Problem

Construct a functional model of a temperature switch and test it.

Equipment

Plug-in board	06033.00	1
Relay, 1017 V	39148.00	1
Lamp holder E10	17049.00	1
Filament lamp, 12 V/0.1 A, E10, 1 pc.	07505.03	(1)
Resistor, 10 kΩ	39104.30	1
Adjustable resistor 10 kΩ	39108.03	1
NTC resistor, 1.3 Ω	39110.03	1
Transistor BC337	39127.20	1
Wire building block	39120.00	4
Connecting cables, 25 cm, red	07360.01	2
Connecting cables, 25 cm, blue	07360.04	1
Connecting cables, 50 cm, red	07361.01	2
Connecting cables, 50 cm, blue	07361.04	2
Multi-range meter	07028.01	1
Power supply, 0...12 V-, 6 V~, 12 V~	13505.93	1

Set-Up and Procedure

— Set up experiment as shown in Fig. 1. Switch on power supply unit and set direct voltage to 12 V. Select measurement range of 1 V- on multi-range meter.

— Set adjustable resistor just far enough so that the relay responds and the filament lamp lights up.

— Warm up NTC resistor with your hand until the relay drops out and the filament lamp goes out. Measure voltage U_{BE} between base and emitter and note measurement under (1).

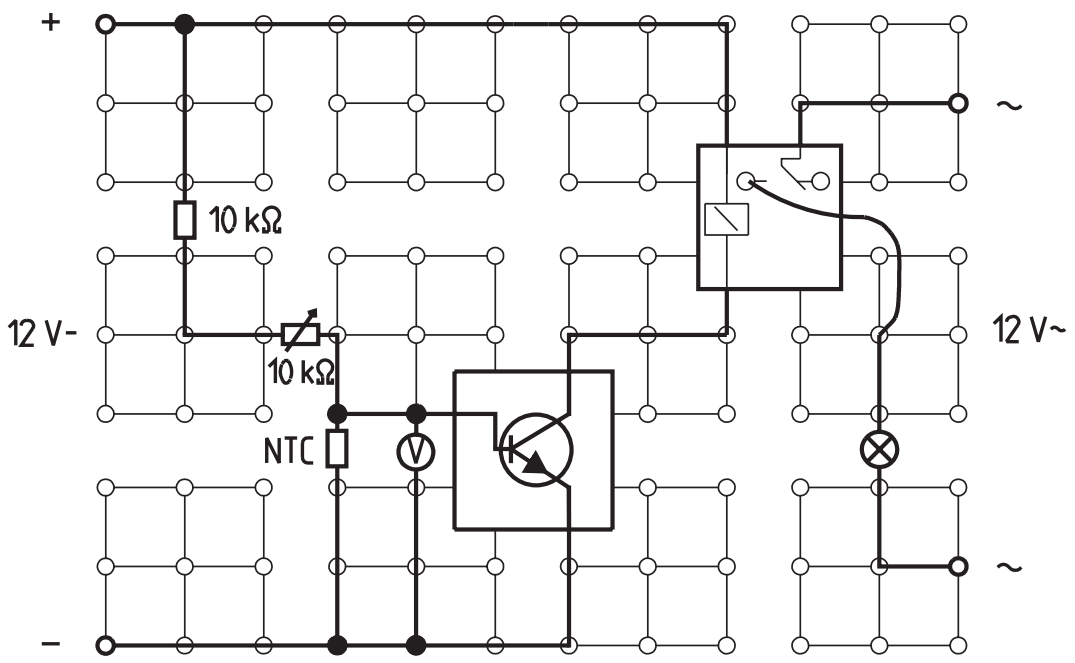
— Let NTC resistor cool off and observe meter. When the relay responds and the filament lamp lights up again, measure base-emitter voltage U_{BE} and note measurement under (2).

Observations and Measurement Results

(1) Relay drops out; U_{BE} =.....

(2) Relay responds; U_{BE} =.....

Fig. 1



Evaluation

1. Why does the relay drop out when the NTC resistor is warmed?

2. By what percentage must the base-emitter voltage U_{BE} be increased for the relay to respond again?

3. How would the circuit behave if the NTC resistor were positioned close enough to the filament lamp for the lamp to warm it?
   Note: The filament lamp functions as an electrical source of heat in this model.

4. How would you have to alter the circuit for the operating current to be interrupted when cooled off?

5. List some possible applications for transistor-temperature switches where the operating current is a) interrupted, b) switched on with an increase in temperature.

6. How does the current gain of the transistor effect the behavior of the temperature switch?

(How does a transistor-temperature switch work?)

In this experiment, the transistor is used as a switch amplifier for amplifying the minimal changes in voltage caused by the warming or cooling of the NTC resistor enough that it can switch a relay on and off.
The NTC resistor used as a temperature sensor is part of a voltage divider which produces the base bias for the transistor. It is set so that it is just within the switching range of the relay.
If you regard the filament lamp switched by the relay as an electrical heat source, you can use this experiment to teach the students about the functioning of a two-position temperature control.
Don't forget that the transistor in this circuit does not actually function as a switch, but rather as a direct current amplifier. The relay functions as a switch. Two transistors are necessary for an actual threshold switch.

Notes on Set-Up and Procedure
Alternating voltage is used for the filament lamp switched by the relay so that the students see that the heat source, represented by the filament lamp in this case, can be operated at any voltage, regardless of the operating voltage of the transistor.
You can connect the temperature sensor to the circuit with two connection cables and bring it into thermal contact with the filament lamp. This creates a closed-loop control circuit.

Observations and Measurement Results
(1) Relay drops out; U_{BE} = 0.60 V
(2) Relay responds; U_{BE} = 0.62 V

Evaluation
1. When the NTC resistor is warmed, its resistance decreases, thereby causing the base voltage of the transistor to decrease. Consequently, the collector current decreases until it drops below the holding current of the relay.
2. The relay responds when base-emitter voltage increases from 0.60 V to 0.62 V. This is an increase of 3.3 %.
3. When the NTC resistor is brought into contact with the heat source, represented by the filament lamp in this experiment, then the circuit functions as a temperature controller. When the NTC resistor is warmed to a certain temperature by the filament lamp, the relay interrupts the heater current. This causes the temperature to decrease again until it drops below a certain minimum value and the heater current switches back on. This process repeats itself continually so that the temperature remains constant within a specific range.
4. The break contact on the relay must be used to interrupt the operating current when the circuit cools off.
5. Temperature switches which interrupt the operating current when warmed can be used in greenhouses with electrical heating or for regulating the temperature in aquariums, for example.
   Temperature switches which switch the operating current on when warmed can be used as fire alarms or for temperature controllers in cooling systems.
6. The amount of current amplification from the transistor influences the sensitivity of the switch to temperature changes. With high current amplification, even minimal changes in temperature are enough to trigger the switch.

T	EEP 13.8	Temperature Control of Transistors	PHYWE

(How does a transistor-temperature switch work?)

Room for notes