



# Inverter Tips: The output voltage waveform

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With the development and improvement of semiconductor devices, inverters that provide AC alternating energy to domestic or industrial loads have become popular. These are used in multiple applications from DC continuous energy sources or battery energy storage sources, offering versatility, supply security and efficiency in both single-phased and three-phased power supplies.

## SINE WAVE

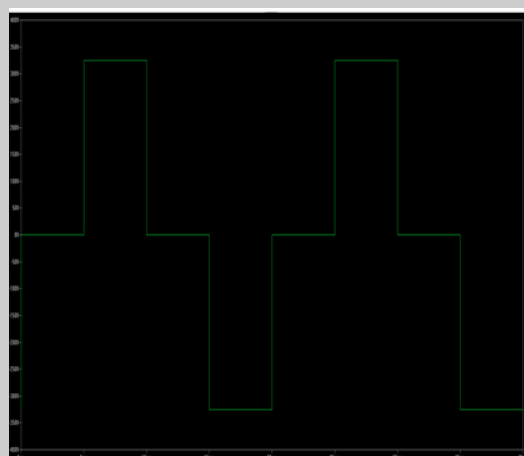


## 1ph and 3ph inverters

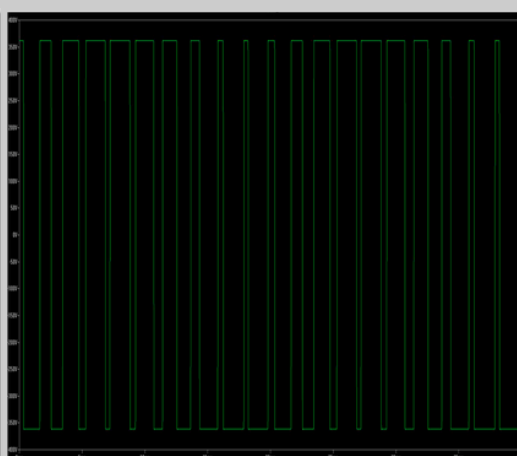
Inverters are static converters that **transform direct current into alternating current through the use of semiconductor switches** that have been developed in recent decades, becoming more efficient, fast and cheap (MOSFETs, IGBTs, Silicon Carbide transistors, GaN transistors) with multiple topologies and control modes.

The topologies and transistor technology used affect the output voltage-frequency regulation capability and the **output voltage waveform**. This aspect is especially important to achieve a good integration result with the final application.

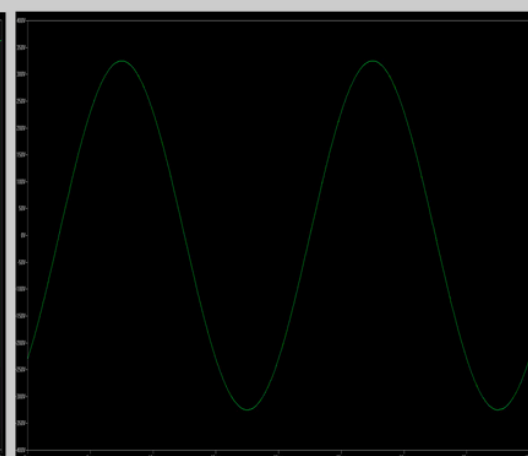
The output of an inverter can have several types of waveforms, the main ones are as follows:



*Modified sinewave (square wave)*



*SinusPWM wave*



*Pure sinus wave*

### Modified sinewave output inverters

Modified sinewave output inverters are normally controlled to have the **same peak voltage as the main harmonic and the same RMS value**, so that a pure resistive load behaves as if it were fed by a pure sine wave. However, the harmonic content of this type of voltage output depends on the peak voltage/RMS voltage ratio. The Total Harmonic Distortion (THD) can range from a minimum of 30% to over 50%.

## SPWM inverters

SPWM inverters **can regulate the RMS value of the fundamental voltage but cannot change the peak voltage**. In this case there is a harmonic content starting with multiples of the ratio of the switching frequency and the fundamental output frequency. This type of output is used especially for the supply of AC motors.

The presence of harmonics can be negative or dangerous for the application and can cause the following problems to the loads:

- ✦ Problems in Power Supplies with PFC (power factor correction)
- ✦ Some fluorescent lights with standard ballasts or low frequency transformers are stressed
- ✦ Power tools that use "solid state" regulators or variable speed control do not work properly
- ✦ It sometimes causes EMC interference in some TV sets, cameras and audio amplifiers
- ✦ Decrease in efficiency and overheat in motors due to harmonic currents in the iron and windings
- ✦ A pulsating torque appears depending on the harmonic currents that generate mechanical stress in the motors and their loads
- ✦ High-frequency currents can occur in common mode and pass through the bearings of the motors, accelerating their degradation
- ✦ Reliability problems in some sensible medical equipment

In addition, modified sinewave inverters are usually only protected by standard fuses, which are not fast enough to protect the inverter in case of short circuit or overload.

## Pure sinusoidal output inverters

Inverters with pure sinusoidal output enhance SPWM topologies by adding a filter specially designed to **eliminate switching harmonics**. This leaves only the fundamental harmonic, providing a **negligible THD of less than 4%**, which is even better than the waveform present in most places of the network. As a result, the inverter **provides a supply free of interferences and avoids overheating in applications**.

Inverters with pure sinusoidal output offer the following advantages:

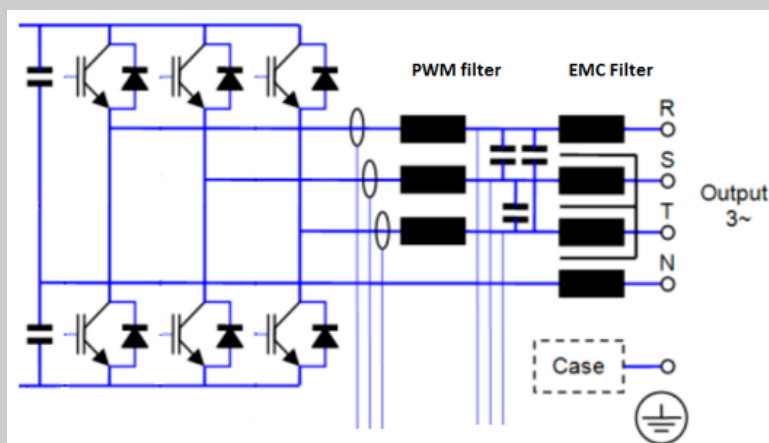
- ✓ Inductive loads like microwave ovens and motors run correctly, quieter and cooler
- ✓ Reduces audible and electrical noise
- ✓ There is no electrical stress in the insulation due to harmonic components of voltage higher than the peak voltage of the fundamental
- ✓ There is no pulsating excitation current that generates a high frequency pulsating torque for the motors and their loads
- ✓ Prevents breakdowns in power supplies and systems with input power factor correction (PFC)
- ✓ EMC interference and the need for shielded wiring are reduced or eliminated
- ✓ It can be efficiently electronically protected in overload, short-circuits and overvoltage conditions
- ✓ It is easy to regulate all parameters: peak voltage, rms voltage and frequency

Using a pure sinewave inverter is an advantage as it can basically run any type of equipment versus using a modified sinewave / PSWM wave inverter.

### About Premium's Inverters

All Premium inverters are designed to provide a pure sinusoidal output voltage with a **low harmonic content and THD less than 2%** (16 measures average) and a maximum switching frequency component value of less than 2.5% of the fundamental.

Full Bridge Inverter





The use of advanced semiconductors in Premium's inverters (HyperFast IGBT or SiC transistors) reach switching frequencies above 20 kHz with low losses, allowing a **compact and a very efficient filtering stage**. This stage provides the inverter with fast and robust protection against over-currents and short-circuits. All solutions use components with the latest generation of ferromagnetic materials.

Also, all inverters include an **EMC output filter** to meet the emissions according to industrial and railway standards.

**#WEAREPREMIUM** Premium is one of the largest power supply companies in Europe, offering solutions to the industrial market being some of them in high-tech machinery, transportation, energy or extreme environments applications. Founded in 1981, Premium designs and manufactures power conversion systems for customers all around the world. Premium's power range includes DC/DC converters, uninterruptible power supplies, DC/AC inverters, AC/DC power supplies and any solution that requires high reliability from 50W to 50kW. Custom is Premium's standard, so any current product variation or new development can be done by our R&D department, a team of over 50 engineers with a wide know-how. All products comply with the specifications and regulations that each application requires and all projects, from the concept, design and until the homologation of the product, are carried out in Barcelona under strict quality controls.

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