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DESIGN AND IMPLEMENTATION OF AN AUTO-TEMP CONTROL SYSTEM FOR DISTRIBUTION TRANSFORMER

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ABSTRACT

Unreliability and interruptions facing power supply are evidence of the excessive heat generated in power systems, as a result of the inefficiency of oil cooling medium employed in distribution transformers. The design and implementation of a prototype automatic temperature control system is to be employed as a method towards solving the above stated problem of excessive temperature rise in distribution transformers. The prototype design consists of a PIC microcontroller programmed in C language, an LM35 temperature sensor, an electric fan and other diverse electronic component. It operates a mechanism that detects temperature rise in the transformer and automatically turns on the cooling fan at extreme temperature conditions. A 16x2 LCD is employed as the medium for temperature display unit of the transformer. The resulting prototype functions in a way that it has the ability to detect every 1^{o}C rise and reduction in the temperature of the transformer. Thus, at extreme temperature conditions, the automatic temperature control system diminishes the excessive heat generated in the transformer to the appropriate working temperature condition.

Keywords: *cooling, distribution transformers, heat, prototype, PIC microcontroller, temperature control system*

INTRODUCTION

A transformer can be referred to as a power transmission device system that basically converts one voltage level into another voltage level without altering the frequency of the system. During this conversion process, losses occur in the core and windings of the said system. These losses are generally termed heat losses. As a result of these losses in the transformer. the output power of the transformer drops and returns a bit less than its input power. The increase in the rating and capacity of a transformer directly results to an increase in its generated heat. There are different mediums of cooling system conversant with this power system device, they basically include: air, water, oil mediums of cooling systems. The oil and water-cooling mediums of cooling systems in the past years has been done manually. Due to its manual operation characteristic, it is faced with the disadvantage and challenge of not recognizing over heating (Bharathidasan, *et al.*, 2019).

Transformer design most takes into consideration the thermal behavioral aspect. Therefore, precise and proper temperature calculations to a reasonable extent guarantees good quality, performance and long-life expectancy of transformers. The temperature gradient between conductor and oil consists of a gradient inside the solid winding insulation and a gradient inside the boundary layer at the winding surface must be optimal. The gradient inside the solid insulation depends on the thickness of the enamel, paper insulation and oil pockets between conductor and paper wrapping. The heat transfer at the winding surface of a transformer is determined by the cooling conditions approach. The two basic approaches mostly in use are: The Natural Convective Cooling (ON) and The Forced Convective Cooling (OD).

During the operation of the transformers, heat losses occur and the windings temperature get heated up. Heat losses in the transformer include the losses in iron core, due to the magnetic induction and the copper losses that occur as a result of the flow of electrical current through the windings of the transformer. It is paramount to set up a medium of external cooling system to reduce the heating up of the transformer winding temperature. While the standard average temperatures for the standard-class dry transformers are 80ºC, 115 ºC and 150 ºC, the temperatures of the hottest point reach 150 ºC, 185 ºC and 220 ºC respectively. The expected life of transformers at various operating temperatures is not exactly known. (Buyukbicakci *et al.*, 2014).

LITERATURE REVIEW

Amuthan *et al.*, (2017) designed a quadrant cooling type transformer, in this medium, the transformer is cooled by the exterior fan using solar energy. The fans are located in different quadrants with an angle difference of 45 degrees in each quadrant. This method is synonymous to the ONAF method in which air is blown on the cooling fin of the transformer from four angles thereby generating swift cooling. The fans are directly connected to solar panels in this case therefore constant cooling occurs whenever UV rays comes up.

Tekade and Rakhonde (2014) created a microcontroller-based cooling system for transformers. Transformer cooling control was achieved by using an ATmega8L microcontroller handled the automation cooling mechanism of the transformer. The microcontroller senses excessive rise in the winding temperature and the oil temperature via a temperature indicator and oil temperature indicator and then automatically puts on the fan or trip the transformer conditioned on the temperature level of the transformer to curtail overheating and decline in the life span of the transformer life.

Modi (2012) also did a project on the control panel of the transformer employing the services of a microcontroller and power electronics device. In his work, the heat generated in the transformer is transposed directly to the heat sinks and there, cooling mediums (i.e. fans) made available outside the transformer works the transformer walls. The fans outside the transformer are given a parallel form of connection arrangement.

METHODOLOGY

This section of the article explains the method (i.e. the design consideration and construction) employed in solving the initial stated problems. For the construction of the prototype, the electrical components listed below were employed in the design following due consideration and calculation process. Components are as follows;

- Temperature sensor
- Microcontroller
- LCD display
- Diodes
- Capacitors
- Resistors
- Relay
- Voltage regulator
- Push button
- Buzzer

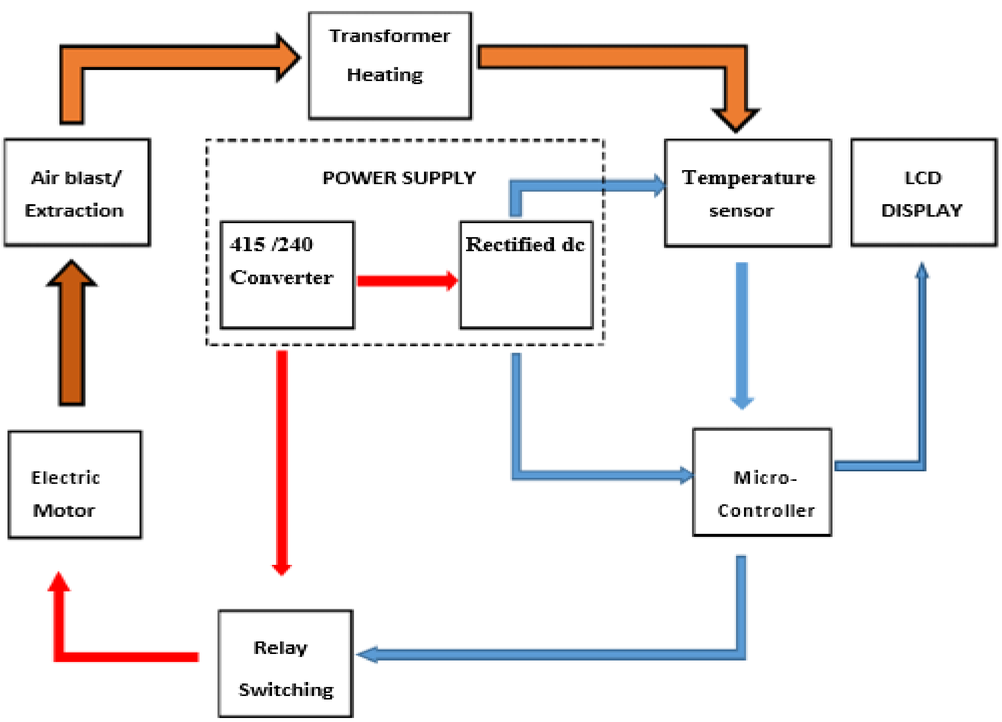

Figure 1: Block diagram for the design consideration

DESIGN CONSIDERATIONS AND CALCULATION REQUIREMENTS

The different stages involved in the design of the automatic temperature control system of a distribution transformer are as follows:

1. Power supply.
2. Microcontroller circuit
3. Temperature sensor
4. LCD display unit
5. Buzzer
6. Control buttons
7. Fan

TRANSFORMER

The transformer is a single-phase step down 220V/12V with a maximum secondary current rating of 0.75A. Making some design assumptions, let:

IS_{max} = Maximum Secondary Current= 0.75A

VP_{max} = Primary Voltage = 220V
VS_{max} = Secondary Voltage= 12V

PT = Transformer Max. Output Power

$$PT = VS_{max} \times IS_{max} \quad (1)$$

PT = 12V x 0.75A = 9VA

DIODE BRIDGE

Diodes generally offers a forward voltage drop of 0.7Volts to every voltage supplied into them and offers a voltage drop of 1.4V against every half cycle of the alternating voltage supplied into the bridge. Mathematically, this is expressed below using the following equations.

VS_{max} = Input voltage to diode bridge
V_{DIODE} = Diode forward Drop =0.7V

$$V_{OUT} = VS_{max} – 2\ (V_{Diode}) \quad (2)$$

V_{OUT} = 12V – (2 x 0.7)
V_{OUT} = 10.6V

The equivalent output DC Voltage from the diode bridge:

$V_{DC} = V_{OUT} \times 0.7071$

$V_{DC} = 10.61 \times 0.7071$
V_{DC} = 7.501V

The output power (P_{out}) in watts of the rectifier:

$P_{out} = V_{dc} \times IS_{max}$
$P_{out} = 7.501 \times 0.75$
P_{out} = 5.63watts

FILTER CAPACITOR

A capacitor is placed on the output of the diode bridge to smoothen out ripples from the pulsating DC voltage produced from the diode bridge. The ripple factor is a ratio of the ripple voltage (V_{RPP}) to the DC voltage on the output of the rectifier.

V_{RPP} = Vout – Vdc (3)

V_{RPP} = 10.61 – 7.50
V_{RPP} = 3.11V

Ripple Factor, (γ) = V_{RPP}/ V_{DC} (4)

γ = 3.11/7.501 = 0.415

The capacitance of a capacitor suitable to smoothen out an AC voltage with such ripple voltage can be calculated using the expression below

C = 0.7 * I / V_{RPP} * F (5)

Where,
I = max output current = 0.75A
F = Pulsating DC Frequency = 2 x AC voltage frequency

F = 2 x f, f = 50Hz; F = 2 x 50Hz; F = 100Hz

Calculating Peak to peak ripple voltage,
V_{RPP} = Peak to peak ripple voltage
V_{RPP} = 2 x Vrpp (6)
V_{RPP} = 2 x 3.11V
V_{RPP} = 6.22V

C = Capacitance of a capacitor,
C = (0.7*0.75A) /(6.22*100Hz)
C = 0.0008441F
C = 844.1µF

An 844.1µF capacitor is not feasible, and as such a 1000µF electrolytic capacitor will be employed. The effect of a 1000µF capacitor on the ripple voltage at the output of the rectifier circuit can be calculated using the expression as follows:

Change in V_{RPP} = 0.7 * I / C * F (7)
Change in V_{RPP} = 0.7 * 0.75 / 1000 µF * 100Hz
= 5.25V
V_{RPP} = 5.25V / 2
V_{RPP} = 2.625V

VOLTAGE REGULATOR

The LM7805 IC voltage regulator can supply a regulated power at 5V and a maximum current of 1A. The LM78XX voltage regulator series can effectively operate when the voltage supplied to its input is at least 2V greater than its output voltage. LM7805 whose output is 5V, the minimum input voltage can is calculated as follows;

$V_{min} = V_{out} + V_{ref}$

Where,

V_{min} = minimum input voltage.

V_{out} = required output voltage = 5V

V_{ref} = reference voltage = 2V

V_{min} = 5+2 = 7V

V_{DC} = 7.501V and as such is greater than 7V, thus the LM7805 can be employed as the voltage regulator. The LM7805 tolerance of ±0.2V at its output, hence at full load (i.e. 1mA) its output voltage drops to 4.8V as such its percentage voltage regulation is calculated as:

Voltage Regulation = (V_{NL}- V_{FL}) / V_F
V_{FL} = Full Load voltage
V_{NL} = No Load voltage
V_{NL} = 5V; V_{FL} = 5V – 0.2V = 4.8V
VR = (5V- 4.8V / 4.8) * 100 = 4.17%

MICROCONTROLLER
The microcontroller section consists of the power, reset button and the oscillator circuit.

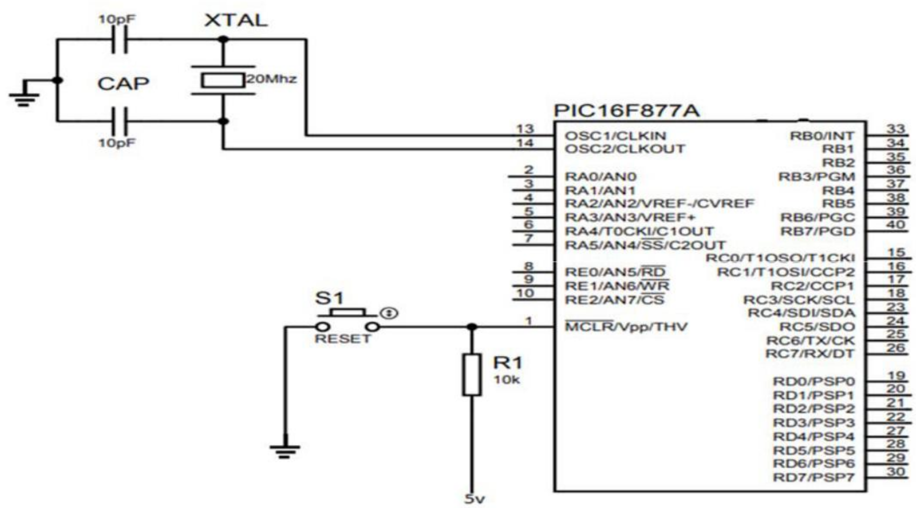

Figure 2: Microcontroller Unit

MICROCONTROLLER POWER SUPPLY
The microcontroller is supplied with a stable 5V at its V_{dd} pin 13 and 32 while it is grounded at its V_{ss} pin at 12 and 31 respectively.

OSCILLATOR
The fastest and the maximum working operation of the microcontroller is achieved when it is driven by a 20MHz oscillator as seen from the microcontroller's datasheet. Microcontroller instruction execution speed is the rate in terms of time in which the microcontroller will execute the commands stored in its program memory.

Microcontroller's instruction execution speed = (1 / Frequency) * 4 cycles. At a frequency of 20MHz, the execution speed of the microcontroller can be calculated as;

(1 / 20000000) * 4 cycles = 20µS

Frequency (MHz)	Frequency Tolerance (ppm max.) [at 25°C±3°C]	Frequency Shift by Temperature (ppm max.) [Standard Condition: +25°C]	Frequency Aging (ppm max./Year)	ESR* (Ωmax.)	Load Capacitance (pF)	Drive Level (μW max.)
20.0000	±100	±100 (-30 to +85°C)	±5	80	8	300

Figure 3: Datasheet of 20mhz crystal oscillator

OSCILLATOR LOADING CAPACITOR JUSTIFICATION

The 20MHz crystal oscillator uses two supporting capacitors; C_1 and C_2, these capacitors help ensure that each pulse produced by the crystal oscillator is perfectly timed. The parasitic capacitance ($C_{parasitic}$): $C_{parasitic} = C_{input} + C_{stray}$

We can therefore calculate value of the capacitors the across the 20MHz crystal by applying the formula;

$$C_L = 1 / (1/C_2 + 1/ C_3) + C_{Paracitic} \qquad (8)$$

Where $C_2 = C_3 = C$

$C_L = 1 / (1/C + 1/ C) + C_{Paracitic}$

$C_{Paracitic} = 0$, CL = Loading capacitor = 8Pf

$C_L = 1 / (1/C + 1/ C) + 0$

C = 2 x CL; C = 2 x 8pF = 16pF

A 16pF capacitor is feasible and as a result a 10pF ceramic capacitor is employed for the design. This A/D Converter module can also operate in sleep mode in which clock is derived from its internal RC oscillator. Following points may help you to understand the concept of reference voltages.

ADC MODULE OF THE PIC MICROCONTROLLER

Analog to Digital Converter (ADC) is a device that converts an analog quantity (continuous voltage) to discrete digital values. Most of the PIC Microcontrollers have built in ADC Module. In this project, PIC16F877A is used.

When the ADC input is $-V_{ref}$, result will be 0000000000

When the ADC input is $+V_{ref}$, result will be 1111111111

Resolution of ADC = $(+V_{ref} – -V_{ref})/(2 – 1)$, which is the minimum voltage required to change the ADC result by one bit.

Here ADC Resolution = (5 – 0)/(1024 – 1) = 5/1023 = 0.004887V

So, if the input is 5V, ADC Value is 5/0.004887 = 1023 = 11111111 (binary)

If the input is 0.004887V, ADC Value is 0.004887/0.004887 = 1 = 00000001(binary)

TEMPERATURE SENSOR

The LM35 temperature sensor has three terminals pins by which it is connected. Pin 1 is the input pin, pin 2 is the output pin and pin three is the ground pin. Input pin (pin-1) is connected to 5V supply, the output pin (pin 2) is connected to an analog input pin (RA0) of the microcontroller and pin 3 of the LM35sensor is grounded.

LCD UNIT

The LCD is powered by the system 5V

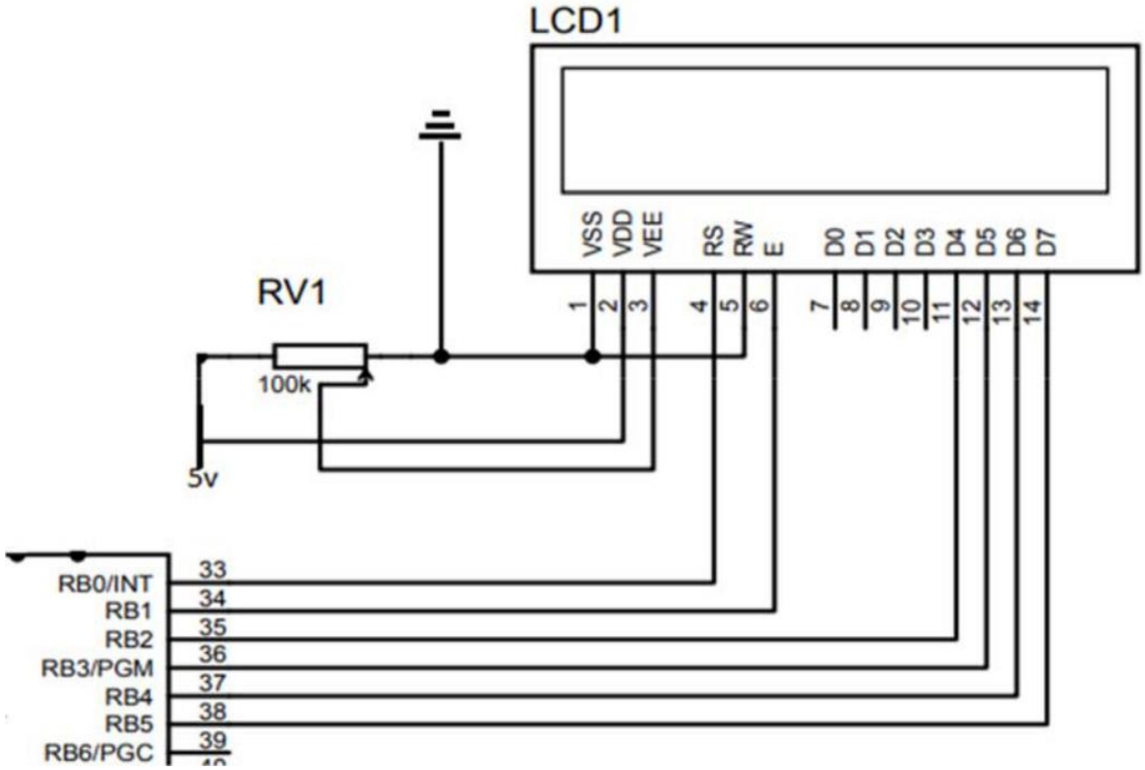

Figure 4: LCD Connection

The connection of the LCD screen is as follows;
RESET (RS) pin is connected to pin 33 of the microcontroller.
ENABLE (E) is connected to pin 34 of the microcontroller.
Data pin4 (D4) was connected to pin 35 of the microcontroller.
Data pin5 (D5) was connected to pin 36 of the microcontroller.
Data pin6 (D6) was connected to pin 37 of the microcontroller.
Data pin6 (D7) was connected to pin 38 of the microcontroller.

BUZZER

The buzzer switch was connected to pin 16 of the microcontroller.

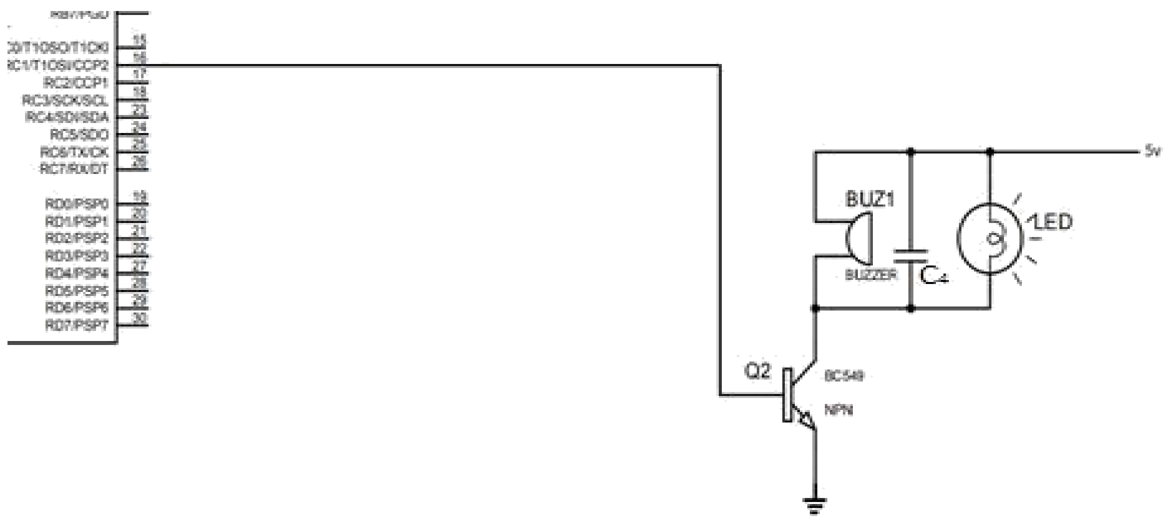

Figure 5: Buzzer connection

The capacitor C4 serves as a voltage holding capacitor, to keep the LED active for a short time even after the voltage supply is turned off. The voltage across the capacitor, which is time dependent, can be found by using Kirchhoff's current law, where the current discharging the capacitor must equal the current through the load (in this case the internal resistance of the LED serves as the load). This results in the linear differential equation

$C.dv/dt + V/R = 0$

Where, C = the capacitance of the capacitor.

Solving this equation for V yields the formula for exponential decay:

$$V(t) = V_0 \text{ x } e^{-t/RC} \quad (9)$$

Where V_0 is the capacitor voltage at time t = 0. The time required for the voltage to fall to is called the RC time constant and is given by: $\tau = RC4$. (10)

Where τ is measured in seconds, R in Ohms and C in Farads. To achieve a voltage, hold time of 0.4sec, and taking the internal resistance of the LED bulb to be 820Ω (measured value at room temperature), we can compute the required capacitor as follows:

$\tau = 0.4s$

$R = 820\ \Omega$

$C_4 = \tau / R$

$C_4 = 0.4s / 820\ \Omega$ $C_4 =$

465.11µF

A 465.11µF capacitor not feasible, thus a 470µF electrolytic capacitor is employed in the design.

CONTROL BUTTONS

The control buttons S2, S3 and S4 which indicate increment, decrement and OK respectively were connected to pins 20, 21 and 22 of the microcontrollers respectively in an active low mode using the conventional 10Ω pull up resistors.

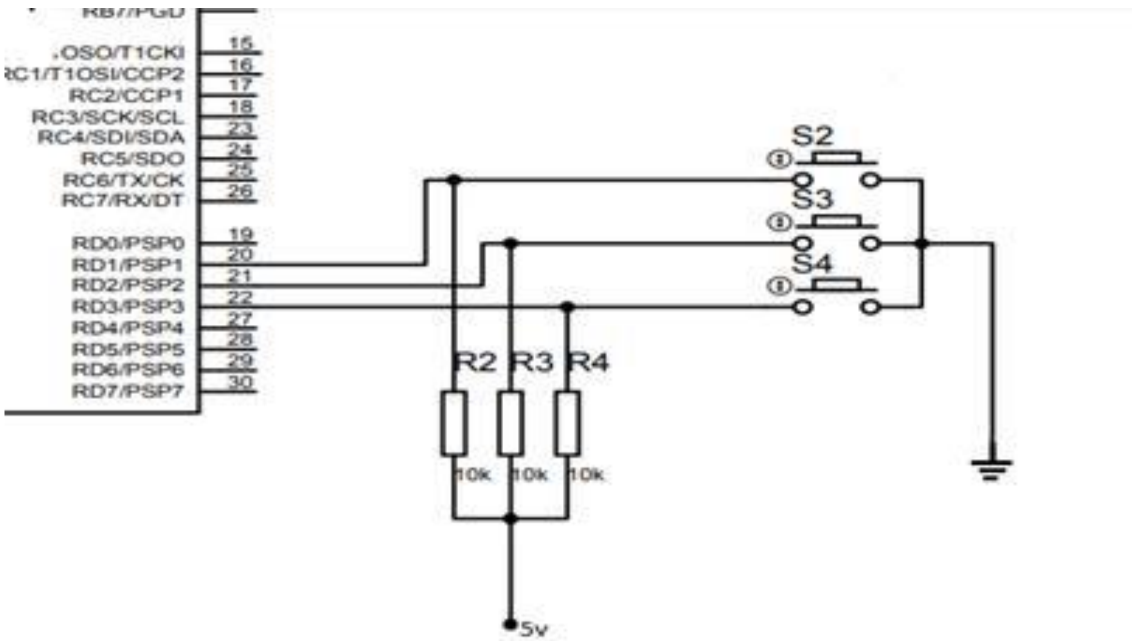

Figure 6: Control buttons

FAN

The fan employed in the design is a 5V DC motor with a maximum current rating of 100mA.

CONSTRUCTION

Construction of the project consists of various sections which includes gathering and soldering of components on the vero board to form a circuit, loading of program into the microcontroller and casing. Attachment and connection of component with circuit board.

The circuit components are soldered firmly on the vero board which proved mounting surface for them. The vero board is a continuous type which provide room for the use of neater circuit and less use of jumpers. The process of construction is as follows;

Vero board type is chosen – continuous vero board is used in this case. Simulated circuit from Proteus is brought in view as guide.

Each component is mounted and soldered rightly as shown in the working circuit diagram or placed according to choose following the right connection for electric path on the vero board. The circuit is tested for continuity using a multimeter. The continuity test is very important as points where isolation is required may be bridged and this can lead to a total destruction of components as electronic components are very sensitive. Points where continuity are needed are also tested as a break in conduction can lead to malfunction or total failure of the circuit.

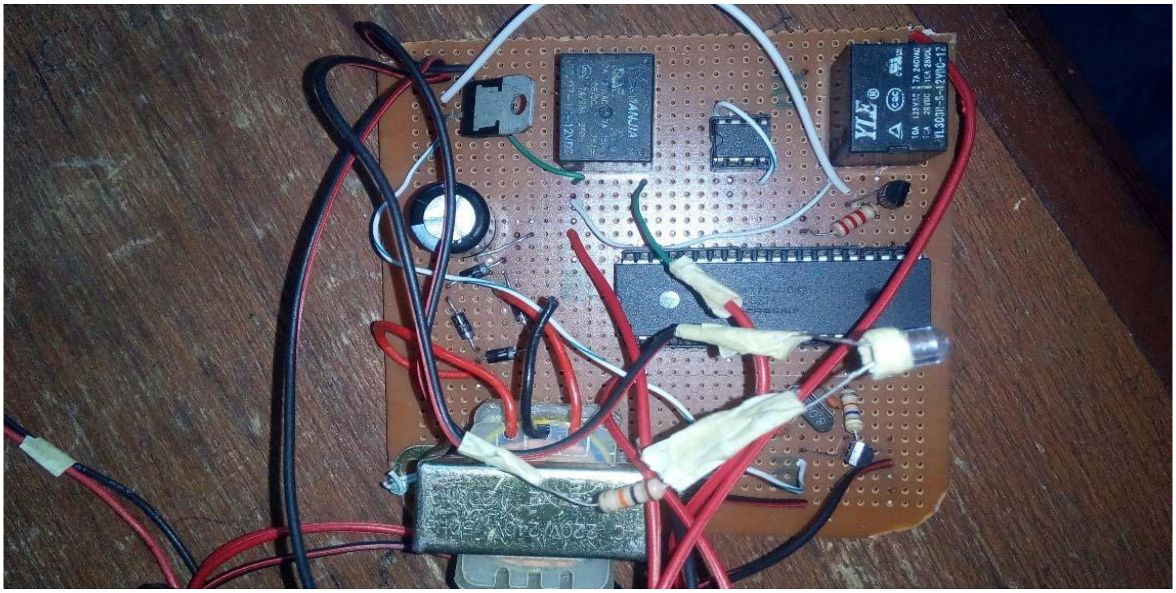

Figure 7: Mounting, circuit coupling and soldering of components

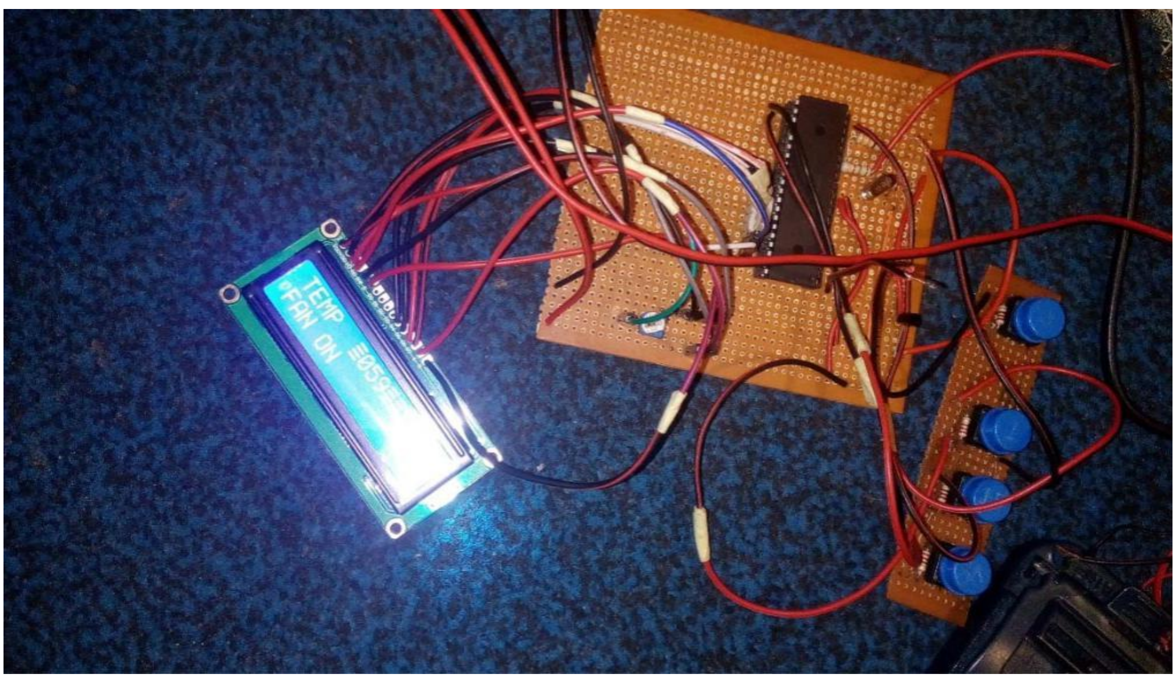

Figure 8: Mounting, Circuit coupling and Soldering of Components

RESULTS

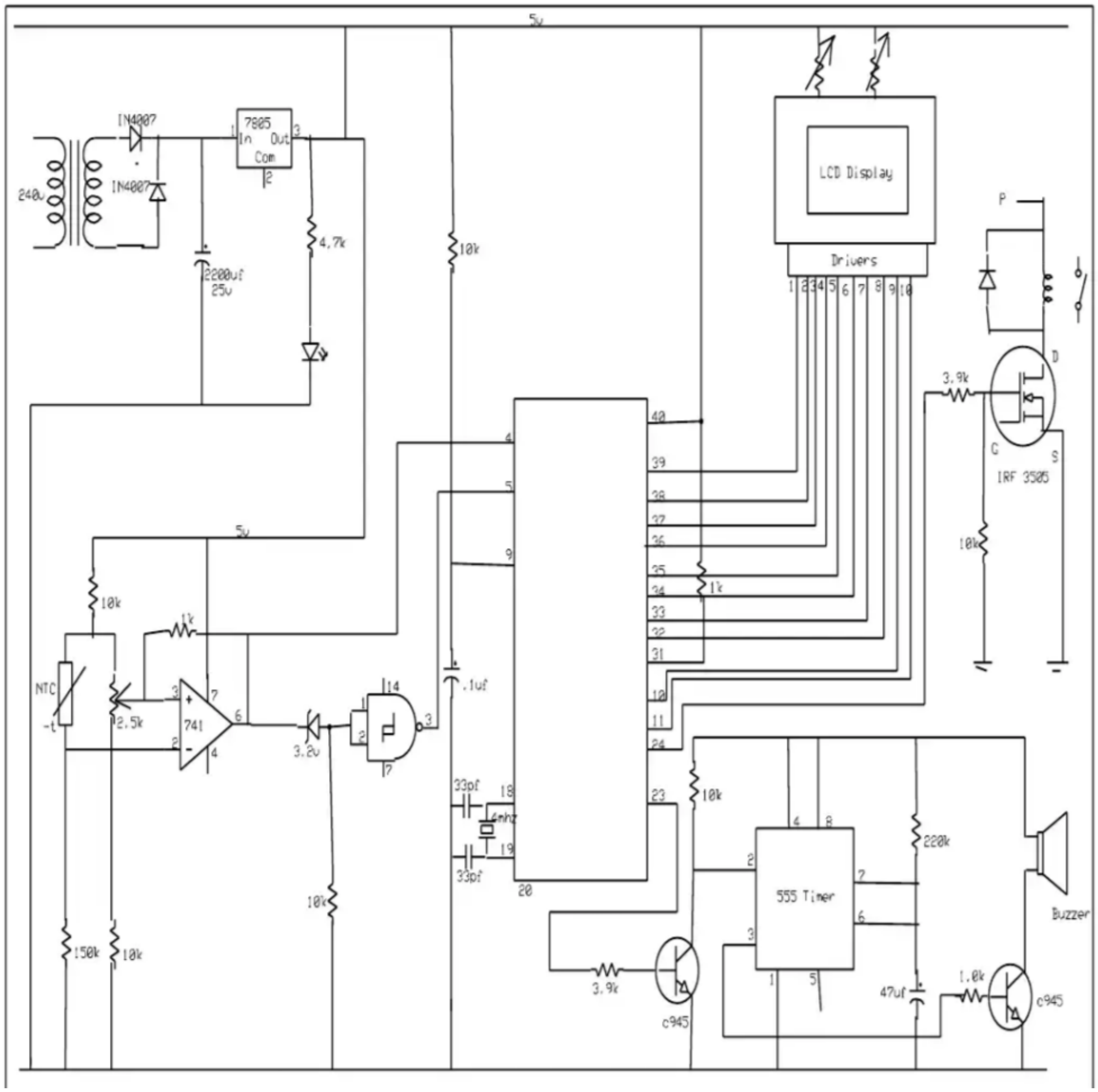

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Figure 9: Overall circuit diagram

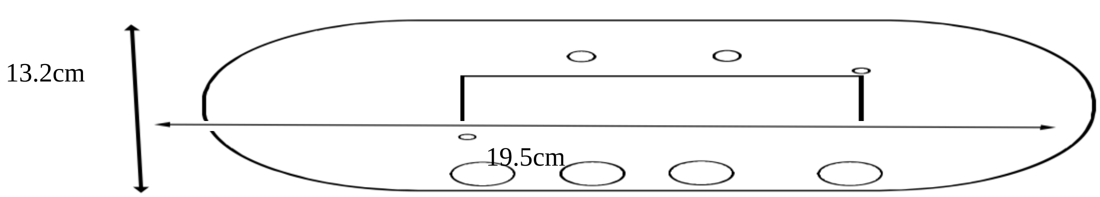

Figure 10: Casing layout and dimension (front view)

Figure 11: Casing layout and dimension (side view)

PICTORIAL VIEWS FROM THE DESIGN

Figure 12: Casing (Side view)

Figure 13: Casing (Top view)

PARAMETER	TEST CONDITIONS	T_J†	µA7805C			UNIT
			MIN	TYP	MAX	
Output voltage	I_O = 5 mA to 1 A, V_I = 7 V to 20 V, $P_D \leq 15$ W	25°C	4.8	5	5.2	V
		0°C to 125°C	4.75		5.25	
Input voltage regulation	V_I = 7 V to 25 V	25°C		3	100	mV
	V_I = 8 V to 12 V			1	50	
Ripple rejection	V_I = 8 V to 18 V, f = 120 Hz	0°C to 125°C	62	78		dB
Output voltage regulation	I_O = 5 mA to 1.5 A	25°C		15	100	mV
	I_O = 250 mA to 750 mA			5	50	
Output resistance	f = 1 kHz	0°C to 125°C		0.017		Ω
Temperature coefficient of output voltage	I_O = 5 mA	0°C to 125°C		−1.1		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz	25°C		40		µV
Dropout voltage	I_O = 1 A	25°C		2		V
Bias current		25°C		4.2	8	mA
Bias current change	V_I = 7 V to 25 V	0°C to 125°C			1.3	mA
	I_O = 5 mA to 1 A				0.5	
Short-circuit output current		25°C		750		mA
Peak output current		25°C		2.2		A

Figure 14: Testing results

After thorough check for bridge and continuity, polarity test and earthing test, the device is connected to the main power source which is the same value and potential in its designed operating condition. Various test is carried out on the device. Tests on normal operating condition and worse case scenarios are carried out and data taken.

The designed Automatic temperature control device for inductive loads passed the necessary load tests and analysis conducted with it, thus could be employed for the excessive temperature rise regulation in distribution transformers with high efficiency. Below is the achieved circuit diagram of the automatic temperature control device.

DISCUSSIONS

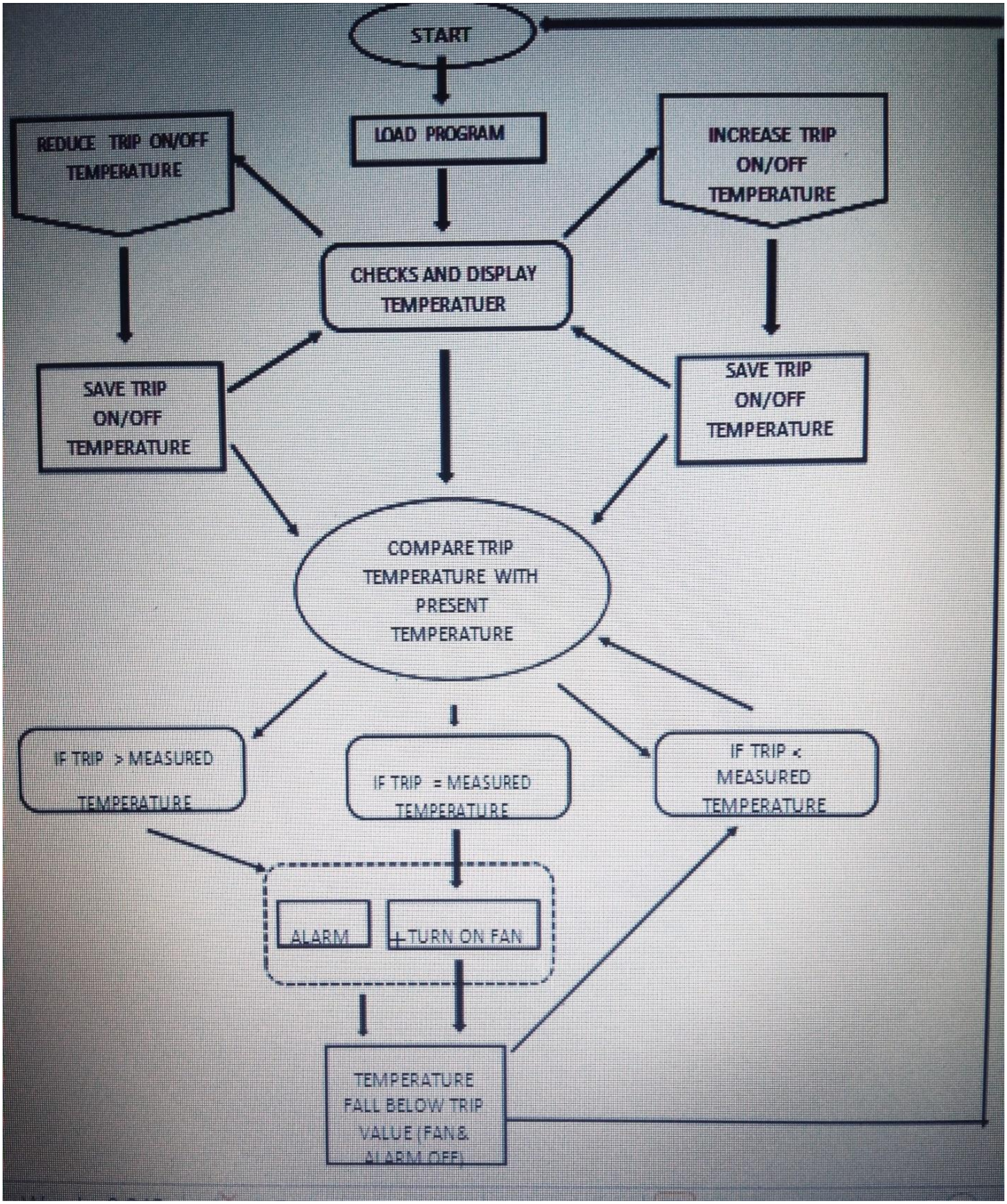

Figure 15: Temperature flow chat of the system

The LM35 temperature sensor is fixed firmly to the body of the transformer. This temperature sensor produces an analog voltage signal at its output terminal which is directly proportional to the temperature of its environment. The heat dissipated by the transformer is detected by the temperature sensor through conduction and as such the temperature sensor produces an increasing or decreasing voltage signal at its output when the transformer heats up or cools down respectively. This voltage signal is sent through wires to the analog to digital converter (ADC) register of the PIC16877A microcontroller. The ADC converts the analog signals from the temperature sensor to digital signals and stores it in the designated registers of the microcontroller's memory.

Pre-set temperature values are also inputted into designated registers of the microcontroller's memory with aid of three contact switches. These pre-set values are reference values that govern the operation and decisions of the microcontroller. The temperature of the transformer which is required to trigger the fan relay and turn on the fan depicts an example of a pre-set temperature value. If the temperature of transformer exceeds the pre-set value in the microcontroller's memory, the microcontroller triggers the fan relays, thus the fan comes on and blows cool air into the cooling chambers and fins of the transformer. The fan is only turned off when the temperature of the transformer drops below the pre-set value. The LCD screen displays the temperature of the transformer to ensure that the temperature is properly monitored. The LCD also acts as a visual interface between the device operator and the microcontroller by displaying pre-set temperature values that are being entered and stored in the microcontroller's memory. Lastly the LCD shows changes in the fan status whenever it comes on or goes off.

CONCLUSIONS

The device is finally tested and proven to work optimally but as always there always is room for modification. Such recommendation and modification would be stated and explained in the section below. This device – automatic temperature control of distribution transformers and can be applied in various aspect of our society where a steady temperature is required such as industries, bakeries, incubators, homes, halls and offices, etc.

- For higher efficiency and longevity, a three-phase induction motor should be used because of their rugged nature and ability to withstand heat and other environmental factors.
- An SMS notification system should also be put in place so as to alert the DSOs whenever temperature values rise above the allowable degree so that he can be notified

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APPENDIX

PIC16F87XA

28/40/44-Pin Enhanced Flash Microcontrollers

Devices Included in this Data Sheet:

- PIC16F873A
- PIC16F874A
- PIC16F876A
- PIC16F877A

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 other 28-pin or 40/44-pin PIC16CXXX and PIC16FXXX microcontrollers

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
- Synchronous Serial Port (SSP) with SPI™ (Master mode) and I^2C™ (Master/Slave)
- Universal Synchronous Asynchronous Receiver Transmitter (USART/SCI) with 9-bit address detection
- Parallel Slave Port (PSP) – 8 bits wide with external $\overline{RD}$, $\overline{WR}$ and $\overline{CS}$ controls (40/44-pin only)
- Brown-out detection circuitry for Brown-out Reset (BOR)

Analog Features:

- 10-bit, up to 8-channel Analog-to-Digital Converter (A/D)
- Brown-out Reset (BOR)
- Analog Comparator module with:
  - Two analog comparators
  - Programmable on-chip voltage reference (VREF) module
  - Programmable input multiplexing from device inputs and internal voltage reference
  - Comparator outputs are externally accessible

Special Microcontroller Features:

- 100,000 erase/write cycle Enhanced Flash program memory typical
- 1,000,000 erase/write cycle Data EEPROM memory typical
- Data EEPROM Retention > 40 years
- Self-reprogrammable under software control
- In-Circuit Serial Programming™ (ICSP™) via two pins
- Single-supply 5V In-Circuit Serial Programming
- Watchdog Timer (WDT) with its own on-chip RC oscillator for reliable operation
- Programmable code protection
- Power saving Sleep mode
- Selectable oscillator options
- In-Circuit Debug (ICD) via two pins

CMOS Technology:

- Low-power, high-speed Flash/EEPROM technology
- Fully static design
- Wide operating voltage range (2.0V to 5.5V)
- Commercial and Industrial temperature ranges
- Low-power consumption

Device	Program Memory		Data SRAM (Bytes)	EEPROM (Bytes)	I/O	10-bit A/D (ch)	CCP (PWM)	MSSP		USART	Timers 8/16-bit	Comparators
	Bytes	# Single Word Instructions						SPI	Master I^2C			
PIC16F873A	7.2K	4096	192	128	22	5	2	Yes	Yes	Yes	2/1	2
PIC16F874A	7.2K	4096	192	128	33	8	2	Yes	Yes	Yes	2/1	2
PIC16F876A	14.3K	8192	368	256	22	5	2	Yes	Yes	Yes	2/1	2
PIC16F877A	14.3K	8192	368	256	33	8	2	Yes	Yes	Yes	2/1	2

PIC16F877A PIN DIAGRAM (40 Pins)

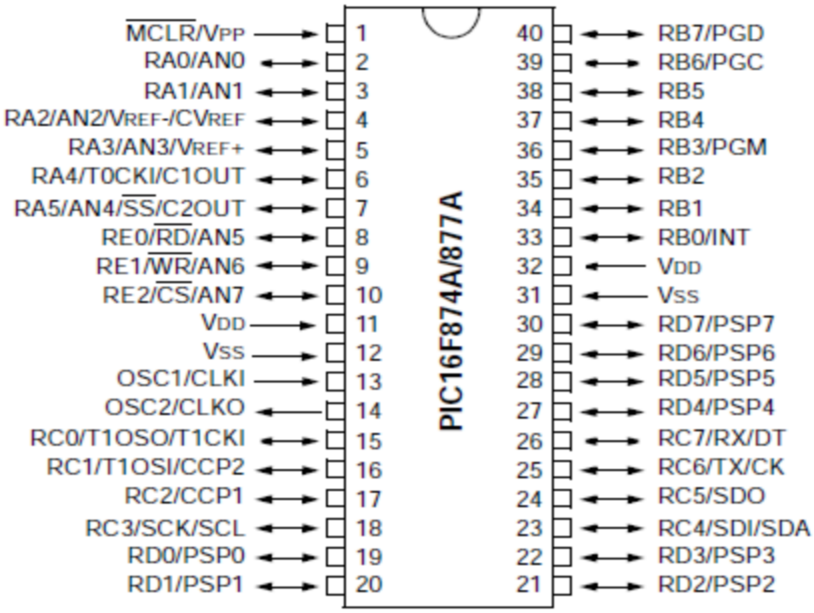

TABLE 1-1: PIC16F87XA DEVICE FEATURES

Key Features	PIC16F873A	PIC16F874A	PIC16F876A	PIC16F877A
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 (bytes)	128	128	256	256
Interrupts	14	15	14	15
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
Analog Comparators	2	2	2	2
Instruction Set	35 Instructions	35 Instructions	35 Instructions	35 Instructions
Packages	28-pin PDIP 28-pin SOIC 28-pin SSOP 28-pin QFN	40-pin PDIP 44-pin PLCC 44-pin TQFP 44-pin QFN	28-pin PDIP 28-pin SOIC 28-pin SSOP 28-pin QFN	40-pin PDIP 44-pin PLCC 44-pin TQFP 44-pin QFN

1N4007 DIODES