Design of Digitally Controlled Power Board for Generating Coded Pulse from Laser Diode Array.

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Abstract: Driver circuits are most normally used to intensify signals from controllers or microcontrollers with a specific end goal to control switches in semiconductor gadgets. Current innovation in Laser generator board contains simple circuit for controlling the laser pillar. The viability of simple hardware is dependably lower than that of advanced circuits. We composed an advanced identical hardware for controlling and working Laser. This can be utilized to supplant old simple innovation which has the few weaknesses. The primary piece of this is power MOSFETs, DAC, ADC, transistors, Microcontroller, inductor, Capacitor, and so forth by utilizing these segments simple hardware can be recreated carefully. The benefit of utilizing advanced hardware is we can get precise estimations of the all parameters with which we are managing all through the era of the coded beat. As all the looked at parameters which are planning in this specific space are advanced henceforth requires the less force of operation when contrasted with the simple utilized hardware. The result of this work will help in building up an upgraded outline of a Laser Control Board for creating the coded laser shaft for assortment of utilizations.

Index terms: Handling Efficiency, Low power, MOSFET, Size-Efficient, Fast Operation.

1. INTRODUCTION

Expanding utilization of high power lasers in industry has prompted to the expanding requests concerning the powerful techniques for streamlining and control of the laser controlling parameters, which are in charge of the consequences of the laser radiation materials association. Upgrades in the laser shaft qualities furthermore, alteration of the shaft force profile to the procedure result in better coupling of the laser pulse vitality to the objective material and in this way in more effective preparing.

Laser power control board is the most important part of board used in the devices containing main use of Laser such as Laser Target Designator (LTD), Laser Range Finder (LPF), missile guidance and etc. The main purpose of the board is to convert the power coming from the battery in terms of the voltages i.e. we can get 5-12 from the battery available with us on field but for generating the coded pulse we have to operate number of diodes connected in series, for this purpose we need higher voltage and current in controlled manner so that it can be applied to the series combination of the diodes. Previous proposed circuitry uses analog components such as operational amplifiers, level shifters for converting the voltages level. This is the conventional used circuit nowadays with many of the complications such as power management, maximum space over the device, controlling of the many operational amplifier at one time needs precise and concise power control, etc. Due to this reasons cost of the device containing this board also gets high. Main application of these devices is on field means where the war is going on so it should not take that much amount of the time load or for adjustment of the parameters of it. Rather than this it will be very useful for the person who is operating the equipment if he would have to turn it on at once. In case of the analog or tradition board the power leakage can also happens as this is running on the count of several (> 100 V) if voltage leaks then it might be the risk of person's health who is handling this. All this parameters are taken into the consideration while designing of the digital power control board.
In this paper we focus on the interactive use of generating and controlling of the laser beam by using the digital devices and parameters in order to decrease the cost, power leakage and to increase effectiveness.

2. FUNDAMENTAL MATERIALS

We cannot convey vast measure of supply with gadgets since we need to utilize this gadget on field in which our laser control board is joined, rather than this we can convey little bundles of battery for controlling that gadget however laser diode needs the supply regarding 100V or more prominent than that for this reason we can utilize the accompanying circuit to build the voltage level.

2.1 Electronic Chopper

From AC supply system, variable DC output voltage can be obtained through the use of phase controlled converters or motor generator sets. The conversion of fixed dc voltage to adjustable dc output voltage, through the use semiconductor devices, can be carried out by the two types of dc to dc converters. A chopper is static device that converts fixed dc input voltage to a variable dc output voltage directly. A chopper may be thought of ac dc equivalent of an AC transformer since they behave in an identical manner. As chopper involves one stage conversion, these are more efficient. Choppers are now being used all over the world for rapid transit systems. These are also used in trolley cars, marine hoists. Chopper system offers smooth control, high efficiency, fast response and regeneration. Step up chopper or boost converter is used to increase the input voltage level of its output side.

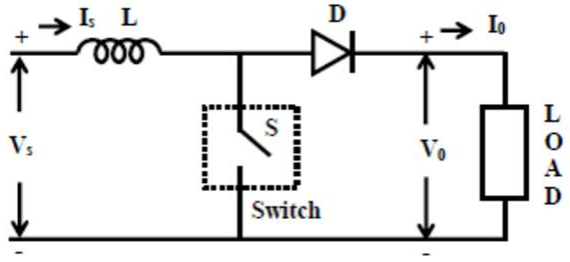

Figure 1: Chopper circuit used for boosting voltage

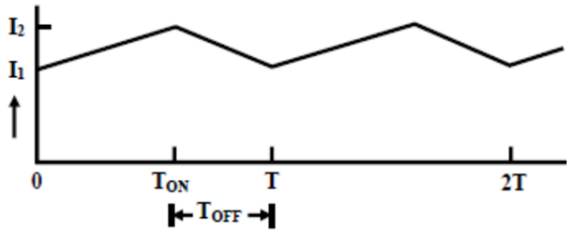

Figure 2: Output waveform of current from chopper circuit

Where,

Vs = Supply Voltage
L = Inductor
Is= Supply Current
S = Switch
Vo = Output Voltage
Io = Output Current
D = Diode
T = Total time priod

2.2 Capacitor Bank

Capacitor stores energy in electric field. The stored energy is not maintained indefinitely, as the dielectric present between the plates allow for a certain amount of current leakage which results in the gradual dissipation of the stored energy. Capacitor bank is an interconnection of such capacitors either in series or parallel based on requirement. Capacitor bank generally used to power factor correction and reactive power compensation.

2.3 MOSFETs as a Switch

MOSFET as we know works when channel is formed in case of enhancement type. So consider taking a n-type enhancement type MOSFET on which we interface a circuit utilizing channel and source as switch associations. The circuit finishes when the channel is framed and deplete to source conduction begins. To make the channel, we need to apply adequate voltage (greater than edge) to the Gate. So this is the way switch can be controlled. On the off chance that entryway is at 0 or -ve potential your circuit associated at drain and source wont direct and if gate is at adequate +ve potential, the channel will be framed which finishes the other circuit. This is the way MOSFET can be utilized as a SWITCH.

2.4 Laser Diode

Laser diode, also known as an injection laser or diode laser, is a semiconductor device that produces coherent radiation (in which the waves are all the same frequency and phase) in the visible or infrared (IR) spectrum when current passes through it. For the generation of the laser pulse we apply the obtained 100V to the series of Laser Diodes to produce the constant coded pulse of laser.

2.5 FET as a Voltage controlled Resistor

By operating the MOSFET in the triode region, we have a resistor with an esteem that can be controlled electronically. These resistors thusly might be utilized as the control component in more convoluted electronic circuits. An imperative part of the utility of the MOSFET in this application comes from the way that the control flag is very much disengaged from the resistor terminals.

2.6 8051 Microcontroller

AT89C51RD2/ED2 is high performance CMOS Flash version of the 80C51 CMOS single chip 8-bit microcontroller. It contains a 64-Kbyte Flash memory block for code and for data. We use this as our central controller for the controlling of the laser coded pulse.

2.7 Digital to Analog Converter (DAC)

The DAC0808 is an 8-bit monolithic digital-to-analog converter (DAC) featuring a full scale output current settling time of 150 ns while dissipating only 33 mW with ±5V supplies. The resolution of this DAC is

Vref/256, it means that change In 1 LSB of binary input will cause a change of Vref/256 at output. We are actually varying the resistance of the MOSFETs by using the DAC 0808. A resistance of 2.54K is connected at the output pin of DAC we are converting the output current into the voltage by using the voltage drop across the resistance. By proper calibrations of output current produced by DAC 0808 we have selected the resistance of 2.54K.For example, when the value of "FF" is given to the DAC 0808 the output current produced by Iout is 5mA hence, voltage drop across the gate will be nearly 12.6V these will on the MOSFET by giving the output current of 12A. Hence we can vary the voltage drop across the gate by sending the different values at the input of DAC0808. The formula for the output current is give below

$$Io=K\left(\frac{A1}{2}+\frac{A2}{4}+\frac{A3}{8}+\frac{A4}{16}+\frac{A5}{32}+\frac{A6}{64}+\frac{A7}{128}+\frac{A8}{256}\right)\ldots(1)$$

Where $k=\left(\frac{Vref}{R}\right)$

Table.1 Chart of individual test values of DAC

Code to DAC(Hexadecimal)	**Vg** (Volts)	**Ids** (Ampere)
FF	8.90613	12.0401
F3	8.40518	11.01
EF	7.925	10.283
EA	7.46974	8.895
E5	6.25487	7.256
DE	5.93254	5.524
D9	5.623	4.896

2.8 Analog to Digital Converter (ADC)

ADC0804 is an 8 bit successive approximation analogue to digital converter from National semiconductors. The features of ADC0804 are differential analogue voltage inputs, 0-5V input voltage range, no zero adjustment, built in clock generator, reference voltage can be externally adjusted to convert smaller analogue voltage span to 8 bit resolution etc.

We are utilizing the ADC with the end goal of just taking the input from the circuit that precisely current that we need to supply to the laser diode is coming to it or not. We inspected the measure of current originating from the diode to the little resistor with the goal that we can read the qualities from ADC0804 from microcontroller. We have some pre-spared values in controller that we have computed from the individual testing from the ADC 0804.We will check the acquired an incentive with pre-spared esteem and play out the operation on our variable resistor.

3. DISCUSSION AND WORKING

We have used different electronic components to design circuit such as, Power MOSFETs, Resistors, Transistors, Capacitor Bank, ADC, DAC, Microcontroller (8051) etc. as stated above. A constant voltage is provided by the chopper circuit to the Power MOSFETs (Use for the switching) as required by their specification to turn them on and off whenever required. MOSFETs are connected between capacitor bank & laser diode circuit are used as a switch. The switching action of a MOSFETs is controlled by the driver connected to it, this driver can be controlled by the microcontroller so as we can call it digital switching of MOSFET, the operations of the switching of the MOSFET is opposite in case of the N-MOS and P-MOS transistor, also we can note that the MOSFET used for the switching action are power MOSFET so that they can handle the higher voltages across them. Whenever MOSFETs across capacitor & power supply are in ON state remaining MOSFETs are in OFF state. This implies that, capacitor bank gets charged only in OFF time. In ON time of pulse, capacitor starts discharging across laser diode circuitry. At the same time bank is disconnected from power supply.

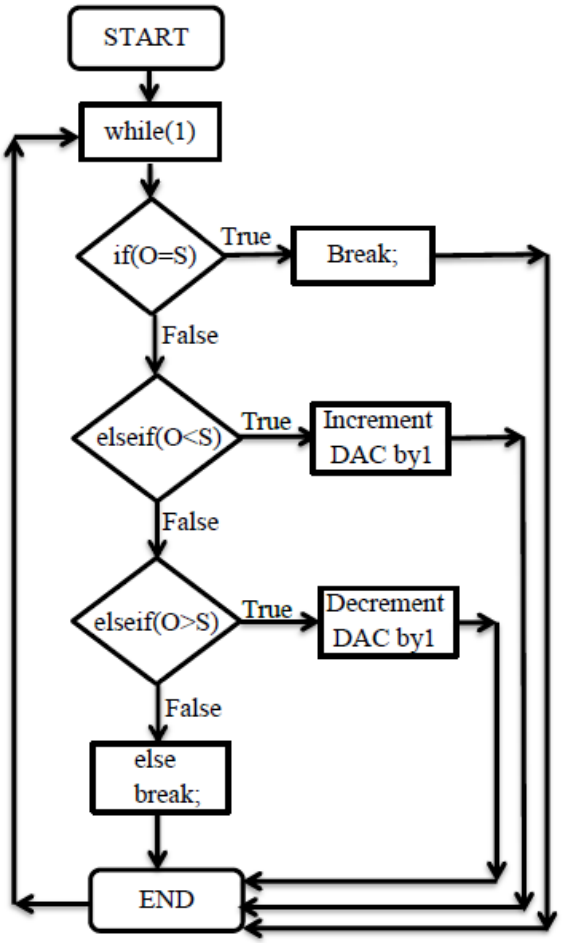

Figure 3: Flowchart of the feedback algorithm.

Where,
O= Obtained Value
S= Stored Value

We calculated the time constant by basic equation such that it will get charged during OFF time of pulse. So, capacitor gets charged in that time. In second half MOSFETs across power supply & capacitor bank are in OFF state & MOSFETs across capacitor bank &laser diode circuitry is in ON state. Capacitors will provide (approximately constant voltage) across laser circuitry. Now current driven by circuitry may vary with intensity required by laser diode (from several minimum current to the maximum current as specified for by the user requirement). For different current requirements we vary the resistance provided by laser diode circuitry by varying resistance of MOSFET (voltage controlled MOSFET as a resistor). As the resistance across circuitry increases, the current driven from capacitor bank is lower & vice versa.

Now this variable MOSFET (as resistance) is controlled by DAC (digital to analog converter-0808) & microcontroller (8051). We have interfaced many switches with microcontroller. By pressing each switch the DAC will take specific value from microcontroller in form of digital bits & converts it into respective analog voltage signal.This voltage signal is then provided to gate of MOSFET to vary the resistance. For each required current for laser diode the value of resistance required from MOSFET can be calculated. Similarly the voltage provided to gate of MOSFET & code which provided by microcontroller can be calculated. As we know that the number of switches that can be interfaced to the microcontroller is less so for this we can use the matrix keypad.

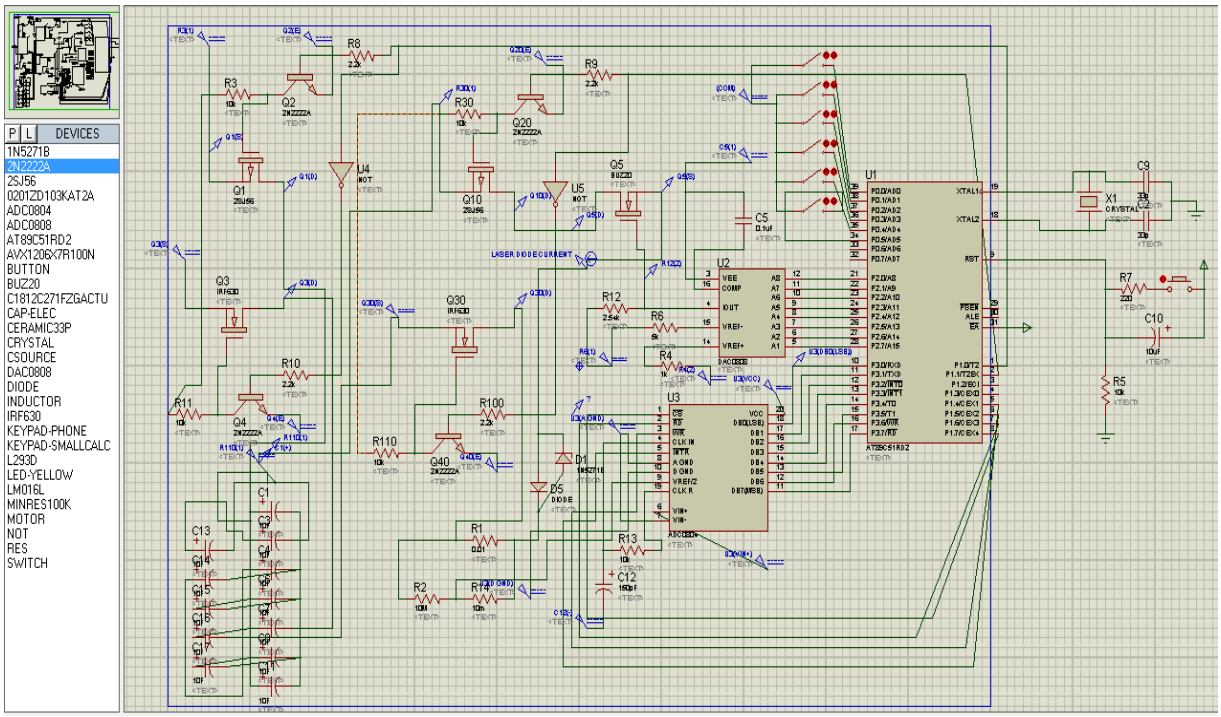

Figure 4: Simulation picture of circuit under simulation for generation of coded laser pulse in Proteous Professional Software

This will give us the maximum possible combination that we can use for the various values of current which will be provided by the user. The estimated model for this working with help of the block diagram is given in the fig 5 .which shows all the blocks and continuous working of the system and the same working model of the designed circuit is designed and tested in the Proteus Professional software and we have checked its working as shown in the fig4.

4. CONCLUSION

The effective digital way of controlling an coded laser pulse generated by the laser diode and experimental analysis concerning the output characteristics of the laser are presented in this paper. We have developed a system in which the voltage across the series pulse of the laser diode remains constant to operate them and we varied current digitally to generate the coded pulse from the array of laser diode. The system is more efficient as compared to the conventional analog system which uses operational amplifier and other devices.

The experimental tests conducted on the power MOSFET as a switch for the different values given from the microcontroller to the DAC and then the output of the DAC is applied to the GATE terminal of the power MOSFET as switch are obtained for the different values of the current. The graph of linearity of current is as shown in the fig6.

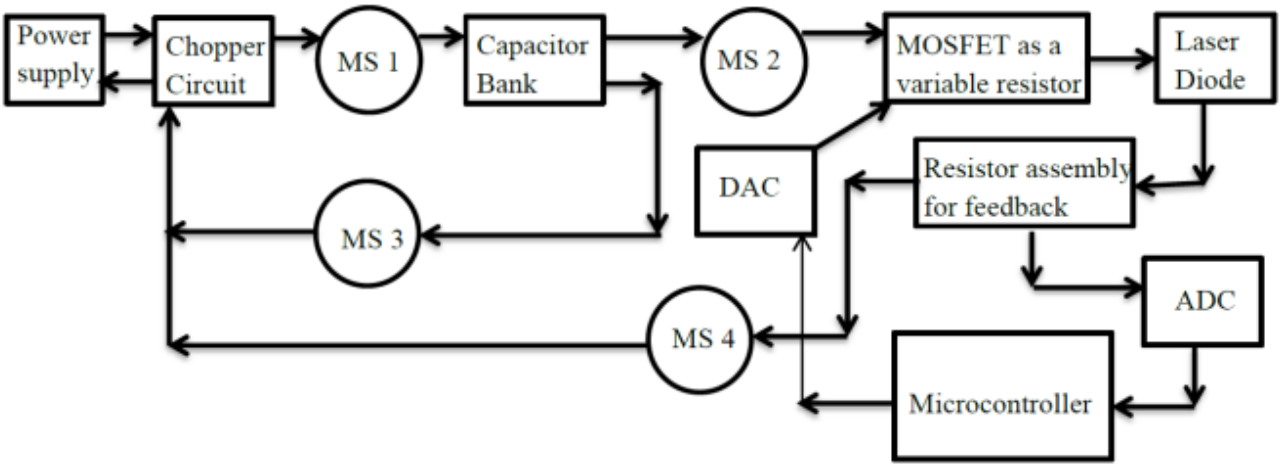

Figure 5: Block diagram of main circuit under simulation for generation of coded pulse

The current across the diode array may get varied due to the loading effect of the components or any other factors which are not known to us so the care is taken by the feedback circuitry which will constantly check the current sampled through the resistor and maintain the current by changing the values of the DAC which are directly fed to the power MOSFET as a resistor.

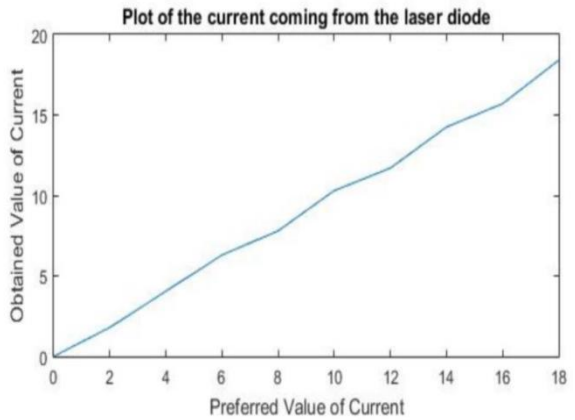

Figure 6: Output current compared to the preferred value of current.

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