UM10854

LPC54102 SPM Solution Hardware User Manual (OM13078)

Rev. 1.1 — 26th October 2015 Hardware User manual

Document information

Info	Content
Keywords	LPC54102, LPC54100, Sensor Processing
Abstract	LPC54102 Sensor Processing/Motion Solution Hardware User Manual

Revision history

Rev	Date	Description
1.0	<20141104>	First draft
1.1	<20151026>	Added note on BMI160 and AMS001 component changes. Clarified use of correct LPCOpen package for different board builds.

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1. Introduction

The LPC54102 Sensor Processing/Motion Solution (SPM-S) combines the LPC54102 MCU and a range of MEMS sensors in a two board set, complemented by a software framework optimized for always-on sensing applications. The hardware consists of an LPCXpresso54102 board and Sensor Shield Board (SSB), developed by NXP for flexibility and ease of use. The solution can be used with a wide range of development tools, including the NXP's LPCXpresso IDE, Keil uVision and IAR EWARM.

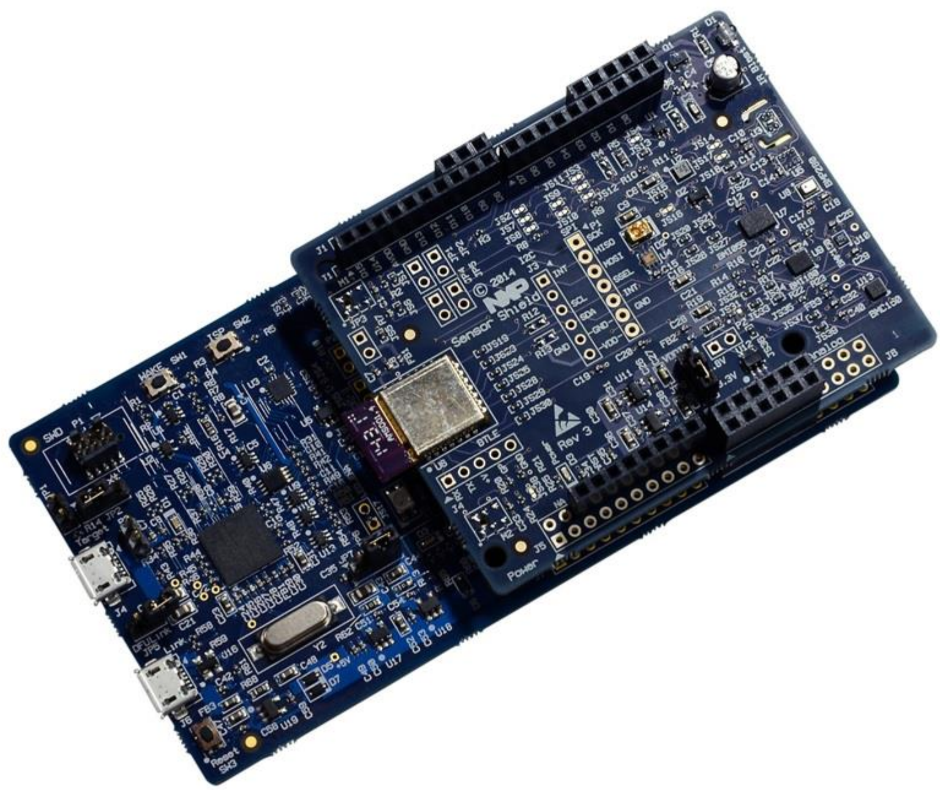

Fig 1. LPC54102 Sensor Processing/Motion Solution

The LPCXpresso54102 SPM-S includes the following features:

- LPCXpresso54102 development board with:
    - Built-in Link2 high-speed USB based debug probe
    - Connectivity for external debug probes
    - Tri-color LED
    - Target Reset, ISP and WAKE buttons
    - On-board 1.8/3.3V or external power supply options

  - Built-in MCU power consumption and supply voltage measurement for LPC54102 device and sensor board
  - UART, I²C and SPI port bridging from LPC54102 target to USB via Link2 device
  - FTDI UART connector
  - LPC54102 in LQFP64 package
- Sensor Shield Board with:
  - Bosch Sensortec sensors: BMI160 inertial measurement unit (BMI055 on earlier boards), BMC150 digital compass, BMM150 magnetometer, BMP280 pressure/temperature sensor
  - Murata pressure/temperature sensor
  - MAX44000 ambient light and proximity sensor
  - ACKme AMS001 (or AMS002 on earlier production units) Bluetooth LE module
  - IR remote control driver/receiver
  - Dual Knowles digital microphones
  - Headers for easy prototyping of additional SPI and I²C sensors
- Software
  - Free NXP Sensor Framework
  - Free Bosch Sensortec BSXlite sensor fusion library

This manual covers features, configuration and use of the hardware in the Solution. For information on use of the Sensor Framework please refer to the Programmer's Manual.

The SSB is mounted on the expansion connectors of the LPCXpresso54102 during manufacture. The boards are configured for the default operation of the Sensor Framework software and its operation with the Bosch BSX Lite library.

2. Getting Started

The flash memory of the LPC54102 MCU on the SPM-S is pre-programmed with an example application to show operation of the BSX Lite sensor fusion library within the NXP Sensor Framework. The example application streams board orientation information over the LPC54102 I²C port, via the on-board Link2 debug probe device's USB port, to a host computer (running Windows 7, 8 or 10). The example renders a 3D teapot from the OpenGL library to represent orientation and movement of the board, using accelerometer, gyroscope and magnetometer data processed by the BSX Lite library.

Earlier production units of the Kit were programmed with the LPCOpen 2.14.1 version of the example program (these kits have the ACKme AMS002 BTLE module and BMI055 IMU sensor). It is recommended that you download and use the latest (LPCOpen 3) software for best results.

To run the example application follow these steps:

1) If you have not installed LPCXpresso IDE version 7.8 or later, and have not installed LPCScrypt on your computer, download and run the LPCXPresso Link2

USB driver package driver installer from: http://www.lpcware.com/content/nxpfile/lpcxpresso-link2-usb-driver-package.

2) Ensure JP5 is open (no jumper installed) on the LPCXpresso54102 to make the Link2 processor boot from internal flash memory. The factory-programmed Link2 flash image includes I2C to USB bridging support required to support the demonstration. Connect the host computer to the LPC54102 SPM-S board set at connector J6 using the supplied micro USB cable. Allow about 30 seconds for the board devices to enumerate the first time you connect it

3) Download the example Windows PC application available from the LPCOpen section of the lpcware website at this address: http://www.lpcware.com/content/nxpfile/lpcopen-software-development-platform-lpc5410x-packages

4) Run the teapot.exe application. A 3-dimensional rendition of a multi-colored teapot will be displayed. The board's location and movement will be represented by the teapot's orientation. By pressing the "s" key on your computer the orientation can be reset to match the board's orientation. Note that the board's orientation can be affected by magnetic and electrical fields.

NXP and Bosch Sensortec continue to improve and enhance the Sensor Framework and BSX Lite library. Check http://www.lpcware.com/content/nxpfile/lpcopen-software-development-platform-lpc5410x-packages for the latest updates to the firmware image for this application. If you have any issues running the example program please download the example code for your tool chain of choice mentioned in step (3) above.

3. LPCXpresso54102 Board

The details of the LPCXpresso54102 board described in this manual are limited specific to those specific to this Solution; for a full description of the board's features please refer to the LPCXpresso54102 User Manual (UM10855), available at http://www.lpcware.com/lpcxpressov3boards.

3.1 Power supply configuration

The LPCXpresso54102 includes on-board regulators to supply 3.3V or 1.8V to the LPC54102, configured using JP7. The supply is configured to 3.3V by default.

3.2 Expansion connector

The LPC54102 SPM-S utilizes the LPCXpresso54102 expansion connector to interface to the SSB. Since the Arduino Uno Revision 3 standard does not provide enough signals to support all the functionality required for the SSB, the LPCXpresso54102 board has an extended version of that connection standard. The new expansion connector footprint has been designed for future expansion and provides more connections than are needed to support the LPC54102, so not only a subset of the connectors is installed.

3.3 Supply current/power measurement

The LPCXpresso54102 has built-in power measurement circuitry, controlled by its on-board Link2 debug probe. This circuitry can measure power consumed by the LPC54102 by sampling the voltage dropped across a sense resistor on the board using a differential amplifier, sampled at up to 200kHz by a 12-bit ADC. The power consumed by the SSB can be measured as well, since the SSB has a similar differential amplifier/sense resistor circuit. An analog multiplexer is used to select between these measurement sources. The

Link2 is not user-programmable, so NXP has developed a power measurement tool to utilize these features. Please visit http://www.lpcware.com/lpcxpressoboards for more information.

The LPC54102 SPM-S is design for flexibility and hence has circuitry that may not be required for all applications. Before making power measurements, carefully review the schematics of both boards to understand potential current leakage paths, since these may introduce power consumption that is not relevant to the end application. For example, review the jumpers/solder jumpers related to the sensors, I^2C/SPI/UART connections to the Link2, tricolor LED and BTLE module to understand the options to reduce power supplied to these parts of the board set.

3.4 Host process connections

For applications where the LPC54102 will be used as a slave device, such as in a sensor hub, the PMod™ connector on the LPCXpresso54102 provides a convenient way to connect an external processor. This connector provides connectivity to the LPC54102 SPI0 and I2C2 ports.

4. Sensor Shield Board

The Sensor Shield Board (SSB) is custom-designed expansion board, based on extended version of the Arduino Uno Revision 3 standard. The board includes multiple sensors from Bosch Sensortec and other vendors. Note that the design includes pads for use with other sensors that are not yet generally available.

4.1 Sensors

This section provides a brief overview of the sensors on the SSB.

4.1.1 Bosch Sensortec (motion and pressure/temperature sensors)

The SSB incorporates four Bosch Sensortec sensors: BMI055 or BMI160 inertial measurement unit, BMC150 eCompass, BMM150 magnetometer and BMP280 pressure/temperature. All of these sensors are connected to the same I^2C bus (I2C0 signal) and all have interrupt output lines to the LPCXpresso54102 board except the BMP280. Please refer to http://www.bosch-sensortec.com/ for more information on these sensors.

The BMI055 (if fitted) has a minimum supply voltage of 2.4V, so cannot be used with a 1.8V supply SSB supply voltage setting; it can be used with the LPCXpresso54102 VDD set to 1.8V.

4.1.2 Proximity/ALS Sensor

A Maxim MAX44000 ambient light and proximity sensor is provided on the SSB, along with an IR LED to be used in conjunction with that sensor to implement a proximity detection function. For further information on this device please refer the http://www.maxim-ic.com.

4.1.3 Murata pressure sensor

A Murata ZPA2326 pressure & temperature sensor is installed on the SSB. This sensor cannot be used with 3.3V I/O, so is not connected to the I^2C bus by default in order to prevent accidental damage to the sensor. To use this sensor ensure that the LPC54102 is set to 1.8V (JP7 installed in location 1-2 on the LPCXpresso54102) and use a soldering iron to short SJ14 and SJ17. For further information on this sensor please refer to http://www.murata.com.

4.2 Bluetooth Low Energy (BLE) Module

An ACKme AMS001/AMS002 BTLE module is included on the SSB. This module provides a fully integrated BTLE sub-system which can be configured by and receive/transmit data from/to the LPC54102 via a UART connection. A debug port connector for the AMS002 is provided on the SSB, but this should not be used unless advised to do so by NXP or ACKme. For more information on this module please visit http://ack.me. Note that ACKme is a brand of Zentri.

4.3 IR transmitter/receiver

The SSB includes an IR transmitter/receiver circuit designed to implement IR remote control functionality. By utilizing a Vishay VSOP98260 receiver, the same LED can be used to “learn” IR code transmissions from an IR remote control. For learning the source remote control IR LED must be placed within a few inches of the diode. The LED transmitter circuit is designed to be driven by an SPI port. For more information on the Vishay receiver please visit http://www.vishay.com.

4.4 Digital Microphones

The SSB is fitted with two bottom side mounted Knowles SPH0641LM4H microphones. Note that the board is designed to accommodate top side mounted microphones but these are not installed in this Solution kit.

The microphones can be connected to the SPI port or to an alternative I/O control of the LPCXpresso board MCU not supported by the LPC54102. When using the SPI interface only one microphone can be used at a time. Please see Table 1 for jumper configurations.

For more information on the Knowles microphones please visit http://www.knowles.com/eng/Products/Microphones/Surface-mount-MEMS.

4.5 SSB layout and jumpers

The SSB layout with jumper and connector locations highlighted is shown in Fig 2 below.

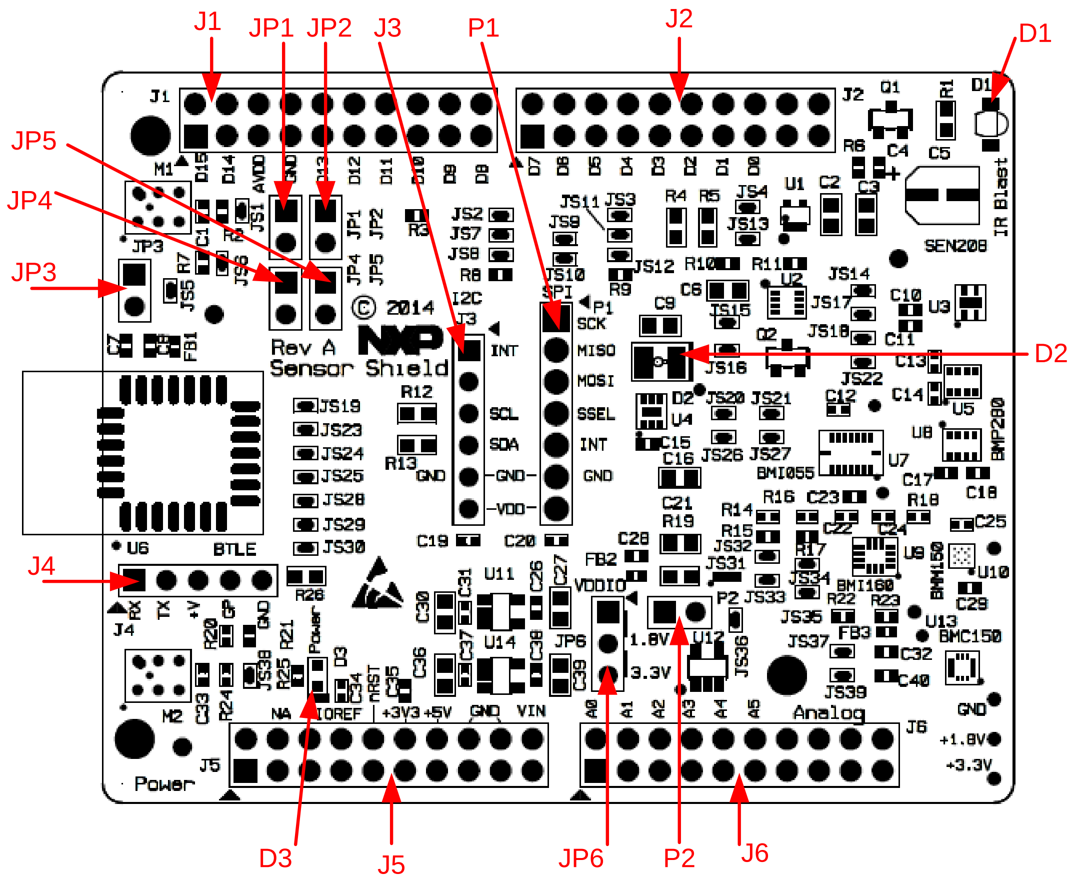

Fig 2. Sensor Shield Board components and interfaces

Table 1 Sensor Shield Board interfaces

Designator	Description
D1	IR circuit LED. D1 is also used as the IR receiving diode for learning IR remote codes.
D2	Proximity sensor IR LED.
D3	Sensor Shield Power LED – LED is on any time power is applied to the board. The D3 LED is powered from the +5V main power in from J5 pin 14. The LED brightness is unaffected by the voltage selected for the sensors.
J1	The odd number pins are compatible with Arduino Uno rev3 Digital 15:8, AREF, SDA & SCL connector. The even numbered pins are used for external access and expansion of the LPCXpresso54102 LPC54102 signals not used by the Arduino Uno rev3 compatible interface.
J2	The odd numbered pins 1 – 13 are compatible with Arduino Uno rev3 Digital 7:0 connector. The even numbered pins, and odd numbered pins 17 and 19, are used for external access and expansion of the LPCXpresso54102 LPC54102 signals not used by the Arduino Uno rev3 compatible interface.
J3	Sensor I^2C expansion header. This header is provided to enable interfacing to an off-board I^2C based sensor.
J4	AMS002 Bluetooth LE module programming / debug access header. Do not attempt to use this connection unless instructed to do so by NXP or ACKme.
J5	The even numbered pins 6 – 20 are compatible with Arduino Uno rev3 Power connector. The odd numbered pins, and even numbered pins 2 and 4 are used.
J6	The even numbered pins 2 – 12 are compatible with Arduino Uno rev3 Analog connector. The odd numbered pins are used for external access and expansion of the LPCXpresso54102 LPC54102 signals not used by the Arduino Uno rev3 compatible interface.
JP1	DMIC2 clock same as DMIC1– 2-position jumper pins. 1) Jumper open (**default**) DMIC2 CLK is not connected to DMIC_CLK from the LPCXpresso54102. 2) Jumper shunted, DMIC2 clock input is connected to DMIC_CLK output from the LPCXpresso54102. Both DMIC1 and DMIC2 will be clocked by the same clockout from the LPCXpresso54102.
JP2	DMIC2 use SPI_SCK – 2 position jumper pins. 1) Jumper open (**default**) SPI_SCK not connected to DMIC2. 2) Jumper shunted to clock DMIC2 from SPI_SCK.
JP3	AMS002 VDD current measurement– 2 position header pins. 1) Jumper open (**default**) by default the header is shunted by 0Ω resistor at JS5. To measure AMS002 current remove the 0Ω resistor at JS5 and insert a current meter across JP3.
JP4	DMIC2 data shares DMIC1 data out– 2-position jumper pins. 1) Jumper open (**default**) DMIC2 data is not connected to DMIC_DATA to the LPCXpresso54102. 2) Jumper shunted, DMIC2 data output is connected to DMIC1 DMIC_DATA output to the LPCXpresso54102. DMIC1 will drive the DMIC_DATA when the DMIC_CLK is low and DMIC2 will drive the DMIC_DATA when the DMIC_CLK is high..
JP5	DMIC2 use SPI_MOSI – 2 position jumper pins. 1) Jumper open (**default**) DMIC2 data out not connected to SPI_MOSI. 2) Jumper shunted to connect DMIC2 data out to SPI_MOSI. The SPI interface must be configured as a slave, and JP1 must be shunted to use DMIC_CLK from the MCU to clock the SPI interface.

Designator	Description
JP6	Sensors voltage select – 3-position jumper pins. 1) Jumper 1 – 2 to select +1.8V sensor voltage. 2) Jumper 2 – 3 (**default**) to select +3.3V sensor voltage. Note: the sensor voltage selected must match the LPCXpresso54102 LPCxxxx VDDIO voltage.
P1	Sensor SPI expansion header. This header provides connections to add an off-board SPI based sensor.
P2	Combined sensor current monitor Vsense measurement. The Vsense can be measured with a volt meter. Pin 1 (square pad) is positive and pin 2 is negative. Sensor current is calculated by dividing the measured voltage at P2 by the Vsense resistance value of 10Ω.

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Date of release: 26th October 2015
Document identifier: UM10854_OM13078