

# Starters for the DC Shunt Wound and Compound Wound Motors

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**Abstract:** DC motor unlike other types of motor has a very high starting current that has the potential of damaging the internal circuit of the armature winding of dc motor, if not restricted to some limited value. This limitation to the starting current of dc motor is brought about by means of the starter. Thus starting methods of dc motor is facilitated by means of a starter, or rather a device containing a variable resistance connected in series to the armature winding so as to limit the starting current of dc motor to a desired optimum value taking into consideration the safety aspect of the motor. A starter allows a DC motor or a DC motor - controlled device to turn ON or OFF. This paper discuss the various types of starters that are used for starting DC motors and also suggests the alternative methods that can be used to construct a dc starter to overcome the limitations of the previously existing starters.

**Keywords:** Soft Starter, IGBT, Electromagnet, Overload Relay (OLR), SCR.

## I. INTRODUCTION

An electrical motor is a machine which converts electric energy into mechanical energy. Its action is based on the principle, when the current carrying conductor is placed in a magnetic field; it experiences a mechanical force whose direction is given by Fleming's left-hand rule.

The starting of a DC motor is different from the starting of all other types of electrical motors. D.C motor is self starting motor [1]. If armature and field of dc shunt motor are energized together, large current is drawn at start but the torque builds up gradually as the field flux increases gradually. To improve the torque per ampere of line current drawn, it is advisable to energize the field first and later the armature. The starting current is given by  $I = V/R_a$  and hence to reduce the starting current to a safe value, either the voltage  $V$  can be reduced or armature circuit resistance  $R_a$  can be increased.

The back emf ( $E_b$ ) is developed as the motor armature starts to rotate in the presence of magnetic field, this also means that the back emf is initially zero and develops gradually as the motor speeds up. Therefore the total motor voltage is given by the equation  $V = E_b + I_a R_a$ . At starting  $E_b=0$  so the equation would be  $V = I_a R_a$  and  $I_a = V/R_a$

From the above equation it can be stated that current is dangerously high as armature resistance i.e.  $R_a$  is extremely small [6]. Hence it becomes very essential to use an external device to limit starting current to an allowable low value. These external devices are called as starters.

A motor's soft starter is a device used with DC electric motors to temporarily reduce the load and torque in the powertrain and electrical current surge of the motor during start up. This reduces the mechanical stress on the motor and shaft [1]

In present times several methods are used by industries for starting of D.C. motor. These external methods used mainly provide safety to DC Motors; if the starters are not used then motor will get damaged easily.

## II. LITERATURE SURVEY

Rohit Kumar [1] gives the study of different types of starters used in industries, i.e. 3-coil starter and 4- point starter in the paper, he also explains why the motor burn if the starters are not used. Rakesh J. Waghmare [2] in his paper he explains the need of a starter for DC motors, various commonly used methods for the starting of dc motors and also introduces a technique of soft starting of the device that is based on triggering of thyristor.

## III. SIMPLE STARTER

To start a DC motor with sufficient starting torque, field current is maximized by keeping the field resistance to zero value. To limit the starting current, a suitable external resistance is connected in series with the armature. As the motor picks up speed, the value of external resistance is gradually decreased to zero so that during running no external resistance remains in the armature circuit.

But each time when one has to restart the motor, the external armature resistance must be set to maximum value by moving the jockey manually. If the supply goes off (due to some problem in the supply side or due to load shedding), motor will come to stop, and all of a sudden if supply is restored the motor would start with full voltage.

This means that, one should be constantly alert to set the resistance to maximum value whenever the motor comes to a stop. This is one major limitation of a simple rheostatic starter.

### IV. 3 POINT STARTER

A 3 point starter is a device that helps in starting and running of a DC shunt motor or a DC compound motor. 3 point starter limits the starting current to allowable lower value.

A 3 point starter is a variable resistance, integrated into number of sections. The contact points of this starter are called as studs which are shown separately as OFF, 1, 2,3,4,5, RUN. The name 3 point starter has been given to this starter as it has 3 main points, which are referred as

1. Line terminal ‘L’ (connected to positive supply.)
2. Armature terminal ‘A’ (connected to armature winding.)
3. Field terminal ‘F’ (connected to field winding.)

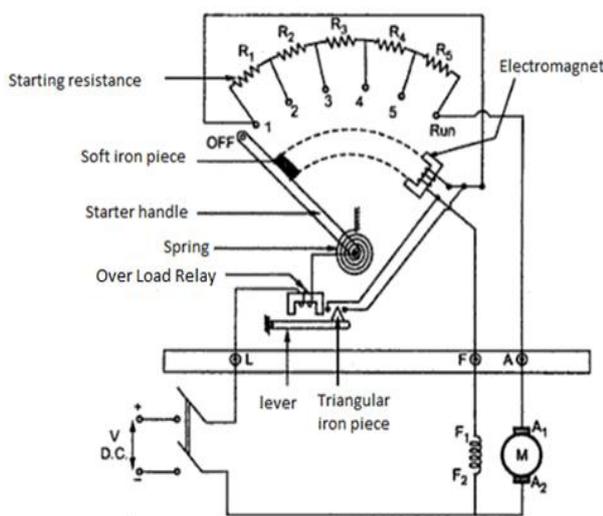


Fig: 1

The point L is connected to an electromagnet called overload relay (OLR). The other end of the OLR is connected to the lower end of conducting lever of starter handle where the spring is attached to the handle, along with these things the handle also consist of a soft iron piece. This handle is free to move, to the other end. The spring is responsible for the movement of the handle. All the resistors are connected in series to the armature. The electromagnet and OLR are the two protection device to the starter.

Working: The supply to the field winding is derived through the electromagnet, so when the field current flows the electromagnet is magnetized. When the handle is in Run position, the soft iron piece connected to handle gets attracted by magnetic field of electromagnet, because of flow of current through electromagnet. The electromagnet holds the handle at RUN position, hence also known as hold on coil. When there is any kind of supply failure, the current flow through electromagnet is affected and it immediately losses its magnetic property and unable to keep soft iron on the handle. Therefore, due to the combination of electromagnet and soft iron, the handle comes to the OFF position whenever there is supply problem. The handle is initially in OFF position when the DC supply is switched ON. Then handle is slowly moved

against the spring force to make contact with stud NO.1. At this point the field winding of DC shunt motor gets supply through the parallel path provided to starting resistance, through electromagnet [6]. While entire starting resistance comes in series with the armature, high starting armature current gets limited. As the handle is moved further, it goes on making contact with stud 2,3,4,5 and so on, thus gradually cutting off series resistance from armature circuit as motor gathers speed. Finally when the starter handle is in RUN position the entire starting resistance is eliminated and the motor runs with the rated speed. Hence 3 point starter also acts as protective device to safeguard the motor from damages.

### V. 4 POINT STARTER

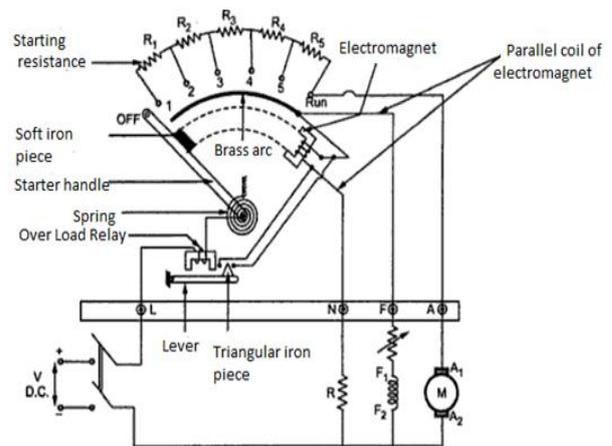


Fig: 2

The 4 point of a 4 point starter are as follows

1. Line terminal ‘L’ (connected to positive supply.)
2. Armature terminal ‘A’ (connected to armature winding.)
3. Field terminal ‘F’ (connected to field winding.)
4. Additional point N (connected to electromagnet.)

4 point starter is identical to 3 point starter, but the addition in the device is a terminal (N) that links the supply to the electromagnet, which brings about changes in the functionality of the device. The N terminal is necessary because higher speed of the motor reduces field current through terminal F, so that the handle is unable to remain in RUN position. Thus it must be ensured that electromagnet always produces a force which is strong enough to hold the handle in its RUN position, against force of the spring, under the operational condition. Such that the current is adjusted by the electromagnet with the help of fixed resistance R connected in series with the electromagnet using the 4<sup>th</sup> point ‘N’.

Apart from this difference the 4 point and 3 point starters are similar all ways.

Working: The current is divided into 3 parts.

1. 1<sup>st</sup> part, current flows starting resistance and then through armature.
2. 2<sup>nd</sup> part, current flows through the field winding F.
3. 3<sup>rd</sup> part, current flows electromagnet in series with the protective resistance R.

With this arrangement any change in the shunt field does not bring about any change in the electromagnet as the two circuits are independent of each other[6]. This indicates that the electromagnetic pull on the soft iron should be high enough at all points of time to keep the handle at its RUN position, or rather prevent the spring force from restoring the handle at its original OFF position, irrespective of how the field rheostat is adjusted.

This is where the 4 point starter differs in its operation from 3 point starter, otherwise both 4 point and 3 point starters are almost similar and are also used for the similar purpose i.e. for limiting the starting current and protecting the DC shunt wound and DC compound wound motors.

**V. IGBT BASED STARTER**

The types of starters discussed above have certain limitations and also some disadvantages like they have moving parts which require maintenance at regular intervals, these starters give jerk to the motor every time the starting process takes place which reduces the efficiency of the DC, etc. So, if the switching devices like MOSFET, SCR or IGBT's are used to construct the starters for soft start of DC motors it would help to overcome all the limitations of the above mentioned starters.

IGBT is a switching device that is made by combining the best qualities of BJT and MOSFET, i.e. IGBT is used as MOSFET input and BJT output characteristics.

Sr No.	Parameters	IGBT	SCR
1.	Gate- Drive Requirements	Lower	Higher
2.	Switching Losses	Less	More
3.	Snubber Circuit Requirements	Small	Large
4.	Efficiency	More efficient being smaller, lighter and generate fewer harmonics	Less efficient being bulky and generate more harmonics
5.	Switching Speed	Faster than BJT but lesser than MOSFET	Slower than IGBT & MOSFET
6.	Input Impedance	High	Low
7.	Second Breakdown Voltage	Absent	Present
8.	Control Parameter	Voltage Controlled device	Current Controlled device
9.	Cost	Costly	Cheap

IGBT processes high input impedance like PMOSFET and has low ON – state power loss as in BJT's. In this way we can consider that the IGBT is better than the MOSFET to be used in a starter. Also the IGBT shows better performance with higher power ratings as required by the bigger motors, i.e. in DC shunt and compound wound motors.

On the other hand SCR can also be considered in making starter for DC motors, but even in this case IGBT is more advantageous as compared to SCR. The comparative study of SCR and IGBT is given below to show that in what all ways IGBT is better as compared to SCR.

**VI. CONCLUSION**

The switching devices would show better performance when considered in constructing the starters for DC motors. The IGBT based starter would not have any moving parts so they would require comparatively less maintenance and will be more durable. The time required for starting the motor is much more by 3 point and 4 point starter as compared to the time required by the switching devices i.e. it would be depended on the switching frequency of the device used. The stepwise performance of the 3 point and 4 point starters would be efficiently replaced by linear and faster performance of the starter if IGBT is used. If simple starters, 3 point or 4 point starters are used for the motors for longer duration of time, then the motor's efficiency is reduced with time. But if IGBT based starter are used for starting DC motors for longer duration of time then the motor does not lose its efficiency. Therefore it can be concluded that IGBT based starters would be better than the existing starters in many aspects.

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