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DRAWING TITLE

# RESOLVING RADIO INTERFERANCE PROBLEMS

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APPLICATION NOTE WAN-002

# RESOLVING RADIO INTERFERENCE PROBLEMS

## Introduction

The purpose of this application note is to provide system installers insight into measuring and resolving interference problems involving Flexcomm communication systems.  Common causes and troubleshooting techniques for many systems problems are included.

On aircraft installations where multiple transceivers are present, it is not uncommon to experience interference problems during radio transmission on other receivers collocated on the aircraft.  System installers have developed industry standard techniques to minimize this interference, such as maximizing distance between radio antennas, using shielded cables, etc.  However, with even the best-designed systems, interference may still be at unacceptable levels.  When this occurs the causes normally fall into the following categories:

1) Improper or inadequate installations.
2) System interaction.
3) Faulty equipment.
4) Inadequately specified equipment for the particular installation.

## Improper or Inadequate Installations

An improper installation occurs when a system does not conform to the specified installation drawings, whereas an inadequate installation signifies a poorly designed system.  Occurrences of this nature include:

1) **Improperly installed RF connectors:** Care must be taken to follow the manufacturer's assembly instructions when installing RF connectors.  Poorly installed connectors will degrade the Voltage Standing Wave Ratio (VSWR) of the cable.  Under extreme conditions, this could increase the transmitter's spurious output to an unacceptable level and possibly result in transmitter failure.  The combined VSWR of the antenna and coax cable should be verified before transmitting on a newly installed system.  The VSWR of the cable and antenna together should not exceed the maximum specified antenna VSWR.  In addition to measuring VSWR, the insertion loss of the cable should be measured.  Loss in excess of the manufacturer's specified loss could indicate a bad connector or pinched cable.  Cable loss is normally specified in dB/ft and the total loss must to be calculated for your length of cable.  Excessive loss will degrade receiver performance as well as transmitter performance and could result in connector or cable failure during transmit due to heating.

   VSWR may be measured with an antenna tester, a directional coupler, or a through line Wattmeter.  Some antennas, such as the AT51, are electronically tuned and the VSWR may not meet specification if power is not supplied to the antenna tuner and the tuner has not been programmed to the test frequency. Programming the antenna tuner can be accomplished by setting the RT-5000 to receive on the frequency of test.

2) **Antennas misrouted to the wrong RF port:** The Flexcomm II radio has two RF output ports. The TNC connector covers the 400 to 960 MHz range and the Type N connector covers the 30 to 400 MHz range. Identical connector ports are found on the antennas designed for the Flexcomm II system. Different connector types were selected to avoid inadvertently swapping antenna ports since they are **not** compatible. In many installations, the coax cable may pass through several bulkhead connectors before reaching the antenna. Installers may not use keyed connectors and thus open the possibility of accidentally swapping antennas or connecting to an entirely different antenna. Port swapping can cause spurious outputs, antenna damage, and power amplifier and/or antenna failure. Continuity to the proper antenna port should be verified before system operation.

3) **Inadequate shielding on cables:** Proper cable specification is critical for EMI control. Signal lines, such as RS-422 buses, must be installed with shielded twisted pairs as called out in the installation wiring diagrams. Care must be taken to carry the shielding through any bulkhead connectors. Failure to shield control cables will result in digital noise coupling into the audio and interference with receivers. Control cabling between tuned antennas and the antenna controller should be shielded and have good grounding on both ends. Grounding of the shield to the airframe at bulkhead connections will also reduce noise from currents flowing on the outside of the shield. Good RF grounding techniques include keeping ground leads as short as possible and no longer than two inches maximum. Failure to shield the control lines and bond the controller to the airframe has resulted in spurious emissions on some installations. This is due to RF energy coupling on the tuner control lines causing the system to malfunction.

   Coax cables should be low loss and at least double shielded. Poorly shielded coax cables can couple RF energy into other wires in the wiring harness and affect other avionic systems on the aircraft. Separating cables with high signal levels from sensitive cables in the wiring harness is also a good practice.

4) **Cables improperly grounded:** When grounding cables, care should be taken to make the ground wire as short as possible. Inductance added by excessive lead length can greatly reduce the value of the shielding. The length of wire used for grounding the cable length should be keep to less than two inches whenever possible. For best EMI suppression, shielded twisted pair cables should be grounded at both ends.

5) **Antennas and equipment improperly grounded:** Failure to bond each system component properly to the airframe can result in EMI. Poor bonding may also cause the system to be adversely effected by lighting and other on board electrical noise.

## System Interaction

System interaction occurs when RF energy, aircraft voltage noise or other system EMI adversely affects another avionic system. Most system interaction can be resolved by following the recommendations for grounding and shielding found in the previous section. However, when multiple transmitters are located in close proximity, inter-modulation products will result when both transmitters are operated simultaneously. Signals, which couple into the antenna and feed back to the

RT-5000, will mix within the power amplifier and will produce spurious output signals at approximately the level applied to the RT-5000 antenna port. This phenomenon exists in all large signal non-linear amplifiers. The spurious signal will be spaced at intervals equal to the frequency difference between the two transmitters. During open field measurements make note of any large signals present and remember these will result in mixing products during transmit.

Another common system interaction is receiver overload. Overload occurs when a transmitter signal couples into another receiver antenna on the aircraft at a level high enough to exceed the dynamic range of the radio. This may result in the squelch opening or reduced receiver sensitivity. This problem is very difficult to solve when both radios are operating close to the same frequency. This problem is alleviated by keeping distance between antennas as far as possible to improve antenna isolation. Another option for resolving this problem is using the TX interlock option available on most transceivers. This input is normally connected to the PTT line and either reduces the receiver's sensitivity or inhibits squelch during PTT activation.

## Faulty Equipment

Interference or spurious signals may also be the result of damaged or defective equipment. When determining if the equipment is operating improperly, it is important to isolate the performance of the equipment from the effects of the system and test equipment. To isolate the problem, the RT-5000 should be tested into a power dummy load and the spurious emissions measured. Review the dynamic range of the spectrum analyzer used in the test and make sure that the input is not overloaded and the measured spurious signal is not below the specified range of the equipment. Some analyzers may require reducing the carrier signal with a cavity or other filter to see the true spurious signal level. If spurious signal levels above –70 dBc are observed while transmitting into a 50 Ohm load, the RT-5000 may be defective. While transmitting into the load, observe if the interference problem has disappeared. If interference is still present, the problem is not due to EMI transmitted from the antenna. The most probable cause would be poorly shielded cables or faulty grounds.

The following two spectrographs are typical spurious output levels of a RT-5000 terminated into a 50 Ohm load. These measurements were made with a HP 8594 spectrum analyzer. It is important to note that the input-related spurious response of the analyzer is rated at <-65 dBc. The spurious signal level was measured below –75 dBc but may be much lower since –75 dBc is 10 dB lower than the analyzer's specified performance.

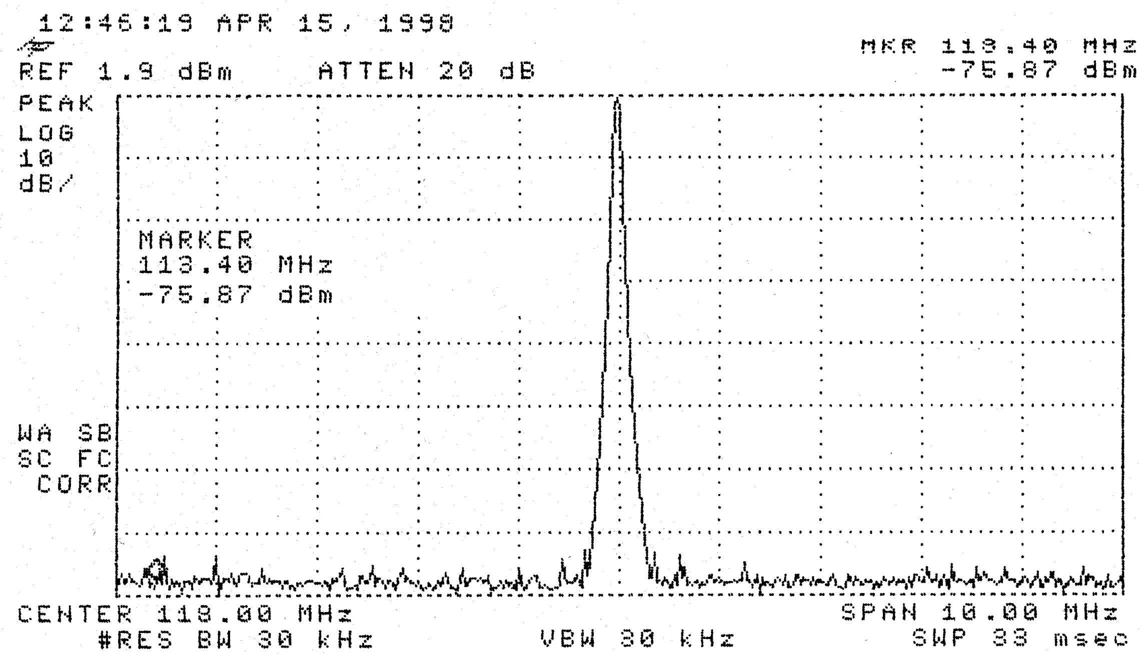


Figure 1. Spectral output of the RT-5000 transmitting at 118 MHz AM with marker set @ 113.4 MHz, 50 Ohm load.

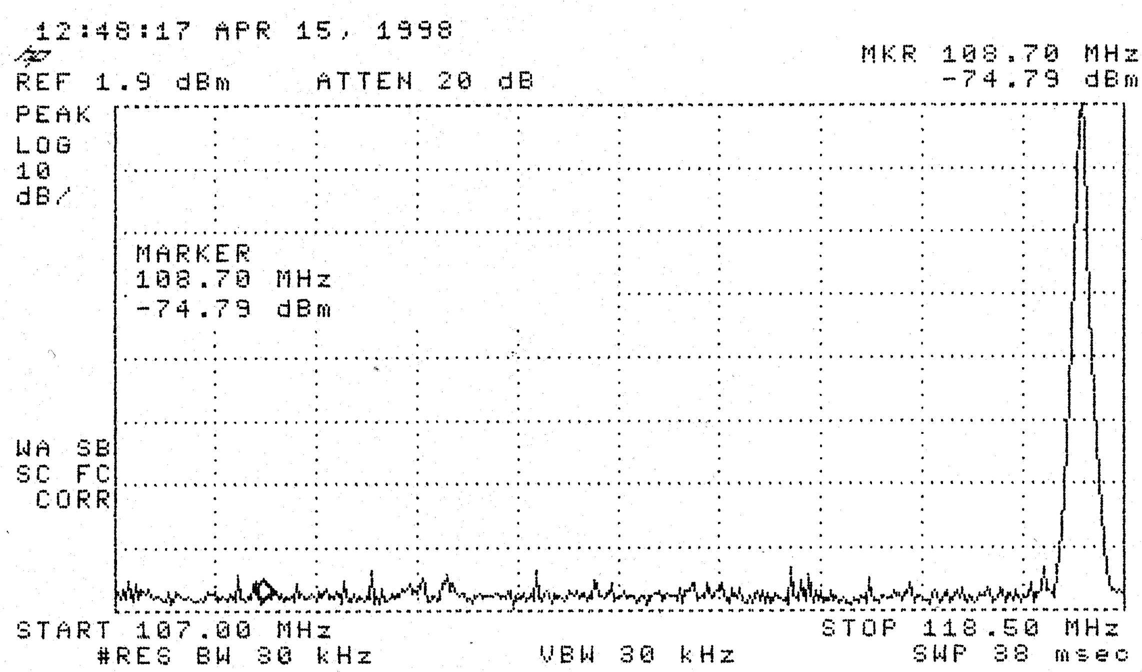


Figure 2. Sideband spectral output of the RT-5000 transmitting on 118 MHz, 50 Ohm load.

  

After the 50 Ohm measurements were complete, the RT-5000 was connected to an AT-50 tunable antenna and no increase in spurious output was noted. When measuring off the air, make sure to note any signals present before keying the radio. As discussed previously, these signals may be mirrored about the carrier during transmit due to inter-modulation in the transmitter. Normal spurious output level should not increase due to connecting to the antenna. If the antenna control box or the antenna has failed, the pin diodes in the antenna may be in an indeterminate state and cause spurious emissions. An increase in spurious signals could also be the result of a poor antenna installation. Review the sections on grounding and bonding.

## Inadequately Specified Equipment for the Particular Installation

On installations where aircraft size or other restrictions limit the obtainable isolation between antennas, interference may be unavoidable due to the equipment performance level. At 118 MHz, the transmission loss was measured between two AT-150 antennas spaced at five feet and a transmission loss of –40 dB was observed. A spurious output of –77 dBc on the transmitter, at the receive frequency, would result in a signal strength at the receiver antenna of –77 dBm (TX power – Spur level dBc – antenna isolation or 40 dBm – 77 dBc - 40dB = -77 dBm). This assumes a TX output power of 10 Watts and that a similar antenna gain was used for both radios. This level would be above the sensitivity for a typical receiver and could open the squelch if a spurious signal happened to fall on the receive channel. To guarantee that a spurious signal would not affect an ATC radio with a nominal sensitivity of –110 dBm, a radio specified with better than –110 dBc spurious signal level for this installation would be required. Placement of the antennas at different elevations on the aircraft will yield better isolation than this situation where the antennas were located on a flat surface. Fortunately, spurious output signals normally occur at only a few discrete frequencies, and thus only a few receiver channels for a given transmit frequency are affected.