Relays

1. Objectives

The main goal of this experiment is to get familiar with basic knowledge about relays parameters and relay driving circuits.

2. Components and instrumentation.

To measure parameters of relays following devices will be used:

- Power supply (12V),
- Square wave generator,
- 2 channel oscilloscope,
- Relays to be measured (R15, RM3, Reed etc.),
- PCB with relay driving circuits (Fig.1, Fig.2).

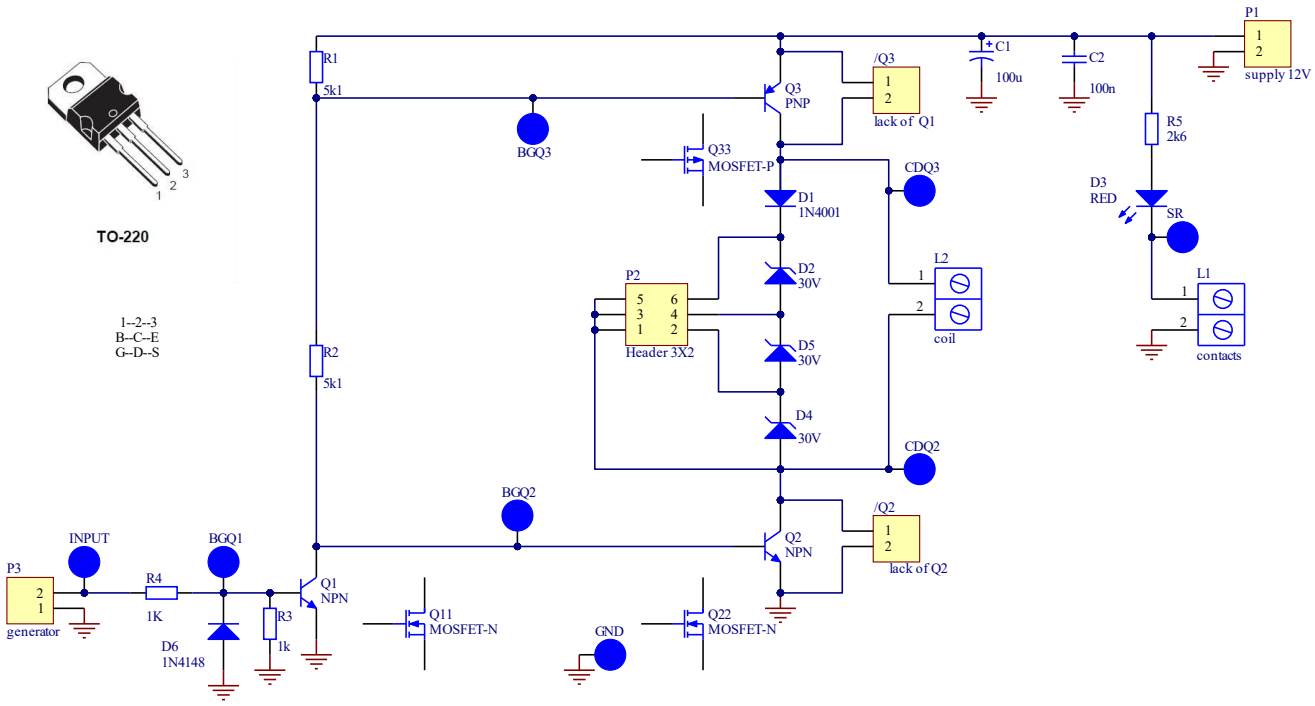

Fig. 1. Schematic of investigated circuit. Transistors Q1, Q2, and Q3 can be BJT or MOSFET.

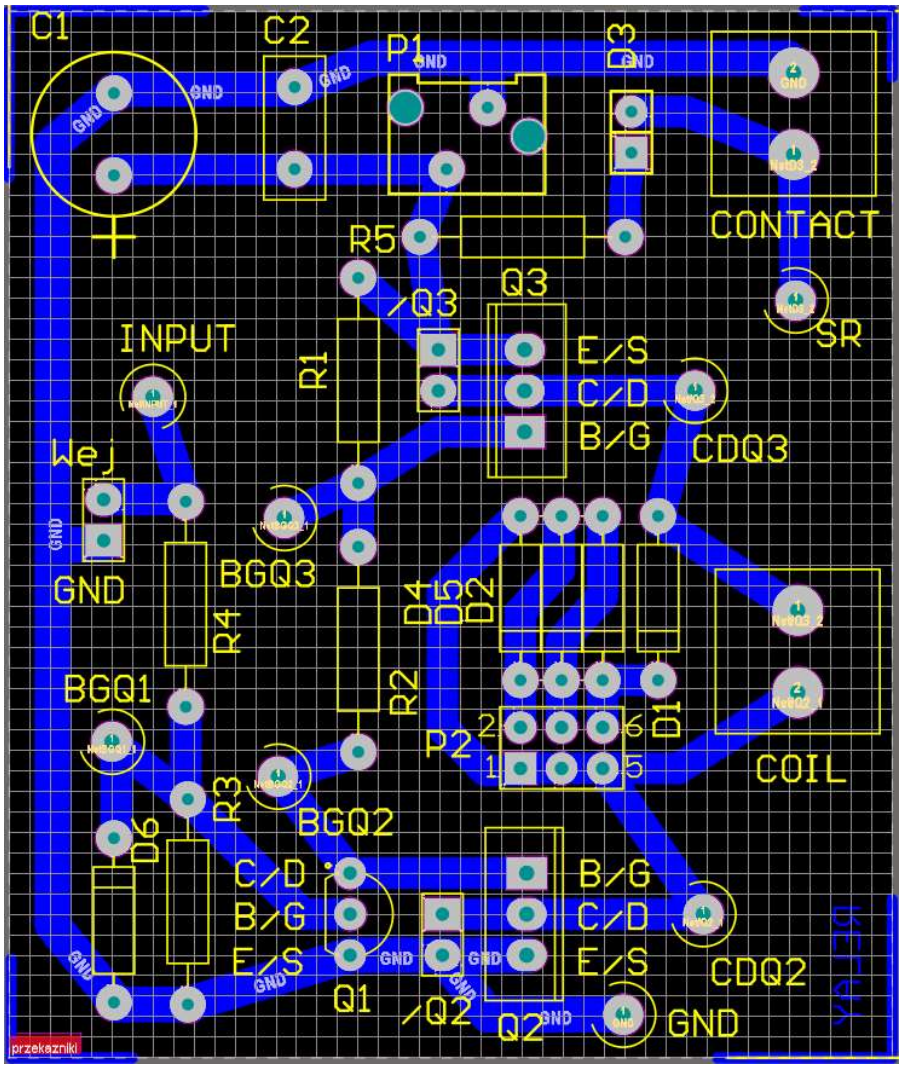

Fig. 2. PCB of investigated circuit.

The PCB is an universal circuits possible to construct one of driving circuits shown in Fig.3. Each of transistor can be BJT or MOSFET and not used transistor may be replaced by a jumper. Choosing one of jumper P3 different maximum voltage over the coil during switching off relay can be chosen. These voltages are 0.7V (jumper 5-6), 30V(3-4), 60V (5-6)and 90V (no jumper).
Diode D3 show if the pole (contact) of the relay is on or off.

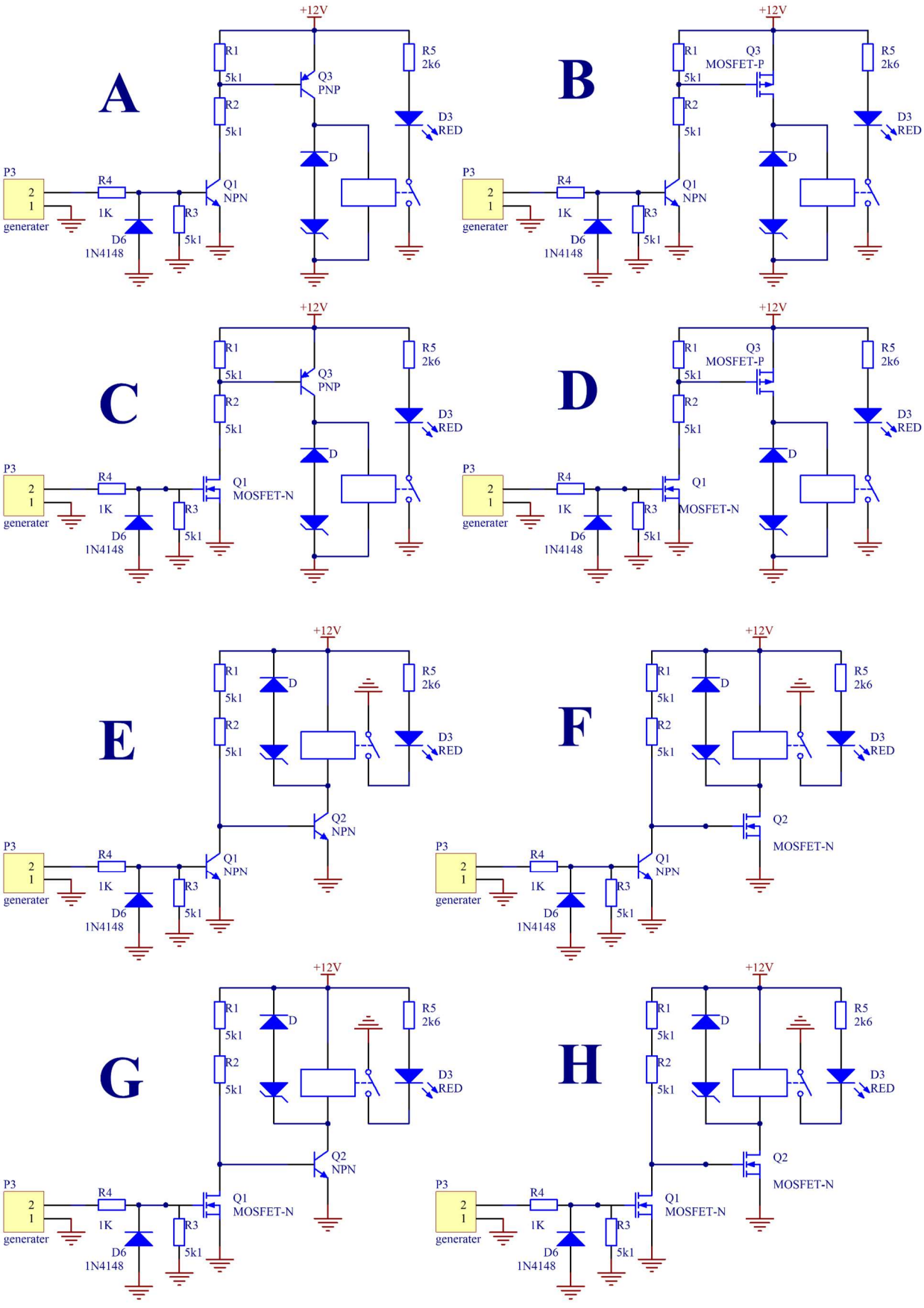

Fig. 3. 8 possible circuits under investigation.

3. Preparation.

Estimated time to prepare for classes is 2 to 6 hours.
Consider, how using PCB from Fig.1 and 2 can be constructed each of driving circuits from Fig.3.
As Q1 transistors: BC527, 2N2222, BS170 can be used, as Q2 – IRFL540, BD and as Q3 IRF9530, BD644
Answer the Problems (chapter 3.2) in written form in Your notebook.

3.1. Readings

[1] Lecture materials ("Actuators").

[2] Data sheets of BJT and MOSFET used as Q1, Q2 and Q3.

[3] Data sheets of relays

3.2. Problems

1. What is a turn-on and turn-off delay times of a digital circuit ?
2. What is the definition of a fall and a rise time of a signal ?
3. Why do we have to use protected diode parallel to coil of the relay?
4. What happens when we use additional Zener diode in coil circuit? How the turn-of time of a relay depends of the voltage of protected diode ?
5. What is a turn-on and turn-off current/voltage of a relay ? How to measure this currents (suggest measurement setup) ?
6. Analyzing the circuit of Fig.1, suggest a driving circuits of 12V load (relay, motor, bulb; driving transistor – NPN, PNP, MOSFET-N, MOSFET-P), that can be actuated from microcontroller supplied with 2V ?
7. What is a threshold voltage of a MOSFET transistor ? What it is in the case of BJT and Darlington BJT ?
8. How to decode abbreviations describing contacts(for example SPDT, DPST etc).

4. Contents of report

All of measurements should be done for at least two different types of relays and two different types of circuit (from A to H – Fig.3)

1. Using suggested circuit (question 6) measure the turn-on and –off currents and voltages of the relay. Using multimeter measure the coil resistance. Put the result to the Table 1.
2. Remove transistors Q2 and Q3, adjust the generator to square wave of frequency about 1kHz, amplitude 9-10V (Q1=BTJ) and 10-15V (Q1=MOSFET) and offset to ½ of amplitude (low level 0V). Using oscilloscope, observe the base/gate (BGQ1) and collector/drain (CDQ1) voltages and establish turn-on and –off delay time as well as threshold voltages of transistor Q1. Put results to table 2 and save corresponding screen shots – add some comment concerning the wave shapes.

In case when Q1 and Q2/Q3 are of different type you can measure thresholds end dely times of BJT and MOSFET on both without removing Q2/Q3 – for Q2 on BGQ2-CDQ2, for Q3 on BGQ3-CDQ3.

3. Adjust the generator to 2Hz and amplitude as in previous point. Apply Q2 (or Q3) and proper jumper in the place of not used transistor. Establish turn-on and –off delay times from the input to: base (gate) of Q1, collector (drain) Q1, collector (drain) Q2 or Q3, contacts of the relay. Observe and establish the bounce time of relay contacts. Collect results in table 3. Save screen shots corresponding to signal on relay contacts. Add some comment concerning the turn-on and –off delay in different points of the circuit.
4. For one of the testing circuit and electromechanical relay establish turn-off time of the relay for different diode voltages od clamp diode. Put result to table 4 and save corresponding screen shots. Answer why the turn-off time depends of the voltage across the coil.

5. Appendix – template of tables

Type of the relay	Rcoil[Ω]	Ion[A]	Uon[V]	Ioff[A]	Uoff[V]
R15/12V					
RM-83/12V					
RM96/12V					
Reed relay/12V					
Semiconductor relay					

Table. 1. Turn-on and -off currents and voltages of a relays.

Type of transistor	Uth[V]	Ton [s]	Corresponding screen shot	Toff[s]	Corresponding screen shot
NPN=					
MOSFET_N channel=					

Table. 2. Turn-on and -off times of npn and MOSTET (Q1 or Q2)

Relay/circuit	Delay to base (gate) Q1 [s]		Delay to collector (drain) Q1 [s]		Delay to collector (drain) Q2 or Q3 [s]		Delay to relay contact (including bounces) [s]		Bounce time [s]		
	-on	-off	-on	-off	-on	-off	-on	-off	-on	-off	Screen no.

Table. 3. Turn-on and -off delays of the driving circuit.

Relay/circuit	Diode voltage [V]	Turn-off delay time [s]	Corresponding screen shot number
	0.7		
	30.7		
	60.7		
	90.7		

Table. 4.Turn -off delays of the rely for different clamp diode voltages.