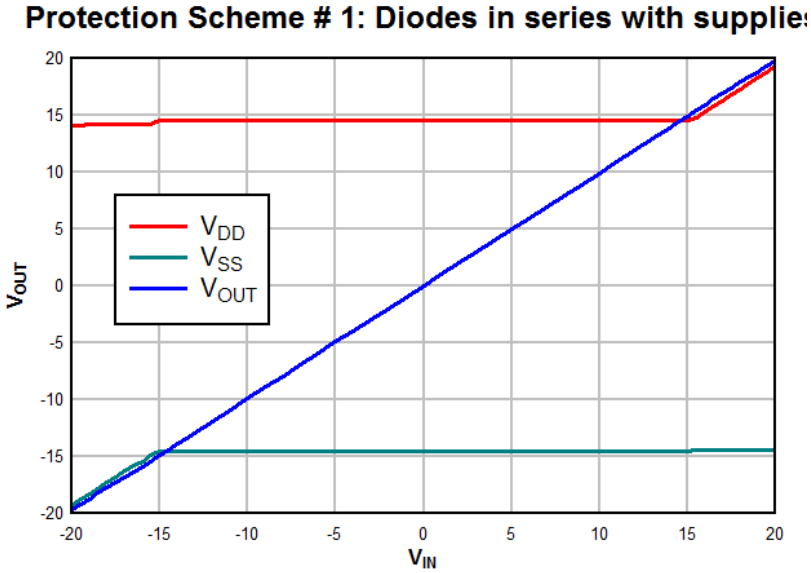
System Level Protection for High-Voltage Multiplexers in Multi-Channel Data Acquisition Systems

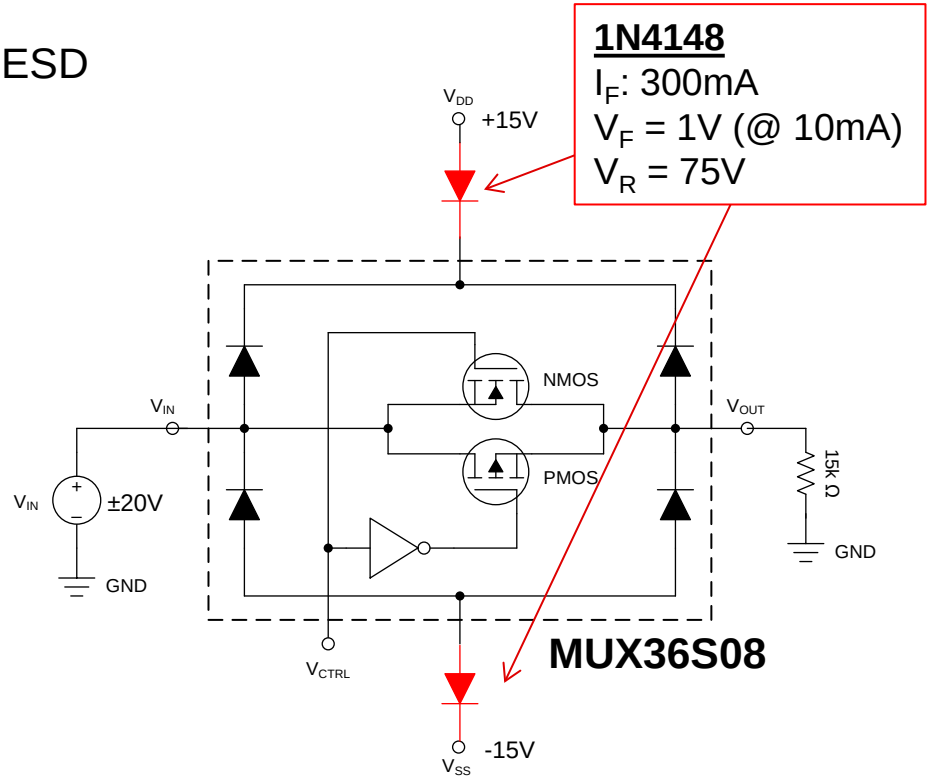
Fault protection schemes using discrete components

Protection scheme #1:

Diodes in series with supplies

- Diode in series with the supplies blocks the ESD diode and parasitic SCR current flows.





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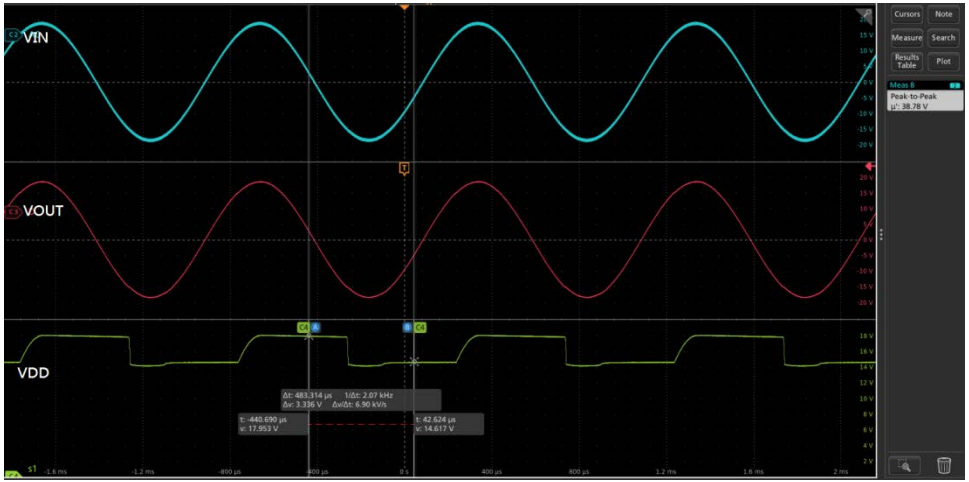
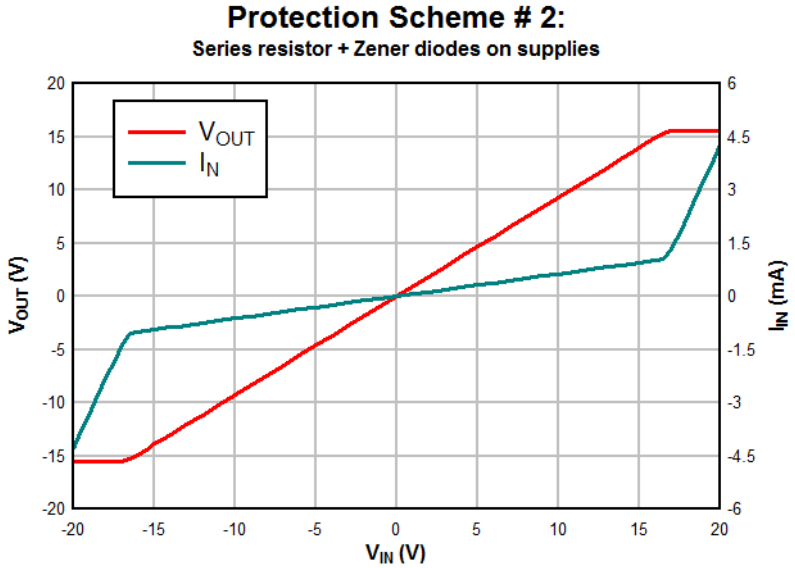


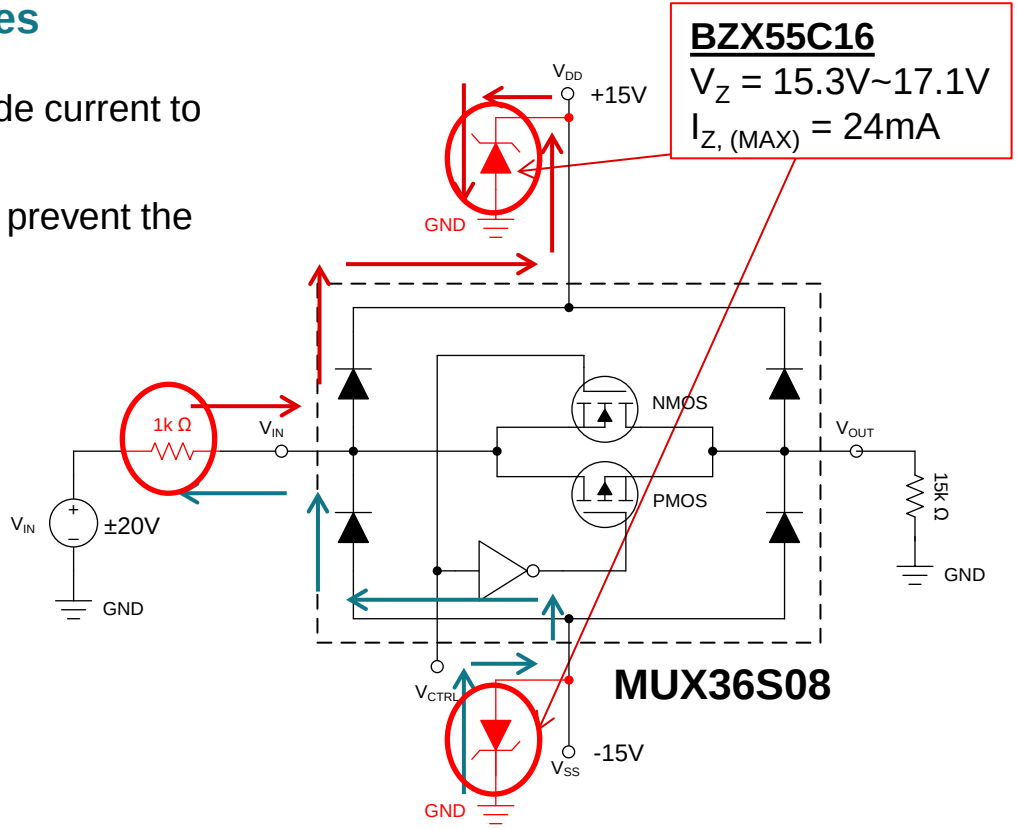
- Good:
  - No impact on the switch R_{ON} and leakage performance
  - Fault channel continues to operate with minimal distortion
  - Low cost
- Bad:
  - V_{DD} and V_{SS} go up together with the input voltage in the fault condition ➔ potential damage to other system components on the same supplies
  - Allows the full input fault voltage to pass through ➔ may cause damage to the downstream device
  - Changing supplies causes changes in MUX RON even for channels not at fault ➔ impact measurement accuracy for all channels

Protection scheme #2:

Series resistor + Zener diodes on supplies

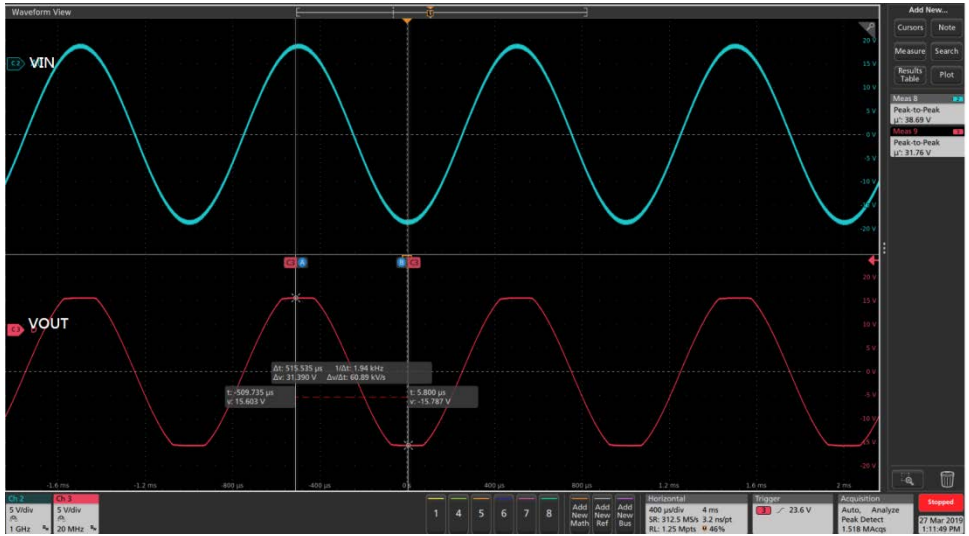
- Current limiting resistor is used to limit the diode current to <10mA.
- Zener diodes help sink and source currents to prevent the supplies from going over V_Z.





Protection scheme #2:

Series resistor + Zener diodes on supplies

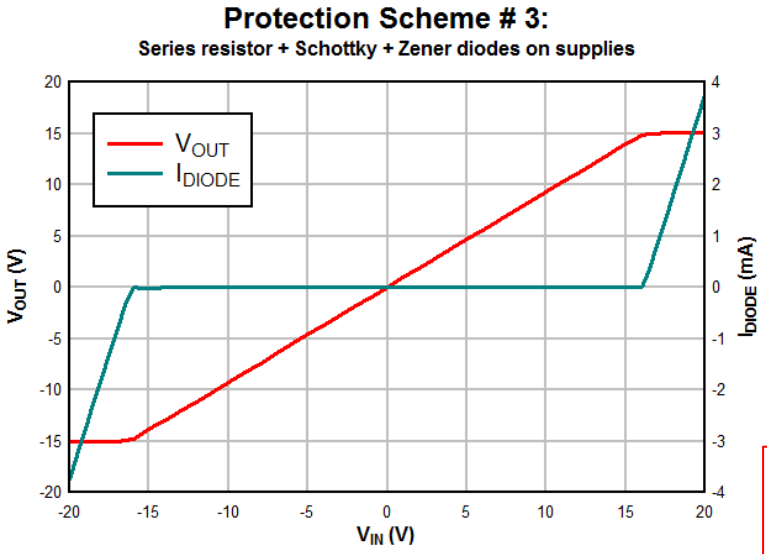


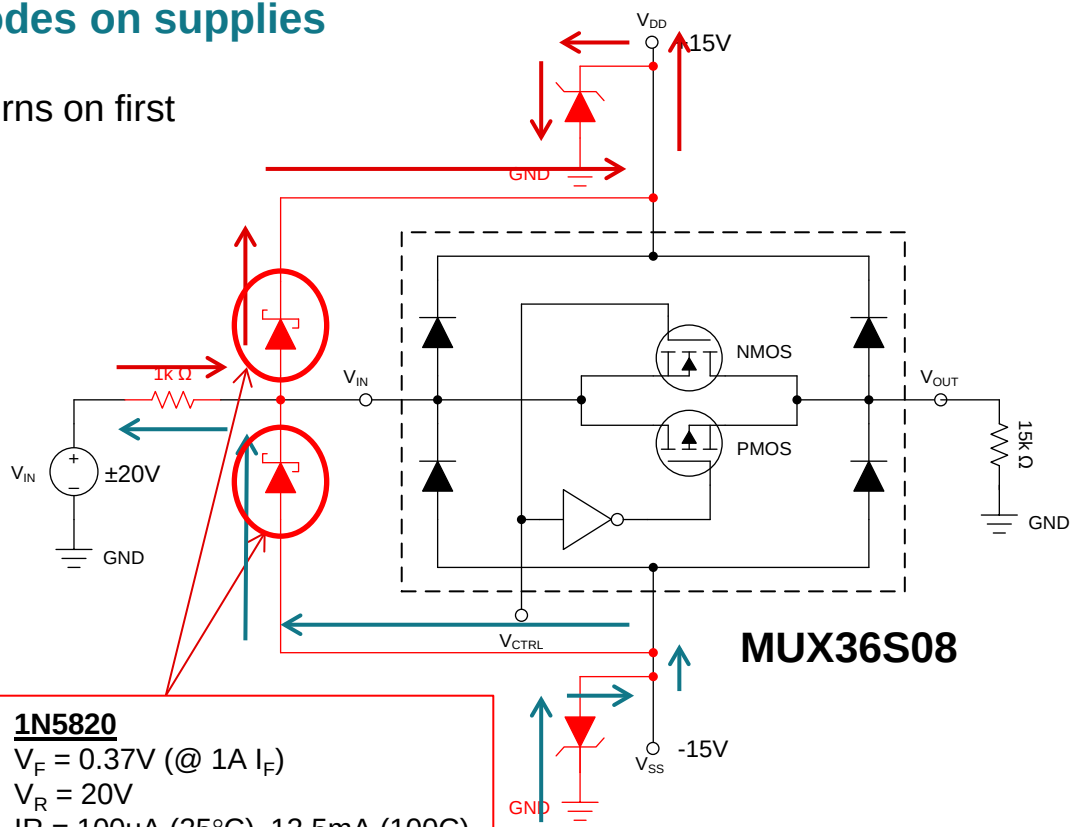
- Good:
  - Output clamped to V_{DD}+ 0.7V or V_{SS} – 0.7V
  - No overvoltage stress on the supplies and downstream circuitry.
- Bad:
  - Increased series resistance ➔ worse THD and impacts accuracy
  - Increased settling time due to the RC combination➔ slower sampling speed
  - Heat produced from current through internal ESD diode➔ Persistent DC fault might cause internal heating and long-term reliability issue.
  - Potential uncontrolled behavior due to other parasitic path on the device.

Protection scheme #3:

Series resistor + Schottky + Zener diodes on supplies

- Schottky diodes (forward voltage ~0.3V) turns on first before the multiplexer's internal diodes.

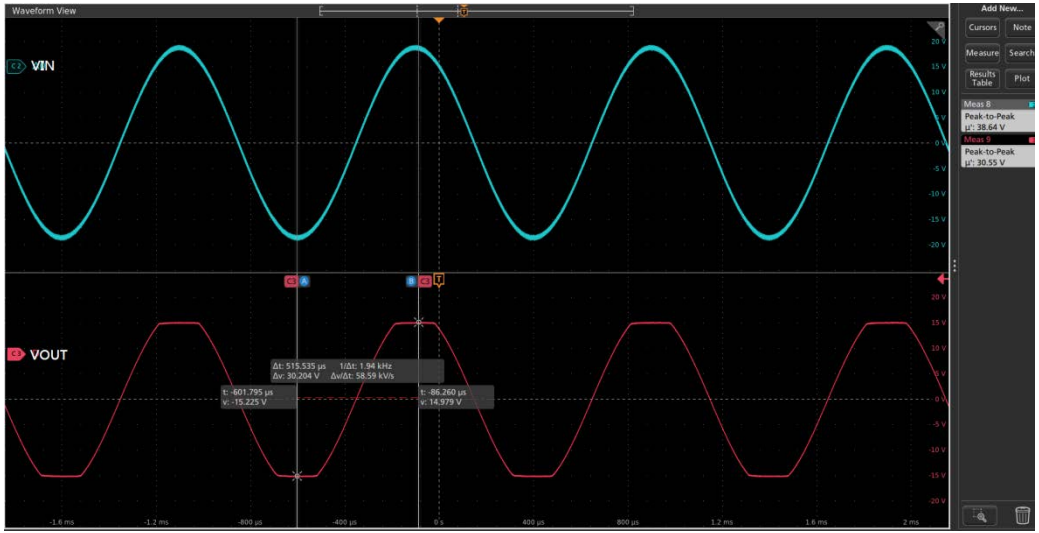




1N5820
V_F = 0.37V (@ 1A I_F)
V_R = 20V
IR = 100uA (25°C), 12.5mA (100C)

Protection scheme #3:

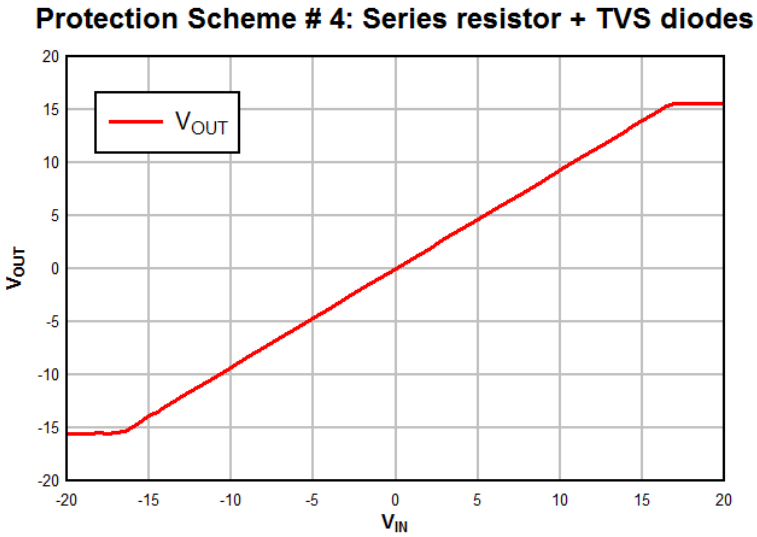
Series resistor + Schottky + Zener diodes on supplies

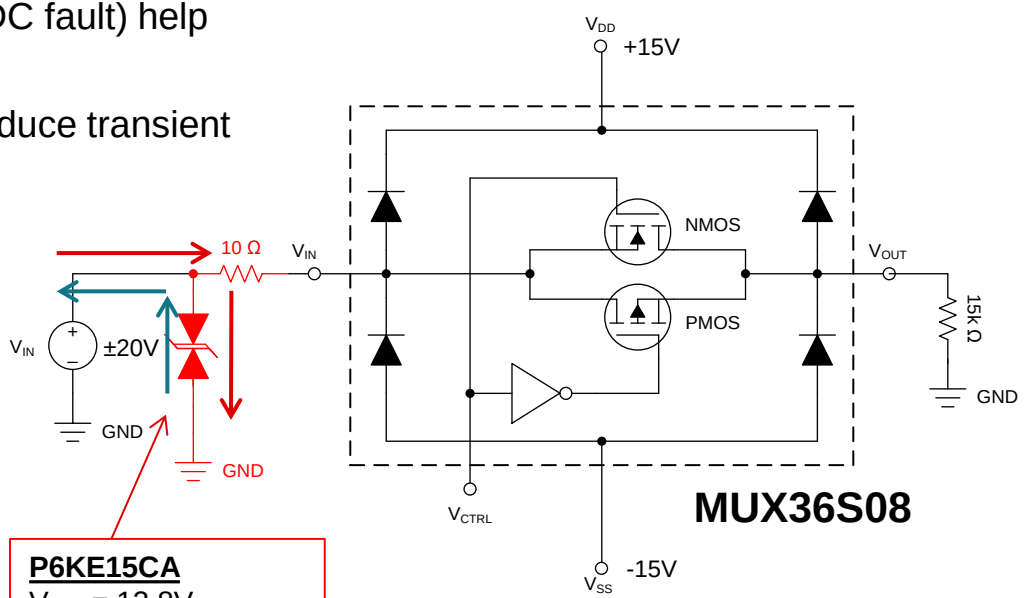


- Good:
  - No overheating concern from ESD diode
  - Output clamped to V_{DD}+ 0.3V or V_{SS} – 0.3V
  - No overvoltage stress on the supplies and downstream circuitry.
  - Much higher current carry capability on the Schottky diodes than internal ESD diodes
- Bad:
  - Increased series resistance ➔ worse THD and impacts accuracy
  - Increased settling time due to the RC combination➔ slower sampling speed
  - Lower reverse voltage rating and worse leakage number for the Schottky diodes ➔ Impact signal dynamic range and measurement accuracy
  - Cost

Protection scheme #4:
Series resistor + TVS (or Zener) diodes

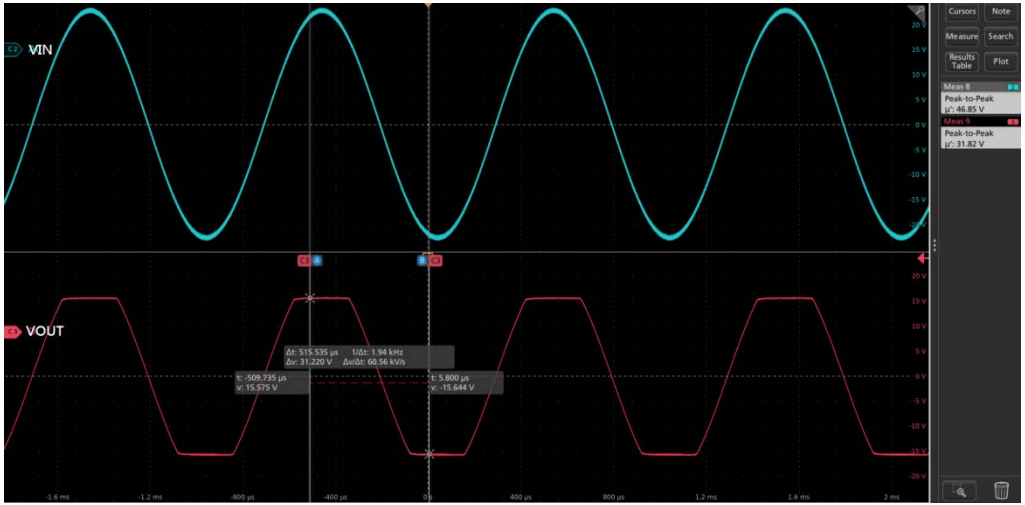
- TVS (for faster transient fault) or Zener (for DC fault) help clamp the input voltage below V_{BR}.
- Series resistor placed after the TVS helps reduce transient current injected into the device





P6KE15CA
V_{WM} = 12.8V
V_{BR} = 14.3V to 15.8V
V_C = 21.8V
I_R = 1uA

Protection scheme #4:
Series resistor + TVS (or Zener) diodes



- Good:
  - Output clamped to the Zener or TVS reverse breakdown voltage
  - No overvoltage stress on the supplies or downstream circuitry
  - No overheating concern from ESD diode
  - Much lower reverse leakage current compared to Schottky diodes
  - Transient fault (ie. ESD) protection from TVS
  - Lower series resistor required
- Bad:
  - Higher parasitic capacitance ➔ slower sampling speed
  - Cost (one TVS or Zener on every channel)