Publishable Summary for 18NRM05 SupraEMI
Grid measurements of 2 kHz -150 kHz harmonics to support normative emission limits for mass-market electrical goods

Overview

The overall aim of this project is to develop new normative measurement techniques to enable regulation of interference caused by mass-market electrical products. The build-up of product emissions in the supraharmonic frequency range of 2-150 kHz, threatens to cause malfunction of other electrical products, power line communications, and critical infrastructure. Unlike other frequency ranges, the 2-150 kHz band has no effective regulation or normative measurement framework. This project has worked with standards committees to develop a new measurement framework to facilitate the setting of realistic and credible 2-150 kHz conducted interference limits and enable the regulation and compliance testing of mass-market goods.

Need

Mass-market electrical products emit interference into the grid conductors, which has been shown to cause malfunctions of other connected products, power line communications equipment and grid infrastructure. At frequencies below 2 kHz, this conducted harmonic interference has been regulated for some years by normative standards and associated compliance testing as part of the EMC (electromagnetic compatibility) directive. However, advances in electronics, and the growth of electric vehicle chargers and renewable energy, have led to increasing amount of interference at higher frequencies in the so-called “supraharmonic” range of 2-150 kHz. This interference is not regulated and its growth is now causing serious concern to utilities and product manufacturers. In 2017, this led to action from the standards community with the establishment of a working group (WG) of the Power Quality (PQ) community (International Electrotechnical Commission’s subcommittee: IEC SC77A) and the radio interference community (Comité International Spécial des Perturbations Radioélectriques: CISPR), to determine the gaps in the normative and regulatory requirements of the supraharmonic band.

One such gap is the lack of a rigorous, repeatable and acceptable measurement method, which is essential to establish a regulatory system for the 2-150 kHz range. To address this gap, IEC SC77A convened an expert task force under WG9, to establish and publish a new normative method for the main PQ measurement standard IEC 61000-4-30. This WG9 has expressed their urgent need to develop a new metrological sound method suitable for measurements in electrical power grids.

In order to develop emissions limits, compatibility levels must reflect the prevailing amount of interference that mass-market goods and grid equipment should operate without malfunction. Interference levels are presently defined taking only the laboratory testing environment into account. How well this assumption compares to real grid conditions and resulting behaviour of appliances must be confirmed. This requires measurements of real products using an artificial mains network (AMN) which are then be compared with measured emissions when the same products are connected in different electricity low voltage (LV) networks.

Emission testing of mass-market goods to ensure compliance against the limits will need to be done in the laboratory rather than the grid. This requires a realistic simulation of the grid which is achieved using an AMN. The AMN impedance characteristics are critical to ensure representative emission results. New grid impedance measurement data is needed to determine whether the AMN impedance characteristics are a realistic representation of the LV networks impedance over the full 2-150 kHz frequency range.

To enable 2-150 kHz regulation, there is a clear need to develop a measurement framework that must be robust, credible and acceptable to mass-market product manufacturers, PQ instrument manufactures, testing laboratories and grid utilities. The involvement of key WG conveners, a range of stakeholders and the close association of the project JRP Chief Stakeholder, is critical to smooth the path to timely new normative methods.

Objectives

The overall objective of the project is to develop a measurement framework for supraharmonics in the electricity network, such that realistic, credible and measurable procedures for compliance assessment can be incorporated into normative standards. The specific objectives of the project are:

1. To formulate a new normative method to measure supraharmonics (2 to 150 kHz) in electricity networks suitable for inclusion in the redefinition of IEC 61000-4-30 Edition 4, and which should be compatible with the method defined by CISPR 16, which is only appropriate for equipment emission measurements in laboratory. In addition, to implement the new method using suitable portable and traceable instrument(s) to measure voltage and current in the supraharmonic frequency range with accuracies of ≤ 1 %.
2. To validate the new method by conducting a laboratory comparison of the new method with the existing methods in IEC 61000-4-7 (2-9 kHz) and CISPR 16 (9-150 kHz) using the respective artificial mains networks (AMN) to represent the impedance of the electricity network, and examining emissions from a selection of electrical appliances.
3. To determine the suitability of supraharmonic compatibility levels (as defined in IEC 61000-2-2) by measuring the emissions from a selection of electrical appliances connected in a selection of LV networks. To use these on-site LV network measurements and to compare with the laboratory measurements to determine the suitability of the AMN approach as a realistic laboratory representation of LV network conditions.
4. To verify the applicability of the AMN characteristics by measuring network impedance characteristics of a number of typical LV electricity networks with a target uncertainty of 5 %. Measurements below 9 kHz will be used to verify the IEC 61000-4-7 AMN and measurements in the range 9 to 150 kHz will be used to verify the CISPR 16 AMN.
5. To contribute to the standards development work of the technical committees IEC SC77A WG 1, 8 and 9, and CISPR 16 by providing recommendations on improvements to supraharmonic measurement methods (4-30), and the normative specification for the AMN in-line impedances (4-7 and 2-2) as well as how these new methods should be applied to compare levels measured in the electricity network with supraharmonic compatibility levels (2-2), and ensure that the outputs of the projects are aligned with their needs, communicated to those developing the standards and to those who will use them, and in a form that can be incorporated into the standards at the earliest opportunity.

Progress beyond the state of the art

A new normative method to measure 2-150 kHz emissions in electricity network (Objective 1) and its laboratory comparison with the IEC 61000-4-7 and CISPR 16 method (Objective 2)

Developing a new emissions measurement method for IEC 61000-4-30 is not simply a case of extending the existing low frequency measurements. Whilst the metrology is reasonably well established below 2 kHz, multiple issues must be resolved related to the digital signal processing (DSP) algorithms and the practicality of a proposed solution for the 2-150 kHz frequency range. Emissions at these frequencies interact in a complex way dictated by the changing impedance of each appliance connected on the same supply. Many appliances have variable operational cycles and emissions change rapidly with time. Unfortunately, the traditional DSP methods do not deal well with fluctuating signals. Therefore, the core of this objective of the project has been to modify and develop a method that can accurately process emissions of this type. However, the proposed solutions were required to be compatible with a traditional analogue method defined by CISPR which is only useful for laboratory measurements of non-fluctuating signals. Furthermore, the 2-150 kHz range contains many resolvable frequency values, which if reported in the same way as for ≤ 2 kHz measurements, would result in 150 thousand results per second, which would be unmanageable for users. In addition, the new method must be highly efficient to compute as it must be implemented in real-time on existing instrumentation platforms. The new method needs to satisfy these conflicting issues and built-on the findings of the EMPIR project 17NRM02.

As the new method must respect the traditional CISPR 16 method, compatibility was demonstrated to gain acceptability by industry. The CISPR method looks at each frequency component in-turn, taking some time to sweep across the 2-150 kHz range, so that it can easily miss any fast-changing emissions. The new method measures all frequencies at the same time, so that it is suitable for fluctuating emissions that better represent real life signals. The project examined the differences between the CISPR and the new method, by making laboratory measurements on a collection of mass market appliances which gave interesting emissions. The results are an essential benchmark for industry to determine the difference between the methods.

Verify and improve the applicability of the AMN characteristics by electricity network emissions measurements (Objective 3) and direct electricity network impedance measurements (Objective 4)

Artificial mains networks attempt to simulate the impedance of the grid over a certain frequency range. This is important as appliance emissions, in the form of current, will only give rise to interfering voltage distortion if there is a finite source impedance. If the value of this artificial impedance is wrong compared to the grid at a given frequency, then the voltage emission will be wrong. At present, IEC 61000-4-7 defines an AMN for use in the range 2-9 kHz whilst the range 9-150 kHz is covered by a different impedance network, namely the AMN defined in CISPR 16. Furthermore, IEC 61000-4-7 considers differential mode measurements of phase-to-neutral signals, while CISPR 16 considers common mode measurements of phase-to-earth voltages. These AMN values were defined by historical impedance measurements, performed decades ago prior to the proliferation of mass-market power electronics, inverters and smart grid innovations. Some more recent work is published by IEC in the context of convertor connections.

Since it is unknown whether these AMN characteristics are representative of today’s electricity networks, the project has used the same appliances as tested in the laboratory, to retest in a selection of three different LV networks to determine cumulative emission levels and the suitability of the existing AMNs.

Following on from the laboratory measurements, it was necessary to determine the characteristics for a new AMN(s) for consideration by standards committees. This required direct measurements of the LV electricity network impedance for a range of different LV networks in order to define the AMN requirements that represent typical LV networks.

The information was verified and augmented by direct injection-based measurements of LV network impedance over the 2-150 kHz band in a variety of LV networks. This overview of network impedance characteristics can be used to propose updated AMNs to the relevant committees such as SC77A WG1 which will ensure future laboratory measurements are as realistic as possible. In addition, grid impedance measurements were developed in EMPIR SmartGrid2 (ENG52) using non-injection techniques. Whilst these techniques work at low frequency, they are not appropriate to the 2-150 kHz range due to the very low prevailing signal levels. Injection based measurements have been developed by TUD and EPV/EHU in university research projects and they have been further developed in this project.

Results

A new normative method to measure 2-150 kHz emissions in electricity network (Objective 1)

Initial work was carried out to define the key metrics of the new method (such as accuracy, time resolution and frequency resolution). A number of published algorithms were reviewed and implemented in simulation software for comparison, using the test waveforms. The performance comparison looked at the accuracy of these methods and computational performance as potential real-time solutions. The results were presented to IEC SC77A WG9 and a short list of methods has been selected for further investigation. The results were published in a peer-reviewed paper (see [4] at the end of the document).

For historical reasons and compatibility with other normative standards, WG9 had to consider the use of digital CISPR-16 (C16) methods and the so-called quasi-peak (QP) output. As the method has many algorithmic parts that can be legitimately implemented in different ways. To assess the range of possible results using all the possible compliant C16 implementation, multiple implementations were made and tested, resulting in a variation in results of some ±40 % with respect to the median value. This extent of variation shows that a reference digital implementation of C16 required that several parameters be fixed to meet the desired accuracy specification in terms of repeatability. Resulting from this work, an option for a normative digital C16 method was presented to WG9 in a form suitable for inclusion in the new standard. This was essentially an arbitrarily choice essentially creating an operationalist reference method.

Another consideration with the digital C16 method is that it requires a relatively high computational effort compared with more traditional power quality (PQ) algorithms such as the windowed Fourier method given in IEC61000-4-7. Mandating of the digital C16 method in the new standard, may render some instrumentation platforms unsuitable for future power quality instrumentation. For this reason, an alternative method was presented to WG9 which was some 20 times less computationally onerous. This method is referred to as Light-QP and is based on the IEC61000-4-7 but also provide the output required by C16. Light-QP has also been presented to WG9 in a form that can be included in an international standard. WG9 have been included both methods in a new proposed normative annex to IEC61000-4-30 in a so-called Committee Draft (CD) International Standard which was circulated to each counties national committee for comment in April 2022. Depending on the comments, it is hoped that the new standard will be published by Spring 2023.

Once a measurement algorithm was selected, it was implemented in a measuring instrument that can be used in the grid. A portable instrument was produced to perform lab and grid measurements as part of the other following JRP objectives. In the future a mass-produced instrument will be needed to make grid measurements for routine grid use.

The objective was fully achieved.

To validate the new method by conducting a laboratory comparison of the new method with the existing methods in IEC 61000-4-7 and CISPR 16 (Objective 2)

As described above, two different potential normative methods have been proposed for emission measurements between 2 and 150 kHz, namely Light-QP and digital C16. In order to assess the performance of these methods and to validate their compatibility with the traditional CISPR16 method, a laboratory comparison was made of these methods against a commercial CISPR16 receiver with associated respective artificial mains networks (AMN) to represent the impedance of the electricity network. This comparison is made by examining the emissions from a selection of electrical appliances which produce emissions.

The results of the analysis show that the two methods are in good agreement when focussing on the emission levels, although some minor differences are observed. These differences are caused by the reproducibility of the emissions of the appliances, differences in the measurement approach, differences in the measurement equipment such as the filters incorporated, and limitations due to the measurement uncertainties. Within these variations the proposed Light QP method is demonstrated to provide results in line with the C16 method. Furthermore, the Light QP method is shown to be a compatible, repeatable, and efficient real-time processing technique when implemented in a practical measurement system developed for on-site measurements.

The objective was fully achieved.

To determine the suitability of supraharmonic compatibility levels (Objective 3)

Two sets of grid measurements in Germany: one in an urban environment and one in a rural environment. Two further sets of measurements in the same industrial environment in the UK at different (electrical) distances: one next to the appliances under test, and the other one further away from them, close to the nearest distribution board. In both cases sampled values were collected and the digital C16 and Light-QP methods has been applied to the raw data.

The analysis has found an overall agreement between the results obtained in different locations and conditions, especially where high-amplitude narrowband emissions are concerned. However, some differences have been also identified in the analysis.

The CISPR 16 results have been compared with the quasi-peak values obtained using the newly developed Light-QP measurement method, obtaining very similar results which show that both methods are suitable to determine compatibility levels on the grid.

The objective was fully achieved.

To verify the applicability of the AMN characteristics by measuring network impedance characteristics of a number of typical LV electricity networks with a target uncertainty of 5 % (Objective 4)

Several measurement campaigns were carried-out in residential, commercial, industrial, and rural areas in several countries. The results in different grids, show that the great majority of the results for impedance magnitudes are lower than the normative reference impedance characteristics but show a substantial variation of measured impedance magnitudes over two decades of frequency. The results will serve as basis to initiate discussions with standards committees about a possible need for changing existing reference impedances.

The objective was fully achieved.

To contribute to the standards development work of the technical committees IEC SC77A WG 1, 8 and 9, and CISPR 16 (Objective 5)

There has been substantial engagement with IEC SC77A WG9 regarding the next version of Power Quality measurements standard IEC61000-4-30 as detailed under Objective 1. Presentations were given to WG9 every 6 months since June 2019 totalling eight meetings, including the latest meeting in February 2022. Several draft outline normative Annex for IEC61000-4-30 have been presented to WG9 with a number of options culminating in the published CD which included the digital C16 and Light-QP methods. Additionally, the conveners of IEC SC77A WG1 and WG8 and CLC SC205 are also being kept informed of the projects progress and joint briefings of WG9 and WG8 have been facilitated by the project team. These committees will make use of the new method (Objective 1) once it has been agreed by individual counties.

Recommendations on AMNs and findings informative on compatibility levels have also been sent to the conveners of the IEC SC77A WGs and CLC.

The objective was fully achieved.

Impact

A total of nine conference papers have been submitted to various events including CPEM 2020, AMPS2021, AMPS2022, CPEM 2022) and 11 open-access articles has been published in peer-reviewed journals (see the list at the end of the document) with two further manuscripts awaiting review. One paper was published for the high-profile electricity system operator conference CIRED2021 and was awarded a “best paper” prize.

An on-line mid-term workshop was held in November 2020 which was well received by the ~70 attendees, the presentations can be downloaded from the project web site. A final workshop was also held in April 2022 attending also by some 70 people. This final event presented the new methods and results obtained from lab and site measurements.

In addition, the stakeholder committee established by the project with 26 members. Regular contact via email was maintained with the Chief stakeholder including attendance at the various meetings of IEC SC77A WG9. The project website was set up and updated regularly. A highly successful three-hour tutorial workshop was held at the CIRED conference in September 2021; this conference is attended by distribution network operators throughout Europe.

Impact on industrial and other user communities

Experience has shown that imposing new regulations on large markets is fraught with political and commercial controversy. The multi-million market for electrical goods is highly competitive and small changes to product designs in order to comply with emissions limits can be hugely expensive to manufacturers in component costs and lost time to market for a new product; ultimately these costs are passed on to consumers. Yet without regulation, these same manufacturers, together with consumers, face the prospect of increased product malfunction and/or failure and/or faster product aging. In the longer term, regulation is in everybody's interest, but rigorous evidence will be needed to prove the case and primarily to agree levels at which product emission limits should be set. The measurement framework developed in this project has a key role to play in this; developing and applying it to determine the levels of emission in the power grid to which other appliances are exposed, is absolutely essential to the credibility and acceptability of new regulations and limits. The regulation of the emissions from mass-market goods should reverse the trend of increasing grid pollution and protect the quality of supply. This is essential to the following stakeholders in the following ways:

Manufacturers of mass market electrical goods and consumers: Although new regulation will bring extra costs, it will protect all appliances from emissions that can cause malfunction or failure. Reliable products are essential to consumers and are important to manufacturer's reputations. However, regulation cannot be *ad hoc* and through the rigorous, realistic and repeatable measurements that the new methods developed will bring, new compatibility levels that will be determined through grid measurement surveys. These will be the basis for a fit for purpose EMC framework protecting reliability, but not being unnecessarily burdensome.

Providers of strategic infrastructure: In the same way that domestic products can malfunction, so can the electronic equipment and control systems that make up key infrastructure. This might include hospital technology, mass transit systems and utilities. Whilst these systems are well-designed when compared to domestic products, unprecedented levels of supraharmonics could pose a threat to this infrastructure. The new EMC structure will instigate and underpin a framework of normative limit-based controls that will assure operational reliability.

Utilities, Transmission and Distribution Grid Operators: An example of the threat to key infrastructure is the power grid, which is the reluctant receipt of supraharmonic emissions. Their effects include, overheating of power transformers, catastrophic failure of the capacitor banks used to regulate the power, false operation of protection circuit breakers and interference with control signals. The JRP has already conducted some grid-based surveys of prevailing levels and more are planned in various countries working with utilities to determine whether or not they have a build-up of disturbance.

Manufacturers of power line communication (PLC) and mains signalling equipment: PLC and mains signalling use the grid wires for data transmission and for control signals, for example those used to operate smart grids. PLC intentionally emits 2-150 kHz signals into the grid, so users and manufacturers have a very strong interest in ensuring that the pollution from electronic devices does not unintentionally jam communications. In all the outputs of the project have been sent to the standards committee that oversees PLC, namely CLC SC205 to help them understand the issues for future PLC.

Electric vehicles, renewables and energy storage manufacturers – users of power convertors: These technologies are vital to CO_2 reduction and their deployment will increase rapidly in the coming decades. Power convertors are used to exchange their energy with the grid, but these electronic systems can also generate substantial supraharmonics. Power convertors are also susceptible to emissions which can interfere with the electronics whose purpose is to synchronise to the grid frequency. Testing convertors both in the lab and when deployed in large numbers on the grid (e.g. heat-pumps, EV chargers), utilities are anxious to know whether they need to plan for mitigating actions to protect the distance levels on the grid. Partners already plan some work of this sort with utilities after the end of the project.

Impact on the metrology and scientific communities

Development of a suitable new supraharmonic measurement system is scientifically challenging involving advanced DSP techniques, fluctuating signal analysis, data visualisation and complex impedance interactions. This has generated important publications where these techniques have been clearly described, in order to contribute to spread both the results of the work, and the contributions to the standards and new instrumentation. The project has developed test rigs and on-site instruments that will form the basis of new services for NMIs and calibration laboratories who will need to develop their measurement capabilities in the 2-150 kHz range. Using the new method, the test and measurement industry will need to respond with new instruments, AMNs which will be used in EMC Testing Laboratories for routine compliance assessments on mass market goods. Already instrument manufacturers have been involved in standard committees and plan to implement the new methods on their mass-produced PQ instrumentation.

Impact on relevant standards

The main objective of this project was to produce a new supraharmonic measurement method to be included in the main PQ measurement standard IEC 61000-4-30. The convener of the special IEC 77A WG9 Task Force for this method, is this project's Chief Stakeholder who has been involved in the drafting of this project and its work on the new method. This relationship has ensured a direct link to implement the projects outputs. The method has also be considered by IEC TC85 WG20 responsible for measurement equipment for grids. The new light-QP method and the digital CISPR 16 method have both been included in the CD version of IEC61000-4-30 published in April 2022.

The project has researched the suitability of the normative AMNs as used to simulate the mains in EMC laboratories. This has been reported to the IEC SC77A WG1 and CISPR/H committees and recommendations as to the suitability of the existing AMN specifications will be made to the standards committees responsible for IEC 61000-4-7 and CISPR 16-1-2. Furthermore, information on the cumulative emissions of mass-market goods in grids is essential information for SC77A WG8 who can use the results to consider the suitability of compatibility limits as dealt with in IEC 61000-2-2.

Longer-term economic, social and environmental impacts

Electronic goods and power grid systems are essential elements of the economy and social structure. Credible and fair regulation is required to ensure that these complex systems do not interfere with each other and cause malfunction. The challenge is to set the regulation limits used in to protect the infrastructure, but not overburden manufacturers and consumers with unnecessary costs. Until now, suitable measurement method for the supraharmonics has existed, so any limits are essentially an educated guess. The project has provided the long-term infrastructure to set and assess limits for mass market goods ensuring the reliable operation of products in a market worth hundreds of billions of Euros. Regulating this interference will ensure the reliable operation of smart grids and the prevent issues connecting and operating future renewable energy technologies.

List of publications

1. Measurement of 2-150 kHz Conducted Emissions in Power Networks, Ritzmann, D., Wright, P., Meyer, J., Khokhlov, V., De La Vega, D. and Fernandez, I., Proceedings of CPEM 2020, https://doi.org/10.36227/techrxiv.13536830.v1

2 “Comparison of Measurement Methods for 2-150 kHz Conducted Emissions in Power Networks”, Deborah Ritzmann, Stefano Lodetti, David De La Vega, Victor Khokhlov, Alexander Gallarreta, Paul Wright, Jan Meyer, Igor Fernández and Dimitrij Klingbeil, IEEE Transactions on Instrumentation and Measurement, Early Access, Nov. 2020, https://doi.org/10.1109/TIM.2020.3039302

3 “A Digital Heterodyne 2 kHz to 150 kHz Measurement Method based on Multi Resolution Analysis”, Paul Wright and Deborah Ritzmann, IEEE Transactions on Instrumentation and Measurement, Early Access, Nov. 2020, https://doi.org/10.1109/TIM.2020.3038290

4 “Traceable measurements of harmonic (2 to 150) kHz emissions in smart grids: uncertainty calculation”, Daniela Istrate, Deepak Amaripadath, Etienne Toutain, Robin Roche, and Fei Gao, Journal of Sensors and Sensor Systems, Vol.9, Issue 2, November 2020, https://doi.org/10.5194/jsss-9-375-2020

5 "The Role of Supply Conditions on the Measurement of High-Frequency Emissions", Adam J. Collin, Antonio Delle Femine, Carmine Landi, Roberto Langella, Mario Luiso and, Alfredo Testa, IEEE Transactions on Instrumentation and Measurement, Volume: 69, Issue: 9, Sept. 2020, https://doi.org/10.1109/TIM.2020.2992824

6. A Digital Heterodyne 2-150 kHz Measurement Method, P.S. Wright and D. Ritzmann, Proceedings of CPEM 2020,https://doi.org/10.36227/techrxiv.13525592.v1

7. "Comparison of Measurement Methods for the Frequency Range 2–150 kHz (Supraharmonics) Based on the Present Standards Framework", Victor Khokhlov, Jan Meyer, Anne Grevener, Tatiano Busatto, Sarah Rönnberg, IEEE Access Vol.8, Page(s): 77618 - 77630 , April 2020, https://doi.org/10.1109/ACCESS.2020.2987996

8. V. Khokhlov, J. Meyer, D. Ritzmann, S. Lodetti, P. S. Wright and D. de la Vega, "Application of Measurement Methods for the Frequency Range 2-150 kHz to Long-term Measurements in Public Low Voltage Networks," *CIRED* 2021, pp. 850-854, https://doi.org/10.1049/icp.2021.2114

9. G. Frigo and J. Braun, "Supraharmonic Dynamic Phasors: Estimation of Time-Varying Emissions," in *IEEE Transactions on Instrumentation and Measurement*, vol. 71, pp. 1-11, 2022, Art no. 1501611, https://doi.org/10.1109/TIM.2022.3166806.

10. Frigo, Guglielmo. 2022. "Measurement of Conducted Supraharmonic Emissions: Quasi-Peak Detection and Filter Bandwidth" *Metrology* 2, no. 2: 161-179. https://doi.org/10.3390/metrology2020011.

11. G. Frigo, "Taylor-Fourier Multifrequency Model for Supra-Harmonic Identification and Estimation," *2021 IEEE 11th International Workshop on Applied Measurements for Power Systems (AMPS)*, 2021, pp. 1-6, https://doi.org/10.1109/AMPS50177.2021.9586035.

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

<table>
<tr><td colspan="2">Project start date and duration:</td><td>1 May 2019, 36 months</td></tr>
<tr><td colspan="3">Coordinator: Paul Wright, NPL   Tel: +44 20 8943 6367   E-mail: paul.wright@npl.co.uk
Project website address: http://empir.npl.co.uk/supraemi/</td></tr>
<tr><td colspan="2">Chief Stakeholder Organisation:
IEC77A WG9 Task Force for the redefinition of Annex C of IEC61000-4-30 (Power Quality Measurements)</td><td>Chief Stakeholder Contact:
Michael Schwenke (IEC SC77A WG9, Head of TF Supraharmonics)</td></tr>
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1. NPL, United Kingdom
2. LNE, France
3. VSL, Netherlands</td><td>External Funded Partners:
4. TUD, Germany</td><td>Unfunded Partners:
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6. SUN, Italy
7. UPV/EHU, Spain</td></tr>
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