MISMATCH IN ELECTROMAGNETIC COMPATIBILITY STANDARDS AND REGULATIONS

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ABSTRACT

SINTEF Energy Research has been involved in cases where there have been problems with electromagnetic compatibility due to either lack of compliance to standards, or a lack of coordination between different standards. By looking at some of the cases, suggestions for revising product standards, power quality regulations and CE-marking process are proposed, and discussed.

INTRODUCTION

For electrical appliances to function properly, there must be acceptable power quality where the appliance is used, and the immunity level of the appliance must be high enough for the appliance to function with the acceptable power quality. When these requirements are satisfied there is electromagnetic compatibility (EMC). In order to ensure EMC there are standards and regulations that specify the required levels of power quality in the power system, and appliance immunity and emission levels.

The norm that regulates power quality requirements in the power system in EU is EN 50160 "Voltage characteristics of electricity supplied by public electricity networks", which was published for the first time in 1994 as a response to the EMC directive in 1989 [1]. The EMC directive was updated in 2004 and 2014 [2]. The Norwegian regulation “Regulation relating to the quality of supply in the Norwegian power system” (FoL) entered into force in 2005, and ensures compliance to EN 50160 [3]. EN 50160 and power quality regulations that ensures compliance to this norm are enforced by national regulators, which in Norway is the Norwegian Water Resources end Energy Directorate (NVE).

CE marking of appliances has been used since 1995 to show that an appliance is complying with relevant directives such as the European EMC directive and Low Voltage directive [4]. It is used on products sold or produced in the EU. In order to ensure compliance with the relevant directives, harmonized standards can be used. This is a voluntary arrangement that help companies comply with regulations, unless compliance to specific standards is required by the regulation. Such standards include IECs 61000 series, where part 3 provides limits for immunity and emission, and part 6 provides generic limits [5].

There always has to be a balance between requirements for power quality, and requirements for immunity and emission levels, as high power quality, and strict emission and immunity limits both require significant costs for different parties. Compatibility levels are set so that they ensure compatibility for most, but not all situations [6]. In order for EMC standards to be effective, they need to be harmonized with relevant regulations, the compatibility level must be coordinated across different standards, and the requirements in regulation must be enforced by relevant legal bodies. Ensuring compliance to harmonized EMC standards and regulations is important both to provide consumer protection and to avoid conflicts between utilities, consumers and appliance producers.

EXAMPLES OF MISMATCHES

While working with power quality research and power quality troubleshooting, SINTEF Energy Research has registered cases where there were problems with EMC that should have been prevented by regulations. Some of the experiences are listed in this chapter.

Appliance immunity and acceptable emission

In one case, several customers over a large area were experiencing problems with a large range of appliances while the supply voltage was within the levels specified in FoL (and EN 50160). The cause of the problems was harmonic- and interharmonic voltages causing electronic control systems in lighting equipment, induction cooktops, electronically controlled thermostats, and other equipment to malfunction. The source of the harmonic- and interharmonic voltages seems to be a prototype wind turbine quite far from the affected customers. Figure 1 and 2 shows how the harmonic- and interharmonic voltages vary when the wind turbine is producing max power and when it is disconnected. The measurements are performed with Elspec Ltd Blackbox instruments.

Figure 1: Harmonic- and interharmonic voltages when the wind turbine is disconnected. The highest value is from the 5. harmonic voltage.

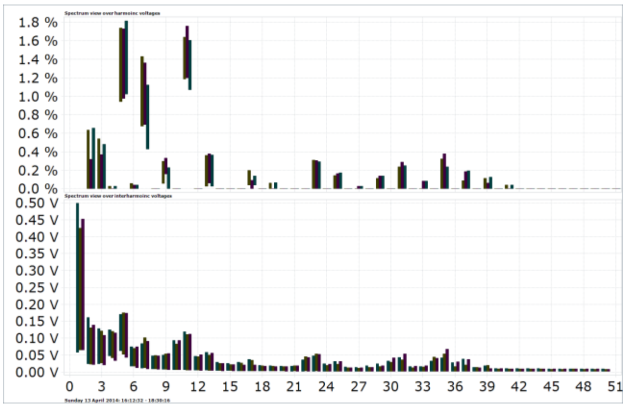

Figure 2: Harmonic- and interharmonic voltages when the wind turbine is producing maximum power. High values of the 5., 7. and 11. harmonic voltages, enlarged values around the 6*n interharmonic voltages.

The relevant DSO however, has limited legal rights to disconnect the turbine from the grid as the Norwegian power quality regulation at the connection point is not violated. It is not known whether the immunity levels for the appliances are set to low, whether the malfunctioning appliances did not comply with the immunity levels they are required to uphold, or if the emission levels are too high to be accepted.

CE approval

In another case an appliance caused larger disturbance in the supply voltage than permitted, even when the supply was stronger than a grid with the IEC reference impedance [7]. The appliance was a 230 V one phase 1.5 kW log splitter. The log splitter had a safety mechanism implemented with a button and a handle located with a distance in between such that both hands of the operator will be in safe distance from harm in order for the machine to operate. However, this also meant the machine had to stop and start for each time a piece of wood was chopped, and due to the high starting current from the directly started asynchronous motor the resulting flicker values was above the limits in FoL and EN 50160 when used for a longer period of time. When tested, the P_{st} value was 1.8, which is above the limits in the Norwegian regulation. The test results are shown in figure 3 which shows RMS voltage and P_{st} values for all three phases on the connection point of the installation where the test was carried out.

It might be that the log splitter had a lot fewer start stop cycles before an upgraded safety feature was introduced, and therefore lower flicker values, but when the additional safety feature was added the appliance was probably not emission tested again. It is the appliance producer's responsibility to ensure that their appliances comply with all relevant standards and regulations through testing, but it seems not all available appliances are sufficiently tested with regard to electromagnetic emission.

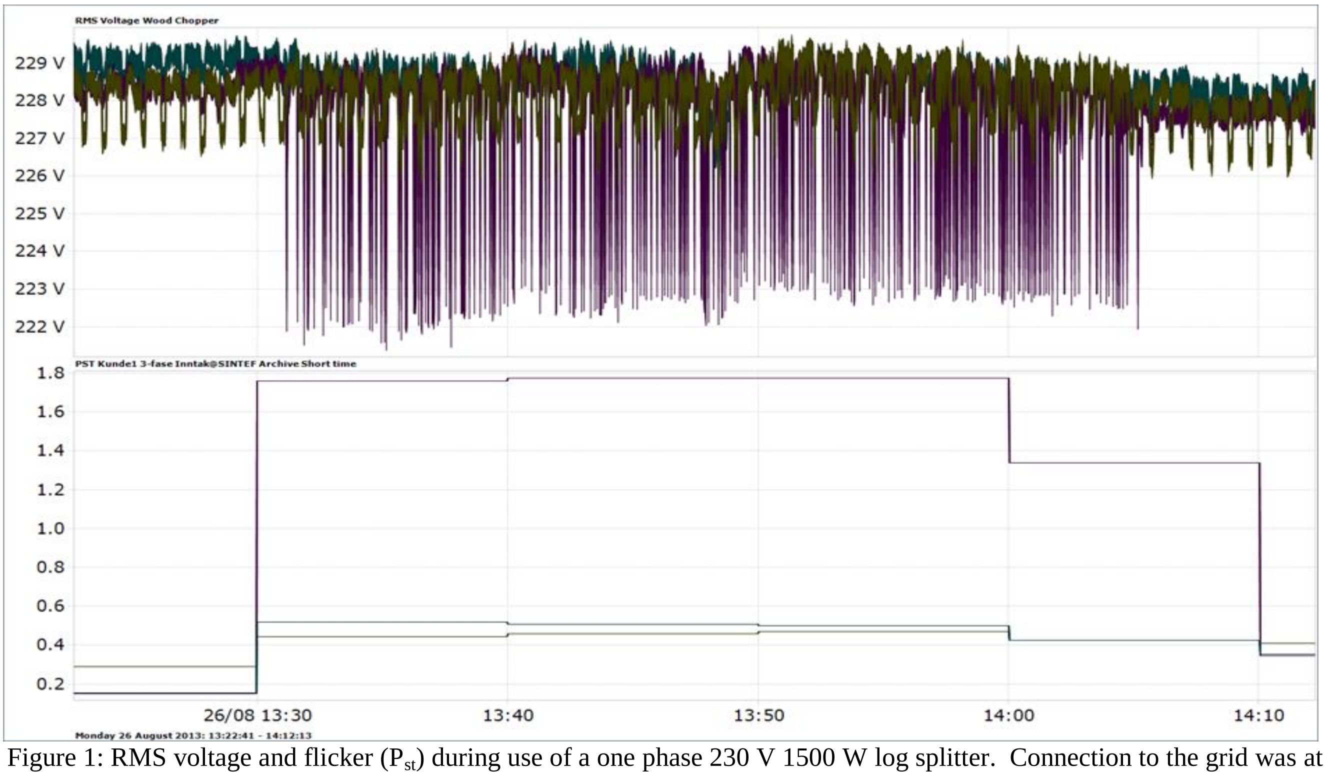

Figure 1: RMS voltage and flicker (P_{st}) during use of a one phase 230 V 1500 W log splitter. Connection to the grid was at a point with network impedance lower than the reference impedance.

Coordination between standards

An example of missing coordination between standards can be found in the testing requirements for fluorescent lights, which are endurance tested up to 230 V +6 % [4]. EN 50160 allows voltage levels on the connection point of an installation to be ±10 % of 230 V, which also is the testing level for many other electric appliances. A possible reason for the + 6 % limit is that voltages up to 230 V +10 % can result in high temperatures in the lamp.

Appliances are generally tested for 230 V ±10 %, but EN 50160 specifies that the voltage at the connection point of the installation should be ±10 % of 230 V. Inside the installation one can expect a voltage drop of up to 4 % meaning the appliance can be connected to a supply voltage of 230 V -14 %. Furthermore, the requirements for slow voltage variations in EN 50160 is specified as a 10 minute average, while shorter periods of over voltages might damage the equipment as they typically are tested for a stable supply voltage only. FoL is somewhat stricter than EN 50160, and requires that measurements for compliance with 230 V ±10 % is measured as 1 minute averages. There is however still a gap between a 1 minute average of a varying voltage and a constant/stable laboratory supply for testing of appliances. The Swedish power quality regulation has limitations on the types of dips appliances should be able to withstand, and which dips the DSO is responsible for preventing in their network [8]. This contributes to decrease the gap between power quality regulations, and product immunity and testing standards.

REQUIRED REVISION OF CURRENT STANDARDS AND REGULATIONS

The compatibility level for EMC defined as the level of which 95 % of the registered disturbances must not be exceeded when measured in the entire network [6]. The emission limit for individual appliances is set lower than this to account for aggregation of several sources. In order to have EMC, an immunity level must be set that satisfies the criterion that 95 % of the immunity levels must exceed the compatibility limit. This is illustrated in figure 4. The figure shows the measured emission in the network, or disturbance level (DL), the compatibility limit and the equipment immunity level, or equipment compatibility level (CL). E and I denote the immunity and emission limits set by standards to ensure EMC. The planning level (PL) is used by individual utilities to achieve some margin to the compatibility level. EMC is planned so that 5 % of the appliances will malfunction when the supply voltage has a disturbance level equal to the compatibility level (CL), and 5 % of the places measured in the network will have higher emission levels than the compatibility level (CL).

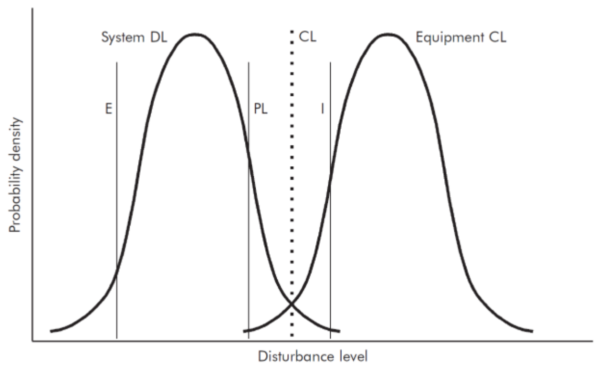

Figure 4: Explanation of the principle behind EMC [6]

When considering the requirements for EMC and the findings in the previous section indicate that there for the system as a whole there is electromagnetic interference (EMI), rather than EMC. This is due to missing coordination between compatibility levels in power quality regulations, immunity limits in product standards, and inadequate appliance testing or possibly even deliberate violation of the rules. These issues can be resolved by revising regulations and or product standards as explained in the next three subsections.

Possible changes in product standards

- Immunity limits and testing procedures should be updated for those appliances that do not comply with the general immunity limits for consumer electronics, such as instance fluorescent lighting.
- Either testing procedures should reflect that supply voltage can vary significantly within a 10 minute period, or power quality regulations should apply for a shorter averaging period.
- Testing procedures and immunity limits should be lower than 230 V – 10 %, or power quality regulations should reflect that voltage on the appliance's terminal is lower than on the connection point.
- Immunity limits and testing procedures for harmonic- and interharmonic voltages should be defined that meets the requirements for EMC when considering both current, and expected future harmonic levels in the power system. This applies for instance to IEC 61000-4-13 and IEC 61000-6-1 that regulates testing of harmonic- and interharmonic voltages and immunity levels for appliances to be used in commercial environments [10,11].

Possible changes in power quality regulations

- Compatibility levels for harmonic- and interharmonic voltages should be set to reflect the observed immunity level for appliances in the power system today. EN 50160 currently has no limitations on interharmonic voltages, and no limitations on harmonic voltages above the 25. . Although the effects of interharmonic voltages are still not well understood, there are available limitations on harmonic voltages in IEC 61000-3-6 [12].

- If testing procedures are to be carried out with constant voltage, then power quality regulations should preferably apply for a shorter averaging period than 10 minutes or with another set of limit values for short duration voltages (primarily over voltages).
- If testing procedures and immunity limits apply for minimum 230 V – 10 %, then power quality regulations should reflect that voltage on the appliance's terminal is lower than on the connection point.
- Acceptable levels of voltage dips could be defined in FoL and EN 50160, similarly to the Swedish regulation.

Possible changes in CE approval process

- Clearer guidelines as to how testing is to be carried out, specifically the requirement to test appliances if significant changes has been made.
- Check compliance to testing requirements, e.g. by taking control samples and reminding and educating producers about requirements.

SELECTING THE PROPER SOLUTIONS

It seems that a challenge related to EMC is coordinating different standards, often made by different standardization bodies. This could be solved by organizing workshops with different standardization bodies and performing state of the art comparisons of standards within similar topics.

When standards are not harmonized, it is often disadvantageous for at least one party to change the requirements in a standard. For instance, if immunity requirements are increased in order to achieve EMC, the cost of production might increase. Setting immunity-, compatibility- and emission levels must therefore be coordinated so that both EMC is achieved and costs are distributed fairly. This being said, compatibility levels are in theory set according to existing emission levels in the network, and the immunity limits should be set according to this compatibility level. It seems therefore that the requirements in product standards should be revised according to the emission which is registered in the power system today. This includes immunity levels for harmonic voltages, acceptable RMS supply voltage, and variations in supply voltage. Harmonic voltages is an important parameter to address, as the harmonic content in the power system can be expected to increase as the use of power electronics is increasing. This should also be reflected in emission limits, as the amount of harmonic content could increase as the number of sources emitting harmonic voltages increase. To some extent this process is automatically regulated by the market, as most producers do not wish to sell appliances that malfunction to consumers that can easily complain and switch to a different manufacturer in the future [6].

Power quality regulations should also be tightened up in terms of allowable voltage variations. Voltage variations that appliances cannot withstand, unless production cost is increased significantly, should be avoided under normal operation/conditions. This concerns voltage dips, in part, and supply voltage variations in particular. The compatibility level could be determined by examining equipment withstand capabilities, and examining other power quality regulations that has already included limitations on dips or has shorter averaging time for supply voltage variations, such as the Swedish and Norwegian regulations respectively.

Addressing the CE approval process has some challenges in terms of costs and efficiency. If a control regime is to be implemented, then this increases costs for the producer and the regulating body, and the product design process become a little more time consuming and complicated.

Finally, the purpose of EMC is not that all appliances function properly in every setting, which would require large costs. Compatibility levels and emission- and immunity limits should rather be set so that most appliances function in most settings, and that costs are distributed fairly while providing adequate consumer protection.

CONCLUSION

Power quality cases SINTEF has been involved in have shown that there is a mismatch and lack of coordination between different EMC standards and regulations. This concerns appliance immunity limits compared to emission levels in the power system, immunity limits compared to the compatibility level in power quality regulations, and compliance to immunity limits and CE testing. Ensuring harmonized EMC standards and regulations is important to provide consumer protection and avoiding conflicts between utilities, consumers and producers. Relevant standardization groups and regulators should therefore revise the some of the current standards and regulations to coordinate compatibility levels, and immunity- and emission limits.

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