HARMONIC MINIMIZATION OF A SOLAR FED CASCADE H-BRIDGE INVERTER USING ARTIFICIAL NEURAL NETWORK

BURRI RAHELA
PG Student
Department of Electrical and Electronic Engineering,
J.B. Institute of Engineering and Technology, Hyderabad.

ABSTRACT – This paper presents a single –phase 11-level (5 H-Bridges) cascaded multilevel DC-AC grid –tied inverter. Each inverter bridge is connected to a200w solar panel .OPALRT lab was used as the hardware in the loop (HIL) real-time control system platform where a maximum power point Tracking (MPPT) algorithm was implemented based on the inverter output power to the power grid as well as a phase locked loop (PLL) for phase and frequency match. A novel SPWM scheme is proposed in this paper to be used with the solar panels that can account for voltage profile fluctruations among the panels during the day. Simulation and experimental results are shown for voltage and current during synchronization mode and power transferring mode to validate the methodology for grid connection of renewable resources.

1.Introduction:

The typical definition for a harmonic is “a sinusoidal component of a periodic wave or quantity having a frequency that is an integral multiple of the fundamental frequency.” Some references refer to “clean” or “pure” power as those without any harmonics. But such clean waveforms typically only exist in a laboratory. Harmonics have been around for a long time and will continue to do so. In fact, musicians have been aware of such since the invention of the first string or woodwind instrument. Harmonics (called “overtones” in music) are responsible for what makes a trumpet sound like a trumpet, and a clarinet like a clarinet. Electrical generators try to produce electric power where the voltage waveform has only one frequency associated with it, the fundamental frequency. In the North America, this frequency is 60 Hz, or cycles per second. In European countries and other parts of the world, this frequency is usually 50 Hz. Aircraft often uses 400 Hz as the fundamental frequency. At 60 Hz, this means that sixty times a second, the voltage waveform increases to a maximum positive value, then decreases to zero, further decreasing to a maximum negative value, and then back to zero. The rate at which these changes occurs is the trigometric function called a sine wave, as shown in figure 1.1. This function occurs in many natural phenomena, such as the speed of a pendulum as it swings back and forth, or the way a string on a voilin vibrates when plucked.

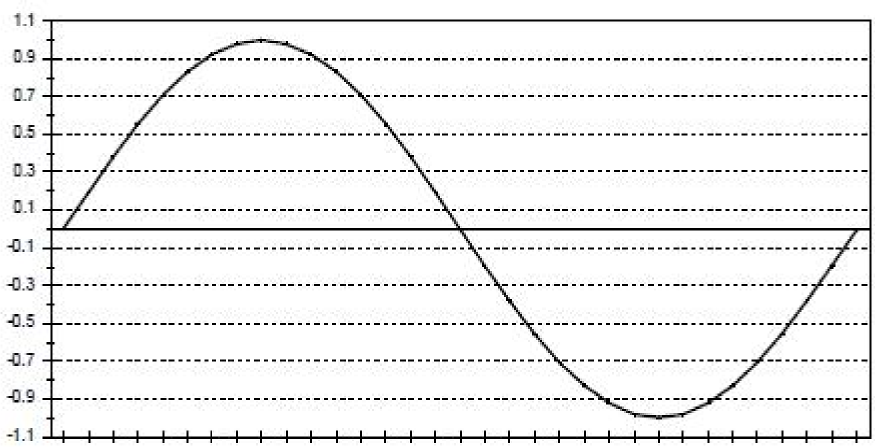

Figure 1.1 Sine Wave

The frequency of the harmonics are different, depending on the fundamental frequency. For example, the 2nd harmonic on a 60 Hz system is 2*60 or 120 Hz. At 50Hz, the second harmonic is 2* 50 or 100Hz. 300Hz is the 5th harmonic in a 60 Hz system, or the 6th harmonic in a 50 Hz system. Figure 1.2 shows how a signal with two harmonics would appear on an oscilloscope-type display, which some power quality analyzers provide.

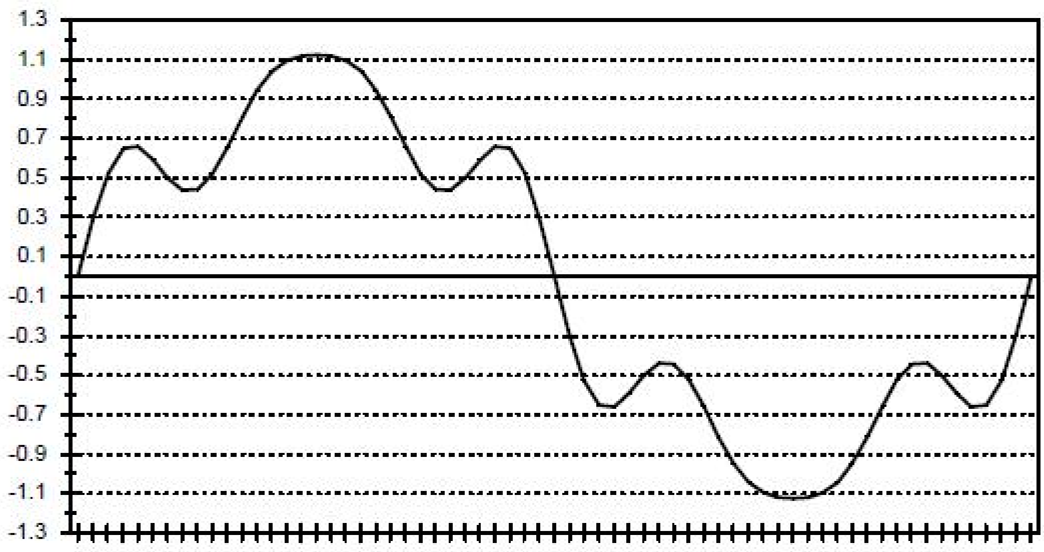

Figure 1.2. Fundamental with two harmonics

In order to be able to analyze complex signals that have many different frequencies present, a number of mathematical methods were developed. One of the more popular is called the Fourier Transform. However, duplicating the mathematical steps required in a microprocessor or computer-based instrument is quite difficult. So more compatible processes, called the FFT for Fast Fourier Transform, or DFT for Discrete Fourier Transform, are used. These methods only work properly if the signal is composed of only the fundamental and harmonic frequencies in a certain frequency range (called the Nyquist frequency, which is one-half of the sampling frequency). The frequency values must not change during the measurement period. Failure of these rules to be maintained can result in mis-information. For example, if a voltage waveform is comprised of 60 Hz and 200 Hz signals, the FFT cannot directly see the 200 Hz. It only knows 60, 120, 180, 240,..., which are often called “bins”. The result would be that the energy of the 200 Hz signal would appear partially in the 180Hz bin, and partially in the 240 Hz bin. An FFT-based processer could show a voltage value of 115V at 60 Hz, 18 V at the 3rd harmonic, and 12 V at the 4th harmonic, when it really should have been 30 V at 200 Hz. These in-between frequencies are called “interharmonics”. There is also a special category of interharmonics, which are frequency values less than the fundamental frequency value, called sub-harmonics. For example, the process of melting metal in an electric arc furnace can result large currents that are comprised of the fundamental , interharmonic, and subharmonic frequencies being drawn from the electric power grid. These levels can be quite high during the melt-down phase, and usually effect the voltage waveform.

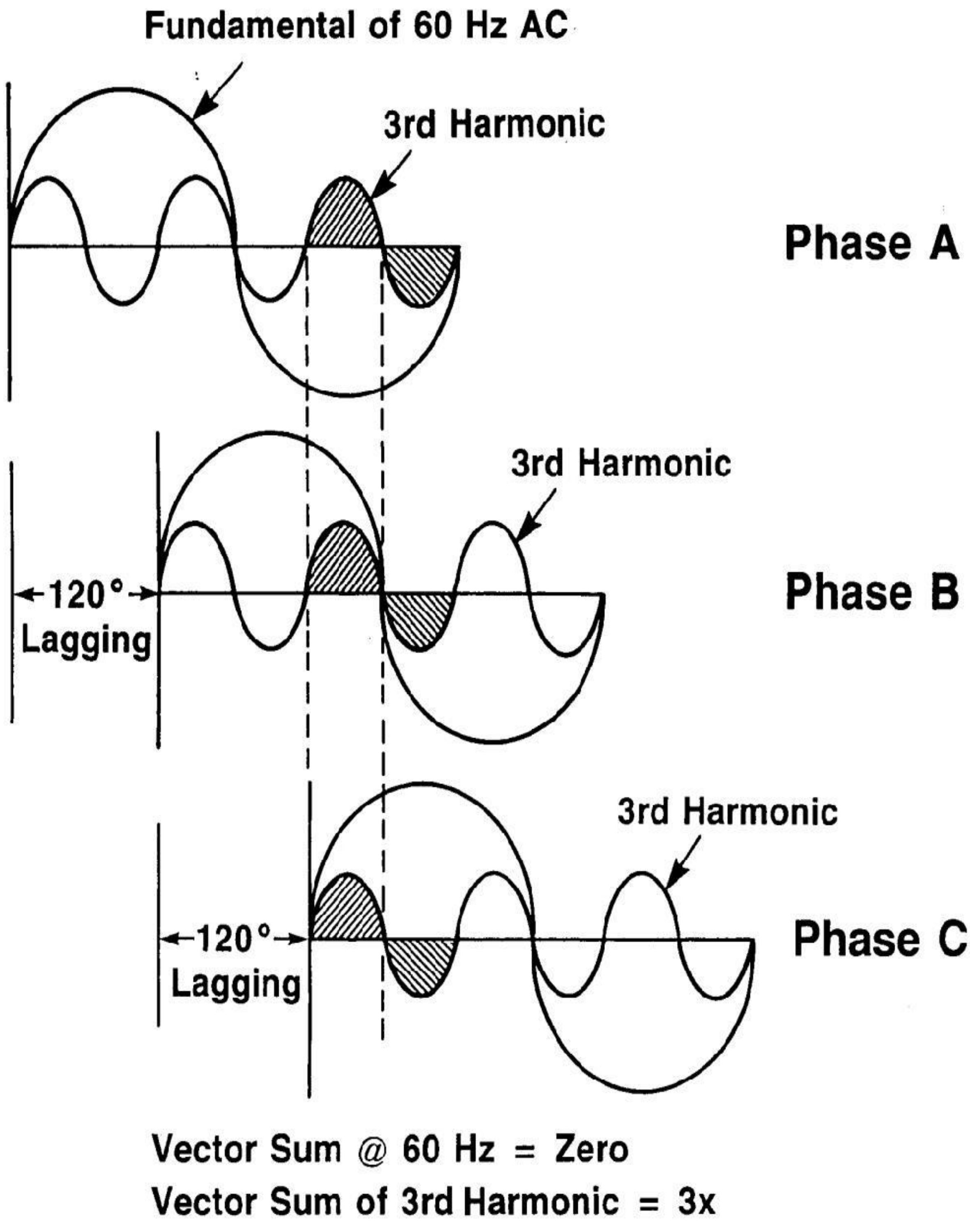

Figure 1.3. Additive Third Harmonics

Table1.1 Harmonic Sequencing Values in Balanced Systems.

HARMONIC	FUND	2ND	3RD	4TH	5TH	6TH	7TH	ETC
SEQUENCE	+	-	0	+	-	0	+	.....

How this electricity is used by the different type of loads can have an effect on "purity" of the voltage waveform. Some loads cause the voltage and current waveforms to lose this pure sine wave appearance and become distorted. This distortion may consist of predominately harmonics, depending on the type of load and system impedances. Since this article is about harmonics, we will concentrate on those types of sources. "The main sources of harmonic current are at present the phase angle controlled rectifiers and inverters."These are often called static power converters. These devices take AC power and convert it to another form, sometimes back to AC power at the same or different frequency, based on the firing scheme. The firing scheme refers to the controlling mechanism that determines how and when current is conducted. One major variation is the phase angle at which which conduction begins and ends. A typical such converter is the switching-type power supplies found in most personal computers and peripheral equipment, such as printers. While they offer many benefits in size, weight and cost, the large increase of this type of equipment over the past fifteen years is largely responsible for the increased attention to harmonics. Figure .shows how a switching-type power supply works. The AC voltage is converted into a DC voltage, which is further converted into other voltages that the equipment needs to run. The rectifier consists of semi-conductor devices (such as diodes) that only conduct current in one direction. In order to do so, the voltage on the one end must be greater than the other end.

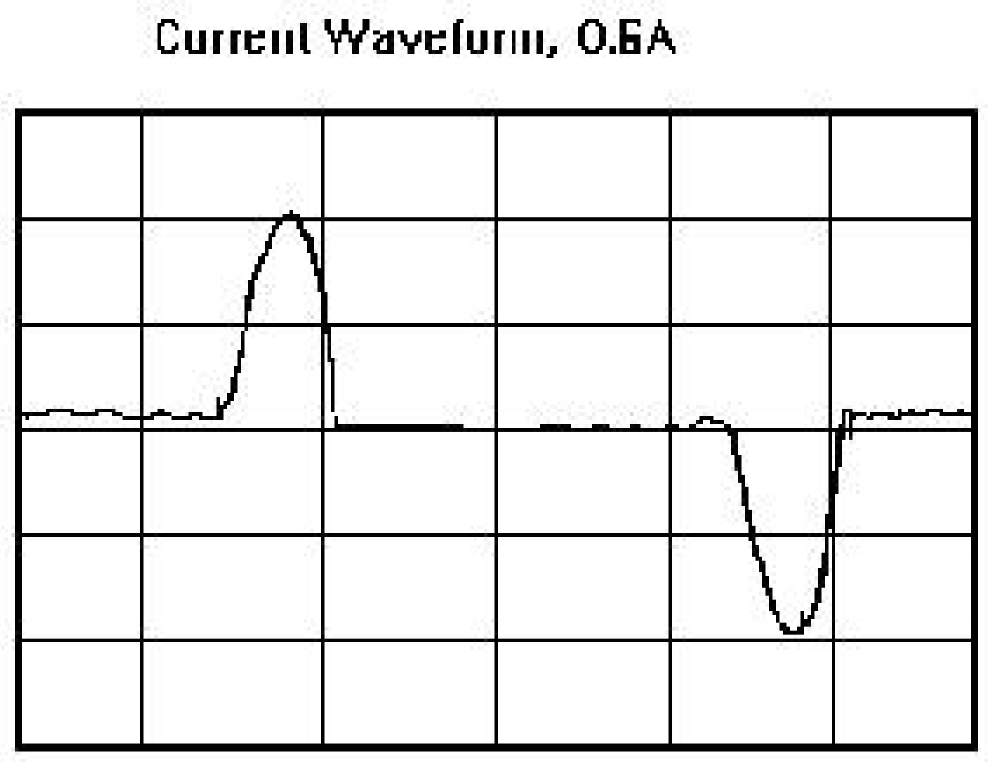

Figure 1.4. Current Waveform

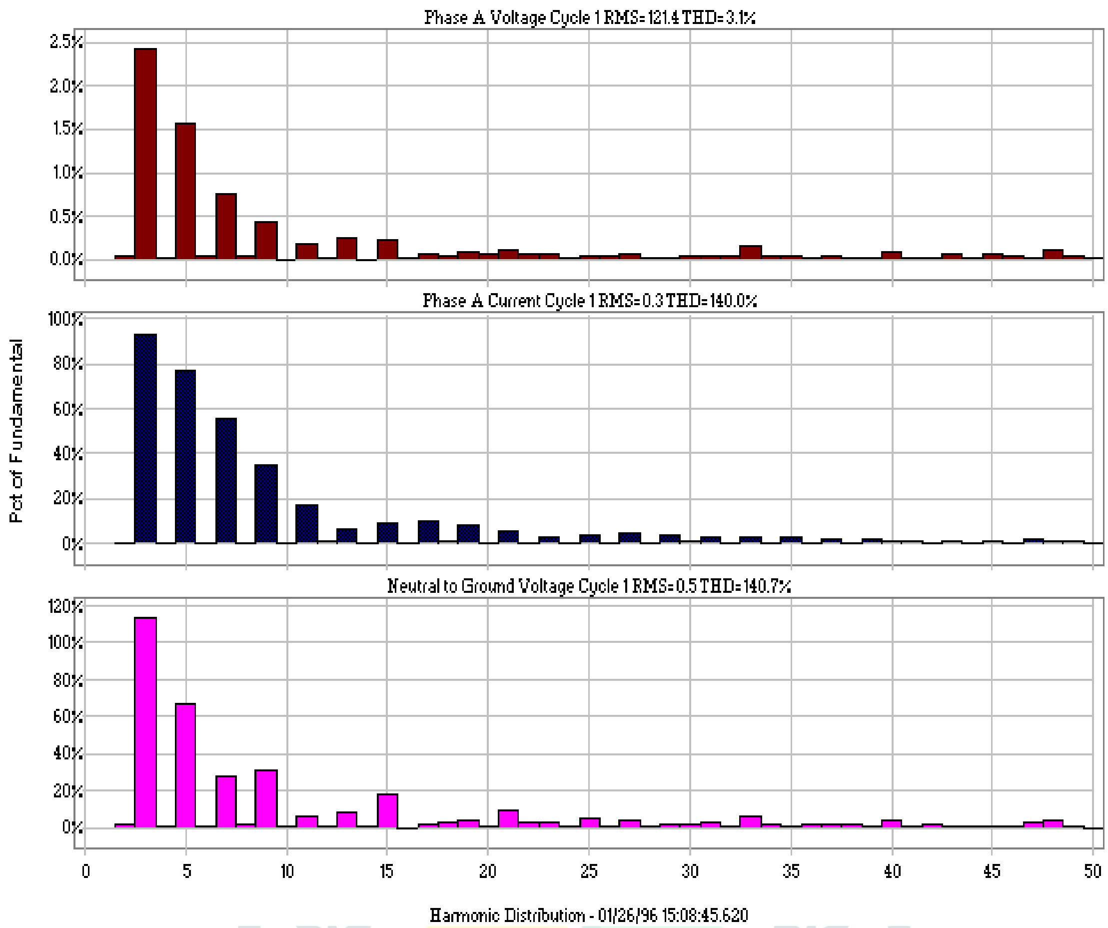

Figure.1.5. Harmonic Spectrum of Current Waveform

If the rectifier had only been a half wave rectifier, the waveform would only have every other current pulse, and the harmonic spectrum .

REFERENCES

1. Anbu, K., & S. Kataria., (2015). Access to Library Resources through Portable Devices A pre-design Prototype for Creating Library Websites. Proc. 4th IEEE Int. Symp. Emerg. Trends Technol. Libr. Inf. Serv., pp. 1–5.
2. Sandhu, G., (2015). Re-Envisioning Library and Information Services in the wake of Emerging Trends and Technologies. Proc. 2015 4th Int. Symp. Emerg. Trends Technol. Libr. Inf. Serv., 153–160.
3. Hayman, R., & Smith E. E. (2015). Sustainable decision making for emerging educational technologies in libraries. Ref. Serv. Rev.,43(1), 7–18.
4. Sethi. R., (2015). Emerging Technique in Libraries : Cloud Computing. Proc. 4th Int. Symp. Emerg. Trends Technol. Libr. Inf. Serv., 2–4.
5. Johnson, E. D. M., (2016). The Right Place at the Right Time : Creative Spaces in Libraries. The Future of Library Space: Advances in Library Administration and Organization, 36(1), 351.
6. International Federation of Library Associations and Institutions (IFLA)(2016). IFLA Trend Report, 34.

7. Letnikova G. and Xu., N. (2017). Academic library innovation through 3D printing services. Libr. Manag., 38(4/5),208–218,.
8. Mazumdar N. R., (2007). Skills for Library and Information Professionals Working in Borderless Library. Proc. 5th Conv. Plan. 2007, Gauhati Univ. held on December 7-8, Guwahati, 421–429.
9. American Library Association (ALA). (2009). Core Competences of Librarianship. 1–5.
10. Canadian Association of Research Libraries (CARL). (2010), Core Competencies for 21st Century CARL librarians.10.
11. Corrall. S., (2010). Educating the academic librarian as a blended professional: A review and case study. Libr. Manag., 31(8/9),567– 593.
12. Hui-fang, Q., (2010). The Discussion about the Best Structural Model of Knowledge-based Librarians under Network Environment. Proceedings of 2010 IEEE International Conference on Networking and Digital Society, 640–643.
13. Partridge J. M., Helen M., and Menzies L., (2010). Victoria and Lee and Carrie. The contemporary librarian : skills, knowledge and attributes required in a world of emerging technologies. Libr. Inf. Sci. Res., 32(4),265–271.
14. Sharma, P. L., (2011). Changing role of librarians in digital library era and need of professional skills, efficiency & competency. Indian Streams Reserach J., 1(Xii), 1–4.
15. Tzoc, E., & Millard, J., (2011), Technical skills for new digital librarians. Libr. Hi Tech News, 28(8), 11–15.
16. Satpathy, S. K., (2011). ICT Skills of LIS Professionals in Engineering Institutions of Orissa, India : A Case Study. Libr. Philos. Pract., 627.
17. Arokyamary J. R., & Ramasesh C.P., (2011). Emerging Trends and Technologies : Impact of Information Communication Technologies (ICTs) On Libraries and LIS. MySCIENCE, VII(1-2), 34–41.