AirPrime XP2210

Product Technical Specification

41113676
Rev 4.0

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Revision History

Revision number	Release date	Changes
1.0	January 20, 2020	Creation
1.1	February 13, 2020	Updates: • Patents and Trademarks sections • Product Highlights and Features • Specifications table
2.0	March 16, 2020	Updates: • Removed Sleep 2 mode under Power Saving in Table 2-6 • Revised Update Rate in Table 2-6

Revision number	Release date	Changes
3.0	April 08, 2020	Minor text edits Under Product Highlights and Features on page 9: • Changed 16 acquisition-channel GPS to 12 • Changed LLE support to 14 days Removed SGE Under PVT Logger Function on page 11: • Removed valid and checksum • Changed 8 KB to 4.8 KB • Changed internal flash to external flash Under Description of I/O Pins on page 15 (chapter 1): • Change 3.39 V to 3.6 V Added BMI160 sensor in Figure 1-1 Under Table 2-3: • Changed Normal to Normal (Floating) • Changed BootROM to BootROM (Pull high) and added step 5 Under Table 2-6: • Removed maximum cold start from TTFF description • Changed Position Accuracy to 1.5 m without aid • Added 460800 bps baud rate Under Absolute Maximum Ranges on page 18: • Changed maximum power supply voltage to 3.6 V Under Table 3-12, Table 3-15, Table 3-16, and Table 3-17, removed GA and BD from description Under Table 3-18, removed Galileo and BeiDou from description Under Table 3-10, Table 3-13, and Table 3-19, changed QZSS to 193-201 Revised Figure 4-1 and Figure 4-3, and changed bypass capacitors to decoupling capacitors Under Module Placement on page 47, changed 3D to 3-axis Under Module Calibration on page 47, changed 3D to 3-axis and added GLONASS
3.1	April 15, 2020	Minor abbreviation edits
4.0	July 02, 2020	Modified UART damping resistor value Modified values in Table 7-1

Contents

1: Function Description

Note: See Appendix - Abbreviations for the full meaning of abbreviations in this guide.

Overview

The XP2210 is a UDR receiver that is capable of tracking GPS and GLONASS systems simultaneously. This module provides an external antenna interface that supports passive GNSS antennas.

The XP2210 is one of the smallest multi-GNSS modules on the market with an ultra-compact size of 9.5 x 10.4 x 2.1 mm in a QFN package. It supports multiple interfaces such as I2C that can be used instead of UART.

The XP2210 is a multi-constellation GNSS receiver and can track GPS and GLONASS systems concurrently. It also provides high sensitivity (-161 dBm).

The XP2210 is based on the market-proven Sony CXD5608GF GNSS engine and comes with an embedded 3-axis gyroscope and 3-axis accelerometer to achieve the best dead-reckoning performance without an odometer.

Its advanced algorithm smooths tracing when GNSS signal reception is at its poorest or suffers from severe multi-path reflections within dense high building surroundings or beneath overpasses. The benefits include applications in locations such as underground car parks, tunnels, or urban canyons.

Target Applications

- M2M applications
- Asset management
- Surveillance systems

Product Highlights and Features

- 24 tracking/ 12 acquisition-channel GPS and GLONASS
- Supports QZSS
- Sensitivity: -161 dBm
- Update rate: 1 Hz (default), 10 Hz
- High accuracy 1PPS timing (+-20 ns) and the pulse width is 125 ms / 250 ms / 500 ms
- LLE support for Fast TTFF (LLE data is injected in flash from FTP; only supports 14 days)
- PVT logger function
- Supports interface types I2C / UART
- Consumption current (@3.3 V) for GPS and GLONASS constellations:
  - Acquisition:22mA / 25mA / 29mA (minimum / typical / maximum)
  - Tracking: 18mA / 21mA / 29mA (minimum / typical / maximum)
- RoHS compliant
- RED compliant

Precautions

Important: *Please read carefully before you start.*

If you use the GNSS receiver inside buildings, tunnels, or beside any huge objects, the GNSS signals might be cut off or weakened. Please do not assume the receiver has malfunctioned.

This document provides the necessary guidelines for a successful system design using the XP2210 modules. For detailed module specifications, refer to this guide.

The XP2210 is an electrostatic-sensitive device; please DO NOT touch the module directly. Follow ESD safety rules when handling. When using the XP2210 for the first time, it is strongly recommended that you test the module outdoors with open sky for at least 12 minutes and 30 seconds to ensure receiving the complete navigation message.

System Block Diagram

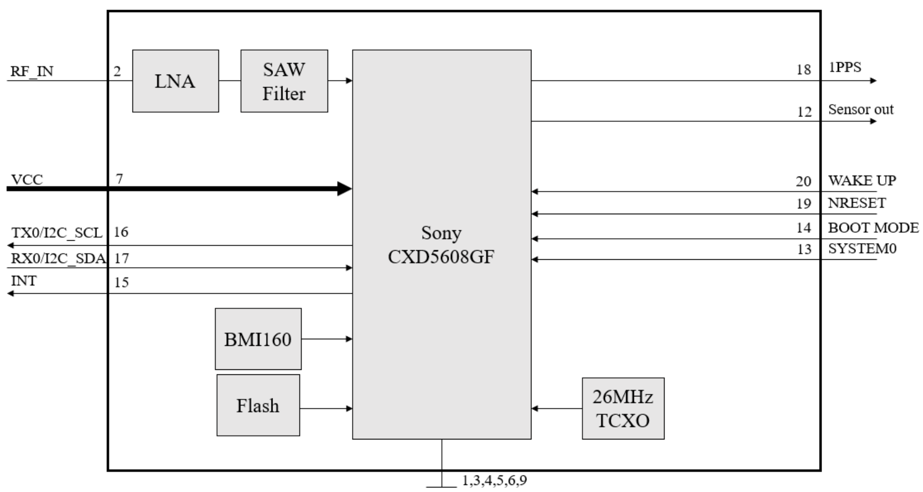

Figure 1-1: System Block Diagram

I2C

The I2C interface is a serial input and output port, operating as a slave device.

- Slave receiving
- Slave address: 0x24
- Speed grades: Standard-mode 100 kbit/s, Fast-mode 400 kbit/s

1PPS

The XP2210 generates a one pulse-per-second signal (1PPS) after 3D fixed. It is an electrical signal which precisely indicates the start of a second within an accuracy of 20 ns. The PPS signal is provided through a designated output pin for external applications.

LLE for Fast TTFF

The LLE provides pre-download proprietary ephemeris data to speed up TTFF. This feature is useful when a satellite signal is weak or when there is no signal; it allows for the module to still get position information quickly. LLE ephemeris can be downloaded from an FTP server via the Internet. LLE supports GPS ephemeris injection.

PVT Logger Function

PVT logger function is enabled in the XP2210 module, and allows for the module to become a logger-capable (built-in internal flash) device and record GNSS data such as UTC, latitude, and longitude; it helps with record logging and debugging.

The external flash of the module has 4.8 KB for this function and uses the smart overlapping mechanism to keep the latest logger data.

2: Specifications

Mechanical Dimensions

Dimension: (Unit: mm, Maximum height: 2.3)

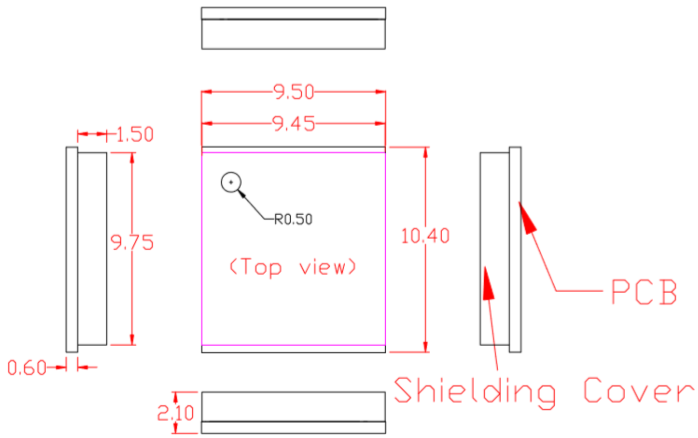

Figure 2-1: Mechanical Dimensions

Pin Configuration

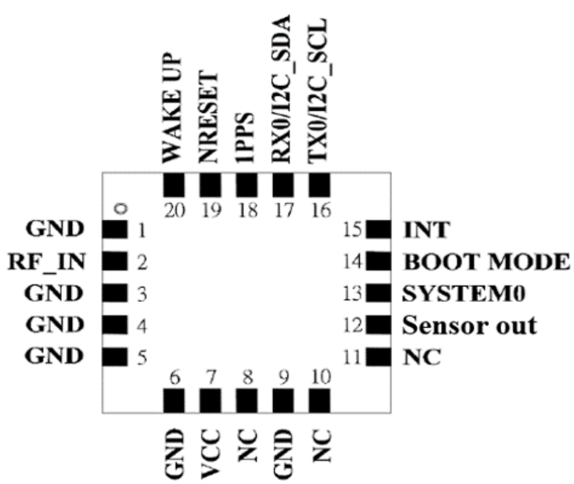

Figure 2-2: Pin Configuration

Pin Dimension

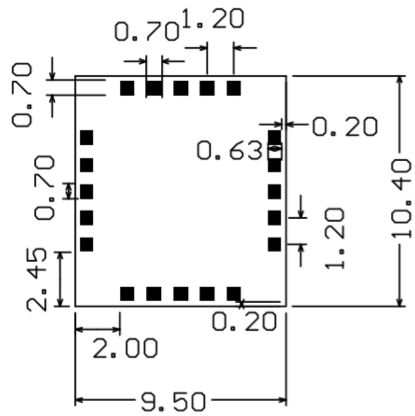

Figure 2-3: Pin Dimension

Pin Assignment

Table 2-1: Pin Assignment

Pin	Name	I/O	Description and Note	Active Low / High	IO Voltage Domain	Reset State[a]	Recommendation for Unused Pad
1	GND	P	Ground		0V		Mandatory connection
2	RF_IN	I	GNSS RF signal input				Mandatory connection
3	GND	P	Ground		0V		Mandatory connection
4	GND	P	Ground		0V		Mandatory connection
5	GND	P	Ground		0V		Mandatory connection
6	GND	P	Ground		0V		Mandatory connection
7	VCC	P	Main DC power input		3.3V		Mandatory connection
8	NC		None connected		0V		Left open
9	GND	P	Ground		0V	I, PD[a]	Mandatory connection
10	NC		None connected				Left open
11	NC		None connected				Left open
12	SENSOR OUT	O	TBD				Left open
13	SYSTEM0	I	UART / I2C		3.3V	I, PD[a]	Left open
14	BOOT MODE	I	BOOT firmware setting	H	0V	I, PD[a]	Left open
15	INT	O	Interrupt pin for I2C		3.3V	O, PU[a]	Left open

Table 2-1: Pin Assignment (Continued)

Pin	Name	I/O	Description and Note	Active Low / High	IO Voltage Domain	Reset State[a]	Recommendation for Unused Pad
16	TX0/I2C_SCL	I/O	Serial data output for NMEA output (TTL) / I2C series clock (in slave mode)		3.3V		Mandatory connection
17	RX0/I2C_SDA	I/O	Serial data output for firmware update (TTL) / I2C series data (in slave mode)		3.3V		Mandatory connection
18	1PPS	O	1PPS time mark output		3.3V	O, PU[a]	Left open
19	NRESET	I	Reset input	L	3.3V	I, PU[a]	Left open
20	WAKE UP	I	Wake up from power saving	H	0V	I, PD[a]	Left open

a. I = Input, O = Output, PU = Pull Up, PD = Pull Down, H = High, T = High Impedance

Description of I/O Pins

- **Pin1**—GND (Ground)
- **Pin2**—RF_IN

  The GNSS RF signal input which can be connected to a passive antenna.
- **Pin3**—GND (Ground)
- **Pin4**—GND (Ground)
- **Pin5**—GND (Ground)
- **Pin6**—GND (Ground)
- **Pin7**—VCC
  - Main DC power supply (3.21 V to 3.6 V; typical: 3.3 V)
- **Pin8**—NC (None Connected)
- **Pin9**—GND (Ground)
- **Pin10**—NC (None Connected)
- **Pin11**—NC (None Connected)
- **Pin12**—SENSOR OUT (TBD)
- **Pin13**—SYSTEM0
  - Can be used to set the UART or I2C interface.

Table 2-2: UART/ I^2C Interface by SYSTEM0 Setting

SYSTEM0	Interface
High (default 3.3 V)	UART
Low	I2C

Note: UART signals are named with respect to module. Directions are also listed with respect to the module. For example, UART_RX0 is an output from the host to the module. UART_TX0 is an output from the module to the host.

- **Pin14**—BOOT MODE

Table 2-3: BOOT MODE Pin Setting

Mode	Function
Normal (Floating)	The module automatically enters normal mode by default.
BootROM (Pull high)	Enter Boot ROM mode to upgrade by firmware, using these steps, when the module does not work normally or the upgrade fails: 1. The BOOT MODE pin must be initially connected to “VCC”. 2. Power on the module’s main power. 3. Use “SWGNSSTool’ to upgrade the firmware. 4. The BOOT MODE pin can be removed from “VCC” when the upgrade process is completed. 5. Push the NRESET button to reset the module and allow it to boot up normally.

- **Pin15**—INT
    - This is the interrupt sync. It is used to determine whether NMEA is stored in the I2C buffer.
    - If NMEA data is ready and stored in the I2C buffer, the pin will become high.
    - When the I2C bus is busy, the INT pin becomes high. When the I2C bus is not busy, the INT pin becomes low.
- **Pin16**—TX0/I2C_SCL

  Through the SYSTEM0 setting, the user can define this pin role as either UART_TX0 or I2C_SCL.
    - For TX0 pin: UART 0 transmitter; outputs GNSS information for application.
    - For I2C_SCL pin: It can transceive clock and communicate with host.
- **Pin17**—RX0/I2C_SDA

  Through the SYSTEM0 setting, the user can define this pin role as either UART_RX0 or I2C_SDA.
    - For RX0 pin: UART 0 receiver; to receive commands from the system.
    - For I2C_SDA pin: It can transceive data and communicate with host.
- **Pin18**—1PPS

  This pin provides a one pulse-per-second signal output. If not used, keep this pin floating.
- **Pin19**—NRESET

  Active on low for the module to reset. If not used, keep this pin floating.

Table 2-4: NRESET Level

Level	Min (V)	Typ (V)	Max (V)
Low	0	-	0.5
High (default)	2.1	-	3.3

- **Pin20**—WAKE UP

  Active on high will wake up the module from power-saving mode.

Table 2-5: WAKEUP Level

Level	Min (V)	Typ (V)	Max (V)
Low (default)	0	-	0.5
High	2.1	-	3.3

Specifications

Table 2-6: Specification Data

Description	
GNSS Chipset	Sony CXD5608GF
Frequency	GPS/QZSS L1, 2.046 MHz BW NB (centered on 1575.42 MHz) GLONASS L1, ~8.3 MHz BW (1597–1606 MHz), 14 channels (-7 to +6)
Sensitivity	Acquisition: -147 dBm Tracking: -161 dBm
SV Numbers	GPS #1~32 GLONASS #65~88(see Chapter 3 for details)
Protocol	NMEA 0183 v4.10
TTFF (No. of SVs ≥ 6, C/N > 40dB)	Hot start: 2 seconds typical Warm start: 33 seconds typical Cold start: 35 seconds typical
Position Accuracy	Without aid: 1.5 m (CEP 50)
Velocity Accuracy	Without aid: 0.1 m/s
Timing Accuracy (1PPS Output)	+-20 ns within 125 ms / 250 ms / 500 ms in one pulse
Altitude	15,000m maximum
Velocity	Maximum 138 m/s
Acceleration	Maximum 1.5 G
Update Rate	1 Hz (default), 10 Hz
Baud Rate	115200 bps (default) 460800 bps
Power Supply	VCC: 3.0 V to 3.6 V (typical: 3.3 V)
Current Consumption @ 3.3V,1Hz Update Rate	GPS and GLONASS: Acquisition: 22mA / 25mA / 29mA (minimum / typical / maximum) Tracking: 18mA / 21mA / 29mA (minimum / typical / maximum)
Power Saving	Idle: 8mA (typical) Sleep 0 mode: 3mA (typical) Sleep 1 mode: 2mA (typical)
NRESET Current @ 3.3V	2 mA (typical)
Working Temperature	-40 °C to +85 °C
Dimension	9.5 x 10.4 x 2.1 mm, SMD
Weight	0.4 g

Absolute Maximum Ranges

The maximum power supply voltage is 3.6 V.

Table 2-7: Maximum Ranges

	Symbol	Minimum	Maximum	Unit
Power Supply Voltage	VCC	3.0	3.6	V

Operating Conditions

Table 2-8: Operating Conditions

Parameter	Condition	Minimum	Typical	Maximum	Unit
RX0 TTL H Level	**VCC=3.3 V**	2.1	-	3.3	V
RX0 TTL L Level		0	-	1.1	V
TX0 TTL H Level		2.6	-	3.3	V
TX0 TTL L Level		0	-	0.6	V

3

3: Protocols

NMEA Output Sentences

Table 3-1 lists all NMEA output sentences specifically developed and defined by Sony. The NMEA version used is 4.10.

Table 3-1: Position Fix Indicator

Option	Description
GGA	Time, position and fix type data.
GLL	Geographic Position – Latitude / Longitude
GNS	GNSS Fix Data
GSA	GNSS receiver operating mode, active satellites used in the position solution and DOP values
GSV	Number of GPS satellites in view, satellite ID numbers, elevation, azimuth, and SNR values.
RMC	Time, date, position, course and speed data. Recommended minimum navigation information.
VTG	Course over ground and ground speed
ZDA	Time and date
PSWIRAW	GNSS raw measurement data
PSWIVELW	Current status of speeding warning
PSWIEPE	Current value of EPE
PSWIUSEN	UDR raw measurement

Table 3-2 lists NMEA output sentences used in GPS and GLONASS systems.

Table 3-2: NMEA v4.10 Output Sentence for GPS and GNSS[a]

System	GGA	GSA	GSV	RMC	VTG	ZDA
GPS	GPGGA	GPGSA	GPGSV	GPRMC	GPVTG	GPZDA
GNSS (GPS and GLONASS)	GNGGA	GNGSA	GPGSV GLGSV	GNRMC	GNVTG	GNZDA
QZSS			GQGSV			

a. In Talker ID, GP is a short term of “GPS”, GL is “GLONASS”, GQ is “QZSS” and GN is “GNSS”.

GGA—Time, Position, and Related Data of Navigation Fix

Table 3-3 explains the sentence below.

GPS satellite or GPS and GLONASS satellites:

```
$GPGGA,185942.00,3732.999923,N,12658.999901,E,1,12,0.7,
-18.1,M,18.3,M,x.x,xxxx*79
```

Table 3-3: GGA Data Format

Name	Example	Units	Description
Header	$		
Talker ID	GP		GP: Using only GPS for positioning GL: Using only GLONASS for positioning GA: Using only Galileo for positioning BD: Using only BeiDou for positioning GQ: Using only QZSS for positioning GN: Using combined satellite systems for positioning
Sentence ID	GGA		
UTC Time	080105.08		hh [hr] mm [min] ss.ss [sec]
Latitude	2459.9326		dd [deg] mm.mmmm [min]
N/S Indicator	N		N: North latitude or S: South latitude
Longitude	12127.4423		dd [deg] mm.mmmm [min]
E/W Indicator	E		E: East longitude or W: West longitude
Quality Indicator	1		See Table 3-4
Number of satellites in use	12		
HDOP	1.0		Horizontal Dilution of Precision
MSL Altitude	14.7	meters	Antenna Altitude above/below mean sea level
Units	M	meters	Units of antenna altitude
Geoidal Separation	17.0	meters	
Units	M	meters	Units of geoids separation
Age f DGPS Data	x.x	second	Null fields when DGPS is not used
Differential reference station ID	xxxx		Null fields when DGPS is not used
Checksum	*5C		
<CR><LF>			End of message termination

Table 3-4: Position Fix Indicator

Value	Description
0	Fix not available
1	GPS Fix
2	Differential GPS Fix

GLL—Geographic Position—Latitude / Longitude

Table 3-5 explains the sentence below:

```
$GNGLL,2459.9354,N,12127.4428,E,080115.00,A,A*76
```

Table 3-5: GLL Data Format

Name	Example	Units	Description
Header	$		
Talker ID	GN		GP: Using only GPS for positioning GL: Using only GLONASS for positioning GA: Using only Galileo for positioning BD: Using only BeiDou for positioning GQ: Using only QZSS for positioning GN: Using combined satellite systems for positioning
Sentence ID	GLL		
Latitude	2459.9354		dd [deg] mm.mmmm [min]
N/S Indicator	N		N: North latitude or S: South latitude
Longitude	12127.4428		dd [deg] mm.mmmm [min]
E/W Indicator	E		E: East longitude or W: West longitude
UTC of Position	080115.00		hh [hr] mm [min] ss.ss [sec]
Status	A		A: Data valid V: Data not valid
Mode Indicator	A		Positioning system Mode Indicator: A: Autonomous mode D: Differential mode E: dead-reckoning mode N: Data not valid
Checksum	*76		
<CR><LF>			End of message termination

GNS—GNSS Fixed Data

Table 3-6 explains the sentence below:

```
$GNGNS,080003.00,2459.9340,N,12127.3997,E,AN,06,2.5,29.0,M,1
7.0,M,x.x,xxxx,V*1D
```

Table 3-6: GNS Data Format

Name	Example	Units	Description
Header	$		
Talker ID	GN		GP: Using only GPS for positioning GL: Using only GLONASS for positioning GA: Using only Galileo for positioning BD: Using only BeiDou for positioning GQ: Using only QZSS for positioning GN: Using combined satellite systems for positioning
Sentence ID	GNS		
UTC of Position	080005.00		hh [hr] mm [min] ss.ss [sec]
Latitude	2459.9340		dd [deg] mm.mmmm [min]
N/S Indicator	N		N: North latitude or S: South latitude
Longitude	12127.3997		dd [deg] mm.mmmm [min]
E/W Indicator	E		E: East longitude or W: West longitude
Mode Indicator	AN		Positioning system Mode Indicator (1st character: GPS, 2nd character: GLONASS): A: Autonomous mode D: Differential mode E: dead-reckoning mode N: Data not valid
Number of satellites in use	06		
HDOP	2.5		
MSL Altitude	29.0 M	meters	Antenna Altitude above/below mean sea level
Geoidal Separation	17.0 M	meters	
Age of DGPS Data	x.x	second	Null fields when DGPS is not used
Differential reference station ID	xxxx		Null fields when DGPC is not used
Navigation status	V		NMEA 4.1(TBD)
Checksum	*1D		
<CR><LF>			End of message termination

GSA—GNSS DOP and Active Satellites, Including GPS (GPGSA), GPS, and GLONASS (GNGSA)

Table 3-7 explains the sentence below.

GPS satellite:

`$GPGSA,A,3,01,03,06,09,11,12,17,19,23,28,,,1.6,0.9,1.2,1*29`

GPS and GLONASS satellites:

`$GNGSA,A,3,02,05,15,20,21,24,29,30,,,,,1.5,0.8,1.3,1*33`

`$GNGSA,A,3,67,76,77,83,,,,,,,,,1.5,0.8,1.3,2*37`

Table 3-7: GSA Data Format for NMEA v4.10

Name	Example	Units	Description
Header	$		
Talked ID	GP		GP: Using only GPS for positioning GL: Using only GLONASS for positioning GA: Using only Galileo for positioning BD: Using only BeiDou for positioning GQ: Using only QZSS for positioning GN: Using combined satellite systems for positioning
Message ID	GSA		
Mode 1	A		A: Automatically switch 2D / 3D See Table 3-8
Mode 2	3		1: Fix not available, 2: 2D, 3: 3D See Table 3-9
Satellite Used	01		SV on Channel 1, see Table 3-10
Satellite Used	03		SV on Channel 2, see Table 3-10
Satellite Used			SV on Channel 12
PDOP	1.6		Position dilution of precision
HDOP	0.9		Horizontal dilution of precision
VDOP	1.2		Vertical dilution of precision
System ID	1		See Table 3-11
Checksum	*29		
<CR> <LF>			End of message termination

Table 3-8: Mode 1

Value	Description
M	Manual—forced to operate in 2D or 3D mode
A	2D Automatic—allows switching to 2D / 3D mode automatically

Table 3-9: Mode 2

Value	Description
1	Fix not available
2	2D (<4 SVs used)
3	3D (≥4 SVs used)

Table 3-10: Satellite ID

Version	GPS	GLONASS	QZSS
4.10	01–32	65–88	193-201

Table 3-11: System ID

System	ID
GPS	1
GLONASS	2

GSV—Satellites in View

Table 3-12 explains the sentences below.

GPS satellite:

```
$GPGSV,4,1,14,6,67,28,47,2,53,299,45,17,39,135,45,12,35,283,
43,1*5C
```

GLONASS satellite:

```
$GLGSV,2,1,07,1,64,188,27,8,60,41,33,23,44,12,34,22,30,88,41
,2*40
```

QZSS satellite:

```
$GQGSV,1,1,02,01,58,118,32,03,68,060,32,,,,,,,,,0*69
```

Table 3-12: GPGSV Data Format for NMEA v4.10

Name	Example	Units	Description
Header	$		
Talker ID	GP		GP: Using only GPS for positioning GL: Using only GLONASS for positioning GQ: Using only QZSS for positioning GN: Using combined satellite systems for positioning
Sentence ID	GSV		
Total Number of Sentences	4		(Depending on the number of satellites tracked, multiple messages of GSV data may be required)
Sentence Number	1		
Total Number of Satellites in View	14		
Satellite ID	6		Channel 1, see Table 3-13
Elevation	67	degrees	Channel 1 (Maximum 90)
Azimuth	28	degrees	Channel 1 (True, Range 0 to 359)
SNR (C/No)	47	dB-Hz	Range 0 to 99, (null when not tracking)
Elevation	35	degrees	Channel 4 (Maximum 90)
Azimuth	283	degrees	Channel 4 (True, Range 0 to 359)
SNR (C/No)	43	dB-Hz	Range 0 to 99, (null when not tracking)
Signal ID	1		See Table 3-14
Checksum	*5C		
<CR> <LF>			End of message termination

Table 3-13: Satellite ID

Version	GPS	GLONASS	QZSS
4.10	01–32	65–88	193-201

Table 3-14: Signal ID

System	ID
GPS	1
GLONASS	2

RMC—Recommended Minimum Navigation Information

Table 3-15 explains the sentence below.

GPS satellite:

```
$GPRMC,151907.00,A,3733.000087,N,12659.000097,E,0.0,0.0,
050718,,,A,V*28
```

GPS and GLONASS satellites:

```
$GNRMC,054403.00,A,2305.766823,N,12017.027308,E,0.2,231.1,
100719,,,A,V*30
```

Table 3-15: RMC Data Format for NMEA v4.10

Name	Example	Units	Description
Header	$		
Talker ID	GP		GP: Using only GPS for positioning GL: Using only GLONASS for positioning GQ: Using only QZSS for positioning GN: Using combined satellite systems for positioning
Sentence ID	RMC		RMC
UTC Time	054403.00		hh [hr] mm [min] ss.ss [sec]
Status	A		A: data valid V: data not valid
Latitude	2305.766823		dd [deg] mm.mmmm [min]
N/S Indicator	N		N: North latitude S: South latitude
Longitude	12017.027308		dd [deg] mm.mmmm [min]
E/W Indicator	E		E: East longitude W: West longitude
Speed over Ground	0.2	Knots/hr	
Course over Ground	231.1	degrees	
Date	100719		dd [day] mm [month] yy [year]
Magnetic Variation		degrees	
E/W Indicator			E: East W: West
Mode	A		A: Autonomous mode D: Differential mode E: dead-reckoning mode N: Data not valid

Table 3-15: RMC Data Format for NMEA v4.10

Name	Example	Units	Description
Navigation Status	V		S: Safe C: Caution U: Unsafe V: Invalid NMEA v4.10 and above only
Checksum	*30		
<CR> <LF>			End of message termination

VTG—Course and Speed Information Relating to the Ground

Table 3-16 explains the sentence below.

GPS satellite:

```
$GPVTG,165.48,T,,M,0.03,N,0.06,K,A*37
```

GPS and GLONASS satellites:

```
$GNVTG,0.0,T,,M,0.0,N,0.0,K,A*13
```

Table 3-16: VTG Data Format

Name	Example	Units	Description
Header	$		
Talker ID	GP		GP: Using only GPS for positioning GL: Using only GLONASS for positioning GQ: Using only QZSS for positioning GN: Using combined satellite systems for positioning
Sentence ID	VTG		
Course	165.48	degrees	Measured heading
Reference	T		TRUE
Course		degrees	Measured heading
Reference	M		Magnetic Variation (By Customization)
Speed Over Ground	0.03	Knots	Measured horizontal speed
Units	N		Knots
Speed Over Ground	0.06	km/hr	Measured horizontal speed
Units	K		Kilometers per hour
Mode	A		A: Autonomous mode D: Differential mode E: dead-reckoning mode N: Data not valid
Checksum	*37		
<CR><LF>			End of message termination

ZDA—Time and Date

Table 3-17 explains the sentence below.

GPS satellite:

```
$GPZDA,151907.00,05,07,2018,,*64
```

GPS and GLONASS satellites:

```
$GNZDA,000024.00,06,01,1980,,*79
```

Table 3-17: ZDA Data Format

Name	Example	Units	Description
Header	$		
Talker ID	GP		GP: Using only GPS for positioning GL: Using only GLONASS for positioning GQ: Using only QZSS for positioning GN: Using combined satellite systems for positioning
Sentence ID	ZDA		
UTC Time	151907.00		hh [hr] mm [min] ss.ss [sec]
Day	05		01 to 31
Month	07		01 to 12
Year	2018		
Local zone hours	00		NULL
Local zone minutes	00		NULL
Checksum	*64		
<CR> <LF>			End of message termination

PSWIRAW—Raw Measurement Data

Table 3-18 explains the sentence below.

```
$PSWIRAW,084109.00,1,12,30.60,24978488.510,90377.141,
-145.3,1,7874433.564,22830620.159,-11452247.121,
-64,4302,14.156,4*40
```

Table 3-18: PSWIRAW Data Format

Name	Example	Units	Description
Message ID	$PSWIRAW		$PSWIRAW header
UTC Date	20190904		Coordinated Universal Date. Format: yyyymmdd
UTC Time	095849.00		Coordinated Universal Time. Format: hhmmss.ss
System ID	1		1: GPS 2: GLONASS 5: QZSS
Satellite ID	015		Identification number for each satellite
CNR	37.13	dB-Hz	Quality of received signals
Pseudorange	21442795.307	meters	Raw GNSS measurements
Cycle Slip Flag	1		Index for cycle slip in carrier phase measurement
Satellite Position (X)	-12247689.878		X coordinate in ECEF system
Satellite Position (Y)	9952300.944		Y coordinate in ECEF system
Satellite Position (Z)	21086004.996		Z coordinate in ECEF system
Frequency Channel	-64		Frequency channel for GLONASS
Age of Ephemeris	8946		Age of ephemeris for each satellite system
Ionosphere Correction	5.429	meters	Ionosphere correction
Sync Status	2		G+G data sync status 0: None 1: Bit sync 2: Subframe sync 3/4: Exact sync (measurement is usable)
Checksum	56		
<CR> <LF>			End of message termination

Table 3-19: Satellite ID

Version	GPS	GLONASS	QZSS
4.10	01–32	65–88	193-201

PSWIVELW—Status of Speed Warn

Speed warn allows the user to set the maximum velocity that will be considered safe. If the speed is over this value, the speed warn will be activated.

Table 3-20 explains the sentence below.

```
$PSWIVELW,20190905,055601.00,1*27
```

Table 3-20: PSWIVELW Data Format

Name	Example	Units	Description
Message ID	$PSWIVELW		$PSWIVELW header
UTC Date	20190904		Coordinated Universal Date. Format: yyyymmdd
UTC Time	095849.00		Coordinated Universal Time. Format: hhmmss.ss
Status	1		The status of overspeed
Checksum	56		
Termination	<CR><LF>		End of message termination

PSWIEPE—Estimated Position Error

EPE is the horizontal and vertical Estimated Position Error based on the HDOP and VDOP.

Table 3-21 explains the sentence below.

```
$PSWIEPE,20190905,060310.00,10.5,7.6,4.6,6.0,7.3*56
```

Table 3-21: PSWIEPE Data Format

Name	Example	Units	Description
Message ID	$PSWIEPE		$PSWIEPE header
UTC Date	20190904		Coordinated Universal Date. Format: yyyymmdd
UTC Time	095849.00		Coordinated Universal Time. Format: hhmmss.ss
3D EPE	10.5	meter	
2D EPE	7.6	meter	
Latitude EPE	4.6	meter	
Longitude EPE	6.0	meter	
Height EPE	7.3	meter	
Checksum	56		
Termination	<CR><LF>		End of message termination

PSWIUSEN—Sensor Raw Data

Raw measurement brings more information for analysis, production line, and application. The information should output as a NMEA sentence. the output frequency is the same as the NMEA sentences.

explains the sentence below:

```
$PSWIUSEN,20190904,081118.731,28.75,0.017377,0.001222,0.9701
40,-
0.045241,0.005482,0.004122,0.003678,0.000000,0.000000,85.485
977,6,OK*79<CR><LF>
```

Table 3-22: PSWIUSEN Data Format

Name	Example	Units	Description
Message ID	$PSWIEPE		$PSWIEPE header
UTC Date	20190904		Coordinated Universal Date. Format: yyyymmdd
UTC Time	095849.00		Coordinated Universal Time. Format: hhmmss.ss
Temperature	28.75		Current temperature of MEMS sensor
Acceleration for X-axis	0.001222	g	Acceleration for X-axis in navigation frame. Always output
Acceleration for Y-axis	0.970140	g	Acceleration for Y-axis in navigation frame. Always output
Acceleration for Z-axis	-0.045241	g	Acceleration for Z-axis in navigation frame. Always output
Rotation rate for X-axis	0.005482	Rad/s	Rotation rate for X-axis in navigation frame. Always output
Rotation rate for Y-axis	0.004122	Rad/s	Rotation rate for Y-axis in navigation frame. Always output
Rotation rate for Z-axis	0.003678	Rad/s	Rotation rate for Z-axis in navigation frame. Always output
Roll	0.000000	Degree	Roll in navigation frame. 0 before first 3D fix
Pitch	0.000000	Degree	Pitch in navigation frame. 0 before first 3D fix
Heading	85.485977	Degree	Heading in navigation frame. 0 before first 3D fix
Status	6	NA	UDR calibration status: 1 to 6
Checksum	56		
Termination	<CR><LF>		End of message termination

NMEA Command Protocols

Command Meaning: Execute GNSS startup process

Command: `AT+GNSSSTART=0`

Response: `+GNAASTART,OK`

Mode:
- 0 = Cold start
- 1 = Warm start
- 2 = Hot start

Example:

Command	Response
Cold Start: `AT+GNSSSTART=0`	`+GNAASTART,OK`

Note: Refer to the XP2210 Software User Guide for more details.

4: Reference Design

This section provides reference schematic designs for best performance.

Reference Schematic Design for Using UART and I2C

The XP2210 provides several interfaces to process GNSS NMEA data (specified by firmware):

- UART – this interface can support NMEA output; refer to Figure 4-1.
- I2C – this interface can support NMEA output; refer to Figure 4-2.

Reference Schematic Design for UART

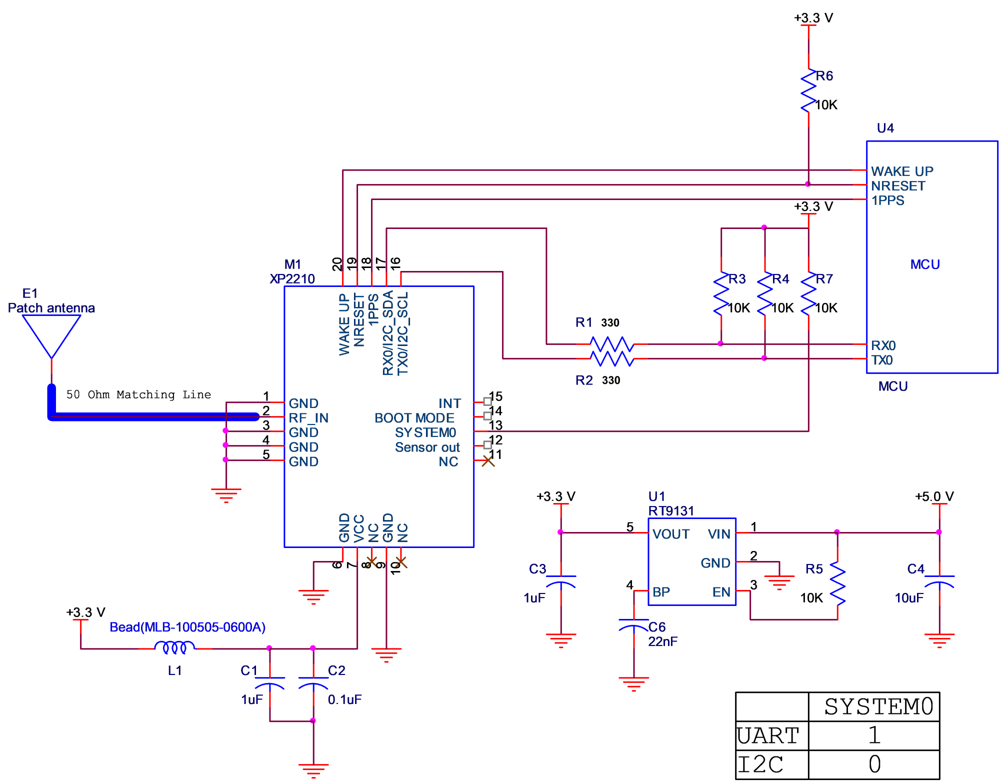

Figure 4-1: Reference Schematic Design for UART

- *Notes:*

  •Ferrite bead L1 is added for power noise reduction. Use one with an equivalent impedance (600Ω at 100MHz; IDC 200mA).

  •Place C1 and C2 decoupling capacitors as close to the module as possible.

  •Damping resistors R1 and R2 can be modified based on system application for EMI.

Reference Schematic Design for I2C

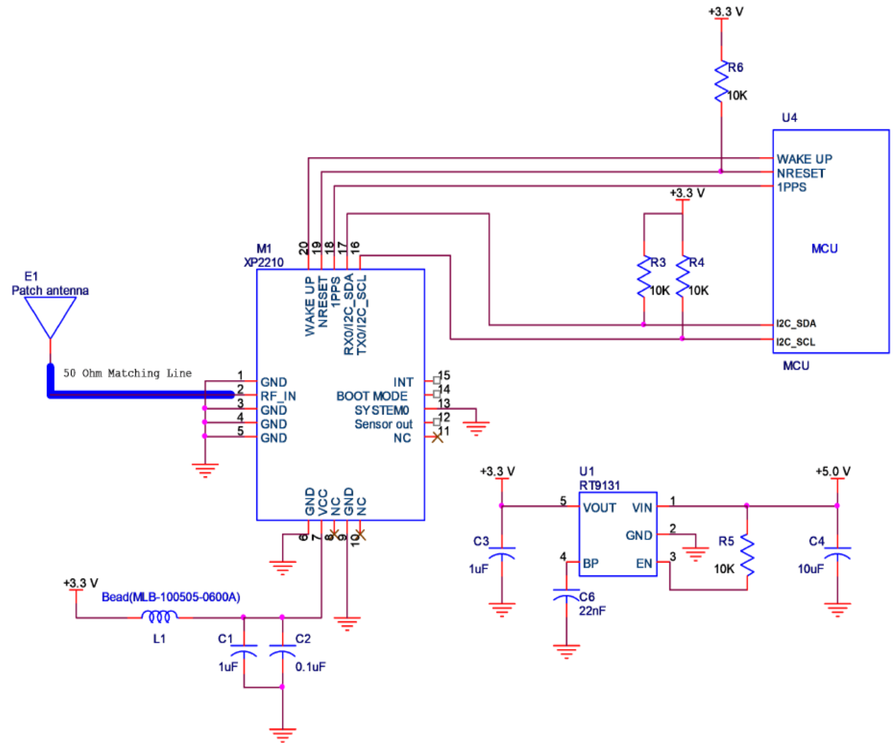

Figure 4-2: Reference Schematic Design for I2C

- *Notes:*

  •Ferrite bead L1 is added for power noise reduction. Use one with an equivalent impedance (600Ω at 100MHz; IDC 200mA).

  •Place C1 and C2 decoupling capacitors as close to the module as possible.

  •Pull high resistors R3 and R4 can be modified based on system application for I2C.

  •The INT pin of module connects to the MCU's INT pin (INT_H: data is ready for MCU to access; INT_Low: data transfer is finished).

Reference Schematic Design for Using Antennas

Reference Schematic Design for a Patch (Passive) Antenna

Connect the passive antenna directly to RF_IN (pin 2).

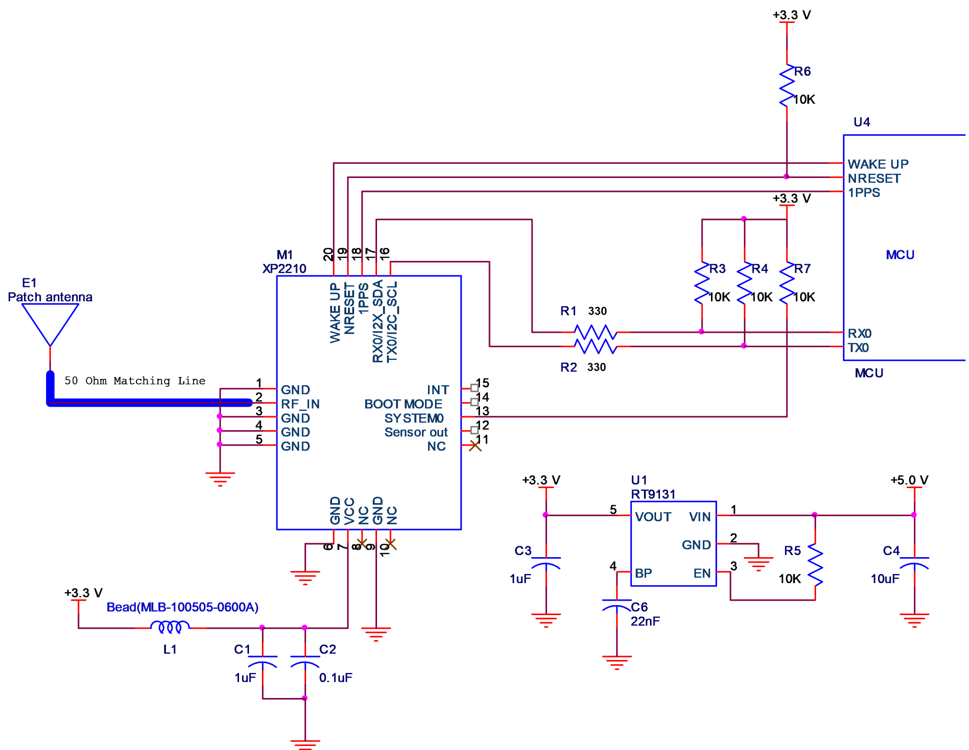

Figure 4-3: Reference Schematic Design for a Patch (Passive) Antenna

- *Notes:*

•Ferrite bead L1 is added for power noise reduction. Use one with an equivalent impedance (600Ω at 100MHz; IDC 200mA).

•Place C1 and C2 bypass capacitors as close to the module as possible.

•Damping resistors R1 and R2 can be modified based on system application for EMI.

Contact Sierra Wireless Sales for more information or antenna implementation support.

5: General Rules for Circuit Design

This section provides rules to obtain the best performance when using the XP2210.

Power Supply

A low ripple voltage and stable power supply is required for the XP2210 to perform optimally. An unstable power source will significantly impact GNSS RF reception performance. To achieve high-quality performance, additional considerations to stabilize power supply include:

1. Adding a ferrite bead, power choke, or low pass filter for power noise reduction.
2. Adding a linear regulator (LDO) rather than a switched DC/DC power supplier.
3. Using enough decoupling capacitors with VCC input for stable voltage.

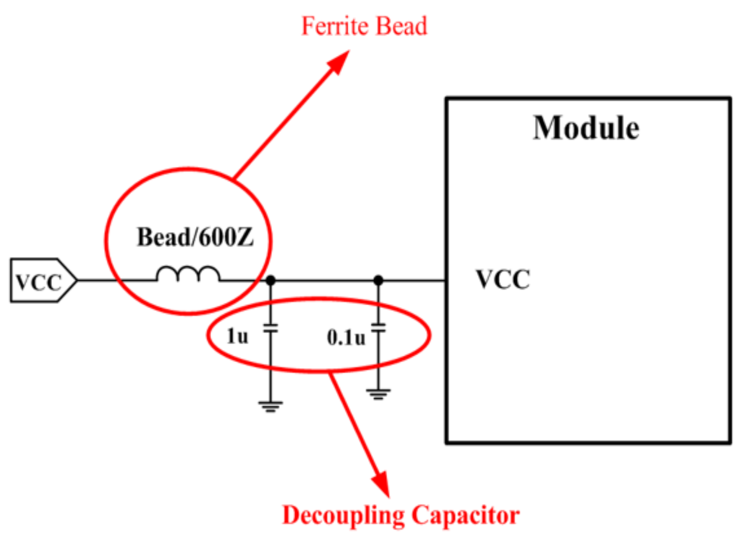

Figure 5-1: Power Supply Design

UART / I2C Serial Interface

UART (RX / TX)

1. UART is the TTL level interface that carries baud rate at 115200bps or 460800 bps.
2. Placing a damping resistor in series on the RX and TX trace of the module could reduce noise from the host MCU or high speed digital logics. Fine-tuning the damping resistor is required to efficiently suppress noise. The damping resistor is a wire-wound component and may function as a choke coil.
3. Do not connect diode(s) to RX/TX as it will decrease the signal driving capability which might adversely affect the RX/TX signal level. In some cases no data output will occur.
4. If RS232 logic-level is needed, a level shifter should be used. For more information refer to UART to RS232 Interface.
5. If USB logic-level is needed, refer to UART to USB Interface.

I2C (SCL / SDA)

1. The I2C interface is convenient for system integration. Sony CXD5608GF only supports slave mode (default slave address is 0x24). The bit rate is up to 1Mbit/s for fast mode plus (default Normal mode is 100 kbit/s). Additionally, the XP2210 supports manual or automatic indicator for data transfer in slave mode.
2. Pull-up resistors must be added for the I^2C bus as shown below:

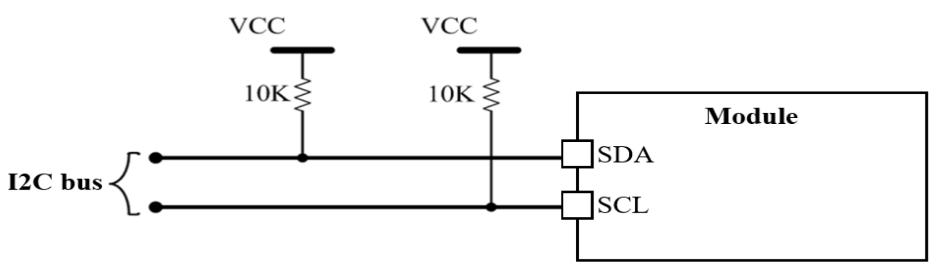

Figure 5-2: I2C Pull Up Resistors

Antenna Compliance Design

The GNSS antenna is the receiving part of the device that acquires weak GNSS signals from the sky. A common solution is to use a ceramic patch antenna because of its small form factor and low cost.

A passive antenna is a standalone component without a signal amplifier such as an LNA. Patch antennas and chip antennas are the most commonly used passive antennas with GNSS modules. When using an external passive antenna, ensure that it is correctly fine-tuned to ensure best possible signal strength.

Designing an External Passive Patch Antenna

1. In general, a 50Ω patch antenna will work well with the GNSS module. The antenna can be connected to the antenna IN pin with a 50Ω impedance trace.
2. Keep the patch antenna far away from noise sources such as the switch power supply, high speed digital logic signal, and radar wave guide.
3. The 50Ω trace should be kept as short as possible to reduce the chance of picking up noise from the air and PCB. A simple direct-line trace is recommended.
4. If needed, a matching circuit can be placed between the patch antenna and the module. The matching circuit design could vary depending on the patch antenna.
5. For 50Ω matching, refer to the following figure.

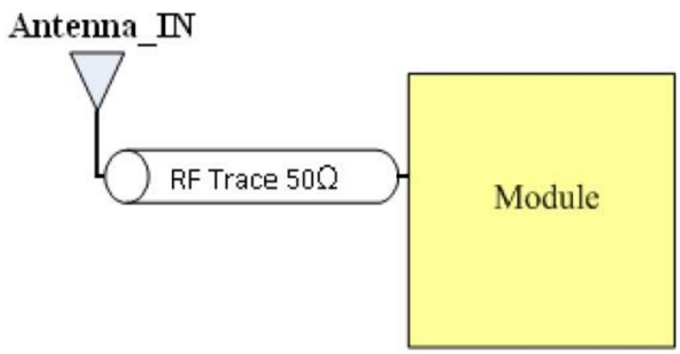

Figure 5-3: PCB trace design for antenna impedance matching

6. It is not necessary for the antenna design to use an active antenna. The module design includes an external LNA that provides enough signal gain. Sierra Wireless recommends the usage of a passive antenna that achieves the best signal performance.
7. Use a shorter trace to improve the path losses, noise factor, and sensitivity.

1PPS

1PPS signal is an output pulse signal used for timing applications. Its electrical characteristics are:

- Voltage level: 3.3V (typical)
- Period: 1s
- Accuracy (jitter): +-20 ns
- 125ms pulse width duration

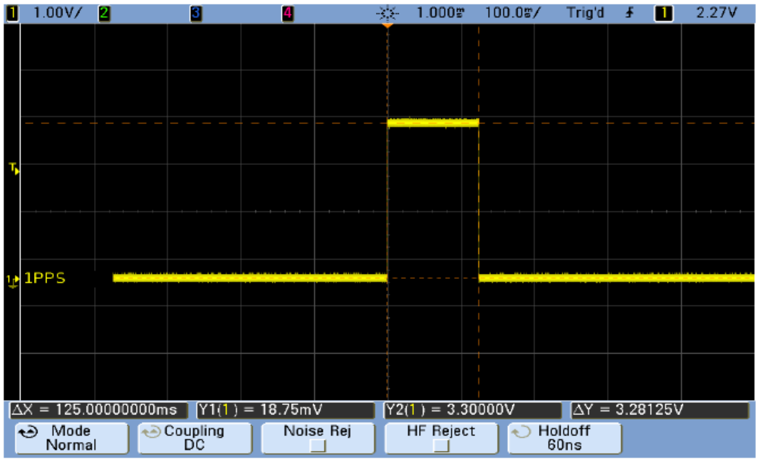

Figure 5-4: 1PPS Signal

Layout Guidelines

The following layout guidelines should be followed during the design process.

Layout Underneath the Module

The XP2210 modules have high receiving sensitivity at approximately -161dBm. During hardware integration, try to avoid noise or harmonics in the following bands to prevent unnecessary reception degradation:

- **GPS — 2.046 MHz BW NB GPS (centered on 1575.42 MHz)**
- **GLONASS (GLO) — ~8.3 MHz BW (1597–1606 MHz), 14 channels (-7 to +6)**

Modern GNSS positioning products integrate many components such as an LCD screen, MCU, high speed digital signal (access memory card) and RF system (i.e. cellular module, BT, Wi-Fi, DVB-T). These may cause poor GNSS RF reception; keep these components away from the module to avoid noise interference.

Do not leave any trace or mark underneath the XP2210 as indicated by the red area in the following figure:

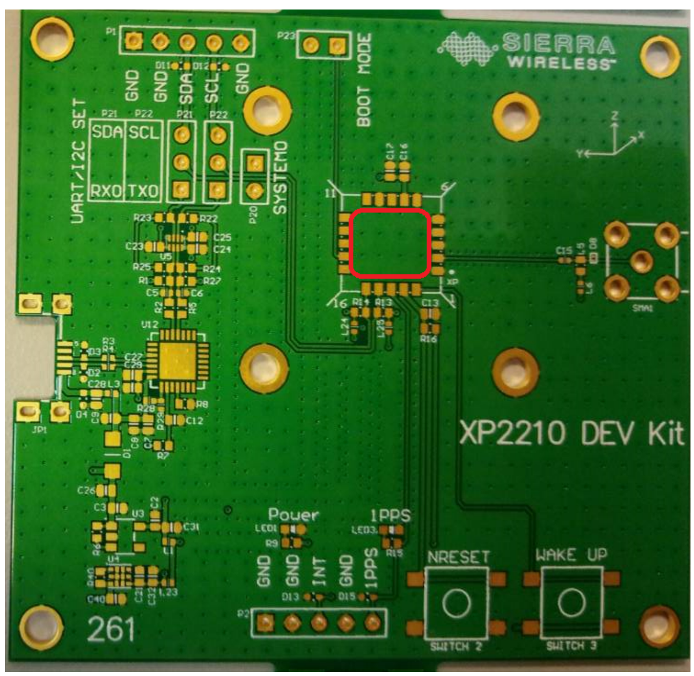

Figure 5-5: Module with a Clean GND Plane

Also, do not place any trace such as I2C (SCL/SDA), USB (DP/DN) or UART (TX/RX) underneath the XP2210 as this will cause a decrease in sensitivity.

Placement

- Place the decoupling capacitors for VCC close to the module.
- Place the damping resistors for TX/RX close to the module.

Do not place:
- in proximity to high-speed digital processing circuitry
- in proximity to high-current switching power circuitry
- in proximity to clock sources circuitry

Trace

1. USB differential signals should be traced closely and of equal length for better noise immunity and minimum radiation.
2. Apply the 50Ω impedance of RF trace for matching RF impedance.
3. Any right angle turn in trace routing should be done with two 135 degree turns or an arc turn.

Figure 5-6: Examples of Turns in Trace Routing

It is better to have an independent trace of power source for all components as shown in the figure below:

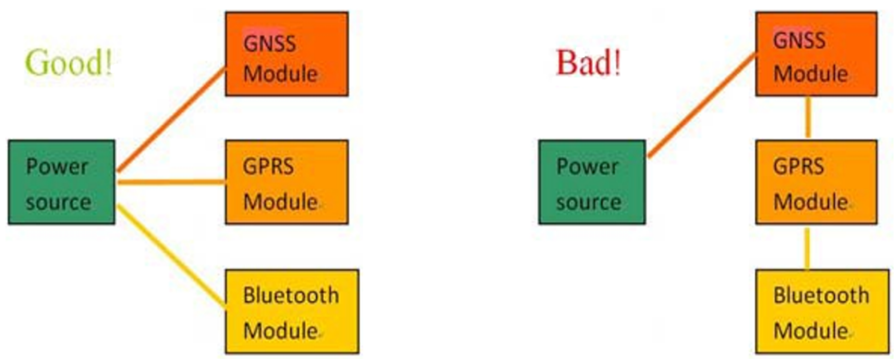

Figure 5-7: Examples of Independent Trace

4. It is recommended to route the USB-related line within the inner layer.

Ground Segmentation

In general, the separation of ground between the module and the rest of the system is recommended to avoid interference. If this is not possible, it is best to follow these rules:

- segmentation of ground between digital and analog system
- high current and low current system
- different radiation systems such as GPS and GSM/WCDMA/LTE.

One way to segment the ground is to place digital and noise components at one corner of the board, while placing analog and quiet components at the opposite corner of the board.

Note: Make sure there is no crossing of microstrip or current between the two component sets with ground; each set is to be contacted to one point only.

Another method is to place the two different sets at different layers of the board, while the ground of each layer is contacted at one point only which is ideally located at the border of the board.

Module Assembly

This section describes the assembly of the XP2210 module to the PCB after completion of the layout, and also provides troubleshooting steps.

Module Placement

This is an electrostatic-sensitive device. Please do not touch the UDR module directly and also follow the ESD safety rule when handling. Careful consideration should be made in regard to the housing and the environment where it will be placed.

As shown in Figure 5-8, the module should be faced towards open sky. This module contains a 3-axis accelerometer and 3-axis gyroscope sensor which have installation limitations. Sierra Wireless strongly recommends the horizontal titling angle be less than 45 degrees during proper system sensor calibration.

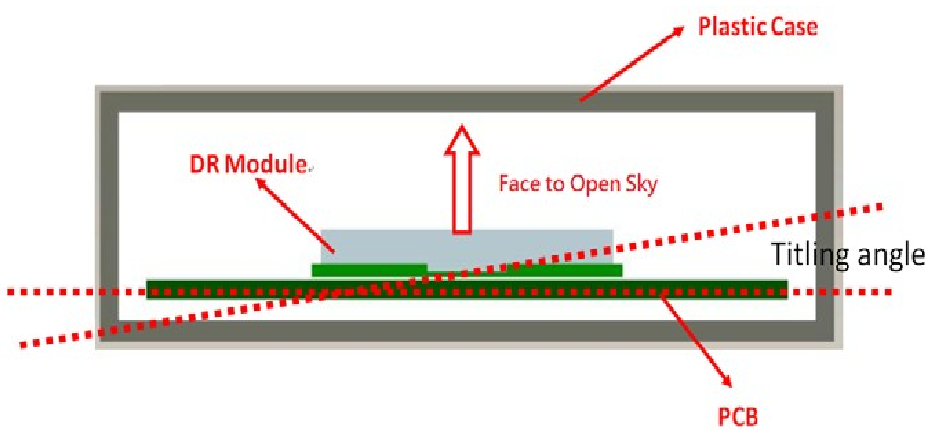

Figure 5-8: Placement of the XP2210 Module

While setting the module for a road test, make sure the module is properly fastened and placed in a horizontal position.

Module Calibration

The 3-axis accelerometer and 3-axis gyroscope sensors inside the module require calibration. In most cases, the system needs to be calibrated only once. The goal is to calibrate the system so that it can operate in estimated mode (dead-reckoning).

Navigation systems obtaining GPS+GLONASS data from the UDR board will achieve smoother position traces for vehicular tracking. The DR system is designed so that during driving it continues performing self-calibration, even if no initial calibration is done.

This ensures that the navigation system maintains true tracing in time of need. During the calibration process, the calibration level can gradually increase as the user drives on the road under open-sky weather conditions. When calibration is fully achieved, the reconstruction of the GPS will be smoother in the presence of an open sky GNSS signal. Please use the following calibration procedure:

1. Drive the car under an open sky and remain there until a position fix is obtained. In the GNSS tool software, the GNSS status should appear as 3D Fix. After the vehicle has stopped with a 3D Fix, wait for about a minute to ensure that the Gyro offset is automatically initialized with a reliable value.
2. Drive the car and keep the speed higher than 30km/hr along a rectangle contour with a side length over 400m. Go one lap around this rectangle block clockwise as shown in Figure 5-9:

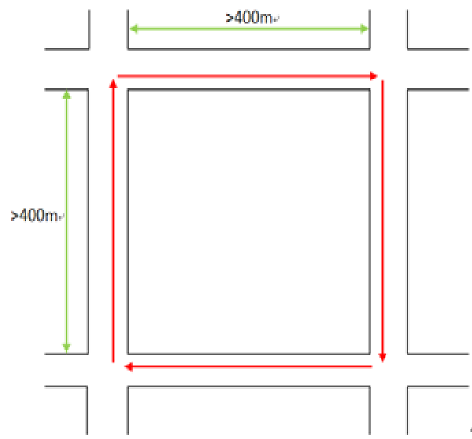

Figure 5-9: Driving Around a Rectangular Block

3. Since the calibration is not finished, run a counterclockwise circle for one lap around this rectangle block with same speed and distance as in Step 2. See Figure 5-10:

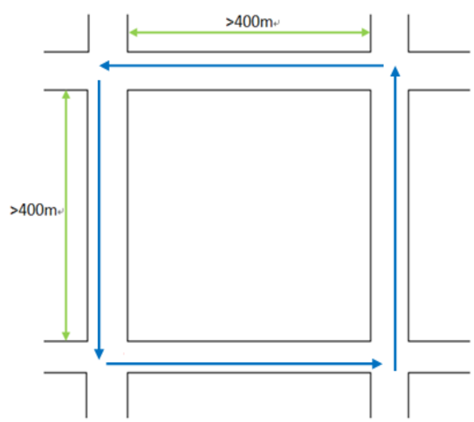

Figure 5-10: Running Counter-Clockwise

4. Make sure the calibration status (see Table 5-1) is in the PSWIUMEAS message. When the calibration process is done, the calibration status displays 6 then the UDR performance can start its execution.

Table 5-1: Module Calibration Status

Calibration Status	Definition
0-4	Under calibration.
5	Navigation has started and calibration is still in progress.
6	Calibration is done.

6: Troubleshooting

Checking the Working Status of the Module

To check the working status of the module, first check to see the NMEA sentence output through TX using various application tools. For example, you may use the Windows tool HyperTerminal, or you may use another GNSS application program.

Secondly, if there is no NMEA output at the TX pin, this indicates that the module is currently not working. Please double check your schematic design. The following is a list of possible items to check:

- **Item 1: VCC**

  The voltage should be kept between 3.0V to 3.6V (typical: 3.3V).
- **Item 2: TX0**

  The TX0 pin of the module outputs normal GNSS NMEA information.

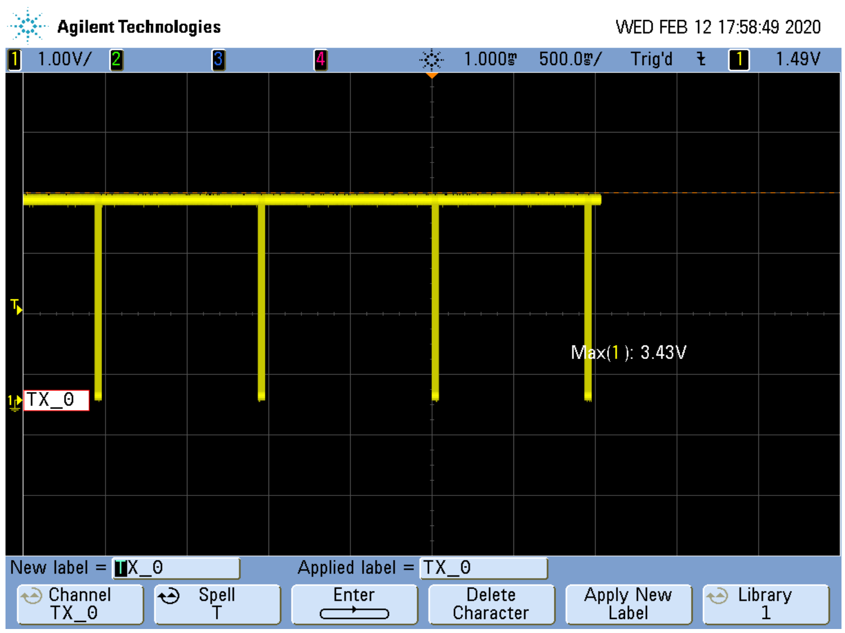

Figure 6-1: TX0 pin GNSS NMEA Information

7: Characteristic Impedance of the RF Input Line

Sierra Wireless uses the AppCAD tool to simulate 50Ω impedance for the RF PCB layout.

Table 7-1: Antenna Matching

RF Line Width (W)	PCB FR4 Thickness	Dielectric Parameters	Copper Thickness per ounce
10 mils	5.6 mils	4.6	1.4 mils

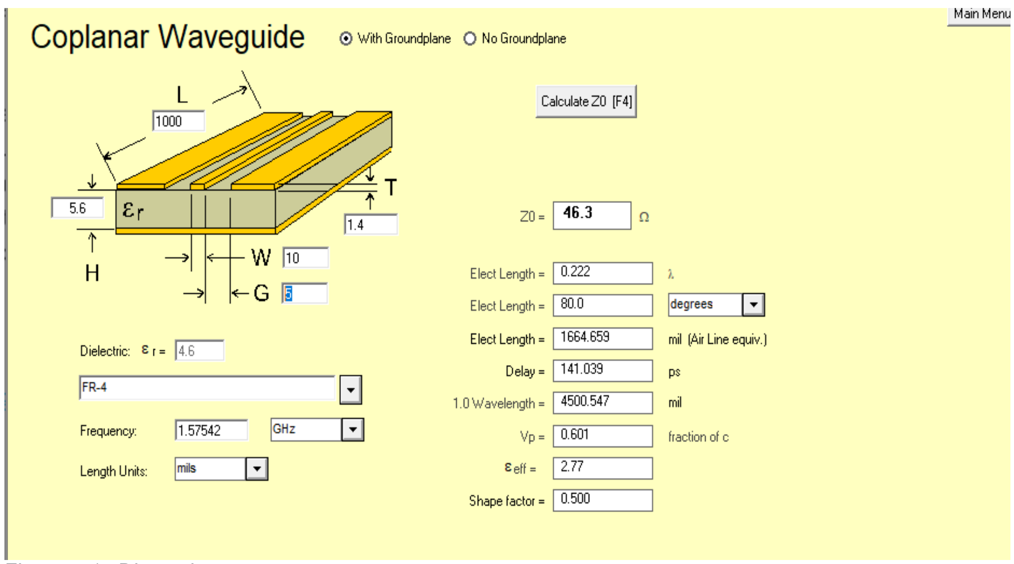

Figure 7-1: Dimensions

Note that:

- For multi-layer layouts, you can place a ground layer in the second layer to minimize the trace width in a specific PCB (such as FR4) and impedance.
- For impedance calculation, there is free software available to calculate the trace width or impedance. Once such software package is: http://www.hp.woodshot.com/

8: UART to RS232 Interface

Typically, an RS232 or USB interface is required to connect the PC to the Sierra Wireless GNSS module for communication. Most Sierra Wireless modules use a set of communication ports in TTL-logic. A bridge IC may be needed for RS232 signal conversion.

The supported baud rates are 460800 and 115200 bps.

Please refer to the reference circuit in Figure 8-1 below for RS232 signal conversion. An SP3220E IC is used here as an example.

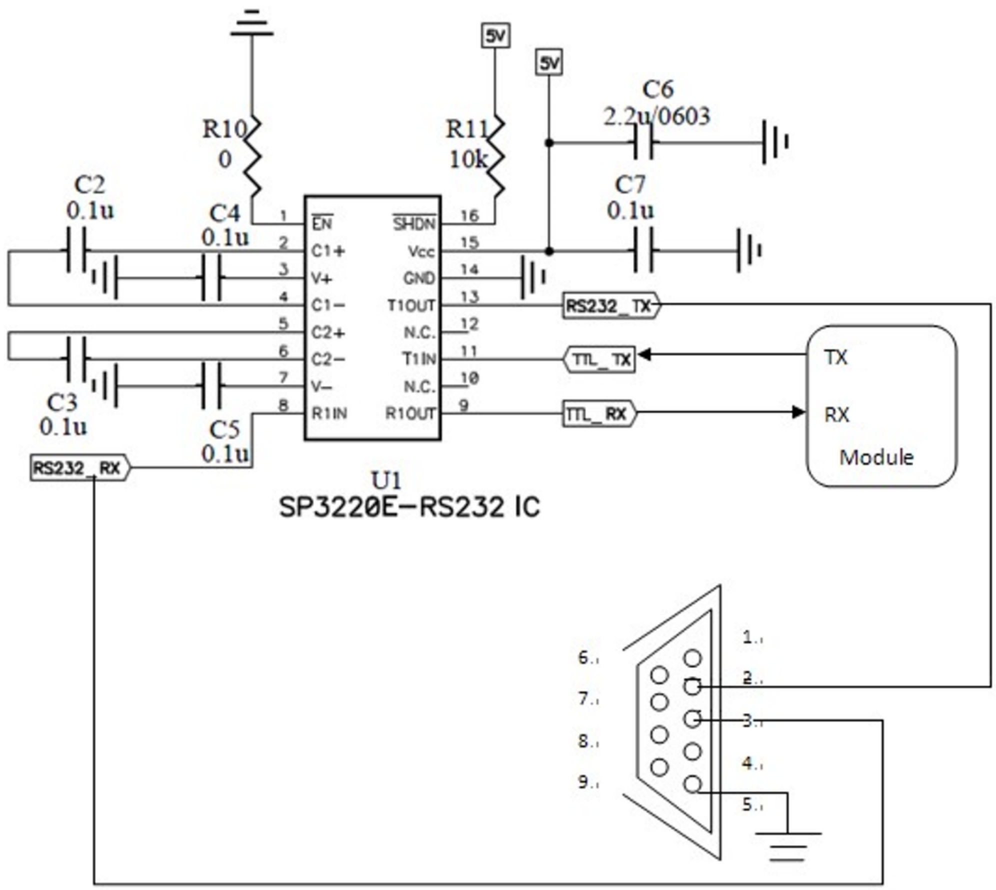

Figure 8-1: RS232 Signal Conversion Example

9: UART to USB Interface

If the Sierra Wireless module you have purchased does not come with a USB interface, it is possible to connect the module to an external USB IC. To further enhance the transfer speed, use one that is capable of USB version 2.0. Once the driver for the chosen USB Bridge IC is successfully installed in Windows or another operating system, the USB Bridge IC will automatically be recognized as a COM port.

Note: A proper driver must be installed for the USB to be recognized by the operating system.

Please refer to the reference circuits in Figure 9-1 below for the conversion. A CP2102 IC is used here as an example.

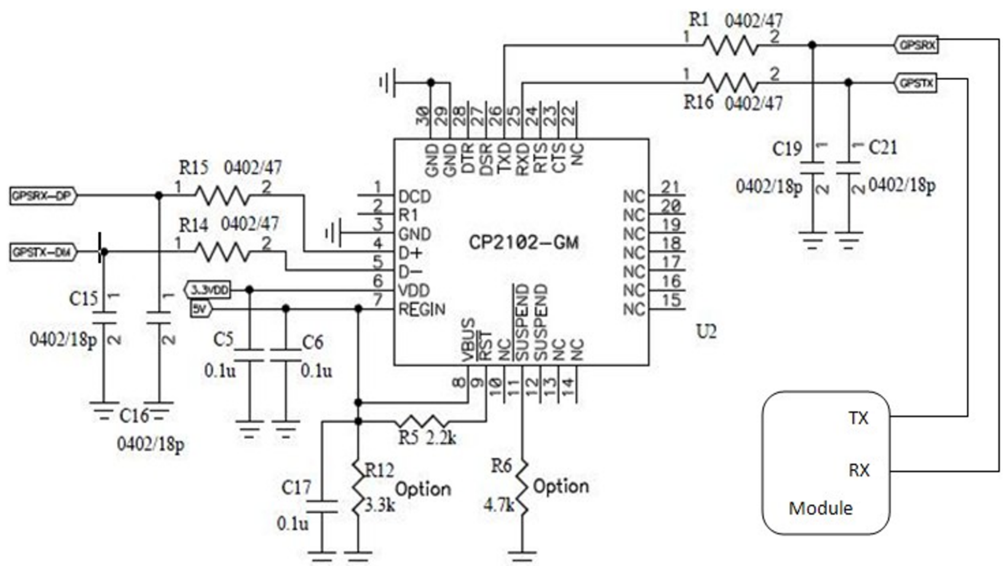

Figure 9-1: UART to USB

Pin 29 and Pin 30 are the bottom ground pads which are not documented in the IC datasheet. You may ignore these two pins in the drawing.

A: Appendix - Abbreviations

Table A-1: Abbreviations

Acronym or term	Definition
AGPS	Assisted GPS
FTP	File Transfer Protocol
GLONASS	Global Navigation Satellite System
GPS	Global Positioning System
LDO	Low Dropout Regulator
LLE	Long Life Ephemeris
M2M	Machine to Machine
NMEA	National Marine Electronics Association
PVT	Position Velocity Time
QFN	Quad Flat No-Lead
QZSS	Quasi-Zenith Satellite System
SBAS	Satellite-Based Augmentation System
TTFF	Time To First Fix
UART	Universal Asynchronous Receiver-Transmitter
UDR	Untethered Dead Reckoning
1PPS	one pulse-per-second