1. What is an inverter?

Answer:
An inverter is a device that **changes DC (Direct Current) into AC (Alternating Current)**. For example, a battery gives DC, but our home appliances need AC to work — the inverter makes that possible.

2. Why do we need an inverter?

Answer:
Most devices at home or in industries run on AC, but batteries and solar panels give DC. So, we use an inverter to **convert DC to usable AC power**.

3. What are the main components of an inverter?

Answer:

- **DC source** (like a battery or solar panel)
- **Switching devices** (like transistors or IGBTs)
- **Control circuit** (to turn switches on and off properly)
- **Filter** (to smooth the output AC waveform)

4. What is the difference between inverter and UPS?

Answer:
Both provide backup power, but:

- **Inverter** takes a few seconds to start after power goes off.
- **UPS (Uninterruptible Power Supply)** gives **instant power** and is used for computers or important machines.

5. What are the types of inverters?

Answer:

- **Square wave inverter** – cheap, but not suitable for sensitive electronics.
- **Modified sine wave inverter** – better than square wave, works for most devices.
- **Pure sine wave inverter** – gives output like the power from the grid, best for all appliances.

6. What is PWM (Pulse Width Modulation) in inverters?

Answer:
PWM is a smart way of turning the switch ON and OFF really fast to **create an AC-like output** from DC. It helps make the output smoother and more like the actual sine wave we get at home.

7. What are the commonly used switching devices in inverters?

Answer:

- **MOSFETs** – good for low and medium power.
- **IGBTs (Insulated Gate Bipolar Transistors)** – better for high power applications because they can handle large voltage and current.

8. What is the difference between single-phase and three-phase inverters?

Answer:

- **Single-phase inverter** gives power through two wires, used in homes.
- **Three-phase inverter** gives power through three wires, used in industries where more power is needed.

9. What is THD (Total Harmonic Distortion)?

Answer:
THD tells us how close the inverter's output is to a perfect sine wave. **Lower THD means cleaner and better-quality power**, which is safer for appliances.

10. What happens if the load connected to the inverter is too high?

Answer:
If the load (appliances connected) is more than the inverter's capacity, it can:

- Overheat,
- Shut down,
- Or get damaged.

That's why inverters have **overload protection**.

11. What is an H-Bridge inverter and why is it used?

Answer:
An **H-Bridge** is a circuit using four switches arranged like an "H" to control the direction of current flow. It helps **produce both positive and negative cycles of AC** from DC. It's common in motor drives and small inverters.

12. Explain the working of a unipolar and bipolar PWM inverter.

Answer:

- **Bipolar PWM**: Output switches between +V and -V.
- **Unipolar PWM**: Output switches between +V, 0, and -V — giving **better efficiency and less noise**.

13. What is the role of a filter in an inverter?

Answer:
The filter, usually made of **inductors and capacitors**, is used to **smooth out the output**, removing the jagged edges caused by fast switching. This gives a clean sine wave.

14. How does a grid-tied inverter work?

Answer:
A **grid-tied inverter** sends power directly into the electricity grid. It **synchronizes with grid voltage and frequency**, so solar or wind energy can be used along with grid power.

15. What protection features are commonly used in inverters?

Answer:

- **Over-voltage protection**
- **Over-current protection**
- **Short-circuit protection**
- **Thermal shutdown** if it gets too hot
- **Reverse polarity protection**

16. What is meant by PWM (Pulse Width Modulation) control?

Answer: In this method, we keep the DC input fixed but adjust how long the inverter stays ON or OFF to control the AC output voltage. It's like using a dimmer for lights.

17. What are the advantages of PWM control?

Answer:

- We can get the exact voltage we want without extra parts.
- Harmonics (unwanted frequencies) are reduced, improving power quality.
- Less need for filtering since higher order harmonics can be removed easily.

18. What are the disadvantages of harmonics present in the inverter system?

Answer:

- Causes motors to overheat, reducing their performance.
- Can interfere with control and measurement systems.
- Can waste energy in the system.
- In sensitive equipment, torque fluctuations can either damage or (rarely) help the system.

Technical & Application-Based Questions

1. How does a PWM (Pulse Width Modulation) inverter work?

A PWM inverter turns DC (direct current) into AC (alternating current) by rapidly switching the power **on and off** in tiny time slices. It changes how **long** the switch stays on or off (called “pulse width”) to shape the output.

Why it’s useful: This method helps control the **voltage and frequency** of the output AC power smoothly, saving energy and reducing electrical noise.

2. What is the role of IGBTs or MOSFETs in an inverter?

IGBTs (Insulated Gate Bipolar Transistors) and MOSFETs (Metal-Oxide Semiconductor Field Effect Transistors) act like **electronic switches** in an inverter.

- They **turn the power on and off** very fast.
- This switching creates an **AC-like output** from a DC source.

Main Point: They are the heart of the inverter’s operation—efficient, fast, and reliable.

3. Explain the working of a unipolar vs. bipolar inverter.

- **Bipolar inverter**: The voltage swings from **+V to -V** (like a see-saw).
- **Unipolar inverter**: The voltage only goes from **+V to 0** and **-V to 0**, not directly from +V to -V.

Comparison:

Type	Output Wave	Harmonics	Efficiency
Bipolar	More square-shaped	Higher	Lower
Unipolar	Smoother (less noise)	Lower	Higher

Unipolar is generally preferred in modern systems due to less electrical noise.

4. How does an inverter control output frequency and voltage?

- The **frequency** (how fast the current changes direction) is controlled by adjusting how **often** the switches (like IGBTs) turn on and off.
- The **voltage** is controlled by changing **how long** the switch stays on (pulse width).

Example: Faster switching = higher frequency; shorter pulse = lower voltage.

5. What is THD (Total Harmonic Distortion) and how does it affect inverter performance?

THD means **extra unwanted waves** mixed into the clean AC output of an inverter. Think of it like static in a music signal.

Why it matters:

- High THD = **More heat**, **less efficiency**, and **damage** to sensitive devices.
- Low THD = **Clean power**, **better performance**, and **longer life** of connected devices.

Good inverters try to **minimize THD** using filters and better switching techniques (like PWM).

Practical Scenario-Based Questions

1. What protection mechanisms are used in inverters (overcurrent, overvoltage, etc.)?
Inverters have **built-in safety systems** to protect themselves and connected devices, like a fuse protects a circuit.

Common Protections Include:

- **Overcurrent protection:** Stops the inverter if too much current flows (like a short circuit).
- **Overvoltage protection:** Cuts off power if the voltage rises dangerously.
- **Overtemperature protection:** Shuts down if the inverter gets too hot.
- **Short-circuit protection:** Prevents damage if wires touch unexpectedly.
- **Reverse polarity protection:** Saves the inverter if battery wires are connected the wrong way.

These mechanisms keep the system **safe, stable, and long-lasting**.

2. If an inverter overheats, what could be the possible reasons?
Common Reasons:

- **Overloading:** Drawing more power than the inverter's rated for.
- **Poor ventilation:** Heat can't escape due to blocked air vents or dusty fans.
- **High ambient temperature:** Working in a hot room makes things worse.
- **Continuous operation at full load:** No break = more heat.
- **Faulty cooling system:** Fans or heat sinks not working.

Allow **cool-down time**, keep it **clean**, and avoid **exceeding limits**.

3. What happens if we connect an inductive load to an inverter?

An inductive load (like a fan, motor, or fridge) draws **extra current** when starting, like a car needing a push to start.

What happens:

- **Inrush current**: The motor demands a sudden spike of power.
- This can cause **overload or shutdown** if the inverter isn't designed for it.
- **Poor waveform** handling can lead to **heating and reduced motor life**.

Use an inverter that supports **"motor loads"** or **has surge capacity**.

4. How do you select an inverter for a particular load or application?

Just like choosing a power bank for your phone, you must **match the inverter** to your device needs.

Steps:

1. **Know your total power needs (in watts)**.
2. **Add some buffer** (usually 25–30% extra).
3. **Check type of load**: resistive (bulb, heater) vs. inductive (motor, pump).
4. **Decide waveform**: Pure sine wave for sensitive devices; square wave for simple loads.
5. **Check voltage & frequency** compatibility with appliances.

Always pick **a little higher capacity** than your load to be safe.

5. What are the key parameters to look for in an inverter datasheet?

The datasheet is like the **"spec sheet"** of a phone—tells you what it can do.

Key Parameters:

- **Rated Power Output (W or kW)**
- **Input Voltage Range (DC)**
- **Output Voltage & Frequency (AC)**
- **Efficiency (%)**
- **THD (Total Harmonic Distortion)**
- **Surge Power Capacity** (important for inductive loads)
- **Protection Features** (overload, short circuit, etc.)
- **Cooling Type** (fan, passive)
- **Waveform Type** (pure sine, modified sine)

Reading these ensures the inverter **suits your load and won't get damaged**.

Basic Understanding

1. Can you draw and explain a basic single-phase inverter circuit diagram?

A basic single-phase inverter uses four switches (MOSFETs or IGBTs) arranged in an H-Bridge configuration.

- **Working**: Switches are turned on in pairs (S1 & S4 or S2 & S3) to reverse the current direction across the load.
- **Output**: Produces an AC waveform from a DC source by switching the current direction.

2. What are the key components used in an inverter circuit?

- **DC source** (battery or rectified AC)
- **Switching Devices**: IGBTs or MOSFETs
- **Gate Driver Circuit**: For controlling switching devices
- **Freewheeling Diodes**: Protects from back EMF
- **Filter Circuit (LC filter)**: To smooth output waveform
- **Controller (PWM generator/microcontroller)**

3. Why is a freewheeling diode used in an inverter circuit?

- It provides a path for **inductive current** when the switch is off.
- Protects switching devices from voltage spikes due to **inductive kickback**.

4. Explain the working of a full-bridge inverter with a circuit diagram.

- **Full-bridge inverter** uses 4 switches (S1 to S4).
- S1 & S4 ON → Positive output
- S2 & S3 ON → Negative output
- **Freewheeling diodes** protect during switch-off.
- Produces a full-cycle AC output.

5. What is the function of the DC source in an inverter circuit?

- It provides the **primary energy** which the inverter converts into an **alternating waveform** suitable for AC loads.

Switching Devices & Control

6. Which switching devices are commonly used — MOSFET, IGBT, or SCR? Why?

- **MOSFETs**: Better at high switching frequency, low power

- **IGBTs**: Handle higher power, lower switching frequency
- **SCRs**: Rare in modern inverters due to complex control
- **Most commonly used**: IGBT (for power), MOSFET (for speed)

7. Can you explain the gate pulse sequence for a full-bridge inverter?

- **Complementary pairs**:
    - S1 & S4 → Turn ON together
    - S2 & S3 → Turn ON together
- A **dead-time** is introduced to prevent short-circuit

8. Why do we use complementary switching in a bridge inverter?

- To reverse current direction through the load.
- Avoids short circuit across DC bus.

9. What is dead time in inverter switching?

- A **short delay** between turning OFF one switch and turning ON the complementary one.
- Prevents **shoot-through fault** (short-circuit between supply rails).

10. What kind of driver circuits are used in inverter design?

- **Gate driver ICs**: Like IR2110, IR2184
- Placed **between control logic and switching device gates**
- They amplify the signal and provide **isolation** (optocoupler-based drivers)