Publishable Summary for 21NRM06 EMC-STD
Metrology for emerging electromagnetic compatibility standards

Overview

All electronic equipment within the European Market must fulfil the essential requirements of the European EMC Directive 2014/30/EU, with compliance demonstrated using harmonised electromagnetic compatibility (EMC) standards. However due to emerging radio services and state of the art technologies employed in Smart Grids, Internet of Things (IoT), electromobility, and other cutting-edge applications, the standards used to effectively address these new interference scenarios are lacking. This requires validated and traceable methods to assess the electromagnetic emissions in complex situations such as in situ testing of large size/high-power equipment mainly in the scope of CISPR37 & CISPR11 and interference in wireless communications mainly in the scope of CISPR16. This project aims to significantly contribute to the development of CISPR 37 and to the revision of CISPR 11 and CISPR 16 through new electromagnetic emissions test methods for harsh environments, fully traceable time-domain measurement techniques, new calibration methods for the response to pulses of receivers and the statistical evaluation of interferences in compliance assessments.

Need

All electronic equipment within the European Market must fulfil the essential requirements of the European EMC Directive 2014/30/EU [1]. The common approach is to show compliance with the harmonised standards using EMC tests at specialised laboratories. However, as new interference scenarios are identified due to emerging radio services and the state-of-the-art technologies employed in, for example, Smart Grids, IoT, electromobility and sustainable energy applications, the current standardised EMC testing methodologies are no longer sufficient or applicable. This has been emphasized by CENELEC TC 210 as well as CISPR which is continuously working towards updated and novel EMC standards. Likewise, IEC also tackles EMC problems at lower frequencies, currently focusing on interference below 150 kHz, as for smart energy meters.

One standard under development (the CISPR 37 Ed. 1.0) is intended to bridge the gaps left by CISPR 11 in terms of in situ testing outside standardised test sites. In this regard, CISPR\CIS\B\WG7 was created to develop CISPR37 and it needs support from universities and NMIs for developing traceable electromagnetic emissions measurement methods optimised for in situ assessment of large-size/high-power equipment (such as photovoltaic installations, electric road systems and electric car fast-charging stations).

According to CISPR\CIS\A, metrological research is required for the application of time-domain electromagnetic interference (EMI) measurement based on direct sampling techniques. The standard that defines the characteristics and key specifications of measuring receivers, CISPR 16-1-1, lacks clarity when it comes to the metrological definition of the calibration method and regarding the standard reference to use for traceability of pulse response of detectors. A complete waveform specification for receiver pulse calibration is needed.

In addition, the statistical analysis of interference and its correlation with communication quality metrics are of utmost importance as the increase of wirelessly connected devices poses challenges due to the increased use of IoT and the advent of 5G. The APD measuring function can assess the degradation suffered by digital communication systems, provided it is reformulated in two key aspects: extension below 1 GHz and measurement bandwidth set according to the characteristics of the communication channel. Both changes should be incorporated in standards such as CISPR 16-1-1 and CISPR 11. Likewise, a specific calibration method for the APD measuring function of the EMI receivers needs to be developed to provide the required traceability.

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Objectives

The overall aim of the project is to support standardisation in electromagnetic compatibility (EMC) through the introduction of new, validated, and traceable emissions measurement methods for the revision of and forthcoming development of CISPR EMC standards.

1. To develop traceable electromagnetic emissions measurement methods optimised for in situ assessment of large-size/high-power equipment and to validate the proposed test procedures in harsh environments (e.g., factory premises and photovoltaic installations), which requires development and improvement of live impedance measurement methods in low (30 Hz – 150 kHz) and high (150 kHz – 30 MHz) frequency ranges for conducted emission testing with a target uncertainty of 6 dB. This also includes the characterisation of influence factors such as non-stationary interferences and sources of background noise, correcting the impact of transient interference, and defining a measurement protocol for selecting adequate antenna location, height, and polarisation, and other relevant parameters for the radiated emissions test setup. A report on the methods will be submitted to CISPR/CIS/B/WG7 to support the development of the forthcoming CISPR 37.
2. To provide metrological evidence of the validity of time-domain electromagnetic interference (EMI) measurement systems, based on direct sampling techniques, and to define standardisable conditions at which the usage of oscilloscopes/baseband digitisers is acceptable or preferred in comparison to measuring receivers based on frequency sweep or stepped scan techniques. The estimation of the uncertainty in time-domain EMI measurement systems will be addressed. A report recommending an amendment of Annex B and Annex C of the current CISPR 16-1-1 standard will be submitted to CISPR/CIS/A/WG1 & WG2.
3. To improve the standard calibration method for the response to pulses of measuring receivers through a complete waveform specification of the calibration pulse generator. To develop alternative reference waveforms with well-defined mathematical description and spectral properties to include in standards as a means of validating the weighting function of the detectors, thus reducing the uncertainty of the receiver’s response to pulses calibration to 0.2 dB. A report on the proposed calibration methods for the response to pulses of measuring receivers will be submitted to CISPR/CIS/A/WG1 & WG2 to support amendment of CISPR 16-1-1.
4. To redefine the standard amplitude probability distribution (APD) measuring function in EMI measuring receivers as part of the emissions compliance assessment based on the communication quality metrics. To define the criterion for establishing emissions limits based on APD measurements making it part of the emission compliance assessment. A report on the redefined APD measuring function will be submitted to CISPR/CIS/A/WG1 & WG2 and CISPR/CIS/B/WG1 to support amendment of CISPR 16-1-1 and CISPR 11 respectively.
5. To contribute to the standards development work of the technical committees CISPR/CIS/A/WG1 & WG2 (supporting revision of CISPR 16-1-1), CISPR/CIS/B/WG1 (supporting revision of CISPR 11), and CISPR/CIS/B/WG7 (supporting development of new CISPR 37) to ensure that the outputs of the project are aligned with their needs. To communicate quickly to those developing the standards and to those who will use them (test laboratories and manufacturers related to IoT, E-mobility, and technologies), and in a form that can be incorporated into the standards at the earliest opportunity

Progress beyond the state of the art and results

Development of emission test methods for harsh environments (Objective 1)

The 30 Hz-150 kHz frequency range will be extensively researched, and novel measurement methods will be developed for conducted emission testing. A precise correlation between reference and complex test environments will be based on accurate impedance measurements, never performed before.

For the 150 kHz – 30 MHz range, time-domain techniques and phase information will be also included to improve accuracy and uncertainty. The proposed use of time-domain measurement methods with the mains and Equipment Under Test (EUT) impedance characterisation will help to reduce the previously reported in situ uncertainty values of up to 25 dB towards the maximum 6 dB target found at conventional EMC test laboratories.

For radiated emission testing, the new methods proposed by draft standards such as CISPR 37 will be investigated, implemented, and verified in actual test environments. In addition, innovative measurement systems capable of measuring and processing new interference scenarios like impulsive-transient or short-duration emissions will be proposed along with a software solution featuring time and frequency domain triggering to ensure that worst emissions are captured.

Specifying time-domain interference measuring receivers in EMC standards (Objective 2)

The operation of the direct-sampling time-domain measuring receivers will be extensively studied to create a clear argument supporting their implementation in EMC standards such as CISPR 16, as an alternative to the conventional frequency-domain solutions. The effect on measurement accuracy will be evaluated for each stage of the receiving track, including hardware and signal processing, as well as for various receivers of different specifications, to clearly indicate whether they are suitable for the given applications, and with what uncertainty. Novel signal processing algorithms exclusive to the time-domain receivers will be implemented and evaluated to optimise the measurement speed, accuracy and precision, and allow to capture the rare EMI events that could be missed by the conventional methods.

Methods for calibration of measuring receivers (Objective 3).

Currently used methods for calibration of EMI receivers and their weighting detectors will be revised and further developed through a complete waveform specification of the calibration pulse generator. Those improvements target a future update of the CISPR 16-1-1 standard. Current methods for calibration of EMI receivers and their weighting detectors recommended in the CISPR 16-1-1 standard are not well suited for commercial calibration laboratories due to their demands on measurement equipment and complexity. Introducing a whole new set of more repeatable, reproducible, and less hardware stringent calibration and verification methods will enable calibration laboratories to perform calibrations of EMI receivers more efficiently. Moreover, the new calibration methods will allow easier interlaboratory comparisons avoiding traditionally used base-band pulse generators.

The APD interference detector in emissions compliance assessment (Objective 4)

The APD measuring function will be redefined as an interference detector suitable for compliance assessment of EMI in digital communication systems. A more general, improved formulation of the APD will be developed and emissions limits will be defined, based on the degradation suffered by digital communication systems when subject to the EMI of the EUT. The updated APD will be applicable for frequencies below 1 GHz and the measurement bandwidth will be made according to the characteristics of the communication channel. Time-domain measuring instruments will be employed to accelerate APD measurements through a multi-channel/multi-band approach. Finally, a traceable calibration method for the APD function will be developed through reference signals emulating noise models with well-known statistical properties. This translates into significant progress in comparison to current EMC standard testing methods that rely on emissions measurements according to weighting detectors at a fixed RBW and the pass/fail criteria based on fixed limit lines defined on broad frequency ranges.

Outcomes and impact

Outcomes for industrial and other user communities

The impedance and low frequency conducted emission based on impedance measurement methods will be taken up and offered as a service by EMC test laboratories (e.g, TUBITAK, EMC-BCN). This will allow test laboratories and product manufacturers to considerably improve their conducted emission tests by offering them more accurate measurement results and by alleviating the harsh grid impedance effects. These methods will also provide better knowledge about the impedance of electric networks which will allow manufacturers of electronic equipment (e.g., grid connected power converters and electrical vehicles) to improve the R&D phase of production thereby ensuring higher confidence in internal EMC pre-compliance results. This would facilitate a more reliable design considering EMC control measures and hence a reduction in time and subsequently cost.

The time domain method will be taken up and offered as a service by EMC test laboratories (e.g, TUBITAK, EMC-BCN) to end users (e.g., manufacturers of photovoltaic cells, wind turbines, smart grids). This will allow industry to acquire short duration/transient interference and worst-case emission measurements in harsh environments in real time. As opposed to conventional frequency-domain instrumentation like EMI receivers, this will allow industry to achieve a drastic reduction of measurement time, from hours to less than a minute.

The software solutions will be taken up by TUBITAK and EMC-BCN and provided to end users (e.g., other EMC laboratories and manufacturers) who need onsite EMC testing for their products. This will provide accurate and practical on-site test opportunities for them to validate their products as per the relevant EMC standards such as CISPR37.

The instrumentation will be taken up by TUBITAK, RISE, EMC-BCN, UNIGE and incorporated into their measurement and consultancy services and offered as a service to customers who need on-site EMC testing for their products and require verification and comparison tests for their EMC test systems. This will allow industry to validate their products which are not suitable for transferring to EMC laboratories due to physical and power constraints. Participants will also consider the possibility of transforming this development into a commercially available product it to third parties such as EMC test laboratories, either sold or as part of a verification service.

In addition, the test methods and assessment methodologies based on APD detectors will be taken up by CISPR/CISA committees to facilitate more reliable measurement procedures for radiated electromagnetic emissions at real sites, backed up by the quantification of disturbance to telecommunication systems. This will allow manufacturers (e.g., railways that feature large moving sources, potentially disturbing deployed telecommunication systems with signalling functions) to demonstrate the compliance and safety assessment in a more straightforward way. This will facilitate reduced duration of safety assessment and demonstration of compliance (usually blocking the permit to operate). Additionally, the broader use of APD as an interference detector will benefit industry because it mitigates the risk of over/under testing their products, which inevitably happens today due to the utilisation of non-optimum weighting detectors for emissions assessments.

Outcomes for the metrology and scientific communities

The time domain receivers and calibration methods will allow NMIs and DIs to update their calibration services and provide the necessary traceability and reduce the measurement uncertainties in comparison to the typical figures in the standards. In addition, through their contribution to the project both NMIs and calibration/testing laboratories will benefit from facilitating interlaboratory comparisons of EMI receivers and pulse generators. In addition, the report on comparison of a measuring receiver calibration using the traditional pulse generator and the new alternative reference waveform with a commercial arbitrary waveform generator (AWG) will be made publicly available. This will allow other NMIs, calibration testing/laboratories and members from the scientific community to take up results from the project and improve the calibration of their capabilities.

The joint interdisciplinary research of emissions measurements in harsh environments and the further development of APD as an interference detector will improve scientific understanding in this technical field. New research lines are expected to be generated. For example, doctoral Networks (Marie Skłodowska-Curie Actions) addressing EMC challenges in innovative applications (e.g., ETERNITY for EMC in medical equipment, PETER for electromagnetic risks management, ETOPIA for power applications).

At least six research papers will be submitted for publication in high impact open access peer-reviewed journals. This will be key for the scientific community to accept the calibration (APD calibration, new waveforms for calibrating the response to pulses of the measuring receivers) and the on-site testing methods proposed for harsh environments. Moreover, as part of the knowledge transfer actions addressed to the metrology and scientific communities, a two-day training course will be organised. The highly technical profile of this activity is more suited for people in academia, NMIs and technicians in companies' testing/calibration departments.

Finally, in a broader sense, the metrology capabilities of involved NMIs will be strengthened to provide metrology that supports emerging EMC standards and coordinated metrology research of involved participants in the future. By bringing together leading EU NMIs and universities in this area, the required metrological capacity will be established that aligns with the needs of stakeholders and standardisation bodies.

Outcomes for relevant standards

In a broad sense, the project will support the EU Directive 2014/30/EU which aims to ensure the functioning of the internal market by requiring equipment to comply with an adequate level of electromagnetic compatibility. The project will have a significant positive impact on the execution of the Directive by providing EMC test and calibration methods and supporting draft and active standards. More specifically, the consortium will promote the results of the project within the standardisation community and will provide input into the standardisation process, mainly of CISPR.

Through agile communication and coordinated interaction between the project consortium, the Chief Stakeholder and the target committees CISPR\CIS\A (Radio-interference measurements and statistical methods) and CISPR\CIS\B (interference in industrial, scientific and medical RF apparatus) the results from the project will be presented in the form of meetings, workshops (3), reports and guides (8) and datasets. Thanks to this project, at least 3 standards will be directly benefited from the research. One of them, CISPR 37 about radiofrequency disturbance measurements in situ and on defined sites, is a completely new standard that has been requested by the industry for decades. The other two, CISPR 11 and CISPR 16-1-1 are very fundamental and well stablished standards upon which other product testing standards are based. Improvements in those standards will result in a waterfall effect that eventually will propagate the project outcomes to other EMC standards.

Longer-term economic, social and environmental impacts

One sector that will considerably benefit from project outcomes is the industrial, scientific and medical (ISM) one because the most prominent target standards in the scope of the project is CISPR 37. Like CISPR 11 that was partially used for years as a reference standard for large equipment, CISPR 37 is expected to be used as a reference by many other standards and will have broad influence on applications such as renewables and wireless power transfer, and their integration in microgrids and power distribution infrastructure, railways, automotive, and those production lines currently using non-standard EMC test methods. Such sectors are strategic due to their contribution to the Gross Domestic Product (GDP) and European jobs.

In particular, as declared by the European Commission (EC), the objective for solar energy is to establish Photovoltaic (PV) systems as a clean, competitive and sustainable energy technology. Therefore, the improvement and production of new EMC standards for atypical equipment can improve the certification of PV installations and consequently achieve the objective of implementing solar energy, which will benefit economically the end-users, to reduce their energy consumption and produce their own clean energy, and the companies which provide the PV infrastructure.

The EC also supports European industry in the move to a low-carbon economy and improves the energy efficiency of products through eco-design legislation. This is strictly related to the energy industries like PV and green transport. The new EMC standards will contribute, from an EMC point of view to evaluation of all the novel electric engines and energy-efficient functional modes like regenerative braking that is employed by Electrical Vehicle (EV) such as trains, metros and e-buses.

Moreover, citizens can have direct social benefits from the energy and transport industries. A sustainable mobility is beneficial for the free movement around the European Union (EU), and according to the European Economic and Social Committee (EESC), these movers represent a poll for innovation, creativity, and willingness to work hard. The use of renewable energy technologies has a direct positive impact on the health of the European citizens. Therefore, the validation and procedures developed with the actual official standards in lieu of non-standard methods will allow speeding up the certification and the confidence in being compliant with the European Directives. In addition, taking advantage in the improvement of standardised, repeatable and traceable methods for in situ EMC testing of large-size/high-power equipment, reliable test results for a wide variety of locations will be obtained. Thus, manufacturers, conformity assessment bodies and consumers can benefit from reliable and faster compliance processes with the European EMC Directive 2014/30/EU and this presents significant opportunities for free movement of goods in European Single Market, promising potential cost savings and time.

List of publications

n/a

This list is also available here: https://www.euramet.org/repository/research-publications-repository-link/

Project start date and duration:	1 October 2022, 36 months
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Chief Stakeholder Organisation: Fuji Electric Europe GmbH	Chief Stakeholder Contact: Yasutoshi Yoshioka

Internal Beneficiaries:	External Beneficiaries:	Unfunded Beneficiaries:
1. TUBITAK, Türkiye 2. CMI, Czechia 3. GUM, Poland 4. INTA, Spain 5. RISE, Sweden 6. SIQ, Slovenia	7. EMC-BCN, Spain 8. UNIGE, Italy 9. UTwente, Netherlands	n/a