

RECOMMENDATION ITU-R M.1179*

**PROCEDURES FOR DETERMINING THE INTERFERENCE COUPLING MECHANISMS
AND MITIGATION OPTIONS FOR SYSTEMS OPERATING IN BANDS ADJACENT
TO AND IN HARMONIC RELATIONSHIP WITH RADAR STATIONS
IN THE RADIODETERMINATION SERVICE**

(Question ITU-R 207/8)

(1995)

Summary

This Recommendation provides administrations with measurement procedures to identify the interference coupling mechanism(s), receiver front-end overload or radar spurious emissions, and methods to mitigate the interference from radar stations in the radiodetermination service to fixed radio-relay stations and fixed-satellite earth stations.

The ITU Radiocommunication Assembly,

considering

- a) that both fixed and mobile radar stations in the radiodetermination service are widely implemented in bands adjacent to and in harmonic relationship with the 4, 5 and 6 GHz bands used by the fixed and fixed-satellite services;
- b) that fixed radio-relay stations and fixed-satellite earth stations are vulnerable to interference from radar stations that have fundamental (necessary) and spurious emissions with high peak power levels;
- c) that fixed radio-relay stations have largely adopted digital modulation and fixed-satellite earth stations are rapidly moving towards the use of digital modulations which may be more susceptible to interference from radar pulsed type emissions;
- d) that fixed radio-relay stations and fixed-satellite earth stations use low-noise amplifiers which have inherent wide bandwidths and gains of 10-20 dB for fixed radio-relay stations and 50-65 dB for earth stations;
- e) that under the conditions stated in a) through d), interference to stations in the fixed and fixed-satellite services may be caused by radar station necessary emissions causing receiver front-end overload;
- f) that high levels of radar spurious emissions may cause interference to fixed radio-relay stations in the 4, 5 and 6 GHz bands and fixed-satellite earth stations in the 4 GHz band;
- g) that Radiocommunication Study Group 8 is studying the question of efficient use of the radio spectrum by radar systems including the study of inherent spurious emission characteristics of various types of output devices (see Question ITU-R 202/8);
- h) that Radiocommunication Study Group 9 has been studying the effects of unwanted emissions from radar systems on systems in the fixed service (see Question ITU-R 159/9);
- j) that Radiocommunication Study Group 9 has proposed interference mitigation options to enhance compatibility between radar stations in the radiodetermination service and fixed radio-relay stations (Recommendation ITU-R F.1097);
- k) that measurement procedures to positively identify the interference coupling mechanisms and mitigate the interference are not widely known,

* This Recommendation should be brought to the attention of the International Maritime Organization (IMO), the International Civil Aviation Organization (ICAO), the International Maritime Radio Association (CIRM), the World Meteorological Organization (WMO) and Radiocommunication Study Groups 4 and 9.

recommends

1 that in cases of radar interference to earth stations operating in the 4 GHz band and fixed radio-relay stations operating in the 4, 5 and 6 GHz bands, the following action(s) should be taken:

- the procedures described in Annex 1 should be used to identify the interference coupling mechanism (see Notes 1 and 2);
- after the interference coupling mechanism has been identified, one of the interference mitigation options described in Annex 2 for the interference coupling mechanism identified should be applied.

NOTE 1 – If the receiving system does not have a bandpass (preselector) filter *ahead* of the low-noise amplifier, it may be more cost-effective to install a bandpass (preselector) filter *ahead* of the low-noise amplifier prior to performing the tests in Annex 1. If the interference continues after the installation of the filter, the Annex 1 measurements to identify the interference coupling mechanism must be performed.

NOTE 2 – If the interference coupling mechanism is identified as radar transmitter spurious emissions, the radar will need to be identified if it is desirable to filter the radar transmitter output. Installation of filters in the radar transmitter may not be achievable if the radiodetermination station is mobile and there are numerous radars such as the case of radionavigation radars operated under licences of many administrations. Also, the installation of a filter in a radar may not be achievable due to the type of output device, size, weight and performance trade-offs.

ANNEX 1

Determination of interference coupling mechanism

1 Introduction

Interference mitigation measures will be ineffective unless the correct interference coupling mechanism (receiver front-end overload or radar transmitter spurious emissions) is identified. This Annex describes methods by which the interference mechanism may be determined, so that appropriate mitigation measures may be implemented as reliably as possible. It should be noted that the tests and measurements required to determine the interference mechanism are not necessarily easy to perform, even if personnel at the facility has access to the necessary test equipment (a spectrum analyser and digital oscilloscope are recommended, at a minimum). (In carrying out measurements on radar emissions, care should be taken to ensure that overload of the measurement equipment does not occur as damage may be caused to measuring equipment.)

Commercially available RF front-end bandpass filters are relatively inexpensive and can be installed relatively quickly. Installation of such a filter *ahead* of the first LNA/LNB/LNC (low noise amplifier/mixer/downconverter) in the receiver RF front-end is recommended as a first step when the interfering radar signal is outside the normal allocated receive band for the fixed radio-relay or earth station. If the only interference mechanism is receiver front-end overload and the radar signal is occurring outside the receive band, then the filter should mitigate the problem.

It is also possible for receiver front-end overload interference and radar spurious emission interference to occur simultaneously. In that case, installation of a bandpass filter on the receive station will only eliminate the front-end overload interference component; the station will still experience interference effects due to the radar spurious emissions. Because of this possibility, the installation of a bandpass filter on the receive station *ahead* of the LNA/LNB/LNC is recommended before tests for radar spurious emission interference are attempted. If no such filter is installed, then the absence of receiver front-end overload must be verified through tests described below.

Finally, it should be noted that a receiver front-end amplifier which also incorporates a mixer/downconverter (LNB or LNC) may generate undesired products in the desired receive band when it is in an overload condition, as shown in Annex 2. These products may be easily mistaken for radar spurious emissions in the earth station band. Thus, it is critical that the possibility of receiver front-end overload be eliminated by installation of a front-end bandpass filter before tests for spurious emissions are performed.

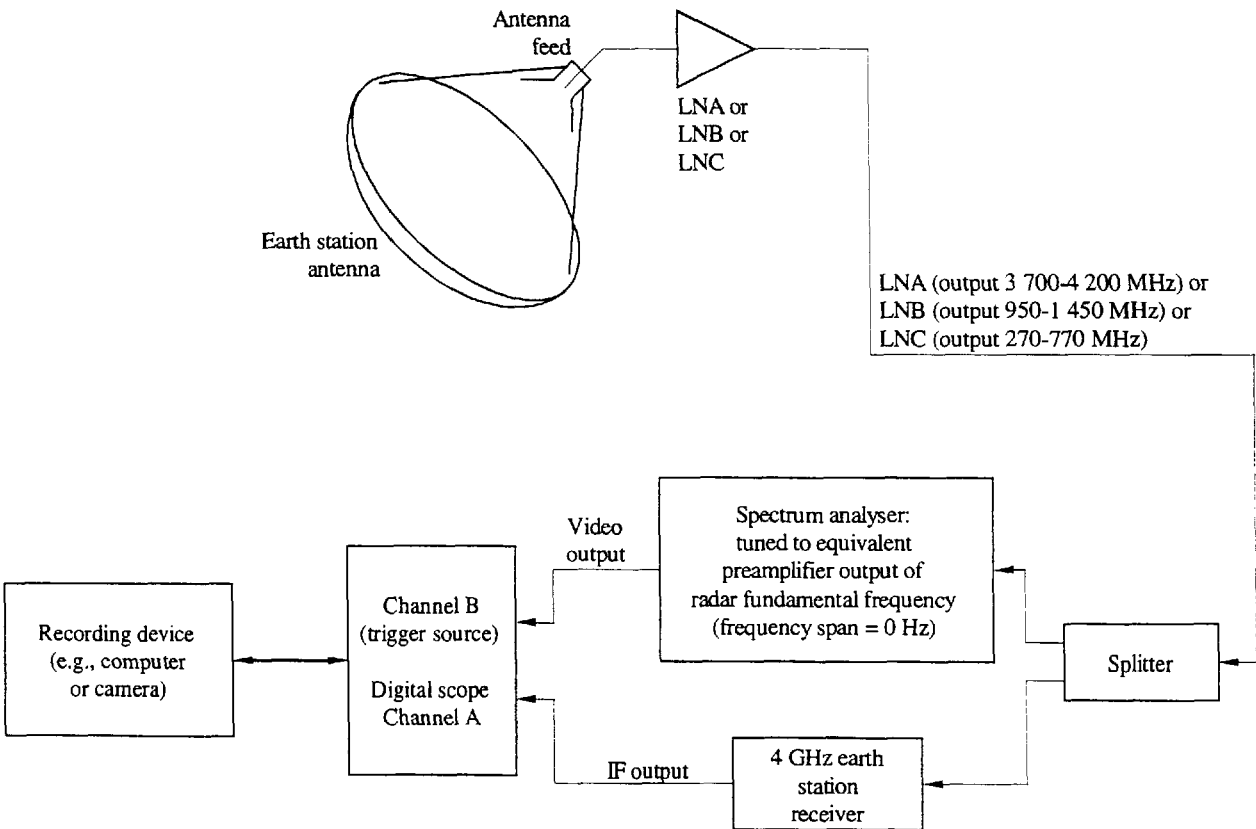
2 Measurement procedures

2.1 Determination of front-end overload

There are several steps in the process of determining whether or not front-end overload is occurring in a receiver. The first and most obvious step is to physically examine the RF front-end of the system, usually at the antenna, and determine if any preselection already exists. It is important not to be misled by schematic diagrams, which may indicate the presence of filters which may not have actually been installed, or by narrow frequency ranges which are specified on an amplifier case (e.g. “3.7-4.2 GHz”); the actual amplifier response may be much wider than the label indicates. If RF bandpass filtering *ahead* of the first preamplifier is verified as being present, then it is very unlikely that the coupling mechanism is receiver front-end overload. If no such filtering is present, then such a filter should be installed. If the installation results in elimination of the problem, then the mechanism is probably front-end overload.

If a bandpass filter for the earth station is unavailable, or for any other reason the presence of front-end overload must be independently verified, then the following measurement procedure can be performed through the front-end of the receive station during an interference event. The goal of this measurement is to determine the extent, if any, to which the amplifier is gain-compressing when energy from the radar is received. In order to document this effect clearly, it is necessary to simultaneously monitor the radar energy at the radar fundamental frequency, as well as the response of the earth station to that energy. A block diagram for the hardware arrangement to be used in this test is shown in Fig. 1.

FIGURE 1
Block diagram for determination of interference coupling mechanism. Characteristics of either front-end overload or radar spurious emissions are observed in coincidence with radar pulses



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With reference to Fig. 1, this test is performed with the antenna feed horn connected directly into the earth station's front-end amplifier (LNA/LNB/LNC). THERE SHOULD *NOT* BE ANY BANDPASS FILTER AHEAD OF THE LNA/LNB/LNC DURING THIS TEST UNLESS IT IS NORMALLY A PART OF THE SYSTEM. The signal out of the amplifier is then split into two paths. One side of the split is sent to a spectrum analyser, and the analyser video output is in turn routed to one channel of an oscilloscope (see Note 1). The analyser should be tuned to the equivalent preamplifier output of the radar fundamental frequency and the analyser frequency span should be set to 0 Hz. (If two or more radar fundamentals are produced, any one of them will suffice.) The analyser IF bandwidth should be set to 1 MHz, and analyser trace sweeping should be suspended.

NOTE 1 – Documentation of these measurements is important. Either a digital oscilloscope that can transfer data to a magnetic medium or an analogue oscilloscope with a camera can be used for this purpose.

The other side of the split is routed to the earth station receiver, and the receiver's IF output is routed to a second channel of the oscilloscope. The oscilloscope should be triggered from the radar pulse train coming out of the spectrum analyser. Thus, both the radar pulse train and the receiver response to that pulse train may be simultaneously observed on the oscilloscope. If the radar is overloading the earth station front-end, then gain compression should be observed on the IF trace when pulses from the radar are observed on the other oscilloscope trace. Examples of such responses are shown for an LNA and an LNB in Figs. 2-5.

A variation on this technique can be implemented on an antenna that incorporates two cross-polarized feeds: install a bandpass filter *ahead* of the preamplifier on one feed. If interference subsequently occurs on the unfiltered feed but not on the filtered feed, then the problem is receiver front-end overload. As a caveat, however, it should be noted that interference may be polarization-dependent, and the cross polarization between feeds can unintentionally produce a filtering effect of its own. So it is critical, if this technique is attempted, that both feeds are known to have previously been affected by the interference simultaneously.

2.2 Simultaneous occurrence of front-end overload and spurious emission interference

As stated at the beginning of this section, it is entirely possible for both receiver front-end overload and radar spurious emission interference to occur simultaneously. This would be the case if a radar produced strong spurious emissions at the receive station's centre frequency, while the receive station was being operated with an unpreselected front-end. However, before the spurious emission interference problem can be addressed, the possibility of front-end overload must first be eliminated by installing an RF filter on the earth station.

2.3 Determination of radar spurious emissions

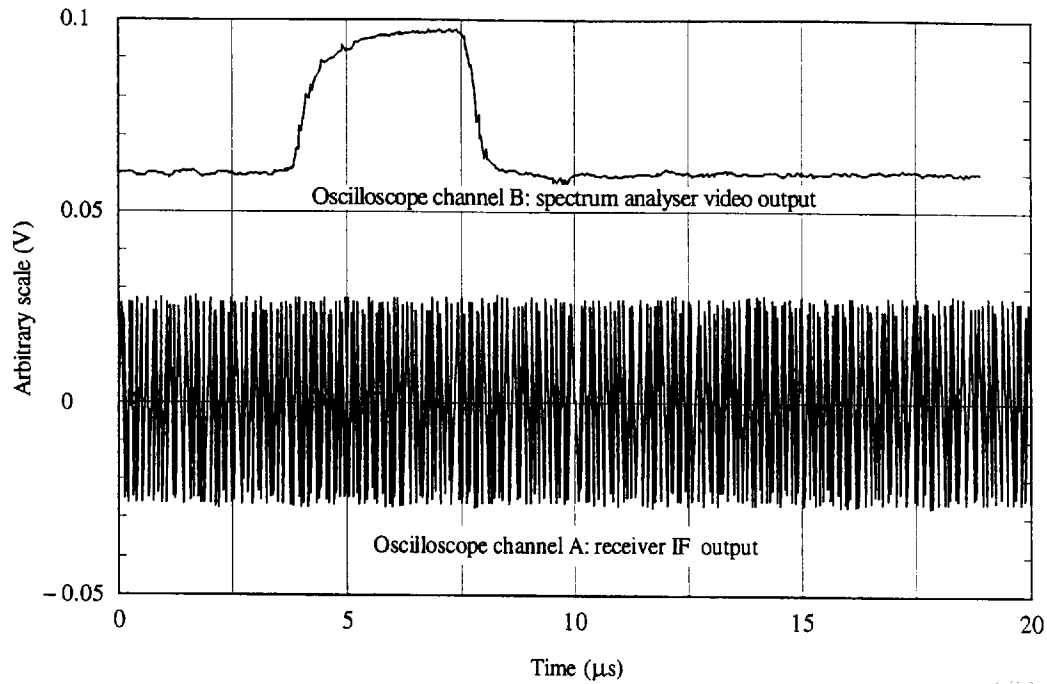
If tests for receiver front-end overload are negative or interference persists when a bandpass filter has been installed ahead of the first RF amplifier in the receive station, then the interference is probably occurring as a result of radar transmitter spurious emissions in the receive band of the station.

It must be emphasized that, if the tests for radar spurious emission interference are to utilize unpreselected earth station RF front-ends, as shown in Fig. 1, then the possibility that interference is caused by receiver front-end overload **must** be eliminated before these tests are conducted. While the use of a bandpass filter on the earth station front-end is not absolutely required under these circumstances, the presence of such a filter during the tests increases the confidence that no receiver front-end overload is occurring.

FIGURE 2

Channels A and B of oscilloscope when test arrangement of Fig. 1 is used and LNB front-end is not overloaded.

Note that time axis is much faster, due to faster expected recovery time of LNB

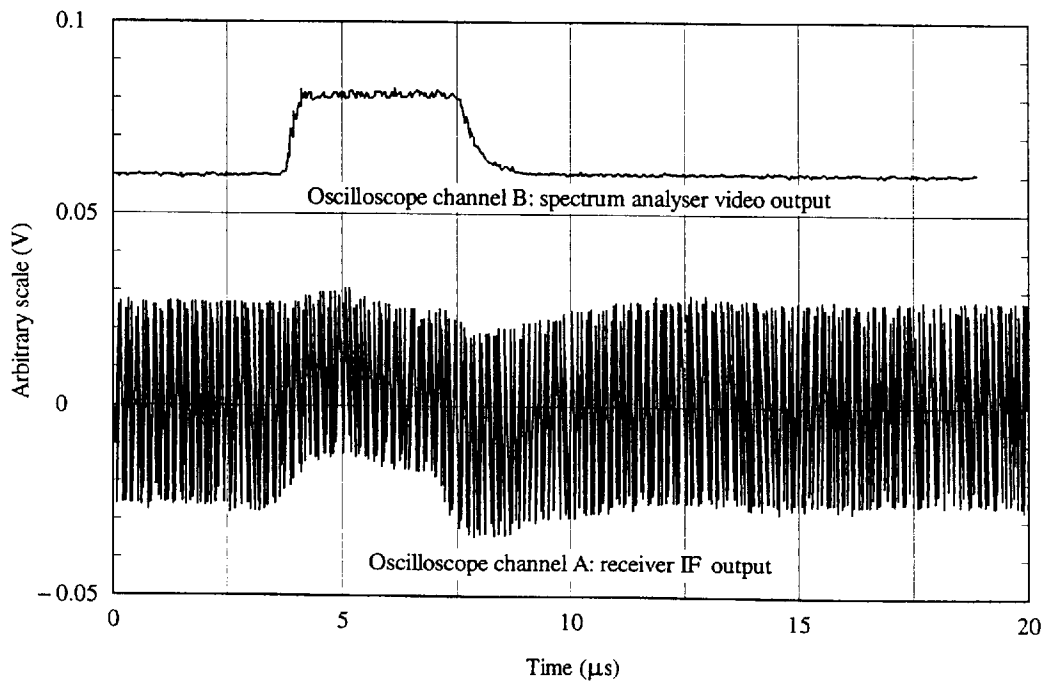


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FIGURE 3

Channels A and B of oscilloscope when test arrangement of Fig. 1 is used and LNB front-end is overloading

Note faster recovery time of LNB than of LNA (interval the same as pulse width)



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