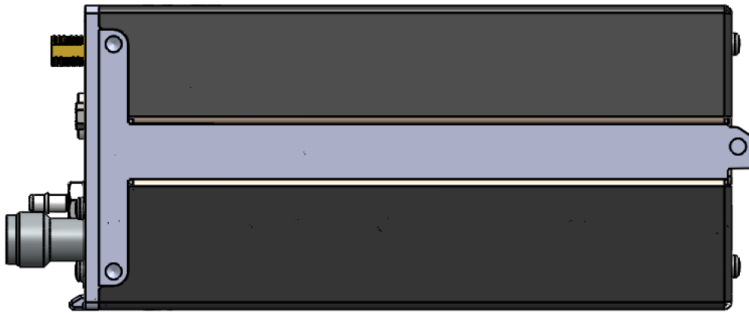




TT26 ADS-B Transponder Installation Manual



01633-00-AC
24 January 2017

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1. Preface

1.1 Purpose

This manual describes the physical and electrical characteristics and the installation requirements for a TT26 ADS-B transponder.

1.2 Scope

This document applies to the installation of the TT26 ADS-B Transponder.

At the publication date of this manual the software version identifier for the TT26 is 1.6 and the FPGA version identifier is 1.5. The software and FPGA versions are subject to change without notice.

1.3 Changes from Previous Issue

Section 1.4 and 5.5.2: Added document reference for TMAP specification.

Section 3.1: Added C145c class information.

Section 4.1 and 5.2: Removal of quick release tray.

Section 12: Update installation drawings.

1.4 Document Cross References

DEV/TMAP/005 Enhanced TMAP Protocol Specification Issue 3.0

2. Introduction

2.1 TT26 Description

The TT26 ADS-B transponder system is an ED-73E compliant Mode S level 2els datalink transponder, with support for ADS-B extended squitter, elementary surveillance and SI codes, which also meets the relevant environmental requirements of ED-14G. The TT26 has a nominal power output of 250 watts, and meets the power output requirements for Class 1.

The TT26 has a built in WAAS GPS receiver which meets the requirements for DO-229D class Beta1, and provides a position source for ADS-B transmissions from the transponder. The ADS-B function meets DO-260B class B1S.

The built in pressure sensor provides altitude measurement up to 70,000 feet.

The TT26 is certified to ETSO C10b, ETSO C88b, ETSO C145c, ETSO C112e and ETSO C166b A2.

The TT26 is controlled using a separate controller; the controller forms part of the system and is required for full compliance with the altimetry TSO and transponder TSO.

The TT26 runs from either 14 volt nominal or 28 volt nominal DC power supply with no configuration changes required.

The TT26 responds to both legacy Mode A/C interrogations and to Mode S interrogations from both ground radar and airborne collision avoidance systems. In all cases, the interrogations are received by the TT26 on 1030MHz, and replies are transmitted on 1090MHz.

2.2 Interfaces

2.2.1 TT26 ADS-B Transponder Unit

The TT26 has a single TNC antenna connection to a transponder antenna, a single SMA connector to an active GPS antenna, a single 25 way D-type

connector and a static pressure connector. The 25 way D-type interface provides the following services:

Power Input	The TT26 operates on 11 to 33 volts DC.
Controller Datalink	A two wire data link is used to connect the TT26 and the controller. Depending on TT26 option, this interface can be provided over a half-duplex RS-485 interface (TMAP RS-485 bus) or a full duplex RS-232 interface (TMAP over RS-232).
Second Datalink	A secondary RS-232 interface provides access to GPS data.
“On ground” input	Allows automatic flight/ground mode switching for aircraft with a squat switch.

3. Technical Specifications

3.1 TT26 Transponder Unit (01629-00)

Specification	Characteristics
Compliance	ETSO C112e Class 1 Level 2els, ETSO C166b A2 Class B1S, ETSO C10b, ETSO C88b, ETSO C145c Class Beta 1
FCC Identification	VZI01629
Applicable documents	EUROCAE ED-73E, EUROCAE ED-14G (RTCA DO-160G), RTCA DO-181E, RTCA DO-260B, AS8003, AS392C, DO-229D
Software	ED-12B (RTCA DO-178B) Level B
Hardware	DO-254 Level C
Power Requirements	11 – 33 volts DC. Typical 8 watts @ 14Volts.
Altitude	70,000 feet
Humidity	Tested to Category A in DO-160G
Operating Temperature	-55°C to +55°C
Transmitter Frequency	1090MHz \pm 1MHz
Transmitter Power	250 watts nominal; 125 watts minimum at antenna after allowing for 0.5dB connector losses and 1.5dB cable losses.
Transmitter Modulation	8M89 V1D
Receiver Frequency	1030 MHz
Receiver Sensitivity	-74dBm \pm 3dB

Physical Specifications (including connectors)

Height	62 mm (2.44")
Width	71.5 mm (2.81")
Length	153 mm (6.02")
Weight	475 g (1.05 lbs)

3.2 Installation Approval

The conditions and tests required for the TSO approval of the TT26 are minimum performance standards. It is the responsibility of those desiring to install this transponder on or within a specific type or class of aircraft to determine that the aircraft operating conditions are within the TSO standards. The transponder may be installed only if further evaluation by the user/installer documents an acceptable installation that is approved by the appropriate airworthiness authority.

3.3 Non-ETSO Function

The internal altimeter has been qualified to operate at altitudes of up to 70,000 feet. The applicable ETSO certification applies to 50,000 feet. For altitudes above 50,000 feet the altimeter tolerance extrapolates the allowed value in the applicable standards; the tolerance at 70,000 feet is not more than 380 feet.

4. Unit and Accessories supplied

4.1 TT26 ADS-B Transponder Items

The TT26 includes the following items:

Unit Description	Qty	Part Number
TT26 Mode S Transponder	1	01629-00

4.2 Installation Kit

The optional TT26 installation kit includes the following items:

Unit Description	Qty	Part Number
Connector, coaxial TNC	1	00723-00
Headshell, 25 way	1	00726-00
25 way D-type contact housing (female)	1	00866-00
Crimp Terminal, Female, 22-24 AWG	20	00730-00
Hose clip, small	2	00734-00
Connector, coaxial SMA	1	01645-00

4.3 Required Items

Additional items you will require, but which are not in the TT26 package, include:

- Antenna and fixing hardware. The TT26 is compatible with any transponder antenna approved to ETSO C74 or C112, and any GPS antenna approved to ETSO or TSO C190.
- Cables. You need to supply and fabricate all required cables. Guidance on cable types is given in section 5 below.

- **Fixings.** To mount the transponder body directly using the tapped holes you will need three M4 bolts.

5. Installation

5.1 Unpacking and Inspecting Equipment

Carefully unpack the transponder and make a visual inspection of the unit for evidence of any damage incurred during shipment. If the unit is damaged, notify the shipping company to file a claim for the damage. To justify your claim, save the original shipping container and all packaging materials.

5.2 Transponder Mounting

The TT26 ADS-B transponder is designed to be mounted in any convenient location in the cockpit, the cabin, or an avionics bay.

- Select a position in the aircraft that is not too close to any high external heat source.
- Avoid sharp bends and placing the cables too near to the aircraft control cables.

The TT26 transponder is mounted directly to the airframe using bolts into the three threaded holes in the chassis. Section 12 contains mounting point positions.

To mount the transponder to the airframe, proceed as follows.

- Ensure that the chassis of the TT26 is flush with the mounting surface, which should be flat, and sufficiently strong to support the transponder firmly.
- Secure the TT26 using three M4 bolts. The bolts should be stainless steel, or other corrosion proof finish and should be sized so that there is between 5 mm and 7 mm of thread engagement into the mounting holes. The bolts must be secured using a thread locking compound, LOCTITE 242 or equivalent. Torque the bolts to between 1 Nm and 1.5 Nm, taking care not to over tighten.

5.3 Cooling Requirements

The TT26 ADS-B transponder meets all applicable ETSO requirements without forced air-cooling.

Attention should however be given to the incorporation of cooling provisions to limit the maximum operating temperature if the TT26 is installed in close proximity to other avionics. The reliability of equipment operating in close proximity in an avionics bay can be degraded if adequate cooling is not provided.

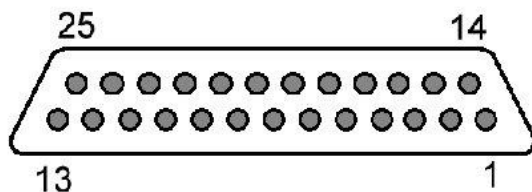
5.4 TT26 Transponder Electrical Connections

The TT26 has a single 25 way male connector which provides the data and power inputs to the transponder. A single TNC coaxial connector attaches to the transponder antenna, and a single SMA connector attaches to the GPS antenna.

5.4.1 TT26 Interface – Pinout

Pin	Signal	Direction
1	Ground	-
2	TMAP1A	Bidirectional
3	TMAP1B	Bidirectional
4	Ground	-
5	RS-232 Aux	Input
6	Ground	-
7	RS-232 Aux	Output
8	TMAP2A	Bidirectional
9	TMAP2B	Bidirectional
10	Ground	-
11	Auxiliary Power	Output
12	Ground	-
13	Not Connected	
14	Ground	-
15	11-33 VDC	Power Input
16	Reserved	-
17	Not Connected	-
18	Not Connected	-
19	Squat In	Input
20	Not Connected	-
21	Not Connected	-
22	Not Connected	-
23	Not Connected	-
24	RS-232 Control RX	Input
25	RS-232 Control TX	Output

The following diagram shows the connector orientation as viewed from the wiring side.



5.5 TT26 Transponder Interface Details

5.5.1 Power Input

The power supply can be 11-33 volts DC; no voltage adjustment is required. Use a 3 Amp (or greater) circuit breaker for power supply protection to the TT26.

It is always good practice to use more than one ground wire in an installation. This is particularly important when the transponder is mounted on a non-conducting surface, such as a composite structure. With only one wire there could be only a single grounding path for the transponder, controller and antenna.

5.5.2 TMAP Control Port

TMAP is a Trig serial protocol that provides a bi-directional interface between the TT26 and a control system. The protocol is documented in DEV/TMAP/005 Enhanced TMAP Protocol Specification.

Depending on configuration options the TT26 may be controlled by the TMAP RS-485 bus on pins 2, 3, 8 and 9, or by TMAP over RS-232 on pins 24 and 25. Check which option you have before proceeding.

5.5.2.1 TMAP over RS-485 Bus

Each TMAP RS485 interface comprises a balanced pair of signals, called A and B, both of which must be connected for communication to work.

There are two sets of TMAP pins on the TT26, TMAP1 A and B, and TMAP2 A and B. This is to support future installation wiring options. The two sets are identical, and either pair (TMAP1 or TMAP2) may be used to connect to the control head; you will also need to add a ground wire.

5.5.2.2 TMAP over RS-232

When controlled using RS-232, the controller connects using pins 24, 25 and a ground wire. The interface is fully compatible with RS-232 signalling levels.

5.5.2.3 Secondary Port

The unused RS-485 or RS-232 interface that is not being used as a control port will be available for Altimetry input and output. The behaviour of the input depends on system configuration, defined below. The output always reflects the current altimetry source, regardless of input configuration.

Note: The TMAP RS-485 interface is optional, and may not be present on systems using the RS-232 control pair on pins 24 and 25.

5.5.3 Auxiliary RS-232 Interface

The RS-232 interface on pins 5 and 7 is used for GPS data. The GPS can be configured for either internal or external mode of operation as described in section 6. The interface is fully compatible with RS-232 signalling levels.

5.5.4 Auxiliary Power

The TT26 provides 6.0 volts on pin 11. This output is intended for diagnostic use, but can also be used to power small auxiliary equipment or a controller providing current consumption does not exceed 300 mA.

5.5.5 Squat Switch Input

The Squat switch input allows the transponder to automatically switch between Airborne and Ground modes, and affects both the Mode S reply behaviour and the ADS-B reporting behaviour. The input will be asserted when the voltage to ground is pulled below approximately 4 volts. The logical sense of the input can be programmed to be either active low or active high.

On an aircraft with no appropriate squat switch circuit this input should be left unconnected, and the transponder programmed to ignore the input.

5.6 D Connector Crimp Terminals

The 25 way connector supplied with the TT26 installation kit are MIL standard versions of the popular sub miniature D type connector family, and use individual crimp terminals and a receptacle. The MIL specification for this family of connectors is MIL-C-24308. We supply crimp terminals because these are more reliable than soldered connections, and are easier to assemble in-situ in an aircraft, where soldering is impractical. They also allow individual wires to be removed and replaced in a receptacle without replacing the whole connector.

The socket contacts used in the 25 way connector conform to MIL part number M39029/63-368, and are suitable for wire gauges from 20 to 24 AWG.

These contacts are widely used in avionics installation, and there are many tools available on the market that will reliably crimp them to the wiring. Because the contacts are a MIL standard, there is also a MIL standard for the crimp tool, although other proprietary solutions are also available.

The MIL reference for the basic style of hand tool is M22520/2-01. This style of tool can crimp many different contact types, and relies on interchangeable "positioners" to hold the actual contact in use. The MIL reference for the positioner that you need for the crimps we supply is M22520/2-08.

Any tool that complies with these references can be used to crimp these contacts. One of the most popular vendors of these small hand tools is Daniels Manufacturing Corporation (see www.dmctools.com). Their AFM8 hand tool complies with M22520/2-01, and their K13-1 positioner is M22520/2-08

compliant, so the combination will crimp the supplied connectors.

Once crimped, the contacts should be slotted into the rear of the connector shell. Push the contact in until the retaining tab clicks into place. Tug gently to confirm the contact is locked in place.

5.7 Wiring Considerations

The connection from the TT26 transponder to the aircraft and controller uses a minimum of four (4) signal lines; the TMAP pair and the Power and Ground pair, although it is good practice to add additional ground wires to the interface. In a certified installation the normal wire choice would be Tefzel hook-up wire. Wire of 20 AWG is more than adequate for the task; in installations where weight is an issue, wire of 22 or 24 AWG can also be used. Where lighter wires than 20 AWG are used the individual wires should be laced together for support.

5.8 GPS Antenna

The TT26 is compatible with any GPS antenna approved to ETSO or TSO C190.

The following table shows recommended antennas.

Antenna Manufacturer	Antenna Model	TSO
Trig Avionics	TA70	TSO-C190
Cobham Antennas (Comant)	CI 429-200 CI 419-200	TSO-C190 TSO-C190
Sensor Systems Inc	S67-1575-135 S67-1575-145 S67-1575-137	TSO-C190 TSO-C190 TSO-C190

5.9 GPS Antenna Cable

A low loss cable terminating at the TT26 in an SMA connector is required. The recommended cable is RG400 or RG142. Total cable loss including

connectors should be less than 10dB.

5.10 Transponder Antenna

The TT26 is compatible with any transponder antenna approved to ETSO or TSO C74 or C112.

5.11 Transponder Antenna Cable

A low loss cable terminating at the transponder in a TNC connector is required.

The TT26 is designed to meet Class 1 requirements with an allowance of 2 dB for loss in the connectors and cable used to connect it to the antenna.

Excessive loss will degrade both transmitter output power and receiver sensitivity.

Allowing 0.25dB loss for the connector at each end of the antenna cable assembly leaves an allowance of 1.5dB maximum loss for the cable itself. An acceptable cable:

- Has less than 1.5dB loss for the run length needed
- Has a characteristic impedance of 50 Ohms
- Has double braid screens or has a foil and braid screen

For cable runs of less than 2.5 metres, RG400 is a good choice.

5.12 Static Pressure Connection

The TT26 includes an altitude encoder which must be connected to the same source of static pressure as the primary altimeter on the aircraft. The TT26 static pressure port provides a mounting spigot intended for nominal 3mm or 1/8 inch inside diameter tubing.

In all cases, the static line should include drainage provisions and should be routed in accordance with CS 23.1325 or other applicable airworthiness provisions for the aircraft.

6. Installation Setup and Test

The system controller uses the TMAP protocol to provide important system parameters to the TT26, including the Mode S address. The following items should be configured in the system controller.

6.1 Core Configuration Items

6.1.1 Aircraft Address

The Mode S Address is a 24 bit number issued to the aircraft by the registration authority for the aircraft. These addresses are usually written as a 6 digit hexadecimal number, although you may also encounter one written as an 8 digit octal number.

6.1.2 Aircraft Registration

The aircraft registration is the unique alphanumeric string that identifies the aircraft. It used as the default flight ID.

6.1.3 Aircraft Speed Class

Mode S transponders can transmit their maximum airspeed characteristics to aircraft equipped with TCAS. This information is used to help identify threats and to plan avoiding action by the TCAS equipped aircraft. The airspeeds are grouped in ranges; select the range that corresponds to the aircraft.

6.1.4 Aircraft Category

To assist ATC tracking of aircraft, an aircraft category can be transmitted by Mode S transponders. Select the aircraft category that most closely matches the aircraft in which the TT26 is installed.

6.1.5 Squat Switch Source

The Squat switch input allows the TT26 to automatically switch between Airborne and Ground modes. If the squat switch input is not connected the “Ignore Squat Switch” option must be selected.

6.1.6 Aircraft Length and Width

On the ground, ADS-B transmits encoded aircraft size information which is used by ATC to identify taxiing routes and potential conflicts. The aircraft length and width (wingspan) should be configured.

6.1.7 GPS Antenna Offset

The GPS antenna offset is used together with the aircraft length and width to manage taxiway conflicts. A typical GPS installation does not report the geographic position of the centre of the aircraft, or even the tip of the nose of the aircraft; instead it usually reports the location of the actual GPS antenna (not the GPS receiver). In normal flight operations this distinction is of no practical importance at all, but if ADS-B is used to manage taxiway conflicts, a significant offset in antenna position could mean that the aircraft is not in the same place as the ADS-B reported position. Although primarily intended for position correction on large transport aircraft, General Aviation aircraft can also have a significant offset. For example, if the aircraft has a long tail boom and the GPS antenna is on the top of the tail, the GPS position could be 4 metres or more from the nose of the aircraft.

Enter the position of the GPS antenna relative to the nose of the aircraft. The position is stored and transmitted to the nearest 2 metres; great accuracy in measurement is not required.

6.2 Interface Configuration

6.2.1 Altimetry Source

The transponder has an internal altimeter, and that is the primary source for altimetry. The system can also be configured to use an external air data

computer, or to receive the altimetry data over the link from the controller.

In all three cases the altimetry data will be transmitted from the secondary data output (either RS232 or RS485, depending on which port is the control port). This output uses Shadin S format messages at 9600 bps. Only the D, a and b records are provided, as well as the Shadin checksum.

If the system is configured to use external air data, the input protocol expected is also Shadin S format.

6.2.2 GPS Source

The transponder has an internal GPS receiver, and that is the primary position source for ADS-B operation. The GPS data is routed internally to the transponder and is also transmitted on the auxiliary serial port (pin 7).

The internal GPS can be disabled and an external position source used. In this case the data input is read from the auxiliary serial input (pin 5); the output on pin 7 is disabled.

The GPS I/O uses Accord legacy protocol. This protocol is detailed in ES-GPSBL, “NexNav Mini Nominal Technical Description”.

7. Post Installation Checks

Post installation checks should be carried out in accordance with your certification requirements. These checks should include:

- Mode S interrogations to verify correct address programming.
- Verification of the reported altitude using a static tester.
- Where installed, verification of correct squat switch ground/airborne indications.
- Interrogations to verify the receiver sensitivity. A Mode S transponder should have a minimum triggering level (MTL) of between -77 dBm and -71 dBm. Failure to meet this requirement usually indicates antenna or coaxial cable problems.
- Interrogations to verify the transmitted power. The installation should have no less than 125 watts at the antenna (and no more than 500 watts). Failure to meet this requirement is also generally due to antenna or wiring issues.
- Verification of the GPS position source and ADS-B outputs. Whenever a valid position is received by the transponder and the transponder is in any mode other than Standby, ADS-B Extended Squitters should be observed on the transponder test set.

8. Continued Airworthiness

Other than for periodic functional checks required by the regulations, the TT26 ADS-B transponder has been designed and manufactured to allow “on condition maintenance”. This means that there are no periodic service requirements necessary to maintain continued airworthiness, and no maintenance is required until the equipment does not properly perform its intended function. When service is required, a complete performance test should be accomplished following any repair action. Repairs should only be carried out in accordance with Trig Avionics Limited service procedures.

9. Limited Warranty

Trig Avionics Limited warrants our products to be free from defects in materials and workmanship for a period of six (6) months from the date of installation by an authorised dealer.

This warranty covers repair and/or replacement at our option, of any parts found to be defective, provided such defects in our opinion are due to faulty material or workmanship and are not caused by tampering, abuse, or normal wear.

All warranties are F.O.B.

Trig Avionics Limited
Heriot Watt Research Park
Riccarton, Currie, EH14 4AP

Trig Avionics will not accept or pay for any charges for warranty work performed outside our factory without prior written consent.

This warranty applies only to products in normal use. It does not apply to units or circuit boards defective due to improper installation, physical damage, tampering, lightning or other electrical discharge, units with altered serial numbers, or units repaired by unauthorised persons or in violation of Trig Avionics Limited service procedures.

Trig Avionics Limited assumes no responsibility for any consequential losses of any nature with respect to any products or services sold, rendered, or delivered.

10. Environmental Qualification Forms

Nomenclature:	TT26 ADS-B Transponder	
Part Number:	01629-00-(xx)	
ETSO:	C112e, C166b, C10b, C88b, C145c	
Manufacturer:	Trig Avionics Limited	
Address:	Heriot Watt Research Park, Riccarton, Currie, Scotland, EH14 4AP	
Conditions	DO-160G Section	Description of Conducted Tests
Temperature and Altitude	4.0	Category E1
Low temperature ground survival	4.5.1	-55°C
Low temperature short-time operating	4.5.1	-55°C
Low temperature operating	4.5.2	-55°C
High temperature operating	4.5.4	+55°C
High temperature short-time operating	4.5.3	+55°C
High temperature ground survival	4.5.3	+85°C
Loss of Cooling	4.5.5	Cooling air not required (+55°C operating without cooling air)
Altitude	4.6.1	70,000 feet
Decompression	4.6.2	N/A
Overpressure	4.6.3	N/A
Temperature Variation	5.0	Equipment tested to Category B
Humidity	6.0	Equipment tested to Category A
Operational Shocks	7.2	Equipment tested to Category B

Crash Safety	7.3	Equipment tested to Category B type 5
Vibration	8.0	Aircraft zone 2; type 3, 4, 5 to category S level M, type 1 (Helicopters) to category U level G
Explosion	9.0	Equipment identified as Category X – no test required
Waterproofness	10.0	Equipment identified as Category X – no test required
Fluids Susceptibility	11.0	Equipment identified as Category X – no test required
Sand and Dust	12.0	Equipment identified as Category X – no test required
Fungus	13.0	Equipment identified as Category X – no test required
Salt Spray	14.0	Equipment identified as Category X – no test required
Magnetic Effect	15.0	Equipment tested to Category Z, 0.3m
Power Input	16.0	Equipment tested to Category BXX
Voltage Spike	17.0	Equipment tested to Category B
Audio frequency conducted susceptibility	18.0	Equipment tested to Category B
Induced signal susceptibility	19.0	Equipment tested to Category AC
Radio frequency susceptibility	20.0	Equipment tested to Category TT
Radio frequency emission	21.0	Equipment tested to Category B
Lightning induced transient susceptibility	22.0	Equipment tested to Category B2H2L2
Lightning direct effects	23.0	Equipment identified as Category X – no test required
Icing	24.0	Equipment identified as Category X – no test required
Electrostatic Discharge	25.0	Equipment tested to Category A
Fire, Flammability	26.0	Equipment identified as Category C

11. ADS-B Compliance

TT26 ADS-B transponders include support for Extended Squitter ADS-B out. The TT26 is a DO-260B compliant broadcast participant.

11.1 ADS-B Parameters Supported

The following table summarises the ADS-B parameters that are transmitted by the TT26.

Parameter		BDS Register
SPI		0,5
Emergency Indicator		0,5
Barometric Altitude		0,5
Quality Indicator (NIC)		0,5
Airborne Position	Latitude	0,5
	Longitude	0,5
Quality Indicator (NIC)		0,6
Surface Position	Latitude	0,6
	Longitude	0,6
Surface Ground Speed		0,6
Surface Ground Track		0,6
Aircraft Identification		0,8
Airborne Ground Velocity		0,9
Geometric to Barometric altitude difference		0,9
Geometric Vertical Rate		0,9
Squawk Code		6,1

Emergency Status	6,1
Quality Indicator (NACp)	6,5
Quality Indicator (NACv)	6,5
Quality Indicator (SIL)	6,5
Version Indicator	6,5
Surface Length/Width	6,5
Surface Antenna Offset	6,5

In all cases, uncompensated latency due to the transponder and internal GPS is less than 150 milliseconds.

11.2 FAA 91.227 Compliance

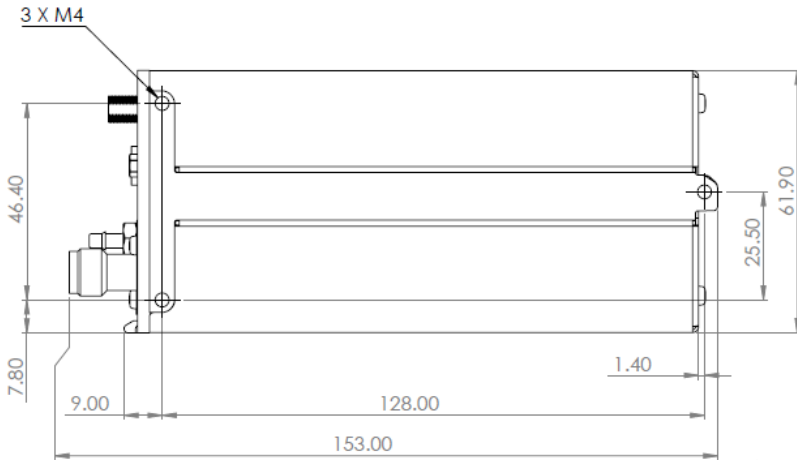
A TT26 can form the basis of 14 CFR 91.227 compliant ADS-B installation. For installations seeking certification to 91.227 or other applicable standards, additional compliance information is available on request from Trig Avionics Limited.

11.3 AMC 20-24 Compliance

A TT26 can form the basis of an AMC 20-24 compliant ADS-B installation. For installations seeking certification to AMC20-24 or other applicable standards, additional compliance information is available on request from Trig Avionics Limited.

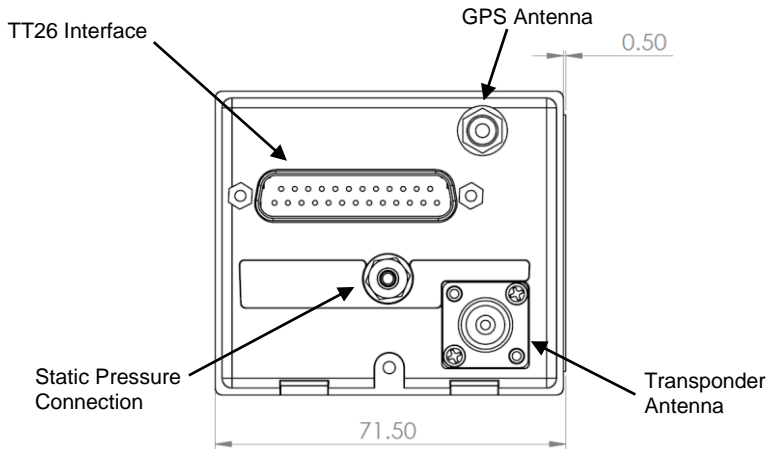
12. Installation Drawings

12.1 *Direct Chassis Mount*



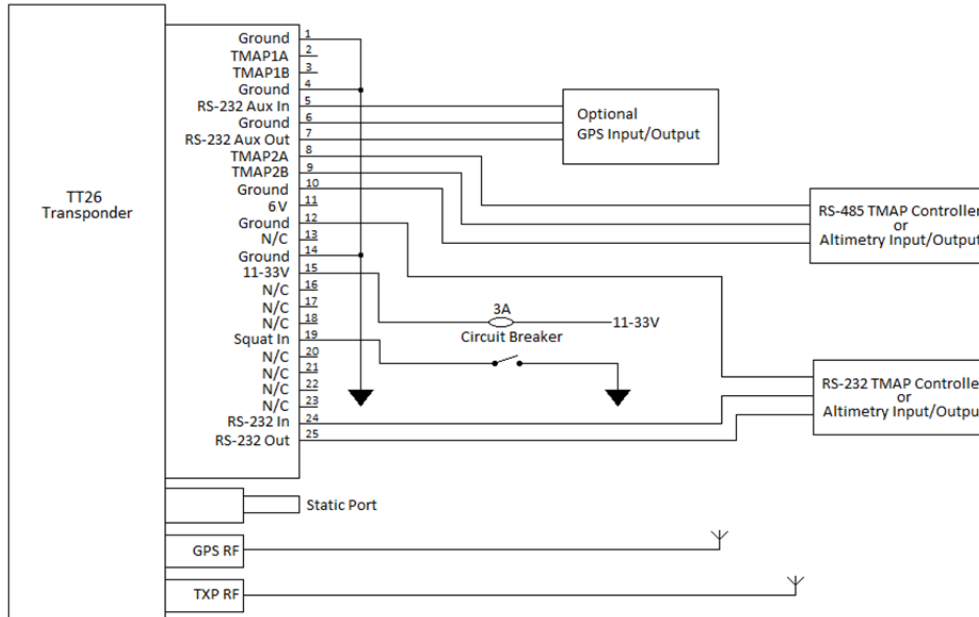
All dimensions in millimetres

12.2 Connector Arrangement



All dimensions in millimetres

13. Basic Interconnect Diagram



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