



# USER GUIDE

## Condor Series GPS Modules

  
**The right one.™**

 **Trimble.**



# Safety Information

## Warnings and Cautions

An absence of specific alerts does not mean that there are no safety risks involved. Always follow the instructions that accompany a Warning or Caution. The information they provide is intended to minimize the risk of personal injury and/or damage to the equipment. In particular, observe safety instructions that are presented in the following formats:

**WARNING** – A Warning alerts you to a likely risk of serious injury to your person and/or damage to the equipment.

**CAUTION** – A Caution alerts you to a possible risk of damage to the equipment and/or loss of data.

## Operation and storage

**WARNING** – The Condor™ GPS receiver is ready to accept NMEA commands approximately 2 seconds after power-up. If a command is sent to the receiver within this 2 second window, the receiver will ignore the command. The Condor GPS receiver will not respond to commands sent within the 2 second window and will discard any associated command data.

**WARNING** – Operating or storing the Condor GPS receiver outside the specified temperature range can damage it. For more information, see the product specifications on the data sheet.

## Routing any cable

**CAUTION** – Be careful not to damage the cable. Take care to avoid sharp bends or kinks in the cable, hot surfaces (for example, exhaust manifolds or stacks), rotating or reciprocating equipment, sharp or abrasive surfaces, door and window jambs, and corrosive fluids or gases.

## AC adaptor safety

An international adaptor kit is provided with the Condor Starter Kit.

**WARNING** – Using an incorrect AC adaptor can damage your product and may void your warranty. To use AC adaptors safely:

- Use only the AC adaptor intended for the Condor GPS timing receiver. Using any other AC adaptor can damage your product and may void your warranty.
- Do not use the AC adaptor with any other product.
- Make certain that the input voltage on the adaptor matches the voltage and frequency in your location.
- Make certain that the adaptor has prongs compatible with your outlets.
- AC adaptors are designed for indoor use only. Avoid using the AC adaptor in wet outdoor areas.
- Unplug the AC adaptor from power when not in use.
- Do not short the output connector.
- There are no user-serviceable parts in this product.
- Should damage to the AC adaptor occur, replace it with a new Trimble AC adaptor.

## Handling

**CAUTION** – The Condor GPS module is packed according to ANSI/EIA-481-B and JSTD-033A. All of the handling and precaution procedures must be followed. Deviation from following handling procedures and precautions voids the warranty.

**CAUTION** – Operators should not touch the bottom silver solder pads by hand or with contaminated gloves. Ensure that no hand lotion or regular chlorinated faucet water comes in contact with the module before soldering.

**CAUTION** – Do not bake the units within the tape and reel packaging. Repeated baking processes will reduce the solderability.

**CAUTION** – Follow the thermal reflow guidelines from IPC-JEDEC J-STD-020C

# Setting up the Condor Starter Kit

**In this chapter:**

- System requirements
- Removing the Condor carrier board from the motherboard
- Interface protocols
- Condor LC2101 starter kit
- Setting up the starter kit
- Setting up the software toolkit

This chapter describes the elements of the Condor starter kit and how to set it up.

The hardware integration is described in [Chapter 4, Condor Carrier Board](#).

# System requirements

## Hardware

- . The Trimble Condor Starter Kit.
- . User-provided connectors and extension cords to connect the Condor GPS module to the computer, antenna interface, and other devices as required.
- . +24 VDC power supply.
- . User-provided equipment to analyze the PPS accuracy and a BNC connector to connect it to the Condor starter kit.

## Computer

- . An office computer running a version of the Windows® operating system (Windows 2000 or later)
- . The computer must have one of the following service packs installed:
  - Service Pack 2, for Windows Vista® or Windows XP
  - Service Pack 4, for Windows 2000

## System software

- . Trimble GPS Studio software. The software is used to monitor the GPS performance of the Condor and to change its settings. The software is compatible with the Windows 2000, Windows XP, and Windows Vista operating system.
- . The National Marine Electronics Association (NMEA) protocol is an industry standard navigation data protocol. There are also proprietary query and set packets. See [Appendix A, NMEA 0183 Protocol](#).

# Removing the Condor carrier board from the motherboard

**WARNING** – Before opening the interface unit, disconnect the unit from any external power source and confirm that both you and your work surface are properly grounded for ESD protection.

The Condor GPS module is secured to a carrier board and is then attached to the motherboard standoffs with Phillips head screws, allowing for removal and integration with the user's application. Follow these steps to remove the receiver from the motherboard:

1. Disconnect power to the enclosure.
2. Remove the base plate and unplug the RF cable from the receiver.

3. Use a small Phillips screwdriver to remove the hardware that holds the Condor GPS receiver to the motherboard.
4. Gently slip the board loose from the motherboard I/O connector.

## Interface protocols

The Condor family of GPS modules use the NMEA 0183 protocol. This is an industry standard protocol that is common to marine applications. NMEA provides direct compatibility with other NMEA-capable devices such as chart plotters, radar, and so on. The Condor GPS module supports the GGA, GSV, GSA, and RMC NMEA messages.

## Condor LC2101 starter kit

The Condor LC2101 GPS module is available in a starter kit or as an individual receiver and associated antenna. The starter kit includes all the components necessary to quickly test and integrate the receiver.

The starter kit includes the Condor LC2101 GPS module on a carrier board, mounted on an interface motherboard in a durable metal enclosure. The kit also contains:

- Miniature magnetic mount antenna
- Two additional sample Condor LC2101 GPS modules
- Interface cable, USB
- AC/DC power supply adapter:
  - Input: 100 – 240 VAC
  - Output: 24 VDC

*Note – The Condor LC2101 GPS module is available as an individual receiver, or with the Condor LC2101 module mounted on a carrier board.*

## Starter kit interface unit

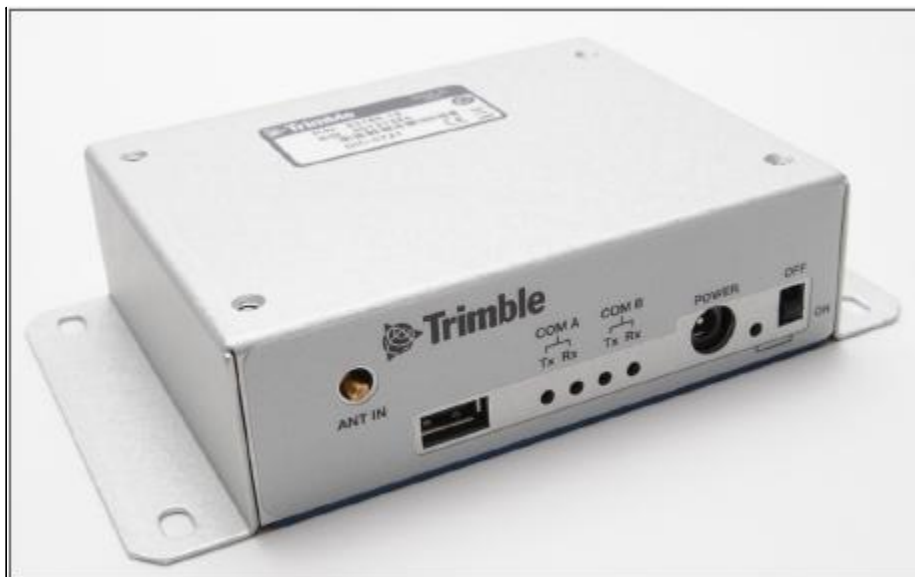
The starter kit interface unit consists of a USB interface that is compatible with most computer communication ports. Power (24 VDC) is supplied through the power connector on the front of the interface unit. The motherboard features a switching power supply which converts this voltage input to the 3.3 V required by the receiver and the antenna. The USB connector allows for an easy connection to an office computer using the USB interface cable provided in the starter kit. The metal enclosure protects the receiver and the motherboard for testing outside of the laboratory environment.

The Condor LC2101 GPS receiver, installed in the Starter Kit interface unit, is a single port receiver. Only port B is available from the carrier board header pins. A straight-in, panel-mounted RF MCX connector supports the GPS antenna connection. The center conductor of the MCX connector also supplies +3.3 VDC for the low-noise amplifier of the active antenna.

This following figure shows the receiver in the metal enclosure:



The following figure shows the starter kit interface unit:





### Pulse-per-second (PPS)

The receiver provides a 4 us wide, TTL-compatible Pulse-Per-Second (PPS). The PPS is a positive pulse available on the BNC connector of the interface unit. The rising edge of the pulse is synchronized to GPS. The timing accuracy is  $\pm 25$  ns 1 sigma. The PPS from the BNC connector can drive a 50  $\Omega$  load.

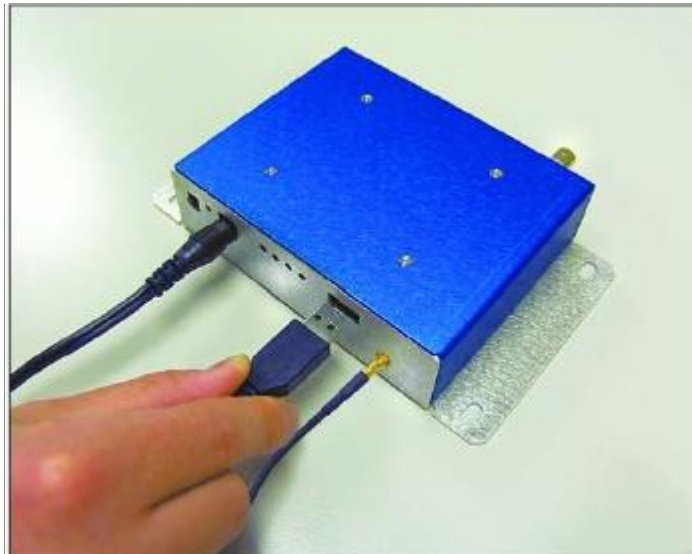
## Setting up the starter kit

*Note* – You can either set up the starter kit temporarily for testing or evaluation purposes, or embed it permanently into your system. The procedure is largely the same.

1. Start up an office computer that is running a suitable Windows operating system and service pack and that has a free USB port.
2. Select and then save all the relevant files to a directory on the hard drive.
3. To use the Trimble GPS Studio application to communicate with the GPS receiver, you must install the FTDI driver on your computer. The starter kit uses a USB 2.0 dual serial port emulator interface chip from Future Technology Devices International Ltd. (FTDI).

To do this, click the CDM\_Setup.exe file that you downloaded earlier. If the installation is successful, a message FTDI CDM Drivers have been successfully installed appears.

4. Click **OK**.
5. Connect one end of the USB cable (supplied) to the USB connector on the interface unit:

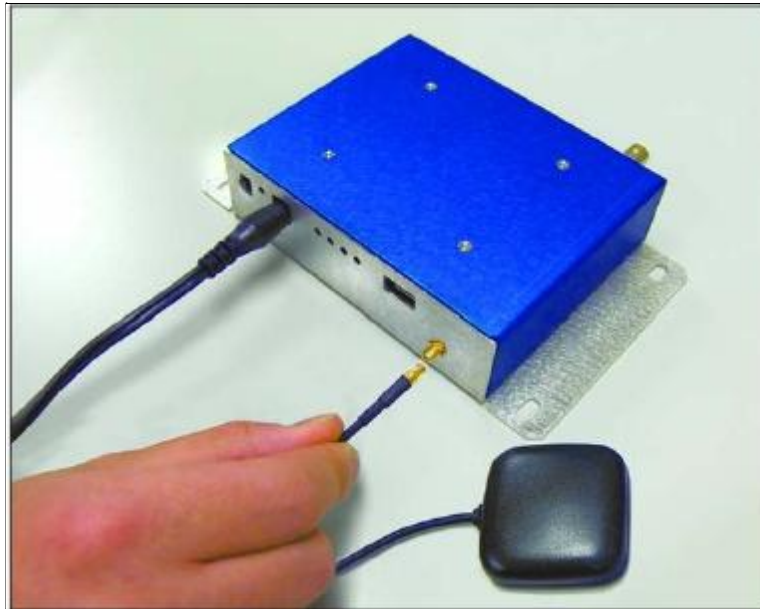


6. Connect the other end of the USB cable to your computer. The USB cable now supplies power to the unit.

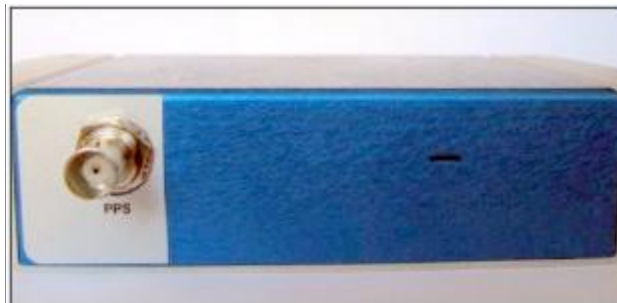
7. Turn on the interface unit. The Power LED lights up green.

*Note* – Two additional power adapters are supplied—an international AC / DC adapter and an automotive DC/DC adapter.

8. The FTDI driver automatically assigns two virtual COM ports to the USB port. When you need to assign the virtual COM ports, they appear on the monitor screen. To view the ports, select *System Properties / Device Manager / Ports*.  
Use the COM port for Port B of the starter kit. This is usually the higher number of the two virtual ports.
9. Connect the magnetic mount GPS antenna to the interface unit:



10. Place the antenna outside.
11. Connect to the BNC connector on the rear of the interface unit for the PPS output:



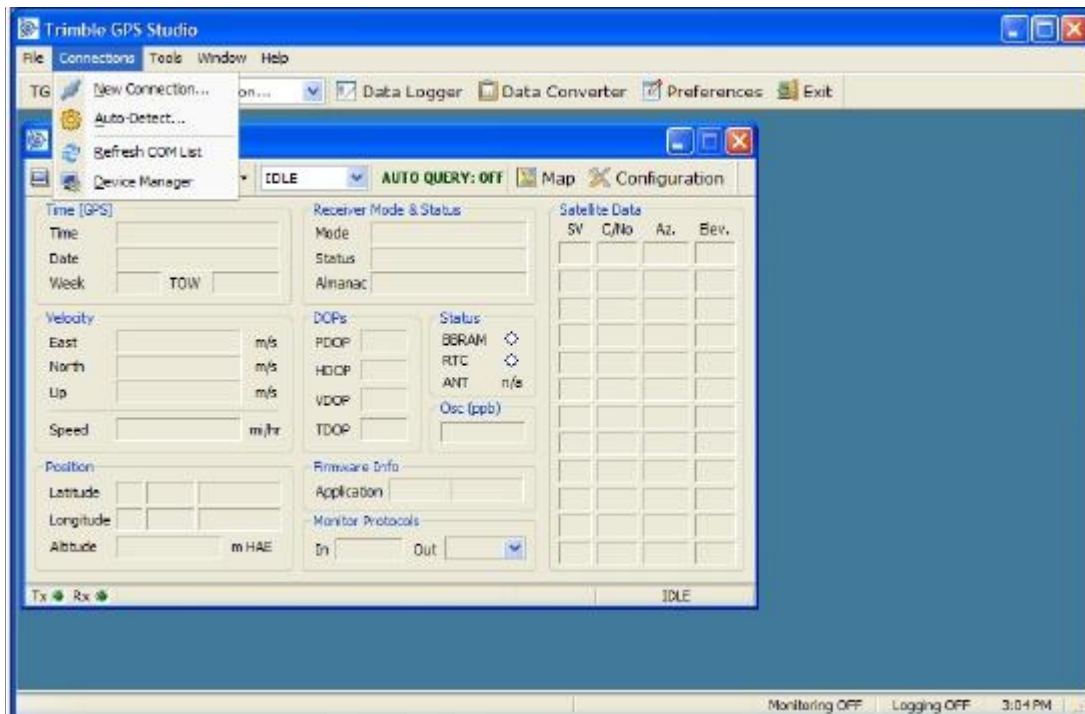
12. Set up the Trimble GPS Studio application as described in the next section.

## Setting up the software toolkit

The Trimble GPS Studio application is used to monitor GPS performance and to assist system integrators in developing a software interface for the GPS module. It runs on the Windows 2000/XP and Windows Vista platforms.

To use the Trimble GPS Studio application to monitor the receiver's performance:

1. Use the USB cable to connect the starter kit to the computer.
2. Download the Trimble GPS Studio application onto your computer's hard drive.
3. Start the Trimble GPS Studio application and then select *Connections / New Connection* from the main window menu bar:



4. In the *New Connection* dialog, select the correct COM port for Port B of the starter kit and then select the *Auto-detect settings* checkbox:



5. Click **OK**.

When the Trimble GPS Studio application has started communication with the receiver, a success message appears.

6. Connect a GPS antenna to the receiver. Once the receiver has a position fix, the following information appears:
  - position
  - time
  - satellites tracked
  - GPS receiver status



**Notes –**

*The receiver also sends a health report every few seconds, even if satellites are not being tracked.*

*By default, Port B is set to NMEA protocol, 9600 baud, 8 data bits, parity none, 1 stop bit, no flow control.*

*If there is no data in the Monitor window, or if some data fields remain blank for a long time, the GPS module may not be communicating with the computer. Check the interface cable connections again and verify the serial port selection and settings.*

# Features and Specifications

**In this chapter:**

- Key features
- Specifications
- Absolute maximum limits
- Recommended operating conditions
- ESD protection

This chapter describes the features and performance specifications of the Condor series GPS modules.

## Key features

The Condor family of value-optimized GPS modules includes different form factors and feature sets, allowing the system designer to choose the optimal module solution for a particular application.

The *Condor LC2101* and *LC210A* GPS modules are single-sided and are packaged in tape and reel for pick-and-place manufacturing processes: 28 reflow-solderable edge castellations provide an interface to your design without costly I/O and RF connectors.

The *Condor LC2201* is in a 38-pin QFN package, also in tape and reel for pick-and-place manufacturing. Each module is manufactured and factory tested to Trimble's high quality standards.

- . Dimensions:
  - Condor LC2101 and Condor LC210A :  
19 mm width x 19 mm length x 2.54 mm height
  - Condor LC2201:  
10 mm width x 11 mm length x 2.01 mm height
- . Pick-and-place assembly, tape and reel packaging, reflow solderable
- . No I/O or RF connector
- . Low power usage
- . World class tracking and acquisition sensitivity
- . Supports active and passive antenna designs
- . 22 tracking channels
- . Supports NMEA 0183 protocol
- . Carrier board and starter kit available
- . RoHS compliant (lead-free)

# Specifications

## Condor LC2101, Condor LC210A, and Condor LC2201 receiver performance

These are L1 frequency (1575.42 MHz), C/A code, 22-channel, continuous tracking receivers.

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<b>Update rate</b>	NMEA	1 Hz
<b>Accuracy (24 hour static)</b>	Horizontal (without SBAS)	<2.5 m 50%, <5 m 90%
	Horizontal (with SBAS)	<2.0 m 50%, <4 m 90%
	Altitude (without SBAS)	<5 m 50%, <8 m 90%
	Altitude (with SBAS)	<3 m 50%, <5 m 90%
	Velocity	0.06 m/sec
	PPS (static)	±25 ns 1 sigma
<b>Acquisition (autonomous operation)</b>	Reacquisition	<2 sec 50%
	Hot start	<2 sec 50%
	Warm start	35 sec 50%
	Cold start	38 sec 50%
<b>Sensitivity<sup>1</sup></b>	Tracking	-160 dBm
	Acquisition sensitivity	-146 dBm
<b>Operational</b>	Speed Limit	515 m/s

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<sup>1</sup>Results when the Condor LC2201 receiver is tested with an external low-noise amplifier (LNA).

## Interface

### Condor LC2101 and Condor LC210A

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<b>Connectors</b>	28 surface mount edge castellations
<b>Serial port</b>	1 UART, 2.8 VTTL compatible
<b>PPS</b>	2.8 VTTL compatible
<b>Protocols</b>	National Marine Electronics Association (NMEA) 0183

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### Condor LC2201

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<b>Connectors</b>	38 surface mount, quad flat no leads package
<b>Serial port</b>	1 UART, 2.8 VTTL compatible
<b>PPS</b>	2.8 VTTL compatible
<b>Protocols</b>	National Marine Electronics Association (NMEA) 0183

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## Physical

### Condor LC2101

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<b>Dimensions (W x L x H)</b>	19 mm x 19 mm x 2.54 mm
<b>Weight</b>	1.724 grams, including metal shield

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### Condor LC210A

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<b>Dimensions (W x L x H)</b>	19 mm x 19 mm x 2.54 mm
<b>Weight</b>	1.633 grams, including metal shield

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### Condor LC2201

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<b>Dimensions (W x L x H)</b>	10 mm x 11 mm x 2.01 mm
<b>Weight</b>	0.364 grams, including metal shield

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## Environmental

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<b>Operating temperature</b>	-40 °C to +85 °C
<b>Storage temperature</b>	-55 °C to +105 °C
<b>Vibration</b>	0.008 g <sup>2</sup> /Hz, 5 Hz to 20 Hz 0.05 g <sup>2</sup> /Hz, 20 Hz to 100 Hz -3 dB/octave, 100 Hz to 900 Hz
<b>Operating humidity</b>	5% to 95%, R.H., non-condensing, at +40 °C

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## Absolute maximum limits

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**CAUTION** – Absolute maximum ratings indicate conditions beyond which permanent damage to the device may occur. Electrical specifications do not apply when you are operating the device outside its rated operating conditions.

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### Condor LC2101 and Condor LC210A absolute maximum limits

Parameter		Min	Max	Unit
Power supply	Power supply voltage (Vcc) on Pin 12	-0.3	3.6	V
	Standby voltage (Vcc) on Pin 12 *	-0.3	3.6	V
Antenna	Input power at RF input		+10	dBm

### Condor LC2201 absolute maximum limits

Parameter		Min	Max	Unit
Power supply	Power supply voltage (Vcc) on Pin 15, 24, and 32	-0.3	3.6	V
	Standby voltage (Vcc) on Pin 4	-0.3	3.6	V
Antenna	Input power at RF input		+10	dBm

### Condor LC2101 and Condor LC210A Input/Output pin threshold voltages

Parameter	Status	Min	Max	Unit
Input pin voltage (RXD, Reserved Pins, RESET)	High	2.0	3.6	V
	Low	-0.3	0.8	V
Output pin voltage (TXD)	High (I <sub>oh</sub> = 1.6~14 mA)	2.4	V <sub>cc</sub>	V
	Low (I <sub>ol</sub> = 1.6~14 mA)	-0.3	0.4	V

### LC2201 Input/Output pin threshold voltages

Parameter	Status	Min	Max	Unit
Input pin voltage (RXD, Reserved Pins, RESET, STANDBY)	High	2.0	3.6	V
	Low	-0.3	0.8	V
Output pin voltage (TXD)	High (I <sub>oh</sub> = 1.6~14 mA)	2.4	V <sub>cc</sub>	V
	Low (I <sub>ol</sub> = 1.6~14 mA)	-0.3	0.4	V

## Recommended operating conditions

Minimum and maximum limits apply over the full operating temperature range unless otherwise noted.

### Condor LC2101 recommended operating conditions

Parameter	Conditions	Min	Typical	Max	Unit
<b>Primary supply voltage</b>		3.0		3.6	V
<b>Current draw, continuous tracking</b>	Maximum: 85 °C, 3.6 V Minimum: -40 °C, 3.0 V Typical: 25 °C, 3.3 V	31	37	42	mA
<b>Power consumption, continuous tracking</b>	Maximum: 85 °C, 3.6 V Minimum: -40 °C, 3.0 V Typical: 25 °C, 3.3 V	93.00	122.10	151.20	mW
<b>Current draw</b>	Typical: 20 °C				
Standby mode with $V_{rtc} = 2.96$ V $V_{rtc}$ applied			5		uA
Standby mode using $V_{cc} = 3.3$ V serial command			2.42		mA
<b>Supply ripple noise</b>	1 Hz to 1 MHz			50	mV <sub>pp</sub>
	GPS TCXO frequency $\pm 5$ kHz			1	mV <sub>pp</sub>
<b>Hardware RESET</b>	Assert RESET pin to clear STANDBY memory.	100			ms
<b>Input gain at RF input</b>		0 (passive antenna)		25	dB
<b>External LNA noise</b>				2	dB

### Condor LC210A recommended operating conditions

Parameter	Conditions	Min	Typical	Max	Unit
<b>Primary supply voltage</b>		3.0		3.6	V
<b>Current draw, continuous tracking</b>	Maximum: 85 °C, 3.6 V Minimum: -40 °C, 3.0 V Typical: 25 °C, 3.3 V	31	37	42	mA
<b>Power consumption, continuous tracking</b>	Maximum: 85 °C, 3.6 V Minimum: -40 °C, 3.0 V Typical: 25 °C, 3.3 V	93.00	122.10	151.20	mW
<b>Current draw</b>	Typical: 20 °C				
Standby mode with $V_{rtc} = 2.96$ V $V_{rtc}$ applied			5		uA
Standby mode using $V_{cc} = 3.3$ V serial command			2.42		mA
<b>Supply ripple noise</b>	1 Hz to 1 MHz			50	mV <sub>pp</sub>
	GPS TCXO frequency $\pm 5$ kHz			1	mV <sub>pp</sub>

Parameter	Conditions	Min	Typical	Max	Unit
Hardware RESET	Assert RESET pin to clear STANDBY memory.	100			ms
RTC input	The Condor LC210A GPS module must have an RTC signal on pin 17.		Frequency: 32.768 kHz Amplitude: 1.5 V		
Input gain at RF input		0 (passive antenna)		25	dB
External LNA noise				2	dB

### Condor LC2201 recommended operating conditions

Parameter	Conditions	Min	Typical	Max	Unit
Primary supply voltage		3.0		3.6	V
Current draw, continuous tracking	Maximum: 85 °C, 3.6 V Minimum: -40 °C, 3.0 V Typical: 25 °C, 3.3 V	31	33	42	mA
Power consumption, continuous tracking	Maximum: 85 °C, 3.6 V Minimum: -40 °C, 3.0 V Typical: 25 °C, 3.3 V	93.00	122.10	151.20	mW
Current draw	Typical: 20 °C				
Standby mode with $V_{rtc} = 2.96$ V $V_{rtc}$ applied			5		uA
Standby mode using $V_{cc} = 3.3$ V serial command			2.42		mA
Standby mode using $V_{cc} = 3.3$ V STANDBY pin			840		uA
Supply ripple noise	1 Hz to 1 MHz GPS TCXO frequency $\pm 5$ kHz			50	mV <sub>pp</sub>
Hardware RESET	Assert RESET pin to clear STANDBY memory.	100			ms
RTC input	RTC signal on pin 2 from either an XTAL or buffered clock.		32.768		kHz
Input gain at RF input		17		25	dB
External LNA noise				2	dB

### ESD protection

ESD testing was performed using test standard IEC 1000-4-2. All inputs and outputs are protected to  $\pm 500$  V ESD level.

The RF IN pin is protected up to 1 kV. If you require a higher level of compliance, you must add additional electrostatic and surge protection.

## Interface Characteristics

**In this chapter:**

- Condor LC2101 pin assignments
- Condor LC210A pin assignments
- Condor LC2201 pin assignments

This chapter provides a detailed description of the Condor GPS receiver interface.

## Condor LC2101 pin assignments

GND	1		28	GND
GND	2		27	GND
RF_in	3		26	Reserved
GND	4		25	Reserved
Reserved	5		24	TXD
Vrtc	6		23	Reserved
Reserved	7		22	Reserved
Reserved	8		21	Reserved
Reserved	9		20	RXD
Reserved	10		19	PPS
RESET	11		18	Reserved
Vcc	12		17	Reserved
GND	13		16	Reserved
GND	14		15	GND

### Pin description

Pin	Name	Description	Function	Note
1	GND	Ground	Ground	Connect to common ground.
2	GND	Ground	Ground	Connect to common ground.
3	RF_in	GPS RF input	Input	50 $\Omega$ unbalanced (coaxial) RF input.
4	GND	Ground	Ground	Connect to common ground.
5	Reserved	Reserved		Do not connect
6	Vrtc	RTC backup power	Input	2.0 V to Vcc. Always connect to battery or Vcc.
7	Reserved	Reserved		Do not connect.
8	Reserved	Reserved		Do not connect.
9	Reserved	Reserved		Do not connect.
10	Reserved	Reserved		Do not connect.
11	RESET	System reset	Input	100 ms active low. Do not connect if not used.
12	Vcc	Main power	Input	3.0 V to 3.6 V, typical 3.3 V.
13	GND	Ground	Ground	Connect to common ground.
14	GND	Ground	Ground	Connect to common ground.
15	GND	Ground	Ground	Connect to common ground.
16	Reserved	Reserved		Do not connect.
17	Reserved	Reserved		Do not connect.
18	Reserved	Reserved		Do not connect.
19	PPS	Pulse per second	Output	1 Hz timing pulse. Do not connect if not used.
20	RXD	UART Receive	Input	TTL logic level serial port receive.
21	Reserved	Reserved		Do not connect.
22	Reserved	Reserved		Do not connect.
23	Reserved	Reserved		Do not connect.
24	TXD	UART Transmit	Output	TTL Logic level serial port transmit.
25	Reserved	Reserved		Do not connect.

Pin	Name	Description	Function	Note
26	Reserved	Reserved		Do not connect.
27	GND	Ground	Ground	Connect to common ground.
28	GND	Ground	Ground	Connect to common ground.

## Detailed pin descriptions

### RF\_in pin

The RF input pin is the 50  $\Omega$  unbalanced GPS RF input, and can be used with active or passive antennas.

Refer to the application designs for examples of antenna power circuits.

### Vrtc pin

Supply can range from 2.0 V to Vcc. Maintains non-volatile RAM and the RTC for hot and warm starts.

### Vcc pin

This is the primary voltage supply pin for the module.

### PPS pin

Pulse-per-second. This logic level output provides a 1 Hz timing signal to external devices. The pulse width of this signal is 4  $\mu$ s.

### RXD pin

This logic level input is the serial port receive line (data input to the module). The baud rate for the port is not user-configurable.

### TXD pin

This logic level output is the serial port transmit line (data output from the module). The baud rate for the port is not user-configurable.

### Reserved pins

There are several reserved pins on the Condor LC2101 GPS module. Do not connect these pins.

## Protocols

NMEA 0183 is available on the Condor LC2101 GPS module.

## Serial port default settings

The Condor LC2101 GPS module supports two serial ports. The default settings are as follows:

Port direction	Pin #	Protocol	Characteristics				
			Baud rate	Data bits	Parity	Stop bits	Flow control
TXD	24	NMEA out	9600	8	None	1	None
RXD	20	NMEA in	9600	8	None	1	None

- Baud rate, data bits, parity, and stop bits are user configurable.
- Flow control is not available on the serial ports.

A detailed description of the protocol is given in [Appendix A, NMEA 0183 Protocol](#).



## Condor LC210A pin assignments

GND	<b>1</b>		<b>28</b>	GND
GND	<b>2</b>		<b>27</b>	GND
RF_in	<b>3</b>		<b>26</b>	Reserved
GND	<b>4</b>		<b>25</b>	Reserved
Reserved	<b>5</b>		<b>24</b>	TXD
Vrtc	<b>6</b>		<b>23</b>	Reserved
Reserved	<b>7</b>		<b>22</b>	Reserved
Reserved	<b>8</b>		<b>21</b>	Reserved
Reserved	<b>9</b>		<b>20</b>	RXD
Reserved	<b>10</b>		<b>19</b>	PPS
RESET	<b>11</b>		<b>18</b>	Reserved
Vcc	<b>12</b>		<b>17</b>	RTC_CLK
GND	<b>13</b>		<b>16</b>	Reserved
GND	<b>14</b>		<b>15</b>	GND

### Pin description

Pin	Name	Description	Function	Note
1	GND	Ground	Ground	Connect to common ground.
2	GND	Ground	Ground	Connect to common ground.
3	RF_in	GPS RF input	Input	50 $\Omega$ unbalanced (coaxial) RF input.
4	GND	Ground	Ground	Connect to common ground.
5	Reserved	Reserved		Do not connect.
6	Vrtc	RTC backup power	Input	2.0 V to Vcc. Always connect to battery or Vcc.
7	Reserved	Reserved		Do not connect.
8	Reserved	Reserved		Do not connect.
9	Reserved	Reserved		Do not connect.
10	Reserved	Reserved		Do not connect.
11	RESET	System reset	Input	100 ms active low. Do not connect if not used.
12	Vcc	Main power	Input	3.0 V to 3.6 V, typical 3.3 V.
13	GND	Ground	Ground	Connect to common ground.
14	GND	Ground	Ground	Connect to common ground.
15	GND	Ground	Ground	Connect to common ground.
16	Reserved	Reserved		Do not connect.
17	RTC_CLK	32 kHz RTC input	Input	Real Time Clock input.
18	Reserved	Reserved		Do not connect.
19	PPS	Pulse per second	Output	1 Hz timing pulse. Do not connect if not used.
20	RXD	UART Receive	Input	TTL logic level serial port receive.
21	Reserved	Reserved		Do not connect.
22	Reserved	Reserved		Do not connect.
23	Reserved	Reserved		Do not connect.
24	TXD	UART Transmit	Output	TTL logic level serial port transmit.
25	Reserved	Reserved		Do not connect.

Pin	Name	Description	Function	Note
26	Reserved	Reserved		Do not connect.
27	GND	Ground	Ground	Connect to common ground.
28	GND	Ground	Ground	Connect to common ground.

## Detailed pin descriptions

### RF\_in pin

The RF input pin is the 50Ω unbalanced GPS RF input, and can be used with active or passive antennas.

Refer to the application designs for examples of antenna power circuits.

### Vrtc pin

Supply can range from 2.0 V to Vcc. Maintains non-volatile RAM and the RTC for hot and warm starts.

### RESET pin

Connects to the host system reset controller or GPIO for host controlled resetting of the GPS module.

### RTC\_CLK pin

A clock signal at 1.2–1.5 V logic levels capable of driving the Condor LC210A GPS module RTC. The limits are 0 V through 2.0 V on this input. Best results are achieved with a sine wave.

### VCC pin

This is the primary voltage supply pin for the module.

### PPS pin

Pulse-per-second. This logic level output provides a 1 Hz timing signal to external devices. The pulse width of this signal is 4 us.

### RXD pin

This logic level input is the serial port receive line (data input to the module). The baud rate for the port is not user-configurable.

### TXD pin

This logic level output is the serial port transmit line (data output from the module). The baud rate for the port is not user-configurable.

## Reserved pins

There are several reserved pins on the Condor LC210A GPS module. Do not connect these pins.

## Protocols

NMEA 0183 is available on the Condor LC210A GPS module.

## Serial port default settings

The Condor LC210A GPS module supports one serial port. The default settings are as follows:

Port direction	Pin #	Protocol	Characteristics				
			Baud rate	Data bits	Parity	Stop bits	Flow control
TXD	24	NMEA out	9600	8	None	1	None
RXD	20	NMEA in	9600	8	None	1	None

- Baud rate, data bits, parity, and stop bits are user configurable.
- Flow control is not available on the serial ports.

A detailed descriptions of the protocol is given in [Appendix A, NMEA 0183 Protocol](#).

# Condor Carrier Board

**In this chapter:**

- Condor carrier board
- Connectors
- Serial interface
- Pulse-per-second (PPS)
- Mounting
- GPS antenna
- Mechanical specification

## Condor carrier board



## Connectors

### Digital IO/Power connector

The Condor carrier board GPS receiver uses a single 8-pin (2x4) male header connector for both power and data I/O. The power and I/O connector, J4, is a surface mount micro terminal strip. This connector uses 3.2 mm (0.126 inch) high pins on 2 mm (0.079 inch) spacing.

The manufacturer of this connector is Samtec, part number TMM104-01-T-D-SM.

### Mating connectors

A surface mount mating connector from those specified by Samtec as compatible to Samtec part number TMM-104-01-T-D-SM is recommended.

### RF connector

The RF connector mounted on the Condor carrier board receiver is a right-angle MCX.

## Antenna options

Trimble offers a 3.3 V DC mini magnetic or unpackaged ultra-compact antenna and cable for use with the Condor GPS module.

## Digital IO/Power connector pin-out

The digital IO/Power connector pin-out information is provided below:

Pin	Number	Function	Description
1		TXD	UART transmit, 2.8 V TTL
2		Prime power input	3.0 V DC to 3.6 V DC
3		Reserved	Do not connect
4		V <sub>rtc</sub>	The RTC backup supply, 2.0 V DC to V <sub>cc</sub>
5		Reserved	Do not connect
6		1 PPS	One Pulse-Per-Second, 2.8 V TTL
7		RXD	UART receive, 2.8 V TTL
8		GND	Ground, power, and signal

## Serial interface

The Condor GPS module provides direct TTL-compatible serial I/O. The RX and TX signals on the J4 I/O connector are driven directly by the UART on the Condor module. Interfacing these signals directly to a UART in your application circuitry provides direct serial communication without the complication of RS-232 or RS-422 line drivers.

## Pulse-per-second (PPS)

The Condor GPS timing receiver provides a 4  $\mu$ s wide, TTL-compatible Pulse-Per-Second (PPS). The PPS is a positive pulse available on pin 6 of the power and I/O connector.

## Mounting

There are four mounting holes at the corners of the PCB that accept  $3/16$ " hex or round standoffs with a  $3/8$ " height, and #2-2-56 or M2 mounting screws. Space-constrained environments may require a different standoff.

## GPS antenna

Trimble offers the following two antenna options for use with the Condor GPS module:

- A 3.3 VDC unpackaged ultra-compact antenna.

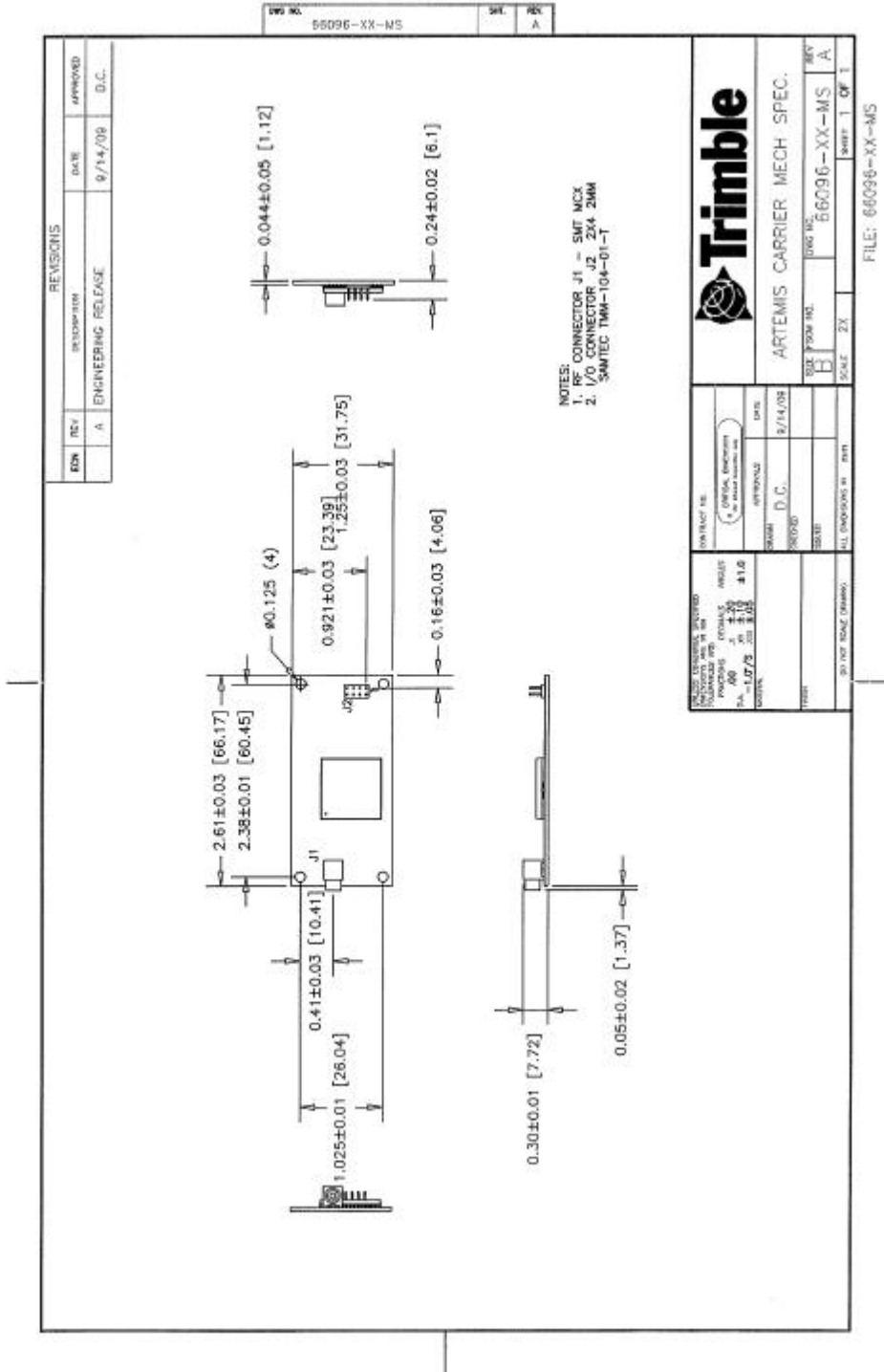


- A magnetic mount antenna:



The antenna receives the GPS satellite signals and passes them to the receiver. The GPS signals are spread-spectrum signals in the 1575 MHz range and do not penetrate conductive or opaque surfaces. Therefore, the antenna must be located outdoors with a clear view of the sky.

# Mechanical specification



REV NO. 66096-XX-MS SHEET NO. 1 REV. A

REVISIONS			
REV	DESCRIPTION	DATE	APPROVED
A	ENGINEERING RELEASE	9/14/09	D.C.

ARTEMIS CARRIER MECH SPEC.	
DATE: 9/14/09	REV: 1
SIZE: 2X	SCALE: 1 OF 1
FILE: 66096-XX-MS	
APPROVED BY: D.C.	DATE: 9/14/09
SKETCHED BY: D.C.	
CHECKED BY: D.C.	
ALL DIMENSIONS IN: mm	
3D FILE NAME: 66096-XX-MS	
PARTIAL DATA IS NOT TO BE USED FOR MANUFACTURING PURPOSES. DIMENSIONS ARE GIVEN IN MILLIMETERS UNLESS OTHERWISE SPECIFIED. DIMENSIONS ARE GIVEN IN INCHES UNLESS OTHERWISE SPECIFIED. DIMENSIONS ARE GIVEN IN MILLIMETERS UNLESS OTHERWISE SPECIFIED.	DIMENSIONS ARE GIVEN IN MILLIMETERS UNLESS OTHERWISE SPECIFIED. DIMENSIONS ARE GIVEN IN INCHES UNLESS OTHERWISE SPECIFIED. DIMENSIONS ARE GIVEN IN MILLIMETERS UNLESS OTHERWISE SPECIFIED.



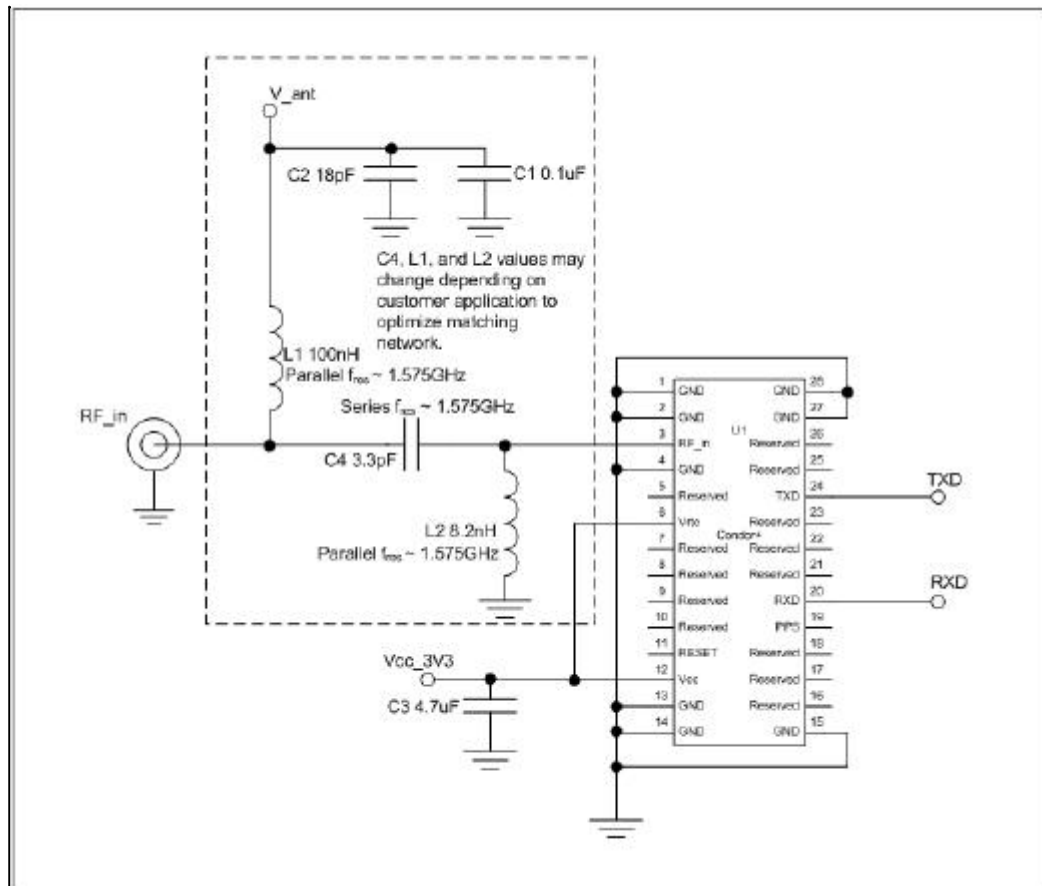
# Application Circuits

## In this chapter:

- ▣ Condor LC2101 GPS module with an active antenna
- ▣ Condor LC2101 GPS module with a passive antenna
- ▣
- ▣
- ▣

This chapter describes the Condor GPS module with different antenna connections.

## Condor LC2101 GPS module with an active antenna



In the schematic:

- The RESET pin is not used and is left disconnected.
- Battery backup for the RTC is not used and is tied to Vcc.
- RTC\_out is not used and is left disconnected.
- The PPS output pin is not used and is left disconnected.
- Do not connect reserved pins.
- The external LNA gain range is 17 dB ~ 25 dB.

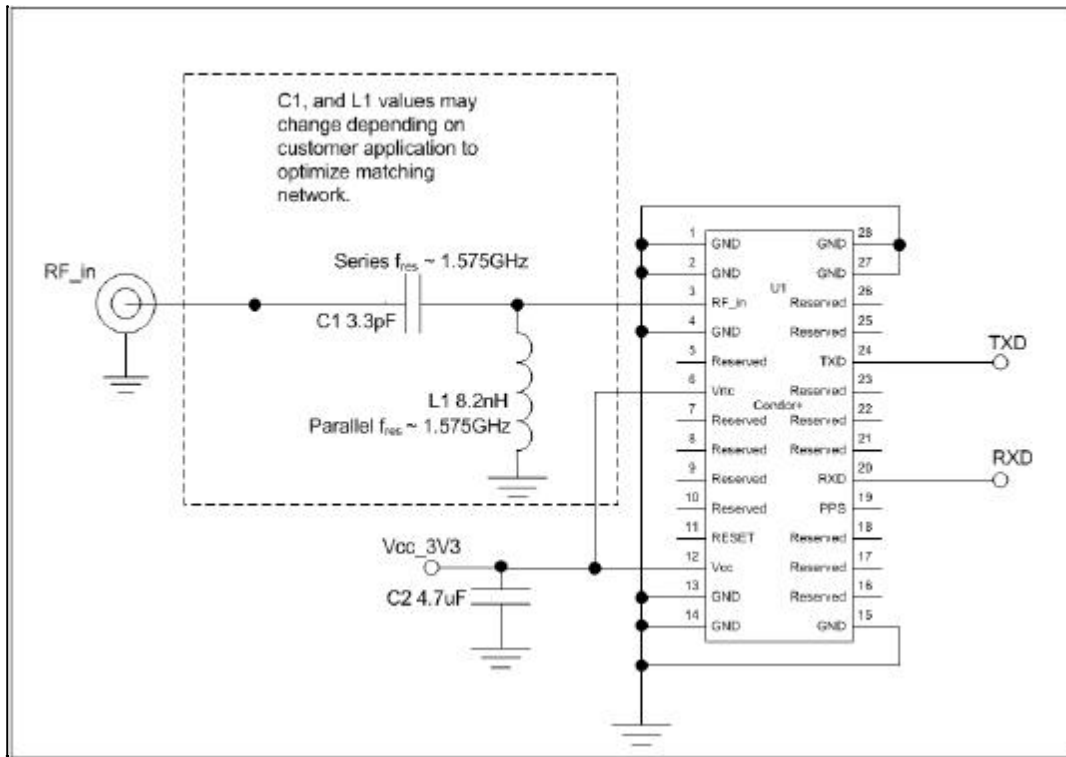
You can optimize the values of L2 and C4 by applying a GPS signal from a simulator and adjusting the component values (up and down) to determine the best combination that provides the maximum displayed C/N value from the constant-level GPS signal. Alternatively, use a network analyzer to optimize the input return loss.

For more information on PCB layout and tuning, see [Chapter 6, RF Layout Considerations](#).

The following table shows the component information:

Component	Description	Manufacturer	Part Number
C1	0.1 $\mu$ F, 0402 capacitor	CAL-CHIP	GMC04X7R104K16NTLF
C2	18 pF, 0402 capacitor	KEMET	C0402C180J5GAC
C3	4.7 $\mu$ F, 0603 capacitor	Panasonic	ECJ-1VB0J475M
C4	3.3 pF, 0402 capacitor	KEMET	C0402C339C5GACTU
L1	100 nH, 0603 inductor, surface mount	Coil Craft	0603CS-R10XJLU
L2	8.2 nH, 0402 inductor, surface mount	Panasonic	ELJRF8N2ZFB
U1	Conдор LC2101 GPS module	Trimble	2S52D-BV
J1	MCX connector	Tyco	1A65227-1

## Condor LC2101 GPS module with a passive antenna



In the schematic:

- The RESET pin is not used and is left disconnected.
- Battery backup for the RTC is not used and is tied to Vcc.
- The PPS output pin is not used and is left disconnected.
- Do not connect reserved pins.

You can optimize the values of L1 and C1 by applying a GPS signal from a simulator and adjusting the component values (up and down) to determine the best combination that provides the maximum displayed C/N value from the constant-level GPS signal. Alternatively, use a network analyzer to optimize the input return loss.

For more information on PCB layout and tuning, see [Chapter 6, RF Layout Considerations](#).

The following table shows the component information:

Component	Description	Manufacturer	Part Number
C1	3.3 pF, 0402 capacitor	KEMET	C0402C339C5GACTU
C2	4.7 $\mu$ F, 0603 capacitor	Panasonic	ECJ-1VB0J475M
L1	8.2 nH, 0402 inductor, surface mount	Panasonic	ELJRF8N2ZFB
U1	Condor LC2101 GPS module	Trimble	2S52D-BV
J1	MCX connector	Tyco	1A62427-1

# RF Layout Considerations

**In this chapter:**

- General recommendations
- Design considerations for RF track topologies
- PCB considerations

This chapter outlines RF design considerations for the layout of the Condor GPS receiver.

## General recommendations

The design of the RF transmission line that connects the GPS antenna to the Condor module is critical to system performance. If the overall RF system is not implemented correctly, the Condor module performance may be degraded.

The radio frequency (RF) input on the Condor module is  $50\ \Omega$ , unbalanced. There are ground castellations (pins 2 and 4) on both sides of the RF input castellation (pin 3). This RF input may be connected to the output of an LNA that has a GPS antenna at its input, or to a passive antenna through a low-loss  $50\ \Omega$ , unbalanced transmission line system.

If the GPS antenna needs to be located at a significant distance from the Condor module, the use of an LNA at the antenna location is necessary to overcome the transmission losses from the antenna to the Condor module. Trimble recommends that, in the case of a passive antenna, the transmission line losses from the antenna to the module be less than 2 dB. Otherwise, add an LNA to the system.

Determine the specifications for the external LNA as follows:

- The specification of noise figure for the Condor LC2101 or Condor LC210A GPS module is 3 dB at room temperature and 4 dB over the temperature range  $-40\ ^\circ\text{C}$  to  $\pm 85\ ^\circ\text{C}$ .
- The specification of noise figure for the Condor LC2201 GPS module is 7 dB at room temperature and 8 dB over the temperature range  $-40\ ^\circ\text{C}$  to  $\pm 85\ ^\circ\text{C}$ .
- The noise figure for the external LNA should be as low as possible, with a recommended maximum of 1.5 dB. Trimble recommends that the gain of the LNA exceeds the loss that is measured from the LNA output to the module input by 7 dB. For example, if the loss from the external LNA output is 7 dB, the recommended minimum gain for the LNA is 27 dB. In order to keep losses at the LNA input to a minimum, Trimble recommends that you connect the antenna directly to the LNA input, to ensure the minimum loss.
- To connect to the LNA output or to a passive antenna, use a  $50\ \Omega$ , unbalanced transmission system. This transmission system may take any form, such as microstrip, coaxial, stripline, or any other  $50\ \Omega$  characteristic impedance unbalanced, low-loss system.

You must keep noise sources with frequencies at or near 1575 MHz away from the RF input. In the case of a passive antenna, make sure that the antenna is not placed in a noisy location (such as too close to digital circuitry) as performance may be degraded. You can use a shielded transmission line system (stripline, coaxial) to route the signal if noise ingress is a concern.

When using an active antenna and if you want to power this antenna from the RF transmission line, you will need a bias-tee connector at the Condor module end. A simple series inductor (parallel resonant at 1575 MHz), and shunt capacitor (series resonant at 1575 MHz) to which the bias voltage is supplied is sufficient.

In the printed circuit board (PCB) layout, Trimble recommends that you keep the copper layer on which the Condor module is mounted clear of solder mask and copper (vias or traces) under the module. This is to ensure mating of the castellations between the Condor module and the board to which it is mounted, and to ensure that there is no interference with features beneath the Condor module that may cause it to lift during the reflow solder process.

For a microstrip RF-transmission line topology, Trimble recommends that the layer immediately below the one to which the Condor module is mounted is ground plane:

- For the Condor LC2101 or Condor LC210A modules, pins 2 and 4 should be directly connected to the ground plane with low inductance connections.
- For the Condor LC2201 module, pins 17 and 19 should be directly connected to the ground plane with low inductance connections.
- Pin 3, the RF input, can be routed on the top layer using the proper geometry for a  $50\ \Omega$  system.

## Design considerations for RF track topologies

You must take the following into consideration when designing the RF layout for the Condor module:

- The PCB track connection to the RF antenna input must:
  - Have a  $50\ \Omega$  impedance.
  - Be as short as possible.
  - Be routed away from potential noise sources such as oscillators, transmitters, digital circuits, switching power supplies, and other sources of noise.
  - Transition from the circuit board to the external antenna cable, which is typically a RF connector, if an external antenna is used.
- The PCB track connection to the RF antenna input must not have:
  - Sharp bends.
  - Components overlaying the track.
  - Routing between components (to avoid undesirable coupling).
- RF and bypass grounding must be direct to the ground plane through its own low-inductance via.
- You can use an active or a passive antenna. If you use a passive antenna, the connection to the antenna input must be very short.
- You can mount a patch antenna on the same PCB as the Condor module. Designers must be aware of noise-generating circuitry and must take proper design precautions (for example, shielding).

- If there are any ground planes on the same layer as the microstrip trace, refer to the Coplanar Waveguide design. ***This aspect is not covered in this manual.***
- As a general help to prevent radiation and coupling, it helps to think of voltages and currents as electrical and magnetic fields. The electric field forms ***between*** a positive and negative charge. The magnetic field forms ***around*** a trace with current flow. You can minimize the radiation by keeping the fields under control, which means minimizing the area in which the fields form out and by separating areas with stronger fields.
- Keep the path of supply currents and their GND return currents as close as possible together. The same applies for signal currents and their GND return currents.
- Keep signal traces, which are likely to interfere with each other, apart and separate them with GND areas.
- Route supply traces and their corresponding GND return paths to separate functional blocks with separate traces and connect them only at the feed point.
- Have at least one uninterrupted GND plane on or in your PCB. The GND plane should be separated by functional blocks, but within a functional block, do not route signals across the GND plane. Route signals on another layer.

Signal traces on a GND plane can block the way for GND return currents thereby opening up current loops and increase radiation. Even worse, slots in a GND plane can act as a slot-antenna structure and radiate or receive radiation on the resonating frequency.

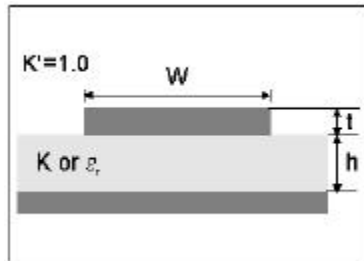
- Surround the PCB edges with GND on top and bottom and stitch them together with many vias. This reduces edge radiation from traces nearby the PCB edge. On a PCB with separated GND planes, do the same on every GND area to prevent radiation from one area into another.
- Do not route signal traces across the borders of GND areas. Route them first to the GND star point and from there back to another GND area. Thereby you reduce GND coupling between the functional groups and you reduce the size of the current loop thereby reducing radiation.
- In digital circuits, lower the rising time of edges if possible. Fast rising edges (sharp square wave signals) generate many harmonics at higher frequencies. Lowering the rising time of digital outputs at the source, for example by inserting series resistors near digital output pins of ICs, will reduce the generated harmonics and thereby reduce the radiation of high frequencies.
- Always aim to minimize the sources of radiation. It is much easier and less costly to not generate radiation than trying to get rid of radiation by shielding.



## PCB considerations

The minimum implementation is a two-layer PCB substrate with all the RF signals on one side and a solid ground plane on the other. You may also use multilayer boards. Two possible RF transmission line topologies include microstrip and stripline.

### Microstrip transmission lines



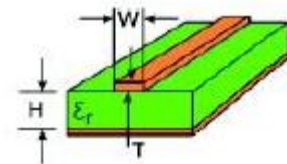
### Ground plane design recommendation

Use a complete ground plane immediately under the PCB layer on which the Condor GPS module is mounted. On the same layer as the module, flood or “copper pour” around the signal tracks and then connect to the ground plane using low inductance vias. A single ground plane is adequate for both analog and digital signals.

### Designing a microstrip transmission line

Use a  $50\ \Omega$  unbalanced transmission system for connections to the LNA output. The following PCB parameters affect impedance:

- Track width ( $W$ )
- PCB substrate thickness ( $H$ )
- PCB substrate permittivity ( $\epsilon_r$ )
- PCB copper thickness ( $T$ ) and proximity of same layer ground plane (to a lesser extent)



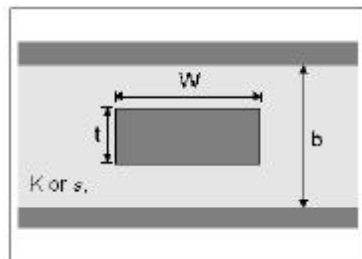
The following table shows typical track widths for an FR4 material PCB substrate (permittivity  $\epsilon_r$  of 4.6 at 1.5 GHz) and different PCB thickness. The thickness of the top layer is assumed as being one ounce copper. If using a multi-layer PCB, the thickness is the distance from the signal track to the nearest ground plane.

Substrate material	Permittivity	Substrate thickness H (mm)	Track width W (mm)
FR4	4.6	1/6	2.91
		1.2	2.12
		1.0	1.81
		0.8	1.44
		0.6	1.07
		0.4	0.71
		0.2	0.34

### Microstrip design recommendations

Trimble recommends that the antenna connection PCB track is routed around the outside of the module outline, kept on a single layer, and has no bends greater than 45 degrees. For production reasons, Trimble recommends that you do not route the track under the module.

### Stripline transmission lines



### Ground plane design recommendation

The stripline topology requires three PCB layers: two for ground planes and one for signal. One of the ground plane layers may be the layer to which the Condor GPS module is mounted. If this is the case:

- The top layer must be flooded with ground plane and connected to all ground castellations on the Condor module.
- The RF input should be connected to the signal layer below using a via.
- The layer below the signal layer is the second ground plane.
- Connect the two ground planes with vias, typically adjacent to the signal trace.
- Other signals of the Condor module may be routed to additional layer using vias.

For the symmetric strip line topology where the signal trace is an equal distance from each ground plane, the following applies:

Substrate material	Permittivity	Substrate thickness H (mm)	Track width W (mm)
FR4	4.6	1.6	0.631
		1.2	0.438
		1.0	0.372
		0.8	0.286
		0.6	0.2
		0.4	0.111
		0.2	N/A

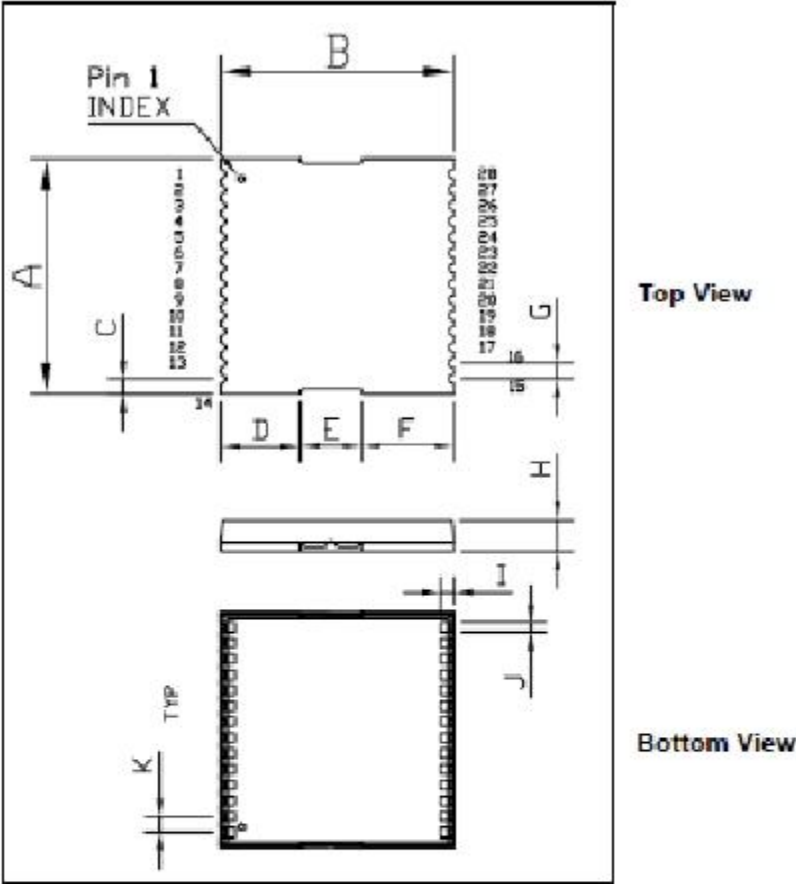
# Mechanical Specifications

**In this chapter:**

- ▣ Condor LC2101 and Condor LC210A modules—mechanical outline drawing
- ▣ Soldering a Condor LC2101 or Condor LC210A module to a printed circuit board
- ▣
- ▣

This chapter provides product drawings and instructions for soldering the Condor GPS receiver to a printed circuit board.

# Condor LC2101 and Condor LC210A modules—mechanical outline drawing



Condor GPS receiver, footprint

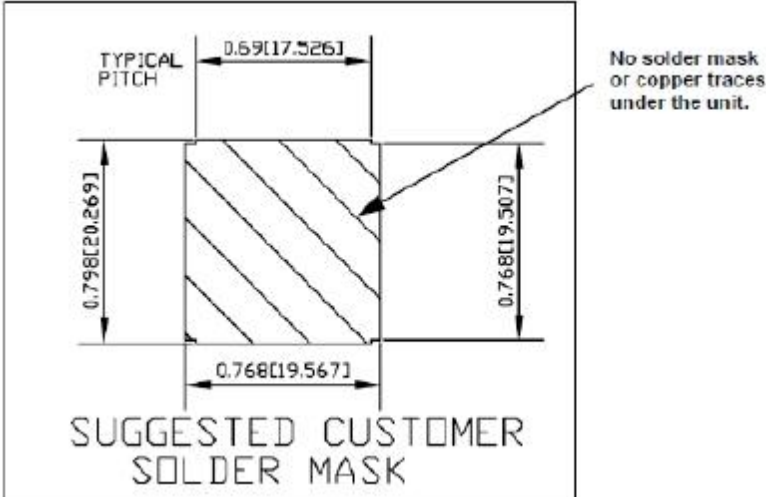
Outline Dimensions ( Inch  $\pm 0.004$  / mm  $\pm 0.10$  )

A	B	C	D	E	F	G	H	I	J	K
0.75	0.75	0.049	0.256	0.197	0.295	0.050	0.100	0.045	0.030	0.050
19.00	19.00	1.25	6.50	5.00	7.50	1.27	2.54	1.14	0.76	1.27

# Soldering a Condor LC2101 or Condor LC210A module to a printed circuit board

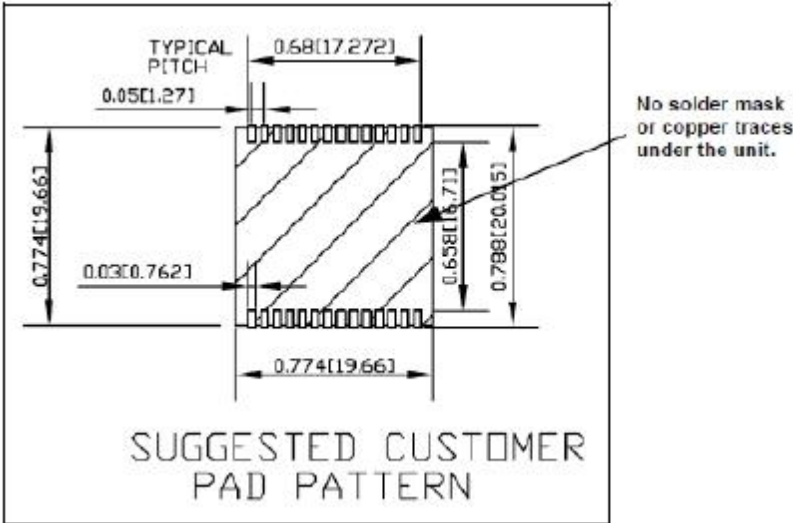
## Solder mask

When soldering the Condor module to a PCB, keep an open cavity underneath the Condor module (that is, do not place copper traces or solder mask underneath the module). The diagram below illustrates the required solder mask.



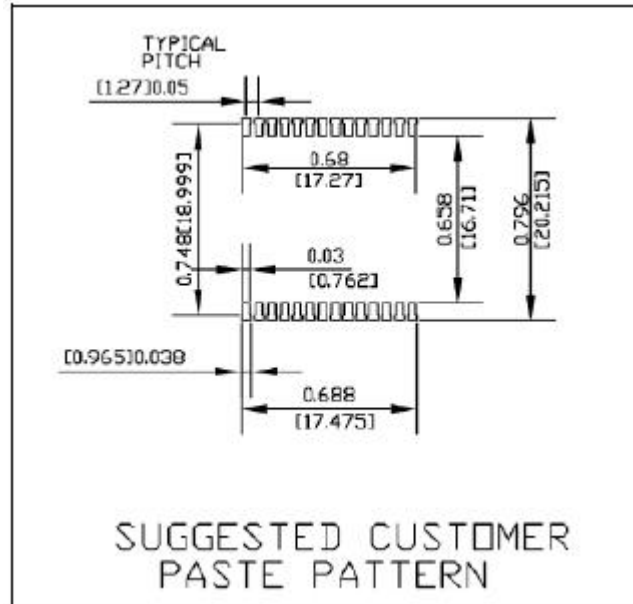
## Pad pattern

The required user pad pattern is shown below.



## Paste mask

To ensure good mechanical bonding with sufficient solder to form a castellated solder joint, use a solder mask ratio of 1:1 with the solder pad. When using a  $5 \pm 1$  mil stencil to deposit the solder paste, Trimble recommends a 4 mil toe extension on the stencil.



# Packaging

## In this chapter:

- ▣ Introduction
- ▣ Reel
- ▣

Follow the instructions in this chapter to ensure the integrity of the packaged and shipped Condor GPS receiver modules.



## Introduction

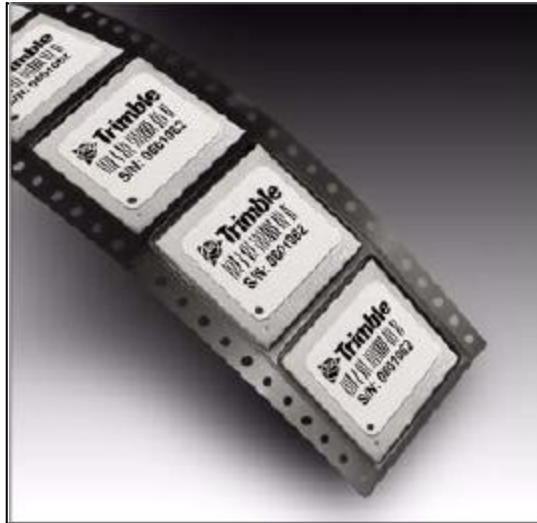
The Condor GPS modules are packaged in tape and reel for mass production.

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**CAUTION** – The reel is sealed in a moisture proof Dry Pac bag. Please follow all the directions printed on the package for handling and baking.

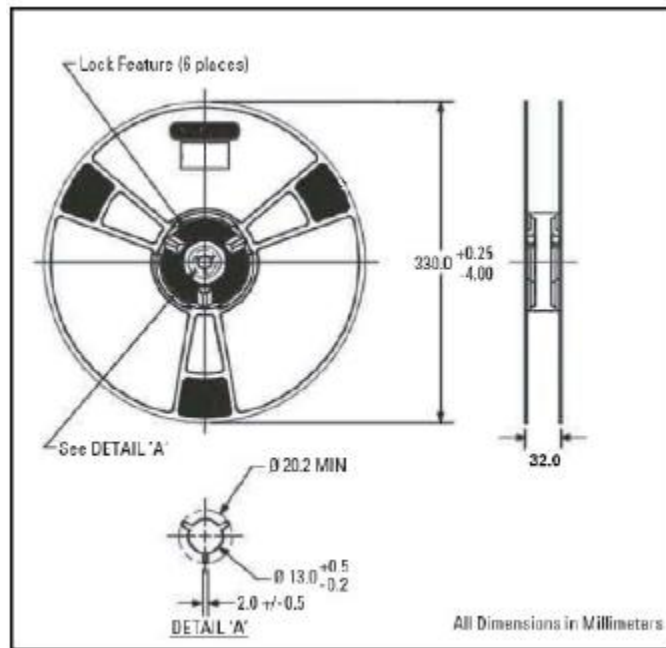
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The Condor GPS modules are packaged in a reel with 100 or 500 pieces.



## Reel

You can mount the 13-inch reel in a standard feeder for the surface mount pick and place machine.



## Weight

### Condor LC2101 and Condor LC210A modules

Description	Weight (approx)
100 pieces with reel packaging, desiccant, and humidity indicator	0.79 kg (1.74 lb.)
100 pieces with reel packaging, desiccant, humidity indicator, and brown pizza box	1.02 kg (2.25 lb.)
500 pieces with reel packaging, desiccant, and humidity indicator	1.47 kg (3.24 lb.)
500 pieces with reel packaging, desiccant, humidity indicator, and white pizza box	1.70 kg (3.74 lb.)

### Condor LC2201 modules

Description	Weight (approx)
100 pieces with reel packaging, desiccant, and humidity indicator	0.321 kg (0.7 lb.)
100 pieces with reel packaging, desiccant, humidity indicator, and brown pizza box	0.455 kg (1.00 lb.)
500 pieces with reel packaging, desiccant, and humidity indicator	0.457 kg (1.01 lb.)
500 pieces with reel packaging, desiccant, humidity indicator, and brown pizza box	0.592 kg (1.31 lb.)

# Shipping and Handling

## In this chapter:

- Shipping and handling guidelines
- Moisture precondition
- Baking procedure
- Soldering paste
- Solder reflow
- Recommended soldering profile
- Optical inspection
- Cleaning
- Soldering guidelines
- Rework
- Conformal coating
- Grounding the metal shield

This chapter provides detailed guidelines for shipping and handling the Condor GPS receiver to ensure compliance with the product warranty.

# Shipping and handling guidelines

## Handling

The Condor GPS module is shipped in tape and reel for use with an automated surface mount machine. This is a lead-free module with silver plating. Do not allow bodily fluids or lotions to come in contact with the bottom of the module.

---

**CAUTION** – The Condor GPS module is packed according to ANSI/EIA-481-B and JSTD-033A. All of the handling and precaution procedures must be followed. Deviation from the following handling procedures and precautions voids the warranty.

---

## Shipment

The reel of Condor GPS modules is packed in a hermetically sealed moisture barrier bag (DryPac) and then placed in an individual carton. Handle with care to avoid breaking the moisture barrier.

## Storage

The shelf life for the sealed DryPac is 12 months if stored at <40 °C and with <90% relative humidity.

## Moisture indicator

A moisture indicator is packed individually in each DryPac to monitor the environment—it has five indicator spots that are blue when the pack leaves the factory. If the indicator changes to pink, follow the instructions printed on the moisture barrier and bake as required.

## Floor life

The reel of Condor GPS modules is vacuum sealed in a moisture barrier bag (DryPac). Once the bag is opened, moisture will bond with the modules. In a production floor environment, an open reel needs to be processed within 72 hours, unless it is kept in a nitrogen-purged dry chamber. If the moisture indicator changes to pink, follow the baking instructions printed on the moisture barrier.

The Condor GPS module is a lead-free component and is RoHS compliant. This unit is also plated with immersion silver that makes soldering easier. The silver may tarnish over time and appear yellowish, but this should not affect the solderability.

---

**CAUTION** – Operators should not touch the bottom silver solder pads by hand or with contaminated gloves. Ensure that no hand lotion or regular chlorinated faucet water comes in contact with the module before soldering.

---

## Moisture precondition

You must take precautions to minimize the effects of the reflow thermal stress on the module. Plastic molding materials for integrated circuit encapsulation are hygroscopic and absorb moisture. This is dependent on the time and the environment.

Absorbed moisture will vaporize during the rapid heating of the solder reflow process, generating pressure to all the interface areas in the package, followed by swelling, delamination, and even cracking of the plastic. Components that do not exhibit external cracking can have internal delamination or cracking which affects yield and reliability.

<b>CAUTION</b>	<b>4</b> Level
THIS BAG CONTAINS MOISTURE SENSITIVE DEVICES. Do not open except under controlled conditions. shelf life in sealed bag: 12 months @ <40C and <90% RH.	
1) Peak package body temperature 245C.	
2) After this bag is opened, devices that will be subjected to IR reflow vapor-phase reflow, or equivalent processing must be: a. Mounted within 72 hrs @ factory conditions of <30C/60% RH or b. Stored at <20% RH.	
3) Devices require baking, before mounting if: a. Humidity card is >20% when read at 23C±5C or b. 2a or 2b are not met.	
4) if baking is required, devices may be baked for 24 hrs minimum at 125C-0/+5C.	
Bag Seal Date: mm/dd/yy expiration date: 12 months from seal date	

## Baking procedure

If baking is necessary, Trimble recommends baking in a nitrogen-purge oven.

---

Temperature	125 °C
Duration	24 hours
After baking	Store in a nitrogen-purged cabinet or dry box to prevent absorption of moisture

---

**CAUTION** – Do not bake the units within the tape and reel packaging. Repeated baking processes will reduce the solderability.

---

## Soldering paste

The Condor GPS module itself is not hermetically sealed. Trimble strongly recommends using the “No Clean” soldering paste and process. The castellation solder pad on this module is plated with silver plating. Use Type 3 or above soldering paste to maximize the solder volume. The following is an example:

---

Solder paste	Kester EM909
Alloy composition	Sn96.5Ag3Cu.5 (SAC305) 96.5% Tin / 3% Silver / 0.5% Copper
Liquidus Temperature	221 °C
Stencil Thickness	5 mil (0.005") Stencil opening requires 4 mil toe over-paste in the X and Y directions.

---

Consult the solder paste manufacturer and the assembly process for the approved procedures.

## Solder reflow

A hot air convection oven is strongly recommended for solder reflow. For the lead-free solder reflow, Trimble recommends using a nitrogen-purged oven to increase the solder wetting. Reference IPC-610D for the lead free solder surface appearance.

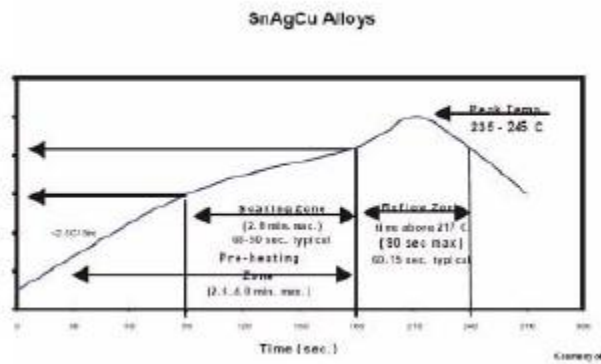
---

**CAUTION** – Follow the thermal reflow guidelines from the IPC-JEDEC J-STD-020C.

---

The size of this module is 916.9 mm<sup>3</sup>. According to J-STD-020C, the peak component temperature during reflow is 245+0 °C.

## Recommended soldering profile



Select the final soldering thermal profile very carefully. The thermal profile depends on the choice of the solder paste, thickness and color of the carrier board, heat transfer, and the size of the penalization.

---

**CAUTION** – For a double-sided surface-mount carrier board, the unit must be placed on the secondary side to prevent falling off during reflow.

---

## Optical inspection

After soldering the Condor GPS module to the carrier board, follow the IPC-610 specification and use a 3x magnification lens to verify the following:

- Each pin is properly aligned with the mount pad.
- The pads are properly soldered.
- No solder is bridged to the adjacent pads. X-ray the bottom pad if necessary.

## Cleaning

When the Condor GPS module is attached to the user board, a cleaning process voids the warranty. Please use a “no-clean” process to eliminate the cleaning process. The silver-plated Condor GPS module may discolor with cleaning agent or chlorinated faucet water. Any other form of cleaning solder residual may cause permanent damage and will void the warranty.

## Soldering guidelines

### Repeated reflow soldering

The Condor GPS lead-free silver plated module can withstand two reflow solder processes. If the unit must mount on the first side for surface-mount reflow, add glue on the bottom of the module to prevent it falling off when processing the second side.

### Wave soldering

The Condor GPS module cannot soak in the solder pot. If the carrier board is mixed with through-hole components and surface mount devices, it can be processed with one single lead-free wave process. The temperature of the unit will depend on the size and the thickness of the board. Measure the temperature on the module to ensure that it remains under 180 °C.

### Hand soldering

For the lead-free Condor GPS module, use a lead-free solder core, such as Kester 275 Sn96.5/Ag3/Cu0.5. When soldering the module by hand, keep the soldering iron below 260 °C.

## Rework

The Condor GPS module can withstand one rework cycle. The module can heat up to the reflow temperature to precede the rework. Never remove the metal shield and rework on the module itself.

## Conformal coating

Conformal coating on the Condor GPS module is not allowed and will void the warranty

## Grounding the metal shield

The Condor GPS module is designed with numerous ground pins that, along with the metal shield, provide the best immunity to EMI and noise. Any alteration by adding ground wires to the metal shield is done at the customer's own risk and may void the warranty.



# NMEA 0183 Protocol

**In this appendix:**

- Introduction
- NMEA 0183 communication interface
- NMEA 0183 message structure
- Field definitions
- NMEA 0183 message options
- NMEA 0183 message formats
- Exception behavior
- Condor GPS module proprietary NMEA messages

This appendix provides a brief overview of the NMEA 0183 protocol, and describes both the standard and optional messages offered by the Condor modules.

## Introduction

NMEA 0183 is a simple, yet comprehensive ASCII protocol which defines both the communication interface and the data format. The NMEA 0183 protocol was originally established to allow marine navigation equipment to share information. Since it is a well established industry standard, NMEA 0183 has also gained popularity for use in applications other than marine electronics.

For those applications requiring output only from the GPS receiver, NMEA 0183 is a popular choice since, in many cases, an NMEA 0183 software application code already exists. The Condor is available with firmware that supports a subset of the NMEA 0183 messages: GGA, GSA, GSV, and RMC.

For a complete copy of the NMEA 0183 standard, contact:

NMEA National Office

## NMEA 0183 communication interface

NMEA 0183 allows a single source (talker) to transmit serial data over a single twisted wire pair to one or more receivers (listeners). The table below lists the standard characteristics of the NMEA 0183 data transmissions.

Signal	NMEA standard
Baud rate	4800 <i>Note – The Condor GPS module is fixed to a 9600 baud rate.</i>
Data bits	8
Parity	None (Disabled)
Stop bits	1

## NMEA 0183 message structure

The NMEA 0183 protocol covers a broad array of navigation data. This broad array of information is separated into discrete messages which convey a specific set of information. The entire protocol encompasses over 50 messages, but only a sub-set of these messages apply to a GPS receiver like the Condor module. The NMEA message structure is described below.

\$IDMSG, D1, D2, D3, D4, . . . . ., Dn\*CS [CR] [LF]

Where:

---

\$	Signifies the start of a message
ID	The talker identification is a two letter mnemonic which describes the source of the navigation information. The GP identification signifies a GPS source.
MSG	The message identification is a three letter mnemonic which describes the message content and the number and order of the data fields.
,	Commas serve as delimiters for the data fields.
Dn	Each message contains multiple data fields (Dn) which are delimited by commas.
*	The asterisk serves as a checksum delimiter.
CS	The checksum field contains two ASCII characters which indicate the hexadecimal value of the checksum.
[CR] [LF]	The carriage return [CR] and line feed [LF] combination terminate the message.

---

NMEA 0183 messages vary in length, but each message is limited to 79 characters or less. This length limitation excludes the "\$" and the [CR][LF]. The data field block, including delimiters, is limited to 74 characters or less.

## Field definitions

Many of the NMEA data fields are of variable length, and the user should always use the comma delimiters to parse the NMEA message data field. The following table specifies the definitions of all field types in the NMEA messages supported by Trimble:

Type	Symbol	Definition
Status	A	Single character field: A=Yes, data valid, warning flag clear V=No, data invalid, warning flag set
<b>Special Format Fields</b>		
Latitude	llll.lll	Fixed/variable length field: Degreesminutes.decimal-2 fixed digits of degrees, 2 fixed digits of minutes and a variable number of digits for decimal-fraction of minutes. Leading zeros always included for degrees and minutes to maintain fixed length. The decimal point and associated decimal-fraction are optional if full resolution is not required.
Longitude	yyyyy.yyy	Fixed/Variable length field: Degreesminutes.decimal-3 fixed digits of degrees, 2 fixed digits of minutes and a variable number of digits for decimal-fraction of minutes. Leading zeros always included for degrees and minutes to maintain fixed length. The decimal point and associated decimal-fraction are optional if full resolution is not required.
Time	hhmmss.ss	Fixed/Variable length field: hoursminutesseconds.decimal-2 fixed digits of minutes, 2 fixed digits of seconds and a variable number of digits for decimal-fraction of seconds. Leading zeros always included for hours, minutes, and seconds to maintain fixed length. The decimal point and associated decimal-fraction are optional if full resolution is not required.
Defined		Some fields are specified to contain pre-defined constants, most often alpha characters. Such a field is indicated in this standard by the presence of one or more valid characters. Excluded from the list of allowable characters are the following that are used to indicate field types within this standard: "A", "a", "c", "hh", "hhmmss.ss", "llll.ll", "x", "yyyy.yy"

---

Type	Symbol	Definition
<b>Numeric Value Fields</b>		
Variable	x.x	Variable length integer or floating numeric field. Optional leading and trailing zeros. The decimal point and associated decimal-fraction are optional if full resolution is not required (example: 73.10=73.1=073.1=73).
Fixed HEX	hh	Fixed length HEX numbers only, MSB on the left
<b>Information Fields</b>		
Fixed Alpha	aa	Fixed length field of upper-case or lower-case alpha characters.
Fixed Number	xx	Fixed length field of numeric characters

**Note –**

- Spaces should only be used in variable text fields.
- Units of measure fields are appropriate characters from the Symbol column unless a specified unit of measure is indicated.
- Fixed length field definitions show the actual number of characters. For example, a field defined to have a fixed length of 5 HEX characters is represented as hhhhh between delimiters in a sentence definition.

## NMEA 0183 message options

The Condor GPS module can output the messages listed in the table below. In its default configuration (as shipped from the factory), the Condor module outputs only the messages in the table below. Typically NMEA messages are output at a 1 second interval with the "GP" talker ID and checksums. These messages are output at all times during operation, with or without a fix.

Message	Description
GGA	GPS fix data (default)
GSA	GPS DOP and active satellites (default)
GSV	GPS satellites in view (default)
RMC	Recommended minimum specific GPS/Transit data (default)
CHN	GPS channel status
GLL	Geographic position - Latitude/Longitude
VTG	Track Made Good and Ground Speed
ZDA	Time and date

**Note –** Only RMC, GGA, GSV, and GSA are default. If you change the output contents, the receiver only keeps them while Vcc or Vrtc is present. If Vcc or Vrtc are removed, the output goes back to the default settings.

# NMEA 0183 message formats

## CHN - Channel Usage Status

The CHN message identifies the GPS satellites, including their PRN number, SNR value, and status.

```
$PMTKCHN,xxxxx *hh<CR><LF>
```

Position number	Description
1 -2	Satellite number
3-4	SNR in dB
5	Channel status 0 - Idle 1 - Searching 2 - Tracking
hh	Checksum

Example:

```
$PMTKCHN,23502,28452,16352,19452,13512,07512,10402,08452,03462,06442,  
48502,00000,20352,00000,00000,00000,00000,00000,00000,00000,000  
00,00000,00000,00000,00000,00000,00000,00000,00000,00000*43
```

## GGA-GPS Fix Data

The GGA message includes time, position and fix related data for the GPS receiver.

```
$GPGGA,hhmmss.ss,llll.lll,a,nnnnn.nnn,b,t,uu,  
v.v,w.w,M,x.x,M,y.y,zzzz*hh <CR><LF>
```

Field number	Description
1	UTC of Position
2, 3	Latitude, N (North) or S (South)
4, 5	Longitude, E (East) or W (West)
6	GPS Quality Indicator: 0 = No GPS, 1 = GPS, 2 = DGPS
7	Number of Satellites in Use
8	Horizontal Dilution of Precision (HDOP)
9, 10	Antenna Altitude in Meters, M = Meters
11, 12	Geoidal Separation in Meters, M=Meters. Geoidal separation is the difference between the WGS-84 earth ellipsoid and mean-sea-level.
13	Age of Differential GPS Data. Time in seconds since the last Type 1 or 9 Update
14	Differential Reference Station ID (0000 to 1023)
hh	Checksum

---

## GLL Geographic Position - Latitude/Longitude

The GLL message contains the latitude and longitude of the present vessel position, the time of the position fix and the status.

```
$GPGLL,1111.11111,a,yyyyy.yyyyy,a,hmmss.ss,A,i*hh<CR>
<LF>
```

Field	Field Description
1,2	Latitude, N (North) or S (South)
3,4	Longitude, E (East) or W (West)
5	UTC of position (when UTC offset has been decoded by the receiver)
6	Status: A = Valid, V= Invalid
7	Mode Indicator A=Autonomous Mode D=Differential Mode E=Estimated (dead reckoning) Mode M=Manual Input Mode S=Simulated Mode N-Data Not Valid
hh	Checksum

## GSA - GPS DOP and Active Satellites

The GSA messages indicates the GPS receiver's operating mode and lists the satellites used for navigation and the DOP values of the position solution.

```
$GPGSA,a,x,xx,xx,xx,xx,xx,xx,xx,xx,xx,xx,xx,xx,
xx,x.x,x.x,x.x*hh<CR><LF>
```

Field number	Description
1	Mode: M = Manual, A = Automatic. In manual mode, the receiver is forced to operate in either 2D or 3D mode. In automatic mode, the receiver is allowed to switch between 2D and 3D modes subject to the PDOP and satellite masks.
2	Current Mode: 1 = fix not available, 2 = 2D, 3 = 3D
3 - 14	PRN numbers of the satellites used in the position solution. When less than 12 satellites are used, the unused fields are null
15	Position dilution of precision (PDOP)
16	Horizontal dilution of precision (HDOP)
17	Vertical dilution of precision (VDOP)
hh	Checksum

## GSV - GPS Satellites in View

The GSV message identifies the GPS satellites in view, including their PRN number, elevation, azimuth and SNR value. Each message contains data for four satellites. Second and third messages are sent when more than 4 satellites are in view. Fields #1 and #2 indicate the total number of messages being sent and the number of each message respectively.

```
$GPGSV, x, x, xx, xx, xx, xxx, xx, xx, xx, xxx, xx, xx, xx,
xxx, xx, xx, xx, xxx, xx*hh<CR><LF>
```

Field number	Description
1	Total number of GSV messages
2	Message number: 1 to 3
3	Total number of satellites in view
4	Satellite PRN number
5	Satellite elevation in degrees (90 °Maximum)
6	Satellite azimuth in degrees true (000 to 359)
7	Satellite SNR (C/No), null when not tracking
8, 9, 10, 11	PRN, elevation, azimuth and SNR for second satellite
12, 13, 14, 15	PRN, elevation, azimuth and SNR for third satellite
16, 17, 18, 19	PRN, elevation, azimuth and SNR for fourth satellite
hh	Checksum

## RMC - Recommended Minimum Specific GPS/Transit Data

The RMC message contains the time, date, position, course, and speed data provided by the GPS navigation receiver. A checksum is mandatory for this message and the transmission interval may not exceed 2 seconds. All data fields must be provided unless the data is temporarily unavailable. Null fields may be used when data is temporarily unavailable.

```
$GPRMC, hhmmss.ss, A, llll.ll, a, yyyyy.yy, a, x.x, x.
x, xxxxxx, x.x, a, i*hh<CR><LF>
```

Field number	Description
1	UTC of Position Fix (when UTC offset has been decoded by the receiver).
2	Status: A - Valid V - Navigation receiver warning
3, 4	Latitude, N (North) or S (South).
5, 6	Longitude, E (East) or W (West).
7	Speed over the ground (SOG) in knots
8	Track made good in degrees true.
9	Date: dd/mm/yy
10, 11	Magnetic variation in degrees, E = East / W = West

Field number	Description
12	Position System Mode Indicator: A = Autonomous D = Differential E = Estimated M = Manual input S = Simulation mode N = Data not valid
hh	Checksum (mandatory for RMC)

## VTG Track Made Good and Ground Speed

The VTG message conveys the actual track made good (COG) and the speed relative to the ground (SOG).

```
$GPVTG,x.x,T,x.x,M,x.x,N,x.x,K,i*hh<CR><LF>
```

Field	Description
1,2	Track Made Good in degrees true.
3,4	Track Made Good in degrees magnetic.
5,6	Speed Over Ground (SOG) in knots.
7,8	SOG in kilometer per hour.
9	Mode indicator: A=Autonomous mode D=Differential mode E=Estimated (dead reckoning) mode M=Manual input mode S=Simulated mode N=Data not valid
hh	Checksum

## ZDA Time and Date

The ZDA message contains Time of Day in UTC: the day, the month, the year and the local time zone.

```
$GPZDA,hhmmss.ss,xx,xx,xxxx,,*hh<CR><LF>
```

Field	Description
1	UTC (when UTC offset has been decoded by the receiver)
2	Day (01 to 31)
3	Month (01 to 12)
4	Year
5	Null (empty)
6	Null (empty)
hh	Checksum



*Note – Field 5 and 6 are null fields in the Condor receiver output. A GPS receiver cannot independently identify the local time zone offsets.*

---

**CAUTION** – If the UTC offset is not available, time output will be in GPS time until the UTC offset value is collected from the GPS satellites. When the offset becomes available, the time will jump to UTC time.

---

*Note – The time can be used as a timetag for the 1PPS. The ZDA message comes out 100-500 msec after the PPS.*

## Exception behavior

When no position fix is available, some of the data fields in the NMEA messages will be blank. A blank field has no characters between the commas.

### Interruption of GPS signal

If the GPS signal is interrupted temporarily, the NMEA will continue to be output according to the user-specified message list and output rate. Position and velocity fields will be blank until the next fix, but most other fields will be filled.

## Condor GPS module proprietary NMEA messages

Packet type	Description
000	Test packet
001	Acknowledgement of PMTK command
010	Output system message
101	Hot start
102	Warm start
103	Cold start
104	Factory reset
161	Sleep / Wake command
251	Set NMEA baud rate
300	Set fix interval
301	Set DGPS mode
313	Set SBAS enable
314	Set NMEA sentence and frequency
324	Set T S I P / antenna / PPS configuration
330	Set Datum
331	Set Datum advance
390	Set user option
400	Query fix interval

Packet type	Description
401	Query DGPS mode
413	Query SBAS enable
414	Query current NMEA output
424	Query T SIP / antenna / PPS configuration
430	Query Datum
431	Query Datum advance
490	Query user option
500	Current fix interval
501	Current DGPS mode
513	Current SBAS enable
514	Current NMEA output
530	Current Datum
590	Current user option
605	Query firmware release version
705	Firmware release information
ANT	Returns antenna status
710	GPS Ephemeris for a single satellite, see <a href="#">Condor aGPS module</a> ,
711	Almanac data for a single satellite, see <a href="#">Condor aGPS module</a> ,
712	Contains current GPS reference time, see <a href="#">Condor aGPS module</a> ,
713	Contains the reference location for GPS receiver, see <a href="#">Condor aGPS module</a> ,

The message structure is:

Preamble, TalkerID, PktType, DataField, \*, CHK1, CHK2, CR, LF

### Packet length

The maximum length of each packet is restricted to 255 bytes.

### Packet contents

Field	Description
Preamble	One byte character. `\$`
TalkerID	Four bytes character string. `PMTK`
PktType	An identifier used to tell the decoder how to decode the packet. Three byte character string, from `000` to `999`
DataField	The DataField has variable length depending on the packet type. A comma symbol `,` must be inserted ahead each data field to help the decoder process the DataField.
*	1 byte character. The star symbol is used to mark the end of the DataField.

Field	Description
CHK1, CHK2	Two byte character string. CHK1 and CHK2 are the checksum of the data between Preamble and '*'.
CR, LF	Two bytes binary data. The two bytes are used to identify the end of a packet.

Sample packet: \$PMTK000\*32<CR><LF>

## NMEA packet protocol

In order to inform the sender whether the receiver has received the packet, an acknowledge packet PMTK\_ACK should return after the receiver receives a packet.

### Packet Type: 000 PMTK\_TEST

Packet meaning	Test Packet
DataField	None

Example: \$PMTK000\*32<CR><LF>

### Packet Type: 001 PMTK\_ACK

Packet meaning	Acknowledge of PMTK command
DataField	PMTK001, Cmd, Flag
Cmd	The command / packet type that the acknowledgement responds to.
Flag	0 - Invalid command / packet. 1 - Unsupported command / packet type. 2 - Valid command / packet, but action failed. 3 - Valid command / packet, and action succeeded

Example: \$PMTK001,604,3\*32<CR><LF>

### Packet Type: 010 PMTK\_SYS\_MSG

Packet meaning	Output system message
DataField	Msg: The system message. 0 - UNKNOWN 1 - STARTUP

Example: \$PMTK010,001\*2E<CR><LF>

### Packet Type: 101 PMTK\_CMD\_HOT\_START

---

Packet meaning	Hot Restart: Use all available data in the NV store.
DataField	None

---

Example: \$PMTK101\*32<CR><LF>

### Packet Type: 102 PMTK\_CMD\_WARM\_START

---

Packet meaning	Warm Restart: Do not use Ephemeris at re-start.
DataField	None

---

Example: \$PMTK102\*31<CR><LF>

### Packet Type: 103 PMTK\_CMD\_COLD\_START

---

Packet meaning	Cold Restart: Do not use Time, Position, Almanacs, and Ephemeris data at re-start.
DataField	None

---

Example: \$PMTK103\*30<CR><LF>

### Packet Type: 104 PMTK\_CMD\_FULL\_COLD\_START

---

Packet meaning	Full Cold Restart: Essentially a cold restart, but the system/user configurations are also cleared on restart, that is, the receiver is reset to the factory default.
DataField	None

---

Example: \$PMTK104\*37<CR><LF>

### Packet Type: 161 PMTK\_SLEEP\_CTL

---

Packet meaning	Control the Sleep mode of the receiver.
DataField	PMTK161,Mode 0 - Sleep 1 - Wake

---

Example: \$PMTK161,0\*28<CR><LF>

### Packet Type: 251 PMTK\_SET\_NMEA\_BAUDRATE

---

Packet meaning	Set NMEA port baud rate.
DataField	PMTK251,Baudrate <b>Baudrate setting:</b> 0 (default) 4800 9600 14400 19200 38400 57600 115200

---

Example: \$PMTK251,38400\*27<CR><LF>

### Packet Type: 300 PMTK\_API\_SET\_FIX\_CTL

---

Packet meaning	API_Set_Fix_Ctl This parameter controls the rate of position fixing activity.
DataField	PMTK300,FixInterval,0,0,0,0 FixInterval: Position fix interval [msec]. Must be larger than 200.

---

Example: \$PMTK300,1000,0,0,0,0\*1C<CR><LF>

### Packet Type: 301 PMTK\_API\_SET\_DGPS\_MODE

---

Packet meaning	API_Set_Dgps_Mode DGPS correction data source mode.
DataField	PMTK301,Mode Mode: DGPS data source mode. 0 - Reserved 1 - Reserved 2 - WAAS (Default)

---

Example: \$PMTK301,1\*2D<CR><LF>

### Packet Type: 313 PMTK\_API\_SET\_SBAS\_ENABLED

---

Packet meaning	API_Set_Sbas_Enabled Enable to search a SBAS satellite or not.
DataField	Enabled: Enable or disable 0 = Disable 1 = Enable (Default)

---

Example: \$PMTK313,1\*2E<CR><LF>

## Packet Type: 314 PMTK\_API\_SET\_NMEA\_OUTPUT

---

Packet meaning      API\_Set\_NMEA\_Out  
Set NMEA sentence output frequencies.  
*Note – Only RMC, GGA, GSV, and GSA are default. If you change the output contents, the receiver will only keep them while Vcc or Vrtc is present, unless you use packet type 390 to save the settings to Flash memory so that they are maintained during a power cycle.*

DataField            There are 19 data fields that individually present output frequencies for the 8 supported NMEA sentences.

**Supported NMEA sentences:**

Sentence	Description
0 NMEA_SEN_GLL,	// GPGLL interval - Geographic position, latitude and longitude
1 NMEA_SEN_RMC,	// GPRMC interval - Recommended minimum specific GNSS sentence
2 NMEA_SEN_VTG,	// GPVTG interval - Course over ground and ground speed
3 NMEA_SEN_GGA,	// GPGGA interval - GPS fix data
4 NMEA_SEN_GSA,	// GPGSA interval - GNSS DOPS and active satellites
5 NMEA_SEN_GSV,	// GPGSV interval - GNSS satellites in view
17 NMEA_SEN_ZDA,	// GPZDA interval – Time & date
18 NMEA_SEN_MCHN,	// PMTKCHN interval – GPS channel status

**Supported frequency settings:**

Setting	Description
0	Disabled or not supported sentence
1	Output once every one position fix
2	Output once every two position fixes
3	Output once every three position fixes
4	Output once every four position fixes
5	Output once every five position fixes

---

Example: \$PMTK314,1,1,0,1,1,1,0,0,0,0,0,0,0,0,0,0,0,0\*29<CR><LF>

This command sets GLL output frequency to once every 1 position fix, and RMC to output once every 1 position fix, and so on.

To restore the system default setting: \$PMTK314,-1\*04<CR><LF>

## Packet Type: 324 PMTK\_API\_SET\_OUTPUT\_CTL

---

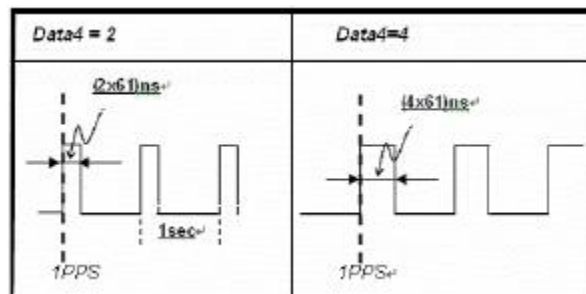
Packet meaning	Write the TSIP / antenna / PPS configuration data to the Flash memory.
DataField	<b>[Data0]:TSIP Packet[on/off]</b> 0 - Disable TSIP output (Default). 1 - Enable TSIP output. <b>[Data1]:Antenna Detect[on/off]</b> 0 - Disable antenna detect function (Default). 1 - Enable antenna detect function. <b>[Data2]:PPS on/off</b> 0 - Disable PPS function. 1 - Enable PPS function (Default). <b>[Data3]:PPS output timing</b> 0 - Always output PPS (Default). 1 - Only output PPS when GPS position is fixed. <b>[Data4]:PPS pulse width</b> 1~16367999: 61 ns~(61 x 1636799) ns (Default = 69)

---

Return:

\$PMTK001,324,,3 is returned if the configuration setting is successful.

\$PMTK001,324,,2 is returned if the configuration setting fails.



Example: \$PMTK324,1,1,1,1,1,1\* <checksum><CR><LF>

## Packet Type: 330 PMTK\_API\_SET\_DATUM

---

Packet meaning	API_Set_Datum Set datum.
DataField	Datum: 0: WGS84 1: TOKYO-M 2: TOKYO-A  Supports 219 different datums. The total datums are listed in Appendix B. If you change the default WGS84, the receiver only keeps the new value while Vcc or Vrtc is present. If Vcc and Vrtc are removed the output will go back to the default settings.

---

Example: \$PMTK330,0\*2E<CR><LF>

## Packet Type: 331 PMTK\_API\_SET\_DATUM\_ADVANCE

---

Packet meaning	API_Set_Datum_Advance Set user defined datum.
DataField	<b>PMTK331,majA,ecc,dX,dY,dZ</b> majA: User defined datum semi-major axis [m] ecc: User defined datumeccentric [m] dX: User defined datum to WGS84 X axis offset [m] dY: User defined datum to WGS84 X axis offset [m] dZ: User defined datum to WGS84 X axis offset [m]

---

### Example:

\$PPMTK331, 6377397.155, 299.1528128, -148.0, 507.0,685.0\*16<CR><LF>

## Packet Type: 390 PMTK\_API\_SET\_USER\_OPTION

---

Packet meaning	API_Set_Flash_User_Option Writes the user setting to the Flash memory to override the default setting.  <b>CAUTION</b> – You may use this command a maximum of eight (8) times. After this, the Flash memory must be erased by reloading the firmware.
DataField	<b>PMTK390, Lock, Update_Rate, Baud_Rate, GLL_Period, RMC_Period, VTG_Period, GSA_Period, GSV_Period, GGA_Period, ZDA_Period, MCHN_Period, Datum, DGPS_Mode, RTCM_Baud_Rate</b> Lock: Not zero—freeze the setting; 0—allow further settings Update_Rate: 1~5 Hz Baud_Rate: 115200, 57600, 38400, 19200, 14400, 9600, 4800 RTCM_Baud_Rate: 115200, 57600, 38400, 19200, 14400, 9600, 4800 XXXX_Period: NMEA sentence output period DGPS_Mode: 0—disable; 1—RTCM; 2—SBAS Datum: More than 200 datums are supported. See <a href="#">Appendix B, Datum List</a> . The typical value is 0 (WGS84), 1 (Tokyo-M), 2 (Tokyo-A).

---

Example: \$PMTK390,1,1,38400,1,1,1,1,1,1,1,0,0,2,9600\*2B<CR><LF>

## Packet Type: 400 PMTK\_API\_Q\_FIX\_CTL

---

Packet meaning	API_Query_Fix_Ctl
DataField	None
Return	PMTK_DT_FIX_CTL

---

Example: \$PMTK400\*36<CR><LF>



### Packet Type: 401 PMTK\_API\_Q\_DGPS\_MODE

---

Packet meaning	API_Query_Dgps_Mode
DataField	None
Return	PMTK_DT_DGPS_MODE

---

Example: \$PMTK401\*37<CR><LF>

### Packet Type: 413 PMTK\_API\_Q\_SBAS\_ENABLED

---

Packet meaning	API_Query_Sbas_Enabled
DataField	None
Return	PMTK_DT_SBAS_ENABLED

---

Example: \$PMTK413\*34<CR><LF>

### Packet Type: 414 PMTK\_API\_Q\_NMEA\_OUTPUT

---

Packet meaning	API_Query_NMEA_Out Query current NMEA sentence output frequencies.
DataField	None
Return	PMTK_DT_NMEA_OUTPUT

---

Example: \$PMTK414\*33<CR><LF>

### Packet Type: 424 PMTK\_API\_Q\_OUTPUT\_CTL

---

Packet meaning	Write the TSIP / antenna / PPS configuration data to the Flash memory.
DataField	<b>[Data0]:TSIP Packet[on/off]</b> 0 - Disable TSIP output. 1 - Enable TSIP output. <b>[Data1]:Antenna Detect[on/off]</b> 0 - Disable antenna detect function. 1 - Enable antenna detect function. <b>[Data2]:PPS on/off</b> 0 - Disable PPS function. 1 - Enable PPS function. <b>[Data3]:PPS output timing</b> 0 - Always output PPS. 1 - Only output PPS when GPS position is fix. <b>[Data4]:PPS offset</b> 1~16367999: 61 ns~(61 x 1636799) ns

---

Example: \$PMTK424\*<checksum><CR><LF>

### Packet Type: 430 PMTK\_API\_Q\_DATUM

---

Packet meaning	API_Query_Datum Query default datum
DataField	None
Return	PMTK_DT_DATUM

---

Example: \$PMTK430\*35<CR><LF>

### Packet Type: 431 PMTK\_API\_Q\_DATUM\_ADVANCE

---

Packet meaning	API_Query_Datum_Advance Query user defined datum
DataField	None
Return	PMTK_DT_DATUM

---

Example: \$PMTK431\*34<CR><LF>

### Packet Type: 490 PMTK\_API\_GET\_USER\_OPTION

---

Packet meaning	API_Get_Flash_User_Option Returns the current user setting from the Flash memory. For detailed information, see <a href="#">Packet Type: 590 PMTK_DT_FLASH_USER_OPTION</a> , page 96.
DataField	None
Return	PMTK_DT_FLASH_USER_OPTION

---

Example: \$PMTK490\*33<CR><LF>

### Packet Type: 500 PMTK\_DT\_FIX\_CTL

---

Packet meaning	These parameters control the rate of position fixing activity.
DataField	FixInterval: Position fix interval. (msec). [ >= 200]

---

Example: \$PMTK500,1000,0,0,0,0\*1A<CR><LF>

### Packet Type: 501 PMTK\_DT\_DGPS\_MODE

---

Packet meaning	DGPS data source mode
DataField	Mode: DGPS data source mode 0 = Reserved 1 = Reserved 2=WAAS

---

Example: \$PMTK501,1\*2B<CR><LF>

### Packet Type: 513 PMTK\_DT\_SBAS\_ENABLED

---

Packet meaning	Enable to search a SBAS satellite or not.
DataField	Enabled: Enable or disable 0 = Disable 1 = Enable

---

Example: \$PMTK513,1\*28<CR><LF>

### Packet Type: 514 PMTK\_DT\_NMEA\_OUTPUT

---

Packet meaning	NMEA sentence output frequency setting
DataField	There are 19 data fields that present output frequencies for the 19 supported NMEA sentences individually. For more information, see <a href="#">Packet Type: 314 PMTK_API_SET_NMEA_OUTPUT</a> , page 90.

---

Example: \$PMTK514,0,1,0,1,1,1,0,0,0,0,0,0,0,0,0,0,0,0,1\*2F<CR><LF>

### Packet Type: 530 PMTK\_DT\_DATUM

---

Packet meaning	Current datum used.
DataField	PMTK530,Datum Datum: 0=WGS84 1=TOKYO-M 2=TOKYO-A

---

Example: \$PMTK530,0\*28<CR><LF>

### Packet Type: 590 PMTK\_DT\_FLASH\_USER\_OPTION

---

Packet meaning	User setting in the Flash memory.
DataField	There are a total of 11 data fields that represent the following: <ol style="list-style-type: none"><li>1. Number of times available for recording the user setting.</li><li>2. Update_Rate: 1~5</li><li>3. NMEA baud rate in bps</li><li>4-11 NMEA sentence output period (GLL, RMC, VTG, GSA, GSV, GGA, ZDA, MCHN)</li><li>12 Datum</li><li>13 DGPS mode: 0 (disable), 1 (RTCM), 2 (SBAS)</li><li>14 RTCM baud rate in bps</li></ol>

---

Example: \$PMTK590,0,1,9600,1,1,0,1,5,1,0,0,0,2,9600\*2A<CR><LF>

### Packet Type: 605 PMTK\_Q\_RELEASE

---

Packet meaning	Query the firmware release information.
DataField	None.
Return	PMTK_DT_RELEASE

---

Example: \$PMTK605\*31<CR><LF>

### Packet Type: 705 PMTK\_DT\_RELEASE

---

Packet meaning	Firmware release information.
DataField	PMTK705, ReleaseStr, Build_ID, Date Code, Checksum ReleaseStr -Firmware release name and version Build_ID - Build ID set in CoreBuilder for firmware version control. Date code - YYYYMMDD Checksum

---

Example: \$PMTK705,AXN\_1.30,0000,20090609,\*20<CR><LF>

## Packet Type: PMTKANT

---

Packet meaning	Antenna status (must be enabled by the PMTK324 command).
DataField	PMTKANT,N N (antenna status) 0 = Open. 1 = Normal 2 = Short
Return	None

---

Example: \$PMTKANT,0

## Condor aGPS module

### Packet Type: 710 PMTK\_DT\_EPH

---

Packet meaning	The packet contains GPS Ephemeris data for a single satellite.
DataField	\$PMTK710,SV,W[1],...W[24]*CS<CR><LF>, where:

Name	Description
\$PMTK710	GPS ephemeris data (navigation model) for a single satellite.
SV	Satellite PRN number (represented in HEX characters) for the ephemeris data to follow.
W[1] ~ W[24]	words of the ephemeris subframe data from words 3 to 10 of subframes 1, 2, and 3. Each word has 24-bit data represented in 6 HEX characters. See ICD-GPS-200C for the navigation data format.
CS	8-bit accumulative checksum of all bytes in between the \$ and * characters in hexadecimal.

Example: The packet contains ephemeris data of satellite PRN 5.

```
$PMTK710,05,629000,574EE4,3AAA7A,554163,A948F7,761A5E,000004,059B35,7  
6FBA7,37B25E,48A37C,FBD803,EE48ED,1036A1,0E9E5E,1A5E51,FFF5E2,5410DE,  
FFC226,477F89,1AF42E,DDE7C0,FFA7D6,7607AB*1A <CR><LF>
```

## Packet Type: 711 PMTK\_DT\_ALM

Packet meaning	The packet contains GPS Almanac data for a single satellite.
DataField	\$PMTK711,SV,Week,W[1],...W[8]*CS<CR><LF>, where:
<b>Name</b>	<b>Description</b>
\$PMTK711	GPS Almanac data for a single satellite.
SV	Satellite PRN number (represented in HEX characters) for the almanac data to follow.
Week	Almanac reference GPS week number represented in HEX characters).
W[1] ~ W[8]	8 words of the almanac data from words 3 to 10 of subframes 1,2,3. Each word has 24-bit data represented in 6 HEX characters. See ICD-GPS-200C for the almanac data format.
CS	8-bit accumulative checksum of all bytes inbetween the \$ and * characters in hexadecimal.

Example: The packet contains almanac data of satellite PRN 1.

```
$PMTK711,1,1368,41330D,631D59,FD7600,A10D2F,913D43,BA5512,C118C1,0500  
39*08<CR><LF>
```

## Packet Type: 712 PMTK\_DT\_TIME

Packet meaning	The packet contains current GPS reference time. For quick TTFF, the accuracy of reference time must be less than 2 seconds.
DataField	\$PMTK712,week,TOW,TOW_rms,FS_TOW,FS_rms*CS<CR><LF>, where:
<b>Name</b>	<b>Description</b>
\$PMTK712	Reference GPS time.
week	GPS week number.
TOW	GPS time of week of the transmission of the \$ character at the start of the message
TOW_rms	RMS accuracy of the above TOW relative to when the \$ character was transmitted [ms]
FS_TOW	GPS time of week of the last Frame Synch pulse inserted (outdated, no longer used).
FS_rms	RMS accuracy [ns] (outdated, no longer used).
CS	8-bit accumulative checksum of all bytes inbetween the \$ and * characters in hexadecimal.

Example: The packet indicates that the current GPS week number 1368, GPS TOW 192657.291, and the accuracy of the time information is 30 ms.

```
$PMTK712,1368,192657.291,30,0,0*0F<CR><LF>
```

## Packet Type: 713 PMTK\_DT\_LOC

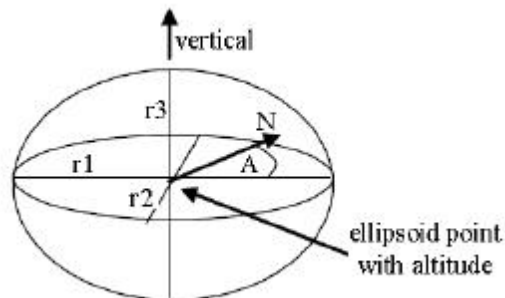
Packet meaning	The packet contains contains reference location for the GPS receiver. For quick TTFF, the accuracy of the location shall be less than 30 km.
DataField	\$PMTK713,Lat,Long,Alt,Unc_SMaj,Unc_SMin,Bear,Unc_Vert,Conf *CS<CR><LF>, where:

Name	Description
\$PMTK713	Reference Location
Lat	WGS84 geodetic latitude [degrees]
Long	WGS84 geodetic longitude [degrees]
Alt	WGS84 ellipsoidal altitude in [m]
Unc_SMaj	Horizontal uncertainty semi-major axis [m]
Unc_Smin	Horizontal uncertainty semi-minor axis [m]
Bear	Error ellipse semi-major axis bearing [degrees]
Unc_Vert	Vertical uncertainty [m]
Conf	The confidence by which the position of a target entity is known to be within the shape description, expressed as a percentage between 0—100.
CS	8-bit accumulative checksum of all bytes inbetween the \$ and * characters in hexadecimal.

Example: The packet indicates that the GPS receiver is at latitude 24.772816, longitude 121.022636 with uncertainty of 333 m in semi-major axis, 333 m in semi-minor axis, and 50 m in vertical.

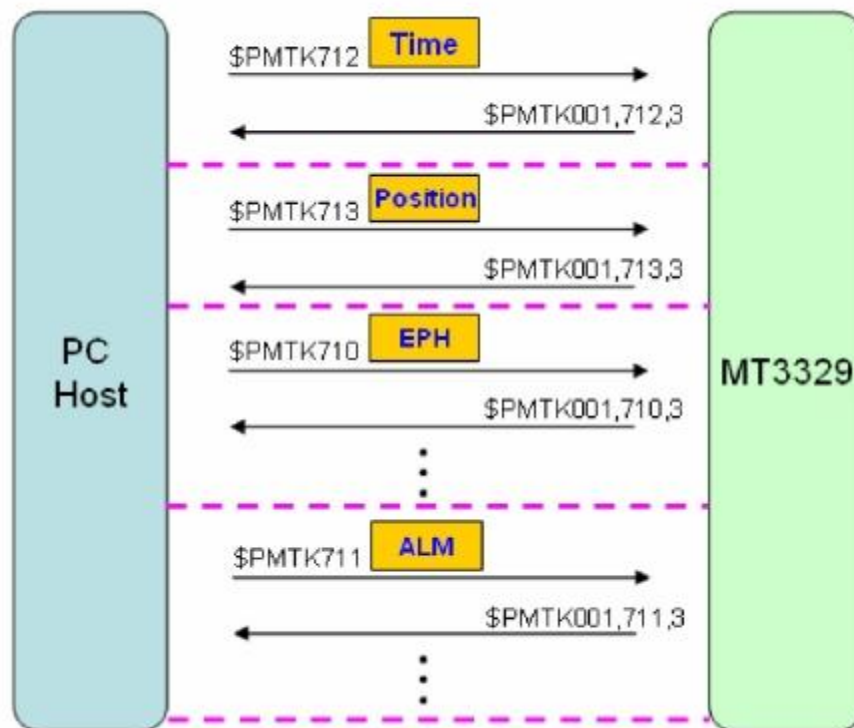
\$PMTK713,24.772816,121.022636, 160,333,333,6,50\*25<CR><LF>

*Note – The ellipsoid point is used with altitude and uncertainty ellipsoid to describe location error shape. See also 3GPP TS 23.032:*



## Assistance data transfer protocol

The transfer protocols of assistance data are as follows:





## Datum List

This appendix includes an international datum list.

No	Datum	Region
0	WGS1984	International
1	Tokyo	Japan
2	Tokyo	Mean For Japan, South Korea, Okinawa
3	User Setting	User Setting
4	Adindan	Burkina Faso
5	Adindan	Cameroon
6	Adindan	Ethiopia
7	Adindan	Mali
8	Adindan	Mean For Ethiopia, Sudan
9	Adindan	Senegal
10	Adindan	Sudan
11	Afgooye	Somalia
12	Ain El Abd1970	Bahrain
13	Ain El Abd1970	Saudi Arabia
14	American Samoa1962	American Samoa Islands
15	Anna 1 Astro1965	Cocos Island
16	Antigua Island Astro1943	Antigua(Leeward Islands)
17	Arc1950	Botswana
18	Arc1950	Burundi
19	Arc1950	Lesotho
20	Arc1950	CuMalawi
21	Arc1950	Mean for Botswana, Lesotho, Malawi, Swaziland, Zaire,Zambia, Zimbabwe
22	Arc1950	Swaziland
23	Arc1950	Zaire
24	Arc1950	Zambia
25	Arc1950	Zimbabwe
26	Arc1960	Mean For Kenya Tanzania
27	Arc1960	Kenya
28	Arc1960	Tanzania
29	Ascension Island1958	Ascension Island
30	Astro Beacon E 1945	Iwo Jima
31	Astro Dos 71/4	St Helena Island
32	Astro Tern Island (FRIG) 1961	Tem Island
33	Astronomical Station 1952	Marcus Island
34	Australian Geodetic 1966	Australia, Tasmania
35	Australian Geodetic 1984	Australia, Tasmania
36	Ayabelle Lighthouse	Djibouti
37	Bellevue (IGN)	Efate and Erromango Islands
38	Bermuda 1957	Bermuda
39	Bissau	Guinea-Bissa

<b>No</b>	<b>Datum</b>	<b>Region</b>
40	Bogota Observatory	Colombia
41	Bukit Rimpah	Indonesia (Bangka and Belitung Ids)
42	Camp Area Astro	Antarctica (McMurdi Camp Area)
43	Campo Inchauspe	Argentina
44	Canton Astro 1966	Phoenix Island
45	Cape	South Africa
46	Cape Canaveral	Bahamas, Florida
47	Carthage	Tunisia
48	Chatham Island Astro 1971	New Zealand (Chatham Island)
49	Chua Astro	Paraguay
50	Corrego Alegre	Brazil
51	Dabola	Guinea
52	Deception Island	Deception Island, Antarctica
53	Djakarta (Batavia)	Indonesia (Sumatra)
54	Dos 1968	New Georgia Islands (Gizo Island)
55	Easter Island 1967	Easter Island
56	Estonia Coordinate System 1937	Estonia
57	European 1950	Cyprus
58	European 1950	Egypt
59	European 1950	England, Channel Islands, Scotland, Shetland Islands
60	European 1950	England, Ireland, Scotland, Shetland Islands
61	European 1950	Finland, Norway
62	European 1950	Greece
63	European 1950	Iran
64	European 1950	Italy (Sardinia)
65	European 1950	Italy (Sicily)
66	European 1950	Malta
67	European 1950	Mean For Austria, Belgium, Denmark, Finland, France, W Germany, Gibraltar, Greece, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland
68	European 1950	Mean For Austria, Denmark, France, West Germany, Netherland, Switzerland
69	European 1950	Mean For Iraq, Israel, Jordan, Lebanon, Kuwait, Saudi Arabia, Syria
70	European 1950	Portugal, Spain
71	European 1950	Tunisia
72	European 1979	Mean For Austria, Finland, Netherlands, Norway, Spain, Sweden, Switzerland
73	Fort Thomas 1955	Nevis & Kitts (Leeward Islands)
74	Gan 1970	Republic Of Maldives
75	Geodetic Datum 1970	New Zealand
76	Graciosa Base SW 1948	Azores (Faial, Graciosa, Pico, Sao, Jorge, Terceira)
77	Guam 1963	Guam

<b>No</b>	<b>Datum</b>	<b>Region</b>
78	Gunung Segara	Indonesia (Kalimantan)
79	Gux 1 Astro	Guadalcanal Island
80	Herat North	Afghanistan
81	Hermannskogel Datum	Croatia-Serbia, Bosnia-Herzegovina
82	Hjorsey 1955	Iceland
83	Hongkong 1963	Hongkong
84	Hu T zu Shan	Taiwan
85	Indian	Bangladesh
86	Indian	India,Nepal
87	Indian	Pakistan
88	Indian 1954	Thailand
89	Indian 1960	Vietnam (Con Son Island)
90	Indian 1960	Vietnam (Near 16 deg N)
91	Indian 1975	Thailand
92	Indonesian 1974	Indonesia
93	Ireland 1965	Ireland
94	ISTS 061 Astro 1968	South Georgia Islands
95	ISTS 073 Astro 1969	Diego Garcia
96	Johnston Island 1961	Johnston Island
97	Kandawala	Sri Lanka
98	Kerguelen Island 1949	Kerguelen Island
99	Kertau 1948	West Malaysia and Singapore
100	Kusaie Astro 1951	Caroline Islands
101	Korean Geodetic System	South Korea
102	LC5 Astro 1961	Cayman Brac Island
103	Leigon	Ghana
104	Liberia 1964	Liberia
105	Luzon	Philippines (Excluding Mindanao)
106	Luzon	Philippines (Mindanao)
107	MPoraloko	Gabon
108	Mahe 1971	Mahe Island
109	Massawa	Ethiopia (Eritrea)
110	Merchich	Morocco
111	Midway Astro 1961	Midway Islands
112	Minna	Cameroon
113	Minna	Nigeria
114	Montserrat Island Astro 1958	Montserrat (Leeward Island)
115	Nahrwan	Oman (Masirah Island)
116	Nahrwan	Saudi Arabia
117	Nahrwan	United Arab Emirates
118	Naparima BWI	Trinidad and Tobago
119	North American 19	Alaska (Excluding Aleutian Ids)

<b>No</b>	<b>Datum</b>	<b>Region</b>
120	North American 1927	Alaska (Aleutian Ids East of 180 degW)
121	North American 1927	Alaska (Aleutian Ids West of 180 degW)
122	North American 1927	Bahamas (Except San Salvador Islands)
123	North American 1927	Bahamas (San Salvador Islands)
124	North American 1927	Canada (Alberta, British Columbia)
125	North American 1927	Canada (Manitoba, Ontario)
126	North American 1927	Canada (New Brunswick, Newfoundland, Nova Scotia, Quebec)
127	North American 1927	Canada (Northwest Territories, Saskatchewan)
128	North American 1927	Canada (Yukon)
129	North American 1927	Canal Zone
130	North American 1927	Cuba
131	North American 1927	Greenland (Hayes Peninsula)
132	North American 1927	Mean For Antigua, Barbados, Barbuda, Caicos Islands, Cuba, Dominican, Grand Cayman, Jamaica, Turks Islands
133	North American 1927	Mean For Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua
134	North American 1927	Mean For Canada
135	North American 1927	Mean For Conus
136	North American 1927	Mean For Conus (East of Mississippi, River Including Louisiana, Missouri, Minnesota)
137	North American 1927	Mean For Conus (West of Mississippi, Rive Excluding Louisiana, Minnesota, Missouri)
138	North American 1927	Mexico
139	North American 1983	Alaska (Excluding Aleutian Ids)
140	North American 1983	Aleutian Ids
141	North American 1983	Canada
142	North American 1983	Conus
143	North American 1983	Hawaii
144	North American 1983	Mexico, Central America
145	North Sahara 1959	Algeria
146	Observatorio Meteorologico 1939	Azores (Corvo and Flores Islands)
147	Old Egyptian 1907	Egypt
148	Old Hawaiian	Hawaii
149	Old Hawaiian	Kauai
150	Old Hawaiian	Maui
151	Old Hawaiian	Mean For Hawaii, Kauai, Maui, Oahu
152	Old Hawaiian	Oahu
153	Oman	Oman
154	Ordnance Survey Great Britain 1936	England
155	Ordnance Survey Great Britain 1936	England, Isle of Man, Wales

<b>No</b>	<b>Datum</b>	<b>Region</b>
156	Ordnance Survey Great Britian 1936	Mean For England, Isle of Man, Scotland, Shetland Island, Wales
157	Ordnance Survey Great Britian 1936	Scotland, Shetland Islands
158	Ordnance Survey Great Britian 1936	Wales
159	Pico de las Nieves	Canary Islands
160	Pitcaim Astro 1967	Pitcaim Island
161	Point 58	Mean For Burkina Faso and Niger
162	Pointe Noire 1948	Congo
163	Porto Santo 1936	Porto Santo, Maderia Islands
164	Provisional South American 1956	Bolovia
165	Provisional South American 1956	Chile (Northern Near 19 deg S)
166	Provisional South American 1956	Chile (Southern Near 43 deg S)
167	Provisional South American 1956	Colombia
168	Provisional South American 1956	Ecuador
169	Provisional South American 1956	Guyana
170	Provisional South American 1956	Mean For Bolivia Chile, Colombia, Ecuador, Guyana, Peru, Venezuela
171	Provisional South American 1956	Peru
172	Provisional South American 1956	Venezuela
173	Provisional South Chilean 1963	Chile (Near 53 deg S) (Hito XVIII)
174	Puerto Rico	Puerto Rico, Virgin Islands
175	Pulkovo 1942	Russia
176	Qatar National	Qatar
177	Qomoq	Greenland (South)
178	Reunion	Mascarene Island
179	Rome 1940	Italy (Sardinia)
180	S-42 (Pulkovo 1942)	Hungary
181	S-42 (Pulkovo 1942)	Poland
182	S-42 (Pulkovo 1942)	Czechoslovakia
183	S-42 (Pulkovo 1942)	Latvia
184	S-42 (Pulkovo 1942)	Kazakhstan
185	S-42 (Pulkovo 1942)	Albania
186	S-42 (Pulkovo 1942)	Romania
187	S-JTSK	Czechoslovakia (Prior 1 Jan1993)
188	Santo (Dos) 1965	Espirito Santo Island
189	Sao Braz	Azores (Sao Miguel, Santa Maria Ids)
190	Sapper Hill 1943	East Falkland Island
191	Schwarzeck	Namibia
192	Selvagem Grande 1938	Salvage Islands
193	Sierra Leone 1960	Sierra Leone
194	South American 1969	Argentina

<b>No</b>	<b>Datum</b>	<b>Region</b>
195	South American 1969	Bolivia
196	South American 1969	Brazil
197	South American 1969	Chile
198	South American 1969	Colombia
199	South American 1969	Ecuador
200	South American 1969	Ecuador (Baltra, Galapagos)
201	South American 1969	Guyana
202	South American 1969	Mean For Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Trinidad and Tobago, Venezuela
203	South American 1969	Paraguay
204	South American 1969	Peru
205	South American 1969	Trinidad and Tobago
206	South American 1969	Venezuela
207	South Asia	Singapore
208	Tananarive Observatory 1925	Madagascar
209	Timbalai 1948	Brunei, E Malaysia (Sabah Sarawak)
210	Tokyo	Japan
211	Tokyo	Mean For Japan, South Korea, Okinawa
212	Tokyo	Okinawa
213	Tokyo	South Korea
214	Tristan Astro 1968	Tristan Da Cunha
215	Viti Levu 1916	Fiji (Viti Levu Island)
216	Voirol 1960	Algeria
217	Wake Island Astro 1952	Wake Atoll
218	Wake-Eniwetok 1960	Marshall Islands
219	WGS 1972	Global Definition
220	WGS 1984	Global Definition
221	Yacare	Uruguay
222	Zanderij	Suriname

