

Active and Passive Electronic Components

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Understanding Active and Passive Electronic Components

Electronic circuits are built from two main families of components: **active components** that can amplify or control signals, and **passive components** that only store, dissipate, or filter energy. Recognizing which parts are active or passive is essential for troubleshooting PCBs, designing power supplies, and analyzing why a control board fails in HVAC or refrigeration equipment.

What makes a component active or passive?

Active components require an external power source and can introduce energy into the circuit, typically by amplifying, switching, or processing signals. Passive components do not generate power; instead, they resist, store, or transfer energy, which makes them simpler and generally more reliable over long operating hours.

Key criteria

Criterion	Active components	Passive components
Power requirement	Need external bias or supply to operate correctly	Operate without dedicated supply; work from the circuit itself
Signal behavior	Can amplify, modulate, or switch signals	Cannot amplify; only attenuate, store, or filter
Typical role	Processing, logic, regulation, high-level control	Biasing, timing, filtering, matching, energy storage
Examples	Transistors, diodes, ICs, LEDs	Resistors, capacitors, inductors, transformers, LDRs, thermistors

List of active components and their roles

Active devices are the “intelligent” part of a board: they decide when current flows, how much gain is applied, and how digital data is processed.
In low-voltage control boards for compressors or fan motors, these parts are usually the first suspects when there is no response or unstable regulation.

Common active components

Active component	Function in a circuit	Typical HVAC / industrial example
Transistor (BJT, MOSFET)	Amplifies or switches current; acts as electronic valve	Driving a relay coil, controlling DC fan speed
Diode	Allows current in one direction only; used for rectification and protection	Bridge rectifier in SMPS, free-wheel diode on solenoid
LED (light emitting diode)	Indicates status by emitting light when forward-biased	Power, alarm, or compressor-run indicators
Photodiode	Converts light into current; used in sensors and receivers	Infrared receiver in remote control boards
Integrated circuit (IC)	Combines many transistors/diodes into one package for logic, control, or power conversion	Microcontroller, driver IC, or op-amp in control module
Seven-segment display (LED)	Numeric indicator built from multiple LEDs driven by an IC	Temperature or error-code display on controllers
Rechargeable/non-rechargeable battery	Provides DC supply for memory backup or standalone devices; considered active in many classifications because it delivers energy into the circuit	RTC backup battery or wireless sensor power source

Compared with simple mechanical switches, active devices react faster, allow precise analog control, and integrate protection features such as soft-start or current limiting.

List of passive components and their behavior

Passive components shape voltage and current waveforms, store energy, and protect sensitive active devices from surges and noise.
Without properly sized passive parts, even the best microcontroller will fail due to ripple, spikes, or thermal stress.

Core passive components

Passive component	Main function	Typical use case
Resistor	Limits current, divides voltage, sets bias points	LED current limiting; feedback networks in SMPS
LDR (light-dependent resistor)	Changes resistance with light level; part of sensor circuits	Automatic lighting or ambient-light sensing

Passive component	Main function	Typical use case
Thermistor (NTC / PTC)	Resistance varies with temperature; used for sensing and inrush limiting	Temperature probes on coils or defrost sensors
Capacitor	Stores charge, filters noise, stabilizes supply rails	DC bus smoothing, EMI filtering, start/run capacitors
Inductor	Stores energy in magnetic field; filters current or forms resonant circuits	Output choke in DC-DC converter, EMI filter
Switch (mechanical)	Opens or closes circuit path manually or by actuator	On/off pushbuttons, limit switches
Variable resistor / potentiometer	Adjustable resistance for calibration or user settings	Set-point knob on thermostat or speed control
Transformer	Transfers energy between windings; adapts voltage and provides isolation	Mains step-down transformer, control transformer

Passive parts rarely fail catastrophically; instead, their values drift with heat, age, or overload, which can slowly push a regulation loop out of tolerance.

Active vs passive: practical comparisons

A good way to understand the difference is to compare how active and passive components behave in typical low-voltage control circuits.

This is especially relevant when diagnosing PCB faults in refrigeration controllers or inverter drives.

Energy and control capabilities

Aspect	Active component example	Passive component example
Signal amplification	Transistor boosting sensor signal before ADC	No amplification; resistor network only scales sensor voltage
Switching function	MOSFET turning compressor relay on/off using low-power logic signal	Toggle switch manually interrupts line but cannot be gated electronically
Power gain	Audio or gate driver IC increases output power vs. input	Transformer changes voltage and current but does not create power gain
Dependence on supply	Stops functioning without bias or Vcc	Still presents resistance, capacitance, or inductance characteristics without dedicated supply

In digital control boards, active devices act as the *brain*, while passive parts form the *skeleton and blood vessels* that route and condition energy so the brain can work reliably.

Component symbols and schematic reading

Every component is represented by a standardized symbol on schematics, which allows engineers and technicians to understand complex boards quickly.

Learning these symbols is critical for decoding service manuals, drawing custom circuits, or reverse-engineering a defective PCB.

Representative symbols

Component	Typical symbol characteristics
Transistor	Three-terminal symbol (emitter, base, collector or source, gate, drain) with arrow indicating current direction
Diode / LED / photodiode	Triangle-to-bar symbol; LED adds outward arrows; photodiode adds inward arrows
Resistor / variable resistor	Zig-zag or rectangular symbol; arrow or extra terminal for variable types
Capacitor	Two parallel lines (or one curved for polarized electrolytic)
Inductor	Series of loops or rectangles; transformer shows two inductors with coupling bars or core symbol
LDR / thermistor	Resistor symbol with diagonal arrows or small temperature mark to indicate dependency

Knowing the symbol set reduces troubleshooting time because it becomes easy to identify where signals are amplified, rectified, filtered, or limited on any board.

Why both active and passive parts are essential in modern electronics

Real-world products, from inverter air conditioners to smart thermostats, rely on the interplay between active controllers and passive networks.

Active components process information and drive loads, while passive components ensure clean power, stable references, and EMC compliance.

In a typical microcontroller-based board:

- The **microcontroller, transistors, and driver ICs** handle logic, timing, and switching.
- **Resistors, capacitors, and inductors** form power filters, RC timing networks, and snubbers to protect the active silicon.
- **Sensors such as thermistors and LDRs** translate physical variables into electrical signals that the active devices can interpret.

ACTIVE

PASSIVE

