

EXD-SC1

SMT ADS-B Receiver Module

1. Brief introduction

EXD-SC1 is an ultra-small ADS-B receiver module that supports ADS-B CSV, MavLink, DF17/DF18, as well as custom private output protocols with simple UART interface. The module has a built-in two-stage SAW filter and a high-gain low-noise amplifier, which can effectively filter out



most of the out-of-band noise in the air for a better signal-to-noise ratio, with a typical receive sensitivity of -85dBm. The module uses industrial-grade chips, crystal oscillators, passive components, and can work stably from -40 °C to +80 °C.

The module uses stamp hole PCB design and supports the reflow soldering process, which is convenient for integration or OEM use, especially suitable for detect and avoid (DAA) systems for unmanned aerial vehicles (UAV).

Main Features

- RoHS and CE certified
- Ultra-small size, low power consumption (<60mA @3.3V)
- Max. sensitivity -85dBm, jamming and ESD protection
- Multiple protocols output, DF17/DF18, MavLink and CSV
- Simple UART TTL interface, baud rate between 9600 and 921600
- Easy to mount stamp hole PCB design
- Evaluation board with IPEX and GH1.25-6P connector available

Fields of application

- ADS-B in device
- SAA / DAA (Sense and Avoid / Detect and Avoid)
- UAS ground stations and high-density traffic surveillance

2. Limit parameters

Table 1 Limit parameter ranges

parameter	value	unit
Supply voltage range V_{in}	-0.5-3.6	V
All other pin input voltage ranges	-0.5- V_{in}	V
Antenna maximum input power	5	dBm
Operating temperature	-40 to +85	°C
Storage temperature	-50 to +125	°C

3. Basic parameters

Table 2 Basic operating parameters

parameter	least	typical	utmost	unit
Supply voltage	3.0	3.3	3.6	V
Operating current		55	60	mA
Receive sensitivity	-85	-90		dBm
Receive dynamic range	-100		-10	dBm
Antenna input impedance		50		Ω
The IO pin input is low	-0.3		0.7	V
The IO pin input is high	$V_{CC}-1.2$		$V_{CC}+0.7$	V
The IO pin outputs high	$V_{CC}-0.4$			V
The IO pin outputs low			0.5	V
IO pin high-level output current	10			mA
The IO pin sinks current at a low level	15			mA
Target processing power	100			Batches/racks
Operating frequency		1090		MHz
Range: 1		250		km

1 The data tested by our 5dBi 1090M antenna for a wide field of view on the roof.

4. Technical Description

Table 3 Module pin definitions

grade	name	Pin type	description
1	VCC	power supply	3.3V power supply
2	TX1	CMOS output	Auxiliary serial port output
3	RX1	CMOS input	Auxiliary serial port input
4	TX0	CMOS output	Main serial output
5	RX0	CMOS input	Main serial port input
6	GND	GND	Power Ground
7	NC	NC	Must be suspended
8	GND	GND	Power Ground
9	SCK	CMOS output	SPI communication pins
10	MISO	CMOS input	SPI communication pins
11	MOSI	CMOS output	SPI communication pins
12	CS	CMOS output	SPI communication pins
13	GND	GND	Power Ground
14	GND	GND	Power Ground
15	RF_IN	RF input	RF signal input
16	GND	GND	Power Ground
17	Frame_detect	CMOS output	Frame indicates output pin, external LED
18	PPS	CMOS input	1PPS second pulse input pin
19	GND	GND	Power Ground
20	IO	CMOS output	Common IO pins
21	NC	NC	Must be suspended
22	NC	NC	Must be suspended
23	NC	NC	There is no electrical connection
24	NC	NC	There is no electrical connection
25	NC	NC	There is no electrical connection
26	RESET	CMOS input	Low level reset, internal pull-up to VCC

Note: For general use, only VCC, GND, TX0, RX0, and RF_IN pins need to be connected, and pin 17 Frame_detect can be connected to an external LED to indicate whether to receive an ADS-B data frame. Other pins can be used for customized special functions, such as TX1, RX1, and PPS pins can be connected to external GNSS modules, ordinary IO pins can be connected to external status indicators, and SPI pins can be used to plug in large-capacity FLASH.

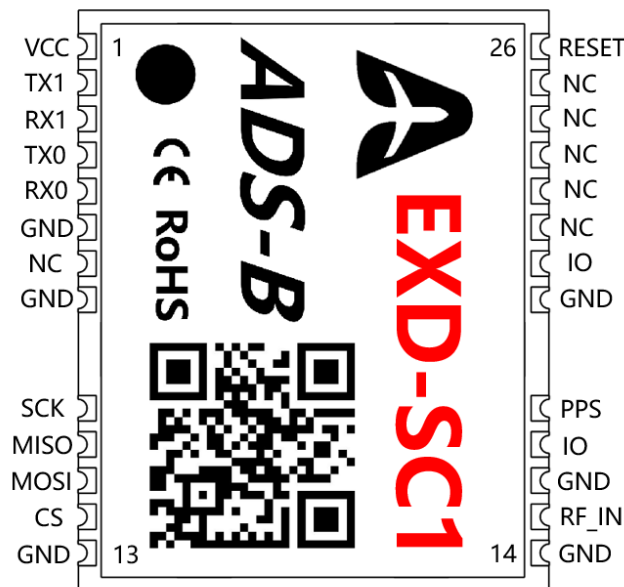


Figure 1 Pin definition diagram

4.1 Precautions for the use of modules

In order to achieve excellent performance of EXD-SC1, users need to pay attention to the following points when using this module:

- Choose a 3.3V LDO power supply with low ripple and control the power ripple within 50mVpp.
- Try not to use other digital signals with high frequency and large amplitude near the module. It is better to fill all the parts below the module with ground.
- Place the antenna interface as close as possible to the RF input pin of the module, and the impedance matching is 50 ohms.

4.2 PCB Recommended Package

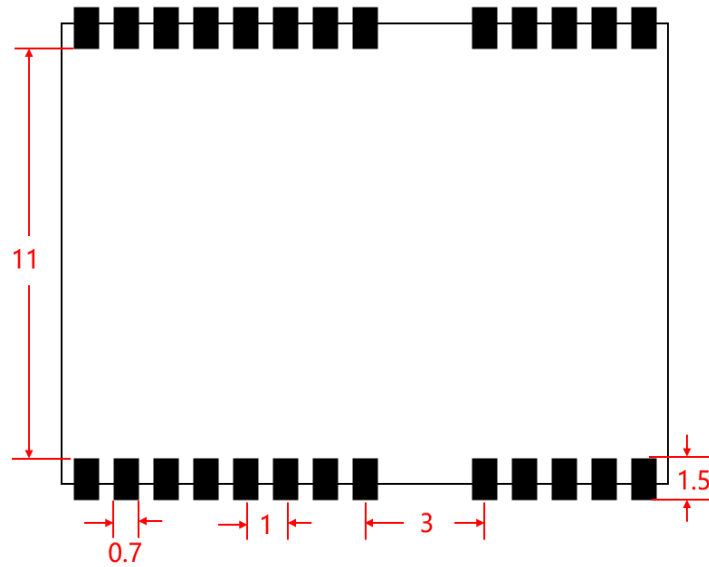


Figure 2 Recommended package (in mm)

4.3 Dimensions

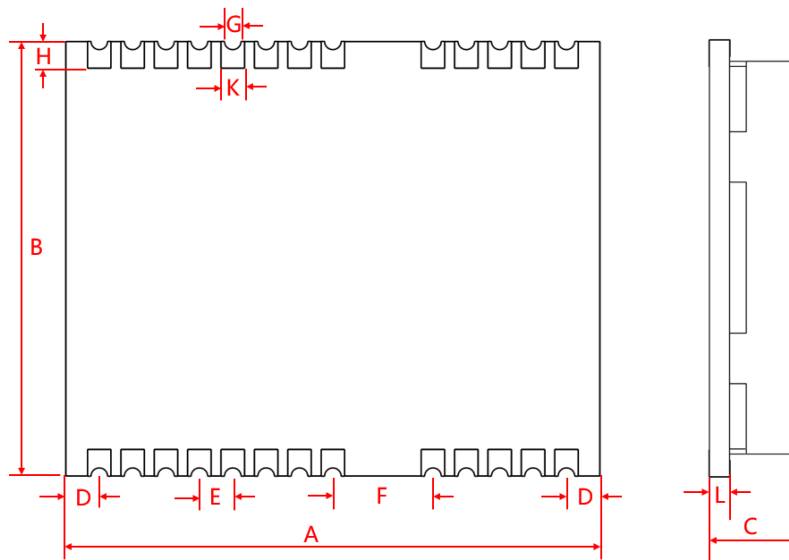


Figure 3 dimensions

Table 4 Module dimensions

Symbol	Min. (mm)	Typ. (mm)	Max. (mm)
A	15.8	16	16.2
B	12.8	13	13.2
C	2.7	2.8	2.9
D	0.9	1	1.1

E	0.9	1	1.1
F	2.9	3	3.1
G	0.4	0.5	0.6
H	0.6	0.7	0.8
K	0.6	0.7	0.8
L	0.7	0.8	0.9

5. Evaluation board

The EXD-SC1 is available with an evaluation board for easy testing. The EV kit uses the IPEX Gen 1 antenna connector and GH1.25-6P connector interface to facilitate connection with commonly used flight controllers, and the recommended power supply voltage is 5V. The schematic diagram of the EV kit is as follows:

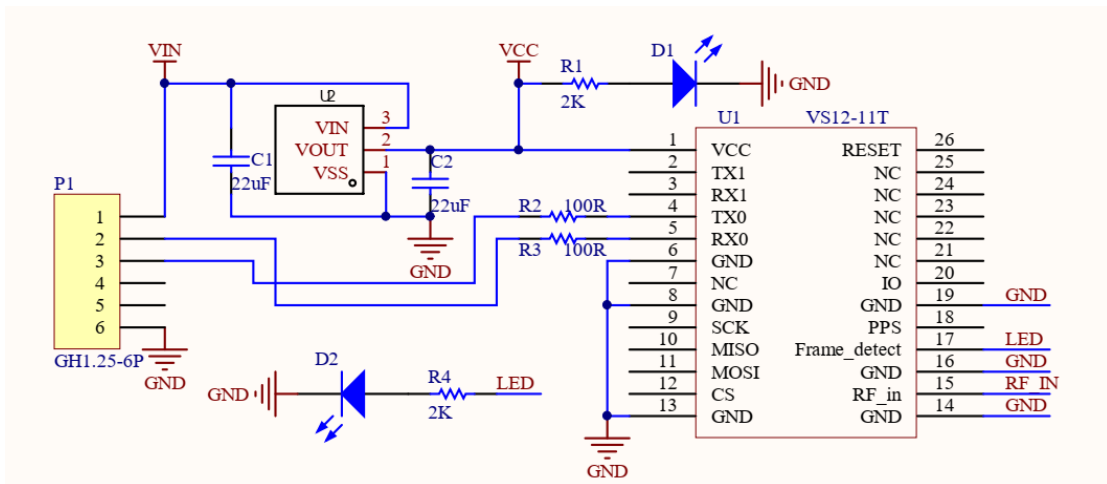


Figure 4: Schematic diagram of the EV kit



Figure 5: Evaluation board product diagram

The EV kit uses a standard GH1.25-6P connector with the following pins defined (with a corresponding silk screen on the back of the board):

Table 5 Evaluation board pin definitions

grade	name	illustrate
1	VIN	Power supply (between 3.5V and 5.5V)
2	UART_RX	UART serial input pin, 3.3V level
3	UART_TX	UART serial output pin, 3.3V level
4, 5	NC	no electronic connection
6	GND	Ground (power supply negative).

6. Detail description

The EXD-SC1 is an ultra-small, low-power module for ADS-B signal reception, with a typical receive sensitivity of -90dBm and an average operating current of about 55mA. Due to the high input sensitivity, the module only needs to be connected to an ordinary passive antenna to reach a monitoring range of more than 200km. The EXD-SC1 is very easy to use, and all communication and settings can be done through the serial port. The serial port is 3.3V TTL level, and the baud rate is between 9600-921600 (the factory default is 115200), and it is recommended to use a higher baud rate, which can ensure the real-time performance of data output in busy airspace. In order to improve the performance of the receiving module, it is recommended to use a dedicated 1090MHz, 3dBi antenna or more, powered by a low-ripple 3.3V LDO power supply, and add a 22uF and 100nF capacitor between the 3.3V power supply and GND to reduce the power supply ripple, and a 22uF tantalum capacitor is recommended.

6.1 Working Modes

EXD-SC1 has 7 working modes, and the factory default working mode is Mode **1**. The serial port configuration allows you to configure the device in different working modes. The following table provides a brief description of the various modes.

Table 6 EXD-SC1 operating modes are introduced

Mode	commands	Output data format
Mode 0	VS11,0#	Serial port data output is disabled
Mode 1	VS11,1#	Output the aircraft data immediately when the latitude and longitude of the aircraft are updated with plaintext data format (CSV), in the following format \$781CD5,CQH8549,022.1757,113.8552,10393,805,183,-0.65,5045,7C# \$780686,CDG1196,022.5400,113.8672,4511,726,27,0.32,3136,42#
Mode 2	VS11,2#	Summarized the aircraft information and output all the data once per second, and stops the output after not receiving the aircraft information for 3 consecutive seconds, in the following format \$7810EA,DKH1157,022.5921,113.7482,3901,596,250,0,6321,56# \$7808A5,,022.6822,113.7679,3360,712,354,3.57,3360,44# \$4BA94E,THY24,022.5186,113.5512,44927,958,118,-0.32,5740,1E#
Mode 3	VS11,3#	Outputs the data in MavLink2 format, and the output is summarized once per second FD 26 00 00 58 01 9C F6 00 00 37 04 78 00 4B 6C 5D 0D 09 48 CE 43 EC 34 2A 00 3F 5B EC 3A D3 04 03 00 00 00 01 00 00 00 00 00 00 00 00 0A 02 FD 25
Mode 4	VS11,4#	Outputs DF17/DF18 ADS-B text data in real time in the following format *8D89630AEA469858011C0864254E; *8D780BC5230D8078CF8C204F503E; *8D780BC5581BD30422CB6A10347F;
Mode 5	VS11,5#	Outputs the DF17/DF18 ADS-B text data with signal strength marker, and the format is as follows +408D7811AEF8230003004978F833A2; +4F8D7811AE990C3C0E98300794501F; +458D7804569908F021B0081E49DFE4;
Mode 6	VS11,6#	Outputs data in MavLink V1 format, and aggregates the output once a second FE 26 28 01 9C F6 98 12 78 00 F0 48 77 0D 80 96 99 43 50 98 9E 00 61 61 84 5B E0 FF 3F 00 2B 04 00 43 42 4A 35 35 37 30 00 00 03 03 03 CC

● Aircraft Plaintext Output (Mode1 and Mode2)

Each ASCII frame starts with \$ and ends with #+ <CR><LF>, and the data for each field is separated by ",", leaving the field blank when there is no data in the field content. where the altitude is the barometric altitude (the unit is meter), the unit of speed is km/h, the unit of climb rate is m/s, and the checksum is \$ (excluding \$) to the last ", "

(inclusive,) all data is taken as a hexadecimal value.

ICAO	Call	latitude	longitude	height	Speed	course	Rate of climb	Transponder number	Checksum	Ending character #
------	------	----------	-----------	--------	-------	--------	---------------	--------------------	----------	--------------------

For example:

```
$7811AD,CSZ9457,022.4753,113.7895,8930,474,230,10.72,2433,4E#
$4BA94E,THY24_,022.5175,113.5534,44927,958,118,-0.32,5740,16#
$78136B,CSZ9937,022.6667,113.9978,3299,578,349,-0.65,4225,22#
$780254,,022.6010,113.8319,3474,312,154,11.05,0000,08#
$78136B,CSZ9937,022.6673,113.9977,3299,578,349,-0.65,4225,28#
$78008A,CSN6082,022.5227,113.7874,15240,621,352,5.20,3373,2B#
```

● MavLink2 packet output (Mode3)

For details about the aircraft data in MavLink2 protocol format, please refer to the MavLink2 protocol document, the data is a hexadecimal data stream, each frame of data starts with a 0xFD, and Mode3 summarizes all aircraft information received in the previous second and outputs it once per second, in the following format:

```
FD 26 00 00 56 01 9C F6 00 00 2D 07 78 00 ED F2 67 0D 9F 72 A6 43 40 5D 80
00 58 4D 3E 5E 00 00 03 00 00 00 01 4F 4B 41 32 39 33 31 00 00 0A 01 7B 84 FD
26 00 00 F9 01 9C F6 00 00 32 34 76 00 A0 B3 7A 0D 00 27 E1 43 10 4B 95 00 9D
47 0B 64 20 00 3F 00 2F 00 00 53 49 41 38 30 37 5F 00 00 05 01 49 C5
```

● MavLink V1 Packet Output (Mode 6)

For details about the aircraft data in MavLink V1 protocol format, please refer to the MavLink protocol documentation, the data is a hexadecimal data stream, and the data starts with 0xFE each frame, and is summarized and output once per second like Mode 3, in the following format:

```
FE 26 28 01 9C F6 98 12 78 00 F0 48 77 0D 80 96 99 43 50 98 9E 00 61 61 84
5B E0 FF 3F 00 2B 04 00 43 42 4A 35 35 37 30 00 00 03 03 03 CC FE 26 F1 01 9C
F6 22 12 78 00 B0 52 6B 0D 80 25 D5 43 D0 FD 8B 00 52 5A 0D 5D E0 FF 3F 00
F4 02 00 43 53 5A 39 33 36 38 00 00 03 01 57 E3
```

● ADS-B Original Packet Output (Mode 4)

The original ADS-B packet is the text data of the DF17/DF18 ADS-B, and the data

is output in real time. Each ASCII frame starts with *, to; + < CR><LF> ends.

For example:

```
*8D780BC5581B86C4842957C96C3F;  
*8D780BC599886F9B10C406E69A89;  
*8D89630AEA469858011C0864254E;  
*8D780BC5230D8078CF8C204F503E;  
*8D780BC5581BD30422CB6A10347F;
```

● **ADS-B Packets with Signal Strength (Mode 5)**

In working mode 5, the serial port outputs ADS-B text data with signal strength flag in real time. In this mode, the output of a 112-bit raw data frame is a 15-byte ASCII frame with the MSB first, and each ASCII frame starts with +, starting with; + < CR><LF > ends. The first character is a "+" sign of additional signal strength, and the next information is the received ADS-B data.

For example:

```
+408D7811AEF8230003004978F833A2;  
+4F8D7811AE990C3C0E98300794501F;  
+458D7804569908F021B0081E49DFE4;
```

Important Notes:

The signal strength in front of the data is only the field strength of the received data frame, not the measured distance to the transmitter from it. The range of values is approximately between 0x20 (long-range signal) and 0x80 (short-range signal).

6.2 UART Interface Information

The EXD-SC1 can be connected to a host system or microcontroller via the UART interface (main serial ports RX0 and TX0). The UART interface can be used to send ADS-B messages and receive control messages. There are 4 types of baud rate options, namely 9600, 115200, 460800 and 921600, the default baud rate is 115200, the I/O level is TTL 3.3V, and the UART interface protocol is: n,8,1.

6.3 Introduction to Configuration Commands

All configuration directives start with "VS" and end with "#". The parameters in

the configuration directive are separated by ",". If it is a query command, you do not need to fill in the parameters. OK is returned if the configuration is successful, otherwise ERR is returned.

Table 7 Command

	command	illustrate
Get version	VS00,#	Returns the firmware version and firmware time after receiving it.
Set working mode	VS11,1#	VS11, the following value is the set mode. The mode range is 0-6. For example, in the example on the left, the working mode is set to Mode 1.
Set baud rate	VS14,3#	VS14, the following value is the set baud rate. 0 represents 9600, 1 represents 115200, 2 represents 460800, 3 represents 921600, and the factory default is 115200.

6.4 Firmware Upgrades

EXD-SC1 supports serial port firmware upgrade, if necessary, please contact sales to obtain the corresponding upgrade package and upgrade operation method.

7. Reliability testing and certification

- **Reliability testing**

THE EXD-SC1 MODULE CAN OPERATE IN TEMPERATURES RANGING FROM -40°C TO 80°C.

- **RoHS Certified**

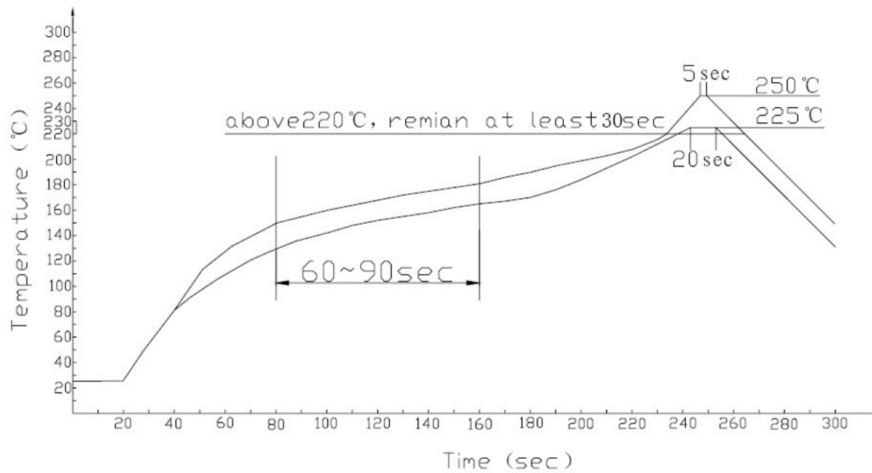
The EXD-SC1 module is RoHS compliant.

- **CE marked**

The EXD-SC1 module has obtained the EU CE electromagnetic compatibility certification.

8. Module welding and storage

8.1 Reflow soldering curves



Note:

Adjust the equilibration time to ensure that the gas is rationalized when the solder paste is melted. If there are too many voids on the PCB, the equilibration time can be increased. Considering that the product is placed in the soldering area for a long time (at a temperature above 180°C), the placement time should be shortened as much as possible in order to prevent damage to the components and the base plate.

Important features of curves:

Rising speed = 1~4°C /sec, 25°C to 150°C average warm-up temperature = 140°C to 150°C, 60sec~90sec temperature fluctuation = 225°C to 250°C, about 30sec falling speed = 2~6°C/sec, to 183°C, about 15sec total time = about 300sec

8.2 ESD Protection

The EXD-SC1 module is an electrostatic sensitive device. Frequent electrostatic contact can cause unintentional damage to the module. In addition to operating in accordance with the standard electrostatic protection requirements, the following points should be followed as much as possible:

1) Unless the PCB GND is already well grounded, the first position of the contact module should be the PCB GND.

2) When connecting the antenna, please connect the GND first, and then connect the signal cable.

3) When contacting some RF circuits, please do not touch the charging capacitors, and keep away from devices and equipment that can generate static electricity, such as dielectric antennas, coaxial wires, soldering irons, etc.

4) To avoid charge discharge through the RF input, do not touch the exposed part of the antenna medium. For situations where the contact antenna medium may be exposed, an anti-static protection circuit needs to be added to the design.

5) When soldering connectors and antennas connected to the RF input, make sure to use a static-free welding gun.

Update history

Time	version	Modify the record
2024-04-20	V1.0	Initial release
2024-05-27	V1.1	Schematic diagram of the evaluation board has been added
2024-06-25	V1.2	Fix some minor error descriptions in the documentation
2024-07-30	V1.3	<ol style="list-style-type: none">1. Added Mavlink V1 output format2. The default baud rate is changed to 115200

Cooperative consulting

Our team is skilled in software and hardware development and support tailor made for special application. If you need to customize products, please contact our sales.

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