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Single-phase Inverter

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Electrical Engineering Science Education Title: Single-phase Inverter

Overview:

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 convert DC voltage to AC through switching action that flips the polarity of the input DC source at the output or load side for part of a switching period. 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 be added using hardware or software circuitry.

Procedures:

1. Switching Source Setup
 - 1.1 Set two function generators with outputs as square waves at 10kHz frequency and 48% duty ratio.
 - 1.1.1 The function generators should be synchronized so that their output signals are 180° out of phase.
 - 1.1.2 The 2% dead time is used as 1% on each side of the square wave output.
 - 1.2 Test that the function generators' outputs are as expected by observing them on the oscilloscope screen.
 - 1.2.1 Capture the scope screen.
 - 1.3 Turn the function generator outputs OFF but leave the generators themselves ON.
 - 1.4 Set your DC power supply to 15V and leave it disconnected from any circuitry.
 - 1.4.1 Turn it OFF once it is set.
2. Half-Bridge Inverter
 - 2.1 The half-bridge inverter is tested with the upper and lower MOSFETs switched independently.
 - 2.2 Build the circuit shown in Fig. 1.
 - 2.2.1 Use the 51Ω resistor from prior experiments as the load.

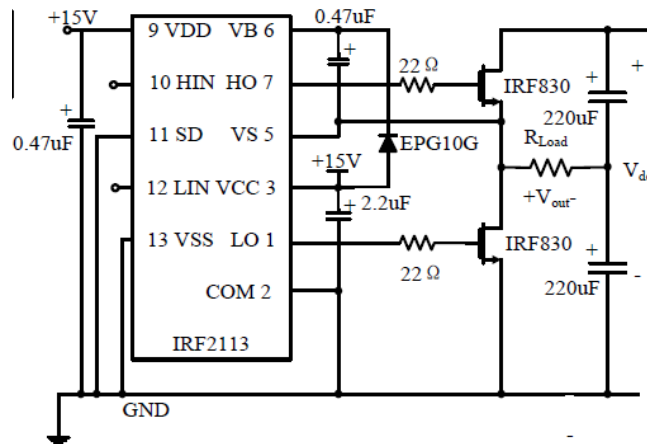


Fig. 1. Half-Bridge Setup

- 2.3 Connect the input V_{dc} to +15V.
 - 2.3.1 Keep the DC power supply OFF.
- 2.4 Connect a regular probe between high-out (HO) and ground.
 - 2.4.1 Connect a differential probe across the load to measure V_{out} .
 - 2.4.1.1 Make sure that your scope scaling is at 10x and probe scaling is at 20x.
 - 2.4.1.2 Do not forget to scale all your measurements accordingly.
- 2.5 Connect one function generator output to high-in (HIN) which is used to control upper MOSFET switching.
 - 2.5.1 Connect its ground to the common ground of the circuit.
 - 2.5.2 Connect the other function generator output to low-in (LIN) which is used to control lower MOSFET switching.
- 2.6 Capture the waveforms and measure the output voltage peak and frequency.
- 2.7 Record the input current and voltage readings on the DC power supply.
- 2.8 Turn OFF your DC power supply and disconnect the function generator output from the circuit.

Representative 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. Dead-time prevents a shoot-through condition where both the upper and lower switches are conducting thus shorting the input DC supply. 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:

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.