Introduction

The present document describes the graphical user interface (GUI) that allows the initialization and control of the EVAL-L9963-MCU evaluation board by changing parameters through the SPI protocol. The STSW-L9963 GUI has been developed using Labview and it uses, as microcontroller interface, the on board microcontroller SPC574S64E3 with preloaded FW.

Hardware connection

The STSW-L9963 GUI is intended to be used with the EVAL-L9963-MCU for system with up to 14 Li-Ion cells. In case more cells need to be controlled it’s necessary to add the EVAL-L9963-NDS expansion board to control more cells. Up to 14 EVAL-L9963-NDS, for a grand total of 15 board with EVAL_L9963-MCU, can be added to the system and controlled by the STSW-L9963 GUI.
1 Preliminary actions

Before running the STSW-L9963 GUI on your PC some third part SW packages has to be installed:

- NI Labview-runtime 2014
- NI VISA-RUNTIME
- FTDI driver
  - Before using the UART/USB bridge FT2232H on the EVAL-L9963-MCU, the Virtual Com Port (VCP) driver needs to be installed. It can be downloaded by the FTDIChip website.

When all the above packages have been installed reboot your PC.
2 GUI description

When the setup is finished, the user needs to check whether all the hardware connections are correct (see EVAL-L9963-MCU user manual for further information) and run GUI clicking on: STSW-L9963.exe

Figure 3. Main GUI interface

There are 4 areas in the GUI which are: battery and diagnostic information, configuration and diagnostics Tabs and general operation buttons such as “COM selection”, “save”, “load” configurations, and “diagnostic” as well as “data logger enable” etc.

2.1 Voltage, current and temperature indicators

Figure 4. Voltage, current and temperature indicators

With reference to Figure 4. Voltage, current and temperature indicators, in the main GUI interface we have the following gauge indicators:
1. Cell voltage indicators
2. Temperature sensor indicators
3. Total battery voltage indicator
4. VTREF measurement indicator
Each indicator has the following structure:

**Figure 5. Gauge indicator structure**

![Gauge indicator structure](image)

The indicator shows the voltage measured by ADC and converted in volt, the EN flag that allows the user to enable the channel, a LED on the left indicating the under-voltage condition and a LED on the right indicating the over voltage condition. Under and over voltage threshold can be configured in the “configuration tab” described below in this manual.

**Figure 6. Chart option**

![Chart option](image)

Selecting the check box “Chart” all the gauges will be converted in chart graphics with the plot of the history of the value versus time.

### 2.1.1 IC temperature

The chip temperature is available in the indicator of Figure 7. IC temperature indicator:

**Figure 7. IC temperature indicator**

![IC temperature indicator](image)

The chip temperature and the possible over temperature are calculated from the SPI register of L9963.
2.1.2 Configurable GPIO voltage values

In the indicator of Figure 8, GPIO voltage and under-voltage, over-voltage condition are represented the voltage values and the over-voltage and under-voltage (LED) of the configurable GPIO. The GPIO configurations and limits are selectable in the “configuration tab” described below in this manual.

![Figure 8. GPIO voltage and under-voltage, over-voltage condition](image)

2.1.3 Coulomb counter

The GUI allows to use the Coulomb counting capability of the L9963. The Coulomb counter can be enabled in the “configuration tab” described below in this manual.

![Figure 9. Coulomb counter](image)

In the Coulomb counter section, the user can select the shunt resistor in mΩ and visualize the Instantaneous current value synchronized with voltage measurements, the instantaneous current value calibrated, the time base, the accumulator value (A) and the calculated accumulator capability in (Ah). Three LEDs represent the available diagnostics: open of positive or negative sense resistor lead and the Coulomb counter accumulator overflow. With the RST button the Coulomb counter accumulator can be reset.

2.1.4 Manual balancing

The GUI allows the user to select, using the checkbox, the cell to discharge using the manual balancing capability of the L9963. The discharge will be activated till the check box is selected or till the maximum balancing time is reached (see the L9963 datasheet) or the undervoltage of the cell is reached. For further information please check the L9963 datasheet.

![Figure 10. Manual cell balancing checkbox](image)
2.2 Devices ID configuration

The STSW-L9963 allows the use of a single EVAL-L9963-MCU board or a chained system composed by an EVAL-L9963-MCU and up to 14 EVAL-L9963-NDS connected using the vertical isolated interface (please see Figure 1. EVAL-L9963-NDS connection schemes). For each device in the system is necessary to define a unique ID in order to be addressed and configured. The first operation to start working with the L9963 is to configure the device ID. The section represented in Figure 11. ID configuration section allows the user to configure the devices IDs.

In the ID text box, the user has to write the ID of devices present in the system, up to 15 devices can be configured (1x EVAL-L9963-MCU and up to 14x EVAL-L9963-NDS). In case of single device (only EVAL-L9963-MCU) only “1” has to be written in the box Figure 12. Single board configuration).

Once the ID has been correctly written in the box, the user has to press “Configure IDs” button in order to configure the devices with the procedure described in L9963 DS. If the connection is correct the ACK LED will be green, otherwise will turn red. The user can clear all the IDs pressing on “Clear IDs” button, if the IDs are correctly cleared the ACK LED will be green, otherwise it will turn red.

2.3 GUI communication time interval configuration

STSW-L9963 allows to configure the time interval communication with the onboard microcontroller: There are 6 options:
80 ms, 100 ms, 200 ms, 300 ms, 400 ms, 500 ms.
When the desired time interval has been chosen, to let it become operative, the user must click on “Time interval button”. If the operation has been correctly accomplished the ACK LED will be green, otherwise it will turn red. The time interval will impact on the refresh rate of the whole GUI and on the time scale of voltage charts.

2.4 Automatic device configuration

With the automatic device configuration feature, the user can configure multiple devices with a saved configuration.

The user can try different device configurations, when he found the preferred one, he can save it using the “Save configuration” button. If in a second time he wants to reuse the same configuration, he can reload it using the “Load configuration” button and apply it to the device selected by the “Dev ID display” dropdown menu and pressing the “Configure device” button; if the operation has been correctly accomplished the ACK LED will be green, otherwise it will turn red. It is necessary to pay attention to the fact that the configuration will be applied only to the selected device.

2.5 Firmware version

The EVAL-L9963-MCU board comes with a preloaded FW in the microcontroller flash memory. Using the button in Figure 15. Firmware version check, the user is informed on which version is loaded on the microcontroller. This feature helps to debug the correct communication between PC and microcontroller and allows to check the correct FW download on the EVAL-L9963-MCU.
Clicking on the “Get Firmware version” if the board is correctly connected via USB cable to the PC, all the driver has been correctly installed, and the microcontroller is correctly working, the user can get the preloaded firmware version. The correct value is version 1.5 as in Figure 15. Firmware version check.

2.6 Data logger

The STSW-L9963 GUI allows to log the measurement on a text file in order to be post elaborated.

![Image of the STSW-L9963 GUI]

**Figure 16. Data logging procedure**

In order to enable the datalogging feature, the following procedure has to be followed:

- Configure the device ID
- Configure the device register as described below in this manual
- Enable the cell voltage to be logged clicking on the EN box of the gauges
- Click on the “Single write/read” button to send the configuration to the L9963
- Select the “Data logger” check box and finally select the “Diagnostic” check box in order to enable the cyclic measurement in the GUI.

When the user decides to stop the data logging, the “Diagnostic” check box has to be unselect. A text file will be generated in the data directory where the GUI is located. The file will be named with date and time of acquisition.
The generated file is a text file with equally spaced values that can be easily imported in Excel or other data analysis tools.

The file structure is described in Figure 18. Data log file organization. Each line is acquired with the timing defined in GUI communication time interval configuration (Section 2.3 GUI communication time interval configuration).

**Figure 17. Data logging file location and name**

**Figure 18. Data log file organization**
2.7 Transceiver selection

On the EVAL-L9963-MCU two transceivers L9963T are present. In Figure 19. EVAL-L9963-MCU transceiver schematization there is a schematization of the transceiver connection.

Under normal functioning condition, the microcontroller communicates with onboard L9963 thanks to the L9963T marked as U16. Checking the "SWAP" checkbox (see Figure 20. Transceiver SWAP checkbox) the communication is swapped from U16 to U18 allowing the microcontroller to communicate with a remote L9963 (i.e. an EVAL-L9963-NDS) connected on ISOPORT2.

Checking the box if the operation has been correctly accomplished the ACK LED it will be green, otherwise it will turn red.

2.8 COM port communication

The STSW-L9963 GUI communicates with the onboard microcontroller on the EVAL-L9963-MCU through a virtual COM port over USB. In order to correctly establish the communication between GUI and EVAL-L9963-MCU it’s necessary to correctly select the COM port on which the board is connected.
Using the I/O dropdown menu the user can select the COM port on which the board is connected. If the communication is correctly established the COM LED and the ACK LED will be green, if something goes wrong, they will turn red. With the “Reset COM port” button it’s possible to reset the COM port and reinitialize the microcontroller.

In order to double check if the communication between GUI and microcontroller is correctly established, the user can use the procedure described in Section 2.5 Firmware version to check the actual firmware version loaded on the microcontroller.

2.9 Diagnostic activation

The STSW-L9963 allows to activate the diagnostic and measurement function once or in continuous mode.

![Figure 22. Diagnosis activation](image)

The user can activate the single measurement and diagnostic reading pressing on the “Diagnostic once” button. Once pressed all the measurement will be updated and the diagnostics in the diagnostic tabs (see below in this document for description) will be updated. Checking the “Diagnostic” check box a cyclic update of measure and diagnostic will be accomplished by the GUI with the time base set in “Time interval configuration” (see Section 2.3 GUI communication time interval configuration).

2.10 Stop the GUI

Using the “STOP” button in Figure 22. Diagnosis activation, the user can stop the GUI that will be also closed.
2.11 L9963 register management

The STSW-L9963 GUI allows the user to directly manage L9963 registers bitwise or using the graphical tools present in the GUI.

![Bitwise control of L9963 registers](image)

The bitwise register control can be done using the tools represented in Figure 24. An example of automatic register configuration. The user can choose the register of L9963 he wants to read or write using the "Configuration registers" dropdown menu. With the "Write/read" dropdown menu, one can decide to write or read the specific register. The bitwise configuration can be done clicking directly on the bit name fields, the value will toggle once clicked and the final Hex value of the register can be read in "mosi" textbox. In order to correctly address the device, especially in a distributed configuration, the user has to choose the correct device ID on which to send the command. This choice can be done using the "Dev ID" dropdown menu. The menu is populated according to the device ID configuration (see Section 2.2 Devices ID configuration). The value ‘0’ means a broadcast command sent to all the chain of distributed devices. Clicking on the “Single write/read” button the user can send the MOSI and can read the MISO that will be written in Hex format in the “miso” textbox and decoded in the rightmost column of the bitwise description.

Some registers can be configured graphically thanks to the GUI features. In the following figure you can see an example referring to the cell voltage measurement enabling.
In Figure 24. An example of automatic register configuration, the user has enabled the CELL 1, CELL 4 and CELL 14 voltage measurement by flagging the “EN” checkbox in the corresponding voltage gauge. The VCELLS_EN register is updated accordingly. In order to let the configuration become operative the user has to define the Device ID to which he wants to apply the configuration and then click on the “Single write/read” button.

**ATTENTION:** for all the configuration made in the GUI using the graphical tool, in order to apply the configuration, the user has to always follow these steps:

1. Select the configuration by graphical tools.
2. Define the Device ID to which apply the configuration using the “Dev ID” dropdown menu.
3. Click on “Single write/read” button to send the configuration.
3 Configuration, PCB open wire diagnostic and seep mode tab

In this section, the L9963 configuration, PCB open wire diagnostic and seep mode tab will be covered.

3.1 GPIO thresholds configuration

In this section of the GUI it’s possible to graphically configure the GPIO3 to GPIO9 over-voltage and under-voltage thresholds.

![GPIOs thresholds configuration](image)

The thresholds are expressed in Volts and the GUI will perform the due calculation to configure the corresponding L9963 SPI registers GPIOx_THR (for further information please check L9963 datasheet). To let the configuration be operative the user must follow the procedure described at the end of Section 2.11 L9963 register management.

3.2 Cells and battery thresholds configuration

In this section of the GUI it’s possible to graphically configure the cells over-voltage and under-voltage thresholds (L9963 register VCELL_THRESH_UV_OV), the whole battery, in terms of sum of selected cells, thresholds (L9963 register VBAT_SUM_TH) (for further information please check L9963 datasheet). To let the configuration be operative the user must follow the procedure described at the end of Section 2.11 L9963 register management.

![Cells and battery thresholds configuration](image)
3.3 Current thresholds configuration

In this section of the GUI it’s possible to graphically configure the over-current threshold in normal mode (L9963 register CSA_THRESH_NORM) and in sleep mode (L9963 register CSA_GPIO_MSK) (for further information please check L9963 datasheet). To let the configuration be operative the user must follow the procedure described at the end of Section 2.11 L9963 register management.

![Current thresholds configuration](GADG270520200954SA)

3.4 ADC SOC filter configuration

In this section of the GUI it’s possible to graphically configure the ADC SOC filter configuration (L9963 register ADCV_CONV): the filter (average on a number of measurements) to be applied when SOC routine is run (for further information please check the L9963 datasheet). Please note that this parameter has an impact on the cell voltage conversion time. To let the configuration be operative the user must follow the procedure described at the end of Section 2.11 L9963 register management.

![ADC SOC filter configuration](GADG270520200955SA)

3.5 Ratiometric GPIO measurement

In this section of the GUI it’s possible to graphically activate by checkboxes GPIO ratiometric conversion in respect VTREF_MEAS (L9963 SPI register GPIOx_MEAS field ratio_abs_x_sel) (for further information please check the L9963 datasheet). To let the configuration be operative the user must follow the procedure described at the end of Section 2.11 L9963 register management.

![Ratiometric GPIO measurement checkboxes](GADG270520200956SA)
3.6 ADC voltage conversion configuration

In this section of the GUI it’s possible to graphically configure the different fields of L9963 ADCV_CONV register that is used to configure ADC voltage conversion, for further information please check L9963 datasheet. To let the configuration be operative the user must follow the procedure described at the end of Section 2.11 L9963 register management.

![Figure 30. ADCV_CONV L9963 register graphical checkboxes](image)

The user may use these checkboxes to manually start a one-shot conversion. It’s not necessary to configure these checkboxes during cyclic conversion.

3.7 Coulomb counter enabling

In this section of the GUI it’s possible to graphically activate the Coulomb counter routine controlling the CoulombCounter_en bit of L9963 SPI register CSA_GPIO_MASK (for further information please check the L9963 datasheet). To let the configuration be operative the user must follow the procedure described at the end of Section 2.11 L9963 register management. Activating this checkbox, the Coulomb counter section of the GUI, described in Section 3.7 Coulomb counter enabling of this user manual, becomes operative.

![Figure 31. Coulomb counter enabling checkbox](image)

3.8 L9963 communication timeout disabling

The L9963 has a function, called communication timeout, that monitors the communication between the L9963 and MC. In case the communication with MCU is missing for certain time, defined in L9963 datasheet, the L9963 will go in sleep mode. In this section of the GUI it’s possible to graphically disable the communication timeout controlling the comm_timeout_dis bit of L9963 SPI register Bal_1 (for further information please check the L9963 datasheet). To let the configuration be operative the user must follow the procedure described at the end of Section 2.11 L9963 register management.

![Figure 32. L9963 Communication timeout disabling checkbox](image)
3.9 PCB open wire diagnostic

This section of the GUI implements the procedure that allows to detect loss of cell wire at PCB connector. The detailed procedure is described in L9963 datasheet.

![Figure 33. PCB open wire diagnostic](image)

By clicking on the “PCB open wire” button, the user will start the procedure for the loss of cell wire at PCB connector detection. When the button is pressed, if the operation has been correctly accomplished the ACK LED will be green, otherwise it will turn red. In case an open wire is detected on a cell, the corresponding LED will turn red, otherwise it will be green.

3.10 Cyclic wake up and sleep mode operation

The L9963 has the possibility of executing cyclic wake up measurements. In this section of the GUI is possible to configure all the related registers.

![Figure 34. Cyclic wake up and sleep mode operation](image)

Using the checkboxes and cursors it is possible to configure the fields of the L9963 registers related to the cyclic wake up measurement: ADCV_CONV, NCYCLE_PROG_1, NCYCLE_PROG_2 on (for further information please check L9963 datasheet). The user can configure the parameters and then click on “Enter sleep mode” button to send the “enter the sleep mode” set of command to the L9963. When the button is pressed, if the operation has been correctly accomplished the ACK LED will be green, otherwise it will turn red. If the L9963 is in sleep mode, the LED D13 on EVAL_L9963_MCU board will turn OFF.
4 Diagnostic information tab

The STSW-L9963 GUI allows the user to check the diagnostic of the L9963. The diagnostic-information tab is divided in two parts: one fixed with some synthetic information on cells status and another composed by five sub-tabs.

4.1 Synthetic cells information

The downmost part of diagnostic information tab is a table that synthetizes some information on cells voltage. This part of the GUI, as all the diagnostic related parts of the GUI, is operative when the user presses the "Diagnostic once" button or checks the continuous diagnostic check box (please Section 2.9 Diagnostic activation).

In Figure 36. Synthetic cell voltage information is reported the table that contains the following information:

- The maximum cell voltage value registered among all the cells in the measurement cycle and the cell index in which it’s measured
- The minimum cell voltage value registered among all the cells in the measurement cycle and the cell index in which it’s measured
- The maximum voltage value registered on the single cell in the measurement cycle (orange row)
- The minimum voltage value registered on the single cell in the measurement cycle (cyan row)
4.2 General diagnostic tab

In this tab are reported the status of the general diagnostics of the L9963. Each LED represents a bit field of the L9963 diagnostic registers related to general the L9963 status (for further details please check the L9963 datasheet).

Figure 37. General diagnostic sub tab

4.3 Cell diagnostic tab

In this tab are reported the status of the diagnostics of the L9963 related to cells status. Each LED represents a bit field of the L9963 diagnostic registers related to cells status. The Tab is divided in:

- Cell open diagnostics
- Cell balancing under voltage
- Balancing resistor/MOSFET open load
- Balancing resistor/MOSFET short diagnostic

For further details please check the L9963 datasheet.

Figure 38. Cells diagnostic sub tab
4.4 BIST results tab

In this tab are reported the results of the BIST operations of the L9963. Each LED represents a bit field of the L9963 diagnostic registers related to BIST. The tab is divided in:

- Open BIST
- Mux BIST
- BIST related to balancing comparator
- BIST related to GPIO
- The BIST related to the internal regulators’ comparators

For further details please check the L9963 datasheet.

Figure 39. BIST results sub tab

4.5 GPIO diagnostics tab

In this tab are reported the status of the diagnostics of the L9963 related to GPIO status. Each LED represents a bit field of the L9963 diagnostic registers related to GPIO (for further details please check the L9963 datasheet).

Figure 40. GPIO diagnostics sub tab
4.6 Histogram tab

In this tab it’s possible to represent the cells and GPIOs voltage value in an histogram representation.

**Figure 41. Cells and GPIO voltages histogram representation**

The user can select the voltage to represent in the chart selecting it in the bottom-right selector box. It’s possible to represent all the measured cells voltage values and GPIO voltage values. In order to start the measurement, the user has to select the checkbox “Histogram on”. In the upper-right the progressive number of measures are registered in the textbox marked with “#”. Minimum value, maximum value and average are registered.
In this tab are represented with LED all the fields of raw upstream data from burst commands (0x78, 0x7A, 0x7B)'s feedback. For further information please check the L9963 datasheet.

Figure 42. Raw upstream data of burst commands 0x78 and 0x7A (frames 1 and 2)

Figure 43. Raw upstream data of burst command 0x7A (frames 3 to 8)
Figure 44. Raw upstream data of burst command 0x7A (frames 9 to 13)

Figure 45. Raw upstream data of burst command 0x7B
In this section an example of GUI usage will be described.

### 6.1 HW settings

In order to follow this example, you will need the following HW settings:

- EVAL-L9963-MCU
- USB cable
- Power supply:
  - At least 3 output 0 – 30 V (if possible 60 V):
    - 1 output to power L9963 (0:60 V)
    - 1 output to simulate cells common mode voltage (0:60 V)
    - 1 output to simulate cell voltage (0:5 V)

![Figure 46. HW setup](image)

In order to simulate some cells with power supply, it is necessary to follow the setup as per Figure 46. HW setup. For further setup of the EVAL-L9963-MCU, please check the EVAL-L9963-MCU user manual.

### 6.2 GUI connection setup

In order to connect the STSW-L9963 GUI on your PC to the EVAL-L9963-MCU you have to follow these steps:

1. Select the COM port according to your device manager. The COM led will become green.
2. Press on the “get firmware version” button to check the communication with μC and the firmware version. The version should be 1.5.
3. In the “ID assignment” text box, it is necessary to write 1 because you are using one L9963 then press “Configure IDs Button”, the ACK LED will become green. If the D13 LED on the board was switched OFF it will be switched ON and will not switch OFF anymore.
6.3 Thresholds configuration

In order to correctly configure the cells voltage thresholds, the user have to follow these steps:
1. Go to configuration tab.
2. Select Cell overvoltage and undervoltage. i.e. UV 2.8 V and OV 4.250 V.
3. The VCELL_THRESH_UV_OV register will be automatically updated.
4. Select dev ID 1.
5. Select Write.
6. Press on the “Single write/read” button.
7. If communication with the L9963 is ok the ACK LED will become green.
For battery thresholds please follow these steps:
1. Select Battery overvoltage and undervoltage, i.e. UV 39.2 V and OV 59.5 V.
2. The VBAT_SUM_TH register will be automatically updated.
4. Select Write.
5. Press on the “Single write/read” button.
6. If communication with the L9963 is ok the ACK LED will become green.

![Battery voltage thresholds configuration](image)

**Figure 49. Battery voltage thresholds configuration**

6.4 **Measure enabling**

In order to enable the measurement, the user should follow these steps:
1. Select cell voltage gauge with the EN check box. At least cells 1,2,13,14 must be selected.
2. The VCELLS_EN register will be automatically updated.
3. Select dev ID 1.
4. Select write.
5. Press on the “Single write/read” button.
6. If communication with the L9963 it’s ok the ACK LED will become green.
6.5 Measurement starting

In order to start measurement, the user should follow these steps:
1. Select time interval, i.e. 100 ms. This is the refresh rate of GUI measurement.
2. Press on the “Time interval” button to apply setting. The ACK LED will became green.
3. Check the diagnostic checkbox to start the measurement.
If all the setup are correctly done the user should see the results as in Figure 52. Expected results.

**Figure 52. Expected results**

- **Cell2 voltage=3.3V**
- **Common mode on Cell1=3.6V**
- **Floating voltage**
- **Active Cell voltages sum = 3.61838V+3.36233V+0+0.47250V=7.45322V**

At this point the user can explore other tabs, in example, the diagnostics, described in the above paragraphs.
Revision history

Table 1. Document revision history

<table>
<thead>
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<th>Date</th>
<th>Revision</th>
<th>Changes</th>
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<tr>
<td>15-Jun-2020</td>
<td>1</td>
<td>Initial release.</td>
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