WAVECONTROL

EMF Assessment of Railway Systems and their Environment

APPLICATION NOTE

AN_SMP2_RAIL_SYS_V1.00

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Table of Contents

Application note

Railway Systems and their Environment

SMP2

This application is directed to

- Railroad Manufacturers
- Railroad Operators
- Rail component manufacturers
- Public bodies responsible for railway environmental safety

Scope of Application note

The purpose of this application note is to describe how human exposure to electromagnetic fields can be measured in the railway environment based on the regulations described in Section 2 (see Reference Standards). Specifically, it covers evaluation of magnetic fields from DC to 20 kHz.

It describes how to perform the measurement using the **Wavecontrol SMP2** EMF meter and **WP400** field probe. In addition, the use of the **WPH-DC** probe is demonstrated, particularly targeted at measurement of static magnetic field exposure due to DC-powered railroads.

IMPORTANT NOTE: ***Wavecontrol*** *is not responsible for any errors that this document may contain, nor for the consequences of a poor application of the standards. This application note is only provided as an aid and should never be used as a substitute for the standards to which it refers, which we recommend should be carefully read.*

1. INTRODUCTION

Daily commuting by train has become an important part of our lives. As train users and workers, we may be exposed to electromagnetic fields (EMF) in the railway environment at levels higher than those found in other places of our normal daily lives. The measurement and evaluation of EMF levels is important to avoid excessive exposure of passengers and workers ensuring that it remains below the established maximum limits.

This application note describes measurement procedures with the aim of monitoring the level of exposure of the human body to electromagnetic fields in the railway environment. Compliance must be checked by comparing the values obtained with exposure limits such as the **ICNIRP** [1] reference values, the **IEEE** [2] maximum permissible exposure (MPE), the **European Directive 2013/35/EU** [3] action levels (ALs), or other national laws.

In the railway environment, passengers and workers are exposed to high frequency (telecommunication systems) and low frequency EMF (electrical and electronic train components).

High frequency exposure, which can be produced by telecommunication infrastructure and ICT devices, does not fall within the scope of this application note.

In the case of low frequency exposure, the main sources are the rolling stock (railway vehicles) and the energy supply.

2. REFERENCE STANDARDS

The main regulatory body addressing EMF levels in the railway environment at international level is **IEC** [4], and the related standard is:

- **IEC 62597:2019** *"Measurement procedures of magnetic field levels generated by electronic and electrical apparatus in the railway environment with respect to human exposure"*.

At European level, **CENELEC** [5] provides the following standard:

- **EN 50500:2008/A1:2015** *"Measurement procedures of magnetic field levels generated by electronic and electrical apparatus in the railway environment with respect to human exposure"*.

Both standards generally have the same measurement heights, procedures, and conditions. However, according to **IEC 62597** measurement procedures should be taken following the standard (if any) specific to the country where the measurements are carried out.

3. MEASUREMENT PROCEDURES

Figure 1 summarizes the general measurement procedure in the train environment:

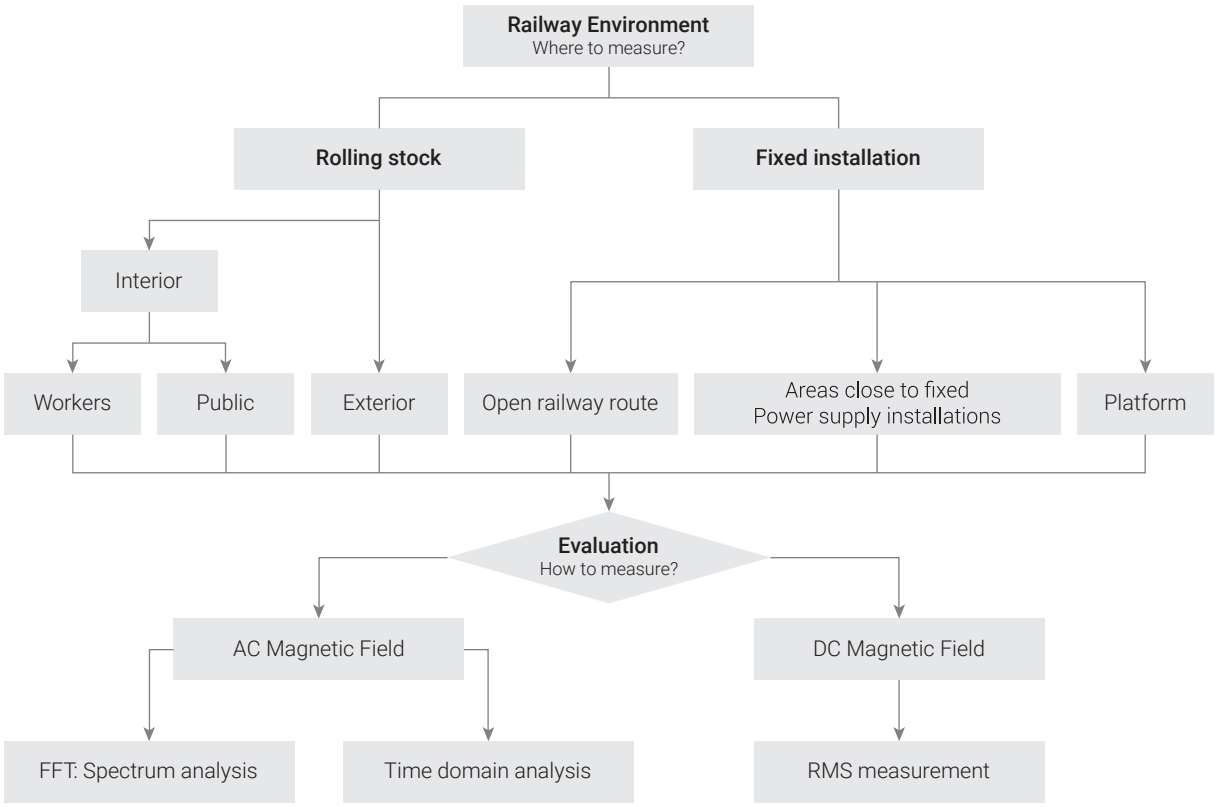

Figure 1: Hierarchical diagram describing the measurement procedure based on the measurement location and conditions and the evaluation method in a railway environment.

3.1 EMF Sources and Measurement Locations

In railways, there are three electromagnetic sources that can affect humans: the **rolling stock,** the **traction power supply** and the **signaling equipment**. Since detectable emissions from these three sources are in the frequency range of DC to 20 kHz, measurements are usually limited to this range.

As the power of signaling equipment is low in comparison with the other field sources, its contribution can be considered negligible. Consequently, the measurement procedure of railway systems is divided into the two main cases described below.

NOTE: *All distances in the following sections refer to the central point of the field probe.*

3.1.1 Rolling Stock

Measurements are performed in the interior and exterior of the rolling stock, as specified below.

For each point, the three axes of the magnetic field must be measured, with one of the axes parallel to the rails. One measurement is sufficient for each measuring point and condition.

A. Interior of the rolling stock

- **Area accessible by workers:** Measurements should be taken near the sources of emission (for example, power converters, power cables and power inductors) in places where workers habitually carry out their duties, as for example, the driver's seat, or where they may have to spend some time as part of their job, for example carrying out repair work. Measurement heights shall be 0.9 m and 1.5 m above the ground. The horizontal measuring distance to the walls should be 0.3 m or the minimum distance (>0.3 m) from where the workers may have to position themselves.

Figure 2: **SMP2 + WP400** mounted on a tripod at a height of 1.5 m in the train driver cabin near the driver's seat.

- **Public areas:** Measurements should be carried out in the closest possible position to the emission sources of the train (for example, power converters, power cables and power inductors) where the public may find themselves.

In this case, the measurement heights of all public areas should be 0.3 m, 0.9 m and 1.5 m above the ground. The measurement distance to the walls should be 0.3 m or the minimum distance (>0.3 m) from where the general public may be.

Figure 3: **SMP2** mounted on a tripod at 1.5 m *(top image)* and at 30 cm distance from where the public may be for assessment in public areas. Using the horizontal extension, the **SMP2** can also be placed on the tripod disk at a height of 0.3 m *(bottom image)*.

General conditions:

- The measurements must be performed in both static and dynamic conditions (see Section 3.2).
- The 3 axes of the magnetic field must be measured in static condition for 30 - 60 s.
- All 3 axes of the magnetic field must be measured in dynamic condition, from standstill to maximum speed with maximum acceleration, then coasting (in idle mode) for a minimum of 10 s and finally, maximum electrical brake to stop.

B. Exterior of the rolling stock

- **For workers and general public:** Measurements should be performed at a horizontal distance of 0.3 m in the closest possible position to the emission sources of the train (for example, power converters, power cables and power inductors) and at 0.5 m, 1.5 m and 2.5 m height from the top of the running rails. Measurements for the general public should not be performed at the same side of the third rail with respect to the tracks.

General conditions:

- Measurements must be carried out in static conditions (see Section 3.2)
- All 3 axes of the magnetic field must be measured in static condition for a duration of 30 - 60 s.

Figure 4: Assessment of the exterior of the rolling stock with the **SMP2** mounted on a tripod at 50 cm in the area closest to the emission source.

3.1.2 Fixed Installation

Compliance assessment of the infrastructures should include the fixed electric traction system of the railway environment.

A. Open railway routes (public and workers)

Measurements related to the public should be carried out at the horizontal distances described in Table 1. If the closest access is farther than these distances, the minimum accessible distance is used. Measurement height should be 1.5 m above the ground (understood as the place where the public may stand).

NOTE: *It is important to bear in mind that there may be combined systems of urban and main lines that require the consideration of other distances. Likewise, there may be cases in which the maximum field level is not in the center of the track. In such cases, the point of maximum field strength should be considered.*

In the case of workers, measurement should be taken at the closest possible position to the emission sources from where workers may be.

Position	Horizontal distance from the center of the track	Remarks
Main line	10 m (for general public)	Unless different legal requirements stipulate otherwise
Urban transport	3 m (for general public)	Unless different legal requirements stipulate otherwise
Trams, trolley buses, etc.	0 m	-
Level crossings	0 m	-
Bridges	0 m	-
Underpass	0 m	-

Table 1: Position and horizontal measuring distances for accessible public areas.

Figure 5: **SMP2** mounted at 1.5 m on the center of the train track.

B. Areas close to fixed power supply installations (public and workers): Measurements should be performed at the closest possible position, where public or workers may be, to the emission sources from fixed power supply installations such as substations. Measurements are taken at the heights 0.3 m, 0.9 m and 1.5 m from all public areas, and at 0.9 m and 1.5 m for areas exclusively for workers. The horizontal measuring distance to walls or fences is 0.3 m or the minimum distance (>0.3 m) from where public and workers may be.

Figure 6: The **SMP2** mounted in a railway electric traction substation at a height of 0.9 m.

C. Platforms (Public and workers):
Measurements on the platforms should be carried out at a height of 0.9 m and 1.5 m above the platform level, and at a horizontal distance of 0.3 m from the edge of the platform.

Figure 7: Assessment of the train station platform with the SMP2 mounted at recommended heights using the horizontal tripod extension.

NOTE: *A supplementary requirement is stated in **IEC 62597** that in some countries, measurement procedures for fixed installations should be coherent and compatible with the measurement procedures for general electric power systems, stated in the **IEC 62110** standard, which is applicable only to public areas. In such case, for open railway route and platforms the horizontal distance is taken at 0.2 m from the closest distance where the public may be.*

*The platform measurement distance should be 0.5 m, 1.0 m and 1.5m above the platform level with a horizontal distance of 0.3 m from the edge of the platform using the three-point measurement method in **IEC 62110**. For more information on this standard, please refer to the application note [6].*

3.2 Test conditions

Test conditions for the two previously discussed cases are as follows:

- **Rolling stock test:**
  Tests should be carried out under normal operating conditions. The conditions during magnetic field measurements are given below:
  - **Static condition:**
    The rolling stock is stopped. The traction circuits are connected to the power supply, but not operating. The auxiliary circuits should be operational, and all corresponding appliances (for example, air conditioning/heating systems, lights, window heaters, electric generators, and so on) should be active.
  - **Dynamic condition:**
    The rolling stock commences movement from a stop point with maximum acceleration to maximum speed, followed by coasting and maximum electrical brake to stop. In this case, the traction circuits are under voltage and operating. As in the previous condition, the auxiliary circuits should be operational, and all devices active.

In some cases, for example in urban transport, rolling stock or supply systems cannot accelerate with maximum line current under the specified test conditions. In such cases, the emissions should be calculated using an appropriate method, for example linear extrapolation, based on the measurement results and monitored line current.

NOTE: *It is highly recommended to pay attention to the emissions of the railroad car-transported equipment and those of the third rail or catenary. The emissions from the transported equipment will vary depending on the current in the device, while the emissions from the third rail or catenary will vary depending on the number of cars and current.*

Measurement must be carried out as far as possible from the influence of other rolling stock. In the case of different electrical brake systems, they have to be tested separately if possible[1].

- **Infrastructure test:**
  - **Open railway route:**
    There should be constant monitoring and recording of the actual line current of the open railway route during emission tests.
  - **Substations:**
    The actual loading of the substation should be noted during tests, since the load can vary considerably within short time periods and emissions are related to load.

In both cases, maximum emissions should be calculated using appropriate methods (for example, extrapolation) based on the measurement results.

For the test environment, it is important to know that any source of magnetic induction outside the rolling stock and along the tracks can influence the measurements carried out. Beforehand and during measurements, it is necessary to indicate the positions of any possible external sources in the execution plan, in order to correlate specific magnetic induction values.

1. Bear in mind that in some test conditions, for example at the interface between power supply and rolling stock, separation is not possible.

4. EVALUATION METHODS

- **DC magnetic field**

  Evaluation of static magnetic field is done using the formula shown in Eq.(1) to obtain the resultant H-field with an isotropic tri-axial probe, as the summation of the three components of the field (see Figure 8).

$$H = \sqrt{H_x^2 + H_y^2 + H_z^2} \qquad (1)$$

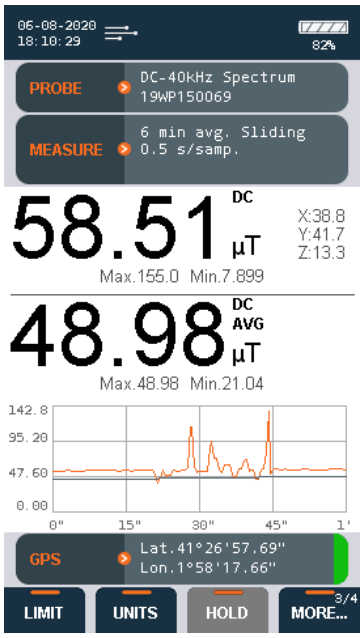

Figure 8: Static field measurement using the SMP2 + WPH-DC probe.

- **AC magnetic field**

  As defined by **ICNIRP guidelines** [7, 8], two possible methods are: Fast Fourier Transform (FFT) in frequency domain and the Weighted Peak Method (WPM) in time domain.

  The **WPM** is the preferred method for exposure assessment and the one used by the **SMP2**, (see Figure 9). It consists of an evaluation of the signal in the temporal domain, $dB(t)$ or $B(t)$, implemented in the **SMP2** with digital signal processing, in order to perform a spectral weighting and an assessment with respect to a reference standard limit curve.

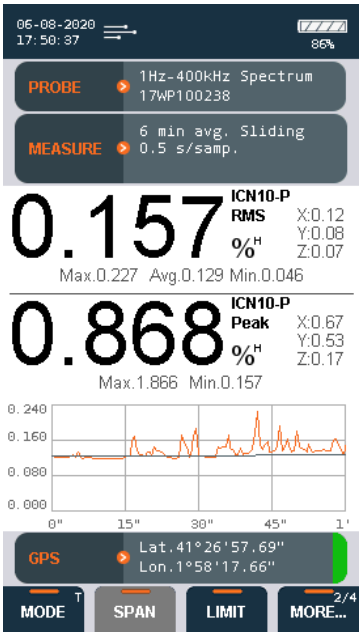

Figure 9: Direct % result with respect to the selected limits using WPM.

NOTE: *The **EN 50500** and **IEC 62597** standards state that both methods (FFT and WPM) produce identical results for sinusoidal magnetic fields, comparable results for periodic magnetic fields, but different results for impulse-shaped and multifrequency fields. In the last case, there is an overestimation of the result when using the FFT method, which is why the WPM is strongly recommended.*

With the aid of the high accuracy **WP400** field probe, the **SMP2** device performs the WPM measurement taking all the frequency band into account and automatically weighting the results in peak and RMS values, which are dependent on the selected limit curve. The result of the measurement is given as a percentage (%) of the standard limit.

The **SMP2** also computes the FFT of the signal, thus providing a spectrum (frequency domain) view of the signal (see Figure 10).

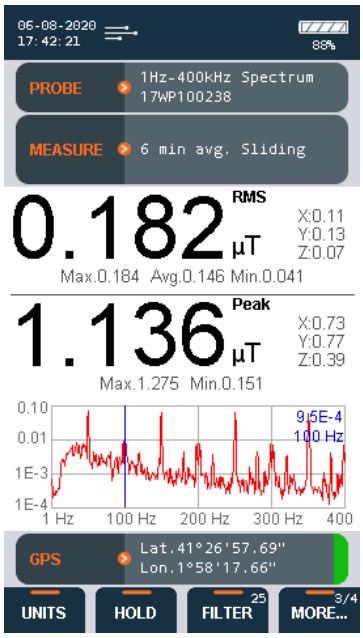

Figure 10: FFT measurement using the SMP2 + WP400.

In summary, the device automatically produces a result that represents the % compliance with the limit. The only thing required of the operator is to select the desired standard limit and if the result generated is less than 100%, the limit is being met (see Fig. 9). We will see in Section 6.2.2 how to perform a measurement in time domain (recommended method) with the FFT information at the same time - the ideal solution for a complete assessment.

5. SPECIFICATION OF MEASUREMENT INSTRUMENT

The measuring equipment must meet the following requirements:

- **Field probes:**
  - **DC magnetic field:** Tri-axial isotropic probe
  - **AC magnetic field:** Tri-axial isotropic probe with three orthogonal loops, each loop with a maximum area of 100 cm^2 and a minimum frequency range of 5 Hz to 20 kHz.
- **Summation of spatial components:** Simultaneous measurement of the three orthogonal components of the field should be performed, with the total H field given by the formula shown in Eq.(1).
- In the case of AC fields, the summation should be done in the temporal domain using the WPM.
- **Data logging:** It is recommended to use a device that allows data to be saved for subsequent evaluation.
- **Dynamic range:** Should cover from a minimum of 5% to 200% of the limit to be applied.
- **Isotropy:** ≤ 5 %
- **Linearity:** At most ±5 % in the required dynamic range.
- **Calibration and accuracy:** ≤ 20 % of uncertainty of the entire measurement chain from the probe to the display system. It is mandatory that all measuring devices should be calibrated for the applied frequency range.

The **SMP2** + **WP400** + **WPH-DC** combination meets all the requirements described above.

With regards to AC magnetic fields, the **WP400** incorporates specific cutting-edge features such as the WPM specified by the **ICNIRP** [9].

For DC magnetic fields, a unique combination of the **SMP2** and the **Wavecontrol WPH-DC** probe, covering a range from DC to 40 kHz, allows measurement of static magnetic fields (0 Hz) and variable fields up to 40 kHz. This combination meets the requirements for DC magnetic field measurements and can be selected by choosing the DC mode, as shown in Figure 11.

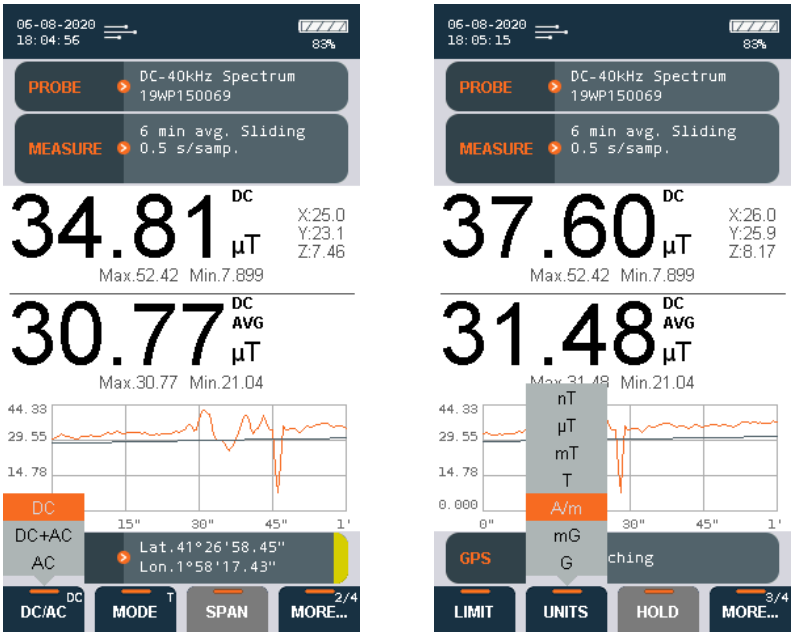

Figure 11: **SMP2 + WPH-DC** probe dynamic menu selecting DC/DC-AC/AC *(left)* and units related to H field *(right)*.

6. SMP2 MEASUREMENT GUIDE

In railway environments, the most relevant fields are static and low frequency magnetic fields. This section illustrates, using the **SMP2** + **WP400** + **WPH-DC**, the procedures for carrying out static field measurements and AC measurements in temporal domain with or without FFT information.

We recommend using the tripod horizontal extension (part number ***WSNA0002***) to attain heights of 0.3 m, 0.5 m, and 0.9 m. We also recommend placing the horizontal extension in a balance position, refer to figures 3, 4 and 6.

Figure 12: **SMP2** EMF meter combined with the **WP400** (1 Hz – 400 kHz) probe for AC magnetic field measurements *(left)* and the **WPH-DC** (DC – 40 kHz) probe for static magnetic field measurements *(right)*.

6.1 Static Field Measurement

Using the **SMP2** + **WPH-DC** probe, DC field measurements can be performed following the steps below:

- Select the Field type to DC (in the dynamic menu AC/DC), as seen in Figure 11 (left). The next step is to move the **SMP2** around to look for maximum levels.
- Go to **MENU → MEASUREMENT OPTIONS** and set **'Measurement time'** to **'Not limited'**.
- Set **MODE** to **'Time'** and press **LOG** to start the measurement.
- Allow the unit to measure for a reasonable time duration until your maximum value stops increasing, then save the measurement using **LOG**. In the results obtained, as in Figure 13, it will be possible to see the maximum and minimum values.
- Compare the maximum DC value measured with the standard being used. It is also possible to select a limit and obtain a direct reading in % compared to the limit.

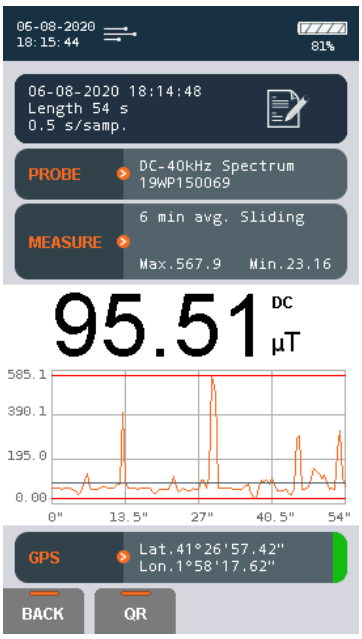

Figure 13: Final results for static field measurement.

6.2 AC Magnetic Field Measurement in Time Domain

There are two methods to perform AC measurement in the time domain, depending on whether the user is interested in only the information in time or with FFT information. To perform measurements in the time domain for both cases, the steps described below should be followed:

- Go to **MENU → MEASUREMENT OPTIONS** and Set **'Measurement time'** to **'Not limited'**. (See Figures 14a and 14b). A time duration can be chosen if needed, but it is preferable to have the liberty to record a different time for each measurement as you can start and stop (from the **SMP2** or from the PC with the fiber optic option) whenever you need with the parameter set to **'Not limited'**.

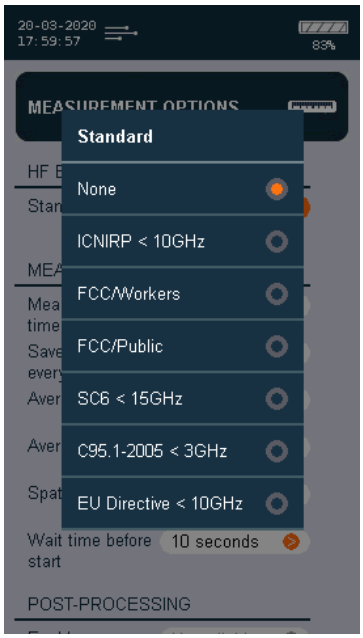

Figure 14a: Standard selection.

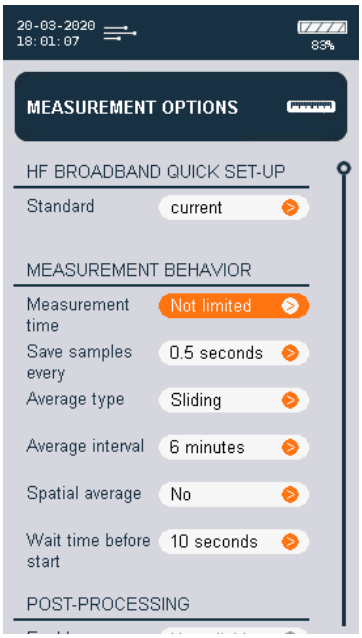

Figure 14b: Predefined measurement settings according to standards.

- Select the **Field**, E/H (In railway applications, H field must be chosen) (see Figure 14c).

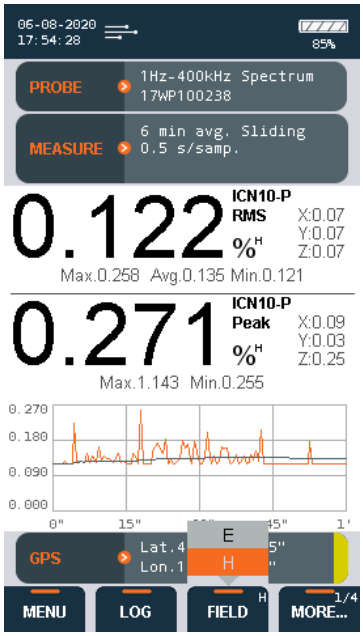

Figure 14c: Field selection.

- Set the **FILTER** to 1 Hz (10 Hz is recommended if it is certain that there is no signal present from 5 Hz to 10 Hz. Please note that with the 1 Hz filter the unit is less responsive to fast changing signals).

- Set the desired **LIMIT** from the list of selectable limits (see Figure 14d).

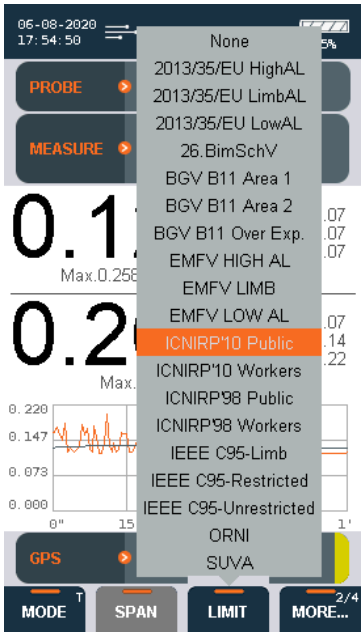

Figure 14d: List of available limits.

- Move around slowly with your **SMP2** to locate areas with maximum field values.
- Place the **SMP2** on a tripod at the desired height (see Section 3.1 for heights corresponding to measurement in the railway environment) [2].

2. Spatial average can also be activated in the **MEASUREMENT BEHAVIOUR** setting, which allows you to take measurements at different heights, with an average value for all measurements taken.

6.2.1 AC Magnetic Field Measurement without FFT information

In this mode, the measurement result without FFT can be obtained as follows:

- Set the unit **MODE** to **'TIME'**.
  In this mode, all the information is provided each 0.5 second of the % of peak and RMS value.
- Press the **LOG** button to start the measurement and press **LOG** again to stop when needed (if a time duration was defined in the measurement options then just press **LOG** once and allow the **SMP2** to finish measurement. A beep is emitted when measurement is completed). Please remember that remote control of the **SMP2** is possible with the fiber optic option.
- Find the measurement (as in Figure 15) in **MENU → MEASUREMENT LOG** or download the measurement data using the **SMP2 Reader**. The final value will be the maximum weighted % of the limit selected. If the value is below 100%, you are below the limit.

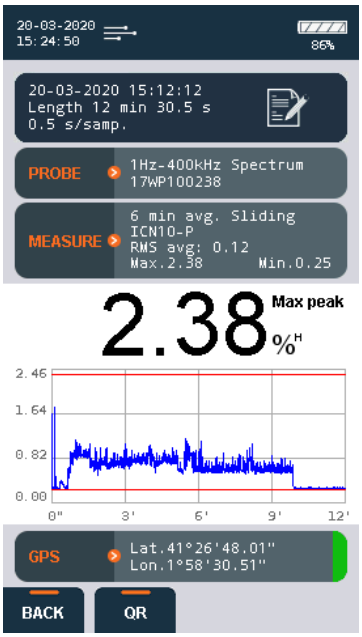

Figure 15: **SMP2 + WP400** Measurement without FFT information.

6.2.2 AC Magnetic Field Measurement with FFT information

In this mode, the measurement result is given with FFT information, which can be obtained following the steps described below:

- Set the unit **MODE** to **'FFT'**.
- Define the dynamic menu settings:
  - **AXIS** to **'Total'**
  - **HOLD** to **'Max'**
  - **SPAN** to **40 kHz** (to comply with the DC – 20 kHz frequency range of the standard)

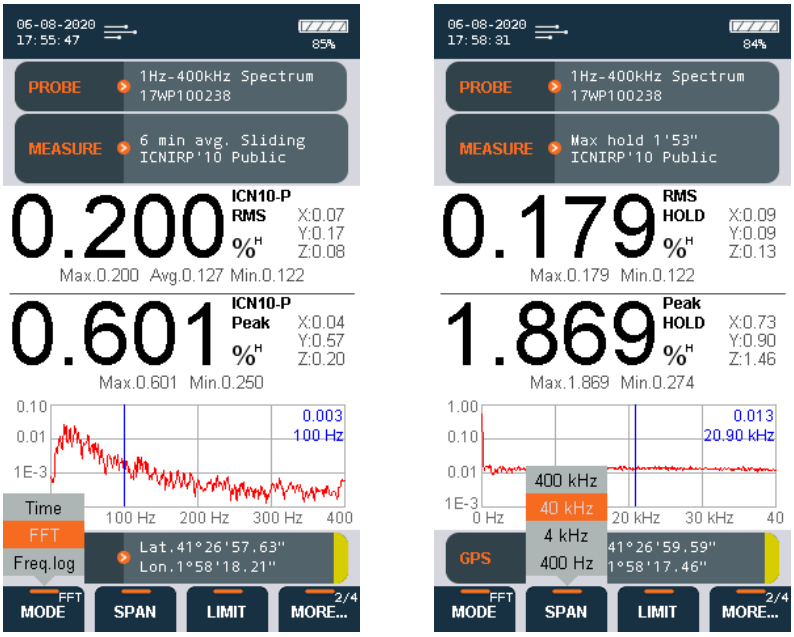

Figure 16: SMP2 + WP400 FFT functions on the dynamic menu: FFT MODE selection *(left)* and SPAN selection *(right)*.

- With **'Max. hold'** activated, wait until the measurement ceases to increase (**'Max. hold'** can be reset by holding down the **'Max. hold'** button or pressing the reset button in the dynamic menu). Press **LOG** to save the results.
  The result will be the % value of the selected limit with FFT information (see Figure 17).

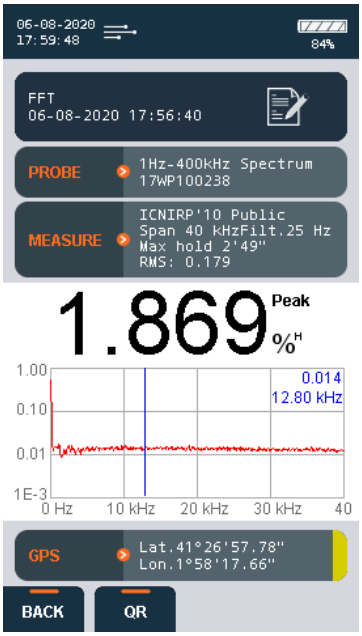

Figure 17: **SMP2 + WP400** measurement results with FFT information.

7. MEASUREMENT REPORT

The minimum information that must be provided:

- Date and time of measurement.
- Post-processing method.
- Measurement configuration.
- Environmental conditions (e.g. weather conditions).
- Measurement uncertainty (for more information on the calculation, refer to [10]).
- Spectrum analysis for selected places, for example with high emission levels or a third-party request.
- Any modifications, which must be justified, under measurement conditions specified by the standard.

The following information should be recorded during the rolling stock tests:

- Track and direction of movement.
- Train configuration: vehicles and their relative position.
- Approximate weight of the rolling stock.
- Position of the active pantographs.
- Feeding stations.
- Nature of the return circuit (single or double track) and return current cables.
- Location of booster transformers and power supply stations related to the measuring position.

The standards also recommend recording information on the line current, as far as possible, corresponding to the total consumption of the rolling stock, its speed and catenary voltage. Other relevant information on the area and location where the measurements are carried out can also be provided.

8. CONCLUSIONS

This application note covers measurement procedures and methods for assessing human exposure to magnetic fields generated by devices, systems and installations that are intended for use in railway environments. It is important to emphasize the need to measure the H field, which is primarily done by means of an isotropic field probe and a non-conductive tripod to avoid influence of the operator on the equipment.

It is important to have frequency information to evaluate the signal harmonics (Figure 10). By using the **SMP2** with the **WP400** probe (which implements the WPM), it is possible to obtain a value which is directly compared as a % of the regulatory limits.

The combination of the **SMP2** and **WP400** and **WPH-DC** probes meets all the requirements for AC and DC magnetic field measurements, respectively, making it ideal to perform this type of test and evaluation for H fields.

In addition, combining a single **SMP2** device with the two aforementioned probes allows the realization of both types of measurements, covering the different applications in the railway environment:

- Frequency domain analysis (FFT) – both probes, **WPH-DC** and **WP400** (DC and AC)
- Temporal domain analysis (WPM) – **WP400** (AC only)

The measurement results are given with the possibility of their direct comparison with a list of limits (set by **ICNIRP**, **IEEE, EU Directives 2013/35/EU** and other safety bodies) available to the user.

APPENDIX 1. References

[1] ICNIRP: International Commission on Non-Ionizing Radiation Protection (*www.icnirp.org*)

[2] IEEE: Institute of Electrical and Electronics Engineers (*www.ieee.org*)

[3] European Union Directive 2013/35/EU, of 26 June 2013 on the minimum health and safety regulations regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields), 20th Directive in accordance with Article 16, section 1 of Directive 89/391/CEE and repealing Directive 2004/40/EC of 29 April 2004.

[4] IEC: International Electrotechnical Commission (*www.iec.ch*)

[5] CENELEC: Comité Europeo de Normalización Electrotécnica (*www.cenelec.eu*)

[6] Wavecontrol Application Note on Energy Industry.

[7] ICNIRP Guidelines: *"Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields (up to 300 GHz)"*, Health Physics 74(4): 494-522, 1998.

[8] ICNIRP Guidelines: *"Guidelines for limiting exposure to electromagnetic fields (100 kHz to 300 GHz)"*, Health Physics 118(5): 483-524, 2020.

[9] ICNIRP Statement: *"Guidance on determining compliance of exposure to pulsed and complex non-sinusoidal waveforms below 100 kHz with ICNIRP guidelines"*, Health Physics 84(3): 383-387, 2003.

[10] Wavecontrol Application Note: Calculation of the total measurement uncertainty of a field strength meter.

APPENDIX 2. Details about the SMP2 combined with field probes, WPH-DC and WP400

	SMP2 + WPH-DC	SMP2 + WP400
Fields (different units available)	Only H fields	Both E and H fields
Applications in railway systems	Static magnetic field	AC magnetic field
Frequency range	DC – 40 kHz	1 Hz – 400 kHz
Standard limits	ICNIRP, EU/EC, ACGIH	ICNIRP, EU, IEEE, SC6 and more
Real-time spectral analysis based on FFT	Yes	Yes
WPM for real-time comparison with limits	No	Yes
Broadband measurement	Yes	Yes
Readily prepared to incorporate other limits without changing hardware	Yes	Yes
RMS and peak values	Yes	Yes
Automatic probe detection	Yes	Yes
Different SPAN for spectral analysis	Yes (40 Hz, 400 Hz, 4 kHz, 40 kHz)	Yes (400 Hz, 4 kHz, 40 kHz, 400 kHz)
High pass filters	1 Hz	1 Hz, 10 Hz, 25 Hz and 100Hz
Low pass filters	1 Hz	None
Max hold function	Yes	Yes
Temporary measurement of a single frequency	Yes	Yes
Display of X, Y, Z components and the resulting field value	Yes	Yes
Min, Max, Max hold and Averages	Yes	Yes

Other features of the SMP2:

- Screen with configuration information, results and graphical representation
- Free firmware updates
- Cutting-edge integrated GPS
- Fiber optic and USB connection for data download and device control
- Large storage capacity
- Screen capture function for quality report presentation
- Field level alarm with adjustable threshold
- Internal rechargeable Li-on battery with more than 24 hours of autonomy
- Light and easy to use

APPENDIX 3. Some of the main global regulatory bodies

- International Commission on Non-ionizing Radiation Protection (**ICNIRP**)
- World Health Organization (**WHO**)
- International Electrotechnical Commission (**IEC**)
- Comité Europeo de Normalización Electrotécnica (**CENELEC**)
- European Union (**EU**)
- Federal Communications Commission (**FCC**)
- Occupational Safety and Health Administration (**OSHA**)

National authorities are mainly responsible for standardization and provision of scientific advice and guidance on the effects of non-ionizing radiation (NIR) on health and the environment, such as low frequency electromagnetic fields to protect people and the environment from EMF exposure.

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