# UM0617
# User manual

## STEVAL-TCS004V1, 16-bit port expander demonstration board based on the STMPE1601, ST7263BK6

## Introduction

This document explains the functioning of the port expander demonstration board which consists of the STMPE1601 port expander IC and the ST7263BK6 microcontroller, as the $I^2C$ master, along with a PC graphical user interface (GUI).

The objective of this demonstration board is to display the features and capabilities of the port expander chip (STMPE1601) using a Windows® based host software application and one of several USB low-speed microcontrollers (ST7263BK6) from STMicroelectronics acting as a control device.

The host software and the ST7 source code provide a user friendly environment to use the demonstration board in the following modes:

- Standalone mode
- PC GUI mode

In both modes, power to the board is provided from a USB mini B-type connector.

In this demonstration board, the ST7263BK6 microcontroller acts as the $I^2C$ master and controls one STMPE1601 device functioning as the $I^2C$ slave. The STMPE1601 devices are used to interface a matrix keypad, dedicated keys, special function keys and PWM controllers. All these interfaces are controlled by using just $I^2C$ communication between the master and the slave device.

In run mode, events such as key press (matrix, special function or dedicated keys), rotator controller, power mode, etc. are captured and displayed on the LCD screen and in the scan window of the PC GUI.

For interfacing with the PC GUI, the application layer is built above the USB core library which makes all the hardware control of the USB interface transparent.

The PC GUI supports various power saving modes of the port expander and wakeup feature to return to default operational mode.

In addition, the board has the provision for an alternate $I^2C$ path for external control.

The board also has an ICC connector to re-program the ST7 microcontroller Flash memory.

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# 1 Getting started

## 1.1 System requirements

In order to use the port expander demonstration board with the Windows operating system (OS), a recent version such as Windows 7 or Windows XP must be installed on the PC.

The version of the Windows OS installed on your PC may be determined by clicking on the system icon in the control panel.

## 1.2 Package contents

The port expander demonstration board includes the following items:

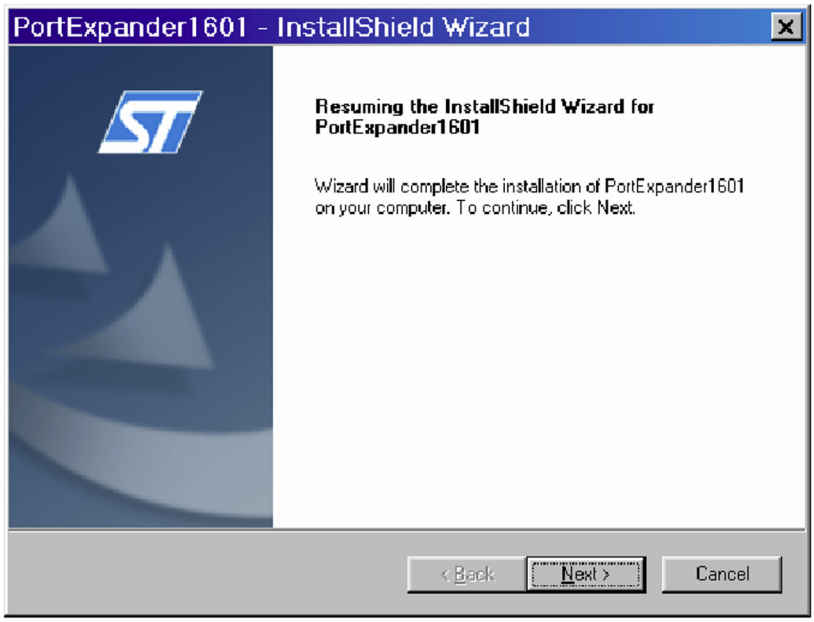
- Hardware content
  - One demonstration board
- Software content
  - PC GUI software to be used along with demonstration board
- Documentation
  - User manual

## 1.3 Software installation

To install the PC GUI software, follow these steps:

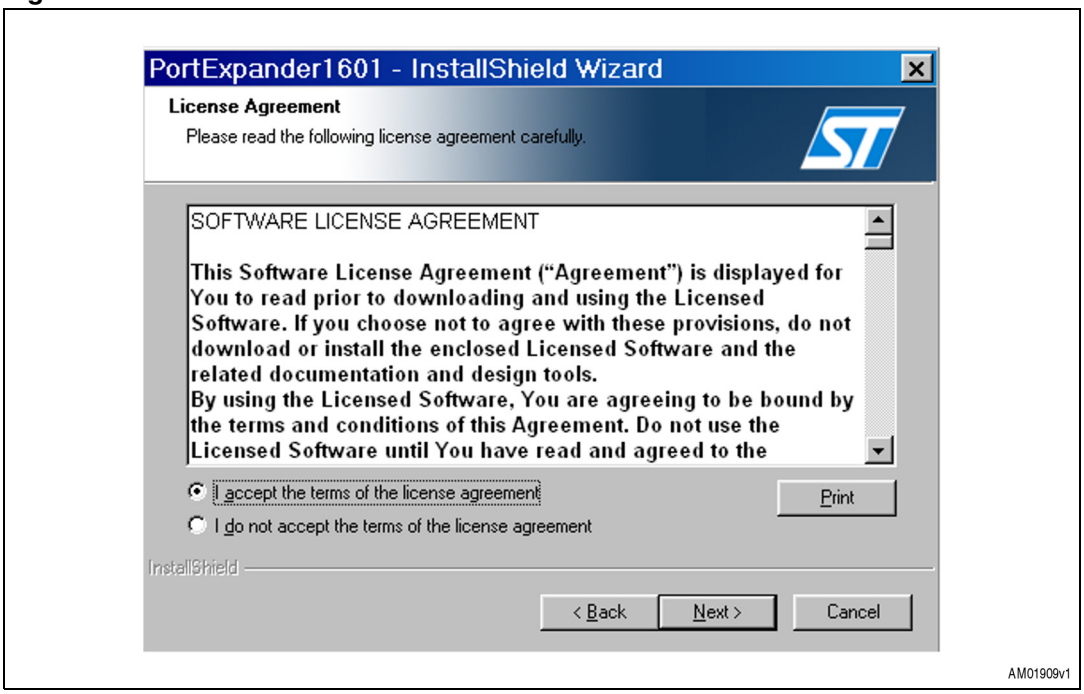
- Step1: As soon as the user clicks the setup.exe Icon. The following window appears.

**Figure 1. Installation window**



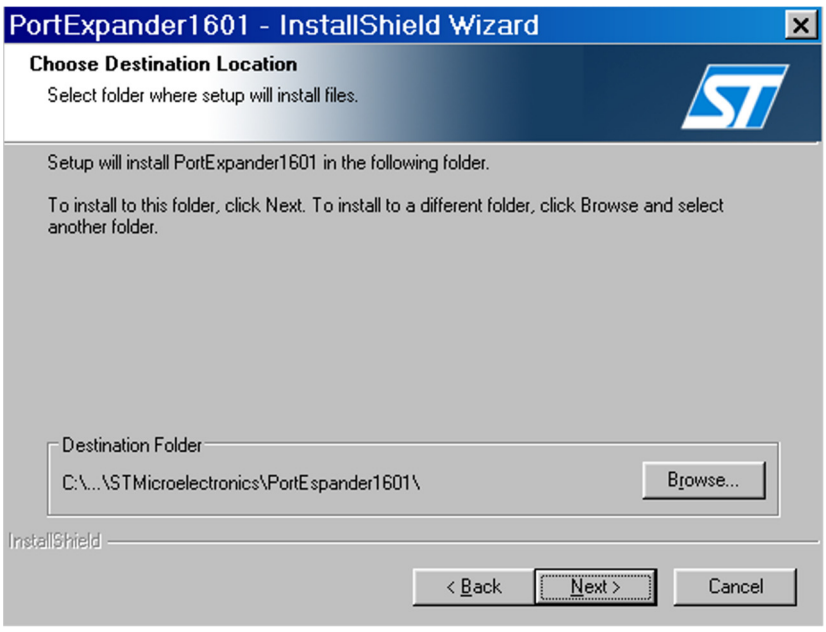
- Step 2: Read the license file and click the Yes button if you accept the license.

**Figure 2. License Window**



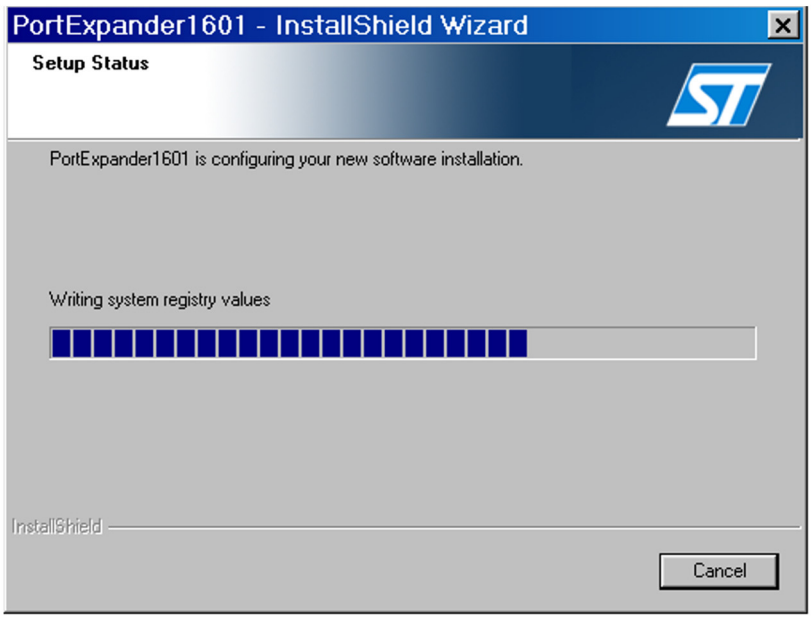

- Step 3: Please select the folder in which you want to install the software. By default it installs the software in the following path- C:\Program Files\STMicroelectronics\PortExpanderSTMPE1601.

**Figure 3. Destination folder**



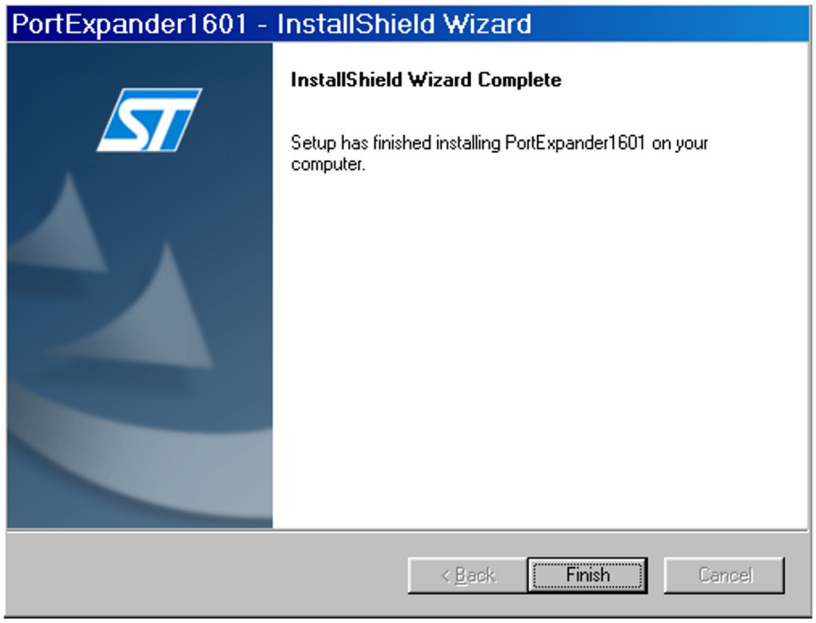
- Step 4: After you select the folder and click the Next button, installation of the software begins.

**Figure 4. Installation ongoing**




- Step 5

**Figure 5. Installation complete**

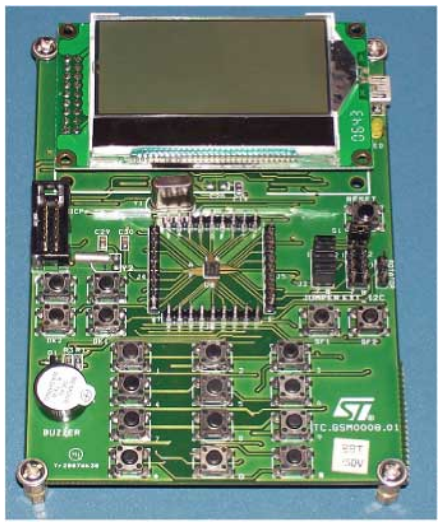



After clicking the finish button, the software has been installed in the selected directory or in the default directory. A shortcut for this software is available in the start menu. This user manual is also available in the same directory.

## 1.4 Hardware installation

*Figure 6* below shows a snapshot of the STMPE1601 demonstration board.

**Figure 6. STEVAL-TCS004V1 port expander demonstration board**




### 1.4.1 Power supply

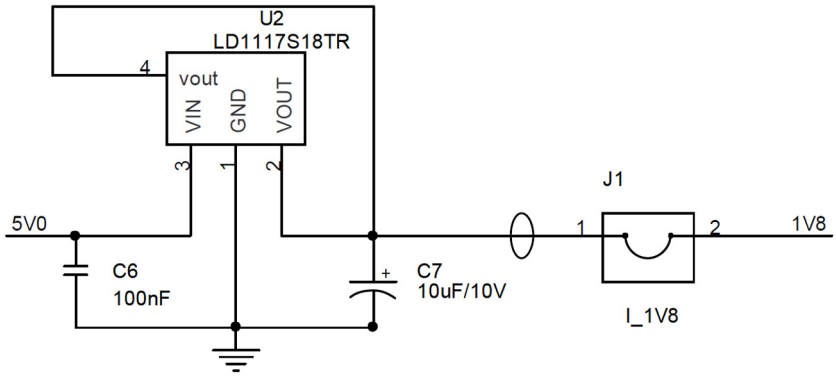
The demonstration board is directly powered by the USB mini B-type connector (bus powered).

### 1.4.2 Jumper settings

There are four jumpers J1, J2 (Jumper) and EXT_I$^2$C connectors are available on the board. The correct positioning of these connectors is necessary for the proper functioning of the demonstration board.

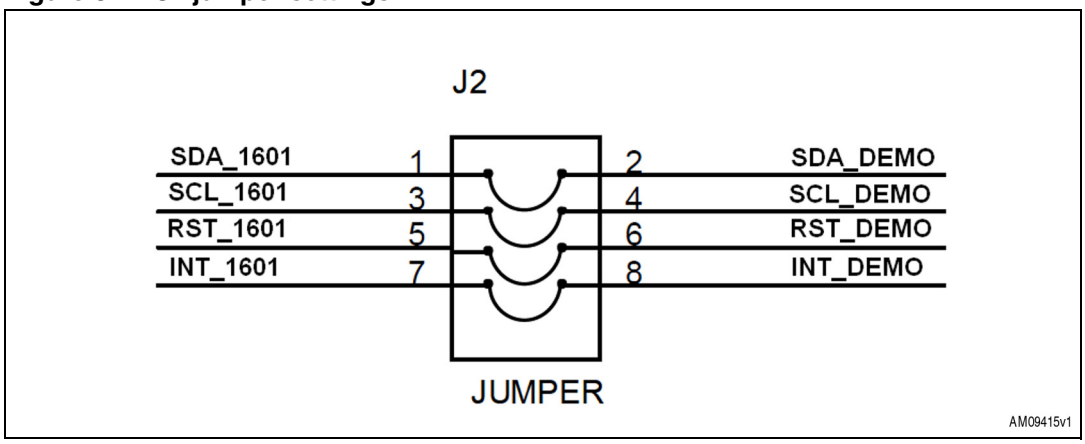
- J1: J1 is the jumper between the 1.8 V supply voltage and the supply pins of the STMPE1601 as shown in *Figure 7*. It my be used for measuring the current consumed by the 1.8 V power supply or the STMPE1601 device.

**Figure 7. J1 jumper for current measurement**



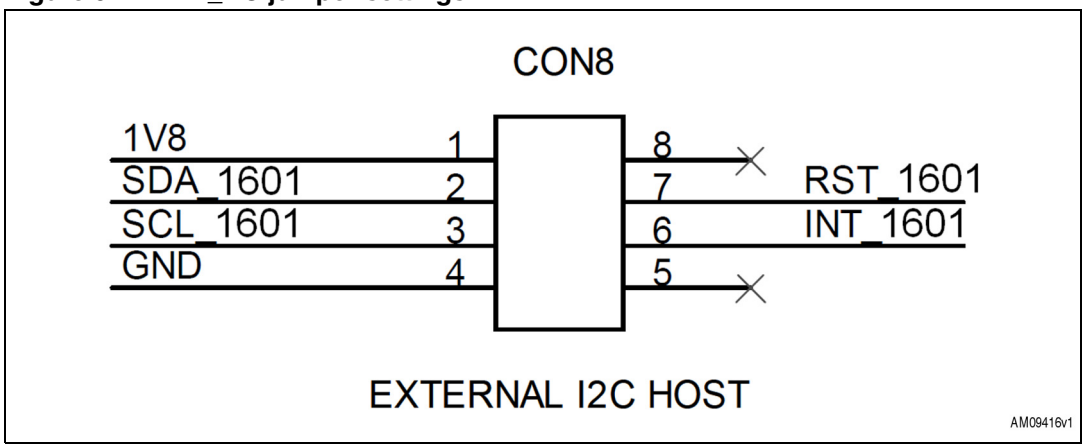
- J2: The J2 jumper structure is shown in *Figure 8*. The control lines of the STMPE1601 device are connected to the ST7 controller device through these jumpers. By default, it is necessary to short these lines.

**Figure 8. J2 jumper settings**




EXT_I²C: The EXT_I²C jumper structure is shown in *Figure 9*. The EXT_I²C jumper is an 8-pin connector used by the external I²C host to control the STMPE1601 device. See *Section 4* for more details.

**Figure 9. EXT_I²C jumper settings**



# 2 Running the STMPE1601 port expander demonstration board

This port expander demonstration board consists of two main parts:

- PC GUI
- Demonstration board.

In standalone mode, the demonstration board can be used without the PC GUI.

Please connect J1 and J2 jumpers before connecting the power supply to enable the demonstration board.

## 2.1 Running in standalone mode

Within a few seconds of plugging in the power supply, a welcome message appears on the LCD screen which means that the demonstration has started correctly.

Then a series of messages appear on the LCD screen. At the end, a help manual explaining the features available in the standalone mode appears. For the first time user, it is advisable to go through the help manual in order to use the demonstration correctly by pressing key '1' available on the demonstration board. You can exit this help manual by pressing key '2'.

If you find that no message appears on the LCD after connecting the power supply, remove the power supply and plug it in again, and then observe. The message should now appear on the LCD. If this does not happen, even after removing and plugging in the power supply several times, it is necessary to contact technical support.

The following features are available in standalone mode.

### 2.1.1 PWM outputs

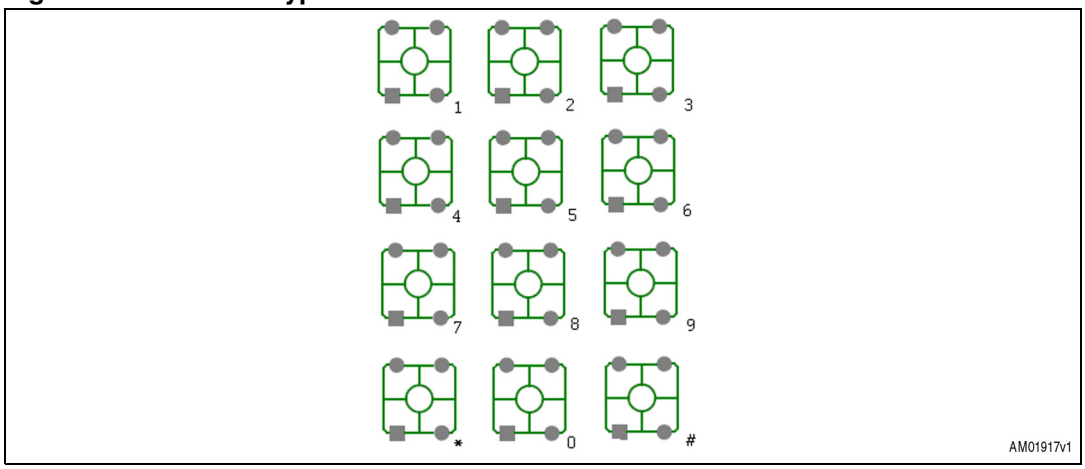
There are 4 PWM outputs available in the STMPE1601 device. However only two PWM outputs are used. One PWM output (PWM3) is used to drive the buzzer available in the demonstration board and the second PWM signal (PWM 4) is used to drive the LCD backlight.

In standalone mode some provision is provided on the keypad to change certain features of the PWM outputs for e.g. volume in case of buzzer (PWM3 duty cycle) or LCD blinking (PWM4 period) using the keypad.

### 2.1.2 Matrix keypad

There is a 6x2 normal keypad (key 0-9, '*' and '#') available on the demonstration board as shown in *Figure 10*.

**Figure 10. Normal keypad**



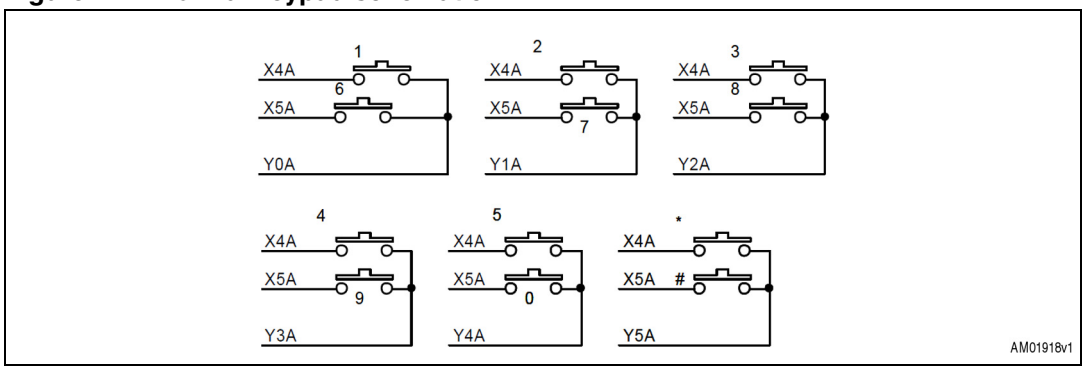

You can observe 3 simultaneous key press events at most. The key press events are recorded on a 128x64 monochrome LCD. Other than key press detection, this keypad is used for certain special purposes if the first key pressed is one of the following:

- Key '*' pressed event: If the first key pressed is '*' then the keypad goes into locked state and then no other key except the 'Reset' button is detected. The keypad is unlocked from the key press event detection when key '*' is pressed again.
- Key '#' pressed event: If the first key pressed is '*' then the keypad goes into PWM programming mode and then it is necessary to follow the instructions on the LCD screen to proceed further. The '*' key is unavailable to lock the keypad in this mode.
- Key '0' pressed event: If the first key pressed is '0' then the LCD displays the help menu. The '*' key is unavailable to lock the keypad in this mode.

# 3 Ghost key detection

The current version of the demonstration board does not deal with ghost key detection in order to keep the demo simple. To understand better please see *Figure 11*.

**Figure 11. Normal keypad schematic**




As shown in *Figure 11.*, if key '1' and key '2' are pressed, then you can observe that by pressing these keys, the input columns lines X4 are shorted with output row lines y1 and y0. So now if you press key '7', the input column line X5 is also shorted with y0 (along with y1). Therefore, depending on the keypad controller scanning, either key '6' or key '7' may be reported instead of the correct key pressed. So in this case, while the correct key pressed is key '7', key '6' may also be falsely reported.

### 3.0.1 Dedicated keypad demo

Similar to normal key press, there are 2 dedicated keys available on the demonstration board. Dedicated key press events are displayed in a separate row on the LCD screen. These keys (Dk1 and DK2) are used to increase/decrease certain features of the PWM outputs depending on the option selected during PWM programming using the keypad. For e.g., if Buzzer sound is selected for PWM3, DK1 is used to increase the buzzer volume and DK2 is used to decrease it. Similarly if LCD blinking is selected for (PWM4) then Dk1 is used to increase the period (reduce blinking frequency) and Dk2 is used to decrease the period (increase blinking frequency). However these are effective only if selected during PWM programming.

### 3.0.2 Special function key demo

There are two special function keys, SF1 and SF2, available on the demonstration board. These lines are driven by input column lines X4 (for SF1) and X5 (SF2). As mentioned in the STMPE1601 datasheet, if you have already pressed SF1 and then you try to press key 1 to 5 and '*', then these keys are not detected. Similarly if you have already pressed SF2, then if you try to press key 6 to 9, 0 and '#', then these keys are not observed.

SF1 and SF2 are also used to control enable/disable for the PWM output controlling buzzer and LCB backlight. If you pressed SF1, the LCD starts blinking, which is reset in case you press SF1 again. Similarly if you press SF2, then the buzzer sounds and is stopped by pressing SF2 again.

### 3.0.3 Screen-saver mode in standalone mode

The demo enters screen-saver mode if there is no key press event for quite some time and exits screen-saver mode once a key press is detected. Although the key press event is not observed on the LCD screen. Furthermore, any special function associated with a key is not performed when the demo is exiting screen-saver mode.

### 3.0.4 Programming PWM signals in standalone mode

There is an option in demo mode to program the PWM signal from the 4 PWM program available in the demo. The programming procedure on the demonstration board is as follows:

- Press key '#'
- Press 1 to enter PWM programming mode
- Select correct option to select DK1 or DK2 or exit by pressing key 1, 2, 3 or 4.

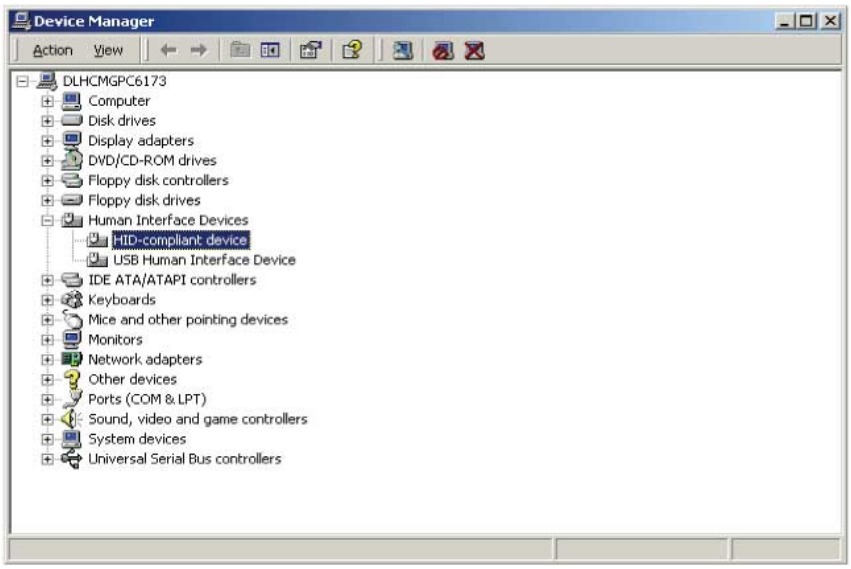
These instructions are also visible on the LCD screen which help to easily program the PWM.

## 3.1 Running in PC GUI mode

In addition to the functions mentioned in the above section, PC GUI mode is also available. To run the GUI, the demonstration board must first be connected to the PC with the USB mini B-type cable, after positioning the jumper settings as described in *Section 1.4.2*.

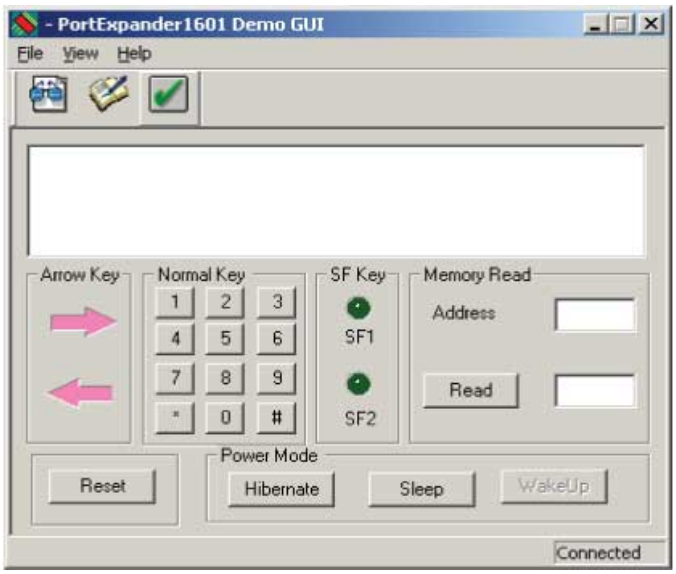
As a result, you should find the demonstration board enumerated as a HID device, as shown in *Figure 12*, and then the board is ready for use. If this message does not appear contact technical support.

**Figure 12. Enumeration result**




When starting the STMPE1601 GUI on the PC, a graphical interface appears (*Figure 13*) for controlling the demonstration board. This PC software is used to issue various commands and to control data transfer between the PC and the ST7 peripheral.

**Figure 13. STMPE1601 PC GUI**




As seen in *Figure 13*, you can check whether the board is connected or not by clicking the connection check button. If the board is not connected then the following message appears:

**Figure 14. Board not connected message**


And if the board is connected the following message appears:

**Figure 15. Board connected message**


Once this is done, the PC GUI is properly connected to the demonstration board and ready for use.

There are two operation modes in which the GUI operates:

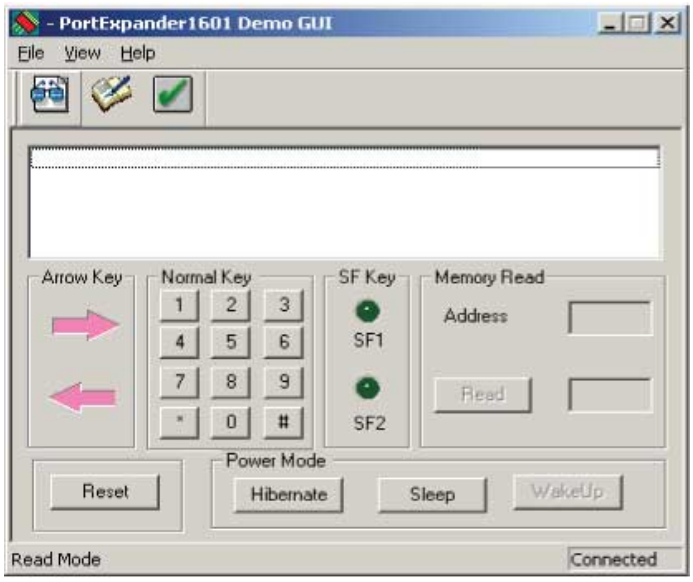
- Read/scan mode
- Write/program mode

In addition to these two modes, there are two power-down options available in the GUI to put the STMPE1601 into power-down mode. Again there is a Reset option available to return the demo to its default settings.

### 3.1.1 Read/scan mode

Enter the Read/scan mode by clicking the Read/scan button as highlighted in *Figure 16*.

**Figure 16. Read/scan mode**

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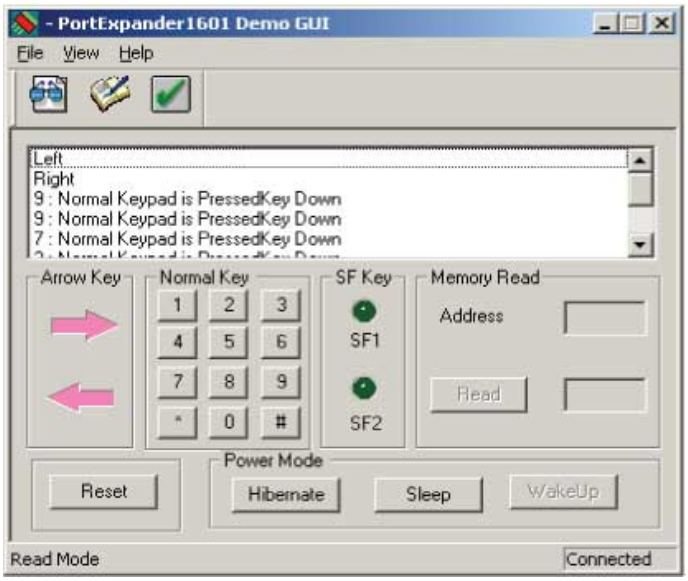
In Read/scan mode, you can observe the key press, dedicated key press, and rotator events. These events are also recorded in the scan window while the current session of scanning is ongoing so that you can observe or track the past activity, as shown in *Figure 17*.

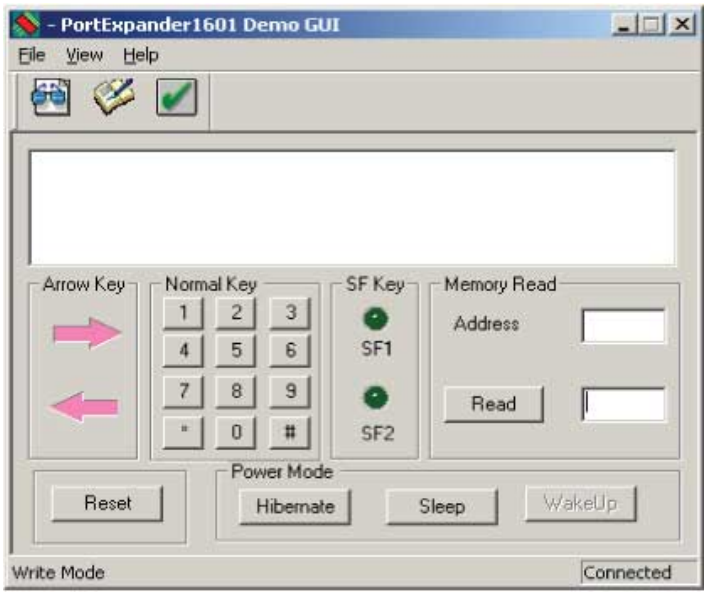
**Figure 17. Events in scan Window**




## 3.1.2 Write/program mode

Enter this mode by clicking Write/program button, as highlighted in *Figure 18*.

**Figure 18. Write/program mode**



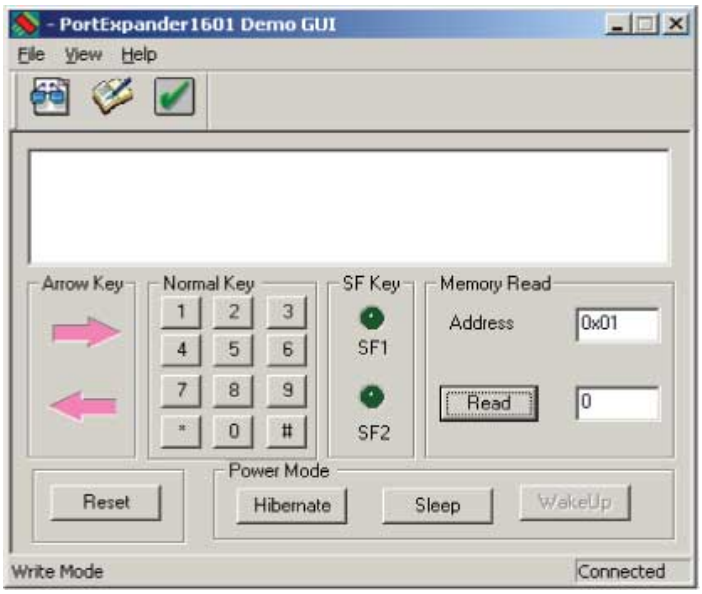

After clicking the Write/program button, the Write mode becomes active if previous scanning being carried out has stopped.

The Write mode provides the feature of reading the internal memory of either slaves, or to program any PWM output.

### 3.1.3 Reading the internal memory of the STMPE1601

Read the internal memory of a particular STMPE1601 slave device by selecting the Memory Read section from the pop menu as shown in *Figure 19*. Then you can read the memory by writing the 8-bit address in the Address box and then clicking Read. The return data is in HEX format.

**Figure 19. Reading the internal memory of the STMPE1601**



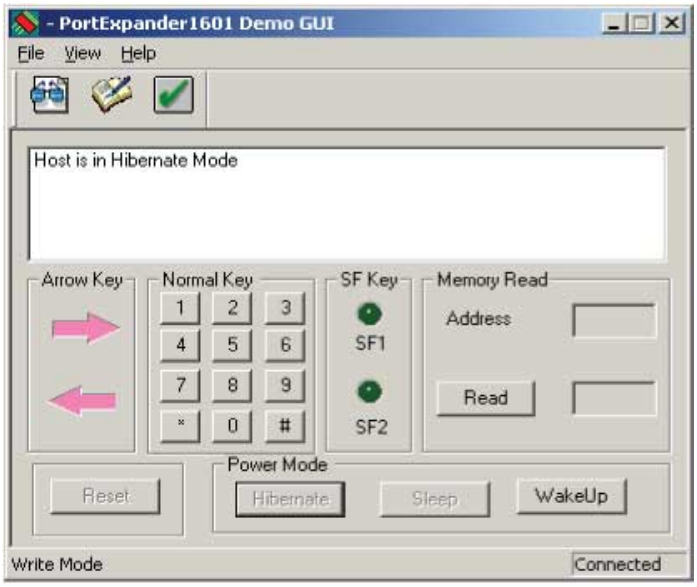

### 3.1.4 Power-down mode

There are 2 power-down modes as mentioned below:

- Hibernate mode
- Sleep mode

The STMPE1601 slave devices can be put into hibernate mode or sleep mode by clicking the corresponding button available on the GUI.

**Figure 20. Entering hibernate mode**

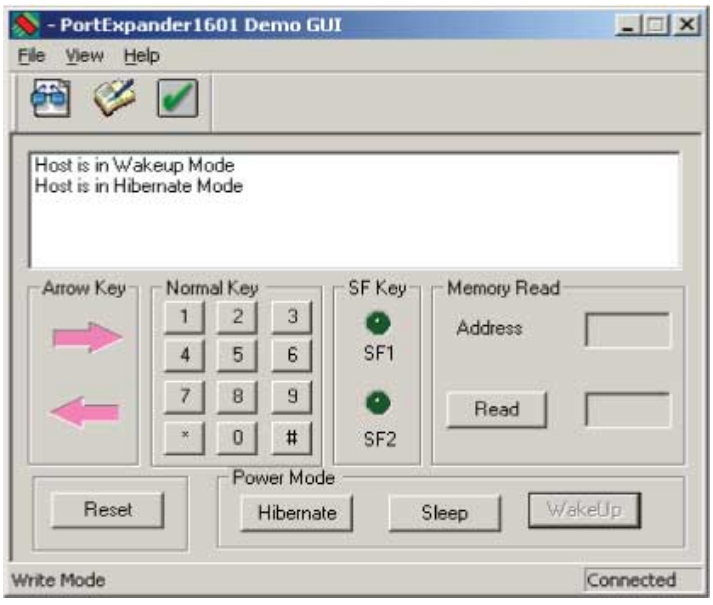



Similarly, we can enter sleep mode. There is a corresponding message that also appears on the LCD screen.

In hibernate mode, you can observe that the clock to PWM is stopped and the output LEDs stop blinking.

While in sleep mode, PWM keeps running as it is controlled by the 32 kHz clock. To exit the demo in the low power mode, click the wakeup button. A message appears in the Scan w window as soon as the demo comes out of the power-down mode as shown in *Figure 21.* You can also exit sleep mode by clicking any normal or dedicated key available in the demonstration board.

**Figure 21. Wakeup from hibernate mode**



# 4 Using the external I²C master

You can also use an external I²C master by using the 8-pin EXT_I²C connector explained in *Section 1.4.2*.

To control the STMPE1601 device using the external masters, follow these steps:

- First set remove the jumper settings of the J2 jumper to free the demo from ST7 control.
- Now use the EXT_I²C connectors to connect the external I²C host to different control lines of the STMPE1601 device which are 1V8, Gnd, RST, INT, SCL and SDA.

Now the demonstration board is ready to control using the external I²C. In this mode, the PC GUI is not available to the external user. Again you must use the slave address as specified in the demo which is 0x84 for the STMPE1601 device.

After using the external I²C master, to return to the normal mode, to do following:

- After completing the required operations, remove the EXT_I²C connectors.
- Connect the J2 jumper.
- Click the Reset button on the demonstration board to put the demo back into action.

These I²C lines are working at 5 V power supply so external I²C master should use 5 V power supply.

# Appendix A Schematics and bill of material

**Figure 22. STMPE1601 demonstration board schematic (part 1)**

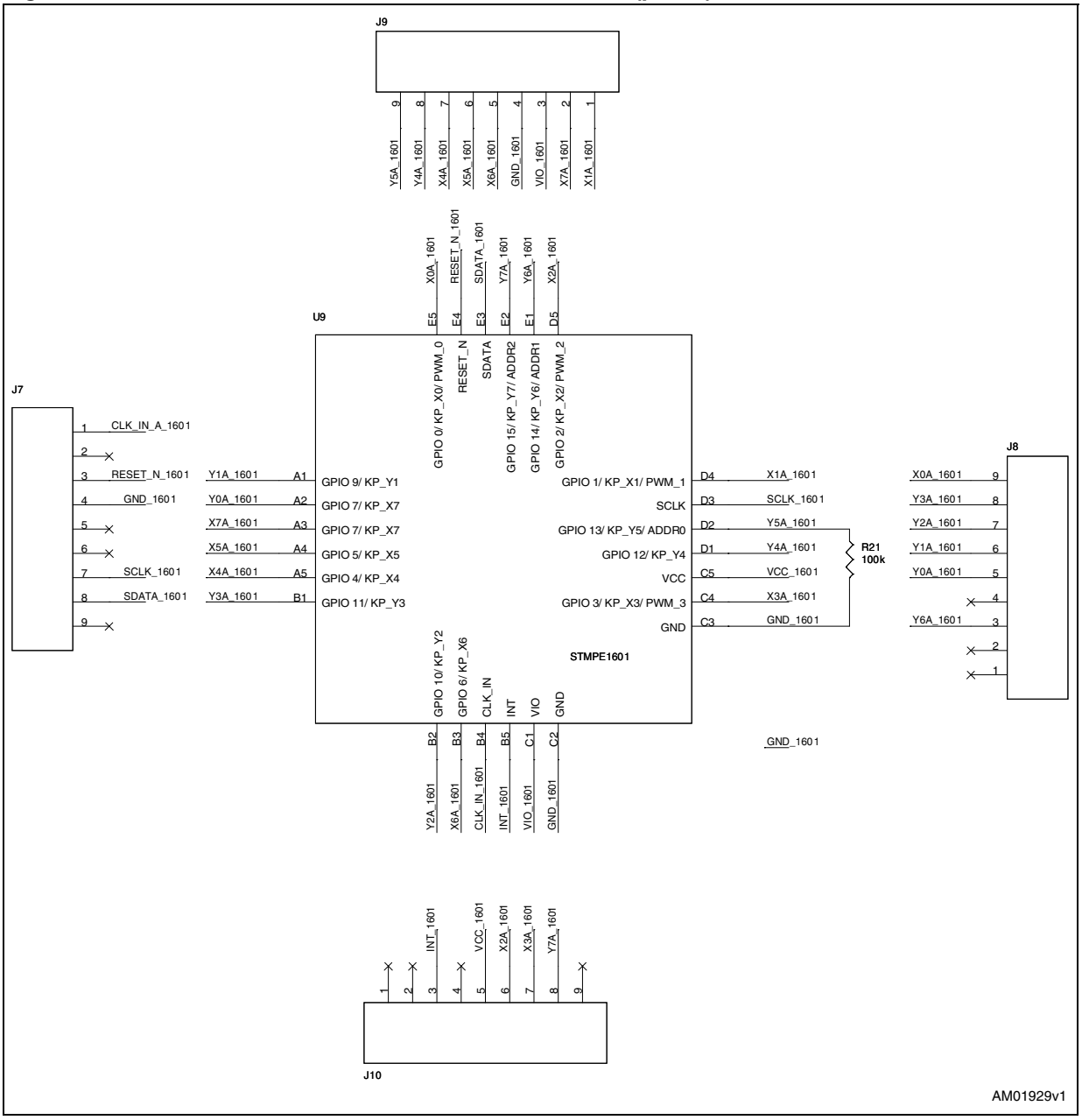


**Figure 23. STMPE2403 demonstration board schematic (part 2)**

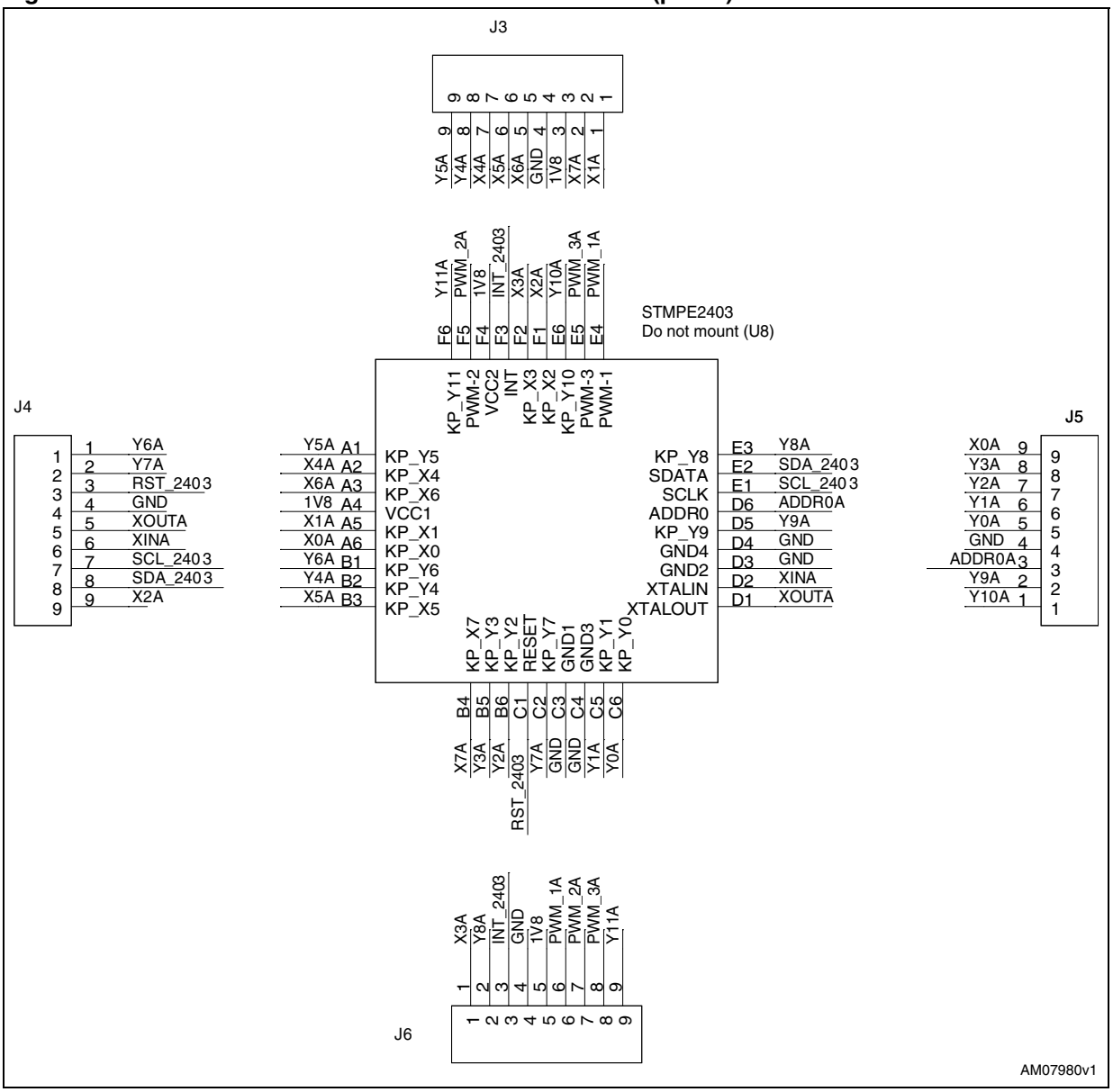


**Figure 24. STMPE1601 schematics**

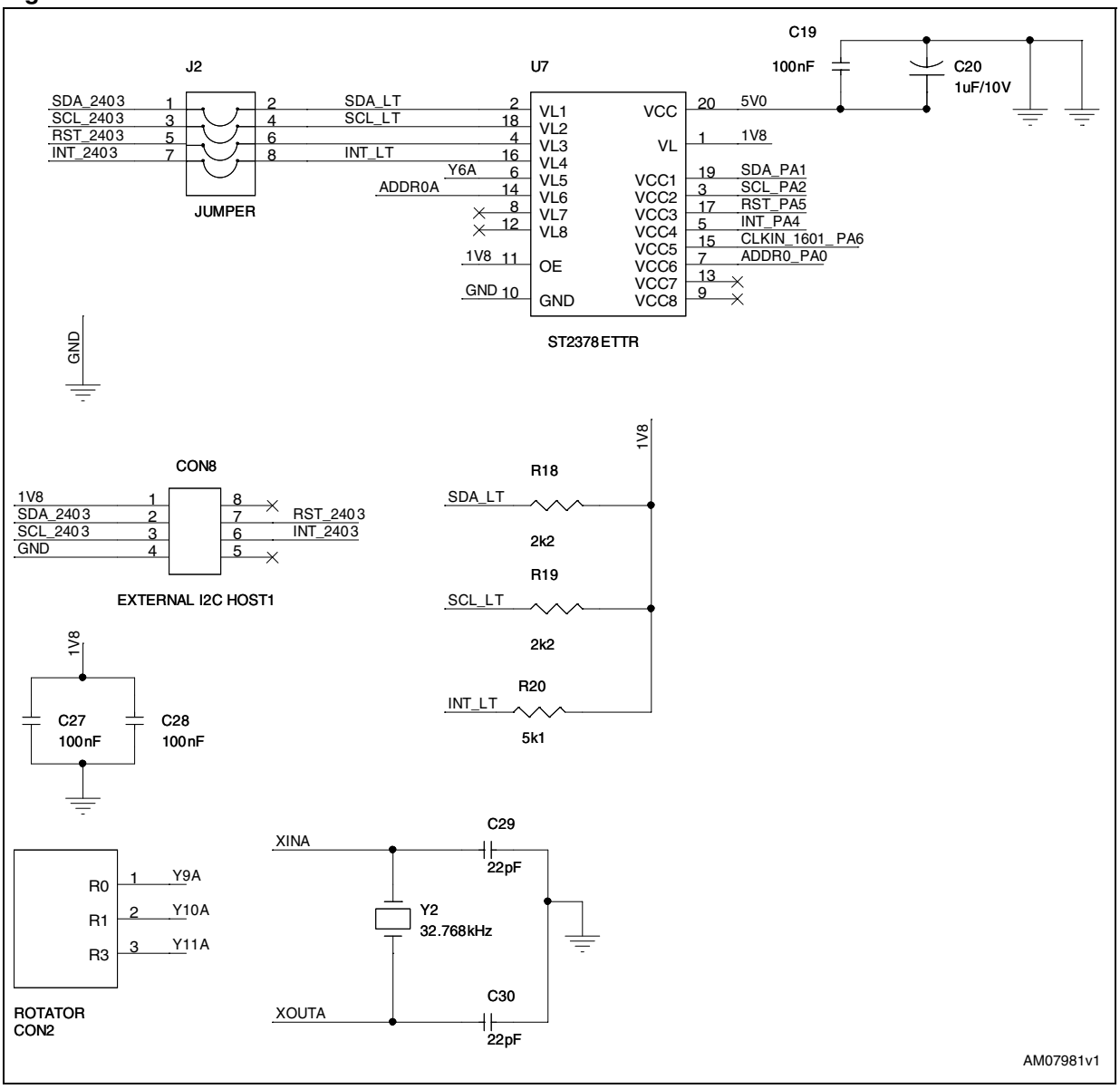


**Figure 25. Keypad schematic**

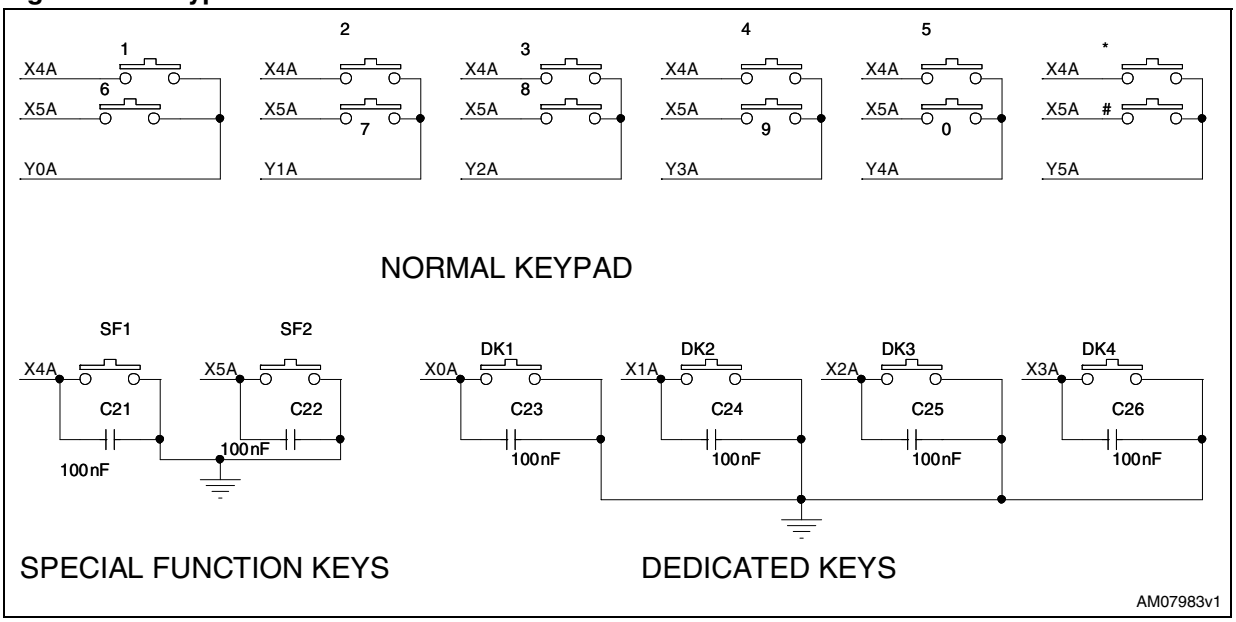


**Figure 26. LCD interface and power supply schematics**

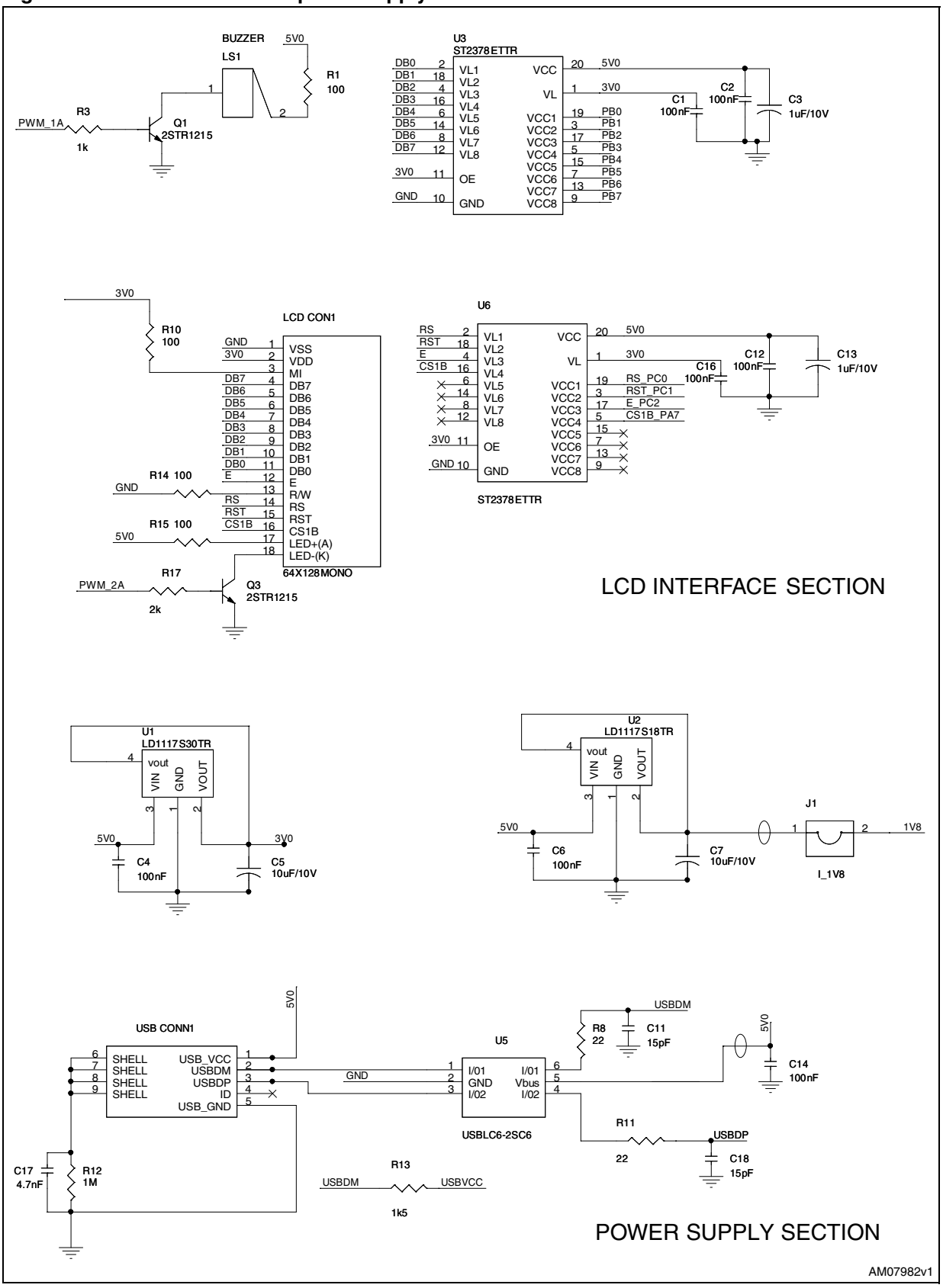
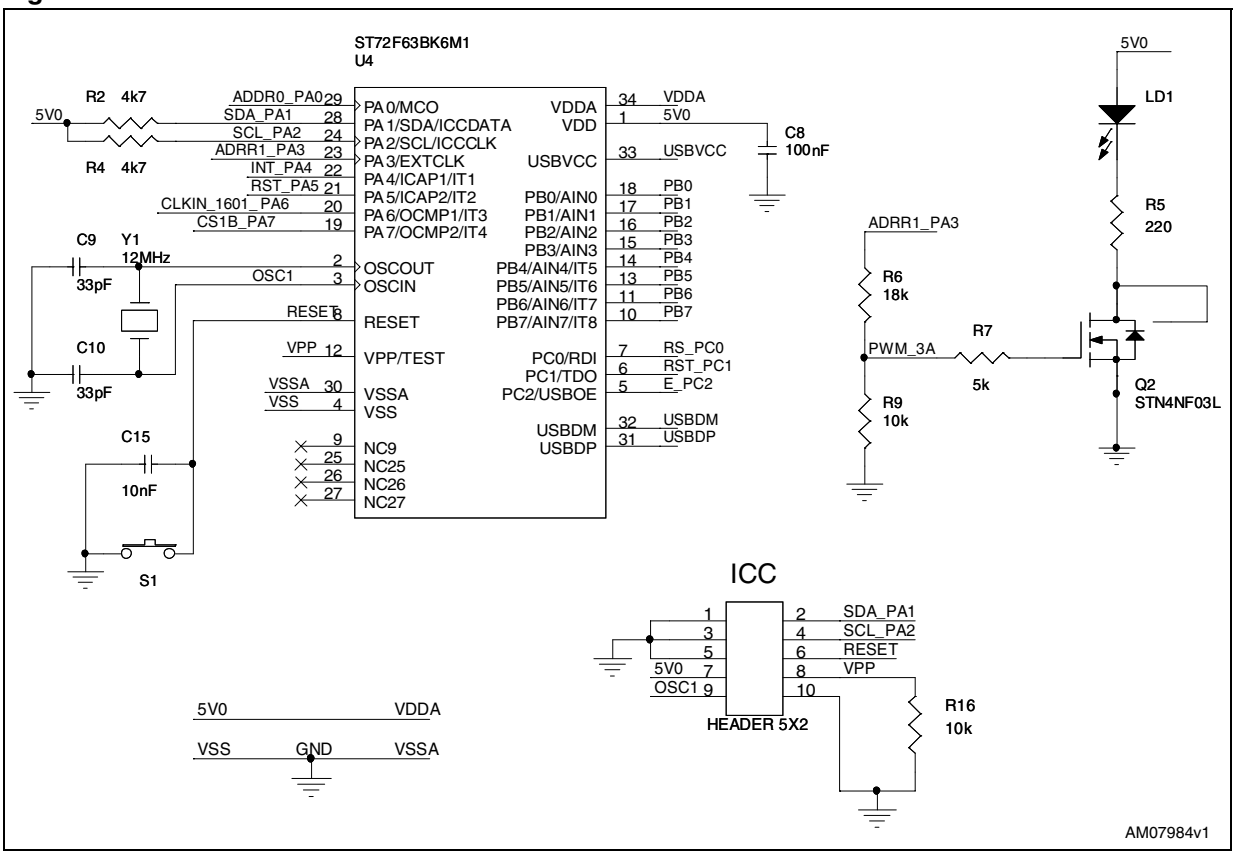


**Figure 27. ST7 microcontroller schematics**




## A.1 Bill of material

**Table 1. BOM**

| Reference | Value / generic part number | Package |
|---|---|---|
| SF1,DK1,1,SF2,DK2,2,DK3,3,DK4,4,5,6,7,8,9,0,*,# | SW pushbutton | Push button |
| CON1 | Header 5X2 | IDC-10B |
| CON2 | Rotator | SIP3 |
| C1,C2,C4,C6,C8,C12,C14,C16,C19,C21,C22,C23,C24,C25,C26,C27,C28 | 100 nF | 805 |
| C3,C13,C20 | 1 µF/10 V | RB-5.5 |
| C5,C7 | 10 µF/10 V | RB-5.5 |
| C9,C10 | 33 pF | USB-B |
| C11,C18 | 15 pF | 805 |
| C15 | 10 nF | 805 |
| C17 | 4.7 nF | 805 |
| C29,C30 | 22 pF | 805 |

Table 1. BOM (continued)

| Reference | Value / generic part number | Package |
|---|---|---|
| D1 | LED | LED-3 mm |
| EXTERNAL $I^2C$ HOST1 | CON8 BERG 2 WAY | 2 x SIP4 |
| J1 | I_1 V8 | SIP2 |
| J2 | JUMPER BERG 2 WAY | 2 x SIP4 |
| J3,J4,J5,J6 | Bugstick single | SIP2 |
| J7,J8,J9,J10 | Bugstick single | SIP9 |
| LCD CON1 | 64X128MONO BERG 2 WAY | 2 x SIP9 |
| LS1 | BUZZER | AXIAL |
| Q1,Q3 | 2STR1215 | SOT-23 |
| Q2 | STN4NF03L | SOT-223 |
| R1,R10,R14,R15 | 100 E | 805 |
| R2,R4 | 4.7 kΩ | 805 |
| R3 | 1 kΩ | 805 |
| R5 | 220 E | 805 |
| R6 | 18 kΩ | 805 |
| R7 | 5 kΩ | 805 |
| R8,R11 | 22 E | 805 |
| R9,R16 | 10 kΩ | 805 |
| R12 | 1 MΩ | 805 |
| R13 | 1.5 kΩ | 805 |
| R17 | 2 kΩ | 805 |
| R18,R19 | 2.2 kΩ | 805 |
| R20 | 5.1 kΩ | 805 |
| S1 | Reset | Push button |
| USB CONN1 | USB-B | Any |
| U1 | LD1117S30TR | SOT-223 |
| U2 | LD1117S18TR | SOT-223 |
| U3,U6,U7 | ST2378ETTR | TSSOP20 |
| U4 | ST72F63BK6M1 | SO-34 |
| U5 | USBLC6-2SC6 | SOT-23-6L |
| U8 (do not mount) | STMPE2403 | TFBGA36 |
| U9 | STMPE1601 | TFBGA24 |

Table 1. BOM (continued)

| Reference | Value / generic part number | Package |
|---|---|---|
| Y1 | 12 MHz | CRYS |
| Y2 | 32.768 kHz | XTAL-3 |

# Revision history

Table 2. Document revision history

| Date | Revision | Changes |
|---|---|---|
| 22-Mar-2011 | 1 | Initial release. |

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