**Problem**

Determine the resistance values for a PTC resistor with various currents and at various temperatures.

**Equipment**

| | | |
|---|---|---|
| Plug-in board | 06033.00 | 1 |
| Lamp holder E10 | 17049.00 | 1 |
| Filament lamp, 4 V/0.04 A, E10, 1 pc. | 06154.03 | (1) |
| PTC resistor | 39110.04 | 1 |
| Wire building block | 39120.00 | 1 |
| Connecting cables, 25 cm, red | 07360.01 | 1 |
| 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 | 2 |
| Power supply, 0...12 V-, 6 V~, 12 V~ | 13505.93 | 1 |

Matches

**Set-Up and Procedure**

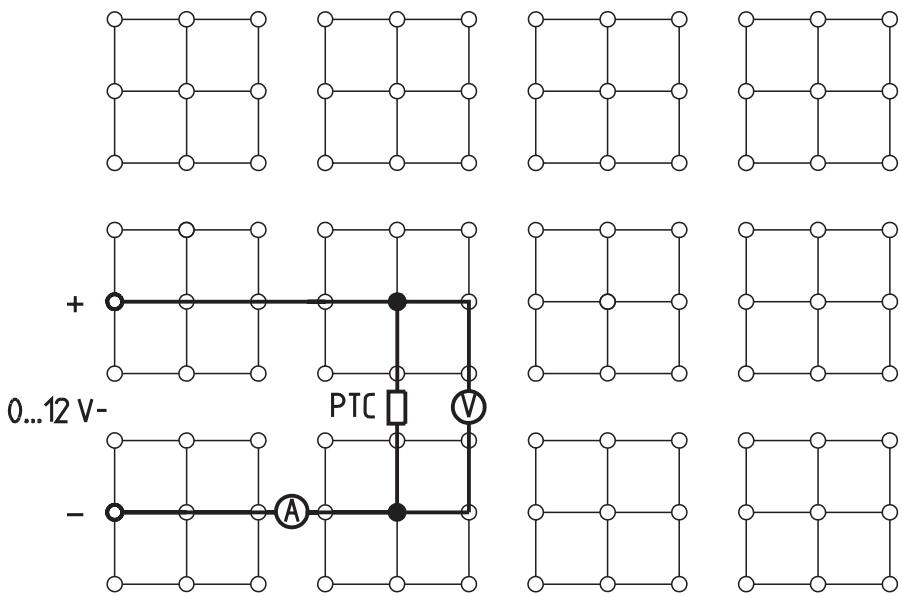
First Experiment

— Set up experiment as shown in Fig. 1.
— Set measurement ranges to 3 V- and 30 mA-.
— Switch on power supply unit and set current first to 15 mA and then to 30 mA, noting the respective voltages necessary for this.
— Note: When setting the current to 30 mA, observe the current meter closely and, if necessary, reset voltage until current remains constant.
— After the second measurement, touch the PTC resistor with your fingers and observe current meter.
— Note observations and measurements under (1).
— Switch power supply unit off.

Second Experiment

— Change experiment set-up. Replace wire building block in circuit with filament lamp and set measurement range to 10 V-.
— Switch on power supply unit and set current once again to 30 mA.
— Warm PTC resistor with a lighted match.
— While warming the PTC resistor, observe the current meter and filament lamp.
**Important!** You should hold the lighted match with the flame next to the resistor at least 5 mm away. Too much heat will destroy the resistor.
— Keep observing the current meter and filament lamp after removing the lighted match from the PTC resistor. Touch the PTC resistor with your fingertips to cool it off more quickly.
— Note observations under (2).
— Switch power supply unit off.

Fig. 1



**Observations and Measurement Results**

(1) Table 1

| I /mA | U /V | R /Ω |
|---|---|---|
| 15 | | |
| 30 | | |

Observations:

(2)

**Evaluation**

1. Summarize the results of the first experiment.

2. How would you explain the behavior of the PTC resistor?

(How does a PTC resistor react to an increase in temperature?)

In connection with Ohm's Law, the student have already learned that pure metallic conductors have a resistance which increases with increasing temperature.
PTC resistors (**P**ositive **T**emperature **C**oefficient) behave the same way in a certain temperature range. Both of these experiments are used to prove this.
The first experiment does not just serve as an introduction to this topic. It is also useful for demonstrating the terms self-heating (in the first experiment) and external heating (in the second experiment). The second experiment is useful in confirming these concepts.

**Notes on Set-Up and Procedure**
The experiment set-ups should not present a problem to the students if they are already relatively familiar with connecting and operating the multi-range meters.
When heating externally with the lighted match, they should be extra careful not to destroy the PTC resistor.

**Observations and Measurement Results**
(1) Table 1

| I /mA | U /V | R /Ω |
|---|---|---|
| 15 | 0.63 | 42 |
| 30 | 1.93 | 64 |

Observations: When determining voltage for I = 30 mA, the indicator on the current meter drops several times so that voltage must be reset often.
When the PTC resistor is touched, current drops a few mA.

(2) Current drops rapidly as soon as the lighted match warms the PTC resistor and continues dropping until the filament lamp goes out.
The current rises back up as soon as the lighted match is removed from the PTC resistor. If the NTC resistor is touched, thereby cooling it more quickly, then the current rises even faster. Eventually, the current returns to its original value, and the filament lamp shines at its original intensity.

**Evaluation**
1. The resistance value of the PTC resistor increases when the current is increased. It also increases when the component is touched.
2. Both the current flowing through the PTC resistor and the students' fingers (which are warmer than room temperature) warm the PTC resistor. This causes an increase in its resistance. With self-heating, however, the current must exceed a certain value for the change in resistance to be apparent.
When the PTC resistor is touched in the second experiment, the temperature of the students' fingers is considerably less than that of the PTC resistor. Thus, the resistor is cooled off when touched, thereby decreasing its resistance.

**Notes**
PTC resistors are also referred to as PTC thermistors. They are widely used in circuits for measuring technique, control technique, and automatic control.
As opposed to pure metal resistors, PTC resistors only behave as demonstrated in these experiments in a certain temperature range (e.g. 30...110°C). Outside of this range, they can behave the same way as NTC resistors. A complete explanation of the behavior of the PTC resistor using a conductivity model is complicated and probably too complicated for a physics course for secondary school students.

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(How does a PTC resistor react to an increase in temperature?)

Room for notes