UM1479
User manual

STEVAL-IPR002V1: M24LR64-R based data logger and event logger

Introduction

The M24LR64-R is a dual interface EEPROM which targets a wide range of applications such as industrial or medical equipment and consumer electronics. RFID (13.56 MHz) and I^2C serial communication are the two interfaces available with the EEPROM. This user guide describes how to use the “M24LR64-R data logger/event logger”, an autonomous battery-powered RFID tag with logging capability for recording and storing the sensor data of the following sensors:

- Temperature sensor
- Humidity sensor
- Vibration
- Freefall
- Tamper
- Light

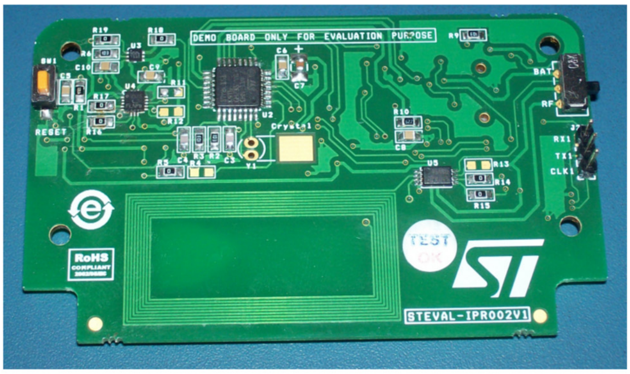
The value of different sensors is stored inside the EEPROM and these logged values can then be retrieved over the RFID interface for evaluation at a later stage. This data logger can be inserted along with any transported article and this article can then be tracked throughout the supply chain, and the data can be scanned at any point using an RFID reader.

This system can operate in two modes:

- Data logger mode
- Event logger mode

In data logger mode, the system reads all the sensor values once every second and stores them inside the EEPROM. The system stops logging the data when the allocated memory for a particular sensor is filled. In event logger mode, the system configures the threshold limits for each sensor. Whenever the sense value is outside the set threshold limits, it is stored in the EEPROM.

Figure 1. M24LR64 EEPROM-based data logger



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1 Getting started

1.1 Package

The contents of the complete package are:

- Hardware content:
  - Demonstration board: STEVAL-IPR002V1
- Documentation:
  - User manual (this document)
  - Schematics, Gerber files, BOM
- Firmware:
  - Pre-programmed STM8L microcontroller soldered on the demo board
- GUI installation file.

1.2 System set-up

This is a 3 V coin cell operated system. Sensor values are logged inside the EEPROM and are evaluated using the graphical user interface which retrieves the data over RF.

1.2.1 System prerequisites

This system has three different stages:

1. Pre-data/event logging stage
2. Data/event logging stage
3. Post data/event logging stage

The pre-data/event logging stage is used to select the mode of the system. The system can be selected in data logger mode or event logger mode. This selection is done using the GUI.

When selected in data logger mode, all the sensors are enabled for logging every one second.

When selected for event logger mode, the boundary limits for different sensors are configured using the GUI. These boundary conditions are the threshold values for sensors. When the sensor measured value is outside these values, they are logged inside the EEPROM.

Data/event logging stage is the run-time stage of the system where sensor values are stored inside the EEPROM.

The post data/event logging stage is the retrieval stage in which the logged values are read by the RFID reader and evaluated on the GUI.

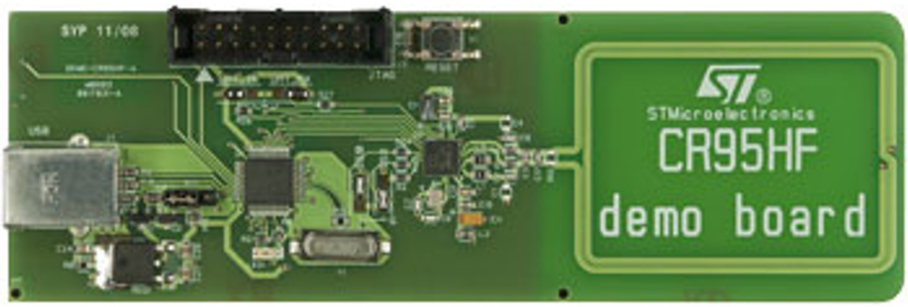
Therefore, the prerequisites to evaluate the data logger are the following:

- CR95HF demo board or STARTKIT-M24LR-A RFID reader
- STEVAL-IPR002V1 data logger board
- CR2032 - 3 V coin cell (MAXELL or equivalent)
- Data logger graphical user interface for connecting the RFID reader to the computer and for the handling of the data logger board.

1.2.2 CR95HF demo board

The CR95HF demo board is a demonstration kit for the ST CR95HF 13.56 MHz multiprotocol contactless transceiver. The CR95HF-A demo board is powered through the USB bus and no external power supply is required. It includes a CR95HF contactless transceiver, a 47 x 34 mm 13.56 MHz inductive etched antenna, and its associated tuning components.

Figure 2. CR95HF demo board



1.2.3 Startkit-M24LR-A RFID reader

The STARTKIT-M24LR-A reader is connected to the host-computer USB port. It manages RF ISO 15693 commands (high-level inventory and transparent commands) and M24LR64-R-based transponders. This is a medium range RFID reader (see *Figure 3*).

Figure 3. STARTKIT M24LR-A RFID reader

1.2.4 STEVAL- IPR002V1 event logger board

This is a data logger board with the following major components:

- STM8L microcontroller
- STTS751 temperature sensor
- M24LR64-R EEPROM with onboard antenna for RF communication
- LIS3DH MEMS
- Humidity sensor
- Photo sensor
- 3 V coin cell.

Figure 4 and *5* show different components available on the board.

Figure 4. Data logger components on TOP

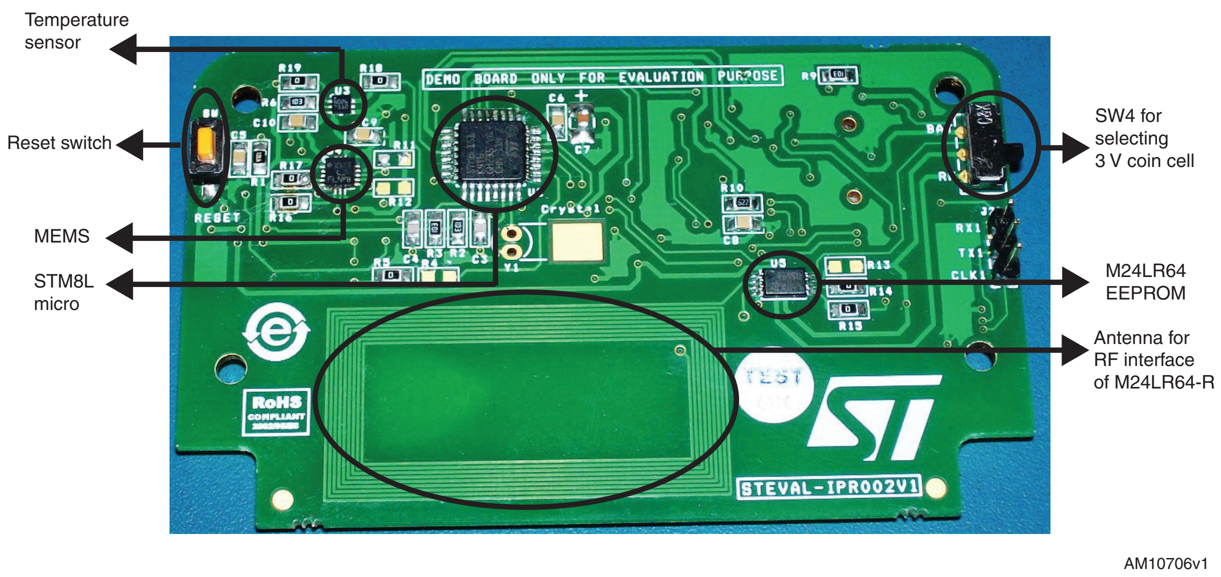
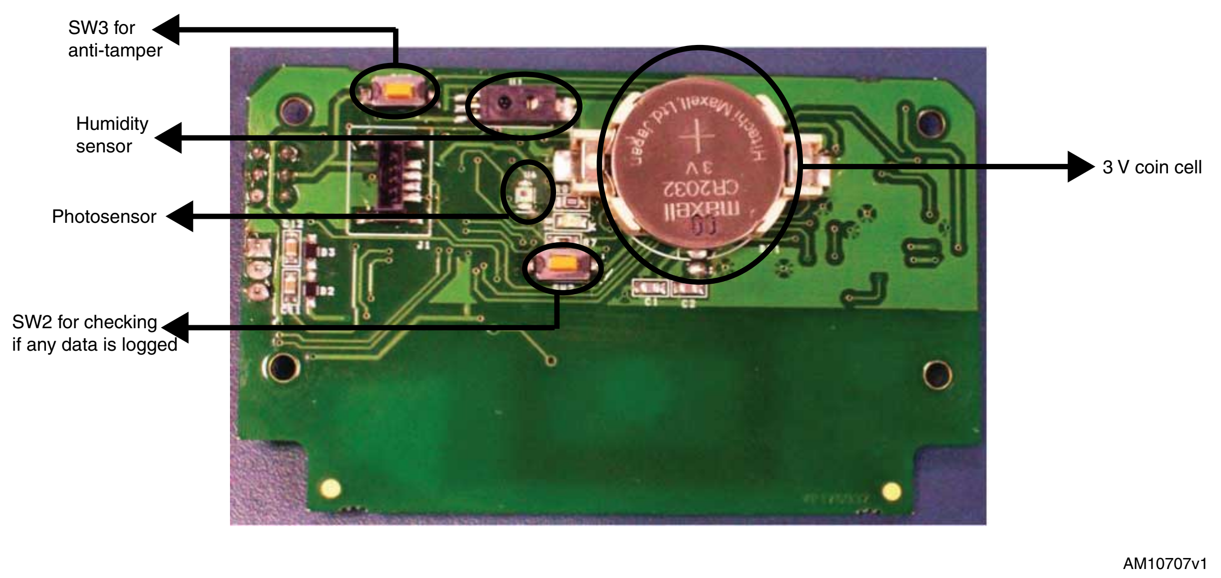


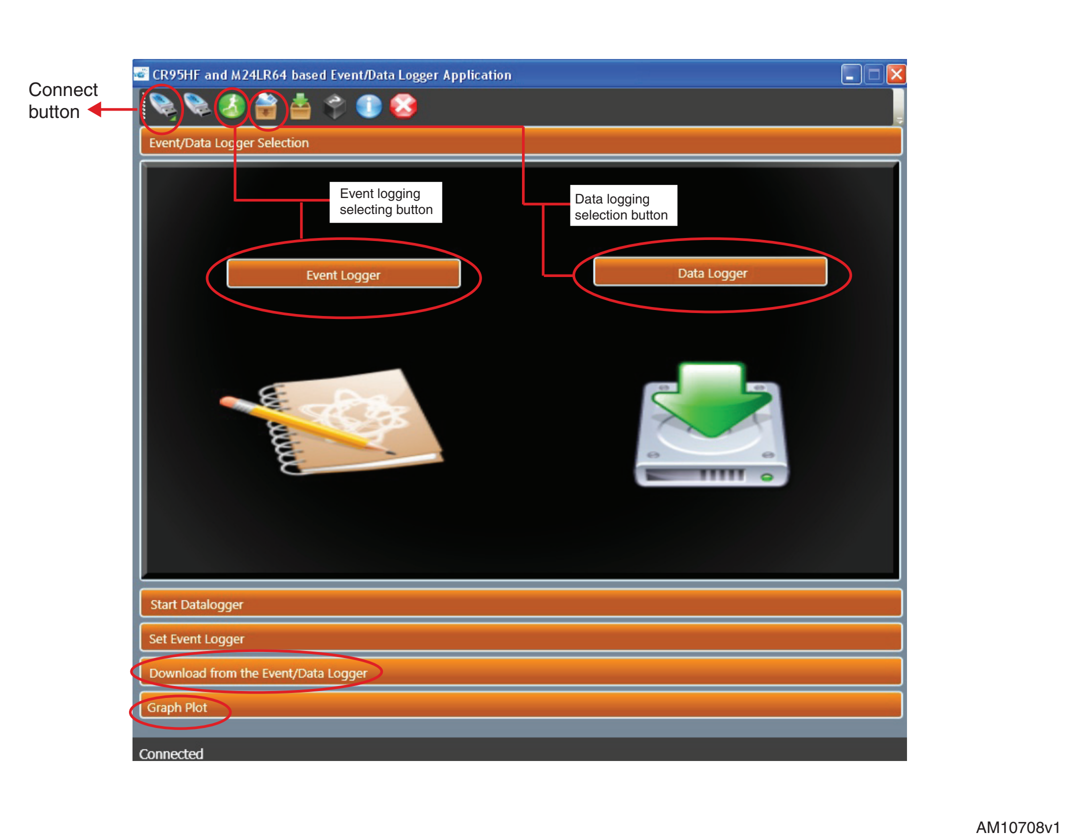
Figure 5. Data logger components at bottom side



1.2.5 Graphical user interface for the system

This system can be configured as data logger or event logger using a GUI. *Figure 6* shows the GUI window for the application.

Figure 6. Event/data logging GUI window



Click on the “Event Logger” button to configure the event logger application or on the “Data Logger” button to select the data logger application.

1.2.6 Data logger GUI

The data logger graphical user interface has 3 windows:

1. Start datalogger
2. Download from the Event/Data Logger
3. Graph Plot

Start DataLogger is used to enable all the sensors for data logging. Click on the “Data Logger” button, as shown in *Figure 6*. *Figure 7* shows the Start the Datalogger GUI window.

The “Download from the Data/Event Logger” option is used to read the logged data from the EEPROM. Click on “Download from the “Data Logger/Event Logger” button as shown in *Figure 7*.

Figure 8 shows the window for downloading the logged data.

“Graph Plot” is used to plot the logged data on the graph and store it in .xls format. Click on “Graph Plot” as shown in *Figure 7*.

Figure 9 shows the window for this. Check the sensors to choose which plots to see.

Figure 7. Start data logger GUI window

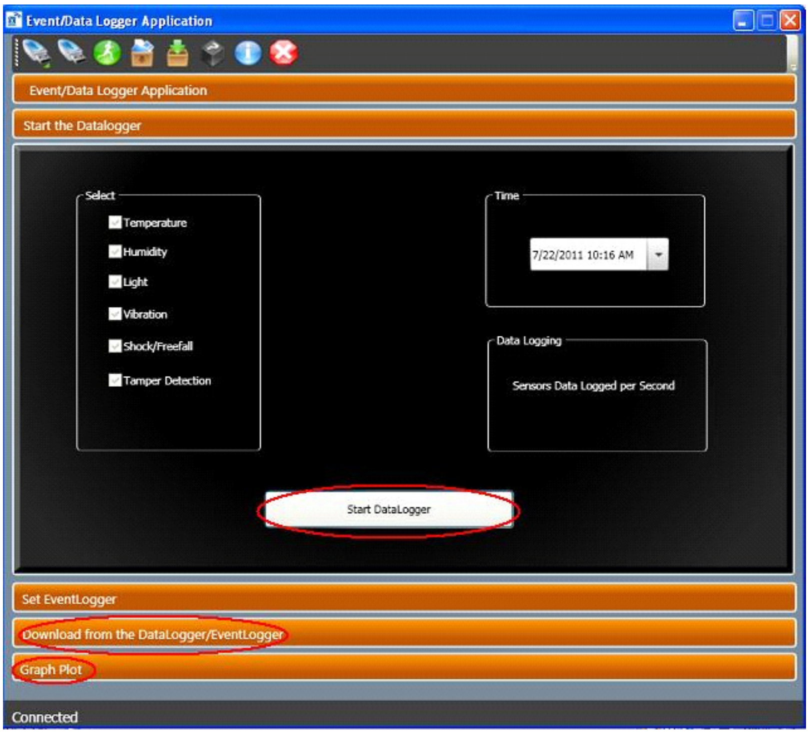


Figure 8. Download from DataLogger/EventLogger GUI window

Figure 9. Graph plot GUI window

1.2.7 Event logger GUI

The event logger GUI window has 3 areas:

1. Set event logger
2. Download from the Event/Data Logger
3. Graph plot

"Set Event Logger" is used to select and configure the threshold limits of sensors. Click on the "Event Logger Selection" button as shown in *Figure 6*. *Figure 10* shows the Set EventLogger GUI window.

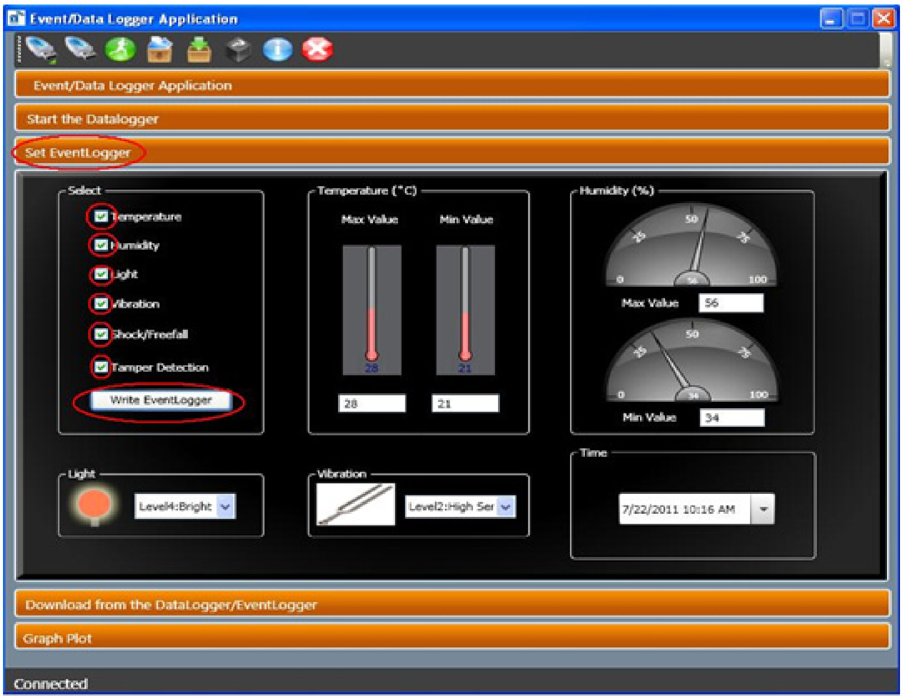
The Download from DataLogger/EventLogger is used to read the logged data from the EEPROM. Click on "Download from the DataLogger/EventLogger" button as shown in *Figure 7*.

Figure 8 shows the window for downloading the logged data.

Graph Plot is used to plot the logged data on the graph and storing it in .xls format. Click on "Graph Plot" as shown in *Figure 7*.

Figure 9 shows the window for this. Check the sensors to choose which plot to see.

Figure 10. Event logger GUI Window



1.2.8 Starting the data logger application

Install the event/data logging GUI using the GUI exe. There are two GUI installation set-ups; one for the STARTKIT-M24LR-A RFID reader and another for the CR95HF demo board. Install the GUI according to the e-reader available.

The data logger system has 3 stages:

1. Pre-data logger stage
2. Data logging stage
3. Post data logging stage

1.2.9 Pre-data logger stage

This stage is for enabling all the sensors for logging the data. In this stage the board power comes from the RFID reader and no external cell is needed.

Below are the steps for the pre-data logger stage configuration:

1. Connect the RFID reader (CR95HF demo board/STARTKIT-M24LR-A reader) to the computer.
2. Put the switch SW4 into the downward position, as shown in *Figure 11*.
3. Place the data logger board (STEVAL-IPR002V1) on the reader, as shown in *Figure 12*.
4. Open the event/data logger GUI application.
5. Press the “Connect” button on the GUI, as shown in *Figure 6*. An information message for board connection is seen on the GUI as shown in *Figure 13*. If the message shows “Board is not connected” then again place the data logger board properly near the RFID reader and press the “Connect” button.
6. Click on the “Data Logger Selection” button as shown in *Figure 6*. The GUI window for data logger opens as shown in *Figure 7*.
7. The time for starting the logger can be changed using the dropdown in the “Time” section. This time is used to configure the RTC of the STM8L which is used for time stamping of logged data.
8. Press the “Start the Datalogger” button to configure the board for data logging.
9. If the GUI shows the error message “Board is not connected”, close the GUI and open it again and start with step 3 above.
10. If the board is configured for data logging then the “Data Recorded” message is displayed on the GUI. Click on “OK”.

Figure 11. SW4 downward position to disconnect the coin cell

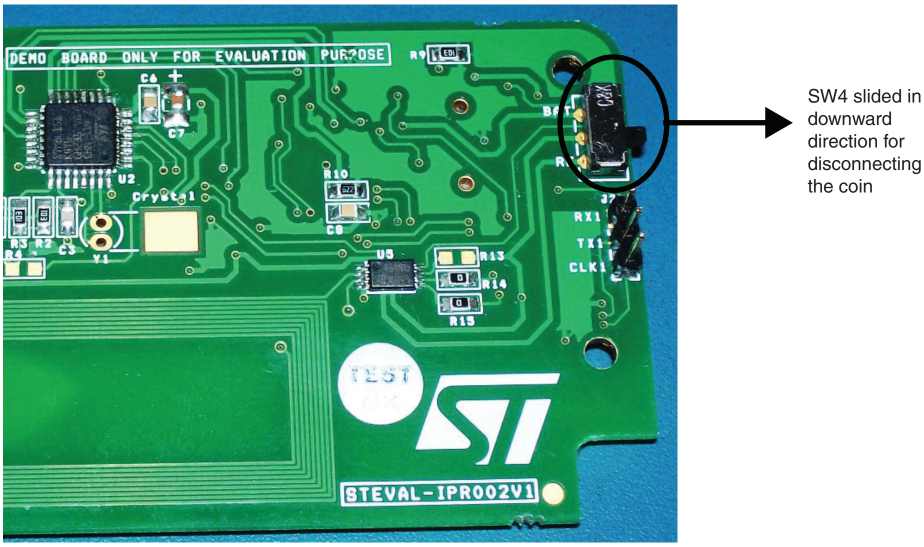


Figure 12. RFID reader with data logger board

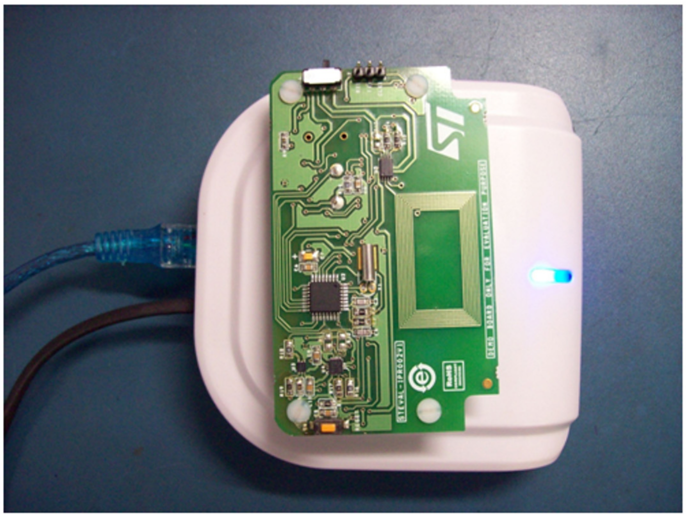
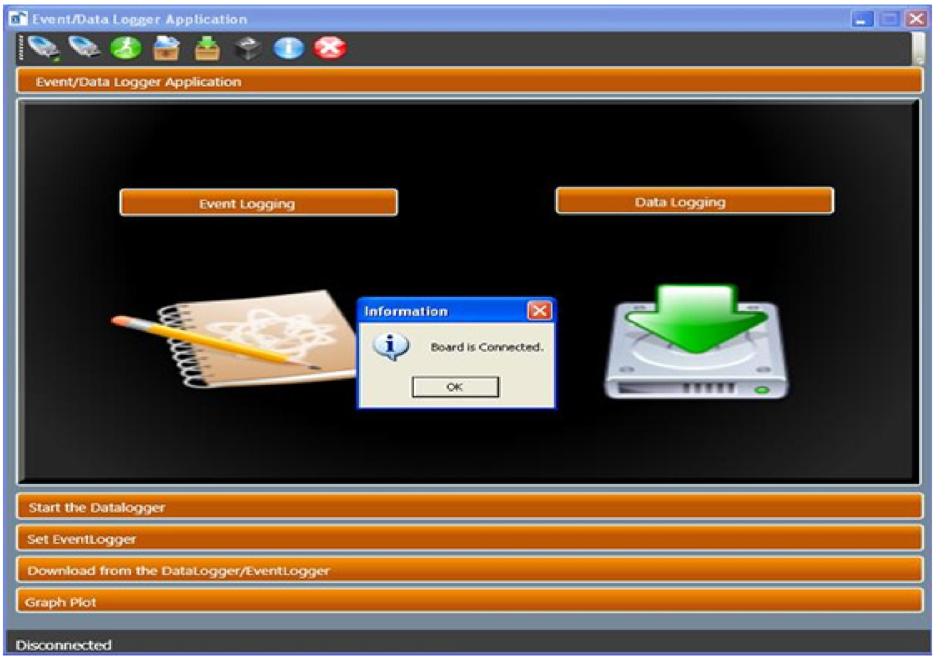


Figure 13. Information message - board is connected to GUI



1.2.10 Data logger stage

This stage is the logger stage of the system. In this phase the STEVAL-IPR002V1 board logs all sensor values every one second.

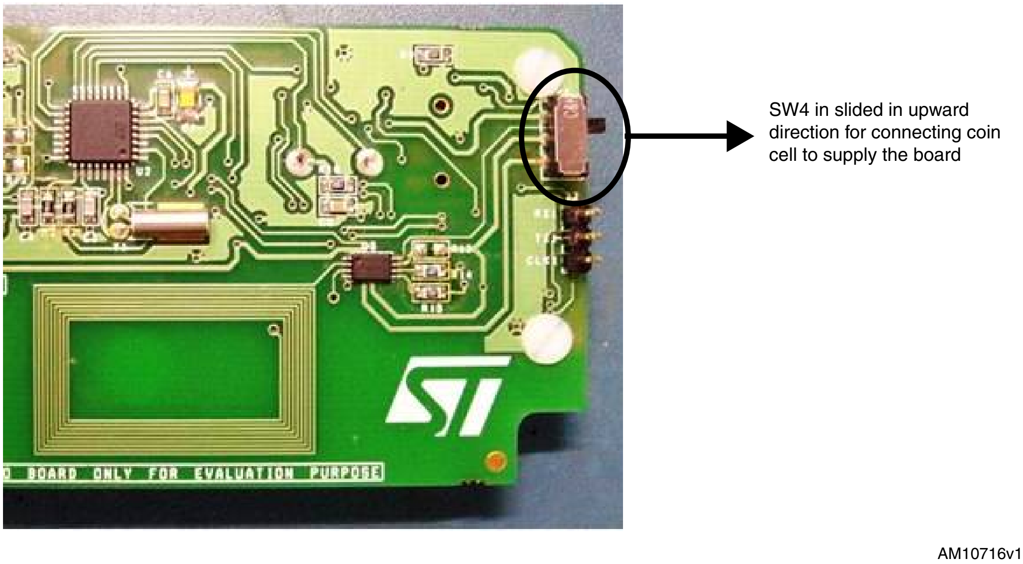
Below are the steps for starting the data logger stage:

1. Put the switch SW4 into the downward position, as shown in *Figure 11*.
2. Insert a 3 V coin cell (CR2032) into the connector, as shown in *Figure 5*.
3. Put the switch SW4 into the upward position, as shown in *Figure 14*, the board is powered up by the coin cell. This starts the data logger application. The start time is taken as the time which was configured in the pre-data logger stage.
4. All the selected sensor data is logged inside the EEPROM every one second.
5. To stop the data logging, put the switch SW4 into the downward position, as shown in *Figure 11*.

Note: Once the data logger is stopped using switch SW4, then starting it again through SW4 reinitializes the internal clock reference of the data logger. Therefore, on restarting the data logger the new start time should be configured using the “Start the Data logger” GUI window. SW4 is used to connect/disconnect the coin cell from the system.

Note: Data is logged at an interval of 1 second. Once the memory for a particular sensor is full, no more data is written inside the EEPROM for that sensor.

Figure 14. SW4 upward position for connecting the coin cell



1.2.11 Post data logger stage

The post data logger stage is used to download the logged data in the computer and compare this data.

Below are the steps for the post data logger stage:

1. Put the switch SW4 into the downward position, as shown in *Figure 11*.
2. Connect the RFID reader to the computer.
3. Place the STEVAL-IPR002V1 on the RFID reader, as shown in *Figure 12*.
4. Open the GUI application.
5. Press the “Connect” button as shown in *Figure 6*. It shows the message “Board is connected”, If the board is not connected, close the GUI, reopen it, and press the “Connect” button again.
6. Click on the “Download from the Data logger/Event Logger” tab as seen in the bottom of the GUI window, as shown in *Figure 15*. The GUI window, as seen in *Figure 8*, opens.
7. Press the “Get DataLogger/EventLogger” button on the GUI window.
8. The window shows the values for different sensors on the GUI. These values, as seen on the GUI, are the last stored values of the sensors. Each sensor also has a log count which shows the number of values logged for that sensor.
9. *Figure 8* shows the condition.
10. Click on the “Graph Plot” tab at the bottom of the GUI window.
11. This opens the plotter window shown in *Figure 16*. Select the sensor whose plot is to be seen and then click the “Plot” button.
12. Double click on the plot to expand it. To exit from expanded plot, again double click on it and it returns to step 10.

13. To zoom in, use the scroll up on the mouse or the '+' button on the keyboard, and to zoom out use the scroll down on the mouse or the '-' button on the keyboard. To slide the graph right or left, click on graph, left click on the mouse and slide to the right side or left side.
14. To store the data in .xls, click on the “Save Plot” button and save the xls file.

Figure 15. Download from the DataLogger/EventLogger

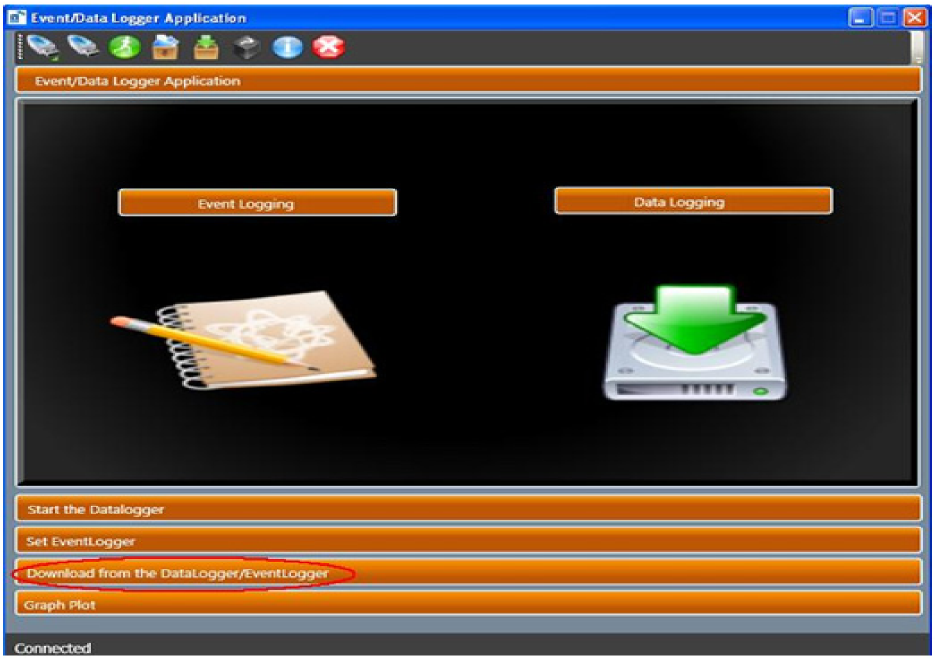
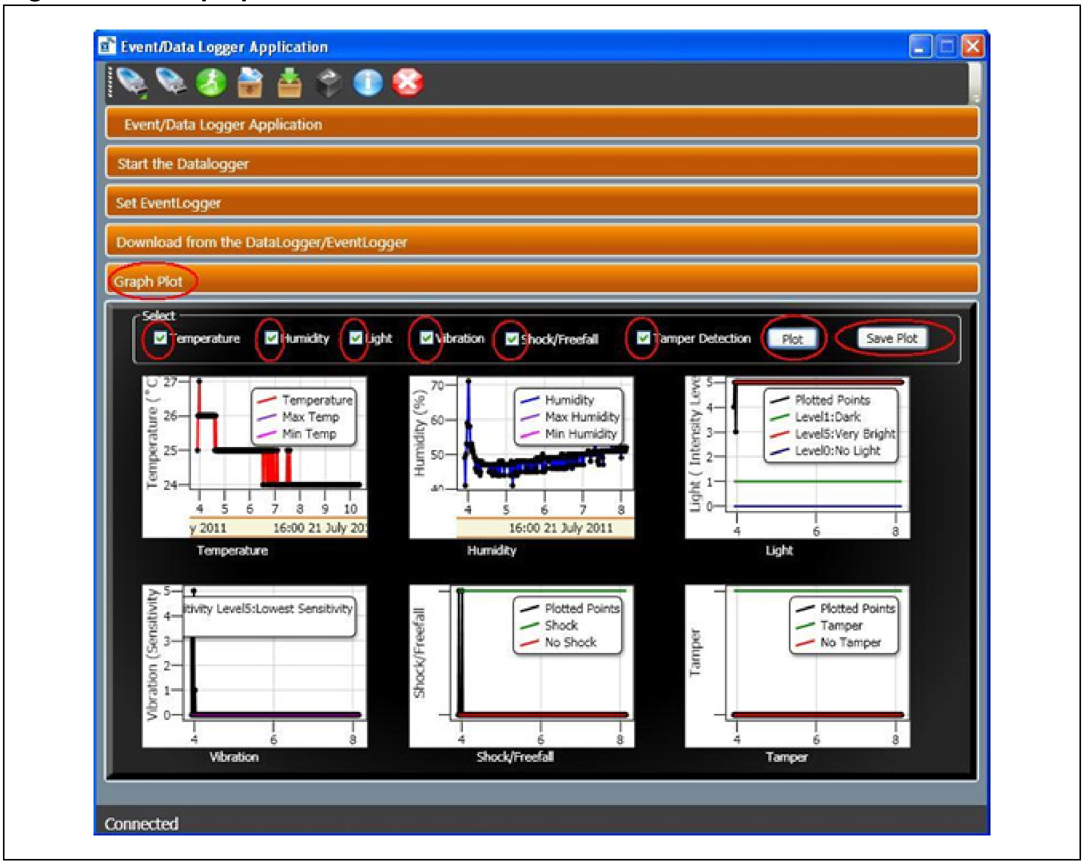


Figure 16. Graph plot window



Note: In the data logger plot there are no threshold limits for the sensor and so these are not seen inside the plot window. Therefore, there is no marking for maximum and minimum temperature and maximum and minimum humidity on the plot.

1.2.12 Starting the event logger application

The GUI installed for the data logger also has the option for an event logger application.

As with the data logger, the event logger system also has 3 stages:

1. Pre-event logger stage
2. Event logging stage
3. Post event logging stage

1.2.13 Pre-event logger stage

This stage is for selecting the sensors for logging the data and configuring the boundary conditions for different sensors. In this stage the board power is coming from the RFID reader and no external cell is needed.

Below are the steps for pre-data logger stage configuration:

1. Connect the RFID reader (CR95HF demo board/STARTKIT-M24LR-A reader) to the computer.
2. Put the switch SW4 into the downward position, as shown in *Figure 11*.

3. Place the data logger board (STEVAL-IPR002V1) on the reader, as shown in *Figure 12*.
4. Open the event/data logger GUI application.
5. Press the “Connect” button on the GUI, as shown in *Figure 6*. The information message for board connection is seen on the GUI, as shown in *Figure 13*. If the message is “Board is not connected” then again place the data logger board properly near the RFID reader and press the “Connect” button.
6. Click on the “Event Logger Selection” button, as shown in *Figure 6*. The GUI window for the event logger opens as shown in *Figure 10*.
7. Select the sensors whose values are to be logged in the “Select” section of the GUI. Click on the check box to select the sensor.
8. Enter the maximum and minimum values for the temperature sensor and the humidity sensor. Light and vibration can have 5 different levels for the thresholds which can be selected from the dropdown menu. If the sensors are not selected in the “Select” section, their value cannot be configured.
9. The time for starting the logger can be changed using the dropdown in the “Time” section. This time is used to configure the RTC of the STM8L which is used for time stamping of logged data.
10. Click the “Write EventLogger” button to configure the boundary values for different selected sensors.
11. If the GUI shows the error message “Board is not connected”, close the GUI, open it again and start with step 3 above.
12. If the board is configured for data logging, the “Data Recorded” message is displayed on the GUI. Click on “OK”.

1.2.14 Event logger stage

This is the logger stage of the system. In this phase the STEVAL-IPR002V1 board logs the sensor values which are outside the boundary limits configured in pre-event logger stage.

Below are the steps for staring the event logger stage:

1. Put the switch SW4 into the downward position, as shown in *Figure 11*.
2. Insert a 3 V coin cell (CR2032) into the connector, as shown in *Figure 5*.
3. Put the switch SW4 into the upward position, as shown in *Figure 14*, the board is powered up by the coin cell. This starts the event logger application. The start time is taken as the time which was configured in the pre-event logger stage.
4. If a sensor is selected and its value exceeds the boundary limit which is configured in the pre-event logger stage, then it is logged inside the EEPROM. In the case of tamper, data is logged only when the tamper switch(SW3) is pressed.
5. To stop the data logging, put the switch SW4 into the left position, as shown in *Figure 11*.
6. To stop the data logging, put the switch SW4 into the downward position as shown in *Figure 11*.

Note: Once the event logger is stopped using switch SW4 then starting it again through SW4 reinitializes the internal clock reference of the data logger. Therefore, on restarting the data logger the new start time should be configured using the “Set Event Logger” GUI window. SW4 is used to connect/disconnect the coin cell from the system.

1.2.15 Post event logger stage

The post event logger stage is used to download the logged data in the computer and compare this data.

Below are the steps for the post event logger stage:

1. Put the switch SW4 into the downward position, as shown in *Figure 11*.
2. Connect the RFID reader to the computer.
3. Place the STEVAL-IPR002V1 on the RFID reader, as shown in *Figure 12*.
4. Open the GUI application.
5. Press the “Connect” button, as shown in *Figure 6*. It shows the message “Board is connected”. If the board is not connected, close and reopen the GUI, and press the “Connect” button again.
6. Click on the “Download from the DataLogger/EventLogger” tab, as seen in the bottom of the GUI window, as shown in *Figure 15*. A GUI window, as seen in *Figure 8*, opens.
7. Press the “Get DataLogger/EventLogger” button on the GUI window.
8. The window shows the values for different sensors on the GUI. These values, as seen on the GUI, are the last stored values of the sensors. Each sensor also has a log count which shows the number of values logged for that sensor.
9. *Figure 8* shows the condition.
10. Click on the “Graph Plot” tab at the bottom of the GUI window.
11. This opens the plotter window shown in *Figure 16*. Select the sensor whose plot is to be seen and then click the “Plot” button.
12.
13. Double click on the plot to expand it. To exit from the expanded plot, again double click on it and it returns to step 10.
14. To zoom in, use the scroll up on the mouse or the '+' button on the keyboard, and to zoom out use the scroll down on the mouse or the '-' button on the keyboard. To slide the graph right or left, click on the graph, left click on the mouse and slide to the right side or left side.
15. To store the data in .xls, click on the “Save Plot” button and save the xls file.

Note: The event logger mode logging time is recorded as hours and minutes only. Seconds are not recorded inside the EEPROM. Therefore the plot shows values on a minute scale only.

2 System overview

This data logger demo is used to log the data of 6 sensor parameters inside the EEPROM using the I^2C communication. This logged data is retrieved from the EEPROM over the RF interface using the RFID reader.

The M24LR64-R EEPROM has 8 Kbyte (8192 bytes) of memory. In this data logger application, EEPROM memory is partitioned as follows:

1. RTC date and time: 8 bytes
2. Temperature sensor: 3064 bytes
3. Humidity sensor: 1024 bytes
4. Freefall: 1024 bytes
5. Vibration: 1024 bytes
6. Light: 1024 bytes
7. Tamper: 1024 bytes

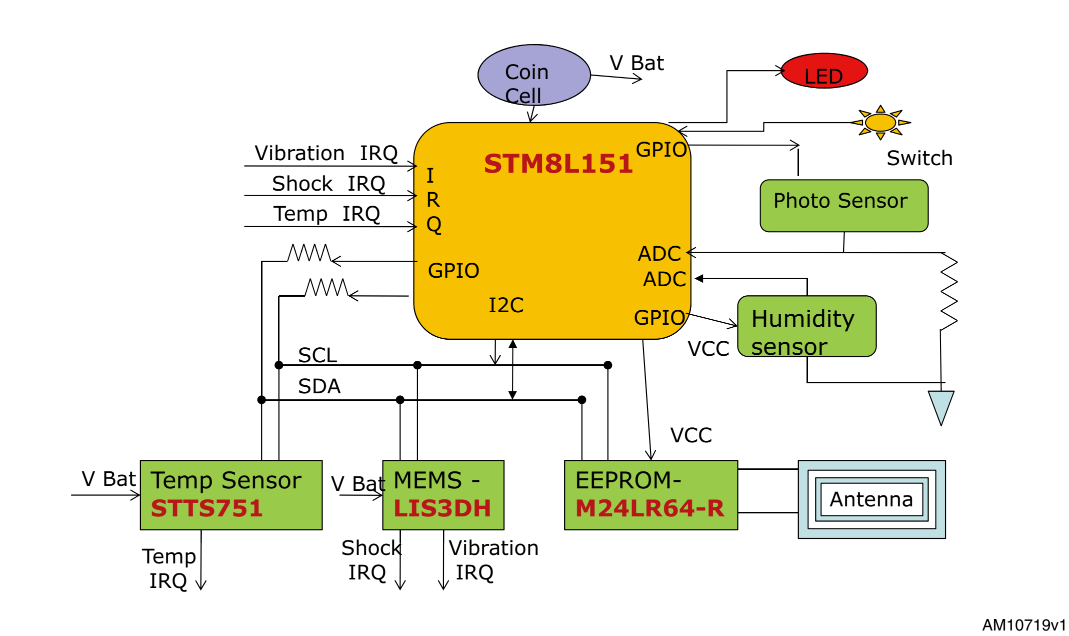
Total values which can be logged in the EEPROM along with time stamping for each value are:

1. For temperature: maximum 764 values
2. For humidity: maximum 254 values
3. For freefall: maximum 255 values
4. For vibration: maximum 255 values
5. For light: maximum 255 values
6. For tamper: maximum 255 values

If the log count for any sensor has reached its maximum value, the data logging for that sensor stops. There is no overwriting of data for any sensor.

2.1 Hardware design description

Figure 17. Block diagram



The SW4 is used to connect and disconnect the 3 V coin cell to/from the system. Battery connection is needed for the data logging stage. For the pre-data/event logging and post data/event logging stage, power is supplied by the RFID reader and the battery is not needed in the system.

The SW2 switch is used to check if any of the data is logged in the EEPROM or not.

Below are the steps to follow:

1. After the data/event logging stage, slide SW4 to the downward position and then back to the upward position, i.e. power-on reset the system.
2. Press switch SW2.
3. If any of the sensors have logged the data inside the EEPROM, the LED D1 blinks on the data logger board.
4. Logged data can be read using the RFID reader.

2.1.1 Temperature sensor for temperature data logging

The STTS751 temperature sensor is used in this application. This is a digital temperature sensor having an I^{2}C communication interface for interfacing with the microcontroller.

In the case of Event Logger mode:

Temperature thresholds are set for maximum and minimum temperature limits using the GUI and RFID reader. When the measured temperature is outside these limits the value is logged inside the EEPROM along with the date, hour and minute of logging.

In the case of Data Logger mode:

The temperature value is measured every second and is recorded inside the memory along with a time stamp.

2.1.2 MEMS for freefall and vibration data logging

The LIS3DH is the MEMS device used in this application. The LIS3DH MEMS device has been used to identify a freefall event and a vibration level event for the data logger board.

Whenever the data logger board undergoes a freefall, the date, hour, and minute of that instance is logged inside the EEPROM as a freefall event.

For a vibration event, 5 levels are defined based on the empirically observed results of the MEMS output for shaking the data logger board. These levels are defined as: highest sensitivity, high sensitivity, medium sensitivity, low sensitivity and lowest sensitivity.

In the case of Event Logger mode:

The threshold for the vibration level is defined using the GUI and the RFID reader. When the vibration seen by the data logger board is equal to or greater than this threshold, the value is logged as a vibration event along with the date, hour, and minute of the event.

In the case of Data Logger mode:

At every second, board vibration is checked and the value is logged inside the EEPROM. If there is no vibration on the board, it is logged as no vibration level in the EEPROM.

2.1.3 Humidity sensor for percentage humidity data logging

The HIH-5030 is the humidity sensor from Honeywell. Output of this sensor is analog voltage which is measured using ADC of the STM8L microcontroller and then converted into percentage humidity.

In the case of event logger mode:

Maximum and minimum threshold values for percentage humidity are configured using the GUI and the RFID reader. In the event logger system, the humidity value is calculated every 1 second, and if this value is outside the configured threshold values, it is logged inside the EEPROM along with the date, hour, and minute of that instance.

In the case of data logger mode:

At every second, the humidity value is calculated and stored inside the EEPROM.

2.1.4 Photo sensor for light data logging

The APDS-9004 is a photo sensor which is used to sense the ambient light in the data logger application. Output of the photo sensor is an analog voltage which is measured using ADC of the STM8L microcontroller.

For light intensity logging, 5 levels are defined based on an empirically observed voltage level output of the photo sensor circuit. These levels are defined as: dark, semi dark, normal, bright, and very bright.

In the case of event logger mode:

The threshold for the light level is defined using the GUI and the RFID reader. When the light intensity as seen by the data logger board is equal to or greater than this threshold, the value is logged as an event along with the date, hour, and minute inside the EEPROM. After every second, this comparison of threshold light intensity and present light intensity is done and then, accordingly, the event is logged inside the EEPROM. This logging of count for light intensity is checked every 1 second. In the case of data logger mode:

At every second, the light intensity value is calculated and stored inside the EEPROM.

If the photo sensor output is lower than the level defined as DARK level, it is logged as NO LIGHT in the EEPROM.

2.1.5 Switch press for tamper event simulation

The SW3 is a pushbutton switch which is used for the simulation of tamper detection.

In the case of event logger mode:

Whenever this switch is pressed, an event is logged inside the EEPROM as tamper event.

In the case of data logger mode:

At every second, the system checks for switch press. If the switch is pressed then it is logged as tamper, or else no tamper is logged inside the EEPROM.

2.2 Hardware layout

Figure 18 and *19* below show the component layout to help the user locate different components/sections on the board.

Figure 18. Hardware layout: data logger top

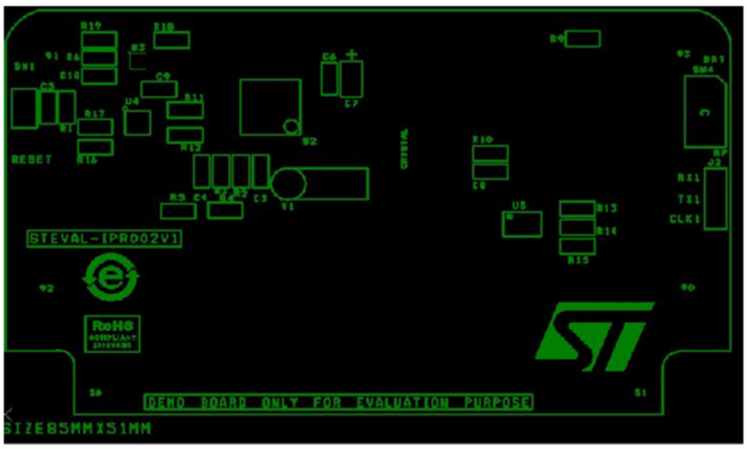


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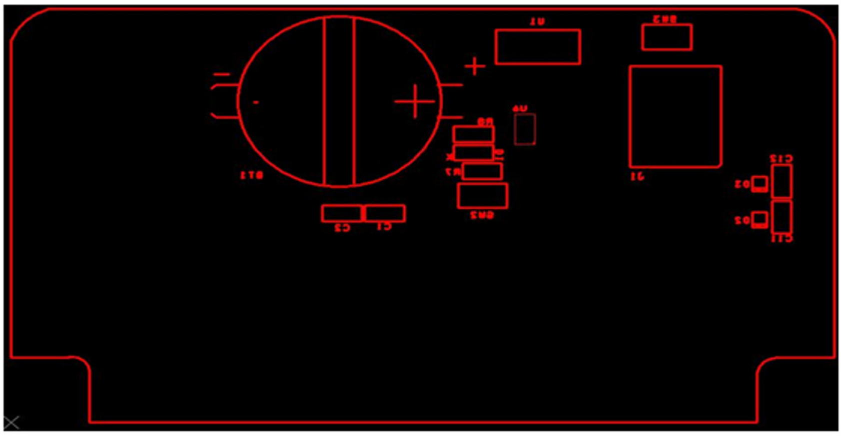
Figure 19. Hardware layout: data logger bottom



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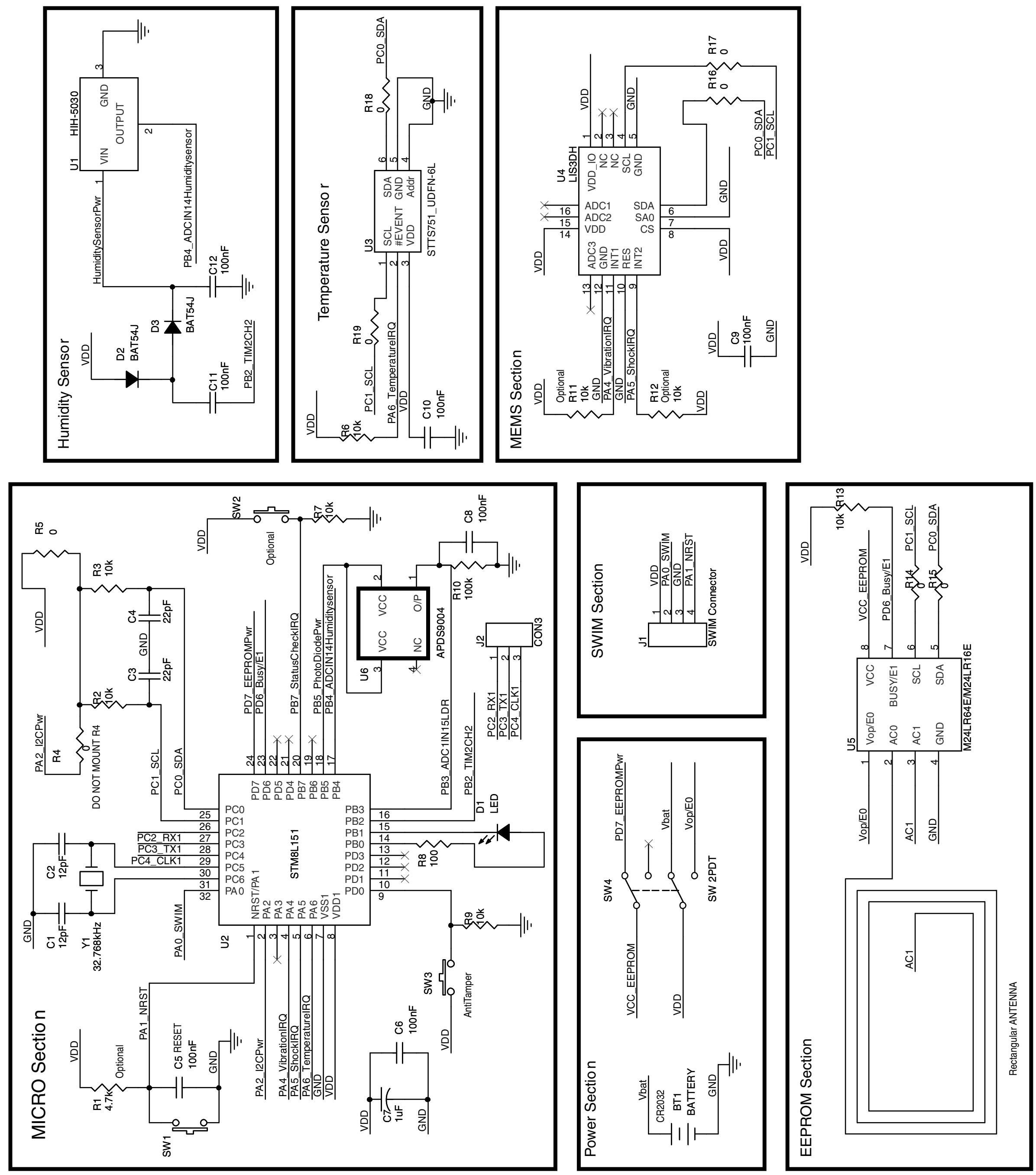
2.3 Hardware schematic

The following figures represent the schematic diagrams for the board.

Figure 20. Schematic



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2.4 Bill of materials

Table 1. Bill of material

Category	Reference designator	Component description	Package	Manufacturer	Manufacturer's order code / orderable part number or equivalent	Supplier	Supplier ordering code	Comments
ST devices	U2	Microcontroller	LQFP32	STMicroelectronics	STM8L151K4T6			
	U3	Temperature sensor	UDFN-6L	STMicroelectronics	STTS751-0DP3F			
	U4	MEMS	LGA16	STMicroelectronics	LIS3DH			
	U5	EEPROM	TSSOP8	STMicroelectronics	M24LR64-DW6T/2			
	D2, D3	Diode	SOD323	STMicroelectronics	BAT54J			
	U1	Humidity sensor	SMD	Honeywell	HIH5030			
	U6	Photo sensor	SMD	Avago Technologies US Inc.	APDS-9004-020	Digi-Key	516-1716-1-ND	
	BT1	Coin cell connector	Through hole	Tyco Electronics	796136-1	Digi-Key	A99327CT-ND	
	J1	SWIM connector	SMT, 4-pin, 1.27 mm pitch	ERNI	284697	ERNI	284697	
	J2	Berg strip	4x1-pin Berg strip	Any		Samtec	TSW-104-23-G-S	
Capacitors	C1,C2	12 pF	SMD0805	AVX Corporation or equivalent	08051A120JAT2A	Digi-Key	478-5011-1-ND	
	C3,C4	22 pF	SMD0805	AVX Corporation or equivalent	08051A220JAT2A	Digi-Key	478-1280-1-ND	
	C5,C6,C8, C9,C10,C11, C12	100 nF	SMD0805	Panasonic - ECG or equivalent	ECJ-2VF1C104Z	Digi-Key	PCC1843CT-ND	
	C7	1 µF	SMD0805	Panasonic - ECG or equivalent	ECJ-2FF1E105Z	Digi-Key	PCC2230CT-ND	

Table 1. **Bill of material (continued)**

Category	Reference designator	Component description	Package	Manufacturer	Manufacturer's order code / orderable part number or equivalent	Supplier	Supplier ordering code	Comments
LEDs	D1	LED, red color	SMD0805	Lite-On Inc	LTST-C170CKT	Digi-Key	160-1176-1-ND	
Resistors	R1	4.7 kΩ	SMD0805	Panasonic - ECG or equivalent	ERJ-6GEYJ472V	Digi-Key	P4.7KATR-ND	
	R2,R3,R6, R7,R9,R11, R12,R13	10 kΩ	SMD0805	Panasonic - ECG or equivalent	ERJ-6ENF4221V	Digi-Key	P4.22KCTR-ND	R11,R12,R13 not mounted
	R8	100	SMD0805	Panasonic - ECG or equivalent	ERJ-6GEYJ101V	Digi-Key	P100ACT-ND	
	R10	100 kΩ	SMD0805	Panasonic - ECG or equivalent	ERJ-6GEYJ104V	Digi-Key	P100KACT-ND	
	R4,R5,R14, R15,R16, R17,R18, R19	0	SMD0805	Panasonic - ECG or equivalent	ERJ-6GEY0R00V	Digi-Key	P0.0ACT-ND	Mount one out of R4/R5
Switches	SW1,SW2, SW3	Pushbutton	SMD	MULTICOMP	DTSM-32S-B	Farnell	9471898	
	SW4	DPDT Switches	Through Hole	C&K Components	JS202011AQN	Digi-Key	401-2000-ND	
Crystal	Y1	32.768 kHz	Through hole	ECS Inc	ECS-3X8X	Mouser	X1123-ND	Not mounted

3 Revision history

Table 2. Document revision history

Date	Revision	Changes
24-Apr-2012	1	Initial release.