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Texas Instruments New Product Update

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New Product Update:
Mid-Voltage Latch Up Immune Multiplexers and Switches

Parker Dodson/Sameer Arora

2Q21

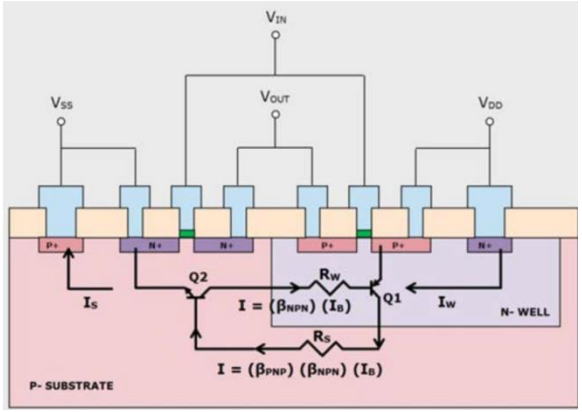
Agenda

- Latch-up and Latch-up immunity
  - CMOS latch-up
  - Latch-up immunity
  - Latch-up immune multiplexers – System benefits
- TMUX72xx – Newly released latch-up immune devices
- TMUX7xxxF – Newly released latch-up immune & fault-protected devices
  - Additional fault protections offered

CMOS Latch-up

What is Latch-up?

Latch-up is a fault condition which creates a short circuit between supply rails that will not resolve unless power is cycled or the system is destroyed.

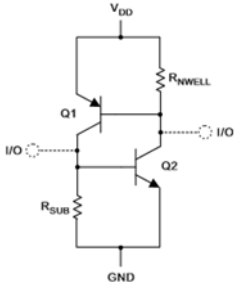


A CMOS inverter cross section with parasitic structure

What causes latch-up?

Latch-up is caused when current is injected into an input or the input exceeds the power rails of the device. This causes a parasitic structure, typically a PNPN structure referred to as a thyristor or Silicon Controlled Rectifier (SCR)

Equivalent parasitic structure circuit for CMOS inverter (PNPN / SCR)



Latch-up immunity

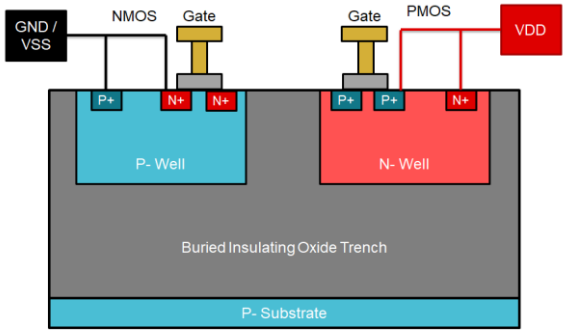
How to prevent latch-up?

There are a few ways to mitigate latch-up with the two most common being:

1. Implement an insulated oxide trench between PMOS and NMOS devices
2. Use guard rings to siphon off extra charge that could cause a latch-up event

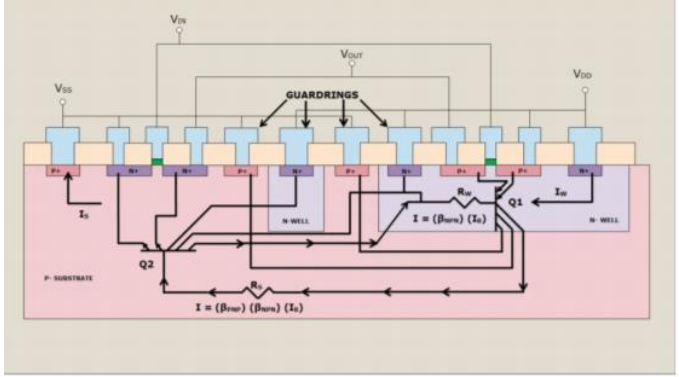
Why aren't all parts latch-up immune?

Not all parts are latch-up immune because it may not be possible to accommodate the extra layout space needed to implement latch up immunity in every device.



A CMOS inverter cross section with insulating oxide trench

A CMOS inverter cross section with guard rings

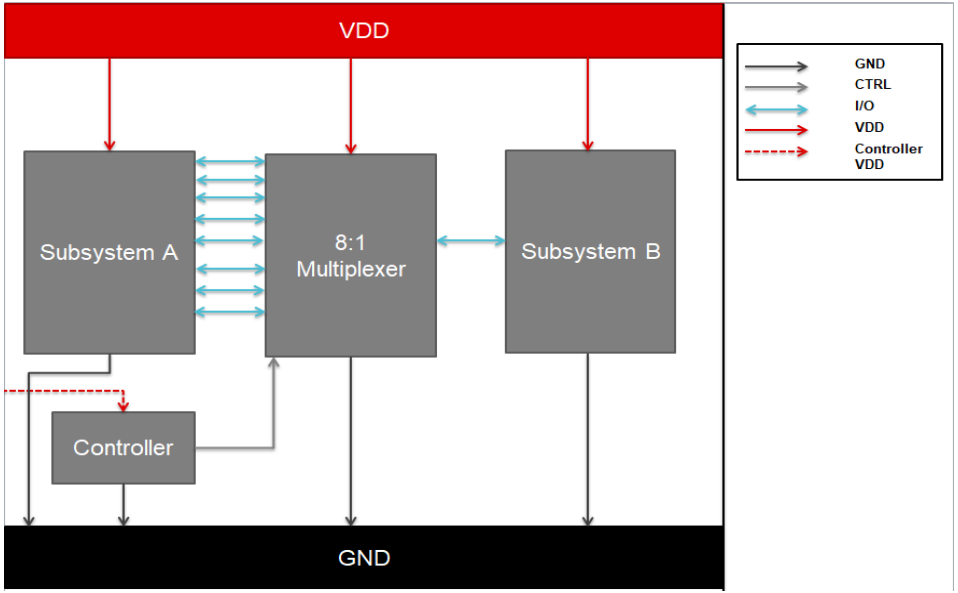


System benefits of latch-up immune multiplexers

Using latch-up immune multiplexers can help mitigate system-damaging faults.

In the diagram on the right:

- **Scenario 1: No latch-up immunity**
  - If subsystem A/B produces an injected current or EOS event on the I/O of the Mux, VDD will be pulled to GND, potentially causing damage to subsystem A/B
- **Scenario 2: Includes latch-up immunity**
  - If subsystem A/B produces an injected current or EOS event on the I/O of the Mux, VDD will not be pulled to GND preventing damage to subsystem A/B



Mid-voltage | TMUX72xx Family

+44-V inputs | Low R_{ON} multiplexer | High current capability | Latch-up immunity

Features

- Operating supply voltage:
  - Single-supply: **+4.5 V to +44 V**
  - Dual-supply: **±4.5 V to ±22 V**
  - Rail-to-rail analog input range
  - 1.8-V control logic
- Precision features:
  - Low leakage current: **100 pA (typ); 10 nA (max)**
  - Low charge injection: **15 pC (typ)**
  - Low on-resistance (R_{ON}): **2 Ω (typ)**
- Protection features:
  - **Latch-up immunity**
  - Fail-safe logic
- Packages:
  - TSSOP (PW) – **P2P with competition**
  - QFN – **P2P with competition**

Applications

- ATE test equipment
- Data acquisition (DAQ)
- Battery monitoring
- Programmable logic controllers (PLC)
- Analog input modules

Benefits

- Wide supply range supports rail-to-rail operation
- Low R_{ON} and charge injection improves accuracy
- High current capability allows wide-range current measurement

Devices	Configuration	Channels
TMUX7219	**2:1**	**1**
TMUX7211 **TMUX7212** TMUX7213	**1:1**	**4**
TMUX7208	**8:1**	**1**
TMUX7209	**4:1**	**2**

Mid-voltage | TMUX7219

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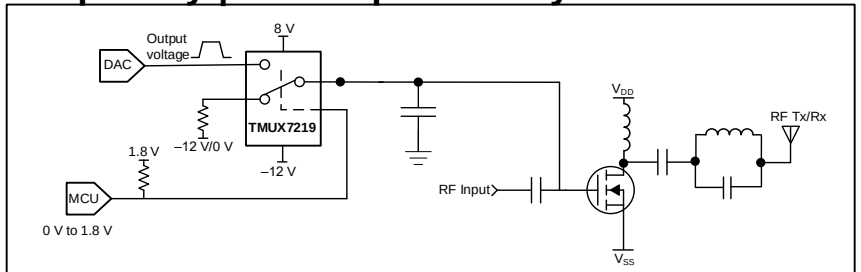
Features

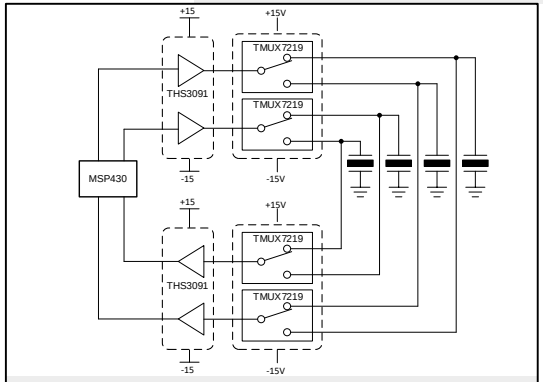
- Operating supply voltage:
  - Single-supply: **+4.5 V to +44 V**
  - Dual-supply: **±4.5 V to ±22 V**
  - Rail-to-rail analog input range
  - 1.8-V control logic
- Precision features:
  - Low leakage current: **100 pA (typ); 30 nA (max)**
  - Low R_{ON} flatness: **0.85 Ω (max)**
  - Low on-resistance (R_{ON}): **2.1 Ω (typ)**
- Protection features:
  - **Latch-up immunity**
  - Fail-safe logic
- Packages:
  - DGK (VSSOP) – **P2P with competition**
- Operating temperature: **-40°C to 125°C**

Applications

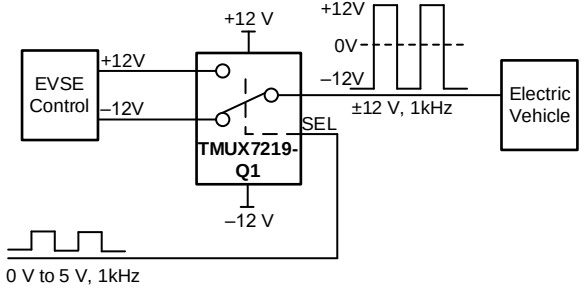
- Remote radio unit (RRU)
- Factory automation and control
- Programmable logic controllers (PLC)
- Analog input modules
- Semiconductor test equipment
- EV charging station power module



- **EE: Remote radio units (RRU)**
- **Application:** 2:1, 1-ch switch is used to control of the power amplifier gate driver in GaN application



- **EE: Ultrasonic sensing gas meter**
- **Application:** 2:1, 1-ch switch is used to select the Rx and Tx path of transducer



- **EE: EV charging station**
- **Application:** 2:1, 1-ch is used for PWM signal generation for EVSE control pilot

TMUX7219 application: Power amplifier gate driver

+44-V inputs | Low R_{ON} multiplexer | High current capability | Latch-up immunity

Features

- Operating supply voltage:
  - Single-supply: **+4.5 V to +44 V**
  - Dual-supply: **±4.5 V to ±22 V**
  - Rail-to-rail analog input range
  - 1.8-V control logic
- Precision features:
  - Low leakage current: **100 pA (typ); 30 nA (max)**
  - Low R_{ON} flatness: **0.85 Ω (max)**
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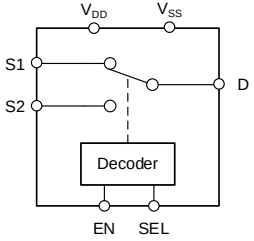
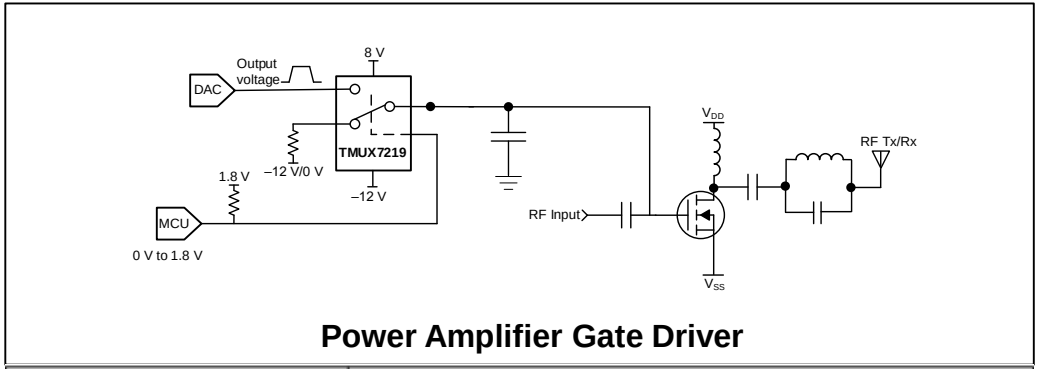
- Protection features:
  - **Latch-up immunity**
  - Fail-safe logic
- Packages:
  - DGK (VSSOP) – **P2P with competition**
- Operating temperature: **-40°C to 125°C**



EN	SEL	On Switch
0	X	None
1	0	S1
1	1	S2

*EN pin has pull-up to logic high
*SEL pins have pull-down to logic low



Power Amplifier Gate Driver

PARAMETERS	VALUES	
	GAN application	LDMOS application
Supply (V_{DD})	8 V	5 V
Supply (V_{SS})	-12 V	0 V
MUX I/O signal range	-12 V to 8 V (Rail-to-Rail)	0 V to 5 V (Rail-to-Rail)

Application details:

- 2:1, 1-ch switch is used to control of the power amplifier gate driver in GaN application
- Utilizing a switch allows a system to control when the DAC is connected to the power amplifier, and can stop biasing the power amplifier by switching the gate voltage

Key TMUX7219 Features:

- Dual supply range of **±4.5 V to ±22 V** allows the switch to work with **GaN power amplifiers**
- Wide single supply range **4.5 V to 44 V** works well with **LDMOS power amplifiers**
- **Low on-leakage and off-leakage current** and **ultra-low charge injection** makes this device suitable for high-precision industrial systems.

TMUX7xxxF family – Latch-up immune + fault protection

The TMUX7xxxF family is a subset of the latch-up immune mid-voltage portfolio that offers additional fault protection.

	Latch-up immunity	Fail-safe logic	Powered-off protection	OV/UV protection
TMUX72xx	YES	YES	NO	NO
TMUX7xxxF	YES	YES	YES	YES

- **Latch-up immunity:** Device does not latch-up therefore mitigating system damage during current injection or EOS.
- **Fail-safe logic:** Device is in off state until valid VDD; Logic pins can accept 0 V to max-rated VDD when device VDD = 0 V.
- **Powered-off protection:** Device remains HI-Z when VDD = 0 V and can accept up to +/-60 V on analog input pins without sustaining damage and only passing a small leakage current through the device.
- **OV/UV protection:** Device detects faults up to +/-60 V (+/-85 V from supply to analog I/O) and responds by either opening the output or clamping it to the positive fault supply (VDD or VFP depending on device)

TMUX73xxF/ TMUX74xxF

±60-V protection | ±5-V to ±24-V supplies | 1.8-V logic | Flat R_{ON} | Latch-up immunity

Features

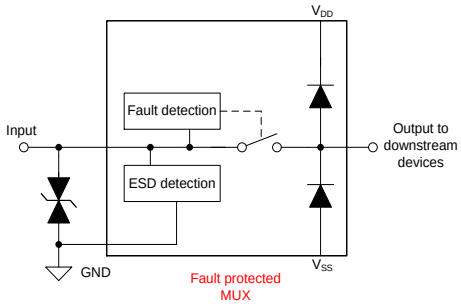
- Wide supply range: ±5 V to ±24 V (dual), 8 V to 48 V (single)
- Integrated protection features:
  - Overvoltage tolerance, from input to supplies or input to output: **±85 V**
  - Overvoltage protection: **±60 V**
  - **Powered-off** protection: **±60 V**
  - **Adjustable** overvoltage triggering threshold (TMUX7462F)
  - **Interrupt flags** to indicate fault channel information (TMUX7412F)
- **R_{ON} flatness** : 4 Ω (TMUX73xxF) or 0.5 Ω (TMUX74xxF)
- Non-fault channels continue to operate with low leakage currents
- Latch-up immunity by device construction
- Logic levels: **1.8 V** to VDD
- Low distortion: THD 0.0015% (TMUX74xxF)
- Fully specified for device temperature: -40°C to 125°C T_A
- Industry-standard TSSOP and smaller WQFN package

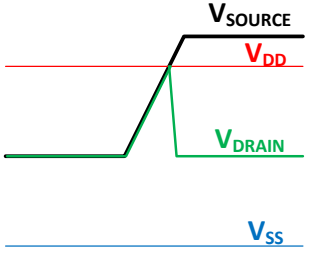
Applications

- Factory automation
- Field transmitters
- Programmable logic controllers (PLC)
- Analog input modules
- ATE test equipment
- Battery monitoring

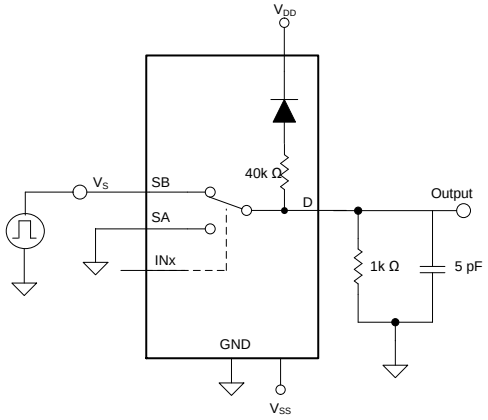
Benefits

- **Fault tolerance**: Protect downstream components against overvoltage conditions.
- **Better system robustness**: Device continues to operate with low leakage current for non-fault channels. Fault flag provides valuable system diagnostic information for external LED displays.
- **Compatible with next-gen processor**: 1.8-V logic support

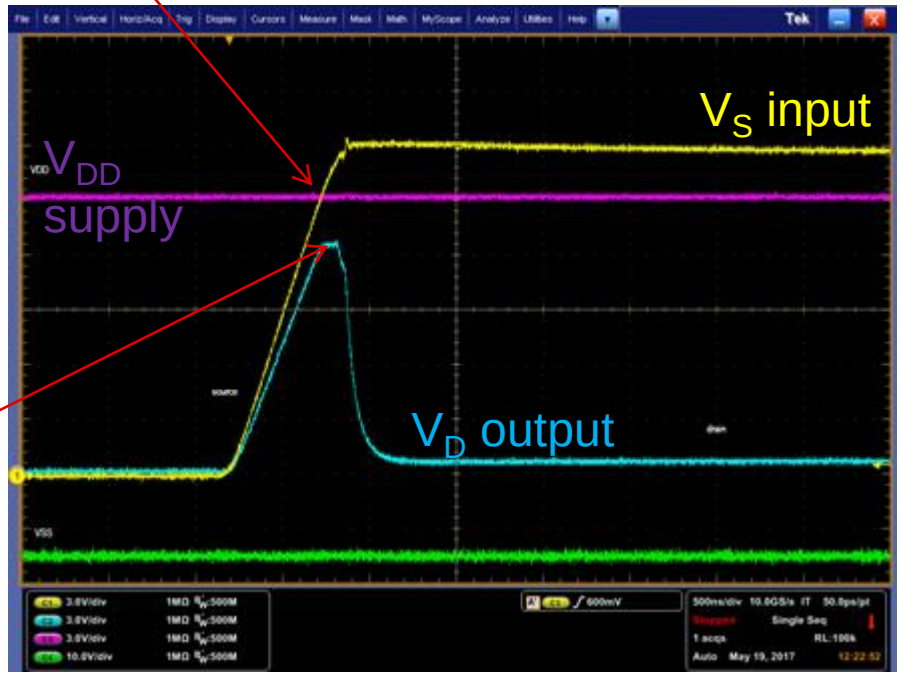




TMUX7308F | Zero overshoot fault protection



$V_S > V_{DD}$ fault



- No overshoot at the output during a fault condition
  - Overvoltage condition is blocked at the input
  - Protects downstream components from high voltage conditions

TMUX7308F competitiveness

		TMUX7308F	Key benefit over competition
Overvoltage tolerance		-60 V to +60 V	Robust operation in rugged environments. Supports IEC 60364-4-41 SELV regulation without additional external protection.
RON (Typ)/(Max)		250 Ω / 380 Ω	
RON_FLAT (MAX)		4 Ω	Enhanced precision over the full analog input range.
ON leakage current (Typ/Max)		300 pA / 25 nA	
IDD (Typ)		1.3 mA	
Transition time (Typ/Max)		165 ns/ 230 ns	Faster settling time enables high speed data acquisition.
Source OFF capacitance (Typ)		4 pF	
Channel ON capacitance (Typ)		19 pF	
1.8-V compatible logic		√	Interface with low voltage IOs without the need of level shifters.
Protection features	Overvoltage protection	√	
	Powered-off protection	√	
	Latch-up immunity	√	
	Output voltage clamping	√	
	Digital input proteciton	√	
	ESD (HBM)	√ 8 kV	Enhanced protection for industrial applications.
Package options		QFN TSSOP SOIC	QFN PCB footprint is 50% smaller compared to TSSOP.

TMUX7462F

Quad-channel protector | ±60-V protection | ±5-V to ±24-V supplies | 10-Ω R_{ON}

Features

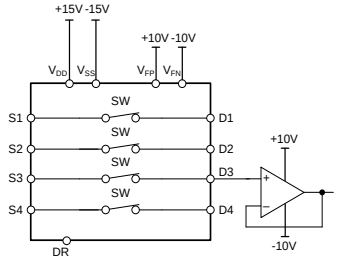
- Wide supply range: ±5 V to ±24 V (dual), 8 V to 48 V (single)
- Integrated protection features:
  - Overvoltage tolerance, from input to supplies or input to output: **±85 V**
  - Overvoltage protection: **±60 V**
  - **Powered-off** protection: **±60 V**
  - **Adjustable** overvoltage triggering threshold
  - **Interrupt flag** to indicate overvoltage fault
- Low R_{ON}: 10 Ω
- Flat R_{ON} over full input range: 0.5 Ω
- Non-fault channels continue to operate with low leakage currents
- Latch-up immunity by device construction
- Programmable output state during fault
- Logic levels: **1.8 V** to VDD
- Fully specified for device temperature: -40°C to 125°C T_A
- Industry-standard TSSOP and smaller WQFN package

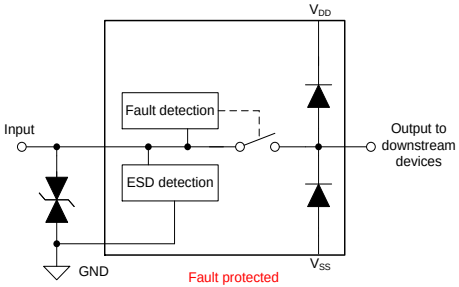
Applications

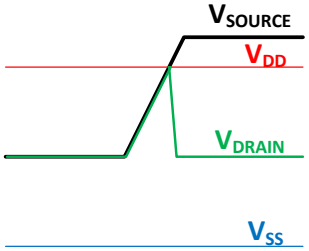
- Factory automation
- Field transmitters
- Programmable logic controllers (PLC)
- Analog input modules
- ATE test equipment
- Battery monitoring

Benefits

- **Fault tolerance**: Protect downstream components against overvoltage conditions.
- **Better system robustness**: Device continues to operate with low leakage current for non-fault channels. Fault flag provides valuable system diagnostic information for external LED displays.
- **Compatible with next-gen processor**: 1.8-V logic support







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Resources

- Application report:
  - Using Latch-Up Immune Multiplexers to Help Improve System Reliability

- Data sheets:
  - TMUX7219
  - TMUX7208/09
  - TMUX7211/12/13
  - TMUX7308F
  - TMUX7412F
  - TMUX7462F

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