Operation of Short Wave broadcast transmitting stations

Foreword

This document is an overview of the application of the peculiar Field Analyzer Narda model EHP200 to the Long-wave, Medium-wave and Short-wave broadcasting stations.
The topics and results shown here come from real on-site tests performed at the Short-wave broadcast station of *Prato Smeraldo* located nearby Rome, Italy, and owned by RAIWAY – the Italian national broadcast Company.
Its purpose is to illustrate the motivations that led RAIWAY to start a project which includes a number of EHP-200 probes, customized housings for outdoor installation, WiFi communication and custom-made control software.

EHP-200 Isotropic E-H Field Analyzer installed on RF-transparent tripod and with optical cable connection

Short wave communication

Nowadays, the majority of the Countries are using the short waves to broadcast news and services worldwide as well as to ensure reliable communication in geographical regions not covered by such radio networks like those based on FM bands. Other considerations of strategic nature support the decision of keeping active the short wave broadcasting, that's basically reliable and easy to receive,
From the beginning of the radio communication era, the frequencies between 3 and 23 MHz appeared as particularly suitable for very long distance communications – several thousands of kilometers – with relatively low power transmitters, due to the reflection produced by the peculiar ionized regions of the troposphere acting as "mirrors" of the incident waves.
However, for the ionized regions are originated by the solar activity they're subjected to daily and seasonal changes from nearly total to no reflection at all; the reflection characteristics are also deeply changing in relation with the operating frequency. The broadcasters must therefore adopt such technical solutions aimed to ensure permanent service, like transmitting in different frequency bands during the day.

Short wave transmitting stations

The Short Wave transmitting stations are considered amongst the most complex Broadcast systems. The following description is an overview of the operation and of the management of such installations.
First to consider, Short Wave transmitting stations are operated continuously 24 hours per day.
During the 24 hours, the following changes are applied hourly (average) and to each one of the installed transmitters:

1. Change of antenna or, alternatively, change of its radiation diagram at least for one of the two planes (horizontal/vertical);

2. Emission frequency, according to the international spectrum allocations;

3. Emission power, for not exceeding the exposure limits as stated by the national and international regulations.

A more detailed analysis of the above points shows how complex the controls to ensure correct operations are:

1. Every transmitting centre is equipped by antennas of fixed or rotating type. The fixed antennas are generally of curtain type, in some cases with possibility of adjusting the main lobe of few tenths of degrees in both horizontal and vertical planes. This allows for optimizing the emissions towards the target area. The rotating antennas, which can be oriented according to the transmission directions, are available in a limited number.
   Both families of antennas – fixed or rotating – can be of multi-frequency or of band type. In conclusion, the type of service and the geographic area to reach determine the choice of the antenna.

2. The emission frequencies are those determined internationally in order to minimize the interferences between the various broadcasters; the choice of the frequency involves also the choice of the proper antenna type (that one operating in the selected frequencies and in the required direction).

3. The emission power is primarily referred to the regulations and laws in use, which define the maximum levels of exposure for the population and for the workers.
   Moreover, but less frequently, the output power can be subjected to agreements between broadcasters in order to minimize the interferences.

Short-wawe curtain antenna station

Measurement tasks

In a typical Short Wave broadcast station, the electromagnetic field measurements can be described as:

Technically difficult: the peculiar characteristics of the field nearby a high power transmitter may influence the measuring instruments resulting in measurements affected by severe errors.
An example is the influence of cables, handles, metallic supports etc. to the measurements made by loop antennas or isotropic probes.

Complex: it is usually needed to survey a wide area surrounding the station, in various points at the same time and in all weather conditions.

Potentially hazardous: due to the presence of very high field levels at frequencies that may be related to biological tissues sensitiveness.

Concurrent: to get control of the station functionality, the measurements results must be processed and analyzed without delays in between.

Measurement methods limits

For the reasons explained by following, the fields to measure nearby broadcast LW – MW – SW stations are almost always in the peculiar near field region, and therefore both electric (E, in V/m) and magnetic (H, in A/m) fields must be measured at the same point.
Conventional field measurement methods consisting in using isotropic diode probes for E-field and loops for H-field may show intrinsic errors that prejudices the correct calculation of the real field values.
Reasons of these errors can be found in the physical layout of the measuring instruments and sensors: the diode probes, when in the near field, can show a significant degradation of isotropy due to the resistive strip line connecting the tri-axial dipoles to the measuring unit; the connecting cable of the magnetic loop antennas is also affecting the measurement accuracy due to the unpredictable scattering phenomena.

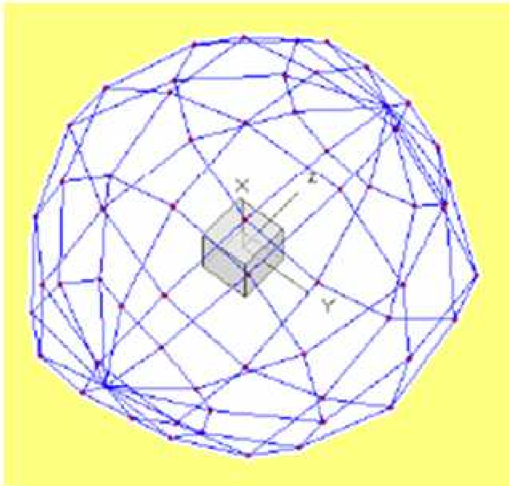
EHP-200: an innovative approach

The Narda EHP-200 is an innovative isotropic field probe with built-in Frequency Spectrum Analysis in the 9 kHz – 30 MHz range.
The operating principle is based on:

- Three field sensors for the measurement of the electric component of the field
- Three field sensors for the measurement of the magnetic component of the field
- The 9 kHz – 30 MHz receiver, supply and communication circuitry, installed within the field sensors.

The complete probe is of very reduced dimensions (92 x 92 x 109 mm), thus allowing practically spot measurements.
The EHP-200 can be used in a wide range of field levels (0.02 to 1000 V/m; 0.6 mA/m to 300 A/m), performs separate 3-axis and total values measurements and features a frequency resolution bandwidth down to 1 kHz for detailed measurements.
An optical output provides for the data communication to PC.

Basing on its peculiar characteristics, the Narda EHP-200 can be successfully utilized in systems intended to measure the actual fields generated by broadcast transmitters, to ensure safety around the sites of large antennas, to control the transmitted power in the actual radiation direction, to test the functionality of the transmitting antennas and to identify the borders between near and far field regions.



EHP-200 3-D isotropy.
Max. deviation from ideal spherical:
H-field: 0,76 dB
E-field: 0,64 dB

Wave impedance calculation

The presence of the electric and magnetic field sensors in the same measuring probe – i.e. in the same spatial position – allows the EHP-200 to perform the calculation of the wave impedance **Zw** (in Ohm)
by computing the ratio between the total values of E and H (the total value is the sum of the vectors X – Y – Z measured by the tri-axial sensors.
Zw depends on the distance from the source.
In far field, the plane wave impedance is equal to the impedance of free space: 377 Ohm.
In near field, Zw is determined by the characteristics of the source.

Wave impedante (Zw) calculation by EHP-200 software:

$$Zw\,(\Omega) = \frac{\sqrt{Ex^2 + Ey^2 + Ez^2}}{\sqrt{Hx^2 + Hy^2 + Hz^2}}$$

Considering the wavelength, the field measurements nearby broadcast LW – MW – SW stations are almost always in the peculiar near field region that can extend from the antenna up to a distance of three times the wavelength. The wavelengths range as follows:

- LW transmitter: 1500 ÷ 2000 m
- MW transmitter: 200 ÷ 600 m
- SW transmitters: 13 ÷ 75 m

Measuring the Zw changes in relation to the distance from the antenna allows for better determination of the near and far field borders as well as of the transmitting antenna performances.
This method is particularly suitable for evaluating the non-linear, scattered near-field region of large broadcast antenna systems.

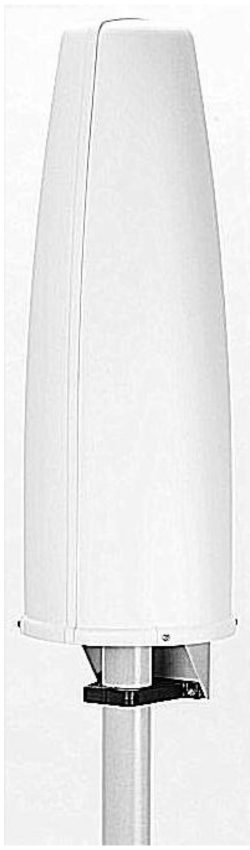
Outdoor installation

The installation places of the field probes are at the limits of the interdicted area of the SW station. The original idea was to use an optical cable for data communication and a DC cable to connect to a central DC supply. However, this solution would have demanded expensive underground installation and would haven't allow the required possibility of relocating the probes in different measurement points. Hence, the system layout has been customized this way:

Measuring unit: a weatherproof, RF transparent housing (the same of the Area Monitor AMS-8060) accommodates the EHP-200 and 5 GHz WiFi modem.

Power supply: provided by a rechargeable battery and an adequately-sized solar panel installed in a movable structure and placed far away from the probe enough to prevent influence on the field measurements.

Communication: by means of 5 GHz Wi-Fi with access point installed on the top of the station control building.
The 5 GHz Wi-Fi communication link has been tested on field and resulted reliable and not interfering with the field measurements.



RF-transparent housing
for outdoor installation

narda Safety Test Solutions an L3 Communications Company

Conclusions

The emission parameters to control are several, and individual for each single transmitter operated in the installation. Therefore, a local control network is fundamental in order to ensure the correctness of the emission parameters.

This result can be achieved by installing some units of the Electromagnetic Field Analyzer Narda EHP-200 properly positioned in the station area and connected to a central unit (server) by means of Wi-Fi communication.

This system allows for controlling simultaneously and for each single transmitter: the frequency, the antenna and the output power.

By means of specific software applications it is possible to generate alarms or feedback for automatic control, e.g. when the radiated power exceeds the exposure limits.

By the continuous monitoring and the periodic data recording, it is possible to generate an electronic log book of the whole station.

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