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Project Title: LOW COST DIGITAL STARTER WITH SPEED CONTROL OF DC SHUNT MOTOR

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ABSTRACT

In engineering academic institutions, the DC shunt motor is started by conventional starters using rheostat as a current limiting device along with some protective devices such as No Volt relay and over load relay in the form of electromagnet. This type of starters are often suffered by mechanical failure which leads to malfunction itself and speed control is also implemented by current limiting device called rheostat. Sometimes the movable metal contact of rheostat refuses to move itself and suppose that a power failure occurs, manual operation must be needed for positioning the movable contact as such in initial conditions immediately. The usage of resistive element in both starting and speed control results in ohmic losses in the form of heat. This project proposal imposes that the above said drawbacks can be eliminated by low cost Digital starter with speed control of DC shunt motor using ARDUINO along with buck converters.

LITERATURE SURVEY

As per statistics, more than 80% of the colleges have Electrical and Electronics Engineering branch which are having a DC machines Laboratory which includes the experiment on DC motors. This experiment is also performed by allied branches. These DC motors are started by conventional starters and the speed is varied with the help of rheostats.

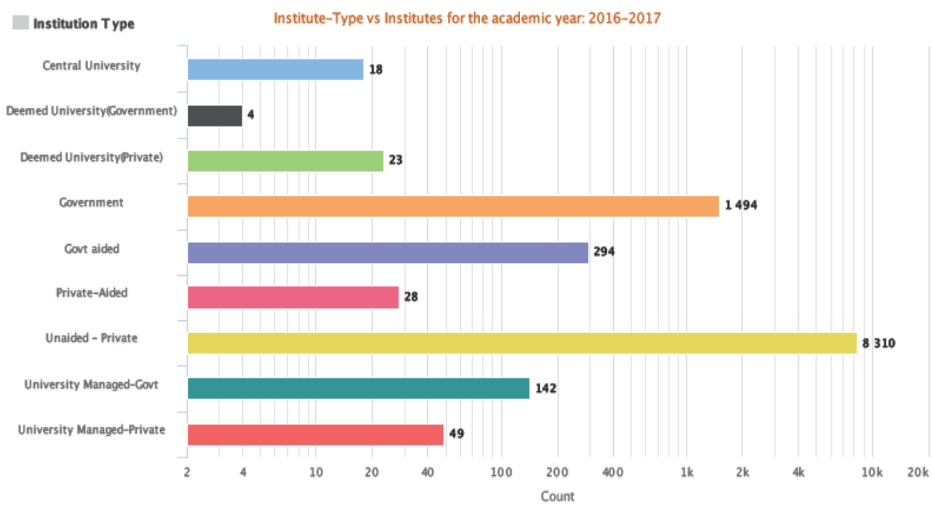

Figure 1: Number of Institutions having experiments on DC motors**.**

A brief description about existing system and their disadvantages are given below:

EXISTNG SYSTEM

1) RHEOSTAT:

The speed variation of DC shunt motors are done by varying rheostats .The initial precaution of speed variation experiment is that the field rheostat should be kept at minimum position and armature rheostat should be kept at maximum position .Now if the supply goes off (due to some problem in the supply side or due to load shedding), motor will come to a stop. All on a sudden, let us imagine, supply is restored. This may cause damage to the coils. In other words, one should.be constantly alert to set the resistance to maximum value whenever the motor comes to a stop. Also the rheostat suffers from several disadvantages. They are described below:

- **Ageing:**

Figure 2: AGEING OF RHEOSTATS

The above figure clearly describes the crack occurred due to ageing. This may interrupt the usual operation of the rheostats.

- **Poor contacts:**

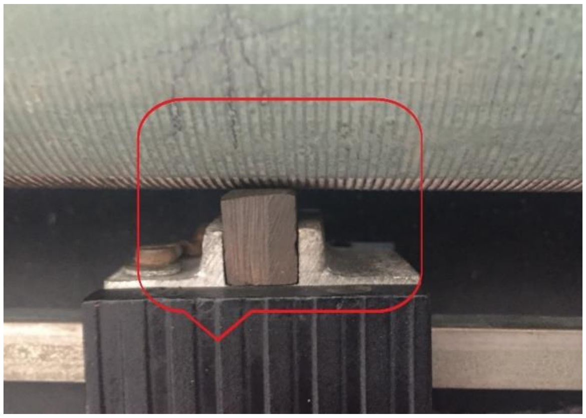

Figure 3: poor contacts in rheostats.

These poor contacts mentioned in Figure 3 won't allow flexible operation.

- **Accumulation of dust and sand:**

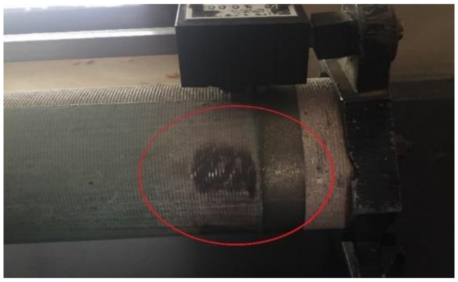

Figure 4: ACCUMULATION OF DUST AND SAND

Due to these dust particles the rheostat may lose its insulation property. This is a dangerous issue because shock will arise during the manual operation of rheostats.

2) CONVENTIONAL STARTERS**:**

It is an extensively used to start a D.C shunt motor. It not only overcomes the difficulty of a plain resistance starter, but also provides additional protective features such as over load protection and no volt protection. The diagram of a 3-point starter connected to a shunt motor is shown in Fig.3.

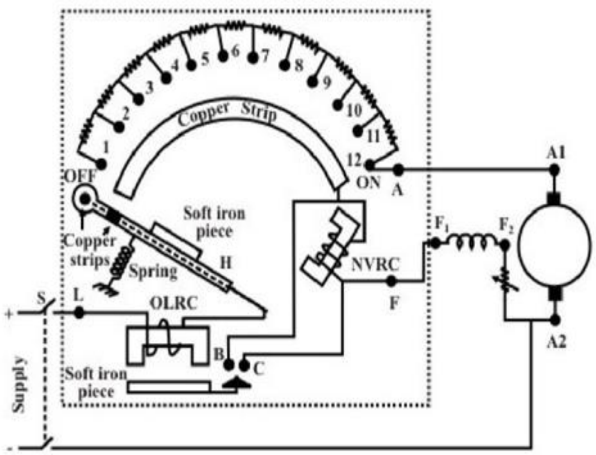

Figure 5: Three Point Starter

Initially the handle is in the OFF position. Neither armature nor the field of the motor gets supply. Now the handle is moved to stud number 1. In this position armature and all the resistances in series gets connected to the supply. Field coil gets full supply as the rectangular strip makes contact with arc copper strip. As the machine picks up speed handle is moved further to stud number 2. In this position the external resistance in the armature circuit is less as the first resistance is left out. Field however, continues to get full voltage by virtue of the continuous arc strip. Continuing in this way, all resistances will be left out when stud number 12 (ON) is reached. In this position, the electromagnet (NVRC) will attract the soft iron piece attached to the handle. But these starters suffers from several disadvantages which are described below:

- **Corrosion:**

Figure 6: Corrosion of conventional starters

Corrosion arises in conventional starters due to ageing. Due to corrosion the starter may not work properly. This results in failure of flexible spring movement. Due to failure in spring movement when the power is turned off the starter handle may not return to initial position which will damage the motor coils if the supply is restored quickly.

- **Sparking:**

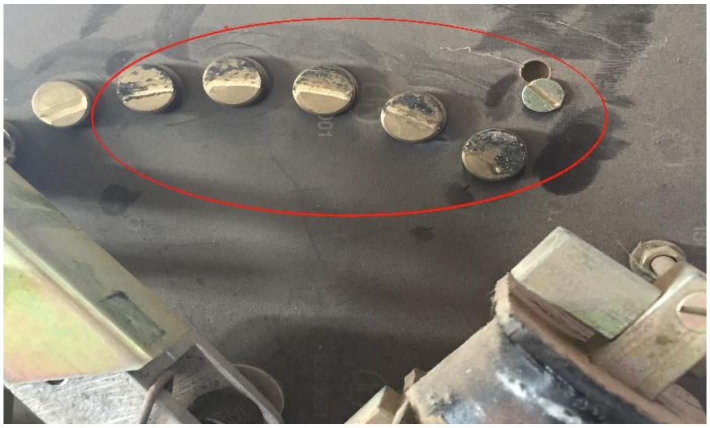

Figure 7: Sparking in conventional starters

As the contacts are not continuous, SPARKING will arise because of inductive kick. The black marks in the coil defines the damage caused due to sparking.

PROPOSED SYSTEM

The model proposed by us makes use of power electronic converter operating along with ARDUINO microcontroller. Power semiconductor devices (IGBT, MOSFET etc.) operate either in saturation or cutoff region where the losses are minimal when compared to ohmic losses incurred by rheostat. To address these issues, proposed model takes advantage of low power loss of power semiconductor devices and eliminates the manual adjustment to maintain the speed .The speed variation is done with the help of rotory encoder .We employ soft starting of the dc motor using Buck convertor. We have programmed in a manner such that the rotory encoder position will be returned to zero when there arise interrupt in power supply. Thus complete safety to both the motor and operating personnel can be ensured. The block diagram is shown below:

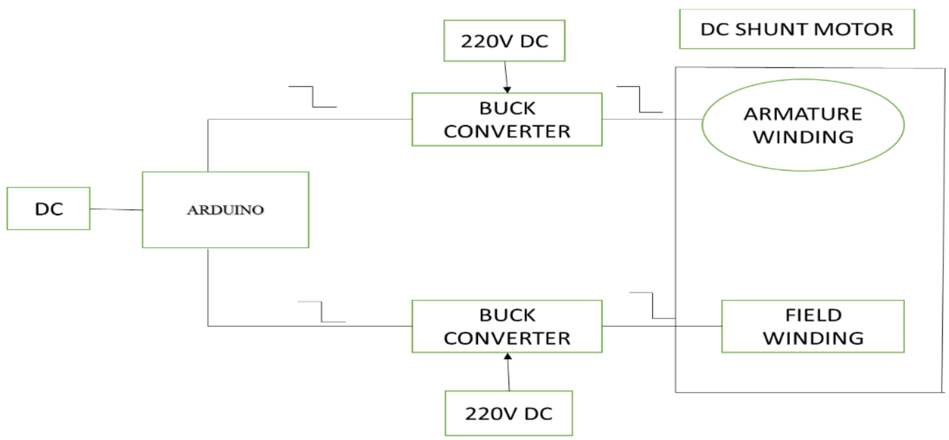

Figure 8: Block diagram

TOOLS REQUIRED

HARDWARE REQUIRED:

1) Buck converter:

A buck converter is a static power electronic device which converts fixed dc input voltage to a variable dc output voltage. It can be step up or step down. It is also considered as a dc equivalent of an AC transformer since they behave in an identical manner.

The performance of these applications will be improved if we use a variable DC supply. It will help to improve controllability of the equipments also. Examples of such applications are subway cars, trolley buses, battery operated vehicles etc. Chopper systems offer smooth control, high efficiency, faster response and regeneration facility. The power semiconductor devices used for a chopper circuit can be force commutated thyristor, BJT, MOSFET, IGBT and GTO.

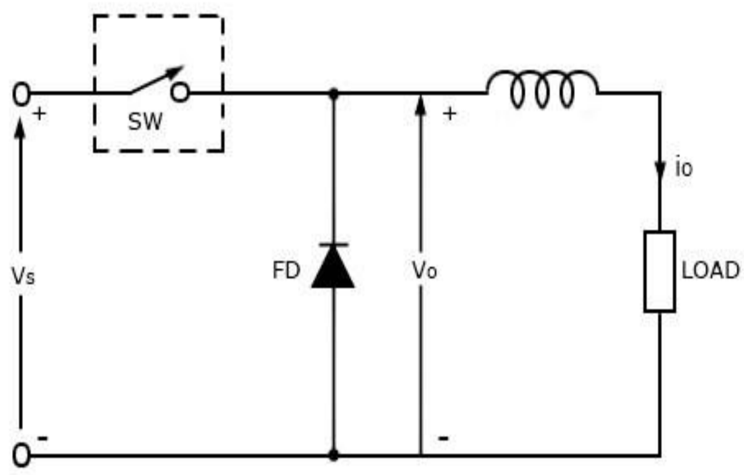

Figure 9: Buck Converter Circuit.

2) IGBT Gate Driver:

The TLP250 is a gate driver for MOSFET and IGBT. The driver has an input stage and output stage. It also have power supply configuration. TLP250 is more suitable for MOSFET and IGBT. The TLP250 driver is optically isolated i.e. the input and output of TLP250 is isolated from each other through an opto-coupler. The isolation is optical – the input stage is an LED and the receiving output stage is light sensitive. Whenever input stage LED light falls on output stage photo detector diode, output becomes high.

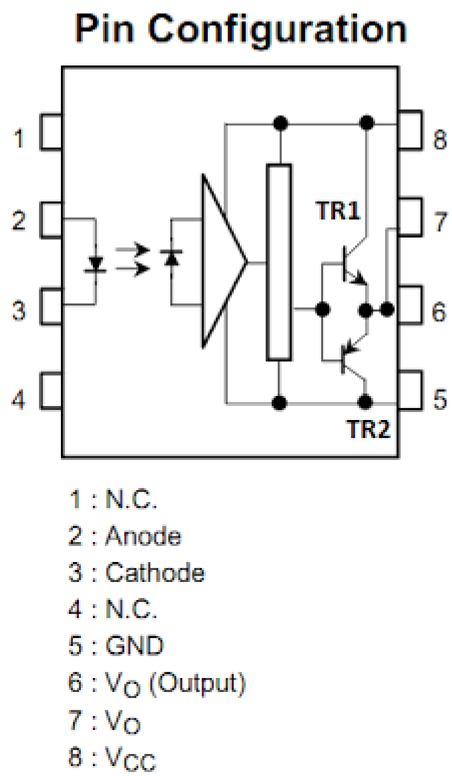

Figure 10: Pin Diagram

3) Microcontroller:

Arduino is an open-source single-board microcontroller, descendant of the open-source Wiring platform, designed to make the process of using electronics in multidisciplinary projects more accessible. The hardware consists of a simple open hardware design for the Arduino board with an Atmel AVR processor and on-board input/output support. The software consists of a standard programming language compiler and the boot loader that runs on the board. Arduino hardware is programmed using a Wiring-based language (syntax and libraries), similar to C++ with some slight simplifications and modifications and a Processing-based integrated development environment.

Figure 11: Arduino Uno Board

DESIGN IMPLEMENTATION:

A)BUCK CONVERTER DESIGN

Buck converter is a power electronic device which converts fixed DC to variable DC. The output equation of the buck converter is

Vout = D * Vs.

Where Vout is the output voltage,

Vs is the supply voltage and

D is the duty cycle.

DUTY CYCLE D =Ton/T

Where T = Ton +Toff.

A.1) CALCULATION OF INDUCTANCE OF THE DC MOTOR:

A.1.1) INDUCTANCE OF ARMATURE WINDING OF DC MOTOR:

The dc motor is supplied with LOW VOLTAGE AC SOURCE. The field winding is connected across the supply. The current and voltage readings are taken for various supply voltage.

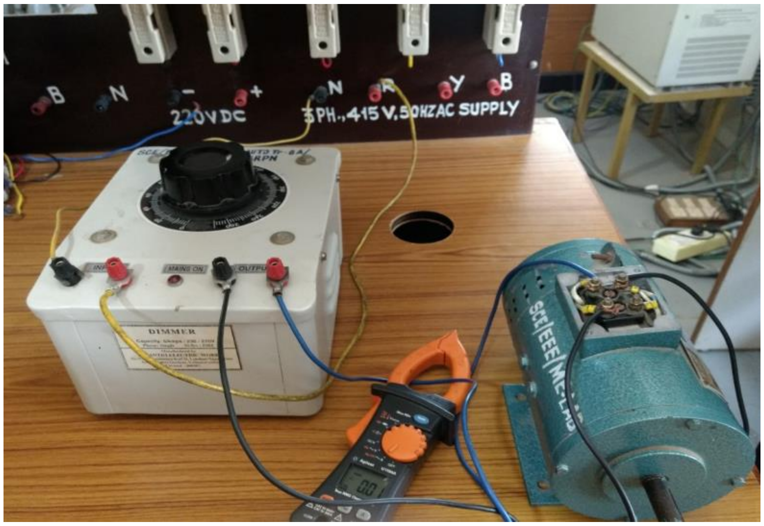

Figure 12: Experiment for finding Inductance of the motor

Table 1: FINDING THE IMPEDANCE OF THE ARMATURE:

VOLTAGE(V)	CURRENT(I)	IMPEDANCE(Z)
20	0.11	181.82
40	0.18	222.22
60	0.27	222.22
		AVERAGE:208.75

Impedance Z = V / I.

Z = 208.75Ω.

$X_L = \sqrt{Z^2 - R^2}$.

ARMATURE WINDING RESISTANCE R =168 Ω.

$X_L = \sqrt{208.75^2 - 168^2}$.

X_L =123.91ohms.

$X_L = 2\pi f L$.

Where f is the supply frequency which is 50 HZ,

L is the Inductance of the motor.

$L = X_L / 2\pi f$.

L = 123.91/ 2*3.14*50=0.394H

INDUCTANCE OF THE ARMATURE WINDING OF THE MOTOR = 0.394

A.1.2) INDUCTANCE OF FIELD WINDING OF DC MOTOR:

TABLE 2: FINDING THE FIELD IMPEDANCE OF THE MOTOR:

VOLTAGE(V)	**CURRENT(I)**	**IMPEDANCE(Z)**
40	0.03	2000
60	0.02	3000
80	0.02	4000
		AVERAGE:3000

Impedance Z = V / I.

Z = 3000Ω.

$X_L = \sqrt{Z^2 - R^2}$.

FIELD WINDING RESISTANCE R =685 Ω.

$X_L = \sqrt{3000^2 - 685^2}$.

X_L =292.74ohms.

$X_L = 2\pi fL$.

Where f is the supply frequency which is 50 HZ,

L is the Inductance of the motor.

$L = X_L / 2\pi f$.

L = 292.74/ 2*3.14*50=9.34H

INDUCTANCE OF THE FIELD WINDING OF THE MOTOR = 9.34 H.

A.1.3) SELECTION OF SWITCH:

For selecting suitable switch the performance of the motor should be noted first. By knowing the performance of the motor we can detect the maximum current limit of the switch. The performance of the motor is identified by the following test:

Figure 13: Speed Control Test Of Dc Motor.

In this test first the field current is kept constant and the following values are noted:

TABLE 3: CONSTANT FIELD CURRENT (If=0.26A and I_L=0.38A)

VOLTAGE(V)	SPEED(rpm)
220	1424
196	1392
198	1305
200	1275
202	1273

TABLE 4: CONSTANT ARMATURE VOLTAGE (V=196 VOLTS)

Line Current (A)	Field current(A)	Speed(rpm)
0.38	0.26	1250
0.37	0.25	1295
0.35	0.23	1344
0.32	0.21	1494

From the above experiment we can conclude that the **switch should able to withstand up to 5A.**

A.1.4) DESIGN OF BUCK CONVERTER:

We are designing a digital starter for the following DC motor.

The ratings of the motor are

POWER =O.25 HP,

SPEED =1500 RPM,

VOLTAGE =220 V,

CURRENT=1AMPS.

A.1.4.1) BUCK CONVERTER FOR CONTROLLING ARMATURE WINDING OF THE MOTOR:

a) MAXIMUM DUTY CYCLE (D):

D = Vout * N/ Vin*max.*

Vout is the output voltage.

N is the efficiency.

Vin*max* is the supply voltage

Assuming efficiency to be 80%

So D = 200 * 0.8/220

MAXIMUM DUTY CYCLE D = 0.72

b) INDUCTOR RIPPLE CURRENT (Δ IL):

Δ **I**L = **(Vin*max.* - Vout) * D/ f_S * L.**

f_S is the switching frequency and

L is the inductance.

Δ **I**L = (220 – 200) * 0.72/20KHZ *0.39(switching frequency is assumed to be 20 KHZ).

FOR INDUCTANCE VALUE PLEASE REFER **A.1.2**

INDUCTOR RIPPLE CURRENT Δ I**L = 1.85 MA.**

c) MAXIMUM OUTPUT CURRENT OF IGBT (I_{MAXOUT}):

I_{MAXOUT} = **I_{LMIN}** – **(Δ** I**L / 2)**

Where **ILMIN** is the minimum value of the current limit of IGBT

I_{MAXOUT} = 15-(1.85MA/2)

I_{MAXOUT} = **14.99 A.**

Since the value of I_{MAXOUT} > OUTPUT CURRENT we need to calculate maximum switching current

d) SPECIFIC MAXIMUM SWITCHING CURRENT (Isw):

Isw = I_{OUT} + **(Δ IL / 2).**

Isw=5 + (O.96mA/2)

Isw = 5.009 A.

As a result we have to select Diode that should withstand 5.009A.

By repeating the above calculations the buck converter for field winding can also be calculated. As a result we found that both diodes should withstand more than 6A current. Hence we have choosen **IGBT FGA25N120** as the switching device.

SOFTWARE IMPLEMENTATION

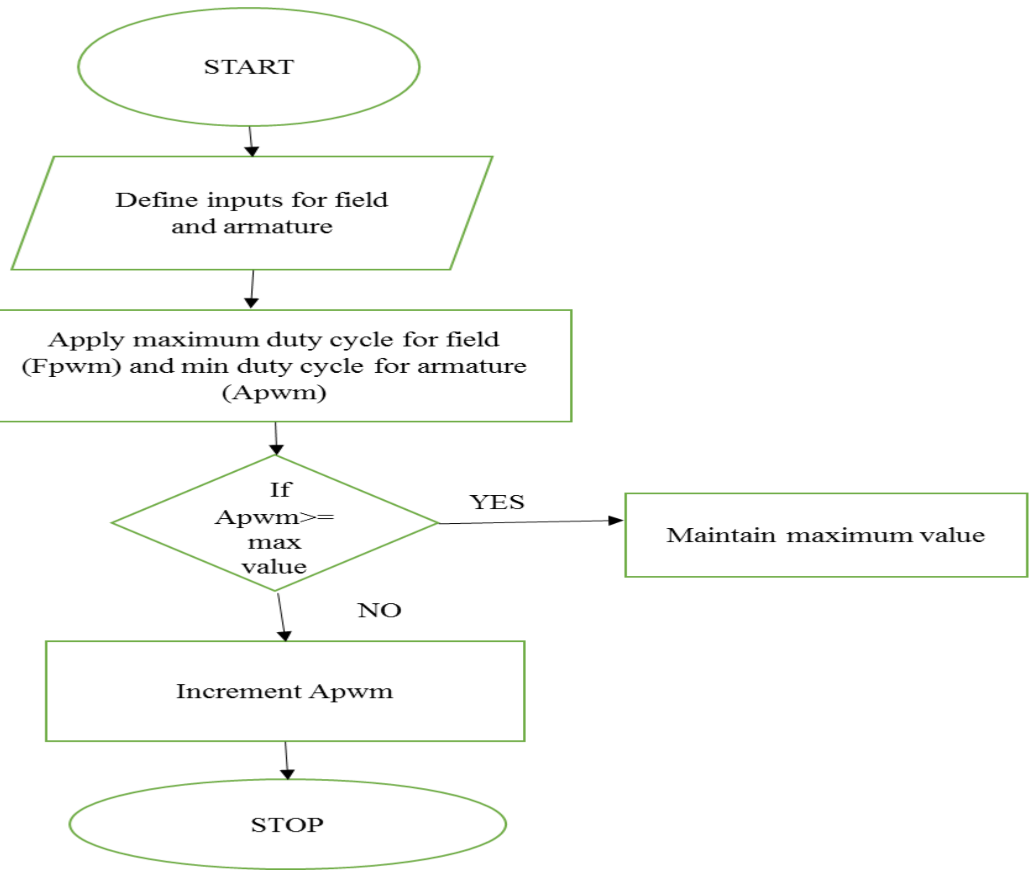

Figure 14: Flow chart for soft starting

TESTING

The starting current comparison between both conventional and soft starters are shown below:

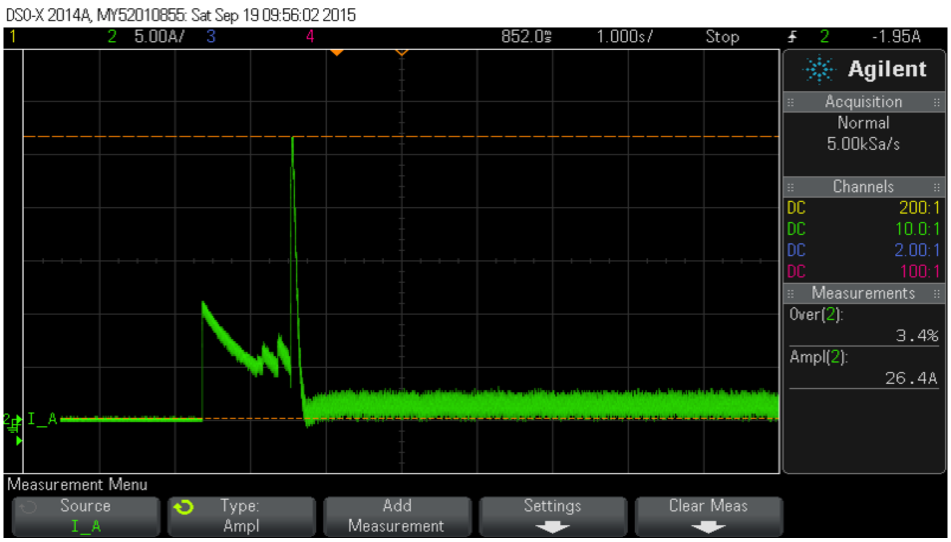

Figure 15: Starting current of conventional starters

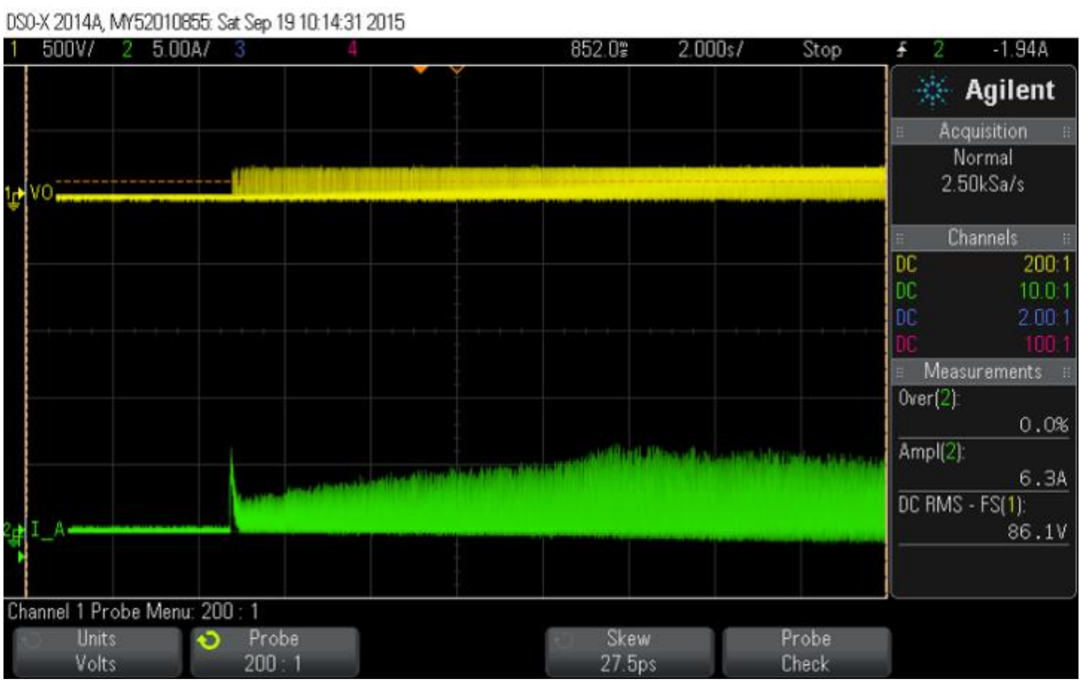

Figure 16: Starting current of soft starter

After comparing both conventional and digital starter it is found that the starting current of digital starter is more times lesser than the conventional starters.

HARDWARE SETUP:

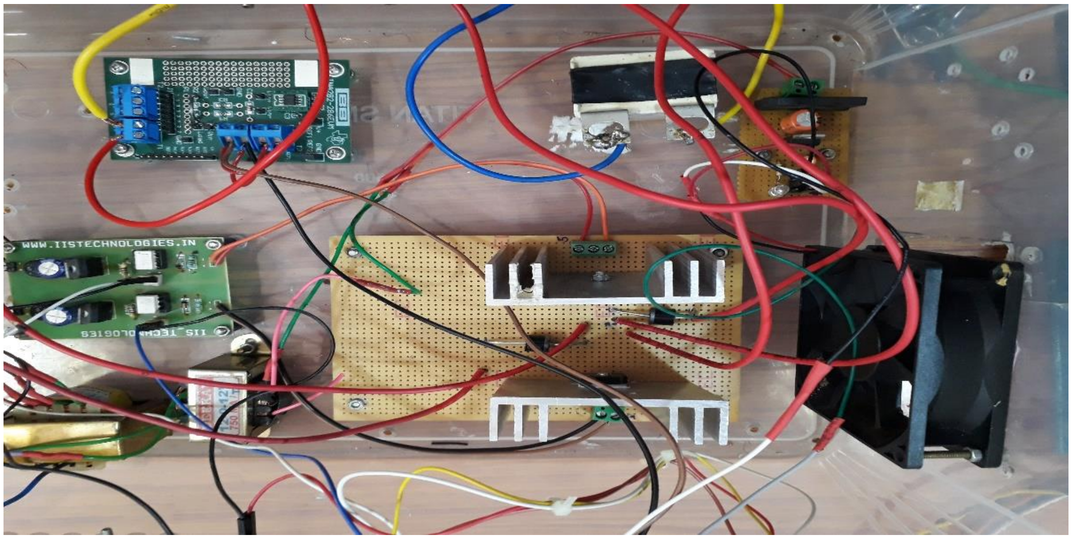

Figure 17: Hardware setup of Digital starter

Figure 18: Working of Digital Starter

RESULT

The applied voltage is controlled by varying the duty cycle. The duty cycle variation is done by regulating the rotory encoder. We can obtain smooth starting of the motor and by varying the voltage, speed can also be varied. By implementing this project, complete safety can be assured. In this digital generation we expect our digital starter will replace conventional starters in all academic institutions.

BASE PAPER

1. IEEE Soft Starter Vol. 34, No. 1, Pp. 52-59, February 2008.

OTHER REFERENCES

1. Dr. P.S. Bimbhra, Power Electronics, Third Edition, Khanna Publication.
2. A TEXT BOOK OF ELECTRICAL TECHNOLOGY by B.L.THERAJA&A.K.THERAJA.
3. Muhammad H. Rashid “Power Electronics”, 3rd Edition, Prentice Hall, 2004
4. Gopal K.Dubey, Fundamentals of Electrical Drives.
5. Steven F. 2010. Arduino Microcontroller: Processing for Everyone. Morgan & Claypool, 325 pp. ISBN: 9781608454389.