Appendix G: User Manual

Please refer to the following pages for the manual.

EQUIPMENT INSTALLATION MANUAL

FOR

FREEFLIGHT SYSTEMS

RA-4000 SERIES RADAR ALTIMETERS

Part Numbers 84560-XX

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REVISION HISTORY		
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A	Initial release	02-Oct-05
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1 Introduction

This manual contains installation data and specifications for the FreeFlight Systems RA-4000 Series Radar Altimeters (P/N 84560-XX), hereafter referred to as the RA-4000. The RA-4000 meets the requirements for a TSO-C87 Radar Altimeter with Precision Equipment output.

The RA-4000 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). Altitude is calculated by assessing the round trip delay of a signal reflected from the ground.

The system consists of three Line Replaceable Units (LRUs): the RA-4000 Receiver/Transmitter (R/T) Unit and two Antenna Units (refer to section 2.4). Refer to Figure 1-1 for a system block diagram.

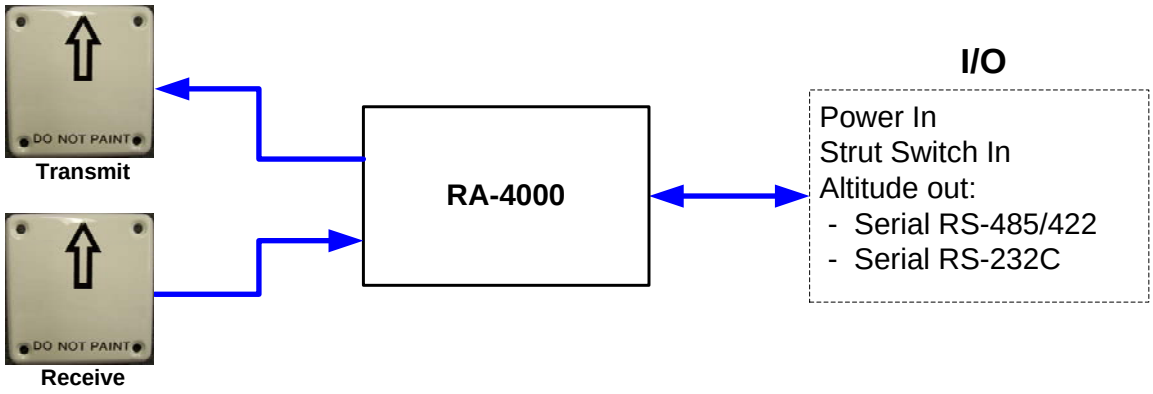


Figure 1-1: RA-4000 System Block Diagram

1.1 Reference Documents

Document Number	Title
RTCA/DO-160E	Environmental Conditions and Test Procedures for Airborne Equipment; 29-July-97 (incorporating Change 1 dated 14-Dec-00, Change 2 dated 12-June-01, and Change 3 dated 05-Dec-02).
RTCA/DO-178B	Software Considerations In Airborne Systems And Equipment Certification; 1-Dec-92.
TSO-C87	AIRBORNE LOW-RANGE RADIO ALTIMETER; 1-Feb-1966.
RTCA/DO-155	Minimum Performance Standards Airborne Low-Range Radar Altimeters; 1-Nov-1974.
ARINC 429	Mark 33 Digital Information Transfer System; May 17, 2004

1.2 Table of Acronyms & Abbreviations

The following acronyms and abbreviations are used throughout this document.

Abbreviation	Definition
A	Ampere
AGL	Above Ground Level
BCD	Binary Coded Decimal
dB	Decibels
EFIS	Electronic Flight Instrument System
FAR	Federal Aviation Regulations
FFS	FreeFlight Systems
FMCW	Frequency Modulated Continuous Wave
FMS	Flight Management System
Hz	Hertz
LRU	Line Replaceable Unit
LSB	Least-Significant Bit
MHz	Mega-Hertz
ms	Milliseconds
NCD	No Computed Data
NMS	Navigation Management System
ns	Nanoseconds
P/N	Part Number
R/T	Receiver / Transmitter
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

2 Description

A complete system consists of an RA-4000 R/T unit (P/N 84560-XX) and two antennas (refer to section 2.4). The RA-4000 provides AGL altitude information from -20 feet up to 2000 feet maximum via computer interface.

The RA-4000 Radar Altimeter system utilizes a reliable solid-state voltage-controlled oscillator (VCO) to drive its transmitter. Embedded processors precisely measure the signal delay, calculate the altitude, and provide a simple to use computer interface.

2.1 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, and 377 on the ARINC 429 interface. Following is a description of different modes for the unit.

2.1.1 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 4.1.2.1.4).

2.1.2 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.

2.1.3 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 4.1.2.1.4) provides an indication of the input signal.

2.1.4 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.

2.2 System Limitations

2.2.1 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.

2.2.2 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.

2.2.3 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 RA-4000 system provides normal operation below 2000 feet.

2.2.4 Response Time

When flying the RA-4000 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 RA-4000 system surveys ground directly below the aircraft, and should not be relied on as either a forward looking or warning device.

2.3 Specifications

Specifications for the RA-4000 system are listed in Tables 2-1 through 2-3.

Table 2-1: System Technical Characteristics

Parameter	Value
Type	Dual antenna, FMCW
Compatible Antennas	1) FreeFlight P/N 9-1203-115-00 2) EDO P/N DM PN19-2-1
Altitude Range	-20 to 2000 feet
Altitude Accuracy	0 to 100 feet +/- 3 feet 100 to 500 feet +/- 3% 500 to 2000 feet +/- 5%
Frequency Range	100 MHz sweep 4.25 - 4.35 GHz
Sweep Frequency	100 Hz
Input Voltage	20-36 VDC (Internal fuse and reverse polarity protection)
Input Current	400 mA Max @ 28 VDC (steady-state)
Max. Inrush Current	7 A for 1 ms @ 28 VDC
Altitude Output, Rate	25 Hz
Altitude Latency	less than 100 ms (63% of final value)
Operating Temperature	-55°C to +70°C
Self-Test / Reset	On system power-up
Environmental	DO-160E
Certifications	TSO-C87, DO-178B Level C

Table 2-2: RA-4000 Physical Characteristics

Parameter	Value
Weight	1.9 lb
Height	3.06”
Length (Including mounting flange)	6.78”
Width	3.15”
Connectors	2 each TNC antenna connectors 1 each 22 pin circular connector

Table 2-3: Antenna (P/N 9-1203-115-00) 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

2.4 Component and Accessory Part Numbers

Each RA-4000 unit is shipped individually, as indicated in Table 2-4. Two antennas and associated wiring are also required for installation. An Installation kit is available from FreeFlight, as indicated in Table 2-5. The items listed in Table 2-6 are required, but not supplied by FreeFlight.

Table 2-4: RA-4000 Install Kit

ITEM	FREEFLIGHT P/N	QUANTITY
RA-4000 R/T Unit	84560-XX	1 required

Table 2-5: Optional FreeFlight Install Kit and Parts

ITEM	FREEFLIGHT P/N	QUANTITY
Optional Installation Kit	84933-00	1 required
Coax Cable RG-142 B/U (30 ft)	0123-0012-00	1 per kit
Antennas	9-1203-115-00	2 per kit
Connector TNC	0129-0017-00	4 per kit
22 Pin connector RA-4000 Series	84443	1 per kit
Connector Backshell Strain Relief	84444	1 per kit

Note: EDO Corporation's Radar Altimeter Antenna (EDO P/N PN19-2-1) is also compatible with FreeFlight Systems RA-4000 Radar Altimeter Unit. These antennas are not sold by FreeFlight Systems and must be purchased from the manufacturer directly or from any EDO antenna dealer. Refer to the manufacturer's documentation for the specifications for these antennas.

Table 2-6: Other Accessories

ITEM	FREEFLIGHT P/N	QUANTITY
System Wiring	N/A	As required
Circuit Breaker	N/A	1
System Indicator	N/A	1
Mounting Tray for altimeter	1900-3121-X2	1

2.5 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.

3 Electrical Interface

Electrical interconnection to the RA-4000 is made via 22-pin connector. Refer to Table 3-1 for a description of the pin out.

Table 3-1: RA-4000 Interface Pin out

Pin	Name	Function	Direction	Level
1	**Ground**	Ground	-	Ground
2	**Ground**	Ground	-	Ground
3	**Power In**	Aircraft voltage in	In	20-36 VDC
4	**Power In**	Aircraft voltage in	In	20-36 VDC
5	**Reset**	Reserved	In	NO CONNECT
6	Reserved			
7	Reserved			
8	**Strut**	Strut (active low)	In	Ground or open
9	Reserved			
10	**429 Speed Select***	ARINC 429 Output Speed Select: Low Speed (default, pin open) High Speed (pin to ground)	In	Ground or open
11	**ARINC-TXB***	Navigation Port ARINC 429	Out	ARINC 429
12	**ARINC-TXA***	Navigation Port ARINC 429	Out	ARINC 429
13	**Nav-TX**	Navigation Port RS-232C Transmit	Out	RS-232C
14	**Nav-RX**	Navigation Port RS-232C Receive	In	RS-232C
15	**PGM-EN**	Reserved	In	NO CONNECT
16	Reserved			
17	Reserved			
18	**Nav-Bias**	RS-485 100 ohm ground connection	-	RS-485 Ground
19	**Nav-Com**	Navigation Port Ground	-	Ground
20	**Nav-Com**	Navigation Port Ground	-	Ground
21	**Nav-TXA**	Navigation Port Serial RS-485/422	Out	RS-485/422
22	**Nav-TXB**	Navigation Port Serial RS-485/422	Out	RS-485/422

*Only applicable to part number 84560-02.

3.1 Ground

Aircraft ground is connected on two pins.

3.2 Power In

Aircraft power of 20-36 VDC is connected on two pins.

3.3 Reset

This circuit is reserved for factory test purposes only. Do not connect.

3.4 Strut Input

The Strut signal is an active low input. That is, the input should be grounded when the aircraft is on the ground.

3.5 Nav TX/RX

The Nav-TX/RX lines use RS-232C signal levels. The RS-232C Nav-TX output carries the same data as the RS-485/422 Nav-TXA/TXB pair. The Nav-TX/RX lines are used to initiate the Altitude Zero Calibration function and to reprogram the unit via serial RS-232C protocol. Note that it may be advantageous to route these lines to a point which facilitates shorting them for the Altitude Zero Calibration (see 6.5.1). 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.

3.6 PGM-EN

The Program-Enable input is used to reprogram the unit. Do not connect in normal operation.

3.7 Nav-Bias

This pin provides a 100 ohm resistive ground connection for the RS-485 communications circuit.

3.8 Nav-Com

These connections provide a direct ground reference, if desired.

3.9 Nav-TXA/TXB

Used as the primary data interconnect, these pins are driven by an LTC485 device.

3.10 ARINC-TXA/TXB

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

3.11 ARINC Speed Select

This pin is 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.

4 Functional Interfaces

The FreeFlight Systems Radar Altimeter provides serial RS-232/422/485 interfaces and an ARINC 429 interface (Part Number 84560-02 only).

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 56,000 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.

4.1.2.1 Packet Structure

Each packet conforms to the following structure:

Field	DLE	ID	LEN	DATA	CHECKSUM	DLE	ETX
Content	0x10	0xDF	0x03	3 bytes	1 byte	0x10	0x03

4.1.2.1.1 DLE (Data Link Escape Character)

Fixed byte = 0x10.

4.1.2.1.2 ID (Identification)

Fixed byte = 0xDF.

4.1.2.1.3 Len (Length)

Fixed byte = 0x03.

4.1.2.1.4 Data

Three data bytes are defined as follows:

Table 4-1: Data Field Definition

Byte	Definition
1	Altitude High byte of a 2-byte binary field. (Units: Feet; Range: -20 to 2500)
2	Altitude Low byte of a 2-byte binary field.
3	Status Byte (See Table 4-2)

Table 4-2: Status Byte Bit Definition

Bit	High (1) Indication	Low (0) Indication
0 – Altitude	Ascending	Descending
1 – Self Test	Test in progress	Normal operation
2 – Status	Unit Failure	Normal operation
3 – Invalid	Unlocked / Invalid output	Locked / Valid output
4 – Strut	De-asserted (In air)	Asserted (On ground)
5 – Reserved		
6 – Reserved		
7 – Reserved		

4.1.2.1.5 Checksum

This is the one-byte 2's complement of the sum of all the data bytes, including the packet ID and LEN bytes (i.e. 0xDF03). Refer to Table 4-3 for a sample packet with normal status (descending, locked, and good status) and an altitude of 1000 feet.

Table 4-3: Sample Packet at 1000'

Byte	DLE	ID	LEN	Alt Hi	Alt Lo	Status	Chk	DLE	ETX
Value	0x10	0xDF	0x03	0x03	0xE8	0x00	0x33	0x10	0x03

4.1.2.1.6 DLE (Data Link Escape Character)

Fixed byte = 0x10.

4.1.2.1.7 ETX (End Of Text Character)

Fixed data byte = 0x03.

4.1.2.2 DLE Stuffing

This protocol requires that an occurrence of the DLE (0x10) character in either the data or checksum must be followed by another DLE character. The receiver therefore, should remove, or "unstuff", the second DLE character when two are received in sequence. Note that the "unstuffing" should occur prior to calculation of the checksum.

4.2 ARINC 429 Interface

This section applies to part number 84560-02 only.

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 3.11) and are transmitted at a rate of 25 Hz.

4.2.2 Protocol Definition

> **Note**:
> The information in this section is intended for engineering personnel and is not required for installation.

4.2.2.1 Parity

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

4.2.2.2 Source/Destination Indicator (SDI)

The SDI of all labels is set to 00.

4.2.2.3 ARINC 429 Labels

The following labels are transmitted:

Label (octal)	Description	SSM	
		Non-Fault	Fault
164	Radio Altitude (Binary)	NCD/NORM	FAIL
165	Radio Altitude (BCD)	NCD/NORM	N/A*
377	Equipment ID	NORM	NORM

*In case of a failure, label 165 is not transmitted.

5 Mechanical

5.1 RA-4000 Mounting

The mounting requirements for the RA-4000 are illustrated in Figure 5-1.

5.2 Connectors

Interfaces to the RA-4000 are provided through three connectors as described below in Table 5-1.

Table 5-1: Connector Descriptions

Function	Description
Aircraft interconnections	This 22-pin circular connector mates with AMPHENOL P/N 10-565995-231N.
TX Antenna	This TNC connector mates with AMPHENOL P/N 225554-6
RX Antenna	This TNC connector mates with AMPHENOL P/N 225554-6

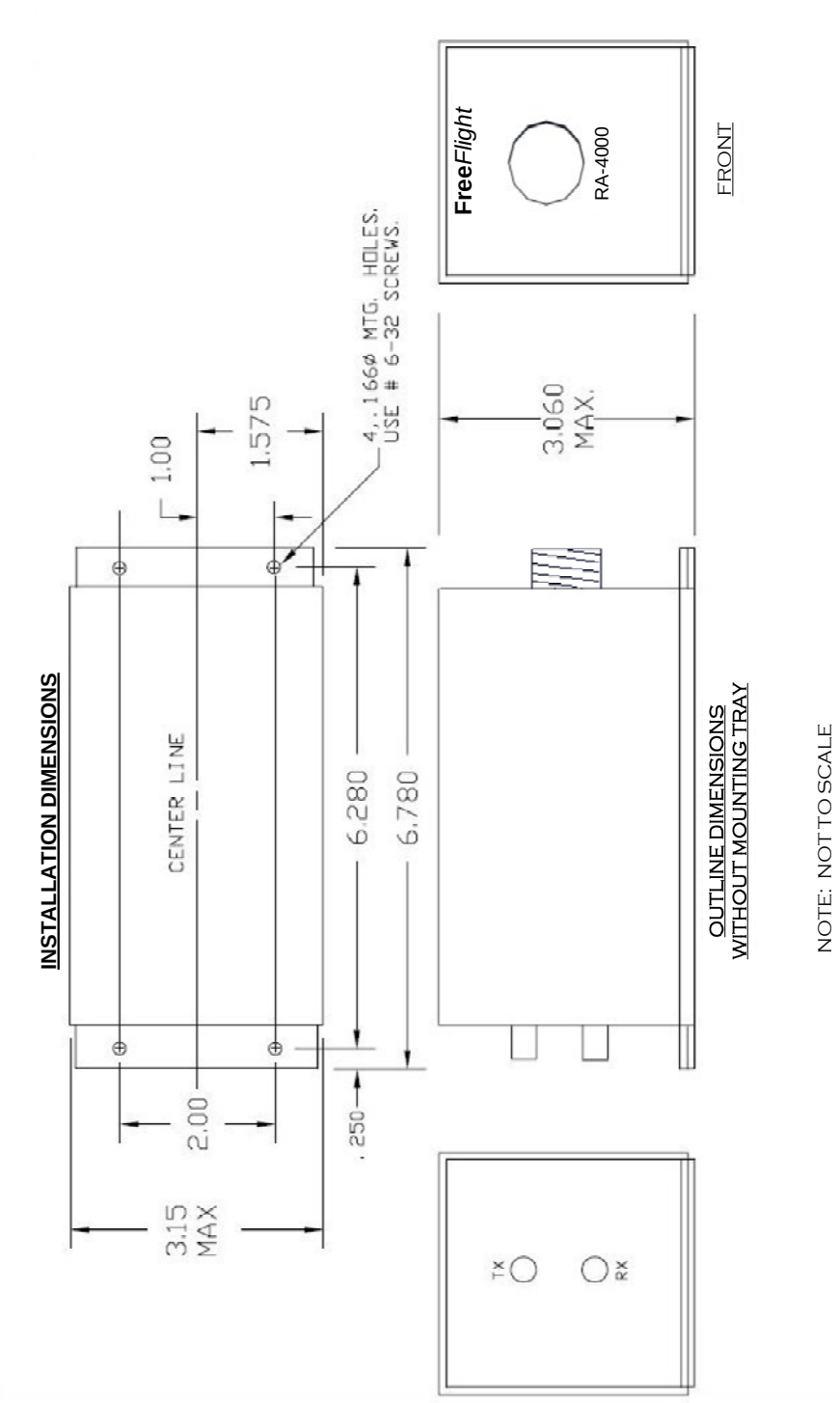
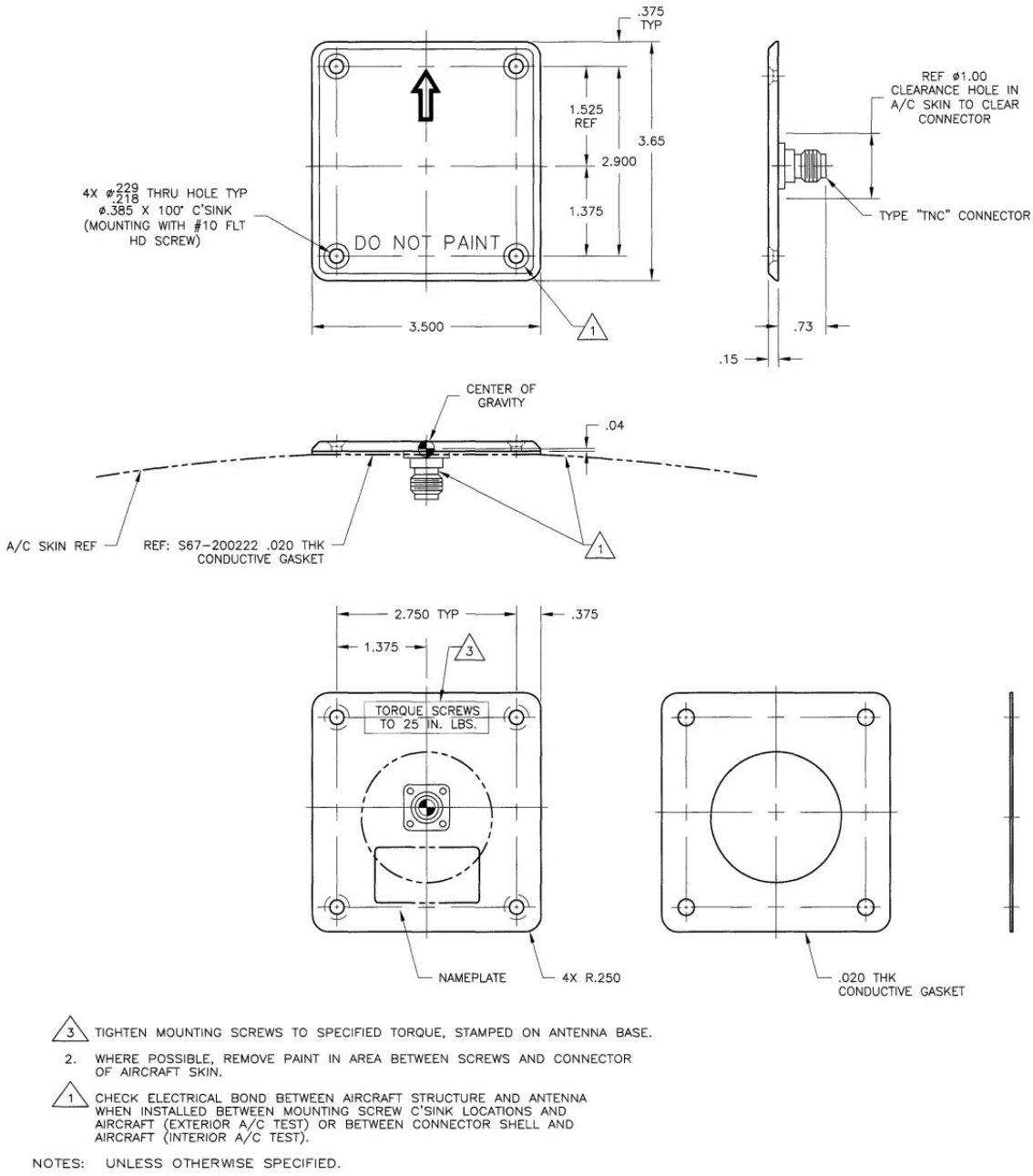


Figure 5-1: RA-4000 Installation Drawing

5.3 Antenna Mounting

Refer to Figure 5-2 for mounting information for antenna P/N 9-1203-115-00. All dimensions are specified in inches.



3 TIGHTEN MOUNTING SCREWS TO SPECIFIED TORQUE, STAMPED ON ANTENNA BASE.

2. WHERE POSSIBLE, REMOVE PAINT IN AREA BETWEEN SCREWS AND CONNECTOR OF AIRCRAFT SKIN.

1 CHECK ELECTRICAL BOND BETWEEN AIRCRAFT STRUCTURE AND ANTENNA WHEN INSTALLED BETWEEN MOUNTING SCREW C'SINK LOCATIONS AND AIRCRAFT (EXTERIOR A/C TEST) OR BETWEEN CONNECTOR SHELL AND AIRCRAFT (INTERIOR A/C TEST).

NOTES: UNLESS OTHERWISE SPECIFIED.

Figure 5-2: Antenna (P/N 9-1203-115-00) Installation Drawing

6 Installation

6.1 General Information

This chapter contains suggestions and factors to consider before installing an RA-4000 radar altimeter into an aircraft. Adherence to the suggestions will assure satisfactory performance from the system.

6.2 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 paragraph 2.4 for equipment and optional parts supplied.

6.3 Equipment Limitations

For a compliant installation in accordance with the Technical Standard Order (TSO) and the Federal Aviation Regulations (FAR), the RA-4000 installation must meet the following requirements:

- "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."

- RA-4000 must be connected to a display in a manner that yields no additional inaccuracies and with maximum additional latency of 80 ms (TSO-C87 §2.1). 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 RA-4000 must utilize a failure warning indicator plainly discernible under all normal flight conditions (TSO-C87 §2.6b) driven by the status and the invalid bit of the RA-4000 status byte (see Table 4-2: Status Byte Bit Definition).

- The antenna installation must comply with the specifications in Section 6.4 Antenna Installation.

6.4 Antenna Installation

6.4.1 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 6-1: Propagation Delay and Attenuation of the Antenna Cable

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

Table 6-2 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 6-2: 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 6-2 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 6-2 the maximum cable length must be recomputed by the installer.

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

6.4.2 Antenna Mounting Requirements

Refer to Figure 5-2 for mounting instructions. For proper performance and TSO compliance of the RA-4000, 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 should be mounted with the arrows pointing forward. They may be mounted side-by-side or in-line.
- 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 60-degree cone 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.
- 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.

6.5 RA-4000 Installation

The RA-4000 unit installation layout is shown in Figure 5-1. 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 with ADF antenna cables.

Note: Aircraft which exhibit electrical noise on the airframe or have surfaces or panels which are not properly bonded can cause the altimeter to attempt to "relock" above 2000 feet AGL, thus causing erratic altitude output. Thorough bonding of all control surfaces, gear doors, access panels, etc. should cure the symptom, but in certain extreme circumstances, it may be necessary to install an on/off switch to disable the unit above 2000 feet. This condition is only noticeable above 2000 feet and does not degrade performance below 2000 feet AGL.

6.5.1 Altitude Zero Calibration

The RA-4000 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 RA-4000 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 may not be correct.

1. Remove or disable the Strut input to the system.
2. Clear all obstacles from around aircraft (including personnel).
3. Turn unit on and let run for a minimum of 5 minutes to warm up.
4. Turn off unit and all aircraft power.
5. Short together RS-232C navigation port TX and RX pins.
6. Switch power on for approximately 30 seconds.
7. Switch power off and remove the short from the TX and RX lines.
8. Switch power on. After the self-test is complete, the unit should now output 0' while on ground.
9. Test and repeat as necessary.
10. Restore the Strut input, if necessary.

6.5.2 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.

6.5.3 Final Testing

1. During takeoff observe AGL and verify that it is increasing while the aircraft is climbing.
2. After aircraft exceeds 2000 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 2000 feet AGL.

Appendix A – Environmental Categories

Refer to Table A-1 for a summary of RA-4000 Test Categories.

Table A-1: DO-160E Test Categories

Environmental Test	DO-160E Section	Category	Compliance Method
Temperature and Altitude	4	D2	T
Temperature Variation	5	B	T
Humidity	6	B	T
Shock/Crash Safety	7	B	T
Vibration	8	S Curve C & U2	T
Explosion Proofness	9	n/a	X
Waterproofness	10	W	T
Fluids Susceptibility	11	n/a	X
Sand and Dust	12	n/a	X
Fungus	13	n/a	X
Salt Spray	14	n/a	X
Magnetic Effect	15	Z	T
Power Input	16	B	T
Voltage Spike	17	A	T
Audio Frequency Conducted Susceptibility – Power Inputs	18	B	T
Induced Signal Susceptibility	19	ZC	T
Radio Frequency Susceptibility	20	RR	T
Emission of Radio Frequency Energy	21	M	T
Lightning, Induced Transient Susceptibility	22	A2XXX	T
Lightning Direct Effects	23	n/a	X
Icing	24	n/a	X
Electrostatic Discharge	25	A	T
Fire, Flammability	26	C	T

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