UM0963
User manual

STEVAL-IFS012V1 demonstration board based on multiple temperature sensors and RTCs

Introduction

This document explains the functioning of the multi-device temperature sensor and real-time clock (RTC) demonstration board. The complete system consists of a motherboard with an ST72F651AR6 microcontroller and daughter cards having temperature sensors and RTCs. The temperature sensors supported by this system are:

- STLM20
- STTS424E02
- STTS75
- STDS75
- STLM75
- STCN75

The RTCs supported by this system are:

- M41T81S
- M41T82
- M41T83

This board can operate in two modes:

- Standalone / external power mode
- USB-powered mode / full-featured mode

The board's configuration and operation in both modes is explained in different sections. To select the desired mode, there is a power selection switch (SW5) on the board which enables the appropriate selection. When this board is connected to a computer through the USB cable, it also behaves as a mass storage device. The default state of the board (with USB connection) is mass storage mode. It can switch to temperature sensor mode using a graphical user interface (GUI).

Figure 1. Multi-device temperature sensor demonstration board

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Table 1. Abbreviations

Abbreviation	Term
GUI	Graphical user interface
LCD	Liquid crystal display
USB	Universal serial bus
RTC	Real-time clock
°C	Degree centigrade
EEPROM	Electrically erasable programmable read-only memory
Kb	1024 bits

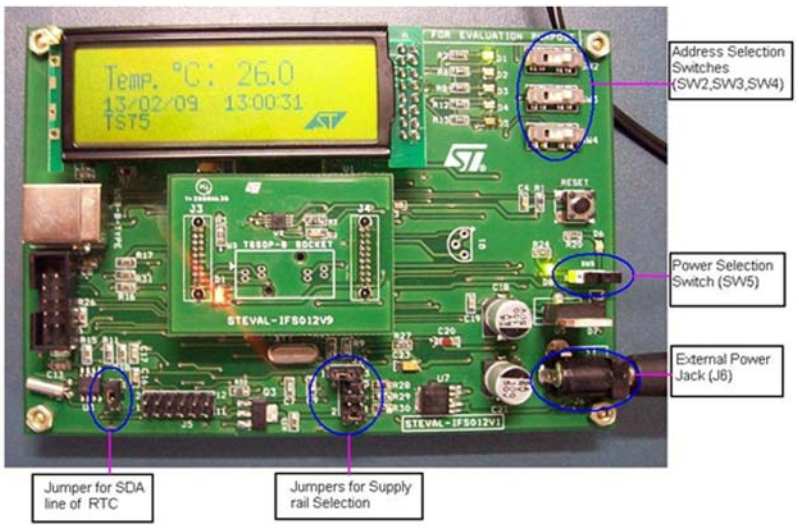
1.1 Package contents

The multi-device temperature sensor demonstration board includes the following items:

- Hardware content:
  - One motherboard
  - Two daughter cards (STTS75 - TSSOP8 package and STLM20 - UDFN package) The daughter cards for all sensors and RTCs can be ordered individually.
- Documentation:
  - User manual
  - Quick reference manual
- GUI installation file

1.2 Hardware description

Figure 2. Hardware description of demonstration board



1.2.1 On board components

- Major blocks present on the STEVAL-IFS012V1 are:
  - Microcontroller
  - 64 MB NAND Flash
  - RTC
  - Graphic LCD (122 x 32 pixels)
  - 3 V button battery
  - Power jack for external power supply
  - USB jack for USB connection
  - Switches SW2, SW3 and SW4 to configure the address of the temperature sensor
  - Power selection switch (SW5) to select between external power and USB power
- Major blocks present on the RTC daughter cards are:
  - M41T82/ M41T83/ M41T82SMY6E - RTCs
  - STM32F103C8 - Microcontroller
  - FOX924B-12 - TCXO
  - EDLSD224H5R5C - super capacitor

1.2.2 Power supply selection

The board can work in two different power supply modes:

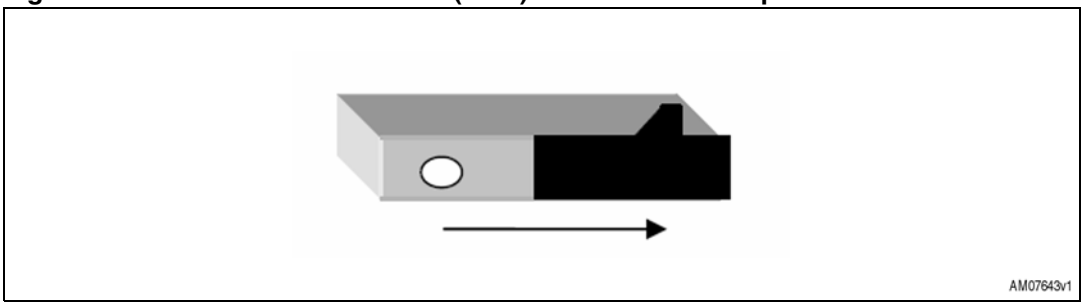
1. External power mode
2. USB-powered mode

Selection of the required power mode is done through the SW5 switch.

External power mode selection

To select the external supply mode position the switch (SW5) as shown in *Figure 3*. Then plug in the DC adapter (8 V - 20 V,1 A and center positive) with a female connector to the power jack (J6) and the green LED (D8) turns on.

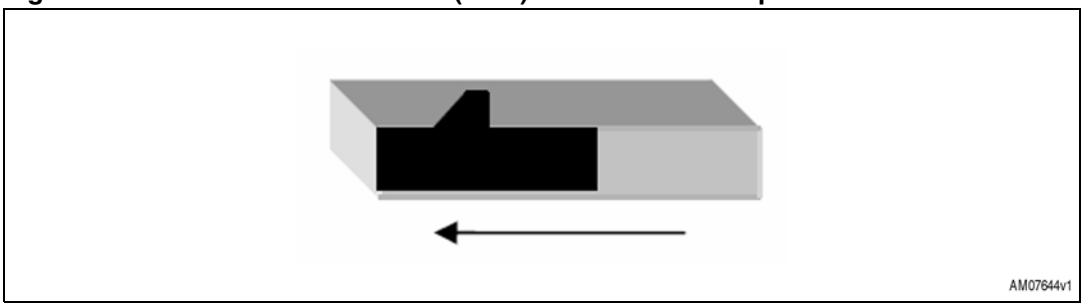
Figure 3. Power selection switch (SW5) to select external power



USB-powered mode selection

To select the USB-powered mode, unplug the external power supply and then position the power switch as shown in the figure below.Then plug the USB cable into the USB socket (J2) on the board. The red LED (D6) turns on and board powers up with USB power.

Figure 4. Power selection switch (SW5) to select for USB power



Note: Only one power supply should be plugged in (either USB or external power adapter) at any given time. The power LED (green (D8) for external supply and red (D6) for USB supply) turns on as soon as the power is plugged in, but the power is connected to the board only by the appropriate switch settings as shown in Figure 3 and 4.

2 External power mode of the board

This mode is also referred to as the standalone mode of the board. In this mode the board is supplied by an external power supply and continuously displays the time and temperature on the LCD. A computer interface is not necessary for this mode.

2.1 Powering of the board

The motherboard can be powered to 5 V using an external supply or a USB supply whereas the daughter cards can be powered to either 1.8 V, 2.5 V, 3.3 V, or 5.0 V using the jumpers (J16 and JP1) on the motherboard.

Follow these steps to power the board:

1. Position the power selection switch (SW5) to external power mode as shown in *Figure 3*
2. Place the jumper on J16.

To supply the temperature sensor daughter card with 5 V, place the jumper on 1 and 2 of J16. If the daughter card is to be supplied with an alternate voltage (1.8 V/2.5 V/3.3 V) then follow these steps:

1. Place jumper on pins 2 and 3 of J16
2. To supply the daughter card with 3.3 V, place the jumper on pins 1 and 2 of JP1 or to select for 2.5 V place the jumper on pins 3 and 4 of JP1 or for 1.8 V place the jumper on pins 5 and 6 of JP1. Refer to the summary in *Table 2*.

Table 2. Power selection for daughter card

Jumpers		
Needed voltage	**J16**	**JP1**
5 V	Pins 1 and 2	n/a
3.3 V	Pins 2 and 3	Pins 1 and 2
2.5 V		Pins 3 and 4
1.8 V		Pins 5 and 6

Note: (Only one jumper should be present on JP1 at any given time).

3. Plug in the DC power supply through the adapter (8 V - 20 V, 1 A output). As soon as power is plugged in, the green LED (D8) turns on.

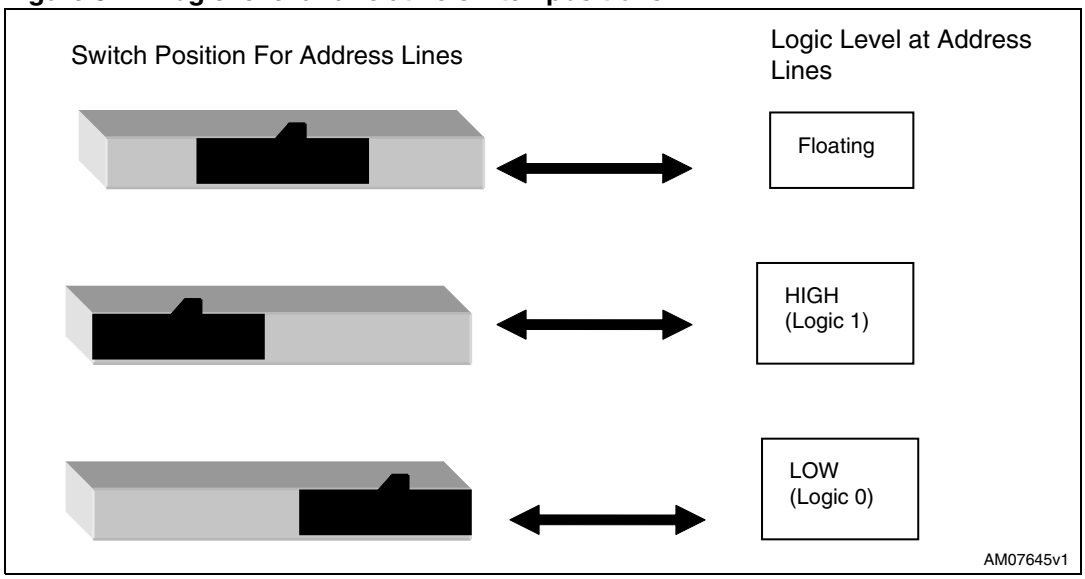
Note: This LED (D8) shows only that power is connected or not. Power to the board is selected using the power selection switch (SW5).

2.2 Address selection on the board

This demonstration board supports different temperature sensors and RTCs which are present on different daughter cards. For digital temperature sensors, the address lines are configured using the switches (SW2, SW3, SW4) present on the motherboard.

The logic level is assigned to the address line using the address selection switches. The figure below shows the position of the switch and the respective logic level assigned by that switch.

Figure 5. Logic level and relative switch positions



2.2.1 Address configuration of different sensors using the switches

The following sections detail the configuration of the address lines of different sensors.

STTS75, STDS75, STLM75 and STCN75

The STTS75, STDS75, STLM75 and STCN75 all are digital temperature sensors with three address lines. There are eight possible addresses for these sensors.

SW2 corresponds to A0, SW3 corresponds to A1 and SW4 corresponds to A2 address lines of the sensors.

The addresses allowed and their settings for the STTS75, STDS75, STLM75 and STCN75 are as follows:

- Address 1 = 0x90, => SW4 = 0, SW3 = 0, SW2 = 0
- Address 2 = 0x92, => SW4 = 0, SW3 = 0, SW2 = 1
- Address 3 = 0x94, => SW4 = 0, SW3 = 1, SW2 = 0
- Address 4 = 0x96, => SW4 = 0, SW3 = 1, SW2 = 1
- Address 5 = 0x98, => SW4 = 1, SW3 = 0, SW2 = 0
- Address 6 = 0x9A, => SW4 = 1, SW3 = 0, SW2 = 1
- Address 7 = 0x9C, => SW4 = 1, SW3 = 1, SW2 = 0
- Address 8 = 0x9E, => SW4 = 1, SW3 = 1, SW2 = 1

Table 3. Switch settings for selecting different addresses of STT75/STLM75/STDS75/STCN75

Address line	Address 1 (0x90)	Address 2 (0x92)	Address 3(0x94)	Address 4 (0x96)	Address 5 (0x98)	Address 6 (0x9A)	Address 7 (0x9C)	Address 8 (0x9E)
SW2 (A0)								
SW3 (A1)								
SW4 (A2)								

STTS424E02

The STTS424E02 is also a digital temperature sensor with three address lines. There are eight possible addresses for this sensor.

SW2 corresponds to A0, SW3 corresponds to A1 and SW4 corresponds to A2 address lines of the sensors.

The addresses allowed and their settings for the STTS424 and STTS424E02 sensors are as follows:

- Address 1 = 0x30, => SW4 = 0, SW3 = 0, SW2 = 0
- Address 2 = 0x32, => SW4 = 0, SW3 = 0, SW2 = 1
- Address 3 = 0x34, => SW4 = 0, SW3 = 1, SW2 = 0
- Address 4 = 0x36, => SW4 = 0, SW3 = 1, SW2 = 1
- Address 5 = 0x38, => SW4 = 1, SW3 = 0, SW2 = 0
- Address 6 = 0x3A, => SW4 = 1, SW3 = 0, SW2 = 1
- Address 7 = 0x3C, => SW4 = 1, SW3 = 1, SW2 = 0
- Address 8 = 0x3E, => SW4 = 1, SW3 = 1, SW2 = 1

Table 4. Switch settings for selecting different addresses of the STTS424E02

Address line	Address 1 (0x30)	Address 2 (0x32)	Address 3 (0x34)	Address 4 (0x36)	Address 5 (0x38)	Address 6 (0x3A)	Address 7 (0x3C)	Address 8 (0x3E)
SW2 (A0)								
SW3 (A1)								
SW4 (A2)								

STLM20

The STLM20 is an analog temperature sensor with no address lines. After setting the address, press the reset button (RESET) present on the board.

Then the board starts to function showing the temperature, time and sensor name on the LCD.

Note: If the M41T81S RTC is to be selected, then the jumper for the SDA line of RTC (J2) should be connected before pressing the RESET button on the board. Otherwise, the RTC daughter card for the M41T82 or M41T83 should be plugged in the motherboard and jumper J2 should be removed before powering up the board.

2.3 Values in temperature sensor registers in standalone mode

2.3.1 STTS75, STLM75, STDS75 and STCN75

Table 5. Default values of sensor registers

Register name	Value
Oversaturation (Tos)	35 degree centigrade
Hysteresis (Thys)	15 degree centigrade
Configuration (Tconfig)	0x00

2.3.2 STTS424E02

Table 6. Default values of sensor registers

Register name	Value
Configuration	0x00, 0x08 (alarm enabled)
Alarm temperature lower boundary trip	15 degree centigrade
Alarm temperature upper boundary trip	30 degree centigrade
Critical temperature trip	35 degree centigrade

2.3.3 STLM20

The STLM20 is an analog sensor and thus there is no register configuration for it. Also, there is no alert output from the sensor.

2.4 Sequence for operation of the board in standalone mode

In order to operate the board in standalone mode, follow these steps:

1. Plug the temperature sensor daughter card or the RTC daughter card into the motherboard
2. If the temperature sensor daughter card is plugged in, then configure the address lines of the sensor accordingly, using the switches SW2, SW3, SW4 as explained in *Section 2.2*.
3. Position the power selection switch (SW5) to select the external power supply as shown in *Figure 3*
4. If the M41T82 RTC is to be selected, then remove the RTC daughter card and put the jumper on the SDA line of the RTC (J2).
5. Plug the power adapter into the board and switch on the supply
6. Press the reset button (RESET) present on the board
7. The application starts running. If the temperature sensor daughter card is selected, then the temperature and time are displayed on the LCD. If the RTC daughter card is selected, then the RTC date, time and device name are displayed on the LCD.

Note: To change the address of the sensor, switch off the supply, configure the new address and again plug in the supply. The application starts with a new address configuration.

3 USB power/GUI mode of board

The second mode of operation of this multi-device temperature sensor and RTC board is with a GUI through a USB connection.

In this mode if the GUI is not connected, then the board behaves as a mass storage device and is seen as a removable drive on the computer.

To use the board in temperature sensor or RTC demonstration mode, connect it to the computer using a USB cable and the board communicates with the GUI using USB communication protocol. The GUI is used to configure the temperature sensor and RTC registers and to explore all their features.

3.1 Getting started

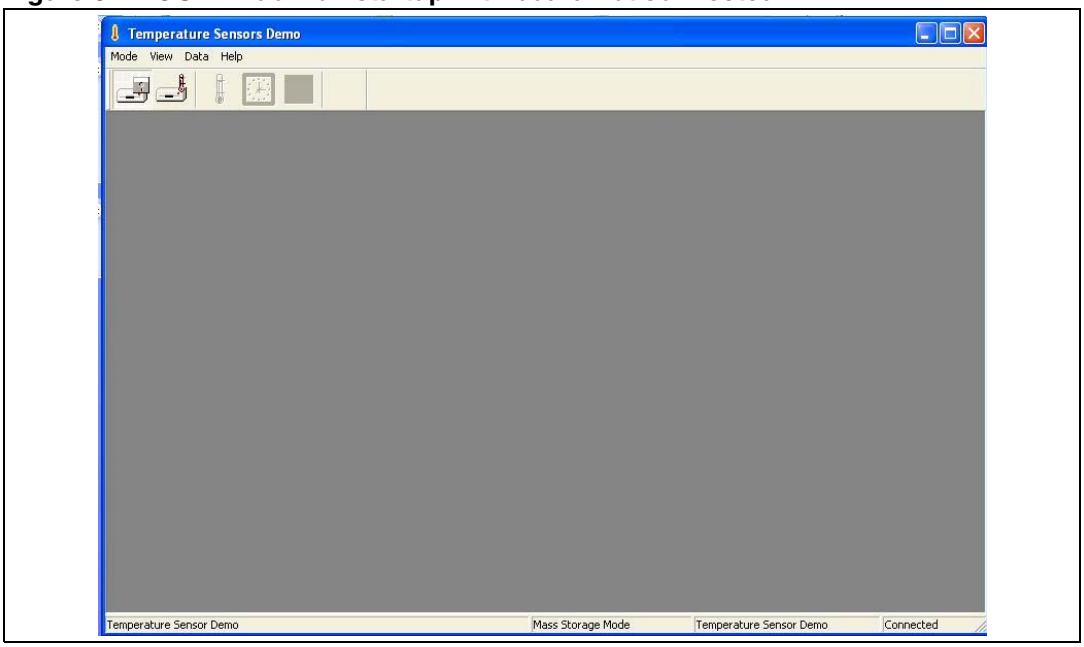
The GUI is to be installed from the link given in the installation CD.

Double click on the executable (.exe) file to install the GUI on the host system.

To install the GUI, the user should have administrative rights, as the setup overwrites files (.dll) in the system folder that are protected by administrative rights. If the user doesn't have administrative rights, this GUI cannot be installed (error message: 0x80040707 appears).

After installation, open up the temperature sensor GUI by clicking on the GUI icon and the GUI window opens as shown in the figure below.

Figure 6. GUI window on startup with board not connected



3.2 Powering of board in GUI mode

Follow these steps for powering the board in GUI mode:

1. Position the power selection switch (SW5) to USB power mode as shown in *Figure 4*.
2. Place the jumper on J16.

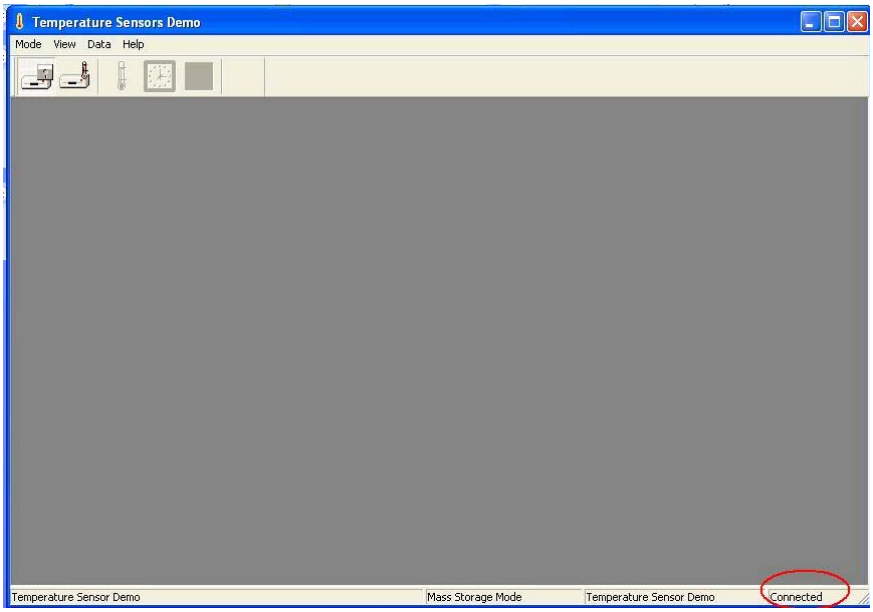
To supply the daughter card with 5 V, place the jumper on pins 1 and 2 of J16. If the daughter card is to be supplied with an alternate voltage (1.8 V/2.5 V/3.3 V) then follow these steps:

1. Place jumper on pins 2 and 3 of J16.
2. To supply daughter card with 3.3 V, place the jumper on pins 1 and 2 of JP1 or to select for 2.5 V place the jumper on pins 3 and 4 of JP1 or for 1.8 V place the jumper on pins 5 and 6 of JP1. Refer to *Table 2*. (At any given time, only one jumper should be present on JP1).
3. Plug the USB cable into the USB socket on the board. As soon as the USB cable is plugged in, the red LED (D6) turns on.

Note: This LED (D6) shows only that the USB is connected or not. Power to the board is selected using the power selection switch (SW5).

4. After plugging in the USB cable and if the power switch is correctly positioned, then the status in the status bar of the GUI changes to “Connected” as shown in the figure below.

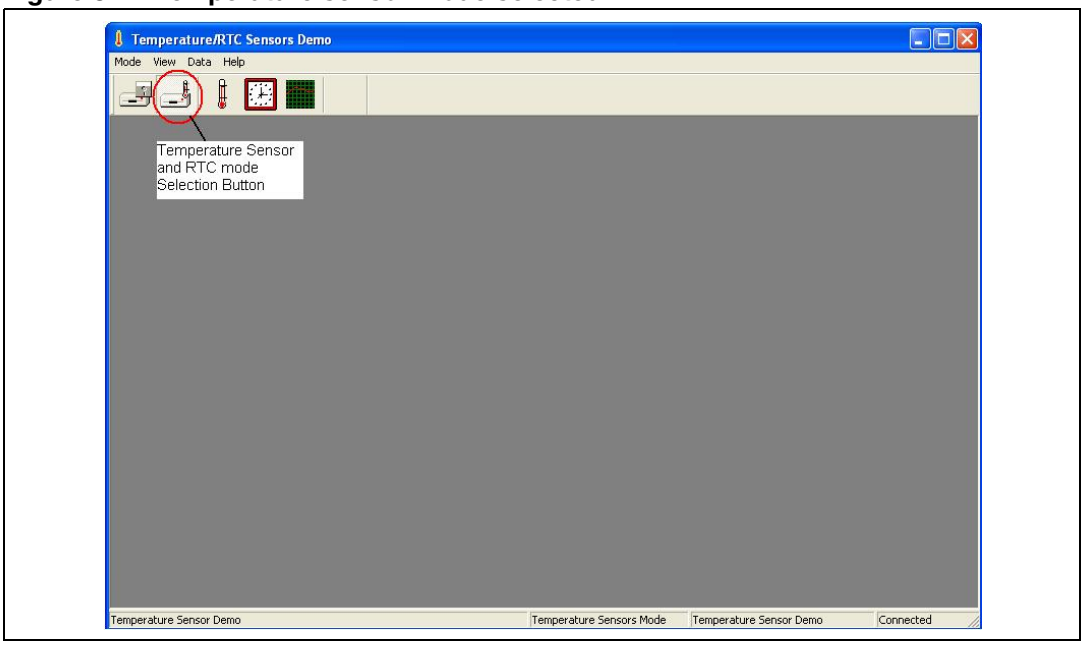
Figure 7. Board connected to GUI and status changed to “Connected” in status bar



3.3 Switching to temperature sensor and RTC mode

By default, the board is in mass storage mode and when the GUI is opened, it shows the mass storage mode in the status bar. Once the board is connected to the GUI and the status changes to “Connected” in the status bar, press the temperature sensor and RTC mode selection button in the toolbar to switch to temperature sensor and RTC demonstration mode. As the GUI goes in temperature sensor and RTC mode, all three icons (temperature sensor, RTC and plotter) become active. The GUI appears as shown in the figure below.

Figure 8. Temperature sensor mode selected

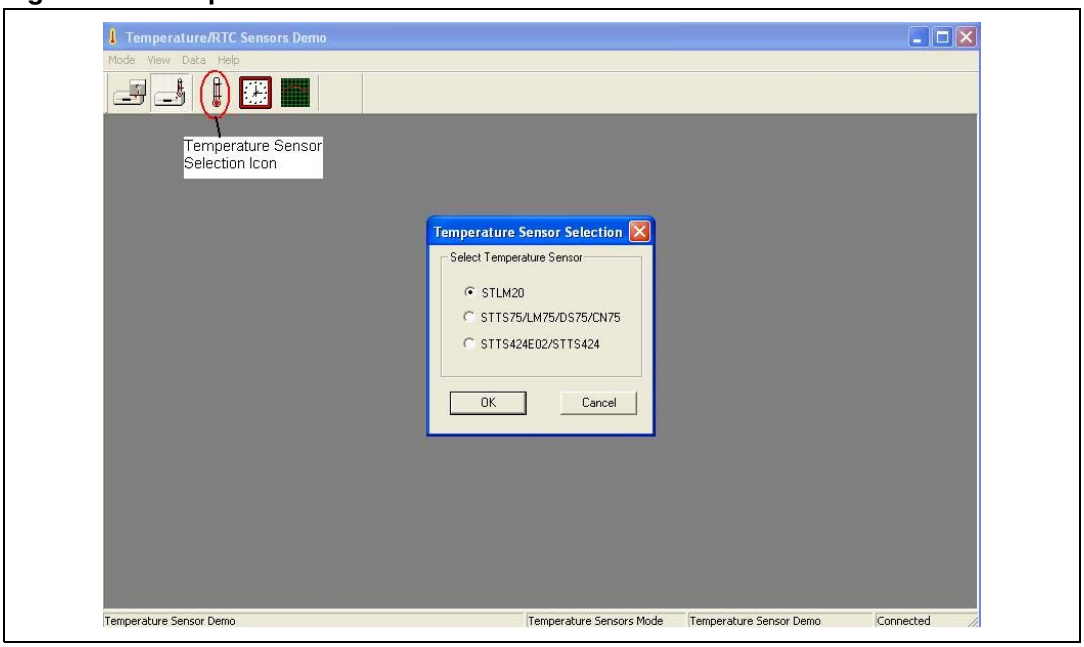


The LCD shows the ST logo and waits for the selection of the daughter card.

Pressing the temperature sensor icon from the toolbar opens up the list of sensors in the GUI as shown in *Figure 9*. Select the desired sensor from the displayed radio buttons and press the OK button in the GUI. If the sensor present on the board is not the one selected in the GUI, an error message pops up in the GUI showing the wrong selection of the sensor. In this case, re-select the correct sensor from the GUI and press the OK button.

When the correct sensor is selected, the window for it opens up in the GUI.

Figure 9. Temperature sensor selection window



There are 6 sensors supported by the motherboard and there are three different GUI windows to support all the sensors. A GUI selection window exists for:

1. STTS75/STLM75/STDS75/STCN75
2. STTS424E02
3. STLM20

3.3.1 GUI window for STTS75, STLM75, STDS75, STCN75 sensors

The STTS75, STLM75, STDS75, and STCN75 sensors are supported by a single GUI window as shown in *Figure 11*. There are radio buttons for selecting one of four possible sensors (STTS75, STLM75, STDS75, and STCN75). The LCD display shows TS75 for all of the STTS/LM//DS/CN temperature sensors.

In order to operate these sensors using the GUI, follow these steps:

1. Select one of the radio buttons present in the “Select the temperature sensor” area in the GUI. This enables the GUI for one of the selected sensors (STTS75/STLM75/STDS75/STCN75)
2. Choose the address from the drop-down menu of “Choose Address”. If the address selected from the GUI is the same as the one configured on the board (as described in *Section 2.3.2*) the remaining part of the GUI is enabled, else an error message appears in the GUI as shown in *Figure 11*. In this case, select the correct address from GUI.
3. Configure the different registers of the sensor and observe the behavior in the GUI and on the board.

Figure 10. GUI selection window for STTS75/STDS75/STLM75/STCN75

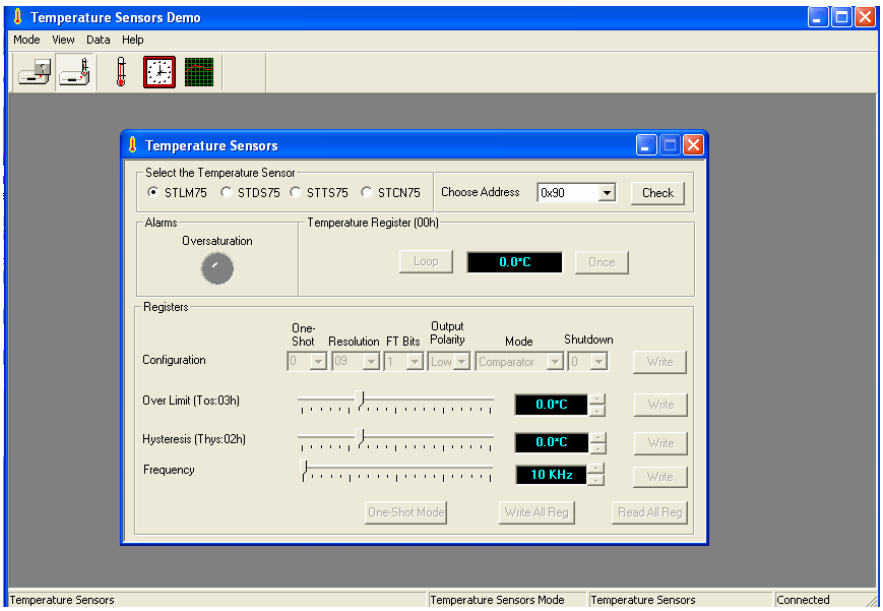


Figure 11. Address error message

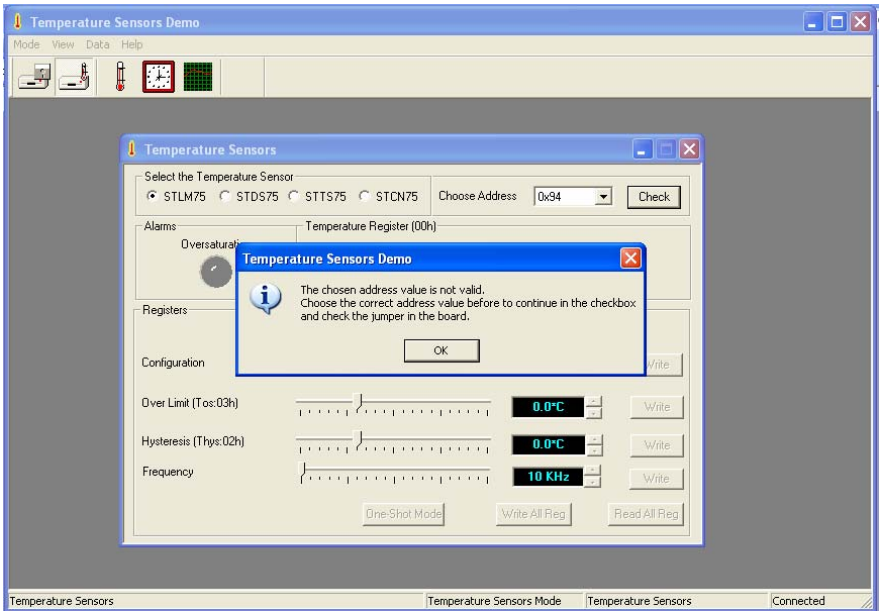
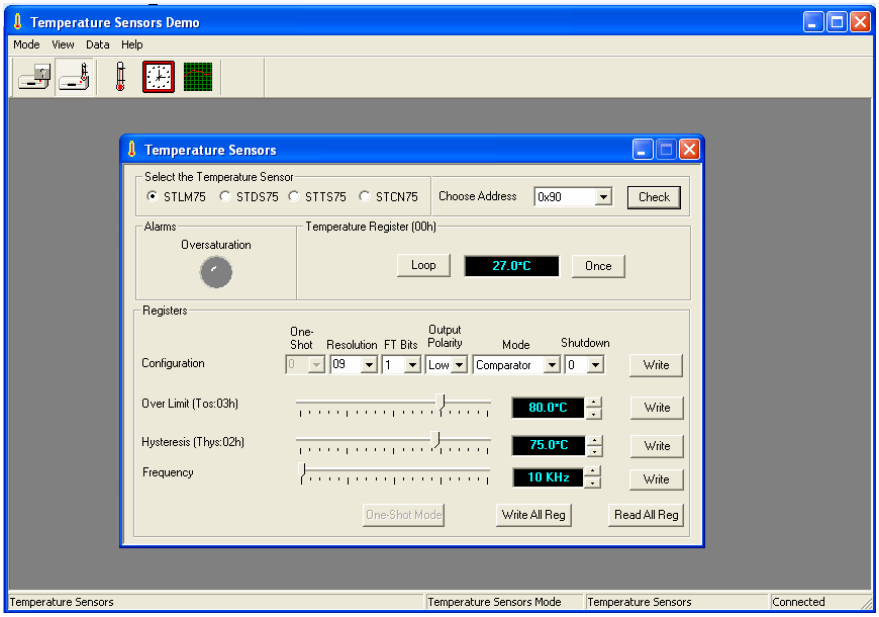


Figure 12. Active temperature sensor window



3.3.2 Register configuration for STTS75, STLM75, STDS75, STCN75 sensors

There are four different registers which control the behavior of each sensor:

- 8-bit configuration register
- 16-bit oversaturation (Tos) register
- 16-bit hysteresis (Thys) register
- 16-bit read-only temperature register

The GUI has a register section to configure these registers.

1. Configuration register
   - Select the desired bits from the drop-down choices in the configuration register
   - Press the write button to program the sensor with the selected value
   - The One-Shot is enabled only for the STTS75 sensor
2. Oversaturation register (Tos):
   - This register is used to enter the oversaturation temperature
   - Enter the desired temperature using the slider or up/down button
   - Press the write button to program the sensor with the selected temperature
   - The setting configuration is shown in *Figure 13*
3. Hysteresis register (Thys):
   - This register is used to enter the hysteresis temperature
   - Enter the desired hysteresis temperature using the slider or up/down button
   - Press the write button to program the sensor with this value of hysteresis
   - The setting configuration is shown in *Figure 13*

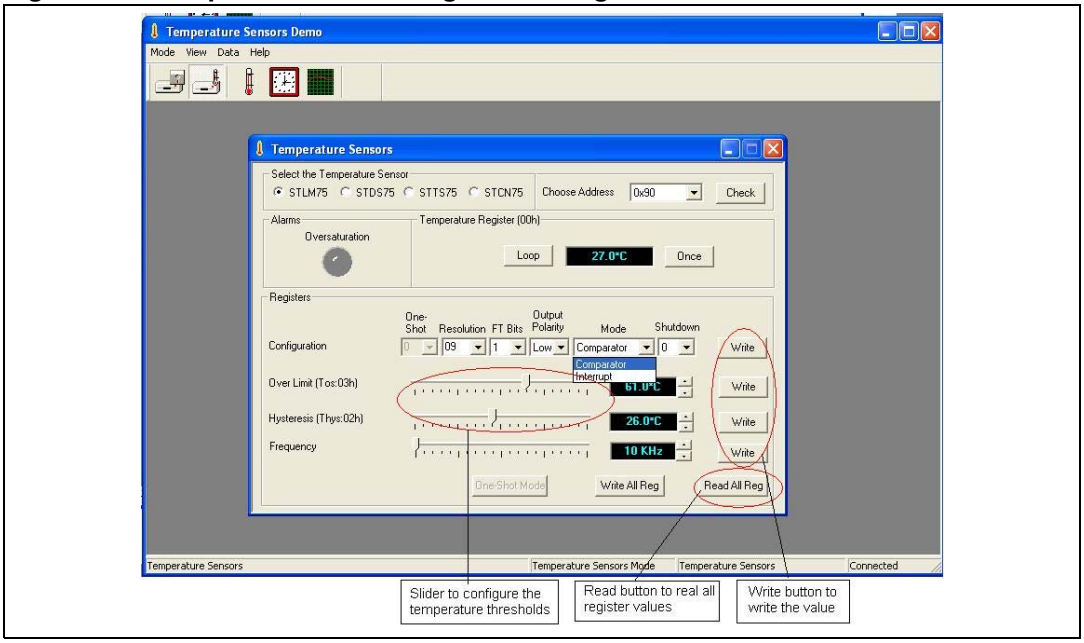
4. Temperature register
   - This register is used to show the temperature measured by the sensor
   - The Once button is used to read the temperature at any one instant
   - The Loop button is used to continuously measure and display the temperature
   - Alarms appear in the GUI only when the Once or Loop button is pressed. Pressing Once reads the instantaneous temperature value and latches the instantaneous alarm condition in the GUI. Pressing the Loop button allows continuous monitoring of the temperature and alarm condition and displays these in the GUI. Stopping the Loop button latches the last measured value of temperature and the last alarm condition in the GUI.

The Read button is used for reading the values back from the sensor present on the board. As soon as the address is checked, the sensor registers show the default settings of the registers in this window.

There is a One-shot mode button present in the GUI which functions only for the STTS75 sensor. The one-shot mode puts the sensor in shutdown mode and then reads the temperature only once. Setting the one-shot mode causes the shutdown bit of the configuration register to be set to '1'. To return the sensor to normal mode, write the shutdown bit to '0'.

There is a slider for the Frequency setting for I^2C communication with sensor. This is by default fixed to 10 kHz. In order to avoid disruption of sensor communication with the microcontroller, this frequency slider does not affect the sensor I^2C communication frequency.

Figure 13. Temperature sensor register settings



3.3.3 Alarm in STTS75, STLM75, STDS75, STCN75 sensors

The alarm status can be observed in the Once or Loop condition. Upon pressing the Once button, the instantaneous alarm condition is latched in the GUI, whereas in the Loop condition, the alarm condition is monitored continuously and is displayed in the GUI. When the loop condition is stopped, the last status of the alarm is latched and shown in the GUI.

This alarm is used to indicate the behavior of the OS pin output of the temperature sensor.

- Default state: alarm off
- Temperature rises above oversaturation temperature (Tos): alarm LED lights up
- Temperature falls below Thys: alarm off

On the motherboard this alarm signal is shown by the D5 LED. This is a red LED which turns on whenever there is an alert signal from the sensor and goes off when the alert is not present.

3.3.4 GUI window for STTS424E02 sensor

The STTS424E02 is a simple digital temperature sensor also having on-chip 2Kb EEPROM. The GUI for the STTS424E02 also has an option for supporting the STTS424 without EEPROM.

Follow these steps to operate the STTS424E02 sensor in GUI mode:

1. Plug the daughter card of the STTS424E02 into the motherboard
2. Select the STTS424/STTS424E02 sensor option from the GUI as shown in *Figure 9*
3. Select the STTS424E02 sensor radio button from the sensor options in “Select the Temperature Sensor” area in the GUI. Upon selecting the STTS424E02 sensor, the “Edit EEPROM” option is also enabled in the GUI.
4. Check the address from the “Choose Address” area. If the address configured on the board (as explained in *Section 2.3.3*) is different from the address selected from the GUI, an error message appears in the GUI. In case of error, select the correct address.
5. All the registers show the default readings at first selection
6. Press the “Loop” button to continuously read the temperature in the GUI
7. Configure the different registers through the GUI and observe the behavior of the sensor

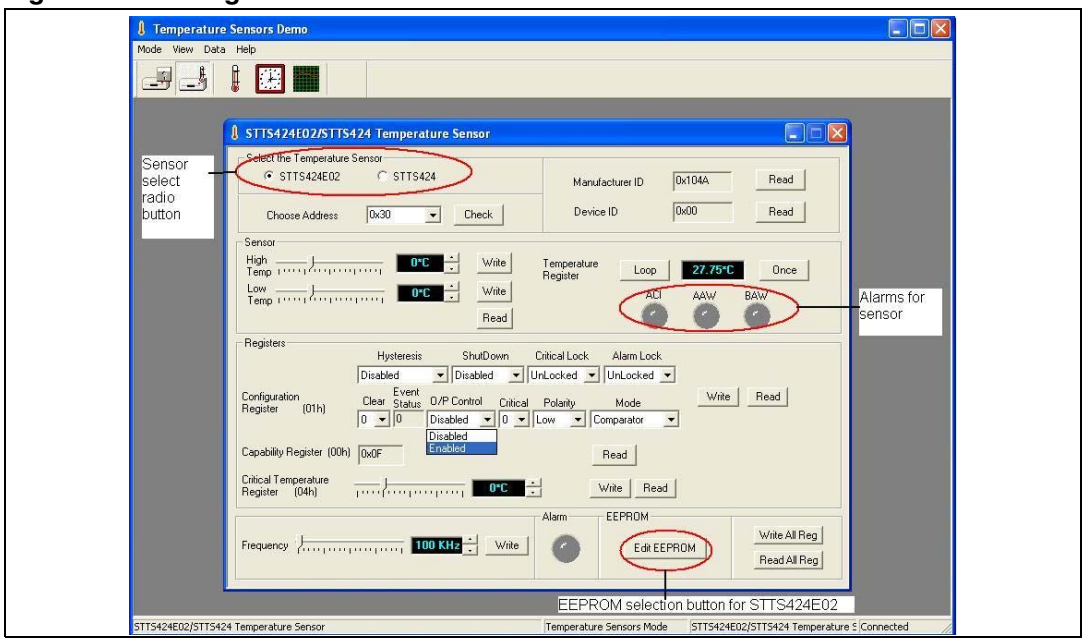
3.3.5 Register configuration for STTS424E02 sensor

There are four read/write registers in the STTS424E02 temperature sensor:

- Configuration register
  - The GUI has drop-down choices for the bits of the configuration register. Select the desired bits in the configuration register
  - Press the write button to program the sensor with the selected value. *Figure 14* shows the settings
- Upper temperature register:
  - This register is used to enter the alarm temperature upper boundary settings for the sensor
  - Enter the desired temperature using the slider or up/down button
  - Press the write button to program the sensor with the selected temperature. *Figure 14* shows the settings
- Lower temperature register:
  - This register is used to enter the alarm temperature lower boundary settings for the sensor
  - Enter the desired temperature setting using the slider or up/down button
  - Press the write button to program the sensor with this value. *Figure 14* shows the settings
- Critical temperature register:
  - This register is used to enter the critical temperature settings for the sensor
  - Enter the desired temperature setting using the slider or up/down button
  - Press the write button to program the sensor with this value. *Figure 14* shows the settings
- Temperature register (read-only):
  - This register is used to show the temperature measured by the sensor.
  - The Once button is used to read the temperature at any one instant.
  - The Loop button is used to continuously measure and display the temperature.

There is a slider for setting the frequency of I^2C communication for sensor communication and is set by default to 100 kHz. In order to avoid communication failure, this slider does not affect the frequency in the sensor.

Figure 14. Configuration of the STTS424/STTS424E02 sensor



There are three alarms in the STTS424E02 sensor:

1. Below alarm window (BAW):
   – This alarm occurs when the measured temperature goes below the temperature setting established in the alarm temperature lower boundary register (lower temp register). The BAW alarm in the GUI lights up. As the measured temperature rises above the threshold setting in the below alarm window, the alarm switches off.
2. Above alarm window (AAW):
   – This alarm occurs when the measured temperature goes above the temperature setting established in the alarm temperature upper boundary register (upper temp register). The AAW alarm in the GUI lights up. As the measured temperature falls below the threshold setting in the above alarm window, the alarm switches off.
3. Above critical temperature (ACI):
   – This alarm occurs when the measured temperature goes above the temperature setting established in the critical temperature register. The ACI alarm in the GUI lights up. As the measured temperature falls below the threshold setting in the critical alarm, the alarm switches off.

   The “Alarm” icon also lights up in the GUI only when the O/P Control bit is enabled in the configuration register and one of the above-mentioned alarms has occurred. Only then does the alarm LED on the board (D5) light up as well.

   The status of the BAW, AAW, ACI alarms can be seen in the GUI either in once or loop mode. Pressing the Once button shows the instantaneous alarm conditions and latches these in the GUI. These conditions are refreshed upon pressing again the Once button. Pressing the loop button allows continuous monitoring of the alarm conditions and displays them in the GUI. Stopping the loop button latches the last conditions of the alarms in the GUI. These are refreshed either by using the Loop or Once read button again.

   For the initial address check, the default state of the upper temp register, lower temp register and critical temp register is 0x00, thus the alarm conditions for AAW and ACI are met and these alarms are lit up in the GUI.

Note: 1 The alarm observed only when the register settings follow this order: Critical temperature > Above alarm window temperature > Below alarm window temperature.

2 To observe the alarms occurring on board, O/P Control bit should be enabled in the configuration register.

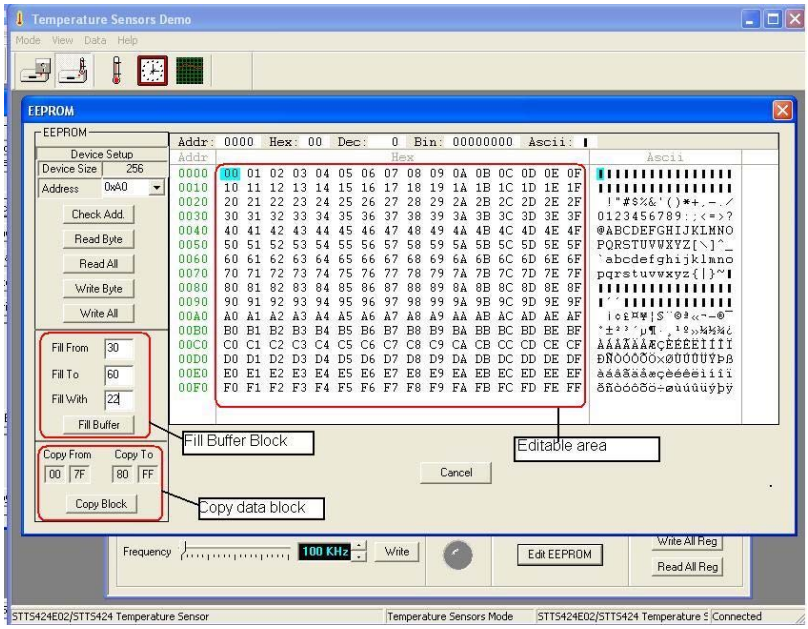
3.3.6 EEPROM setting for the STTS424E02 sensor

The STTS424E02 sensor has on-chip EEPROM of 2 Kbit. When the STTS424E02 sensor is selected in the GUI, the “Edit EEPROM” button is enabled. The EEPROM window opens upon clicking the Edit EEPROM button.

Follow these steps to use the EEPROM of the STTS424E02 sensor:

1. Select the address of the EEPROM. The last three of bits of the EEPROM address are derived from the last 3 bits of the temperature sensor address.
2. When the correct address is selected, the GUI for EEPROM is enabled with an editable area of 256 bytes.
3. To read the data byte at any specific location, select the location in the editable window and press the read byte button, which reads the selected location data from the sensor EEPROM and displays it at the location in the editable area in the GUI.
4. The read all button reads all of the 256 bytes from the sensor EEPROM and displays this in the editable area
5. To write a single byte at a specific location, change the byte value by typing and press the enter button on the keyboard. Then press the write Byte button to write the data in the EEPROM.
6. To write all the 256 bytes of EEPROM, press the write all button in the GUI which writes the bytes given in the editable field. To change the bytes in the editable field, type the new value and press enter and then type a new value in another location. After all the values are changed, press the write all button to program the values in the EEPROM.
7. The Fill Buffer area in the GUI is used to fill the EEPROM area with same data byte. Type the memory location from where the data is to be written and also the destination memory location address. Then enter the data byte in the “Fill With” area. Pressing the Fill Buffer button programs the EEPROM selected area with the selected data byte. This data byte can be seen in the GUI by pressing the read all button.
8. The Copy Block area is used to copy the data from the memory location 0x00-0x7F to the location 0x80-0xFF. Thus both upper and lower 1 Kbit data are similar after the copy block command.
9. The settings for the EEPROM of the STTS424E02 sensor are shown in *Figure 15*

Figure 15. EEPROM setting for the STTS424E02

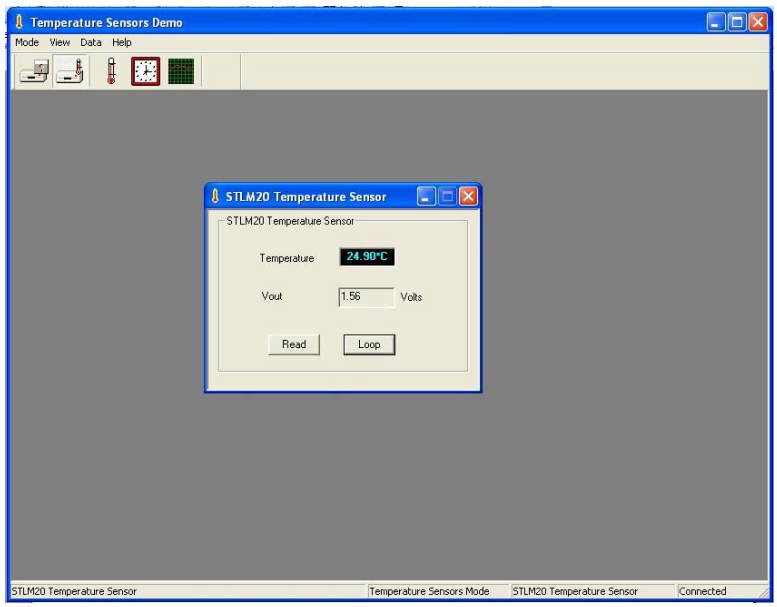


3.3.7 GUI window for the STLM20 sensor

The STLM20 is an analog temperature sensor. Follow these steps to use the GUI for the STLM20:

1. Plug the STLM20 daughter card into the motherboard.
2. Select the STLM20 sensor in the GUI as explained in *Figure 16*
3. The once button reads at that moment the sensor value and voltage output value from the sensor.
4. The loop button continuously reads the temperature and voltage from the STLM20

Figure 16. GUI window for the STLM20 temperature sensor



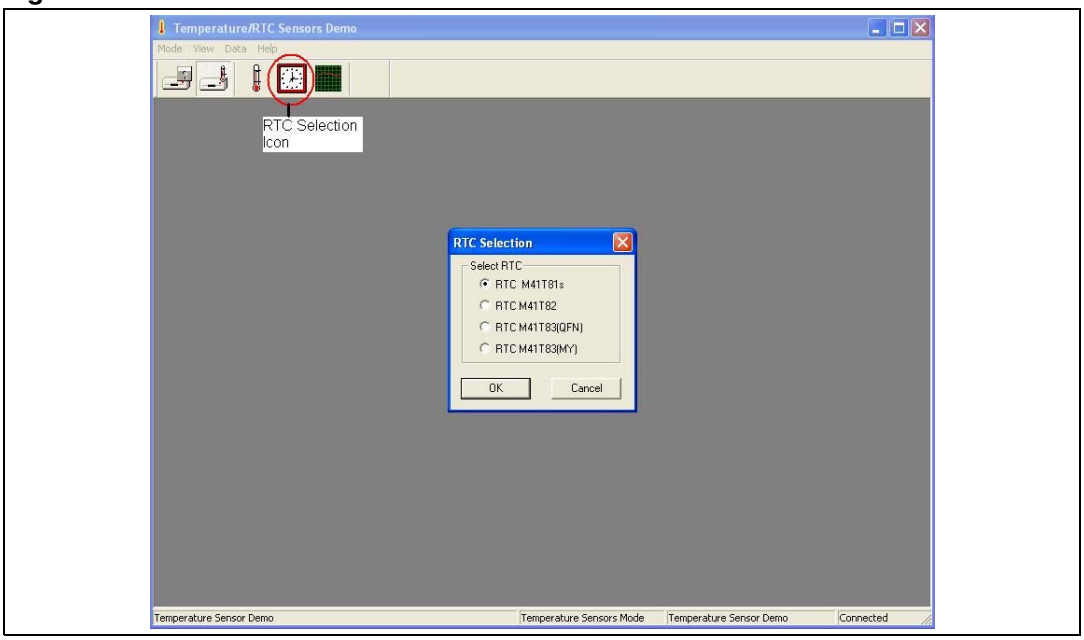
3.4 RTC mode of GUI

The GUI supports the demonstration of four RTCs:

- M41T81S RTC mounted on the motherboard
- M41T82 RTC mounted on a separate daughter card
- M41T83(QFN package) mounted on a separate daughter card
- M41T83(SOX18 package) mounted on a separate daughter card

The RTC mode of the GUI is selected through the RTC Selection icon in the GUI. Pressing the RTC selection icon shows the selection menu for the RTC, as shown in *Figure 17*.

Figure 17. RTC selection window



3.5 Configuring the M41T81S RTC

The M41T81S RTC is mounted on the motherboard and jumper J2 is used for selecting the SDA line of this RTC.

Follow these steps to select the M41T81S RTC:

1. Place the jumper on J2
2. Plug any temperature sensor daughter card into the motherboard
3. Power up the motherboard using the USB cable
4. Open the GUI and select the RTC selection icon as shown in *Figure 17*
5. Select M41T81s from the menu and press OK
6. The M41T81s RTC window opens up as shown in *Figure 18*

On powering up the board, the RTC clock is seen as halted, showing the time of power-down. The clock starts running only after resetting the HT bit in the RTC GUI window. In standalone mode, the HT bit is handled in the firmware.

3.5.1 M41T81S RTC date and time setting

1. Click on the RTC selection icon in the toolbar of the GUI. The RTC selection radio button appears in the GUI as shown in *Figure 17*
2. Select the RTC M41T81s and the RTC selection window opens up as shown in *Figure 18*
3. The “Update” button is used to enable the configuration of the RTC. Pressing the “Update” button enables the GUI window for the RTC configuration. It also reads the RTC registers from the on-board RTC and displays these in the GUI.
4. After pressing the “Update” button, reset the HT bit to see the clock ticking on the display
5. The user can configure the RTC date and time by clicking on the “Set Time” button in the GUI which then programs the on-board RTC with the system date and time.
6. “CEB”, “Stop Bit”, and “OFIE Bit” are the check boxes to enable or disable the respective bit in the RTC. Checking the box and then pressing the write button sets the bits and un-checking them and clicking on the write button resets the bits.
7. The “Program” button configures the RTC with the current settings visible in the GUI
8. The “RTC Reg” button shows the RTC registers and the values present in those registers as shown in *Figure 19*

Figure 18. GUI window for the M41T81S RTC

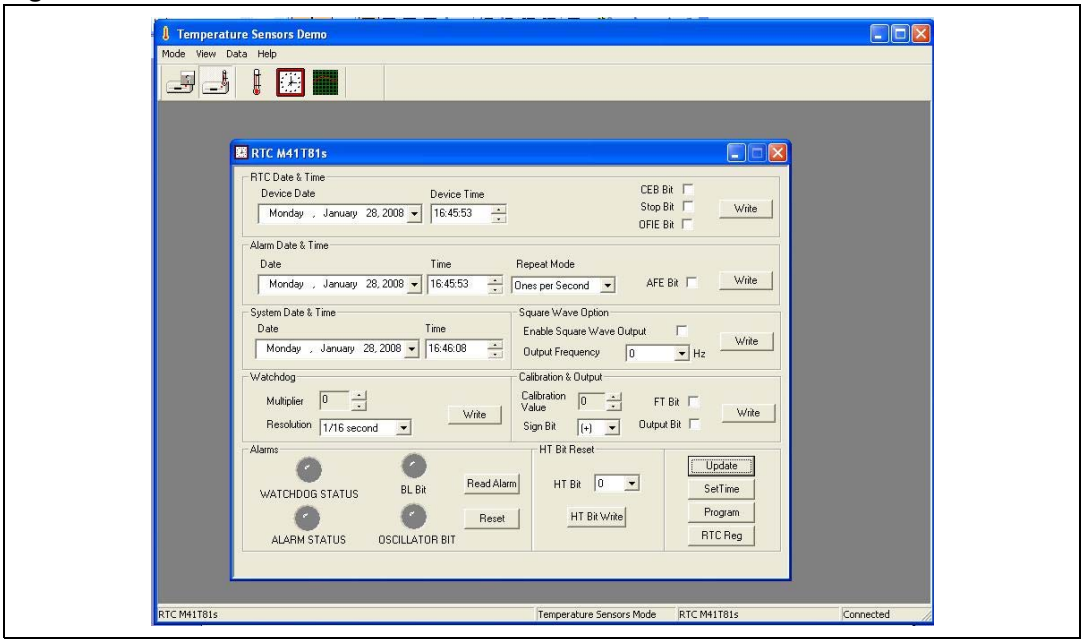
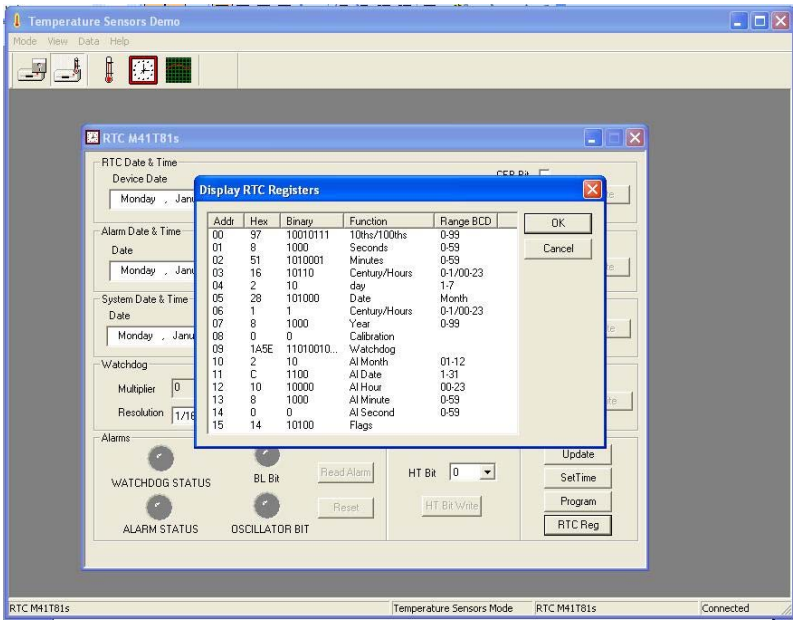


Figure 19. M41T81S RTC registers



3.5.2 M41T81S RTC alarm setting

- Set the alarm date and time using the alarm section of the RTC GUI window
- Select the AFE bit to observe the alarm output on the IRQ pin of the RTC on the board. If the AFE bit is not set, then upon an alarm condition, the alarm flag is set in the flag register of the RTC, but the LED (D3) on the board does not light up as there is no active signal on the IRQ pin
- Press the write button to enter these alarm settings in the RTC present on the board. The repeat mode setting is for setting the repetitive alarm
- The alarm status can be seen in the GUI by pressing the read alarm button. Pressing the read alarm again clears the alarm register of the RTC and its new status is shown in the GUI
- The Reset button is used to reset the OF bit in the alarm register and the corresponding oscillator bit alarm is also cleared by the reset button

3.5.3 M41T81S RTC watchdog configuration

- The watchdog of the RTC is enabled by configuring the multiplier and resolution settings and pressing the write button
- The time period for the watchdog is calculated by a resolution x multiplier value. This value is in seconds.
- The watchdog alarm occurs when the time set in the watchdog register has elapsed
- The status of the watchdog alarm can be seen only by pressing the read alarm button. Pressing it again clears the WDG flag in the alarm register of the RTC and its status is shown in the GUI. The watchdog alarm on the motherboard can be cleared by writing to the watchdog register. Writing zero in the watchdog register disables the watchdog function.

3.5.4 M41T81S RTC square wave configuration

- The square wave of the RTC is configured by setting the frequency in the square wave registers
- Set the output frequency from the drop-down menu and check the Enable Square Wave Output check box to observe the square wave on the IRQ pin of the RTC
- The alarm LED (D3) lights up on the board for the square wave output on the IRQ pin

Note: If the Enable Square Wave Output check box is not checked, then there is no square wave at the IRQ pin of the RTC and hence the alarm LED (D3) does not glow on the board.

3.5.5 M41T81S RTC digital calibration configuration

- Enter a calibration value between 0 - 31 in the calibration register
- Select positive or negative calibration by selecting the sign in the sign bit drop-down menu
- Press the write button to configure the RTC calibration register with the selected settings

3.5.6 M41T81S RTC HT bit configuration

At every power-down the HT bit is set and upon re-powering, the HT bit is set. To start the display of the clock upon consecutive powering, the HT bit should be reset each time.

- The HT bit set and reset option is selected from the drop-down menu
- Setting the HT bit halts the clock display of the RTC
- Resetting the HT bit resumes the clock display of the RTC

3.5.7 M41T81S RTC FT bit and output bit configuration

- The FT bit is a check box. If none of the RTC interrupt functions (alarm/WDG/SQW) are selected, then checking this box selects the frequency test function of the RTC and the D3 LED lights up. Resetting the bit switches off the frequency test function.
- The Output bit check box is used to demonstrate the output driver function of RTC. If none of the alarm functions (alarm/WDG/SQW/FT) is selected, then checking this bit allows the IRQ pin of the RTC to be high, the D3 LED lights up. Resetting the check box to blank causes the D3 LED to light up on the motherboard.

3.5.8 Configuring M41T82 (SO8 package) RTC

The M41T82 RTC is available in an SO8 package and is mounted on a separate daughter card. Follow these steps to select the M41T82 RTC:

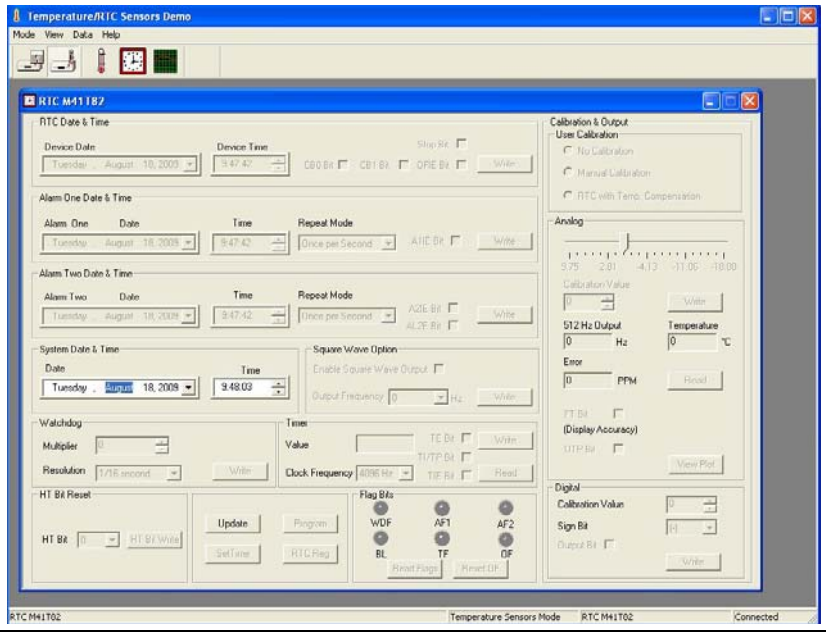
1. Remove jumper J2 from the motherboard
2. Plug the M41T82 RTC daughter card into the motherboard (Take notice of the notch on the daughter card connector for mounting)
3. Power up the motherboard using the USB cable (slide the switch SW5 to the left)
4. Open the GUI and select the RTC selection icon as shown in *Figure 17*
5. Select M41T82 RTC from the menu and press OK
6. The M41T82 RTC window opens up as shown in *Figure 20* and the LCD on the motherboard shows the RTC date and time along with the name of the M41T82 RTC

Note: Upon power-up, the RTC clock registers are halted and not updated because the halt bit (HT) is set to "1". This allows the user to know the time of power-down. The HT bit must be reset to "0" for the clock to read the present time.

3.5.9 M41T82 RTC date and time setting

1. Click on the RTC selection icon in the toolbar of the GUI. The RTC selection radio button appears in the GUI as shown in *Figure 17*.
2. Select RTC M41T82 and this window opens up as shown in *Figure 20*
3. Press the Update button to enable the configuration of the RTC. It also allows the user to read all the RTC registers and displays them on the GUI
4. After pressing the Update button, reset the HT bit by writing it to "0". This updates the clock to the present time
5. Configure the RTC date and time by clicking on the Set Time button which programs the on-board RTC with the system date and time
6. CB0, CB1, and Stop Bit, are check boxes to enable or disable the respective bit in the RTC. Checking the box and then pressing the write button sets the bits. Un-checking them and clicking on write button resets the bits
7. The Program button configures the RTC with the current settings visible in the GUI.
8. Instead of manually clicking on the write button for each register, click on the RTC Reg button to update all the registers

Figure 20. GUI window for the M41T82 RTC



3.5.10 M41T82 RTC alarm setting

The M41T82 RTC has two alarm functions (alarm one and alarm two)

- Alarm one
  - Set the alarm date and time.
  - Press the write button to program alarm one.
  - The alarm status can be seen in the GUI by pressing the read flags button. When the alarm time matches the RTC time, the AF1 bit is set to a “1” in the flag register. Pressing the read flags button again clears the AF1 bit.
  - There is no alarm output pin in the M41T82.
- Alarm two
  - Set the alarm date and time
  - Select the AL2E bit and click the write button to program alarm two
  - The alarm status can be seen in the GUI by pressing the read flags button. When the alarm time matches the RTC time, the AF2 bit is set to a “1” in the flag register. Pressing the read flags button again clears the AF2 bit
  - There is no alarm output pin in the M41T82

3.5.11 M41T82 RTC watchdog configuration

- The watchdog is enabled by configuring the multiplier and resolution settings and pressing the write button.
- The time period for the watchdog is calculated by a resolution x multiplier value. This value is in seconds.
- The watchdog alarm occurs when the time set in the watchdog register has elapsed
- The status of the watchdog alarm can be seen only by pressing the read flags button. When the watchdog alarm occurs, the WDF bit is set to a “1” in the flag register.

Pressing the read flags button again clears the WDF bit. Writing zeroes to the watchdog register disables this feature

- There is no watchdog output pin in the M41T82

3.5.12 M41T82 RTC timer configuration

- Set a timer value between 1 and 255 in the value's text box and select the resolution from the clock frequency drop-down menu
- Enable the timer by checking the TE bit. If the TE bit is not enabled, then timer does not start counting
- Press the write button to enter the timer configuration
- When the timer counts down to 1, the TF bit is set in the flag register
- The status of the timer alarm can be seen only by pressing the read flags button. Pressing the read flags button again clears the TF bit
- There is no timer output pin in the M41T82

3.5.13 M41T82 RTC digital calibration configuration

- Enter a calibration value between 0-31 in the calibration register
- Select positive or negative calibration by selecting the sign in the sign bit drop-down menu
- Press the write button to configure the RTC calibration register with the selected settings

3.5.14 M41T82 RTC analog calibration configuration

The M41T82 RTC has an analog calibration feature which is used for calibrating the drift in the crystal frequency. The GUI has three options:

1. No calibration: no analog calibration is done in this case. Clicking on the read button displays the temperature of the daughter card
2. Manual calibration: this mode is used for calibrating the frequency drift of the crystal using the analog calibration register. The analog calibration register can be written with any value between –18 pF and 9.75 pF with a step size of 0.25 pF. The slider is used to select the value and the value can also be seen in the calibration value section. Press the write button to update the calibration data. Pressing the read button reads the FT output frequency, PPM error and daughter card temperature. Each press of the read button takes ~3 seconds to calculate and display the ppm error and frequency in the GUI.
3. RTC with temp. compensation: This mode is used for auto-calibration every 3.5 seconds. In this mode the PPM error is calculated every 3.5 seconds and the calibration register value is loaded inside the analog calibration register to nullify this PPM error. Pressing the read button shows these values in the GUI. The View Plot button is used for plotting the PPM error and the temperature vs. time graph. Samples are taken every 3.5 seconds and plotted in the GUI window. At the start of plotting, the user can configure logging the data in .xls format. The Start button is used to start the plotting. *Figure 23* shows the plotter options for the RTC PPM error and temperature vs. time.

3.5.15 M41T82 RTC HT bit configuration

The halt bit (HT) is set on every power-down. This feature allows the user to know when the power-down occurred. The HT bit must be reset to “0” for the clock to read the present time.

- The HT bit set and reset option is selected from the drop-down menu.
- Setting the HT bit halts the clock display of the RTC.
- Resetting the HT bit resumes the clock display of the RTC.

3.5.16 M41T82 RTC FT bit configuration

When the FT bit is enabled, the output on the FT pin is 512 Hz. LED D3 also turns on when the FT bit is enabled. Resetting the FT bit switches off the frequency test function.

3.5.17 M41T82 RTC OF bit configuration

If the oscillator fail (OF) bit is set to a “1”, this indicates that the oscillator has either stopped or was stopped for some period of time. This bit is set to a “1” on initial power-up. The user needs to clear it by clicking the Reset OF button.

3.5.18 M41T82 RTC BL bit

The BL bit is a read-only bit. If BL = 1, it indicates the battery voltage is less than 2.5 V. The user needs to change the battery before it drains out and loses the data.

3.5.19 Configuring M41T83 (QFN package) RTC

The M41T83 RTC is a QFN package and is mounted on a separate daughter card.

Follow the steps below to select the M41T83 RTC:

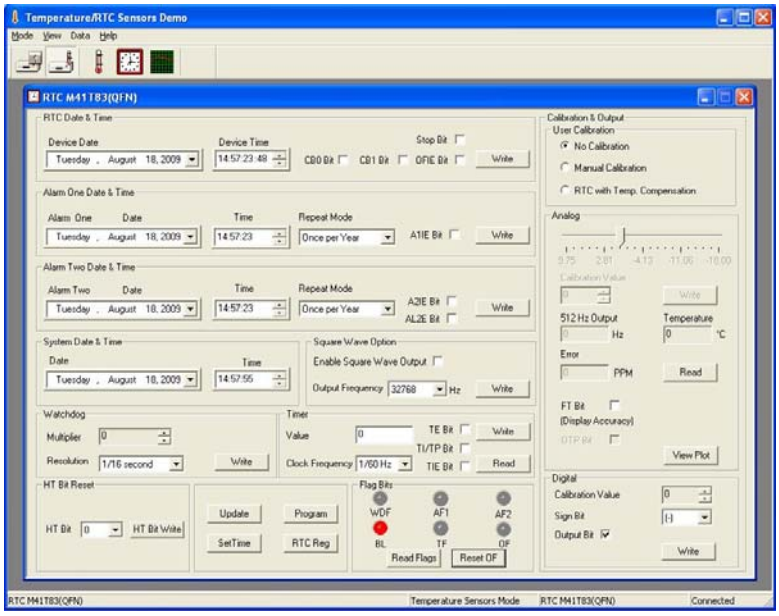
1. Remove jumper J2 from the motherboard
2. Plug the M41T83 (QFN package) RTC daughter card into the motherboard (take notice of the notch on the daughter card connector for mounting)
3. Power up the motherboard using the USB cable (slide the switch SW5 to the left)
4. Open the GUI and select the RTC selection icon as shown in *Figure 17*
5. Select the M41T83 (QFN) RTC from the menu and press OK
6. The M41T83 RTC window opens up as shown in *Figure 21* and the LCD on the motherboard shows the RTC date and time along with the name of the M41T83QFN RTC

Note: Upon power-up of the device, the RTC clock registers are halted and not updated because the halt bit (HT) is set to “1”. This allows the user know the time when the power down occurred. The HT bit must be reset to “0” for the clock to read the present time.

3.5.20 M41T83_QFN RTC date and time setting

- Click on the RTC selection icon in the toolbar of the GUI. The RTC selection radio button appears in the GUI as shown in *Figure 17*
- Select RTC M41T83 QFN and the window opens up as shown in *Figure 21*
- Press the Update button to enable the configuration of the RTC. It also allows the user to read all the RTC registers and displays them in the GUI
- After pressing the Update button, reset the HT bit by writing it to '0' which updates the clock to the present time
- Configure the RTC date and time by clicking on the Set Time button which programs the on-board RTC with the system date and time
- CB0, CB1, Stop Bit, and OFIE bits are check boxes to enable or disable the respective bit in the RTC. Checking the box and then pressing the write button sets the bits. Un-checking them and clicking on the write button resets the bits
- The Program button configures the RTC with the current settings visible in the GUI
- Instead of manually clicking on the write button for each register, click on the RTC reg button to update all the registers

Figure 21. GUI window for M41T83_QFN RTC



3.5.21 M41T83_QFN RTC alarm setting

The M41T83_QFN RTC has two alarm functions (alarm one and alarm two):

- Alarm one
  - Set the alarm date and time
  - Select the A1IE check box to see the alarm status on the interrupt output pin (IRQ1). The LED D4 lights up on the motherboard whenever the alarm occurs
  - Press the write button to program alarm one
  - The alarm status can be seen in the GUI by pressing the read flags button. When the alarm time matches the RTC time, the AF1 bit is set to a "1" in the flag register.

Pressing the read flags button again clears the AF1 bit. If the A1IE bit is also checked, the LED D4 on the motherboard lights up when the alarm occurs.

- Alarm two
  - Set the alarm date and time
  - Select the AL2E bit to enable the alarm two function. Check the A2IE bit check box to see the alarm status on the interrupt output pin (IRQ2). The LED D2 lights up on the motherboard whenever the alarm occurs
  - Press the write button to program alarm two
  - The alarm status can be seen in the GUI by pressing the read flags button. When the alarm time matches the RTC time, the AF2 bit is set to “1” in the flag register. Pressing the read flags button again clears the AF2 bit. If the A2IE bit is also checked, the LED D2 on the motherboard lights up when the alarm occurs

3.5.22 M41T83_QFN RTC watchdog configuration

- The watchdog is enabled by configuring the multiplier and resolution settings and pressing the write button.
- The time period for watchdog is calculated by a resolution x multiplier value. This value is in seconds.
- The watchdog alarm occurs when the time set in watchdog register has elapsed.
- The status of watchdog alarm can be seen only by pressing the read flags button. When the watchdog alarm occurs, the WDF bit is set to “1” in the flag register. Pressing the read flags button again clears the WDF bit. When the watchdog alarm occurs, the LED D4 also turns on. The LED D4 turns off only by writing to the watchdog register. Writing zeroes to the watchdog register disables this feature.

3.5.23 M41T83_QFN RTC timer configuration

- Set a timer value between 1 and 255 in the value's text box and select the resolution from the clock frequency drop-down menu.
- Enable the timer by selecting the TE bit. If TE bit is not enabled, then the timer does not start the counting. Use the TI/TP check box to select the mode of the timer.
- Press the write button to enter the timer value
- The TIE bit is used to enable the interrupt output pin (IRQ1).
- The status of the timer alarm can be seen by pressing the read flags button. Whenever the timer counts down to 1, the TF is set in the flag register. Pressing the read flags button again clears the TF bit. If the TIE bit is set and the timer alarm occurs, the LED D4 lights up on the motherboard. The LED D4 goes off when the flag register is read.

3.5.24 M41T83_QFN RTC digital calibration configuration

- Enter a calibration value between 0 - 31 in the calibration register
- Select positive or negative calibration by selecting the sign in the Sign Bit drop-down menu
- Press the write button to configure the RTC calibration register with the selected settings

3.5.25 M41T83_QFN RTC analog calibration configuration

The M41T83_QFN RTC has an analog calibration feature which is used for calibrating the drift in the crystal frequency.

The GUI has three options:

1. No calibration: No analog calibration is done in this case. Clicking on the read button displays the temperature of the daughter card
2. Manual calibration: This mode is used for calibrating the frequency drift of the crystal using the analog calibration register. The analog calibration register can be written with any value between –18 pF and 9.75 pF with a step size of 0.25 pF. The slider is used to select the value and the value can be seen in the Calibration Value section. Press the write button to update the calibration data. Pressing the read button reads the FT output frequency, PPM error and daughter card temperature. Each press of the read button takes ~3 seconds to calculate and display the ppm error and frequency in the GUI
3. RTC with Temp. Compensation: This mode is used for auto-calibration every 3.5 seconds. In this mode the PPM error is calculated every 3.5 seconds and the calibration register value is loaded inside the analog calibration register to nullify this PPM error. Press the read button to see these values in the GUI. In this mode FT and auto read is active by default and cannot be changed.

Note: The frequency test function (FT) operates only when all other interrupt functions are disabled (OFIE, watchdog, TIE, alarm 1, and Out). If any interrupt function is enabled, then the frequency test function is disabled and read of PPM error and frequency shows 0 values in the GUI.

The View Plot button is used for plotting the PPM error and temperature vs. time graph. Samples are taken every 3.5 seconds and plotted in the GUI window. At the start of plotting, the user can configure logging the data in .xls format. The Start button is used to start the plotting. *Figure 23* shows the plotter options for the RTC PPM error and temperature vs. time.

3.5.26 M41T83_QFN RTC HT bit configuration

The halt bit (HT) is set on every power-down. This feature allows the user to know when the power down occurs. The HT bit must be reset to “0” for the clock to read the present time.

- The HT bit set and reset option is selected from the drop-down menu.
- Setting the HT bit halts the clock display of the RTC.
- Resetting the HT bit resumes the clock display of the RTC.

3.5.27 M41T83_QFN RTC FT bit configuration

When the FT bit is enabled, the output on the IRQ1 pin is 512 Hz (with all other interrupt functions disabled: OFIE, watchdog, TIE, alarm 1 and Out). LED D3 also turns on when the FT bit is enabled. Resetting the FT bit witches off the frequency test function.

3.5.28 M41T83_QFN RTC square wave configuration

- Select the square wave output frequency from the output frequency drop-down menu
- Check the enable square wave output check box to enable the square wave function
- Press the write button to update the square wave data
- LED D5 blinks on the motherboard to show the status of the square wave output of the RTC

3.5.29 M41T83_QFN RTC OF bit configuration

If the oscillator fail (OF) bit is set to a “1”, this indicates that the oscillator has either stopped or was stopped for some period of time. This bit is set to a “1” on initial power-up. The user needs to clear it by clicking on the reset OF button. If the OFIE bit is set, the LED D4 turns on when there is an oscillator failure.

3.5.30 M41T83 RTC BL bit

The BL bit is a read-only bit. If BL = 1, it indicates the battery voltage is less than 2.5 V. The user needs to change the battery before it drains out and loses the data.

3.5.31 Configuring M41T83 (SOX18 package) RTC

The M41T83 RTC is an SOX18 package and is mounted on a separate daughter card. This RTC has an on-chip silicon crystal and thus needs no external crystal for operation.

Follow these steps to select the M41T83_MY RTC:

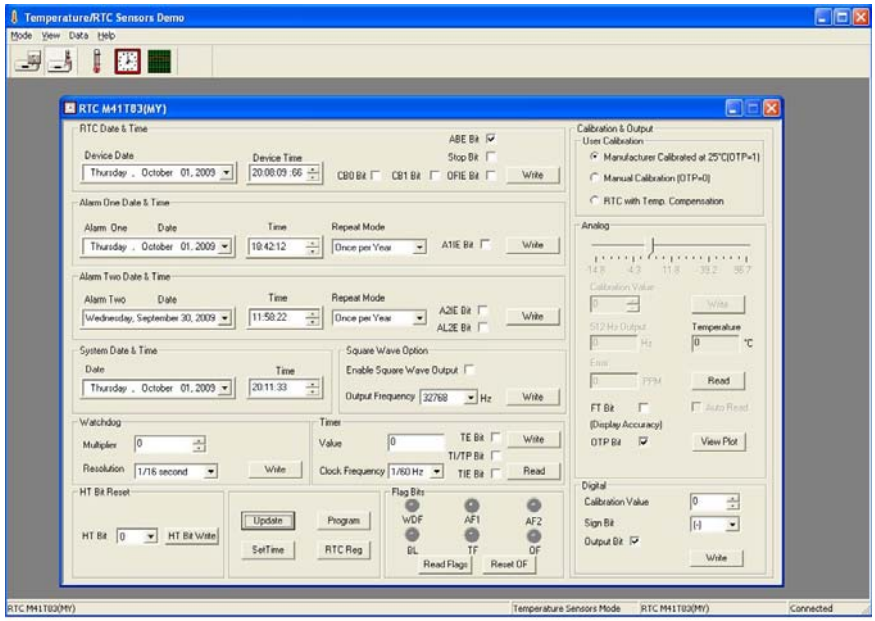
1. Remove jumper J2 from the motherboard
2. Plug the M41T83 (SOX18 package) RTC daughter card into the motherboard (Take notice of the notch on the daughter card connector for mounting)
3. Power up the motherboard using the USB cable (slide the switch SW5 to the left)
4. Open the GUI and select the RTC selection icon as shown in *Figure 17*
5. Select M41T83 (SOX18) RTC from the menu and press OK
6. The M41T83 (SOX18) RTC window opens up as shown in *Figure 22* and the LCD on the motherboard shows the RTC date and time along with the name of the M41T83MY RTC

Note: Upon power-up, the RTC clock registers are halted and not updated because the halt bit (HT) is set to “1”. This allows the user to know the time when the power-down occurred. The HT bit must be reset to “0” for the clock to read the present time.

3.5.32 M41T83_SOX18 RTC date and time setting

1. Click on the RTC selection icon in the toolbar of the GUI. The RTC selection radio button appears in the GUI as shown in *Figure 17*
2. Select RTC M41T83 MY and the window opens up as shown in *Figure 22*
3. Press the Update button to enable the configuration of the RTC. It also allows the user to read all the RTC registers and displays them on the GUI
4. After pressing the Update button, reset the HT bit by writing it to “0” which updates the clock to the present time
5. Configure the RTC date and time by clicking on the Set Time button in the GUI which programs the on-board RTC with the system date and time
6. The CB0, CB1, Stop bit, and OFIE bits are check boxes to enable or disable the respective bit in the RTC. Checking the box and then pressing the write button sets the bits. Un-checking them and clicking on the write button resets the bits
7. The Program button configures the RTC with the current settings visible in the GUI
8. Instead of manually clicking on the write button for each register, click on the RTC Reg button to update all the registers

Figure 22. GUI window for the M41T83_SOX18 RTC



3.5.33 M41T83_SOX18 RTC alarm setting

The M41T83_SOX18 RTC has two alarm functions (alarm one and alarm two):

- Alarm one
  - Set the alarm date and time.
  - Check the A1IE check box to see the alarm status on the interrupt output pin (IRQ1). The LED D4 lights up on the motherboard whenever the alarm occurs.
  - Press the write button to program alarm one.
  - The alarm status can be seen in the GUI by pressing the read flags button. When the alarm time matches the RTC time, the AF1 bit is set to a “1” in the flag register.

Pressing the read flags button again clears the AF1 bit. If the A1IE bit is also checked, the LED D4 on the motherboard lights up when the alarm occurs.

- Alarm two
  - Set the alarm date and time.
  - Check the AL2E bit to enable the alarm two function. Check the A2IE bit check box to see the alarm status on the interrupt output pin (IRQ2). The LED D2 lights up on the motherboard whenever the alarm occurs.
  - Press the write button to program alarm two.
  - The alarm status can be seen in the GUI by pressing the read flags button. When the alarm time matches the RTC time, the AF2 bit is set to a “1” in the flag register. Pressing the read flags button again clears the AF2 bit. If the A2IE bit is also checked, the LED D2 on the motherboard lights up when the alarm occurs.

3.5.34 M41T83_SOX18 RTC watchdog configuration

- The watchdog is enabled by configuring the multiplier and resolution settings and pressing the write button
- The time period for the watchdog is calculated by a resolution x multiplier value. This value is in seconds
- The watchdog alarm occurs when the time set in the watchdog register has elapsed
- The status of the watchdog alarm can be seen only by pressing the read flags button. When the watchdog alarm occurs, the WDF bit is set to a “1” in the flag register. Pressing the read flags button again clears the WDF bit. When the watchdog alarm occurs, the LED D4 also lights up. The LED D4 goes off only by writing to the watchdog register. Writing zeroes to the watchdog register disables this feature.

3.5.35 M41T83_SOX18 RTC timer configuration

- Set a timer value between 1 and 255 in the value's text box and select the resolution from the clock frequency drop-down menu.
- Enable the timer by checking the TE bit. If the TE bit is not enabled, then timer does not start the counting. Use the TI/TP check box to select the mode of the timer
- Press the write button to enter the timer.
- The TIE bit is used to enable the interrupt output pin (IRQ1)
- The status of the timer alarm can be seen by pressing the read flags button. Whenever the timer counts down to 1, the TF bit is set in the flag register. Pressing the read flags button again clears the TF bit. If the TIE bit is set and the timer alarm occurs, the LED D4 lights up on the motherboard. The LED D4 goes off by reading the flag register.

3.5.36 M41T83_SOX18 RTC digital calibration configuration

- Enter a calibration value between 0 - 31 in the calibration register
- Select positive or negative calibration by selecting the sign in the sign bit drop-down menu
- Press the write button to configure the RTC calibration register with the selected settings

3.5.37 M41T83_SOX18 RTC analog calibration configuration

The M41T83_SOX18 RTC has an analog calibration feature which is used for calibrating the drift in the crystal frequency.

The GUI has 3 options:

1. Manufacturer calibrated at 25 °C (OTP = 1): This is the factory calibration mode. In this mode the OTP bit of the RTC is set and the factory-calibrated value of the calibration register is loaded inside the analog calibration register
2. Manual calibration (OTP = 0): This mode is used for calibrating the frequency drift of the crystal using the analog calibration register. The analog calibration register can be written with any value between –18 pF and 9.75 pF with a step size of 0.25 pF. The slider is used to select the value and the value can be seen in the Calibration Value section. Press the write button to update the calibration data. Pressing the read button reads the FT output frequency, PPM error and daughter card temperature. Each press of the read button takes ~3 seconds to calculate and display the ppm error and frequency in the GUI
3. RTC with temp. compensation: This mode is used for auto-calibration every 3.5 seconds. In this mode the PPM error is calculated every 3.5 seconds and the calibration register value is loaded inside the analog calibration register to nullify this PPM error. Press the read button to see these values in the GUI. In this mode FT and auto-read is active by default and cannot be changed.

Note: The frequency test function (FT) operates only when all other interrupt functions are disabled (OFIE, watchdog, TIE, alarm 1, and Out). If any interrupt function is enabled, then the frequency test function is disabled and read of PPM error and frequency shows 0 values in the *GUI.*

The View Plot button is used for plotting the PPM error and temperature vs. time graph. Samples are taken every 3.5 seconds and plotted in the GUI window. At the start of plotting, the user can configure logging the data in .xls format. The Start button is used to start the plotting. *Figure 23* shows the plotter options for the RTC PPM error and temperature vs. time.

3.5.38 M41T83_SOX18 RTC HT bit configuration

The halt bit (HT) is set on every power-down. This feature allows the user to know when the power-down occurred. The HT bit must be reset to “0” for the clock to read the present time.

- The HT bit set and reset option is selected from the drop-down menu
- Setting the HT bit halts the clock display of the RTC
- Resetting the HT bit resumes the clock display of the RTC

3.5.39 M41T83_SOX18 RTC FT bit configuration

When the FT bit is enabled, the output on the IRQ1 pin is 512 Hz (with all other interrupt functions disabled: OFIE, watchdog, TIE, alarm 1 and out). LED D3 also turns on when the FT is enabled. Resetting the FT bit switches off the frequency test function.

3.5.40 M41T83_SOX18 RTC square wave configuration

- Select the square wave output frequency from the output frequency drop-down menu
- Check the enable square wave output check box to enable the square wave function
- Press the write button to update the square wave data
- LED D5 blinks on the motherboard to show the status of the square wave output of the RTC

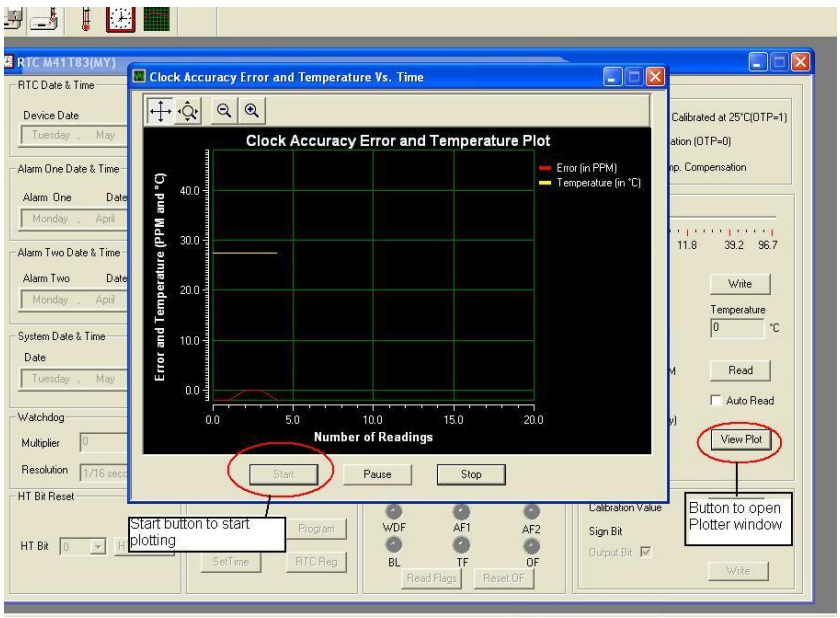
3.5.41 M41T83_SOX18 RTC OF bit configuration

If the oscillator fail (OF) bit is set to a “1”, this indicates that the oscillator has either stopped or was stopped for some period of time. This bit is set to a “1” on initial power-up. The user needs to clear it by clicking on the reset OF button. If the OFIE bit is set, the LED D4 lights up when there is an oscillator failure.

3.5.42 M41T83_SOX18 RTC BL bit

The BL bit is a read-only bit. If BL = 1, it indicates the battery voltage is less than 2.5 V. The user needs to change the battery before it drains out and loses the data.

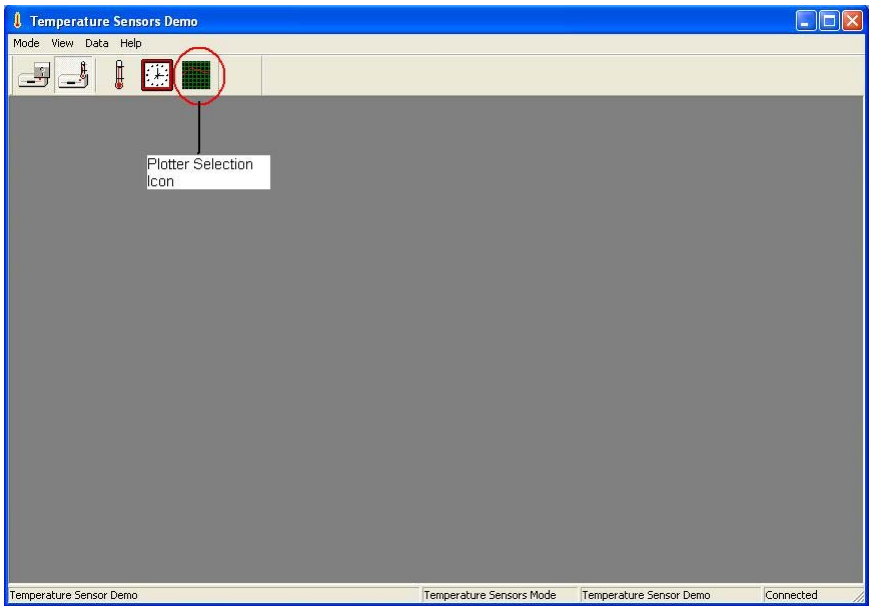
Figure 23. RTC plotter window



3.6 Plotter mode

There is a plotter icon in the toolbar as shown in *Figure 24*. Click on this icon to open up the plotter application in the GUI. This plotter can be used to plot the temperature variation with respect to time in real time (dynamic mode) or the temperature data can be stored in NAND Flash present on the board and plotted at a later time (NAND mode).

Figure 24. Plotter selection window



3.6.1 Dynamic mode

The dynamic mode of the plotter is used to plot the real-time temperature variation with respect to time. In this mode the sensor measures the temperature at a selected frequency and, in parallel, plots that temperature on the graph.

Follow these steps to plot the graph in dynamic mode:

1. Select the dynamic mode from the mode selection drop-down menu in the plotter window
2. Select the desired frequency (200 milliseconds / 500 milliseconds /1 second /10 seconds) from the time interval drop-down menu. This frequency denotes the time interval between readings
3. Click on the Play button in the toolbar. It opens the plotter and starts plotting the graph as shown in *Figure 25*
4. To stop the plotting, click on the Stop button in the toolbar
5. Use the toolbar present in the graph window to expand or compress the scale on the graph. This is shown in *Figure 26*
6. To store the image of the graph on the computer, click on the floppy icon in the toolbar of the plotter window. It stores the graph as .tsg format
7. To store the graph data as text format in an excel sheet, click on the excel sheet icon in the toolbar. It saves the temperature readings in excel format
8. In order to see the previously stored graphs, click on the folder icon in the toolbar and open the .tsg file

Figure 25. Plotter window for dynamic mode

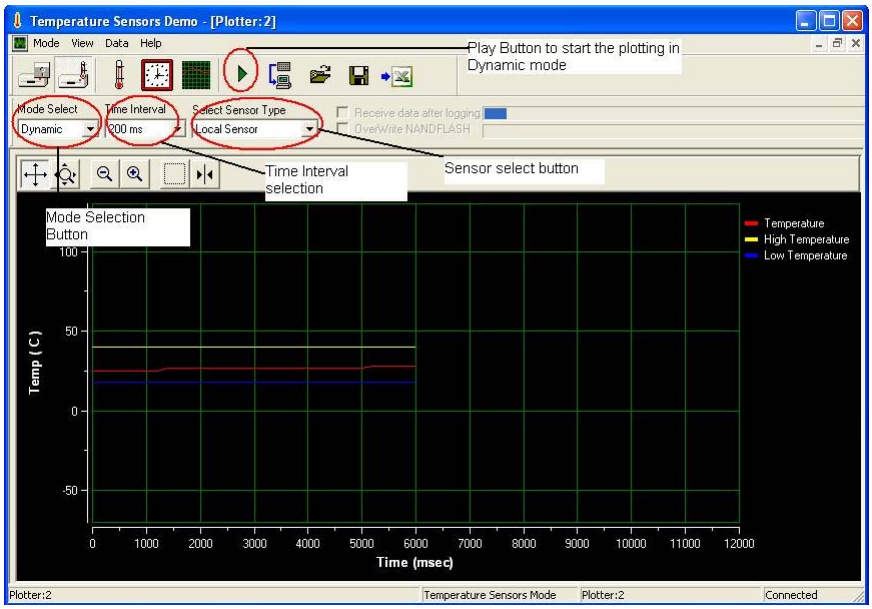
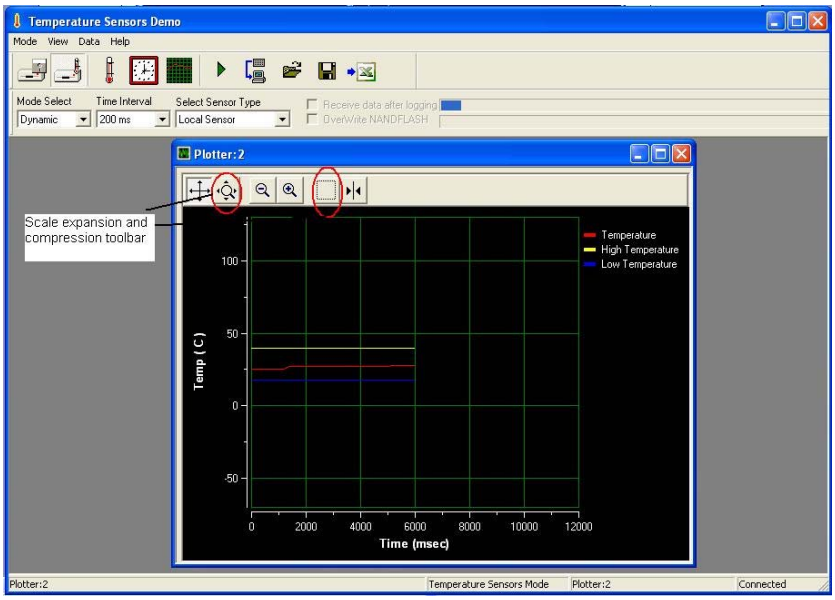


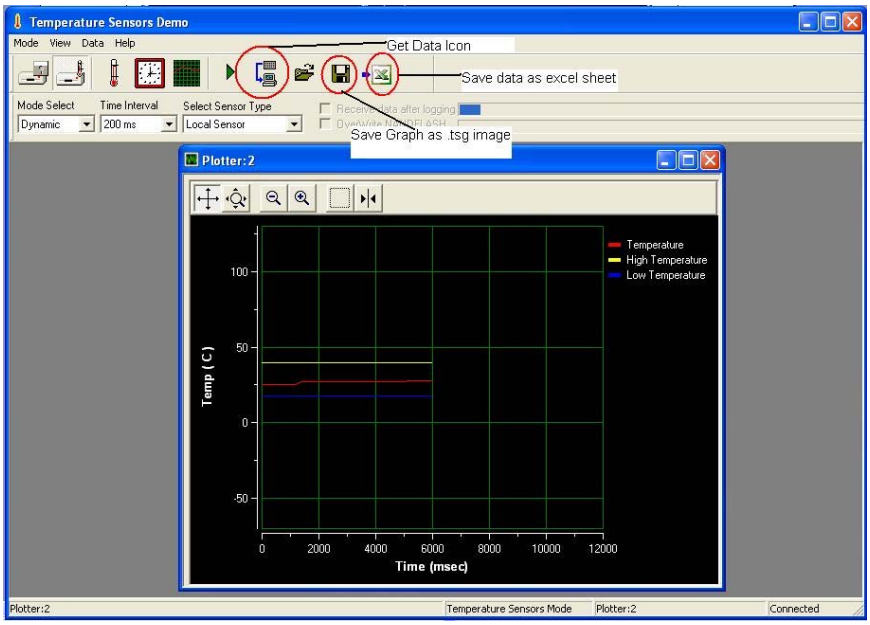
Figure 26. Plotter window with dynamic mode graph



3.7 NAND mode

- This mode is used for logging the temperature data in the NAND Flash present on the board. This logged data can be viewed at a later time in the graphical format in this window
- Select the NAND mode from the mode selection drop-down menu in the plotter window
- Select the desired frequency (200 milliseconds / 500 milliseconds /1 sec /10 sec) from the “Time Interval” drop-down menu. This frequency denotes the time interval between readings
- Click on the Play button in the toolbar. It starts logging the data in the NAND Flash present on the board. A total of 100 Kb of NAND Flash is used for data logging. The percentage of NAND filled is shown by the status bar in the toolbar of the plotter window. The first status bar shows that data is being logged while the second status bar shows the percentage of data logged
- To stop logging data, click on the Stop button in the toolbar
- To read the logged data from the on-board NAND, click on the GET DATA icon in the toolbar. It reads the data from the board and then plots the graph of temperature versus time. This is shown in *Figure 27*
- Use the toolbar present on the graph window to expand or compress the scale on the graph
- To store the image of the graph on the computer, click on the floppy icon in the toolbar of the plotter window. It stores the graph as .tsg format
- To store the graph data as text format in an excel sheet, click on the excel sheet icon in the toolbar. It saves the temperature readings in excel format
- In order to see the previously stored graphs, click on the folder icon in the toolbar and open the .tsg file
- If the user wants the graph to plotted as soon as the data logging has stopped, then the check box “Receive data after logging” should be checked before starting the logging of data (i.e. before clicking the Play button)
- Checking the box “Overwrite NAND Flash” overwrites the data in NAND Flash in the event that all 100 Kb are used. In this case the user loses the previously stored data.

Figure 27. Plotter window with NAND mode



Note: At each logging of data in NAND Flash, previously stored data is lost and NAND Flash is overwritten with new data.

3.8 Application LEDs

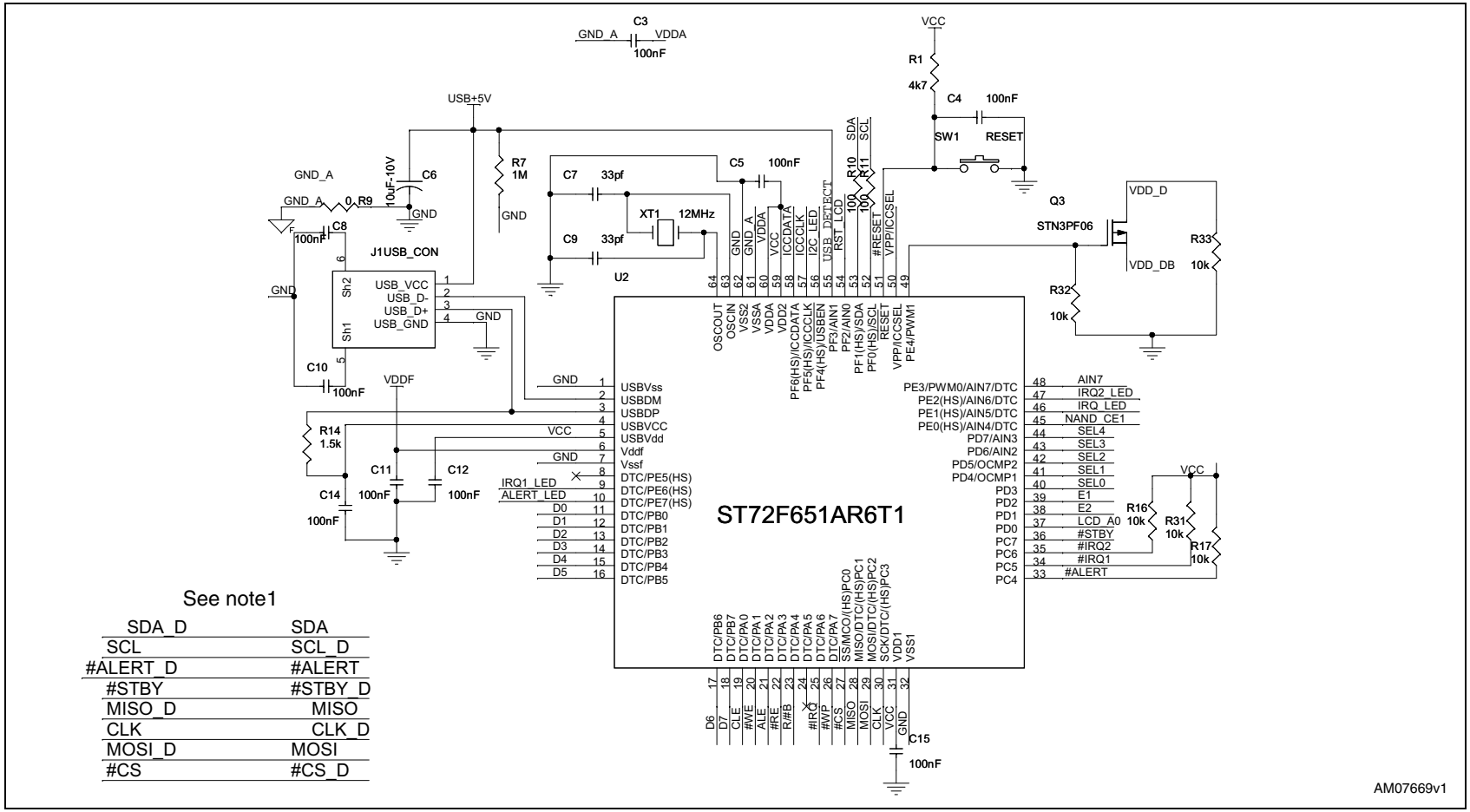
There are 5 application-specific LEDs on the board:

1. I^2C LED: This is a green LED (D1) which blinks whenever there is an I^2C communication occurring in the application
2. IRQ LED: This is a red LED (D3) which lights up according to the signal status on the IRQ pin of the M41T81S RTC
3. IRQ1 LED: This is a red LED (D4) which lights up according to the signal status on the #IRQ1 pin of the M41T83 RTC
4. IRQ2 LED: This is a red LED (D2) which lights up according to the signal status on the #IRQ2 pin of the M41T83 RTC
5. Alarm LED: This is a red LED (D5) which lights up according to the ALARM output signal of the temperature sensors or for the SQW output option of the M41T83 RTC
6. Power_USB LED: This is a red LED (D6) which lights up as soon as the USB cable is plugged in
7. Power_EXT LED: This is a green LED (D8) which glows as soon as the external adapter is plugged into the DC adapter jack

Appendix A Schematics

This is the schematic for the motherboard.

Figure 28. Schematic part 1



Note: 1 Versus Figure 29

Figure 29. Voltage translator section

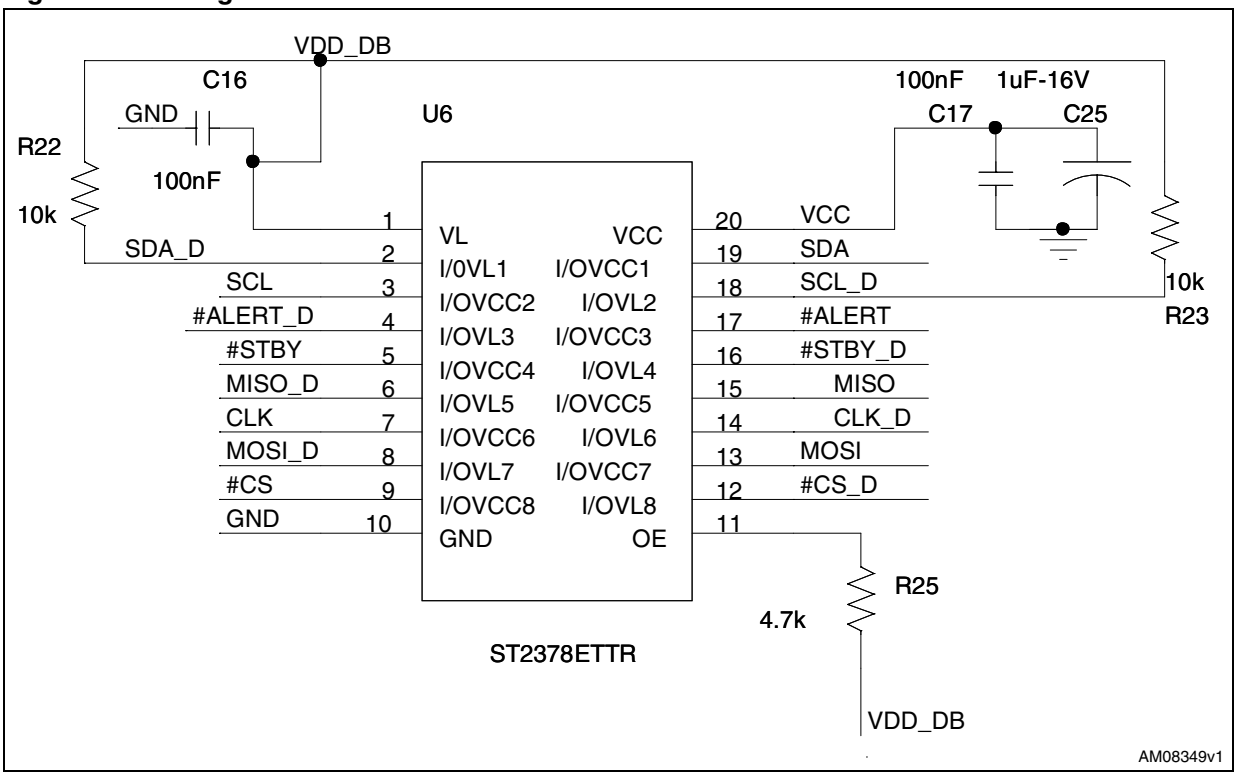


Figure 30. NAND Flash section

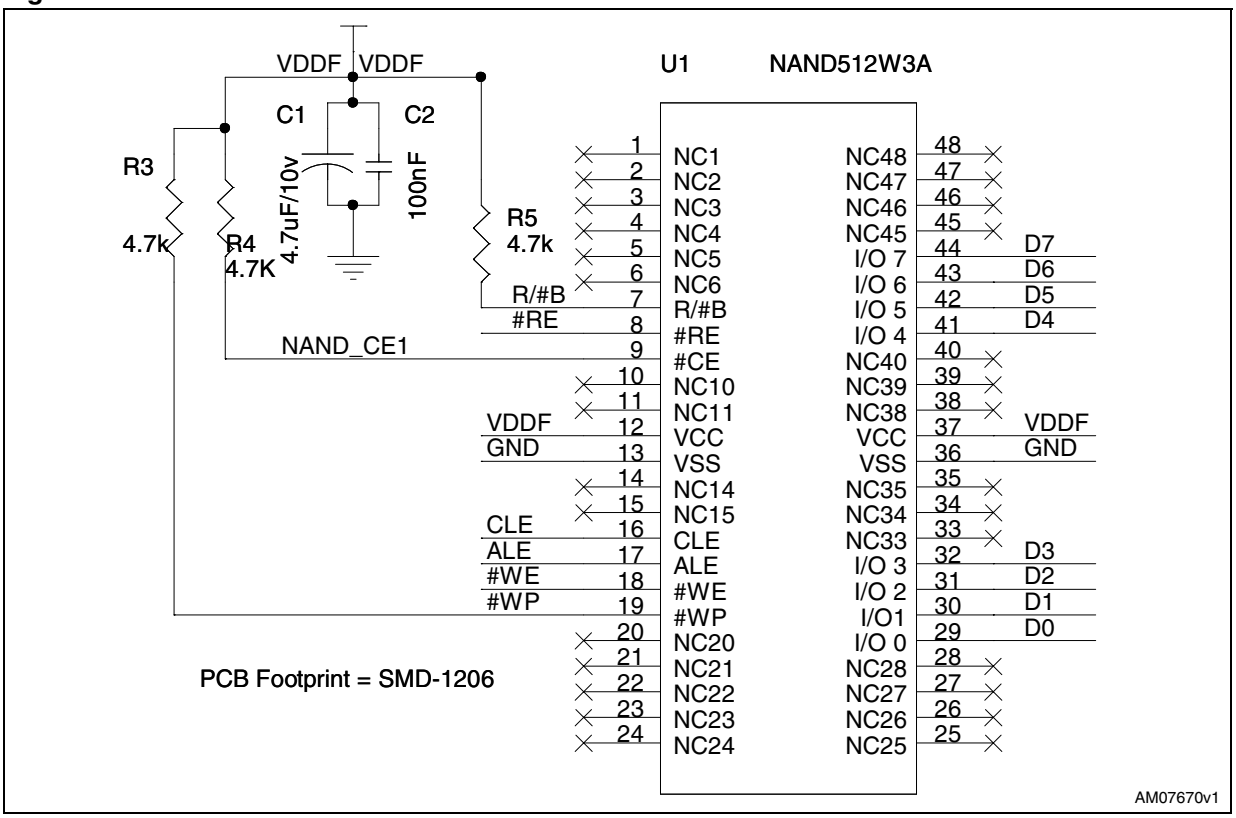


Figure 31. LEDs section

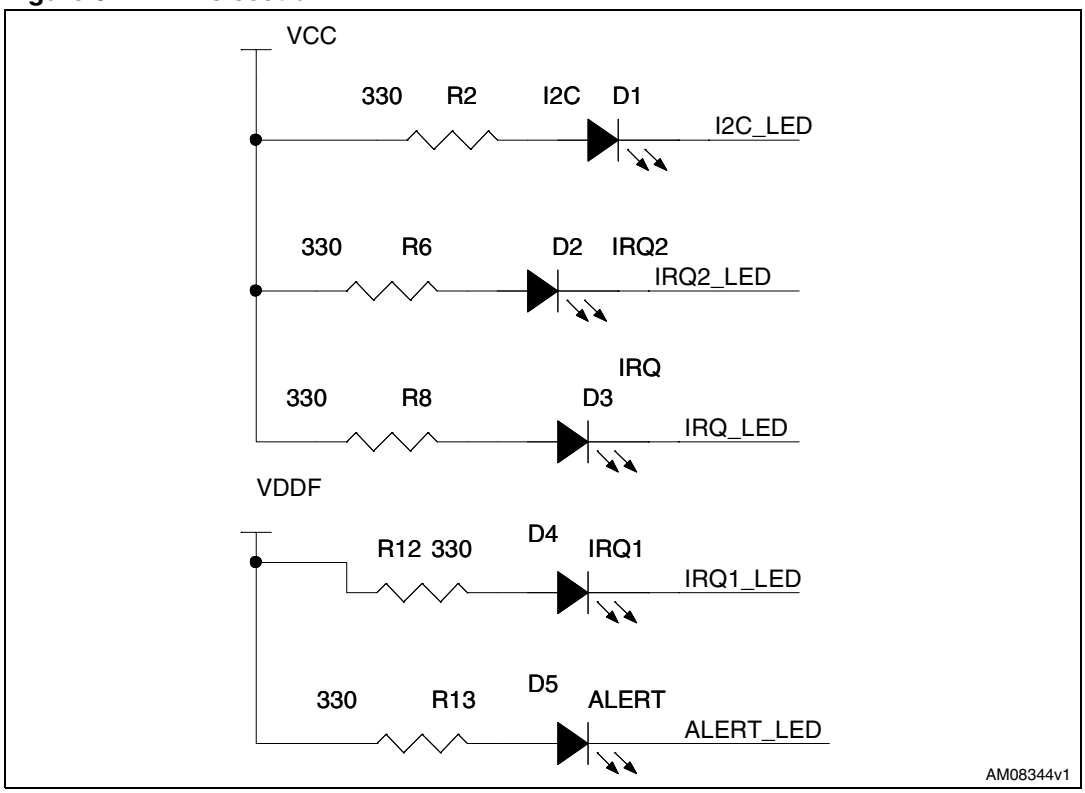


Figure 32. RTC section

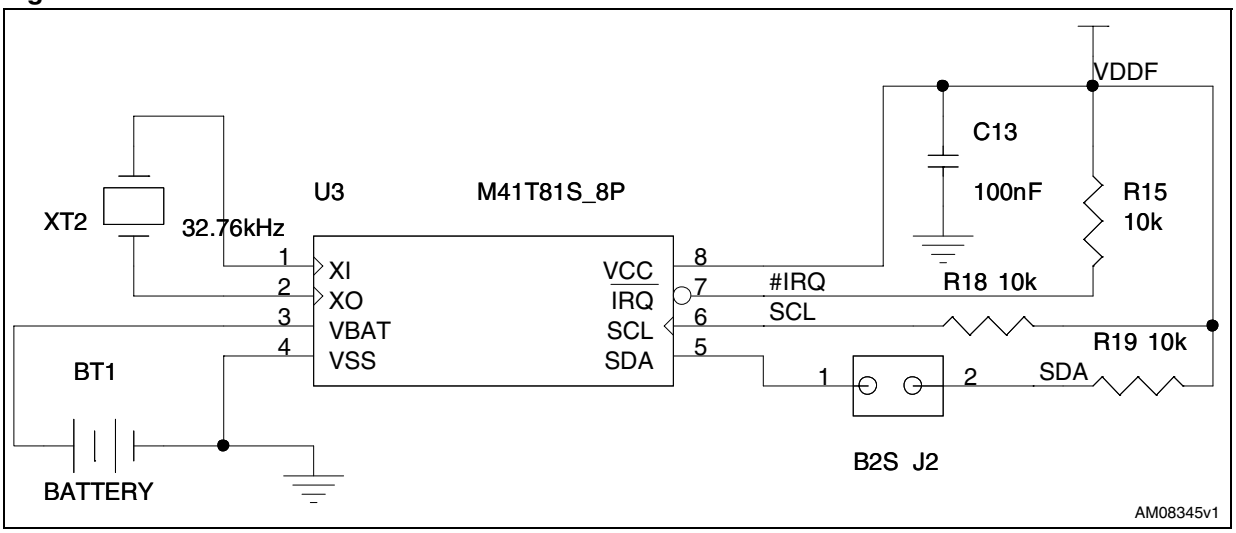


Figure 33. Address lines section

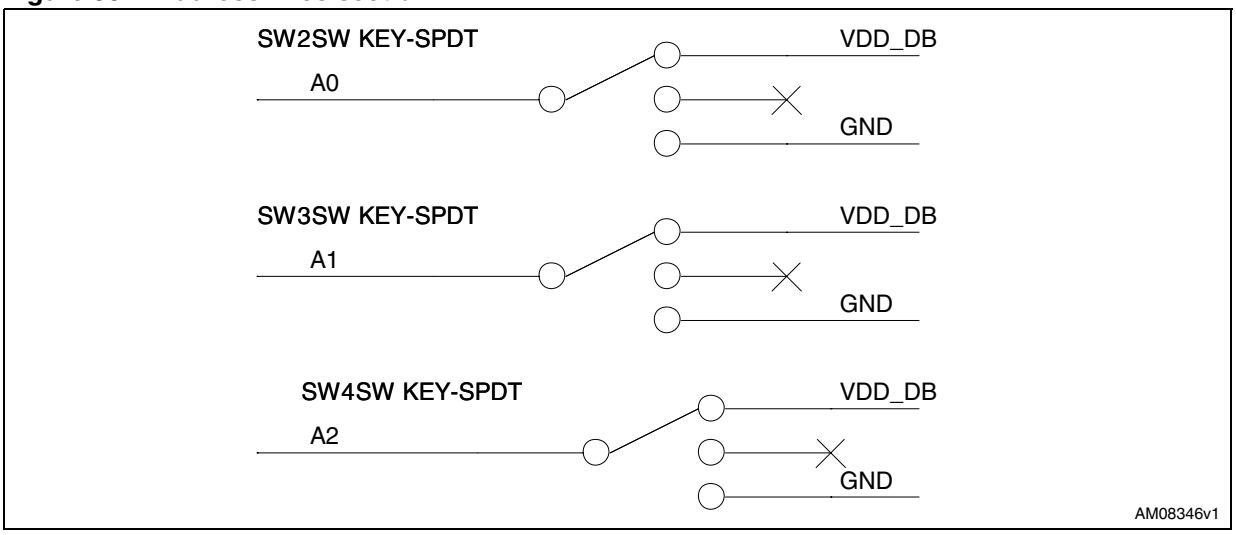


Figure 34. Jumper section

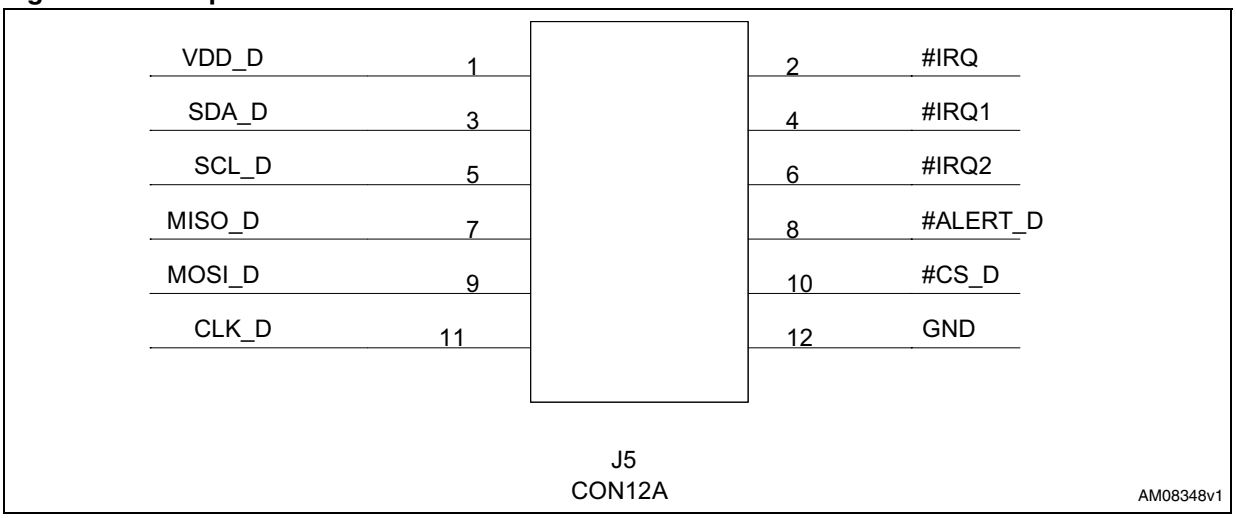


Figure 35. Female_CON section

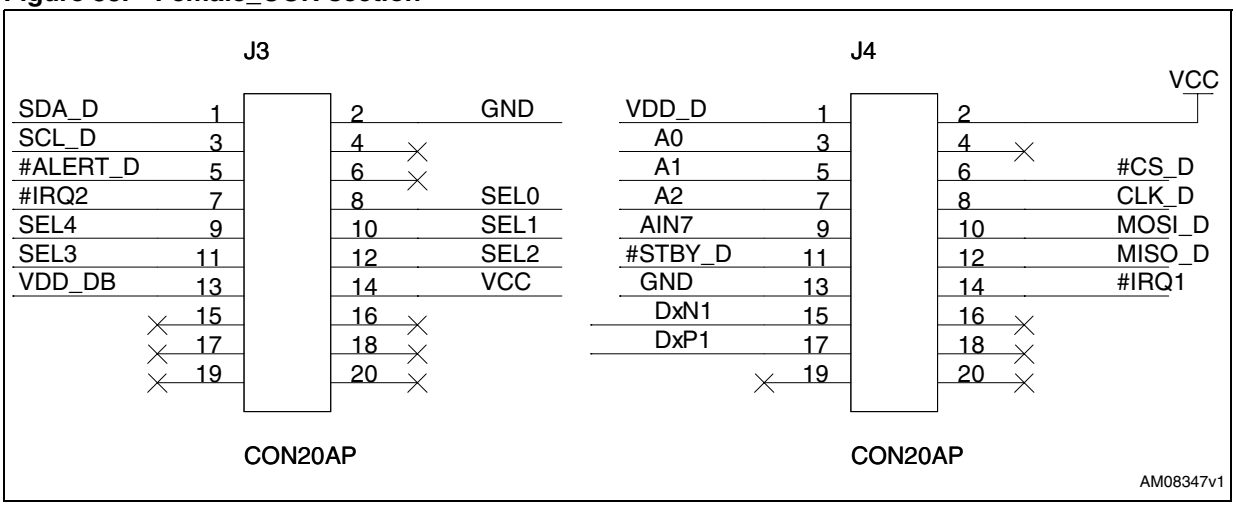


Figure 36. Power supply section

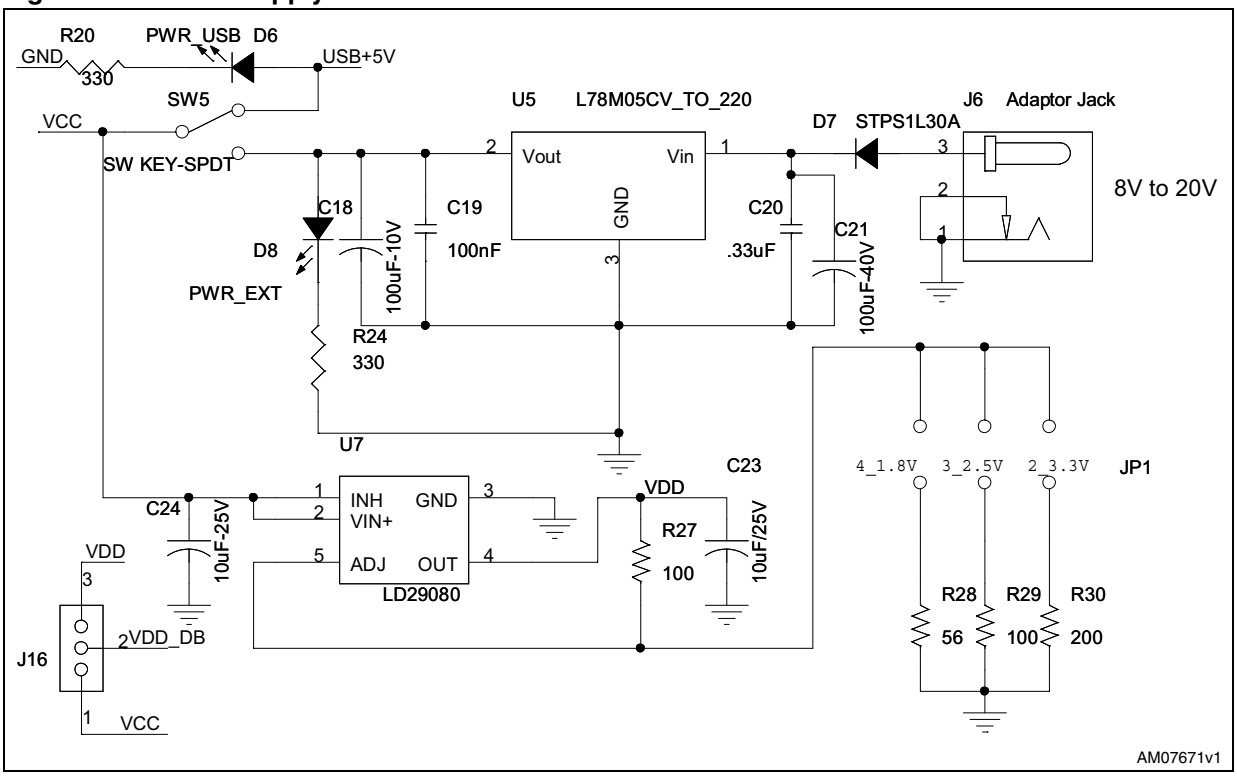


Figure 37. LCD section

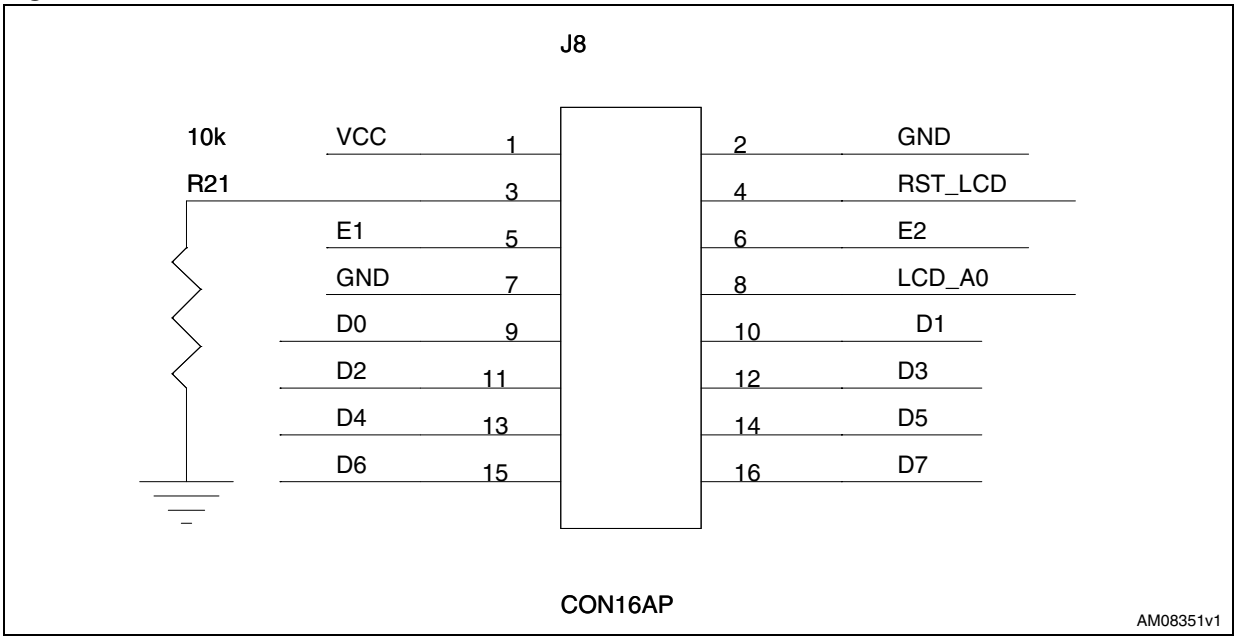
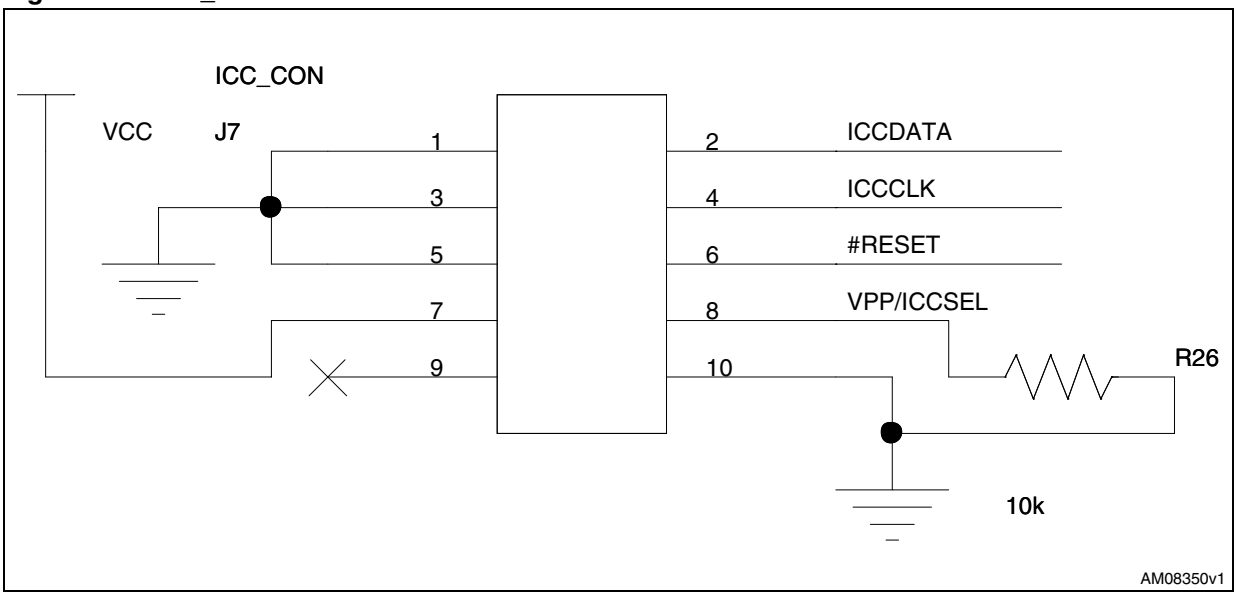


Figure 38. ICC_CON section



Appendix B Bill of material

Table 7. BOM

Reference	Component description	Package	Manufacturer	Manufacturer's order code / orderable part number	Supplier	Supplier order code	Comment
U1	NAND Flash	TSOP48	Numonyx	NAND512W3A2BN6E	Farnell	1224401	
U2	Microcontroller	TQFP64	STMicroelectronics	ST72F651AR6T1E			
U3	RTC	SO8	STMicroelectronics	M41T81SM6E			
U5	Voltage regulator	TO-220	STMicroelectronics	L7805CV			
U6	Voltage translator	TSSOP20	STMicroelectronics	ST2378ETTR			Not mounted
U7	Voltage regulator	PPAK	STMicroelectronics	LD29080PT			
Q3	PMOS	SOT-223	STMicroelectronics	STN3PF06			
D7	Schottky diode	SMA	STMicroelectronics	STPS1L30A			
Q1	NPN transistor	Through-hole	Any	2N3906			Not mounted
XT1	Crystal 12 MHz	Through-hole	Any				
XT2	32.768 kHz	Through-hole	Any				
RESET	Push-button	Push-button	Any				
J1	USB connector	Through-hole	Any				
J2,J3	Daughter card connector	Through-hole	Sametec	TFC110X1-L-D	Integrated Electronics	TFC110X1-L-D	
J5	SIP-10 (berg strip)	2 x SIP6	Any				
J6	Adapter jack	Through-hole	Any				
J7	HEADER 5X2	IDC-10B	Any				
J8	LCD connector	SIP-16 (berg strip)					

Table 7. BOM (continued)

Reference	Component description	Package	Manufacturer	Manufacturer's order code / orderable part number	Supplier	Supplier order code	Comment
D2,D3, D4,D6	Red LED	LED-3 mm	Any				
D1,D8	Green LED	LED-3 mm	Any				
D5	Blue LED	LED-3 mm	Any				
C1	Capacitor (electrolytic)/4.7 µF	SMD	Any				
C2,C3,C4, C5,C8,C10, C111,C12, C13,C14, C15,C16, C17, C19	100 nF	SMD0805	Any				
C6	Electrolytic (10 µF/10 V)	SMD	Any				
C7,C9	33 pF	SMD0805	Any				
C18	Electrolytic (100 µF/10 V)	SMD	Any				
C20	0.33 µF	SMD0805	Any				
C21	100 µF/40 V	SMD	Any				
C23	10 µF	SMD	Any				
C24	10 µF/50 V	SMD	Any				
R1,R3,R4, R5,R25	4.7 kΩ	SMD0805	Any				
R2,R6,R8, R12,R13, R20,R24	330 Ω	SMD0805	Any				
R7	1 MΩ	SMD0805	Any				
R9	0	SMD0805	Any				

Table 7. BOM (continued)

Reference	Component description	Package	Manufacturer	Manufacturer's order code / orderable part number	Supplier	Supplier order code	Comment
R10,R11	100 Ω	SMD0805	Any				
R14	1.5 kΩ	SMD0805	Any				
R15,R16, R17,R18,R19, R21,R22,R23, 26,R31	10 kΩ	SMD0805	Any				
R27,R29	100 Ω	SMD0805	Any				
R28	200 Ω	SMD0805	Any				
R30	56 Ω	SMD0805	Any				
R32	100 kΩ	SMD0805	Any				
LCD	Graphical LCD		Techstar	TS12232C	Techstar	TS12232C	
SW2,SW3, SW4	DP3T switches	Through-hole	ALPS	1123868	Farnell	STSSS2121	
SW5	SPDT switch	Through-hole	EAO	674345	Farnell	09-03290-01	
BT1	Battery connector + battery (3 V)	Through-hole	Any				

Revision history

Table 8. Document revision history

Date	Revision	Changes
14-Oct-2010	1	Initial release