Labor of Fundamentals of Electronics and Power Electronics

Exercise No. 18
THYRISTOR RECTIFIER

18.1 Basic information

The main goal of the exercise is full-wave thyristor rectifier voltages and currents measurement and characteristics analysis. The rectifier is supplied through transformer with sectional secondary winding.

References:

Ferenczi O.: Linear power supplies DC-DC converters
Tse Chi Kong: Linear circuit analysis
http://en.wikipedia.org/wiki/Thyristor#Switching_characteristics
Baranecki A.: Laboratorium układów elektronicznych. Cz. 1, Cz. 2
Kaźmierkowski M.P., Matysik J. T.: Wprowadzenie do elektroniki i energoelektroniki

18.2 Exercise description

In Fig. 18.1 view of the console front panel is shown Fig. 18.1
In the laboratory console are:

- step-down grid transformer with 220/2x9 ratio protected 1.6 A fuse,
- two, bisectional anodic chokes L1/L2 and L3/L4,
- two thyristors Ty1, Ty2 BT10/50 type,
- three resistive (1Ω each) shunts for thyristors and load currents observation,
- 2x9 Ω and 18 Ω power resistors, and bisectional choke L5/L6 connected as a rectifier load. Due to different resistors and inductances configuration 12 different load circuit models are possible,
- potentiometer as a phase fire controller. Left-maximal position of the potentiometer handwheel corresponds with 180 ^{0}el thyristor firing angle.

The two power supplies for thyristor control circuits are 12 V. The voltages are supplied by inner connector in main panel of the laboratory setup.
Please, choose both 12 V on the main control panel (two buttons 12V).

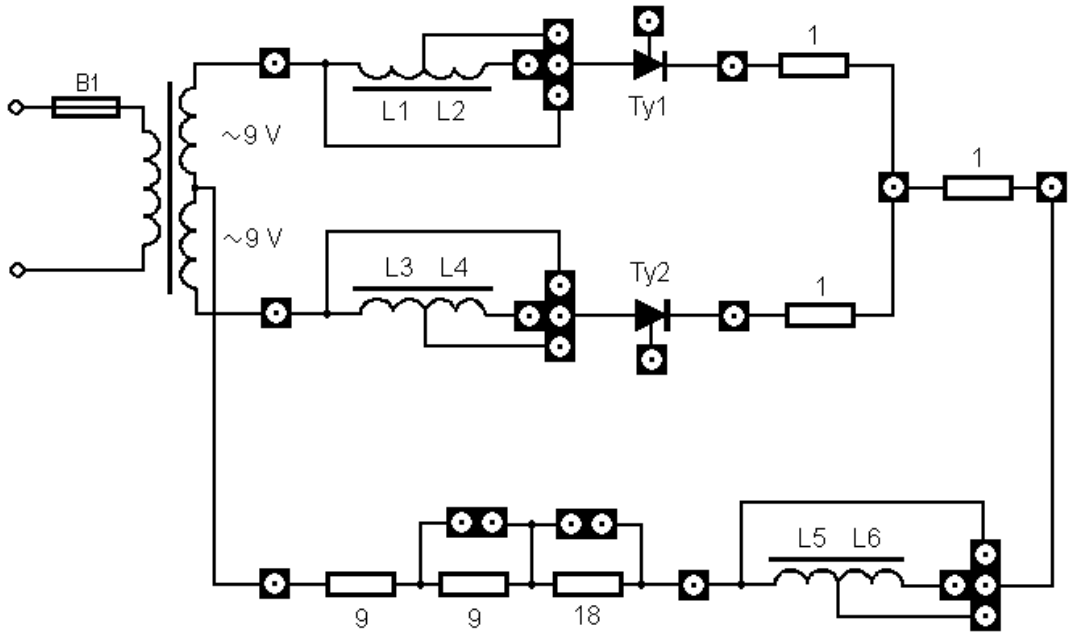

Fig. 18.1

18.3 Exercise program

18.3.1 Controllable full-wave thyristor rectifier basic tests. The rectifier is supplied by transformer with sectional secondary winding. The load has a pure resistive character – resistive load (R).The scheme is shown in Fig. 18.2.

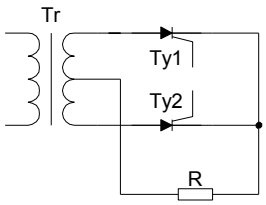

Fig. 18.2

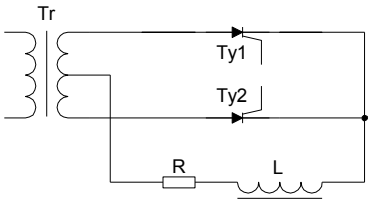

Fig. 18.3

a) Choose resistor R value e.g. 36 Ω. Make all necessary connections and modifications in the circuit to eliminate the load L5/L6 choke, and in anodic thyristor circuits, eliminate L1/L2 and L3/L4 chokes. Turn-on the supply.
b) Connect oscilloscope probes, measure and observe supply voltage and load voltage.
c) Observe output voltage shape changes in function of thyristor firing angle.
d) Draw load voltage synchronously with supply voltage for different values firing angles: $\alpha \approx 180^0$, $\alpha = 150^0$, $\alpha = 120^0$, $\alpha = 90^0$, $\alpha = 60^0$, $\alpha = 30^0$, and $\alpha \approx 0^0$. Afterwards, calculate analytically average values of the output voltage. Make an assumption that observed waveforms is a slice of sine curve. Use a digital voltmeter and measure DC load voltage. Compare the theoretical and experimental results. Explain differences.
e) Complete the output voltage measurements for firing angles: $\alpha=15^0$, $\alpha=45^0$, $\alpha=75^0$, $\alpha = 105^0$, $\alpha=135^0$, $\alpha=165^0$. Draw a rectifier characteristics $U_{0\alpha}/U_0 = f(\alpha)$, where: $U_{0\alpha}$ – average voltage value on the load terminals for arbitrary firing angle α. U_0 – average voltage value for fully fired thyristor.
f) For firing angles mentioned in 18.3.1d observe thyristor Ty1 current and voltage; both thyristor currents Ty1, Ty2; thyristor Ty1 current and load current. Draw all observed waveforms synchronised in time.
g) Turn-off the supply.

18.3.2 Controllable full-wave thyristor rectifier tests. The rectifier is supplied by transformer with sectional secondary winding. The load has resistance-inductive (LR) character. The scheme is shown in Fig. 18.3.
a) Build load model: two section of the load resistor should be short-circuited, and the load choke L5/L6 is connected in series. Turn-on the supply.
b) Connect oscilloscope probes, measure and observe supply voltage and load voltage. Set the firing angle $\alpha = 90^0$. Draw the waveforms.
c) Reconnect oscilloscope probes and observe load voltage and load current; load current and load choke voltage. Draw all observed waveforms synchronised in time.
d) For firing angles mentioned in 18.3.1d make all necessary measurements and draw rectifier control characteristics $U_{0\alpha}/U_0 = f(\alpha)$.
e) Observe thyristor Ty1 current and voltage; both thyristor currents Ty1, Ty2; thyristor Ty1 current and load current for another firing angles than $\alpha = 90^0$.
f) Turn-off the supply.

18.3.3 Commutation process in controllable full-wave thyristor rectifier tests. The load is resistive (R) and resistance-inductive (LR). The scheme is shown in Fig. 18.4

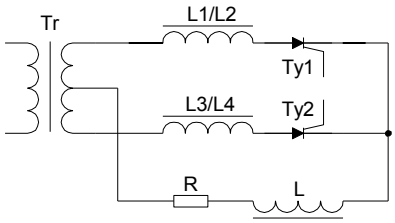

Fig. 18.4

a) In case of resistive R load (short-circuited L5/L6 choke) with different firing angles α observe Ty1 and Ty2 currents. Draw thyristors current in commutation process time period.
b) Repeat thyristors current commutation process observation for resistance-inductive LR load.