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Radiocommunication Sector of ITU

Recommendation ITU-R SM.2061-0
(08/2014)

**Test procedure for measuring
direction finder immunity against
multi-path propagation**

SM Series
Spectrum management

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Note: This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.

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RECOMMENDATION ITU-R SM.2061-0*

**Test procedure for measuring direction finder immunity
against multi-path propagation**

(2014)

Scope

The Recommendation provides test procedures for measuring the immunity against multi-path propagation of fixed and mobile direction finders (DF).

Keywords

DF, direction finder, test procedure, immunity, multi-path propagation, reflections, open-air-test-site, OATS

Related ITU Recommendations, Reports

Recommendation ITU-R SM.2060.

Report ITU-R SM.2354.

NOTE – In every case the latest edition of the Recommendation/Report in force should be used.

The ITU Radiocommunication Assembly,

considering

- a) that ITU-R has published the direction finder (DF) immunity against distorted wave fronts of different DF methods in the ITU Handbook on Spectrum Monitoring (Edition 2011);
- b) that the immunity against distorted wave fronts is an important specification of a DF since distorted wave fronts from multipath propagation are typical in practice;
- c) that the specification of DF immunity against distorted wave fronts strongly depends on the test procedures applied;
- d) that a test procedure for DF immunity against distorted wave fronts must be independent of the direction finder design;
- e) that well-defined test procedures for DF immunity against distorted wave fronts to test the influence of multi-path propagation under approximated real-world conditions, if adopted by all manufacturers of direction finders intended for civil radio monitoring, will have the advantage for the users of such direction finders, that an easier and more objective assessment of products from different manufacturers is possible,

recommends

1 that the measurement method in Annex 1 should be used to determine and report the immunity against distorted wave fronts due to multi-path propagation on fixed and mobile direction-finding systems.

* Radiocommunication Study Group 1 made editorial amendments to this Recommendation in 2015 in accordance with Resolution ITU-R 1.

Annex 1

Immunity against distorted wave fronts due to multi-path propagation: test procedure for fixed and mobile direction finder

1 General considerations

Under normal circumstances, wave propagation between the emitter and DF is disrupted by buildings, mountains, hills, etc. Even if we have direct line of sight, secondary waves will still arise due to reflection, refraction and diffraction and superimpose the direct wave at the receiving location as interfering fields. If the interfering wave component has a lower power level than the desired wave component, the bearing error can be minimized by choosing suitable design parameters in the direction finder. This Recommendation serves to measure the DF immunity to distorted wave fronts caused by a secondary wave (reflection). It is meant to be used for an exemplary measurement of one single sample of the serial production version of the DF system under test.

2 Principle of measurement

The measurement will be conducted under simplified conditions, thus permitting great simplicity of the tests and easy repeatability of the results at any time and at any site. In order to simulate a multipath environment, an arrangement of two transmitting antennas (two-wave field produced by a single transmitter) is proposed subsequently. Both antennas are connected to the test transmitter via a power divider. By using an attenuator, the amplitude of the signal which represents the reflection (secondary wave) can be set, and hence determine the amplitude relation between direct (primary) and reflecting (secondary) path. The angle of arrival and the phase angle of the secondary wave is varied. Considering the objective to simplify the measurement, effects of modulation type (including phase and time variant signals), signal duty cycle, bandwidth, signal polarization, and signal duration, noise and other signal and DF quality parameters (e.g. DF sensitivity) are intentionally ignored to reduce the complexity of the tests procedure and the time duration of the measurements. The measurement takes place in an otherwise reflection-free environment such as an open-air-test-site (OATS) or an anechoic chamber.¹

In addition to the recommended measurement procedure described here, it is possible to measure the DF immunity against distorted wave fronts by means of multi-channel emulators which can simulate the propagation effects of a real environment, in situations where an OATS or anechoic chamber is not readily available.

3 Measurement set up

The proposed measurement setup is shown in Fig. 1. In order to ensure a well-defined dual-path propagation scenario, the environment of the DF and transmitting antennas should be free of reflecting obstacles and interferences as indicated in Recommendation ITU-R SM.2060-0. The distances between the DF antenna and both transmitting antennas, as well as the height of all antennas involved should be in line with Recommendation ITU-R SM.2060-0.

¹ OATS definition can be found in a number of standards documents such as ANSI C63.7, CISPR or EN55 022. The OATS is considered as line-of sight with no interference signal, no reflection and far-field (Fraunhofer Region).

4 Measurement procedure

In order to simulate a basic multipath wave environment (two-wave field produced by a single transmitter), an experimental test bed as shown in Fig. 1 is recommended:

- an un-modulated continuous wave input signal S on various measurement frequencies within the operational frequency range of the DF is generated using a signal generator;
- the input signal S is divided into $S1$ and $S2$ signals by means of a power divider;
- the $S1$ signal is transmitted by transmit antenna 1; and
- attenuation and phase shift is added to the $S2$ signal before it is transmitted by transmit antenna 2 from a different angle than $S1$.

Both $S1$ and $S2$ signals must have a power level high enough to ensure a minimum S/N of 20 dB (in order to ensure that system noise does not affect the measurement results).

Due to the fact that the DF immunity to distorted wave fronts tends to vary with frequency it is required to repeat the measurement for various measurement frequencies. The measurement frequencies are selected in line with Recommendation ITU-R SM.2060-0.

For each measurement frequency, the $S2$ signal from antenna A2 (the “reflected” signal) is varied in azimuth, amplitude and phase shift as follows:

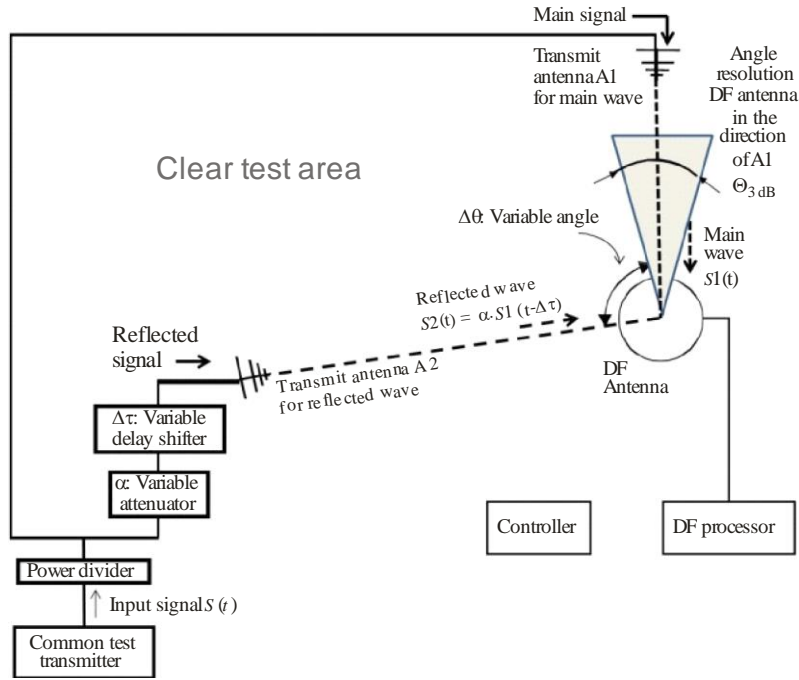
- the angle of arrival difference $\Delta\theta$ between the reflected wave $S2$ and the main wave $S1$ is set to 20° , 60° and 90° ;
- the amplitude ratio α of the reflected wave $S2$ and the main wave $S1$ is set so that the power level of $S2$ is 0.25 (–6 dB) with respect to $S1$ at the DF antenna. Note that α takes into account all gains and losses over cables, antennas and air;
- the positive time delay difference $\Delta\tau$ of the reflected wave $S2$ is set so that a phase difference $\Delta\phi$ of $0^\circ\pm 5^\circ$, $90^\circ\pm 5^\circ$ and $200^\circ\pm 5^\circ$ between $S1$ and $S2$ occurs at the DF antenna. Note that $\Delta\tau$ takes into account all propagation delays over cables, antennas and air. Note further that the phase shift can be applied by a variable phase shifter or a delay line, besides $\pm 5^\circ$ have been included to consider uncertainties of the setup configuration, e.g. small variations of the antenna locations during placement.

For all different settings described above, the bearing error is measured and the RMS bearing error is calculated with the formula stated in Recommendation ITU-R SM.2060-0, resulting in one RMS bearing error per measurement frequency. The final result is presented as a table or chart indicating the RMS bearing error for each measurement frequency as indicated in Table 1.

It should be noted that the recommended measurement procedure is focused on a single angle of arrival of the primary wave. However, it would be desired in specific cases that different angles of arrival of the primary wave are measured by rotating the antenna. If such specific test conditions are applied, this should be indicated in the test reports.

FIGURE 1

Measurement setup for determining the direction finder immunity to distorted wave fronts



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TABLE 1

Sample test data table

[Signal modulation: _____ Signal polarization: _____ S2 relative power level at the DF antenna: ___ (dB)

Index	True	$\Delta\theta$	$\Delta\phi$	Frequency 1		Frequency 2		Frequency 3		Frequency M	
	Azimuth			DF	Δ	DF	Δ	DF	Δ	DF	Δ
1	0°	20°	0°								
2			90°								
3			200°								
		60°	0°								
			90°								
			200°								
		90°	0°								
			90°								
			200°								
...

Note that Δ is the difference between the true azimuth (angle of the transmitter's test antenna) and the displayed bearing on the DF equipment.

Example for a specification in a data sheet of DF immunity against multi-path propagation conditions:

Frequency	f_1	f_2	f_3	...	f_N
RMS DF error	RMS DF error at f_1	RMS DF error at f_2	RMS DF error at f_3	...	RMS DF error at f_N
