AirPrime XS1110

Product Technical Specification

SIERRA WIRELESS®

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Revision History

Revision number	Release date	Changes
1.0	August 26, 2019	Creation
1.1	September 02, 2019	Updated: • Table 2-1 on page 13 • Table 2-6 on page 16 • Table 3-14 on page 23 • Figure 5-5 on page 40
1.3	February 13, 2020	Updated: • Patents and Trademarks sections • Product Highlights and Features • Specifications table
2.0	March 16, 2020	Removed Sleep mode under Power Saving in Table 2-6

Revision number	Release date	Changes
3.0	April 08, 2020	Added Appendix - Abbreviations Minor text edits Added SGE duration under SGE on page 9 Under PVT Logger Function on page 9: • Removed valid and checksum • Changed internal to external • Changed 8 KB to 4.8 KB 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 • Changed max altitude to 80,000 • Added another baud rate value Under Table 3-10, Table 3-13, Table 3-19, changed QZSS to 193-201 On page 33, page 34, page 35, changed bypass capacitors to decoupling capacitors
4.0	July 2, 2020	Modified UART damping resistor value Modified values in Table 7-1

Contents

>> | 1: Function Description

Overview

The XS1110 is a receiver that is capable of tracking GPS and GLONASS systems simultaneously. This module provides an external antenna interface that supports passive GNSS antennas.

The XS1110 is one of the smallest multi-GNSS modules on the market with an ultra-compact size of 6.7 x 7.0 x 2.1 mm in a QFN package. It supports multiple interfaces such as I2C that can be used instead of UART.

The module is integrated with a low drop out LDO which allows for the lowest possible power consumption while offering optimum GNSS sensitivity and performance.

The XS1110 is based on the latest Sony CXD5605GF chipset and supports all standard GNSS features including QZSS, Anti-Jamming, and AGPS.

Target Applications

- Handheld Devices
- M2M applications
- Asset management
- Surveillance systems
- Wearable products

Product Highlights and Features

- 24 tracking / 12 acquisition-channel GPS and GLONASS, or GPS and Galileo, or GPS and BeiDou receiver
- Supports QZSS and SBAS
- Sensitivity: -161 dBm
- Update rate: 1 Hz (default)
- High accuracy 1PPS timing (+-25ns) and the pulse width are 125 ms / 250 ms / 500 ms.
- LLE support for Fast TTFF (LLE data is injected in flash from FTP; supports 3 / 7 / 14 days)
- SGE orbit prediction for fast TTFF
- PVT logger function
- Supports interface types I2C/UART
- Consumption current (@1.8 V) for GPS and GLONASS constellations:
  - Acquisition:15 mA / 18 mA / 22 mA (minimum / typical / maximum)
  - Tracking: 12 mA / 15 mA / 22 mA (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 XS1110 module. For detailed module specifications, refer to this guide.

The XS1110 is an electrostatic-sensitive device; please DO NOT touch the module directly. Follow ESD safety rules when handling. When using the XS1110 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.

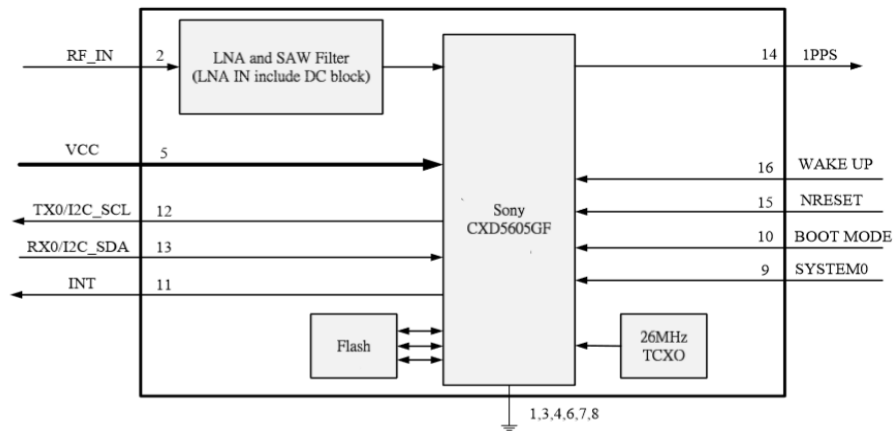# System Block Diagram

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 XS1110 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 25 ns. The PPS signal is provided through a designated output pin for additional 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 get position information quickly. LLE can be downloaded from an FTP server via the Internet. LLE injection type can support GPS, GLONASS, Galileo, BeiDou and QZSS.

SGE

The SGE is for quick positioning by itself when information received from the satellites is sufficient. When SGE is enabled, the XS1110 will automatically calculate and then predict single ephemeris up to three days. The predicted information will be saved into the memory and the XS1110 will then use the saved information for later positioning. The valid duration of SGE data is three days.

PVT Logger Function

The PVT logger function is enabled in the XS1110 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 for 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.

Normal Mode

In Normal mode, the XS1110 module keeps on operating normally and updates the latest navigation message anytime to get an accurate positional information.
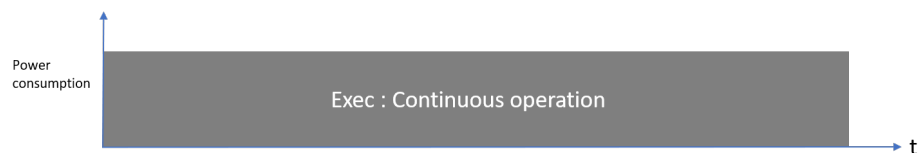

Figure 1-2: Power Consumption in Normal Mode

Low Power Tracking
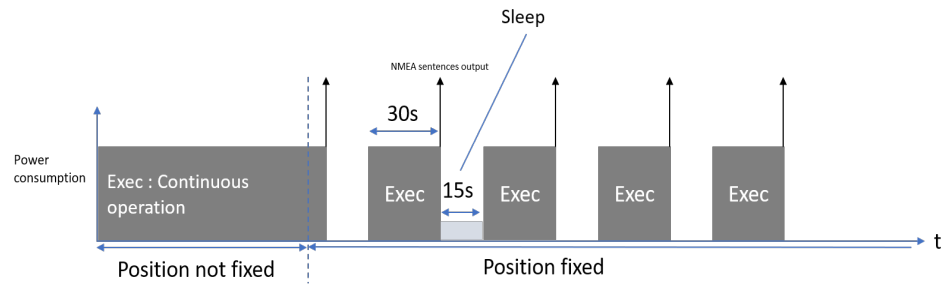
Figure 1-3: Power Consumption in Low Power Tracking

When low power tracking of XS1110 is enabled, in the beginning, it keeps receiving a GNSS navigation message. This GNSS navigation message is continually received for about 12 minutes and 30 seconds and includes the ephemeris, almanac, and satellite health in open sky.

After that, the module runs to cycle between Sleep (15 secs) and Exec (30 secs) as shown in Figure 1-3.

Before the XS1110 module enters into a sleep state, it outputs "GNSSLOWP,ENTRY,OK" messages in NMEA sentences to indicate that sleep mode will be executed. Once the XS1110 wakes up, it outputs "GNSSLOWP, WAKEUP, OK" to indicate that the module has woken up and will start updating the navigation message.

The module executes hot start internally after waking up every time, then it acquires satellite information for about 30 seconds to update the TOW (time of the week).The module will check all of the satellite ephemeris status and ensure that all updated data is the latest. Once update is complete, the modules enters into the sleep cycle. If it doesn't, it will keep acquiring satellites in an exec status until all the navigation messages are completely updated as this is helpful for ensuring positional accuracy.

The module will hot start after waking up from an intermittent behavior and, within 30 seconds, track satellites to update the TOW (time of the week). Then the module will check all of the satellite ephemeris to ensure data update is complete. If there are no issues, the module gets into the next sleep cycle. Otherwise, the module will switch into continuous operation and keep tracking until data update is complete.
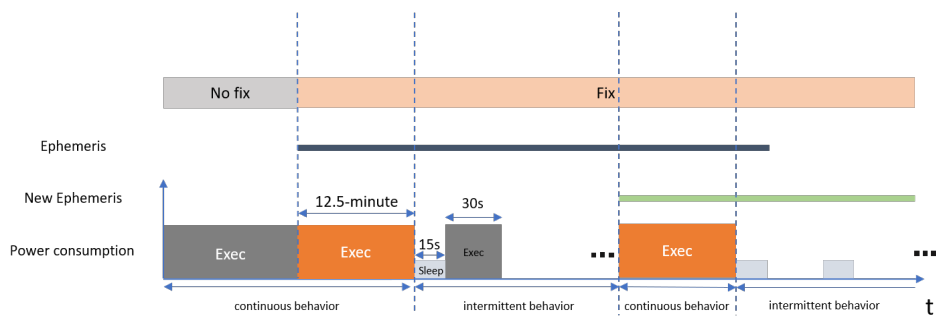
Figure 1-4: Low Power Tracking Behavior
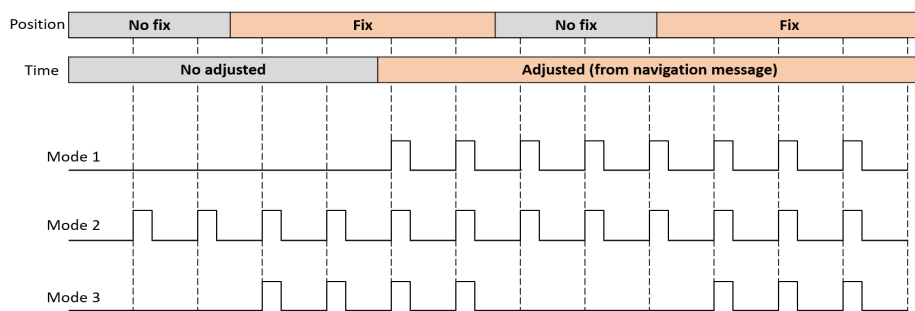
Figure 1-5: 1PPS Output Types

>> 2: Specifications

Mechanical Dimensions

Dimension: (Unit: mm, Maximum height: 2.3)
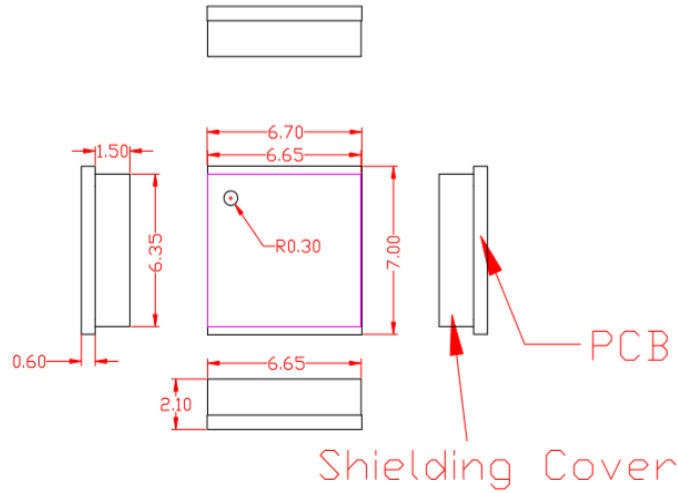
Figure 2-1: Mechanical Dimensions

Pin Configuration
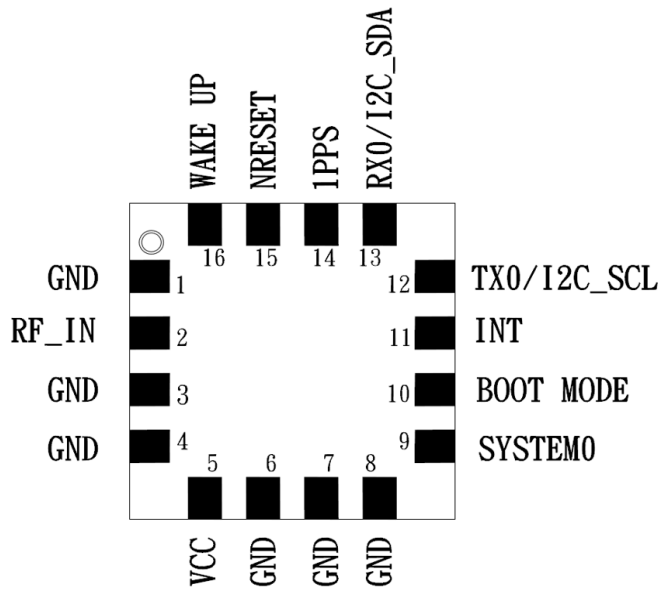
Figure 2-2: Pin Configuration

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	VCC	PI	Main DC power input		1.8V		Mandatory connection
6	GND	P	Ground		0V		Mandatory connection
7	GND	P	Ground		0V		Mandatory connection
8	GND	P	Ground		0V		Mandatory connection
9	SYSTEM0	I	UART / I2C interface setting		1.8V	I, PD[a]	Left open
10	BOOT MODE	I	BOOT firmware setting	H	0V	I, PD[a]	Left open
11	INT	O	Interrupt pin for I2C		1.8V	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
12	TX0 / I2C_SCL	I/O	Serial data output for NMEA output (TTL) / I2C series clock (in slave mode)		1.8V		Mandatory connection
13	RX0 / I2C_SDA	I/O	Serial data output for firmware update (TTL) / I2C series data (in slave mode)		1.8V		Mandatory connection
14	1PPS	O	1PPS time mark output		1.8V	O, PU[a]	Left open
15	NRESET	I	Reset input	L	1.8V	I, PU[a]	Left open
16	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**: VCC

   Main DC power supply (1.71 V to 1.89 V; typical: 1.8 V)
- **Pin6**: GND (Ground)
- **Pin7**: GND (Ground)
- **Pin8**: GND (Ground)
- **Pin9**: SYSTEM0

   Can be used to set the UART or I2C interface.

Table 2-2: SYSTEM0 Setting

SYSTEM0	Interface
High (default 1.8 V)	UART
Low	I2C

- **Pin10**: 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 WAKEUP 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.

- **Pin11**: 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.
- **Pin12**: 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 transceiver clock and communicate with host.
- **Pin13**: 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 transceiver data and communicate with host.

Note: UART signals are named with respect to Module and directions are 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**: 1PPS

  This pin provides a one pulse-per-second signal output. If not used, keep this pin floating.
- **Pin15**: 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)	1.2	-	1.8

- **Pin16**: WAKE UP

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

Table 2-5: WAKEUP Level

Level	Min (V)	Typ (V)	Max (V)
Low (default)	0	-	0.5
High	1.2	-	1.8

Specifications

Table 2-6: Specification Data

Description	
GNSS Chipset	Sony CXD5605GF
Frequency	GPS / QZSS / SBAS 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) Galileo E1, 4.092 MHz BW (centered on 1575.42 MHz) BEIDOU B1, 4.092 MHz BW (1559.05 –1563.14 MHz)
Sensitivity	Acquisition: -147dBm Tracking: -161dBm
SV Numbers	GPS #1~32 GLONASS #65~88 (see Chapter 3 for details) BEIDOU #1~30 Galileo # 1~30
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 (CEP50)
Velocity Accuracy	Without aid: 0.1 m/s
Timing Accuracy (1PPS Output)	+-25 ns within 125 ms / 250 ms / 500 ms in one pulse
Altitude	80,000 m maximum

Table 2-6: Specification Data (Continued)

Description	
Velocity	Maximum 138 m/s
Acceleration	Maximum 1.5 G
Update Rate	1 Hz
Baud Rate	115200 bps (default)
Power Supply	VCC: 1.71 V to 1.89 V (typical: 1.8 V)
Current Consumption @ 1.8 V,1 Hz Update Rate	GPS and GLONASS, GPS and Galileo, or GPS and BEIDOU: Acquisition: 15 mA / 18 mA / 22 mA (minimum / typical / maximum) Tracking: 12 mA / 15 mA / 22 mA (minimum / typical / maximum)
Power Saving	Idle: 4 mA (typical) Sleep 0 mode: 1 mA (typical) Sleep 1 mode: 350 µA (typical)
NRESET Current @ 1.8 V	500 µA (typical)
Working Temperature	-40 °C to +85 °C
Dimension	6.7 x 7.0 x 2.1 mm, SMD
Weight	0.2 g

Absolute Maximum Ranges

The maximum power supply voltage is 1.89 V.

Table 2-7: Maximum Ranges

	Symbol	Minimum	Maximum	Unit
Power Supply Voltage	VCC	1.71	1.89	V

Operating Conditions

Table 2-8: Operating Conditions

Parameter	Condition	Minimum	Typical	Maximum	Unit
RX0 TTL H Level		1.2	-	1.8	V
RX0 TTL L Level	**VCC=1.8 V**	0	-	0.5	V
TX0 TTL H Level		1.4	-	1.8	V
TX0 TTL L Level		0	-	0.3	V

3: Protocols

NMEA Output Sentences

Table 3-1 lists all NMEA output sentences specifically developed and defined by Sony.

Table 3-1: Position Fix Indicator

Option	Description
GGA	Time, position and fix type 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

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

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		Use NMEA 4.1 version
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
Galileo	3
Beidou	4
QZSS	5

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 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	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
Galileo	3
BeiDou	4
QZSS	5

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 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	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

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

Name	Example	Units	Description
Mode	A		A: Autonomous mode D: Differential mode E: Dead reckoning mode N: Data not valid
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 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	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 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	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 protocol header
UTC Time	084109.00		hh [hr]mm [min] ss.ss [sec]
System ID	1		1: GPS 2: GLONASS 3: Galileo 4: BeiDou, 5: QZSS
Satellite ID	12		Channel 1, see Table 3-19
SNR (C/No)	30.60	dB-Hz	Range 0 to 99, (null when not tracking)
Pseudorange	24978488.510	meters	Raw pseudorange measurements
Time Sync Carrier Phase	90377.141	Cycle	Raw carrier phase measurement sync to GPS time
Doppler	-145.3	Hz	Doppler frequency measurement
Cycle Slip Flag	1		Index for cycle slip in carrier phase measurement
Satellite Position (X)	7874433.564		X coordinate in ECEF system
Satellite Position (Y)	22830620.159		Y coordinate in ECEF system
Satellite Position (Z)	-11452247.121		Z coordinate in ECEF system
Frequency Channel	-64		Frequency channel for GLONASS
Age of Ephemeris	4302		Age of ephemeris for each satellite system
Ionosphere Correction	14.156	meters	Ionosphere correction value
Sync Status	4		G+B data sync status 0: None 1: Bit sync 2: Subframe sync 3/4: Exact sync (measurement is usable)
Checksum	*40		
<CR> <LF>			End of message termination

Table 3-19: Satellite ID

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

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 XS1110 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 XS1110 provides several interfaces to process GNSS NMEA data (specified by firmware):

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

Reference Schematic Design for UART
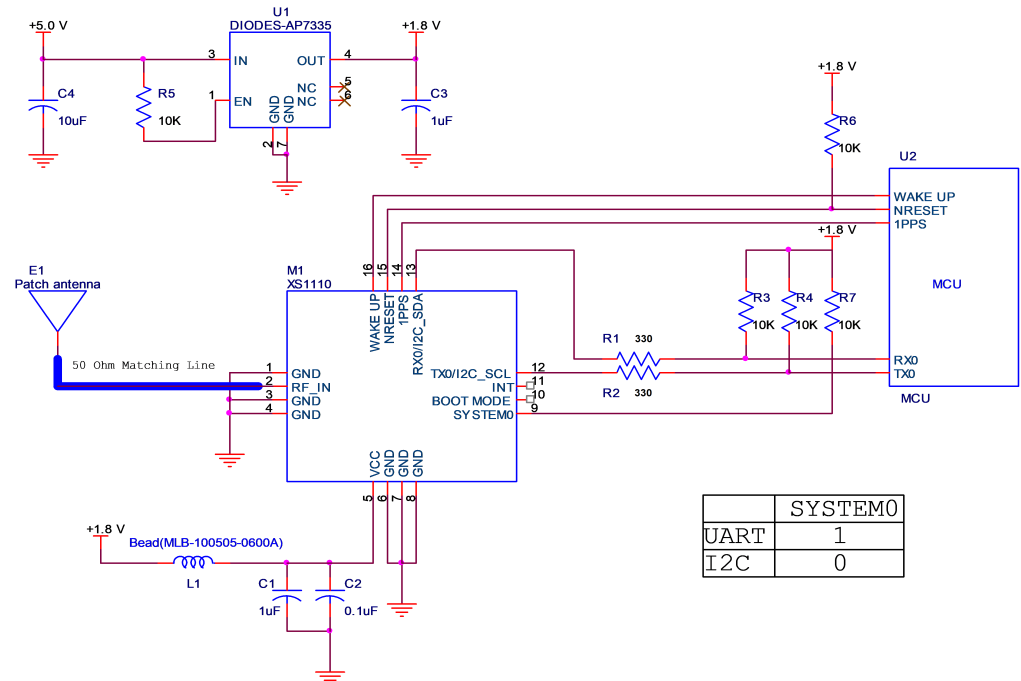
Figure 4-1: Reference Schematic Design for UART

Notes:

1. Ferrite bead L1 is added for power noise reduction. Use one with an equivalent impedance (600Ω at 100MHz; IDC 200mA).
2. Place C1 and C2 decoupling capacitors as close to the module as possible.
3. Damping resistors R1 and R2 can be modified based on system application for EMI.

Reference Schematic Design for I2C
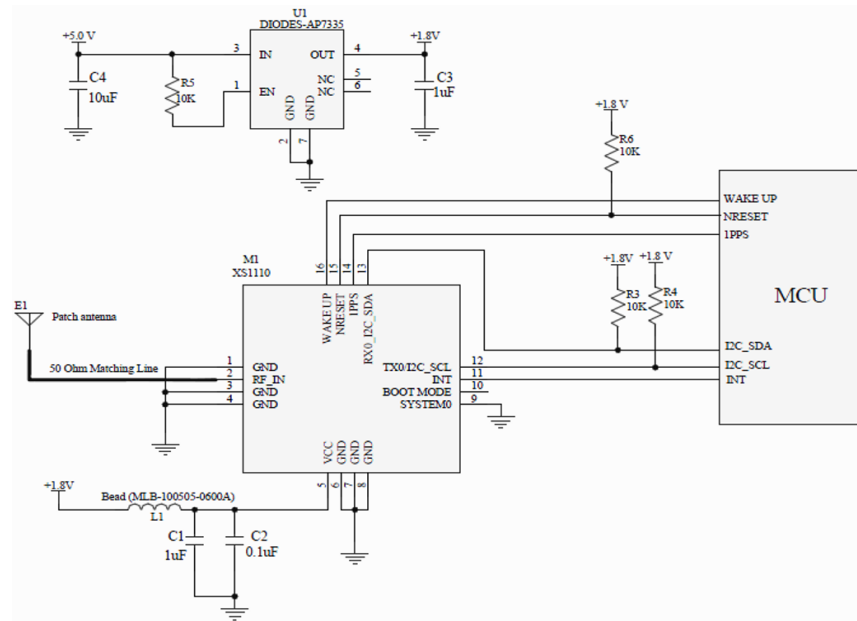
Figure 4-2: Reference Schematic Design for I2C

Notes:

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

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

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

4. The INT pin of module connect to 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).
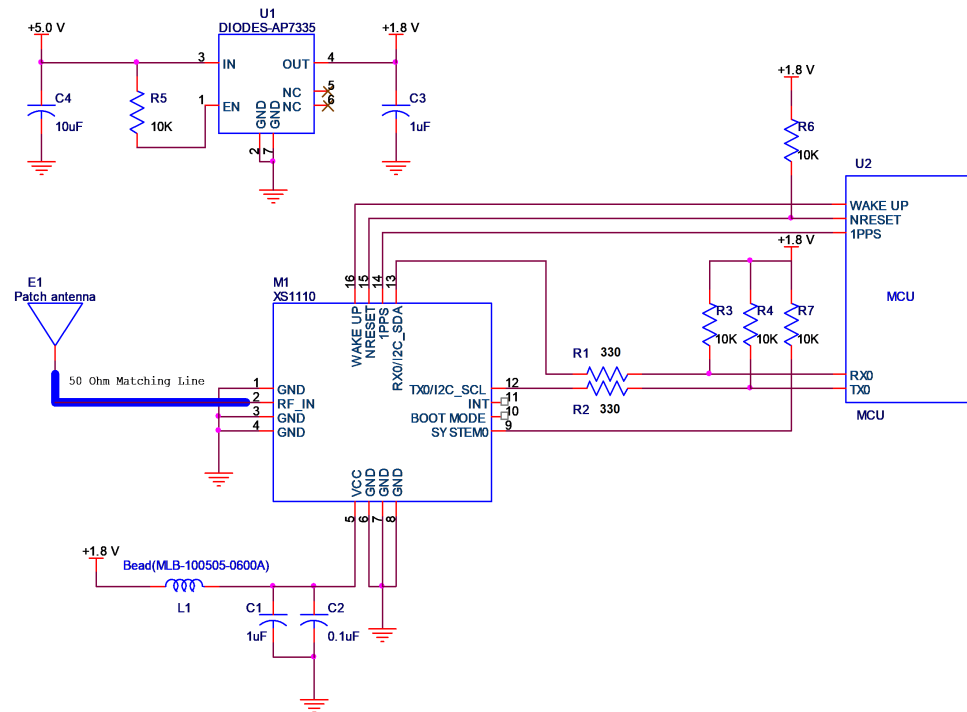
Figure 4-3: Reference Schematic Design for a Patch (Passive) Antenna

Notes:

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

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

3. Damping resistors R1 and R2 can be modified based on the 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 XS1110.

Power Supply

A low ripple voltage and stable power supply is required for the XS1110 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.
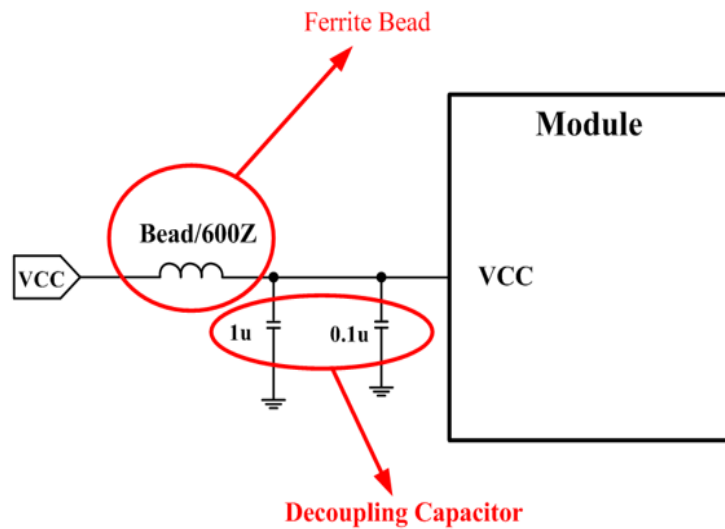
Figure 5-1: Power Supply Design

UART / I2C Serial Interface

UART (RX / TX)

1. UART is the TTL level interface that carries baud rate at 115200 bps 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. Don't 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 CXD5605GF 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 XS1110 supports manual or automatic indicator for data transfer in slave mode.

2. Pull-up resistors must be added for the I2C bus as shown below:
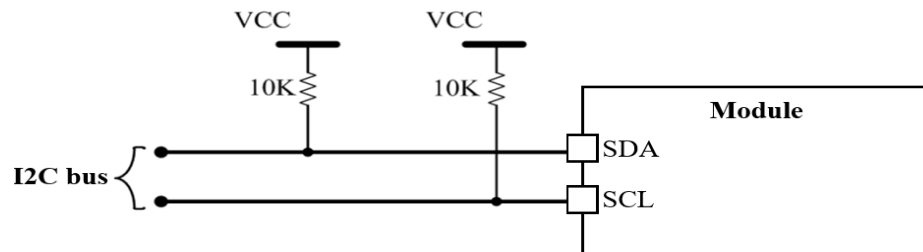
Figure 5-2: I2C Pull Up Resistors

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 50 Ω patch antenna will work well with the GNSS module. The antenna can be connected to the antenna IN pin with a 50 Ω 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 50 Ω 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 50 Ω matching, refer to the following figure.
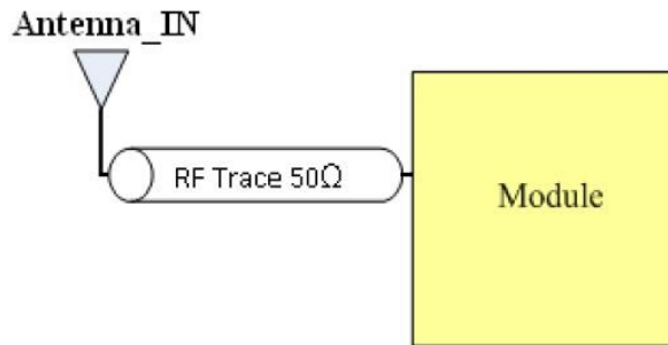
Figure 5-3: PCB trace design for antenna impedance matching

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: 1.8 V (typical)
- Period: 1 s
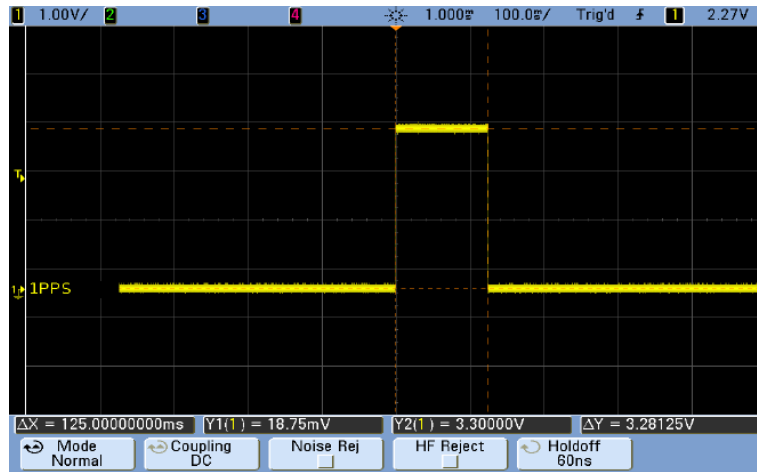- Accuracy (jitter): +-25 ns
- 125 ms pulse width duration

Figure 5-4: 1PPS Signal

For signal level shift, when the host system is 3.3 V and the GNSS module is 1.8 V, the host system can control the GNSS module by using a signal level shift circuit (refer to Figure 5-5 below). The values of R1 to R6 are default values; these values can be adjusted to achieve control in the actual design. The 2N7002L can select low RDS (On) to reduce power consumption through a voltage drop.
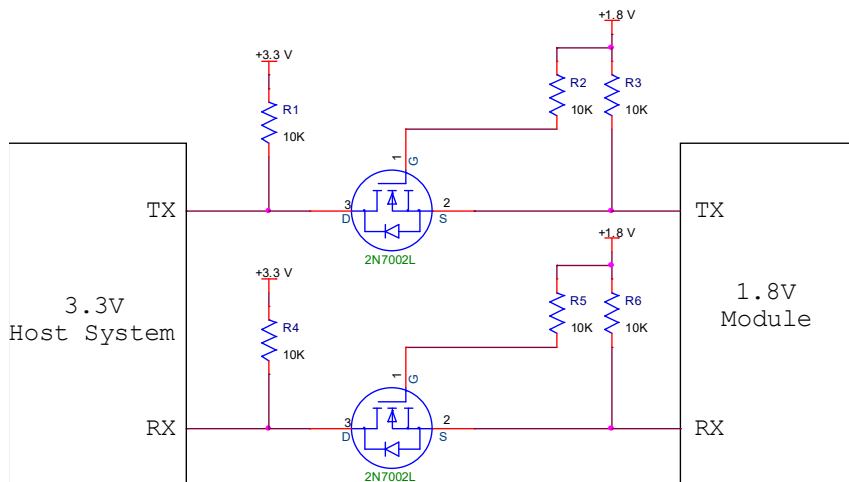
Figure 5-5: Signal Level Shift Circuit

Layout Guidelines

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

Layout Underneath the Module

The XS1110 modules have high receiving sensitivity at around -161 dBm. 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)**
- **BeiDouSystems (BDS) — 4.092 MHz BW (1559.05 –1563.14 MHz)**
- **Galileo (GAL) — 4.092 MHz BW (centered on 1575.42 MHz)**

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 XS1110 as indicated by the red area in the following figure:
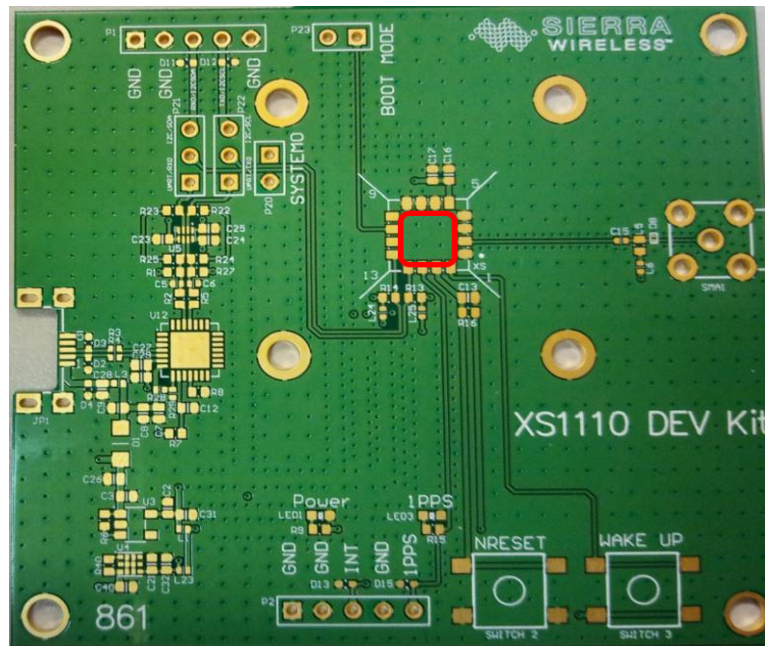
Figure 5-6: Module with a Clean GND Plane

Also, do not place any trace such as I2C (SCL/SDA), USB (DP/DN) or UART (TX/RX) underneath the XS1110 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 50 Ω 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 5-7: 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:
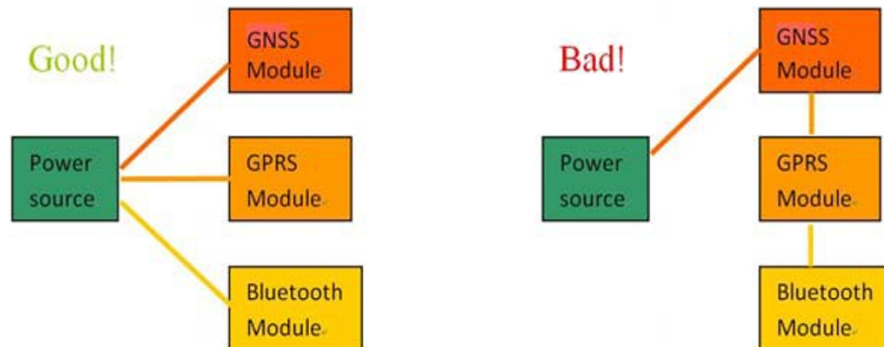
Figure 5-8: Examples of Independent Trace

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.

>>| 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 1.71V to 1.89 V (typical: 1.8 V).

Item 2: TX0

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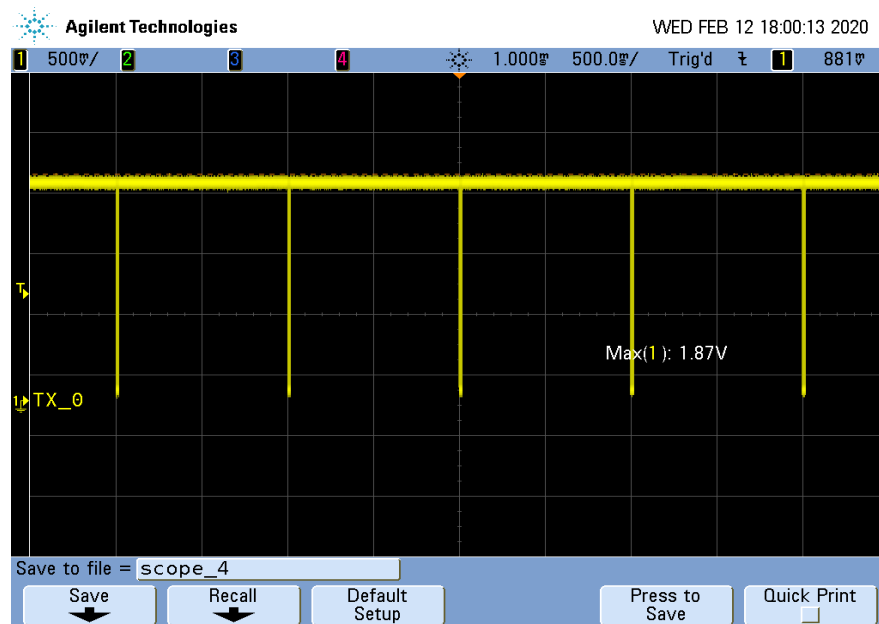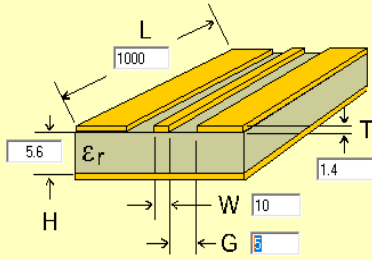

Figure 6-1: TX0

7: Characteristic Impedance of the RF Input Line

We used the AppCAD tool to simulate 50 Ω 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.

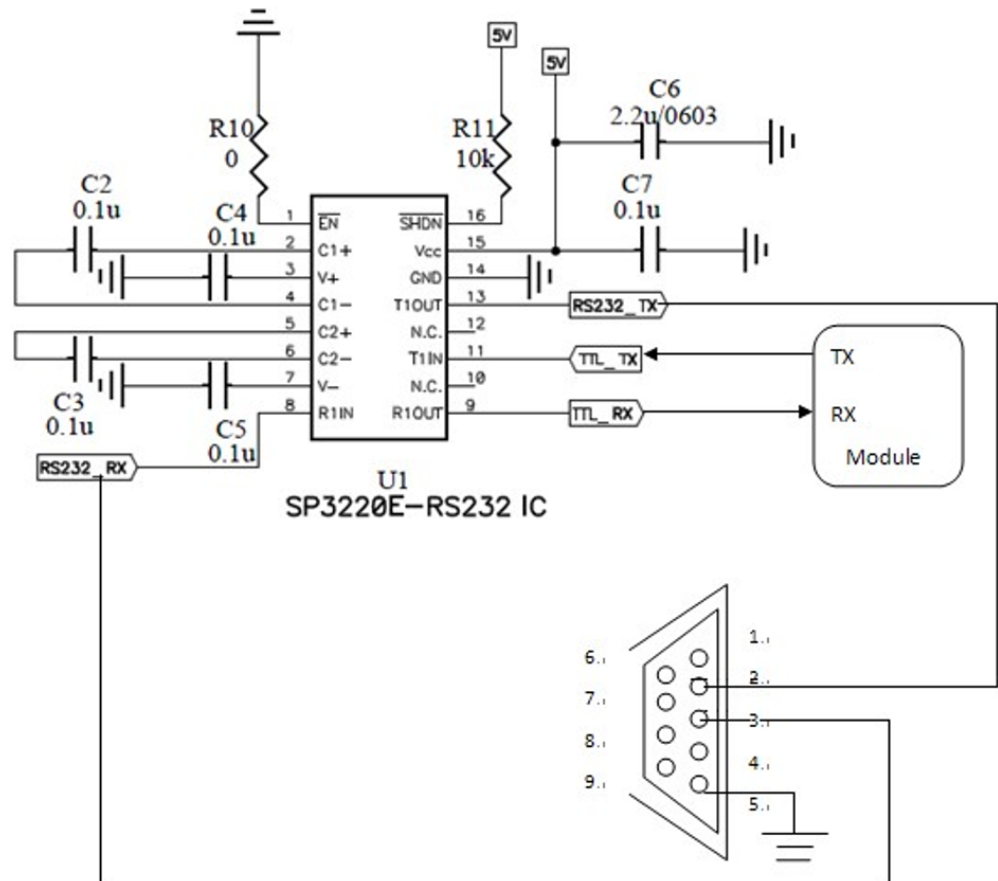*Figure 8-1: RS232 Signal Conversion Example*

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 transferring 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.
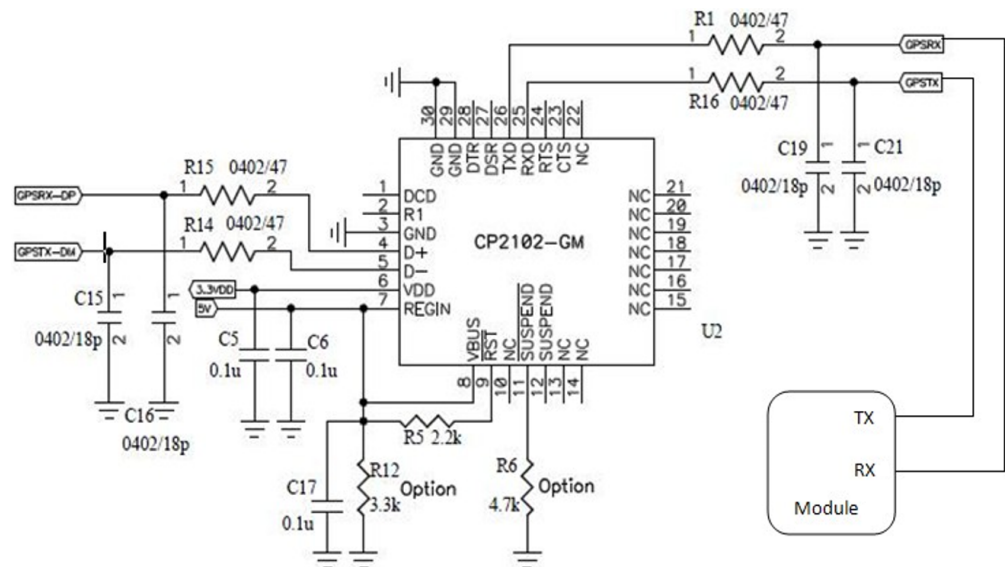

Figure 9-1: UART to USB

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
SGE	Self Generated Ephemeris
TTFF	Time To First Fix
UART	Universal Asynchronous Receiver-Transmitter
1PPS	one pulse-per-second