PAM-7Q
u-blox 7 GPS Antenna Module
Hardware Integration Manual

Abstract

This document provides the necessary information to successfully design in and configure the PAM-7Q u-blox 7 GPS antenna module featuring the u-blox 7 positioning engine. This module has the exceptional performance of the u-blox 7 receiver and delivers high sensitivity and minimal acquisition times.

Incorporating the PAM‑7Q into customer designs is simple and straightforward, thanks to the embedded antenna, low power consumption, simple interface, and sophisticated interference suppression that ensures maximum performance even in GPS-hostile environments.

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Document Information

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Document status explanation

Objective Specification	Document contains target values. Revised and supplementary data will be published later.
Advance Information	Document contains data based on early testing. Revised and supplementary data will be published later.
Early Production Information	Document contains data from product verification. Revised and supplementary data may be published later.
Production Information	Document contains the final product specification.

European Union regulatory compliance

PAM-7Q complies with all relevant requirements for RED 2014/53/EU. The PAM-7Q Declaration of Conformity (DoC) is available at www.u-blox.com within Support > Product resources > Conformity Declaration.

This document applies to the following products:

Product name	Type number	ROM/FLASH version	PCN reference
PAM-7Q	PAM-7Q-0-000	ROM1.00	N/A

Preface

u-blox Technical Documentation

As part of our commitment to customer support, u-blox maintains an extensive volume of technical documentation for our products. In addition to our product-specific technical data sheets, the following manuals are available to assist u-blox customers in product design and development.

- **GPS Compendium:** This document, also known as the GPS book, provides a wealth of information regarding generic questions about GPS system functionalities and technology.
- **Receiver Description including Protocol Specification:** This document describes messages, configuration and functionalities of the u-blox 7 software releases and receivers.
- **Hardware Integration Manuals:** These manuals provide hardware design instructions and information on how to set up production and final product tests.
- **Application Notes:** These documents provide general design instructions and information that applies to all u-blox GNSS positioning modules.

How to use this Manual

This manual has a modular structure. It is not necessary to read it from the beginning to the end.

The following symbols are used to highlight important information within the manual:

☞ An index finger points out key information pertaining to module integration and performance.

⚠ **A warning symbol indicates actions that could negatively influence or damage the module.**

Questions

If you have any questions about PAM-7Q Hardware Integration, please:

- Read this manual carefully.
- Contact our information service on the homepage http://www.u-blox.com
- Read the questions and answers on our FAQ database on the homepage http://www.u-blox.com

Technical Support

Worldwide Web

Our website (www.u-blox.com) is a rich pool of information. Product information, technical documents and helpful FAQ can be accessed 24h a day.

By E-mail

If you have technical problems or cannot find the required information in the provided documents, contact the closest Technical Support office. To ensure that we process your request as soon as possible, use our service pool email addresses rather than personal staff email addresses. Contact details are at the end of the document.

Helpful Information when Contacting Technical Support

When contacting Technical Support please have the following information ready:

- Receiver type (e.g. PAM-7Q-0-000), Datacode (e.g. 172100.0100.000) and firmware version (e.g. ROM1.00)
- Receiver configuration
- Clear description of your question or the problem together with a u-center logfile
- A short description of the application
- Your complete contact details

Contents

1 Quick reference

When using this manual for a design, make sure you also have the corresponding data sheet for the specific positioning module (see the Related documents section).

2 Hardware description

2.1 Overview

PAM-7Q module is standalone GPS positioning receiver featuring the high performance u-blox 7 positioning engine. They are easy to integrate and combine exceptional positioning performance with highly flexible power, design, and connectivity options.

☞ For product features see the PAM-7Q Data Sheet [1].

☞ To determine which u-blox product best meets your needs, see the product selector tables on the u-blox website (www.u-blox.com).

2.2 Architecture

PAM-7Q module consists of two functional parts - the RF block and the digital block (see Figure 1).

The RF block includes the input matching elements, the SAW band pass filter, the integrated LNA and the oscillator, while the digital block contains the u-blox 7 GNSS engine, the RTC crystal and additional elements such as the optional FLASH Memory for enhanced programmability and flexibility.
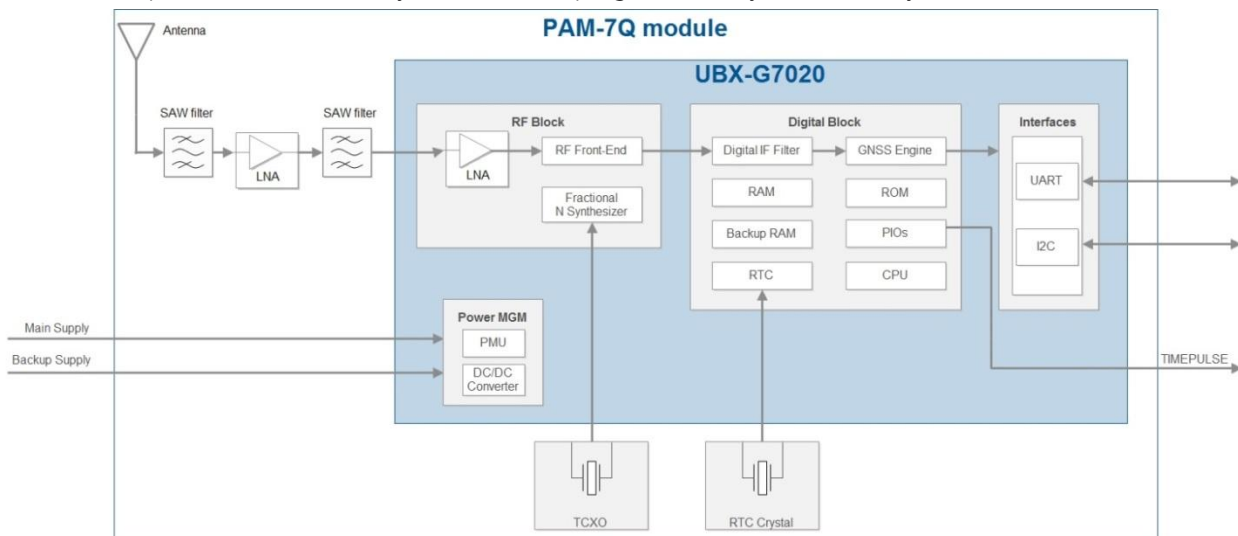
Figure 1: PAM-7Q block diagram

2.3 Operating modes

u-blox receivers support different power modes. These modes represent strategies of how to control the acquisition and tracking engines in order to achieve either the best possible performance or good performance with reduced power consumption.

2.3.1 Continuous Mode

During a cold start, a receiver in Continuous Mode continuously deploys the acquisition engine to search for all satellites. Once the receiver can calculate a position and track a sufficient number of satellites, the acquisition engine powers off, resulting in significant power savings. The tracking engine continuously tracks acquired

satellites and acquires other available or emerging satellites. Whenever the receiver can no longer calculate a position or the number of satellites tracked is below the sufficient number, the acquisition engine powers on again to guarantee a quick reacquisition. Even if the acquisition engine powers off, the tracking engine continues to acquire satellites.

☞ For best performance, use **continuous mode**.

2.3.2 Power Save Mode

Two Power Save Mode (**PSM**) operations called **ON/OFF** and **Cyclic tracking** are available. These use different ways to reduce the average current consumption in order to match the needs of the specific application. PSM operations are set and configured using serial commands. For more information, see the u-blox 7 Receiver Description Including Protocol Specification [2].

2.4 Configuration

The configuration settings can be modified using UBX protocol configuration messages. The modified settings remain effective until power-down or reset. If these settings have been stored in BBR (Battery Backed RAM), then the modified configuration will be retained, as long as the backup battery supply is not interrupted.
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2.4.1 Electrical Programmable Fuse (eFuse)

PAM-7Q includes an integrated eFuse memory for permanently saving configuration settings.
The eFuse memory can also be used to store the configuration. The customer can program the eFuse.

⚠ **eFuse is One-Time-Programmable; it cannot be changed if it has been programmed once.**

String to change the default Baud rate:

Baud Rate	String
UART Baud Rate 1200	B5 62 06 41 09 00 01 01 30 81 00 00 00 00 FE 01 22
UART Baud Rate 2400	B5 62 06 41 09 00 01 01 30 81 00 00 00 00 FD 00 21
UART Baud Rate 4800	B5 62 06 41 09 00 01 01 30 81 00 00 00 00 FC FF 20
UART Baud Rate 19200	B5 62 06 41 09 00 01 01 30 81 00 00 00 00 FB FE 1F
UART Baud Rate 38400	B5 62 06 41 09 00 01 01 30 81 00 00 00 00 FA FD 1E
UART Baud Rate 57600	B5 62 06 41 09 00 01 01 30 81 00 00 00 00 F9 FC 1D
UART Baud Rate 115200	B5 62 06 41 09 00 01 01 30 81 00 00 00 00 F8 FB 1C

Table 1: Strings to change baud rate

2.5 Connecting power

The PAM-7Q positioning module has two power supply pins: **VCC** and **V_BCKP**.

2.5.1 VCC: Main Supply Voltage

The **VCC** pin provides the main supply voltage. During operation, the current drawn by the module can vary by some orders of magnitude, especially if enabling low-power operation modes. For this reason, it is important that the supply circuitry be able to support the peak power (see datasheet for specification) for a short time.

PAM-7Q module integrates a DC/DC converter. This allows reduced power consumption, especially when using a main supply voltage above 2.5 V.

☞ When switching from backup mode to normal operation or at start-up, PAM-7Q module must charge the internal capacitors in the core domain. In certain situations, this can result in a significant current draw. For low power applications using Power Save and backup modes, it is important that the power supply or low ESR capacitors at the module input can deliver this current.

2.5.2 V_BCKP: Backup Supply Voltage

If the module supply has a power failure, then **V_BCKP** will supply the real-time clock (RTC) and battery backed RAM (BBR). Use of valid time and the GNSS orbit data at start-up will improve the GNSS performance, as with hot starts, warm starts, AssistNow Autonomous and AssistNow Offline. If no backup battery is connected, the module performs a cold start at power up.

☞ Avoid high resistance on the V_BCKP line: During the switch from main supply to backup supply, a short current adjustment peak can cause high voltage drop on the pin with possible malfunctions.

☞ As long as the PAM-7Q module is supplied to **VCC**, the backup battery is disconnected from the RTC and the BBR to avoid unnecessary battery drain (see Figure 2). In this case, **VCC** supplies power to the RTC and BBR.
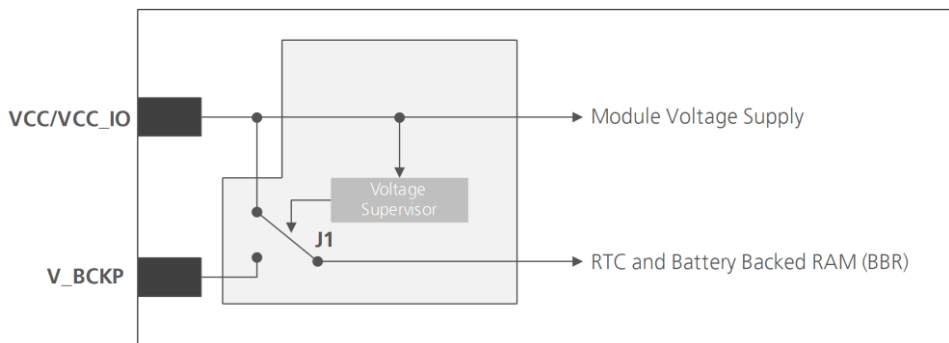

Figure 2: Backup battery and voltage (for exact pin orientation, see data sheet)

2.6 Interfaces

2.6.1 UART

PAM-7Q positioning module includes a Universal Asynchronous Receiver Transmitter (UART) serial interface **RxD/TxD** supporting configurable baud rates. The baud rates supported are specified in the u-blox 7 Receiver Description Including Protocol Specification [2].

The signal output and input levels are 0 V to VCC. An interface based on RS232 standard levels (+/- 12 V) can be implemented using level shifters such as Maxim MAX3232. Hardware handshake signals and synchronous operation are not supported.

2.6.2 Display Data Channel (DDC)

An I^{2}C compatible Display Data Channel (DDC) interface is available for serial communication with an external host CPU. The interface only supports operation in slave mode (master mode is not supported). The DDC protocol and electrical interface are fully compatible with the Fast-Mode of the I^{2}C industry standard. DDC pins **SDA** and **SCL** have internal pull-up resistors.

For more information about the DDC implementation, see the u-blox 7 Receiver Description Including Protocol Specification [2]. For bandwidth information, see the Data Sheet. For timing, parameters consult the I ^{2}C-bus specification [7].

☞ The u-blox 7 DDC interface supports serial communication with u-blox cellular modules. See the specification of the applicable cellular module to confirm compatibility.

☞ With u-blox 7, when reading the DDC internal register at address 0xFF (messages transmit buffer), the master must not set the reading address before every byte is accessed, as this could cause faulty behavior.

After every byte is read from register 0xFF, the internal address counter is incremented by one, saturating at 0xFF. Therefore, subsequent reads can be performed continuously.

2.7 I/O pins

2.7.1 TIMEPULSE

A configurable time pulse signal is available with the PAM-7Q module. By default, the time pulse signal is configured to 1 pulse per second. For more information see the u-blox 7 Receiver Description including Protocol Specification [2].

3 Design

3.1 Design checklist

Designing-in a PAM-7Q module is easy, especially when based on a u-blox reference design. This section lists the most important items for a simple design check. The design checklist can also help to avoid an unnecessary PCB respin and achieve the best possible performance. Follow the design checklists when developing PAM-7Q GPS applications. This can significantly reduce development time and costs.

3.1.1 Schematic checklist

Power supply requirements

❑	GNSS positioning modules require a stable power supply. In selecting a strategy to achieve a clean and stable power supply, any resistance in the VCC supply line can negatively influence performance. Consider the following points:

   o	Wide power lines or even power planes are preferred.

   o	Avoid resistive components in the power line (e.g. narrow power lines, coils, resistors, etc.).

   o	Placing a filter or other source of resistance at VCC can create significantly longer acquisition times.

❑	Is the power supply (VCC) within the specified range? (see the PAM-7Q Data Sheet [1])

❑	Compare the peak supply current consumption of your PAM-7Q module with the specification of the power supply. (See the PAM-7Q Data Sheet [1] for more information.)

❑	At the module input, use low ESR capacitors that can deliver the required current/charge for switching from backup mode to normal operation.

Backup battery

❑	Use of valid time and the GNSS orbit data at startup will improve the GNSS performance i.e. enables hot starts, warm starts and the AssistNow Autonomous process as well as AssistNow Offline. To make use of these features connect a battery to V_BCKP to continue supplying the backup domain in case of power failure at VCC.

☞	 If no backup supply voltage is available, connect the **V_BCKP** pin to **VCC**).

3.1.2 Layout checklist

☞   See section 3.3.

❑   Is the GNSS module located according to the recommendation?
❑   Has the grounding concept been followed?
❑   Add a ground plane underneath the GNSS module to reduce interference.
❑   For improved shielding, add as many vias as possible around the serial communication lines, underneath the GNSS module etc.
❑   Have appropriate EOS/ESD/EMI protection measures been included? This is especially important for designs including cellular modules.

3.1.3 Antenna checklist

❑   Make sure the antenna is not placed close to noisy parts of the circuitry. (E.g. micro-controller, display, etc.)

3.2 Design considerations for minimal designs

For a minimal design with a PAM-7Q GPS module, the following functions and pins need consideration:

• Connect the Power supply to **VCC**.

• Assure an optimal ground connection to all ground pins of the module.

• Choose the required serial communication interface (UART or DDC) and connect the appropriate pins to your application.

• If you need improved start-up or use AssistNow Autonomous in your application, connect a backup supply voltage to **V_BCKP**.

3.2.1 Minimal design

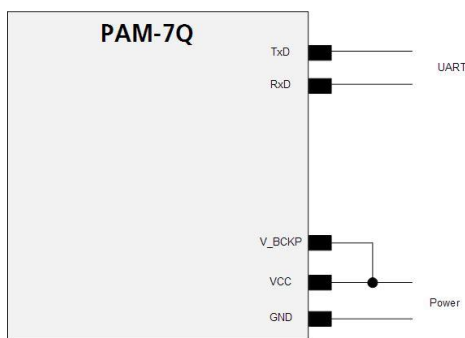This is a minimal setup for a GNSS receiver with a PAM-7Q module:

Figure 3: PAM-7Q passive antenna design

Function	PIN	No	I/O	Description	Remarks
Power	**VCC**	4	I	Supply Voltage	Provide clean and stable supply.
	GND	3	I	Ground	Assure a good **GND** connection to **GND** pin of the module, preferably with a large ground plane.
	V_BCKP	5	I	Backup Supply Voltage	It is recommended to connect a backup supply voltage to **V_BCKP** in order to enable warm and hot start features on the positioning modules. Otherwise, connect to **VCC**.
UART	**TxD**	2	O	Serial Port	Communication interface
	RxD	1	I	Serial	Serial input. Internal pull-up resistor to VCC. Leave open if not used.
System	**TIMEPULSE**	6	O	Time pulse Signal	Configurable Time pulse signal (one pulse per second by default). Leave open if not used.
	SDA	7	I/O	DDC Data	DDC Data
	SCL	8	I	DDC Clock	DDC Clock.

Table 2: Pinout PAM-7Q

3.3 Layout

This section provides important information for designing a robust GNSS system.

GNSS signals at the surface of the Earth are about 15 dB below the thermal noise floor. When defining a GNSS receiver layout, the placement of the PAM-7Q, as well as grounding, shielding and jamming from other digital devices, are crucial issues requiring careful consideration.

3.3.1 PCB mounting

The PAM-7Q can be mounted on a customer PCB ("motherboard" in the instructions below) by using standard 2.54 mm pitch 1x8 pin header (for example Samtec TLW-108-06-G-S). Two dummy pads are used to solder the module metal shield on the motherboard. Reference pad layout is shown in Figure 4.
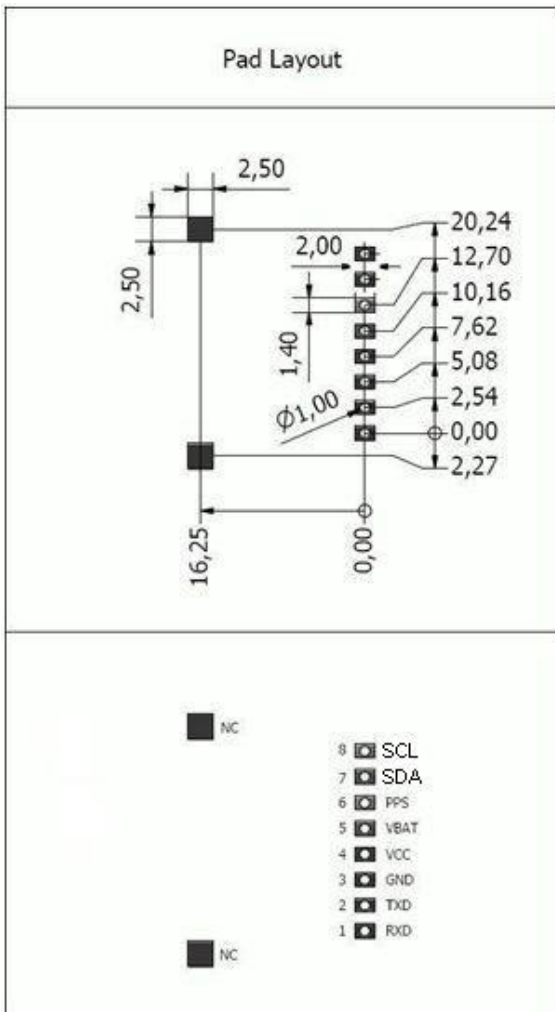
Figure 4: Pad layout of mounting side for PAM-7Q module.

There are some rules that need to be followed in order to maintain good performance for the on-board patch antenna of the PAM-7Q:

- Solder the pin header to the module in such way that the pins are as short as possible on the antenna side of the PAM-7Q module (see Figure 5).
- Place any active circuitry (processors, memory busses, switching regulators, etc.) on the motherboard as far away as possible from the PAM-7Q module.
- Design a solid VDD source for the PAM-7Q module (VDD supply voltage ripple should be <50 mVp-p).
- If there is no need for the PPS and DDC signal, a 4-pin header (for example Samtec TLW-104-06-G-S) can be used to contact pins #1 through #4. However, the 8-pin header is recommended since it is mechanically more robust. In this case, pins #5 to #8 may be left floating on the motherboard.
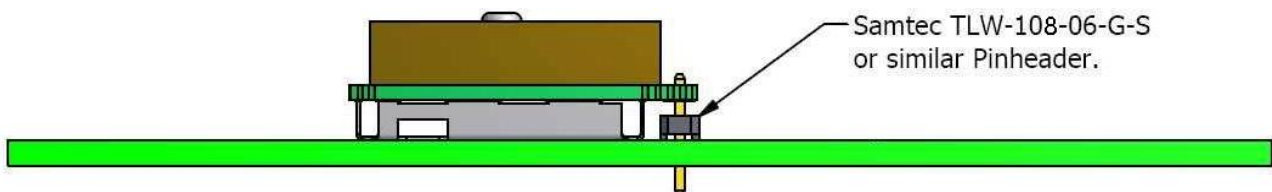

Figure 5: Side view of the pin header assembly for the PAM-7Q module.

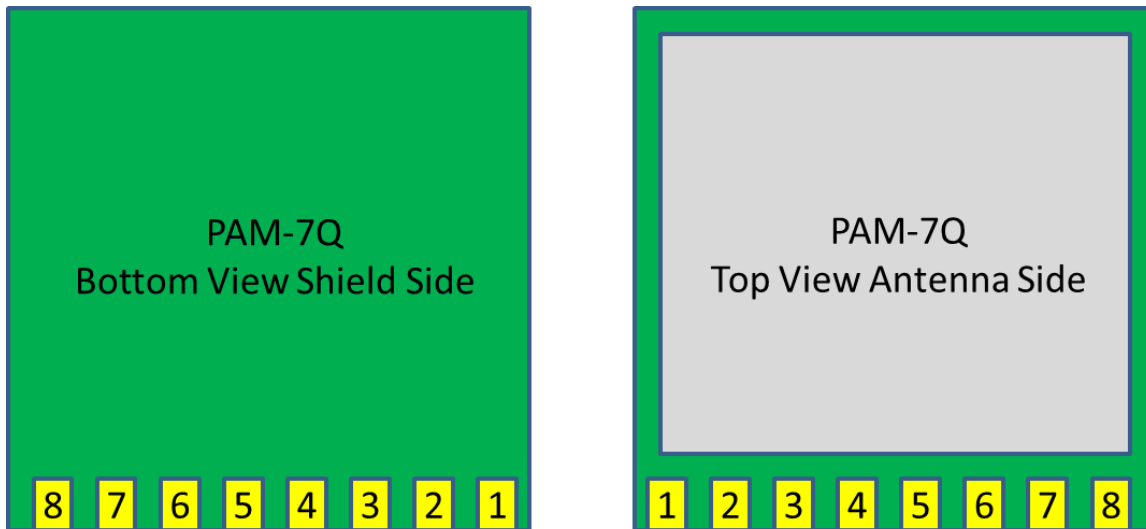Figure 6 describes the footprint for PAM-7Q module.

Figure 6: PAM-7Q footprint

3.3.2 Placement

A very important factor in achieving maximum performance is the placement of the receiver on the PCB. Make sure that the PAM-7Q is separated from any other digital circuits on the system board. To achieve this, position the module's digital part towards the digital section on the system PCB. Exercise care if placing the receiver in proximity to heat-emitting circuitry. The RF part of the receiver is very sensitive to temperature, and sudden changes can have an adverse impact on performance.

⚠️ **The RF part of the receiver is a temperature sensitive component. Avoid high temperature drift and air vents near the receiver.**

4 Migration to PAM-7Q module

4.1 Hardware migration

The PAM-7Q is form-factor compatible with the UP501.

Pin	Fastrax UP501	PAM-7Q
1	RXD	RxD
2	TXD	TxD
3	GND	GND
4	VDD 3.0 to 4.2 V	VCC 2.7 to 3.6 V
5	VDD_B 2.0 to 4.2 V	V_BCKP 1.4 to 3.6 V
6	PPS	TIMEPULSE
7	-	SDA
8	-	SCL

Table 3: Pins for UP501 to PAM-7Q migration

4.2 Software migration

Fastrax UP501 is based on MTK chipset, while PAM-7Q has u-blox 7 GNSS engine. For functionality aspects, protocol porting, and software interface considerations when migrating from the Fastrax UP501 to the u-blox PAM-7Q, see the NMEA manual for Fastrax IT500 Series GPS/GNSS receivers [6] and the u-blox 7 Receiver Description including Protocol Specification [2].

5 Product handling

5.1 Packaging, shipping and storage

For information pertaining to reels and tapes, shipment and storage information, as well as drying for preconditioning, see the specific PAM-7Q Data Sheet [1].

5.2 Soldering

5.2.1 Hand soldering

Use a soldering iron temperature setting equivalent to 350 °C.

5.2.2 Optical inspection

After soldering the PAM-7Q module, consider an optical inspection step to check whether:

• The module is properly aligned

• All pads are properly soldered

• No excess solder has created contacts to neighboring pads, or possibly to pad stacks and vias nearby

5.2.3 Cleaning

In general, cleaning the populated modules is strongly discouraged. Residues underneath the modules cannot be easily removed with a washing process.

• Cleaning with water will lead to capillary effects where water is absorbed in the gap between the baseboard and the module. The combination of residues of soldering flux and encapsulated water leads to short circuits or resistor-like interconnections between neighboring pads.

• Cleaning with alcohol or other organic solvents can result in soldering flux residues flooding into the two housings, areas that are not accessible for post-wash inspections. The solvent will also damage the sticker and the ink-jet printed text.

• Ultrasonic cleaning will permanently damage the module, in particular the quartz oscillators.

The best approach is to use a "no clean" soldering paste and eliminate the cleaning step after the soldering.

5.2.4 Rework

The PAM-7Q module can be unsoldered from the baseboard using a hot air gun or a soldering iron. Use a wide iron tip to unsolder all the pins at the same time. In general, we do not recommend using a hot air gun because this is an uncontrolled process and might damage the module.

⚠️ **Attention: use of a hot air gun can lead to overheating and severely damage the module. Always avoid overheating the module.**

After the module is removed, clean the pads before placing and hand soldering a new module.

⚠️ **Never attempt a rework on the module itself, e.g. replacing individual components. Such actions immediately terminate the warranty.**

In addition, manual rework on particular pins by using a soldering iron is allowed. Manual rework steps on the module can be done several times.

5.2.5 Conformal coating

Certain applications employ a conformal coating of the PCB using HumiSeal® or other related coating products. These materials affect the HF properties of the GNSS module, and it is important to prevent them from flowing into the module. The RF shields do not provide 100% protection for the module from coating liquids with low viscosity; therefore, care is required in applying the coating.

☞ Conformal Coating of the module will void the warranty.

5.2.6 Casting

Casting is not allowed. The OEM is strongly advised to qualify such processes in combination with the PAM-7Q module before implementing this in the production.

☞ Antenna element of PAM-7Q must have free space at least 1mm for any plastic case or radome.

5.2.7 Grounding metal covers

Attempts to improve grounding by soldering ground cables, wick or other forms of metal strips directly onto the EMI covers is done at the customer's own risk. The numerous ground pins should be sufficient to provide optimum immunity to interferences and noise.

☞ u-blox makes no warranty for damages to the PAM-7Q module caused by soldering metal cables or any other forms of metal strips directly onto the EMI covers.

5.2.8 Use of ultrasonic processes

Some components on the PAM-7Q module are sensitive to Ultrasonic Waves. Use of any Ultrasonic Processes (cleaning, welding etc.) may cause damage to the GNSS Receiver.

☞ u-blox offers no warranty against damages to the PAM-7Q module caused by any Ultrasonic Processes.

5.3 EOS/ESD/EMI precautions

When integrating GNSS positioning modules into wireless systems, careful consideration must be given to electromagnetic and voltage susceptibility issues. Wireless systems include components, which can produce Electrical Overstress (EOS) and Electro-Magnetic Interference (EMI). CMOS devices are more sensitive to such influences because their failure mechanism is defined by the applied voltage, whereas bipolar semiconductors are more susceptible to thermal overstress. The following design guidelines are provided to help in designing robust yet cost effective solutions.

⚠ **To avoid overstress damage during production or in the field it is essential to observe strict EOS/ESD/EMI handling and protection measures.**

⚠ **To prevent overstress damage at the RF_IN of your receiver, never exceed the maximum input power (see the *PAM-7Q Data Sheet* [1]).**

5.3.1 Electrostatic discharge (ESD)

Electrostatic discharge (ESD) is the sudden and momentary electric current that flows between two objects at different electrical potentials caused by direct contact or induced by an electrostatic field. The term is usually used in the electronics and other industries to describe momentary unwanted currents that may cause damage to electronic equipment.

5.3.2 ESD handling precautions

ESD prevention is based on establishing an Electrostatic Protective Area (EPA). The EPA can be a small working station or a large manufacturing area. The main principle of an EPA is that there are no highly charging materials near ESD sensitive electronics, all conductive materials are grounded, workers are grounded, and charge build-up on ESD sensitive electronics is prevented. International standards are used to define typical EPA and can be obtained for example from International Electrotechnical Commission (IEC) or American National Standards Institute (ANSI).

GNSS positioning modules are sensitive to ESD and require special precautions when handling. Particular care must be exercised when handling patch antennas, due to the risk of electrostatic charges. In addition to standard ESD safety practices, the following measures should be taken into account whenever handling the receiver.

- Unless there is a galvanic coupling between the local GND (i.e. the work table) and the PCB GND, then the first point of contact when handling the PCB must always be between the local GND and PCB GND.
- Before mounting an antenna patch, connect ground of the device

- When handling the RF pin, do not come into contact with any charged capacitors and be careful when contacting materials that can develop charges (e.g. patch antenna ~10 pF, coax cable ~50 - 80 pF/m, soldering iron, …)

- To prevent electrostatic discharge through the RF input, do not touch any exposed antenna area. If there is any risk that such exposed antenna area is touched in non ESD protected work area, implement proper ESD protection measures in the design.

- When soldering RF connectors and patch antennas to the receiver's RF pin, make sure to use an ESD safe soldering iron (tip).

⚠ **Failure to observe these precautions can result in severe damage to the GNSS module!**

5.3.3 ESD protection measures

⚠ **GNSS positioning modules are sensitive to Electrostatic Discharge (ESD). Special precautions are required when handling.**

5.3.4 Electromagnetic interference (EMI)

Electromagnetic interference (EMI) is the addition or coupling of energy originating from any RF emitting device. This can cause a spontaneous reset of the GNSS receiver or result in unstable performance. Any unshielded line or segment (>3mm) connected to the GNSS receiver can effectively act as antenna and lead to EMI disturbances or damage.

The following elements are critical regarding EMI:

- Unshielded connectors (e.g. pin rows etc.)
- Weakly shielded lines on PCB (e.g. on top or bottom layer and especially at the border of a PCB)
- Weak GND concept (e.g. small and/or long ground line connections)

EMI protection measures are recommended when RF emitting devices are near the GNSS receiver. To minimize the effect of EMI a robust grounding concept is essential. To achieve electromagnetic robustness follow the standard EMI suppression techniques.

http://www.murata.com/products/emc/knowhow/index.html

http://www.murata.com/products/emc/knowhow/pdf/4to5e.pdf

Improved EMI protection can be achieved by inserting a resistor (e.g. R>20 Ω) or better yet a ferrite bead (BLM15HD102SN1) or an inductor (LQG15HS47NJ02) into any unshielded PCB lines connected to the GNSS receiver. Place the resistor as close as possible to the GNSS receiver pin.

Example of EMI protection measures on the RX/TX line using a ferrite bead:
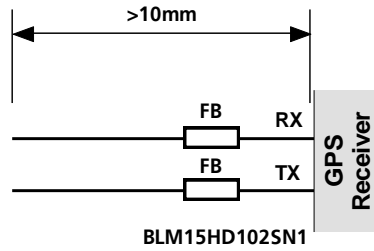
Figure 7: EMI Precautions

VCC can be protected using a feed thru capacitor.

Intended use

☞   In order to mitigate any performance degradation of a radio equipment under EMC disturbance, system integration shall adopt appropriate EMC design practice and not contain cables over three meters on signal and supply ports.

5.3.5 Applications with cellular modules

GSM uses power levels up to 2 W (+33 dBm). Consult the Data Sheet for the absolute maximum power input at the GNSS receiver.

5.3.5.1 Isolation between GPS and GSM antenna

In a handheld type design, an isolation of approximately 20 dB can be reached with careful placement of the antennas relative to the GPS receiver.
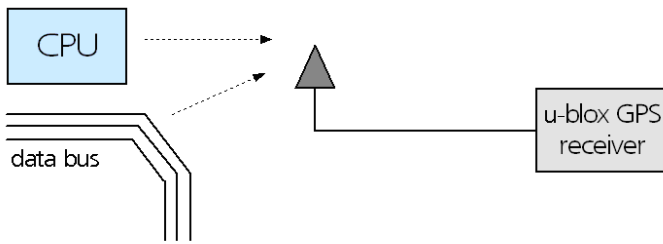
5.3.5.2 Increasing jamming immunity

Jamming signals come from in-band and out-band frequency sources.

5.3.5.3 In-band jamming

With in-band jamming the signal frequency is very close to the GPS frequency of 1575 MHz (see Figure 8). Such jamming signals are typically caused by harmonics from displays, micro-controller, bus systems, etc.
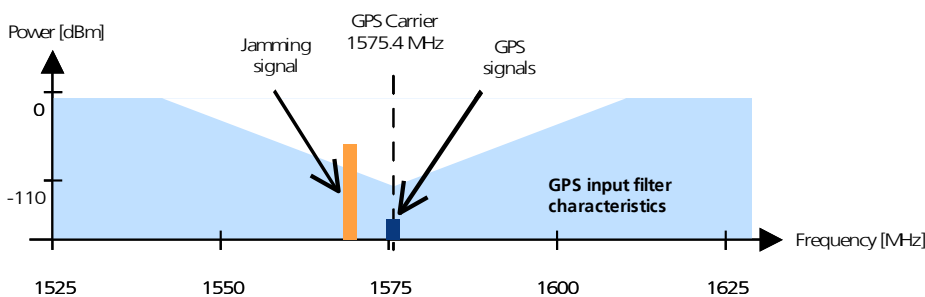
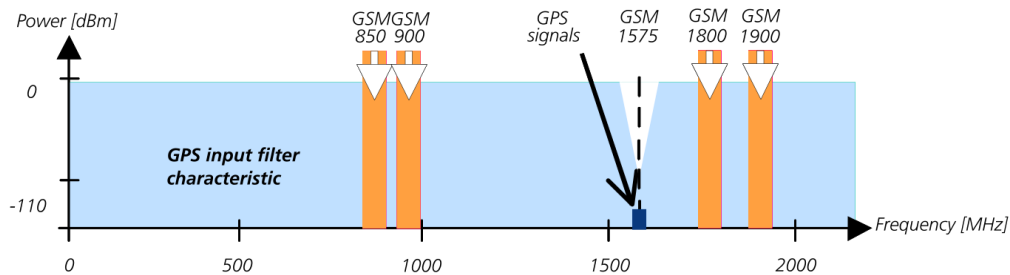**Figure 8: In-band jamming signals**

Figure 9: In-band jamming sources

Measures against in-band jamming include:

- Maintaining a good grounding concept in the design
- Shielding
- Layout optimization
- Filtering
- Placement of the GPS antenna

5.3.5.4 Out-band jamming

Out-band jamming is caused by signal frequencies that are different from the GPS carrier (see Figure 10). The main sources are wireless communication systems such as GSM, CDMA, WCDMA, Wi-Fi, BT, etc.

Figure 10: Out-band jamming signals

Measures against out-band jamming include maintaining a good grounding concept in the design.

☞ For design-in recommendations in combination to Cellular operation see Appendix (Appendix A.1).

☞ See the GPS Implementation and Aiding Features in u-blox wireless modules [5].

6 Product testing

6.1 u-blox in-series production test

u-blox focuses on high quality for its products. To achieve a high standard it is our philosophy to supply fully tested units. Therefore, at the end of the production process, every unit is tested. Defective units are analyzed in detail to improve the production quality.

This is achieved with automatic test equipment, which delivers a detailed test report for each unit. The following measurements are done:

- Digital self-test (Software Download, verification of FLASH firmware, etc.)
- Measurement of voltages and currents
- Measurement of RF characteristics (e.g. C/No)
- Traceability down to component level
- X-Ray and Automated Optical Inspection (AOI)
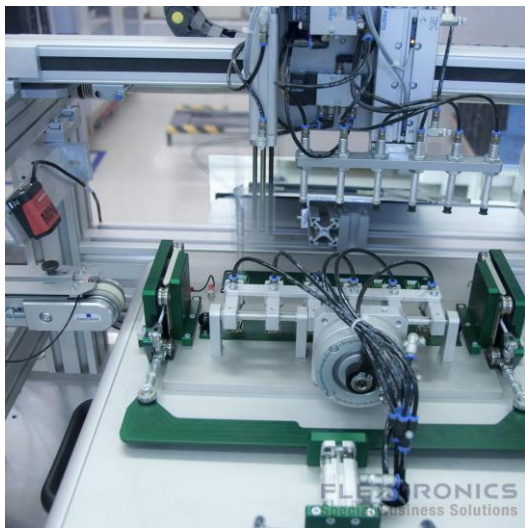- Ongoing Reliability Tests

Figure 11: Automatic Test Equipment for Module Tests

Figure 12: X-Ray Inspection

6.2 Test parameters for OEM manufacturer

Because of the testing done by u-blox (with 100% coverage), it is obvious that an OEM manufacturer does not need to repeat firmware tests or measurements of the GNSS parameters/characteristics (e.g. TTFF) in their production test.

An OEM manufacturer should focus on:

- Overall sensitivity of the device (including antenna, if applicable)
- Communication to a host controller

6.3 System sensitivity test

The best way to test the sensitivity of a GNSS device is with the use of a 1-channel GNSS simulator. It assures reliable and constant signals at every measurement.

Figure 13: 1-channel GNSS simulator

u-blox recommends the following Single-Channel GNSS Simulator:

- Spirent GSS6100 (GPS)
- Spirent GSS6300 (GPS/GLONASS)
  Spirent Communications Positioning Technology   www.spirent.com

6.3.1 Guidelines for sensitivity tests

1. Connect a 1-channel GNSS simulator to the OEM product via an antenna.

2. Choose the power level in a way that the "Golden Device" would report a C/No ratio of 38-40 dBHz

3. Power up the DUT (Device Under Test) and allow enough time for the acquisition

4. Read the C/No value from the NMEA GSV or the UBX-NAV-SVINFO message (e.g. with u-center)

5. Compare the results to a "Golden Device" or a PAM-7Q Evaluation Kit.

6.3.2 'Go/No go' tests for integrated devices

The best test is to bring the device to an outdoor position **with excellent sky view** (HDOP < 3.0). Let the receiver acquire satellites and compare the signal strength with a "Golden Device".

☞ As the electro-magnetic field of a redistribution antenna is not homogenous, indoor tests are in most cases not reliable. These kind of tests may be useful as a 'go/no go' test but not for sensitivity measurements.

Appendix

A Abbreviations

Abbreviation	Definition
ANSI	American National Standards Institute
CDMA	Code Division Multiple Access
EMC	Electromagnetic compatibility
EMI	Electromagnetic interference
EOS	Electrical Overstress
EPA	Electrostatic Protective Area
ESD	Electrostatic discharge
GLONASS	Russian satellite system
GND	Ground
GNSS	Global Navigation Satellite System (general term for any system, GPS, GLONASS, etc.)
GPS	Global Positioning System
GSM	Global System for Mobile Communications
IEC	International Electrotechnical Commission
PCB	Printed circuit board
QZSS	Quasi-Zenith Satellite System

Table 4: Explanation of abbreviations used

A.1 Design-in recommendations in combination with cellular operation

Product		Receiver Chain					Cellular and GNSS Simultaneous operation			
							Passive GNSS Antenna		Active GNSS Antenna	
Family	Variant	Antenna	SAW LNA	SAW	On-chip LNA	SAW	2G cellular	3G/4G cellular	2G/3G/4G cellular	
MAX-6	Any				•	•	✓		✓	✓
NEO-6	Any				•	•	✓		✓	✓
LEA-6	Any				•	•	✓		✓	✓
EVA-7	M				•		✓		✓	✓
MAX-7	C				•		✓		✓	✓
MAX-7	W				•		✓		✓	✓
MAX-7	Q				•		✓		✓	✓
NEO-7	N		•		•		✓	✓	✓	✓
NEO-7	M				•		✓		✓	✓
NEO-7	P			•	•		✓	✓	✓	✓
PAM-7	Q	•	•	•	•		✓	✓	✓	✓

<center>• = integrated   ✓ = optimal performance</center>

Table 5: Combinations of u-blox GNSS modules with different cellular technologies (2G/3G/4G).

☞ See the GPS Implementation and Aiding Features in u-blox wireless modules [5].

Related documents

[1]   PAM-7Q Data Sheet, Docu. No UBX-13002455

[2]   u-blox 7 Receiver Description including Protocol Specification, Docu. No GPS.G7-SW-12001

[3]   u-blox 7 Firmware Version 1.0 Release Note, Docu. No GPS.G7-SW-12003

[4]   GPS Compendium, Doc No GPS-X-02007

[5]   GPS Implementation and Aiding Features in u-blox wireless modules, Doc No GSM.G1-CS-09007

[6]   NMEA manual for Fastrax IT500 Series GPS/GNSS receivers, Docu. No UBX-13003181

[7] I^2C-bus specification, Rev. 5, Oct 2012, http://www.nxp.com/documents/other/UM10204_v5.pdf

☞   For regular updates to u-blox documentation and to receive product change notifications please register on our homepage (http://www.u-blox.com)

Revision history

Revision	Date	Name	Status / Comments
R01	07-Nov-2013	jfur	Objective Specification
R02	23-Jan-2014	jfur	Advance Information. Updated product picture (patch antenna side) in cover page. Updated section 5.2 Soldering.
R03	05-Mar-2014	jfur	Early Production Information
R04	12-May-2014	jfur	**Added** **• = integrated** ✓ **= optimal performance** Table 5: Blocking dependence on different cellular technology (2G/3G/4G).
R05	05-Dec-2014	jfur	Removed section wave soldering and ground plane related contents.
R06	06-Oct-2017	msul	Added information on RED DoC in European Union regulatory compliance (page 2), added Intended use statement in section 5.3.4 Electromagnetic interference (EMI), updated legal statement in cover page and added Documentation feedback e-mail address in contacts page.

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