

STEVAL-ISB012V1 Li-Ion battery monitor and gas-gauge based on the STC3105

Introduction

This document describes an easy and compact solution to monitor voltage, current, and capacity of single cell Li-Ion batteries using the STC3105, which has a highly efficient gas-gauge. In addition, the board has an internal charger in order to charge the battery. Battery charging can be done through the USB port or by using a DC adaptor.

The board contains the following devices:

- Battery monitoring device STC3105
- Microcontroller STM32F102C8
- Voltage regulator LD1117AXX33
- Li-Ion battery charger STC4054
- Step-up converter L6920

Figure 1. STEVAL-ISB012V1 single cell Li-Ion battery monitor and gas-gauge based on the STC3105



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1 Key features

- The board demonstrates the capability of the STC3105 device which uses the Coulomb counter method to track the state-of-charge in order to track when the battery is charging or discharging.
- The STC3105 uses accurate measurements of the battery voltage to estimate battery's initial state of charge (SOC). The board also measures current, voltage, relaxation time and other battery parameters set by the user using the STC3105 battery monitoring device. The onboard STM32 microcontroller is interfaced with USB, STC3105, LCD, and switches.
- Battery parameters are sent to the PC via the USB using the virtual COM port and can be observed using the HyperTerminal as well as the GUI.
- The board can also display parameters on the LCD. 4 switches are available for scrolling through the MENU.
- Charging and discharging status is displayed by the + and - sign respectively on the LCD and also the LED (D2) toggles during charging of the battery and is turned off during discharging.
- The board also shows low voltage and SOC alarms using LED D13 depending on respective thresholds set by the user.
- A battery with a capacity up to ± 10950 mAh can be monitored by the board (with a 20 m Ω sense resistor).
- An external/internal charger can be selected for charging the battery using a switch (SW8). This allows the user to use/evaluate the STC3105 with their own battery charger system.
- The onboard charger STC4054 can be used as an internal charger for the Li-Ion battery. The USB is used for communication with the PC to send the various battery parameters. Power from the USB micro-B connector can also be used to power on the board and charge the battery.
- The user also has an option of interfacing their microcontroller to the STC3105 device using jumpers. The onboard monitoring device STC3105 can be disconnected from the onboard microcontroller and the user can connect their own microcontroller (gas-gauge host device) using the relevant pins.

1.1 Typical applications

- Battery monitoring for handheld devices such as PDAs, mobile phones, MP3 players
- Medical and health care products such as a Glucometer
- Digital cameras, USB-chargers, digital photo frames
- Consumer applications using an Li-Ion battery.

2 Getting started

2.1 Package

The STEVAL-ISB012V1 demonstration board package includes the following:

- Hardware content
 - Demonstration board STEVAL-ISB012V1
- Documentation
 - User manual (this document)
 - Schematics, Gerber files, BOM list
- Microcontroller firmware
 - Pre-programmed STM32F102C8T6 device soldered onto the demonstration board.
- Virtual COM port driver
- Gas-gauge application GUI.

2.2 Setting up the board

The following steps should be taken to set up the board:

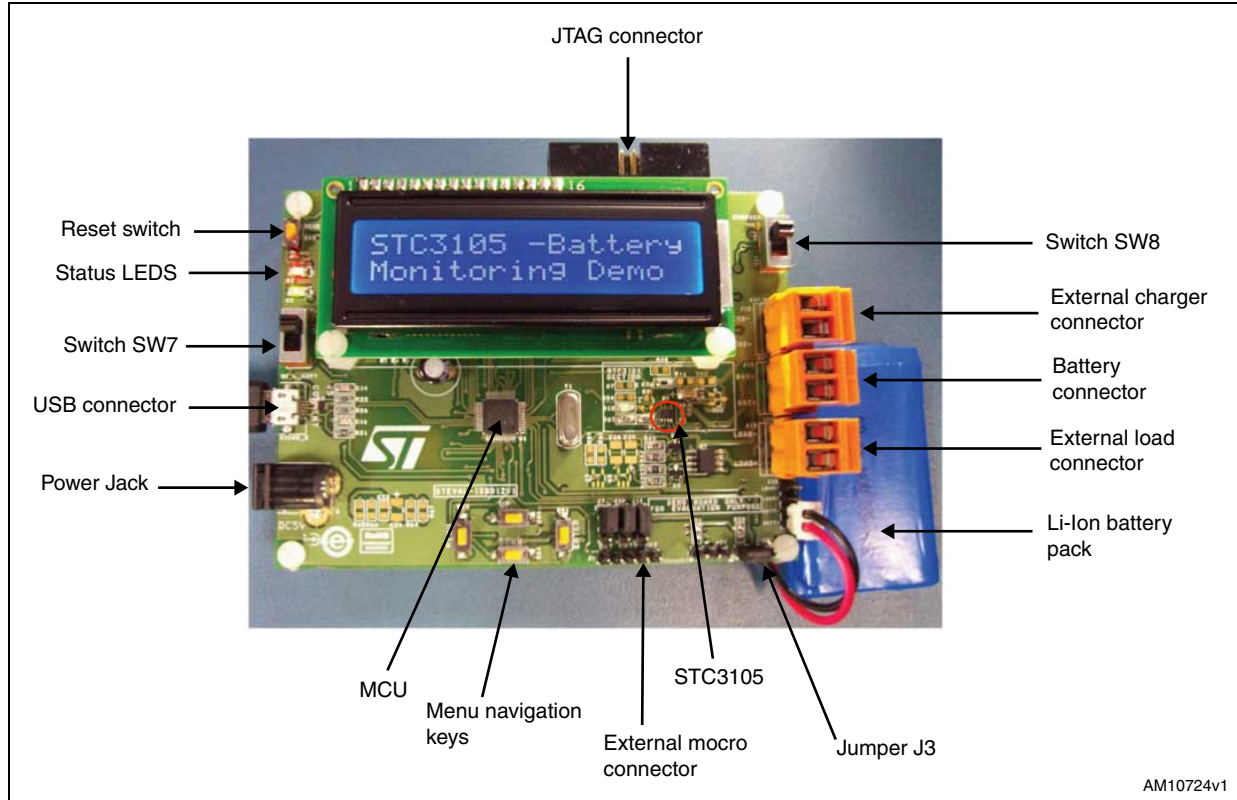
1. Standalone operation
 - Set the jumper between pin 1 and 2 of J3. This ensures the clearing of the RAM registers of the STC3105 and indicates the connection of a fresh battery. For details refer to jumper J3.
 - The board can be powered up by a power adapter (5 V power supply), by connecting the micro-B USB cable or by the battery to be monitored.
 - Connect the Li-Ion battery pack to the board with appropriate polarity across J14. A welcome message (STC3105 battery monitoring demo) is displayed on the LCD during startup. Once again, place the jumper between pin 2 and 3 of J3. For details refer to jumper J3.
 - Now use the navigation keys (SW1, SW2, SW3, and SW4) to scroll through the menu.
2. Battery charging and discharging

If an external power source (USB or 5 V adaptor) is present, the internal charger can be used to charge the battery using switch SW8.

 - Switch SW7 is used to select between the wall adapter or USB as the power source.
 - An external charger can also be connected directly across J12. Switch SW8 is used to select either an internal or external charger.
 - External load can also be connected to the board across J13 or J15. When external load and power supply is not present, the board itself acts as a load to the battery and discharges it.
 - Make sure to connect the external power supply source if battery voltage is below cut-off voltage. It is shown by LED D2. Cut-off voltage is set to 3.2 V, below this any external load (connected at J13/J15) is also disconnected by MOSFET Q7 (acting as a switch between battery and external load).

- 3. Displaying battery parameters on PC HyperTerminal
 - To display battery parameters on the HyperTerminal, connect the micro-B cable and open a new HyperTerminal window. Details are given in [Figure 2](#).

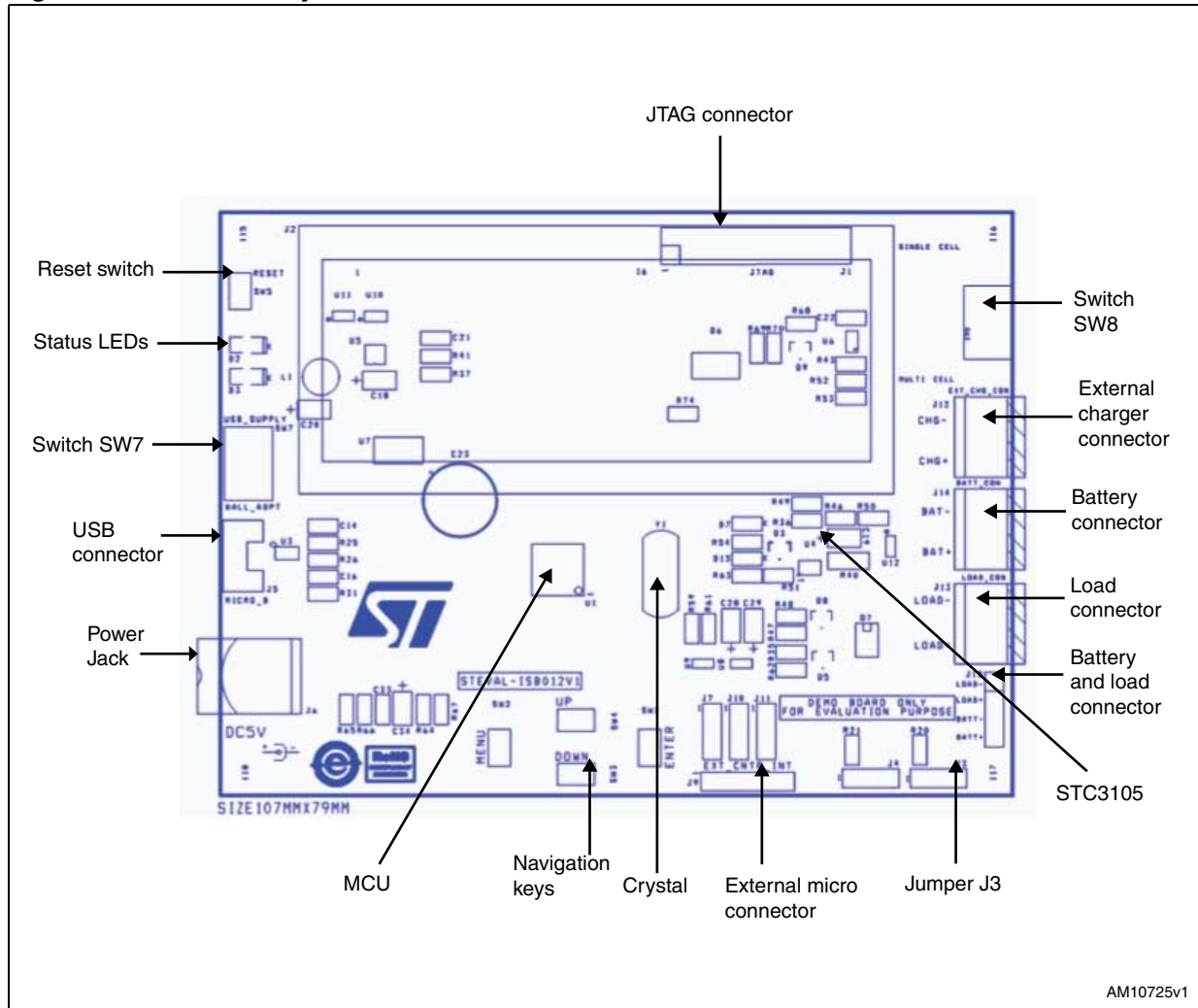
Figure 2. STEVAL-ISB012V1 single cell Li-Ion battery monitor



2.3 Hardware layout

The hardware layout of the PCB is shown in *Figure 3*, which shows all the components mounted on the board.

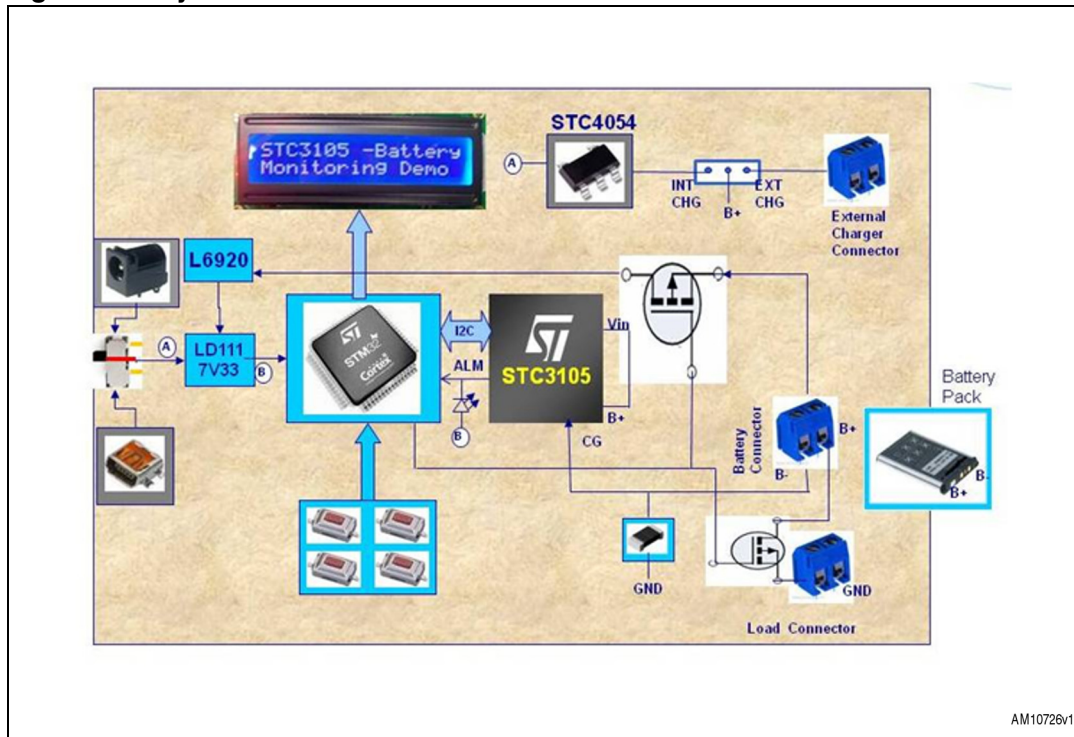
Figure 3. Hardware layout



3 System overview

3.1 General description of product architecture

Figure 4. System architecture details



System architecture details

- The STM32 communicates with the STC3105 using I²C communication protocol to obtain information regarding battery capacity, relaxation time, current, voltage, etc.
- The board is able to run on a battery source. When the battery reaches its critical voltage, the board goes into shutdown mode. To keep track of the battery status, the STC3105 is always powered up by the battery.
- The L6920 is configured to step up input voltage to 5 V. Then, LD1117AS33TR produces a constant output voltage of 3.3 V to power on the LCD and the STM32.
- LCD and switches are used for user interface.
- Onboard charger is provided to charge the battery.
- Two manual slide switches are provided on the board. The SW7 slide switch is used to allow the user to choose only one external power supply at a time i.e. either USB or an external wall adapter.
- The second manual slide switch (SW8) is used to select the battery charger, either internal or external.
- A MOSFET is provided between the battery and the L6920 which connects the board (and is acting as a load to the battery) to the battery in the absence of any external power source (USB/wall adapter) and similarly disconnects boards from the battery in the presence of any external power source.

- In a similar manner, another MOSFET is provided between an external load and battery. When battery voltage falls below the cut-off value (3.15 V), it disconnects the external load from the battery.
- Whenever the microcontroller accesses the STC3105 registers, the LED (D3) blinks and the values are updated.
- LED D2 toggles if the battery is in a charging position with either an internal or external charger. This LED is turned off if the battery is being discharged and is turned on if the battery voltage is below 3.2 V.
- LED D13 turns on if any alarm condition occurs i.e. battery voltage or SOC goes below the threshold set by the user. A related message also appears on the LCD. Similarly, if the battery is absent or deeply discharged, this LED turns on and a warning message appears on the screen.

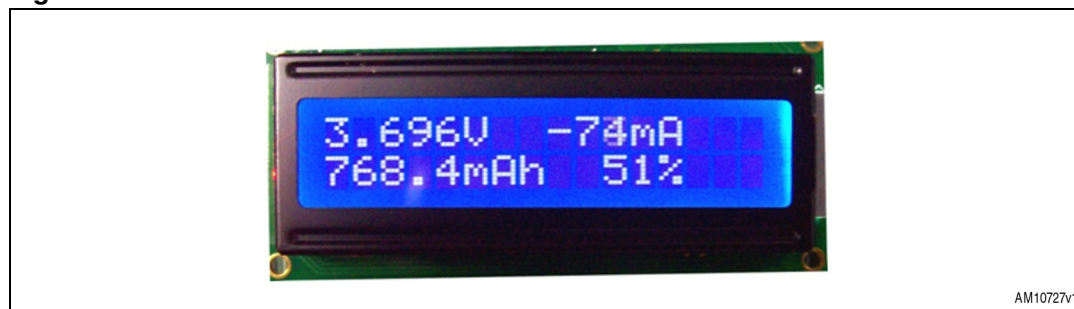
3.2 Automatic battery capacity learning

Whenever a new battery is connected to the board it automatically estimates the present SOC percentage depending on the open circuit voltage (refer to step 3 below). Initially, the total capacity of the battery is assumed to be default, i.e. 1500 mAh here. The user can change the total capacity of the battery to the required value as mentioned in [Section 5.1](#).

In order to learn the actual capacity of the battery we need to first discharge it completely and then charge it back to 100%. To achieve this, follow the steps below:

1. Do not connect external charger with the board and change switch position SW8 towards external charger. This ensures that the battery is not charged on first connection. Place the jumper between pin 1 and 2 of J3.
2. Connect power source (USB/wall adapter) to the board and then connect the battery.
3. Steps 1 and 2 ensure the battery is neither being charged nor discharged and so it measures OCV in order to estimate initial SOC of the battery.
4. Now, in order to discharge the battery we must disconnect the external power source, the board acts as a load and consumes power from the battery.
5. Similarly, if the user wants to charge the battery, either an internal or external charger can be used by adjusting SW8 accordingly.
6. Battery parameters appear on the LCD screen as shown in [Figure 5](#).

Figure 5. Data screen



7. Change the jumper position to pin 2 and 3 of J3.
8. When battery voltage falls below 3.2 V, LED D2 turns on and indicates that battery is low. Now, it is recommended to start charging the battery using an internal or external charger in order to avoid a deep discharge of the battery.

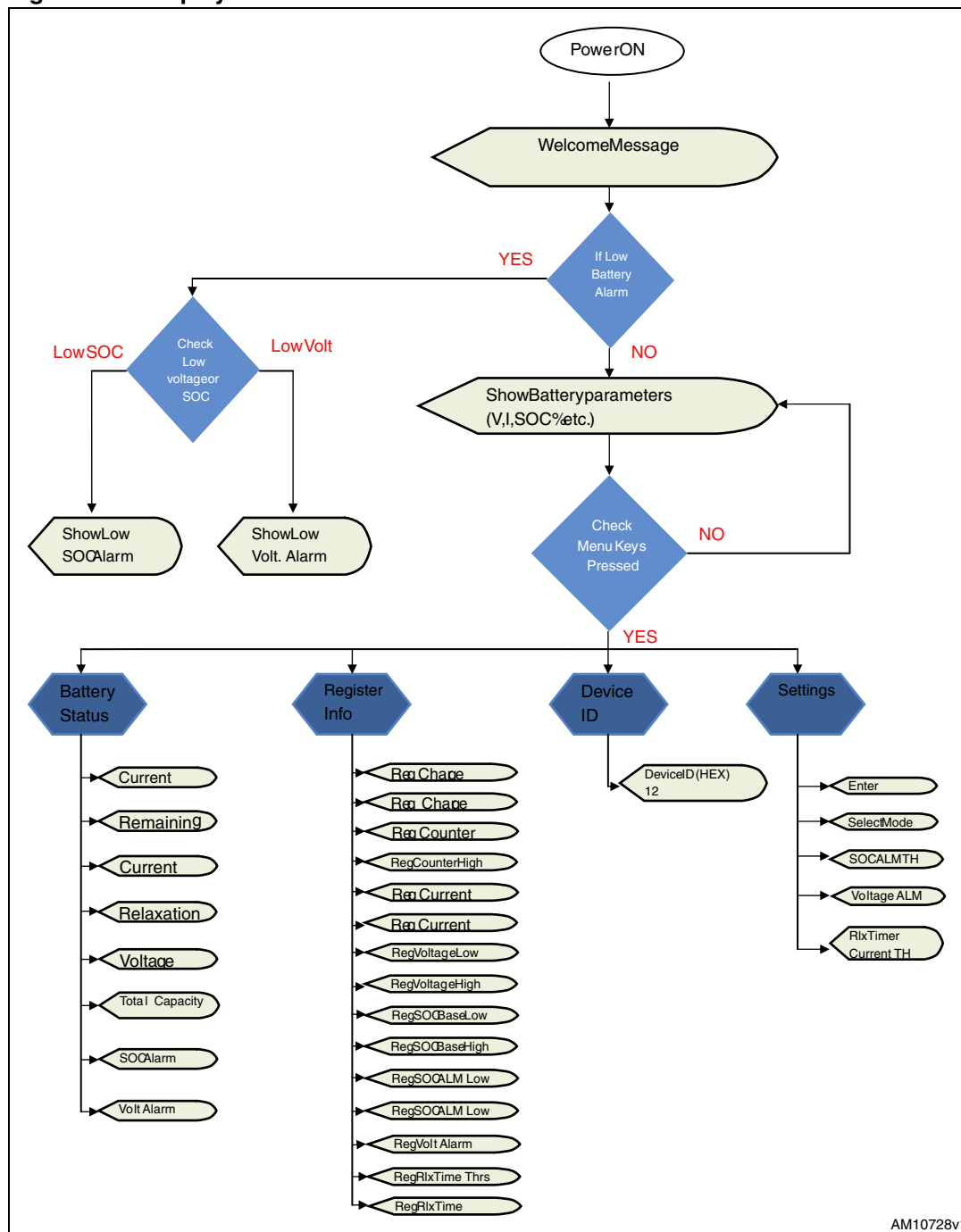
9. If charging is still not enabled, battery voltage falls further and the board enters shutdown mode. When battery voltage is around 2.7 V the board is turned off.
10. A fully charged condition is achieved when charging current falls below 50 mA for about 30 seconds along with a battery voltage of at least 4.17 V. This can be seen by a change in name from “Total Capacity” to “Actual Capacity”. This can be observed on both the LCD and HyperTerminal.

Note: If battery charging is stopped inside the ‘automatic battery capacity leaning phase’, it does not impact it as the STC3105 takes care of battery capacity calculations by using its registers. The only thing to be taken into account is that the battery should not be removed from the system and battery voltage should be above 3.1 V. If any of the conditions are not met, battery capacity learning restarts.

4 User interface section

There are various options available on the board to display the battery status, device ID, register info, etc. *Figure 6* shows all the information which it is possible to display on the LCD by using the relevant keys.

Figure 6. Display flow chart



During startup the following welcome message appears on the LCD display.

Figure 7. Welcome message



If the battery is absent or empty (below 3 V), the user sees either of these two messages, as shown in [Figure 8](#) and [9](#), and the battery must be connected to the board.

Figure 8. Battery absent message

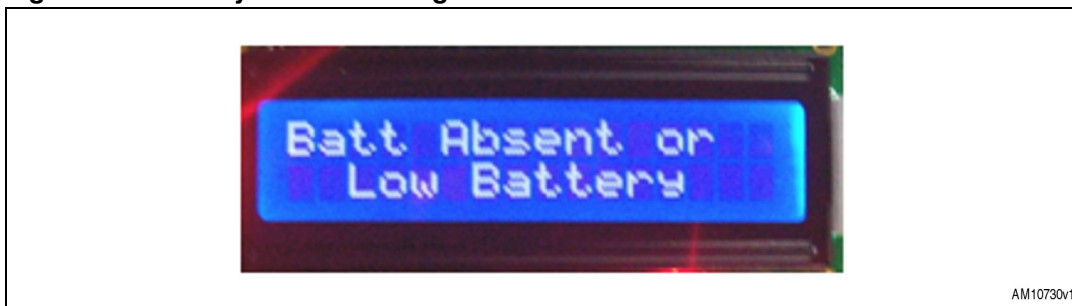
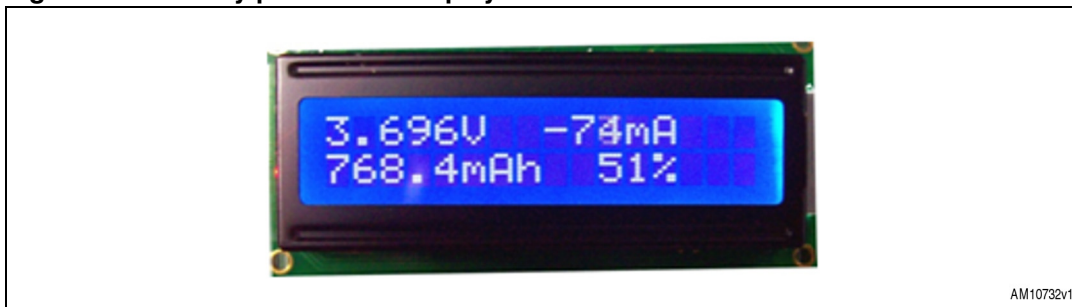


Figure 9. Battery low indication



After some delay from the welcome message, the LCD automatically starts displaying various battery parameters (data screen), as shown in [Figure 10](#):

Figure 10. Battery parameters display



On pressing the MENU key, program execution enters the main menu, as shown in [Figure 11](#):

Figure 11. Main menu screen



While scrolling through the menu, (by pressing the menu button or navigation buttons) one of the options is always indicated by the arrow mark "<-", as shown in [Figure 9](#). By pressing the enter key the corresponding tab is selected, which is indicated by the arrow mark "<-".

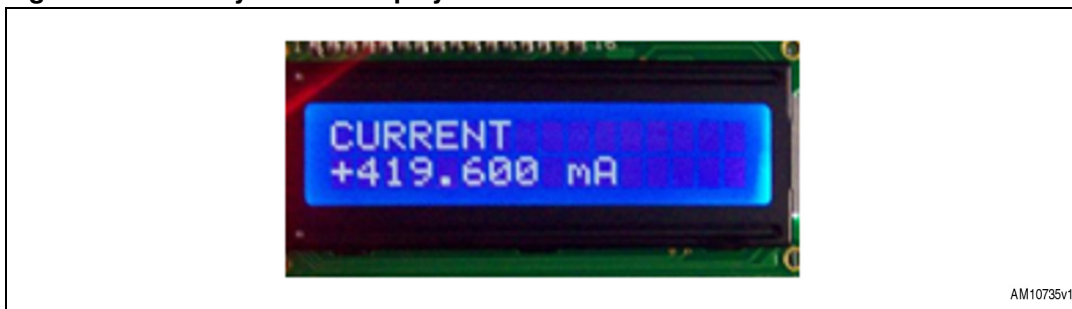
To scroll between the different options, use the UP and DOWN switches. For example, if relaxation time "RLX TIME" is being displayed on the LCD screen, as shown in [Figure 12](#):

Figure 12. Relaxation time display on LCD

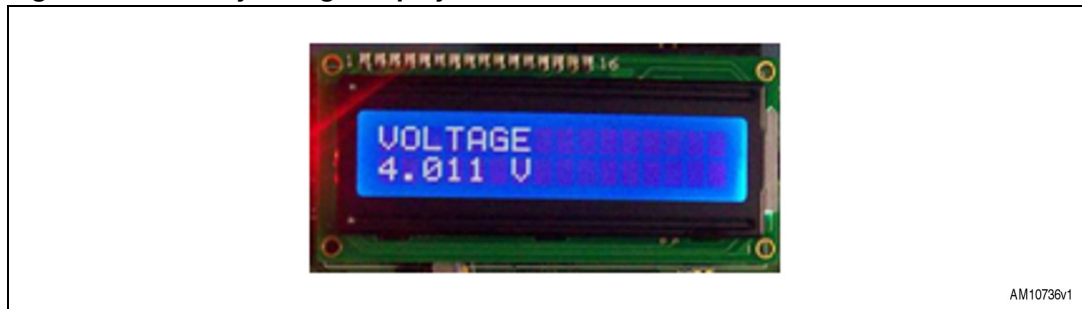


On pressing DOWN, the LCD displays current, as shown in [Figure 13](#).

Figure 13. Battery current display



If the UP key is pressed, then the voltage is displayed, as shown in [Figure 14](#).

Figure 14. Battery voltage display

On pressing the MENU key, control exits all the sub levels and returns to the main menu screen. If the MENU key is pressed again, the battery parameter display appears.

There are 5 switches mounted on the board to scroll through these available options. They are as follows:

- SW1: enter switch; to select the currently indicated option using the arrow
- SW2: menu switch; to go to the main menu from any point of the display menu
- SW3 and SW4: UP and DOWN switches; to scroll between the different options displayed on the LCD
- SW5: reset switch; to reset the microcontroller.

5 STC3105 parameter setting and display

5.1 How to enter the capacity of the battery

When a new battery is connected to the board, depending on requirements, the user can enter the total capacity of the battery. If the user doesn't enter the capacity of the battery, a default value of a total capacity equal to 1500 mAh is considered and all the data is shown accordingly.

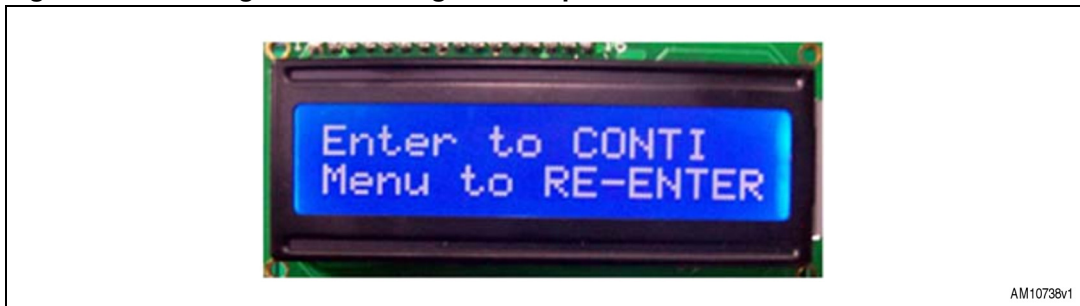
To enter the battery capacity, select the “Settings” tab and select the appropriate option. Now the user is able to see the image shown below in [Figure 15](#):

Figure 15. Entry of parameters related to SOC



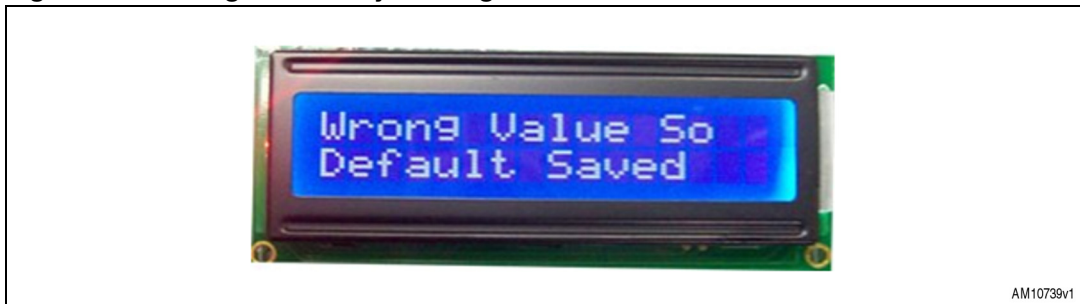
Using the UP and DOWN switch sets the number. To move to the next digit, press enter. When all the digits are set the user is able to see the image shown in [Figure 16](#):

Figure 16. Message after entering value of parameter



If the user enters the wrong value i.e. 0 or more than ± 10950 mAh (with 20 m Ω sense resistor) then it shows the message as in [Figure 17](#), and the default value i.e. 1500 mAh, is stored. When the value entered is right, it is updated in total capacity.

Figure 17. Wrong value entry message



If the capacity is entered (for example 740 mAh), and capacity learning is not completed, the user sees the image in [Figure 18](#) on the LCD showing total capacity.

Figure 18. Total capacity display



If capacity learning is over, the actual capacity is displayed on the LCD for total capacity, as shown in [Figure 19](#).

Figure 19. Change in the name of total capacity after complete learning of capacity



5.2 Entering low SOC threshold of the battery

This is the threshold value of SOC below which the battery is supposed to be empty or if the charge available in the battery is not sufficient to run the load. The board indicates an alarm once the battery capacity (SOC) drops below this. If the user wants to change the LOW SOC alarm threshold (it changes the contents of "REG_ALARM_SOC_LOW" and "REG_ALARM_SOC_HIGH") from the default value, i.e. 10% of default battery capacity (150 mAh), the user must use the setting menu.

Figure 20. Alarm parameter setting



To enter the battery LOW SOC Alarm, select the "Settings" tab and select the appropriate option. Now the user is able to see the image shown in [Figure 15](#).

Using the UP and DOWN switch sets the number. To move to the next digit, press enter.

When all the digits are set, the user is able to see the image shown in [Figure 16](#).

If the user enters any value below 150 mAh or above 7300 mAh, the board shows the message in [Figure 17](#) and enters default value, i.e. 150 mAh.

5.3 Entering low voltage threshold of the battery

If the user wants to change the “low voltage alarm threshold” from the default value i.e. 2.9 V, 3.2 V, they must use the setting ‘MENU’.

Note: The low voltage alarm threshold is configurable and different to the cut-off voltage, which is fixed at 3.15 V and used to disconnect an external load from the battery.

To enter the battery low voltage alarm threshold, select the “Settings” tab and select the appropriate option. Now the user is able to see the image shown below:

Figure 21. Low voltage alarm setting



The UP and DOWN switch sets the number. To move to the next digit, press enter.

When all the digits are set the user is able to see the image shown in [Figure 16](#).

This parameter changes the contents of “REG_ALARM_VOLTAGE”.

If the user enters any value below 2.9 V or above 4.2 V, the board shows the message in [Figure 17](#) and enters the default value, i.e. 2.9 V.

5.4 Entering RLX counter current threshold

If the user wants to change the relaxation counter current threshold from the default value, i.e. 40 mA, it is necessary to use the setting 'MENU'.

To enter the battery relaxation counter current threshold, select the "Settings" tab and select the appropriate option. It is now possible to see the information in [Figure 22](#):

Figure 22. Relaxation counter current threshold value entry



Using the UP and DOWN switch sets the number. We can enter this threshold value in multiples of 20 mA only. To move to the next digit, press enter.

When all the digits are set, the user is able to see the information shown in [Figure 16](#).

If the user enters any value below 40 mA or above 4.8 A, the board shows the information in [Figure 17](#). If the user enters a value that is not a multiple of 20 mA, then the value entered is automatically for the lower closest value available in multiples of 20 mA, e.g. if the user enters 65 mA, then the board automatically accepts 60mA as it is the closest value lower than 65 mA and also a multiple of 20 mA.

5.5 Status LED description

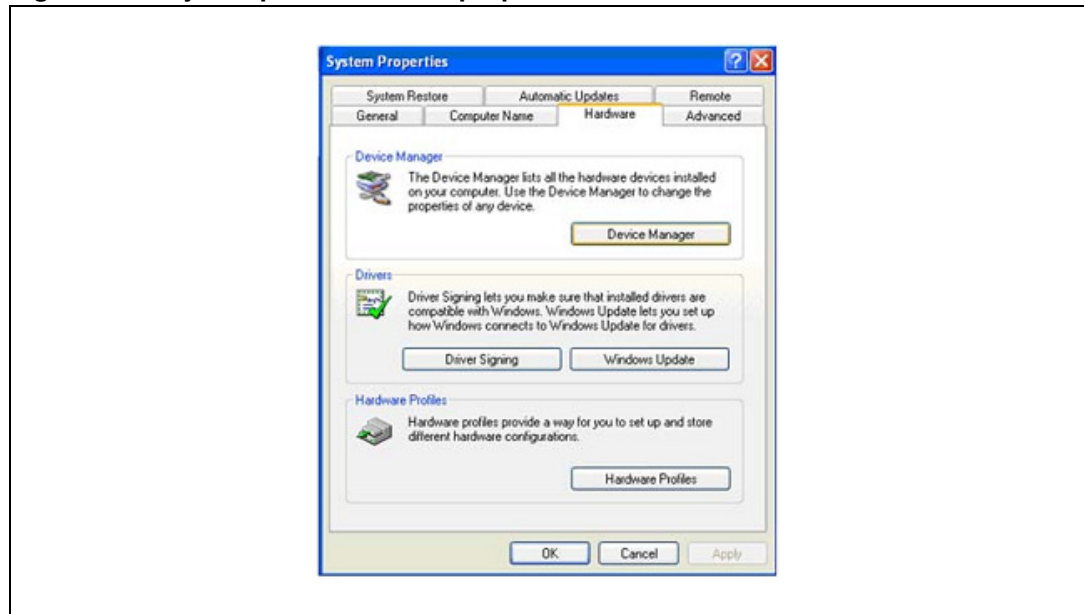
Table 1. LED description

LED	Description	Toggling	OFF	ON
D2	Charging/discharging status	Charging	Discharging	Battery below 3.15 V
D3	STC3105 register access	Register being accessed per second	No access	Some problem
D13	Alarm LED	Alarm situation, refer to message on display	No alarm	Alarm occurred, refer to displayed message to see type of alarm

5.6 HyperTerminal display settings

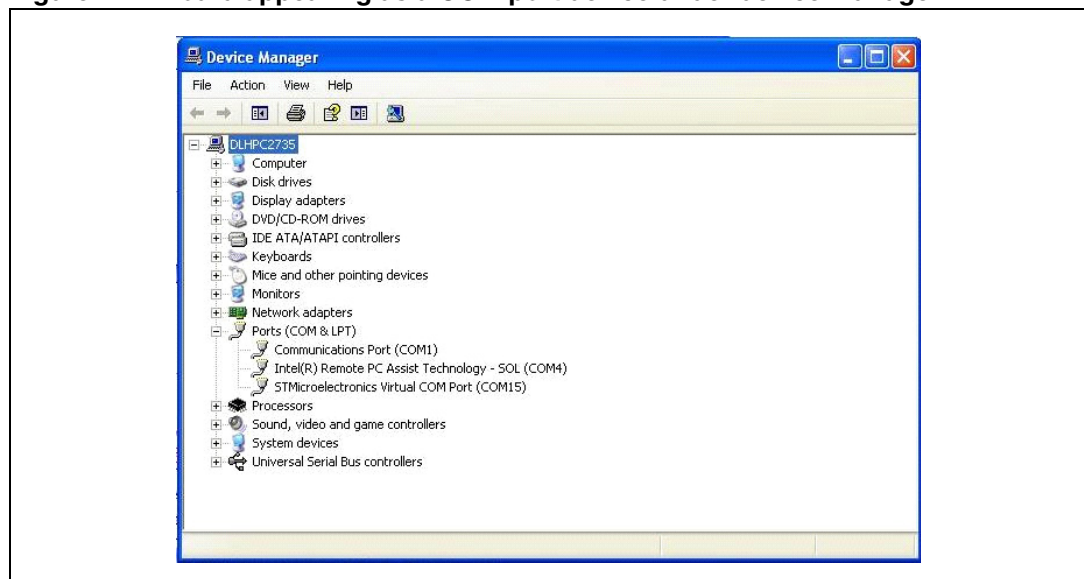
The STC3105 board supports the virtual COM port feature. After installing the driver provided for the virtual COM port or the gas-gauge GUI driver (which automatically installs the virtual COM port driver in addition to the GUI), the user can see the battery parameters and other register information on the HyperTerminal window of the PC. To do this, the user should connect the micro-USB cable between the board and the PC, and select the device manager under the hardware tab of system properties, as shown in [Figure 24](#).

Figure 23. My computer hardware properties



Now the user is able to see the “STM Virtual COM Port” under ports (COM & LPT). Take a note of the COM port number.

Figure 24. Board appearing as a COM port device under device manager



Open the HyperTerminal window as shown in [Figure 24](#) and select the same COM port number which was shown with the name “STM Virtual COM Port”. Set the properties as shown in [Figure 26](#).

Figure 25. HyperTerminal settings

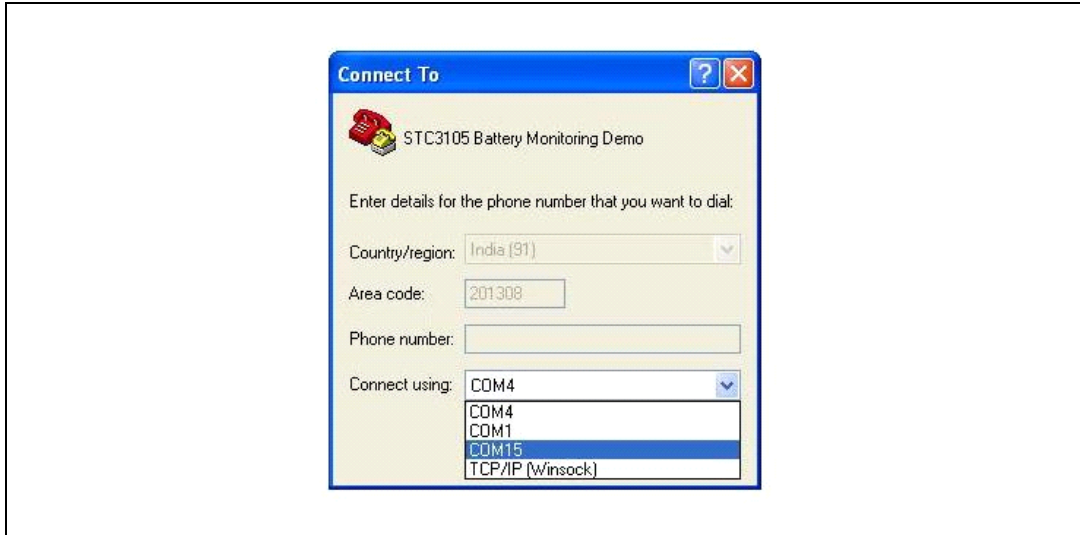


Figure 26. COM port property settings

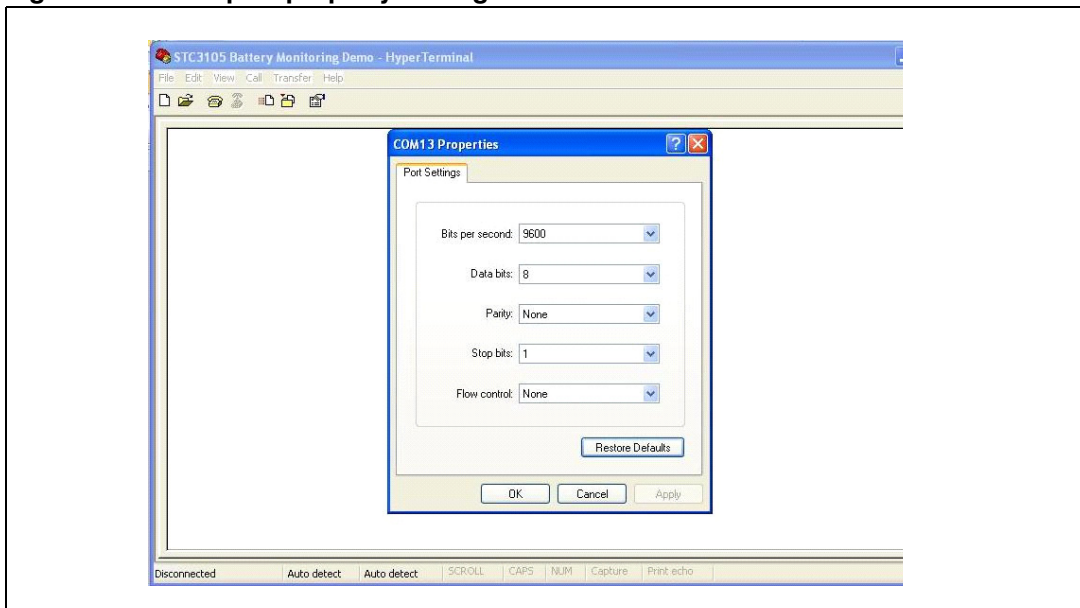
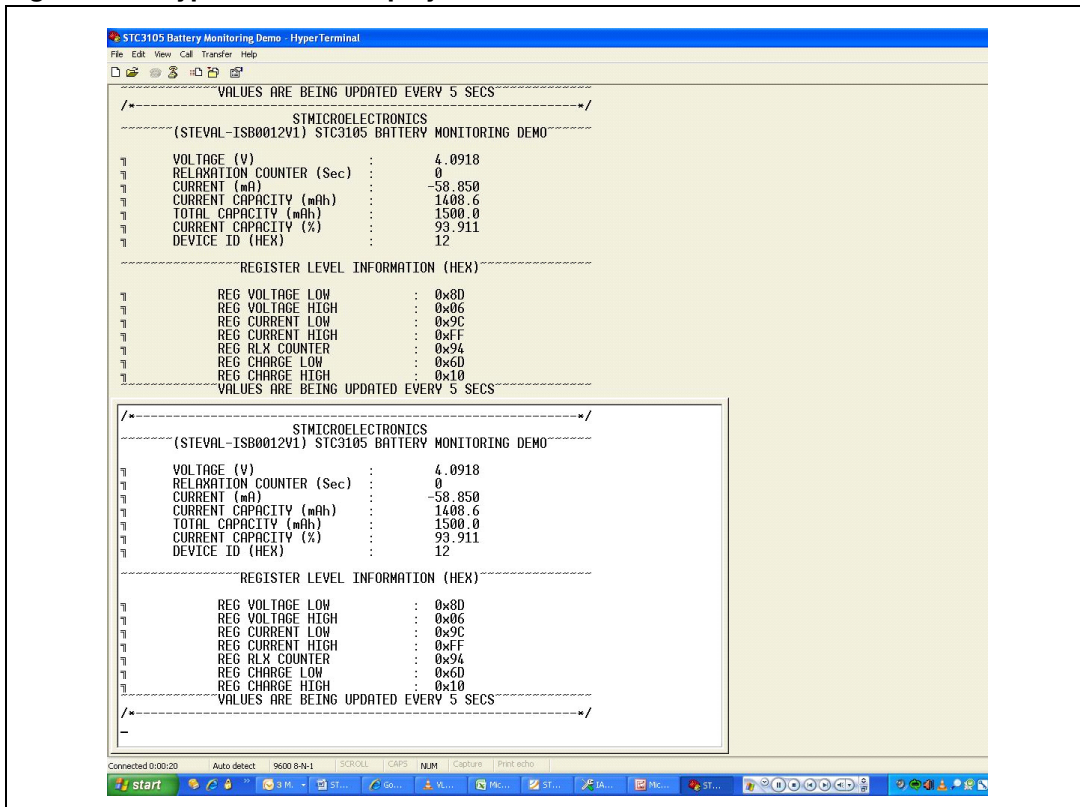


Figure 27. HyperTerminal display



Once the HyperTerminal is open, the parameters are shown, as in [Figure 27](#). These parameters are updated on the HyperTerminal every 5 seconds (as configured in the firmware). With the capture text feature of the HyperTerminal, it is possible to create a text file showing the information regarding the battery status. Open this file with WordPad.

6 Graphical user interface application

It is possible to monitor and set various battery parameters using a GUI, which also communicates with the demo board through the USB (virtual COM port). Only one of the two, HyperTerminal or GUI, can be run at any one time. The key features of the GUI are:

- It can show gas-gauge results such as voltage, current, etc. at the log frequency set by the user.
- It also shows three different graphs of voltage, current, and SOC percentage with respect to time.
- The user can set various parameters like key battery parameters (battery total capacity, etc.), alarm parameters (SOC and voltage alarm), board hardware parameters (sense resistor, vin resistor), and some other battery parameters.
- The gas-gauge can also be started and stopped using the GUI.
- It is also possible to read mode and control registers as well as write some bits of these two registers.

After proper installation of the GUI demo, the user can read and write various parameters of the board as mentioned below.

6.1 Installation of the GUI

- Click the setup package and start the installation of the application.

Figure 28. GUI installation step 1

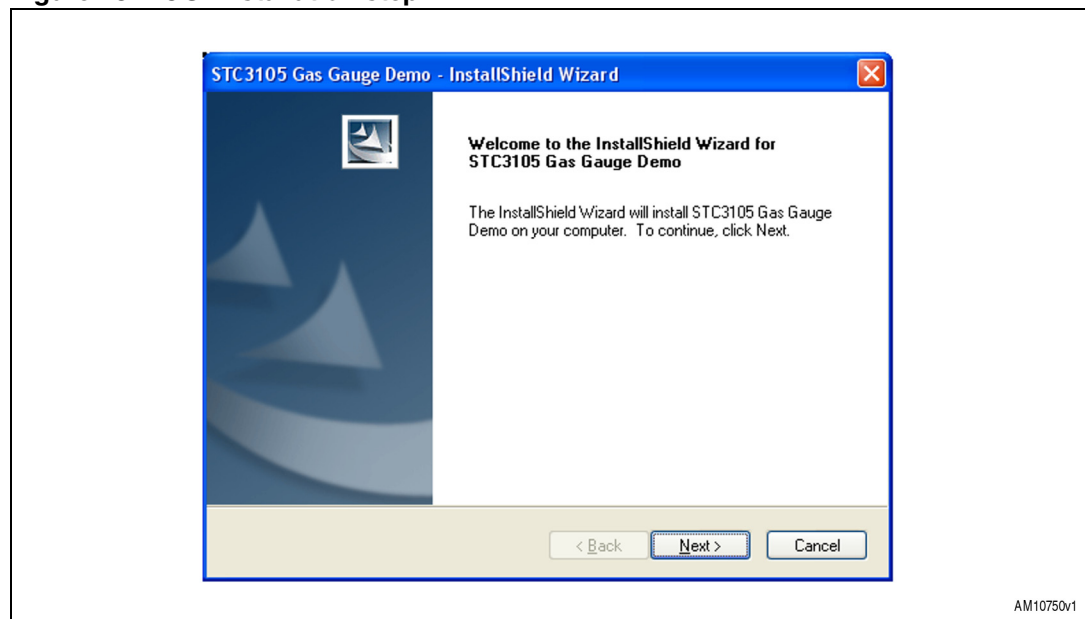
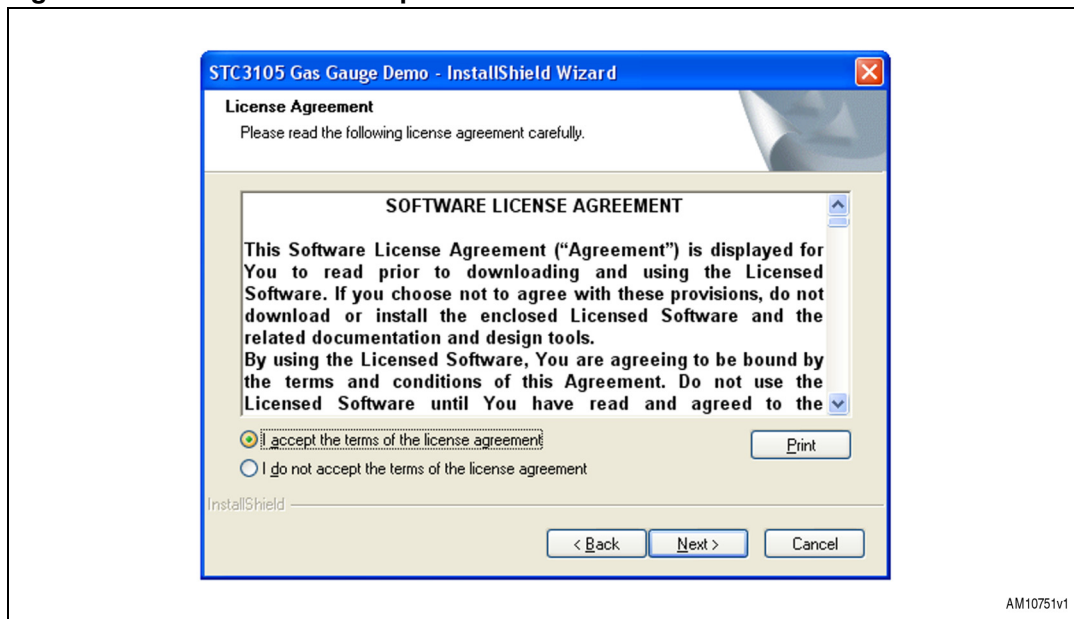
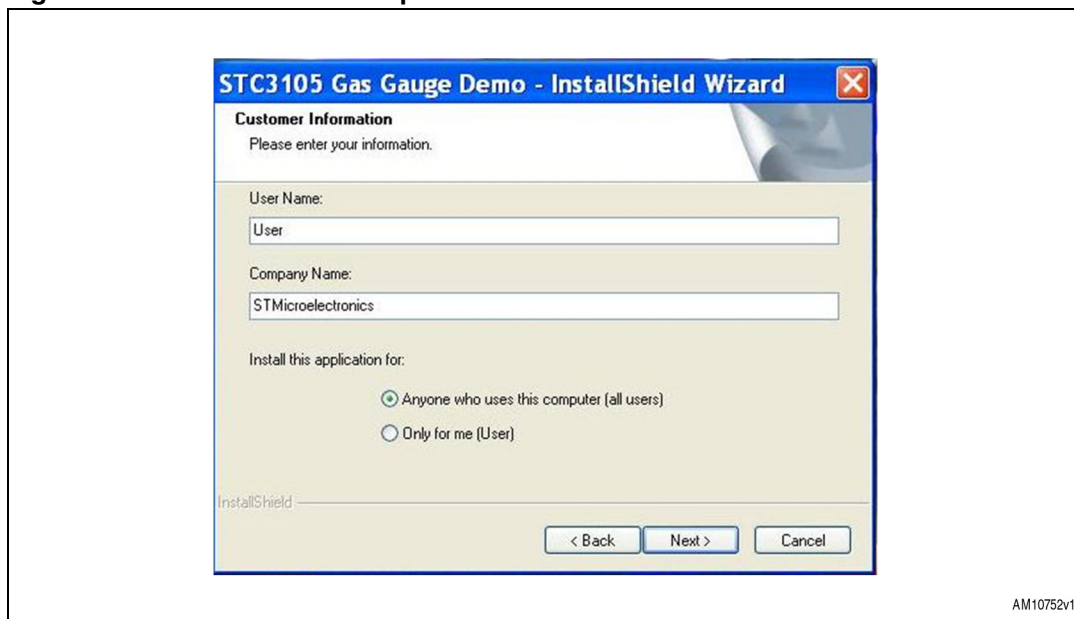


Figure 29. GUI installation step 2



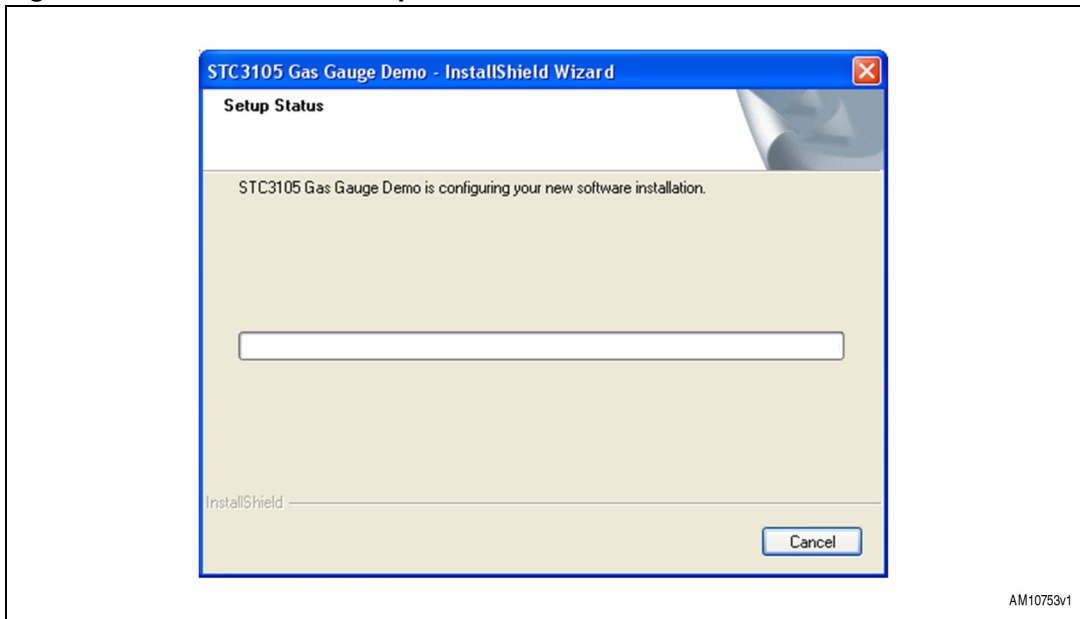
- Accept the license agreement and click Next.

Figure 30. GUI installation step 3



- Click Next to continue installing the application.

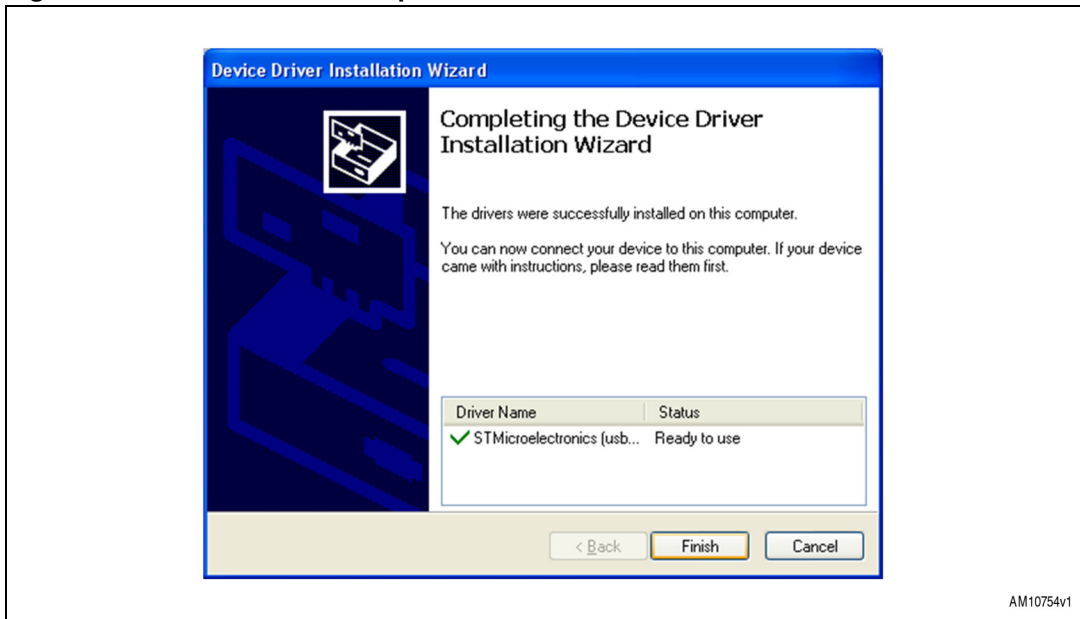
Figure 31. GUI installation step 4



AM10753v1

- The setup installs the application and then starts the installation of the virtual COM port driver.

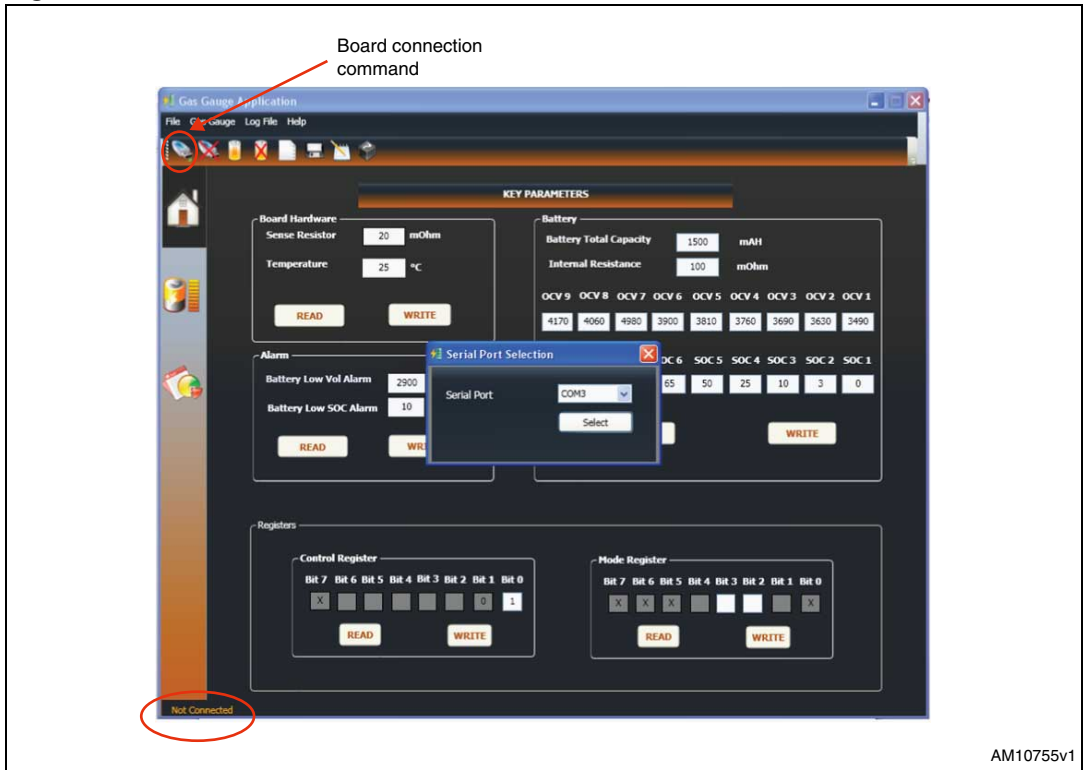
Figure 32. GUI installation step 5



AM10754v1

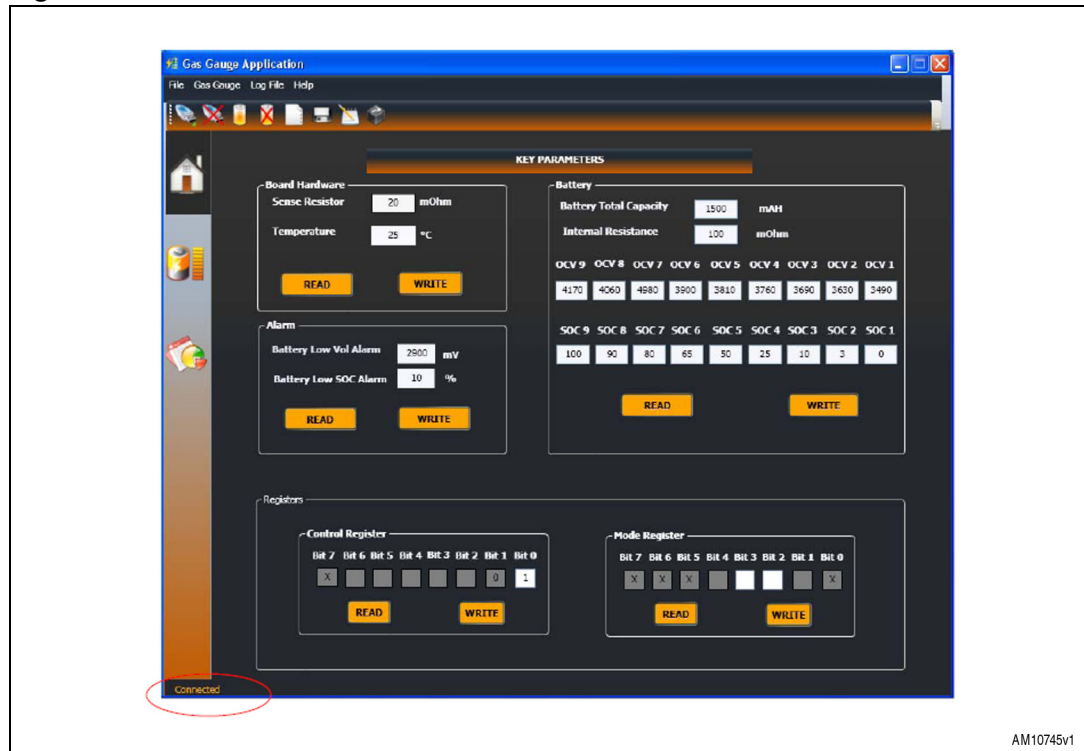
6.2 Board initialization

Figure 33. Board connection command



AM10755v1

Figure 34. Board connected



AM10745v1

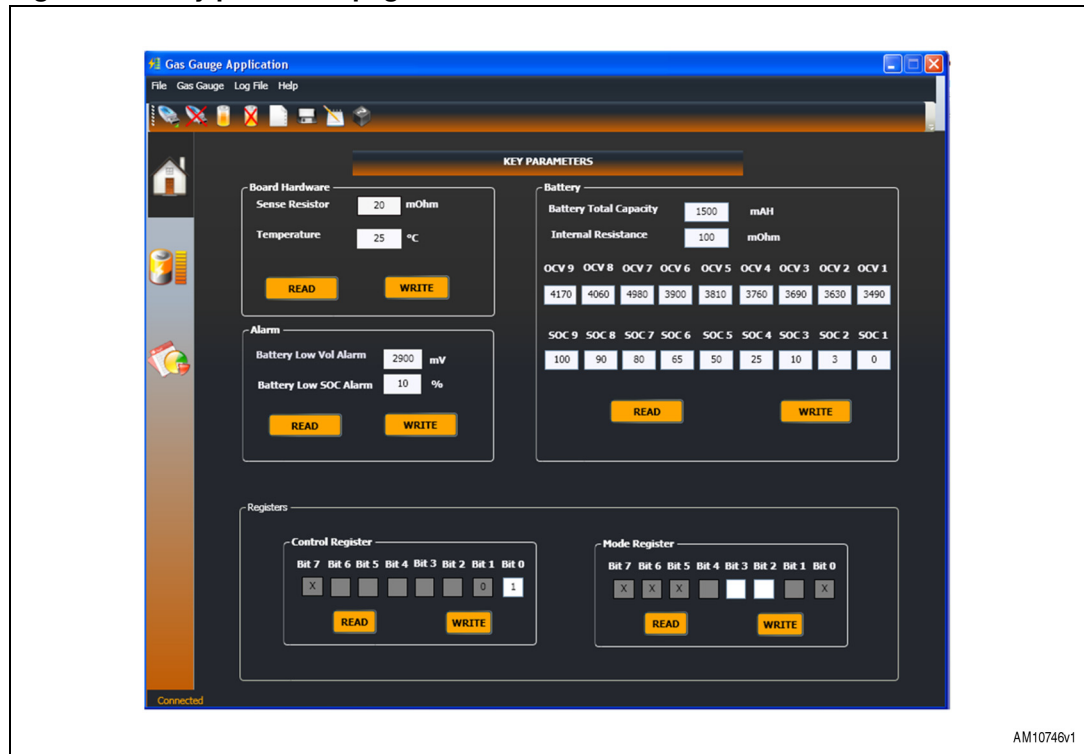
To start evaluating board parameters and its configuration, the user must first connect the board to a USB port using the USB micro-B cable and then connect the GUI using the connect tab. When the board is connected properly to the GUI, it shows the message “The board is connected”, as shown in [Figure 34](#).

6.3 Key battery parameters

The following are the parameters that appear on the first page (key parameter page) of the GUI, as shown in [Figure 35](#).

- Board hardware: it is possible to read and write the value of the sense resistor as well as the room temperature value.
- Alarm: it is possible to R/W the battery low voltage alarm as well as the low SOC alarm.
- Battery parameters: it is possible to read and write total battery capacity, internal resistance of the battery pack as well as the open circuit voltage and its relative SOC percentage table to be used for an estimation of initial SOC of battery depending on the open circuit voltage.
- Control register: it is possible to read the value of the control register as well as write the 1st bit (bit 0) of this register.
- Mode register: it is possible to read the value of the mode register as well as write the 3rd and 4th bits (bit 2 and 3).

Figure 35. Key parameter page

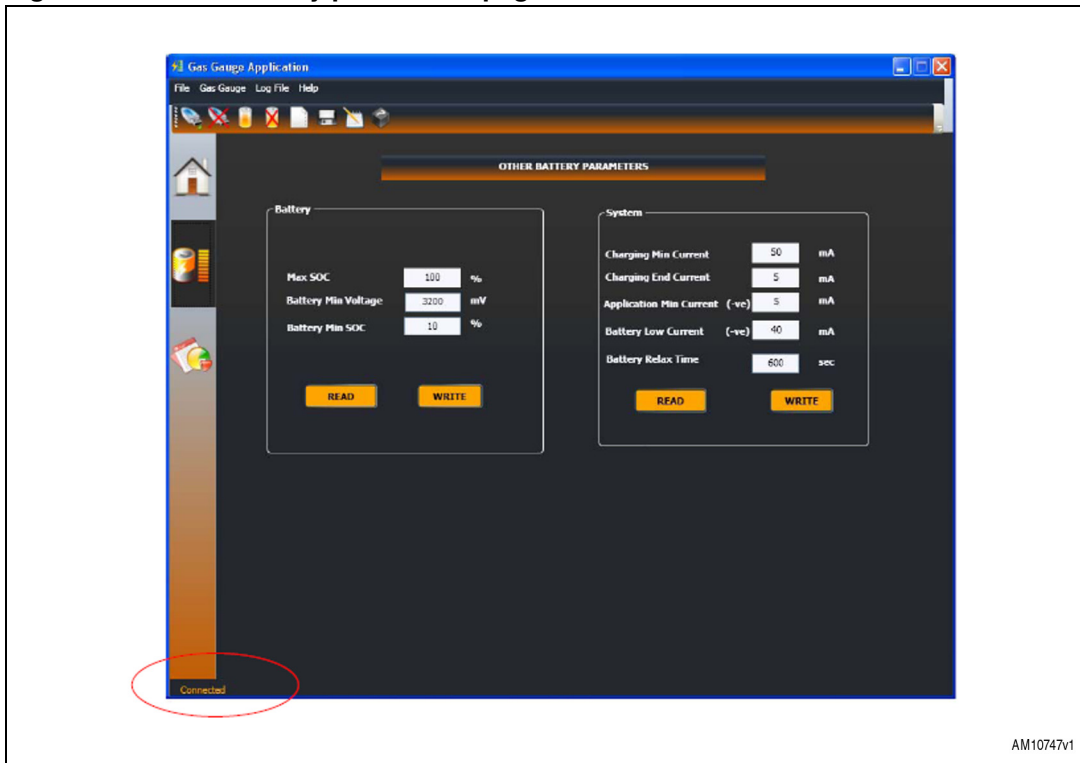


6.4 Other battery parameters

The following are the parameters that appear on the first page of the GUI, as shown in [Figure 36](#).

- Battery parameters: it is possible to read and write the value of:
 - Maximum SOC at which the battery is assumed to be fully charged entered here in percentage of “battery total capacity” (defined under key battery parameters).
 - Battery min. voltage defines the cut-off voltage below which the battery is assumed to be empty and the external load is disconnected and indicated by LED D2 glowing.
 - Battery min. SOC corresponding to SOC at battery nearly empty (%).
 - System parameters: it is possible to read and write various parameters like battery relaxation time (battery relaxation time before OCV measurement in seconds), battery low current (relaxation timer current threshold, i.e battery max. discharge current for OCV measurement), application min. current (minimum application current consumption in mA (<0)), charging end current (end charge current in mA), charging min. current (min. charge current in mA).

Figure 36. Other battery parameters page

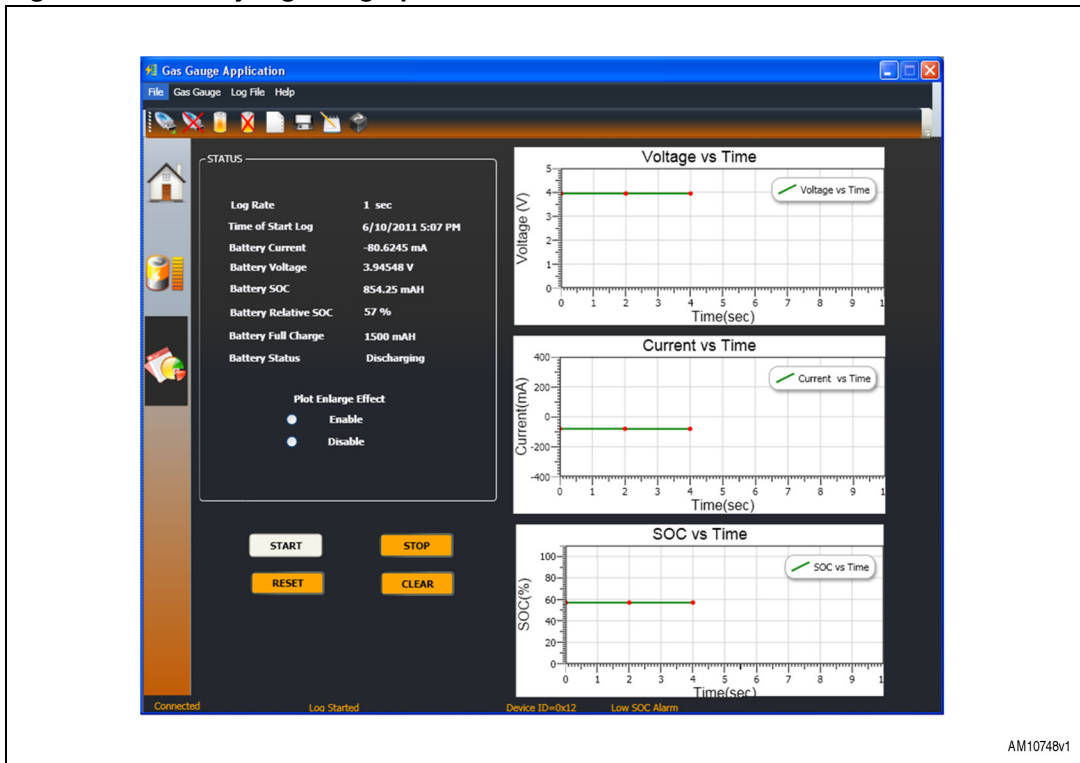


6.5 Battery status and data log

Here it is possible to observe various battery parameters at a regular interval (set by configurable log rate), in addition, it is also possible to observe the separate graphs of battery voltage, current and SOC percentage in respect to time, on the same page as shown in [Figure 37](#). The zoomed view of graphs, as well as zoom in and zoom out, can be seen by simply positioning the mouse over the desired graph. This option can be enabled and disabled through the options available on the same page. If the user wants to start a new log there is also an available option to clear the previous screen. The log rate can also be changed by using the appropriate option. The following are the key features:

- Observe various parameters like battery voltage, battery current, battery SOC (in mAH) etc. at a regular interval set by the log rate.
- The GUI can display separate graphs of battery voltage, current and SOC percentage in respect to time on the same page.
- Zoom in and zoom out effect of graph is also available.
- It is possible to clear the log if necessary in order to view a new log.

Figure 37. Battery log and graph



Note: For more details please refer to the help file available in the GUI.

7 Hardware design description

The board supports both USB and a wall adapter (external supply). A switch (SW7) is used to choose between these two. When an external supply is absent the whole board consumes power from the battery. In this case the step-up converter device L6920 steps up battery voltage to 5 V. The voltage from these sources (external or L6920) is connected to a low drop-out regulator (LD1117V) which gives 3.3 V output. This output is used for powering up devices such as the LCD, microcontroller, etc.

The STC3105 battery monitoring device always receives power from the battery. In order to avoid the loss of data stored in the RAM registers of the STC3105 during power-off.

7.1 Microcontroller (STM32)

The STM32 is a 32-bit MCU based on the popular ARM 32-bit Cortex™-M3 CPU. The STM32 device (STM32F102C8T6A) used in this demonstration board runs at 48 MHz. The microcontroller has single-cycle multiplication and hardware division. The device supports low power mode such as sleep, stop, and also standby. This device (microcontroller) has up to 5 communication interfaces which includes two I²Cs (400 kHz), three USARTs, two SPIs (12 Mbit/s), and USB 2.0 full-speed interface. For more details refer to the STM32F102x8 datasheet and RM0008 reference manual. For this application, a minimum of one I²C to interface with the STC3105 is needed, a USB to support a USB based charger and USB data transfer, and some general purpose IOs for the user interface, are required. The part numbers used to develop this application are shown in [Table 2](#).

Table 2. Microcontroller details

Feature	Description
Sales type	STM32F102C8T6A:USB access line, USB 2.0 full-speed interface
Package	LQFP-48 (7 x 7) mm
Flash - Kbytes	64
SRAM - Kbytes	10
Operating voltage	2.0 to 3.6 V

The microcontroller is used to communicate with and control the STC3105 device, USB communication to display data on the PC, LCD driving, interfacing menu keys and menu operation.

7.2 Battery monitor IC (STC3105)

The STC3105 monitors the critical parameters of a single-cell Li-Ion battery (voltage, and current, SOC, etc.) and includes hardware functions to implement a gas-gauge for battery charge monitoring, based on a programmable 12- to 14-bit A-D converter. With a typical 20 mΩ external sense resistor, the gas-gauge system provides a capacity of up to ±10950 mAh with a resolution of 0.2 mAh, as described below.

- Calculation of the maximum battery capacity being supported by the STC3105:

The voltage drop across the external sense resistor is integrated during a conversion period and input to a 12- to 14-bit AD converter. The output conversion is accumulated into a 28-bit accumulator. The LSB value is set by the internal gain and internal reference and is 11.77 μV at maximum resolutions. The conversion cycle for n bit resolution is 2ⁿ clock cycles. Using the 32,768 Hz internal clock, the conversion cycle time is 125 to 500 ms for a 12- to 14-bit resolution. The AD converter output is in 2's complement format. When a conversion cycle is completed, the result is added to the charge accumulator.

The LSB value of the charge accumulator (in mAh) = LSB value of ADC * conversion cycle time * 10⁻³ sense resistor * 3600.

(LSB value of ADC= 11.77 μV, conversion time 500 mS for 14-bit resolution; sense resistor = 10 mΩ to 50 mΩ)

Maximum capacity of battery supported (in ± mAh) = LSB value of charge accumulator * 2²⁸.

Resolution of charge register = maximum capacity of battery supported 2¹⁶.

Table 3. Maximum capacity and charge register LSB resolution for various values of R_{sense}

Sense resistor value	Maximum capacity of battery supported (in ± mAh)	Resolution of charge register (in mAh)
10 mΩ	21900	0.6
20 mΩ	10950	0.3
30 mΩ	7300	0.2
40 mΩ	5450	0.16
50 mΩ	4350	0.13

The device is programmable through the I²C interface. This device also has 16-RAM bytes, 1-byte unique device ID, and an ALM pin. RAM contents are retained even up to a minimum battery voltage of 2.0 V. For more details refer to the STC3105 datasheet.

Table 4. STC3105 details

Feature	Description
Order code	STC3105IQT
Package	TDFN 3.0 X 2.0 X 0.75
Operating voltage	2.7 to 5.5 V
Operating current consumption	50 μA

7.3 ESD protection device

ESDAULC6-3BP6 are monolithic application specific devices dedicated to ESD protection of high-speed interfaces, such as USB 2.0, Ethernet links and video lines. For more details please refer to the device datasheet.

Table 5. USBLC6 details

Feature	Description
Order code	ESDAULC6-3BP6
Package	SOT-666

7.4 Voltage regulator

The LD1117 is a low drop voltage regulator able to provide up to 800 mA of output current, available even in the adjustable version (VREF = 1.25 V). High efficiency, low drop voltage, and the low quiescent current make them particularly suitable for low noise, low power applications, and in battery powered systems. For more details please refer to the device datasheet.

A power supply of 3.3 V is generated using this IC to power up the LCD, microcontroller, and all other peripherals except the STC3105 which is always powered up from the battery only.

Table 6. Voltage regulator

Feature	Description
Sales type	LD1117AS33TR
Package	SOT-223

7.5 STC4054 charger IC

The STC4054 charger IC is a linear mode charger which charges the battery at 4.2 V at programmable current level. During constant current charging mode, the charging current is programmed to a value of around 350 mA. This value is selected by connecting a 1% 2.8 kΩ resistor Rprog across the PROG pin. When the battery voltage approaches the charge voltage (4.20 V), the charger enters into a constant voltage charging mode and the charging current decreases. When the current level reaches the end-of-charge level, the battery is almost fully charged, and the charger enters maintenance mode. For more details please refer to the device datasheet.

Table 7. Voltage regulator

Feature	Description
Order code	STC4054GR
Package	TSOT23-5L

7.6 Power MOSFET

There are two MOSFETs under a single 8-pin package. One of these MOSFETs is used to connect the external load to battery and the other one is for the demo board to battery.

Table 8. Power MOSFET

Feature	Description
Sales Type	STS4DPF20L
Package	SO-8

8 Connectors and jumpers

8.1 JTAG connector

Figure 38. JTAG connector

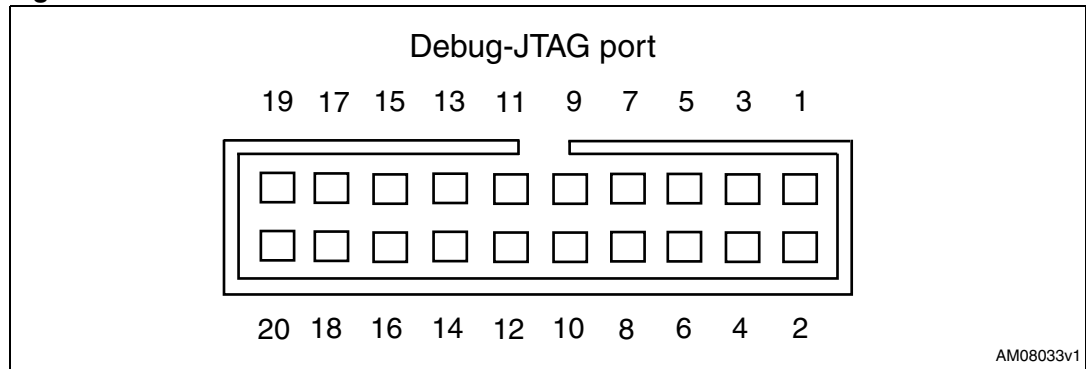


Table 9. Pin description of JTAG

Pin Number	Description	Pin number	Description
1	3.3 V power	2	3.3 V power
3	TRST	4	GND
5	TDI	6	GND
7	TMS	8	GND
9	TCK	10	GND
11	RTCK	12	GND
13	TDO	14	GND
15	nSRST	16	GND
17	DBGRQ	18	GND
19	DBGACK	20	GND

The JTAG connector is available on the board for re-programming the microcontroller and debugging.

8.2 USB connector

The standard USB micro-B type (5-pin) connector is used. An additional 4 connections (pins 6-9 in the schematics) are connected to the body of the connector. The maximum current drawn by the board from the USB host/hub should be less than 500 mA in any condition to respect the USB specifications

Figure 39. Micro-B USB connector



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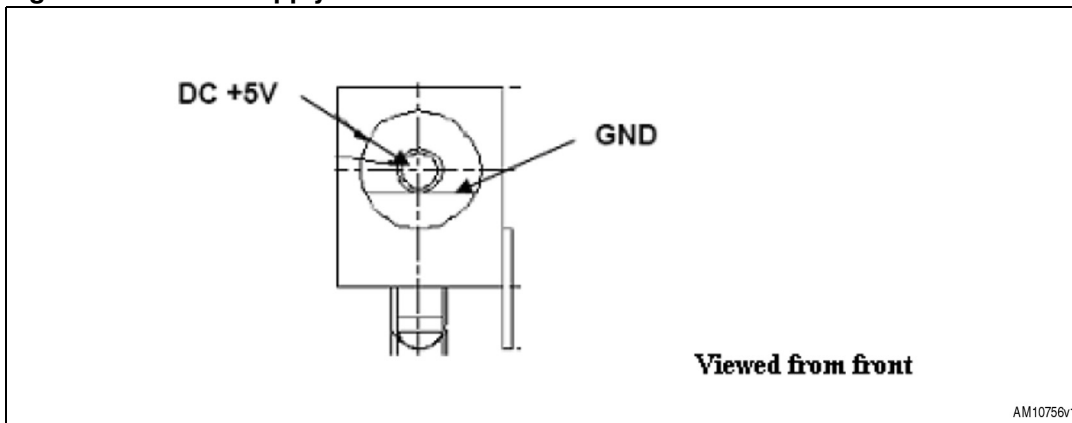
Table 10. USB connector pin description

Pin number	Description
1	VBUS (power): +5 V supply from USB bus
2	DM: USB D- signal
3	DP: USB D+ signal
4	--
5	GND: ground signal
6	SHIELD
7	SHIELD
8	SHIELD
9	SHIELD

8.3 Power supply connector

The adaptor connector is available for connecting an external voltage source. An adaptor of 5 V DC can be used.

Figure 40. Power supply connector



8.4 LCD connector

Table 11. LCD connector pin description

Pin no.	Details
1	GND
2	3.3 V
3	Contrast – connect to 3.3 V through resistor
4	RS
5	GND
6	Enable
7	GND
8	GND
9	GND
10	GND
11	D4
12	D5
13	D6
14	D7
15	3.3 V
16	GND

8.5 Jumper J7

Table 12. ALM pin connection of STC3105

Jumper	Description
1 - 2	Connecting the ALM pin of the STC3104 with onboard MCU STM32
2 - 3	Connecting the ALM pin of the STC3105 with external MCU

8.6 Jumper J10

Table 13. SDA pin for I²C communication

Jumper	Description
1 - 2	Connecting the SDA pin of the STC3105 with onboard MCU STM32
2 - 3	Connecting the SDA pin of the STC3105 with external MCU

8.7 Jumper J11

Table 14. SCL pin for I²C communication

Jumper	Description
1 - 2	Connecting the SCL pin of the STC3105 with onboard MCU STM32
2 - 3	Connecting the SCL pin of the STC3105 with external MCU

8.8 Jumper J9: external MCU connection

Table 15. Pinout for external microcontroller connections

Jumper	Pin function	Description
1	Alarm	Pinout for the ALM pin of the STC3105 for external MCU
2	NC	NC
3	I2C_SDC	Pinout for the SDA line for external MCU
4	I2C_SCL	Pinout for the SCL line for external MCU
5	GND	Pinout for the GND connection for external MCU

8.9 Jumper J3

Table 16. Jumper J3 configuration details

Jumper	Description
1 - 2	Put the jumper in this position before powering up the board when a new battery is connected. This ensures a clearing of the STC3105 RAM resistors.
2 - 3	Put the jumper in this position once the parameters of the battery appear on screen. As shown in Figure 5

This jumper is basically used to ensure that the RAM registers of the STC3105 device are cleared at the time of powering up the board.

8.10 Jumper 15

It is used to connect the load as well as the battery to the board.

Table 17. Jumper J15 configuration details

Jumper	Description
1 - 2	For load connection
2 - 3	For battery connection

8.11 Terminal block J12

Table 18. Terminal block J12 details

Pin	Description
CHG+	Charger positive terminal
CHG-	Charger negative terminal

8.12 Terminal block J14

Table 19. Terminal block J14 details

Pin	Description
B+	Battery positive terminal
B-	Battery negative terminal

8.13 Terminal block J13

Table 20. Terminal block J13 details

Pin	Description
Load+	External load positive terminal
Load-	External load negative terminal

Note: The load is connected to the battery via a MOSFET. Once battery voltage falls below 3.15 V, the MOSFET disconnects load from the battery. This prevents the battery from going into deep discharge.

8.14 Charger selection switch: SW8

This switch is used to select between an internal (onboard) charger and an external charger. Indication is printed on the board.

8.15 External power supply selection switch: SW7

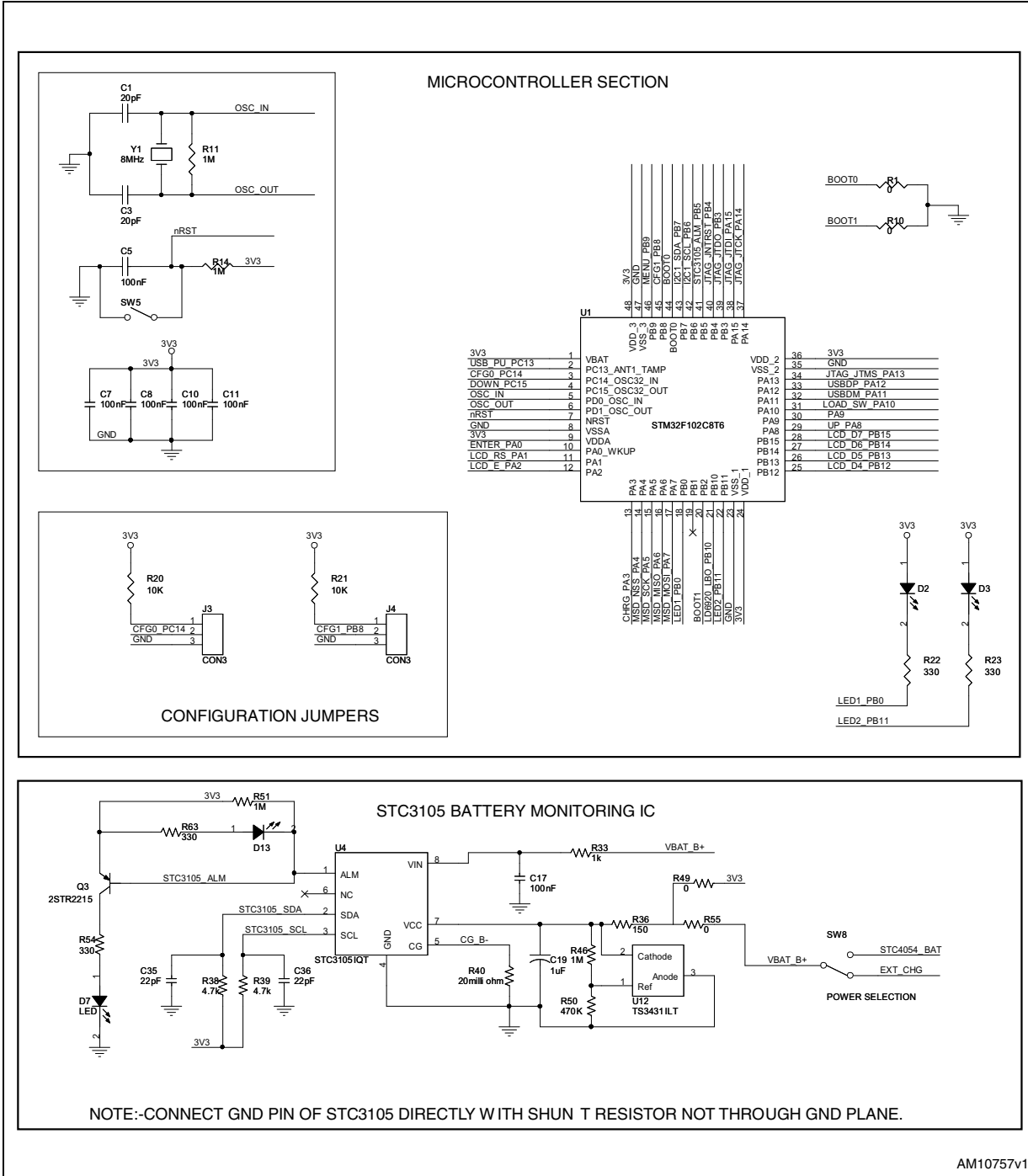
This switch is used to select between the USB and Wall adapter. Indication is printed on the board.

8.16 uSD connector: J8

The provision of an external uSD card to store various battery parameters in the future has been made.

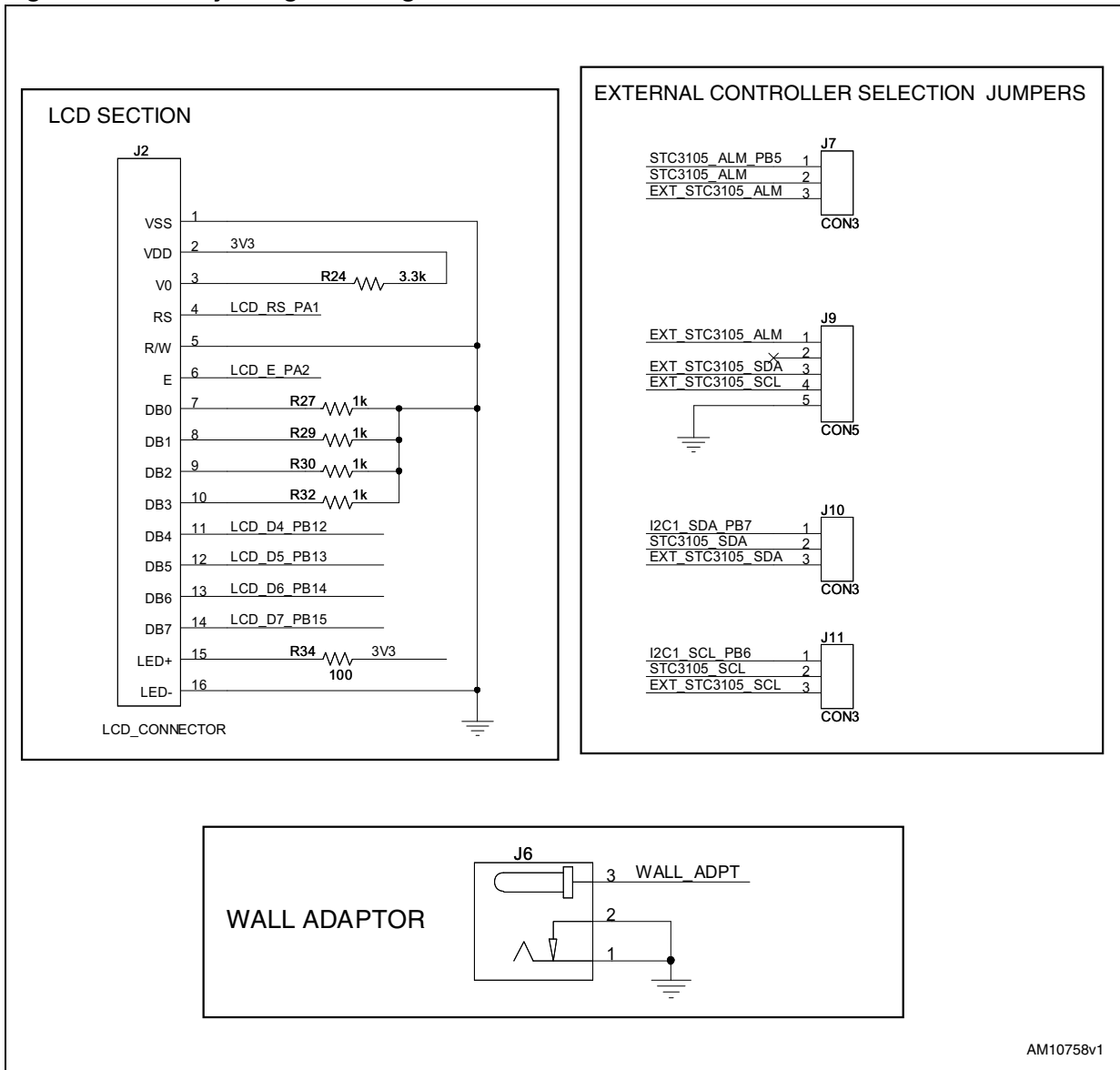
9 Hardware schematic

Figure 41. Microcontroller and battery monitoring section



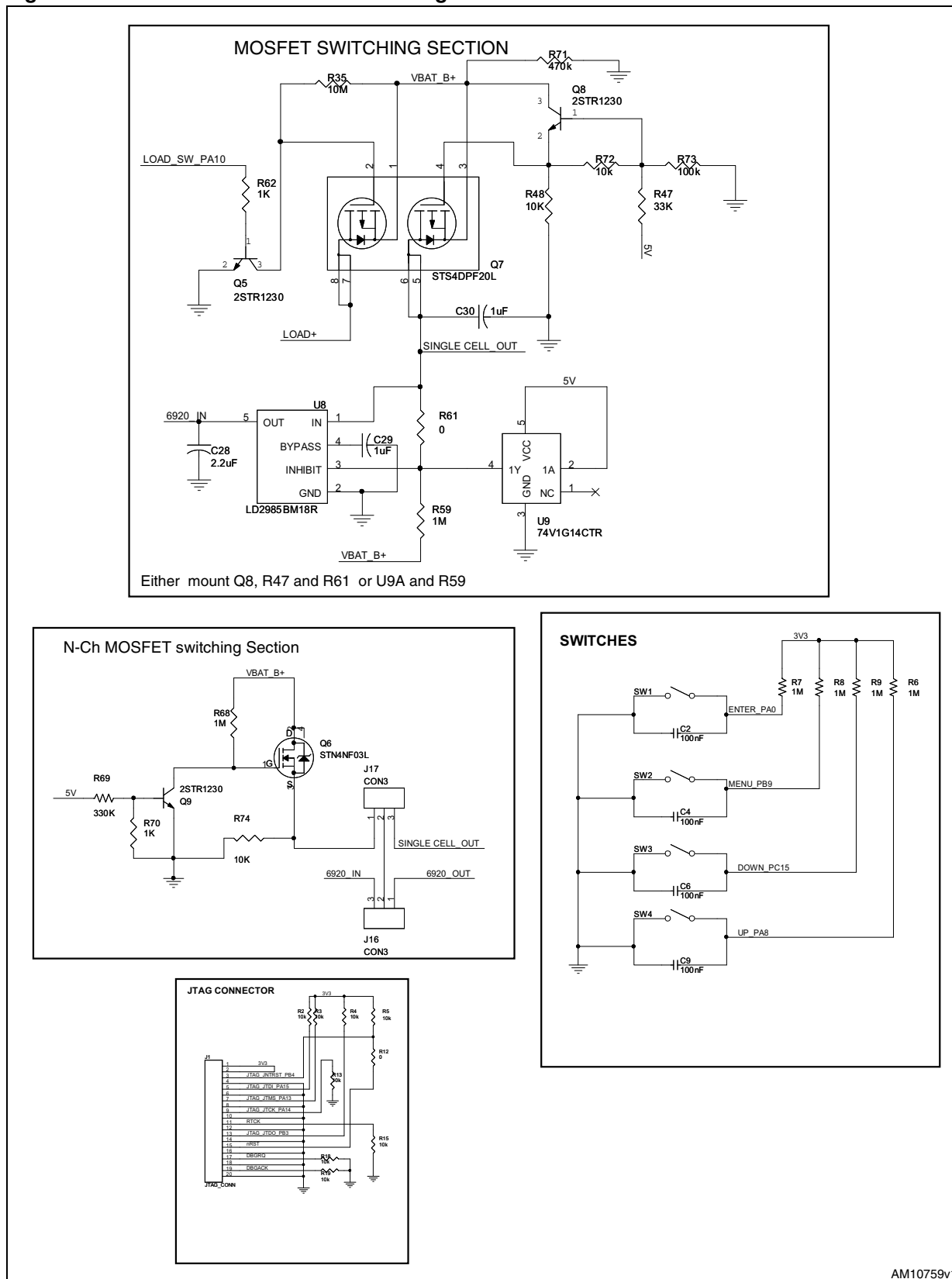
AM10757v1

Figure 42. Battery charger and regulator section



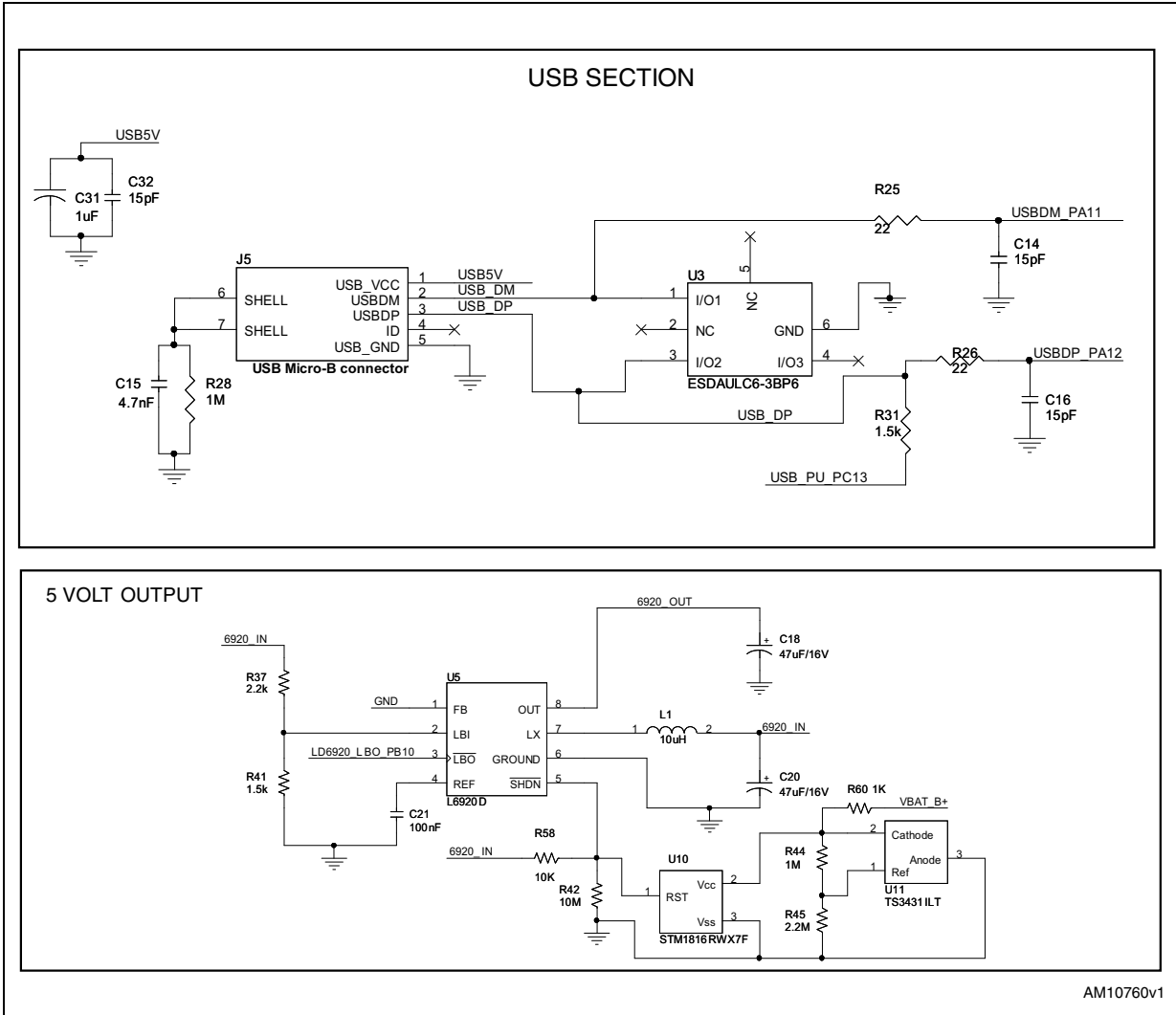
AM10758v1

Figure 43. Switches and MOSFET switching section



AM10759v1

Figure 44. USB and 5 V output section



AM10760v1



10 Bill of material

UM1481

Table 21. Bill of material

Category	Ref. design.	Component description	Package	Manufacturer	Manufacturer's ordering code / orderable part number or equivalent	Supplier	Supplier ordering code
ST devices	U1	STM32 low-density USB access line, 48-pin, 32 K Flash, 6 K RAM	LQFP48	STMicroelectronics	STM32F102C8T6A		
	U10	Reset circuit	SOT23-3 (WX)	STMicroelectronics	STM1816RWX7F		
	U3	ESDAULC6-3BP6 ESD protection for high-speed interface	SOT-666	STMicroelectronics	ESDAULC6-3BP6		
	U4	Battery monitor IC with Coulomb counter/gas-gauge	TDFN 3.0 X 2.0 X 0.75	STMicroelectronics	STC3105IQT		
	U5	Step-up converter	TSSOP8	STMicroelectronics	L6920D		
	U6	800 mA standalone linear Li-Ion battery charger with thermal regulation	TSOT23-5L	STMicroelectronics	STC4054GR		
	U7	Low drop fixed and adjustable positive voltage regulators	SOT-223	STMicroelectronics	LD1117AS33TR		
	D5, D6	STPS1L30U (low drop power Schottky rectifier)	SMB	STMicroelectronics	STPS1L30U		
	Q7	DUAL P-channel 20 V STripFET™ Power MOSFET	SO-8	STMicroelectronics	STS4DPF20L		
	U8	Very low drop and low noise voltage regulator low ESR capacitors compatible, with inhibit function. (1.8 V)	SOT23-5L	STMicroelectronics	LD2985BM18R		

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Bill of material

Table 21. Bill of material (continued)

Category	Ref. design.	Component description	Package	Manufacturer	Manufacturer's ordering code / orderable part number or equivalent	Supplier	Supplier ordering code
ST devices	Q6	N-channel 30 V STripFET™ II power MOSFET	SOT-223	STMicroelectronics	STN4NF03L		
	Q5, Q8, Q9	Low voltage fast-switching NPN power transistor	SOT-23	STMicroelectronics	2STR1230		
	Q3	Low voltage fast-switching PNP power transistor	SOT-23	STMicroelectronics	2STR2215		
	U9	Single Schmitt inverter	SOT323-5L	STMicroelectronics	74V1G14CTR		
	U11, U12	Programmable shunt voltage reference	SOT23-3L	STMicroelectronics	TS3431ILT		
Crystal and oscillator	Y1	Quartz crystal 8 MHz	SMD	ECS Inc	ECS-80-S-5PX-TR	Digi-Key	XC1243CT-ND
Connectors and jumpers	J1	JTAG connector	Box header, right angle, 20-way, 2x10-pin, 2.54 mm x 2.54 mm pitch	Protectron	P9604-20-15-1		
	J6	Power jack 2.5 mm	Socket, DC power, 2.5 mm, right angle, locking type	Protectron	PDCJ01-08	Protectron	PDCJ01-08
	J3, J4, J7, J10, J11, J16 and J17	CON3	1x3 header, 2.54 mm pitch	Any			

**Table 21. Bill of material (continued)**

Category	Ref. design.	Component description	Package	Manufacturer	Manufacturer's ordering code / orderable part number or equivalent	Supplier	Supplier ordering code
Connectors and jumpers	J9	CON5	1x5 header 2.54 mm x 2.54 mm pitch				1
	J12, J13, J14	Header, top entry, 2-way, through hole vertical plug	2-pin through hole vertical plug, 5.08 mm pitch	WEIDMULLER	SL 5.08/2/180	Farnell	Part# 1121826
	J12, J13, J14	Socket block, screw, 2-way, 26-14AWG, pitch spacing: 5.08 mm	Pluggable terminal block, no. of contacts: 2	WEIDMULLER	BL 5.08/2	Farnell	Part# 1131811
	J2	LCD_connector 14022	1x16 header, 2.54 mm pitch	Any			
	J5	USB micro-B connector	SMD	Molex	47589-0001	MOUSER	538-47589-0001
	J15	BATT and LOAD_CONN	Header 4-pin, 1x4 way, 2.54 mm pitch	Any			
	J8	μSD connector	SMD	Proconn Technology	MSPN09-D0-1002		1
Capacitors	C14, C16, C32	15 pF	SMD0805	Any			
	C1, C3	20 pF	SMD0805	Any			
	C15	4.7 nF	SMD0805	Any			


Table 21. Bill of material (continued)

Category	Ref. design.	Component description	Package	Manufacturer	Manufacturer's ordering code / orderable part number or equivalent	Supplier	Supplier ordering code
Capacitors	C2,C4,C5, C6,C7,C8, C9,C10,C11, C17,C21, C22,C33	100 nF	SMD0805	Any			
	C19,C29, C30,C31	1 μ F	SMD0805	Any			
	C35,C36	22 pF	SMD0805	Any			
	C18,C20	47 μ F/16 V	EIA 3216-18/ size B or aluminum electrolytic capacitors - SMD 25 V 47 μ F 20% 5X5.7	Any/Lelon	Any/VZS470M1ETR-0506	Any/Mouser	140-VZS470M1ETR0506
	C23	100 μ F/16 V	Aluminum electrolytic capacitors - leaded 100 μ F 16 V	Panasonic-ECG	ECE-A1CKA101	Mouser	667-ECE-A1CKA101
	C28	2.2 μ F	SMD0805	Any			
	C33,C34	4.7 μ F	SMD0805	Any			
LEDs	D2,D3,D7, D13 (red)	LED	SMD0805	Any			
Inductors	L1	10 μ H	SMD	Coiltronics/Div of Cooper/Bussmann	SD53-100-R	Digi-Key	513-1457-1-ND
Resistors	R1,R10,R12, R49(DNM), R61(DNM),	0	SMD0805	Any			

**Table 21. Bill of material (continued)**

Category	Ref. design.	Component description	Package	Manufacturer	Manufacturer's ordering code / orderable part number or equivalent	Supplier	Supplier ordering code
Resistors	R22, R23, R54, R63	330 Ω	SMD0805	Any			
	R24	3.3 kΩ	SMD0805	Any			
	R2, R3, R4, R5, R13, R15, R18, R19, R58, R72, R74	10 kΩ	SMD0805	Any			
	R25, R26	22 Ω	SMD0805	Any			
	R27, R29, R30, R32, R33, R47, R62, R70, R60	1 kΩ	SMD0805	Any			
	R6, R7, R8, R9, R11, R14, R20, R21, R28, R44, R46, R48, R51, R52, R59, R68	1 MΩ	SMD0805	Any			
	R31, R41	1.5 kΩ	SMD0805	Any			
	R34	100 Ω	SMD0805	Any			
	R36	150 Ω	SMD0805	Any			
	R37, R53	2.2 kΩ	SMD0805	Any			
	R38, R39	4.7 kΩ	SMD0805	Any			
	R40	Resistor, metal strip, 0.02 Ω 0.5% 0.5 W	SMD01206	OHMITE	OHMITE LVK12R020DER	Farnell	Part# 1462292
	R43	2.8k (1%)	SMD0805	Any			
	R35, R42	10 M	SMD0805	Any			

Table 21. Bill of material (continued)

Category	Ref. design.	Component description	Package	Manufacturer	Manufacturer's ordering code / orderable part number or equivalent	Supplier	Supplier ordering code
Resistors	R45	2.2 M Ω	SMD0805	Any			
	R50, R71	470 k Ω	SMD0805	Any			
	R64, 65, 67, R73	100 k Ω	SMD0805	Any			
	R47	33 k Ω	SMD0805	Any			
	R69	330 k Ω	SMD0805	Any			
Switches	SW1, SW2, SW3, SW4, SW5	Pushbutton switch, SMD	Tactile switch, SPNO, SMD. 6 mm x 3.5 mm	MULTICOMP	DTSM-32S-B	Farnell	Part# 9471898
	SW7, SW8	Slide Switch, 2 position, Vertical, Black T/H	Through hole, 3.0 mm pitch	TE connectivity	SLS121PC04	Digi-Key	450-1598-ND
Others		Oriole LCD, 16 x 2 alpha numeric LCD	Modular	Oriole			

11 References

1. STC3105 datasheet
2. STM32 datasheet

12 Abbreviations

Table 22. Abbreviations

Term	Meaning
SOC	Battery state of charge i.e. capacity/charge available in battery
LED	Light emitting diode
LDO	Low dropout regulator
MCU	Microcontroller unit
GUI	Graphical user interface
LCD	Liquid crystal display
mAH	Milli-ampere hour
USB	Universal serial bus
Li-Ion	Lithium Ion
MOSFET	Metal oxide semiconductor field effect transistor
uSD	Micro SD card

13 Revision history

Table 23. Document revision history

Date	Revision	Changes
07-Aug-2012	1	Initial release.

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