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Кафедра основ схемотехніки

ЛАБОРАТОРНИЙ ПРАКТИКУМ

з курсу

„ОСНОВИ СХЕМОТЕХНІКИ"

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Протокол

Laboratory work № 1.1

Studding voltage divider and regulator of voltage

1 Work goal

After work completion student must be able to do:

1.1. Make voltage divider and regulator of voltage.

1.2. Calculate voltage divider and regulator of voltage on the same coefficient of transmission.

1.3. Calculate coefficient of transmission by analytical or by experiment.

1.4. Calculate the best resistor in the regulator of voltage.

1.5. Decrease and increase output voltage.

2 Key statements

The main purpose of voltage divider is decreasing the voltage. The main parameter of voltage divider is determining amplification factor

$$K = \frac{U_{moutput}}{U_{minput}}, \qquad (1)$$

It is without Rn is:

$$K = \frac{R_2}{R_1 + R_2}, \qquad (2)$$

where R_1 і R_2 – resistance of high and low shoulders of voltage divider;

$U_{m\text{вх}}$ та $U_{m\text{вих}}$ – amplitude of input and output voltage.

Input resistance of voltage dividers is equal

$$R_{\text{input}} = R_1 + R_2.$$

Power which is lost on the resistor constant voltage is

$$P = U_R I_R = \frac{U_R^2}{R} = I_R^2 R, \qquad (3)$$

where U_R – voltage on resistor R;

I_R – current , which is flows across resistor R.

If the resistor is under variable voltage the power is

$$P = \frac{1}{2} U_{R\,m} I_{R\,m} = \frac{1}{2} \frac{U_{R\,m}^2}{R} = \frac{1}{2} I_{R\,m}^2 R, \qquad (4)$$

де $U_{R\,m}$ – amplitude of the voltage on the resistor;

$I_{R\,m}$ – amplitude of current .

Voltage divider is work under $R_{\text{н}}$, which is connecting to low shoulder in parallel. Then determine amplification factor.

$$K_{\text{н}} = \frac{R_2 \| R_{\text{н}}}{R_2 + R_2 \| R_{\text{н}}}, \qquad (5)$$

де $R_2 \| R_н = \dfrac{R_2 R_н}{R_2 + R_н}$ – resistance of low shoulder.

The regulator of voltage is voltage divider in which are regulated high or low shoulders.

The diagram of work is on Fig. 2.1.

There is E – sores of input signal;

Osc U_{input} та Osc U_{output} – oscillographs;

K – key, which is connects $R_н$.

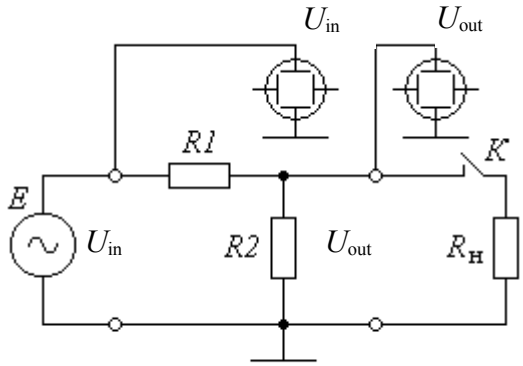


Fig. 2.1

3 Home work

3.1 Make diagram of experiment of voltage divider .

3.2 Calculate resistance of shoulders of voltage divider for determining amplification factor $K_{col} = 0{,}6$ при $R_{in} \geq 1$ кОм.

3.3 For input voltage $U_{min} = 30$ В do calculation the power which is lost on the resistors (4).

3.4 Make diagram of experiment of voltage divider and find all elements.

4 Laboratory assignment

4.1 Tune up laboratory stand, open file № 1.1 Подільник".

4.2 Make on laboratory stand (Fig. 4.1)

Circuit for studding amplifier is consisted of field of choosing of elements (Fig.4.2).

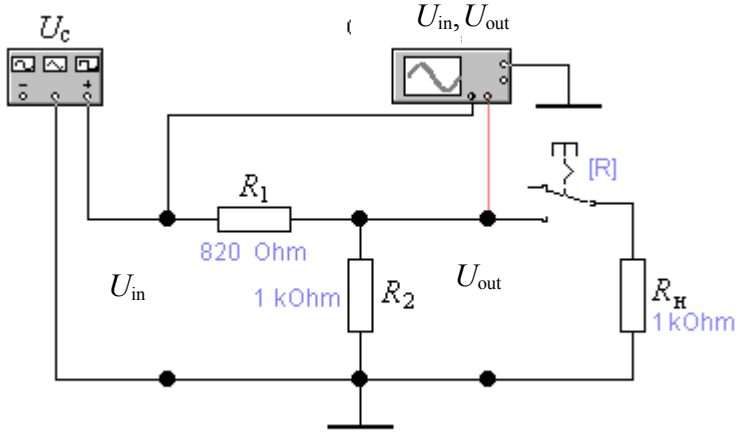


Fig. 4.1

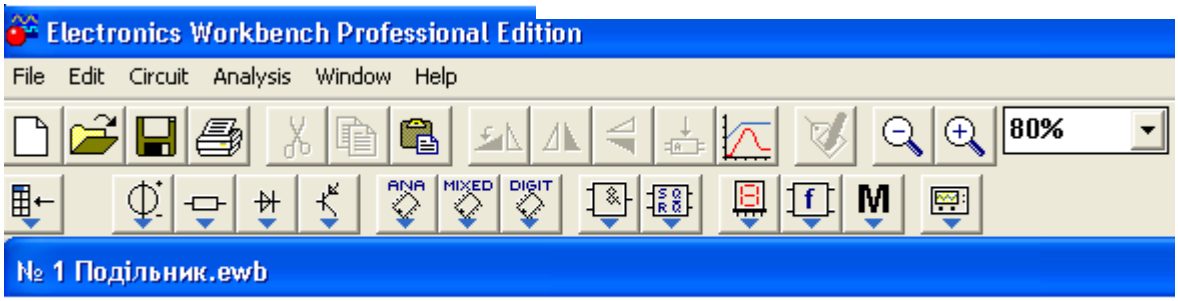


Fig. 4.2

For this work will do the same operation:

– mark and transfer the elements;
– connection the elements in circuit;
– installation parameters of elements;
– connection of measuring devices.

4.2.1 Select and transference the elements.

For the difficult circuits it is necessary to transport from field choosing of elements (fig. 4.2) end field of elements (fig. 4.3) on the work table the same: the source of input voltage E, resistors $R1$, $R2$ та $R_н$, ground, oscillograph, key and six point.

Put cursor on the element which you need (fig. 4.2) end double left click by mouse. Front panel is going open. (рис. 4.3).

Fig. 4.2

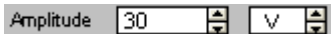
Put cursor on the element which you need end double left clicki by mouse end holding it put the element which you need. After that the element will be red.

4.2.2 The connection of elements in circuit:

– Put cursor on the output of element. There is a big point in the output;
– left click the mouse, hold it, end connect it to element;
– If you see the back put the mouse. There is a connection between two elements.

4.2.3 How to set parameters of elements.

Set input voltage п. 3.3:

– point cursor on the sores of signal U_c (Fig. 4.1), double left click on mouse panel go to open (Fig. 4.4);
– in the window 

set input voltage п. 3.3;
– in the window 

set frequency 1 кГц;
– set sine wave signal by key  ; close the panel  .
– set resistance R_1 end R_2. Put cursor on the resistor icon end double left click by mouse; panel going to open (Fig. 4.5). Put there what you calculate.

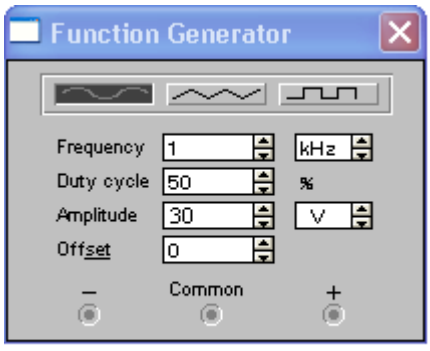


Fig. 4.4

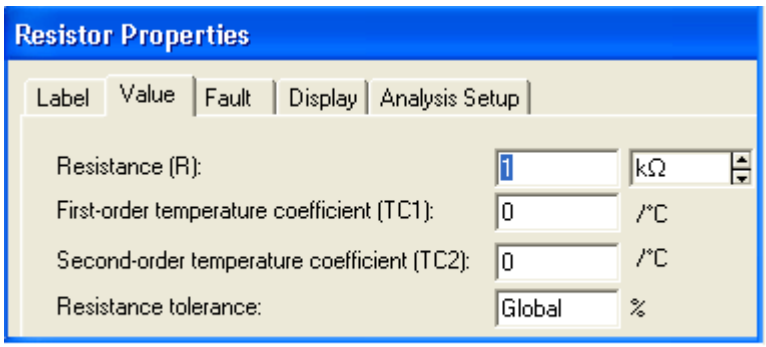


Fig. 4.5

4.2.4 Point the chosen elementsв.

After that you can name this element by *Label* (Fig. 4.5).

4.2.5 How to connect measuring devices.

connect the oscillograph to the voltage divider. Click the key  , 

Fig. 4.6

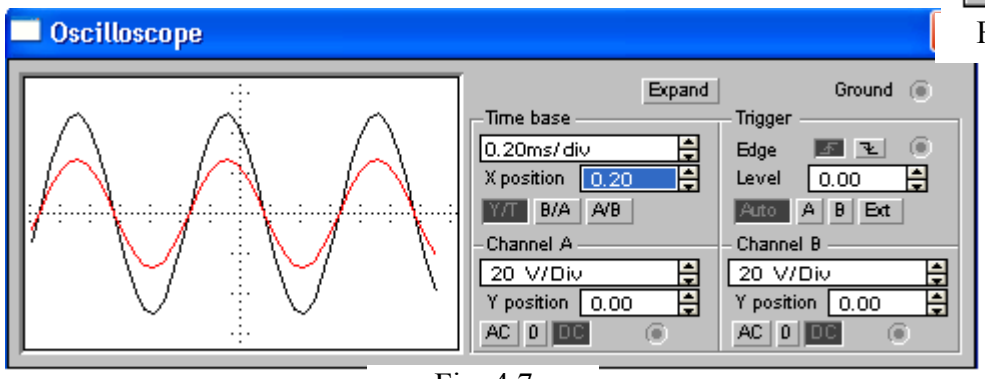


Fig. 4.7

(Fig. 4.6).

Connect output channel *A* of oscillograph to input , end output channel *B* – to output voltage divider, end output *Ground* – to ⊥ п. 4.2.2. situation Channel A end Channel B is on the oscillograph (Fig. 4.7).

4.2.6 What can you market connection :

– put point cursor on the connection end i double left click by mouse; panel going to open;

– put point cursor on the color, left click by mouse end confirm this with OK key.

4.3 Study voltage divider without $R_н$.

4.3.1 Destroy the connection by key *R* (see. Fig. 4.1).

4.3.2 Switch on the diagram  by mouse .

4.3.3 open the oscillograph (fig. 4.6). Two rays are going to start blinking on the screen: a black one – for input signal and red one – for output signal (Fig. 4.7).

4.3.4 Measure the amplitude input U_{minput} end output $U_{moutput}$ end draw according to scale time diagram, input voltage is on the top, output voltage is on the bottom, considering signal phase.

4.3.5 Measuring the amplitude 4.3.4:

– stop the picture by *Pause* enlarge the picture by key *Expand* on the oscillograph (Fig. 4.7);

– stop the picture *Pause*;

The amplitude U_{minput} та $U_{mвoutput}$ are measuring by markers 1 і 2 (Fig. 4.8).
You can count off amplitude value in the middle icon:

$$U_{minput} = VA2;$$
$$U_{moutput} = VB2.$$

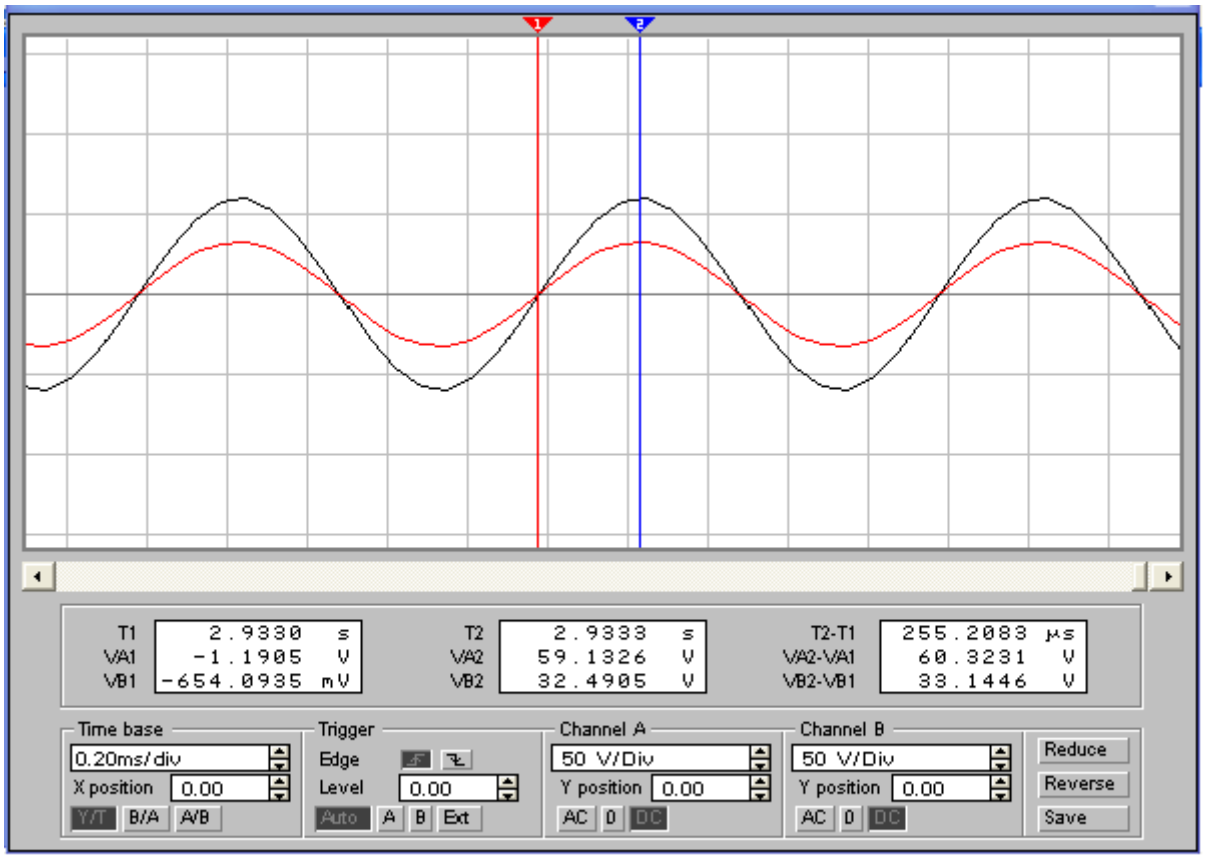


Fig. 4.8

4.3.6 Write down measurement results in table 4.1.
4.3.7 Calculate determine amplification factor end compare with p 3.2.
4.3.8 To calculate the noise

$$\Delta = \frac{K_{cal} - K}{K} * 100\%.$$

Table 4.1

U_{minput} V	$U_{moutput}$, V	K_{cal}	K	Δ, %

4.4 Study the regulator of voltage

4.4.1 please put the result of 3.2 R_1 end R_2 (Fig. 4.1).

Table 4.2

R_{1nom}, кОм	$\frac{R_1}{R_{1\ nom}}$	$U_{m\ in}$, V	$U_{m\ out}$, V
	0.0		
	0.5		
	1.0		
	2.0		

Table 4.3

R_{2nom}, кОм	$\frac{R_2}{R_{2\ nom}}$	$U_{m\ in}$, V	$U_{m\ out}$, V
	0.0		
	0.5		
	1.0		
	2.0		

4.4.2 Increase end decrease R_1 та R_2 end measure the amplitude output voltage, put the results into table 4.2 end 4.3.

4.4.3 Make conclusions.

4.5 Study voltage divider under resistor

Table 4.4

Режим	U_m output, V
Не навант. стан	
Навант.	

4.5.1 Put R_1 end R_2 3.2 .

4.5.2 Calculate 4.3.5 the amplitude output voltage $U_{m\text{out}}$ without R_n end put the result into table 4.4.

4.5.3 Switch on the resistor R_n to output voltage divider by key R (Fig. 4.1).

4.5.4 Switch on the resistor $R_n = 0{,}5\ R_2$.

4.5.5 Calculate 4.3.5 the amplitude output voltage $U_{m\text{out}}$ with R_n end put the result into table 4.4.

4.5.6 Make conclusions.

5 Protocol content

5.1 Homework implementation

5.1.1 Circuit of studying.

5.1.2 Calculations 3.2 end 3.3.

5.1.3 Forms table 4.1; 4.2; 4.3; 4.4.

5.2 Laboratory assignment implementation

5.2.1 Time work diagram 4.3.4.

5.2.2 Calculations' 4.3.7 and 4.3.8.

5.2.3 Table 4.1.

5.2.4 Conclusions 4.3.8.

5.2.5 Table 4.2; 4.3.

5.2.6 Conclusions 4.4.3 and 4.4.4.

5.2.7 Table 4.4.

5.2.8 Conclusions 4.5.6.

6 Control questions

6.1 What is does voltage devider do.

6.2 Influence of the resistors R_1 end R_2 on the output voltage.

6.3 Influence of the resistors R_n on the output voltage.

Literature

Воробйова О.М., Іванченко В.Д. Основи схемотехніки. У 2-х част.: Навчальний посібник. – Одеса: ОНАЗ ім. О.С. Попова, 2004. Ч. 1. – С. 14 – 18.

Laboratory work № 1.3

Studding of transformer and diode circuits

1. Work goal

After this work the student must be able to do:

1.1. Make up the circuits one half period straighten devices with a transformer in input end two half period straighten devices with a transformer in input.

1.2 Calculate the coefficient of transformation.

1.3 Calculate by experiment the amplitude of direct forward straighten voltage in this work.

1.4 Change the polar of straighten voltage in this work.

1.5 Calculate the middle output voltage.

2 Key statements

Transformer Tr (Fig. 2.1) consist of primary end secondary winding with voltage U_1 end U_2. The primary winding is input , end secondary – is output.

The main parameter is the coefficient of transformation N, which is calculated as:

$$N = \frac{W_2}{W_1}.$$

W_2 -number of coil secondary winding

W_1 –primary winding.

The amplitude of voltage the same:

$$\frac{U_{m2}}{U_{m1}} = N$$

.

In the circuits of straighten we use reduced transformer, in whitch $U_{m2} < U_{m1}$, $N < 1$.

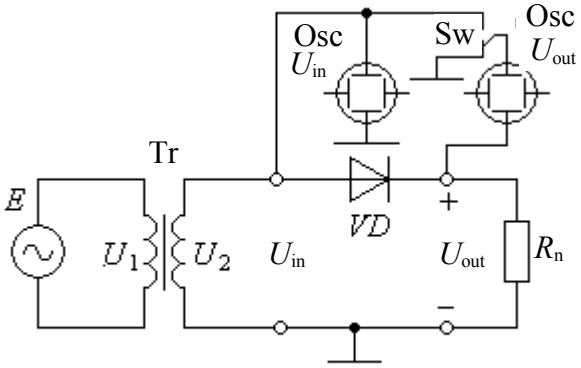


Fig. 2.1

One half period straighten devices with a transformer in input make be polar voltage in one polar voltage. (Fig. 2.1)

The amplitude output voltage $U_{m\text{out}}$ is near input voltage. $U_{m\text{dir}}$ – direct voltage on the diode:

$$U_{m\text{out}} = U_{m\text{in}} - U_{m\text{dir}}.$$

The amplitude output forward voltage $U_{m\text{rev}}$ diode.

The circuit One half period straighten devices with a transformer in input with positive input voltage is on the Fig. 2.1.

3 Homework

3.1 Design the circuit One half period straighten devices with a transformer in input .

3.2 Write time diagram of work circuit one half period straighten devices with a transformer in input.

3.3 Calculate voltage U_{m2} secondary winding of the transformer when $U_{m1} = 220$ В end the coefficient of transformation $N = \frac{1}{30}$.

3.4. Calculate the amplitude output voltage $U_{m\text{out}}$. One half period straighten devices , if $U_{m\text{dir}} = 0{,}7$ V.

4 Laboratory assignment

4.1 Tune up laboratory stand

4.1.1 Open file “№ 1.3.1 Діодні схеми” (Fig. 4.1).

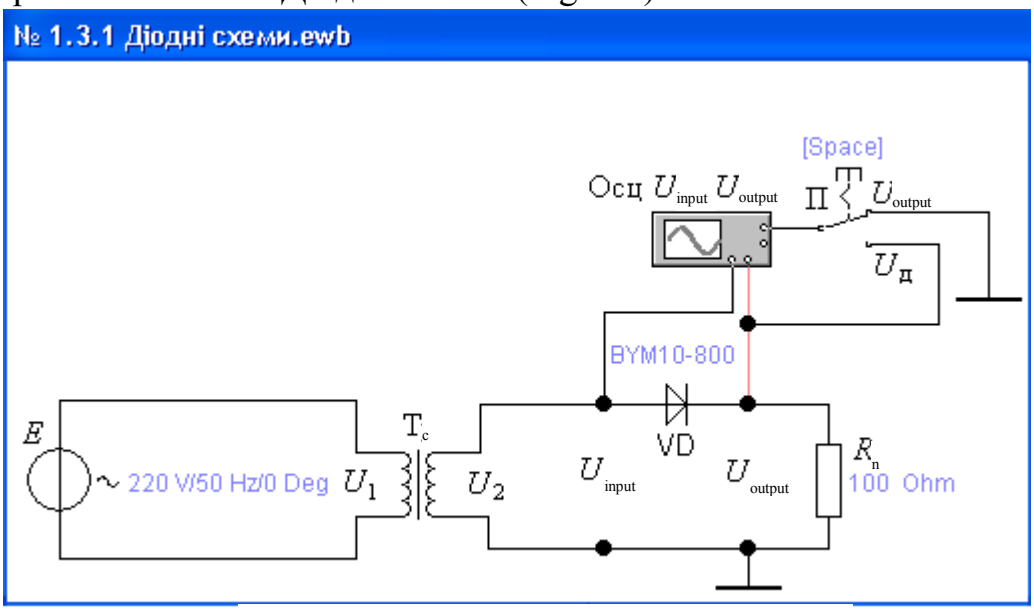


Fig. 4.1

Тут Osc U_{in}, U_{out} – two signal oscilograph.

4.1.2 Put $E = 220$ V, Put cursor on the element.

Double left click the mouse E (Fig. 4.1)

Panel is openning (fig. 4.2), put in the window voltage 220 V, end frequency 50 Hz end click OK.

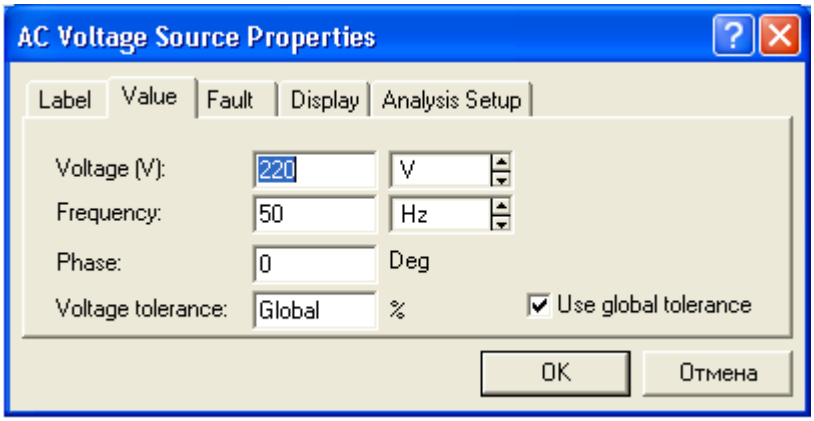


Fig. 4.2

4.1.3 Put the coefficient of transformation 1/30, Put cursor on the element Tr (Fig. 4.1) end double left click the mouse.

Panel is opening (Fig. 4.3), left click the mouse *Edit* i.

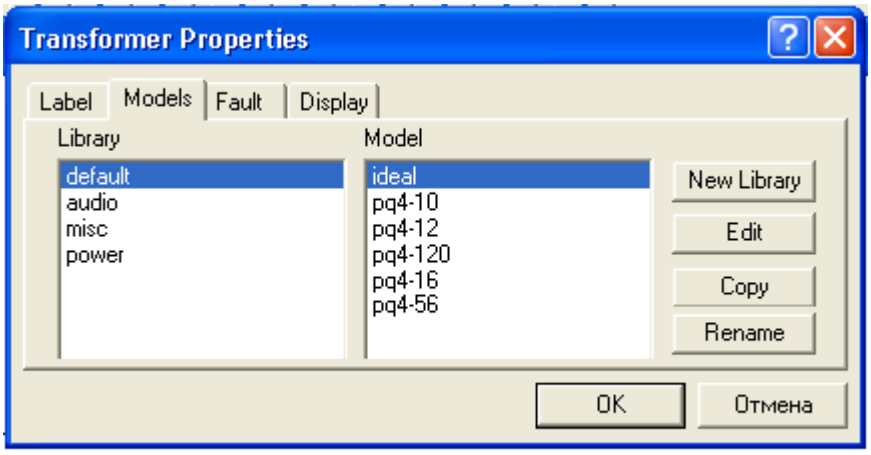


Fig. 4.3

In the window (fig. 4.4), 

put (1/*N=30*), end click OK.

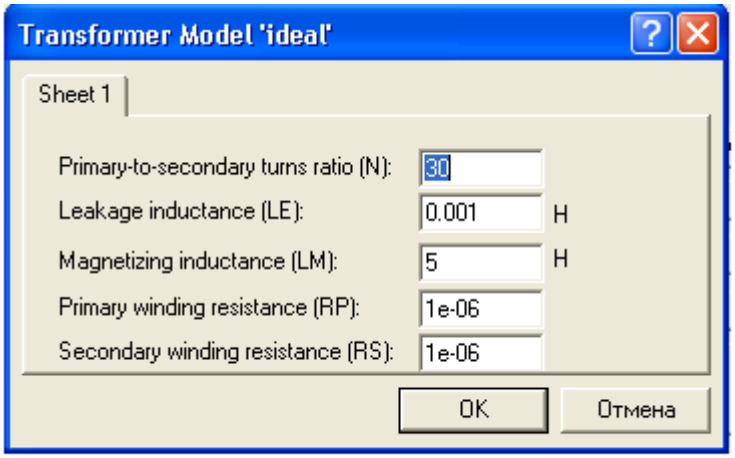


Fig. 4.4

4.1.4 Put cursor on the resistor R_n icon end double left click by mouse; panel going to open (Fig. 4.5). Put there what you calculate. Click OK.

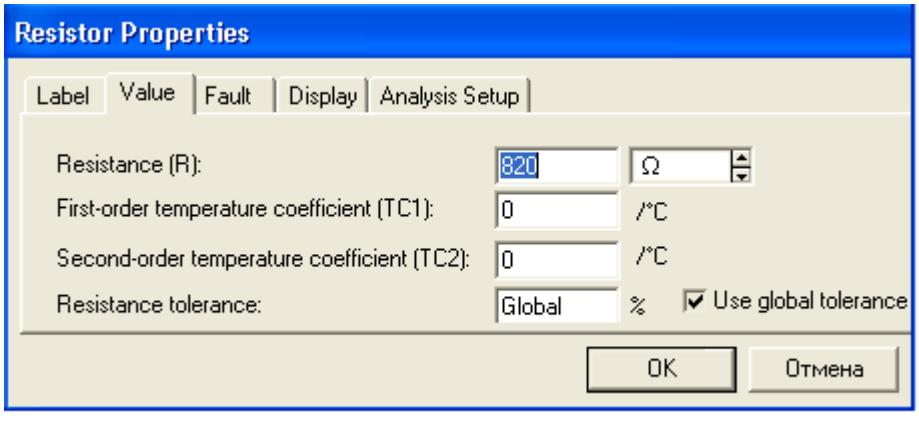


Fig. 4.5

4.2 Sstudy input end output voltage end votage on the diod..

4.2.1 Click  .

4.2.2 Connect the channel *A* end *B* of oscilograph to input end output straighten devices P in U_{out} by key *Space*.

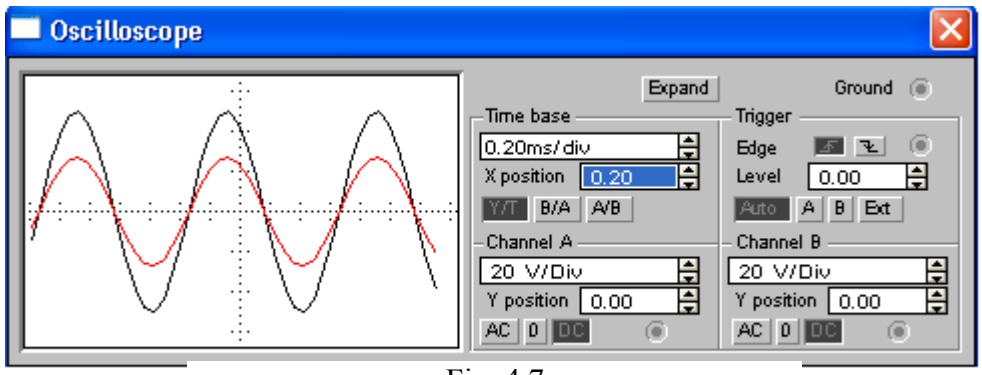


Fig. 4.7

4.2.3 Open the oscilograph. Click the key  .

Connect output channel *A* of oscillograph to input , end output channel *B* – to output voltage situation Channel A end Channel B is on the oscillograph.

There are two signals there. The black is input voltage end the red is output voltage (Fig. 4.6).

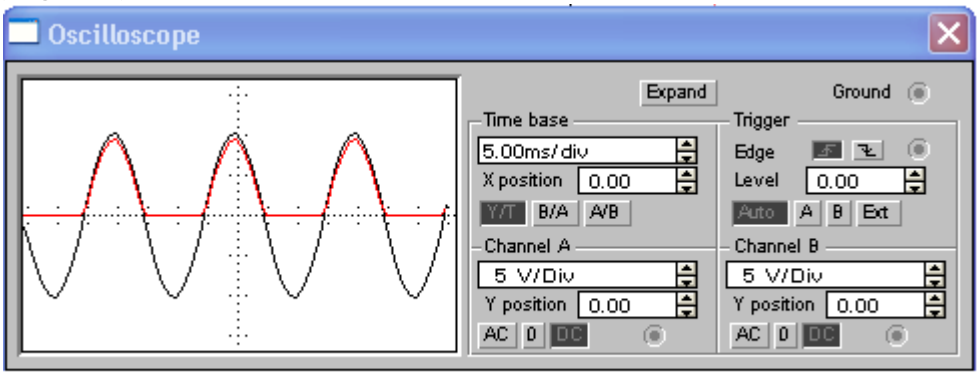


Fig. 4.6

4.2.4 Calculate the amplitude of input voltage U_{min}, on the diode U_{md} end output voltage U_{mout} drown in the scale time diagram $U_{in}(t)$, $U_{d}(t)$, $U_{out}(t)$.

Measuring the amplitude

– stop the picture by *Pause* enlarge the picture by key *Expand* on the oscillograph (Fig. 4.6);

–stop the picture *Pause*;

The amplitude U_{minput} та $U_{mвoutput}$ are measuring by markers 1 і 2 (Fig. 4.7).

$$U_{minput} = VA2;$$
$$U_{moutput} = VB2.$$

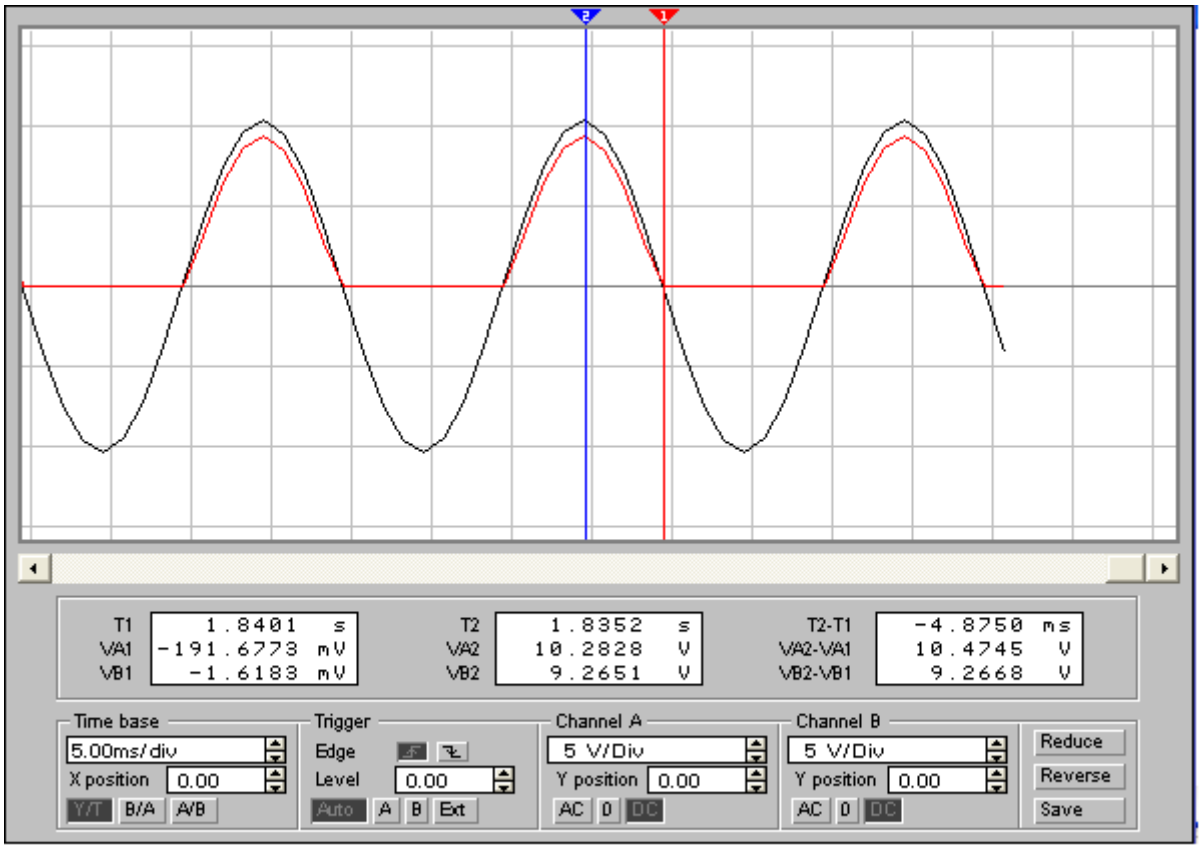


Fig. 4.7

The amplitudes are in the middle window:

$$U_{m\ \text{input}} = VA2,$$

$$U_{m\ \text{output}} = VB2.$$

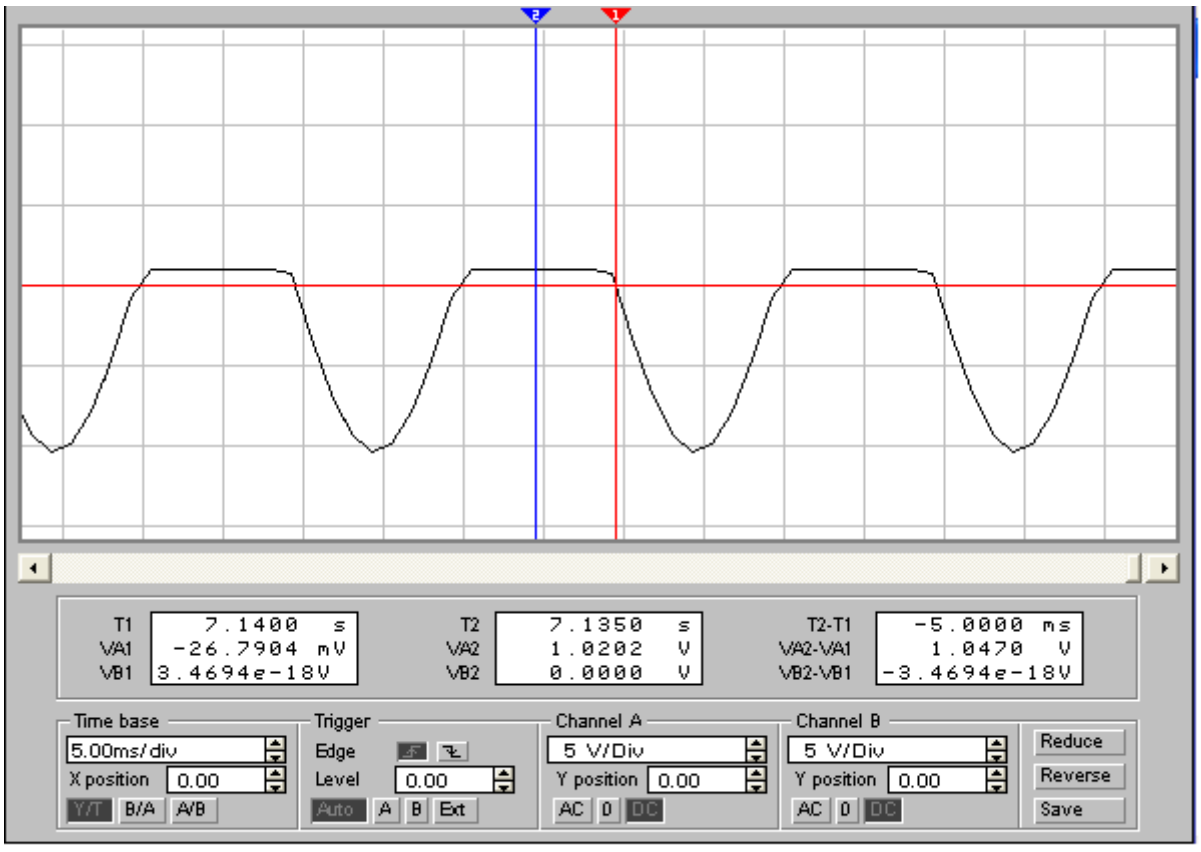


Fig. 4.8

For the calculation the voltage on the diode connect the channel *A* of the oscilograph to diode P in U_d by key *Space*.

There is diode voltage (Fig. 4.8).

Put the marker 1 end 2 on the zero end amplitude of the diode. There is amplitude of the diode in the middle window:

$$U_{m\text{dir}} = VA2.$$

For the forward voltage of the diode put the marker on the amplitude of negative voltage.

$$U_{m\text{rev}} = VA2.$$

4.2.5 Calculate the mistake

$$\delta = U_{\text{meas}} - U_{\text{cal}}$$

$$\Delta = \frac{U_{\text{meas}} - U_{\text{cal}}}{U_{\text{cal}}} * 100\ \%.$$

4.2.6 Put the results to table. 4.1.

Table 4.1 – Measuring results

	Calcul	**Measuing**	**δ, V**	**Δ, %**
U_{m1}, V				
U_{m2}, V				
$U_{m\ \text{in}}$, V				
$U_{m\ \text{out}}$, V				
$U_{m\ \text{dir}}$, V	–		–	–
$U_{m\ \text{rev}}$, V				

4.2.7 make the conclusions of amplitude of:

– first end secondary voltage;

–secondary voltage of transformation voltage end input voltage of straightening;

– input end output voltage of straightening;

– direct end forward voltage.

4.2.8 Make the conclusions of the noise: $U_{m\text{in}}$, $U_{m\text{out}}$, $U_{m\text{rev}}$.

Table 4.2

R_{n}, Om	$U_{m\ \text{out}}$, V
50	
5	

4.2.9 study block load influence on output voltage end count output voltage amplitude by methods. 4.2.4 with $R_{\text{n1}} = 50$ Om end $R_{\text{n2}} = 5$ Om.

Write down measure results to the table 4.2.

4.2.10 Make the conclusions about influence of the resistors on the amplitude output voltage.

5 The work must consist of

5.1 Homework

5.1.1 The circuits of listened 3.1.

5.1.2 Time diagram 3.2.

5.1.3 Culculations 3.3 and 3.4.

5.1.4 Table 4.1 and 4.2.

5.2 Laboratory assignment

5.2.1 Time diagram 4.2.4.
5.2.2 Table 4.1.
5.2.3 Conculations 4.2.8.
5.2.4 Table 4.2.
5.2.5 Conculiation 4.2.10.

6 Key statements

6.1 Principles of work.
6.2 Parameters of transformer.
6.3 Suppression of amplitude input end output voltage.
6.4 Changing of polar direct voltage.
6.5 Direct end forward voltage on the diod.

Literature

1 Воробйова О.М., Іванченко В.Д. Основи схемотехніки. У 2-х част.: Навчальний посібник. – Одеса: ОНАЗ ім. О.С. Попова, 2004. Ч. 1. – С. 26 – 42.

2 Батушев В.А. Электронные приборы: Учебник для вузов. – М.: Высшая школа, 1980. – С. 29 – 82.

Laboratory work № 1.2

Studying semiconductor devices

1 Work goal

On work completion a student is expected to learn:
1.1 Make up the circuits of measurement of semiconductor devices.
1.2 Draw the BAX semiconductor devices.

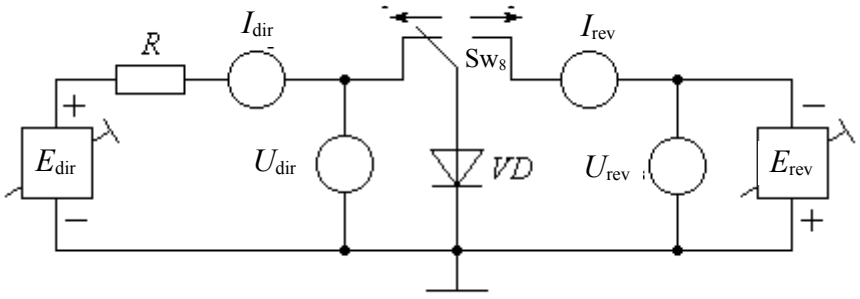


Fig. 2.3

1.3 Culculate the parameters of semiconductor devices.

2 Key statements

Semiconductor devices have conductivity in one way.

If semiconductor devices are under direct voltage its current is big and its voltage is small. If the diode is good 0,7 V. If semiconductor devices are under forward voltage its current is small and its voltage is big.

So, the diode current follow in one way. So the diode is used in straighten devices..

VAD the diode is on (Fig. 2.1).

One of the variety is voltage regulator diode. The direct VAD of diode like a voltage regulator diode. Under forward voltage of stabilization U_{st}, *p-n*-passage voltage regulator diode is broken its forward current is big in the rigime of pierce (Fig. 2.2). Voltage regulator diode are used in regulating voltage devices.

In this work we must measure the diode end voltage regulator diode. Circuit of experiment is on Fig. 2.3.

I_{dir}

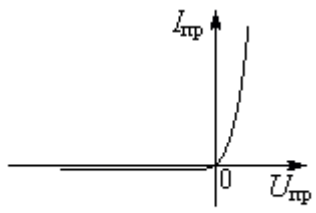


Рисунок 2.1 – ВАХ діода

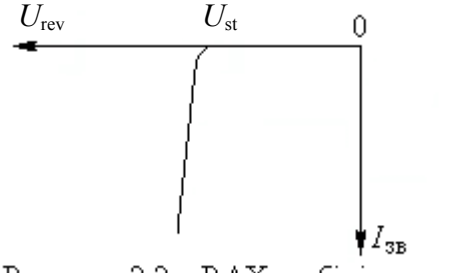


Рисунок 2.2 – ВАХ стабілітрона

U_{dir}

Fig. 2.1

I_{rev}

Fig. 2.2

3.1 draw circuit of experiment of semiconductor diode.

3.2 drown theoretical VAD semiconductor diode.

3.3 drown experimental VAD voltage regulator diode .

3.4 Make up table 4.1.

4 Laboratory assignment

4.1 Compare your circuit end laboratory stent.

The sores of direct voltage E_{dir} is E_1, end forward voltage is E_2.

$П_8$ make up forever end revers voltage.

Direct current I_{dir} end direct voltage U_{dir} are measuring by devices I_1 end U_1.

Forward current I_{rev} end forward voltage U_{rev} are measuring by devices I_2 and U_2.

4.2 Switch on the stand by "General desk switching on" switch on the E_1 end E_2.

4.3 *Fixed the VAH semiconductor diode*

4.3.1 Switch on the Sw_6 in "CB".

4.3.2 Switch on the diode to the 4.

4.3.3 make up VAH $I_d = f(U_d)$ semiconductor diode.

4.3.4 1 Switch on the Sw_8 "Straight".

4.3.5 make up VAH $I_д = f(U_d)$ semiconductor diode.

Change the direct current I_{dir} (devise I_1) by R_6, you must measure direct voltage U_{dir} (device U_1) end put the result o the VAH $I_{пр} = f(U_{dir})$. Without table.

4.3.6 Change Sw_8 in "Reverse".

4.3.7 Change the forward current U_{rev} (devise U_2) by R_{12}, you must measure I_{rev} (device I_2) end put the result o the VAH $I_{rev} = f(U_{rev})$. Without table.

4.3.8 Calculate the differential resistance of diode for the middle point direct aria of VAH:

$$r_d = \frac{\Delta U_{dir}}{\Delta I_{dir}}.$$

Table 4.1

$r_д$, Om	$r_{ст}$, Om

The result put to the table 4.1.

4.3.9 make the conclusion:

– between measuring direct current end direct voltage;

– between measuring forward current end forward voltage;

– determine between measuring direct end forward currents;

– Determine between measuring direct end forward voltage.

4.4 ***Drowne VAH of voltage regulator diode***

4.4.1 Connect the voltage regulator diode to 4.

4.4.2 Make up the VAH voltage regulator diode $I_s = f(U_s)$.

4.4.3 make up VAH $I_d = f(U_d)$ semiconductor voltage regulator diode 4.3.5 ... 4.3.7.

4.4.4 Calculate the differential resistance of voltage regulator diode for the middle point direct aria of VAH:

$$r_{st} = \frac{\Delta U_{rev}}{\Delta I_{rev}}.$$

The result put to the table 4.1.

4.4.5 make the conclusion:

– between measuring direct current end direct voltage;

– between measuring forward current end forward voltage;

– determine between measuring direct end forward currents;

– determine between measuring direct end forward voltage.

4.4.6 Compare r_d end r_{st} make the conclusions.

5. Protocol content

5.1 homework implementation

5.1.1 circuit 3.1.

5.1.2 VAH 3.2 and 3.3.

5.2 laboratory assignment implementation

5.2.1 VAH semiconductor diode 4.3.5 snd 4.3.7.

5.2.2 calculation 4.3.8.

5.2.3 table 4.1.

5.2.4 Conclusion 4.3.9.

5.2.5 VAH voltage regulator diode 4.4.3.

5.2.6 calculation 4.4.4

5.2.7 Conclusion 4.4.5 and 4.4.6.

6 Key questions

6.1 Principles of semiconductor diode work.

6.2 Principles of semiconductor work voltage regulator diode.

6.3 Way VAH semiconductor diode.

6.4 Way VAH semiconductor voltage regulator diode.

Рекомендована література

1 Воробйова О.М., Іванченко В.Д. Основи схемотехніки. У 2-х част.: Навчальний посібник. – Одеса: ОНАЗ ім. О.С. Попова, 2004. Ч. 1. – С. 26 – 42.

2 Батушев В.А. Электронные приборы: Учебник для вузов. – М.: Высшая школа, 1980. – С. 29 – 82.