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CHARACTERISTICS OF SINE WAVE AC POWER:
DEFINITIONS OF ELECTRICAL CONCEPTS, SPECIFICATIONS & OPERATIONS

Excerpt from Inverter Charger Series Manual

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1.0 DEFINITIONS OF ELECTRICAL CONCEPTS, SPECIFICATIONS & OPERATIONS

Polar Coordinate System: It is a two-dimensional coordinate system for graphical representation in which each point on a plane is determined by the radial coordinate and the angular coordinate. The radial coordinate denotes the point's distance from a central point known as the pole. The angular coordinate (usually denoted by **Ø or** O t) denotes the positive or anti-clockwise (counter-clockwise) angle required to reach the point from the polar axis.

Vector: It is a varying mathematical quantity that has a magnitude and direction. The voltage and current in a sinusoidal AC voltage can be represented by the voltage and current vectors in a Polar Coordinate System of graphical representation.

Phase, Ø: It is denoted by"Ø" and is equal to the angular magnitude in a Polar Coordinate System of graphical representation of vectorial quantities. It is used to denote the angular distance between the voltage and the current vectors in a sinusoidal voltage.

Power Factor, (PF): It is denoted by "PF" and is equal to the Cosine function of the Phase "Ø" (denoted CosØ) between the voltage and current vectors in a sinusoidal voltage. It is also equal to the ratio of the Active Power (P) in Watts to the Apparent Power (S) in VA. The maximum value is 1. Normally it ranges from 0.6 to 0.8.

Voltage (V), Volts: It is denoted by "V" and the unit is "Volts" – denoted as "V". It is the electrical force that drives electrical current (I) when connected to a load. It can be DC (Direct Current – flow in one direction only) or AC (Alternating Current – direction of flow changes cyclically).

Current (I), Amps, A: It is denoted by "I" and the unit is Amperes – denoted as "A". It is the flow of electrons through a conductor when a voltage (V) is applied across it.

Frequency, Hz: It is a measure of the number of occurrences of a repeating event per unit time. For example, cycles per second (or Hertz) in a sinusoidal voltage.

Resistance, R: It is the property of a conductor that opposes the flow of current when a voltage is applied across it. In a resistance, the current is in phase with the voltage. It is denotes by "R" and its unit is "Ohm" - also denoted as "Ω".

Reactance, X: It is the property of capacitors and inductors in a circuit that opposes the flow of current due to AC voltage applied across the circuit. The phase of the current will either lead or lag the voltage in time. It will lead if the net reactance is capacitive and will lag if the net reactance is inductive.

Impedance, Z: It is the vectorial sum of Resistance and Reactance in a circuit.

Peak Value: It is the maximum value. For a sine wave, it is equal to 1.414 times the RMS value. For example, in a 120 VAC sine wave voltage, the RMS value is 120 V and the peak value is 120 X1.414 = 169.68 or approximately 170 V.

RMS Value: Root Mean Square – a statistical average value of a varying quantity that changes between positive and negative values with respect to time. For example, in a 120 VAC system, the RMS value is 120 V.

Active Power (P), Watts: It is denoted as "P" and the unit is "Watt". It is the power which is dissipated in the load due to the resistance. The Energy Meter (Kilo Watt Hour Meter) measures the energy consumed which is = Active Power consumed in Watts multiplied by the time in Hours and the utility companies bill the users based on this power consumption. This Active Power "P" in Watts = RMS Voltage X RMS current X Power Factor (Cos Ø).

Reactive Power (Q), VAR: Denoted as "Q" and the unit is VAR. Mathematically, this power Q = RMS Voltage "V" X RMS current "A" X Sin Ø (Sine Function Value of the Phase Ø between the voltage and the current vectors). The magnitude of this power will be 0 if the Phase Ø between the voltage and the current vectors is 0 degrees or the Power Factor is unity (1). This power will increase as the Power Factor decreases below unity (1). This power is not consumed by the load but travels to the load in the (+) half cycle of the sinusoidal voltage and is returned back to the load in the (-) half cycle of the sinusoidal voltage. This back and forth flow of energy is due to the capacitive and inductive reactances in the load. Hence, when averaged over a span of one cycle, there is no consumption of power. However, on an instantaneous basis, this power has to be provided by the AC source and the AC source, the transmission lines and the gear have to be sized accordingly. The Energy Meter (Kilo Watt Hour Meter) does not measure this power but the Utility Companies have to provide this additional power. Hence, the Utility Companies require that the Power Factor of the load should be very close to unity (1) so that they do not have to transmit this additional reactive power that is not being paid for. To bring the low Power Factor of the load to near unity (1), the Utility Companies require use of Power Factor correction devices at the load location.

Apparent Power (S), VA: Denoted as "S" and unit is VA. This power is the vectorial sum of the Active Power in Watts and the Reactive Power in "VAR". In magnitude, it is equal to the RMS value of voltage "V" X the RMS value of current "A". The AC power source is required to provide this power. Please note that this power is more than the Active Power in Watts.

Load: Electrical device to which an electrical voltage is fed.

Linear Load: A load which draws sinusoidal current when a sinusoidal voltage is fed to it. For example incandescent lamp, heater, electric motor, etc.

Non Linear Load: A load which does not draw a sinusoidal current when a sinusoidal voltage is fed to it. For example non power factor corrected Switched Mode Power Supplies used in computers, audio video equipment, battery chargers, etc.

Resistive Load: A load that consists of pure resistance (like incandescent lamps, heaters, etc.)

Reactive Load: A load that consists of resistance and reactance like electric motor driven loads, fluorescent lights, computers, audio / video equipment, etc.

CHARACTERISTICS OF SINE WAVE AC POWER

Sine Wave: In a voltage that has a sine (sinusoidal) waveform (see Fig. 1), the instantaneous value and polarity of the voltage varies cyclically with respect to time. For example, in one cycle in a 120 VAC, 60 Hz system, it slowly rises in the positive direction from 0 V to a peak positive value "Vpeak" = +170 V, slowly drops to 0 V, changes the polarity to negative direction and slowly increases in the negative direction to a peak negative value "Vpeak" = -170 V and then slowly drops back to 0 V. There are 60 such cycles in 1 sec. Cycles per second is called the "Frequency" and is also termed "Hertz (Hz)".

Cycle: For a sine wave (see Fig.2.1 above), it is the complete event starting with a rise from zero to a maximum amplitude, its return to zero, the rise to a maximum in the opposite direction, and then its return to zero.

120 / 240 VAC Sine Wave AC Power Distribution for Residential Application: The waveform of the electrical voltage distributed by the grid / the utility companies is like a sine wave. For example, in North America, the grid / utility voltage for residential use is single phase, 120 / 240 VAC, 60 Hz. and consists of two 120 VAC, 60 Hz Line Voltages (also called "Lines" or "Legs") and a common "Neutral". The two 120 VAC, 60 Hz. Lines (Legs) are 180 degrees apart in phase. The voltage between each Line (Leg) and the Neutral is 120 VAC and between the two Lines (Legs) is 240 VAC. **Please see details in the Section 8 titled "120 / 240 VAC Single Split Phase System and Multi-wire Branch Circuits."**

RMS and Peak Values in Sine Wave AC Power: As explained above, in a sine wave, the values of AC voltage (Volt, V) and current (Ampere, A) vary with time. Two values are commonly used – Root Mean Square (RMS) value and peak value. The values of the rated output voltage and current of an AC power source are specified in RMS values.

Power Factor in Sine Wave AC Power: When a voltage is applied to a load, a current flows. If a Linear Load is connected to this type of voltage, the load will draw current which will also have the same sine wave-form. However, the peak value of the current will depend upon the impedance of the load. Also, the Phase Ø of the Sine Wave-form of the current drawn by the Linear Load may be the same or lead / lag the sine wave-form of the voltage. This phase difference determines the Power Factor of the load. In a resistive type of load, the sine wave-form of the current drawn by the load has 0 degrees phase difference Ø with the sine wave-form of the voltage of the AC power source. The Power Factor of a resistive load is unity (1).

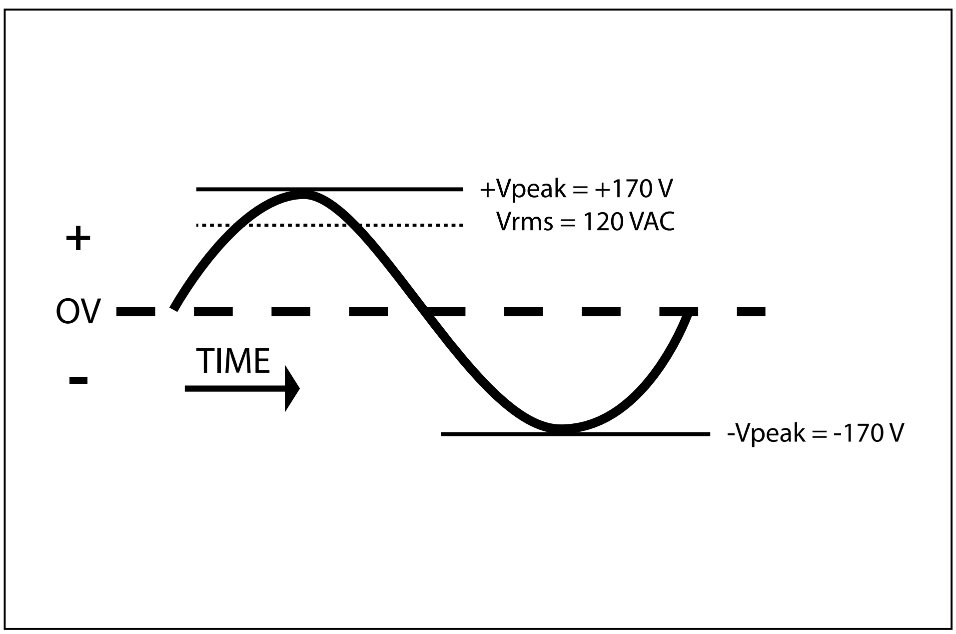

Fig. 1: 120 VAC Sine Wave

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