DC Motor Starters

Acknowledgement: *The materials presented in this lecture has been taken from open source, reference books etc. This can be used only for student welfare and academic purpose.*

Name of the Faculty: Dr. Sheetla Prasad

Recap

- Needs of DC motors
- Back EMF in DC motor
- Classification of DC motor
- Torque in DC motor
- DC motor Characteristics
- Speed control of DC motor

Lecture-18 Objectives

- Starting of DC motor
- Swinburne's test
- Efficiency
- Application of DC motor

Starting of DC motors – Necessity of Starters

- We know that in a DC motor, the back e.m.f.,

$$E_b = V - I_a R_a$$

$$\therefore I_a = \frac{V - E_b}{R_a}$$

- At starting, when the motor is stationary, back e.m.f. is zero.

$$\therefore I_a = \frac{V}{R_a}$$

- If the motor is directly switched on to the supply, the armature will draw a heavy current from the supply because of small armature resistance.

Necessity of Starters – Example

- 5 H.P., 220 V shunt motor has a full-load current of 20 A and an armature resistance of about 0.5 ohms. If this motor is directly switched on to supply, it would take an armature current of 220/0.5 = 440 A which is 22 times the full-load current.
- This high starting current may result in:
  - ✓ burning of armature due to excessive heating effect
  - ✓ damaging the commutator and brushes due to heavy sparking
  - ✓ excessive voltage drop in the line to which the motor is connected

Control of Starting Current

- In order to avoid excessive current at starting, a variable resistance is inserted in series with the armature circuit.
- This resistance is gradually reduced as the motor gains speed and it is cut out completely when the motor has attained full speed.
- The value of starting resistance is generally such that starting current is limited to 1.25 to 2 times the full-load current.

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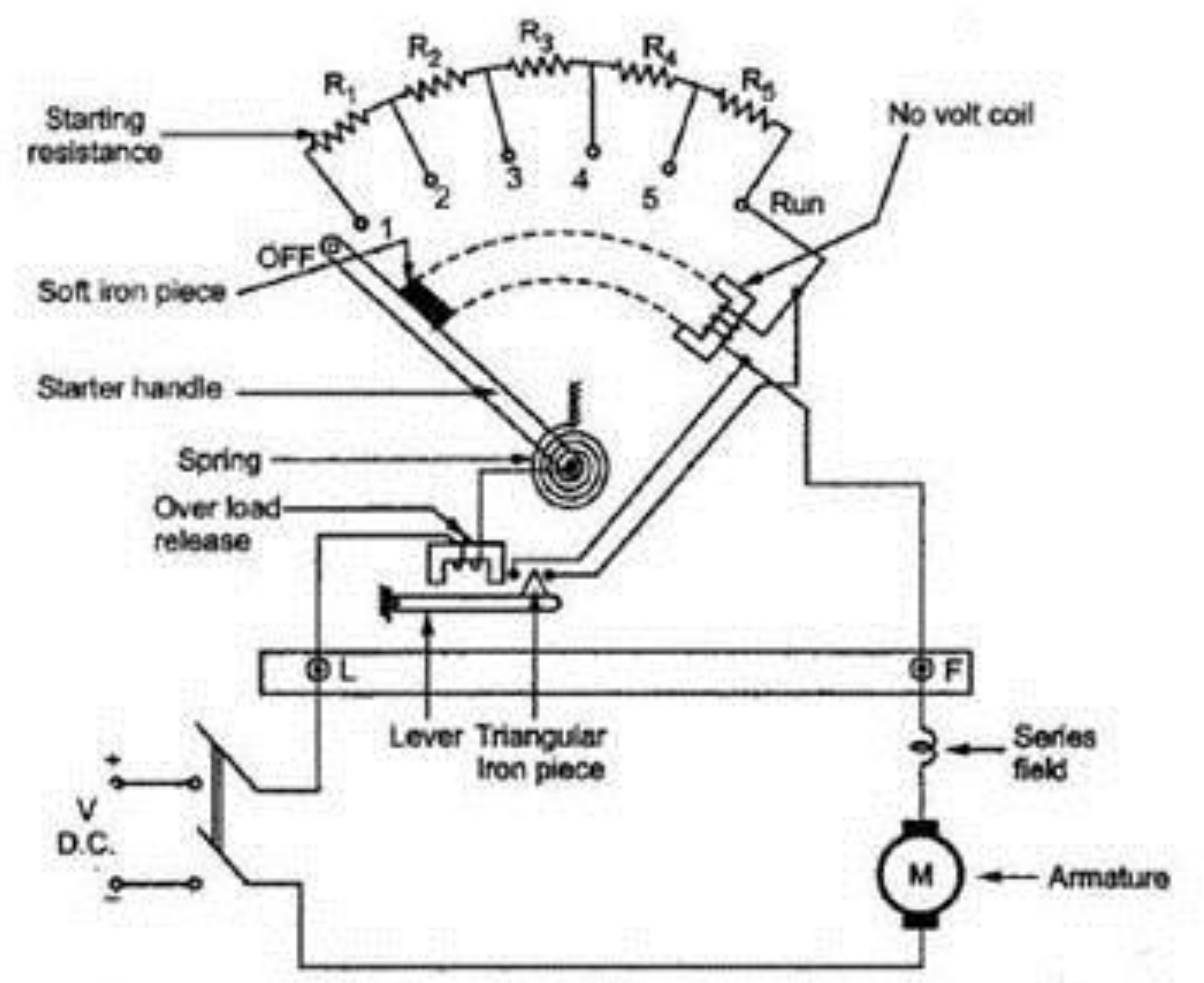
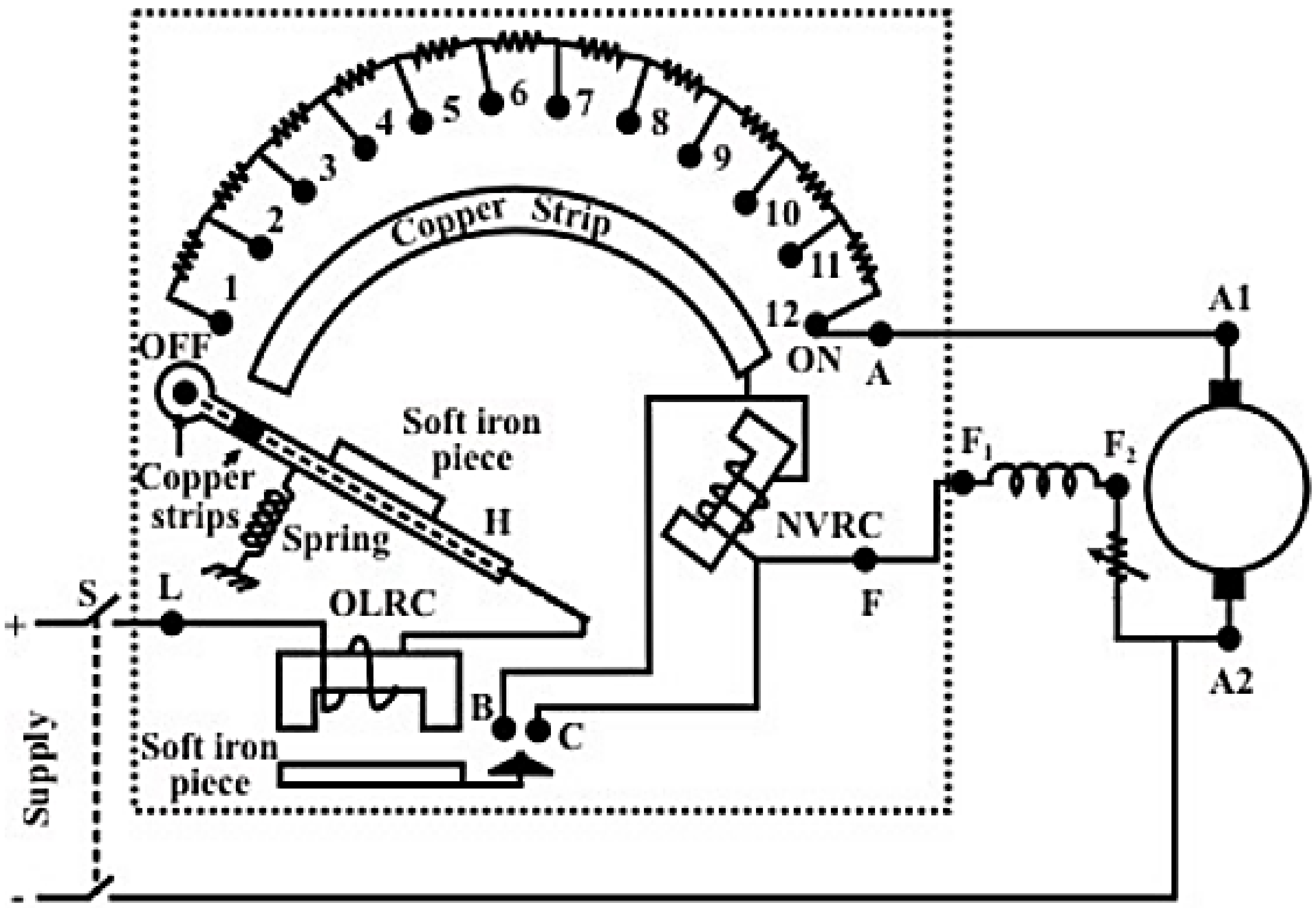
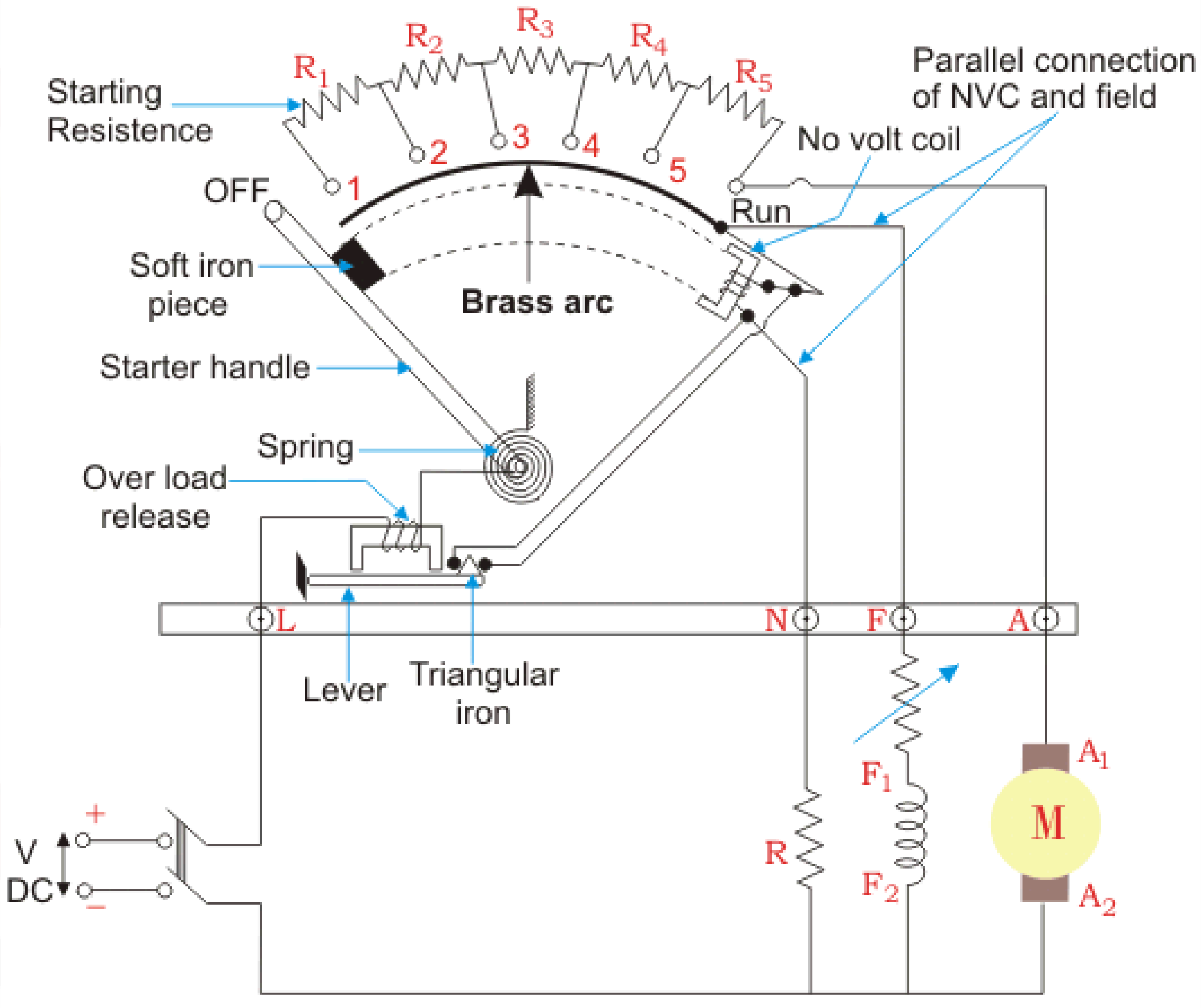
Two Point Starter



Three Point Starter



Four Point Starter



Four Point Starter

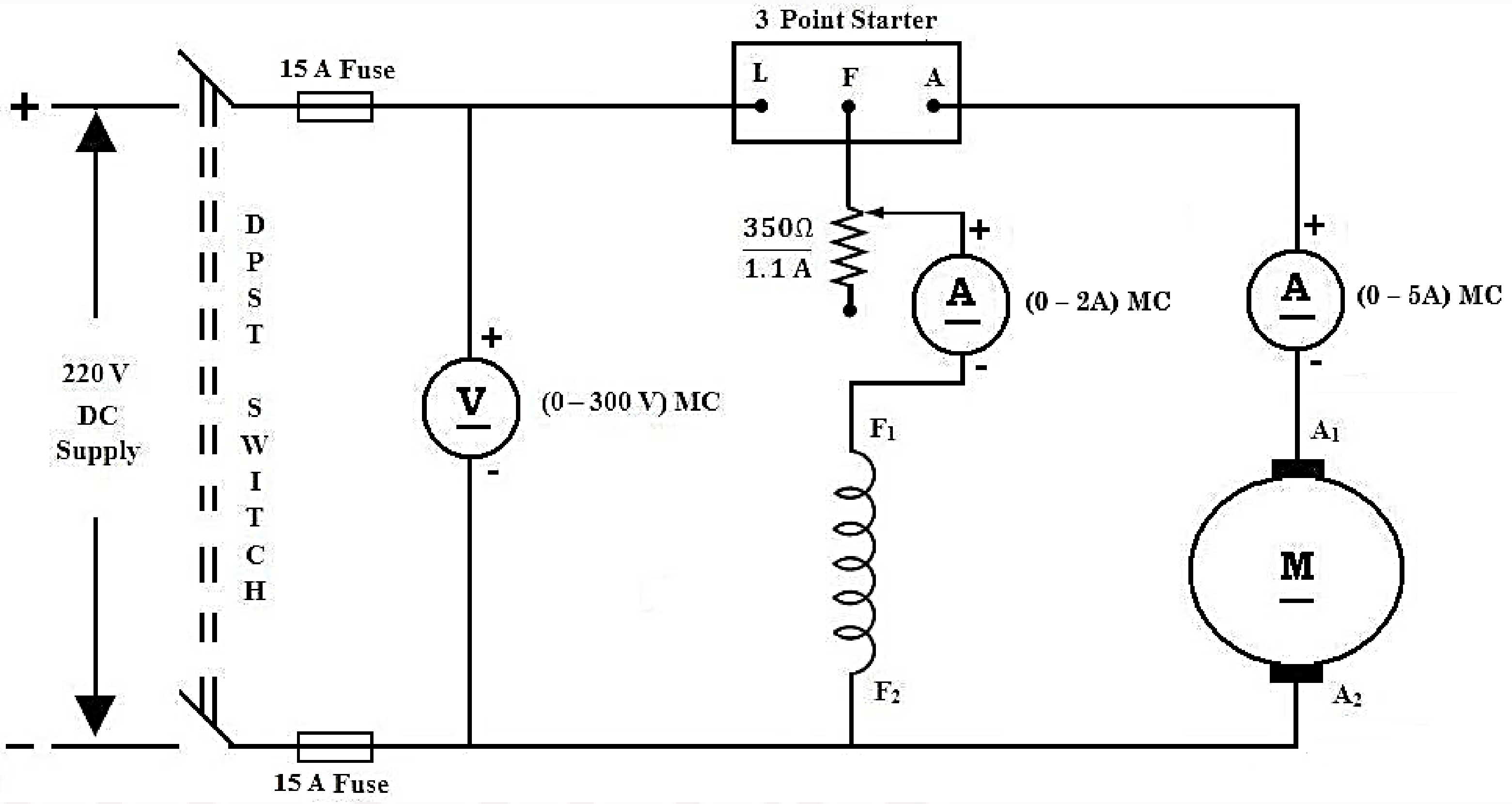
Testing of DC Motor

- Brake test
- Swinburne's test
- Hopkinson's test
- Retardation test

Swinburne's Test

- In this method, the d.c. machine (generator or motor) is run as a motor at no load and losses of the machine are determined.
- Once the losses of the machine are known, its efficiency at any desired load can be determined in advance.
- This method is applicable to those machines in which flux is practically constant at all loads e.g., shunt and compound machines.

Swinburne's Test



Data Observed

- Supply voltage V = __ volts
- No load shunt field current I_{sh} = __ amps
- No load armature current I_{a0} = __ amps

Swinburne's Test – Calculation of Constant Loss

$$\text{Constant loss, } W_C = \text{Input to motor} - \text{Armature copper loss}$$

$$\text{Line Current, } I_{L0} = I_{a0} + I_{sh}$$

$$\text{No load input to motor} = V.I_{L0} = V.(I_{a0} + I_{sh})$$

$$\text{Armature copper loss, } P_c = {I_{a0}}^2.R_a$$

$$W_C = V.(I_{a0} + I_{sh}) - {I_{a0}}^2.R_a$$

Efficiency of the Machine when Running as Motor

$$\text{Armature current}, I_a = I_L - I_{sh}$$

$$\text{Input power to motor}, P_i = V.I_L$$

$$\text{Armature copper loss}, P_C = {I_a}^2.R_a = (I_L - I_{sh})^2.R_a$$

$$\text{Total losses}, P_T = \text{Armature copper loss} + \text{Constant loss}$$

$$\text{Output power}, P_O = \text{Input} - \text{Total losses} = P_i - P_T$$

$$\text{Output Power } P_O \text{ in HP} = \left(\frac{P_O \text{ in watts}}{735.5}\right)$$

Applications of DC Motors

Shunt Motor:

- Blowers and fans
- Centrifugal and reciprocating pumps
- Lathe machines
- Machine tools
- Milling machines
- Drilling machines

Applications of DC Motors

Series Motor:

- Cranes
- Hoists , Elevators
- Trolleys
- Conveyors
- Electric locomotives

Applications of DC Motors

Compound Motor:

- Rolling mills
- Punches
- Shears
- Heavy planers
- Elevators

Summary

- Starting of DC motor
- Swinburne’s test
- Efficiency
- Application of DC motor