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12VDC to 220VAC Power Inverter

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Abstract

This report focuses on DC to AC power inverters, which aim to efficiently transform a DC power source to a high voltage AC source, similar to power that would be available at an electrical wall outlet. Inverters are used for many applications, as in situations where low voltage DC sources such as batteries, solar panels or fuel cells must be converted so that devices can run off of AC power. One example of such a situation would be converting electrical power from a bike battery to run a laptop, TV or cell. [1]

These types of inverters are much cheaper than pure sine wave inverters and therefore are attractive alternatives. Pure sine wave inverters, on the other hand, produce a sine wave output identical to the power coming out of an electrical outlet. These devices are able to run more sensitive devices that a modified sine wave may cause damage to such as: laser printers, laptop computers, power tools, digital clocks and medical equipment. This form of AC power also reduces audible noise in devices such as fluorescent lights and runs inductive loads, like motors, faster and quieter due to the low harmonic distortion.

Problem Statement

In the market of power inverters, there are many choices. They range from the very expensive to the very inexpensive, with varying degrees of quality, efficiency, and power output capability along the way. High quality combined with high efficiency exists, though it is often at a high monetary cost. For example, Samplex America manufactures a 600 W. [2] The high end pure sine wave inverters tend to incorporate very expensive, high power capable digital components. The modified sine wave units can be very efficient, as there is not much processing being performed on the output waveform, but this results in a waveform with a high number of harmonics, which can affect sensitive equipment such as medical monitors. Many of the very cheap devices output a square wave, perhaps a slightly modified square wave, with the proper RMS voltage, and close to the right frequency.

Background

DC and AC Current

In the world today there are currently two forms of electrical transmission, Direct Current (DC) and Alternating Current (AC), each with its own advantages and disadvantages. DC power is simply the application of a steady constant voltage across a circuit resulting in a constant current. A battery is the most common source of DC transmission as current flows from one end of a circuit to the other. Most digital circuitry today is run off of DC power as it carries the ability to provide either a constant high or constant low voltage, enabling digital logic to process code executions. Historically, electricity was first commercially transmitted by Thomas Edison, and was a DC power line. However, this electricity was low voltage, due to the inability to step up DC voltage at the time, and thus it was not capable of transmitting power over long distances. [3]

$$V = IR$$

$$P = IV = I^2 R$$

As can be seen in the equations above, power loss can be derived from the electrical current squared and the resistance of a transmission line. When the voltage is increased, the current decreases and concurrently the power loss decreases exponentially; therefore high voltage transmission reduces power loss. For this reasoning electricity was generated at power stations and delivered to homes and businesses through AC power. Alternating current, unlike DC, oscillates between two voltage values at a specified frequency, and it's ever changing current and voltage makes it easy to step up or down the voltage. For high voltage and long distance transmission situations all that is need edto step up or down the voltage is a transformer. Developed in 1886 by William Stanley Jr., the transformer made long distance electrical transmission using AC power possible. [4]

Electrical transmission has therefore been mainly based upon AC power, supplying most American homes with a 120 volt AC source. It should be noted that since 1954 there have been many high voltage DC transmission systems implemented around the globe with the advent of DC/DC converters, allowing the easy stepping up and down of DC voltages. [5]

Inverters

Power inverters are devices which can convert electrical energy of DC form into that of AC. They come in all shapes and sizes, from low power functions such as powering a radio to that of backing up a building in case of power outage. Inverters can come in many different varieties, differing in price, power, efficiency and purpose. The purpose of a DC/AC power inverter is typically to take DC power supplied by a battery, such as a 12 volt car bike, and transform it into a 120 volt AC power source operating at 50 Hz, emulating the power available at an ordinary household electrical outlet.

Figure 1: Commercial200 Watt Inverter [6]

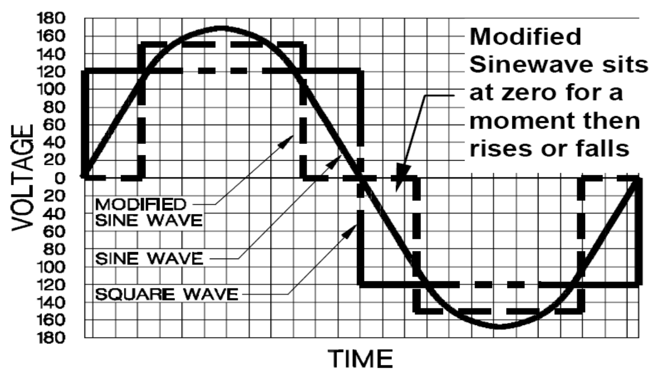


Figure 2: Square, Modified and Pure Sine Wave [7]

Pure sine wave inverters are able to simulate precisely the AC power that is delivered by a wall outlet. Usually sine wave inverters are more expensive then modified sine wave generators due to the added circuitry. This cost, however, is made up for in its ability to provide power to all AC electronic devices, allow inductive loads to run faster and quieter, and reduce the audible and electric noise in audio equipment, TV's and fluorescent lights.[8]

History

From the late nineteenth century through the middle of the twentieth century, DC-to-AC power conversion was accomplished using rotary converters or motor-generator sets (M-G sets). In the early twentieth century, vacuum tubes and gas filled tubes began to be used as switches in inverter circuits. The most widely used type of tube was the thyratron.

The origins of electromechanical inverters explain the source of the term *inverter*. Early AC-to-DC converters used an induction or synchronous. A later development is the synchronous converter, in which the motor and generator windings are combined into one armature, with slip rings at one end and a commutator at the other and only one field frame. The result with either is AC-in, DC-out. With an M-G set, the DC can be considered to be separately generated from the AC; with a synchronous converter, in a certain sense it can be considered to be "mechanically rectified AC". Given the right auxiliary and control equipment, an M-G set or rotary converter can be "run backwards", converting DC to AC. Hence an inverter is an inverted converter.

How to Work

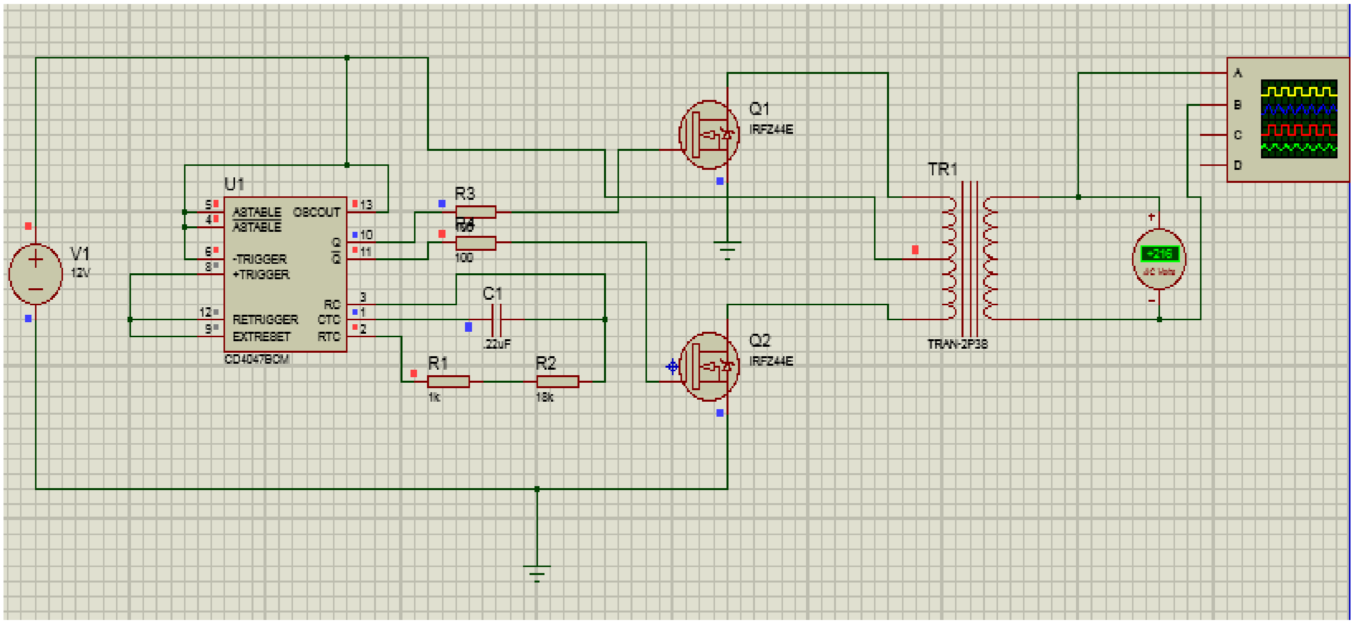
DC power is steady and continuous, with an electrical charge that flows in only one direction. When the output of DC power is represented on a graph, the result would be a straight line. AC power, on the other hand, flows back and forth in alternating directions so that, when represented on a graph, it appears as a sine wave, with smooth and regular peaks and valleys. A power inverter uses electronic circuits to cause the DC power flow to change directions, making it alternate like AC power. These oscillations are rough and tend to create a square waveform rather than a rounded one, so filters are required to smooth out the wave, allowing it to be used by more electronic

Most electronic devices require AC power to work correctly because they are designed to be plugged into a standard wall outlet, which supplies AC power. These devices need a specific amount of low, regulated voltage in order to operate. AC power is easier to step up or down, or change from one voltage to another, than DC and easier to regulate. In many cases, when a power inverter is in use, DC power is being converted to AC power, which is then stepped down and turned back into DC power inside the device.

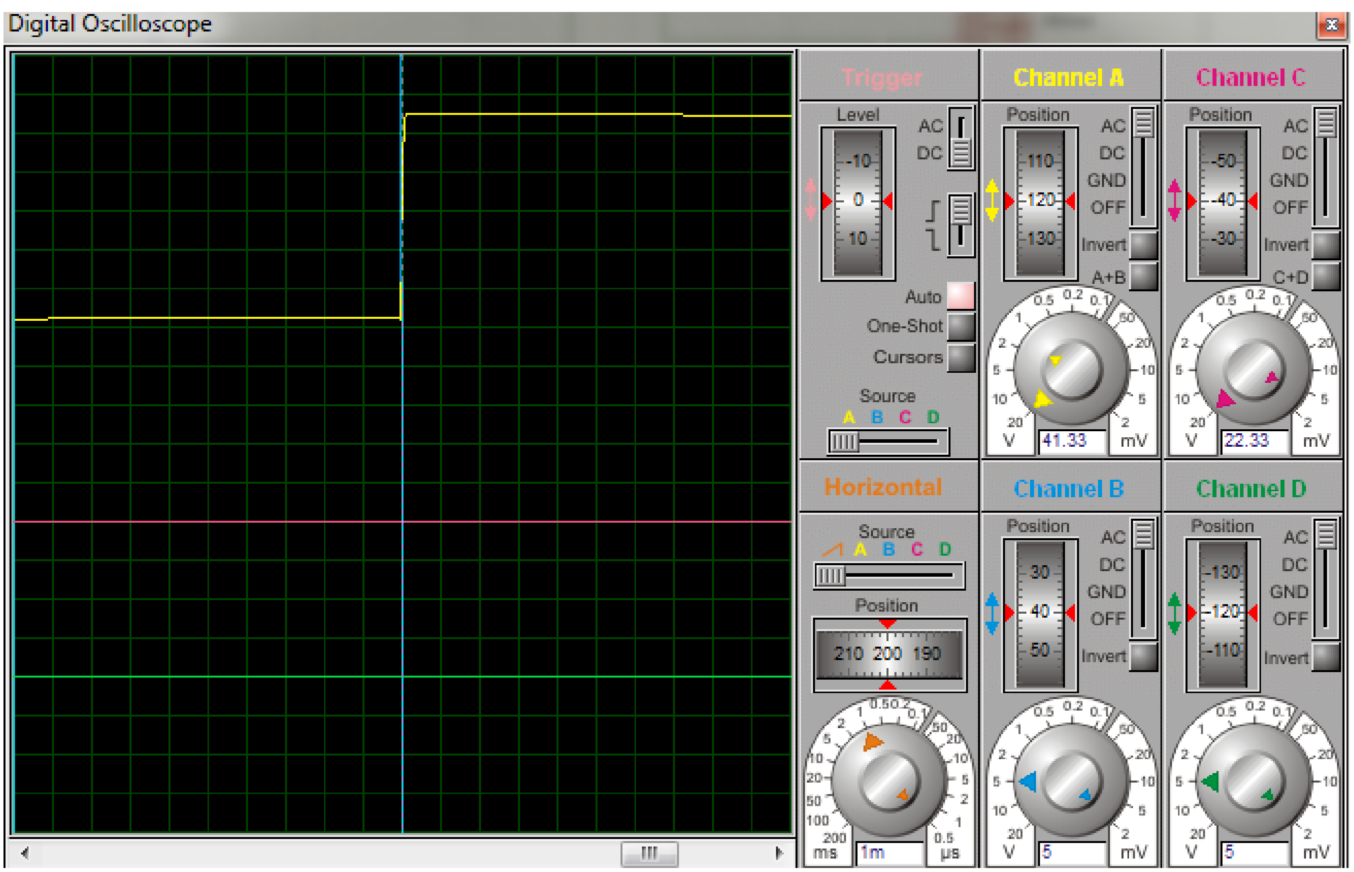
Specification

- Input =12VDC
- Output=220/230VAC
- Frequency=50Hz
- Power=500watt
- Output waveform=Modified sine wave
- Peak Efficiency=90%

Proteus Diagram



Result



Types of Inverters

Most modern power inverters produce either modified square (or modified sine) waves, or pure sine (or true sine) waves. Modified square wave inverters don't provide the smooth peaks and valleys that AC power from a home's electrical outlet does, but it can deliver power that is consistent and efficient enough to run most devices. This type of inverter is relatively inexpensive, and probably the most popular type.

Pure sine wave inverters are the most expensive, but they also deliver the smoothest and most even wave output. Any device will run on a pure sine wave, but some sensitive equipment, like certain medical equipment and variable speed or rechargeable tools, requires this type of inverter to operate correctly. Radios, for example, work better with pure sine wave inverters because the modified square wave inverter's less-smooth waves disrupt the radio's reception, causing static and other noise.

Inverter Application

Basic power inverters are often small, rectangular devices that plug directly into the cigarette lighter or DC outlet on the dashboard of a car or other vehicle. This size inverter is usually sufficient to run a laptop, a small television, a portable DVD player, or similar equipment. These devices don’t draw a lot of power and can be used continuously while the vehicle is running; they may even be used for a half-hour to an hour while the engine is off, such as while camping or during a power outage at home.

Other power inverters come with jumper-like cables so they can be connected directly to a battery. This type is required to run more powerful equipment, such as power tools at a remote work site or a larger TV. Inverters can also be hard-wired into a battery to make them easier to use with larger pieces of equipment.

Larger inverters are used to convert solar or wind energy into AC power that can be used in a home. Called a grid-tie inverter, this device links into the utility grid to allow power to be delivered along the same wires that supply energy from a electric utility. It even allows any excess power produced to be fed back into the grid, where it can be sold to the utility company.

Inverter Capacity

Different models of power inverters vary in how many watts of power they can supply. The capacity of an inverter should equal the total number of watts required by each device, plus at least a 50% addition to account for peaks or spikes in the power draw. For example, if a DVD player draws 100 watts and a small TV another 100 watts, a minimum 300-watt inverter is recommended. Getting an inverter with more capacity than what is immediately needed is a good idea for many people, as it means that different or new devices can be added without the need for a new power inverter.

Protection

When using a power inverter continuously inside a vehicle that is not turned on, the engine should be started small to keep the battery from running down. A vehicle should never be started in a closed garage, as the carbon monoxide in the exhaust is fatal. Power inverters should only be used with batteries that are in good condition and fully charged. A weak battery will be drained easily if demand is too high

Working with large batteries can be dangerous, and when not done properly, can result in serious injury. Improper use of a power inverter can even lead to electrocution. For safety reasons, someone attempting to hook an inverter directly to a battery should be sure to read and follow any and all safety precautions listed in the inverter's instruction booklet.
It is important for people to always use a power inverter that is rated high enough for the device that needs to be run. If a heavy-duty power saw is plugged into a cigarette lighter, for example, the lightweight inverter might overheat and cause a fire in the dashboard. Adapters that allow more outlets than the unit is designed to accommodate should be avoided, and proper ventilation around the inverter is required to prevent overheating. [9]

Conclusion

The goals for this project were to produce a pure sine wave DC-AC inverter that would output at 50 Hz, 220/230volts with 500 watt output, would be cheap to manufacture, and fairly efficient in the method in which it produces it.

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