POWER ELECTRONICS PROJECT
THREE PHASE INVERTER

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Abstract

The project is about designing and implementing three phase inverter with resistive and inductive load. 180 degree conduction mode, 120 degree conduction mode, 180 degree conduction mode with pwm and sinosoidal pwm has been used. 60 volt dc is provided as input to AC-DC three phase inverter. The simulations has been performed with Multisim and Labview. The pulses in hardware implementation has been generated using STM32F407 i.e 32-bit microcontroller. In hardware, only 180 degree conduction mode and sinosoidal pwm has been implemented. IR2110 has been used as gate driver IC and TLP250 has been used as optocoupler to isolate the grounds of microcontroller from ground of load.

Chapter 1

Intoduction

Three Phase inverter is a DC-AC converter that converts an incoming DC voltage to three phase square wave AC at the output. The basic principle of conversion is just the switching action. Given below the circuit of DC-AC three phase inverter.
It is a combination of two half bridge circuits. The Voltage across the load appears square wave as a result of switching action. Three phase DC-AC inverter is shown in Fig. 1.1

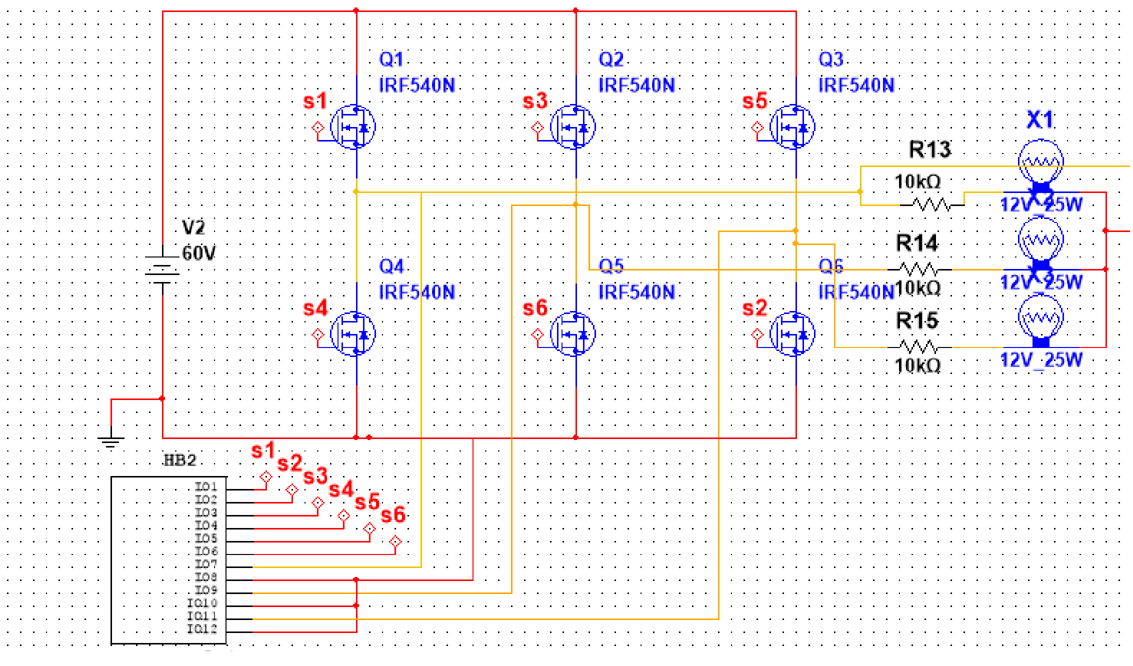

FIGURE 1.1: Three phase inverter

1.1 Modes of Conduction

For switching, IGBTS or MOSFETs are usually used. On the gate of MOSFETs pulses are provided for switching. Input pulses in a leg of inverter are complementry. Pulse given to s1 will be complementry to pulse given to s4. s1 and s4, s3 and s6, s2 and s5 must not conduct at one time.

There are normally 2 common modes of Conduction of a 3 phase inverter:

- 180 degree Conduction Mode
- 120 degree Conduction Mode

The difference between these two mode of conduction is in switching sequences provided to the gates. In 180 degree conduction mode each switch is on for 180 degree and three switches conducts at a time. In 120 degree conduction mode each switch is on for 120 degree and two switches conducts at a time.
There is a significant difference in 180 and 120 degree conduction modes of three phase inverter. 180 degree conduction mode is better in terms of utilization of source but it has a drawback that during switching action there are significant chances of short circuit. On the other hand, in 120 degree conduction mode, we have no chance of short circuit because there is a delay of 60 degree between switching of two MOSFETS in the same branch. But 120 degree conduction mode is not better in term of source utilization as area under the curve in both, line and phase voltages is less as compared with 180 degree conduction mode.
In addition to these two modes, there are high frequency pwm modes and sinosoidal pwm mode, both of which are part of this project.

Chapter 2

Hardware Implementation

For its hardware implementation, we need the following components.

- Microcontroller for Gate Pulses (in our case STM32F407).
- MOSFETS (IRF540/IRF450).
- Gate Driver IC (IR2110).
- Optocoupler (TLP250).
- High Frequency Diode (UF4007)

2.1 Opto-Coupler TLP250

We use opto coupler TLP250 to provide isolation to the micro controller from second stage which consists of High side Power MOSFETS draws much current. High side Mosfets means its source is not fully grounded but used both as high and low.

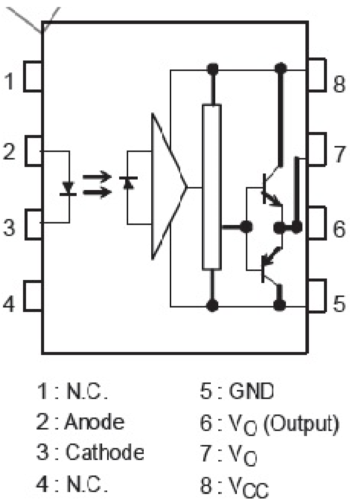

Figure 2.1: TLP250 pin configuration

Pin 2 is connected to the microcontroller via resistance of 330 ohm.
Pin 3 is connected to the ground of microcontroller, 1 and 4 are kept open.
On the other side of IC,
Pin 8 is connected to Vcc.
Pin 5 is connected to ground.
Pin 6 and Pin 7 are short circuited as shown in figure, we can take output from any of these pin.

2.2 MOSFET driver IR2110

The IR2110 is high voltage, high speed power MOSFET and IGBT driver with independent high and low side referenced output channels. IR2210 can with stand voltage upto 500v (offset voltage). Its output pins can provide peak current upto 2 ampere. Gate driver circuit with IR2110 is shown below:

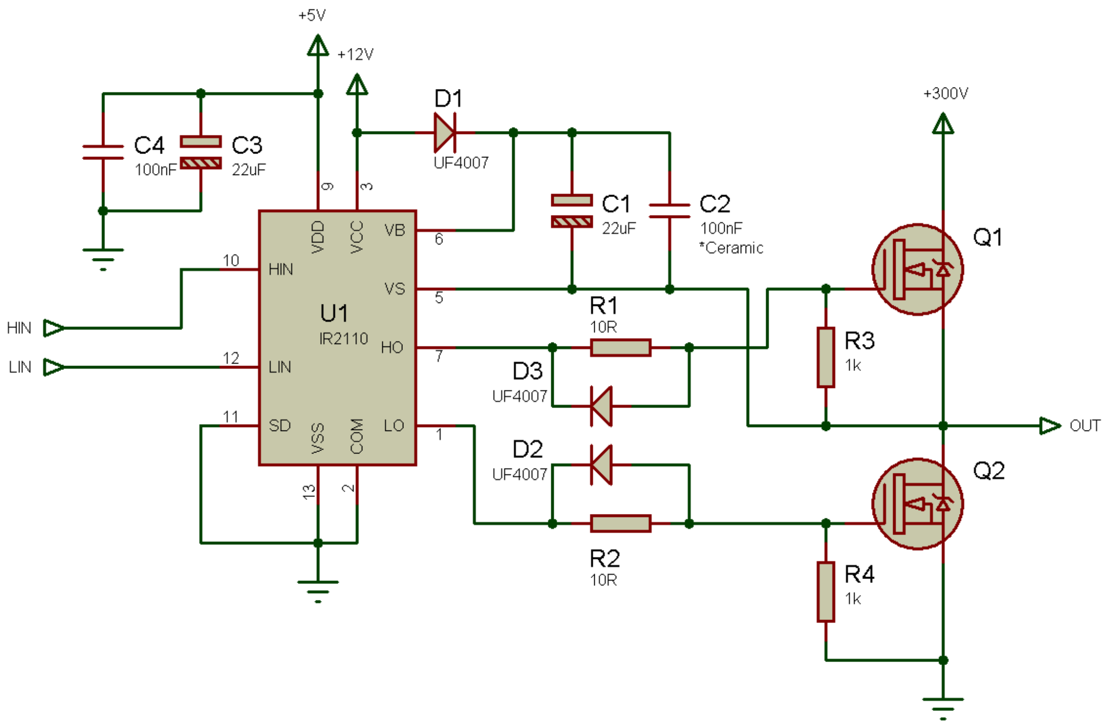

FIGURE 2.2: Gate driver circuit with IR2110

HO pin is connected to the gate of upper side MOSFET in a single branch. LO pin is connected to the gate of lower side MOSFET in the same branch. Another advantage of this IC is dead time that it creates automatically between HO and LO, this simplifies our programming and as well as it reduces the risk of short circuit

2.3 MOSFET IRF450

IRF450 and IRF540 are power MOSFETs that are designed for applications such as switching regulators, switching convertors, motor drivers, relay drivers, and drivers for high power bipolar switching transistors requiring high speed and low gate drive power. . We choose MOSFETS IRF450 because in its internal circuitry we already have a diode connected between drain to source that allows our inductive load to discharge without damaging the MOSFET

Chapter 3

Simulations

3.1 180 degree conduction mode

The simulations regarding 180 degree conduction mode are shown below. The pulses are generated and fed to mosfet gates. In practical these pulse are generated by STM32f407 microcontroller. Pulses are generated by configuring a timer TIM4 and then 6 pins have been toggled at 60 degrees from each other as shown in Fig. 3.1. Fig. 3.2 and 3.3 shows line to neutral and line to line voltages at 180 degree conduction mode.

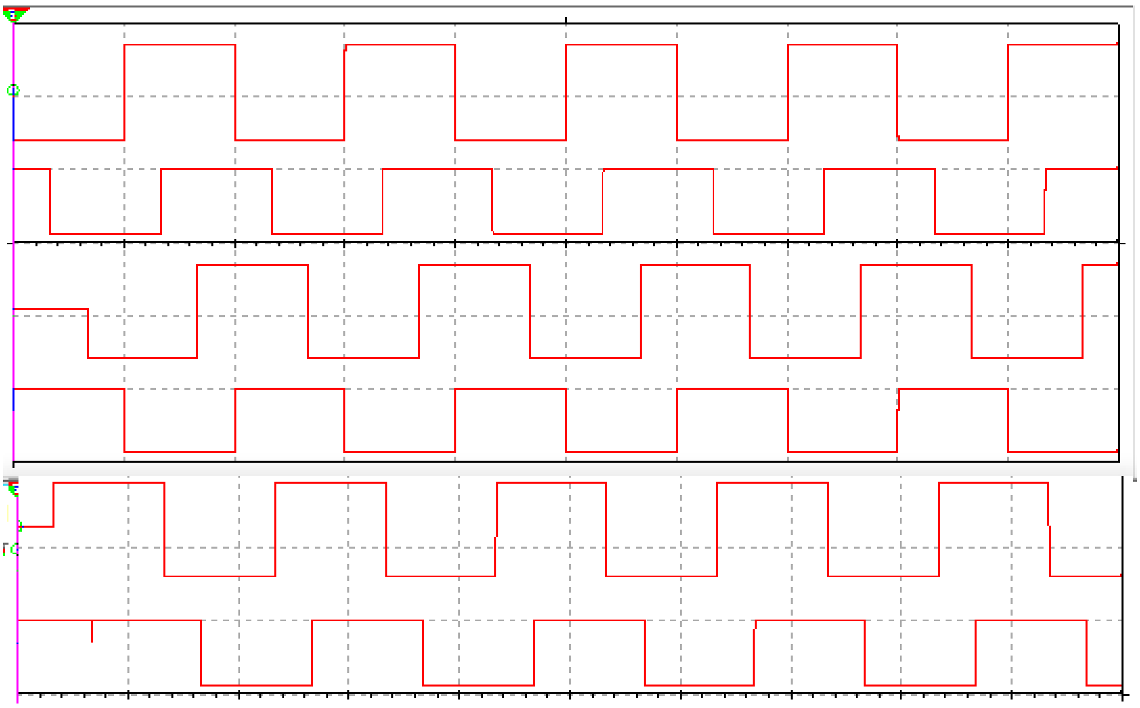

FIGURE 3.1: switching sequence at 180 conduction mode

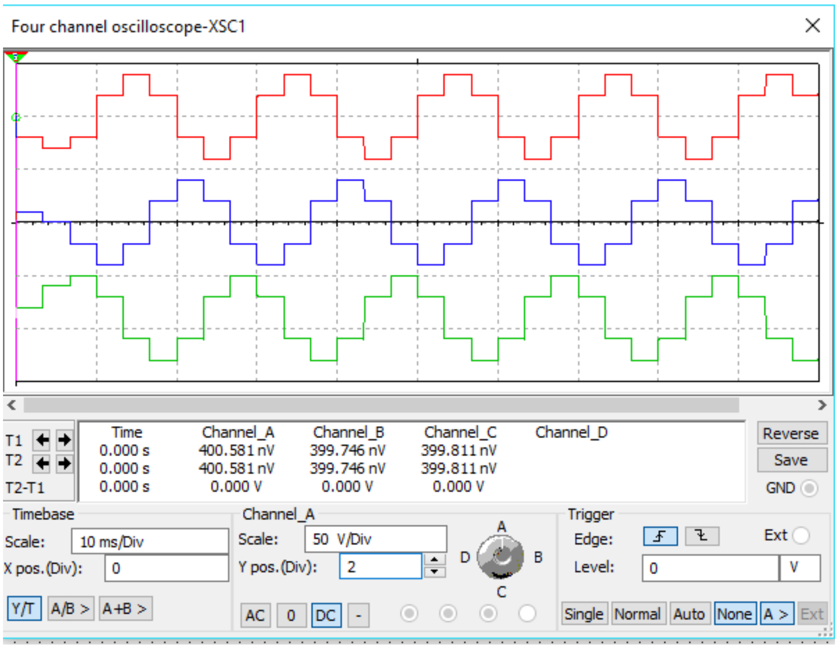

FIGURE 3.2: Line to neutral voltages at 180 conduction mode

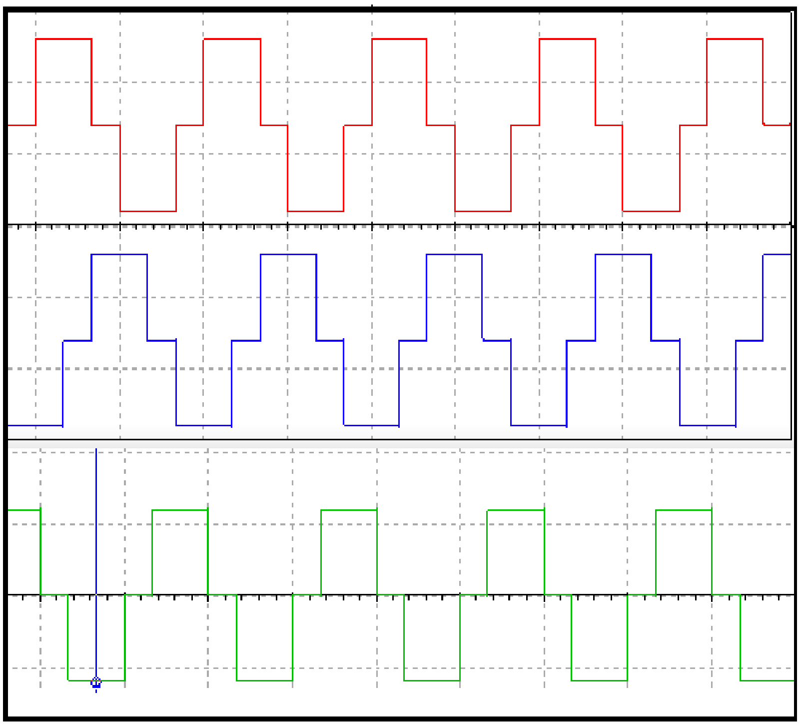

FIGURE 3.3: Line to line voltages at 180 conduction mode

It can be seen that peak voltage in Fig. 3.2 is $\frac{2V_s}{3}$ whil e in Fig. 3.3 it is V_s.

3.2 180 degree conduction mode with variable frequency

For variable frequency graphical user interface has been developed with labview. Block diagram and front panel window is shown in Fig 3.4 and Fig. 3.5 respectively.

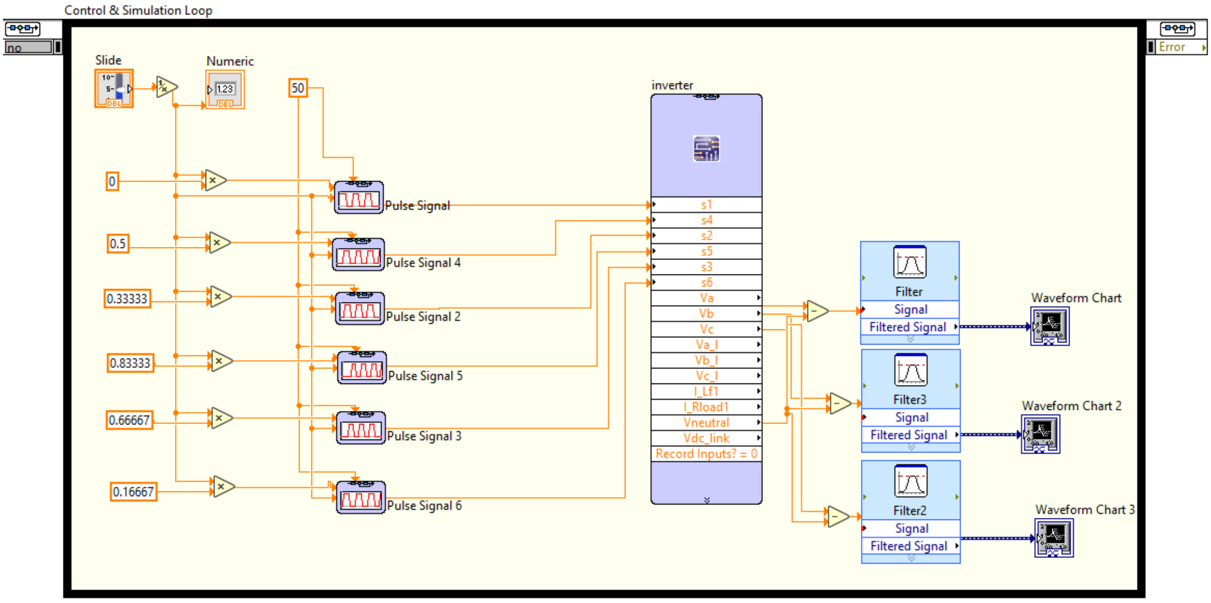

FIGURE 3.4: block diagram

FIGURE 3.5: front panel

3.3 180 degree conduction mode with pwm operation

Input to gates of MOSFETs in this case are AND of the pulses shown in 3.1 and high frequency pulse train of 4 kHz. Fig. 3.6 and 3.7 shows line to neutral and line to line voltages at 180 degree conduction mode with pwm operation.

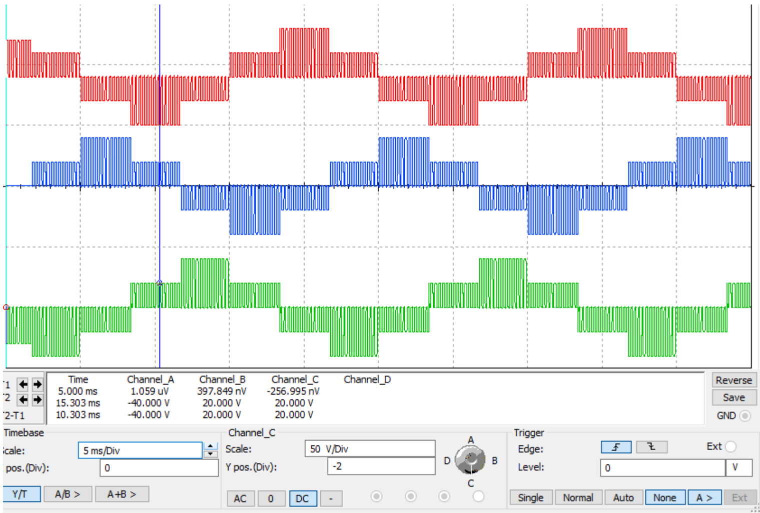

FIGURE 3.6: Line to neutral voltages at 180 conduction mode with pwm operation

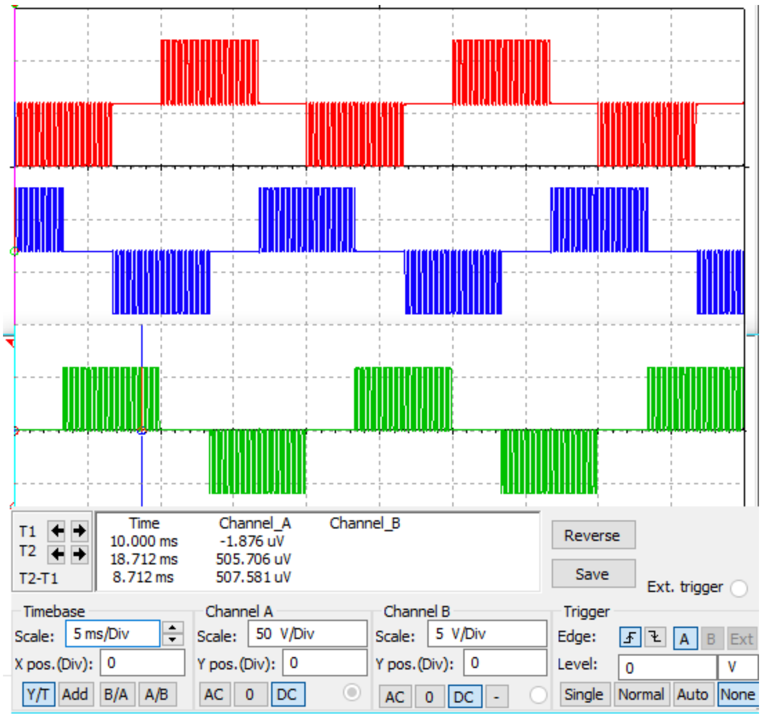

FIGURE 3.7: Line to Line voltages at 180 conduction mode with pwm operation

3.4 120 degree conduction mode

The simulations regarding 180 degree conduction mode are shown below. The pulses shown in Fig.3.8 are generated and fed to mosfet gates. Fig. 3.9 and 3.10 shows line to neutral and line to line voltages at 180 degree conduction mode.

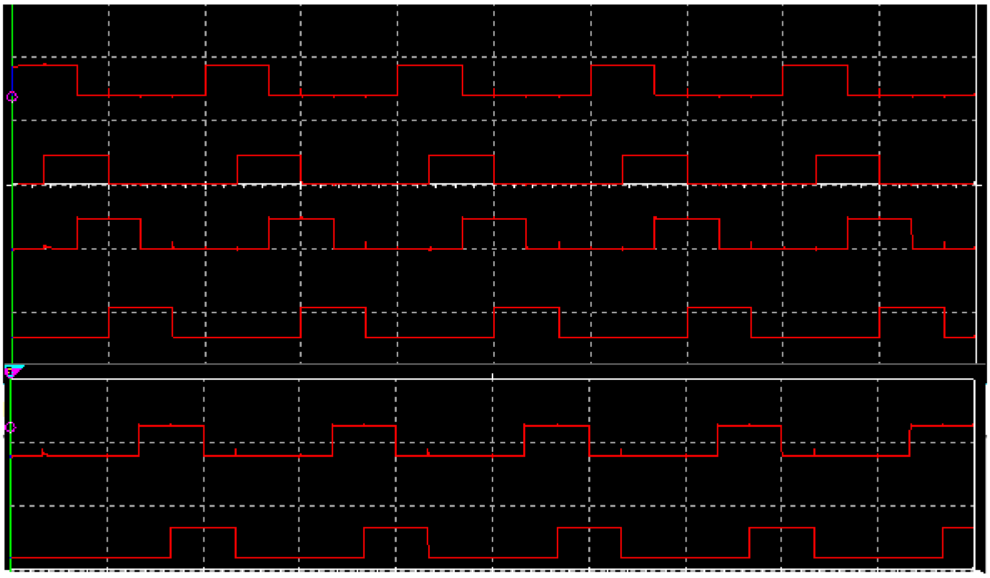

FIGURE 3.8: switching sequence at 120 conduction mode

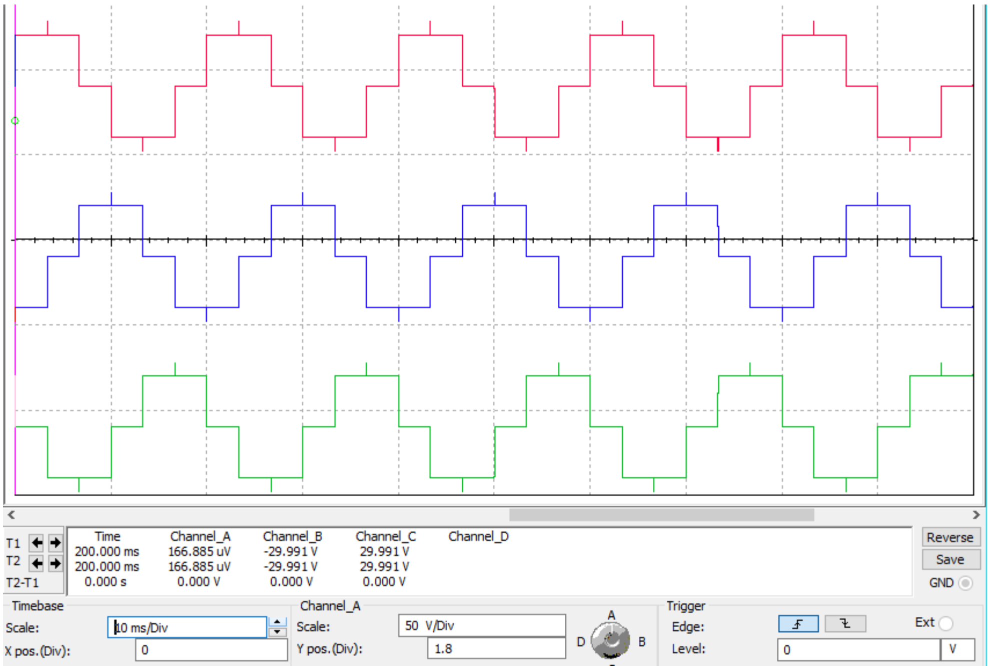

FIGURE 3.9: Line to neutral voltages at 120 conduction mode

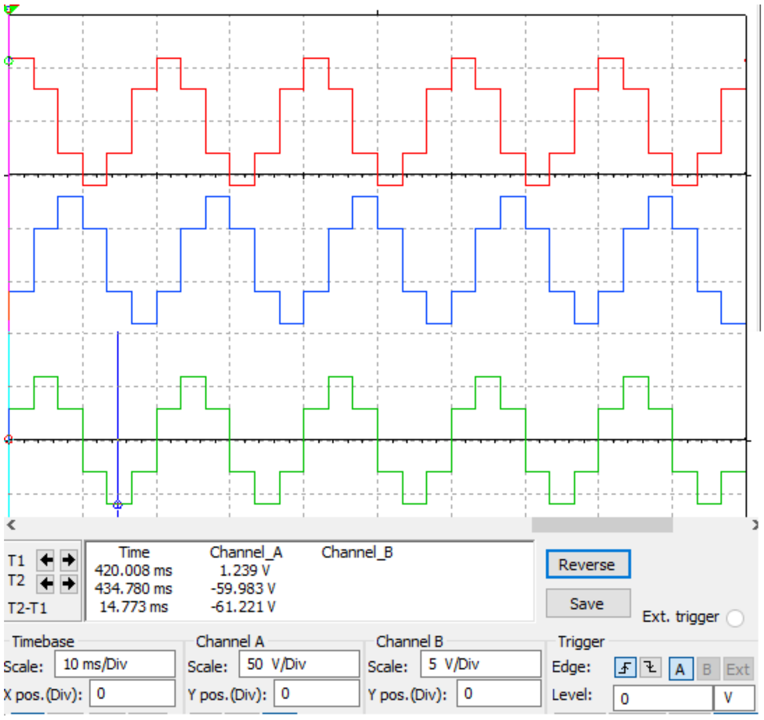

FIGURE 3.10: Line to line voltages at 120 conduction mode

3.5 Sinosoidal pulse width modulation

In multisim, spwm has been generated by sine wave of 50 Hz and triangular wave of 2 kHz. These two waves are fed to LM741 which is an op-amp and has been used as a comparator. LM741 gives spwm as an output which is shown Fig. 3.12.

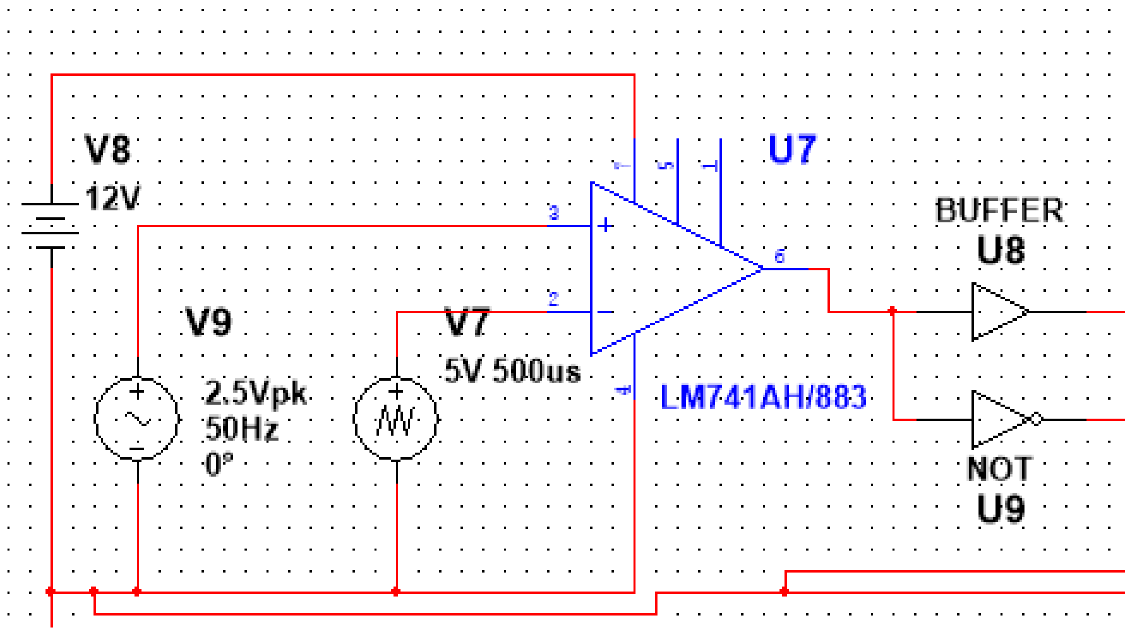

FIGURE 3.11: generation of spwm

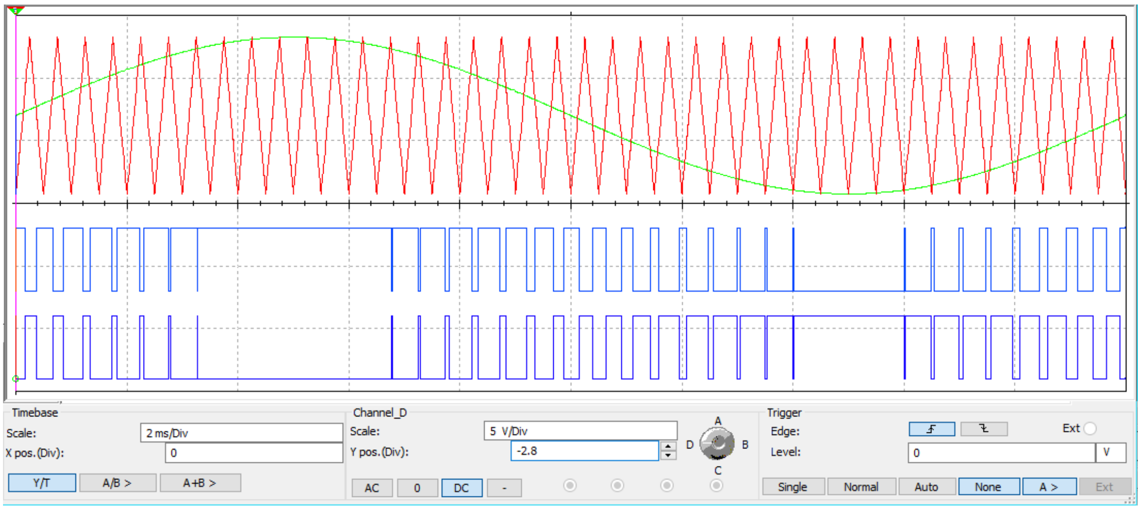

FIGURE 3.12: sinosoidal PWM

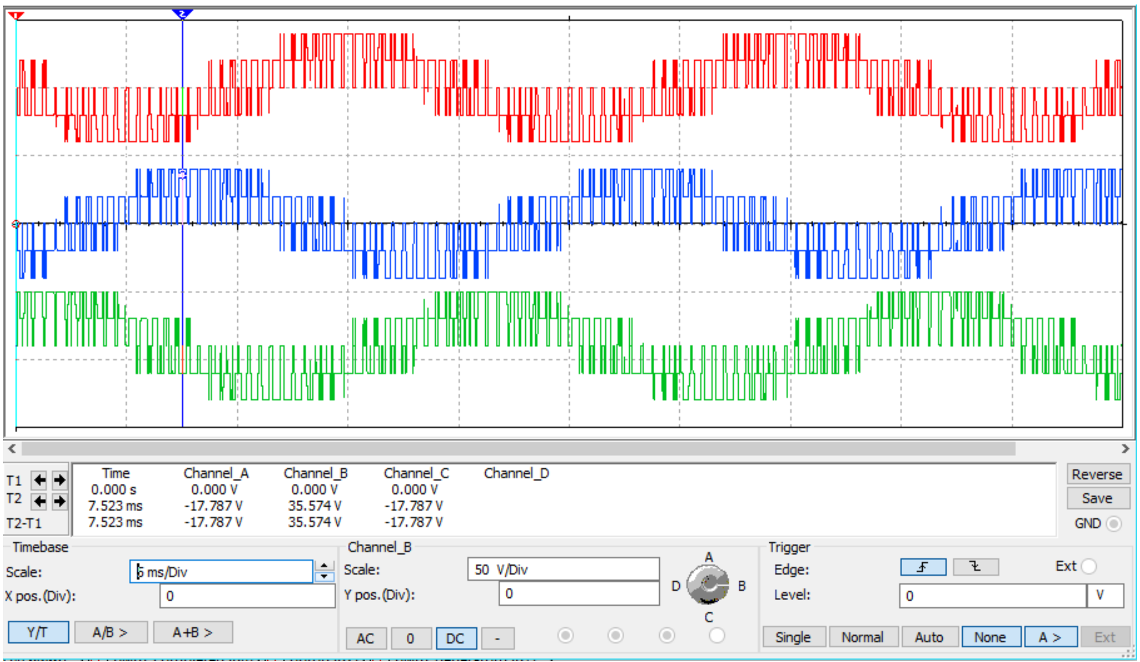

FIGURE 3.13: Line to neutral voltages with spwm

In practical, sine wave table has been generated for 50Hz cycle. The table contains 256 values. The frequency of pwm is 9.6kHz. Channels 1, 2 and 3 and 1N, 2N and 3N of timer TIM1 has been used for phase a, b and c.

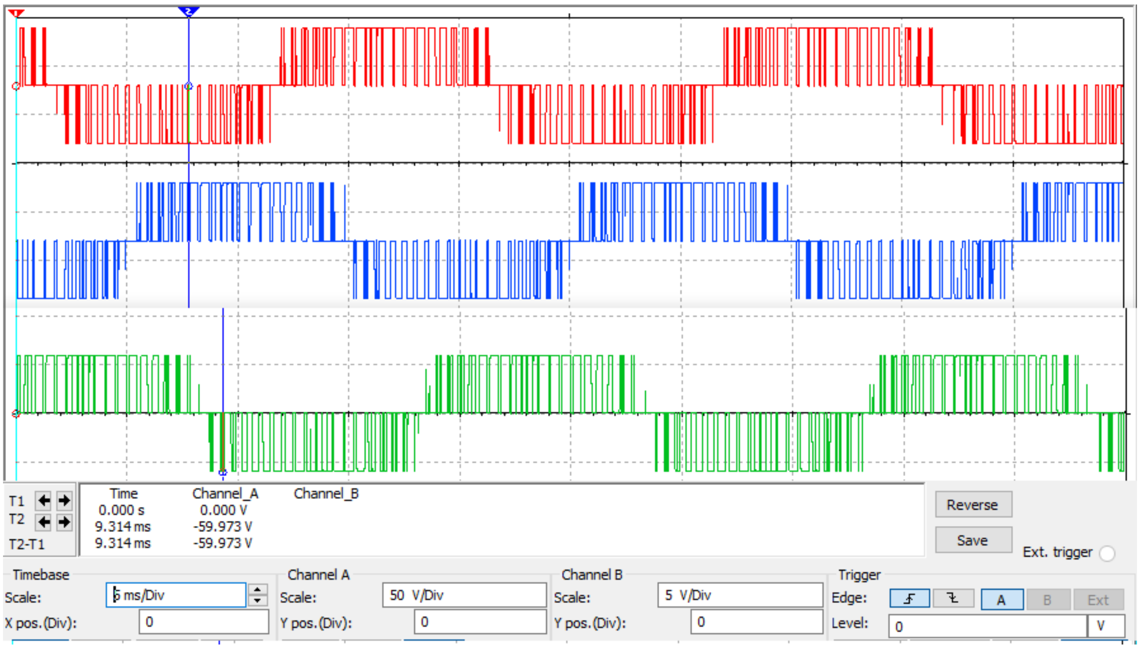

FIGURE 3.14: Line to line voltages with spwm

It can be seen that peak voltage in Fig. 3.13 is $\frac{2V_s}{3}$ whil e in Fig. 3.14 it is V_s.

Chapter 4

Conclusion

When a switch is off there is practically no current, and when it is on and power is being transferred to the load, there is almost no voltage drop across the switch. Power loss, being the product of voltage and current, is thus in both cases close to zero. PWM also works well with digital controls, which, because of their on/off nature, can easily set the needed duty cycle. SPWM technique is one of the most used techniques for pure sine wave inverter due to its controlling property but it introduces delay in switching and also it requires dedicated processors. Three phase inverters are used in grid, electric motor speed control and in refrigeration compressors.