Electronics

Components and Basic Circuits
Transistor Circuits

Physics Leaflets

P4.1.6.2

The transistor as a switch

Experiment Objectives

- Learning about the transistor as a switch
- Setting the transistor's switching point with a voltage divider
- Crossing the switching point in the voltage divider with a variable resistance (LDR and PTC)

Basic Information

In this experiment, the transistor is used as a switch in a simple circuit. For this, a base current I_B controls the transistor so that the collector-emitter path is conductive. A lamp indicates this current.

For a transistor's current gain: $B_I = \frac{I_C}{I_B}$.

In the first part of the experiment, a switch turns the base current on. The base-emitter junction's voltage drop corresponds to the diode path. At the same time, the collector-emitter junction becomes conductive, i.e. the collector-emitter path's resistance becomes so small that only a very small voltage drop can still be measured here.

In the second part, a regulation resistor is initially used to look for the switching point. The regulation resistor and the LDR (Light Dependent Resistor) together form a voltage divider. The control voltage U_{BE} is set so that the base-emitter path just becomes nonconductive. Strong illumination onto the LDR increases its resistance so that the voltage rises at the base, and thus current flows through. In turn, current thus flows through the collector-emitter path and the lamp.

In the third part, the experiment is conducted with a PTC (Positive Temperature Coefficient resistor).

The circuit elements studied are deployed in different applications for automatic switching operations and two-step regulator circuits. The transistor thus replaces in principle a relay.

Apparatus

1 Plug-in board DIN A4	576 74
1 STE Transistor BD 137, NPN, emitter bottom	578 67
1 STE Toggle switch, single pole	579 13
1 STE Lamp holder E 10, top	579 06
1 Set of 10 lamps E 10, 12 V/3 W	505 08
1 STE Resistor 1 kΩ, 1.4 W, 5 %	577 44
1 STE Regulation resistor 10 kΩ, 1 W	577 80
1 STE Photoresistor LDR 05	578 02
1 STE PTC probe 30 Ω	578 06
1 STE Heating element, 100 Ω, 2 W	579 38
1 Set of 10 bridging plugs	501 48
1 DC power supply 0...+/- 15 V	521 45
2 Multimeters LDanalog 20	531 120
4 Pair of cables, 50 cm, red and blue	501 45

KEM/JN 0407

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Setup and Procedure

a) Transistor as a switch

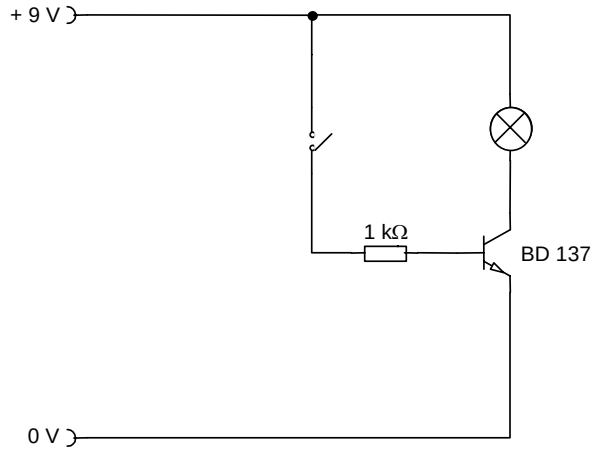

Illustration 1

– Setup according to Illustration 1. Turn on the power supply and set the operating voltage to 9 V.

– Turn on the circuit and observe the incandescent lamp.

– Turn the circuit back off and measure the base current I_B, the voltage U_{BE}, the voltage U_{CE} and the collector current I_C.

– Turn on the circuit and repeat the measurements.

b) Transistor with LDR in the base voltage divider

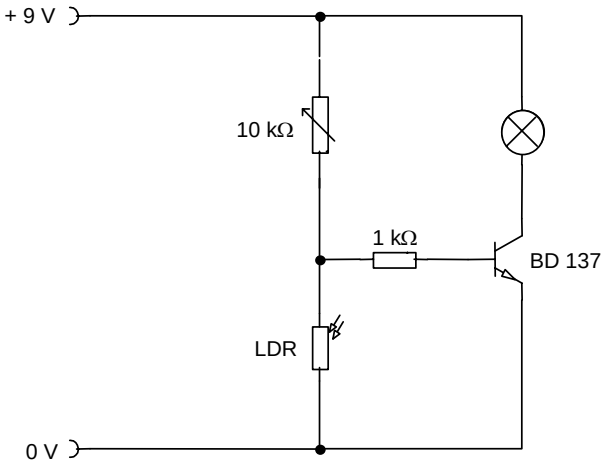

Illustration 2

– Setup according to Illustration 2. Turn on the power supply and set the operating voltage to 9 V.

– Arrange the circuit so that the LDR is uniformly illuminated, e.g. having it point toward a window. The LDR's illumination should not be changed while setting the switching point.

– Set the regulation resistor so that the incandescent lamp just stops shining.

– Cover the LDR and observe the incandescent lamp. It should now shine.

– Measure the base current I_B, the voltage U_{BE}, the voltage U_{CE} and the collector current I_C when the LDR is illuminated and when it is not.

c) Transistor with PTC in the base voltage divider

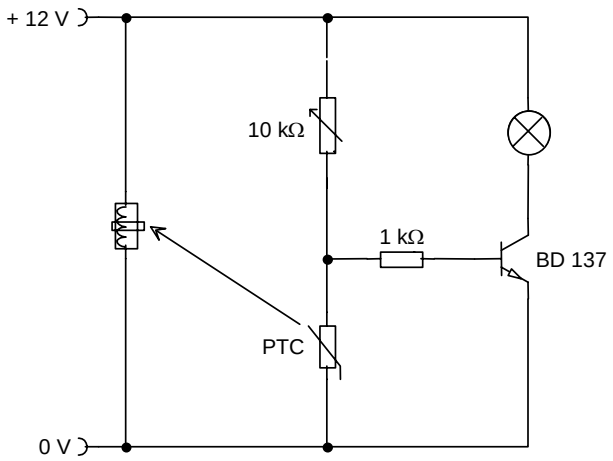

Illustration 3

– Setup according to Illustration 3. Turn on the power supply and set the operating voltage to 12 V.

– The PTC's temperature should not be changed while setting the switching point.

– Set the regulation resistor so that the incandescent lamp just stops shining.

– Heat up the PTC by inserting it into the STE heating element and observe the incandescent lamp. The incandescent lamp should now shine. Depending on the thermal capacity, this can take some time. (Warming it up can also be done with hot water.)

– Measure the base current I_B, the voltage U_{BE}, the voltage U_{CE} and the collector current I_C for a cold PTC and a warm one.

Measurement Examples

a) Transistor as a switch

Switch	$\frac{I_B}{\text{mA}}$	$\frac{U_{BE}}{\text{V}}$	$\frac{U_{CE}}{\text{V}}$	$\frac{I_C}{\text{mA}}$	Lamp
off	0	0	8.9	0	not shining
on	8	0.8	0.02	210	shining

b) Transistor with LDR in the base voltage divider

LDR	$\frac{I_B}{\text{mA}}$	$\frac{U_{BE}}{\text{V}}$	$\frac{U_{CE}}{\text{V}}$	$\frac{I_C}{\text{mA}}$	Lamp
illuminated	0.32	0.68	8	57	not shining
not illuminated	3.0	0.76	0.3	200	shining

c) Transistor with PTC in the base voltage divider

PTC	$\frac{I_B}{\text{mA}}$	$\frac{U_{BE}}{\text{V}}$	$\frac{U_{CE}}{\text{V}}$	$\frac{I_C}{\text{mA}}$	Lamp
cold	0.26	0.68	12	54	not shining
warm	2.6	0.76	1.2	240	shining

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