

GLONASS & GPS HW designs

Recommendations with u-blox 6 GPS receivers

Application Note

Abstract

This document provides design recommendations for GLONASS & GPS HW designs with u-blox 6 module or chip designs.



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1 Introduction

This document provides recommendations for GLONASS & GPS HW designs with u-blox 6 module or chip designs. It describes the necessary steps to prepare new designs for GLONASS and GPS capability.

2 GLONASS background

GLONASS is an acronym for **GLO**bal **NA**avigation **S**atellite **S**ystem (GLObal'naya Navigatsionnaya Sputnikovaya Sistema in Russian). It is a satellite positioning system operated by the Russian government and similar to the US Navstar GPS system. GLONASS and Navstar GPS share principles in data transmission and positioning methods, although there are important differences.

GLONASS is backed by the Russian government. The satellite constellation is almost complete with Full Operational Capability (FOC) planned for the end of 2011. GLONASS is expected to be required by law on GNSS devices sold to the Russian government. In addition the Russian government is pushing through legislation for ERA-GLONASS. This system, which is equivalent to e-Call, would require GLONASS/GSM black boxes in all cars.

2.1 GLONASS history

- 1982: 1st GLONASS satellites launched
- 1995: full operation achieved
- 2001: only 7 satellites in operation, program for GLONASS relaunch
- 2004: 1st improved GLONASS-M satellites launched,
- 2011-12: Full operation expected with 24 operational satellites

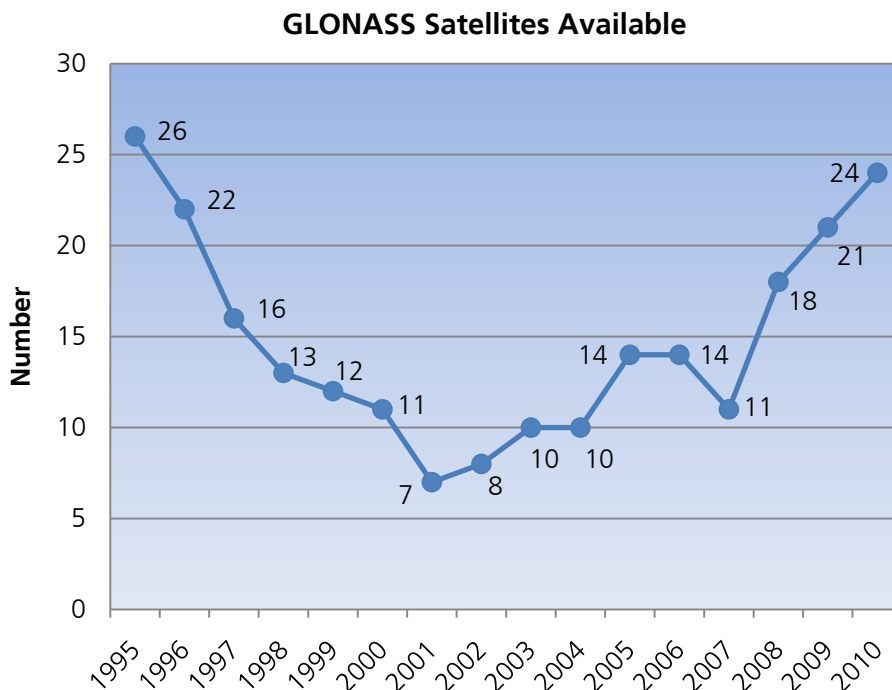


Figure 1: Development of GLONASS satellite constellation: 1995-2010

2.2 GLONASS performance

2.2.1 Coverage

With its current constellation of 21 satellites, GLONASS provides the following coverage (see Figure 2):

- Russia and the polar regions to 100%
- Rest of world from 80 – 99%

24 satellites are required to provide coverage over the entire globe.

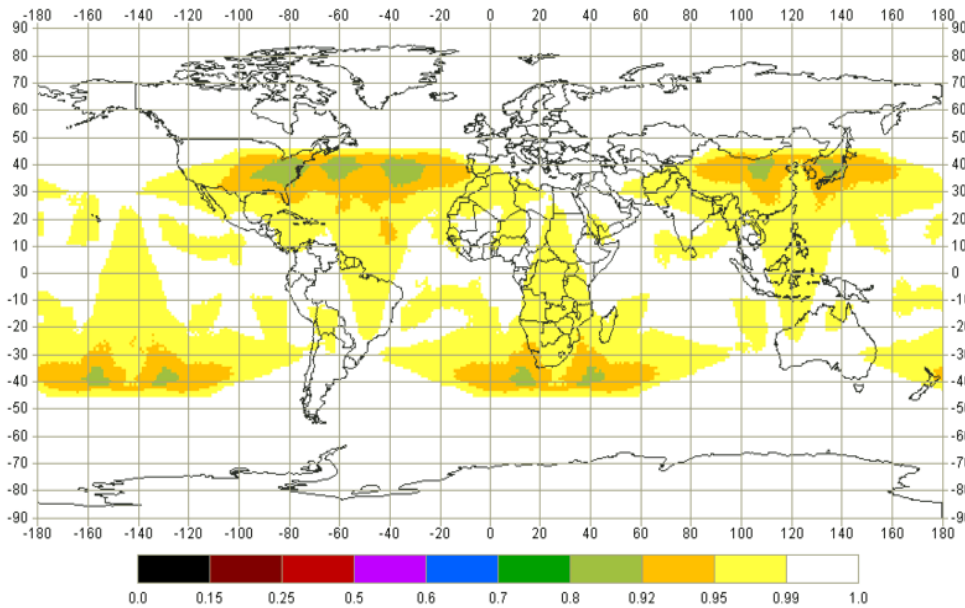


Figure 2: GLONASS coverage (Note: white areas represent 100% coverage)

2.2.2 Accuracy

GLONASS provides a horizontal position accuracy of ~ 5- 9 meter (>10 m outside Russia).



Lack of ionosphere correction with GLONASS is a disadvantage in comparison to GPS.

2.3 GLONASS vs. GPS

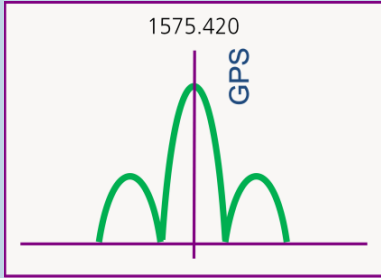
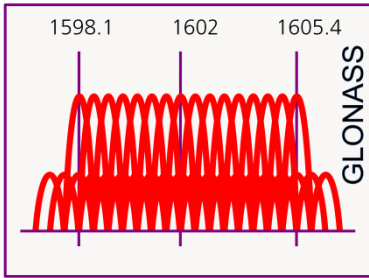
	GPS	GLONASS
Number of Satellites ¹	31 operational	21 operational, 4 planned in 2011
Operated by	US Government	Russian Space Forces
Full Operational Capability (FOC)	Since 1995	Planned End of 2011 (earliest)
Orbits ²	6 planes, 55° inclination	3 planes, 64.8° inclination
Signal modulation & frequency type ³ <small>(for Standard Positioning Service)</small>	CDMA @1575.42 MHz (Code Division Multiple Access) 	FDMA @ 1602 MHz (Frequency Division Multiple Access) 
Orbits data, validity & correction (Ephemeris/Almanac)	modified Keplerian orbital elements Ionosphere correction Validity up to 4 h	Satellites position, velocity & acceleration No Ionosphere correction available Validity up to 1 h
Typical Positioning Accuracy ⁴	~ 2- 6 m worldwide	~ 5 - 9 m (>10 m outside Russia)

Table 1: Comparison of GLONASS and GPS

¹ 24 operational satellites required for worldwide coverage.

² Potential improvement of PDOP precision by 15 to 30 % of GPS + GLONASS (51 SV) vs. GPS only (32 SV) receiver.

³ In contrast to GPS, all GLONASS SVs transmit carrier signals at different L-band frequency => Different signal decoding architecture required.

⁴ (Russian source - Depends on location). Clock and orbit accuracy better with GPS solution (ionosphere correction available).

2.4 GLONASS FDMA signal structure

Each GLONASS satellite transmits at a unique frequency between 1598 – 1609 MHz, with a spacing between satellites of 562.5 kHz. The unique⁵ frequency allows the satellites to be identified.

In contrast, all GPS satellites transmit at the very same frequency (1575 MHz) and are identified by a unique gold code (CDMA).

2.5 GLONASS navigation message

Table 2 describes various aspects of the GLONASS navigation message and compares it with the GPS navigation message.

Parameter	GLONASS	GPS
Data rate	50 bps	50 bps
Ephemeris transmission	8 seconds	18 seconds
Ephemeris validity	30 minutes	Up to 4 hours
Complete almanac transmission	Within 2.5 minutes	12.5 minutes
Ionosphere correction	No	Yes

Table 2: GLONASS navigation message compared with GPS

2.6 GLONASS time and coordinate system

Table 3 describes elements of the GLONASS time and coordinate system and compares them with GPS.

Parameter	GLONASS	GPS
Reference time	MSK- Moscow Standard Time (UTC + 3)	GPS Time (UTC – leap seconds)
Coordinate system	PZ-90 (differs by approximately 0.4 m from WGS-84)	WGS-84

Table 3: GLONASS time and coordinate system

⁵ In fact, two satellites always use the same frequency but they are placed at opposite sides of the orbits such that only one is visible at any time. This allows for the identification of the satellite.

2.7 GPS and GLONASS signals

Figure 3 shows the frequencies of GPS/Galileo and GLONASS signals.

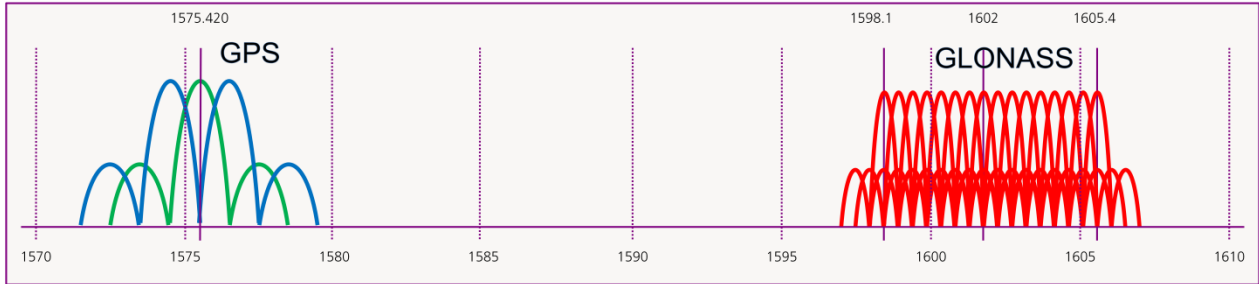


Figure 3: GPS/Galileo and GLONASS signals

The GPS/Galileo band is separated from the GLONASS band by 25MHz (!)

As seen in Figure 4, a typical GPS SAW filter blocks GLONASS signals. In comparison, a GPS & GLONASS SAW filter allows both GPS and GLONASS signals to pass through (see Figure 5).

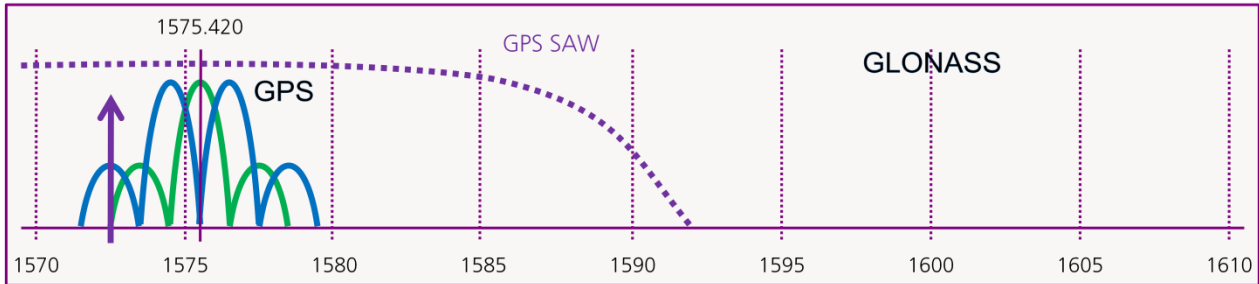


Figure 4: GPS SAW filter

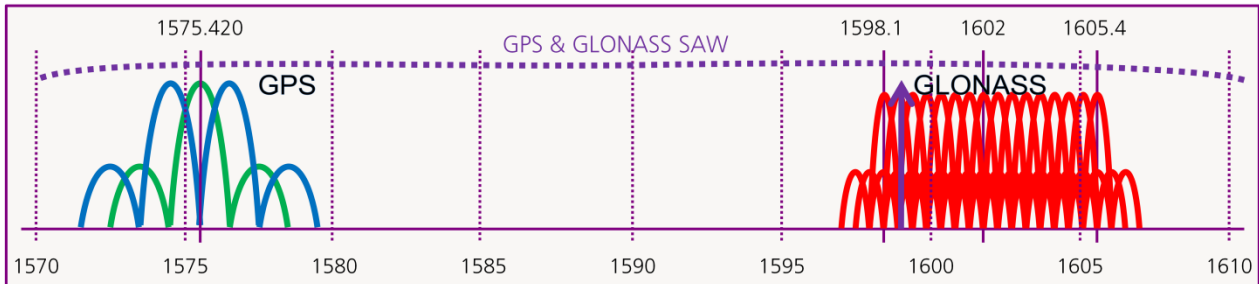


Figure 5: GPS & GLONASS SAW filter

3 GLONASS HW design recommendations

u-blox 6 designs for GLONASS require:

- u-blox 6 design with **Flash**
- **Wide RF path** (antenna, SAW) to allow GLONASS & GPS signals to pass (see Figure 6)

3.1 u-blox 6 design with Flash

u-blox will only provide a Flash GLONASS / GPS firmware image. For this reason it is absolutely necessary that the design includes a parallel Flash which can be updated when the GLONASS / GPS firmware is available.

3.2 Wide RF path

As seen in section 2.7, the GLONASS / GPS satellite signals are not at the same frequency. For this reason the RF path, LNA, filter, and antenna must be modified accordingly to let both signals pass.

3.2.1 Filter

- Use a GPS & GLONASS SAW filter (see Figure 6) that lets both GPS and GLONASS signals pass (see the recommended parts list in section 3.5)
- In case an active antenna is used, make sure the filter (if any) inside is wide enough.

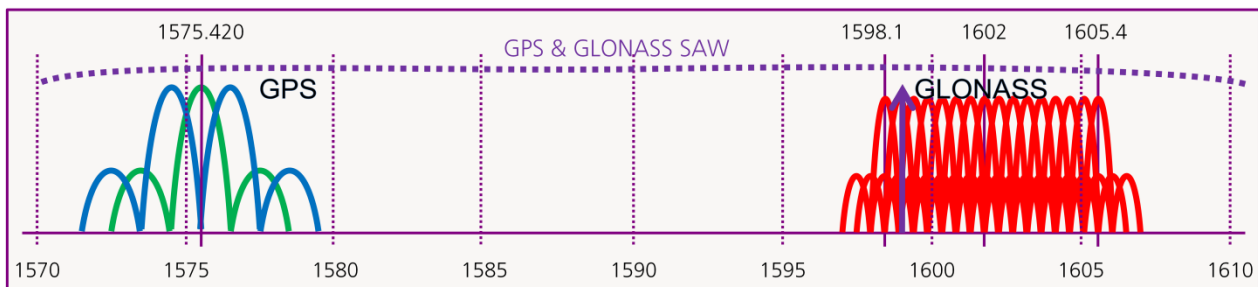


Figure 6: GPS & GLONASS SAW filter

3.2.2 Antenna

3.2.2.1 Active antenna

Usually an active GPS antenna includes a GPS band pass filter that filters out the GLONASS signal (see Figure 4). For this reason make sure that the filter in the active antenna is wide enough.

In combined GPS & GLONASS antennas, the antenna is tuned for receiving both signals and the filter has a larger bandwidth to provide optimal GPS & GLONASS signal reception (see Figure 6).

Use a good performance GPS & GLONASS active antenna (for recommended components see section 3.5.3)

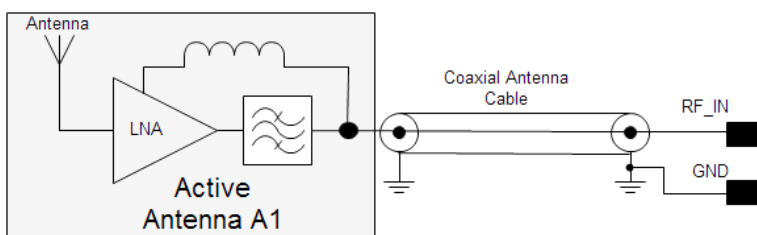


Figure 7: GPS & GLONASS active antenna

3.2.2.2 Passive Antenna

The bandwidth of a ceramic patch antenna narrows with size (see Table 4).

size	Typical bandwidth
36*36*4 mm	40 MHz
25*25*4 mm	20 MHz
18*18*4 mm	10 MHz
15*15*4 mm	8 MHz
12*12*4 mm	7 MHz
10*10*4 mm	5 MHz

Table 4: Typical bandwidths for GPS patch antennas

Figure 8 shows a 12*12*4 mm patch antenna with 20*20 mm ground plane, tuned to GPS. This patch bandwidth is so narrow that it cannot be simultaneously matched to GPS and GLONASS.

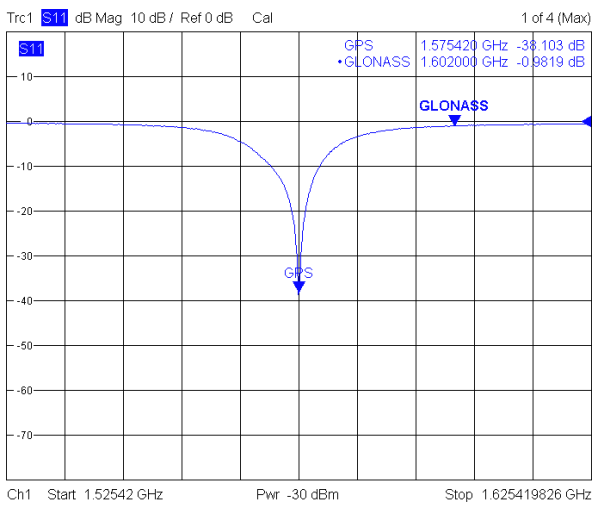


Figure 8: 12*12*4 patch antenna on 20*20 mm GND plane

Figure 9 shows a 25*25*4 mm patch antenna with 60*60 mm ground plane. Due to the larger bandwidth, it can be matched to GPS and GLONASS.

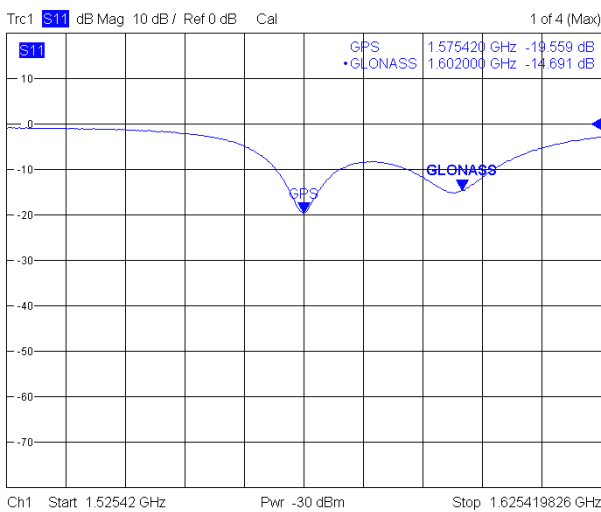


Figure 9: 25*25*4 mm patch antenna on 60*60 mm GND plane

Figure 10 show a 36*36*4 mm patch antenna. Due to the large bandwidth, the antenna is also tolerant with changes in the ground plane.

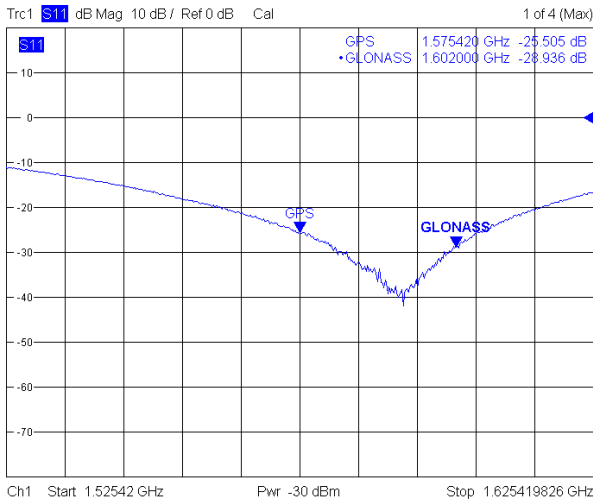


Figure 10 36*36*4 mm patch antenna

👉 Use at least a 25*25*4 mm patch antenna, better 36*36*4 mm patch antenna and tune it so that GPS & GLONASS signals are received.

3.3 Module designs

For GPS & GLONASS designs chose the LEA-6 GLONASS ready module, which has a wide RF path and includes an internal Flash.

3.3.1 Module design with active antenna

Figure 11 shows a GPS & GLONASS active antenna design with the LEA-6 GLONASS ready module.

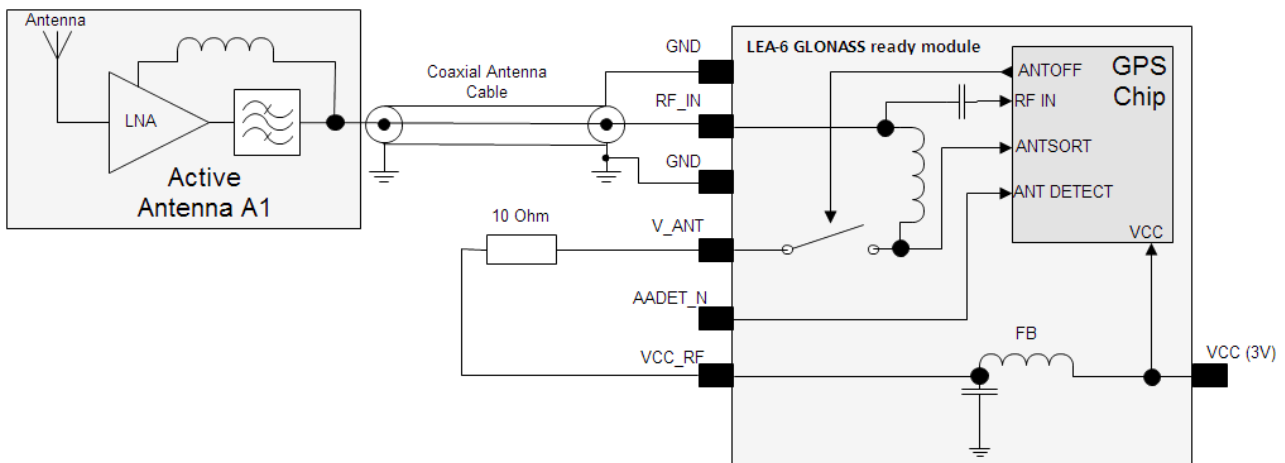


Figure 11: Module design with active antenna

👉 Use a good performance GPS & GLONASS active antenna (for recommended components see section 3.5.3).

3.3.2 Module design with passive antenna

Figure 12 shows a GPS & GLONASS passive antenna design with the LEA-6 GLONASS ready module. For best performance with passive antenna designs use an external LNA.

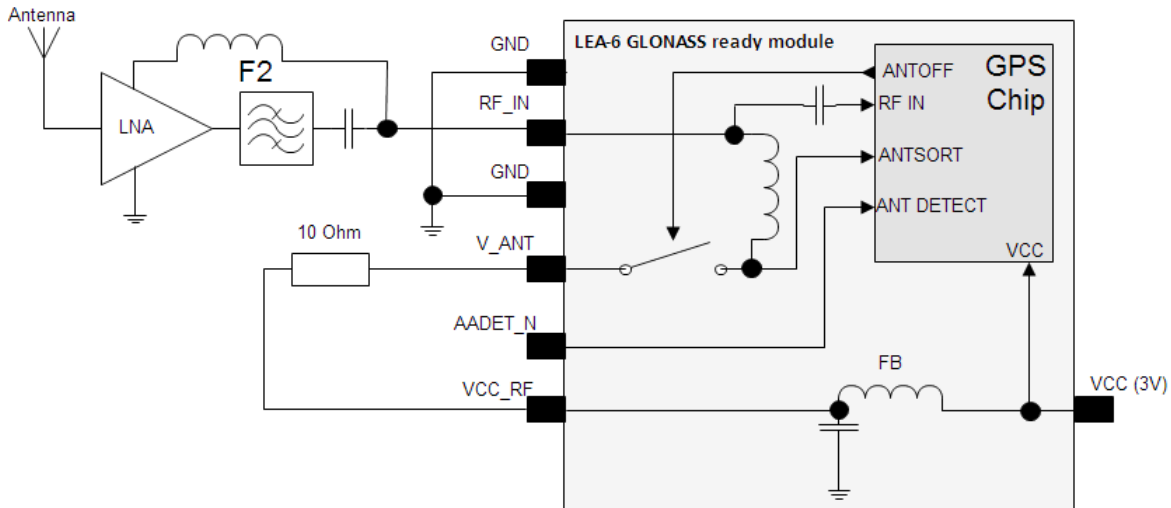


Figure 12: Module design with passive antenna

A standard GPS LNA has enough bandwidth to amplify GPS and GLONASS.

For recommended SAW Filters for GPS & GLONASS (Part F2 in Figure 12) see section 3.5.1

3.4 Chip designs

For GPS & GLONASS designs chose the UBX-G6000, UBX-G0010 chipset and parallel Flash.

- Antenna path needs to allow GPS & GLONASS signals to pass
- A SAW filter is needed, which lets GPS and GLONASS signals pass (see section 3.5.2)

3.4.1 Chipset design with active antenna

Figure 13 shows a GPS & GLONASS active antenna design with chipset.

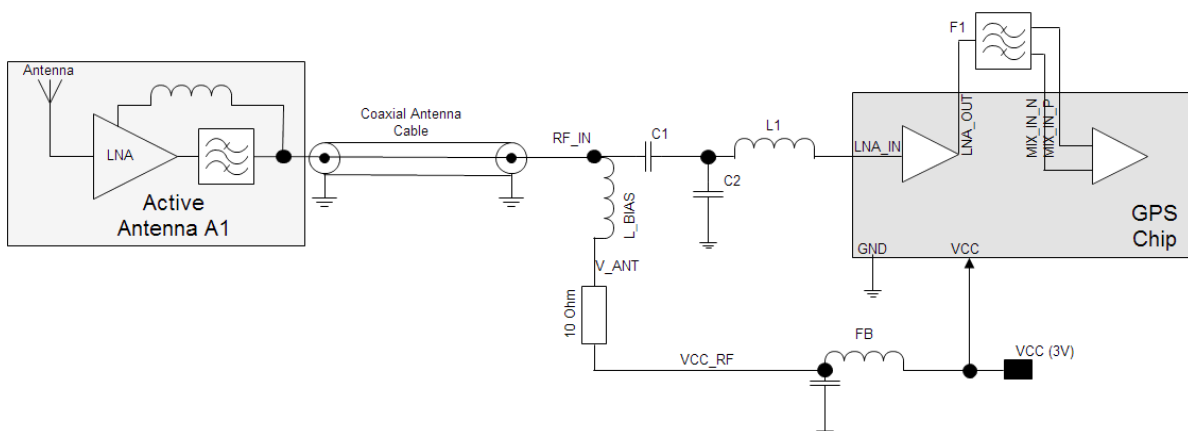


Figure 13: Chipset design with active antenna

For recommended GPS & GLONASS active antenna see section 3.5.3.

☞ For recommended RF bandpass SAW filter balanced type (50 Ω//100 Ω) for GPS/GLONASS (part F1 in Figure 13) see section 3.5.2

3.4.2 Chipset design with passive antenna

Figure 14 shows a GPS & GLONASS passive antenna design with chipset. For best performance with passive antenna designs use an external LNA.

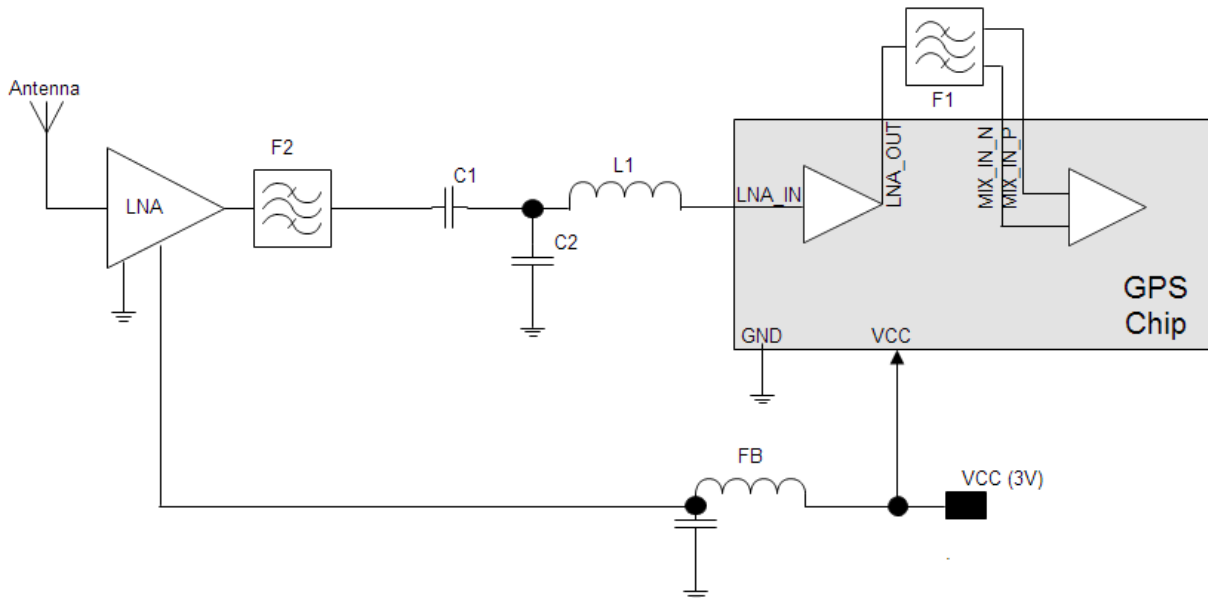


Figure 14: Chipset design with passive antenna

A standard GPS LNA has enough bandwidth to amplify GPS and GLONASS.

- ☞ For recommended GPS & GLONASS active antenna see section 3.5.3.
- ☞ For recommended SAW Filters for GPS & GLONASS (Part F2 in Figure 14) see section 3.5.1
- ☞ For recommended RF bandpass SAW filter balanced type (50 Ω//100 Ω) for GPS/GLONASS (part F1 in Figure 14) see section 3.5.2

3.5 Recommended parts

3.5.1 Recommended SAW Filters for GPS/GLONASS (F2)

Manufacturer	Order No.	Comments
muRata (www.murata.com)	SAFFB1G58KB0F0A	Low insertion loss
muRata (www.murata.com)	SAFFB1G58KA0F0A	High attenuation
muRata (www.murata.com)	SAFEA1G58KA0F00	High attenuation

Table 5: Recommend parts list for LNA protection filter (F2)

3.5.2 Recommended RF bandpass SAW filter balanced type (50 Ω//100 Ω) for GPS/GLONASS (F1)

Manufacturer	Order No.	Comments
muRata (www.murata.com)	SAFEA1G58FB0F00	pin compatible to SAFEB1G57FM0F00

Table 6: Recommend parts list for GPS/GLONASS SAW RF bandpass filter (F1)

3.5.3 Recommended GPS & GLONASS active antenna (A1)

Manufacturer	Order No.	Comments
Inpaq (www.inpaq.com.tw)	GPSGLONASS03D-S3-00-A	3 V 6 mA
Taoglas (www.taoglas.com)	AA.160.301111	36*36*4mm, 3-5V 30mA

Table 7: Recommend GPS & GLONASS active antenna (A1)

4 GLONASS SW integration

To activate Glonass system modes on u-blox GLONASS ready module or chip designs, the customer application will have to:

- Upgrade the (Flash) firmware once available.
- Send UBX proprietary commands for activating and switching to Glonass reception (SW command will be documented in the u-blox 6 Receiver Description including Protocol Specification [5]).

Related documents

- [1] LEA-6 Data Sheet, Docu. No GPS.G6-HW-09004
- [2] UBX-G6010, UBX-G6000/UBX-G0010 Data Sheet, Docu No GPS.G6-X-09004
- [3] LEA-6 / NEO-6 / MAX-6 Hardware Integration Manual, Docu. No GPS.G6-X-09007
- [4] UBX-G6010, UBX-G6000/UBX-G0010 Hardware Integration Manual, Docu. No GPS.G6-X-09006
- [5] u-blox 6 Receiver Description including Protocol Specification, Docu. No GPS.G6-SW-10018

Revision history

Revision	Date	Name	Status / Comments
-	May 24, 2011	jfur	Initial release
	June 16, 2011	jfur	added Taoglas 36x36x4 antenna

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