System Level Protection for High-voltage Multiplexers in Muti-channel Data Acquisition Systems

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Agenda

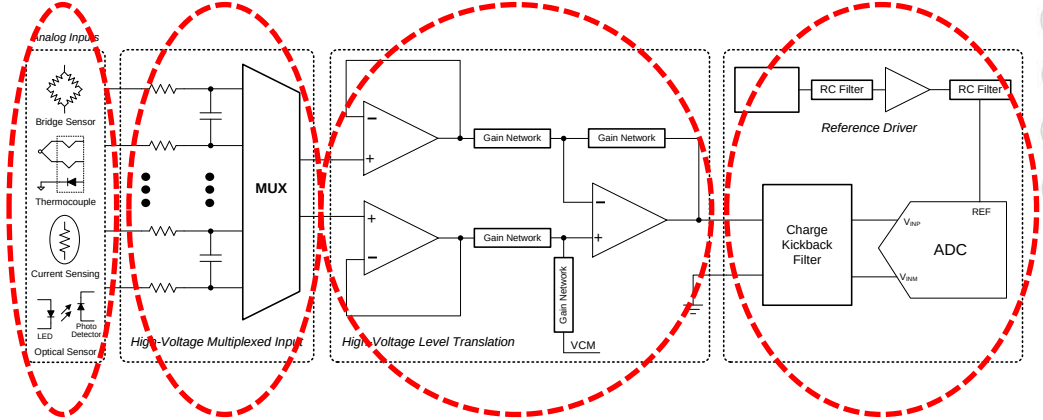
- Overview
  - What causes fault condition
  - How does fault condition impact the system
- Protection schemes using discrete components
  - Diodes in series with supplies
  - Series resistor + Zener diodes on supplies
  - Series resistor + Schottky + Zener diodes on supplies
  - Series resistor + TVS diodes
- Multiplexers with integrated protection
  - TMUX1072
  - MPC50x
- Comparison and conclusion

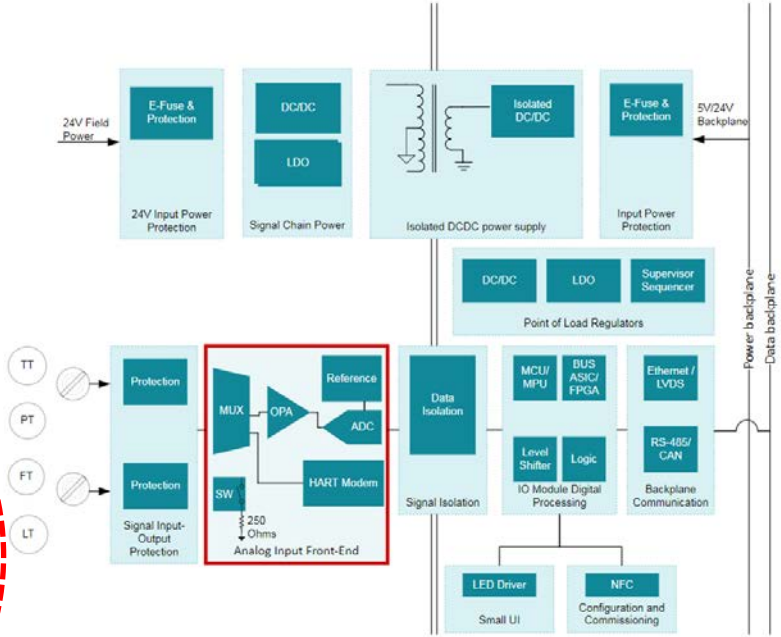
System Level Protection for High-Voltage Multiplexers in Multi-Channel Data Acquisition Systems

Overview

Multiplexers (MUX) in typical data acquisition system

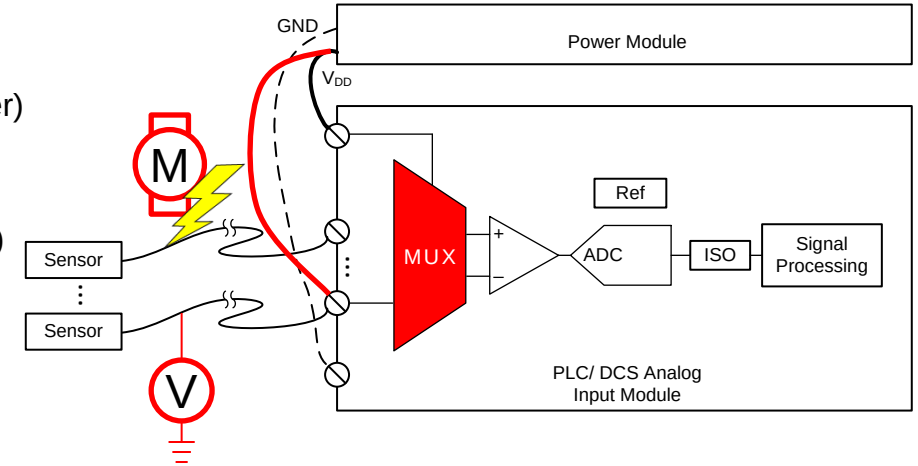
- A analog multiplexer is often used on the front end of a data acquisition system to multiplex multiple channels into one precision signal chain.
- Benefit:
  - Save components
  - Save board space and routing
  - Save cost





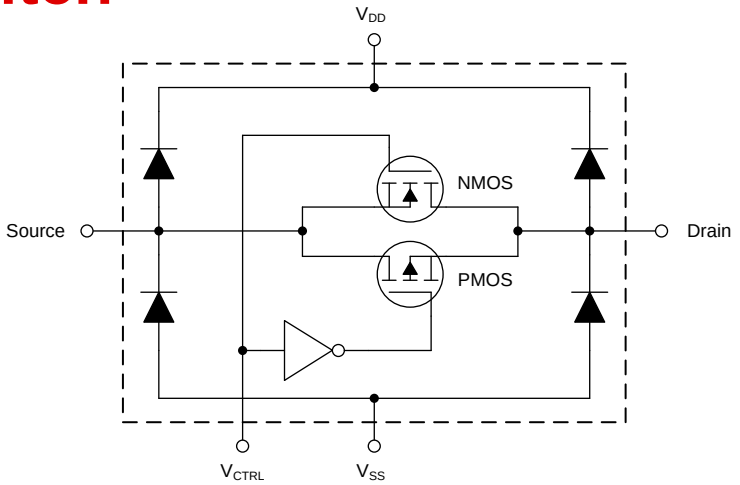
Sources of fault condition

- Fault condition definition:
  - A voltage applied to the input of a multiplexer exceeds the voltage at the power supply pins
- Overvoltage occurs because of :
  1. EMI/ transient disturbance
     - Switching power electric devices (welder, starter)
     - Rotating electrical devices
  2. Human error:
     - Mis-wiring (connection to high voltage, OC, SC)
     - Incorrect grounding (floating, different ground)
  3. Component failure/ Wire short
  4. Environmental disturbance
     - Lightning strike
     - ESD
     - Arching (relay/switches)



Basic construction of a CMOS switch

- A typical CMOS switch is constructed with N-channel MOSFET and P-channel MOSFET in parallel:
  - Logic high enables the NMOS and conducts negative signal.
  - Logic low enables the PMOS and conducts positive signal.
- A multiplexer is constructed with multiple switches in parallel with either the source or the drain pin connected.
- ESD protection diodes are typically implemented on the input and output to clamp to V_{DD} and V_{SS}.
  - $V_{FORWARD}$ is typically 0.6~0.7V.
  - Can typically carry up to 30mA of current.
- Parasitic diodes/ BJTs are also presented in a typical CMOS switch construction.



How fault condition impacts the system operation

If $V_{IN} > V_{DD} + 0.7V$ or $V_{IN} < V_{SS} - 0.7V$:

1. High diode current destroys the ESD structure and causes device failure.
2. Supply rise to the overvoltage level and destroys other devices connected to the supply.
3. If the power supplies are floating, devices connected to the same supplies become powered by the input signal ➔ unknown and uncontrolled operation.
4. If the power supplies are grounded, the PMOS device will turn on and pass the input to the output ➔ possibly damages downstream components
5. Fault channel causes increased leakage current to other channels on the same device ➔ Impact measurement accuracy
6. Current induced through the parasitic BJTs causes latch-up ➔ device failure