SHLD-GPM+ TECHNICAL DESCRIPTION

sHLD Module Series

Document: sHLD-GPM+ Technical Description

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About the Document

History

Revision	Description	Date	Author
0.01.00	Create	3/2/19	DIO
1.00.00	First release	7/5/19	-

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1 Introduction

This document defines the sHLD-GPM+ GNSS module and describes the hardware interface that is connected to the customers Arduino application.
This document can help customers quickly understand module interface specifications, electrical and mechanical details, as well as other related information of the module. Associated with the quick start guide and demo software, customers can use this document to easily set up the module.

2 Product Concept

2.1 General Description

The Designer Systems sHLD-GPM+ is a highly integrated 99 Channel simultaneous GPS and GLONASS GNSS positioning module allowing your robotic application to determine its location and speed on the earth's surface. Specifically designed for the Arduino UNO user (can also be used on all the other Arduino variants) the sHLD-GPM+ features I2C communication to leave the Arduino UART for other functions eg. debug etc.
GNSS data received by the sHLD-GPM+ is stored within internal registers which are updated once per second and include Latitude (i.e. vertical), Longitude (i.e. horizontal), Altitude (meters), Time & date (UTC), Heading (True), Speed (kilometres per hour) and satellites detected.
In addition the sHLD-GPM+ features an on-board 3 Axis Accelerometer which can be used to determine inclination for rover and aircraft applications and raw 'g' force for acceleration/impact detection.

GPS data received by the sHLD-GPM+ is stored within internal registers which are updated once per second.

Due to compact form factor, ultra-low power consumption and extended temperature range, sHLD-GPM+ is a best choice for a wide range of positional, speed and altitude applications.

The module fully complies with the RoHS directive of the European Union

2.2 Key Features

The following table describes the key features of the sHLD-GPM.

Table 1: Key Features

Features	Details
Power Supply	• Supply Voltage: 5.0 ~ 12.0VDC • Typical Supply Voltage: 9.0VDC
Frequency band	• GPS L1 Band Receiver (1575.42MHz) • GLONASS L1 Band Receiver (1601.71MHz)
Accuracy	Autonomous < 2.5 m CEP @ -130dBm
Velocity	Accuracy Without aid <0.1m/s
Acceleration	Accuracy Without aid 0.1m/s²
Reacquisition Time	< 1 second
Cold Start	35 seconds @ -130dBm typ.
Warm Start	< 5 seconds @ -130dBm typ.
Hot Start	< 1second @ -130dBm typ.
Sensitivity	• Acquisition -149dBm • Tracking -167dBm • Re-acquisition -161dBm
Environmental	• Operating Temperature -40°C to 85°C • Storage Temperature -45°C to 125°C
Dynamic Performance	• Maximum Altitude Max.18000m • Maximum Velocity Max.515m/s • Maximum Acceleration 4G
Accelerometer range	0 to 2G
Accelerometer inclination	-50 to +50 degrees (pitch and roll)
I^2C Speed	400kHz max.
Dimensions	56 x 53 x 8.5mm
Weight	16g approx.

3 Application

3.1 GPS Basics

The heart of the sHLD-GPM+ is a GIobal Positioning System receiver module and antenna that receive signals from satellites orbiting the earth.

There are 32 of these satellites in the American run GPS system, 24 in the Russian GLONASS system, each sending its own unique signal to the earth's surface for pickup by any GPS receiver, which searches the sky for available satellites.

Upon detecting the satellites in view and their current position the receiver uses the satellites with highest signal strength to calculate, using triangulation, the receiver's latitude, longitude & altitude** (position).
Should the receiver also be moving, speed in kilometres per hour, and heading, in degrees true north, can also be determined. The GPS parameters stored are listed below.

For example the offices of Designer Systems in Truro, UK are located 50 degrees, 15.817 minutes North latitude and 5 degrees, 3.549 minutes West longitude.

*** LLA format to WGS-84 ellipsoid.*

Table 2: GPS Parameters

Parameter	Description
Time	UTC time in format HH:MM:SS
Date	UTC date in format DD/MM/YY
Latitude	Latitude in format DD M.MMMM either North or South of the equator
Longitude	Longitude in format DDD M.MMMM either West or East of an imaginary line drawn vertically through Greenwich in the UK
Altitude	Altitude in format MMMMM metres above sea level
Speed	Speed in format KKK.K kilometres per hour
Heading	Heading in format DDD.D degrees

3.2 Installation

To gain the best reception the GPM should be used outside with a good view of the sky. Trees and buildings will cause the GPS signals being received to degrade and positional/speed information may be lost. To greatly improve reception the GPM should be mounted above a metal base.

3.3 Operation

When power is applied to the GPM the unit immediately starts to search for satellites. The GPM can start in one of three (3) modes, as follows:

Table 3: Start-up modes

Mode	Description
Cold start	This mode only applies when the GPM has been powered-up for the first time after being removed from its packaging. As the GPM does not know where it is on the earth's surface, it starts to hunt for groups of satellites to determine its location. This process may take up to 30 minutes before positional information is available; it is suggested that a battery be connected and the unit left in the open air until the STATUS indicator starts to flash.
Warm Start	This mode applies to a GPM that has already been 'cold-started' and whose location has not changed significantly when powered up again or has been powered down for at least one (1) hour. Positional information is normally available again within 5 seconds of power re-application.
Hot Start	This mode applies when the GPM has been powered off for less than 60 minutes. Positional information is normally available again within 1-10 seconds of power re-application.

The warm and hot start -up modes are possible due to an internal backup battery which powers the Real Time Clock (RTC) and almanac memory when external power is removed.

3.4 Indication

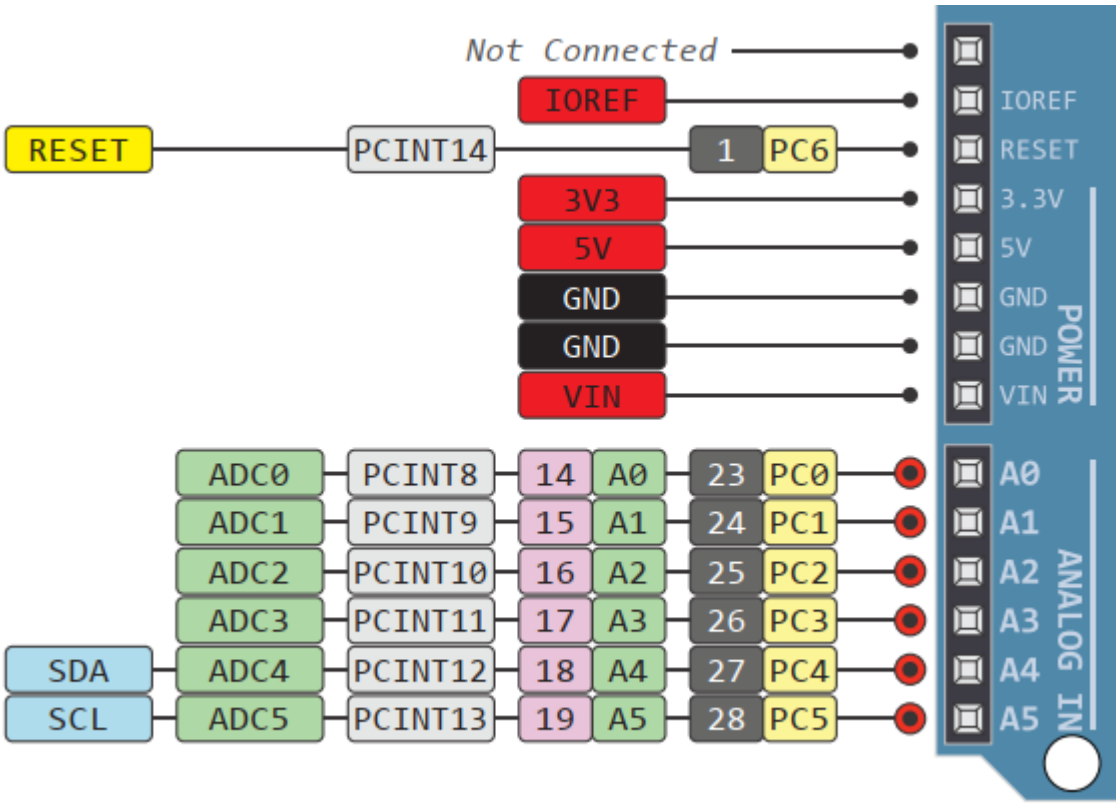
The STATUS indicator is used to provide visual feedback of the current GPM condition. There are three (3) conditions as follows.

Table 4: Status Indication

Indication	Description
ON	Power applied and no positional information
Flashing slowly	Positional information being received
Flashing fast	GPM in motion (>10km/h)

These conditions will change as the GPM moves around its location and under objects that may block the satellite signals.

3.5 Pin Assignment



3.6 Power Supply

3.6.1 Power Supply Pins

The GPM provides a supply input and ground connections on the 8pin hole group that connect to the VIN supply on the Arduino board POWER header. The table below describes the module supply and ground pins.

Table 5: Power Supply Pins

Pin Name	Pin No	Description	Min	Typ.	Max	Unit
VIN	8	Power Supply	5.0	9.0	12.0	V
GND	6,7	Power Ground				
5V	5	5V power for pullups		5.0		V

3.7 I²C Interface

3.7.1 I²C Interface Pins

The GPM provides I²C data (SDA) and clock (SCL) connections on a 6pin hole group that connect to the SDA and SCL on the Arduino board ANALOG IN header. The table below describes the module I²C pins.

Table 6: I²C Interface Pins

Pin Name	Pin No	I/O	Description	Comment
SDA	5	DIO	I2C Data	5.0V level
SCL	6	CO	I2C Clock	5.0V level

The GPM features 4.7K ohms I²C pullups to the 5V supply from the Arduino board. If the pullups are not needed then remove R2 & R3 with a soldering iron.

3.7.2 I²C Communication

Up to four GPM modules may be connected to the same Raspberry-Pi board or I²C bus and accessed individually using their own individual address.
The following table shows how the pads are soldered for the different binary addresses.

Table 7: I²C Address Settings

Address (xx)	A0	A1
00	OPEN	OPEN
01	SHORT	OPEN
10	OPEN	SHORT
11	SHORT	SHORT

The binary address (xx) above is used in conjunction with the device ID 11010xxD ($0xD0_{hex}$) to form the complete device address i.e. if both jumpers are left unconnected (default) then the device address would be $1101000D_{binary}$.
The 'D' bit determines if a read or a write to the GPM is to be performed. If the 'D' bit is set '1' then a register read is performed or if clear '0' a register write.

3.7.3 I²C Registers

To read individual data and status registers a device write then read must be undertaken by the Arduino.
The write consists of a Start condition, device ID ('D' bit clear), register to start read and a Stop condition.
This is followed by a read, which consists of a Start condition, device ID ('D' bit set), followed by data from the register specified and terminated with a Stop condition. The GPM also auto increments the register specified for every additional read requested by the Master I²C device, which allows more than one register to be read in one transaction. This allows for example Register 0 to Register 5, current UTC time, to be read in one transaction (see Figure 3 for I²C read protocol).
There are 70 individual registers that can be read within the GPM as follows:

Table 8: I²C Registers

Register name	Type	Register address		Description
		Hex	Binary	
Hours tens	r	00	00000000	UTC hours tens digit
Hours units	r	01	00000001	UTC hours units digit
Minutes tens	r	02	00000010	UTC minutes tens digit
Minutes units	r	03	00000011	UTC minutes units digit
Seconds tens	r	04	00000100	UTC seconds tens digit
Seconds units	r	05	00000101	UTC seconds units digit
Day tens	r	06	00000110	UTC day of month tens digit
Day units	r	07	00000111	UTC day of month units digit
Month tens	r	08	00001000	UTC month tens digit
Month units	r	09	00001001	UTC month units digit
Year thousands	r	0A	00001010	UTC year thousands digit
Year hundreds	r	0B	00001011	UTC year hundreds digit
Year tens	r	0C	00001100	UTC year tens digit
Year units	r	0D	00001101	UTC year units digit
Latitude degrees tens	r	0E	00001110	Latitude degrees tens digit
Latitude degrees units	r	0F	00001111	Latitude degrees units digit

Register name	Type	Register address		Description
		Hex	Binary	
Latitude minutes tens	r	10	00010000	Latitude minutes tens digit
Latitude minutes units	r	11	00010001	Latitude minutes units digit
Latitude minutes tenths	r	12	00010010	Latitude minutes tenths digit
Latitude minutes hundredths	r	13	00010011	Latitude minutes hundredths digit
Latitude minutes thousandths	r	14	00010100	Latitude minutes thousandths digit
Latitude minutes ten thousandths	r	15	00010101	Latitude minutes ten thousandths digit
Latitude character	r	16	00010110	Latitude direction character N = North, S = South
Longitude degrees hundreds	r	17	00010111	Longitude degrees hundreds digit
Longitude degrees tens	r	18	00011000	Longitude degrees tens digit
Longitude degrees units	r	19	00011001	Longitude degrees units digit
Longitude minutes tens	r	1A	00011010	Longitude minutes tens digit
Longitude minutes units	r	1B	00011011	Longitude minutes units digit
Longitude minutes tenths	r	1C	00011100	Longitude minutes tenths digit
Longitude minutes hundredths	r	1D	00011101	Longitude minutes hundredths digit
Longitude minutes thousandths	r	1E	00010110	Longitude minutes thousandths digit
Longitude minutes ten thousandths	r	1F	00010111	Longitude minutes ten thousandths digit
Longitude character	r	20	00100000	Longitude direction character W = West, E = East
GPS quality indicator	r	21	00100001	GPS quality value (0 = No GPS, 1 = GPS/GLONASS, 2 = DGPS)
Satellites in use tens	r	22	00100010	Satellites in use tens digit
Satellites in use units	r	23	00100011	Satellites in use units digit
HDOP tens	r	24	00100100	HDOP tens digit
HDOP units	r	25	00100101	HDOP units digit
HDOP tenths	r	26	00100110	HDOP tenths digit

Register name	Type	Register address		Description
		Hex	Binary	
Altitude metres ten thousands	r	27	00100111	Altitude metres ten thousands digit
Altitude metres thousands	r	28	00101000	Altitude metres thousands digit
Altitude metres hundreds	r	29	00101001	Altitude metres hundreds digit
Altitude metres tens	r	2A	00101010	Altitude metres tens digit
Altitude metres units	r	2B	00101011	Altitude metres units digit
Heading true hundreds	r	2C	00101100	Heading true hundreds digit
Heading true tens	r	2D	00101101	Heading true tens digit
Heading true units	r	2E	00101110	Heading true units digit
Heading true tenths	r	2F	00101111	Heading true tenths digit
Not used	r	30	00110000	Not used returns zero
Not used	r	31	00110001	Not used returns zero
Not used	r	32	00110010	Not used returns zero
Not used	r	33	00110011	Not used returns zero
Speed km/h hundreds	r	34	00110100	Speed km/h hundreds digit
Speed km/h tens	r	35	00110101	Speed km/h tens digit
Speed km/h units	r	36	00110110	Speed km/h units digit
Speed km/h tenths	r	37	00110111	Speed km/h tenths digit
GPS mode	r	38	00111000	GPS mode (A = Autonomous Mode, D = Differential Mode, E = Estimated (dead reckoning) Mode, M = Manual Input Mode, S = Simulated Mode, N = Data Not Valid)
Accelerometer raw X MSB	r	39	00111001	Accelerometer raw X MSB value
Accelerometer raw X LSB	r	3A	00111010	Accelerometer raw X LSB value
Accelerometer raw Y MSB	r	3B	00111011	Accelerometer raw Y MSB value
Accelerometer raw Y LSB	r	3C	00111100	Accelerometer raw Y LSB value

Register name	Type	Register address		Description
		Hex	Binary	
Accelerometer raw Z MSB	r	3D	00111101	Accelerometer raw Z MSB value
Accelerometer raw Z LSB	r	3E	00111110	Accelerometer raw Z LSB value
Accelerometer pitch	r	3F	00111111	Accelerometer pitch (0-50 degrees, MSb (0x80) = sign bit)
Accelerometer roll	r	40	01000000	Accelerometer roll (0-50 degrees, MSb (0x80) = sign bit)
Not used	r	41	01000001	Not used returns zero
Not used	r	42	01000010	Not used returns zero
Not used	r	43	01000011	Not used returns zero
Not used	r	44	01000100	Not used returns zero
Not used	r	45	01000101	Not used returns zero
Firmware and status	r	46	01000110	Firmware (Bit 0-3 = minor version, Bit 4-5 = major version, Bit 6 = Position found when set, Bit 7 = In motion when set (> 10km/h)

3.7.4 I²C Register Restoration

All received data is formatted into decimal units (i.e. hundreds, tens & units) and stored in individual registers to facilitate either value or character restoration.
Value restoration can be undertaken by multiplying the required register by its multiplier e.g. to restore the value of register R0 'Hours tens' the register contents are multiplied by ten (10).
Character restoration, to allow the output to a PC via. RS232 or display of data on a LCD panel etc. can be undertaken by the addition of the constant value $48_{decimal}$, 30_{hex}.

3.7.5 UTC Time/Date Format

The standard GPS time coordinate system is called Universal Coordinated Time or UTC.
This time format replaced Greenwich Mean Time (GMT) in 1986 and is of the same value. Time zones relative to GMT should add or subtract a standard value to gain the correct time.

3.7.6 I²C Read Example

To read the complete time from registers 0 to 5 (Current time = 14:32:56, Device address = default) write:

'Point to register 0
Byte 1 (GPM Adr) $1101000\mathbf{0}_{binary}$
Byte 2 (Set register) $0_{decimal}$, 00_{hex}

'Read register 0 - 5
Byte 1 (GPM Adr) $1101000\mathbf{1}_{binary}$
Byte 2 Hours tens $1_{decimal}$, 01_{hex}
Byte 3 Hours units $4_{decimal}$, 04_{hex}
Byte 4 Minutes tens $3_{decimal}$, 03_{hex}
Byte 5 Minutes units $2_{decimal}$, 02_{hex}
Byte 6 Seconds tens $5_{decimal}$, 05_{hex}
Byte 7 Seconds units $6_{decimal}$, 06_{hex}

3.8 Backup Battery

3.8.1 Battery Replacement

The GPM backup battery needs replacing if no time/date data can be read or time to first fix is significantly long.
The CR1220 type lithium battery can be replaced by sliding out the old battery and sliding in a new battery [positive uppermost].

Please dispose of the exhausted battery responsibly.

3.9 Application Software

3.9.1 Demonstration Software

Arduino demonstration software is available to download from the website
www.designersystems.co.uk/robotics

4 Electrical Characteristics

4.1 Absolute Maximum Ratings

Absolute maximum ratings for power supply and voltage on digital pins of the module are listed in the following table.

Table 9: Absolute Maximum Ratings

Parameter	Min.	Max.	Unit
Power Supply Voltage (V+)	-0.3	16.0	V
Backup Battery Voltage (Lithium cell)	-0.3	4.5	V
Input Voltage on SDA and SCL	-0.3	3.6	V
Storage temperature	-45	100	^{o}C

4.2 Operating Conditions

Normal operational conditions are listed in the following table.

Table 10: Normal Operating Conditions

Parameter	Min.	Typ.	Max.	Unit
Power Supply Voltage (V+)	5.0	9.0	12.0	V
Backup Battery Voltage (Lithium cell)	1.5	3.0	4.3	V
Input voltage on SDA and SCL		5.0		V
Peak Supply Current (V+ = 9.0V)			15	mA
Operating Temperature	-10	25	50	^{o}C

4.3 Current Consumption

Normal values for current consumption @ 9.0V V+ are listed in the following table.

Table 11: Current Consumption

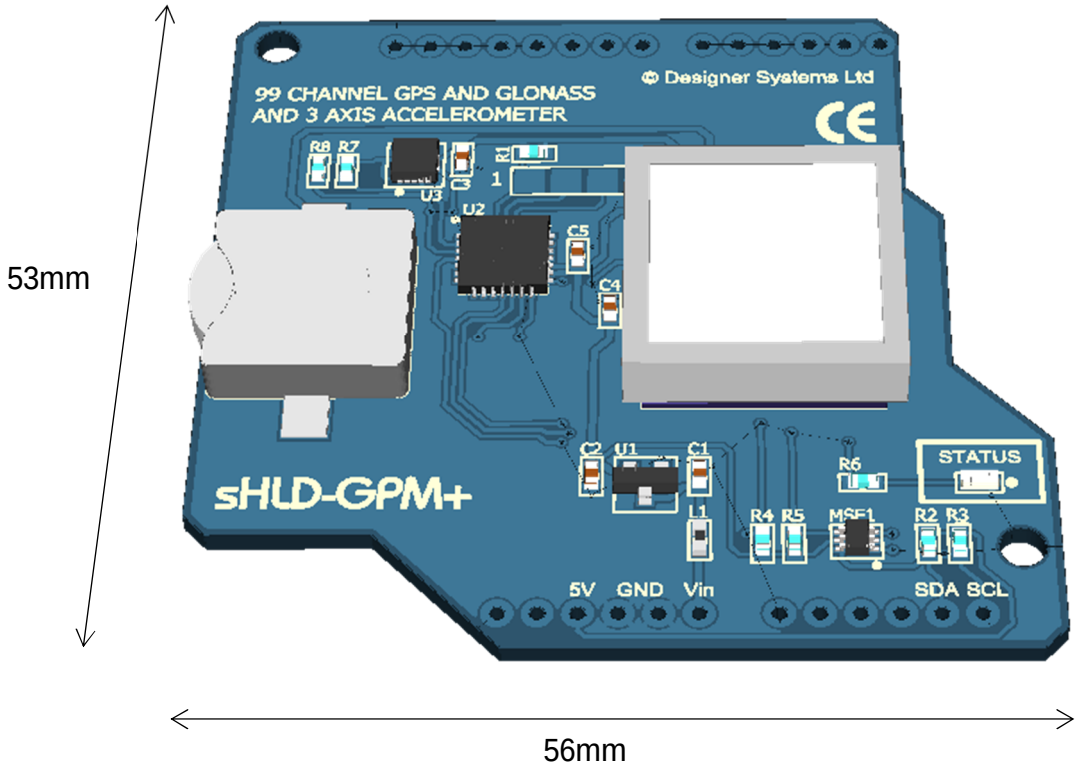
Parameter	Min.	Typ.	Max.	Unit
Supply Current – Acquisition (GPS)		9.5		mA
Supply Current – Tracking (GPS)		8.0		mA
Supply Current – Acquisition (GPS + GLONASS)		11.0		mA
Supply Current – Tracking (GPS + GLONASS)		9.5		mA
Backup Battery		7		uA

5 Mechanical

5.1 Dimensions

Mechanical drawing – all dimensions in millimetres.

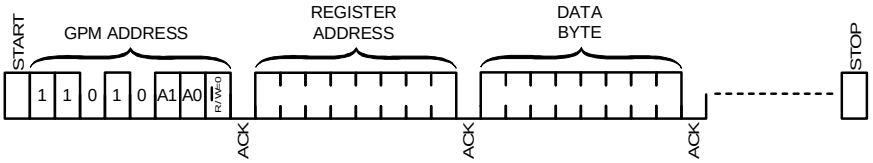
Figure 1: Dimensions



6 References

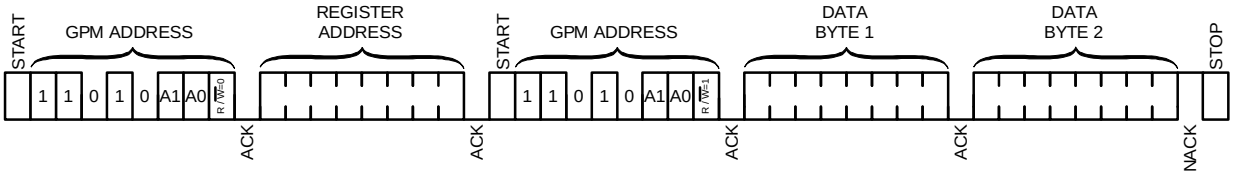
6.1 I²C protocols

Figure 2: I²C Write protocol



Multiple bytes may be written before the 'STOP' condition. Data is written into registers starting at 'REGISTER ADDRESS', then 'REGISTER ADDRESS' +1, then 'REGISTER ADDRESS' +2 etc.
Each byte transfer is acknowledged 'ACK' by the GPM until the 'STOP' condition.

Figure 3: I²C Read protocol



'DATA BYTE 1 & 2' are register values returned from the GPM. Each byte written is acknowledged 'ACK' by the GPM, every byte read is acknowledged 'ACK' by the I2C Master. A Not-acknowledge 'NACK' condition is generated by the I2C Master when it has finished reading.

7 Appendix

Table 12: Related Documents

Document Name	Remark
Quectel_L86_Hardware_Design_V1.2.pdf	More information about the L86 GNSS module used in this product

Table 13: Terms and Abbreviations

Abbreviation	Description
GPS	Global Positioning System
GLONASS	Global Navigation Satellite System
CEP	Circular Error Probable
HDOP	Horizontal Dilution Of Precision
ESD	Electrostatic Discharge
I^2C	Inter-Integrated Circuit
GNSS	Global Navigation Satellite System

8 Compliance

WEEE Consumer Notice

This product is subject to Directive 2012/19/EC of the European Parliament and the Council of the European Union on Waste of Electrical and Electronic Equipment (WEEE) and, in jurisdictions adopting that Directive, is marked as being put on the market after August 13, 2005, and should not be disposed of as unsorted municipal/public waste. Please utilise your local WEEE collection facilities in the disposition and otherwise observe all applicable requirements. For further information on the requirements regarding the disposition of this product in other languages please visit www.designersystems.co.uk

RoHS Compliance

This product complies with Directive 2011/65/EC (RoHS 2) and 2015/863/WU (RoHS 3) of the European Parliament and the Council of the European Union on the Restriction of Hazardous Substances (RoHS) which prohibits the use of various heavy metals (lead, mercury, cadmium, and hexavalent chromium), polybrominated biphenyls (PBB) and polybrominated diphenyl ethers (PBDE), Bis(2-Ethylhexyl) phthalate (DEHP), Benzyl butyl phthalate (BBP), Dibutyl phthalate (DBP) and Diisobutyl phthalate (DIBP).

REACH Compliance

This product complies with Regulation 1907/2006 convering the Registration, Evaluation, Authorisation and restriction of Chemicals (REACH). Designer Systems Ltd confirms that none of its products or packaging contain any of the 174 Substances of Very High Concern (SVHC) on the REACH Candidate List in a concentration above the 0.1% by weight allowable limit.

Battery Recycling

This product features an internal lithium coin cell that must be recycled at end of life. To remove slide the coin cell from its holder and to preserve natural resources please recycle the battery properly.