Temperature Indicator for °C, °F, °K and °Ra

SUNIL KUMAR

A digital temperature indicator is an immensely useful instrument in the fields of electronics, instrumentation and laboratory use for measurement of temperature. The different types and makes of analogue and digital temperature indicators available in the market are expensive and give temperature readings on a single scale. Presented here is a microcontroller (MCU) based temperature indicator that can display the temperature in four different scales such as Celsius, Fahrenheit, Kelvin and Rankine. It can measure temperatures from 0°C to 150°C.

Celsius temperature scale is based on 0°C for freezing point and 100°C for boiling point of water, with the interval between the two being divided into 100 equal parts. This scale is used in scientific work everywhere.

Fahrenheit temperature scale is based on 32°F for freezing point and 212°F for boiling point of water, with the interval between the two being divided into 180 equal parts.

Kelvin is defined as the scale of temperature with absolute zero as zero and the triple point of water as 273.16K. (Triple point of a substance is the temperature and pressure at which the three phases—gas, liquid and solid—of that substance coexist in thermodynamic equilibrium.) On this scale, 0K represents absolute zero, which is the temperature at which molecules of a substance have their lowest possible energy. Many physical laws and formulae can be expressed more simply by using an absolute temperature scale. Accordingly, Kelvin scale has become the international standard for scientific temperature measurement.

Rankine scale measures thermodynamic temperature corresponding to Fahrenheit. Zero in Rankine is the same as zero in Kelvin. A temperature of -459.67°F is equal to 0°R.

Relations between Celsius and other scales are given in the table below.

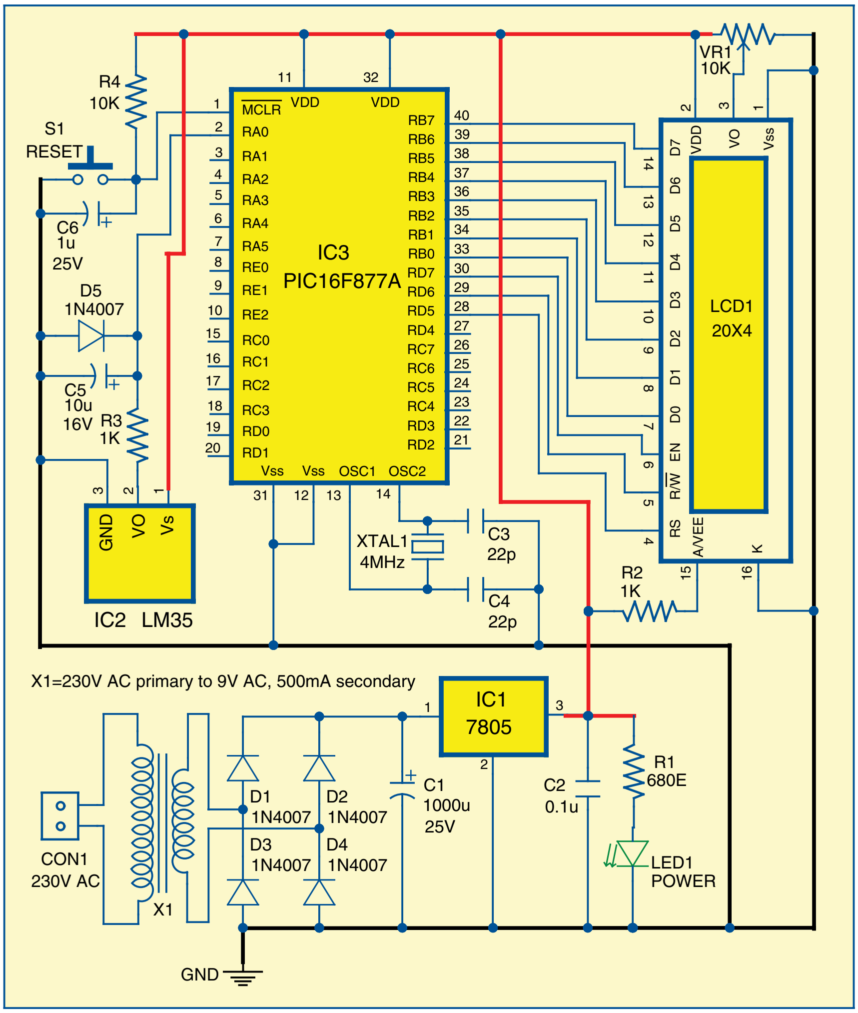


Fig. 1: Circuit diagram of the temperature indicator

Circuit and working

Fig. 1 shows the circuit diagram of the temperature indicator. It comprises voltage regulator 7805 (IC1), temperature sensor LM35 (IC2), micro-

Relations Between Celsius and Other Scales

Celsius	Fahrenheit	F=(C×1.8) +32
Celsius	Kelvin	K=C+273.16
Celsius	Rankine	Ra=(C×1.8) +32+459.67

PARTS LIST

Semiconductors:

IC1	- 7805, 5V voltage regulator
IC2	- LM35 temperature sensor
IC3	- PIC16F877A MCU
D1-D5	- 1N4007 rectifier diode
LED1	- 5mm LED

Resistors (all 1/4-watt, ±5% carbon):

R1	- 680-ohm
R2, R3	- 1-kilo-ohm
R4	- 10-kilo-ohm
VR1	- 10-kilo-ohm potmeter

Capacitors:

C1	- 1000µF, 25V electrolytic
C2	- 0.1µF ceramic disk
C3, C4	- 22pF ceramic disk
C5	- 10µF, 16V electrolytic
C6	- 1µF, 25V electrolytic

Miscellaneous:

LCD1	- 20×4 LCD
XTAL1	- 4MHz crystal oscillator
S1	- Tactile switch
CON1	- 2-pin connector terminal
X1	- 230V AC primary to 9V AC, 500mA secondary transformer

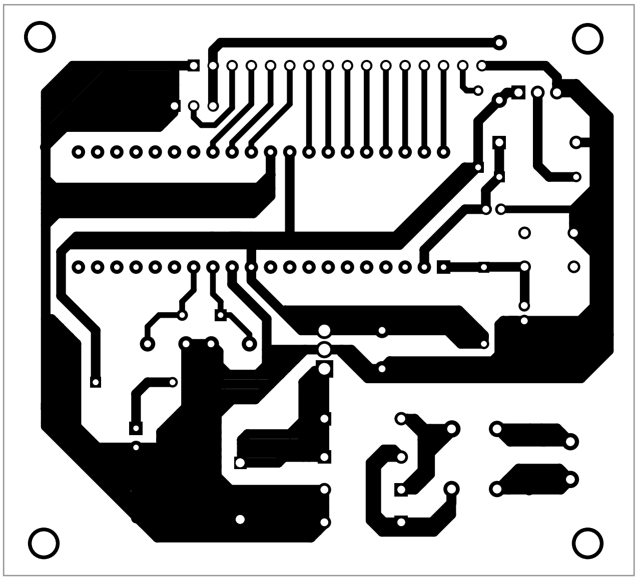


Fig. 2: Actual-size PCB pattern of the temperature indicator

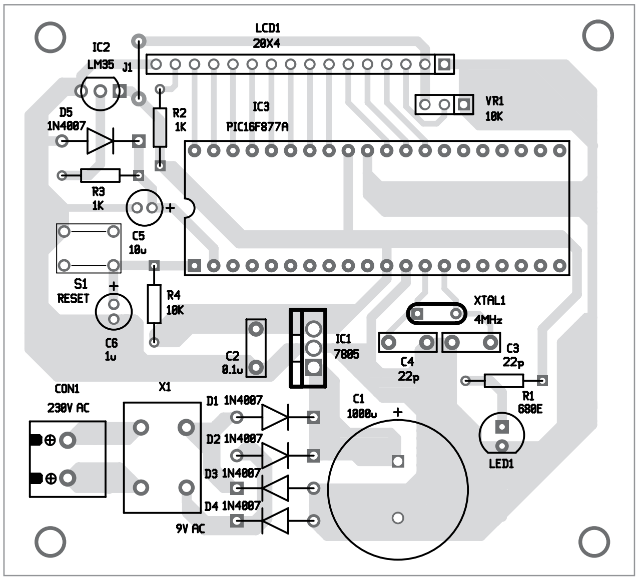


Fig. 3: Component layout of the PCB

EFY Note

The source code of this project is included in this month's EFY DVD and is also available for free download at *source.efymag.com*

controller (MCU) PIC16F877A (IC3), a 20 × 4 LCD display module (LCD1) and a few discrete components. LM35 is a precision integrated circuit temperature sensor, whose output voltage is linearly proportional to Celsius (Centigrade) temperature.

This sensor has a linear +10.0 mV/°C scale factor. It operates from 4V to 30V. It measures from –55 to +150°C temperature range. LM35 output is given to the analogue-to-digital converter (ADC) of the MCU. This Centigrade temperature is converted to Fahrenheit (°F), Kelvin (°K) and Rankine (°Ra), and displayed on the LCD module.

Analogue channel AN0 of the MCU receives the analogue signal from the temperature sensor for conversion to its 10-bit digital equivalent. A 4MHz crystal is connected to pins 13 and 14 of the MCU to provide a basic clock frequency.

Active low-reset function is provided by combining resistor R4 and capacitor C6. Switch S1 is used for the manual resetting of the MCU.

230V AC mains voltage is stepped down by transformer X1 to deliver the secondary output of 9V, 500mA. Transformer output rectified by full-wave rectifier comprising diodes D1 through D4 is filtered by capacitor C1. DC output is regulated at +5V by IC1. Capacitor C2 is used to bypass ripples, if any, in positive supply.

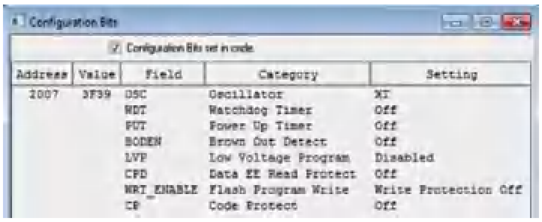
Construction and testing

An actual-size, single-side PCB for the MCU based temperature controller is shown in Fig. 2 and its component layout in Fig. 3. Assemble the circuit on the PCB to minimise assembly time and errors. Use an IC base for the MCU.

Software

The program is written in C language and compiled using HI-TECH compiler along with MPLAB to generate a hex code. The generated hex code is burnt into the MCU using a programmer with configuration bits as shown in Fig. 4. The program is well commented and easy to understand.

The software program consists of lcd.h header file and many other functions. The header file is used to control the LCD module for initialising and to display the various messages and datum such as temperature. There are many functions like delay, hex-to-bcd, display, ADC_Init, ADC_Read and Temperature that are used in the program for various functions.


Configuration Bits

Configuration Bits set in code

Address	Value	Field	Category	Setting
2007	3F39	OSC	Oscillator	XT
		WDT	Watchdog Timer	Off
		PUT	Power Up Timer	Off
		BODEN	Brown Out Detect	Off
		LVP	Low Voltage Program	Disabled
		CPD	Data EE Read Protect	Off
		WRT_ENABLE	Flash Program Write	Write Protection Off
		CP	Code Protect	Off

Fig. 4: Configuration bits

Delay function is used to provide the delay as per variable time. ADC of MCU PIC16F877A is initialised for ADC operation by ADC_Init function. Function ADC_Read takes the analogue signal, converts it into digital data and returns for analogue temperature equivalent digital data.

Converted digital data is converted into bcd format by hex-to-bcd function. Temperature function is used to convert ADC data into various temperature parameter units. Display function is used to display the data on the LCD. ●

Sunil Kumar is BE (electronics engineering), College of Engineering, Dr Ambedkar Institute of Technology, Bengaluru