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Supraharmonics in the Electric Power Grid: Detection and Measurement in Textile Industry

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***Abstract:*.**
Solar and wind energy technologies, as well as smart grids, have gotten a lot of attention lately in the electric power distribution system. With the help of power electronics equipment, it is possible to convert energy from natural power sources into electrical power. The electronics technologies have resulted in the discovery of new emissions that occur between frequency 2 and 150 kHz, which is outside of the conventional power quality frequency range. Supraharmonics is the term used to describe these emissions, which are found all over the planet (SH). As a result, these emissions have a significant negative influence on the power quality and lifespan of the electrical distribution system. In the textile business, inverters are used to modernise the machines in accordance with the process requirements. In the home, inverters are being used in air conditioners, refrigerators, and ceiling fans to reduce power usage. In addition, solar panels are becoming increasingly popular as a means of transitioning to a more environmentally friendly energy source, with inverters being used to convert the DC voltage to the alternating current. Due to these factors, conductive emission occurs in the frequency range of 2kHz to 150kHz, which is referred to as Supraharmonics. Interference sources, victims, and consequences are addressed in detail.
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***Key words*: Harmonics, EMI, Supra Harmonics, 2.5 to 150 kHz.**

I. Introduction

Grids are changing due to (1) increased incorporation of sustainable power sources including solar photovoltaic and wind power, (2) the electrification of automobiles demanding battery recharging techniques, (3) the approaching decentralized energy management trend and (4) the use of electrical machines. Power electronics offers the technological solutions to CO2 challenges listed above. All of these new technologies contribute to grid concerns by generating emissions in the conventional power quality frequency band of 0–2 kHz..

Supraharmonics are a distinct sort of emission that happens between 2 and 150 kHz and can be distinguished from other types of emission. Several power converters, including rectifiers diode, dc to dc converters, Inverters, are used extensively in these technologies. Their integration into power networks results in serious power quality issues, notably with regard to sulphur dioxide emissions. Changing Harmonic Emission levels are a relatively new occurrence in the electrical grid that is associated with the use of renewable energy sources such as solar and wind. Furthermore, the SH emission range is significantly depend on the quantity of power electronics equipment connected to a power grid [1]. As more renewable energy sources are integrated into the electricity system, SH emissions are injected. So, in recent years, several studies have been carried out to identify, measure, and minimise this new high-frequency phenomenon [2]. Recently, many problems like as household equipment failures, capacitor overheating, and electromagnetic incompatibility have been reported due to strong SH emission. As a result of increased thermal stress induced by SH emissions, the life of electrical appliances is reduced.

A growing number of fully automated processes necessitates power electronic devices

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like variable frequency drives and servo drives. However, by emitting in the 0–2 kHz range, these new technologies cause grid issues. Supraharmonic emissions (between 2–150 kHz) have also emerged as power electronics converter switching frequencies increase to produce more compact and efficient equipment. All these technologies rely on power converters such as inverters and rectifiers. Integration into electrical grids causes significant power quality issues, particularly supraharmonic emission.

Pollution and noise have caused a labour shortage in the textile industry. Because the textile industry is nonstop, technicians must maintain their power electrical devices. If any of the gadgets fail, substantial profits are lost. Thus, the technician must take all precautions to avoid component failure. Technicians currently know about 0-2kHz harmonics and their mitigation, but not supraharmonics. Supraharmonics research and study is now popular in research institutes. The textile mill's main goal is to turn cotton into yarn, a six-stage process. These are discussed briefly for benefit of understanding. Textile mills are classified as card, combed, and ring spun. The card sliver system cleans raw cotton and card it into thick yarn (sliver). It has draw frame and comber machines to ensure consistent sliver thickness and remove short fibres. This method of turning sliver into yarn utilises speed frames and ring frames (thin thread).

The definition of Supraharmonics is highlighted in this study. The findings of a practical experiment done in textile mills are discussed in this paper.

II. SUPRAHARMONICS

The harmonics were in the range of 0–2 kHz in frequency. Many modern gadgets, particularly those powered by renewable energy (RE), raise worries about high levels of noise exceeding 2 kHz, which is a concern for many people. All kind of current and voltage waveforms disruption occurring between the spectrum range of 2 to 150 kHz is referred to as SH [12], and it is used to depict this distortion. When electronic switching technologies slice the voltage sinusoidal waveform between the cutoff and conducting states, they generate extremely large harmonics such as SH. Circuits such as inverter circuits, for example, are known to produce harmonics. Electrical device breakdown, especially touchscreen technologies, mechanical resonant frequency noise, and thermal expansion stress are all possible consequences of these massive harmonics, which might shorten the equipment's lifespan. PLCs and power-electronic converters [14] are the most significant producers of SH on the grid. To understand SH creation, it is necessary to first understand harmonics. When dealing with constant loads, the voltage quality has an impact on the demand current, which in turn has an impact on the utility grid. The voltage waveform deviation results in a current waveform deviation, which in turn induces the voltage waveform to be affected [15]. Even though the input voltage is virtually sinusoidal, the load consumes a disordered amount of current. As a result, a sine input voltage results in a quasi-load voltage if applied.

Fortunately, modern power-electronic technology, such as controlled power supplies and energy transformation devices, has brought the problem back to life. Switched mode power supply (SMPS) have progressed from using transformers operating at 50 or 60 Hz to adopting high frequency transformers. Apart from the magnetic flux current, which is negligible when compared to the practically sinusoidal load current, transformers were essentially linear devices. SCRs with non-sinusoidal characteristics are extensively used in modern power supplies. As a result, Fourier analysis detects its waveform as a frequency range of fundamental frequencies and harmonic components. Every time the current distortion is measured, it is discovered that the voltage deformation at some of these frequencies is the maximum [12] and [18]. A significant amount of influence is exerted on power systems by the harmonic content of such non - sinusoidal current waveform. As a result of the high frequency operation of power electronics interface converters, they produce increased harmonic distortions [19–21]. Because there is less iron core, there is less weight, mass, and expenditure. The disruption of frequencies that are higher than the low-frequency harmonic spectrum receives very little attention in the scientific community. This was most likely due to low levels of disruption in previous years.

III. SUPRAHARMONIC IMPLICATIONS AND CHARACTERISTICS

SH has recently gained increased attention [21] because of the potential impact on other networked devices. Increased capacitive current may damage the power supply, will result in increased safety hazards because of the use of the SH. In addition, it may consequence in (a) obvious faults through sense of touch technician modules and lightbulb duller, (b) decrease the operating period of Lighting systems, (c) contact errors (PLC communication systems), (d) getting too hot of transformers and static var compensators, (f) failure of safety protection equipment, (g) failure of

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communication among smart meters, and (h) malfunction of household components, medical equipment, and surveillance systems, as well as road transport controls.. Additionally, the SH distortions generated by non - linear loads would result in significant energy wastage, which would have a severe influence on electricity transmission systems and their components. Furthermore, it has been demonstrated that SH has an impact on network instability in poorly built networks with hybrid renewable energy inverters, resulting in bogus inverter activation [4] and [21] in badly designed networks with renewable energy system inverters. Unless the dangers of SH are identified and addressed, it is reasonable to believe that they are potentially harmful.

The desire to improve power-factor and reduce harmonic interference in inverter at low-frequency output current used in grid connected equipment has resulted in an increase in SH emissions [21]. In this case, the Supraharmonics is created by the power electronic switches of IGBT switching frequency of the inverter and can be exported to the grid. If the inverter does not function or does not provide output, the unit is classified as a SH basin [22]. The main grid's RE sources, which use inverters as output interfaces, have the potential to generate significant Supraharmonics. A current is driven by two driving forces that are generated by a connection between an inverter and the grid, as depicted in Figure 1. Primary emission is a quantity of the current generated by power electronics or any other electrical equipment that is either ordinary or supraharmonic in nature. Secondary emission, on the other hand, is a regular or supraharmonic portion of current caused by sources external to the device (e.g., from a power source).

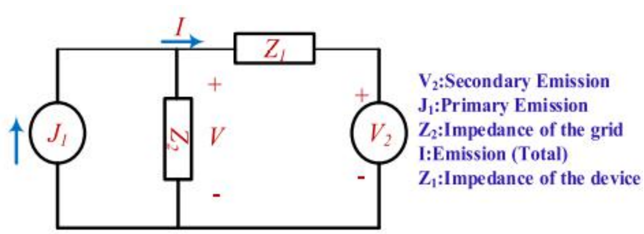

Fig 1: Equivalent circuit for emission of primary & secondary

IV. THE ANALYSIS OF SUPRAHARMONICS BASED ON REAL-TIME MEASUREMENTS

SH is conducted in a textile mill in Tamilnadu, India, where the Supraharmonics measurements are taken. Even though there are numerous PQ measuring devices available on the market today, the manufacturer Powerside https://powerside.com is developing the PQube 3 metre, which measures the Supraharmonics in the power quality frequency band between 2.5 and 150 kHz to quantify the power quality frequency band. This instrument has been approved for Class A PQ permitting in accordance with IEC 61000-4-30 [2]. Dranetz also manufactures the PQ metre, which is used to measure harmonics (https://www.dranetz.com). However, it is possible that another manufacturer has that feature, which will be investigated further. The Pqube 3 metre has been installed in the Textile mill for the purpose of collecting data for the study. At the textile mill, the instrument is fixed on a weekly basis, for a total of one week. Every one second, the data is gathered, and it captures every power quality event that occurs. Figure 2 depicts a single line diagram of load sharing and the capability of the shared load system.

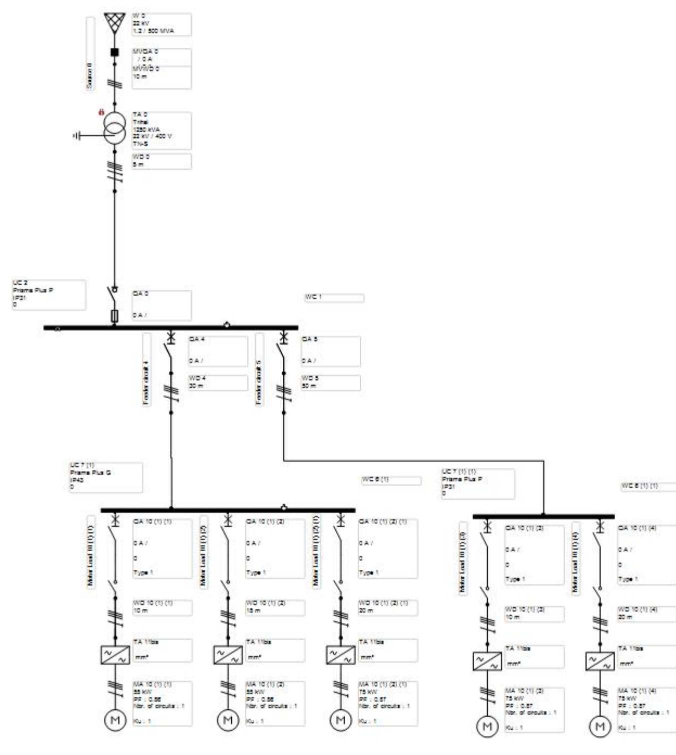

Fig 2: Power line diagram of Textile mill.

The industry's sanctioned demand for electricity at this location is 1250 KVA, according to the utility. There are nonlinear loads on the machines, which are fed by a frequency converter that provides power to the motors. The total installed power of a single machine ranges between 45kW and 55 kW, depending on the model. The Pqube 3 meter is linked to the load side, and data is collected for a period of one week in continuous operation. The data is collected on a day-to-day

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basis. The Supraharmonics level is observed in different frequency spectrums, and the voltage peak at 2kHz is measured to be 30 Vpk.

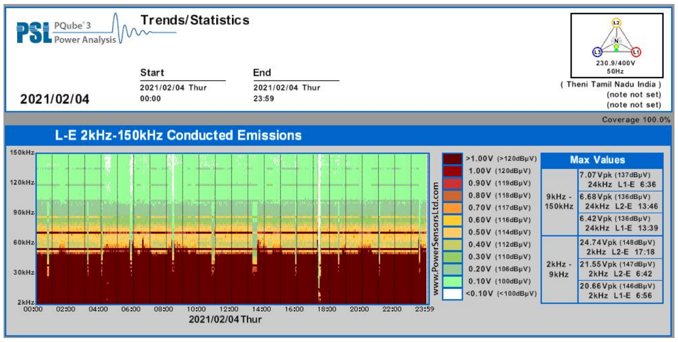

Fig 3: Real time graph on Supraharmonics taken through Pqube meter for one day.

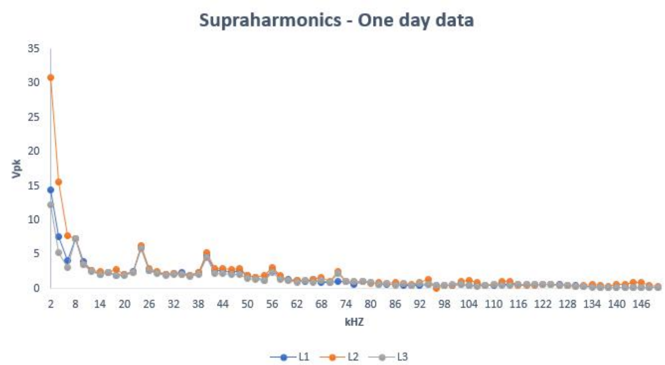

Fig 4: One day data on Volage peak vs kHZ.

V. Conclusion

In power-electronic converters, harmonic distortions occur. Whenever these technologies are incorporated into the electrical grid, these distortions present major issues. Disadvantageous harmonic emission about 2 kHz occurs in typical grid-commutated power-electronic converters This is achieved by using pulse-width modulation (PWM) waveforms having fast switching frequencies to reduce discrete low-order harmonics. But these signals may induce heightened harmonics emission in the 2–150 kHz range, which acts differently than harmonic emission at lower frequencies. Numerous studies at textile mills revealed the predominance of supraharmonic emissions today.

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