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Hysteresis Controller Using MOSFET Gate Driver Circuit

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Abstract: ***The main objective of this work is to protect the d.c motor in term to flow a heavy current more than the rated current of the motor. We have achieved this objective by using hysteresis current controller. The d.c machine was rated as 2.5amp, .75hp, 1500 rpm, 250v d.c shunt wound. We already had power converter performances also converter. So we simulated in PSIM software with load conditions. Successfully we fabricated the MOSFET gate driver circuit, current controller circuit and tested with the motor running under load.***

Keywords: Hysteresis controller, MOSFET, power converter, gate driver circuit, power circuit

1. Introduction

Power converters are described in [1]&[2].Basic operation of MOSFET, its working areas are also discussed in [1]&[2]. Among them MOSFET is the most significant part. Its general features are thoroughly studied in later chapters. Metal-oxide-semiconductor field effect transistor (MOSFET) has basically three main parts Gate, Drain and Source. Protective measures are essential in any case of any power device.

Brief view of safe operating zone and related topics are covered here. We need to know the protective measures in any kind of machinery or devices to handle it properly otherwise major damage can occur. Theory of fabrication of power circuit, linear power supplies (fabrication and operation), selection of power device are briefly described to get a small outline view about design [3].

Basically, hysteresis controller is used for electrical drives such as permanent magnet synchronous motor. This is known as classical hysteresis controller. In this work, the current control of converter is a hysteresis current controller. It is used due to simple, fast dynamic response and insensitive to load parameters. In this method each phase consists of comparator and hysteresis band. The switching signals are generated due to error in the current. The error comes from comparing between the reference current and actual current. The main task of this method of control is to force the input current to follow the reference current in each phase. In this method of control, the deviation of the current between the upper and lower in the hysteresis band is limited.

The whole paper is directed as follows. Section II only describes the basic Hysteresis Controller Fabrication. The outcome of the work as a current controller are being covered in section III. And finally, section IV concludes this paper.

2. Fabrication

This chapter is related to fabrication and operation of the 24logic controller circuit. First one is power supply circuit, from which we get the power supply. This supply drives the 555 timer circuit, which is astable multivibrator circuit. This circuit gives us +5v. Now this voltage is applied into optocoupler(4N35)and then op-amp(LM741). Then output connected to current sensor(LA55P). After that we connect it to voltage amplifier and at last to the Power MOSFET(IRF3205) to output characteristics.

Power supply circuit(12v and 5v):-

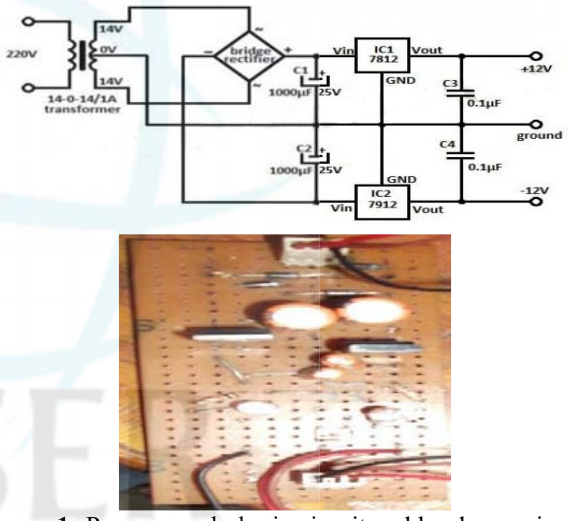


Figure 1: Power supply logic circuit and hardware circuit for 12/5v.

In the power supply circuit at first we have to use a step down transformer of 12-0-12 or 14-0-14 to the a.c source voltage to get lower a.c voltage, which give one positive voltage, one negative and another is connected to ground. Positive voltage and negative voltage is connected to 4 diodes(IN4007) and make a bridge rectifier which has high reliability, low forward voltage drop, lo leakage, high current capability and convert the a.c voltage into d.c voltage. Then two 1000micro F capacitor connected to parallel with it to ripple the voltage wave formation. Then the positive input d.c voltage and negative input d.c voltage is connected to voltage regulator 7812 and 7912 respectively. This IC can changes the higher voltage into lower +12v and -12v. Here we again connected two 0.1 micro F capacitor rippling the wave, and finally we get the +12v d.c, -12v d.c. For getting the +5v d.c and -5v d.c we have to use 9-0-9 step down transformer for 9v a.c and then

convert into d.c by bridge rectifier. After that use voltage regulator use 7805(for +5v) and 7905(for-5v). Capacitor used 2200 micro F and 10 micro F for rippling purpose. The procedure followed same as for getting +12v and -12v.

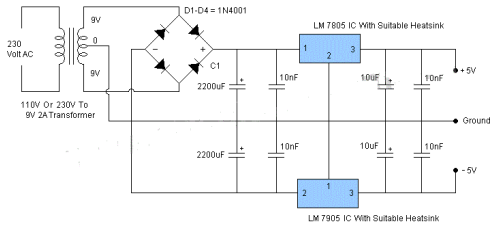


Figure 2: Power supply logic circuit for 5v

555 timer circuit (Astable Multivibrator)

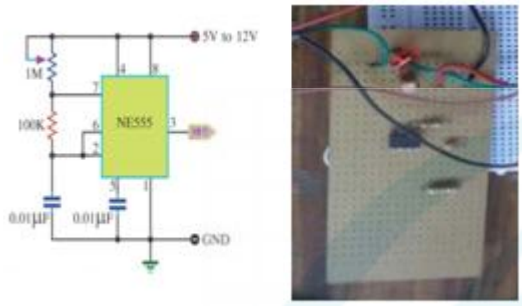
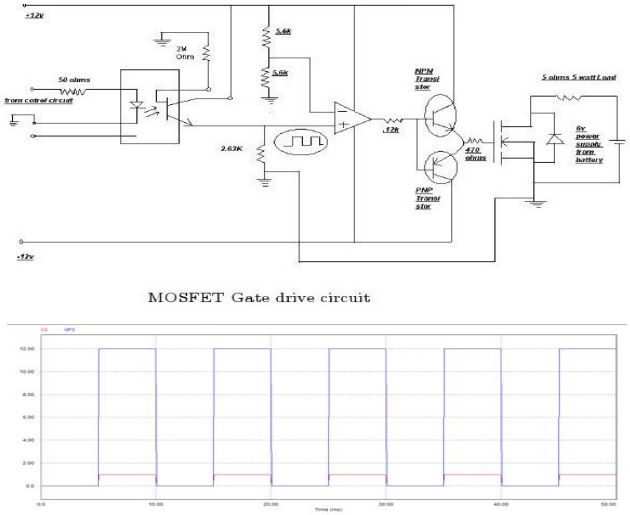


Figure 3: 555 Timer (NE555) logic circuit

The output of the power supply circuit is connected to this timer logic circuit, 5v to 12v connected with pin no 8(Vcc), then shorted with pin no 4(Reset). Then connect a 1M ohm resistance across pin4(reset) and pin 7(discharge). Another resistance of 100 k ohm is connected across pin 7(discharge) and pin 2(trigger). Next pin 6(threshold) shorted with pin 2(trigger). Two 0.1 micro F capacitors are connected in series between pin2(trigger)and pin 5(control). At last pin5(control) is connected to pin1(Ground). Then we can get output at pin3.

Power MOSFET Gate drive circuit:-

The position signal pulses obtained from the logic circuit varying between +5 Volt and 0 Volt do not have enough power to drive the MOSFET switches. So the power contained pulses needs to be enhanced. However, logic circuit output pulse should not be directly used as inputs to the base drive circuit. This is because the logic ground and power ground should be isolated using an optocoupler. The operation of optocoupler is as follows. The (5,0) volt pulses from output of logic circuit is fed via 50 ohms resistance to the primary diode of the optocoupler, because I F (diode forward current is 10 mA) by actual calculation we get above result, A rectangular current pulse is set up in the diode which causes photoemission accordingly. When photon are not emitted (i.e., When the pulse is at logic low), and if the photons are emitted (i.e., When the pulse is at logic high)



Output of driver circuit

Figure 4: MOSFET Gate Driver Circuit and Output of Driver Circuit

Thus the inverting input of the op-amp comparator is kept always constant; so that, it can compare with the output of the opto coupler, whereas none inverting input is connected with the output of the opto coupler. Thereby the output of the comparator is low ¡12 Volt. Conversely, when the output pulse of the control circuit is at logic HIGH. When pulse is at +12 Volt, the CL100 is turned ON so that the base of the power transistor is high, the corresponding power transistor is ON. When the pulse is at ¡12 Volt, the CK100 is turned ON causing the base of the power transistor to be connected to the negative voltage. Suitable circuit for the MOSFET or IGBT - based switches.

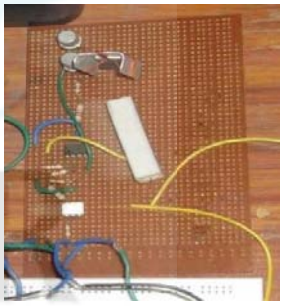


Figure 5: Fabrication of MOSFET gate drive circuit

Current Sensor Circuit

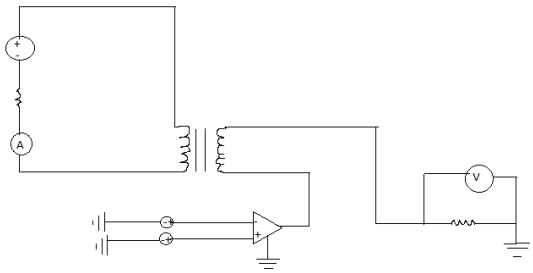


Figure 6: Current sensor basic circuit

Current Sensor or hall effect sensor has basic structure as transformer. It has secondary and primary winding with the ratio of 1:1000. Primary input have a d.c source and then connect an ammeter. Secondary gives the output which is connected with an op-amp. It gives a low output voltage i.e

56m V. So the voltage will be amplified by voltage amplifier.

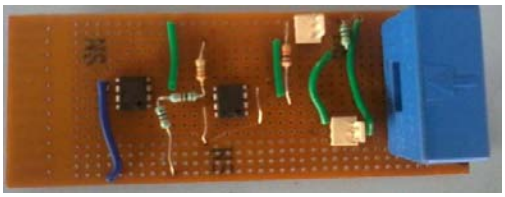


Figure 7: Fabrication of Current sensor circuit

Voltage Amplifier Circuit

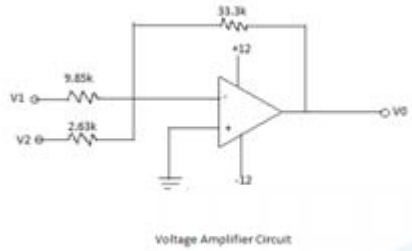


Figure 8: Voltage Amplifier basic circuit

The output of the current sensor connected with v2 terminal. V1 terminal is connected with -6v. V1 is fed by this process. Here is process of summing circuit and the output voltage is amplified by this circuit, through this procedure output of the current sensor is transformed in 6.12 v from 56m v.

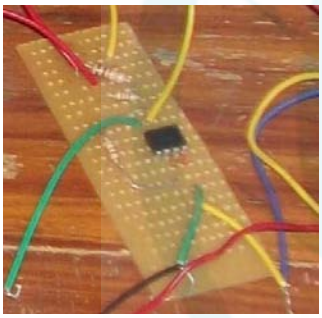


Figure 9: Fabrication of Voltage Amplifier circuit

3. Outcomes

In this part, we ultimately control the current using our proposed method..

Current limiter circuit

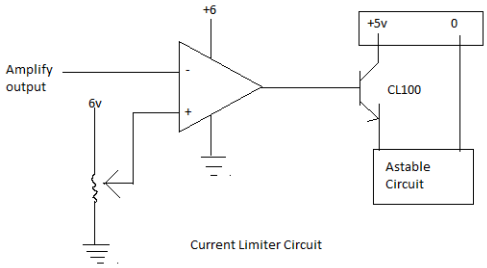


Figure 10: Current Limiter circuit

In the current limiter circuit output of the voltage amplifying circuit apply to the inverting terminal and non inverting terminal connected to resistor and output connected to transistor. If input greater than reference then o/p is 0 when it less than reference the output will be positive voltage. Thus we can protect the motor against the heavy current whenever heavy current flow 0 output of the current limiting circuit will cause the disconnection from the main circuit.

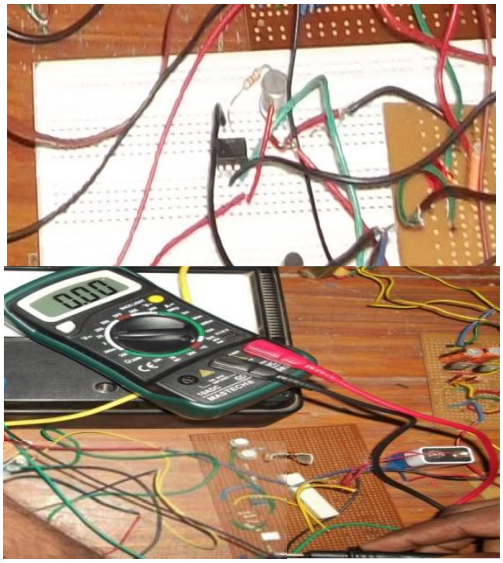


Figure 11: Fabrication of Current Limiter circuit and Logic 0 State

4. Conclusion

The present work undertaken by the author is to analysis and hardware fabrication of d.c drive with hysteresis current controller scheme using MOSFET used as a switch and MOSFET gate driver circuit.
The next steps in the development that may be taken up future work may be

1) To develop a closed loop adjustable speed drive with an appropriate controller implemented on DSP/FPGA platform.
2) To develop the same for parallel operation of IGBTs instead of MOSFET.
3) Try advanced strategies like sensor less drive developed, torque ripple minimisation.

References

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