Basics of Analog Multiplexers 4

TIPL 2604

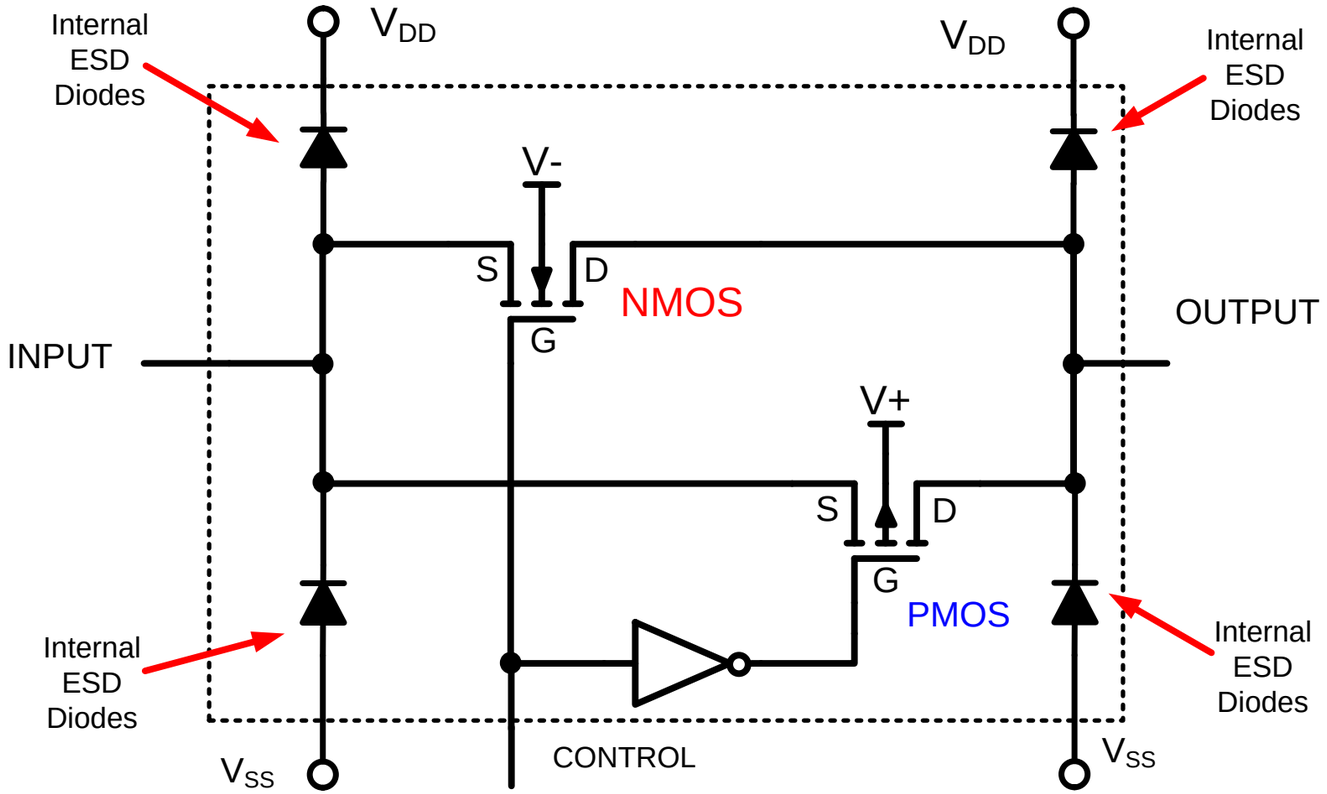
TI Precision Labs – Op Amps

Prepared by Abhijeet Godbole and Art Kay

Presented by Peggy Liska

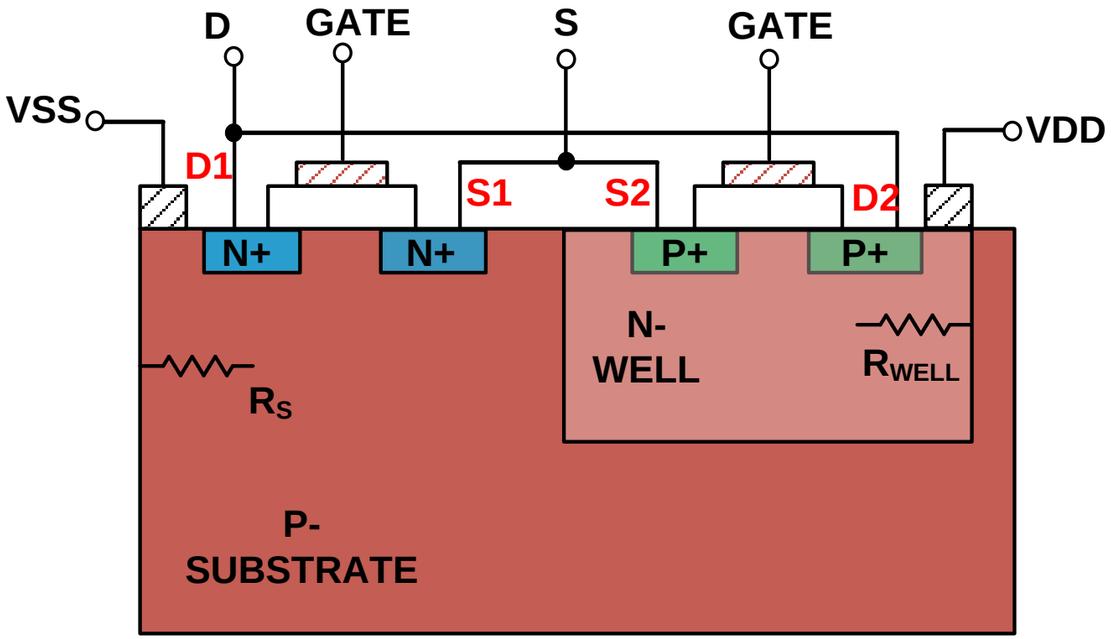
Prerequisites: ESD & EOS (TIPL1401 – 1414)

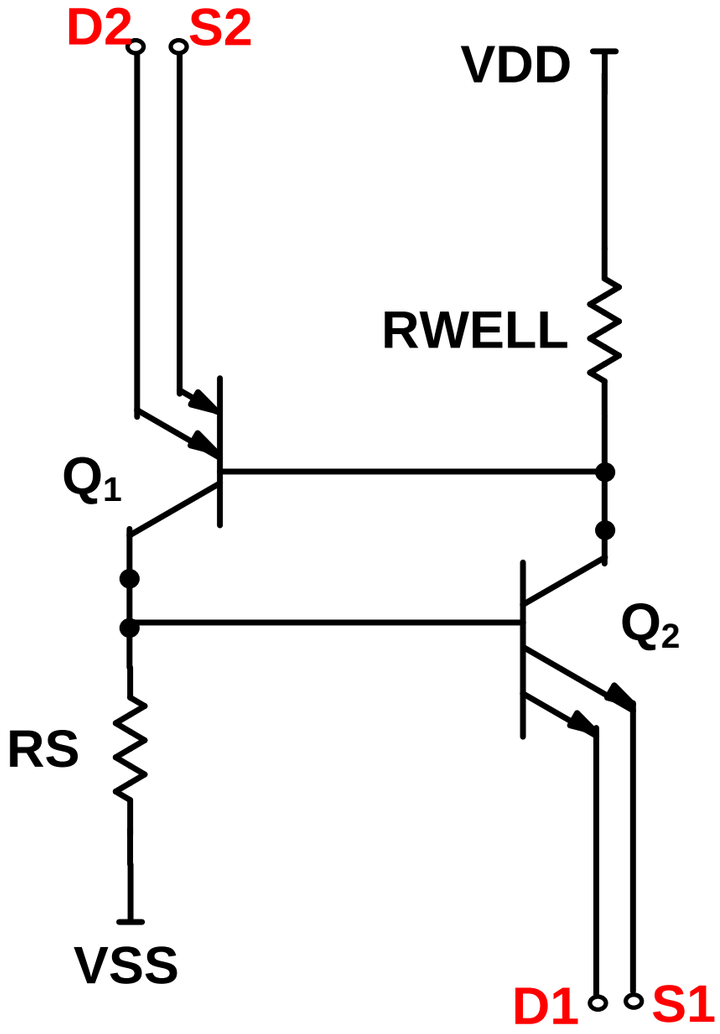
Basic Construction of CMOS Switch



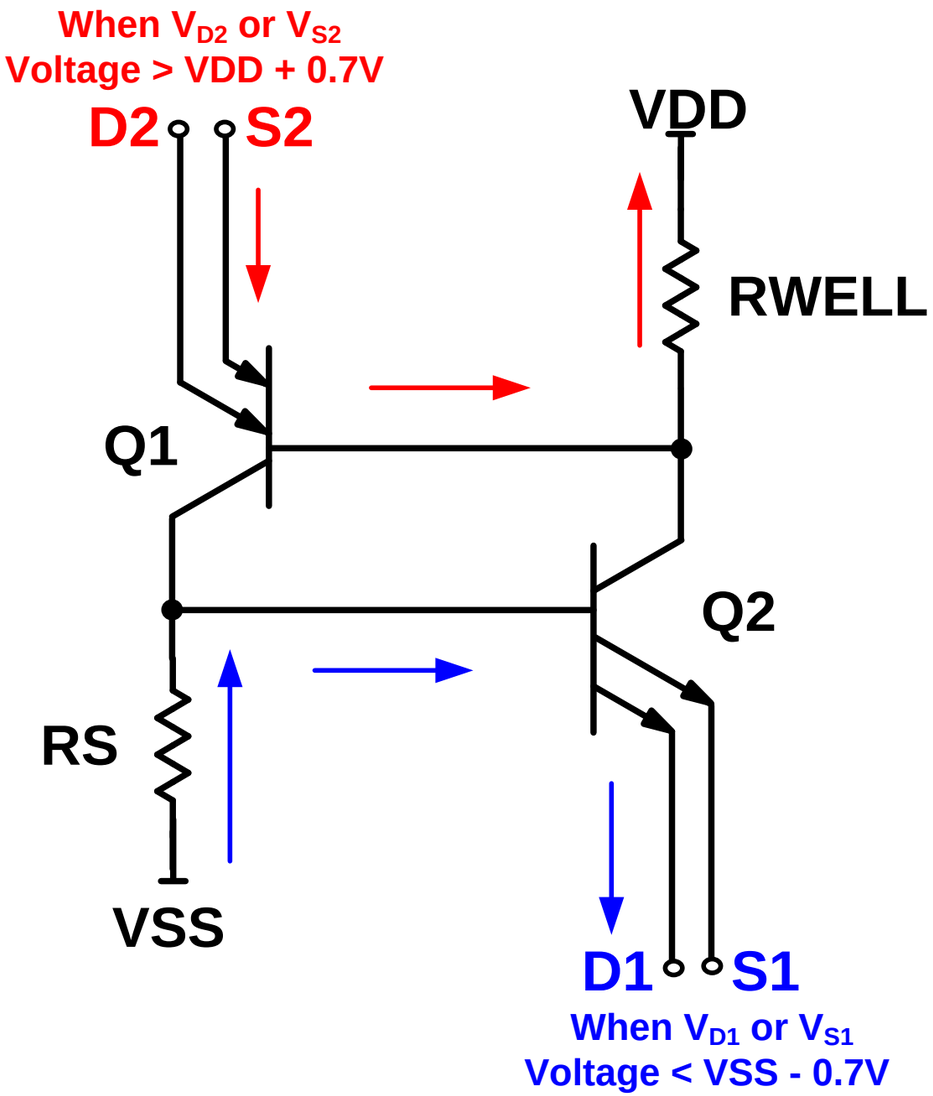
- Parallel combination of N and P channel FET
- Control Signal determines state of the switch
  - Logic High = On
- NMOS impedance = low for negative input
- PMOS impedance = low for positive input
- ESD diodes protect internal circuit from electrostatic discharge

Parasitic Latch-Up in CMOS Switches



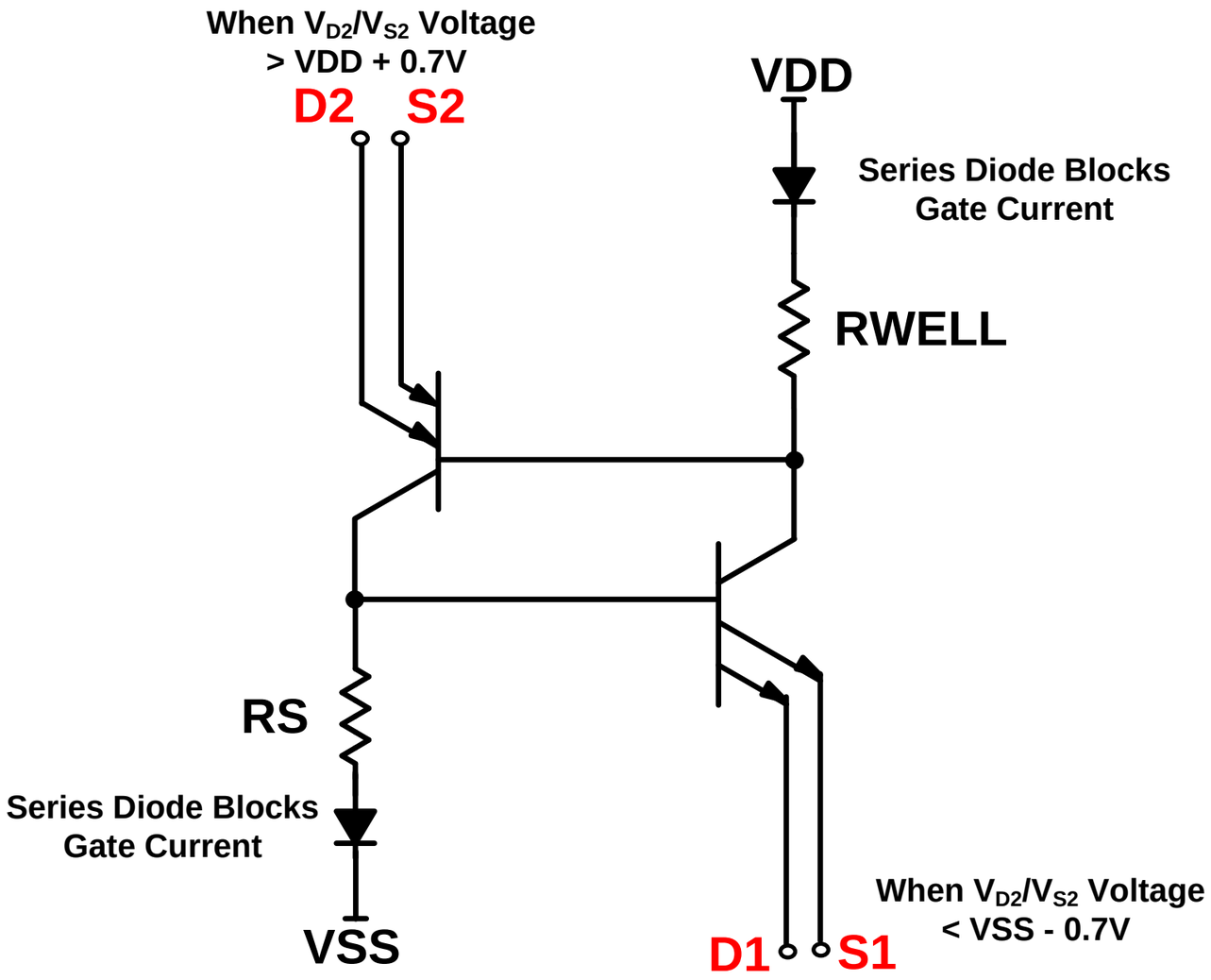


Parasitic Latch-Up in CMOS Switches: SCR Latch



- The parasitic SCR mechanism is shown in here.
- SCR action takes place when either terminal of the switch (source or the drain) is either one diode drop more positive than VDD or one diode drop more negative than VSS.
- Once Triggered, high current will flow between the supplies.

Series Diode Protection Against Latch up



- Series diodes used in VDD and VSS path prevents latch up
- These diodes does not allow reverse gate current to flow in case of over voltage condition
- Input voltage swing limits to

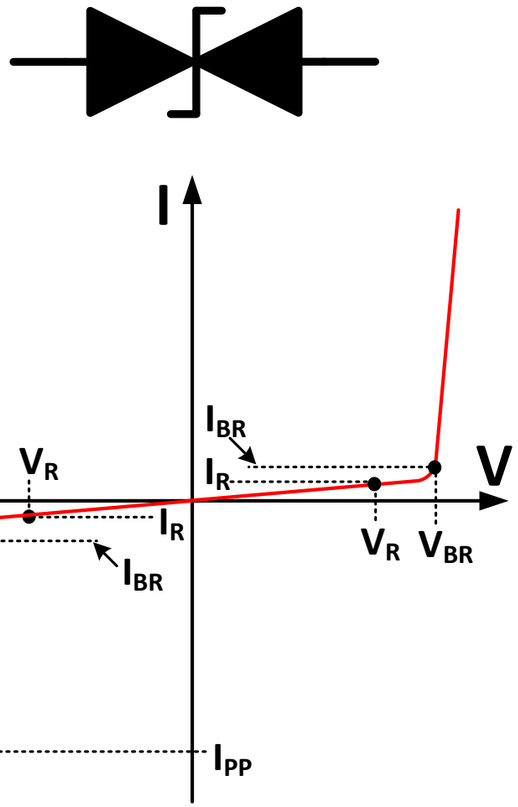
  $V_{IN} <= V_{DD} – 0.7V$ (Typical)
  $V_{IN} >= V_{SS} + 0.7V$ (Typical)

- Reverse voltage of diodes should be greater than maximum over voltage input range

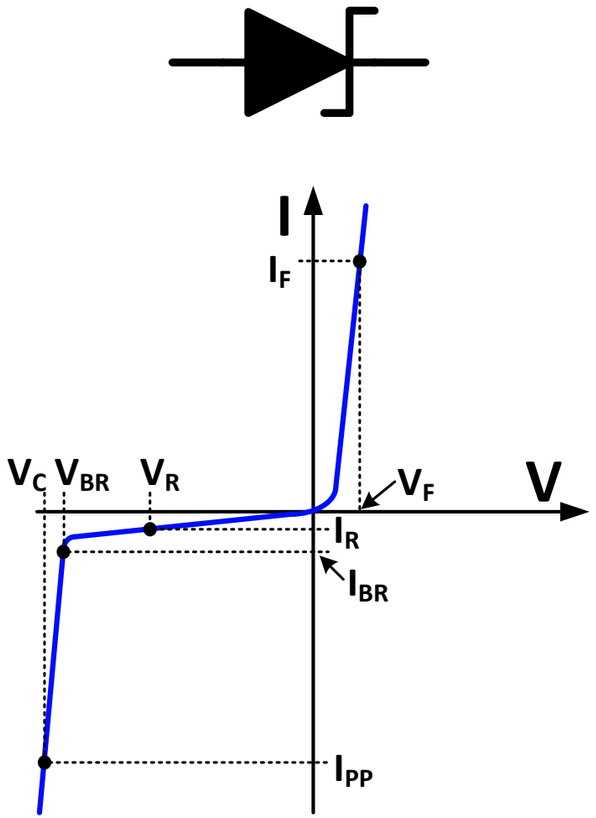
A short background on TVS diodes

Symbol	Parameter
V_{BR}	Breakdown voltage
V_R	Stand-off voltage
V_C	Clamping voltage
V_F	Forward voltage drop
I_{BR}	Breakdown Current @ V_{BR}
I_R	Reverse Leakage @ V_R
I_F	Forward Current @ V_F
I_{PP}	Peak Pulse current @ V_C

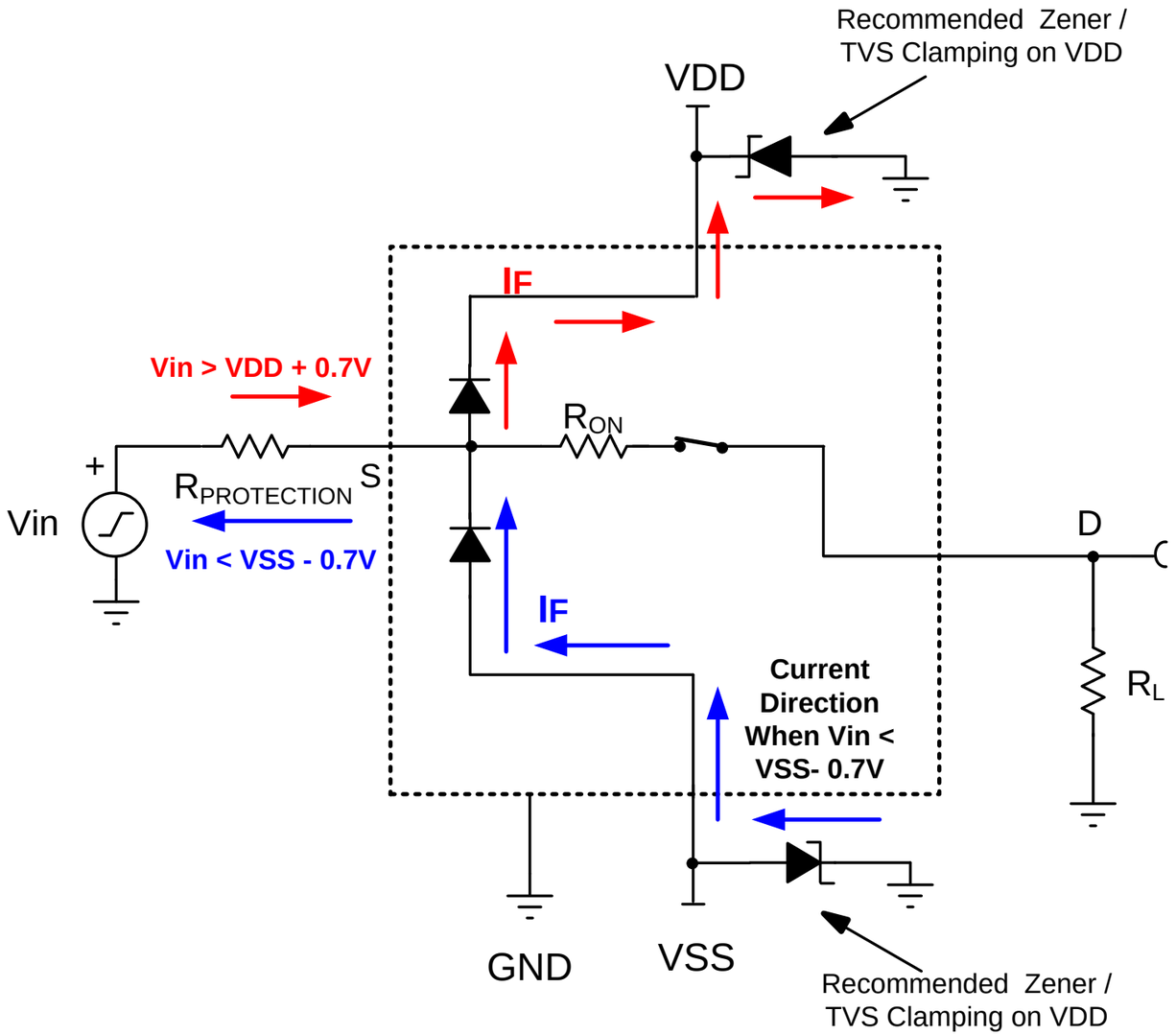
Bidirectional



Unidirectional



Internal ESD Diode & Resistor as EOS Protection



$R_{PROTECTION}$ Example Calculation

$V_{DD} = +15V \quad V_{SS} = -15V$

$V_{OVER\ VOLTAGE}$ at Input Channel $= (+/-)\ 20V$

Let's say internal ESD diode current should not exceed 5mA.

$I_{LIMIT} = 5mA$

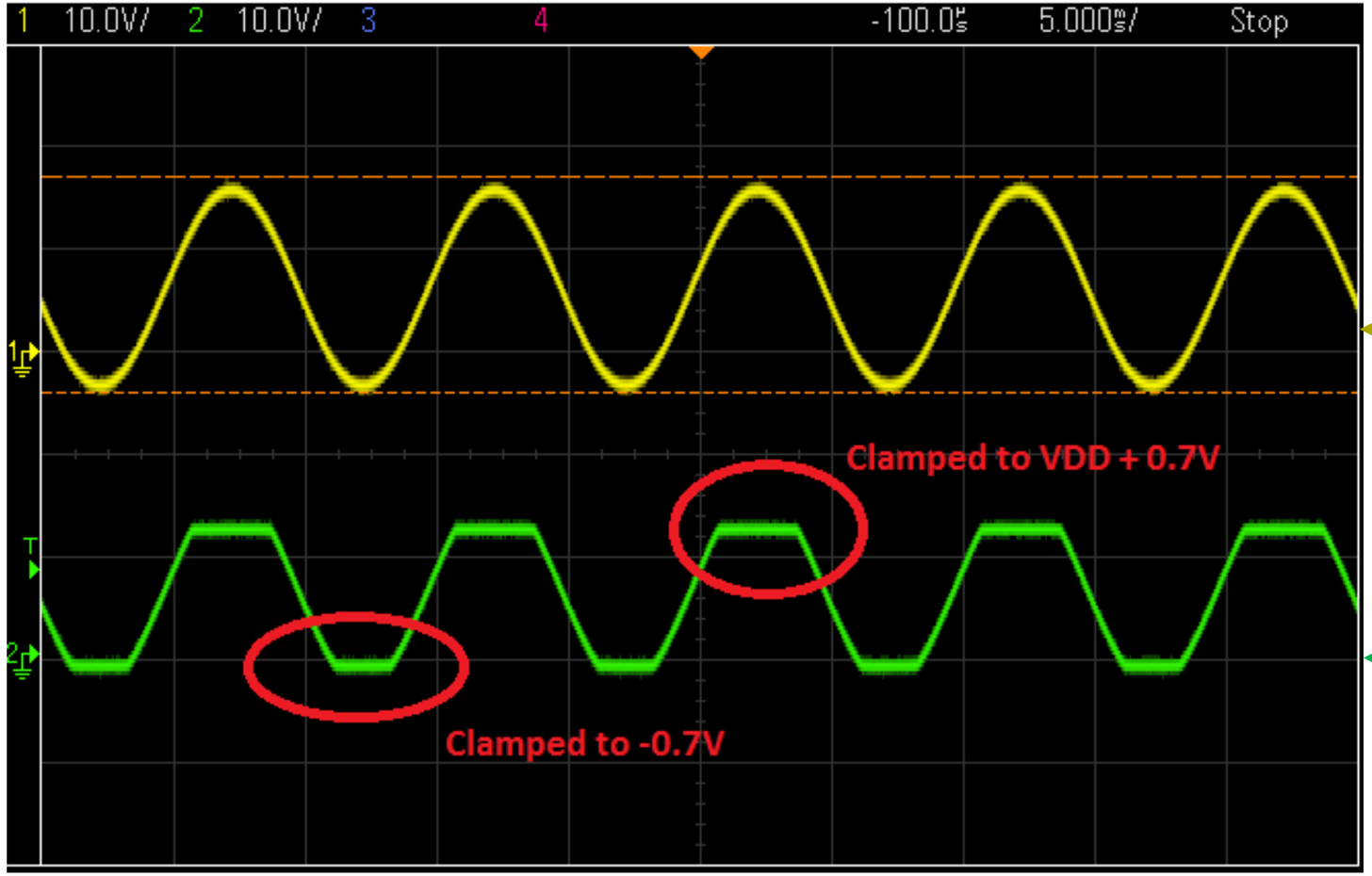
$$R_{PROTECTION} = \frac{V_{IN} - V_{DD} - V_{BE}}{I_{LIMIT}}$$

$$R_{PROTECTION} = \frac{20V - 15V - 0.7V}{5mA}$$

= 860 Ohm.

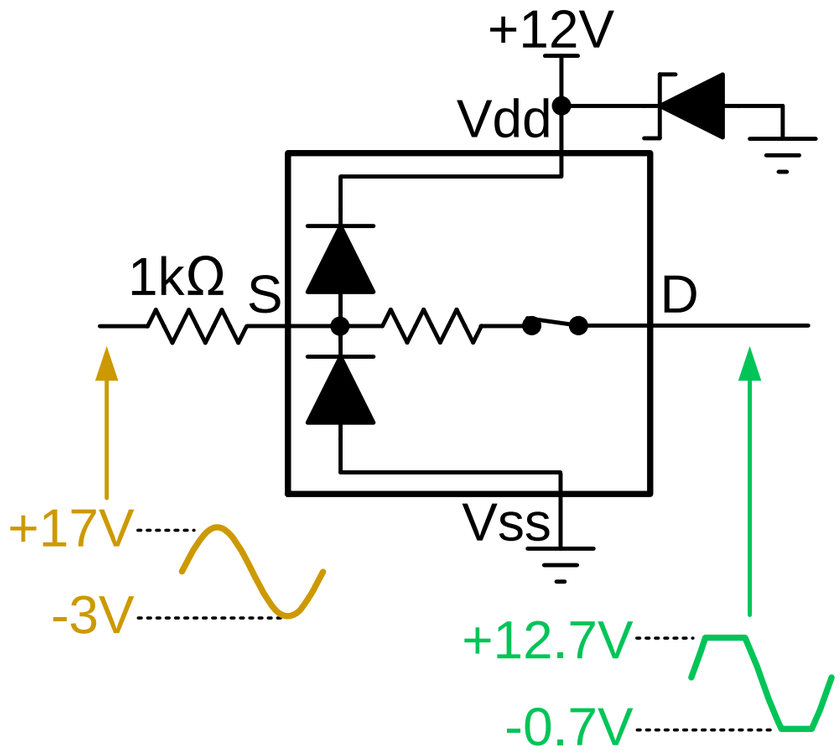
Choose 910 Ohms - Standard Value

MUX36S08 Over voltage Fault Performance



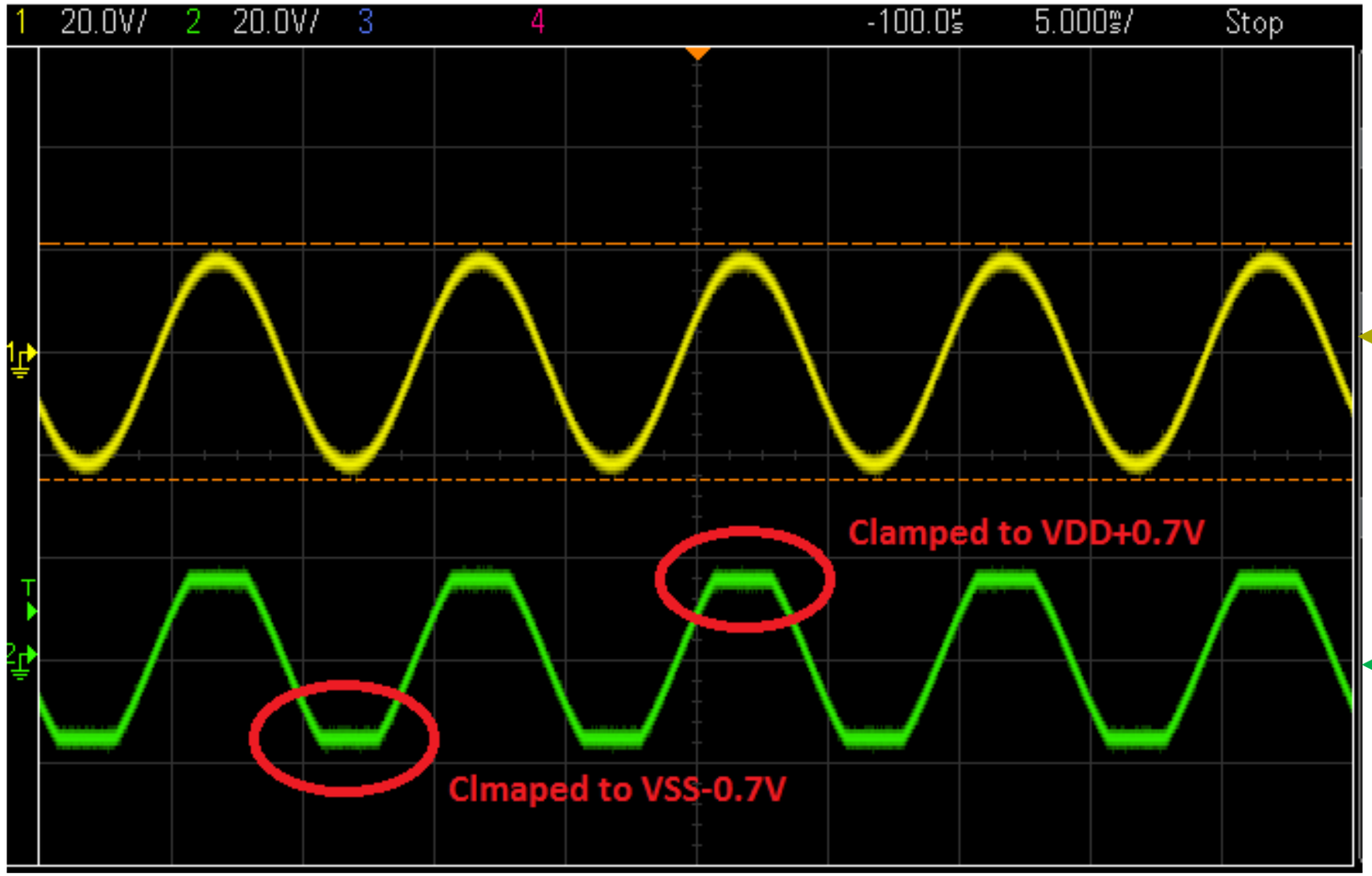
Input
S

Output
D



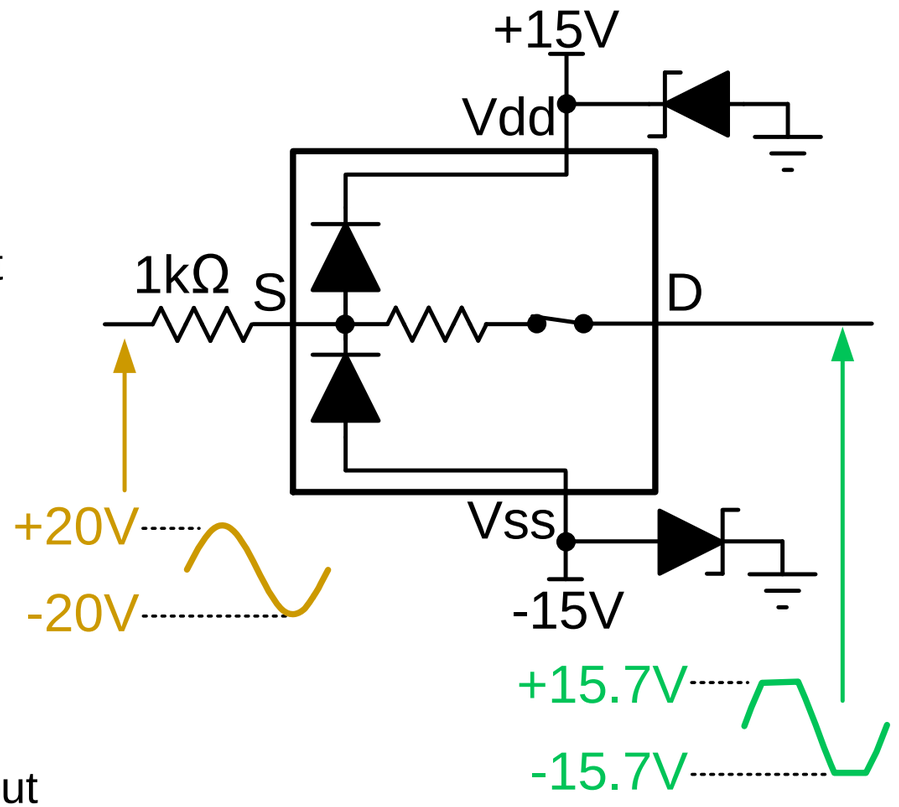
Vin = 20Vpp, 7V dc offset

MUX36S08 Over voltage Fault Performance



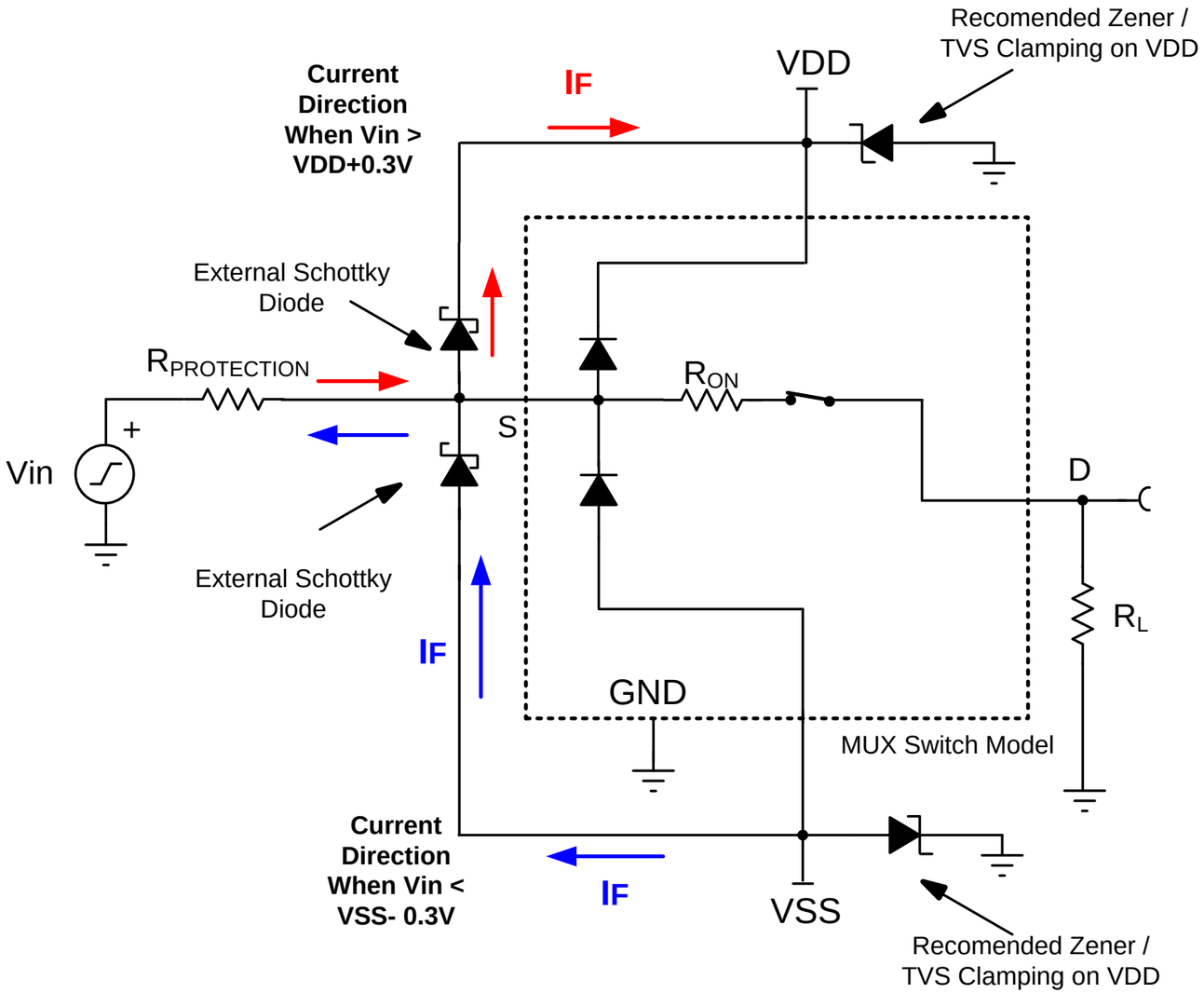
Input
S

Output
D



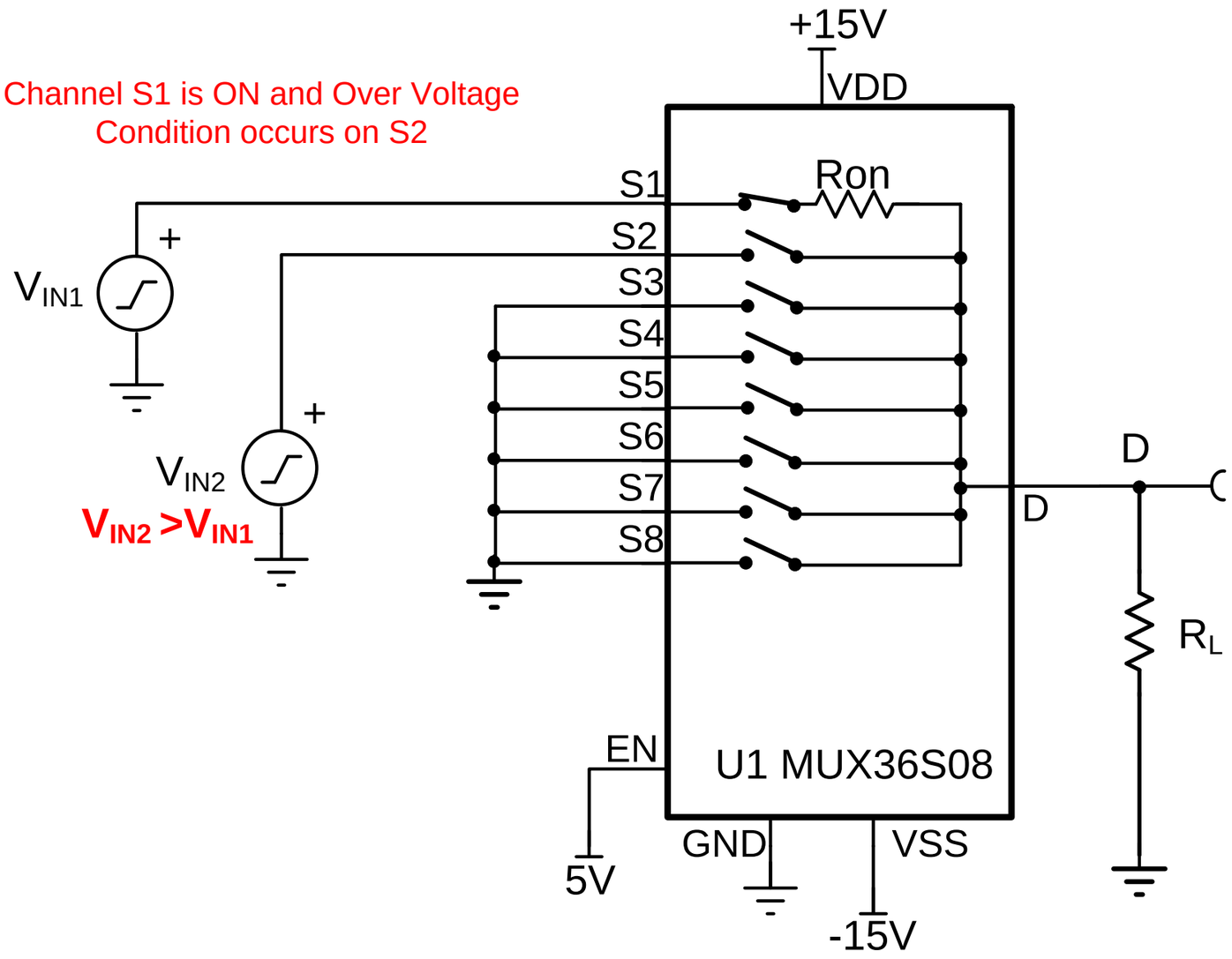
Vin = 40Vpp, 0V dc offset

Using External Clamping Diode as EOS Protection

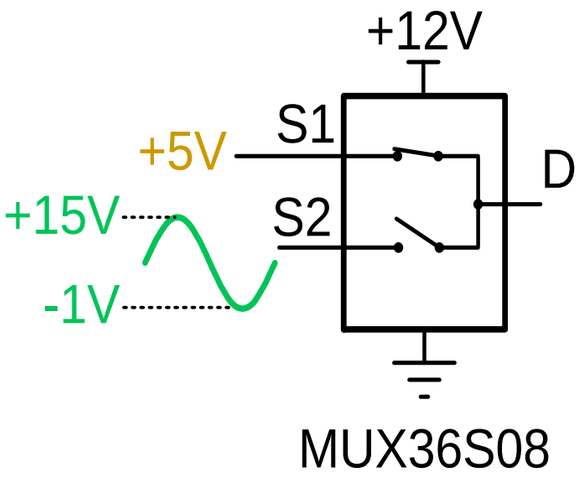


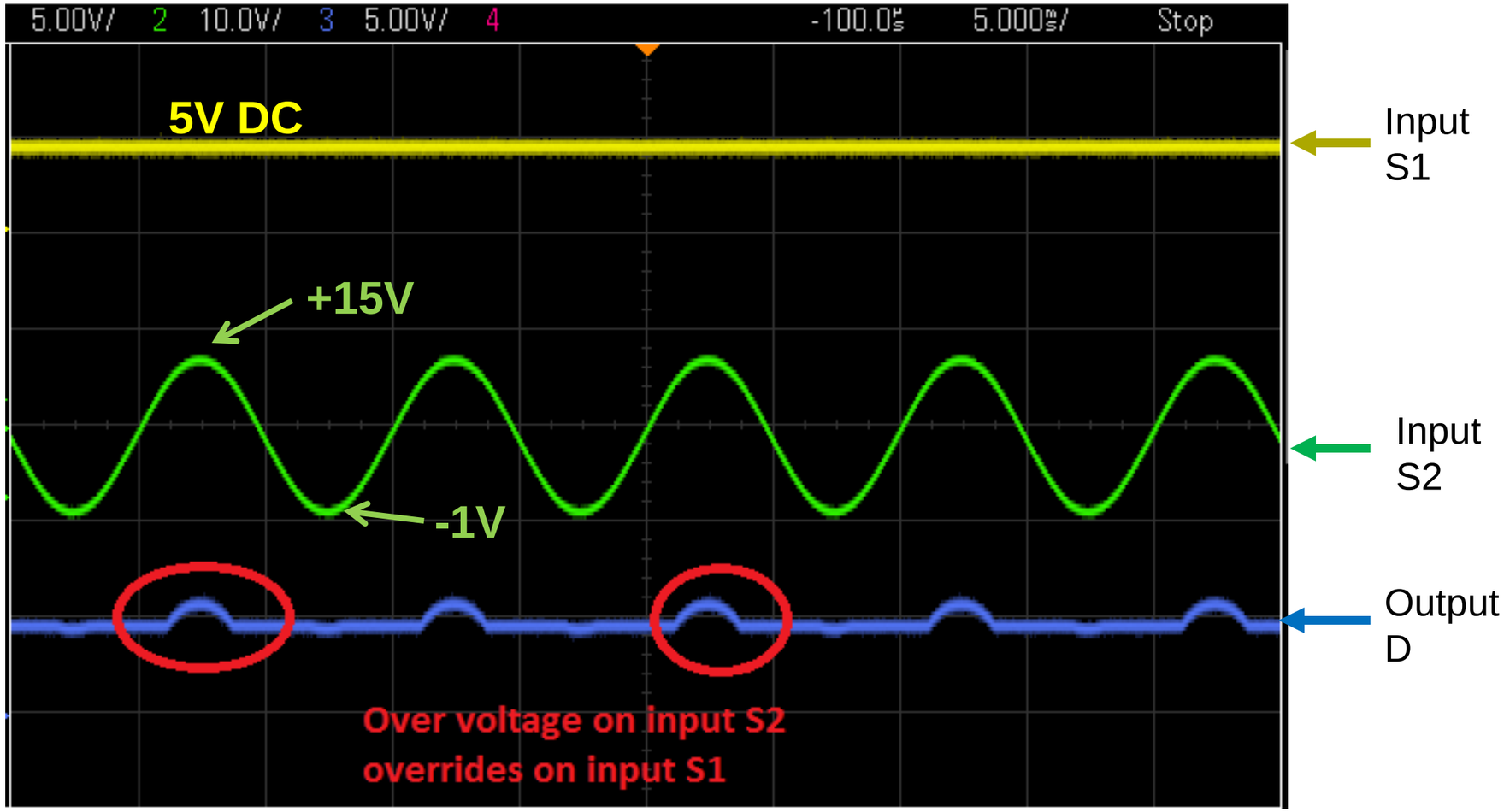
Over Voltage Applied on OFF Channel

Channel S1 is ON and Over Voltage Condition occurs on S2

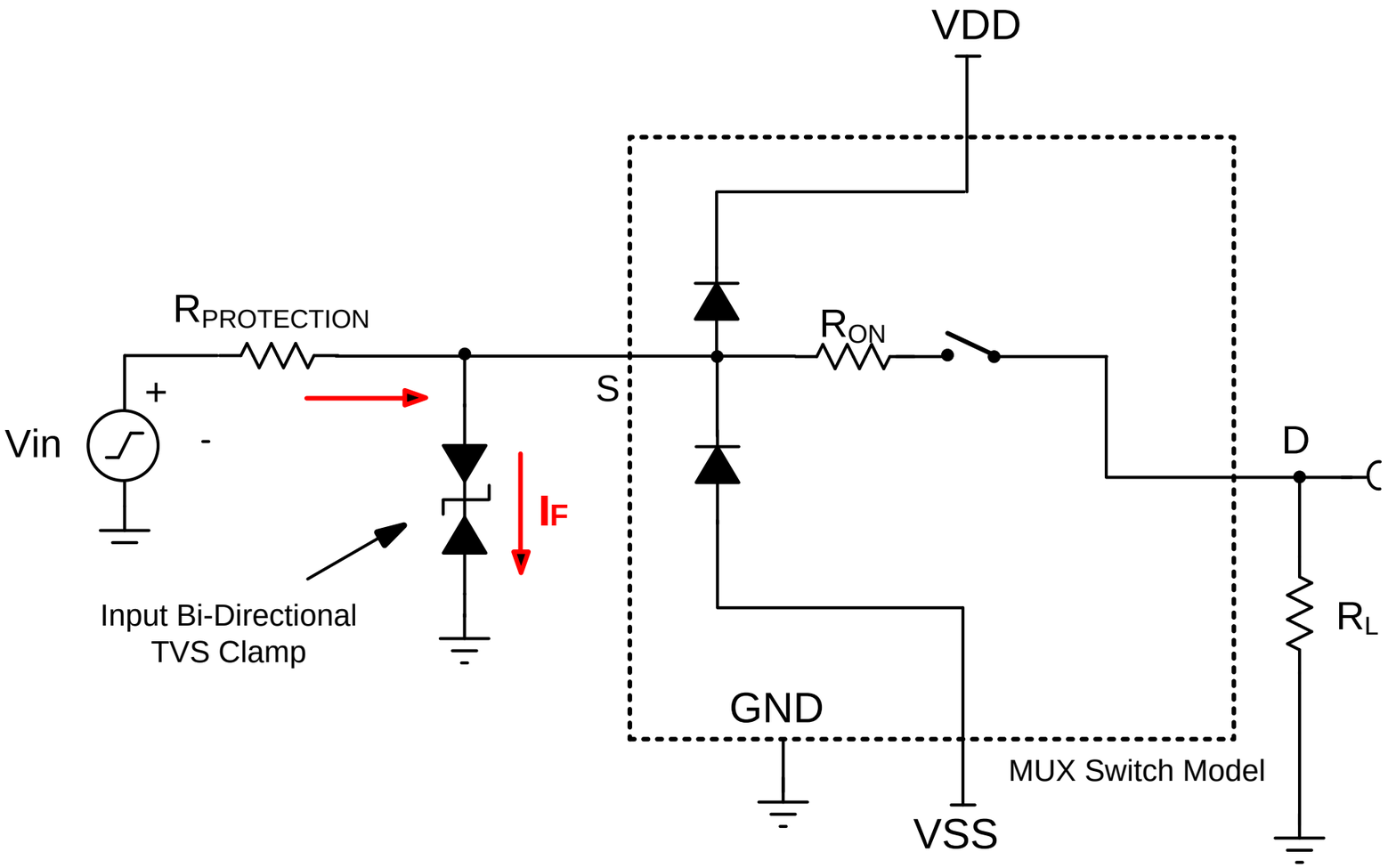


MUX36S08 Over voltage Fault Performance



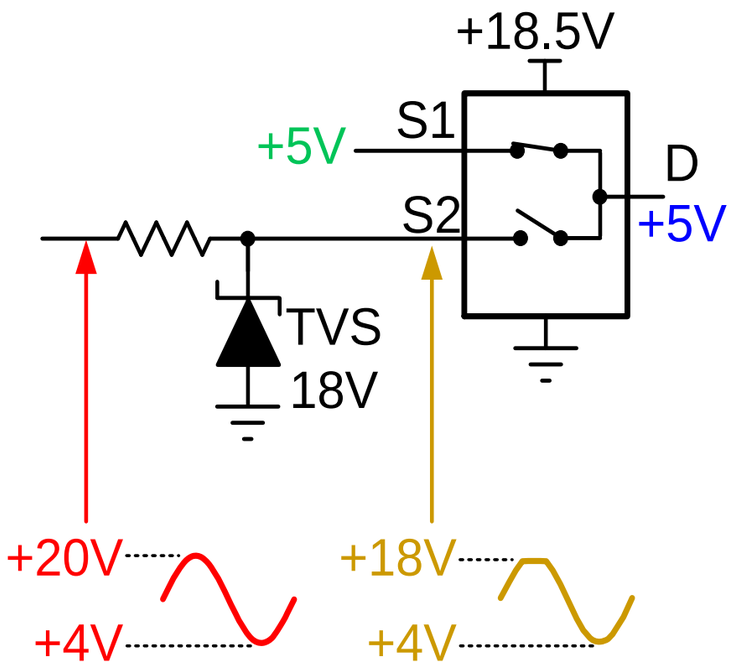


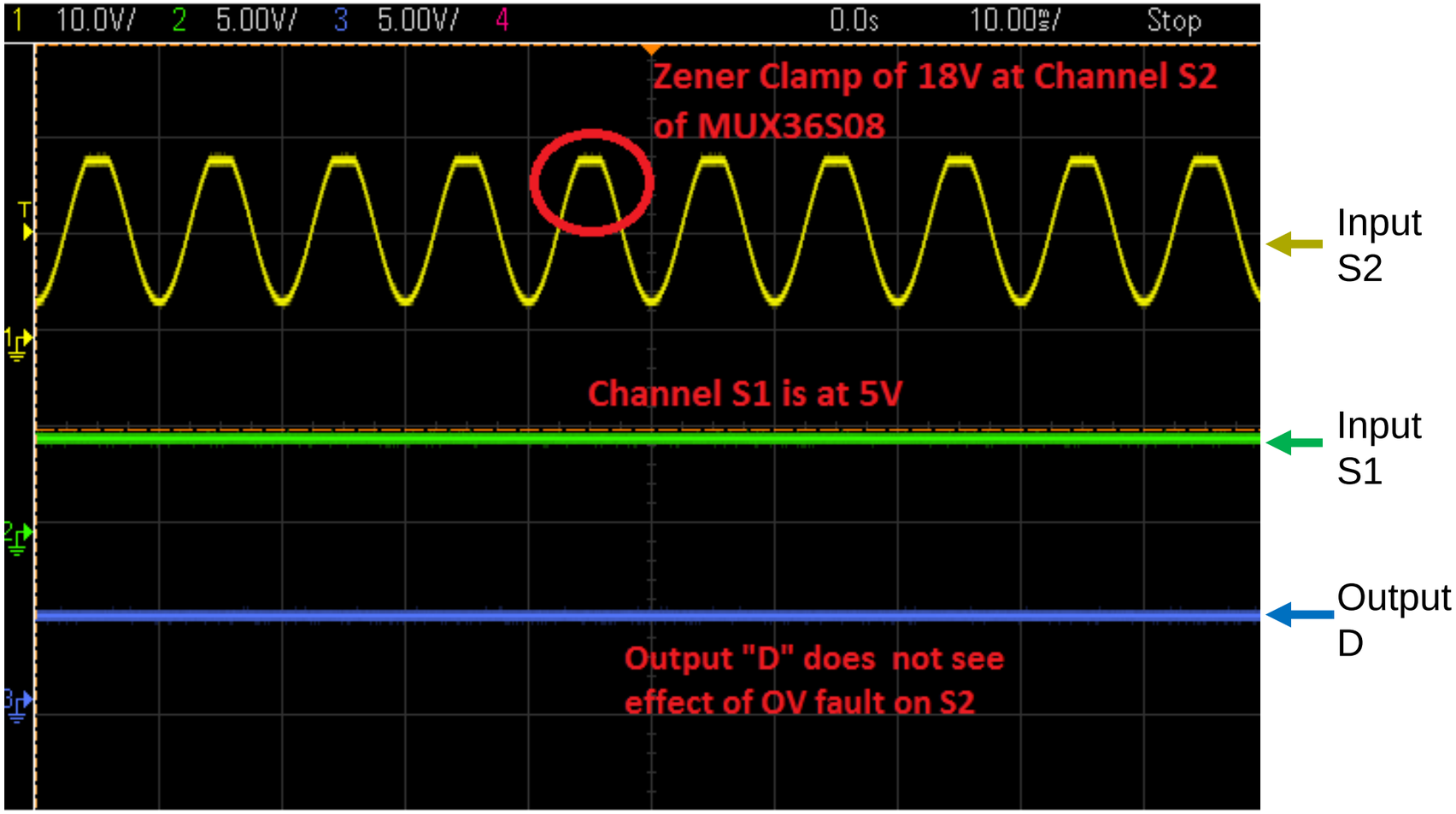
Zener/TVS clamping at Input as EOS Protection



- Input voltage clamped using zener or TVS diode
- Series resistor acts as a current limiting resistor
- For Unipolar operation, Zener diode or unidirectional TVS diode can work
- For Bipolar operation Bi-directional TVS diode has to be selected

MUX36S08 Over voltage Fault Performance





Thanks for your time!
Please try the quiz.