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CHAPTER 3

MATERIALS AND EXPERIMENTAL TECHNIQUES/METHODOLOGY

3.1 INTRODUCTION

This chapter explains Single Phase Full Bridge Inverter with the help of circuit diagram and various relevant waveforms. Comparison between unipolar and bipolar inverters have also been studied ~~detailed.~~ Single Phase Full Bridge Inverter is basically a voltage source inverter. Unlike Single Phase Half Bridge Inverter, this inverter does not require two ~~three~~ wire AC ~~DC~~ input supply. Rather, two wire DC input power source suffices the requirement. The inverter is an electrical gadget that changes over DC input supply to symmetric AC voltage of standard greatness and recurrence at the output side. It is additionally named as DC to AC converter. An ideal inverter information and result can be addressed either in a sinusoidal and non-sinusoidal waveform. In the event that the info source to the inverter is a voltage source, the inverter is supposed to be known ~~as a~~ voltage source inverter (VSI) and in the event that the info source to the inverter is ~~an~~ ongoing source, it is called as current source inverter (CSI). Inverters are characterized into 2 sorts as indicated by the kind of burden being utilized i.e., single-phase inverters, and three-phase inverters. Single-stage inverters are additionally arranged into 2 sorts of half-bridge inverter and full-bridge inverter. This chapter makes sense of the definite development and working of a full-span inverter.

3.2 CLASSIFICATION OF INVERTERS

Inverters are classified into 5 types they are

According to the output characteristics

- Square wave inverter
- Sine wave inverter
    - Modified sine wave inverter.

According to the source of the inverter

- Current source inverter
- Voltage source inverter

According to the type of load

Single-phase inverter

- Half-bridge inverter

- Full bridge inverter

According to different PWM technique

- Simple pulse width modulation (SPWM)
- Multiple pulse width modulation (MPWM)
- Sinusoidal pulse width modulation (SPWM)
- Modified sinusoidal pulse width modulation (MSPWM)

SQUARE WAVE INVERTER

The square wave inverter is a kind of inverter which changes DC capacity to AC power. The square wave inverter is easier in plan and more effective than a sine wave inverter. In any case, the square wave won't be fitting for certain loads, on the grounds that the huge harmonic contents can cause interference. A few electromechanical gadgets don't function admirably with square wave power. Assuming that the load is reactive, there will be loss of productivity because of responsive power misfortune, so the effectiveness benefit of the inverter might be invalidated. Resistive loads additionally may experience the ill effects of transmitted obstruction because of consonant substance.

SINE WAVE INVERTER

An unadulterated sine wave inverter will change direct flow (DC) into exchanging flow (AC) which can then be utilized to convey great electrical flow (like utility norms, voltage: 230V, recurrence: 50/60hz) to a wide range of home machines. Moreover, unadulterated sine wave inverters are additionally transformers.

MODIFIED SINE WAVE INVERTER

Modified sine wave inverters are a cost-effective choice to run appliances and equipment that is less sensitive to power fluctuations, such as lights and some tools. Modified sine wave inverters simulate AC power inverted from DC batteries.

CURRENT SOURCE INVERTER

Current Source Inverter is a type of inverter circuit that changes the dc current at its input into equivalent ac current. It is abbreviated as CSI and sometimes called a current fed inverter. Here the input provided to the circuit is a stiff dc current source rather than dc voltage source.

In CSI, the input voltage is kept invariable and the amplitude of output voltage does not show dependency on load. But the waveform representation and the magnitude of the current flowing through the load depends upon the nature of the load impedance.

The figure 3.1 given below represents the circuit representation of a single-phase current source inverter with ideal MOSFETs:

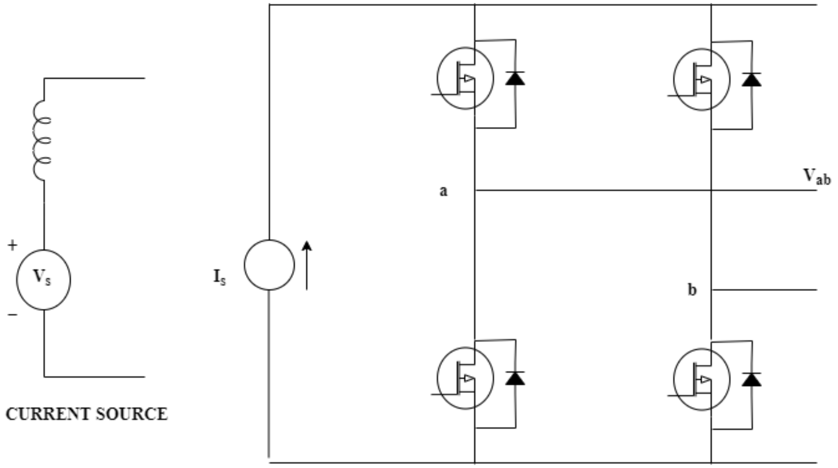


Fig 3.1 Schematic diagram of Single-phase Current Source Inverter

VOLTAGE SOURCE INVERTER

A voltage source inverter or VSI is a device that converts unidirectional voltage waveform into a bidirectional voltage waveform, in other words, it is a converter that converts its voltage from DC form to AC form. An ideal voltage source inverter keeps the voltage constant through-out the process.

A VSI usually consists of a DC voltage source, voltage source, a transistor for switching purposes, and one large DC link capacitor. A DC voltage source can be a battery or a dynamo, or a solar cell, a transistor used maybe an IGBT, BJT, MOSFET, GTO. VSI can be represented in 2 topologies, are single-phase and a 3-phase inverter, where each phase can be further classified into a Half-bridge inverter and full-bridge inverter.

The figure 3.2 given below represents the circuit representation of a single-phase voltage source inverter with ideal MOSFETs:

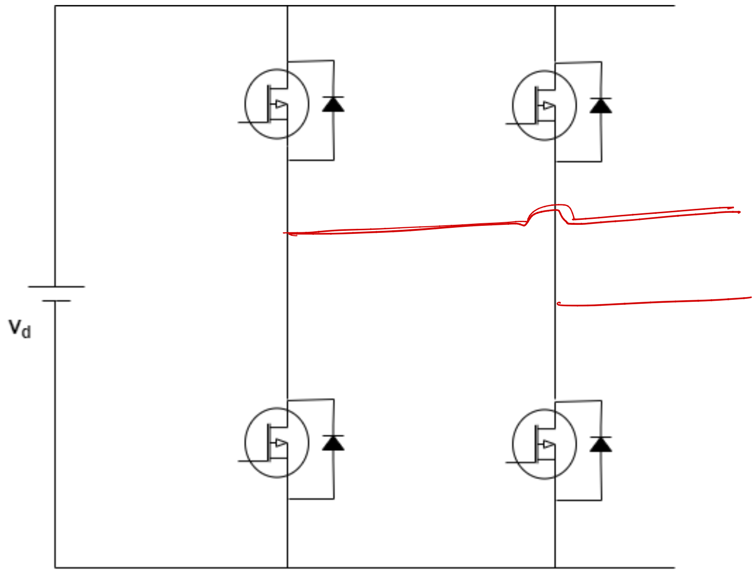


Fig 3.2 Schematic diagram of Single-phase Voltage Source Inverter

3.3 SINGLE PHASE INVERTER TOPOLOGY

There is a type of circuit used is single-phase inverter circuit which is full bridge configuration. Inverters have been widely used for applications, from small switched power supplies for a computer to large electric utility applications to transport bulk power.

3.3.1 FULL-BRIDGE INVERTER

A full bridge single phase inverter is a switching device that generates a square wave AC output voltage on the application of DC input by adjusting the switch turning ON and OFF based on the appropriate switching sequence, where the output voltage generated is of the form +Vdc, -Vdc, or 0. It comprises of four power switches and it is utilized in higher power rating application. The four switches are S1, S2, S3 and S4. The tasks can be partitioned into two cases which is, first, switches S1 and S4 are turned ON and kept ON for the one-half time frame and S2 and S3 are switched OFF and created yield voltage across the heap is equivalent to Vdc. Second, when S2 and S3 are turned ON, the switches S1 and switches S4 are switched OFF. Furthermore, the result voltage is equivalent to −Vdc.

3.4 SINGLE PHASE INVERTER (SPWM)

In SPWM technique, we use two switching Methods.

1. Bipolar Switching
2. Unipolar Switching

3.4.1 FOR BI-POLAR SWITCHING:

$S_{1,}$ S_2 and S_3 S_4 are turned on or turned off at the same time. The output of leg A is equal and opposite to the output of leg B. The output voltage is determined by comparing the control signal , and the triangular signal as shown in Figure 1(a) to get the switching pulses for the devices, and the switching pattern is as follows.

S_1 is on => , = and S_2 is on => = 0 , , =

S_3 is on => V_{an} = and S_4 is on => = 0 , , =

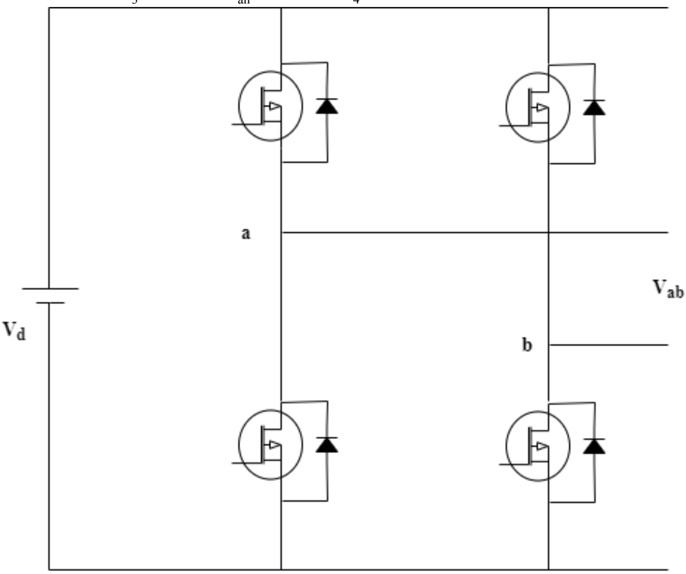
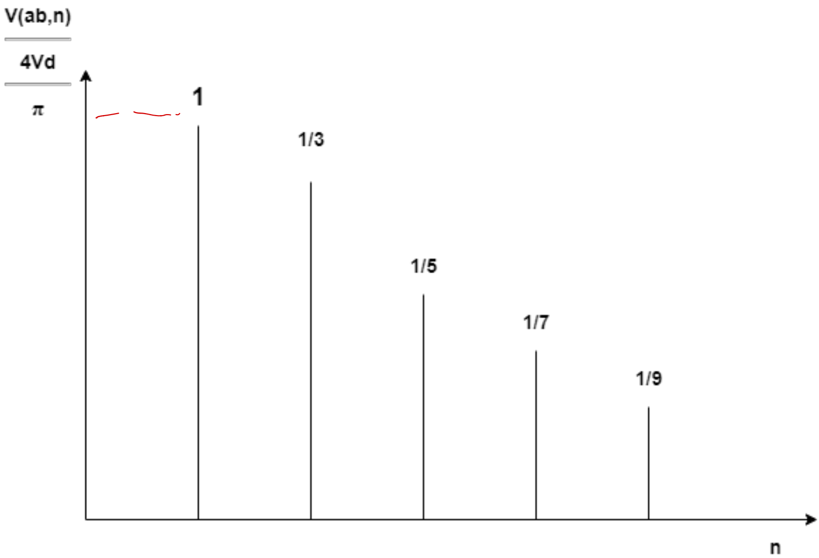


Fig 3.3 Schematic Diagram of Single-Phase Inverter

- The output signal we get contains Fundamental and Lower order Harmonics, e.g., 3^{rd},5^{th},7^{th},9^{th} Harmonics. 3^{rd} Harmonics voltage and current will make problem like provide low or sometimes high torque, which can damage the motors.
- So, we have to use Fundamental input to the machine to run smoothly.



Fig

We can write the Fundamental in terms of:

Where n= 1,3,5,7…. Odd

- **Modulation Index** () of a modulation scheme describes by how much the modulated variable of the carrier signal varies around its unmodulated level.
- **Modulation Frequency** () is the encoding of information in a carrier wave by varying the instantaneous frequency of the wave.

i. >1 (Over Modulation) (not included in SPWM)

ii. 0<<1 (Under Modulation)

, Where = fundamental value of

- Here, we have provided as sine wave, as it's respective frequency and as triangular wave and as its respective frequency to find out the wave form of gate pulses given to Switches S_1 S_2 as I_{g1} and Switches S_3 S_4 as I_{g3}.
- I_{g1}=ON, when means S_1 S_2 is ON simultaneously.
- I_{g3}=ON, when means S_3 S_4 is ON simultaneously.

During ON and OFF of the both of the switches there is a dead time which means all the switches are remain off for a while.

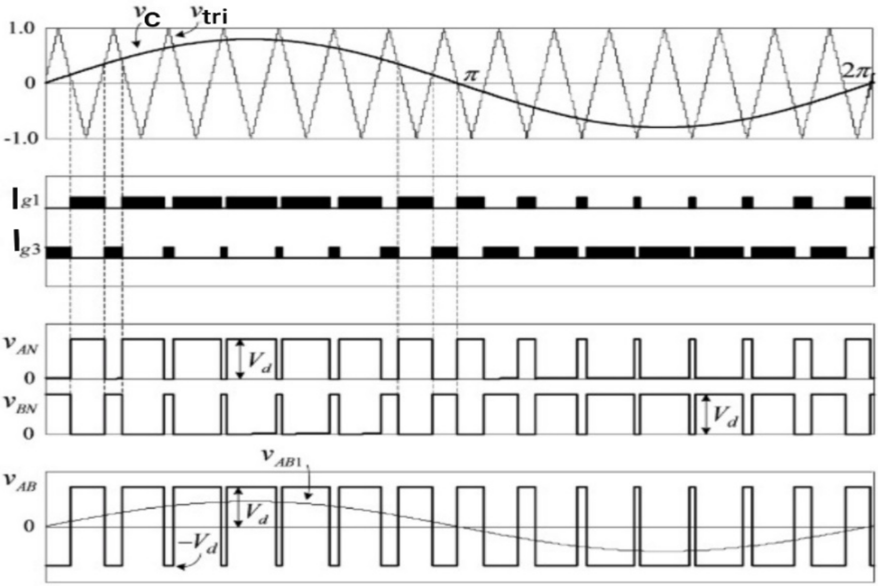
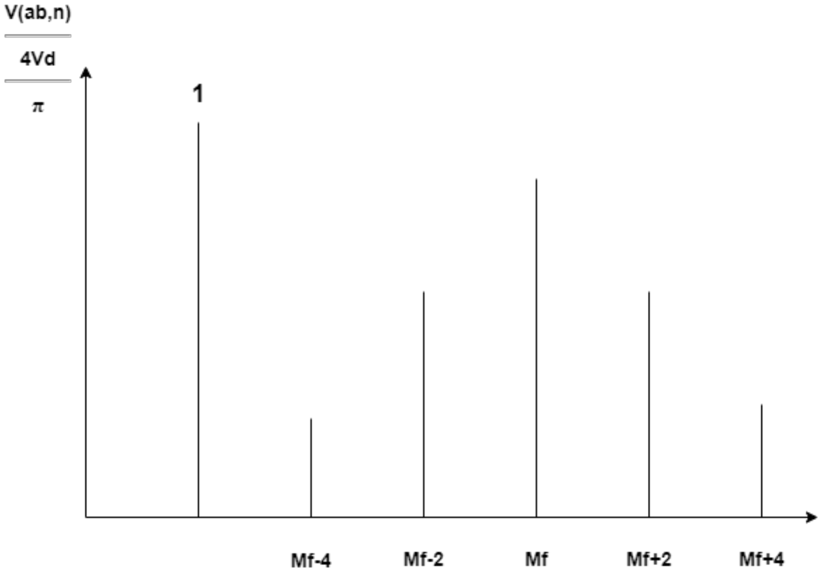


Fig Waveform Comparison of Vc and Vref in Bipolar Single-phase Inverter

Number of Harmonics:

Where K= Odd when J=Even
And K= Even when J=Odd
E.g., Suppose we take =9, then = =
Or = =
So = 5 7 ~~9~~ 11 13 = 13 15 ~~18~~ 21 23
From this we can conclude that we can eliminate harmonics near to so more will be the value of better the sinusoidal waveform we can get.



SINGLE PHASE INVERTER (SPWM)
3.4.2 FOR UNI-POLAR SWITCHING

In Unipolar Switching, we have to use switches separately as S_1 S_4 and S_3 S_2 to find out the waveforms.

Here we have to take 3 different waveforms to find out the output voltage waveform and gate pulses I_{g1}, I_{g2}, I_{g3} and I_{g4} for switches S_1, S2, S3 and S_4 respectably.

- When > , S_1 is ON, I_{g1} is provided.
- When < , S_4 is ON, I_{g4} is provided.
- When > , S_3 is ON, I_{g3} is provided.
- When < , S_2 is ON, I_{g2} is provided.

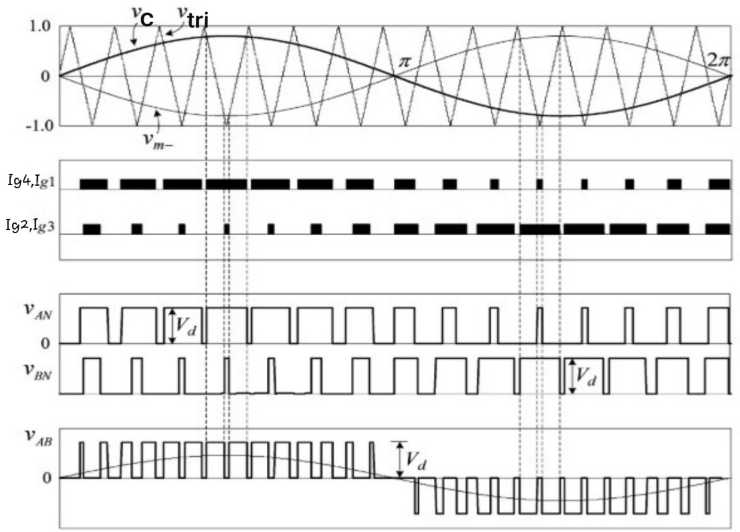


Fig Waveform Comparison of Vc and Vref in Unipolar Single-phase Inverter

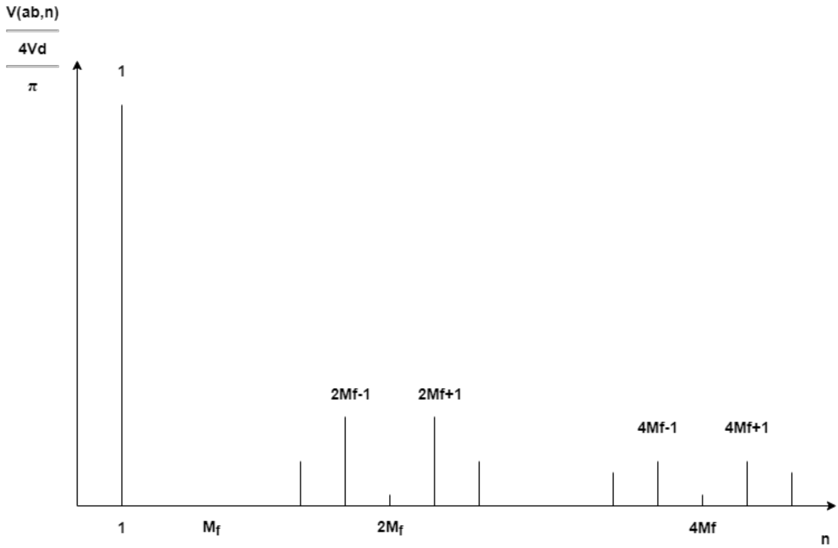
Number of Harmonics:

Where K= Odd when J=Odd as must be even because 2 multiply with any odd or even result will be even. To get as odd and must be Odd.

E.g., Suppose we take =9, then = =

Or = =

Means = 15 17 ~~18~~ 19 21 or 33 35 ~~36~~ 37 39



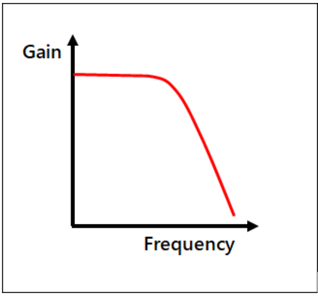
Because of 2 times of ,we can eliminate more harmonics in unipolar nearer to than bipolar as in bipolar we can able to eliminate harmonics near .

In this Project, Single-Phase Inverter is used with input DC voltage of 100 volt to get an output voltage of AC more than 100 volt as a square wave form. Due to absence of any Filter Output waveform provide with the AC in square wave. So, to Filter out the Harmonics and noise can be cut and specific signals can be identified which is in sinusoidal signal, we had used LC filter.

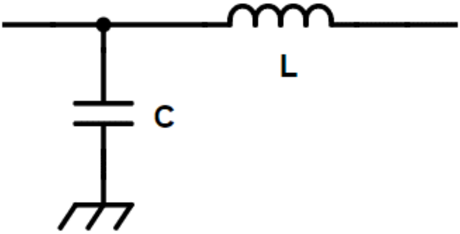
3.5 LC FILTER

LC filters refer to circuits consisting of a combination of inductors (L) and capacitors (C) to cut or pass specific frequency bands of an electric signal. Capacitors block DC currents but pass AC more easily at higher frequencies. Conversely, inductors pass DC currents as they are, but pass AC less easily at higher frequencies. In other words, capacitors and inductors are passive components with completely opposite properties. By combining these components with opposite properties, noise can be cut and specific signals can be identified.

LOW-PASS FILTERS (LPF)



Low-pass filters are filter circuits that pass DC and low-frequency signals and cut high-frequency signals. They are the most widely used filter circuits and are mainly used to cut high-frequency noise.

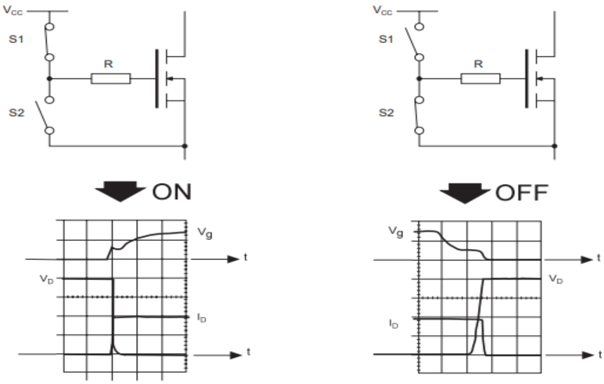


3.5 DRIVE CIRCUITS FOR IGBTs or MOSFETs

Not at all like the bipolar semiconductor, which is current driven, Power MOSFETs, with their protected entryways, are voltage driven. An essential information on the standards of driving the gates of these gadgets will permit the creator to accelerate or dial back the exchanging speeds as per the prerequisites of the application. It is frequently useful to consider the entryway as a basic capacitor while examining drive circuits.
IGBTs are simply voltage driven switches, because their insulated gate behaves like a capacitor. Conversely, switches such as triacs, thyristors and bipolar transistors are "current" controlled, in the same way as a PN diode.

3.5.1 DRIVING A GATE

driving a gate consists of applying different voltages: 15V to turn on the device through S1, and 0V to turn off the device through S2. A remarkable effect can be seen in both the turn-on and turn-off switching waveforms; the gate voltage exhibits a "step", remaining at a constant level while the drain voltage rises or falls during switching. The voltage at which the gate voltage remains during switching is known as the Miller voltage, . In most applications, this voltage is around 4 to 6V, depending on the level of current being switched. This feature can be used to control the switching waveforms from the gate drive.



Vcc
S1
R
S2
ON
Vg
t
VD
ID
t
Vcc
S1
R
S2
OFF
Vg
t
VD
ID
t