HDU-ITMO Joint Institute

ELECTRICAL ENGINEERING

LABORATORY WORK 1

RESEARCH ON DC ELECTRIC SOURCE CHARACTERISTICS

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2020

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Laboratory work № 1: «Research on DC electric source characteristics»

OBJECTIVES

to study operating modes of electrical energy sources

to study the procedure of experimental identification of the electrical energy source equivalent circuit parameters

PROGRAM OF WORK

External characteristics of the electrical power source study.

Identification of the electrical source equivalent circuit parameters based on experimental data.

OVERVIEW

The lab is dedicated to understanding the maximum power transfer theorem by study operating modes of electrical energy sources. The lab is performed using LTspice software for circuit analysis and simulation. The equivalent circuit is used to model the DC circuit behavior. The students learn how to create circuits in LTspice, simulate, and plot specific functions. This Lab sets the basis for further working with LTspice for the analysis of more complex circuits.

GUIDANCE:

1. In the «LTspice» application an electrical circuit should be composed as it shown in Figure 1.1.
   - In «LTspice» electrical circuit should include: **voltage block** (Menu Edit→Component→voltage) - which is an ideal Electromotive force (EMF) source block, **Resistor** (Menu Edit→Resistor) - active resistance,

GND (Menu Edit→Place GND) - special point with electric potential equal to 0.

In Figure 1.1 «Electric source» block is composed as equivalent circuit of the real source of electric energy with internal resistance r and EMF E **connected in series**, «Electric load» block is a resistive load with resistance equal to Rn.

2. Set the parameter value of the power source elements r and E defined by the instructor. These parameters should be defined experimentally.
3. Measure the open circuit voltage U_0 and put the result in the Table 1.1. To do this in the «LTspice» application, it's enough to remove the resistance Rn leaving the gap.

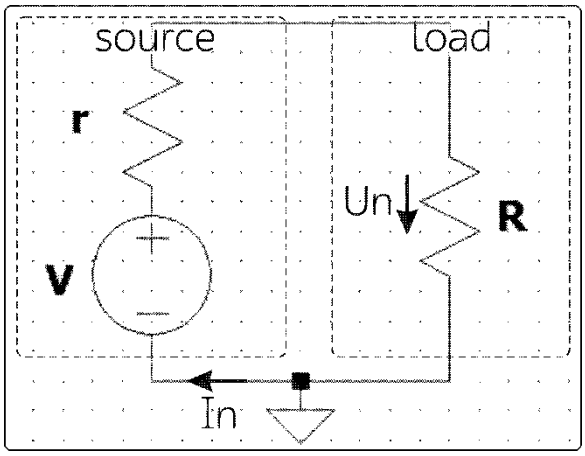

Fig. 1.1 - The Equivalent circuit of real electrical energy source with load in the LTspice application.

4. By changing resistance Rn determine its value which provides voltage in the load equal to $U_0/2$. Enter determined value in the table as r.
5. By varying resistance Rn from 0 [Ω] to 10000 [Ω] accordingly to the Table 1.1, obtain corresponding values of Un and put them into the Table 1.1.
6. Calculate and add values of the following parameters to the Table 1.1 (k = 1...11):
   - Current in Load $In_k = Un_k/Rn_k$ [A];
   - Power dissipated in Load $Pn_k = Un_k^2/Rn_k$ [W].

7. For each pair of current values and line voltages for k = 2...10 calculate and put in the Table 1.1 source internal resistance $r_k = (U_{k-1} - U_k)/(In_k - In_{k-1})$ [Ω]; Find an estimate of the source's internal resistance **r** as a root mean square value

$$r = \sqrt{\sum_{k=2}^{10} r_k^2 \Big/ 9}.$$

8. Calculate and put the values of the following parameters into the Table 1.1:
   - Efficiency $\eta_k = Rn_k/(r + Rn_k)$;
   - Source short-circuit current $Isc = U_0/r$ [A].
9. Draw a line on the plot through points [0, $E = U_0$] and [Isc, 0] which will be the calculated external characteristic and show points of the experimental characteristic according to the Table 1.1. on the same plot.
10. According to the Table 1.1, build power dependencies of load Pn(In) and efficiency η(In).

Table 1.1

k	Measurements		Calculations r = ___ [Ω], E = ___ [V], Isc = ___ [mA]			
	Rn [Ω]	Un [V]	I [mA]	Pn [W]	η	r [Ω]
1	r	U_0	0	0	1	
2	10000					
3	8000					
4	6000					
5	5000					
6	2500					
7	1000					
8	500					
9	250					
10	100					
11	0					

CONTENT OF THE REPORT

1. The equivalent circuit.
2. Filled Table 1.1.
3. Example of calculation for one arbitrary row of the Table 1.1.
4. Plot of the calculated and experimental characteristic of the source.
5. Dependency diagrams for Pn(In) and η(In).