Q20 High Sensitivity GPS Integration Board

Specification

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Administration page

Record of changes		
Issue	Date	Detail of Changes
A	20th December 2007	First Draft
1	21st December 2007	First Release
1A	9th January 2008	Correction to battery backup link reference

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1 Introduction

Thank you for your interest in the QinetiQ Q20 High Sensitivity Integration Board. The Q20 represents the state of the art in GPS receiver technology. The Q20's high sensitivity enables GPS positioning in locations where other receivers fail to operate and therefore brings the benefits of GPS to a host of new applications.

This document describes the features and specifications of the QinetiQ Q20 High Sensitivity Integration Board, a high-sensitivity, low power, OEM GPS receiver board designed for rapid development and integration with other systems.

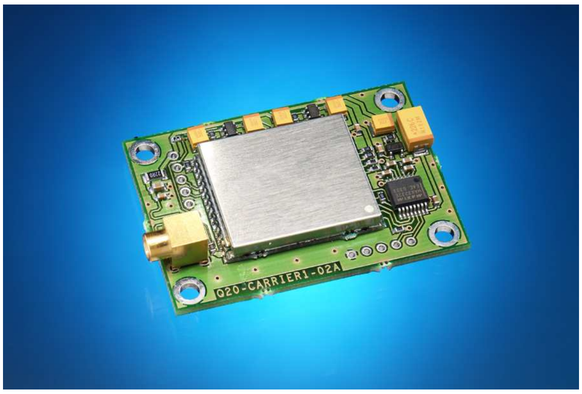

Figure 1 Q20 High Sensitivity Integration Board

The document details the mechanical and electrical characteristics of the integration board, and is intended to aid the integration of the module into higher-level systems and products.

1.1 Technical Assistance

If you are experiencing difficulties integrating the integration board which cannot be resolved using the documentation supplied, please email us at the following address and we will do our best to assist you as quickly as possible.

Send an email to: GPSSupport@qinetiq.com

1.2 Your Comments

We are continually trying to improve our products and services and we value your feedback. If you have any suggestions or comments please forward them to the following address and we will endeavour to take account of them in our future products and updates.

Send an email to: GPSSales@qinetiq.com

2 Q20 Integration Board Functional Description

2.1 General Description

The Q20 Integration Board is a high sensitivity, ultra-compact GPS receiver offering state of the art indoor and outdoor positioning capability. At its heart is the QinetiQ Q20 High Sensitivity GPS module. The high sensitivity of the embedded Q20 module enables operation in environments where conventional GPS receiver technology cannot function, e.g. urban canyons, under wet foliage and indoors. The Q20's novel architecture also enables extremely rapid Time-To-First-Fix (TTFF) in a conventional signal environment. The integration board enables customers to realise emerging commercial GPS opportunities with one low cost, high specification GPS device.

The Q20 is based on a state of the art QinetiQ GPS baseband processor, which provides rapid signal acquisition and very low signal strength tracking capability. The QinetiQ baseband processor provides digital interfaces for access to the positioning output and control of the module functions. Embedded in the processor are highly reliable software, navigation and timing library functions. These have been optimised for execution on the baseband's high performance ARM966 microprocessor.

The baseband processor is integrated with a low noise RF front end to give unprecedented sensitivity in such a small receiver module. The RF front end and associated filtering provide effective protection from out of band interference.

The module also contains a real time clock that can be battery backed and a low drift temperature compensated crystal oscillator. There is onboard memory for storing all the necessary receiver software plus data that can assist acquisition: time, date, frequency bias, last known position, ephemeris and almanac.

2.2 Features

The Q20 Integration Board offers the following features:

- 12 channels to provide an All Satellites in View tracking capability
- Fast Time-To-First-Fix (TTFF)
- High sensitivity with or without Network Assistance
- Almanac and Ephemeris data demodulation at extremely low signal levels
- 2 Serial Ports
- 1 Pulse Per Second (1 PPS) timing output
- Operating Voltage 3.3 – 5.0V
- Wide operating temperature range: -30°C to +80°C
- Small size: 50.0 mm x 35.0 mm x 4.8 mm (excluding RF connector)
- MCX active antenna connector
- Standard 0.1" pitch SIL connectors

2.3 Main Components

The Q20 integration board is a complete GPS receiver requiring a minimum of external components and connections to operate. The user can be up and running simply by connecting power, an antenna and a device to the serial port capable of interpreting standard NMEA data messages. The main functional components within the Q20 integration board are described in §2.3.1 to §2.3.5. below.

2.3.1 GPS Engine

The GPS engine is a Q20 OEM module running high sensitivity GPS application software to generate accurate position solutions in urban environments. More detailed information on the GPS engine is in section 2.4

2.3.2 Battery Backup

The GPS engine contains a real-time clock device, The RTC is battery backed by the provision of a supply voltage on the VBATT pin, thus remaining active when primary power is removed from the Q20 integration board. Maintaining time will enable the module to quickly establish which satellites are in view upon switch on for faster starts from power on. If battery backup of the real-time clock is not required then this pin can be tied internally to VCC by ensuring that link LK1 is fitted, the location of this device is shown in Figure 3, a recommended alternative is that the VBATT pin is tied externally to GND if not used.

2.3.3 Status Indication

The GPS status of the Q20 integration board is indicated by two external signals as follows;

LED 2: A short pulse for each satellite tracked without ephemeris data and therefore not used in any navigation solution.

LED 1: A short pulse for each satellite tracked with ephemeris data with a separating long pulse to indicate if a valid fix is available.

2.3.4 Pulse Per Second

An accurate timing pulse is generated by the Q20 integration board for use by integrators who require access to accurate time information. This pulse is aligned with either GPS or UTC time as required.

2.3.5 Connectors

The Q20 integration board connectors provide access to the power and signal lines of the device. The two connectors used are widely available 0.1” pitch SIL footprint, note the unit is delivered with empty locations for the connectors to allow the integrator to decide on the style of the connector used. The main power and status connector is a 6-way device while the communications connector is a 5-way device. The host platform will require compatible mating parts to be fitted to those selected for the board. Detailed description of the connector pin functions can be found in Section 6.1.

2.3.6 Active Antenna Support

The Q20 integration board provides active antenna support, the bias voltage being derived directly from the VCC supply onto the centre pin of the MCX connector. There is no current limit protection on this pin so care should be exercised to prevent short circuits or current surges when connecting the antenna. To achieve the best sensitivity from the unit it is recommended that an active antenna be used with a gain of 26dB and associated Noise Figure of less than 1dB.

2.4 Q20 OEM Module

The Q20 module is a complete GPS receiver in a package suitable for reflow soldering. The main functional components within the Q20 are shown in Figure 2 and described in detail below.

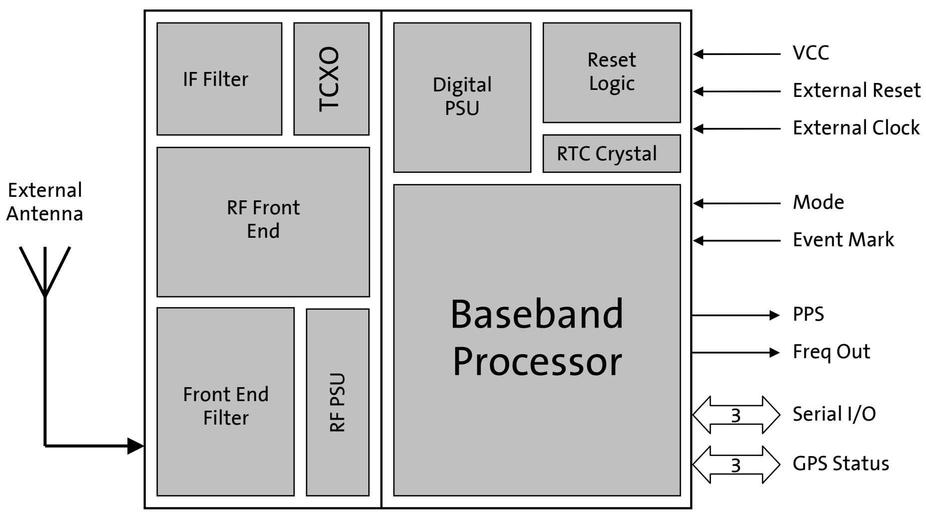

Figure 2: Q20 Block Schematic

2.4.1 RF Front End Filter

GPS signals from the antenna first encounter a high performance ceramic front-end filter which effectively removes any unwanted signals (i.e. signals outside the L1, C/A-code GPS bandwidth).

2.4.2 Radio Frequency Front End

The RF Front End used in the Q20 module is a single Silicon-Germanium BiCMOS device. It amplifies the very weak GPS signals to a magnitude useable by the digital circuits. To do this it requires a power gain in excess 140 dB. Such a high gain, applied to all the signals incident at the antenna, would result in very large signals in the RF/IF system, so it is also necessary to incorporate filters to exclude unwanted signals outside the GPS bandwidth. The RF section of the receiver down-converts the GPS signals to an Intermediate Frequency (IF) which the baseband processor's digital circuits can process. The RF section of the receiver is driven by the reference oscillator.

Control of the RF device is via a digital 4-wire Serial Peripheral Interface (SPI). This interface provides control of power to the RF circuits, Automatic Gain Control (AGC), synthesiser dividers, and Analogue to Digital (A-to-D) thresholds. Adjustable A-to-D thresholds are helpful in improving signal-to-noise ratios when operating in interference environments.

2.4.3 Baseband Processor

2.4.3.1 Signal Processing

The IF signal, received at the RF/baseband interface, is a digitised composite of the signal from all received GPS satellites. It retains the full bandwidth of the GPS signal.

The baseband process separates out the individual satellite signals, by correlation with their individual Pseudo Random Noise (PRN) codes, removes any residual IF and Doppler frequency components and then provides further filtering to a rate at which software techniques become more appropriate.

Signal acquisition is implemented using a parallel search strategy in both code and frequency. In code space the baseband processor provides many more parallel correlators than conventional GPS receivers. Further parallel processing is provided for a search in the frequency domain, by using a powerful dedicated Fast Fourier Transform (FFT) engine implemented in hardware.

The reference oscillator provides the digital clock signal to the baseband processor.

2.4.3.2 Navigation Solution

The baseband processor contains an embedded on-board ARM966 processor, which uses the raw measurements provided by the dedicated signal processing to calculate an accurate navigation solution (position, velocity and time) using an advanced Kalman filter. The processor also executes proprietary algorithms to reject interference and reduce the effects of multipath.

Real Time Clock & EEPROM

The Q20 module contains a Real Time Clock (RTC), reset controller and 32K x 8 Bits of EEPROM connected to the baseband processor on a 2-wire I^2C bus.

On power down, the EEPROM is used to store useful information including an Almanac, Ephemeris, last known position and frequency bias. This information, in conjunction with date and time information from the RTC, enables the Q20 module to rapidly acquire GPS satellite signals from switch-on.

The Q20 module software provides EEPROM management. For example write cycles are managed to provide an EEPROM lifetime of more than 10 years.

2.4.4 Reset Logic

An onboard reset control is provided to perform a controlled reset of the device under 'brown-out' conditions. Reset occurs at 2.85 V ±100 mV.

2.5 Operation on power up

On application of power the Q20 integration board will perform a power-on reset and transition to the normal mode of operation.

2.6 Operation on power interrupt

The Q20 module contains a reset controller. In the condition of power interrupt or power 'brown-out' it will perform a reset and transition to the normal mode of operation once the cause of the interrupt has been removed. Reset occurs at 2.85V ±100 mV on the Q20 module VCC input. As the Q20 reset controller is after the voltage regulation of the input supply the voltage to the integration board at which the reset event will occur is typically 3.0V

2.7 Power Consumption

Mode	Current Consumption (mA)
Normal	160
Software Update	200 Max consumption during sequence

Table 1 - Q20 Integration Board Power Consumption

2.8 Protocols

The Q20 integration board supports several different serial protocols; these are described in the Q20 GPS Receiver Module Interface Control Document, [1].

Protocol	Type	Runs On
NMEA	Output, ASCII, 0183, V2.1 and V2.2	COM 1, COM 2
QinetiQ ASCII command set	Input / output, ASCII, QinetiQ proprietary	COM 1, COM 2
Network Assist	Input, QinetiQ proprietary	COM 1, COM 2

Table 2 - Q20 Integration Board Serial Data Protocols

! Note Individual messages may be switched on / off under software control. This is on a per-module basis, i.e. a message disabled on one COM port will be disabled on both other COM ports.

3 Performance Specification

Receiver Type	12 parallel channel C/A L1 (1575.42 MHz)	
Performance	RF Reception Sensitivity	-185 dBW acquisition -189 dBW tracking
Signal Acquisition	Hot Warm Cold Reacquisition	<1 sec <38 sec <45 sec <0.5 sec
Physical	Module dimensions H x W x D (mm)	50.0 x 35.0 x 4.8
	Supply voltage	+3.3V - +5V DC
	Operating / Storage Temp	-30°C to + 80°C / -55°C to +85°C
	Max Velocity / Altitude	515 ms-1 / 18,000m
	Max Acceleration / Jerk	4g / 1 gs-1
Accuracy	Position: Outdoor/Indoor	<5m / <50m typical
	Velocity	<0.05ms-1
Power @ 3V3	Normal Operation RTC only Mode	500 mW (nominal @ 3.3VDC) < 15 µW
Interfaces	Serial Timing GPS Status	2 UART ports 1 PPS ±15 ns accuracy 2 status indicators
	Protocols	NMEA 0183 QinetiQ Proprietary ASCII Network Assist

Table 3 - Q20 Integration Board Performance Specification

4 Mechanical Specification

4.1 PCB Outline

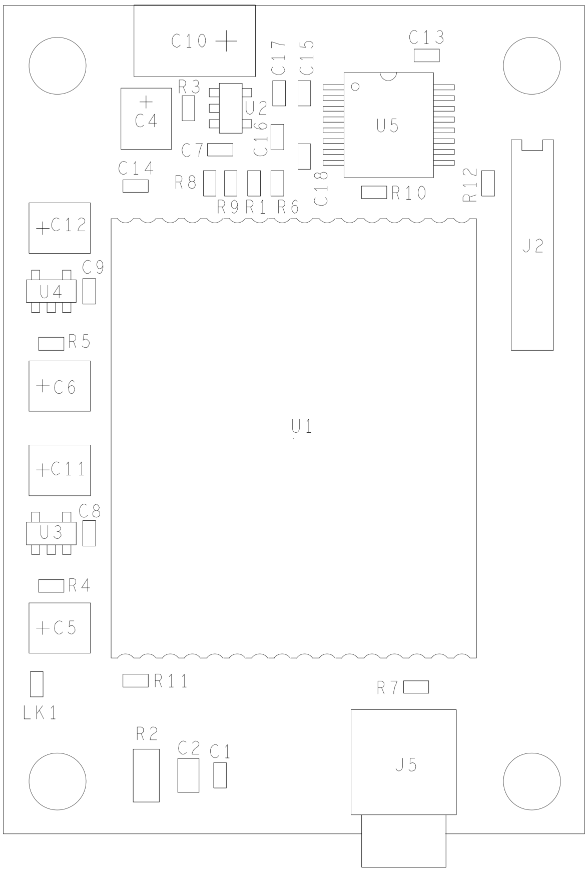

Figure 3 - Q20 Integration Board Mechanical Outline

4.2 Dimensions

Parameter	Specification	Tolerance	Unit
Length	50.0	+0.0 / -0.2	mm
Width	35.0	+0.0 / -0.2	mm
Height	8.0	±0.1	mm
Pitch connector pad	2.54	±0.05	mm

Table 4 - Q20 Integration Board Mechanical Specification

4.3 Recommended Layout Footprint

All dimensions are in mm, drill errors should be non-cumulative. Hole diameters are specified as finished and should be plated through. Mounting holes are plated and connected to GND signal.

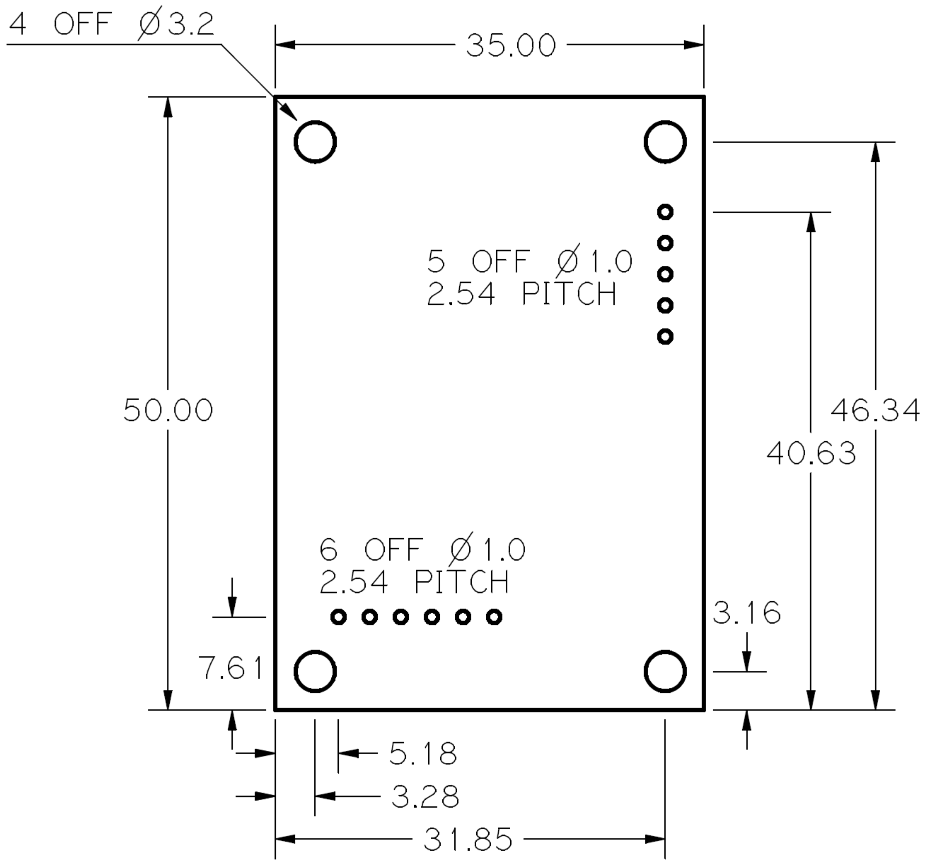

Figure 4 – Q20 Integration Board Recommended PCB Layout

4.4 Electrical Connections

4.4.1 Power Connector (J1)

Pin Number	Name	Type	Description
1	VCC	PWR	+3.3V - +5V DC Power Input
2	1PPS	O	Pulse Per Second Output
3	LED 2	O	GPS status LED 2
4	LED 1	O	GPS status LED 1
5	GND	PWR	Digital Ground
6	VBATT	PWR	+1.8V to +5.5V Backup power for RTC

Table 5 – Integration Board Power Connector Pin Allocations

4.4.2 Communications Connector (J2)

Pin Number	Name	Type	Description
1	COM 1 RX	I	COM 1 Serial Data Input
2	COM 1 TX	O	COM 1 Serial Data Output
3	COM 2 RX	I	COM 2 Serial Data Input
4	COM 2 TX	O	COM 2 Serial Data Output
5	GND	PWR	Digital Ground

Table 6 – Integration Board Communications Connector Pin Allocations

5 Electrical Specification

5.1 Absolute Maximum Ratings

Parameter	Symbol	Min	Max	Units
Power Supply Voltage	VCC	-0.3	5.0	V
Input Pin Voltage	V_{IN}	-0.3	5.0	V

Table 7 – Integration Board Absolute Maximum Ratings

! Warning Stressing the device beyond the 'Absolute Maximum Ratings' may cause permanent damage. The integration is not protected against over-voltage or reversed voltages. Voltage spikes exceeding the power supply voltage specification given in the table above must be reduced by using appropriate protection diodes.

5.2 Operating Conditions

Parameter	Symbol	Min	Max	Units
Power Supply Voltage	VCC	3.0	5.0	V
Power Supply Voltage Ripple	VCCPP		70	mV
Backup Battery Voltage	VBATT	1.8	VCC	V
Output Pin Low Voltage (CMOS)	V_{OL}	0	0.4	V
Output Pin High Voltage (CMOS	V_{OH}	0.67 x VCC	VCC	V
Input Pin Voltage (COMMS)	V_{INC}	-12	12	V
Input Pin Low Voltage (COMMS)	V_{ILC}	-12	-3	V
Input Pin High Voltage (COMMS)	V_{IHC}	3	12	V
Output Pin Low Voltage (COMMS)	V_{OLC}	-10	3	V
Output Pin High Voltage (COMMS)	V_{OHC}	3	10	V

Table 8 - Q20 Integration Board Operating Conditions

! Warning Operation beyond the 'Operating Conditions' is not recommended and extended exposure beyond the 'Operating Conditions' may affect device reliability.

5.3 Q20 Integration Board I/O Details

Pin Name	O/P (mA)	Open Collector	Schmitt I/P	Bias	FTYP	5V Tolerant
COMx TX [0:1]	4	No	Out Only	None	230k	-
COMx RX [0:1]	In Only	-	No	Up	-	-
1PPS	6	No	-	Low	1M	Yes
LED x	6	No	-	High	1M	Yes

Table 9 - Q20 Integration Board I/O Details

5.4 RF Input Parameters

Parameter	Frequency	Typical @ +25°C	-40°C to +80°C	Units
Insertion loss	1573.42 – 1577.42	1.25	1.5 max	dB
Input filter attenuation	824 – 829	67.0	50.0 min	dB
	1850 – 1910	53.0	45.0 min	dB
	1710 – 1785	24.0	10.0 min	dB
	2400 - 2484	50.0	20.0 min	dB
Max power in-band	1573.42 – 1577.42	-90.0	-90.0	dBm

Table 10 – Q20 Integration Board RF Input Parameters

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6 Interfaces

6.1 Detailed Pin Description

There are two SIL connectors used in the integration board, individual pin descriptions are given in §6.1.1and §6.1.2. Pin 1 of each connector is located closest to the adjacent board mounting holes.

6.1.1 J1 – Power Connector

6.1.1.1 Pin 1 – VCC

Primary power for the integration board. All input power (except battery backup for the real time clock – VBATT) is derived from this input. The input range is between +3.3V - +5V DC with a nominal current consumption of 150mA during normal operation. This input should be decoupled with at least a 47μF low-ESR capacitor close to the pin.

6.1.1.2 Pin2 – 1PPS

One pulse per second output. This pin provides an accurate output pulse aligned to GPS or UTC time. The pulse is 100μs wide positive going the leading edge of which is on-time. The output is at 3V3 CMOS level and is capable of sourcing 6mA.

6.1.1.3 Pin3 – LED 2

LED 2 is configured as a GPS status LED output. The signal is at 3V3 CMOS levels and is capable of sourcing or sinking 6mA. This signal indicates how many satellites are tracked but are not used in the navigation solution by generating a pulse once per satellite in a 4 second window. The signal is active low with a nominal pulse width of 50ms.

6.1.1.4 Pin 4 – LED 1

LED 1 is configured as a GPS status LED output. The signal is at 3V3 CMOS levels and is capable of sourcing or sinking 6mA. This signal indicates how many satellites are tracked and used in the navigation solution by generating a pulse once per satellite in a 4 second window. The signal is active low with a nominal pulse width of 50ms.

6.1.1.5 Pin5 – GND

Electrical ground for the integration board circuitry.

6.1.1.6 Pin6 – VBATT

Battery backup supply for the real-time clock. Power to maintain operation of the real-time clock is derived from this input. The input range is between 1.8VDC – VCC with a nominal current consumption of 3μA in the absence of VCC. Care should be exercised to ensure that VBATT cannot exceed VCC as latch-up of the real-time clock device can occur rendering the integration board inoperative.

6.1.2 J2 – Communications Connector

6.1.2.1 Pin 1 – TX 1

COM 1 serial port - transmit signal. This pin outputs the transmitted data from the primary communications UART. This signal is an output only and is at true RS232 levels as specified in EIA-232.

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6.1.2.2 Pin 2 – RX 1

COM 1 serial port - receive signal. This pin receives the data sent to the primary port of the integration board. This signal is an input only and is at true RS232 levels as specified in EIA-232.

6.1.2.3 Pin 3 – TX 2

COM 2 serial port - transmit signal. This pin outputs the transmitted data from the second communications UART. This signal is an output only and is at true RS232 levels as specified in EIA-232.

6.1.2.4 Pin 4 – RX 2

COM 2 serial port - receive signal. This pin receives the data sent to the second port of the integration board. This signal is an input only and is at true RS232 levels as specified in EIA-232.

6.1.2.5 Pin – 5 – GND

Electrical ground for the integration board circuitry.

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7 References

[1] QinetiQ Q20 High Sensitivty GPS Receiver Interface Control Document, QINETIQ/FST/ICD035773/2.9, 08^{th} November 2007.

8 Abbreviations

1 PPS	One Pulse Per Second
AGC	Automatic Gain Control
AHB	ARM™ High-speed Bus
APB	ARM™ Peripheral Bus
A-to-D	Analogue to Digital
C/A-code	GPS Coarse/Acquisition-code
dBi	decibel isotropic
dBW	decibel Watts
EEPROM	Electrically Erasable Programmable Read-Only Memory
ESD	Electro-Static Discharge
FFT	Fast Fourier Transform
FIFO	First In First Out
GNSS	Global Navigation Satellite System
GPIO	General Purpose Input Output
GPS	Global Positioning System
Hz	Hertz (cycles per second)
ICD	Interface Control Document
IF	Intermediate Frequency
IRQ	Interrupt Request
L1	Link 1 frequency (1575.42 MHz)
LED	Light Emitting Diode
LNA	Low Noise Amplifier
MHz	Mega Hertz (10^6 cycles per second)
mW	Milli Watt (10^{-3} Watt)
NCO	Numerically Controlled Oscillator
NMEA	National Marine Electronics Association
PCB	Printed Circuit Board
PDOP	Position Dilution Of Precision
PLL	Phase Lock Loop
ppm	parts per million
PRN	Pseudo Random Noise
PVT	Position, Velocity, Time
RF	Radio Frequency
SiGe	Silicon-Germanium
SPI	Serial Peripheral Interface
TBC	To Be Confirmed
TCXO	Temperature Compensated Crystal Oscillator
UTC	Universal Time Co-ordinated

9 Glossary

Acquisition	The initial process of aligning a spread spectrum receiver's local pseudo random code sequence with the corresponding sequence received from the transmitter
C/A-code	Coarse/Acquisition-code. A unique (per satellite) pseudo-random code used to modulate the GPS carrier. The C/A-code is 1023 bits long and repeats every millisecond (1.023 MHz chipping rate). C/A-code is currently transmitted only on the L1 frequency of 1575.42 MHz.
Cold start	A Cold Start is defined as starting the acquisition process using no previous GPS almanac, ephemeris, and degraded time and position data.
Fix	The generation of a single GPS based position solution. This may include the time to acquire sufficient satellite signals (usually four) to calculate a position solution, and to demodulate ephemeris data from the navigation data stream.
Hot start	A Hot Start is defined as starting the acquisition process using a valid almanac, valid ephemeris, position to better than 1 km accuracy and time to better than 1 ms accuracy.
Sensitivity	The smallest RF signal received that can be used to provide a useful output. In the case of a GPS receiver this is the lowest signal level that can be used to contribute to a position solution.
Signal to Noise	The dimensionless ratio of bit energy to noise plus interference energy accumulated over the period of one bit.
Tracking	Maintaining the alignment of the incoming GPS satellite signal with the receiver’s replica code.
Warm start	A Warm Start is defined as starting the acquisition process using a valid almanac, position better than 10 km accuracy and time better than 1s accuracy.