

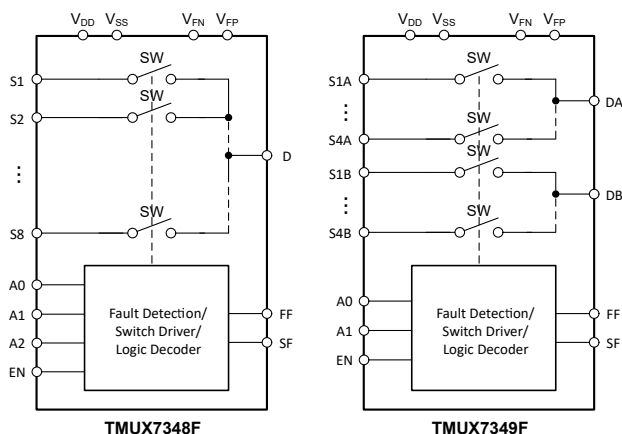
# TMUX734xF ±60-V Fault-Protected, 8:1 and Dual 4:1 Multiplexers With Adjustable Fault Threshold, Latch-Up Immunity, and 1.8-V Logic

## 1 Features

- Wide supply range:
  - Dual supply: ±5 V to ±22 V
  - Single supply: 8 V to 44 V
- Integrated fault protection:
  - [Overvoltage protection, source to supplies or source to drain: ±85 V](#)
  - [Overvoltage protection: ±60 V](#)
  - [Power-off protection: ±60 V](#)
  - [Adjustable overvoltage triggering thresholds](#)
    - $V_{FP}$ : 3 V to  $V_{DD}$ ,  $V_{FN}$ : 0 V to  $V_{SS}$
  - [Interrupt flags to indicate overall and specific fault channel information](#)
  - [Non-fault channels continue to operate with low leakage currents](#)
  - [Output clamped to the fault supply in overvoltage condition](#)
- [Latch-up immunity by device construction](#)
- [Logic capable: 1.8-V](#)
- [Fail-safe logic: up to 44 V independent of supply](#)
- Break-before-make switching
- Industry-standard TSSOP and smaller WQFN package

## 2 Applications

- [Factory automation and control](#)
- [Programmable logic controllers \(PLC\)](#)
- [Analog input modules](#)
- [Semiconductor test equipment](#)
- [Battery test equipment](#)
- [Servo drive control module](#)
- [Data acquisition systems \(DAQ\)](#)



Functional Block Diagram

## 3 Description

The TMUX7348F and TMUX7349F are modern complementary metal-oxide semiconductor (CMOS) analog multiplexers in 8:1 (single ended) and 4:1 (differential) configurations. The devices work well with dual supplies (±5 V to ±22 V), a single supply (8 V to 44 V), or asymmetric supplies (such as  $V_{DD} = 12$  V,  $V_{SS} = -5$  V). The overvoltage protection is available in powered and powered-off conditions, making the TMUX7348F and TMUX7349F devices suitable for applications where power supply sequencing cannot be precisely controlled.

The device blocks fault voltages up to +60 V and –60 V relative to ground in both powered and powered-off conditions. When no power supplies are present, the switch channels remain in the OFF state regardless of switch input conditions and logic control status. Under normal operation conditions, if the analog input signal level on any  $S_x$  pin exceeds positive fault supply ( $V_{FP}$ ) or negative fault supply ( $V_{FN}$ ) by a threshold voltage ( $V_T$ ), then the channel turns OFF and the  $S_x$  pin becomes high impedance. When the fault channel is selected, the drain pin (D or  $D_x$ ) is pulled to the fault supply voltage ( $V_{FP}$  or  $V_{FN}$ ) that was exceeded. The devices provide two active-low interrupt flags (FF and SF) to provide details of the fault. The FF flag indicates if any of the source inputs are experiencing a fault condition, while the SF flag is used to decode which specific inputs are experiencing a fault condition.

The low capacitance, low charge injection, and integrated fault protection enables the TMUX7348F and TMUX7349F devices to be used in front end data acquisition applications where high performance and high robustness are both critical. The devices are available in standard TSSOP package and smaller WQFN package (ideal if PCB space is limited).

### Device Information

PART NUMBER <sup>(1)</sup>	CONFIGURATION	PACKAGE <sup>(2)</sup>	PACKAGE SIZE <sup>(3)</sup>
TMUX7348F	1 Channel 8:1	PW (TSSOP, 20)	6.5 mm × 6.4 mm
TMUX7349F	2 Channel 4:1	RTJ (WQFN, 20)	4 mm × 4 mm

- (1) See [Device Comparison](#) table.
- (2) For all available packages, see the orderable addendum at the end of the data sheet.
- (3) The package size (length × width) is a nominal value and includes pins, where applicable.



## Table of Contents

<b>1 Features</b> .....	1	8.9 Fault Recovery Time.....	32
<b>2 Applications</b> .....	1	8.10 Fault Flag Response Time.....	33
<b>3 Description</b> .....	1	8.11 Fault Flag Recovery Time.....	33
<b>4 Revision History</b> .....	2	8.12 Charge Injection.....	34
<b>5 Device Comparison Table</b> .....	3	8.13 Off Isolation.....	34
<b>6 Pin Configuration and Functions</b> .....	3	8.14 Crosstalk.....	35
<b>7 Specifications</b> .....	6	8.15 Bandwidth.....	36
7.1 Absolute Maximum Ratings.....	6	8.16 THD + Noise.....	36
7.2 ESD Ratings.....	6	<b>9 Detailed Description</b> .....	37
7.3 Thermal Information.....	7	9.1 Overview.....	37
7.4 Recommended Operating Conditions.....	7	9.2 Functional Block Diagram.....	37
7.5 Electrical Characteristics (Global).....	8	9.3 Feature Description.....	38
7.6 ±15 V Dual Supply: Electrical Characteristics.....	9	9.4 Device Functional Modes.....	41
7.7 ±20 V Dual Supply: Electrical Characteristics.....	12	<b>10 Application and Implementation</b> .....	44
7.8 12 V Single Supply: Electrical Characteristics.....	15	10.1 Application Information.....	44
7.9 36 V Single Supply: Electrical Characteristics.....	18	10.2 Typical Application.....	44
7.10 Typical Characteristics.....	21	10.3 Power Supply Recommendations.....	46
<b>8 Parameter Measurement Information</b> .....	28	10.4 Layout.....	46
8.1 On-Resistance.....	28	<b>11 Device and Documentation Support</b> .....	49
8.2 Off-Leakage Current.....	28	11.1 Documentation Support.....	49
8.3 On-Leakage Current.....	29	11.2 Receiving Notification of Documentation Updates.....	49
8.4 Input and Output Leakage Current Under Overvoltage Fault.....	29	11.3 Support Resources.....	49
8.5 Break-Before-Make Delay.....	30	11.4 Trademarks.....	49
8.6 Enable Delay Time.....	31	11.5 Electrostatic Discharge Caution.....	49
8.7 Transition Time.....	31	11.6 Glossary.....	49
8.8 Fault Response Time.....	32	<b>12 Mechanical, Packaging, and Orderable   Information</b> .....	49

## 4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

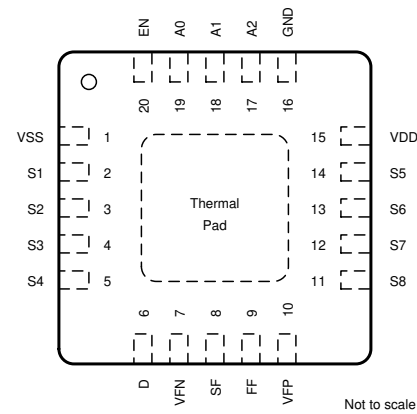
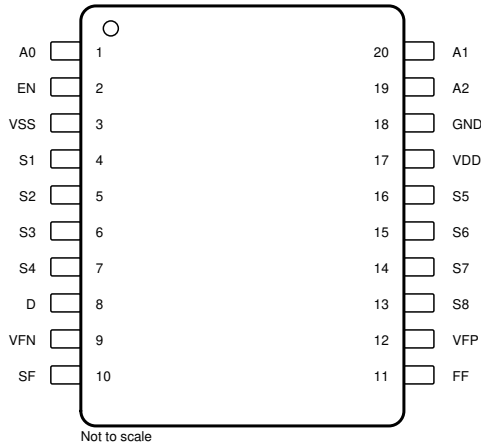
<b>Changes from Revision A (November 2022) to Revision B (July 2023)</b>	<b>Page</b>
• Updated the <i>Device Information</i> table to include configuration and package size.....	1
• Changed the status of the TSSOP (20) package for the TMUX734xF device from: <i>Preview</i> to: <i>Active</i> .....	1

<b>Changes from Revision * (April 2022) to Revision A (November 2022)</b>	<b>Page</b>
• Changed the status of the WQFN (20) package for the TMUX734xF device from: <i>Preview</i> to: <i>Active</i> .....	1

## 5 Device Comparison Table

PRODUCT	DESCRIPTION
TMUX7348F	+60 V/ –60 V tolerant, fault-protected, latch-up immune, single-ended 8:1 multiplexers with adjustable fault threshold
TMUX7349F	+60 V/ –60 V tolerant, fault-protected, latch-up immune, dual 4:1 multiplexers with adjustable fault threshold

## 6 Pin Configuration and Functions



**Figure 6-1. PW Package, 20-Pin TSSOP (Top View)** **Figure 6-2. RTJ Package, 20-Pin WQFN (Top View)**

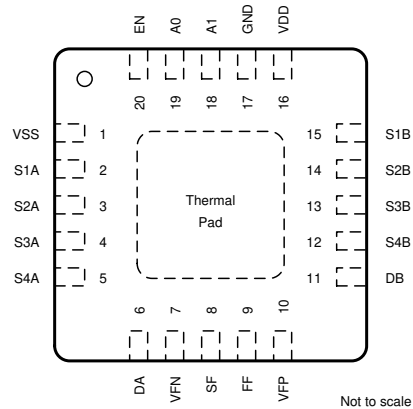
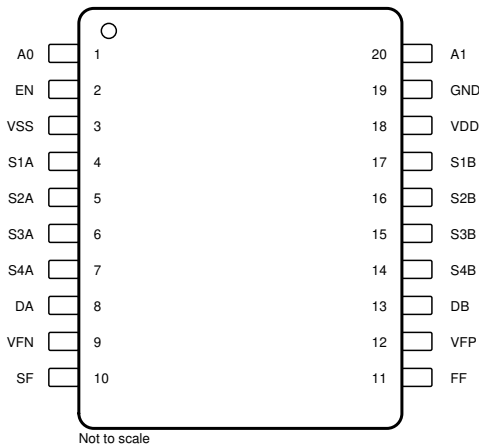
**Table 6-1. Pin Functions: TMUX7348F**

NAME	PIN		TYPE <sup>(1)</sup>	DESCRIPTION
	TSSOP	WQFN		
A0	1	19	I	Logic control input address 0 (A0). The pin has a 4-M $\Omega$ internal pull-down resistor. This pin can also be used together with the specific fault pin (SF) to indicate which input is under fault. For more details, see <a href="#">Section 9.4.3</a> .
A1	20	18	I	Logic control input address 1 (A1). The pin has a 4-M $\Omega$ internal pull-down resistor. This pin can also be used together with the specific fault pin (SF) to indicate which input is under fault. For more details, see <a href="#">Section 9.4.3</a> .
A2	19	17	I	Logic control input address 2 (A2). The pin has a 4-M $\Omega$ internal pull-down resistor. This pin can also be used together with the specific fault pin (SF) to indicate which input is under fault. For more details, see <a href="#">Section 9.4.3</a> .
D	8	6	I/O	Drain pin. Can be an input or output. The drain pin is not overvoltage protected and shall remain within the recommended operating range.
EN	2	20	I	Active high logic enable (EN) pin. The pin has a 4-M $\Omega$ internal pull-down resistor. The device is disabled and all switches become high impedance when the pin is low. When the pin is high, the A <sub>x</sub> logic inputs determine individual switch states. For more details, see <a href="#">Section 9.4.3</a> .
FF	11	9	O	General fault flag. This pin is an open drain output and is asserted low when overvoltage condition is detected on any of the source (S <sub>x</sub> ) input pins. Connect this pin to an external supply (1.8 V to 5.5 V) through a 1-k $\Omega$ pull-up resistor.
GND	18	16	P	Ground (0 V) reference.
S1	4	2	I/O	Overvoltage protected source pin 1. Can be an input or output.
S2	5	3	I/O	Overvoltage protected source pin 2. Can be an input or output.
S3	6	4	I/O	Overvoltage protected source pin 3. Can be an input or output.
S4	7	5	I/O	Overvoltage protected source pin 4. Can be an input or output.
S5	16	14	I/O	Overvoltage protected source pin 5. Can be an input or output.
S6	15	13	I/O	Overvoltage protected source pin 6. Can be an input or output.
S7	14	12	I/O	Overvoltage protected source pin 7. Can be an input or output.
S8	13	11	I/O	Overvoltage protected source pin 8. Can be an input or output.
SF	10	8	O	Specific fault flag. <a href="#">Table 9-1</a> shows how this pin is an open drain output and is asserted low when overvoltage condition is detected on a specific pin, depending on the state of A0, A1, and A2. Connect this pin to an external supply (1.8 V to 5.5 V) through a 1-k $\Omega$ pull-up resistor.

**Table 6-1. Pin Functions: TMUX7348F (continued)**

PIN			TYPE <sup>(1)</sup>	DESCRIPTION
NAME	TSSOP	WQFN		
V <sub>DD</sub>	17	15	P	Positive power supply. This pin is the most positive power-supply potential. For reliable operation, connect a decoupling capacitor ranging from 0.1 μF to 10 μF between V <sub>DD</sub> and GND.
V <sub>FN</sub>	9	7	P	Negative fault voltage supply that determines the overvoltage protection triggering threshold on the negative side. Connect to V <sub>SS</sub> if the triggering threshold will be the same as the device's negative supply. For reliable operation, connect a decoupling capacitor ranging from 0.1 μF to 10 μF between V <sub>FN</sub> and GND.
V <sub>FP</sub>	12	10	P	Positive fault voltage supply that determines the overvoltage protection triggering threshold on the positive side. Connect to V <sub>DD</sub> if the triggering threshold will be the same as the device's positive supply. For reliable operation, connect a decoupling capacitor ranging from 0.1 μF to 10 μF between V <sub>FP</sub> and GND.
V <sub>SS</sub>	3	1	P	Negative power supply. This pin is the most negative power-supply potential. In single-supply applications, this pin can be connected to ground. For reliable operation, connect a decoupling capacitor ranging from 0.1 μF to 10 μF between V <sub>SS</sub> and GND.
Thermal Pad			—	Thermal pad. The thermal pad is not connected internally. It is recommended that the pad be tied to GND or V <sub>SS</sub> for best performance.

(1) I = input, O = output, I/O = input and output, P = power



**Figure 6-3. PW Package, 20-Pin TSSOP (Top View)**

**Figure 6-4. RTJ Package, 20-Pin WQFN (Top View)**

**Table 6-2. Pin Functions: TMUX7349F**

PIN			TYPE <sup>(1)</sup>	DESCRIPTION
NAME	TSSOP	WQFN		
A0	1	19	I	Logic control input address 0 (A0). The pin has a 4-MΩ internal pull-down resistor. This pin can also be used together with the specific fault pin (SF) to indicate which input is under fault. For more details, see <a href="#">Section 9.4.3</a> .
A1	20	18	I	Logic control input address 1 (A1). The pin has a 4-MΩ internal pull-down resistor. This pin can also be used together with the specific fault pin (SF) to indicate which input is under fault. For more details, see <a href="#">Section 9.4.3</a> .
DA	8	6	I/O	Drain terminal A. Can be an input or output. The drain pin is not overvoltage protected and shall remain within the recommended operating range.
DB	13	11	I/O	Drain terminal B. Can be an input or output. The drain pin is not overvoltage protected and shall remain within the recommended operating range.
EN	2	20	I	Active high logic enable (EN) pin. The pin has a 4-MΩ internal pull-down resistor. The device is disabled and all switches become high impedance when the pin is low. When the pin is high, the Ax logic inputs determine individual switch states. This pin can also be used together with the specific fault pin (SF) to indicate which input is under fault. For more details, see <a href="#">Section 9.4.3</a> .
FF	11	9	O	General fault flag. This pin is an open drain output and is asserted low when overvoltage condition is detected on any of the source (Sx) input pins. Connect this pin to an external supply (1.8 V to 5.5 V) through a 1-kΩ pull-up resistor.
GND	19	17	P	Ground (0 V) reference
S1A	4	2	I/O	Overvoltage protected source pin 1A. Can be an input or output.
S1B	17	15	I/O	Overvoltage protected source pin 1B. Can be an input or output.

**Table 6-2. Pin Functions: TMUX7349F (continued)**

PIN			TYPE <sup>(1)</sup>	DESCRIPTION
NAME	TSSOP	WQFN		
S2A	5	3	I/O	Overvoltage protected source pin 2A. Can be an input or output.
S2B	16	14	I/O	Overvoltage protected source pin 2B. Can be an input or output.
S3A	6	4	I/O	Overvoltage protected source pin 3A. Can be an input or output.
S3B	15	13	I/O	Overvoltage protected source pin 3B. Can be an input or output.
S4A	7	5	I/O	Overvoltage protected source pin 4A. Can be an input or output.
S4B	14	12	I/O	Overvoltage protected source pin 4B. Can be an input or output.
SF	10	8	O	Specific fault flag. Table 9-2 provides how this pin is an open drain output and is asserted low when overvoltage condition is detected on a specific pin, depending on the state of A0, A1, and EN. Connect this pin to an external supply (1.8 V to 5.5 V) through a 1-kΩ pull-up resistor.
V <sub>DD</sub>	18	16	P	Positive power supply. This pin is the most positive power-supply potential. For reliable operation, connect a decoupling capacitor ranging from 0.1 μF to 10 μF between V <sub>DD</sub> and GND.
V <sub>FN</sub>	9	7	P	Negative fault voltage supply that determines the overvoltage protection triggering threshold on the negative side. Connect to V <sub>SS</sub> if the triggering threshold will be the same as the device's negative supply. For reliable operation, connect a decoupling capacitor ranging from 0.1 μF to 10 μF between V <sub>FN</sub> and GND.
V <sub>FP</sub>	12	10	P	Positive fault voltage supply that determines the overvoltage protection triggering threshold on the positive side. Connect to V <sub>DD</sub> if the triggering threshold will be the same as the device's positive supply. For reliable operation, connect a decoupling capacitor ranging from 0.1 μF to 10 μF between V <sub>FP</sub> and GND.
V <sub>SS</sub>	3	1	P	Negative power supply. This pin is the most negative power-supply potential. In single-supply applications, this pin can be connected to ground. For reliable operation, connect a decoupling capacitor ranging from 0.1 μF to 10 μF between V <sub>SS</sub> and GND.
Thermal Pad			—	Thermal pad. The thermal pad is not connected internally. It is recommended to tie the pad to GND or V <sub>SS</sub> for best performance.

(1) I = input, O = output, I/O = input and output, P = power

## 7 Specifications

### 7.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)<sup>(1)</sup>

		MIN	MAX	UNIT
V <sub>DD</sub> to V <sub>SS</sub>	Supply voltage		48	V
V <sub>DD</sub> to GND		-0.3	48	V
V <sub>SS</sub> to GND		-48	0.3	V
V <sub>FP</sub> to GND	Positive fault clamping voltage	-0.3	V <sub>DD</sub> + 0.3	V
V <sub>FN</sub> to GND	Negative fault clamping voltage	V <sub>SS</sub> - 0.3	0.3	V
V <sub>S</sub> to GND	Source input pin (Sx) voltage to GND	-65	65	V
V <sub>S</sub> to V <sub>DD</sub>	Source input pin (Sx) voltage to V <sub>DD</sub>	-90		V
V <sub>S</sub> to V <sub>SS</sub>	Source input pin (Sx) voltage to V <sub>SS</sub>		90	V
V <sub>D</sub>	Drain pin (D or Dx) voltage	V <sub>FN</sub> -0.7	V <sub>FP</sub> +0.7	V
V <sub>EN</sub> or V <sub>Ax</sub>	Logic control input pin voltage (EN, A0, A1, A2) <sup>(2)</sup>	GND - 0.7	48	V
V <sub>xF</sub>	Logic output pin (SF, FF) voltage <sup>(2)</sup>	GND - 0.7	6	V
I <sub>EN</sub> or I <sub>Ax</sub>	Logic control input pin current (EN, A0, A1, A2) <sup>(2)</sup>	-30	30	mA
I <sub>xF</sub>	Logic output pin (SF, FF) current <sup>(2)</sup>	-10	10	mA
I <sub>S</sub> or I <sub>D (CONT)</sub>	Source or drain continuous current (Sx or D)	I <sub>DC</sub> ± 10 % <sup>(3)</sup>	I <sub>DC</sub> ± 10 % <sup>(3)</sup>	mA
T <sub>stg</sub>	Storage temperature	-65	150	°C
T <sub>A</sub>	Ambient temperature	-55	150	°C
T <sub>J</sub>	Junction temperature		150	°C
P <sub>tot</sub> <sup>(4)</sup>	Total power dissipation (QFN)		1900	mW
P <sub>tot</sub> <sup>(5)</sup>	Total power dissipation (TSSOP)		800	mW

(1) Operation outside the *Absolute Maximum Ratings* may cause permanent device damage. Absolute maximum ratings do not imply functional operation of the device at these or any other conditions beyond those listed under *Recommended Operating Conditions*. If briefly operating outside the *Recommended Operating Conditions* but within the *Absolute Maximum Ratings*, the device may not sustain damage, but it may not be fully functional. Operating the device in this manner may affect device reliability, functionality, performance, and shorten the device lifetime.

(2) Stresses have to be kept at or below both voltage and current ratings at all time.

(3) Refer to Recommended Operating Conditions for I<sub>DC</sub> ratings.

(4) For QFN package: P<sub>tot</sub> derates linearly above T<sub>A</sub> = 70°C by 28.5 mW/°C

(5) For TSSOP package: P<sub>tot</sub> derates linearly above T<sub>A</sub> = 70°C by 12.0 mW/°C

### 7.2 ESD Ratings

		VALUE	UNIT
V <sub>(ESD)</sub>	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup>	±3500
		Charged device model (CDM), per JEDEC specification JESD22-C101 or ANSI/ESDA/JEDEC JS-002 <sup>(2)</sup>	±750

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process. Manufacturing with less than 500-V HBM is possible if necessary precautions are taken.

(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process. Manufacturing with less than 250-V CDM is possible if necessary precautions are taken.

### 7.3 Thermal Information

THERMAL METRIC <sup>(1)</sup>		TMUX7348F/ TMUX7349F		UNIT
		PW (TSSOP)	RTJ (WQFN)	
		20 PINS	20 PINS	
R <sub>θJA</sub>	Junction-to-ambient thermal resistance	84.3	35.3	°C/W
R <sub>θJC(top)</sub>	Junction-to-case (top) thermal resistance	22.7	28.3	°C/W
R <sub>θJB</sub>	Junction-to-board thermal resistance	37.3	13.5	°C/W
Ψ <sub>JT</sub>	Junction-to-top characterization parameter	1.0	0.3	°C/W
Ψ <sub>JB</sub>	Junction-to-board characterization parameter	36.7	13.5	°C/W
R <sub>θJC(bot)</sub>	Junction-to-case (bottom) thermal resistance	N/A	4.1	°C/W

(1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC Package Thermal Metrics](#) application report.

### 7.4 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

		MIN	NOM	MAX	UNIT
V <sub>DD</sub> – V <sub>SS</sub> <sup>(1)</sup>	Power supply voltage differential	8		44	V
V <sub>DD</sub>	Positive power supply voltage	5		44	V
V <sub>FP</sub>	Positive fault clamping voltage	3		V <sub>DD</sub>	V
V <sub>FN</sub>	Negative fault clamping voltage	V <sub>SS</sub>		0	V
V <sub>S</sub>	Source pin (Sx) voltage (non-fault condition)	V <sub>FN</sub>		V <sub>FP</sub>	V
V <sub>S</sub> to GND	Source pin (Sx) voltage (fault condition)	–60		60	V
V <sub>S</sub> to V <sub>DD</sub> <sup>(2)</sup>	Source pin (Sx) voltage to V <sub>DD</sub> or V <sub>D</sub> (fault condition)	–85			V
V <sub>S</sub> to V <sub>SS</sub> <sup>(2)</sup>	Source pin (Sx) voltage to V <sub>SS</sub> or V <sub>D</sub> (fault condition)			85	V
V <sub>D</sub>	Drain pin (D, Dx) voltage	V <sub>FN</sub>		V <sub>FP</sub>	V
V <sub>EN</sub> or V <sub>AX</sub>	Logic control input pin voltage (EN, A0, A1, A2)	0		44	V
V <sub>XF</sub>	Logic output pin (SF, FF) voltage	0		5.5	V
T <sub>A</sub>	Ambient temperature	–40		125	°C
I <sub>DC</sub> <sup>(3)</sup>	Continuous current through switch	T <sub>A</sub> = 25°C		9	mA
		T <sub>A</sub> = 85°C		6.5	
		T <sub>A</sub> = 125°C		5	

(1) V<sub>DD</sub> and V<sub>SS</sub> can be any value as long as 8 V ≤ (V<sub>DD</sub> – V<sub>SS</sub>) ≤ 44 V.

(2) Under a fault condition, the potential difference between source pin (Sx) and supply pins (V<sub>DD</sub> and V<sub>SS</sub>.) or source pin (Sx) and drain pins (D, Dx) may not exceed 85 V.

(3) Fault supplies are tied to the primary supplies (V<sub>FP</sub> = V<sub>DD</sub>, V<sub>FN</sub> = V<sub>SS</sub>)

## 7.5 Electrical Characteristics (Global)

at  $T_A = 25^\circ\text{C}$  (unless otherwise noted)

PARAMETER		TEST CONDITIONS	$T_A$	MIN	TYP	MAX	UNIT
<b>ANALOG SWITCH</b>							
$V_T$	Threshold voltage for fault detector		$25^\circ\text{C}$		0.7		V
<b>LOGIC INPUT/ OUTPUT</b>							
$V_{IH}$	High-level input voltage	EN, Ax pins	$-40^\circ\text{C}$ to $+125^\circ\text{C}$	1.3		44	V
$V_{IL}$	Low-level input voltage	EN, Ax pins	$-40^\circ\text{C}$ to $+125^\circ\text{C}$	0		0.8	V
$V_{OL(FLAG)}$	Low-level output voltage	FF and SF pins, $I_O = 5\text{ mA}$	$-40^\circ\text{C}$ to $+125^\circ\text{C}$			0.35	V
<b>POWER SUPPLY</b>							
$V_{UVLO}$	Undervoltage lockout (UVLO) threshold voltage ( $V_{DD} - V_{SS}$ )	Rising edge, single supply	$-40^\circ\text{C}$ to $+125^\circ\text{C}$	5.1	6	6.4	V
		Falling edge, single supply	$-40^\circ\text{C}$ to $+125^\circ\text{C}$	5	5.8	6.3	V
$V_{HYS}$	$V_{DD}$ Undervoltage lockout (UVLO) hysteresis	Single supply	$-40^\circ\text{C}$ to $+125^\circ\text{C}$		0.2		V
$R_{D(OVP)}$	Drain resistance to supply rail during overvoltage event on selected source pin		$25^\circ\text{C}$		40		$\text{k}\Omega$



## 7.6 ±15 V Dual Supply: Electrical Characteristics

$V_{DD} = +15\text{ V} \pm 10\%$ ,  $V_{SS} = -15\text{ V} \pm 10\%$ ,  $GND = 0\text{ V}$  (unless otherwise noted)

Typical at  $V_{DD} = +15\text{ V}$ ,  $V_{SS} = -15\text{ V}$ ,  $T_A = 25^\circ\text{C}$  (unless otherwise noted)

PARAMETER		TEST CONDITIONS	$T_A$	MIN	TYP	MAX	UNIT
<b>ANALOG SWITCH</b>							
$R_{ON}$	On-resistance	$V_S = -10\text{ V to } +10\text{ V}$ , $I_S = -1\text{ mA}$	25°C	180	250		$\Omega$
			-40°C to +85°C		330		
			-40°C to +125°C		390		
$\Delta R_{ON}$	On-resistance mismatch between channels	$V_S = -10\text{ V to } +10\text{ V}$ , $I_S = -1\text{ mA}$	25°C	2.5	8		$\Omega$
			-40°C to +85°C		12		
			-40°C to +125°C		13		
$R_{FLAT}$	On-resistance flatness	$V_S = -10\text{ V to } +10\text{ V}$ , $I_S = -1\text{ mA}$	25°C	1.5	3.5		$\Omega$
			-40°C to +85°C		4		
			-40°C to +125°C		4		
$R_{ON\_DRIFT}$	On-resistance drift	$V_S = 0\text{ V}$ , $I_S = -1\text{ mA}$	-40°C to +125°C		1		$\Omega/^\circ\text{C}$
$I_{S(OFF)}$	Source off leakage current <sup>(1)</sup>	$V_{DD} = 16.5\text{ V}$ , $V_{SS} = -16.5\text{ V}$ Switch state is off $V_S = +10\text{ V} / -10\text{ V}$ $V_D = -10\text{ V} / +10\text{ V}$	25°C	-1	0.1	1	nA
			-40°C to +85°C		-1	1	
			-40°C to +125°C		-4	4	
$I_{D(OFF)}$	Drain off leakage current <sup>(1)</sup>	$V_{DD} = 16.5\text{ V}$ , $V_{SS} = -16.5\text{ V}$ Switch state is off $V_S = +10\text{ V} / -10\text{ V}$ $V_D = -10\text{ V} / +10\text{ V}$	25°C	-1	0.1	1	nA
			-40°C to +85°C		-3	3	
			-40°C to +125°C		-14	14	
$I_{S(ON)}$ $I_{D(ON)}$	Output on leakage current <sup>(2)</sup>	$V_{DD} = 16.5\text{ V}$ , $V_{SS} = -16.5\text{ V}$ Switch state is on $V_S = V_D = \pm 10\text{ V}$	25°C	-1.5	0.3	1.5	nA
			-40°C to +85°C		-5	5	
			-40°C to +125°C		-22	22	
<b>FAULT CONDITION</b>							
$I_{S(FA)}$	Input leakage current during overvoltage	$V_S = \pm 60\text{ V}$ , $GND = 0\text{ V}$ , $V_{DD} = V_{FP} = 16.5\text{ V}$ , $V_{SS} = V_{FN} = -16.5\text{ V}$	-40°C to +125°C		±110		$\mu\text{A}$
$I_{S(FA)}$ Grounded	Input leakage current during overvoltage with grounded supply voltages	$V_S = \pm 60\text{ V}$ , $GND = 0\text{ V}$ , $V_{DD} = V_{SS} = V_{FP} = V_{FN} = 0\text{ V}$	-40°C to +125°C		±135		$\mu\text{A}$
$I_{S(FA)}$ Floating	Input leakage current during overvoltage with floating supply voltages	$V_S = \pm 60\text{ V}$ , $GND = 0\text{ V}$ , $V_{DD} = V_{SS} = V_{FP} = V_{FN} = \text{floating}$	-40°C to +125°C		±135		$\mu\text{A}$
$I_{D(FA)}$	Output leakage current during overvoltage	$V_S = \pm 60\text{ V}$ , $GND = 0\text{ V}$ , $V_{DD} = V_{FP} = 16.5\text{ V}$ , $V_{SS} = V_{FN} = -16.5\text{ V}$ , $-15.5\text{ V} \leq V_D \leq 16.5\text{ V}$	25°C	-50	±10	50	nA
			-40°C to +85°C		-70	70	
			-40°C to +125°C		-90	90	
$I_{D(FA)}$ Grounded	Output leakage current during overvoltage with grounded supply voltages	$V_S = \pm 60\text{ V}$ , $GND = 0\text{ V}$ , $V_{DD} = V_{SS} = V_{FP} = V_{FN} = 0\text{ V}$	25°C	-50	±1	50	nA
			-40°C to +85°C		-100	100	
			-40°C to +125°C		-500	500	
$I_{D(FA)}$ Floating	Output leakage current during overvoltage with floating supply voltages	$V_S = \pm 60\text{ V}$ , $GND = 0\text{ V}$ , $V_{DD} = V_{SS} = V_{FP} = V_{FN} = \text{floating}$	25°C		±3		$\mu\text{A}$
			-40°C to +85°C		±5		
			-40°C to +125°C		±8		
<b>LOGIC INPUT/ OUTPUT</b>							
$I_{IH}$	High-level input current	$V_{EN} = V_{Ax} = V_{DD}$	25°C	-2	±0.6	2	$\mu\text{A}$
			-40°C to +125°C		-2	2	
$I_{IL}$	Low-level input current	$V_{EN} = V_{Ax} = 0\text{ V}$	25°C	-1.1	±0.6	1.1	$\mu\text{A}$
			-40°C to +125°C		-1.2	1.2	
<b>SWITCHING CHARACTERISTICS</b>							
$t_{ON(EN)}$	Enable turn-on time	$V_S = 10\text{ V}$ , $R_L = 4\text{ k}\Omega$ , $C_L = 12\text{ pF}$	25°C		165	265	ns
			-40°C to +85°C			285	
			-40°C to +125°C			300	

### 7.6 ±15 V Dual Supply: Electrical Characteristics (continued)

$V_{DD} = +15\text{ V} \pm 10\%$ ,  $V_{SS} = -15\text{ V} \pm 10\%$ ,  $GND = 0\text{ V}$  (unless otherwise noted)

Typical at  $V_{DD} = +15\text{ V}$ ,  $V_{SS} = -15\text{ V}$ ,  $T_A = 25^\circ\text{C}$  (unless otherwise noted)

PARAMETER		TEST CONDITIONS	$T_A$	MIN	TYP	MAX	UNIT
$t_{OFF(EN)}$	Enable turn-off time	$V_S = 10\text{ V}$ , $R_L = 4\text{ k}\Omega$ , $C_L = 12\text{ pF}$	25°C		350	400	ns
			-40°C to +85°C			400	
			-40°C to +125°C			420	
$t_{TRAN}$	Transition time	$V_S = 10\text{ V}$ , $R_L = 4\text{ k}\Omega$ , $C_L = 12\text{ pF}$	25°C		170	225	ns
			-40°C to +85°C			245	
			-40°C to +125°C			260	
$t_{RESPONSE}$	Fault response time	$V_{FP} = 15\text{ V}$ , $V_{FN} = -15\text{ V}$ , $R_L = 4\text{ k}\Omega$ , $C_L = 12\text{ pF}$	25°C		300		ns
$t_{RECOVERY}$	Fault recovery time	$V_{FP} = 15\text{ V}$ , $V_{FN} = -15\text{ V}$ , $R_L = 4\text{ k}\Omega$ , $C_L = 12\text{ pF}$	25°C		1.4		$\mu\text{s}$
$t_{RESPONSE(FLAG)}$	Fault flag response time	$V_{FP} = 15\text{ V}$ , $V_{FN} = -15\text{ V}$ , $V_{PU} = 5\text{ V}$ , $R_{PU} = 1\text{ k}\Omega$ , $C_L = 12\text{ pF}$	25°C		110		ns
$t_{RECOVERY(FLAG)}$	Fault flag recovery time	$V_{FP} = 15\text{ V}$ , $V_{FN} = -15\text{ V}$ , $V_{PU} = 5\text{ V}$ , $R_{PU} = 1\text{ k}\Omega$ , $C_L = 12\text{ pF}$	25°C		0.9		$\mu\text{s}$
$t_{BBM}$	Break-before-make time delay	$V_S = 10\text{ V}$ , $R_L = 4\text{ k}\Omega$ , $C_L = 12\text{ pF}$	-40°C to +125°C	50	120		ns
$Q_{INJ}$	Charge injection	$V_S = 0\text{ V}$ , $C_L = 1\text{ nF}$	25°C		-15		pC
$O_{ISO}$	Off-isolation	$R_S = 50\ \Omega$ , $R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ , $V_S = 200\text{ mV}_{RMS}$ , $V_{BIAS} = 0\text{ V}$ , $f = 1\text{ MHz}$	25°C		-82		dB
$X_{TALK}$	Intra-channel crosstalk	$R_S = 50\ \Omega$ , $R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ , $V_S = 200\text{ mV}_{RMS}$ , $V_{BIAS} = 0\text{ V}$ , $f = 1\text{ MHz}$	25°C		-95		dB
	Inter-channel crosstalk (TMUX7349F)				-103		
BW	-3 dB bandwidth (TMUX7348F)	$R_S = 50\ \Omega$ , $R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ , $V_S = 200\text{ mV}_{RMS}$ , $V_{BIAS} = 0\text{ V}$	25°C		150		MHz
	-3 dB bandwidth (TMUX7349F WQFN Package)				280		
	-3 dB bandwidth (TMUX7349F TSSOP Package)				240		
$I_{Loss}$	Insertion loss	$R_S = 50\ \Omega$ , $R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ , $V_S = 200\text{ mV}_{RMS}$ , $V_{BIAS} = 0\text{ V}$ , $f = 1\text{ MHz}$	25°C		-9		dB
THD+N	Total harmonic distortion plus noise	$R_S = 40\ \Omega$ , $R_L = 10\text{ k}\Omega$ , $V_S = 15\text{ V}_{PP}$ , $V_{BIAS} = 0\text{ V}$ , $f = 20\text{ Hz to } 20\text{ kHz}$	25°C		0.0014		%
$C_{S(OFF)}$	Input off-capacitance	$f = 1\text{ MHz}$ , $V_S = 0\text{ V}$	25°C		3.5		pF
$C_{D(OFF)}$	Output off-capacitance (TMUX7348F)	$f = 1\text{ MHz}$ , $V_S = 0\text{ V}$	25°C		28		pF
	Output off-capacitance (TMUX7349F)	$f = 1\text{ MHz}$ , $V_S = 0\text{ V}$	25°C		15		pF
$C_{S(ON)}$ $C_{D(ON)}$	Input/Output on-capacitance (TMUX7348F)	$f = 1\text{ MHz}$ , $V_S = 0\text{ V}$	25°C		30		pF
	Input/Output on-capacitance (TMUX7349F)	$f = 1\text{ MHz}$ , $V_S = 0\text{ V}$	25°C		17		pF

## 7.6 ±15 V Dual Supply: Electrical Characteristics (continued)

$V_{DD} = +15\text{ V} \pm 10\%$ ,  $V_{SS} = -15\text{ V} \pm 10\%$ ,  $GND = 0\text{ V}$  (unless otherwise noted)

Typical at  $V_{DD} = +15\text{ V}$ ,  $V_{SS} = -15\text{ V}$ ,  $T_A = 25^\circ\text{C}$  (unless otherwise noted)

PARAMETER		TEST CONDITIONS	$T_A$	MIN	TYP	MAX	UNIT
<b>POWER SUPPLY</b>							
$I_{DD}$	$V_{DD}$ supply current	$V_{DD} = V_{FP} = 16.5\text{ V}$ , $V_{SS} = V_{FN} = -16.5\text{ V}$ , $V_{AX} = 0\text{ V}$ , $5\text{ V}$ , or $V_{DD}$ , $V_{EN} = 5\text{ V}$ or $V_{DD}$	25°C	0.24	0.5		mA
			-40°C to +85°C			0.5	
			-40°C to +125°C			0.5	
$I_{SS}$	$V_{SS}$ supply current	$V_{DD} = V_{FP} = 16.5\text{ V}$ , $V_{SS} = V_{FN} = -16.5\text{ V}$ , $V_{AX} = 0\text{ V}$ , $5\text{ V}$ , or $V_{DD}$ , $V_{EN} = 5\text{ V}$ or $V_{DD}$	25°C	0.14	0.4		mA
			-40°C to +85°C			0.4	
			-40°C to +125°C			0.4	
$I_{GND}$	GND current	$V_{DD} = V_{FP} = 16.5\text{ V}$ , $V_{SS} = V_{FN} = -16.5\text{ V}$ , $V_{AX} = 0\text{ V}$ , $5\text{ V}$ , or $V_{DD}$ , $V_{EN} = 5\text{ V}$ or $V_{DD}$	25°C	0.075			mA
$I_{FP}$	$V_{FP}$ supply current	$V_{DD} = V_{FP} = 16.5\text{ V}$ , $V_{SS} = V_{FN} = -16.5\text{ V}$ , $V_{AX} = 0\text{ V}$ , $5\text{ V}$ , or $V_{DD}$ , $V_{EN} = 5\text{ V}$ or $V_{DD}$	25°C		10		μA
$I_{FN}$	$V_{FN}$ supply current	$V_{DD} = V_{FP} = 16.5\text{ V}$ , $V_{SS} = V_{FN} = -16.5\text{ V}$ , $V_{AX} = 0\text{ V}$ , $5\text{ V}$ , or $V_{DD}$ , $V_{EN} = 5\text{ V}$ or $V_{DD}$	25°C		10		μA
$I_{DD(FA)}$	$V_{DD}$ supply current under fault	$V_S = \pm 60\text{ V}$ , $V_{DD} = V_{FP} = 16.5\text{ V}$ , $V_{SS} = V_{FN} = -16.5\text{ V}$ , $V_{AX} = 0\text{ V}$ , $5\text{ V}$ , or $V_{DD}$ , $V_{EN} = 5\text{ V}$ or $V_{DD}$	25°C	0.25	1		mA
			-40°C to +85°C			1	
			-40°C to +125°C			1	
$I_{SS(FA)}$	$V_{SS}$ supply current under fault	$V_S = \pm 60\text{ V}$ , $V_{DD} = V_{FP} = 16.5\text{ V}$ , $V_{SS} = V_{FN} = -16.5\text{ V}$ , $V_{AX} = 0\text{ V}$ , $5\text{ V}$ , or $V_{DD}$ , $V_{EN} = 5\text{ V}$ or $V_{DD}$	25°C	0.15	0.5		mA
			-40°C to +85°C			0.5	
			-40°C to +125°C			0.5	
$I_{GND(FA)}$	GND current under fault	$V_S = \pm 60\text{ V}$ , $V_{DD} = V_{FP} = 16.5\text{ V}$ , $V_{SS} = V_{FN} = -16.5\text{ V}$ , $V_{AX} = 0\text{ V}$ , $5\text{ V}$ , or $V_{DD}$ , $V_{EN} = 5\text{ V}$ or $V_{DD}$	25°C	0.15			mA
$I_{FP(FA)}$	$V_{FP}$ supply current under fault	$V_S = \pm 60\text{ V}$ , $V_{DD} = V_{FP} = 16.5\text{ V}$ , $V_{SS} = V_{FN} = -16.5\text{ V}$ , $V_{AX} = 0\text{ V}$ , $5\text{ V}$ , or $V_{DD}$ , $V_{EN} = 5\text{ V}$ or $V_{DD}$	25°C		9		μA
$I_{FN(FA)}$	$V_{FN}$ supply current under fault	$V_S = \pm 60\text{ V}$ , $V_{DD} = V_{FP} = 16.5\text{ V}$ , $V_{SS} = V_{FN} = -16.5\text{ V}$ , $V_{AX} = 0\text{ V}$ , $5\text{ V}$ , or $V_{DD}$ , $V_{EN} = 5\text{ V}$ or $V_{DD}$	25°C		9		μA
$I_{DD(DISABLE)}$	$V_{DD}$ supply current (disable mode)	$V_{DD} = V_{FP} = 16.5\text{ V}$ , $V_{SS} = V_{FN} = -16.5\text{ V}$ , $V_{AX} = 0\text{ V}$ , $5\text{ V}$ , or $V_{DD}$ , $V_{EN} = 0\text{ V}$	25°C	0.15	0.5		mA
			-40°C to +85°C			0.5	
			-40°C to +125°C			0.5	
$I_{SS(DISABLE)}$	$V_{SS}$ supply current (disable mode)	$V_{DD} = V_{FP} = 16.5\text{ V}$ , $V_{SS} = V_{FN} = -16.5\text{ V}$ , $V_{AX} = 0\text{ V}$ , $5\text{ V}$ , or $V_{DD}$ , $V_{EN} = 0\text{ V}$	25°C	0.1	0.4		mA
			-40°C to +85°C			0.4	
			-40°C to +125°C			0.4	

- (1) When  $V_S$  is positive,  $V_D$  is negative. And when  $V_S$  is negative,  $V_D$  is positive.
- (2) When  $V_S$  is at a voltage potential,  $V_D$  is floating. And when  $V_D$  is at a voltage potential,  $V_S$  is floating.

### 7.7 ±20 V Dual Supply: Electrical Characteristics

V<sub>DD</sub> = +20 V ± 10%, V<sub>SS</sub> = -20 V ± 10%, GND = 0 V (unless otherwise noted)

Typical at V<sub>DD</sub> = +20 V, V<sub>SS</sub> = -20 V, T<sub>A</sub> = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T <sub>A</sub>	MIN	TYP	MAX	UNIT
<b>ANALOG SWITCH</b>							
R <sub>ON</sub>	On-resistance	V <sub>S</sub> = -15 V to +15 V, I <sub>S</sub> = -1 mA	25°C	180	250		Ω
			-40°C to +85°C			330	
			-40°C to +125°C			390	
ΔR <sub>ON</sub>	On-resistance mismatch between channels	V <sub>S</sub> = -15 V to +15 V, I <sub>S</sub> = -1 mA	25°C	2.5	8		Ω
			-40°C to +85°C			12	
			-40°C to +125°C			13	
R <sub>FLAT</sub>	On-resistance flatness	V <sub>S</sub> = -15 V to +15 V, I <sub>S</sub> = -1 mA	25°C	8	10		Ω
			-40°C to +85°C			12	
			-40°C to +125°C			12	
R <sub>FLAT</sub>	On-resistance flatness	V <sub>S</sub> = -13.5 V to +13.5 V, I <sub>S</sub> = -1 mA	25°C	1.5	3.5		Ω
			-40°C to +85°C			4	
			-40°C to +125°C			4	
R <sub>ON_DRIFT</sub>	On-resistance drift	V <sub>S</sub> = 0 V, I <sub>S</sub> = -1 mA	-40°C to +125°C		1		Ω/°C
I <sub>S(OFF)</sub>	Source off leakage current <sup>(1)</sup>	V <sub>DD</sub> = 22 V, V <sub>SS</sub> = -22 V Switch state is off V <sub>S</sub> = +15 V / -15 V V <sub>D</sub> = -15 V / +15 V	25°C	-1	0.1	1	nA
			-40°C to +85°C			-1	
			-40°C to +125°C			-4	
I <sub>D(OFF)</sub>	Drain off leakage current <sup>(1)</sup>	V <sub>DD</sub> = 22 V, V <sub>SS</sub> = -22 V Switch state is off V <sub>S</sub> = +15 V / -15 V V <sub>D</sub> = -15 V / +15 V	25°C	-1	0.1	1	nA
			-40°C to +85°C			-3	
			-40°C to +125°C			-14	
I <sub>S(ON)</sub> I <sub>D(ON)</sub>	Output on leakage current <sup>(2)</sup>	V <sub>DD</sub> = 22 V, V <sub>SS</sub> = -22 V Switch state is on V <sub>S</sub> = V <sub>D</sub> = ±15 V	25°C	-1.5	0.3	1.5	nA
			-40°C to +85°C			-5	
			-40°C to +125°C			-22	
<b>FAULT CONDITION</b>							
I <sub>S(FA)</sub>	Input leakage current during overvoltage	V <sub>S</sub> = ± 60 V, GND = 0 V, V <sub>DD</sub> = V <sub>FP</sub> = 22 V, V <sub>SS</sub> = V <sub>FN</sub> = -22 V	-40°C to +125°C		±95		μA
I <sub>S(FA) Grounded</sub>	Input leakage current during overvoltage with grounded supply voltages	V <sub>S</sub> = ± 60 V, GND = 0 V, V <sub>DD</sub> = V <sub>SS</sub> = V <sub>FP</sub> = V <sub>FN</sub> = 0 V	-40°C to +125°C		±135		μA
I <sub>S(FA) Floating</sub>	Input leakage current during overvoltage with floating supply voltages	V <sub>S</sub> = ± 60 V, GND = 0 V, V <sub>DD</sub> = V <sub>SS</sub> = V <sub>FP</sub> = V <sub>FN</sub> = floating	-40°C to +125°C		±135		μA
I <sub>D(FA)</sub>	Output leakage current during overvoltage	V <sub>S</sub> = ± 60 V, GND = 0 V, V <sub>DD</sub> = V <sub>FP</sub> = 22 V, V <sub>SS</sub> = V <sub>FN</sub> = -22 V -21 V ≤ V <sub>D</sub> ≤ 22 V	25°C	-50	±10	50	nA
			-40°C to +85°C			-70	
			-40°C to +125°C			-90	
I <sub>D(FA) Grounded</sub>	Output leakage current during overvoltage with grounded supply voltages	V <sub>S</sub> = ± 60 V, GND = 0 V, V <sub>DD</sub> = V <sub>SS</sub> = V <sub>FP</sub> = V <sub>FN</sub> = 0 V	25°C	-50	±1	50	nA
			-40°C to +85°C			-100	
			-40°C to +125°C			-500	
I <sub>D(FA) Floating</sub>	Output leakage current during overvoltage with floating supply voltages	V <sub>S</sub> = ± 60 V, GND = 0 V, V <sub>DD</sub> = V <sub>SS</sub> = V <sub>FP</sub> = V <sub>FN</sub> = floating	25°C		±3		μA
			-40°C to +85°C			±5	
			-40°C to +125°C			±8	
<b>LOGIC INPUT/ OUTPUT</b>							
I <sub>IH</sub>	High-level input current	V <sub>EN</sub> = V <sub>Ax</sub> = V <sub>DD</sub>	25°C	-2.2	± 0.6	2.2	μA
			-40°C to +125°C			-2.2	
I <sub>IL</sub>	Low-level input current	V <sub>EN</sub> = V <sub>Ax</sub> = 0 V	25°C	-1.1	± 0.6	1.1	μA
			-40°C to +125°C			-1.2	

## 7.7 ±20 V Dual Supply: Electrical Characteristics (continued)

 $V_{DD} = +20\text{ V} \pm 10\%$ ,  $V_{SS} = -20\text{ V} \pm 10\%$ ,  $GND = 0\text{ V}$  (unless otherwise noted)

 Typical at  $V_{DD} = +20\text{ V}$ ,  $V_{SS} = -20\text{ V}$ ,  $T_A = 25^\circ\text{C}$  (unless otherwise noted)

PARAMETER		TEST CONDITIONS	$T_A$	MIN	TYP	MAX	UNIT
<b>SWITCHING CHARACTERISTICS</b>							
$t_{ON(EN)}$	Enable turn-on time	$V_S = 10\text{ V}$ , $R_L = 4\text{ k}\Omega$ , $C_L = 12\text{ pF}$	25°C	175	300		ns
			-40°C to +85°C			325	
			-40°C to +125°C			350	
$t_{OFF(EN)}$	Enable turn-off time	$V_S = 10\text{ V}$ , $R_L = 4\text{ k}\Omega$ , $C_L = 12\text{ pF}$	25°C	350	400		ns
			-40°C to +85°C			400	
			-40°C to +125°C			420	
$t_{TRAN}$	Transition time	$V_S = 10\text{ V}$ , $R_L = 4\text{ k}\Omega$ , $C_L = 12\text{ pF}$	25°C	170	245		ns
			-40°C to +85°C			270	
			-40°C to +125°C			285	
$t_{RESPONSE}$	Fault response time	$V_{FP} = 20\text{ V}$ , $V_{FN} = -20\text{ V}$ , $R_L = 4\text{ k}\Omega$ , $C_L = 12\text{ pF}$	25°C		300		ns
$t_{RECOVERY}$	Fault recovery time	$V_{FP} = 20\text{ V}$ , $V_{FN} = -20\text{ V}$ , $R_L = 4\text{ k}\Omega$ , $C_L = 12\text{ pF}$	25°C		1.3		$\mu\text{s}$
$t_{RESPONSE(FLAG)}$	Fault flag response time	$V_{FP} = 20\text{ V}$ , $V_{FN} = -20\text{ V}$ , $V_{PU} = 5\text{ V}$ , $R_{PU} = 1\text{ k}\Omega$ , $C_L = 12\text{ pF}$	25°C		110		ns
$t_{RECOVERY(FLAG)}$	Fault flag recovery time	$V_{FP} = 20\text{ V}$ , $V_{FN} = -20\text{ V}$ , $V_{PU} = 5\text{ V}$ , $R_{PU} = 1\text{ k}\Omega$ , $C_L = 12\text{ pF}$	25°C		0.9		$\mu\text{s}$
$t_{BBM}$	Break-before-make time delay	$V_S = 10\text{ V}$ , $R_L = 4\text{ k}\Omega$ , $C_L = 12\text{ pF}$	-40°C to +125°C	50	120		ns
$Q_{INJ}$	Charge injection	$V_S = 0\text{ V}$ , $C_L = 1\text{ nF}$	25°C		-17		pC
$O_{ISO}$	Off-isolation	$R_S = 50\ \Omega$ , $R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ , $V_S = 200\text{ mV}_{RMS}$ , $V_{BIAS} = 0\text{ V}$ , $f = 1\text{ MHz}$	25°C		-85		dB
$X_{TALK}$	Intra-channel crosstalk	$R_S = 50\ \Omega$ , $R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ , $V_S = 200\text{ mV}_{RMS}$ , $V_{BIAS} = 0\text{ V}$ , $f = 1\text{ MHz}$	25°C		-95		dB
	Inter-channel crosstalk (TMUX7349F)				-103		
BW	-3 dB bandwidth (TMUX7348F)	$R_S = 50\ \Omega$ , $R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ , $V_S = 200\text{ mV}_{RMS}$ , $V_{BIAS} = 0\text{ V}$	25°C		150		MHz
	-3 dB bandwidth (TMUX7349F WQFN Package)				285		
	-3 dB bandwidth (TMUX7349F TSSOP Package)				245		
$I_{LOSS}$	Insertion loss	$R_S = 50\ \Omega$ , $R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ , $V_S = 200\text{ mV}_{RMS}$ , $V_{BIAS} = 0\text{ V}$ , $f = 1\text{ MHz}$	25°C		-9		dB
THD+N	Total harmonic distortion plus noise	$R_S = 40\ \Omega$ , $R_L = 10\text{ k}\Omega$ , $V_S = 20\text{ V}_{PP}$ , $V_{BIAS} = 0\text{ V}$ , $f = 20\text{ Hz to } 20\text{ kHz}$	25°C		0.0014		%
$C_{S(OFF)}$	Input off-capacitance	$f = 1\text{ MHz}$ , $V_S = 0\text{ V}$	25°C		3.5		pF
$C_{D(OFF)}$	Output off-capacitance (TMUX7348F)	$f = 1\text{ MHz}$ , $V_S = 0\text{ V}$	25°C		28		pF
	Output off-capacitance (TMUX7349F)	$f = 1\text{ MHz}$ , $V_S = 0\text{ V}$	25°C		14		
$C_{S(ON)}$ $C_{D(ON)}$	Input/Output on-capacitance (TMUX7348F)	$f = 1\text{ MHz}$ , $V_S = 0\text{ V}$	25°C		30		pF
	Input/Output on-capacitance (TMUX7349F)	$f = 1\text{ MHz}$ , $V_S = 0\text{ V}$	25°C		16		
<b>POWER SUPPLY</b>							
$I_{DD}$	$V_{DD}$ supply current	$V_{DD} = V_{FP} = 22\text{ V}$ , $V_{SS} = V_{FN} = -22\text{ V}$ , $V_{AX} = 0\text{ V}$ , 5 V, or $V_{DD}$ , $V_{EN} = 5\text{ V}$ or $V_{DD}$	25°C	0.24	0.5		mA
			-40°C to +85°C			0.5	
			-40°C to +125°C			0.5	
$I_{SS}$	$V_{SS}$ supply current	$V_{DD} = V_{FP} = 22\text{ V}$ , $V_{SS} = V_{FN} = -22\text{ V}$ , $V_{AX} = 0\text{ V}$ , 5 V, or $V_{DD}$ , $V_{EN} = 5\text{ V}$ or $V_{DD}$	25°C	0.14	0.4		mA
			-40°C to +85°C			0.4	
			-40°C to +125°C			0.4	
$I_{GND}$	GND current	$V_{DD} = V_{FP} = 22\text{ V}$ , $V_{SS} = V_{FN} = -22\text{ V}$ , $V_{AX} = 0\text{ V}$ , 5 V, or $V_{DD}$ , $V_{EN} = 5\text{ V}$ or $V_{DD}$	25°C		0.075		mA

### 7.7 ±20 V Dual Supply: Electrical Characteristics (continued)

$V_{DD} = +20\text{ V} \pm 10\%$ ,  $V_{SS} = -20\text{ V} \pm 10\%$ ,  $GND = 0\text{ V}$  (unless otherwise noted)

Typical at  $V_{DD} = +20\text{ V}$ ,  $V_{SS} = -20\text{ V}$ ,  $T_A = 25^\circ\text{C}$  (unless otherwise noted)

PARAMETER		TEST CONDITIONS	$T_A$	MIN	TYP	MAX	UNIT
$I_{FP}$	$V_{FP}$ supply current	$V_{DD} = V_{FP} = 22\text{ V}$ , $V_{SS} = V_{FN} = -22\text{ V}$ , $V_{AX} = 0\text{ V}$ , $5\text{ V}$ , or $V_{DD}$ , $V_{EN} = 5\text{ V}$ or $V_{DD}$	$25^\circ\text{C}$		10		$\mu\text{A}$
$I_{FN}$	$V_{FN}$ supply current	$V_{DD} = V_{FP} = 22\text{ V}$ , $V_{SS} = V_{FN} = -22\text{ V}$ , $V_{AX} = 0\text{ V}$ , $5\text{ V}$ , or $V_{DD}$ , $V_{EN} = 5\text{ V}$ or $V_{DD}$	$25^\circ\text{C}$		10		$\mu\text{A}$
$I_{DD(FA)}$	$V_{DD}$ supply current under fault	$V_S = \pm 60\text{ V}$ , $V_{DD} = V_{FP} = 22\text{ V}$ , $V_{SS} = V_{FN} = -22\text{ V}$ , $V_{AX} = 0\text{ V}$ , $5\text{ V}$ , or $V_{DD}$ , $V_{EN} = 5\text{ V}$ or $V_{DD}$	$25^\circ\text{C}$		0.25	1	mA
			$-40^\circ\text{C}$ to $+85^\circ\text{C}$			1	
			$-40^\circ\text{C}$ to $+125^\circ\text{C}$			1	
$I_{SS(FA)}$	$V_{SS}$ supply current under fault	$V_S = \pm 60\text{ V}$ , $V_{DD} = V_{FP} = 22\text{ V}$ , $V_{SS} = V_{FN} = -22\text{ V}$ , $V_{AX} = 0\text{ V}$ , $5\text{ V}$ , or $V_{DD}$ , $V_{EN} = 5\text{ V}$ or $V_{DD}$	$25^\circ\text{C}$		0.15	0.5	mA
			$-40^\circ\text{C}$ to $+85^\circ\text{C}$			0.5	
			$-40^\circ\text{C}$ to $+125^\circ\text{C}$			0.5	
$I_{GND(FA)}$	GND current under fault	$V_S = \pm 60\text{ V}$ , $V_{DD} = V_{FP} = 22\text{ V}$ , $V_{SS} = V_{FN} = -22\text{ V}$ , $V_{AX} = 0\text{ V}$ , $5\text{ V}$ , or $V_{DD}$ , $V_{EN} = 5\text{ V}$ or $V_{DD}$	$25^\circ\text{C}$		0.15		mA
$I_{FP(FA)}$	$V_{FP}$ supply current under fault	$V_S = \pm 60\text{ V}$ , $V_{DD} = V_{FP} = 22\text{ V}$ , $V_{SS} = V_{FN} = -22\text{ V}$ , $V_{AX} = 0\text{ V}$ , $5\text{ V}$ , or $V_{DD}$ , $V_{EN} = 5\text{ V}$ or $V_{DD}$	$25^\circ\text{C}$		9		$\mu\text{A}$
$I_{FN(FA)}$	$V_{FN}$ supply current under fault	$V_S = \pm 60\text{ V}$ , $V_{DD} = V_{FP} = 22\text{ V}$ , $V_{SS} = V_{FN} = -22\text{ V}$ , $V_{AX} = 0\text{ V}$ , $5\text{ V}$ , or $V_{DD}$ , $V_{EN} = 5\text{ V}$ or $V_{DD}$	$25^\circ\text{C}$		9		$\mu\text{A}$
$I_{DD(DISABLE)}$	$V_{DD}$ supply current (disable mode)	$V_{DD} = V_{FP} = 22\text{ V}$ , $V_{SS} = V_{FN} = -22\text{ V}$ , $V_{AX} = 0\text{ V}$ , $5\text{ V}$ , or $V_{DD}$ , $V_{EN} = 0\text{ V}$	$25^\circ\text{C}$		0.15	0.5	mA
			$-40^\circ\text{C}$ to $+85^\circ\text{C}$			0.5	
			$-40^\circ\text{C}$ to $+125^\circ\text{C}$			0.5	
$I_{SS(DISABLE)}$	$V_{SS}$ supply current (disable mode)	$V_{DD} = V_{FP} = 22\text{ V}$ , $V_{SS} = V_{FN} = -22\text{ V}$ , $V_{AX} = 0\text{ V}$ , $5\text{ V}$ , or $V_{DD}$ , $V_{EN} = 0\text{ V}$	$25^\circ\text{C}$		0.1	0.4	mA
			$-40^\circ\text{C}$ to $+85^\circ\text{C}$			0.4	
			$-40^\circ\text{C}$ to $+125^\circ\text{C}$			0.4	

(1) When  $V_S$  is positive,  $V_D$  is negative. And when  $V_S$  is negative,  $V_D$  is positive.

(2) When  $V_S$  is at a voltage potential,  $V_D$  is floating. And when  $V_D$  is at a voltage potential,  $V_S$  is floating.

## 7.8 12 V Single Supply: Electrical Characteristics

$V_{DD} = +12\text{ V} \pm 10\%$ ,  $V_{SS} = 0\text{ V}$ ,  $GND = 0\text{ V}$  (unless otherwise noted)  
Typical at  $V_{DD} = +12\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $T_A = 25^\circ\text{C}$  (unless otherwise noted)

PARAMETER		TEST CONDITIONS	$T_A$	MIN	TYP	MAX	UNIT
<b>ANALOG SWITCH</b>							
$R_{ON}$	On-resistance	$V_S = 0\text{ V to } 7.8\text{ V}$ , $I_S = -1\text{ mA}$	25°C	180	250		$\Omega$
			-40°C to +85°C			330	
			-40°C to +125°C			390	
$\Delta R_{ON}$	On-resistance mismatch between channels	$V_S = 0\text{ V to } 7.8\text{ V}$ , $I_S = -1\text{ mA}$	25°C	2.5	8		$\Omega$
			-40°C to +85°C			12	
			-40°C to +125°C			13	
$R_{FLAT}$	On-resistance flatness	$V_S = 0\text{ V to } 7.8\text{ V}$ , $I_S = -1\text{ mA}$	25°C	7	30		$\Omega$
			-40°C to +85°C			45	
			-40°C to +125°C			75	
$R_{FLAT}$	On-resistance flatness	$V_S = 1\text{ V to } 7.8\text{ V}$ , $I_S = -1\text{ mA}$	25°C	1.5	7		$\Omega$
			-40°C to +85°C			8	
			-40°C to +125°C			8	
$R_{ON\_DRIFT}$	On-resistance drift	$V_S = 6\text{ V}$ , $I_S = -1\text{ mA}$	-40°C to +125°C		1		$\Omega/^\circ\text{C}$
$I_{S(OFF)}$	Source off leakage current <sup>(1)</sup>	$V_{DD} = 13.2\text{ V}$ , $V_{SS} = 0\text{ V}$ Switch state is off $V_S = 10\text{ V} / 1\text{ V}$ $V_D = 1\text{ V} / 10\text{ V}$	25°C	-1	0.1	1	nA
			-40°C to +85°C			-1	
			-40°C to +125°C			-4	
$I_{D(OFF)}$	Drain off leakage current <sup>(1)</sup>	$V_{DD} = 13.2\text{ V}$ , $V_{SS} = 0\text{ V}$ Switch state is off $V_S = 10\text{ V} / 1\text{ V}$ $V_D = 1\text{ V} / 10\text{ V}$	25°C	-1	0.1	1	nA
			-40°C to +85°C			-3	
			-40°C to +125°C			-14	
$I_{S(ON)}$ $I_{D(ON)}$	Output on leakage current <sup>(2)</sup>	$V_{DD} = 13.2\text{ V}$ , $V_{SS} = 0\text{ V}$ Switch state is on $V_S = V_D = 10\text{ V or } 1\text{ V}$	25°C	-1.5	0.3	1.5	nA
			-40°C to +85°C			-5	
			-40°C to +125°C			-22	
<b>FAULT CONDITION</b>							
$I_{S(FA)}$	Input leakage current during overvoltage	$V_S = \pm 60\text{ V}$ , $GND = 0\text{ V}$ , $V_{DD} = V_{FP} = 13.2\text{ V}$ , $V_{SS} = V_{FN} = 0\text{ V}$	-40°C to +125°C		$\pm 145$		$\mu\text{A}$
$I_{S(FA)}$ Grounded	Input leakage current during overvoltage with grounded supply voltages	$V_S = \pm 60\text{ V}$ , $GND = 0\text{ V}$ , $V_{DD} = V_{SS} = V_{FP} = V_{FN} = 0\text{ V}$	-40°C to +125°C		$\pm 135$		$\mu\text{A}$
$I_{S(FA)}$ Floating	Input leakage current during overvoltage with floating supply voltages	$V_S = \pm 60\text{ V}$ , $GND = 0\text{ V}$ , $V_{DD} = V_{SS} = V_{FP} = V_{FN} = \text{floating}$	-40°C to +125°C		$\pm 135$		$\mu\text{A}$
$I_{D(FA)}$	Output leakage current during overvoltage	$V_S = \pm 60\text{ V}$ , $GND = 0\text{ V}$ , $V_{DD} = V_{FP} = 13.2\text{ V}$ , $V_{SS} = V_{FN} = 0\text{ V}$ $1\text{ V} \leq V_D \leq 13.2\text{ V}$	25°C	-50	$\pm 10$	50	nA
			-40°C to +85°C			-70	
			-40°C to +125°C			-90	
$I_{D(FA)}$ Grounded	Output leakage current during overvoltage with grounded supply voltages	$V_S = \pm 60\text{ V}$ , $GND = 0\text{ V}$ , $V_{DD} = V_{SS} = V_{FP} = V_{FN} = 0\text{ V}$	25°C	-50	$\pm 1$	50	nA
			-40°C to +85°C			-100	
			-40°C to +125°C			-500	
$I_{D(FA)}$ Floating	Output leakage current during overvoltage with floating supply voltages	$V_S = \pm 60\text{ V}$ , $GND = 0\text{ V}$ , $V_{DD} = V_{SS} = V_{FP} = V_{FN} = \text{floating}$	25°C		$\pm 3$		$\mu\text{A}$
			-40°C to +85°C			$\pm 5$	
			-40°C to +125°C			$\pm 8$	
<b>LOGIC INPUT/ OUTPUT</b>							
$I_{IH}$	High-level input current	$V_{EN} = V_{Ax} = V_{DD}$	25°C	-2	$\pm 0.6$	2	$\mu\text{A}$
			-40°C to +125°C			-2	2
$I_{IL}$	Low-level input current	$V_{EN} = V_{Ax} = 0\text{ V}$	25°C	-1.1	$\pm 0.6$	1.1	$\mu\text{A}$
			-40°C to +125°C			-1.2	1.2

### 7.8 12 V Single Supply: Electrical Characteristics (continued)

$V_{DD} = +12\text{ V} \pm 10\%$ ,  $V_{SS} = 0\text{ V}$ ,  $GND = 0\text{ V}$  (unless otherwise noted)

Typical at  $V_{DD} = +12\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $T_A = 25^\circ\text{C}$  (unless otherwise noted)

PARAMETER		TEST CONDITIONS	$T_A$	MIN	TYP	MAX	UNIT
<b>SWITCHING CHARACTERISTICS</b>							
$t_{ON(EN)}$	Enable turn-on time	$V_S = 8\text{ V}$ , $R_L = 4\text{ k}\Omega$ , $C_L = 12\text{ pF}$	25°C	160	265	ns	
			-40°C to +85°C	285			
			-40°C to +125°C	300			
$t_{OFF(EN)}$	Enable turn-off time	$V_S = 8\text{ V}$ , $R_L = 4\text{ k}\Omega$ , $C_L = 12\text{ pF}$	25°C	420	485	ns	
			-40°C to +85°C	485			
			-40°C to +125°C	500			
$t_{TRAN}$	Transition time	$V_S = 8\text{ V}$ , $R_L = 4\text{ k}\Omega$ , $C_L = 12\text{ pF}$	25°C	160	215	ns	
			-40°C to +85°C	230			
			-40°C to +125°C	240			
$t_{RESPONSE}$	Fault response time	$V_{FP} = 12\text{ V}$ , $V_{FN} = 0\text{ V}$ , $R_L = 4\text{ k}\Omega$ , $C_L = 12\text{ pF}$	25°C	220	ns		
$t_{RECOVERY}$	Fault recovery time	$V_{FP} = 12\text{ V}$ , $V_{FN} = 0\text{ V}$ , $R_L = 4\text{ k}\Omega$ , $C_L = 12\text{ pF}$	25°C	0.69	$\mu\text{s}$		
$t_{RESPONSE(FLAG)}$	Fault flag response time	$V_{FP} = 12\text{ V}$ , $V_{FN} = 0\text{ V}$ , $V_{PU} = 5\text{ V}$ , $R_{PU} = 1\text{ k}\Omega$ , $C_L = 12\text{ pF}$	25°C	110	ns		
$t_{RECOVERY(FLAG)}$	Fault flag recovery time	$V_{FP} = 12\text{ V}$ , $V_{FN} = 0\text{ V}$ , $V_{PU} = 5\text{ V}$ , $R_{PU} = 1\text{ k}\Omega$ , $C_L = 12\text{ pF}$	25°C	0.65	$\mu\text{s}$		
$t_{BBM}$	Break-before-make time delay	$V_S = 8\text{ V}$ , $R_L = 4\text{ k}\Omega$ , $C_L = 12\text{ pF}$	-40°C to +125°C	30	90	ns	
$Q_{INJ}$	Charge injection	$V_S = 6\text{ V}$ , $C_L = 1\text{ nF}$	25°C	-11	pC		
$O_{ISO}$	Off-isolation	$R_S = 50\ \Omega$ , $R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ , $V_S = 200\text{ mV}_{RMS}$ , $V_{BIAS} = 6\text{ V}$ , $f = 1\text{ MHz}$	25°C	-76	dB		
$X_{TALK}$	Intra-channel crosstalk	$R_S = 50\ \Omega$ , $R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ , $V_S = 200\text{ mV}_{RMS}$ , $V_{BIAS} = 6\text{ V}$ , $f = 1\text{ MHz}$	25°C	-93	dB		
	Inter-channel crosstalk (TMUX7349F)			-103			
BW	-3 dB bandwidth (TMUX7348F)	$R_S = 50\ \Omega$ , $R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ , $V_S = 200\text{ mV}_{RMS}$ , $V_{BIAS} = 6\text{ V}$	25°C	130	MHz		
	-3 dB bandwidth (TMUX7349F WQFN Package)			250			
	-3 dB bandwidth (TMUX7349F TSSOP Package)			218			
$I_{LOSS}$	Insertion loss	$R_S = 50\ \Omega$ , $R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ , $V_S = 200\text{ mV}_{RMS}$ , $V_{BIAS} = 6\text{ V}$ , $f = 1\text{ MHz}$	25°C	-9	dB		
THD+N	Total harmonic distortion plus noise	$R_S = 40\ \Omega$ , $R_L = 10\text{ k}\Omega$ , $V_S = 6\text{ V}_{PP}$ , $V_{BIAS} = 6\text{ V}$ , $f = 20\text{ Hz to } 20\text{ kHz}$	25°C	0.0022	%		
$C_{S(OFF)}$	Input off-capacitance	$f = 1\text{ MHz}$ , $V_S = 6\text{ V}$	25°C	4	pF		
$C_{D(OFF)}$	Output off-capacitance (TMUX7348F)	$f = 1\text{ MHz}$ , $V_S = 6\text{ V}$	25°C	31	pF		
	Output off-capacitance (TMUX7349F)	$f = 1\text{ MHz}$ , $V_S = 6\text{ V}$	25°C	16			
$C_{S(ON)}$ $C_{D(ON)}$	Input/Output on-capacitance (TMUX7348F)	$f = 1\text{ MHz}$ , $V_S = 6\text{ V}$	25°C	34	pF		
	Input/Output on-capacitance (TMUX7349F)	$f = 1\text{ MHz}$ , $V_S = 6\text{ V}$	25°C	20			
<b>POWER SUPPLY</b>							
$I_{DD}$	$V_{DD}$ supply current	$V_{DD} = V_{FP} = 13.2\text{ V}$ , $V_{SS} = V_{FN} = 0\text{ V}$ , $V_{AX} = 0\text{ V}$ , $5\text{ V}$ , or $V_{DD}$ , $V_{EN} = 5\text{ V}$ or $V_{DD}$	25°C	0.24	0.5	mA	
			-40°C to +85°C	0.5			
			-40°C to +125°C	0.5			
$I_{SS}$	$V_{SS}$ supply current	$V_{DD} = V_{FP} = 13.2\text{ V}$ , $V_{SS} = V_{FN} = 0\text{ V}$ , $V_{AX} = 0\text{ V}$ , $5\text{ V}$ , or $V_{DD}$ , $V_{EN} = 5\text{ V}$ or $V_{DD}$	25°C	0.14	0.4	mA	
			-40°C to +85°C	0.4			
			-40°C to +125°C	0.4			
$I_{GND}$	GND current	$V_{DD} = V_{FP} = 13.2\text{ V}$ , $V_{SS} = V_{FN} = 0\text{ V}$ , $V_{AX} = 0\text{ V}$ , $5\text{ V}$ , or $V_{DD}$ , $V_{EN} = 5\text{ V}$ or $V_{DD}$	25°C	0.075	mA		



## 7.8 12 V Single Supply: Electrical Characteristics (continued)

 $V_{DD} = +12\text{ V} \pm 10\%$ ,  $V_{SS} = 0\text{ V}$ ,  $GND = 0\text{ V}$  (unless otherwise noted)

 Typical at  $V_{DD} = +12\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $T_A = 25^\circ\text{C}$  (unless otherwise noted)

PARAMETER		TEST CONDITIONS	$T_A$	MIN	TYP	MAX	UNIT
$I_{FP}$	$V_{FP}$ supply current	$V_{DD} = V_{FP} = 13.2\text{ V}$ , $V_{SS} = V_{FN} = 0\text{ V}$ , $V_{AX} = 0\text{ V}$ , $5\text{ V}$ , or $V_{DD}$ , $V_{EN} = 5\text{ V}$ or $V_{DD}$	$25^\circ\text{C}$		10		$\mu\text{A}$
$I_{FN}$	$V_{FN}$ supply current	$V_{DD} = V_{FP} = 13.2\text{ V}$ , $V_{SS} = V_{FN} = 0\text{ V}$ , $V_{AX} = 0\text{ V}$ , $5\text{ V}$ , or $V_{DD}$ , $V_{EN} = 5\text{ V}$ or $V_{DD}$	$25^\circ\text{C}$		10		$\mu\text{A}$
$I_{DD(FA)}$	$V_{DD}$ supply current under fault	$V_S = \pm 60\text{ V}$ , $V_{DD} = V_{FP} = 13.2\text{ V}$ , $V_{SS} = V_{FN} = 0\text{ V}$ , $V_{AX} = 0\text{ V}$ , $5\text{ V}$ , or $V_{DD}$ , $V_{EN} = 5\text{ V}$ or $V_{DD}$	$25^\circ\text{C}$		0.25	1	mA
			$-40^\circ\text{C}$ to $+85^\circ\text{C}$			1	
			$-40^\circ\text{C}$ to $+125^\circ\text{C}$			1	
$I_{SS(FA)}$	$V_{SS}$ supply current under fault	$V_S = \pm 60\text{ V}$ , $V_{DD} = V_{FP} = 13.2\text{ V}$ , $V_{SS} = V_{FN} = 0\text{ V}$ , $V_{AX} = 0\text{ V}$ , $5\text{ V}$ , or $V_{DD}$ , $V_{EN} = 5\text{ V}$ or $V_{DD}$	$25^\circ\text{C}$		0.15	0.5	mA
			$-40^\circ\text{C}$ to $+85^\circ\text{C}$			0.5	
			$-40^\circ\text{C}$ to $+125^\circ\text{C}$			0.5	
$I_{GND(FA)}$	GND current under fault	$V_S = \pm 60\text{ V}$ , $V_{DD} = V_{FP} = 13.2\text{ V}$ , $V_{SS} = V_{FN} = 0\text{ V}$ , $V_{AX} = 0\text{ V}$ , $5\text{ V}$ , or $V_{DD}$ , $V_{EN} = 5\text{ V}$ or $V_{DD}$	$25^\circ\text{C}$		0.17		mA
$I_{FP(FA)}$	$V_{FP}$ supply current under fault	$V_S = \pm 60\text{ V}$ , $V_{DD} = V_{FP} = 13.2\text{ V}$ , $V_{SS} = V_{FN} = 0\text{ V}$ , $V_{AX} = 0\text{ V}$ , $5\text{ V}$ , or $V_{DD}$ , $V_{EN} = 5\text{ V}$ or $V_{DD}$	$25^\circ\text{C}$		9		$\mu\text{A}$
$I_{FN(FA)}$	$V_{FN}$ supply current under fault	$V_S = \pm 60\text{ V}$ , $V_{DD} = V_{FP} = 13.2\text{ V}$ , $V_{SS} = V_{FN} = 0\text{ V}$ , $V_{AX} = 0\text{ V}$ , $5\text{ V}$ , or $V_{DD}$ , $V_{EN} = 5\text{ V}$ or $V_{DD}$	$25^\circ\text{C}$		7.5		$\mu\text{A}$
$I_{DD(DISABLE)}$	$V_{DD}$ supply current (disable mode)	$V_{DD} = V_{FP} = 13.2\text{ V}$ , $V_{SS} = V_{FN} = 0\text{ V}$ , $V_{AX} = 0\text{ V}$ , $5\text{ V}$ , or $V_{DD}$ , $V_{EN} = 0\text{ V}$	$25^\circ\text{C}$		0.15	0.5	mA
			$-40^\circ\text{C}$ to $+85^\circ\text{C}$			0.5	
			$-40^\circ\text{C}$ to $+125^\circ\text{C}$			0.5	
$I_{SS(DISABLE)}$	$V_{SS}$ supply current (disable mode)	$V_{DD} = V_{FP} = 13.2\text{ V}$ , $V_{SS} = V_{FN} = 0\text{ V}$ , $V_{AX} = 0\text{ V}$ , $5\text{ V}$ , or $V_{DD}$ , $V_{EN} = 0\text{ V}$	$25^\circ\text{C}$		0.1	0.4	mA
			$-40^\circ\text{C}$ to $+85^\circ\text{C}$			0.4	
			$-40^\circ\text{C}$ to $+125^\circ\text{C}$			0.4	

 (1) When  $V_S$  is  $10\text{ V}$ ,  $V_D$  is  $1\text{ V}$ . Or when  $V_S$  is  $1\text{ V}$ ,  $V_D$  is  $10\text{ V}$ .

 (2) When  $V_S$  is at a voltage potential,  $V_D$  is floating. Or when  $V_D$  is at a voltage potential,  $V_S$  is floating.

### 7.9 36 V Single Supply: Electrical Characteristics

$V_{DD} = +36\text{ V} \pm 10\%$ ,  $V_{SS} = 0\text{ V}$ ,  $GND = 0\text{ V}$  (unless otherwise noted)

Typical at  $V_{DD} = +36\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $T_A = 25^\circ\text{C}$  (unless otherwise noted)

PARAMETER		TEST CONDITIONS	$T_A$	MIN	TYP	MAX	UNIT
<b>ANALOG SWITCH</b>							
$R_{ON}$	On-resistance	$V_S = 0\text{ V to } 28\text{ V}$ , $I_S = -1\text{ mA}$	25°C	180	250		$\Omega$
			-40°C to +85°C		330		
			-40°C to +125°C		390		
$\Delta R_{ON}$	On-resistance mismatch between channels	$V_S = 0\text{ V to } 28\text{ V}$ , $I_S = -1\text{ mA}$	25°C	2.5	8		$\Omega$
			-40°C to +85°C		12		
			-40°C to +125°C		13		
$R_{FLAT}$	On-resistance flatness	$V_S = 0\text{ V to } 30\text{ V}$ , $I_S = -1\text{ mA}$	25°C	8	65		$\Omega$
			-40°C to +85°C		75		
			-40°C to +125°C		90		
$R_{FLAT}$	On-resistance flatness	$V_S = 1\text{ V to } 28\text{ V}$ , $I_S = -1\text{ mA}$	25°C	1.5	3		$\Omega$
			-40°C to +85°C		4		
			-40°C to +125°C		4		
$R_{ON\_DRIFT}$	On-resistance drift	$V_S = 18\text{ V}$ , $I_S = -1\text{ mA}$	-40°C to +125°C		1		$\Omega/^\circ\text{C}$
$I_{S(OFF)}$	Source off leakage current <sup>(1)</sup>	$V_{DD} = 39.6\text{ V}$ , $V_{SS} = 0\text{ V}$ Switch state is off $V_S = 30\text{ V} / 1\text{ V}$ $V_D = 1\text{ V} / 30\text{ V}$	25°C	-1	0.1	1	nA
			-40°C to +85°C		-1	1	
			-40°C to +125°C		-4	4	
$I_{D(OFF)}$	Output on leakage current <sup>(2)</sup>	$V_{DD} = 39.6\text{ V}$ , $V_{SS} = 0\text{ V}$ Switch state is off $V_S = 30\text{ V} / 1\text{ V}$ $V_D = 1\text{ V} / 30\text{ V}$	25°C	-1	0.1	1	nA
			-40°C to +85°C		-3	3	
			-40°C to +125°C		-14	14	
$I_{S(ON)}$ $I_{D(ON)}$	Output on leakage current <sup>(1)</sup>	$V_{DD} = 39.6\text{ V}$ , $V_{SS} = 0\text{ V}$ Switch state is on $V_S = V_D = 30\text{ V or } 1\text{ V}$	25°C	-1.5	0.3	1.5	nA
			-40°C to +85°C		-5	5	
			-40°C to +125°C		-22	22	
<b>FAULT CONDITION</b>							
$I_{S(FA)}$	Input leakage current during overvoltage	$V_S = 60 / -40\text{ V}$ , $GND = 0\text{ V}$ $V_{DD} = V_{FP} = 39.6\text{ V}$ , $V_{SS} = V_{FN} = 0\text{ V}$	-40°C to +125°C		$\pm 110$		$\mu\text{A}$
$I_{S(FA)} \text{ Grounded}$	Input leakage current during overvoltage with grounded supply voltages	$V_S = \pm 60\text{ V}$ , $GND = 0\text{ V}$ $V_{DD} = V_{SS} = V_{FP} = V_{FN} = 0\text{ V}$	-40°C to +125°C		$\pm 135$		$\mu\text{A}$
$I_{S(FA)} \text{ Floating}$	Input leakage current during overvoltage with floating supply voltages	$V_S = \pm 60\text{ V}$ , $GND = 0\text{ V}$ $V_{DD} = V_{SS} = V_{FP} = V_{FN} = \text{floating}$	-40°C to +125°C		$\pm 135$		$\mu\text{A}$
$I_{D(FA)}$	Output leakage current during overvoltage	$V_S = 60 / -40\text{ V}$ , $GND = 0\text{ V}$ , $V_{DD} = V_{FP} = 39.6\text{ V}$ , $V_{SS} = V_{FN} = 0\text{ V}$ $1\text{ V} \leq V_D \leq 39.6\text{ V}$	25°C	-50	$\pm 10$	50	nA
			-40°C to +85°C		-70	70	
			-40°C to +125°C		-90	90	
$I_{D(FA)} \text{ Grounded}$	Output leakage current during overvoltage with grounded supply voltages	$V_S = \pm 60\text{ V}$ , $GND = 0\text{ V}$ , $V_{DD} = V_{SS} = V_{FP} = V_{FN} = 0\text{ V}$	25°C	-50	$\pm 1$	50	nA
			-40°C to +85°C		-100	100	
			-40°C to +125°C		-500	500	
$I_{D(FA)} \text{ Floating}$	Output leakage current during overvoltage with floating supply voltages	$V_S = \pm 60\text{ V}$ , $GND = 0\text{ V}$ , $V_{DD} = V_{SS} = V_{FP} = V_{FN} = \text{floating}$	25°C		$\pm 3$		$\mu\text{A}$
			-40°C to +85°C		$\pm 5$		
			-40°C to +125°C		$\pm 8$		
<b>LOGIC INPUT/ OUTPUT</b>							
$I_{IH}$	High-level input current	$V_{EN} = V_{Ax} = V_{DD}$	25°C	-3.2	$\pm 0.6$	3.2	$\mu\text{A}$
			-40°C to +125°C		-3.2	3.2	
$I_{IL}$	Low-level input current	$V_{EN} = V_{Ax} = 0\text{ V}$	25°C	-1.1	$\pm 0.6$	1.1	$\mu\text{A}$
			-40°C to +125°C		-1.2	1.2	

## 7.9 36 V Single Supply: Electrical Characteristics (continued)

 $V_{DD} = +36\text{ V} \pm 10\%$ ,  $V_{SS} = 0\text{ V}$ ,  $GND = 0\text{ V}$  (unless otherwise noted)

 Typical at  $V_{DD} = +36\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $T_A = 25^\circ\text{C}$  (unless otherwise noted)

PARAMETER		TEST CONDITIONS	$T_A$	MIN	TYP	MAX	UNIT
<b>SWITCHING CHARACTERISTICS</b>							
$t_{ON(EN)}$	Enable turn-on time	$V_S = 18\text{ V}$ , $R_L = 4\text{ k}\Omega$ , $C_L = 12\text{ pF}$	25°C	185	390		ns
			-40°C to +85°C			460	
			-40°C to +125°C			530	
$t_{OFF(EN)}$	Enable turn-off time	$V_S = 18\text{ V}$ , $R_L = 4\text{ k}\Omega$ , $C_L = 12\text{ pF}$	25°C	380	450		ns
			-40°C to +85°C			450	
			-40°C to +125°C			450	
$t_{TRAN}$	Transition time	$V_S = 18\text{ V}$ , $R_L = 4\text{ k}\Omega$ , $C_L = 12\text{ pF}$	25°C	185	230		ns
			-40°C to +85°C			245	
			-40°C to +125°C			255	
$t_{RESPONSE}$	Fault response time	$V_{FP} = 36\text{ V}$ , $V_{FN} = 0\text{ V}$ , $R_L = 4\text{ k}\Omega$ , $C_L = 12\text{ pF}$	25°C		210		ns
$t_{RECOVERY}$	Fault recovery time	$V_{FP} = 36\text{ V}$ , $V_{FN} = 0\text{ V}$ , $R_L = 4\text{ k}\Omega$ , $C_L = 12\text{ pF}$	25°C		0.67		$\mu\text{s}$
$t_{RESPONSE(FLAG)}$	Fault flag response time	$V_{FP} = 36\text{ V}$ , $V_{FN} = 0\text{ V}$ , $V_{PU} = 5\text{ V}$ , $R_{PU} = 1\text{ k}\Omega$ , $C_L = 12\text{ pF}$	25°C		110		ns
$t_{RECOVERY(FLAG)}$	Fault flag recovery time	$V_{FP} = 36\text{ V}$ , $V_{FN} = 0\text{ V}$ , $V_{PU} = 5\text{ V}$ , $R_{PU} = 1\text{ k}\Omega$ , $C_L = 12\text{ pF}$	25°C		0.65		$\mu\text{s}$
$t_{BBM}$	Break-before-make time delay	$V_S = 18\text{ V}$ , $R_L = 4\text{ k}\Omega$ , $C_L = 12\text{ pF}$	-40°C to +125°C	50	100		ns
$Q_{INJ}$	Charge injection	$V_S = 18\text{ V}$ , $C_L = 1\text{ nF}$	25°C		-16		pC
$O_{ISO}$	Off-isolation	$R_S = 50\ \Omega$ , $R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ , $V_S = 200\text{ mV}_{RMS}$ , $V_{BIAS} = 6\text{ V}$ , $f = 1\text{ MHz}$	25°C		-78		dB
$X_{TALK}$	Intra-channel crosstalk	$R_S = 50\ \Omega$ , $R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ , $V_S = 200\text{ mV}_{RMS}$ , $V_{BIAS} = 6\text{ V}$ , $f = 1\text{ MHz}$	25°C		-95		dB
	Inter-channel crosstalk (TMUX7349F)				-103		
BW	-3 dB bandwidth (TMUX7348F)	$R_S = 50\ \Omega$ , $R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ , $V_S = 200\text{ mV}_{RMS}$ , $V_{BIAS} = 6\text{ V}$	25°C		130		MHz
	-3 dB bandwidth (TMUX7349F WQFN Package)				255		
	-3 dB bandwidth (TMUX7349F TSSOP Package)				220		
$I_{LOSS}$	Insertion loss	$R_S = 50\ \Omega$ , $R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ , $V_S = 200\text{ mV}_{RMS}$ , $V_{BIAS} = 6\text{ V}$ , $f = 1\text{ MHz}$	25°C		-9		dB
THD+N	Total harmonic distortion plus noise	$R_S = 40\ \Omega$ , $R_L = 10\text{ k}\Omega$ , $V_S = 18\text{ V}_{PP}$ , $V_{BIAS} = 18\text{ V}$ , $f = 20\text{ Hz to } 20\text{ kHz}$	25°C		0.0014		%
$C_{S(OFF)}$	Input off-capacitance	$f = 1\text{ MHz}$ , $V_S = 18\text{ V}$	25°C		4		pF
$C_{D(OFF)}$	Output off-capacitance (TMUX7348F)	$f = 1\text{ MHz}$ , $V_S = 18\text{ V}$	25°C		31		pF
	Output off-capacitance (TMUX7349F)	$f = 1\text{ MHz}$ , $V_S = 18\text{ V}$	25°C		16		
$C_{S(ON)}$ $C_{D(ON)}$	Input/Output on-capacitance (TMUX7348F)	$f = 1\text{ MHz}$ , $V_S = 18\text{ V}$	25°C		34		pF
	Input/Output on-capacitance (TMUX7349F)	$f = 1\text{ MHz}$ , $V_S = 18\text{ V}$	25°C		19		
<b>POWER SUPPLY</b>							
$I_{DD}$	$V_{DD}$ supply current	$V_{DD} = V_{FP} = 39.6\text{ V}$ , $V_{SS} = V_{FN} = 0\text{ V}$ , $V_{AX} = 0\text{ V}$ , 5 V, or $V_{DD}$ , $V_{EN} = 5\text{ V}$ or $V_{DD}$	25°C	0.24	0.5		mA
			-40°C to +85°C			0.5	
			-40°C to +125°C			0.5	
$I_{SS}$	$V_{SS}$ supply current	$V_{DD} = V_{FP} = 39.6\text{ V}$ , $V_{SS} = V_{FN} = 0\text{ V}$ , $V_{AX} = 0\text{ V}$ , 5 V, or $V_{DD}$ , $V_{EN} = 5\text{ V}$ or $V_{DD}$	25°C	0.14	0.4		mA
			-40°C to +85°C			0.4	
			-40°C to +125°C			0.4	
$I_{GND}$	GND current	$V_{DD} = V_{FP} = 39.6\text{ V}$ , $V_{SS} = V_{FN} = 0\text{ V}$ , $V_{AX} = 0\text{ V}$ , 5 V, or $V_{DD}$ , $V_{EN} = 5\text{ V}$ or $V_{DD}$	25°C		0.075		mA

### 7.9 36 V Single Supply: Electrical Characteristics (continued)

$V_{DD} = +36\text{ V} \pm 10\%$ ,  $V_{SS} = 0\text{ V}$ ,  $GND = 0\text{ V}$  (unless otherwise noted)

Typical at  $V_{DD} = +36\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $T_A = 25^\circ\text{C}$  (unless otherwise noted)

PARAMETER		TEST CONDITIONS	$T_A$	MIN	TYP	MAX	UNIT
$I_{FP}$	$V_{FP}$ supply current	$V_{DD} = V_{FP} = 39.6\text{ V}$ , $V_{SS} = V_{FN} = 0\text{ V}$ , $V_{AX} = 0\text{ V}$ , $5\text{ V}$ , or $V_{DD}$ , $V_{EN} = 5\text{ V}$ or $V_{DD}$	$25^\circ\text{C}$		10		$\mu\text{A}$
$I_{FN}$	$V_{FN}$ supply current	$V_{DD} = V_{FP} = 39.6\text{ V}$ , $V_{SS} = V_{FN} = 0\text{ V}$ , $V_{AX} = 0\text{ V}$ , $5\text{ V}$ , or $V_{DD}$ , $V_{EN} = 5\text{ V}$ or $V_{DD}$	$25^\circ\text{C}$		10		$\mu\text{A}$
$I_{DD(FA)}$	$V_{DD}$ supply current under fault	$V_S = 60 / -40\text{ V}$ , $V_{DD} = V_{FP} = 39.6\text{ V}$ , $V_{SS} = V_{FN} = 0\text{ V}$ , $V_{AX} = 0\text{ V}$ , $5\text{ V}$ , or $V_{DD}$ , $V_{EN} = 5\text{ V}$ or $V_{DD}$	$25^\circ\text{C}$		0.25	1	mA
			$-40^\circ\text{C}$ to $+85^\circ\text{C}$			1	
			$-40^\circ\text{C}$ to $+125^\circ\text{C}$			1	
$I_{SS(FA)}$	$V_{SS}$ supply current under fault	$V_S = 60 / -40\text{ V}$ , $V_{DD} = V_{FP} = 39.6\text{ V}$ , $V_{SS} = V_{FN} = 0\text{ V}$ , $V_{AX} = 0\text{ V}$ , $5\text{ V}$ , or $V_{DD}$ , $V_{EN} = 5\text{ V}$ or $V_{DD}$	$25^\circ\text{C}$		0.15	0.5	mA
			$-40^\circ\text{C}$ to $+85^\circ\text{C}$			0.5	
			$-40^\circ\text{C}$ to $+125^\circ\text{C}$			0.5	
$I_{GND(FA)}$	GND current under fault	$V_S = 60 / -40\text{ V}$ , $V_{DD} = V_{FP} = 39.6\text{ V}$ , $V_{SS} = V_{FN} = 0\text{ V}$ , $V_{AX} = 0\text{ V}$ , $5\text{ V}$ , or $V_{DD}$ , $V_{EN} = 5\text{ V}$ or $V_{DD}$	$25^\circ\text{C}$		0.12		mA
$I_{FP(FA)}$	$V_{FP}$ supply current under fault	$V_S = 60 / -40\text{ V}$ , $V_{DD} = V_{FP} = 39.6\text{ V}$ , $V_{SS} = V_{FN} = 0\text{ V}$ , $V_{AX} = 0\text{ V}$ , $5\text{ V}$ , or $V_{DD}$ , $V_{EN} = 5\text{ V}$ or $V_{DD}$	$25^\circ\text{C}$		9		$\mu\text{A}$
$I_{FN(FA)}$	$V_{FN}$ supply current under fault	$V_S = 60 / -40\text{ V}$ , $V_{DD} = V_{FP} = 39.6\text{ V}$ , $V_{SS} = V_{FN} = 0\text{ V}$ , $V_{AX} = 0\text{ V}$ , $5\text{ V}$ , or $V_{DD}$ , $V_{EN} = 5\text{ V}$ or $V_{DD}$	$25^\circ\text{C}$		7.5		$\mu\text{A}$
$I_{DD(DISABLE)}$	$V_{DD}$ supply current (disable mode)	$V_{DD} = V_{FP} = 39.6\text{ V}$ , $V_{SS} = V_{FN} = 0\text{ V}$ , $V_{AX} = 0\text{ V}$ , $5\text{ V}$ , or $V_{DD}$ , $V_{EN} = 0\text{ V}$	$25^\circ\text{C}$		0.15	0.5	mA
			$-40^\circ\text{C}$ to $+85^\circ\text{C}$			0.5	
			$-40^\circ\text{C}$ to $+125^\circ\text{C}$			0.5	
$I_{SS(DISABLE)}$	$V_{SS}$ supply current (disable mode)	$V_{DD} = V_{FP} = 39.6\text{ V}$ , $V_{SS} = V_{FN} = 0\text{ V}$ , $V_{AX} = 0\text{ V}$ , $5\text{ V}$ , or $V_{DD}$ , $V_{EN} = 0\text{ V}$	$25^\circ\text{C}$		0.1	0.4	mA
			$-40^\circ\text{C}$ to $+85^\circ\text{C}$			0.4	
			$-40^\circ\text{C}$ to $+125^\circ\text{C}$			0.4	

(1) When  $V_S$  is 30 V,  $V_D$  is 1 V. Or when  $V_S$  is 1 V,  $V_D$  is 30 V.

(2) When  $V_S$  is at a voltage potential,  $V_D$  is floating. Or when  $V_D$  is at a voltage potential,  $V_S$  is floating.

## 7.10 Typical Characteristics

at  $T_A = 25^\circ\text{C}$ ,  $V_{DD} = 15\text{ V}$ , and  $V_{SS} = -15\text{ V}$  (unless otherwise noted)

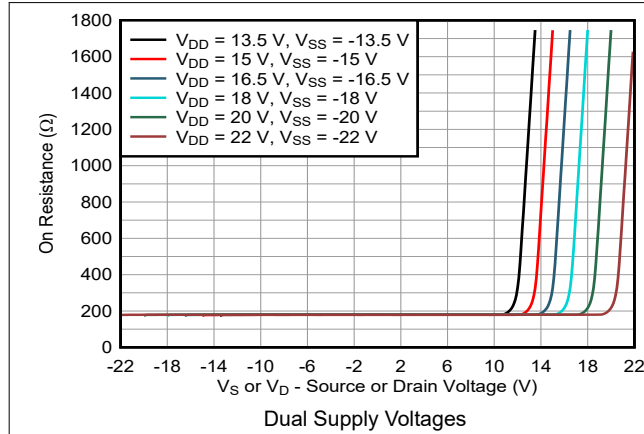


Figure 7-1. On-Resistance vs Source or Drain Voltage

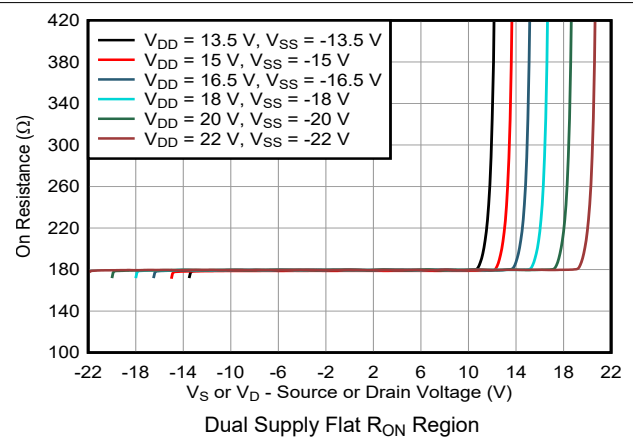


Figure 7-2. On-Resistance vs Source or Drain Voltage

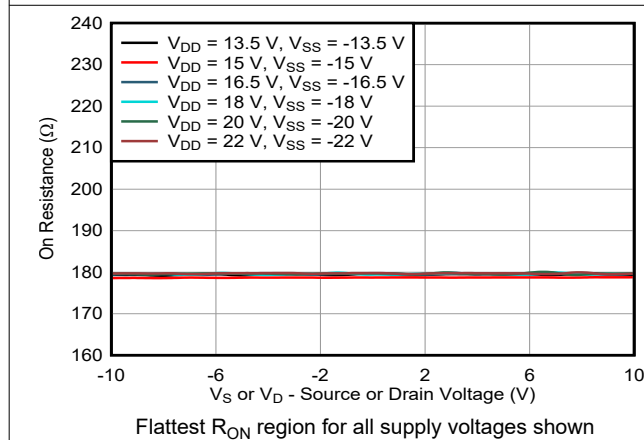


Figure 7-3. On-Resistance vs Source or Drain Voltage

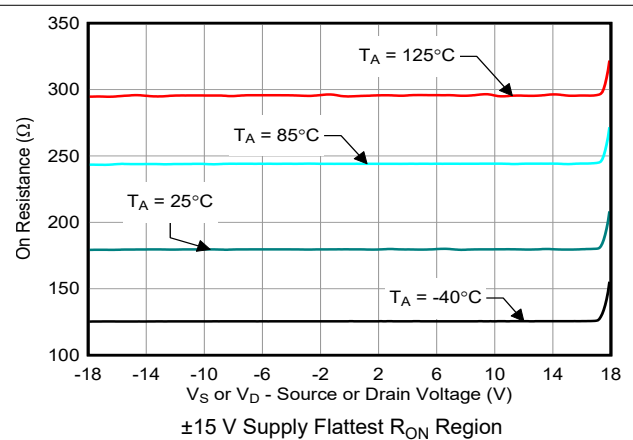


Figure 7-4. On-Resistance vs Source or Drain Voltage

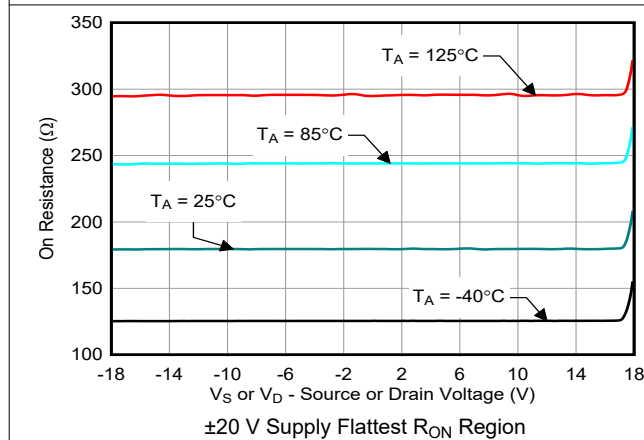


Figure 7-5. On-Resistance vs Source or Drain Voltage

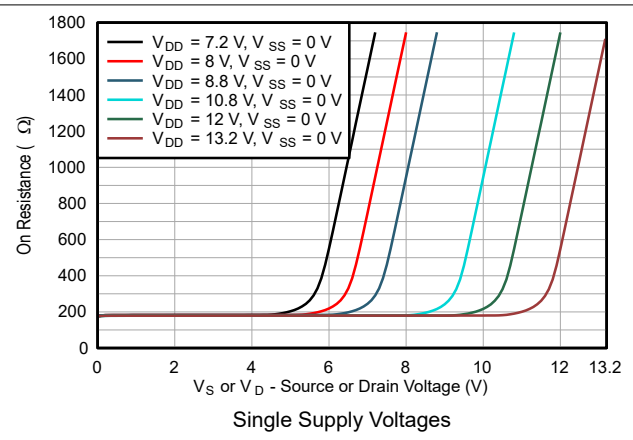


Figure 7-6. On-Resistance vs Source or Drain Voltage

### 7.10 Typical Characteristics (continued)

at  $T_A = 25^\circ\text{C}$ ,  $V_{DD} = 15\text{ V}$ , and  $V_{SS} = -15\text{ V}$  (unless otherwise noted)

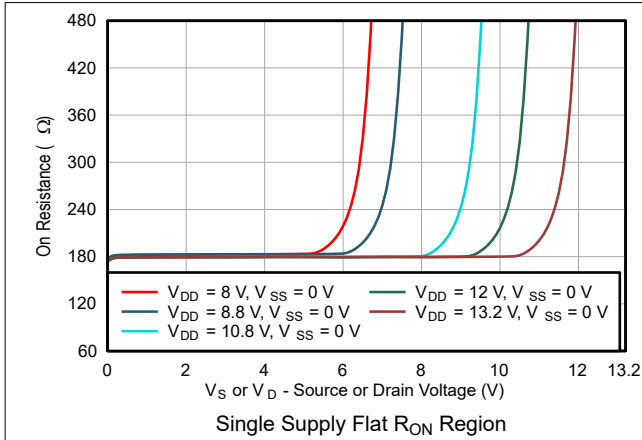


Figure 7-7. On-Resistance vs Source or Drain Voltage

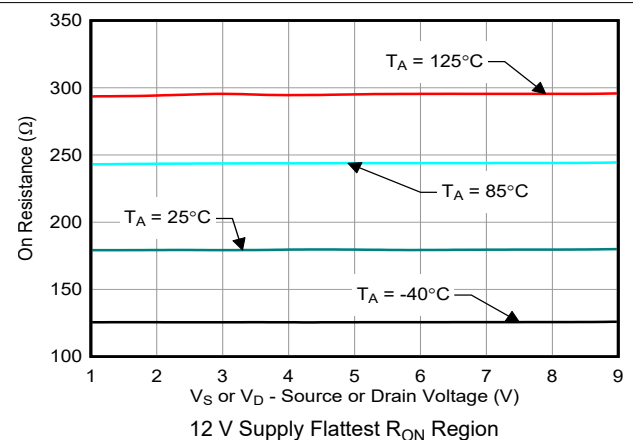


Figure 7-8. On-Resistance vs Source or Drain Voltage

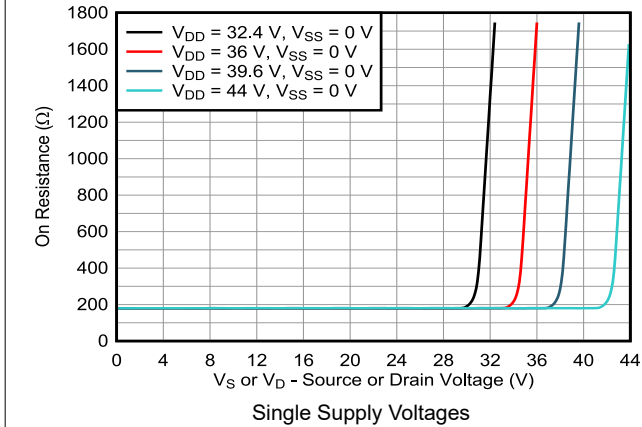


Figure 7-9. On-Resistance vs Source or Drain Voltage

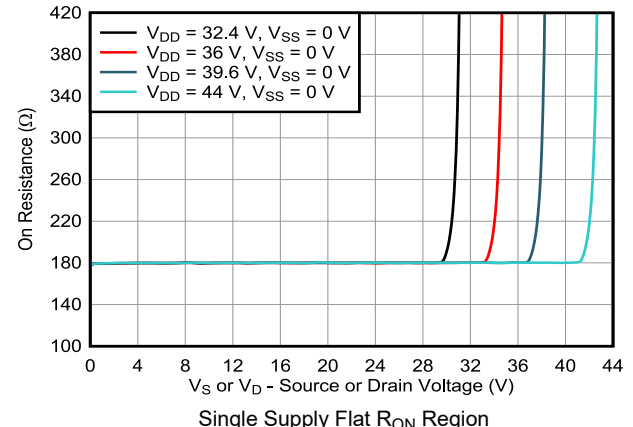


Figure 7-10. On-Resistance vs Source or Drain Voltage

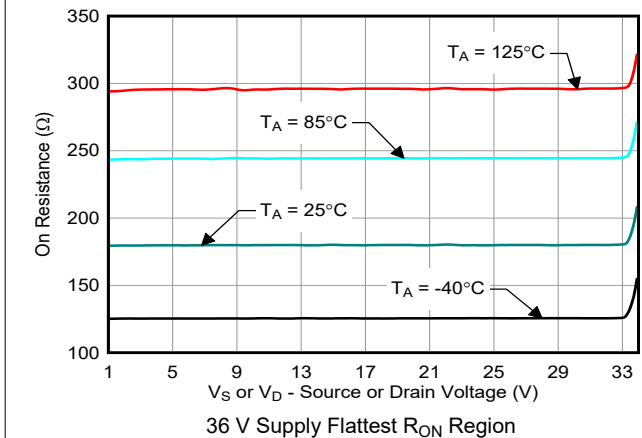


Figure 7-11. On-Resistance vs Source or Drain Voltage

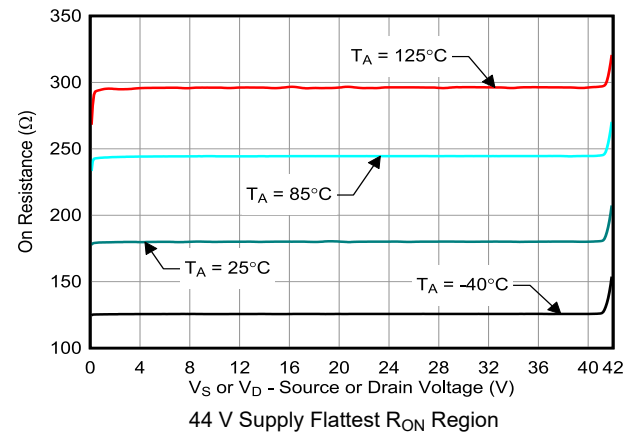
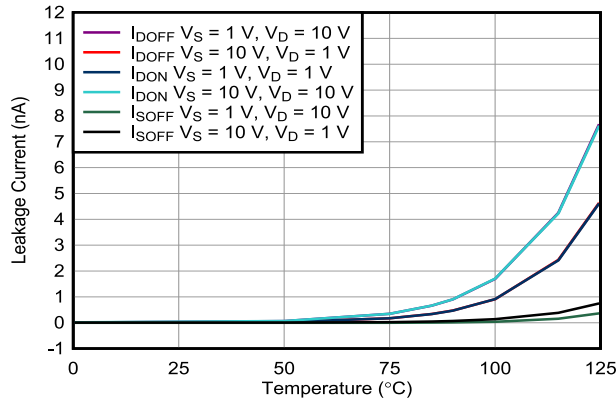


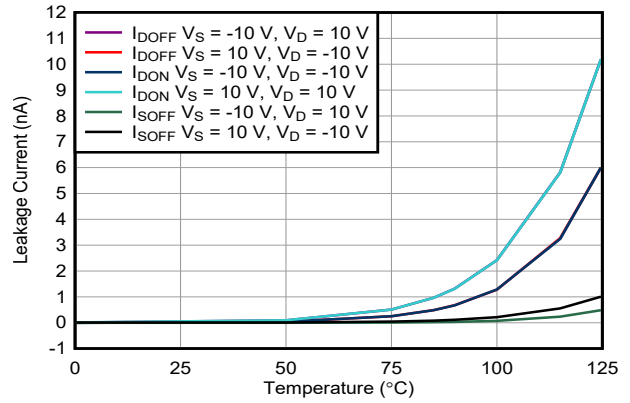
Figure 7-12. On-Resistance vs Source or Drain Voltage

## 7.10 Typical Characteristics (continued)

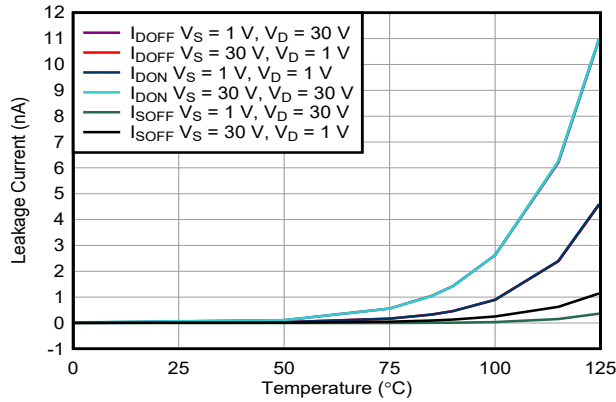
at  $T_A = 25^\circ\text{C}$ ,  $V_{DD} = 15\text{ V}$ , and  $V_{SS} = -15\text{ V}$  (unless otherwise noted)



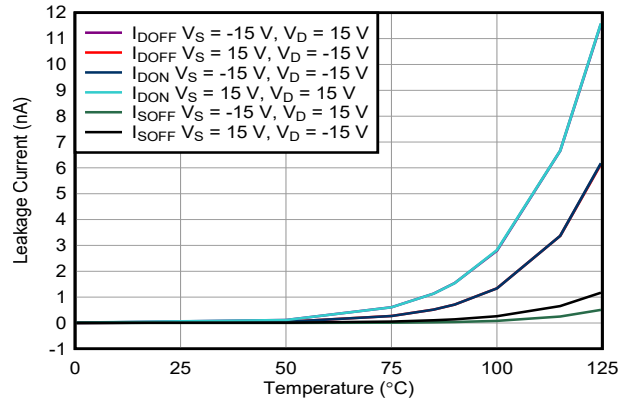
**Figure 7-13. Leakage Current vs Temperature**



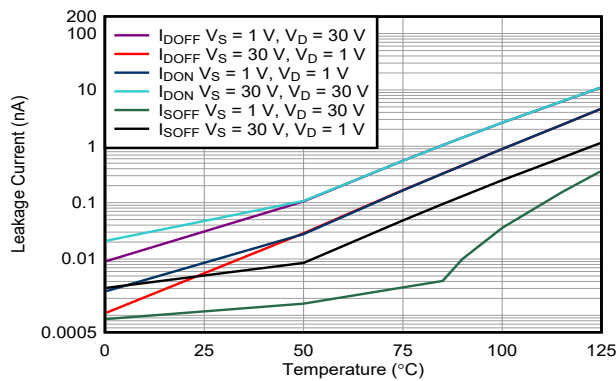
**Figure 7-14. Leakage Current vs Temperature**



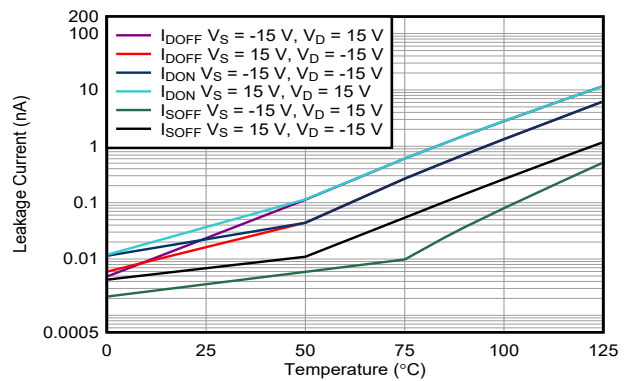
**Figure 7-15. Leakage Current vs Temperature**



**Figure 7-16. Leakage Current vs Temperature**



**Figure 7-17. Leakage Current vs Temperature**



**Figure 7-18. Leakage Current vs Temperature**

### 7.10 Typical Characteristics (continued)

at  $T_A = 25^\circ\text{C}$ ,  $V_{DD} = 15\text{ V}$ , and  $V_{SS} = -15\text{ V}$  (unless otherwise noted)

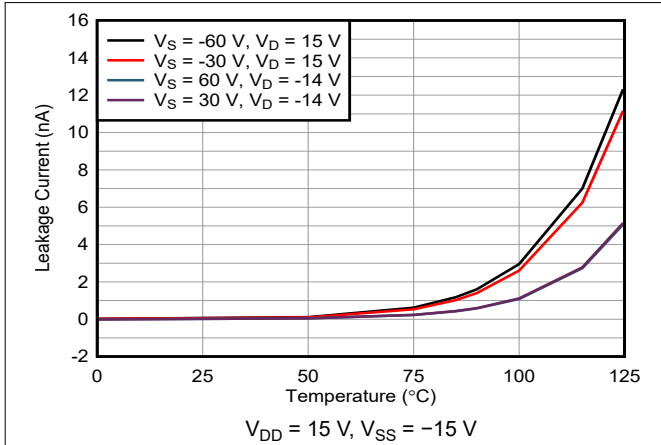


Figure 7-19.  $I_{D(FA)}$  Overvoltage Leakage Current vs Temperature

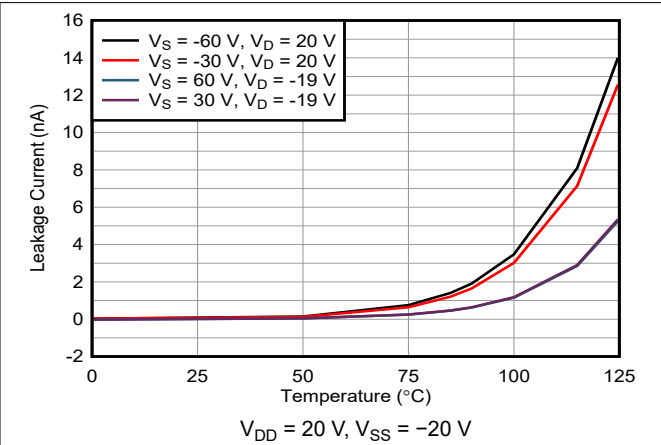


Figure 7-20.  $I_{D(FA)}$  Overvoltage Leakage Current vs Temperature

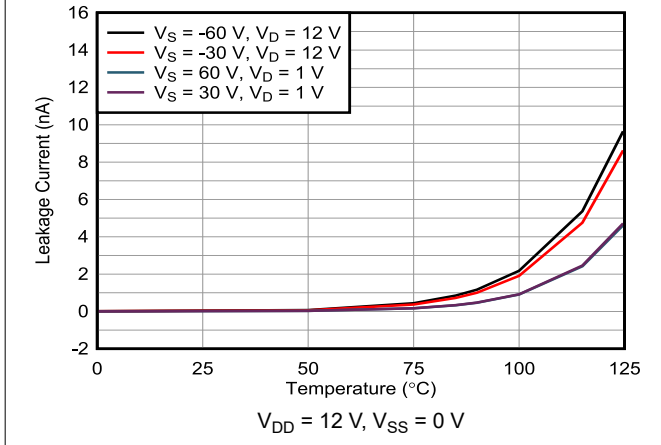


Figure 7-21.  $I_{D(FA)}$  Overvoltage Leakage Current vs Temperature

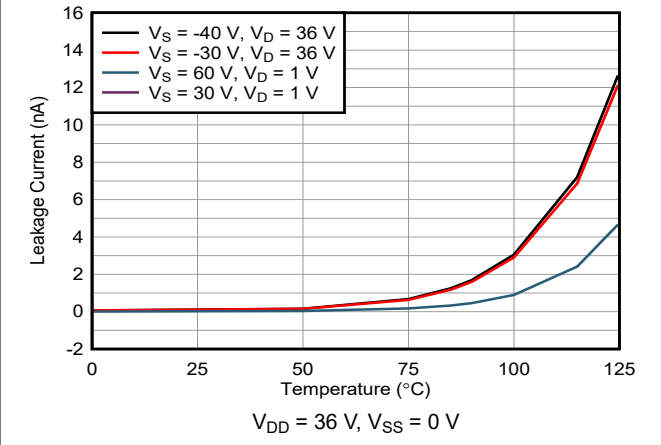


Figure 7-22.  $I_{D(FA)}$  Overvoltage Leakage Current vs Temperature

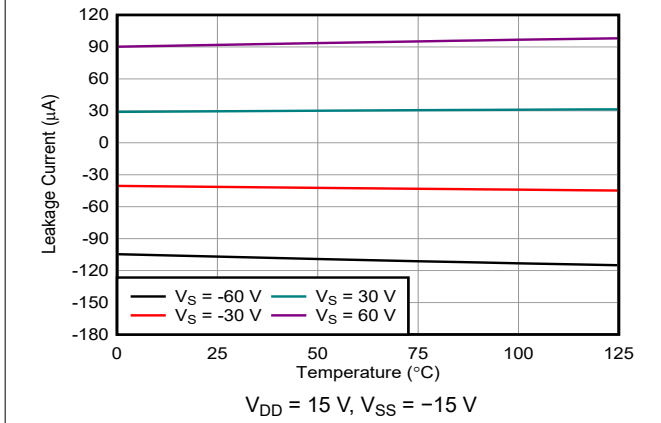


Figure 7-23.  $I_{S(FA)}$  Overvoltage Leakage Current vs Temperature

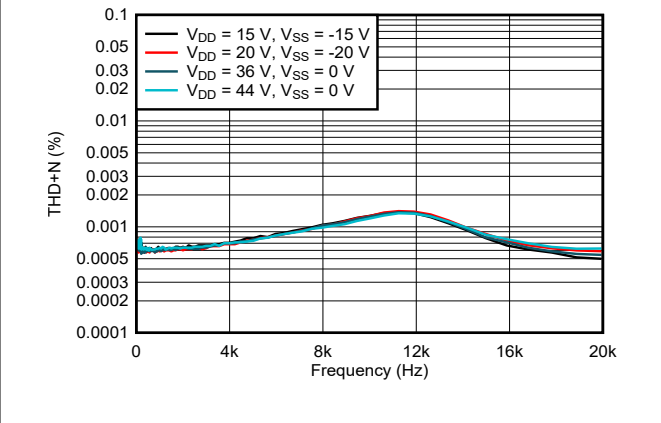
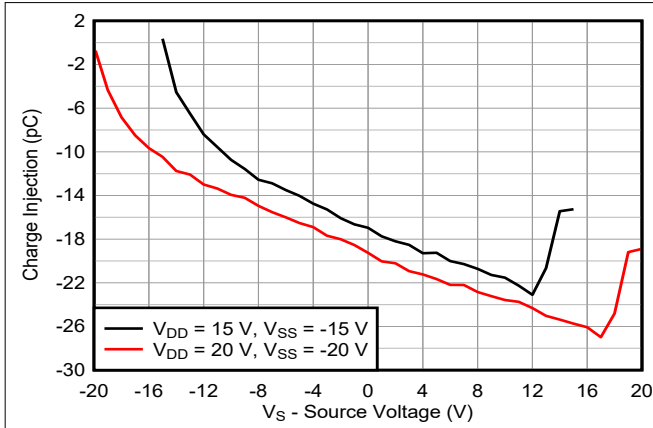


Figure 7-24. THD+N vs Frequency

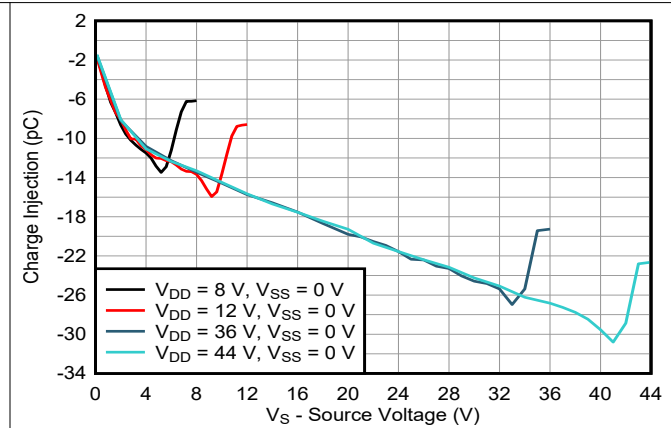


### 7.10 Typical Characteristics (continued)

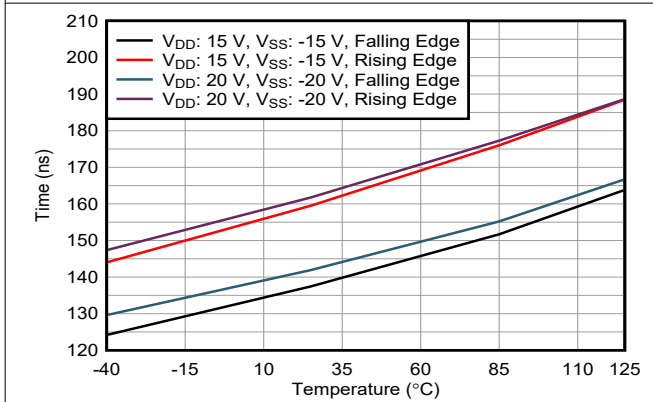
at  $T_A = 25^\circ\text{C}$ ,  $V_{DD} = 15\text{ V}$ , and  $V_{SS} = -15\text{ V}$  (unless otherwise noted)



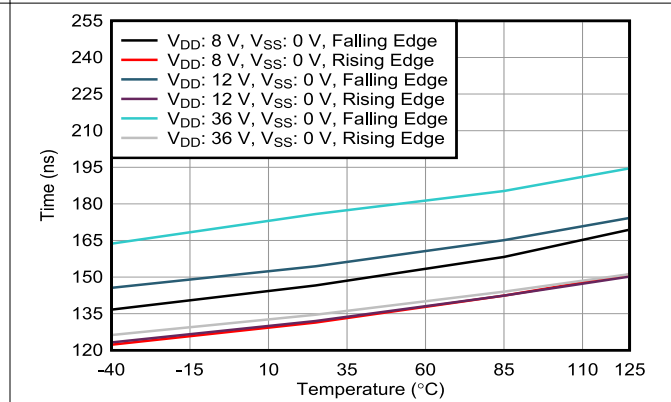
**Figure 7-25. Charge Injection vs Source Voltage – Dual Supply**



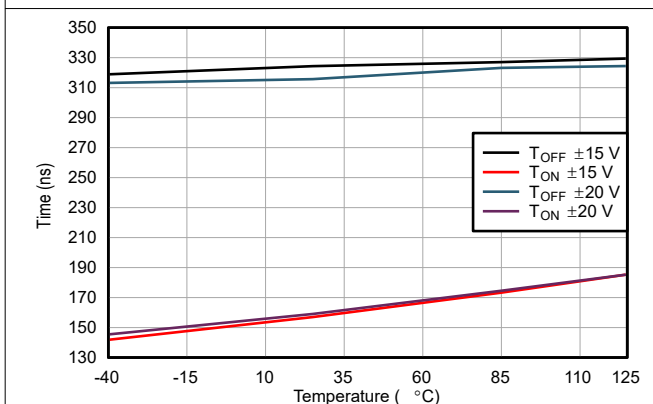
**Figure 7-26. Charge Injection vs Source Voltage – Single Supply**



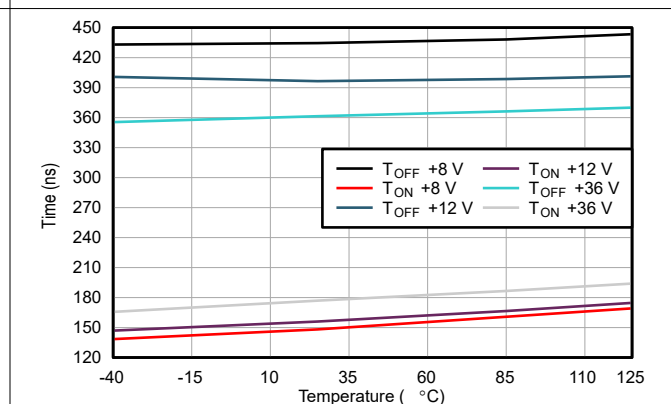
**Figure 7-27. Transition Times vs Temperature**



**Figure 7-28. Transition Times vs Temperature**



**Figure 7-29. Turn-On and Turn-Off Times vs Temperature**



**Figure 7-30. Turn-On and Turn-Off Times vs Temperature**

## 7.10 Typical Characteristics (continued)

at  $T_A = 25^\circ\text{C}$ ,  $V_{DD} = 15\text{ V}$ , and  $V_{SS} = -15\text{ V}$  (unless otherwise noted)

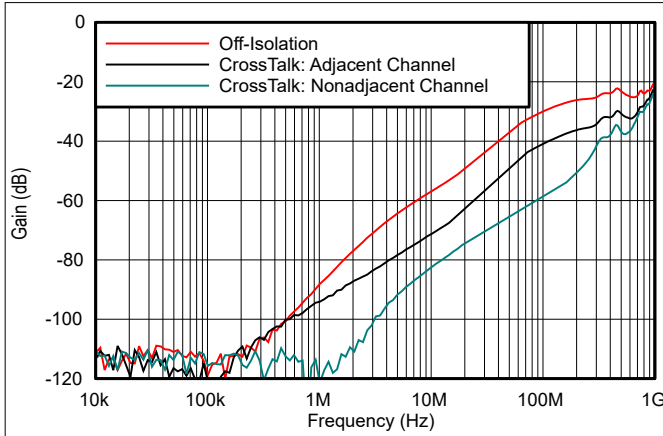


Figure 7-31. Off Isolation and Crosstalk vs Frequency

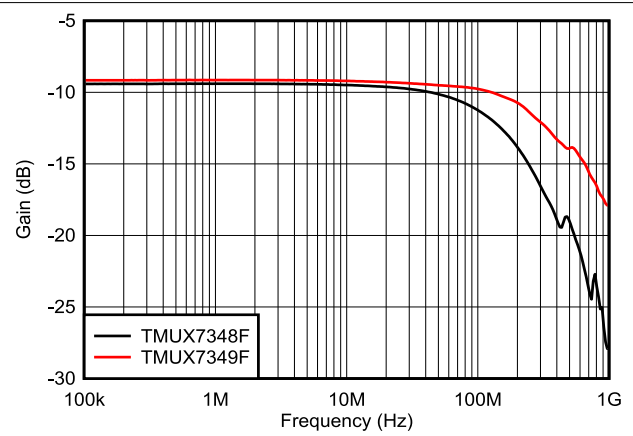


Figure 7-32. On Response vs Frequency

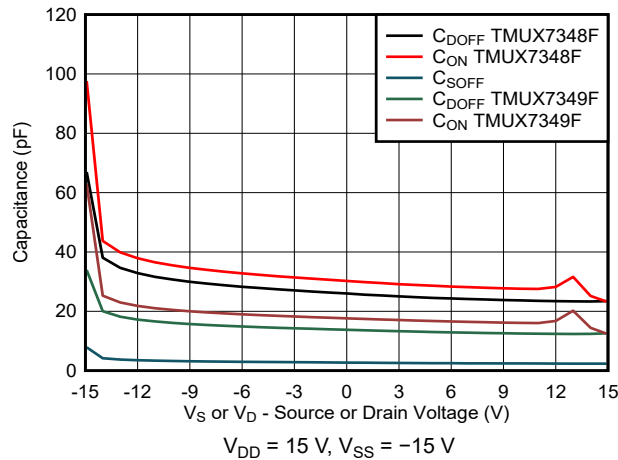


Figure 7-33. Capacitance vs Source or Drain Voltage

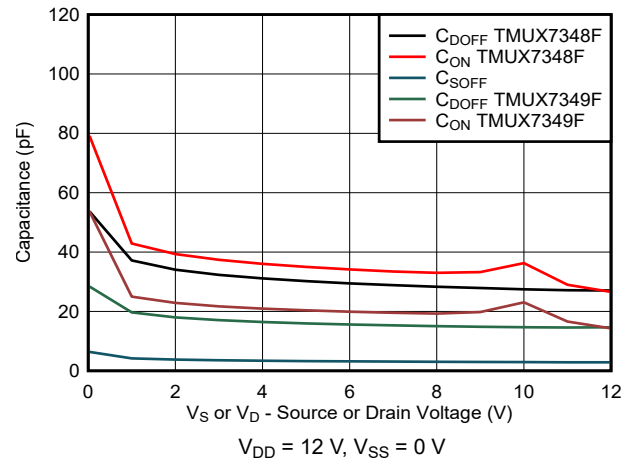


Figure 7-34. Capacitance vs Source or Drain Voltage

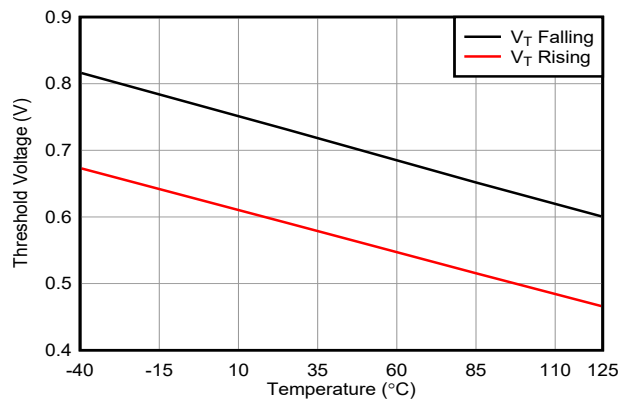


Figure 7-35. Threshold Voltage vs Temperature

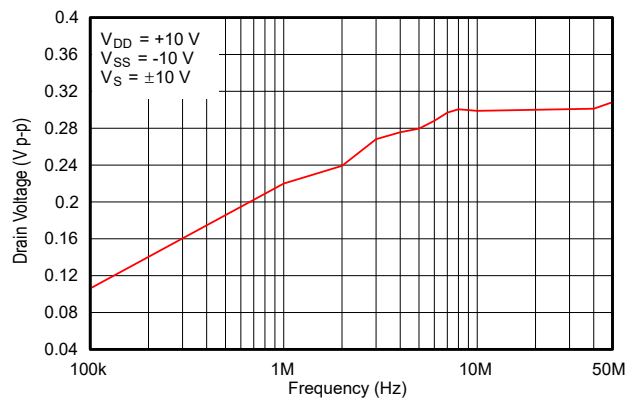


Figure 7-36. Large Signal Voltage Off Isolation vs Frequency

## 7.10 Typical Characteristics (continued)

at  $T_A = 25^\circ\text{C}$ ,  $V_{DD} = 15\text{ V}$ , and  $V_{SS} = -15\text{ V}$  (unless otherwise noted)

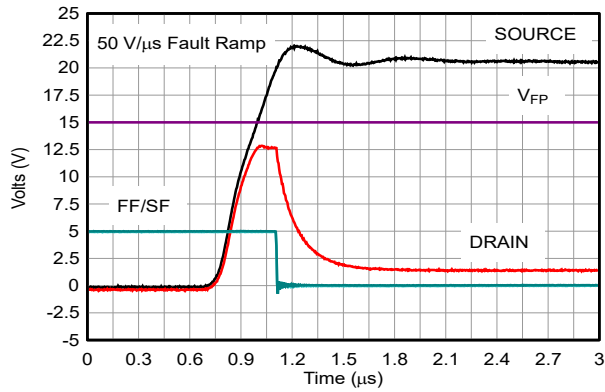


Figure 7-37. Drain Output Response – Positive Overvoltage

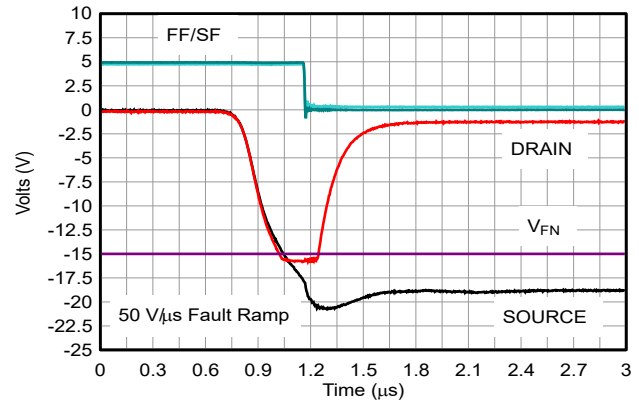


Figure 7-38. Drain Output Response – Negative Overvoltage

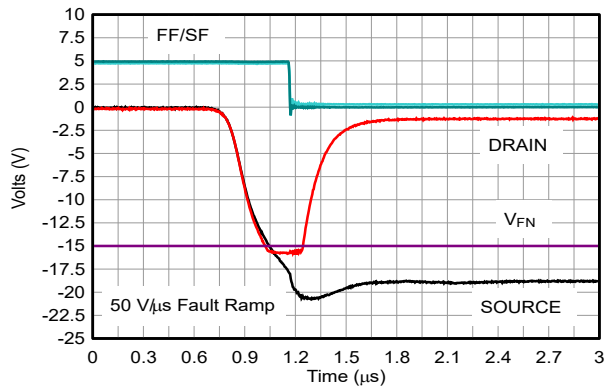


Figure 7-39. Drain Output Recovery – Positive Overvoltage

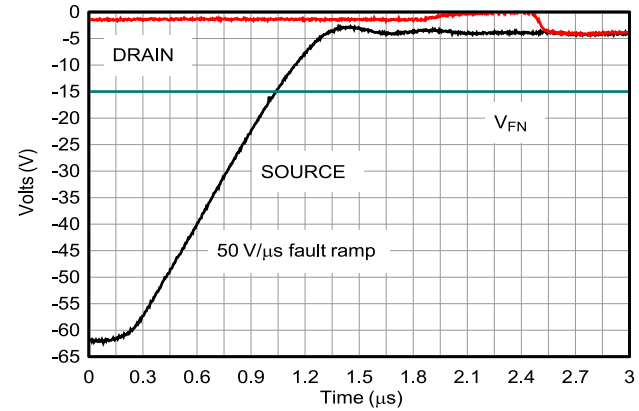


Figure 7-40. Drain Output Recovery – Negative Overvoltage

## 8 Parameter Measurement Information

### 8.1 On-Resistance

The on-resistance of the TMUX7348F and TMUX7349F is the ohmic resistance across the source (Sx) and drain (Dx) pins of the device. The on-resistance varies with input voltage and supply voltage. The symbol  $R_{ON}$  is used to denote on-resistance. Figure 8-1 shows the measurement setup used to measure  $R_{ON}$ .  $\Delta R_{ON}$  represents the difference between the  $R_{ON}$  of any two channels, while  $R_{ON\_FLAT}$  denotes the flatness that is defined as the difference between the maximum and minimum value of on-resistance measured over the specified analog signal range.

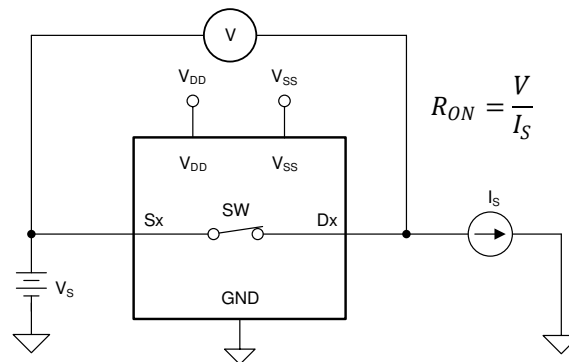


Figure 8-1. On-Resistance Measurement Setup

### 8.2 Off-Leakage Current

There are two types of leakage currents associated with a switch during the off state:

1. Source off-leakage current  $I_{S(OFF)}$ : the leakage current flowing into or out of the source pin when the switch is off.
2. Drain off-leakage current  $I_{D(OFF)}$ : the leakage current flowing into or out of the drain pin when the switch is off.

Figure 8-2 shows the setup used to measure both off-leakage currents.

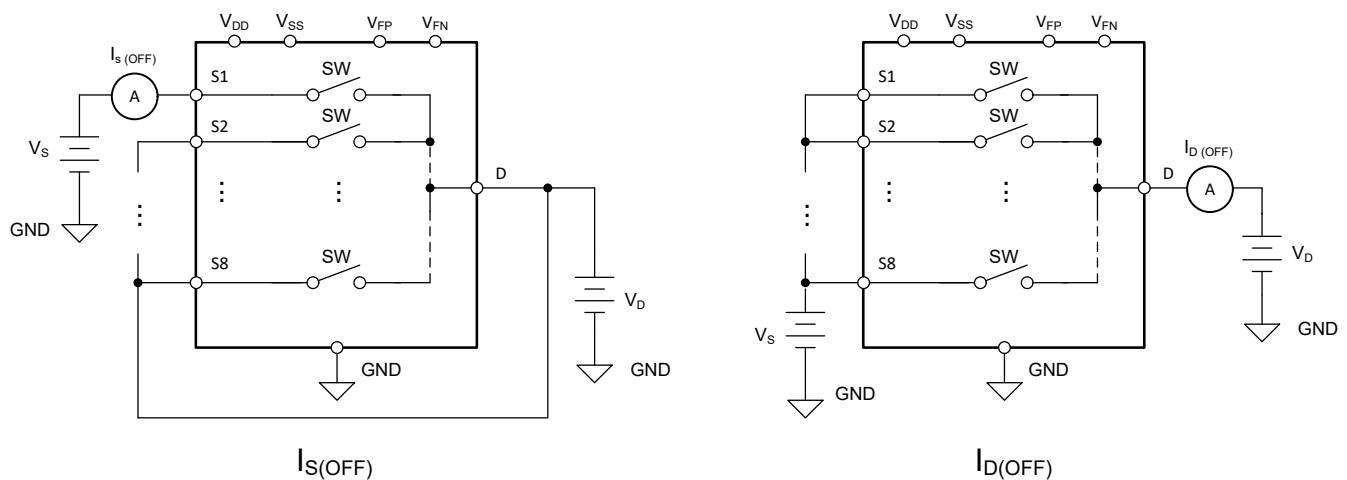


Figure 8-2. Off-Leakage Measurement Setup

### 8.3 On-Leakage Current

Source on-leakage current ( $I_{S(ON)}$ ) and drain on-leakage current ( $I_{D(ON)}$ ) denote the channel leakage currents when the switch is in the on state.  $I_{S(ON)}$  is measured with the drain floating, while  $I_{D(ON)}$  is measured with the source floating. Figure 8-3 shows the circuit used for measuring the on-leakage currents.

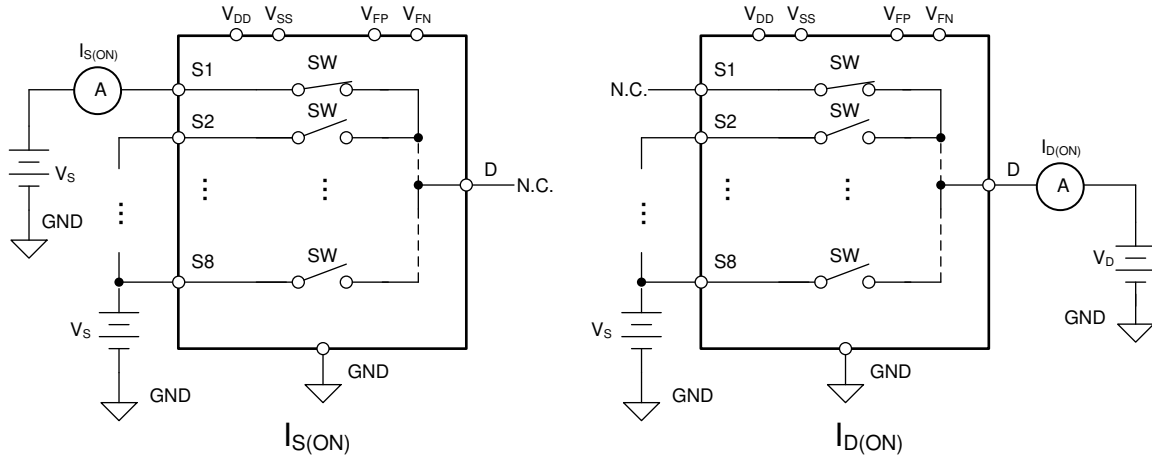


Figure 8-3. On-Leakage Measurement Setup

### 8.4 Input and Output Leakage Current Under Overvoltage Fault

If the voltage for any of the source pins rises above the fault supplies ( $V_{FP}$  or  $V_{FN}$ ), the overvoltage protection feature of the TMUX7348F and TMUX7349F is triggered to turn off the switch under fault, keeping the fault channel in high-impedance state.  $I_{S(FA)}$  and  $I_{D(FA)}$  denotes the input and output leakage current under overvoltage fault conditions, respectively. For  $I_{D(FA)}$ , the device is disabled to measure leakage current on the drain pin without being impacted by the 40 k $\Omega$  impedance to the fault supply. When the overvoltage fault occurs, the supply (or supplies) can either be in normal operating condition (Figure 8-4) or abnormal operating condition (Figure 8-5). During abnormal operating condition, the supply (or supplies) can either be unpowered ( $V_{DD} = V_{SS} = V_{FN} = V_{FP} = 0$  V) or floating ( $V_{DD} = V_{SS} = V_{FN} = V_{FP} =$  no connection), and remains within the leakage performance specifications.

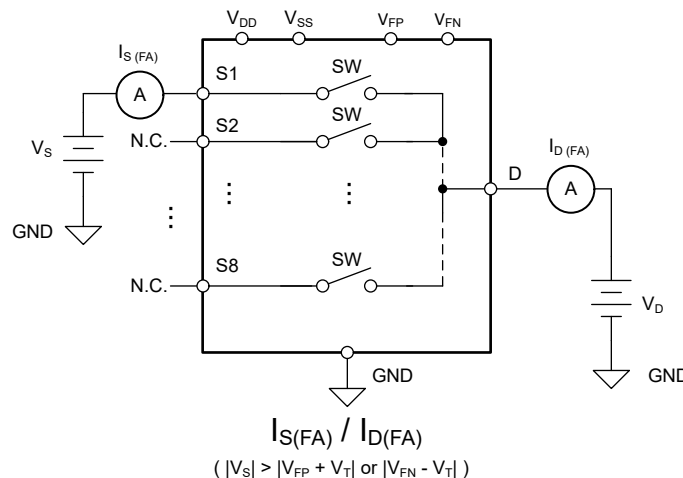
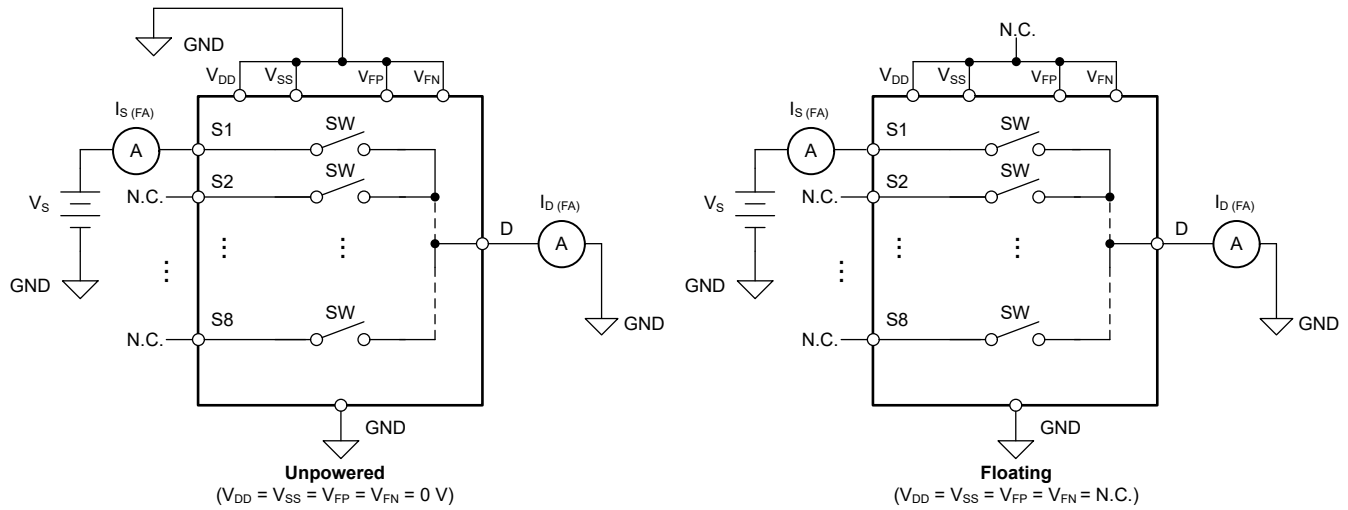


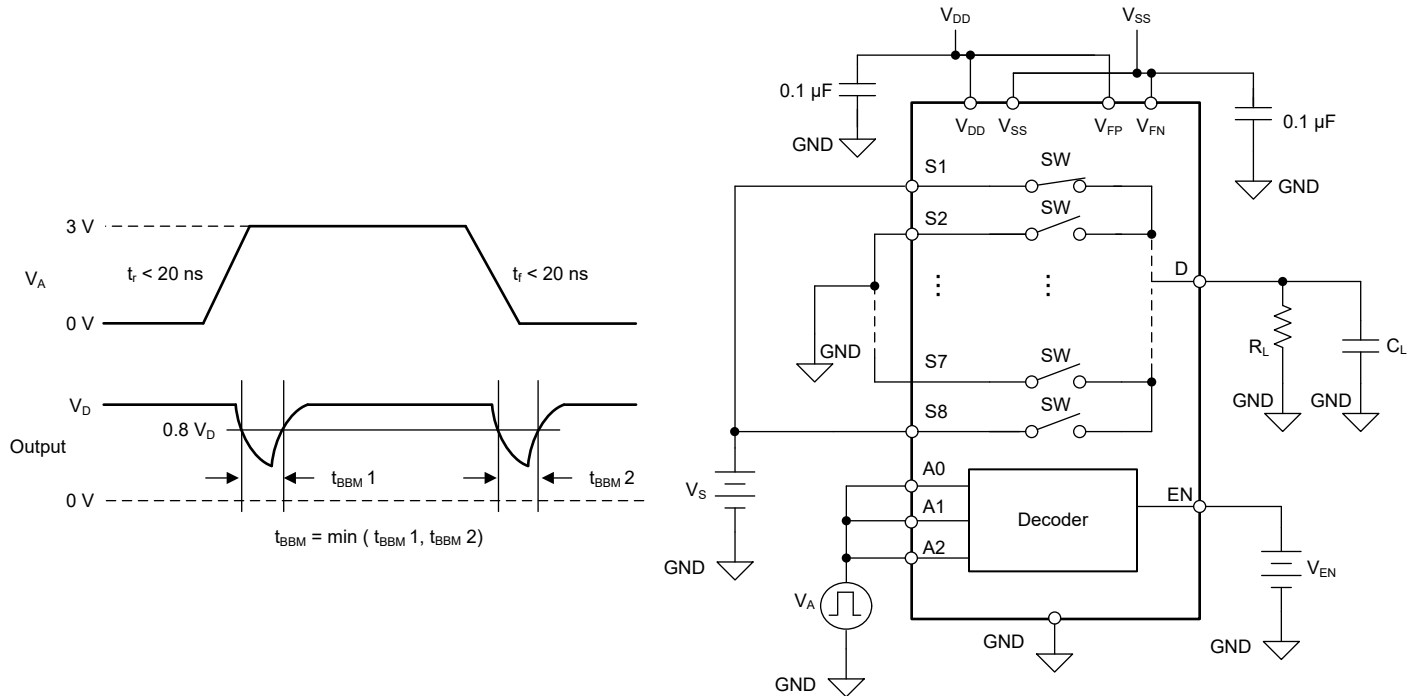
Figure 8-4. Measurement Setup for Input and Output Leakage Current under Overvoltage Fault with Normal Supplies



**Figure 8-5. Measurement Setup for Input and Output Leakage Current Under Overtolerance Fault with Unpowered or Floating Supplies**

### 8.5 Break-Before-Make Delay

The break-before-make delay is a safety feature of the TMUX7348F and TMUX7349F. The ON switches first break the connection before the OFF switches make connection. The time delay between the *break* and the *make* is known as break-before-make delay. Figure 8-6 shows the setup used to measure break-before-make delay, denoted by the symbol  $t_{BBM}$ .



**Figure 8-6. Break-Before-Make Delay Measurement Setup**

## 8.6 Enable Delay Time

$t_{ON(EN)}$  time is defined as the time taken by the output of the TMUX7348F and TMUX7349F to rise to a 90% final value after the EN signal has risen to a 50% final value.  $t_{OFF(EN)}$  is defined as the time taken by the output of the TMUX7348F and TMUX7349F to fall to a 10% initial value after the EN signal has fallen to a 50% initial value. Figure 8-7 shows the setup used to measure the enable delay time.

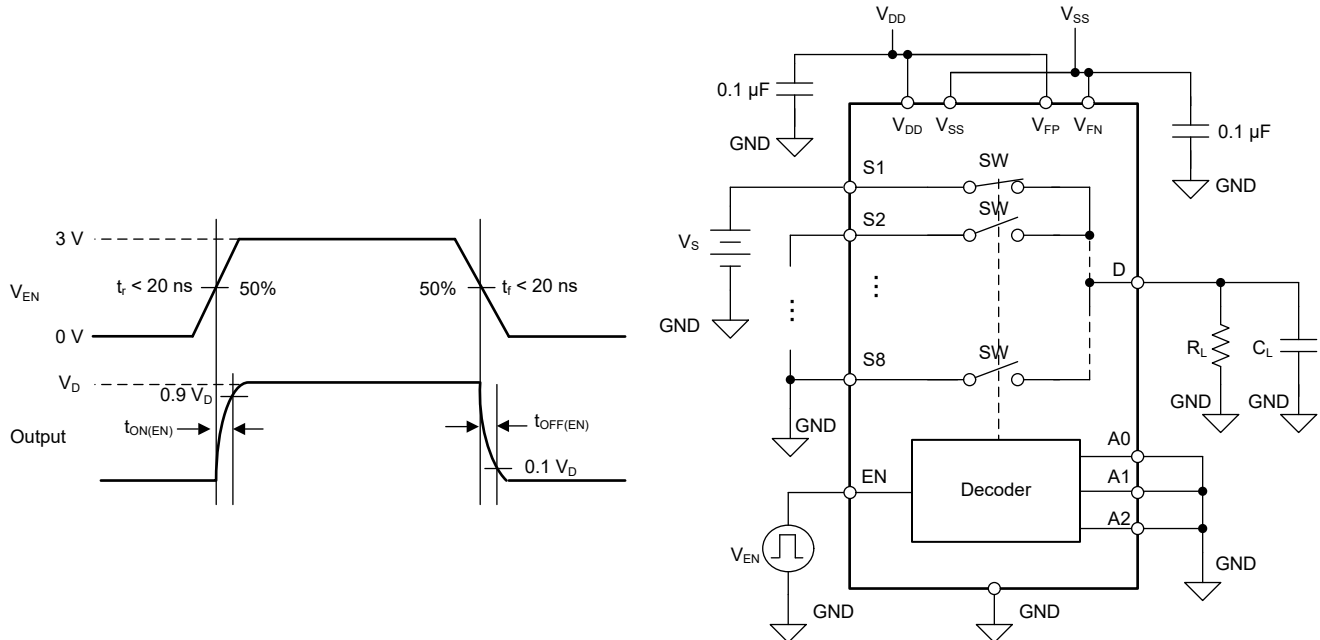


Figure 8-7. Enable Delay Measurement Setup

## 8.7 Transition Time

Transition time is defined as the time taken by the output of the device to rise (to 90% of the transition) or fall (to 10% of the transition) after the address signal ( $A_x$ ) has fallen or risen to 50% of the transition. Figure 8-8 shows the setup used to measure transition time, denoted by the symbol  $t_{TRAN}$ .

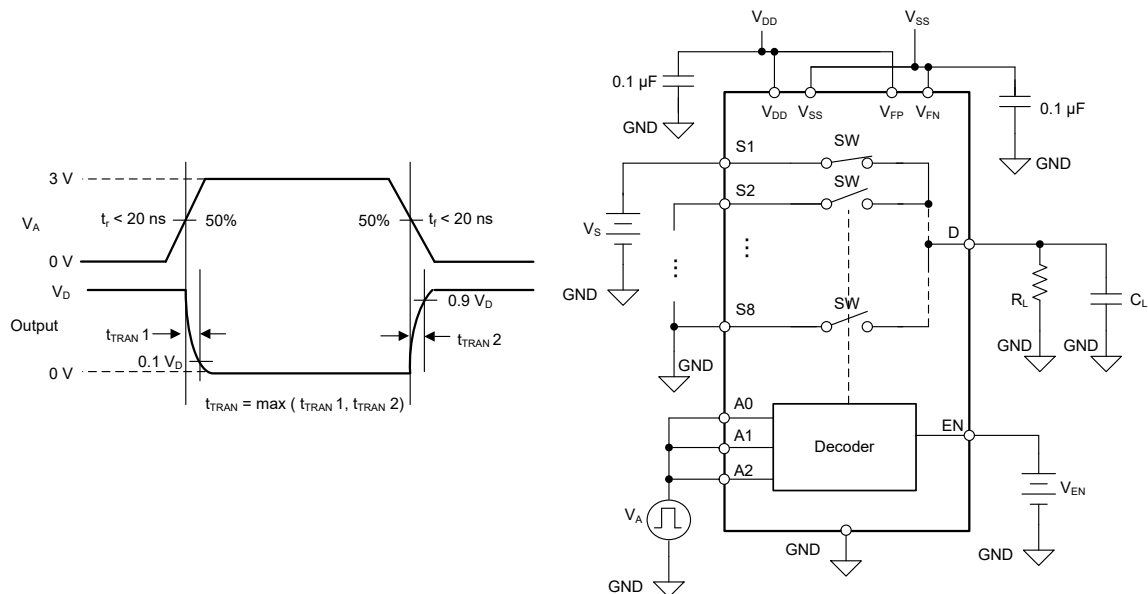


Figure 8-8. Transition Time Measurement Setup

### 8.8 Fault Response Time

Fault response time ( $t_{RESPONSE}$ ) measures the delay between the source voltage exceeding the fault supply voltage ( $V_{FP}$  or  $V_{FN}$ ) by 0.5 V and the drain voltage failing to 50% of the maximum output voltage. Figure 8-9 shows the setup used to measure  $t_{RESPONSE}$ .

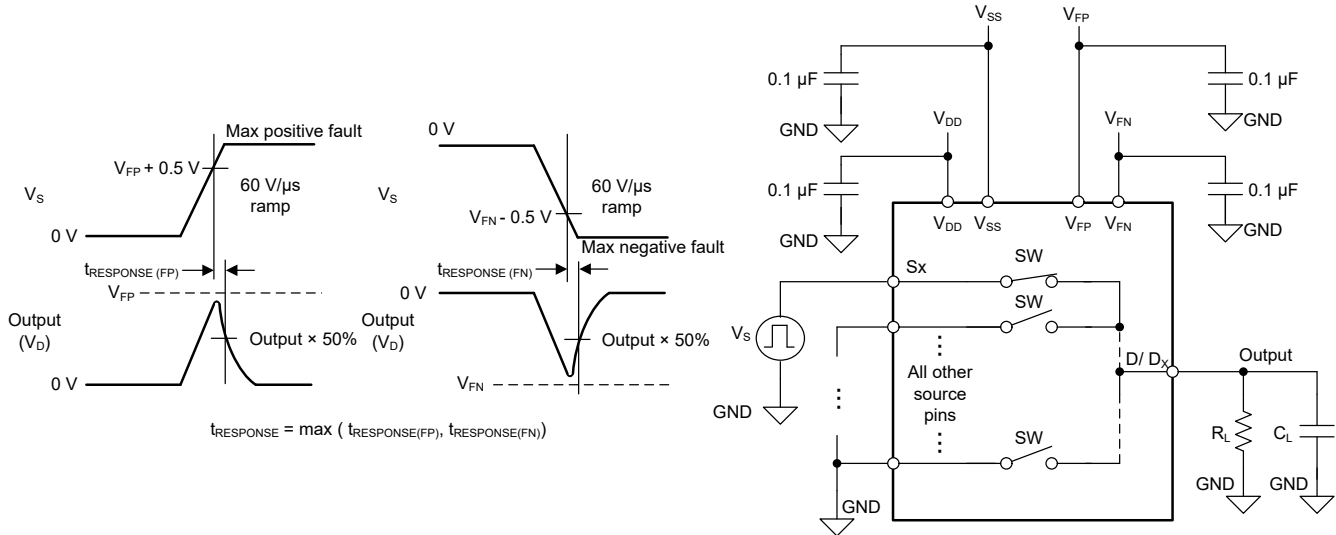


Figure 8-9. Fault Response Time Measurement Setup

### 8.9 Fault Recovery Time

Fault recovery time ( $t_{RECOVERY}$ ) measures the delay between the source voltage falling from overvoltage condition to below fault supply voltage ( $V_{FP}$  or  $V_{FN}$ ) plus 0.5 V and the drain voltage rising from 0 V to 50% of the final output voltage. Figure 8-10 shows the setup used to measure  $t_{RECOVERY}$ .

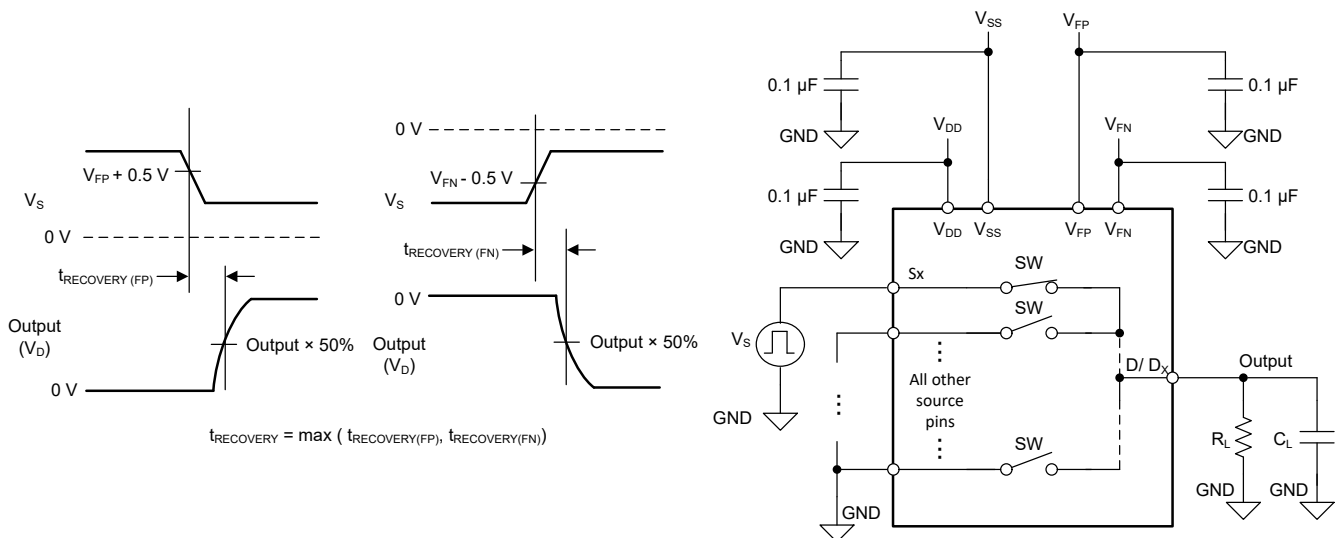


Figure 8-10. Fault Recovery Time Measurement Setup



## 8.10 Fault Flag Response Time

Fault flag response time ( $t_{\text{RESPONSE(FLAG)}}$ ) measures the delay between the source voltage exceeding the fault supply voltage ( $V_{FP}$  or  $V_{FN}$ ) by 0.5 V and the general fault flag (FF) pin or specific fault flag (SF) pin to go below 10% of its original value. Figure 8-11 shows the setup used to measure  $t_{\text{RESPONSE(FLAG)}}$ .

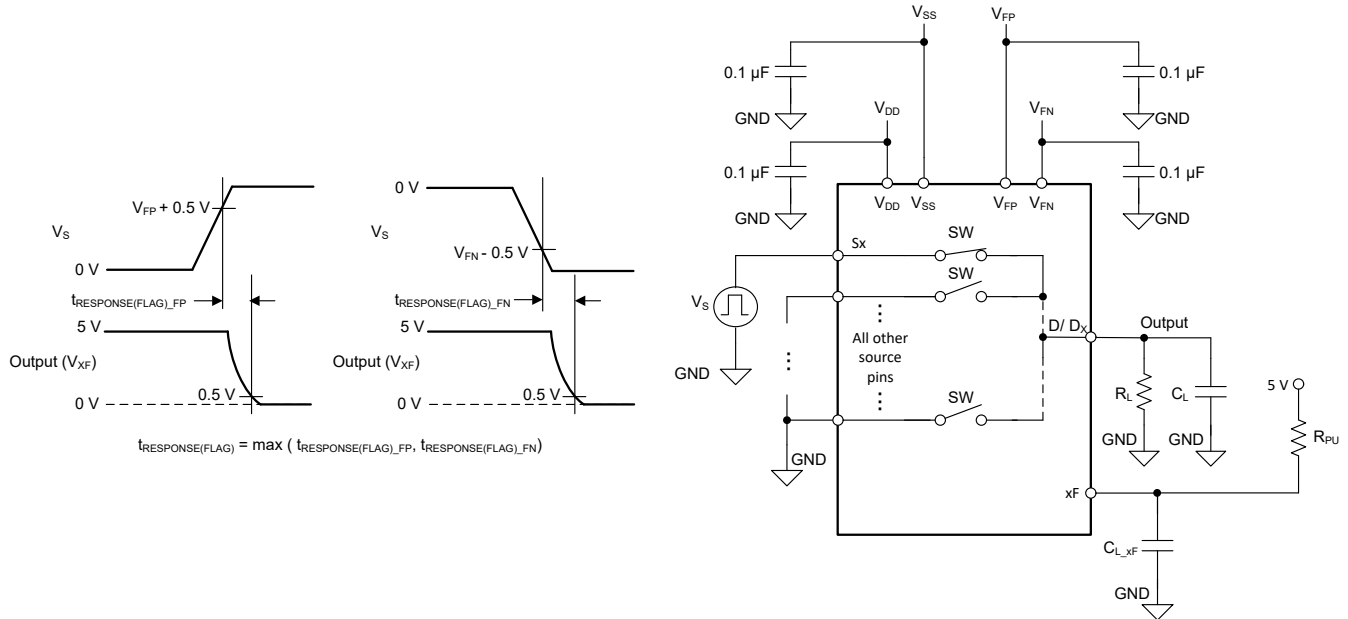


Figure 8-11. Fault Flag Response Time Measurement Setup

## 8.11 Fault Flag Recovery Time

Fault flag recovery time ( $t_{\text{RECOVERY(FLAG)}}$ ) measures the delay between the source voltage falling from overvoltage condition to below fault supply voltage ( $V_{FP}$  or  $V_{FN}$ ) plus 0.5 V and the general fault flag (FF) pin or the specific fault flag (SF) pin to rise above 3 V with 5 V external pull-up. Figure 8-12 shows the setup used to measure  $t_{\text{RECOVERY(FLAG)}}$ .

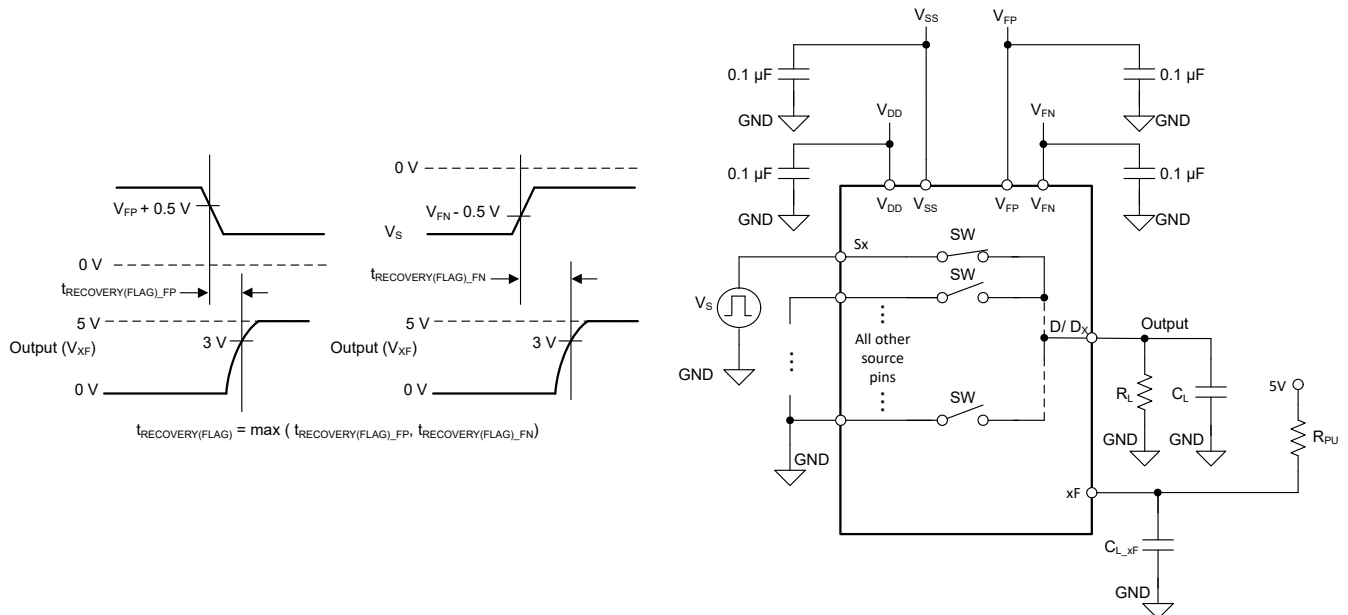


Figure 8-12. Fault Flag Recovery Time Measurement Setup

## 8.12 Charge Injection

Charge injection is a measure of the glitch impulse transferred from the logic input to the analog output during switching, and is denoted by the symbol  $Q_{INJ}$ . Figure 8-13 shows the setup used to measure charge injection from the source to drain.

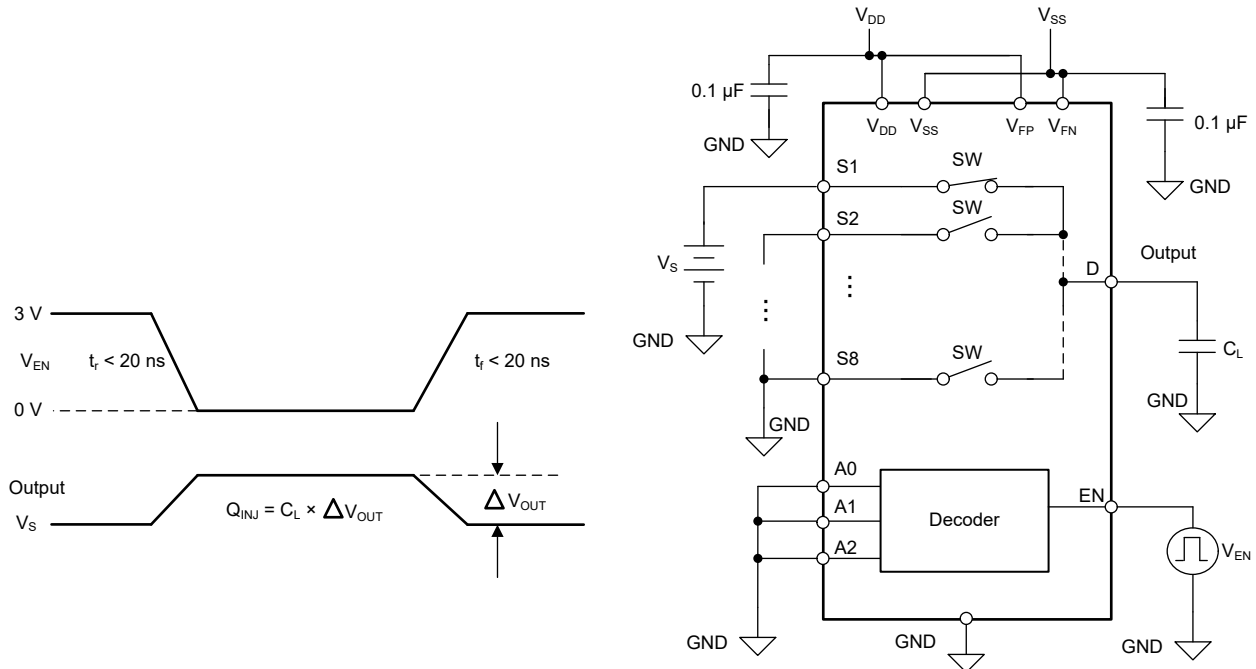


Figure 8-13. Charge-Injection Measurement Setup

## 8.13 Off Isolation

Off isolation is defined as the ratio of the signal at the drain pin ( $D_x$ ) of the device when a signal is applied to the source pin ( $S_x$ ) of an off-channel. Figure 8-14 and Equation 1 shows the setup used to measure, and the equation used to calculate off isolation.

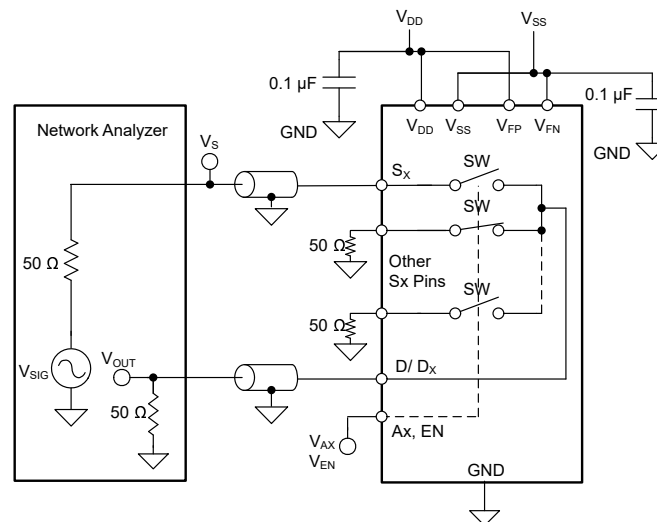


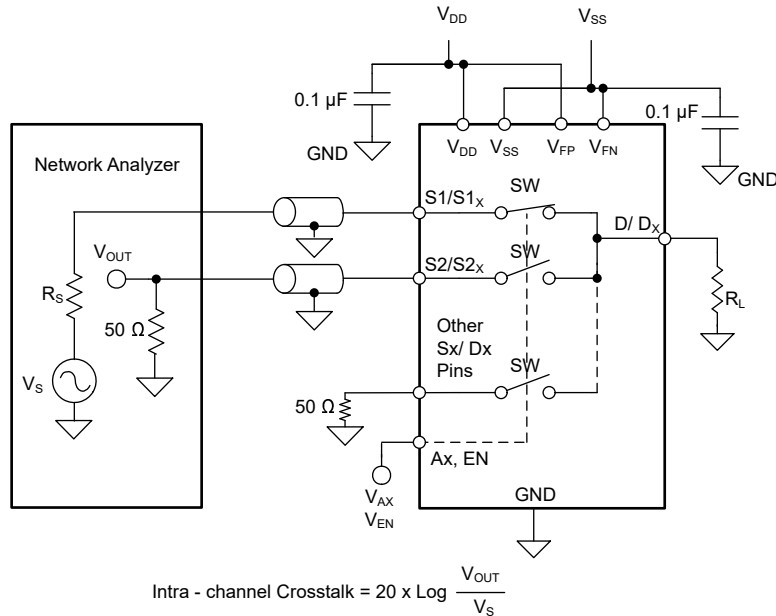
Figure 8-14. Off Isolation Measurement Setup

$$\text{Off Isolation} = 20 \times \text{Log} \frac{V_{OUT}}{V_S} \quad (1)$$

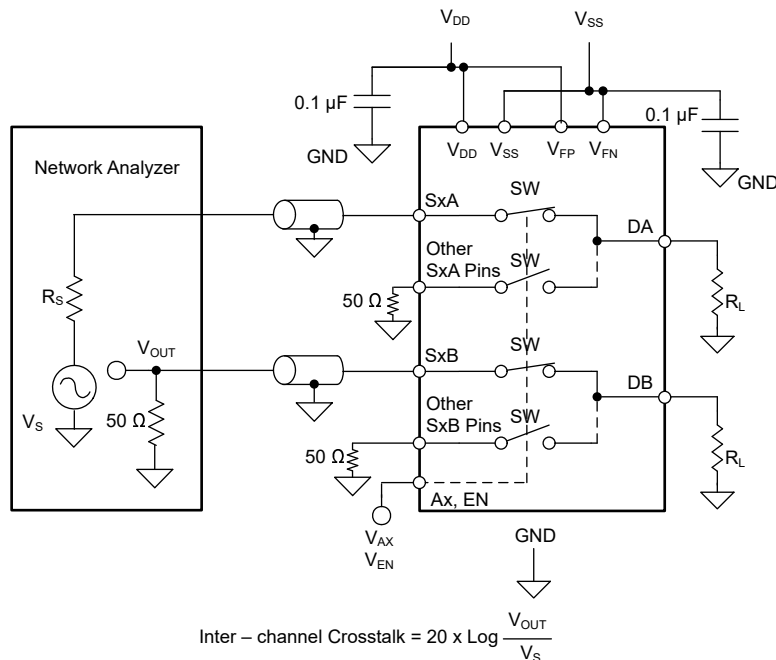
## 8.14 Crosstalk

There are two types of crosstalk that can be defined for the devices:

1. Intra-channel crosstalk ( $X_{TALK(INTRA)}$ ): **Figure 8-15** shows the voltage at the source pin ( $S_x$ ) of an off-switch input when a signal is applied at the source pin of an on-switch input in the same channel.
2. Inter-channel crosstalk ( $X_{TALK(INTER)}$ ): **Figure 8-16** shows the voltage at the source pin ( $S_x$ ) of an on-switch input, when a signal is applied at the source pin of an on-switch input in a different channel. Inter-channel crosstalk applies only to the TMUX7349F device.



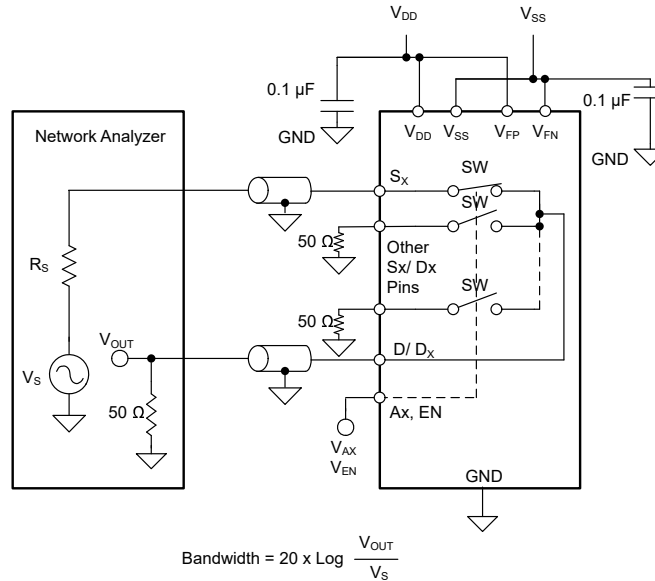
**Figure 8-15. Intra-Channel Crosstalk Measurement Setup**



**Figure 8-16. Inter-Channel Crosstalk Measurement Setup**

### 8.15 Bandwidth

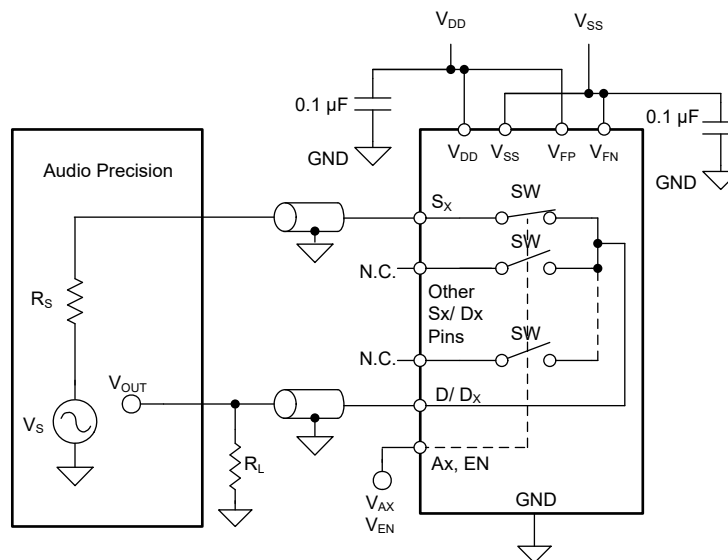
Bandwidth (BW) is defined as the range of frequencies that are attenuated by < 3 dB when the input is applied to the source pin (Sx) of an on-channel, and the output is measured at the drain pin (D or Dx) of the TMUX7348F and TMUX7349F. Figure 8-17 shows the setup used to measure bandwidth of the switch.



**Figure 8-17. Bandwidth Measurement Setup**

### 8.16 THD + Noise

The total harmonic distortion (THD) of a signal is a measurement of the harmonic distortion, and is defined as the ratio of the sum of the powers of all harmonic components to the power of the fundamental frequency at the multiplexer output. The on-resistance of the TMUX7348F and TMUX7349F varies with the amplitude of the input signal and results in distortion when the drain pin is connected to a low-impedance load. Total harmonic distortion plus noise is denoted as THD+N. Figure 8-18 shows the setup used to measure THD+N of the devices.



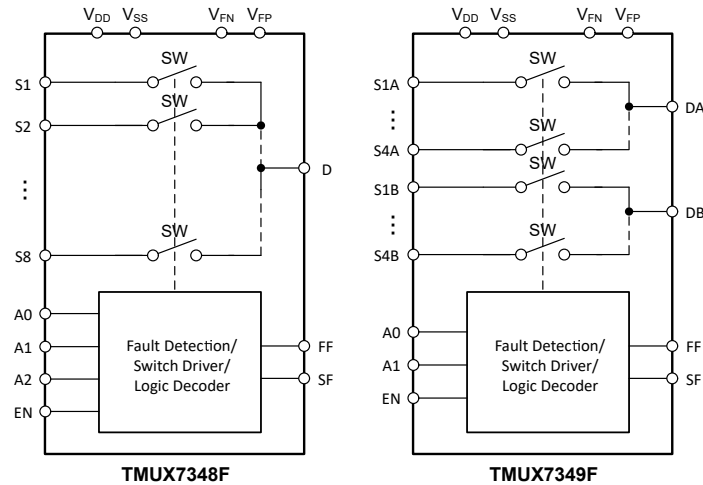
**Figure 8-18. THD+N Measurement Setup**

## 9 Detailed Description

### 9.1 Overview

The TMUX7348F and TMUX7349F are a modern complementary metal-oxide semiconductor (CMOS) analog multiplexers in 8:1 (single ended) and 4:1 (differential) configurations. The devices work well with dual supplies ( $\pm 5$  V to  $\pm 22$  V), a single supply (8 V to 44 V), or asymmetric supplies (such as  $V_{DD} = 15$  V,  $V_{SS} = -5$  V). The devices have an overvoltage protection feature on the source pins under powered and powered-off conditions, allowing them to be used in harsh industrial environments.

### 9.2 Functional Block Diagram



## 9.3 Feature Description

### 9.3.1 Flat ON- Resistance

The TMUX7348F and TMUX7349F are designed with a special switch architecture to produce ultra-flat on-resistance ( $R_{ON}$ ) across most of the switch input operation region. The flat  $R_{ON}$  response allows the device to be used in precision sensor applications since the  $R_{ON}$  is controlled regardless of the signals sampled. The architecture is implemented without a charge pump so no unwanted noise is produced from the device to affect sampling accuracy.

### 9.3.2 Protection Features

The TMUX7348F and TMUX7349F offer a number of protection features to enable robust system implementations.

#### 9.3.2.1 Input Voltage Tolerance

The maximum voltage that can be applied to any source input pin is +60 V or –60 V, regardless of the supply voltage. This allows the device to handle typical voltage fault conditions in industrial applications. Take caution: the device is rated to handle a maximum stress of 85 V across different pins, such as the following:

1. **Between source pins and supply rails:**

For example, if the device is powered by  $V_{DD}$  supply of 20 V, then the maximum negative signal level on any source pin is –60 V to maintain the 60 V maximum rating on any source pin. If the device is powered by  $V_{DD}$  supply of 40 V, then the maximum negative signal level on any source pin is reduced to –45 V to maintain the 85 V maximum rating across the source pin and the supply.

2. **Between source pins and one or more of the drain pins:**

For example, if channel S1(A) is ON and the voltage on S1(A) pin is 40 V. In this case, the drain voltage is also 40 V. The maximum negative voltage on any of the other source pins is –45 V to maintain the 85 V maximum rating across the source pin and the drain pin.

#### 9.3.2.2 Powered-Off Protection

When the supplies of TMUX7348F and TMUX7349F are removed ( $V_{DD}/V_{SS} = 0$  V or floating), the source ( $S_x$ ) pins of the device remain in the high impedance (Hi-Z) state, and the source ( $S_x$ ) and drain ( $D_x$ ) pins of the device remain within the leakage performance mentioned in the *Electrical Characteristics*. Powered-off protection minimizes system complexity by removing the need to control the power supply sequencing of the system. The feature prevents errant voltages on the input source pins from reaching the rest of the system and maintains isolation when the system is powering up. Without powered-off protection, the signal on the input source pins can back-power the supply rails through the internal ESD diodes and potentially cause damage to the system. For more information on powered-off protection, refer to the [Eliminate Power Sequencing with Powered-Off Protection Signal Switches](#) application brief.

The switch remains OFF regardless of whether the  $V_{DD}$  and  $V_{SS}$  supplies are 0 V or floating. A GND reference must always be present for proper operation. Source and drain voltage levels of up to  $\pm 60$  V are blocked in the powered-off condition.

#### 9.3.2.3 Fail-Safe Logic

Fail-safe logic circuitry allows voltages on the logic control pins to be applied before the supply pins, protecting the device from potential damage. The switch is specified to be in the OFF state, regardless of the state of the logic signals. The logic inputs are protected against positive faults of up to +44 V in the powered-off condition, but do not offer protection against the negative overvoltage condition.

Fail-safe logic also allows the TMUX7348F and TMUX7349F devices to interface with a voltage greater than  $V_{DD}$  during normal operation to add maximum flexibility in system design. For example, with a  $V_{DD}$  of = 15 V, the logic control pins could be connected to +24 V for a logic high signal which allows different types of signals, such as analog feedback voltages, to be used when controlling the logic inputs. Regardless of the supply voltage, the logic inputs can be interfaced as high as 44 V.

### 9.3.2.4 Overvoltage Protection and Detection

The TMUX7348F and TMUX7349F detect overvoltage inputs by comparing the voltage on a source pin (Sx) with the fault supplies ( $V_{FP}$  and  $V_{FN}$ ). A signal is considered overvoltage if it exceeds the fault supply voltages by the threshold voltage ( $V_T$ ).

When an overvoltage is detected, the switch automatically turns OFF regardless of the logic controls. The source pin becomes high impedance and allows only a small leakage current to flow through the switch and the overvoltage does not appear on the drain. When the overvoltage channel is selected by the logic control, the drain pin (D or Dx) is pulled to the supply that was exceeded. For example, if the source voltage exceeds  $V_{FP}$ , then the drain output is pulled to  $V_{FP}$ . If the source voltage exceeds  $V_{FN}$ , then the drain output is pulled to  $V_{FN}$ . The pull-up impedance is approximately 40 k $\Omega$ , and as a result, the drain current is limited to roughly 1 mA during a shorted load (to GND) condition.

Figure 9-1 shows a detailed view of how the pullup or down controls the output state of the drain pin under a fault scenario.

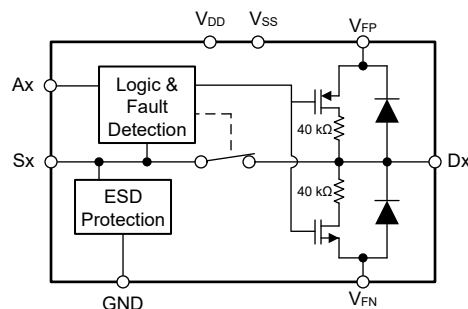


Figure 9-1. Detailed Functional Diagram

$V_{FP}$  and  $V_{FN}$  are required fault supplies that set the level at which the overvoltage protection is engaged.  $V_{FP}$  can be supplied from 3 V to  $V_{DD}$ , while the  $V_{FN}$  can be supplied from  $V_{SS}$  to 0 V. If the fault supplies are not available in the system, then the  $V_{FP}$  pin must be connected to  $V_{DD}$ , while the  $V_{FN}$  pin must be connected to  $V_{SS}$ . In this case, overvoltage protection then engages at the primary supply voltages  $V_{DD}$  and  $V_{SS}$ .

### 9.3.2.5 Adjacent Channel Operation During Fault

When the logic pins are set to a channel under a fault, the overvoltage detection will trigger, the switch will open, and the drain pin will be pulled up or down as described in Section 9.3.2.4. During such an event, all other channels not under a fault can continue to operate as normal. For example, if S1 voltage exceeds  $V_{FP}$ , and the logic pins are set to S1, the drain output is pulled to  $V_{FP}$ . Then if the logic pins are changed to set S4, which is not in overvoltage or undervoltage, the drain will disconnect from the pullup to  $V_{FP}$  and the S4 switch will be enabled and connected to the drain, operating as normal. If the logic pins are switched back to S1, the S4 switch will be disabled, the drain pin will be pulled up to  $V_{FP}$  again, and the switch from S1 to drain will not be enabled until the overvoltage fault is removed.

### 9.3.2.6 ESD Protection

All pins on the TMUX7348F and TMUX7349F support HBM ESD protection level up to  $\pm 3.5$  kV, which helps the device from getting ESD damages during the manufacturing process.

The drain pins (D or Dx) have internal ESD protection diodes to the fault supplies  $V_{FP}$  and  $V_{FN}$ . Therefore, the voltage at the drain pins must not exceed the fault supply voltages to prevent excessive diode current. The source pins have specialized ESD protection that allows the signal voltage to reach  $\pm 60$  V regardless of the supply voltage level. Exceeding  $\pm 60$  V on any source input may damage the ESD protection circuitry on the device and cause the device to malfunction if the damage is excessive.

### 9.3.2.7 Latch-Up Immunity

Latch-up is a condition where a low impedance path is created between a supply pin and ground. This condition is caused by a trigger (current injection or overvoltage), but once activated, the low impedance path remains even after the trigger is no longer present. This low impedance path may cause system upset or catastrophic damage due to excessive current levels. The latch-up condition typically requires a power cycle to eliminate the low impedance path.

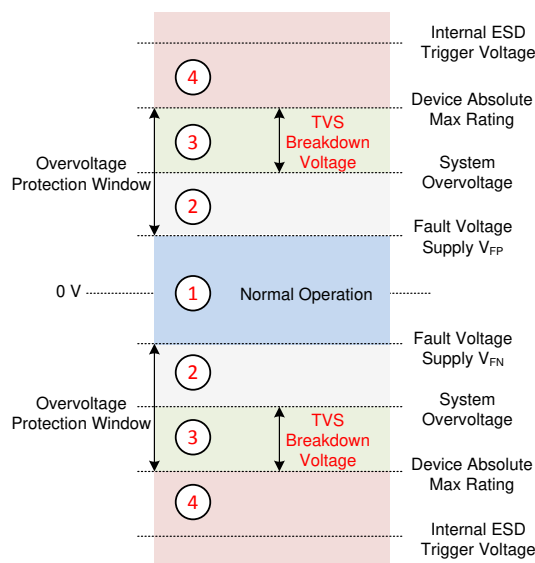
The TMUX7348F and TMUX7349F devices are constructed on silicon on insulator (SOI) based process where an oxide layer is added between the PMOS and NMOS transistor of each CMOS switch to prevent parasitic structures from forming. The oxide layer is also known as an insulating trench and prevents triggering of latch up events due to overvoltage or current injections. The latch-up immunity feature allows the TMUX7348F and TMUX7349F to be used in harsh environments. For more information on latch-up immunity refer to the [Using Latch-Up Immune Multiplexers to Help Improve System Reliability](#) application report.

### 9.3.2.8 EMC Protection

The TMUX7348F and TMUX7349F are not intended for standalone electromagnetic compatibility (EMC) protection in industrial applications. There are three common high voltage transient specifications that govern industrial high voltage transient specifications: IEC61000-4-2 (ESD), IEC61000-4-4 (EFT), and IEC61000-4-5 (surge immunity). A transient voltage suppressor (TVS), along with some low-value series current limiting resistors, are required to prevent source input voltages from going above the rated  $\pm 60$  V limits.

When selecting a TVS protection device, it is critical to ensure that the maximum working voltage is greater than both the normal operating range of the input source pins to be protected and any known system common-mode overvoltage that may be present due to incorrect wiring, loss of power, or short circuit. [Figure 9-2](#) shows an example of the proper design window when selecting a TVS device.

Region 1 denotes the normal operation region of TMUX7348F and TMUX7349F where the input source voltages stay below the fault supplies  $V_{FP}$  and  $V_{FN}$ . Region 2 represents the range of possible persistent DC (or long duration AC overvoltage fault) presented on the source input pins. Region 3 represents the margin between any known DC overvoltage level and the absolute maximum rating of the TMUX7348F and TMUX7349F. The TVS breakdown voltage must be selected to be less than the absolute maximum rating of the TMUX7348F and TMUX7349F, but greater than any known possible persistent DC or long duration AC overvoltage fault to avoid triggering the TVS inadvertently. Region 4 represents the margin system designers must impose when selecting the TVS protection device to prevent accidental triggering of ESD cells of the TMUX7348F and TMUX7349F devices.



**Figure 9-2. System Operation Regions and Proper Region of Selecting a TVS Protection Device**



### 9.3.3 Overvoltage Fault Flags

The voltages on the source input pins of the TMUX7348F and TMUX7349F are continuously monitored, and the status of whether an overvoltage condition occurs is indicated by an active low general fault flag (FF). The voltage on the FF pin indicates if any of the source input pins are experiencing an overvoltage condition. If any source pin voltage exceeds the fault supply voltages by a  $V_T$ , the FF output is pulled-down to below  $V_{OL}$ .

The specific fault (SF) output pins, on the other hand, can be used to decode which inputs are experiencing an overvoltage condition. As provided in [Table 9-1](#) and [Table 9-2](#), the SF pin is pulled-down to below  $V_{OL}$  when an overvoltage condition is detected on a specific source input pin, depending on the state of the A0, A1, A2, and EN logic pins.

Both the FF pin and SF pin are open-drain output and external pull-up resistors of 1 k $\Omega$  are recommended. The pull-up voltage can be in the range of 1.8 V to 5.5 V, depending on the controller voltage the device interfaces with.

### 9.3.4 Bidirectional and Rail-to-Rail Operation

The TMUX7348F and TMUX7349F conducts equally well from source (Sx) to drain (D or Dx) or from drain (D or Dx) to source (Sx). Each signal path has very similar characteristics in both directions. It is important to note, however, that the overvoltage protection is implemented only on the source (Sx) side. The voltage on the drain is only allowed to swing between  $V_{FP}$  and  $V_{FN}$  and no overvoltage protection is available on the drain side.

The primary supplies ( $V_{DD}$  and  $V_{SS}$ ) define the on-resistance profile of the switch channel, whereas the fault voltage supplies ( $V_{FP}$  and  $V_{FN}$ ) define the signal range that can be passed through from source to drain of the device. It is good practice to use voltages on  $V_{FP}$  and  $V_{FN}$  that are lower than  $V_{DD}$  and  $V_{SS}$  to take advantage of the flat on-resistance region of the device for better input-to-output linearity. The flattest on-resistance region extends from  $V_{SS}$  to roughly 3 V below  $V_{DD}$ . Once the signal is within 3 V of  $V_{DD}$  the on-resistance will exponentially increase and may impact desired signal transmission.

### 9.3.5 1.8 V Logic Compatible Inputs

The TMUX7348F and TMUX7349F devices have 1.8 V logic compatible control for all logic control inputs. 1.8 V logic level inputs allows the TMUX7348F and TMUX7349F to interface with processors that have lower logic I/O rails and eliminates the need for an external translator, which saves both space and BOM cost. For more information on 1.8 V logic implementations refer to [Simplifying Design with 1.8 V Logic Muxes and Switches](#).

### 9.3.6 Integrated Pull-Down Resistor on Logic Pins

The TMUX7348F and TMUX7349F have internal weak pull-down resistors to GND so that the logic pins are not left floating. The value of this pull-down resistor is approximately 4 M $\Omega$ , but is clamped to about 1  $\mu$ A at higher voltages. This feature integrates up to four external components and reduces system size and cost.

## 9.4 Device Functional Modes

The TMUX7348F and TMUX7349F offer two modes of operation (Normal mode and Fault mode) depending on whether any of the input pins experience an overvoltage condition.

### 9.4.1 Normal Mode

In Normal mode operation, signals of up to  $V_{FP}$  and  $V_{FN}$  can be passed through the switch from source (Sx) to drain (D or Dx) or from drain (D or Dx) to source (Sx). As provided in [Table 9-1](#) and [Table 9-2](#), the address (Ax) pins and the enable (EN) pin determine which switch path to turn on. The following conditions must be satisfied for the switch to stay in the ON condition:

- The difference between the primary supplies ( $V_{DD} - V_{SS}$ ) must be higher or equal to 8 V. With a minimum  $V_{DD}$  of 5 V.
- $V_{FP}$  must be between 3 V and  $V_{DD}$ , and  $V_{FN}$  must be between  $V_{SS}$  and 0 V.
- The input signals on the source (Sx) or the drain (D or Dx) must be between  $V_{FP} + V_T$  and  $V_{FN} - V_T$ .
- The logic control (Ax and EN) must have selected the switch.

### 9.4.2 Fault Mode

The TMUX7348F and TMUX7349F enters into Fault mode when any of the input signals on the source (Sx) pins exceed  $V_{FP}$  or  $V_{FN}$  by a threshold voltage  $V_T$ . Under the overvoltage condition, the switch input experiencing the fault automatically turns OFF regardless of the logic status, and the source pin becomes high impedance with a negligible amount of leakage current flowing through the switch. When the fault channel is selected by the logic control, the drain pin (D or Dx) is pulled to the fault supply that was exceeded through a 40 k $\Omega$  internal resistor.

In the Fault mode, the general fault flag (FF) is asserted low. [Table 9-1](#) and [Table 9-2](#) provides how the specific flag (SF) is asserted low when a specific input path is selected.

The overvoltage protection is provided only for the source (Sx) input pins. The drain (D or Dx) pin, if used as signal input, must stay in between  $V_{FP}$  and  $V_{FN}$  at all time since no overvoltage protection is implemented on the drain pin.

### 9.4.3 Truth Tables

Table 9-1 shows the truth tables for the TMUX7348F under normal and fault conditions.

**Table 9-1. TMUX7348F Truth Table**

EN	A2	A1	A0	Normal Condition	Fault Condition							
					State of Specific Flag (SF) when fault occurs on							
				On Switch	S1	S2	S3	S4	S5	S6	S7	S8
0	0	0	0	None	0	1	1	1	1	1	1	1
0	0	0	1	None	1	0	1	1	1	1	1	1
0	0	1	0	None	1	1	0	1	1	1	1	1
0	0	1	1	None	1	1	1	0	1	1	1	1
0	1	0	0	None	1	1	1	1	0	1	1	1
0	1	0	1	None	1	1	1	1	1	0	1	1
0	1	1	0	None	1	1	1	1	1	1	0	1
0	1	1	1	None	1	1	1	1	1	1	1	0
1	0	0	0	S1	0	1	1	1	1	1	1	1
1	0	0	1	S2	1	0	1	1	1	1	1	1
1	0	1	0	S3	1	1	0	1	1	1	1	1
1	0	1	1	S4	1	1	1	0	1	1	1	1
1	1	0	0	S5	1	1	1	1	0	1	1	1
1	1	0	1	S6	1	1	1	1	1	0	1	1
1	1	1	0	S7	1	1	1	1	1	1	0	1
1	1	1	1	S8	1	1	1	1	1	1	1	0

Table 9-2 shows the truth tables for the TMUX7349F under normal and fault conditions.

**Table 9-2. TMUX7349F Truth Table**

EN	A1	A0	Normal Condition	Fault Condition								
				State of Specific Flag (SF) when fault occurs on								
			On Switch	S1A	S2A	S3A	S4A	S1B	S2B	S3B	S4B	
0	0	0	None	0	1	1	1	1	1	1	1	1
0	0	1	None	1	0	1	1	1	1	1	1	1
0	1	0	None	1	1	0	1	1	1	1	1	1
0	1	1	None	1	1	1	0	1	1	1	1	1
1	0	0	S1x	1	1	1	1	0	1	1	1	1
1	0	1	S2x	1	1	1	1	1	0	1	1	1
1	1	0	S3x	1	1	1	1	1	1	0	1	1
1	1	1	S4x	1	1	1	1	1	1	1	1	0

## 10 Application and Implementation

### Note

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes, as well as validating and testing their design implementation to confirm system functionality.

### 10.1 Application Information

The TMUX7348F and TMUX7349F are part of the fault protected switches and multiplexers family of devices. The ability to protect downstream components from overvoltage events up to  $\pm 60$  V makes these switches and multiplexers suitable for harsh environments.

### 10.2 Typical Application

In analog input programmable logic controllers (PLC) a multiplexer is often used to switch multiple sensors to a single ADC. By using a multiplexer, the number of components in the system can be reduced to save system cost and size. In a PLC module a  $\pm 10$  V input signal range is common for interfacing with external field transmitters and sensors; however, there are a number of fault cases that may occur that can be damaging to many of the integrated circuits. Such fault conditions may include, but are not limited to, human error from wiring connections incorrectly, component failure or wire shorts, electromagnetic interference (EMI) or transient disturbances, and so forth.

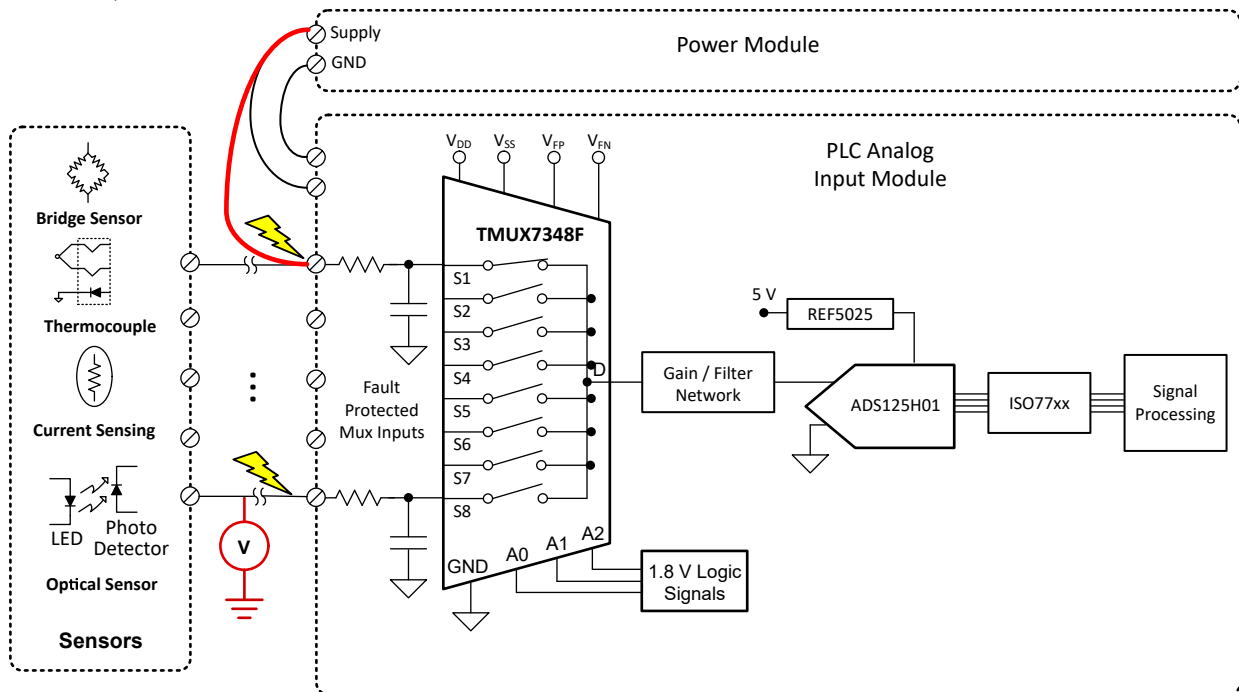


Figure 10-1. Typical Application

## 10.2.1 Design Requirements

Table 10-1. Design Parameters

PARAMETER	VALUE
Positive supply ( $V_{DD}$ ) mux	+15 V
Negative supply ( $V_{SS}$ ) mux	-15 V
Positive fault voltage supply ( $V_{FP}$ ) mux and ADC	+10 V
Negative fault voltage supply ( $V_{FN}$ ) mux and ADC	-10 V
Power board supply voltage	24 V
Input or output signal range non-faulted	-10 V to 10 V
Overvoltage protection levels	-60 V to 60 V
Control logic thresholds	1.8 V compatible, up to 44 V
Temperature range	-40°C to +125°C

## 10.2.2 Detailed Design Procedure

The previous image shows the case where an incorrect wiring condition occurred and one of the input connectors shorted to the power board supply voltage. If the board supply voltage is higher than the fault voltage supply of the multiplexer, then the TMUX7348F or TMUX7349F will disconnect the source input from passing the signal to protect the downstream ADC. The drain pin of the mux will be pulled up to the fault voltage supply voltage  $V_{FP}$  through a 40 k $\Omega$  resistor to allow the ADC to determine a fault condition has occurred.

## 10.2.3 Application Curves

The previous example shows how the fault protection of the TMUX7348F or TMUX7349F is utilized to protect downstream components from damage due to wiring the connections incorrectly from the power module. Figure 10-2 shows an example of positive overvoltage fault response with a fast fault ramp rate of 58 V/ $\mu$ s. Figure 10-3 shows the extremely flat on-resistance across source voltage while operating within a common signal range of  $\pm 10$  V. These features make the TMUX7348F or TMUX7349F an ideal solution for factory automation applications that can face various fault conditions but also require excellent linearity and low distortion.

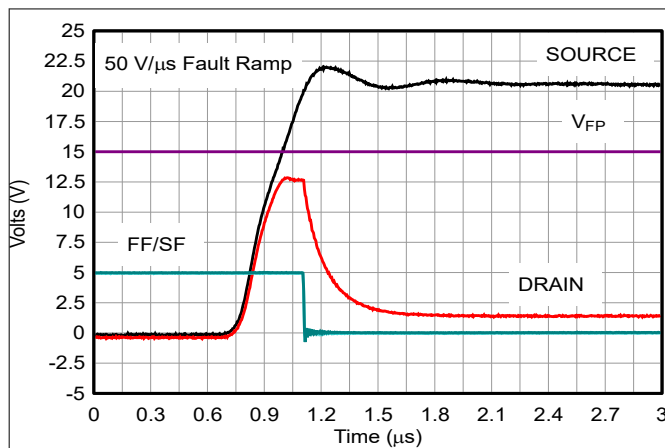


Figure 10-2. Positive Overvoltage Response

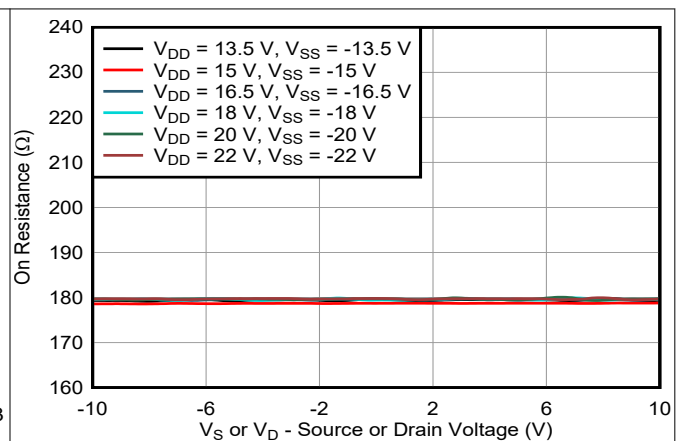


Figure 10-3.  $R_{ON}$  Flatness in Non-Fault Region

### 10.3 Power Supply Recommendations

The TMUX7348F and TMUX7349F operate across a wide supply range of  $\pm 5$  V to  $\pm 22$  V (8 V to 44 V in single-supply mode). They also perform well with asymmetrical supplies such as  $V_{DD} = 12$  V and  $V_{SS} = -5$  V. For improved supply noise immunity, use a supply decoupling capacitor ranging from 0.1  $\mu$ F to 10  $\mu$ F at both the  $V_{DD}$  and  $V_{SS}$  pins to ground. Always ensure the ground (GND) connection is established before supplies are ramped.

The fault supplies ( $V_{FP}$  and  $V_{FN}$ ) provide the current required to operate the fault protection, and thus, must be low impedance supplies. They can be derived from the primary supplies by using a resistor divider and buffer or be an independent supply rail. The fault supplies must not exceed the primary supplies as it might cause unexpected behavior of the switch. Use a supply decoupling capacitor ranging from 0.1  $\mu$ F to 10  $\mu$ F at both the  $V_{FP}$  and  $V_{FN}$  pins to ground for improved supply noise immunity.

The positive supply ( $V_{DD}$ ) must be ramped before the positive fault rail ( $V_{FP}$ ) for proper power sequencing of the TMUX7348F and TMUX7349F. Similarly, the negative supply ( $V_{SS}$ ) must be ramped before the negative fault voltage rail ( $V_{FN}$ ).

### 10.4 Layout

#### 10.4.1 Layout Guidelines

The following images illustrate examples of a PCB layout with the TMUX7348F and TMUX7349F. Some key considerations are as follows:

- For reliable operation, connect a decoupling capacitor ranging from 0.1  $\mu$ F to 10  $\mu$ F between  $V_{DD}$  and  $V_{SS}$  to GND. We recommend a 0.1  $\mu$ F and 1  $\mu$ F capacitor, placing the lowest value capacitor as close to the pin as possible. Make sure that the capacitor voltage rating is sufficient for the  $V_{DD}$  and  $V_{SS}$  supplies.
- Multiple decoupling capacitors can be used if there is a lot of noise in the system. For example, a 0.1- $\mu$ F and 1- $\mu$ F can be placed on the supply pins. If multiple capacitors are used, then placing the lowest value capacitor closest to the supply pin is recommended.
- Keep the input lines as short as possible.
- Use a solid ground plane to help distribute heat and reduce electromagnetic interference (EMI) noise pickup.
- Do not run sensitive analog traces in parallel with digital traces. Avoid crossing digital and analog traces if possible, and only make perpendicular crossings when necessary.

#### 10.4.2 Layout Example

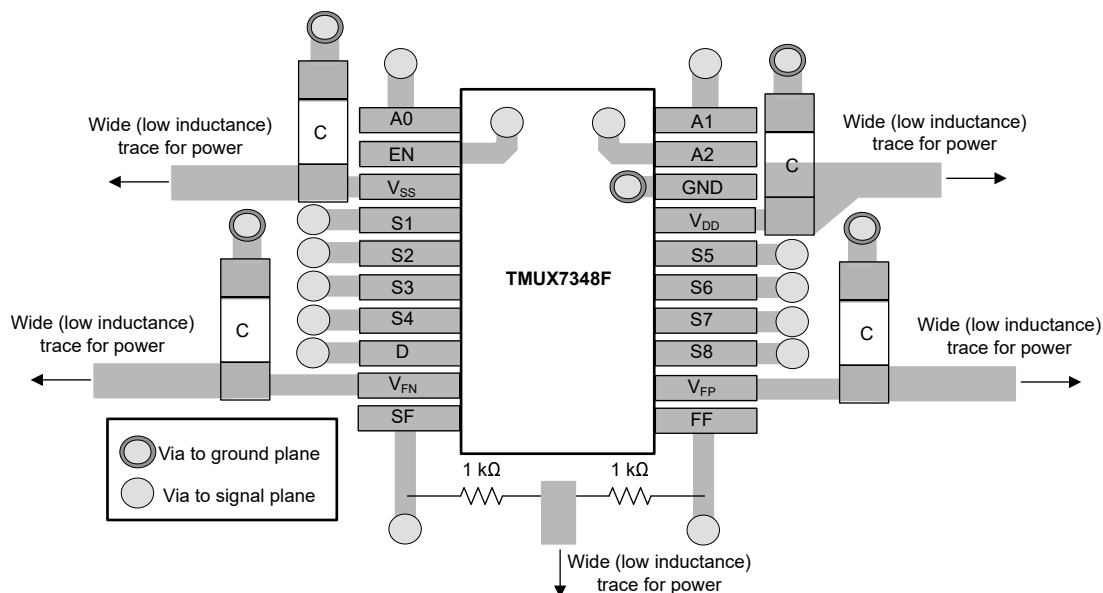
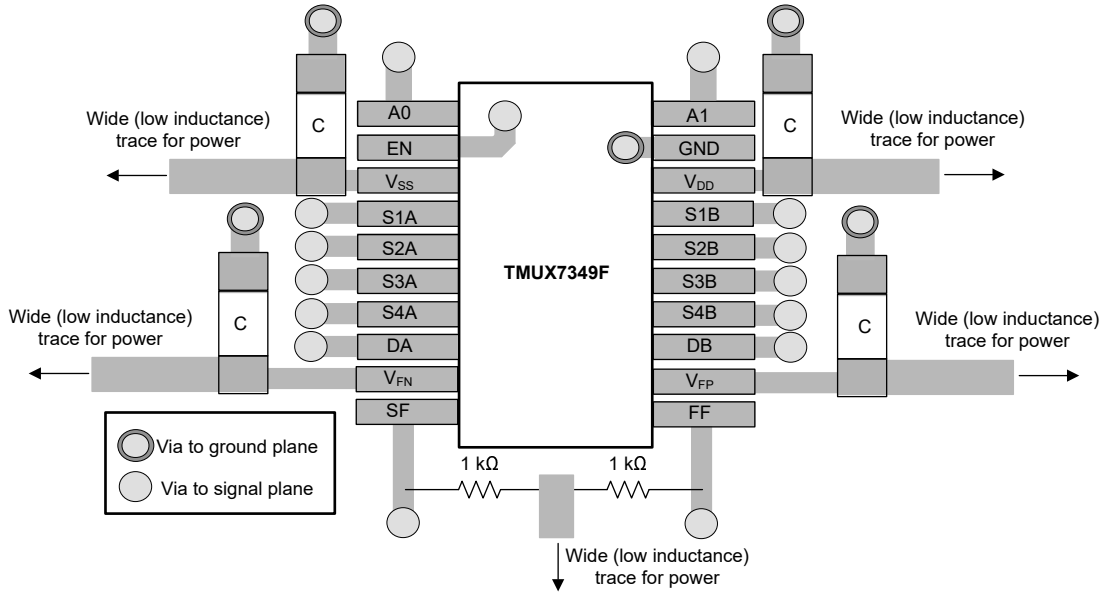
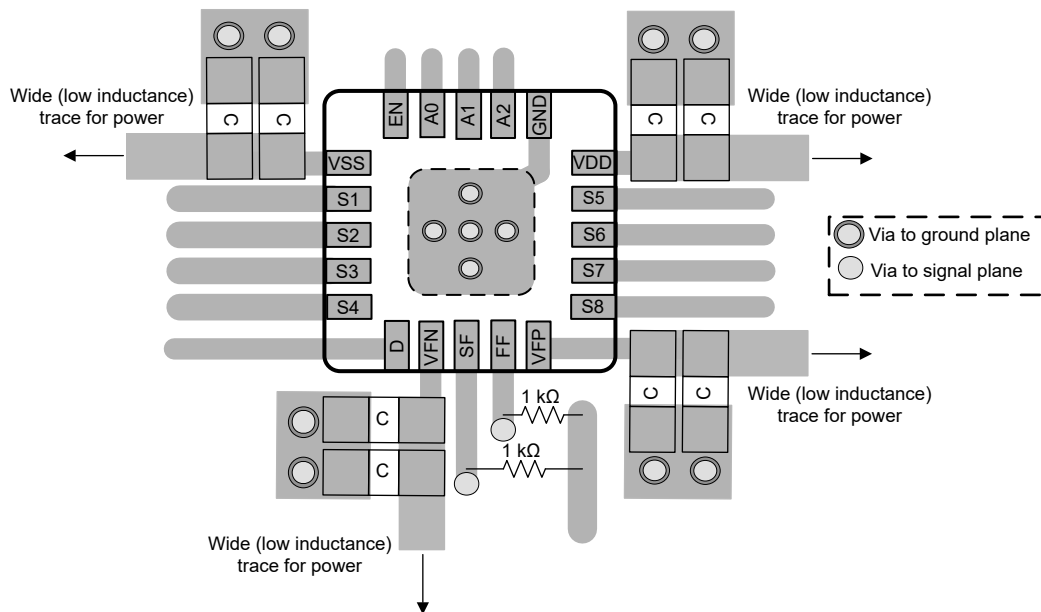


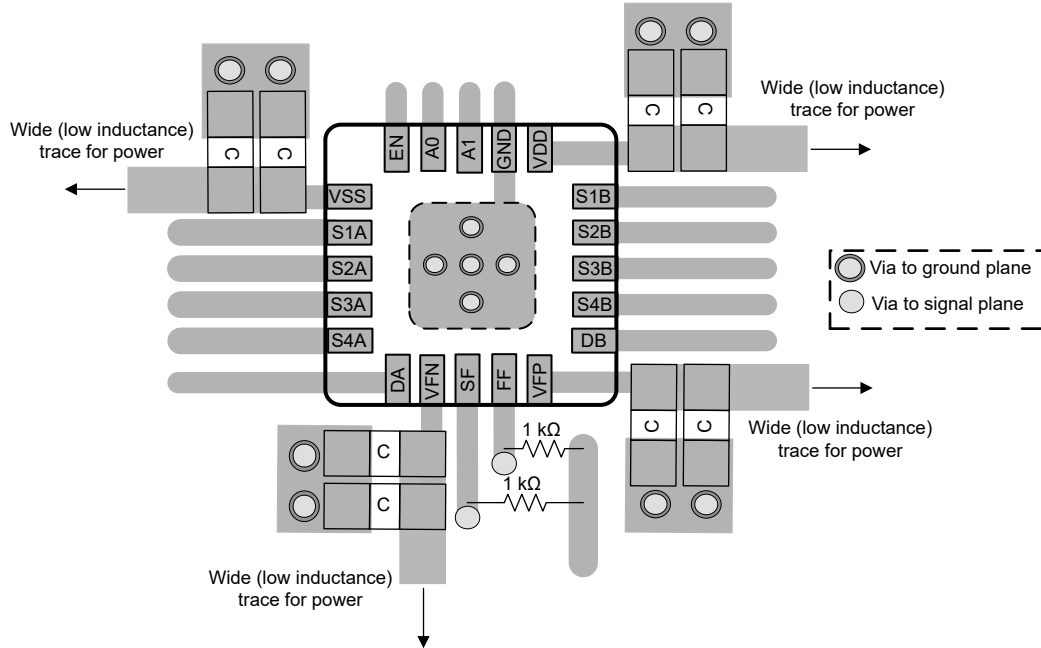
Figure 10-4. TMUX7348FPW Layout Example



**Figure 10-5. TMUX7349FPW Layout Example**



**Figure 10-6. TMUX7348FQFN Layout Example**



**Figure 10-7. TMUX7349FQFN Layout Example**



## 11 Device and Documentation Support

### 11.1 Documentation Support

#### 11.1.1 Related Documentation

- Texas Instruments, [Eliminate Power Sequencing with Powered-Off Protection Signal Switches application brief](#)
- Texas Instruments, [Implications of Slow or Floating CMOS Inputs application note](#)
- Texas Instruments, [Improving Analog Input Modules Reliability Using Fault Protected Multiplexers application report](#)
- Texas Instruments, [Multiplexers and Signal Switches Glossary application report](#)
- Texas Instruments, [Protection Against Overvoltage Events, Miswiring, and Common Mode Voltages application report](#)
- Texas Instruments, [Using Latch-Up Immune Multiplexers to Help Improve System Reliability application report](#)

#### 11.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on [ti.com](https://www.ti.com). Click on *Subscribe to updates* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

#### 11.3 Support Resources

[TI E2E™ support forums](#) are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

#### 11.4 Trademarks

TI E2E™ is a trademark of Texas Instruments.  
All trademarks are the property of their respective owners.

#### 11.5 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

#### 11.6 Glossary

[TI Glossary](#) This glossary lists and explains terms, acronyms, and definitions.

## 12 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

**PACKAGING INFORMATION**

Orderable part number	Status (1)	Material type (2)	Package   Pins	Package qty   Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
<a href="#">TMUX7348FPWR</a>	Active	Production	TSSOP (PW)   20	2000   LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	TM7348F
TMUX7348FPWR.B	Active	Production	TSSOP (PW)   20	2000   LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	TM7348F
<a href="#">TMUX7348FRTJR</a>	Active	Production	QFN (RTJ)   20	3000   LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	TMUX 7348F
TMUX7348FRTJR.B	Active	Production	QFN (RTJ)   20	3000   LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	TMUX 7348F
<a href="#">TMUX7349FPWR</a>	Active	Production	TSSOP (PW)   20	2000   LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	TM7349F
TMUX7349FPWR.B	Active	Production	TSSOP (PW)   20	2000   LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	TM7349F
<a href="#">TMUX7349FRTJR</a>	Active	Production	QFN (RTJ)   20	3000   LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	TMUX 7349F
TMUX7349FRTJR.B	Active	Production	QFN (RTJ)   20	3000   LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	TMUX 7349F

(1) **Status:** For more details on status, see our [product life cycle](#).

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "-" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

**Important Information and Disclaimer:** The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

**OTHER QUALIFIED VERSIONS OF TMUX7348F :**

- Enhanced Product : [TMUX7348F-EP](#)

NOTE: Qualified Version Definitions:

- Enhanced Product - Supports Defense, Aerospace and Medical Applications

**TAPE AND REEL INFORMATION**

**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TMUX7348FPWR	TSSOP	PW	20	2000	330.0	16.4	6.95	7.0	1.4	8.0	16.0	Q1
TMUX7348FRTJR	QFN	RTJ	20	3000	330.0	12.4	4.25	4.25	1.15	8.0	12.0	Q2
TMUX7349FPWR	TSSOP	PW	20	2000	330.0	16.4	6.95	7.0	1.4	8.0	16.0	Q1
TMUX7349FRTJR	QFN	RTJ	20	3000	330.0	12.4	4.25	4.25	1.15	8.0	12.0	Q2

**TAPE AND REEL BOX DIMENSIONS**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TMUX7348FPWR	TSSOP	PW	20	2000	353.0	353.0	32.0
TMUX7348FRTJR	QFN	RTJ	20	3000	367.0	367.0	35.0
TMUX7349FPWR	TSSOP	PW	20	2000	353.0	353.0	32.0
TMUX7349FRTJR	QFN	RTJ	20	3000	367.0	367.0	35.0

## GENERIC PACKAGE VIEW

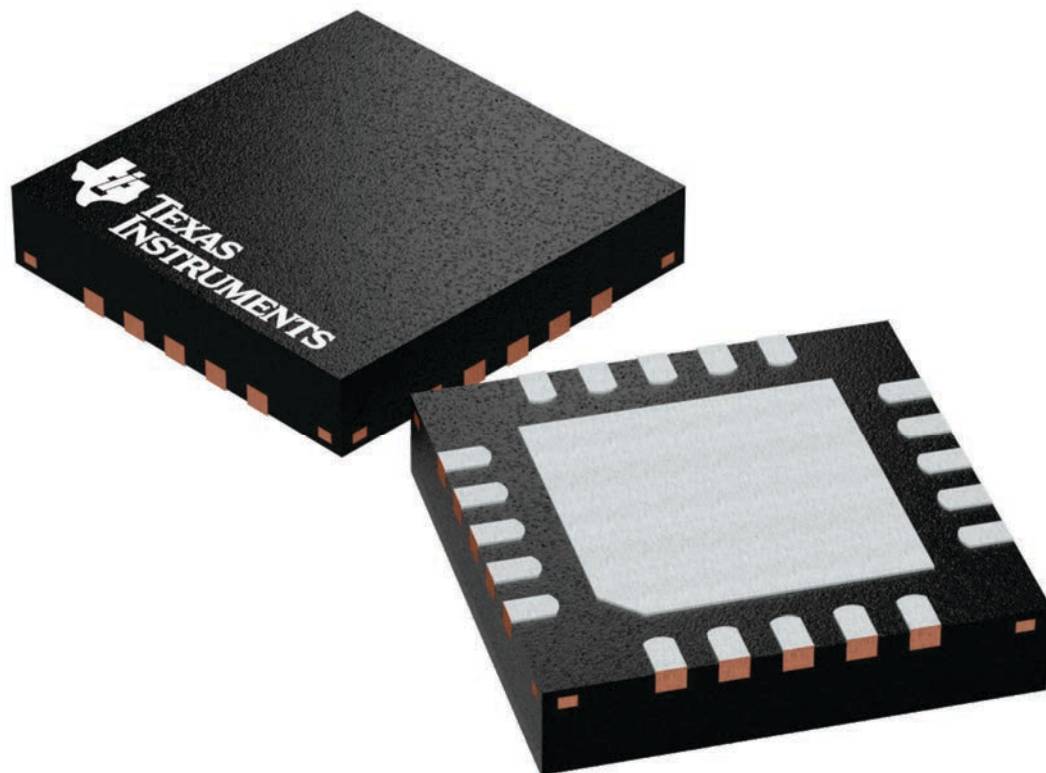
**RTJ 20**

**WQFN - 0.8 mm max height**

4 x 4, 0.5 mm pitch

PLASTIC QUAD FLATPACK - NO LEAD


This image is a representation of the package family, actual package may vary.  
Refer to the product data sheet for package details.



4224842/A

# DATA BOOK PACKAGE OUTLINE

LEADFRAME EXAMPLE
4222370

DRAFTSMAN: H. DENG	DATE: 09/12/2016		DIMENSIONS IN MILLIMETERS								
DESIGNER: H. DENG	DATE: 09/12/2016	 <b>TEXAS INSTRUMENTS</b> SEMICONDUCTOR OPERATIONS	CODE IDENTITY NUMBER 01295								
CHECKER: V. PAKU & T. LEQUANG	DATE: 09/12/2016		<b>ePOD, RTJ0020D / WQFN, 20 PIN, 0.5 MM PITCH</b>								
ENGINEER: T. TANG	DATE: 09/12/2016										
APPROVED: E. REY & D. CHIN	DATE: 10/06/2016										
RELEASED: WDM	DATE: 10/24/2016										
TEMPLATE INFO: EDGE# 4218519	DATE: 04/07/2016	<table border="1" style="display: inline-table; border-collapse: collapse;"> <tr> <td style="padding: 2px;">SCALE</td> <td style="padding: 2px;">SIZE</td> </tr> <tr> <td style="text-align: center;">15X</td> <td style="text-align: center;">A</td> </tr> </table>	SCALE	SIZE	15X	A	<table border="1" style="display: inline-table; border-collapse: collapse;"> <tr> <td style="padding: 2px;">REV</td> <td style="padding: 2px;">PAGE</td> </tr> <tr> <td style="text-align: center;">A</td> <td style="text-align: center;">1 OF 5</td> </tr> </table>	REV	PAGE	A	1 OF 5
SCALE	SIZE										
15X	A										
REV	PAGE										
A	1 OF 5										

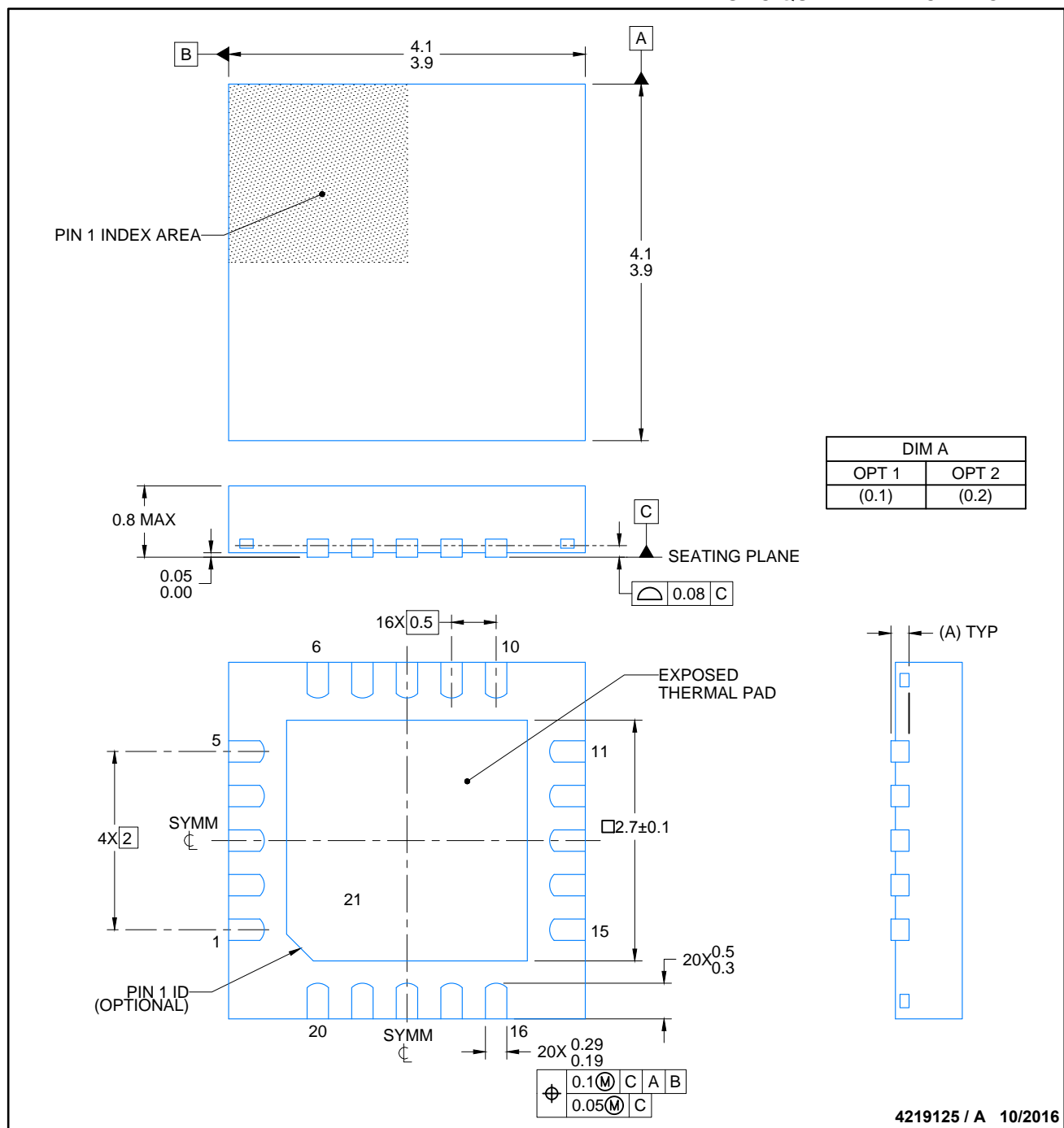
4219125

# RTJ0020D

# PACKAGE OUTLINE

WQFN - 0.8 mm max height

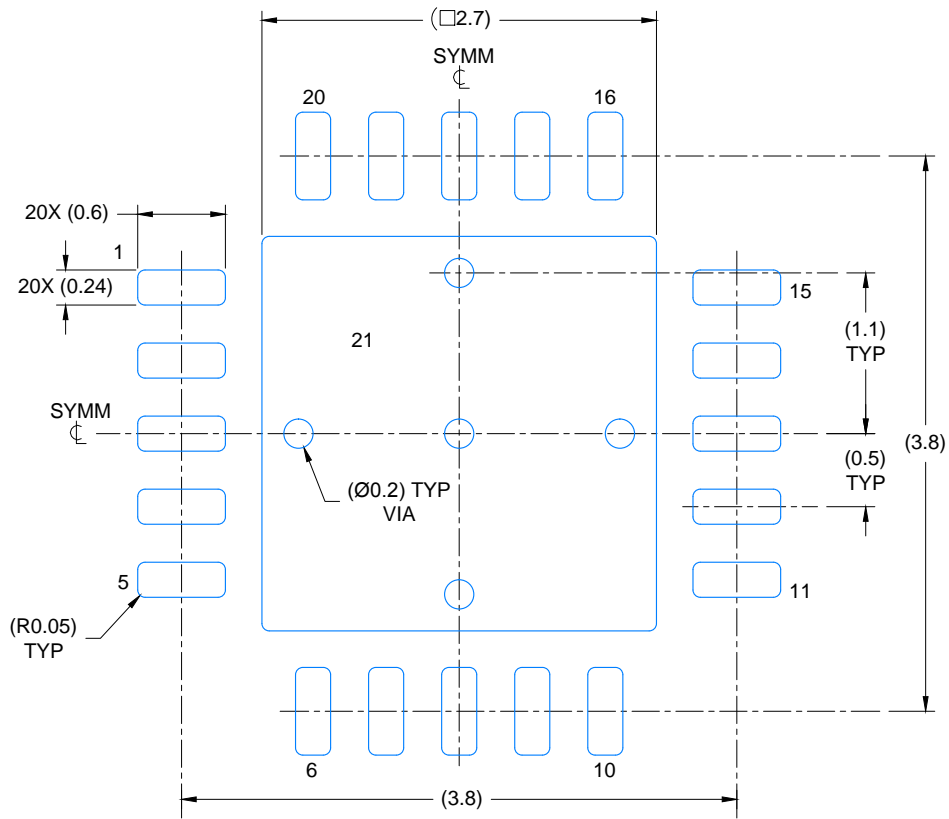
PLASTIC QUAD FLATPACK - NO LEAD



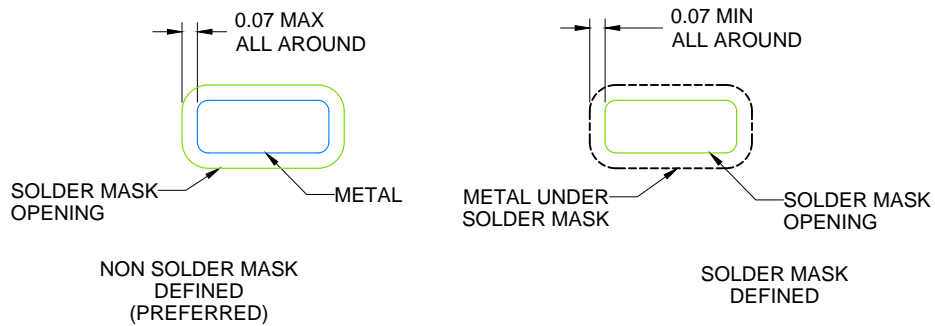
**NOTES:**

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.





LAND PATTERN EXAMPLE  
SCALE: 20X



SOLDER MASK DETAILS

4219125 / A 10/2016

NOTES: (continued)

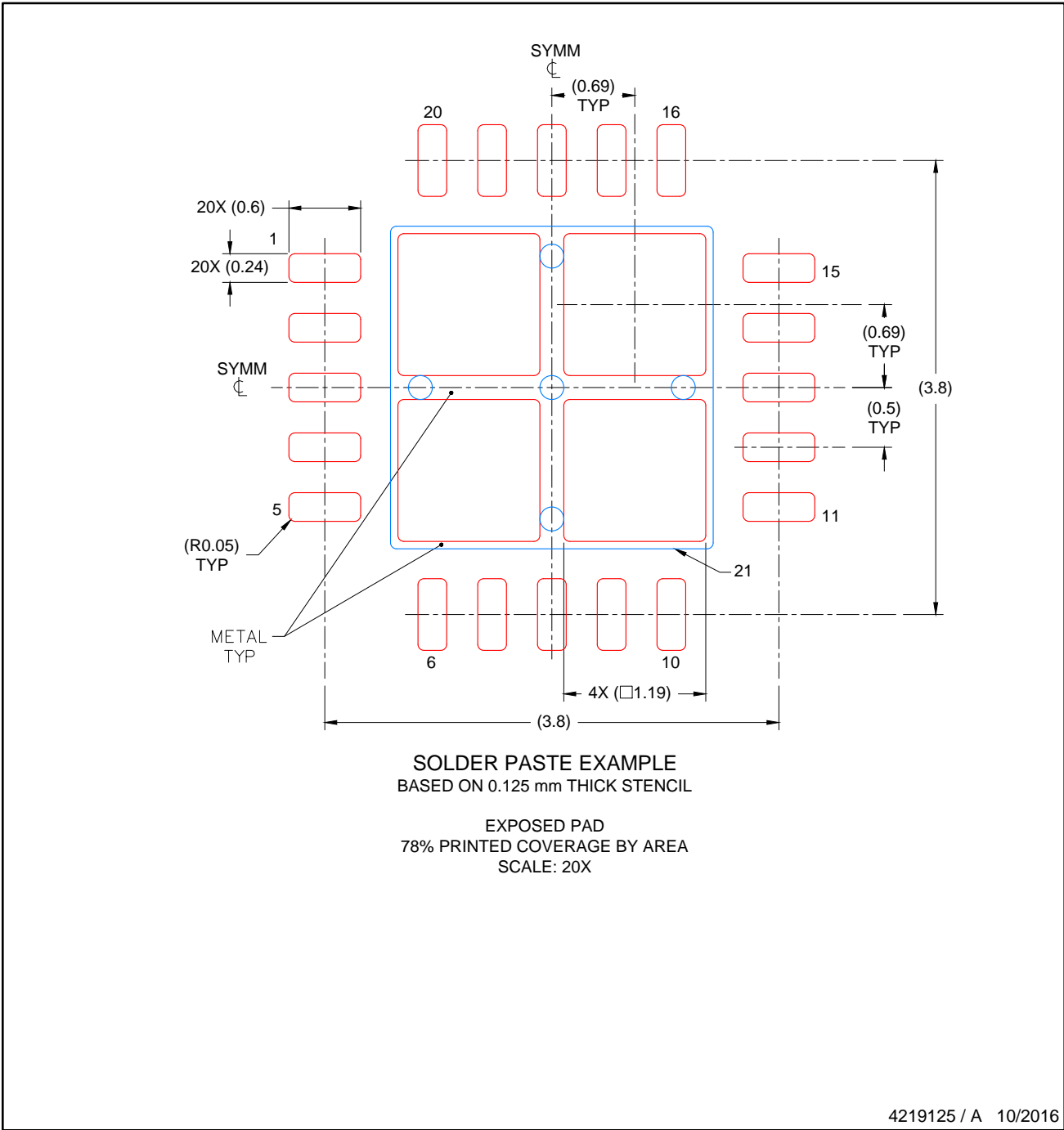
4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 ([www.ti.com/lit/slua271](http://www.ti.com/lit/slua271)).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.

# EXAMPLE STENCIL DESIGN

WQFN - 0.8 mm max height

RTJ0020D

PLASTIC QUAD FLATPACK - NO LEAD



NOTES: (continued)

- 6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations..

# REVISIONS

REV	DESCRIPTION	ECR	DATE	ENGINEER / DRAFTSMAN
A	RELEASE NEW DRAWING	2160736	10/24/2016	T. TANG / H. DENG

SCALE	SIZE
NTS	A

4219125

REV	PAGE
A	5 OF 5

PW0020A



# PACKAGE OUTLINE

## TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



4220206/A 02/2017

NOTES:

- All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
- This drawing is subject to change without notice.
- This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
- This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
- Reference JEDEC registration MO-153.

# EXAMPLE BOARD LAYOUT

PW0020A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE: 10X



SOLDER MASK DETAILS

4220206/A 02/2017

NOTES: (continued)

- 6. Publication IPC-7351 may have alternate designs.
- 7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

# EXAMPLE STENCIL DESIGN

PW0020A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL  
SCALE: 10X

4220206/A 02/2017

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

## IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#) or other applicable terms available either on [ti.com](https://www.ti.com) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2025, Texas Instruments Incorporated