



Report ITU-R SM.2503-0
(07/2022)

**Evaluation of radiated electromagnetic
disturbances of household appliances and
their interferences over an Internet of
Things network in the 915 MHz frequency
band**

SM Series
Spectrum management



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Foreword

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***Note:** This ITU-R Report was approved in English by the Study Group under the procedure detailed in Resolution ITU-R 1.*

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REPORT ITU-R SM.2503-0

Evaluation of radiated electromagnetic disturbances of household appliances and their interferences over an Internet of Things network in the 915 MHz frequency band

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Scope

Electronic devices and their networks, including those not used for telecommunications, can produce significative electromagnetic disturbances that may affect the functionalities of current and future telecommunications systems such as Internet of Things (IoT) and their applications. This Report evaluates the levels of electromagnetic disturbances generated by household appliances and how these interferences may affect the functioning of a Wireless Sensor Network (WSN) operating in the 915 MHz band in some administrations, a system which is widely used within IoT due to its technical flexibility and low cost. The work was divided into three stages. The first stage evaluated the electromagnetic disturbances coming from the household appliances, the second stage involved the characterization of the WSN by evaluating the Received Signal Strength Indication (RSSI) and the Packet Error Rate (PER), and finally, the third stage consisted in the assessment of the RSSI and PER with the insertion of the household appliance in the test. The results showed that the researched household appliances did not follow normative limits and significantly affected the functioning of a WSN.

Acronyms and Abbreviations

ABNT	Associação Brasileira de Normas Técnicas (Brazilian Association of Technical Standards)
CISPR	International Special Committee on Radio Interference
IEC	International Electrotechnical Commission
NBR	Norma Brasileira (Brazilian Standard)
PER	Packet error rate
RSSI	Received signal strength indication
SAC	Semi-anechoic chamber
Vac	Volts alternating current
WSN	Wireless sensor network

1 Introduction

Modern electro-electronic equipment and their networks, including those not intended to telecommunications, can produce relevant electromagnetic disturbances.

These occurrences are related to the operational dynamics of its electronic systems, the presence of switched power supplies, nonlinear loads, electromechanical devices and logic circuits among others. These electrical influences can be manifested both in radiated and in conductive ways and, if not mitigated at its source, can degrade and pollute the electromagnetic spectrum.

This context is potentially serious in a residential environment, rich in density, quantity and diversity of electro-electronic equipment and their networks which can directly affect the functionalities of radiocommunications services in the users or consumers area.

This study evaluated the behaviour of a Wireless Sensor Network (WSN) when submitted to the disturbances caused by household appliances through the analysis of Received Signal Strength Indication (RSSI) and Packet Error Rate (PER).

The work was divided into three stages. The first measured the electromagnetic emissions of the household appliances. Subsequently, the characterization of a WSN was performed with the respective RSSI and PER. Finally, the WSN was evaluated in the same criteria when home appliances were inserted in the test.

2 Equipment and installations

All the measurements took place inside an ETS-LINDGREN Semi-anechoic Chamber (SAC) workable from 9 kHz to 220 GHz, with a turntable.

Two antennas were used: UltraLog, model HL562E, for measurements from 30 MHz to 1 GHz, and Double Ridged Guide antenna, model 3117, for measurements from 30 MHz to 6 GHz.

The meter was a Rohde & Schwarz, model ESIB 40 EMI Test Receiver with selectable bandwidths of 200 Hz, 9 kHz, 120 kHz and 1 MHz with peak, average and quasi-peak detectors as requested by IEC CISPR 16-1.

Variable attenuators from JFW Industries, models 50R-029 (0 to 70 dB with the precision of 0.5 dB) and 50R-019 (0 to 10 dB with the precision of 0.2 dB) were applied to the WSN. A network analyser from Agilent Technologies, model E5071B, was used to evaluate these attenuators.

The radio module was a BE900, homologated by Anatel (Agência Nacional de Telecomunicações). It features wireless communication for monitoring and control applications using 2-FSK modulation with maximum 250 kbit/s. It carries a programmable ATmega328 AVR processor, CC1101 RF transceiver with 10 dBm power output, sensitivity of -112 dBm with 1% of PER, using a band-pass filter adjusted to operate in the Industrial, Scientific and Medical (ISM) bands 902-907.5 MHz and 915-928 MHz.

This work considers the measurements made with two blenders (220 Vac and 127 Vac) and a vacuum cleaner as the household appliances. Additionally, a microwave oven and a refrigerator were used for combined measurements. They were chosen because they are typical in residential environments and were available at the time of the research, and were used with the aim to extract more complete results.

The measurements were developed in *Instituto de Pesquisas Eldorado* as part of graduate research at *Pontifícia Universidade Católica de Campinas* (São Paulo, Brazil).

3 Methodology

First was performed the validation of the SAC based on methodology presented by ABNT NBR IEC/CISPR 22¹. The background noise analysis was also performed scanning the spectrum with antenna ranging from 1 to 4 metres of height, in vertical and horizontal positions. Attenuators were also analysed from 400 MHz to 1 000 MHz with the Network Analyzer to obtain the performance compared with the datasheet.

In order to develop measurements of radiated electromagnetic disturbances, the household appliances were placed 80 cm away from the floor on a wooden table and over the turntable, keeping the distance of 10 metres from the measuring antenna, as can be seen in Fig. 1.

¹ Implementation of CISPR Publication 22 in Brazil.