

# Engineering Notes

## Oncore Active Antenna





## **Caution!**

**The Oncore Active Antenna printed circuit boards (PCBs) contain parts and assemblies sensitive to damage by electrostatic discharge (ESD). Use ESD precautionary procedures when handling the antenna unit.**

# Contents

<b>1. Product Description</b>	<b>4</b>
<b>2. Product Specifications</b>	<b>5</b>
<b>3. Relative Radiation Pattern</b>	<b>6</b>
<b>4. Mechanical Dimensions</b>	<b>7</b>
<b>5. Antenna System RF Parameters Consideration</b>	<b>8</b>
<b>6. RF Cable Length for AVL Applications</b>	<b>9</b>
<b>7. Recommended Antenna Placement</b>	<b>11</b>
<b>8. Motorola Part Numbers</b>	<b>12</b>

## APPENDIXES

<b>A. RF Connectors/Cables Information</b>	<b>13</b>
<b>B. Environmental Tests</b>	<b>16</b>

# 1. Product Description

The Oncore GPS Antenna is designed to operate with Motorola's successful family of Oncore GPS receivers, as well as many GPS receivers from other manufacturers. The antenna design reflects Motorola's standard for high performance when operating in foliage/urban canyon environments and in the presence of electromagnetic interference. The antenna module is housed inside a molded polycarbonate encasement that provides a rugged and durable protective cover, ready for exposure to the elements.

The antenna module's electrical circuitry and components are contained within the sealed antenna assembly. The major components include a low profile microstrip patch antenna, the ceramic RF filters, Low Noise Amplifier (LNA), and RG-174 type coaxial cable in a variety of lengths available with various connector terminations. The antenna module is designed and tuned to efficiently collect the L1 band signal transmitted from GPS satellites at a nominal frequency of 1575.42 MHz. Once collected, the signals are filtered, amplified and relayed to the GPS receiver. The RF signal filtration included in the antenna design provides excellent protection against out-of-band interference. The active GPS antenna requires only 20 mA at 5 Vdc of power which is supplied directly from the GPS receiver by multiplexing on the interconnecting coaxial cable.

The small footprint, low profile package and shielded LNA ensure superior performance while operating in a variety of GPS environments. Some of the other critical antenna parameters include RF Gain of 24 dB (typical including cable and connector losses) with a Noise Figure of 1.8 dB (typical).

The antenna is designed to withstand harsh automotive environmental conditions with an operating temperature range is from -40°C to +100°C. The environmental tests that were conducted during the antenna qualification process included rain and salt spray tests as well as mechanical vibration up to 7.7G and shock up to 100G tests per MIL STD 810E specification.

Reliability, responsive integration support, and long term commitment from Motorola make the Oncore Active GPS Antenna the high quality choice for the OEM or GPS System integrator.

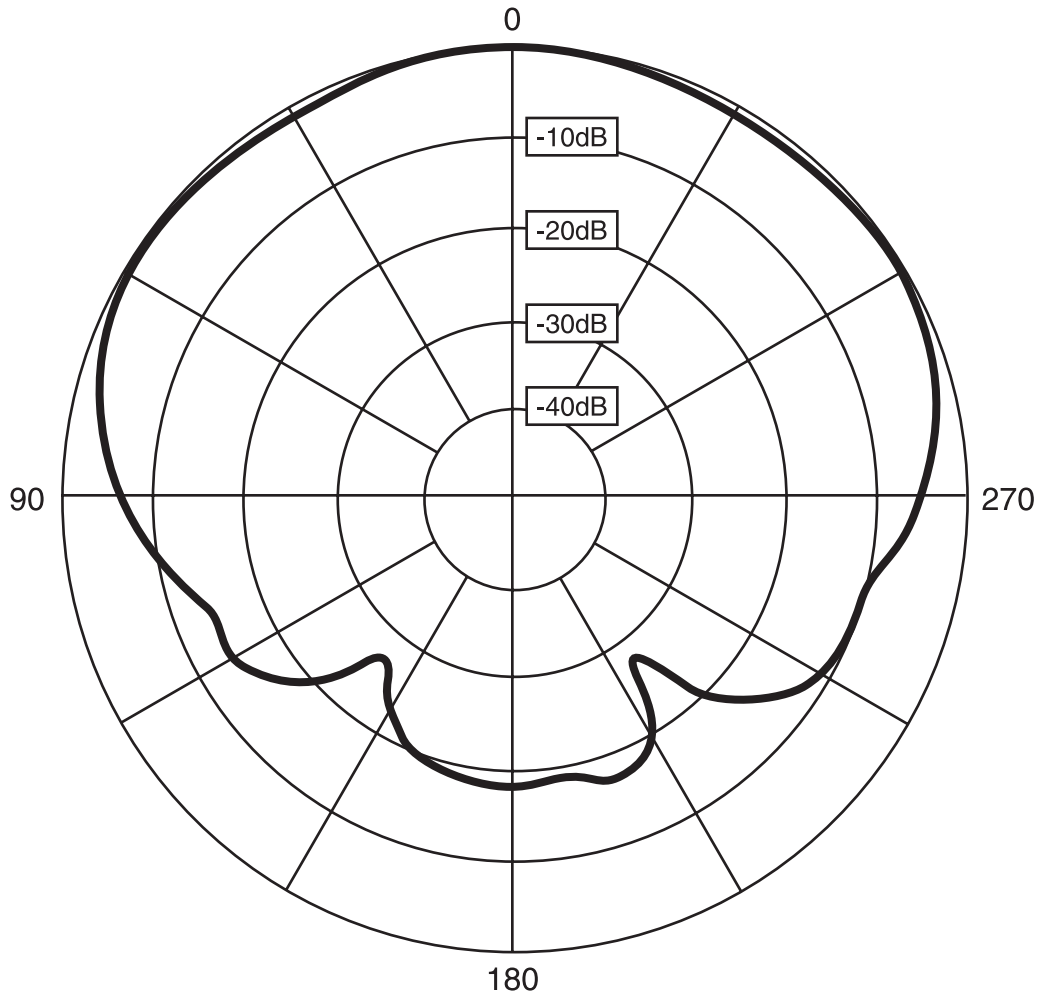
## 2. Product Specifications

### Active GPS Antenna Technical Characteristics

General Characteristics	Antenna Description	Low profile active microstrip patch antenna molded plastic radome Electrically shielded LNA PWB assembly
	Operating Frequency	L1 (1575.42 MHz, +/- 2 MHz)
Performance Characteristics	Input Impedance	50 Ohm
	VSWR	1.5 (typical) @ 1575.42 MHz
	Bandwidth	45 MHz @ 3 dB points (typical)
	Polarization	Right hand circular
	Azimuth Coverage	360 degrees
	Elevation Coverage	0 degrees to 90 degrees
	Gain Characteristics of Antenna Element	+3 dBic minimum at zenith (typical) 0 dBic minimum at 30 degrees elevation (typical) -10 dBic minimum at 0 degrees elevation (typical)
	Filtering	-25 dB @ 1670 MHz (typical) -25 dB @ 1480 MHz (typical)
	LNA Gain	24 dB (typical, including 6 dB cable loss)
	Noise Figure	1.8 dB (typical)
	Electrical Characteristics	Burnout Protection
Dynamics		Vibration: 7.7G per Military Standard 810E Method 514.4 Shock: 100G (18 ms sawtooth) Military Standard 810E Method 516.4
Physical Characteristics	Power Requirements	5 ± 0.5 Vdc, 50 mV p-p ripple (maximum)
	Power Consumption	20 mA @ 5 Vdc (typical)
Environmental Characteristics	Dimensions	49.6 L x 43.0 W x 18.0 H mm 33.3 L x 29.8 W x 8.8 H mm (substrate w/shield)
	Weight	< 40 grams (housed assembly, less cable)
	Cable Connector	90 degree OSX/MCX (subminiature push on) BNC, SMA, GT-5
	Antenna to Receiver Interconnections	Single RG-174U type coaxial cable 6 meters (20 ft.) long (10 dB maximum loss at 1575.42 Mhz) Single RG-174U type coaxial cable 203 mm (8 in.) long
Miscellaneous	Operating Temperature	-40°C to +100°C
	Storage Temperature	-40°C to +100°C
	Humidity	95% noncondensing +30°C to +60°C
	UV Radiation	1200 hrs. @ +63°C w/rain @ 12 min./hr.
	Salt Spray Test	Spray 5% NaCL solvent at +35°C for 320 hrs.
Optional Features	Mounting options: - Magnetic mount - Direct mount Subassembly of Patch Antenna and shielded LNA PWB with 6 meters of RG-174U type coaxial cable with 90 degree OSX/MCX connector	

### 3. Relative Radiation Pattern

Motorola Part # GNCxxxxxxx

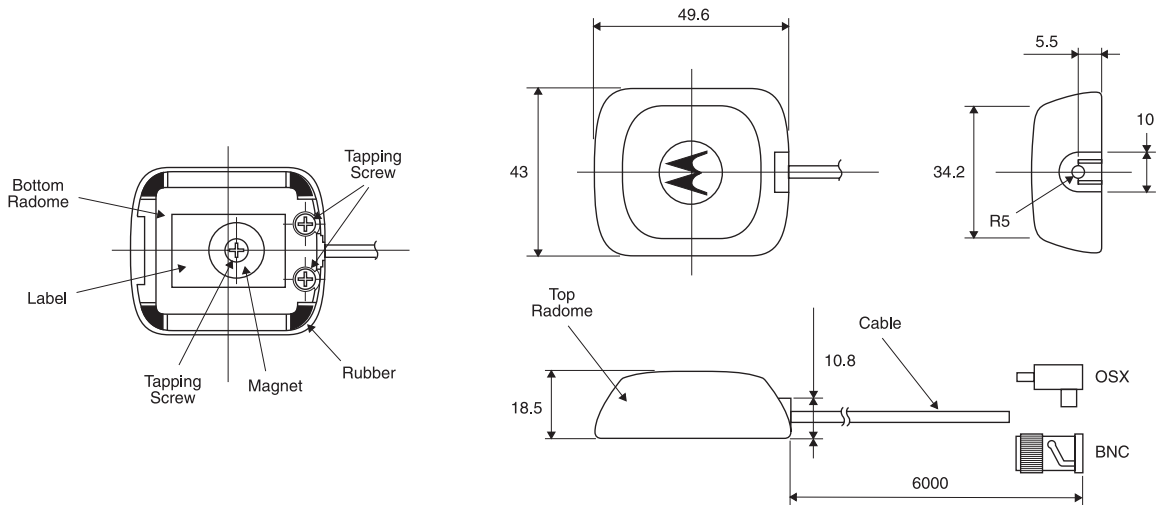


Cross Sectional View

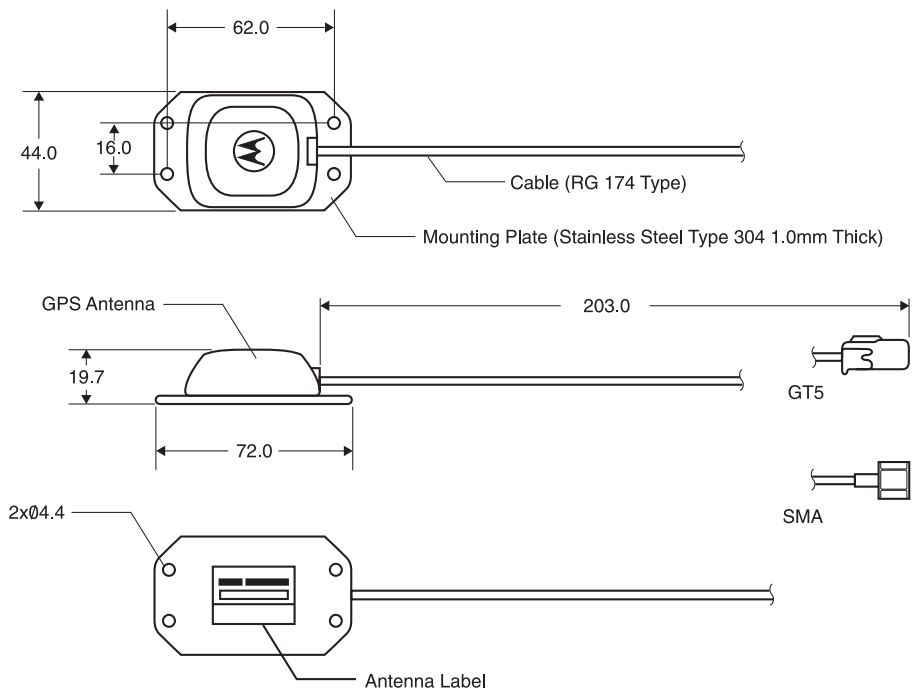
## 4. Mechanical Dimensions

All dimensions are in mm. For reference purposes only.

### Magnetic Mount Configuration



### Direct Mount Configuration



#### Notes:

1. For the magnet type GPS antenna - the pull force of the GPS antenna, that is, straight upward vertical pull force is 1.5 kgf (minimum). Typically it is 1.8 kgf. This is a permanent/rare earth (Neodymium) type of magnet.
2. Direct mount mounting plate is attached to antenna base using commercial grade 3M VHB: 4914 acrylic foam tape. VHB: 4914 foam joining is double coated acrylic foam with acrylic pressure sensitive adhesive on both sides. It provides static shear, peel adhesion and resistance to solvents, UV light and elevated temperature. Combined with the screw as a secondary method for securing the mounting plate (bracket) to the antenna base, VHB: 4914 tape passed all the qualification tests (see Appendix B).
3. The minimum pull force that the cable/radome interface will withstand is 6 kg.

#### Recommended Mounting Hardware

The recommended screws are 6-32 (English) or M3x0.6 (metric) for securing the mounting bracket onto the attached surface or plate. The suggested hole size is from 3.05 to 3.10 mm in diameter or as user feels appropriate.

## 5. Antenna System RF Parameters Consideration

### ONCORE TECHNICAL APPLICATION NOTE

#### Active Antenna & GT Oncore Receiver System

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-58/RG-174 type 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.  $G = G_1 + G_2 + G_3 \dots$ ). The optimal gain of the antenna, cabling and any in-line amplifiers and splitters for the standard GT Oncore (model R3) is  $> 10$  but  $< 26$  dB. See the table below for other Oncore receiver models. 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 as indicated above and in the table below. For the system illustrated below, the external gain is approximately 22 dB in front of the receiver.

- 2) System noise (F) is not to exceed 4 dB. The cascaded system noise figure formula is

$$f = f_1 + \frac{f_2 - 1}{g_1} + \frac{f_3 - 1}{g_1 g_2} + \dots, \quad (= 1.9 \text{ dB for the system below})$$

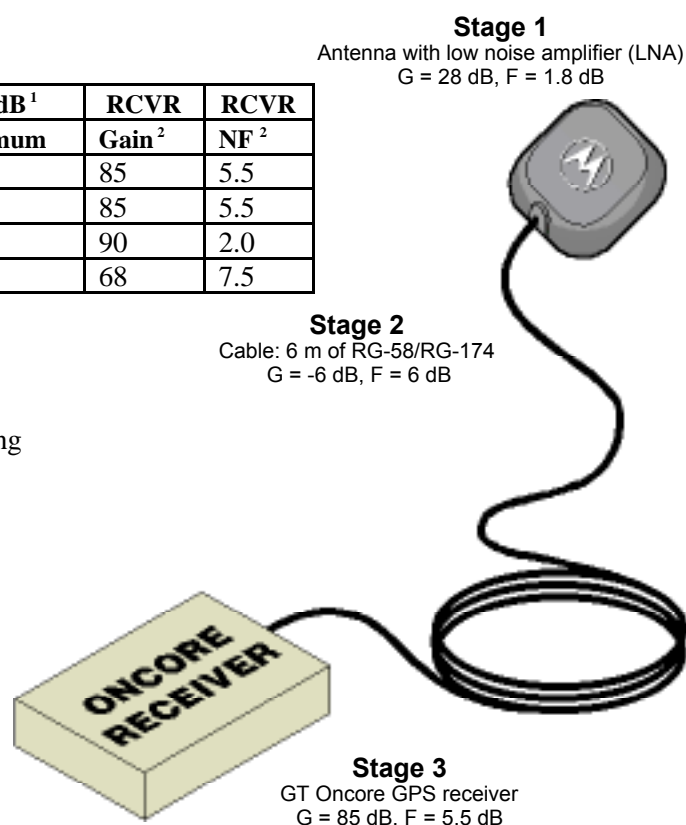
where  $f_1$  is the noise figure for stage one and  $g_1$  is the gain for stage one. Note that all of these values are absolute. Recall the formula for converting absolute values to decibels:

$$X(\text{dB}) = 10 \log(x).$$

Platform	Model	External Gain Range in dB <sup>1</sup>			RCVR	
		Minimum	Optimum	Maximum	Gain <sup>2</sup>	NF <sup>2</sup>
GT	R1	> 10	22	< 35	85	5.5
GT	R3	> 10	22	< 26	85	5.5
GT w/ (LNA)	R4	> 8	15	< 18	90	2.0
VP	B3	> 10	18	< 26	68	7.5

Notes:

1. All values indicated in this section are referenced over operating temperature

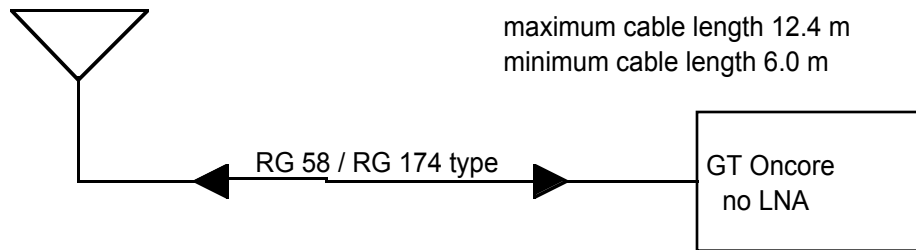




## 6. RF Cable Length for AVL Applications

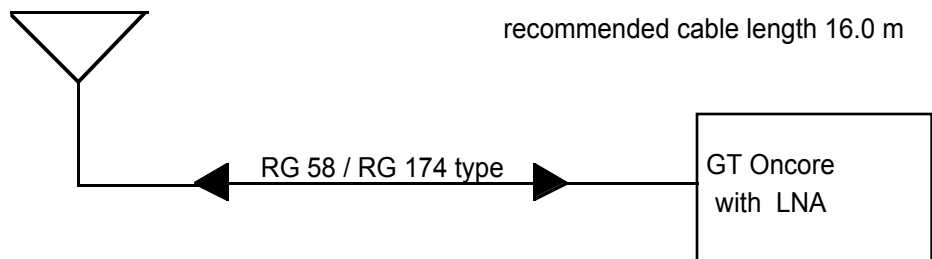
Config. 1

GT Oncore no LNA (model R3)  
Oncore Active Antenna



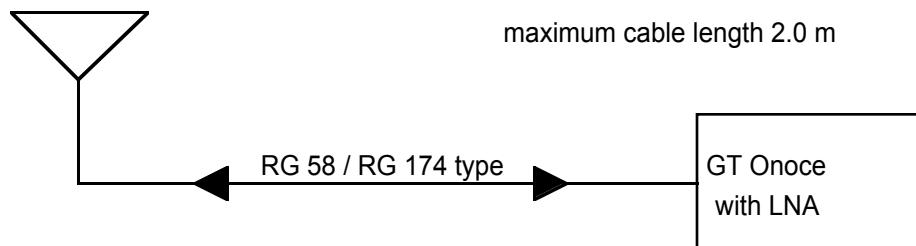
Config. 2

GT Oncore with LNA (model R4 - under development)  
Oncore Active Antenna



Config. 3

GT Oncore with LNA (model R4 - under development)  
Oncore Passive Antenna (under development)



**Note:** All values on this page represent antenna performance at +25°C.

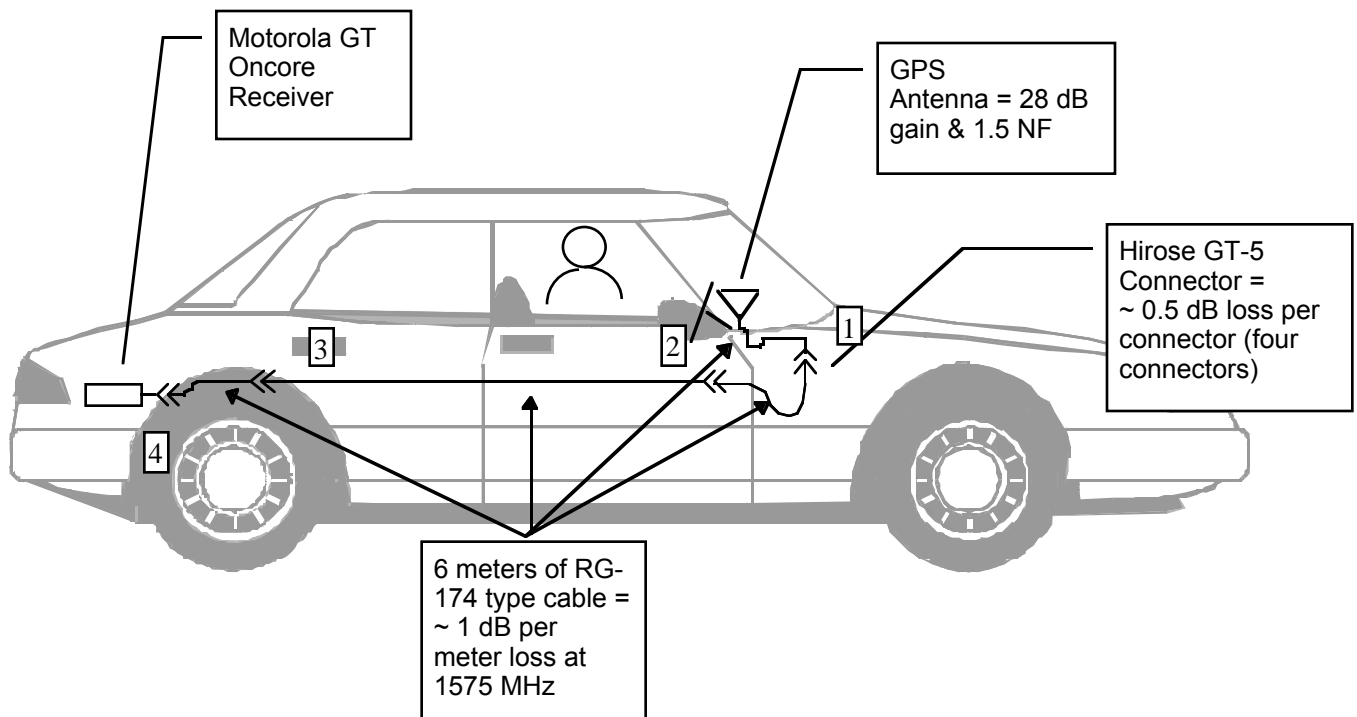
## Oncore GPS System Example

The graphic below illustrates an automotive application using the Motorola GT Oncore receiver mounted in the trunk and a GPS antenna mounted in the front dash area. Assumptions were made as to the connector (four Hirose GT-5 connections) and cable type (~6 meters of RG-174 type of cable) and the approximate associated losses (Conservative losses: 1 dB per meter for the cable and 0.5 dB per connector connection) at 1575 MHz. The GT Oncore (model R3) was designed to operate within an external gain range measured at the front of the receiver of greater than 10 but less than 26 dB. The gain at the front of the GT Oncore based on the information and assumptions above is well within the external gain range of the receiver. The calculated gain is approximately 20 dB (see system gain table below). Changing any of the above assumptions or system components illustrated below will necessitate the recalculation of the system gain. Refer to Section 5 of the Antenna System application note.

System Gain Table

System Component	Gain (dB)
Antenna	~28
Connectors (4 ea.)	- 2
Cable	- 6
Gain at front end of receiver	20

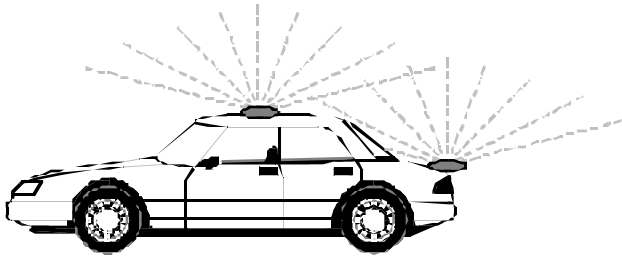
Note: All values are at 25°C



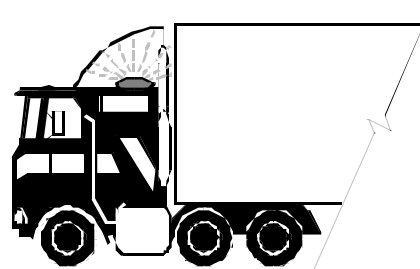
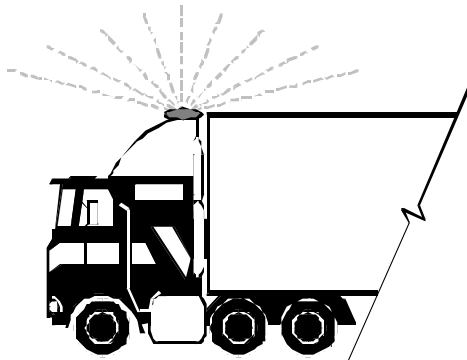
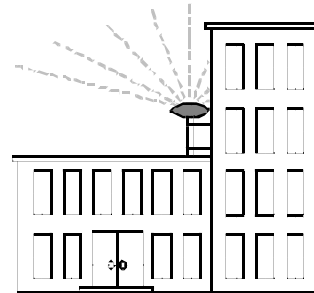
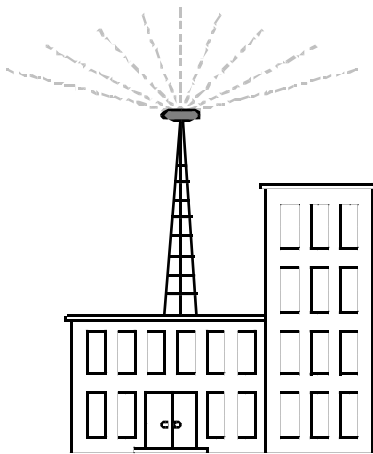
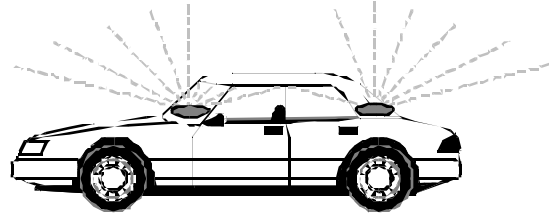
—<<— Mating RF Connectors (see Appendix A)

## 7. Recommended Antenna Placement

**1st Choice Placement**  
Recommended antenna placement



**2nd Choice Placement**  
If recommended placements are not available, these may suffice



Note: On trucks, antennas can be placed inside a fiberglass airfoil or on the driver's side exterior rear view mirror

## 8. Motorola Part Numbers

Table 4 shows the various mounting styles and types of connectors that are offered. Also the Motorola model numbers and outline drawings are included in the table for reference.

**TABLE 4.0**

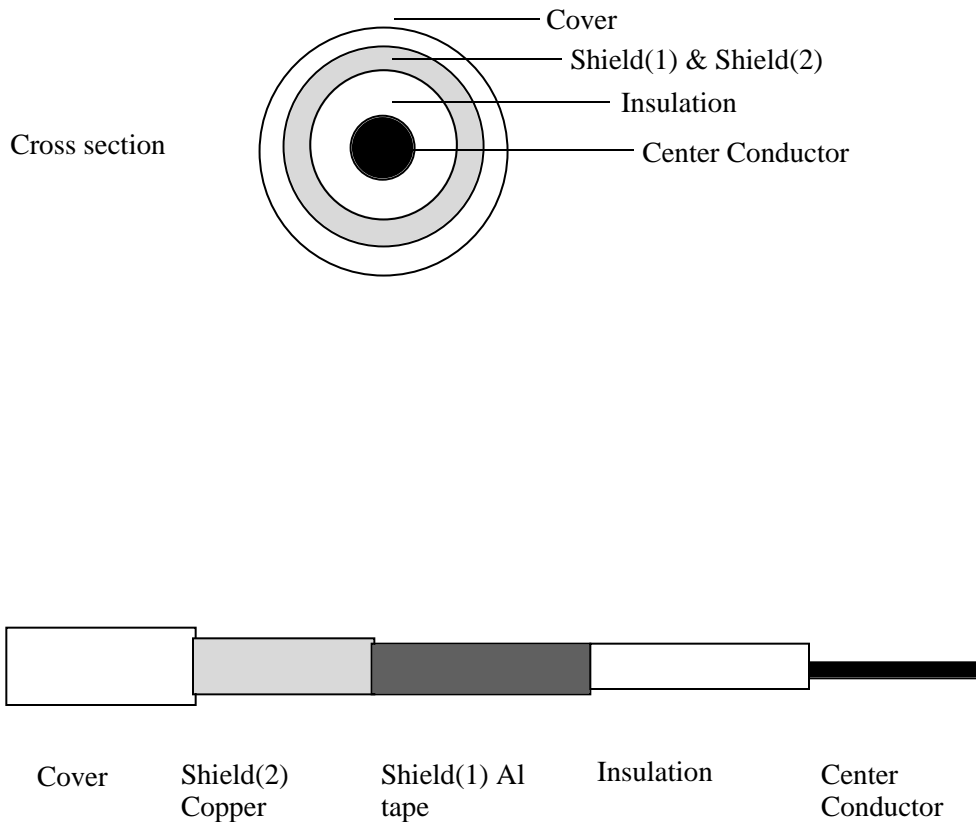
<b>Motorola Model No:</b>	<b>Mounting Style</b>	<b>Length of Cable (mm)</b>	<b>Connector Style</b>
GCNAC1242X	Mounting Plate (Bracket)	203 ±5	Hirose GT5
GCNAC1232X	Mounting Plate (Bracket)	203 ±5	Straight SMA plug
GCNAC1121X	Magnet	6000 ±70	BNC plug
GCNAC1111X	Magnet	6000 ±70	Right angle OSX/MCX plug
GCNSU1110X (Substrate)	N/A	6000 ±70	Right angle OSX/MCX plug

**Note:** For Motorola model number GCNSU1110X, the GPS antenna will not have the top and bottom radome including the two screws and the rubber gasket. The label will be on the metal shield of the substrate assembly which will be the same size as the regular labels.

## Appendix A. RF Connectors/Cables Information

This page covers the construction and electrical characteristics of “H-1.5D-SEXL” coaxial cable which is a part of the GPS antenna assembly. This is very similar to the 50 ohm RG174 cable type. Figure 1.0 shows the simplified views of this cable. Table 2.0 shows the key characteristics of this type of coaxial cable.

**FIGURE 1.0**



**TABLE 2.0 - Cable Structure & Performance**

Items :		Dimension	Specification
Center	Material	-	Tinned Annealed Copper Wire
Conductor	Diameter	mm	.54 (7 strands of .18 mm)
Insulation	Material	-	Irradiated Polyethylene
	Thickness	mm	.54
	Outside Diameter	mm	1.62
Shield (1)	Material	-	Both side aluminium coated polyester tape
	Outside Diameter	mm	1.7
Shield (2)	Material	-	Tin coated copper wire braid
	Diameter of wire	mm	.1
	Ends/Carriers	-	5/16
Cover	Material	-	Heat resistance black PVC
	Thickness	mm	.39
	Outside Diameter	mm	3.0 +/- .20
Conductance		$\Omega$ /km	Less than 105
Non-Conductance		M $\Omega$ /km	More than 1100
Capacitance		pF/m	110 (typ.) at 1 kHz
Impedance		$\Omega$	50 +/- 2
Operational Temperature Range		$^{\circ}$ C	-40 to +105
Storable Temperature Range		$^{\circ}$ C	-40 to +105
ATTENUATION		dB/m	Typical .73 at 900 MHz
		dB/m	Maximum .84 at 900 MHz
		dB/m	Typical .94 at 1500 MHz
		dB/m	Maximum 1.08 at 1500 MHz
		dB/m	Typical 1.10 at 1900 MHz
		dB/m	Maximum 1.21 at 1900 MHz

### TABLE 3.0 - Antenna Cable RF Connectors

The following RF Connectors are used to terminate cables of various Antenna-97 models.

<b>Antenna Model #</b>	<b>Antenna Cable Connector Type</b>	<b>Manufacturer</b>	<b>Manufacturer's Part #</b>
<b>GCNAC1232X</b>	<b>SMA</b>	<b>PHOENIX / PELCO</b>	<b>20-0200-0670P</b>
<b>GCNAC1242X</b>	<b>GT-5</b>	<b>HIROSE</b>	<b>559-0078-2 / 559-0108-1</b>
<b>GCNAC1121X</b>	<b>BNC</b>	<b>M/A-Com</b>	<b>3201-7388-10 / 3231-7399-10</b>
<b>GCNAC1111X</b>	<b>OSX</b>	<b>PHOENIX / PELCO</b>	<b>13-2800-0670</b>

Contact the following Companies for information on mating connectors:

Phoenix / Pelco           (800) 323-9562 or (630)595-2300;  
M/A-Com                 (800) 366-2266 or (847) 776-0700;  
Hirose                   (805) 522-7958;  
LoDan Electronics       (847) 398-4995.

## B. Environmental Tests

Provided below is an outline of the product durability and environmental specifications on the active GPS antenna assembly. Both magnet and mounting plate (bracket) style GPS antennas were qualified using the following test outline.

**TABLE 3.0 :Durability Validation Tests**

<b>Type of Test</b>	<b>Test Description</b>
• Thermal cycling	Heat Cycle Test: Temp: -40 to +100 °C Power: 5V DC on/off cycling
• Thermal Shock	Thermal Shock Test: Temp.: -40 to +100 °C
• Humidity	Heat/Humidity cycle Test: Cycling temp. -10 to 60 °C at 65 to 95% R.H.  Moisture Resistance Test: Constant temp. at 60 °C, 90% R.H.
• High Temp. Tests	High Temp. Storage Test: at +100°C .  High Temp. Operating Test: Constant 5V DC at +100 °C
• Low Temp. Tests	Low Temp. Storage Test: at -40 °C.  Low Temp. Operating Test: Constant 5V DC at -40 °C.
• Vibration Test	Random Vibration Test: Ref. spec. no.:MIL STD 810E ,Method 514.4. 7.7 G's RMS,1 hr per axis, all three axis.
• Mech. Shock Test	Mechanical Shock Test: Ref. spec. no.: MIL STD 810E, Method 516.4, Procedure I modified. 30 G's/18 ms for min. 100 G's/10 ms for min.
• Drop Test	Drop Test: Ref. spec. no.: MIL STD 810E, Method 516.4, Procedure IV modified. 1 meter drop onto concrete surface.
• Shipping Drop Test	Shipping Drop Test
• ESD Test	ESD Test: Test from 5 KV to 15 kV .



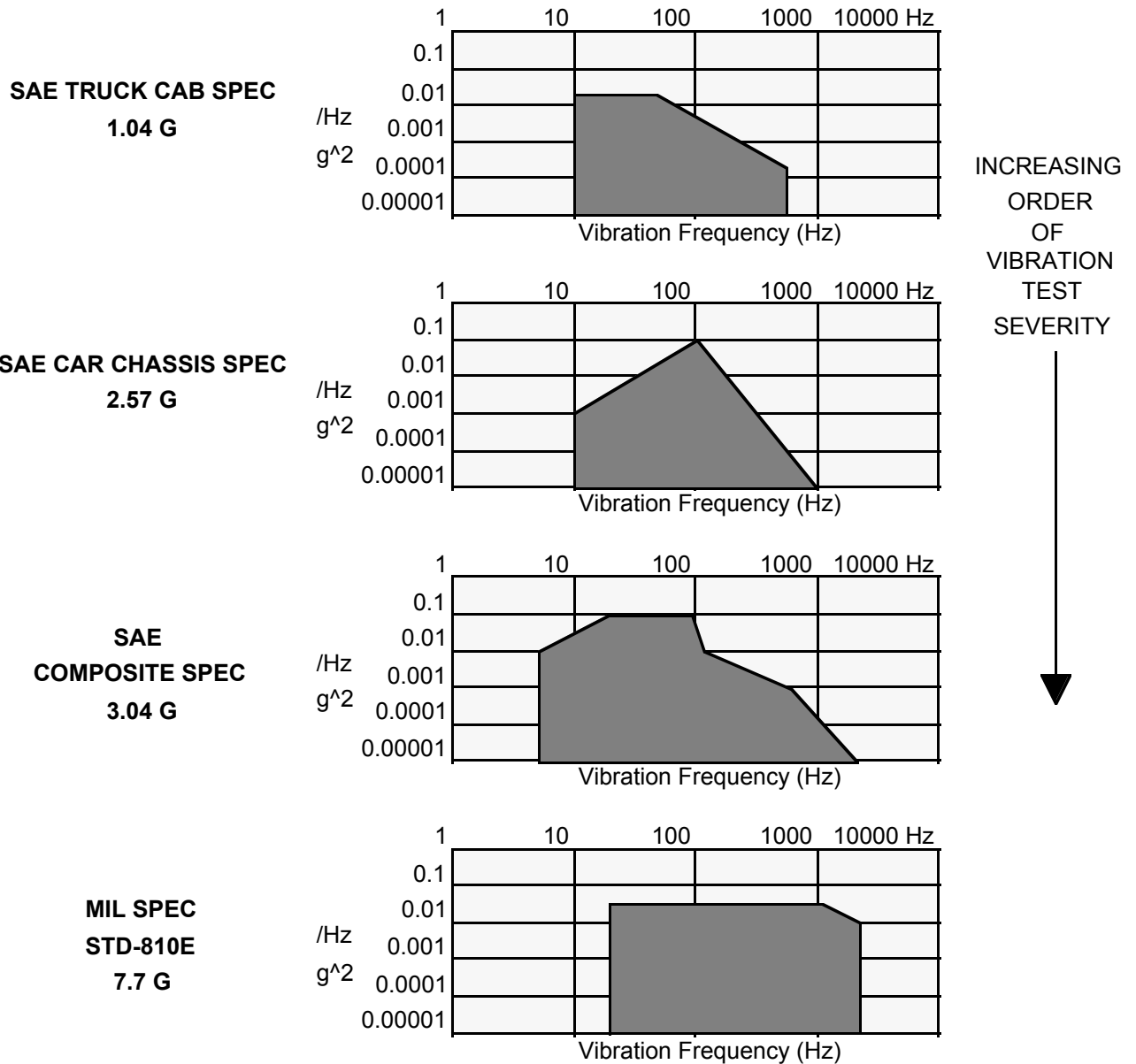
**TABLE 3.1 - Environmental Validation Tests**

<b>Type of Test</b>	<b>Test Description</b>
• Salt Spray	Salt Atmosphere Test: Spray 5% NaCL solvent (at 35 °C).
• Ultraviolet Radiation	Weather Resistance Test: This is a standard JISD spec. Temp. of panel 63 °C
• Chemical Compatibility	Oil Resistant Test:
• Rain Test	Water Proofing Test: at 80 °C, spray water at 600 mm/hour for one hour

# ONCORE ANTENNA-97 VIBRATION TEST PERFORMANCE

## Mechanical Vibration:

MIL SPEC 810E, Method 514.4: (Random Shock, 1 hour per axis)



## Mechanical Shock:

**Survival:** 30G peak; 18ms duration - 500 pulses  
 100G peak, 10 ms duration - 10 pulses