VIAVI Solutions

Application Note

Reducing RF Leakage Using VIAVI Solutions Antenna Couplers

This application note explains the RF attenuation provided by VIAVI transponder antenna couplers, how to maximize attenuation, and avoid interference with ATC and nearby aircraft.

Today, there is an inherent issue with ground testing of an aircraft fitted with an ADS-B transponder. Since an ADS-B transponder automatically reports its position, this presents a problem for TCAS or ADS-B In equipped aircraft when testing above field elevation, especially around congested airspace. As a result, the FAA issued SAFO 17002 in 2017 to follow proper procedures and use antenna shielding to prevent test signals propagation.

VIAVI antenna couplers provide greater than 20dB of isolation (25dB+ typical). This level of attenuation was adequate to eliminate interference with TCAS equipped aircraft. Although nearby aircraft may still pick up the test aircraft's DF11 squitter, it is unlikely the test aircraft will hear the interrogation from the airborne TCAS and never reply.

We now have ADS-B ground stations positioned all over the globe. ADS-B ground stations have a -84dBm level of sensitivity which can pick up RF leakage from your test event if not properly shielded and rebroadcast your test aircrafts position causing interference with TCAS and ADS-B In equipped aircraft.

Although VIAVI manufactured antenna couplers are constructed for maximum attenuation, there are multiple test set up variations that can cause RF leakage. Ideally, the couplers conductive gasket works best seated to a metallic (unpainted) surface. Some antennas may be taller and/or have a flange that does not allow for a proper seal. Ball and stub antenna configurations may not allow for proper sealing of the gasket to the aircraft skin, or certain antenna types simply may not be accommodated with available couplers. The aircraft fuselage type (composite vs. aluminum) can also allow for leakage.

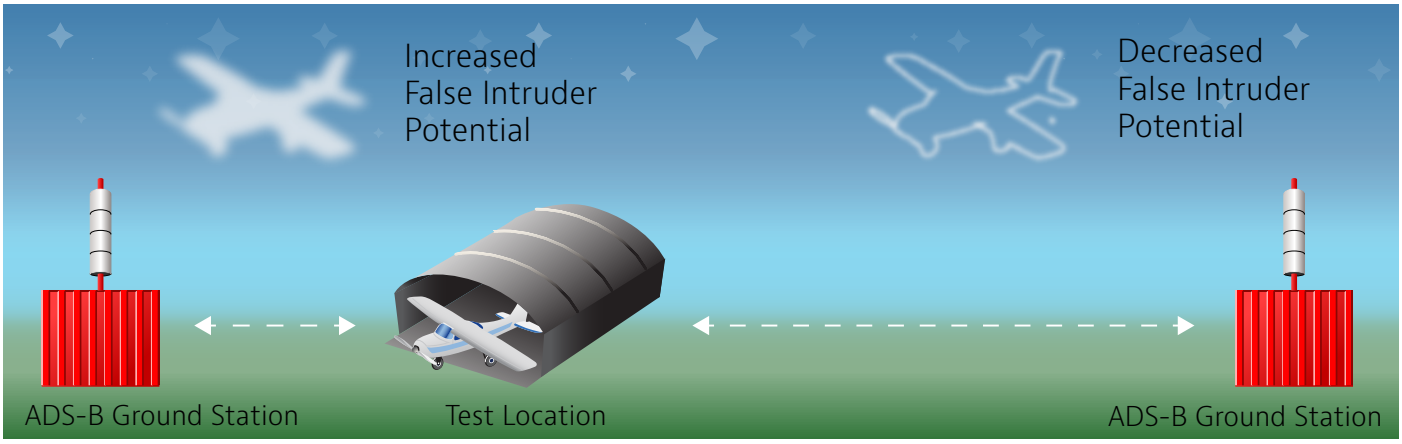
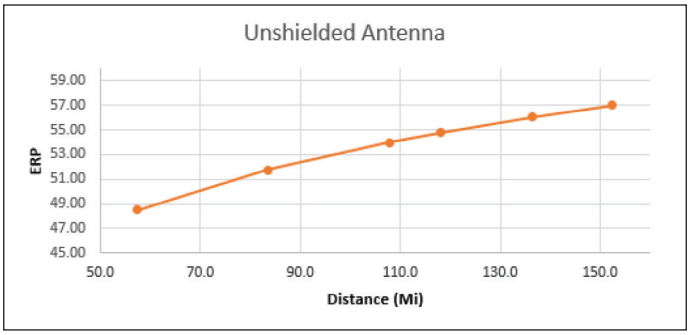


Fig. 1 The potential of creating a False Intruder is based on the coupler RF Leakage, isolation from the hangar, and the relative distance of the Ground Station to the Testing Location

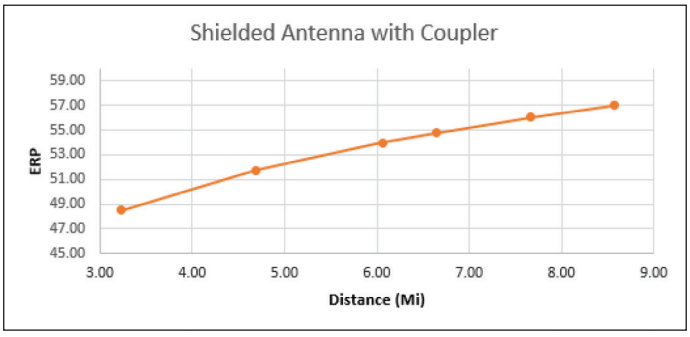
To put this all into perspective, the below chart shows the distance a typical transponder with an **unshielded** antenna can radiate in miles and be picked up by an ADS-B ground station. This example assumes a ground station sensitivity of -84dBm. (Airborne TCAS and ADS-B receivers are less sensitive (-74dBm).

Transponder (Watts)	Radiated Power (ERP)	Distance (Miles)
71W	48.51 dBm	57.43
250W	53.98 dBm	107.77
500W	56.99 dBm	152.41



To illustrate the effectiveness of using a coupler on the tested antenna and/or using a coupler as a shield for diversity systems, see below table and graph. This represents a typical attenuation of 25dB provided by the coupler, the RF leakage path loss and resultant distance is as follows. This example is worst case.

Transponder (Watts)	Radiated Power (ERP)	Distance (Miles)
71W	23.51 dBm	3.23
250W	28.98 dBm	6.06
500W	31.99 dBm	8.57



The above example does not consider testing inside a hangar, which may provide for additional shielding.

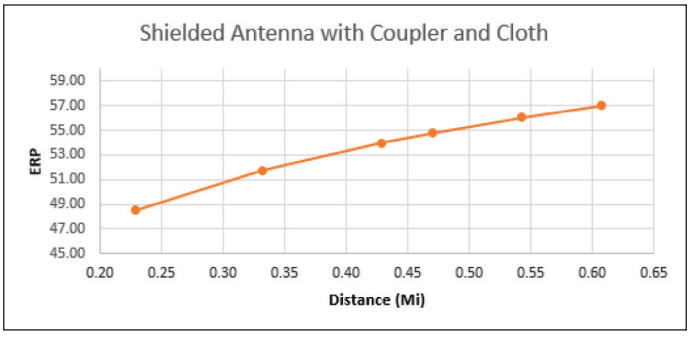
In most cases, the antenna coupler provides adequate attenuation to limit false intruders. But, depending on the ground station's location in relation to your test location, the attenuation provided **may not be adequate to prevent your test event from being picked up by ATC and rebroadcast.**

What can you do to maximize the attenuation to prevent this interference?

VIAVI has tested various RF cloths that have proven quite effective, providing additional attenuation. By placing the RF cloth over the coupler affixed to the

aircraft (tape the edges or attached via suction cups resulted in the following:

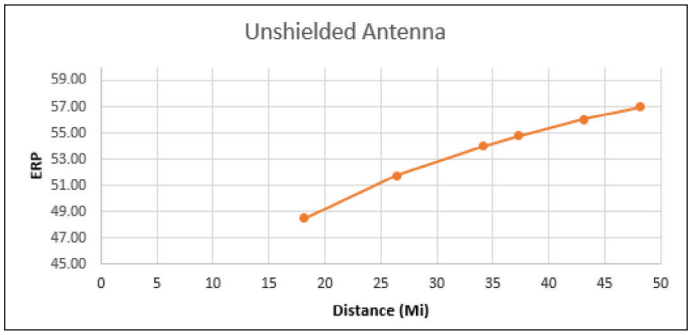
Transponder (Watts)	Radiated Power (ERP)	Distance (Miles)
71W	.51 dBm	.23
250W	5.98 dBm	.43
500W	8.99 dBm	.61

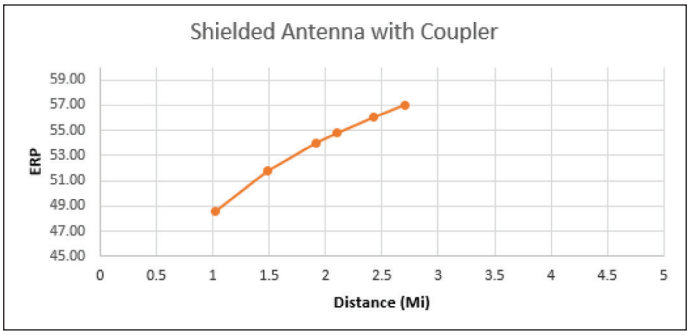


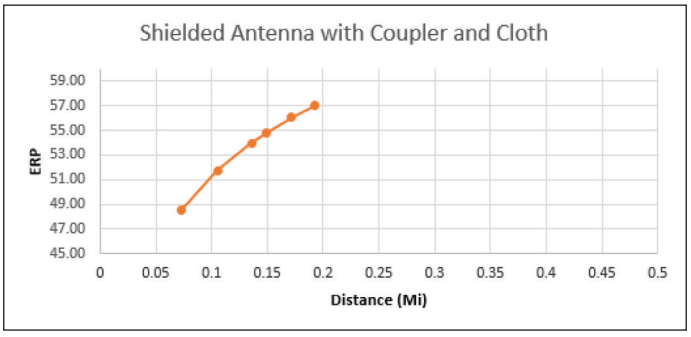
Using an RF cloth, in addition to testing indoors, should help prevent the propagation of test signals.

Airborne Receivers (TCAS / ADS-B-In)

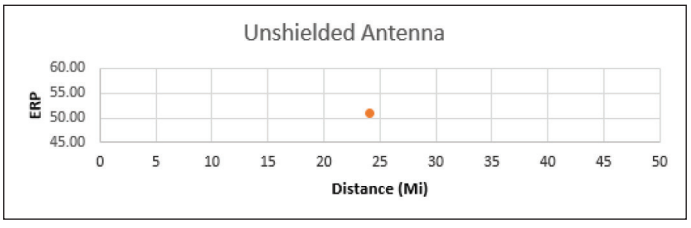
Using the same data points for attenuation , and -74dBm as receiver sensitivity for aircraft equipped with TCAS or ADS-B-In receivers, the below charts indicate how far out the RF signal from your test event will pick up a transmitted DF11 squitter by airborne systems, if not rebroadcast by an ADS-B ground station.

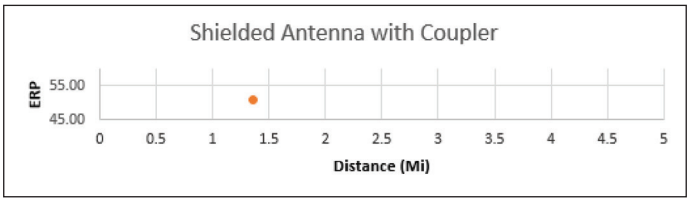


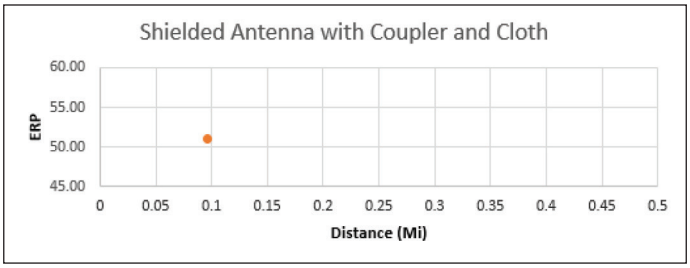




TCAS systems will detect the ADS-B squitter and then interrogate the transponder UUT. With no coupler or RF shield installed, as shown below, the UUT would need to be within 24.8 miles to hear the interrogation, 1.4 miles with a coupler installed, and less than .1 miles with added RF cloth for additional attenuation. If the UUT does not hear the interrogation, then it will not reply. This graph depicts the effectiveness of VIAVI antenna couplers to airborne receivers without being rebroadcast from a ground station.







For best testing practices, observe the following:

- Assure the antenna coupler is in good working condition (inspect the gasketing)
- Verify the clamping mechanism (if applicable) is in working order and clean of any grease or dirt.
- Inspect the cable used between the test set and coupler. Assure the cables are not frayed and are in good working order. (a bad cable can act as an antenna)
- Clean the antenna of any grease or dirt
- Assure the coupler has a proper fit on the antenna with no gaps and that the gasket **firmly compresses** onto the skin of the aircraft.
- The VIAVI UC-584S top-mount antenna has a software gasket allowing it to be placed over the upper antenna without a clamping mechanism
- For diversity systems, use a second antenna coupler (preferred for best attenuation over the RF Block provided with the IFR6000/6015 for this application) or antenna shield to cover any transponder antennas that are not being tested
- If possible, for aircraft with redundant systems, shut off the untested system, or use additional couplers on the untested antennas.
- When using a coupler as an RF block on the untested antenna, it's good practice to terminate the couplers RF connector with a 50-ohm load (lab testing has proven minimal effect)
- Understand the location of nearby ADS-B ground stations
- As a precaution and when able, test in the hangar with all doors closed for additional shielding.
- RF fabric can be placed over the coupler and taped to the aircraft fuselage to gain additional attenuation if needed.
- Reference the FAA's Safety Alert for Operators (SAFO) 17002

Once you have couplers installed on the transponder antenna's, you can perform a leakage test using the IFR6000 and RF antenna. Verify proper setup and test within 50' of the aircrafts antenna.

Navigate to the XPDR Test List, and run the POWER/FREQ Test. If the aircraft responds, observe the ERP (leakage) displayed and distance chart below. If you have over 28dB of ERP, verify your couplers have a good seal (this represents 25dB of attenuation provided by the coupler). If there is an ADS-B ground station within the noted range, additional shielding is warranted.

Measured ERP (Leakage)	Distance (Feet)	Distance (Miles)
34dBm	56,904	10.74
32dBm	45,200	8.56
30dBm	28,519	6.80
28dBm	25,904	5.40
26dBm	22,654	4.29
24dBm	17,994	3.41
22dBm	14,294	2.71
20dBm	11,354	2.15
18dBm	9,019	1.71
16dBm	7,164	1.36
14dBm	5,690	1.08

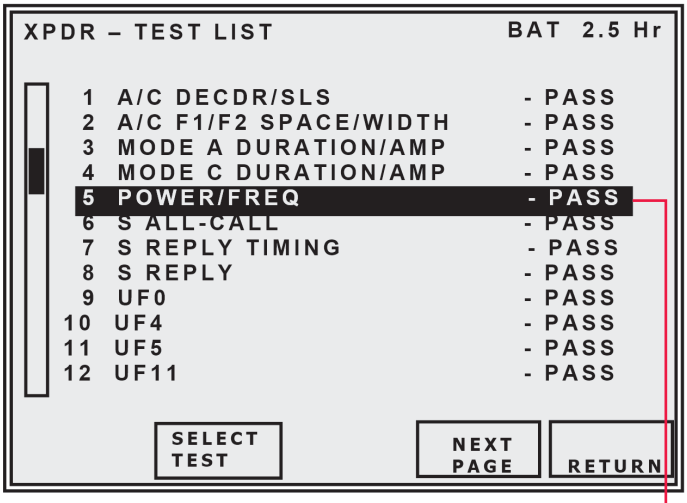


Fig 2. Navigate to the XPDR Test List.

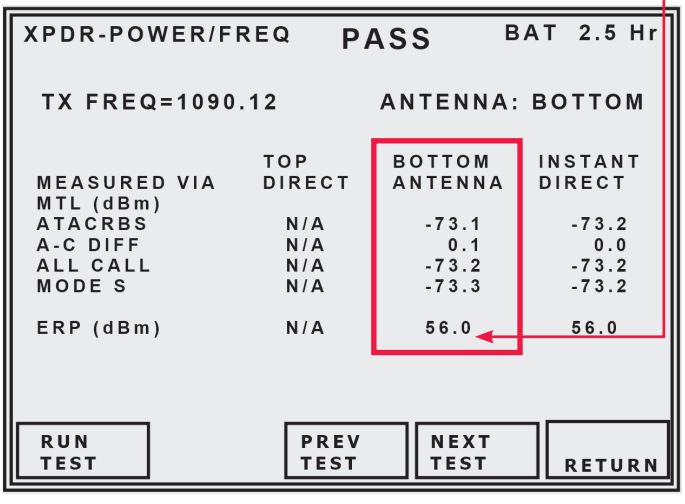
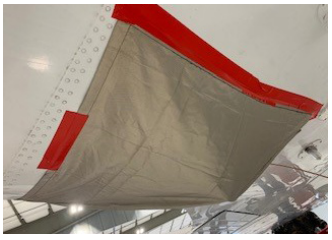


Fig 3. Observe the displayed ERP and refer to the above chart.

There are various RF Fabrics available on the market today. Select a woven nickel and/or copper type fabric with 80+dB of shielding effectiveness for best results. Amazon has a variety to choose from with various sizes readily available.

Note – Due to the variations in aircraft configurations, test sites and ADS-B ground station location, VIAVI makes no claims to completely eliminate RF interference that may be picked up by nearby aircraft, or ADS-B ground station and rebroadcast as a false intruder.



For best isolation, taping the fabric to the aircrafts skin may be warranted.

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