

## ONCORE ENGINEERING NOTE

### *UT Plus Oncore*

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# UT Plus Oncore™ GPS Receiver

**General  
Characteristics****Performance  
Characteristics****Serial  
Communication****Electrical  
Characteristics****Physical  
Characteristics****Environmental  
Characteristics****Miscellaneous**

Receiver Architecture	<ul style="list-style-type: none"><li>• 8 parallel channel</li><li>• L1 1575.42 MHz</li><li>• C/A code (1.023 MHz chip rate)</li><li>• Code plus carrier tracking (carrier aided tracking)</li></ul>
Tracking Capability	<ul style="list-style-type: none"><li>• 8 simultaneous satellite vehicles</li></ul>
Dynamics	<ul style="list-style-type: none"><li>• Velocity: 1000 knots (515 m/s); &gt; 1000 knots at altitudes &lt; 60,000 ft.</li><li>• Acceleration: 4 g</li><li>• Jerk: 5 m/s<sup>3</sup></li><li>• Vibration: 7.7G per Military Standard 810E</li></ul>
Acquisition Time (Time To First Fix, TTFF)	<ul style="list-style-type: none"><li>• &lt; 20 s typical TTFF-hot (with current almanac, position, time and ephemeris)</li><li>• &lt; 50 s typical TTFF-warm (with current almanac, position and time)</li><li>• &lt; 300 s typical TTFF-cold</li><li>• &lt; 1.0 s internal reacquisition (typical)</li></ul>
(Tested at -30 to +85°C)	
Positioning Accuracy	<ul style="list-style-type: none"><li>• 100 m 2dRMS with SA as per DoD specification</li><li>• Less than 25 m SEP without SA</li></ul>
Timing Accuracy (1 Pulse Per Second, 1 PPS)	<ul style="list-style-type: none"><li>• Time RAIM algorithm</li><li>• &lt; 130 ns (1 sigma) with SA on</li><li>• In position hold mode, &lt; 50 ns (1 sigma) with SA on</li></ul>
Jamming Immunity	<ul style="list-style-type: none"><li>• Immune to the following CW jamming signal levels measured at the input to the Oncore Active Antenna when the receiver is in position-hold mode. Values are typical.<ul style="list-style-type: none"><li>-50 dBm @ 1570 MHz</li><li>-79 dBm @ 1575.42 MHz</li><li>-56 dBm @ 1580 MHz</li></ul></li></ul>
Antenna	<ul style="list-style-type: none"><li>• Active micro strip patch antenna module</li><li>• Powered by receiver module (5-80 mA @ 5 Vdc)</li></ul>
Datum	<ul style="list-style-type: none"><li>• WGS-84</li></ul>
Output Messages	<ul style="list-style-type: none"><li>• Latitude, longitude, height, velocity, heading, time (Motorola binary protocol)</li><li>• Software selectable output rate (continuous or poll)</li><li>• TTL interface (0 to 5 V)</li></ul>
Power Requirements	<ul style="list-style-type: none"><li>• 5 ± 0.25 Vdc; 50 mVp-p ripple (max.)</li></ul>
"Keep-Alive" BATT Power	<ul style="list-style-type: none"><li>• External 2.5 Vdc to 5.25 Vdc; 5 µA (typ.) @ 2.5 Vdc</li></ul>
Power Consumption	<ul style="list-style-type: none"><li>• &lt; 0.9 W @ 5 Vdc with active antenna drawing 20 mA</li></ul>
Dimensions	<ul style="list-style-type: none"><li>• 2.00 x 3.25 x 0.64 in. [50.8 x 82.6 x 16.3 mm]</li></ul>
Weight	<ul style="list-style-type: none"><li>• 1.8 oz. (51 g)</li></ul>
Connectors	<ul style="list-style-type: none"><li>• Data/power: 10 pin (2x5) unshrouded header on 0.100 in. centers</li><li>• RF: right angle OSX (subminiature snap-on)</li></ul>
Antenna to Receiver Interconnection	<ul style="list-style-type: none"><li>• Single coaxial cable</li><li>• Antenna sense circuit</li></ul>
Operating Temperature	<ul style="list-style-type: none"><li>• -40°C to +85°C</li></ul>
Humidity	<ul style="list-style-type: none"><li>• 95% noncondensing +30°C to +60°C</li></ul>
Altitude	<ul style="list-style-type: none"><li>• 60,000 ft. (18 km) (max.)</li><li>• &gt; 60,000 ft. (18 km) for velocities &lt; 1000 knots</li></ul>
Standard Features	<ul style="list-style-type: none"><li>• Time RAIM</li><li>• 100PPS output</li><li>• Automatic site survey</li><li>• Jamming protection</li></ul>
Optional Features	<ul style="list-style-type: none"><li>• Lithium battery</li><li>• Straight OSX RF connector</li></ul>

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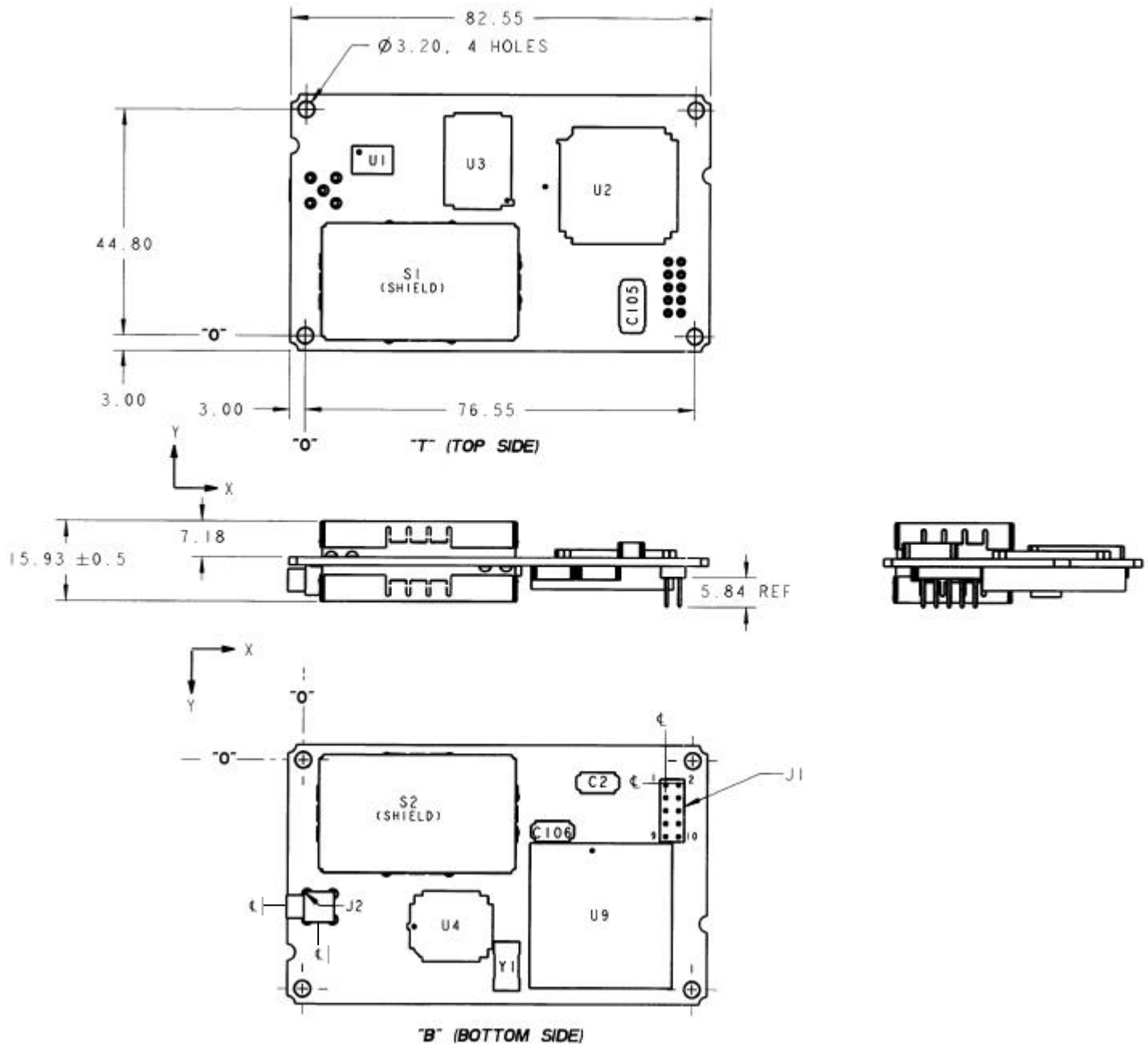
## 2. Product Description

The Motorola UT Plus Oncore GPS receiver has the following basic features:

- L1 frequency C/A code receiver
- Searches for, acquires, and tracks satellites on 8 parallel channels; receiver will always attempt to track the 8 satellites with the highest elevation angles
- Electrical and mechanical form factor equivalent to VP Oncore and UT Oncore
- Optimized signal processing for operation in foliage environments and urban canyons
- Position filter reduces abrupt changes to position due to constellation changes
- Serial input/output using the Motorola binary protocol
- Position, velocity and time solution:
  - height referenced to WGS-84 ellipsoid or other user defined datum
  - heading referenced to true north only
  - time referenced to GPS time or UTC
- Acquisition times (TTFF - time to first fix):
  - hot start (w/ ephemeris): 20 s typical
  - warm start (w/o ephemeris): 50 s typical
  - cold start (w/o almanac, time, date, position): 300 s typical
- Reacquisition times after view of satellites obstructed:
  - after 15 s obstruction: < 1.0 s typical internal  
3.0 s typical
  - after 30 minute obstruction: 300 s typical
- 1PPS (One Pulse Per Second) output accuracy with SA on:
  - normal mode: 130 ns (1 sigma)
  - position-hold mode: 50 ns (1 sigma)
- If battery backup power supplied:
  - uses last known position at power-up to minimize acquisition time
  - time and date retained by real-time clock (RTC) to minimize acquisition time
  - user entered data and settings retained
- Antenna sense circuit detects if antenna is properly connected
- Time Receiver Autonomous Integrity Monitoring (Time RAIM) to allow detection and isolation of satellites that could introduce timing errors
- UT Plus model numbers:
  - R5122U111x - standard version
  - R5222U111x - on-board Lithium battery
  - R5122U115x - right angle OSX antenna connector

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## 3. Mechanical



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## Component Locations:

Part	PCB Side	Location (Nominal to center)		Size (Nominal)		
		X	Y	Width (X)	Length (Y)	Height
C2	B	57.8	4.4	5.7	3.3	2.6
C105	T	64.2	6.0	4.4	7.5	2.9
C106	B	49.1	13.9	5.7	3.3	2.6
J1*	B	71.2	4.4	4.9	12.3	8.2
J2	B	3.4	28.8	6.0	6.0	5.4
S1	T	10.6	22.6	39.3	23.8	6.9
S2	B	10.6	22.6	39.3	23.8	6.9
U1	T	13.0	34.9	3.8	5.0	1.6
U2	T	59.4	29.9	22.0	22.0	1.5
U3	T	33.8	34.7	8.4	17.8	2.5
U4	B	29.3	32.6	13.9	11.5	3.3
U9	B	58.6	30.4	24.0	24.0	4.4

\* Location measured to centerline of pin #1

All dimensions in mm

## 4. Electrical

### Main Power

Voltage	4.75 V to 5.25 V 50 mV peak to peak ripple
Current	155 mA typical (without antenna)
Power	0.8 W maximum (without antenna)

### Backup Power

Externally applied backup power

Voltage	2.5V to 5.25V
Current	5 $\mu$ A typical @ 2.5 V 100 $\mu$ A typical @ 5.0 V

### Optional Lithium Battery

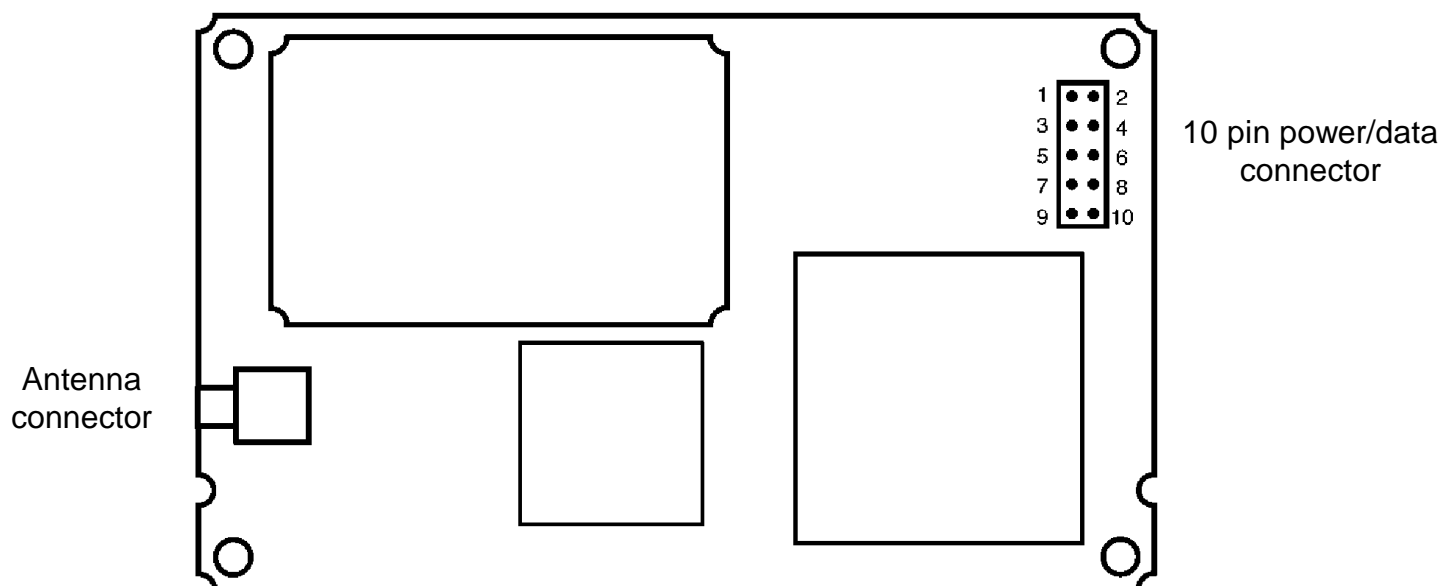
Onboard rechargeable cell is charged when main power is on

Voltage	3 V
Capacity	15 mAh approximately 3 months between charges
Recharge	approximately 8 hours for a full charge
Lifetime	5 years minimum

## 5. Pin-Out Diagram

Pin	Signal	Description
1	BATT	externally applied backup power
2	PWR	5 V main power
3	GND	ground
4	VPP	reprogramming voltage
5	N/A	not used
6	1PPS	timing pulse
7	1PPS RTN	timing pulse return
8	TTL TXD1	primary output
9	TTL RXD1	primary input
10	TTL RTN	return

**UT Plus Oncore Circuit Board**



## **6. EMC (Electro-Magnetic Compatibility) Considerations**

### **RF Shielding**

The areas of RF circuitry on the UT Plus Oncore receiver board are covered with tin-plated shields to guard against potential interference from external sources. When mounting the Oncore receiver near or around RF sources such as radios and cellular phones, it is recommended that the Oncore be tested in the target environment to identify potential interference issues prior to final design.

### **Interference**

Because the Oncore GPS receiver contains a very sensitive RF receiver, you must observe certain precautions to prevent possible interference from the host system. Since the electromagnetic environment will vary for each embedded application, it is not possible to define exact guidelines to ensure complete electromagnetic compatibility.

### **Testing**

To determine the effect of potential interference sources on the GPS receiver, perform a test using an evaluation kit receiver as a comparison. Use a satellite simulator if at all possible so that the input signal will be consistent. Mount one GPS receiver in the target application with all devices powered on. Mount the second GPS receiver in the Oncore evaluation kit housing. Connect both receivers to the type of antenna to be used in the product system. Use two computers to monitor the signal strength reported in the Position/Status/Data Message. If both receivers report a C/No value within 2 dB, then there is probably little or no damaging interference in the system. If the receiver in the target application reports signal strengths more than 2 dB lower, then the system performance will be sub-optimal.



## 7. RTC (Real Time Clock)

The real-time clock (RTC) is a standard feature on the UT Plus Oncore. It is used to minimize the time to first fix (TTFF). The date and time will be retained in the RTC if battery backup power is applied when main power is off.

The user has two options regarding time initialization:

- 1) Set the date and time **BEFORE** the receiver acquires any satellites, or
- 2) Let the receiver automatically set the date and time **AFTER** the receiver acquires the first satellites.

Note: The date and time cannot be manually set while the receiver is tracking satellites.

Without battery backup, the receiver will have an incorrect time on start up. To obtain a faster time to first fix, the time, date and GMT offset should be initialized if both the main power and battery backup power have been disconnected.

## 8. 1PPS Signal Description

- 0 to 5 V pulse
- Pulse accuracy:
  - Normal mode: < 130 ns (one sigma) with SA on
  - Position-hold mode: < 50 ns (one sigma) with SA on
- Rise time from 0 to 5 V is approximately 20 to 30 ns with a recommended maximum line loading of 50 pF
- 1PPS time mark is synchronous with rising edge of pulse
- Pulse width is approximately 200 ms ( $\pm 1$  ms), i.e. the falling edge occurs approximately 200 ms after the rising edge
- Pulse can be advanced to account for antenna cable delay using the 1PPS Cable Delay command
- Pulse location can be delayed using the 1PPS Offset command to position the pulse at any desired time within the one second window

## 9. TTL Serial Interface

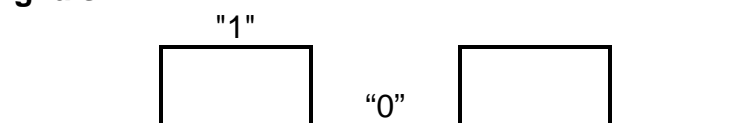
The serial interface signals **TTL TXD1** and **TTL RXD1** are used to configure and communicate with the Oncore GPS receiver. The **TTL RTN** ground signal is also required to complete the serial interface. These signals are regular TTL signals directly to/from the microprocessor with voltage ranges from 0 to 5V. There is no additional protection or signal conditioning besides the internal protection of the microprocessor. For input signals, minimum input high voltage is 2.0 V and the maximum input high voltage is 5.0 V. Minimum input low voltage is 0.0 V and the maximum input low voltage is 0.8 V. For output signals, minimum output high voltage is 2.4 V and the maximum output low voltage is 0.5 V. The maximum capacitance of TTL output signals is 50 pF.

This interface is not a conventional RS-232 interface that can connect to a PC (which is normally equipped with RS-232 interface) directly. An RS-232 driver/receiver is required to make this connection. The driver/receiver provides a voltage shifting from 0 to 5 V to a positive and negative voltage (for example, +/- 10 V), and also has an inversion process in it. Some RS-232 driver/receiver IC's (Integrated Circuits), such as the Motorola MC145407, will provide all these functions with only a +5 V power supply.

The microprocessor used on the UT Plus Oncore is the standard MC68331.

- MC68331 DC characteristics:
  - sink/drain current: 5.3 mA maximum
  - source/drive: 0.8 mA
  - impedance: high

### TTL Signals:



### Signal Level Voltage Ranges:

Level	TTL		RS-232	
	Minimum	Maximum	Minimum	Maximum
Logic "0"	0.0 V	0.8 V	5 V	15 V
Logic "1"	2.4 V	5.0 V	-5 V	-15 V

### Nominal Voltage Levels (i.e. when transmit/receive lines are idle):

Signal	Pin	Level
TTL TXD1	8	Logic "1"
TTL RXD1	9	Logic "0"

## 10. Serial Command Set

The UT Plus Oncore supports Motorola binary input and output. For detailed descriptions of the commands, refer to Chapter 6 of the Oncore User's Guide.

### Motorola Binary Commands

Motorola binary commands can be used to initialize, configure, control, and monitor the GPS receiver. The Motorola binary commands are supported on the primary comm port at 9600 baud. The commands supported by the UT Plus Oncore are:

@@Ab	GMT Offset
@@Aw	Time Mode
@@Ac	Date
@@Aa	Time of Day
@@Ad	Latitude
@@Ae	Longitude
@@Af	Height
@@Ag	Mask Angle
@@Ea	Position/Status/Data Message
@@Bb	Visible Satellite Status Message
@@Bj	Leap Second Pending Status
@@Aq	Atmospheric Correction Mode
@@Ap	Set User Datum
@@Ao	Select Datum
@@Cb	Almanac Data Input
@@Be	Almanac Data Output
@@Sz	Power-on Failure Message
@@Cj	Receiver ID
@@Fa	Self-Test
@@Cf	Set-to-Defaults
@@Bo	UTC Offset Status Message
@@Az	1PPS Cable Delay
@@Ay	1PPS Offset
@@AP	Pulse Output
@@As	Position-Hold Position
@@At	Position-Hold Mode
@@En	Time RAIM Setup and Status Message

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## Default Settings

When in the default mode, the GPS receiver is in Motorola binary communications mode and has no output messages enabled.

### User selectable:

Mask angle	0 degrees
Time mode	UTC
Datum ID code	49 (WGS'84)
Atmospheric correction option	iono enabled
1PPS cable delay	0 ns
1PPS offset	0 ns
Position-hold position	0° N, 0° E, 0 m
Position-hold mode	off

### Not user selectable:

I/O format	binary
3-D to 2-D PDOP threshold	6.0
2-D to 0-D HDOP threshold	12.0

## 11. Precise Timing Mode

The UT Plus Oncore is optimized for precise timing applications. In order to achieve the best timing performance, the receiver should be used in position-hold mode. The position of the antenna must be determined by a site survey, by averaging GPS position fixes, or by using the new AutoSurvey feature. Once the position is determined, perform the following:

- 1) use the Position-Hold Position command to enter in the known position,
- 2) use the Position-Hold Mode command to enable the position-hold mode,
- 3) use the 1PPS Cable Delay and/or 1PPS Offset commands to adjust the timing of the precise pulse, and
- 4) use the Time RAIM Setup and Status Message to set the Time RAIM alarm threshold and enable the output message.

The AutoSurvey feature of the UT Plus receiver is activated using the Position-Hold Mode command. This mode will automatically perform a positioning averaging algorithm to determine the position of the antenna. When the AutoSurvey is complete, the receiver will automatically use the average position in the Position-Hold Mode. For more information, refer to the Oncore User's Guide.

### Receiver-antenna interface:

### Antenna requirements:

Frequency	1575.42 MHz (L1)
Bandwidth	30 MHz typical
Polarization	right hand circular
Gain pattern	hemispherical      +3 dBic at the zenith 0 dBic at 30° above the horizon -6 dBic at the horizon
Gain requirement	10 to 33 dB at receiver input
Noise figure	2.2 dB maximum
VSWR	1.5:1 typical at L1 2.5:1 maximum at L1
Power	5 V, 15 to 80 mA

### 13. Antenna Sense Circuit Description

The UT Plus Oncore receiver is capable of detecting the presence of an antenna. The receiver utilizes an antenna sense circuit, which can detect **under current** (open) and **over current** (shorted or exceeding maximum limit) conditions. The status of the antenna circuit is reported in the serial output in the Position/Status/Data (@@Ea) and the Self-Test (@@Fa) messages.

The antenna sense circuit is useful in verifying that the antenna is properly connected to the receiver and is drawing the proper amount of current. The antenna sense status should be checked after installation and monitored regularly.

#### **Under current condition:**

Good indication: greater than 15 mA

Bad indication: less than 5 mA

#### **Over current condition:**

80 mA maximum for normal operation

45 mA maximum for short circuit

When the receiver detects an **over current** situation, it will automatically shut down the power to the RF section until the fault is cleared. Upon detecting an **under current** situation, the receiver will continue to operate as normal, but will flag the fault mode in the two serial messages.

An external power supply can be used if an application requires more than 80 mA to power the antenna system. If an external power supply is used, a DC block must be installed in the antenna cable connected to the GPS receiver.

## 14. RF System Guidelines

Both the gain and the noise of the overall system affect the performance of the A/D converter in a GPS receiver. The illustration below illustrates typical values for the Oncore family of GPS receivers when used with the Motorola antenna and standard RG-174 cable. The thresholds and ranges listed should be considered with a tolerance of 2 to 3 dB.

System constraints:

- 1) The gain in decibels is cumulative through all stages (i.e.  $G = G1 + G2 + G3...$ ). For the UT Plus Oncore receiver, optimal gain of the antenna, cabling and any in-line amplifiers and splitters is 10 to 33 dB. The Oncore receiver may operate outside of the optimal gain range but performance will degrade. Therefore, Motorola does not recommend operating outside of the optimal gain range indicated. For the system below, the gain is 24 dB at the receiver connector.
- 2) System noise (F) is not to exceed 4 dB. The cascaded system noise figure formula is

$$f = f1 + \frac{f2-1}{g1} + \frac{f3-1}{g1 \cdot g2} + \dots, \quad (= 1.9 \text{ dB for the system below})$$

where  $f1$  is the noise figure for stage one and  $g1$  is the gain for stage one. Note that all of these values are absolute. Recall the formula for converting absolute values to decibels:

$$F(\text{dB}) = 10 \cdot \log(f)$$

