Three-Phase DC-AC Inverter

Ebrihem Al Namie, Brandon Bornkamp, Hunter Lagrone, Anthony Marasco, Carmine Taffo, Marc Tuholski
Advisor: Stephen Carr, Ph.D.
Trine University
One University Avenue, Angola, Indiana 46703

Trine University
Electrical and Computer Engineering

Introduction:

An inverter is a power electronics device used to convert DC power to AC power. Our group designed a three-phase inverter to convert a 12 V DC signal from a series combination of batteries to a 12 V_{RMS} line-to-line, 60 Hz AC signal for three phases when attached to a delta connected, purely resistive load of 18 W. The 18 W load is comprised of three 6 W incandescent lightbulbs. For proof of concept, we use one oscilloscope to display the PWM signals used to drive the electronics and another oscilloscope to display the sinusoidal waveforms across the load.

Components and Design:

- MCU PWM signal generation: FRDM-KL25Z microcontroller PWM timer
- Half H-Bridge Controller: LT1160 Half H-Bridge n-channel MOSFET driver, two 1 uF 50 V ceramic capacitors, and a 1N4002 diode (1 per phase)
- Half H-Bridge: six 2SK2713-ND power MOSFETs (2 per phase)
- Filter: 3 series connected 10 mH toroidal power inductors and 3 delta connected 100 uF 50 V electrolytic capacitors
- Feedback control: A to B phase bridge rectifier circuit with voltage divider
- Boost Converter: KNARCO DC 12 V step up to 24 V Regulator
- Load: 18 W, delta connected load of three 6 W incandescent lightbulbs
- Electrical Battery: Series combination of 6 V batteries

Testing:

- MCU PWM: Verifying phase shifts and periods of three phases via oscilloscope
- Half H-Bridge: Verifying phase shifts and periods of three phases via oscilloscope
- Filter: Verifying the FFT of the output closely resembles the FFT of a 60 Hz sinusoid
- Feedback control: A to B phase bridge rectifier circuit with voltage divider
- Boost Converter: Verifying the boost converter could produce and maintain a 24 V, 1 A output from the 12 V input for the PWM
- Electrical Battery: Verifying the batteries could supply the

Future Work:

The following are ideas to further improve the Three-Phase DC-AC Inverter:

- Debugging PCB to allow for the design to be placed into the enclosure
- Replace the boost converter to be feedback friendly while also providing enough power
- Implementing feedback control design

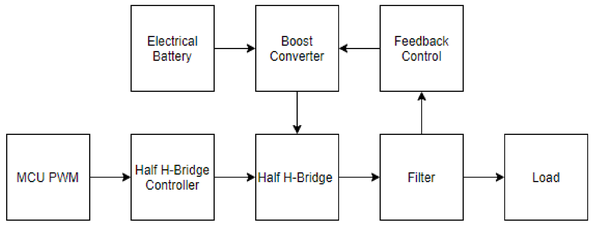

Figure 1: Block Diagram for our design

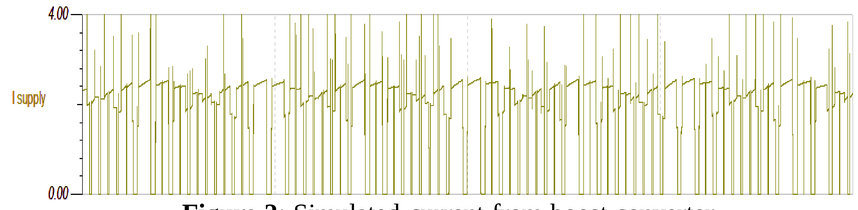

Figure 2: Simulated current from boost converter

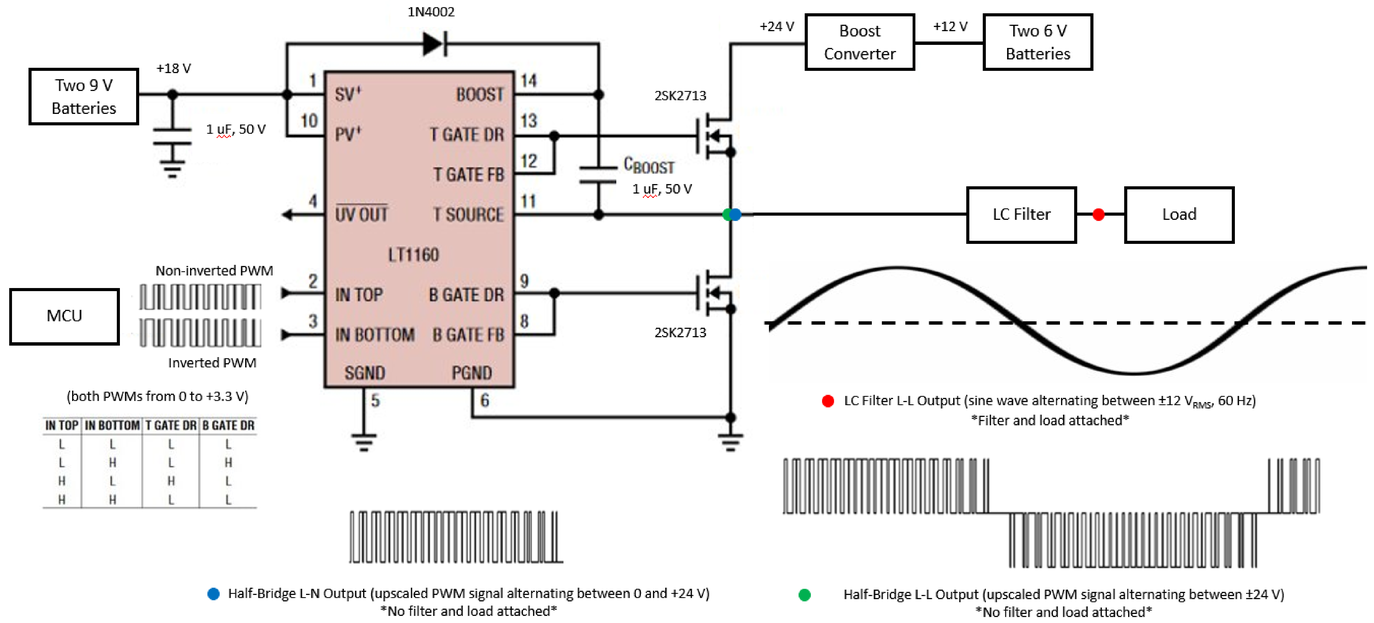

Figure 3: Single phase for our design

Conclusion:

Our DC to 3-phase inverter met a handful of different specifications. The inverter input is 12 V DC from a series combination of batteries. We will use a microcontroller to generate PWM signals, both inverted and noninverted, for each phase. The noninverted and inverted PWM signals are then sent into an LT1160 IC chip that controls the switching of n-channel power MOSFETs. A boost converter will connect the batteries to the "logic 1" side of the Half-H bridge to essentially scale up the PWM signal from the microcontroller to the necessary peak voltage. This signal is then sent into a filter to smooth out the signal so that we may obtain a 12 V_{RMS}, 60 Hz AC output.

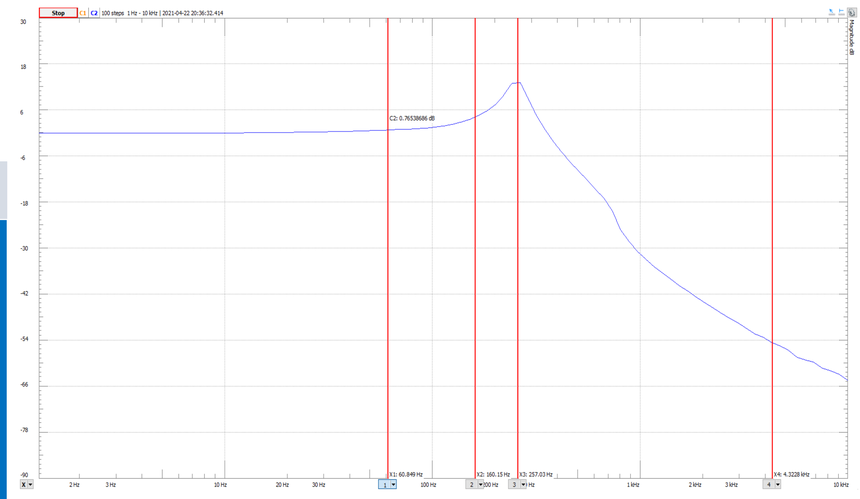

Figure 4: Filter Frequency Response measured on AD2