UM0752
User manual

STEVAL-MKI062V1, iNEMO™ (iNErtial MOdule) demonstration board based on MEMS devices and STM32F103Rx

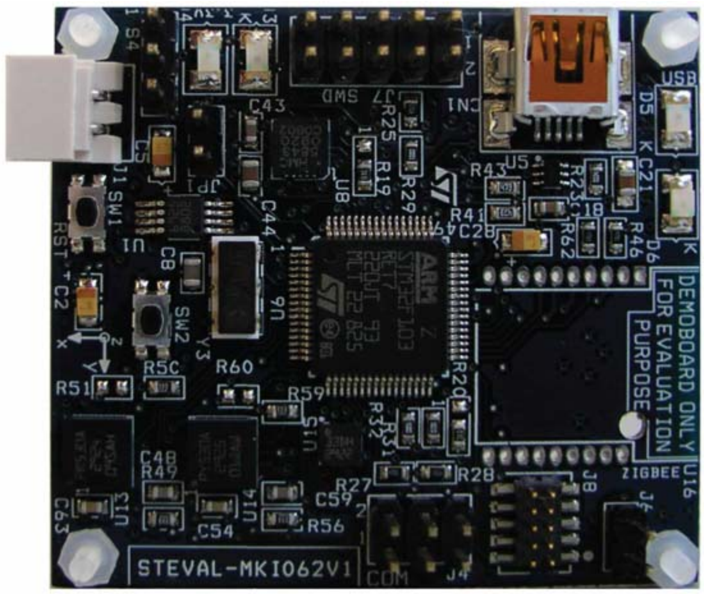
Introduction

iNEMO™ is a unique platform that uses ST's most advanced inertial sensors. It provides a complete set of inertial measurements using a combination of accelerometers, gyroscopes and magnetometers, as well as a set of environmental measurements using pressure and temperature sensors.

iNEMO™ is a 9-DOF (degree of freedom) inertial system and represents a complete hardware platform that can be implemented in many applications such as virtual reality, augmented reality, image stabilization, human machine interfaces and robotics.

A complete set of communication interfaces (USB, ZigBee®, COM), with various power supply options in a small size form factor (4.5 x 5 cm) make iNEMO™ a flexible and open demonstration platform.

Figure 1. iNEMO™ platform



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1 Overview

1.1 Features

- STM32F103: low-power, high-performance, 32-bit microcontroller powered by ARM® Cortex™-M3
- Two power supply options: power connector or USB connector
- Battery monitoring via a low battery output signal
- Boot from user Flash, system memory or SRAM
- LPR530AL: 2-axis gyroscope (roll, pitch) 300°/sec full-scale, analog output, optional additional filters
- LPY530AL: 2-axis gyroscope (pitch, yaw) 300°/sec full-scale, analog output, optional additional filters
- LIS331DLH: 3-axis accelerometer ±2g/±4g/±8g full-scale, SPI digital output
- HMC5843: 3-axis magnetometer, configurable full-scale ±4 Gauss (max), I^2C digital output
- LPS001DL: pressure sensor, 300-1100 mbar, absolute full-scale, I^2C digital output, barometer
- STLM75: temperature sensor ranging from -55°C to +125°C, I^2C digital interface
- Wireless capability through ZigBee module plug-in
- MicroSD card slot
- 3.3 V TTL/CMOS COM connector with request to send (RTS) and clear to send (CTS) signals
- USB2.0 full-speed connection
- Reset button
- User LED and user button

1.2 Demonstration software

To facilitate user developments and sensor data analysis, the STEVAL-MKI062V1 demonstration kit includes a graphical user interface that can display sensor outputs, as well as a firmware library for easy use of the various demonstration board features. The latest version of the firmware package and PC graphical user interface can be downloaded from the STEVAL-MKI062V1 web page: *http://www.st.com*.

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2 Hardware layout and configuration

The STEVAL-MKI062V1 demonstration board has been designed to manage all sensor features through the 32-bit microcontroller STM32F103RET. The hardware block diagram in *Figure 2* illustrates the connections between the STM32F103RET peripherals and the sensors, while *Figure 3* and *Figure 4* show the location of these features on the demonstration board.

The reference system of the iNEMO platform is shown in *Figure 1*.

Figure 2. Block diagram

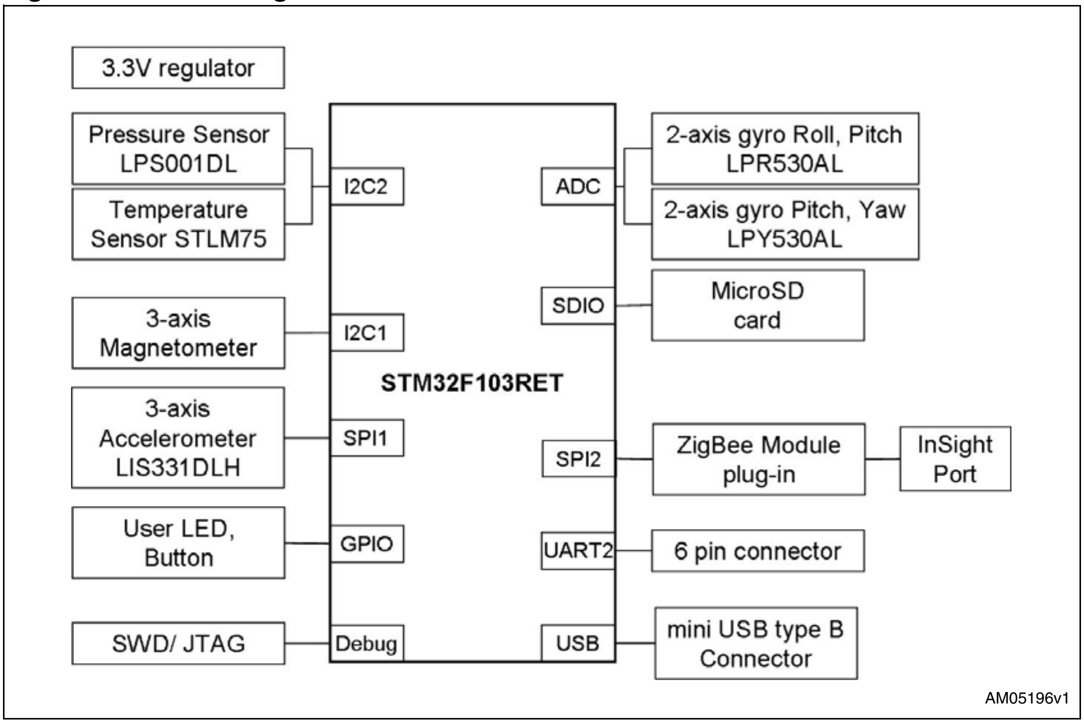

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Figure 3. TOP layout

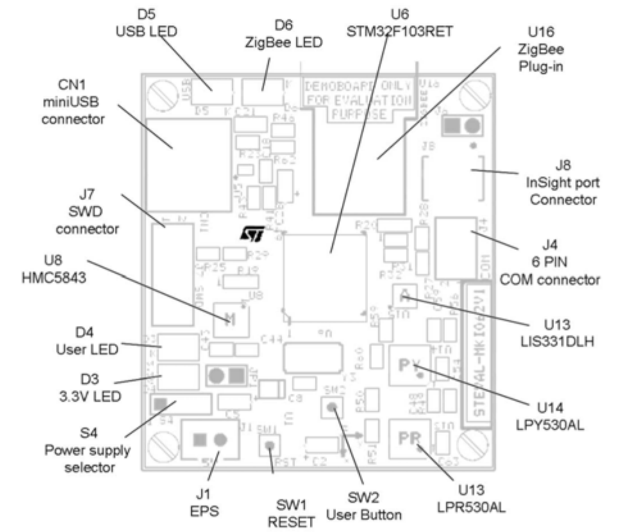
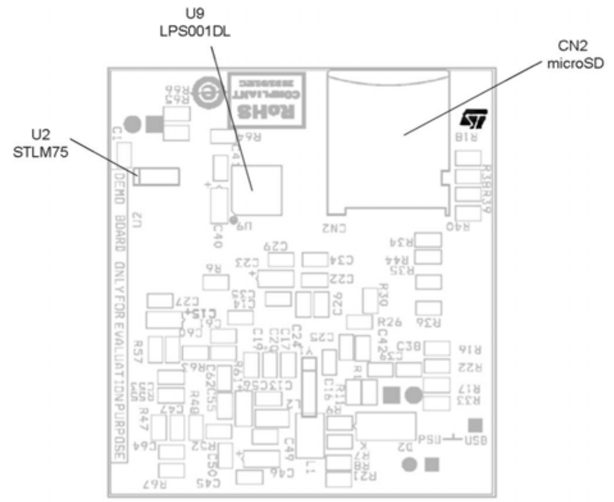


Figure 4. Bottom layout



2.1 Power supply

The STEVAL-MKI062V1 is supplied by the L6925D step-down DC-DC converter, set by the feedback resistors (R7, R9) to 3.3 V DC output generation. The board can be powered by a power supply of up to 5.5 V DC; the SMTY5 prevents the device from being damaged in case of accidental overload and in case of reverse polarity.

It is possible to configure one of two power supply sources.

- 5 V DC power adapter connected to the J1 connector (5 V on silkscreen for power supply unit).
- 5 V DC power with 100 mA limitation from CN1, type B USB connector.

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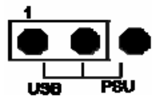
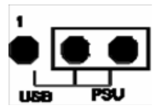
The power supply option is configured by setting the switch S4 as shown in *Table 1*. The LED D4 is turned on when the STEVAL-MKI062V1 board is powered correctly.

When a USB cable connects the STEVAL-MKI062V1 to a PC, the LED D5 turns on regardless of the selected power supply source.

Table 1. Power supply selector

Power source	S4 configuration
USB	
PSU	

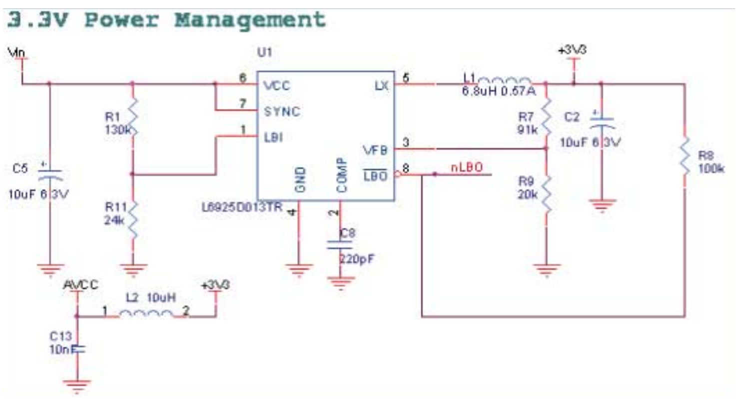
L6925 is a high-efficiency monolithic synchronous step-down regulator capable of delivering up to 800 mA of continuous output current. The input voltage ranges from 2.7 V to 5.5 V. The output voltage can be selected by an external divider.

Equation 1

$$V_{OUT} = 0.6 * \left(1 + \frac{R_7}{R_9}\right)$$

A low battery input (LBI) pin is available. This pin is internally connected to a comparator with a threshold of 0.6 V. By using an external resistor divider connected between the battery voltage and ground, it is possible to fix a threshold for the battery voltage. When the voltage at the LBI pin goes lower than 0.6 V, the LBO pin is forced low. As shown in *Figure 5*, when R1 is set to 130 kΩ and R11 to 24 kΩ, the LBI voltage is lower than 0.6 V when VCC_IN goes lower than 3.85 V. The LBO signal is connected to a GPIO of the STM32x microcontroller.

Figure 5. 3.3 V power supply stage



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2.2 MCU

The STEVAL-MKI062V1 demonstration board hosts an STM32F103RET.

The high density STM32F103x performance line family of devices incorporates the high-performance ARM® Cortex™-M3 32-bit RISC core that operates at up to 72 MHz, as well as high-speed embedded memories (Flash memory up to 512 kbytes and SRAM up to 64 kbytes), and an extensive range of enhanced I/Os and peripherals connected to two APB buses.

All the devices offer three 12-bit ADCs, four general-purpose 16-bit timers plus one PWM timer, as well as standard and advanced communication interfaces: up to two I^2Cs, three SPIs, five USARTs, a USB and an SDIO.

The STM32F103x devices operate with a 2.0 to 3.6 V power supply. They are available in both the -40 to +85 °C temperature range and the -40 to +105 °C extended temperature range. A comprehensive set of power-saving modes enables the design of low-power applications.

The complete STM32F103x performance line family offers devices in five different package types, from 36 pins to 100 pins. For further information on the STM32 microcontroller family, refer to the web page: *http://www.st.com/stm32*.

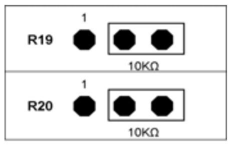
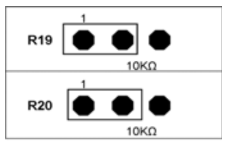
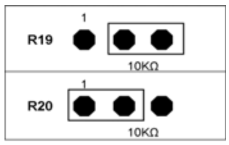
2.3 Boot options

The STEVAL-MKI062V1 demonstration board can boot from three types of memory.

- Embedded user Flash
- System memory with boot loader for ISP
- Embedded SRAM for debugging

The boot option is defined according to the assembly position of the two 3-pad 10 k configuration resistors R19 and R20, as described in *Table 2*. The labeled position 1 is at 3.3 V.

Table 2. Boot option selector

Boot from	Configuration
Boot from user Flash when R19 is set as shown. R20 is not required in this configuration (default setting).	
Boot from embedded SRAM when R19 and R20 are set as shown.	
Boot from system memory when R19 and R20 are set as shown.	

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2.4 Clock source

Two external clock sources are available on the STEVAL-MKI062V1 demonstration board for the STM32F103RET and RTC.

- Y1, 32 kHz crystal for embedded RTC.
- Y3, 8 MHz. It can be removed when the STM32F103Rx's internal RC clock is used. Y3 does not need external capacitances.

2.5 Reset source

The reset signal of the STEVAL-MKI062V1 demonstration board is active low and the reset sources include:

- a reset button SW1.
- a debugging tool from the serial wire debug (SWD)/JTAG connector J7.

The JP1 jumper is used to reset the STM32F103RET embedded JTAG test access port (TAP) controller each time a system reset occurs. JP1 connects the test reset (TRST) signal from the JTAG connection with the system reset signal RESET#. By default JP1 is not fitted.

2.6 Bi-axial gyroscopes

The STEVAL-MKI062V1 is provided with two kinds of bi-axial gyroscopes.

- LPR530AL pitch and roll ±300°/s analog gyroscope
- LPY530AL pitch and yaw ±300°/s analog gyroscope

The LPx503AL is a low-power, two-axis, micro-machined gyroscope that can measure angular rates along the pitch and yaw/roll axes.

The two gyroscopes have the same characteristics and application schematics are shown in *Figure 6* and *Figure 7*. Refer to their respective datasheets for details.

Figure 6. LPR530AL gyroscope schematic

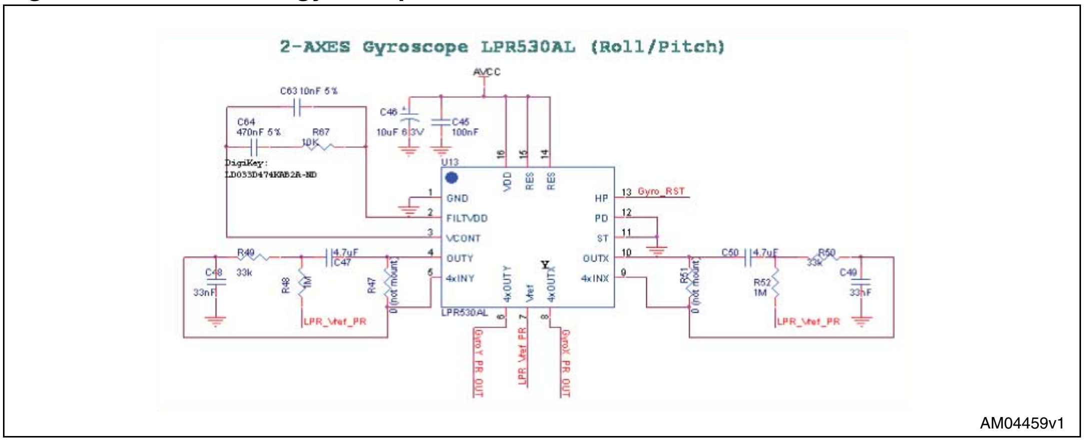

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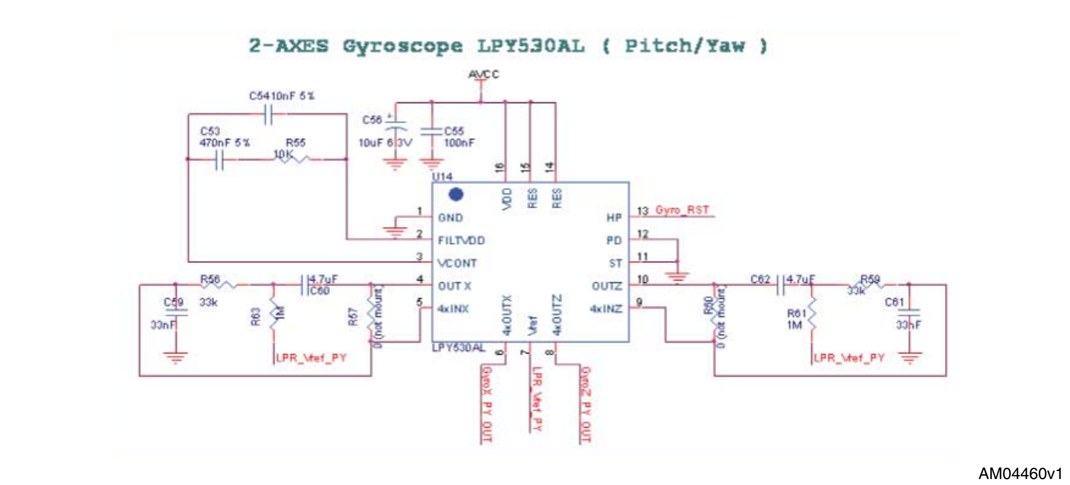
Figure 7. LPY530AL gyroscope schematic



In the STEVAL-MKI062V1, the output rate response of both LPx530AL has been limited in band thanks to external low-pass and high-pass filters (optional, see *Figure 8*) in addition to the embedded low-pass filter (ft = 140 Hz).

The cut-off frequency is set by the values of R and C in *Figure 8*.

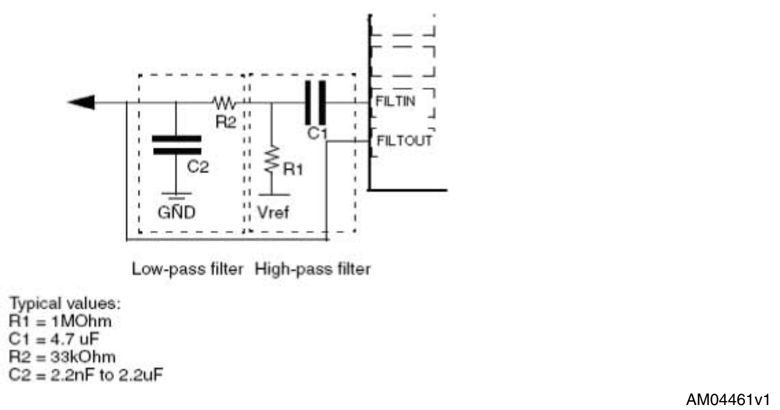
Equation 2

$$f_{HP} = \frac{1}{2\pi R_1 C_1} = 0.03\ \text{Hz}$$

Equation 3

$$f_{LP} = \frac{1}{2\pi R_2 C_2} = 14\ 6\text{Hz}\Big|_{C2=33nF}$$

Figure 8. External filter configuration of the gyroscope



For each gyroscope output, the filter can be disabled by soldering a 0 Ω resistor in the position shown in *Table 3*.

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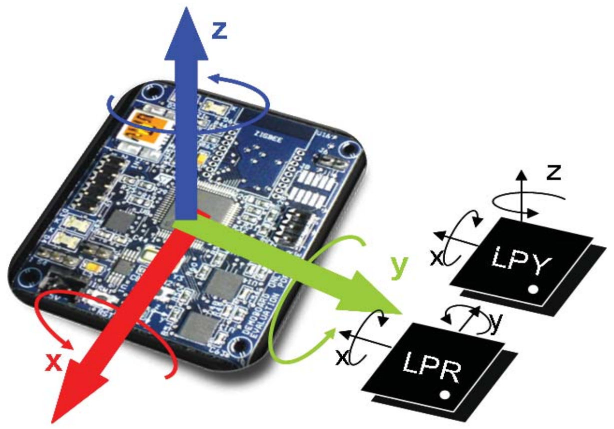
Table 3. Filter disable option

Axes	Resistor
4xOUTY LPR530AL	R47
4xOUTX LPR530AL	R51
4xOUTX LPY530AL	R57
4xOUTZ LPY530AL	R60

The axes orientation of the two gyroscopes with respect to the STEVAL-MKI062V1 reference system is shown in *Figure 9* and detailed in *Table 4*.

Figure 9. Bi-axial gyroscope orientation



The analog outputs and the Vref of the gyroscopes are connected to the ADC_IN pins of the STM32F103RET, as described in *Table 4*.

Table 4. Gyroscope connection and orientation

Gyroscope	Gyroscope output	iNEMO	GPIO	ADC_IN
LPR530AL	4xOUTY	X	PC0	ADC_IN_10
	4xOUTX	-Y	PC1	ADC_IN_11
	Vref		PC2	ADC_IN_12
LPY530AL	4xOUTX	-Y	PC5	ADC_IN_15
	4xOUTZ	Z	PC4	ADC_IN_14
	Vref		PB0	ADC_IN_8

The filter reset pins of the two gyroscopes are connected to the GPIO PB5 of the STM32F103RET, so as to allow the user to reset the gyroscope filter (refer to the datasheet for details).

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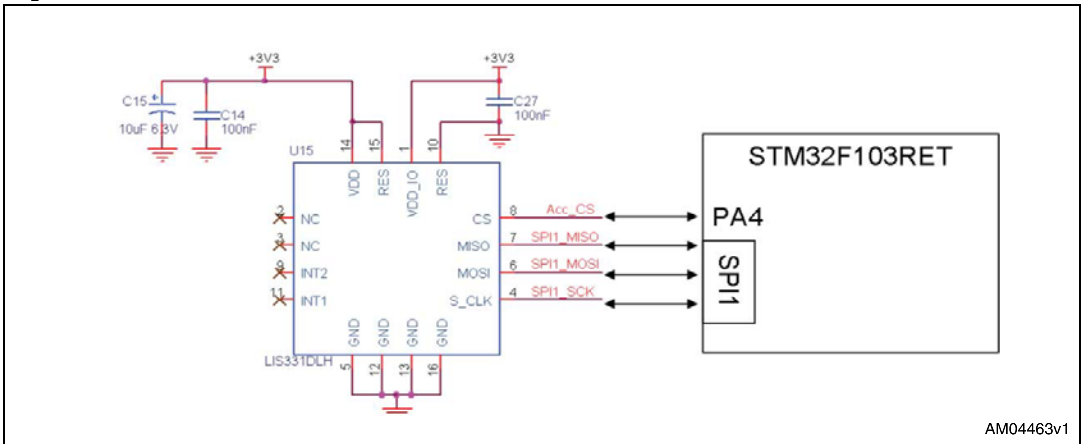
2.7 3-axis accelerometer

The STEVAL-MKI062V1 demonstration board includes a 3-axis accelerometer, LIS331DLH.

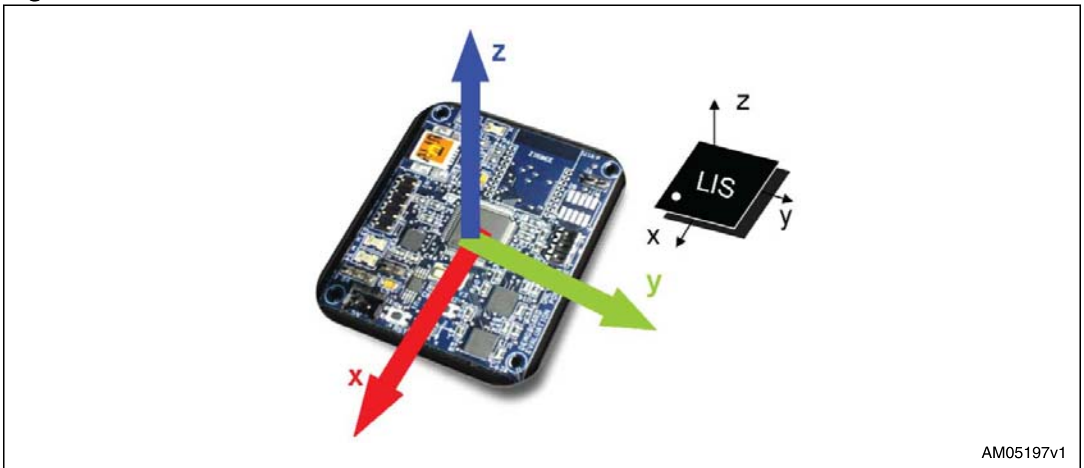
The LIS331DLH is an ultra-low-power, high-performance, 3-axis linear accelerometer with a digital I^{2}C/SPI serial interface standard output. It is connected to the MCU through the SPI serial communication with hardware chip select, as shown in *Figure 10*.

Figure 10. Accelerometer schematic



The orientation of LIS331DLH's axes with respect to the board reference system is illustrated in *Figure 11*. Refer to the datasheet for further details.

Figure 11. Accelerometer orientation



2.8 3-axis magnetometer

The Honeywell HMC5843 is a 3-axis magnetometer designed for low magnetic field sensing, with a digital interface for applications such as low-cost compassing and magnetic field measurements.

It uses I^{2}C communication at a speed of 100 kHz. The slave address is 0x3C.

The Data Ready pin is also connected to a GPIO of the MCU to manage the Data Ready interrupt. Refer to the datasheet for further details.

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The schematics and orientation of the magnetometer are shown in *Figure 12* and *Figure 13* respectively.

Figure 12. Magnetometer schematic

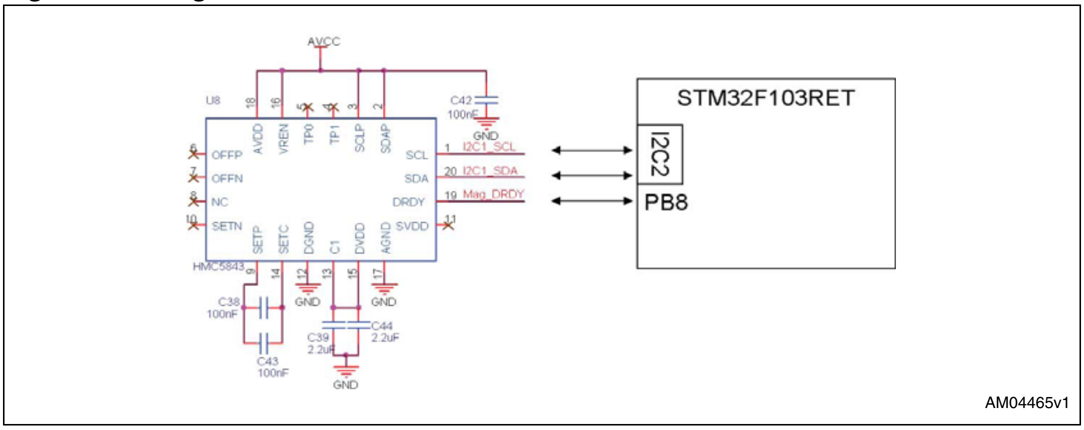
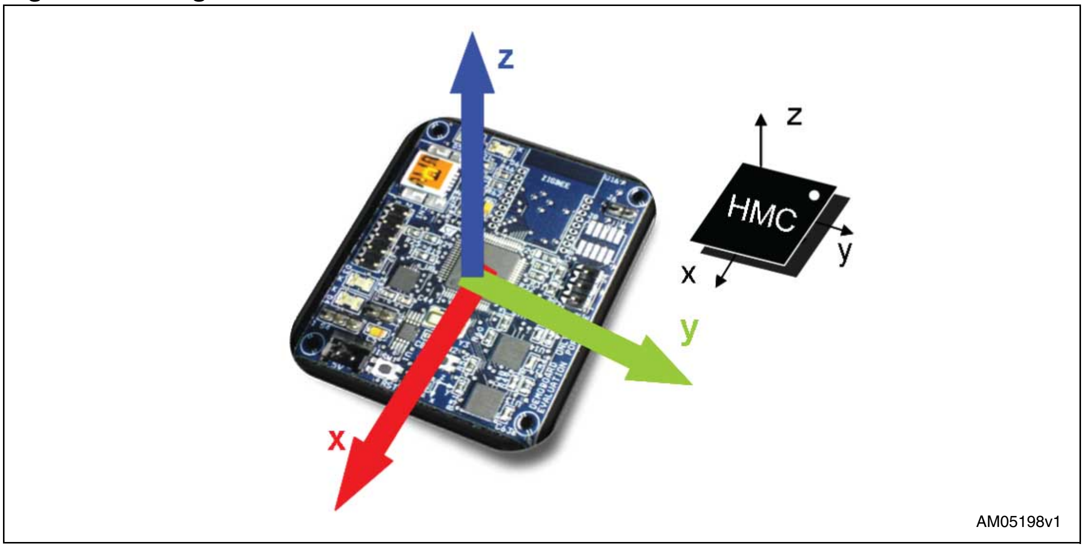


Figure 13. Magnetometer orientation



2.9 Pressure sensor

The LPS001DL is a high-resolution, digital output pressure sensor packaged in an LGA holed package (ST patent pending). The complete device includes a sensing element based on a piezoresistive Wheatstone bridge approach, and an IC interface that takes the information from the sensing element to the external world as a digital signal.

On the STEVAL-MKI062V1 board, the pressure sensor uses I^2C communication and its slave address is set to 0xBA. The LPS001DL features two fully programmable interrupt sources (INT1 and INT2), which may be configured to trigger different pressure events.

The device may also be configured to generate, through the interrupts pins, a Data Ready signal (Drdy) which indicates when new measured data is available, thus simplifying the synchronization of data in digital systems. Refer to the datasheet for further details. The connection between the LPS001DL and the MCU is shown in *Figure 14*.

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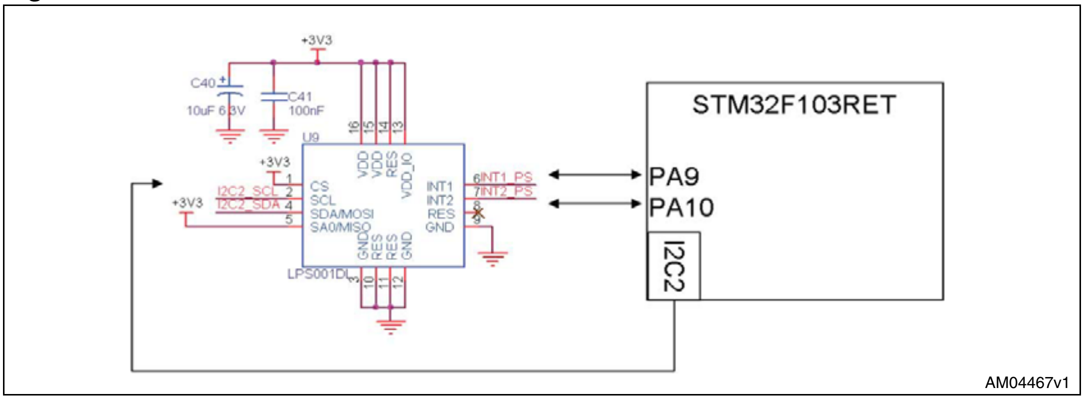
Figure 14. Pressure sensor schematic



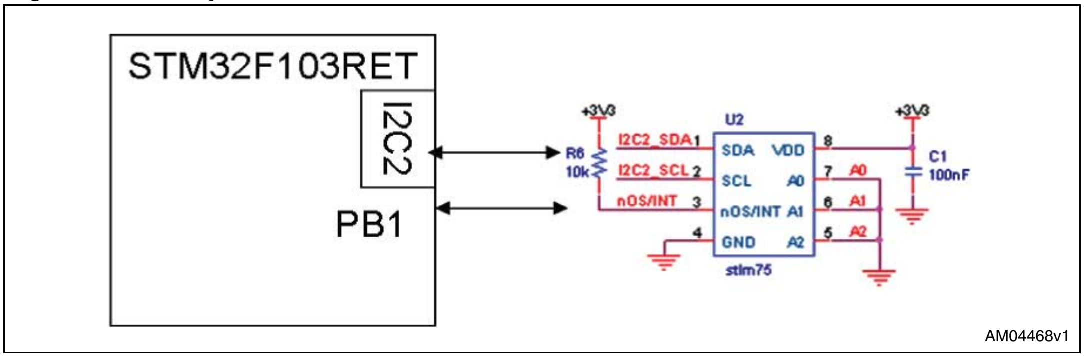
2.10 Temperature sensor

The board also provides an I^2C interface temperature sensor STLM75 (-55°C to +125°C) connected to the I^2C2 of the STM32F103RET.

Because the STLM75 pins A_2, A_1 and A_0 are grounded, the slave address of the sensor is settled to 0x90. The STLM75 has a dedicated open-drain over-limit signal/interrupt (OS/INT) output that features a thermal alarm function. Refer to the datasheet for further details.

The connection between the STLM75 and the MCU is shown in *Figure 15*.

Figure 15. Temperature sensor schematic



2.11 ZigBee module plug-in

A SPZB260-PRO ZigBee module can be soldered onto the STEVAL-MKI062V1 board. The SPZB260-PRO is a low power consumption ZigBee module optimized for embedded applications. It enables OEMs to easily add wireless capability to electronic devices. The module is based on the SN260 ZigBee network processor that integrates a 2.4 GHz, IEEE 802.15.4-compliant transceiver as well as an IEEE 802.15.4 PHY and MAC. A 24 MHz high-stability Xtal is available on the module to perform the timing requirements as per the ZigBee specifications. A single supply voltage is requested to power the module. An integrated 2.5 GHz specific Murata antenna is also integrated. The voltage supply also determines the level of the I/O ports, making it easy to interface with the host system.

The module is controlled by means of a standard serial interface (SPI), facilitating connection to a variety of host microcontrollers.

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As shown in *Figure 17*, J8 is the 10-pin, dual-row, 0.05-inch pitch InSight™ connector provided for the programming and debugging interface of the SPZB260-PRO module. It contains the four SIF signals (SIF_MOSI, SIF_MISO, SIF_LOADB, SIF_CLK), two packet trace signals (PTI_EN and PTI_DATA), as well as voltage and ground connections. Through the InSight™ port cable, it connects directly to the InSight™ Adapter, which allows programming and debug access within the InSight™ desktop (see *Figure 16* and *Table 5*).

The LED indicator D6 is driven by a link activity signal to provide a visual indication of the module's behavior.

A jumper J6 is installed between pin1 of the J8 InSight™ connector and the SPZB260 power supply pin. It should be closed only when the InSight^{TM} Adapter is configured to supply the module and the board. However, we suggest to never use this configuration and to always leave J6 open, using the two power supply options described in *Section 2.1: Power supply*.

The connections between the MCU and the ZigBee module are summarized in *Table 6*.

Figure 16. InSight™ port connector

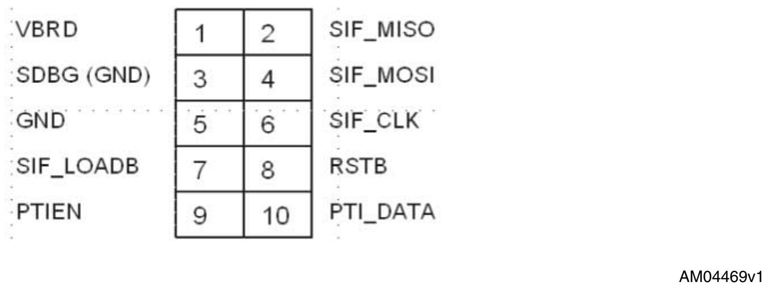

Table 5. InSight™ J8 port pins

Pin number	Signal name	Direction	Description
1	VBRD	Power	2.1 to 3.6 V supply for the SPZB260
2	SIF_MISO	Output	Serial interface, master in, slave out
3	SDBG	Output	Debug signal to be used on future pin-compatible products. Normally grounded through R65 (R66 not soldered).
4	SIF_MOSI	Input	Serial interface, master out, slave in
5	GND	Power	Ground
6	SIF_CLK	Input	Serial interface, clock signal
7	SIF_LOAD B	I/O	Serial interface, load strobe

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Figure 17. ZigBee module schematic

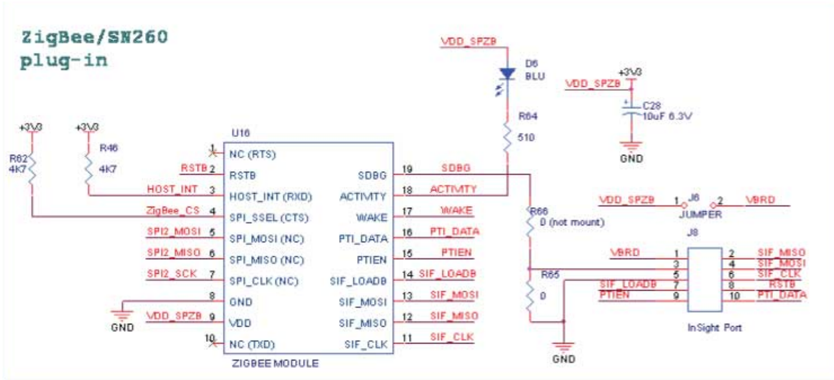

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Table 6. MCU - ZigBee connection

ZigBee signal	MCU pin
RSTB	PC7
HOST_INT	PC6
ZigBee_CS	PB12
SPI2 MOSI/MISO/CLK	PB15/PB14/PB13
WAKE	PA8

2.12 MicroSD card

The MicroSD slot CN2 (*Figure 18*) is available on the bottom side of the STEVAL-MKI062V1 and is connected to the SDIO of the STM32F103RET, as summarized in *Table 7*.

Figure 18. MicroSD slot

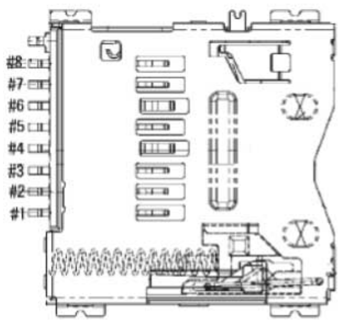

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Table 7. MicroSD slot connections

Pin number	Description	Pin number	Description
1	MicroSDcard_D2 (PC10)	5	MicroSDcard_CLK (PC12)
2	MicroSDcard_D3 (PC11)	6	GND
3	MicroSDcard_CMD (PD2)	7	MicroSDcard_D0 (PC8)
4	+3.3 V	8	MicroSDcard_D1 (PC9)

2.13 COM connector

The 6-pin COM connector J4 is connected to the UART2 pins of the STM32F103RET as shown in *Figure 19* and *Table 8*. It presents the hardware data flow control through the CTS and RTS signals.

Note: J4 does not have a transceiver; it is directly connected to the microcontroller pins, so the user has to prevent any overload/overvoltage on these pins.

Figure 19. J4 COM connector

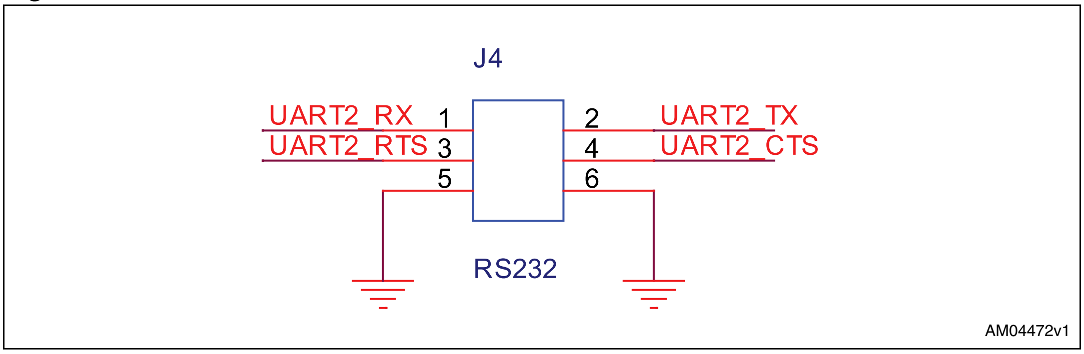

Table 8. COM connector pinout

Pin number	Description	Pin number	Description
1	UART2_RX (PA3)	5	UART2_RTS (PA1)
2	UART2_TX (PA2)	6	UART2_CTS(PA0)
3	GND	7	GND

2.14 USB

The STEVAL-MKI062V1 is provided with USB2.0 compliant full-speed communication via a USB type B connector (CN1), shown in *Figure 20* and detailed in *Table 9*, with a dedicated EMI filter and line termination through USBUF02W6 (U5).

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Figure 20. USB mini B connector (CN1)

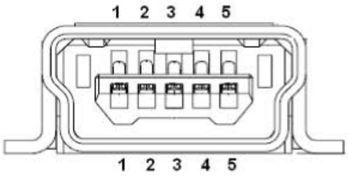

Table 9. USB mini B connector pinout

Pin number	Description
1	Vbus (power)
2	DM (PA11)
3	DP(PA12)
4	N.C.
5	Ground

2.15 User LED and button

The STEVAL-MKI062V1 demonstration board has one LED D3 and one push button SW2 available for the user's application (the GPIO pins are shown in *Table 10*).

Table 10. GPIO pins of user LED and button

Device	MCU GPIO
D3	PB9
SW2	PC13

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Appendix A Schematics and bill of materials

Figure 21. Schematic

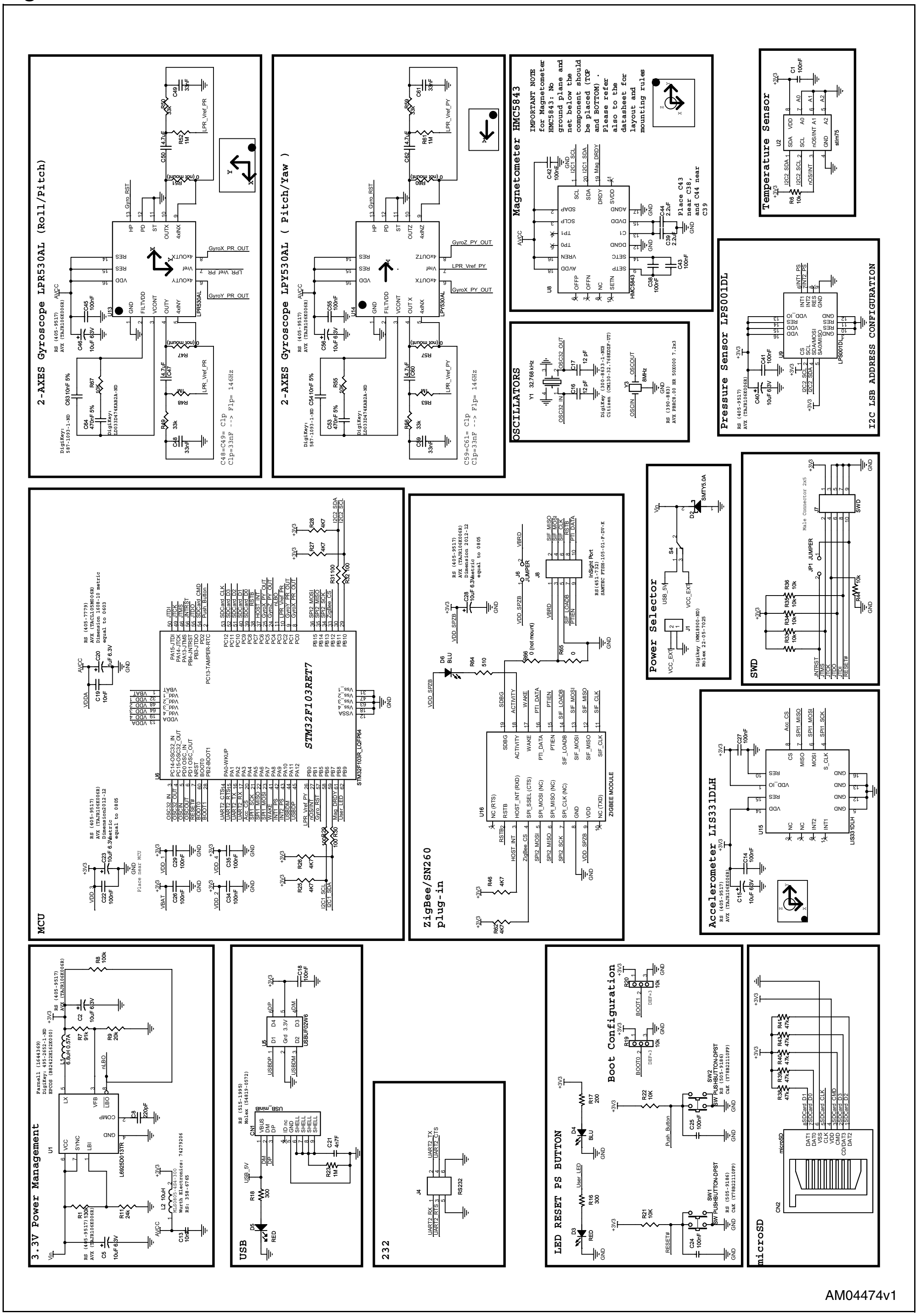

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Table 11. BOM

Item	Qty	Reference	Part/value
1	1	CN1	USB_miniB
2	1	CN2	MicroSD
3	17	C1,C14,C18,C22,C24,C25,C26,C27,C29,C34, C35,C38,C41,C42,C43,C45,C55	100 nF 10%
4	8	C2,C5,C15,C23,C28,C40,C46,C56	10 µF 6.3 V
5	1	C8	220 pF 10%
6	4	C13,C19,C54,C63	10 nF 5%
7	2	C16,C17	12 pF 5%
8	1	C20	1 µF 6.3 V
9	1	C21	4.7 nF 10%
10	2	C39,C44	2.2 µF
11	4	C47,C50,C60,C62	4.7 µF
12	4	C48,C49,C59,C61	0.33 µF
13	2	C53,C64	470 nF 5%
14	1	D2	SMTY5.0A
15	2	D3,D5	RED
16	2	D4,D6	BLU
17	2	JP1,J6	Jumper
18	1	J1	Battery connector
19	1	J4	RS-232 (strip line, male, 6-pin 2 x 3)
20	1	J7	SWD (strip line, male, 10-pin 2 x 5)
21	1	J8	InSight Port 2 x 5
22	1	L1	6.8 µH
23	1	L2	10 µH
24	1	R1	130 kΩ 1%
25	10	R6,R21,R22,R33,R34,R35,R36,R44,R55,R67	10 kΩ 1%
25.bis	2	R19,R20	10 kΩ 1%
26	1	R7	91 kΩ 1%
27	1	R8	100 kΩ 1%
28	1	R9	20 kΩ 1%
29	6	R25,R26,R27,R28,R46,R62	4.7 kΩ 1%
30	1	R11	24 kΩ 1%
31	2	R16,R18	300 1%
32	1	R17	200 1%

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Table 11. BOM (continued)

Item	Qty	Reference	Part/value
33	5	R23,R48,R52,R61,R63	1 MΩ 1%
34	4	R29,R30,R31,R32	100 Ω 1%
35	5	R38,R39,R40,R41,R43	47 kΩ 1%
36	1	R65	0 Ω 1%
36.bis	5	R47,R51,R57,R60,R66	0 Ω 1%
37	4	R49,R50,R56,R59	3.3 kΩ 1%
38	1	R64	510 Ω 1%
39	2	SW1,SW2	SW push button-DPST
40	1	S4	SWITCH 1X2 (strip line, male, 3-pin 1 x 3)
41	1	U1	L6925D013TR
42	1	U2	stlm75
43	1	U5	USBUF02W6
44	1	U6	STM32F103R_LQFP64
45	1	U8	HMC5843
46	1	U9	LPS001DL
47	1	U13	LPR530AL
48	1	U14	LPY530AL
49	1	U15	LIS331DLH
50	1	U16	ZigBee_Module
51	1	Y1	Crystal oscillator 32.768 kHz
52	1	Y3	Crystal oscillator 8 MHz
53	4	Spacer	Nylon spacer
54	4	Nut	Nylon
55	4	Screw	Nylon

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Revision history

Table 12. Document revision history

Date	Revision	Changes
21-Jan-2010	1	Initial release.

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