Voltage Regulator Reverse Polarity

Selecting a Linear Voltage Regulator

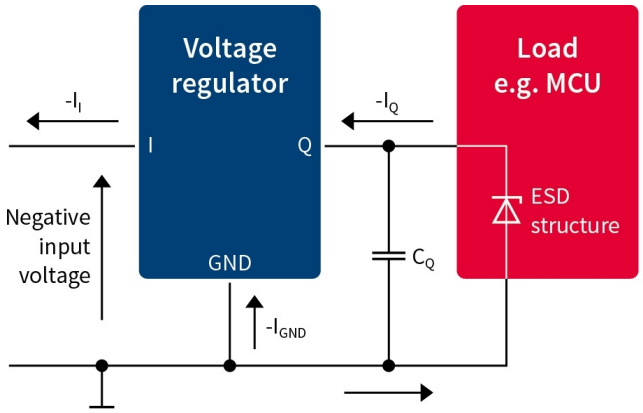
NPN bipolar voltage regulators (TLE4x8x)

PNP bipolar voltage regulators and trackers (TLE4xxx except TLE4x8x)

MOSFET voltage regulators (TLE7xxx and TLF80511)

The following reverse polarity situations might occur in the automotive environment:

- Output voltage higher than input voltage (e.g. V_I = 0V, V_Q = 5V.)
- Input open, positive output voltage applied (i.e. $V_I = V_Q$).
- Input voltage negative, output tied to GND.

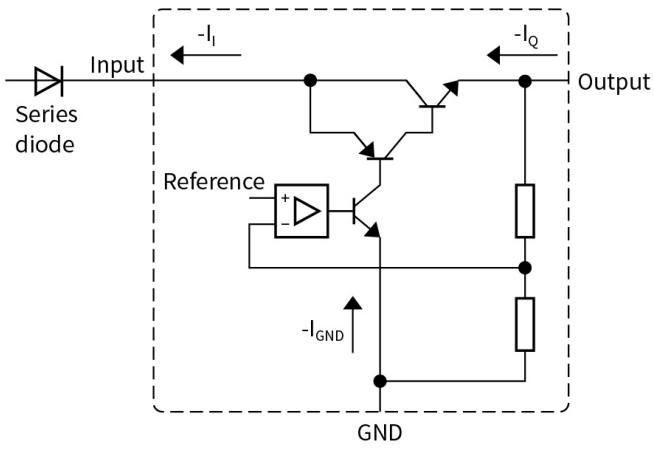


Reverse current in the voltage regulator

In reverse polarity situations, current may flow into the GND pin of the regulator as well as into the output pin Q. Depending on the type of the pass transistor, different protection should be applied:

NPN bipolar voltage regulators (TLE4x8x)

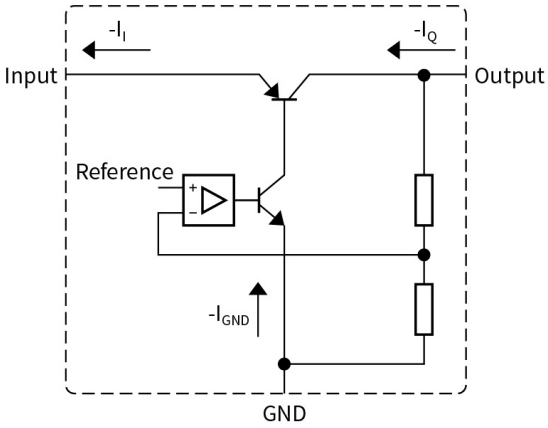
Linear voltage regulators with an NPN pass transistor offer no reverse polarity protection. If the input voltage is lower than the output voltage, an unlimited current will flow through parasitic junctions. Hence a blocking diode at the input is needed to withstand a steady state reverse battery condition. This series diode adds an additional drop and must be sized to hold off the system's maximum negative voltage as well as the regulator's maximum output current.



Current in reverse polarity (NPN bipolar regulator)

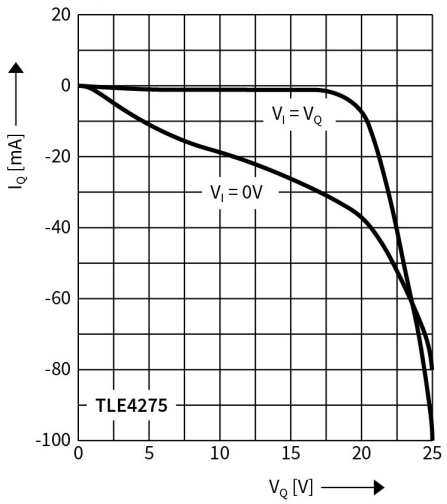
PNP bipolar voltage regulators and trackers (TLE4xxx except TLE4x8x)

Regulators with PNP pass transistors allow negative supply voltage. The reverse current is limited by the PNP transistor in reverse polarity conditions. Therefore a reverse protection diode at the input is not needed.

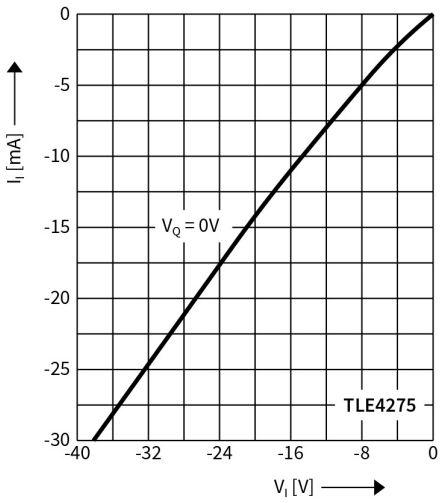


Current in reverse polarity (PNP bipolar regulator)

The typical reverse currents of bipolar PNP regulators are shown in the graphs below:



Typical reverse current (TLE4275)



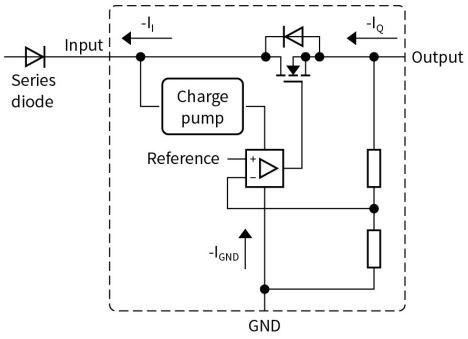
Typical reverse current (TLE4275)

The reverse voltage causes several small currents to flow into the IC, hence increasing its junction temperature.

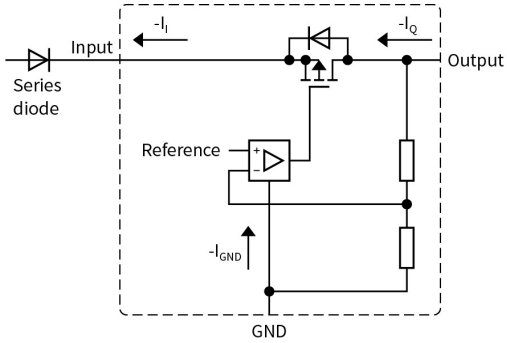
As thermal shutdown circuitry does not work in the reverse polarity condition, designers have to consider the temperature increase in their thermal design.

MOSFET voltage regulators (TLE7xxx and TLF80511)

Linear voltage regulators with a MOSFET (NMOS or PMOS) transistor as the pass element offer no reverse polarity protection. An unlimited reverse current would flow through the MOSFET's reverse diode. Therefore, a series diode at the IC input is mandatory. During normal operation, it will be forward biased, adding an additional drop voltage to the system. Therefore, a Schottky diode with a low forward voltage is recommended.

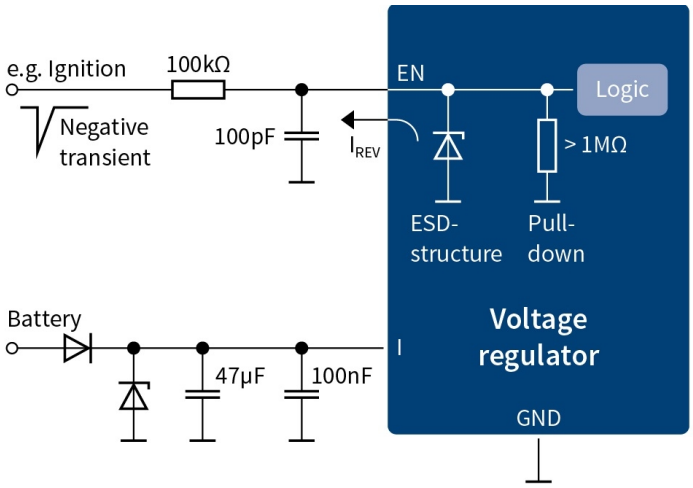


Current in reverse polarity (NMOS regulator)



Current in reverse polarity (PMOS regulator)

Regarding the Enable (Inhibit) pin, negative voltages must not be applied. Nevertheless, to allow negative transients to flow, a high-ohmic resistor can be added in series to protect the input structure. The maximum negative current must not exceed 0.5mA.



Negative transients at the inhibit pin of an NMOS regulator

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