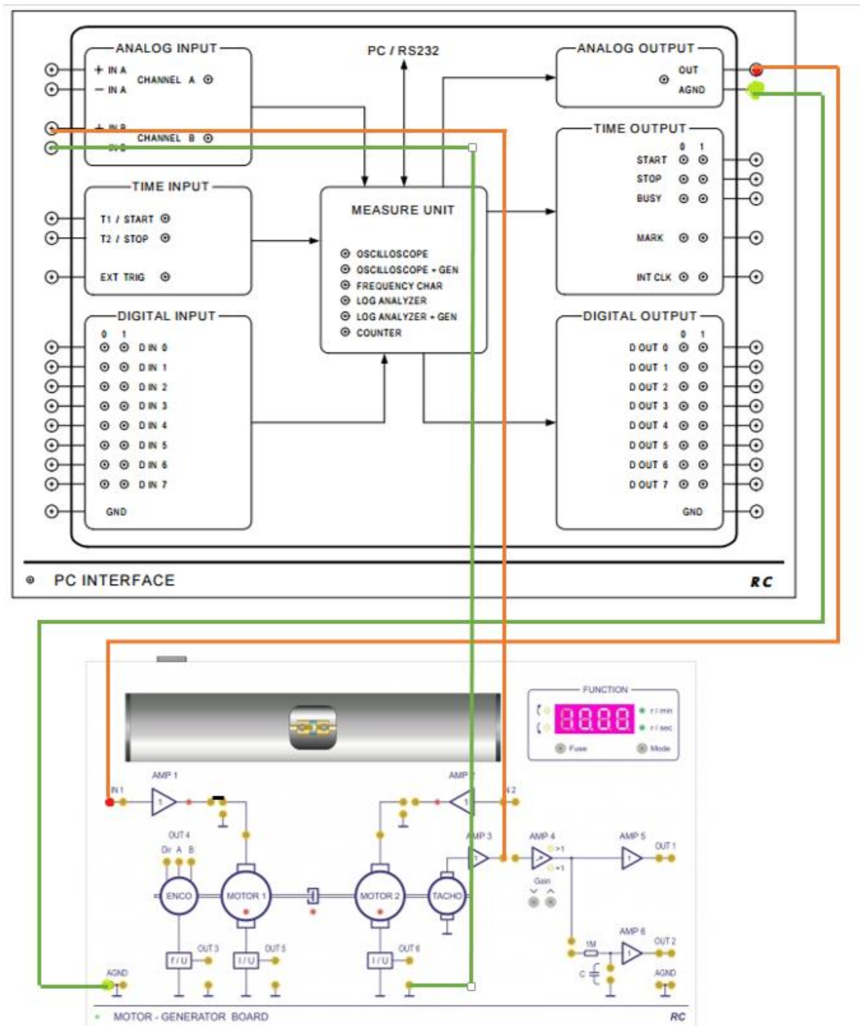
DC engine measurement

In this task you will get to know with teaching environment rc2000– μLAB and with system engine-generator model. You will generate pulses and depict step response in rc2000 environment.

Task:

1. Get to know with teaching environment rc2000– μLAB and with system engine-generator model.
2. Assemble DC engine model in accordance the scheme.
3. Measure static characteristics of the model using a environment rc2000– μLAB.
4. Measure a step response for three working points and define transfer function and model parameters.

Scheme

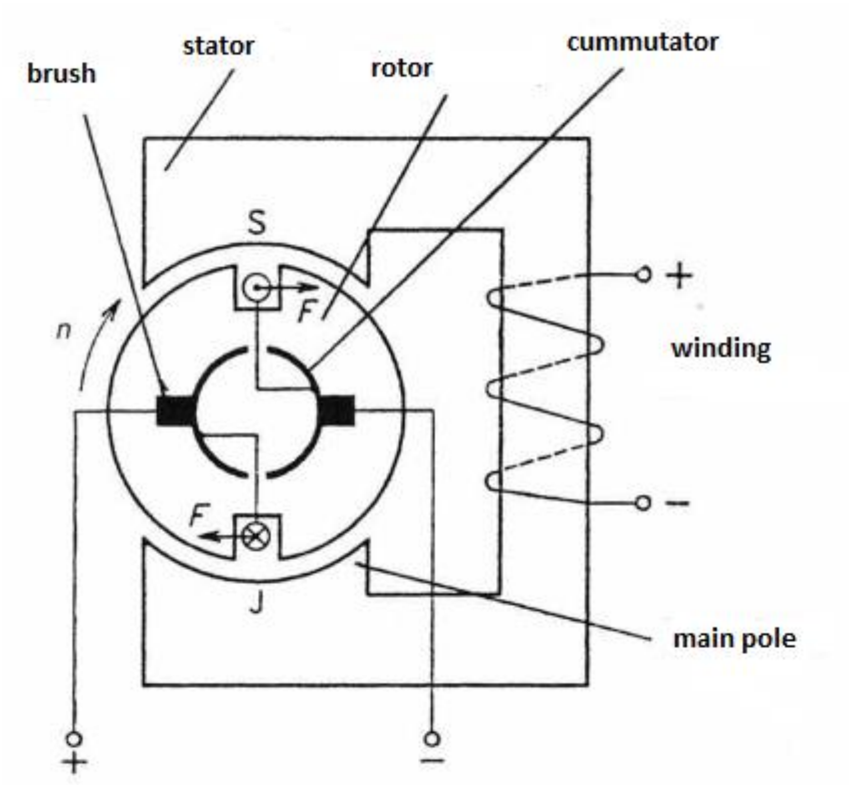


Pic. 1 Block diagram

Theoretical analysis

DC motor is based on the principle of forces acting on the current-carrying conductor, which is placed in a magnetic field. Commutator is supplied by direct current. This current starts flowing through the armature coil, to which, due to the location in the magnetic field, will cause a magnetic force. The direction of this force is determined by Fleming's left-hand rule. To turn the anchor about 360 degrees, current have to change his polarity. This change in current in the rotor winding is done by commutator.

[https://www.vutbr.cz/www_base/zav_prace_soubor_verejne.php?file_id=55519]



Controling rotates of the DC engine

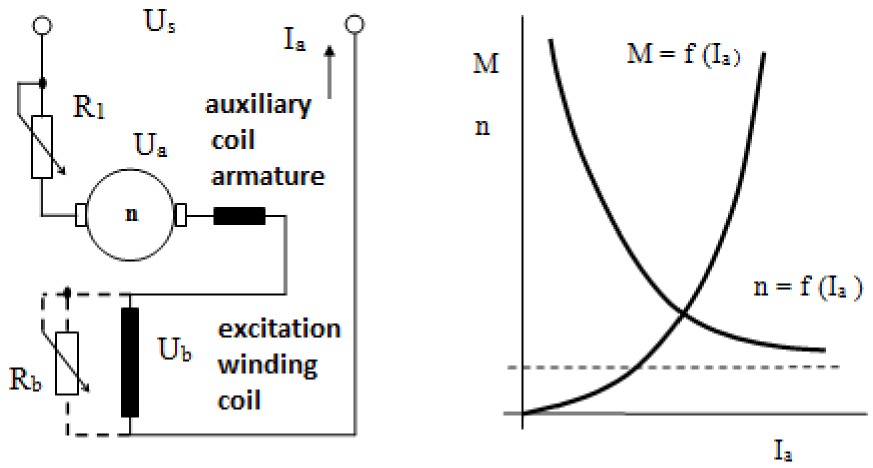
- **Resistance R_a change** in the armature circuit connecting additional resistance. This control method is little used because of the great loss of this resistance especially at high powers. But it can be used to start the motor.
- **flux Φ change** if the stator contains coil windings. In the motor with permanent magnets magnetic flux can not be changed, since it is determined by the properties of the magnet. Mechanical properties are softened by reducing the magnetic flux (field weakening).
- **terminal voltage U change** is the continuous change of the engine rotational speed in the whole range of the engine. It is controlling with low losses and allows you to change the direction of rotation.

DC motor with series connection

Stator windings are connected in series to the same source of power. energy as the rotor winding. By this excitation of the stator magnetic field and its size is tied to a rotor magnetic field in the rotor. Properties for acceleration can be controlled by series resistance in the motor armature. Torque depends on the current which passes through the rotor.

Rotation speed can be well controlled using a resistance connected in series to the stator windings and rotor - increasing resistance weakens the stator magnetic field. When starting a series resistor must have value equal to zero. Speed increases when the load fall.

Reverse rotation can be accomplished very easily by changing polarity of the ends of the stator field windings. This changes the sense of the stator field magnetic flux.

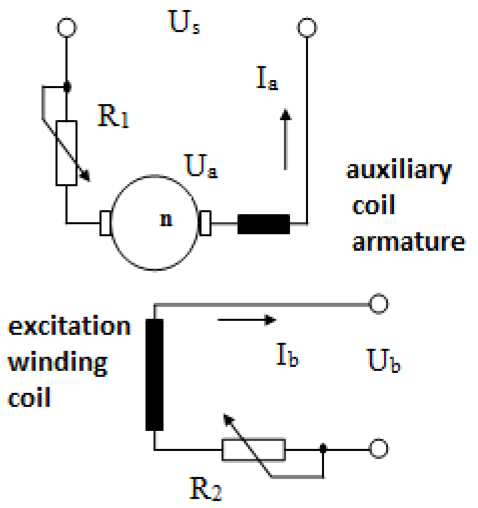


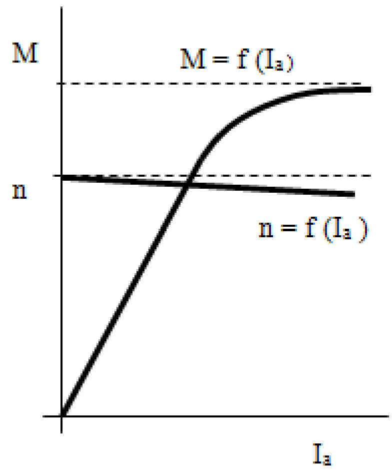
DC motor with shunt connection

Stator winding is connected to another source of energy than the rotor winding. This ensures a constant excitation and thus the size of the stator electromagnetic field in the rotor chamber. The rotor magnetic field depends on the power rotor and the stator field is not directly bound - therefore this type of engine may be controlled easiest. Rotor speed depends only on the voltage applied to the rotor coil. Torque depends on the current which passes through the rotor. For large engines in the stator winding series resistance is added, by which size can be controlled star of the engine (by influencing the magnitude of the magnetic field).

Speed and torque characteristics are "hard" - the rotor speed is not practically falling. Torque increases constantly until saturation.

Reverse rotation can be accomplished very easily by changing polarity of the ends of the stator field windings. This changes the sense of the stator field magnetic flux.



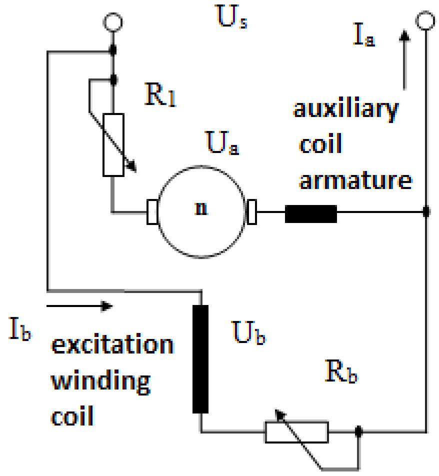


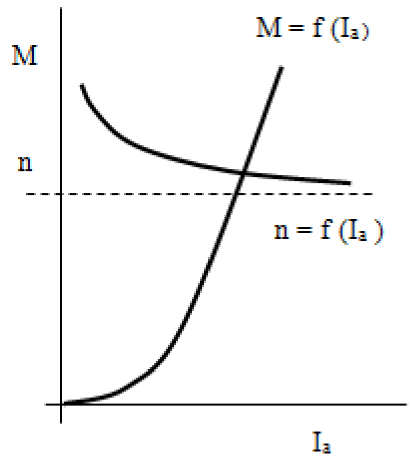
DC motor with compound connection

Stator windings are connected in parallel on the same source of power. energy as the rotor winding. This bound excitation stator and rotor magnetic field and thus the size of the electromagnetic field in the rotor chamber. Rotor speed depends on the voltage supplied to the rotor coil. Torque depends on the current which passes through the rotor and is very stable. Unless the stator magnetic flux in a state saturated (nominal - ie. At lower supply voltage) the speed characteristic is hyperbole and torque characteristic is parabole (torque depends on the quad current passing through). The speed falls with rising load - rotation characteristic is "soft". In the saturated state, rotoe speed is nearly constant and the torque characteristics straightened herself. The starting torque is great - so used to drive with very frequent starts and it starts with a heavy load (eg. Cranes - separating machines, conveyor belts, etc.).

Speed is controlled well by using a resistance connected in series to the exciter stator windings thereby attenuates the stator magnetic field. Series resistance can only reduce the speed.

These derivative engines should not be used where they the load could be disconnected during operation. Due to the shape of the characteristics of the engine it could rotate above all limits (or at least the value of speed which could threaten the stability of the rotating mechanical parts) and could lead to mechanical rotor crash. The load must be connected via a fixed coupling or a toothed gear.



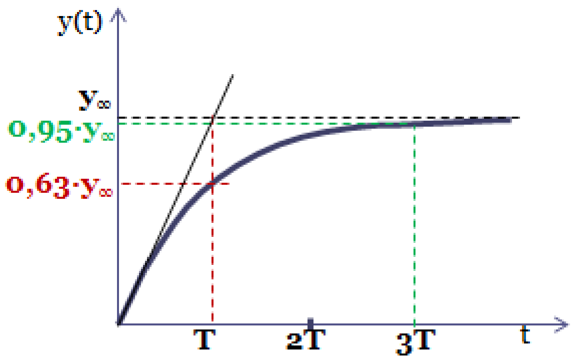


Pulse width modulation (PWM)

Pulse Width Modulation, or PWM is discrete modulation for transfer analog signal using binary signal. As a two-valued variable can be used, for example, voltage, current, or luminous flux. The signal is transmitted by the Duty cycle. For demodulation of such a signals just low-pass filter is enough. Due to its characteristics is a pulse width modulation is often used in power electronics for controlling the voltage or current.

Specifying time constant:

We determine Time constant T using a tangent to step response or determining time($t_{0,63} = T$) for 0,63y_∞ value or for time ($t_{0,95} = 3T$) for 0,95y_∞ value.



$$G(s) = \frac{k}{Ts+1}$$

$$k = \frac{y_\infty}{u_\infty}$$

Measurement procedure

1. Check the wiring diagram according to block diagram
2. Divide the range into 10 levels and set the input signal and measurement parameters in rc2000 – μLAB environment.
3. Measure a static characteristic of the model for positive values voltage power. Save the output on disc.
4. Measure a static characteristic of the model for negative values voltage power. Save the output on disc.

Recorded values for positive voltage values			
n	rpm	U[V]	y[V]
1			
. . .			
10			

Test questions

1. What is static characteristic?
2. What is step response?
3. How is possible to control rotates of the DC engine?
4. For what time values is time constant equal to T?

Answers

1. Static characteristic is dependency of the output signal on the input signal in steady-state.
2. Step response is response of the dynamic system for the Heaviside step functions.
3. Resistance R_a change,, flux Φ change, terminal voltage U change.
4. Time constant T is time when regulated variable reaches 63% of the steady state value.