OSTBAYERISCHE TECHNISCHE HOCHSCHULE REGENSBURG

DC MACHINE - SMALL

AYHAM ALHALAIBI JULIA BLECHLE CLARA HUBER

***Abstract*—In this experiment the behavior of a small DC machine was studied in different operating modes. The machine was operated in three different modes: *Idle*, *loaded generator*, and *loaded motor*. The test machine was connected to a variable power supply 0V...12V and a DC generator was loaded with 5 resistors in parallel, which can be switched on and off with a switch box. Both machines had a built-in meters for the armature current and voltage also for the number of rotations.**

I. IDLE MODE EXPERIMENT

A. Electric motor force

The induced voltage in the generator is called electric motor force (EMK).

To examine the relation between the electric motor force and the rotations n, the machine is operated without load and the motor voltage and current as well as EMK which is induced in the generator can be measured.

For this experiment the initial 5000rpm will be reduced by 1000rpm each time. At 5000rpm the motor has its maximum voltage $U_A = 11.94V$.

The machine constant c and the magnetic flux Φ_E are experimentally determined (different for each machine).

$$c \cdot \Phi_E = \frac{U_q}{n} = \frac{8.8\text{V}}{4000/60\text{s}} = 0.132\text{Vs} \tag{1}$$

The arithmetic mean is calculated using the following equation:

$$\frac{1}{5}\sum_{k=1}^{5} c \cdot \Phi_E = \frac{0.6621Vs}{5} = 0.13242Vs \tag{2}$$

$n[min^{-1}]$	$EMK[V]$	$U_A[V]$	$I_A[A]$	$c \cdot \varphi_E[Vs]$
5000	11.10	11.94	0.420	0.1332
4000	8.80	9.61	0.390	0.1320
3000	6.60	7.30	0.357	0.1320
2000	4.43	5.00	0.327	0.1329
1000	2.20	2.68	0.276	0.1320

Table I: Idle Mode

In the figure 1 the relation between the electric motor force EMK and the number of rotations n is shown. The relation is linear and they are directly proportional.

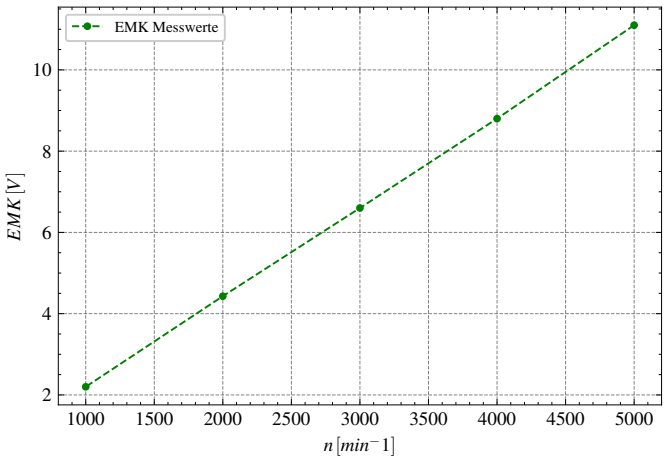

Figure 1: Idle Mode

II. LOADED GENERATOR MODE

In the generator mode the generator machine is powering the motor. The rotations are set at 4000rpm.

In the previous experiment the motor voltage was measured at 4000rpm. Throughout this experiment this voltage will be kept constant at $U_q(4000rpm) = 8.8V$. The load resistors are getting connected into the circuit one by one.

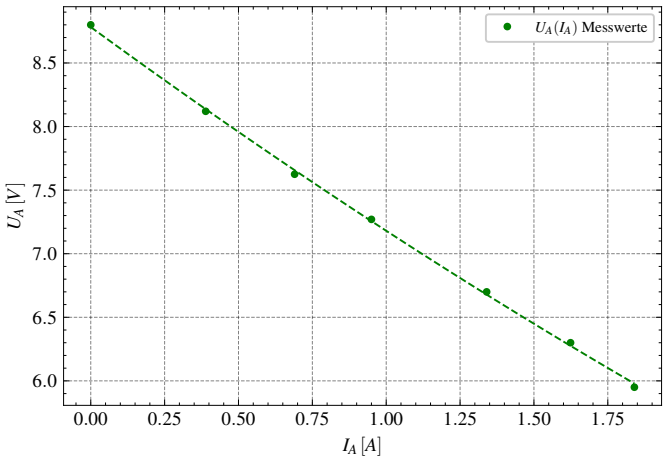

Figure 2: loaded generator mode

To determine the resistance R_A of the generator the potential over said resistor as well as the current running through it are needed.

$$R_A = \frac{U_{RA}}{I_A} = \frac{U_A - U_q}{I_A} \tag{3}$$

With the arithmetic mean

$$\frac{1}{6}\sum_{k=1}^{6} c \cdot R_A = 1,62\Omega \tag{4}$$

III. LOADED MOTOR MODE

In the loaded motor mode the voltage U_A is kept constant, first at 9V later at 12V, and is loaded through the generator with the load resistors (S1 - S5).

The relation between the armature voltage and the rotor rotations is given through the machine constant c as described in 5.

$$n_0 = \frac{U_A}{c \cdot \Phi_E} \tag{5}$$

And the correlation between the inner torque and armature current:

$$M_i = \frac{c \cdot \Phi_E \cdot I_A}{2\pi} \tag{6}$$

Between the inner and the measured torque, Power is lost through Copper P_{Cu} and friction P_{fric}.

To measure the Torque of the motor a metal arm (10cm) fixed to its bearing and a small scale are used. With the following equation the torque is calculated for each of the resistor combinations:

$$M = \text{Weight} \cdot \text{g} \cdot \text{length} \qquad g = 9.81\text{m}^2 \quad l = 10\text{cm} \tag{7}$$

Switches	$n[min^{-1}]$	$I_A[A]$	Weight[g]	$M[m\,Nm]$
All Open	3766	0.386	8.08	7.924
S1	3548	0.724	9.29	9.110
S2	3385	0.958	10.75	10.54
S1+S2	3261	1.146	11.53	11.31
S1+S2+S3	3080	1.400	13.75	13.48
S1+S2+S3+S4	2962	1.565	15.15	14.86
All Closed	2868	1.680	16.70	16.38

Table II: Loaded motor mode - $U_A = 9V$

Switches	$n[min^{-1}]$	$I_A, [A]$	Weight [g]	$M[m\,Nm]$
All Open	5100	0.41	8.06	7.90
S1	4760	0.87	8.66	8.49
S2	4563	1.20	9.22	9.04
S1+S2	4390	1.44	10.15	9.95
S1+S2+S3	4150	178.00	12.48	12.24
S1+S2+S3+S4	3980	2.02	14.60	14.32
All Closed	3910	2.20	16.93	16.60

Table III: Loaded motor mode - $U_A = 12V$

The plot 3 shows the torque of the motor driven with two different voltages U_A. It also displays the linear correlation between the torque and rotations.

After disregarding the Copper and friction and assuming linearity the plot 3 perfectly demonstrates how changing the voltage results in a shift of the torque curve on the n-axis and showing the direct proportionality between the voltage and the rotations. Also see equation 5.

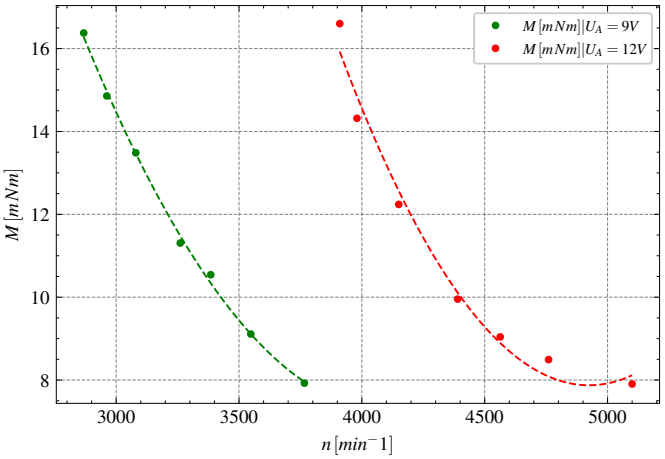

Figure 3: loaded motor mode