energies

Editorial

Power Conditioning and Power Protection for Electronic Systems

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1. Introduction

Electrical energy is the most convenient form of energy, and modern society takes it for granted that it is always available by our side. We have a legacy AC power grid where systems were historically developed based on the assumption that electricity is generated in bulk at far-away sites from our cities and neighbourhoods. Nationwide AC transmission and distribution networks use the advantages of line frequency transformers for voltage conversions with 'adequate' efficiency.

Given the distributed nature of these AC power networks, with many long-distance high-voltage transmission lines and electrical substations distributed over wider geographical regions, they are naturally exposed to acts of God, such as extreme weather events and lightning strikes. Furthermore, with the increasing complexity of the power networks, complex control systems are utilized at network substations, which could occasionally have accidental failures due to system reliability issues or human errors. The overall effect is that these unexpected random events could create power quality issues and systemic issues such as overloading and sudden load shedding. This usually results in several categories of power quality issues, such as:

- Over-voltages (swells) and under-voltages (sags) with variations of root mean square (RMS) voltage beyond the specified limits;
- Brown out conditions, where RMS voltage drops below standard values for longer periods of time;
- Short-term or longer-term blackout conditions where electrical supply is completely disconnected
- Harmonic components of the line frequency exceeding specified standards;
- Short-term high-voltage spikes of fractional cycle time, usually in the range of a few tens of microseconds to milliseconds, superimposed on the line frequency AC waveform;
- Frequency deviations;
- Power factor and unbalanced issues;
- Flicker.

Figure 1 depicts these power quality issues from the perspective of a power generation and distribution company. The most important aspect of these power quality issues is that the end users cannot predict these with adequate notice to correct them or protect their electrical systems from the damaging issues related to these random occurrences.

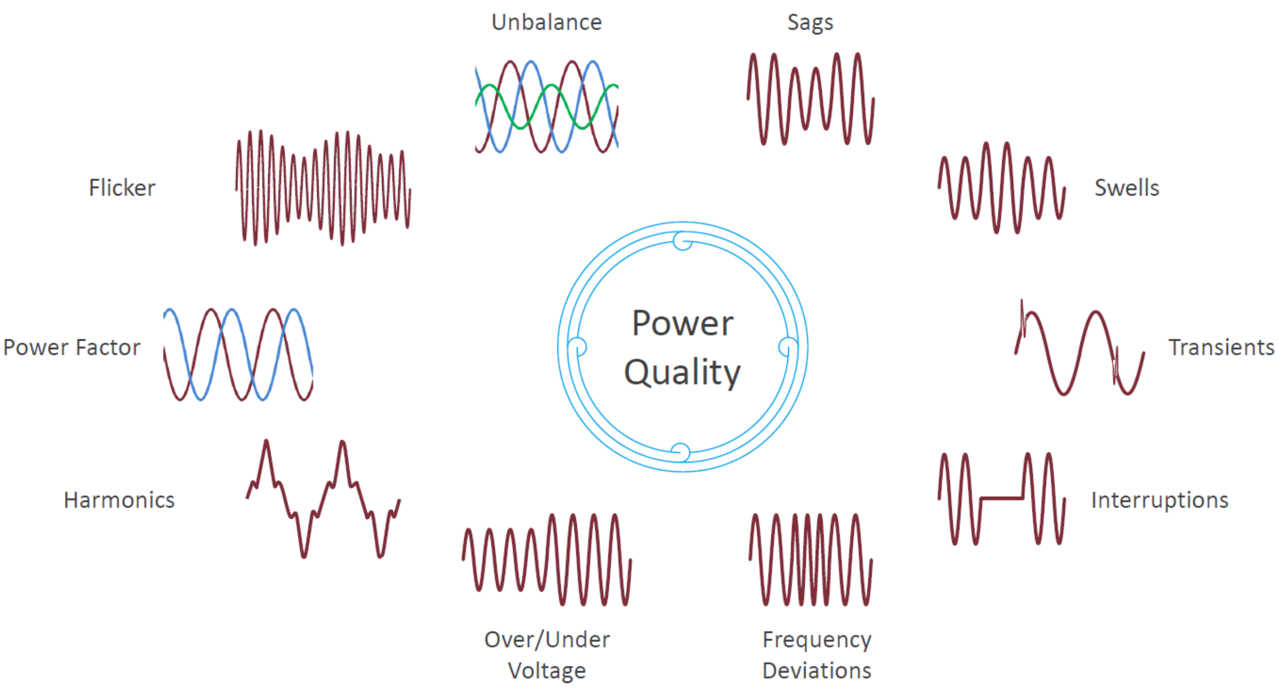

Figure 1. Power Quality from the viewpoint of a power generation and transmission company (Source: Transpower New Zealand).

2. Modern Appliances Such as Infotainment Systems, White Goods, and LED Lighting

The older generations of electrical systems (before the 1970s) were dominated by AC operable electrical loads, such as incandescent lamps, induction motors, synchronous motors, and ohmic heating systems.

Modern systems are dominated by electronic converter systems such as AC–DC converters, DC–DC converters, and DC–AC converters (inverters). These distributed power electronic building blocks are powered by precisely regulated low-voltage DC power rails, and, medium-voltage DC buses such as 160 V DC to over 400 V DC rails powering higher power systems such as brushless DC motors.

Figure 2 depicts the differences between linear DC power supplies in the 1960s and 1970s and the modern switch-mode power supplies with complex converter stages, power factor correction, and supervisory blocks. As Figure 2a depicts, the isolation transformer at the front end of the older linear DC power supplies was a natural buffer against short-term high-voltage transient surges [1].

However, in the modern switch-mode converters, as depicted by Figure 2b, line frequency AC waveform is directly rectified and applied to the high-frequency DC–DC converters with power factor correction function, which creates a quite complex circuit block, which can be seriously affected by power quality issues. Common mode transients that could induce between live or neutral and the earth terminal of the AC power input could be quite disastrous to power semiconductors as well as control integrated circuits [1].

In the modern scenario of IOT and electronics, complex integrated circuits, progressing towards system-on-a-chip (SoC) concepts, are powered by DC power rails as low as 1.2–0.7 V. Complex power conversion interfaces are used to power these systems from our central AC supply or a renewable resource on-site. Whichever the energy supply, these complex electronic products with processors, memories, and complex software algorithms are notably sensitive to power quality issues.

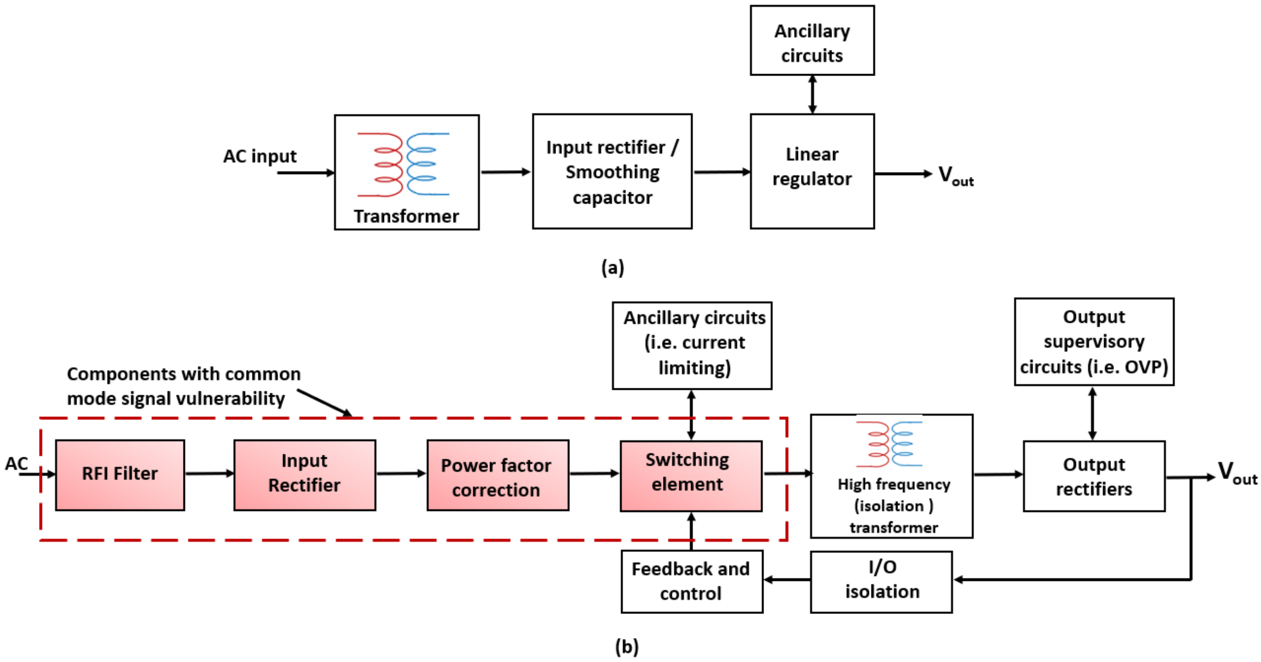

Figure 2. Comparison of linear power supplies and modern SMPS: (**a**) simple linear power supply with an isolation transformer (**b**) modern off-the-line switching power supply and its components vulnerable to power quality issues such as swells, sags, and transient over-voltages.

Given the three specific scenarios summarised so far, namely (i) AC power network does not guarantee power quality, (ii) state-of-the-art electronic systems carry complex power converters with many semiconductors, and (iii) complex electronic modules with semiconductor parts with with very small feature size transistors, to safeguard the electronics from power quality issues, both energy companies and product designers should be aware of the power quality issues and how to mitigate them.

Renewable Energy Systems

With the worldwide interest in reducing non-renewable energy resources, solar and wind systems proliferate everywhere. The moment a DC power-based renewable energy resource is connected to the AC grid via a power conversion interface, more sophisticated electronic systems become connected at the AC electricity supply point of a residential or commercial building. Conversion systems within this interface have much more complex power converter units with maximum power point tracking [2]. In addition, the solar and wind generator units exposed to an open environment are vulnerable to acts of God and extreme weather events, safeguarding against power quality issues is an important design requirement.

3. Contributions by the Special Issue Papers

The *Energies* Special Issue on *Power Conditioning and Power Protection for Electronic Systems* has selected five papers for publication. The first paper by Jason David et al. [3] discusses how sustained over-voltages can impact the age of electronic components in the power conversion stages by analyzing its effects on capacitors used in the AC–DC conversion stages.

The second paper by Sadeeshwara Silva et al. [4] discusses the application of air-gaped ferrite cores in a relatively novel transient surge protection technique, now known as supercapacitor assisted surge absorber (SCASA) [5], which was commercialized by Thor Technologies, Australia, based on a granted US patent [5]. Additionally, the paper by Fernando et al. [6] shows how small-sized supercapacitors in the range of a few Farads could be at the heart of this SCASA technique, where repeated transient surges with peak voltages up to 6.6 kV can be safely absorbed, even though supercapacitors have DC voltage ratings of less than 3 V. This SCASA technique is based on a new theoretical concept now identified as supercapacitor-assisted loss management (SCALoM) [7]

The third publication by Hong-Keun Ji et al. [8] discusses how the detection of DC series arcs could help prevent fires on ships. This was based on a study conducted concerning accidents in ships. The fourth paper [9] by the same lead author summarises the study related to AC system arcs. It demonstrates how a phase analysis was performed using the PRSA analysis method to detect series arc signals and identify types of loads when series arc faults occur.

The last paper in the collection, with the principal authorship of Sung-Wook Kim [10], provides a detailed discussion on metal oxide varistor (MOV) deterioration under energised conditions. The information summarised in the article evidences that under energised conditions, any MOV could become deteriorated due to third harmonic component of the AC waveform. Given that MOVs are universally used in transient surge protection systems [1], including the new SCASA technique [5], this encourages the detailed study of the deterioration behaviour of MOVs under energised conditions.

4. Conclusions

In summary, this Special Issue of *Energies* and its articles offer new additions to our knowledge of power conditions and protection. We encourage researchers to submit more articles to the next Special Issue under the same primary topic.

Conflicts of Interest: The authors declare no conflict of interest.

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