THESIS REPORT ON

AC SINE WAVE GENERATION BY USING SPWM INVERTER

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Declaration

We hereby declare that this thesis is based on the results found by ourselves. Materials of work found by other researchers are mentioned by reference. This thesis, neither in whole nor in part, has been previously submitted for any degree.

Signature of the Supervisor Signature of the Author

Acknowledgement

With deep sense of gratitude we express our sincere thanks to our supervisor, Amina Hasan Abedin, senior lecturer, BRAC University for her guidance in carrying out this work under her supervision, encouragement and cooperation .We are also thankful to all the staff members of the department for their full cooperation

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ABSTRACT:

This paper contains the analysis of basic inverter topologies. pulse width modulation inverter has been briefly explained by giving operational methods and simulated circuits. Different methods of inverter have also being described with identical model. Among those, one method has been implemented with software simulation.

CHAPTER 1:

INTRODUCTION

Inverters are circuits that convert dc to ac. We can easily say that inverters transfer power from a dc source to an ac load. The objective is to create an ac voltage when only a dc voltage source is available. A variable output voltage can be obtained by varying the input dc voltage and maintaining the gain of the inverter constant. On the other hand, if the dc voltage is fixed & not controllable, a variable output voltage can be obtained by varying the gain of the inverter, which is normally accomplished by pulse-width-modulation (PWM) control within the inverter. The inverter gain can be defined as the ratio of the ac output voltage to dc input voltage.

1.1: APPLICATIONS

Different applications of inverter are given below:

- **Adjustable-speed ac motor drivers**
- **Uninterruptible power supplies (UPS)**: An uninterruptible (UPS) uses batteries and an inverter to supply AC power when main power is not available. When main power is restored, a rectifier supplies DC power to recharge the batteries.
- **AC appliances run from an automobile battery**
- **HVDC power transmission**: With HVDC power transmission, AC power is rectified and high voltage DC power is transmitted to another location. At the receiving location, an inverter in a static inverter plant converts the power back to AC.
- **Electric vehicle drives**: Adjustable speed motor control inverters are currently used to power the traction motors in some electric and diesel-electric rail vehicles as well as some battery electric vehicles and hybrid electric highway vehicles such as the Toyota Prius and Fisker Karma. Various improvements in inverter technology are being developed specifically for electric vehicle applications.[2] In vehicles with regenerative braking, the inverter also takes power from the motor (now acting as a generator) and stores it in the batteries.

- **Air conditioning**: An air conditioner bearing the inverter tag uses a variable-frequency drive to control the speed of the motor and thus the compressor
- **DC power source utilization**:An inverter converts the DC electricity from sources such as batteries, solar panels', or fuel to AC electricity. The electricity can be at any required voltage; in particular it can operate AC equipment designed for mains operation, or rectified to

produce DC at any desired voltage. Micro inverter converts direct current from individual solar panels into alternating currentfor the electric grid. They are grid tie designs by default.

- **Induction heating**: Inverters convert low frequency main AC power to higher frequency for use in induction. To do this, AC power is first rectified to provide DC power. The inverter then changes the DC power to high frequency AC power.
- **Variable frequency drives**: A variable frequency drive controls the operating speed of an AC motor by controlling the frequency and voltage of the power supplied to the motor. An inverter provides the controlled power. In most cases, the variable-frequency drive includes a rectifier so that DC power for the inverter can be provided from main AC power. Since an inverter is the key component, variable-frequency drives are sometimes called inverter drives or just inverters.

1.2:CLASSIFICATION OF INVERTER

Basically Inverters are two types:

- Single-phase inverter
- Three-phase inverter

Different types of inverter:

- Full-bridge inverter
- Half-bridge inverter
- Pulse-width modulated inverter
- Current-source inverter
- Variable DC-link inverter
- Boost inverter
- Resonant pulse inverter
- Multilevel inverter
- Six-step inverter

CHAPTER 2:
BASIC CONCEPTS OF INVERTER

In this section there are basic concepts of the operation of full-bridge inverter & half-bridge inverter.

2.1: FULL-BRIDGE CONVERTER:

The full bridge converter is the basic circuit that converts dc to ac. An ac output is synthesized from a dc input by closing and opening the switches in the appropriate sequence. The output voltage V_0 can be $+V_{dc}$, $-V_{dc}$, or zero depending on the switch is closed. We have to make sure that switches are opened and closed in sequence otherwise short circuit could be happened.

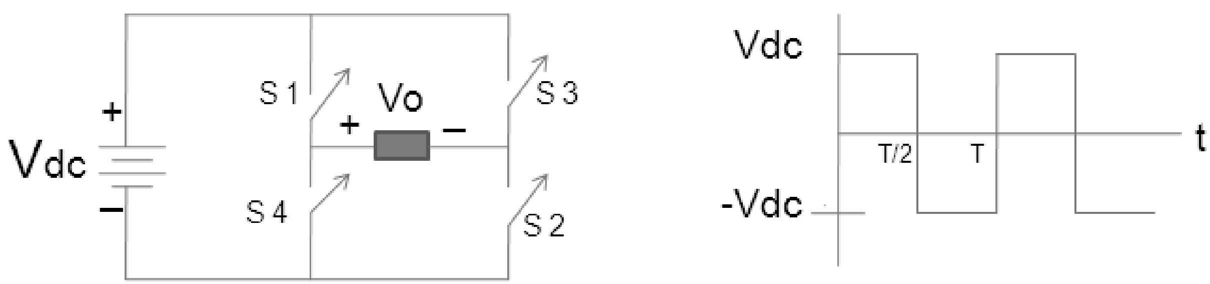


FIG1: Full-bridge inverter and square wave

SWITCHES CLOSED	OUTPUT VOLTAGE, V_0
S1 AND S2	+VDC
S3 AND S4	-VDC
S1 AND S3	0
S2 AND S4	0

TABLE 1: Switching combination & output voltage

Note that S1 and S4 should not be closed at the same time, nor should S2 and S3, otherwise, a short circuit would exist across the dc source. Real switches don't turn on or off instantaneously.Therefore, transition times must be accommodated in the control of the switches. Overlap of the switch "on" times will result in a short circuit, sometimes called a "shoot-through" fault, across the dc voltage source. The time allowed for switching is called "blanking" time.

2.2: HALF-BRIDGE INVERTER:

The half- bridge converter can be used as an inverter. This circuit can also be used as dc power circuit. In the half bridge inverter the number of switches is reduced to two by dividing the dc source voltage into two parts with the capacitors. Each capacitor will be the same value and will have voltage Vdc\2 across it. When s1 is closed the load voltage is –Vdc\2.when s2 is closed, the load voltage is Vdc\2.thus, a square-wave output or a bipolar pulse-width modulated output, as described in the following section can be produced.
The voltage across an open switch is twice the load voltage, or Vdc .as with the full bridge inverter blanking time for the switches is required to prevent a short circuit across the source, and feedback diodes are required to provide continuity of current for inductive load.

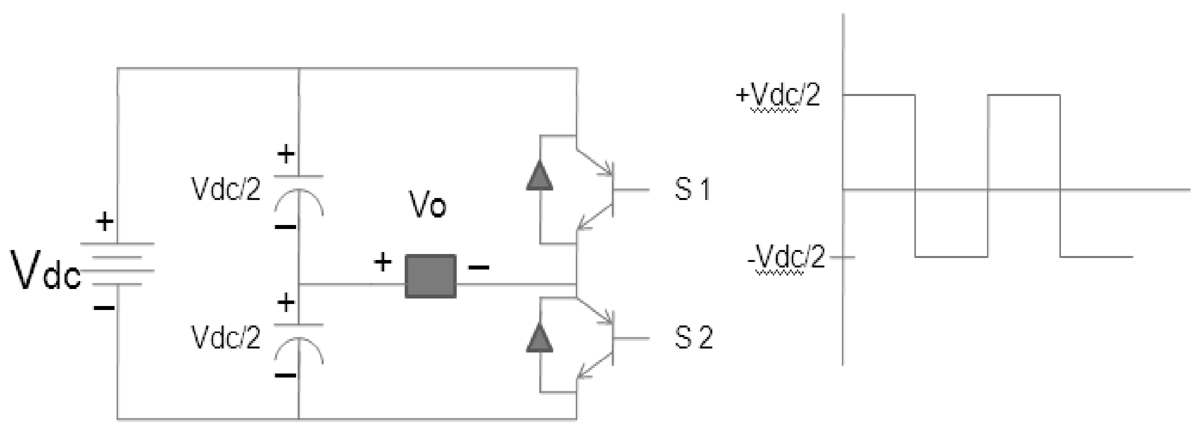


FIG2: Half-bridge inverter and its output

2.3: MODIFIED SINEWAVE INVERTER:

A very common upgrade to the square wave inverter is the modified sine wave inverter. In the modified sine wave inverter, there are three voltage levels in the output waveform, high, low, and zero (figure), with a dead zone between the high and low pulses. The modified sine wave is a closer approximation of a true sine wave than is a square wave, and can be used by most household electrical devices. As such, it is extremely common to see this type of inversion in commercial quality inverters.

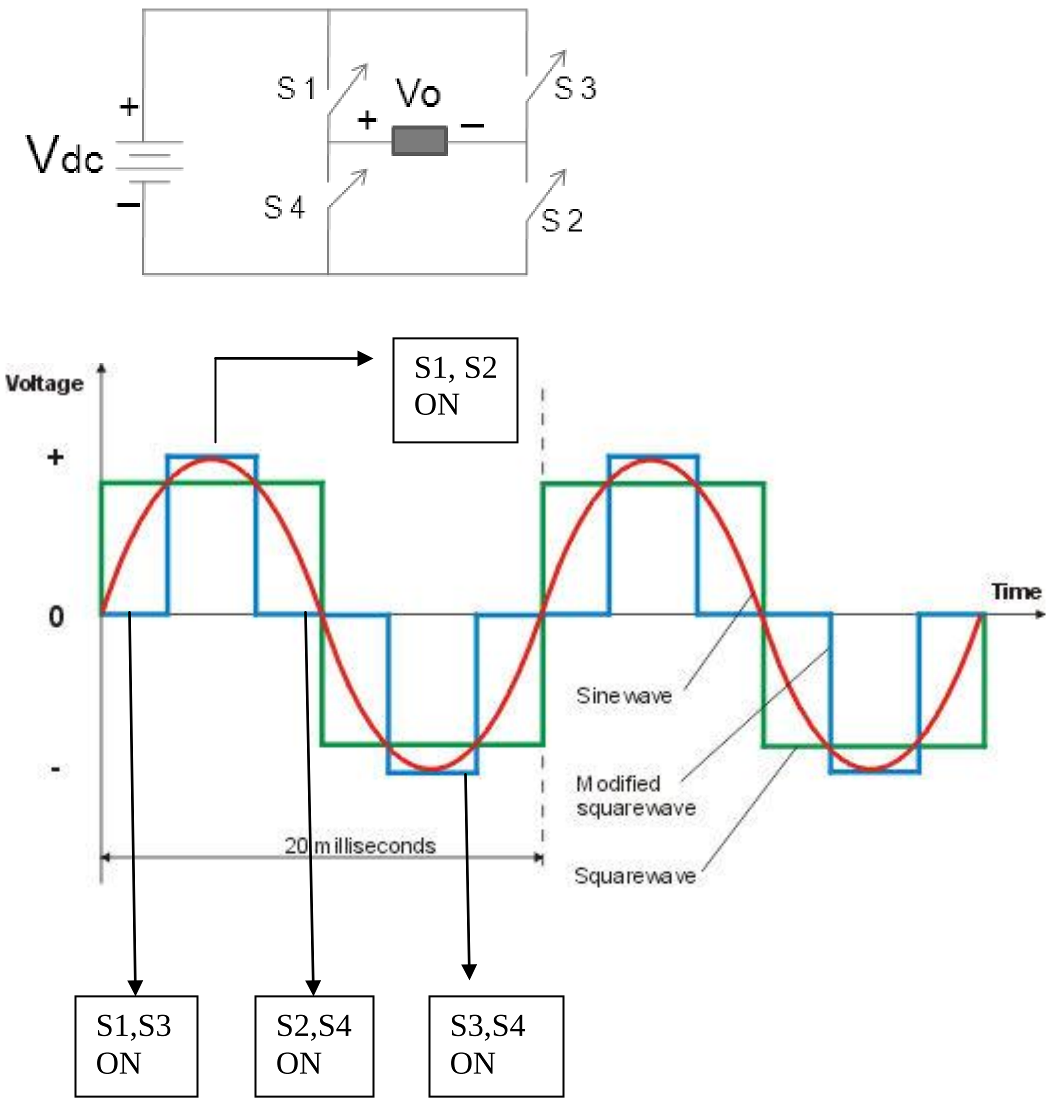


FIG3: Output of Modified sine wave inverter

Despite being much more viable than a simple square wave, the modified sine wave has some serious drawbacks. Like the square wave, modified sine waves have a large amount of power efficiency loss due to significant harmonic frequencies and devices that rely on the input power waveform for a clock timer will often not work properly. Despite the inherent drawbacks, many devices can work while powered by a modified sine source. This makes it an affordable design option for such implementations as household uninterruptible power supplies.

2.4: PULSE-WIDTH MODULATION INVERTER

To design an Inverter, many power circuit topologies and voltage control methods are used. The most important aspect of the Inverter technology is the output waveform. To filter the waveform (Square wave, quasi sine wave or Sine wave) capacitors and inductors are used. Low pass filters, are used to reduce the harmonic components.

In pulse width modulated (PWM) inverters, the input DC voltage is essentially constant in
Magnitude and the AC output voltage has controlled magnitude and frequency. Therefore the
Inverter must control the magnitude and the frequency of the output voltage. This is achieved by
PWM of the inverter switches and hence such inverters are called PWM inverters.
For square-wave inverters, the input DC voltage is controlled in order to adjust the magnitude of the output AC voltage. Therefore the inverter has to control only the frequency of the output voltage. The output AC voltage has a waveform similar to a square-wave.

Square wave switching method will produce more harmonic contents in inverter output compared to pulse width modulation switching technique.

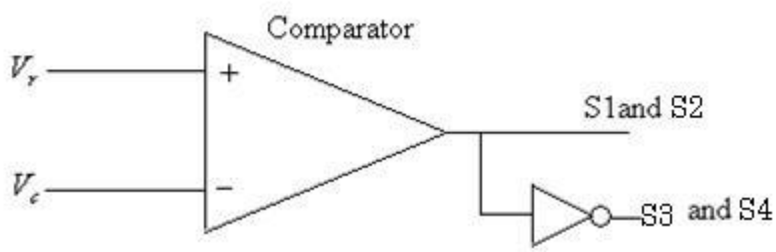
SPWM or sinusoidal pulse width modulation is widely used in power electronics to digitize the power so that a sequence of voltage pulses can be generated by the on and off of the power switches. The pulse width modulation inverter has been the main choice in power electronic for decades, because of its circuit simplicity and rugged control scheme. SPWM switching technique is commonly used in industrial applications. SPWM techniques are characterized by constant amplitude pulses with different duty cycle for each period. The width of this pulses are modulated in order to obtain inverter output voltage control and to reduce its harmonic content. Sinusoidal pulse width modulation or SPWM is the most common method in motor control and inverter application. Conventionally, to generate the signal, triangle wave as a carrier signal is compared with the sinusoidal wave, whose frequency is the desired frequency. The reason for using PWM techniques is that they provide voltage and current wave shaping customized to the specific needs of the applications under consideration.

By using PWM techniques, the frequency spectra of input waveforms can be changed such that the major non-fundamental components are at relatively high frequency and also to reduce the switching stress imposed on the power switching devices. Most PWM is generated by comparing a reference waveform with a triangular carrier waveform signal.
However, the reference waveform may come in various shapes to suit the converter topology, such as sine wave and distorted sine wave. A sinusoidal waveform signal is used for PWM in DC to AC converter where it is used to shape the output AC voltage to be close to a sine wave.

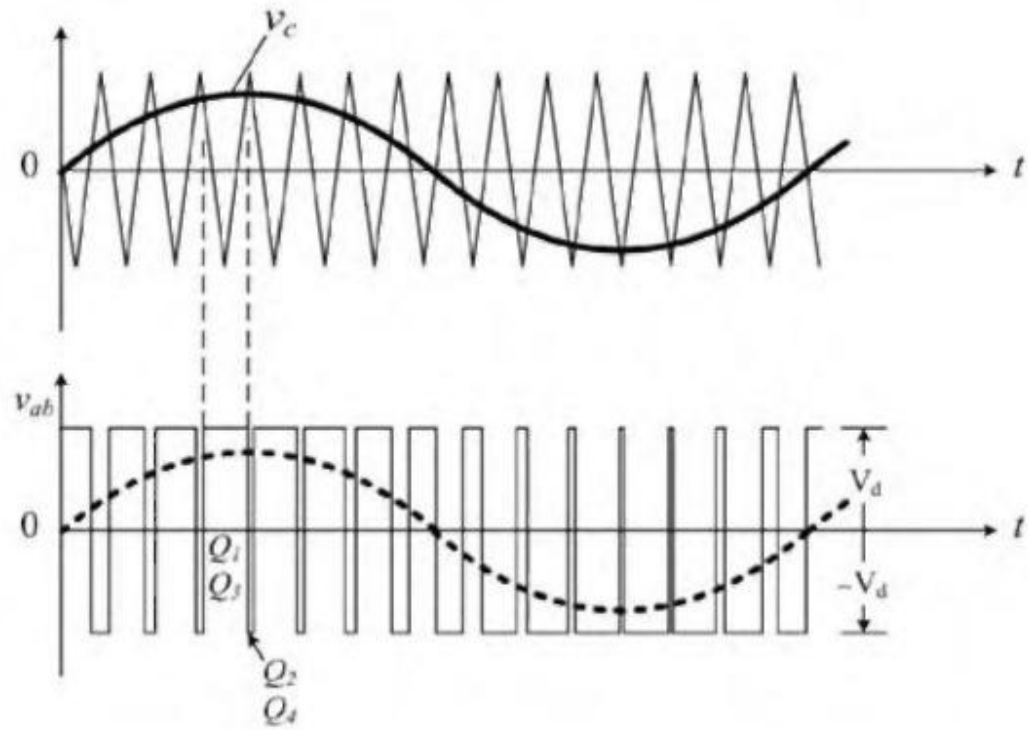
The commonly used techniques are:

1. Single pulse width modulation
2. Multiple pulse width modulation
3. Sinusoidal pulse width modulation
4. Modified pulse width modulation
5. Phase displacement control

<u>Bipolar switching</u>:



When the instantaneous value of the sine reference is larger than the triangular carrier the output is at +Vdc and when the reference is less than the carrier, the output is at –Vdc.
S1 and S2 are on when for Vsine>Vtri and Vo=+Vdc
S3 and S4 are on when for Vsine<Vtri and Vo=-Vdc

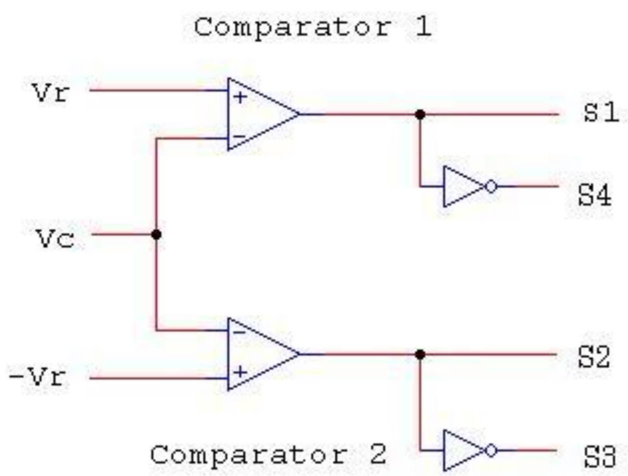


This version of SPWM is known as bipolar because the output voltage alternates between +Vdc to -Vdc.

Unipolar switching:

S1 On –Vsine>Vtri
S2 On –Vsine<Vtri
S3 On –Vsine>Vtri
S4 On –Vsine<Vtri

Vo varies from Vdc to 0 or –Vdc to 0 and all four switches follow high frequencysignals.



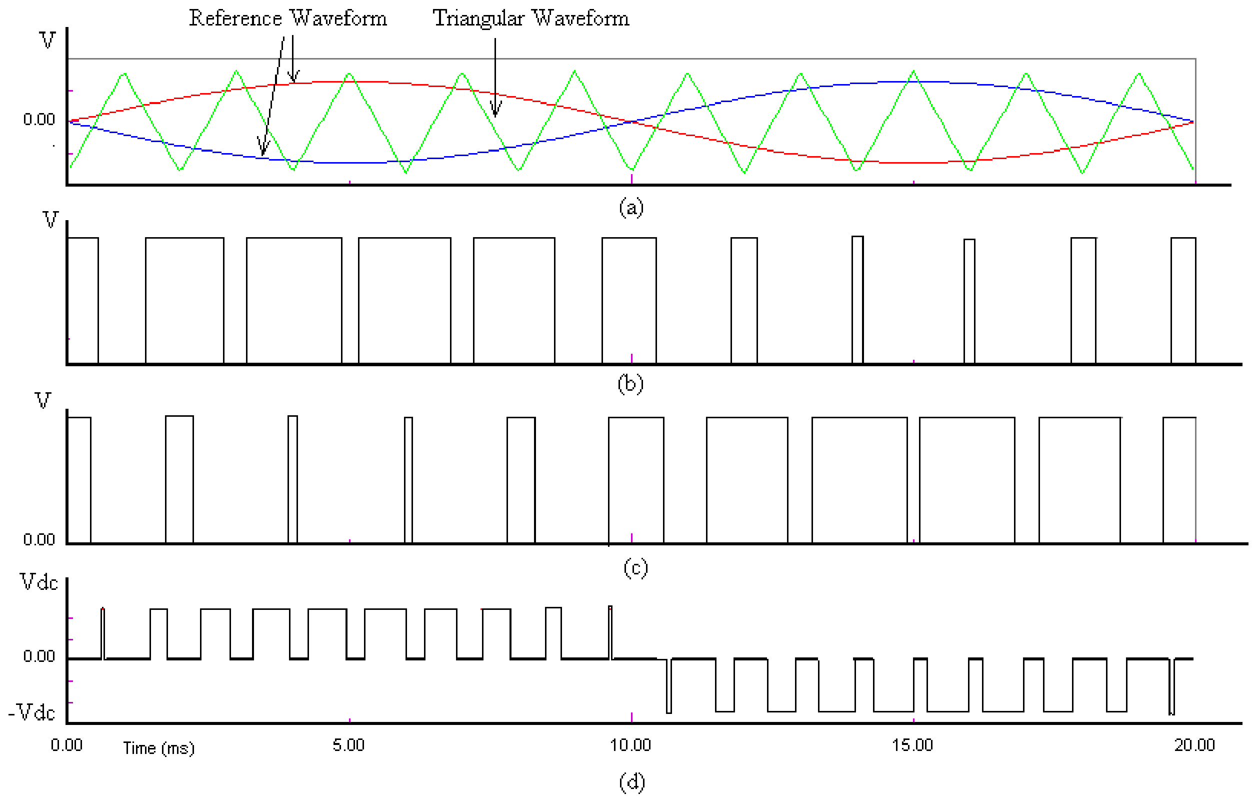


FIG4:a) Comparison between reference waveform and triangular waveform ,(b) &(c)Gating pulses , (d) The instantaneous output voltage

This version of SPWM is known as unipolar switching, because the output voltage is either +Vdc to 0 or –Vdc to 0.

2.5: PWM DEFINATIONS AND CONSIDERATIONS:

The frequency modulation ratio (m_f):

The frequency modulation ratio m_f is defined as the ratio of the frequencies of the carrier reference signal:

m_f=f(carrier)/f(reference)

= f (tri)/f (sine)

Amplitude modulation ratio (m_a):

The amplitude modulation ratio ma defined as ratio of the amplitudes of the reference and carrier signals;

m_a=Vm (reference)/Vm(carrier)

=Vm(sine)/Vm(tri)

If ma<=1 the amplitudes of the fundamental frequency of the output voltage V_l is linearly proportional to ma that is

$V_l = m_a.v$ (dc)

The amplitude of the fundamental frequency of the PWM output is thus controlled by m_a.This is significant in the case of an unregulated dc supply voltage because the value of ma can be adjusted to compensate for variations in dc supply voltage, producing a constant-amplitude output. Alternatively, ma can be varied to change the amplitude of the output. If m_a is greater than 1, the amplitude of the output increases with ma, but not linearly.

Switches:

The switches in the full bridge circuit must be capable of carrying current in either direction for pulse width modulation, just as they did for square wave operation. Feedback diodes across the switching devices are necessary. Another consequence of real switches is that they do not turn on and off instantly. Therefore it is necessary to allow for switching times in the control of the switches, just as it was for square wave inverter.

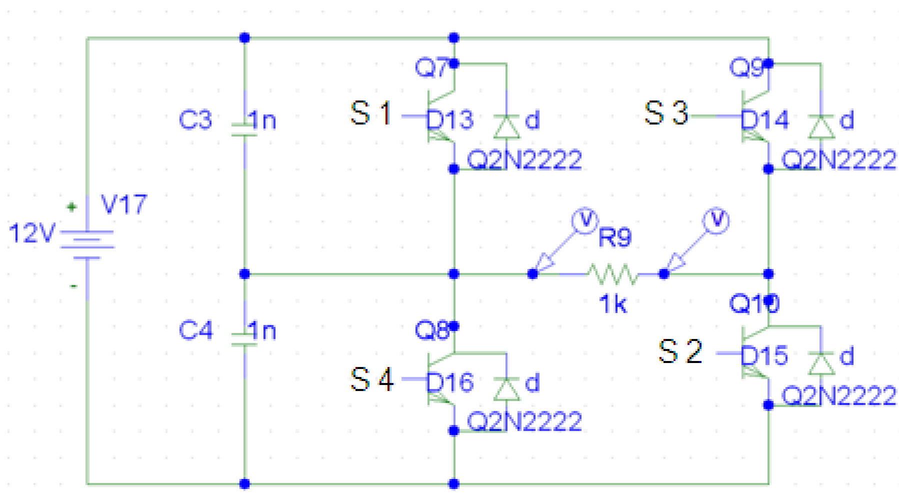
Reference voltage:

The sinusoidal reference voltage must be generated within the control of the full bridge inverter or taken from an outside reference. It may seem as though the function of Inverter Bridge is unnecessary, because the sinusoidal voltage must be present before the inverter can operate to produce sinusoidal output. However there is little power required from the reference voltage. The power supplied to the load is provided by the dc power source and this is intended purpose of the inverter. The reference signal is not restricted to a sine wave, it could also be an audio signal and the full bridge circuit could be used as an audio amplifier.

CHAPTER 3:
SIGNAL GENERATION AND DRIVING SWITCHES

3.1: SIGNAL GENERATION BY USING OP-AMP

By using op-amp for inverting and non-inverting operation we can get negative and positive pulse (square wave). For turning on switch 1 & 2 we can provide positive pulse, but at same time switch 3 & 4 should be turned off and for turning on switch 3 & 4 by giving a negative pulse we have to keep switch 1 & 2 turned off. Then finally we'll get a square wave output.



3.2: A MODEL OF CIRCUIT FOR DRIVING SWITCH

Here is the sample of the circuit for generating pulse for switches combining with op-amp and optocoupler:

For generating positive pulse:

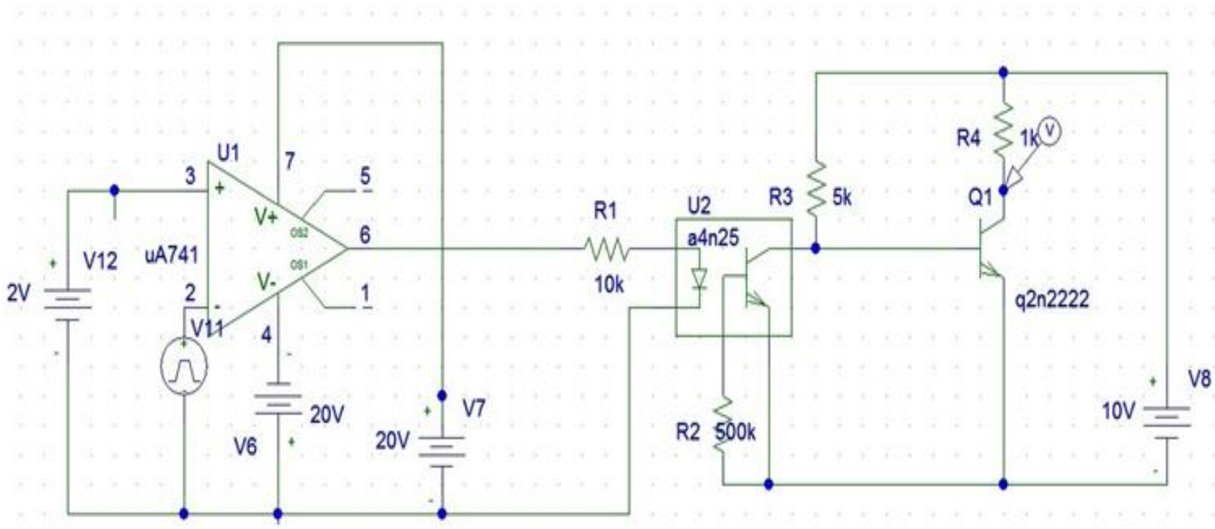


FIG5: Circuit diagram for positive pulse using opamp & optocoupler.

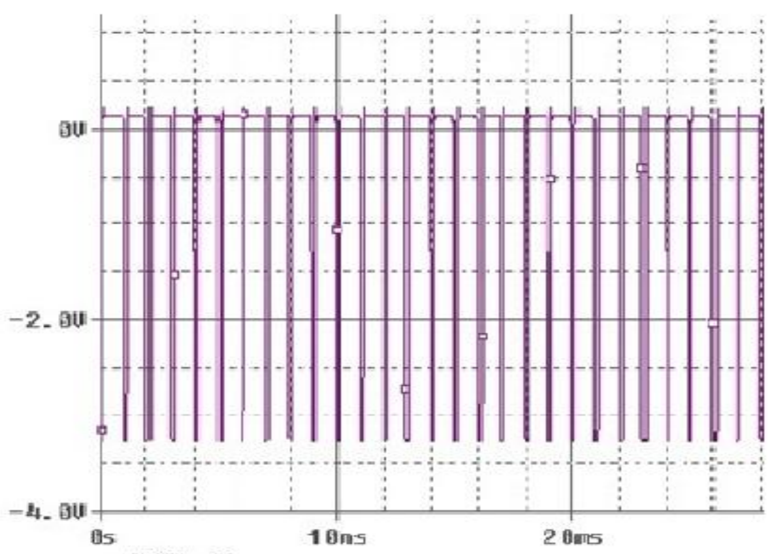


FIG6:Output

<u>For generating negative pulse:</u>

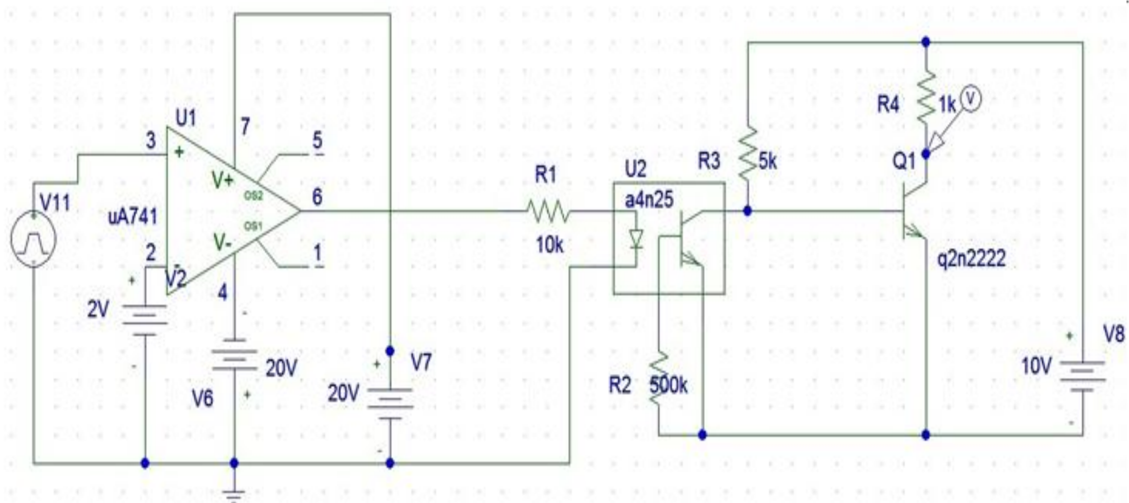


FIG7: Circuit diagram for negative pulse using opamp & optpcoupler

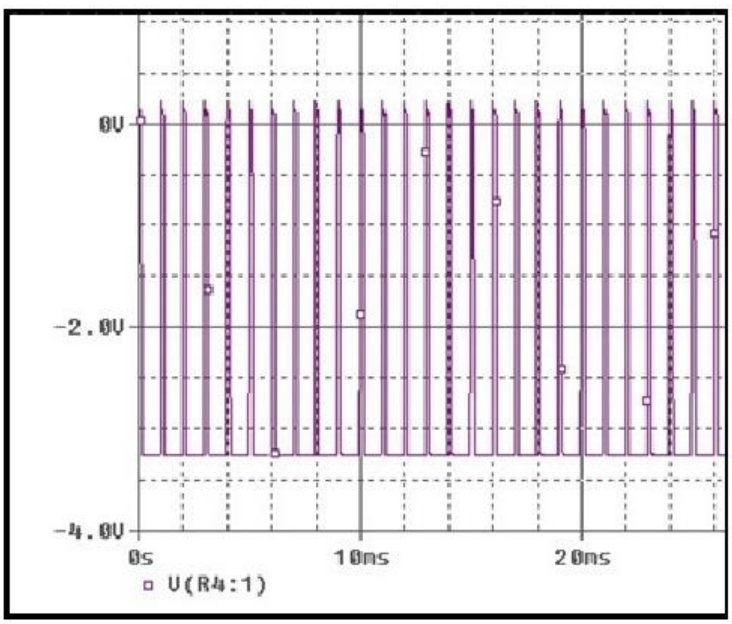


FIG8: Output

Finally these negative and positive pulses will give a square wave voltage output. Here optocoupler is used to isolate the bases of switch pairs.

<u>3.3: IMPORTANCE OF BASE ISOLATION:</u>

For operating power transistors as switches an appropriate gate voltage or base current must be applied to the drive. The transistors into the saturation mode low on-state voltage .the control voltage should be applied between the gate and source terminal s or between the base and emitter terminals. The power converters generally require multiple transistor and each transistor must be gated individually. We can use Optocouplerfor isolating the base of the switches to avoid short-circuit and provide particular signal to particular switches.

<u>3.4: OPTOCOUPLER</u>

It is a small device that allows the transmission of a signal between parts of a circuit while keeping those two parts electrically isolated. Inside a typical optocoupler there are two things – a LED and a phototransistor. When a current runs through the LED, it switches on - at which point the phototransistor detects the light and allows another current to flow through it. And then when the LED is off, current cannot flow through the phototransistor. All the while the two currents are completely electrically isolated (when operated within their stated parameters).

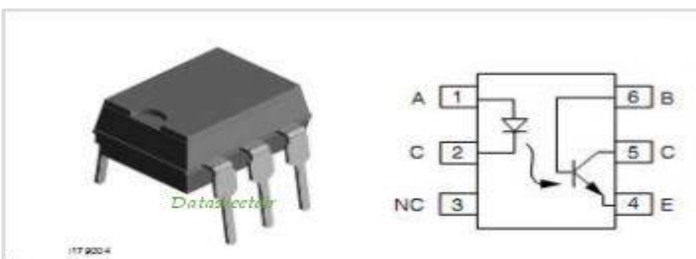


FIG9:Optocoupler

<u>Applications of Optocoupler</u>:

- Size and weight. Relays are much larger, and heavier;
- Solid state – no moving parts, so no metal fatigue;
- Optocouplers are more suited to digital electronics – as they don't have moving parts they can switch on and off *much* quicker than a relay;
- Much less current required to activate than a relay coil
- The input signal's impedance may change, which could affect the circuit – using an optocoupler to split the signal removes this issue.

3.5: SWITCH SELECTION

MOSFET vs IGBT:

Two main types of switches are used in power electronics. One is the MOSFET, which is designed to handle relatively large voltages and currents. The other is the insulated gate bipolar transistor, or IGBT. Each has its advantages, and there is a high degree of overlap in the specifications of the two.

IGBTs tend to be used in very high voltage applications, nearly always above 200V, and generally above 600V. They do not have the high frequency switching capability of MOSFETs, and tend to be used at frequencies lower than 29kHz. They can handle high currents, are able to output greater than 5kW, and have very good thermal operating ability, being able to operate properly above 100 Celsius. One of the major disadvantages of IGBTs is their unavoidable current tail when they turn off. Essentially, when the IGBT turns off, the current of the gate transistor cannot dissipate immediately, which causes a loss of power each time this occurs. This tail is due to the very design of the IGBT and cannot be remedied. IGBTs also have no body diode, which can be good or bad depending on the application. IGBTs tend to be used in high power applications, such as uninterruptible power supplies of power higher than 5kW, welding, or low power lighting.

MOSFETS have a much higher switching frequency capability than do IGBTs, and can be switched at frequencies higher than 200 kHz. They do not have as much capability for high voltage and high current applications, and tend to be used at voltages lower than 250V and less than 500W. MOSFETs do not have current tail power losses, which makes them more efficient than IGBTs. Both MOSFETs and IGBTs have power losses due to the ramp up and ramp down of the voltage when turning on and off (dV/dt losses). Unlike IGBTs, MOSFETs have body diode.

Generally, IGBTs are the sure bet for high voltage, low frequency (>1000V, <20kHz) uses and MOSFETs are ideal for low voltage, high frequency applications (<250V, >200kHz). In between these two extremes is a large grey area. In this area, other considerations such as power, percent duty cycle, availability and cost tend to be the deciding factors.

3.6: IMPORTANCE OF GENERATING SINE WAVE

The pure sine inverter, which is also referred to as a "true" sine wave, utilizes sine wave in order to provide your appliances with power. A sine wave, which is produced by rotating AC machinery, is the type of wave that is generally provided by the utility company with the help of a generator.

The benefits of using a pure sine wave inverter include:

- Square wave output is sometime harmful for the electrical devices.
- All equipment currently on the market is designed for use with sine waves.
- Some appliances, particularly microwaves and variable speed motors, will not produce full output if they do not use sine wave power.
- Some appliances, such as light dimmers and bread makers, will not work at all without sine wave power.
- A true sine wave source is produced most easily for high power applications through rotating electrical machinery such as naval gas-turbine generators, house-hold diesel or gasoline backup generators, or the various generators employed by power companies that employ a shaft torque to create an AC current

On the downside, pure sine wave inverters are more expensive than the other types of inverters.

CHAPTER 4:
METHODS OF MAKING INVERTER

There are different types of method for generating pwm.Some of the techniques are shown below.

4.1: Typical dc-ac conversion:
Most inverters do their job by converting the incoming DC into AC . We can a pwm signal by using a pwm generating chip (eg: SG3524,MC3PHAC) or op-amp. But in these conventional inverters the voltage gain is very low.

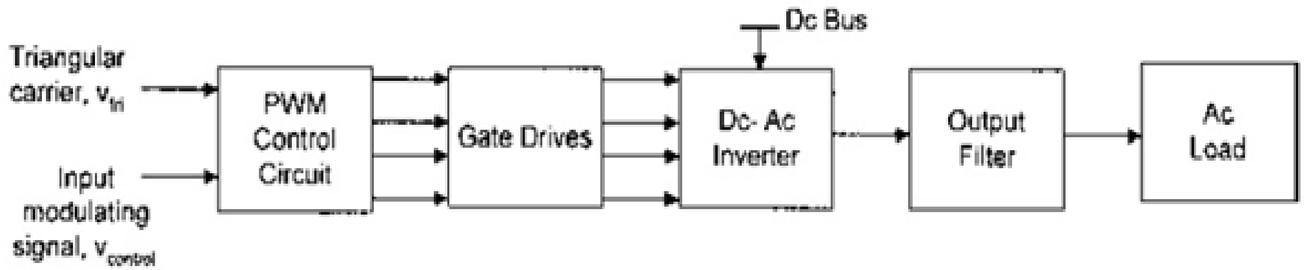


FIG10 : Block diagram of typical DC-AC inverter

In this model of opamp is used as a comparator which requires comparison of a triangular carrier, Vtriwith an input modulating signal,so as to generate the turn-on and turn-off signals for the switch mode inverter(shown in FIG:10).

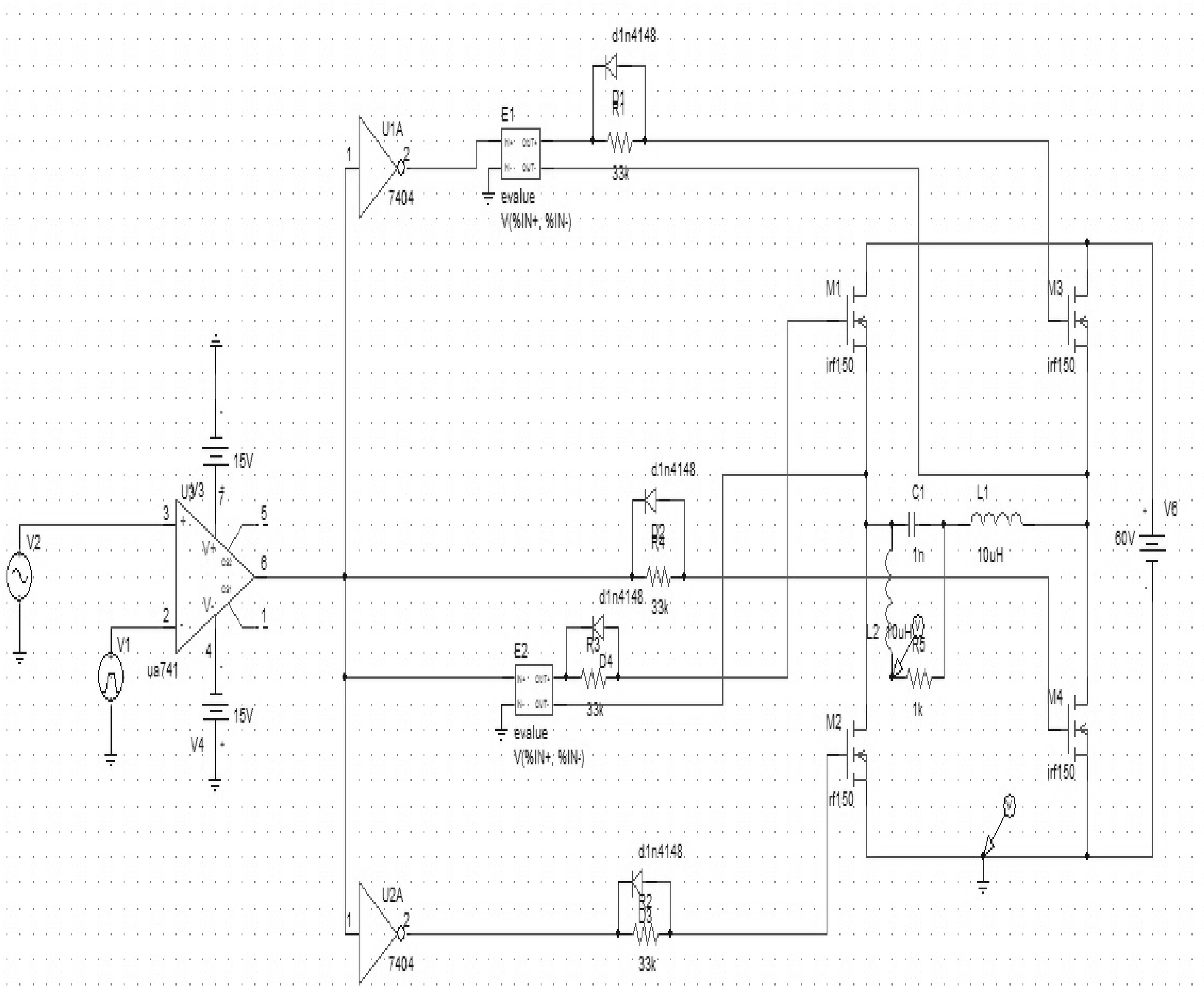


FIG11 : Circuit diagram of typical PWM inverter.

Gate drive circuits interface these switching signalsto the semiconductor power switches in the inverter. The output voltage of theinverter is typically a quasi-rectangular ac. waveform with significant harmoniccontent. For applications requiring near-sinusoidal voltage with reducedharmonic distortion, a low-pass output filter is connected at the inverter outputterminals before driving the load. FIG:11 shows the circuit for a MOSFET-based inverterin the full-bridge configuration. The unfiltered output voltage can becontrolled by appropriate switching combinations of the MOSFET.

4.2: Using a transformer:

By using a transformer an inverter can be made by using its polarity. It is also possible to step up the resulting AC. But it increases the weight and size of the inverter. It also have a negative impact on output due to the saturation of the core. A model of this method is shown below:

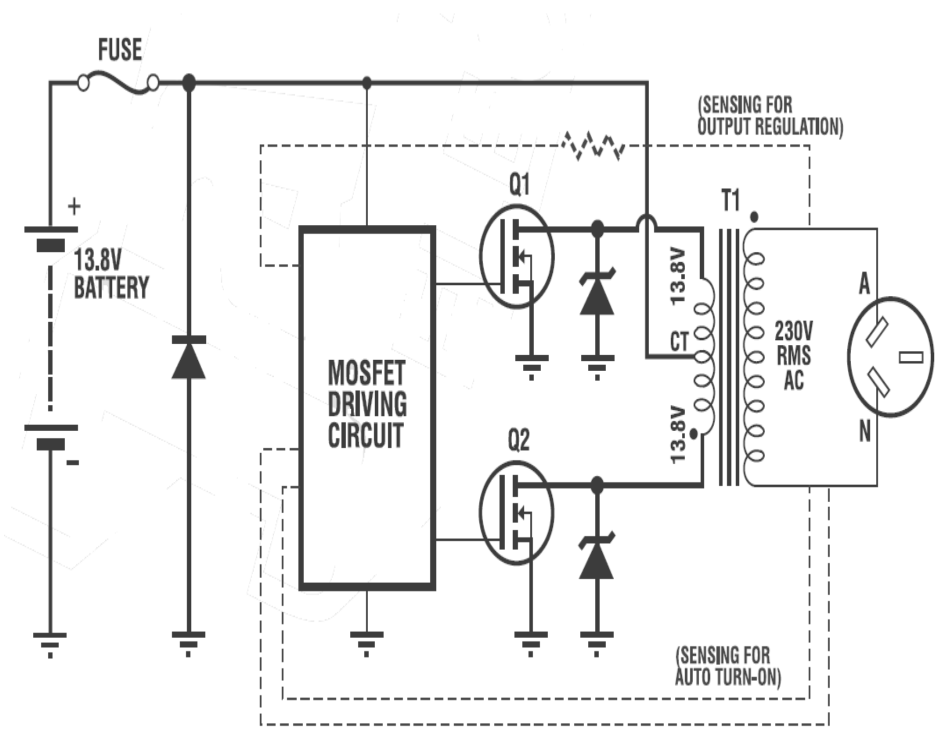


FIG12: Inverter stepped up by transformer

If dc volt is applied to a transformer, it creates saturation in core. For this reason, we need to add two zener diodes across the switches. Two switches (q1, q2) are with the terminal of primary side of centre tap transformer. When q1 is on then polarity appears in the terminal of the transformer. When q2 is on, then reverse type of polarity appears in the terminal of the transformer. For this type of sequential switching technique results a sinusoidal wave.

4.3: Using Microcontroller:

All the above mentioned methods are analog designs of inverter. We also like mention digital implementation of inverter using microcontroller.The proposed alternative approach is to replace the conventional method with the use of microcontroller. Theuse of microcontroller brings the flexibility to change the real-time control algorithms without further changes in hardware. It is also low cost and has a small size of control circuit for the single phase full bridge inverter.

For generating SPWM we have chosen microcontroller PIC 16F877A. Basically we have studied about the detailed information about microcontroller and the mechanism of generating PWM. It can be done by using a micro c program.

Algorithm for generating SPWM:

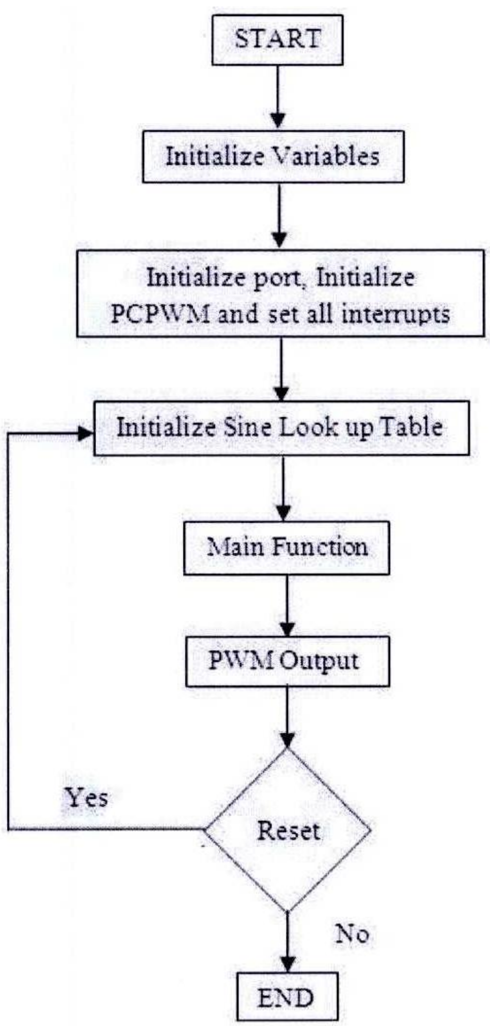


FIG13: Flow chart of SPWM

Fig:11 shows the flow chart of single phase sinusoidalPWM signal. In this flow chart “initialize variables”means initialize the user defined memory cell, “initialize
port” initializes the ports in software by which the portswork as output ports. After that “Initialize PCPWM”initializes the modules which are used to generate PWM.

Then “set all interrupts” initializes all interrupts which area associated with all kinds of desired interrupts. Then“Initialize Sine Look up Table” stores the sampling valueof sine wave. Those sampling value will go in PDC Register. And the PTMR register will generate theTriangular wave. Then the signal becomes SinusoidalPWM signal with dead time. The microcontroller checks whether the generation is completed or not, if yes, takeanother sampling of the sine wave table, if not, it waits until completion.

<u>Coding of sinusoidal PWM</u>:

The micro c program for generating pulse width modulation is given below.

```
// Microcontroller : P16F877
// PWM module is set on RC2 (CCP1)  Pin No 17.
// Freq : 50kHz
// X-tal : 20MHz

 short i,j;
 int k;
 void check_display();
 void main()
 {
  PORTC = 0; // Set PORTC to $FF
  TRISC = 0; // PORTC is output
  TRISB = 0xFF;

  Pwm1_Init(50000); // Freq 50kHz (You can change u want)
  Pwm1_Start(); // Start PWM

  i = 0;
  j = 12.75;       // Start 5% duty
  k=0;
while (1)
{
```

```
 if(PORTB.F0 == 0)       // SW1 for increase Duty  5%
  {
  i=i+j;
  delay_ms(20);
  Pwm1_change_duty(i);
  T2CON.TMR2ON=1;
  Delay_us(10);
  k=k++;
  delay_ms(50);
  }

  if(PORTB.F1 == 0)       // SW1 for decrease Duty  5%
  {
  i=i-j;
  delay_ms(20);
  Pwm1_change_duty(i);
  T2CON.TMR2ON=1;
  Delay_us(10);
  k=k--;
  delay_ms(50);
  }

}   // Endless Loop
}  //main
```

This program is written in micro c. Then using this code we need to burn the microcontroller with the help of INFRA PIC WRITER. An external oscillator is connected to the output port. Then oscillator shows the pulse width modulation output.

Pin configuration of PIC16F877A microcontroller:

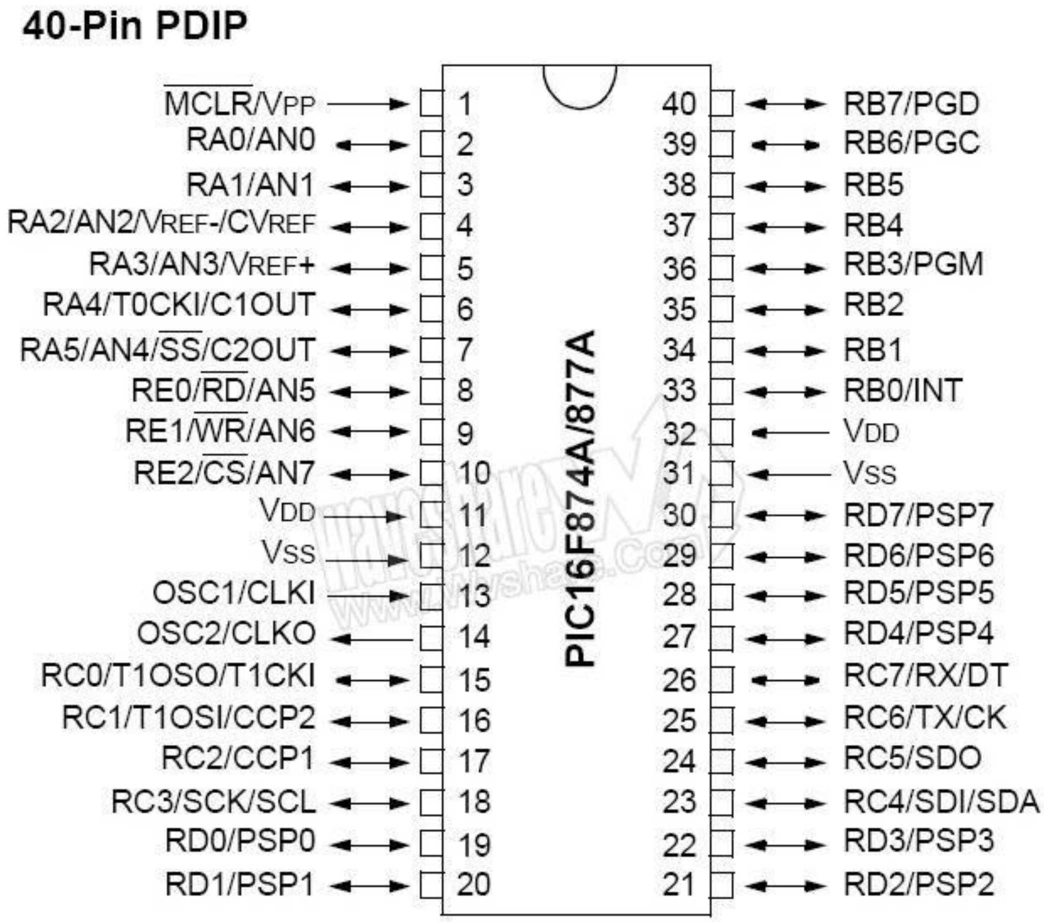


FIG14: PIC16F877A

4.4: Using DC-DC converter:

By using two dc-dc converter we can make sine wave inverter. Though it needs two converters the size of the inverter get increased. It also gives low voltage output and low efficiency. We can use 3 kinds of inverter:

1. Buck Converter
2. Boost converter
3. Chuk inverter

.If bothof the similar inverters are connected like the diagram which is shown will act like an inverter & give a sinusoidal output.

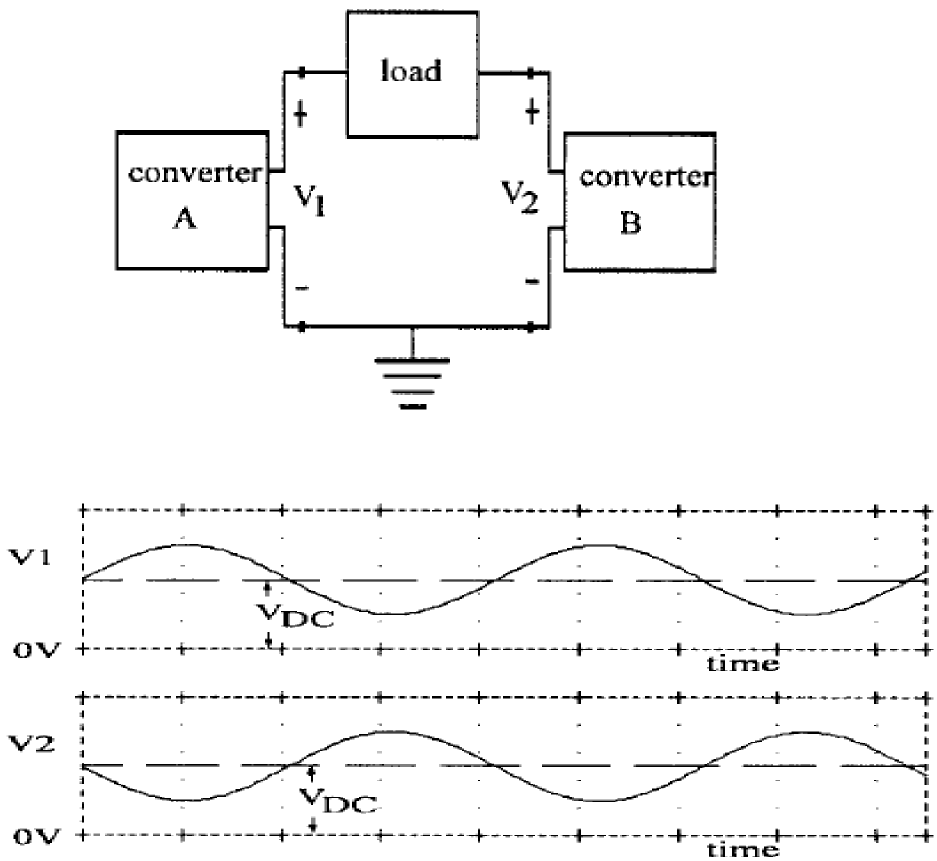


FIG15: A basic approach to achieve dc–ac conversion, with boost characteristics

The conventional voltage source inverter (VSI)shown in FIG9, referred to as a buck inverter which is probably the most important power converter topology. It is used in many distinct industrial and commercial applications. Among these applications, uninterruptible power supply (UPS) and ac motor drives are the most important. One of the characteristics of the buck inverter is that the instantaneous average output voltage is always lower that the input dc voltage.As a consequence, when an output voltage larger than the input one is needed, a boost dc–dc converter must be used between the dc source and inverter as shown in FIG17.

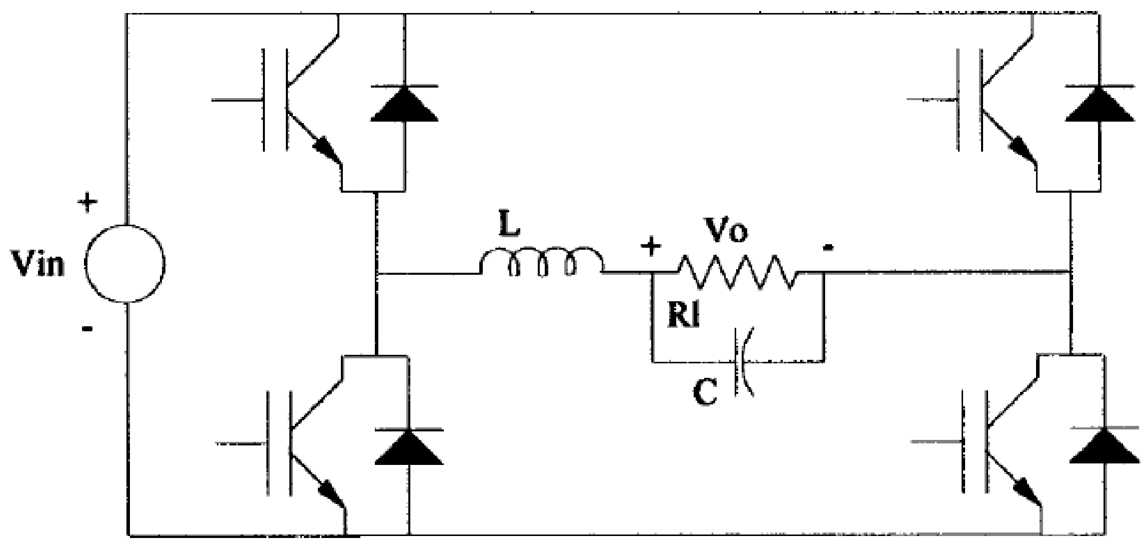


FIG16: Conventional VSI or BUCK inverter

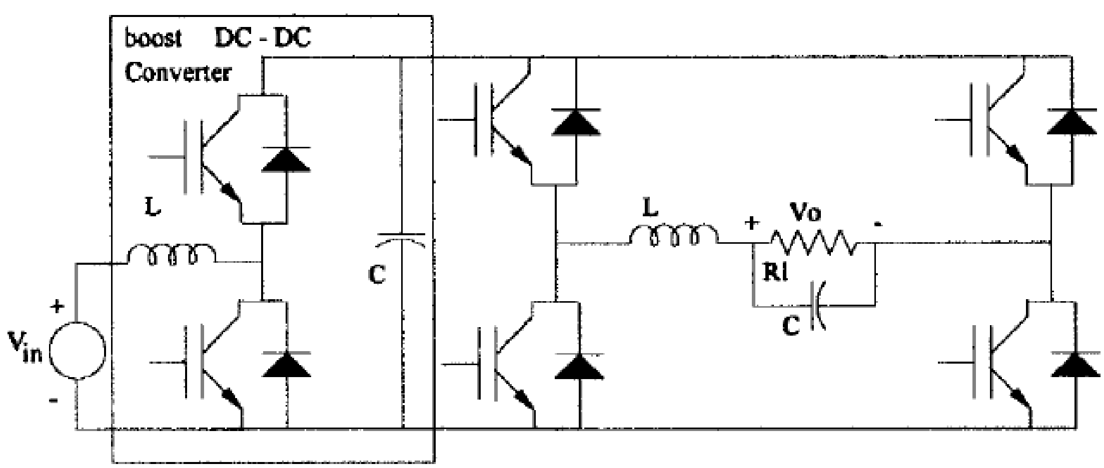


FIG17: Circuit used to generate an ac voltage larger than the dc input voltage

Depending on the power and voltage levels involved, this solution can result in high volume, weight, cost, and reduced efficiency. So here is a new VSI is shown in fig, referred to as boostinverter, which naturally generates an output ac voltage loweror larger than the input dc voltage depending on the duty cycle.

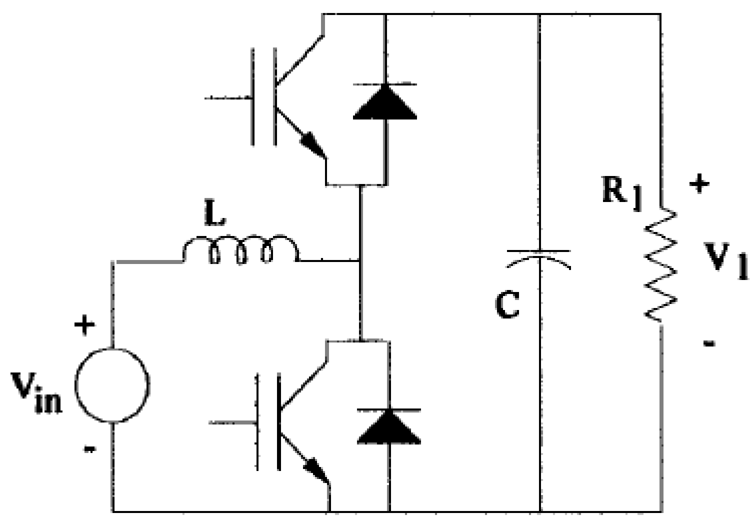


FIG18: The current bidirectional boost dc–dc converter

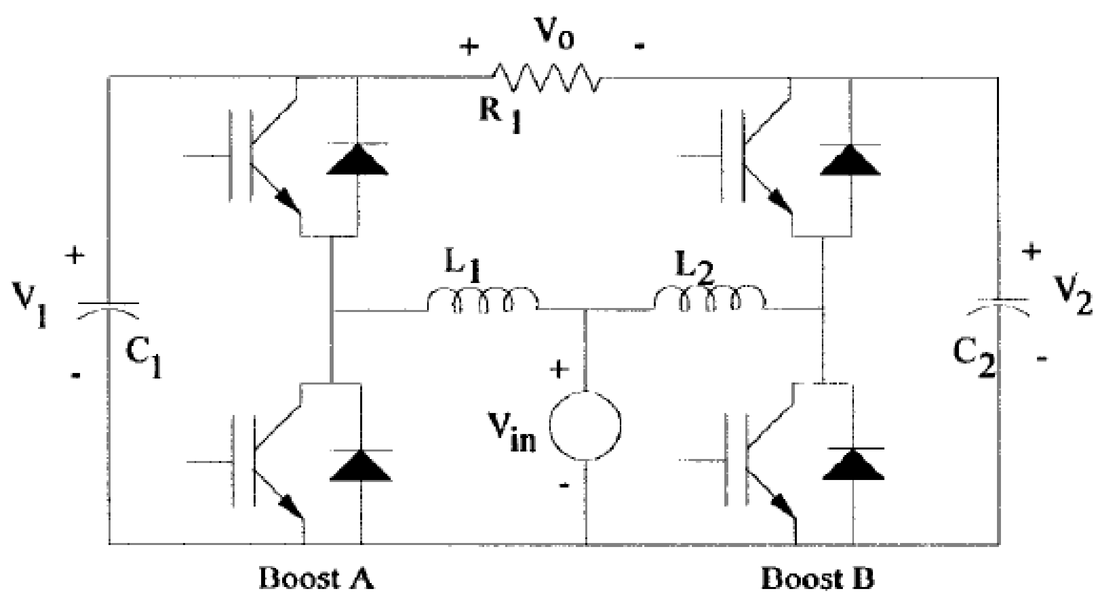


FIG19: The proposed dc–ac boost converter

PRINCIPLE OF OPERATION:

The proposed boost inverter achieves dc–ac conversion, as indicated in FIG8, by connecting the load differentially acrosstwo dc–dc converters and modulating the dc–dc converteroutput voltages sinusoidally.

The blocks A and B represent dc–dc converters. Theseconverters produce a dc-biased sine wave output, so that eachsource only produces a unipolar voltage. The modulation ofeach converter is 180 out of phase with the other, whichmaximizes the voltage excursion across the load. The load isconnected differentially across the converters. Thus, whereasa dc bias appears at each end of the load, with respect toground, the differential dc voltage across the load is zero. Thegenerating bipolar voltage at output is solved by a push–pullarrangement. Thus, the dc–dc converters need to be currentbidirectional.The current bidirectional boost dc–dc converter is FIG18. A circuit implementation of the boost dc–ac converteris shown in Fig. 19.

For a dc–dc boost converter, by using the averaging concept the voltage relationship can be obtained for the continuous conduction mode by

V1/Vin =1/1-D ; D= Duty Cycle

The voltage gain, for the boost inverter, can be derived asfollows: assuming that the two converters are 180 out ofphase, then the output voltage is given byVo=V1-V2= Vin/(1-D)- Vin/D

Vo/Vin=(2D-1)/D(1-D)

The gain characteristic of the boost inverter is shown inFIG20. It is interesting to note that the feature of zero outputvoltage is obtained for D=0.5 . If the duty cycle is variedaround this point, then there will be an ac voltage at the outputterminal.

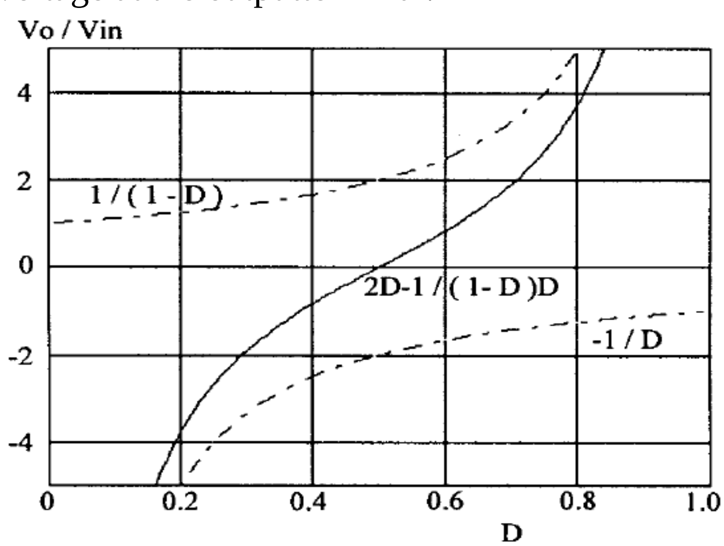
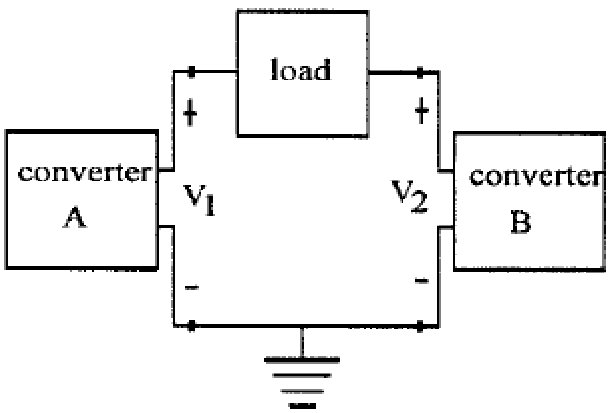


FIG20: DC gain characteristics

CHAPTER 5:
IMPLEMENTATION OF AN INVERTER CIRCUIT

In this chapter there is an implementation of an inverter according to the method we discussed in previous chapter using DC-DC converter.
The circuit which is experimented here is based on diagram shown below (already discussed about in previous chapter).



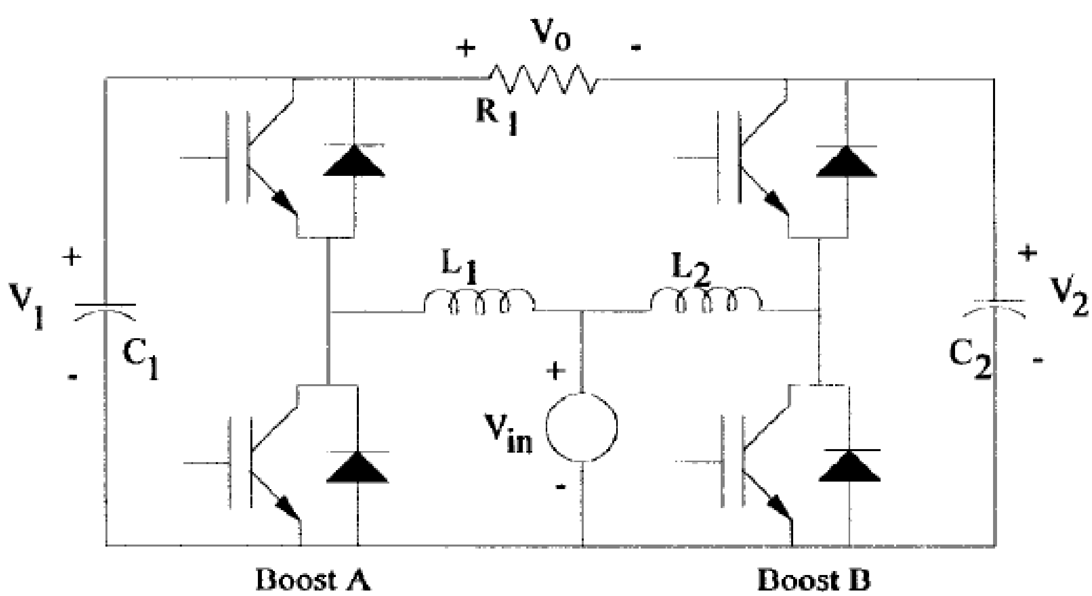


FIG21: A basic approach to achieve dc–ac conversion, with boost characteristics

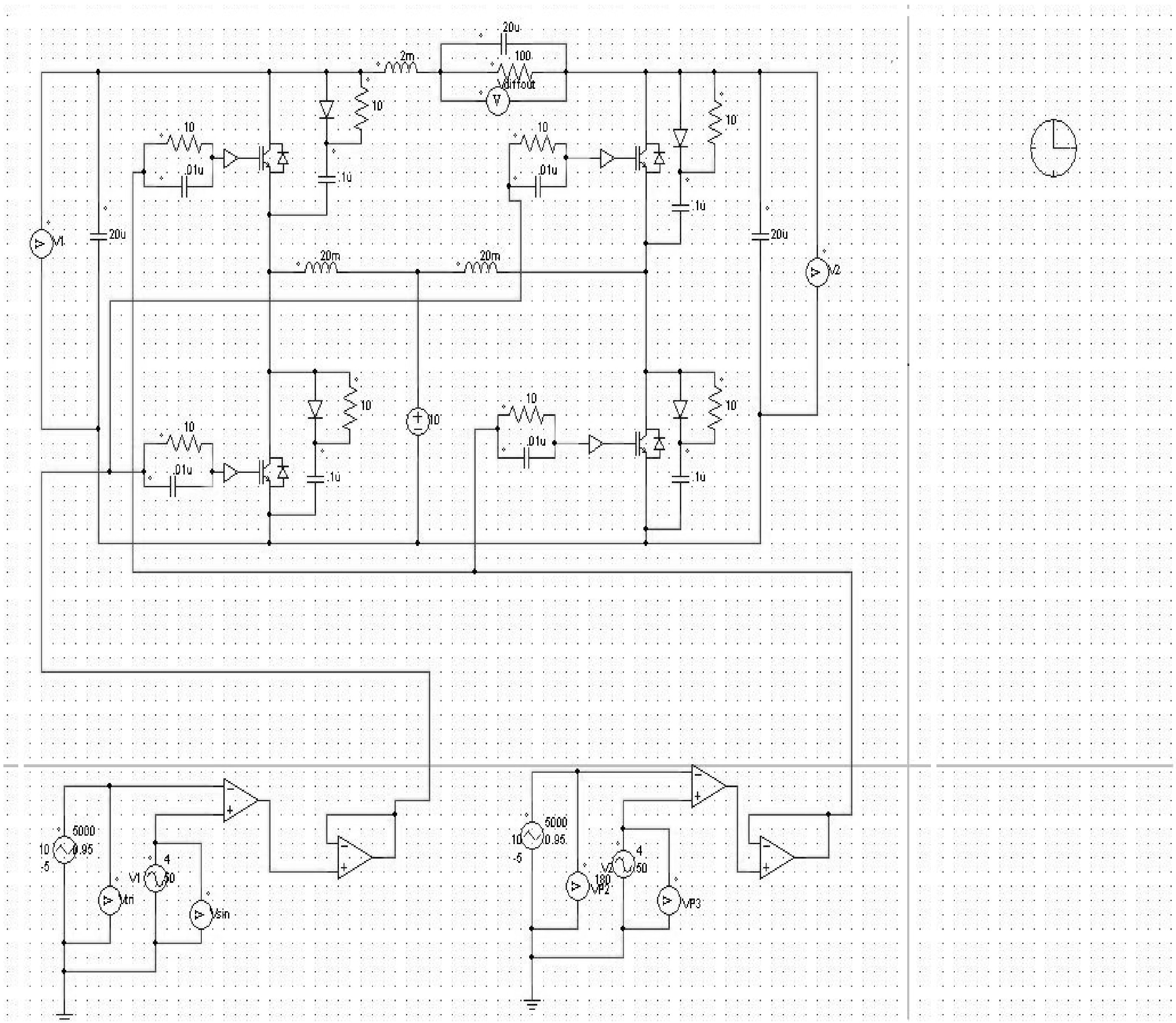


Fig 22: Circuit diagram of SPWM inverter.

In this circuit we have used two DC-DC converters connected according to FIG21. To make the gate pulse we have used two op-amps. It works as a comparator with a triangular signal (carrier signal) and sine wave (reference signal) connected through a voltage follower to remove the effect of the impedance of source signal. We have used IGBT as switches. Circuits around the switches are placed to reduce the pressure on switches. This is called snubber circuit. When a switching device changes its state from ON-state to OFF-state, the impedance of the device abruptly jumps to a very high level, blocking the current. But the current still tends to keep flowing through the switch, which induces a high voltage across the switch. The faster the current decreases, the higher the induced voltage becomes. It may reach to sufficiently high level to destroy the switch. If the switch is unable to withstand the high induced voltage, it will be destroyed, and can no more block the current as an OFF-state switch. To avoid this, an auxiliary network is connected across the switch that prevents the induced voltage from going too high. The network is called a snubber. By simulating this circuit we’ve got a sinusoidal ac output after appropriate switching combination. This circuit is simulated for 50 Hz and 4v peak amplitude.

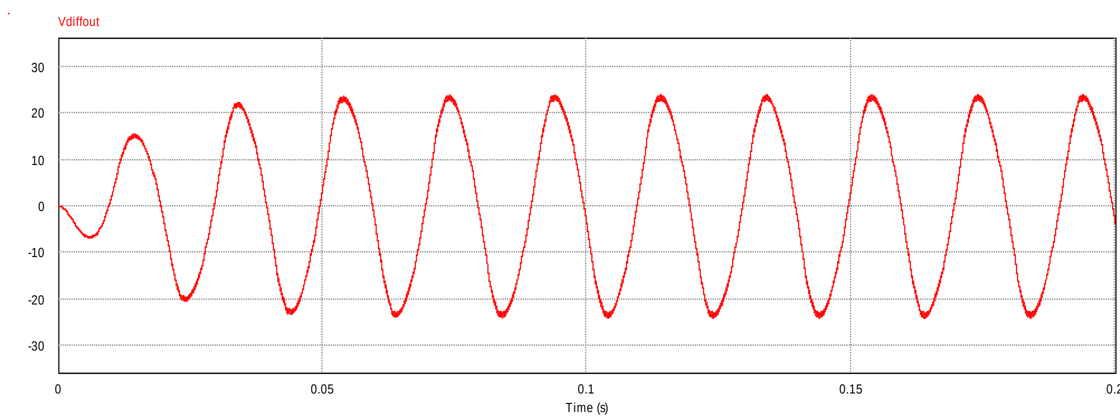
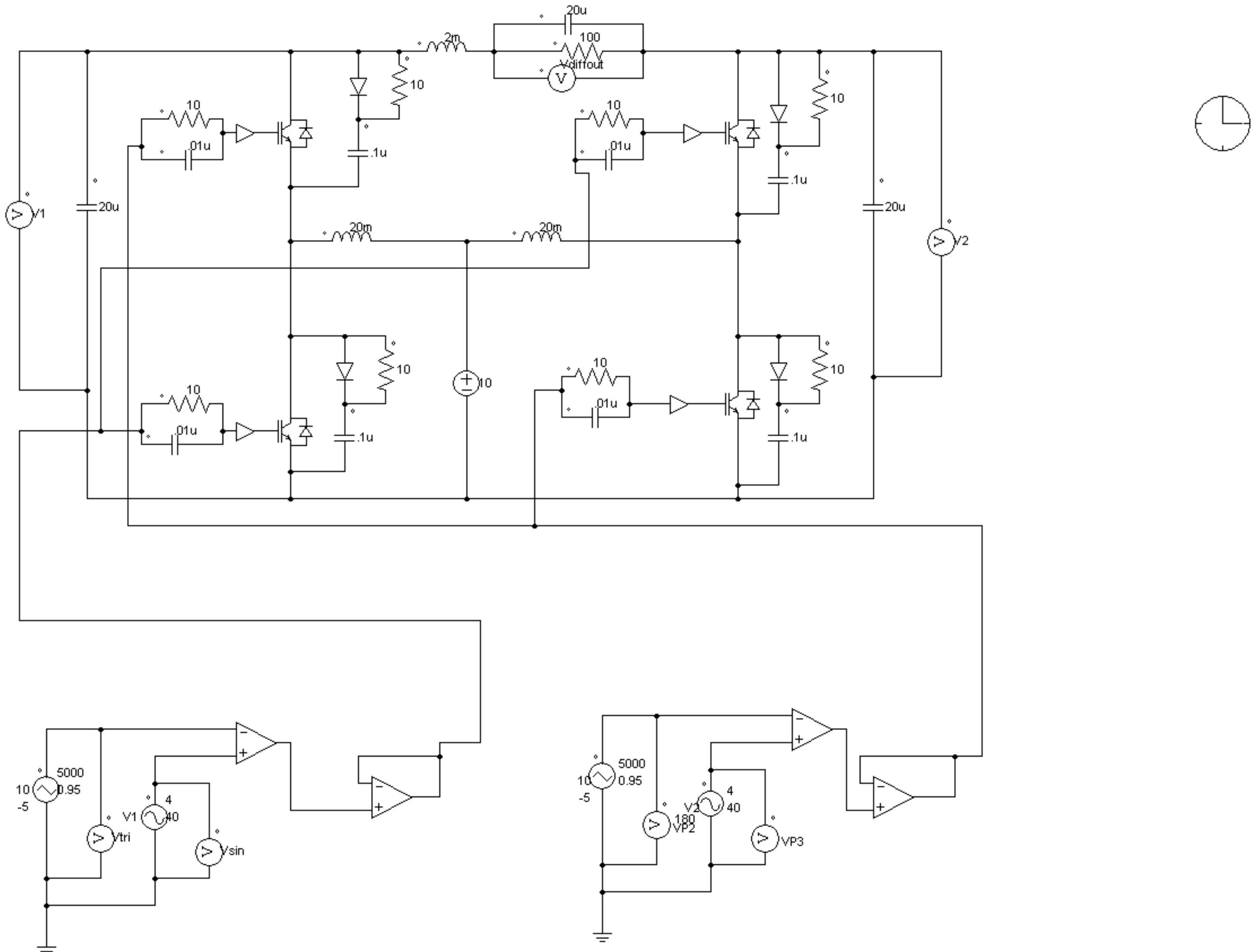


FIG23: PSIM simulation of this inverter.

This simulation shows time period=0.02 which means output frequency of the inverter circuit is 50 Hz. Now for different frequency and peak amplitude this circuit is being tested to show the change in output.

For reference signal 40hz:



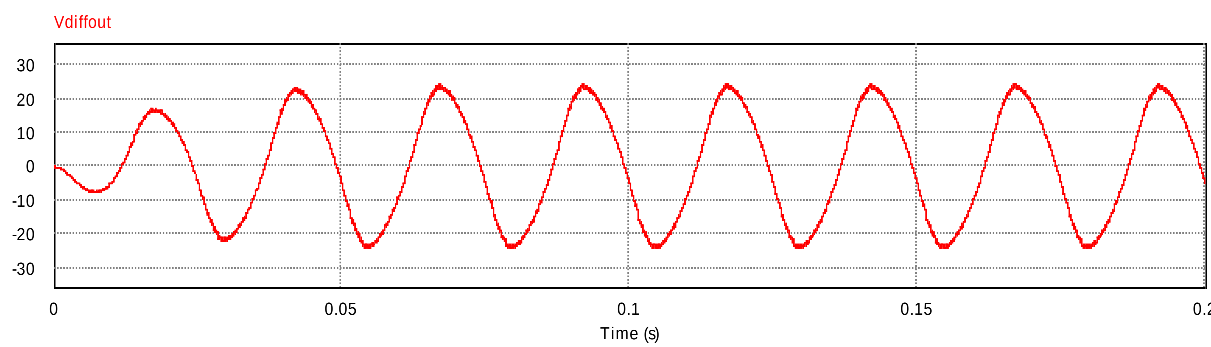
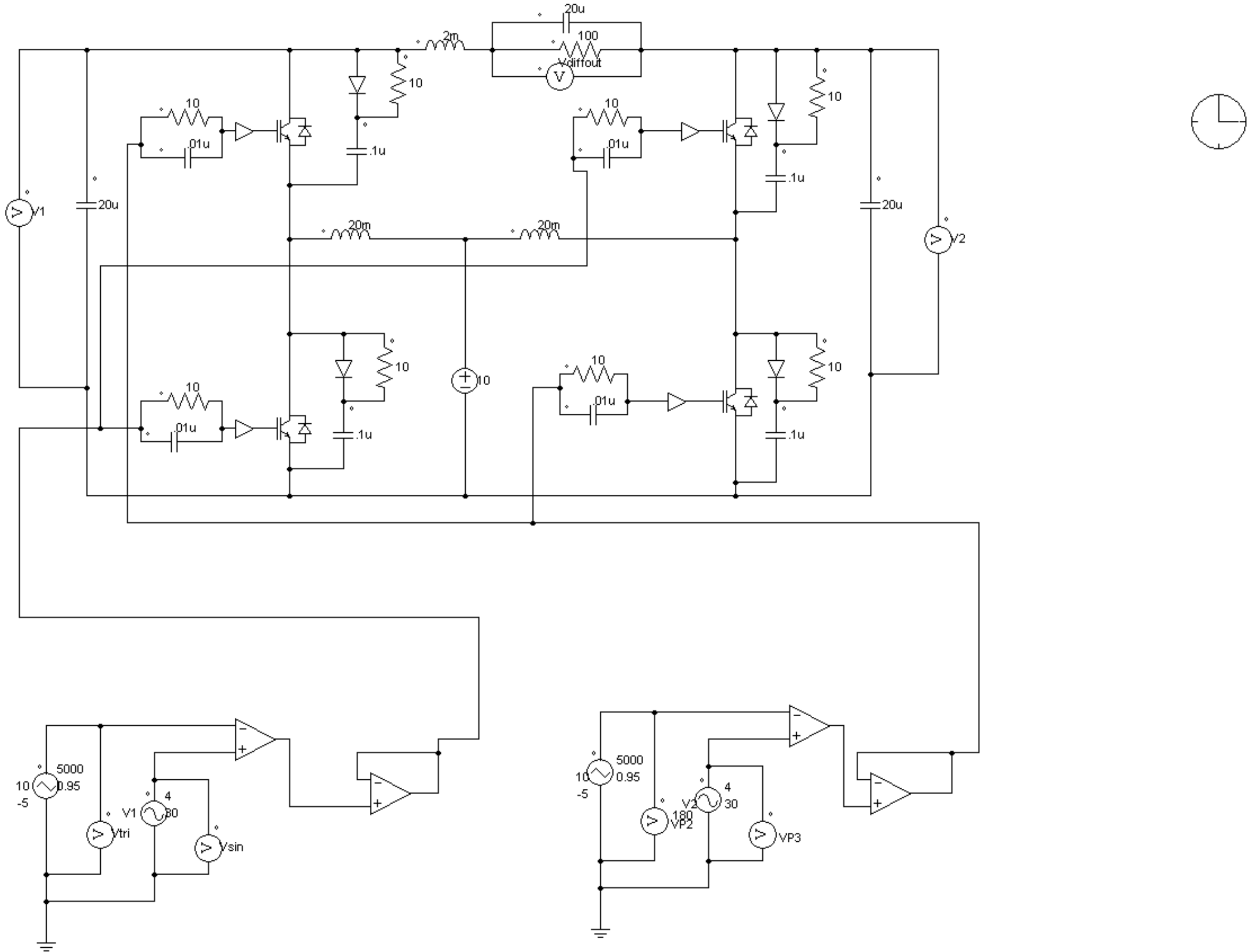


FIG24: PSIM simulation showing T=0.025(F=40HZ)

<u>For reference signal 30hz</u>:



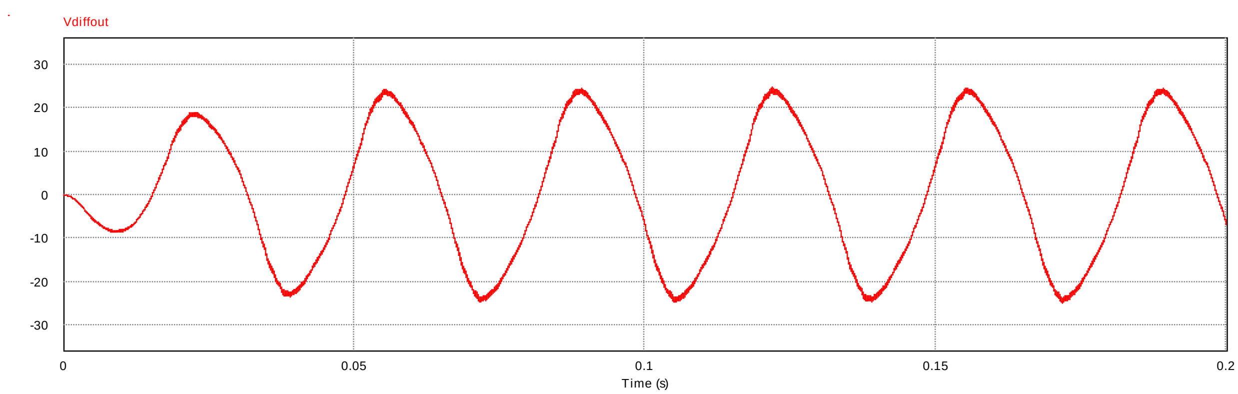


FIG25: PSIM simulation showing T=0.033(F=30HZ)

For peak amplitude 3V:

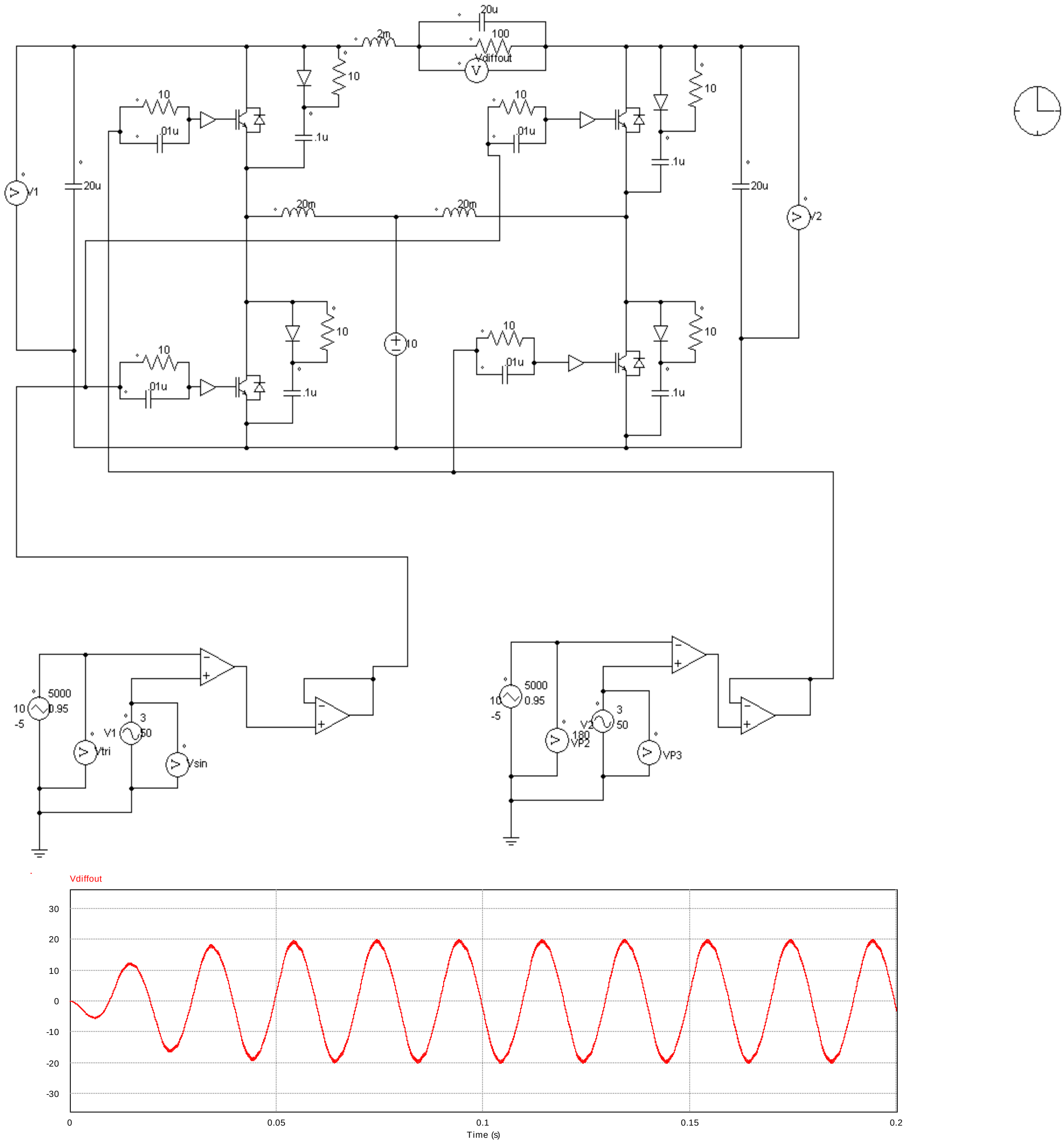


FIG26: PSIM showing change in amplitude for 3v

<u>For peak amplitude 2V</u>:

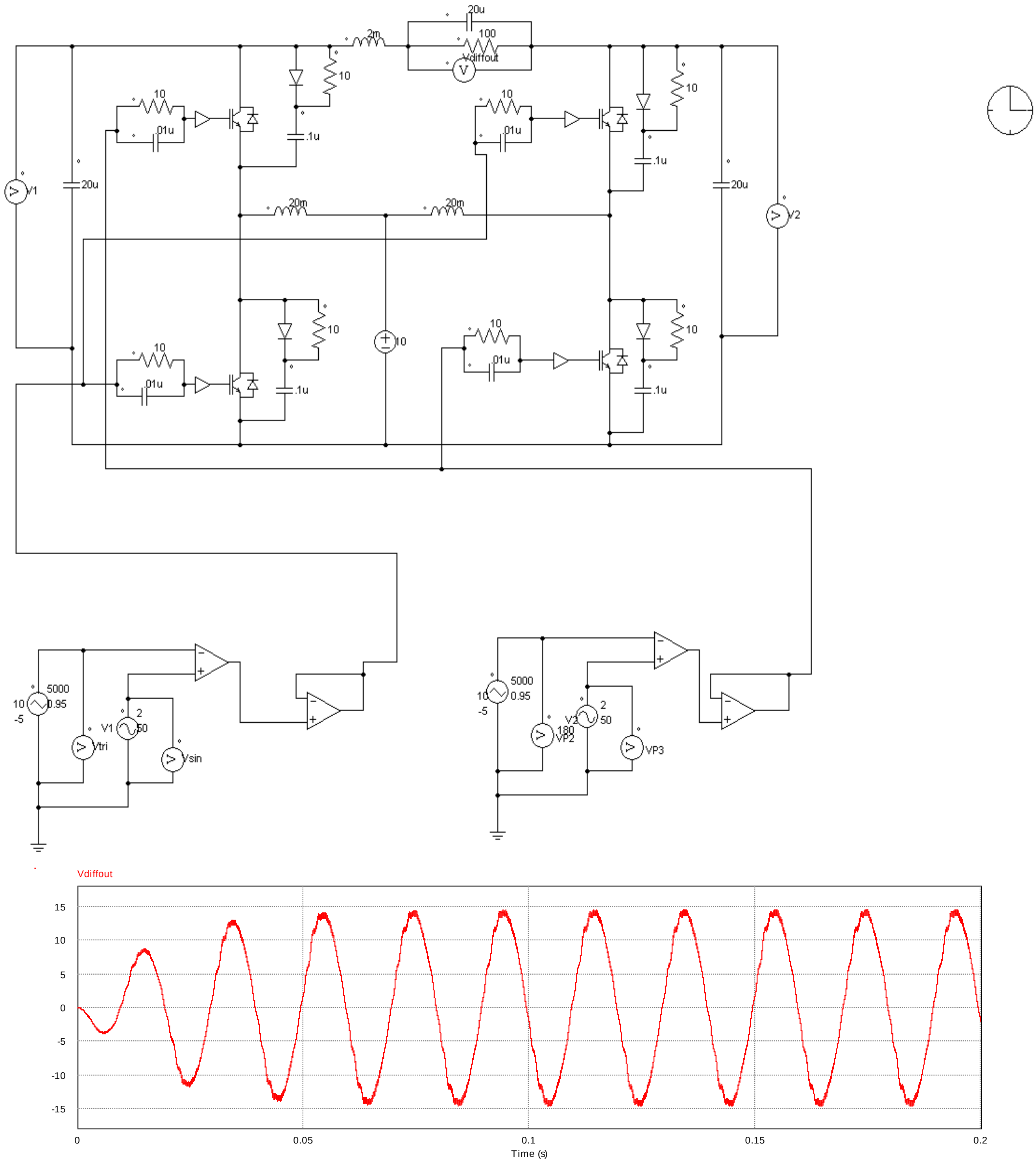


FIG27: PSIM showing change in amplitude for 2v

For different frequencies a table is given below showing output frequency:

Frequency of reference signal(hz)	Time period, T	Output Frequency (hz)	THD
130	.0077	130	2.023
120	0.00833	120	1.97
115	0.0087	115	1.94
110	0.0091	110	2.06
100	0.01	100	2.19
80	0.0125	80	2.52
75	0.0133	75	2.712
70	0.01428	70	2.78
60	0.0167	60	3.69
55	0.01818	55	3.84
50	0.02	50	4.49
40	0.025	40	5.63

TABLE 2: Frequency and THD for different reference signal ferquency

It proves that the inverter is working with changed frequency and giving the same output frequency with reference signal frequency. This table is also showing THD(Total harmonic distortion) for relative frequencies. For 115hz reference signal it's showing the least THD. It means 115hz is representing the best sinusoidal wave. The wave shape of for 115 hz is given below.

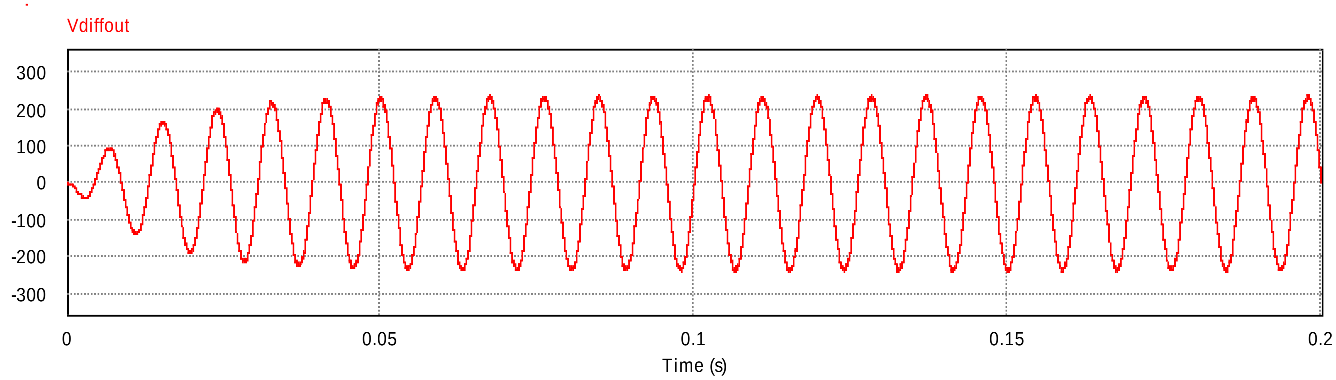


FIG 28: PSIM simulation for 115 hz

For different peak amplitudes (keeping the frequency fixed at 50 hz) an another table is given showing the changed output voltage:

Peak amplitude of reference signal (V)	Output Voltage (V)
4	24
3.5	22
3	20
2.5	18
2	14
1.5	11
1	7.7

TABLE 3: Out voltage for different peak amplitude

Data collected by simulating with different peak amplitude & frequency proves that the inverter circuit is responding perfectly by showing changed output for individual case.

If in the DC voltage source is 100V applied this inverter gives an output of almost 240V. So this inverter can be used for high voltage application. The simulation result is given below.

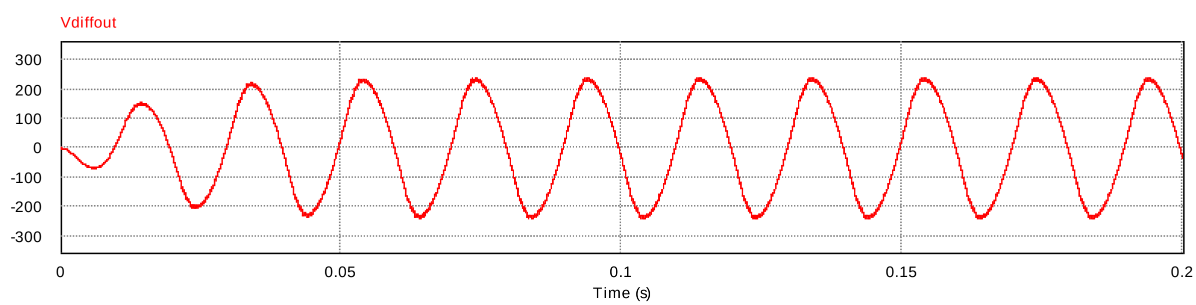


FIG 29: PSIM simulation for 100V dc source

CHAPTER 6
CONCLUSION

In looking at the components selected and the simulations created beforethe actual construction of the inverter, everything was built in mind for the purpose of efficiency and keeping power losses to a minimum.

This project is a stepping stone to a cheaper and efficient pure sine wave inverter, by using the data collected in this report as well as the schematics and recommendations the product produced here can be improved upon.
A dc–ac voltage source converter has been proposed and studied both theoretically and experimentally. According to our opinion, the boost inverter is suitable for applications where the output ac voltage needs to be larger than the dc input and can offer economic and technical advantages over the conventional VSI.

The circuit simulated in figure 15, a transformer can be connected in order to increase the output voltage. The op-amps used in that circuit can easily be replaced by microcontroller for getting pulses. In that case there is no need of external components foe base isolation because, each pin of microcontroller has separate ground.

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