Module – 3

DC MOTOR CONTROL

Lecture – 1

STARTING OF A D.C. MOTOR

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Outcomes

- Explain different starting methods of a DC motor
  - Full voltage starting
  - Three/Four point starters
  - Magnetic motor starters
  - Thyristor motor starters

Introduction

- To start any motor two requirements must be met:
  - protection from flow of excessive current during the starting period
  - starting torque should be made as large as possible
- High armature current -
  - In a dc motor, the armature current is given by:

$$I_a = \frac{V_t - E_b}{R_a}$$

  - Three factors limiting the armature current are
    - Terminal voltage (V_t)
    - counter emf (E_b)and
    - armature resistance (R_a).
  - Counter emf is very small upon starting,
  - So the current used by the armature is very high
- Inserting a starting resistance in series with the armature reduce the high starting current

Starting Resistance

- At starting, the a motor is stationary,
- No counter emf is being generated, and therefore *Eb is zero.*
- Only thing to limit the current drawn is the armature resistance, which in most motor is very low.
  - Consider a 10 hp motor with armature resistance of 0.25 Ω connected to a 125 V supply,

$$I_a = \frac{V_t - E_b}{R_a} = \frac{125 - 0}{0.25} = 500\ \text{A}$$

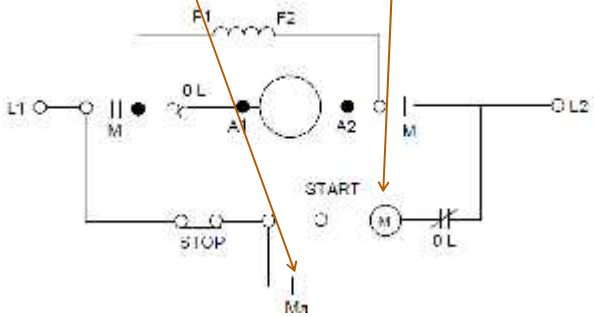
  - This large inrush current (10 times full load current) would in all probability damage the motor winding, brushes, insulation.
  - So, an external resistance or some other voltage reduction method is placed in series with the motor armature during the starting.
  - Consider a 230 V DC motor with armature resistance 0.5 ohm. Starting resistance for a full load current of 40 A is

$$R_s = \frac{V_t}{I_a} - R_a = \frac{230}{60} - 0.5 = 3.33\ \Omega$$

- Starting resistors are variable resistances, full resistance is inserted initially and then be cut out by successive steps until the motor has reached its full speed.

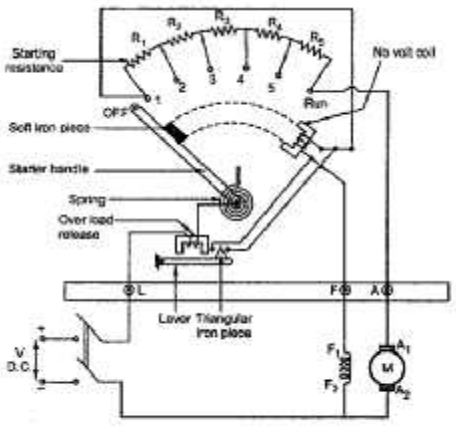
Full Voltage Starter

- Small dc motors can be connected directly across the supply.
  - they have low friction, small inertia, and higher percent of armature resistance.
- When the START button is pushed the coil M is energized and all M contacts are closed, causing motor to start.
  - The auxiliary contact (Ma - holding or maintaining contact) keeps the coil M energized after the START button is released..
- If the STOP button is pushed or overload protection operates, the coil M will be de-energized opening contacts and stopping the motor.

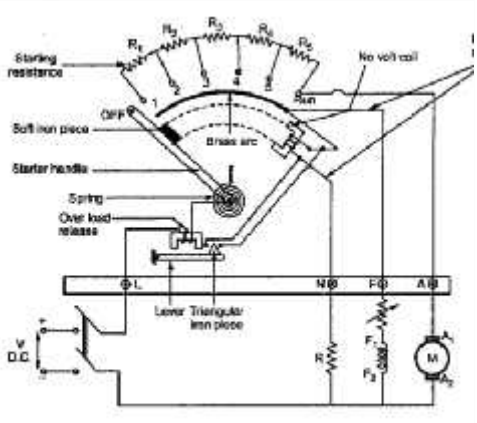


Manual DC Motor Starters

- consists of resistance connected in the armature circuit and gradually removed manually by advancing a lever
- two types of manual starters - 3-point and 4-point starters



3 point Starter

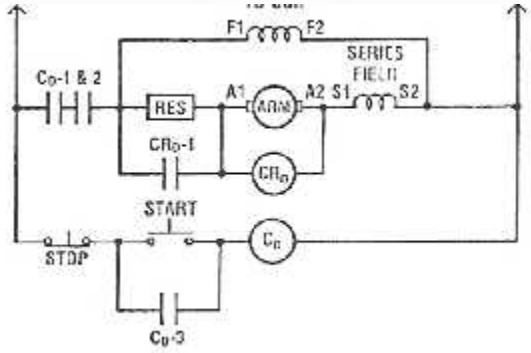


4 point Starter

Magnetic DC Motor Starters

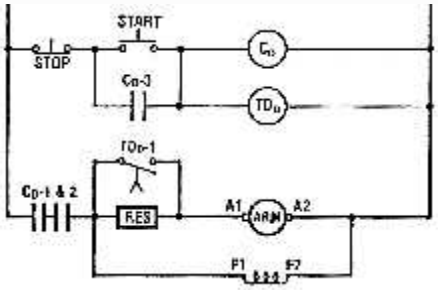
- switching is done through the use of magnetic relays and contactors
- Magnetic starters can incorporate several features like reduced voltage starting, dynamic braking, automatic reversing etc.
- starter using **counter EMF acceleration**
  - When the voltage across the armature reaches a certain *value, a relay is energized to remove the* starting resistance.

This type of controller automatically adjusts the starting time intervals, depending *upon* the load on the motor



Working – Refer Book, Pg. 98,99

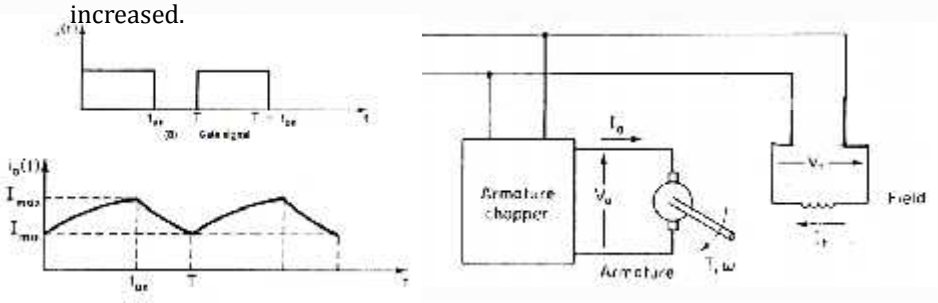
- Starting using **timing relay**
- time delay relay to remove starting resistors in steps after definite time interval.



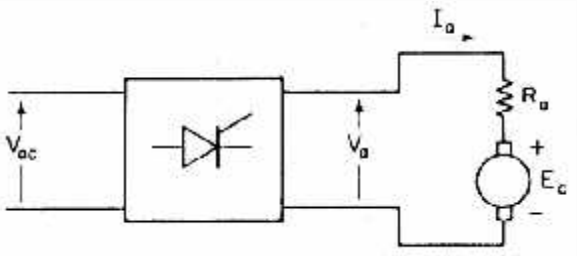
- After a preset time, contact (TDD-1) closes to remove the resistance from the circuit.
- and the motor is connected directly across the line.

THYRISTOR STARTING

- use a dc chopper circuit for starting purpose
  - power electronic device such as thyristor, a power transistor or a GTO are used as chopper
  - not use any resistance to reduce armature voltage.
  - Field is supplied directly from the dc source
  - supply is switched on and off rapidly to give a variable output voltage.
  - To start the motor the gate firing controller will make T_{ON} small and T_{OFF} large.
  - Once the motor starts to run and build up counter emf, T_{ON} will be increased.



- we have ac source available, we can use **thyristor controlled rectifier** for starting
- By controlling the firing angle of thyristor the armature voltage can be varied from zero to full value



- Most of the modern dc drives will have starting mechanism built in it as speed control and starting can be performed by the same device

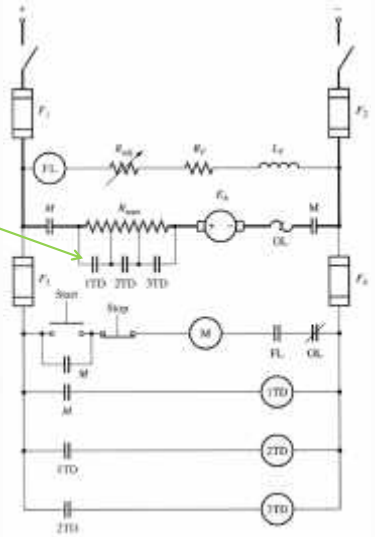
Multiple time relays

A common DC motor starting circuit:

A series of time delay relays shut contacts removing each section of the starting resistor at approximately correct times.

Notice that the relay 1TD is energized at the same time as the motor starts – contacts of 1TD will shut a part of the starting resistor after some time. At the same instance, relay 2TD is energized and so on…

Observe also 4 fuses protecting different parts of the circuit and the overload in series with the armature winding.



Multiple cemf relay

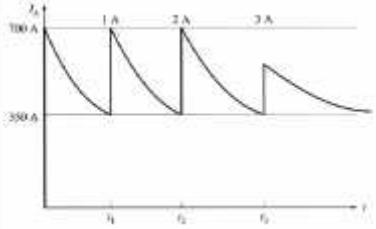
Another type of motor starter:

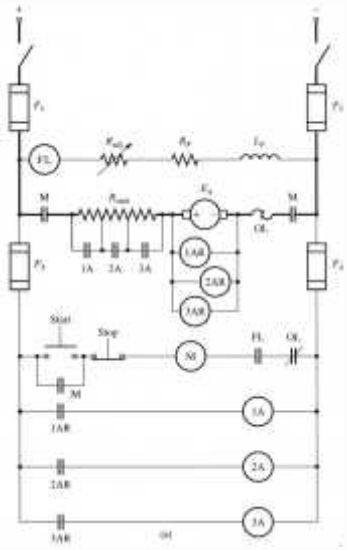
A series of relays sense the value of armature voltage E_A and cut out the starting resistors as it riches certain values.

This starter type is more robust to different loads.

FL is the *field loss relay*: if the field is lost for any reason, power to the M relay will be turned off.

Armature current in a DC motor during starting.





Thank You

Next Lecture:
Speed Control of DC Motor