TEXAS INSTRUMENTS
TMUX7211, TMUX7212, TMUX7213
SCDS416B – OCTOBER 2020 – REVISED APRIL 2021

TMUX721x 44 V, Low-RON, 1:1 (SPST), 4-Channel Precision Switches with Latch-Up Immunity and 1.8-V Logic

1 Features

- Latch-Up Immune
- Dual Supply Range: ±4.5 V to ±22 V
- Single Supply Range: 4.5 V to 44 V
- Low On-Resistance: 2 Ω
- High Current Support: 330 mA (Maximum) (WQFN)
- High Current Support: 220 mA (Maximum) (TSSOP)
- –40°C to +125°C Operating Temperature
- 1.8 V Logic Compatible
- Fail-Safe Logic
- Rail-to-Rail Operation
- Bidirectional Operation

2 Applications

- Sample-and-Hold Circuits
- Feedback Gain Switching
- Signal Isolation
- Field Transmitters
- Programmable Logic Controllers (PLC)
- Factory Automation and Control
- Ultrasound Scanners
- Patient Monitoring and Diagnostics
- Electrocardiogram (ECG)
- Data Acquisition Systems (DAQ)
- Semiconductor Test Equipment
- LCD Test
- Instrumentation: Lab, Analytical, Portable
- Ultrasonic Smart Meters: Water and Gas
- Optical Networking
- Optical Test Equipment

3 Description

The TMUX7211, TMUX7212, and TMUX7213 are complementary metal-oxide semiconductor (CMOS) switches with four independently selectable 1:1, single-pole, single-throw (SPST) switch channels. The devices work with a single supply (4.5 V to 44 V), dual supplies (±4.5 V to ±22 V), or asymmetric supplies (such as V_{DD} = 12 V, V_{SS} = –5 V). The TMUX721x supports bidirectional analog and digital signals on the source (Sx) and drain (Dx) pins ranging from V_{SS} to V_{DD}.

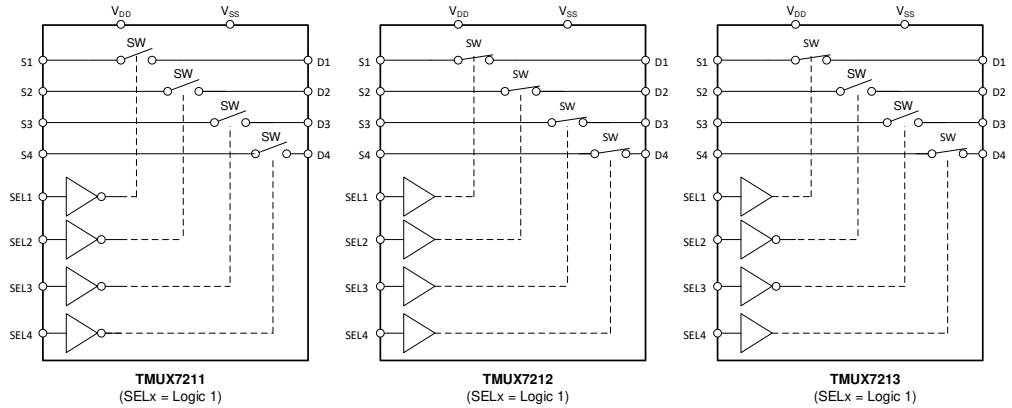
The switches of the TMUX721x are controlled with appropriate logic control inputs on the SELx pins. The TMUX721x are part of the precision switches and multiplexers family of devices and have very low on and off leakage currents allowing them to be used in high precision measurement applications.

The TMUX721x family provides latch-up immunity, preventing undesirable high current events between parasitic structures within the device typically caused by overvoltage events. A latch-up condition typically continues until the power supply rails are turned off and can lead to device failure. The latch-up immunity feature allows the TMUX721x family of switches and multiplexers to be used in harsh environments.

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
TMUX7211	TSSOP (16) (PW)	5.00 mm × 4.40 mm
TMUX7212 TMUX7213	WQFN (16) (RUM)	4.00 mm × 4.00 mm

(1) See the package option addendum at the end of the data sheet for all available packages.



TMUX721x Block Diagrams

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4 Revision History

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

Changes from Revision A (March 2021) to Revision B (April 2021)	Page
• Included Break-before-make time delay for TMUX7213	8
• Updated the *Charge Injection Compensation* figure	27

Changes from Revision * (December 2020) to Revision A (March 2021)	Page
• Added high current support for WQFN in Features section	1
• Added thermal information for QFN package	6
• Updated I_{DC} specs for TSSOP package in *Source or Drain Continuous Current* table	6
• Added I_{DC} specs for QFN package in *Source or Drain Continuous Current* table	6
• Updated V_{DD} rise time value from 100ns to 1µs in $T_{ON(VDD)}$ test condition	8
• Updated C_L value from 1nF to 100pF in Charge Injection test condition	8
• Updated Figure 7-10 *Leakage Current vs Temperature*	15

5 Device Comparison Table

PRODUCT	DESCRIPTION
TMUX7211	Low-Leakage-Current, Precision, 4-Channel, 1:1 (SPST) Switches (Logic Low)
TMUX7212	Low-Leakage-Current, Precision, 4-Channel, 1:1 (SPST) Switches (Logic High)
TMUX7213	Low-Leakage-Current, Precision, 4-Channel, 1:1 (SPST) Switches (Logic Low + Logic High)

6 Pin Configuration and Functions

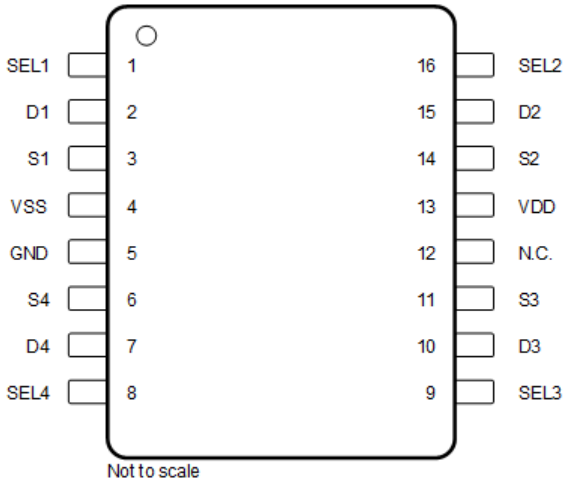


Figure 6-1. PW Package
16-Pin TSSOP
Top View

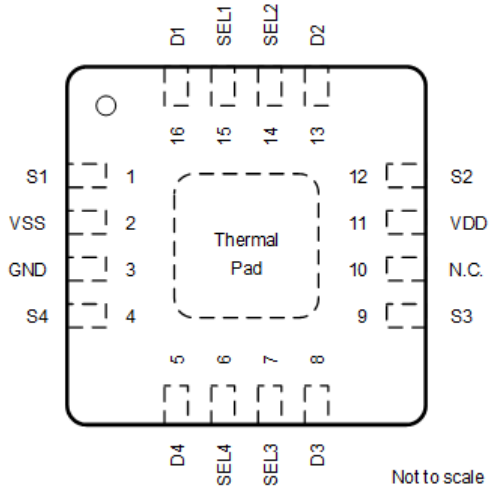


Figure 6-2. RUM Package
16-Pin WQFN
Top View

Table 6-1. Pin Functions

PIN			TYPE(1)	DESCRIPTION(2)
NAME	TSSOP	WQFN		
D1	2	16	I/O	Drain pin 1. Can be an input or output.
D2	15	13	I/O	Drain pin 2. Can be an input or output.
D3	10	8	I/O	Drain pin 3. Can be an input or output.
D4	7	5	I/O	Drain pin 4. Can be an input or output.
GND	5	3	P	Ground (0 V) reference
N.C.	12	10	—	No internal connection. Can be shorted to GND or left floating.
S1	3	1	I/O	Source pin 1. Can be an input or output.
S2	14	12	I/O	Source pin 2. Can be an input or output.
S3	11	9	I/O	Source pin 3. Can be an input or output.
S4	6	4	I/O	Source pin 4. Can be an input or output.
SEL1	1	15	I	Logic control input 1, has internal pull-down resistor. Controls channel 1 state as shown in Section 9.5.
SEL2	16	14	I	Logic control input 2, has internal pull-down resistor. Controls channel 2 state as shown in Section 9.5.
SEL3	9	7	I	Logic control input 3, has internal pull-down resistor. Controls channel 3 state as shown in Section 9.5.
SEL4	8	6	I	Logic control input 4, has internal pull-down resistor. Controls channel 4 state as shown in Section 9.5.
VDD	13	11	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_{DD} and GND.
VSS	4	2	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_{SS} and GND.
Thermal Pad			—	The thermal pad is not connected internally. No requirement to solder this pad, if connected it is recommended that the pad be left floating or tied to GND

(1) I = input, O = output, I/O = input and output, P = power.
(2) Refer to Section 9.4 for what to do with unused pins.

7 Specifications

7.1 Absolute Maximum Ratings

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

		MIN	MAX	UNIT
$V_{DD} - V_{SS}$	Supply voltage		48	V
V_{DD}		–0.5	48	V
V_{SS}		–48	0.5	V
V_{SEL} or V_{EN}	Logic control input pin voltage (SELx)	–0.5	48	V
I_{SEL} or I_{EN}	Logic control input pin current (SELx)	–30	30	mA
V_S or V_D	Source or drain voltage (Sx, Dx)	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, Dx)		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 (QFN)(5)		1650	mW
	Total power dissipation (TSSOP)(5)		700	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 QFN package: P_{tot} derates linearly above T_A = 70°C by 24.2mW/°C.
For TSSOP package: P_{tot} = 700 mW (max) and derates linearly above T_A = 70°C by 10.7mW/°C.

7.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all pins(1)	±1500	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.

7.3 Thermal Information

THERMAL METRIC[1]		TMUX721x		UNIT
		PW (TSSOP)	RUM (WQFN)	
		16 PINS	16 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	94.5	41.5	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	25.5	25.1	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	41.1	16.5	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	1.1	0.3	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	40.4	16.4	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	N/A	2.9	°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
$V_{DD} – V_{SS}$ [1]	Power supply voltage differential	4.5		44	V
V_{DD}	Positive power supply voltage	4.5		44	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		44	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 V ≤ (V_{DD} – V_{SS}) ≤ 44 V, and the minimum V_{DD} is met.
(2) Refer to *Source or Drain Continuous Current* table for I_{DC} specifications.

7.5 Source or Drain Continuous Current

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

CONTINUOUS CURRENT PER CHANNEL (I_{DC}) [2]		T_A = 25°C	T_A = 85°C	T_A = 125°C	UNIT
PACKAGE	TEST CONDITIONS				
PW (TSSOP)	+44 V Dual Supply[1]	220	160	100	mA
	±15 V Dual Supply	220	160	100	mA
	+12 V Single Supply	190	130	90	mA
	±5 V Dual Supply	170	120	80	mA
	+5 V Single Supply	130	90	60	mA
RUM (WQFN)	+44 V Single Supply[1]	330	220	120	mA
	±15 V Dual Supply	330	220	120	mA
	+12 V Single Supply	260	180	110	mA
	±5 V Dual Supply	240	160	100	mA
	+5 V Single Supply	180	120	80	mA

(1) Specified for nominal supply voltage only.
(2) Refer to Total power dissipation (P_{tot}) limits in A*bsolute Maximum Ratings* table that must be followed with max continuous current specification.

7.6 ±15 V Dual Supply: Electrical Characteristics

V_{DD} = +15 V ± 10%, V_{SS} = –15 V ±10%, GND = 0 V (unless otherwise noted)
Typical at V_{DD} = +15 V, V_{SS} = –15 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A	MIN	TYP	MAX	UNIT
ANALOG SWITCH							
R_{ON}	On-resistance	V_S = –10 V to +10 V I_D = –10 mA Refer to On-Resistance	25°C		2	2.7	Ω
			–40°C to +85°C			3.4	Ω
			–40°C to +125°C			4	Ω
ΔR_{ON}	On-resistance mismatch between channels	V_S = –10 V to +10 V I_D = –10 mA Refer to On-Resistance	25°C		0.1	0.18	Ω
			–40°C to +85°C			0.19	Ω
			–40°C to +125°C			0.21	Ω
$R_{ON\ FLAT}$	On-resistance flatness	V_S = –10 V to +10 V I_S = –10 mA Refer to On-Resistance	25°C		0.2	0.46	Ω
			–40°C to +85°C			0.65	Ω
			–40°C to +125°C			0.7	Ω
$R_{ON\ DRIFT}$	On-resistance drift	V_S = 0 V, I_S = –10 mA Refer to On-Resistance	–40°C to +125°C		0.008		Ω/°C
$I_{S(OFF)}$	Source off leakage current(1)	V_{DD} = 16.5 V, V_{SS} = –16.5 V Switch state is off V_S = +10 V / –10 V V_D = –10 V / + 10 V Refer to Off-Leakage Current	25°C	–0.25	0.05	0.25	nA
			–40°C to +85°C	–3		3	nA
			–40°C to +125°C	–20		20	nA
$I_{D(OFF)}$	Drain off leakage current(1)	V_{DD} = 16.5 V, V_{SS} = –16.5 V Switch state is off V_S = +10 V / –10 V V_D = –10 V / + 10 V Refer to Off-Leakage Current	25°C	–0.25	0.05	0.25	nA
			–40°C to +85°C	–3		3	nA
			–40°C to +125°C	–20		20	nA
$I_{S(ON)}$ $I_{D(ON)}$	Channel on leakage current(2)	V_{DD} = 16.5 V, V_{SS} = –16.5 V Switch state is on V_S = V_D = ±10 V Refer to On-Leakage Current	25°C	–0.4	0.1	0.4	nA
			–40°C to +85°C	–1		1	nA
			–40°C to +125°C	–3		3	nA
LOGIC INPUTS (SEL / EN pins)							
V_{IH}	Logic voltage high		–40°C to +125°C	1.3		44	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		0.4	1.2	µA
I_{IL}	Input leakage current		–40°C to +125°C	–0.1	–0.005		µA
C_{IN}	Logic input capacitance		–40°C to +125°C		3.5		pF
POWER SUPPLY							
I_{DD}	V_{DD} supply current	V_{DD} = 16.5 V, V_{SS} = –16.5 V Logic inputs = 0 V, 5 V, or V_{DD}	25°C		35	56	µA
			–40°C to +85°C			65	µA
			–40°C to +125°C			80	µA
I_{SS}	V_{SS} supply current	V_{DD} = 16.5 V, V_{SS} = –16.5 V Logic inputs = 0 V, 5 V, or V_{DD}	25°C		5	20	µA
			–40°C to +85°C			24	µA
			–40°C to +125°C			35	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.

7.7 ±15 V Dual Supply: Switching Characteristics

V_{DD} = +15 V ± 10%, V_{SS} = –15 V ± 10%, GND = 0 V (unless otherwise noted)
Typical at V_{DD} = +15 V, V_{SS} = –15 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A	MIN	TYP	MAX	UNIT
t_{ON}	Turn-on time from control input	V_S = 10 V R_L = 300 Ω, C_L = 35 pF Refer to Turn-on and Turn-off Time	25°C		100	175	ns
			–40°C to +85°C			205	ns
			–40°C to +125°C			225	ns
t_{OFF}	Turn-off time from control input	V_S = 10 V R_L = 300 Ω, C_L = 35 pF Refer to Turn-on and Turn-off Time	25°C		80	205	ns
			–40°C to +85°C			225	ns
			–40°C to +125°C			240	ns
t_{BBM}	Break-before-make time delay (TMUX7213 Only)	V_S = 10 V, R_L = 300 Ω, C_L = 35 pF	25°C		27		ns
			–40°C to +85°C	5			ns
			–40°C to +125°C	5			ns
$t_{ON (VDD)}$	Device turn on time (V_{DD} to output)	V_{DD} rise time = 1 µs R_L = 300 Ω, C_L = 35 pF Refer to Turn-on (VDD) Time	25°C		0.17		ms
			–40°C to +85°C		0.18		ms
			–40°C to +125°C		0.18		ms
t_{PD}	Propagation delay	R_L = 50 Ω , C_L = 5 pF Refer to Propagation Delay	25°C		260		ps
Q_{INJ}	Charge injection	V_S = 0 V, C_L = 100 pF Refer to Charge Injection	25°C		60		pC
O_{ISO}	Off-isolation	R_L = 50 Ω , C_L = 5 pF V_S = 0 V, f = 100 kHz Refer to Off Isolation	25°C		–70		dB
O_{ISO}	Off-isolation	R_L = 50 Ω , C_L = 5 pF V_S = 0 V, f = 1 MHz Refer to Off Isolation	25°C		–50		dB
X_{TALK}	Crosstalk	R_L = 50 Ω , C_L = 5 pF V_S = 0 V, f = 100 kHz Refer to Crosstalk	25°C		–114		dB
X_{TALK}	Crosstalk	R_L = 50 Ω , C_L = 5 pF V_S = 0 V, f = 1MHz Refer to Crosstalk	25°C		–93		dB
BW	–3dB Bandwidth	R_L = 50 Ω , C_L = 5 pF V_S = 0 V Refer to Bandwidth	25°C		56		MHz
I_L	Insertion loss	R_L = 50 Ω , C_L = 5 pF V_S = 0 V, f = 1 MHz	25°C		–0.15		dB
ACPSRR	AC Power Supply Rejection Ratio	V_{PP} = 0.62 V on V_{DD} and V_{SS} R_L = 50 Ω , C_L = 5 pF, f = 1 MHz Refer to ACPSRR	25°C		–68		dB
THD+N	Total Harmonic Distortion + Noise	V_{PP} = 15 V, V_{BIAS} = 0 V R_L = 10 kΩ , C_L = 5 pF, f = 20 Hz to 20 kHz Refer to THD + Noise	25°C		0.0004		%
$C_{S(OFF)}$	Source off capacitance	V_S = 0 V, f = 1 MHz	25°C		28		pF
$C_{D(OFF)}$	Drain off capacitance	V_S = 0 V, f = 1 MHz	25°C		45		pF
$C_{S(ON)}$, $C_{D(ON)}$	On capacitance	V_S = 0 V, f = 1 MHz	25°C		145		pF

7.8 ±20 V Dual Supply: Electrical Characteristics

V_{DD} = +20 V ± 10%, V_{SS} = –20 V ±10%, GND = 0 V (unless otherwise noted)
Typical at V_{DD} = +20 V, V_{SS} = –20 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A	MIN	TYP	MAX	UNIT
ANALOG SWITCH							
R_{ON}	On-resistance	V_S = –15 V to +15 V I_D = –10 mA Refer to On-Resistance	25°C		1.7	2.5	Ω
			–40°C to +85°C			3	Ω
			–40°C to +125°C			3.6	Ω
ΔR_{ON}	On-resistance mismatch between channels	V_S = –15 V to +15 V I_D = –10 mA Refer to On-Resistance	25°C		0.1	0.18	Ω
			–40°C to +85°C			0.19	Ω
			–40°C to +125°C			0.21	Ω
$R_{ON\ FLAT}$	On-resistance flatness	V_S = –15 V to +15 V I_S = –10 mA Refer to On-Resistance	25°C		0.3	0.6	Ω
			–40°C to +85°C			0.8	Ω
			–40°C to +125°C			0.95	Ω
$R_{ON\ DRIFT}$	On-resistance drift	V_S = 0 V, I_S = –10 mA Refer to On-Resistance	–40°C to +125°C		0.008		Ω/°C
$I_{S(OFF)}$	Source off leakage current(1)	V_{DD} = 22 V, V_{SS} = –22 V Switch state is off V_S = +15 V / –15 V V_D = –15 V / + 15 V Refer to Off-Leakage Current	25°C	–1	0.05	1	nA
			–40°C to +85°C	–4.5		4.5	nA
			–40°C to +125°C	–33		33	nA
$I_{D(OFF)}$	Drain off leakage current(1)	V_{DD} = 22 V, V_{SS} = –22 V Switch state is off V_S = +15 V / –15 V V_D = –15 V / + 15 V Refer to Off-Leakage Current	25°C	–1	0.1	1	nA
			–40°C to +85°C	–4.5		4.5	nA
			–40°C to +125°C	–33		33	nA
$I_{S(ON)}$ $I_{D(ON)}$	Channel on leakage current(2)	V_{DD} = 22 V, V_{SS} = –22 V Switch state is on V_S = V_D = ±15 V Refer to On-Leakage Current	25°C	–1	0.1	1	nA
			–40°C to +85°C	–1.5		1.5	nA
			–40°C to +125°C	–8		8	nA
LOGIC INPUTS (SEL / EN pins)							
V_{IH}	Logic voltage high		–40°C to +125°C	1.3		44	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		0.4	1.2	µA
I_{IL}	Input leakage current		–40°C to +125°C	–0.1	–0.005		µA
C_{IN}	Logic input capacitance		–40°C to +125°C		3.5		pF
POWER SUPPLY							
I_{DD}	V_{DD} supply current	V_{DD} = 22 V, V_{SS} = –22 V Logic inputs = 0 V, 5 V, or V_{DD}	25°C		33	65	µA
			–40°C to +85°C			74	µA
			–40°C to +125°C			90	µA
I_{SS}	V_{SS} supply current	V_{DD} = 22 V, V_{SS} = –22 V Logic inputs = 0 V, 5 V, or V_{DD}	25°C		7	26	µA
			–40°C to +85°C			30	µA
			–40°C to +125°C			45	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.

7.9 ±20 V Dual Supply: Switching Characteristics

V_{DD} = +20 V ± 10%, V_{SS} = –20 V ±10%, GND = 0 V (unless otherwise noted)
Typical at V_{DD} = +20 V, V_{SS} = –20 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A	MIN	TYP	MAX	UNIT
t_{ON}	Turn-on time from control input	V_S = 10 V R_L = 300 Ω, C_L = 35 pF Refer to Turn-on and Turn-off Time	25°C		100	185	ns
			–40°C to +85°C			210	ns
			–40°C to +125°C			230	ns
t_{OFF}	Turn-off time from control input	V_S = 10 V R_L = 300 Ω, C_L = 35 pF Refer to Turn-on and Turn-off Time	25°C		90	210	ns
			–40°C to +85°C			225	ns
			–40°C to +125°C			235	ns
t_{BBM}	Break-before-make time delay (TMUX7213 Only)	V_S = 10 V, R_L = 300 Ω, C_L = 35 pF	25°C		28		ns
			–40°C to +85°C	10			ns
			–40°C to +125°C	10			ns
$t_{ON (VDD)}$	Device turn on time (V_{DD} to output)	V_{DD} rise time = 1 µs R_L = 300 Ω, C_L = 35 pF Refer to Turn-on (VDD) Time	25°C		0.17		ms
			–40°C to +85°C		0.18		ms
			–40°C to +125°C		0.18		ms
t_{PD}	Propagation delay	R_L = 50 Ω , C_L = 5 pF Refer to Propagation Delay	25°C		260		ps
Q_{INJ}	Charge injection	V_S = 0 V, C_L = 100 pF Refer to Charge Injection	25°C		92		pC
O_{ISO}	Off-isolation	R_L = 50 Ω , C_L = 5 pF V_S = 0 V, f = 100 kHz Refer to Off Isolation	25°C		–70		dB
O_{ISO}	Off-isolation	R_L = 50 Ω , C_L = 5 pF V_S = 0 V, f = 1 MHz Refer to Off Isolation	25°C		–50		dB
X_{TALK}	Crosstalk	R_L = 50 Ω , C_L = 5 pF V_S = 0 V, f = 100 kHz Refer to Crosstalk	25°C		–112		dB
X_{TALK}	Crosstalk	R_L = 50 Ω , C_L = 5 pF V_S = 0 V, f = 1MHz Refer to Crosstalk	25°C		–93		dB
BW	–3dB Bandwidth	R_L = 50 Ω , C_L = 5 pF V_S = 0 V Refer to Bandwidth	25°C		48		MHz
I_L	Insertion loss	R_L = 50 Ω , C_L = 5 pF V_S = 0 V, f = 1 MHz	25°C		–0.14		dB
ACPSRR	AC Power Supply Rejection Ratio	V_{PP} = 0.62 V on V_{DD} and V_{SS} R_L = 50 Ω , C_L = 5 pF, f = 1 MHz Refer to ACPSRR	25°C		–68		dB
THD+N	Total Harmonic Distortion + Noise	V_{PP} = 20 V, V_{BIAS} = 0 V R_L = 10 kΩ , C_L = 5 pF, f = 20 Hz to 20 kHz Refer to THD + Noise	25°C		0.0003		%
$C_{S(OFF)}$	Source off capacitance	V_S = 0 V, f = 1 MHz	25°C		28		pF
$C_{D(OFF)}$	Drain off capacitance	V_S = 0 V, f = 1 MHz	25°C		45		pF
$C_{S(ON)}$, $C_{D(ON)}$	On capacitance	V_S = 0 V, f = 1 MHz	25°C		145		pF

7.10 44 V Single Supply: Electrical Characteristics

V_{DD} = +44 V, V_{SS} = 0 V, GND = 0 V (unless otherwise noted)
Typical at V_{DD} = +44 V, V_{SS} = 0 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A	MIN	TYP	MAX	UNIT
ANALOG SWITCH							
R_{ON}	On-resistance	V_S = 0 V to 40 V I_D = –10 mA Refer to On-Resistance	25°C		2	2.4	Ω
			–40°C to +85°C			3.2	Ω
			–40°C to +125°C			3.8	Ω
ΔR_{ON}	On-resistance mismatch between channels	V_S = 0 V to 40 V I_D = –10 mA Refer to On-Resistance	25°C		0.1	0.18	Ω
			–40°C to +85°C			0.19	Ω
			–40°C to +125°C			0.21	Ω
$R_{ON\ FLAT}$	On-resistance flatness	V_S = 0 V to 40 V I_D = –10 mA Refer to On-Resistance	25°C		0.65	0.8	Ω
			–40°C to +85°C			1.1	Ω
			–40°C to +125°C			1.2	Ω
$R_{ON\ DRIFT}$	On-resistance drift	V_S = 22 V, I_S = –10 mA Refer to On-Resistance	–40°C to +125°C		0.007		Ω/°C
$I_{S(OFF)}$	Source off leakage current(1)	V_{DD} = 44 V, V_{SS} = 0 V Switch state is off V_S = 40 V / 1 V V_D = 1 V / 40 V Refer to Off-Leakage Current	25°C	–1	0.05	1	nA
			–40°C to +85°C	–7		7	nA
			–40°C to +125°C	–50		50	nA
$I_{D(OFF)}$	Drain off leakage current(1)	V_{DD} = 44 V, V_{SS} = 0 V Switch state is off V_S = 40 V / 1 V V_D = 1 V / 40 V Refer to Off-Leakage Current	25°C	–1	0.05	1	nA
			–40°C to +85°C	–7		7	nA
			–40°C to +125°C	–50		50	nA
$I_{S(ON)}$ $I_{D(ON)}$	Channel on leakage current(2)	V_{DD} = 44 V, V_{SS} = 0 V Switch state is on V_S = V_D = 40 V or 1 V Refer to On-Leakage Current	25°C	–1	0.05	1	nA
			–40°C to +85°C	–3.5		3.5	nA
			–40°C to +125°C	–5		5	nA
LOGIC INPUTS (SEL / EN pins)							
V_{IH}	Logic voltage high		–40°C to +125°C	1.3		44	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		0.6	1.2	µA
I_{IL}	Input leakage current		–40°C to +125°C	–0.1	–0.005		µA
C_{IN}	Logic input capacitance		–40°C to +125°C		3.5		pF
POWER SUPPLY							
I_{DD}	V_{DD} supply current	V_{DD} = 44 V, V_{SS} = 0 V Logic inputs = 0 V, 5 V, or V_{DD}	25°C		44	79	µA
			–40°C to +85°C			88	µA
			–40°C to +125°C			105	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.

7.11 44 V Single Supply: Switching Characteristics

V_{DD} = +44 V, V_{SS} = 0 V, GND = 0 V (unless otherwise noted)
Typical at V_{DD} = +44 V, V_{SS} = 0 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A	MIN	TYP	MAX	UNIT
t_{ON}	Turn-on time from control input	V_S = 18 V R_L = 300 Ω, C_L = 35 pF Refer to Turn-on and Turn-off Time	25°C		80	185	ns
			–40°C to +85°C			205	ns
			–40°C to +125°C			225	ns
t_{OFF}	Turn-off time from control input	V_S = 18 V R_L = 300 Ω, C_L = 35 pF Refer to Turn-on and Turn-off Time	25°C		90	205	ns
			–40°C to +85°C			220	ns
			–40°C to +125°C			228	ns
t_{BBM}	Break-before-make time delay (TMUX7213 Only)	V_S = 18 V, R_L = 300 Ω, C_L = 35 pF	25°C		27		ns
			–40°C to +85°C	10			ns
			–40°C to +125°C	10			ns
$t_{ON (VDD)}$	Device turn on time (V_{DD} to output)	V_{DD} rise time = 1 µs R_L = 300 Ω, C_L = 35 pF Refer to Turn-on (VDD) Time	25°C		0.14		ms
			–40°C to +85°C		0.15		ms
			–40°C to +125°C		0.15		ms
t_{PD}	Propagation delay	R_L = 50 Ω , C_L = 5 pF Refer to Propagation Delay	25°C		270		ps
Q_{INJ}	Charge injection	V_S = 22 V, C_L = 100 pF Refer to Charge Injection	25°C		104		pC
O_{ISO}	Off-isolation	R_L = 50 Ω , C_L = 5 pF V_S = 6 V, f = 100 kHz Refer to Off Isolation	25°C		–70		dB
O_{ISO}	Off-isolation	R_L = 50 Ω , C_L = 5 pF V_S = 6 V, f = 1 MHz Refer to Off Isolation	25°C		–50		dB
X_{TALK}	Crosstalk	R_L = 50 Ω , C_L = 5 pF V_S = 6 V, f = 100 kHz Refer to Crosstalk	25°C		–112		dB
X_{TALK}	Crosstalk	R_L = 50 Ω , C_L = 5 pF V_S = 6 V, f = 1MHz Refer to Crosstalk	25°C		–93		dB
BW	–3dB Bandwidth	R_L = 50 Ω , C_L = 5 pF V_S = 6 V Refer to Bandwidth	25°C		46		MHz
I_L	Insertion loss	R_L = 50 Ω , C_L = 5 pF V_S = 6 V, f = 1 MHz	25°C		–0.15		dB
ACPSRR	AC Power Supply Rejection Ratio	V_{PP} = 0.62 V on V_{DD} and V_{SS} R_L = 50 Ω , C_L = 5 pF, f = 1 MHz Refer to ACPSRR	25°C		–66		dB
THD+N	Total Harmonic Distortion + Noise	V_{PP} = 22 V, V_{BIAS} = 22 V R_L = 10 kΩ , C_L = 5 pF, f = 20 Hz to 20 kHz Refer to THD + Noise	25°C		0.0003		%
$C_{S(OFF)}$	Source off capacitance	V_S = 22 V, f = 1 MHz	25°C		28		pF
$C_{D(OFF)}$	Drain off capacitance	V_S = 22 V, f = 1 MHz	25°C		45		pF
$C_{S(ON)}$, $C_{D(ON)}$	On capacitance	V_S = 22 V, f = 1 MHz	25°C		145		pF

7.12 12 V Single Supply: Electrical Characteristics

V_{DD} = +12 V ± 10%, V_{SS} = 0 V, GND = 0 V (unless otherwise noted)
Typical at V_{DD} = +12 V, V_{SS} = 0 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A	MIN	TYP	MAX	UNIT
ANALOG SWITCH							
R_{ON}	On-resistance	V_S = 0 V to 10 V I_D = –10 mA Refer to On-Resistance	25°C		2.8	5.4	Ω
			–40°C to +85°C			6.8	Ω
			–40°C to +125°C			7.4	Ω
ΔR_{ON}	On-resistance mismatch between channels	V_S = 0 V to 10 V I_D = –10 mA Refer to On-Resistance	25°C		0.13	0.21	Ω
			–40°C to +85°C			0.23	Ω
			–40°C to +125°C			0.25	Ω
$R_{ON\ FLAT}$	On-resistance flatness	V_S = 0 V to 10 V I_S = –10 mA Refer to On-Resistance	25°C		1	1.7	Ω
			–40°C to +85°C			1.9	Ω
			–40°C to +125°C			2	Ω
$R_{ON\ DRIFT}$	On-resistance drift	V_S = 6 V, I_S = –10 mA Refer to On-Resistance	–40°C to +125°C		0.015		Ω/°C
$I_{S(OFF)}$	Source off leakage current(1)	V_{DD} = 13.2 V, V_{SS} = 0 V Switch state is off V_S = 10 V / 1 V V_D = 1 V / 10 V Refer to Off-Leakage Current	25°C	–0.25	0.01	0.25	nA
			–40°C to +85°C	–2		2	nA
			–40°C to +125°C	–16		16	nA
$I_{D(OFF)}$	Drain off leakage current(1)	V_{DD} = 13.2 V, V_{SS} = 0 V Switch state is off V_S = 10 V / 1 V V_D = 1 V / 10 V Refer to Off-Leakage Current	25°C	–0.25	0.05	0.25	nA
			–40°C to +85°C	–2		2	nA
			–40°C to +125°C	–16		16	nA
$I_{S(ON)}$ $I_{D(ON)}$	Channel on leakage current(2)	V_{DD} = 13.2 V, V_{SS} = 0 V Switch state is on V_S = V_D = 10 V or 1 V Refer to On-Leakage Current	25°C	–0.5	0.05	0.5	nA
			–40°C to +85°C	–1		1	nA
			–40°C to +125°C	–3		3	nA
LOGIC INPUTS (SEL / EN pins)							
V_{IH}	Logic voltage high		–40°C to +125°C	1.3		44	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		0.4	1.2	µA
I_{IL}	Input leakage current		–40°C to +125°C	–0.1	–0.005		µA
C_{IN}	Logic input capacitance		–40°C to +125°C		3.5		pF
POWER SUPPLY							
I_{DD}	V_{DD} supply current	V_{DD} = 13.2 V, V_{SS} = 0 V Logic inputs = 0 V, 5 V, or V_{DD}	25°C		30	44	µA
			–40°C to +85°C			52	µA
			–40°C to +125°C			62	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.

7.13 12 V Single Supply: Switching Characteristics

V_{DD} = +12 V ± 10%, V_{SS} = 0 V, GND = 0 V (unless otherwise noted)
Typical at V_{DD} = +12 V, V_{SS} = 0 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A	MIN	TYP	MAX	UNIT
t_{ON}	Turn-on time from control input	V_S = 8 V R_L = 300 Ω, C_L = 35 pF Refer to Turn-on and Turn-off Time	25°C		170	225	ns
			–40°C to +85°C			276	ns
			–40°C to +125°C			315	ns
t_{OFF}	Turn-off time from control input	V_S = 8 V R_L = 300 Ω, C_L = 35 pF Refer to Turn-on and Turn-off Time	25°C		75	248	ns
			–40°C to +85°C			285	ns
			–40°C to +125°C			310	ns
t_{BBM}	Break-before-make time delay (TMUX7213 Only)	V_S = 8 V, R_L = 300 Ω, C_L = 35 pF	25°C		30		ns
			–40°C to +85°C	13			ns
			–40°C to +125°C	13			ns
$t_{ON (VDD)}$	Device turn on time (V_{DD} to output)	V_{DD} rise time = 1 µs R_L = 300 Ω, C_L = 35 pF Refer to Turn-on (VDD) Time	25°C		0.17		ms
			–40°C to +85°C		0.18		ms
			–40°C to +125°C		0.18		ms
t_{PD}	Propagation delay	R_L = 50 Ω , C_L = 5 pF Refer to Propagation Delay	25°C		270		ps
Q_{INJ}	Charge injection	V_S = 6 V, C_L = 100 pF Refer to Charge Injection	25°C		12		pC
O_{ISO}	Off-isolation	R_L = 50 Ω , C_L = 5 pF V_S = 6 V, f = 100 kHz Refer to Off Isolation	25°C		–70		dB
O_{ISO}	Off-isolation	R_L = 50 Ω , C_L = 5 pF V_S = 6 V, f = 1 MHz Refer to Off Isolation	25°C		–50		dB
X_{TALK}	Crosstalk	R_L = 50 Ω , C_L = 5 pF V_S = 6 V, f = 100 kHz Refer to Crosstalk	25°C		–112		dB
X_{TALK}	Crosstalk	R_L = 50 Ω , C_L = 5 pF V_S = 6 V, f = 1MHz Refer to Crosstalk	25°C		–93		dB
BW	–3dB Bandwidth	R_L = 50 Ω , C_L = 5 pF V_S = 6 V Refer to Bandwidth	25°C		125		MHz
I_L	Insertion loss	R_L = 50 Ω , C_L = 5 pF V_S = 6 V, f = 1 MHz	25°C		–0.25		dB
ACPSRR	AC Power Supply Rejection Ratio	V_{PP} = 0.62 V on V_{DD} and V_{SS} R_L = 50 Ω , C_L = 5 pF, f = 1 MHz Refer to ACPSRR	25°C		–70		dB
THD+N	Total Harmonic Distortion + Noise	V_{PP} = 6 V, V_{BIAS} = 6 V R_L = 10 kΩ , C_L = 5 pF, f = 20 Hz to 20 kHz Refer to THD + Noise	25°C		0.0001		%
$C_{S(OFF)}$	Source off capacitance	V_S = 6 V, f = 1 MHz	25°C		35		pF
$C_{D(OFF)}$	Drain off capacitance	V_S = 6 V, f = 1 MHz	25°C		50		pF
$C_{S(ON)}$, $C_{D(ON)}$	On capacitance	V_S = 6 V, f = 1 MHz	25°C		145		pF

7.14 Typical Characteristics

at T_A = 25°C (unless otherwise noted)

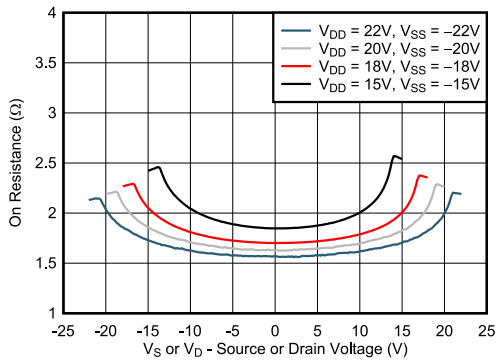


Figure 7-1. On-Resistance vs Source or Drain Voltage - Dual Supply

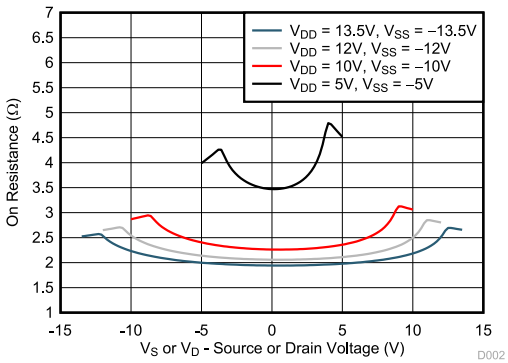


Figure 7-2. On-Resistance vs Source or Drain Voltage - Dual Supply

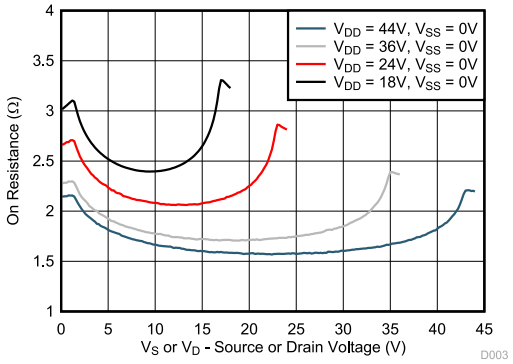


Figure 7-3. On-Resistance vs Source or Drain Voltage - Single Supply

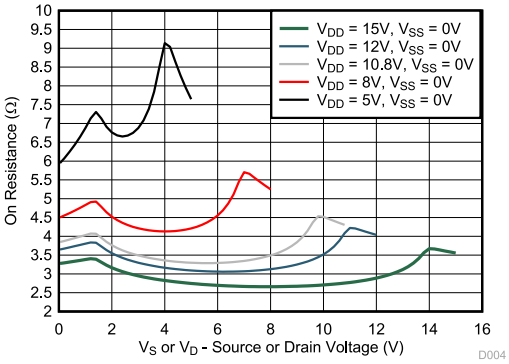
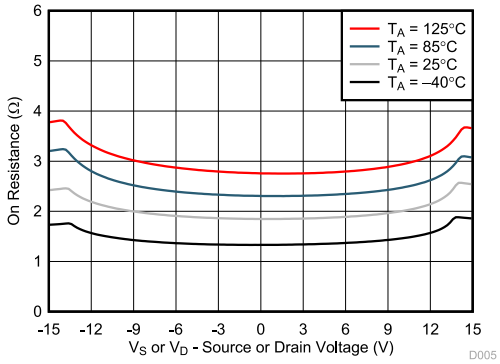
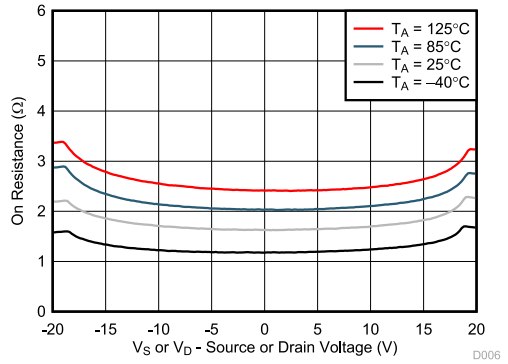


Figure 7-4. On-Resistance vs Source or Drain Voltage - Single Supply



V_{DD} = 15 V, V_{SS} = -15 V

Figure 7-5. On-Resistance vs Temperature

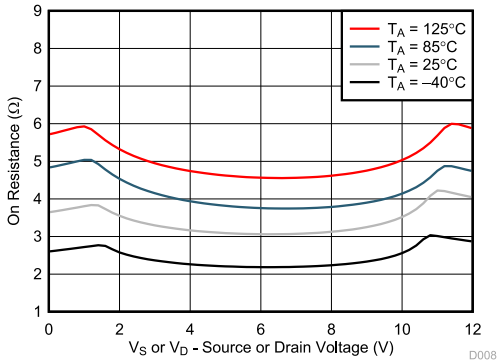


V_{DD} = 20 V, V_{SS} = -20V

Figure 7-6. On-Resistance vs Temperature

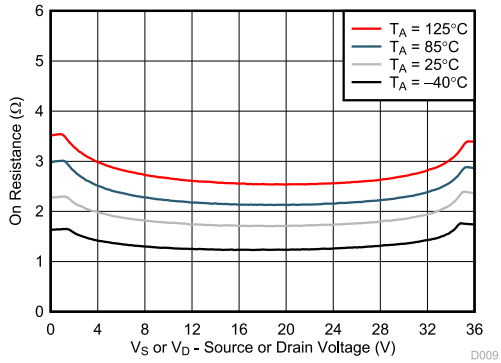
7.14 Typical Characteristics (continued)

at T_A = 25°C (unless otherwise noted)



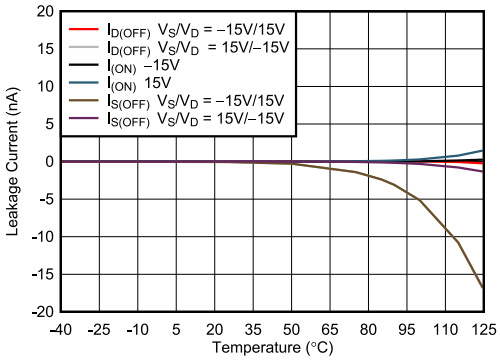
V_{DD} = 12 V, V_{SS} = 0 V

Figure 7-7. On-Resistance vs Temperature



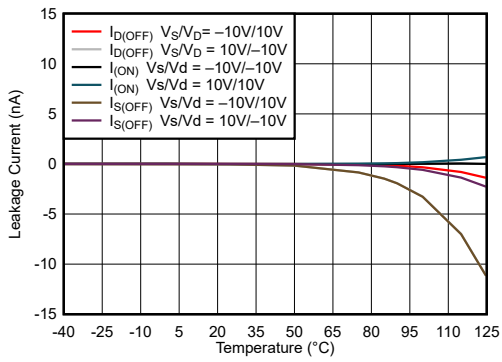
V_{DD} = 36 V, V_{SS} = 0 V

Figure 7-8. On-Resistance vs Temperature



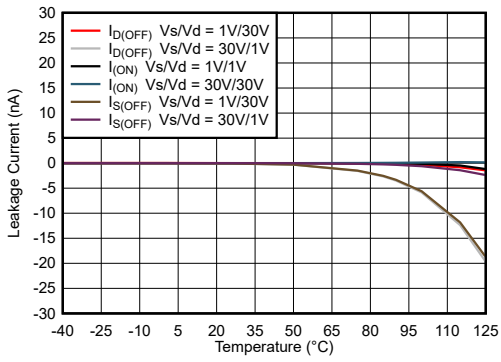
V_{DD} = 20 V, V_{SS} = -20V

Figure 7-9. Leakage Current vs Temperature



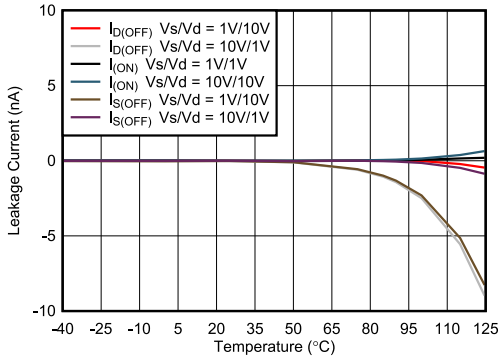
V_{DD} = 15 V, V_{SS} = -15 V

Figure 7-10. Leakage Current vs Temperature



V_{DD} = 36 V, V_{SS} = 0 V

Figure 7-11. Leakage Current vs Temperature



V_{DD} = 12 V, V_{SS} = 0 V

Figure 7-12. Leakage Current vs Temperature

7.14 Typical Characteristics (continued)

at T_A = 25°C (unless otherwise noted)

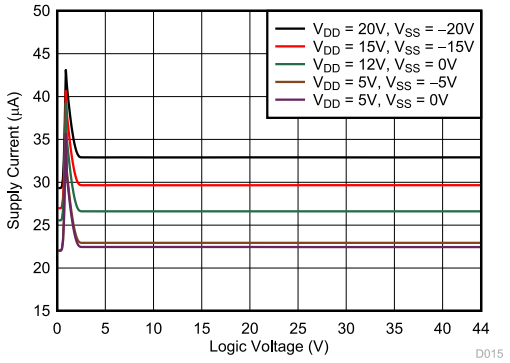


Figure 7-13. Supply Current vs Logic Voltage

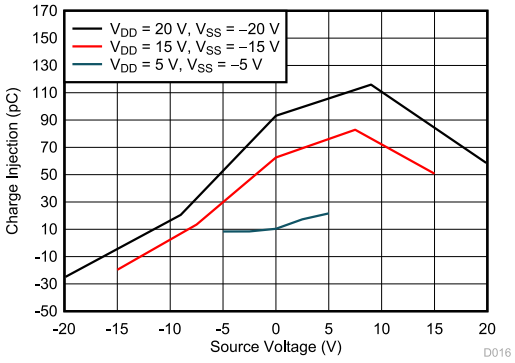


Figure 7-14. Charge Injection vs Source Voltage - Dual Supply

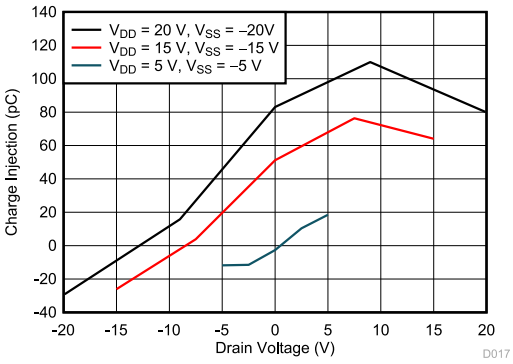


Figure 7-15. Charge Injection vs Drain Voltage - Dual Supply

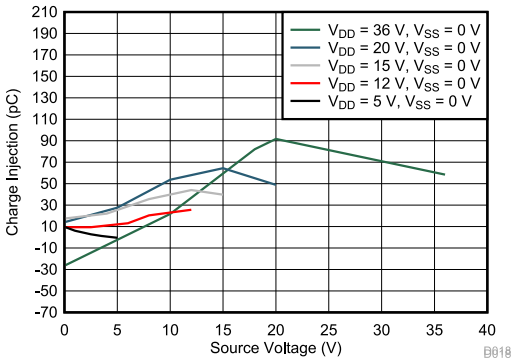


Figure 7-16. Charge Injection vs Source Voltage - Single Supply

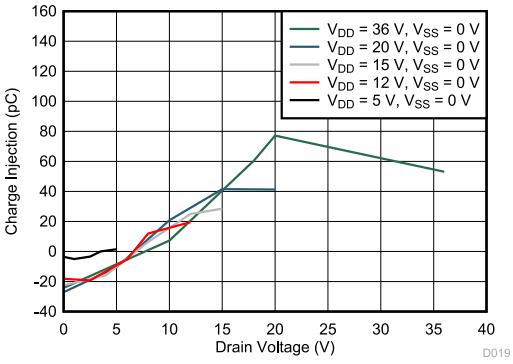
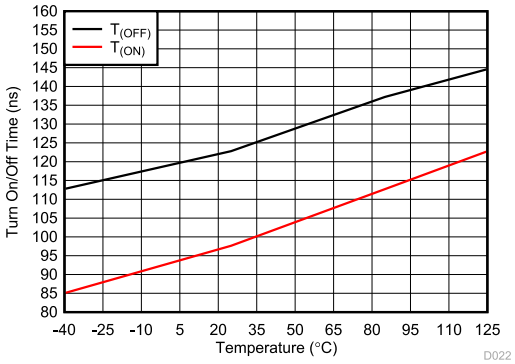


Figure 7-17. Charge Injection vs Drain Voltage - Single Supply

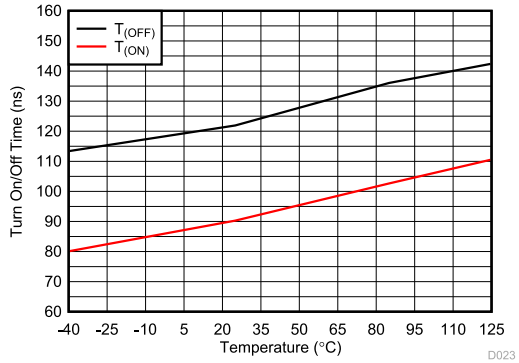


V_{DD} = 15 V, V_{SS} = -15 V

Figure 7-18. T_{ON} and T_{OFF} vs Temperature

7.14 Typical Characteristics (continued)

at T_A = 25°C (unless otherwise noted)



V_{DD} = 36 V, V_{SS} = 0 V

Figure 7-19. T_{ON} and T_{OFF} vs Temperature

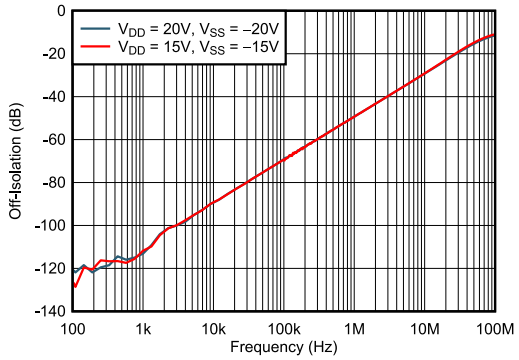


Figure 7-20. Off-Isolation vs Frequency

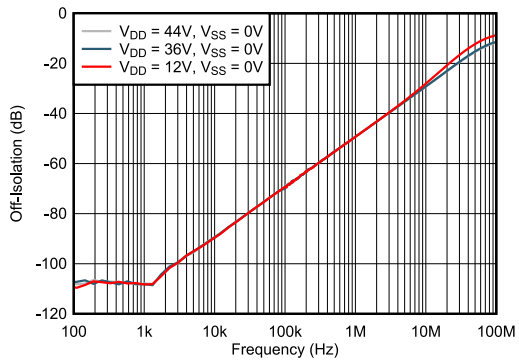
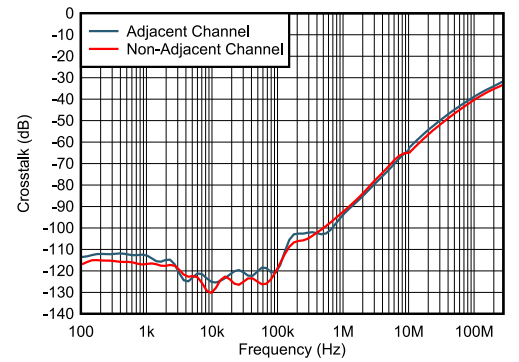


Figure 7-21. Off-Isolation vs Frequency



V_{DD} = +15 V, V_{SS} = -15 V

Figure 7-22. Crosstalk vs Frequency

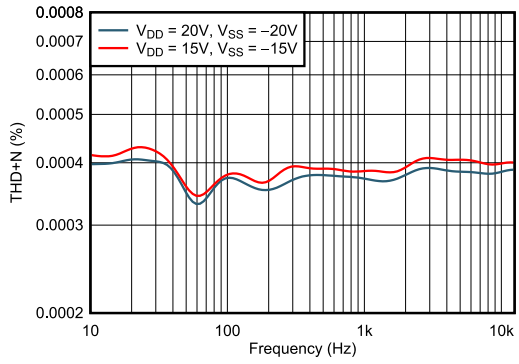


Figure 7-23. THD+N vs Frequency (Dual Supplies)

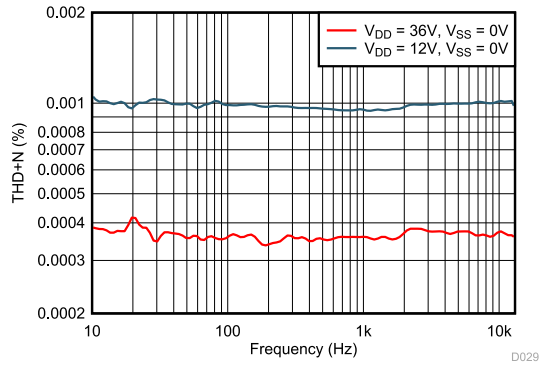
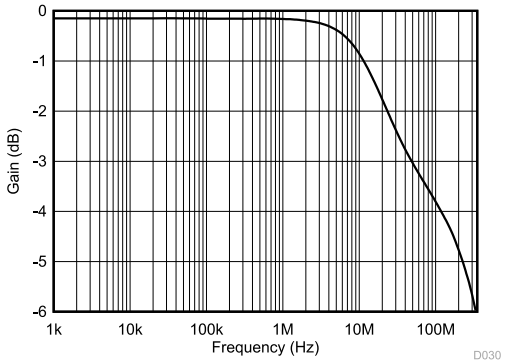


Figure 7-24. THD+N vs Frequency (Single Supplies)

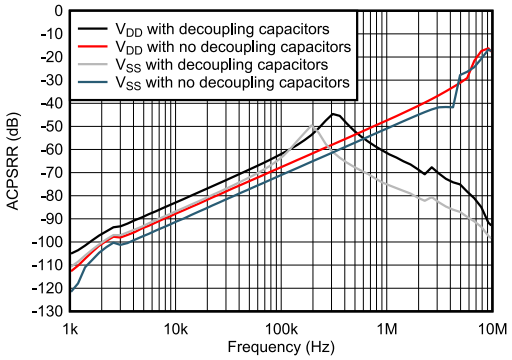
7.14 Typical Characteristics (continued)

at T_A = 25°C (unless otherwise noted)



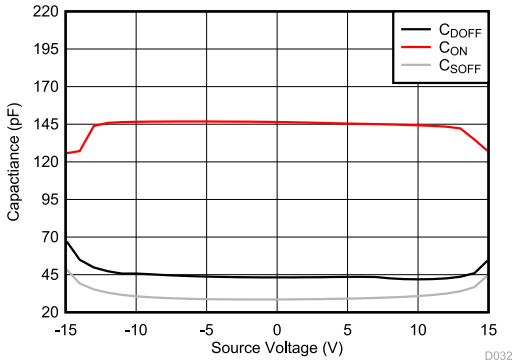
V_{DD} = +15 V, V_{SS} = -15 V

Figure 7-25. On Response vs Frequency



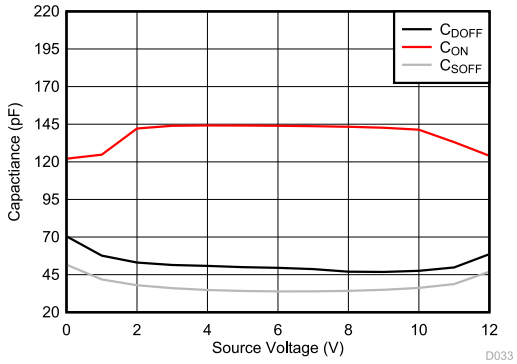
V_{DD} = +15 V, V_{SS} = -15 V

Figure 7-26. ACPSRR vs Frequency



V_{DD} = +15 V, V_{SS} = -15 V

Figure 7-27. Capacitance vs Source Voltage or Drain Voltage



V_{DD} = 12 V, V_{SS} = 0 V

Figure 7-28. Capacitance vs Source Voltage or Drain Voltage

8 Parameter Measurement Information

8.1 On-Resistance

The on-resistance of a device is the ohmic resistance between 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. The measurement setup used to measure R_{ON} is shown in Figure 8-1. Voltage (V) and current (I_{SD}) are measured using this setup, and R_{ON} is computed with $R_{ON} = V / I_{SD}$:

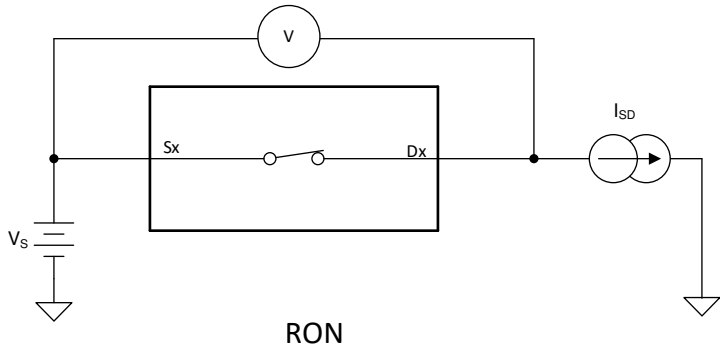


Figure 8-1. On-Resistance Measurement Setup

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.
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 $I_{D(OFF)}$.

The setup used to measure both off-leakage currents is shown in Figure 8-2.

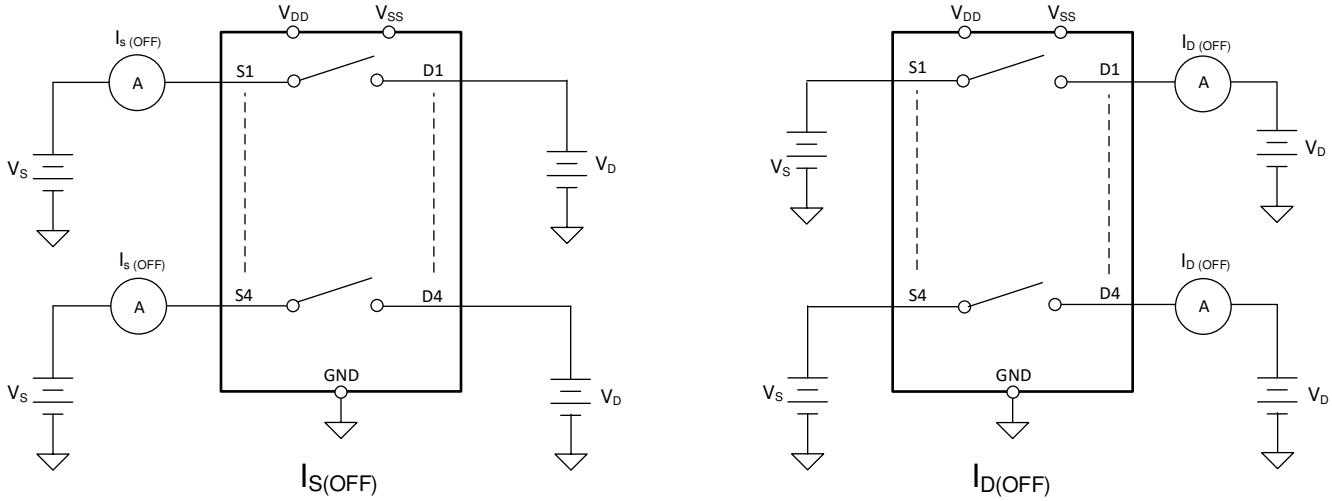


Figure 8-2. Off-Leakage Measurement Setup

8.3 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 8-3 shows the circuit used for measuring the on-leakage current, denoted by $I_{S(ON)}$ or $I_{D(ON)}$.

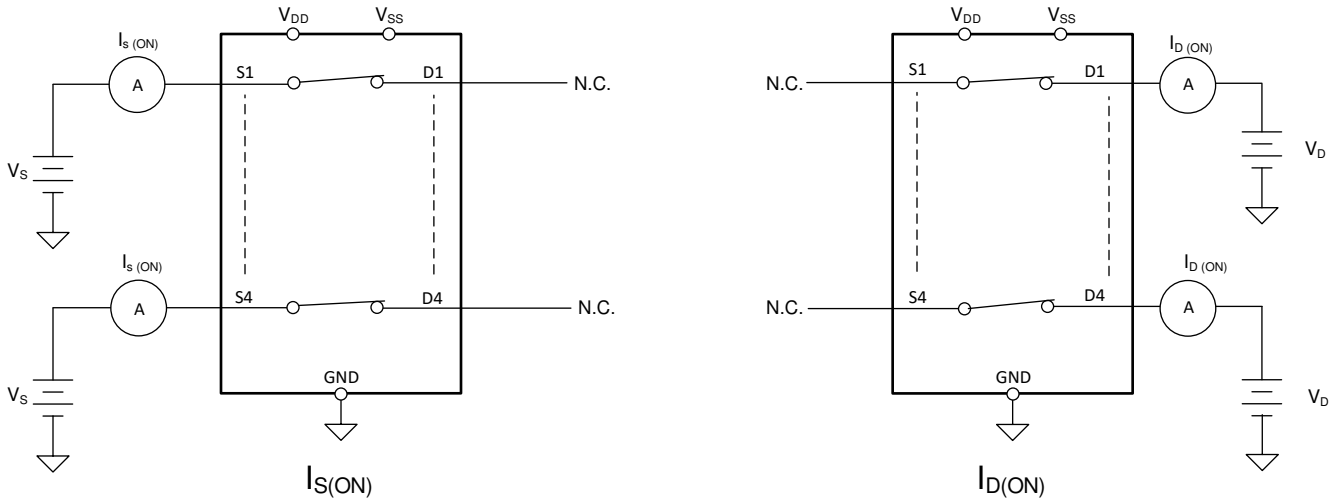


Figure 8-3. On-Leakage Measurement Setup

8.4 t_{ON} and t_{OFF} Time

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 8-4 shows the setup used to measure turn-on time, denoted by the symbol t_{ON}.

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 8-4 shows the setup used to measure turn-off time, denoted by the symbol t_{OFF}.

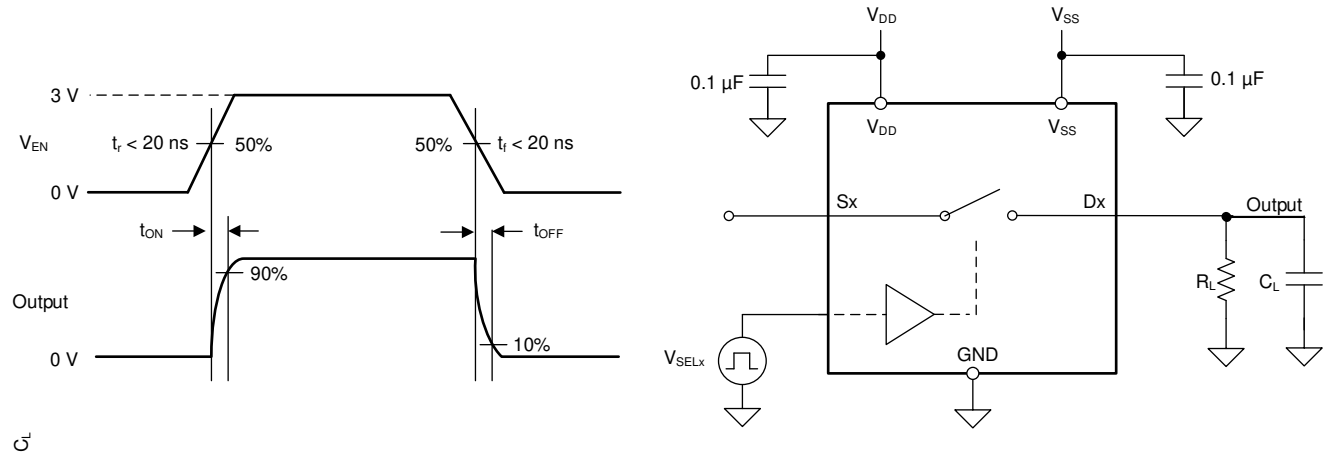


Figure 8-4. Turn-On and Turn-Off Time Measurement Setup

8.5 $t_{ON\ (VDD)}$ 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 8-5 shows the setup used to measure turn on time, denoted by the symbol $t_{ON\ (VDD)}$.

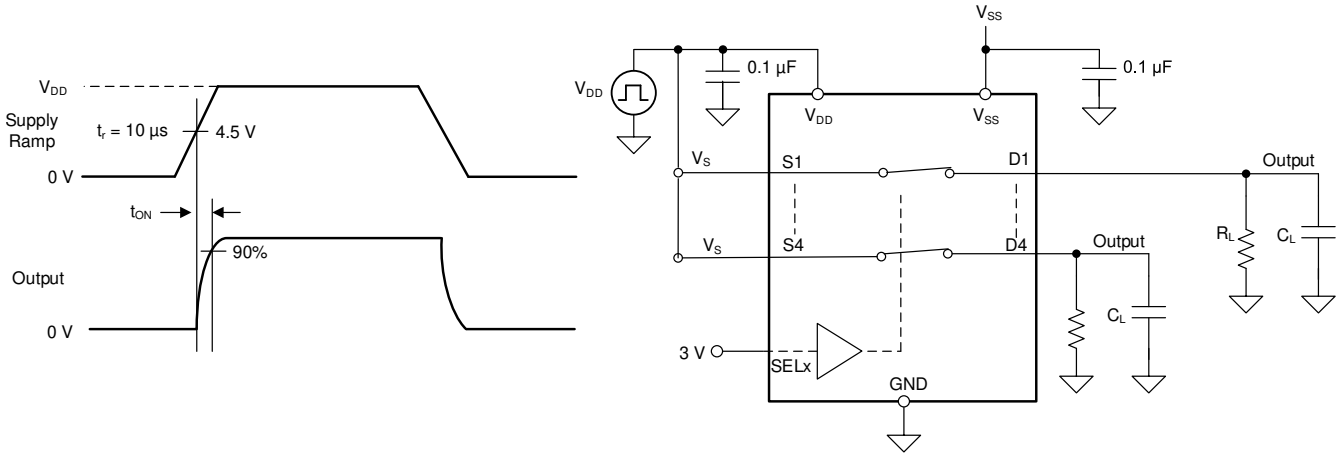


Figure 8-5. $t_{ON\ (VDD)}$ Time Measurement Setup

8.6 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 8-6 shows the setup used to measure propagation delay, denoted by the symbol t_{PD}.

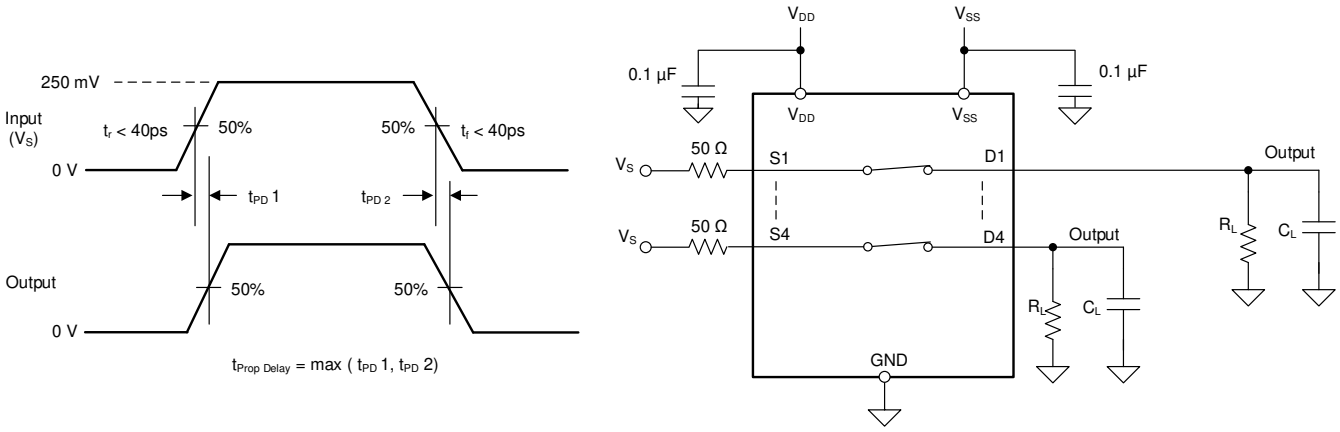


Figure 8-6. Propagation Delay Measurement Setup

8.7 Charge Injection

The TMUX721x devices have 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 8-7 shows the setup used to measure charge injection from source (Sx) to drain (Dx).

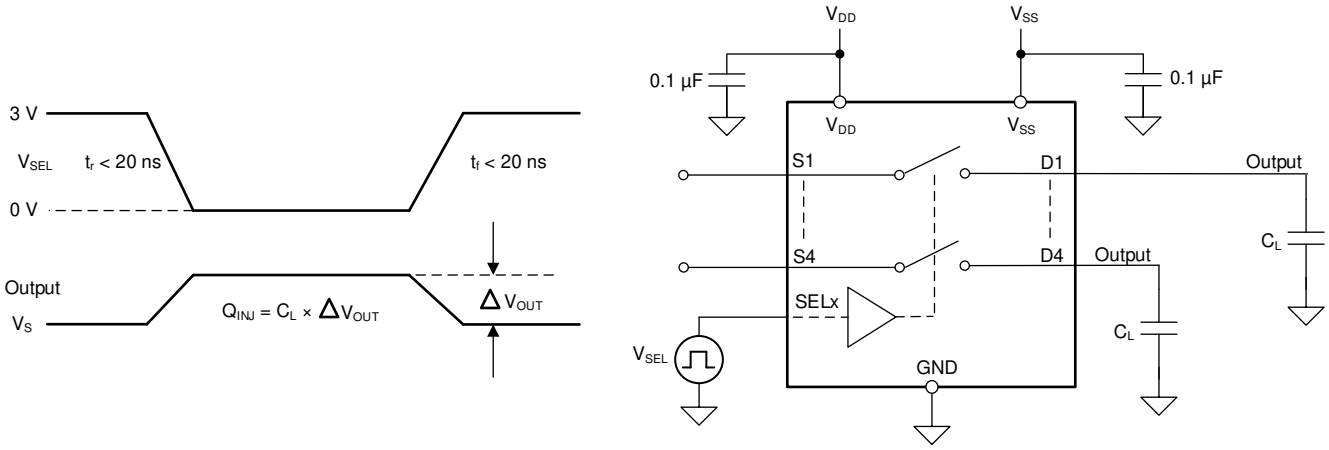
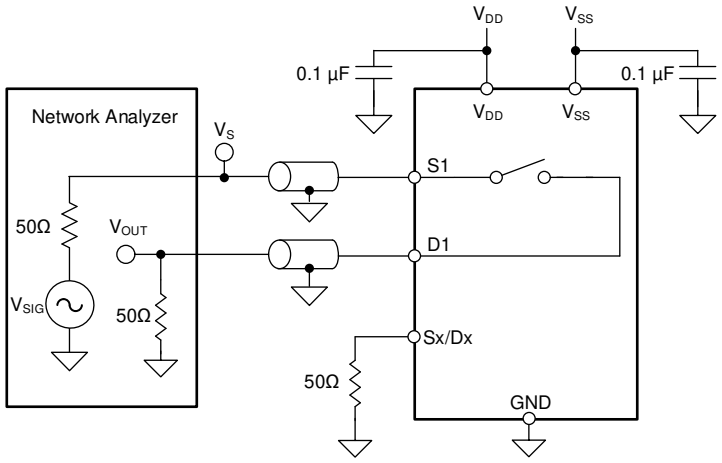


Figure 8-7. Charge-Injection Measurement Setup

8.8 Off Isolation

Off isolation is defined as the ratio of the signal at the drain pin (Dx) of the device when a signal is applied to the source pin (Sx) of an off-channel. The characteristic impedance, Z_0, for the measurement is 50 Ω. Figure 8-8 shows the setup used to measure off isolation. Use off isolation equation to compute off isolation.

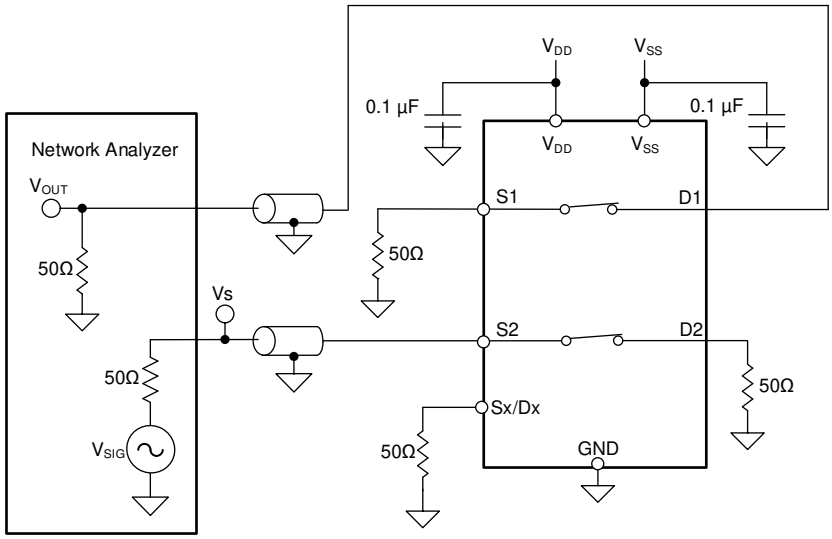


$$Off\ Isolation = 20 \times Log \frac{V_{OUT}}{V_S}$$

Figure 8-8. Off Isolation Measurement Setup

8.9 Channel-to-Channel Crosstalk

Crosstalk is defined as the ratio of the signal at the drain pin (Dx) of a different channel, when a signal is applied at the source pin (Sx) of an on-channel. The characteristic impedance, Z_0, for the measurement is 50 Ω. Figure 8-9 shows the setup used to measure, and the equation used to compute crosstalk.

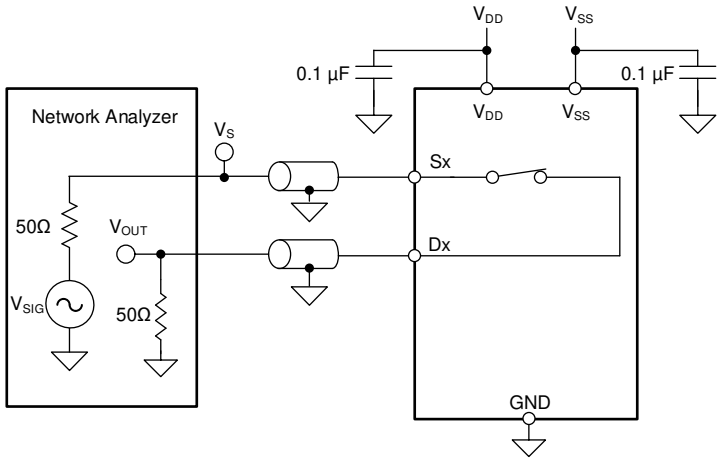


$$Crosstalk = 20 \times Log \frac{V_{OUT}}{V_S}$$

Figure 8-9. Channel-to-Channel Crosstalk Measurement Setup

8.10 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 (Dx) of the device. The characteristic impedance, Z_0, for the measurement is 50 Ω. Figure 8-10 shows the setup used to measure bandwidth.



$$Bandwidth = 20 \times Log \frac{V_{OUT}}{V_S}$$

Figure 8-10. Bandwidth Measurement Setup

8.11 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.

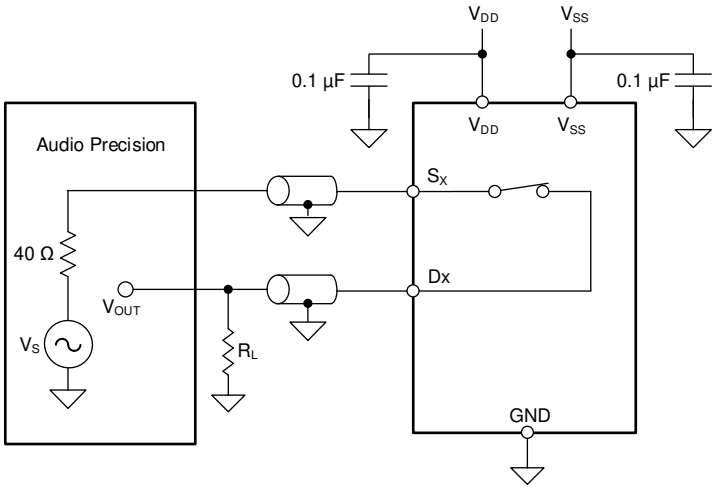
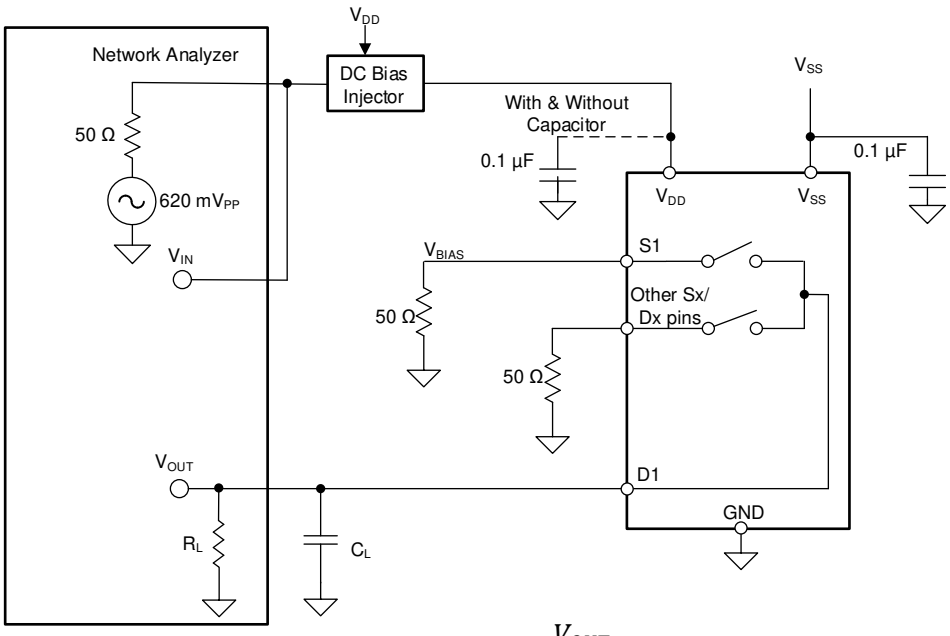


Figure 8-11. THD + N Measurement Setup

8.12 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 100 mV_{PP}. The ratio of the amplitude of signal on the output to the amplitude of the modulated signal is the AC PSRR.



$$PSRR = 20 \times Log \frac{V_{OUT}}{V_{IN}}$$

Figure 8-12. AC PSRR Measurement Setup

9 Detailed Description

9.1 Overview

The TMUX7211, TMUX7212, and TMUX7213 are 1:1 (SPST), 4-Channel switches. The devices have four independently selectable single-pole, single-throw switches that are turned-on or turned-off based on the state of the corresponding select pin.

9.2 Functional Block Diagram

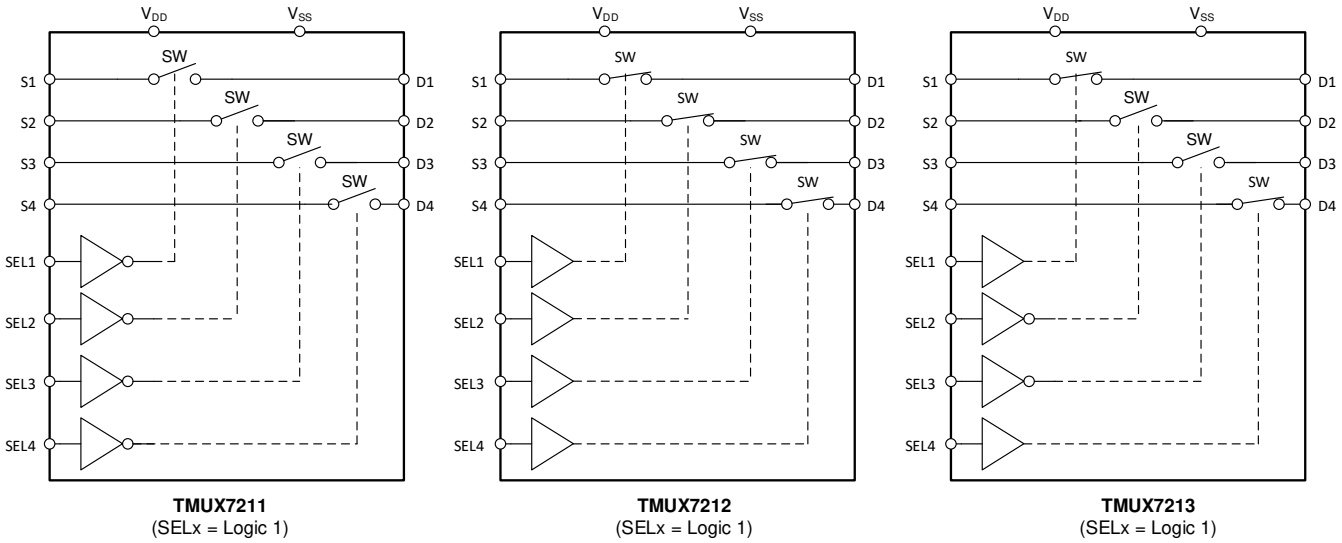


Figure 9-1. TMUX721x Functional Block Diagram

9.3 Feature Description

9.3.1 Bidirectional Operation

The TMUX721x conducts equally well from source (Sx) to drain (Dx) or from drain (Dx) to source (Sx). Each channel has similar characteristics in both directions and supports both analog and digital signals.

9.3.2 Rail-to-Rail Operation

The valid signal path input and output voltage for TMUX721x ranges from V_{SS} to V_{DD}.

9.3.3 1.8 V Logic Compatible Inputs

The TMUX721x devices have 1.8-V logic compatible control for all logic control inputs. 1.8-V logic level inputs allows the TMUX721x 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*.

9.3.4 Fail-Safe Logic

The TMUX721x supports Fail-Safe Logic on the control input pins (SEL1, SEL2, SEL3, and SEL4) allowing for operation up to 44 V, regardless of the state of the supply pin. 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 select pins of the TMUX721x to be ramped to 44 V while V_{DD} and V_{SS} = 0 V. The logic control inputs are protected against positive faults of up to 44 V in powered-off condition, but do not offer protection against negative overvoltage conditions.

9.3.5 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 TMUX721x 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 TMUX721x family of switches and multiplexers to be used in harsh environments. For more information on latch-up immunity refer to *Using Latch Up Immune Multiplexers to Help Improve System Reliability*.

9.3.6 Ultra-Low Charge Injection

The TMUX721x devices have a transmission gate topology, as shown in Figure 9-2. Any mismatch in the stray capacitance associated with the NMOS and PMOS causes an output level change whenever the switch is opened or closed.

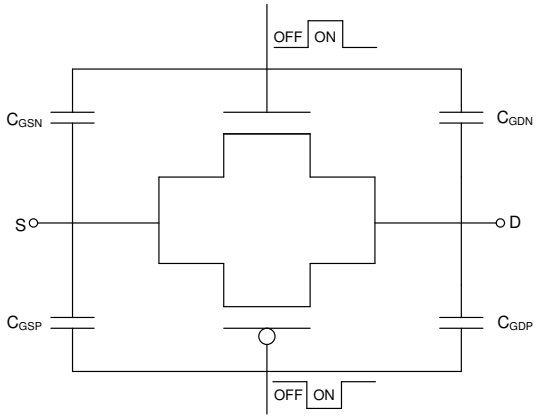


Figure 9-2. Transmission Gate Topology

The TMUX721x contains specialized architecture to reduce charge injection on the Drain (Dx). To further reduce charge injection in a sensitive application, a compensation capacitor (Cp) can be added on the Source (Sx). This will ensure that excess charge from the switch transition will be pushed into the compensation capacitor on the Source (Sx) instead of the Drain (Dx). As a general rule of thumb, Cp should be 20x larger than the equivalent load capacitance on the Drain (Dx). Figure 9-3 shows charge injection variation with source voltage with different compensation capacitors on the Source (Sx) side.

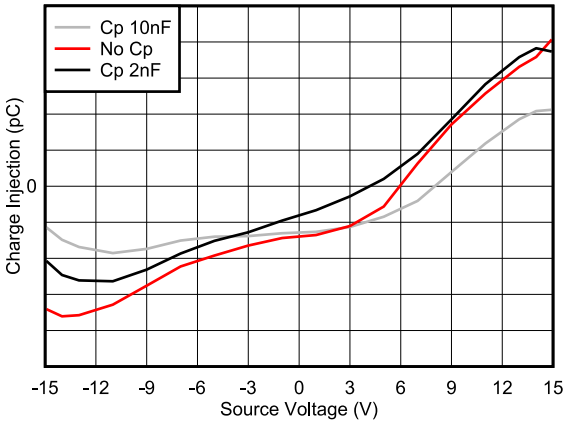


Figure 9-3. Charge Injection Compensation

9.4 Device Functional Modes

The TMUX721x devices have four independently selectable single-pole, single-throw switches that are turned-on or turned-off based on the state of the corresponding select pin. The control pins can be as high as 44 V.

The TMUX721x devices can be operated without any external components except for the supply decoupling capacitors. The SELx pins have internal pull-down resistors of 4 MΩ. If unused, SELx 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 (Sx or Dx) should be connected to GND.

9.5 Truth Tables

Table 9-1, Table 9-2, and Table 9-3 show the truth tables for the TMUX7211, TMUX7212, and TMUX7213, respectively.

Table 9-1. TMUX7211 Truth Table

SEL x (1)	CHANNEL x
0	Channel x ON
1	Channel x OFF

Table 9-2. TMUX7212 Truth Table

SEL x (1)	CHANNEL x
0	Channel x OFF
1	Channel x ON

Table 9-3. TMUX7213 Truth Table

SEL1	SEL2	SEL3	SEL4	ON / OFF CHANNELS(2)
0	X	X	X	CHANNEL 1 OFF
1	X	X	X	CHANNEL 1 ON
X	0	X	X	CHANNEL 2 ON
X	1	X	X	CHANNEL 2 OFF
X	X	0	X	CHANNEL 3 ON
X	X	1	X	CHANNEL 3 OFF
X	X	X	0	CHANNEL 4 OFF
X	X	X	1	CHANNEL 4 ON

(1) x denotes 1, 2, 3, or 4 for the corresponding channel.
(2) X = do not care.

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 TMUX721x is part of the precision switches and multiplexers family of devices. These devices operate with dual supplies (±4.5 V to ±22 V), a single supply (4.5 V to 44 V), or asymmetric supplies (such as V_{DD} = 12 V, V_{SS} = –5 V), and offer true rail-to-rail input and output.The TMUX721x offers low R_{ON}, low on and off leakage currents and ultra-low charge injection performance. These features makes the TMUX721x a family of precision, robust, high-performance analog multiplexer for high-voltage, industrial applications.

10.2 Typical Application

One example to take advantage of TMUX721x precision performance is the implementation of parametric measurement unit (PMU) in the semiconductor automatic test equipment (ATE) application.

In Automated Test Equipment (ATE) systems, the Parametric Measurement Unit (PMU) is tasked to measure device (DUT) parametric information in terms of voltage and current. When measuring voltage, current is applied at the DUT pin, and current range adjustment can be done through changing the value of the internal sense resistor. There is sometimes a need, depending on the DUT, to use even higher testing current than natively supported by the system. A 4 channel SPST switch, together with external higher current amplifier and resistor, can be used to achieve the flexibility. The PMU operating voltage is typically in mid voltage (up to 20 V). An appropriate switch like the TMUX721x with low leakage current (0.05 nA typical) works well in these applications to ensure measurement accuracy and low R_{ON} and flat $R_{ON\_FLATNESS}$ allows the current range to be controlled more precisely. Figure 10-1 shows simplified diagram of such implementations in memory and semiconductor test equipment.

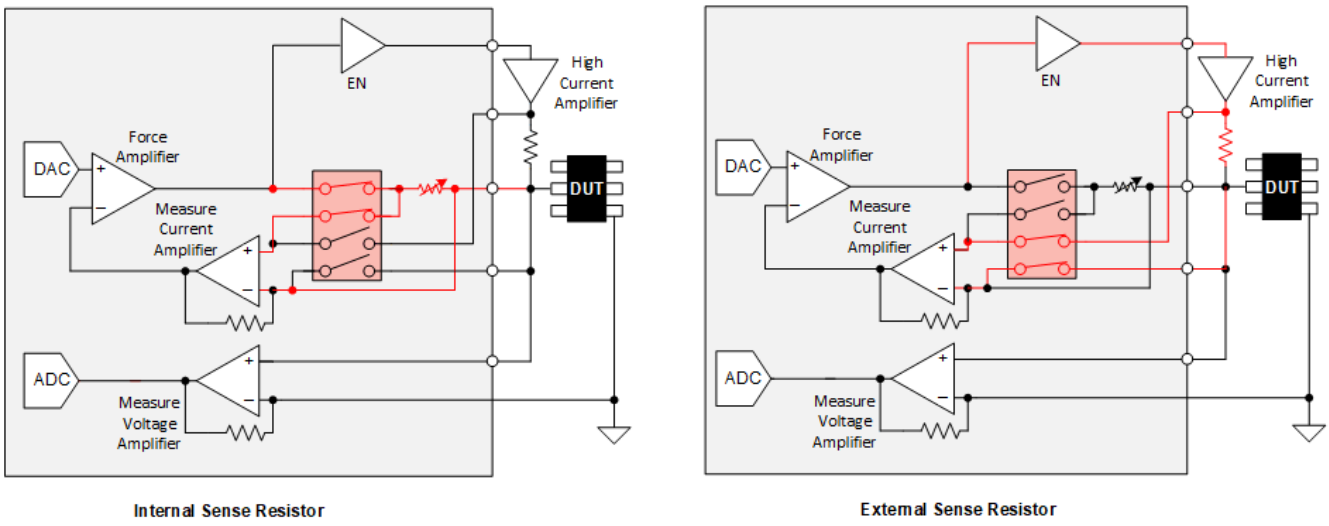


Figure 10-1. High Current Range Selection Using External Resistor

10.2.1 Design Requirements

For this design example, use the parameters listed in Table 10-1.

Table 10-1. Design Parameters

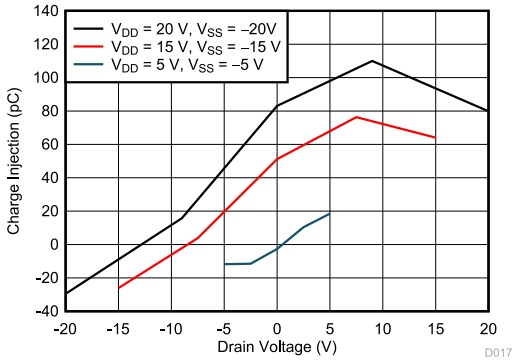
PARAMETERS	VALUES
Supply (V_{DD})	20 V
Supply (V_{SS})	- 10 V
Input / Output signal range	-10 V to 20 V (Rail-to-Rail)
Control logic thresholds	1.8 V compatible

10.2.2 Detailed Design Procedure

The application shown in High Current Range Selection Using External Resistor demonstrates how the TMUX721x can be used in semiconductor test equipment for high-precision, high-voltage, multi-channel measurement applications. The TMUX721x 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 TMUX721x can be operated without any external components except for the supply decoupling capacitors. The select pins have an internal pull-down resistor to prevent floating input logic. All inputs to the switch must fall within the recommend operating conditions of the TMUX721x including signal range and continuous current. For this design with a positive supply of 20 V on V_{DD}, and negative supply of -10 V on V_{SS}, the signal range can be 20 V to -10 V. The max continuous current (I_{DC}) can be up to 370 mA as shown in the *Recommended Operating Conditions* table for wide-range current measurement.

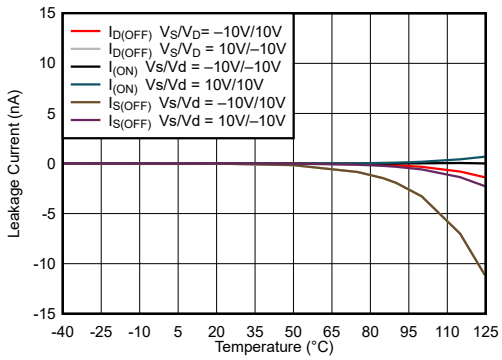
10.2.3 Application Curve

The TMUX721x have excellent charge injection performance and ultra-low leakage current, making them ideal choices to minimize sampling error for the sample and hold application.



T_A = 25°C

Figure 10-2. Charge Injection vs Drain Voltage



V_{DD} = 15 V, V_{DD} = -15 V

Figure 10-3. On-Leakage vs Source or Drain Voltage

11 Power Supply Recommendations

The TMUX721x device operates across a wide supply range of of ±4.5 V to ±22 V (4.5 V to 44 V in single-supply mode). The device also perform well with asymmetrical supplies such as V_{DD} = 12 V and V_{SS} = –5 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 ground and power planes. Always ensure the ground (GND) connection is established before supplies are ramped.

12 Layout

12.1 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 12-1 shows progressively better techniques of rounding corners. Only the last example (BEST) maintains constant trace width and minimizes reflections.

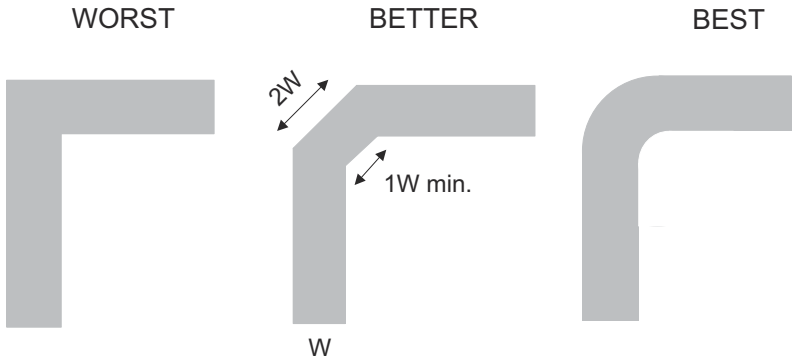


Figure 12-1. Trace Example

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.

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.

12.2 Layout Example

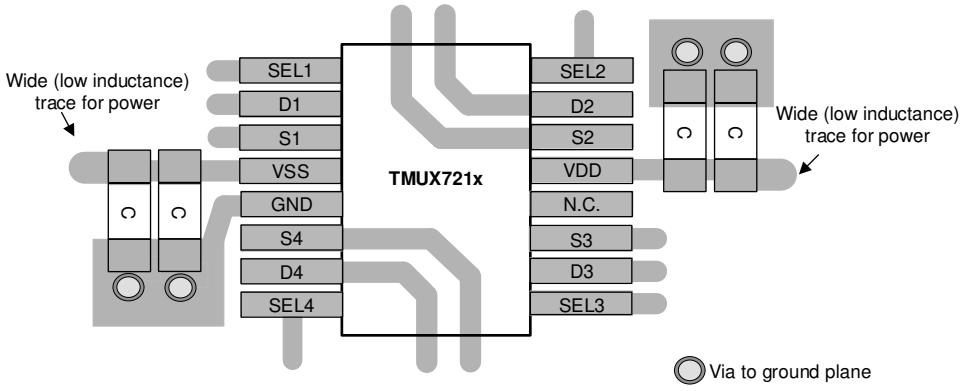


Figure 12-2. TMUX721x Layout Example

13 Device and Documentation Support

13.1 Documentation Support

13.1.1 Related Documentation

- Texas Instruments, *Using Latch Up Immune Multiplexers to Help Improve System Reliability* application note
- 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, *Sample & Hold Glitch Reduction for Precision Outputs Reference Design* reference guide
- 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 note
- Texas Instruments, *True Differential, 4 x 2 MUX, Analog Front End, Simultaneous-Sampling ADC Circuit* application note
- Texas Instruments, *QFN/SON PCB Attachment* application note
- Texas Instruments, *Quad Flatpack No-Lead Logic Packages* application note

13.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on 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.

13.3 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.

13.4 Trademarks

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

13.5 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.

13.6 Glossary

TI Glossary	This glossary lists and explains terms, acronyms, and definitions.

14 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 Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
PTMUX7212RUMR	ACTIVE	WQFN	RUM	16	3000	Non-RoHS & Non-Green	Call TI	Call TI	-40 to 125		Samples
TMUX7211PWR	PREVIEW	TSSOP	PW	16	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	X211	
TMUX7211RUMR	PREVIEW	WQFN	RUM	16	3000	Non-RoHS & Non-Green	Call TI	Call TI	-40 to 125		
TMUX7212PWR	ACTIVE	TSSOP	PW	16	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	X212	Samples
TMUX7212RUMR	PREVIEW	WQFN	RUM	16	3000	Non-RoHS & Non-Green	Call TI	Call TI	-40 to 125		
TMUX7213PWR	ACTIVE	TSSOP	PW	16	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	X213	Samples
TMUX7213RUMR	PREVIEW	WQFN	RUM	16	3000	Non-RoHS & Non-Green	Call TI	Call TI	-40 to 125		

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

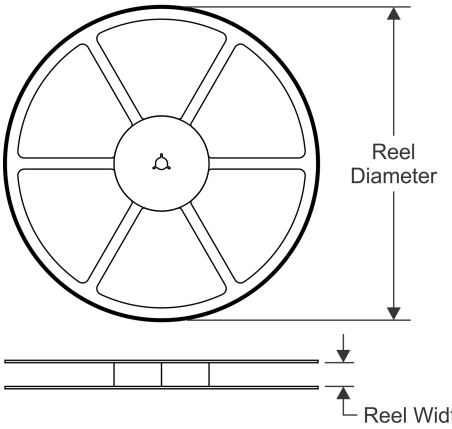
(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

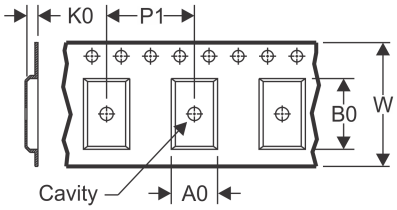
(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

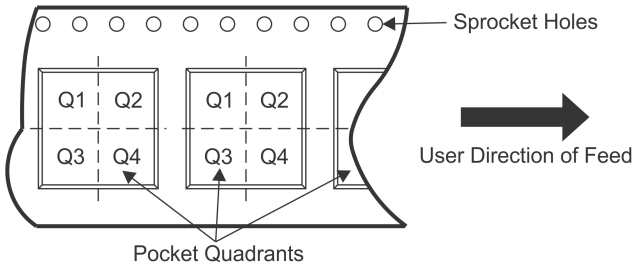


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

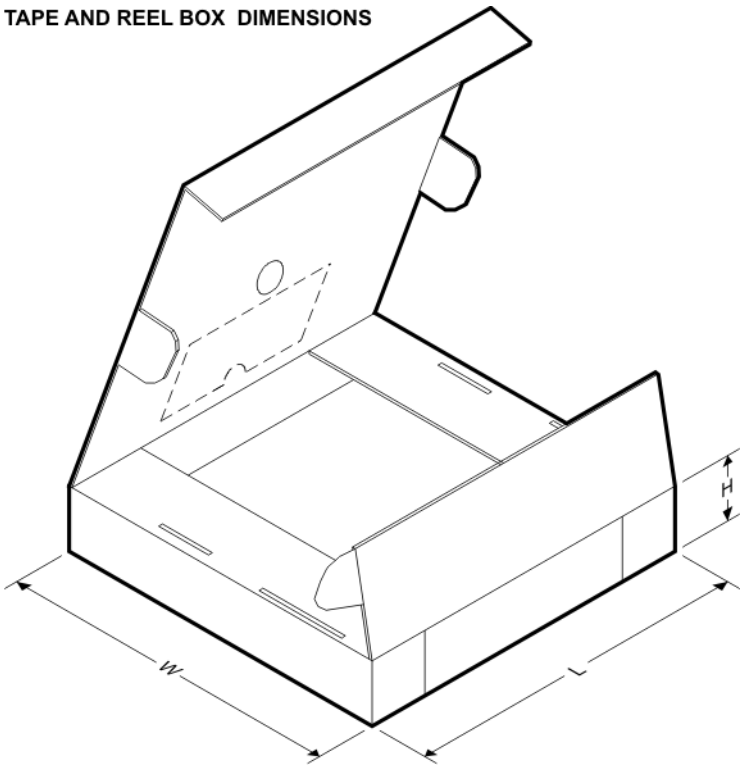
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
TMUX7212PWR	TSSOP	PW	16	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
TMUX7213PWR	TSSOP	PW	16	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1

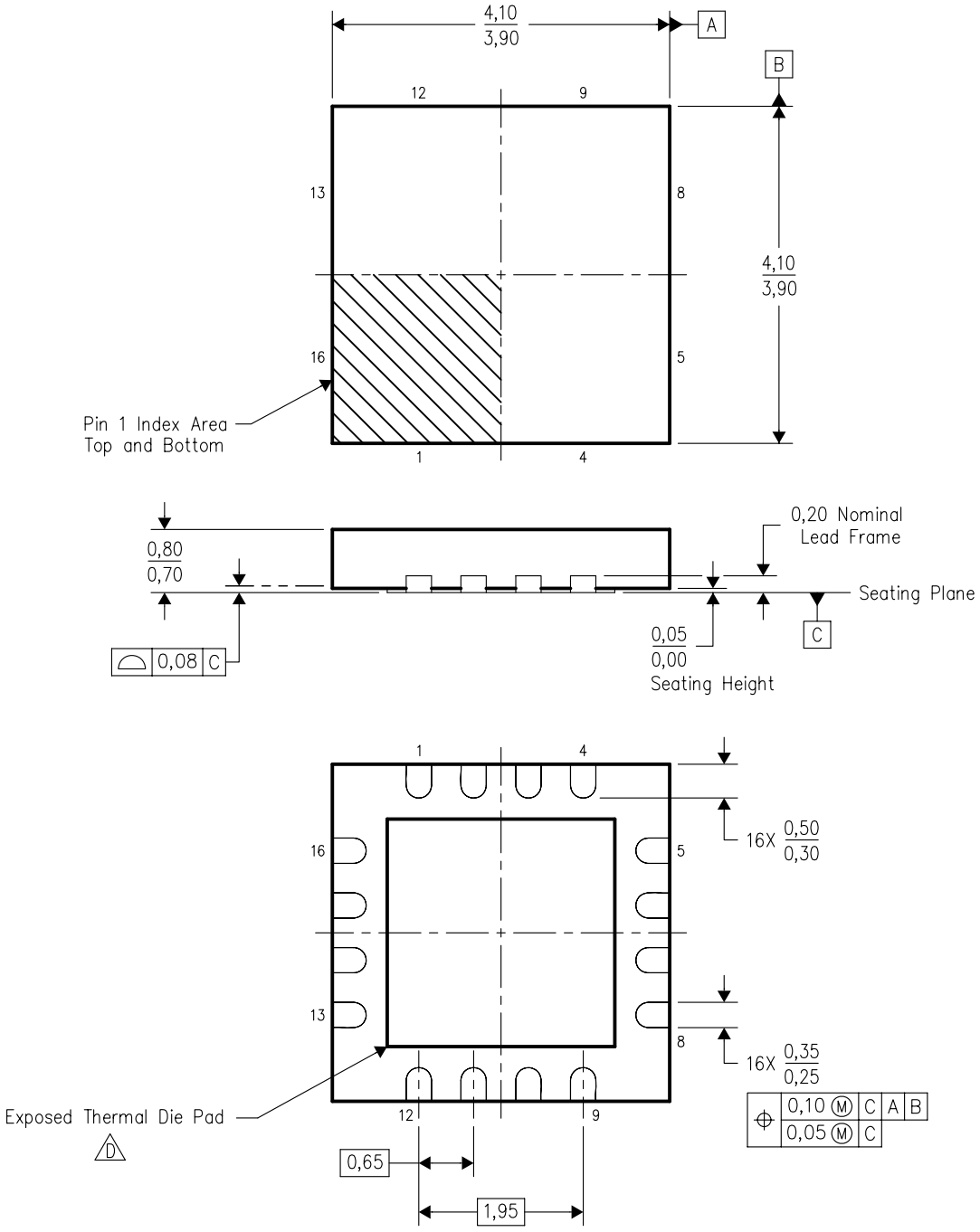
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TMUX7212PWR	TSSOP	PW	16	2000	853.0	449.0	35.0
TMUX7213PWR	TSSOP	PW	16	2000	853.0	449.0	35.0

RUM (S–PQFP–N16) PLASTIC QUAD FLATPACK



4209092/A 10/2007

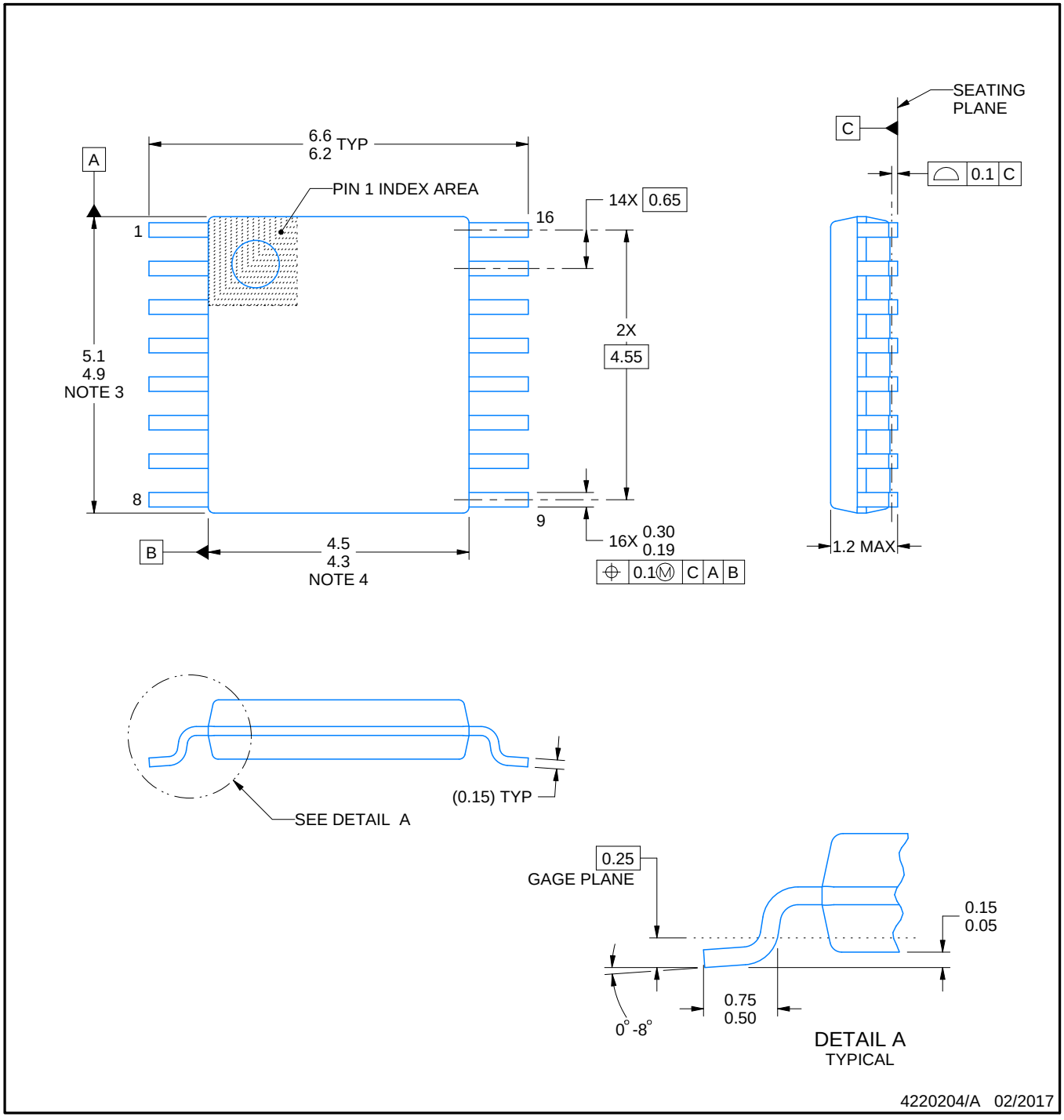
NOTES:
A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M–1994.
B. This drawing is subject to change without notice.
C. QFN (Quad Flatpack No–Lead) package configuration.
D. The package thermal pad must be soldered to the board for thermal and mechanical performance. See the Product Data Sheet for details regarding the exposed thermal pad dimensions.
E. Package complies to JEDEC MO–220 variation WGGC–3.

PACKAGE OUTLINE

PW0016A

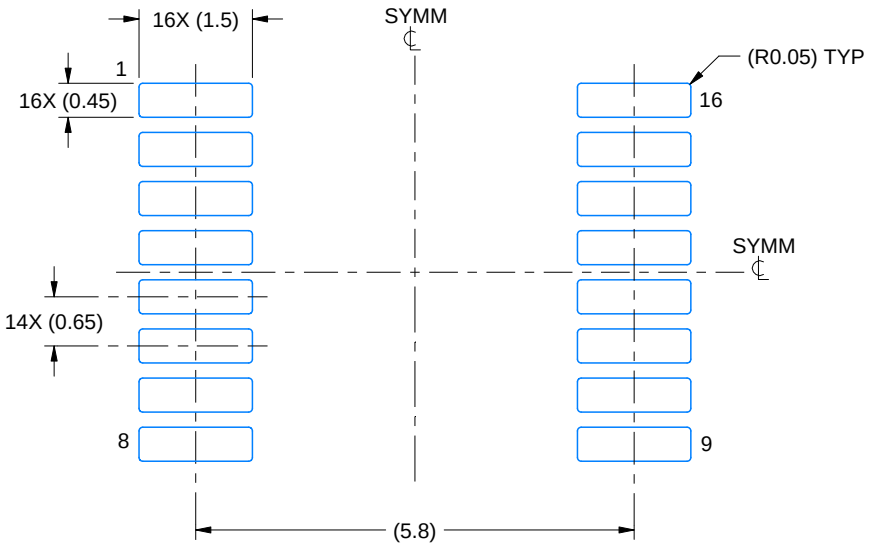
TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE

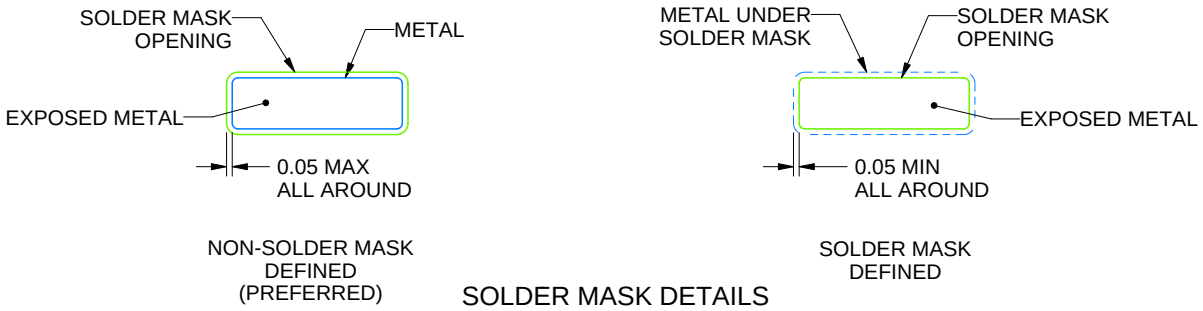


NOTES:

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. 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.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-153.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 10X



SOLDER MASK DETAILS

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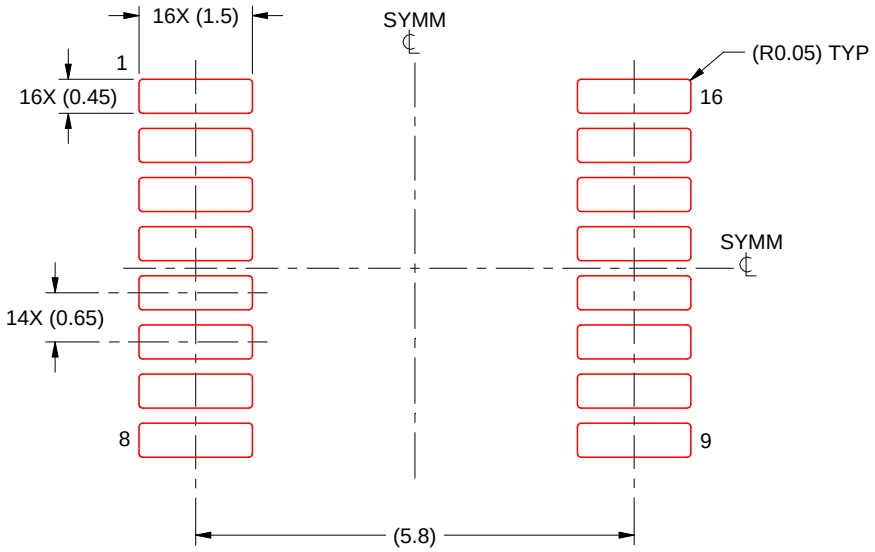
NOTES: (continued)

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



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

4220204/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.

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