

Ensuring the Health of Your Site's Receive Antenna

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Reliable communication depends equally on transmit and receive performance, yet the receive antenna paths are often left unmonitored. Traditional verification requires disconnecting the feedline, introducing service interruptions and unnecessary wear on critical RF connections. For remote sites and critical-communications systems, this creates a significant operational risk: receive-side issues may go undetected until end users report reduced coverage or degraded audio.

This application note explains the challenges of monitoring receive antennas across common site configurations and introduces a continuous, in-line monitoring approach that eliminates downtime and enables early detection of feedline and antenna degradation —before system performance is impacted.

Who Should Read This

This application note is intended for RF system managers, technicians, and network engineers responsible for maintaining public safety, utility, and other critical communications systems. These users often manage multiple remote sites where routine manual testing is impractical or disruptive. The Bird 4046E Receive Antenna Monitor enables continuous in-line visibility into the receive path performance without requiring a site visit.

Background: Traditional Antenna Measurement Methods

The primary objective of any radio frequency (RF) transmission site is to ensure continued reliable communication among all its users. While site architectures vary widely, antenna health has traditionally been assessed by measuring forward and reflected power and calculating return loss or voltage standing wave ratio (VSWR). Comparing this calculated value against both accepted standard levels and historical data can help to establish baseline performance and provide insight about the overall health of the antenna over the life of the installation.

In some cases, however, the site requirements may call for the transmission antenna to operate independently of the receive antenna, effectively removing the possibility of making the power measurements on the receive side. This creates a challenge for maintenance personnel, who must assess receive antenna performance without disconnecting the feedline, disrupting service, or scheduling frequent site visits solely to verify return loss.

This application note reviews typical antenna performance expectations and the conventional instruments used to characterize them. This will be followed by presenting three common site configurations involving separate transmit and receive antennas with the last helping to illustrate the problem to solve. This paper concludes by describing how the [Bird 4046E Receive Antenna Monitor](#) can help address the problem and perform the required measurements.

Antenna Performance Expectations

Return loss is a measure of how well an antenna is impedance-matched to the transmission line to which it is connected and is represented by the S_{11} (S-parameter) measurement made with a

vector network analyzer (VNA) (see **Figure 1**). The VNA sources an incident signal and measures the reflected signal to compute return loss or VSWR. Return loss values typically lower than -14 dB (or a VSWR of less than 1.5:1) indicate an acceptable match, meaning that little power is lost and more of the available power is transferred to and from the antenna.

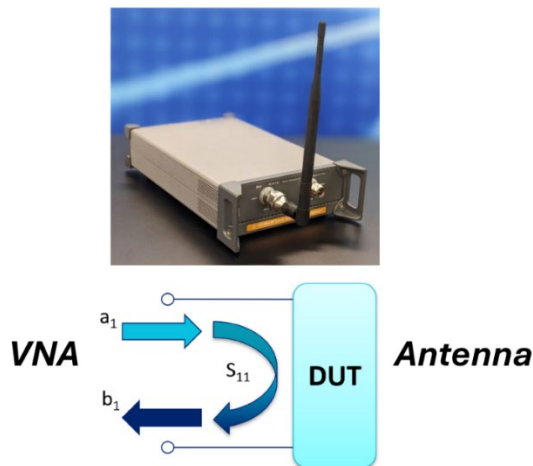


Figure 1: A vector network analyzer can be used to measure return loss or VSWR and help indicate the health of an antenna. The VNA source sweeps a series of signals across a frequency range, applied at the device under test (DUT) input – the antenna – and measures the reflected response, then calculates the result.

It is more common for site technicians to perform routine antenna maintenance using a cable and antenna analyzer, which limits the broad features set of a VNA to just providing return loss or VSWR readings along with the ability to graphically display the results and measurement data (**Figure 2**).

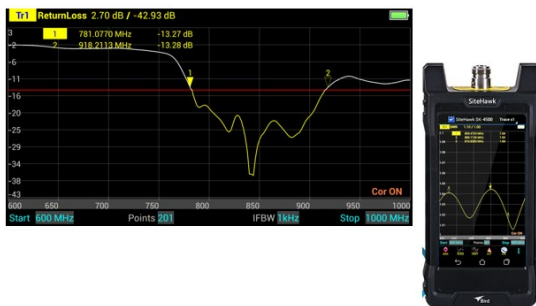


Figure 2: A cable and antenna analyzer can be used to measure the return loss and VSWR characteristics of an antenna.

disconnect the antenna to perform the

measurements. This process can disrupt service and contributes to mechanical wear and long-term strain on cables and connectors.

Overview of Different Site Configurations

To illustrate the need for monitoring the health of independent receive antennas, the following three site examples are presented.

Single Antenna, Same Transmit and Receive Frequency

Consider a system such as a digital selective calling (DSC) marine radio, where transmission and reception occur on the same frequency (e.g., 156.525 MHz) using a single shared antenna. A block diagram of this is shown in **Figure 3**.

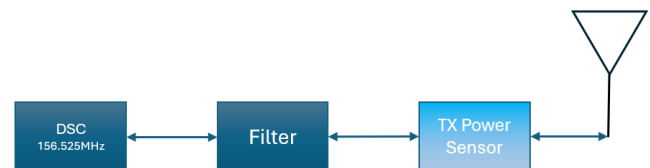


Figure 3: Block diagram of a configuration for a DSC marine radio which can monitor the health of the antenna by way of a transmit power sensor.

When the radio is keyed, the transmitted signal passes through a filter and a transmit (TX) power sensor before reaching the antenna. The TX power sensor will monitor forward and reflected power and calculate the return loss. This type of sensor is often able to measure from tens up to hundreds of watts and allows the operator to access those measurements from a remote, network-connected interface. This same sensor may be configured with conditional alarming where, if a predefined threshold is exceeded – for instance, elevated VSWR due to damage of either the transmission line or the antenna – the system can automatically issue a notification to an external monitoring platform.

Single Antenna for Multi-channel Radio System, Different Transmit and Receive Frequencies

Figure 4 illustrates multiple channel radio system in separate transmit (TX) and receive (RX) groups with a duplexer helping to isolate the signals into two distinct bands. The opposing side of the duplexer shows a common path between the TX and RX signals that lead out to the antenna. Again, the TX power sensor is placed in the transmission line to provide constant insight into the health of the transmission line and antenna.

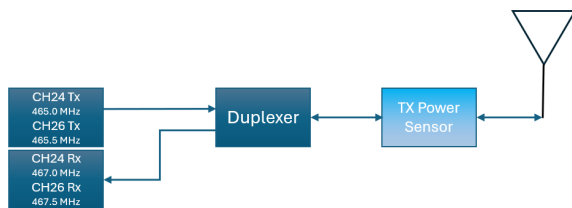


Figure 4: Block diagram of a site configuration where groups of transmit and receive radios share the transmission line and antenna while being monitored by transmit power sensor.

Two Antennas, Different Transmit and Receive Frequencies with Repeaters

Consider a repeater site in which the transmit and receive paths are fully isolated and separate antennas are used for each function (**Figure 5**). As in the previous examples, the transmit path can be continuously monitored using a TX power sensor, providing visibility into transmission line and antenna health during normal operation. Unfortunately, another sensor of the same type cannot be used on the receive side. The receive signals are significantly lower in power, about -73 dBm (or close to fifty picowatts), and fall well below the detection capability of the TX power sensors. Therefore, a new method for convenient and periodic measurement of the receive antenna is required.

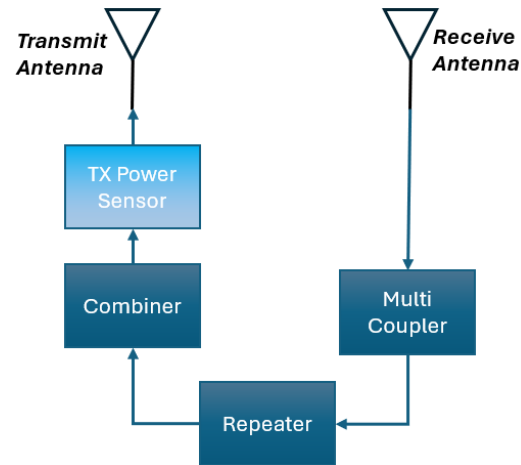


Figure 5: With the transmit and receive sides isolated, there is no longer a means for monitoring the health of the receive antenna.

Proposal to Monitor the Receive Antenna

One approach for verifying the quality of the antenna match (**Figure 6**) is the use of an in-line switched reflectometer that:

- Temporarily interrupts the connection between the antenna and the base station or repeater
- Injects a controlled test signal into the antenna at one or more discrete frequency points
- Measures the reflected response from the antenna at each frequency
- Calculates return loss at each measurement point

4046E RX Antenna Monitor Block Diagram

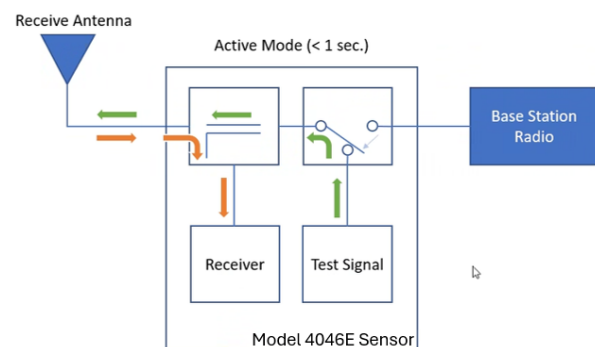


Figure 6: The 4046E receive antenna monitor briefly switches in its test signal to measure the antenna return loss at select frequencies.

A technician may initially qualify the installation of the receive antenna monitor by using a cable/antenna analyzer or VNA to sweep the feed line and measure return loss at different points, such as those with the greatest loss values, much like what is seen in **Figure 7**.

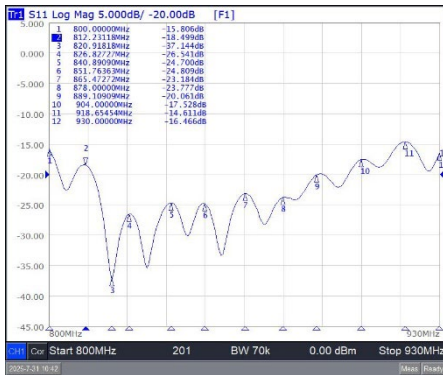


Figure 7: Sweeping 800-930 MHz on an antenna designed for use at public safety sites with measurement markers set at the points with the greatest return loss. To be used as a reference in comparison to measurements taken by the installed sensor.

With the receive antenna monitor installed in-line with the sensor, the technician can then access the sensor’s embedded web interface and configure corresponding measurement points, specifying names, frequencies, and tolerances for each (**Figure 8**).

Configured Measurement Points					
Point Name	Point	Alarms	Center Freq (MHz)	RT Loss Min/Max (dB)	+
Alpha	Active	Enabled	800.0	-18 / -14	✎ -
Beta	Active	Enabled	812.2	-21 / -17	✎ -
Charlie	Active	Enabled	820.9	-39 / -35	✎ -
Delta	Active	Enabled	826.8	-39 / -35	✎ -
Echo	Active	Enabled	840.9	-27 / -23	✎ -
Foxtrot	Active	Enabled	851.8	-27 / -23	✎ -

Figure 8: Example of complementary measurement points configured at the receive monitor that overlap with the points of interest determined by the line sweep.

Measurements are then performed at scheduled times and intervals—such as during periods of low repeater activity—and the results are displayed through the sensor’s web interface. (**Figure 9**).

Last Return Loss Measurements			
Measurement Point	Frequency	Last Return Loss	Timestamp (local)
Alpha	800.00 MHz	-15.7 dB	7/31/25, 11:17 AM
Beta	812.20 MHz	-18.7 dB	7/31/25, 11:17 AM
Charlie	820.90 MHz	-33.9 dB	7/31/25, 11:17 AM
Delta	826.80 MHz	-25.9 dB	7/31/25, 11:17 AM
Echo	840.90 MHz	-24.3 dB	7/31/25, 11:17 AM
Foxtrot	851.80 MHz	-24.5 dB	7/31/25, 11:17 AM
Golf	865.50 MHz	-23.0 dB	7/31/25, 11:17 AM
Hotel	878.00 MHz	-23.7 dB	7/31/25, 11:17 AM
India	889.10 MHz	-19.8 dB	7/31/25, 11:17 AM
Juliette	905.00 MHz	-17.5 dB	7/31/25, 11:17 AM
Kilo	918.70 MHz	-14.4 dB	7/31/25, 11:17 AM
Lima	930.00 MHz	-16.2 dB	7/31/25, 11:17 AM

Figure 9: The operator can determine the time and interval at which the return loss measurements are made to ensure no disruption to service.

One point deviates a bit more than expected in comparison to the reference sweep in Figure 7.

A comparison between the receive antenna monitor’s measurement points and the initial analyzer sweep shows a change at the 820.9 MHz frequency point. While the value itself is still quite good in comparison to general expectations for antenna match (-14 dB), the deviation serves as a cue that something has changed and could be cause for concern. In this example, the technician defined an expected return loss value of -37 dB at this frequency, with acceptable limits of ± 2 dB. Because the new measurement falls outside this defined tolerance, an alarm is generated and displayed within the sensor’s user interface.

Alarms			
Alarm Type	Value	Timestamp (local)	Message
Return Loss	-34.2 dB	7/31/25, 10:56 AM	Return Loss overrange on point ID: 3, name: Charlie, freq: 821, rLoss: -34.2, maximum: -35.0

Figure 10: Return loss alarm conditions are reflected in the Status view of the sensor’s web interface.

The technician cannot be expected to remain on site to continuously monitor antenna conditions using a laptop and web browser – they need to move on to their next job. Instead, the sensor can be configured to generate alarms and forward them to an SNMP-based network management system, where events can be centrally monitored and addressed as they occur. (**Figure 11a & 11b**).

Description	Source	Time
maxRTLAlarmTrap	10.128.0.177	2025-07-31 11:35:30

Figure 11: A. (top) The sensor can be configured for SNMP v2c or v3 traps to be sent to alarm management software running on a remote system.

B. (bottom) Alarms are received by the management software with brief details on the problem, the IP address of the sensor the alarm originated from, and when that alarm occurred.

Summary

The objective of any RF communication site is to provide reliable, continuous service to all users operating within its assigned frequency bands. Achieving this requires that both transmit and receive antennas remain in good operating condition. While testing of an antenna can be accomplished by way of determining return loss from forward and reflected power from the transmitter using a directional power sensor such as the [Bird 4042E or 4043E](#)), there are many sites

where this is not possible due to the use of independent transmit and receive antennas. While a technician could be dispatched to a remote site and use a cable and antenna analyzer like the [SiteHawk model SK-4500-TC](#) to verify the match of the antenna, this would involve disconnecting the antenna for some extended time and disrupting service.

To address this challenge, Bird proposes installing the [4046E RX Antenna Monitor](#) between the antenna and receiver. This sensor can be configured to perform periodic return loss measurements during periods of low system activity, with each measurement typically completed in less than one second. The sensor eliminates the need for continuous oversight and can be configured to generate alarm conditions over a network connection using SNMP, notifying operators only when a defined condition is exceeded.

Conclusion

Continuous visibility into receive-path performance is essential for maintaining reliable communications, particularly at remote and mission-critical sites. Traditional verification methods require disconnecting the antenna, introducing service interruptions and making routine monitoring impractical. By installing the 4046E Receive Antenna Monitor between the antenna and receiver, technicians gain a non-intrusive way to verify return loss, establish baseline performance, and receive SNMP-based alarms when measured conditions deviate from expected values.

Proactive receive-path monitoring reduces the need for routine site visits, supports early detection of degradation, and helps maintain consistent system performance. For public safety, utility, and other critical-communications networks, preserving receive-path integrity is essential—and continuous monitoring helps ensure potential issues are identified before they impact system reliability.

[Learn more about the Bird 4046E Receive Antenna Monitor.](#)