PC Configurable P89V51RD2 based Digital Clock Displaying the Day, Date, Time, and Temperature on a 128x64 Graphical LCD Module

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ABSTRACT
This study discusses about the designing of a real time, PC configurable standalone digital clock implemented on a 128x64 graphical LCD and built around an eight bit microcontroller. The graphical LCD is interfaced with an 8051 core microcontroller. Also a temperature sensor LM35 via ADC and a serial Real Time Clock chip DS1307 via I2C protocol are interfaced to the microcontroller to display the day, date, time and temperature with variable font size onto the graphical LCD module. The digital clock implemented here is provided a power backup facility through a CMOS battery for time updating during power cut. The clock can be configured by connecting it to the COM port of PC and writing in a particular format into the HyperTerminal. The digital clock can be implemented as a subsystem and fits into many real time switching applications just like biometric attendance system, etc.

Keywords
RTC, Graphical LCD, I2C protocol, Microcontroller, temperature sensor.

1. INTRODUCTION
The electronic clocks are much reliable, accurate, maintenance free and portable. In this digital world the digital clocks have outdated the use of conventional analog timekeeping machines. A digital clock is not so different. Just it handles the timekeeping functions electronically rather than mechanically. So in a digital clock, there is an electrical power supply. There is an electronic timebase that "ticks" at some known and accurate rate. There is an electronic "gearing mechanism" of some sort -- generally a digital clock handles gearing with a component called a "counter." And there is a display, usually either LEDs (light emitting diodes) or an LCD (liquid crystal display). Digital clocks typically use the 50 or 60 hertz oscillation of AC power or a 32,768 hertz crystal oscillator as in a quartz clock to keep time. Digital clocks display the hour of the day in 24 hour format or 12 hour format (with some indication of AM or PM). The proposed system is a microcontroller controlled digital clock with day, date, time and temperature displayed on a 128x64 graphical LCD module.

2. HARDWARE REQUIREMENTS

2.1 Graphical LCD module
It is a twenty pin liquid crystal display module with eight-bit parallel data bus, three control pins along with power pins and backlight control. It is a 128x64 Graphical LCD and it is divided into two parts-controlled by two different controllers. Each part is further divided into rows and columns. Each controller must be addressed independently. Each part is divided into eight horizontal pages which are eight bit high. To display different font types, corresponding header files have been created. These header files contain the bitmap information of all alphabetic, numeric characters and symbols of a particular font. These header files are included into the main program.

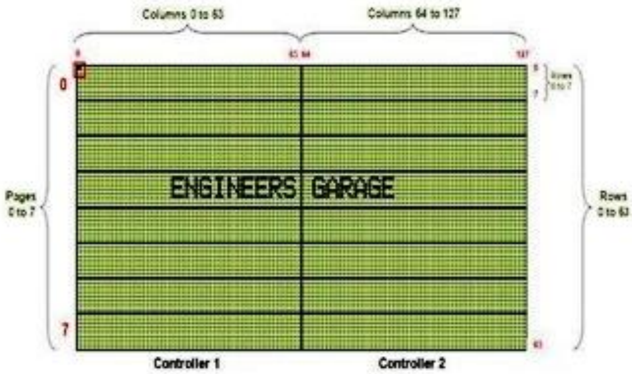

Fig 1. A 128x64 Graphical LCD arrangement. (courtesy: www.engineersgarage.com)

2.2 Serial RTC DS1307
The DS1307 serial real-time clock (RTC) is a low power, full binary-coded decimal (BCD) clock/ calendar. Address and data are transferred serially through an I2C, bidirectional bus. The clock/ calendar provides seconds, minutes, hours, day, date, month and year information. The end of the month date is automatically adjusted for months with fewer than 31 days, including corrections adjusted for leap year. The clock operates in either the 24-hour or 12-hour format with AM/PM indicator. The DS1307 has a built-in power-sense circuit that detects power failures and automatically switches to the backup supply. Timekeeping operation continues while the part operates from the backup supply. The internal oscillator circuitry is designed to operate with a 32.768 kHz quartz crystal.

2.3 Lithium Battery
A small 3V lithium coin cell battery is connected to the pin-3 and pin-4 of DS1307 serial RTC chip. Battery voltage must be held between the minimum and maximum limits for proper operation. A lithium battery with 48mAh or greater will back up the DS1307 for more than 10 years in the absence of power.

2.4 LM35 temperature sensor

The sensors of the LM34/LM35 series are precision integrated-circuit temperature sensors whose output voltage is linearly proportional to the Fahrenheit/ Celsius temperature. The LM34/LM35 requires no external calibration since it is inherently calibrated. It outputs 10mV for each degree of Fahrenheit/ Celsius temperature.

2.5 ADC0804

Analog-to-Digital Converters are among the most widely used devices for data acquisition. Microcontrollers can read and process digital signals, but in the physical world everything is analog like temperature, pressure, humidity, etc. An ADC converts the analog electrical input signals from transducers to digital output signals. ADC 0804 is an 8-bit parallel ADC. It has 8-bit resolution and the maximum conversion time is 110µs. Now, consider the case of connecting an LM35 to an ADC0804. Since the ADC0804 has 8-bit resolution with a maximum of 256 steps and the LM35 (or LM34) produces 10 mV for every degree of temperature change, we can condition Vin of the ADC0804 to produce a Vout of 2560 mV full-scale output. Therefore, in order to produce the full-scale Vout of 2.56 V for the ADC0804, we need to set Vref/2 = 1.28. This makes Vout of the ADC804 correspond directly to the temperature as monitored by the LM35.

2.6 P89V51RD2 Microcontroller

The system is built around an eight bit microcontroller i.e. NXP P89V51RD2. It is 8051 core microcontroller with 32 I/O lines, 5V operating voltage from 0MHz to 40MHz, 3 Timers/Counters, 9 Interrupts/4 priority levels, 64K+8K on-chip Flash user code memory with ISP, 1K on-chip RAM, SPI, Dual Data Pointers, WDT, 5-channel PCA. The microcontroller is made to operate on 11.0592MHz clock rate to achieve a baud rate of 9600. This is the standard baud rate for communication with PC using UART protocol. 8051 core microcontrollers of NXP family have some exclusive features like In-System Programmable capability through serial com port.

2.7 MAX232

A level converter like MAX 232 is required in the circuit because the serial port of the PC uses RS232 voltage levels (+12V for logic 0 and -12 V for logic 1) which is much higher voltage than the TTL logic (0V for logic 0 and +5V for logic 1) used by the microcontroller.

3. FIRMWARE

3.1 Serial Communication- I2C Protocol

As the RTC we have used in the circuit is a serial RTC thus unlike a parallel RTC chip which requires eight data lines the serial RTC can be interfaced to the microcontroller using just two pins. These two pins are SDA (serial data pin) and SCL (serial clock pin). The protocol used for this serial communication is known as TWI (two wire interface) or I2C. The DS1307 operates as a slave device on the I2C bus. Access is obtained by implementing a START condition and providing a device identification code followed by a register address. Subsequent registers can be accessed sequentially until a STOP condition is executed.

3.2 Temperature Sensor

The room temperature in degree Celsius was read by the LM35 sensor in analog form and converted to the corresponding digital values by using an ADC and then fed to the Microcontroller. The microcontroller controls when to start the conversion process and when to end the conversion process, read the converted value into one of its registers and then send it to the display.

3.3 Graphical LCD initializations

To interface this LCD with microcontroller, there are two registers (input and output register) are provided in the LCD. The selection of these registers is made through RS and RW signals. Input register is used to give instructions and data to the LCD whereas the Output register is used to read data from DDRAM and to check the busy flag status.

Creating Fonts: Each small font in the proposed system is of size 5x7 pixels. For eg. If we want to make a bitmap of character 8 of 5x7 pixel size than we have to give the following bytes to the microcontroller:

DB 36h, 49h, 49h, 49h, 36h, 00h ; numeral 8

```
00000
01110
10001
10001
01110
10001
10001
01110
```

Fig 2. Bitmap of the numeral '8'.

3.4 Hyper terminal

A specific format is designed to be written into the hyper terminal window to update the digital clock parameters whenever required. The format is **:HHMMSS-DDMMYY-W**. For example, if someone type the values :213220-190213-2 into the hyper terminal window and then on ENTER key press the RTC gets uploaded with new time i.e hours 21, minutes 32, seconds 20 - date 19, month 02, year 13 - weekday 2 means Tuesday.

4. SYSTEM OPERATION

The proposed system is developed as per the schematic shown in figure-3. The schematic and layout of the proposed system was designed in Eagle PCB layout editor. The major components are P89V51RD2 microcontroller, ADC 0804, DS1307, LM35, MAX232, 128x64 Graphical LCD module.

5. CONCLUSION

In the proposed design a simple, portable, user friendly, attractive and multifunctional timekeeping system has been developed and implemented. The same timekeeping system can be implemented on different type of display systems like seven segment display modules, led matrix modules, led displays, numeric displays. It is highly accurate and can accommodate more functions like if the alarm circuitry is required to be added in the design, the firmware can be updated easily.

6. EXPERIMENTAL RESULTS

The experimental results of the proposed system are shown in Figure-4, Figure-5 and Figure-6. The day, date, time and temperature displayed nicely on the graphical LCD module. The backlight of graphical LCD module can be made off during day time as it consumes most of the power in the circuit developed. The RTC DS1307 continuously keeps on updating the time even in the absence of main supply for years. This is due the backup supplied by the coin cell battery to the real-time clock integrated chip. The whole system works on +5 Volt DC supply. The programmer developed using MAX232 works well for P89V51RD2 microcontroller. Temperature sensor is working at its best and the room temperature was displayed on the graphical LCD module. The proposed system is completely hardwired and developed on a general purpose PCB.

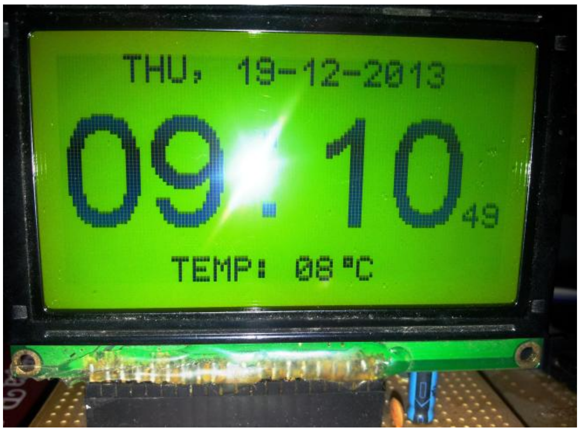

Fig 4. Graphical LCD panel showing the day, date, time and temperature.

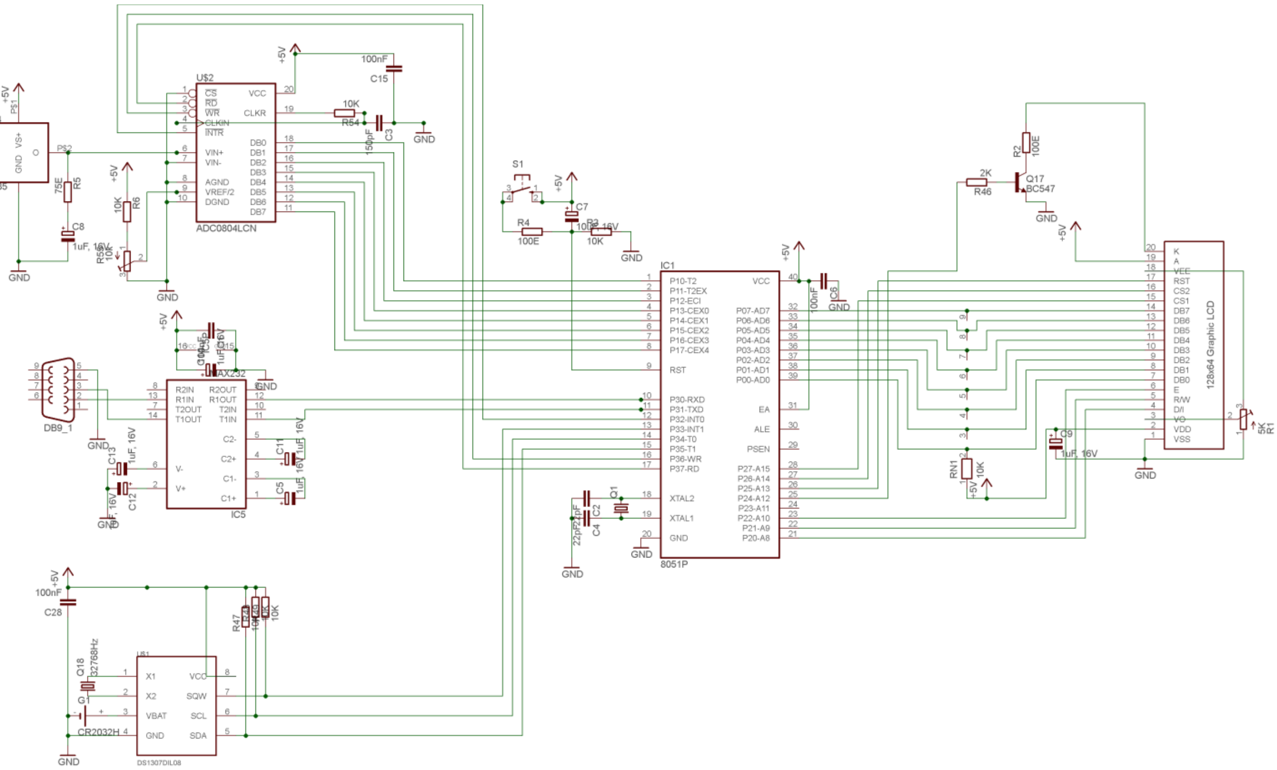

Fig 3. Complete schematic diagram for the proposed system edited in EAGLE PCB Layout Editor

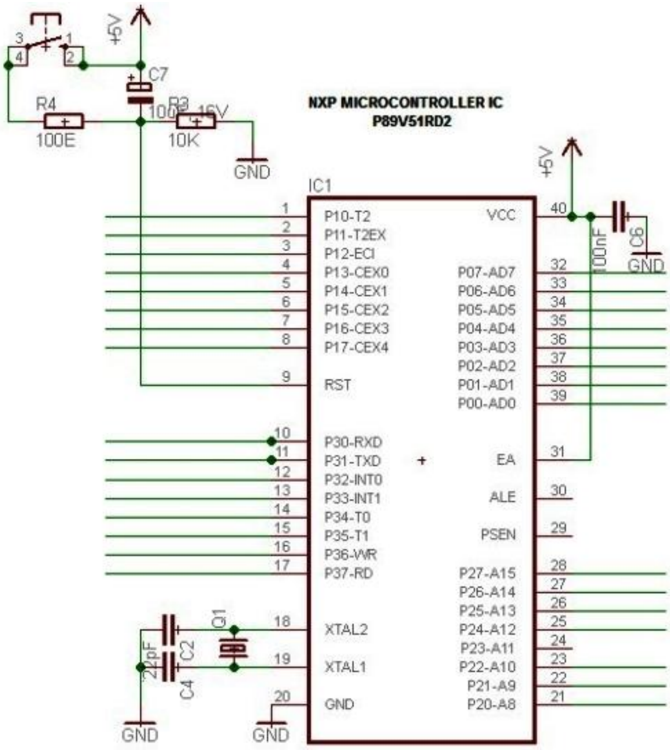

Fig 4. Schematic sub-block-1

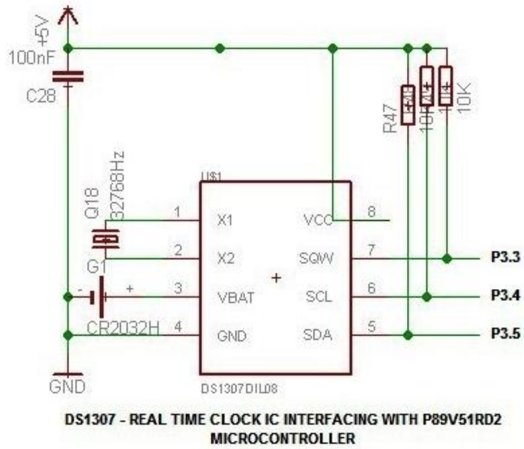

Fig 5. Schematic sub-block-2

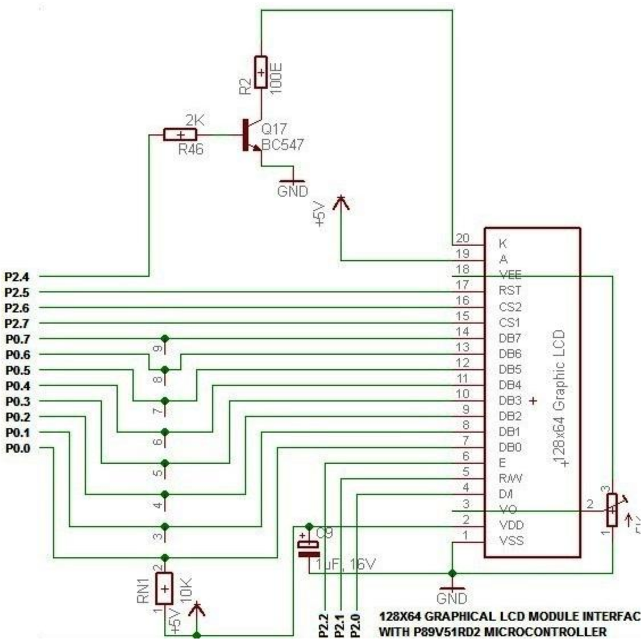

Fig 6. Schematic sub-block-3

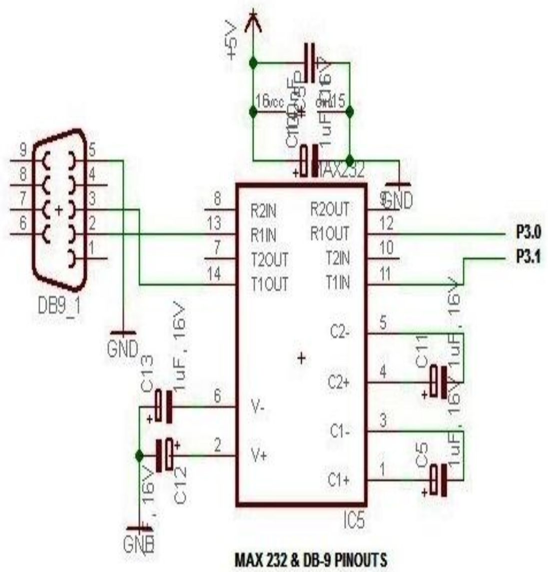

Fig 7. Schematic sub-block-4

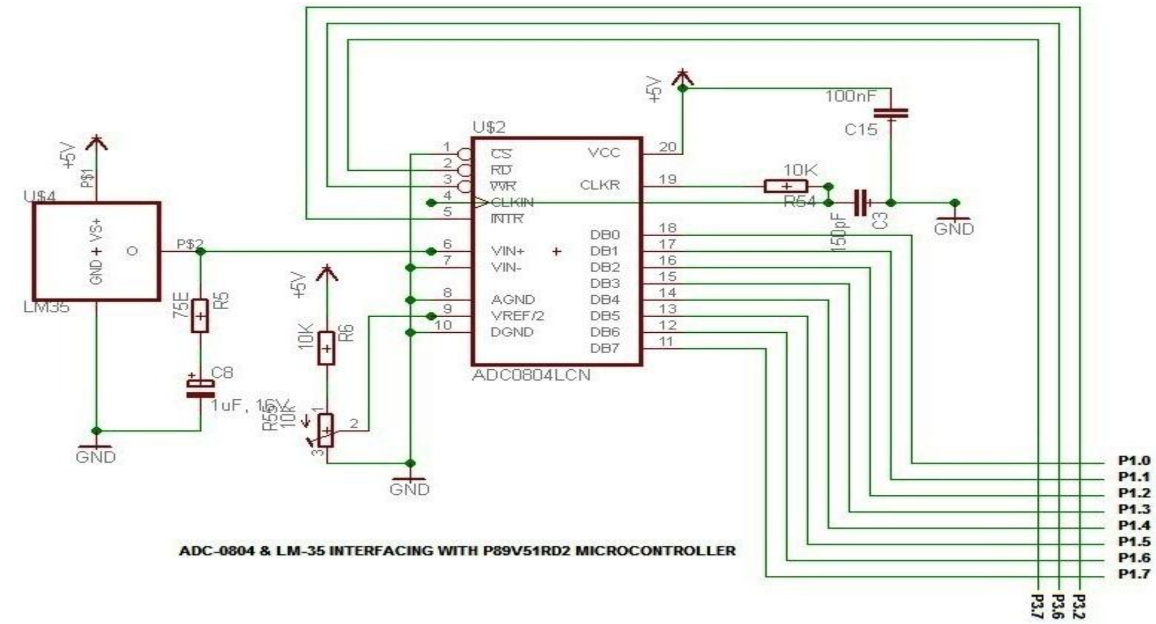

Fig 8. Schematic sub-block-5

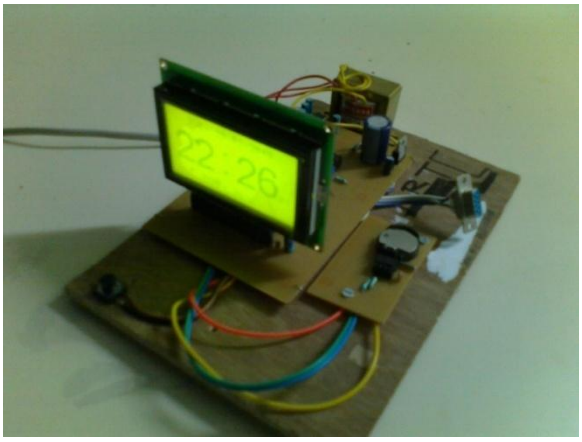

Fig 9. Top view of the developed system board.

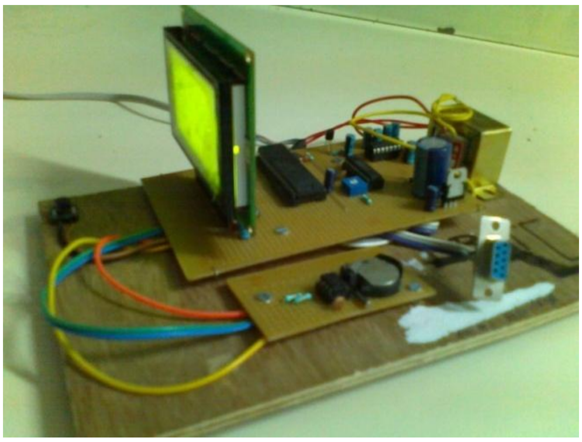

Fig 10. Side view of the developed system board.

7. ACKNOWLEDGEMENT
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8. REFERENCES
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