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PW-SB169 PW-SB1611

Soroban development kit with LCD, RTC, SD Card

Description	Hardware description of the Soroban development kit		
Document version	Date	Version	Changes
	January 2007	1.0	Initial version.
	October 2007	1.1	Cosmetic changes, added reference to SB1611

1 Introduction

Soroban is a low-power general purpose development board with real-time clock and data recording capability. It is probably the smallest existing development board in the MSP430 world with this level of functionality. Everything has been designed with small size and low power consumption in mind so that it can be actually used as a hand-held device even in the development phase. It uses a Texas Instruments MSP430 microcontroller which is designed for low-power hand-held applications.

This document is valid for both PW-SB169 and PW-SB1611 because the hardware is the same. Only the on-chip memory is different.

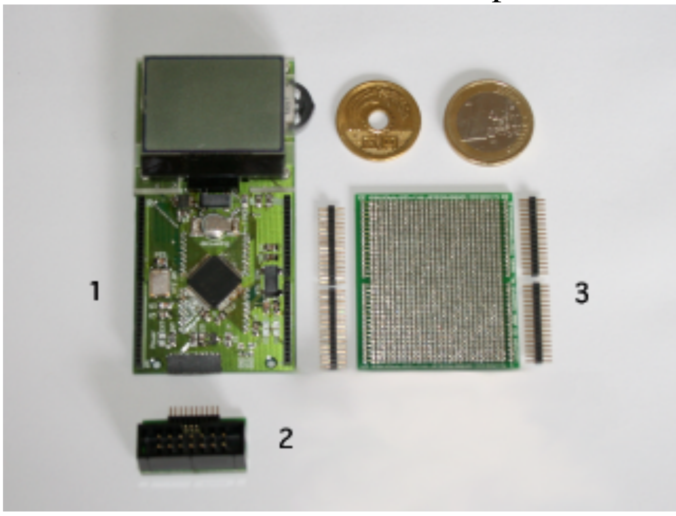
The applications for Soroban are long span measurements where the CPU power is critical. Typical examples are:

- Medical measurements; monitoring of heart rate, blood oxygen, body temperature, ECG…
- Sport measurements: measurements of oxygen and heart rate for marathon runners, measurement of oxygen for extreme conditions such as high altitude mountain climbers.
- Long-time meteorological measurements.
- Soroban kit can also be used as a microcontroller programming training platform. It is provided with an expansion board on which chips can easily be soldered. The hole pitch is 1,27, which makes it easy to use both 1.27 SOT chips, but also 2.54 regular DIL chips.

2 Hardware description

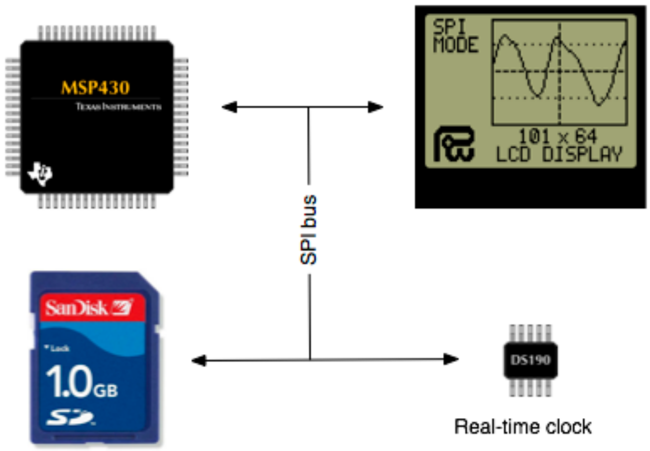
As shown on the next picture, the Soroban development kit consists in a mother board (1), a universal PCB daughterboard (2) and a JTAG adapter (3).

The board size is 80 x 40 mm. The coins on the picture are not part of the kit.



2.1. Motherboard hardware

Soroban motherboard can be summarized with the following block diagram. It is built around a MSP430F169 or F1611microcontroller, and has a real-time clock, an SD card slot a 101 x 64 pixels graaphic LCD and a navigation button (not represented in the block diagram)..



2.2. Board overview

Here is a list of Soroban's components and a short description of their functionality.

2.2.1 Microcontroller:

As said previously, the microcontroller used in this hardware is a MSP430. We have chosen the F169 model which should cover most of the applications with its 8 12-bit ADC converters, 2 DAC, USARTs, SPI, I2C, timers, etc.. It features 60 kBytes of flash memory and 2K RAM. It is pin-compatible with the 14x series which are cheaper MCUs without I2C capability.

A new version has been produced with a MSP430F1611 which has more RAM (10kBytes instead of 2) but less Flash (48k instead of 60).

A specifications sheet have been placed on our hompepage at the dollowing URL: http://passworld.co.jp/CustomerSupport . There are 2 documentations. One called MSP430F169Specs is a description of the chip characteristics. Another one, called MSP430F169UG.pdf is a user guide. This is the document you need for accurate information on the chip itself in order to use its features at best. CAREFUL: if you want a hardcopy, be sure of what you do. This latter document is more than 400 pages long.

All the software sample code provided by Texas Instruments can be used for reference in order to start software development. Texas Instruments' software archive is caled slaco69b.zip and is available at TI's homepage.

2.2.2 Real-time clock:

The DS 1390 real-time clock is a SPI compatible real-time clock with alarm capability. Although the MSP 430 can handle time with its low frequency crystal, we have chosen this solution to avoid time management in software amd also because this chip can run in standalone even when the board is not powered as explained hereafter. Among its advantages:

The DS1390 manages time including leap years, day of the week, day of the month, hour (12 or 24) minutes, seconds, hundreds;

Allows a time of the day alarm;

Manages the charge of its own backup battery or capacitor (we have chosen a 0.2 F supercap);

Switches automatically to its backup battery or capacitor when the power is down;

As this chip's power consumption is extremely low, the time can be updated even when the circuit is powered off. For the time being, we didn't test how long the time can be kept, but as the power consumption is typically 500 nA, the clock should run for about 10 days without being powered.

A full documentation of this chip is available on our homepage at the following URL: http://passworld.co.jp/CustomerSupport . It is named MaximRTC.pdf. It contains all information to control the chip and modify the driver that we provide in the file **RTCTest.rar** (same URL). We have implemented some of the features of this chip, but the implementation is not complete.

2.2.3 SD card

Soroban can store data in an SD card in SPI mode. The SD card holder is a reverse type holder soldered under the board. A simplified FAT 16 file system can be implemented in order to allow data reading on a PC. We have chosen the SD format because of its size and its SPI access mode. Another advantage is that it also can accept MMC cards.

Sample code showing how to write data blocks to the SD card can be found on our homepage at the following URL:

http://passworld.co.jp/CustomerSupport .

NOTE: we provide now a FAT16 file system implementation but only in executable library form. This version is restricted: 5 files maximum and each file has a 250-byte header.

A non restricted executable version can be purchased, and a source license is also available.

2.2.4 LCD

Soroban is equipped with a 101x64 LCD. The power consumption is high compared to the MCU, but still moderate. Power measurements shows that Soroban draws about 5 mA in measurement mode (display included). In this experiment, the display was always on, and the MCU low-power mode was not used and it was running at 8 MHz.

An oscilloscope-like application has been written, that outputs acceleration levels in 2 dimensions, which proves that this LCD can be used for dynamic graphics. However, don't expect to display Tom & Jerry animations.

Sample code showing how to write characters and graphics to the LCD can be found on our homepage at the following URL:

http://passworld.co.jp/CustomerSupport .

The file is named LCDDemo.rar. It shows how to write characters on the screen, and also bitmaps (e.g. your company logo).

2.2.5 Navigation switch

We have chosen a 3-position (up, down, select) navigation switch. It is extremely thin (less than 2mm) and fits under the LCD. It can be used to create a menu navigation.

Sample code showing how to write characters and graphics to the LCD can be found on our homepage at the following URL:

http://passworld.co.jp/CustomerSupport .

The file is named **NavSwitch.rar** and it provides a reference software to catch navigation interrupts and avoid bounces of the switch.

2.3. Other info about the board

Tis board is meant to receive extensions for your developments.

2.3.1. Expansion connectors

We have used 4 connectors for expansion purposes. All the MCU pins are linked to these connectors. These connectors are 1.27 pitched pin headers and sockets (female on Soroban, male on the mezzanine). As these connectors are single row fine pitched connectors, they should be handled with care. See next chapter for detail.

2.3.2 JTAG connector

Regular 14-pin JTAG connectors found on most of evaluation boards are quite big (almost 9 mm in height and width and 25.4 mm in length. This is a lot too big for a hand-held application. We have therefore used a thinner connector, 1.8 mm in height, 13mm wide, 10 pins. The pitch is 1.27, and we provide a connector adaptor allowing to connect the board to the standard Texas Instruments 14-positons flat cable.

2.3.3 Mezzanine

Soroban is delivered with one experiment mezzanine. It features a matrix of metallized holes, 26 lines,33 columns (therefore 858 possible connexions). 64 of these holes (line A and line Z) are connected to the CPU pins. The pitch of these holes is 1.27mm, allowing to use SOT packaged circuits, and also 2.54 mm through hole circuits.

3 Getting started

Soroban is compatible with TI's parallel or USB emulation tools. TI's free version of CCE (Code Composer Essentials) allowed us to develop all the experimentation programs. It is limited to 8kBytes exec code, and therefore may not be sufficient, depending on the application complexity.

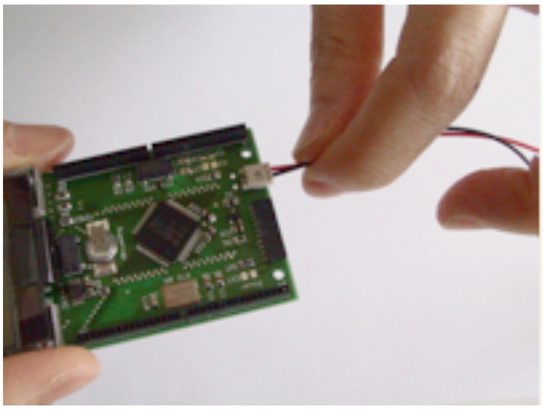
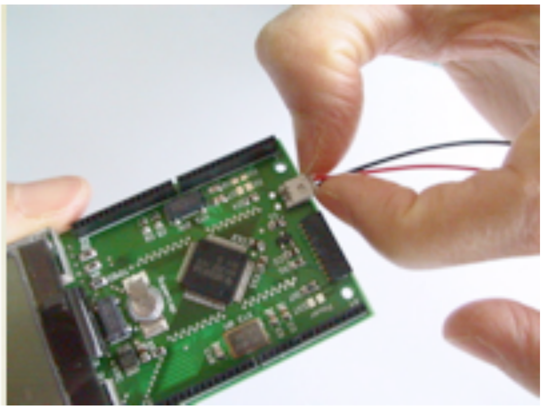
3.1. Power supply

Soroban can be powered by any voltage between 3.7V and 6V. It is meant to be powered by Li-ion pr Li-polymer batteries as well as other types (e.g. 4 AAA batteries).

There are 2 places for power connectors. One has a pitch of 2.54 and the other 1.25 ~ 1.27. This latter pitch fits many types of Li-ion batteries.

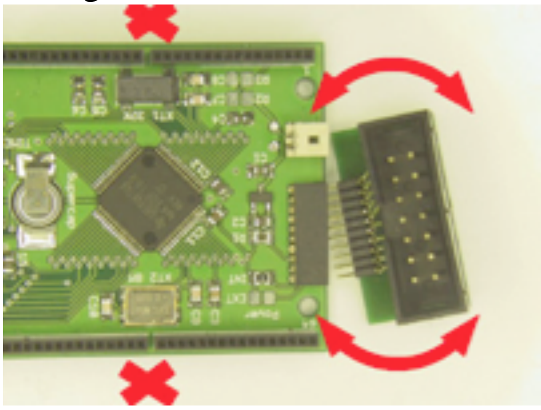
We have recently updated the board with a small 1.25 mm connector form Hirose (DF130 series).

Although this should be common sense, never pull the wire as indicated in the left image, but pull the connector with you nails or wih a small instrument if your nails are too short.

3.2. Plugging the JTAG interface

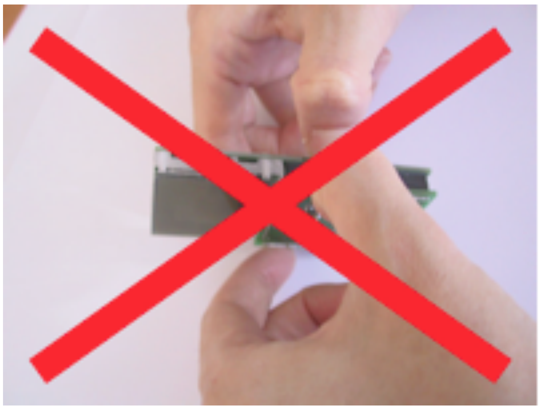
The next pictures show howto plug the JTAG interface. Do not hold the card by the connectors (red crosses on the image), you could brake them. Insert the adapter at one side and then push the other side. If it does not enter at once, turn it left-right a couple of times while pushing it into the board connector. It should enter smoothly. If you feel it gets blocked, do not force it.

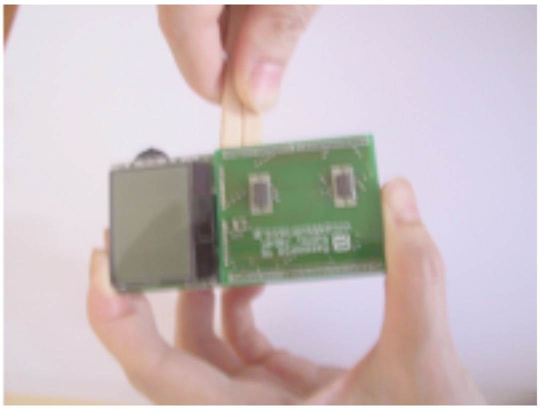



3.3. Plugging and removing the mezzanine board

When you plug the mezzanine, do exactly as for the JTAG connector: start inserting one side of the board, then press gradually to fit all the connectors into the board.

When removing the mezzanine board (see the pictures above), do not pull directly as shown on the left picture hereafter. Use a piece of wood as indicated on the right picture.

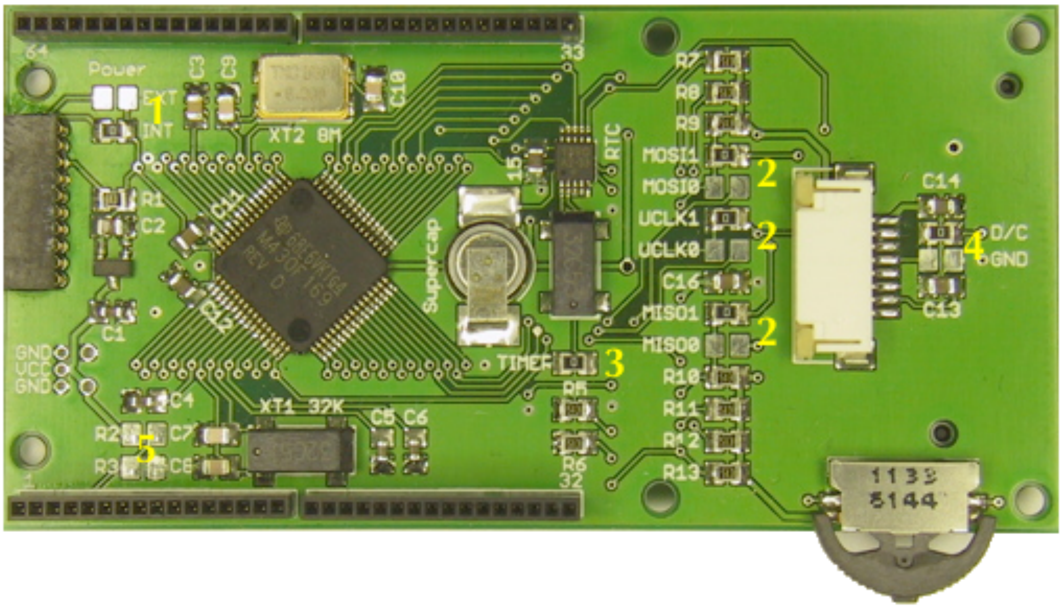




3.4. Jumper and resistors configuration.

This describes the board factory configuration and the possible modifications of the resistors. The following picture shows the location of the various jumpers and resistors. We would advice that you change this once you have verified that the board works as expected.

Here is a short description of these configurations. The following picture shows what should be changed. The yellow numbers correspond to the paragraphs (e.g. yellow number 1 corresponds to paragraph 3.4.1, and so on).



3.4.1 Power supply

Please refer to point 1 on the top left of the picture.

You can configure the power supply to be internal (the board is powered by its battery) or external (the board is powered by the JTAG interface. Therefore, you should either put a SMD jumper beside "INT" or "EXT".

If you configure the board to have its own power source (default), you can supply a DC voltage to the power input. The power contacts on the board were designed to cope with either polarity. You just have to solder the power connector (1.25 or 1.27 mm pitch) with the power in the middle.

2.2 SD SPI configuration

Please refer to point 2 on the right of the picture.

In case you want a dedicated port for the SD card (for instance if you want to ensure a maximal throughput), you can set SMD jumpers to MOSI0, UCLK0, and MISO0 instead of the default MOSI1, UCLK1 and MISO1. The default was set to the port 1 in order to leave the possibility to easily use the I2C bus which shares the same pins as the port 0.

2.3. TIMER

Please refer to point 3 on the middle-botom of the picture.

It is possible to use the real-time clock to wake up the MSP430. In this case, a jumper has to be set to "TIMER", which sets the RTC output to port1.4.

2.4. LCD SPI mode

Please refer to point 4 on the right of the picture.

The 101x64 LCD used in Soroban has 2 modes. One 3-wire SPI and one 4-wire SPI mode. In 4-wire mode (default), the extra wire tells the LCD whether the current bytes are command or data. By removing the D/C jumper and setting it to GND, it is possible to use the LCD in 3-wire mode.

2.5 Battery measurement

Please refer to point 1 on the bottom left of the picture.

It is possible to measure the battery level by setting two resistors R2 and R3. These resistors output a fraction of the input battery voltage (i.e. before the LDO regulator), which can be measured on port P6.7. These resistors depend on the kind of battery you use.

3.5. Starting code composer or IAR

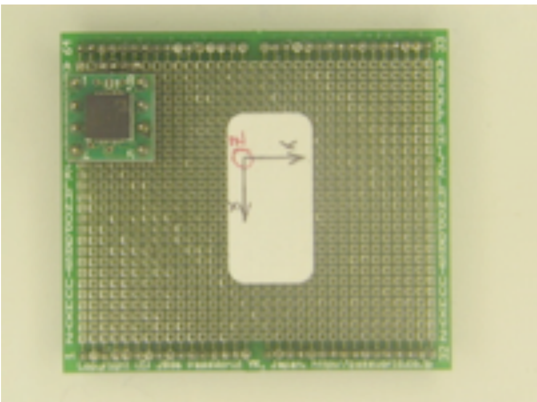
Code composer essentials can be downloaded from TI's home page. IAR can be downloaded from IAR systems or simply from our homepage. Install it, enter the license key if you use IAR, and you are ready to go.

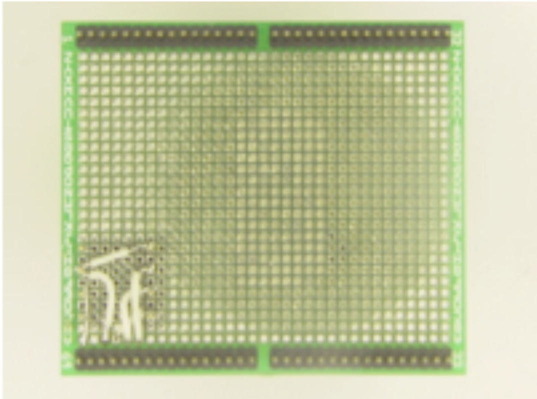
Download one of the sample programs, (for instance LCDTest) open the folder and double click the project file. It should open at once. Compile and run, and you should see a minimal program to use the LCD.

Soroban programming will be extensively described in another document for software.

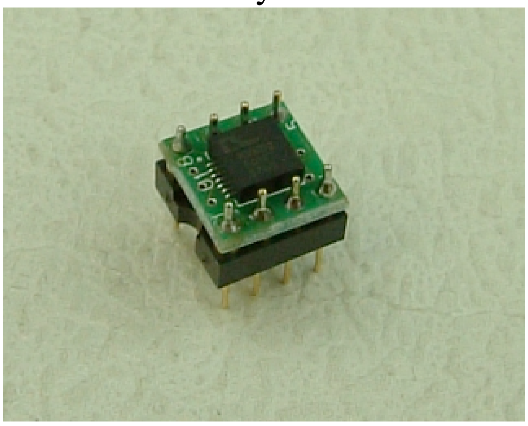
4 Developing your own hardware.

You probably bought this board for evaluation before developing your own hardware, in which case you may start with the small universal printed circuit that comes with the board. As an example, we are going to describe the development of an accelerometer.





These 2 pictures show our accelerometer implementation. We have used an accelerometer made by Kionix.



The next picture shows a closeup of this acclerometer. it is solddered on a DIP-8 like printed circuit which makes it very convenient for prototyping. This little board is based on a Kionix 3D analog accelerometer. Only power and ground has to be provided, and the accelerometer provides voltages corresponding to the 3 axis. These voltage are then used measured using P6.0, P6.1, P6.2 at a rate of approximately 100 Hz in our application.

As you can see, this application required 5 wires to be soldered, and we built the program based on Texas Instruments MSP430 sample code. This experiment is explain in more detail in Soroban Software guide.

For your own applications, please always refer to Appendix 1 which describes the pin assignment of the mezzanine.

5 Conslusion

We have designed this board with portability in mind and we have shown its ability to be used in home designs as well as prototypes for portable measurement devices used in medical applications for example.

We are aware that this first version is not perfect, and we would be glad to receive your comments and feature requests.

Do not hesitate to go to our homepage regularily as there will be updates to our software and documentation.

Appendix 1

Extension board pin assignment

All pins of the MSP430F169 / F1611 are mirrored on the mezzanine board with the same numbering. Here is an extensive description of the pins. Let's start with color conventions.

Color	
Black	Used, but available (e.g, VCC, ground, SPI bus) or pins that are unlikely to be reused (crystal pins).
Red	Used by Soroban and not available to other applications
Blue	Used in Soroban factory setting, but can be modified to another pin, but can be modified by moving a jumper (e.g. SPI port 0)
Green	Unused in Soroban and therefore fully available to the mezzanine.

Here is the pin assignment table

(1) SD card protection switch should not be among the interrupt-enabled signals because it cannot be changed without removing the board. However it has been placed here in order to group the SD related switches although it occupies a possible interrupt. However, as the port2 is completely unused by the main board, there is quite some room for interrupt signals.

(2) P1.4 is connected to real-time clock output if the SMD jumper labeled "timer" is soldered.

(3) These 3 lines are not used in the default Soroban implementation. However, the user may choose to dedicate this port to memory card in case there is a great amount of data to be written at a high rate (e.g. audio recorder). In this case, the jumpers labeled UCLK0, MISO0 and MOSI0 have to be moved to UCLK1, MISO1 and MOSI1 respectively.

Hint for people developing a mezzanine: print the following table, and write in the column "soroban usage" what it will be connected to. Example: GPS module Rx, GPS module reset, etc. It will be easier for the design of your board. This way, you will not reuse pins that are already in use.

Pin Nb	MSP430 use	Soroban usage
1	DVcc	
2	P6.3/A3	
3	P6,4/A4	
4	P6.5/A5	Battery monitoring
5	P6.6/A6	
6	P6.7/Ay/SVSin	
7	Vref+	
8	Xin	
9	Xout	
10	Veref+	
11	Vref- / Veref-	
12	P1.0/TAck	Navigation switch UP
13	P1.1/TA0	Navigation switch DOWN
14	P1.2/TA1	SD card detection
15	P1.3/TA2	SD card protection. (1)
16	P1.4/SMCLK	Real-time clock alarm (2)
17	P1.5/TA0	
18	P1.6/TA1	
19	P1.7/TA2	
20	P2.0/ACK	
21	P2.1/TAINCLK	
22	P2.2/CAOUT/TA0	
23	P2.3/CA0/TA1	
24	P2.4/CA1/TA2	
25	P2.5/Rosc	
26	P2.6/ADC12CLK/ DMAE0	
27	P2.7/TA0	
28	P3.0/STE0	
29	P3.1/MOSI0/SDA	(3)
30	P3.2/MISO0	(3)
31	P3.3/UCLK0/SCL	(3)
32	P3.4/UTDXD0	
33	P3.5/UTRXD0	
34	P3.6/UTDXD1	

Pin Nb	MSP430 use	Soroban usage
35	P3.7/UTRXD1	
36	P4.0/TB0	SD card chip select
37	P4.1/TB1	Real-time clock chip select
38	P4.2/TB2	LCD chip select
39	P4.3/TB3	
40	P4.4/TB4	LCD reset
41	P4.5/TB5	LCD Data/Command
42	P4.6/TB6	
43	P4.7/TBCLK	
44	P5.0/STE1	
45	P5.1/MOSI1	
46	P5.2/MISO1	
47	P5.3/UCLK1	
48	P5.4/MCLK	
49	P5.5/SMCLK	
50	P5.6/ACLK	
51	P5.7/TBOUTH/SVSOUT	
52	XT2OUT	
53	XT2IN	
54	TDO/TDI	
55	TDI/TCLK	
56	TMS	
57	TCK	
58	RST/NMI	
59	P6.0/A0	
60	P6.1/A1	
61	P6.2/A2	
62	AVss	
63	DVss	
64	AVCC	

Appendix 2.

Mezzanine dimensions

For your custom-made development, here are the dimensions of the mezzanine board.

The connectors'pitch is 1.27mm, and their location is defined on the following drawing.

Note: 46.5 mm is the max length of the default (development board) mezzanine. But it is possible to extend as much as you want as long as the LCD is not hidden.