

Simulation and Implementation of 7 level Switched Capacitor Inverter

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Engineering Degree in
Electrical and Electronics Engineering

By

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SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
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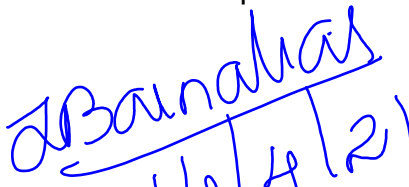
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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **M.NILOFAR YASMINE** (Reg. No. 37140060) and **R.SHALINI** (Reg. No. 37140077) who carried out the project entitled "**Simulation & implementation of 7 level switched capacitor inverter** " under our supervision from December 2020 to April 2021.


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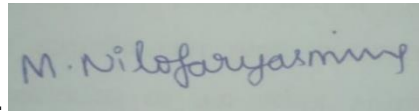
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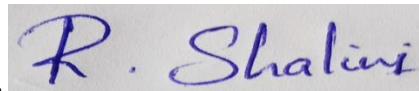
DECLARATION

We **M.NILOFAR YASMINE** (Reg. No. 37140060) and **R.SHALINI** (Reg. No. 37140077) hereby declare that the Project Report entitled “**SIMULATION & IMPLEMENTATION OF 7 LEVEL SWITCHED CAPACITOR INVERTER**” done by us under the guidance of **Mr.J.Barnabas paul Glady** is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Electrical and Electronics Engineering.

1.



2.



DATE: 08.04.2021

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ABSTRACT

In the recent years, construction inverters (MLI) are extremely getting used for medium voltage and high power applications because of their numerous blessings like low voltage stress on the facility switches. This project proposes a switched electrical condenser primarily based 7-level single part electrical converter. Five-level electrical converter imposes serious stress on power switches of the electrical converter. By increasing the degree within the signal of the electrical converter circuit, distortion and stress will be reduced and this will be achieved by exploitation multi-level inverters. Multi-level inverters (MLI) are designed by having single or multiple sources. Higher level MLIs want additional parts. Advances in multi-level inverters embody development of multi-level topology with less parts and better level. A 7level six switch electrical converter structure is planned to convert the DC supply and to AC and feed RL load. this method has lower total harmonic distortion compared to different strategies. The system was designed and tested exploitation Matlab simulation software package and hardware.

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LIST OF SYMBOLS AND ABBREVIATIONS

ω_0	-	Resonant Angular Frequency
C_r	-	Resonant Capacitor
C_s	-	Series Resonant Capacitor
L_r	-	Resonant Inductor
L_s	-	Series Resonant Inductor
I_r	-	Resistance Current
R	-	Resistor
V_C	-	Capacitor Voltage
V_{ds}	-	Drain to Source Voltage
V_{in}	-	Input Voltage
V_{out}	-	Output Voltage
X_c	-	Capacitive Reactance
X_l	-	Inductance Reactance
Z	-	Impedance
AC	-	Alternating Current

CISC	- Complex Instruction Set Computer
CPU	- Central Processing Unit
CTR	- Current Transfer Ratio
DC	- Direct Current
DCM	- Discontinuous Current Mode
DIAC	- Diode Alternating Current
DVM	- Discontinuous Voltage Mode
ESR	- Equivalent Series Resistance
ICSP	- In Circuit Serial Programming
IGBT	- Insulated Gate Bi-Polar Transistor
ILBC	- Interleaved Boost Converter
MCLR	- Master Clear
PFC	- Power Factor Correction
PIC	- Peripheral Interface Controller
SIM	- Simulator
THD	- Total Harmonic Distortion

CHAPTER 1

INTRODUCTION

1.1 GENERAL

Large inverters have historically happy the ever-increasing demand of high-energy industrial applications, that presently extends from the tens to many megawatts. Some samples of this truth square measure the medium voltage vary (2.3 to 13.8 KV) AC motor drives. Nowadays, it's problematic to attach only 1 power semiconductor switch on to the grid because of the high voltage vary. so as to unravel this issue, a replacement sort of power convertor has been introduced as an answer in high power applications. structure Converters use high speed shift elements, avoiding the matter of linking them on to the grid by connecting single devices among multiple DC levels. structure Converters square measure found in several applications; industrial motor drives, utility interfaces for renewable energy systems (photovoltaic, wind energy and fuel cells), versatile AC transmission systems (FACTS), high voltage DC transmission (HVDC), and traction drives systems.

The advantages of this kind of convertor over the standard 2 level convertor are:

- They can operate through a lower shift frequency.
- They draw input current with terribly low harmonic distortion.
- They manufacture a smaller common mode voltage, reducing the strain within the motor bearings.
- They generate a way wave as associate degree output with abundant lower harmonic distortion and dv/dt stresses.

These square measure a number of the disadvantages once the quantity of levels within the convertor is increased:

- Unbalanced voltages square measure introduced.
- A larger quantity of switches square measure needed.

- A additional advanced controller is needed because of the quantity of capacitors, which require to be balanced.

Several structure topologies are developed within the previous few years. {they square measure|they're} additional advanced to modulate than the 2 level ancient converters as a result of the quantity of shift alternatives that are out there. within the last 3 decades, 3 main convertor topologies have emerged from the numerous

Proposed:

- Diode Clamped (Neutral Clamped).
- Flying electrical device (Capacitor Clamped).
- Cascade Voltage supply, standard structure Converter(M2C).

Furthermore, many modulation techniques are developed for these converters. The modulation techniques include: curved pulse dimension modulation (SPWM), selective harmonic elimination (SHE-PWM) and area vector modulation (SVM). the most recent and most promising such topology for prime power applications is that the standard structure convertor (M2C). numerous management and modulation ways are recommended for this topology. The aim of this master thesis project is to deeply investigate and valuate one in all them, supported a carrier phase-shifted Pulse dimension Modulation (PWM) technique. Four completely different management topologies mistreatment part Shift PWM techniques on standard structure Converters square measure studied and explored during this work. These topologies may have 3 loops of control: Averaging management supported the currents within the convertor, Individual equalisation management supported the output current and capacitors voltages, and Arm equalisation management supported the voltage distinction between the arms of the convertor. furthermore these topologies square measure simple to implement and don't demand high process levels. This project proposes a shift frequency that meets the 2 needed criteria: low enough to keep up price practicableness, and high enough to achieve a harmonic performance target. in addition, this work proposes associate degree analytic expression for the output voltage spectrum of the convertor, that permits prediction of harmonic performance.

1.2 BACKGROUND

A multi-level electrical converter could be a power device engineered to synthesize a desired AC voltage from many levels of DC voltages. Multi level inverters are a crucial development in recent years, thanks to their capability to extend the voltage and power delivered to the motor with semiconductors that square measure out there these days. structure inverters have gained additional attention in high power applications as a result of it's got several benefits. It will understand high voltage and high power output by mistreatment semiconductor switches while not the utilization of electrical device and dynamic voltage balance circuits. once the quantity of output levels will increase, harmonics of the output voltage and current additionally as magnetic force interference (EMI) decrease. the essential thought of a structure electrical converter is, to attain higher power by employing a series of power semiconductor switches with many lower voltage dc sources to perform the facility conversion by synthesizing a way voltage wave. To obtain a coffee distortion output voltage nearly curved, a triggering signal ought to be generated to manage the shift frequency of every power semiconductor switch. during this paper the triggering signals of multi-level electrical converter square measure designed by mistreatment the curved PWM theme. a unique structure electrical converter is intended and enforced during this paper. the key feature of the projected topology is that the reduction of power elements. the aim of structure topology is to cut back voltage rating of power switch. Therefore, it always use at high power application. By combining output voltages in structure kind, it's benefits of low dv/dt , low input current distortion, and lower shift frequency. As a results of benefits of structure topology, many topologies have emerged in recent years. The business demand higher power applications, the specification of power device is higher. though IGBT has options of high power rating and high voltage stress, it cannot operate at high frequency. and also the style of IGBT gate driver is sophisticated. MOSFET is that the applicable element to control at high frequency, however power rating isn't pretty much as good as IGBT. to unravel the matter, many alternative topology of structure use low rating element at high power application.

The multilevel approach for DC to AC conversion offers many advantages such as

- The staircase waveform not only exhibits a better harmonic profile but also reduces the dv/dt stresses. Thus, the filter requirements can be greatly brought down (or even eliminated), while electromagnetic compatibility problems can be reduced.
- The voltage stresses on the semiconductor devices are much lesser as compared to the overall operating voltage. Thus, a high voltage waveform can be obtained with comparatively low voltage rated switches.
- MLIs produce much smaller common mode voltage and thus the stress in the bearings of a motor connected to a multilevel motor drive can be reduced.
- Many multilevel topologies offer the possibility to obtain a given voltage level with multiple switching combinations. These redundant states can be utilized to program a fault tolerant operation. v. MLIs can draw input current with low distortion.
- Renewable energy sources such as photovoltaic, wind, and fuel cells can be easily interfaced to a multilevel converter system and can be controlled for equal load sharing amongst the input sources.

1.3 CONSTRUCTION DEVICE TOPOLOGIES

In the gift chapter of the work there's in short description of the foremost necessary topologies developed. during this regard, there'll be mentioned their benefits and downsides whereas discussing the various configurations and their operation principles.

1.3.1 DIODE CLAMPED CONSTRUCTION DEVICE

The first invention in construction converters was the alleged neutral purpose clamped electrical converter. it had been at the start planned as a 3 level electrical converter. it's been shown that the principle of diode clamping will extended to any level. A diode clamped leg circuit is shown in Figure one.1. The main benefits and downsides of this topology are:

1.3.1 ADVANTAGES:

- High potency for the elemental switch frequency.
- The capacitors are often pre-charged along at the required voltage level.
- The capacitance demand of the electrical converter is decreased because of all phases sharing a standard DC link.

1.3.1 DISADVANTAGES:

- Packaging for inverters with a high variety of levels might be a drag because of the quadratic ally relation between the quantity of diodes and also the numbers of levels.
- Intermediate DC levels tend to be uneven while not the suitable management creating the important power transmission a drag.
- Uneven rating within the diodes required for the device.

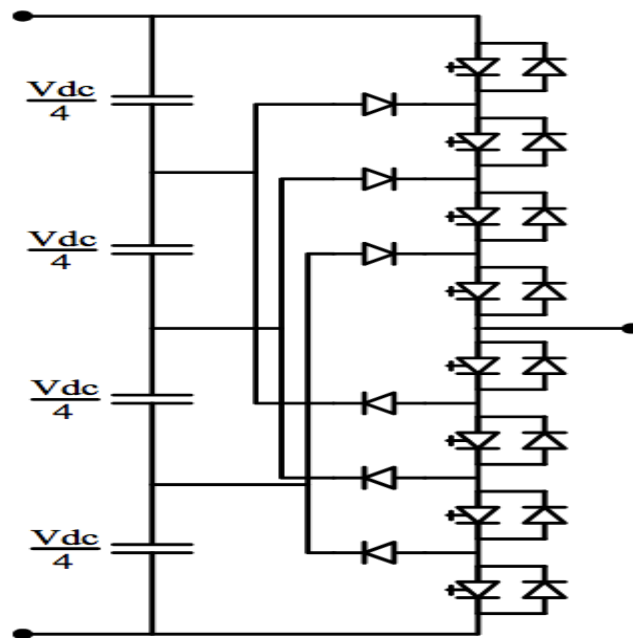


Fig:1.1: One phase 5-level structure of a Diode Clamped Inverter

Some of the applications victimisation construction Diode Clamped converters are:

- An interface between High voltage DC conductor and AC conductor.
- High power medium voltage variable speed drives.
- Static power unit compensation.

1.3.2 FLYING ELECTRICAL CONDENSER CONSTRUCTION DEVICE

As another for the diode clamped electrical converter is that the electrical condenser clamped electrical converter planned by Meynard and Foch, that shared several of the benefits. The structure of the electrical condenser clamped {inverter|electrical device} is comparable to it of the diode clamped converter. the most distinction is that the diodes used for the clamping ar replaced by capacitors. A Flying electrical condenser device leg circuit is shown in Figure 1-3. For this topology the foremost common application is static power unit generation.

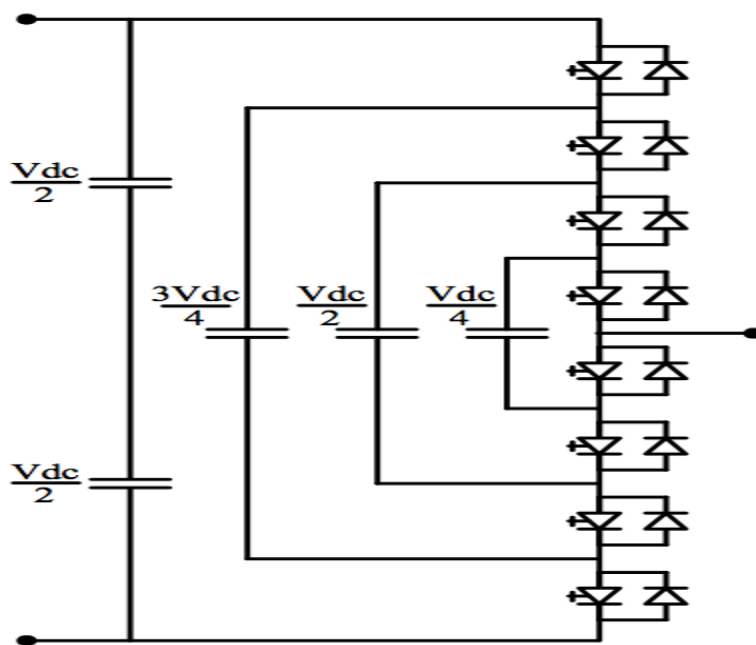


Fig:1.2: One phase 5-level structure of a Flying Capacitor Inverter

The main benefits and downsides of this topology are:

1.3.2 ADVANTAGES:

- management of the important and reactive power transmission.
- the big amounts of capacitors permit the electrical converter to handle voltages drops and spikes, and short outages.
- Redundancies within the switch states ar on the market so as to balance the voltages within the capacitors.

1.3.2 DISADVANTAGES:

- potency is reduced for real power transmission.

- The big quantity of capacitors is costlier and hulking than the diodes within the neutral purpose clamped electrical converter. conjointly packaging is a difficulty in high variety of level converters.
- data format of the system and pre charging the electrical condenser voltages may be a complicated procedure.

1.3.3 CASCADE VOLTAGE SUPPLY

The cascaded construction electrical converter is predicated on the series association of single leg or double leg (H bridges) inverters with separate DC sources or capacitors. for every of those 2 varieties of configurations many states exist concerning to the switches states. Figure 1-3, the one leg unit, has three states for every of the 2 doable current(s) directions whereas the double unit has four states.



Fig:1.3: Left: Single Leg Unit. Right Double Leg Unit

The main benefits and downsides of this topology are:

1.3.3 ADVANTAGES:

- The modularized structure permits straightforward packaging and storage
- The amount of doable voltage levels is over double the quantity of capacitors within the double leg unit (H bridge).

1.3.3 DISADVANTAGES:

- Separated DC sources or electrical condenser ar needed for every module.
- A additional complicated controller is needed because of the number of capacitors, which require to be balanced.

1.3.4 LITERATURE SURVEY

Comparison of the standard CHB five-level inverters with alternative inverters is self-addressed during this literature survey.

Kouro S et al.,(2010) given a quick summary of well-established structure converters powerfully orienting to their current state in industrial applications to then center the discussion on the new converters that have created their means into the trade. additionally, new promising topologies were mentioned. Recent advances created in modulation and management of structure converters was conjointly self-addressed. an excellent a part of this paper was dedicated to show nontraditional applications power-driven by structure converters and the way structure converters have become associate degree sanctionative technology in several industrial sectors.Finally, some future trends and challenges within the any development of this technology were mentioned to encourage future contributions that address open issues and explore new prospects.

Bronislaw Malinowski M et al.,(2010) given a survey of various topologies, management ways and modulation techniques utilized by cascaded structure inverters. The cascaded structure inverters had evolved from a theoretical construct to real applications because of many exceptional options sort of a high degree of modularity, the likelihood of connecting on to medium voltage, high power quality, each input and output, high availableness, and therefore the management of power flow within the regenerative version. Regenerative and advanced topologies were conjointly mentioned. Applications wherever the mentioned options play a key role area unit shown. Finally, future developments were self-addressed.

Farivar G et al.,(2016) planned a cascaded H-Bridge (CHB) structure device primarily based electrical phenomenon (PV) system with no voltage or current sensors at the dc-side. the most advantage of eliminating the dc-side sensors simplifies the hardware, resulting in lower price and better dependability of the PV system. a unique theme estimating the capacitors' voltages from the output ac voltage of the electrical converter was developed. The theme permits replacement all dc-side voltage detectors by one voltage sensor at the ac-side of the device. what is more, the dc current sensors,

conventionally needed for the most power trailing (MPPT) were conjointly eliminated. Instead, the outputs from the capacitors' voltage management systems area unit utilised for the MPPT. The operation of the planned system beneath the switch device failure must be studied very well within the future to boost the dependability of the system.

Chavarria J et al.,(2013) planned associate degree energy-balance management strategy for a cascaded single-phase grid-connected H-bridge structure electrical converter linking nindependent electrical phenomenon (PV) arrays to the grid. The management theme was supported associate degree energy-sampled information model of the PV system and permits the look of a voltage loop linear separate controller for every array, guaranteeing the soundness of the system for the total vary of PV array operational conditions. The management style was tailored to phase-shifted and level-shifted carrier pulse dimension modulations to share the management action among the cascade-connected bridges so as to at the same time synthesize a structure wave shape and to stay every of the PV arrays at its most power operational purpose. An FPGA-based style operational at a lower switch frequency to cut back switch losses would be envisaged for the PS-PWM case however would result tougher if LS-PWM is adopted since rock bottom switch frequency is proscribed by each the magnitude relation rotating frequency/grid frequency and therefore the management action resolution supported by the FPGA platform.

Coppola M et al.,(2016) projected a complicated management strategy for grid tied electrical phenomenon (PV) cascaded H bridge (CHB) electrical converter. The circuit topology consists of a correct range of power cells (H bridge configuration) connected serial and equipped by individual PV modules. The adopted management methodology was a mixed way PWM technique performed by suggests that of a algorithmic program to see cells' change state. The cells' state was associated with the necessity of charging or discharging a specific cell way more than the others by shrewd the voltage error at every dc link (e.g. by considering the distinction between the MPPT reference and also the measured quantity). a fanatical P&O MPPT permits to manage severally the voltage of every dc link, so increasing the ability extraction even in match conditionsThe

management section is enforced on FPGA by employing a d-SPACE real time hardware platform, so getting totally dedicated digital circuits.

Villanueva E et al.,(2009) developed a single-phase cascaded H-bridge device for a grid-connected electrical phenomenon (PV) application. The structure topology consists of many H-bridge cells connected serial, each connected to a string of PV modules. The adopted management theme permits the freelance management of every dc-link voltage, enabling, during this method, the pursuit of the most outlet for every string of PV panels. to boot, low ripple sinusoidal-current waveforms ar generated with virtually unity power issue. The device options many blessings like the generation of high-quality currents, the capability to work at a lower change frequency than a two-level device, and also the modularity that may cut back the price of the answer.

Farivar G et al.,(2016) introduced a cascaded H-bridge structure device (CHB-MC) based mostly StatCom system that was able to operate with very low dc capacitance values. The theoretical limit is calculated for the most electrical device voltage ripple, and therefore minimum dc capacitance values that may be utilized in the device. The projected low-capacitance StatCom (LC-StatCom) was able to operate with giant electrical device voltage ripples, that ar terribly on the brink of the calculated theoretical most voltage ripple. the most voltage stress on the semiconductors within the LC-StatCom is under in a very standard StatCom system. The variable cluster voltage magnitude within the LC-StatCom system drops well below the most grid voltage, that permits a set most voltage on the individual capacitors. A high-bandwidth system is intended for the projected StatCom to produce management of the electrical device voltages throughout extremely dynamic transient events. the desired energy storage for the LC-StatCom system shows vital reduction compared to a standard StatCom style.

Khoucha F et al.,(2010) proposed hybrid cascaded H-bridge structure motor drive direct torsion management (DTC) theme for electrical vehicles (EVs) or hybrid EVs. The management methodology was supported DTC operational principles. The mechanical device voltage vector reference is computed from the mechanical device flux and torsion errors obligatory by the flux and torsion controllers. This voltage reference is then generated employing a hybrid cascaded H-bridge structure electrical converter,

wherever every part of the electrical converter will be enforced employing a dc supply, which might be offered from fuel cells, batteries, or ultra-capacitors. This electrical converter provides nearly curved voltages with terribly low distortion, even while not filtering, mistreatment fewer change devices. additionally, the structure electrical converter will generate a high and stuck change frequency output voltage with fewer change losses, since solely the tiny power cells of the electrical converter operate at a high change rate. Therefore, a high performance and conjointly economical torsion and flux controllers ar obtained, sanctionative a DTC answer for multilevel-inverter-powered motor drives.

Vazquez S et al.,(2010) projected many management and modulation techniques for structure cascaded H-bridge (CHB) power device topology. during this paper, the steady-state power balance within the cells of a single-phase two-cell CHB is studied. the aptitude to be furnished with active power from the grid or to deliver active power to the grid in every cell is analyzed in keeping with the dc-link voltages and also the desired ac output voltage worth. the boundaries of the most and minimum input active powers for a stable operation of the CHB ar addressed .The given associate degree analysis is an acceptable tool to ascertain the planning criteria for the 3C-CHB synchronous rectifier or succeeding application.

Napoles J et al.,(2013) a brand new management strategy, supported the SHM-PWM technique that may tolerate completely different electrical device voltage levels for Cascaded H-Bridge structure Converters. as compared with different techniques, during this case it's doable to manage the amplitude of every cell beneath balanced or unbalanced conditions with a reduced range of operation tables while still manufacturing terribly high-quality waveforms at low change frequency. associate degree example of associate degree application which can take pleasure in such a theme is in a very structure UPS. during this case the technique can be able to meet grid voltage standards even once the batteries ar charged to completely different voltages. The experimental results support that the tactic {in a|during a|in associate degree exceedingly|in a very} two-cell device validates the technique for an imbalance vary from third to 100%.

CHAPTER 2

CIRCUIT OPERATION

2.1 EXISTING SYSTEM- CONSTRUCTION CASCADE CONVERTER

The cascaded construction convertor is one among many construction configurations. it's fashioned by connecting over one single-phase H-bridge convertor nonparallel as shown in Fig. 3.1 every convertor generates a sq. wave voltage wave shape with completely different duty ratios, that along type the output voltage wave shape as in Fig. 4.. rather than sq. waves, it's additionally potential to induce PWM output voltages; but, during this paper, first harmonic change are going to be emphasised rather than high frequency PWM change.

Voltage of a electric cell. gift fuel cells ar usually manufacturing dc voltages between 30V and 50V at full-load. once one among these fuel cells is connected to Associate in Nursing electrical converter, they'll not be ready to turn out ac grid level voltages. A dc dc boost convertor is usually needed to spice up the voltage level for the electrical converter. This boost convertor, additionally to boosting the electric cell voltage, additionally regulates the electrical converter input voltage and isolates the low and high voltage circuits. The electrical converter for a residential application is either single- or dual-phase.

Residential applications et al, together with hospitals, schools, living accommodations buildings etc. have a daily load profile with hours of full-load operation and hours of low-load operation. the applying are going to be designed for full-load conditions; but, throughout low load operation, thanks to the load dependent characteristics of the fuel cells, the electric cell voltage may be up to five hundredth over the full-load case. This increase within the voltage needs derating of the electrical converter devices. The dc-dc boost convertor keeps the dc-link constant so the electrical converter switches don't seem to be essentially derated; but, the dc-dc convertor switches still need to be derated. It additionally will increase the price while not abundant of a profit considering that isolation or voltage boost may not be essential during this application. a far better answer is that the level reduction technique delineate in employing a construction dc-dc

converter provision power to a three-phase electrical converter. Level reduction is completed by inhibiting fuel cells one by one once the load current decreases. Then, the voltage across the electrical converter switches is reduced, still maintaining the voltage and power needed by the electrical converter and also the load. Note that the extent reduction technique is projected for applications like living accommodations buildings, schools, hospitals, etc. wherever the load varies throughout the day. However, the load variation is usually not fast; thus, high frequency change of the construction dc-dc converter isn't a tangle. Since this converter simply changes the dc voltage level once needed, the management of the converter is very easy.

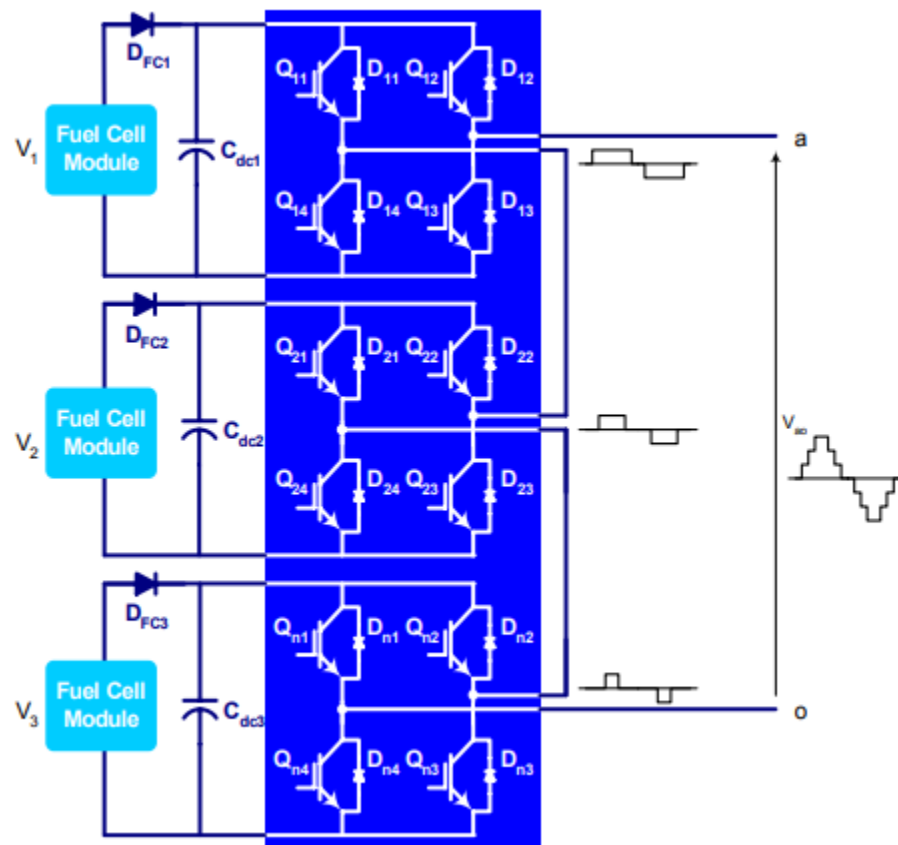


Fig:2.1: 5-level cascaded multilevel inverter

The repressed H-bridges and fuel cells may be wont to charge batteries to extend the potency and also the utilization of the fuel cells any. Moreover, since the time period of a electric cell is usually given in operative hours, by alternating the repressed fuel

cell(s), the operative time period of the electric cell may also be extended. Since a straightforward sine-triangle comparison is getting used rather than change angle optimisation techniques, total harmonic distortion (THD) may be a priority.

2.1.1 DRAWBACKS

- Every H Bridge wants a separate dc supply. variety of DC supply is accumulated as variety of output level will increase.
- Communication between the full-bridges is needed to attain the synchronization of reference and also the carrier waveforms.
- Needs separate dc sources for real power conversions, and so its applications are somewhat restricted

2.2 PROJECTED TOPOLOGY

This project proposes a switched electrical condenser primarily based 7-level single section electrical converter. Two-level electrical converter imposes serious stress on power switches of the electrical converter. By increasing the degree within the signal of the electrical converter circuit, distortion and stress may be reduced and this will be achieved by exploitation multi-level inverters. Multi-level inverters (MLI) are designed by having single or multiple sources. Higher level MLIs would like a lot of elements. Advances in multi-level inverters embrace development of multi-level topology with less elements and better level. A 7-level six switch electrical converter structure is projected to convert the DC supply and to AC and feed RL load. this method has lower total harmonic distortion compared to alternative ways.

The supply voltage is split into 3 0.5 over the DC-links exploitation 3 capacitors. The positive 0.5 cycle and also the negative 0.5 cycle is obtained with the employment of a full bridge circuit; whereby the auxiliary circuit is employed to get levels like V_{dc} and $3V_{dc}$. solely 2 switches are conducting for every level generation, which ends in higher potency of the electrical converter topology. The projected system are reduced device counts, driver circuits, standard structure, improved power quality and better potency. Figure. 3.2 depicts the projected changed structure of seven-level electrical converter. The projected configuration is a lot of helpful for single-phase applications. The seven-level electrical converter could be a standard structure and also the levels may be

extended by clamping the DC-link voltage with further auxiliary circuits. The elaborated operation of every half is as follows;

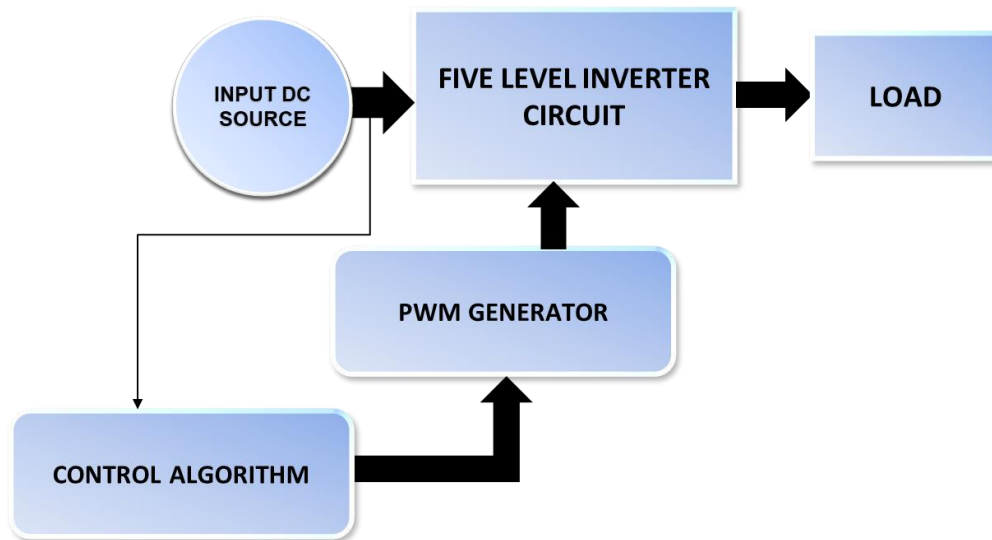


Fig:2.2: design of the projected topology

2.3 SEVEN LEVEL ELECTRICAL CONVERTER

Multi-level inverters have shown famous performance during this times. Multi-level inverters, higher the extent, less the distortion within the signal and stress across the switch reduces likewise. Multi-level inverters (MLI) are designed by having single or multiple sources. Higher level MLIs would like a lot of elements. Advances in multi-level inverters embrace development of multi-level topology with less elements and better level. Figure three shows the 7-level six switch multi-level electrical converter topology that converts DC input to 7-level signal. This topology consists of 2 DC sources and 6 switches. Table one shows the change states of 7-level six switch electrical converter.

Table:2.1:The switching states of 7-level six switch inverter.

Level of Voltage	S1	S2	S3	S4	S5	S6
Vdc	1	1	0	0	0	0
2Vdc/3	0	1	0	0	1	0
Vdc/3	0	1	0	0	0	1
0	0	1	0	1	0	0
-Vdc/3	0	0	1	0	1	0
-2Vdc/3	0	0	1	0	0	1
-Vdc	0	0	1	1	0	0

2.4 CIRCUIT CONFIGURATION

Fig. 1 shows the proposed five-level inverter. This inverter has four switches S1, S3, S3 and S4 and four diodes D1, D3, D3 and D4. The two capacitors C1 and C3 will act as voltage divider as in. The auxiliary switch, is formed by a bidirectional switch S5 and four diodes D5, D6, D7 and D8 is connected between node A and positive terminal of load.

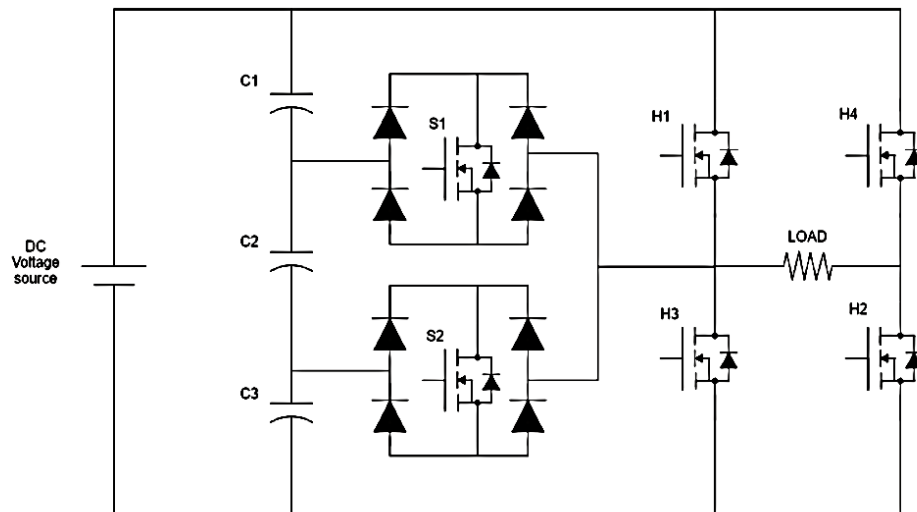


Fig:2.3: Circuit diagram of the proposed 7 level inverter

2.4.1 STAGE ADVANTAGES

Few advantages of the contemplated system when compared to the existing MLI are discussed below. They are:

2.4.2 MAIN POWER SWITCHES

To obtain a five level output voltage as in a conventional MLI, eight switches are required but this topology uses five switches which gradually reduces the switches rate by 37.5% and the auxiliary switch power rating is less comparative to main switches.

2.4.3 DIODES AND CAPACITORS

The proposed topology has only two capacitors; therefore there is no problem of voltage unbalance. When compared with other multilevel topologies it uses only 80% of capacitors than in flying capacitor. It has eight diodes, whereas diode clamped topology uses twenty diodes. As we are using only two capacitors for voltage division, there is no much problem of voltage

2.4.4 OPERATION OF THE CIRCUIT

There are five modes of operation to generate five level output (V_s , $V_s/3$, 0, $-V_s/3$, $-V_s$) depending on different switching combinations output can be varied;

- Mode 1: By switching on switches S1 and S4 maximum positive output voltage V_s is generated. The closed loop path is formed through V_s , S1, R, S4 and V_s
- Mode 3: Half the voltage $V_s/3$ is obtained by turning ON switches S5 and S4. As soon as S5 gets turned ON it makes diodes D5 and D8 forward bias. Hence a closed loop is formed through V_s , D5, S5, D8, S4 and V_s . The closed loop path for the current is shown in Fig.3.
- Mode 3: Zero output is generated when the load get short circuited. It is done by switching on S3 and S4 or S1 and S3. The closed loop formed is shown in Fig.4.
- Mode 4: For voltage $-V_s/3$ switches S5 and S3 are turned ON. Similar as mode 3 but here diodes D6 and D7 are forward biased. The closed loop path for the current is V_s , S3, R, D7, D6 and V_s as shown in Fig.5.

- Mode 5: Negative maximum voltage $-V_s$ is obtained by making switches S3 and S3 ON, the load negative terminal directly connects to the supply and positive terminal to the ground. Hence the voltage across the load will be $-V_s$. The closed loop path is shown in Fig.6.

Table I shows the switching table to generate five level output. The dynamic voltage balancing between the two capacitors is automatically restored by these switching combinations

2.5 CONTROL ALGORITHM

Simple sine pulse width modulation technique is used to generate the control signals for the five-level as shown in Fig. 4. A high-frequency carrier is compared with the level shifted modulated sine waveform to produce the switching signals for switches S1 to S5. It can be noticed that the switching pulses S3 and S4 are complementary and operate at a fundamental switching frequency; wherein other switches are operating at the higher switching frequency. Whereas, the modulation index M_a decides the output voltage level. It should be maintained between 0-1 for linear control in output voltage. $M_a > 1$ leads to over modulation which results in higher harmonics in the output phase voltages.

CHAPTER 3

SIMULATION RESULTS

3.1 RESULTS AND DISCUSSION

The proposed topology is verified through Matlab simulation and experimental prototype model. The simulated waveforms of the input voltage, dc-link capacitor voltages, seven-level inverter output voltage and their corresponding load currents respectively. The voltage across the capacitors is maintained at 150V to generate Seven-level output voltage waveform. It can be noticed that the output voltage is always maintained constant during load transitions. By employing a suitable controller the output voltage can be regulated for both step changes in load as well as input voltage changes. Illustrates the measured frequency spectrum of both inverter five-level output voltage and load current waveforms. The %THD of the output current is within IEEE standard limits.

3.2 EXISTING SYSTEM- 5 LEVEL SIMULATION - CIRCUIT

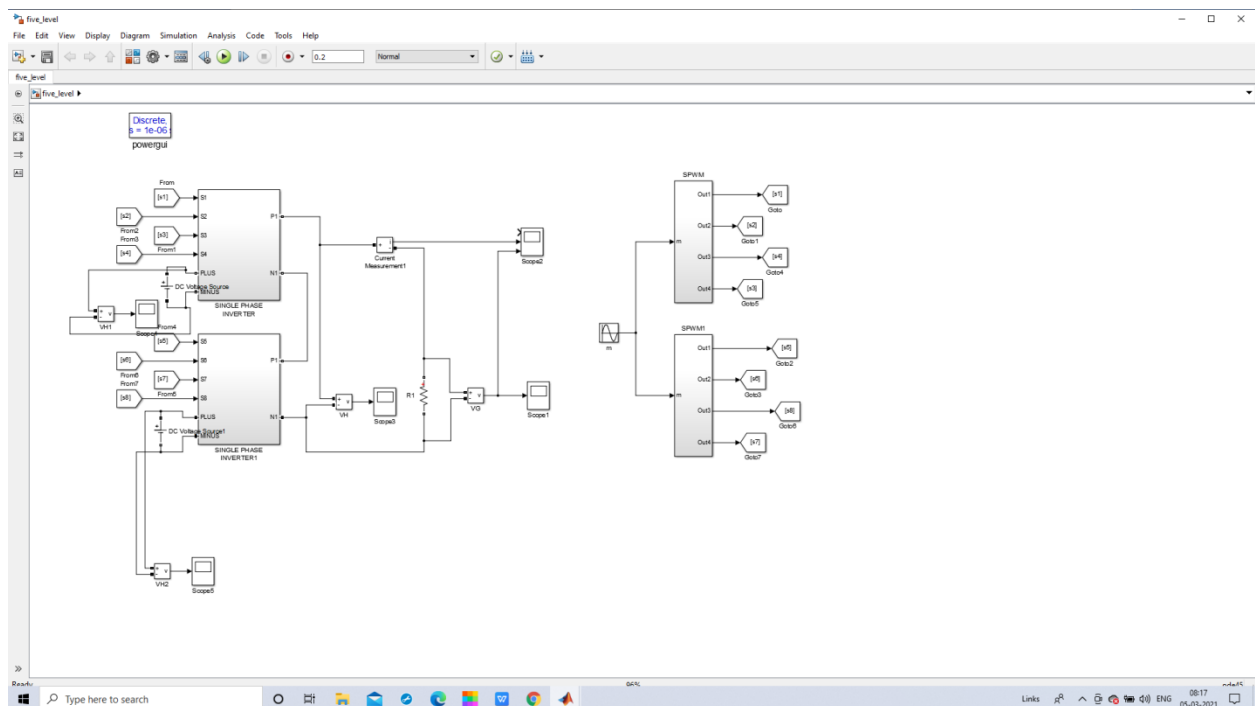


Fig:3.1:Circuit diagram of 5 level simulation-existing system

3.3 INPUT DC VOLTAGE SOURCE ACROSS 1 PHASE INVERTER

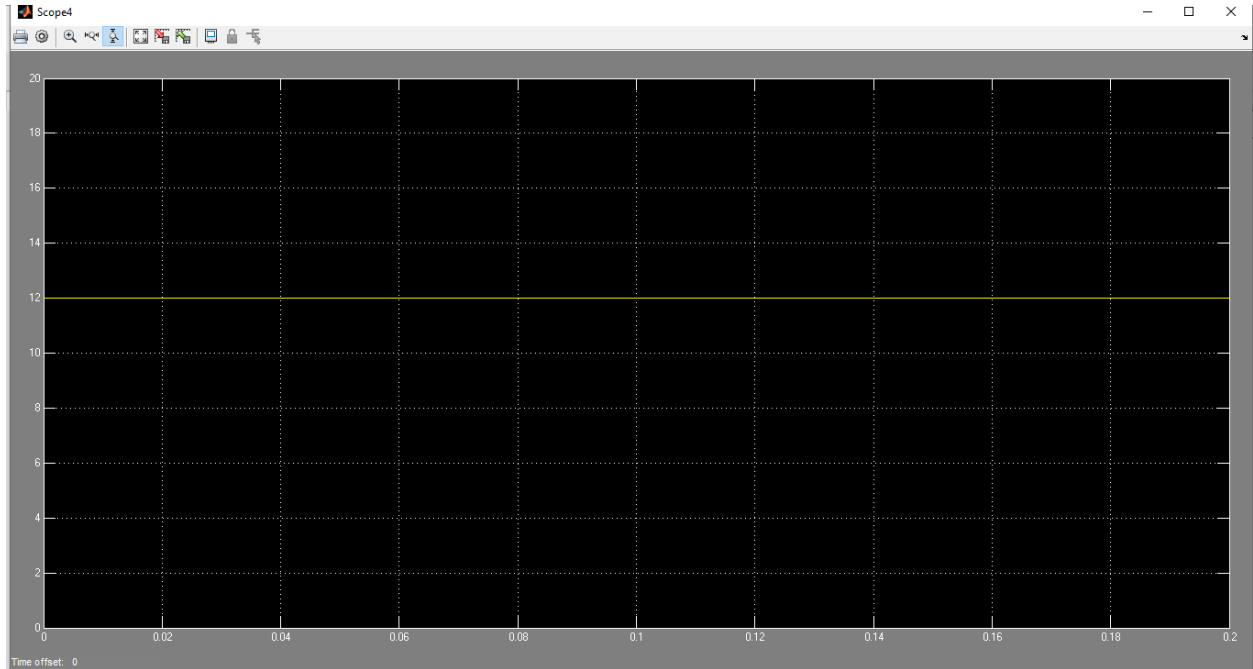


Fig:3.2:Input dc voltage source across single phase inverter

The above figure.3.2 shows Input voltage of 12V using matlab simulation

3.4 INPUT DC VOLTAGE SOURCE ACROSS 1 PHASE INVERTER 1

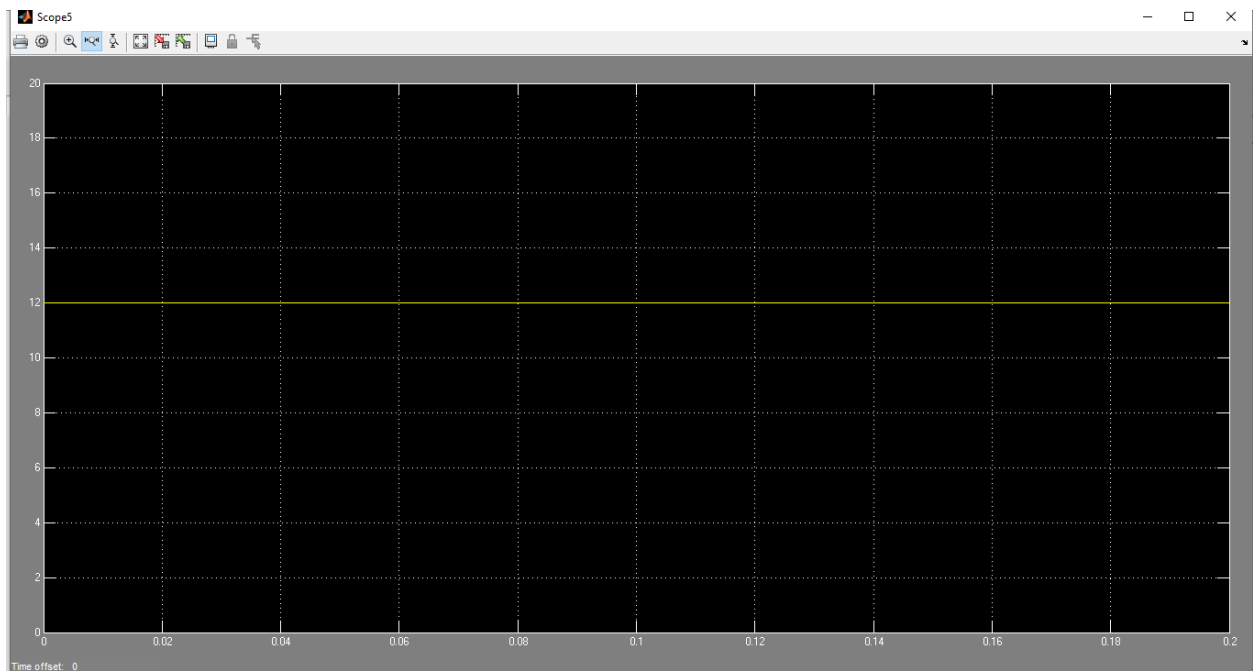


Fig:3.3:Input dc voltage source across single phase inverter 1

3.4.1 CURRENT AND VOLTAGE OUTPUT

OUTPUT CURRENT = 0.04A

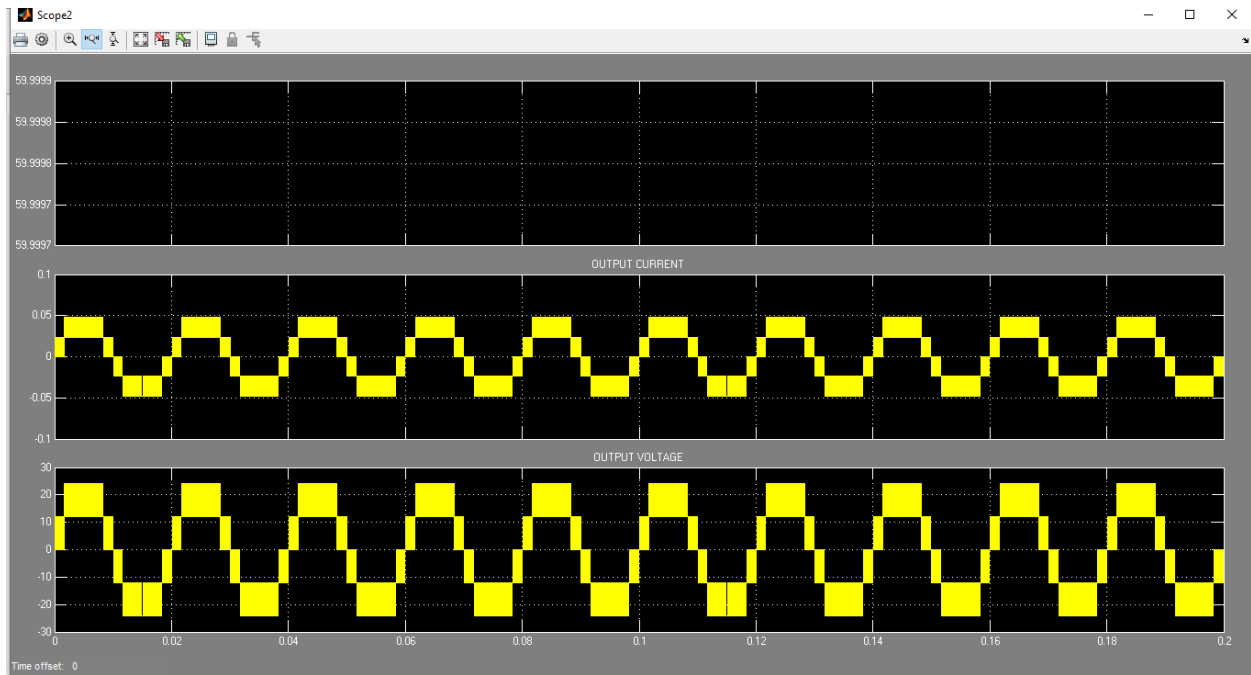


Fig:3.4:Current and voltage output

The above figure.3.4 Scope is connected across output voltage and current. We taken to the output of 24V

3.4.2 OUTPUT VOLTAGE

OUTPUT VOLTAGE = 24V

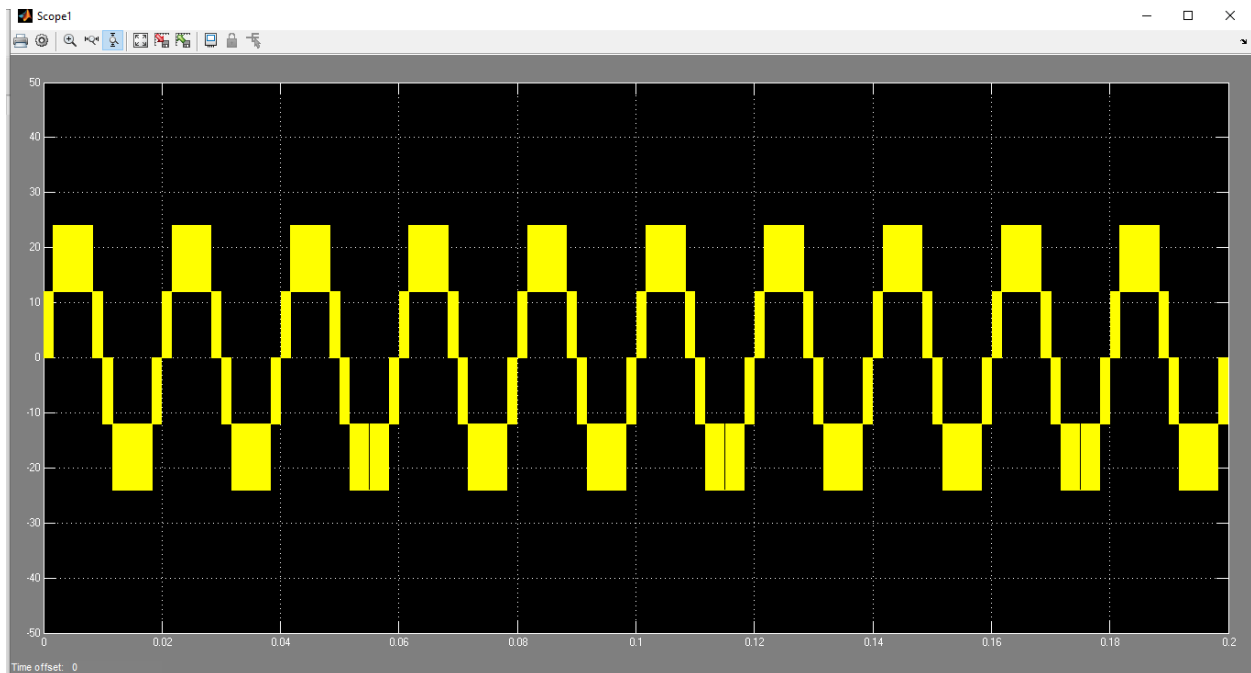


Fig:3.5:Output voltage

TOTAL HARMONIC DISTORTION(THD) = 26.99%

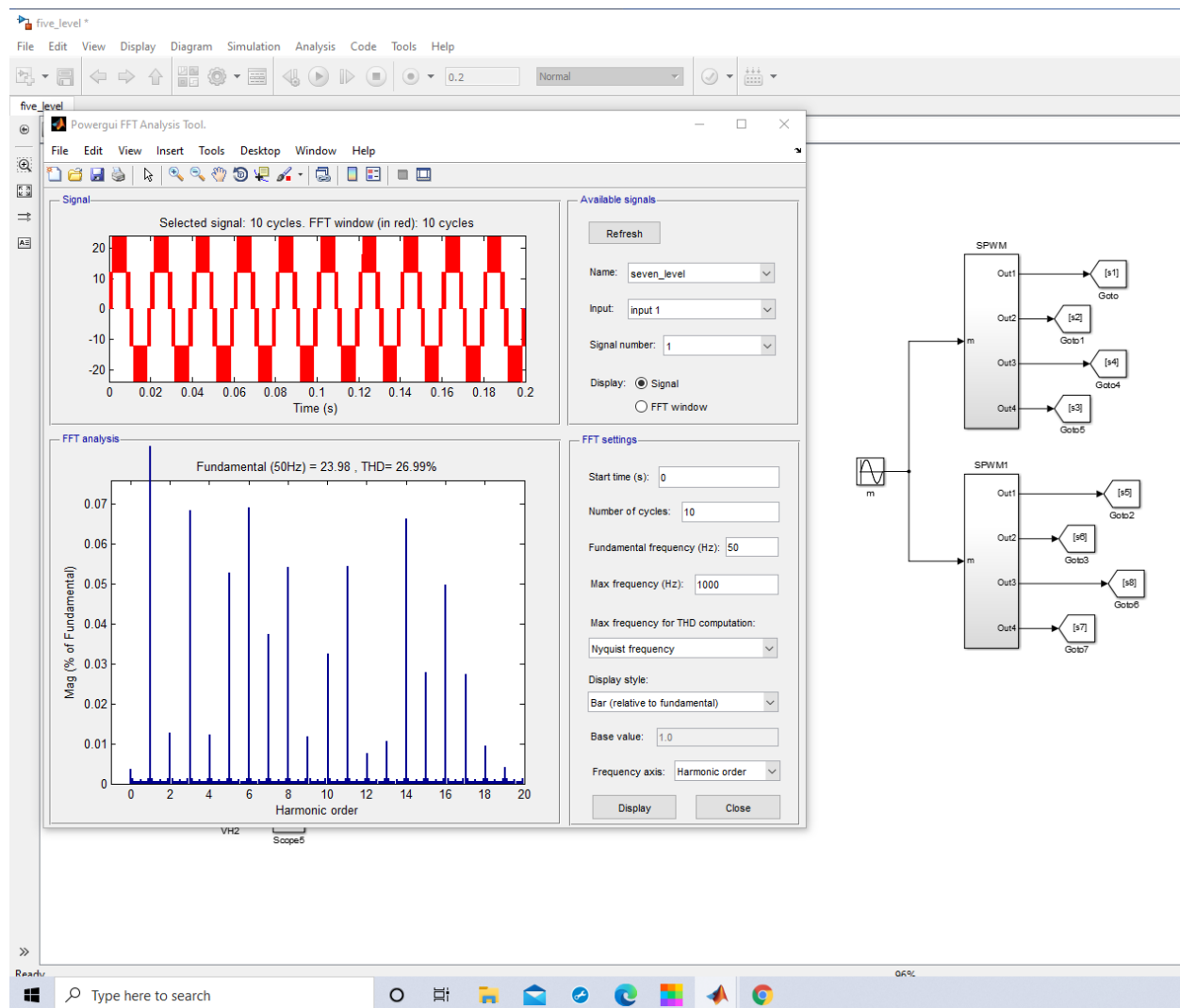


Fig:3.6: Total harmonic distortion of 5 level

The above figure.3.6 We are taken to the Total Harmonic Distortion. That was 26.99% for 5 level simulation.

3.5 PROPOSED SYSTEM 7 LEVEL SIMULATION

3.5.1 PROGRAM CODE

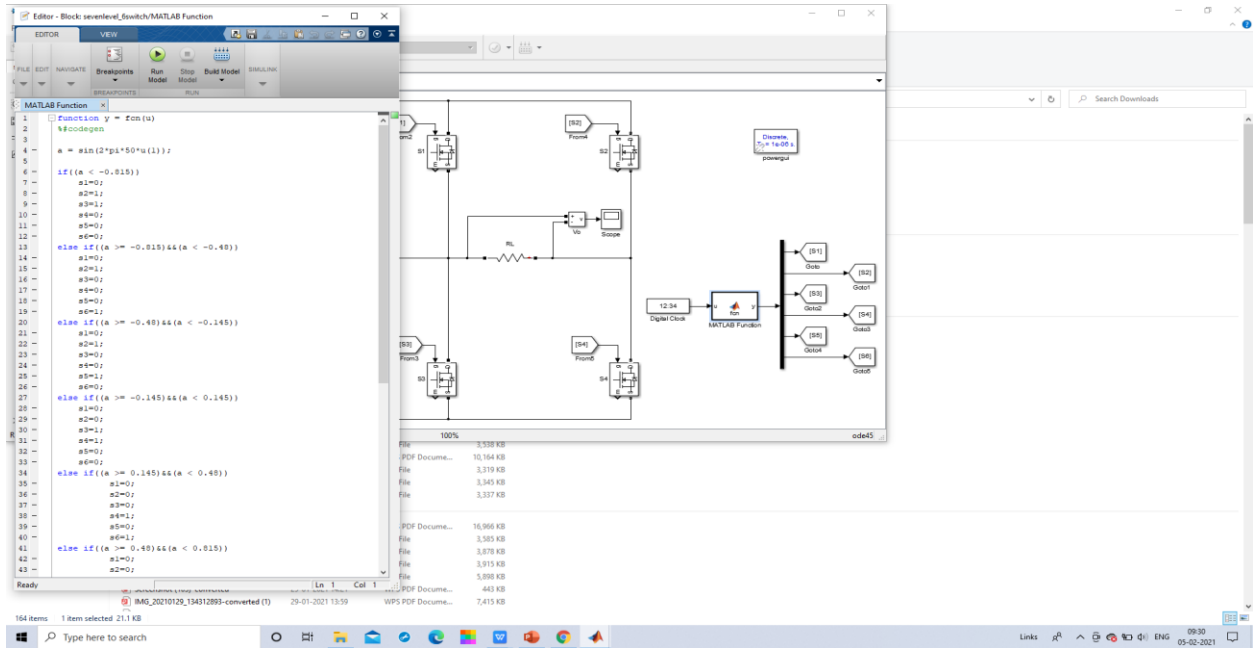
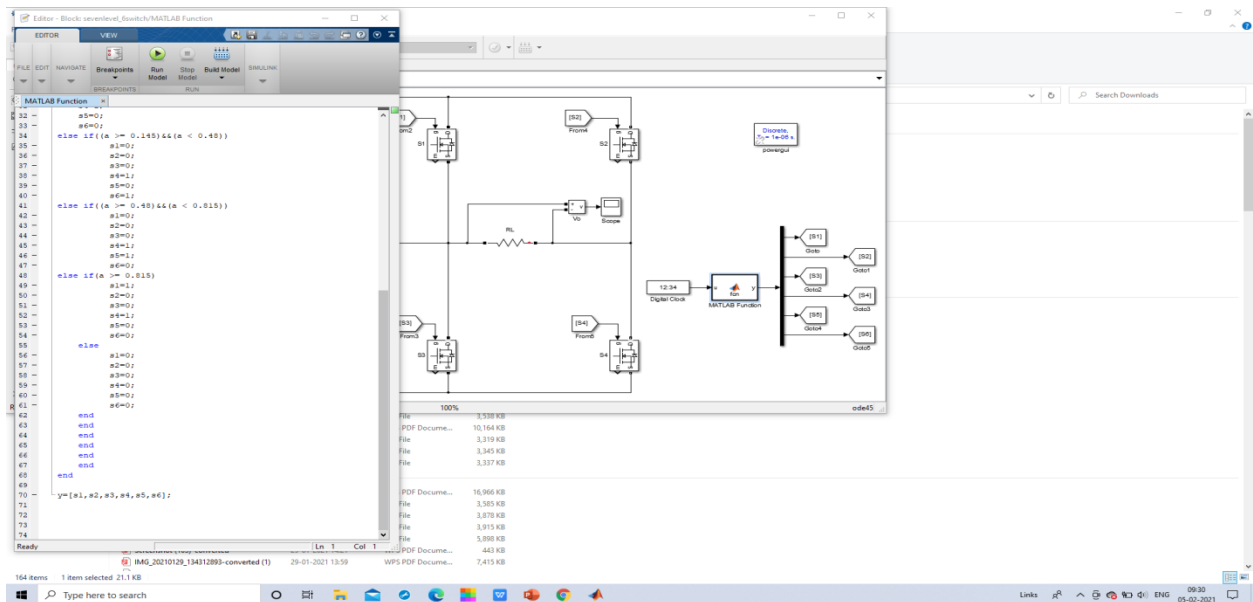


Fig.3.7:Program code for proposed system



This is the program code of proposed system for 7 level simulation

3.5.2 CIRCUIT – 7 LEVEL

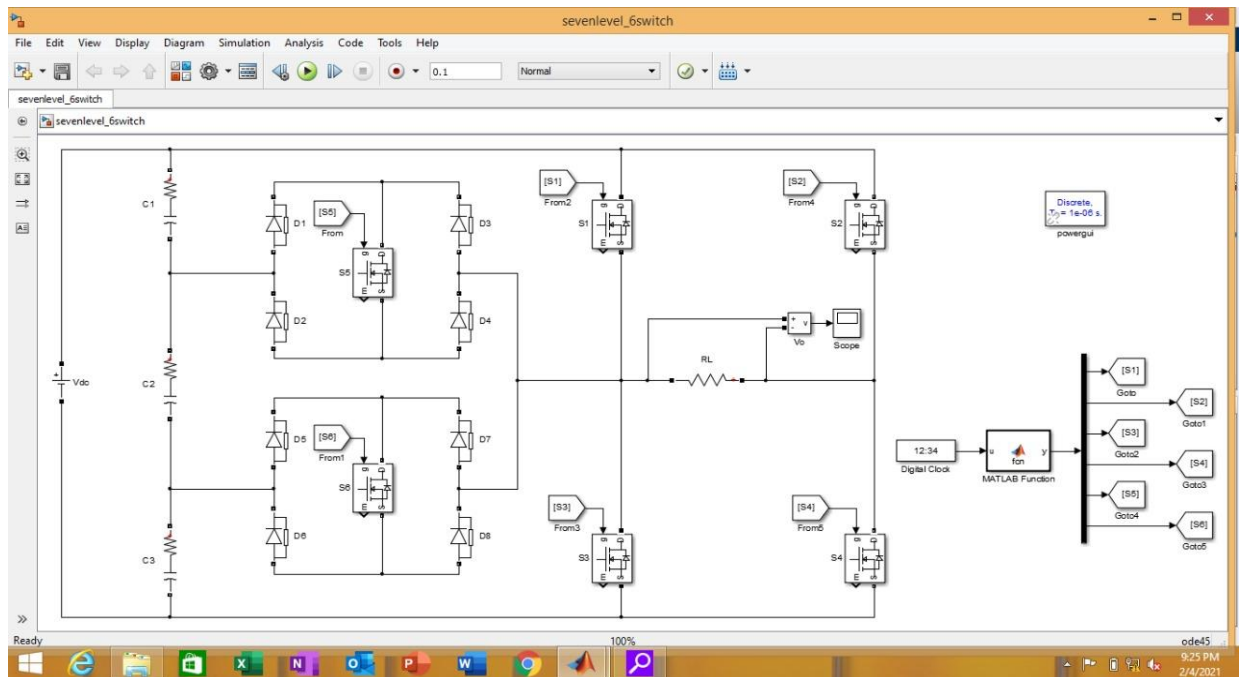


Fig:3.8:Circuit diagram of 7 level simulation-proposed system

3.5.3 INPUT VOLTAGE

INPUT VOLTAGE = 24V

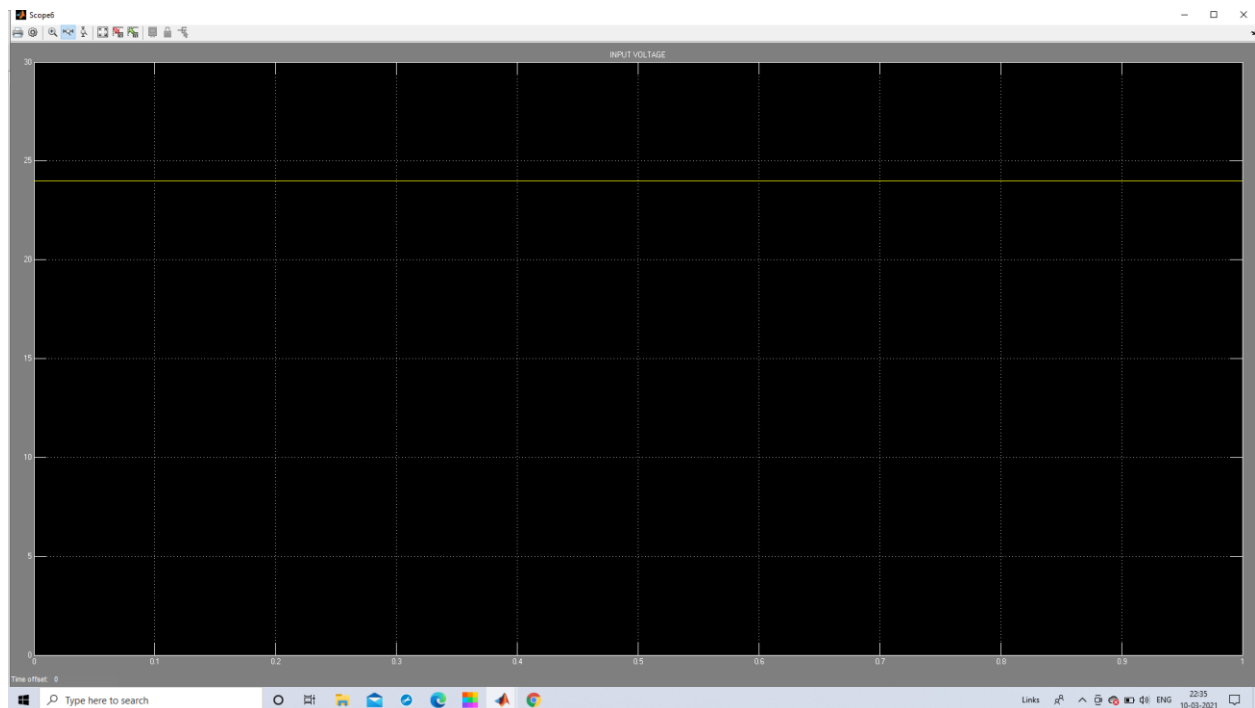


Fig:3.9:Input voltage

The above figure.3.9 shows input voltage=24v and the output is taken as 24 volt.

3.5.3 INPUT CURRENT

INPUT CURRENT = 0.24A

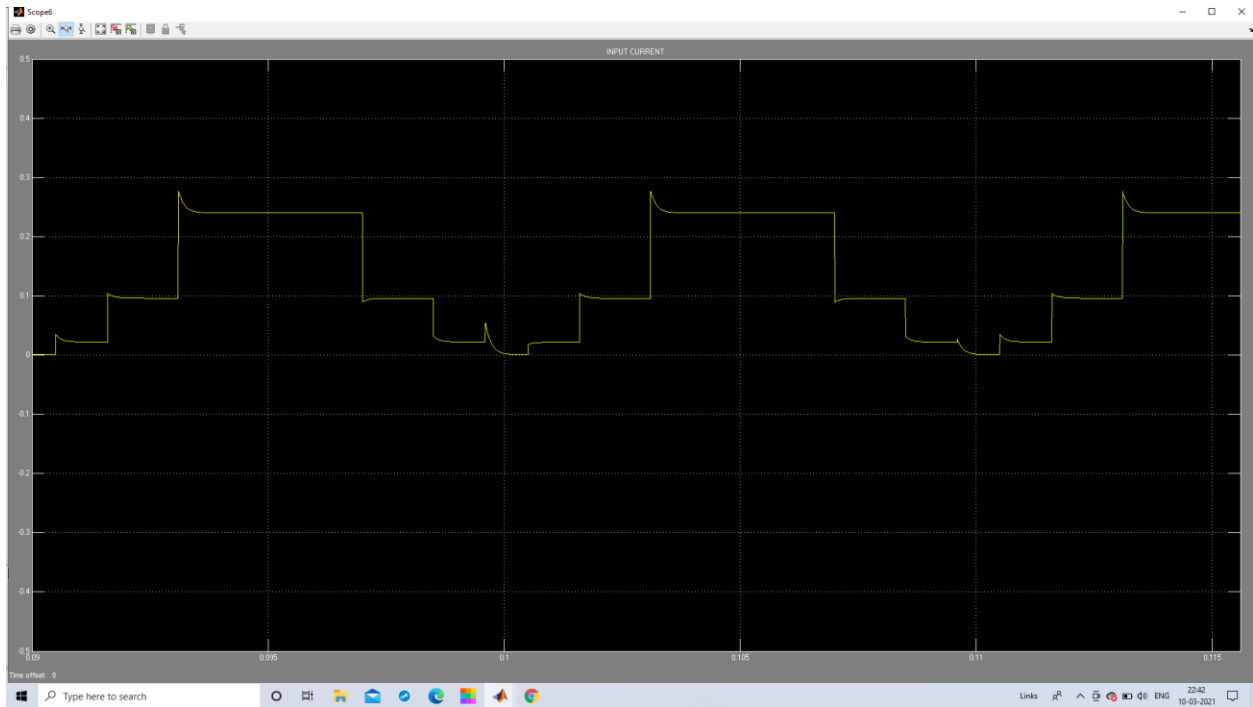


Fig:3.10:Input current

The above figure.3.10 shows Input current=0.24A, it is connected across input current.

3.5.3 INPUT POWER

INPUT POWER = 5.7W

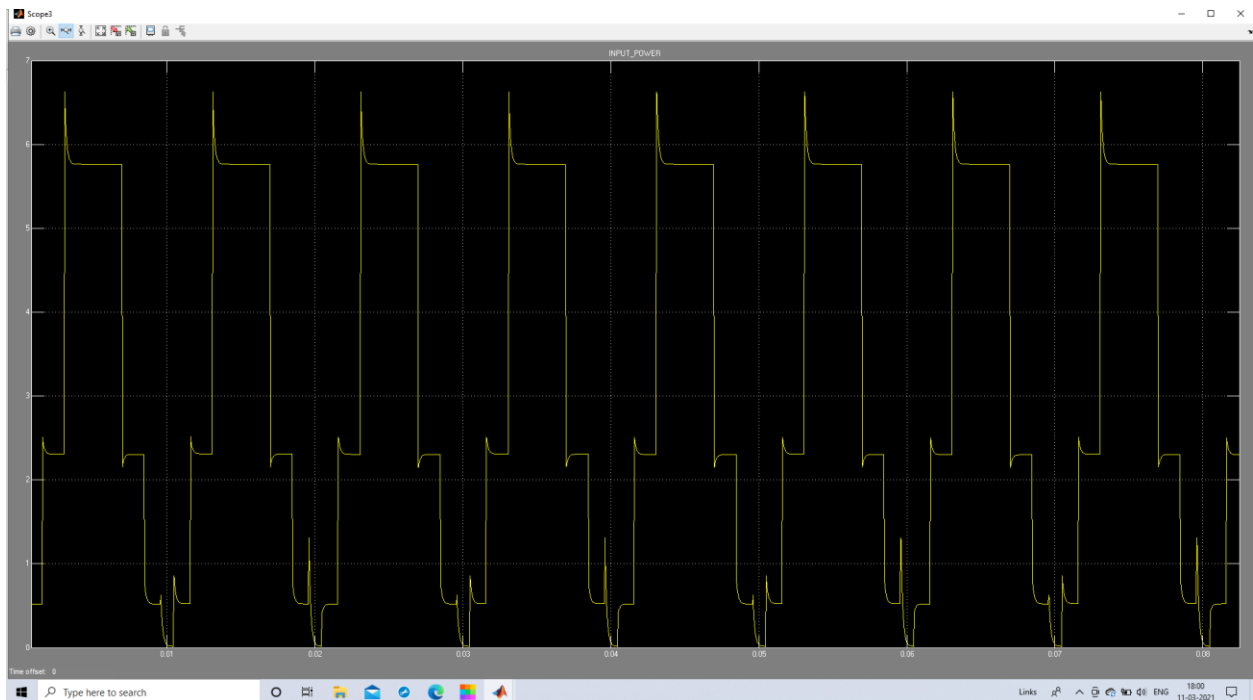


Fig:3.11:Input power

The above figure.3.11 shows Input power=5.7W, Product of input current and voltage gives the input power.

3.5.4 OUTPUT VOLTAGE

OUTPUT VOLTAGE = 24V

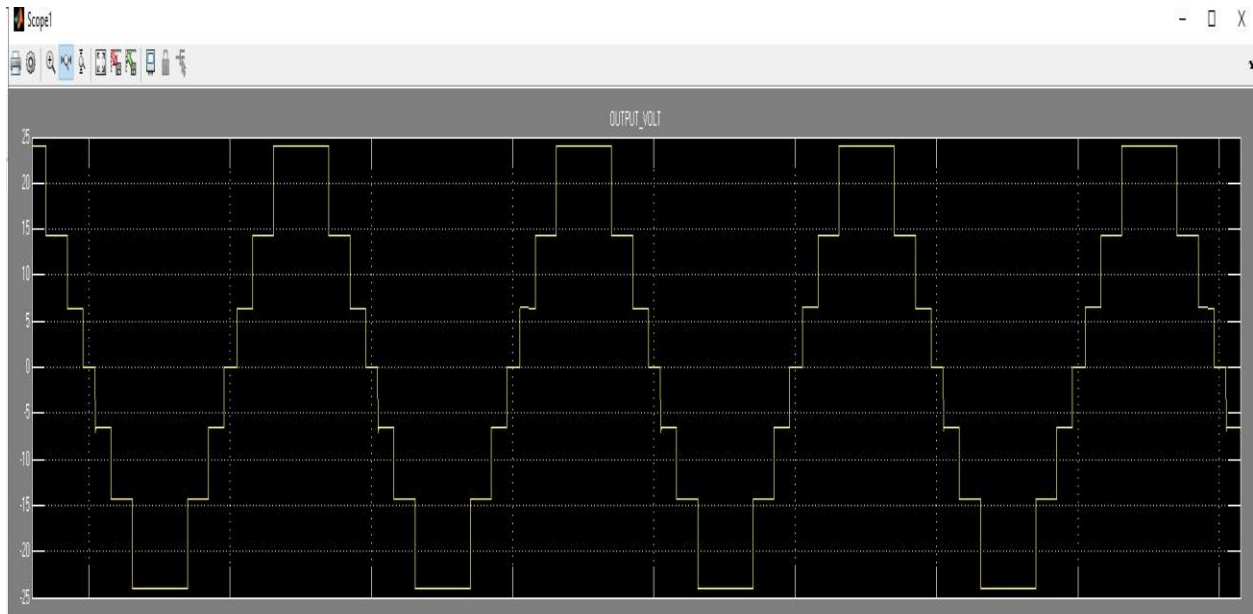


Fig:3.12:Output voltage

The above figure.3.12 shows as Scope is connected across input voltage and the output is taken as 24V

3.5.4 OUTPUT CURRENT

OUTPUT CURRENT = 0.24V

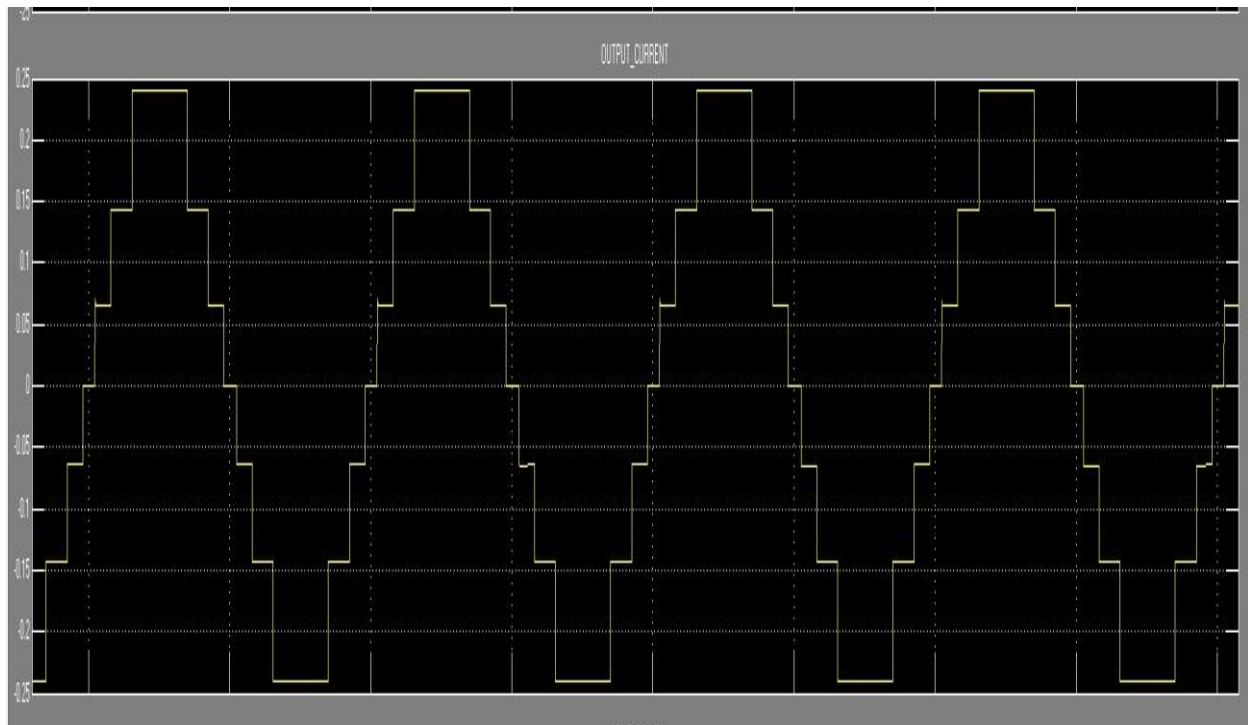


Fig.3.13:Output current

The above figure.3.13 shows as output current=0.24A in this simulation we are taken to the output current using matlab.

3.5.4 OUTPUT POWER

OUTPUT POWER = 5.7W

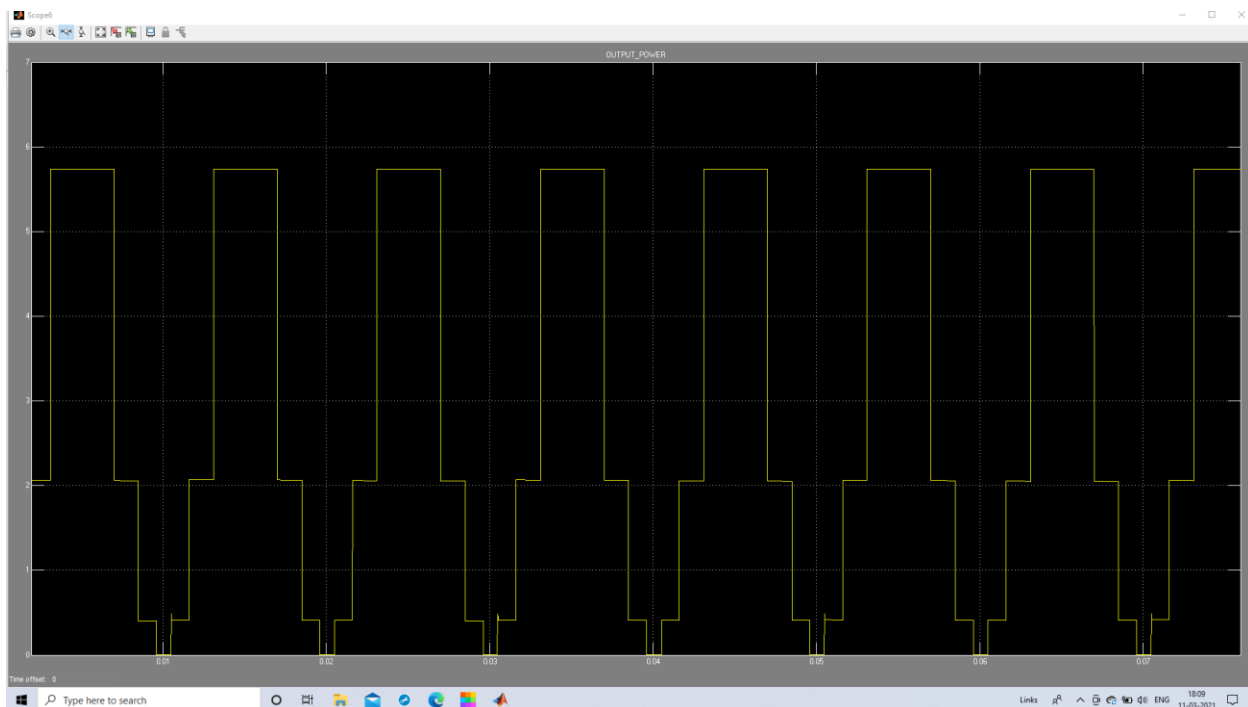


Fig:3.14:Output power

The above figure.3.14 shows as output power of 5.7w

In this 7 level inverter, we simulated for voltage, current and power was executed. We given to the input for 24V voltage and 0.24A current and 5.7W power. The same output was executed.

Total harmonic distortion is reduced.

3.5.5 CAPACITOR VOLTAGE 1

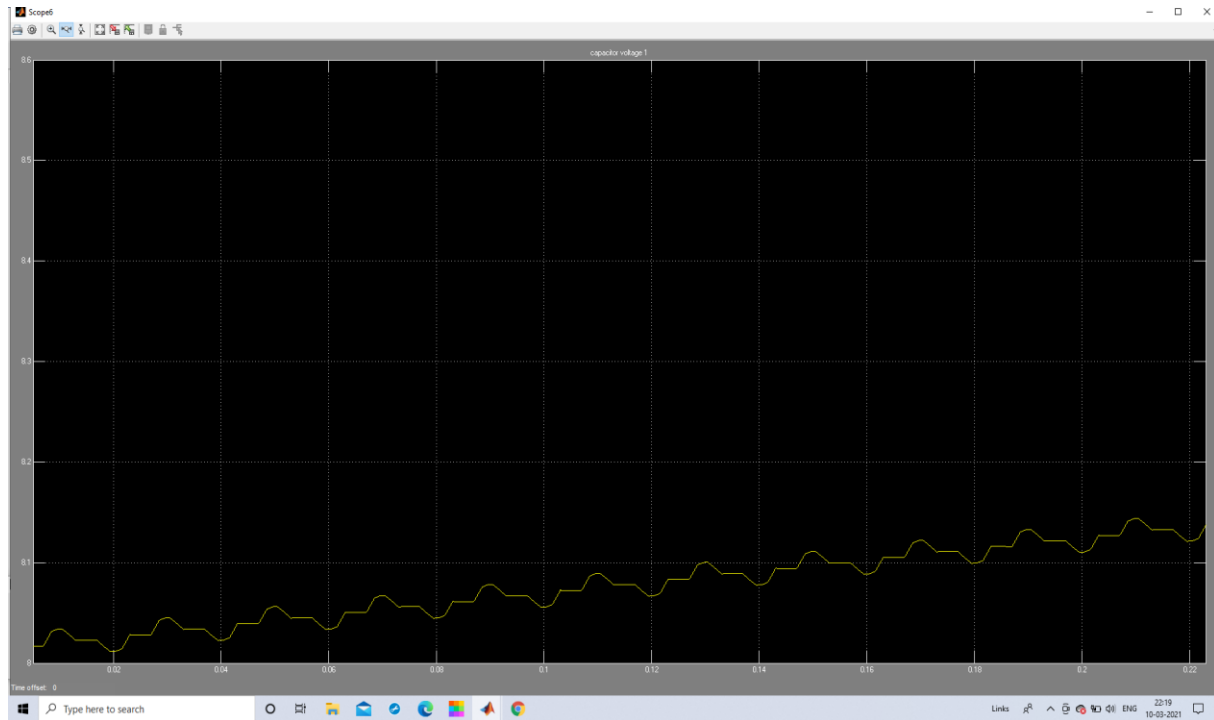


Fig:3.15:Capacitor voltage 1

The above figure.3.15 shows as Scope is connected across capacitor1.

3.5.5 CAPACITOR VOLTAGE 2

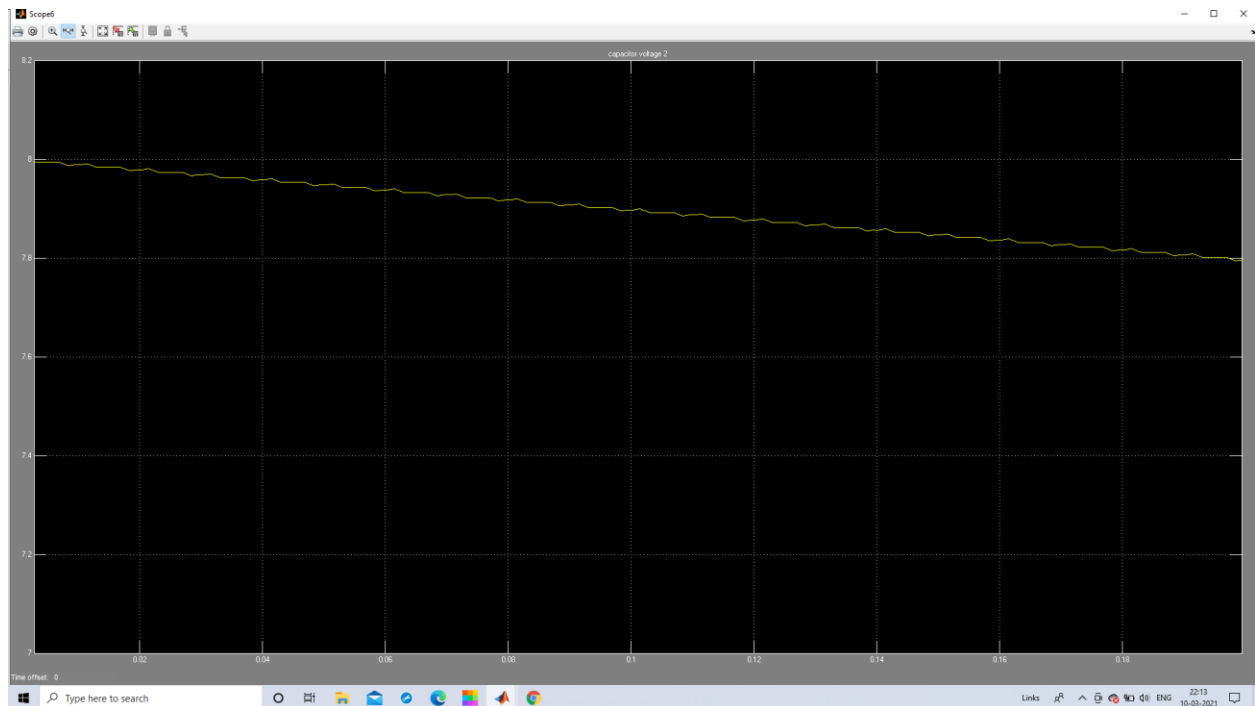


Fig:3.16:Capacitor voltage 2

The above figure 3.16 shows as Scope is connected across capacitor2

3.5.5 CAPACITOR VOLTAGE 3

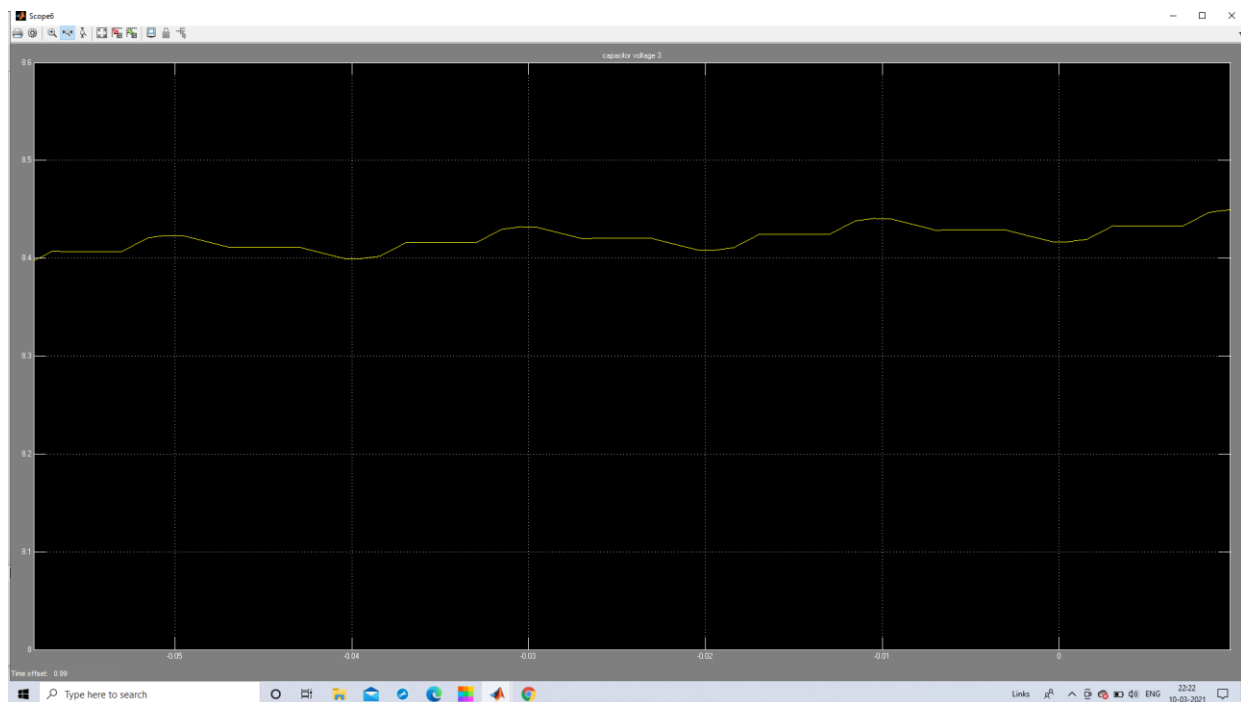


Fig:3.17:Capacitor voltage 3

The above figure.3.17 shows as Scope is connected across capacitor3

3.5.6 7 LEVEL THD

TOTAL HARMONIC DISTORTION = 13.79%

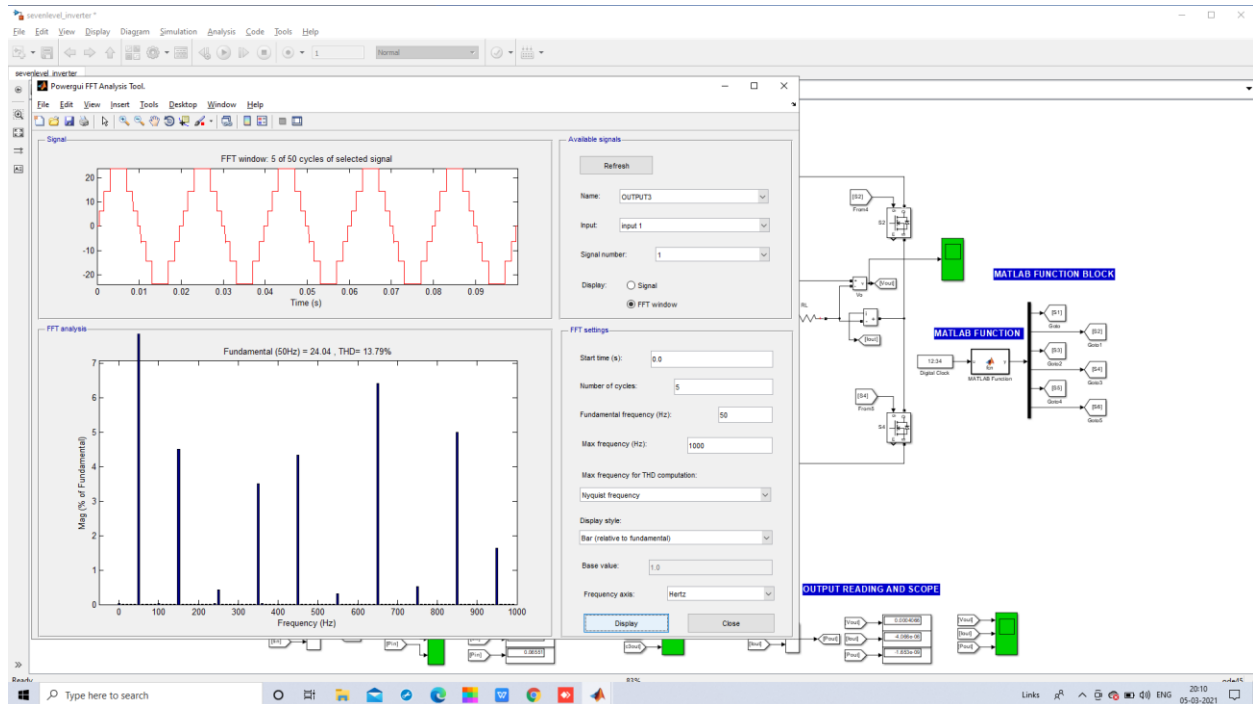


Fig:3.18: Total harmonic distortion of 7 level

The 7 level inverter has reduced the total harmonic distortion shows as figure.3.18

CHAPTER 4

HARDWARE DISCRPTION

4.1 MICROCONTROLLER

A microcontroller may be a pc. All computers whether or not we tend to area unit talking a couple of laptop computer or an oversized digital computer or a microcontroller have many things in common:

- All computers have a central {processing unit|CPU|C.P.U.|central processor|processor|mainframe|electronic equipment|hardware|computer hardware} (central processing unit) that executes programs. If you're sitting at a microcomputer straight away reading this text, the computer hardware therein machine is capital punishment a program that implements the net browser that's displaying this page.
- The computer hardware hundreds the program from somewhere. On your desktop machine, the browser program is loaded from the hard disc.
- The pc has some RAM (random-access memory) wherever it will store "variables."
- And the pc has thusme input and output devices so it will ask individuals. On your desktop machine, the keyboard and mouse area unit input devices and also the monitor and printer area unit output devices. a tough disk is AN I/O device -- it handles each input and output. The microcomputer you're victimization may be a "general purpose computer" that may run any of thousands of programs. Microcontrollers area unit "special purpose computers." Microcontrollers do one issue well. There area unit variety of alternative common characteristics that outline microcontrollers. If a pc matches a majority of those characteristics, then you'll be able to decision it a "microcontroller":
- Microcontrollers area unit "embedded" within another device (often a client product) so they'll management the options or actions of the merchandise. Another name for a microcontroller, therefore, is "embedded controller."

- Microcontrollers are a unit dedicated to 1 task and run one specific program. The program is kept in memory board (read-only memory) and usually doesn't modification.
- Microcontrollers are a unit typically low-power devices. A microcomputer is sort of continually obstructed into a receptacle and would possibly consume fifty watts of electricity. A battery-operated microcontroller would possibly consume fifty milliwatts.
- A microcontroller encompasses a dedicated device and sometimes (but not always) encompasses a little crystal rectifier or show|LCD|digital display|alphanumeric display} display for output. A microcontroller additionally takes input from the device it's dominant and controls the device by causation signals to completely different parts within the device.

4.1.1 DIGITAL SIGNAL CONTROLLER

Microchip Technology's control & Power Conversion family of dsPIC Digital Signal Controllers provides an easy-to-use resolution for applications requiring control. Microchip Technology introduced twenty 16-bit Flash small controllers that offer the industry's highest performance.

The DSPIC family of Digital Signal Controllers options a fully-enforced digital signal processor (DSP) engine, thirty unit of measurement non-pipelined performance, C compiler friendly style, and a well-known Microcontroller design and style surroundings. The twenty new dsPIC30F2010 devices kind 3 product families targeting control and power conversion, sensor, and general applications.

The DSPIC core may be a 16-bit (data) non-pipelined changed Harvard machine that mixes the management benefits of a superior 16-bit Microcontroller with the high computation speed of a completely enforced DSP to provide a tightly coupled, single-chip single-instruction stream resolution for embedded systems styles. The initial 20-dsPIC30F2010 devices feature twelve Kbytes to a hundred and forty four Kbytes of on-chip secure Flash program memory area and up to eight Kbytes of knowledge area. Operational voltage appeals to several Microcontroller applications that stay at five volts,

whereas several DSPs area unit restricted to three.3-supply V most. Devices area unit planned in 40-pin package.

4.1.2 DSPIC 30F2010 PIN CONFIGURATION

The design of dspic30f2010 is shown in fig.5.5 and pin diagram in shown in fig.4.1

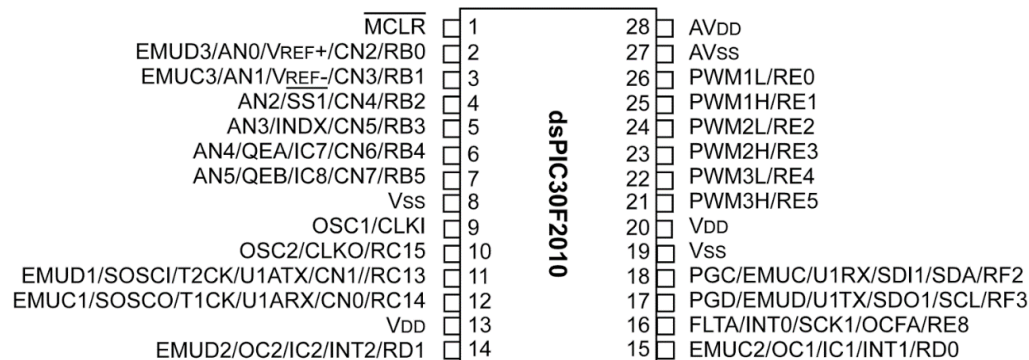


Fig:4.1: DSPIC 30F2010pin Configuration

The DSPIC control PWM module is optimized for applications, like 3-phase AC induction motors, 3-phase brushless DC motors, and switched reluctance motors. The control PWM module has either six or eight output pins and three or four PWM generators, relying upon the device. The output pins is also designed as complementary output pairs or as freelance outputs.

Critical PWM operational parameters, like output polarity, area unit programmed in non-volatile memory for safety. The non-volatile choices cut back the chance of putting the PWM outputs in an exceedingly state which may injury the ability devices connected to Peripheral.

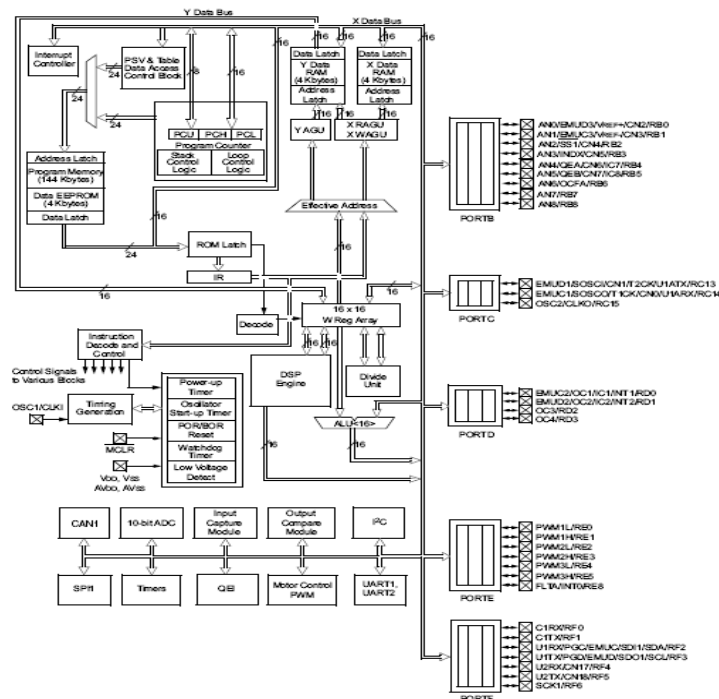


Fig.4.2: Dspic30f2010 design practical diagram

4.1.3 DSPIC small CONTROLLER

options High Performance changed RISC computer hardware

- Modified Harvard design
- C compiler optimized instruction set design with versatile addressing modes
- 24-bit wide directions, 16-bit wide knowledge path
- 48 Kbytes on-chip Flash program area (16K Instruction words)
- Kbytes of on-chip knowledge RAM
- 1 Kbytes of non-volatile knowledge EEPROM

4.2 MOSFET

- This N-Channel improvement mode atomic number 14 gate power field result semiconductor is a sophisticated power MOSFET designed, tested, and bound to face up to a fixed level of energy within the breakdown avalanche mode of operation.
- The invention of the ability MOSFET was partially driven by the restrictions of bipolar power junction transistors (BJTs), which, till recently, was the device of alternative in power physics applications.

- All of those power MOSFETs are unit designed for applications like shift regulators, shift converters, motor drivers, relay drivers, and drivers for top power bipolar shift transistors requiring high speed and low gate drive power.

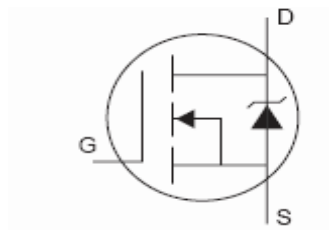


Fig:4.3: MOSFET image

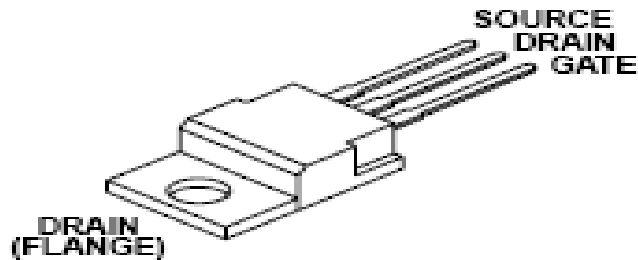


Fig:4.4: Hardware model MOSFET

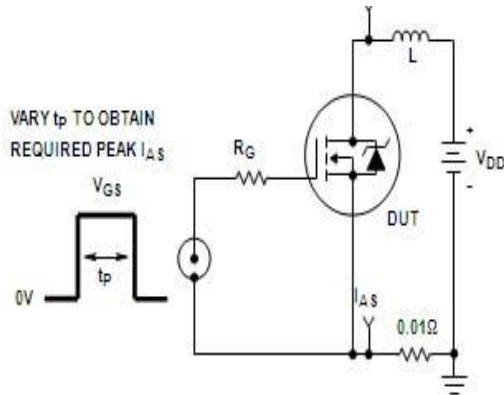


Fig:4.5: Unclamped Energy Waveforms

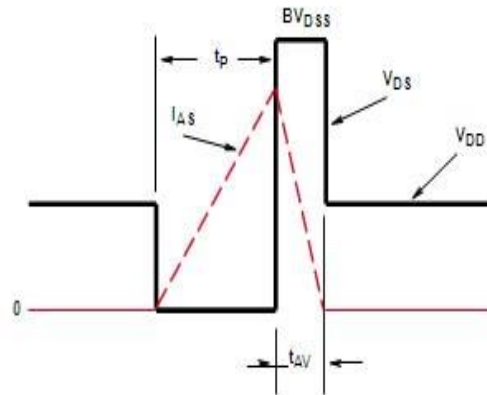


Fig:4.6: Unclamped Energy take a look at Circuit

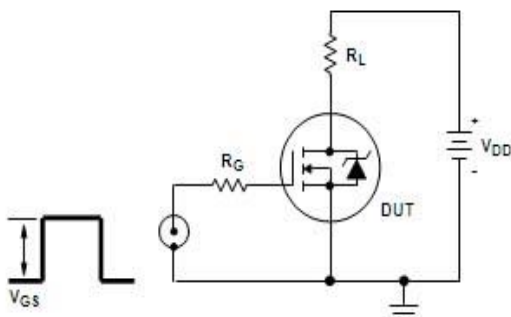


Fig:4.7: shift Time take a look at Circuit

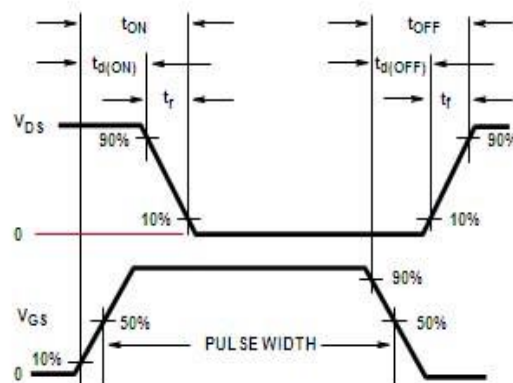


Fig:4.8: shift Waveforms

The transfer characteristic of an N-channel MOSFET is shown in figure below

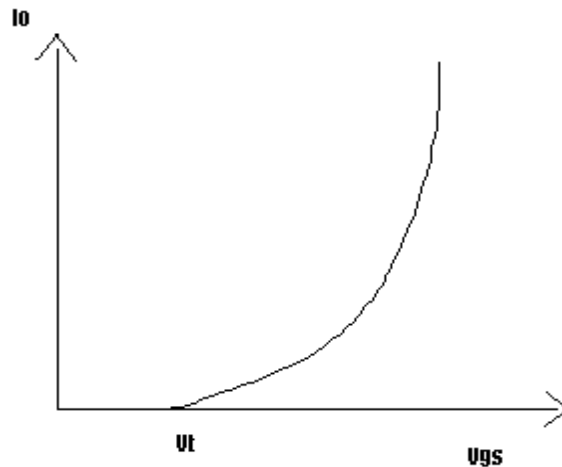


Fig:4.9: Transfer characteristic of N-channel MOSFET

4.2.1 OPTIONS OF MOSFET

- MOSFET has lower shift losses however its on-resistance and conductivity losses are a lot of.
- MOSFET may be a voltage-controlled device.
- MOSFET has positive temperature co-efficient for resistance. This makes operation of MOSFET simple. If a MOSFET shares increased current at first, it heats up quicker its resistance rises and this increased resistance causes this current to shift to alternative devices in parallel
- In MOSFET secondary break down doesn't occur, as a result of its positive temperature co-efficient.
- MOSFET's in higher voltage ratings have a lot of conductivity losses

4.3 POWER OFFER

There are many varieties of power offer. Most are designed to convert the Voltage AC Mains electricity to an acceptable low voltage offer for electronic Circuits and alternative Devices. an influence offer will be weakened into a series of blocks, every of that performs a specific operate. Here the AC offer main is given to the transformer. The electrical device having the various voltages.

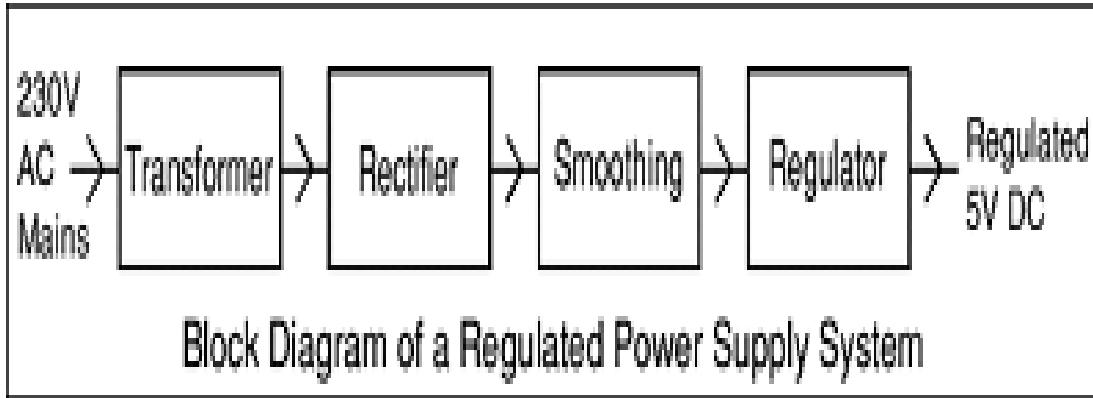


Fig:4.10:Block diagram of regulated power offer

The output from the electrical device is given to the rectifier circuit. during this rectifier circuit the AC voltage is born-again to DC voltages. The corrected DC voltage is given to the regulator circuit. The output of the regulator is relying upon the regulator IC chosen within the circuit.

4.3.1BRIDGE RECTIFIER

A bridge rectifier will be created exploitation four individual diodes, however it's additionally out there in special packages containing the four diodes needed. it's referred to as a rectifier. Smoothing is performed by an outsized price capacitance connected across the DC offer to act as a reservoir, provision current to the output once the varied DC Voltage from the rectifier is falling.

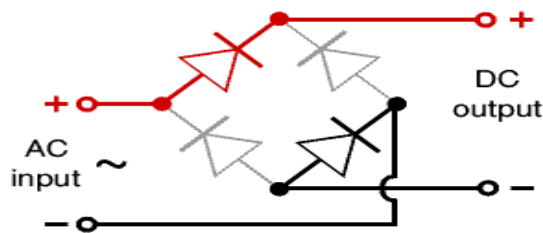


Fig:4.11: Bridge rectifier

The fig 4.11 shows the wrinkled DC, ironed DC by the filter capacitors. The electrical device charges quickly close to the height of the varied DC, and so discharges because it provides current to the output. Note that smoothing considerably will increase the common DC voltage to nearly the height price ($1.4 \times$ RMS value). for instance, 6V RMS AC is corrected to full wave DC of regarding four.6V RMS (1.4V is lost within the bridge

rectifier), with smoothing this increase to nearly the height price giving one.4 × 4.6 = 6.4V swish DC. Smoothing isn't good because of the electrical device voltage falling a touch because it discharges, Giving alittle ripple voltage. for several circuits a ripple that is 100% of the availability Voltage is satisfactory and also the equation below offers the specified price for the Smoothing electrical device. a bigger electrical device can offer less ripple. The electrical device price should Be doubled once smoothing half-wave DC.

4.3.2 REGULATOR

Voltage regulators ICs ar out there with mounted (typically five, thirteen and 15V) or variable Output voltages. they're additionally rated by the most current they'll pass. Negative Voltage regulators ar out there, in the main to be used in twin provides. Most regulators embody some automatic protection from excessive current ('overload protection') and warming ('thermal protection').

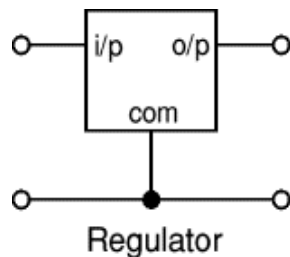


Fig:4.12: Regulator



Fig:4.13: Regulator IC

Many of the mounted transformer ICs has three leads and appearance like power transistors, like the 7805 +5V 1A regulator shown on the correct. They embody a hole for attaching a sink if necessary.

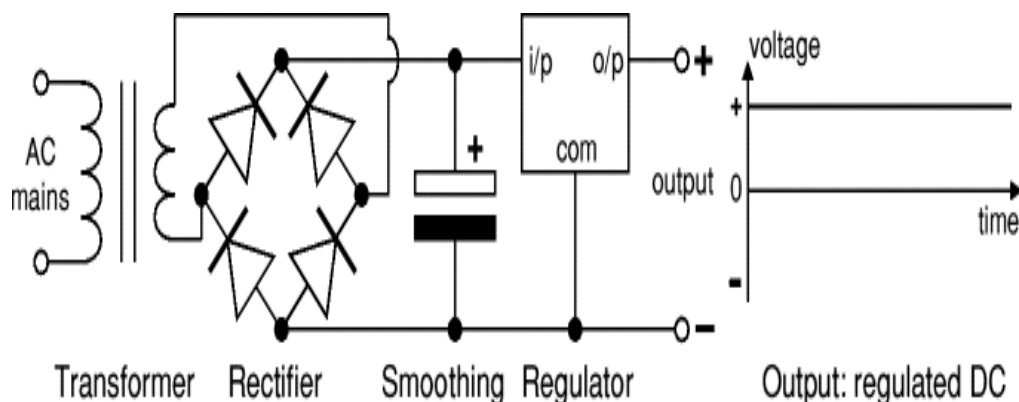


Fig:4.14: Rectifier circuit diagram and wave kind

The higher than fig four.14 shows the rectifier circuit diagram and also the regulated output voltage. The regulated DC output is extremely swish with no ripple. it's appropriate for all electronic circuits. In typically there ar 2 varieties of regulators ar used. specifically the positive and negative sort regulators. For positive sort regulators 78** series of regulators ar used. For negative sort regulators 79** series of regulators ar used. Depends upon the voltage and kind of the voltage the regulator IC is chosen.

4.3.3 OPTO ISOLATOR

The higher than fig four.17 shows the circuit diagram for opto isolator. The operate of the opto-isolator is to isolation between the facility circuit and negative feedback circuit. In typically the management aspect power is a smaller amount compared to the facility circuit. For separating the high voltage aspect and also the low voltage aspect the opto-isolator enjoying a significant role. ordinarily the output of the opto-isolator is inverse of the input pulse. therefore just in case of electrical converter circuits the output of the opto-isolator is given to the transistors and once more the signal are inverted and given to the driving force IC.

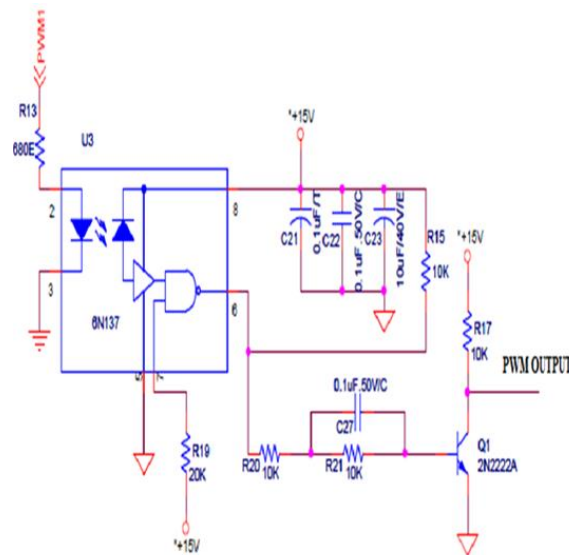


Fig:4.15: Opto isolator diagram

Normally the output of the opto isolator is inverted output of the opto isolator input. that the output of the isolator is given to a NOT gate IC. The inverted output of the opto IC is once more inverted by exploitation the 4584 NOT gate IC. From the output of the NOT gate is given to the and performance IC. Here the output from the NOT gate is given to the management logic circuit. The output of the management logic is given to the driving force IC.

4.3.4 DRIVER CIRCUIT DIAGRAM

MOSFET gate driver could be a power electronic equipment that accepts a low-power input from a controller IC and produces the acceptable high-current gate drive for an influence MOSFET. A gate driver is employed once a pulse-width-modulation (PWM) controller cannot give the output current needed to drive the gate capacitance of the associated MOSFET.

Gate drivers is also enforced as dedicated ICs, distinct transistors, or transformers. they'll even be integrated at intervals a controller IC. Partitioning the gate-drive operate off the PWM controller permits the controller to run cooler and be a lot of stable by eliminating the high peak currents and warmth dissipation required to drive an influence MOSFET at terribly high frequencies. The on top of fig four.18 shows the driving force circuit diagram. IR3110 IC is employed to drive the MOSFET'S. The output of the opto-isolator is given to the IR3110 ic. There ar 2 output signals ar generated from the drive ic particularly each the output pulses ar inverted to every different. The resistivity of the MOSFET is a lot of, that the signals that ar given to the gate ought to be high gain for that the driving force ic is employed in MOSFET based mostly circuits.

A MOSFET drive circuit is intended to attach the gate on to a voltage buswith no intervening resistance apart from the resistivity of the drive circuit switch. Gate driver acts as a high-energy buffer stagebetween the PWM output of the management device and gates of the first power shift MOSFET.

In this project the shift device used is MOSFET IRF 840. The voltage rating is 500v and also the current rating is eight A. Resistance and condenser (RC) snubber circuit is connected across the all the shift devices. This snubber circuits provide the protection to shift devices from the dv/dt and di/dt . One diode additionally connected across the shift

devices , this diodes ar flow into the present at a similar time reverse bias the reverse currents that is flows to the shift devices.

4.3.5 TLP250 OPTO-DRIVER IC

The TLP250 is Associate in Nursing opto isolated gate driver. It options 8mA junction rectifier drive current whereas the driving force are often provided from 30V. This chip is appropriate for driving high speed shift apps, I tested the shift up to 1MHz. the driving force will come on to one.4A to confirm quick gate shift. If the high sides every has Associate in Nursing isolated provide and also the low sides have a provide the provision will go as high because the isolation can hold. appropriate for speed management H-bridge applications. provided by a 14V (suggested) regulated provide the driving force will switch open collector applications, that is power provides or switch mode power provides amongst others, however will switch extremely nearly something field-effect transistor driven.

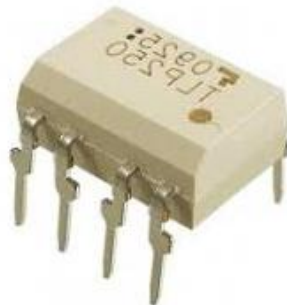


Fig:4.16: Opto Isolator Circuit Diagram

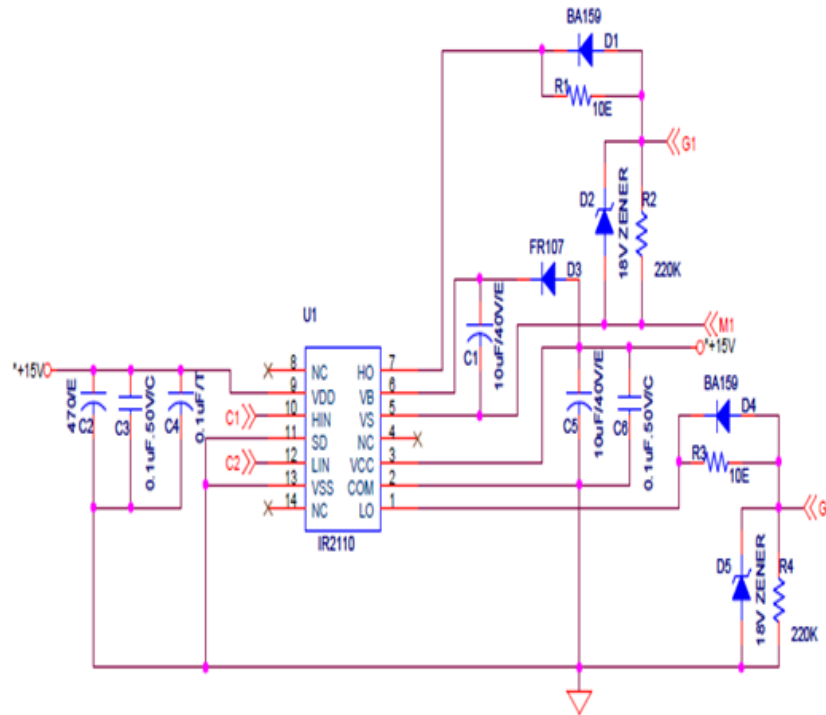


Fig:4.17: Driver circuit diagram

Gate driver circuit is circuit integral a part of power physics converters that is employed to drive power semiconductor devices like BJT's, IGBT's and MOSFETs. Output of DC DC converters chiefly rely on behavior of gate driver circuits. Its mean if gate driver circuit doesn't drive gate of MOSFET device properly, your designed DC DC convertor output won't be in step with your demand. so style of gate driver circuit is critically vital in coming up with of power physics converters.

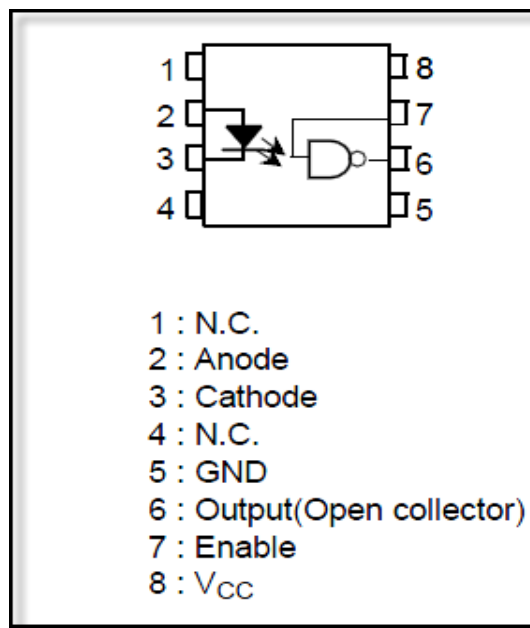


Fig:4.18: Pin Configurations

The TOSHIBA TLP340 consists of a GaAlAs lightweight emitting diode and a integrated pic detector. This unit is 8-lead DIP package. TLP340 is appropriate for gate driving circuit of IGBT or power MOS field-effect transistor.

- Input threshold current: 4mA (max)
- provide current: 11mA (max)
- provide voltage: 10-34V
- Output current: ± 1.4 A (max)
- shift time t_{pLH}/t_{pHL} : zero.4 μ s (max)
- Isolation voltage: 3400Vrms (min)

The operate of Opto mechanical device is isolate to the feedback loop from power circuit. Pulse dimension modulation signal (PWM one to PWM 13) comes from DSPIC Processor. This signal isn't directly fed through an influence circuit. Suppose feedback loop (DSPIC) is connected to power circuit while not isolation circuit, the feedback loop could get affected. thus we want to isolation circuit interface between power circuit and feedback loop

Table:4.1: Opto Coupler Truth Table

Input	Enable	Output
H	H	L
L	H	H
H	L	H
L	L	H

4.4 HARDWARE RESULTS

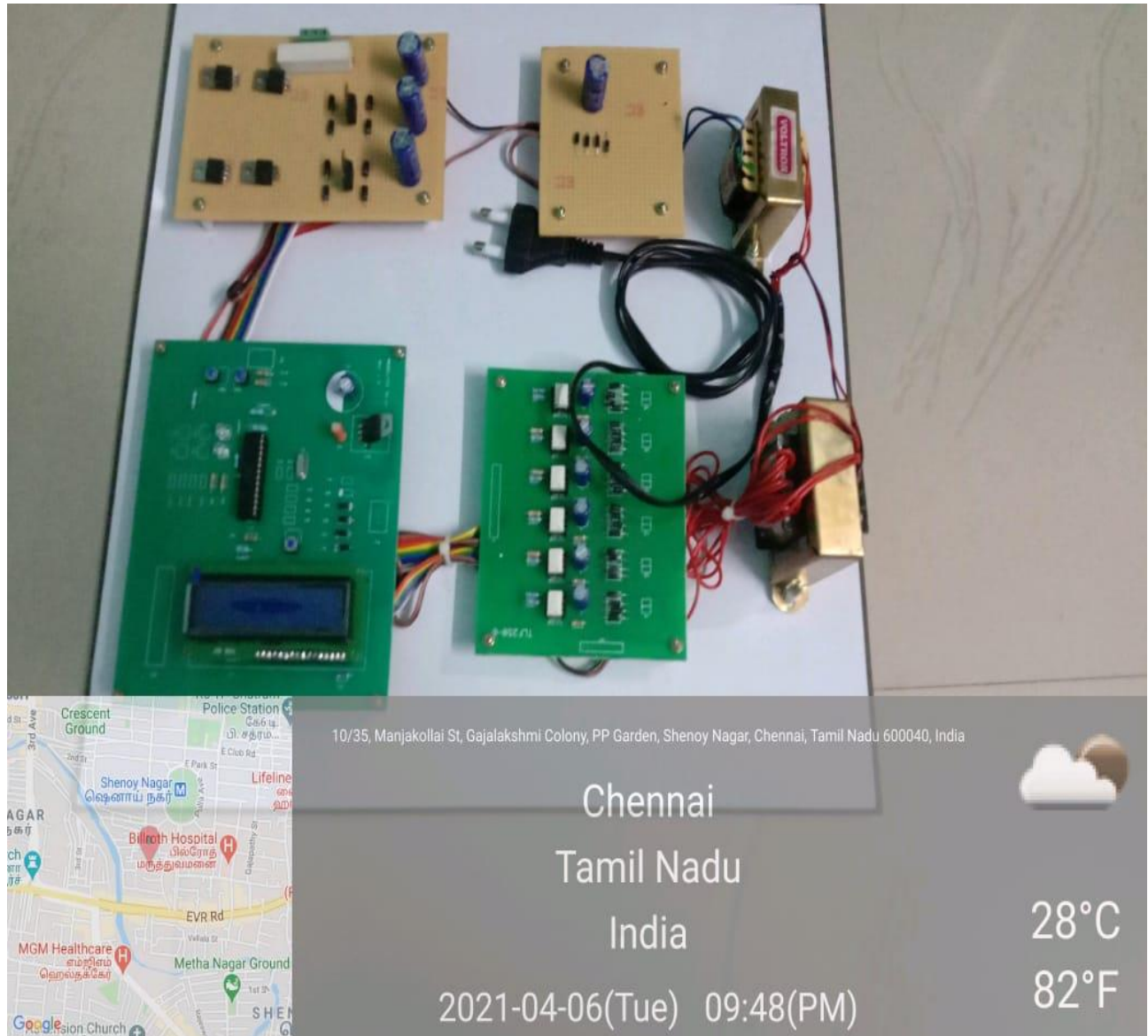


Fig:4.19:Hardware results

In this 7 level inverter we have to use for pic microcontroller DSPIC30F010, voltage regulator 7805, reset switch to on and off purpose, LED, optocouplers, capacitors, diodes, transformer.

4 diodes connected to form bridge rectifier, capacitors, transformer 12V, here IRF740 MOSFET H-bridge are provided, R load (resistive type load), capacitors for filtering purpose are provided.

4.5 INPUT VOLTAGE

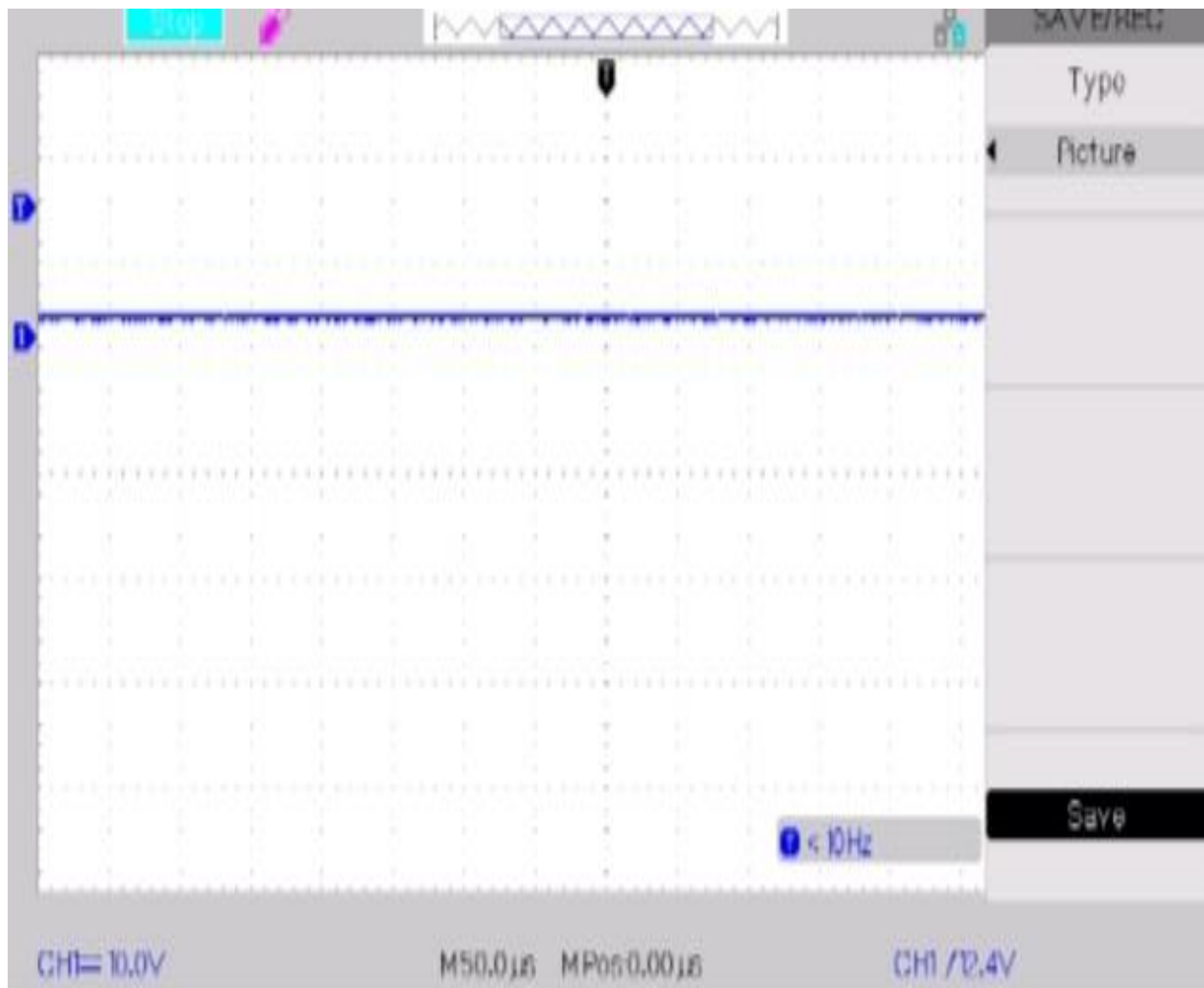


Fig:4.20:Input voltage

4.6 OUTPUT VOLTAGE

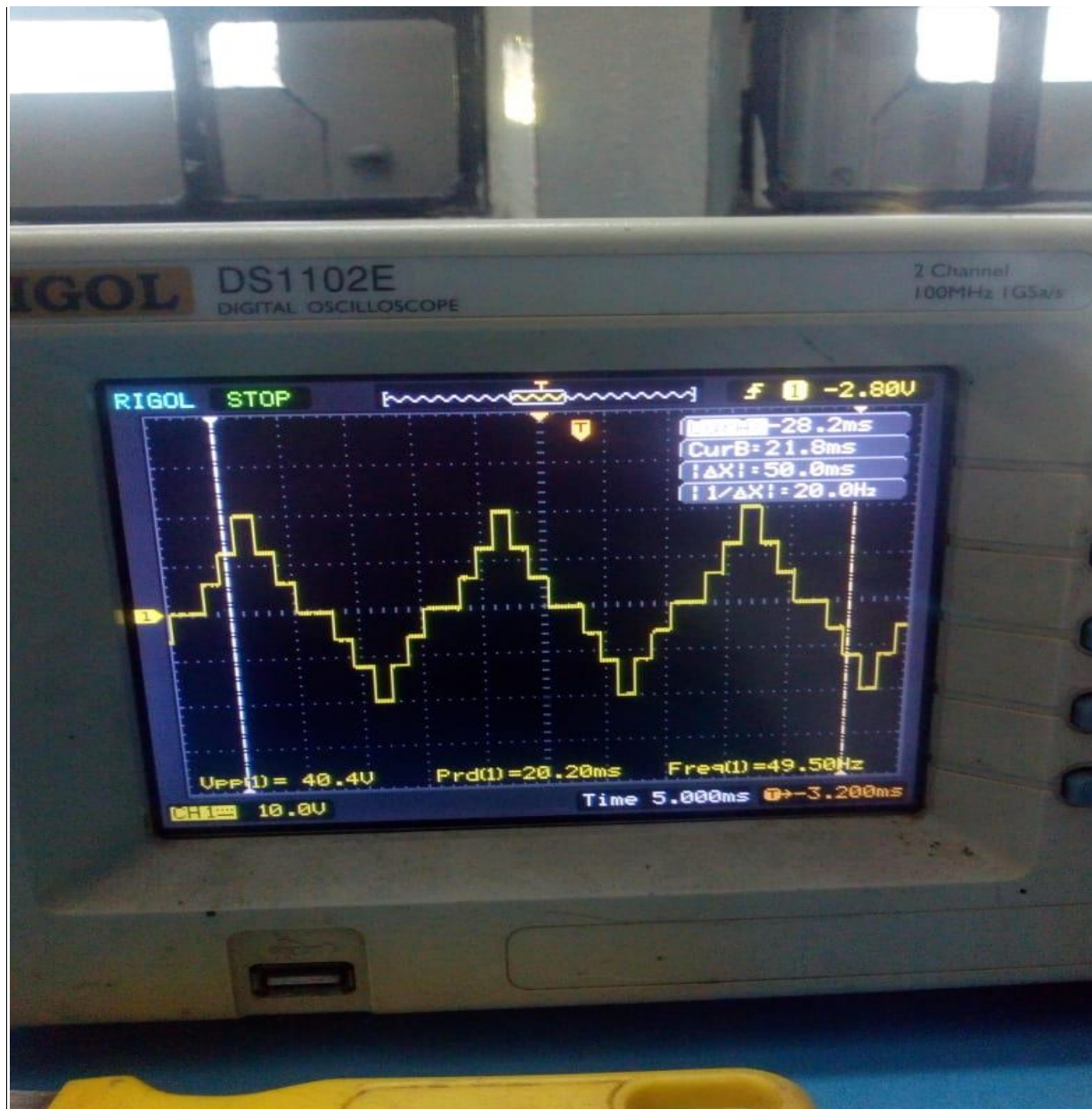


Fig:4.21:Output voltage

CHAPTER 5

CONCLUSION

The planned reduced switch seven level electrical converter provide improved output waveforms and lower THD. This project has given a completely unique PWM shift theme for the planned structure electrical converter. during this project just one reference signal and is compared with a triangular wave signal to come up with the PWM signals. Here 2 DC voltage levels are utilized in these multi-level inverters. So, this methodology of configuration is thought as symmetrical cascaded electrical converter. By dominant the modulation index and completely different levels of the output voltages achieved. while not mistreatment any further passive parts, the electrical converter can improve the performance parameters. The THD of the voltage and current waveforms also are measured and at intervals the IEEE limits.

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