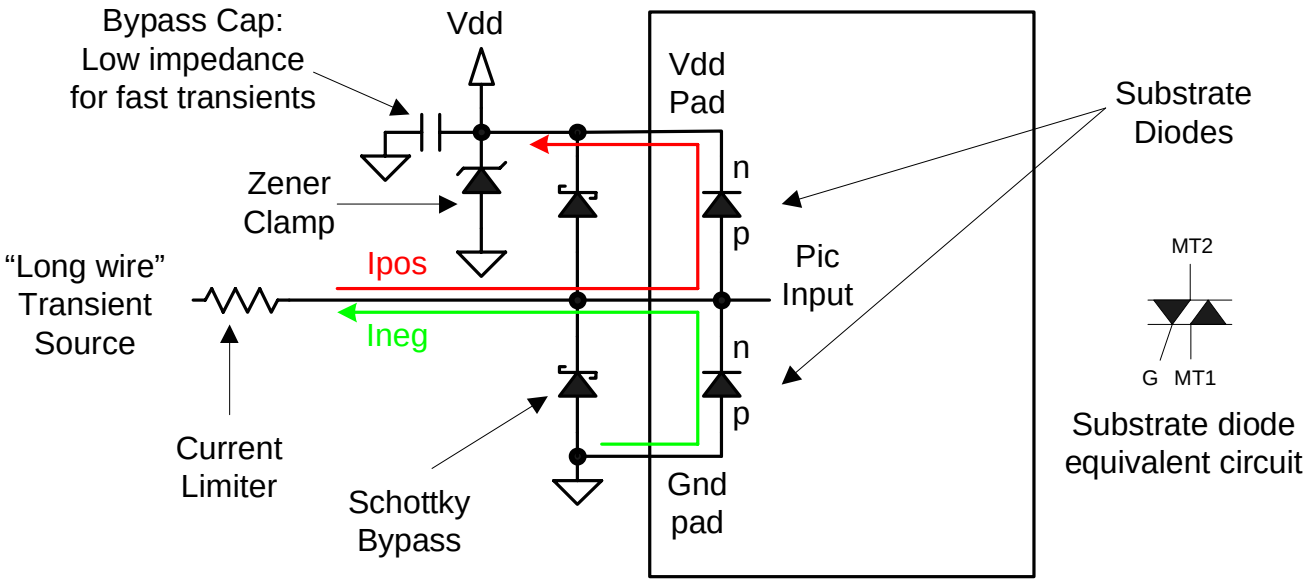
Semiconductor input latchup and protection



Long wires or signal traces connected to ANY semiconductor device can pick up and apply trasients which may be of nanosecond duration but several hundreds of volts. This type of transient is very hard to find and simply looking for it can make it go away! Any device will have these substrate diodes to the Vdd and ground rails which are reversed biased during normal operation, except for open drain devices which only have diodes typically to ground. It is this NPNP, four layer structure which causes the problem. Either of the NP junctions can act as the gate of what is essentially a TRIAC.

If either of the substrate diodes are forward biased, the resulting latchup current can thyristor clamp the Vdd rail to ground and brown out the power system. On a PIC with brownout detect set, an internal reset is initiated so the system seems to recover. Without a brownout detect, the rail is clamped until the voltage goes below the hold limit, or worse, until the device falls off the board (If the power supply is able to supply the current.) The device may simply sit there, doing nothing but getting warm or locked up because the internal state machine has been disturbed. Once forward biased with enough current, the substrate diode will also exhibit an increased reverse leakage current which can make the external pull-up and pull-down networks to weak to overcome!

By clamping the susceptible inputs with external, lower Vforward devices, the substrate diodes never become forward biased. The zener clamp prevents the Vdd rail from being driven high by long duration transients and the bypass cap next to the Schottky clamp provides a low impedance path for fast transients. A series resistor of a few tens of ohms can protect the Schottky bypass and clamping circuits from destructive currents.

There is an entire industry segment dedicated to providing protection devices for just this purpose!