TN72 GPS Position Source Installation Manual

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Trig Avionics Limited
Heriot Watt Research Park
Riccarton, Edinburgh
EH14 4AP
Scotland, UK

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1. Preface

1.1 Purpose

This manual describes the physical and electrical characteristics and the installation requirements for a TN72 GPS Position Source and recommends the configuration settings for the associated transponder.

1.2 Scope

This document applies to the installation of the TN72 GPS Position Source. Information about configuration of Trig transponders is included, but for full installation data on the transponder please use the applicable transponder installation manual.

1.3 Changes from Previous Issue

Cover Page   New photograph of product.

1.4 Document Cross-References

00455-00	TT31 Transponder Installation Manual	AR
00560-00	TT21/TT22 Transponder Installation Manual	AQ

2. Introduction

2.1 TN72 Description

The TN72 GPS Position Source is an ETSO-C199 class B compliant GPS, suitable for use as an ADS-B position source for a Trig transponder. When installed in accordance with this manual it forms part of an ADS-B Out system that is compatible with airborne traffic systems and surface surveillance equipment.

The TN72 supports two ADS-B applications:

- The TN72 implements the position source requirements of the Traffic Awareness Beacon System (TABS) and is certified to ETSO-C199.

- The TN72 implements the position source requirements of FAR 91.227 for amateur built experimental and light sport aircraft in the USA.

Note: There is no configuration required on the TN72 itself; the GPS receiver always sends all required data for both TABS and 91.227. The system behaviour is determined by the configuration of the transponder that the TN72 is connected to.

The Traffic Awareness Beacon System (TABS) is intended for voluntary equipage on aircraft exempted from carrying Automatic Dependent Surveillance - Broadcast (ADS-B) equipment, such as gliders, balloons and aircraft without electrical systems. The TN72 in conjunction with a Trig transponder provides a C199 compliant solution for those aircraft.

The TN72 TABS solution can also be fitted to any aircraft operating outside ADS-B mandated airspace to enhance traffic situational awareness. The TN72 provides a position source with TSO Design Assurance and non-zero quality indicators for interoperability with all kinds of traffic receivers.

> *Note: When configured for TABS the TN72 and transponder does not meet the requirements to fly in ADS-B airspace defined in FAR 91.225.*

For amateur built experimental and light sport aircraft in the USA the TN72

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can be used to satisfy the position source requirements of FAR 91.227 when connected to a Trig transponder. The limitation to experimental and light sport aircraft is because the TSO approval for the TN72 does not include all the design data to support this application in certified aircraft, but when installed in accordance with this manual and used with the Trig TT22 and Trig TT31 transponders the TN72 meets the technical requirements of FAR 91.227 and the performance requirements of the applicable TSOs.

2.2 Interfaces

The TN72 has a single QMA antenna interface suitable for connection to a range of active GPS antennas. A 9 way D type connector is used for power input and data output from the GPS.

Power Input	The TN72 operates on 11 to 33 volts DC, and is compatible with 12, 14, 24 and 28 volt systems.
GPS Interface	An RS232 compatible output provides the GPS data to the transponder.
Pulse Output	An RS422 compatible output provides one pulse per second synchronised to the GPS clock. This output is not used on the Trig transponders.

3. Technical Specifications

3.1 TN72 GPS Position Source Unit (01655-00)

Specification	Characteristics
Compliance	TSO-C199 Class B
	ETSO-C199 Class B
Applicable documents	TSO-C199, RTCA DO-160G, RTCA DO-260B
Power Requirements	11 – 33 Volts DC. Typical 1 Watt @ 14Volts.
Altitude	35,000 feet
Operating Temperature	-40°C to +70°C
Receiver Type	1575.42 MHz L1, C/A code receiver with SBAS capability
Tracking Sensitivity	-135 dBm
Physical Specifications (including mounting flange)	
Height	30mm (1.2")
Width	80mm (3.1")
Length	75mm (2.9")
Weight	0.22lbs. (110 g)

3.2 Installation Approval

The conditions and tests required for the TSO approval of the TN72 TABS GPS Position Source are minimum performance standards. It is the responsibility of those desiring to install this receiver on or within a specific type or class of aircraft to determine that the aircraft operating conditions are within the TSO standards. The receiver may be installed only if further evaluation by the user/installer documents an acceptable installation that is approved by the appropriate airworthiness authority.

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3.3 Incomplete TSO article

The TN72 is a remote mount TSO-C199 compliant class B position source. As such the following functional requirements from TSO-C199 Appendix 1 are not implemented.

- A1.2.7.1 Antenna Requirements

- A1.2.7.2 Antenna Installation

- A1.2.7.3 Antenna Hazards

- A1.2.8.2 Battery Operation

4. Unit and Accessories supplied

4.1 TN72 GPS Position Source Items

The TN72 GPS Position Source includes the following items:

Unit Description	Qty	Part Number
TN72 GPS Position Source	1	01655-00-01
TN72 GPS Installation Kit	1	01690-00

4.2 Installation Kit

The TN72 installation kit includes the following items:

Unit Description	Qty	Part Number
TN72 Installation Manual	1	01691-00
Connector Co-axial QMA	1	01697-00
Headshell, 9 Way	1	00725-00
9 way D-type contact housing (female)	1	00727-00
Crimp Terminal, Female, 22-24 AWG	9	00730-00

4.3 Required Items

Additional items you will require, but which are not in the TN72 package, include:

- Antenna and fixing hardware. See section 4.4 below for antenna recommendations.

- Cables. You need to supply and fabricate all required cables. Guidance on cable types is given in section 5 below.

- Fixings. To secure the GPS receiver to the airframe you will need 4 flat head screws and four self-locking nuts. If the aircraft does not

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have existing mounting provisions you may need to fabricate
additional brackets to support the GPS receiver.

To complete the ADS-B Out solution you will need an appropriate transponder.

4.4 GPS Antenna Considerations

The TN72 is compatible with any GPS antenna approved to ETSO C190 or
C144a; the recommended antenna is the Trig TA70.

Where a non-TSO antenna is used, the antenna must include an integral
amplifier with gain of not less than 20dB. An example of a suitable non-TSO
antenna is the RAMI AV-GPS.

To meet the performance requirements for ADS-B the antenna must have an
unobstructed view of satellites, and conventional GPS antennas are intended for
attachment to the top of the aircraft skin. In some aircraft with composite
construction, such as gliders, it is possible to use a GPS antenna mounted
internally that still has adequate performance. There are many possible
solutions. A suitable antenna:

- Has an integral amplifier with gain of not less than 20 dB.

- Operates on 5 volt phantom power with less than 40 mA current.

- Has good visibility of satellites all the way down to the horizon.

5. Installation

5.1 Unpacking and Inspecting Equipment

Carefully unpack the GPS receiver 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 GPS Receiver Mounting

The TN72 GPS Position Source is designed to be mounted in any convenient location in the cockpit, the cabin, or an avionics bay.

The following installation procedure should be followed, remembering to allow adequate space for installation of cables and connectors.

- Select a position in the aircraft that is not too close to any high external heat source.   (The TN72 is not a significant heat source itself and does not need to be kept away from other devices for this reason).

- Avoid sharp bends and placing the cables too near to the aircraft control cables.

- Secure the unit to the aircraft using four screws and locking nuts. Rivets can alternatively be used. The GPS receiver should be mounted to a flat surface.

5.3 Cooling Requirements

The TN72 TABS GPS Position Source meets all applicable TSO requirements without forced air-cooling.

Attention should however be given to the incorporation of cooling provisions to limit the maximum operating temperature if the TN72 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.

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5.4 TN72 GPS Position Source Electrical Connections

The TN72 has a single 9 way male socket which provides the data and power connections to the GPS receiver. A single QMA coaxial connector attaches to the antenna cable.

5.4.1 TN72 Interface – Pinout

Pin	Signal	Direction
1	Power 11-33V	Power
2	Ground	-
3	One PPS RS-422 A	Output
4	One PPS RS-422 B	Output
5	Ground	-
6	RS232 Control	Input
7	Position Out	Output
8	Reserved	-
9	Reserved	-

5.5 TN72 GPS Position Source Interface Details

5.5.1 Power Input

The power supply can be 11-33 Volts DC; no voltage adjustment is required. Use a 1 Amp circuit breaker for power supply protection to the TN72.

5.5.2 GPS Position Output

The GPS position output is an RS-232 compatible port operating at 9600 bps. It should be routed to the appropriate GPS position input on the transponder. The data format is NMEA compatible with proprietary extensions. It can be used as a position input for any NMEA compatible equipment.

In normal operation the RS232 control input to the GPS is not used.

5.5.3 One PPS Output

The TN72 provides a one pulse-per-second output that is synchronised to the GPS clock. This is encoded on an RS-422 balanced pair.

The one PPS output is not used in Trig transponders.

5.6 D Connector Crimp Terminals

The 9 way connector supplied with the TN72 installation kit is a MIL standard version 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 conform to MIL part number M39029/63-368, and are also 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

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confirm the contact is locked in place.

5.7 Wiring Considerations

A typical installation uses two wires for power and ground, and two wires to connect from the GPS to the transponder, signal and ground.

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 Antenna Installation

The antenna should be installed according to the manufacturer's instructions.

The GPS/SBAS antenna mounting location and cable connections are very important. The antenna should not be mounted close to VHF COM transmitter antennas, and other antennas emitting high power. Special care should be taken to ensure that the GPS antenna is not mounted in close proximity to antennas that may emit harmonic interference at the L1 frequency of 1575.42 MHz. Refer to AC 20-138C "Airworthiness Approval of Global Navigation Satellite System (GNSS) Equipment" for additional information and guidelines. For best performance, select a location with an unobstructed view of the sky above the aircraft when in level flight.

5.8.1 Antenna Power

The TN72 receiver utilises an active antenna which means the antenna includes a low noise amplifier. The power for the low noise amplifier is provided from the GPS receiver via the antenna coax cable. The TN72 supplies a nominal 5 volt supply at up to 40 mA.

5.8.2 Recommended Cable

RG400 or RG142 is recommended. A maximum length of 50 ft is recommended. The cable loss including connectors should not exceed 10dB.

5.8.3 QMA Connector

This section describes the technique for attaching the antenna cable to the supplied QMA connector.

The supplied connector can be completed using a wide range of commercial crimp tools. The die apertures for the outer shield should be approximately 5.5 mm.

- Strip back the coax cable to the dimensions in the table, as shown in the diagram below. Slide 25 mm (1 inch) of heat shrink tubing over the cable.

- Slide the outer crimp sleeve over the cable – it must go on before securing the centre contact.

Heat Shrink Tubing
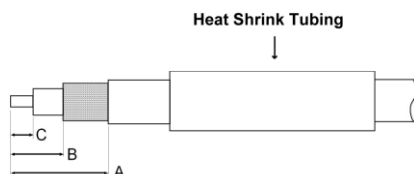
Dimension	Cut size (mm)	Cut size (inches)
A	12	0.47
B	3.7	0.14
C	2	0.08

- Solder the centre contact to the cable – heat contact using a dry soldering iron, flow a small amount of solder into the bore hole of the contact, insert cable and solder to contact. Clean contact and cable, remove excess solder.

- Insert the cable into the connector – the centre contact should click into place in the body, the inner shield should be inside the body of the connector and the outer shield should be outside the body.

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- Crimp the outer sleeve over the shield.

- Slide heat shrink tubing forward (flush to connector) and heat to shrink the tubing.

6. Installation Setup and Test

There are no configuration items on the TN72. This section describes the correct configuration for a connected Trig TT21 or TT22 transponder with software version 2.12 or later, or a Trig TT31 transponder with software version 3.16 or later. Earlier transponder software versions can use the TN72 as an uncertified NMEA position source, but may not recognise the later settings described here.

6.1 Configuration Items

6.1.1 GPS Input

The TN72 outputs NMEA encoded position and velocity data as well as additional integrity information used for TSO-C199 compliance, and the information used for FAR 91.227 compliance. The transponder can therefore be configured to operate using the TN72 as an uncertified NMEA position source, as a TSO-C199 TABS position source, or in certain circumstances as a FAR 91.227 compatible position source. Select one of the following:

NMEA 0183   Transponder sends ADS-B data, SIL set to zero.

C199 TABS   Transponder sends ADS-B data in accordance
                            with TSO C199; SIL = 1, SDA = 1.

Trig TN72 SIL 3   Transponder sends ADS-B data in accordance
                            with FAR 91.227; SIL = 3, SDA = 2.

6.1.2 GPS/TIS Line Speed

The TN72 runs at 9600 bps.

> *Note: The TIS output and GPS input speeds are not separately controlled on the TT21/TT22. Not all combinations of GPS input and TIS output will work if the TIS device operates on a fixed speed other than 9600 bps.*

6.1.3 GPS Certification Level

If you are using the TN72 as a simple NMEA GPS source, it should be set to uncertified. When a C199 TABS GPS source is selected the certification level is not used by the Trig transponder; TSO-C199 uses a special encoding of the design assurance flags. When compliance with FAR 91.227 is being configured, the GPS certification level can be set to level C.

6.1.4 GPS NAC velocity

The GPS NACv for the TN72 is 10 m/s. This configuration item is not required on a Trig transponder if the C199 TABS GPS source is selected – the TABS system automatically allocates the NACv value.

6.1.5 GPS Antenna Offset

The GPS antenna offset is used together with the aircraft length and width to manage taxiway conflicts. A TN72 GPS installation does not report the geographic position of the centre of the aircraft; instead it reports the location of the 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.

6.1.6 1090 MHz Receiver Installed

The ADS-B transmissions include an indication to the ground stations of whether your aircraft includes a 1090 MHz ADS-B receiver. This can be used by the ground stations to manage the volume of traffic they must send. Set this to "Yes" if the aircraft has a 1090 MHz ADS-B receiver installed.

6.1.7 UAT Receiver Installed

The ADS-B transmissions include an indication to the ground stations of whether your aircraft includes a UAT ADS-B receiver. This can be used by the ground stations to manage the volume of traffic they must send. Set this to "Yes" if the aircraft has a UAT receiver installed.

6.1.8 Squat Switch

Automatic air/ground switching is where the transponder automatically changes between sending airborne ADS-B reports and transponder replies to sending surface position reports. It can be accomplished using a conventional landing gear switch, an airspeed switch in the pitot/static system, an air data input to the transponder, or using GPS data. Automatic air/ground switching is optional for TABS applications, but is required to comply with FAR 91.227.

> *Note: Surface position reporting is used to facilitate ground taxying operations at airports. In a classic TABS application such as a hot air balloon or unpowered glider there is no benefit in air/ground switching, and the squat switch should be configured as None.*

If the aircraft has a physical squat switch it should be used for air/ground determination. If it does not the TN72 can be used to emulate a squat switch by selecting "Auto on GPS data" as the squat switch source.

This GPS based air/ground determination is only suitable for powered fixed wing aircraft because it uses ground speed and vertical speed to distinguish between airborne and surface modes. Aircraft which can fly with very low ground speed including rotorcraft, airships, ultralight aircraft and self-launching gliders must use additional means such as airspeed switches or squat switches to reliably determine when they are airborne and when they are on the surface. If you have not installed one of these systems do not enable automatic switching using GPS alone in these types of aircraft.

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7. Post Installation Checks

Post installation checks should be carried out in accordance with your certification requirements. Basic functionality can be verified as follows:

- Place the aircraft in the open with a good view of the sky.

- Apply power to the transponder and the GPS position source. The transponder can be left in Standby mode.

- Repeatedly press the Fn button on the transponder control panel until the ADS-B diagnostic screen is displayed. It will initially display dashes "—" for the position fix.

- After two minutes the GPS should have obtained a position fix and a position corresponding to the aircraft location should be displayed.

- Where configured, verification of correct squat switch ground/airborne indications. In an aircraft with a squat switch, setting the Mode switch to ALT when the aircraft is on the ground should leave the transponder in GND mode; when the aircraft becomes airborne, the mode will switch automatically to ALT. When GPS emulation of the squat switch has been configured the mode changes need the GPS to have an adequate position fix. GPS based air/ground transitions can take more than 30 seconds to register.

8. Continued Airworthiness

Other than for periodic functional checks required by the regulations, the TN72 GPS Position Source 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 two (2) years 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 FCA Trig at:

> Trig Avionics Limited
> Heriot Watt Research Park
> Riccarton, Edinburgh, 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 Compliance

Conditions	DO-160G	Description of Conducted Tests
Temperature and Altitude	4.0	Equipment tested to Categories: A4, C4 (equivalent to A1, C1, but ground survival low limited to -40°C)
Low temperature ground survival	4.5.1	-40°C
Low temperature short-time operating	4.5.1	-40°C
Low temperature operating	4.5.2	-20°C
High temperature operating	4.5.4	+55°C
High temperature short-time operating	4.5.3	+70°C
High temperature ground survival	4.5.3	+85°C
Loss of Cooling	4.5.5	Cooling air not required (+70°C operating without cooling air)
Altitude	4.6.1	35,000 feet
Decompression	4.6.2	8,000 to 35,000 feet in 15 seconds
Overpressure	4.6.3	-15000 feet
Temperature Variation	5.0	Equipment tested to Category C
Humidity	6.0	Equipment tested to Category A
Operational Shocks	7.2	Equipment tested to Category A
Crash Safety	7.3	Equipment identified as Category X – no test required
Vibration	8.0	Aircraft zone 2; type 3, 4, 5 to category S level M; type 1 (Helicopters) to category U level G
Magnetic Effect	15.0	Equipment tested to Category Y
Power Input	16.0	Equipment tested to Category BXX
Audio frequency conducted susceptibility	18.0	Equipment tested to Category B

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Electrostatic Discharge	25.0	Equipment tested to Category A
Fire, Flammability	26.0	Category C

11. ADS-B Compliance

TN72 GPS Position Sources provide a position source for compatible
transponders that meet the requirements of TSO-C199. It provides position
(including geometric altitude) and velocity data, as well as limited integrity
data. The TN72 can also be used under certain circumstances to satisfy the
position source requirements of FAR 91.227.

11.1 TSO-C199 TABS Compliance

The TT21, TT22 and TT31 transponders are TSO-C166b compliant ADS-B
transmitters. When connected to the TN72 TSO-C199 Class B GPS position
source and configured for TABS GPS operation all transmitted ADS-B data
complies with section A1.2.5 of TSO-C199.

When configured as TSO-C199 position source with a Trig transponder the
system will report:

Parameter	Value	Meaning
Quality Indicator NIC (Navigation Integrity Category)	6	Radius of containment < 926 metres
Quality Indicator NAC_P (Navigational Accuracy for Position)	>= 4 (Dynamic)	Position Uncertainty <1852 metres
Quality Indicator NAC_V (Navigational Accuracy Category for Velocity)	1	10 m/s
Quality Indicator SIL (Source Integrity Level)	1	Error probability < 1 x 10^{-3}

The Traffic Awareness Beacon System (TABS) is intended for voluntary
equipage on aircraft exempted from carrying Automatic Dependent
Surveillance - Broadcast (ADS-B) equipment, such as gliders, balloons and
aircraft without electrical systems.

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11.2 FAA 91.227 Compliance

When installed in accordance with this manual and used with the Trig TT22 and Trig TT31 transponders the TN72 meets the technical requirements of FAR 91.227 and the performance requirements of the applicable TSOs.

When configured as "TN72 SIL = 3" position source with a Trig transponder the system will report:

| Parameter	Value	Meaning
Quality Indicator NIC (Navigation Integrity Category)	>= 7 (Dynamic)	Radius of containment <370.4 metres
Quality Indicator NAC_P (Navigational Accuracy for Position)	>= 8 (Dynamic)	Position Uncertainty <92.6 metres
Quality Indicator NAC_V (Navigational Accuracy Category for Velocity)	1	10 m/s
Quality Indicator SIL (Source Integrity Level)	3	Error probability $< 1 \times 10^{-7}$

11.3 CS-ACNS Compliance

The TN72 has not been demonstrated to meet the requirements of CS-ACNS for use as a position source for a certified aircraft.
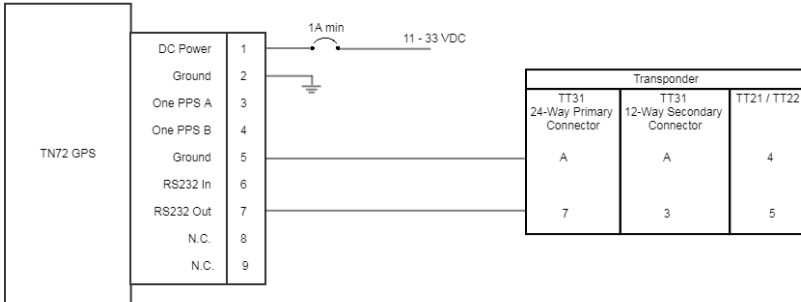
11.4 ADS-B Support

If you require additional information and data to support an ADS-B installation then please contact support@trig-avionics.com.

12. Installation Drawings

All dimensions in millimetres
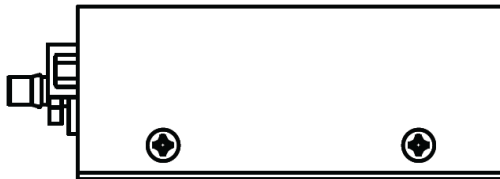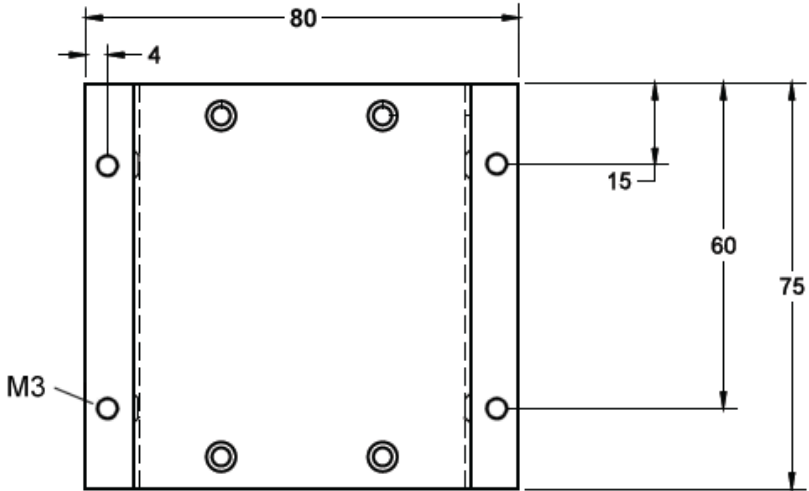
13. Basic Interconnect Diagram

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