RA-6500/5500 SERIES

RADAR ALTIMETER

INSTALLATION MANUAL

Part Numbers

P/N 87990-XX-XXXX

Document No. 88222

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History of Revisions

Dates of Revision are:

Revision – 1 (Engineering Release)..... 4/27/2021

Revision – 2 (Engineering Release)..... 6/4/2021

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SECTION 1 GENERAL INFORMATION

1.1 Introduction

This manual contains installation data and specifications for the FreeFlight Systems RA-6500 and RA-5500 series Radar Altimeters (P/N 87990-XX-XXXX), hereafter referred to as the RA-6500. The RA-6500 meets the requirements for precision equipment of TSO-C87a, Functional Class A: Approach and Landing, and the requirements for category A/L/A1 & C/A radar altimeters of ETSO-C87a and EUROCAE ED-30.

The radar altimeter is designed to provide altitude above ground level (AGL) data to an electronic flight instrument system (EFIS), an integrated Flight Management System (FMS), or a Navigation Management System (NMS). The RA-6500 calculates AGL altitude by bouncing a Frequency Modulated Continuous Wave (FMCW) signal off the ground below the aircraft and reading the return signal. The altitude is computed from the time delay derived from mixing the transmit and receive signals together.

The system consists of three Line Replaceable Units (LRUs): the radar altimeter Receiver/Transmitter (R/T) Unit and two antenna units (refer to Section 1.9). Refer to Figure 1 for a system block diagram.

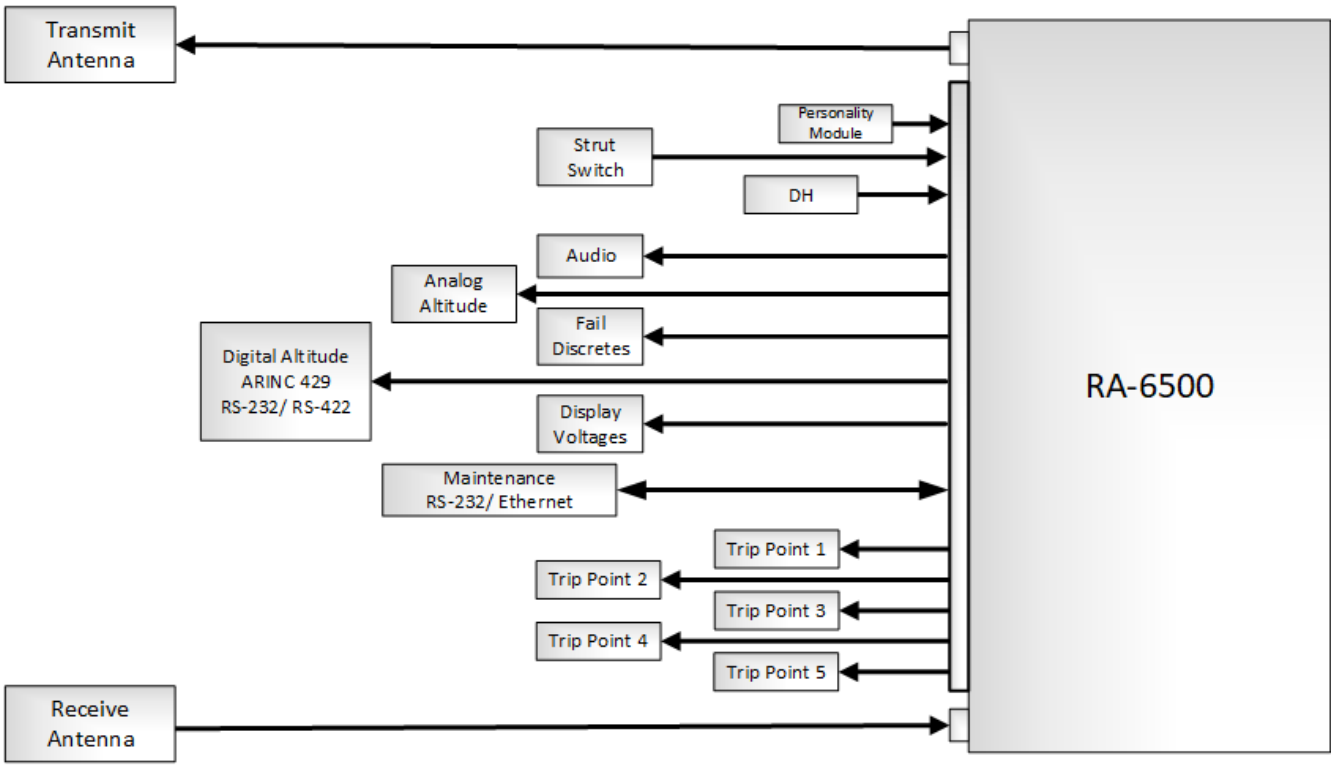


Figure 1: Radar Altimeter System Block Diagram

1.2 Referenced Documents

Table 1: List of Referenced Documents

Document Numbers	Title
RTCA/DO-160G	Environmental Conditions and Test Procedures for Airborne Equipment, 12/8/2010
RTCA/DO-178C	Software Considerations In Airborne Systems And Equipment Certification, 12/1/1992
TSO-C87a	Airborne Low-Range Radio Altimeter, 5/31/12
ETSO-C87a	European Technical Standard Order; Low Range Radio Altimeters, 12.07.13
EUROCAE/ED-30	Minimum Performance Specification for Airborne Low Range Radio (Radar) Altimeter Equipment, March 1980 including Edition 2, June 1, 1980
ARINC 429	Mark 33 Digital Information Transfer System; May 17, 2004
AC 25-7D	Flight Test Guide for Certification of Transport Category Airplanes, 05/04/2018
CAT.IDE.H.145	Acceptable Means of Compliance (AMC) and Guidance Material (GM) to Annex IV Commercial air transport operations [Part CAT], March 2017

1.3 Non-TSO Functions

The RA-6500 does not contain any non-TSO functionality.

1.4 Acronyms and Abbreviations

All acronyms and abbreviations used within this manual are defined upon initial use and followed by their shortened version in parentheses as used in the remainder of the manual. Items used within document numbers or quoted material are not included.

Table 2: Acronyms and Abbreviations

Abbreviation	Definition
A	Ampere
AGL	Above Ground Level
BCD	Binary Coded Decimal
dB	Decibels
EFIS	Electronic Flight Instrument System

ETSO	European Technical Standard Order
EUROCAE	European Organization for Civil Aviation Equipment
FAR	Federal Aviation Regulations
FCC	Federal Communications Commission
FFS	FreeFlight Systems
FMCW	Frequency Modulated Continuous Wave
FMS	Flight Management System
Hz	Hertz
LRU	Line Replaceable Unit
LSB	Least-Significant Bit
MFD	Multi-Function Display
MHz	Mega-Hertz
ms	Milliseconds
NCD	No Computed Data
NMS	Navigation Management System
ns	Nanoseconds
NVG	Night Vision Goggles
P/N	Part Number
R/T	Receiver / Transmitter
Rad Alt	Radar Altimeter
RX	Receive
SDI	Source/Destination Indicator
SSM	Sign/Status Matrix
TNC	Threaded Neill-Concelman [connector]
TSO	Technical Standard Order
TX	Transmit
VCO	Voltage-Controlled Oscillator
VDC	Volts Direct Current

1.5 Alert Symbol Usage

The following Warning, Caution, and Note symbols are used throughout this manual and their hierarchy is structured as shown below. When an item applies to an entire section it will be identified at the beginning of the applicable section. Otherwise, it will immediately precede the information for which it applies.

Warnings are identified when failure to properly follow the instructions provided may cause serious injury to personnel or damage to equipment if not followed.

Cautions are identified when failure to properly follow the instructions provided may cause serious damage to equipment, or unintended operation, if not followed.

Notes are identified to provide additional information or explanation to the user.

1.6 General System Description

A complete system consists of a radar altimeter R/T unit (P/N 87990-XX-XXXX) and two antennas (refer to Section 1.9). The radar altimeter provides AGL altitude information from -20 feet up to 2500 feet maximum. The altitude AGL is defined as the vertical distance from the antennas to the terrain. Embedded processors precisely measure the signal delay, calculate the altitude, and provide a simple to use display interface.

1.6.1 Operational Modes

Once the unit has completed a reset, it begins outputting data at a 25 Hz rate. Data consists of the altitude and a status byte on the RS-232/422/485 interface (refer to SECTION 4 for a description of the protocol) and labels 164, 165, 352, and 377 on the ARINC 429 interface. Following is a description of different modes for the unit.

1.6.1.1 Power-On Self-Test

At power on, the system initializes operation and performs a self-test for approximately 20 seconds. In the self-test, the lock circuitry is tested, and a test signal applied to the receive circuitry. During this time, the unit reports an altitude of 40±3 feet and asserts the “Self-Test” bit in the status byte (see Section 4.1).

1.6.1.2 Altitude Zero Calibration

When the Altitude Zero Calibration mode is selected during installation, the unit automatically calibrates the zero-altitude point. This automatically compensates for different cable lengths and different antenna installation heights above the ground that would otherwise bias the altitude reading.

1.6.1.3 On Ground Operation

While on the ground, the unit is susceptible to erroneous readings caused by signals returned from nearby buildings or personnel. Utilization of the strut input allows the unit to ignore these erroneous signals and report zero feet. The “Strut” bit of the status byte (see Section 4.1) provides an indication of the input signal. The system forces a valid altitude output of 0 foot if the strut indicates that the aircraft is on the ground.

1.6.1.4 Normal Operation

When the unit detects a locked signal and does not have a strut indication (i.e. – aircraft in the air), it reports altitude with the “Signal” bit indicating locked. If unusual terrain, aircraft orientation, or environmental conditions prevent a stable received signal, the “Signal” bit of the status word indicates unlocked.

1.6.2 Normal Operation Procedure

1.6.2.1 Pre-Flight Checklist

1. Turn on power on the control head or display (after starting engines).
2. Verify the unit self-tests for approximately 20 seconds (during which it displays 40±3 feet and sets the self-test flag).
3. After the self-test mode, the unit should output 0 feet while the aircraft is on the ground.
4. Adjust the brightness of the display, if necessary.
5. Adjust the volume of the audio output, if necessary.
6. Set the Decision Height (DH) on the display as appropriate.

1.6.2.2 During Flight

1. Adjust the Decision Height level on the display as necessary.

1.7 Limitations

1.7.1 Systems Limitations

For a compliant installation in accordance with the TSO and the Federal Aviation Regulations (FAR), the RA-6500 Series installations must meet the following requirements.

1.7.1.1 General

- "This article meets the minimum performance and quality control standards required by technical standard order TSO-C87a. Installation of this article requires separate approval."

- "The conditions and tests required for TSO approval of this article are minimum performance standards. It is the responsibility of those desiring to install this article either on or within a specific type or class of aircraft to determine that the article, when installed, performs in accordance with the design specifications that meet this TSO. The article may be installed only if further evaluation by the applicant documents an acceptable installation and is approved by the Administrator."

1.7.1.2 Installation

- The Radar altimeter must be connected to a display in a manner that yields no additional inaccuracies and with maximum additional latency of 80 ms. Added display inaccuracies trade with latency at a rate of ±1 ft to 40 ms; i.e., a display introducing ±1 ft of presentation error requires that the permissible installation/display component of latency decreases from 80 ms to 40 ms.

- The display connected to the radar altimeter must utilize a failure warning indicator plainly discernible under all normal flight conditions (ED30 §2.5) driven by the status and the invalid bit of the radar altimeter status byte (see).

- The antenna installation must comply with the specifications in Section 5.4.2.

1.7.2 Equipment Limitations[1]

1.7.2.1 Terrain

At altitudes above 1500 feet, terrain with poor reflectivity may cause the unit to unlock. Examples of unfavorable terrain are dry, loose soil, (e.g. - tilled farmland), or sand.

1.7.2.2 Excessive Pitch/Roll

An excessive pitch or roll attitude may also cause the system to unlock. This sensitivity increases with altitude. In general, below 1500 feet a 30-degree bank is tolerated. Above 1500 feet, the aircraft should be maintained within a 20-degree bank for proper operation. If the unit unlocks due to marginal conditions, it will automatically relock when a signal sufficient for ranging is detected.

1.7.2.3 Rapid Descent

In cases of extremely rapid descent, both the response time of the system and pitch of the aircraft may prevent normal operation. At a descent rate of 1500 feet/minute or less, the radar altimeter system provides normal operation below 2500 feet.

1.7.2.4 Response Time

When flying the radar altimeter system over rapidly changing terrain, e.g., a cliff or ravine, the system is limited by the 100 ms maximum response time of the unit.

Note:
The radar altimeter system surveys ground directly below the aircraft and should not be relied on as a forward-looking device.

1.7.3 Radio Altimeter Antennas

Compatible Radio altimeter antenna supplied by FreeFlight Systems include:

- FreeFlight P/N: 89486, See Section 1.10.1

[1] Actual limitations and values TBD

1.8 Technical Characteristics

1.8.1 RA-6500 Series

Table 3: System Specifications

Parameter	Value
Type	Dual Install, Dual antenna, FMCW
Compatible Antennas	1) FFS P/N 89617 and 89616 For additional antennas see Section 1.10.1
Altitude Range	-20 to 2500 feet
Altitude Accuracy	3 to 300 feet +/- 3 feet 100 to 500 feet +/- 3% Above 500 feet +/- 5%
Frequency Range	4.25 - 4.35 GHz
Sweep Frequency	100 Hz ± 20 Hz
Output Power	Max 200 mW
Input Voltage	10-40 VDC (Resettable internal fuse and reverse polarity protection)
Input Current	1 A Max @ 28 VDC (steady-state) (Preliminary)
Max. Inrush Current	2 A for 1 ms @ 28 VDC (Preliminary)
Altitude Output, Rate	25 Hz
Altitude Latency	less than 100 ms (63% of final value)
Self-Test / Reset	On system power-up
FCC	TBD
5G Compatibility	Mitigates interference from 5G sources
Environmental	DO-160G, see SECTION 3
Certifications	TSO-C87a, Functional Class A: Approach and Landing ETSO-C87a, Category A/L/A1 & C/A DO-178C Level B DO-160G

Table 4: Physical Characteristics

Parameter	Value
Weight	< 1.9 lbs
Height	3.06”
Length (Including mounting flange and connectors)	6.95”
Width	3.15”
Connectors	2 each TNC antenna connectors 1 each 66-pin circular connector 1 each 10/100 ethernet receptacle

Table 5: Antenna Physical Characteristics

Parameter	Value
Quantity	2
Weight	0.3 lbs (0.6 lbs total)
Dimensions	3.5" W x 3.65" L x .15" H

1.8.2 In-Flight Conditions

The altitude accuracy specified in Section 1.8 is met under the following conditions (per TSO-C87a and ETSO-C87a Category L):

Table 6: In-Flight Conditions

Parameter	Value[2]
Horizontal Velocity	0 to 1000 knots (0 to 1688 ft/s or 514 m/s)
Vertical Velocity*	0 to 20 ft/s up to 100 ft 0 to 25 ft/s above 100 ft

[2] Final values TBD

Roll Angle	0 to ±20°
Pitch Angle	0 to ±20°
Extended Roll Angles	At bank angles from 20° to 30° the error is less than 20% of the indicated altitude.

***Note:** Any errors induced by the Doppler shift in the frequency of the returned signal due to high vertical velocities are removed in software.

1.8.3 Altitude Rounding

To reduce the noise in the altitude output on the digital outputs of the radar altimeter, the altitude is rounded depending on the current altitude reading. Table 7 specifies the altitude rounding performed by the radar altimeter.

Table 7: Altitude Rounding

Altitude (ft)	Rounded To Nearest (ft)
-20 - 119	1
120 - 199	2
200 - 499	5
500 - 999	20
1000 - 2099	50
2100+	100

1.9 Parts and Equipment

1.9.1 RA-6500 Series Items

The RA-6500 Series and optional installation kit part numbers are listed below:

Each radar altimeter unit is shipped individually, as indicated in Table 8. Two antennas and associated wiring are also required for installation. Optional installation kits are available from FreeFlight Systems, as indicated in Table 10 and Table 11.

Table 8: Radar Altimeter Configuration (see Table 9 for ordering information)

ITEM	FFS P/N*	QUANTITY
RA-6500 Radar Altimeter LRU Unit	87990-1X-XXXX	1 required
RA-5500 Radar Altimeter LRU Unit	87990-2X-XXXX	1 required

***Note:** Future configuration place holders.

Table 9: Initial Part Numbers Available to Order

FFS P/N	Model Name	Model Description
87990-10	RA-6500	RA6500 Dual Install capable Radar Altimeter
87990-11	RA-6500	RA6500 Dual Install capable Radar Altimeter with KNI-415 / 416 Interface
87990-20	RA-5500	RA5500 Single Install Radar Altimeter
87990-21	RA-5500	RA6500 Single Install Radar Altimeter with KNI-415 / 416 Interface

Table 10: Optional Installation Kit 1 with Antennas

ITEM	FFS P/N	QUANTITY
Optional Installation Kit	89614-00	1 required
Coax Cable RG-142 B/U (30 ft)	0123-0012-00	1 per kit
Antennas (model: Sensor Systems)	89617	2 per kit
Connector TNC	0129-0017-00	4 per kit
66 Pin connector	89613	1 per kit
Connector Backshell Strain Relief	89615	1 per kit

Table 11: Optional Installation Kit 2 with Antennas

ITEM	FFS P/N	QUANTITY
Optional Installation Kit	89614-00	1 required
Coax Cable RG-142 B/U (30 ft)	0123-0012-00	1 per kit
Antennas (model: RAMI)	89616	2 per kit
Connector TNC	0129-0017-00	4 per kit
66 Pin connector	89613	1 per kit
Connector Backshell Strain Relief	89615	1 per kit

Table 12: Optional Installation Kit 3 without Antennas

ITEM	FFS P/N	QUANTITY
Optional Installation Kit	89614-00	1 required
Coax Cable RG-142 B/U (30 ft)	0123-0012-00	1 per kit
Connector TNC	0129-0017-00	4 per kit
66 Pin connector	89613	1 per kit
Connector Backshell Strain Relief	89615	1 per kit

FreeFlight Systems also offers an optional TSO-C87a certified Radar Altimeter Indicator, called RAD-45, for either standard installations or NVG compatible installations (Table 13). This indicator is not required (but may be used as alternate indication of radar altitude) for installations where the Radar Altimeter is connected to an EFIS. For stand-alone installations, an indicator is required. An optional installation kit for the indicator is also available (Table 14).

Table 13: Optional Indicator

ITEM	FFS P/N	QUANTITY
RAD-45 Radar Altimeter Display (Standard)	88226-00-XXXX	1 optional
RAD-45 Radar Altimeter Display (NVG)	88226-10-XXXX	1 optional

Table 14: Optional Indicator Installation Kit

ITEM	FFS P/N	QUANTITY
Optional Installation Kit	84949-00	1 optional
Connector DB-25 Female	9-2190-188-10	1 per kit
Connector Hood with Level	9-2190-188-20	1 per kit
Mounting Screws	9-2804-068-10	1 per kit

FreeFlight Systems also offers a delay line that eliminates the need for the minimum cable length requirement specified in Section 5.4.1.

Table 15: Optional Cable Delay

ITEM	FFS P/N	QUANTITY
21’ Cable Delay	85856-00	1 optional

1.10 Required Materials Not Supplied

The following items are required for proper installation but not supplied:

Table 16: Installation Materials Not Supplied

ITEM	FFS P/N	QUANTITY
System Wiring	N/A	As required
Circuit Breaker (2A, slow-acting)	N/A	1

1.10.1 List of Other Approved Radio Altimeter Antennas

The RA-6500 Series may be installed with the following radio altimeter antennas (not supplied by FFS) summarized below:

Model/Description	Mount Style	Manufacturer	Part Number
Radio Altimeter Antenna TBD	Screw Mount	L3Harris	PN19-2-1

1.11 License Requirements

As installed in the aircraft, the radar altimeter does not require an FCC operator's license. For information, reference FCC 47 CFR Part 87.89 Minimum operator requirements.

SECTION 2 RA-6500 INTERFACES

This section provides general information for installing the RA-6500 Series into an aircraft. This section contains mounting dimensions, pin outs, and interface details pertaining to installation. Adherence to these installation procedures and information will assure satisfactory system performance.

2.1 Unpacking and Inspecting Equipment

Exercise care when unpacking each item. Visually inspect each item for evidence of damage incurred during shipment. If a damage claim must be filed, save the shipping container to substantiate the claim. When all equipment and the installation kit have been inspected, save the packing material and container in case the unit is to be stored or reshipped. See paragraph 1.4 for parts and equipment.

2.2 Equipment Mounting

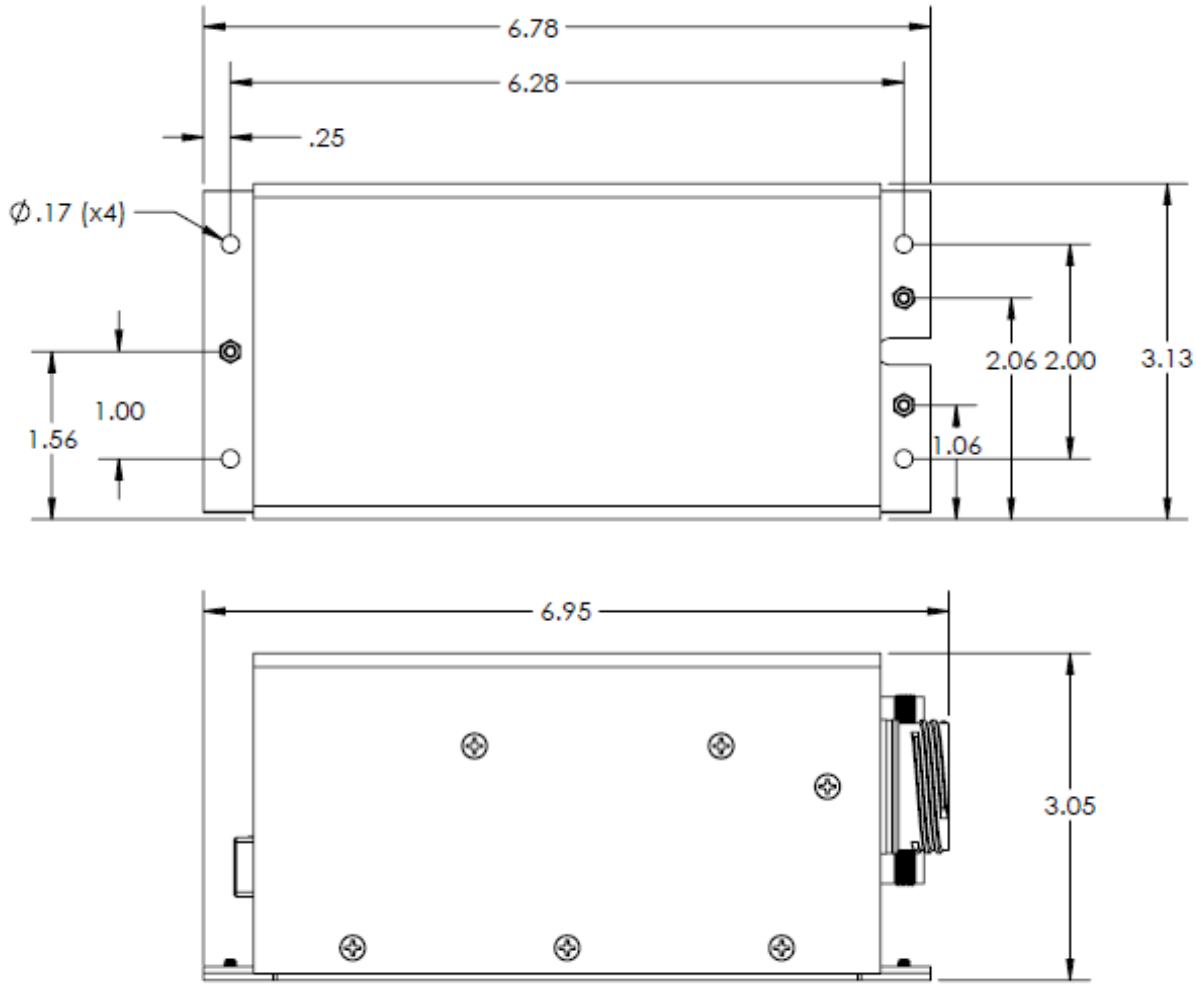
Installation procedures should be followed closely allowing adequate space for installation of cables and connectors.

U.S. standard units of measure are the primary means of identifying dimensions, weights, etc. The equivalent metric values may also be shown in brackets (e.g. 1.0 in [25.4 mm]).

The mounting requirements for the radar altimeter are illustrated in Figure 2 and Figure 3**Error! Reference source not found.**. Mounting information for antenna P/N 89617 is illustrated in . Mounting information for antenna P/N 89616 is illustrated in Figure 5. Mounting information for the optional radar altimeter mounting tray, P/N 84947-00, is illustrated in **Error! Reference source not found.**

Table 17: Connector Descriptions

Function	Description
Aircraft interconnections	This 66-pin circular connector mates with TE DEUTSCH P/N 2GZRC12 19-37
TX Antenna	This TNC connector mates with AMPHENOL P/N 225554-6
RX Antenna	This TNC connector mates with AMPHENOL P/N 225554-6
Ethernet Maintenance	Female RJ45 receptacle mates with standard male RJ45 plug



*Note: All Dimensions are in inches.

Figure 2: RA-6500 Dimensions

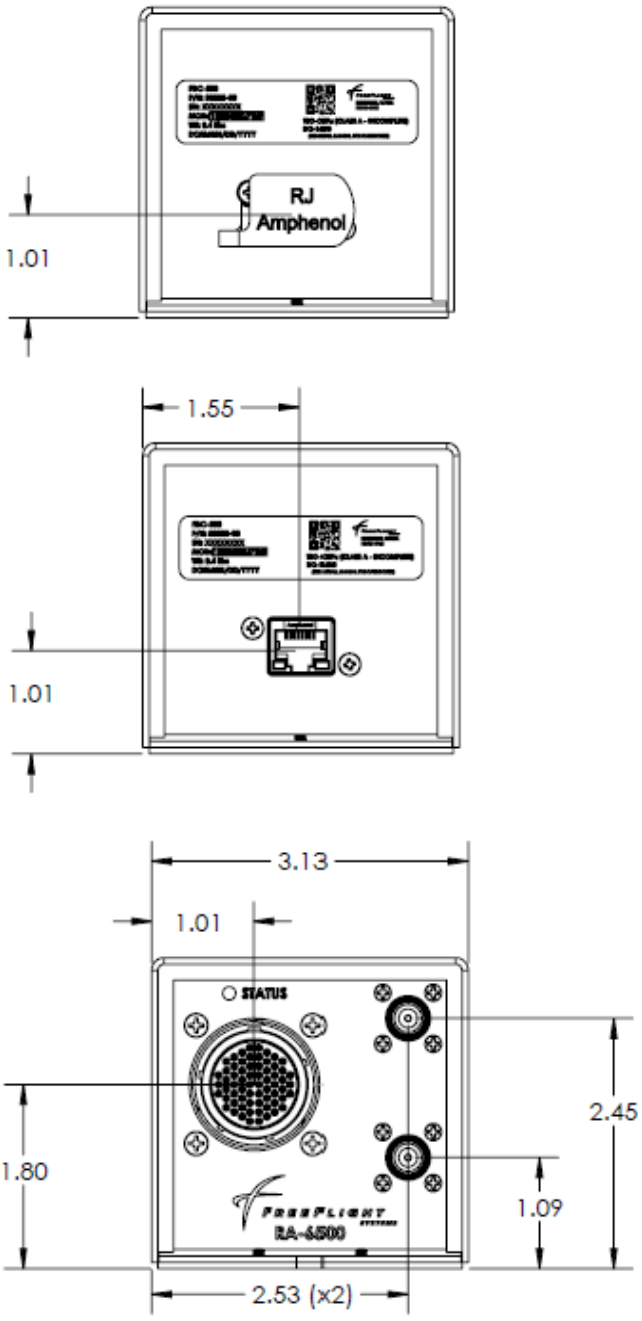


Figure 3: RA-6500 Front and Rear Dimensions

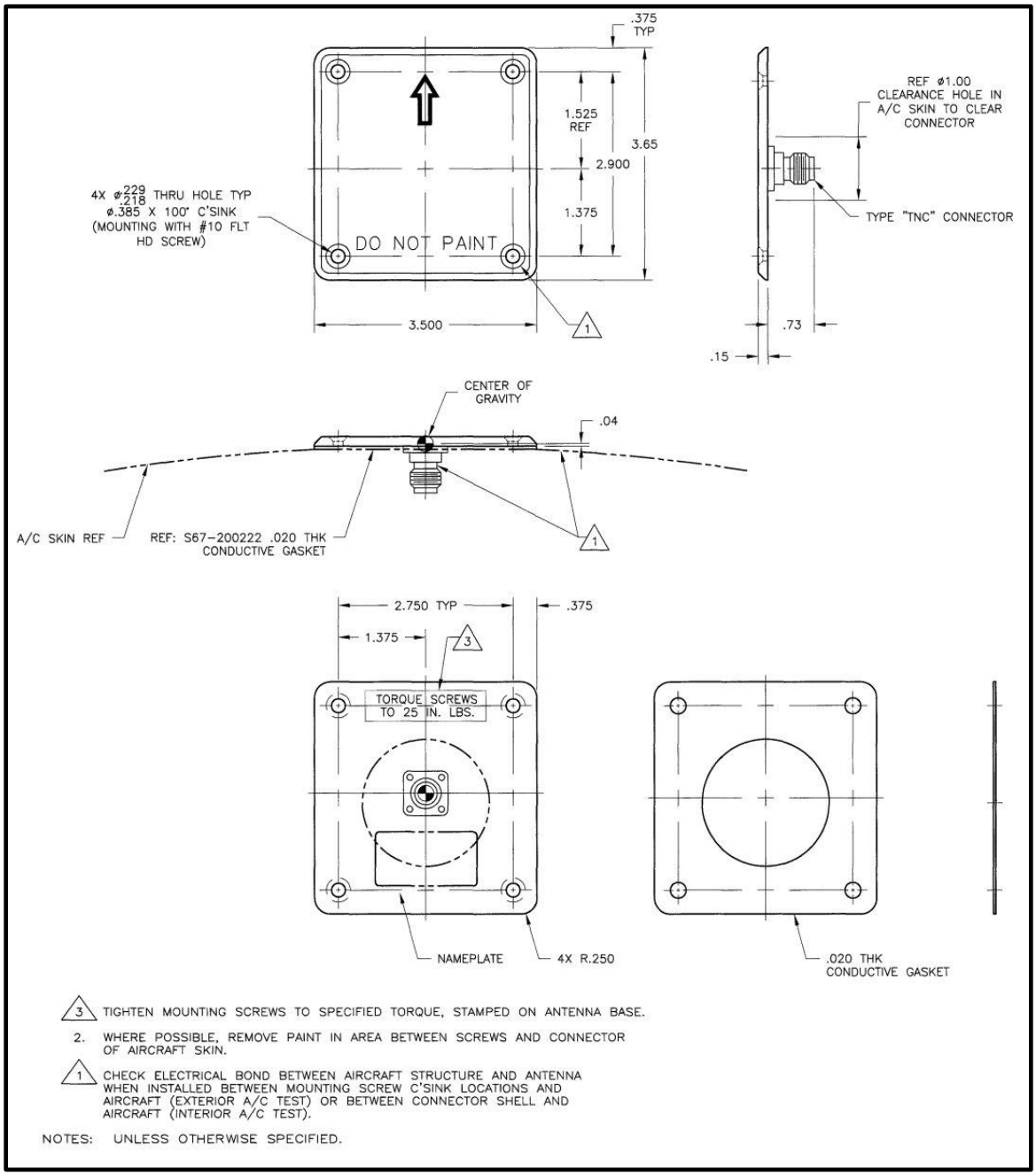
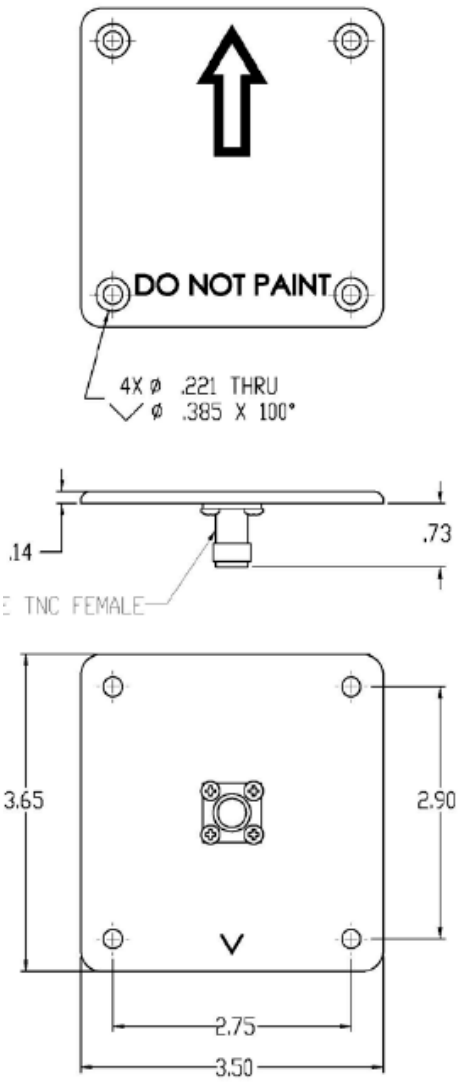


Figure 4: Antenna (P/N 89617) Installation Drawing



Part Number	AV-601
Market	General Aviation

The AV-601 antenna is designed specifically to meet FAA TSO-C87a specifications. Qualification testing includes meeting the requirements of EUROCAE ED-30, Edition 2, "Minimum Performance Standards for Airborne Low Range Radar Altimeter Equipment", as modified by Appendix 1 of the TSO.

PRODUCT SPECIFICATIONS

Application	Airborne Low Range Radar Altimeter
Frequency	4200-4400 MHz
VSWR	≤ 1.5:1 (4275-4325 MHz) ≤ 2.3:1 (4200-4400 MHz)
Polarization	Linear
Radiation Pattern Beam widths	Roll Plane(E): 45° min. Pitch Plane (H): 40° min.
Impedance	50 Ohms
Gain	9.5 dBi
Power	5 watts avg./500 watts max.
Side Lobe Level	-40 dB
Lightning Protection	DC Grounded
Finish	Skydrol-resistant Polyurethane Enamel
Mesh Gasket	3.50" X 3.65" X .02"
FAA TSO	C87a
Weight	0.25 lb (113g) max.
Connector	TNC Female

Figure 5: Antenna (P/N 89616) Installation Drawing

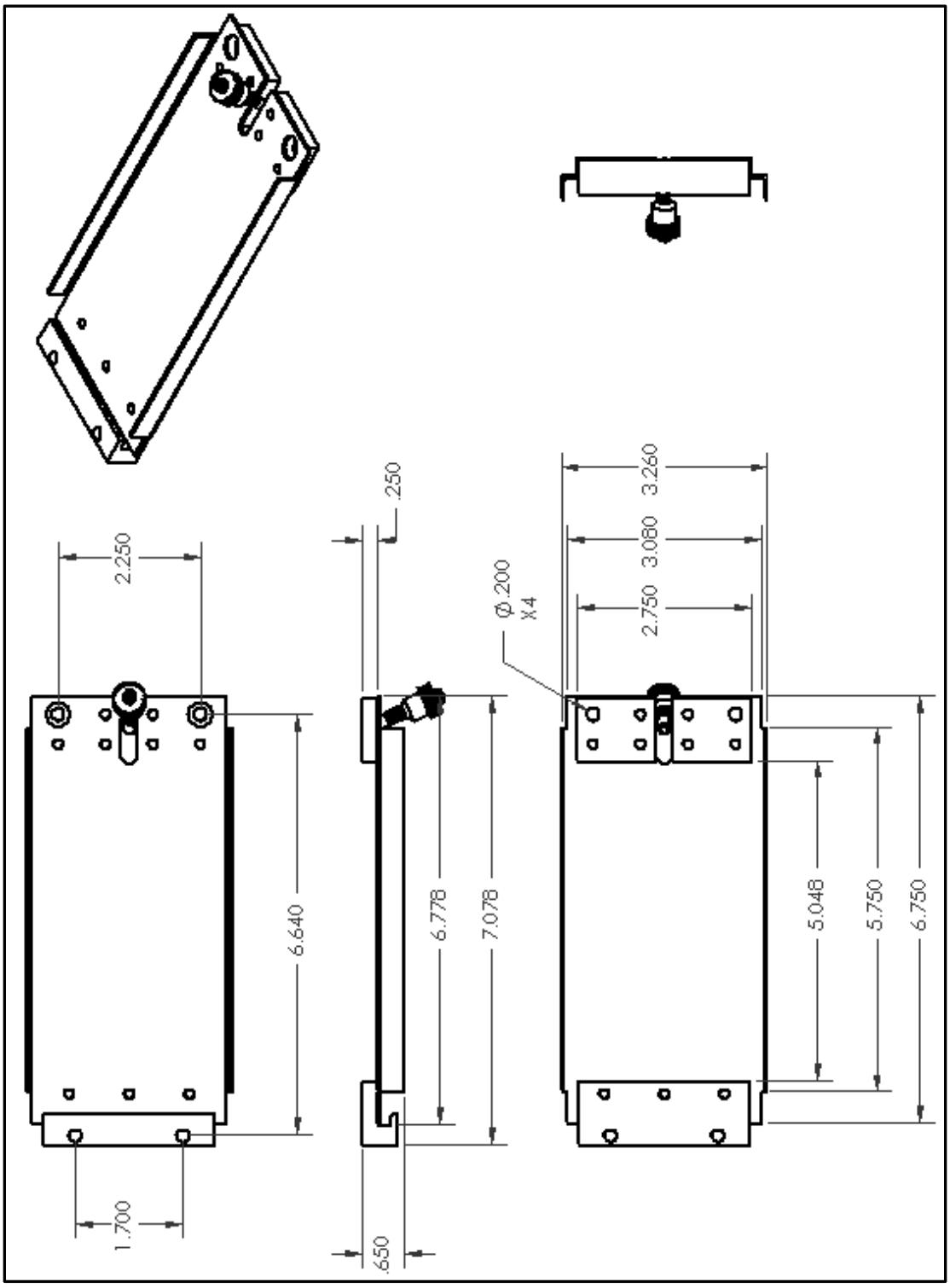


Figure 6: Mounting Tray Installation Drawing

2.3 Cooling Requirements

No cooling requirements.

2.4 Electrical Connections

2.4.1 Interface – D38999 66 Pin Connector

Table 18: RA-6500 Main 66 Pin D38999 Pinout

Number	Description
1	Aircraft Power Input
2	Aircraft Power Input
3	Aircraft Ground
4	Push-To-Test
5	ARINC 429 OUT 2A
6	ARINC 429 OUT 2B
7	Reserved
8	Aircraft Ground
9	Ground
10	Signal 3 GND
11	Reserved
12	Reserved
13	ARINC 429 OUT 1A
14	ARINC 429 OUT 1B
15	Serial Port 232 TX+
16	Signal 1 GND
17	Reserved
18	Reserved
19	PM 3.3 - 3.6 VDC
20	PM i2c Clock
21	PM i2c Data
22	PM ground
23	Reserved
24	Reserved
25	NAV Port B (serial Port 232 3 TX-)
26	NAV Port A (serial Port 422 3 TX+)

27	maint Port 2 232 RX
28	maint Port 2 232 TX
29	Signal 2 GND
30	GND
31	Precision Alt analog +
32	Precision Alt analog -
33	Trip Point 1
34	VALID (active high)
35	DH Enable
36	VALID (active low)
37	GND
38	RA_FAIL
39	Programming pin for processor
40	GND
41	Reserved
42	Trip Point 2
43	28 VDC out filtered
44	AUX1 Alt analog +
45	AUX1 Alt analog -
46	GND
47	Reserved
48	AUX2 Alt analog +
49	AUX2 Alt analog -
50	Trip Point 3
51	-5 VDC out
52	Reserved
53	Strut Switch
54	Dual Install Strap 1
55	ARINC speed strap Out Port 1[3]
56	ARINC speed strap Out Port 2[3]
57	Trip Point 4
58	+30 VDC out
59	Audio + output

[3] Low Speed (default, pin open)
High Speed (pin to ground)

60	Dual Install Strap 2
61	Reserved
62	Audio - output
63	Trip Point 5
64	Reserved
65	Reserved
66	Reserved

2.4.2 Ground

Aircraft ground is connected on two pins.

2.4.3 Power Input

Aircraft power of 12-40 VDC is connected on two pins.

2.4.4 PTT Input

PTT, Push-To-Test input allows the pilot to press the PTT switch on the display to verify the display functionality.

2.4.5 Strut Switch Input

The Strut signal is an active low input by default. That is, the input should be grounded when the aircraft is on the ground. Strut input polarity can be set during configuration.

2.4.6 Serial Ports 1, 2, and 3

The port 1 and 2 lines use RS-232C signal levels. Serial port 3 uses a RS-485/422 TXA/TXB pair. The RS-232C output carries the same data as the RS-485/422 TXA/TXB pair.

2.4.7 Audio Output +/-

The audio connection produces 30 mW ±10 mW into a 500 Ω load. Audio output can be enabled or disabled in the configuration settings. Audio output, when enabled and connected, will annunciate configured trip point values and decision height.

2.4.8 Decision Height Enable

This pin provides an input for the KNI-416 display unit to trigger when the Decision Height altitude is descended through. When activated, an audible tone is generated followed by the words “Decision Height” through the audio output pins. Decision height input polarity can be set during configuration.

2.4.9 Maintenance Port RS-232 TX/RX

The maintenance port is an RS-232C signal level port specifically for zero calibration, installation configuration and maintenance.

The Maintenance-TX/RX lines are used to initiate the Altitude Zero Calibration function. Note that it may be advantageous to route these lines to a point which facilitates shorting them for the Altitude Zero Calibration (see 5.5.2). If this is done, care should be taken that the lines do not accidentally short during normal flight. During normal operation after the Zero Calibration has been accomplished, these lines should not be connected.

2.4.10 Ethernet Connection

The Ethernet port is for maintenance and installation configuration exclusively.

2.4.11 ARINC 429 Out 1 and 2 -TXA/TXB

ARINC 429 labels 164, 165, and 377 are transmitted on this interface at a rate of 25 Hz. Cabling should be shielded twisted pair with shield grounded to aircraft and radar altimeter chassis.

2.4.12 ARINC Speed Select

These pins are used to configure the unit to output low-speed (12 kbps) or high-speed (100 kbps) ARINC 429 data. If this pin is left open (default) the system will output low-speed ARINC data. If the pin is connected to ground, the system will output high-speed ARINC data.

2.4.13 Dual Installation Select

These pins are used to configure the RA-6500 for aircraft with dual radar altimeter installations. To configure the system for dual installation, the strapping must be made in the mating 66-pin connector for only the secondary RA-6500 LRU. Strap the Dual Install Strap 1 (DS1) pin and the Dual Install Strap 2 (DS2) pin together using a conductor wire no more than six inches long.

When the Dual Install Strap 1 (DS1) and Dual Install Strap 2 (DS2) pins are strapped, the strapped RA-6500 will automatically configure itself so that the two units will not interfere while operating. Both units are designed to be continuously powered during flight to get correct zero readings while on the ground.

2.4.14 Personality Module

The personality module stores specific information regarding the installation during configuration. Connect the personality module on the mating connector so that it will remain in the aircraft if necessary, to replace an RA-6500 LRU, reducing time needed to reconfigure the system.

2.4.15 Trip Points

There are five trip point connections on the RA-6500. Trip points are controlled in the configuration settings as follows:

- Output can be enabled or disabled
- Output polarity can be set high or low
- Trip point altitude values can be set in feet

2.4.16 Altitude Validity Flag Discretes

The Altitude Validity Flags (VALID, /VALID), are inactive if valid altitude data has been generated within the previous 5 seconds. The VALID flag is active high and can source up to 250mA at 20V nominal. The /VALID flag is active low and can sink up to 250mA. The maximum voltage for the /VALID pin is 50Vdc.

2.4.17 External Power for Analog Display

The RA-6500 provides three separate voltage signals for the KNI-416 analog display. These voltages are required for the display to operate correctly. The voltages provided are -5 VDC, 28 VDC filtered, and +30 VDC.

2.4.18 Analog Altitude Out

Outputs Precision Equipment and Auxiliary #1 have fixed scale factors. Output Auxiliary #2 is selectable between option 1 and option 2 based on configuration setting selected at installation.

Noun	Range in Ft		Slope	Offset	Format Pin
	Minimum	Maximum			
Precision Equipment	-20	2500	-10.0 mV/ft	Zero ft = 0.000V	
Auxiliary #1	-20	500	20mV/ft	Zero ft = 0.400V	
	500	2500	3 mV/ft		
Auxiliary #2 (option 1)	-20	2500	-4mV/ft	Zero ft = 0.000V	Open
Auxiliary #2 (option 2)	-20	480	20mV/ft	Zero ft = 0.400V	Ground
	480	2500	non-linear [4]		

[4] 10*(1+LN((ALT+20)/500))

SECTION 3 RTCA/DO-160 ENVIRONMENTAL QUALIFICATIONS

U.S. standard units of measure are the primary means of identifying dimensions, weights, etc. The equivalent metric values may also be shown in brackets (e.g. 1.0 in [25.4 mm]).

3.1 RA-6500 Series Equipment and UAT DO-160G Qualification

Conditions	Para	Category (DO-160G)
Temperature and Altitude	4	F2 (-40ºF to +158ºF [-40ºC to +70ºC])/D/A
Operating Low Temperature	4.5.2	-55ºF [-40°C] (F2)
Operating High Temperature	4.5.4	+158ºF [+70°C] (F2)
Short-Time Operating Low Temperature	4.5.1	-55ºF [-40°C] (F2)
Short-Time Operating High Temperature	4.5.3	+158ºF [+70°C] (F2)
Ground Survival Low Temperature	4.5.1	-67°F [-55°C] (F2)
Ground Survival High Temperature	4.5.3	+185°F [+85°C] (F2)
Loss of Cooling	4.5.5	Z (N/A – No cooling required)
Altitude	4.6	+55,000ft (F2)
Decompression	4.6.2	(8K to 55K < 15 seconds) (A2)
Overpressure	4.6.3	(170kPa)
Temperature Variation	5	B (5°C per min)
Humidity	6	B (Severe humidity environment)
Operational Shock/Crash Safety	7	B (Standard shock and crash safety)
Vibration	8	S (Curve C) standard & U2 (Curve F and F1) robust
Explosive Atmosphere	9	E1
Waterproofness	10	N/A
Fluids Susceptibility	11	N/A
Sand and Dust	12	N/A
Fungus Resistance	13	N/A
Salt Fog	14	N/A
Magnetic Effect	15	Z
Power Input	16	B
Voltage Spike	17	A

Conditions	Para	Category (DO-160G)
Audio Frequency Conducted Susceptibility – Power Inputs	18	Z
Induced Signal Susceptibility	19	ZCX
Radio Frequency Susceptibility	20	Y
Emission of Radio Frequency Energy	21	MM
Lightning, Induced Transient Susceptibility	22	A3J3L3 (shielded)
Lightning Direct Effects	23	N/A
Icing	24	N/A
Electrostatic Discharge	25	N/A
Fire, Flammability	26	N/A

SECTION 4 FUNCTIONAL INTERFACE SPECIFICATIONS

The FreeFlight Systems Radar Altimeter provides serial RS-232/422/485 interfaces and an ARINC 429 interface.

The following sections describe the protocols used.

4.1 RS-232/422/485 Interface

4.1.1 Data Rate

Data is transmitted in multi-byte packets at configurable BAUD rates including 56,000 and 115200 (default) baud (LSB first, 8 data bits, one start, one stop, no parity). System altitude packets are output at a rate of 25 Hz.

4.1.2 Protocol Definition

> **Note**:
>
> The information in this section is intended for engineering personnel and is not required for installation.
>
> Protocol definition details (RA6500-IS) can be requested from FreeFlight Systems Support.

4.2 ARINC 429 Interface

4.2.1 Data Rate

All ARINC 429 labels are transmitted at either low or high speed ARINC baud rates as configured at installation time (see Section 2.4.12) and are transmitted at a rate of 25 Hz.

4.2.2 ARINC Protocol Definition

> **Note**:
>
> The information in this section is intended for engineering personnel and is not required for installation.
>
> ARINC label format additional details RA-6500-IS can be requested from FreeFlight Systems Support.

4.2.2.1 Parity

The parity bit of all labels is set to odd parity.

4.2.2.2 ARINC 429 Labels

The following labels are transmitted:

Table 19: ARINC 429 Output Labels

Label (octal)	Description
164	Radio Altitude (Binary)
165	Radio Altitude (BCD)
352	Info
377	Equipment ID

4.3 Analog Altitude Output

This section applies to model RA-6500/5500 (P/N 87990-X1-XXXX) only.

4.3.1 Replacement to the KRA-405B

The RA-6500 (P/N 87990-10-XXXX) contains the FreeFlight data converter module that translates altitude data to analog voltage signals designed to operate the KNI-416 Altimeter display. The RA-6500 will also provide the necessary voltage signals to drive the KNI-416 display. The RA-6500 also provides warning discretes, trip point discretes, and audio output to drive the KNI-416 display.

4.3.2 RA-6500 Outputs from KNI-416

The RA-6500 outputs +28 VDC filtered, +30 VDC, and -5VDC in order to provide the necessary voltages to operate the KNI-416 display. The RA-6500 also provides the analog voltage outputs for altitude data.

4.3.3 RA-6500 Inputs from KNI-416

The RA-6500 inputs the decision height (DH) enable discrete from the KNI-416. When enabled the RA-6500 issues an aural alert for decision height. The aural alert consists of a tone followed by the spoken words “decision height” when descending through the decision height altitude. This function has hysteresis to prevent multiple callouts unnecessarily. The push-to-test pin is also an input to the RA-6500 to verify the display functionality.

SECTION 5 INSTALLATION

5.1 General Information

This chapter contains suggestions and factors to consider before installing a radar altimeter into an aircraft. Adherence to the suggestions will assure satisfactory performance from the system.

5.2 Dual Installation System Interaction

When installed in an approved configuration, mutual interaction between individual radar altimeters is not operationally significant.

5.3 Unpacking and Inspecting Equipment

Exercise care when unpacking each unit. Make a visual inspection of each unit for evidence of damage incurred during shipment. If a claim for damage is to be made, save the shipping container to substantiate the claim. When all equipment and the installation kit have been inspected, save the packing material and container in case the unit is to be stored or reshipped. See Section 1.9 for equipment and optional parts supplied.

5.4 Antenna Installation

5.4.1 Antenna Cable Selection

The antenna cables must have a certain minimum and maximum length for the system to perform accurately and comply with the TSO. The absolute minimum cable length is limited by the required minimum signal propagation delay caused by the cable and the antenna height above the ground when the aircraft is on the ground. The absolute maximum cable length is limited by the maximum allowable attenuation of the signals caused by the cable.

Table 20: Propagation Delay and Attenuation of the Antenna Cable

Min Total Propagation Delay (ns)	Max Attenuation (dB)
31	8.5

Table 21 shows typical values of propagation velocities, attenuations, and the minimum bend radius for commonly used cable types. Consult the cable manufacturer's specifications for the exact values for the cables used in the installation.

Table 21: Typical Antenna Cable Lengths

Cable	Min Total Length[1] (ft)	Max Total Length[2] (ft)	Min Bend Radius[3] (in)	Propagation Velocity (c)	Attenuation/100' (dB) @ 4.35 GHz
RG-142	21.0	28.8	3	69.4 %	29.5
RG-393	21.0	47.8	6	69.4 %	17.8

Note: Total length refers to the combined lengths of the TX and the RX cables.

[1] The minimum cable length specified assumes that the antennas are mounted 18” above the ground, resulting in a 3 ns return delay (The propagation delay in air is approximately 1 ns per foot). If the manufacturer’s data indicates a different propagation velocity than the one given in Table 21 the minimum cable length must be recomputed by the installer.

[2] If the manufacturer’s data indicates a different attenuation than the one given in Table 20the maximum cable length must be recomputed by the installer.

[3] The manufacturer specified minimum bend radius may differ.

5.4.2 Antenna Mounting Requirements

Refer to for mounting information. For proper performance and TSO compliance of the radar altimeter, the radar altimeter antennas must be installed according to the following rules:

- Antennas should be mounted parallel to the ground within a pitch angle of 6° when the aircraft is in level flight.
- Antennas must be mounted with the arrows pointing along the same line. See Figure 7. They should be mounted in-line although a side-by-side configuration is also acceptable with the Sensor Systems antenna (P/N 89617). The EDO antenna may only be mounted in-line.

Note: The EDO antennas may only be mounted in-line and should not be mounted side-by-side. Only the Sensor Systems antenna may be mounted side-by-side.

- If the antennas are mounted in-line, which is the preferred configuration, the transmit antenna should be mounted in front of the receive antenna.
- The angle between the pitch of both antennas should not exceed 6°.
- The antennas should be mounted such that no protrusion is visible to either antenna within a 120-degree cone (±60 degrees) below the aircraft.
- Antennas should be mounted at least 18" apart and within 40" of each other.
- The antenna height above the ground when the aircraft is on the runway should be more than the separation distance between the two antennas.
- Antennas should be mounted as close to the aerodynamic center of the aircraft as possible to reduce the effects of aircraft attitude on the altitude measurement.
- The base of the antenna should be properly grounded. The maximum resistance should be less than 0.9 Ohms.

- Antennas should not be mounted closer than 3’ to a DME, transponder, ADF or VHF antenna.
- During installation, avoid locations near high heat sources or where fuel, oil or excessive moisture may collect. Bond and shield all parts of the aircraft electrical system such as generators and ignition systems.

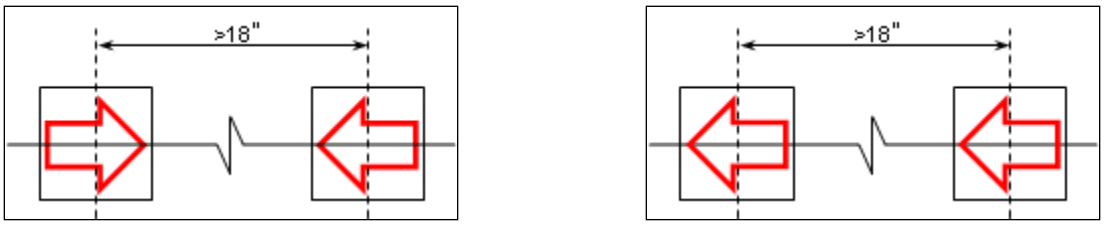


Figure 7: Antenna Orientation

Arrows may point at each other, away from each other, or the same direction. However, they must be positioned to point along the same center line.

5.5 Radar Altimeter Installation

The radar altimeter unit installation layout is shown in Figure 8 and Figure 9. Route all data and power cables away from circuits carrying high current, pulse-transmitting equipment, 400 Hz circuits and other sources of interference. Do not route altimeter antenna cables with ADF antenna cables.

5.5.1 Display interconnect

5.5.1.1 RAD-40/45 Display

Figure 8 shows the typical display interconnection between the radar altimeter and the optional FreeFlight Systems RAD-40/45 Radar Altimeter Display.

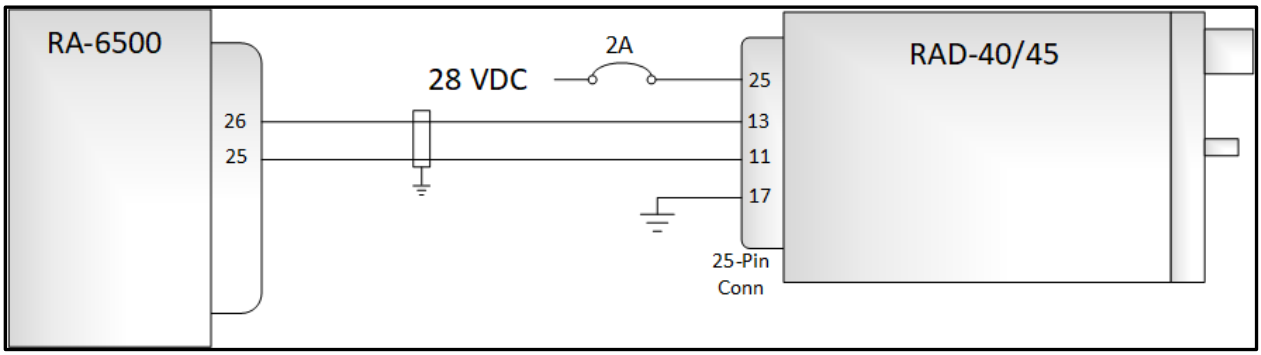


Figure 8: Typical Radar Altimeter to RAD-40/45 Interconnections Diagram

5.5.1.2 ARINC 429 Display

Figure 9 shows the typical display interconnection between the RA-6500 and an ARINC 429 EFIS or MFD.

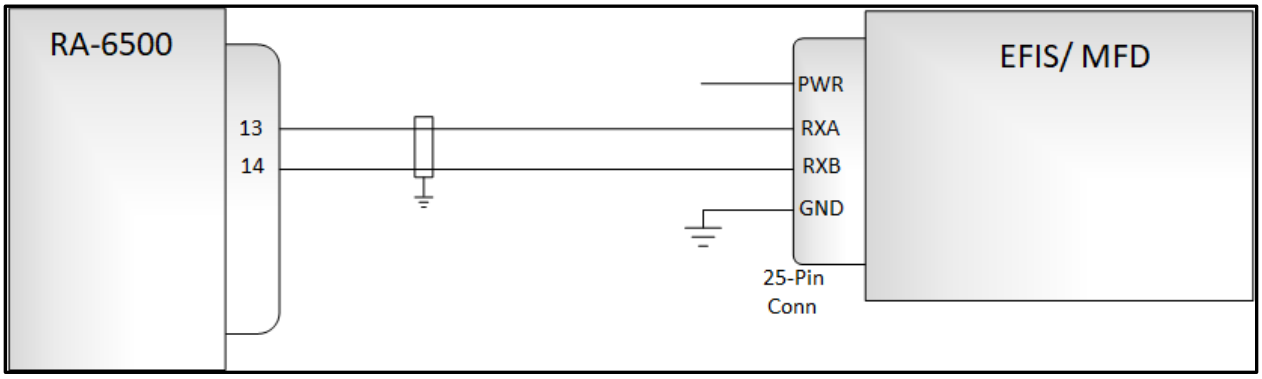


Figure 9: Typical Radar Altimeter to EFIS/MFD Interconnection Diagram

5.5.2 Altitude Zero Calibration

The radar altimeter should be calibrated to account for the antenna height above ground when a zero-foot altitude is desired. This procedure should be performed once on initial install of the unit or after servicing the unit. Reflections due to surrounding obstacles may cause inaccurate calibration. It is recommended to Zero the radar altimeter in an open area away from buildings, trees, or other large reflecting surfaces to improve accuracy.

Note: If this procedure is not performed on install, after service, or is improperly performed, altitude output of the radar altimeter may not be correct.

1. T.B.D.

5.6 Post-Installation Testing

5.6.1 Pre-Flight Check List

1. Turn on power (after starting engines).
2. Verify the unit self-tests for approximately 20 seconds (during which it displays 40±3 feet and sets the self test flag).
3. After the self-test mode, the unit should output 0 feet while the aircraft is on the ground.

5.6.2 Final Testing

1. During takeoff observe AGL and verify that it is increasing while the aircraft is climbing.
2. After aircraft exceeds 2500 feet AGL verify that unit indicates “unlocked”.
3. With the aircraft above 3000 feet AGL in an open area:
    a. Put the aircraft into a 500-foot per minute descent.
    b. The unit should lock and start outputting valid altitude by 2500 feet AGL.

SECTION 6 TYPICAL INTERCONNECT DIAGRAMS AND SCHEMATICS

6.1 Typical System Configurations

This section contains general wiring diagrams examples for popular configurations.

Strut input will vary on each aircraft depending on the equipment installed. Refer to the aircraft manual to determine the appropriate input signal to the RA-6500/5500.

 The RA-6500 and RA-5500 requires FAA approval before installation.

 Contact FreeFlight Systems for additional information and STC validation.

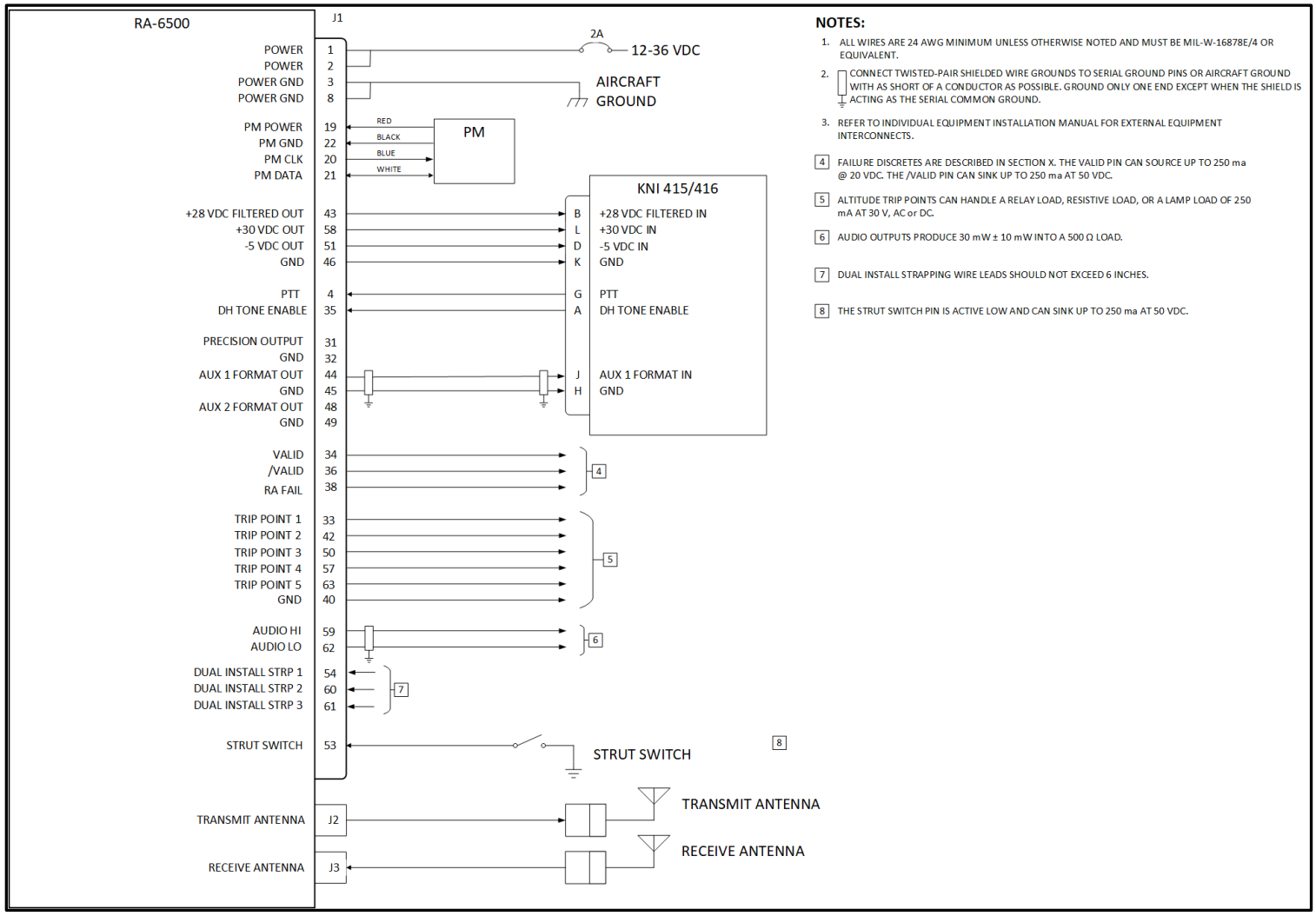


Figure 10: RA-6500 to KNI-416 Display Typical Wiring Diagram

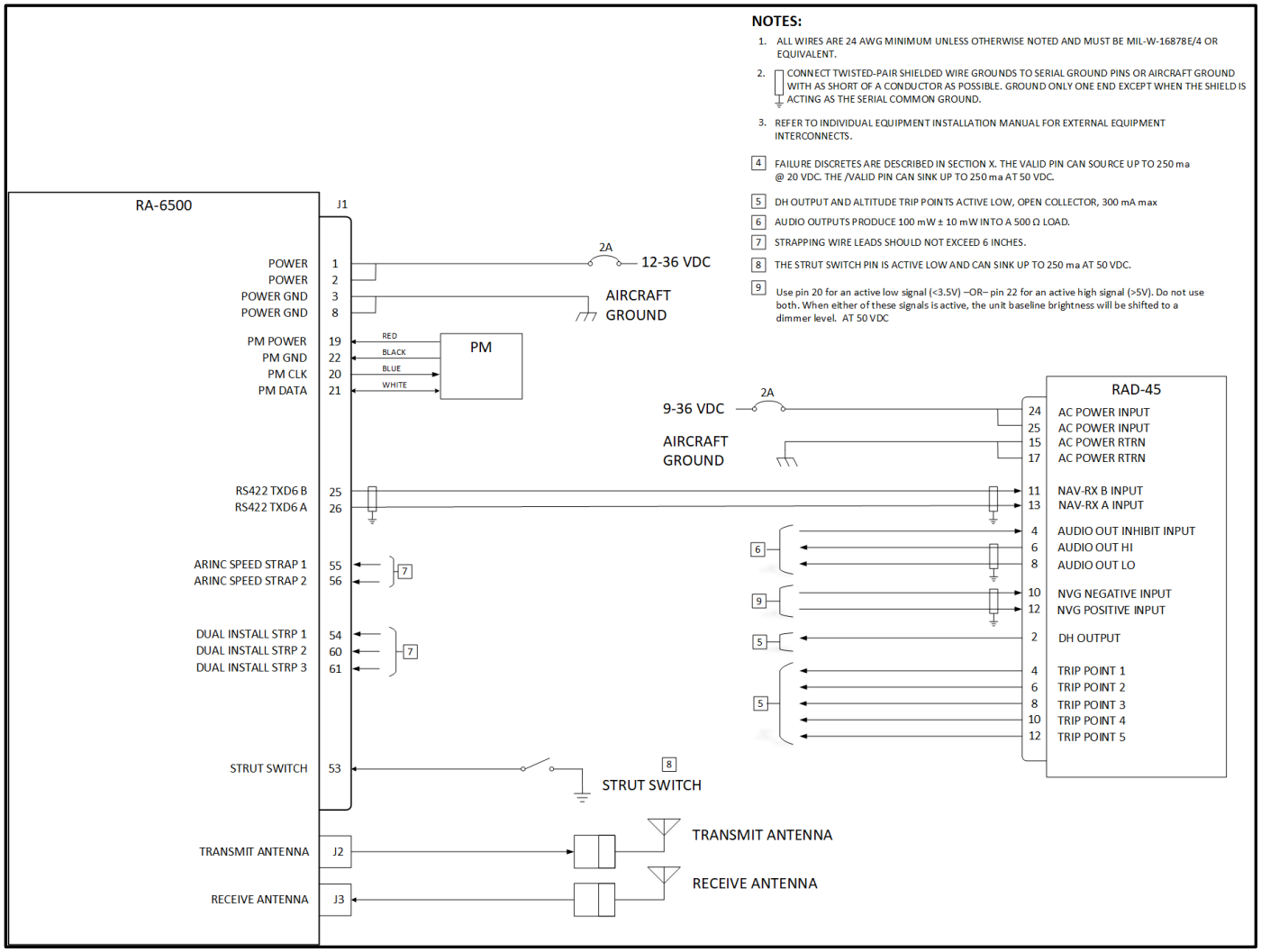


Figure 11 : RA-6500 to RAD-45 Typical Wiring Diagram

SECTION 7 TROUBLESHOOTING

7.1 General

In general, the troubleshooting techniques for the RA-6500 are comprised of ensuring the proper connections to the unit are made, verifying these connections are complete, and power cycling the Rad Alt in the event of erroneous data/outputs.

7.2 RA-6500 LED Status and Troubleshooting Procedures

Table 22: LED Description[5]

LED Color	Status/Explanation	Suggested Corrective Action
Off	Power is off.	Apply power to Rad Alt. If LED stays powered off check connections on Rad Alt.
Red	Power is on with POST is in process or failed, or BIT has failed (after 20-second warm-up period).	Check connections on front and back of Rad Alt. Cycle power to Rad Alt.
Green	Power is on. BIT has passed and no valid altitude data is being generated.	Check connections on front and back of Rad Alt. Cycle power to Rad Alt and any other LRU's connected to Rad Alt.
Green/Cyan alternating	Power is on. BIT has passed and valid altitude data is being generated within the previous 5 seconds.	N/A.

[5] Subject to change.

SECTION 8 CONTINUED AIRWORTHINESS

8.1 Periodic Maintenance, Calibration, and Repair

8.1.1 Periodic Maintenance

There is no periodic maintenance to be performed on the RA-6500 System. If a software update is issued for the RA-6500, a Service Bulletin will be issued with complete instructions for performing the update.

8.1.2 Calibration

There is no calibration to be performed on the RA-6500 System. Calibration is performed at the FreeFlight Systems manufacturing facility.

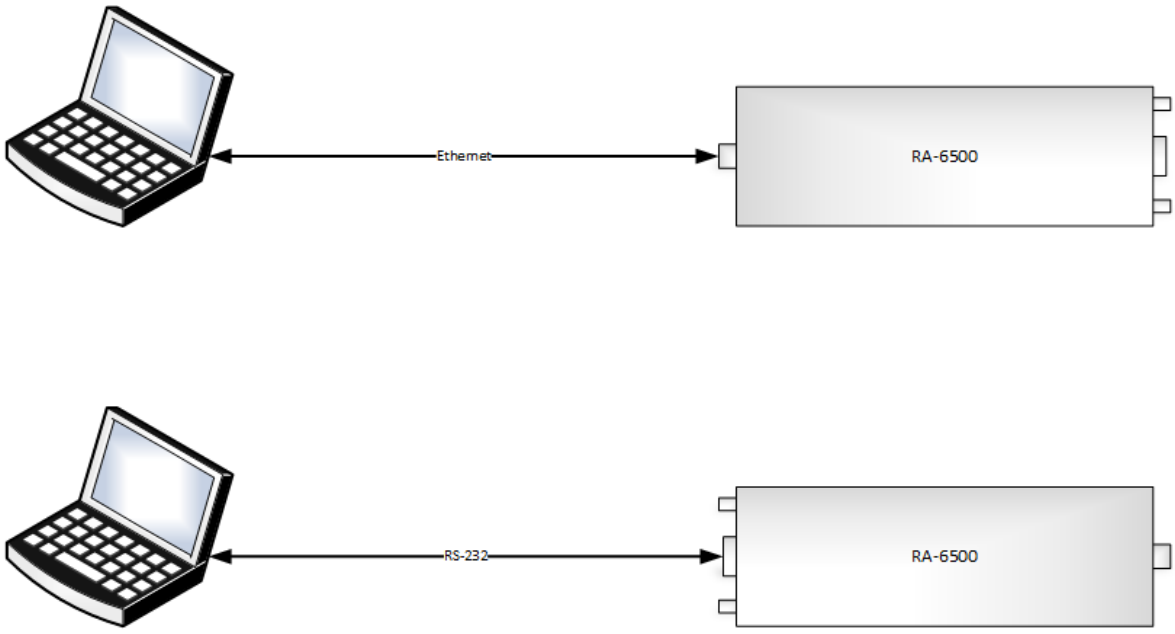
8.1.3 Repair

There is no field-level repair to be performed on the RA-6500 System. All repairs must be returned to FreeFlight Systems with an RMA.

8.2 MAINTENANCE INTERFACE DIAGRAMS

The diagrams below represent of the available options for accessing the maintenance port of the RA-6500 series.

Figure 12: Maintenance Connections for RA-6500



8.2.1 Maintenance Port Interface Commands

TBD.

SECTION 9 WARNING DISCLAIMER

TBD.

SECTION 10 LIMITED WARRANTY

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