Variable voltage dividers

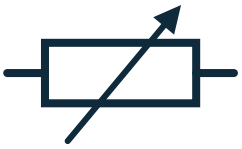
LEARNING INTENTION

We are learning how a variable resistor sets the point at which a sensing circuit switches.

SUCCESS CRITERIA — I CAN

- ☐ state the purpose of a variable resistor in a sensing circuit
- ☐ calculate the variable resistor setting for a switching point
- ☐ explain how changing the variable resistor changes the switching point
- ☐ state the effect of a resistance change on current and voltage

Why use a variable resistor?



Variable resistor symbol

A **variable resistor** has a resistance you can adjust by turning a knob or sliding a track.

In a sensing circuit it replaces the fixed resistor. Turning it sets the **switching point**: the light level or temperature at which the output switches.

This is called adjusting the **sensitivity**. A user can set it without changing any parts.

DATASHEET · VARIABLE DIVIDER

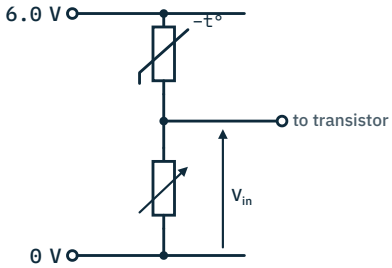
01 One sensor + one variable resistor in series.

02 The transistor switches when V_{in} reaches its switching voltage. Questions give the value (often 0.7 V).

03 Change R_{var} → change the condition at which V_{in} reaches that voltage.

04 Turning R_{var} also changes R_t and the current.

Calculating the setting



Hot-sensing fan control

In this greenhouse fan circuit the thermistor is at the top, so it is hot-sensing.

At the switching point, V_{in} is exactly the switching voltage. Use that to find R_{var}.

Variable voltage dividers

WORKED EXAMPLE **Setting the switch-on temperature**

1 GIVEN	2 FIND	3 FORMULA	4 SUBSTITUTE	5 ANSWER + UNIT
V_s = 6.0 V thermistor (top) at 30 °C switch at V_{in} = 0.7 V	R_{var}	R_{th} from table $V_1 = V_s - V_{in}$ $V_1/V_2 = R_1/R_2$	R_{th} = 8.0 kΩ V_1 = 6.0 − 0.7 = 5.3 V 5.3/0.7 = 8.0/R_{var} R_{var} = 8.0 × 0.7 ÷ 5.3	**R_{var} = 1.06 kΩ**

Set the variable resistor to this value and the fan switches on at 30 °C.

Turning the knob

R_{var} ↑

R_{var} takes a bigger share, so V_{in} is higher at every temperature.

Switches sooner

V_{in} reaches 0.7 V while R_{th} is still large: about 14 °C if Rvar = 2.2 kΩ instead of 30 °C.

R_{var} ↓

The opposite: it now needs to be hotter before the fan switches on.

WORKED EXAMPLE **What the variable resistor does to the circuit**

1 GIVEN	2 FIND	3 FORMULA	4 SUBSTITUTE	5 ANSWER + UNIT
V_s = 6.0 V R_{fixed} = 1.0 kΩ R_{var} = 2.0 kΩ	R_t and I	$R_t = R_1 + R_2$ I = V/R	R_t = 1.0 + 2.0 = 3.0 kΩ I = 6.0 ÷ 3.0	**I = 2.0 mA** R_t = 3.0 kΩ

Turn the variable resistor up: R_t up, so I down, so the voltage across the fixed resistor goes down.

SHORT CIRCUIT

× WHAT EXAMINERS SAW

Asked for the effect of increasing a variable resistor, many pupils did not state what happens to the current or to the voltage across the other resistor.

V THE FIX

Work it through: R_{var} ↑ → R_t ↑ → I ↓ → V across the fixed resistor ↓ (V = IR) → V across R_{var} ↑ (Kirchhoff's 2nd law). State each quantity asked for.

Course report 2024 Q8(c): effect of increasing resistance on V_1 and on the current.

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What the knob does

TURNING THE KNOB (THERMISTOR 20 KΩ AT THE BOTTOM, 5 V)

1. R_{var} = 50 kΩ → V_{out} = 1.43 V
2. R_{var} = 100 kΩ → V_{out} = 0.83 V
3. R_{var} = 150 kΩ → V_{out} = 0.59 V
4. bigger top R → lower V_{out} → So it must get colder to reach 0.7 V

WORKED EXAMPLE Effect of turning the knob

1 GIVEN	2 FIND	3 FORMULA	4 SUBSTITUTE	5 ANSWER + UNIT
LDR (bottom), variable resistor (top) variable resistor increased	switch-on light level	bigger top R → smaller V_{out}	needs a higher LDR R to reach 0.7 V so it must be darker	**Switches on when darker**

WORKED EXAMPLE Setting a variable resistor

1 GIVEN	2 FIND	3 FORMULA	4 SUBSTITUTE	5 ANSWER + UNIT
V_s = 5 V thermistor (bottom) = 20 kΩ at 10 °C switch at V_{out} = 0.7 V	R_{var} (top)	V_{top} = 5 − 0.7 = 4.3 V R_{var}/R_{th} = 4.3/0.7	R_{var} = 20 × 4.3/0.7	**123 kΩ**

Variable voltage dividers

WRONG

Variable resistor: senses temperature

It does not sense anything.

RIGHT

Variable resistor: sets the switching level

It is adjusted by the user.

REAL ENGINEERING · KIRKTON GROWERS

Kirkton Growers (fictional) run glasshouses near Dundee. Tomatoes need different temperatures as they grow.

Each fan controller has a variable resistor. Staff turn it to set the temperature at which the vent fan starts, with no rewiring.

PROBE · QUICK CHECKS

1. State what the variable resistor sets in a sensing circuit. _____
2. R_{var} is turned up. What happens to the current? _____
3. Thermistor at the top. Which way should R_{var} go to make the fan start at a lower temperature?

_____

EXAM READY · 10 MARKS

1 **State** the purpose of the variable resistor in a sensing circuit. **[1]**

2 A thermistor (top) is 8.0 kΩ at 30 °C. V_s = 6.0 V. The transistor switches when V_{in} = 0.7 V. **Calculate** the setting of the variable resistor (bottom). **[3]**

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3 The variable resistor is increased. **Explain** the effect on the temperature at which the fan switches on. **[2]**

4 A 6.0 V supply is connected to a 1.0 kΩ resistor in series with a variable resistor set to 2.0 kΩ. **Calculate** the current. **[2]**

5 The variable resistor is increased. **State** the effect on the current and on the voltage across the 1.0 kΩ resistor. **[2]**