Series dc Motor

Motor cutaway

- Lets start by studying the cut away of a dc machine. The parts are indicated on the figure. It is basically the same as shunt dc motor in shape. Of course it differs in the turns of the armature and field turns resistance; since they will be connected in series and a high armature current must flow in order to provide torque both Rf and Ra are small. In shunt dc motor, however, Ra is small but Rf is large.

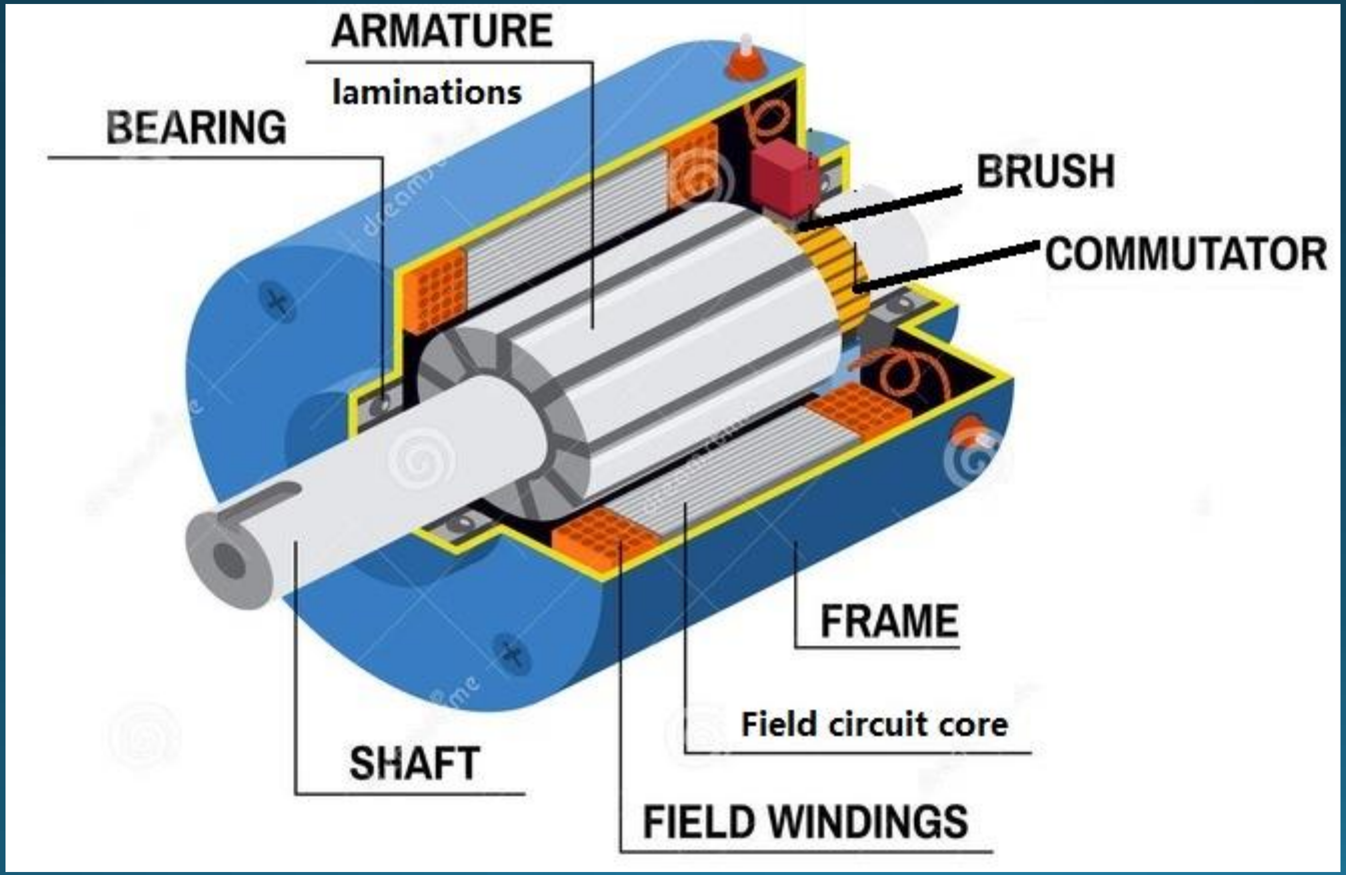


Figure 1

Series dc motor model

- The series dc motor is composed of two circuits in series. The armature circuit and the field circuit.

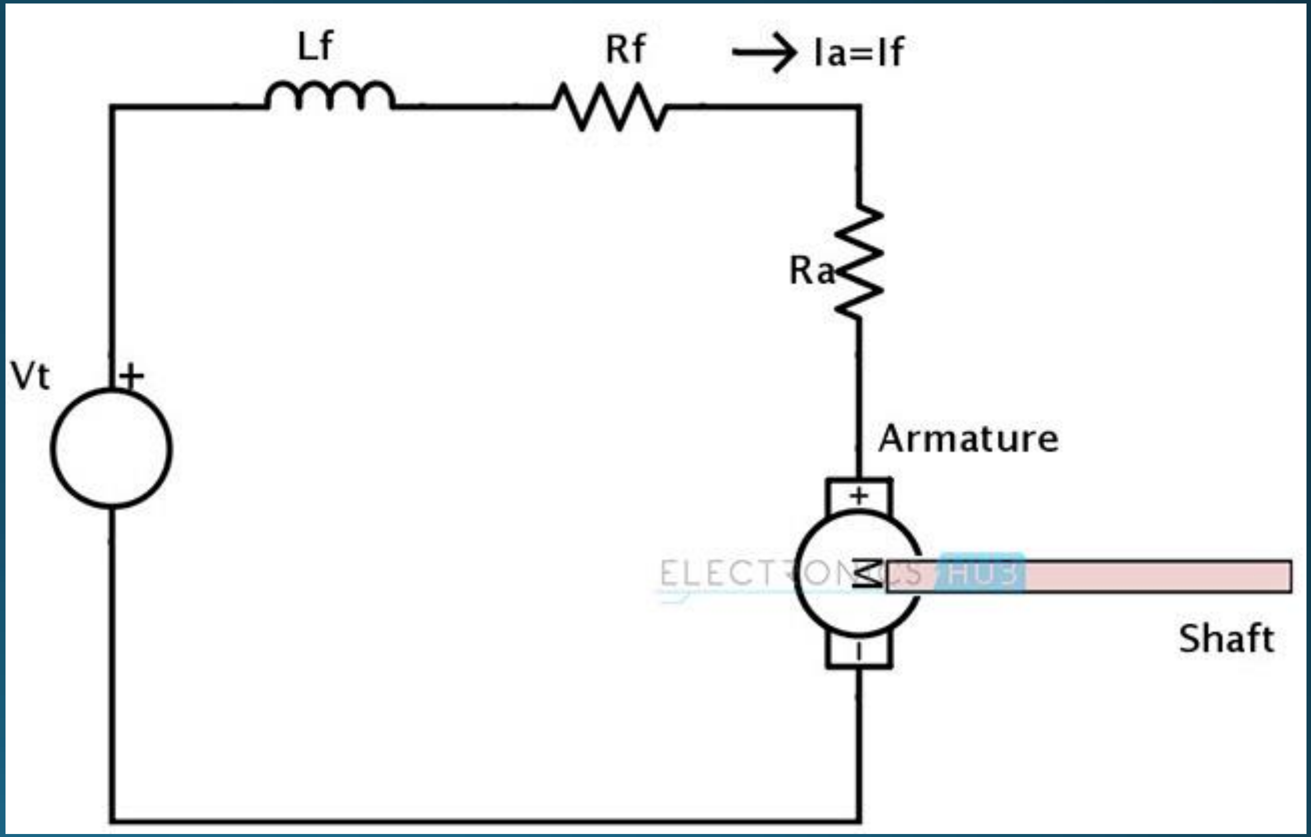


Figure 2

Series dc motor schematic circuit

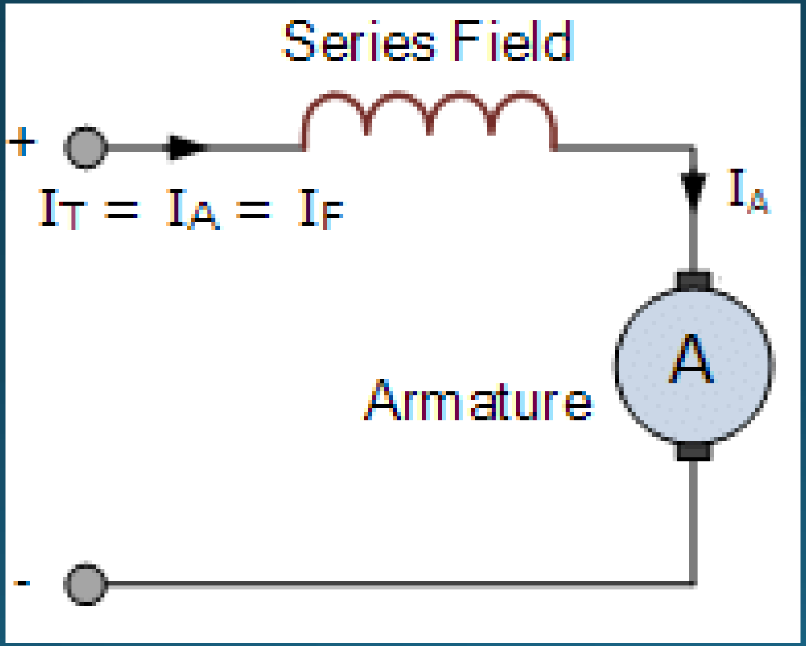


Figure 3

Series DC motor name plate

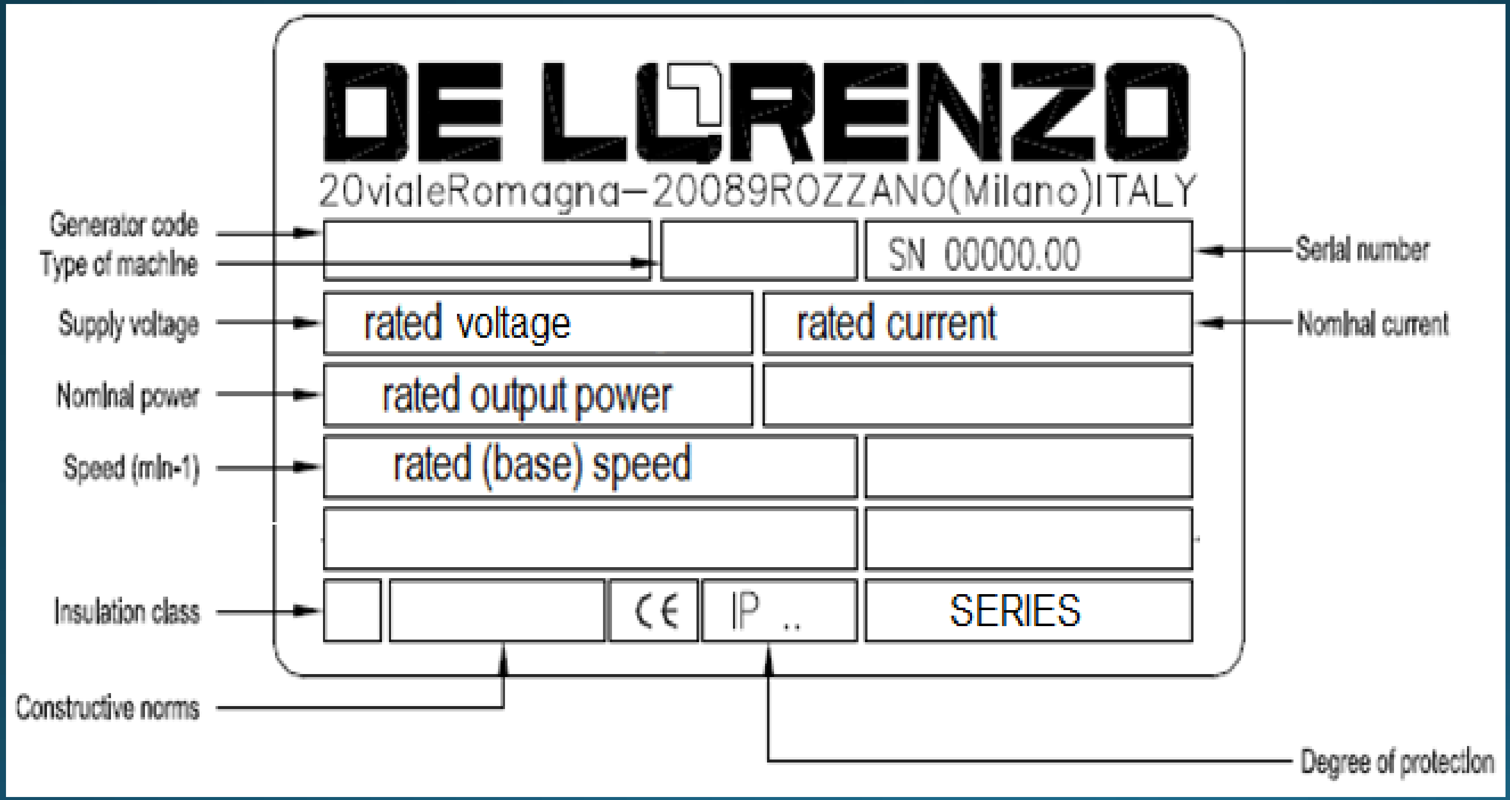


Figure 4

Starting series dc motor

It is possible to limit the starting current of the motor by inserting a resistor in series with armature circuit as we did in the shunt dc motor. Look at the following relationships

$E_a = k\phi\omega$

$I_a = (V_a - E_a)/R_a$

At the beginning of motion of motor shaft, the rotational speed is zero, thus Ea is zero and since Ra has small values the starting current will exceed the maximum current that can be sustained by the armature coils and this will damage the motor. Inserting this resistor will reduce the starting current, then when the motor gains enough speed, this resistor is taken out.

Torque speed characteristics of series dc motor

- The torque and speed of a series dc motor are inversely and non linearly proportional. Their characteristics is given by the following equation:

$$\omega = \frac{V_T}{\sqrt{Kc}} \frac{1}{\sqrt{\tau_{ind}}} - \frac{R_A + R_S}{Kc}$$

- Where:

 - ωfl is the full load (base) speed and is the

speed on the name plate

of the motor

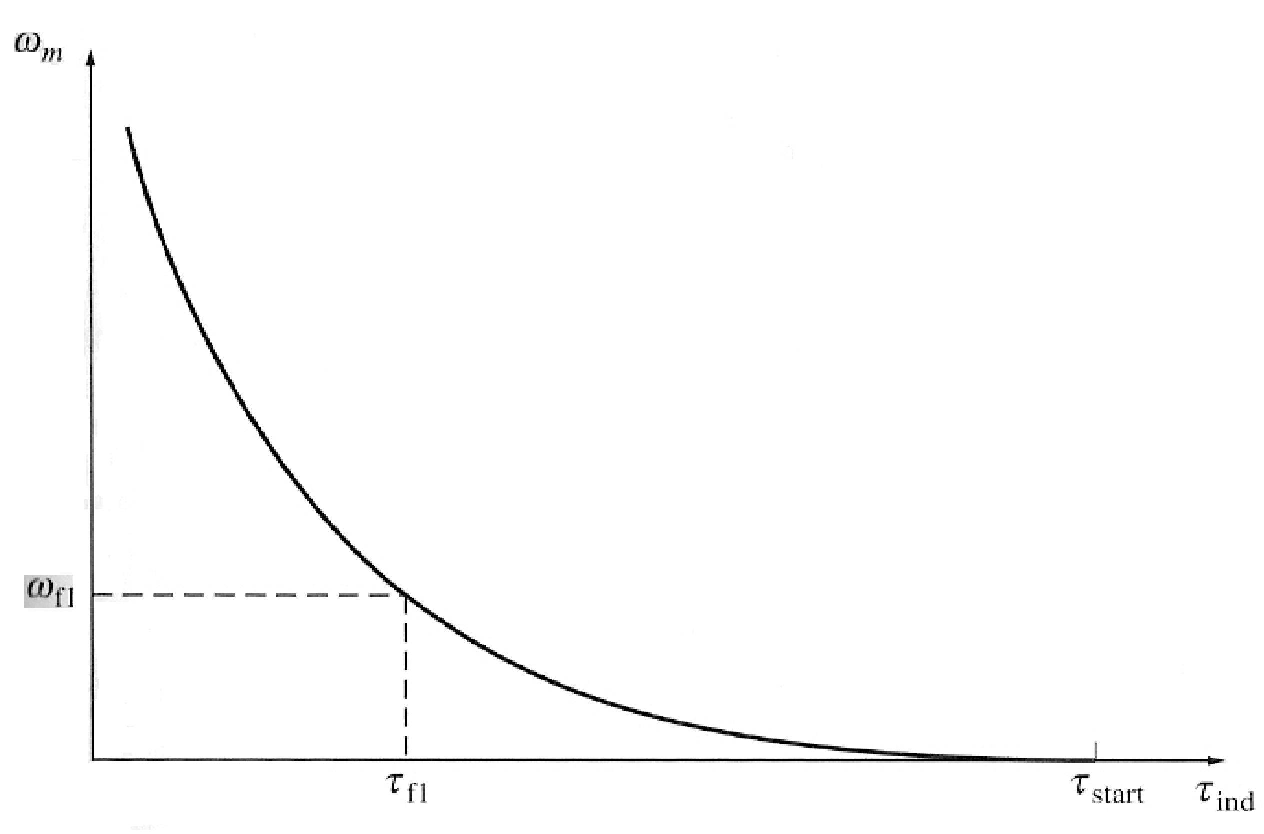


Figure 5

Speed control of series dc motor

- The series dc motor relationships are more complex than the shunt dc motor because the field and the armature currents are the same.
- Never the less, we will adopt a concept that we must have concluded from the previous experiment;

- in a dc machine, as the armature current decreases (by decreasing the armature voltage or increasing the inserted armature resistance), the motor speed decreased below the base speed.

i.e $I_a\downarrow \Rightarrow \omega\downarrow$

- in a dc machine, as the filed current decreases (by decreasing the increasing the inserted field resistance), the motor speed increased above the base speed.

i.e $I_f\downarrow \Rightarrow \omega\uparrow$

- The main two ranges for speed control are:

- Below the base speed (armature control), and this includes;

  a) adjusting armature (not terminal) voltage control

  b) inserting an adjustable armature resistor

- Above the base speed (field control)

  a) inserting an adjustable resistor in the field circuit

1. Flux control methods

a) Field divertor

- A veritable resistance is connected parallel to the series field. This variable resistor is called as divertor, as the desired amount of current can be diverted through this resistor and hence current through field coil can be decreased. Hence, flux can be decreased to the desired amount and speed can be increased above its previous values before the divertor. If↓ ⇒ω↑

- Further increase in the resistance (as if we are taking it out of the circuit) means that the speed will decrease back to its previous value.

- This method is used above the base speed.

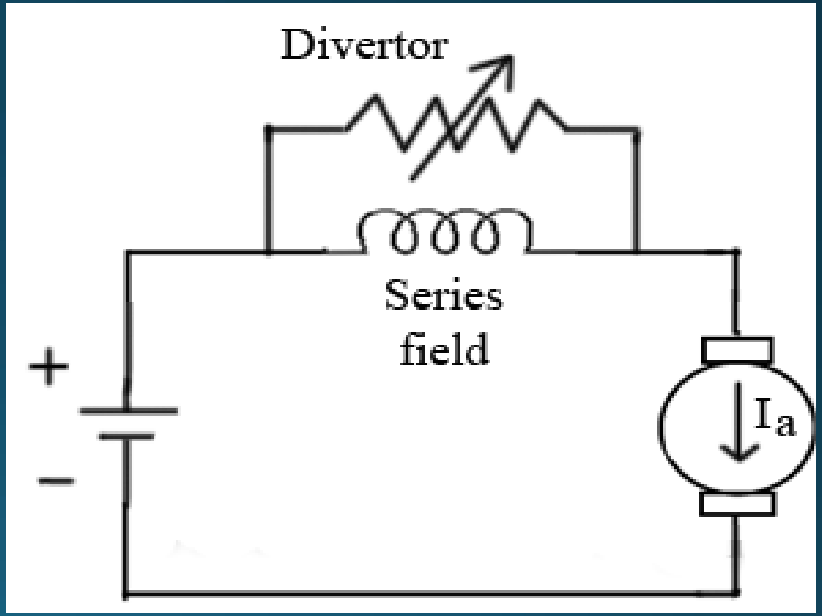


Figure 6

1. Flux control methods

b) Armature divertor

- Divertor is connected across the armature. This will reduce the armature current and we concluded, decreasing Ia will decrease the speed. $I_a \downarrow \Rightarrow \omega \downarrow$

- Further increase in the resistance (as if we are taking it out of the circuit) means that the speed will increase back to its previous value.

- This method is used below the base speed.

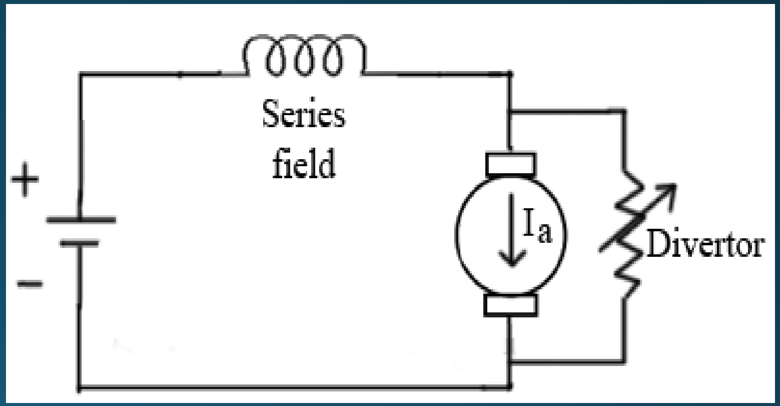


Figure 7

1. Flux control methods

- c) Tapped field control
- field coil is tapped dividing number of turns. Thus we can select different value of Ø by selecting different number of turns.
- This method is used above the base speed.

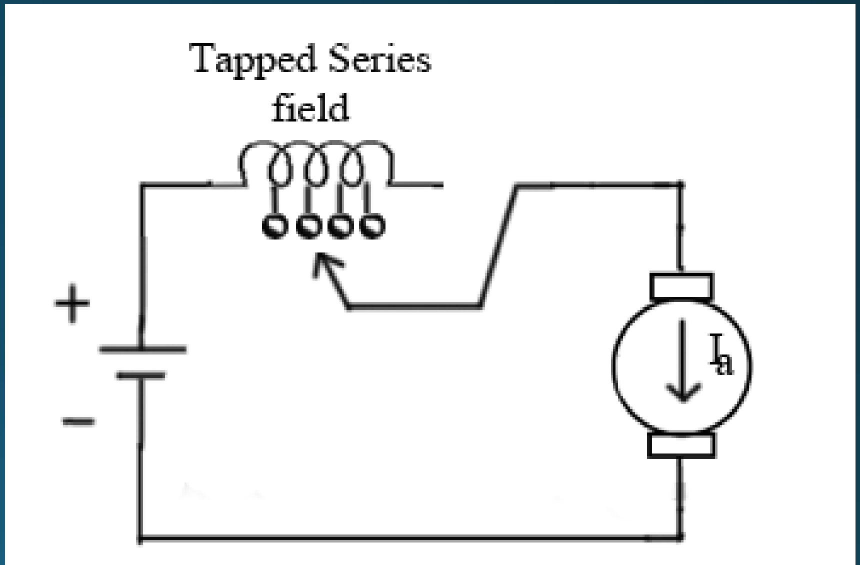


Figure 8

1. Flux control methods

- d) Paralleling field coils
- In this method, several speeds can be obtained by regrouping coils. (recall that parallel inductors have an equivalent inductance less than the smallest one)
- This method is used above the base speed.

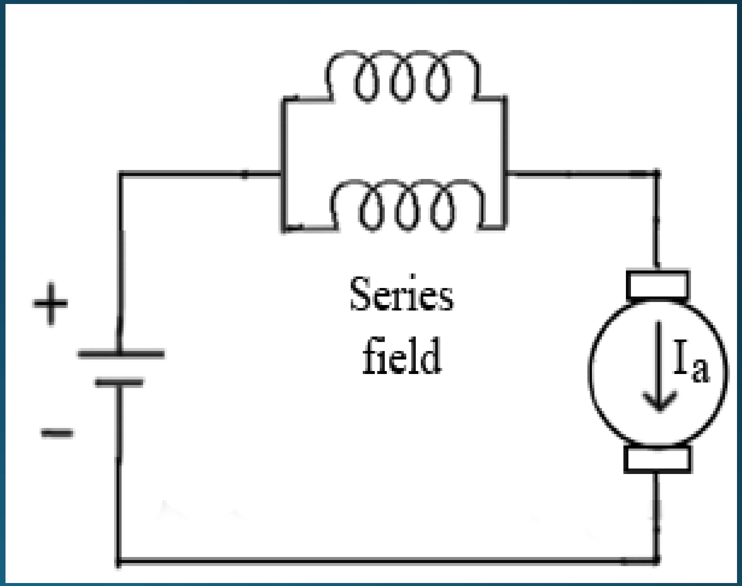


Figure 9

2. Varying the armature voltage

- Reducing voltage across the armature reduces speed in proportion with it.

Reversal of direction of rotation of a series dc motor

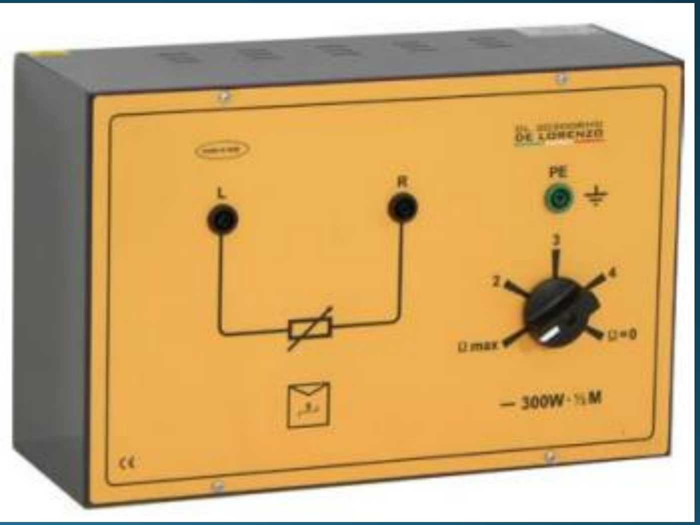
- You can reverse the direction of rotation of a series dc motor by two ways:

1- reversing the armature current

2- reversing the field current

- Reversing both current will cause the motor to rotate in the original direction

Experimental setup



Series dc motor

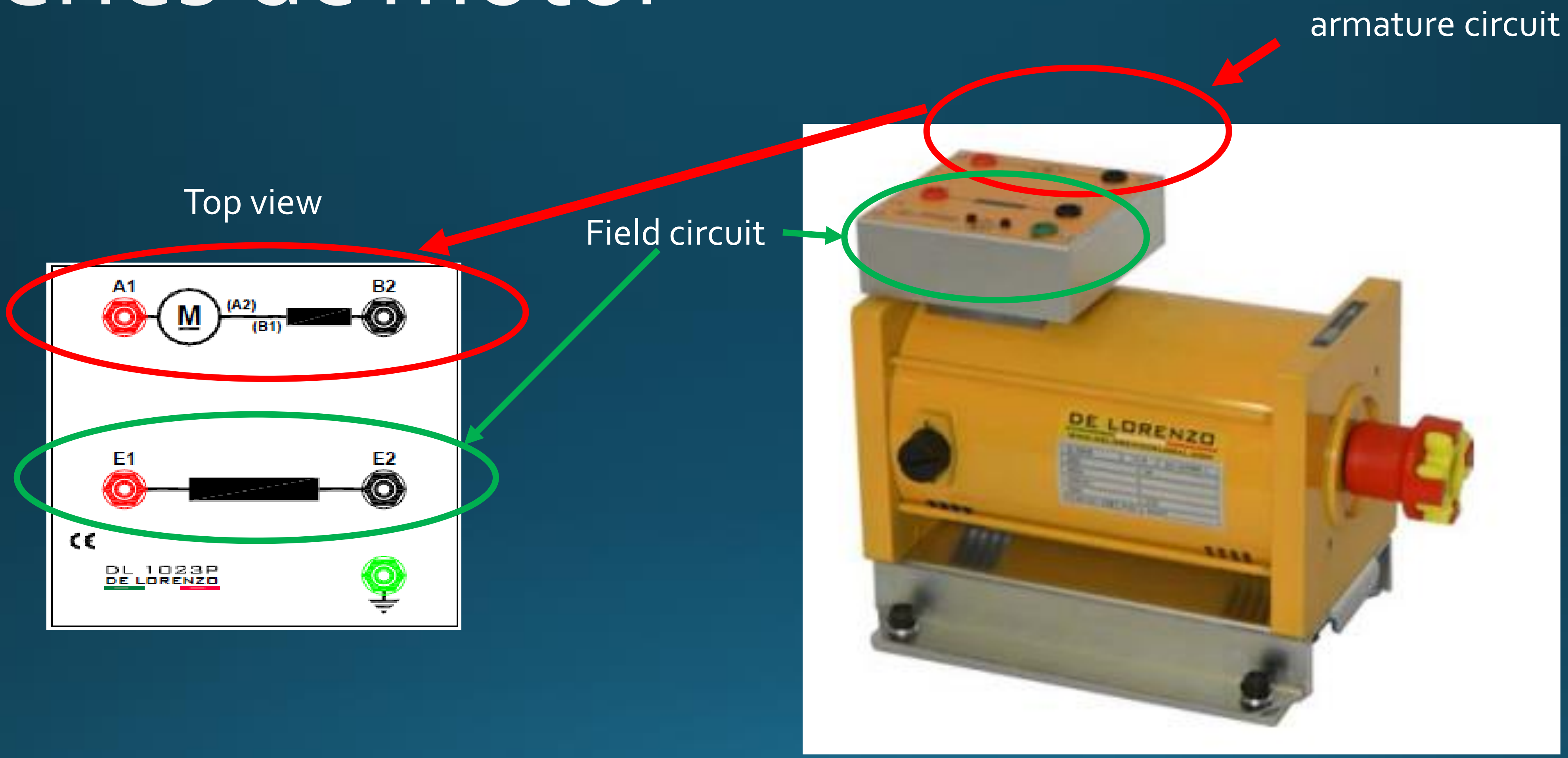


Figure 11

Power supply

- The dc motor requires a dc power supply to operate it. As you know well by know, we have two dc power supplies in the lab;

- The one circled by blue and has Vmax=240V, Imax=10A.
- The one circled by yellow and has Vmax=220V, Imax=1A.

- The motor terminal (line) current = armature current = field current (from the name plate)
- = 7A
- Clearly the supply circled yellow is not suitable.

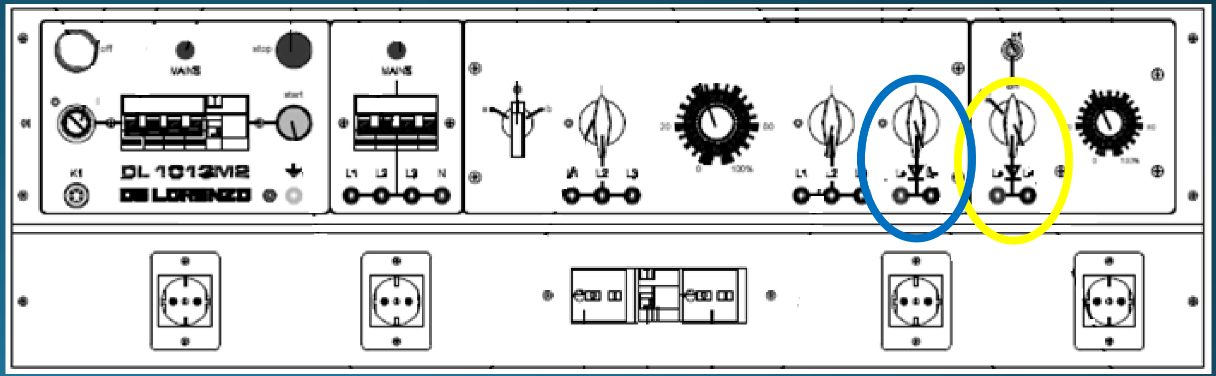


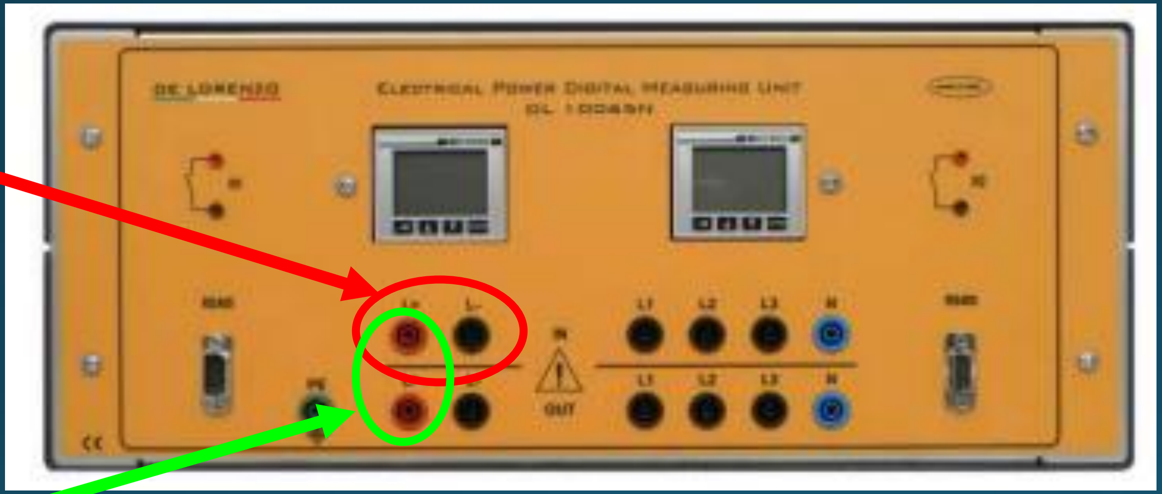
Figure 12

Digital multimeter

Dc voltmeter (horizontally)

Don’t forget about the common node

Dc ammeter (vertically)



Using this unit you can measure one voltage and one current as long as there is a common point

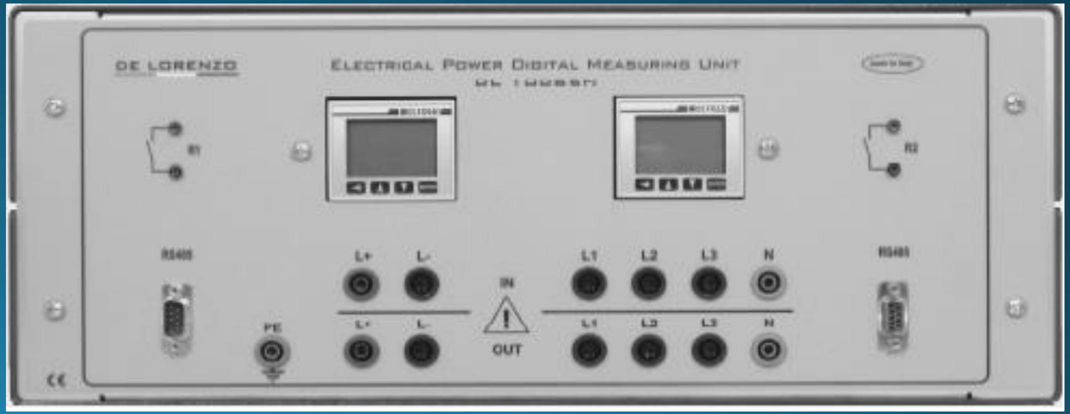


Figure 13

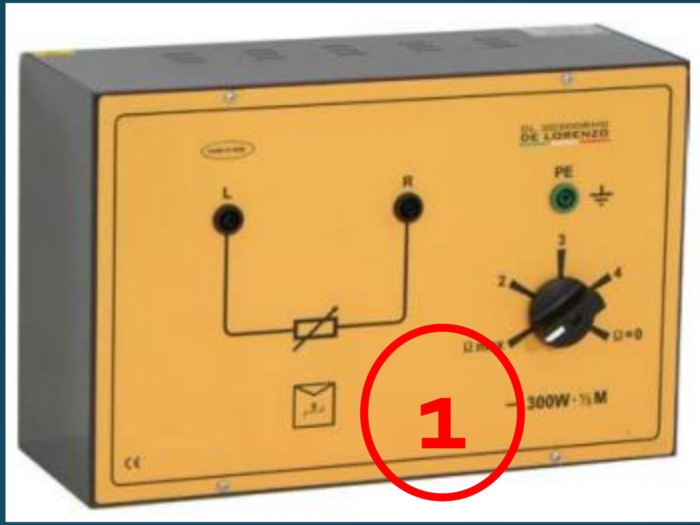
Resistors

Since the current is 7A in this motor and is the same for both field and armature circuits we will make our selections.

- Resistor 1 has high power rating (1.1KW) and small ohmic value (about 30 ohm) which makes it suitable for the armature circuit which has high armature current. It will be used to start the motor.

- Resistor 2, is a specially designed resistor. It can sustain 2.2 A which is not good enough to be inserted in series with armature circuit. However it designed to be used in parallel with the armature or the field circuits for speed control purposes.

Basically, it has a minimum fixed value plus a variable portion. But why? Using the resistor in parallel impose the danger of shorting the field or the armature circuits if the resistor value drops to zero. As we learned during the previous experiment if the flux drops to zero, the motor theoretically accelerates to infinite speed which is impossible and will cause the motor to fail down.



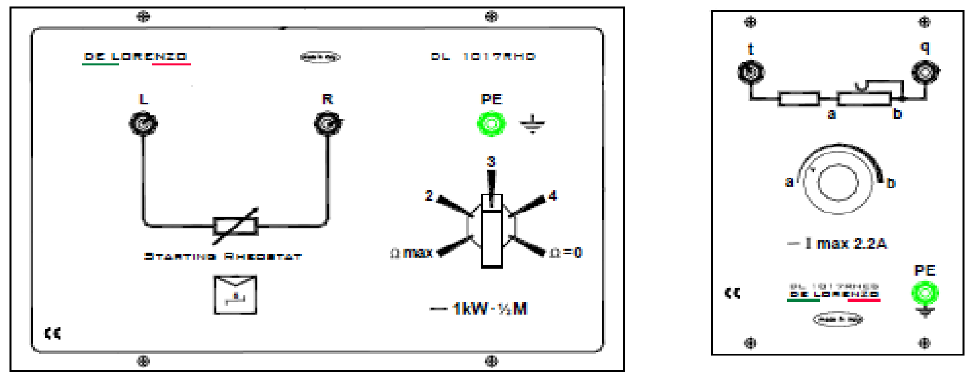
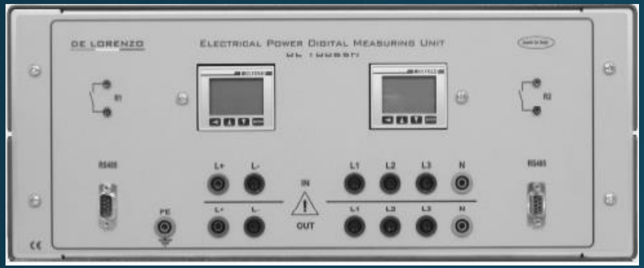
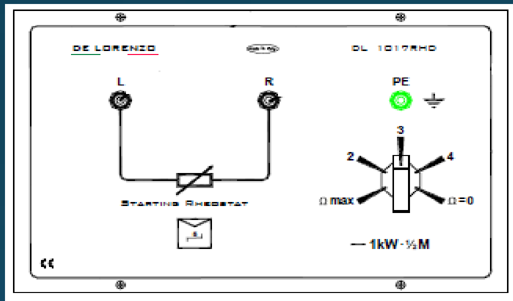


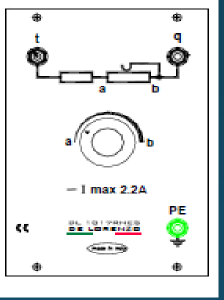
Figure 14

Circuit Connection

- Now we will connect the circuit in Figure 15 using the components illustrated in the previous slides.







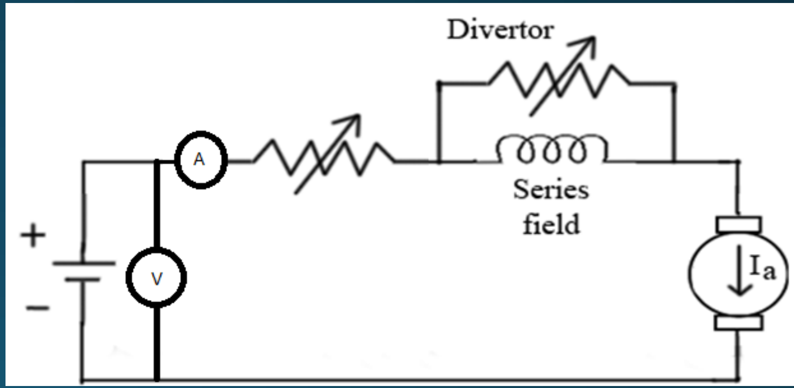
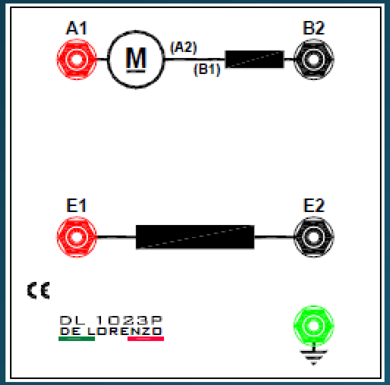
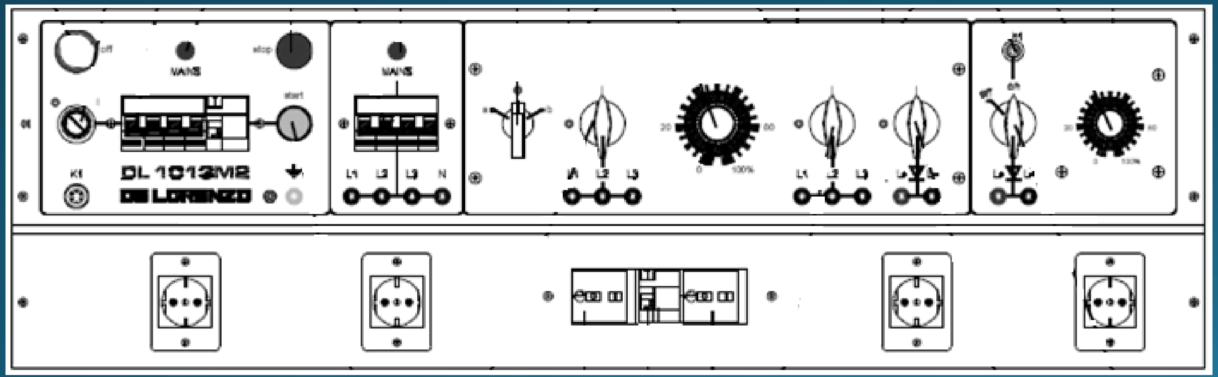
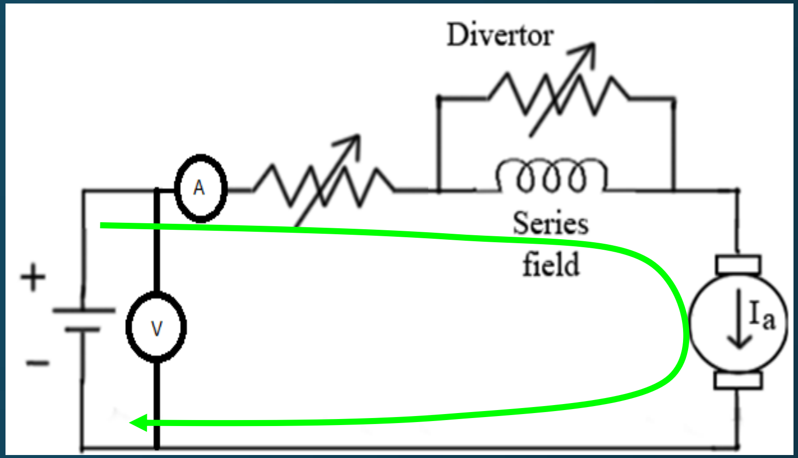


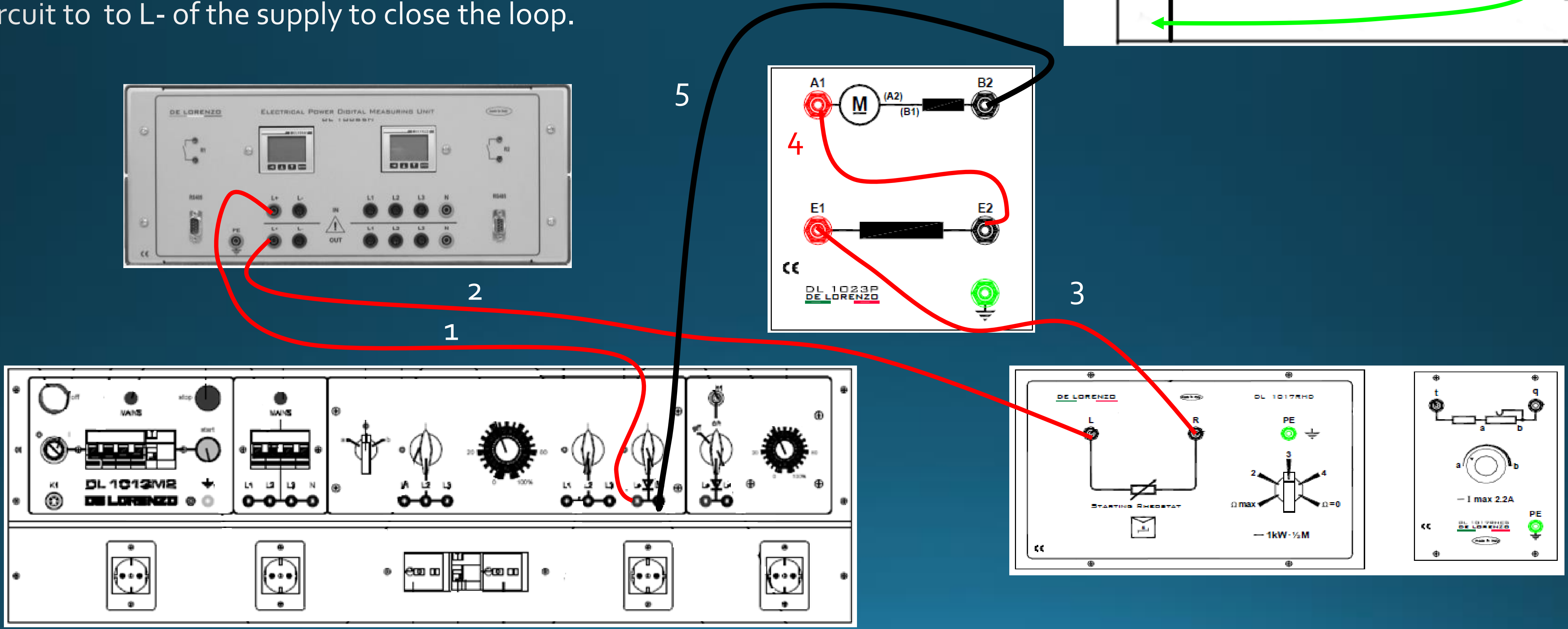
Figure 15



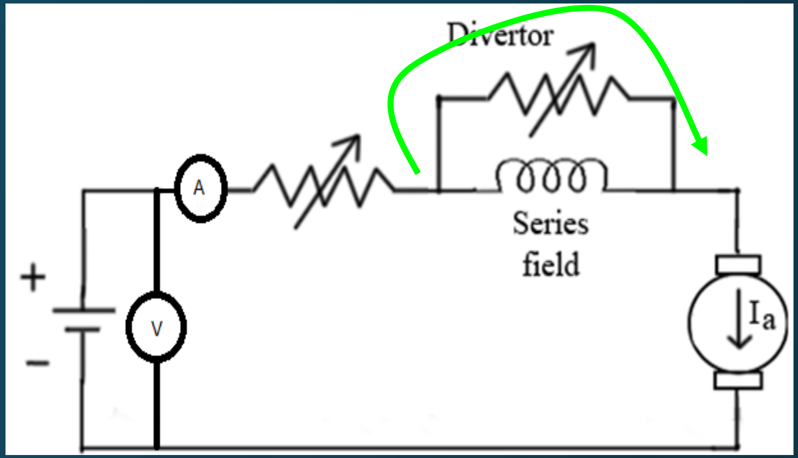


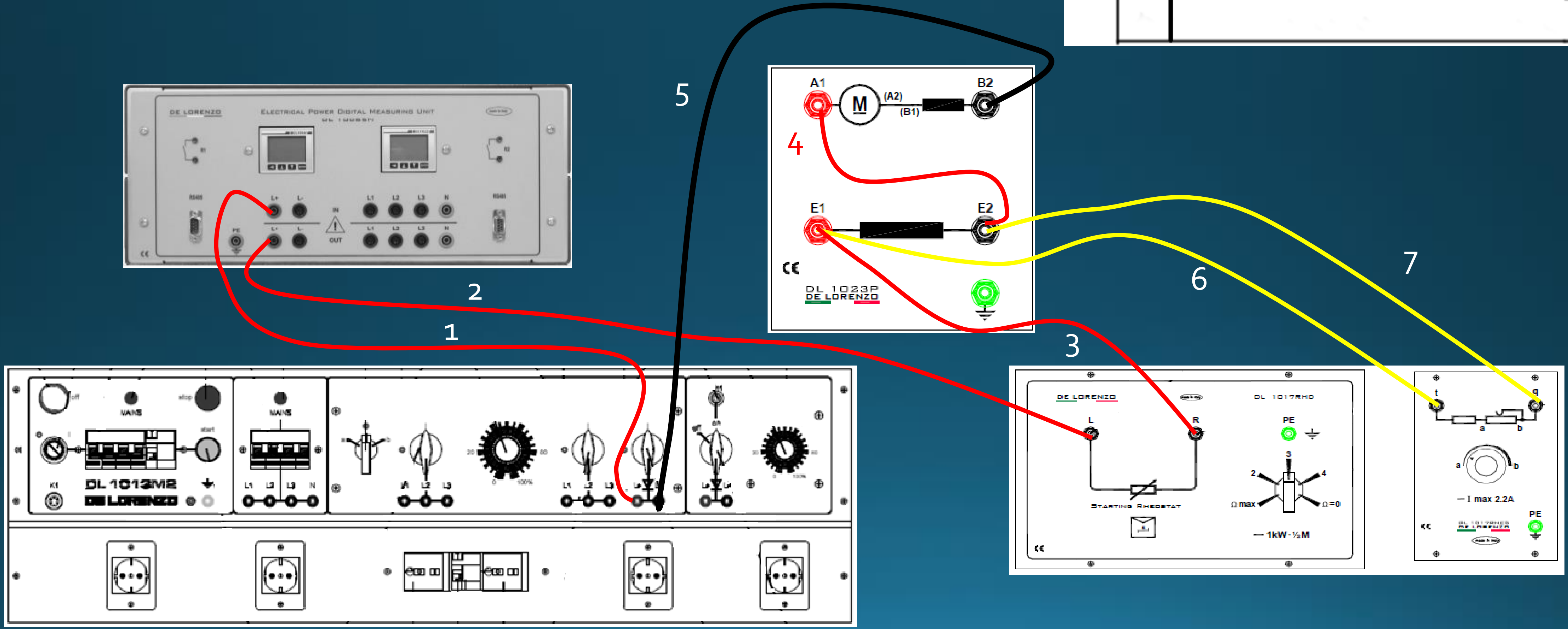
- Lets start with the circuit indicated by the green loop to the right. We will start with wire 1 connecting L+ from the dc power supply to the upper terminal of the ammeter. Exiting the ammeter using wire 2 we will head to a terminal in the adjustable armature resistor. Wire 3 will connect the resistor to the field circuit. The other terminal of the field is connected to a terminal in the armature circuit (you can choose the black terminal if you want (B2), it will only reverse the direction of rotation). Finally, wire 5 connected the other end of the armature circuit to to L- of the supply to close the loop.



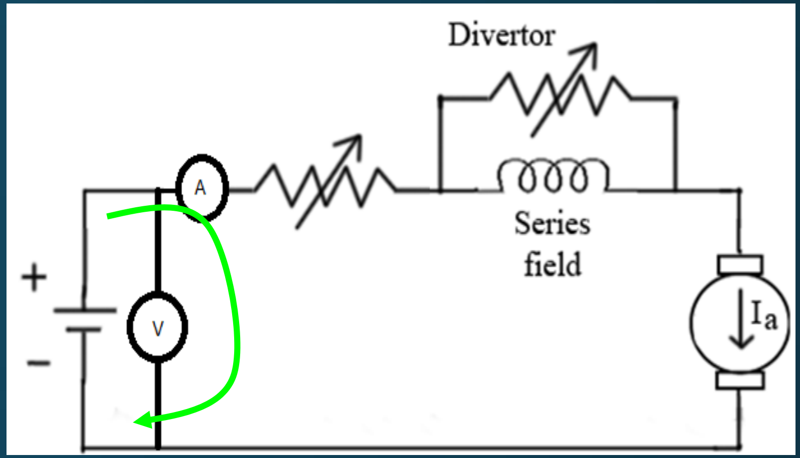


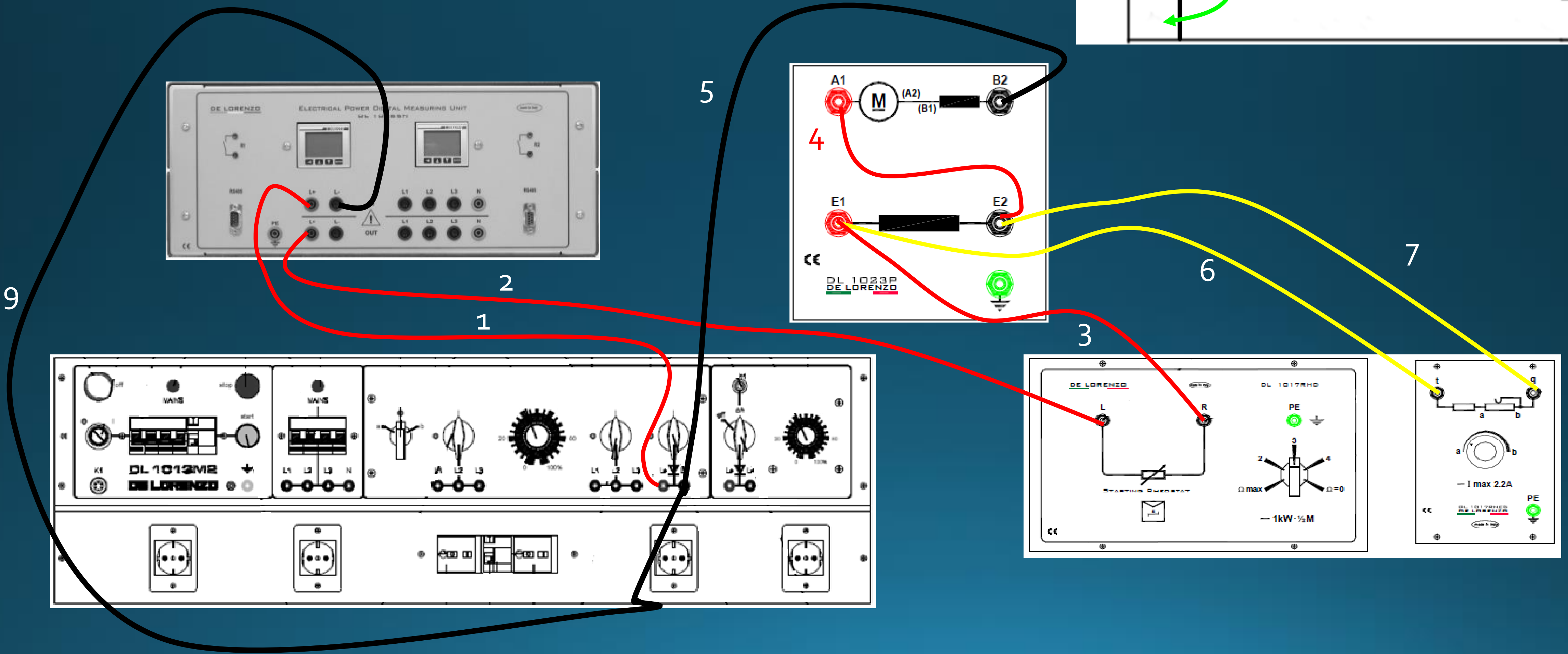
- Now lets connect the divertor (parallel field resistor) indicated by the green loop to the right. We will start with wire 6 , which will connect the common point between the starting resistor and the field circuit to the divertot (so any end of wire 3 will do).
- Wire 7 will connect the other end of the divertor to the other end of the field circuit which is the same as the start of the armature circuit.





- The final step is to connect the voltmeter. As you know the voltmeter and the ammeter has a common terminal. Which is already connected to L+ of the supply. So to complete the voltage measurements we will connect the other terminal of the voltmeter via wire 8 to L- of the supply

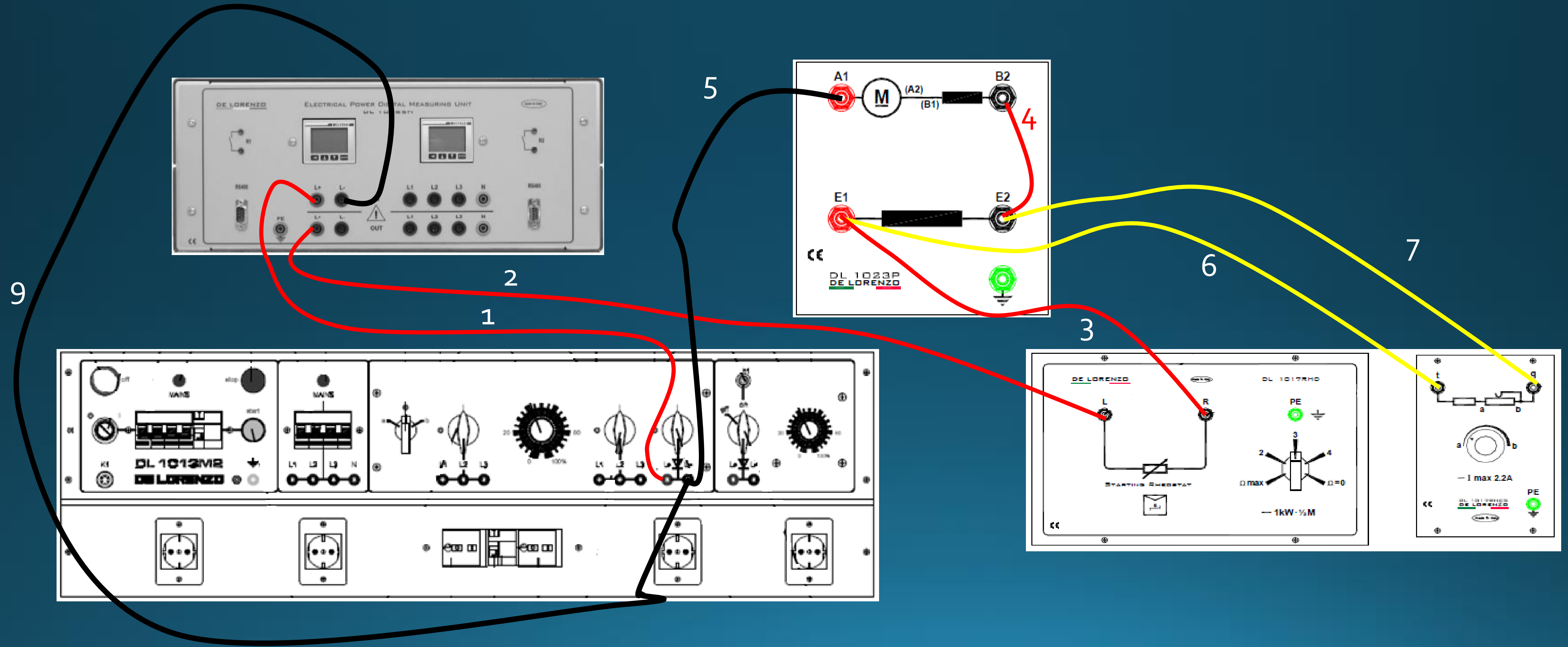




Reversal of direction of rotation

Method 1

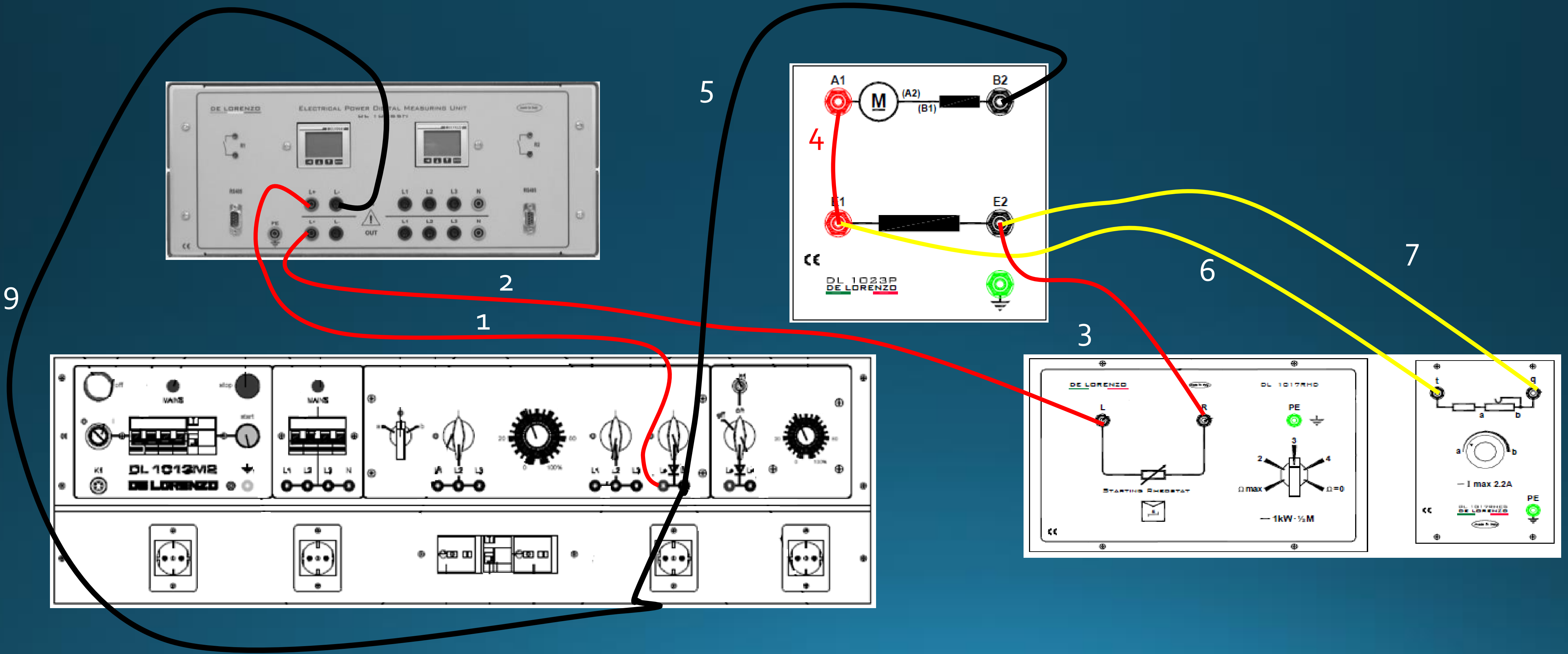
By reversing the armature current. You can achieve this by switching wire (4) and wire (5) entering the armature circuit, as follows



Reversal of direction of rotation

Method 2

By reversing the field current. You can achieve this by switching wire (3) and wire (4) entering the field circuit, as follows



Good luck everyone
Stay home .. Stay safe

Prepared by:
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