TRANSFORMER PROTECTION

AND CONTROL

A Project Report

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BONAFIDE CERTIFICATE

Certified that this project report entitled **"Transformer Protection And Control Using PIC Controller"** is the bonafide work of

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ABSTRACT

Monitoring the electrical parameters of Transformers to protect the ransformers is essential in Laboratories and Industries. For the measurement of electrical parameters, individual meters are used to measure current, voltage and frequency.

When individual meters are used it will increase the cost, space and also human error is produced during observation. So in order to avoid that we have designed and developed a device. By using this device, it is possible to monitor and control all transformers that are connected in a network, from a control center with a single system, which is extremely cost-effective.

A PIC microcontroller is used as a processor which read all the electrical parameters from the Transformer. And displays all the electrical parameters using the LCD display sequentially. Depending on the measured value the PIC controller will act and perform the On-Load Tap Changing and Load Sharing. Since we have used embedded technology. The hardware is very compact in size, the response time is less than 2µsec and the cost involved is also very low.

The project helps to increase the performance of the transformers.

ACKNOWLEDGEMENT

The satisfaction that accompanies the successful completion of any task would be incomplete without the mention of the people who made it possible, whose constant guidance and the encouragement crowns all the efforts with success.

Our sincere thanks to our guide **Mr. G.N Muruganandhan,** M.E., Asst.professor, Department of Electrical and Electronics Engineering, Kumaraguru College of Technology, who guided us throughout the project and encouraged us to successfully complete our work.

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We are also grateful to the dynamic support of all our staffs, non –teaching staffs and the friends, who helped us in many ways during the course of this project

DEDICATED

TO OUR

BELOVED WELL WISHERS

:ONTENTS

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LIST OF SYMBOLS AND ABBREVIATIONS

AC- Alternating Current
PIC- Peripheral Interface Controller
LCD- Liquid Crystal Display.
ADC- Analog to Digital Converter.
DPST-Double Pole Single Through.
OS- Operating System.
TTL- Transistor Transistor Logic.
PCB- Printed Circuit Board.
ZCD- Zero Crossing Detector.
LED- Light Emitting Diode.
SPDT- Single Pole Double Through.
DPDT- Double Pole Double Through.
NC-Normally Closed.
NO-Normally Open.
AC- Auxiliary Contact.
Hz- Hertz.
OLTC- On-Load Tap Changing.
Np-Primary Turns.
Ns-Secondary Turns.
Ep-Primary Voltage.
Es-Secondary Voltage.

1.1 INTRODUCTION:

Transformers outages have a considerable economic impact on the operation of an electrical network. Many have worked on transformer in different manner. But our aim is to ensure an accurate assessment of the transformer condition. Techniques that allow diagnosing the integrity through non-intrusive tests can be used to optimize the maintenance effort and to ensure maximum availability and reliability. With the increasing average age of transformer, there is an increasing need to know the internal condition. For this purpose, on- and off- line methods and systems have been developed in recent years. On-line monitoring of transformers can be used continuously during the operation of transformers and offers in that way a possibility a record different relevant stresses, which can affect the lifetime. The automatic evaluation of these data allows the early detection of an oncoming fault. And they are controlled by On-load Tap Changing and Load Sharing.

1.2 ADVANCEMENT IN TRANSFORMER PROTECTION:

The conventional methods used to protect the transformers are

Differential Protection: Merz-Price Protection.

The CT's are present on both secondary side and primary side when the current in both the CT's are equal the is not operate. When there is a difference in the current is produced due to the fault the relay operates and trips the circuit.

The Problems encountered in Differential Protection:

1) Unmatched Characteristics of CT's:

There exists difference in the Current Transformer characteristics appreciable difference in the secondary currents which can operate the relay.

2) Ratio Change Due To Tap Change:

When the Tap is changed, the turns ratio is altered this causes unbalance on both sides.

3) Difference in Lengths of Pilot Wires:

Due the difference in length of pilot wires on both sides the unbalance condition may result.

1.3 EMBEDDED SYSTEM OVER CONVENTIONAL METHODS:

1) The power consumed by the control circuit is less.
2) The Complexity is reduced due to programmed controller.
3) Unmatched Characteristics due to ratio change of the CT's is avoided.
4) The unbalance due to Tap changing and difference in lengths of pilot wires is avoided by typical programming.
5) It is of low cost, delay is very less.

1.4 SCOPE OF THE PROJECT:

In recent years, there has been lot of researchers focused on Transformer protection and control against various load conditions because of emerging technologies like artificial intelligence. Online monitoring of electrical machines in critical applications has been increasingly necessary to improve the reliability and to minimize fatigue failure. This project aims at developing an online monitoring, protection and controlling the Transformer using embedded techniques.

1.5 OBJECTIVE:

The objective of this project is to monitor, protect the Power Transformers from over load and temperature along with automatic tap changing and load sharing according to the desired voltage and load.

1.6 ORGANISATION OF THE REPORT:

This report presents about the monitoring, protection and corresponding control operation of Transformer at various load conditions. And different techniques involved in the above mentioned operation. Chapter 1: Introduces about the fundamentals of Transformer protection, monitoring and speed control. The methodology used for different operating modes are explained.

Chapter 2: The monitoring section of the project and corresponding hardware details are discussed. The overload voltage, current, load protection scheme are explained in Chapter 3.Chapter 4: describes about the Control section Chapter 5: Discuss about the PIC controller used. The Report is concluded in Chapter 6 with the inference of test results and a scope for further enhancement

1.7 SYSTEM DIAGRAM:

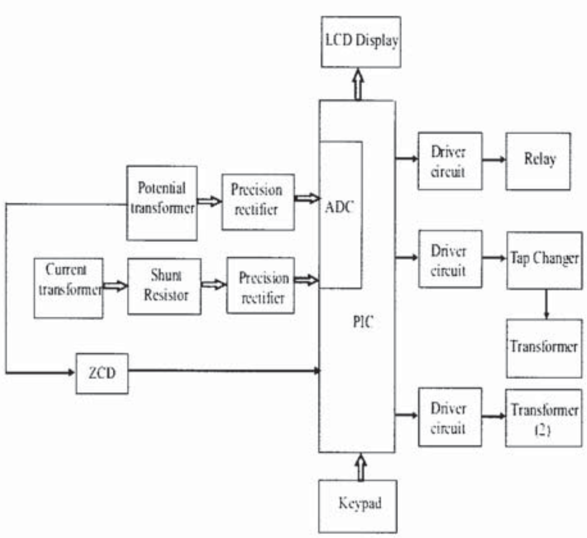


Fig 1.1 System Diagram To Control Transformer

1.8 METHODOLOGY:

The individual measuring devices, cost, complexity of the system is reduced using a PIC controller which is used to monitor and control the electrical parameters of transformer along with load sharing and tap changing capability.

1.9 MODULES UNDERTAKEN:

Monitoring and Protection:

1) Voltage
2) Current
3) Frequency

Monitoring:

The above parameters are monitored using PIC. Current and Voltage are measured by using current and potential transformers. The Frequency is measured using ZCD (Zero Cross Detector).The measured analog value is converted to digital signal inside PIC for further processing.

Protection:

The magnitude of voltage and current that are measured by their respective measuring transformers are compared with the predefined magnitude of current and voltage. If the value of the measured quantity is more than the predefined value then the PIC immediately activate the relay and trip the circuit there by protect the Transformer from Over voltage condition.

Control:

The control method involved are,

1) On-Load Tap Changer
2) Automatic Load Sharing

On-Load Tap Changer:

The voltage of the secondary of the transformer is measured using a potential transformer it is connected to the precision rectifier. The rectified output will be given to ADC which is inbuilt in the PIC microcontroller. The keypad is interfaced with microcontroller which is used to enter the desired voltage value. The microcontroller compares the acquired voltage from the transformer. Then the microcontroller activates the corresponding relay to change the tap automatically.

Automatic Load Sharing:

We use Transformers in which one act as the Main Transformer and other act as Additional Transformer. When load is connected parallel to it. Initially the loads will consume the power from the main transformer.

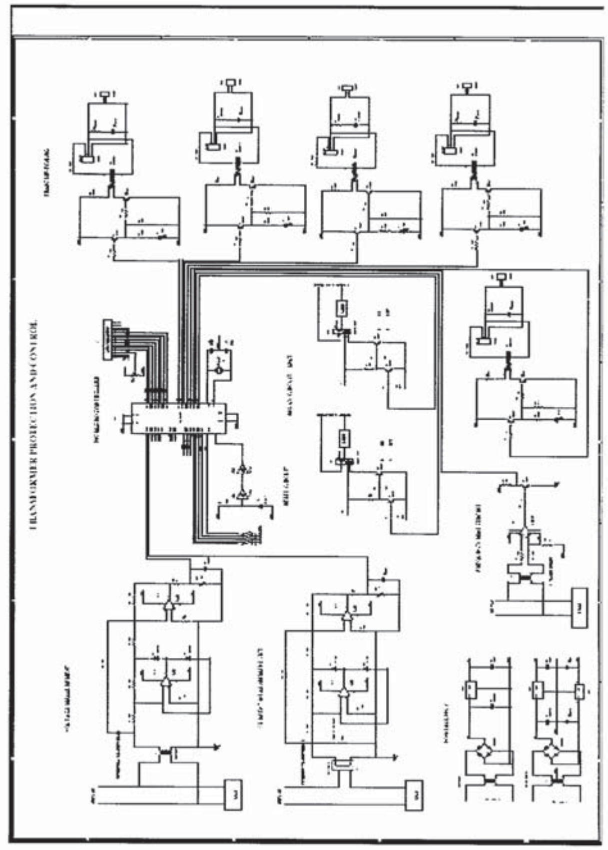
If the voltage is more than the maximum rating of the transformer the controller will activates the relay corresponding the other transformer will act according to the power required. Thus the load is shared according to the consumed power.

Display:

All the monitored parameters like voltage, current and Frequency are displayed in a LCD interfaced to PIC as a running display.

Since we have used embedded technology, the hardware is very

1.10 OVERALL CIRCUIT DIAGRAM:



1.11 OVERALL DESCRIPTION:

Power Transformer play an important role in the industries for delivering power at variable voltage and current hence for its efficient operation and long term maintenance Transformers should be monitored on regular basis. When monitoring, protection and control are done separately the circuitry becomes bulky and it needs huge space for all the equipments to be present and it also increases cost and manual operation is also necessarily needed. To avoid these problems all the three units are made as one unit and there is one digital controller (PIC) controlling all these functions.

PIC Controller is a general purpose device, which integrates a number of the components of a microprocessor system on to single chip. It has inbuilt CPU, memory and peripherals to make it as a mini computer. A Controller combines on to the same microchip. The advantage of this controller is that it is smaller in size, consumes less power and is in expensive.

The electrical parameters such as the current, voltage and frequency are continuously monitored and the transformer is protected from the over voltage and over current by using the controller, the over loading of the transformer is avoided by the load sharing technique .the change in voltage is done by selecting the corresponding key in the key pad available which is interfaced with the controller.

Voltage is stepped down by potential transformer to 5 v and it is rectified by means of a precision rectifier to overcome the loss due to the diode potential then this dc value is interfaced to the PIC controller directly since this controller has a 8 channel and a 10 bit resolution ADC. the controller. The variation of the voltage from 0 to 5 volts is directly proportional to the variation of voltage from 0 to 230 scales. For measuring the frequency we use the zero crossing detectors to detect the zero crossing of the sine wave and these zero crossing is sent as pulses to the controller and the number of pulses per second gives the frequency.

The overvoltage and over current protection is obtained through the comparison done by the controller, it compares the input voltage and the current values with the predefined values stored in the controller according to the rating of the transformer. When the voltage or the current exceeds the predefined value the relays operate and disconnect the transformer.

The overload protection is obtained by load sharing by another transformer. When the current value exceeds the current rating of the transformer during the overload period the relay is turned on and another transformer is added to share the load.

The tap changing is obtained by connecting the TRIAC switches in the secondary of the transformer according to the voltage needed, numbers of turns are included and the corresponding TRIAC is on, hence the required output voltage is obtained.

The input voltage needed is selected by the operator through the key pad available this is sensed by the controller and the corresponding TRIAC is operated. The tap changing is done when the transformer is in line. The supply to the controller is given by rectifying the single phase 230 volts supply to a 5 volts DC supply this is done through the bridge rectifier and current limiting resistors and the obtained 5 volt supply is given to the PIC controller.

CHAPTER: 2
MONITORING SECTION

2.1 VOLTAGE MEASUREMENT:

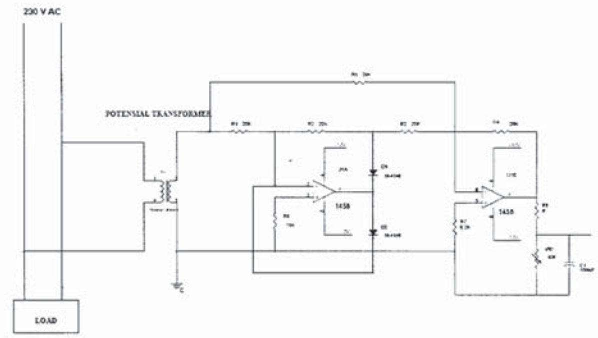


Fig 2.1 Voltage Measurement Circuit

This circuit is designed to monitor the supply voltage. The supply voltage that has to monitor is step down by the potential transformer. Usually we are using the 0-6v potential transformer. The step down voltage is rectified by the precision rectifier. The precision rectifier is a configuration obtained with an operational amplifier in order to have a circuit behaving like an ideal diode or rectifier.

The full wave rectifier is the combination of half wave precision rectifer and summing amplifier. When the input voltage is negative, there is a negative voltage on the diode too so it works like an open circuit, there is no current in the load and the output voltage is zero. When the input is positive, it is amplified by the operational amplifier and it turns the diode on. There is current in the load and because of the feedback, the output voltage is equal to the input.

The full-wave rectifier depends on the fact that both the half-wave rectifier and the summing amplifier are precision circuits. It operates by producing an inverted half-wave-rectified signal and then adding that signal at double amplitude to the original signal in the summing amplifier. The result is a reversal of the selected polarity of the input signal.

Then the output of the rectified voltage is adjusted to 0-5v with the help of variable resistor VR1. Then given to ripples are filtered by the C1 capacitor. After the filtration the corresponding DC voltage is given to PIC

2.2 CURRENT MEASUREMENT:

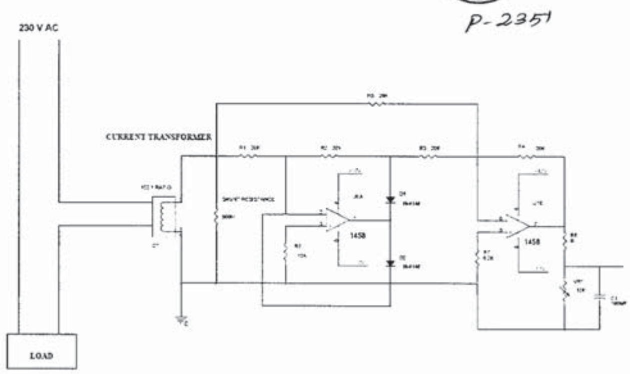


Fig 2.2 Current Measurement Circuit

This circuit is designed to monitor the supply current. The supply current that has to monitor is step down by the current transformer. The step down current is converted by the voltage with the help of shunt resistor. Then the converted voltage is rectified by the precision rectifier. The precision rectifier is a configuration obtained with an operational amplifier in order to have a circuit behaving like an ideal diode or rectifier.

The full wave rectifier is the combination of half wave precision rectifer and summing amplifier. When the input voltage is negative, there is a negative voltage on the diode too so it works like an open circuit, there is no current in the load and the output voltage is zero. When the input is positive, it is amplified by the operational amplifier and it turns the diode on. There is current in the load and because of the feedback, the output voltage is equal to the input.

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2.3 FREQUENCY MEASUREMENT:

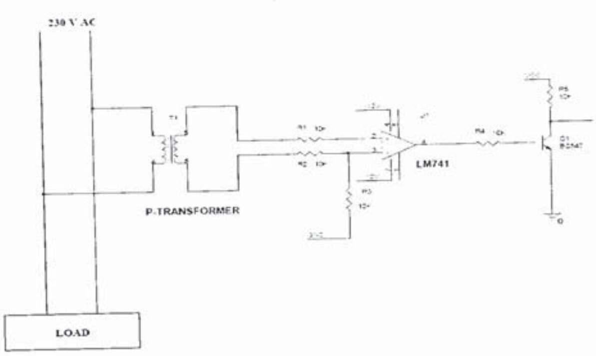


Fig 2.3 Frequency Measurement Circuit.

This circuit is designed to find the frequency in the power line. The power line voltage is monitored through the potential transformer. The potential transformer is used to step down the mains supply voltage to low voltage level. The voltage level is from 230V AC to 6V AC. Then the output of the transformer is given to Zero Crossing Detector.

The zero crossing detectors are constructed by the operational amplifier LM 741. The inverting and non inverting input terminals are connected to the potential transformer and current transformer terminals respectively. So the input sine wave signal is converted in to square wave signals. The square signal is in the range of +12v to -12v level. Then the square wave signal is given to base of the BC 547 switching transistor in order to convert the TTL voltage 0 to 5v level. This square wave signal is given to the PIC and measure the frequency with help of software.

2.4 PRESENT TAP SELECTED:

We have employed opto-isolator cum high speed switching relay, which is connected to the secondary of the transformer. Clicking the corresponding tap buttons in the keypad available the voltages are viewed in the LCD display, and the tap position can be changed.

2.5 LCD MODULE:

LCD's also used as the numerical indicators, especially in the digital watches where their much smaller current than the LED displays(microamperes compared with milli amperes) prolong battery life .Liquid crystals are organic(carbon) compounds, which exhibit both solid and Liquid properties. A'cell'with transparent metallic conductor ,called electrodes,on opposite daces ,containing a liquid crystal, and on which falls, goes dark when a voltage isapplied across the electrodes.The effect is due to molecular arrangement with in the liquid crystal.

The LCD used in the project consist of two rows.Each row consists of maximium 16 characters, so using this display only maximium of 32 characters can be displayed.

CHAPTER: 3
PROTECTION SECTION

3.1 PROTECTION METHOD AND EQUIPMENT:

- **Over Voltage protection.**
- **Over Current protection.**
- **Over load protection.**

The above parameters are sensed and verified with the base values by PIC. If the measured values exceed the base values the relay driver transmitts the signal to the relay which isolates the drive from the supply thereby protecting the motor from any faults. But in overload protection it protects it by swithing another transformer to share the load.

RELAY CIRCUIT - SPST

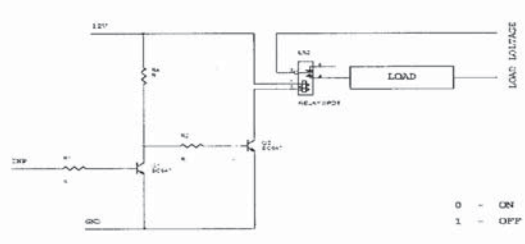


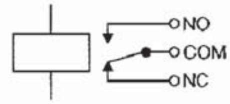
Fig 3.1 Relay Circuit.

3.2 RELAY:

A relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and they are double throw (changeover) switches. Relays allow one circuit to switch a second circuit which can be completely separate from the first. For example a low voltage battery circuit can use a relay to switch a 230V AC mains circuit. There is no electrical connection inside the relay between the two circuits; the link is magnetic and mechanical.

The coil of a relay passes a relatively large current, typically 30mA for a 12V relay, but it can be as much as 100mA for relays designed to operate from lower voltages. Most ICs (chips) cannot provide this current and a transistor is usually used to amplify the small IC current to the larger value required for the relay coil. The maximum output current for the popular 555 timer IC is 200mA so these devices can supply relay coils directly without amplification.

Relays are usually SPDT or DPDT but they can have many more sets of switch contacts, for example relays with 4 sets of changeover contacts are readily available. Most relays are designed for PCB mounting but you can solder wires directly to the pins providing you take care to avoid melting the plastic case of the relay. The animated picture shows a working relay with its coil and switch contacts. You can see a lever on the left being attracted by magnetism when the coil is switched on. This lever moves the switch contacts. There is one set of contacts (SPDT) in the foreground and another behind them, making the



The relay's switch connections are usually labeled COM, NC and NO:

- **COM** = Common, always connect to this; it is the moving part of the switch.
- **NC** = Normally Closed, COM is connected to this when the relay coil is **off**.
- **NO** = Normally Open, COM is connected to this when the relay coil is **on**.

3.3 CIRCUIT DESCRIPTION(Relay Driver):

This circuit is designed to control the load. The load may be motor or any other load. The load is turned ON and OFF through relay. The relay ON and OFF is controlled by the pair of switching transistors (BC 547). The relay is connected in the Q2 transistor collector terminal. A Relay is nothing but electromagnetic switching device which consists of three pins. They are Common, Normally close (NC) and Normally open (NO).

The relay common pin is connected to supply voltage. The normally open (NO) pin connected to load. When high pulse signal is given to base of the Q1 transistors, the transistor is conducting and shorts the collector and emitter terminal and zero signals is given to base of the Q2 transistor. So the relay is turned OFF state.

When low pulse is given to base of transistor Q1 transistor, the transistor is turned OFF. Now 12v is given to base of Q2 transistor so the transistor is conducting and relay is turned ON. Hence the common terminal and NO terminal of relay are shorted. Now load gets the supply voltage through relay.

CHAPTER: 4
CONTROL SECTION

4.1 ON-LOAD TAP CHANGING:

It is used in Industries and Electronic circuit. First the voltage of the secondary of the transformer is measured with the help of a potential transformer. This potential transformer will step down the power supply voltage (230V to 6V) level. Then the secondary of the potential transformer will be connected to the precision rectifier, which is constructed with the help of op–amp. The advantages of using precision rectifier are it will give peak voltage output as DC; rest of the circuits will give only RMS output.

Then the rectified output will be given to ADC which in built in the PIC microcontroller. In PIC microcontroller we have already programmed with our objective:

The transformer primary voltage is already fed into the controller and the number of turns in the primary is also feed. Now by knowing the secondary desired voltage obtained from the keypad, the number of turns needed for the desired voltage is calculated using the formula,

$$Ns=(Es/Ep) * Np$$

From the number of turns obtained from the formula, the controller chooses the required tap to be selected. Hence through the driver circuit, the Triac is switched on and the required voltage is obtained in the secondary side

ADC is nothing but analog to digital converter in which the analog voltage is converted into corresponding digital signal. The advantages are low power consumption, High efficiency and also we can get different voltage effectively from the Transformer.

SYSTEM DIAGRAM

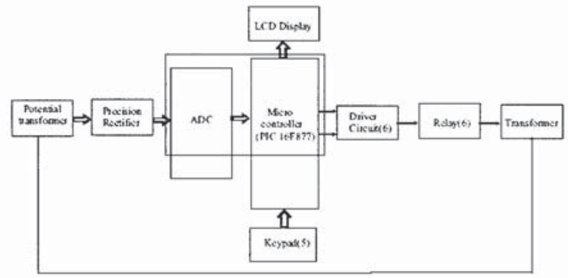


Fig 4.1 On-load Tap Changing System Diagram.

4.2 AUTOMATIC LOAD SHARER OF TRANSFORMERS

In this project we are using two Transformers one acts as the main Transformer and other acts as additional Transformers. The load is connected to the transformers parallely.

Initially the loads consume the power from the main transformer. The consumed load voltage is given to potential transformer. The AC. That AC voltage will be rectified with the help of a precision rectifier. Then the rectified output will be given to the micro controller through an analog to digital converter.

Current consumed by the loads are measured with the help of a current transformer. The current transformer will convert the load current in to lower values that current output will be converted in to voltage with the help of the shunt resistor. Then the corresponding the AC voltage will be rectified with the help of a precision rectifier. Then the rectified output will be given to the micro controller through an analog to digital converter. Analog to digital converter convert the input analog signal to corresponding digital signal which is given to microcontroller.

Here the microcontroller is the flash type reprogrammable microcontroller in which we have already programmed with our objective. When the consumed load voltage is more than the maximum rating of the Transformer, as soon as the microcontroller activates relay driver circuit. So the second Transformer connected to the load through the relays. Depending upon the consumed power, another additional transformer may also be connected to the load. So the transformers share according to the consumed power. It is of low cost, low power consumption. The load voltage and current are effectively monitored.

This project is very useful to Electricity board in order to save the domestic and power transformers life.

SYSTEM DIAGRAM:

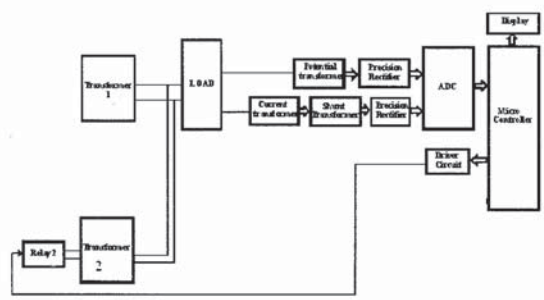


Fig 4.2 Load Sharing System Diagram

CHAPTER: 5
CONCEPTS OF PIC

5.1 PIC CONTROLLER:

Controller is a general purpose device, which integrates a number of the components of a microprocessor system on to single chip. It has inbuilt CPU, memory and peripherals to make it as a mini computer. A Controller combines on to the same microchip:

- The CPU core
- Memory(both ROM and RAM)
- Some parallel digital i/o

Controllers will combine other devices such as:

- A timer module to allow the Controller to perform tasks for certain time periods.
- A serial I/O port to allow data to flow between the Controller and other devices such as a PIC or another Controller.
- An ADC to allow the Controller to accept analogue input data for processing.

Controllers are

- Smaller in size
- Consumes less power
- Inexpensive

Micro Controller is a stand alone unit, which can perform functions on its own without any requirement for additional hardware like I/O ports and external memory. The heart of the Controller is the CPU microprocessor unit. For example Motorola uses a basic 6800 microprocessor core in their 6805/6808 Controller devices.

In the recent years, Controllers have been developed around specifically designed CPU cores, for example the microchip PIC range of Controllers.

5.2 INTRODUCTION TO PIC:

The Controller that has been used for this project is from PIC series. PIC Controller is the first RISC based Controller 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.

5.3 PIC (16F877):

Various Controllers 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.

5.4 PIC START PLUS PROGRAMMER:

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

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

5.5 SPECIAL FEATURES OF PIC CONTROLLER:

CORE FEATURES:

- High-performance RISC CPU
- Only 35 single word instructions to learn
- All single cycle instructions except for program branches which are two cycle
- Operating speed: DC - 20 MHz clock input
  DC - 200 ns instruction cycle
- Up to 8K x 14 words of Flash Program Memory,
  Up to 368 x 8 bytes of Data Memory (RAM)
  Up to 256 x 8 bytes of EEPROM data memory
- Pin out compatible to the PIC16C73/74/76/77
- Interrupt capability (up to 14 internal/external
- Eight level deep hardware stack

- Power-on Reset (POR)
- Power-up Timer (PWRT) and Oscillator Start-up Timer (OST)
- Watchdog Timer (WDT) with its own on-chip RC Oscillator for reliable operation
- Programmable code-protection
- Power saving SLEEP mode
- Selectable oscillator options
- Low-power, high-speed CMOS EPROM/EEPROM technology
- Fully static design
- In-Circuit Serial Programming (ICSP) via two pins
- Only single 5V source needed for programming capability
- In-Circuit Debugging via two pins
- Processor read/write access to program memory
- Wide operating voltage range: 2.5V to 5.5V
- High Sink/Source Current: 25 mA
- Commercial and Industrial temperature ranges
- Low-power consumption:

  < 2mA typical @ 5V, 4 MHz

  20mA typical @ 3V, 32 kHz

  < 1mA typical standby current

5.6 PERIPHERAL FEATURES:

- Timer0: 8-bit timer/counter with 8-bit prescaler
- Timer1: 16-bit timer/counter with prescaler, can be incremented during sleep via external crystal/clock
- Timer2: 8-bit timer/counter with 8-bit period register, prescaler and postscaler
- Two Capture, Compare, PWM modules

  Capture is 16-bit, max resolution is 12.5 ns,

  Compare is 16-bit, max resolution is 200 ns,

  PWM max. Resolution is 10-bit
- 10-bit multi-channel Analog-to-Digital converter
- Synchronous Serial Port (SSP) with SPI. (Master Mode) and I2C. (Master/Slave)
- Universal Synchronous Asynchronous Receiver Transmitter (USART/SCI) with

  9- Bit addresses detection.
- Brown-out detection circuitry for Brown-out Reset (BOR)

5.7 PIN Diagram of PIC 16F877:

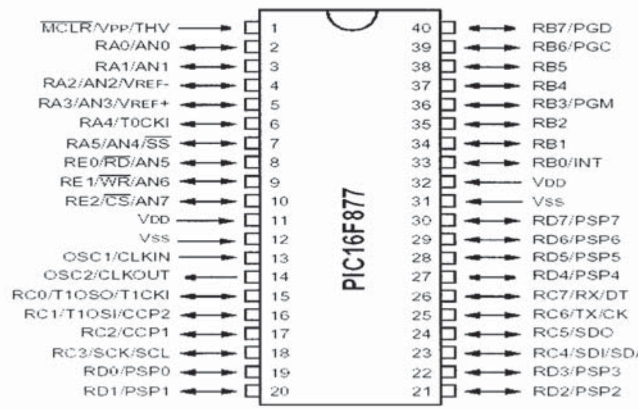


Fig 5.1 PIN Diagram of PIC 16F877

5.8 PIC Micro Controller Circuit Diagram:

PIC MICRO CONTROLLER

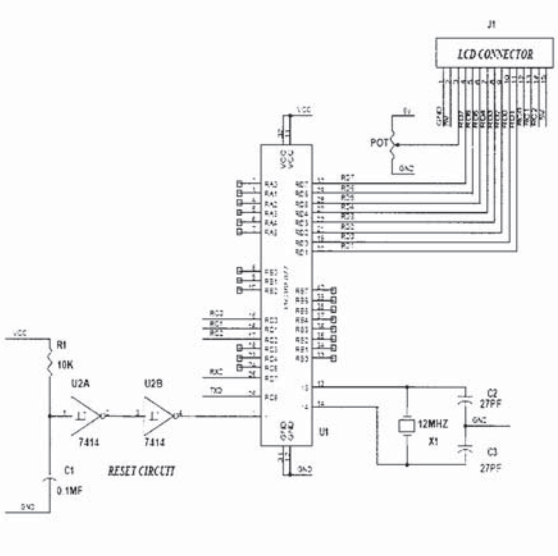


Fig 5.2 Pic Micro Controller Circuit Diagram.

5.9 I/O PORTS:

Some pins for these I/O ports are multiplexed with an alternate function for the peripheral features on the device. In general, when a peripheral is enabled, that pin may not be used as a general purpose I/O pin.

5.10 PORT A AND THE TRISA REGISTER:

PORTA is a 6-bit wide bi-directional port. The corresponding data direction register is TRISA. Setting a TRISA bit (=1) will make the corresponding PORTA pin an input, i.e., put the corresponding output driver in a Hi-impedance mode. Clearing a TRISA bit (=0) will make the corresponding PORTA pin an output, i.e., put the contents of the output latch on the selected pin. Reading the PORTA register reads the status of the pins whereas writing to it will write to the port latch. All write operations are read-modify-write operations. Therefore a write to a port implies that the port pins are read; this value is modified, and then written to the port data latch. Pin RA4 is multiplexed with the Timer0 module clock input to become the RA4/T0CKI pin. The RA4/T0CKI pin is a Schmitt Trigger input and an open drain output. All other RA port pins have TTL input levels and full CMOS output drivers. Other PORTA pins are multiplexed with analog inputs and analog VREF input. The operation of each pin is selected by clearing/setting the control bits in the ADCON1 register (A/D Control Register1).

The TRISA register controls the direction of the RA pins, even when they are being used as analog inputs. The user must ensure the bits in the TRISA register are maintained set when using them as analog inputs.

5.11 PORT B AND TRISB REGISTER:

PORTB is an 8-bit wide bi-directional port. The corresponding data direction register is TRISB. Setting a TRISB bit (=1) will make the corresponding PORTB pin an input, i.e., put the corresponding output driver in a hi-impedance mode. Clearing a TRISB bit (=0) will make the corresponding PORTB pin an output, i.e., put the contents of the output latch on the selected pin. Three pins of PORTB are multiplexed with the Low Voltage Programming function; RB3/PGM, RB6/PGC and RB7/PGD. The alternate functions of these pins are described in the Special Features Section. Each of the PORTB pins has a weak internal pull-up. A single control bit can turn on all the pull-ups.

Four of PORT B's pins, RB7:RB4, have an interrupt on change feature. Only pins configured as inputs can cause this interrupt to occur (i.e. any RB7:RB4 pin configured as an output is excluded from the interrupt on change comparison). The input pins (of RB7:RB4) are compared with the old value latched on the last read of PORTB. The "mismatch" outputs of RB7:RB4 are OR'ed together to generate the RB Port Change Interrupt with flag bit RBIF (INTCON<0>). This interrupt can wake the device from SLEEP.

5.12 PORT C AND THE TRISC REGISTER:

PORT C is an 8-bit wide bi-directional port. The corresponding data direction register is TRISC. Setting a TRISC bit (=1) will make the corresponding PORTC pin an input, i.e., put the

corresponding output driver in a hi-impedance mode. Clearing a TRISC bit (=0) will make the corresponding PORTC pin an output, i.e., put the contents of the output latch on the selected pin. PORTC is multiplexed with several peripheral functions. PORTC pins have Schmitt Trigger input buffers.

5.13 PORT D AND TRISD REGISTERS:

This section is not applicable to the 28-pin devices. PORTD is an 8-bit port with Schmitt Trigger input buffers. Each pin is individually configurable as an input or output. PORTD can be configured as an 8-bit wide microprocessor Port (parallel slave port) by setting control bit PSPMODE (TRISE<4>). In this mode, the input buffers are TTL.

5.14 PORT E AND TRISE REGISTER:

PORTE has three pins RE0/RD/AN5, RE1/WR/AN6 and RE2/CS/AN7, which are individually configurable as inputs or outputs. These pins have Schmitt Trigger input buffers.

The PORTE pins become control inputs for the microprocessor port when bit PSPMODE (TRISE<4>) is set. In this mode, the user must make sure that the TRISE<2:0> bits are set (pins are configured as digital inputs). Ensure ADCON1 is configured for digital I/O. In this mode the input buffers are TTL.

PORTE pins are multiplexed with analog inputs. When selected as an analog input, these pins will read as '0's. TRISE controls the direction of the RE pins, even when they are being used as analog inputs. The user

must make sure to keep the pins configured as inputs when using them as analog inputs.

5.15 PIC CODING:

```
#include<pic.h>
#include<lcd.h>//209 265 266

static bit rly1 @((unsigned) &PORTB*8+0);
static bit rly2 @((unsigned) &PORTB*8+1);
static bit rly3 @((unsigned) &PORTB*8+2);
static bit rly4 @((unsigned) &PORTB*8+3);
static bit rly5 @((unsigned) &PORTB*8+4);
static bit rly6 @((unsigned) &PORTB*8+5);
static bit rly7 @((unsigned) &PORTB*8+6);
static bit rly8 @((unsigned) &PORTB*8+7);


static bit pulse @((unsigned) &PORTC*8+0);
static bit rly9 @((unsigned) &PORTC*8+1);
static bit key1 @((unsigned) &PORTE*8+0);
static bit key2 @((unsigned) &PORTE*8+1);
static bit key3 @((unsigned) &PORTE*8+2);
static bit key4 @((unsigned) &PORTC*8+2);
static bit key5 @((unsigned) &PORTC*8+3);


void adc_init(void);
void adc0(void);
void adc1(void);
void hex_dec_cur(unsigned char);
void hex_dec_vol(unsigned int);
void select_tap();
void display(unsigned char);
void tmr_init();

unsigned int temp1,temp0,volt;
unsigned char j,curr,val;
unsigned char vv,freq;
unsigned int temp2,temp3,count;
```

```
void main()
{
TRISC=0x0d;
TRISB=0x00;
rly1=rly2=rly3=rly4=rly5=rly6=rly7=rly8=rly9=1;

adc_init();
lcd_init();

command(0x80);
lcd_condis("Trans. Productio",16);
command(0xc0);
lcd_condis("& Tap Changer   ",16);
delay(60000);
rly7=0;rly8=1;
delay(60000);
command(0x80);
lcd_condis("Vol:000 I:00.0  ",16);
command(0xc0);
lcd_condis("F:000 Hz        ",16);
tmr_init();
bb=aa=0;

//170 190 210 230 250 270

while(1)
{
adc0();
command(0x84);
hex_dec_vol(volt);

adc1();
command(0x8a);
hex_dec_cur(curr);

    TMR1H=0x00;
    TMR1L=0x00;
    count=0;

    while(pulse==1);
    while(pulse==0);
```

```
     while(pulse==1);
     while(pulse==0);
     TMR1ON=0;
     delay(1000);
     temp2=TMR1H;
     temp3=TMR1L;
          temp2=(temp2<<8) + temp3;
          freq=1000000/temp2;

//   freq=50;
     command(0xc2);
     hex_dec(freq);

if(curr>15 && !bb){rly7=rly8=1; bb=1;}
else  if(curr>10  &&  !aa){rly7=0;rly8=0;  aa=1;
bb=0;}

else if(!aa){rly7=0;rly8=1;}

if(volt>290 || curr>15) rly9=1;
else rly9=0;

if(!key4) select_tap();
}
}

void adc_init()
{
  ADCON1=0x02;            //   5-channel,   Left
justified, ADC control

    TRISA=0xff;           // to select the port A
as input port
  TRISA=0x07;
}

void adc0()
{
temp0=0;
 for(j=0;j<5;j++)
 {
    ADCON0=0x00;          // Channel select (Cha:
```

```
    ADON=1;                         // ADC module ON

    delay(255);
    ADCON0 =0x05;                    // selecting a
particular channel and making the go/done bit
high
    while(ADCON0!=0X01);  //      Chk      whether
conversion finished or not
     temp1 = ADRESH;            //   8   bit   value
taken into one variable
 temp0 = temp0 + temp1;
 }
volt=(temp0/5)*2;
}

void adc1()
{
temp0=0;
 for(j=0;j<5;j++)
 {
    ADCON0=0x08;
    ADON=1;
    delay(255);
    ADCON0 =0x0d;                    // selecting a
particular channel and making the go/done bit
high
    while(ADCON0!=0x09);
    temp1 = ADRESH;
     temp0 = temp0 + temp1;
 }
curr=temp0/5;
}

void hex_dec_vol(unsigned int vai)
{
 h=vai/100;
 hr=vai%100;
 t=hr/10;
 o=hr%10;

 lcd_disp(h+0x30);
 lcd_disp(t+0x30);
```

```
}


void hex_dec_cur(unsigned char vai)
{
 h=vai/100;
 hr=vai%100;
 t=hr/10;
 o=hr%10;

 lcd_disp(h+0x30);
 lcd_disp(t+0x30);
 lcd_disp('.');
 lcd_disp(o+0x30);
}

void select_tap()
{
command(0x80);
lcd_condis("Select Tapping  ",16);
command(0xc0);
lcd_condis("                ",16);

while(key3)
{
if(!key1) val++;
if(!key2) val--;
if(val>6)val=0;
display(val);
delay(6000);
}

if(val==1){rly1=0;rly2=rly3=rly4=rly5=rly6=1;}
else
if(val==2){rly2=0;rly1=rly3=rly4=rly5=rly6=1;}
else
if(val==3){rly3=0;rly2=rly1=rly4=rly5=rly6=1;}
else
if(val==4){rly4=0;rly2=rly3=rly1=rly5=rly6=1;}
else
if(val==5){rly5=0;rly2=rly1=rly4=rly3=rly6=1;}
else
```

```
else rly1=rly2=rly3=rly4=rly5=rly6=1;

command(0x80);
lcd_condis("Vol:000 I:00.0  ",16);
command(0xc0);
lcd_condis("F:000 Hz        ",16);

}

void display(unsigned char va)
{

switch(va)
{

case 1:
command(0xc0);
lcd_condis(" Voltage 170    ",16);
break;

case 2:
command(0xc0);
lcd_condis(" Voltage 190    ",16);
break;

case 3:
command(0xc0);
lcd_condis(" Voltage 210    ",16);
break;

case 4:
command(0xc0);
lcd_condis(" Voltage 230    ",16);
break;

case 5:
command(0xc0);
lcd_condis(" Voltage 250    ",16);
break;

case 6:
command(0xc0);
```

```
break;

default:
command(0xc0);
lcd_condis("None Selected    ",16);
break;

}

}

void tmr_init()
{
    GIE=1;
    PEIE=1;
    TMR1IE=1;
    TMR1ON=0;
}
```

CHAPTER: 6
TEST RESULTS & CONCLUSION

6.1 TEST RESULTS:

6.1.1 LOAD SHARING :

Procedure:

1) The load current is continuously monitored by using the current transformer.

2) When power consumed is low, the load current will also be low, so the Transformer 1 will only be ON and the System Condition will be Normal.

3) When power consumed increases and load current increases to 1.2A both the transformer are in the On condition and the load is shared.

4) When the power consumed is high and when the load current increases beyond 1.5A both the transformer are in the Off condition and the circuit is tripped.

Tabulation:

Load sharing : Current >= 1.2A.

Transformer Protected : Current >1.5A

POWER CONSUMED	LOAD CURRENT	RELAY STATE	TRANSFORMER INCLUDED	SYSTEM CONDITION
60W	0.3A	RELAY1-ON RELAY2-OFF	TRANSFORMER-1	NORMAL
200W	0.9A	RELAY1-ON RELAY2-OFF	TRANSFORMER-1	NORMAL
260W	1.3A	RELAY1-ON RELAY2-ON	TRANSFORMER-1 TRANSFORMER-2	LOAD SHARED
400W	1.8A	RELAY1-OFF RELAY2-OFF	NIL	TRIPPED

Tab 6.1 Load Sharing

6.1.2 ON-LOAD TAP CHANGING :

Procedure:

1) The primary voltage of the transformer is measured and given to the controller. The primary turns value is also set as`250 Turns.

2) The secondary voltage can be set by the keypad to any desired value as (i.e 170,190,210,230,250 etc) according to the requirement.

3) The secondary turns are calculated by the formula,

$$Ns=(Es/Ep)*Np.$$

4) According the required tap is selected.

Tabulation:

OVER VOLTAGE PROTECTION=290V

PRIMARY TURNS	PRIMARY VOLTAGE	SECONDARY VOLTAGE	SECONDARY TURNS	TAP SELECTED
250	230	170	185	1
250	230	190	207	2
250	230	210	228	3
250	230	230	250	4
250	230	250	272	5

6.2 CONCLUSION & FUTURE SCOPE:

The project facilitates to improve the life management by reducing the operating cost and enhance the availability and reliability of the transformers.

We have developed a hardware device and methodology to control over various transformer and their parameters based on PIC microcontroller [micro chip], it found to be more compact, user friendly and less complex, which can readily be used in order to perform several tedious and repetitive tasks. The evaluation of data acquired by display shows the capability to detect oncoming failures within the active part, on-load tap changer and load sharing. Though it is designed keeping in mind about the need for industry, it can extended for other purposes such as commercial & research applications.

Some of the future works that can be implemented are:

1) Pre-fault analysis using intelligent tools.
2) Determination of the life of the transformer insulation using diagnosis method.
3) Analyzing moisture content of the oil

APPENDIX

DATA SHEETS

Philips Semiconductors — Product specification

High-speed diodes — **1N4148; 1N4448**

FEATURES

- Hermetically sealed leaded glass SOD27 (DO-35) package
- High switching speed: max. 4 ns
- General application
- Continuous reverse voltage: max. 75 V
- Repetitive peak reverse voltage: max. 100 V
- Repetitive peak forward current: max. 450 mA

APPLICATIONS

- High-speed switching

DESCRIPTION

The 1N4148 and 1N4448 are high-speed switching diodes fabricated in planar technology, and encapsulated in hermetically sealed leaded glass SOD27 (DO-35) packages.

The diodes are type branded.

Fig.1 Simplified outline (SOD27; DO-35) and symbol.

LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 60134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{RRM}	repetitive peak reverse voltage		–	100	V
V_R	continuous reverse voltage		–	75	V
I_F	continuous forward current	see Fig.2; note 1	–	200	mA
I_{FRM}	repetitive peak forward current		–	450	mA
I_{FSM}	non-repetitive peak forward current	square wave; T_j = 25 °C prior to surge; see Fig.4			
		t = 1 µs	–	4	A
		t = 1 ms	–	1	A
		t = 1 s	–	0.5	A
P_{tot}	total power dissipation	T_{amb} = 25 °C; note 1	–	500	mW
T_{stg}	storage temperature		−65	+200	°C
T_j	junction temperature		–	200	°C

Note

1. Device mounted on an FR4 printed circuit-board; lead length 10 mm.

ELECTRICAL CHARACTERISTICS

T_j = 25 °C unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_F	forward voltage	see Fig.3			
	1N4148	I_F = 10 mA	–	1	V
	1N4448	I_F = 5 mA	0.62	0.72	V
		I_F = 100 mA	–	1	V
I_R	reverse current	V_R = 20 V; see Fig.5		25	nA
		V_R = 20 V; T_j = 150 °C; see Fig.5	–	50	µA
I_R	reverse current; 1N4448	V_R = 20 V; T_j = 100 °C; see Fig.5	–	3	µA
C_d	diode capacitance	f = 1 MHz; V_R = 0; see Fig.6	–	4	pF
t_{rr}	reverse recovery time	when switched from I_F = 10 mA to I_R = 60 mA; R_L = 100 Ω; measured at I_R = 1 mA; see Fig.7	–	4	ns
V_{fr}	forward recovery voltage	when switched from I_F = 50 mA; t_r = 20 ns; see Fig.8	–	2.5	V

THERMAL CHARACTERISTICS

SYMBOL	PARAMETER	CONDITIONS	VALUE	UNIT
$R_{th\ j\text{-}tp}$	thermal resistance from junction to tie-point	lead length 10 mm	240	K/W
$R_{th\ j\text{-}a}$	thermal resistance from junction to ambient	lead length 10 mm; note 1	350	K/W

MICROCHIP

PIC16F87X

28/40-pin 8-Bit CMOS FLASH Microcontrollers

Devices Included in this Data Sheet:

- PIC16F873
- PIC16F874
- PIC16F876
- PIC16F877

Microcontroller Core Features:

- High-performance RISC CPU
- Only 35 single word instructions to learn
- All single cycle instructions except for program branches which are two cycle
- Operating speed: DC - 20 MHz clock input
  DC - 200 ns instruction cycle
- Up to 8K x 14 words of FLASH Program Memory, Up to 368 x 8 bytes of Data Memory (RAM) Up to 256 x 8 bytes of EEPROM data memory
- Pinout compatible to the PIC16C73B/74B/76/77
- Interrupt capability (up to 14 sources)
- Eight level deep hardware stack
- Direct, indirect and relative addressing modes
- Power-on Reset (POR)
- Power-up Timer (PWRT) and Oscillator Start-up Timer (OST)
- Watchdog Timer (WDT) with its own on-chip RC oscillator for reliable operation
- Programmable code-protection
- Power saving SLEEP mode
- Selectable oscillator options
- Low-power, high-speed CMOS FLASH/EEPROM technology
- Fully static design
- In-Circuit Serial Programming™ (ICSP) via two pins
- Single 5V In-Circuit Serial Programming capability
- In-Circuit Debugging via two pins
- Processor read/write access to program memory
- Wide operating voltage range: 2.0V to 5.5V
- High Sink/Source Current: 25 mA
- Commercial and Industrial temperature ranges
- Low-power consumption:
  - < 2 mA typical @ 5V, 4 MHz
  - 20 µA typical @ 3V, 32 kHz
  - < 1 µA typical standby current

Pin Diagram

PDIP

Peripheral Features:

- Timer0: 8-bit timer/counter with 8-bit prescaler
- Timer1: 16-bit timer/counter with prescaler, can be incremented during sleep via external crystal/clock
- Timer2: 8-bit timer/counter with 8-bit period register, prescaler and postscaler
- Two Capture, Compare, PWM modules
  - Capture is 16-bit, max. resolution is 12.5 ns
  - Compare is 16-bit, max. resolution is 200 ns
  - PWM max. resolution is 10-bit
- 10-bit multi-channel Analog-to-Digital converter
- Synchronous Serial Port (SSP) with SPI™ (Master Mode) and I²C™ (Master/Slave)
- Universal Synchronous Asynchronous Receiver Transmitter (USART/SCI) with 9-bit address detection
- Parallel Slave Port (PSP) 8-bits wide, with external RD, WR and CS controls (40/44-pin only)
- Brown-out detection circuitry for Brown-out Reset (BOR)

Key Features PICmicro™ Mid-Range Reference Manual (DS33023)	PIC16F873	PIC16F874	PIC16F876	PIC16F877
Operating Frequency	DC - 20 MHz	DC - 20 MHz	DC - 20 MHz	DC - 20 MHz
Resets (and Delays)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)
FLASH Program Memory (14-bit words)	4K	4K	8K	8K
Data Memory (bytes)	192	192	368	368
EEPROM Data Memory	128	128	256	256
Interrupts	13	14	13	14
I/O Ports	Ports A,B,C	Ports A,B,C,D,E	Ports A,B,C	Ports A,B,C,D,E
Timers	3	3	3	3
Capture/Compare/PWM modules	2	2	2	2
Serial Communications	MSSP, USART	MSSP, USART	MSSP, USART	MSSP, USART
Parallel Communications	—	PSP	—	PSP
10-bit Analog-to-Digital Module	5 input channels	8 input channels	5 input channels	8 input channels
Instruction Set	35 Instructions	35 Instructions	35 Instructions	35 Instructions

FAIRCHILD SEMICONDUCTOR™

August 1986
Revised March 2000

DM74LS14
Hex Inverter with Schmitt Trigger Inputs

General Description

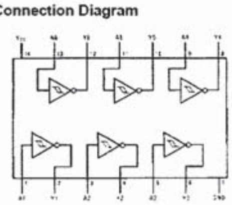
This device contains six independent gates each of which performs the logic INVERT function. Each input has hysteresis which increases the noise immunity and transforms a slowly changing input signal to a fast changing, jitter free output.

Ordering Code:

Order Number	Package Number	Package Description
DM74LS14M	M14A	14-Lead Small Outline Integrated Circuit (SOIC), JEDEC MS-120, 0.150 Narrow
DM74LS14SJ	M14D	14-Lead Small Outline Package (SOP), EIAJ TYPE II, 5.3mm Wide
DM74LS14N	N14A	14-Lead Plastic Dual-In-Line Package (PDIP), JEDEC MS-001, 0.300 Wide

Devices also available in Tape and Reel. Specify by appending the suffix letter "X" to the ordering code.

Connection Diagram



Function Table

$Y = \overline{A}$

Input	Output
A	Y
L	H
H	L

H = HIGH Logic Level
L = LOW Logic Level

National Semiconductor

May 2000

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

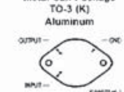
- Output current in excess of 1A
- Internal thermal overload protection
- No external components required
- Output transistor safe area protection
- Internal short circuit current limit
- Available in the aluminum TO-3 package

Voltage Range

LM7805C	5V
LM7812C	12V
LM7815C	15V

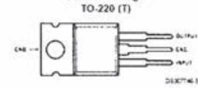
Connection Diagrams

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

Absolute Maximum Ratings (Note 3)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

Input Voltage	
(V_O = 5V, 12V and 15V)	35V
Internal Power Dissipation (Note 1)	Internally Limited
Operating Temperature Range (T_A)	0°C to +70°C
Maximum Junction Temperature	
(K Package)	150°C
(T Package)	150°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 sec.)	
TO-3 Package K	300°C
TO-220 Package T	230°C

Electrical Characteristics LM78XXC (Note 2)

0°C ≤ T_J ≤ 125°C unless otherwise noted.

Output Voltage			5V			12V			15V			Units
Input Voltage (unless otherwise noted)			10V			19V			23V			
Symbol	Parameter	Conditions	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
V_O	Output Voltage	T_J = 25°C, 5 mA ≤ I_O ≤ 1A	4.8	5	5.2	11.5	12	12.5	14.4	15	15.6	V
		P_D ≤ 15W, 5 mA ≤ I_O ≤ 1A	4.75		5.25	11.4		12.6	14.25		15.75	V
		V_{MIN} ≤ V_{IN} ≤ V_{MAX}	(7.5 ≤ V_{IN} ≤ 20)			(14.5 ≤ V_{IN} ≤ 27)			(17.5 ≤ V_{IN} ≤ 30)			V
ΔV_O	Line Regulation	I_O = 500 mA, T_J = 25°C		3	50		4	120		4	150	mV
		ΔV_{IN}	(7 ≤ V_{IN} ≤ 25)			(14.5 ≤ V_{IN} ≤ 30)			(17.5 ≤ V_{IN} ≤ 30)			V
		0°C ≤ T_J ≤ +125°C			50			120			150	mV
		ΔV_{IN}	(8 ≤ V_{IN} ≤ 20)			(15 ≤ V_{IN} ≤ 27)			(18.5 ≤ V_{IN} ≤ 30)			V
		I_O ≤ 1A, T_J = 25°C			50			120			150	mV
		ΔV_{IN}	(7.5 ≤ V_{IN} ≤ 20)			(14.6 ≤ V_{IN} ≤ 27)			(17.7 ≤ V_{IN} ≤ 30)			V
		0°C ≤ T_J ≤ +125°C			25			60			75	mV
		ΔV_{IN}	(8 ≤ V_{IN} ≤ 12)			(16 ≤ V_{IN} ≤ 22)			(20 ≤ V_{IN} ≤ 25)			V
ΔV_O	Load Regulation	T_J = 25°C, 5 mA ≤ I_O ≤ 1.5A		10	50		12	120		12	150	mV
		250 mA ≤ I_O ≤ 750 mA			25			60			75	mV
		5 mA ≤ I_O ≤ 1A, 0°C ≤ T_J ≤ +125°C			50			120			150	mV
I_Q	Quiescent Current	I_O ≤ 1A, T_J = 25°C			8			8			8	mA
		0°C ≤ T_J ≤ +125°C			8.5			8.5			8.5	mA
ΔI_Q	Quiescent Current Change	5 mA ≤ I_O ≤ 1A			0.5			0.5			0.5	mA
		T_J = 25°C, I_O ≤ 1A			1.0			1.0			1.0	mA
		V_{MIN} ≤ V_{IN} ≤ V_{MAX}	(7.5 ≤ V_{IN} ≤ 20)			(14.8 ≤ V_{IN} ≤ 27)			(17.9 ≤ V_{IN} ≤ 30)			V
		I_O ≤ 500 mA, 0°C ≤ T_J ≤ +125°C			1.0			1.0			1.0	mA
		V_{MIN} ≤ V_{IN} ≤ V_{MAX}	(7 ≤ V_{IN} ≤ 25)			(14.5 ≤ V_{IN} ≤ 30)			(17.5 ≤ V_{IN} ≤ 30)			V
V_N	Output Noise Voltage	T_A = 25°C, 10 Hz ≤ f ≤ 100 kHz		40			75			90		μV
$\frac{\Delta V_{IN}}{\Delta V_{OUT}}$	Ripple Rejection	f = 120 Hz, I_O ≤ 1A, T_J = 25°C or	62	80		55	72		54	70		dB
		f = 120 Hz, I_O ≤ 500 mA, 0°C ≤ T_J ≤ +125°C	62			55			54			dB
		V_{MIN} ≤ V_{IN} ≤ V_{MAX}	(8 ≤ V_{IN} ≤ 18)			(15 ≤ V_{IN} ≤ 25)			(18.5 ≤ V_{IN} ≤ 28.5)			V
R_O	Dropout Voltage	T_J = 25°C, I_{OUT} = 1A		2.0			2.0			2.0		V
	Output Resistance	f = 1 kHz		8			18			19		mΩ

Electrical Characteristics LM78XXC (Note 2) (Continued)

0°C ≤ T_J ≤ 125°C unless otherwise noted.

Output Voltage			5V			12V			15V			Units
Input Voltage (unless otherwise noted)			10V			19V			23V			
Symbol	Parameter	Conditions	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
	Short-Circuit Current	T_J = 25°C		2.1			1.5			1.2		A
	Peak Output Current	T_J = 25°C		2.4			2.4			2.4		A
	Average TC of V_{OUT}	0°C ≤ T_J ≤ +125°C, I_O = 5 mA		0.6			1.5			1.8		mV/°C
V_{IN}	Input Voltage Required to Maintain Line Regulation	T_J = 25°C, I_O ≤ 1A		7.5		14.6			17.7			V

Note 1: Thermal resistance of the TO-3 package (K, KC) is typically 4°C/W junction to case and 35°C/W case to ambient. Thermal resistance of the TO-220 package (T) is typically 4°C/W junction to case and 50°C/W case to ambient.

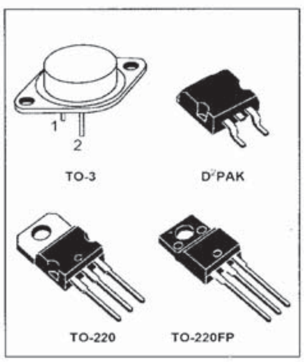
Note 2: All characteristics are measured with capacitor across the input of 0.22 μF, and a capacitor across the output of 0.1μF. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques (t_w ≤ 10 ms, duty cycle ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

Note 3: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. For guaranteed specifications and the test conditions, see Electrical Characteristics.

L7800 SERIES

POSITIVE VOLTAGE REGULATORS

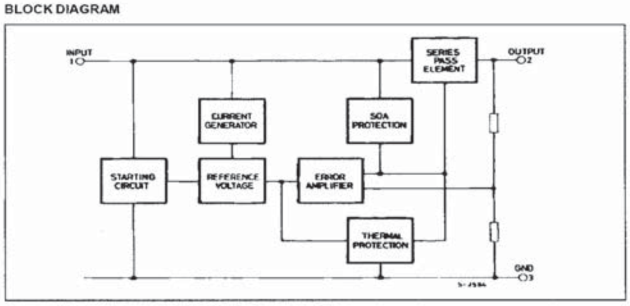
- OUTPUT CURRENT UP TO 1.5 A
- OUTPUT VOLTAGES OF 5; 5.2; 6; 8; 8.5; 9; 12; 15; 18; 24V
- THERMAL OVERLOAD PROTECTION
- SHORT CIRCUIT PROTECTION
- OUTPUT TRANSITION SOA PROTECTION



DESCRIPTION

The L7800 series of three-terminal positive regulators is available in TO-220 TO-220FP TO-3 and D²PAK packages and several fixed output voltages, making it useful in a wide range of applications. These regulators can provide local on-card regulation, eliminating the distribution problems associated with single point regulation. Each type employs internal current limiting, thermal shut-down and safe area protection, making it essentially indestructible. If adequate heat sinking is provided, they can deliver over 1A output current. Although designed primarily as fixed voltage regulators, these devices can be used with external components to obtain adjustable voltages and currents.

BLOCK DIAGRAM



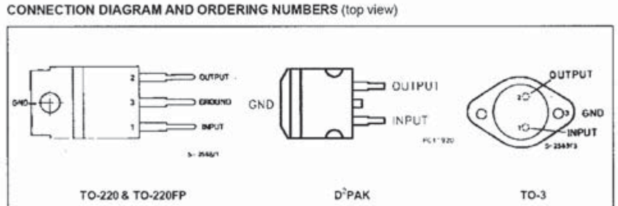
ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_i	DC Input Voltage (for V_O = 5 to 18V) (for V_O = 20, 24V)	35 40	V V
I_o	Output Current	Internally limited	
P_{tot}	Power Dissipation	Internally limited	
T_{op}	Operating Junction Temperature Range (for **L7800**) (for **L7800C**)	-55 to 150 0 to 150	°C °C
T_{stg}	Storage Temperature Range	-65 to 150	°C

THERMAL DATA

Symbol	Parameter		D²PAK	TO-220	TO-220FP	TO-3	Unit
$R_{thj-case}$	Thermal Resistance Junction-case	Max	3	3	5	4	°C/W
$R_{thj-amb}$	Thermal Resistance Junction-ambient	Max	62.5	50	60	35	°C/W

CONNECTION DIAGRAM AND ORDERING NUMBERS (top view)



Type	TO-220	D²PAK (*)	TO-220FP	TO-3	Output Voltage
L7805				L7805T	5V
L7805C	L7805CV	L7805CD2T	L7805CP	L7805CT	5V
L7852C	L7852CV	L7852CD2T	L7852CP	L7852CT	5.2V
L7806				L7806T	6V
L7806C	L7806CV	L7806CD2T	L7806CP	L7806CT	6V
L7808				L7808T	8V
L7808C	L7808CV	L7808CD2T	L7808CP	L7808CT	8V
L7885C	L7885CV	L7885CD2T	L7885CP	L7885CT	8.5V
L7809C	L7809CV	L7809CD2T	L7809CP	L7809CT	9V
L7812				L7812T	12V
L7812C	L7812CV	L7812CD2T	L7812CP	L7812CT	12V
L7815				L7815T	15V
L7815C	L7815CV	L7815CD2T	L7815CP	L7815CT	15V
L7818				L7818T	18V
L7818C	L7818CV	L7818CD2T	L7818CP	L7818CT	18V
L7820				L7820T	20V
L7820C	L7820CV	L7820CD2T	L7820CP	L7820CT	20V
L7824				L7824T	24V
L7824C	L7824CV	L7824CD2T	L7824CP	L7824CT	24V

(*) AVAILABLE IN TAPE AND REEL WITH "TR" SUFFIX

Order this document by MC7900/D

MOTOROLA

Three-Terminal Negative Voltage Regulators

MC7900 Series

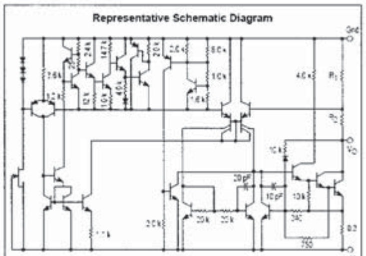
THREE–TERMINAL NEGATIVE FIXED VOLTAGE REGULATORS

The MC7900 series of fixed output negative voltage regulators are intended as complements to the popular MC7800 series devices. These negative regulators are available in the same seven–voltage options as the MC7800 devices. In addition, one extra voltage option commonly employed in MECL systems is also available in the negative MC7900 series.

Available in fixed output voltage options from –5.0 V to –24 V, these regulators employ current limiting, thermal shutdown, and safe–area compensation – making them remarkably rugged under most operating conditions. With adequate heatsinking they can deliver output currents in excess of 1.0 A.

- No External Components Required
- Internal Thermal Overload Protection
- Internal Short Circuit Current Limiting
- Output Transistor Safe–Area Compensation
- Available in 2% Voltage Tolerance (See Ordering Information)

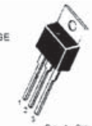
Representative Schematic Diagram



This device contains 26 active transistors.

T SUFFIX
PLASTIC PACKAGE
CASE 221A

Heatsink surface connected to Pin 2

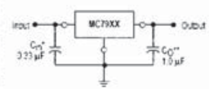


Pin 1 Ground
2 Input
3 Output

D2T SUFFIX
PLASTIC PACKAGE
CASE 936
(D^2PAK)

Heatsink surface (shown as terminal 4 in case outline drawing) is connected to Pin 2.

STANDARD APPLICATION



A common ground is required between the input and the output voltages. The input voltage must remain typically 2.0 V above more negative even during the high point of the input ripple voltage.

XX, These two digits of the type number indicate nominal voltage.
* C_{in} is required if regulator is located an appreciable distance from power supply filter.
** C_O improve stability and transient response.

ORDERING INFORMATION

Device	Output Voltage Tolerance	Operating Temperature Range	Package
MC79XXACD2T	2%	T_J = 0° to +125°C	Surface Mount
MC79XXCD2T	4%		
MC79XXACT	2%		Insertion Mount
MC79XXCT	4%		
MC79XXBD2T	4%	T_J = –40° to +125°C	Surface Mount
MC79XXBT			Insertion Mount

XX indicates nominal voltage

DEVICE TYPE/NOMINAL OUTPUT VOLTAGE

MC7905	5.0 V	MC7912	12 V
MC7905.2	5.2 V	MC7915	15 V
MC7906	6.0 V	MC7918	18 V
MC7908	8.0 V	MC7924	24 V

 Rev 6

NPN general purpose transistors BC546; BC547

FEATURES

- Low current (max. 100 mA)
- Low voltage (max. 65 V).

APPLICATIONS

- General purpose switching and amplification.

DESCRIPTION

NPN transistor in a TO-92; SOT54 plastic package.
PNP complements: BC556 and BC557.

PINNING

PIN	DESCRIPTION
1	emitter
2	base
3	collector

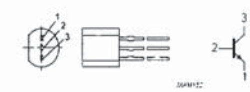


Fig.1 Simplified outline (TO-92; SOT54) and symbol.

LIMITING VALUES

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

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CEO}	collector-base voltage	open emitter			
	BC546		–	80	V
	BC547		–	50	V
V_{CEO}	collector-emitter voltage	open base			
	BC546		–	65	V
	BC547		–	45	V
V_{EBO}	emitter-base voltage	open collector			
	BC546		–	6	V
	BC547		–	6	V
I_C	collector current (DC)		–	100	mA
I_{CM}	peak collector current		–	200	mA
I_{BM}	peak base current		–	200	mA
P_{tot}	total power dissipation	T_{amb} ≤ 25 °C; note 1	–	500	mW
T_{stg}	storage temperature		–65	+150	°C
T_j	junction temperature		–	150	°C
T_{amb}	operating ambient temperature		–65	+150	°C

Note

1. Transistor mounted on an FR4 printed-circuit board.

Philips Semiconductors Product specification

NPN general purpose transistors BC546; BC547

THERMAL CHARACTERISTICS

SYMBOL	PARAMETER	CONDITIONS	VALUE	UNIT
$R_{th\ j-a}$	thermal resistance from junction to ambient	note 1	0.25	K/mW

Note

1. Transistor mounted on an FR4 printed-circuit board.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
I_{CBO}	collector cut-off current	I_E = 0; V_{CB} = 30 V	–	–	15	nA
		I_E = 0; V_{CB} = 30 V; T_j = 150 °C	–	–	5	µA
I_{EBO}	emitter cut-off current	I_C = 0; V_{EB} = 5 V	–	–	100	nA
h_{FE}	DC current gain	I_C = 10 µA; V_{CE} = 5 V; see Figs 2, 3 and 4				
	BC546A		–	90	–	
	BC546B; BC547B		–	150	–	
	BC547C		–	270	–	
	DC current gain	I_C = 2 mA; V_{CE} = 5 V; see Figs 2, 3 and 4				
	BC546A		110	180	220	
	BC546B; BC547B		200	290	450	
	BC547C		420	520	800	
	BC547		110	–	800	
	BC546		110	–	450	
V_{CEsat}	collector-emitter saturation voltage	I_C = 10 mA; I_B = 0.5 mA	–	90	250	mV
		I_C = 100 mA; I_B = 5 mA	–	200	600	mV
V_{BEsat}	base-emitter saturation voltage	I_C = 10 mA; I_B = 0.5 mA; note 1	–	700	–	mV
		I_C = 100 mA; I_B = 5 mA; note 1	–	900	–	mV
V_{BE}	base-emitter voltage	I_C = 2 mA; V_{CE} = 5 V; note 2	580	660	700	mV
		I_C = 10 mA; V_{CE} = 5 V	–	–	770	mV
C_c	collector capacitance	I_E = i_e = 0; V_{CB} = 10 V; f = 1 MHz	–	1.5	–	pF
C_e	emitter capacitance	I_C = i_c = 0; V_{EB} = 0.5 V; f = 1 MHz	–	11	–	pF
f_T	transition frequency	I_C = 10mA; V_{CE} = 5 V; f = 100 MHz	100	–	–	MHz
F	noise figure	I_C = 200 µA; V_{CE} = 5 V; R_S = 2 kΩ; f = 1 kHz; B = 200 Hz	–	2	10	dB

Notes

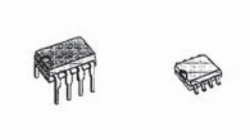
1. V_{BEsat} decreases by about 1.7 mV/K with increasing temperature.
2. V_{BE} decreases by about 2 mV/K with increasing temperature.

SGS-THOMSON MICROELECTRONICS

UA741

GENERAL PURPOSE SINGLE OPERATIONAL AMPLIFIERS

- LARGE INPUT VOLTAGE RANGE
- NO LATCH-UP
- HIGH GAIN
- SHORT-CIRCUIT PROTECTION
- NO FREQUENCY COMPENSATION REQUIRED
- SAME PIN CONFIGURATION AS THE UA709
- ESD INTERNAL PROTECTION



N
DIP8
(Plastic Package)

D
SO8
(Plastic Micropackage)

DESCRIPTION

The UA741 is a high performance monolithic operational amplifier constructed on a single silicon chip. It is intented for a wide range of analog applications.

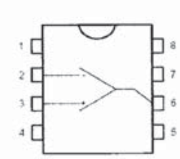
- Summing amplifier
- Voltage follower
- Integrator
- Active filter
- Function generator

The high gain and wide range of operating voltages provide superior performances in integrator, summing amplifier and general feedback applications. The internal compensation network (6dB / octave) insures stability in closed loop circuits.

ORDER CODES

Part Number	Temperature Range	Package N	Package D
UA741C/E	0°C, +70°C	•	•
UA741I	-40°C, +105°C	•	•
UA741M/A	-55°C, +125°C	•	•
Example : UA741CN			

PIN CONNECTIONS (top view)



1 - Offset null 1
2 - Inverting input
3 - Non-inverting input
4 - V_{CC}^-
5 - Offset null 2
6 - Output
7 - V_{CC}^+
8 - N.C.

National Semiconductor

February 1995

LM1558/LM1458 Dual Operational Amplifier

General Description

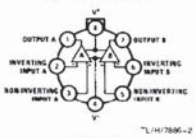
The LM1558 and the LM1458 are general purpose dual operational amplifiers. The two amplifiers share a common bias network and power supply leads. Otherwise, their operation is completely independent.

The LM1458 is identical to the LM1558 except that the LM1458 has its specifications guaranteed over the temperature range from 0°C to +70°C instead of -55°C to +125°C.

Features

- No frequency compensation required
- Short-circuit protection
- Wide common-mode and differential voltage ranges
- Low-power consumption
- 8-lead can and 8-lead mini DIP
- No latch up when input common mode range is exceeded

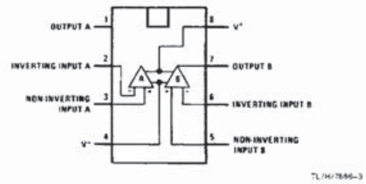
Metal Can Package



Top View

Order Number LM1558H, LM1558H/883 or LM1458H
See NS Package Number H08C

Dual-In-Line Package



Top View

Order Number LM1558J, LM1558J/883, LM1458J, LM1458M or LM1458N
See NS Package Number J08A, M08A or N08E

Absolute Maximum Ratings

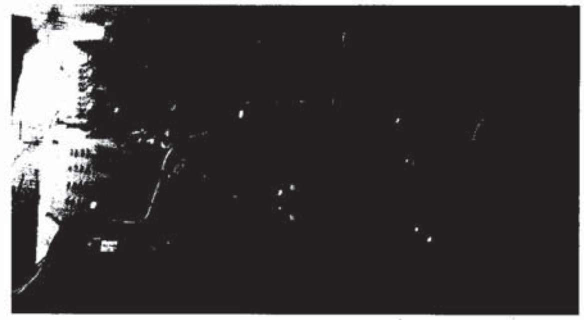
If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications. (Note 4)

Supply Voltage	
LM1558	±22V
LM1458	±18V
Power Dissipation (Note 1)	
LM1558H/LM1458H	500 mW
LM1458N	400 mW
Differential Input Voltage	±30V
Input Voltage (Note 2)	±15V
Output Short-Circuit Duration	Continuous
Operating Temperature Range	
LM1558	-55°C to +125°C
LM1458	0°C to +70°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (Soldering, 10 sec.)	260°C
Soldering Information	
Dual-In-Line Package	
Soldering (10 seconds)	260°C
Small Outline Package	
Vapor Phase (60 seconds)	215°C
Infrared (15 seconds)	220°C

See AN-450 "Surface Mounting Methods and Their Effect on Product Reliability" for other methods of soldering surface mount devices.

ESD tolerance (Note 5)	300V

PHOTOS:



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