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Design of Speed Control of DC Motor

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ABSTRACT

Abstract-in this paper a model is developed to run separately excited direct current (d.c) motor using a single phase alternating current (a.c) source by converting the a.c source into variable d.c source using a buck-boost converter. Main problem d.c motor drive is the starting current due this insulation may damage and also efficiency will decrease so that here in this paper it is solved by using soft starter. The variable pulse width modulation (PWM) is used to regulate the voltage at the end of ac dc buck-boost converter. Here the speed of the dc motor is also controlled using a speed controller which is connected to the soft starter. Thus a MATLAB simulink model is developed where speed of the d.c motor is controlled using the soft starter . PWM based rectifier are efficiently employed in low to medium power applications. Since the ac - dc buck-boost produce voltage higher or lower than the supply voltage .the are most useful in variable dc drives. In a traditional dc motor system a resistor starter is used to monitor the armature current of the motor this is because initially armature current is high which damages the motor .instead of a three point starter. A IGBT based soft starter is used to limit the starting current .and also a PI controller is used to control the speed of the dc motor . this controller calculates the reference current based on as a result in this simulink model of a separately excited dc motor runs on a single phase a.c source with better control . the main advantage is that the motor becomes indepedent of the input voltage level as it can be adjusted . the speed of the dc a motor can also be controlled . the circuit becomes small with less switching and copper losses and the armature current can also be controlled becomes of the soft starter .

INTRODUCTION

Today's industries are increasingly demanding process automation in all sectors. Automation results into better quality, increased production an reduced costs. The variable speed drives, which can control the speed of A.C/D.C motors, are indispensable controlling elements in automation systems. Depending on the applications, some of them are fixed speed and some of the variable speed drives.

The variable speed drives, till a couple of decades back, had various limitations, such as poor efficiencies, larger space, lower speeds, etc., However, the advent power electronic devices such as power MOSFETs, IGBTs etc., and also with the introduction of micro -controllers with many features on the same silicon wafer, transformed the scene completely and today we have variable speed drive systems which are not only in the smaller in size but also very efficient, highly reliable and meeting all the stringent demands of various industries of modern era.

Direct currents (DC) motors have been used in variable speed drives for a long time. The versatile characteristics of dc motors can provide high starting torques which is required for traction drives. Control over a wide speed range, both below and above the rated speed can be very easily achieved. The methods of speed control are simpler and less expensive than those of alternating current motors.

There are different techniques available for the speed control of DC motors. The phase control method is widely adopted, but has certain limitations mainly it generates harmonics on the power line and it also has got p .f when operated lower speeds. The second method is pwm technique, which has got better advantages over the phase control.

In the proposed project, a 5 H.P DC motors circuitry is designed, and developed using pulse with modulation (PWM).The pulse width modulation can be achieved in several ways. In the present project, the PWM generation is done using micro- controller.

In order to have better speed regulation, it is required to have a feedback from the motor. The feedback can be taken either by using a tachogenerator or an optical encoder or the back EMF itself can be used .In present project, we implemented the feedback by using the EMF of the armature as the feedback signal.

The project proposed is a real time working project, and this can be further improvised by using the other safety features, such as field current, air gap magnetic flux, armature current, etc.,

CHAPTER (1)

DC MOTOR

1. DC MOTOR

1. DC MOTOR

1.1 INTRODUCTION TO SPEED CONTROL:

Speed control means intentional change of drive speed to a value required for performing the specific work process. This concept of speed control or adjustment should not be taken to include the natural change in speed which occurs due to change in the load on the shaft.

Any given piece of industrial equipment may have its speed change or Adjusted mechanically by means of stepped pulleys, sets of change gears, variable speed friction clutch mechanism and other mechanical devices. Historically it is proved to be the first step in transition from non adjustable speed to adjustable speed drive. The electrical speed control has many economical as well as engineering advantages over mechanical speed control

The nature of the speed control requirement for an industrial drive depends upon its type. Some drives may require continues variation of speed for the whole of the range from zero to full speed or over a portion of this range , while the others may require two or more fixed speeds

1.2 CLASSIFICATION OF DC MOTORS:

DC motors are classified into three types depending upon the way their field windings are excited. Field windings connections for the three types Of DC motors have been shown in Figure 1.1.

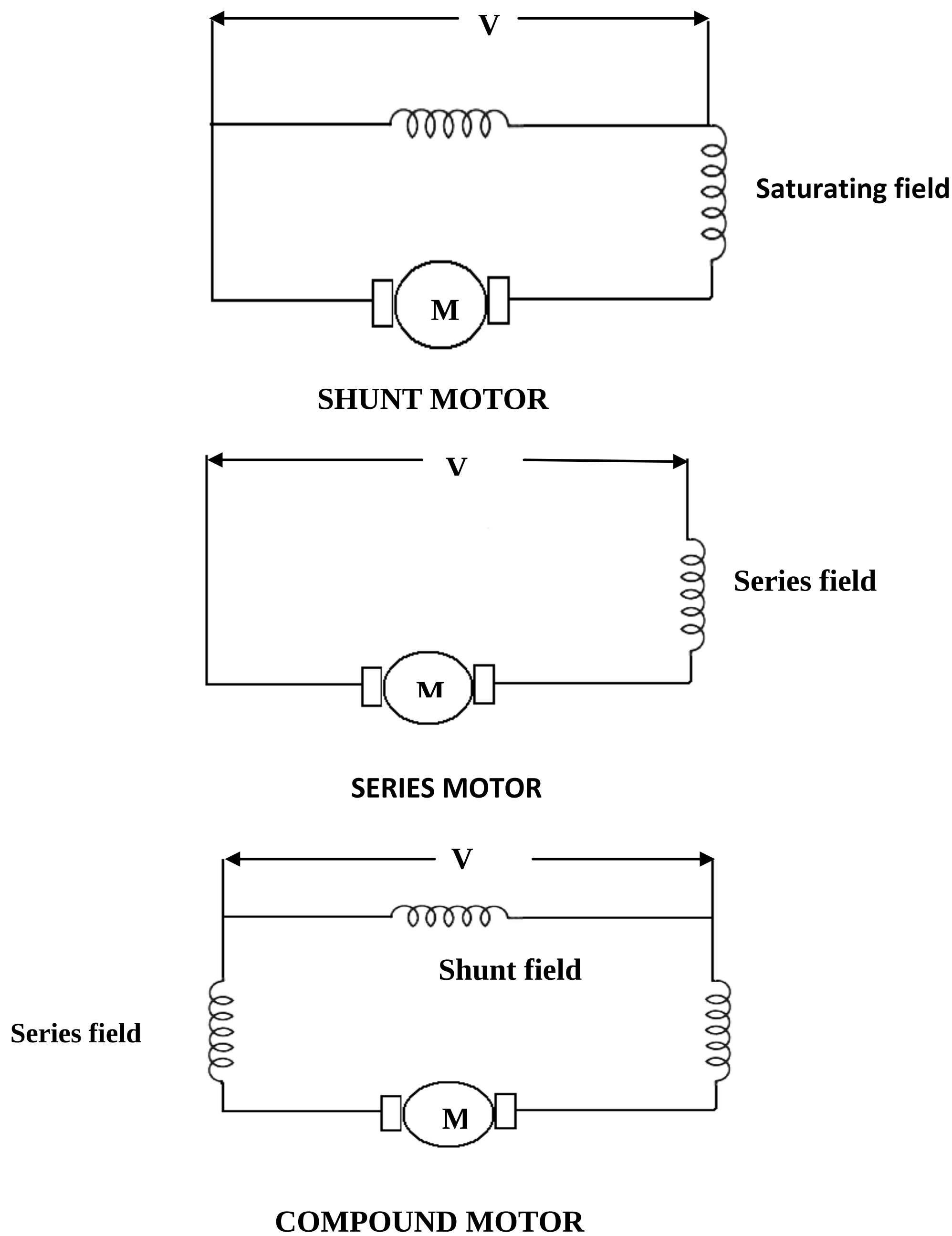


Fig.1.1 Classification of DC Motor

1.3 SPEED CONTROL OF DC MOTORS:

The DC motors are in general much more adaptable speed drives than AC motors which are associated with a constant speed rotating field. Indeed one of the primary reasons for the strong competitive position of DC motors in modern industrial drives is the wide range of specified afforded we know the equation

$$N = K\,(E_b/\phi)$$

$$= K\,(V - I_a R_a / \phi)$$

Where V=supply voltage (volts)

Ia = armature current (amps)

Ra=armature resistance (ohms)

Φ=flux per pole (Weber)

$$E_b = backemf \text{ (volts)}$$

This equation gives two methods of effective speed changes.i.e.

a) The variation of field excitation, if this causes in the flux per pole Φ and is known as the field control.

b) The variation of terminal voltage (V).this method is known as armature control.

1.4 SPEED CONTROL OF SHUNT MOTOR

1.4.1 FLUX CONTROL METHOD:

It is known that Nα1/ Φ by decreasing the flux, the can be increased and vice versa. Hence, name flux or field control method.

The flux of DC motor can be changed by changing I_{sh} with help of a shunt field rheostat. Since I_{sh} in relatively small, shunt field rheostat has to carry only a small, so that rheostat is small in size. This method therefore very efficient in non-interpolar machines the speed can be increased by this method in the ratio 2:1 any further weakening of flux Φ adversely affect the communication.

And hence puts a limit to the maximum speed obtainable with this method in machines fitted with interlopes in ratio of maximum to minimum speeds of 6:1 is fairly common.

The connection diagram for this type of speed control is shown in Figure1.2 below.

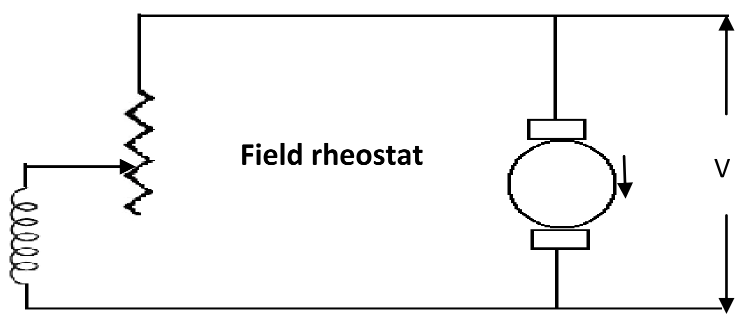
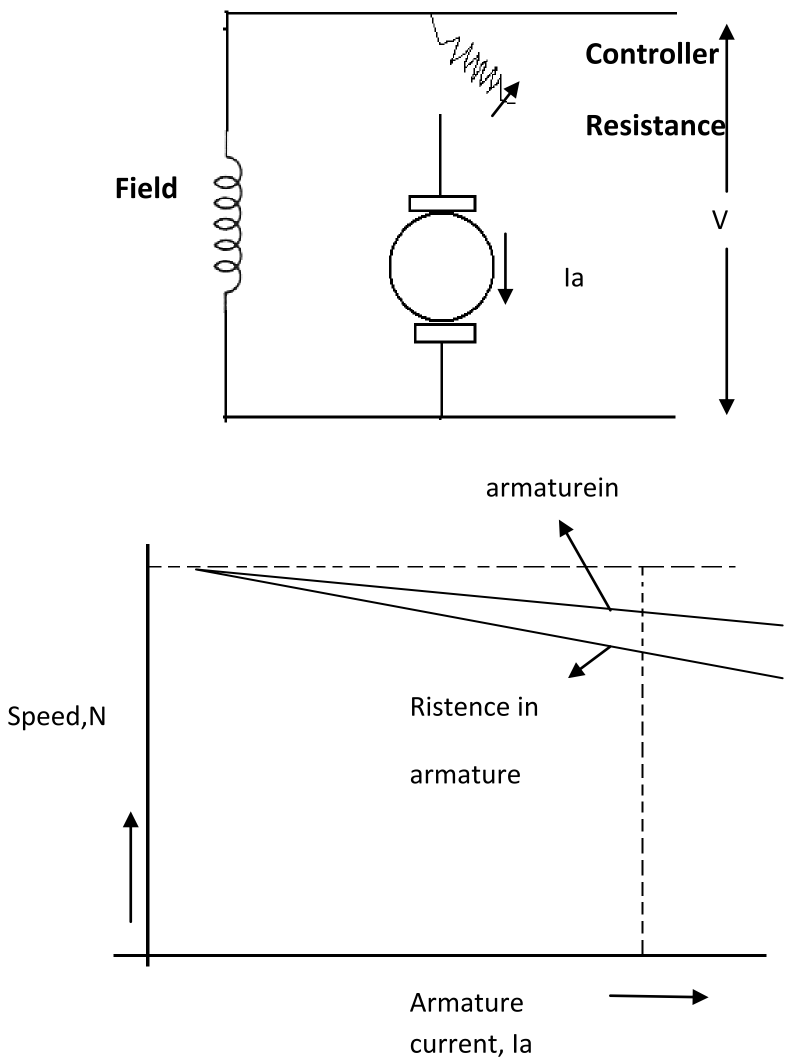


Fig.1.2 Flux Control Method

1.4.2 ARMATURE OR RHEOSTAT CONTROL METHOD:



Rheos **Fig 1.3** **[ethod and Characteristics**

This method is used when speeds below the no load speed are required. As the supply voltage is normally constant, the voltage across the armature is varied by inserting a variable rheostat or controller resistance in series with the armature circuit as shown in Figure1.4 as controller resistance is increased, potential difference across the armature is decreased, thereby decreasing the armature speed. For a load of constant torque, speed is approximately proportional to the potential difference.

Across the armature current characteristics in fig. in seen that greater the resistance

In the armature circuit, greater is the fall in speed

Let

I_{a1} = Armature current in the first case

I_{a2} = Armature current in the second case

N_1, N_2 = corresponding speeds

V = Supply voltage

Then $N_1 \alpha (v - I_{a1} R_a) \alpha E_{b1}$

Let some controller resistance of value R be added to the armature circuit resistance so that its value becomes

$$(R+R_a) = R_t$$

Then

$$N_2 \ \alpha \ (V - I_{a2} R_t) \ \alpha \ E_{b2}$$

$$N_2/N_1 = E_{b2}/E_{b1}$$

Considering no load speed, we have

$$N/N_0 \ (I-(I_a R_t)/ \ (V-I_{a0} R_a)$$

Neglecting Iao Ra w.r.t.toV, we get

$$N=N_o \ (I-(I_a R_t)/ \ V$$

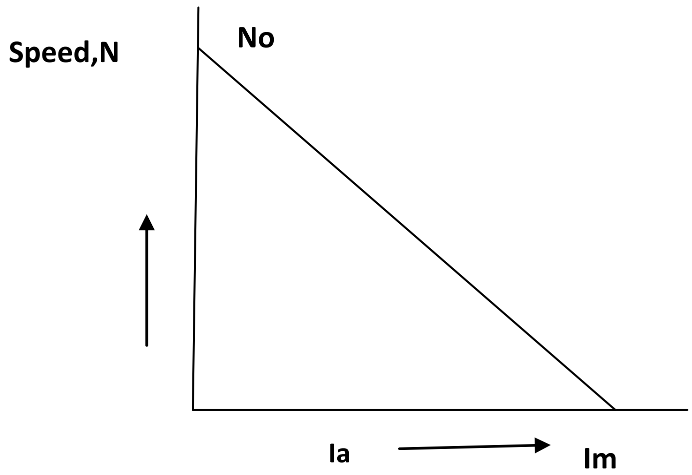


Fig.1.4. Relationship between motor speed and armature current

It is seen that for a given resistance Rt the speed is a linear function of armature current Ia as shown in fig.

The load current for which the speed would be zero is found by putting N=0 in above relation

$$0 = N0\ ((I\text{-}IaRt)/V)$$

Or

$$Ia = V/Rt$$

This maximum current and is known as stalling current. This method is very wasteful, expensive and unsuitable for rapidly changing loads because for a given value of Rt, speed will change with load. A more stable operation can be obtained by using a diverter across the armature in addition to armature control resistance.

Now, the changes in armature current will not be so effective in changing the potential difference across the armature. The connection diagram for this type of speed control arrangement is shown in Figure 1.5 .

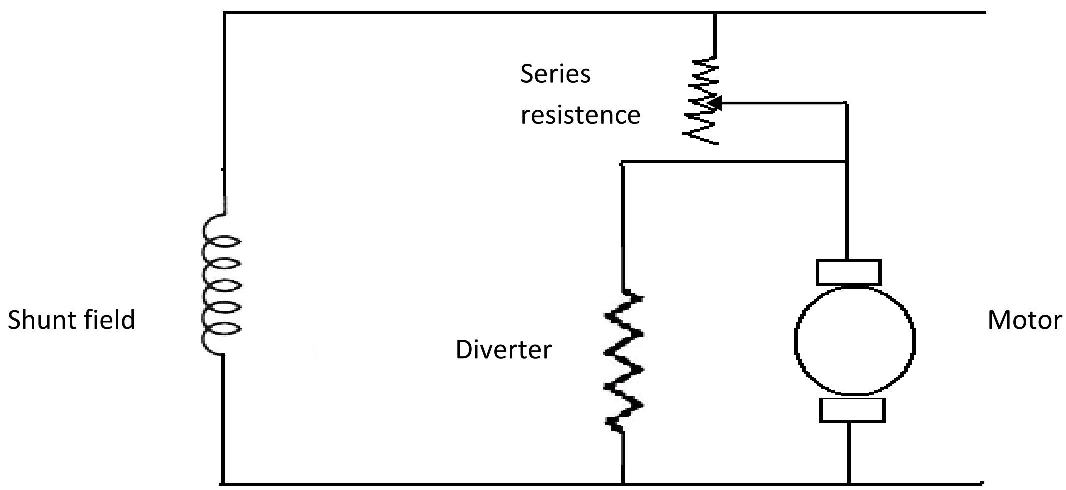


Fig.1.5 Armature Control Method

1.4.3 VOLTAGE CONTROL METHOD:

A) MULTIPLE CONTROL VOLTAGE :

In this method, the shunt field of the motor is connected permanently to a fixed exciting voltage but the armature is supplied with different voltages by connecting it across one at the several different voltages by means of suitable switchgear. The armature will be approximately proportional to these different voltages. The intermediate speeds can be obtained by adjusting the shunt field regulator.

B) WARD-LEONARD SYSTEM:

This system is used where an unusually wide (upto 10:1) and very sensitive speed control is required as for colliery winders , electric excavators and the main drives in steel mills and blooming in paper mills.

The field of the motor (M1) whose speed control is permanently connected across the DC supply lines. The other motor M2 is directly connected to Generator G.

The output voltage of G is directly is fed to the main motor M1. The voltage of generator can be varied from zero to upto its maximum value by means of field regulator. By reversing the direction of the field current of G by means of the reversing switch which RS, generated voltage can be reversed and hence the direction of rotation of M1. It should be remembered that motor set always runs in the same direction.

A modification of the word –Leonard system is known as word –Leonard -linger system which uses a smaller motor generator set with

The addition of a flywheel whose function is to reduce fluctuations in the Power demand from the supply circuit .

The chief advantage of system is its overall efficiency especially at right loads. It has the outstanding merit of giving wide speed Control from maximum in one direction through zero to the maximum in the opposite direction and of giving a smooth acceleration.

1.5 MOTOR APPLICATIONS:

DC motor possesses excellent torque speed characteristics and offer a wide range of speed control. Though efforts are being made to obtain wide range speed control with ac motors, yet the versatility and flexibility of a dc motors can't be matched by a ac motors.

In view of this, the demand for dc motors would continue undiminished even in figure. A brief discussion regarding the dc motor applications is given below.

1.5.1 SHUNT MOTORS:

- For a given field current in a shunt motor, the speed drop from no load to full load is invariably less than 6% t o 8%. In view of this, the shunt motor is termed a constant speed motor. Therefore for constant speed drives in industry, dc shunt motor's can be employ. But this motor can't complete with constant speed squirrel cage induction motor, because the latter cheaper, rugged and requires less maintenance.

- When constant speed service at low speeds is required, the comparison is usually between synchronous motors and dc shunt motors. It is because the construction of high performance poly phase induction motor with large number of poles is difficult. However, for adjustable speed service at low operating speed, dc shunt motor is a preferred choice
- When the driven load requires a wide range of speed control (both below base speed and above base speed), a dc shunt motor is employed, e.g. .in latches etc.

1.5.2 SERIES MOTORS

The outstanding feature of series motor is the automatic decrease in speed as soon as increased load torque is required. The decreasing speed with increase in load torque or vice versa has only a marginal effect on the power taken by the series motor.

- Since a series motor can withstand severe starting duties and can furnish high starting torques , it is best suited for driving hoists, trains , excavators ,cranes, etc. wound motor induction motors compete favorably with series motor's ,but the choice is governed by the economics . However for traction purposes , series motor is the only choice. Therefore series motors are widely used in all types of electric vehicles, eletrictrains, streetcars, battery powered tools, automotive starter motors etc.
- Series motors can be used to drive permanently connected loads, such as fan load, because their torque requirement increases with the square of the speed
- In order to avoid the pollution in big cities, now battery driven automobiles are being introduced on a large scale.

1.5.3 COMPOUND MOTORS

A compound motor with a strong series field has its characteristics approaching that of a series motor. Therefore such type of compound motors are used for loads requiring heavy starting torque which are likely to be reduced to zero

A compound motor with weak series field has its characteristics approaching that of a shunt motor. Weak series field causes more drooping speed torque characteristics than with an ordinary shunt motors. Such compound motors with steeper characteristics, are used where load fluctuates between wide limits intermittently.

1.6. PROJECT OBJECTIVE

The objective of this project is to :

1 .develop buck converter regulator voltage driving by pulse width modulation (pwm) technique using 555 timer .
ii . to design buck converter where can be adjustable DC output voltage using buck converter that regulate voltage using switching element driven by PWM technique using timer 555 converter.
A .transistor used as switching element , where PWM technique is applied to switch the transistor fully on and fully off.
B .by varying resistance to generate various duty cycle based on desired value.
iii .to build a circuit that can control the output voltage which is can step down the output voltage.

2-Scope Project
i .analyzing the applications of power electronic of DC power supply such as rectifier, snubber circuit, and Dc-Dc buck converter.
ii . PWM is generated using 555 timer.
*555 timer can be used to generate PWM, and control duty cycle to be set, than the voltage output can be achieve based value desired .
iii .this project is to develop an adjustable output DC voltage .
*this buck converter will use 555 timer to generate PWM where it will control the duty cycle of switching .by using this circuit, the duty cycle can be adjusted to produce variable output voltage using the buck converter topology formula.

3-Proplem Statement
In the current century, DC motor plays a vital role in industrial areas. DC motors are used widely to a machine, conveyer to produce a production.
Each day DC motor are popular widely used to a certain equipment, to make this motor more reliable :
i . DC-DC converters are required to supply various levels of voltages.
ii .using buck-boost converter also can improve the control speed of DC motor in order to step down the speed desired.
iii .power supply that can be control the output voltage is less in market.

CHAPTER

(2)

SWITCHING DEVICES

2.SWITCHING DEVICES

PWM TECHNIQUES

2. SWITCHING DEVICES AND PWM TECHNIQUE

2.1 POWER SEMICONDUCTOR DEVICES CLASSIFICATION:

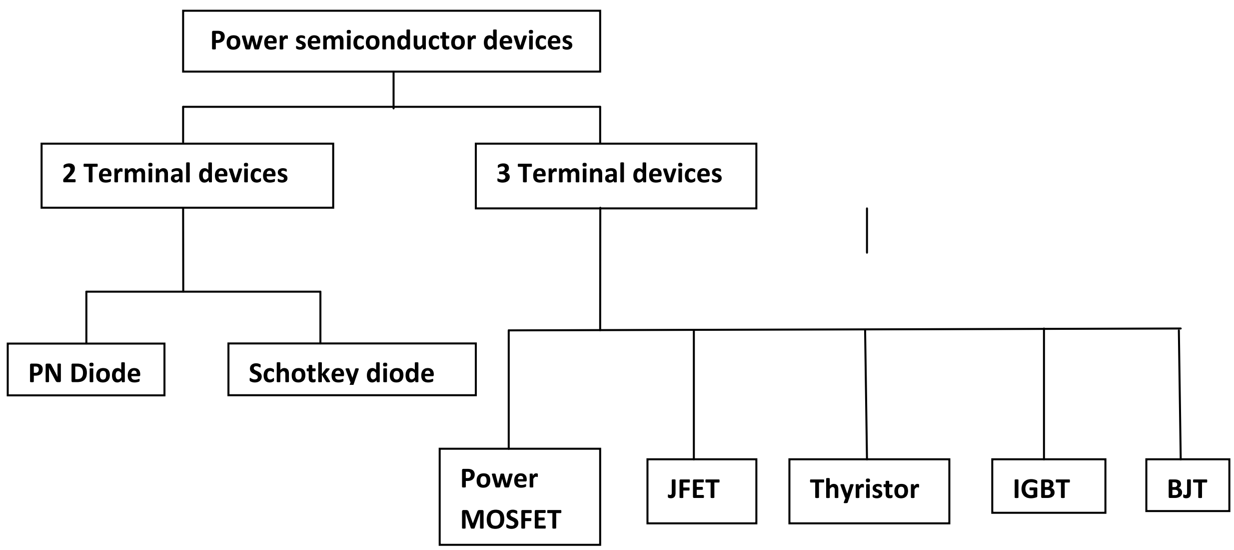


Fig.2.1. Classification ofSwitching Devices

Today's power semiconductor devices are almost exclusively based on silicon material and can be classified as follows:

- Diode
- Thyristor or silicon-controlled rectifier (SCR)
- Bipolar junction transistor (BJT)
- Power MOSFET

2.2 DIODE:

Power diodes provide uncontrolled rectification of power and are used in applications such as electroplating, anodizing, battery charging, welding, power supplies (dc and ac), and variable frequency drives. They are also used in feedback and the freewheeling functions of converters and snubbers. Shows the diode symbol and its volt-ampere characteristics. In the forward biased condition, the diode can be represented by a junction offset drop and a series-equivalent resistance that gives a positive slope in the V-I characteristics. The typical forward conduction drop is 1.0 V. This drop will cause conduction loss, and the device must be cooled by the appropriate heat sink to limit the junction temperature. In the reverse-biased condition, a small leakage current flows due to minority carriers, which gradually increase with voltage. If the reverse voltage exceeds a threshold value, called the breakdown voltage, the device goes through avalanche breakdown, which is when reverse current becomes large and the diode is destroyed by heating due to large power dissipation in the junction.

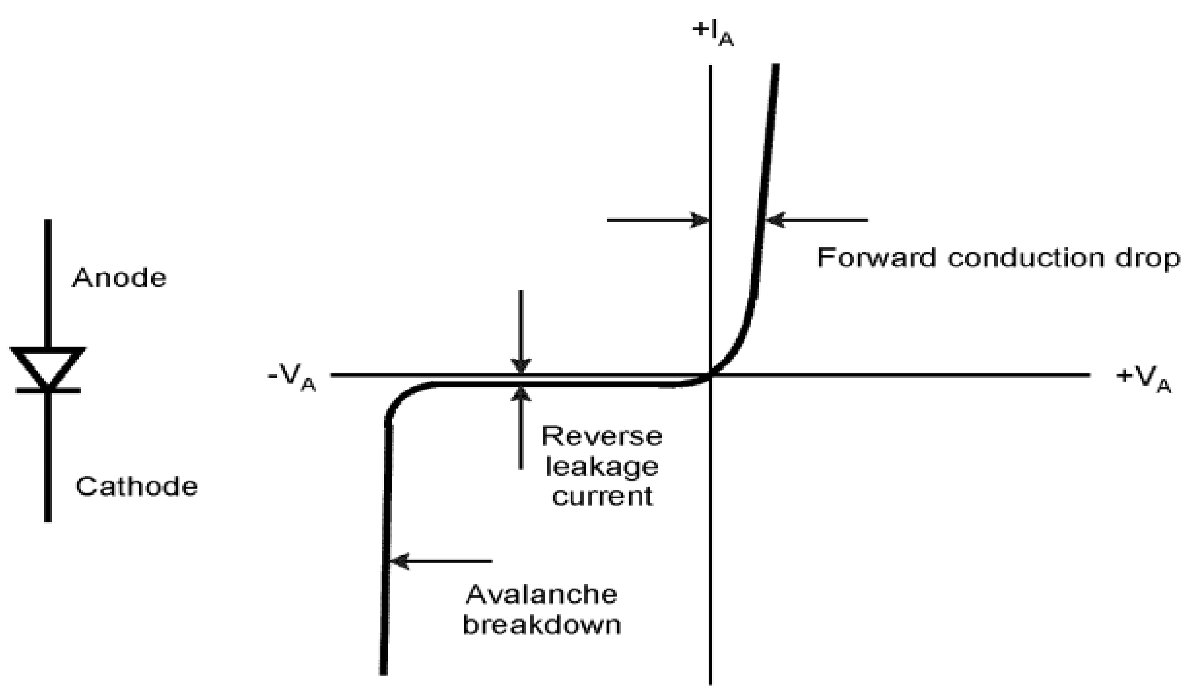


Fig.2.2.Symbol & Characteristics of Diode

2.3 THYRISTORS:

Thyristors or silicon-controlled rectifiers (SCRs) have been the traditional workhorses for bulk power conversion and control in industry. The modern era of solid-state power electronics started due to the introduction of this device in the late 1950s. Basically, it is a trigger into conduction device that can be turned on by positive gate current pulse but once the device is on, a negative gate pulse cannot turn it off. The device turn on process is very fast and turn off process is slow because the minority carriers are to be cleared from the inner junctions by "recovery and recombination" processes

Commercial thyristors can be classified as phase control and inverter types. The thyristors have been widely used in dc and ac drives, lighting, heating and welding control.

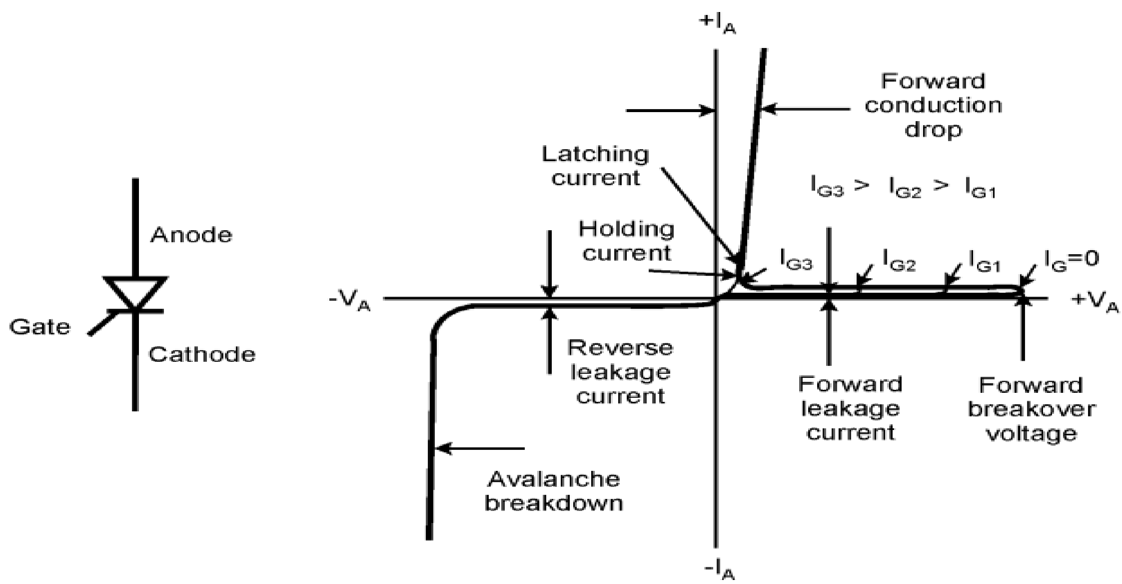


Fig.2.3. Diode symbol and V-I characteristics

2.4 BIPOLAR POWER OR JUNCTION TRANSISTORS (BPTS OR BJTS)

A bipolar junction transistor (BJT), unlike a thyristor-like device, is a two-junction, self-controlled device where the collector current is under the control of the base drive current. Bipolar junction transistors have recently been ousted by IGBTs (insulated gate bipolar transistors) in the higher end and by power MOSFETs in the lower end. The dc current gain (*hFE*) of a power transistor is low and varies widely with collector current and temperature. The gain is increased to a high value in the Darlington connection, as shown in Figure However, the disadvantages are higher leakage current, higher conduction drop, and reduced switching frequency.

The shunt resistances and diode in the base-emitter circuit help to reduce collector leakage current and establish base bias voltages. A transistor can block voltage in the forward direction only (asymmetric blocking). The feedback diode, as shown, is an essential element for chopper and voltage-fed converter applications. Double or triple Darlington transistors are available in module form with matched parallel devices for higher power rating. Power transistors have an important property known as the second breakdown effect. This is in contrast to the avalanche breakdown effect of a junction, which is also known as first breakdown effect. When the collector current is switched on by the base drive, it tends to crowd on the base-emitter junction periphery, thus constricting the collector current in a narrow area of the reverse-biased collector junction. This tends to create a hot spot and the junction fails by thermal runaway, which is known as second breakdown. The rise in junction temperature at the hot spot accentuates the current concentration owing to the negative temperature coefficient of the drop, and this regeneration effect causes collapse of the collector voltage, thus destroying the device.

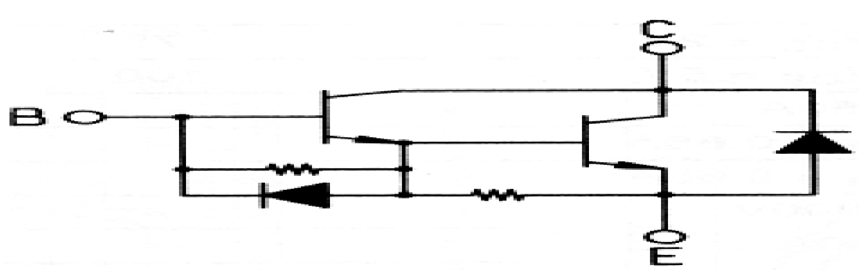


Fig.2.4. Two stage Darlington transistor with bypass diode

2.5 POWER MOSFETS:

Unlike the devices discussed so far, a power MOSFET (metal-oxide semiconductor field effect transistor) is a unipolar, majority carrier, "zero junctions," voltage-controlled device. (a) shows the symbol of an N-type MOSFET and (b) shows its volt-ampere characteristics. If the gate voltage is positive and beyond a threshold value, an N-type conducting channel will be induced that will permit current flow by majority carrier (electrons) between the drain and the source. Although the gate impedance is extremely high at steady state, the effectivegate-source capacitance will demand a pulse current during turn-on and turn-off. The device has asymmetric voltage-blocking capability, and has an integral body diode, as shown, which can carry full current in the reverse direction. The diode is characterized by slow recovery and is often bypassed by an external fast-recovery diode in high-frequency applications.

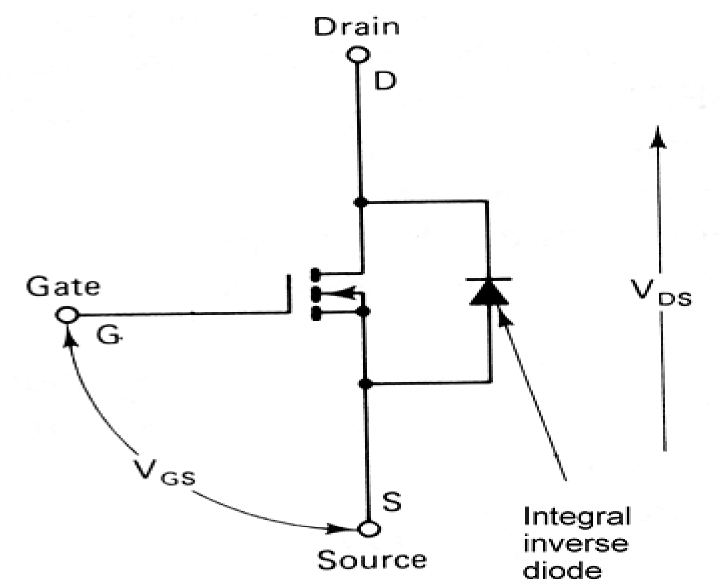


Fig.2.5.Power MOSFET Symbol

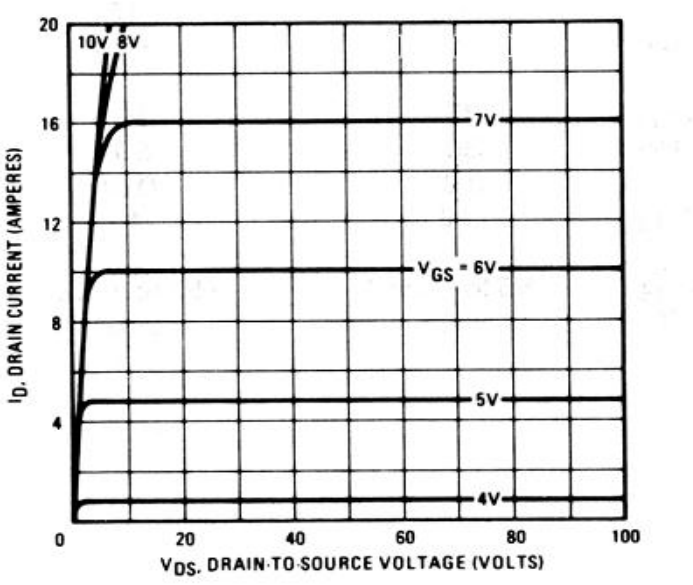


Fig.2.6. V-I characteristics of power MOSFET

CHAPTER

(3)

BUCK CONVERTER TECHNIQUL

Buck converter

Figure 3.1 shows the circuit diagram of a step-down converter, also known as buck converter, with different types of load

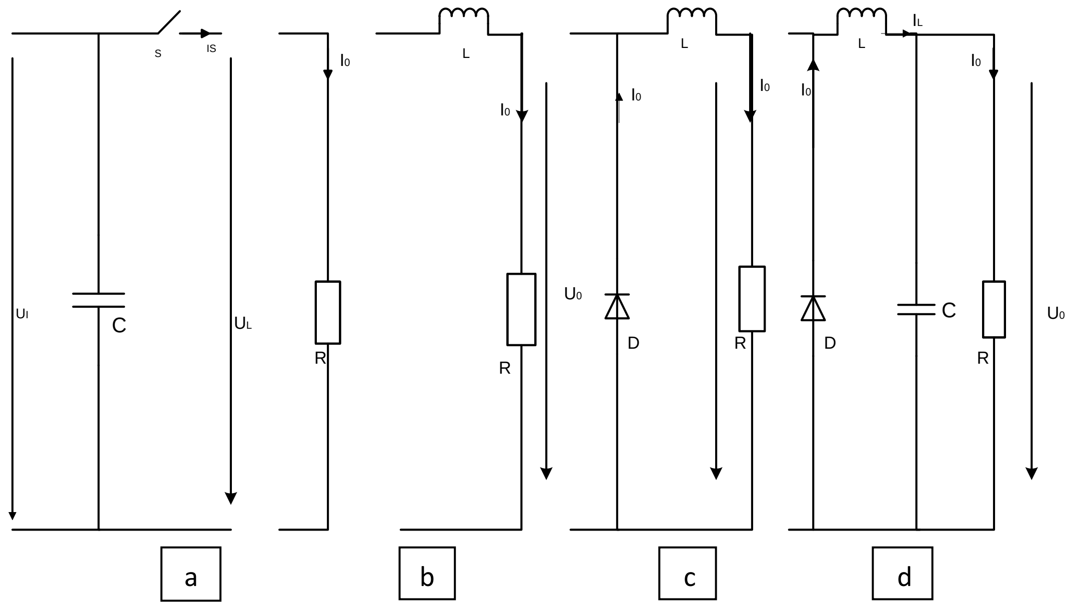


Fig.3.1 Step –down converter

A semiconductor switch S closes and opens periodically, thus tuming the voltage across the load on and off. When the load comprises purely an ohmic resistance (load variant a), the load current is also turned on and off periodically. It is easy to demonstrate that the average value of the output voltage and load current are directly proportional to the pulse-duty- ratio. In this case, the output voltage is always lower than the input voltage, hence the term 'step-down converter'.

U0 = Ul. t(on)/T

However, this type of pulsating current or rippled voltage is unacceptable for most application, so a number of remedial need to be implemented :

A choke (load variant b) is included to smooth the current. The higher the switching frequency, the lower the permissible inductance of the choke .when the switch is in the conductive phase, the current through it and the choke rises linearly, and magnetic energy proportional to the square of the current is stored. When the switch is in the blocking phase, a current needs to keep flowing to allow the magnetic energy to dissipate. As load variant (b) shows however, no current can flow when the switch is open. This induces a negative voltage whose peak value theoretically approaches infinity, immediately destroying the semiconductor switch.

In a free-wheeling diode, the choke current can continue to flow during the blocking phase of the switch. Load variant (c) shows how the free-wheeling diode must be positioned. The current commutates from the switch to the diode; this prevents the induction of voltages which could damage the components. The voltage U0 across the ohmic load is proportional to the choke current. A ripple in the choke current automatically produces a ripple in the voltage.

A smoothing or filtration capacitor connected in parallel with the output of the step-down converter (load variant d) reduces the ripple in the voltage. The degree of residual ripple depends on the value of capacitor and

CHAPTER

(4)

EXPERIMENTAL WORK

4.EXPERIMENTAL WORK

4.1. Circuit diagram

The experimental circuit of 220 v ac separately excited motor is shown in figure(4.1) it consists of Three phase transformer Y/Y 400/98 V , three phase rectifier to convert 170 AC voltage into 230 dc voltage . capacitor buck using three 330 uf 400 v to construct 900 uf which used to smooth the dc input voltage to the motor , semi conductor switch IGBT , FWD , PWM circuit using 555 that allows the motor voltage & speed varies from 0 to motor rated values . The hard ware implementation of the proposed system is shows in fig.4.2.

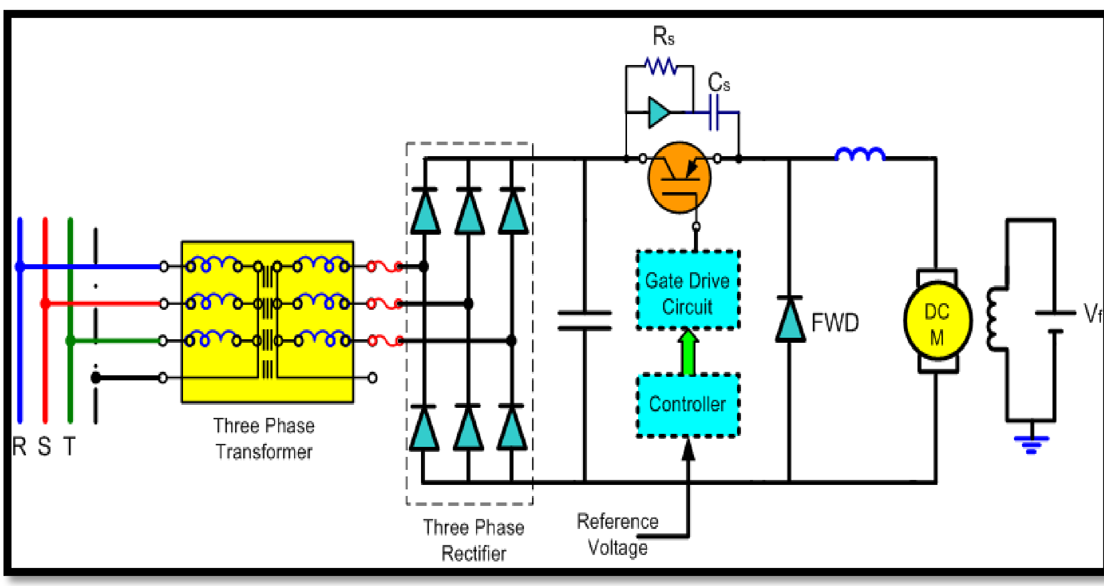


Fig.4.1 the circuit diagram

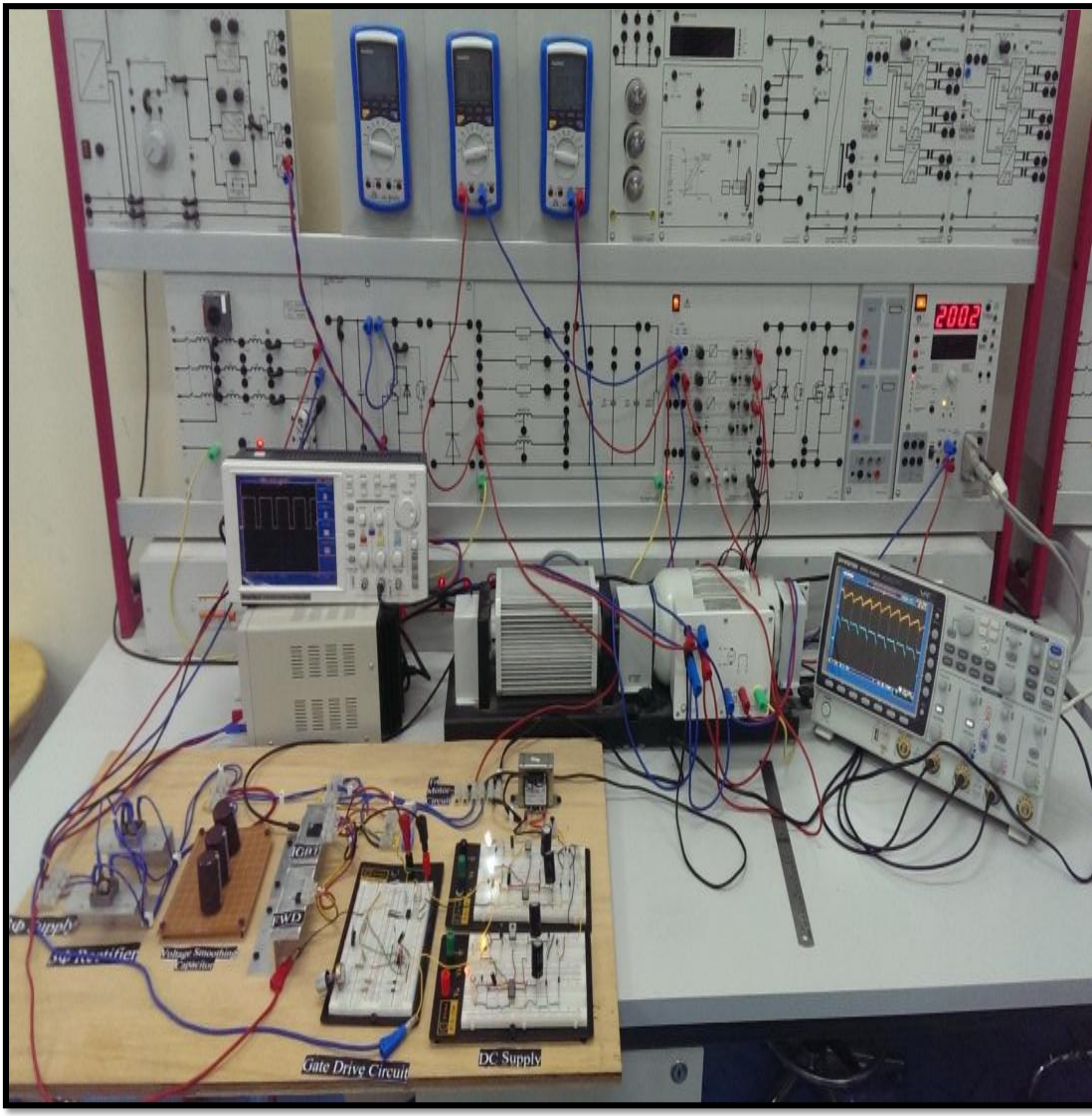


Fig 4.2The hard ware implementation of the proposed system

4.2 BUCK CONVERTER TECHNIQUE

System Discription the system is consist of :

4.2.1. Three phase supply :

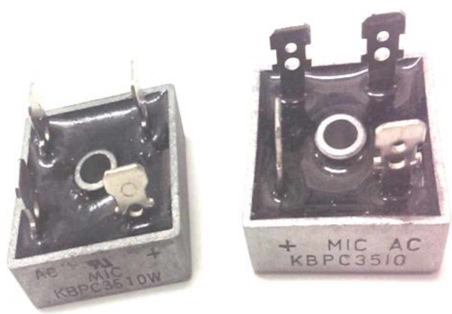
The system is supplied from utaltity supply 400V 60Hz .

4.2.2. Three phase Y/Y Transformer :

In order to obtain the required ac voltage a three phase transformer Y/Y 400V/98V laboratory model has been used to stop down the utility supply from 400V to 98V fig.4.3 shows the three phase transformer .

4.2.3. Three phase rectifier :

Single-phase rectifiers are commonly used for power supplies for domestic equipment. However, for most industrial and high-power applications, three-phase rectifier circuits are the norm. As with single-phase rectifiers, three-phase rectifiers can take the form of a half-wave circuit, a full-wave circuit using a center-tapped transformer, or a full-wave bridge circuit. In this project a three-phase diode bridge rectifier has been used to convert ac voltage to dc voltage as shown in Figure .4.3. The rectifier consists of a three-phase diode bridge, comprising diodes D1 to D6. Figure4.4 shows two single phase bridge rectifier has been used to construct three phase diode rectifier.



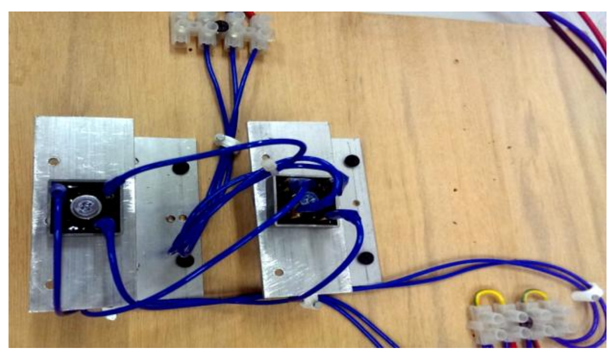


Fig.4.3 Fig.4.4

Figure 4.5 shows of circuit diagram of a three phase bridge rectifier. Figure 4.6 show the three phase retinol waveforms of the three phase supply .while figure 4.8 show the dc output voltage of the three phase rectifier .

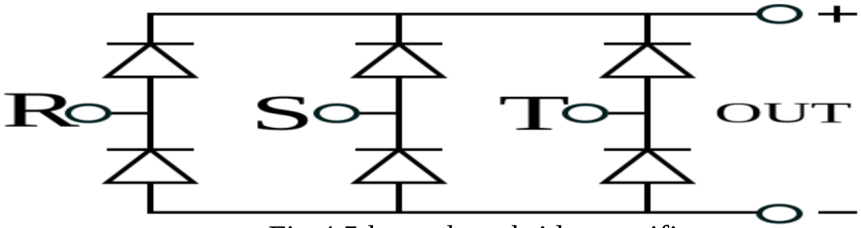


Fig.4.5three phase bridge rectifier

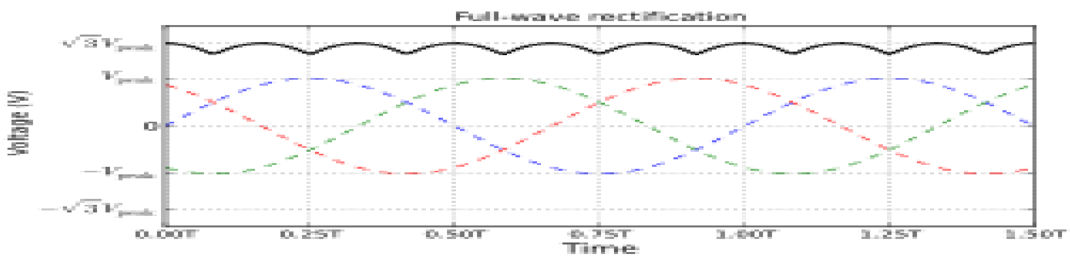


Fig.4.6 Full-Wave rectifier

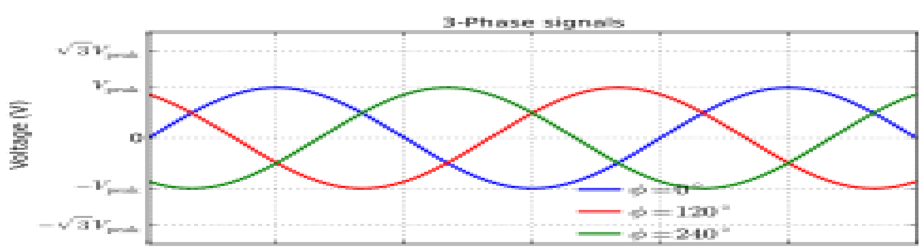


Fig.4.7 Three phase signal

Figure 4.8 and 4.9 show the practical waveform of three phase voltage input bridge rectifier and dc voltage output from three phase bridge rectifier respectively .

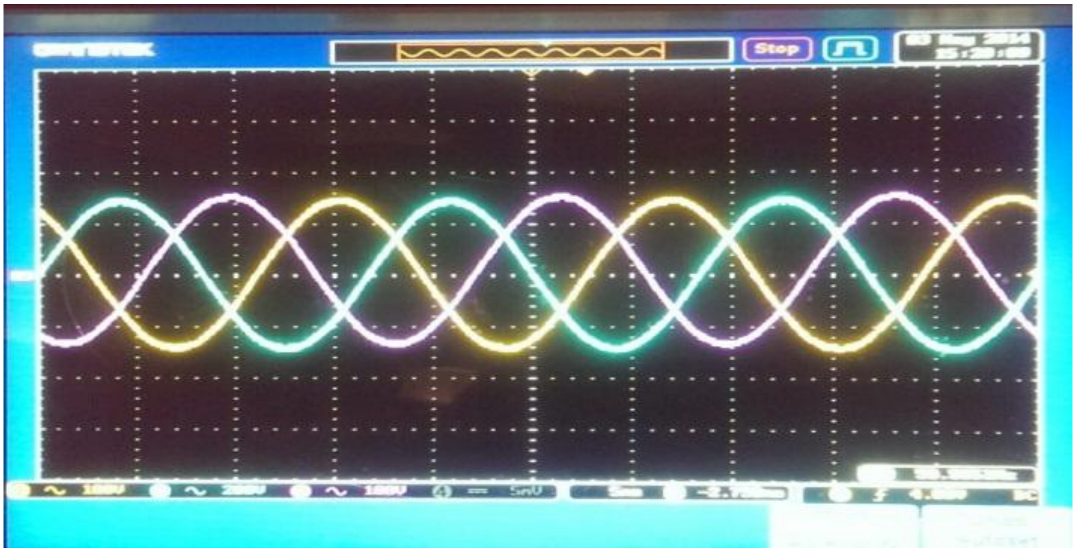


Fig.4.8 output of three phase transformer

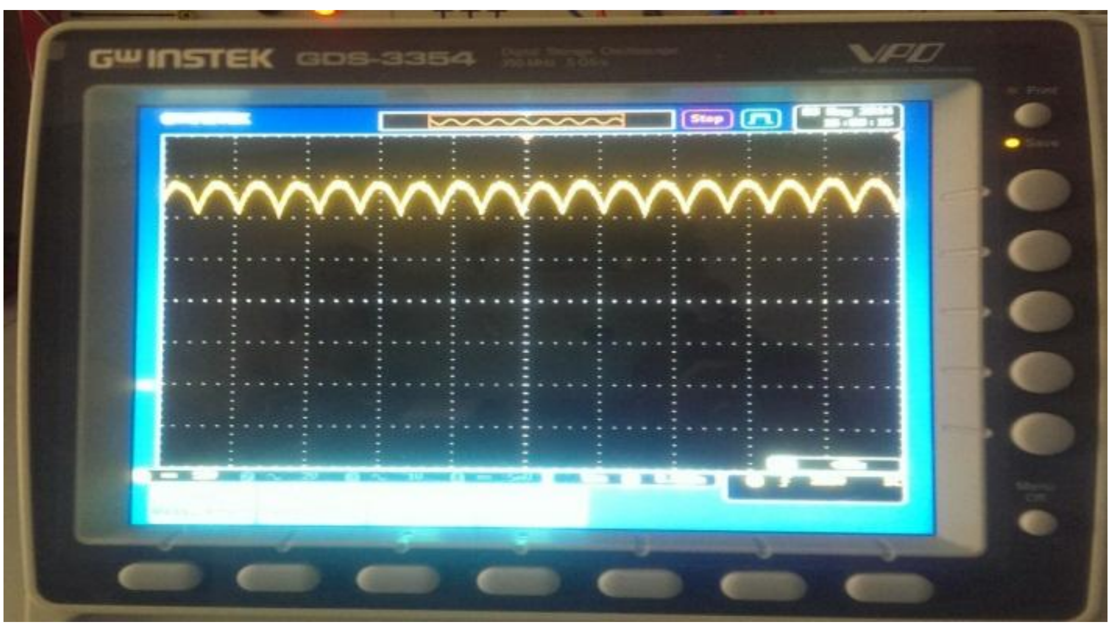


Fig.4.9 Output of three phase bridge

4.2.4.Capacitor

Capacitor is used to smooth the output voltage of three phase rectifier to achieve pure dc voltage to the motor circuit

Capacitor data :

VOLTAGE	***430***
CAPACITANCE	***990uF***

Table.4.1 capacitor data

Figure 4.10 shows the dc input voltage to the buck converter after smoothing (using capacitor bank ***990uF***) .

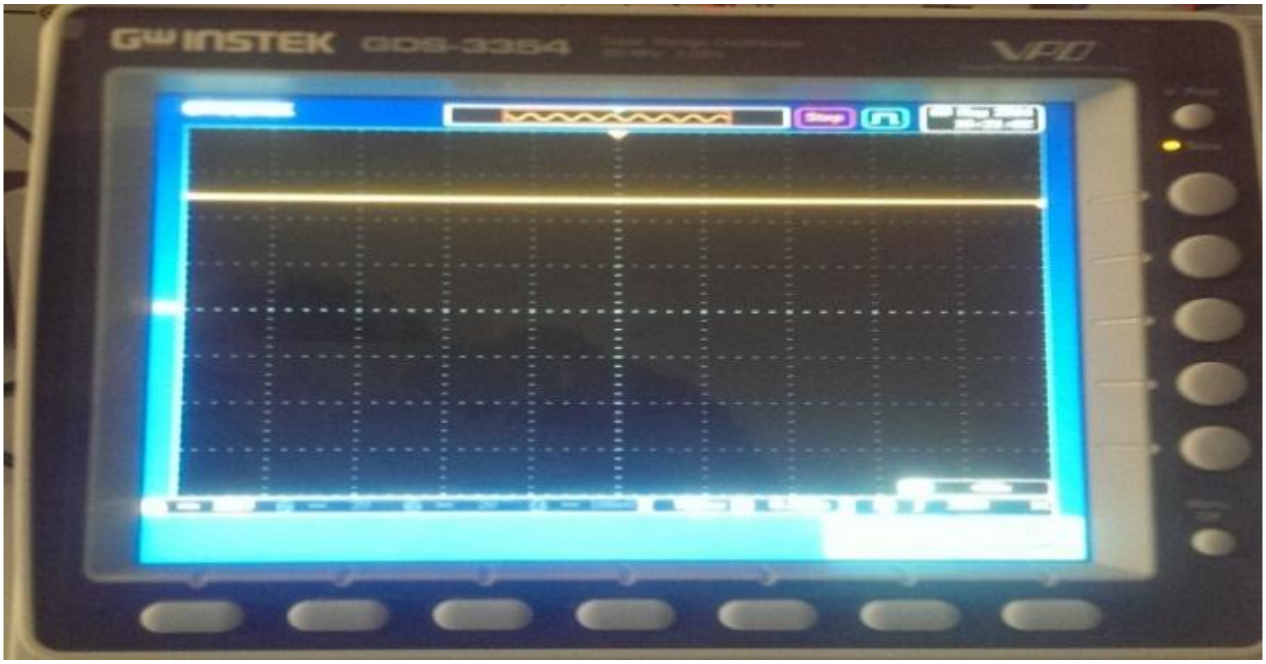


Fig.4.10 Output of dc capacitor

4.2.5. DC Motor

Figure4.11 shows the DC motor used in this project is a laboratory motor made by labolel the motor can be used as shunt or separately excited .
The motor data shown in the table

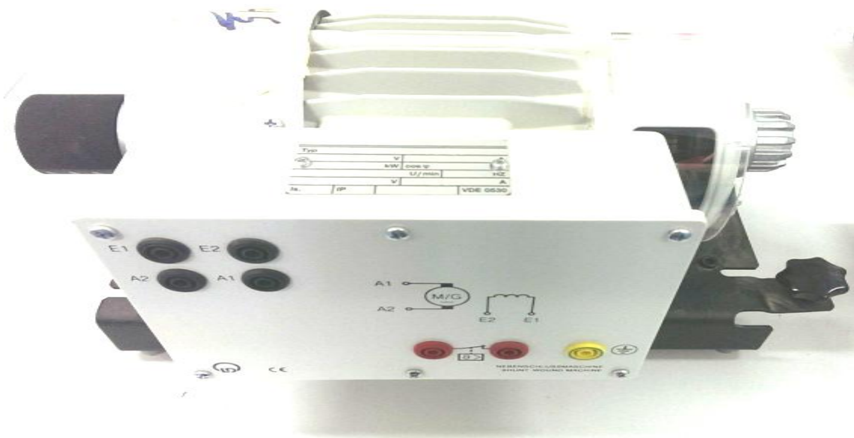


Fig.4.11 . 220 V dc separately excitation motor

Type : 73191 class 0.3			
220 v		1.8 A	
2000 U/min		HZ	
Ueer = 220 v		0.3 A	
IS.B/F	IP 20	88140	VDE 0530

Table.4.2 motor data

4.2.6. FWD (Free Wheeling Diode)

First the reason of using FWD to find pass for motor to gurantee its continuity , and to protect IGBT from over voltage due to energy storage in the induetor . An alterafaste diodetype has been used . figure 4.12 shows diode image omitted from data sheet while figure 4.13 show the practical picture of altrafastreceverg diode .

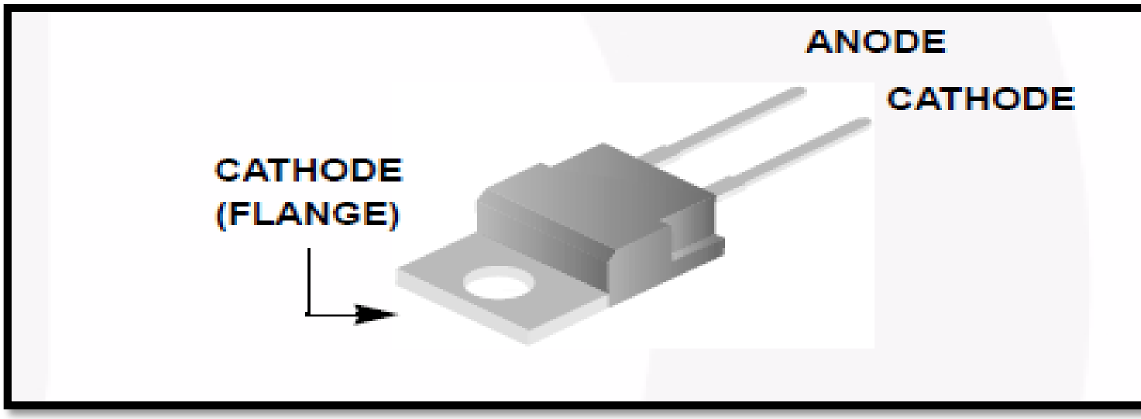


Fig.4.12

Fig.4.13

4.2.7 IBGT.

The IGBT has been selected the work in the buck converter .

Figure 4.14 shows the T\IBGT image taken from data sheet and figure 4.15 shows the practical picture of IBGT connected in the system

Fig.4.14

Fig,4.15

4.2.8 IGBT gate drive circuit .

Motor control inverter applications. The high operating voltage range of the output stage provides the drive voltages required by gate controlled devices. The voltage and current supplied by this octocoupler makes it ideally suited for directly driving IGBTs with rating up to 1200 v/100 A. for IGBTs with higher ratings, the HCPL-320 can be used to drive a discrate power stage which drives the IGBT gate.

Figure 4.16 shows the schematic diagram of the IBGT gate drive cicuit using HCFL gate drive optocoupllr IG . Figure 4.17 shows the practical circuit of IGBT gate drive circuit .

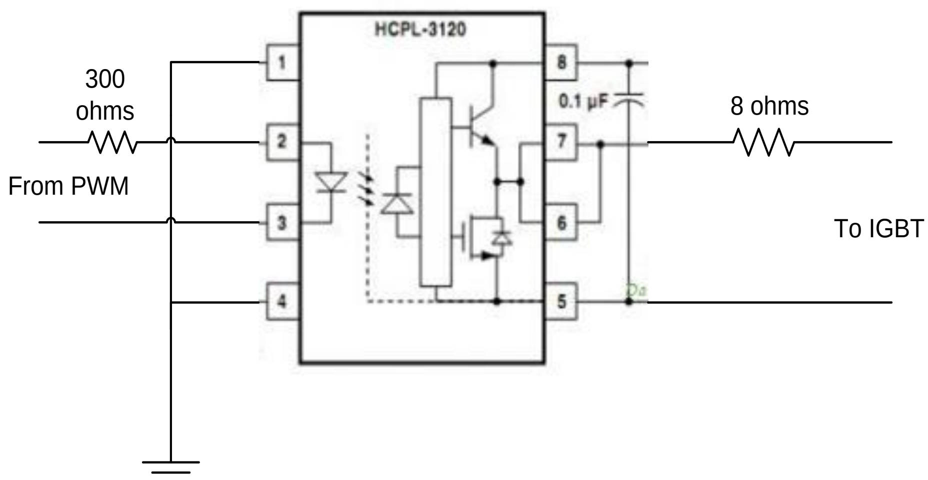


Fig.4.16 schematic diagram of IGBT gate circuit

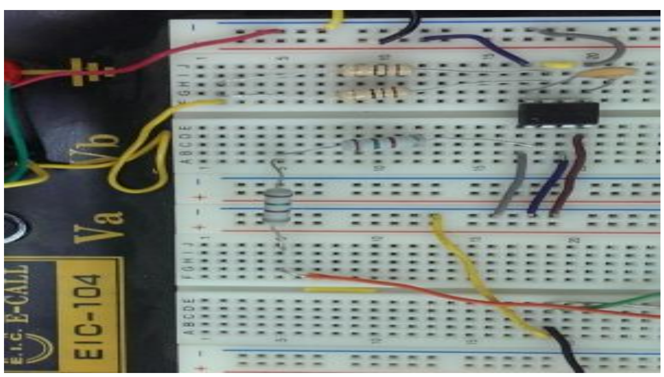


Fig.4.17 IGBT gate drive practical circuit

4.2.9. IBGT Snubber Circuit

In order to product IGBT from over dv/dt due to switching inductive load, a snubber circuit consists of 200 ohms, 33nf and diode. Figure 4.18 shows the circuit diagram of the snubber circuit used in this project .

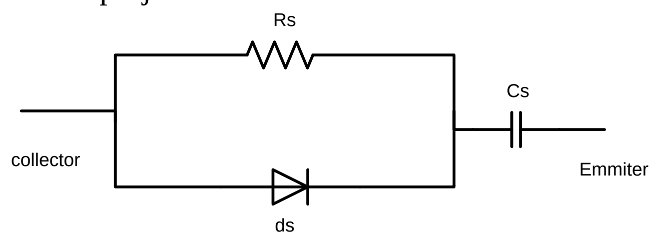


Fig.4.18 IGBTsnubber circuit

3.10. PWM TECHNIQUE:

3.10.1 Introduction:

Pulse-width modulation (PWM) or duty-cycle variation methods are commonly used in speed control of DC motors. The duty cycle is defined as the percentage of digital ‘high’ to digital ‘low’ plus digital ‘high’ pulse-width during a PWM period.

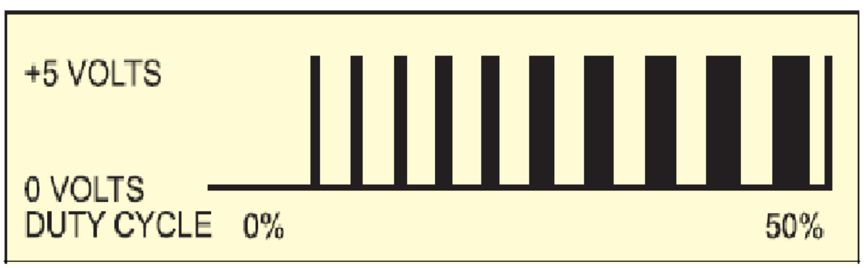


Fig.4.19Pulses With 0% Through 50% Duty Cycle

Figure 4.19shows the 5V pulses with 0% through 50% duty cycle. The average DC Voltage value for 0% duty cycle is zero; with 25% duty cycle the average value is 1.25V (25% of 5V). With 50% duty cycle the average value is 2.5V, and if the duty cycle is 75%, the average voltage is 3.75V and so on. The maximum duty cycle can be 100%, which is equivalent to a DC waveform. Thus by varying the pulse-width, we can vary the average voltage across a DC motor and hence its speed. The average voltage is givenby the following equation:

ý = D. Ymax + (1- D) Ymin

But usually minimum equals zero so the average voltage will be:

ý = D. Ymax

4.2.10. principle

Pulse width modulation control works by switching the supplied to the motor on and off very rapidely. The DC voltage is converted to a square wave signal, alternating between fully on (nearly 230v) and zero, giving the motor a series of power "kicks" .

Pulse width modulation technique (PWM) is a technique for speed control which can overcome the problem of poor starting performance of a motor.

PWM for motor speed control works in a very similar way. Instead of supplying a varying voltage to a motor, it is supplied with a fixed voltage value (such as 230v) which starts it spinning immediately. The voltage is then removed and the motor 'coasts' .By continuing this voltage on/off cycle with a varying duty cycle, the motor speed can be controlled.

The wave forms in the below figure to explain the way in which this method of control operates. In each case the signal has maximum and minimum voltage of 230v and 0v.

By varying the mark space ratio of the signal over the full range, it is possible to obtain any desired average output voltage from 0v to 230v. The motor will work perfectly well, provided that the frequency of the pulsed signal is set correctly, a suitable frequency being 30 Hz setting the frequency too low gives jerky operation. And setting it too high might increase the motor's impedance.

4.2.11. Pulse Width Modulation

A circuit providing an adjustable duty cycle with a minimal effect on frequency is shown in Figure 4.20 This is a modified version provides a continually adjustable duty cycle between approximately 0% and 100% avoiding use of the control input therefore allowing adjustment of the duty cycle with little or no effect on the frequency of oscillation.

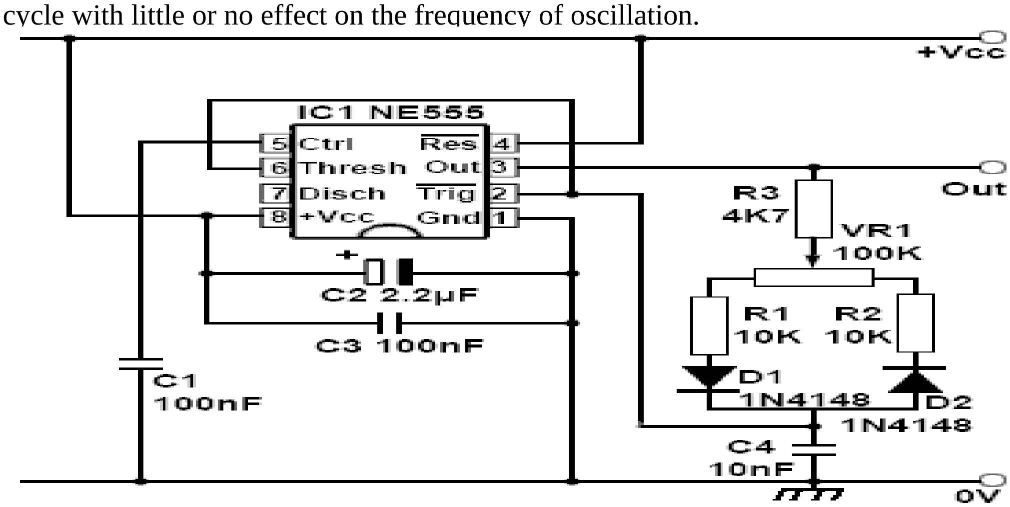


Fig.4.20 0- 100% PWM circuit duty cycle

Figure 4.21 shows the practical implementation of pulse width modulation circuit timer IC555 with duty ratio can be charging from 0% to 100% .

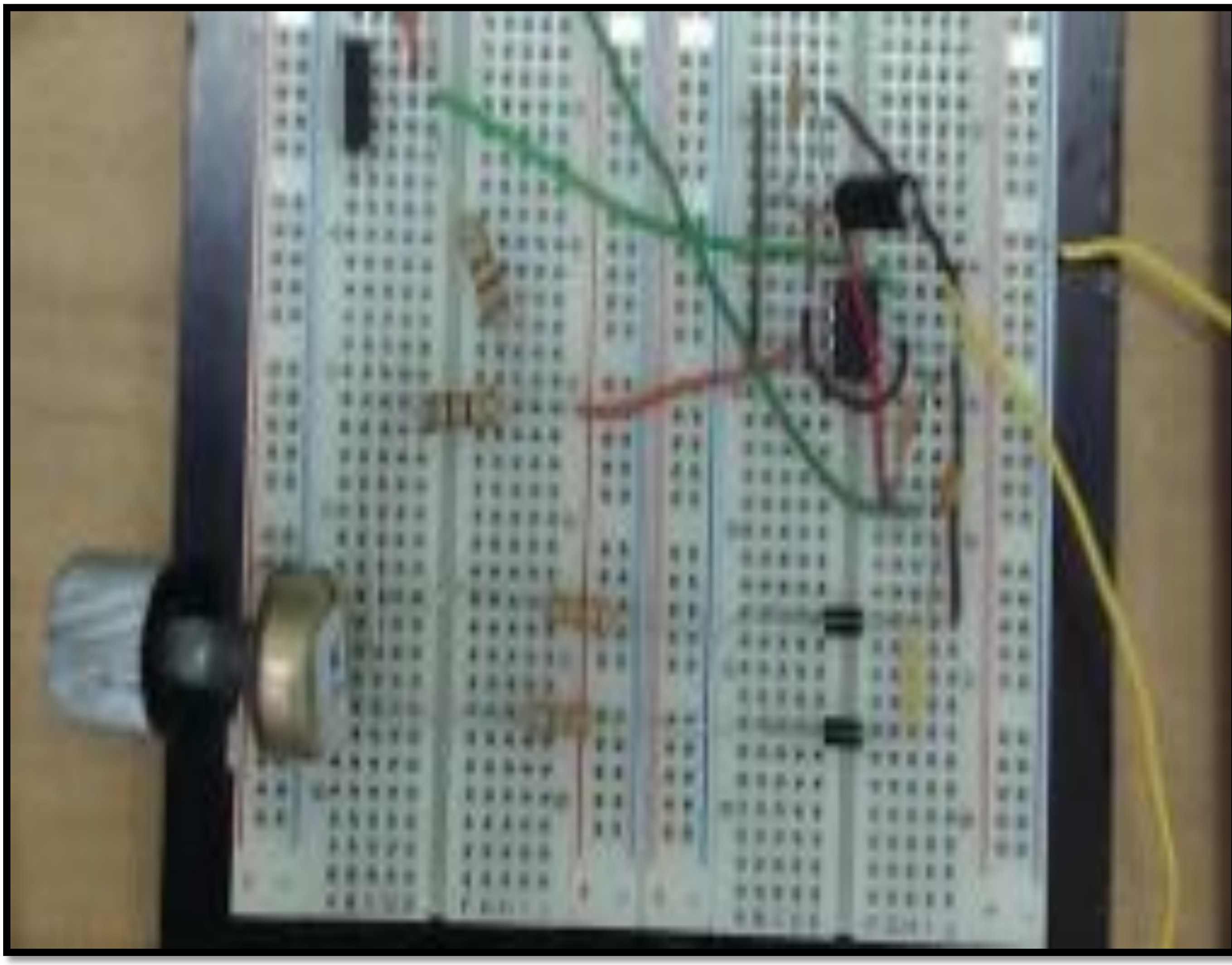


Fig.4.21. PWM Practical Circuit

4.3 The experimental work result

Figure(4.22) shows PWM pulses applied to the IGBT gate figure(4.23) shows the motor voltage (blue line) and motor current (yellow line) at motor speed 0 rpm while th duty cycle equal(0%)

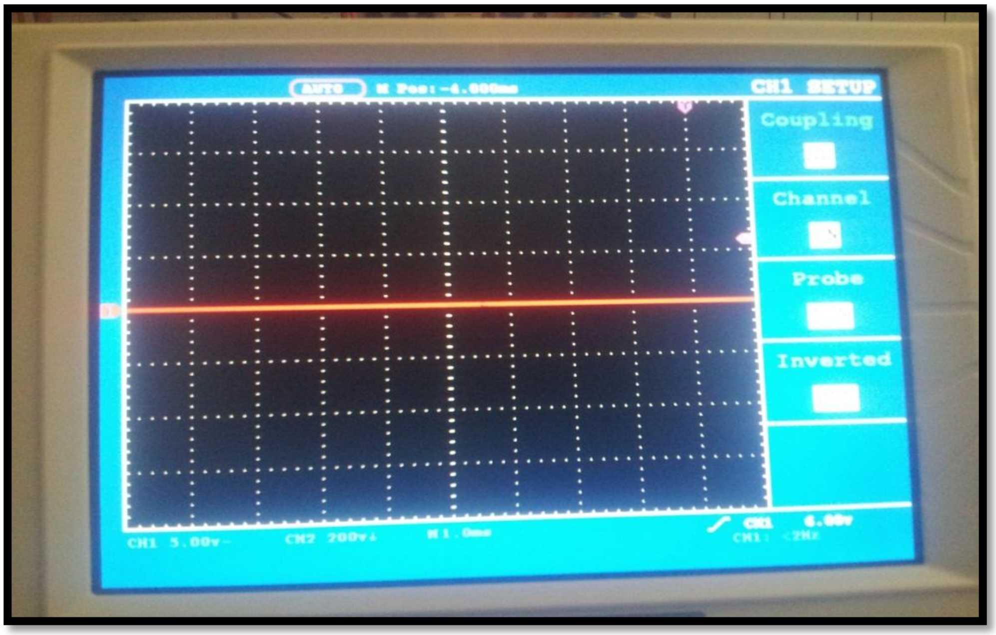


Fig. 4.22 output of gate drive circuit

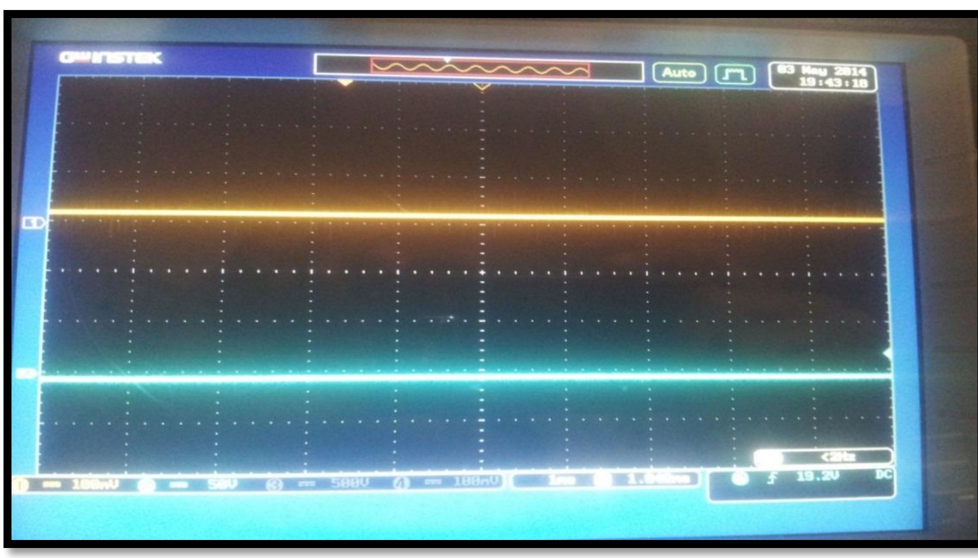


Fig.4.23 Motor current and voltage waveform at 0 rpm

Figure(4.24) shows PWM pulses applied to the IGBT gate figure(4.25) shows the motor voltage (blue line) and motor current (yellow line) at motor speed 250 rpm while th duty cycle equal (0.11%)

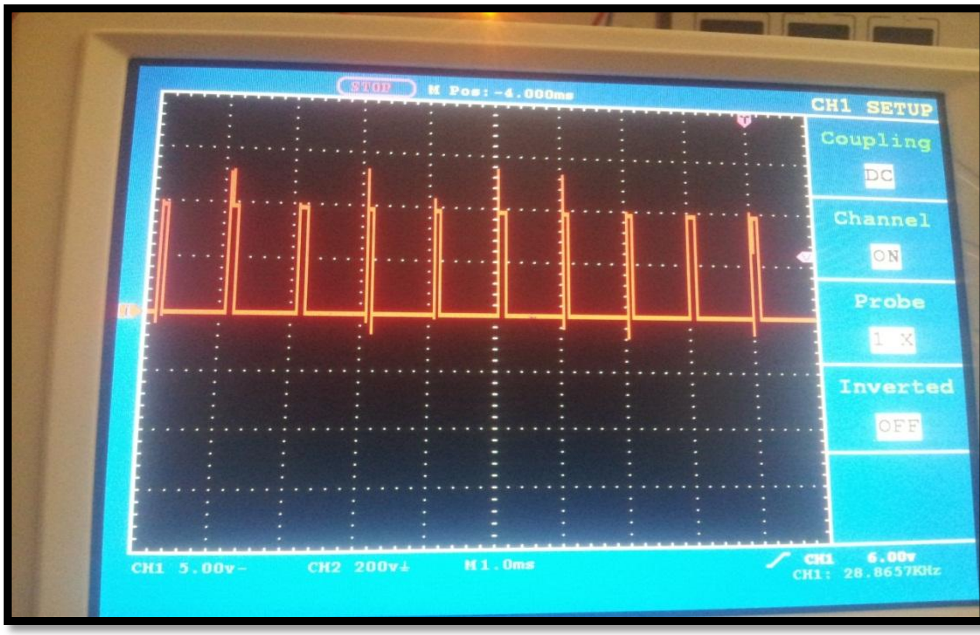


Fig.4.24output of gate drive circuit

Fig.4.25 Motor current and voltage waveform at 250 rpm

Figure(4.26) shows PWM pulses applied to the IGBT gate figure(4.27) shows the motor voltage (blue line) and motor current (yellow line) at motor speed 500 rpm while th duty cycle equal (0.17%)

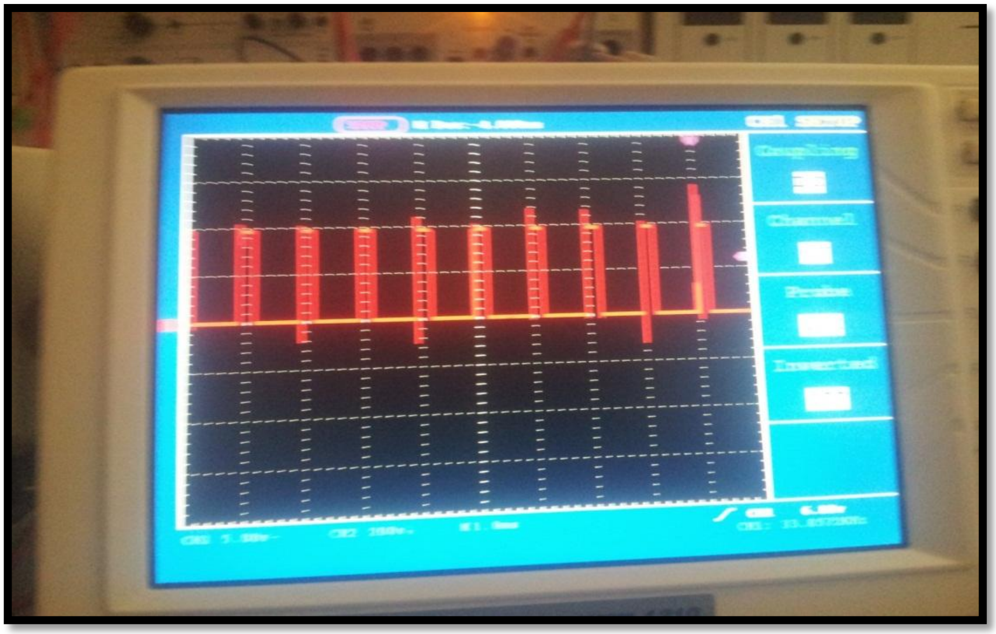


Fig.4.26 output of gate drive cicuit

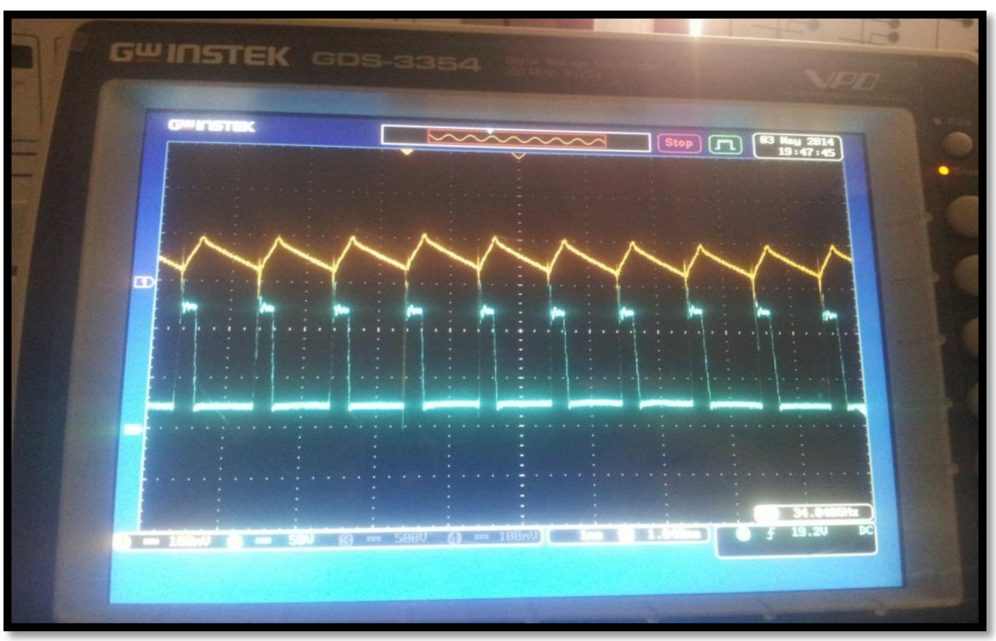


Fig.4.27 Motor current and voltage waveform at 500 rpm

Figure(4.28) shows PWM pulses applied to the IGBT gate figure(4.29) shows the motor voltage (blue line) and motor current (yellow line) at motor speed 750 rpm while th duty cycle equal (0.21%)

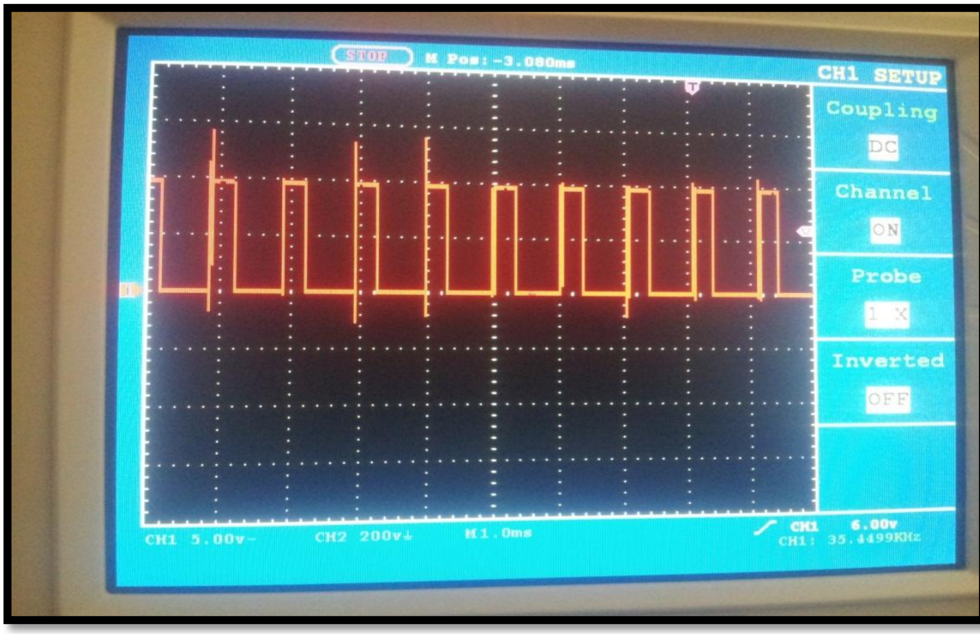


Fig. 4.28 output of gate drive circuit

Fig.4.29 Motor current and voltage waveform at 750 rpm

Figure(4.30) shows PWM pulses applied to the IGBT gate figure(4.31) shows the motor voltage (blue line) and motor current (yellow line) at motor speed 1000 rpm while th duty cycle equal (0.31%)

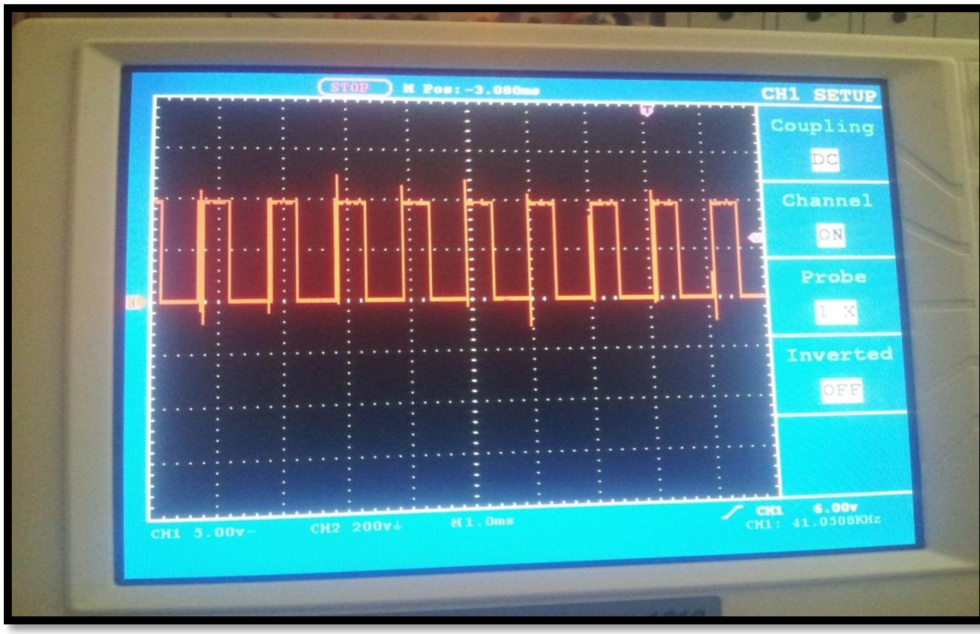


Fig. 4.30 output of gate drive circuit

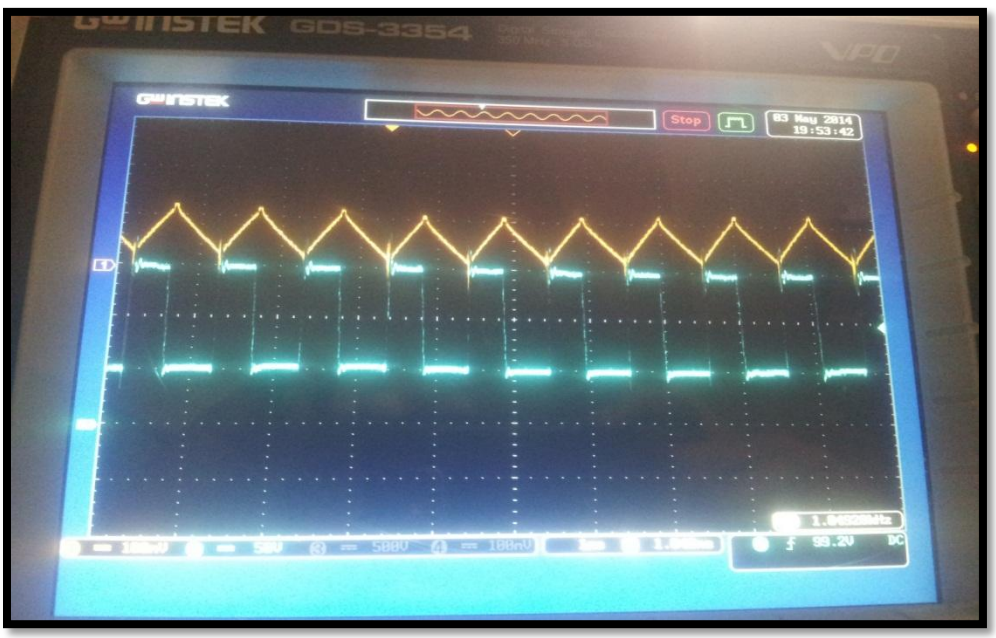


Fig.4.31 Motor current and voltage waveform at 1000 rpm

Figure(4.32) shows PWM pulses applied to the IGBT gate figure(4.33) shows the motor voltage (blue line) and motor current (yellow line) at motor speed 1250 rpm while th duty cycle equal (0.42%)

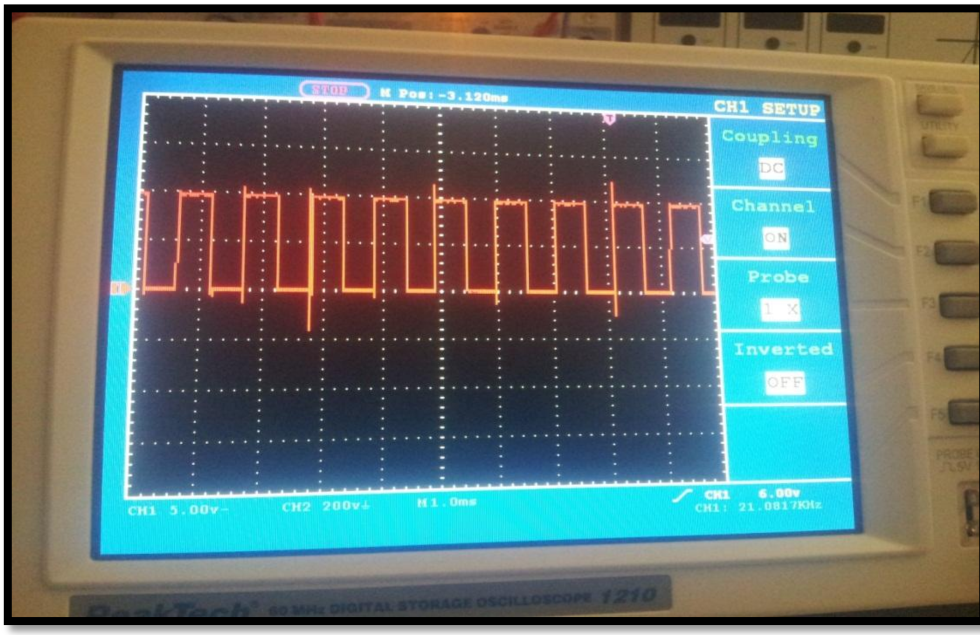


Fig.4.32 output of gate drive circuit

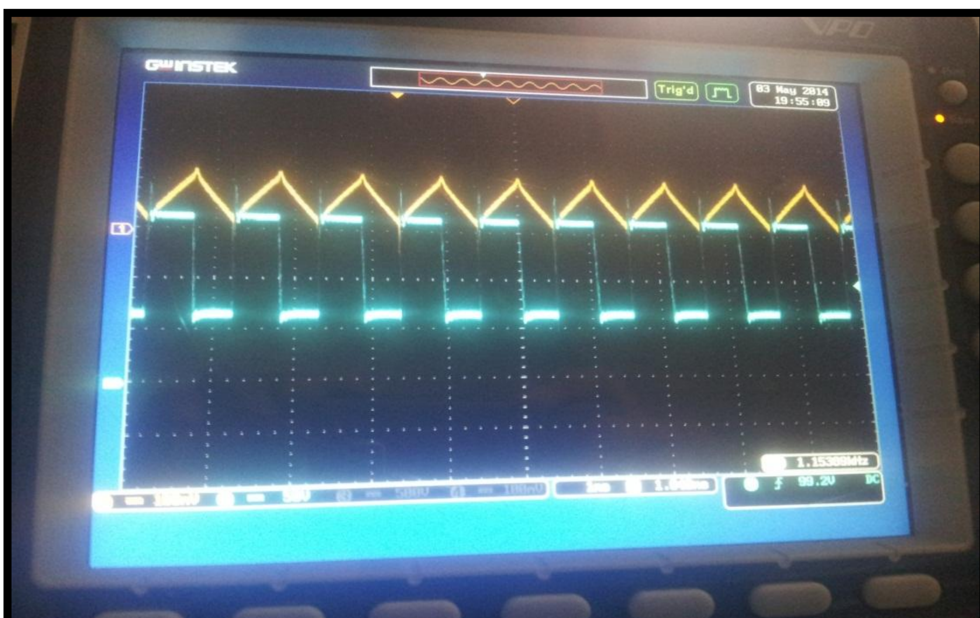


Fig. 4.33 Motor current and voltage waveform at 1250 rpm

Figure(4.34) shows PWM pulses applied to the IGBT gate figure(4.35) shows the motor voltage (blue line) and motor current (yellow line) at motor speed 1500 rpm while th duty cycle equal (0.52%)

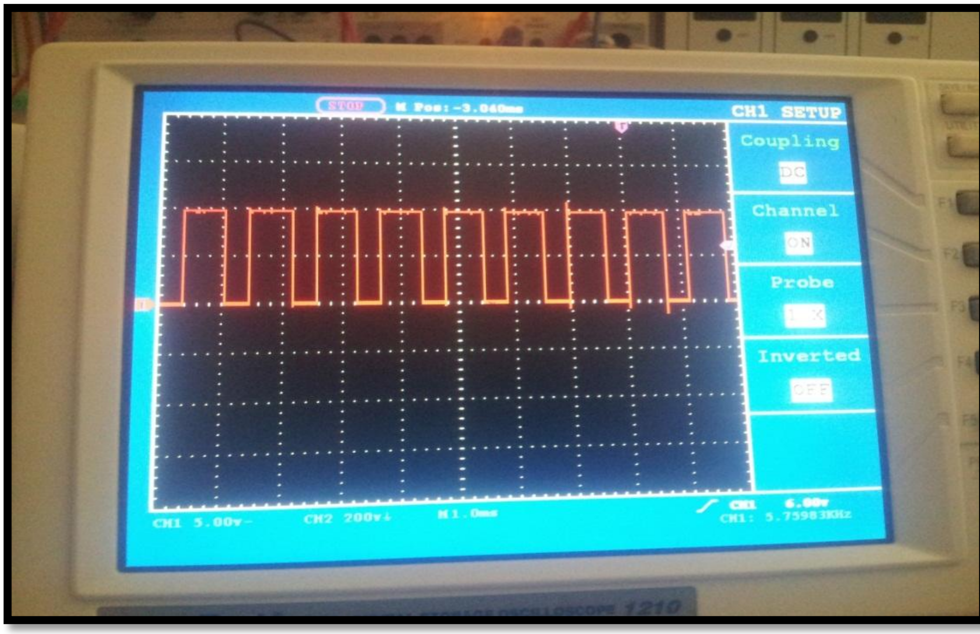


Fig.4.34 output of gate drive circuit

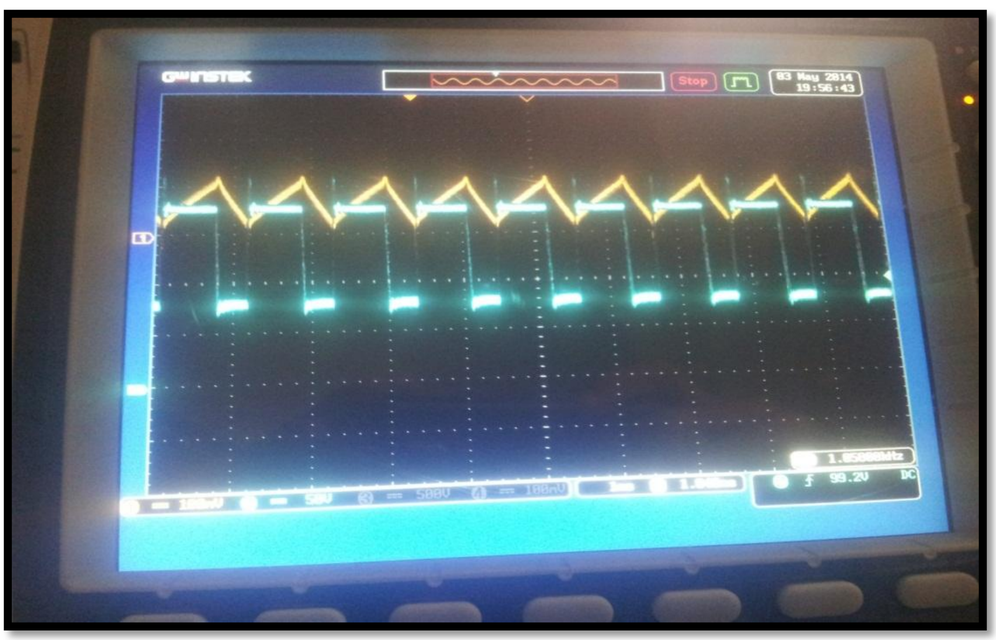


Fig.4.35 Motor current and voltage waveform at 1500 rpm

Figure(4.36) shows PWM pulses applied to the IGBT gate figure(4.37) shows the motor voltage (blue line) and motor current (yellow line) at motor speed 1750 rpm while th duty cycle equal (0.63%)

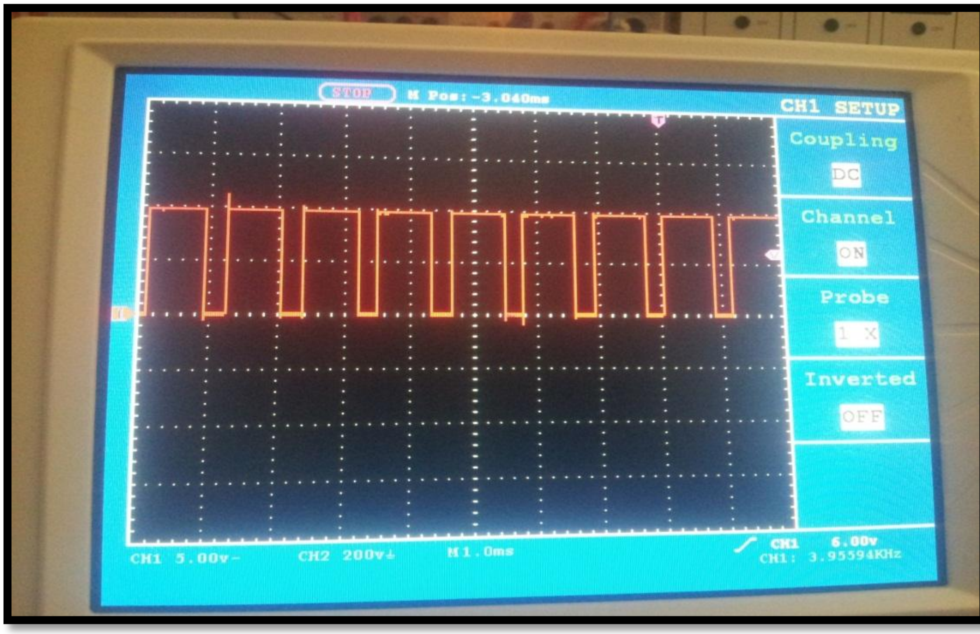


Fig.4.36output of gate drive circuit

Fig.4.37 Motor current and voltage waveform at 1750 rpm

Figure(4.38) shows PWM pulses applied to the IGBT gate figure(4.39) shows the motor voltage (blue line) and motor current (yellow line) at motor speed 1800 rpm while th duty cycle equal (0.73%)

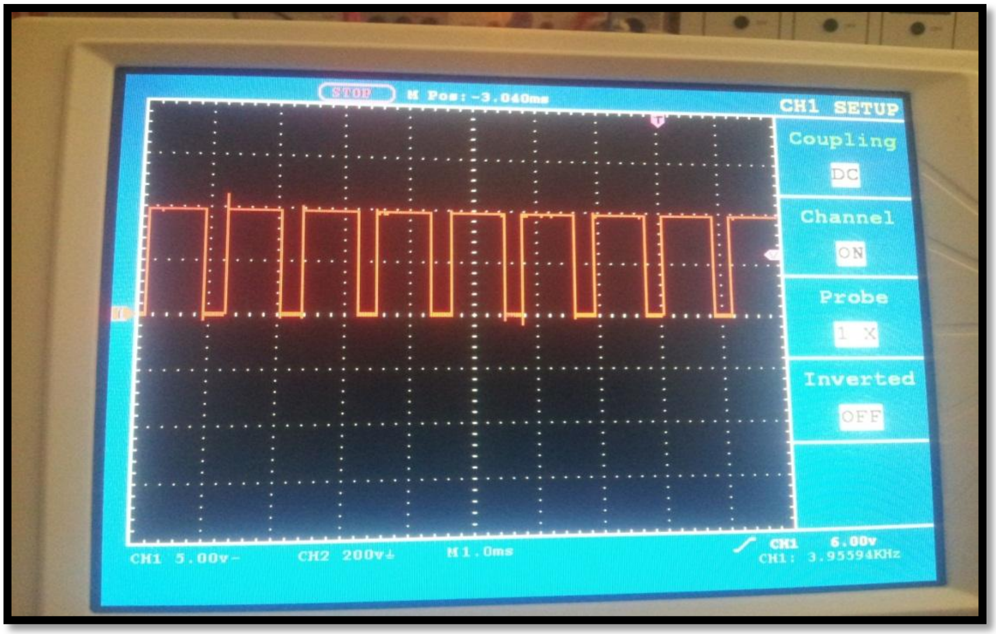


Fig.4.38output of gate drive circuit

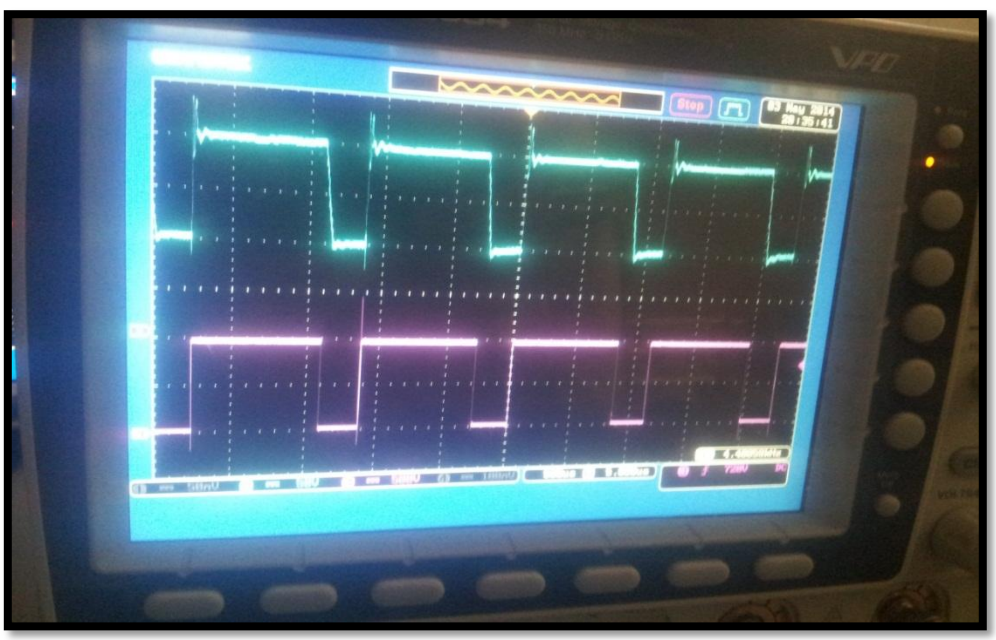


Fig.4.39Motor current and voltage waveform at 1800 rpm

Figure(4.40) shows PWM pulses applied to the IGBT gate figure(4.41) shows the motor voltage (blue line) and motor current (yellow line) at motor speed 2000 rpm while th duty cycle equal (0.86%)

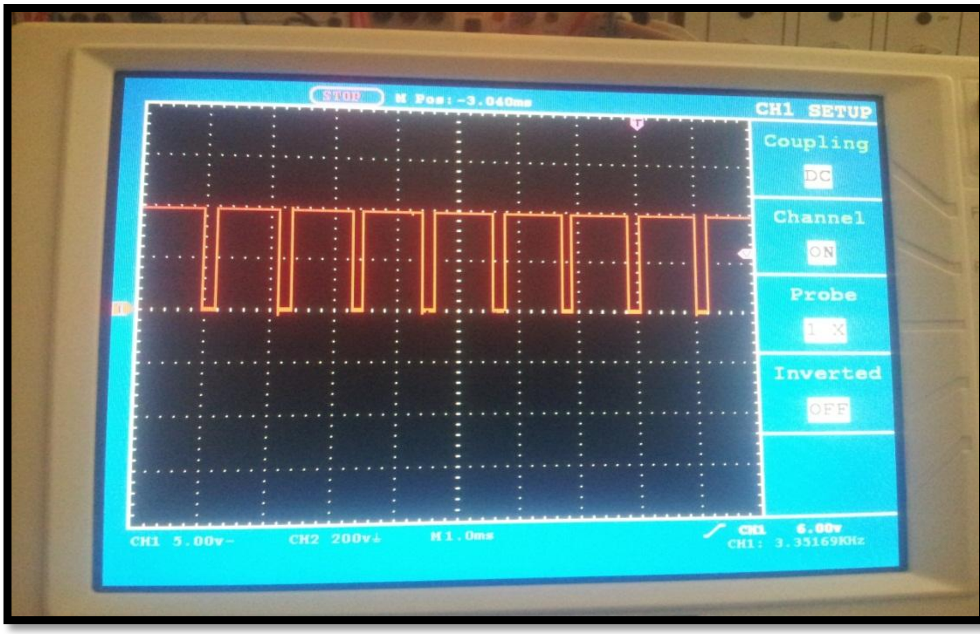


Fig.4.40output of gate drive circuit

Fig.4.41Motor current and voltage waveform at 2000 rpm

4.3.1. Relationship between motor voltage and duty cycle

Table 4.3 shows the values of motor voltage against due to cycle and figure 4.42 shows the relationship between motor voltage and duty cycle .

duty cycle	0	0.17	0.21	0.31	0.42	0.52	0.63	0.73	0.86
Motor Voltage (V)	0	24.5	50.4	73.3	98.2	121.8	146.2	170	200

Table 4.3

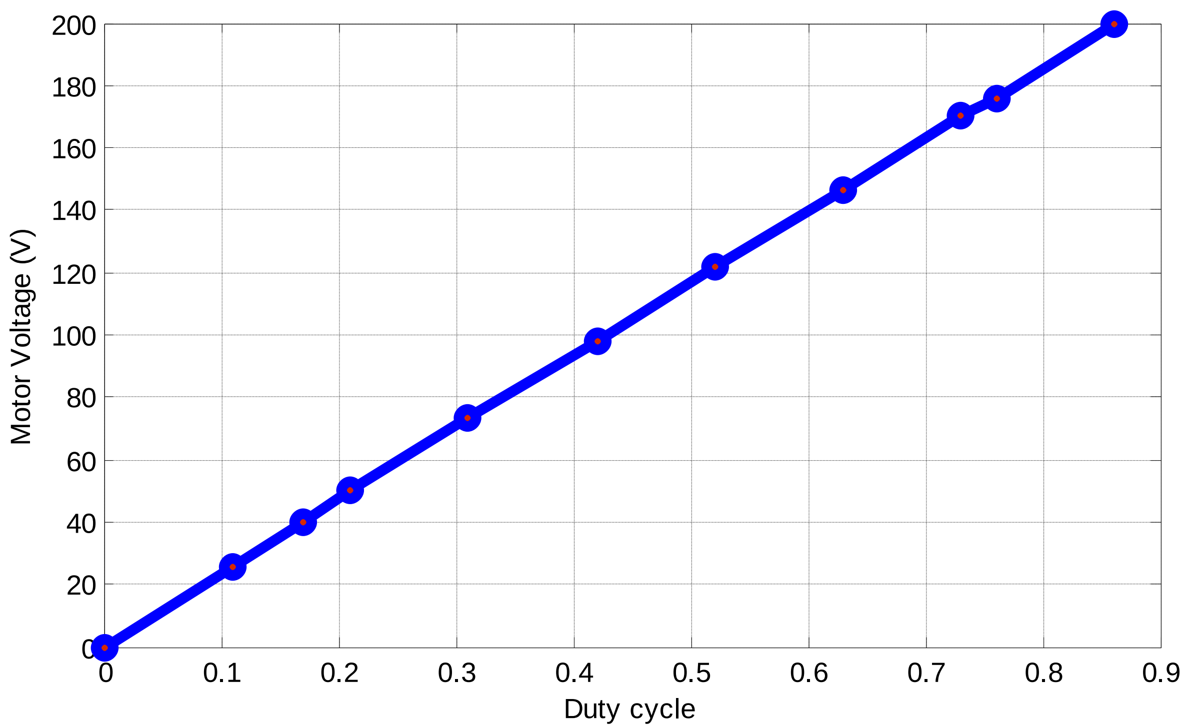


Fig.4.42 Relationship between motor voltage and duty cycle

4.3.2 Relationship between motor Speed and duty cycle

Table 4.4 shows the value of motor speed against duty cycle while figure 4,43 shows the relationship between motor speed and duty cycle .

duty cycle	0	0.17	0.21	0.31	0.42	0.52	0.63	0.73	0.86
motor Speed (rpm)	0	255	510	750	1000	1248	1500	1750	1994

Table 4.3

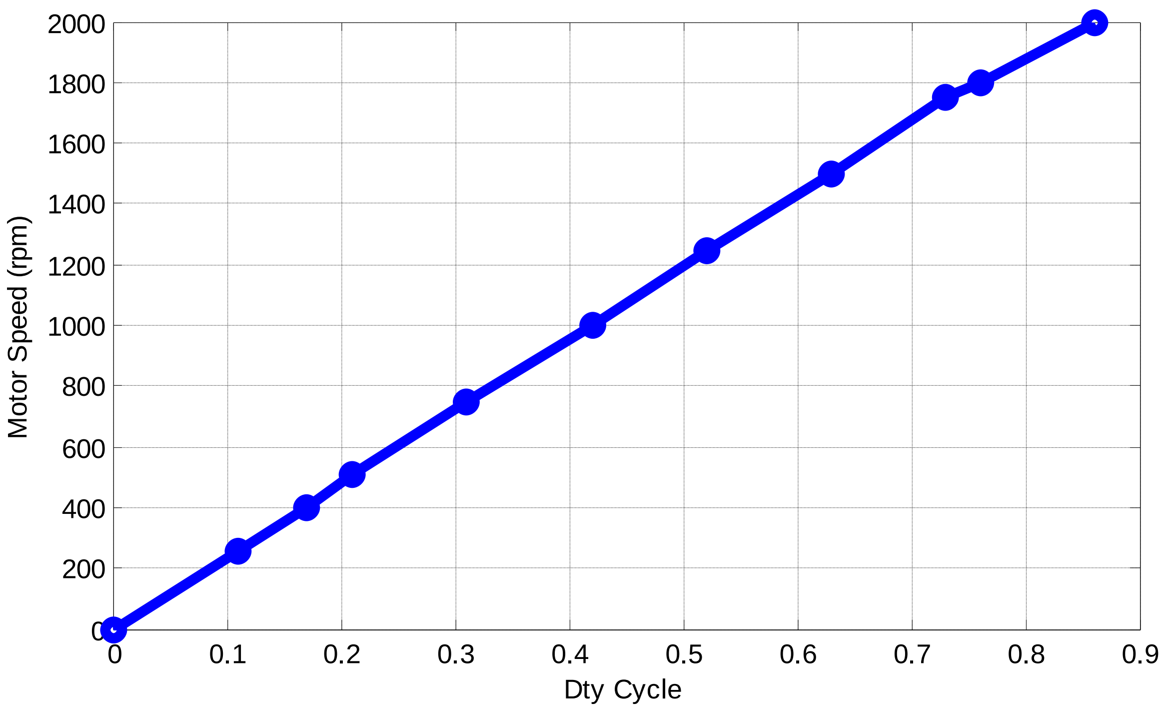


Fig.4.43 Relationship between motor Speed and duty cycle

4.3.3 Relationship between motor voltage and motor speed

Table 4.5 shows the value of motor speed against motor voltage while figure 4,43 shows the relationship between motor speed and it's voltage .

Motor Voltage (V)	0	24.5	50.4	73.3	98.2	121.8	146.2	170	200
motor Speed (rpm)	0	255	510	750	1000	1248	1500	1750	1994

Table 4.5

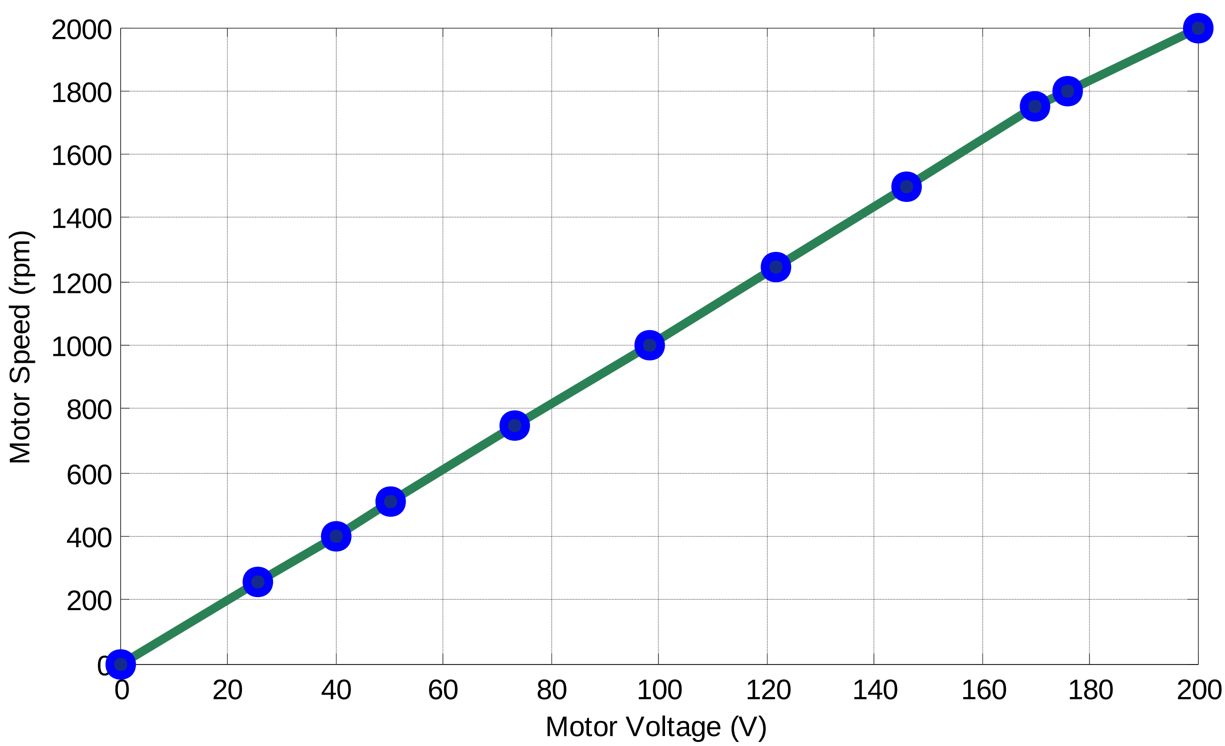


Fig.4.44 Relationship between motor voltage and motor speed

CONCLUSION

Speed Control of dc separately excited motor using Buck converter has been developed and tested:

1- The motor voltage can be regulated from 0 V two 230 V by controlling the duty cycle of switching IGBT on and off.

2- The lab has only one dc supply voltage 200 V which used in this project to fed dc motor field circuit.

3- Three phase Rectifier Circuit has been used to obtain dc voltage to supply motor armature circuit.

4- A simple circuit generate PWM using 555 has been developed and tested.

5- The timer 555 generate PWM and fed it to the IGBT gate drive circuit to control motor speed from 0 rpm to rated motor speed 2000 rpm.

6- This control circuit is easy to implement, low cost gives smooth speed control of dc.

7- Gate drive circuit has been developed using HCPL 3120 IGBT gate. This IC has two function :

1- Isolate the control circuit from power circuit.

2- Amplify the PWM generated by 555 timer to trigger IGBT.

REFERENCE

1- Rashid, Muhammad H. Power electronics . New Delhi :Khanna publisher ,2005 .

2- Bimbhra, Dr P S. Electrical Machinery . New Delhi :Khanna publisher ,1998.

3-Yilmaz H., VanDell W R., Owyang K, and change M.F,''Insulated gate transistor modeling and optimization ,''in IEDM Tech.Dig., 1984,p.724.

4- Rashid, Muhammad H. Power electronics . New Delhi : prentice Hall of India Pvt Ltd ,2001.

5- Bimbhra, Dr P S. Power Electronics. New Delhi khannapublisher , 2005.

6- Bimbhra, Dr P S. Electrical Machinery. . New Delhi khanna publisher 1998.

7- Leonhard, W. Control of electronic drive . New York .springer , 1995.

APPENDIXE

Ordering Informations

Part Number	Marking	Package	Packing Method
GBPC12005	GBPC12005	GBPC 4L	Bulk
GBPC1201	GBPC1201		
GBPC1202	GBPC1202		
GBPC1204	GBPC1204		
GBPC1206	GBPC1206		
GBPC1208	GBPC1208		
GBPC1210	GBPC1210		
GBPC15005	GBPC15005		
GBPC1501	GBPC1501		
GBPC1502	GBPC1502		
GBPC1504	GBPC1504		
GBPC1506	GBPC1506		
GBPC1508	GBPC1508		
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GBPC2508	GBPC2508		
GBPC2510	GBPC2510		
GBPC35005	GBPC35005		
GBPC3501	GBPC3501		
GBPC3502	GBPC3502		
GBPC3504	GBPC3504		
GBPC3506	GBPC3506		
GBPC3508	GBPC3508		
GBPC3510	GBPC3510		
GBPC1201W	GBPC1201W	GBPC-W 4L	
GBPC1202W	GBPC1202W		
GBPC1204W	GBPC1204W		
GBPC1206W	GBPC1206W		
GBPC1208W	GBPC1208W		
GBPC1210W	GBPC1210W		
GBPC15005W	GBPC15005W		
GBPC1501W	GBPC1501W		
GBPC1502W	GBPC1502W		
GBPC1504W	GBPC1504W		
GBPC1506W	GBPC1506W		
GBPC1508W	GBPC1508W		

GBPC 12, 15, 25, 35 SERIES — Bridge Rectifiers (Glass Passivated)

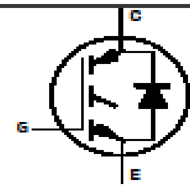
International
IOR Rectifier

PD -95190

IRG4PH50UDPbF

INSULATED GATE BIPOLAR TRANSISTOR WITH ULTRAFAST SOFT RECOVERY DIODE

UltraFast CoPack IGBT



n-channel

V_{CES} = 1200V

$V_{CE(on)\ typ.}$ = 2.78V

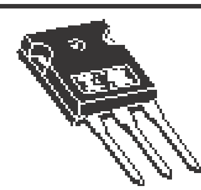
@V_{GE} = 15V, I_C = 24A

Features

- UltraFast: Optimized for high operating frequencies up to 40 kHz in hard switching, >200 kHz in resonant mode
- New IGBT design provides tighter parameter distribution and higher efficiency than previous generations
- IGBT co-packaged with HEXFRED™ ultrafast, ultra-soft-recovery anti-parallel diodes for use in bridge configurations
- Industry standard TO-247AC package
- Lead-Free

Benefits

- Higher switching frequency capability than competitive IGBTs
- Highest efficiency available
- HEXFRED diodes optimized for performance with IGBT's . Minimized recovery characteristics require less/no snubbing



TO-247AC

Absolute Maximum Ratings

	Parameter	Max.	Units
V_{CES}	Collector-to-Emitter Breakdown Voltage	1200	V
I_C @ T_C = 25°C	Continuous Collector Current	45	A
I_C @ T_C = 100°C	Continuous Collector Current	24	
I_{CM}	Pulsed Collector Current ①	180	
I_{LM}	Clamped Inductive Load Current ②	180	
I_F @ T_C = 100°C	Diode Continuous Forward Current	16	
I_{FM}	Diode Maximum Forward Current	180	
V_{GE}	Gate-to-Emitter Voltage	± 20	V
P_D @ T_C = 25°C	Maximum Power Dissipation	200	W
P_D @ T_C = 100°C	Maximum Power Dissipation	78	
T_J T_{STG}	Operating Junction and Storage Temperature Range	-55 to + 150	°C
	Soldering Temperature, for 10 seconds	300 (0.063 in. (1.6mm) from case)	
	Mounting torque, 6-32 or M3 screw.	10 lbf•in (1.1N•m)	

Thermal Resistance

	Parameter	Min.	Typ.	Max.	Units
$R_{θJC}$	Junction-to-Case - IGBT	----	----	0.64	°C/W
$R_{θJC}$	Junction-to-Case - Diode	----	----	0.83	
$R_{θCS}$	Case-to-Sink, flat, greased surface	----	0.24	----	
$R_{θJA}$	Junction-to-Ambient, typical socket mount	----	----	40	
Wt	Weight	----	6 (0.21)	----	g (oz)

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IRG4PH50UDPbF

International
IOR Rectifier

Electrical Characteristics @ T_J = 25°C (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Conditions	
$V_{(BR)CES}$	Collector-to-Emitter Breakdown Voltage③	1200	—	—	V	V_{GE} = 0V, I_C = 250µA	
$\Delta V_{(BR)CES}/\Delta T_J$	Temperature Coeff. of Breakdown Voltage	—	1.20	—	V/°C	V_{GE} = 0V, I_C = 1.0mA	
$V_{CE(on)}$	Collector-to-Emitter Saturation Voltage	—	2.56	3.5	V	I_C = 20A	V_{GE} = 15V
		—	2.78	3.7		I_C = 24A	
		—	3.20	—		I_C = 45A	See Fig. 2, 5
		—	2.54	—		I_C = 24A, T_J = 150°C	
$V_{GE(th)}$	Gate Threshold Voltage	3.0	—	6.0		V_{CE} = V_{GE}, I_C = 250µA	
$\Delta V_{GE(th)}/\Delta T_J$	Temperature Coeff. of Threshold Voltage	—	-13	—	mV/°C	V_{CE} = V_{GE}, I_C = 250µA	
g_{fe}	Forward Transconductance ④	23	35	—	S	V_{CE} = 100V, I_C = 24A	
I_{CES}	Zero Gate Voltage Collector Current	—	—	250	µA	V_{GE} = 0V, V_{CE} = 1200V	
		—	—	6500		V_{GE} = 0V, V_{CE} = 1200V, T_J = 150°C	
V_{FM}	Diode Forward Voltage Drop	—	2.5	3.5	V	I_C = 16A	See Fig. 13
		—	2.1	3.0		I_C = 16A, T_J = 150°C	
I_{GES}	Gate-to-Emitter Leakage Current	—	—	±100	nA	V_{GE} = ±20V	

Switching Characteristics @ T_J = 25°C (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Conditions	
Q_g	Total Gate Charge (turn-on)	—	160	250		I_C = 24A	
Qge	Gate - Emitter Charge (turn-on)	—	27	40	nC	V_{CC} = 400V See Fig. 8	
Q_{gc}	Gate - Collector Charge (turn-on)	—	53	80		V_{GE} = 15V	
$t_{d(on)}$	Turn-On Delay Time	—	47	—		T_J = 25°C	
t_r	Rise Time	—	24	—	ns	I_C = 24A, V_{CC} = 800V	
$t_{d(off)}$	Turn-Off Delay Time	—	110	170		V_{GE} = 15V, R_G = 5.0Ω	
t_f	Fall Time	—	180	260		Energy losses include "tail" and	
E_{on}	Turn-On Switching Loss	—	2.10	—		diode reverse recovery.	
E_{off}	Turn-Off Switching Loss	—	1.50	—	mJ	See Fig. 9, 10, 18	
E_{ts}	Total Switching Loss	—	3.60	4.6			
$t_{d(on)}$	Turn-On Delay Time	—	46	—		T_J = 150°C, See Fig. 11, 18	
t_r	Rise Time	—	27	—	ns	I_C = 24A, V_{CC} = 800V	
$t_{d(off)}$	Turn-Off Delay Time	—	240	—		V_{GE} = 15V, R_G = 5.0Ω	
t_f	Fall Time	—	330	—		Energy losses include "tail" and	
E_{ts}	Total Switching Loss	—	6.38	—	mJ	diode reverse recovery.	
L_E	Internal Emitter Inductance	—	13	—	nH	Measured 5mm from package	
C_{ies}	Input Capacitance	—	3600	—		V_{GE} = 0V	
C_{oes}	Output Capacitance	—	160	—	pF	V_{CC} = 30V See Fig. 7	
C_{res}	Reverse Transfer Capacitance	—	31	—		f = 1.0MHz	
t_{rr}	Diode Reverse Recovery Time	—	90	135	ns	T_J = 25°C See Fig.	
		—	164	245		T_J = 125°C 14	I_F = 16A
I_{rr}	Diode Peak Reverse Recovery Current	—	5.8	10	A	T_J = 25°C See Fig.	
		—	8.3	15		T_J = 125°C 15	V_R = 200V
Q_{rr}	Diode Reverse Recovery Charge	—	260	675	nC	T_J = 25°C See Fig.	
		—	680	1838		T_J = 125°C 16	di/dt = 200A/µs
$di_{(rec)M}/dt$	Diode Peak Rate of Fall of Recovery During t_b	—	120	—	A/µs	T_J = 25°C See Fig.	
		—	76	—		T_J = 125°C 17	

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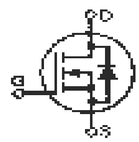
IXYS ADVANCE TECHNICAL INFORMATION

PolarHV™ HiPerFET Power MOSFET

IXFA 14N60P
IXFP 14N60P
IXFH 14N60P

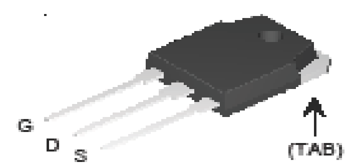
V_{DSS} = 600 V
I_{D25} = 14 A
$R_{DS(on)}$ ≤ 550 mΩ

N-Channel Enhancement Mode

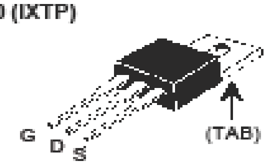


Symbol	Test Conditions	Maximum Ratings	
V_{DSS}	T_J = 25°C to 150°C	600	V
V_{DGR}	T_J = 25°C to 150°C; R_{GS} = 1 MΩ	600	V
V_{GS}	Continuous	±30	V
V_{GSM}	Transient	±40	V
I_{D25}	T_C = 25°C	14	A
I_{DM}	T_C = 25°C, pulse width limited by T_{JM}	42	A
I_{AR}	T_C = 25°C	14	A
E_{AR}	T_C = 25°C	23	mJ
E_{AS}	T_C = 25°C	0.9	J
dv/dt	$I_S \le I_{DM}$, di/dt ≤ 100 A/µs, $V_{DD} \le V_{DSS}$, $T_J \le$ 150°C, R_G = 4 Ω	10	V/ns
P_D	T_C = 25°C	300	W
T_J		-55 ... +150	°C
T_{JM}		150	°C
T_{stg}		-55 ... +150	°C
T_L	1.6 mm (0.062 in.) from case for 10 s	300	°C
	Plastic body for 10 s	250	°C
M_d	Mounting torque (TO-3P,TO-220)	1.13/10	Nm/lb.in.
Weight	TO-247	6	g
	TO-220	4	g
	TO-263	2	g

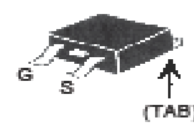
TO-3P (IXTQ)



TO-220 (IXTP)



TO-263 (IXTA)



G = Gate D = Drain
S = Source TAB = Drain

Features

- International standard packages
- Unclamped Inductive Switching (UIS) rated
- Low package inductance
  - easy to drive and to protect

Advantages

- Easy to mount
- Space savings
- High power density

Symbol	Test Conditions (T_J = 25°C, unless otherwise specified)	Characteristic Values Min.	Typ.	Max.	
V_{DSS}	V_{GS} = 0 V, I_D = 250 µA	600			V
$V_{GS(th)}$	V_{DS} = V_{GS}, I_D = 4 mA	3.5		5.5	V
I_{GSS}	V_{GS} = ±30 V_{DC}, V_{DS} = 0			±100	nA
I_{DSS}	V_{DS} = V_{DSS}			5	µA
	V_{GS} = 0 V T_J = 125°C			50	µA
$R_{DS(on)}$	V_{GS} = 10 V, I_D = 0.5 I_{D25} Pulse test, t ≤ 300 µs, duty cycle d ≤ 2 %		450	550	mΩ

DS99319(12/05)

IXYS

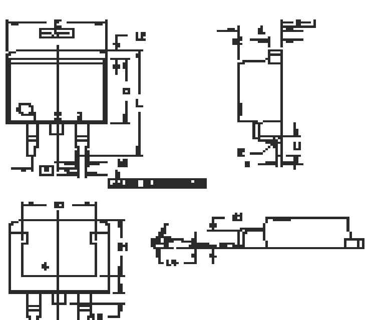
IXFA 14N60P IXFP 14N60P
IXFH 14N60P

Symbol	Test Conditions	Characteristic Values (T_J = 25°C, unless otherwise specified) Min.	Typ.	Max.	
g_{fs}	V_{DS} = 20 V; I_D = 0.5 I_{D25}, pulse test	7	13		S
C_{iss}	V_{GS} = 0 V, V_{DS} = 25 V, f = 1 MHz		2300		pF
C_{oss}			215		pF
C_{rss}			13		pF
$t_{d(on)}$	V_{GS} = 10 V, V_{DS} = 0.5 V_{DSS}, I_D = I_{D25}		23		ns
t_r	R_G = 10 Ω (External)		27		ns
$t_{d(off)}$			70		ns
t_f			26		ns
$Q_{g(on)}$	V_{GS} = 10 V, V_{DS} = 0.5 V_{DSS}, I_D = 0.5 I_{D25}		38		nC
Q_{gs}			14		nC
Q_{gd}			12		nC
R_{thJC}				0.42	K/W
R_{thCK}	(TO-3P)		0.21		K/W
R_{thCK}	(TO-220)		0.25		K/W

Source-Drain Diode

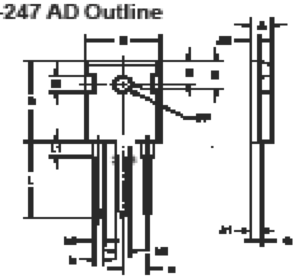
Symbol	Test Conditions	Characteristic Values (T_J = 25°C, unless otherwise specified) min.	typ.	max.	
I_S	V_{GS} = 0 V			14	A
I_{SM}	Repetitive			42	A
V_{SD}	I_F = I_S, V_{GS} = 0 V, Pulse test, t ≤ 300 µs, duty cycle d ≤ 2 %			1.5	V
t_{rr}	I_F = 14 A, -di/dt = 100 A/µs			250	ns
I_{RM}	V_R = 100 V		6		A
Q_{RM}			0.6		µC

TO-263 (IXTA) Outline



Dim.	Millimeter Min.	Millimeter Max.	Inches Min.	Inches Max.
A	4.06	4.83	.160	.190
A1	2.03	2.79	.080	.110
b	0.51	0.99	.020	.039
b2	1.14	1.40	.045	.055
c	0.46	0.74	.018	.029
c2	1.14	1.40	.045	.055
D	8.64	9.65	.340	.380
D1	7.11	8.13	.280	.320
E	9.65	10.29	.380	.405
E1	6.86	8.13	.270	.320
e	2.54	BSC	.100	BSC
L	14.61	15.88	.575	.625
L1	2.29	2.79	.090	.110
L2	1.02	1.40	.040	.055
L3	1.27	1.78	.050	.070
L4	0	0.38	0	.015
R	0.46	0.74	.018	.029

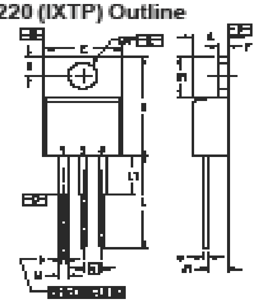
TO-247 AD Outline



Terminals: 1 - Gate 2 - Drain
3 - Source Tab - Drain

Dim.	Millimeter Min.	Millimeter Max.	Inches Min.	Inches Max.
A	4.7	5.3	.185	.209
A_1	2.2	2.54	.087	.102
A_2	2.2	2.6	.059	.098
b	1.0	1.4	.040	.055
b_1	1.65	2.13	.065	.084
b_2	2.87	3.12	.113	.123
C	.4	.8	.016	.031
D	20.80	21.46	.819	.845
E	15.75	16.26	.610	.640
e	5.20	5.72	0.205	0.225
L	19.81	20.32	.780	.800
L1		4.50		.177
ØP	3.55	3.65	.140	.144
Q	5.89	6.40	0.232	0.252
R	4.32	5.49	.170	.216
S	6.15	BSC	242	BSC

TO-220 (IXTP) Outline



Pins: 1 - Gate 2 - Drain

SYM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	.170	.190	4.32	4.83
b	.025	.040	0.64	1.02
b1	.045	.065	1.15	1.65
c	.014	.022	0.35	0.56
D	.580	.630	14.73	16.00
E	.390	.420	9.91	10.66
e	.100 BSC		2.54 BSC	
F	.045	.055	1.14	1.40
H1	.230	.270	5.85	6.85
J1	.090	.110	2.29	2.79
k	0	.015	0	0.38
L	.500	.550	12.70	13.97
L1	.110	.230	2.79	5.84
ØP	.139	.161	3.53	4.08
Q	.100	.125	2.54	3.18

FAIRCHILD SEMICONDUCTOR®

MUR8100E, RURP8100

Data Sheet *November 2013*

8 A, 1000 V Ultrafast Diodes

The MUR8100E, RUR8100 is an ultrafast diode with low forward voltage drop. This device is intended for use as freewheeling and clamping diodes in a variety of switching power supplies and other power switching applications. It is specially suited for use in switching power supplies and industrial application.

Features

- Ultrafast Recovery t_{rr} = 100 ns (@ I_F = 8 A)
- Max Forward Voltage, V_F = 1.8 V (@ T_C = 25°C)
- 1000 V Reverse Voltage and High Reliability
- Avalanche Energy Rated
- RoHS Compliant

Applications

- Switching Power Supply
- Power Switching Circuits
- General Purpose

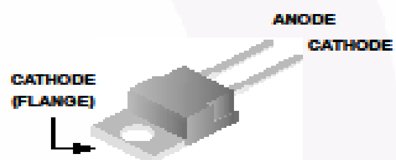
Ordering Information

PART NUMBER	PACKAGE	BRAND
MUR8100E	TO-220AC	MU8100
RURP8100	TO-220AC	RURP8100

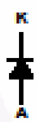
NOTE: When ordering, use entire part number.

Packaging

JEDEC TO-220AC



Symbol



Absolute Maximum Ratings T_C = 25°C, Unless Otherwise Specified

		MUR8100E RURP8100	UNIT
Peak Repetitive Reverse Voltage	V_{RRM}	1000	V
Working Peak Reverse Voltage	V_{RWM}	1000	V
DC Blocking Voltage	V_R	1000	V
Average Rectified Forward Current (T_C = 155°C)	$I_{F(AV)}$	8	A
Repetitive Peak Surge Current (Square Wave 20kHz)	I_{FRM}	16	A
Nonrepetitive Peak Surge Current (Halfwave 1 Phase 60Hz)	I_{FSM}	100	A
Maximum Power Dissipation	P_D	75	W
Avalanche Energy (See Figures 10 and 11)	E_{AVL}	20	mJ
Operating and Storage Temperature	T_{STG}, T_J	-55 to 175	°C

MUR8100E, RURP8100 Rev. C1 1 www.fairchildsemi.com

MUR8100E, RURP8100

Electrical Specifications $T_C = 25^oC$, Unless Otherwise Specified.

SYMBOL	TEST CONDITION	MIN	TYP	MAX	UNIT
V_F	$I_F = 8$ A	-	-	1.8	V
	$I_F = 8$ A, $T_C = 150^oC$	-	-	1.5	V
I_R	$V_R = 1000$ V	-	-	100	µA
	$V_R = 1000$ V, $T_C = 150^oC$	-	-	500	µA
t_{rr}	$I_F = 1$ A	-	-	85	ns
	$I_F = 8$ A, $dI_F/dt = 200$ A/µs	-	-	100	ns
t_a	$I_F = 8$ A, $dI_F/dt = 200$ A/µs	-	50	-	ns
t_b	$I_F = 8$ A, $dI_F/dt = 200$ A/µs	-	30	-	ns
Q_{RR}	$I_F = 8$ A, $dI_F/dt = 200$ A/µs	-	500	-	nC
C_J	$V_R = 10$ V, $I_F = 0$ A	-	30	-	pF
$R_{\theta JC}$		-	-	2.0	$^oC/W$

DEFINITIONS

V_F = Instantaneous forward voltage (pw = 300 µs, D = 2%).

I_R = Instantaneous reverse current.

T_{rr} = Reverse recovery time at $dI_F/dt = 100A/\mu s$ (See Figure 9), summation of $t_a + t_b$.

t_a = Time to reach peak reverse current at $dI_F/dt = 100A/\mu s$ (See Figure 9).

t_b = Time from peak I_{RM} to projected zero crossing of I_{RM} based on a straight line from peak I_{RM} through 25% of I_{RM} (See Figure 9).

Q_{RR} = Reverse recovery charge.

C_J = Junction Capacitance.

$R_{\theta JC}$ = Thermal resistance junction to case.

pw = Pulse width.

D = Duty cycle.

Typical Performance Curves

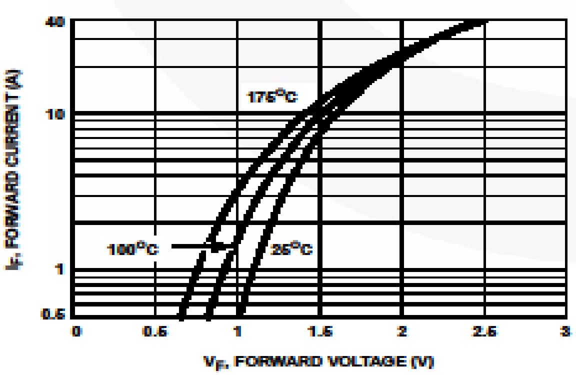


FIGURE 1. FORWARD CURRENT vs FORWARD VOLTAGE

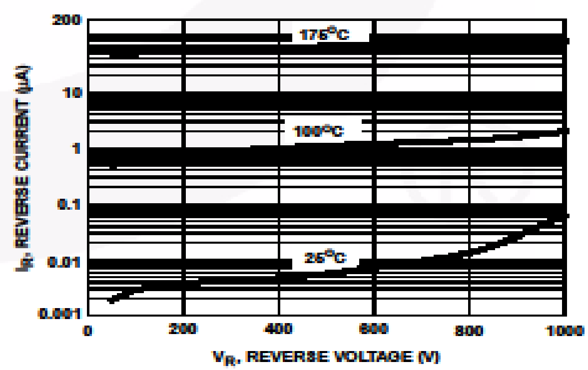


FIGURE 2. REVERSE CURRENT vs REVERSE VOLTAGE

SURGE

1N5817 THRU 1N5819

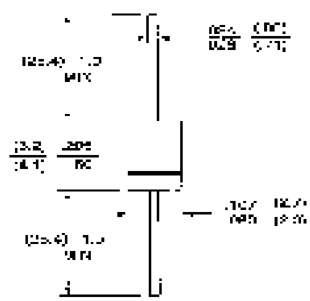
1 AMPERE SCHOTTKY BARRIER RECTIFIERS

VOLTAGE - 20 to 40 Volts CURRENT - 1.0 Ampere

FEATURES

- Plastic package has Underwriters Laboratory Flammability Classification 94V-O utilizing Flame Retardant Epoxy Molding Compound.
- 1 ampere operation at TL = 90°C with no thermal runaway
- Exceeds environmental standards of MIL-S-19500/228
- For use in low voltage, high frequency inverters free wheeling, and polarity protection applications

DO-41



Dimensions in inches and (millimeters)

MECHANICAL DATA

Case: Molded plastic, JEDEC DO-41

Terminals: Axial leads, solderable per MIL-STD-202, Method 208

Polarity: Color band denotes cathode

Mounting position: Any

Weight: 0.012 ounce, 0.3 gram

MAXIMUM RATINGS AND ELECTRICAL CHARACTERISTICS

Ratings at 25°C ambient temperature unless otherwise specified.
Single phase, half wave, 60 Hz, resistive or inductive load

	1N5817	1N5818	1N5819	UNITS
Maximum Recurrent Peak Reverse Voltage	20	30	40	V
Maximum RMS Voltage	14	21	28	V
Maximum DC Blocking Voltage	20	30	40	V
Maximum Average Forward Rectified Current 3/8" Lead Length TL = 90°C		1.0		A
Peak Forward Surge Current 8.3 ms single half sine-wave superimposed on rated load (JEDEC method) TL = 70°C		25		A
Maximum Forward Voltage at 1.0A DC	.45	.55	.60	V
Maximum Forward Voltage at 3.0A DC	.75	.875	.90	V
Maximum Average DC Reverse Current TA = 25°C at Peak Reverse Voltage TA = 100°C		0.5 10		mA mA
Typical Junction Capacitance (Note 1)		110		pF
Typical Thermal Resistance (Note 2)		50		°C/W
Operating Temperature Range Storage Temperature Range		-65 to +125		°C

NOTES:
1. Measured at 1 MHz and applied reverse voltage of 4.0 VDC.
2. Thermal Resistance Junction to Ambient.

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SURGE

RATING AND CHARACTERISTIC CURVES
1N5817 THRU 1N5819

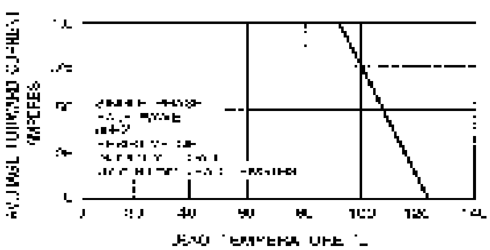

Fig. 1 FORWARD CURRENT DERATING CURVE

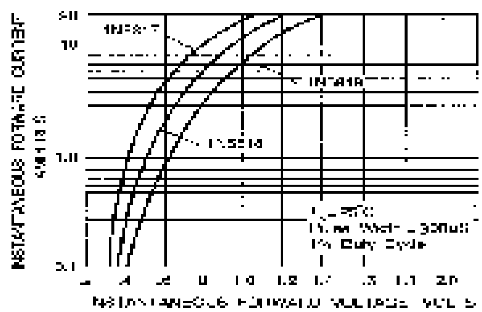

Fig. 2 – TYPICAL INSTANTANEOUS FORWARD CHARACTERISTICS

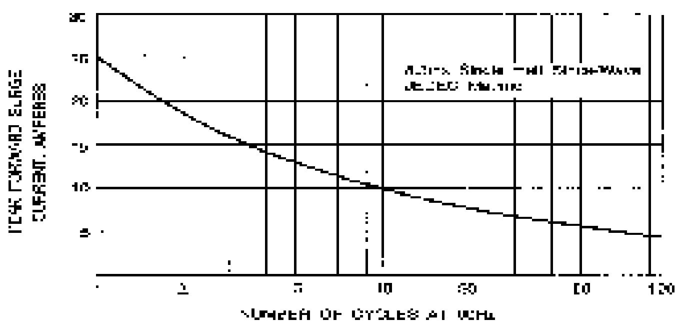

Fig. 3 - MAXIMUM NON-REPETITIVE SURGE CURRENT

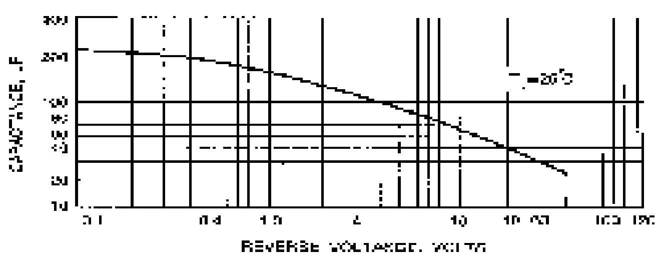

Fig. 4 – TYPICAL JUNCTION CAPACITANCE

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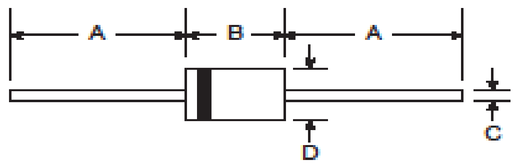
DIODES INCORPORATED

1N5817 - 1N5819

1.0A SCHOTTKY BARRIER RECTIFIER

Features

- Guard Ring Die Construction for Transient Protection
- Low Power Loss, High Efficiency
- High Surge Capability
- High Current Capability and Low Forward Voltage Drop
- For Use in Low Voltage, High Frequency Inverters, Free Wheeling, and Polarity Protection Application
- **Lead Free Finish, RoHS Compliant (Note 5)**



Mechanical Data

- Case: DO-41
- Case Material: Molded Plastic. UL Flammability Classification Rating 94V-0
- Moisture Sensitivity: Level 1 per J-STD-020C
- Terminals: Finish — Tin. Plated Leads Solderable per MIL-STD-202, Method 208
- Polarity: Cathode Band
- Ordering Information: See Page 2
- Marking: Type Number and Date Code
- Weight: 0.3 grams (approximate)

DO-41 Plastic		
Dim	Min	Max
A	25.40	—
B	4.06	5.21
C	0.71	0.864
D	2.00	2.72
All Dimensions in mm		

Maximum Ratings and Electrical Characteristics

@ T_A = 25°C unless otherwise specified

Single phase, half wave, 60Hz, resistive or inductive load.
For capacitive load, derate current by 20%.

Characteristic	Symbol	1N5817	1N5818	1N5819	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	20	30	40	V
RMS Reverse Voltage	$V_{R(RMS)}$	14	21	28	V
Average Rectified Output Current (Note 1) @ T_L = 90°C	I_O	1.0			A
Non-Repetitive Peak Forward Surge Current 8.3ms single half sine-wave superimposed on rated load	I_{FSM}	25			A
Forward Voltage (Note 2) @ I_F = 1.0A @ I_F = 3.0A	V_{FM}	0.450 0.750	0.550 0.875	0.60 0.90	V
Peak Reverse Leakage Current @ T_A = 25°C at Rated DC Blocking Voltage (Note 2) @ T_A = 100°C	I_{RM}	1.0 10			mA
Typical Total Capacitance (Note 3)	C_T	110			pF
Typical Thermal Resistance Junction to Lead (Note 4)	$R_{\theta JL}$	15			°C/W
Typical Thermal Resistance Junction to Ambient	$R_{\theta JA}$	50			
Operating and Storage Temperature Range	T_j, T_{STG}	-65 to +125			°C

Notes:
1. Measured at ambient temperature at a distance of 9.5mm from the case.
2. Short duration test pulse used to minimize self-heating effect.
3. Measured at 1.0MHz and applied reverse voltage of 4.0V DC.
4. Thermal resistance from junction to lead vertical P.C.B. mounted, 0.375" (9.5mm) lead length with 1.5 x 1.5" (38 x 38mm) copper pads.
5. RoHS revision 13.2.2003. Glass and High Temperature Solder Exemptions Applied, see *EU Directive Annex Notes 5 and 7.*

DIODES INCORPORATED

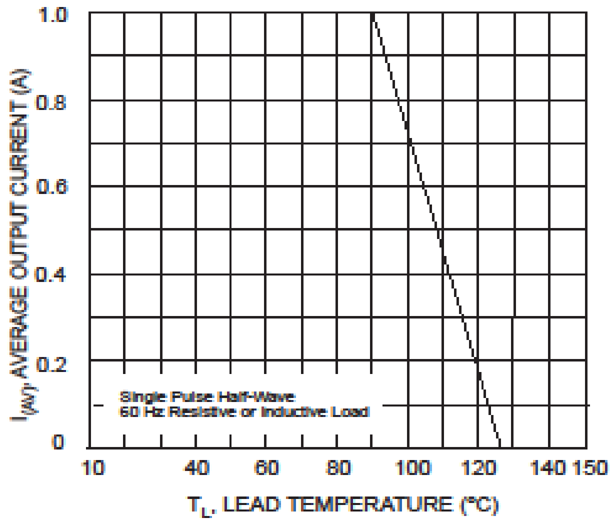


Fig. 1 Forward Current Derating Curve

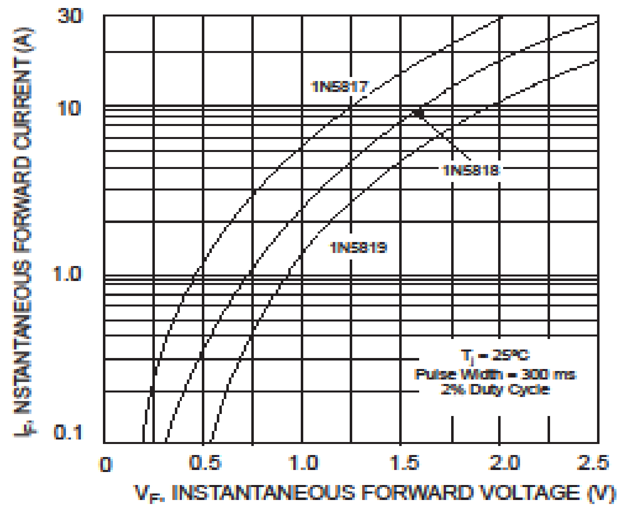


Fig. 2 Typical Forward Characteristics

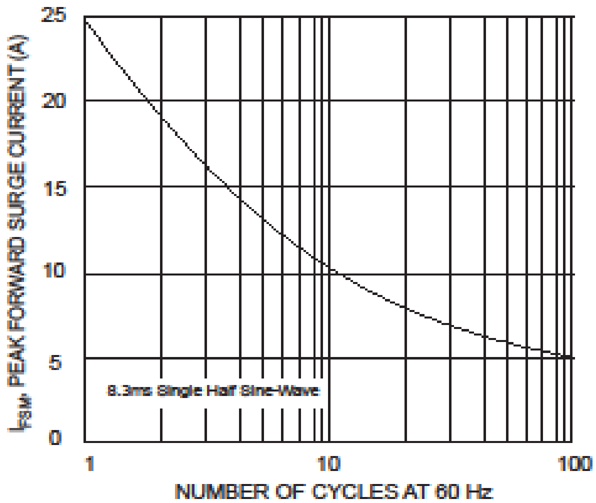


Fig. 3 Maximum Non-Repetitive Peak Fwd Surge Current

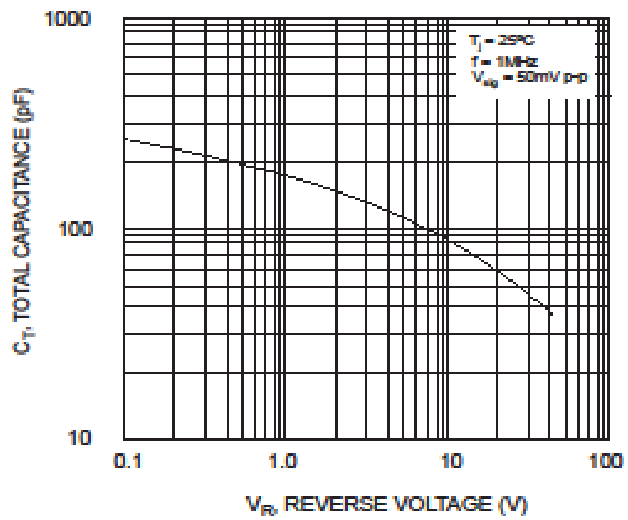


Fig. 4 Typical Total Capacitance

Ordering Information (Note 6)

Device	Packaging	Shipping
1N5817-B	DO-41	1K/Bulk
1N5817-T	DO-41	5K/Tape & Reel, 13-inch
1N5818-B	DO-41	1K/Bulk
1N5818-T	DO-41	5K/Tape & Reel, 13-inch
1N5819-B	DO-41	1K/Bulk
1N5819-T	DO-41	5K/Tape & Reel, 13-inch

Notes: 6. For packaging details, visit our website at http://www.diodes.com/datasheets/ap02008.pdf

BY251 - BY255

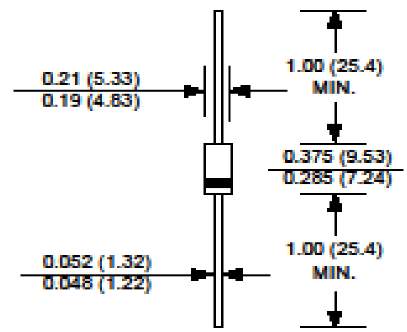
SILICON RECTIFIER DIODES

PRV : 200 - 1300 Volts
Io : 3.0 Amperes

FEATURES :
* High current capability
* High surge current capability
* High reliability
* Low reverse current
* Low forward voltage drop

MECHANICAL DATA :
* Case : DO-201AD Molded plastic
* Epoxy : UL94V-O rate flame retardant
* Lead : Axial lead solderable per MIL-STD-202, Method 208 guaranteed
* Polarity : Color band denotes cathode end
* Mounting position : Any
* Weight : 0.929 grams

DO - 201AD



Dimensions in inches and (millimeters)

MAXIMUM RATINGS AND ELECTRICAL CHARACTERISTICS

Rating at 25 °C ambient temperature unless otherwise specified.
Single phase, half wave, 60 Hz, resistive or inductive load.
For capacitive load, derate current by 20%.

RATING	SYMBOL	BY251	BY252	BY253	BY254	BY255	UNIT
Maximum Repetitive Peak Reverse Voltage	V_{RRM}	200	400	600	800	1300	V
Maximum RMS Voltage	V_{RMS}	140	280	420	560	910	V
Maximum DC Blocking Voltage	V_{DC}	200	400	600	800	1300	V
Maximum Average Forward Current 0.375"(9.5mm) Lead Length Ta = 50 °C	I_F	3.0					A
Peak Forward Surge Current 8.3ms Single half sine wave Superimposed on rated load (JEDEC Method)	I_{FSM}	100					A
Maximum Forward Voltage at I_F = 3.0 Amps.	V_F	1.1					V
Maximum DC Reverse Current Ta = 25 °C	I_R	20					μA
at rated DC Blocking Voltage Ta = 100 °C	$I_{R(H)}$	50					μA
Typical Junction Capacitance (Note1)	C_J	50					pF
Typical Thermal Resistance (Note2)	$R\theta JA$	18					°C/W
Junction Temperature Range	T_J	- 65 to + 175					°C
Storage Temperature Range	T_{STG}	- 65 to + 175					°C

Notes :
(1) Measured at 1.0 MHz and applied reverse voltage of 4.0 V_{DC}
(2) Thermal resistance from Junction to Ambient at 0.375" (9.5mm) Lead Lengths, P.C. Board Mounted.

Rev. 01 : Mar 23, 2002

EIC

Certificate Number: Q10561 Certificate Number: EC7333

RATING AND CHARACTERISTIC CURVES (BY251 - BY255)

FIG.1 - DERATING CURVE FOR OUTPUT RECTIFIED CURRENT

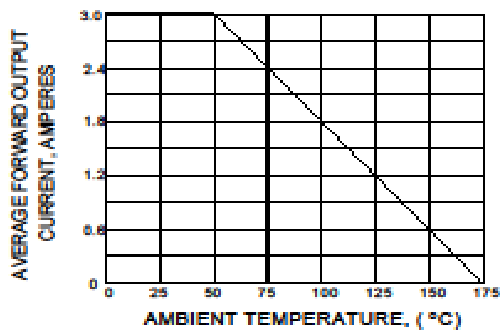


FIG.2 - MAXIMUM NON-REPETITIVE PEAK FORWARD SURGE CURRENT

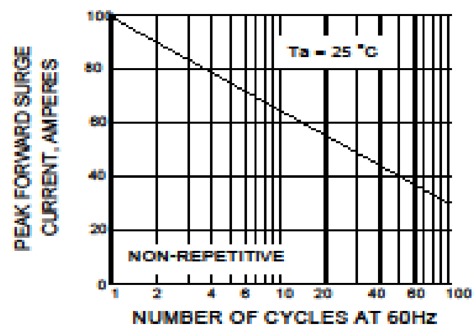


FIG.3 - TYPICAL FORWARD CHARACTERISTICS

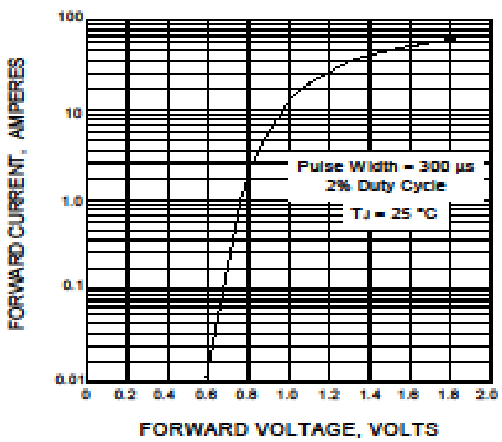


FIG 4 . - TYPICAL JUNCTION CAPACITANCE

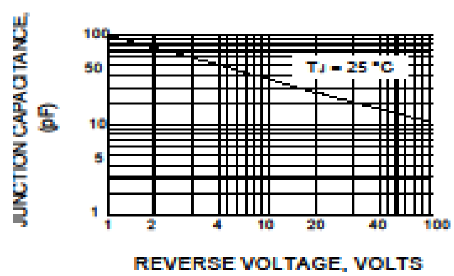
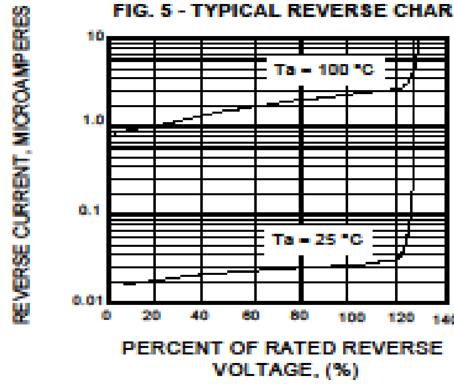


FIG. 5 - TYPICAL REVERSE CHARACTERISTICS



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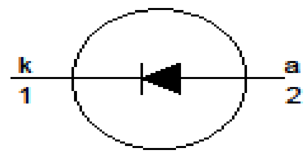
Rectifier diodes fast, soft-recovery

BY329 series

FEATURES

- Low forward volt drop
- Fast switching
- Soft recovery characteristic
- High thermal cycling performance
- Low thermal resistance

SYMBOL



QUICK REFERENCE DATA

V_R = 800 V/ 1000 V/ 1200 V

$I_{F(AV)}$ = 8 A

$I_{FSM} \leq$ 75 A

$t_{rr} \leq$ 135 ns

GENERAL DESCRIPTION

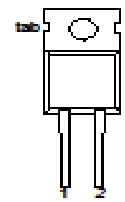
Glass-passivated double diffused rectifier diodes featuring low forward voltage drop, fast reverse recovery and soft recovery characteristic. The devices are intended for use in TV receivers, monitors and switched mode power supplies.

The BY329 series is supplied in the conventional leaded SOD59 (TO220AC) package.

PINNING

PIN	DESCRIPTION
1	cathode
2	anode
tab	cathode

SOD59 (TO220AC)



LIMITING VALUES

Limiting values in accordance with the Absolute Maximum System (IEC 134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.			UNIT
		BY329		-800	-1000	-1200	
V_{RSM}	Peak non-repetitive reverse voltage		-	800	1000	1200	V
V_{RRM}	Peak repetitive reverse voltage		-	800	1000	1200	V
V_{RWM}	Crest working reverse voltage		-	600	800	1000	V
$I_{F(AV)}$	Average forward current[1]	square wave; δ = 0.5; $T_{mb} \leq$ 122 °C	-	8			A
		sinusoidal; a = 1.57; $T_{mb} \leq$ 125 °C	-	7			A
$I_{F(RMS)}$	RMS forward current		-	11			A
I_{FRM}	Repetitive peak forward current	t = 25 µs; δ = 0.5; $T_{mb} \leq$ 122 °C	-	16			A
I_{FSM}	Non-repetitive peak forward current	t = 10 ms	-	75			A
		t = 8.3 ms sinusoidal; T_j = 150 °C prior to surge; with reapplied $V_{RWM(max)}$	-	82			A
I^2t	I^2t for fusing	t = 10 ms	-	28			A^2s
T_{stg}	Storage temperature		-40	150			°C
T_j	Operating junction temperature		-	150			°C

1 Neglecting switching and reverse current losses.

Rectifier diodes
fast, soft-recovery

BY329 series

THERMAL RESISTANCES

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
$R_{th\ j\text{-}mb}$	Thermal resistance junction to mounting base		-	-	2.0	K/W
$R_{th\ j\text{-}a}$	Thermal resistance junction to ambient	in free air.	-	60	-	K/W

STATIC CHARACTERISTICS

T_j = 25 °C unless otherwise stated

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
V_F	Forward voltage	I_F = 20 A	-	1.5	1.85	V
I_R	Reverse current	$V_R = V_{RWM}$; T_j = 125 °C	-	0.1	1.0	mA

DYNAMIC CHARACTERISTICS

T_j = 25 °C unless otherwise stated

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
t_{rr}	Reverse recovery time	I_F = 1 A; $V_R \geq$ 30 V; $-dI_F/dt$ = 50 A/µs	-	100	135	ns
Q_s	Reverse recovery charge	I_F = 2 A; $V_R \geq$ 30 V; $-dI_F/dt$ = 20 A/µs	-	0.5	0.7	µC
dI_R/dt	Maximum slope of the reverse recovery current	I_F = 2 A; $-dI_F/dt$ = 20 A/µs	-	50	60	A/µs

PD- 91621C

International
IOR Rectifier

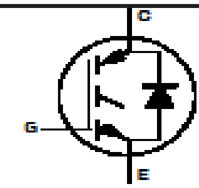
IRG4PH40UD

INSULATED GATE BIPOLAR TRANSISTOR WITH ULTRAFAST SOFT RECOVERY DIODE

UltraFast CoPack IGBT

Features

- UltraFast: Optimized for high operating frequencies up to 40 kHz in hard switching, >200 kHz in resonant mode
- New IGBT design provides tighter parameter distribution and higher efficiency than previous generations
- IGBT co-packaged with HEXFRED™ ultrafast, ultra-soft-recovery anti-parallel diodes for use in bridge configurations
- Industry standard TO-247AC package



n-channel

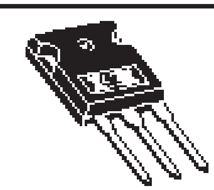
V_{CES} = 1200V

$V_{CE(on)}$ typ. = 2.43V

@V_{GE} = 15V, I_C = 21A

Benefits

- Higher switching frequency capability than competitive IGBTs
- Highest efficiency available
- HEXFRED diodes optimized for performance with IGBT's . Minimized recovery characteristics require less/no snubbing


TO-247AC

Absolute Maximum Ratings

	Parameter	Max.	Units
V_{CES}	Collector-to-Emitter Breakdown Voltage	1200	V
I_C @ T_C = 25°C	Continuous Collector Current	41	A
I_C @ T_C = 100°C	Continuous Collector Current	21	
I_{CM}	Pulsed Collector Current ①	82	
I_{LM}	Clamped Inductive Load Current ②	82	
I_F @ T_C = 100°C	Diode Continuous Forward Current	8.0	
I_{FM}	Diode Maximum Forward Current	130	
V_{GE}	Gate-to-Emitter Voltage	± 20	V
P_D @ T_C = 25°C	Maximum Power Dissipation	160	W
P_D @ T_C = 100°C	Maximum Power Dissipation	65	
T_J T_{STG}	Operating Junction and Storage Temperature Range	-55 to + 150	°C
	Soldering Temperature, for 10 seconds	300 (0.063 in. (1.6mm) from case)	
	Mounting torque, 6-32 or M3 screw.	10 lbf•in (1.1 N•m)	

Thermal Resistance

	Parameter	Min.	Typ.	Max.	Units
$R_{θJC}$	Junction-to-Case - IGBT	——	——	0.77	°C/W
$R_{θJC}$	Junction-to-Case - Diode	——	——	1.7	
$R_{θCS}$	Case-to-Sink, flat, greased surface	——	0.24	——	
$R_{θJA}$	Junction-to-Ambient, typical socket mount	——	——	40	
Wt	Weight	——	6 (0.21)	——	g (oz)

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1/24/06

IRG4PH40UD

International
IOR Rectifier

Electrical Characteristics @ T_J = 25°C (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Conditions	
$V_{(BR)CES}$	Collector-to-Emitter Breakdown Voltage③	1200	—	—	V	V_{GE} = 0V, I_C = 250µA	
$\Delta V_{(BR)CES}/\Delta T_J$	Temperature Coeff. of Breakdown Voltage	—	0.43	—	V/°C	V_{GE} = 0V, I_C = 1.0mA	
$V_{CE(on)}$	Collector-to-Emitter Saturation Voltage	—	2.43	3.1	V	I_C = 21A	V_{GE} = 15V
		—	2.97	—		I_C = 41A	See Fig. 2, 5
		—	2.47	—		I_C = 21A, T_J = 150°C	
$V_{GE(th)}$	Gate Threshold Voltage	3.0	—	6.0		V_{CE} = V_{GE}, I_C = 250µA	
$\Delta V_{GE(th)}/\Delta T_J$	Temperature Coeff. of Threshold Voltage	—	-11	—	mV/°C	V_{CE} = V_{GE}, I_C = 250µA	
g_{fe}	Forward Transconductance ④	16	24	—	S	V_{CE} = 100V, I_C = 21A	
I_{CES}	Zero Gate Voltage Collector Current	—	—	250	µA	V_{GE} = 0V, V_{CE} = 1200V	
		—	—	5000		V_{GE} = 0V, V_{CE} = 1200V, T_J = 150°C	
V_{FM}	Diode Forward Voltage Drop	—	2.6	3.3	V	I_C = 8.0A	See Fig. 13
		—	2.4	3.1		I_C = 8.0A, T_J = 125°C	
I_{GES}	Gate-to-Emitter Leakage Current	—	—	±100	nA	V_{GE} = ±20V	

Switching Characteristics @ T_J = 25°C (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Conditions	
Q_g	Total Gate Charge (turn-on)	—	86	130	nC	I_C = 21A	
Q_{ge}	Gate - Emitter Charge (turn-on)	—	13	20		V_{CC} = 400V See Fig. 8	
Q_{gc}	Gate - Collector Charge (turn-on)	—	29	44		V_{GE} = 15V	
$t_{d(on)}$	Turn-On Delay Time	—	46	—	ns	T_J = 25°C	
t_r	Rise Time	—	35	—		I_C = 21A, V_{CC} = 800V	
$t_{d(off)}$	Turn-Off Delay Time	—	97	150		V_{GE} = 15V, R_G = 10Ω	
t_f	Fall Time	—	240	360		Energy losses include "tail" and	
E_{on}	Turn-On Switching Loss	—	1.80	—	mJ	diode reverse recovery.	
E_{off}	Turn-Off Switching Loss	—	1.93	—		See Fig. 9, 10, 18	
E_{ts}	Total Switching Loss	—	3.73	4.6			
$t_{d(on)}$	Turn-On Delay Time	—	42	—	ns	T_J = 150°C, See Fig. 11, 18	
t_r	Rise Time	—	32	—		I_C = 21A, V_{CC} = 800V	
$t_{d(off)}$	Turn-Off Delay Time	—	240	—		V_{GE} = 15V, R_G = 10Ω	
t_f	Fall Time	—	510	—		Energy losses include "tail" and	
E_{ts}	Total Switching Loss	—	7.04	—	mJ	diode reverse recovery.	
L_E	Internal Emitter Inductance	—	13	—	nH	Measured 5mm from package	
C_{ies}	Input Capacitance	—	1800	—	pF	V_{GE} = 0V	
C_{oes}	Output Capacitance	—	120	—		V_{CC} = 30V See Fig. 7	
C_{res}	Reverse Transfer Capacitance	—	18	—		f = 1.0MHz	
t_{rr}	Diode Reverse Recovery Time	—	63	95	ns	T_J = 25°C See Fig.	
		—	106	160		T_J = 125°C 14	I_F = 8.0A
I_{rr}	Diode Peak Reverse Recovery Current	—	4.5	8.0	A	T_J = 25°C See Fig.	
		—	6.2	11		T_J = 125°C 15	V_R = 200V
Q_{rr}	Diode Reverse Recovery Charge	—	140	380	nC	T_J = 25°C See Fig.	
		—	335	880		T_J = 125°C 16	di/dt = 200A/µs
$di_{(rec)M}/dt$	Diode Peak Rate of Fall of Recovery During t_b	—	133	—	A/µs	T_J = 25°C See Fig.	
		—	85	—		T_J = 125°C 17	

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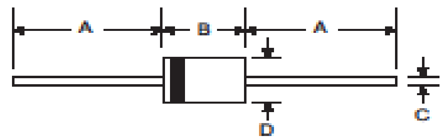
DIODES INCORPORATED

MUR140 - MUR160

1.0A SUPER-FAST RECTIFIER

Features

- Glass Passivated Die Construction
- Super-Fast Recovery Time For High Efficiency
- Low Forward Voltage Drop and High Current Capability
- Surge Overload Rating to 35A Peak
- Ideally Suited for Automated Assembly
- **Lead Free Finish, RoHS Compliant (Note 5)**



Mechanical Data

- Case: DO-41
- Case Material: Molded Plastic. UL Flammability Classification Rating 94V-0
- Moisture Sensitivity: Level 1 per J-STD-020C
- Terminals: Finish — Bright Tin. Solderable per MIL-STD-202, Method 208
- Marking: MUR140: R140
  MUR160: R160
- Polarity: Cathode Band
- Mounting Position: Any
- Weight: 0.35 grams (approximate)

DO-41 Plastic		
Dim	**Min**	**Max**
A	25.40	—
B	4.06	5.21
C	0.71	0.864
D	2.00	2.72
All Dimensions in mm		

Maximum Ratings and Electrical Characteristics

@ $T_A = 25°C$ unless otherwise specified

Single phase, half wave, 60Hz, resistive or inductive load.
For capacitive load, derate current by 20%.

Characteristic	Symbol	MUR140	MUR160	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	400	600	V
RMS Reverse Voltage	$V_{R(RMS)}$	283	424	V
Average Rectified Output Current @ $T_T = 120°C$	I_O	1.0		A
Non-Repetitive Peak Forward Surge Current 8.3ms Single half sine-wave Superimposed on Rated Load (JEDEC Method)	I_{FSM}	35		A
Forward Voltage @ $I_F = 1.0A$, $T_J = 25°C$ @ $I_F = 1.0A$, $T_J = 150°C$	V_{FM}	1.25 1.05		V
Peak Reverse Current @ $T_A = 25°C$ at Rated DC Blocking Voltage @ $T_A = 150°C$	I_{RM}	5.0 150		µA
Reverse Recovery Time (Note 2)	t_{rr}	50		ns
Reverse Recovery Time (Note 3)	t_{rr}	75		ns
Forward Recovery Time (Note 4)	t_{fr}	50		ns
Typical Junction Capacitance (Note 1)	C_j	45		pF
Typical Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	72		K/W
Operating and Storage Temperature Range	T_j, T_{STG}	-65 to +175		°C

Notes:
1. Measured at 1.0MHz and applied reverse voltage of 0V DC.
2. Measured with $I_F = 0.5A$, $I_R = 1.0A$, $I_{rr} = 0.25A$. See Figure 5.
3. Measured with $I_F = 1A$, di/dt = 50A/us.
4. Measured with $I_F = 1.0A$, di/dt = 100A/µs, Duty Cycle ≤ 2.0%.
5. RoHS revision 13.2.2003. Glass and High Temperature Solder Exemptions Applied, see *EU Directive Annex Notes 5 and 7.*

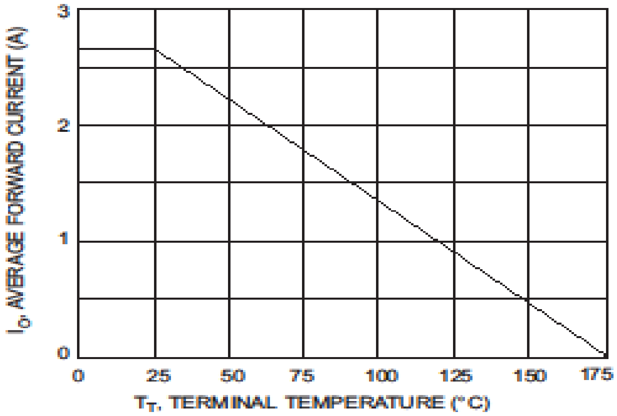


Fig. 1 Forward Current Derating Curve

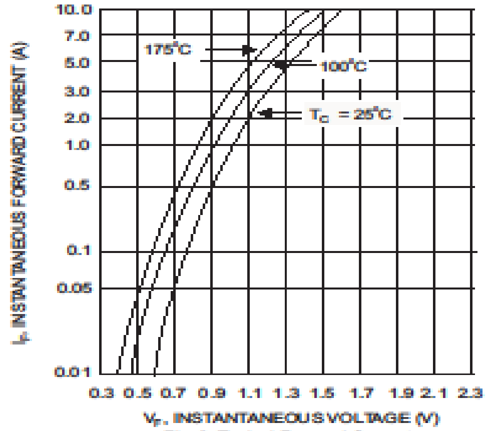


Fig. 2 Typical Forward Current

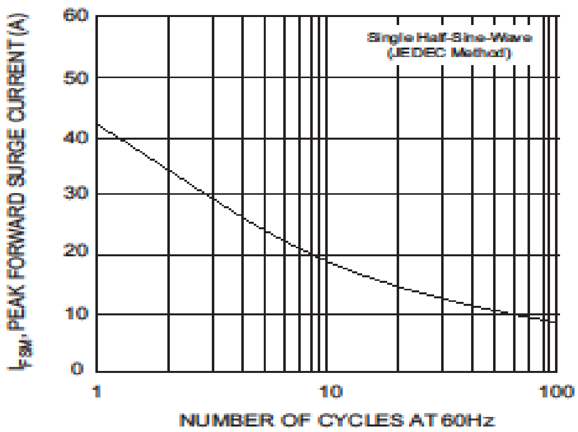


Fig. 3 Surge Current Derating Curve

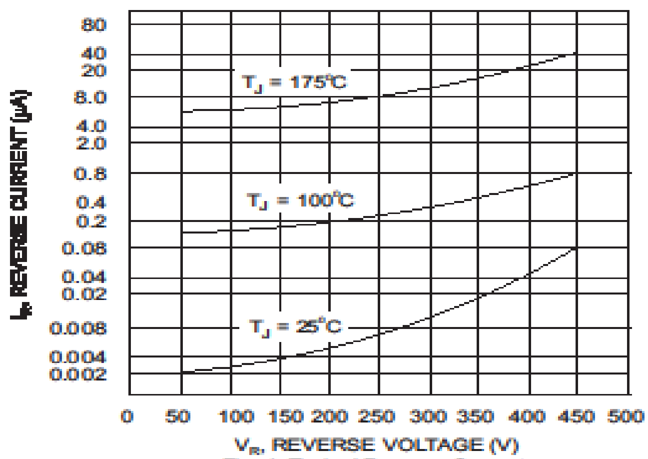


Fig. 4 Typical Reverse Current

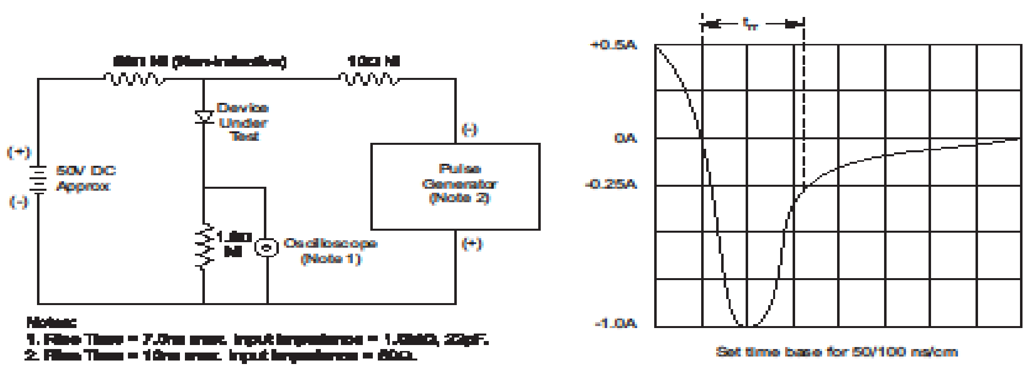


Fig. 5 Reverse Recovery Time Characteristic and Test Circuit

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TECHNICAL DATA SHEET — PY 329 DISCHARGE PASTE

USING FIELDS and PROPERTIES

It is a water based printing paste that is used with transparent or colouring of OP serie pigments, and used to discharge the printing fabric that is convenient for discharging. It has high colour effectivity and soft touching effect on textile printing.
It has an easy using during the printing.
In the condition of application of correct curing process, dry-wet rubbing fastnesses and washing results will be better. Rubbing fastnesses and washing tests should be applied after 24 hours of curing.
Suitable to Eco-Tex 100 Standart.

PHYSICAL-CHEMICAL PROPERTIES

Appearance	:	Transparent paste
pH	:	11-11,5 (20 °C)
Density	:	0,99 g/cm³ (20 °C)
Viscosity	:	[(20 °C) sp: 6, rpm: 20 Brookfield] : 20.000 – 25.000 [mPa.s]

APPLICATION

Printing : The best results could be had in the printing with the meshes of 43-62T.

Preparation : **In order to have discharge effect with PY 329 Discharge Paste ;**

PY 329 Discharge Paste	1000 g
OP Serie Pigment	10-50 g
Decrolin	60 g

After adding Decrolin into PY 329 Discharge Paste this mixture has to be consumed in 12 hours with the terms of heat around. Otherwise the paste will be damaged and become colour changes.
In order to prevent any hairy effect on surface of fabric after the washing, or to have a non taking transfoil property, you can add (3-5 %) SP 203 Fixing Agent into the PY 329 Discharge Paste.
To reduce the viscosity, could be added SP 209 Regulator with (1-3 %) into the PY 329 Discharge Paste.
Never use water to reduce the viscosity. Before use, please stir the ink well. Do not use any additives that are not advised.
After using, the screen should be cleaned with the water.

Curing : Cure at 160 °C for 2 minutes.

SAFETY and STORAGE

In using, does not contain any harmful substances for inhalation and skin. However in case of contact with eyes and mouth or another that is sensible, wash plenty of water. If necessary, seek a medical assistance.

Keep containers dry and tightly closed. Store in ventilated place between (+5)-(+30) °C of temperature.
It should be consumed until 8 months from the production date.

PACKING

In 30 kg of plastic packings.

The technical application and information that have been given above, are designed only as using instructions. Not to be considered a warranty for any other use. When it needs of any help or assistance, the technical department is ready to do it for you.

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TECHNICAL DATA SHEET — PY 349 DISCHARGE PASTE WHITE

USING FIELDS and PROPERTIES

It is a water based printing paste that is used to discharge the printing fabric that is convenient for discharging with having white colour. It has soft touching effect on textile printing.
It has an easy using during the printing.
In the condition of application of correct curing process, dry-wet rubbing fastnesses and washing results will be better. Rubbing fastnesses and washing tests should be applied after 24 hours of curing.
Suitable to Eco-Tex 100 Standart.

PHYSICAL-CHEMICAL PROPERTIES

Appearance : White paste
pH : 11-11,5 (20 °C)
Density : 1,07 g/cm³ (20 °C)
Viscosity : [(20 °C) sp: 6, rpm: 20 Brookfield] : 20.000 – 25.000 [mPa.s]

APPLICATION

Printing : The best results could be had in the printing with the meshes of 43-55T.

Preparation : **In order to have discharge effect with PY 349 Discharge Paste White ;**

PY 349 Discharge Paste White	1000 g
Decrolin	60 g

After adding Decrolin into PY 349 Discharge Paste White this mixture has to be consumed in 12 hours with the terms of heat around. Otherwise the paste will be damaged and become colour changes.
In order to prevent any hairy effect on surface of fabric after the washing, or to have a non taking transfoil property, you can add (3-5 %) SP 203 Fixing Agent into the PY 349 Discharge Paste White.
To reduce the viscosity, could be added SP 209 Regulator with (1-3 %) into the PY 349 Discharge Paste White.
Never use water to reduce the viscosity. Before use, please stir the ink well. Do not use any additives that are not advised.
After using, the screen should be cleaned with the water.

Curing : Cure at 160 °C for 2 minutes.

SAFETY and STORAGE

In using, does not contain any harmful substances for inhalation and skin. However in case of contact with eyes and mouth or another that is sensible, wash plenty of water. If necessary, seek a medical assistance.

Keep containers dry and tightly closed. Store in ventilated place between (+5)-(+30) °C of temperature.
It should be consumed until 8 months from the production date.

PACKING

In 35 kg of plastic packings.

The technical application and information that have been given above, are designed only as using instructions. Not to be considered a warranty for any other use. When it needs of any help or assistance, the technical department is ready to do it for you.