

TMUX6219-Q1 36-V, Low Ron, 2:1 (SPDT) Switch with 1.8-V Logic

1 Features

- AEC-Q100 qualified for automotive applications
 - Device temperature grade 1: -40°C to 125°C ambient operating temperature
- **Functional safety-capable**
 - [Documentation available to aid functional safety system design](#)
- Dual supply range: $\pm 4.5\text{ V}$ to $\pm 18\text{ V}$
- Single supply range: 4.5 V to 36 V
- Low on-resistance: $2.1\ \Omega$
- Low charge injection: -10 pC
- High current support: 330 mA (maximum)
- **1.8 V logic compatible**
- **Fail-safe logic**
- **Rail-to-rail operation**
- **Bidirectional signal path**
- Break-before-make switching

2 Applications

- [EV charging station power module](#)
- [Advanced driver assistance systems \(ADAS\)](#)
- Automotive gateway
- [Analog and digital multiplexing / demultiplexing](#)
- [Automotive head unit](#)
- [Telematics control unit](#)
- [Emergency call \(eCall\)](#)
- [Infotainment](#)
- [Body control modules \(BCM\)](#)
- [Body electronics and lighting](#)
- [Battery management systems \(BMS\)](#)
- [HVAC controller module](#)
- [ADAS domain controller](#)

3 Description

The TMUX6219-Q1 is a complementary metal-oxide semiconductor (CMOS) switch in a single channel, 2:1 (SPDT) configuration. The device works with single supply (4.5 V to 36 V), dual supplies ($\pm 4.5\text{ V}$ to $\pm 18\text{ V}$), or asymmetric supplies (such as $V_{\text{DD}} = 8\text{ V}$, $V_{\text{SS}} = -12\text{ V}$). The TMUX6219-Q1 supports bidirectional analog and digital signals on the source (Sx) and drain (D) pins ranging from V_{SS} to V_{DD} .

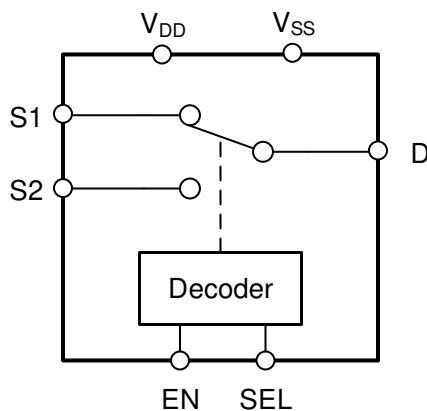
The TMUX6219-Q1 can be enabled or disabled by controlling the EN pin. When disabled, both signal path switches are off. When enabled, the SEL pin can be used to turn on signal path 1 (S1 to D) or signal path 2 (S2 to D). All logic control inputs support logic levels from 1.8 V to V_{DD} , ensuring both TTL and CMOS logic compatibility when operating in the valid supply voltage range. **Fail-Safe Logic** circuitry allows voltages on the control pins to be applied before the supply pin, protecting the device from potential damage.

The TMUX6219-Q1 is part of the precision switches and multiplexers family of devices. These devices have very low on and off leakage currents and low charge injection, allowing them to be used in high precision measurement applications.

Device Information⁽¹⁾

PART NUMBER	PACKAGE	BODY SIZE (NOM)
TMUX6219-Q1	VSSOP (8) (DGK)	3.00 mm × 3.00 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.



TMUX6219-Q1 Block Diagram



Table of Contents

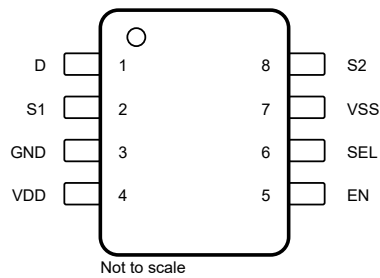
1 Features	1	7.9 Charge Injection.....	23
2 Applications	1	7.10 Off Isolation.....	23
3 Description	1	7.11 Crosstalk.....	24
4 Revision History	2	7.12 Bandwidth.....	24
5 Pin Configuration and Functions	3	7.13 THD + Noise.....	25
6 Specifications	4	7.14 Power Supply Rejection Ratio (PSRR).....	25
6.1 Absolute Maximum Ratings	4	8 Detailed Description	26
6.2 ESD Ratings	4	8.1 Overview.....	26
6.3 Thermal Information	4	8.2 Functional Block Diagram.....	26
6.4 Recommended Operating Conditions	5	8.3 Feature Description.....	26
6.5 Source or Drain Continuous Current	5	8.4 Device Functional Modes.....	28
6.6 ±15 V Dual Supply: Electrical Characteristics	6	8.5 Truth Tables.....	28
6.7 ±15 V Dual Supply: Switching Characteristics	7	9 Application and Implementation	29
6.8 36 V Single Supply: Electrical Characteristics	8	9.1 Application Information.....	29
6.9 36 V Single Supply: Switching Characteristics	9	9.2 Typical Application.....	29
6.10 12 V Single Supply: Electrical Characteristics	10	10 Power Supply Recommendations	30
6.11 12 V Single Supply: Switching Characteristics	11	11 Layout	31
6.12 ±5 V Dual Supply: Electrical Characteristics	12	11.1 Layout Guidelines.....	31
6.13 ±5 V Dual Supply: Switching Characteristics	13	11.2 Layout Example.....	31
6.14 Typical Characteristics.....	14	12 Device and Documentation Support	32
7 Parameter Measurement Information	19	12.1 Documentation Support.....	32
7.1 On-Resistance.....	19	12.2 Receiving Notification of Documentation Updates..	32
7.2 Off-Leakage Current.....	19	12.3 Support Resources.....	32
7.3 On-Leakage Current.....	20	12.4 Trademarks.....	32
7.4 Transition Time.....	20	12.5 Electrostatic Discharge Caution.....	32
7.5 $t_{ON(EN)}$ and $t_{OFF(EN)}$	21	12.6 Glossary.....	32
7.6 Break-Before-Make.....	21	13 Mechanical, Packaging, and Orderable Information	32
7.7 $t_{ON(VDD)}$ Time.....	22		
7.8 Propagation Delay.....	22		

4 Revision History

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

Changes from Revision * (January 2021) to Revision A (June 2021)	Page
• Changed the document status From: <i>Advanced Information</i> To: <i>Production Data</i>	1

5 Pin Configuration and Functions



**Figure 5-1. DGK Package
8-Pin VSSOP
Top View**

Pin Functions

PIN		TYPE ⁽¹⁾	DESCRIPTION ⁽²⁾
NAME	DGK		
D	1	I/O	Drain pin. Can be an input or output.
EN	5	I	Active high logic enable, has internal pull-up resistor. When this pin is low, all switches are turned off. When this pin is high, the SEL logic input determine which switch is turned on.
GND	3	P	Ground (0 V) reference
S1	2	I/O	Source pin 1. Can be an input or output.
S2	8	I/O	Source pin 2. Can be an input or output.
SEL	6	I	Logic control input, has internal pull-down resistor. Controls the switch connection as shown in Table 8-1 .
V _{DD}	4	P	Positive power supply. This pin is the most positive power-supply potential. For reliable operation, connect a decoupling capacitor ranging from 0.1 μ F to 10 μ F between V _{DD} and GND.
V _{SS}	7	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 μ F to 10 μ F between V _{SS} and GND.

- (1) I = input, O = output, I/O = input and output, P = power.
 (2) Refer to [Section 8.4](#) for what to do with unused pins.

6 Specifications

6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)⁽¹⁾ ⁽²⁾

		MIN	MAX	UNIT
$V_{DD}-V_{SS}$	Power supply voltage differential		38	V
V_{DD}	Supply voltage	-0.5	38	V
V_{SS}	Supply voltage	-38	0.5	V
V_{SEL} or V_{EN}	Logic control input pin voltage (SEL, EN) ⁽³⁾	-0.5	38	V
I_{SEL} or I_{EN}	Logic control input pin current (SEL, EN) ⁽³⁾	-30	30	mA
V_S or V_D	Source or drain voltage (Sx, D) ⁽³⁾	$V_{SS}-0.5$	$V_{DD}+0.5$	V
I_{IK}	Diode clamp current ⁽³⁾	-30	30	mA
I_S or I_D (CONT)	Source or drain continuous current (Sx, D)		$I_{DC} + 10\%$ ⁽⁴⁾	mA
T_A	Ambient temperature	-55	150	°C
T_{stg}	Storage temperature	-65	150	°C
T_J	Junction temperature		150	°C
P_{tot}	Total power dissipation ⁽⁵⁾		460	mW

- (1) Stresses beyond those listed under *Absolute Maximum Rating* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Condition*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) All voltages are with respect to ground, unless otherwise specified.
- (3) Pins are diode-clamped to the power-supply rails. Over voltage signals must be voltage and current limited to maximum ratings.
- (4) Refer to *Source or Drain Continuous Current* table for I_{DC} specifications.
- (5) For DGK package: P_{tot} derates linearly above $T_A = 70^\circ\text{C}$ by $6.7\text{mW}/^\circ\text{C}$.

6.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/ JEDEC JS-001, all pins ⁽¹⁾	± 2000	V
		Charged device model (CDM), per JEDEC specification JESD22-C101, all pins ⁽²⁾	± 500	

- (1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
- (2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

6.3 Thermal Information

THERMAL METRIC ⁽¹⁾		TMUX6219-Q1	UNIT
		DGK (VSSOP)	
		8 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	152.1	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	48.4	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	73.2	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	4.1	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	71.8	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	N/A	°C/W

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

6.4 Recommended Operating Conditions

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

		MIN	NOM	MAX	UNIT
$V_{DD} - V_{SS}$ ⁽¹⁾	Power supply voltage differential	4.5		36	V
V_{DD}	Positive power supply voltage	4.5		36	V
V_S or V_D	Signal path input/output voltage (source or drain pin) (Sx, D)	V_{SS}		V_{DD}	V
V_{SEL} or V_{EN}	Address or enable pin voltage	0		36	V
I_S or I_D (CONT)	Source or drain continuous current (Sx, D)			I_{DC} ⁽²⁾	mA
T_A	Ambient temperature	-40		125	°C

(1) V_{DD} and V_{SS} can be any value as long as $4.5\text{ V} \leq (V_{DD} - V_{SS}) \leq 36\text{ V}$, and the minimum V_{DD} is met.

(2) Refer to *Source or Drain Continuous Current* table for I_{DC} specifications.

6.5 Source or Drain Continuous Current

at supply voltage of $V_{DD} \pm 10\%$, $V_{SS} \pm 10\%$ (unless otherwise noted)

CONTINUOUS CURRENT PER CHANNEL (I_{DC})		$T_A = 25^\circ\text{C}$	$T_A = 85^\circ\text{C}$	$T_A = 125^\circ\text{C}$	UNIT
PACKAGE	TEST CONDITIONS				
DGK (VSSOP)	$\pm 15\text{ V}$ Dual Supply	330	210	120	mA
	+36 V Single Supply ⁽¹⁾	300	190	110	mA
	+12 V Single Supply	240	160	100	mA
	$\pm 5\text{ V}$ Dual Supply	240	160	100	mA
	+5 V Single Supply	180	120	80	mA

(1) Specified for nominal supply voltage only.

6.6 ±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	
ANALOG SWITCH								
R_{ON}	On-resistance	$V_S = -10\text{ V to } +10\text{ V}$ $I_D = -10\text{ mA}$ Refer to On-Resistance	25°C	2.1	2.9		Ω	
			-40°C to +85°C			3.8	Ω	
			-40°C to +125°C			4.5	Ω	
ΔR_{ON}	On-resistance mismatch between channels	$V_S = -10\text{ V to } +10\text{ V}$ $I_D = -10\text{ mA}$ Refer to On-Resistance	25°C	0.05	0.25		Ω	
			-40°C to +85°C			0.3	Ω	
			-40°C to +125°C			0.35	Ω	
$R_{ON\ FLAT}$	On-resistance flatness	$V_S = -10\text{ V to } +10\text{ V}$ $I_S = -10\text{ mA}$ Refer to On-Resistance	25°C	0.5	0.6		Ω	
			-40°C to +85°C			0.7	Ω	
			-40°C to +125°C			0.85	Ω	
$R_{ON\ DRIFT}$	On-resistance drift	$V_S = 0\text{ V}$, $I_S = -10\text{ mA}$ Refer to On-Resistance	-40°C to +125°C	0.01			$\Omega/^\circ\text{C}$	
$I_{S(OFF)}$	Source off leakage current ⁽¹⁾	$V_{DD} = 16.5\text{ V}$, $V_{SS} = -16.5\text{ V}$ Switch state is off $V_S = +10\text{ V} / -10\text{ V}$ $V_D = -10\text{ V} / +10\text{ V}$ Refer to Off-Leakage Current	25°C	-0.3	0.1	0.3	nA	
			-40°C to +85°C				3	nA
			-40°C to +125°C				50	nA
$I_{D(OFF)}$	Drain off leakage current ⁽¹⁾	$V_{DD} = 16.5\text{ V}$, $V_{SS} = -16.5\text{ V}$ Switch state is off $V_S = +10\text{ V} / -10\text{ V}$ $V_D = -10\text{ V} / +10\text{ V}$ Refer to Off-Leakage Current	25°C	-2	0.1	2	nA	
			-40°C to +85°C				5	nA
			-40°C to +125°C				70	nA
$I_{S(ON)}$ $I_{D(ON)}$	Channel on leakage current ⁽²⁾	$V_{DD} = 16.5\text{ V}$, $V_{SS} = -16.5\text{ V}$ Switch state is on $V_S = V_D = \pm 10\text{ V}$ Refer to On-Leakage Current	25°C	-2	0.1	2	nA	
			-40°C to +85°C				5	nA
			-40°C to +125°C				70	nA
LOGIC INPUTS (SEL / EN pins)								
V_{IH}	Logic voltage high		-40°C to +125°C	1.3		36	V	
V_{IL}	Logic voltage low		-40°C to +125°C	0		0.8	V	
I_{IH}	Input leakage current		-40°C to +125°C		0.005	1	μA	
I_{IL}	Input leakage current		-40°C to +125°C	-1	-0.005		μA	
C_{IN}	Logic input capacitance		-40°C to +125°C		3		pF	
POWER SUPPLY								
I_{DD}	V_{DD} supply current	$V_{DD} = 16.5\text{ V}$, $V_{SS} = -16.5\text{ V}$ Logic inputs = 0 V, 5 V, or V_{DD}	25°C	30	40		μA	
			-40°C to +85°C				48	μA
			-40°C to +125°C				62	μA
I_{SS}	V_{SS} supply current	$V_{DD} = 16.5\text{ V}$, $V_{SS} = -16.5\text{ V}$ Logic inputs = 0 V, 5 V, or V_{DD}	25°C	3	10		μA	
			-40°C to +85°C				15	μA
			-40°C to +125°C				25	μA

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

(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.

6.7 ±15 V Dual Supply: Switching 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
t_{TRAN}	Transition time from control input	$V_S = 10\text{ V}$ $R_L = 300\ \Omega$, $C_L = 35\text{ pF}$ Refer to Transition Time	25°C		120	175	ns
			-40°C to +85°C			190	ns
			-40°C to +125°C			210	ns
$t_{\text{ON (EN)}}$	Turn-on time from enable	$V_S = 10\text{ V}$ $R_L = 300\ \Omega$, $C_L = 35\text{ pF}$ Refer to Turn-on and Turn-off Time	25°C		100	170	ns
			-40°C to +85°C			185	ns
			-40°C to +125°C			200	ns
$t_{\text{OFF (EN)}}$	Turn-off time from enable	$V_S = 10\text{ V}$ $R_L = 300\ \Omega$, $C_L = 35\text{ pF}$ Refer to Turn-on and Turn-off Time	25°C		100	180	ns
			-40°C to +85°C			195	ns
			-40°C to +125°C			210	ns
t_{BBM}	Break-before-make time delay	$V_S = 10\text{ V}$, $R_L = 300\ \Omega$, $C_L = 35\text{ pF}$ Refer to Break-Before-Make	25°C		50		ns
			-40°C to +85°C		1		ns
			-40°C to +125°C		1		ns
$T_{\text{ON (VDD)}}$	Device turn on time (V_{DD} to output)	V_{DD} rise time = 100ns $R_L = 300\ \Omega$, $C_L = 35\text{ pF}$ Refer to Turn-on (VDD) Time	25°C		0.19		ms
			-40°C to +85°C			0.2	ms
			-40°C to +125°C			0.2	ms
t_{PD}	Propagation delay	$R_L = 50\ \Omega$, $C_L = 5\text{ pF}$ Refer to Propagation Delay	25°C		700		ps
Q_{INJ}	Charge injection	$V_D = 0\text{ V}$, $C_L = 1\text{ nF}$ Refer to Charge Injection	25°C		-10		pC
O_{ISO}	Off-isolation	$R_L = 50\ \Omega$, $C_L = 5\text{ pF}$ $V_S = 0\text{ V}$, $f = 100\text{ kHz}$ Refer to Off Isolation	25°C		-75		dB
O_{ISO}	Off-isolation	$R_L = 50\ \Omega$, $C_L = 5\text{ pF}$ $V_S = 0\text{ V}$, $f = 1\text{ MHz}$ Refer to Off Isolation	25°C		-55		dB
X_{TALK}	Crosstalk	$R_L = 50\ \Omega$, $C_L = 5\text{ pF}$ $V_S = 0\text{ V}$, $f = 100\text{ kHz}$ Refer to Crosstalk	25°C		-117		dB
X_{TALK}	Crosstalk	$R_L = 50\ \Omega$, $C_L = 5\text{ pF}$ $V_S = 0\text{ V}$, $f = 1\text{ MHz}$ Refer to Crosstalk	25°C		-106		dB
BW	-3dB Bandwidth	$R_L = 50\ \Omega$, $C_L = 5\text{ pF}$ $V_S = 0\text{ V}$ Refer to Bandwidth	25°C		40		MHz
I_L	Insertion loss	$R_L = 50\ \Omega$, $C_L = 5\text{ pF}$ $V_S = 0\text{ V}$, $f = 1\text{ MHz}$	25°C		-0.18		dB
ACPSRR	AC Power Supply Rejection Ratio	$V_{PP} = 0.62\text{ V}$ on V_{DD} and V_{SS} $R_L = 50\ \Omega$, $C_L = 5\text{ pF}$, $f = 1\text{ MHz}$ Refer to ACPSRR	25°C		-64		dB
THD+N	Total Harmonic Distortion + Noise	$V_{PP} = 15\text{ V}$, $V_{\text{BIAS}} = 0\text{ V}$ $R_L = 10\text{ k}\Omega$, $C_L = 5\text{ pF}$, $f = 20\text{ Hz}$ to 20 kHz Refer to THD + Noise	25°C		0.0005		%
$C_{\text{S(OFF)}}$	Source off capacitance	$V_S = 0\text{ V}$, $f = 1\text{ MHz}$	25°C		33		pF
$C_{\text{D(OFF)}}$	Drain off capacitance	$V_S = 0\text{ V}$, $f = 1\text{ MHz}$	25°C		48		pF
$C_{\text{S(ON)}}$, $C_{\text{D(ON)}}$	On capacitance	$V_S = 0\text{ V}$, $f = 1\text{ MHz}$	25°C		148		pF

6.8 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	
ANALOG SWITCH								
R_{ON}	On-resistance	$V_S = 0\text{ V to }30\text{ V}$ $I_D = -10\text{ mA}$ Refer to On-Resistance	25°C		2.5	3.2	Ω	
			-40°C to +85°C			4.2	Ω	
			-40°C to +125°C			4.9	Ω	
ΔR_{ON}	On-resistance mismatch between channels	$V_S = 0\text{ V to }30\text{ V}$ $I_D = -10\text{ mA}$ Refer to On-Resistance	25°C		0.1	0.2	Ω	
			-40°C to +85°C			0.25	Ω	
			-40°C to +125°C			0.3	Ω	
$R_{ON\ FLAT}$	On-resistance flatness	$V_S = 0\text{ V to }30\text{ V}$ $I_S = -10\text{ mA}$ Refer to On-Resistance	25°C		0.3	1	Ω	
			-40°C to +85°C			1.5	Ω	
			-40°C to +125°C			2	Ω	
$R_{ON\ DRIFT}$	On-resistance drift	$V_S = 18\text{ V}$, $I_S = -10\text{ mA}$ Refer to On-Resistance	-40°C to +125°C		0.009		$\Omega/^\circ\text{C}$	
$I_{S(OFF)}$	Source off leakage current ⁽¹⁾	$V_{DD} = 39.6\text{ V}$, $V_{SS} = 0\text{ V}$ Switch state is off $V_S = 30\text{ V} / 1\text{ V}$ $V_D = 1\text{ V} / 30\text{ V}$ Refer to Off-Leakage Current	25°C	-0.5	0.1	0.5	nA	
			-40°C to +85°C		-5		5	nA
			-40°C to +125°C		-70		70	nA
$I_{D(OFF)}$	Drain off leakage current ⁽¹⁾	$V_{DD} = 39.6\text{ V}$, $V_{SS} = 0\text{ V}$ Switch state is off $V_S = 30\text{ V} / 1\text{ V}$ $V_D = 1\text{ V} / 30\text{ V}$ Refer to Off-Leakage Current	25°C	-2	0.1	2	nA	
			-40°C to +85°C		-10		10	nA
			-40°C to +125°C		-80		80	nA
$I_{S(ON)}$ $I_{D(ON)}$	Channel on leakage current ⁽²⁾	$V_{DD} = 39.6\text{ V}$, $V_{SS} = 0\text{ V}$ Switch state is on $V_S = V_D = 30\text{ V}$ or 1 V Refer to On-Leakage Current	25°C	-2	0.1	2	nA	
			-40°C to +85°C		-10		10	nA
			-40°C to +125°C		-80		80	nA
LOGIC INPUTS (SEL / EN pins)								
V_{IH}	Logic voltage high		-40°C to +125°C	1.3		36	V	
V_{IL}	Logic voltage low		-40°C to +125°C	0		0.8	V	
I_{IH}	Input leakage current		-40°C to +125°C		0.005	1	μA	
I_{IL}	Input leakage current		-40°C to +125°C	-1	-0.005		μA	
C_{IN}	Logic input capacitance		-40°C to +125°C		3		pF	
POWER SUPPLY								
I_{DD}	V_{DD} supply current	$V_{DD} = 39.6\text{ V}$, $V_{SS} = 0\text{ V}$ Logic inputs = 0 V, 5 V, or V_{DD}	25°C		28	50	μA	
			-40°C to +85°C			58	μA	
			-40°C to +125°C			70	μA	

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

(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.

6.9 36 V Single Supply: Switching 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
t_{TRAN}	Transition time from control input	$V_S = 18\text{ V}$ $R_L = 300\ \Omega$, $C_L = 35\text{ pF}$ Refer to Transition Time	25°C		110	170	ns
			$-40^\circ\text{C to } +85^\circ\text{C}$			185	ns
			$-40^\circ\text{C to } +125^\circ\text{C}$			200	ns
$t_{\text{ON (EN)}}$	Turn-on time from enable	$V_S = 18\text{ V}$ $R_L = 300\ \Omega$, $C_L = 35\text{ pF}$ Refer to Turn-on and Turn-off Time	25°C		110	180	ns
			$-40^\circ\text{C to } +85^\circ\text{C}$			190	ns
			$-40^\circ\text{C to } +125^\circ\text{C}$			200	ns
$t_{\text{OFF (EN)}}$	Turn-off time from enable	$V_S = 18\text{ V}$ $R_L = 300\ \Omega$, $C_L = 35\text{ pF}$ Refer to Turn-on and Turn-off Time	25°C		90	180	ns
			$-40^\circ\text{C to } +85^\circ\text{C}$			195	ns
			$-40^\circ\text{C to } +125^\circ\text{C}$			200	ns
t_{BBM}	Break-before-make time delay	$V_S = 18\text{ V}$, $R_L = 300\ \Omega$, $C_L = 35\text{ pF}$ Refer to Break-Before-Make	25°C		44		ns
			$-40^\circ\text{C to } +85^\circ\text{C}$		1		ns
			$-40^\circ\text{C to } +125^\circ\text{C}$		1		ns
$T_{\text{ON (VDD)}}$	Device turn on time (V_{DD} to output)	V_{DD} rise time = 100ns $R_L = 300\ \Omega$, $C_L = 35\text{ pF}$ Refer to Turn-on (VDD) Time	25°C		0.17		ms
			$-40^\circ\text{C to } +85^\circ\text{C}$			0.19	ms
			$-40^\circ\text{C to } +125^\circ\text{C}$			0.19	ms
t_{PD}	Propagation delay	$R_L = 50\ \Omega$, $C_L = 5\text{ pF}$ Refer to Propagation Delay	25°C		920		ps
Q_{INJ}	Charge injection	$V_D = 18\text{ V}$, $C_L = 1\text{ nF}$ Refer to Charge Injection	25°C		-13		pC
O_{ISO}	Off-isolation	$R_L = 50\ \Omega$, $C_L = 5\text{ pF}$ $V_S = 6\text{ V}$, $f = 100\text{ kHz}$ Refer to Off Isolation	25°C		-75		dB
O_{ISO}	Off-isolation	$R_L = 50\ \Omega$, $C_L = 5\text{ pF}$ $V_S = 6\text{ V}$, $f = 1\text{ MHz}$ Refer to Off Isolation	25°C		-55		dB
X_{TALK}	Crosstalk	$R_L = 50\ \Omega$, $C_L = 5\text{ pF}$ $V_S = 6\text{ V}$, $f = 100\text{ kHz}$ Refer to Crosstalk	25°C		-117		dB
X_{TALK}	Crosstalk	$R_L = 50\ \Omega$, $C_L = 5\text{ pF}$ $V_S = 6\text{ V}$, $f = 1\text{ MHz}$ Refer to Crosstalk	25°C		-106		dB
BW	-3dB Bandwidth	$R_L = 50\ \Omega$, $C_L = 5\text{ pF}$ $V_S = 6\text{ V}$, Refer to Bandwidth	25°C		38		MHz
I_L	Insertion loss	$R_L = 50\ \Omega$, $C_L = 5\text{ pF}$ $V_S = 6\text{ V}$, $f = 1\text{ MHz}$	25°C		-0.19		dB
ACPSRR	AC Power Supply Rejection Ratio	$V_{PP} = 0.62\text{ V}$ on V_{DD} and V_{SS} $R_L = 50\ \Omega$, $C_L = 5\text{ pF}$, $f = 1\text{ MHz}$ Refer to ACPSRR	25°C		-60		dB
THD+N	Total Harmonic Distortion + Noise	$V_{PP} = 18\text{ V}$, $V_{BIAS} = 18\text{ V}$ $R_L = 10\text{ k}\Omega$, $C_L = 5\text{ pF}$, $f = 20\text{ Hz to } 20\text{ kHz}$ Refer to THD + Noise	25°C		0.0004		%
$C_{S(\text{OFF})}$	Source off capacitance	$V_S = 6\text{ V}$, $f = 1\text{ MHz}$	25°C		35		pF
$C_{D(\text{OFF})}$	Drain off capacitance	$V_S = 6\text{ V}$, $f = 1\text{ MHz}$	25°C		49		pF
$C_{S(\text{ON})}$, $C_{D(\text{ON})}$	On capacitance	$V_S = 6\text{ V}$, $f = 1\text{ MHz}$	25°C		146		pF

6.10 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
ANALOG SWITCH							
R_{ON}	On-resistance	$V_S = 0\text{ V to }10\text{ V}$ $I_D = -10\text{ mA}$ Refer to On-Resistance	25°C	4.6		6	Ω
			-40°C to +85°C			7.5	Ω
			-40°C to +125°C			8.4	Ω
ΔR_{ON}	On-resistance mismatch between channels	$V_S = 0\text{ V to }10\text{ V}$ $I_D = -10\text{ mA}$ Refer to On-Resistance	25°C	0.08		0.2	Ω
			-40°C to +85°C			0.32	Ω
			-40°C to +125°C			0.35	Ω
$R_{ON\ FLAT}$	On-resistance flatness	$V_S = 0\text{ V to }10\text{ V}$ $I_S = -10\text{ mA}$ Refer to On-Resistance	25°C	1.2		2	Ω
			-40°C to +85°C			2.2	Ω
			-40°C to +125°C			2.4	Ω
$R_{ON\ DRIFT}$	On-resistance drift	$V_S = 6\text{ V}$, $I_S = -10\text{ mA}$ Refer to On-Resistance	-40°C to +125°C		0.017		$\Omega/^\circ\text{C}$
$I_{S(OFF)}$	Source off leakage current ⁽¹⁾	$V_{DD} = 13.2\text{ V}$, $V_{SS} = 0\text{ V}$ Switch state is off $V_S = 10\text{ V} / 1\text{ V}$ $V_D = 1\text{ V} / 10\text{ V}$ Refer to Off-Leakage Current	25°C	-1	0.1	1	nA
			-40°C to +85°C			5	nA
			-40°C to +125°C			50	nA
$I_{D(OFF)}$	Drain off leakage current ⁽¹⁾	$V_{DD} = 13.2\text{ V}$, $V_{SS} = 0\text{ V}$ Switch state is off $V_S = 10\text{ V} / 1\text{ V}$ $V_D = 1\text{ V} / 10\text{ V}$ Refer to Off-Leakage Current	25°C	-2	0.1	2	nA
			-40°C to +85°C			5	nA
			-40°C to +125°C			70	nA
$I_{S(ON)}$ $I_{D(ON)}$	Channel on leakage current ⁽²⁾	$V_{DD} = 13.2\text{ V}$, $V_{SS} = 0\text{ V}$ Switch state is on $V_S = V_D = 10\text{ V}$ or 1 V Refer to On-Leakage Current	25°C	-2	0.1	2	nA
			-40°C to +85°C			5	nA
			-40°C to +125°C			70	nA
LOGIC INPUTS (SEL / EN pins)							
V_{IH}	Logic voltage high		-40°C to +125°C	1.3		36	V
V_{IL}	Logic voltage low		-40°C to +125°C	0		0.8	V
I_{IH}	Input leakage current		-40°C to +125°C		0.005	1	μA
I_{IL}	Input leakage current		-40°C to +125°C	-1	-0.005		μA
C_{IN}	Logic input capacitance		-40°C to +125°C		3		pF
POWER SUPPLY							
I_{DD}	V_{DD} supply current	$V_{DD} = 13.2\text{ V}$, $V_{SS} = 0\text{ V}$ Logic inputs = 0 V , 5 V , or V_{DD}	25°C		10	35	μA
			-40°C to +85°C			45	μA
			-40°C to +125°C			55	μA

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

(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.

6.11 12 V Single Supply: Switching 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
t_{TRAN}	Transition time from control input	$V_S = 8\text{ V}$ $R_L = 300\ \Omega$, $C_L = 35\text{ pF}$ Refer to Transition Time	25°C		180	185	ns
			-40°C to +85°C			215	ns
			-40°C to +125°C			235	ns
$t_{\text{ON (EN)}}$	Turn-on time from enable	$V_S = 8\text{ V}$ $R_L = 300\ \Omega$, $C_L = 35\text{ pF}$ Refer to Turn-on and Turn-off Time	25°C		120	180	ns
			-40°C to +85°C			210	ns
			-40°C to +125°C			230	ns
$t_{\text{OFF (EN)}}$	Turn-off time from enable	$V_S = 8\text{ V}$ $R_L = 300\ \Omega$, $C_L = 35\text{ pF}$ Refer to Turn-on and Turn-off Time	25°C		130	210	ns
			-40°C to +85°C			235	ns
			-40°C to +125°C			250	ns
t_{BBM}	Break-before-make time delay	$V_S = 8\text{ V}$, $R_L = 300\ \Omega$, $C_L = 35\text{ pF}$ Refer to Break-Before-Make	25°C		40		ns
			-40°C to +85°C	1			ns
			-40°C to +125°C	1			ns
$T_{\text{ON (VDD)}}$	Device turn on time (V_{DD} to output)	V_{DD} rise time = 100ns $R_L = 300\ \Omega$, $C_L = 35\text{ pF}$ Refer to Turn-on (VDD) Time	25°C		0.19		ms
			-40°C to +85°C			0.2	ms
			-40°C to +125°C			0.2	ms
t_{PD}	Propagation delay	$R_L = 50\ \Omega$, $C_L = 5\text{ pF}$ Refer to Propagation Delay	25°C		740		ps
Q_{INJ}	Charge injection	$V_D = 6\text{ V}$, $C_L = 1\text{ nF}$ Refer to Charge Injection	25°C		-6		pC
O_{ISO}	Off-isolation	$R_L = 50\ \Omega$, $C_L = 5\text{ pF}$ $V_S = 6\text{ V}$, $f = 100\text{ kHz}$ Refer to Charge Injection	25°C		-75		dB
O_{ISO}	Off-isolation	$R_L = 50\ \Omega$, $C_L = 5\text{ pF}$ $V_S = 6\text{ V}$, $f = 1\text{ MHz}$ Refer to Off Isolation	25°C		-55		dB
X_{TALK}	Crosstalk	$R_L = 50\ \Omega$, $C_L = 5\text{ pF}$ $V_S = 6\text{ V}$, $f = 100\text{ kHz}$ Refer to Crosstalk	25°C		-117		dB
X_{TALK}	Crosstalk	$R_L = 50\ \Omega$, $C_L = 5\text{ pF}$ $V_S = 6\text{ V}$, $f = 1\text{ MHz}$ Refer to Crosstalk	25°C		-106		dB
BW	-3dB Bandwidth	$R_L = 50\ \Omega$, $C_L = 5\text{ pF}$ $V_S = 6\text{ V}$ Refer to Bandwidth	25°C		42		MHz
I_L	Insertion loss	$R_L = 50\ \Omega$, $C_L = 5\text{ pF}$ $V_S = 6\text{ V}$, $f = 1\text{ MHz}$	25°C		-0.3		dB
ACPSRR	AC Power Supply Rejection Ratio	$V_{PP} = 0.62\text{ V}$ on V_{DD} and V_{SS} $R_L = 50\ \Omega$, $C_L = 5\text{ pF}$, $f = 1\text{ MHz}$ Refer to ACPSRR	25°C		-65		dB
THD+N	Total Harmonic Distortion + Noise	$V_{PP} = 6\text{ V}$, $V_{BIAS} = 6\text{ V}$ $R_L = 10\text{ k}\Omega$, $C_L = 5\text{ pF}$, $f = 20\text{ Hz}$ to 20 kHz Refer to THD + Noise	25°C		0.0009		%
$C_{S(\text{OFF})}$	Source off capacitance	$V_S = 6\text{ V}$, $f = 1\text{ MHz}$	25°C		38		pF
$C_{D(\text{OFF})}$	Drain off capacitance	$V_S = 6\text{ V}$, $f = 1\text{ MHz}$	25°C		56		pF
$C_{S(\text{ON})}$, $C_{D(\text{ON})}$	On capacitance	$V_S = 6\text{ V}$, $f = 1\text{ MHz}$	25°C		150		pF

6.12 ±5 V Dual Supply: Electrical Characteristics

$V_{DD} = +5\text{ V} \pm 10\%$, $V_{SS} = -5\text{ V} \pm 10\%$, GND = 0 V (unless otherwise noted)

Typical at $V_{DD} = +5\text{ V}$, $V_{SS} = -5\text{ V}$, $T_A = 25^\circ\text{C}$ (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A	MIN	TYP	MAX	UNIT
ANALOG SWITCH							
R_{ON}	On-resistance	$V_{DD} = +4.5\text{ V}$, $V_{SS} = -4.5\text{ V}$ $V_S = -4.5\text{ V}$ to $+4.5\text{ V}$ $I_D = -10\text{ mA}$ Refer to On-Resistance	25°C		4	7.2	Ω
			-40°C to +85°C			8.6	Ω
			-40°C to +125°C			10	Ω
ΔR_{ON}	On-resistance mismatch between channels	$V_S = -4.5\text{ V}$ to $+4.5\text{ V}$ $I_D = -10\text{ mA}$ Refer to On-Resistance	25°C		0.1	0.3	Ω
			-40°C to +85°C			0.35	Ω
			-40°C to +125°C			0.4	Ω
$R_{ON\ FLAT}$	On-resistance flatness	$V_S = -4.5\text{ V}$ to $+4.5\text{ V}$ $I_D = -10\text{ mA}$ Refer to On-Resistance	25°C		1.3	2.2	Ω
			-40°C to +85°C			2.5	Ω
			-40°C to +125°C			2.8	Ω
$R_{ON\ DRIFT}$	On-resistance drift	$V_S = 0\text{ V}$, $I_S = -10\text{ mA}$ Refer to On-Resistance	-40°C to +125°C		0.019		$\Omega/^\circ\text{C}$
$I_{S(OFF)}$	Source off leakage current ⁽¹⁾	$V_{DD} = +5.5\text{ V}$, $V_{SS} = -5.5\text{ V}$ Switch state is off $V_S = +4.5\text{ V}$ / -4.5 V $V_D = -4.5\text{ V}$ / $+4.5\text{ V}$ Refer to Off-Leakage Current	25°C	-1	0.1	1	nA
			-40°C to +85°C			4	nA
			-40°C to +125°C			50	nA
$I_{D(OFF)}$	Drain off leakage current ⁽¹⁾	$V_{DD} = +5.5\text{ V}$, $V_{SS} = -5.5\text{ V}$ Switch state is off $V_S = +4.5\text{ V}$ / -4.5 V $V_D = -4.5\text{ V}$ / $+4.5\text{ V}$ Refer to Off-Leakage Current	25°C	-2	0.1	2	nA
			-40°C to +85°C			5	nA
			-40°C to +125°C			50	nA
$I_{S(ON)}$ $I_{D(ON)}$	Channel on leakage current ⁽²⁾	$V_{DD} = +5.5\text{ V}$, $V_{SS} = -5.5\text{ V}$ Switch state is on $V_S = V_D = \pm 4.5\text{ V}$ Refer to On-Leakage Current	25°C	-2	0.1	2	nA
			-40°C to +85°C			5	nA
			-40°C to +125°C			50	nA
LOGIC INPUTS (SEL / EN pins)							
V_{IH}	Logic voltage high		-40°C to +125°C	1.3		36	V
V_{IL}	Logic voltage low		-40°C to +125°C	0		0.8	V
I_{IH}	Input leakage current		-40°C to +125°C		0.005	1	μA
I_{IL}	Input leakage current		-40°C to +125°C	-1	-0.005		μA
C_{IN}	Logic input capacitance		-40°C to +125°C		3		pF
POWER SUPPLY							
I_{DD}	V_{DD} supply current	$V_{DD} = +5.5\text{ V}$, $V_{SS} = -5.5\text{ V}$ Logic inputs = 0 V, 5 V, or V_{DD}	25°C		20	35	μA
			-40°C to +85°C			40	μA
			-40°C to +125°C			50	μA
I_{SS}	V_{SS} supply current	$V_{DD} = +5.5\text{ V}$, $V_{SS} = -5.5\text{ V}$ Logic inputs = 0 V, 5 V, or V_{DD}	25°C		0.001	5	μA
			-40°C to +85°C			8	μA
			-40°C to +125°C			15	μA

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

(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.

6.13 ±5 V Dual Supply: Switching Characteristics

$V_{DD} = +5\text{ V} \pm 10\%$, $V_{SS} = -5\text{ V} \pm 10\%$, $GND = 0\text{ V}$ (unless otherwise noted)

Typical at $V_{DD} = +5\text{ V}$, $V_{SS} = -5\text{ V}$, $T_A = 25^\circ\text{C}$ (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A	MIN	TYP	MAX	UNIT
t_{TRAN}	Transition time from control input	$V_S = 3\text{ V}$ $R_L = 300\ \Omega$, $C_L = 35\text{ pF}$ Refer to Transition Time	25°C		300	400	ns
			-40°C to +85°C			490	ns
			-40°C to +125°C			550	ns
$t_{\text{ON (EN)}}$	Turn-on time from enable	$V_S = 3\text{ V}$ $R_L = 300\ \Omega$, $C_L = 35\text{ pF}$ Refer to Turn-on and Turn-off Time	25°C		220	300	ns
			-40°C to +85°C			350	ns
			-40°C to +125°C			380	ns
$t_{\text{OFF (EN)}}$	Turn-off time from enable	$V_S = 3\text{ V}$ $R_L = 300\ \Omega$, $C_L = 35\text{ pF}$ Refer to Turn-on and Turn-off Time	25°C		210	280	ns
			-40°C to +85°C			330	ns
			-40°C to +125°C			350	ns
t_{BBM}	Break-before-make time delay	$V_S = 3\text{ V}$, $R_L = 300\ \Omega$, $C_L = 35\text{ pF}$ Refer to Break-Before-Make	25°C		50		ns
			-40°C to +85°C	1			ns
			-40°C to +125°C	1			ns
$T_{\text{ON (VDD)}}$	Device turn on time (V_{DD} to output)	V_{DD} rise time = 100ns $R_L = 300\ \Omega$, $C_L = 35\text{ pF}$ Refer to Turn-on (VDD) Time	25°C		0.19		ms
			-40°C to +85°C		0.19	1	ms
			-40°C to +125°C		0.19	1	ms
t_{PD}	Propagation delay	$R_L = 50\ \Omega$, $C_L = 5\text{ pF}$ Refer to Propagation Delay	25°C		650		ps
Q_{INJ}	Charge injection	$V_D = 0\text{ V}$, $C_L = 1\text{ nF}$ Refer to Charge Injection	25°C		-5		pC
O_{ISO}	Off-isolation	$R_L = 50\ \Omega$, $C_L = 5\text{ pF}$ $V_S = 0\text{ V}$, $f = 1\text{ MHz}$ Refer to Off Isolation	25°C		-55		dB
X_{TALK}	Crosstalk	$R_L = 50\ \Omega$, $C_L = 5\text{ pF}$ $V_S = 0\text{ V}$, $f = 100\text{ kHz}$ Refer to Crosstalk	25°C		-117		dB
X_{TALK}	Crosstalk	$R_L = 50\ \Omega$, $C_L = 5\text{ pF}$ $V_S = 0\text{ V}$, $f = 1\text{ MHz}$ Refer to Crosstalk	25°C		-106		dB
BW	-3dB Bandwidth	$R_L = 50\ \Omega$, $C_L = 5\text{ pF}$ $V_S = 0\text{ V}$, Refer to Bandwidth	25°C		43		MHz
I_L	Insertion loss	$R_L = 50\ \Omega$, $C_L = 5\text{ pF}$ $V_S = 0\text{ V}$, $f = 1\text{ MHz}$	25°C		-0.35		dB
ACPSRR	AC Power Supply Rejection Ratio	$V_{PP} = 0.62\text{ V}$ on V_{DD} and V_{SS} $R_L = 50\ \Omega$, $C_L = 5\text{ pF}$, $f = 1\text{ MHz}$ Refer to ACPSRR	25°C		-68		dB
THD+N	Total Harmonic Distortion + Noise	$V_{PP} = 5\text{ V}$, $V_{BIAS} = 0\text{ V}$ $R_L = 10\text{ k}\Omega$, $C_L = 5\text{ pF}$, $f = 20\text{ Hz}$ to 20 kHz Refer to THD + Noise	25°C		0.001		%
THD+N	Total Harmonic Distortion + Noise	$V_{PP} = 5\text{ V}$, $V_{BIAS} = 0\text{ V}$ $R_L = 10\text{ M}\Omega$, $C_L = 5\text{ pF}$, $f = 20\text{ Hz}$ to 20 kHz Refer to THD + Noise	25°C		0.0006		%
$C_{S(\text{OFF})}$	Source off capacitance	$V_S = 0\text{ V}$, $f = 1\text{ MHz}$	25°C		40		pF
$C_{D(\text{OFF})}$	Drain off capacitance	$V_S = 0\text{ V}$, $f = 1\text{ MHz}$	25°C		60		pF
$C_{S(\text{ON})}$, $C_{D(\text{ON})}$	On capacitance	$V_S = 0\text{ V}$, $f = 1\text{ MHz}$	25°C		150		pF

6.14 Typical Characteristics

at $T_A = 25^\circ\text{C}$

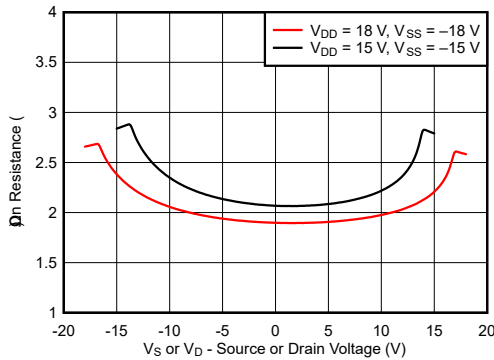


Figure 6-1. On-Resistance vs Source or Drain Voltage – Dual Supply

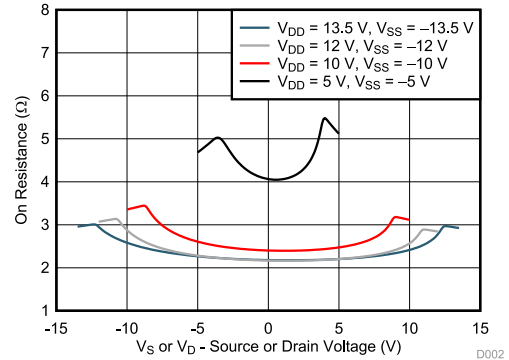


Figure 6-2. On-Resistance vs Source or Drain Voltage – Dual Supply

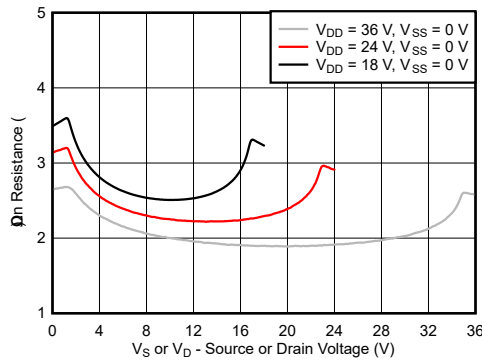


Figure 6-3. On-Resistance vs Source or Drain Voltage – Single Supply

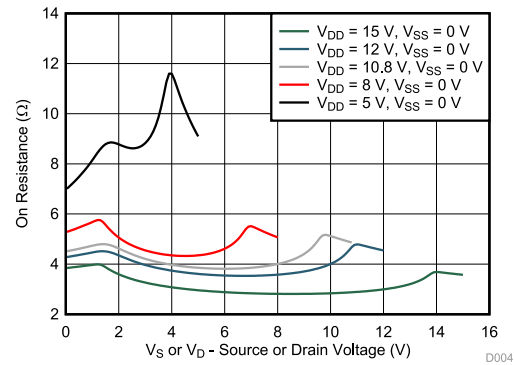


Figure 6-4. On-Resistance vs Source or Drain Voltage – Single Supply

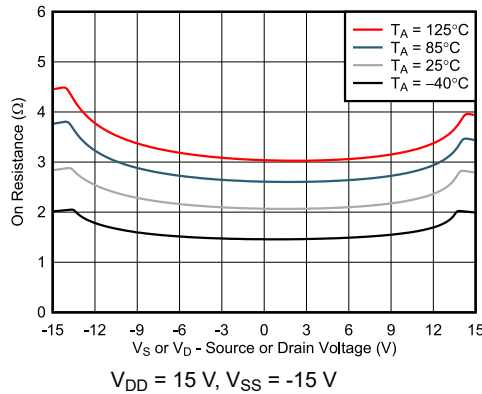


Figure 6-5. On-Resistance vs Temperature

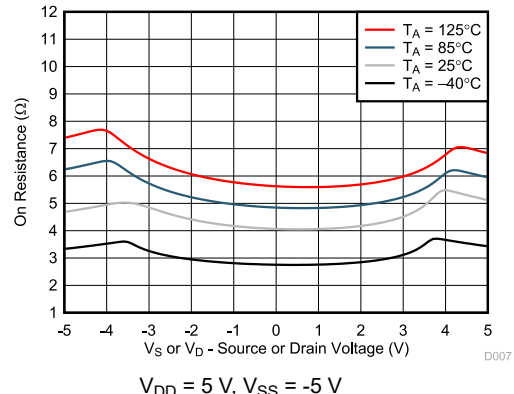


Figure 6-6. On-Resistance vs Temperature

6.14 Typical Characteristics (continued)

at $T_A = 25^\circ\text{C}$

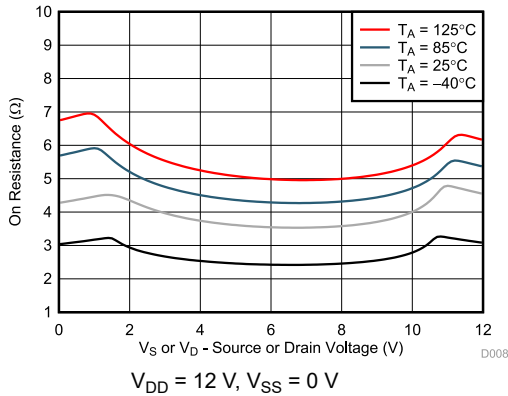


Figure 6-7. On-Resistance vs Temperature

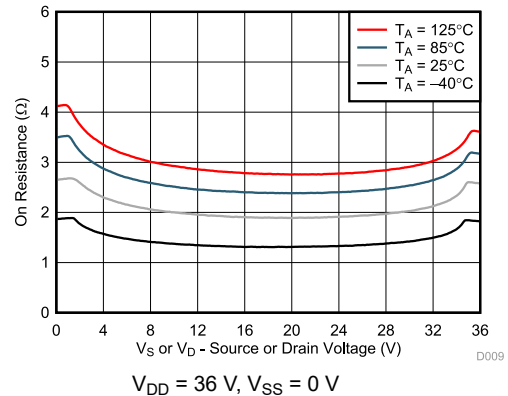


Figure 6-8. On-Resistance vs Temperature

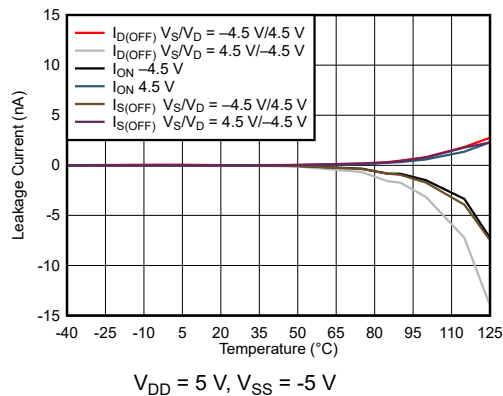


Figure 6-9. Leakage Current vs Temperature

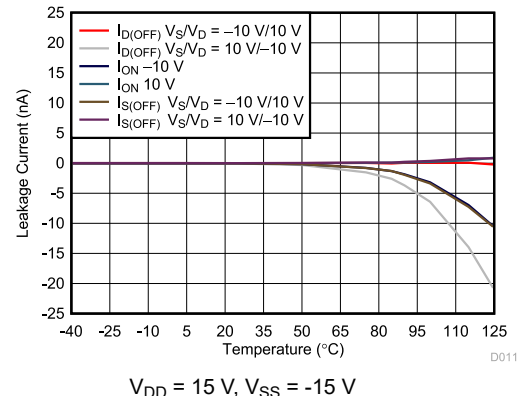


Figure 6-10. Leakage Current vs Temperature

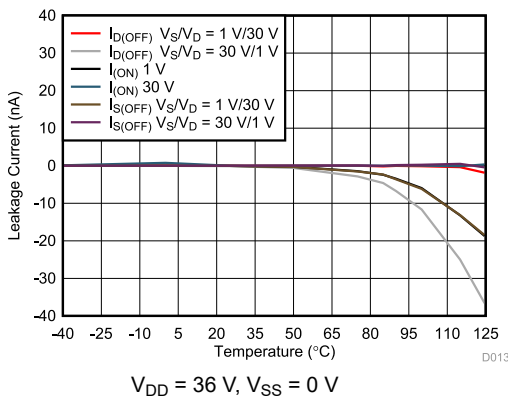


Figure 6-11. Leakage Current vs Temperature

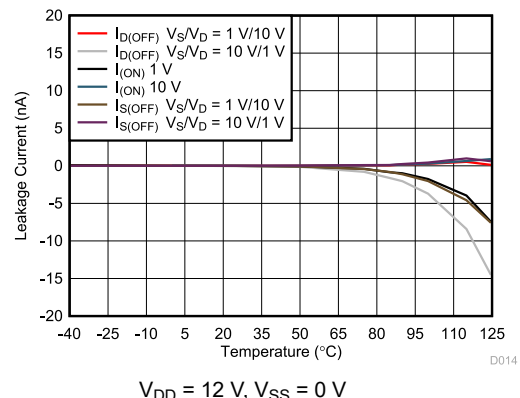


Figure 6-12. Leakage Current vs Temperature

6.14 Typical Characteristics (continued)

at $T_A = 25^\circ\text{C}$

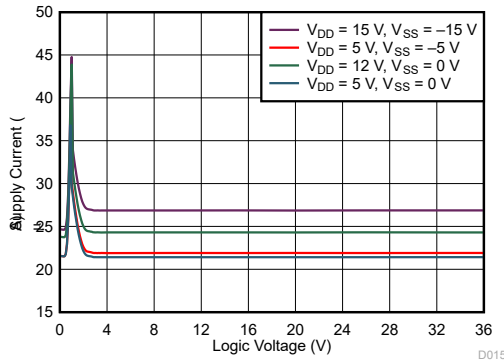


Figure 6-13. Supply Current vs Logic Voltage

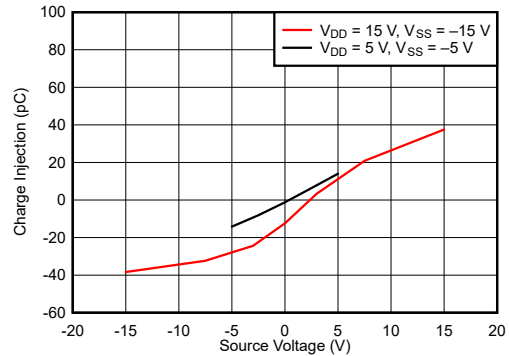


Figure 6-14. Charge Injection vs Source Voltage – Dual Supplies

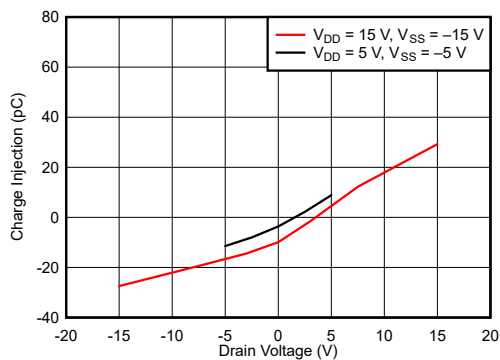


Figure 6-15. Charge Injection vs Drain Voltage – Dual Supplies

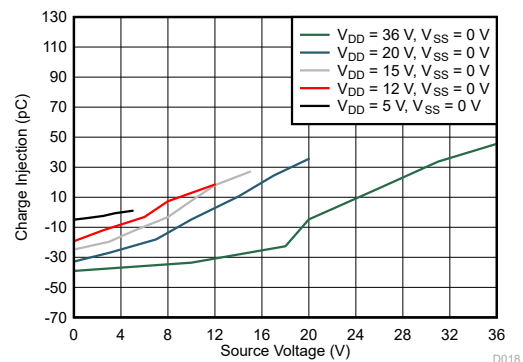


Figure 6-16. Charge Injection vs Source Voltage – Single Supplies

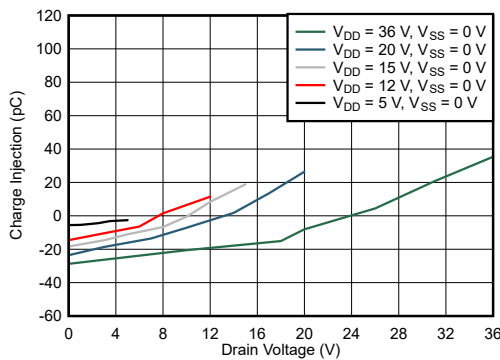


Figure 6-17. Charge Injection vs Drinan Voltage – Single Supplies

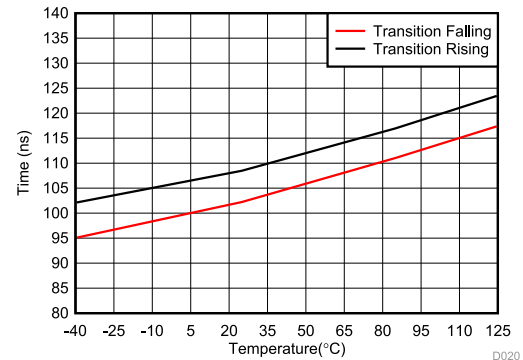
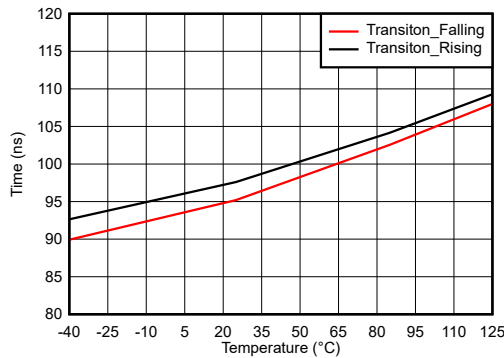


Figure 6-18. $T_{\text{TRANSITION}}$ vs Temperature

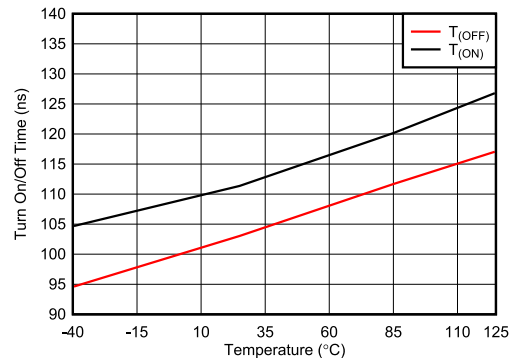
6.14 Typical Characteristics (continued)

at $T_A = 25^\circ\text{C}$



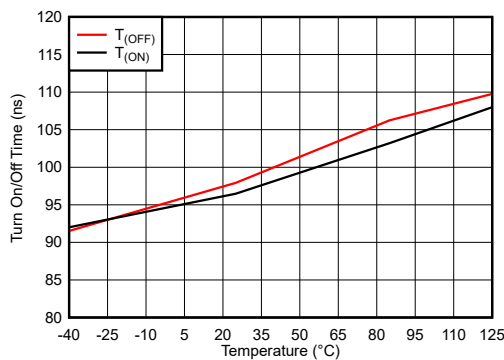
$V_{DD} = 36\text{ V}, V_{SS} = 0\text{ V}$

Figure 6-19. $T_{\text{TRANSITION}}$ vs Temperature



$V_{DD} = 15\text{ V}, V_{SS} = -15\text{ V}$

Figure 6-20. T_{ON} and T_{OFF} vs Temperature



$V_{DD} = 36\text{ V}, V_{SS} = 0\text{ V}$

Figure 6-21. T_{ON} and T_{OFF} vs Temperature

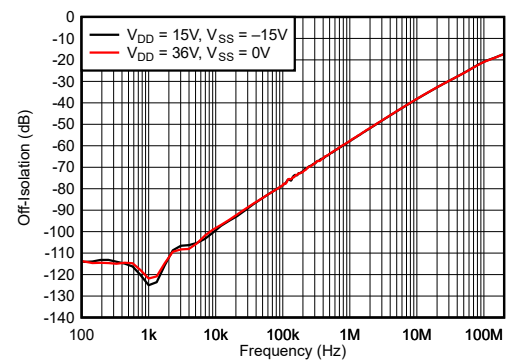
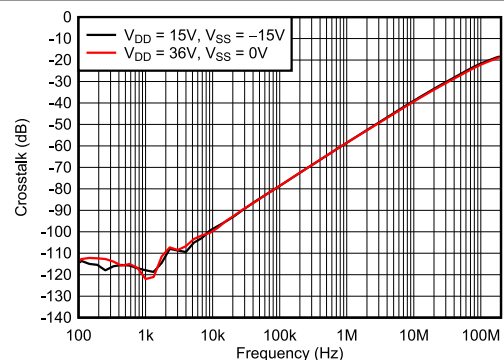
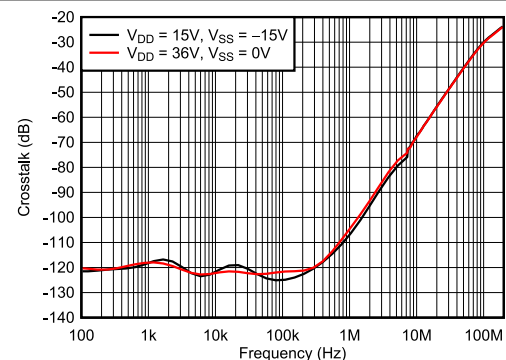


Figure 6-22. Off-Isolation vs Frequency



Switch ON (EN = 1)

Figure 6-23. Crosstalk vs Frequency



Switch OFF (EN = 0)

Figure 6-24. Crosstalk vs Frequency

6.14 Typical Characteristics (continued)

at $T_A = 25^\circ\text{C}$

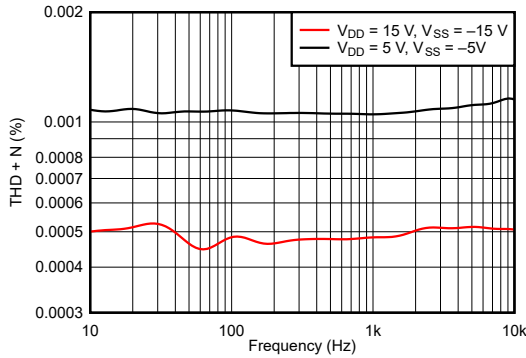


Figure 6-25. THD+N vs Frequency (Dual Supplies)

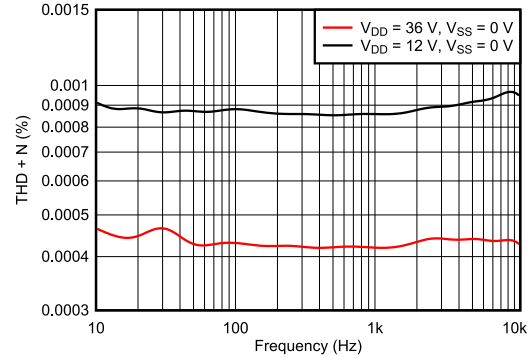
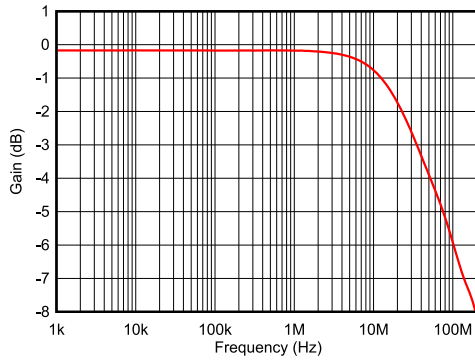
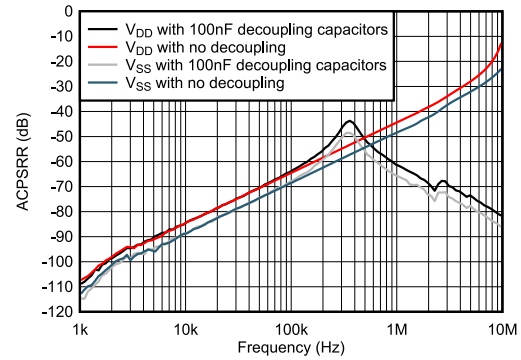


Figure 6-26. THD+N vs Frequency (Single Supplies)



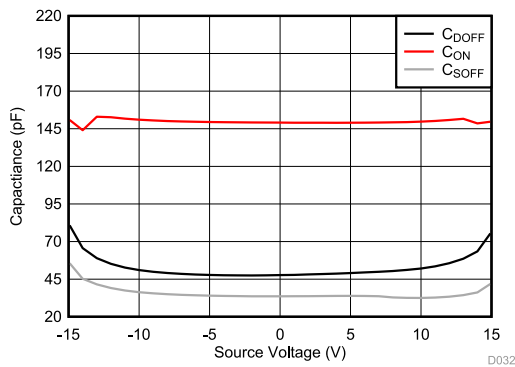
$V_{DD} = 15\text{ V}, V_{SS} = -15\text{ V}$

Figure 6-27. On Response vs Frequency



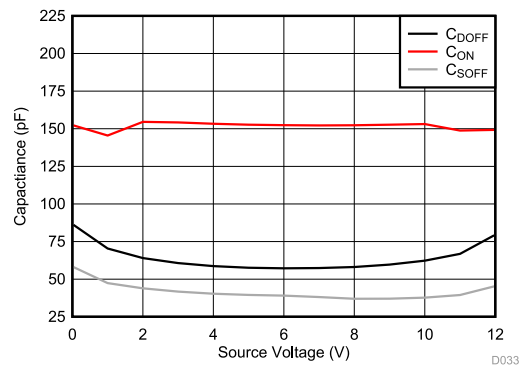
$V_{DD} = +15\text{ V}, V_{SS} = -15\text{ V}$

Figure 6-28. ACPSRR vs Frequency



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

Figure 6-29. Capacitance vs Source Voltage or Drain Voltage



$V_{DD} = 12\text{ V}, V_{SS} = 0\text{ V}$

Figure 6-30. Capacitance vs Source Voltage or Drain Voltage

7 Parameter Measurement Information

7.1 On-Resistance

The on-resistance of a device is the ohmic resistance between the source (Sx) and drain (D) 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 7-1 shows the measurement setup used to measure R_{ON} . Voltage (V) and current (I_{SD}) are measured using the following setup, where R_{ON} is computed as $R_{ON} = V / I_{SD}$:

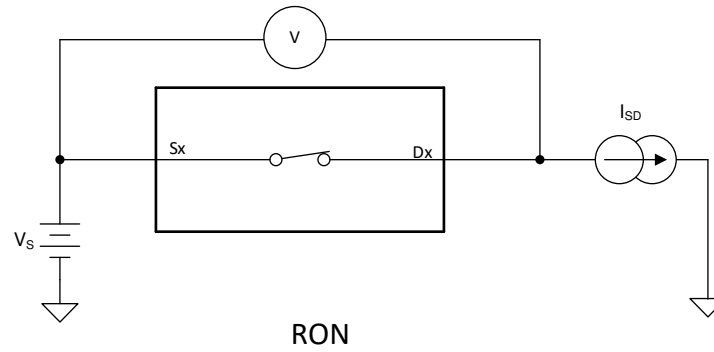


Figure 7-1. On-Resistance

7.2 Off-Leakage Current

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

1. Source off-leakage current.
2. Drain off-leakage current.

Source leakage current is defined as the leakage current flowing into or out of the source pin when the switch is off. This current is denoted by the symbol $I_{S(OFF)}$.

Drain leakage current is defined as the leakage current flowing into or out of the drain pin when the switch is off. This current is denoted by the symbol $I_{D(OFF)}$.

Figure 7-2 shows the setup used to measure both off-leakage currents.

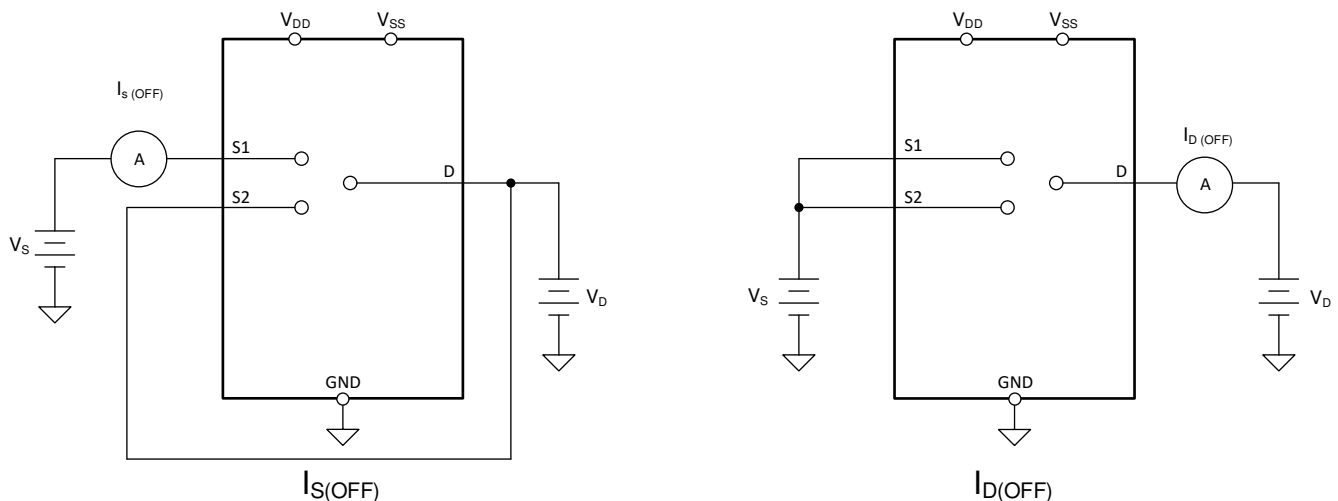


Figure 7-2. Off-Leakage Measurement Setup

7.3 On-Leakage Current

Source on-leakage current is defined as the leakage current flowing into or out of the source pin when the switch is on. This current is denoted by the symbol $I_{S(ON)}$.

Drain on-leakage current is defined as the leakage current flowing into or out of the drain pin when the switch is on. This current is denoted by the symbol $I_{D(ON)}$.

Either the source pin or drain pin is left floating during the measurement. Figure 7-3 shows the circuit used for measuring the on-leakage current, denoted by $I_{S(ON)}$ or $I_{D(ON)}$.

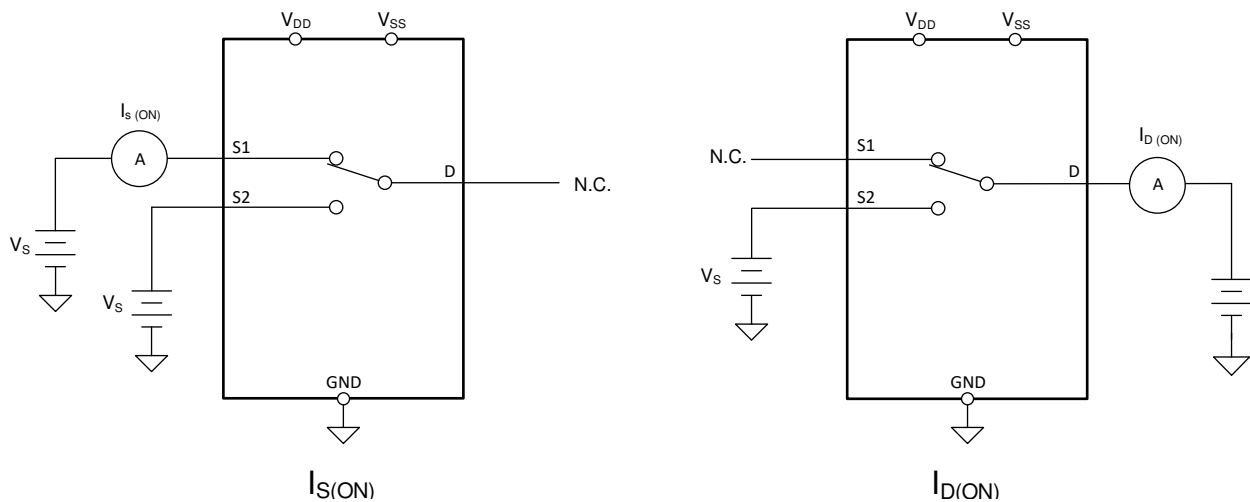


Figure 7-3. On-Leakage Measurement Setup

7.4 Transition Time

Transition time is defined as the time taken by the output of the device to rise or fall 90% after the address signal has risen or fallen past the logic threshold. The 90% transition measurement is utilized to provide the timing of the device. System level timing can then account for the time constant added from the load resistance and load capacitance. Figure 7-4 shows the setup used to measure transition time, denoted by the symbol $t_{TRANSITION}$.

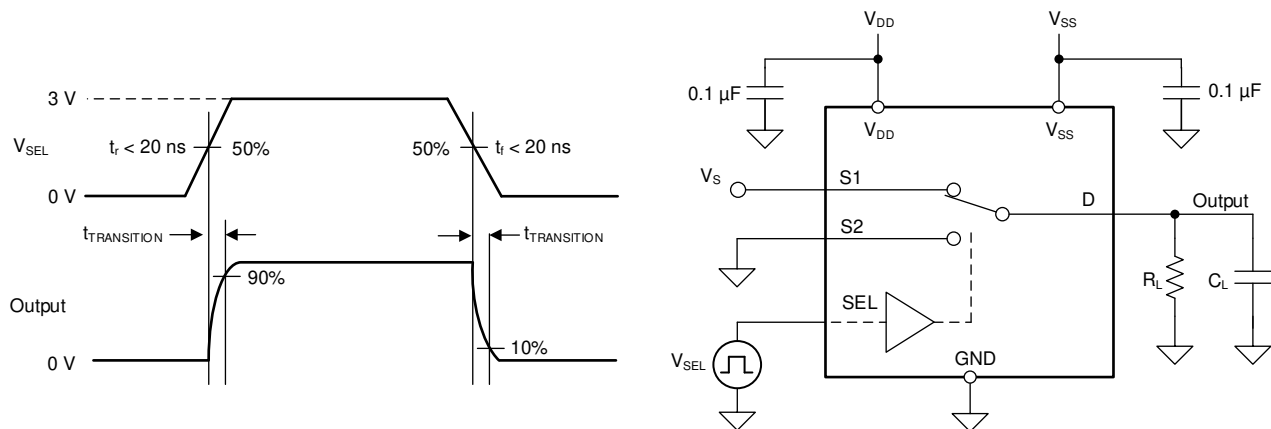


Figure 7-4. Transition-Time Measurement Setup

7.5 $t_{ON(EN)}$ and $t_{OFF(EN)}$

Turn-on time is defined as the time taken by the output of the device to rise to 90% after the enable has risen past the logic threshold. The 90% measurement is utilized to provide the timing of the device. System level timing can then account for the time constant added from the load resistance and load capacitance. Figure 7-5 shows the setup used to measure turn-on time, denoted by the symbol $t_{ON(EN)}$.

Turn-off time is defined as the time taken by the output of the device to fall to 10% after the enable has fallen past the logic threshold. The 10% measurement is utilized to provide the timing of the device. System level timing can then account for the time constant added from the load resistance and load capacitance. Figure 7-5 shows the setup used to measure turn-off time, denoted by the symbol $t_{OFF(EN)}$.

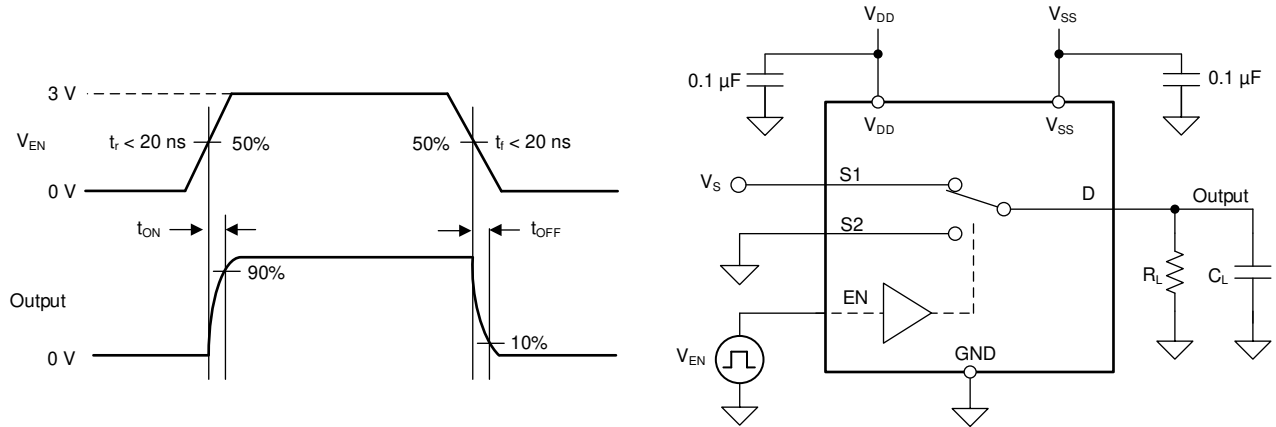


Figure 7-5. Turn-On and Turn-Off Time Measurement Setup

7.6 Break-Before-Make

Break-before-make delay is a safety feature that prevents two inputs from connecting when the device is switching. The output first breaks from the on-state switch before making the connection with the next on-state switch. The time delay between the *break* and the *make* is known as break-before-make delay. Figure 7-6 shows the setup used to measure break-before-make delay, denoted by the symbol $t_{OPEN(BBM)}$.

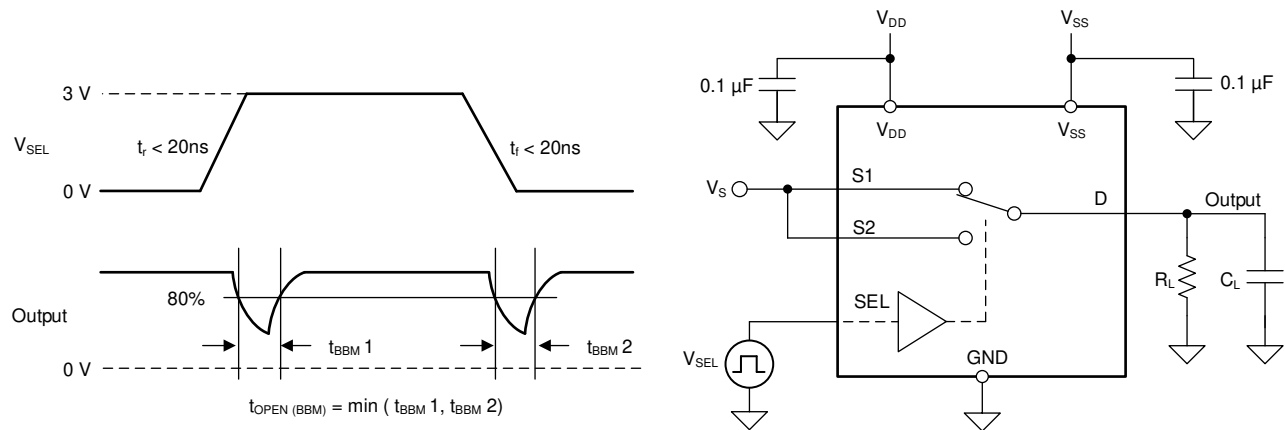


Figure 7-6. Break-Before-Make Delay Measurement Setup

7.7 $t_{ON(VDD)}$ Time

The $t_{ON(VDD)}$ time is defined as the time taken by the output of the device to rise to 90% after the supply has risen past the supply threshold. The 90% measurement is used to provide the timing of the device turning on in the system. Figure 7-7 shows the setup used to measure turn on time, denoted by the symbol $t_{ON(VDD)}$.

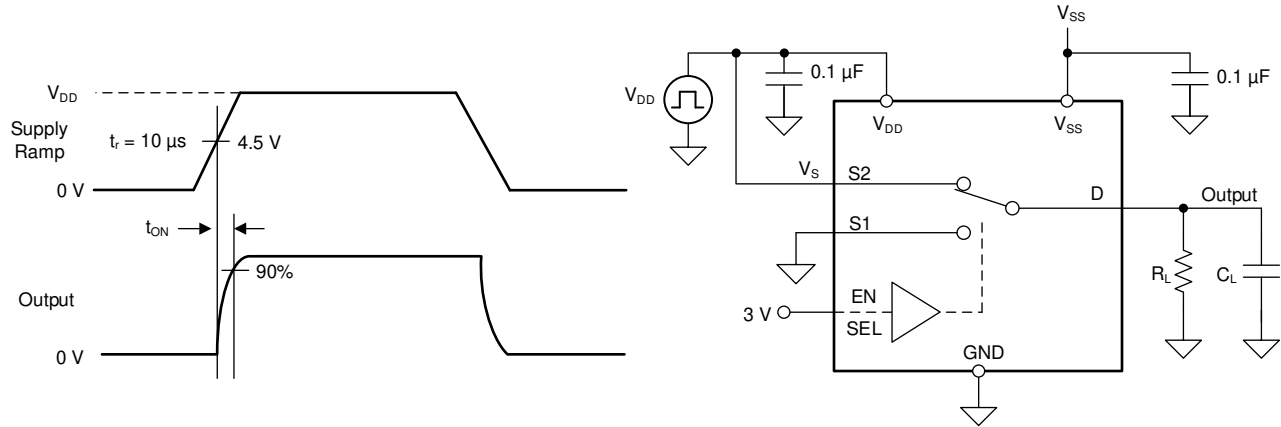


Figure 7-7. $t_{ON(VDD)}$ Time Measurement Setup

7.8 Propagation Delay

Propagation delay is defined as the time taken by the output of the device to rise or fall 50% after the input signal has risen or fallen past the 50% threshold. Figure 7-8 shows the setup used to measure propagation delay, denoted by the symbol t_{PD} .

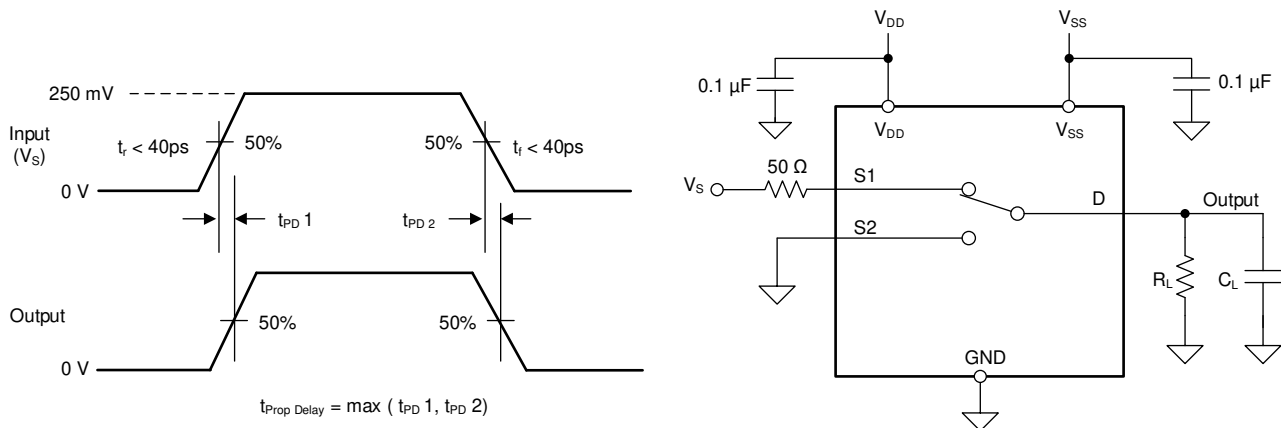


Figure 7-8. Propagation Delay Measurement Setup

7.9 Charge Injection

The TMUX6219-Q1 has a transmission-gate topology. Any mismatch in capacitance between the NMOS and PMOS transistors results in a charge injected into the drain or source during the falling or rising edge of the gate signal. The amount of charge injected into the source or drain of the device is known as charge injection, and is denoted by the symbol Q_C . Figure 7-9 shows the setup used to measure charge injection from source (Sx) to drain (D).

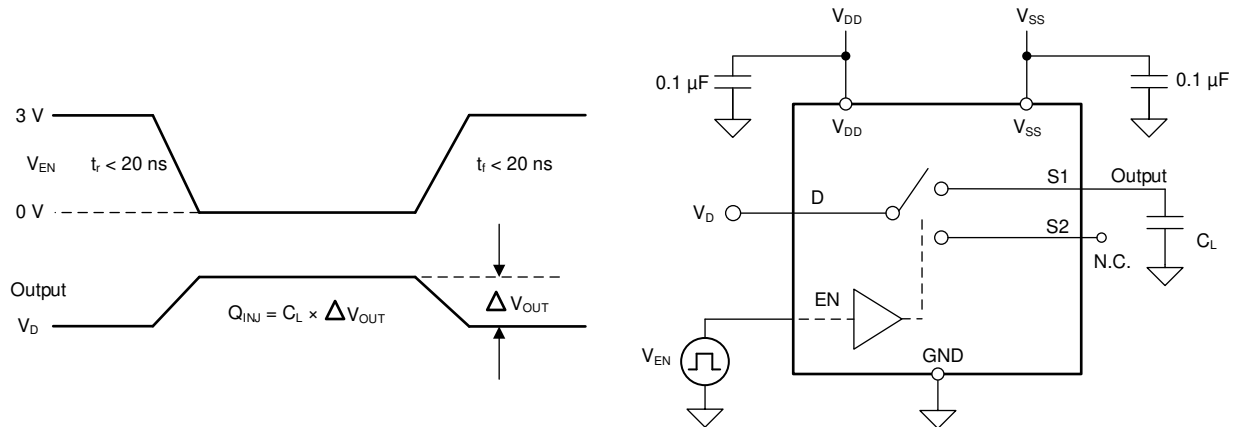


Figure 7-9. Charge-Injection Measurement Setup

7.10 Off Isolation

Off isolation is defined as the ratio of the signal at the drain pin (D) of the device when a signal is applied to the source pin (Sx) of an off-channel. Figure 7-10 shows the setup used to measure, and the equation used to calculate off isolation.

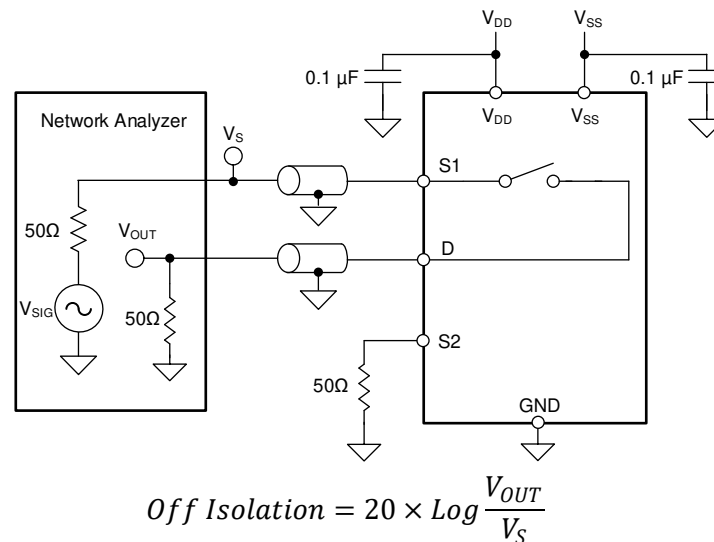


Figure 7-10. Off Isolation Measurement Setup

$$\text{Off Isolation} = 20 \cdot \text{Log} \left(\frac{V_{OUT}}{V_S} \right) \tag{1}$$

7.11 Crosstalk

Crosstalk is defined as the ratio of the signal at the drain pin (D) of a different channel, when a signal is applied at the source pin (Sx) of an on-channel. [Figure 7-11](#) shows the setup used to measure, and the equation used to calculate crosstalk.

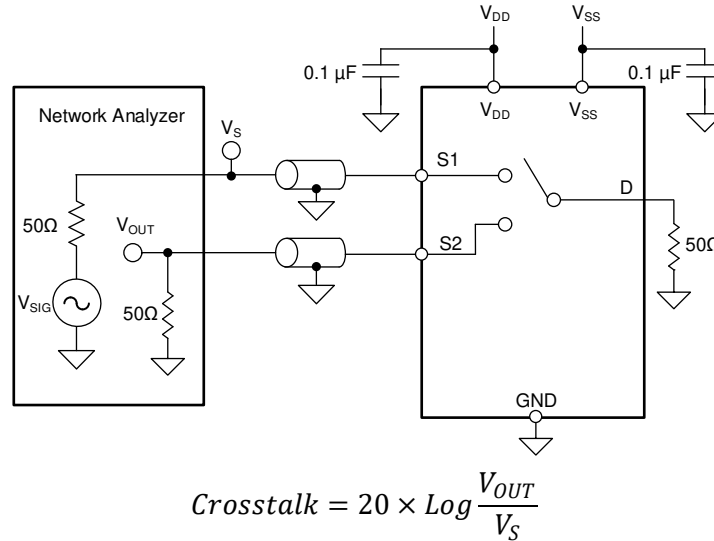


Figure 7-11. Crosstalk Measurement Setup

7.12 Bandwidth

Bandwidth is defined as the range of frequencies that are attenuated by less than 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) of the device. [Figure 7-12](#) shows the setup used to measure bandwidth.

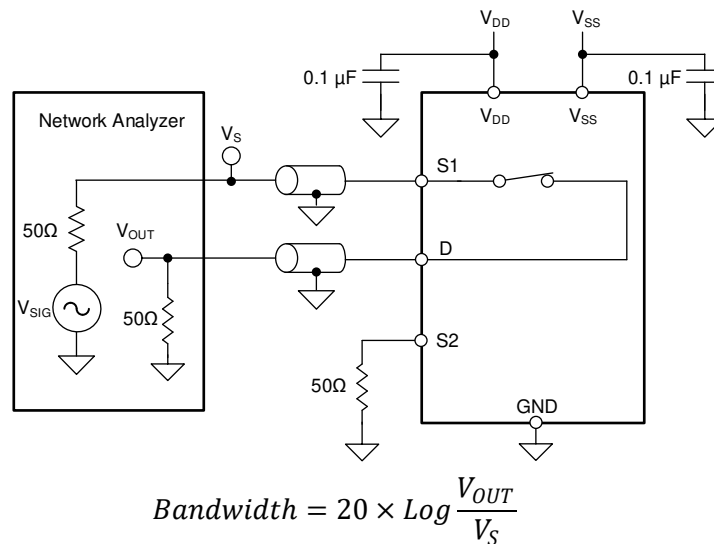


Figure 7-12. Bandwidth Measurement Setup

7.13 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 mux output.

The on-resistance of the device 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.

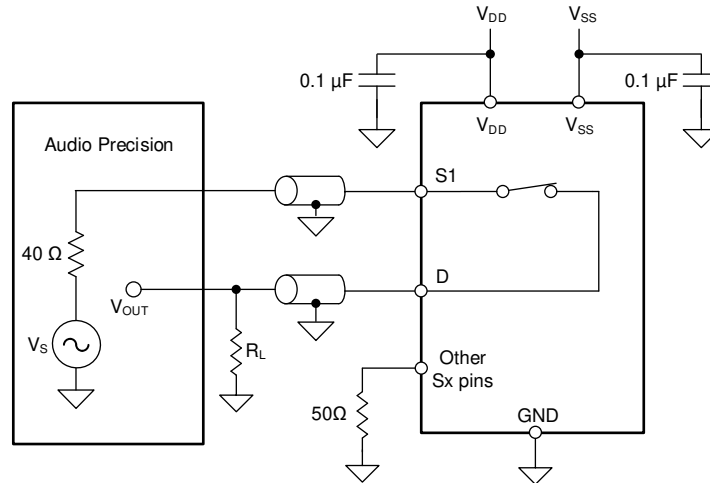


Figure 7-13. THD + N Measurement Setup

7.14 Power Supply Rejection Ratio (PSRR)

PSRR measures the ability of a device to prevent noise and spurious signals that appear on the supply voltage pin from coupling to the output of the switch. The DC voltage on the device supply is modulated by a sine wave of 620 mV_{PP}. The ratio of the amplitude of signal on the output to the amplitude of the modulated signal is the ACPSRR. A high ratio represents a high degree of tolerance to supply rail variation.

This helps stabilize the supply and immediately filter as much of the supply noise as possible.

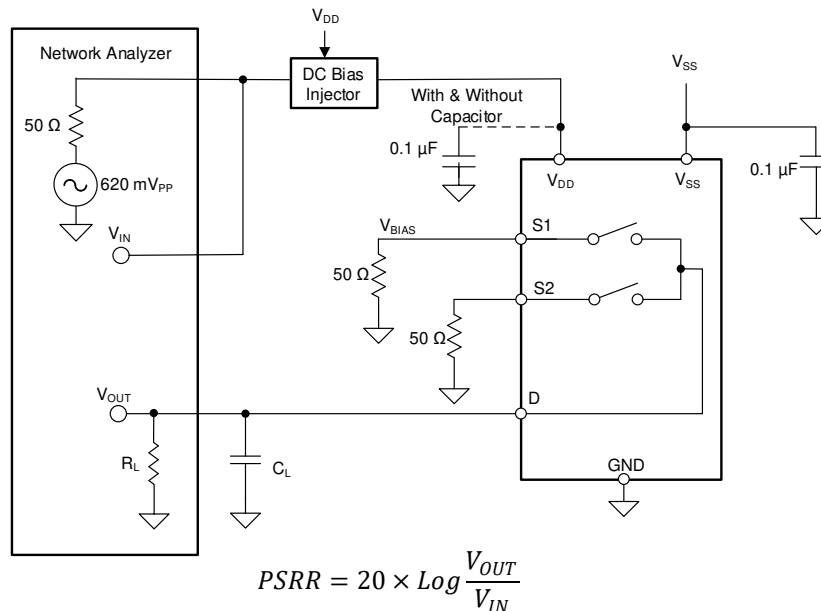


Figure 7-14. ACPSRR Measurement Setup

8 Detailed Description

8.1 Overview

The TMUX6219-Q1 is a 2:1, 1-channel switch. Each input is turned on or turned off based on the state of the select line and enable pin.

8.2 Functional Block Diagram

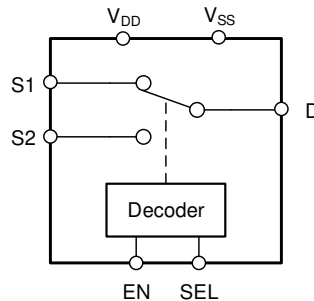


Figure 8-1. TMUX6219-Q1 Functional Block Diagram

8.3 Feature Description

8.3.1 Bidirectional Operation

The TMUX6219-Q1 conducts equally well from source (Sx) to drain (D) or from drain (D) to source (Sx). Each channel has very similar characteristics in both directions and supports both analog and digital signals.

8.3.2 Rail to Rail Operation

The valid signal path input or output voltage for TMUX6219-Q1 ranges from V_{SS} to V_{DD} .

8.3.3 1.8 V Logic Compatible Inputs

The TMUX6219-Q1 has 1.8-V logic compatible control for all logic control inputs. 1.8-V logic level inputs allows the TMUX6219-Q1 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](#).

8.3.4 Fail-Safe Logic

The TMUX6219-Q1 supports Fail-Safe Logic on the control input pins (EN, SEL) allowing for operation up to 36 V above ground, regardless of the state of the supply pins. This feature allows voltages on the control pins to be applied before the supply pin, protecting the device from potential damage. Fail-Safe Logic minimizes system complexity by removing the need for power supply sequencing on the logic control pins. For example, the Fail-Safe Logic feature allows the logic input pins of the TMUX6219-Q1 to be ramped to +36 V while V_{DD} and $V_{SS} = 0$ V. The logic control inputs are protected against positive faults of up to +36 V in powered-off condition, but do not offer protection against negative overvoltage conditions.

8.3.5 Latch-Up Immune

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 TMUX62xx family of 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 TMUX62xx family of switches and multiplexers to be used in harsh environments.

8.3.6 Ultra-Low Charge Injection

The TMUX6219-Q1 has a transmission gate topology, as shown in Figure 8-2. Any mismatch in the stray capacitance associated with the NMOS and PMOS causes an output level change whenever the switch is opened or closed.

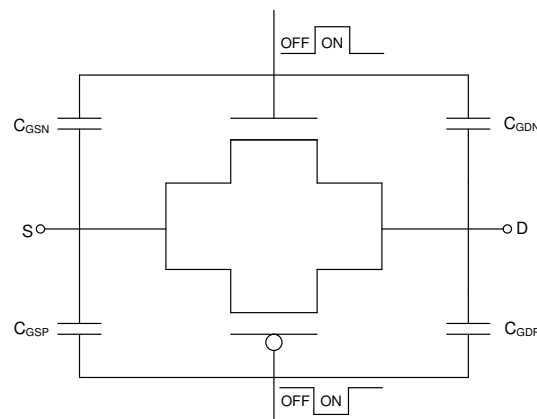


Figure 8-2. Transmission Gate Topology

The TMUX6219-Q1 contains specialized architecture to reduce charge injection on the source (Sx). To further reduce charge injection in a sensitive application, a compensation capacitor (Cp) can be added on the drain (D). This will ensure that excess charge from the switch transition will be pushed into the compensation capacitor on the drain (D) instead of the source (Sx). As a general rule of thumb, Cp should be 20× larger than the equivalent load capacitance on the source (Sx). Figure 8-3 shows charge injection variation with source voltage with different compensation capacitors on the Drain side.

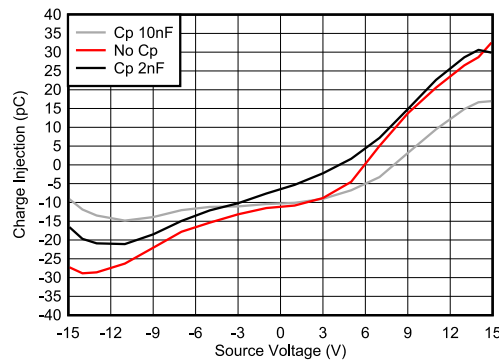


Figure 8-3. Charge Injection Compensation

8.4 Device Functional Modes

When the EN pin of the TMUX6219-Q1 is pulled high, one of the switches is closed based on the state of the SEL pin. When the EN pin is pulled low, both of the switches are in an open state regardless of the state of the SEL pin. The control pins can be as high as 36 V.

The TMUX6219-Q1 can be operated without any external components except for the supply decoupling capacitors. The EN pin has an internal pull-up resistor of 4 M Ω and SEL pin has internal pull-down resistor of 4 M Ω . If unused, EN pin must be tied to V_{DD} and SEL pin must be tied to GND in order to ensure the device does not consume additional current as highlighted in [Implications of Slow or Floating CMOS Inputs](#). Unused signal path inputs (S1, S2, or D) should be connected to GND.

8.5 Truth Tables

[Table 8-1](#) show the truth tables for the TMUX6219-Q1.

Table 8-1. TMUX6219-Q1 Truth Table

EN	SEL	Selected Source Connected To Drain (D) Pin
0	X ⁽¹⁾	All sources are off (HI-Z)
1	0	S1
1	1	S2

(1) X denotes *don't care*.

9 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.

9.1 Application Information

TMUX6219-Q1 is part of the precision switches and multiplexers family of devices. TMUX6219-Q1 offers low RON, low on and off leakage currents and ultra-low charge injection performance. These properties make TMUX6219-Q1 ideal for implementing high precision industrial systems requiring selection of one of two inputs or outputs.

9.2 Typical Application

9.2.1 PWM Signal Generation (EV Charging Station)

One application of the TMUX6219-Q1 is in Electric Vehicle Service Equipment (EVSE). The EVSE is a system that monitors and controls the high voltage power path from the grid to the vehicle. One key feature of an EVSE is the pilot signal wire communication support that requires a 1-kHz, ± 12 -V PWM signal to be transmitted down the length of the charger cable to the vehicle.

The TMUX6219-Q1 can be used to generate 1kHz ± 12 V PWM signal for EVSE control pilot. A 1 kHz square wave at ± 12 V generated by the EVSE on the control pilot line is used to detect the presence of the vehicle, communicate the maximum allowable charging current, and control charging.

Figure 9-1 shows the TMUX6219-Q1 configured for PWM signal generation for EVSE control pilot.

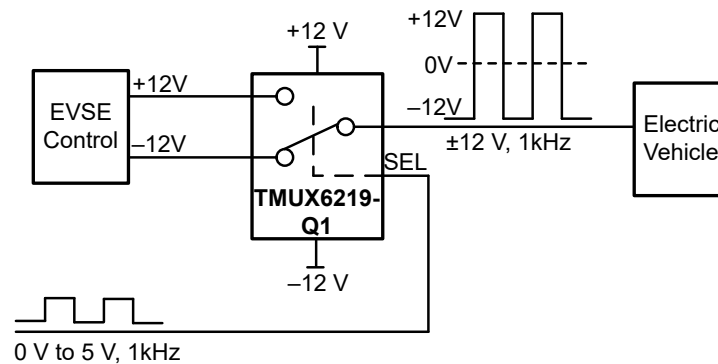


Figure 9-1. PWM Signal Generation (EV Charging Station)

9.2.2 Design Requirements

For the design example, use the parameters listed in Table 9-1 .

Table 9-1. Design Parameters

PARAMETERS	VALUES
Supply (V_{DD})	12 V
Supply (V_{SS})	-12 V
MUX I/O signal range	-12 V to 12 V (Rail-to-Rail)
Control logic thresholds	1.8 V compatible (up to V_{DD})
EN	EN pulled high to enable the switch

9.2.3 Detailed Design Procedure

The application shown in [Figure 9-1](#) demonstrates how to generate a $\pm 12\text{V}$ PWM signal that is created by toggling the TMUX6219-Q1. This PWM signal generated by the EVSE on the control pilot line signals to the car the available current of the charger, and the car will respond with a charging status. This handshake results in a safe method for supplying power to vehicle. The TMUX6219-Q1 can support 1.8 V logic signals on the control input, allowing the device to interface with low logic controls of an FPGA or MCU. The TMUX6219-Q1 can be operated without any external components except for the supply decoupling capacitors. The select pin has an internal pull-down resistor to prevent floating input logic. All inputs to the switch must fall within the recommend operating conditions of the TMUX6219-Q1 including signal range and continuous current. For this design with a positive supply of 12 V on V_{DD} , and negative supply of -12 V on V_{SS} , the signal range can be 12 V to -12 V. The max continuous current (I_{DC}) can be up to 330 mA as shown in the *Recommended Operating Conditions table* for wide-range current measurement.

10 Power Supply Recommendations

The TMUX6219-Q1 operates across a wide supply range of of $\pm 4.5\text{ V}$ to $\pm 18\text{ V}$ (4.5 V to 36 V in single-supply mode). It also performs well with asymmetrical supplies such as $V_{DD} = 8\text{ V}$ and $V_{SS} = -12\text{ V}$.

Power-supply bypassing improves noise margin and prevents switching noise propagation from the supply rails to other components. Good power-supply decoupling is important to achieve optimum performance. For improved supply noise immunity, use a supply decoupling capacitor ranging from 0.1 μF to 10 μF at both the V_{DD} and V_{SS} pins to ground. Place the bypass capacitors as close to the power supply pins of the device as possible using low-impedance connections. TI recommends using multi-layer ceramic chip capacitors (MLCCs) that offer low equivalent series resistance (ESR) and inductance (ESL) characteristics for power-supply decoupling purposes. For very sensitive systems, or for systems in harsh noise environments, avoiding the use of vias for connecting the capacitors to the device pins may offer superior noise immunity. The use of multiple vias in parallel lowers the overall inductance and is beneficial for connections to power and ground planes. Always ensure the ground (GND) connection is established before supplies are ramped.

11 Layout

11.1 Layout Guidelines

When a PCB trace turns a corner at a 90° angle, a reflection can occur. A reflection occurs primarily because of the change of width of the trace. At the apex of the turn, the trace width increases to 1.414 times the width. This increase upsets the transmission-line characteristics, especially the distributed capacitance and self-inductance of the trace which results in the reflection. Not all PCB traces can be straight and therefore some traces must turn corners. [Figure 11-1](#) shows progressively better techniques of rounding corners. Only the last example (BEST) maintains constant trace width and minimizes reflections.

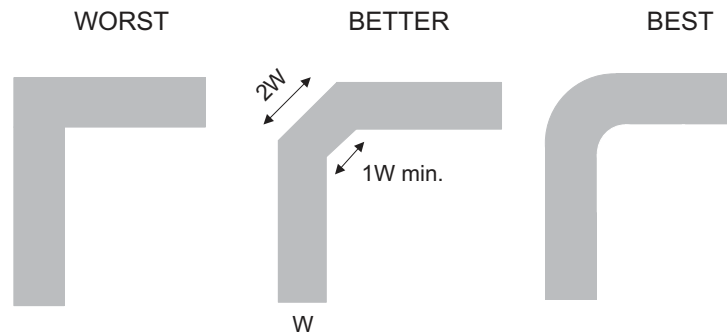


Figure 11-1. Trace Example

Route high-speed signals using a minimum of vias and corners which reduces signal reflections and impedance changes. When a via must be used, increase the clearance size around it to minimize its capacitance. Each via introduces discontinuities in the signal's transmission line and increases the chance of picking up interference from the other layers of the board. Be careful when designing test points, through-hole pins are not recommended at high frequencies.

[Figure 11-2](#) illustrates an example of a PCB layout with the TMUX6219-Q1. Some key considerations are:

- Decouple the supply pins with a 0.1- μF and 1 μF capacitor, placed lowest value capacitor as close to the pin as possible. Make sure that the capacitor voltage rating is sufficient for the supply voltage.
- Keep the input lines as short as possible.
- Use a solid ground plane to help 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.
- Using multiple vias in parallel will lower the overall inductance and is beneficial for connection to ground planes.

11.2 Layout Example

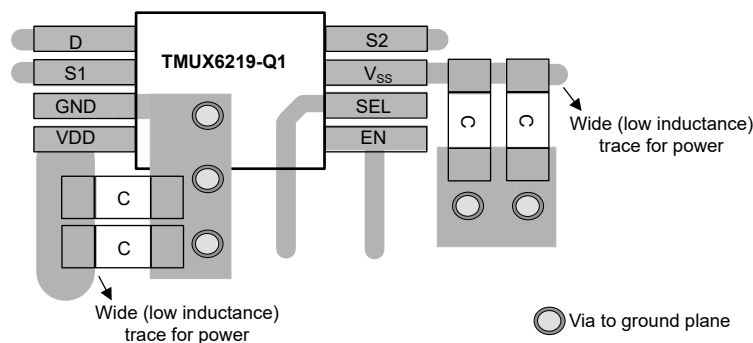


Figure 11-2. TMUX6219-Q1 Layout Example

12 Device and Documentation Support

12.1 Documentation Support

12.1.1 Related Documentation

For related documentation, see the following:

- Texas Instruments, [Improve Stability Issues with Low CON Multiplexers](#) application brief
- Texas Instruments, [Improving Signal Measurement Accuracy in Automated Test Equipment](#) application brief
- Texas Instruments, [Multiplexers and Signal Switches Glossary](#) application report
- Texas Instruments, [QFN/SON PCB Attachment](#) application report
- Texas Instruments, [Quad Flatpack No-Lead Logic Packages](#) application report
- Texas Instruments, [Simplifying Design with 1.8 V logic Muxes and Switches](#) application brief
- Texas Instruments, [System-Level Protection for High-Voltage Analog Multiplexers](#) application report
- Texas Instruments, [TMUX6219-Q1 Functional Safety, FIT Rate, Failure Mode Distribution and Pin FMA](#) functional safety FIT rate, FMD and Pin-FMA

12.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* 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.

12.3 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](#).

12.4 Trademarks

TI E2E™ is a trademark of Texas Instruments.

All trademarks are the property of their respective owners.

12.5 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.

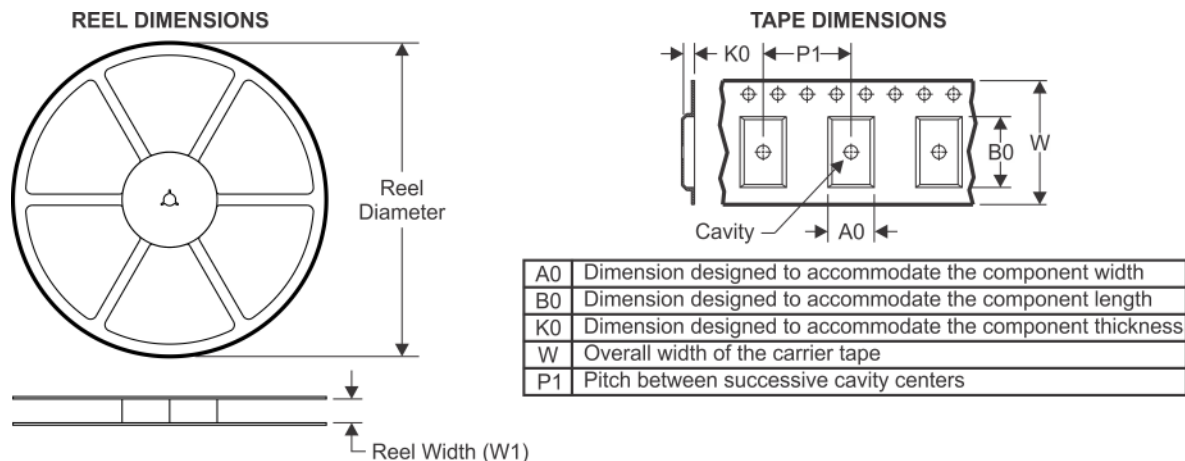
ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

12.6 Glossary

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

13 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.

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
TMUX6219DGKRQ1	VSSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1

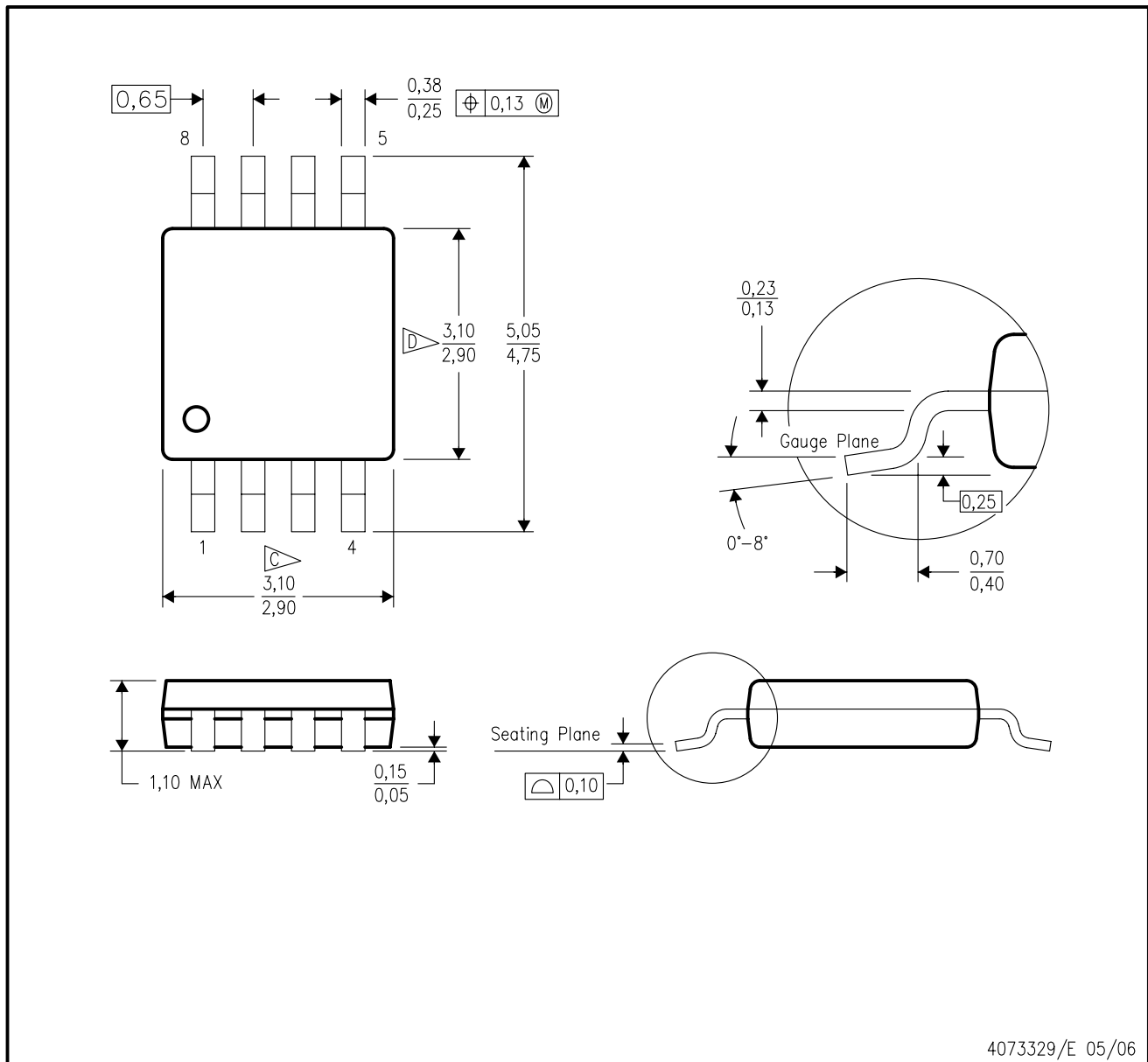
TAPE AND REEL BOX DIMENSIONS


*All dimensions are nominal

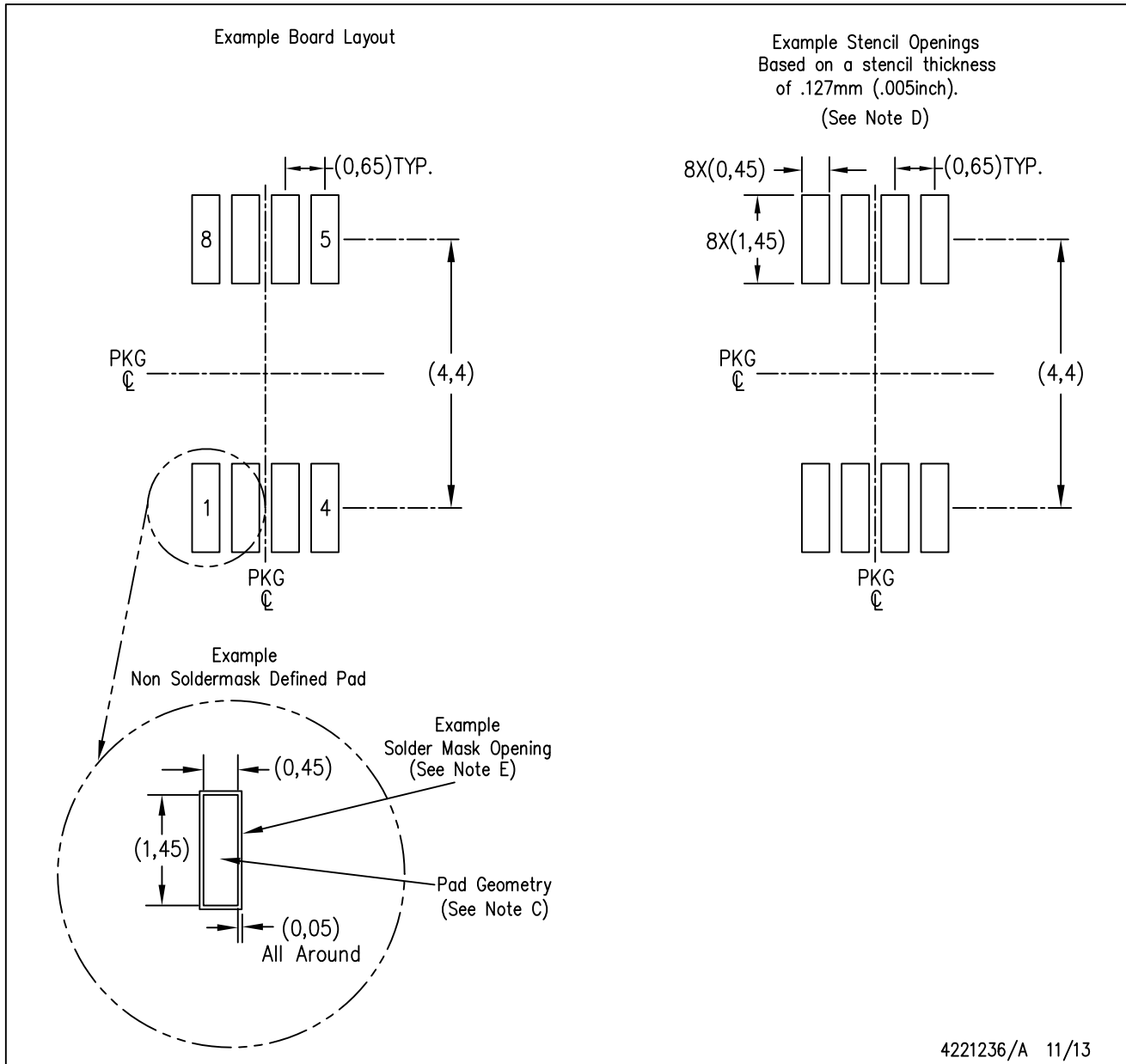
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TMUX6219DGKRQ1	VSSOP	DGK	8	2500	366.0	364.0	50.0

DGK (S-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- A. All linear dimensions are in millimeters.
 - B. This drawing is subject to change without notice.
 - C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 per end.
 - D. Body width does not include interlead flash. Interlead flash shall not exceed 0.50 per side.
 - E. Falls within JEDEC MO-187 variation AA, except interlead flash.



- NOTES:
- A. All linear dimensions are in millimeters.
 - B. This drawing is subject to change without notice.
 - C. Publication IPC-7351 is recommended for alternate designs.
 - D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
 - E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), 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, 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 (<https://www.ti.com/legal/termsofsale.html>) 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.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2021, Texas Instruments Incorporated