Design Guide: TIDA-011043

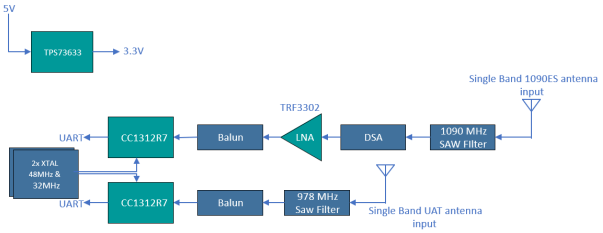
Dual-Band ADS-B Receiver Reference Design

Description

This reference design is a small ADS-B receiver that can capture both 1090MHz and 978MHz ADS-B packets simultaneously. The ADS-B packets are detected, demodulated, and sent to a host by UART for ADS-B data processing.

Resources

TIDA-011043	Design Folder
CC1312R7	Product Folder
TRF3302	Product Folder



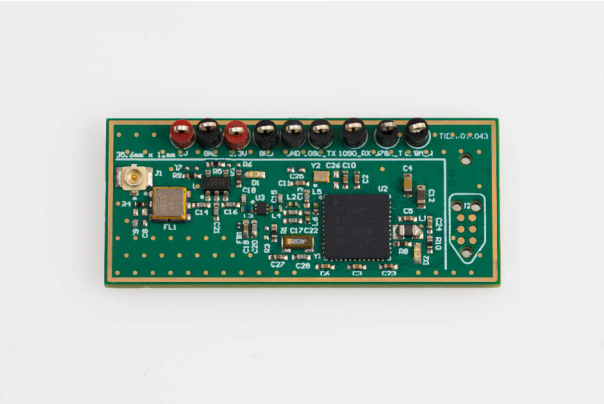
Block Diagram

Features

- Supports both 978MHz and 1090MHz ADS-B packet formats
- Small-size 426mm^2 board space for ready-to-fly testing
- Supports 5V or 3.3V supply input
- Achieves <5% packet error rate between –38dBm to –86dBm signals at 1090MHz

Applications

- Drone / UAS Accessories



Board Photo

Copyright © 2026 Texas Instruments Incorporated

1 System Description

ADS-B radios transmit (ADS-B OUT) and receive (ADS-B IN) aircraft's location, altitude and speed. These radios operate on two center frequencies 1090 ±1MHz and 978MHz ± 0.65MHz for ADS-B 1090ES and ADS-B UAT, respectively. 1090ES is the global standard and universal access transceiver (UAT) is United States-only for low altitude aviation. With the advancement of drone technology, the FAA has recently published proposed rules for beyond visual line of sight (BVLOS) operations where the notable change of regulation is Part 108. Part 108 includes operating rules for BVLOS operations of highly automated drone systems and regulations on the design and manufacture of BVLOS-capable drones. Some examples of BVLOS drones include delivery drones, drone-as-first-responder, agriculture, aerial surveying, and so on. ADS-B IN allows drones to comply with the new Part 108 requirement to maintain awareness of the air traffic near drone operation to avoid manned aircraft. ADS-B OUT is strictly prohibited under Part 108. The ADS-B receiver reference design provides a small and ready-to-fly design for small drones and unmanned aerial systems (UAS).

2 System Overview

2.1 Block Diagram

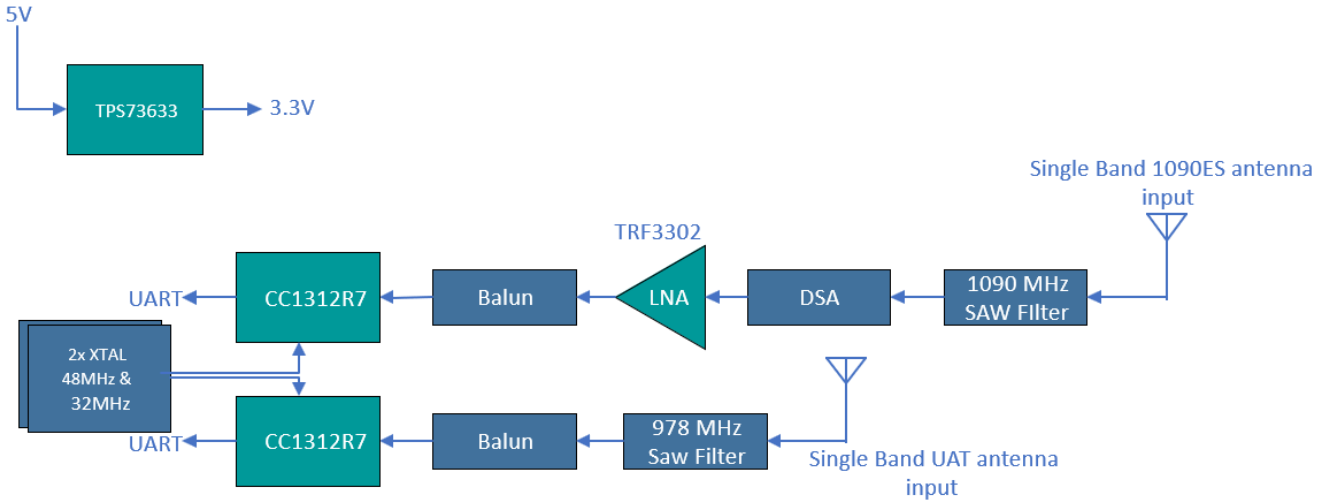


Figure 2-1. Block Diagram

Copyright © 2026 Texas Instruments Incorporated

2.2 Design Considerations

This reference design is a miniature dual-band ADS-B receiver deployable on drone platforms for flight testing. The reference design leverages two independent front ends consisting of a small U. FL antenna port that feeds a signal from an ADS-B antenna into an RF SAW filter and downstream to a discrete LC balun and ultimately into a CC1312R7. The top of the board (the side with antenna port J1) receives and processes the 1090 MHz ADS-B band. The other side of the board receives and processes the 978MHz or UAT band.

For the 978MHz ADS-B signal, this RF chain does not require any additional gain or attenuation for most missions due to the high dynamic range that the CC1312R7 provides natively. However, for the 1090MHz ADS-B signal chain, this design extends the dynamic range by implementing a digital step attenuator (DSA) and the TI LNA TRF3302 to back off the high output signal from close-in aircraft and drive up weaker received ADS-B from far away aircraft, respectively.

An initial connectorized test evaluation was performed by sending an ADS-B waveform from a vector signal generator to various LNA evaluation boards connected to the CC1312R7 LaunchPad™ as shown in Figure 2-1. The testing was performed with the TRF3302 matched for the ADS-B 1090 MHz signal that produced a gain of ~16.4 dB. Additionally, LNAs were evaluated and the results of how it impacted ability to receive signals at various inputs to the CC1312R7 LaunchPad are shown in Figure 2-2. The CC1312R7 LaunchPad as a standalone device under test (DUT) was able to receive the provided ADS-B packets from a dynamic range of -23.5dBm to -73.5dBm and including the TRF3302 the dynamic range shifted to -39.5dBm to -89.5dBm. Additionally, LNAs with ~20dB and ~30dB gain were also paired with the CC1312R7 LaunchPad and the dynamic ranges shifted to approximately -44.5dBm to -95.5dBm and -55.5 to -100dBm.

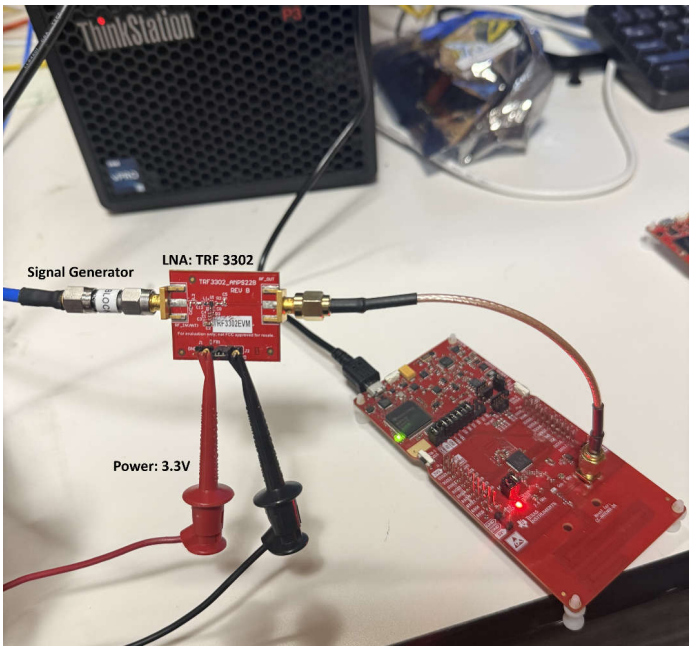


Figure 2-2. ADS-B Connectorized Test Setup

Copyright © 2026 Texas Instruments Incorporated

2.3 Highlighted Products

Texas Instruments addresses these challenges for both 1090ES and UAT bands through a highly integrated RF architecture designed specifically for low-power, high reliability applications. Two CC1312R7 utilized on the same board provide a compact, dual-band receiver capable of monitoring both ADS-B bands. The TI software defined radios integrate an Arm® Cortex®-M4F processor with an RF transceiver front end including an LNA within the device's RF core. The RF core offers a high-level, command-based application program interface to the main on-chip CPU. These cost effective and highly integrated devices have low power draw in receive mode of 5.8 mA and a small 7x7mm QFN package that easily facilitates optimization of SWaP (size, weight and power) for ADS-B receiver board designs for small UAS platforms.

By utilizing a sophisticated radio front-end, the TI architecture provides the high sensitivity required to detect distant aircraft for either ADS-B band. To combat the electrical noise typical of drone platforms, the system employs advanced digital signal processing to filter out interference, ensuring that the flight controller receives clean, actionable positional data. Most importantly, the power profile of the TI solution is optimized for the battery-constrained nature of drones. Through efficient sleep modes and streamlined data processing, the receiver can operate continuously throughout the duration of a mission, providing a "safety net" of situational awareness without significantly impacting the aircraft's flight envelope.

TI also offers a small, low-power wide-band LNA that can be matched for 1090 MHz or 978 MHz bands. The TRF3302 consumes <4.6 mA with an adjustable 1.8 V to 3.3 V input voltage and comes in a 1.3 mm × 1 mm package for SWaP sensitive drone platforms.

Copyright © 2026 Texas Instruments Incorporated

3 Hardware, Software, Testing Requirements, and Test Results

3.1 Hardware Requirements

Evaluation of the reference design requires the following hardware:

- TIDA-011043 reference design board
- 1090/978 MHz antennas
- Waveform generator
- R&S SMBV100B Vector signal generator (VSG) or ADS-B capable transmitter
- Variable attenuator box
- TC2030-CTX-NL J-Tag connect
- UART to USB connector
- RF chamber

3.2 Software

Evaluation of the reference design requires the following software:

- ADS-B firmware patches (Rev 1.0 or later)
- CC13XX SDK 7.10.01.24
- adsb_capture.wv

3.3 Test Setup

This section shows how to set up and test the reference design. Figure 3-1 shows the test setup of the reference design.

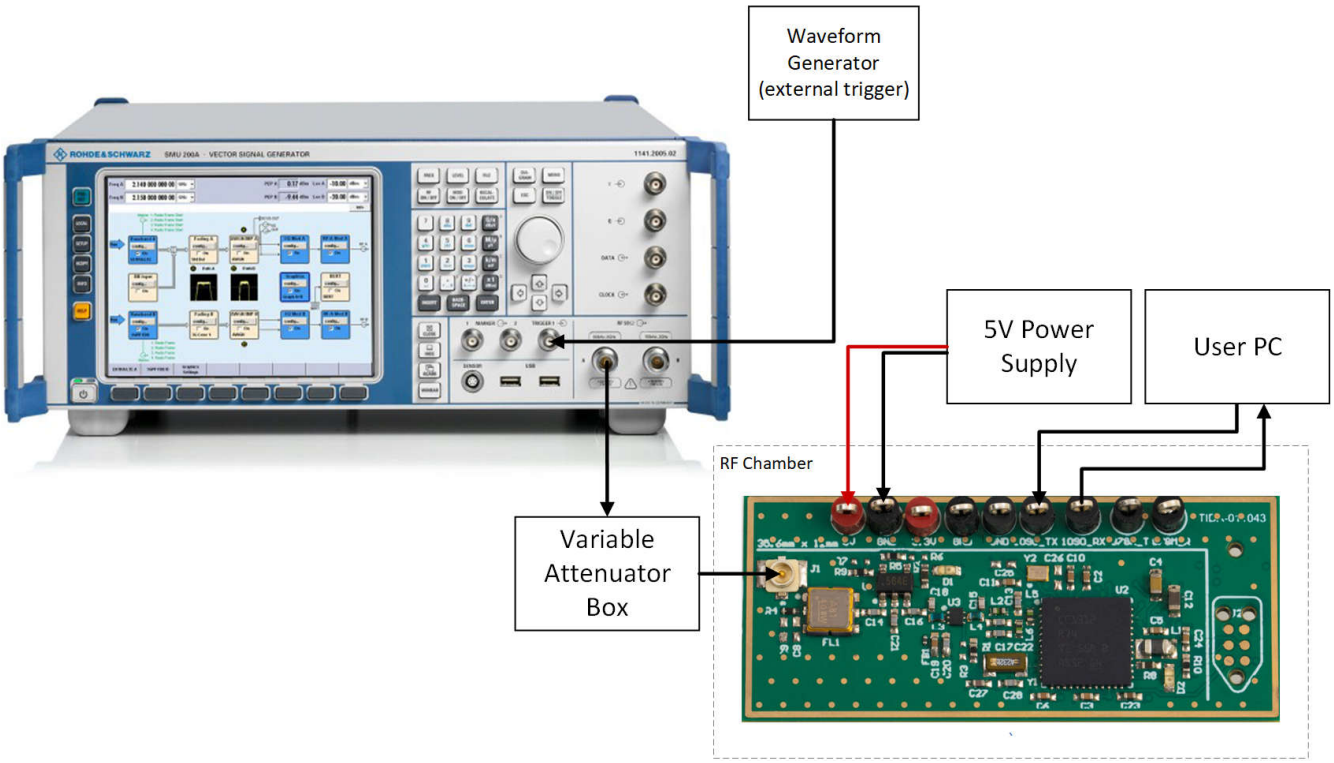


Figure 3-1. Test Setup

Initial Hardware Setup

- J-tag programming – Connect the TC2030-CTX-NL J-Tag connect to J2 on top of board to program the CC1312R7 for the 1090ES receiver and do the same for the J4 connector on the bottom of the board to program the CC1312R7 for the UAT receiver.
- Apply power via the UART serial cable or external power supply - Connect the 5V power supply to the 5V and ensure that the LED D1 is on.

Copyright © 2026 Texas Instruments Incorporated

- The DSA can be controlled via the DIO5/6 lines from the CC1312R7 or configured manually in HW. When R5 and R9 are populated, the DSA attenuation is 0dB. When R6 and R7 are populated, the DSA attenuation is 15.1dB.

3.4 Test Results

3.4.1 ADS-B 1090ES Dynamic Range ve Packet Error Rate (PER)

Test Procedure:

1. Setup the test and VSG
   a. Follow the test setup as shown in Figure 3-1.
   b. On the waveform generator, which is being used as an external trigger, turn on the output and then put it in manual trigger mode. Then, set the burst to 100 cycles of a square wave at 50Hz and a Vpp of 3V.
   c. Load the ADS-B waveform file to the ARB generator of the VSG.
   d. Verify that the ADS-B waveform parameters are as expected.
   e. Set the VSG to external trigger mode, enable the baseband, I/Q and RF modulation.
   f. Set the VSG to 1.09GHz and power level of the VSG to -30dBm.
2. Calculate the baseline input power to the device.
   a. Before starting testing, it is important to connect the output of the signal generator directly into a network analyzer to take note of the baseline input power being fed into the device.
   b. Input power at the same power level will be dependent on environmental facts and will vary across setups. This will then be added to the total dB of the attenuator to become the total input power.
   c. In this example, the baseline power was –24dBm and the attenuator value at Pmax was 13dB which then produced the total input power of –37dBm as seen in the table below.
3. Transmit to calculate packet error rate (PER)
   a. Set the attenuator to –60dB attenuation and start transmitting.
   b. Once transmitting, monitor the UART transmission line with a UART monitoring program that compares number of packets sent using the external trigger to the known good packet data to calculate PER
   c. After all expected packets are sent, decrease the level of attenuation and retransmit ADS-B again until PER is above desired threshold

Shown in Table 3-1 is the dynamic range calculated based on a 5% PER threshold and measured at RF port:

Table 3-1. Dynamic Range

Test Conditions	Sensitivity (dBm)	Saturation limit (dBm)
DSA = 0dB	-86	-54
DSA = 15dB	-70	-38

Copyright © 2026 Texas Instruments Incorporated

3.4.2 ADS-B 1090ES Field Testing

The TIDA-011043 ADS-B receiver board successfully mapped multiple aircraft in the DFW area while paired with an ADS-B antenna PC1900.07.0100AQ indicated on the map for ~2 minutes. A UART to USB bridge connector powered and transferred the UART data to a computer where a TI developed application mapped the ADS-B data to a world map as shown in Figure 3-2. The results show that air traffic can be successfully received from ~50nm radius when looking at the aircraft near Howe, TX to Hillsboro, TX.

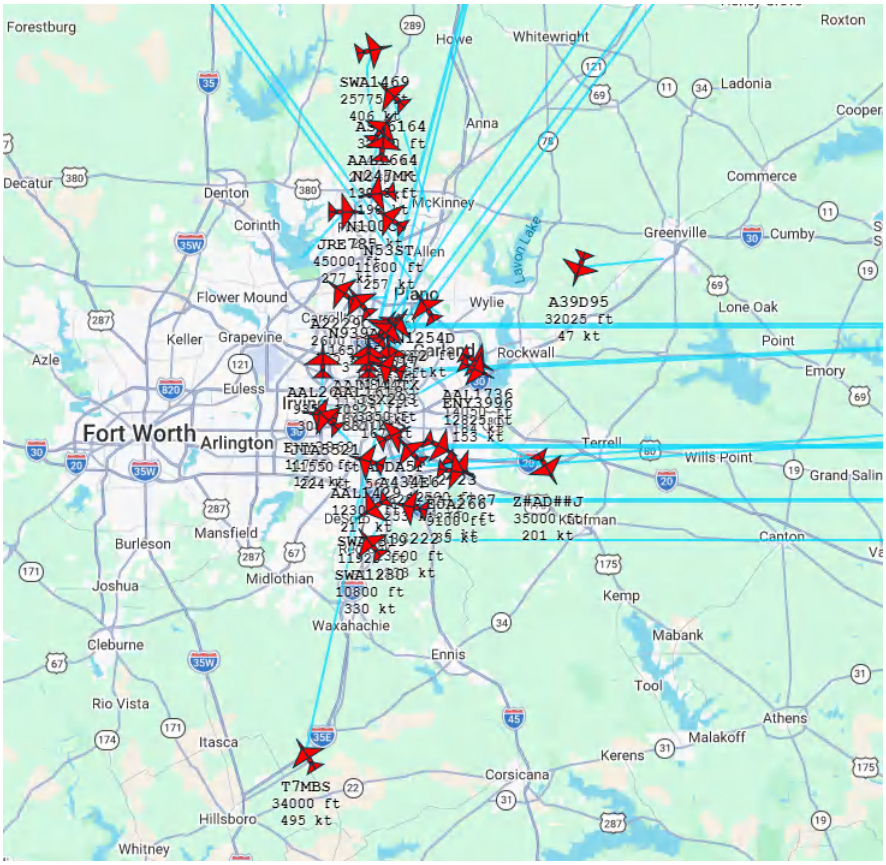


Figure 3-2. ADS-B Traffic Mapping

In another session of tracking aircraft, ADS-B traffic found on the TI ADS-B mapping application shown in Figure 3-2 can be compared to the third-party website "ADS-B Exchange" shown in Figure 3-3. The yellow dot indicates the rough coordinates from where the TIDA-011043 receiver board is located during this session. The locations of the aircraft might slightly vary due to a small, time delay between screen captures of the TI ADS-B mapping application and ADS-B exchange.

For ease of comparison here is a sample of the aircraft found in all screen captures:

- SWA1401 - NW ~14nm
- N185VM - E ~9nm
- EJA331 - SW ~9nm
- N03077U – NW ~19nm

Copyright © 2026 Texas Instruments Incorporated

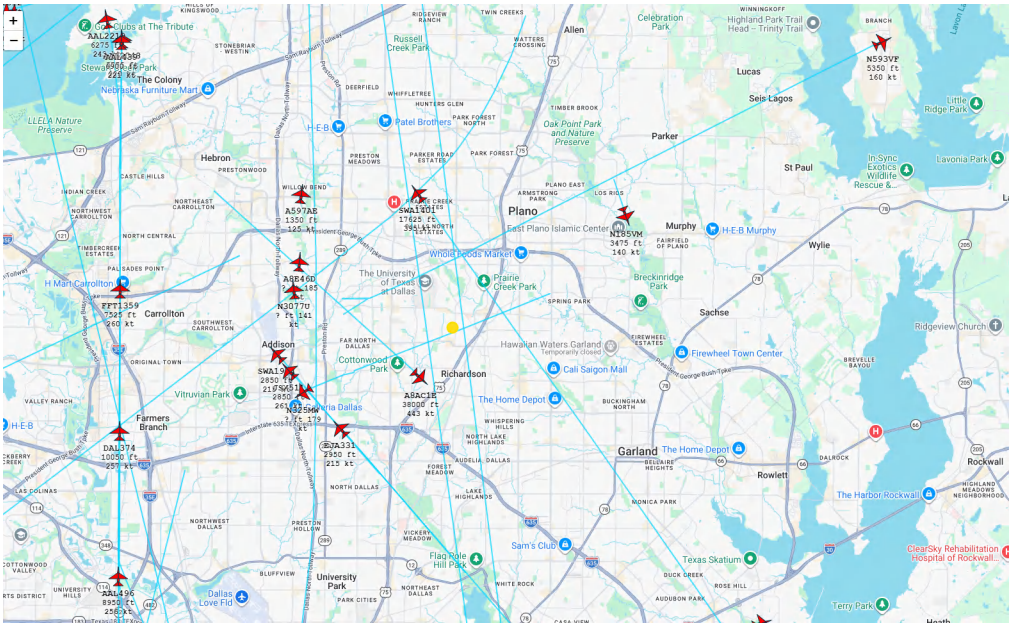


Figure 3-3. TI ADS-B Mapping Application

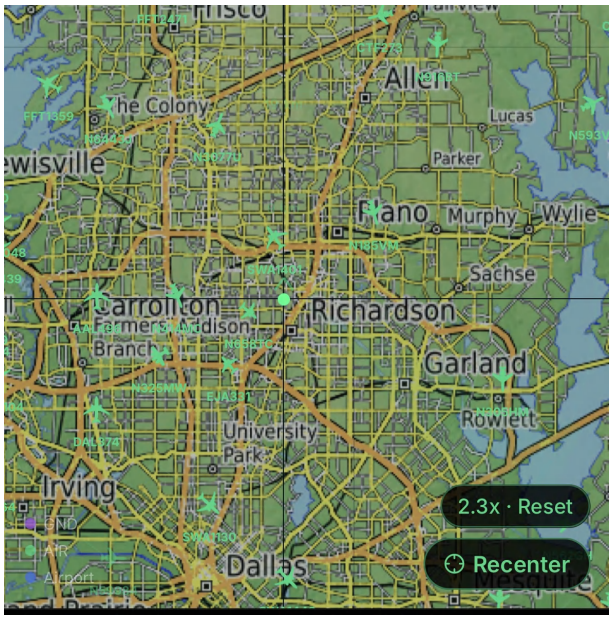


Figure 3-4. ADS-B Exchange Map

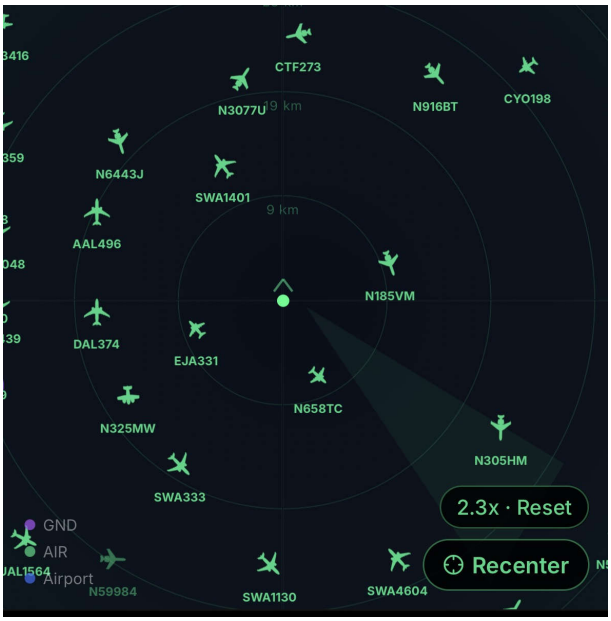


Figure 3-5. RADAR Views

Copyright © 2026 Texas Instruments Incorporated

4 Design and Documentation Support

4.1 Design Files

4.1.1 Schematics

To download the schematics, see the design files on the TIDA-011043 landing page.

4.1.2 BOM

To download the bill of materials (BOM), see the design files at TIDA-011043 landing page.

4.2 Tools and Software

4.2.1 Software

To download the software, see the design files at TIDA-011043 landing page.

4.3 Documentation Support

- Texas Instruments, *CC1312R7 SimpleLink™ 32-bit Arm Cortex-M4F Sub-1 GHz wireless MCU with 704kB Flash*, product page
- Texas Instruments, *TRF3302, 1165MHz-to-1640MHz multiband GPS and GNSS low-noise amplifier (LNA)*, product page

Trademarks

LaunchPad™ is a trademark of Texas Instruments.
All trademarks are the property of their respective owners.

Copyright © 2026 Texas Instruments Incorporated

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you fully indemnify TI and its representatives against any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI’s products are provided subject to TI’s Terms of Sale, TI’s General Quality Guidelines, or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI’s provision of these resources does not expand or otherwise alter TI’s applicable warranties or warranty disclaimers for TI products. Unless TI explicitly designates a product as custom or customer-specified, TI products are standard, catalog, general purpose devices.

TI objects to and rejects any additional or different terms you may propose.

Copyright © 2026, Texas Instruments Incorporated

Last updated 10/2025