NTC thermistor characteristics

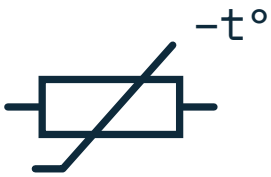
LEARNING INTENTION

We are learning how an NTC thermistor's resistance changes with temperature, and how to use it to sense hot or cold.

SUCCESS CRITERIA – I CAN

- ☐ state how NTC thermistor resistance changes with temperature
- ☐ read resistance from a thermistor graph or table
- ☐ place a thermistor to sense hot or to sense cold
- ☐ calculate values in a thermistor divider

What is an NTC thermistor?



Thermistor symbol

A **thermistor** is an **input device**. Its resistance changes with temperature.

Most thermistors at N5 are **NTC**: negative temperature coefficient. **Hotter → less resistance. Colder → more resistance.**

The symbol is a resistor with a 'hockey-stick' line and the label –t°.

DATASHEET · NTC THERMISTOR

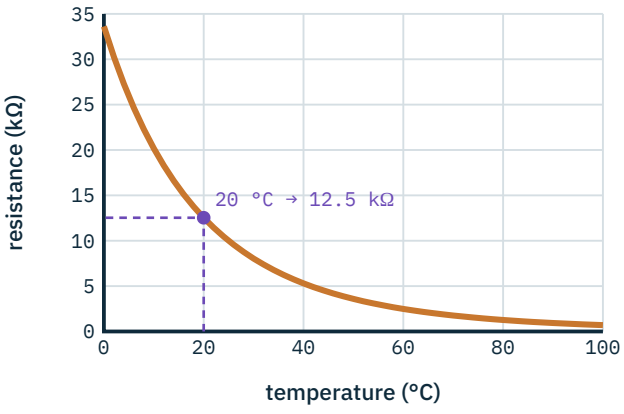
01 Senses: temperature.

02 Temperature up → resistance down.

03 Temperature down → resistance up.

04 Used in: frost alarms, fan controllers, kettles, boilers, battery chargers.

Reading the characteristic



Characteristic of thermistor type TK-10 (fictional)

The graph slopes **down**: that is the 'negative' in NTC.

Read it the same way as an LDR graph: condition along the bottom, up to the line, across to the resistance.

Tables give the same information at set temperatures.

Temp (°C)	0	10	20	30	40	60	80
R (kΩ)	34	20	12.5	8.0	5.3	2.5	1.3

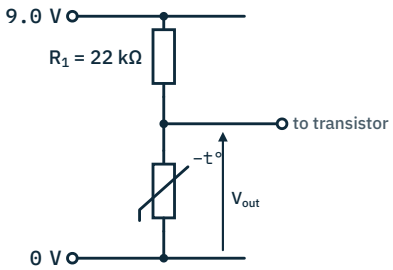
NTC thermistor characteristics

WORKED EXAMPLE **Frost alarm on the Port Ardmore ferry ramp**

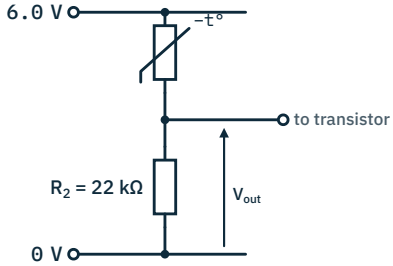
1 GIVEN	2 FIND	3 FORMULA	4 SUBSTITUTE	5 ANSWER + UNIT
V_s = 9.0 V R_1 = 22 kΩ temp = 0 °C	V_{out}	read R_{th} from table $R_t = R_1 + R_{th}$ $I = V/R$, $V = IR$	R_{th} = 34 kΩ (table) R_t = 22 + 34 = 56 kΩ I = 9.0 ÷ 56 = 0.161 mA V_{out} = 0.161 × 34	**V_{out} = 5.46 V**

Port Ardmore is fictional. Cold → thermistor resistance up → V_{out} up: a cold-sensing input.

Sense hot or sense cold?



Thermistor at the bottom: **cold-sensing**



Thermistor at the top: **hot-sensing**

Bottom: cold → V_{out} ↑
Cold → thermistor resistance up → bigger share → V_{out} up.

Top: hot → V_{out} ↑
Hot → thermistor resistance down → R_2 takes a bigger share → V_{out} up.

Swap = opposite
Moving the sensor to the other position reverses the action.

WORKED EXAMPLE **Finding the fixed resistor (ratio method)**

1 GIVEN	2 FIND	3 FORMULA	4 SUBSTITUTE	5 ANSWER + UNIT
V_s = 6.0 V R_{th} (top) = 6.0 kΩ V_{in} = 1.5 V	R_2	$V_s = V_1 + V_2$ $V_1/V_2 = R_1/R_2$	V_1 = 6.0 − 1.5 = 4.5 V 4.5/1.5 = 6.0/R_2 R_2 = 6.0 × 1.5 ÷ 4.5	**R_2 = 2.0 kΩ**

Substitute, transpose, then answer with a unit: three marks.

NTC thermistor characteristics

SHORT CIRCUIT

× WHAT EXAMINERS SAW

Many pupils wrote that thermistor resistance **rises** as it gets hotter. Others described the circuit without mentioning the thermistor's resistance or V_{in} at all.

✓ THE FIX

NTC = Negative Temperature Coefficient: **temperature up → resistance down**. In a description, name the temperature change, the thermistor's resistance change and the change in V_{in}.

Course report 2024 Q10(d); marking instructions give 1 mark each for thermistor resistance and V_{in}.

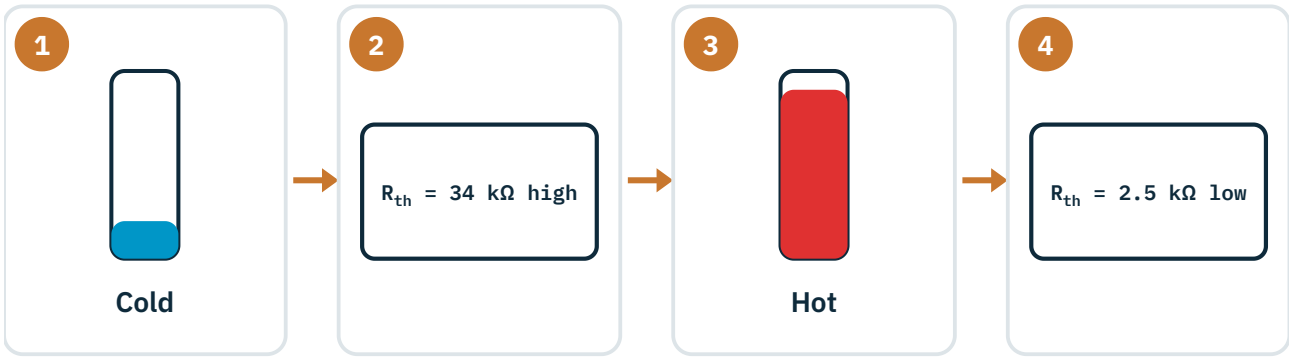
SIGNAL CHAIN

CONDITION	SENSOR	V_{in}	TRANSISTOR	OUTPUT
Temperature falls	Thermistor resistance increases	V_{in} increases	Switches on	Alarm sounds

Model description for a cold-sensing frost alarm (thermistor at the bottom).

Thermistor behaviour step by step

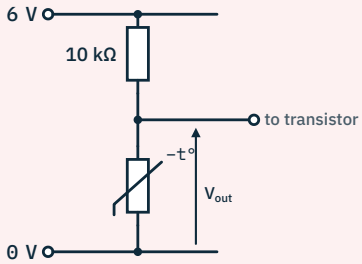
NTC: HOTTER MEANS LOWER RESISTANCE



Cold: 0 °C — Resistance is high — Hot: 60 °C — Resistance is low

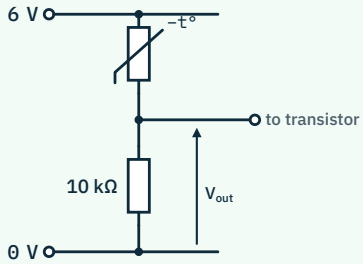
NTC thermistor characteristics

WRONG



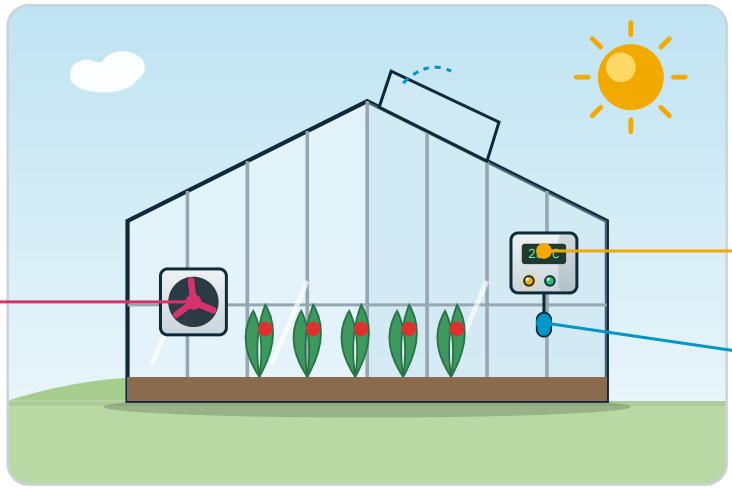
Thermistor at the bottom: V_{out} FALLS as it gets hot (that is a cold sensor).

RIGHT



Hot-sensing: thermistor at the TOP, V_{out} rises when hot.

Hot-sensing in a greenhouse



Fan turns on when hot
OUTPUT

Controller
PROCESS

Thermistor senses air temperature
INPUT

WORKED EXAMPLE Hot-sensing V_{out}

1 GIVEN	2 FIND	3 FORMULA	4 SUBSTITUTE	5 ANSWER + UNIT
V_s = 6 V thermistor (top), R_2 = 10 kΩ (bottom) at 60 °C R_{th} = 2.5 kΩ	V_{out}	$V_{out} = V_s \times R_2/(R_{th} + R_2)$	= 6 × 10/12.5	**4.8 V**

Thermistor at the top → V_{out} rises as it gets hotter.

NTC thermistor characteristics

WORKED EXAMPLE **Reading the thermistor table**

1 GIVEN	2 FIND	3 FORMULA	4 SUBSTITUTE	5 ANSWER + UNIT
need R = 8 kΩ	temperature	find 8.0 kΩ in the table	8.0 kΩ is listed at 30 °C	**30 °C**

REAL ENGINEERING · GLENBRAE DISTILLERY

During fermentation, yeast gives out heat. If the wash gets too hot the yeast dies.

At Glenbrae Distillery (fictional), thermistors in each washback feed a control system. When the temperature rises, the thermistor's resistance falls and cooling water is switched on.



PROBE · QUICK CHECKS

1. What does NTC stand for? _____
2. It gets hotter. What happens to the thermistor's resistance? _____
3. From the table: R at 40 °C? _____

EXAM READY · 11 MARKS

1 **State** what happens to the resistance of an NTC thermistor as its temperature increases. **[1]**

2 Use the table in these notes. **State** the resistance at 30 °C. **[1]**

3 A thermistor is the bottom resistor in a divider. V_s = 9.0 V and R_1 = 22 kΩ. At 20 °C the thermistor is 12.5 kΩ. **Calculate** V_{out}. **[3]**

NTC thermistor characteristics

4 A fan must switch on when a server room gets hot. **State** whether the thermistor should be the top or bottom resistor, and **explain** why. **[3]**

5 In a divider, V_s = 5.0 V, the thermistor (top) is 2.0 kΩ and V_{in} across the bottom resistor must be 2.0 V. **Calculate** the bottom resistor. **[3]**