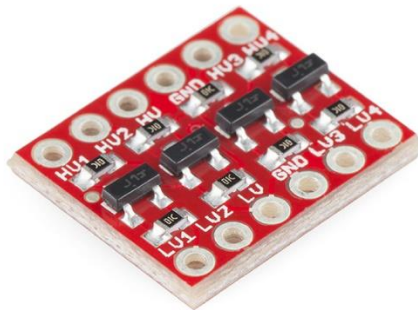


What is a **Level Shifter**?



Swipe >

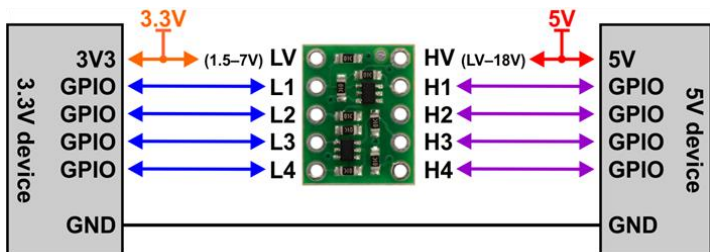


Fahad Bhatti

Founder Oxeltech (Embedded Development Service)

What is a **Level Shifter**?

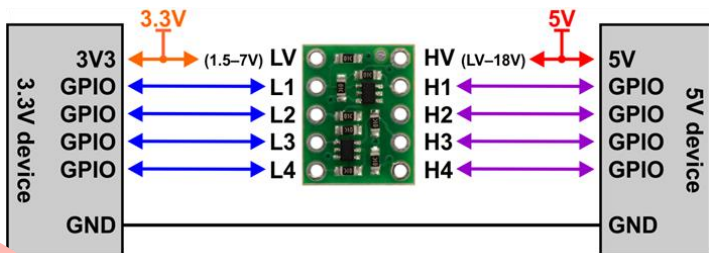
- A circuit that converts voltage levels between devices
- Example: 5V signal shifted down to 3.3V.





Why Do We Need **Level Shifters**?

- Chips use different voltages (1.8V, 3.3V, 5V)
- Logic thresholds differ: 5V chips may need ~3.5V for “high,” but 3.3V outputs only 3.3V → not always recognized
- 3.3V inputs are usually not 5V tolerant → risk of permanent damage



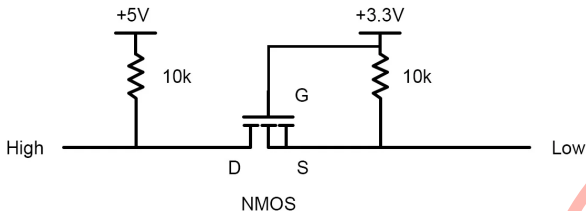
Example: MOSFET-Based Level Shifter

How it works

- Pull-ups hold each side at its supply (5V ↔ 3.3V)
- When one side pulls low, MOSFET conducts and pulls the other side low too
- High levels stay at their own V_{dd} via pull-ups
→ each side safe

Where it's used

- I²C and other open-drain signals
- Cheap, simple, bidirectional



*Image: MOSFET-based
bidirectional level shifter*



Types of **Level Shifters**

Type	Direction	Notes
Resistor Divider	Unidirectional	Cheap, simple, inaccurate at high speeds
Diode Clamp	Unidirectional	Protects against overvoltage, limited for logic translation
MOSFET-based	Bidirectional	Ideal for I ² C and low-speed buses (~1 MHz), not suitable for high-speed use
Op-Amp / Buffer	Unidirectional	Good for MHz-range buses (SPI, UART), adds cost and complexity
Dedicated IC	Uni / Bi	Handles high-speed, multi-channel designs, reliable but more expensive

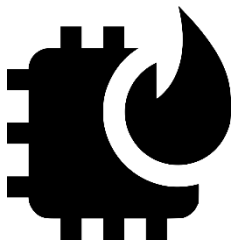
How to Select the **Right Level Shifter**

- Match the **voltage levels** (e.g., 1.8V ↔ 3.3V)
- Identify **number of channels** required
- Decide **direction** (uni or bi-directional)
- Check **speed** of signals
 - I²C (100 kHz – 1 MHz) → MOSFET
 - SPI/UART (MHz range) → Buffer/IC
 - High-speed buses (tens/hundreds MHz) →
Dedicated IC



What If We **Don't Use** Level Shifters?

- Signals misread → unreliable communication
- Data lost or corrupted
- 5V into a 1.8V input → Can lead to 1.8V IC damage



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Founder Oxeltech
(Embedded Development Service)

