Senior Project – Electrical Engineering – 2020

Three-phase Pulse Width Modulated AC/DC Rectifier and DC/AC Inverter

Carmen Ngo

Advisor – Prof. Luke Dosiek

INTRODUCTION:

- Electric cars have batteries that run on direct current (DC) power. The motor can run on either alternating current (AC) or DC power.
- AC is an electric current that periodically reverses direction. DC only flows in one direction.
- AC can be converted to DC using a rectifier. DC can be converted to AC using an inverter.
- Three-phase power is the most common method to transfer power.

DESIGN:

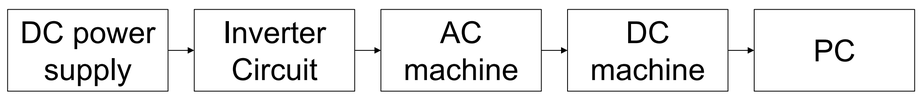

Figure 1: Block Diagram of Inverter System

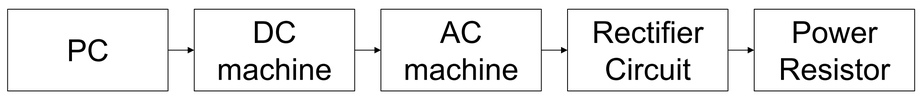

Figure 2: Block Diagram of Rectifier System

- Goals:
  - Successfully replicate and understand the power flow in an electric vehicle
  - Mimic driving and braking in an electric vehicle
    - Driving using an inverter circuit
      - Invert DC power to three-phase AC power
    - Braking using a rectifier circuit
      - Convert three-phase AC power to DC power

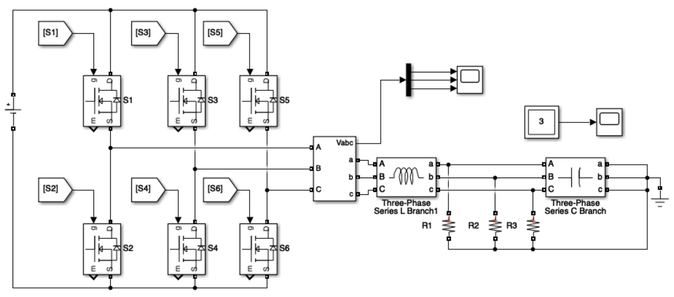

Figure 3: Inverter Circuit

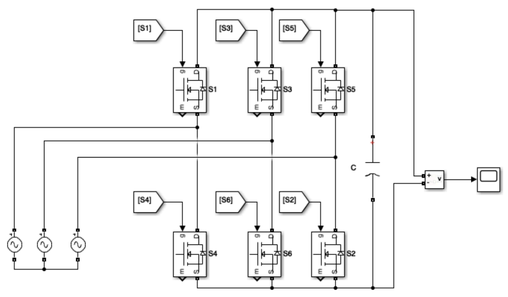

Figure 4: Rectifier Circuit

- Inverter circuit uses IRS2184 half-bridge gate drivers, IRFP054 N-channel MOSFETs, sinusoidal pulse width modulation (SPWM), LC filter for f_c = 138.5 Hz
- Rectifier circuit uses MIC4422 low-side gate drivers, IRFP054 N-channel MOSFETs, and capacitor filter

DESIGN REQUIREMENTS:

- Driving and braking systems should run continuously and start as soon as power is provided
- Three-phase AC output signals should be 50 Hz and 120 degrees phase shifted from each other
- Driving system should move the three-phase AC motor
- Braking system should power a power resistor
- Use SPWM to control the MOSFETs in the inverter and compare each of the three-phase AC input signals to control the MOSFETs in the rectifier

SIMULATION and TESTING:

- Figure 5 shows the SPWM technique and Figure 6 shows the inverter circuit

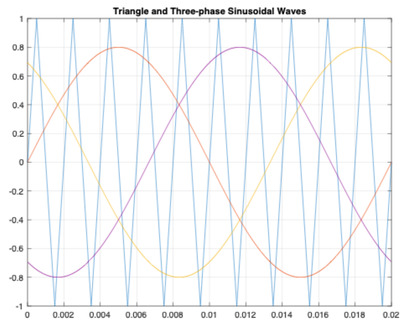

Figure 5: SPWM technique

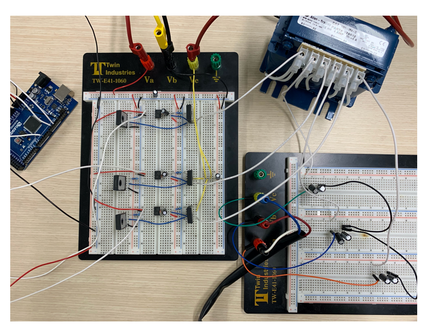

Figure 6: Inverter Circuit

- Figure 7 shows the SIMULINK output of the inverter output and Figure 8 shows the actual output

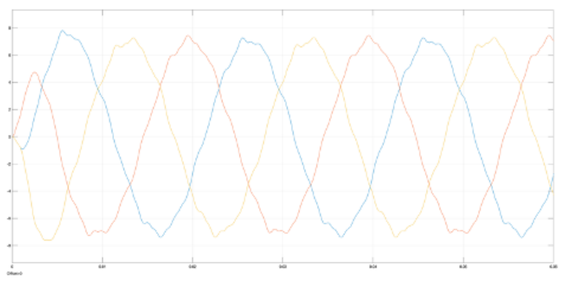

Figure 7: SIMULINK output

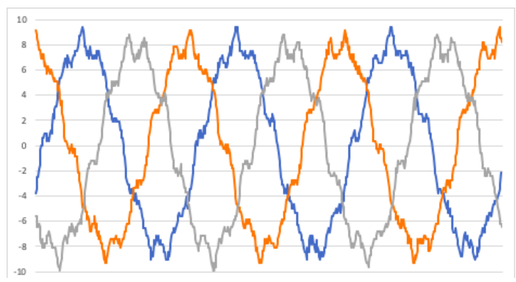

Figure 8: Actual output

- Figure 9 shows the SIMULINK output of the rectifier and Figure 10 shows the actual output

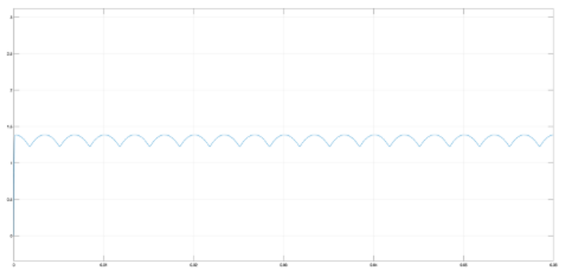

Figure 9: SIMULINK output

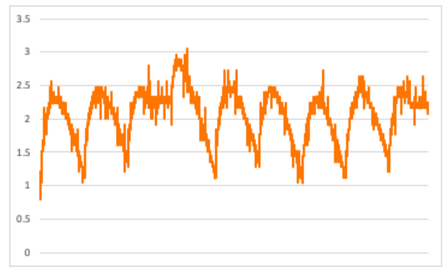

Figure 10: Actual output

RESULTS:

- Driving system runs continuously and as soon as power is provided
  - Each signal of the three-phase AC output has a frequency of 50 Hz and is 120 degrees phase shifted from each other

FUTURE WORK:

- Bidirectional power flow
- Real-time AC input signals for rectifier
  - Non-inverting amplifier
  - AC permanent magnet motor
- Include mechanical load in driving scenario
- Include power resistor in braking scenario
- Feedback control for real-time tuning of magnitude and frequency of inverter output, and average value for rectifier output
- Feedback for speed, torque, or position control of a motor load

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