Transistor Pinout Complete Reference Guide

BJT & MOSFET Pinouts · Multimeter Identification · Part Selection · Assembly Best Practices

1. Package Pinout Overview

The table below summarizes the four most common through-hole and SMD packages. Pin numbers are read with the device front (marked) face toward you and leads pointing downward, left-to-right.

Package	Pin Order (left→right)	Orientation to Read Pins	Notes
TO-92	Varies by part number	Flat face toward you, leads pointing down	Most common small-signal package. No heatsink. Max dissipation ~625 mW. Always verify with datasheet.
SOT-23	Varies; typically: 1(BL) 2(BR) 3(Top)	Dot or chamfer marks Pin 1 on silkscreen	SMD equivalent of TO-92. Pin assignment differs between BJT and MOSFET variants. Confirm datasheet before routing PCB.
TO-220	Varies by part number	Heatsink tab facing away, leads pointing down	Heatsink tab is electrically connected to center pin. Use insulating pad + bushing if mounting to chassis.
TO-92S (wide)	Same as TO-92 for the same part	Flat face toward you, leads pointing down	Wider lead spacing (~2.54 mm). Common in S8050/S8550. Direct mechanical replacement for TO-92.

Critical: Even within the same package, different part numbers may have completely different pin assignments. Always verify against the official datasheet before soldering.

2. Quick Reference Pinout Table — 13 Essential Parts

Pinout shown left-to-right with device front face toward you, leads pointing down. **E** = Emitter **B** = Base **C** = Collector **G** = Gate **D** = Drain **S** = Source

Part No.	Type	Pkg	Pinout (L→R)	Complement / Alt	Key Specs	Notes
2N3904	NPN BJT	TO-92	**E B C**	2N3906 (PNP pair)	Vceo=40V, Ic=200mA, hFE~100-300	Most popular general-purpose NPN. Good for audio & switching.

Part No.	Type	Pkg	Pinout (L→R)	Complement / Alt	Key Specs	Notes
2N3906	PNP BJT	TO-92	**E B C**	2N3904 (NPN pair)	Vceo=40V, Ic=200mA, hFE~100-300	Complementary pair to 2N3904. Identical pinout.
BC547	NPN BJT	TO-92	**C B E**	BC557 (PNP pair)	Vceo=45V, Ic=100mA, hFE~110-800	European standard. CBE order — opposite to 2N3904! Not pin-compatible.
BC557	PNP BJT	TO-92	**C B E**	BC547 (NPN pair)	Vceo=45V, Ic=100mA, hFE~125-800	Complementary to BC547. Same CBE pinout.
S8050	NPN BJT	TO-92	**E B C**	S8550 (PNP pair)	Vceo=25V, Ic=1.5A, hFE~40-400	Higher current than 2N3904. Good for relay/LED array driving.
S8550	PNP BJT	TO-92	**E B C**	S8050 (NPN pair)	Vceo=25V, Ic=1.5A, hFE~40-400	Complementary to S8050. Popular in Chinese designs.
2N5551	NPN BJT	TO-92	**E B C**	2N5401 (PNP pair)	Vceo=160V, Ic=600mA, hFE~80-250	High-voltage NPN. Used in CRT circuits & line drivers.
2N7000	N-MOSFET	TO-92	**S G D**	BS170	Vgs(th)=0.8–3V, Id=200mA	Logic-level N-MOS in TO-92. Good for 3.3V/5V logic switching.
BS170	N-MOSFET	TO-92	**S G D**	2N7000	Vds=60V, Id=500mA, Vgs(th)~0.8V	60V gate rating. Common in signal switching and low-power loads.
IRFZ44N	N-MOSFET	TO-220	**G D S**	IRF3205	Vds=55V, Id=49A, Rds(on)=17.5mΩ	Logic-level gate (Vgs(th)~2–4V). Ideal for PWM motor control.
IRF540N	N-MOSFET	TO-220	**G D S**	IRFZ44N	Vds=100V, Id=33A, Rds(on)=44mΩ	Higher voltage variant. Heatsink tab = Drain.
TIP122	NPN Darl.	TO-220	**B C E**	TIP127 (PNP pair)	Vceo=100V, Ic=5A, hFE>1000	Darlington NPN. Base-Collector-Emitter order. Vce(sat) ~1.4V at 3A.
TIP127	PNP Darl.	TO-220	**B C E**	TIP122 (NPN pair)	Vceo=100V, Ic=5A, hFE>1000	Complementary Darlington to TIP122. Same BCE pinout.

*** Pinout incompatibility warning:** BC547 (C-B-E) and 2N3904 (E-B-C) are NOT pin-compatible despite being functionally similar. Direct substitution without re-routing will reverse E and C, destroying the transistor or causing circuit malfunction.

3. Multimeter Identification Method

Use your multimeter's diode-test mode (diode symbol or beep icon). This method works reliably for BJTs. MOSFETs require a different approach (see Section 3.2).

3.1 BJT Identification — 3-Step Procedure

1. **Step 1 — Find the Base**

- Set multimeter to diode mode.
- Touch the red probe to one pin; touch the black probe to each of the other two pins in turn.
- If both readings show 0.55 V–0.75 V, the red probe is on the Base of an NPN transistor.

- If both readings show 0.55 V–0.75 V with the BLACK probe on that pin, it is the Base of a PNP transistor.
- If no single pin gives two valid readings, the device may be a MOSFET or is damaged.

2. **Step 2 — Distinguish Collector from Emitter**

- For an NPN: keep the red probe on the Base. Measure the remaining two pins with the black probe.
- Both readings will be in the 0.55–0.75 V range. The pin with the slightly HIGHER reading (~2–10 mV more) is the Collector (C); the lower-reading pin is the Emitter (E).
- This small difference arises from the asymmetric doping profile of the BJT structure — it is a reliable test but the difference can be subtle. If unsure, consult the datasheet.

3. **Step 3 — Confirm Polarity**

Observation	Conclusion	Memory Aid
Red probe on Base: both other pins read 0.55–0.75 V	**NPN transistor**	Red (+) on Base → NPN (current flows into Base to turn ON)
Black probe on Base: both other pins read 0.55–0.75 V	**PNP transistor**	Black (−) on Base → PNP (current flows out of Base to turn ON)
All pin combinations show OL or near zero	**Possible MOSFET or damaged device**	Use MOSFET test method (Section 3.2)

3.2 MOSFET Identification

MOSFETs have an insulated gate — the diode test cannot forward-bias G directly. Use this sequence instead:

- Identify the two lower-resistance pins by measuring D-S: a body diode exists between Drain and Source (forward-biased from S to D on N-MOS, D to S on P-MOS).
- Confirm the Gate by elimination — the remaining pin. G-to-S and G-to-D should both show OL (open) on diode mode. Any measurable reading indicates a damaged gate oxide.
- To verify enhancement-mode N-MOS operation: touch G with your finger (static charge builds Vgs), then immediately probe D-S — the channel should now conduct (low resistance). Short G to S to discharge.
- Caution: The finger-static method applies only to enhancement-mode devices. Do not attempt on depletion-mode types.

4. Assembly Best Practices

4.1 Mirror-Image (Board-View) Error

One of the most frequent assembly mistakes: when soldering from the BOTTOM of the PCB, all pin orders are horizontally mirrored compared to the top-view datasheet diagram.

Top View (Component Side)	Bottom View (Solder Side) — MIRRORED!
BC547 TO-92: C — B — E (left to right)	Soldering from bottom: E — B — C (left to right)
IRFZ44N TO-220: G — D — S (left to right)	Soldering from bottom: S — D — G (left to right)

Rule: Always read the datasheet orientation as viewed from the top (component side). Flip your reference mentally — or mark E/B/C directly on the PCB silkscreen rather than using generic 1/2/3 numbers.

4.2 PCB Design Recommendations

- Label each pad by function (E, B, C or G, D, S) on the silkscreen, not just by pin number.
- Draw the TO-92 flat-face outline on the silkscreen to indicate device orientation unambiguously.
- Mark Pin 1 on SOT-23 footprints with a triangle or dot on copper or silkscreen.

- TO-220 heatsink tab is electrically live (usually Drain or Collector). Always use an insulating mica or Kapton pad + nylon bushing when mounting to a metal chassis.
- Add a 10–100 Ohm gate/base resistor in series to suppress ringing and provide ESD protection without significantly slowing switching speed.
- Place a freewheeling diode across any inductive load (relay, motor) switched by a transistor. 1N4148 for signal relays; 1N4007 or Schottky (e.g. 1N5819) for power loads.

4.3 ESD (Electrostatic Discharge) Protection

- MOSFETs are highly susceptible to ESD — gate oxide can rupture at voltages as low as 20 V. Wear an anti-static wrist strap connected to ground when handling bare devices.
- Store MOSFETs with leads shorted together using conductive foam or aluminum foil until ready to solder.
- Use a temperature-controlled, grounded-tip soldering iron. Keep soldering time under 3 seconds per joint. Recommended tip temperature: 300–350 degrees C.
- BJTs are more robust but can still be damaged by ESD in high-frequency or low-noise circuits. The same handling precautions are good practice.

5. Application Selection Guide

Use this table to quickly match a design requirement to the right transistor family and part.

Application	Recommended Part	Design Notes
LED / small load switch (<100 mA)	**2N3904 / BC547**	Rb = (Vin − 0.7 V) / Ib. Use hFE = 50 for conservative Ib. Add 1 kΩ base resistor minimum.
Relay driver	**S8050 / TIP122**	Freewheeling diode (1N4148 or 1N4007) mandatory across relay coil to suppress back-EMF spike.
Low-noise audio preamp	**2N5551 / BC549C**	Bias collector at ~Vcc/2. Add emitter degeneration resistor (100–470 Ω) for thermal stability.
Logic-level shifting (5 V ↔ 3.3 V)	**2N7000 / BSS138**	BSS138 + pull-up resistors on both sides gives bidirectional shifting without extra ICs.
Motor / high-current control (>10 A)	**IRFZ44N / IRF3205**	H-bridge needs 4 FETs. Enforce dead-time (>100 ns) between high/low-side switching to prevent shoot-through.
PWM dimming / speed control	**Any N-MOSFET**	Switching frequency >20 kHz eliminates audible noise. Verify gate charge vs. driver current capability.
Complementary push-pull output	**2N3904 + 2N3906**	Insert diodes (1N4148) in series with bases or bias Vbe to eliminate crossover distortion.

All pinout data compiled from official manufacturer datasheets (ON Semiconductor, Fairchild/onsemi, Vishay, International Rectifier). Verify against the specific revision of the datasheet for your exact part lot. This document is intended as a quick-reference aid; it does not substitute for the full datasheet during design review.

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