showing it clear that we have not used four separate control systems to perform this task, where instead only four temperature sensors (NTC thermisors) are interfaced to the input pins of a single microcontroller. The 40 pins PIC18F4580 is used as the main control unit in the system, taking into consideration that other types of microcontrollers, with enough number of pins, can also be used.

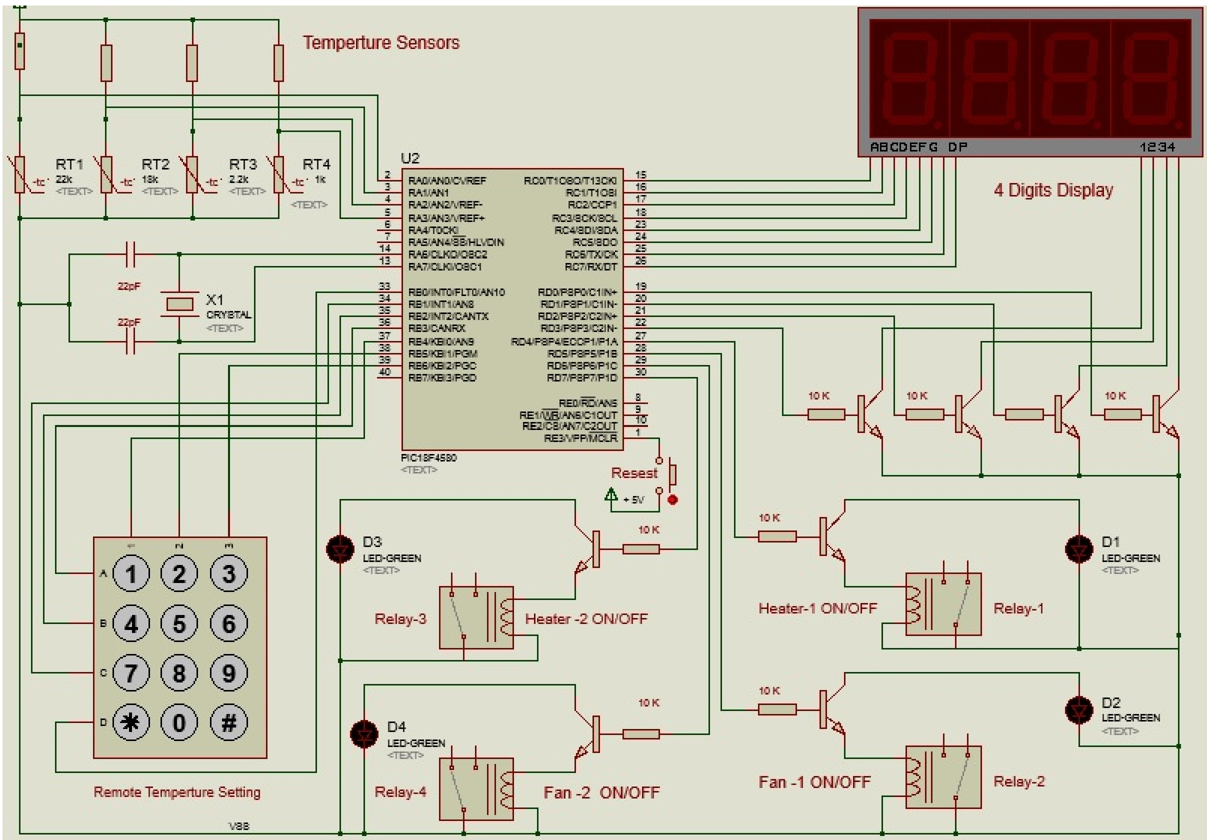

Fig. 3. The multi sensors temperature control system

The temperature is displayed using a 4-digits 7-segments with common input for all the segments, and a separate enable line for each segment. The enable line is used to turn ON and turn OFF a particular segment. At this point, it's reasonable to recall that a character LCD may be used as an alternative display method with advantages of requiring less number of pins to interface with the microcontroller, and simpler way of programming. The 7-segments display is favored here, however, because good readability of the displayed digits is more required.

A. Temperature Setting

For the system to automatically control a temperature, it should have a continuous process of measuring and monitoring. The measured temperature is normally compared with some stored threshold values (possibly maximum and minimum). In Fig. 3, a (3x4) keypad is used to set the threshold temperatures for the different sensors. The use of this keypad requires an interface with the microcontroller via 7 input pins. In fact the keypad is only used for the purpose of simulation, where in line with the objective of this research, we have used, in the fabricated hardware prototype a more practical alternative for temperature setting. Replacing the keypad with an IR (Infra Red) remote device has noticeably minimized the utilization of microcontroller pins. We, in fact, could not simulate the IR receiver because it is not available within the database of the Proteus package. In section five of this paper further exploration regarding the remote control will be introduced.

B. Actuators

Fundamentals of automatic control dictates that some action should be taken if the routine monitoring of the system has come to such a decision. Turning an actuator ON, triggering another subsystem, putting a machine into operation are among a list of possible actions. In the automatic temperature control, a fan may be turned ON if the environment needs to be cooled or alternatively a heater may be put ON to raise the temperature. Both types of actions are simulated in the system as shown in Fig. 3. More fans and/or heaters may in fact be controlled, where their actions may be a response to various sensors based on the way system programs are designed and implemented.

V. THE HARDWARE IMPLEMENTATION

The design outline introduced in the section four of this paper, is used to produce a hardware prototype for our IR remote controlled automatic temperature system. Minor changes to the simulated system illustrated in Fig, 3, are made and the same tool (i.e. Proteus) is also used to develop and produce a proper PCB layout. One thermistor, rather than four, is used in the implementation, and instead of the (3x4) keypad, a miniaturized IR receiver for infrared remote control is interfaced to perform temperature settings. The IR receiver used is the TSOP1738, which is basically a 3-lead frame package being an assembly of a PIN diode and preamplifier. The hardware assembly is shown in Fig. 4.

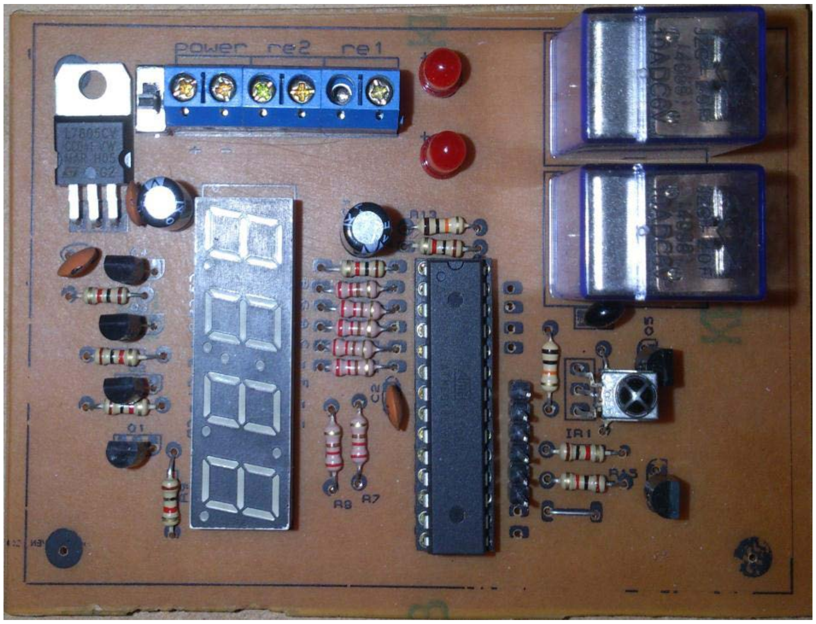

Fig. 4. Hardware assembly of an automatic temperature control system

Transmission systems adopting infrared remote control technology, and only requiring small data rates, are now widely used in application to eliminate keypads [20]. Standard types of IR transmitters are working in the frequency band between 30kHz and 56kHz. The TSOP1738, which is used in our prototype has a carrier frequency of 38kHz. Many commercial transmitters are having similar carrier frequency and hence any of them may suit our application. We, however, required to carefully consider the coding system [21] adopted by the manufacturer of the selected IR transmitter [22]. Timings, storage, as well as synchronization requirements are considered in programming the microcontroller taking into consideration the standard message format of NEC code, as the transmitter used is actually adopting this protocol. The remote control is used to set the threshold temperature values such that the system perform automatic measurements and monitoring to keep the temperature environment within the desired temperature via functioning the proper action (e.g. put the fan or the heater ON or OFF). Hardware reset of the system can also be done using the proper pin. Necessary lab testing were carried out to make sure that message transactions is reliable and performed as per the NEC encoding.

VI. CONCLUSIONS

The paper has presented the temperature measurement and monitoring for a proposed service or industrial application with multi-sensor/ multi-actuator system. The PIC18F450 with 40 pins is used as the main control unit. The system is displaying the temperature using 7 segments LEDs because they offer better readability with respect to LCD. Thermistors are used as temperature sensors due to their suitable characteristics. The Proteus software is used to aid the development of the system in terms of editing, simulation, and PCB layout production. An IR remote control with 38 kHz carrier frequency subsystem is integrated with the temperature control system to perform temperature settings replacing the use of a keypad.

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