SP-12

14 CFR §91.227c, AC 20-165B, Appendix B compliant GPS receiver

TABS TSO-C199

User and Installation manual

General

The SP-12 is a GPS receiver module compliant with FAA requirements to allow ADSB-OUT transmissions from mode-s transponder extended squitters and ADSB transceivers to be flagged with SDA=2 and SIL=3.

It is supplied by typical aircraft DC 12V power and uses an external GPS antenna (a through hole mount puck style active antenna is supplied as standard but other compatible antennas may also be used).

The SP-12 provides GPS information via CAN bus as well as RS232. The latter can use a selection of standard baud rates which are user selectable by means of switch settings accessible inside the unit by removing one of the flanges (two screws).

The GPS receiver

The GPS receiver is based on a NexNav NAVI TABS-110 14000-4 module qualified to the required standards.

Output data rates are:

4Hz for CAN bus transmissions

1Hz for RS232 at 4800 baud

2Hz for RS232 at 9600 baud

4Hz for all other RS232 baud rates

The SP-12 can provide GPS data on both CAN bus and RS232 simultaneously.

SP-12 USAGE

The SP-12 is mostly intended to be used connected via CAN bus in an MGL EFIS system containing a suitable mode-s transponder with CAN bus control like the Trig Avionics models using a MGL CAN bus interface.

However, the RS232 output may also be used and is suitable for use with many other transponder makes that accept a compatible NMEA TABS message. The SP-12, using the RS232 set to the default 115200 baud may be used instead of several alternative GPS sources from other vendors using the same GPS chip set.

Note: Transponders allowing user based “GPS Quality” settings should set the transponder to a suitable setting to transmit SDA =2 and SIL=3.

In case of a MGL transponder or any transponder that can be connected to an MGL EFIS system via CAN bus no further setup is required – the transponder will automatically send the correct SDA and SIL.

Data flow

In a typical transponder system using the SP-12 via CAN GPS data flows from the SP-12 directly to the CAN based transponder interface bypassing the EFIS. For EFIS systems supporting multiple CAN bus networks, please ensure that the SP-12 and the transponder interface are wired to the same CAN bus.

Should the SP-12 not be able to produce a usable GPS data stream the transponder interface will use the GPS information from the EFIS automatically with SDA and SIL set accordingly.

Note: The GPS in the EFIS, while not officially certified tends to be much better than a certified equivalent so expect the EFIS GPS position to be available much faster and far less sensitive to loss of position due to disturbances or weak signals.

The EFIS will use the SP-12 GPS position as backup to its own GPS unless the “TABS” GPS source has been selected as master GPS. Only in this case will the EFIS use its own GPS as backup.

It is recommended to operate the EFIS on its own GPS unless there is a valid reason for not doing so.

SP-12 LED

The SP-12 features a green LED on its panel. This LED has the following states:

LED permanently off or LED permanently on – internal fault. SP-12 is not operational.

Single flash alternating with a pause – SP-12 is operational but GPS module is not, if this persists it may mean that the internal NEXNAV module is faulty.

Double flash alternating with a pause – Both SP-12 and GPS module are operating but no GPS position is available (it tends to take about a minute after power up until a valid position can be resolved if a suitable GPS satellite constellation is visible. Under ideal conditions this time can be shortened to about 35 seconds).

Triple flash followed by pause – System operational and a basic 2D fix has been acquired.

Four flashes followed by pause – System operational and a 3D fix has been acquired.

Five flashes followed by pause – System operational, 3D fix acquired, RAIM active and GPS is providing all required accuracy data based on calculations specified in the certification documents. Note that this requires a minimum of 5 GPS satellites to be visible to the GPS.

Six flashes followed by pause – Power supply voltage dangerously low.

Note: The SP-12, in normal operation, will show the LED steady on for 6 seconds after power up before any flash sequence.

Should the SP-12 detect a MGL EFIS connected to its CAN bus the above described flash sequences will be prefixed with a single, longer flash of 1 second duration.

RAIM

RAIM stands for “Receiver autonomous integrity monitoring”. If at least 5 GPS satellites are visible the position integrity can be determined possibly excluding one or more satellites from the calculation if it has been determined that the satellites in question are transmitting inaccurate data.

HPL,VPL,...

The SP-12 calculates the horizontal and vertical protection limit, VFOM, HFOM, VVFOM, VHFOM, HUL and VUL as required by certification documents and these are transmitted via a dedicated NMEA message on the RS232 port as well as via the CAN bus interface.

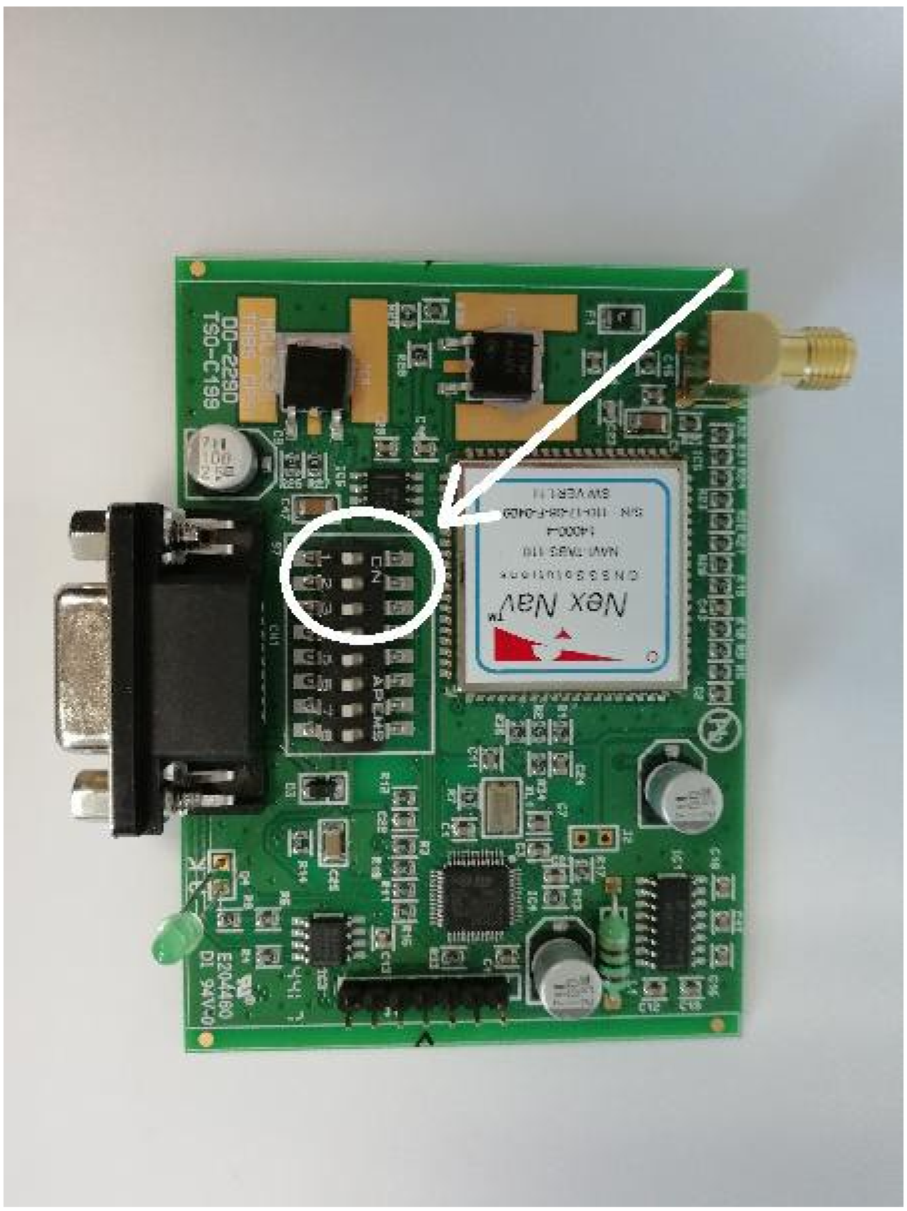
Transponders will re-transmit these figures in their ADSB-OUT message.

RS232 Baudrates

The default factory setting for the RS232 NMEA GPS messages is 115200 baud. This is the native baudrate used by the NexNAV GPS module and thus compatible with other products featuring the same module.

The baudrate may be changed by the user to suit other uses. This is done by opening the unit (two screws) on either end of the module (it does not matter which). Removing the screws allows removal of the cover and the PCB can slide out.

Baudrates are set by adjusting three switches labeled 1 2 and 3 as shown in this image:



1	2	3	Baudrate	Positions per second
off	off	off	115200	4
on	off	off	4800	1
off	on	off	9600	2
on	on	off	19200	4
off	off	on	38400	4
on	off	on	57600	4
off	on	on	230400	4
on	on	on	460800	4

PPS output

The SP-12 provides a differential signaling one pulse per second output conforming to AC-20-165B section B.5.19 identifying time of applicability to the successive position output (i.e. the immediately following position output in case of multiple positions per second).

The signals are marked Pulse Y and Pulse Z.

Pulse Y provides a positive polarity pulse between <0.2V (idle) and >3.0V (pulse).

Pulse Z provides a negative polarity pulse between <0.2V (pulse) and >3.0V (idle).

No pulse is output if no position is available.

Pulse duration is 1 millisecond.

NMEA sentences

The SP-12 outputs the following messages in this order

$GPRMC

$GPGSA

$GPGSV (Note: this is sent at a 1Hz rate even if other messages are sent at a higher rate)

$RAIM (Propriety message by Aspen Avionics)

$GPVTG

$GPGGA

$ACVT (Propriety message by Aspen Avionics)

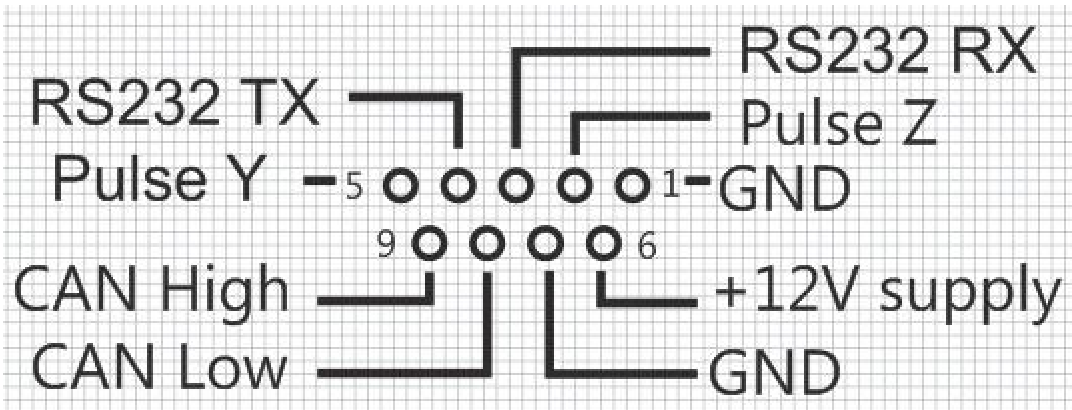
$GPZDA

$GPGLL

For information on the content of messages $RAIM and $ACTV please contact Aspen Avionics/Accord Technology as this information is subject to NDA.

Electrical connections

Connections to the SP-12 are via a standard DP-9 female connector on the SP-12 itself.



Pinout of the connector of the SP-12. If you are wiring up a male counterpart, this layout is applicable to the view on the solder or cable side of the connector.

Power requirements

The SP-12 must be supplied with a DC voltage between 8V and 16V (12-14V nominal).

Current requirements vary between approximately 250mA and 380mA depending on GPS activity.

RS232

The RS232 port provides standard and propriety NMEA GPS messages on the TX line. The RX line is not used and may be left unconnected.

Connect the RS232 TX to the NMEA RX input of your device, ensuring that both devices are set to the same baudrate.

If the devices are supplied from independent, ilolated power supplies you MUST also provide a connection between the SP-12 GND (ground) and your devices ground.

It is permissible to connect more than one device NMEA RX port to the SP-12.

Note that the two pins on the SP-12 marked “GND” are equivalent and internally connected.

Note that the RS232 is not normally used with an MGL EFIS installation – this uses the CAN bus.

CAN bus

The CAN bus is a two wire differential signaling system originating in the automotive sector where it has gained a reputation for robustness and reliability. MGL EFIS systems use the CAN bus extensively to connect to its peripherals which includes the SP-12.

Please read the CAN bus primer at the end of this document if you are not familiar with the CAN bus.

Normally, the SP-12 is used in combination with a mode-s transponder connected to the CAN bus via the MGL transponder interface and the EFIS.

GPS information from the SP-12 is sent directly to the transponder via the CAN bus. This bypasses the EFIS entirely. However, the EFIS also sends GPS information to the transponder interface from its own built in GPS or even other external GPS interfaces (other than the SP-12). The system is designed in such a way that the transponder interface will always use the GPS information from the SP-12 unless the SP-12 is not able to provide this information while another GPS source is able to do so.

This means that the transponder has multiple sources of a GPS position where the position qualifying as TABS TSO-C199 compliant has priority. The transponder transmits two bits of information identifying the “quality” of the GPS source. It will always transmit the correct values depending on which GPS source is being used.

The EFIS itself has a built in GPS but is also able to use external GPS sources such as the SP-12, NMEA or ARINC based.

In normal operating modes the EFIS will always use its own GPS as this is based on a very high quality GPS receiver that integrates SBAS, RAIM as well as anti-jamming algorithms. The EFIS will fall back to an external GPS source depending on what is available should the internal GPS source not provide a position.

The priority scheme is fixed in standard operation: TABS GPS → RS232 NMEA → ARINC.

The user of the EFIS can decide to switch to any available source as primary selection so it is possible to select the SP-12 as main (primary GPS) using the built in GPS and other external sources as backup. This is selected in “system setup menu → Setup GPS”.

The GPS antenna

Image of the included GPS antenna

The GPS antenna is an active “patch” type antenna mounted inside a circular “hockey puck” protective housing. This antenna must me installed such that the puck flat surface faces up (so the cable connection faces down towards the Earth).

The Antenna must be installed on a metallic surface of at least 10cm diameter to act as ground plane. The antenna expects this surface to be present which completes the tune to the GPS frequency band. Failing to adhere to this results in lower sensitivity.

GPS antennas supplied with the SP-12 by MGL Avionics are the only approved GPS antennas to be used with the SP-12. Other antennas may work but may invalidate the SP-12's GPS approval for use as a GPS source for ADS-B purposes.

The SP-12 provides a SMA type antenna port at the rear of the SP-12 housing. The SP-12 is designed to support only active GPS antennas that have a supply voltage range from 3.0 to 3.3V DC. Most active GPS antennas on the market today would be compatible with this requirement. The SP-12 is not intended to be used with passive GPS antennas.

Notes on the SP-12 GPS

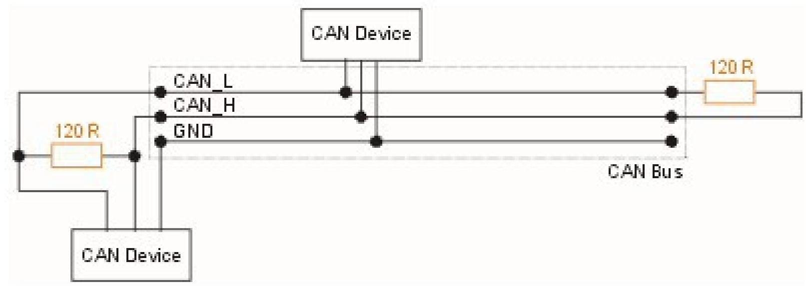
The SP-12 GPS uses an external (supplied) GPS antenna. You may substitute this with another GPS antenna provided it is an active antenna able to operate with a supply voltage of 3.0-3.3V DC.

The SP-12 GPS contains a certified GPS module that is forced to operate in certain ways. This affects both speed to first fix as well as sensitivity. Please ensure that you install the GPS antenna correctly:

1) The GPS antenna must be installed in the correct orientation and have a clear unobstructed view of the sky. Any materials in line of view to the satellites will attenuate the signal. Metal will block the signal completely.
2) Do not install the antenna close to interfering sources such as engines (ignition systems) or COMM antennas including transponder antennas. GPS signals are very weak and are easily interfered with. The certified GPS does not contain multipath rejection or anti-jamming systems. Please keep this in mind to ensure satisfactory performance of the system.
3) Cable length of the supplied antenna is 5 meters. Do not shorten or lengthen this cable as the amplifier in the antenna puck is matched to this cable. The correct way to take up excess length is to roll up the excess in a 10-15cm diameter loop, then flatten the loop so it forms a “8” and cable-tie the center so it remains in this shape.
4) Never route the antenna cable close to any equipment containing high speed digital circuits. Never route the cable in sharp bends – allow a radius of at least 3cm.
5) Mount the GPS antenna as far as possible away from other GPS antennas, VHF communication antennas as well as aircraft transponder antennas.
6) Do not mount the GPS antenna close to engine ignition systems as these can interfere with the GPS signal.

CAN bus primer

The CAN bus (Controller Area Networking) was defined in the late 1980 by Bosch, initially for use in automotive applications.
It has been found to be very useful in a wide variety distributed industrial systems and is becoming popular in avionics applications due its robustness and ease of use.



The connection uses two wires which are twisted around each other. This forms a "balanced transmission line". It helps to reduce emissions and also makes the link more robust against external interferences.

The CAN bus is always implemented as a single cable allowing only short stubs to connect to equipment along the route. Never implement a CAN bus as a "star" or other wiring topology. There can be many devices on a single CAN bus. Each connection to a device is called a "node".

The CAN bus requires termination resistors at each end of the bus. These are to be 120 ohm resistors. 1/4W or 1/8W resistors are usually used here. The resistors must be installed at each end of the bus, not in the center or anywhere else.

For short CAN runs (less than three meters) it is possible to install a single resistor of lesser value (not less than 60 ohms) at any location in the cable run.

The two wires are referred to "CAN High" and "CAN Low". These must connect to the corresponding lines at the devices. Never swap these connections (I.e. Never connect CAN H to CAN L at any device) as the CAN bus will not be able to function.

Never run the CAN bus connection inside a wire harness next to sensitive connection such as audio or signal wires. Never run the CAN bus next to RF cables.

You may use shielded wire as well, for example a twin core shielded cable. In this case please connect the shield to ground at ONE location only. Doing this prevents the possibility of currents flowing via the shield which can lead to interference (ground loop effects).

Making twisted wire

It is very easy to make your own twisted wire. Simply take two equally long wires (for example 5 meters) in parallel and tie one end (both wires) to a fixture (a door handle works well). Insert the other end (both wires) into a drill. Stretch the wires so they are straight. Run the drill for a few short bursts at slow speed and you have a created a perfect twisted pair !

Installations

Guidelines for typical installations:

Trig transponder body with MGL interface

This is used when you would like the EFIS to control the transponder.

The MGL transponder interface plugs into the D25 connector of the Trig transponder. Power and ground is supplied to this interface (typically DC 12-14V on board power). A two wire can bus connects to the EFIS. On “Lite” EFIS systems the CAN bus connector is on the rear of the panel. On full iEFIS systems using an iBOX you have two independent CAN bus systems. Choose one (it does not matter which one).

Connect the CAN bus from the SP-12 to the same CAN bus you used to connect to the transponder. Ensure that your MGL Transponder interface has the latest firmware installed so it will accept the SP-12 GPS information. The required firmware is 120618 or later.

You can update the firmware in the MGL transponder interface very easily. Download the file “TrigXPNDRFirmware.bin” from www.mglavionics.co.za. Follow the firmware tab and select “CAN devices firmware” and download the file. Place it on a SD Micro card and insert into EFIS. Choose “Update MGL Device” from the “System setup Menu”. Follow the prompts.

Other mode-s transponders that have an extended squitter (ES)

You will be using the RS232 output of the SP-12. You only need the TX line which should connect to the NMEA input of your transponder if both your transponder and the SP-12 operate from the same power source (same grounds). If this is not the case you must also wire the ground between SP-12 and your transponder.

The default baudrate of 115200 (Dipswitches 1,2 and 3 are off) is normally used for TABS compliant transponders. However, should your transponder require a different baudrate you may select this without change to the data content transmitted.

You may have to setup your transponder for the required data format. It should be listed as TSO-C199 TABS or similar. If your transponder requires you to enter SIL and SDA then you MUST use SIL=3 and SDA=2. The GPS is not qualified for higher or lower grade operation, however it is reasonable to select a LOWER number for any of these values should your transponder not offer an alternative.

In this case you may still connect the SP-12 as second GPS to your MGL EFIS using the CAN bus.

Note that MGL recommends that you use the GPS that is built into your EFIS as primary GPS source as it is better than the certified equivalent. The EFIS will then use your SP-12 only as backup.

You may select the SP-12 as primary GPS and the built in as backup device should you wish to do that.

Testing your SP-12 / mode-s transponder installation

Once you have completed your installation please perform a ground test of your system before first flight.

You will require a transponder ramp test set with mode-s extended squitter decoder. Avionics shops present at many airports should be able to assist.

Place your transponder in flight mode so it will transmit the extended squitter. Note: you do not have to be in radar coverage for this.

Ensure you have a valid fix from the SP-12 (check the LED flashing sequence – you need 5 flashes for the GPS to send valid RAIM messages needed for the squitter)

Use the facilities available in your transponder ramp test set to verify the data sent by the extended quitter.