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Single Phase Inverter

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Overview

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DC power is unidirectional and flows in one direction, whereas, AC current alternates directions at a frequency of 50-60 Hz. Most common electronic devices are designed to run off of AC power; therefore an input DC source must be inverted to AC. Inverters convert DC voltage to AC through switching action that repeatedly flips the polarity of the input DC source at the output or load side for part of a switching period. A typical power inverter requires a stable DC power input, which is then switched repeatedly using mechanical or electromagnetic switches. The output can be a square-wave, sine-wave or a variation of a sine-wave, depending on circuit design and the user needs.

The objective of this experiment is to build and analyze the operation of DC/AC half-bridge inverters. Half-bridge inverters are the simplest form of DC/AC inverters, but are the building blocks for H-bridge, three-phase, and multi-level inverters. Square-wave switching is studied here for simplicity, but sinusoidal pulse width modulation (SPWM) and other modulation and switching schemes are typically used in DC/AC inverters.

Principles

Inverters consist of switching devices (one, two, four, six, or more) that are switched in a manner that converts a DC input voltage to AC. The switches are typically MOSFETs, IGBTs, SCRs, or others.

The half-bridge inverter provides an AC output voltage with a maximum of $V_{in}/2$, while the full bridge inverter can achieve a maximum of V_{in} . The half-bridge inverter requires two capacitors in parallel with the DC input to split the input into two halves, each at $V_{in}/2$ in a manner similar to a voltage divider, while the full-bridge does not have this requirement. The half-bridge rectifier uses two switches, while the full-bridge uses four switches.

Many advanced inverter topologies, switching schemes, and controllers exist in the power electronics literature, but the half-bridge is the most fundamental building block of most of them. In a half-bridge inverter, the input DC source is split into two halves using two identical capacitors of equal capacitance. The inverter then can tie the output to $+V_{dc}/2$ when the upper inverter switch is on, and to $-V_{dc}/2$ when the lower inverter switch is on. Both switches should not be on at the same time, and dead time when both are off should added using hardware or software circuitry.

Procedure

1. Switching Source Setup

1. Set two function generators with outputs as square-waves at 10 kHz frequency and 48% duty ratio.
 1. The function generators should be synchronized so that their output signals are 180° out of phase.
 2. The 2% dead time is used as 1% on each side of the square-wave output. Dead time prevents a shoot-through condition where both the upper and lower switches are conducting thus shorting the input DC supply.
2. Test that the function generators' outputs are as expected by observing them on the oscilloscope screen.
 1. Capture the scope screen.
3. Turn the function generator outputs OFF but leave the generators themselves ON.
4. Set the DC power supply to 15 V and leave it disconnected from any circuitry.
 1. Turn it OFF once it is set.

2. Half-Bridge Inverter

1. The half-bridge inverter is tested with the upper and lower MOSFETs switched independently.
2. Build the circuit shown in Fig 1.
 1. Use the $51\ \Omega$ resistor as the load.
3. Connect the input V_{dc} to +15V.
 1. Keep the DC power supply OFF.
4. Connect a regular probe between high-out (HO) and ground.
 1. Connect a differential probe across the load to measure V_{out} .
 1. Make sure that the scope scaling is at 10X and probe scaling is at 20X.

2. Do not forget to scale all measurements accordingly.
5. Connect one function generator output to high-in (HIN) which is used to control upper MOSFET switching.
 1. Connect its ground to the common ground of the circuit.
 2. Connect the other function generator output to low-in (LIN) which is used to control lower MOSFET switching.
6. Capture the waveforms and measure the output voltage peak and frequency.
7. Record the input current and voltage readings on the DC power supply.
8. Turn OFF the DC power supply and disconnect the function generator output from the circuit.

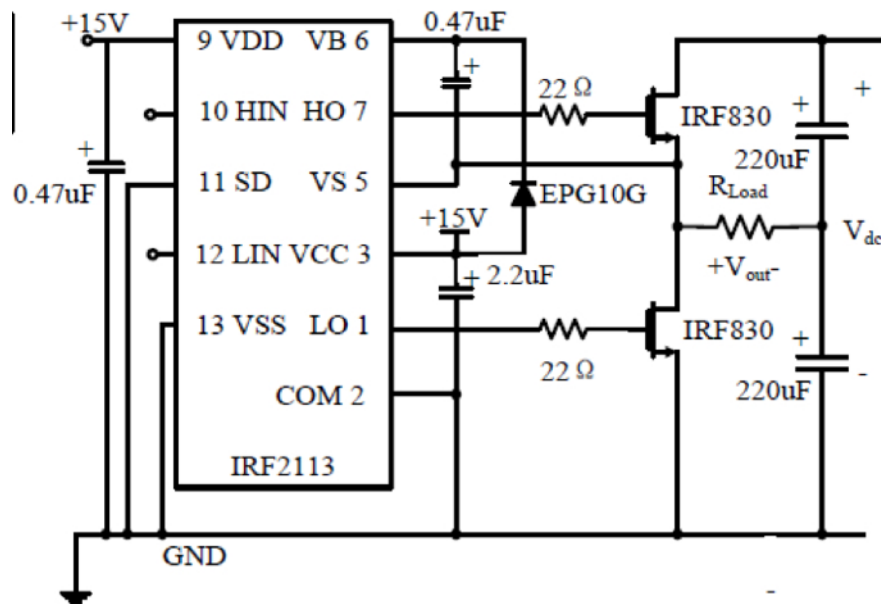


Figure 1: Half-Bridge Setup

Results

It is expected from building this half-bridge inverter that the output voltage waveform is a square-wave with a maximum of $V_{dc}/2$ and a minimum of $-V_{dc}/2$ with some dead-time causing the output voltage to be zero for around 4% of the switching period.

Square-wave inverters have high total harmonic distortion (THD) and are rarely used in real applications, however, they are the building blocks of many more advanced inverters with better switching schemes, e.g. SPWM, that can provide more sinusoidal-like output voltages. This not only improves the THD, but also reduces filtering requirements for undesired harmonics in the output voltage except for the fundamental harmonic, e.g. at 50 or 60 Hz.

Applications and Summary

Inverters are very common in interfacing clean energy sources, e.g. solar photovoltaics, fuel cells, wind turbines, as well as with energy storage systems, e.g. batteries, with the grid. They are essential in uninterruptable power supplies (UPS systems), in micro-grids with clean energy penetration, and in hybrid and electric transportation systems. Among the main applications of inverters is in motor drives where motor control can be provided by adjusting the inverter switching patterns to achieve desired speed and/or torque.