

## STEVAL-ISB005V1/ STEVAL-ISB007V1, USB Li-Ion battery charger

### Introduction

This user manual describes the USB Li-Ion battery charger board. The board has the following devices:

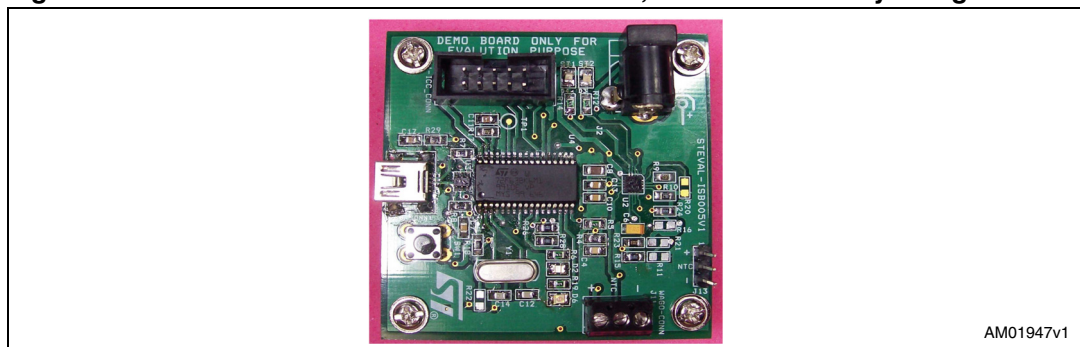
- The L6924D battery charging device (in the case of STEVAL-ISB005V1)/ and the L6924U (in the case of STEVAL-ISB007V1)
- USBLC6-2SC6 ESD protection device
- ST72F63BK6M1 microcontroller
- Reset circuit (optional: STM1001MWX6F).

The L6924 is a standalone Li-Ion/ Li-polymer battery charger. The board can be powered up by a USB or the external DC adaptor. The microcontroller is used for enumeration with the PC and to control the SD pin with respect to the USB high-power bus-powered function specifications. In USB mode, the charging current of the battery complies with the high-power USB device specifications and the L6924 power is supplied by USB 5 V, therefore charging the battery from the USB. A general purpose adaptor socket is also available for use when external power is available. In this case, the L6924 is completely independent of the microcontroller, for more details refer to [Section 5](#). For the L6924U some special settings are to be made, please see [Section 5](#).

The Li-Ion / Li-polymer battery charger device can be used in the following applications:

- Standalone chargers: already implemented in the STEVAL-ISB005V1 and STEVAL-ISB007V1 board. An explanation is given in this document
- USB-powered chargers: already implemented in the STEVAL-ISB005V1 and STEVAL-ISB007V1 board. An explanation is given in this document
- PDAs
- Handheld devices
- Cellular phones
- Digital cameras.

**Figure 1. STEVAL-ISB005V1/ STEVAL-ISB007V1, USB Li-Ion battery charger**



*Note:* The layout is the same for both STEVAL-ISB005V1 and STEVAL-ISB007V1

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# 1 Getting started

## 1.1 Package

The STEVAL-ISB005V1 and STEVAL-ISB007V1 demonstration board package includes the following items:

- Hardware content
  - Demonstration board
- Documentation
  - User manual
- Microcontroller firmware
  - Pre-programmed ST72F63BK6 device soldered onto the demonstration board
  - The source code is also available for the firmware.

## 1.2 Setting up the board

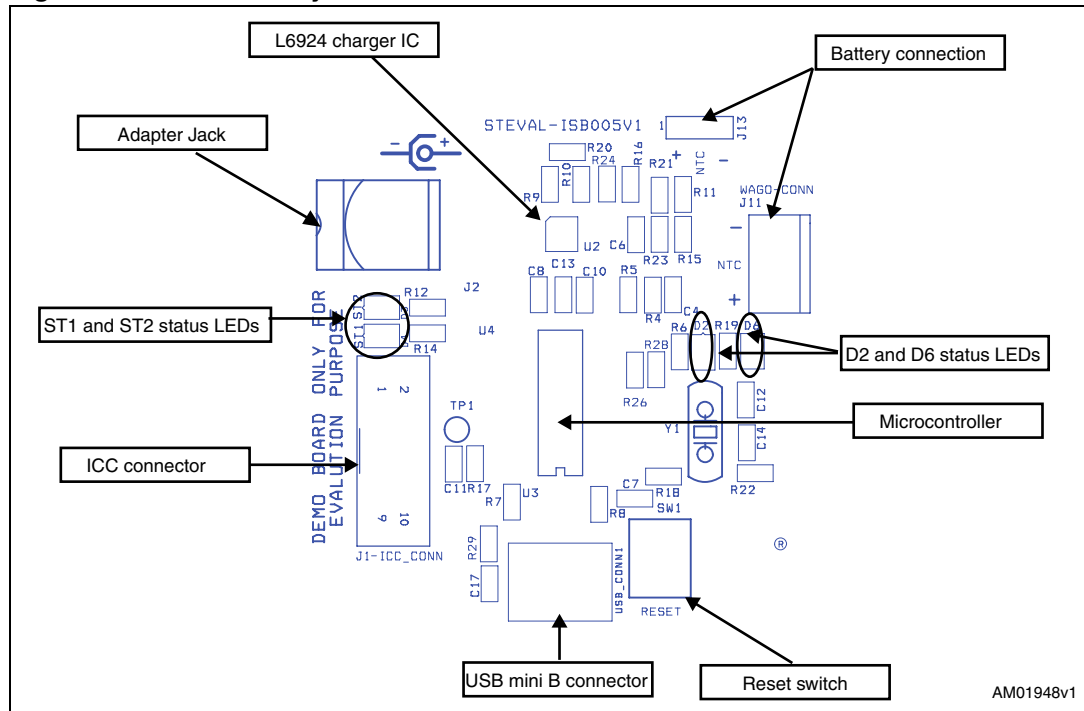
The USB Li-Ion battery charger can be set up as follows.

- Connect the Li-Ion / Li-polymer battery pack to the board with appropriate polarity
- Connect either the adapter or USB cable to the board. If both voltage sources are connected, the battery charging current is drawn from both inputs
- Check the status of the ST1 and ST2 LEDs. These LEDs indicate the status of battery connected to the device. For more details refer to status monitoring ([Section 3.1.7](#)).

## 1.3 Hardware layout

The hardware layout of the PCB is shown in [Figure 2](#), which shows all the components mounted on the board.

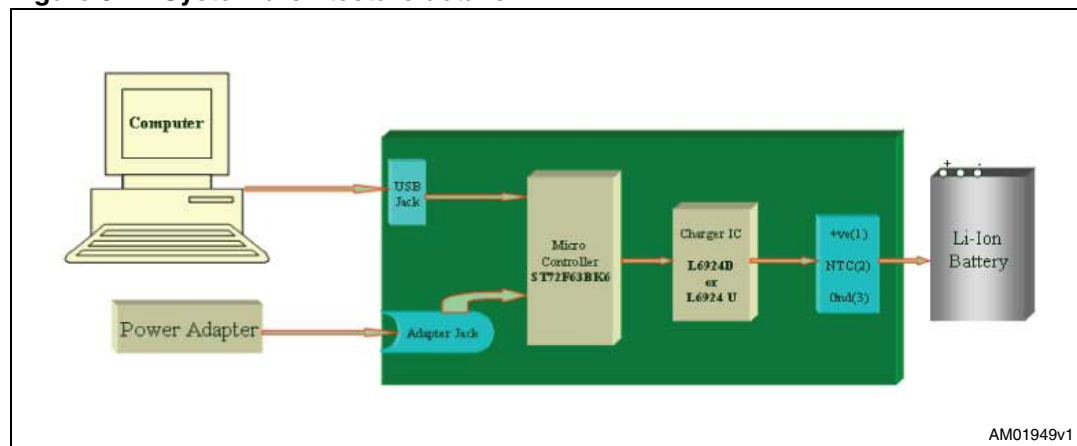
Figure 2. Hardware layout details



## 2 System overview

### 2.1 General description of product architecture

Figure 3. System architecture details



### 2.2 System architecture description

- The application works as a Li-Ion / Li-polymer battery charger
- The system can be used both in USB mode and adapter mode
- The system consists of a battery charger section for Li-Ion / Li-polymer batteries and a microcontroller section for controlling actions
- The LEDs available on the board indicate the status of the charging conditions
- An ICC connector is available to program the microcontroller.



## 3 Design details

### 3.1 L6924D/L6924U for battery charging

The L6924 is a battery charger with integrated power switch for Li-Ion/Li-polymer batteries.

**Table 1. L6924D details**

Feature	Description
Sales type	L6924D
Package	VFQFPN16 (3 mm x 3 mm)
Operating voltage	2.5 V to 12 V

**Table 2. L6924U details**

Feature	Description
Sales type	L6924U
Package	VFQFPN16 (3 mm x 3 mm)
Operating voltage	2.5 V to 12 V

The L6924 is used in linear operation mode.

#### 3.1.1 Fast-charge current (USB current)

Refer to the L6924D datasheet; *Programmable Li-ION battery charger system for portable applications*.

When the battery voltage reaches the pre-charge voltage threshold ( $V_{PRETH}$ ), the L6924D starts the fast-charge phase. In this phase, the device charges the battery with a constant current,  $I_{CHG}$ , programmable through an external resistor.

- $R_{PRG} = V_{BG} * (K_{PRG} / I_{CHG})$
- $K_{PRG}$  is a constant equal to 9500
- $V_{BG}$  is the internal reference equal to 1.23 V

Calculation for the demonstration board is as follows:

To respect the USB high power specifications, the total current taken from the USB connector can be a maximum of 500 mA. Designating 100 mA to the microcontroller and other circuitry (to comply with USB power specifications), 400 mA can be used for the battery charging circuit.

The maximum value of  $I_{CHG}$  is taken as 380 mA. (Reserving 20 mA as a safety margin).

#### Equation 1

$$R_{PRG} = 1.23 \cdot \frac{9500}{380} = 30.75 \text{ k}$$

A standard value of 30 k is chosen for defining the  $I_{CHG}$ , which in this case can draw a maximum value of 390 mA current.

Refer to the L6924U datasheet; *USB compatible battery charger system with integrated power switch for Li-Ion/Li-Polymer*.

For the 6924U device, the  $R_{PRG}$  decides the maximum current taken from the USB ( $I_{USB}$ )

### 3.1.2 Pre-charge current calculation (adaptor current)

Refer to the L6924D datasheet.

The 6924 supports the following configurations for pre-charge current calculations

$I_{PRE}$  is un-connected: The pre-charge current has a value of 10 % of the fast-charge current

$I_{PRE}$  is connected to GND through a resistor: the pre-charge current is higher than the default value

$I_{PRE}$  is connected to  $V_{REF}$  through a resistor: the pre-charge current is lower than the default value.

#### Equation 2

$$R_{PRE} = \frac{V_{BG}}{\frac{I_{PRECH}}{K_{PRE}} - \frac{V_{BG}}{R_{PRG}}}$$

For the 6924D,  $K_{PRE}$  is constant and is equal to 950.

On the STEVAL-ISB005V1 demonstration board, the  $R_{PRE}$  is left un-connected to use the 10 % default value.

Refer to L6924U datasheet.

$I_{PRE}$  is replaced by the  $I_{AC}$  pin. For the 6924U device,  $R_{AC}$  is connected to this pin to determine the adaptor current (up to 1 A).

$R_{AC}$  is calculated from:

- $R_{AC} = (V_{BG} / I_{AC}) * K_{prg}$
- $V_{BG}$  = internal threshold voltage (1.23 V)
- $K_{PRG} = 9500$  (constant)

$R_{AC} = 14 \text{ k}\Omega$  (considered  $I_{AC}$  is 835 mA).

To select the desired configurations please see [Section 5: Changes between L6924D and L6924U](#).

### 3.1.3 Pre-charge voltage

Refer to the L6924D datasheet.

For the 6924D device, the following configurations are supported for pre-charge voltage.

The  $V_{PRE}$  pin is left floating: the default value of 2.8 V is chosen as the pre-charge voltage

The  $V_{PRE}$  pin is connected to GND through a resistor: the default value (2.8 V) is changed.

**Equation 3**

$$R_{VPRE} = R_{PRG} \cdot \frac{V_{PRETH}}{V_{PRETHDEFAULT}}$$

In the demonstration board the  $V_{PRE}$  is left floating to use the default value of 2.8 V. The  $V_{PRE}$  pin is also used for resetting the maximum charge time. If the voltage on  $V_{PRE}$  goes lower than 0.5 V (edge sensitive), the maximum charging time is reset.

For the STEVAL-ISB005V1 demonstration board the  $V_{PRE}$  pin is interfaced with the microcontroller IO pin. This can be used for resetting the maximum charging current by causing a falling edge on this pin.

*Note:* The current version of the firmware doesn't support this feature.

Refer to the L6924U datasheet.

For the 6924U device, 4.2 V is the preset charge voltage. The pre-charge voltage is fixed to 3.0 V, and this can't be programmed in the case of the L6924U.

$V_{PRE}$  is replaced by the MODE pin. For the 6924U mode pin, select between the AC adapter and the USB port. A high level sets the L6924U in USB mode while a low level sets the L6924U in the AC adapter mode.

To select the desired configurations see [Section 5](#).

**3.1.4 End of charge current**

When the charge voltage approaches the selected value (4.1 V or 4.2 V), the voltage regulation phase takes place. The charge current starts to decrease until it goes lower than a programmable end value,  $I_{ENDTH}$ , depending on an external resistor connected between the  $I_{END}$  pin and GND.

**Equation 4**

$$R_{END} = V_{MIN} \cdot \frac{K_{END}}{I_{ENDTH}}$$

Where  $K_{END}$  is 1050; and  $V_{MIN}$  is 50 mV.

This pin is also used to monitor the charge current, because the current injected in  $R_{END}$  is Proportional to  $I_{CHG}$ . The voltage across  $R_{END}$  can be used by a microcontroller to check the charge status. This concept is used in Gas Gauge applications.

The end of charge current is taken as 15 mA.

**Equation 5**

$$R_{END} = 50\text{mV} \cdot \frac{1050}{15\text{mA}} = 3.5\text{k}$$

The  $I_{END}$  pin can be interfaced with the microcontroller to check the status of the charging current for gas gauge application implementation. This feature is not supported by the firmware.

### 3.1.5 Maximum charging time

The capacitor connected at the  $C_{TPRG}$  pin defines the maximum charging time starting from the beginning of the fast-charge phase.

#### Equation 6

$$C_{TPRG}(nF) = \left( \frac{T_{MAX}}{KT} \cdot \frac{V_{BG}}{R_{PRG}} \right) \cdot \frac{10^9}{V_{REF}}$$

$$V_{REF} = 1.8 \text{ V}$$

$$K_T = 279 \times 105$$

$$V_{BG} = 1.23 \text{ V}$$

$T_{MAXCH}$  is the charging time given in seconds.

Pre-charge phase safety timer =  $T_{MAXPRECH} = T_{MAXCH}/8$ .

Referring to the 6924D datasheet, it can be noted that typical charging time for the Li-Ion battery is taken as 3 Hrs (10800 sec). Therefore by calculating the value of  $C_{TPRG}$ .

#### Equation 7

$$C_{TPRG}(nF) = 8.8 \text{ nF}$$

By default, in the STEVAL-ISB005V1 and STEVAL-ISB007V1 demonstration board, a capacitor value of 10 nF is connected on  $C_{TPRG}$ . For a higher capacity battery, the user must increase the  $C_{TPRG}$  value. The user has the provision to increase the  $C_{TPRG}$  value up to 50 nF.

### 3.1.6 Temperature monitoring

A thermistor can be connected between the 'TH' pin and GND for monitoring the temperature of the battery. A resistor is connected between  $V_{REF}$  and the TH pin. As specified in the datasheet:

$$R_{NTC} (0 \text{ C}) = R_{UP}$$

$$R_{NTC} (50 \text{ C}) = R_{UP}/7$$

The  $R_{UP}$  (R4 in schematics) of 1K is available on the board which is connected between  $V_{REF}$  and TH pins.

For applications that do not need to monitor the battery temperature, the NTC can be replaced with a simple resistor whose value is one half of the pull-up resistor  $R_{UP}$ . A default resistance of 470  $\Omega$  is available if temperature sensing is not to be done.

By default, in the STEVAL-ISB005V1 and STEVAL-ISB007V1 demonstration board, a 470  $\Omega$  resistance is connected to the NTC pin. Therefore the user should not connect the NTC pin of the battery to the device.

### 3.1.7 Status monitoring

Two pins, ST1, ST2, are available for monitoring the status. The LEDs are connected at the status pins through the current limiting resistances.  $R=470 \Omega$  is chosen.

These pins are also connected to the microcontroller in case the it needs to read the status. The details of these LEDs are provided below and are taken from the L6924 datasheet; Low-cost Li-Ion battery charger demonstration board based on the ST7263BK6 and L6924D.

**Table 3. Status LEDs indications**

Charge condition	Description	ST1	ST2
Charge in progress	When the device is in pre-charge or fast-charge status	On	Off
Charge done	When the charging current goes lower than the $I_{ENDTH}$	Off	On
Stand by mode	When the input voltage goes under $V_{BAT} - 50\text{ mV}$	Off	Off
Bad battery temperature	When the voltage on the TH pin is out of the programmable window, in accordance with the NTC or PTC thermistor	On	On
Battery absent	When the battery pack is removed	On	On
Over time	When TMAXCH or TMAXPRECH is expired	On	On

### 3.1.8 Shut-down mode

The SD (shutdown) pin is useful for enabling the device. When the pin is connected to GND, the device is operating. When the pin is left floating, the device enters shutdown mode. This pin is controlled by the microcontroller when a USB supply is used, to enable or disable the charging process. In USB mode the charging process is allowed to start only after proper enumeration of the USB by the controller. The charging process status is shown by an LED which is controlled by the microcontroller.

By default, in the STEVAL-ISB005V1 and STEVAL-ISB007V1 demonstration board, the SD pin is connected by making a potential divider through using the R15 and R23 resistor. The microcontroller sets the pin as LOW to enable the device, otherwise the device is shut down.

### 3.1.9 Charging voltage selection

Refer to the L6924D datasheet.

The  $V_{OPRG}$  pin is useful for selecting the charging voltage at VOUT. As described in the datasheet,  $V_{OPRG}$  is floating, and  $V_{OUT} = 4.1\text{ V}$ . If it is connected to GND,  $V_{OUT} = 4.2\text{ V}$ .

A resistor between  $V_{OPRG}$  and GND is available to select this.

By default, in the STEVAL-ISB005V1 demonstration board the  $V_{OPRG}$  pin is connected to GND to support  $V_{OUT} = 4.2\text{ V}$ .

Refer to the L6924U datasheet.

In the case of L6924U the charge voltage is fixed at 4.2 V. (It is not programmable). This pin acts as  $I_{SEL}$ , which is used to switch from high power USB ( $I_{USB}$  up to 500 mA) and low power USB ( $I_{USB}/5$ ) in USB mode. A low level sets the L6924U in low power mode and a high level sets the L6924D in high power mode. When the AC mode is selected, the  $I_{SEL}$  pin must be connected to ground or left floating.

### 3.1.10 Input, output capacitors

As recommended in the 6924D datasheet, the following capacitors are connected.

**Table 4. Input-output capacitors**

Component	Description
1 $\mu$ F ceramic capacitor	Placed close to the $V_{IN}$ and $V_{INSNS}$
1 $\mu$ F ceramic capacitor	Placed close to the $V_{OUT}$ and $V_{OSNS}$

## 3.2 Microcontroller:

The microcontroller used in the STEVAL-ISB005V1 and STEVAL-ISB007V1 demonstration board is the ST72F63BK6M1. This can be replaced by the user depending on their own charger application.

Please note that the microcontroller is needed to respect the USB specifications.

**Table 5. Microcontroller details**

Feature	Description
Sales type	ST72F63BK6M1
Package	SO-34
Program memory	32 K Flash
RAM	1 K
Operating voltage	4 V to 5.5 V

*Note:* The microcontroller (U4) is mounted on the board. The board supports both USB and Adapter mode. On the board the microcontroller plays a role in both adapter as well as USB mode. But it is possible to make the microcontroller independent in adapter mode. To do this, please refer to [Section 5](#).

## 3.3 Reset circuit

The RC circuit is used at the reset pin.

A pushbutton is available for the user to make the microcontroller reset.

The STM1001 reset supervisor is used at the pin with the pushbutton switch.

**Table 6. Low power reset**

Feature	Description
Sales type	STM1001MWX6F
Package	SOT23-3
Reset threshold	4.25 V to 4.75 V. typ=4.38 V

*Note:* By default, in the STEVAL-ISB005V1 and STEVAL-ISB007V1 demonstration board, STM1001 is not mounted.

### 3.4 ICC

The standard ICC connector is available for programming.

### 3.5 USB section and ESD protection

Connections are done between the USB connector and USB port of the microcontroller. USBVCC is connected to the USBDM through a 1k5 resistor. USBLC6-2SC6 is used for ESD protection of the USB.

The very low line capacitance of 100 nF between  $V_{BUS}$  and GND secures a high level of signal integrity, even with the most stringent characterized ESD strikes.

**Table 7. Very low capacitance ESD protection**

Feature	Description
Sales type	USBLC6-2SC6
Package	SOT23-6L
Reverse stand off voltage	5 V
Breakdown voltage	6 V

Though the microcontroller has built-in ESD protection up to 2 kV (human body model), it can be noted that the USBLC6 device provides additional protection of USB signals compliant to IEC61000-4-2 level 4: 15 kV (air discharge), 8 kV (contact discharge). This device usage is recommended for additional protection.

### 3.6 Oscillator

A 12 MHz crystal is used to provide the necessary clock to the microcontroller. Two 33 pF capacitors are used for stabilization.

### 3.7 LED indicators (D2 and D6 status)

**Table 8. D2 and D6 LEDs indications**

Charge condition	Description	D2	D6
Charge in progress	When the device is in pre-charge or fast-charge status	Off	Toggling
Charge done	When the charging current goes lower than the $I_{ENDTH}$	Off	On
Battery absent	When the battery pack is removed	Toggling	Off

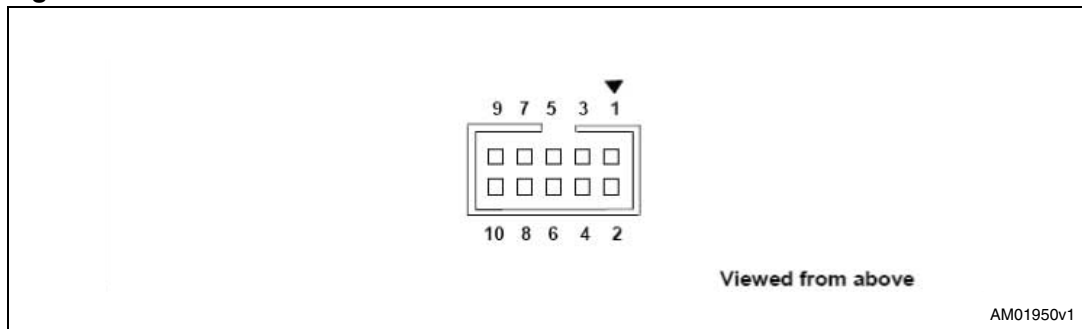
These LEDs are controlled by the microcontroller in addition to the LED control provided in L6924. Depending on the final application, the user can decide to keep the required LEDs for user interface. This indication is provided by the microcontroller through reading ST1 and ST2.

## 4 Connector details

### 4.1 ICC connector:

The standard 10-pin (dual line 5\*2 pin) box header connector is available for ICC programming.

**Figure 4. ICC connector**



**Table 9. ICC connector pin configuration**

Pin no.	Description
1	GND
2	ICCDATA
3	GND
4	ICCCLK
5	GND
6	RESET
7	VIN
8	VPP
9	NC
10	GND

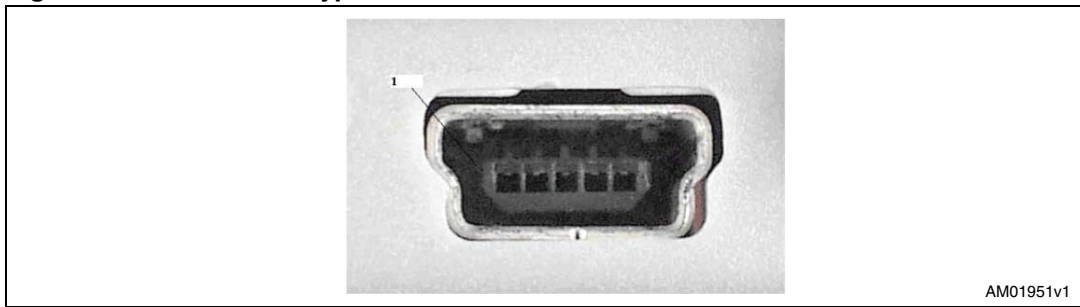
### 4.2 USB connector

The standard USB B type (5-pin) connector is used. Additional 4 connections (pins 6-9 in schematics) are connected to the body of the connector. Make sure that these pins (shell/shield) are connected to the ground through an RC circuit.

The maximum current drawn from the USB host/hub should be less than 500 mA in any condition.



**Figure 5. USB mini-B type connector**



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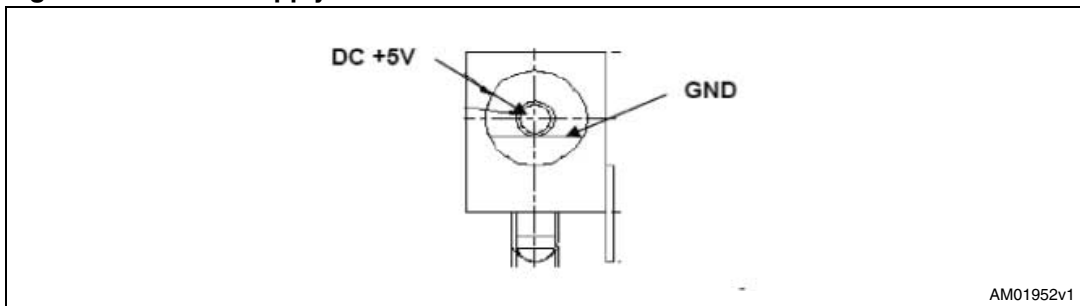
**Table 10. USB connector pin description**

Pin number	Description	Pin number	Description
1	V <sub>BUS</sub> (Power): +5 V supply from USB bus	6	SHIELD
2	DM: USB D- signal	7	SHIELD
3	DP: USB D+ signal	8	SHIELD
4	--	9	SHIELD
5	GND: ground signal		

### 4.3 Power supply connector

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

**Figure 6. Power supply connector**



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## 5 Changes between L6924D and L6924U

The PCB design supports both the 6924D and 6924U device.

The following are the changes in L6924U with respect to L6924D. The summary of changes is provided in below.

There is one input (to which the AC adapter source or USB power source can be connected)

The MODE pin selects the desired source (AC or USB)

Both AC adapter and USB fast-charge current can be separately programmed by connecting external resistors

The I<sub>SEL</sub> pin allows the selection of a low-power mode while operating in USB mode (current reduced to 1/5 of the programmed one)

The pre-charge voltage threshold is no longer programmable, the default value is 3 V

The pre-charge current is no longer programmable, the default value is 10 % of charge current in fast charge

Charge voltage is fixed at 4.2 V (it is no longer possible to select 4.1 V or 4.2 V)

The charging process ends when the charge current falls below the termination current I<sub>END</sub> (set by a resistor connected to I<sub>END</sub> pin, like in L6924D); after a de-glitch time, the end of charge is notified by status pins (in L6924D, other than this termination mode, there is also the possibility to keep charging even if the current is lower than I<sub>END</sub>; the end of charge occurs and is notified only after the max charging time expires).

**Table 11. Summary of changes between L6924D and L6924U**

Pin number in L6924D or L6924U	Functions in L6924D	Functions in L6924U	Comment
9	V <sub>OPRG</sub> If floating V <sub>out</sub> = 4.1 V If GND V <sub>out</sub> = 4.2 V	I <sub>SEL</sub> I <sub>SEL</sub> is used for selecting USB power mode HIGH = charging current I <sub>USB</sub> up to 500 mA LOW = charging current is I <sub>USB</sub> /5 V <sub>out</sub> (not programmable) fixed = 4.2 V	For STEVAL- ISB005V1, V <sub>OPRG</sub> is programmed for 4.2 V
14	V <sub>PRE</sub> V <sub>PRE</sub> = Floating, V <sub>PRETH</sub> = 2.8 V < V <sub>PRE</sub> pin is lower than V <sub>PRE</sub> < 0.8 V, V <sub>PRETH</sub> = 2.8 V, no automatic charge termination V <sub>PRE</sub> < 0.5 V, (edge sensitive) V <sub>PRETH</sub> = 2.8 V, max charging time reset	MODE HIGH = USB mode LOW = AC adaptor mode pre-charge voltage NOT programmable, fixed=3 V	

Table 11. Summary of changes between L6924D and L6924U (continued)

Pin number in L6924D or L6924U	Functions in L6924D	Functions in L6924U	Comment
15	$I_{PRG}$ Charge current program pin	$I_{USB}$ Charge current program pin in USB mode	
16	$I_{PRE}$ Pre-charge current program pin	$I_{AC}$ Charge current program pin in AC mode	

## 6 Charging process

When the USB cable is connected or the user has connected the adaptor, the L6924 starts to charge the battery. Please note that the resistors to select the power source are correctly connected. As mentioned in

### 6.1 USB charger mode

When USB is used as the power supply, ensure that the maximum current drawn from USB doesn't exceed 100 mA before it is configured, and the current required for the charging process is approx 400 mA, depending on the limit of charging current set (390 mA in this case). Therefore, the charging process is allowed to start only after proper enumeration of the USB by the controller, the SD pin of 6924D is controlled by the microcontroller for this purpose.

The additional pins which are interfaced with the microcontroller in this mode for 6924U, are MODE and I<sub>SEL</sub>.

Resistor settings for the SD pin as well as the MODE pin should be properly adjusted, as mentioned in

**Table 12. Actions of the microcontroller in different USB state**

USB state (refer to USB specifications)	USB power budgeting specification	Microcontroller actions	L6924 device actions	L6924U device actions
Attached, powered, default, address states	USB device can draw no more than 100 mA from V <sub>BUS</sub>	USB section enabled, Endpoint0 transactions enabled.	SD pin is high, L6924 device is disabled and draws shutdown mode current $\leq 80 \mu\text{A}$ (see electrical specifications for more details)	SD pin is low, L6924U device is enabled I <sub>SEL</sub> = LOW (charging current is I <sub>USB</sub> /5)

	"bMaxPower")	USB statemachine changed to "configured state" and controls the SD pin for drawing up to 500 mA current from V <sub>BUS</sub>	SD pin low, so L6924 device is enabled, battery is charged. Current drawn from V <sub>BUS</sub> is charge current	SD pin is Low, L6924U device is enabled I <sub>SEL</sub> = HIGH (charging current I <sub>USB</sub> )
Suspended	USB device can draw <2.5 mA current from V <sub>BUS</sub>	Microcontroller executes USB suspend interrupt and enters power saving mode reducing power consumption, All LEDs are off, microcontroller enters HALT mode.	SD pin is high, L6924 device is disabled and draws shutdown mode current <=80 µA (see electrical specifications for more details)	SD pin is high, L6924 device is disabled and draws shutdown mode current <=80 µA (see electrical specifications for more details)

Modifications on the STEVAL-ISB005V1 for different options. As mentioned above the demonstration board can be modified to make specific implementations. For example, the L6924D and L6924U can be used for a single mode only. This is illustrated in .

		Adaptor mode
	(Microcontroller needed for device control and no option for adaptor)	(Device used in independent/standalone mode. No microcontroller needed)
L6924D	This is already implemented on the board (STEVAL-ISB005V1)	SD pin: LOW: keep device enabled So, Mount R15 resistor. De-mount R23. V <sub>OPRG</sub> pin: De-mount R16, mount resistor R24. V <sub>PRE</sub> pin: Floating, V <sub>PRETH</sub> = 2.8 V de-mount resistor R10, R21.
L6924U	This is already implemented on the board (STEVAL-ISB007V1)	SD pin: mount R15 resistor. De-mount R23. I <sub>SEL</sub> pin: mount R24. De-mount R16. MODE pin: mount R11, de-mount R21

To support this feature, R18 in the case of STEVAL-ISB005V1 (L6924D) and R22 in the case of STEVAL-ISB007V1(L6924U) are mounted.

## 6.2 Charging using adaptor only

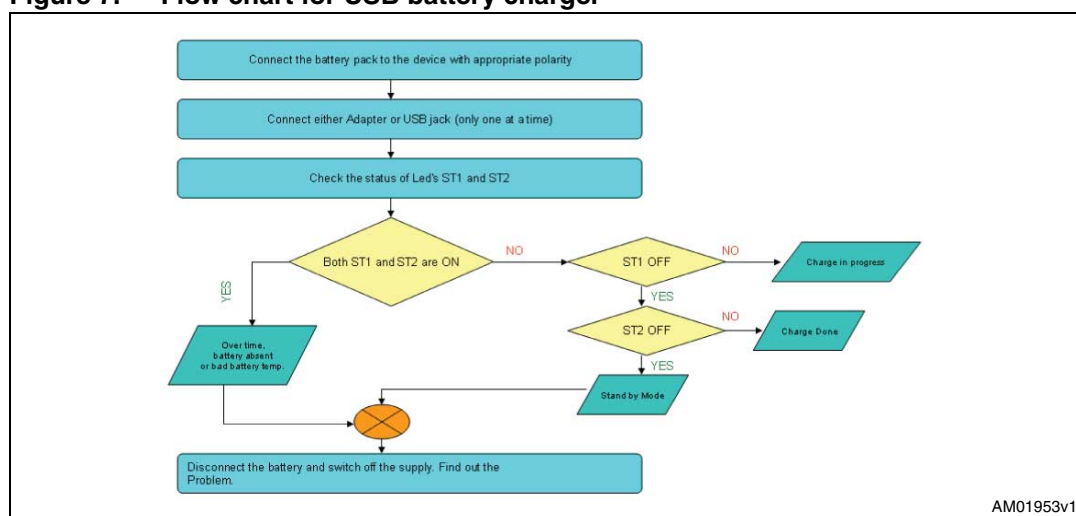
When power is provided through the 5 V adaptor, the option to use the charging circuit independent of the microcontroller is available, as no enumeration is required. In this case 6924 operates independently, but the resistor settings for the SD pin have to be adjusted.

For the 6924U battery charger, the adaptor current can be increased up to 1 A, depending on the value of R20 resistance.

The SD pin is required to be connected to ground in this mode, so resistor settings should be adjusted accordingly, as mentioned in .

## 6.3 Flow chart of USB battery charging process

Figure 7. Flow chart for USB battery charger



## 6.4 Future possibilities

As the microcontroller available on the board is the ST72F63BK6M1, there is a lot of RAM and flash available for the user to do their own firmware updates and modifications. If the user does not want to upgrade the firmware, the present demonstration firmware is good enough to use as a standalone Li-Ion/Li-polymer battery charger.

The  $V_{PRE}$  pin is connected to the microcontroller so that the firmware can make the pin low (edge sensitive) to reset the maximum charging time.

The  $I_{END}$  pin is connected to the analog input (internally connected to the analog to digital converter of the microcontroller). This can be used for the gas gauge application. This is because the voltage across the resistor connected at this pin is proportional to the current delivered to the battery.

The user can make suitable changes for the final application to keep either the LEDs connected at the ST1 and ST2 pins, or manage separate LEDs through the microcontroller.

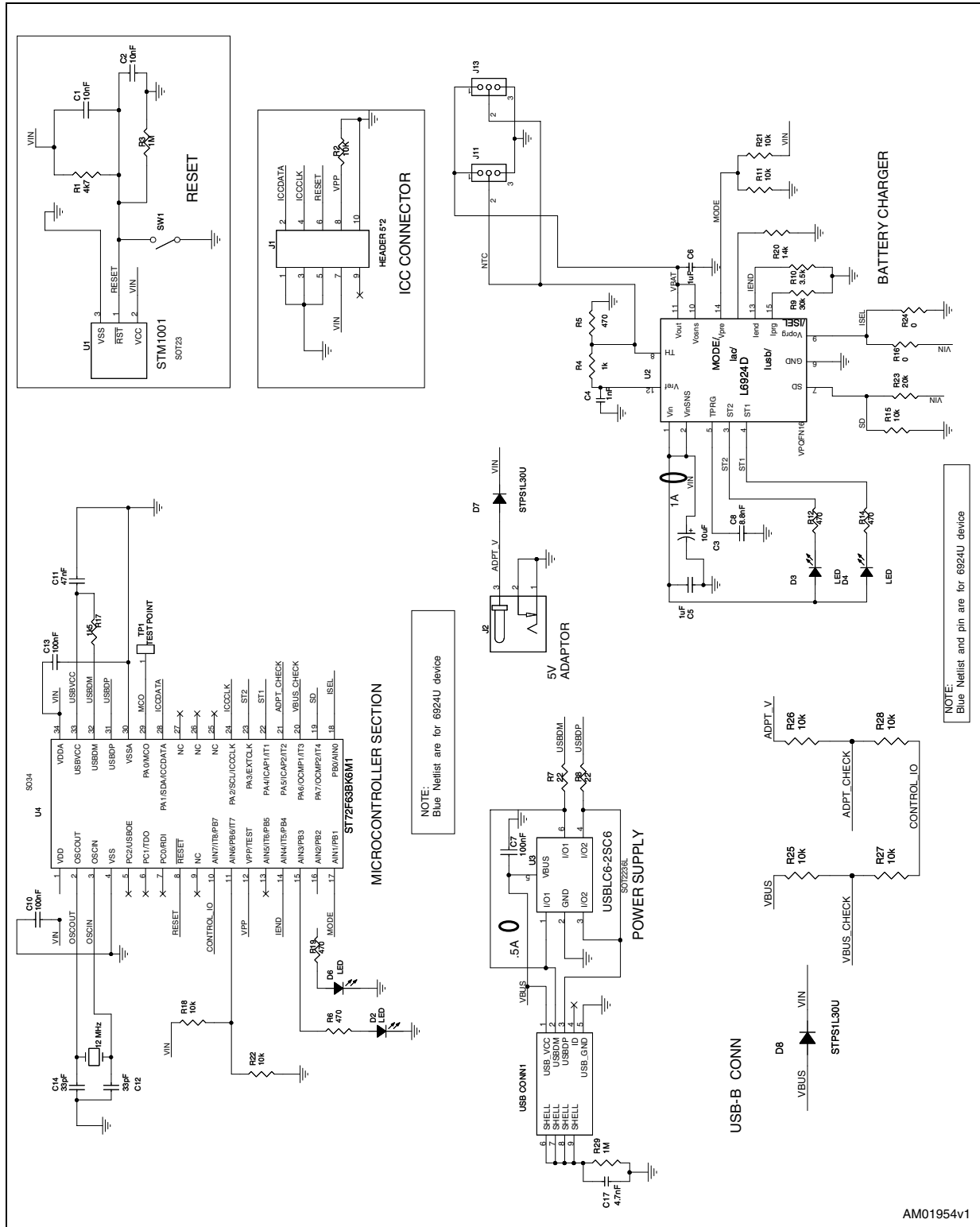
There are devices available, such as the STw4102, which provide standalone battery management and gas gauge application.

## 7 References

1. L6924D datasheet
2. L6924U datasheet
3. L6924D application note
4. STw4102 datasheet;

# 8 Schematics

Figure 8. Battery charger schematic





## 9 Bill of material

Table 14. BOM

Category	Ref. des.	Component description	Package	Manufacturer	Manufacturer's ordering code / orderable part number or equivalent	Supplier ordering code
ST devices	U2	Battery charger L6924U	VFQFPN16	STMicrocontrollers	L6924U	
	U4	Microcontroller ST72F63	SO-34	STMicrocontrollers	ST72F63BK6M1	
	U3	ESD protection device USBLC6	SOT23-6L	STMicrocontrollers	USBLC6-2SC6	
	U1	RESET supervisor STM1001	SOT23-3	STMicrocontrollers	STM1001MWX6F	
	D7,D8	Power Schottky diode STPS1L30	SMB	STMicrocontrollers	STPS1L30U	
Crystal and oscillator	Y1	Q12.0-SS4-30-30/30	11.35mm x 4.35 mm, SS4	Jauch	Q12.0-SS4-30-30/30	
Connectors and jumpers	J11	Battery CONN	Terminal Block-3pin, 3.5 mm Pitch, Screw connection	Any		
	J13	Battery CONN	HEADER1*3, 2.54 mm Pitch, vertical friction lock	Any		
	SW1	Push button switch	(6 mm x 6 mm) push button	Any		
	J1	ICC HEADER	Box Header 2x5pin, 2.54 mm x 2.54 mm Pitch	Any		
	J2	POWER JACK 2.5MM	POWER JACK- 14.17 * 8.96 mm	CUI	PJ-102B	
	USB_CON N 1	SMD USB Mini-B type connector	SMD USB mini-B type connector	Kycon	KMBX-SMT-5S-S-30TR	1
	TP1	Test point	Berg-stick pin			

Table 14. BOM (continued)

Category	Ref. des.	Component description	Package	Manufacturer	Manufacturer's ordering code / orderable part number or equivalent	Supplier ordering code
LEDs	D6	Green LED	SMD0805	Any		
	D2,D3,D4	Yellow LED	SMD0805	Any		
Capacitors	C3	10 $\mu$ F/25 V tantalum/electrolytic	EIA 3216-18/Size A	Any		
	C5,C6	1 $\mu$ F/25 V tantalum/Electrolytic	EIA 3216-18/Size A	Any		
	C1,C2, C8	10 nF	SMD0805	Any		
	C4	1 nF	SMD0805	Any		
	C7,C10,C13	100 nF	SMD0805	Any		
	C11	47 nF	SMD0805	Any		
	C12,C14	33 pF	SMD0805	Any		
	C17	4.7 nF	SMD0805	Any		
Resistors	R1	4.7 k $\Omega$	SMD0805	Any		
	R2,R11, R15,R18, R21,R22, R25,R26, R27,R28	10 k $\Omega$	SMD0805	Any		
	R3,R29	1 M $\Omega$	SMD0805	Any		
	R4	1 k $\Omega$	SMD0805	Any		
	R5,R6,R1, R14,R19	560 $\Omega$	SMD0805	Any		
	R7,R8	22 $\Omega$	SMD0805	Any		
	R9	30 k $\Omega$	SMD0805	Any		
	R10	3.6 k $\Omega$	SMD0805	Any		
	R17	1.5 k $\Omega$	SMD0805	Any		
	R24,R16	0	SMD0805	Any		
	R23	20 k $\Omega$	SMD0805	Any		
	R20	14 k $\Omega$	SMD0805	Any		

*The term "equivalent" has been used where the extract part number from the mentioned vendor may not have been used.*

## 10 Revision history

Table 15. Document revision history

Date	Revision	Changes
28-Jun-2010	1	Initial release

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