The transistor as a time-delay switch (Item No.: P1383500)

Curricular Relevance

Area of Expertise: Physics
Education Level: Age 16-19
Topic: Electricity
Subtopic: Electronics
Experiment: The transistor as a time-delay switch

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Intermediate	10 Minutes	10 Minutes	2 Students

Additional Requirements:

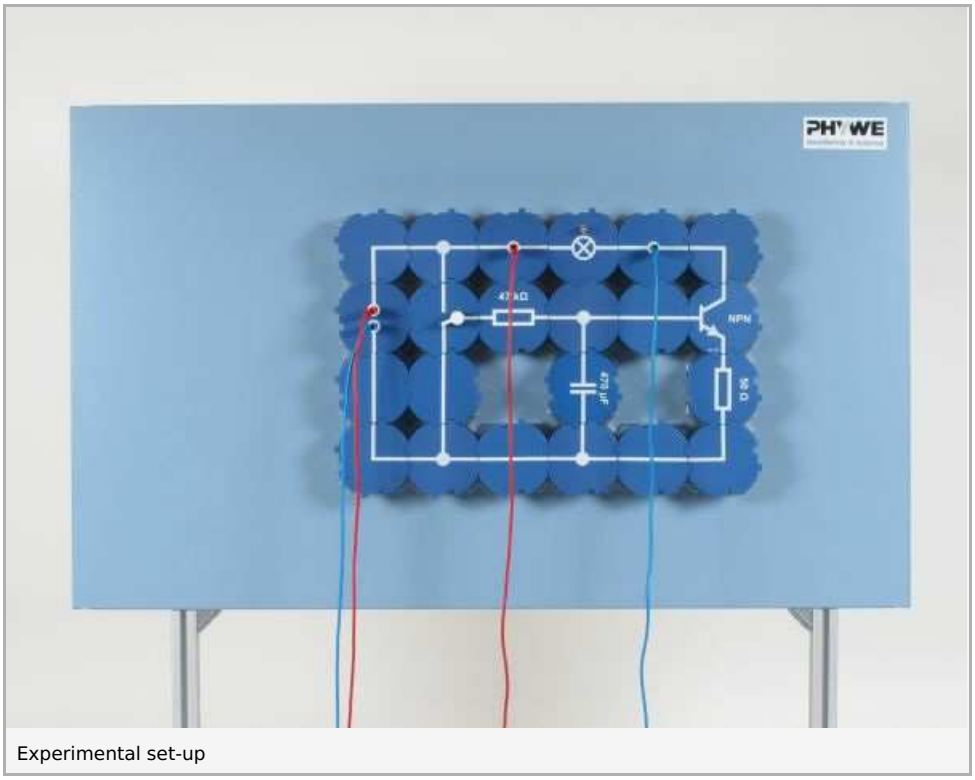
Experiment Variations:

Keywords:

Principle and equipment

Principle

A demonstration is to made of how switching on and switching off can be delayed.



Experimental set-up

Equipment

Position No.	Material	Order No.	Quantity
1	PHYWE power supply, universal DC: 0...18 V, 0...5 A / AC: 2/4/6/8/10/12/15 V, 5 A	13500-93	1
2	Demo Physics board with stand	02150-00	1
3	Stop clock, demo.; diam. 13 cm	03075-00	1
4	Switch, change-over, module DB	09402-02	1
5	Transistor BC337,module DB	09456-00	1
6	Socket for incandescent lamp E10 ,module DB	09404-00	1
7	Connector interrupted, module DB	09401-04	1
8	Resistor 50 Ohm,module DB	09412-50	1
9	Resistor 10 kOhm,module DB	09415-10	1
10	Resistor 47 kOhm,module DB	09415-47	1
11	Capacitor(ELKO)0.047 mF,module DB	09445-47	1
12	Capacitor(ELKO),0.1 mF,module DB	09446-10	1
13	Capacitor(ELKO),0.47 mF,module DB	09446-47	1
14	Electr.symbols f.demo-board,12pcs	02154-03	1
15	Connector, straight, module DB	09401-01	5
16	Connector, angled, module DB	09401-02	4
17	Connector, T-shaped, module DB	09401-03	4
18	Connect.straight w.socket,mod. DB	09401-11	2
19	Filament lamps 12V/0.1A, E10, 10 pieces	07505-03	1
20	Connecting cord, 32 A, 1000 mm, red	07363-01	2
21	Connecting cord, 32 A, 1000 mm, blue	07363-04	2

Robert-Bosch-Breite 10
D - 37079 Göttingen
Tel: +49 551 604 - 0
Fax: +49 551 604 - 107
info@phywe.de
www.phywe.com

Set-up and procedure

- Connect up the circuit as shown in Fig. 1, with the 47 kΩ resistor but without the capacitor.
- Bring the changeover switch to the “discharge” position; set the power supply voltage to 12 V- and select the 10 V- measurement range.
- Switch the changeover switch back and forth several times; observe when the lamp lights up or goes out (1).
- Connect the 470 µF capacitor in the circuit as in Fig. 1; again repeatedly operate the changeover switch and observe when the lamp lights up or goes out; note what you observe (2).
- Operate the changeover switch and the clock simultaneously, and determine the times t_{on} and t_{off} from the moment the switch is operated to the time that full voltage or 0 V voltage is on the lamp; enter the measured values in Table 1.
- Successively connect the combinations of resistors R and capacitors C in the circuit as listed in Table 1; carry out the time measurement for each combination; note the measured values.

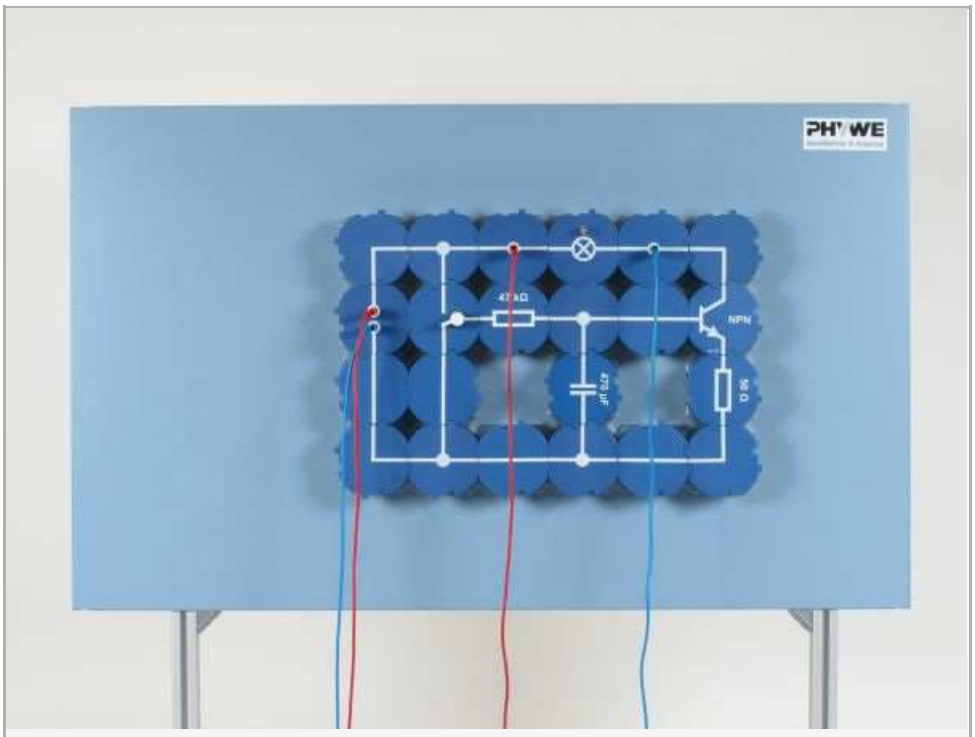


Fig. 1

Observation and evaluation

Observation

1. When no capacitor is used, the lamp lights up or goes out immediately on operating the changeover switch.
2. After a capacitor is inserted in the circuit, the lamp lights up with some delay when the changeover switch is brought to one position, and takes some time to go out when the changeover switch is brought to the other position.

Table 1

$\frac{C}{\mu F}$	$\frac{R}{k\Omega}$	Switching on delay $\frac{t_E}{s}$	Switching off delay $\frac{t_A}{s}$
470	47	31	26
470	10	6	10
100	47	8	6
100	10	4	5

Evaluation

When the capacitor is connected to the positive terminal of the current source via the changeover switch and across the resistance, the capacitor voltage gradually increases. This causes the base-emitter voltage to increase, and the transistor becomes conductive when the base-emitter voltage reaches a value of approximately 0.6 V.

On changing the position of the changeover switch, the capacitor can discharge via the resistance, whereby the capacitor voltage, and so also the base-emitter voltage, now decrease. The collector current of the transistor therefore also decreases.

The delay times on switching on and off are (predominately) determined by the value of the resistance R and the capacity of the capacitor C. The larger the resistance and the capacity, the longer the charging and discharging processes take and, correspondingly, the longer the delay times in switching on and off.

Remarks

This experiment represents a highly simplied principle of a delay circuit, as the transistor continually goes from the non-conducting to the conducting condition. Technically, flip-flops with two transistors are used. These change their switching position abruptly when a threshhold value is exceeded or gone below.

As a result of the relatively long adjusting time of the measuring instrument, and particularly with short delay times, the measured values deviate clearly from the expected values.

In addition, the facts that the discharging process proceeds not only across resistor R but also across the baseemitter resistance of the transistor, and also that the capacitor, when discharging, simultaneously discharges across the base-emitter path, have not been taken into consideration. The 50 Ω resistor inserted in the emitter circuit effects a degeneration, whereby the input resistance of the transistors is appreciably increased (roughly by the current amplification factor of the transistor).This reduces the voltage for the lamp, however, by the voltage drop generated by the emitter current at the emitter resistance.

Robert-Bosch-Breite 10
D - 37079 Göttingen
Tel: +49 551 604 - 0
Fax: +49 551 604 - 107
info@phywe.de
www.phywe.com