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Radiocommunication Sector of ITU

Recommendation ITU-R SM.2138-0
(02/2021)

Test procedure for measuring monitoring system field strength measurement accuracy in the VHF/UHF frequency range

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.2138-0

Test procedure for measuring monitoring system field strength measurement accuracy in the VHF/UHF frequency range

(2021)

Scope

The field strength measurement accuracy of monitoring systems is an important consideration to regulatory authorities and others who must implement monitoring services. It is often difficult to compare different systems due to a number of factors, such as the system architecture, typical use/purpose, size requirements, installation requirements, and other issues. To facilitate basic comparisons between different monitoring systems, and to evaluate existing monitoring systems on a regular basis, this Recommendation provides guidance on standard methods of testing monitoring system field strength measurement accuracy and reporting results.

Keywords

Field strength measurement accuracy, measurement, test site, open-air-test-site, OATS, proper-outdoor-test-site, POTS

Abbreviations

OATS	Open air test site
POTS	Proper outdoor test site
RF	Radio frequency
SNR	Signal to noise ratio
UHF	Ultra-high frequency
VHF	Very-high frequency

Related ITU Recommendations

Recommendation ITU-R SM.378

Recommendation ITU-R SM.2060

Recommendation ITU-R SM.2061

Recommendation ITU-R SM.2096

Recommendation ITU-R SM.2097

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 published typical specifications for the required accuracy of field strength measurements in Recommendation ITU-R SM.378 – Field-strength measurements at monitoring stations;

b) that ITU published methods of performing field strength measurements at monitoring stations in the ITU Handbook on Spectrum Monitoring (Edition 2011);

c) that field strength measurement accuracy may influence the suitability of a monitoring system to fulfil certain monitoring tasks, especially when used in typical operating environments;

d) that test procedures for determining the accuracy of field strength measurements should be independent of the monitoring system design;

e) that test procedures for determining the accuracy of field strength measurements, wherever adopted, will provide for an objective assessment of different monitoring systems,

recommends

1 that the test procedure in Annex 1 should be used to measure and report the test results of the monitoring system field strength measurement accuracy;

2 that the test procedure and conditions used to determine the field strength measurement accuracy should be indicated in the results.

Annex 1

Test procedure for measuring monitoring system field strength measurement accuracy in the VHF/UHF frequency range

1 Introduction

This Recommendation defines a general test procedure to evaluate monitoring system field strength measurement accuracy. The aim of this Annex is to provide a definition of monitoring system field strength measurement accuracy and a standard method to conduct testing, so administrations have a basis for comparison of monitoring system field strength measurement systems from different manufacturers, or evaluate the performance of their own systems on a regular basis, based on their requirements.

The field strength measurement accuracy of a monitoring system is defined as the difference (dB) between the signal field strength (dBμV/m) measured from the monitoring system and that from a calibrated reference field strength measurement system.

A monitoring system consists of the antenna, RF cables, monitoring receiver and software. It is expected that the software has all the necessary corrections for the antenna factor, and losses from RF cables, and switches.

The measurement procedure determines the system field strength measurement accuracy in a defined test condition on a test range under controlled propagation conditions and could be used for calibration purposes of mobile and portable monitoring systems, and for fixed monitoring systems before they are installed.

2 Principle of measurement

The measurement is conducted under simplified environment and setup conditions, with the goal of achieving a repeatable test procedure. For this reason, effects of modulation type (including phase and time variant signals), signal duty cycle, bandwidth, signal polarization, signal duration, effects of noise, other signals, and uncontrollable conditions such as multi-wave/multipath propagation conditions, are intentionally ignored. This reduces the complexity of the test procedure and the time required to perform the measurements.

The ideal test site is an open-air-test-site (OATS) or anechoic chamber, in compliance with international standards.

In practice, a sufficiently large OATS or anechoic chamber may be difficult to find. Alternatively, a low reflective test site may be used that should be clear of buildings, with no large metallic structures or surfaces nearby, and at a sufficient distance from main roads and interfering transmitters. Such an environment can be found in a large open field which could be called a proper-outdoor-test-site (POTS).

It should be noted that measurements in anechoic chambers are usually possible only for UHF or higher frequencies due to the limited size and the reflection properties of the anechoic chamber.

3 Measurement set up

The proposed field strength measurement accuracy setups are shown in Figs 1 and 2.

It is recommended that the measurement setup shown in Fig. 1 is primarily used at a POTS, and that shown in Fig. 2 is primarily used at an OATS or anechoic chamber.

In practice, the signal environment is not controllable at a POTS. Hence, it is necessary to confirm that the selected test frequency is not occupied by another signal before conducting the measurement on that frequency.

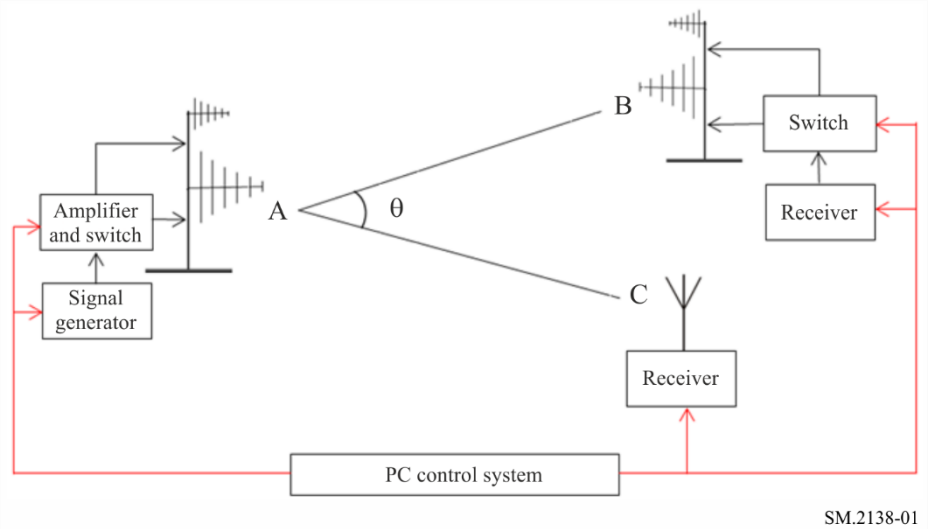
Prior to the measurement procedure, a POTS should be calibrated by means of a field strength measurement system. If an OATS or anechoic chamber is used, it is very important to ensure the validity of the site calibration.

In contrast, when testing at a POTS, the field strength needs to be measured in parallel at reference point B (in Fig. 1) during each measurement to compensate for changes in wave propagation on the POTS, e.g. due to changes in ground conductivity.

The test site may be selected based on practical needs concerning test duration time or the number of systems under test. Measurements conducted at an OATS or in an anechoic chamber tend to be easier to control, whereas measurements conducted at a POTS tend to be more efficient.

3.1 Measurement set up for POTS

FIGURE 1



As shown in Fig. 1, the test system should be configured as follows:

The transmitting system should be placed on point A. The reference field strength measurement system should be placed on point B, and the monitoring system under test should be placed on point C, forming a triangle. The distance from reference system to transmitting system has to be exactly the same as the distance from monitoring system to transmitting system.

The antenna pattern of the reference field strength measurement system should be as similar as possible to the antenna pattern of the monitoring system under test.

To reduce the electromagnetic radiation during the test, and reduce the transmitting power of the signal generator, it is recommended to use a directional antenna with its 3 dB beamwidth no greater than 30 degrees.

To minimize the interaction between the monitoring system and the reference system antennas, the angle θ between the monitoring system and the reference system to the transmitting system should be as large as possible, but no more than 30 degrees.

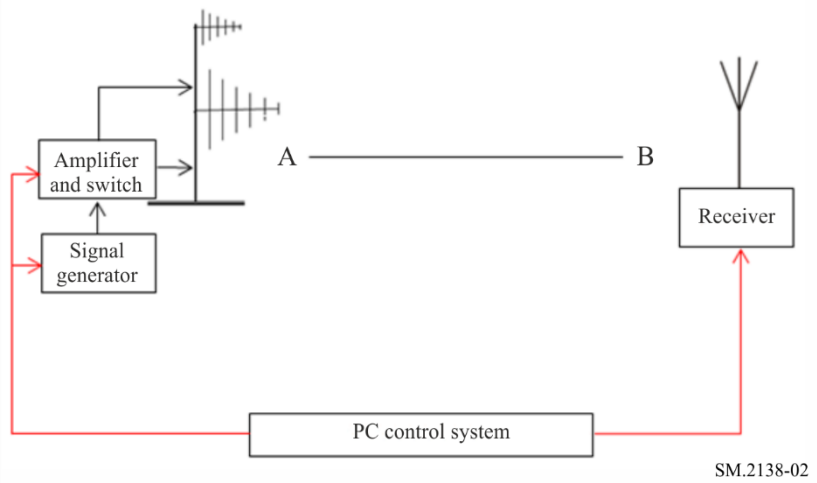
Set the maximum radiation direction of the transmitting antennas to the middle point between the monitoring system and the reference system.

It is recommended that the height of the transmitting antennas and the reference system antennas above the ground should be at least one wavelength of the lowest test frequency to ensure ground reflections do not affect the test.

The height of the transmitting antennas has to be variable over a range of at least one wavelength of the lowest frequency to be tested.

3.2 Measurement set up for anechoic chamber or OATS

FIGURE 2



As shown in Fig. 2, the test system should be configured as follows:

The transmitting system should be placed on point A, and the monitoring system under test should be placed on point B.

To reduce the electromagnetic radiation during the test, and reduce the transmitting power of the signal generator, it is recommended to use a directional antenna with its 3 dB beamwidth no greater than 30 degrees.

Set the maximum radiation direction of the transmitting antennas toward the monitoring system antenna.

If using an OATS, it is recommended the height of the transmitting antennas above the ground should be at least one wavelength of the lowest test frequency to ensure ground reflections do not affect the test.

In case of an OATS or an anechoic chamber with conducting ground plane, the height of the transmitting antennas has to be variable over a range of at least one wavelength of the lowest frequency to be tested. This requirement does not apply to fully anechoic chambers (including anechoic ground plane).

3.3 General considerations

The test frequency selection, the distance from the transmitting antennas to the monitoring system antenna and reference system antennas should comply with Recommendation ITU-R SM.2060 to meet the test requirements, and the far field condition.

All the measurement setup distances, and the antenna heights as indicated above should be noted in the test results.

The measurement bandwidth of the monitoring system should be set to its minimum value.

The automatic gain control (AGC) and, if available, the automatic frequency control (AFC) of the monitoring system should be turned on.

To measure the actual performance of the monitoring system, the system under test should work in its normal operation conditions, such as the mobile monitoring system whose power should be supplied from its own battery, or from the vehicle.

Other settings should be the optimal settings for the monitoring system, and as specified in the technical data sheet or operator manual.

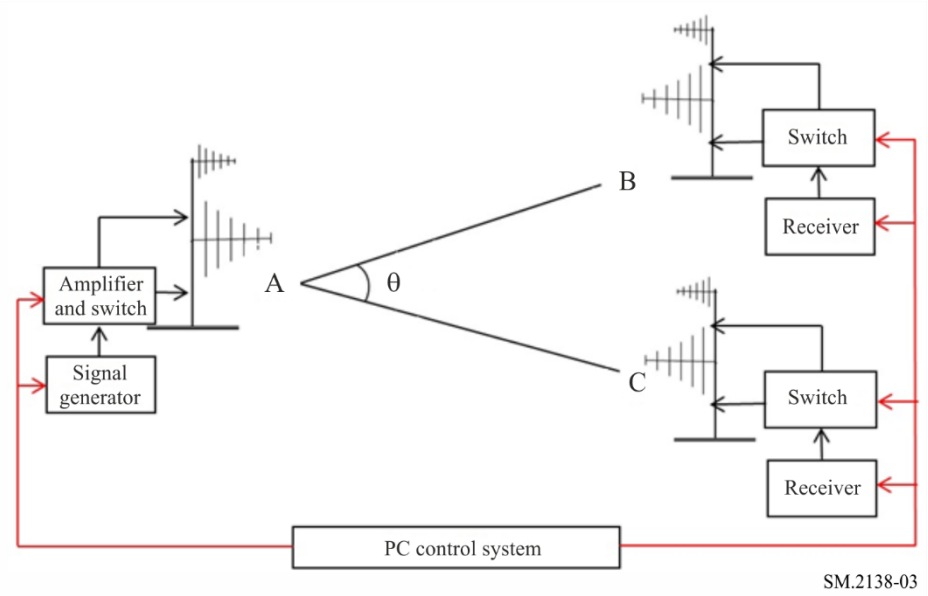
All equipment and accessories (for example, transmitter, transmitting antennas, reference system including the receivers, antennas, and cables etc.) should be calibrated using nationally or internationally accepted procedures. For the best overall precision, it is recommended to calibrate the reference system including the receivers, antennas, cables, and other accessories as a single entity prior to conducting the test.

4 Procedure to determine test frequencies, reference field strength, and antenna heights

4.1 Procedures for testing in a POTS

Locate another reference system on point C in Fig. 1 as shown in Fig. 3, setting the exact same antenna height of the reference system on point C as the antenna height of the monitoring system which will be under test. It is recommended that the reference system B and the reference system C should use the same type of antenna to improve the testing accuracy. The antenna pattern of the reference system should be as similar as possible to the antenna of the monitoring system which will be under test.

FIGURE 3



Set the transmitter with test frequency f_i and unmodulated signal.

Adjust the output signal level of the transmitter until the reference system on point B indicates a received SNR of at least 20 dB.

Vary the height of the transmitting antenna[1] to a position that produces the highest received signal level at the reference system on point B. This is necessary to ensure that the measurement will not be done at a point where direct and ground reflected wave cancel out each other.

Record the output power level of the transmitter, the test frequency, the transmitter antenna height, and at least ten subsequent measurements of the field strength, along with the average value E_{Bi} (dBμV/m) of the reference system B.

At the same time, perform the same field strength measurements with the reference system on point C, recording at least ten subsequent measurements of the field strength, along with the average value E_{Ci} (dBμV/m) of the reference system C.

Calculate the field strength difference D_i between the reference system placed on point B and on point C with the following formula:

$$D_i = E_{Bi} - E_{Ci}$$

Change the test frequency and repeat the above procedure until all frequencies have been tested.

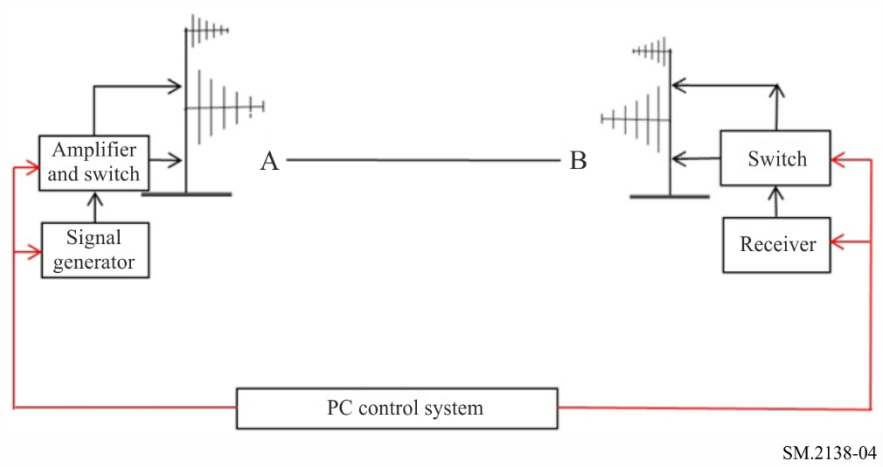
When performing the test frequency selection with the layout of Fig. 3, it is recommended to test as many frequencies as possible and calculate the field strength difference on every frequency. Select the frequencies with the smallest differences as the final test frequencies. These frequencies will be used as part of the measurement procedure described in § 5.1.

[1] Other parameters of the setup geometry may be changed to the same effect, e.g. receiving antennas height, transmitting or receiving positions. In any case, care should be taken to maintain the symmetry between receiving systems and the transmitting antenna emission centre.

4.2 Procedures for testing in an anechoic chamber or OATS

Locate the reference system on point B (Fig. 2) as shown in Fig. 4 and set the antenna of the reference system on point B to the exact same height as the antenna height of the monitoring system which will be under test.

FIGURE 4



Set the transmitter with test frequency f_i and unmodulated signal.

Adjust the output signal level of the transmitter until the reference system indicates a received SNR of at least 20 dB.

In case of an OATS, vary the height of the transmitting antenna[2] to a position that produces the highest received signal level at the reference system on point B. This is necessary to ensure that the measurement will not be done at a point where direct and ground reflected wave cancel out each other. This step is not necessary if a fully anechoic chamber (including anechoic ground plane) is used.

Record the output power level of the transmitter, the test frequency, the transmitter antenna height, and at least ten subsequent measurements of the field strength along with the average value E_i (dBμV/m) of the reference system.

Change the test frequency and transmitter antenna height, repeat the above procedure until all frequencies have been tested. These frequencies will be used as part of the measurement procedure described in § 5.2.

5 Measurement procedure

5.1 Test procedure on a POTS

Locate the monitoring system under test on point C in test site in Fig. 1.

Set the transmitter to one of the test frequencies f_i which were selected in § 4.1 with unmodulated signal and adjust the transmitter antenna height to the values recorded under § 4.1.

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[2] Other parameters of the setup geometry may be changed to the same effect, e.g. receiving antennas height, transmitting or receiving positions. In any case, care should be taken to maintain the symmetry between receiving systems and the transmitting antenna emission centre.

Adjust the output signal level of the transmitter until that the reference system on point B indicates a received SNR of at least 20 dB. Record at least ten subsequent measurements of the field strength along with the average value E_i (dBμV/m) of the reference system.

At the same time, record at least ten subsequent measurements of the field strength from the monitoring system which is under test along with the average value E_i' (dBμV/m).

The field strength measurement accuracy ΔE_i (dB) for the monitoring system at frequency f_i, should be calculated as follows:

$$\Delta E_i = E_i - E_i' - D_i$$

Change the test frequency, repeat the above procedure until all selected frequencies have been tested.

5.2 Test procedure in an anechoic chamber or OATS

Locate the monitoring system under test on point B in test site in Fig. 2.

Set the transmitter with the same test frequency f_i and the same power level selected in § 4.2 with unmodulated signal and adjust the transmitter antenna height to the values recorded under § 4.2.

Record at least ten subsequent measurements of the field strength from the monitoring system which is under test along with the average value E_i' (dBμV/m).

The field strength measurement accuracy ΔE_i (dB) for the monitoring system at frequency f_i, should be calculated as follows:

$$\Delta E_i = E_i - E_i'$$

Change the test frequency and transmitter antenna height, repeat the above procedure until all selected frequencies have been tested.

6 Test result and other issues

The final result is presented as a table and/or chart indicating the field strength measurement accuracy for each of the selected test frequencies as shown in Table 1.

The test report should indicate the field strength levels received by the systems, along with the test location, date, time, and temperature (if working outdoors). The test signal parameters include the centre frequency, amplitude, and modulation settings of the signal generator also should be noted in the test report.

The accuracy of the test results depends on many aspects including the accuracy of the test system, the influence of the test site, the ground reflection, and the test samples on every test frequency. Therefore, it is important to perform the steps outlined in § 4 prior to every measurement conducted on different days or after significant weather changes. All the test equipment and accessories (for example, transmitter, transmitting antennas, reference system including the receivers, antennas and cables, etc.) should be calibrated using nationally or internationally accepted procedures. For the best overall precision, it is recommended to calibrate the reference system including the receivers, antennas, cables, and other accessories as a single entity prior to conducting the test. The test site should also be calibrated in different seasons using nationally or internationally accepted procedures.

The uncertainty of the test including the test system and the test site should be analysed using nationally or internationally accepted procedures, and the uncertainty of the test has to be noted on the test report to facilitate people better use of the test report.

The recommended measurement procedure makes use of unmodulated signals. However, different types of signal modulation may be used if agreed to by all parties and, they are measured and recorded

according to the conditions and methods described in this recommendation. If applied, it should be indicated in the test reports.

It should be noted that, for the mobile monitoring system with a mast which can be elevated to 10 metres or higher, the accuracy of the test will increase with antenna height. For the mobile monitoring system with no mast or with a mast lower than 10 metres, the test result will be degraded due to effects from the vehicle.

All measurement parameters should be compliant with the ITU-R Handbook on Spectrum Monitoring (Bandwidth, etc.), with the same test conditions recorded in the test report and the test results specified in dB.

If the system under test is a direction finder, it should preferably be positioned with its default 0 degree directly facing to the transmitter. If this requirement cannot be met, the orientation toward the target should be recorded in the test result.

Using software to control the transmitter frequencies, and transmitter antenna height, read the results from the monitoring and reference systems, and calculate the test data automatically, will dramatically improve the test efficiency in cases when a large number of similar systems have to be tested.

TABLE 1

Sample test data table

Signal modulation: _____ Signal polarization: _____

Frequency (MHz)	**field strength at reference system E_i (dBμV/m)**	**field strength at monitoring system E'_i (dBμV/m)**	**field strength measurement accuracy ΔE (dB)**
f_1			
f_2			
f_3			
…			…

Example field strength measurement accuracy specification table for a technical data sheet:

Frequency	f_1	f_2	f_3	…	f_N
Field strength measurement accuracy	Field strength measurement accuracy at f_1	Field strength measurement accuracy at f_2	Field strength measurement accuracy at f_3	…	Field strength measurement accuracy at f_N