIAC as being composed of two SCRs joined together, it in fact is constructed from a single piece of semiconducting material, appropriately doped and layered. The actual operating characteristics may differ slightly from that of the equivalent model.

Figure 1. Typical Circuit: Synchronization Across the Triac

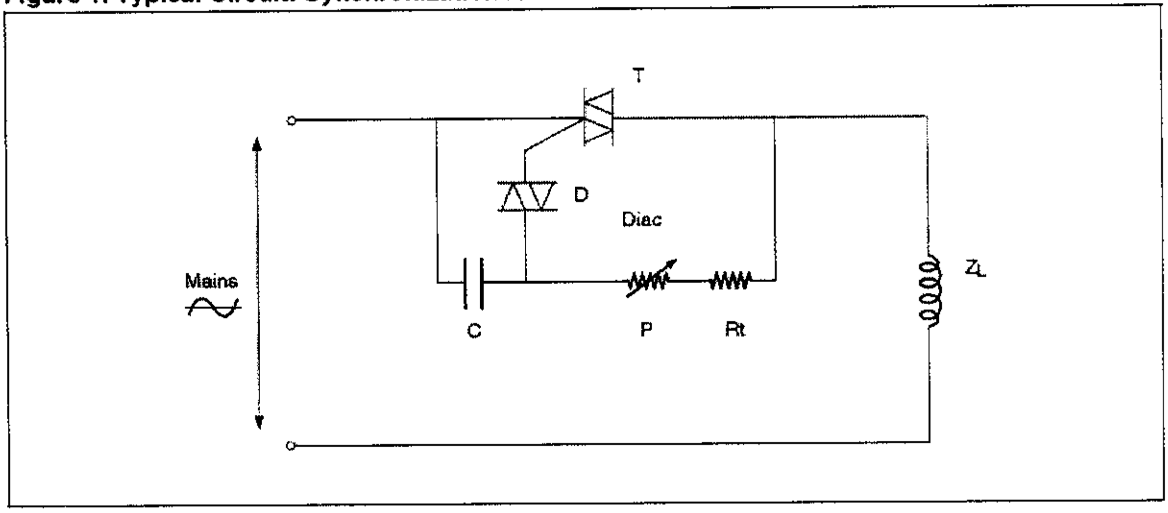


Fig 5.5 Synchronization Across the Triac

Today triacs are well suited to the requirements of switching inductive loads. Nevertheless many users still encounter difficulties when designing triac control circuits which are to be both economical and applicable to inductive loads. The purpose of this article is to present different methods of triac control with their applications and to analyze their relative advantages and disadvantages. A simple circuit offering all the guarantees of reliability is proposed for industrial loads.

5.3.1. Triggering with Synchronization Across the Triac

The triggering circuit with "synchronization across the triac" (See Figure 1 and Figure 2) turns on the component at an angle ß after the current drops to zero, such that ß = ? Tr. Time Tr is defined by the time constant (P + Rt)C. ? = 2 · p · f with f = mains frequency.

Figure 2. Synchronization Across the Triac. Shape of the Signals General Case

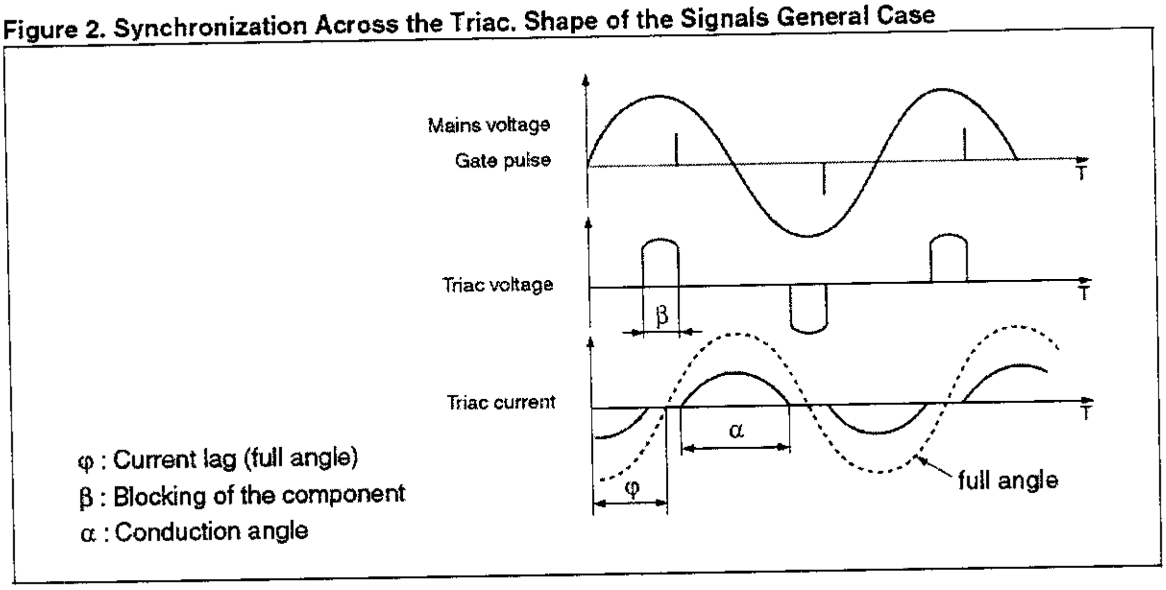


Fig 5.6 Triac shape of the signal General Shape

5.4. Optocoupler

An optocoupler is a combination of a light source and a photosensitive detector. In the optocoupler, or photon coupled pair, the coupling is achieved by light being generated on one side of a transparent insulating gap and being detected on the other side of the gap without an electrical connection between the two sides (except for a minor amount of coupling capacitance). In the Fairchild Semiconductor optocouplers, the light is generated by an infrared light emitting diode, and the photo-detector is a silicon diode which drives an amplifier, e.g., transistor.

The sensitivity of the silicon material peaks at the wavelength emitted by the LED, giving maximum signal coupling. Where the input to the optocoupler is a LED, the input characteristics will be the same, independent of the type of detector employed. The forward bias current threshold is shown at approximately 1 volt, and the current increases exponentially, the useful range of I between 1 mA and 100 mA being delivered at a V between 1.2 and 1.3 volts. Reverse leakage is in the nanoampere range before avalanche breakdown.

The diode equations are provided if needed for computer modeling and the constants of the equations are given for the IR LED's. Note that the junction capacitance is large and increases with applied forward voltage. It is this large capacitance controlled by the driver impedance which influences the pulse response of the LED. The capacitance must be charged before there is junction current to create light emission. This effect causes an inherent delay of 0-20 nanoseconds or more between applied current and light emission in fast pulse conditions. The LED is used in the forward biased mode. Since the current increases very rapidly above threshold, the device should always be driven in a current mode, not voltage driven.

The simplest method of achieving the current drive is to provide a series current-limiting resistor. A silicon diode is shown installed inversely parallel to the LED. This diode is used to protect the reverse breakdown of the LED and is the simplest method of achieving this protection. The LED must be protected from excessive power dissipation in the reverse avalanche region. A small amount of reverse current will not harm the LED, but it must be guarded against unexpected current surges.

5.5. Capacitor Bank Unit

This unit consists of the capacitors of different KVARs which are to be included across the supply in order to improve the power factor in the system whenever it lags. The designing of the KVAR in the capacitor bank is given below,

For a given load of 100 H.P.

Corresponding KW=100X H.P.

=74.6KW

Present power factor = 0.9

Multiplication Factor =0.36

Desired power factor =0.96

Capacitor rating required(KVAR) = KW X M.F

=74.6 X 0.36

=26.85

For power factor between 0.85 & 0.9 the capacitor rating is 30 KVAR for which, TRIAC1 is operated.

For power factor 0.8

Multiplication factor =0.46

KVAR = 74.6 X 0.46

=34.3

=17 KVAR for which,

TRIAC1 & TRIAC2 is operated.

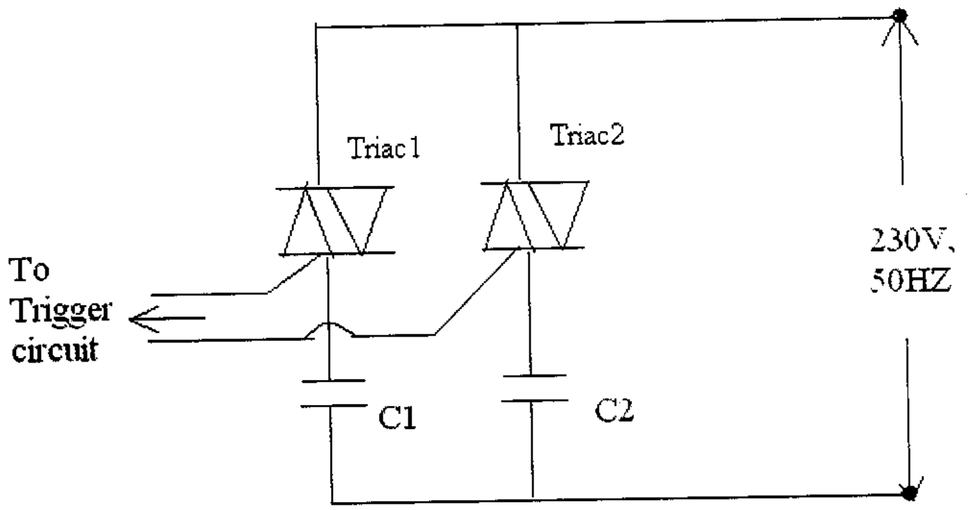


Fig 5.7 Power Factor Improvement Unit

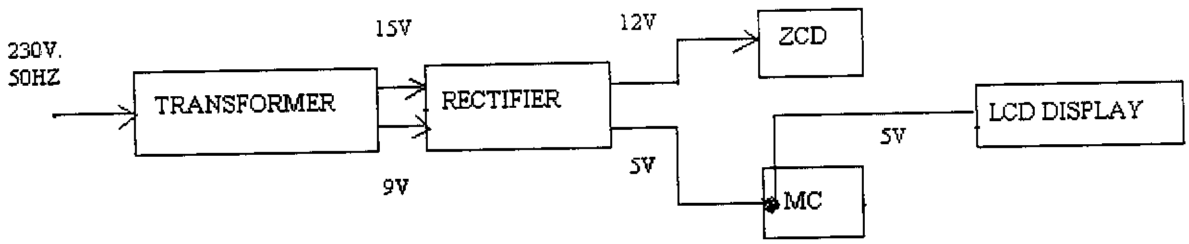


Fig 5.8 POWER SUPPLY TO CONTROL UNIT

5.6 Algorithm for Power Factor Improvement Using ATMEL89C51

The microcontroller used in this project is programmed using Hi-tech C. The program is converted into machine language using MPLAB software. The Algorithm & Flow Chart for this are as follows

Step1: Start the Program

Step2: Assign the Ports in the Microcontroller as Input/Output depending upon the Requirements.

Step3: Initialize the Registers as per the requirements.

Step4: Enable the Global& Peripheral Interrupt.

Step5: Current and Voltage are counted as Pulses and Power Factor is calculated.

Step6: The Power Factor measured in count is multiplied by a suitable value to obtain original value.

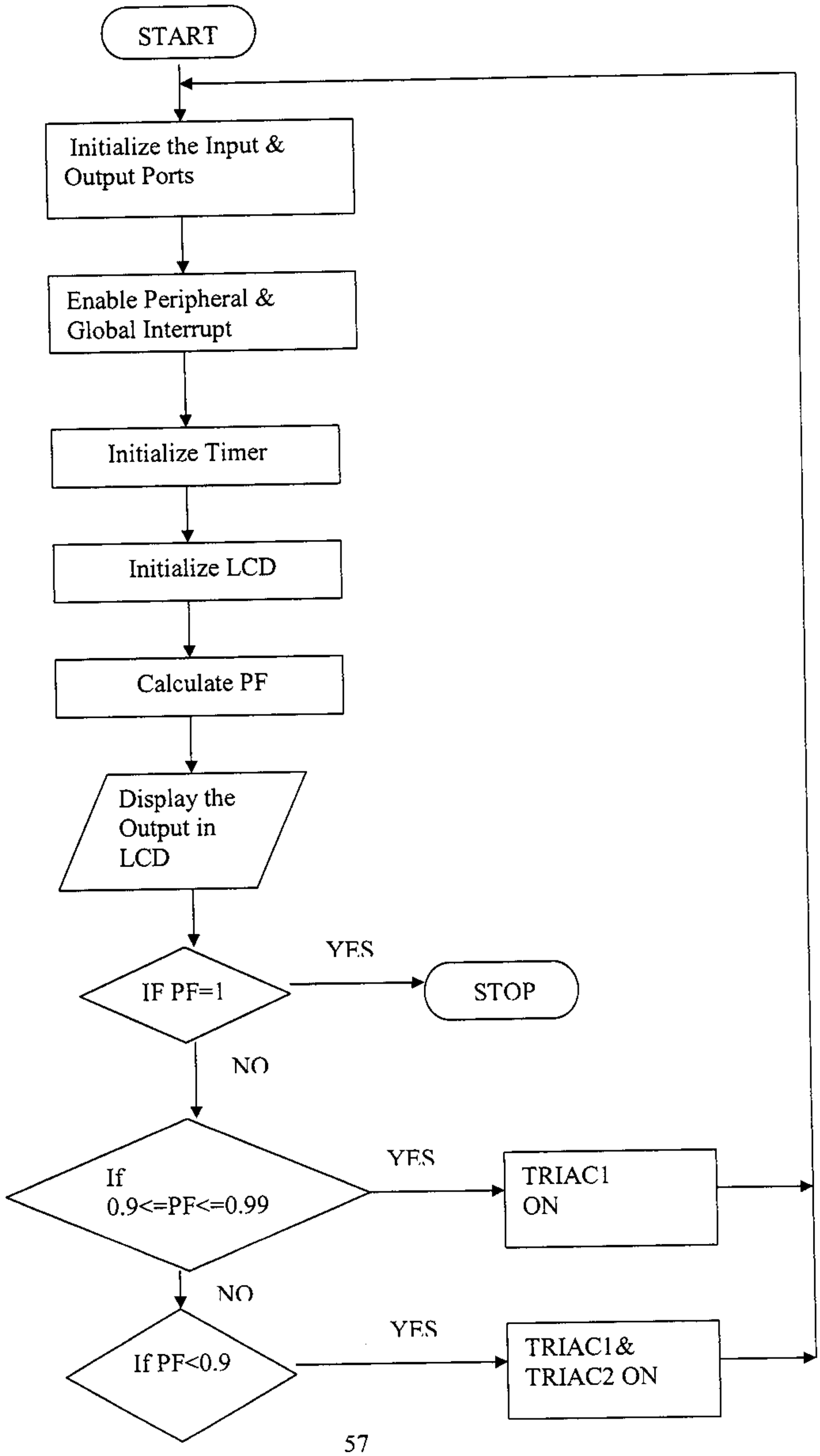
Step7: The value of Power Factor is given to the LCD Display.

Step8: If 0.9<=PF<=0.99, TRIAC 1-ON (GOTO STEP5)

Step9: If PF<0.9, TRIAC 1& TRIAC 2-ON (GOTO STEP5)

Step10: Improved Power Factor Display as 1.00 in LCD.

5.7. Flow Chart for Power Factor Improvement using ATMEL89C51



CHAPTER 6

INDUCTION FURNACE

6. INDUCTION FURNACE

6.1. Introduction

An induction furnace is an electrical furnace in which the heat is applied by induction heating conductive medium (usually a metal in a crucible around which water-cooled magnetic coils are wound. The advantage of the induction furnace is a clean, energy-efficient and well-controllable melting process compared to most other means of metal melting. Most modern foundries use this type of furnace and now also more iron foundries are replacing cupolas with induction furnaces to melt cast iron, as the former emit lots of dust and other pollutants. Induction furnace capacities range from less than one kilogram to one hundred tonnes capacity, and are used to melt iron and steel, copper, aluminium, and precious metals. The one major drawback to induction furnace usage in a foundry is the lack of refining capacity; charge materials must be clean of oxidation products and of a known composition, and some alloying elements may be lost due to oxidation (and must be re-added to the melt).

Operating frequencies range from mains frequency (50 or 60 Hz) to 10 kHz, usually depending on the material being melted, the capacity of the furnace and the melting speed required - a higher frequency furnace is usually faster to melt a charge. Lower frequencies generate more turbulence in the metal, reducing the power that can be applied to the melt.

A preheated 1-tonne furnace melting iron can melt cold charge to tapping readiness within an hour. An operating induction furnace usually emits a hum or whine (due to magnetostriction), the pitch of which can be used by operators to identify whether the furnace is operating correctly, or at what power level.

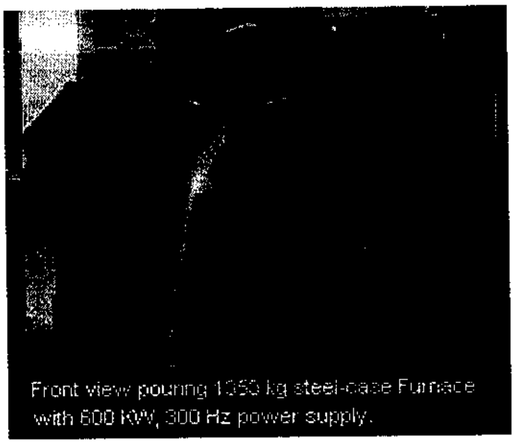


Fig 6.1 Induction Furnace

A control circuit particularly useful for controlling the application of power to a single phase induction furnace from a normal line frequency power supply is provided. The load has a large inductance and a resistance. A switch, preferably formed from thyristors, is provided in series connection with the furnace load.

The two most common induction melting furnace designs are the coreless and channel furnaces. Coreless melting furnaces use a refractory envelope to contain the metal, and surround that by the coil. Operating on the same basis as a transformer, the charge acts as a single secondary turn, thereby producing heat through eddy current flow when power is applied to the multiturn primary coil. When the metal melts, these electromagnetic forces also produce a stirring action. Mixing and melting rates can be controlled by carefully selecting frequency and power.

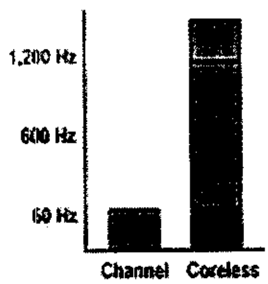


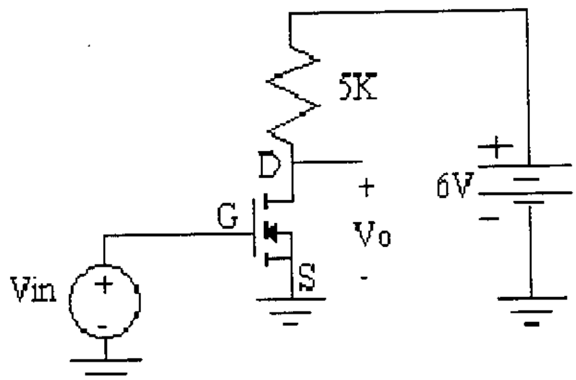
Fig 6.2 Induction Furnace Types

6.2. MOSFET

Induction heating has been developed as a key technology supporting present-day living because of its superior characteristics. It reduces energy consumption, contributes to the protection of environment, and improves productivity.

High-frequency induction heaters using power semiconductor devices are widely spreading due to the clean, highly efficient, and easily controllable heating.

Here is a 12 volt 100 watt DC to AC inverter with center-tapless transformer.



MOSFET inverter circuit. $V_T = 2$ *volts and* $k = 100$ *microA/V²*.

Fig 6.3 Mosfet Inverter Circuit

Mittelmann describes an induction heater having a variable frequency inverter power supply. The frequency of operation of the inverter is said to be selected to provide the maximum efficiency of energy transfer between the output transformer of the inverter and the inductance element used to heat the workpiece. In order to provide the proper amount of heat to the workpiece, Mittelmann monitors the watt-seconds delivered to the output of the inverter. In response to the measured watt-seconds, Mittelmann selectively turns the inverter on and off. Thus, the average heat delivered by the induction heat is controlled

6.3. PIC Microcontroller

The microcontroller that has been used for this project is from PIC series. PIC microcontroller is the first RISC based microcontroller fabricated in CMOS (complimentary metal oxide semiconductor) that uses separate bus for instruction and data allowing simultaneous access of program and data memory. The main advantage of CMOS and RISC combination is low power consumption resulting in a very small chip size with a small pin count. The main advantage of CMOS is that it has immunity to noise than other fabrication techniques.

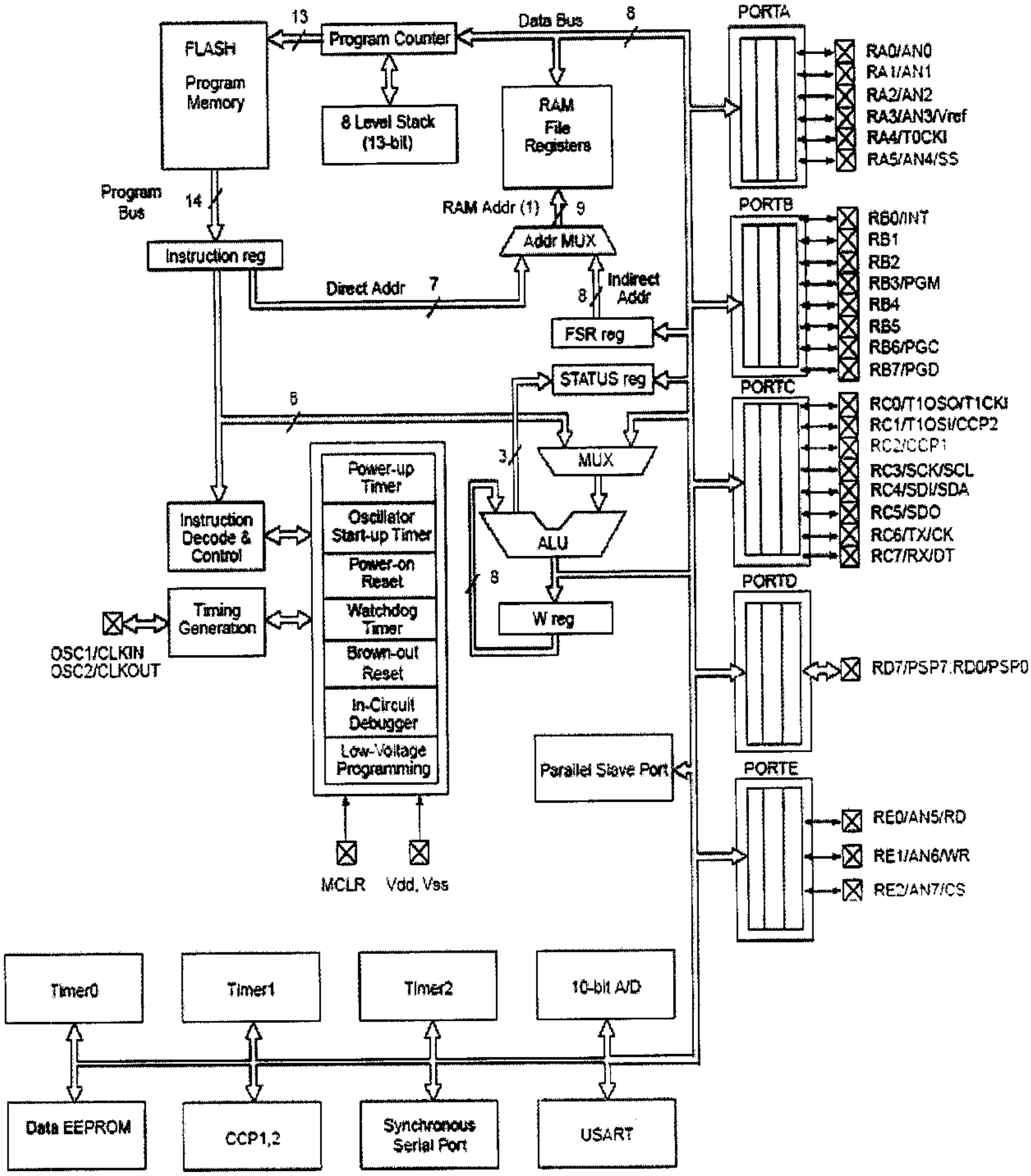
6.3.1. PIC (16F877)

Various microcontrollers offer different kinds of memories. EEPROM, EPROM, FLASH etc. are some of the memories of which FLASH is the most recently developed. Technology that is used in pic16F877 is flash technology, so that data is retained even when the power is switched off. Easy Programming and Erasing are other features of PIC 16F877.

- Pic Start Plus Programmer

The PIC start plus development system from microchip technology provides the product development engineer with a highly flexible low cost microcontroller design tool set for all microchip PIC micro devices. The picstart plus development system includes PIC start plus development programmer.

The PIC start plus programmer gives the product developer ability to program user software in to any of the supported microcontrollers. The PIC start plus software running under mplab provides for full interactive control over the programmer



Note 1: Higher order bits are from the STATUS register.

Fig 6.4 PIC Architecture

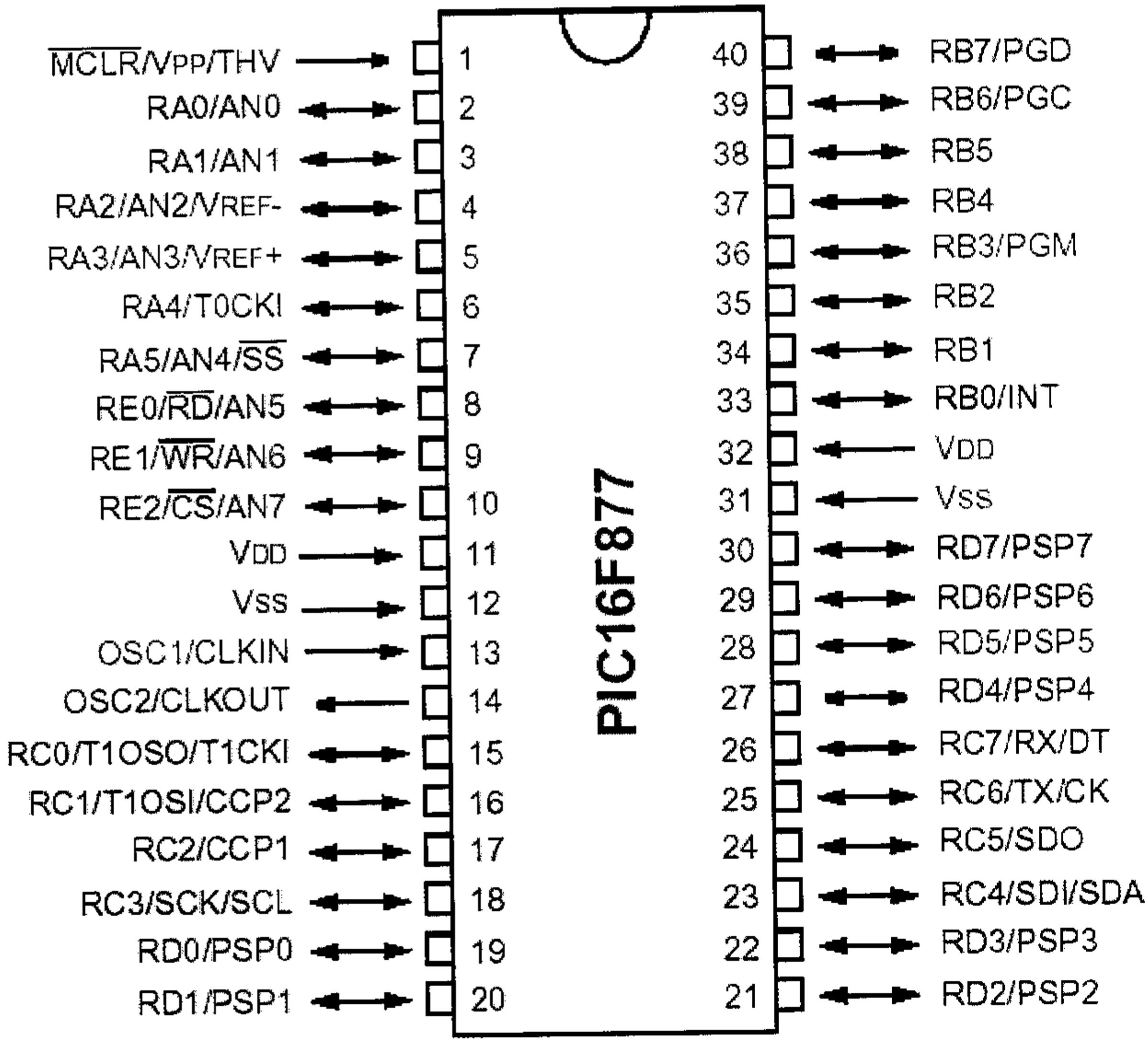


Fig 6.5. Pin diagram of PIC 16F877

DEVICE	PROGRAM FLASH	DATA MEMORY	DATA EEPROM
PIC 16F877	8K	368 Bytes	256 Bytes

TABLE 6.1 Memory specifications Of PIC (16F877).

6.4. Thyristor Frequency Converters

Thyristor (transistor) frequency converters are designed for conversion of mains frequency three-phase current into medium frequency alternating current. These converters are used to supply power to induction melting furnaces, heating and hardening units. The main advantage of thyristor frequency converters over the rotating ones is that due to the absence of idling loss power consumption reduces, efficiency rises, operating costs decreases.

6.5. Harmonics

Ideally, voltage and current waveforms are perfect sinusoids. However, because of the increased popularity of electronic and other non-linear loads, these waveforms quite often become distorted. This deviation from a perfect sine wave can be represented by harmonics sinusoidal components having a frequency that is an integral multiple of the fundamental frequency. Thus, a pure voltage or current sine wave has no distortion and no harmonics, and a non-sinusoidal wave has distortion and harmonics. To quantify the distortion, the term total harmonic distortion (THD) is used. The term expresses the distortion as a percentage of the fundamental (pure sine) of voltage and current waveforms.

The harmonics are of various order from 2 to 60.harmonics of 60^{th} order and above are usually too small are usually neglected.

6.5.1. Current and Voltage Harmonics

Current harmonics are a problem because they cause increased losses in the customer and utility power system components. Transformers are especially sensitive to this problem and may need to be derated to as much as 50% capacity when feeding loads with extremely distorted current waveforms (current total harmonic distortion above 100%).

ANSI/IEEE C57.110-1986 (IEEE Recommended Practice for Establishing Transformer Capacity When Supplying Nonsinusoidal Load Currents) states that a transformer subject to nonsinusoidal load current having more than 5% total harmonics distortion needs to be derated. However, when current THD is below 15%, the derating of the transformer would be so small that it can be neglected. On the other hand, when current THD exceeds 15%, the transformer capability should be evaluated by a professional using IEEE recommendations. It is important to clarify that these IEEE recommendations do not apply to transformers especially designed to feed nonsinusoidal loads.

Loads with highly distorted current waveforms also have a very poor power factor; because of this, they use excessive power system capacity and could be a cause of overloading.

Voltage source electronic adjustable speed drives (ASD) often have a total power factor of approximately 65% because of the highly distorted current. This total power factor could be corrected to approximately 85% using line-side chokes (reactors) on the drive. The chokes limit the rate of rise and the peak value of the line current, dramatically reducing the current THD.

In addition, current harmonics can distort the voltage waveform and cause voltage harmonics. Voltage distortion affects not only sensitive electronic loads but also electric motors and capacitor banks. In electric motors, negative sequence harmonics (i.e. 5^{th} , 11^{th} ,17^{th}), so called because their sequence (ABC or ACB) is opposite of the fundamental sequence, produce rotating magnetic fields. These fields rotate in the opposite direction of the fundamental magnetic field and could cause not only overheating but also mechanical oscillations in the motor-load system.

The problem with capacitor banks, on the other hand, is that the reactance (impedance) of a capacitor bank decreases as the frequency increases. This causes the bank to act as a sink or trap for higher harmonic currents from the surrounding customer and/or utility system. The effect is increased current, increased heating and dielectric stresses that could lead to capacitor bank failure.

6.5.2. Single and Three Phase Harmonics

Single-phase non-linear loads, like personal computers, electronic ballasts and other electronic equipment, generate odd harmonics (i.e. 3^{rd} , 5^{th} , 7^{th} , 9^{th} , etc.). The troublesome harmonics for single-phase loads are the 3^{rd} and odd multiples of the 3 (9^{th} , 15^{th} , etc.). These harmonics are called "triplens" and because the A-phase triplen harmonics, B-phase triplen harmonics and C-phase triplen harmonics are all in the phase with each other. They will add rather than cancel on the neutral conductor of a 3-phase 4-wire system. This can overload the neutral if it is not sized to handle this type of load.

Single-phase load harmonics vs. three-phase load harmonics:

Additionally, triplen harmonics cause circulating currents on the delta winding of a delta-wye transformer configuration. When current triplen harmonics on the neutral of a 3-phase 4-wire system reach the transformer, they are reflected to the delta-connected primary where they circulate. The result is transformer heating similar to that produced by unbalanced 3-phase current. On the other hand, 3-phase non-linear loads like 3-phase ASDs, 3-phase DC drives, 3 phase rectifiers, etc., for not generate current triplen harmonics (3^{rd} , 9^{th} , 15^{th} etc.). These types of loads generate primarily 5^{th} and 7^{th} current harmonics and a lesser amount of 11^{th} , 13^{th} , and higher order.

6.5.3. Crest Factor

The crest factor of any waveform is the ratio of the peak value to the RMS value. In a perfect sine wave, the crest factor is 1.414. Crest factors different than 1.414 indicate distortion in the waveform. Typically distorted current waveforms have crest factors higher than 1.414, and distorted voltage waveforms have crest factors lower than 1.414. Distorted voltage waveforms with crest factors lower than 1.414 are called "flat top" voltage waveforms.

The Computer and Business Equipment Manufacturers Association (CBEMA) recommends a method for derating transformers based on the current crest factor. CBEMA defines the transformer harmonic-derating factor (THDF) as the ratio of 1.414 to the transformer current crest factor. The derated KVA of the transformer would be the nominal KVA of the transformer multiplied by the THDF. This method, however, should only be applied when the distortion in the current is caused by single-phase, non-linear loads (like personal computers) and other office equipment. Also, when using this method, the crest factor measurements should always be made in the secondary of the transformer. A more complete method for transformer derating is the one described by ANSI/IEEE C57.110-1986.

6.5.4. Equipment Need to Measure Distorted Waveforms

A digital oscilloscope is needed to measure the wave shape, THD and amplitude of each harmonic. However, if we simply want to measure the RMS value of the waveform, a "True-RMS" multimeter will suffice.

The term "True-RMS" is used because not all instruments give correct readings when measuring distorted waveforms. The majority of low-cost portable instruments are "average responding-RMS calibrated." These instruments give correct readings for distortion-free sine waves and will typically read low when the current waveform is distorted. Most portable instruments with true RMS capabilities are labeled or listed as such in their owner manuals.

6.5.5. Harmonics Production

Harmonics are the by-products of modern electronics. They occur frequently when there are large numbers of personal computers (single phase loads), uninterruptible power supplies (UPSs), variable frequency drives (AC and DC) or any electronic device using solid state power switching supplies to convert incoming AC to DC. Non-linear loads create harmonics by drawing current in abrupt short pulses, rather than in a smooth sinusoidal manner.

The terms "linear" and "non-linear" define the relationship of current to the voltage waveform. A linear relationship exists between the voltage and current, which is typical of an across-the-line load. A non-linear load has a discontinuous current relationship that does not correspond to the applied voltage waveform.

6.5.6. Reducing Harmonics

- Isolation Transformers

An isolation transformer provides a good solution in many cases. The advantage is the potential to "voltage match" by stepping up or stepping down the system voltage, and by providing a neutral ground reference for nuisance ground faults. This is the best solution when utilizing AC or DC drives that use SCRs as bridge rectifiers.

- Line Reactors

More commonly used for size and cost, the line reactor is the best solution for harmonic reduction when compared to an isolation transformer. AC drives that use diode bridge rectifier front ends are best suited for line reactors. Line reactors (commonly referred to as inductors) are available in standard impedance ranges from 1.5%, 3%, 5% and 7.5%.

- Harmonic Trap Filters

Used in applications with a high non-linear ratio to system to eliminate harmonic currents. Filters are tuned to a specific harmonic such as the 5th, 7th, 11th, etc. In addition, harmonic trap filters provide true distortion power factor correction. Filters can be designed for several non-linear loads or for an individual load

6.6. Filter

It is sometimes desirable to have circuits capable of selectively filtering one frequency or range of frequencies out of a mix of different frequencies in a circuit. A circuit designed to perform this frequency selection is called a filter circuit, or simply a filter.

An practical application of filter circuits is in the "conditioning" of non-sinusoidal voltage waveforms in power circuits. Some electronic devices are sensitive to the presence of harmonics in the power supply voltage, and so require power conditioning for proper operation. If a distorted sine-wave voltage behaves like a series of harmonic waveforms added to the fundamental frequency, then it should be possible to construct a filter circuit that only allows the fundamental waveform frequency to pass through, blocking all (higher-frequency) harmonics.

Traditionally, power factor has been improved using capacitors. With the widespread use of adjustable-speed motor drives, UPS, and other nonlinear loads, power factor improvement has become more complicated. Capacitors can interact with harmonics injected into the power system by the loads, leading to damage to either the capacitors or to components of the system. For low-voltage systems, an empirical approach has been developed for application of tuned filters to nonlinear loads, providing both power factor correction and harmonic removal. As long as the proper precautions are observed, extensive system impedance analysis is not needed

A new low cost hybrid active filter for thyristor-controlled rectifier load is presented to overcome the high cost problem of the active or the other hybrid active filters. The proposed hybrid active filter which consists of tuned (5th and 7th harmonics) LC passive filters, power factor improvement (PFI) capacitor banks, and an active filter compensates power factor as well as harmonic currents. Since most of harmonic currents are filtered by the passive filter and most of reactive power is compensated by the PFI capacitor banks, the power rating of active filter can be minimized, resulting in cost minimization of the proposed hybrid active filter.

A 400kVA hybrid active filter system is implemented and tested using 1MVA thyristor rectifier load to verify the operation and performance.

6.6.1. EMI Filter

The filter protects the external world and the PFC module from each other's noise. It also presents a low AC source impedance to the PFC module. For safety and improved performance the case of the EMI filter should be earthed.

A 6A, 250VAC filter is required for full power operation over the specified PFC module input range. As a rough estimate, the volume of the filter will be two to three times the volume of the PFC module. Systems that don't require the full power capability and/ or the full voltage range of the PFC module can use smaller filters.

The inductance should be on the order of 10μH to 20μH.The EMI filter used should have at least 0.33μF of capacitance on its output (the PFC module side) in order to ensure that it presents a low source impedance to the PFC module at the switching frequency of the module. If the EMI filter does not have sufficient capacitance, or if the EMI filter is remotely located, an agency recognized X capacitor should be added across the line at the input of the PFC module.

6.6.2. Input Protection

The PFC has no internal protection against transients or spikes on the input of the module. The designer must therefore add adequate protection externally to the module. RO recommends a two prong approach that involves secondary and board levels of protection.(Primary protection is usually done at the building's AC panel or service entry point and is not discussed here.) passive PFC Harmonic filtering to improve the input power factor may be implemented by adding a boost pre-regulator to the input [1]. This form of active power factor correction is very effective, but it is very expensive to implement. Passive power factor correction is achieved by adding a filter inductor. The filter inductor must be designed to handle the entire power range of the supply, which normally means a large bulky component, which greatly increases the overall volume of the power supply.

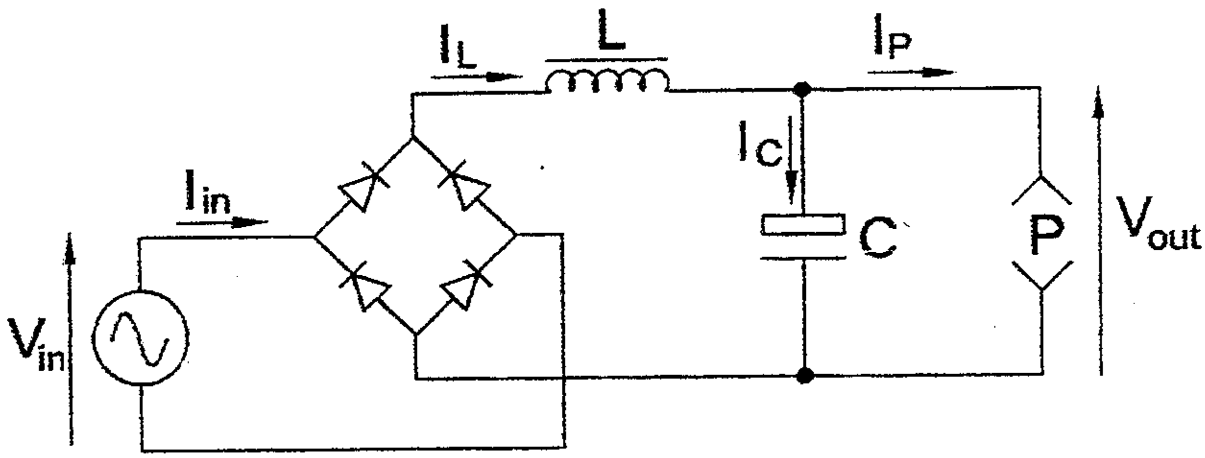


Fig 6.7 Rectifier circuit with passive power factor correction.

6.6.3. Passive Power Factor Correction

A typical ac/dc converter with an output buffer capacitor and a passive inductor for power factor correction is shown in Fig 3.1. P represents the input power to a second dc–dc converter stage. It may be shown that the output voltage ripple and the hold up time of the circuit are determined by the time constant of the capacitor and load resistance.

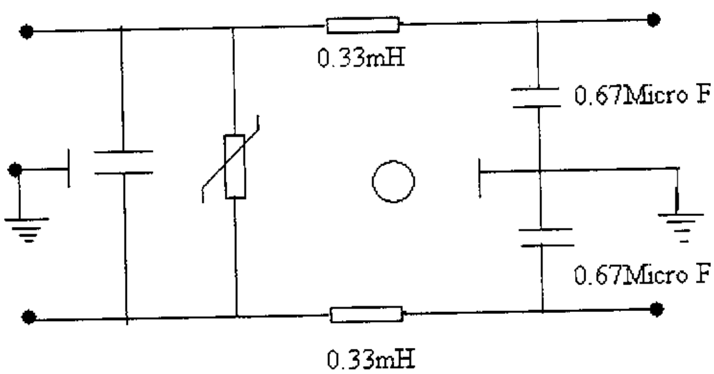


Fig 6.6 EMI Filter

CHAPTER 7

CONCLUSION

CONCLUSION

We have fabricated an Prototype model of inverter and converter using Power electronic devices such as Mosfet, Power diode, IC regulator, PIC16F877.

The model which can be used for a small inductive load.

We have also tested it for various Power factor. we have used the static capacitors for generating the leading current and to control the leading current, we have used the TRIAC switches, we have also successfully fabricated the filter of passive EMI type and tested the output by connecting filter. We have the assembled the unit and totally we have tested using an inductive load instead of induction furnace. We have also simulated the entire thing using simulink keeping this Prototype model of an example a real time Power factor improvement for an induction furnace can be fabricated if financial assistance is by sponsoring companies.

APPENDIX -A
SOFTWARE PROGRAMMING

APPENDIX A: ATMEL89C51 PROGRAMMING CODE

```
#include <AT89X51.H>
#include <math.h>

void lcd_init();
void delay(unsigned int);
void lcd_disp(unsigned char*, unsigned char);
void read(unsigned char);
void write(unsigned char);
void del(unsigned int);
void delay(unsigned int);
void htd(unsigned int);
void dis();
void timer0_init();

sbit rs     = P2^7;
sbit rw     = P2^6;
sbit en     = P2^5;

sbit relay2  = P1^1;
sbit relay1  = P1^0;

sbit input = P1^2;
float x,y;
unsigned int count=0;
unsigned char tenthous,thous,hund,ten,one,tenthous_r,thous_r,hund_r;

void main()
{
lcd_init();
```

```
timer0_init();
read(0x01);
read(0x80);
lcd_disp("  POWER FACTOR  ",16);
read(0xc0);
lcd_disp("    CONTROL     ",16);
delay(65000);
delay(65000);
delay(65000);
delay(65000);
TMOD=0x11;
EA=1;
ET0=1;
while(1)
{
while(input==1);
while(input==0);
TR0=1;
while(input==1);
TR0=0;
timer0_init();
x=count*1.8;
x=x*3.14;
x=x/180;
y=cos(x);
count=y*100;
read(0x01);
read(0x80);
lcd_disp("PF:",3);
htd(count);
read(0x83);
```

```
dis();
delay(10000);

if(count<=80)
  {triac1=0;triac2=1;}


  else if(count<70)
  {
   triac1=triac2=0;
  }
   count=0;
 }
}
void timer0_init()
{
TH0=0xff;
TL0=0x7f;
}
void timer0(void) interrupt 1
{
 TR0=0;
 count++;
 timer0_init();
 TR0=1;
}
void htd(unsigned int hex_val)
{
 tenthous=hex_val/0x2710;
 tenthous_r=hex_val%0x2710;
 thous=tenthous_r/0x3e8;
 thous_r=tenthous_r%0x3e8;
```

```
hund=thous_r/0x64;
hund_r=thous_r%0x64;
ten=hund_r/0x0a;
one=hund_r%0x0a;
}
void dis()
{
 write(hund+0x30);
 write('.');
 write(ten+0x30);
 write(one+0x30);
}
void delay(unsigned int del)
{
 while(del--);
}
void lcd_init()
{
 read(0x38);
 read(0x01);
 read(0x06);
 read(0x0c);
}
void read(unsigned char add)
{
 P0=add;
 rs=rw=0;
 en=1;
 delay(125);
 en=0;
}
```

```
void write(unsigned char dat)
{
 P0=dat;
 rs=en=1;
 rw=0;
 delay(125);
 en=0;
}
void lcd_disp(unsigned char *mess,unsigned char n)
{
 unsigned char i;
 for(i=0;i<n;i++)
 {
  write(mess[i]);
 }
}
```

APPENDIX -B
DATA SHEETS

FEATURES

- Glass passivated
- High maximum operating temperature
- Low leakage current
- Excellent stability
- Available in ammo-pack.

DESCRIPTION

Rugged glass package, using a high temperature alloyed construction.

This package is hermetically sealed and fatigue free as coefficients of expansion of all used parts are matched.

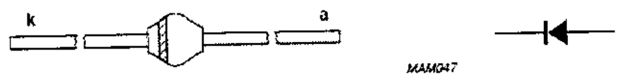


Fig.1 Simplified outline (SOD57) and symbol.

LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{RRM}	repetitive peak reverse voltage				
	1N4001G		–	50	V
	1N4002G		–	100	V
	1N4003G		–	200	V
	1N4004G		–	400	V
	1N4005G		–	600	V
	1N4006G		–	800	V
	1N4007G		–	1000	V
V_R	continuous reverse voltage				
	1N4001G		–	50	V
	1N4002G		–	100	V
	1N4003G		–	200	V
	1N4004G		–	400	V
	1N4005G		–	600	V
	1N4006G		–	800	V
	1N4007G		–	1000	V
$I_{F(AV)}$	average forward current	averaged over any 20 ms period; T_{amb} = 75 °C; see Fig.2	–	1.00	A
		averaged over any 20 ms period; T_{amb} = 100 °C; see Fig.2	–	0.75	A
I_F	continuous forward current	T_{amb} = 75 °C; see Fig.2	–	1.00	A
I_{FRM}	repetitive peak forward current		–	10	A
I_{FSM}	non-repetitive peak forward current	half sinewave; 60 Hz	–	30	A
T_{stg}	storage temperature		–65	+175	°C
T_j	junction temperature		–65	+175	°C

Features

- Compatible with MCS-51™ Products
- 4K Bytes of In-System Reprogrammable Flash Memory
  - Endurance: 1,000 Write/Erase Cycles
- Fully Static Operation: 0 Hz to 24 MHz
- Three-Level Program Memory Lock
- 128 x 8-Bit Internal RAM
- 32 Programmable I/O Lines
- Two 16-Bit Timer/Counters
- Six Interrupt Sources
- Programmable Serial Channel
- Low Power Idle and Power Down Modes

8-Bit Microcontroller with 4K Bytes Flash

AT89C51

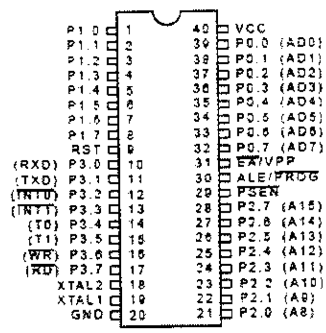
Description

The AT89C51 is a low-power, high-performance CMOS 8-bit microcomputer with 4K bytes of Flash Programmable and Erasable Read Only Memory (PEROM). The device is manufactured using Atmel's high density nonvolatile memory technology and is compatible with the industry standard MCS-51™ instruction set and pinout. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer. By combining a versatile 8-bit CPU with Flash on a monolithic chip, the Atmel AT89C51 is a powerful microcomputer which provides a highly flexible and cost effective solution to many embedded control applications.

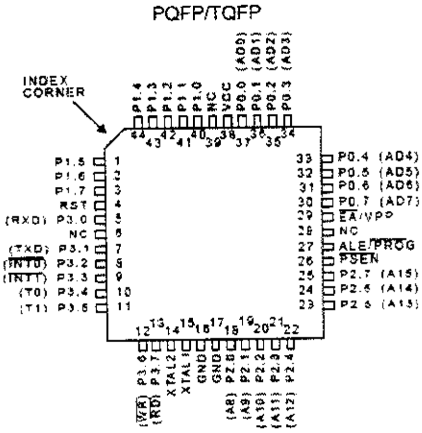
(continued)

Pin Configurations

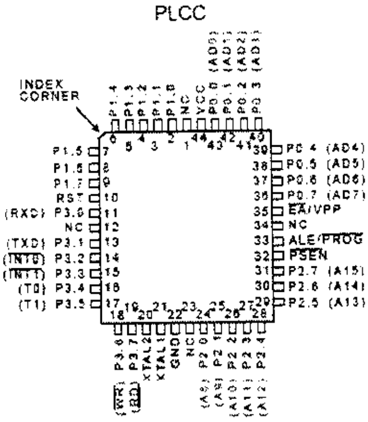
PDIP



PQFP/TQFP



PLCC



0265F-4-12/97

Figure 3. Programming the Flash

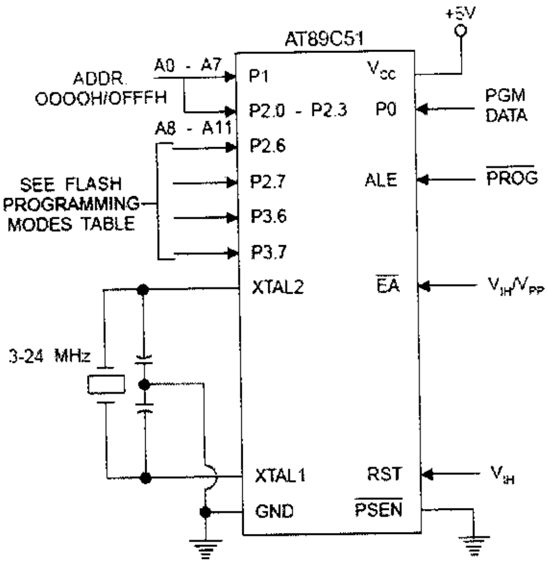
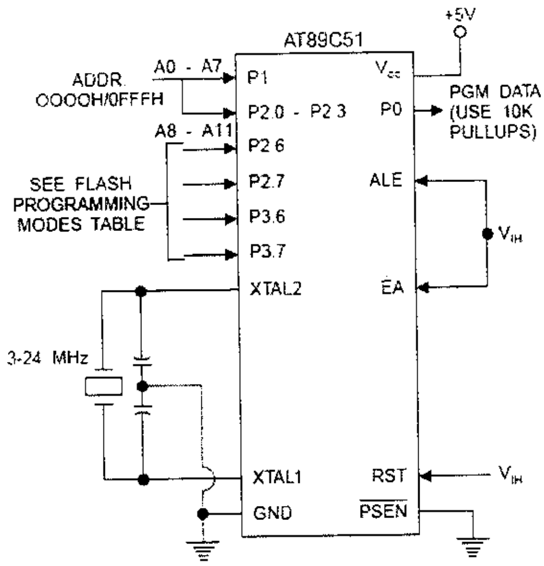


Figure 4. Verifying the Flash



Flash Programming and Verification Characteristics

T_A = 0°C to 70°C, V_{CC} = 5.0 ± 10%

Symbol	Parameter	Min	Max	Units
V_{PP}[1]	Programming Enable Voltage	11.5	12.5	V
I_{PP}[1]	Programming Enable Current		1.0	mA
$1/t_{CLCL}$	Oscillator Frequency	3	24	MHz
t_{AVGL}	Address Setup to $\overline{PROG}$ Low	$48t_{CLCL}$		
t_{GHAX}	Address Hold After $\overline{PROG}$	$48t_{CLCL}$		
t_{DVGL}	Data Setup to $\overline{PROG}$ Low	$48t_{CLCL}$		
t_{GHDX}	Data Hold After $\overline{PROG}$	$48t_{CLCL}$		
t_{EHSH}	P2.7 ($\overline{ENABLE}$) High to V_{PP}	$48t_{CLCL}$		
t_{SHGL}	V_{PP} Setup to $\overline{PROG}$ Low	10		µs
t_{GHSL}[1]	V_{PP} Hold After $\overline{PROG}$	10		µs
t_{GLGH}	$\overline{PROG}$ Width	1	110	µs
t_{AVQV}	Address to Data Valid		$48t_{CLCL}$	
t_{ELQV}	$\overline{ENABLE}$ Low to Data Valid		$48t_{CLCL}$	
t_{EHQZ}	Data Float After $\overline{ENABLE}$	0	$48t_{CLCL}$	
t_{GHBL}	$\overline{PROG}$ High to $\overline{BUSY}$ Low		1.0	µs
t_{WC}	Byte Write Cycle Time		2.0	ms

Note: 1. Only used in 12-volt programming mode.

May 2000

National Semiconductor

LM78XX
Series Voltage Regulators

General Description

The LM78XX series of three terminal regulators is available with several fixed output voltages making them useful in a wide range of applications. One of these is local on card regulation, eliminating the distribution problems associated with single point regulation. The voltages available allow these regulators to be used in logic systems, instrumentation, HiFi, and other solid state electronic equipment. Although designed primarily as fixed voltage regulators these devices can be used with external components to obtain adjustable voltages and currents.

The LM78XX series is available in an aluminum TO-3 package which will allow over 1.0A load current if adequate heat sinking is provided. Current limiting is included to limit the peak output current to a safe value. Safe area protection for the output transistor is provided to limit internal power dissipation. If internal power dissipation becomes too high for the heat sinking provided, the thermal shutdown circuit takes over preventing the IC from overheating.

Considerable effort was expanded to make the LM78XX series of regulators easy to use and minimize the number of external components. It is not necessary to bypass the output, although this does improve transient response. Input bypassing is needed only if the regulator is located far from the filter capacitor of the power supply.

For output voltage other than 5V, 12V and 15V the LM117 series provides an output voltage range from 1.2V to 57V.

Features

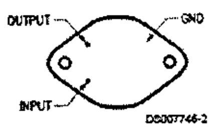
- Output current in excess of 1A
- Internal thermal overload protection
- No external components required
- Output transistor safe area protection
- Internal short circuit current limit
- Available in the aluminum TO-3 package

Voltage Range

LM7805C	5V
LM7812C	12V
LM7815C	15V

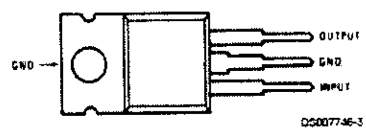
Connection Diagrams

Metal Can Package
TO-3 (K)
Aluminum



Bottom View
Order Number LM7805CK, LM7812CK or LM7815CK
See NS Package Number KC02A

Plastic Package
TO-220 (T)



Top View
Order Number LM7805CT, LM7812CT or LM7815CT
See NS Package Number T03B

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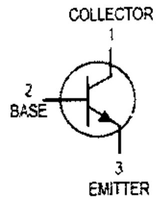
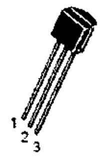
Amplifier Transistors
NPN Silicon

BC546, B
BC547, A, B, C
BC548, A, B, C





CASE 29–04, STYLE 17
TO–92 (TO–226AA)

MAXIMUM RATINGS

Rating	Symbol	BC 546	BC 547	BC 548	Unit
Collector–Emitter Voltage	V_{CEO}	65	45	30	Vdc
Collector–Base Voltage	V_{CBO}	80	50	30	Vdc
Emitter–Base Voltage	V_{EBO}		6.0		Vdc
Collector Current — Continuous	I_C		100		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D		625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D		1.5 12		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}		–55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector–Emitter Breakdown Voltage (I_C = 1.0 mA, I_B = 0)	BC546 BC547 BC548	$V_{(BR)CEO}$	65 45 30	— — —	— — —	V
Collector–Base Breakdown Voltage (I_C = 100 μAdc)	BC546 BC547 BC548	$V_{(BR)CBO}$	80 50 30	— — —	— — —	V
Emitter–Base Breakdown Voltage (I_E = 10 μA, I_C = 0)	BC546 BC547 BC548	$V_{(BR)EBO}$	6.0 6.0 6.0	— — —	— — —	V
Collector Cutoff Current (V_{CE} = 70 V, V_{BE} = 0) (V_{CE} = 50 V, V_{BE} = 0) (V_{CE} = 35 V, V_{BE} = 0) (V_{CE} = 30 V, T_A = 125°C)	 BC546 BC547 BC548 BC546/547/548	I_{CES}	 — — — —	 0.2 0.2 0.2 —	 15 15 15 4.0	 nA μA

REV 1

Triacs sensitive gate

GENERAL DESCRIPTION

Glass passivated, sensitive gate triacs in a plastic envelope, intended for use in general purpose bidirectional switching and phase control applications, where high sensitivity is required in all four quadrants.

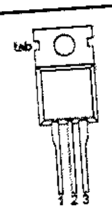
QUICK REFERENCE DATA

SYMBOL	PARAMETER	MAX.	MAX.	MAX.	UNIT
	BT139-	500E	600E	800E	
V_{DRM}	Repetitive peak off-state voltages	500	600	800	V
$I_{T(RMS)}$	RMS on-state current	16	16	16	A
I_{TSM}	Non-repetitive peak on-state current	140	140	140	A

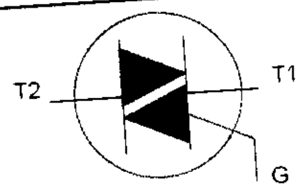
PINNING - TO220AB

PIN	DESCRIPTION
1	main terminal 1
2	main terminal 2
3	gate
tab	main terminal 2

PIN CONFIGURATION



SYMBOL



LIMITING VALUES

Limiting values in accordance with the Absolute Maximum System (IEC 134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.			UNIT
				-500	-600	-800	
V_{DRM}	Repetitive peak off-state voltages		-	500[1]	600[1]	800	V
$I_{T(RMS)}$	RMS on-state current	full sine wave; $T_{mb} \leq 99$ °C	-	16			A
I_{TSM}	Non-repetitive peak on-state current	full sine wave; $T_j = 25$ °C prior to surge					
		t = 20 ms	-	140			A
		t = 16.7 ms	-	150			A
I^2t	I^2t for fusing	t = 10 ms	-	98			A^2s
dI_T/dt	Repetitive rate of rise of on-state current after triggering	$I_{TM} = 20$ A; $I_G = 0.2$ A; $dI_G/dt = 0.2$ A/µs					
		T2+ G+	-	50			A/µs
		T2+ G-	-	50			A/µs
		T2- G-	-	50			A/µs
		T2- G+	-	10			A/µs
I_{GM}	Peak gate current		-	2			A
V_{GM}	Peak gate voltage		-	5			V
P_{GM}	Peak gate power		-	5			W
$P_{G(AV)}$	Average gate power	over any 20 ms period	-	0.5			W
T_{stg}	Storage temperature		-40	150			°C
T_j	Operating junction temperature		-	125			°C

1 Although not recommended, off-state voltages up to 800V may be applied without damage, but the triac may switch to the on-state. The rate of rise of current should not exceed 15 A/µs.

MOTOROLA

DUAL 1-OF-4 DECODER/ DEMULTIPLEXER

The LSTTL/MSI SN54/74LS139 is a high speed Dual 1-of-4 Decoder/Demultiplexer. The device has two independent decoders, each accepting two inputs and providing four mutually exclusive active LOW Outputs. Each decoder has an active LOW Enable input which can be used as a data input for a 4-output demultiplexer. Each half of the LS139 can be used as a function generator providing all four minterms of two variables. The LS139 is fabricated with the Schottky barrier diode process for high speed and is completely compatible with all Motorola TTL families.

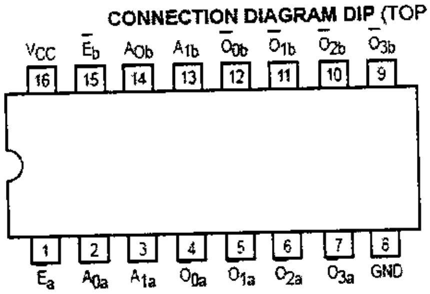
- Schottky Process for High Speed
- Multifunction Capability
- Two Completely Independent 1-of-4 Decoders
- Active Low Mutually Exclusive Outputs
- Input Clamp Diodes Limit High Speed Termination Effects
- ESD > 3500 Volts

SN54/74LS139

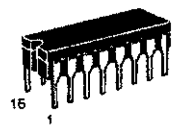
DUAL 1-OF-4 DECODER/ DEMULTIPLEXER

LOW POWER SCHOTTKY

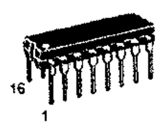
CONNECTION DIAGRAM DIP (TOP VIEW)



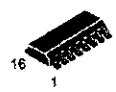
NOTE:
The Flatpak version has the same pinouts (Connection Diagram) as the Dual In-Line Package.



J SUFFIX
CERAMIC
CASE 620-09



N SUFFIX
PLASTIC
CASE 648-08



D SUFFIX
SOIC
CASE 751B-03

ORDERING INFORMATION

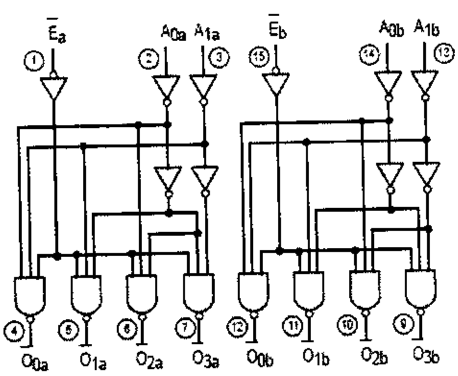
SN54LSXXXJ	Ceramic
SN74LSXXXN	Plastic
SN74LSXXXD	SOIC

PIN NAMES

		LOADING (Note a) HIGH	LOW
A_0, A_1	Address Inputs	0.5 U.L.	0.25 U.L.
$\overline{E}$	Enable (Active LOW) Input	0.5 U.L.	0.25 U.L.
$\overline{O}_0$–$\overline{O}_3$	Active LOW Outputs (Note b)	10 U.L.	5 (2.5) U.L.

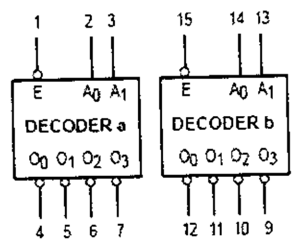
NOTES:
a) 1 TTL Unit Load (U.L.) = 40 μA HIGH/1.6 mA LOW.
b) The Output LOW drive factor is 2.5 U.L. for Military (54) and 5 U.L. for Commercial (74) Temperature Ranges.

LOGIC DIAGRAM



V_{CC} = PIN 16
GND = PIN 8
○ = PIN NUMBERS

LOGIC SYMBOL



V_{CC} = PIN 16
GND = PIN 8

October 1999

National Semiconductor

ADC0808/ADC0809
8-Bit µP Compatible A/D Converters with 8-Channel Multiplexer

General Description

The ADC0808, ADC0809 data acquisition component is a monolithic CMOS device with an 8-bit analog-to-digital converter, 8-channel multiplexer and microprocessor compatible control logic. The 8-bit A/D converter uses successive approximation as the conversion technique. The converter features a high impedance chopper stabilized comparator, a 256R voltage divider with analog switch tree and a successive approximation register. The 8-channel multiplexer can directly access any of 8-single-ended analog signals.

The device eliminates the need for external zero and full-scale adjustments. Easy interfacing to microprocessors is provided by the latched and decoded multiplexer address inputs and latched TTL TRI-STATE® outputs.

The design of the ADC0808, ADC0809 has been optimized by incorporating the most desirable aspects of several A/D conversion techniques. The ADC0808, ADC0809 offers high speed, high accuracy, minimal temperature dependence, excellent long-term accuracy and repeatability, and consumes minimal power. These features make this device ideally suited to applications from process and machine control to consumer and automotive applications. For 16-channel multiplexer with common output (sample/hold port) see ADC0816 data sheet. (See AN-247 for more information.)

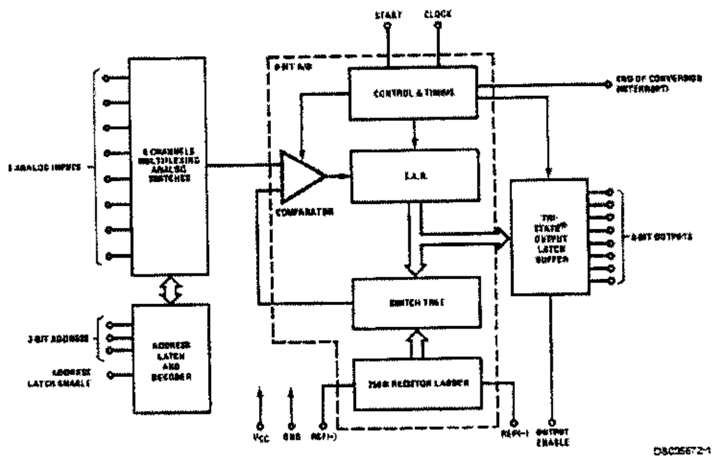
Features

- Easy interface to all microprocessors
- Operates ratiometrically or with 5 V_{DC} or analog span adjusted voltage reference
- No zero or full-scale adjust required
- 8-channel multiplexer with address logic
- 0V to 5V input range with single 5V power supply
- Outputs meet TTL voltage level specifications
- Standard hermetic or molded 28-pin DIP package
- 28-pin molded chip carrier package
- ADC0808 equivalent to MM74C949
- ADC0809 equivalent to MM74C949-1

Key Specifications

- Resolution: 8 Bits
- Total Unadjusted Error: ±½ LSB and ±1 LSB
- Single Supply: 5 V_{DC}
- Low Power: 15 mW
- Conversion Time: 100 µs

Block Diagram

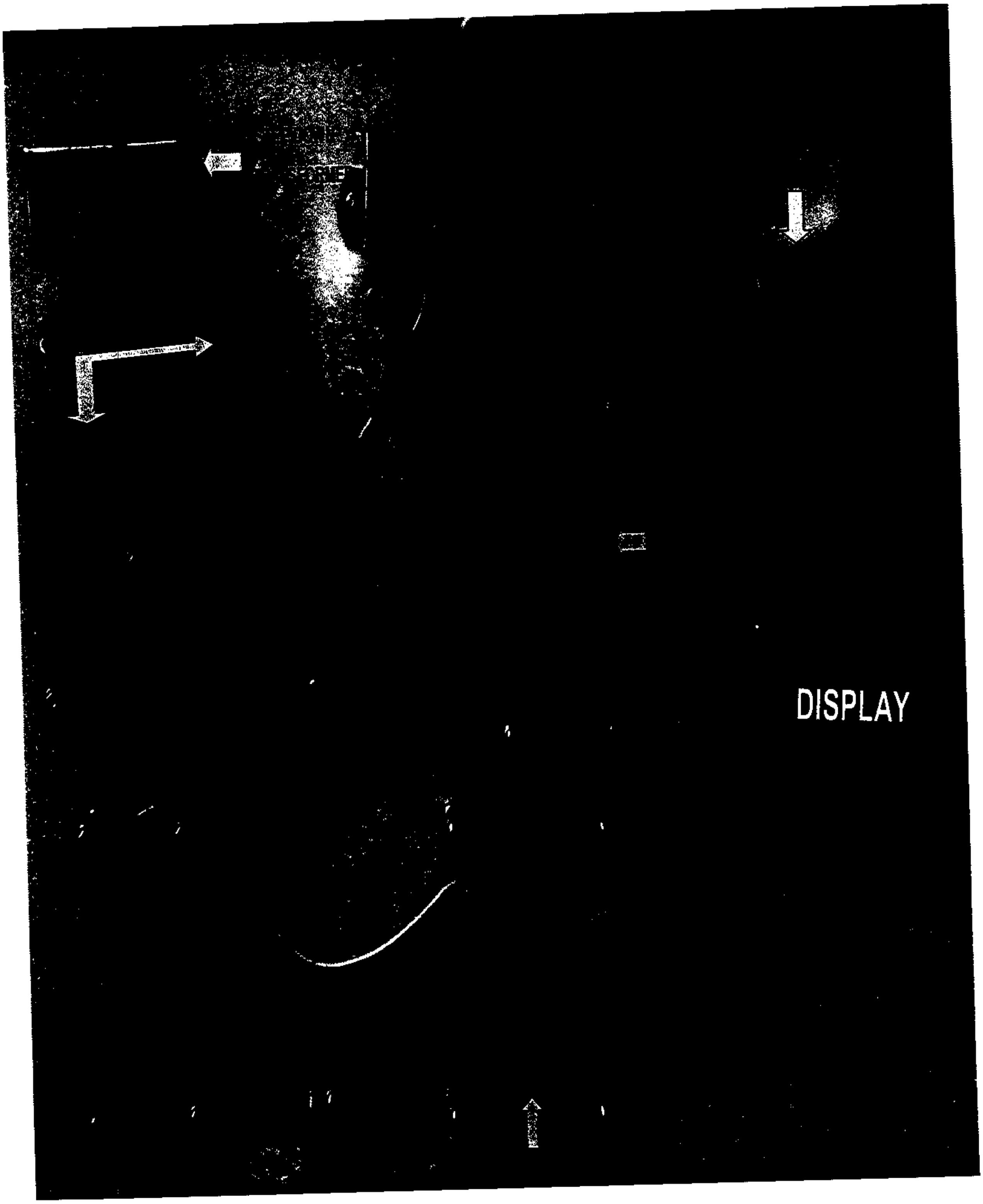


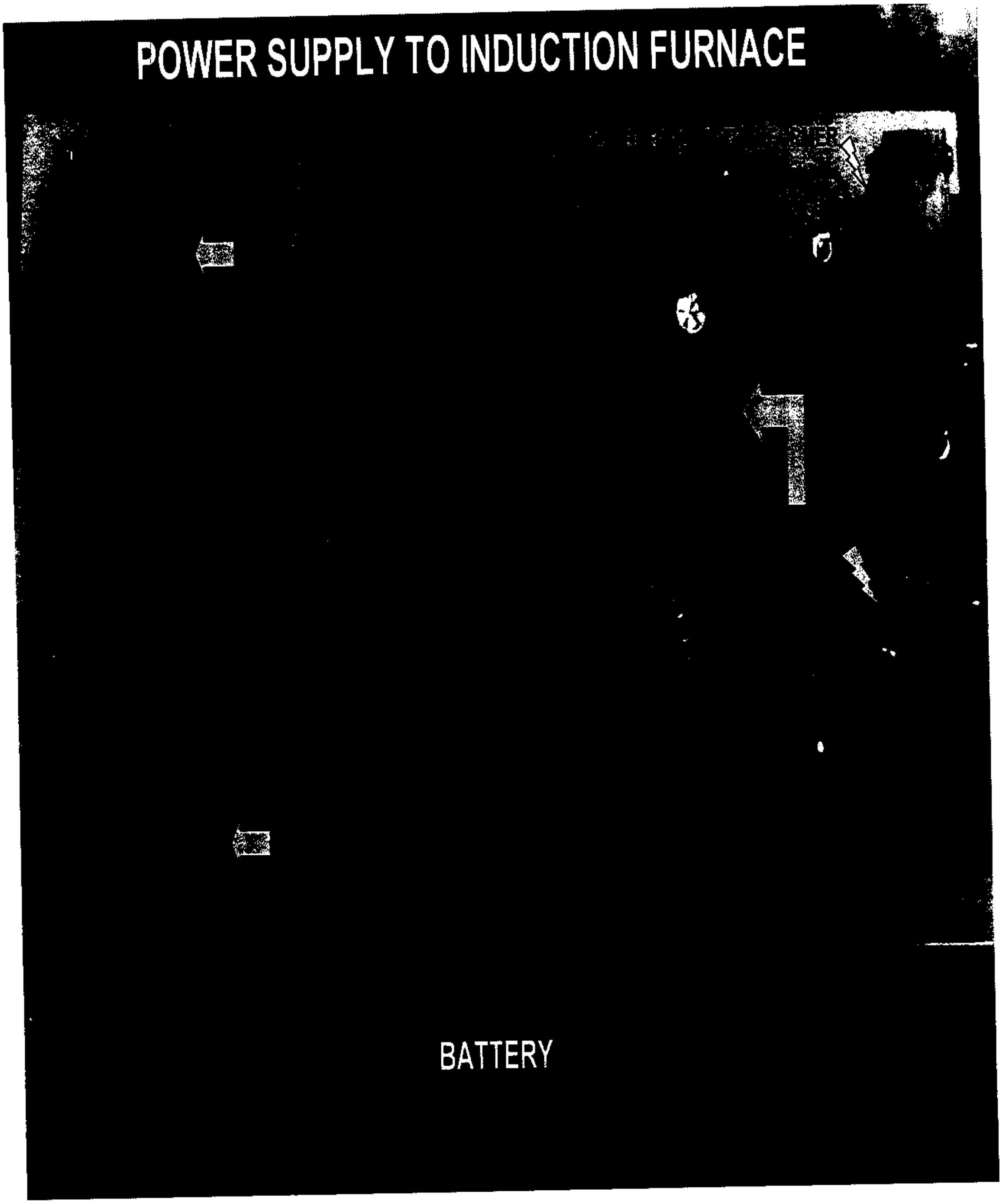
See Ordering Information

TRI-STATE® is a registered trademark of National Semiconductor Corp.

www.national.com

APPENDIX -C
PHOTOS


DISPLAY


POWER SUPPLY TO INDUCTION FURNACE
BATTERY

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REFERENCES

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