Bittium

Belmont HW Over-view

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1 DEFINITIONS, TERMS, ACRONYMS, ABBREVIATIONS

The definitions, terms, acronyms and abbreviations not commonly known are listed in Table 1.

Table 1. Project definitions, terms, acronyms and abbreviations

Abbreviation	Description
3GPP	3rd Generation Partnership Project
4G	4th Generation of standards for mobile phones and mobile tele-communications
BOM	Bill Of Materials
BB	Baseband
Chipset	A set of Integrated Circuits and corresponding SW designed for mo-bile phone functionality
End Product	Validated product ready for commercial deployment
EMS	Electronics Manufacturing Supplier
ETSI	European Telecommunication Standardizing Institute
FCC	Federal Communications Commission
GCF-CC	Global Certification Forum – Certification Criteria
HW	Hardware
ID	Industrial Design
3GPP	3rd Generation Partnership Project
BAT	Basic Acceptance Test
BOM	Bill of Materials
CAT	Category
CR	Change Request
dB	Decibel
dBi	dB (isotropic)
dBm	Decibels relative to one mill watt
eSIM	Embedded SIM

Abbreviation	Description
FCC	Federal Communications Commission (USA)
FreeRTOS	Free Real Time Operating System
GCF	Global Certification Forum
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
IoT	Internet of Things
LED	Light Emitting Diode
LTE	Long Term Evolution
MCU	Microcontroller Unit
MHz	Megahertz
mm	Millimetre
OD	Open Development
PCB	Printed Circuit Board
PS	Project Start
PTCRB	North American cellular operators certification forum (formerly "PCS Type Certification Review Board")
RF	Radio Frequency
SIM	Subscriber Identity Module (Card)
SMD	Surface-Mount Device
SOW	Statement of Work
SPI	Serial Peripheral Interface bus
STM	ST Microelectronics
SW	Software
TC	Test Case
TIS	Total Isotropic Sensitivity

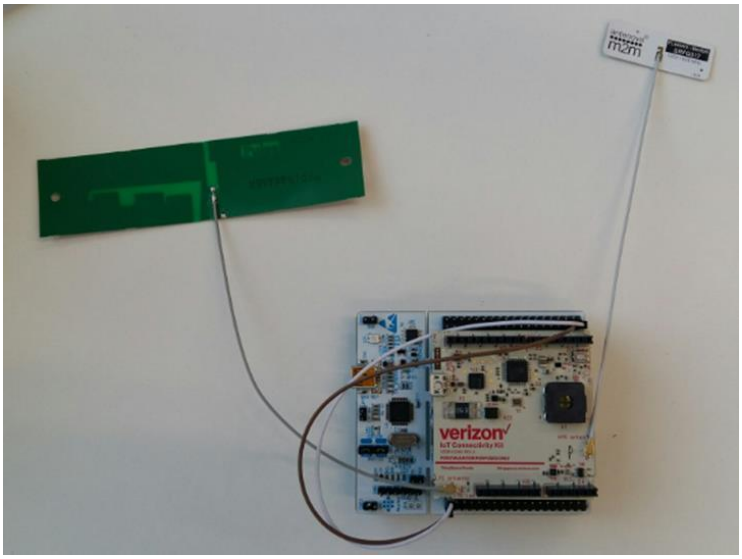
Abbreviation	Description
TRP	Total Radiated Power
UART	Universal Asynchronous Receiver/Transmitter
UICC	Universal Integrated Circuit Card
UL	Uplink

2 PRODUCT OVERVIEW

The Belmont product (hereafter, known as the “Belmont”) is a development kit for Verizon’s partners targeting the consumer device segment of the IoT market.
Verizon and its development partners may use the development kit for development of the products in the IoT market segment including fitness trackers, smart watches, smart glasses, connected shoes, prescription caps, and asset trackers. The typical IoT device requirements from this segment include low power consumption, UICC capability, and self-activation enablement. While Belmont contains cellular and complementary wireless antennas, Verizon’s partners in this segment are expected to design their own antenna solutions for their commercial products.

Belmont Board

Belmont System Including Belmont board, Host board (STM Nucleo L476) and antennas



3 BLOCK DIAGRAM

Belmont board has Sequans LTE Cat-M1 module (VZM20Q) for LTE functionality. LTE module uses eSIM initialized to Verizon network. The VZM20Q is a complete Verizon Wireless certified LTE Category M1 module including base-band, RF and memory, for the design of connected machine-to-machine devices, and other Internet-of-Things devices with embedded LTE connectivity.

GNSS is implemented using Sony CXD5600GF Multi GNSS receiver chipset supporting GPS and Glonass systems. The CXD5600GF is operated as I2C slave device. One additional GPIO pin in the CDX5600GF is used to host board (Nucleo L476) as “data output request” in addition to SDA and SCL.

Belmont has standard Arduino interface which is used to connect it to commercial STM Nucleo L476RG Host Board.

USB connector is used for power supply to Belmont. USB connector can be also used for re-flashing the LTE module (VZM20Q) firmware.

Audio, 3-Axis sensor, Temp/Humidity and ALS sensors are optional modules.

The architecture block diagram of the Belmont is presented on figures below (Fig 1, Fig 2, Fig 3)

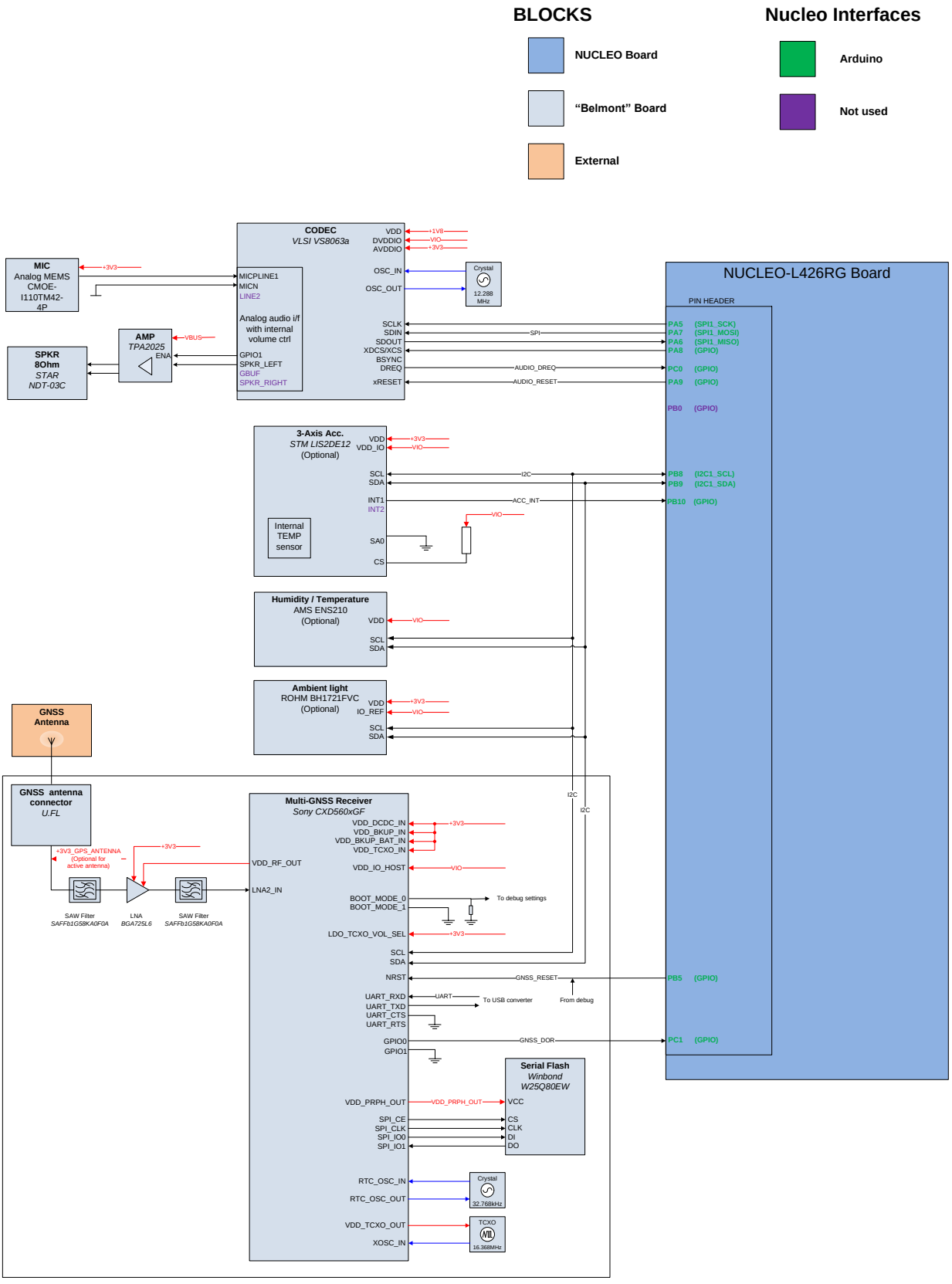


Figure 1. Belmont system GNSS Block Diagram

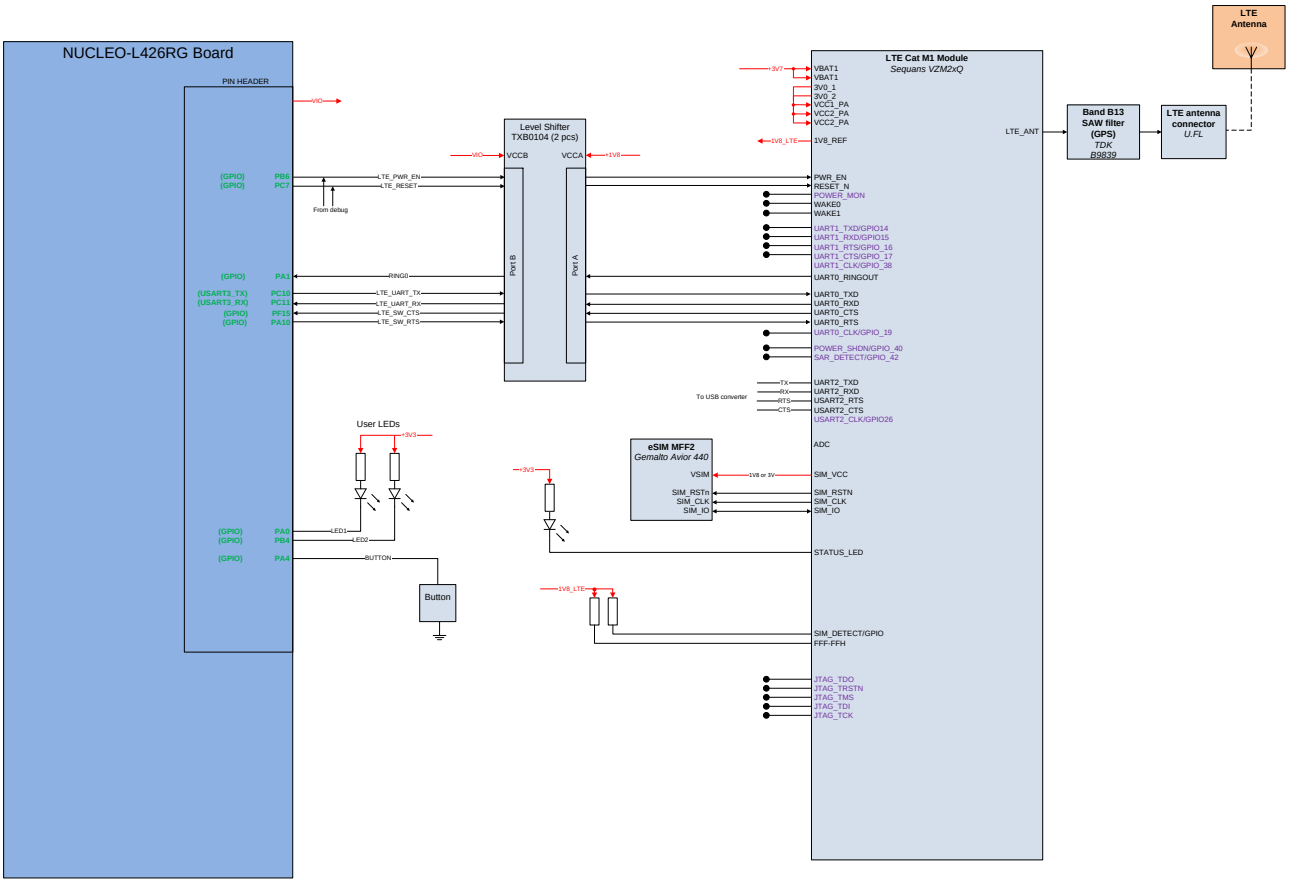


Figure 2. Belmont system LTE Module Block Diagram

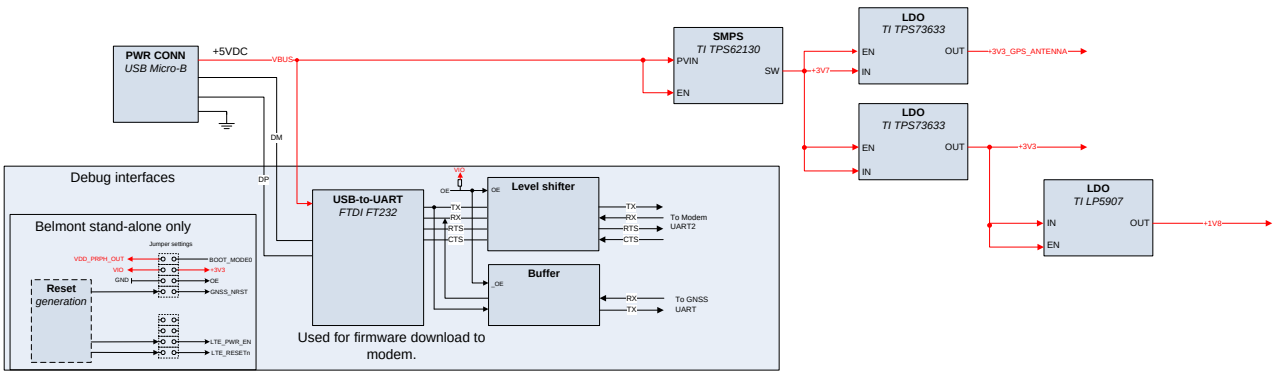


Figure 3. Belmont system Powering and Flashing Block Diagram

4 TECHNICAL SPECIFICALS

General Interfaces	• Arduino (I2C, SPI, UART, UART) • USB • LTE and GNSS Antenna (u.FL)
Supported Frequency Bands	• LTE B13 • GPS / Glonass
Operation voltages	• Vbus: 4.75V – 5.25V • VIO: 3.2V – 3.4V
Environmental	• RoHS compliant, halogen-free
Operating Temperature	• Operational: 0°C to +50°C
Humidity	• 10% to 85%

Table 2. General Specification

4.1 Electrical specification

4.1.1 Sequans VZM20Q LTE Module

Sequans VZM20Q module includes Monarch SQN3330 Cat-M1 baseband, a complete dual band RF front end, memory and required circuitry to meet 3GPP E-UTRA (Long Term Evolution - LTE, Release 13 set of specifications) and Verizon Wireless LTE Cat-M1 UE specifications

See more detailed Technical Specification Ref [1].

4.1.2 Sony CXD5600GF GNSS module

Sony CXD5600GF Multi GNSS receiver is compatible with Global Positioning System (GPS), Global Navigation Satellite System (GLONASS), Quasi-Zenith Satellite System (QZSS) and satellite-based augmentation system (SBAS) and the Indoor Messaging System (IMES). Belmont system GNSS antenna is supporting GPS and Glonass frequencies.

See more detailed technical specification Ref[2].

4.1.3 Giesecke & Devrient eSIM component

Giesecke & Devrient eSIM fulfils ETSI TS 102 671 V2.0.0 Rel.9 M2M UICC Physical and logical characteristics. See more detailed specification Ref[3].

4.2 Absolute Maximum ratings

Parameter	Symbol	Min	Max	Unit
Supply voltage from USB connector	Vbus	-0.3	6.5	V
Supply voltage for I/O	VIO	-0.3	3.6	V
Voltage at I2C, SPI and I/O lines		-0.3	VIO + 0.3	V
Operating temperature		-30	+85	°C

Table 3. Absolute Max ratings

4.3 Recommended ratings and pin out

Parameter	Symbol	Min	Typ	Max	Unit
Supply voltage from USB connector	Vbus	4.75	5.0	5.25	V
Supply voltage for I/O	VIO	3.2	3.3	3.4	V
Supply voltage	+3V7		3.7		V
Supply voltage	+3V3		3.3		V
Supply voltage	+1V8		1.8		V
Supply voltage	+3V3_GPS_ANTENNA		3.3		V
I2C clock speed	I2C_SCL			400	kHz
SPI clock speed, initialisation	SPI_CLK		0.62	1.75	MHz
SPI clock speed, audio transfer (CLKI = 5 x crystal)	SPI_CLK		5.0	8.78	MHz
UART0 baud rate			115200		Bits
UART2 baud rate			921600		Bits

Table 4. Recommended ratings and pin out

4.4 Connectors

4.4.1 Interface between Nucleo and Belmont

Interface between Nucleo L476RG and Belmont board are based on Arduino Uno pin out, but all signal lines can be used as a general purpose I/O-line. Specification is compatible with Nucleo 64 boards and normally used with NUCLEO L476RG board.

Pin out of Belmont board connectors X1, X22, X2, X4, X10, X9, X12 and X5:

Pin	Nucleo-L476RG	Belmont
	CN6	X1, X22
1	NC	Not used
2	IOREF	VIO
3	RESET	Not used
4	3V3	Not used
5	5V	Not used
6	GND	GND
7	GND	GND
8	VIN	Not used
	CN8	X2, X4
1	PA0	LED1
2	PA1	RING0
3	PA4	BUTTON
4	PB0	not used
5	PC1	GNSS_DOR
6	PC0	AUDIO_DREQ

Belmont	Nucleo-L476RG	Pin
X10, X9	CN5	
I2C_SCL	PB8 (I2C1)	1
I2C_SDA	PB9 (I2C1)	2
Not used	AVDD	3
GND	GND	4
SPI_SCK	PA5 (SPI1)	5
SPI_MISO	PA6 (SPI1)	6
SPI_MOSI	PA7 (SPI1)	7
LTE_PWR_EN	PB6	8
LTE_RESET	PC7	9
AUDIO_RESET	PA9	10
X12, X5	CN9	
SPI_XCS	PA8	1
ACC_INT	PB10	2
LED2	PB4	3
GNSS_RESET	PB5	4
LTE_SW_RTS	PB3	5
LTE_SW_CTS	PA10	6
LTE_UART_TX	PC10 (USART3) [1]	7
LTE_UART_RX	PC11 (USART3) [1]	8

Table 5. Pin out of Belmont board connectors

[1]Need external wrap wires from CN7-1 to CN10-35 and from CN7-2 to CN10-37

Signal description of Belmont board connectors X1, X2, X10 and X12

Pins	Signal	Purpose
X1-2	VIO	I/O voltage from Nucleo board. Recommended range is from 1.8V to 3.3V. Belmont power consumption is under 100mA.
X1-6,X1-7 X10-4	GND	Ground

X2-1	LED1	I/O pin to control LED1. When high, LED1 is turned on.
X2-2	RING0	Wake-up signal from modem.
X2-3	BUTTON	I/O-pin. There is external 10k pull-up on this line and switch S1 will ground the line when pressed.
X2-5	GNSS_DOR	Data request from GPS. GPS receiver will indicate with this line, when data is available.
X2-6	AUDIO_DREQ	Audio codec will indicate with this line, when new data can be written to output FIFO.
X10-1	I2C_SCL	I2C serial clock. There is 4k7 external pull-up on Belmont board. Connected to GPS, Accelerometer, Ambient light sensor and Humidity & temperature sensor.
X10-2	I2C_SDA	I2C serial data. There is 4k7 external pull-up on Belmont board. Connected to GPS, Accelerometer, Ambient light sensor and Humidity & temperature sensor.
X10-5	SPI_SCK	Serial clock for SPI. Line is connected between Nucleo and audio codec and Nucleo acts as a master device.
X10-6	SPI_MISO	Serial data from slave to master. Line is connected between Nucleo and audio codec and Nucleo acts as a master device.
X10-7	SPI_MOSI	Serial data from master to slave. Line is connected between Nucleo and audio codec and Nucleo acts as a master device.
X10-8	LTE_PWR_EN	I/O-line to enable/disable modem power up.
X10-9	LTE_RESET	I/O-line which will reset modem, when low.
X10-10	AUDIO_RESET	I/O-line which will reset audio codec, when low.
X12-1	SPI_XCS	I/O-line which is used as SPI chip select. Connected from Nucleo to audio codec and will select the used SPI bus.
X12-2	ACC_INT	Interrupt line from accelerometer. Optional, when accelerometer is used.
X12-3	LED2	I/O-line to control LED2. When high, LED2 is turned on.
X12-4	GNSS_RESET	I/O-line which will reset GNSS system, when low.
X12-5	LTE_SW_RTS	I/O-line used to wake-up modem and indicates that Nucleo is ready to receive data.
X12-6	LTE_SW_CTS	I/O-line used to indicate that modem is waken up and ready to receive data.
X12-7	LTE_UART_TX	UART tx line. This is used to transfer data from Nucleo to modem.

X12-8	LTE_UART_RX	UART rx line. This is used to transfer data from modem to Nucleo.

Table 6. Signal description of Belmont board

4.4.2 Antenna connectors

U.FL connectors from Hirose are used as antenna connectors. Middle pin is signal line and outer ring used as GND. Both connectors use 50 ohms transmission lines for the used bands.

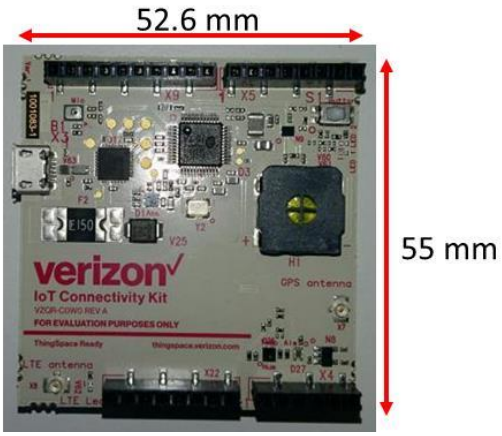
4.4.3 USB

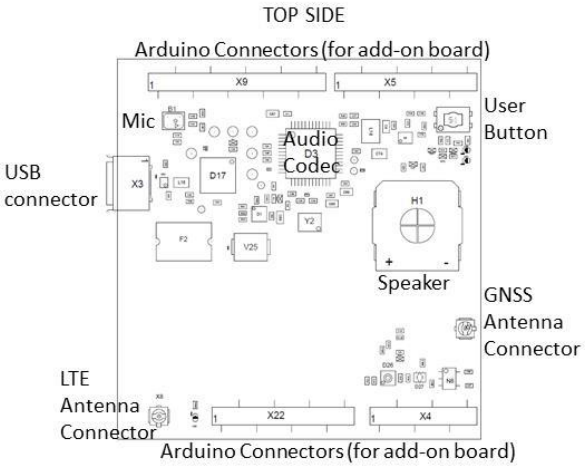
USB2.0 compatible Micro-B connector is used for feeding power to Belmont board and to download new firmware for modem. Pin order is according to standard.

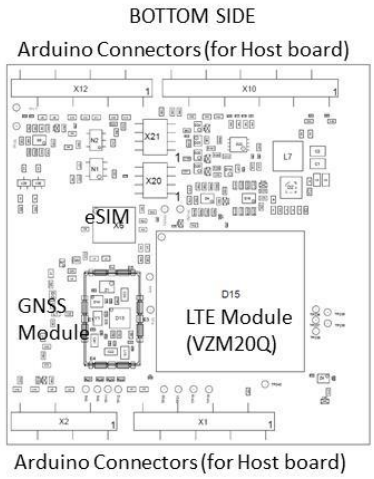
Pin number	Signal description
X3-1	Vbus. +5VDC power source for Belmont board.
X3-2	DM data line, USB2.0 Full speed for FT232RQ
X3-3	DP data line, USB2.0 Full speed for FT232RQ
X3-4	ID, not used
X3-5	GND

Table 7. USB connector

5 MECHANICAL SPECIFICATION







6 ENVIORMENTAL SPECIFICATIONS

Dimensions (LxWxH)	52,6 x 55 x 18 mm
Environmental	RoHS compliant, halogen-free
Operating Temperature	0°C to +50°C
Humidity	10% to 85%, non-condensing
Certifications	FCC CB Safety GCF Verizon OD
Power	USB 2.0 Spec through an external power supply (USB power source)

Table 8. Environmental Spec

7 DESIGN CONSIDERATIONS

7.1 Connectors to Nucleo board

All signals are routed directly from the bottom side connector to the top side connector. On the Belmont board, there are ESD clamping device connected to every used signal line. These circuits protect board against light ESD strikes. On the Nucleo board, signal lines are not protected against ESD. Use device only in area, where ESD does not exist.

7.2 Power

Belmont board will power up automatically after USB cable is inserted. Maximum power consumption of the board is seen when TX power of the modem is at the maximum level and at the same time speaker driven with full power. With this case, USB power source with 1A current capability is needed. Most of use cases will take much less power. Power line is protected with a self-resettable fuse, which tripping current is minimum 1.5A.

7.3 Audio

Audio codec is VS8063A from VLSI Solution. Crystal is selected to be 12.288MHz, which will enable the most common data rates. Codec is controlled over SPI and I/O-lines which control reset and indicates data request are used. A pull-down resistor is connected to reset line to prevent that line is floating if not driven.

Microphone has a typical sensitivity of -42 dBV/Pa at 94dB SPL, 1kHz. Unity gain is used on the board and signal level can be adjusted inside audio codec.

On the speaker path, TPA2025 amplifier is used. TPA2025 is capable of driving speakers with impedance from 4 to 8 ohms. Amplifier has a fixed 20dB gain and volume level is controlled by setting suitable level inside audio codec.

Speaker has a maximum drivel level of 0.8W at 1kHz sine wave. Typical output of the speaker is 90dB/0.5W/10cm.

Note: do not overdrive speaker, speaker may be damaged.

7.4 Modem

Two I/O-lines are used to control power-up of the modem. Recommendation is that LTE_PWR_EN is switched high at minimum of 1ms after Belmont board is powered. LTE_RESET can be switched high at minimum of 1ms after LTE_PWR_EN has been risen. Both lines have external pull-down resistor to keep modem inactive, if lines are not controlled.

Note: naming of serial ports with this module reflects the purpose of the signal at the host processor. Hence modem pin of RX is actually output and TX is input. Respectively RTS is input and CTS output.

7.5 GNSS

GNSS is controlled over I2C. Address of GNSS system is 0x0100 100xb, where x is read/write bit.

I/O-lines are used to reset GNSS and as an interrupt line. Reset is active low and external pull-down resistor will keep GNSS to reset, if signal is not driven.

GNSS is normally used with passive antenna and hence +3.3V for active antenna is disabled. If better performance is needed, active antenna can be taken to use by soldering L17 to the pads.

7.6 LEDs and Button

Design has two LEDs and one button for general use. If power to Belmont board is enabled before Nucleo drives the I/O-lines, LED1 is off and LED2 is on.

Setting the I/O-line for mapped each LED to '1', LED will be turned on.

I/O-line allocated for button has an external pull-up resistor and when button is pressed, line is connected to GND. ESD diode and a small serial resistor is added to protect line against ESD. A small (1nF) capacitor is used to filter signal against glitches.

7.7 Debug

FT232RQ USB-to-UART converter is used to connect UART2 of modem to PC. With the UART2, new firmware can be downloaded to modem or other tools from modem manufacturer can be used. Refer to instructions from Sequans.

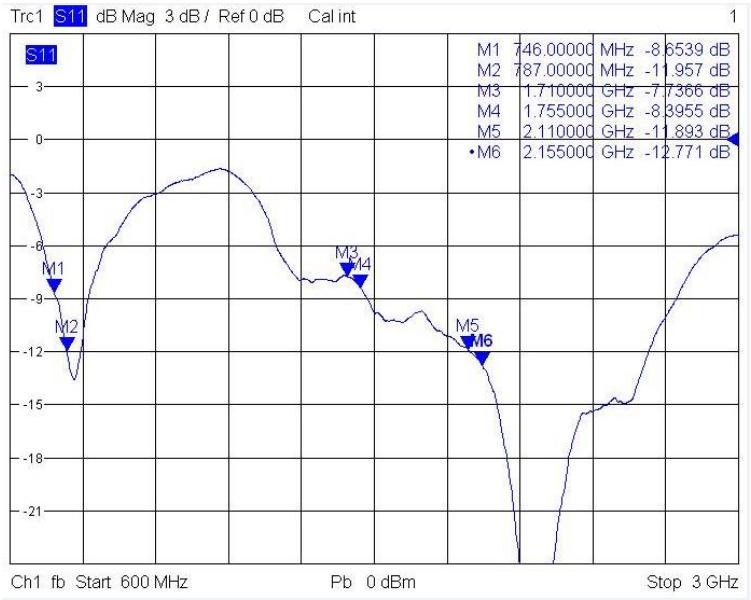
Inside the factory, interface is also used to download firmware to GNSS system.

8 ANTENNA CONSIDERATIONS

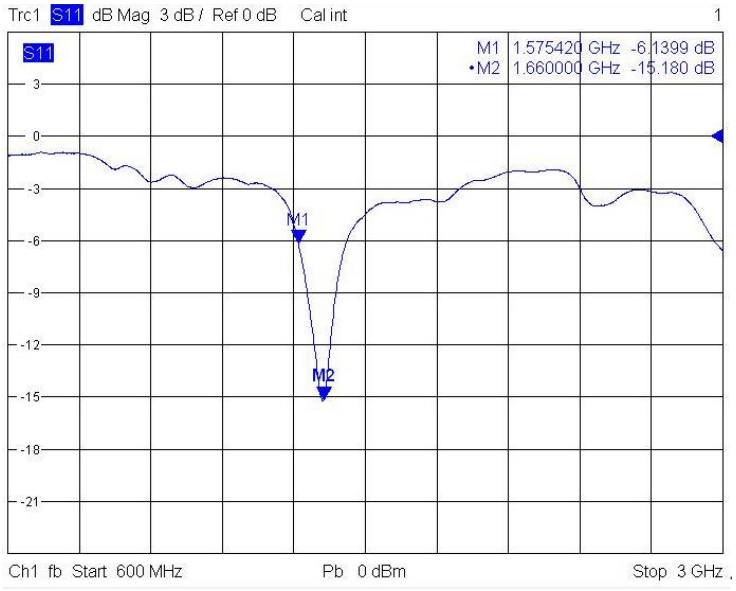
Antenova GNSS antenna (Ref [7]) and Pulse LTE antenna (Ref [6]) are used with Belmont system. Antennas are connected to board using u.FL connector.

8.1 Antenna measurements

The following figure presents Pulse LTE antenna measurements:



The following figure presents Antenova GNSS antenna measurements (NOTE Antenova antenna need to be checked, samples Bittium received doesn't work correctly) :

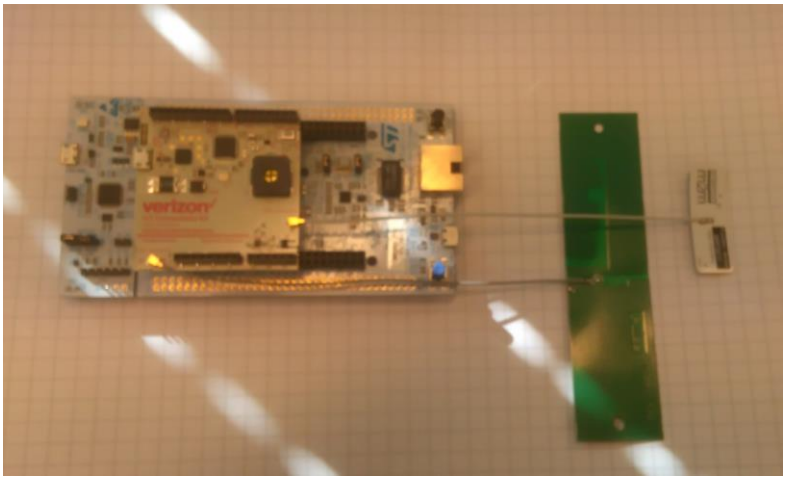


8.2 GPS and LTE B13 interoperability

There is GPS band stop notch filter in LTE 13 antenna line on the Belmont board. The filter is recommended to be used when GPS and LTE antennas are located near to each other.

LTE B13 and GPS interoperability measurement report (Ref[8]) shows the effect of the LTE13 to GPS functionality without the notch filter. The summary of report is:

- Few dB GPS RX desense can be observed under worst case test conditions (LTE13 configured to worst “channel” + LTE13 max TX power + very low isolation between LTE and GPS antenna)
- GPS fix was maintained also under worst case test conditions
- GPS desense not observed when antennas were placed further apart from each other
- GPS band notch filter in LTE13 antenna line is recommended also for next design rounds to ensure good interoperability between LTE13 and GPS systems



9 CERTIFICATIONS (VERIZON)

FCC (FCC ID# TBD)

CB Safety (TBD)

GCF

Verizon OD

References

[1] Monarch Platform – VZM20Q Module

[2] Sony Multi GNSS Receiver CXD5600GF

[3] Giesecke & Devrient SkySIM Avior 440 SMD S3FS9FV Technical Specification

[4] Belmont Schematics

[5] Belmont Layout and PWB manufacturing files

[6] LTE Antenna specification: High Efficiency Wideband LTE Dipole Antenna (Pulse W3554)

[7] GNSS Antenna specification: Antenova Bentoni GNSS Antenna

[8] LTE B13 and GPS interoperability measurement report