Resistance Temperature Detector (RTD)

20 common interview questions and answers

Part 1: Fundamental Principles

1. What is the working principle of an RTD?

An **RTD (Resistance Temperature Detector)** works on the principle that the **electrical resistance of a pure metal changes predictably and repeatably with temperature**. As the temperature of the metal element increases, its resistance increases in a precise, well-documented way. By measuring this resistance, you can determine the exact temperature.

2. What does "Pt100" mean?

"Pt100" is the designation for the most common type of RTD.

- **Pt:** Stands for **Platinum**, the metal used for the sensing element.
- **100:** Stands for **100 ohms (Ω)**, which is the nominal resistance of the sensor at exactly **0°C**.

3. Why is Platinum the most common material for RTDs?

Platinum is the ideal material because it has several key advantages:

- **High Linearity:** It has a very linear and stable resistance-vs-temperature relationship.
- **Chemical Inertness:** It is highly resistant to corrosion and contamination.
- **High Repeatability:** It provides very stable and repeatable measurements over a long period.

- **Wide Range:** It can be used over a broad and useful temperature range (typically -200°C to 650°C).

4. What is the difference between a Pt100 and a Pt1000?

The only difference is their base resistance at 0°C.

- **Pt100:** Has a resistance of **100 Ω at 0°C**.
- **Pt1000:** Has a resistance of **1000 Ω at 0°C**. A Pt1000 is often used in battery-powered applications or 2-wire configurations because its higher resistance makes the error from lead wire resistance ten times less significant.

5. What is the difference between a thin-film and a wire-wound RTD?

This refers to the construction of the sensing element.

- **Wire-Wound:** A fine platinum wire is wrapped around a ceramic or glass core. This type is very stable and accurate but more susceptible to vibration.
- **Thin-Film:** A thin layer of platinum is deposited onto a ceramic substrate. This type is smaller, cheaper, and much more resistant to vibration, making it very common in industrial applications.

Part 2: Wiring Configurations

6. Why are there different wiring configurations for RTDs (2, 3, and 4-wire)?

The different configurations exist to **compensate for the added resistance of the lead wires** connecting the RTD to the transmitter. The resistance of the platinum element is very small, so the resistance of the copper lead wires can cause a significant measurement error if not accounted for.

7. How does a 2-wire RTD work, and what is its limitation?

A 2-wire RTD simply connects the two ends of the platinum element to the transmitter.

- **Limitation:** The transmitter measures the **total resistance** of the RTD element *plus* the two lead wires. This added wire resistance makes the instrument read a temperature that is **falsely high**. It is the least accurate configuration and should only be used for short wire runs.

8. How does a 3-wire RTD work?

A 3-wire RTD is the most common industrial configuration.

- **How it works:** It uses a third wire connected to one side of the RTD element. The transmitter uses this third wire to measure the resistance of one of the leads. By assuming all three wires have the same resistance, it can then subtract the lead wire resistance from the total measurement, providing an accurate temperature reading.

9. How does a 4-wire RTD work, and when is it used?

A 4-wire RTD is the most accurate configuration.

- **How it works:** Two wires are used to supply a constant, precise current through the RTD (the outer leads). The other two wires are used to measure the voltage drop directly across the RTD element itself (the inner leads).
- **Advantage:** According to Ohm's Law (V=IR), the resistance is calculated from this voltage. Because no current flows through the voltage-measuring wires, their resistance has **zero effect** on the measurement.
- **Use:** It is used in laboratories and applications requiring the highest level of accuracy.

Part 3: Performance & Characteristics

10. What is the difference between a Class A and Class B RTD?

These classes, defined by the IEC 60751 standard, specify the sensor's accuracy or tolerance.

- **Class B:** Standard industrial accuracy. Tolerance at 0°C is **±0.3°C**.
- **Class A:** Higher accuracy. Tolerance at 0°C is **±0.15°C**. The tolerance for both classes increases as the temperature moves away from 0°C.

11. How does the accuracy of a Pt100 compare to a thermocouple?

A **Pt100 is significantly more accurate** than a standard thermocouple. A Class A Pt100 is roughly 5 to 10 times more accurate than a standard Type K thermocouple, especially at moderate temperatures.

12. What is "self-heating"?

Self-heating is a small measurement error unique to RTDs. It is caused by the heat generated by the small excitation current that the transmitter sends through the platinum element to measure its resistance. This can cause the RTD to read a fraction of a degree higher than the true ambient temperature.

13. What is the typical temperature range for a standard Pt100 sensor?

A standard industrial Pt100 is typically suitable for a range of **-200°C to 650°C** (-328°F to 1200°F). High-temperature versions are available but are less common.

14. Is the resistance-to-temperature relationship of a Pt100 perfectly linear?

No, but it is **very close to linear**. The relationship has a slight, well-defined curve. High-accuracy transmitters use complex equations (like the Callendar-Van Dusen equation) to precisely convert the resistance to a temperature, accounting for this non-linearity.

Part 4: Application & Comparison

15. When would you choose an RTD over a thermocouple?

You would choose an **RTD** when the application requires:

- **High accuracy.**
- **Excellent long-term stability and repeatability.**
- Measurement in a **moderate temperature range** (below 650°C).

16. When would you choose a thermocouple over an RTD?

You would choose a **thermocouple** for applications involving:

- **Very high temperatures** (above 650°C).
- When a **fast response time** is critical.
- In environments with **high vibration or mechanical shock**.
- When a lower-cost solution is needed for general monitoring.

17. What is a thermowell, and why is it used with an RTD?

A **thermowell** is a permanent, pressure-tight receptacle installed in a pipe or vessel. The RTD probe is inserted into the thermowell.

- **Purpose:** It allows the RTD to be **removed and replaced without shutting down the process**. It also protects the RTD sensor from high pressure, high velocity, and corrosive process fluids.

Part 5: Troubleshooting & Calibration

18. An RTD's reading suddenly goes to a very high, off-scale value. What is the most likely problem?

The most likely problem is a **broken or open lead wire**. The transmitter sends a current through the circuit and expects to see a resistance. If a wire breaks, the circuit becomes open, which the transmitter interprets as an infinitely high resistance, corresponding to an extremely high temperature. This is a common failure mode.

19. The reading from a 3-wire RTD is consistently a few degrees high. What could be the cause?

A common cause is that one of the three lead wires has a **higher resistance** than the other two, perhaps due to a poor connection at a terminal block. The 3-wire compensation method assumes all leads have equal resistance, so an imbalance will cause an error.

20. How is a Pt100 sensor calibrated?

A Pt100 is calibrated by comparing it to a more accurate reference thermometer at several known temperatures.

1. The Pt100 probe and a certified reference probe are placed together in a stable temperature source (like a **dry block calibrator** or a calibrated liquid bath).
2. The resistance of the Pt100 is measured at each temperature point.

3. This measured resistance is compared to the standardized resistance values (from IEC tables) for that exact temperature to determine the error and confirm if it is within its class tolerance. 🔧