# Exercise EA4
# Single-phase induction motors

EXERCISE PROGRAMME

## A. Shaded pole motor.

1. Learning the construction, principles of operation and control circuit of shaded pole motor.

2. Measurement of mechanical characteristic T(n), current characteristic I(n) and efficiency $\eta(P_{out})$.

## B. Capacitor run induction motor.

1. Learning the construction, principles of operation and control circuit of capacitor run motor.

2. Measurement of mechanical characteristic T(n), current characteristic I(n) and efficiency $\eta(P_{out})$ for three different cases:

- 25 [μF] (nominal value of run capacitor for investigated motor)
- 16 [μF]
- without capacitor

Nominal ratings of machines:

Shaded pole motor:

$P_{in}$ / $P_{out}$ = 29 / 5 [W / W] $U_N$ = 220 [V] $I_N$ = 0,19 [A] $n_N$ = 1300 [rpm]

Capacitor run induction motor:

$P_N$ = 750 [W] $U_N$ = 220 [V] $I_N$ = 5,65 [A] $n_N$ = 1370 [rpm] $C_N$ = 25 [μF]

Commutator DC machine (load for capacitor run induction motor):

$P_N$ = 550 [W] $U_N$ = 110 [V] $I_N$ = 6,7 [A] $I_{fN}$ = 0,24 [A]

References:

J. Rusek "Elektrotechnika z elementami napędów", Wyd. AGH, 1993, pp. 125-155
R. Sochocki *"Mikromaszyny elektryczne"*, wyd. Politechniki Warszawskiej, 1996, pp. 32 -42
J. Owczarek i in. *"Elektryczne maszynowe elementy automatyki"*, WNT, 1983, pp. 375-390
A.M. Plamitzer *"Maszyny elektryczne"* Wyd. Nauk.-Tech., 1986, pp. 401-405

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LABORATORY INSTRUCTION (page 1/3)

## 1. Objectives.

The objectives of this laboratory exercise are to investigate the behavior of single-phase induction motors (both shaded pole and capacitor run) in various working states and to measure their characteristics.
The exercise includes measurement of static mechanical and current characteristics as well as efficiency calculations for the motors mentioned.

## 2. Operating procedures.

Warning:
Students are not allowed to switch the power on by themselves. Any action, involvig switching on devices used in the exercise, should be accepted by the teacher.
Before starting, students are obliged to identify all the parts of the exercise circuit and to familiarize themselves with equipment belonging to it, so that the exercise can be carried out safely and effectively. Particularly, the ranges of the meters should be checked and all the regulating knobs should be set to zero positions.
Students can leave the laboratory only when instructed to do so by the teacher.

### 2.1. Measurement of mechanical characteristic T(n), current characteristic I(n) and efficiency $\eta(P_{out})$ of a shaded pole motor.

Motor should be connected directly to the power supply (230 [V], 50 [Hz]). The load consists of a commutator DC microgenerator connected to the R1 variable resistor (151 [Ω]). The field current of the microgenerator should be set to 400 [mA] by varying the resistance of the R2 (1000 [Ω]) resistor. The first reading should be taken without load to the microgenerator but with field current switched on.
The motor can be stably loaded up to 980-1000 [rpm]. Further increasing the load leads the motor to reach the unstable part of the characteristic, and to stop. In every point of the characteristics the following readings should be taken:
- power taken by the motor (to be read from wattmeter)
- current taken by the motor (to be read from ammeter)
- power generated by the load microgenerator (to be read from the voltmeter and ammeter)
- speed of a set (to be read from counter display)

This part of the excercise should be done as quickly as possible, as the motor tends to overheat when excessively loaded.

### 2.2. Measurement of mechanical characteristic T(n), current characteristic I(n) and efficiency $\eta(P_{out})$ of a capacitor run motor.

The motor is loaded by a commutator DC machine with armature circuit connected to the set of four variable resistors (R3) which are used to vary the load of a generator and thus the motor. The field circuit of the generator is supplied directly from a DC network with no means of adjustement. The value of the field current is of 0,24 [A]. The armature current can temporarily reach the value of 10 [A]. The capacitors can be switched on and off separately by changing the positions of appropriate switches (adequately marked on the exercise stand: 0 - off, 1 - on). The motor should not be overloaded more than by 20% because of its increased overheating.

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LABORATORY INSTRUCTION (page 2/3)

## 3. Exercise report.

Exercise report should consist of a filled and signed results sheet and results analysis.

### 3.1. Results sheet.

All the relevant results should be introduced into a results sheet provided (to be printed with this instruction) which at the end of the exercise should be signed by the teacher. The signed results sheet should then be added to the exercise report.

### 3.2. Results analysis.

#### 3.2.1. Shaded pole motor.

For every adjusted value of the load students should calculate:

- electric power losses in the armature of the load generator:
  $\mathbf{\Delta P_{Cu(load)} = I^2_{out(load)} \cdot R_a}$ **[W],** $\mathbf{R_a = 26}$ **[Ω]**

- mechanical power losses of the load generator together with losses in its iron core and power losses in tachogenerator:
  $\mathbf{\Delta P_{mech(load)} + \Delta P_{Fe(load)} = 0{,}0025 \cdot n}$ **[W]**

- output power of the load generator:
  $\mathbf{P_{out(load)} = U_{out(load)} \cdot I_{out(load)}}$ **[W]**

All the above power losses should then be added together to obtain output power of the investigated motor which equals to the input power of the load generator:

$$\mathbf{P_{0ut(motor)} = P_{out(load)} + \Delta P_{Cu(load)} + \Delta P_{mech(load)} + \Delta P_{Fe(load)} = P_{in(load)}}$$

Motor mechanical torque and motor efficency should then be calculated:

$$\mathbf{T = P_{0ut(motor)} / \omega \cdot 100 \text{ [Ncm]}, \quad \omega = \pi \cdot n / 30}$$

$$\eta = \mathbf{P_{0ut(motor)} / P_{in(motor)}}$$

Having the above calculations done, the following characteristics should be drawn:

**figure 1** – mechanical characteristic T(n),
**figure 2** – current characteristic I(n),
**figure 3** - efficiency characteristic $\boldsymbol{\eta}(P_{0ut(motor)})$.

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### 3.2.2. Capacitor run motor.

All the losses, torque and efficency should be calculated in a similar way as for the shaded pole motor. The resistance of the armature winding of the load generator should be taken as $R_a$ = 2,05 [Ω]. The mechanical power and iron core losses are very low relating to the power converted by the machines and, for the speed varying from 1200 [rpm] to 1500 [rpm], can be taken as 4 [W] to 5,2 [W]. The losses for other values of the speed should be lineary interpolated.

In this case the following characteristics should be drawn:

**figure 4** – three mechanical characteristics T(n) for three values of capacitors,
**figure 5** – three current characteristic I(n) for three values of capacitors,
**figure 6** – three efficiency characteristic $\eta(P_{0ut(motor)})$ for three values of capacitors.

Finally the report should contain the conclusions regarding the observed behavior of the motors.