UM0579
User manual

TN100 RF evaluation kit

This document describes the TN100 RF evaluation kit (TN100/M32B-EVAL) used to evaluate the capabilities of the TN100 device for ranging operations and RF data transmission based on the Chirp technology.

The entire package consists of two TN100 sensor boards (version 1.1) and a complete software package.

Both boards are exactly the same and are equipped with:

- a board (TN100-RCM) which integrates both an STM32 microcontroller and a TN100 transceiver
- a set of sensors to detect temperature and accelerations
- one reset (S1) and three general-purpose buttons (S2 to S4)
- four general-purpose LEDs (LD1 to LD4), Tx/Rx activity LED (LD5), power supply LED (LD6)

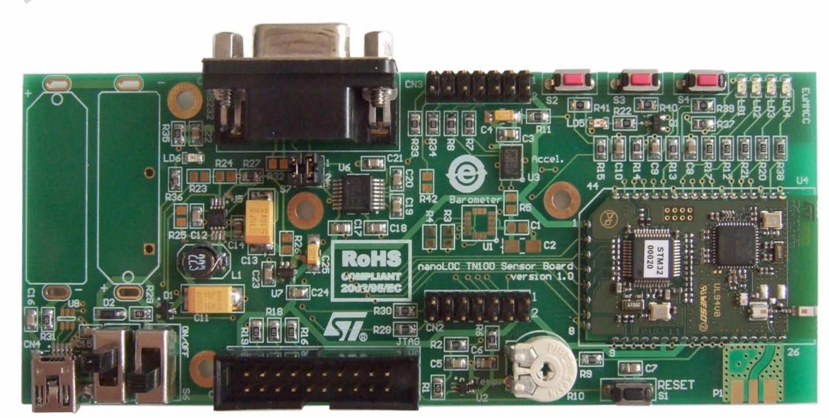
The sensor boards act as source of information providing data regarding distance measurement (ranging), temperature, accelerations, and status.

The software consists of:

- The ST TN100 Application running on a host PC used to interact with the sensor boards and easily perform ranging operations, packet data transmission, and retrieval of on-board sensor data. Additionally, it offers a graphical representation of the two-node network constituted by the sensor boards.
- Firmware running on the STM32 microcontroller including: driver for the TN100 device, drivers for all the sensors such as MEMS, temperature, internal protocol used to exchange data, and commands, among nodes and the PC.

More details on boards and software are provided in the following sections.

Figure 1. TN100 sensor board with STM32 microcontroller



Contents

1 Reference information

1.1 Acronyms and definitions

Table 1. List of acronyms and definitions

Term	Meaning
ARQ	The Automatic Repeat Request (ARQ) scheme is used to achieve correct data transmission.
CSMA/CA	Carrier Sense Multiple Access with Collision Avoidance
CSS	Chirp Spread Spectrum
FEC	The Forward Error Correction coding scheme is a (7, 4) shortened Hamming code and consists of 4 data bits and 3 parity bits. The FEC scheme on the MACFrame reduces the number of retransmissions.
LBS	Location-based services
MAC	Medium Access Controller
MAC retries	Maximum allowed number of retransmission attempts for Data packets.
Ranging	Term used to indicate the capability to determine the distance between two RF devices.
RTLS	Real-time locating system
SPI	Serial Peripheral Interface bus
TDMA	Time Division Multiple Access

1.2 References

1. TN100 RF board datasheet
2. TN100 High performance CSS transceiver enabling location awareness datasheet
3. LIS302DL MEMS motion sensor 3-axis
4. STLM20W87F analog temperature sensor
5. STM32F103CB STM32 ARM-based 32-bit MCU

Please check the STMicroelectronics web site www.st.com for any available updates.

2 Description of the delivered package

The ST RF TN100 Evaluation kit contains the following items:

- One guarantee record card
- Two TN100 sensor boards
- One CD-ROM including the following items:
  - Application and firmware source code
  - User manual
  - Board schematics
  - Datasheets

Please check the STMicroelectronics website www.st.com for any available updates and downloads.

2.1 Hardware overview

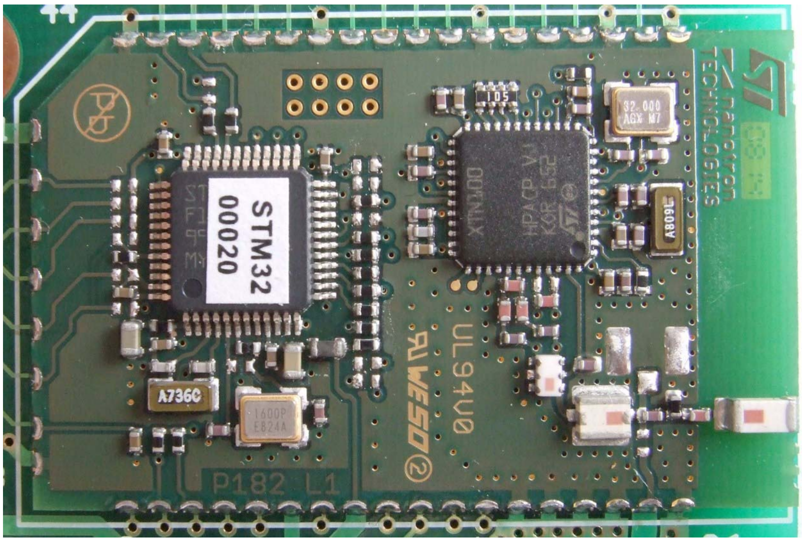
Figure 2 shows the main components of the sensor boards contained in the package.

The TN100 transceiver is a highly integrated mixed signal chip that uses CSS (chirp spread spectrum) wireless communication technology. With its unique ranging capability, the TN100 can measure the link distance between two nodes. Thus, the TN100 supports location awareness applications including location-based services (LBS) and asset tracking (2D/3D RTLS). Ranging is performed during regular data communication and does not require additional infrastructure, power, and/or bandwidth. The TN100 transceiver IC is designed to build up robust, short distance wireless networks operating in the 2.45 GHz ISM band with extremely low power consumption over a wide range of operating temperatures.

The TN100 supports 7-frequency channels with 3 non-overlapping channels. This provides support for multiple physically independent networks and improved coexistence performance with existing 2.4 GHz wireless technologies. Data rates are selectable between 2 Mbps and 125 kbps. The TN100 transceiver includes a sophisticated Medium Access Controller (MAC) with CSMA/CA and TDMA support as well as forward error correction (FEC) and 128-bit hardware encryption. Through its high-speed standard SPI interface, the TN100 can be interfaced with an external microcontroller. It includes a 4-kbit frame buffer so that several receive and transmit frames can be stored simultaneously in the buffers. This solution eliminates the problems of different peak data rates between air and microcontroller interfaces.

ST's STM32 family of 32-bit Flash microcontrollers is based on the breakthrough ARM Cortex™-M3 core - a core specifically developed for embedded applications. The STM32 family benefits from the Cortex-M3 architectural enhancements including the Thumb®-2 instruction set to deliver improved performance with better code density, significantly faster response to interrupts, all combined with industry leading power consumption.

Figure 2. TN100 RF board



The smart TN100 RF board is only 39 mm by 24 mm and less than 3 mm thick. Yet, it integrates all required components for a complete RF circuit based on the innovative transceiver. As well as the chip, this board includes the ST STM32 microcontroller (MCU), a band pass filter, a balun and an integrated 2.4 GHz chip antenna.

More details may be found in *Section 3: TN100 sensor board*.

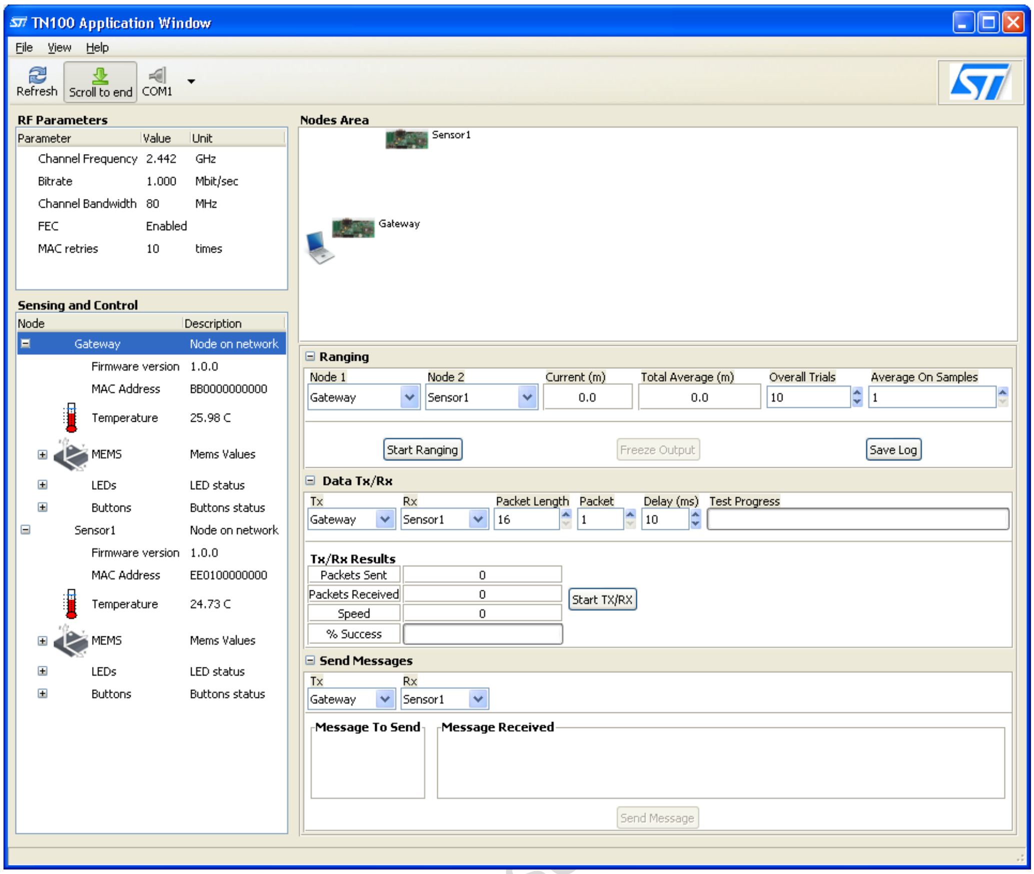
2.2 Software overview

The ST TN100 Application is provided to evaluate the ST TN100 technology and hence perform remote ranging operations between nodes, sending and receiving simple data packets and text messages, getting sensor values, and setting the status of on-board LEDs.

The application's Graphical User Interface is designed for easy interaction with the sensor boards thanks to an integrated environment where all the relevant parameters may be set and monitored (see *Figure 3: TN100 application window*). Additionally, the user is also able to hide and/or show certain features in order to focus on the more relevant data. The benefit consists in being able to launch a single application and perform all possible actions using the ST TN100 technology.

The application provides the user interface for both sensors boards.

Figure 3. TN100 application window



Basically, the application running on the PC cooperates with the firmware running on the sensor nodes and it is able to:

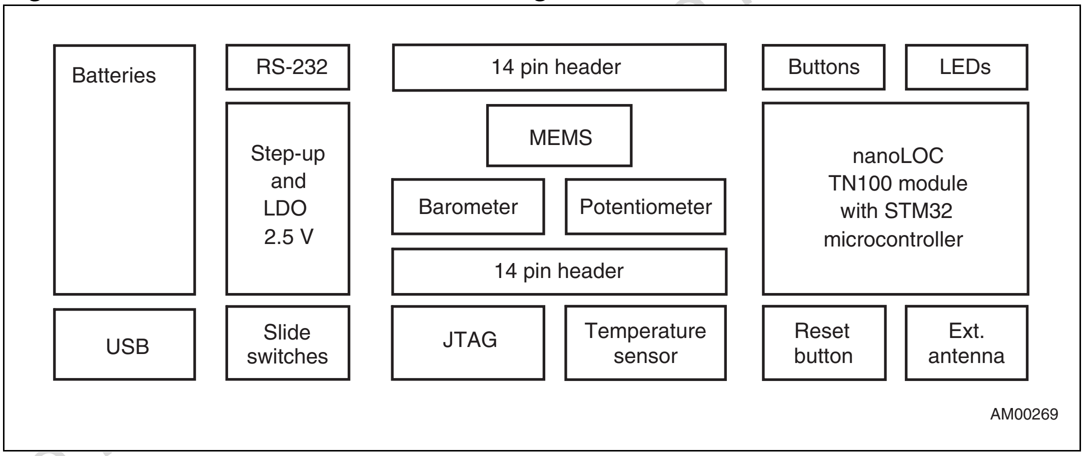
- Get specific parameters such as MAC address, channel, FEC, MAC retries, and so on, for each sensor node
- Get sensor data for each sensor including temperature, acceleration, buttons, LEDs
- Start & Stop packet and message transmissions, and ranging, between sensor nodes
- Set on-board LED status for each sensor node

3 TN100 sensor board

The TN100 sensor board includes the TN100 high performance chirp spread spectrum transceiver enabling location awareness using an STM32F103 Cortex™-M3 32-bit microcontroller. It provides the following features:

- Sensors
  - Temperature meter (U2)- STLM20 (analog)
  - 3-axis accelerometer (U3) - LIS302DL (digital)
  - Potentiometer (R10) (analog)
- RS-232 communication interface, DB9 D-sub connector
- Two 14-pin header connectors (CN2, CN3) for connecting different hooks on extensions
- Power supply options: + 5 V from JTAG (J-Link), USB + 5 V V_{BUS}, NiMH batteries. On-board step-up converter and linear regulator (+ 2.5 V)
- One reset (S1) and three general-purpose buttons (S2 to S4)
- Four general-purpose LEDs (LD1 to LD4), TX/RX activity LED (LD5), power supply LED (LD6)
- Many configuration options for sensors and peripherals
- 20-pin JTAG connector (CN1) for debug purposes

Figure 4. TN100 sensor board block diagram



3.1 Description of connectors

3.1.1 JTAG connector (CN1)

The 20-pin connector (CN1) provides the JTAG interface as shown in *Figure 5*. This interface is primarily used for communicating with a PC using a suitable converter box such as J-Link from IAR Systems™. There exists a wide choice of development tools on the market supporting microcontroller Flash memory programming and application debugging. Using the J-Link DBGACK pin, an external + 5 V power supply can be delivered to the board as an optional supply voltage. (Verify which J-Link revision supports this feature at http://www.segger.com).

Figure 5. JTAG connector pinout

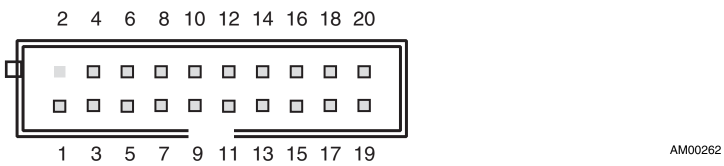


Table 2. JTAG connector (CN1) pin description

Pin	Signal	Pin	Signal	Pin	Signal	Pin	Signal
1	2.5 V DC	6	GND	11	JRTCK, connected to GND by R10 (10 kΩ)	16	GND
2	2.5 V DC	7	JTMS	12	GND	17	DBGRQ connected to GND by R (10 kΩ)
3	JTRST	8	GND	13	JTDO	18	GND
4	GND	9	JTCK	14	GND	19	DBGACK connected to GND by R (10kΩ), used also as an external +5 V power supply
5	JTDI	10	GND	15	NRST	20	GND

3.1.2 Extension connector (CN2)

The 14-pin extension connector CN2 can be used together with the CN3 connector to connect an extension. The CN2 to CN3 pitch distance is 2.54 mm so it makes it possible to connect a standardized bread board or other extension.

Figure 6. Extension connector (CN2) pinout

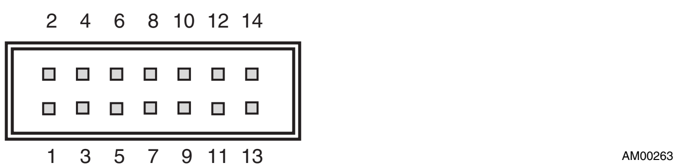


Table 3. Extension connector (CN2) pin description

Pin	STM32 pin	Pin	STM32 pin	Pin	STM32 pin
1	GND	6	PB8	11	PA2
2	2.5 V DC	7	PB9	12	PA3
3	PB5	8	PC13	13	NC
4	PB6	9	PA0	14	NC
5	PB7	10	PA1		

3.1.3 Extension connector (CN3)

The 14-pin extension connector CN3 can be used together with the CN2 connector to connect an extension. The CN2 to CN3 pitch distance is 2.54 mm so it makes it possible to connect a standardized bread board or other extension.

Figure 7. Extension connector (CN3) pinout

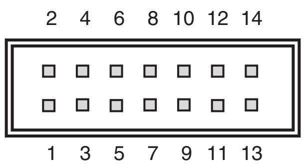


Table 4. Extension connector (CN3) pin description

Pin	STM32 pin	Pin	STM32 pin	Pin	STM32 pin
1	GND	6	PB12	11	PA9
2	2.5 V DC	7	PB13	12	PA10
3	PB2	8	PB14	13	PA11
4	PB10	9	PB15	14	PA12
5	PB11	10	PA8		

3.1.4 USB connector (CN4)

The board includes a mini USB AB SMT connector. The communication lines are not used with the TN100 board. The V_{BUS} + 5 V voltage (pin 1) can be used as an alternative board power supply.

Figure 8. USB connector (CN4) pinout

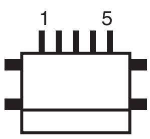


Table 5. USB connector (CN4) pin description

Pin	Connector pin
1	V_{BUS} +5 V
2	D– (not used with nanoLOC TN100 board)
3	D+ (not used with nanoLOC TN100 board)
4	NC
5	GND

3.1.5 RS-232 connector (CN5)

The RS-232 communication is realized by the RS-232 transceiver connected to the USART1 microcontroller serial channel. Signal connections are shown in *Table 6*. This channel can be used for simple communication and for microcontroller internal Flash memory programming. The female 9-pin D-SUB connector type is assembled. The connector pinout and signal connection is shown in *Figure 9*. For correct interconnection with a PC, a direct cable should be used.

Figure 9. RS-232 connector (CN5) pinout

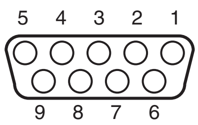


Table 6. RS-232 connector (CN5) pin description

Pin	Connector pin
1	Optionally connected to pins 4, 6 if R32 assembled
2	TX/RX (see *Figure 10*, *Table 7*)
3	RX/TX (see *Figure 10*, *Table 7*)
4	Connected to pin 6
5	GND
6	Connected to pin 4
7	Connected to pin 8
8	Connected to pin 7
9	NC

Figure 10. Switch S7 - RS-232 lines TX/RX cross or direct cable selection

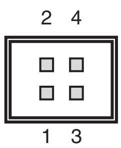
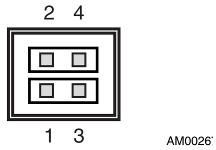
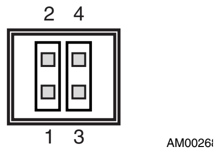


Table 7. RS-232 lines TX and RX, cross or direct cable selection

RS-232 cable selection	Jumper selection
Crossed	
Direct	

3.2 General-purpose and reset buttons

There are four push-buttons available on the board. S1 is a system reset button. Buttons S2 to S4 can be used as general-purpose. The related schematics are in *Table 8*.

Table 8. General-purpose and reset buttons description table

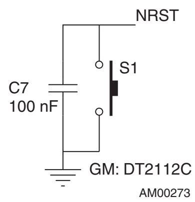
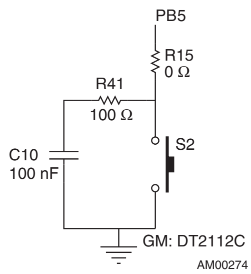
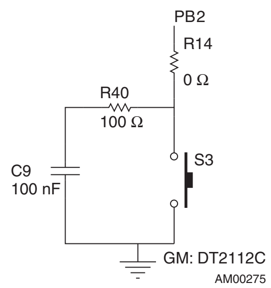
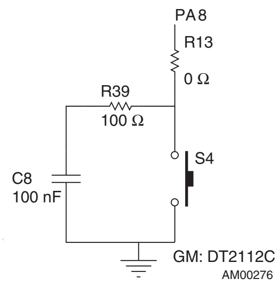
Reference	Board pin connection	Microcontroller pin connection	Function	Schematics
S1	7		Reset	
S2	1	PB5	General-purpose	

Table 8. General-purpose and reset buttons description table (continued)

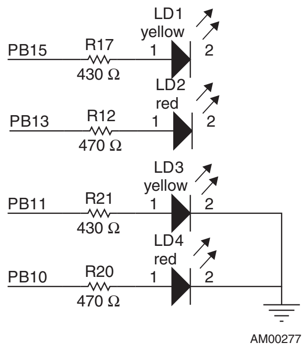
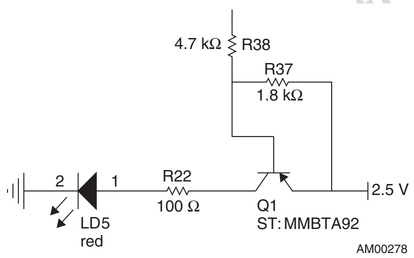
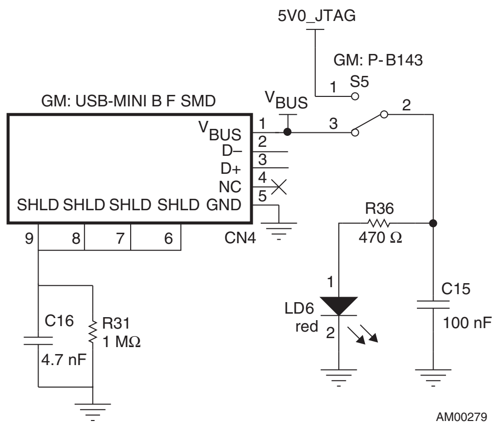
Reference	Board pin connection	Microcontroller pin connection	Function	Schematics
S3	11	PB2	General-purpose	
S4	18	PA8	General-purpose	

3.3 LED indicators

There are 6 LEDs available on the board. LD1 to LD4 are used for general-purpose and are driven directly by the STM32 from the TN100 board. LD5 indicates TX/RX activity and this pin is connected directly to the TN100 device on the board. LD6 indicates the presence of an external + 5 V power supply either from the USB or from the JTAG connection. When LD6 is off, the board is powered from batteries to reduce the overall power consumption.

3.4 Power supply

Table 9. LED indicators

LED	STM32 pin	Function	LEDs schematic
LD1	PB15	General-purpose	
LD2	PB13	General-purpose	
LD3	PB11	General-purpose	
LD4	PB10	General-purpose	
LD5	X	TX/RX activity	
LD6	X	External source voltage supply indication (USB or JTAG)	

The application can be supplied either through the USB connector CN4 (V_{BUS} + 5 V) and the JTAG connector CN1 (pin 19) or from batteries (2 x NiMH) for which there are two options (BAT1, BAT2 directly soldered (2/3 AAA) to the PCB or the BAT3 battery holder (AAA)).

Figure 11. USB connector (CN4)

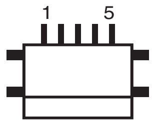


Table 10. CN4 pins description

Pin	Signal
1	+ 5 V V_{BUS}
5	GND

Figure 12. JTAG connector - CN1

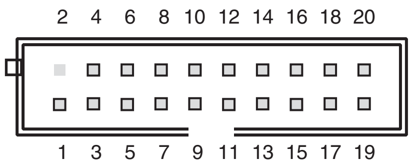


Table 11. CN1 pins description

Pin	Signal
19	+ 5 V
2 - 20	GND (all even pins)

Figure 13. Batteries

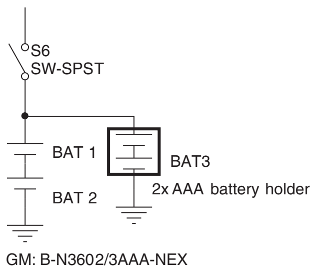


Table 12. Batteries (2 x 1.2 V NiMH)(1)

Component	Signal
BAT1, BAT2	Soldered directly to PCB (2/3 AAA NiMH batteries)
BAT3	2 x AAA Battery holder

1. Default assembly: BAT3 battery holder.

4 Getting started

This section provides a complete description on how to use the kit and how to perform all the relevant operations using the graphical user interface.

4.1 Kit setup

4.1.1 Software installation

Following are described the steps to setup the kit and to start working with it.

1. Double-click on the *tn100demo.exe* file to install the software application.
2. In the **ST TN100 Demo Setup: Installation Folder** dialog box, select the destination folder and click **Install**.
3. When the installation is completed, click **Close**.
4. Open **Start** -> **All Programs** -> **STMicroelectronics** -> **tn100demo,** locate and run the *rfappl* entry to display the TN100 Application window.

4.1.2 Board setup

Each board is provided with a set of batteries and preloaded firmware.

Boards can be powered using the USB connection through CN4 connector or batteries (*Table 13*).

Warning: When using non-rechargeable batteries, please make sure to remove batteries when powering boards from USB.

In order to check whether firmware is present and running, please switch on the board placing S6 in ON position if powering from batteries or use the USB cable in CN4 and place S5 in USB position. If firmware is preloaded, LD1 will blink 5 times within one second. If firmware is not properly installed or has been altered, please refer to *Section 5: Updating firmware nodes* for instructions on how load the firmware image in the board.

Table 13. Power source switch configuration

Power source	Switch S5	Switch S6
USB	USB	OFF
BAT	JTAG	ON

4.2 Application description

4.2.1 Running the application

1. Connect one of the two sensor boards - using the RS232 connector - to the host PC by means of the provided serial cable. The connected board will became the Gateway and will manage the messages coming from the PC and the other sensor nodes. Of course, the Gateway itself is a sensor node as well.
2. Switch on the Gateway: the Gateway must be the first node to be powered-on because it will be then able then to detect the other nodes. LED1 should be continuously blinking once per second as a confirmation that the node is properly configured.
3. Press the Refresh button in the TN100 Application window toolbar to update all the views (Nodes Area, Sensing and Control, Ranging, Data Tx/Rx, and Message send) where the Gateway information is displayed.
4. Click the "+" expander in the first entry, the Gateway, in the Sensing and Control view to view all the available data for such node: Firmware version, MAC address, Temperature, MEMS values from relative on-board sensors, LEDs and button status. It is worth to say that up to now all the data are gathered from the serial cable.
5. Switch on the other sensor board: the Sensor1.This time the sensor board will be detected through RF by the Gateway and the information directly transmitted to the PC which in turn will show the new node wherever expected to appear. LED1 should be continuously blinking once per second as a confirmation that the node has been configured properly.
6. Click the "+" expander in the Sensor1 entry of the Sensing and Control view to see the associated information as done for the Gateway. Now, differently from the Gateway case, the data coming from Sensor1 are gathered via RF.

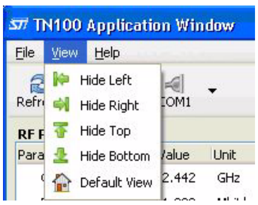
4.2.2 Menu bar and toolbar

Using the commands available in the **View** menu, it is possible to control which views are displayed within the TN100 application framework.

Select one of the following **View** menu commands:

- **Hide Left**, to hide both the RF Parameters and Sensing and Control views
- **Hide Right**, to hide the Nodes Area, Ranging, Data Tx/Rx, and Send Messages views
- **Hide Top**, to show just the Packet Log view and hide all the other views
- **Hide Bottom**, to hide just the Packet Log view and show all the other views
- **Default View**, to show the initial set of views constituted by the RF Parameters, Sensing and Control, and Nodes Area views

Figure 14. View menu



The **Toolbar** contains the following buttons:

- **Refresh**, to let the Application detect any update on the nodes network
- **Scroll to end**, to automatically scroll to the newly inserted row in the Packet Log view
- **COM port**, to display information about the COM port currently in use

Figure 15. Toolbar buttons

4.2.3 Sensing and control

The two boards, the Gateway and the Sensor1, are equally equipped with MEMS (Micro electro mechanical systems) and temperature sensors. The MEMS motion sensor provides data regarding the acceleration (g) detected on the board along the 3 axes (x, y, and z) and the measure is expressed in mg, or (10-3) g. The temperature sensor provides data regarding the temperature detected in the environment.

All these data coming from the sensor board may be seen clicking-on the expander “+” associated to the Gateway and Sensor1 entries within the Sensing and Control view. The MEMS entry in particular requires to be expanded further to read the X, Y, and Z values.

The TN100 Application also controls the status, via RF, of on-board items such as the LEDs.

1. Click the “+” expander in the Sensor1 LED entry of the Sensing and Control view to display the associated LED status. Initially, are all Off.
2. Select LD2 for example and right-click with the mouse.
3. Select On in the contextual menu, the associated icon changes its state and the LED LD2 in the Sensor1 board switches on.

The same can be done for the other LEDs.

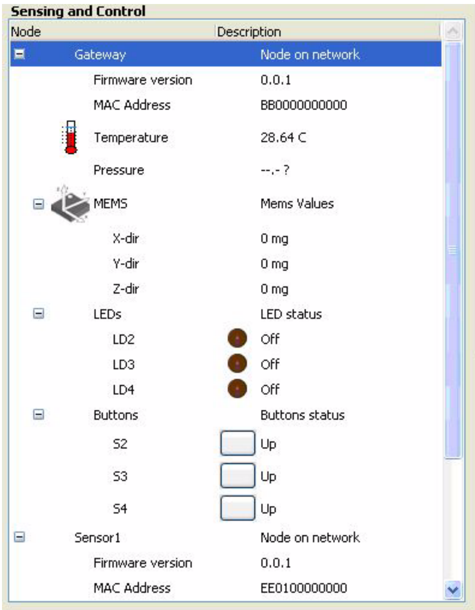
To detect button status, perform the following:

1. Click the “+” expander in the Sensor1 Buttons entry of the Sensing and Control view to display the associated Buttons status. Initially, are all Up.
2. Push the button S3 on the Sensor1 board and keep it pressed for a while, the button icon associated to the button S3 will change its status to Down until the button is released.

The same can be done also for the other buttons.

For each sensor board, the application also displays information regarding the current firmware version and MAC address.

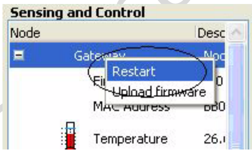
Figure 16. Sensor board parameters



Furthermore, this view can be used to upload the firmware on the Gateway and to restart the firmware in any node. For further information on how to upload a new firmware, please see *Section 5.2: Upload firmware using TN100 application*.

To restart a node, right-click **Node entry** and select **Restart** in the popup menu (*Figure 17*).

Figure 17. Restarting a node



4.2.4 Ranging

One of the more interesting features that may be experimented with is the execution of Ranging operations; that is, being able to get an approximation of the distance between two nodes.

1. Click the "+" expander near the Ranging item to expand the Ranging view.

Figure 18. Ranging view expander

2. Select the two nodes participating to the ranging session within the Node1 and Node2 drop-down lists respectively.
3. Insert the number of trials (for example, NT) you want to perform in order to establish the total average distance in the **Overall Trials** edit box. Default value is 10.

4. Insert how many samples (measures) must be taken into account by the sensor board to calculate an interim average (for example, AS). Default value is 1.

Note: The data in the two fields are linked in the following way: the sensor board sends one average value calculated on AS samples and the process lasts NT times. If, for example, NT=100 and AS=10, one average value will be communicated by the sensor board after 10 measures and that will be repeated 100 times. So, in total 100x10 measures will be taken, 100 times the average value will be communicated. The advantage of this approach is that it reduces air traffic because data is communicated each AS (10 in the example) times. The sensor board sends the current measure without performing any average if the ***Average On Samples*** *field is set to 1.*

5. Click **Start Ranging** once all the data is entered to start the ranging session.

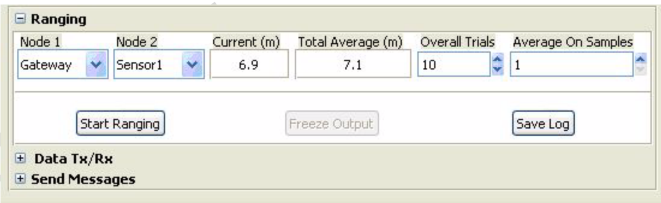
The **Current** (m) box shows the value of the current measured distance. If the **Average On Samples** field is higher than 1, that value will be the calculated average on the field content. At the end, the last calculated measure is displayed. The **Total Average** (m) box shows the total average of all the distances gathered up to now. At the end, the final average calculated on all the measures is displayed.

While ranging is in progress, the **Freeze Output** button may be used to temporarily freeze the display measurement values because they will change frequently. This is only for visualization purposes because the measuring continues. Click **Unfreeze Output** to unfreeze the data output visualization.

Click **Save Log** at the end of the Ranging session to save the log of all the performed measures during the last session. A window will allow you to select a file where to store the data. These data are formatted using a comma separated value style which may be opened for example using Excel or Notepad applications.

To start a new session, insert new values or leave them as they are and click again **Start Ranging**.

Figure 19. Ranging view content



4.2.5 Data Tx/Rx

1. Click the “+” expander on the left of the **Data Tx/Rx** item to expand the Data transmission/reception view.

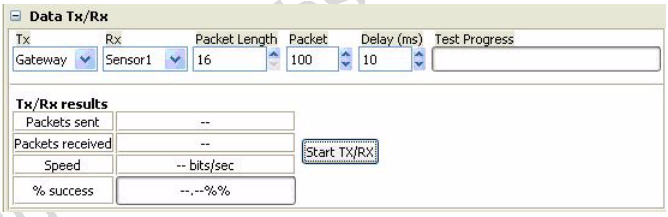
Figure 20. Data Tx/Rx view expander

2. Select the two nodes participating to the data transmission/reception session within the Tx and Rx drop-down lists respectively. The one selected in the Tx field will be the transmitter and the other the receiver.
3. Edit the **Packet Length** field to determine the length of the packet you would like to use. Default value is 16, and the unit of measure is bytes.
4. Edit the **Packet** field to set the number of packet(s) you wish to send. Default value is 1.
5. Edit the **Delay** field to set the delay inserted between the transmissions of two packets. Default value is 10, and the unit of measure is milliseconds (ms).
6. Click **Start Tx/Rx** to start the data transmission test.

The transmission progress is graphically shown in **Test Progress** bar, and numerically in the **Packets sent** and **Speed** fields. At the end of the transmission test, the **Packets received** and **% success** fields will be updated according to the gathered statistics.

To start a new session, insert new values or leave them as they are and click again **Start Tx/Rx**.

Figure 21. Data Tx/Rx view content



4.2.6 Send messages

In addition to exchanging data between the two sensor boards, it is also possible to have them exchange text messages.

1. Click the “+” expander on the left of the **Send Messages** item to expand the view.

Figure 22. Send messages view expander

2. Select the two nodes participating to the message transmission/reception session within the **Tx** and **Rx** drop-down lists respectively.
3. Insert the text message, that the transmitter will send to the receiver, in the **Message to send** box. For example “Hello”.
4. Click **Send Message** to send the message to the selected receiver.

The **Message received** box will show a string like (if the Gateway and Sensor1 were selected as transmitter and receiver respectively):

Sensor1: message recv'd from Gateway “Hello”.

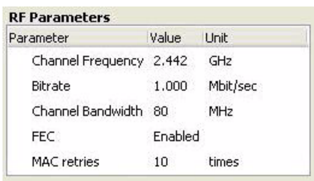
To start a new session, apply changes or leave data as they are and click again **Send message**.

Figure 23. Send messages view content

4.2.7 RF parameters

The TN100 Application also provides an **RF parameters** view that displays a set of typical RF parameters involved in communication with their the associated values and units of measure. Such parameters and values further contribute to a better understanding of the RF context where trials are executed.

Figure 24. RF parameters view content


RF Parameters

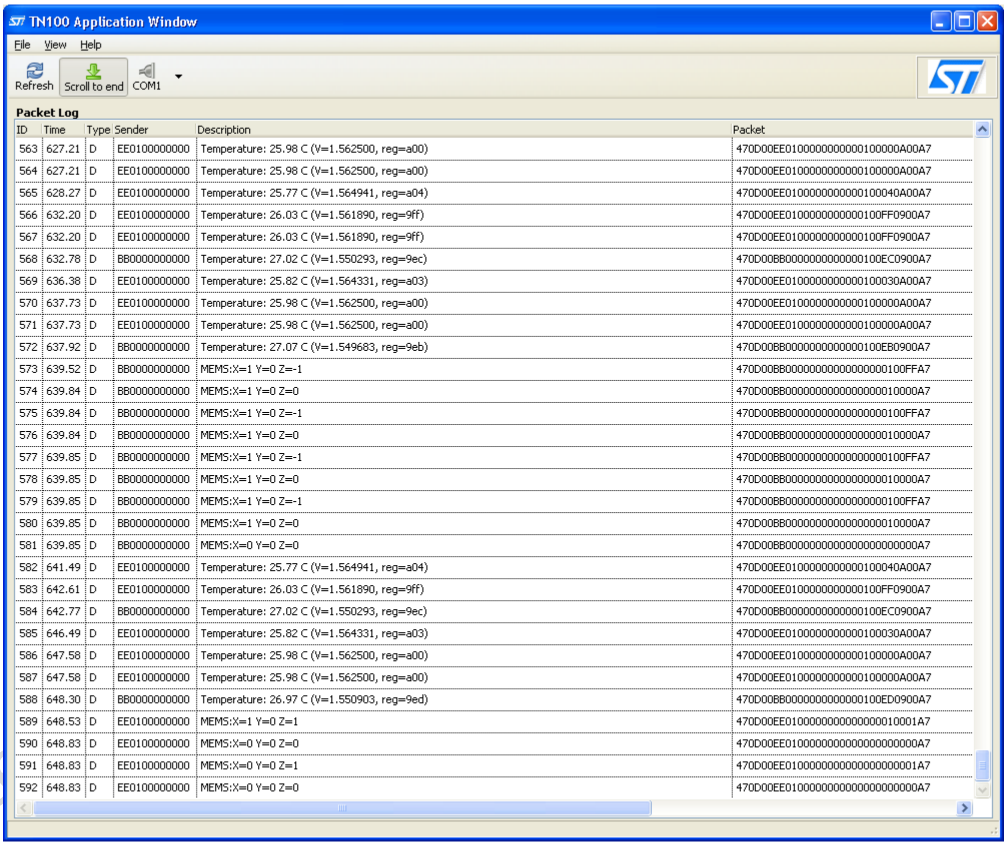
Parameter	Value	Unit
Channel Frequency	2.442	GHz
Bitrate	1.000	Mbit/sec
Channel Bandwidth	80	MHz
FEC	Enabled	
MAC retries	10	times

4.2.8 Packet log

The aim of the Packet Log view is to display detailed information which can be used for debugging reasons; this view is not intended to be used under normal application operation. The table format of such information is organized according to the following fields:

- **ID** is a numeric identifier associated to the transmitted packets.
- **Time** is the number of seconds passed since the application start.
- **Type** is the packet type: R means the packet is a Reply associated to a received command, D means the packet contains Data value as the ones coming from sensors.
- **Sender** is the MAC address of the device sending the packet.
- **Description** is a textual description of the packet.
- **Packet** is the packet content expressed in hexadecimal format.

Figure 25. Packet Log view content



ID	Time	Type	Sender	Description	Packet
563	627.21	D	EE0100000000	Temperature: 25.98 C (V=1.562500, reg=a00)	470D00EE010000000000100000A00A7
564	627.21	D	EE0100000000	Temperature: 25.98 C (V=1.562500, reg=a00)	470D00EE010000000000100000A00A7
565	628.27	D	EE0100000000	Temperature: 25.77 C (V=1.564941, reg=a04)	470D00EE010000000000100040A00A7
566	632.20	D	EE0100000000	Temperature: 26.03 C (V=1.561890, reg=9ff)	470D00EE010000000000100FF0900A7
567	632.20	D	EE0100000000	Temperature: 26.03 C (V=1.561890, reg=9ff)	470D00EE010000000000100FF0900A7
568	632.78	D	BB0000000000	Temperature: 27.02 C (V=1.550293, reg=9ec)	470D00BB000000000000100EC0900A7
569	636.38	D	EE0100000000	Temperature: 25.82 C (V=1.564331, reg=a03)	470D00EE010000000000100030A00A7
570	637.73	D	EE0100000000	Temperature: 25.98 C (V=1.562500, reg=a00)	470D00EE010000000000100000A00A7
571	637.73	D	EE0100000000	Temperature: 25.98 C (V=1.562500, reg=a00)	470D00EE010000000000100000A00A7
572	637.92	D	BB0000000000	Temperature: 27.07 C (V=1.549683, reg=9eb)	470D00BB000000000000100EB0900A7
573	639.52	D	BB0000000000	MEMS:X=1 Y=0 Z=-1	470D00BB0000000000000000100FFA7
574	639.84	D	BB0000000000	MEMS:X=1 Y=0 Z=0	470D00BB000000000000000010000A7
575	639.84	D	BB0000000000	MEMS:X=1 Y=0 Z=-1	470D00BB0000000000000000100FFA7
576	639.84	D	BB0000000000	MEMS:X=1 Y=0 Z=0	470D00BB000000000000000010000A7
577	639.85	D	BB0000000000	MEMS:X=1 Y=0 Z=-1	470D00BB0000000000000000100FFA7
578	639.85	D	BB0000000000	MEMS:X=1 Y=0 Z=0	470D00BB000000000000000010000A7
579	639.85	D	BB0000000000	MEMS:X=1 Y=0 Z=-1	470D00BB0000000000000000100FFA7
580	639.85	D	BB0000000000	MEMS:X=1 Y=0 Z=0	470D00BB000000000000000010000A7
581	639.85	D	BB0000000000	MEMS:X=0 Y=0 Z=0	470D00BB000000000000000000000A7
582	641.49	D	EE0100000000	Temperature: 25.77 C (V=1.564941, reg=a04)	470D00EE010000000000100040A00A7
583	642.61	D	EE0100000000	Temperature: 26.03 C (V=1.561890, reg=9ff)	470D00EE010000000000100FF0900A7
584	642.77	D	BB0000000000	Temperature: 27.02 C (V=1.550293, reg=9ec)	470D00BB000000000000100EC0900A7
585	646.49	D	EE0100000000	Temperature: 25.82 C (V=1.564331, reg=a03)	470D00EE010000000000100030A00A7
586	647.58	D	EE0100000000	Temperature: 25.98 C (V=1.562500, reg=a00)	470D00EE010000000000100000A00A7
587	647.58	D	EE0100000000	Temperature: 25.98 C (V=1.562500, reg=a00)	470D00EE010000000000100000A00A7
588	648.30	D	BB0000000000	Temperature: 26.97 C (V=1.550903, reg=9ed)	470D00BB000000000000100ED0900A7
589	648.53	D	EE0100000000	MEMS:X=1 Y=0 Z=1	470D00EE01000000000000010001A7
590	648.83	D	EE0100000000	MEMS:X=0 Y=0 Z=0	470D00EE01000000000000000000A7
591	648.83	D	EE0100000000	MEMS:X=0 Y=0 Z=1	470D00EE01000000000000000001A7
592	648.83	D	EE0100000000	MEMS:X=0 Y=0 Z=0	470D00EE01000000000000000000A7

5 Updating firmware nodes

The sensor board firmware may be updated through the serial connection using both the TN100 Application or directly through a HyperTerminal using the preloaded boot loader code. If for some reason the boot loader is corrupted, please refer to *Section 5.3: Loading the boot loader into the sensor board*.

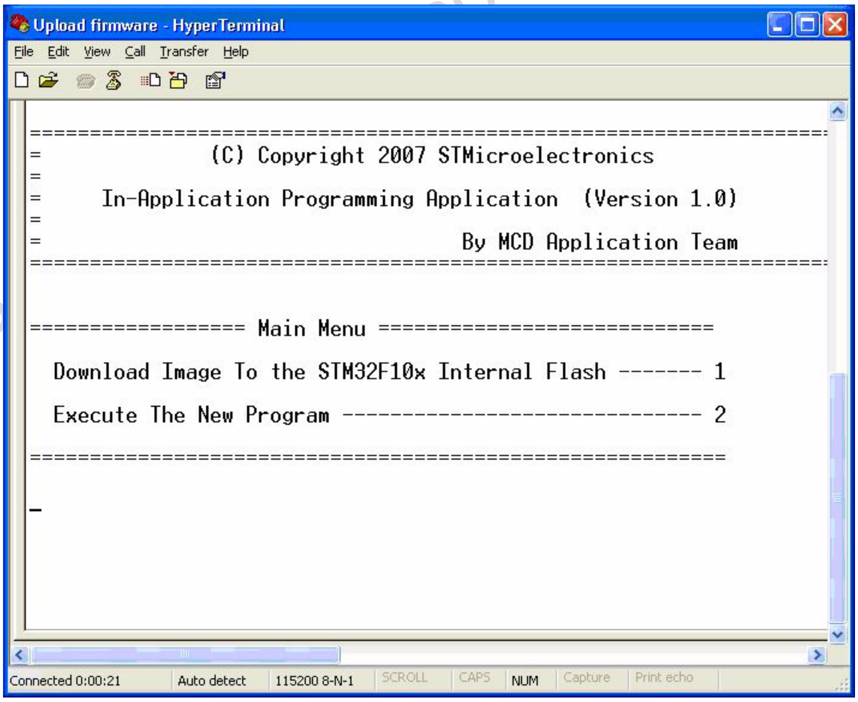
Note: Please make sure to upload the same firmware version in both sensor nodes because unexpected behavior could result otherwise.

5.1 Upload firmware using HyperTerminal

To upload a new firmware version using the HyperTerminal, follow the steps below:

1. Make sure the sensor board is connected with a serial cable, in the COM1 for example, and the TN100 Application is not running.
2. Launch the Windows HyperTerminal application.
3. Define a connection.
   a) In the **Connect To** dialog box, select the COM port, COM1 for example, and press **OK**.
   b) In the **Bits per second** field of the **COM1 Properties** dialog box, select **115200**.
   c) In the **Flow control** field of the **COM1 Properties** dialog box, select **None**.
   d) Press **OK**.

Figure 26. HyperTerminal upload firmware menu



4. Switch on the sensor board.

5. Keep the S2 button pressed and then press and release the RESET button; LEDs LD2, LD3, and LD4 will blink continuously and the HyperTerminal appears as shown in *Figure 26*.
6. Press “1” key as indicated by the HyperTerminal to download the firmware.
7. In the **Transfer** menu, select **Send File ...** .
8. In the **Send file** dialog box, browse for the BIN file containing the firmware to be uploaded.
9. In the **Protocol** drop-down list, set the **Ymodem** entry.
10. Press **Send** to upload the firmware; the Ymodem file is displayed until the upload is completed.
11. At completion of the upload, the HyperTerminal will show the message “Programming Completed Successfully!”
12. Switch off and restart the board to work with the new firmware version.

5.2 Upload firmware using TN100 application

When using the TN100 Application, only one board may be updated at a single time. This is due to the fact that the Gateway is connected by the serial cable to the host PC and each board has to become a Gateway (only once) just for the time required to download the firmware.

To upload a new firmware version using the TN100 Application, follow the steps below:

1. Make sure the Gateway and the TN100 Application are switched on and working.
2. In the **Sensing and Control** view, right-click **Gateway** and select **Upload firmware**.

Figure 27. Upload firmware selection

3. In the **Select file** dialog box, select the BIN file containing the firmware to be uploaded.
4. Press **Open**.

The upload process will start, the Uploading firmware dialog will appear and, meanwhile, LEDs LD2, LD3, and LD4 will be flashing in sequence indicating correct packet reception. At the end, the sensor board will restart and LED LD1 will start to blink continuously again.

To upload the firmware to the other board, switch off the one currently connected and unplug the serial cable. Arrange again the connections and switch on the board to be updated. Once the node appears as Gateway, perform again the steps listed above. At completion, both the sensor boards are updated with the new firmware and can be used again.

5.3 Loading the boot loader into the sensor board

In order to check whether the boot loader is present or not, please do the following:

1. Keep button S2 pressed and reset the board via button S1.
2. LEDs LD2, LD3 and LD4 should now blink as confirmation that the boot loader is present and running.

If the boot loader is not present or is corrupted, please use a JTAG connection to load the *bootloader.hex* file provided in the software installation.

Appendix A Board assembly setup manual

Table 14. Board assembly setup manual

Resistor	Value (Ω)	Assembled	Not assembled
General-purpose buttons			
R13	0	PA8 MCU signal is connected to the general-purpose button S4.	PA8 MCU pin is disconnected from the button S4 and can be freely used for other purposes.
R14	0	PB2 MCU signal is connected to the general-purpose button S3.	PB2 MCU pin is disconnected from the button S3 and can be freely used for other purposes.
R15	0	PB5 MCU signal is connected to the general-purpose button S2.	PB5 MCU pin is disconnected from the button S2 and can be freely used for other purposes.
Power supply			
R28	0	Connects PA3 MCU pin to the low battery out-put signal of the step-up converter U5. The pin can be configured as an external interrupt line.	PA3 MCU pin is disconnected from the LBO pin of U5 and can be freely used for other purposes.
R30	0	Connects PA2 MCU pin to the batteries. The battery voltage can be measured if PA2 is configured as ADC input line.	PA2 MCU pin is disconnected from the batteries and can be freely used for other purposes.
General-purpose LEDs			
R12	470	PB13 MCU signal is connected to the general-purpose LED LD2.	PB13 MCU pin is disconnected from the LED LD2 and can be freely used for other purposes.
R17	470	PB15 MCU signal is connected to the general-purpose LED LD1.	PB15 MCU pin is disconnected from the LED LD1 and can be freely used for other purposes.
R20	470	PB10 MCU signal is connected to the general-purpose LED LD4.	PB10 MCU pin is disconnected from the LED LD4 and can be freely used for other purposes.
R21	470	PB11 MCU signal is connected to the general-purpose LED LD3.	PB11 MCU pin is disconnected from the LED LD3 and can be freely used for other purposes.
MEMS accelerometer			
R7	0	Connects MEMS interrupt 1 pin of the accelerometer to the PB12 MCU pin which can be configured as an external interrupt line.	PB12 MCU pin is disconnected from the MEMS interrupt 1 pin of the accelerometer and can be freely used for other purposes.

Table 14. Board assembly setup manual (continued)

Resistor	Value (Ω)	Assembled	Not assembled
R8	0	Connects MEMS interrupt 2 pin of the accelerometer to the PB14 MCU pin which can be configured as an external interrupt line.	PB14 MCU pin is disconnected from the MEMS interrupt 2 pin of the accelerometer and can be freely used for other purposes.
R11	0	Connects 2.5 V supply voltage to the MEMS accelerometer U3 sensor domain.	Disconnects 2.5 V supply voltage from the MEMS accelerometer U3 sensor domain.
Temperature sensor			
R2	0	Connects temperature sensor output pin to the PA0 MCU pin which can be configured as ADC input.	PA0 MCU pin is disconnected from the temperature sensor output pin and can be freely used for other purposes.
R9	0	Connects potentiometer output pin to the PA1 MCU pin which can be configured as ADC input.	PA1 MCU pin is disconnected from the Potentiometer output pin and can be freely used for other purposes.
R6	0	Connects 2.5 V supply voltage to the temperature sensor U2 and potentiometer R10 domain.	Disconnects 2.5 V supply voltage from temperature sensor U2 and potentiometer R10 sensor domain.
RS-232			
R33		Connects USART TX pin PA9 of the microcontroller to the RS-232 transceiver TX pin.	PA9 MCU pin is disconnected from the RS-232 transceiver TX pin and can be freely used for other purposes.
R34		Connects USART RX pin PA10 of the microcontroller to the RS-232 transceiver RX pin.	PA10 MCU pin is disconnected from the RS-232 transceiver RX pin and can be freely used for other purposes.

Appendix B Bill of materials

Table 15. Description of bill of materials

Designator	Comment	Package	Order code	Assembly instructions
BAT 1, BAT 2	NiMH accumulators		GM®: B-N360 2/3AAA-NEX	No
BAT3	2x AAA battery holder, 2468 - keystone		Farnell: 1093538	Yes
C1, C3, C5, C6, C7, C8, C9, C10, C12, C14, C15, C17, C18, C19, C20, C21, C24	100 nF ceramic	0805		C1 - no
C2, C4	10 µF Tantal / 6.3 V	B	GM: CTS10M/6.3 V	C2 - no
C11, C13	47 µF Tantal / 10 V	D	GM: CTS47M/10 V	Yes
C16, C22	4.7 nF ceramic	0805		Yes
C23	10 nF ceramic	0805		Yes
C25	2.2 µF Tantal / 6.3 V	A	GM: CTS2M2/6.3 V	Yes
CN1	GM: MLW20G		GM: MLW20G Farnell: 1247390 SPC Technology: SPC20508	Yes
CN2, CN3	Header 2X7		GM: S2G14 Farnell: 1319205 Molex®: 10897141	Yes
CN4	USB-MINI B F SMD Molex socket, USB, MINI-B, SMT, W/PEGS		GM: USB-MINI B F SMD Farnell: 1125348	Yes
CN5	RS-232 DB9 female connector		GM: CAN 9 Z 90 Farnell: 1186091 SPC Technology: SPC15457	Yes
D1	Diode	SOT-23	ST: BAT54CFILM	Yes
D2	Diode	SOD-123	ST: STPS0520Z	Yes
L1	22 µH, SMT power inductor		Coilcraft: DO1813H-223ML Coilcraft: DO1608C-153ML	Yes
LD1, LD2, LD3, LD4	Yellow	0805		Yes
LD5, LD6	Red	0805		Yes
P1	Johnson®/Emerson Jack, SMA, PCB, End Launch		Farnell: 1339836	Yes
Q1	PNP transistor	SOT-23	ST: mmbta92	Yes
R1, R12, R20, R36	470 Ω	0805		
R2, R3, R4, R5, R6, R7, R8, R9, R11, R13, R14, R15, R26, R27, R28, R30, R32, R33, R34	0 Ω	0805		R3, R4, R5, R26, R32 - No

Table 15. Description of bill of materials (continued)

Designator	Comment	Package	Order code	Assembly instructions
R10	250 KΩ, 1 MΩ		GM: PTC10VK250 or GM: PT10MVK250 + PT10Z5012B Bourns®: 3319P-3 105 Tyco: CB10MV105M	Yes
R16, R18, R19	10 KΩ	0805		
R17, R21	430 Ω	0805		
R22, R39, R40, R41	100 Ω	0805		
R23	680 KΩ	0805		No
R24	820 KΩ	0805		No
R25	180 kΩ	0805		No
R29	120 Ω	0805		
R31, R35	1 MΩ	0805		
R37	1.8 kΩ	0805		
R38	4.7 kΩ	0805		
R42	1.5 KΩ	0805		No
S1, S2, S3, S4	Push-button		GM: DT2112C GM: P-DT2112C SMD Farnell: 9471898 (SMD) MULTICOMP: DTSM-32S-B (SMD)	Yes
S5	Slide switch		GM: P-B143 Farnell: 1197660 Tyco: SLS121PCFN	Yes
S6	Slide switch		GM: P-B143 Farnell: 1197660 Tyco: SLS121PCFN	Yes
S7	Header 2X2		GM: S2G4 Farnell: 1278358 Molex: 10-89-7082	Yes
U1	Barometer	LGA16	ST: LPS004DL	No
U2	Temperature meter	SOT323-5	ST: STLM20W87F	Yes
U3	MEMS accelerometer	LGA14	ST: LIS302DL	Yes
U4	NanoLOC_STM32_Module _P182		ST	Yes
U5	DC step up converter	MSOP8	ST: L6920DC	Yes
U6	RS-232 transceiver	TSSOP20	MAXIM: MAX3319ECAE	Yes
U7	Ultra low drop-low noise voltage regulator	SOT23.5	ST: LD3985M25R	Yes
U8	ESD protection	SOT23-6L	ST: USBLC6-2P6	No

Appendix C Artwork prints

This section shows the layout of the evaluation board PCB (top and bottom layers).

Figure 28. Evaluation board PCB (top layer)

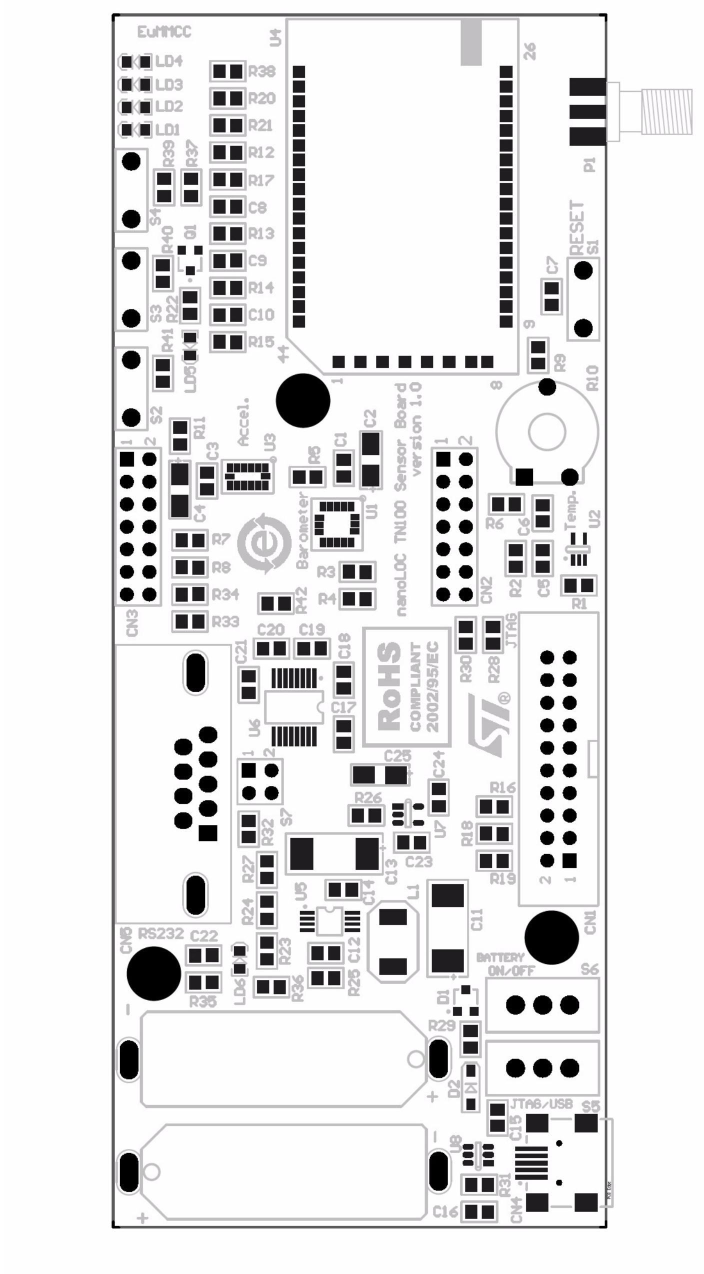
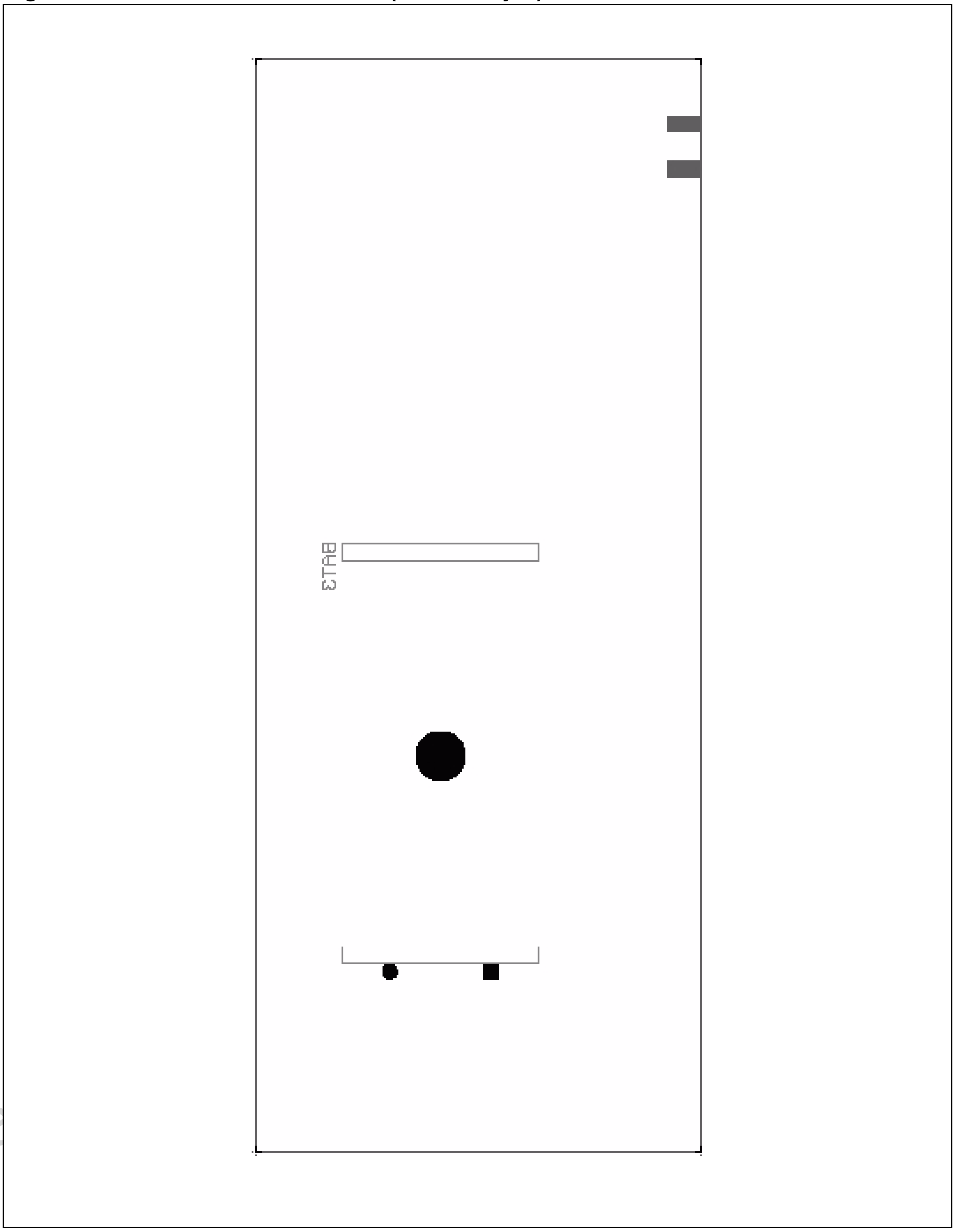


Figure 29. Evaluation board PCB (bottom layer)



Appendix D Schematic diagrams

Figure 30. LED and button schematics

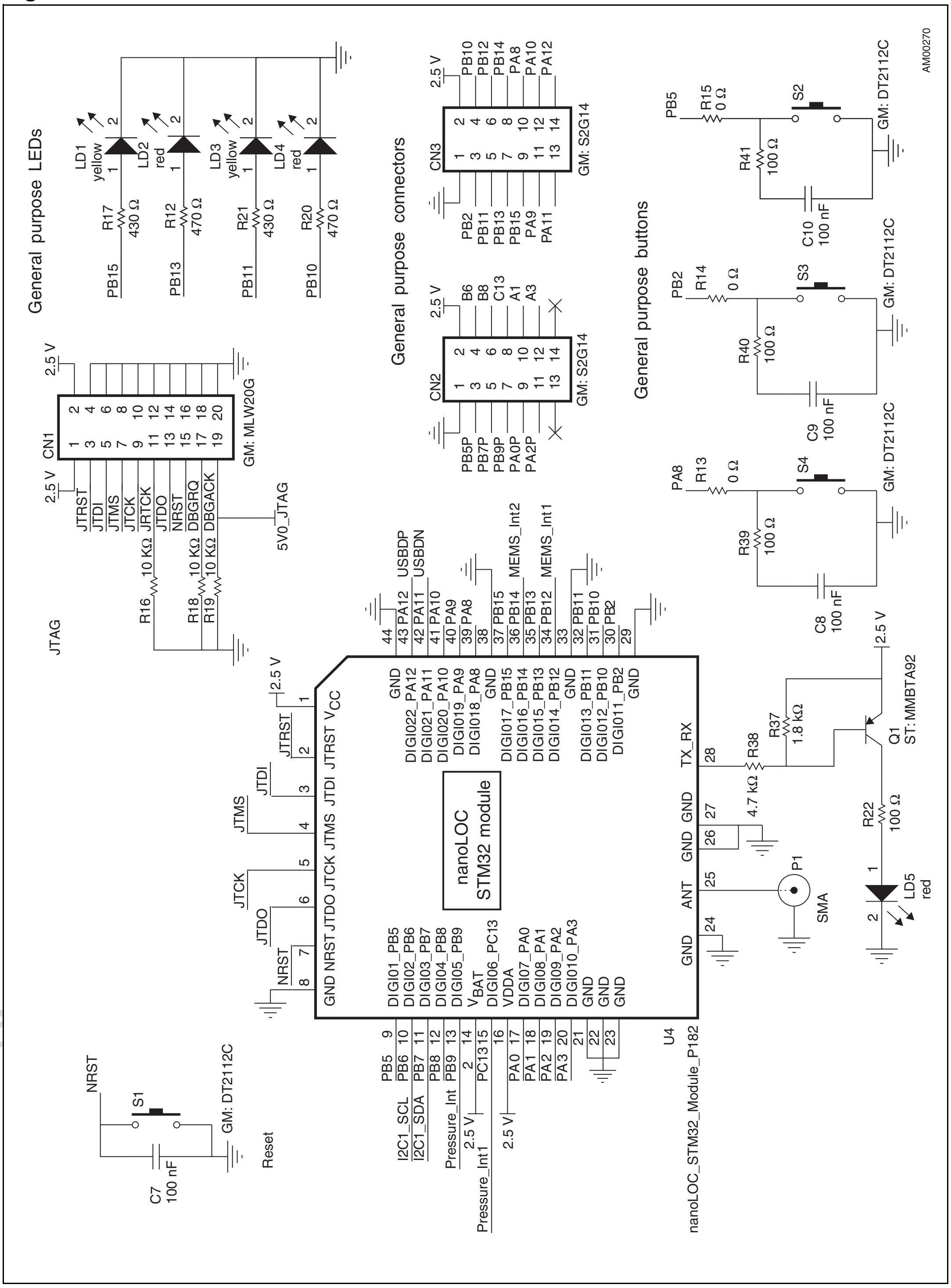


Figure 31. Power supply schematics

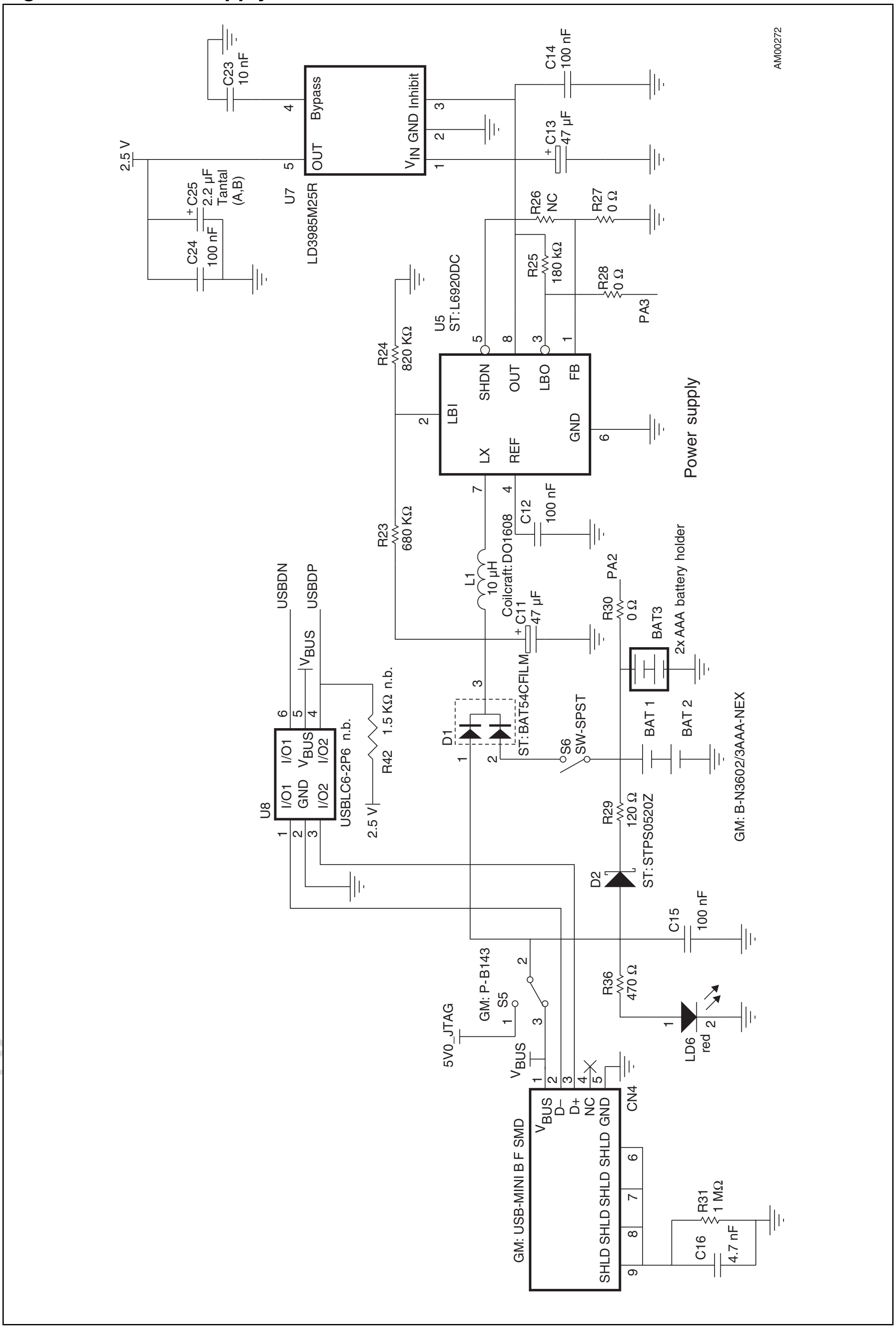
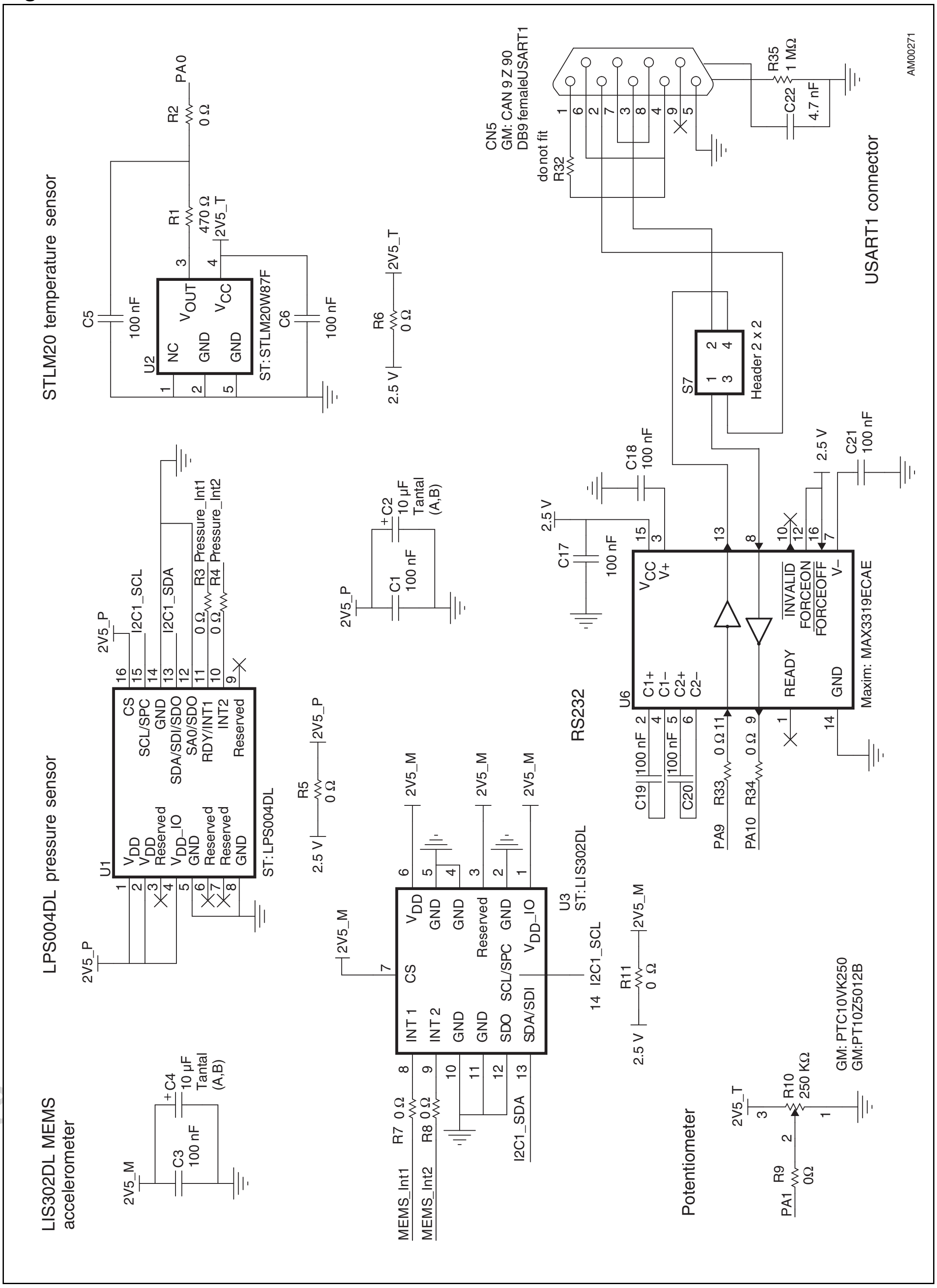


Figure 32. Sensor and RS-232 communication schematics



Revision history

Table 16. Document revision history

Date	Revision	Changes
21-Jan-2009	1	Initial release.

Please Read Carefully: