

TMUX113x 5V, Low-Leakage-Current, 2:1 (SPDT), 3 or 4-Channel Precision Switches

1 Features

- Single supply range: 1.08V to 5.5V
- Dual supply range: $\pm 2.75\text{V}$
- Low leakage current: 3pA
- Low charge injection: -1pC
- Low on-resistance: 2Ω
- -40°C to $+125^\circ\text{C}$ operating temperature
- [1.8V logic compatible](#)
- [Fail-safe logic](#)
- [Rail to rail operation](#)
- [Bidirectional signal path](#)
- Break-before-make switching
- ESD protection HBM: 2000V

2 Applications

- [Field transmitters](#)
- [Programmable logic controllers \(PLC\)](#)
- [Factory automation and control](#)
- [Ultrasound scanners](#)
- [Patient monitoring and diagnostics](#)
- [Electrocardiogram \(ECG\)](#)
- [Data acquisition systems \(DAQ\)](#)
- [ATE test equipment](#)
- [Battery test equipment](#)
- [Instrumentation: lab, analytical, and portable](#)
- [Smart meters: water and gas](#)
- [Optical networking](#)
- [Optical test equipment](#)
- [Portable POS](#)
- [Remote radio units](#)
- [Active antenna system \(mMIMIO\)](#)

3 Description

The TMUX113x devices are precision complementary metal-oxide semiconductor (CMOS) switches with multiple channels. The TMUX1133 is a 2:1, single-pole double-throw (SPDT), configuration with three independently controlled channels and an $\overline{\text{EN}}$ pin to enable or disable all three switches. The TMUX1134 contains four independently controlled SPDT switches. Wide operating supply of 1.08V to 5.5V, or $\pm 2.75\text{V}$ dual supply, allows for use in a broad array of applications from medical equipment to industrial systems. The device supports bidirectional analog and digital signals on the source (Sx) and drain (Dx) pins ranging from V_{SS} to V_{DD} . For single supply applications V_{SS} must be connected to GND.

All logic inputs have [1.8V logic compatible](#) thresholds, allowing for 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.

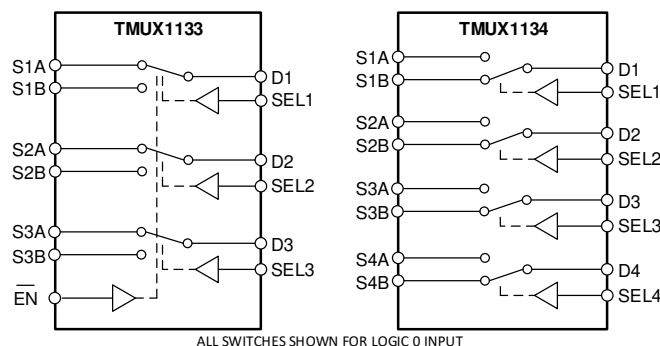
The TMUX113x devices are part of the precision switches and multiplexers family. These devices have very low on and off leakage currents and low charge injection, allowing them to be used in high precision measurement applications. A low supply current of 8nA enables use in portable applications.

Device Information

PART NUMBER	CHANNEL COUNT ⁽¹⁾	PACKAGE ⁽²⁾
TMUX1133	3-Channel	PW (TSSOP, 16)
TMUX1134	4-Channel	PW (TSSOP, 20)

(1) See [Device Comparison](#)

(2) For more information see [Section 12](#)



TMUX113x Block Diagrams



Table of Contents

1 Features	1	7.8 Off Isolation.....	20
2 Applications	1	7.9 Crosstalk.....	21
3 Description	1	7.10 Bandwidth.....	22
4 Device Comparison Table	2	8 Detailed Description	23
5 Pin Configuration and Functions	3	8.1 Overview.....	23
6 Specifications	5	8.2 Functional Block Diagram.....	23
6.1 Absolute Maximum Ratings.....	5	8.3 Feature Description.....	23
6.2 ESD Ratings.....	5	8.4 Device Functional Modes.....	25
6.3 Recommended Operating Conditions.....	5	8.5 Truth Tables.....	25
6.4 Thermal Information.....	6	9 Application and Implementation	26
6.5 Electrical Characteristics ($V_{DD} = 5V \pm 10\%$).....	6	9.1 Application Information.....	26
6.6 Electrical Characteristics ($V_{DD} = 3.3V \pm 10\%$).....	8	9.2 Typical Application.....	26
6.7 Electrical Characteristics ($V_{DD} = 2.5V \pm 10\%$, $V_{SS} = -2.5V \pm 10\%$).....	9	9.3 Power Supply Recommendations.....	28
6.8 Electrical Characteristics ($V_{DD} = 1.8V \pm 10\%$).....	11	9.4 Layout.....	28
6.9 Electrical Characteristics ($V_{DD} = 1.2V \pm 10\%$).....	12	10 Device and Documentation Support	30
6.10 Typical Characteristics.....	14	10.1 Documentation Support.....	30
7 Parameter Measurement Information	17	10.2 Receiving Notification of Documentation Updates..	30
7.1 On-Resistance.....	17	10.3 Support Resources.....	30
7.2 Off-Leakage Current.....	17	10.4 Trademarks.....	30
7.3 On-Leakage Current.....	18	10.5 Electrostatic Discharge Caution.....	30
7.4 Transition Time.....	18	10.6 Glossary.....	30
7.5 Break-Before-Make.....	19	11 Revision History	30
7.6 $t_{ON(EN)}$ and $t_{OFF(EN)}$	19	12 Mechanical, Packaging, and Orderable Information	31
7.7 Charge Injection.....	20		

4 Device Comparison Table

PRODUCT	DESCRIPTION
TMUX1133	2:1 (SPDT), 3-Channel Switch
TMUX1134	2:1 (SPDT), 4-Channel Switch

5 Pin Configuration and Functions

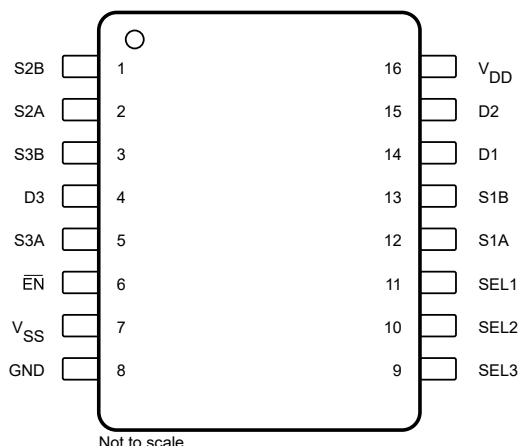


Figure 5-1. TMUX1133: PW Package, 16-Pin TSSOP (Top View)

Table 5-1. Pin Functions TMUX1133

PIN		TYPE ⁽¹⁾	DESCRIPTION ⁽²⁾
NAME	NO.		
S2B	1	I/O	Source pin 2B. Can be an input or output.
S2A	2	I/O	Source pin 2A. Can be an input or output.
S3B	3	I/O	Source pin 3B. Can be an input or output.
D3	4	I/O	Drain pin 3. Can be an input or output.
S3A	5	I/O	Source pin 3A. Can be an input or output.
EN	6	I	Active low logic enable. When this pin is high, all switches are turned off. When this pin is low, the SELx inputs determine switch connection as listed in Table 8-1 .
V _{SS}	7	P	Negative power supply. This pin is the most negative power-supply potential. For reliable operation, connect a decoupling capacitor ranging from 0.1μF to 10μF between V _{SS} and GND. V _{SS} must be connected to ground for single supply voltage applications.
GND	8	P	Ground (0V) reference
SEL3	9	I	Logic control select pin 3. Controls switch 3 connection as listed in Table 8-1 .
SEL2	10	I	Logic control select pin 2. Controls switch 2connection as listed in Table 8-1 .
SEL1	11	I	Logic control select pin 1. Controls switch 1 connection as listed in Table 8-1 .
S1A	12	I/O	Source pin 1A. Can be an input or output.
S1B	13	I/O	Source pin 1B. Can be an input or output.
D1	14	I/O	Drain pin 1. Can be an input or output.
D2	15	I/O	Drain pin 2. Can be an input or output.
V _{DD}	16	P	Positive power supply. This pin is the most positive power-supply potential. For reliable operation, connect a decoupling capacitor ranging from 0.1μF to 10μF between V _{DD} 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

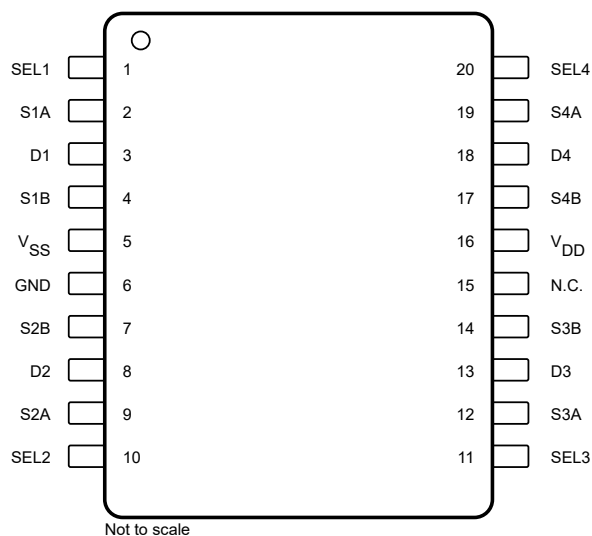


Figure 5-2. TMUX1134: PW Package, 20-Pin TSSOP (Top View)

Table 5-2. Pin Functions TMUX1134

PIN		TYPE ⁽¹⁾	DESCRIPTION ⁽²⁾
NAME	NO.		
SEL1	1	I	Logic control select pin 1. Controls switch 1 connection as listed in Table 8-2 .
S1A	2	I/O	Source pin 1A. Can be an input or output.
D1	3	I/O	Drain pin 1. Can be an input or output.
S1B	4	I/O	Source pin 1B. Can be an input or output.
V _{SS}	5	P	Negative power supply. This pin is the most negative power-supply potential. For reliable operation, connect a decoupling capacitor ranging from 0.1µF to 10µF between V _{SS} and GND. V _{SS} must be connected to ground for single supply voltage applications.
GND	6	P	Ground (0V) reference.
S2B	7	I/O	Source pin 2B. Can be an input or output.
D2	8	I/O	Drain pin 2. Can be an input or output.
S2A	9	I/O	Source pin 2A. Can be an input or output.
SEL2	10	I	Logic control select pin 2. Controls switch 2 connection as listed in Table 8-2 .
SEL3	11	I	Logic control select pin 3. Controls switch 3 connection as listed in Table 8-2 .
S3A	12	I/O	Source pin 3A. Can be an input or output.
D3	13	I/O	Drain pin 3. Can be an input or output.
S3B	14	I/O	Source pin 3B. Can be an input or output.
N.C.	15	Not Connected	Not Connected. Can be shorted to GND or left floating.
V _{DD}	16	P	Positive power supply. This pin is the most positive power-supply potential. For reliable operation, connect a decoupling capacitor ranging from 0.1µF to 10µF between V _{DD} and GND.
S4B	17	I/O	Source pin 4B. Can be an input or output.
D4	18	I/O	Drain pin 4. Can be an input or output.
S4A	19	I/O	Source pin 4A. Can be an input or output.
SEL4	20	I	Logic control select pin 4. Controls switch 4 connection as listed in Table 8-2 .

(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) (3)}

		MIN	MAX	UNIT
$V_{DD}-V_{SS}$	Supply voltage	–0.5	6	V
V_{DD}		–0.5	6	V
V_{SS}		–3.0	0.3	V
V_{SEL} or V_{EN}	Logic control input pin voltage ($\overline{EN}$, SELx)	–0.5	6	V
I_{SEL} or I_{EN}	Logic control input pin current ($\overline{EN}$, SELx)	–30	30	mA
V_S or V_D	Source or drain voltage (SxA, SxB, Dx)	–0.5	$V_{DD} + 0.5$	V
I_S or I_D (CONT)	Source or drain continuous current (SxA, SxB, Dx)	$IDC \pm 10\%$ ⁽⁴⁾	$IDC \pm 10\%$ ⁽⁴⁾	mA
I_S or I_D (PEAK)	Source and drain peak current: (1 ms period max, 10% duty cycle maximum) (Sx, SxA, SxB, D, DA, DB)	$I_{peak} \pm 10\%$ ⁽⁴⁾	$I_{peak} \pm 10\%$ ⁽⁴⁾	mA
T_{slg}	Storage temperature	–65	150	°C
P_{tot}	Total power dissipation ^{(5) (6)}		500	mW
T_J	Junction temperature		150	°C

- (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) The algebraic convention, whereby the most negative value is a minimum and the most positive value is a maximum.
- (3) All voltages are with respect to ground, unless otherwise specified.
- (4) Refer to Recommended Operating Conditions for IDC and I_{Peak} ratings.
- (5) For TSSOP(16)(PW) package: P_{tot} derates linearly above TA=89°C by 8.29mW/°C
- (6) For TSSOP(20)(PW) package: P_{tot} derates linearly above TA=98°C by 9.78mW/°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 or ANSI/ESDA/JEDEC JS-002, all pins ⁽²⁾	±750	

- (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 Recommended Operating Conditions

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

			MIN	NOM	MAX	UNIT
V_{DD}	Positive power supply voltage (single)		1.08		5.5	V
V_{SS}	Negative power supply voltage (dual)		–2.75		0	V
$V_{DD} - V_{SS}$	Supply rail voltage difference		1.08		5.5	V
V_S or V_D	Signal path input/output voltage (source or drain pin) (SxA, SxB, Dx)		V_{SS}		V_{DD}	V
V_{SEL} or V_{EN}	Logic control input pin voltage ($\overline{EN}$, SELx)		0		5.5	V
T_A	Ambient temperature		–40		125	°C
I_{DC}	Continuous current through switch	$T_J = 25^\circ\text{C}$		150		mA
		$T_J = 85^\circ\text{C}$		120		mA
		$T_J = 125^\circ\text{C}$		60		mA
		$T_J = 130^\circ\text{C}$		50		mA

6.3 Recommended Operating Conditions (continued)

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

			MIN	NOM	MAX	UNIT
I_{peak}	Peak current through switch(1 ms period max, 10% duty cycle maximum)	$T_j = 25^{\circ}\text{C}$		300		mA
		$T_j = 85^{\circ}\text{C}$		300		mA
		$T_j = 125^{\circ}\text{C}$		180		mA
		$T_j = 130^{\circ}\text{C}$		160		mA

6.4 Thermal Information

THERMAL METRIC ⁽¹⁾		TMUX1133	TMUX1134	UNIT
		PW (TSSOP)	PW (TSSOP)	
		16 PINS	16 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	120.6	102.2	$^{\circ}\text{C/W}$
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	51.0	43.1	$^{\circ}\text{C/W}$
$R_{\theta JB}$	Junction-to-board thermal resistance	66.8	53.6	$^{\circ}\text{C/W}$
Ψ_{JT}	Junction-to-top characterization parameter	8.7	6.6	$^{\circ}\text{C/W}$
Ψ_{JB}	Junction-to-board characterization parameter	66.2	53.1	$^{\circ}\text{C/W}$
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	N/A	N/A	$^{\circ}\text{C/W}$

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

6.5 Electrical Characteristics ($V_{DD} = 5V \pm 10\%$)

At $T_A = 25^{\circ}\text{C}$, $V_{DD} = 5V$ (unless otherwise noted).

PARAMETER		TEST CONDITIONS	TA	MIN	TYP	MAX	UNIT	
ANALOG SWITCH								
R _{ON}	On-resistance	V _S = 0V to V _{DD} I _{SD} = 10mA Refer to Section 7.1	25°C		2	4	Ω	
			−40°C to +85°C			4.5	Ω	
			−40°C to +125°C			4.9	Ω	
ΔR _{ON}	On-resistance matching between channels	V _S = 0V to V _{DD} I _{SD} = 10mA Refer to Section 7.1	25°C		0.18		Ω	
			−40°C to +85°C			0.4	Ω	
			−40°C to +125°C			0.5	Ω	
R _{ON} FLAT	On-resistance flatness	V _S = 0V to V _{DD} I _{SD} = 10mA Refer to Section 7.1	25°C		0.85		Ω	
			−40°C to +85°C			1.6	Ω	
			−40°C to +125°C			1.6	Ω	
I _{S(OFF)}	Source off leakage current ⁽¹⁾	V _{DD} = 5V Switch Off V _D = 4.5V / 1.5V V _S = 1.5V / 4.5V Refer to Section 7.2	25°C	−0.08	±0.003	0.08	nA	
			−40°C to +85°C		−0.3		0.3	nA
			−40°C to +125°C		−0.9		0.9	nA
I _{D(OFF)}	Drain off leakage current ⁽¹⁾	V _{DD} = 5V Switch Off V _D = 4.5V / 1.5V V _S = 1.5V / 4.5V Refer to Section 7.2	25°C	−0.1	±0.003	0.1	nA	
			−40°C to +85°C		−0.35		0.35	nA
			−40°C to +125°C		−2		2	nA
I _{D(ON)} I _{S(ON)}	Channel on leakage current	V _{DD} = 5V Switch On V _D = V _S = 4.5V / 1.5V Refer to Section 7.3	25°C	−0.1	±0.003	0.1	nA	
			−40°C to +85°C		−0.35		0.35	nA
			−40°C to +125°C		−2		2	nA
LOGIC INPUTS ($\overline{EN}$, SELx)								

6.5 Electrical Characteristics ($V_{DD} = 5V \pm 10\%$) (continued)

At $T_A = 25^\circ\text{C}$, $V_{DD} = 5V$ (unless otherwise noted).

PARAMETER		TEST CONDITIONS	TA	MIN	TYP	MAX	UNIT
V _{IH}	Input logic high		−40°C to +125°C	1.49		5.5	V
V _{IL}	Input logic low			0		0.87	V
I _{IH} I _{IL}	Input leakage current		25°C	±0.005			µA
I _{IH} I _{IL}	Input leakage current		−40°C to +125°C	±0.05			µA
C _{IN}	Logic input capacitance		25°C	1			pF
			−40°C to +125°C	2			pF
POWER SUPPLY							
I _{DD}	V _{DD} supply current	Logic inputs = 0V or 5.5V	25°C	0.008			µA
			−40°C to +125°C	1			µA
DYNAMIC CHARACTERISTICS							
t _{TRAN}	Transition time between channels	V _S = 3V R _L = 200Ω, C _L = 15pF Refer to Section 7.4	25°C	12			ns
			−40°C to +85°C	18			ns
			−40°C to +125°C	19			ns
t _{OPEN} (BBM)	Break before make time	V _S = 3V R _L = 200Ω, C _L = 15pF Refer to Section 7.5	25°C	8			ns
			−40°C to +85°C	1			ns
			−40°C to +125°C	1			ns
t _{ON(EN)}	Enable turn-on time (TMUX1133 Only)	V _S = 3V R _L = 200Ω, C _L = 15pF Refer to Section 7.6	25°C	12			ns
			−40°C to +85°C	21			ns
			−40°C to +125°C	22			ns
t _{OFF(EN)}	Enable turn-off time (TMUX1133 Only)	V _S = 3V R _L = 200Ω, C _L = 15pF Refer to Section 7.6	25°C	6			ns
			−40°C to +85°C	11			ns
			−40°C to +125°C	12			ns
Q _C	Charge Injection	V _S = 1V R _S = 0Ω, C _L = 1nF Refer to Section 7.7	25°C	−1			pC
O _{ISO}	Off Isolation	R _L = 50Ω, C _L = 5pF f = 1MHz Refer to Section 7.8	25°C	−65			dB
		R _L = 50Ω, C _L = 5pF f = 10MHz Refer to Section 7.8	25°C	−45			dB
X _{TALK}	Crosstalk	R _L = 50Ω, C _L = 5pF f = 1MHz Refer to Section 7.9	25°C	−100			dB
		R _L = 50Ω, C _L = 5pF f = 10MHz Refer to Section 7.9	25°C	−90			dB
BW	Bandwidth	R _L = 50Ω, C _L = 5pF Refer to Section 7.10	25°C	220			MHz
C _{SOFF}	Source off capacitance	f = 1MHz	25°C	6			pF
C _{DOFF}	Drain off capacitance	f = 1MHz	25°C	17			pF
C _{SON} C _{DON}	On capacitance	f = 1MHz	25°C	20			pF

(1) When V_S is 4.5V, V_D is 1.5V or when V_S is 1.5V, V_D is 4.5V.

6.6 Electrical Characteristics ($V_{DD} = 3.3V \pm 10\%$)

At $T_A = 25^\circ\text{C}$, $V_{DD} = 3.3V$ (unless otherwise noted).

PARAMETER		TEST CONDITIONS	TA	MIN	TYP	MAX	UNIT
ANALOG SWITCH							
R _{ON}	On-resistance	V _S = 0V to V _{DD} I _{SD} = 10mA Refer to Section 7.1	25°C		3.7	8.8	Ω
			−40°C to +85°C			9.5	Ω
			−40°C to +125°C			9.8	Ω
ΔR _{ON}	On-resistance matching between channels	V _S = 0V to V _{DD} I _{SD} = 10mA Refer to Section 7.1	25°C		0.13		Ω
			−40°C to +85°C			0.4	Ω
			−40°C to +125°C			0.5	Ω
R _{ON} FLAT	On-resistance flatness	V _S = 0V to V _{DD} I _{SD} = 10mA Refer to Section 7.1	25°C		1.9		Ω
			−40°C to +85°C			2	Ω
			−40°C to +125°C			2.2	Ω
I _{S(OFF)}	Source off leakage current ⁽¹⁾	V _{DD} = 3.3V Switch Off V _D = 3V / 1V V _S = 1V / 3V Refer to Section 7.2	25°C	−0.05	±0.001	0.05	nA
			−40°C to +85°C	−0.1		0.1	nA
			−40°C to +125°C	−0.7		0.7	nA
I _{D(OFF)}	Drain off leakage current ⁽¹⁾ (TMUX1133 Only)	V _{DD} = 3.3V Switch Off V _D = 3V / 1V V _S = 1V / 3V Refer to Section 7.2	25°C	−0.1	±0.005	0.1	nA
			−40°C to +85°C	−0.35		0.35	nA
			−40°C to +125°C	−2		2	nA
I _{D(ON)} I _{S(ON)}	Channel on leakage current	V _{DD} = 3.3V Switch On V _D = V _S = 3V / 1V Refer to Section 7.3	25°C	−0.1	±0.005	0.1	nA
			−40°C to +85°C	−0.35		0.35	nA
			−40°C to +125°C	−2		2	nA
LOGIC INPUTS ($\overline{EN}$, SELx)							
V _{IH}	Input logic high		−40°C to +125°C	1.35		5.5	V
V _{IL}	Input logic low			0		0.8	V
I _{IH} I _{IL}	Input leakage current		25°C		±0.005		μA
I _{IH} I _{IL}	Input leakage current		−40°C to +125°C			±0.05	μA
C _{IN}	Logic input capacitance		25°C		1		pF
			−40°C to +125°C			2	pF
POWER SUPPLY							
I _{DD}	V _{DD} supply current	Logic inputs = 0V or 5.5V	25°C		0.006		μA
			−40°C to +125°C			1	μA
DYNAMIC CHARACTERISTICS							
t _{TRAN}	Transition time between channels	V _S = 2V R _L = 200Ω, C _L = 15pF Refer to Section 7.4	25°C		14		ns
			−40°C to +85°C			22	ns
			−40°C to +125°C			22	ns
t _{OPEN} (BBM)	Break before make time	V _S = 2V R _L = 200Ω, C _L = 15pF Refer to Section 7.5	25°C		9		ns
			−40°C to +85°C	1			ns
			−40°C to +125°C	1			ns
t _{ON(EN)}	Enable turn-on time (TMUX1133 Only)	V _S = 2V R _L = 200Ω, C _L = 15pF Refer to Section 7.6	25°C		15		ns
			−40°C to +85°C			22	ns
			−40°C to +125°C			23	ns

6.6 Electrical Characteristics ($V_{DD} = 3.3V \pm 10\%$) (continued)

At $T_A = 25^\circ\text{C}$, $V_{DD} = 3.3V$ (unless otherwise noted).

PARAMETER		TEST CONDITIONS	TA	MIN	TYP	MAX	UNIT
$t_{OFF(EN)}$	Enable turn-off time (TMUX1133 Only)	$V_S = 2V$ $R_L = 200\Omega$, $C_L = 15pF$ Refer to Section 7.6	25°C		8		ns
			-40°C to $+85^\circ\text{C}$			13	ns
			-40°C to $+125^\circ\text{C}$			14	ns
Q_C	Charge Injection	$V_S = 1V$ $R_S = 0\Omega$, $C_L = 1nF$ Refer to Section 7.7	25°C		–1		pC
O_{ISO}	Off Isolation	$R_L = 50\Omega$, $C_L = 5pF$ $f = 1\text{MHz}$ Refer to Section 7.8	25°C		–65		dB
		$R_L = 50\Omega$, $C_L = 5pF$ $f = 10\text{MHz}$ Refer to Section 7.8	25°C		–45		dB
X_{TALK}	Crosstalk	$R_L = 50\Omega$, $C_L = 5pF$ $f = 1\text{MHz}$ Refer to Section 7.9	25°C		–100		dB
		$R_L = 50\Omega$, $C_L = 5pF$ $f = 10\text{MHz}$ Refer to Section 7.9	25°C		–90		dB
BW	Bandwidth	$R_L = 50\Omega$, $C_L = 5pF$ Refer to Section 7.10	25°C		220		MHz
C_{SOFF}	Source off capacitance	$f = 1\text{MHz}$	25°C		6		pF
C_{DOFF}	Drain off capacitance	$f = 1\text{MHz}$	25°C		17		pF
C_{SON} C_{DON}	On capacitance	$f = 1\text{MHz}$	25°C		20		pF

(1) When V_S is 3V, V_D is 1V or when V_S is 1V, V_D is 3V.

6.7 Electrical Characteristics ($V_{DD} = 2.5V \pm 10\%$), ($V_{SS} = -2.5V \pm 10\%$)

At $T_A = 25^\circ\text{C}$, $V_{DD} = +2.5V$, $V_{SS} = -2.5V$ (unless otherwise noted).

PARAMETER		TEST CONDITIONS	TA	MIN	TYP	MAX	UNIT
ANALOG SWITCH							
R_{ON}	On-resistance	$V_S = V_{SS}$ to V_{DD} $I_{SD} = 10\text{mA}$ Refer to Section 7.1	25°C		2	4	Ω
			-40°C to $+85^\circ\text{C}$			4.5	Ω
			-40°C to $+125^\circ\text{C}$			4.9	Ω
ΔR_{ON}	On-resistance matching between channels	$V_S = V_{SS}$ to V_{DD} $I_{SD} = 10\text{mA}$ Refer to Section 7.1	25°C		0.18		Ω
			-40°C to $+85^\circ\text{C}$			0.4	Ω
			-40°C to $+125^\circ\text{C}$			0.5	Ω
$R_{ON\ FLAT}$	On-resistance flatness	$V_S = V_{SS}$ to V_{DD} $I_{SD} = 10\text{mA}$ Refer to Section 7.1	25°C		0.85		Ω
			-40°C to $+85^\circ\text{C}$			1.6	Ω
			-40°C to $+125^\circ\text{C}$			1.6	Ω
$I_{S(OFF)}$	Source off leakage current ⁽¹⁾	$V_{DD} = +2.5V$, $V_{SS} = -2.5V$ Switch Off $V_D = +2V$ / $-1V$ $V_S = -1V$ / $+2V$ Refer to Section 7.2	25°C	–0.08	± 0.005	0.08	nA
			-40°C to $+85^\circ\text{C}$	–0.3		0.3	nA
			-40°C to $+125^\circ\text{C}$	–0.9		0.9	nA
$I_{D(OFF)}$	Drain off leakage current ⁽¹⁾	$V_{DD} = +2.5V$, $V_{SS} = -2.5V$ Switch Off $V_D = +2V$ / $-1V$ $V_S = -1V$ / $+2V$ Refer to Section 7.2	25°C	–0.1	± 0.01	0.1	nA
			-40°C to $+85^\circ\text{C}$	–0.35		0.35	nA
			-40°C to $+125^\circ\text{C}$	–2		2	nA

6.7 Electrical Characteristics ($V_{DD} = 2.5V \pm 10\%$), ($V_{SS} = -2.5V \pm 10\%$) (continued)

At $T_A = 25^\circ\text{C}$, $V_{DD} = +2.5V$, $V_{SS} = -2.5V$ (unless otherwise noted).

PARAMETER		TEST CONDITIONS	TA	MIN	TYP	MAX	UNIT
I _{D(ON)} I _{S(ON)}	Channel on leakage current	V _{DD} = +2.5V, V _{SS} = −2.5V Switch On V _D = V _S = +2V / −1V Refer to Section 7.3	25°C	−0.1	±0.01	0.1	nA
			−40°C to +85°C	−0.35		0.35	nA
			−40°C to +125°C	−2		2	nA
LOGIC INPUTS ($\overline{\text{EN}}$, SELx)							
V _{IH}	Input logic high		−40°C to +125°C	1.2		2.75	V
V _{IL}	Input logic low			0		0.73	V
I _{IH} I _{IL}	Input leakage current		25°C	±0.005			μA
I _{IH} I _{IL}	Input leakage current		−40°C to +125°C			±0.05	μA
C _{IN}	Logic input capacitance		25°C	1			pF
			−40°C to +125°C			2	pF
POWER SUPPLY							
I _{DD}	V _{DD} supply current	Logic inputs = 0V or 2.75V	25°C	0.008			μA
			−40°C to +125°C			1	μA
I _{SS}	V _{SS} supply current	Logic inputs = 0V or 2.75V	25°C	0.008			μA
			−40°C to +125°C			1	μA
DYNAMIC CHARACTERISTICS							
t _{TRAN}	Transition time between channels	V _S = 1.5V R _L = 200Ω, C _L = 15pF Refer to Section 7.4	25°C	12			ns
			−40°C to +85°C			20	ns
			−40°C to +125°C			21	ns
t _{OPEN} (BBM)	Break before make time	V _S = 1.5V R _L = 200Ω, C _L = 15pF Refer to Section 7.5	25°C	8			ns
			−40°C to +85°C	1			ns
			−40°C to +125°C	1			ns
t _{ON(EN)}	Enable turn-on time (TMUX1133 Only)	V _S = 1.5V R _L = 200Ω, C _L = 15pF Refer to Section 7.6	25°C	12			ns
			−40°C to +85°C			21	ns
			−40°C to +125°C			22	ns
t _{OFF(EN)}	Enable turn-off time (TMUX1133 Only)	V _S = 1.5V R _L = 200Ω, C _L = 15pF Refer to Section 7.6	25°C	6			ns
			−40°C to +85°C			14	ns
			−40°C to +125°C			15	ns
Q _C	Charge Injection	V _S = −1V R _S = 0Ω, C _L = 1nF Refer to Section 7.7	25°C	−1			pC
O _{ISO}	Off Isolation	R _L = 50Ω, C _L = 5pF f = 1MHz Refer to Section 7.8	25°C	−65			dB
		R _L = 50Ω, C _L = 5pF f = 10MHz Refer to Section 7.8	25°C	−45			dB
X _{TALK}	Crosstalk	R _L = 50Ω, C _L = 5pF f = 1MHz Refer to Section 7.9	25°C	−100			dB
		R _L = 50Ω, C _L = 5pF f = 10MHz Refer to Section 7.9	25°C	−90			dB
BW	Bandwidth	R _L = 50Ω, C _L = 5pF Refer to Section 7.10	25°C	220			MHz
C _{SOFF}	Source off capacitance	f = 1MHz	25°C	6			pF

6.7 Electrical Characteristics ($V_{DD} = 2.5V \pm 10\%$), ($V_{SS} = -2.5V \pm 10\%$) (continued)

At $T_A = 25^\circ\text{C}$, $V_{DD} = +2.5V$, $V_{SS} = -2.5V$ (unless otherwise noted).

PARAMETER		TEST CONDITIONS	TA	MIN	TYP	MAX	UNIT
C_{DOFF}	Drain off capacitance	$f = 1\text{MHz}$	25°C		17		pF
C_{SON} C_{DON}	On capacitance	$f = 1\text{MHz}$	25°C		20		pF

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

6.8 Electrical Characteristics ($V_{DD} = 1.8V \pm 10\%$)

At $T_A = 25^\circ\text{C}$, $V_{DD} = 1.8V$ (unless otherwise noted).

PARAMETER		TEST CONDITIONS	TA	MIN	TYP	MAX	UNIT	
ANALOG SWITCH								
R _{ON}	On-resistance	V _S = 0V to V _{DD} I _{SD} = 10mA Refer to Section 7.1	25°C	40			Ω	
			-40°C to +85°C			80	Ω	
			-40°C to +125°C			80	Ω	
ΔR _{ON}	On-resistance matching between channels	V _S = 0V to V _{DD} I _{SD} = 10mA Refer to Section 7.1	25°C	0.4			Ω	
			-40°C to +85°C			1.5	Ω	
			-40°C to +125°C			1.5	Ω	
I _{S(OFF)}	Source off leakage current ⁽¹⁾	V _{DD} = 1.98V Switch Off V _D = 1.62V / 1V V _S = 1V / 1.62V Refer to Section 7.2	25°C	-0.05	±0.003	0.05	nA	
			-40°C to +85°C			-0.1	0.1	nA
			-40°C to +125°C			-0.5	0.5	nA
I _{D(OFF)}	Drain off leakage current ⁽¹⁾	V _{DD} = 1.98V Switch Off V _D = 1.62V / 1V V _S = 1V / 1.62V Refer to Section 7.2	25°C	-0.1	±0.005	0.1	nA	
			-40°C to +85°C			-0.5	0.5	nA
			-40°C to +125°C			-2	2	nA
I _{D(ON)} I _{S(ON)}	Channel on leakage current	V _{DD} = 1.98V Switch On V _D = V _S = 1.62V / 1V Refer to Section 7.3	25°C	-0.1	±0.005	0.1	nA	
			-40°C to +85°C			-0.5	0.5	nA
			-40°C to +125°C			-2	2	nA
LOGIC INPUTS ($\overline{EN}$, SELx)								
V _{IH}	Input logic high		-40°C to +125°C	1.07		5.5	V	
V _{IL}	Input logic low			0		0.68	V	
I _{IH} I _{IL}	Input leakage current		25°C	±0.005			μA	
I _{IH} I _{IL}	Input leakage current		-40°C to +125°C	±0.05			μA	
C _{IN}	Logic input capacitance		25°C	1			pF	
			-40°C to +125°C	2			pF	
POWER SUPPLY								
I _{DD}	V _{DD} supply current	Logic inputs = 0V or 5.5V	25°C	0.001			μA	
			-40°C to +125°C			0.85	μA	
DYNAMIC CHARACTERISTICS								
t _{TRAN}	Transition time between channels	V _S = 1V R _L = 200Ω, C _L = 15pF Refer to Section 7.4	25°C	28			ns	
			-40°C to +85°C			48	ns	
			-40°C to +125°C			48	ns	
t _{OPEN} (BBM)	Break before make time	V _S = 1V R _L = 200Ω, C _L = 15pF Refer to Section 7.5	25°C	16			ns	
			-40°C to +85°C			1	ns	
			-40°C to +125°C			1	ns	

6.8 Electrical Characteristics ($V_{DD} = 1.8V \pm 10\%$) (continued)

At $T_A = 25^\circ\text{C}$, $V_{DD} = 1.8V$ (unless otherwise noted).

PARAMETER		TEST CONDITIONS	TA	MIN	TYP	MAX	UNIT
$t_{ON(EN)}$	Enable turn-on time (TMUX1133 Only)	$V_S = 1V$ $R_L = 200\Omega$, $C_L = 15pF$ Refer to Section 7.6	25°C		28		ns
			-40°C to $+85^\circ\text{C}$			48	ns
			-40°C to $+125^\circ\text{C}$			48	ns
$t_{OFF(EN)}$	Enable turn-off time (TMUX1133 Only)	$V_S = 1V$ $R_L = 200\Omega$, $C_L = 15pF$ Refer to Section 7.6	25°C		16		ns
			-40°C to $+85^\circ\text{C}$			27	ns
			-40°C to $+125^\circ\text{C}$			27	ns
Q_C	Charge Injection	$V_S = 1V$ $R_S = 0\Omega$, $C_L = 1nF$ Refer to Section 7.7	25°C		–1		pC
O_{ISO}	Off Isolation	$R_L = 50\Omega$, $C_L = 5pF$ $f = 1\text{MHz}$ Refer to Section 7.8	25°C		–65		dB
		$R_L = 50\Omega$, $C_L = 5pF$ $f = 10\text{MHz}$ Refer to Section 7.8	25°C		–45		dB
X_{TALK}	Crosstalk	$R_L = 50\Omega$, $C_L = 5pF$ $f = 1\text{MHz}$ Refer to Section 7.9	25°C		–100		dB
		$R_L = 50\Omega$, $C_L = 5pF$ $f = 10\text{MHz}$ Refer to Section 7.9	25°C		–90		dB
BW	Bandwidth	$R_L = 50\Omega$, $C_L = 5pF$ Refer to Section 7.10	25°C		220		MHz
C_{SOFF}	Source off capacitance	$f = 1\text{MHz}$	25°C		6		pF
C_{DOFF}	Drain off capacitance	$f = 1\text{MHz}$	25°C		17		pF
C_{SON} C_{DON}	On capacitance	$f = 1\text{MHz}$	25°C		20		pF

(1) When V_S is 1.62V, V_D is 1V or when V_S is 1V, V_D is 1.62V.

6.9 Electrical Characteristics ($V_{DD} = 1.2V \pm 10\%$)

PARAMETER		TEST CONDITIONS	TA	MIN	TYP	MAX	UNIT
ANALOG SWITCH							
R_{ON}	On-resistance	$V_S = 0V$ to V_{DD} $I_{SD} = 10mA$ Refer to Section 7.1	25°C		70		Ω
			-40°C to $+85^\circ\text{C}$			105	Ω
			-40°C to $+125^\circ\text{C}$			105	Ω
ΔR_{ON}	On-resistance matching between channels	$V_S = 0V$ to V_{DD} $I_{SD} = 10mA$ Refer to Section 7.1	25°C		0.4		Ω
			-40°C to $+85^\circ\text{C}$			1.5	Ω
			-40°C to $+125^\circ\text{C}$			1.5	Ω
$I_{S(OFF)}$	Source off leakage current ⁽¹⁾	$V_{DD} = 1.32V$ Switch Off $V_D = 1V / 0.8V$ $V_S = 0.8V / 1V$ Refer to Section 7.2	25°C	–0.05	± 0.003	0.05	nA
			-40°C to $+85^\circ\text{C}$	–0.1		0.1	nA
			-40°C to $+125^\circ\text{C}$	–0.5		0.5	nA
$I_{D(OFF)}$	Drain off leakage current ⁽¹⁾	$V_{DD} = 1.32V$ Switch Off $V_D = 1V / 0.8V$ $V_S = 0.8V / 1V$ Refer to Section 7.2	25°C	–0.1	± 0.005	0.1	nA
			-40°C to $+85^\circ\text{C}$	–0.5		0.5	nA
			-40°C to $+125^\circ\text{C}$	–2		2	nA

6.9 Electrical Characteristics ($V_{DD} = 1.2V \pm 10\%$) (continued)

PARAMETER		TEST CONDITIONS	TA	MIN	TYP	MAX	UNIT
I _{D(ON)} I _{S(ON)}	Channel on leakage current	V _{DD} = 1.32V Switch On V _D = V _S = 1V / 0.8V Refer to Section 7.3	25°C	−0.1	±0.005	0.1	nA
			−40°C to +85°C	−0.5		0.5	nA
			−40°C to +125°C	−2		2	nA
LOGIC INPUTS ($\overline{EN}$, SELx)							
V _{IH}	Input logic high		−40°C to +125°C	0.96		5.5	V
V _{IL}	Input logic low			0		0.36	V
I _{IH} I _{IL}	Input leakage current		25°C		±0.005		µA
I _{IH} I _{IL}	Input leakage current		−40°C to +125°C			±0.05	µA
C _{IN}	Logic input capacitance		25°C		1		pF
			−40°C to +125°C			2	pF
POWER SUPPLY							
I _{DD}	V _{DD} supply current	Logic inputs = 0V or 5.5V	25°C		0.001		µA
			−40°C to +125°C			0.7	µA
DYNAMIC CHARACTERISTICS							
t _{TRAN}	Transition time between channels	V _S = 1V R _L = 200Ω, C _L = 15pF Refer to Section 7.4	25°C		55		ns
			−40°C to +85°C			201	ns
			−40°C to +125°C			201	ns
t _{OPEN} (BBM)	Break before make time	V _S = 1V R _L = 200Ω, C _L = 15pF Refer to Section 7.5	25°C		28		ns
			−40°C to +85°C	1			ns
			−40°C to +125°C	1			ns
t _{ON(EN)}	Enable turn-on time (TMUX1133 Only)	V _S = 1V R _L = 200Ω, C _L = 15pF Refer to Section 7.6	25°C		60		ns
			−40°C to +85°C			201	ns
			−40°C to +125°C			201	ns
t _{OFF(EN)}	Enable turn-off time (TMUX1133 Only)	V _S = 1V R _L = 200Ω, C _L = 15pF Refer to Section 7.6	25°C		45		ns
			−40°C to +85°C			150	ns
			−40°C to +125°C			150	ns
Q _C	Charge Injection	V _S = 1V R _S = 0Ω, C _L = 1nF Refer to Section 7.7	25°C		−1		pC
O _{ISO}	Off Isolation	R _L = 50Ω, C _L = 5pF f = 1MHz Refer to Section 7.8	25°C		−65		dB
		R _L = 50Ω, C _L = 5pF f = 10MHz Refer to Section 7.8	25°C		−45		dB
X _{TALK}	Crosstalk	R _L = 50Ω, C _L = 5pF f = 1MHz Refer to Section 7.9	25°C		−100		dB
		R _L = 50Ω, C _L = 5pF f = 10MHz Refer to Section 7.9	25°C		−90		dB
BW	Bandwidth	R _L = 50Ω, C _L = 5pF Refer to Section 7.10	25°C		220		MHz
C _{SOFF}	Source off capacitance	f = 1MHz	25°C		6		pF
C _{DOFF}	Drain off capacitance	f = 1MHz	25°C		17		pF

6.9 Electrical Characteristics ($V_{DD} = 1.2V \pm 10\%$) (continued)

PARAMETER		TEST CONDITIONS	TA	MIN	TYP	MAX	UNIT
C_{SON} C_{DON}	On capacitance	$f = 1\text{MHz}$	25°C		20		pF

(1) When V_S is 1V, V_D is 0.8V or when V_S is 0.8V, V_D is 1V.

6.10 Typical Characteristics

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

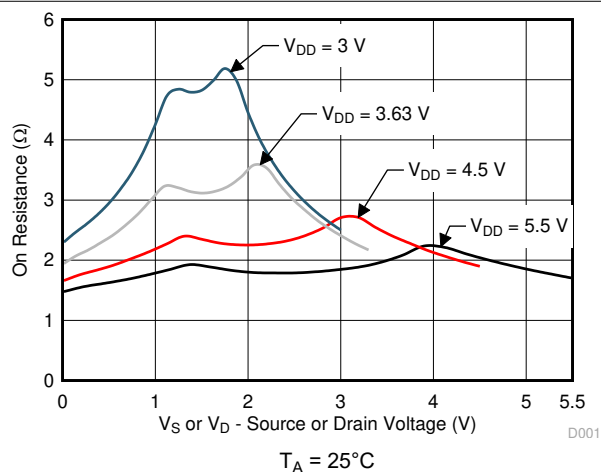


Figure 6-1. On-Resistance vs Source or Drain Voltage

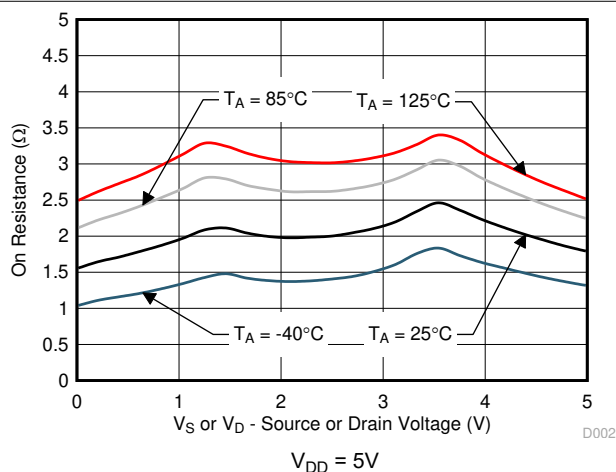


Figure 6-2. On-Resistance vs Temperature

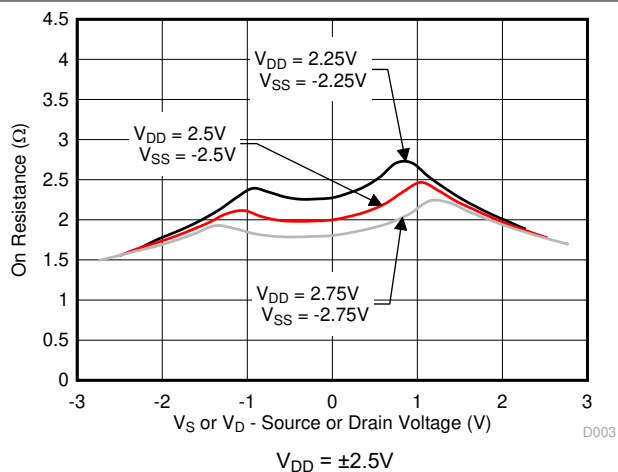


Figure 6-3. On-Resistance vs Temperature

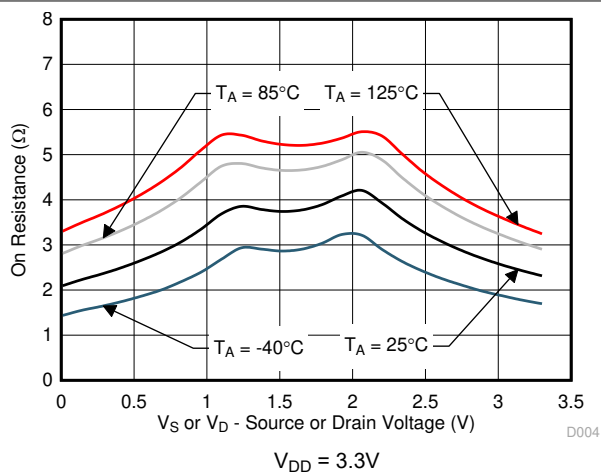


Figure 6-4. On-Resistance vs Temperature

6.10 Typical Characteristics (continued)

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

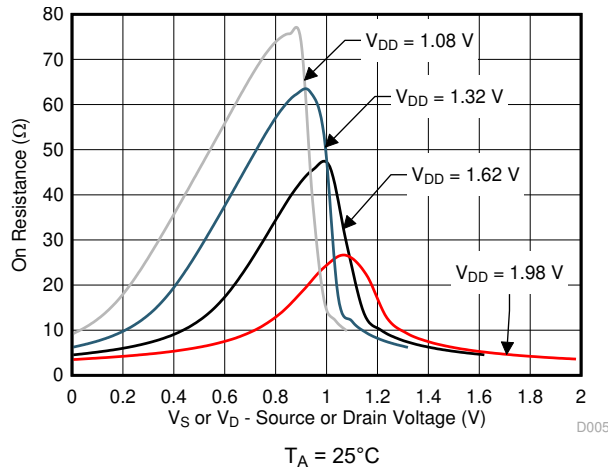


Figure 6-5. On-Resistance vs Source or Drain Voltage

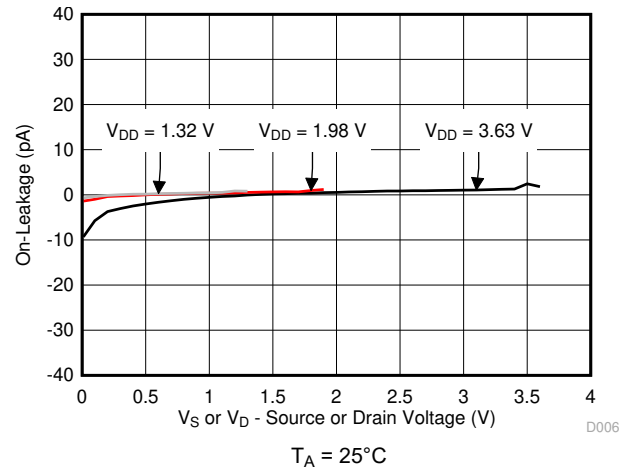


Figure 6-6. On-Leakage vs Source or Drain Voltage

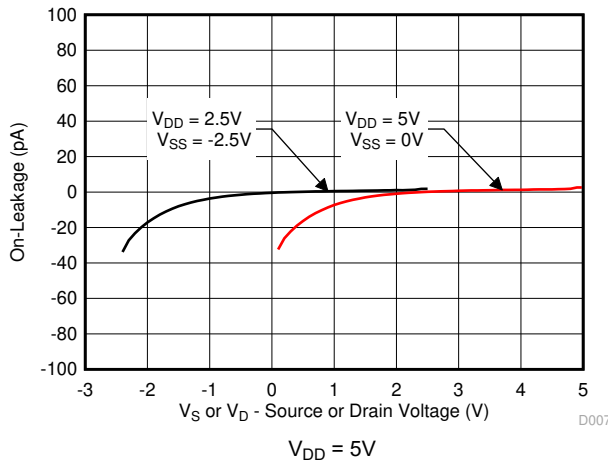


Figure 6-7. On-Leakage vs Source or Drain Voltage

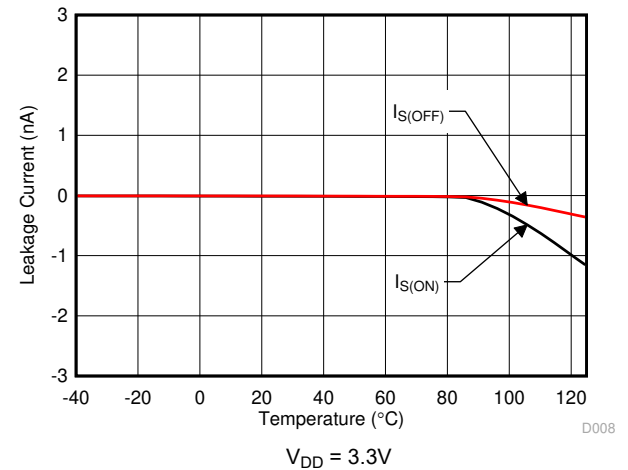


Figure 6-8. Leakage Current vs Temperature

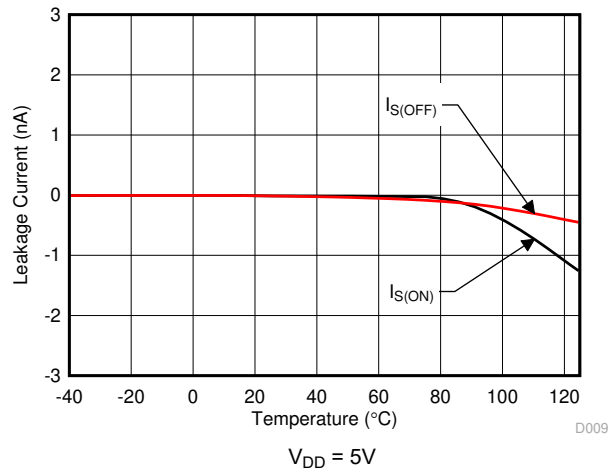


Figure 6-9. Leakage Current vs Temperature

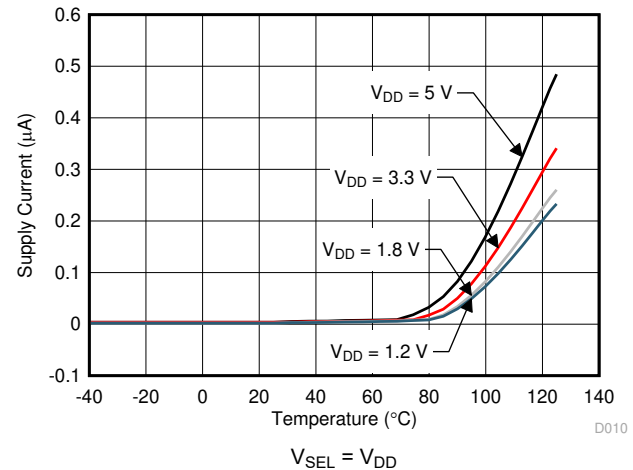


Figure 6-10. Supply Current vs Temperature

6.10 Typical Characteristics (continued)

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

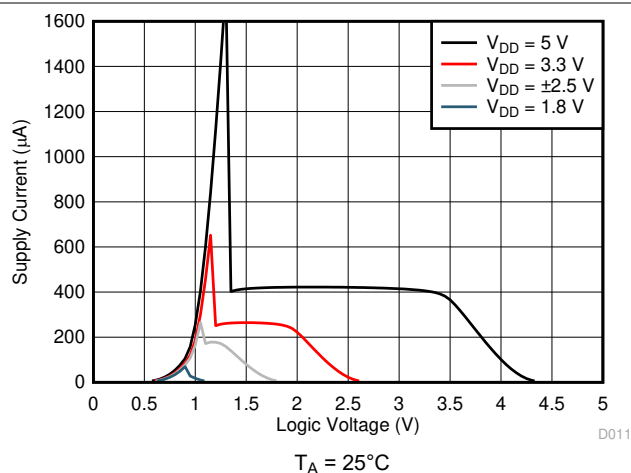


Figure 6-11. Supply Current vs Logic Voltage

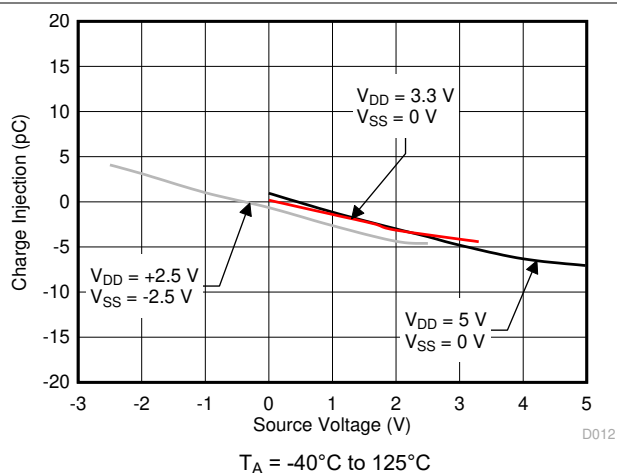


Figure 6-12. Charge Injection vs Source Voltage

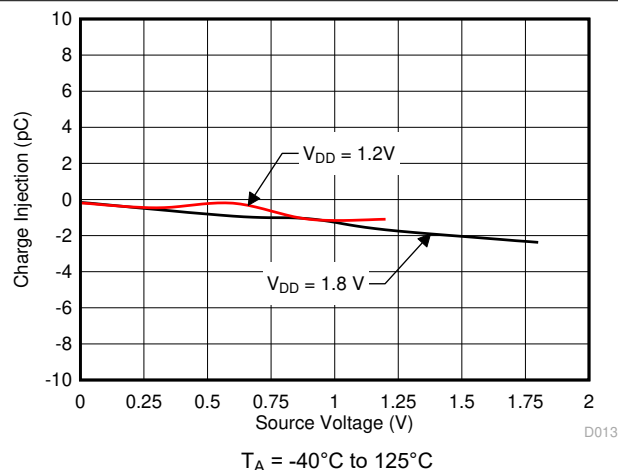


Figure 6-13. Charge Injection vs Source Voltage

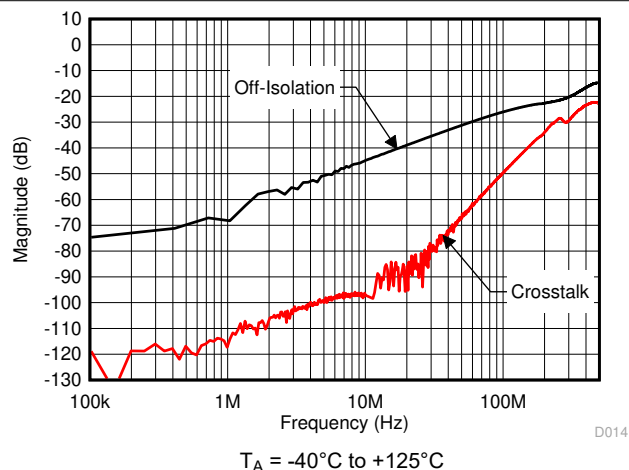


Figure 6-14. Xtalk and Off-Isolation vs Frequency

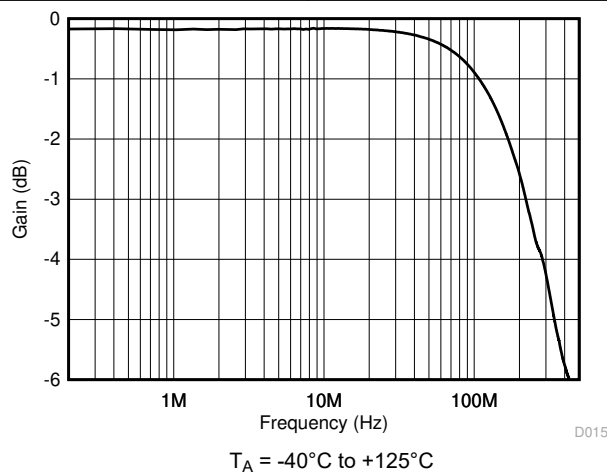


Figure 6-15. On Response vs Frequency

7 Parameter Measurement Information

7.1 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 7-1. Voltage (V) and current (I_{SD}) are measured using this setup, and R_{ON} is computed with $R_{ON} = V / I_{SD}$:

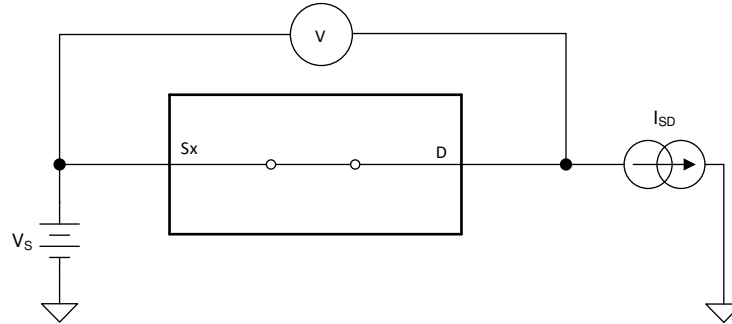


Figure 7-1. On-Resistance Measurement Setup

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 $I_{D(OFF)}$.

The setup used to measure both off-leakage currents is shown in Figure 7-2.

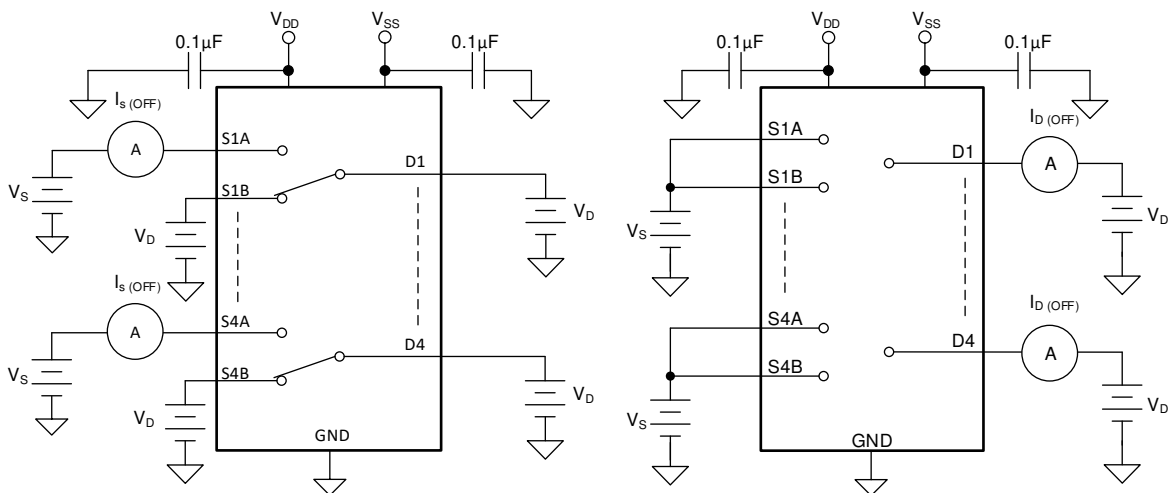


Figure 7-2. Off-Leakage Measurement Setup

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 $I_{D(ON)}$.

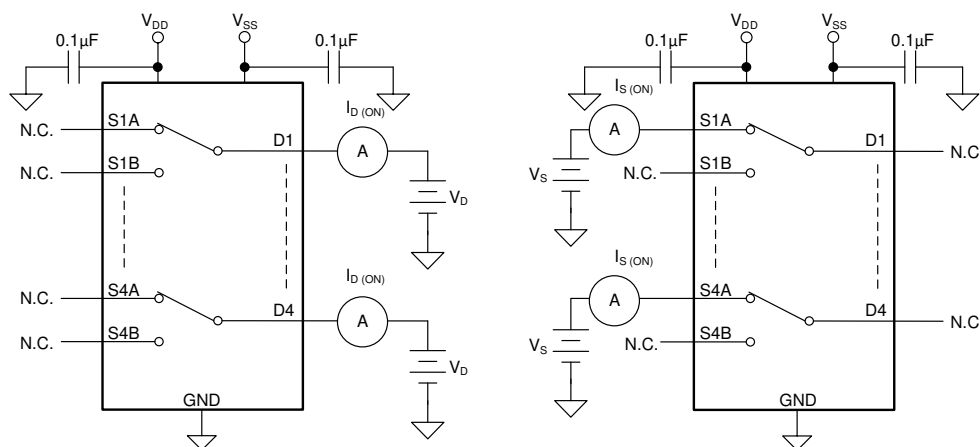


Figure 7-3. On-Leakage Measurement Setup

7.4 Transition Time

Transition time is defined as the time taken by the output of the device to rise or fall 10% after the address signal has risen or fallen past the logic threshold. The 10% 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 $t_{\text{TRANSITION}}$.

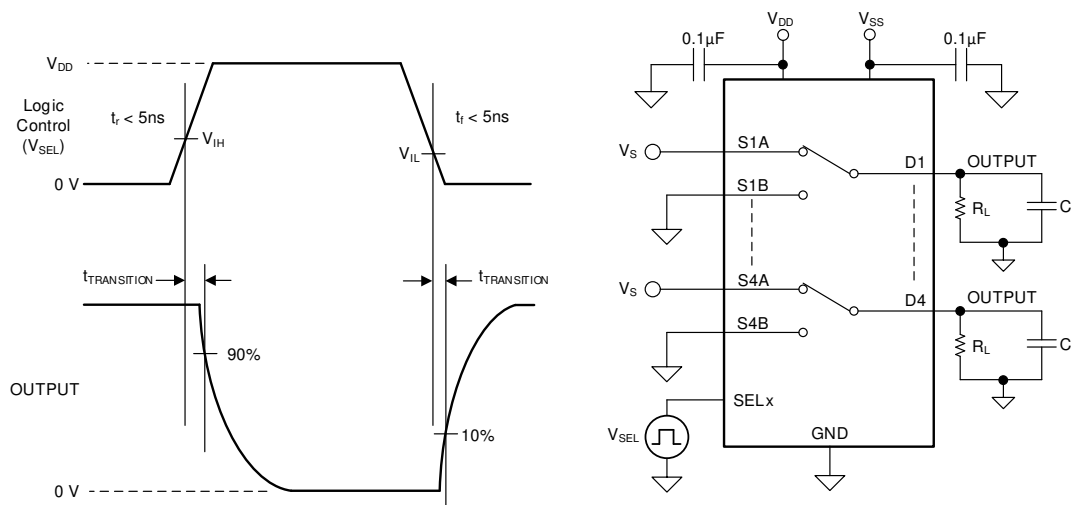


Figure 7-4. Transition-Time Measurement Setup

7.5 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 7-5 shows the setup used to measure break-before-make delay, denoted by the symbol $t_{\text{OPEN(BBM)}}$.

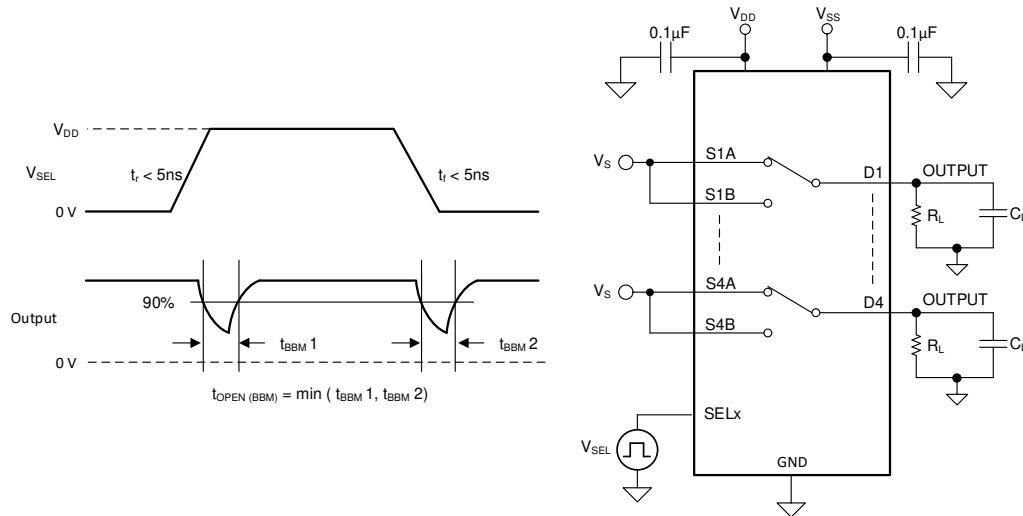


Figure 7-5. Break-Before-Make Delay Measurement Setup

7.6 $t_{\text{ON(EN)}}$ and $t_{\text{OFF(EN)}}$

Turn-on time is defined as the time taken by the output of the device to rise to 10% after the enable has risen 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 7-6 shows the setup used to measure turn-on time, denoted by the symbol $t_{\text{ON(EN)}}$.

Turn-off time is defined as the time taken by the output of the device to fall to 90% after the enable has fallen 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 7-6 shows the setup used to measure turn-off time, denoted by the symbol $t_{\text{OFF(EN)}}$.

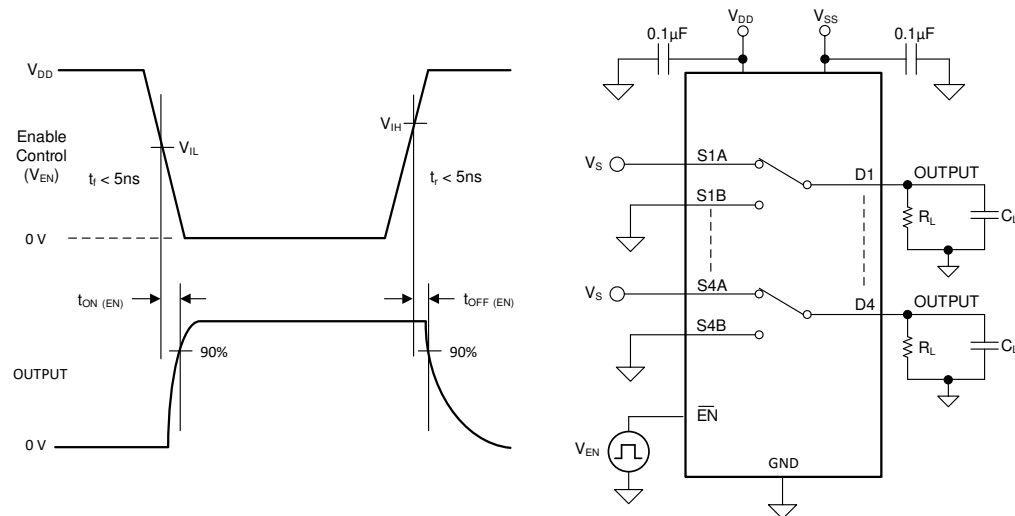


Figure 7-6. Turn-On and Turn-Off Time Measurement Setup

7.7 Charge Injection

The TMUX1133 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 7-7 shows the setup used to measure charge injection from source (Sx) to drain (D).

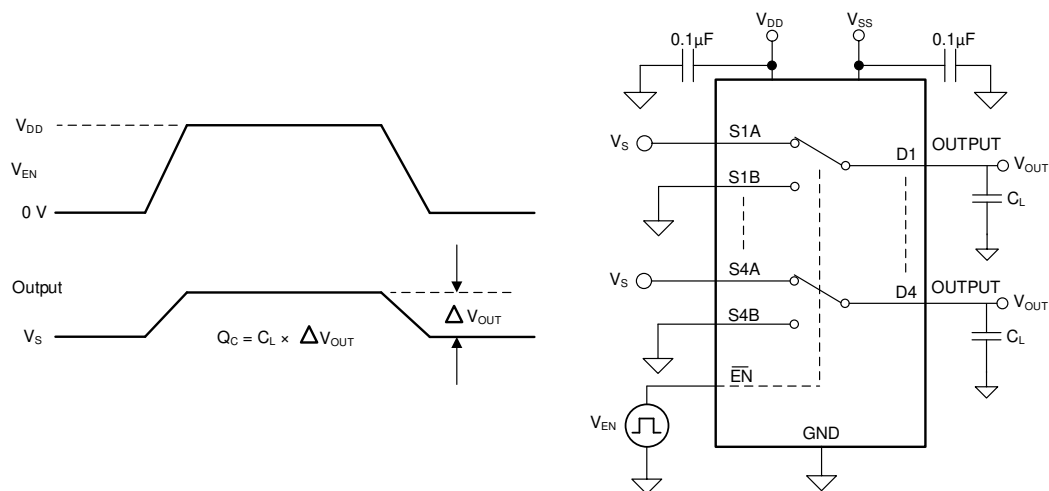


Figure 7-7. Charge-Injection Measurement Setup

7.8 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 7-8 shows the setup used to measure, and the equation used to calculate off isolation.

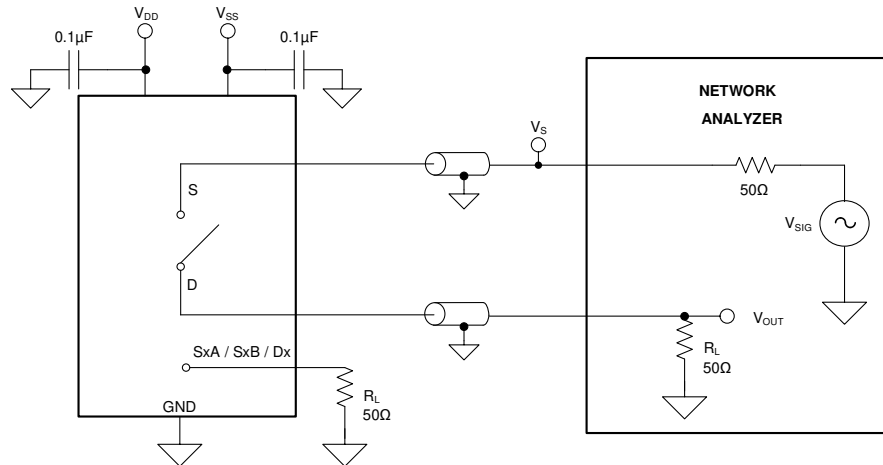


Figure 7-8. Off Isolation Measurement Setup

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

7.9 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 7-9](#) shows the setup used to measure, and the equation used to calculate crosstalk.

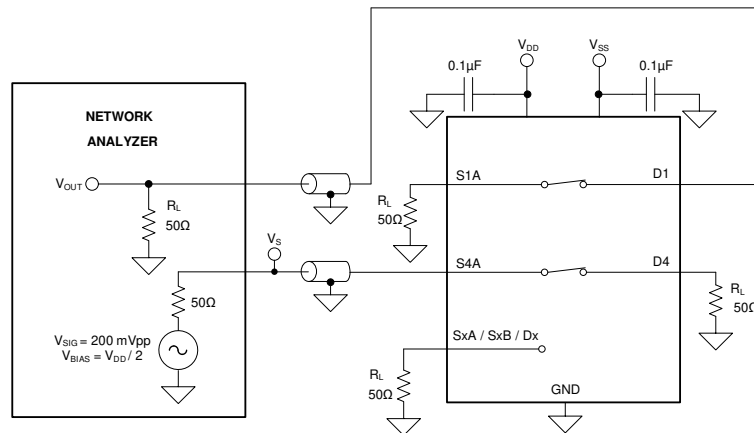


Figure 7-9. Crosstalk Measurement Setup

$$\text{Channel-to-Channel Crosstalk} = 20 \cdot \text{Log} \left(\frac{V_{\text{OUT}}}{V_{\text{S}}} \right) \quad (2)$$

7.10 Bandwidth

Bandwidth is defined as the range of frequencies that are attenuated by less than 3dB 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 7-10](#) shows the setup used to measure bandwidth.

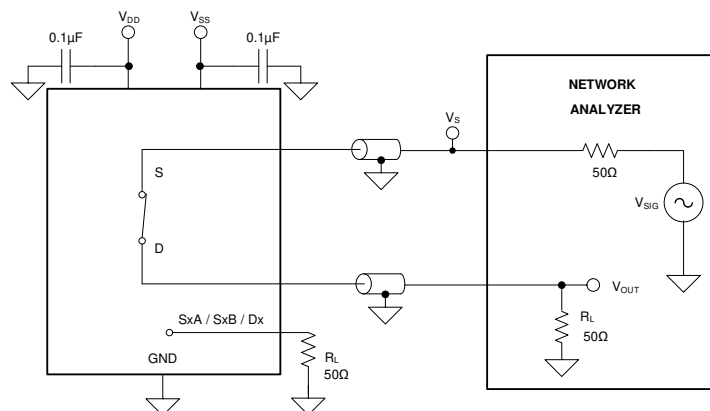


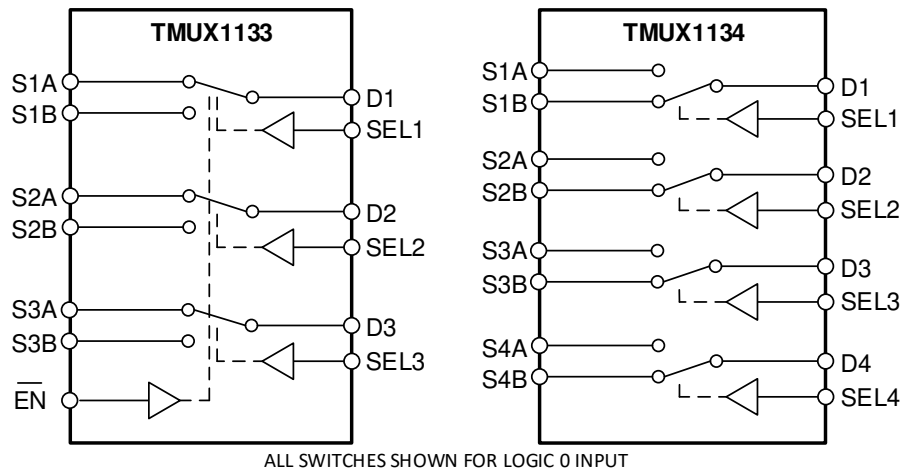
Figure 7-10. Bandwidth Measurement Setup

8 Detailed Description

8.1 Overview

The TMUX1133 contains three independently controlled single-pole double-throw (SPDT) switches and has an active low $\overline{\text{EN}}$ pin to enable or disable all three switches simultaneously. The TMUX1134 contains four independently controlled SPDT switches.

8.2 Functional Block Diagram



8.3 Feature Description

8.3.1 Bidirectional Operation

The TMUX113x devices conduct equally well from source (S_x) to drain (D_x) or from drain (D_x) to source (S_x). 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/output voltage for TMUX113x ranges from V_{SS} to V_{DD} . For single supply applications V_{SS} can be connected to GND.

8.3.3 1.8V Logic Compatible Inputs

The TMUX113x devices have 1.8V logic compatible control for all logic control inputs. The logic input thresholds scale with supply but still provide 1.8V logic control when operating at 5.5V supply voltage. 1.8V logic level inputs allows the TMUX113x devices 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. The current consumption of the TMUX113x devices increase when using 1.8V logic with higher supply voltage as shown in [Figure 6-11](#). For more information on 1.8V logic implementations refer to [Simplifying Design with 1.8V logic Muxes and Switches](#)

8.3.4 Fail-Safe Logic

The TMUX113x devices support Fail-Safe Logic on the control input pins (SEL_x and $\overline{\text{EN}}$) allowing for operation up to 5.5V, regardless of the state of the supply pins. This feature allows voltages on the control pins to be applied before the supply pins, 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 TMUX113x devices to be ramped to 5.5V while $V_{DD} = 0V$. Additionally, the feature enables operation of the TMUX113x devices with $V_{DD} = 1.2V$ while allowing the select pins to interface with a logic level of another device up to 5.5V.

8.3.5 Ultra-low Leakage Current

The TMUX1133 and TMUX1134 provide extremely low on-leakage and off-leakage currents. The TMUX113x devices are capable of switching signals from high source-impedance inputs into a high input-impedance op amp with minimal offset error because of the ultra-low leakage currents. Figure 8-1 shows typical leakage currents of the TMUX113x devices versus input voltage.

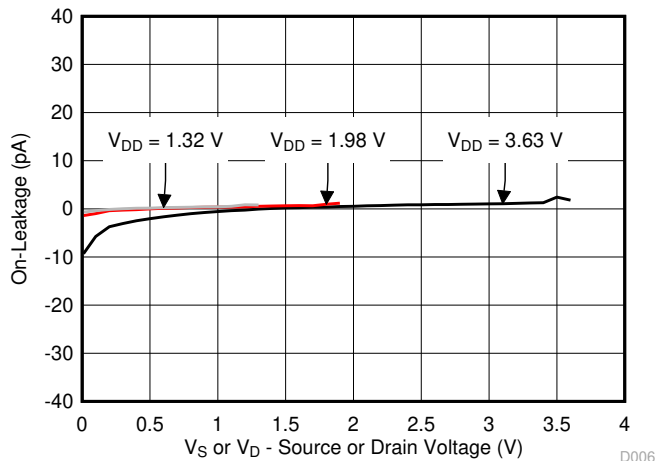


Figure 8-1. Leakage Current vs Input Voltage

8.3.6 Ultra-Low Charge Injection

The TMUX113x devices have 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.

The TMUX113x devices have special charge-injection cancellation circuitry that reduces the source-to-drain charge injection to -1pC at $V_S = 1V$ as shown in Figure 8-3.

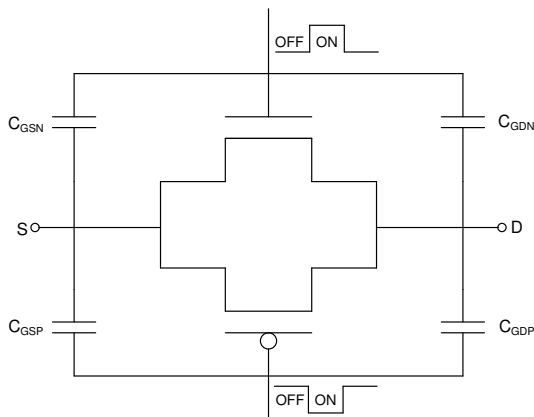


Figure 8-2. Transmission Gate Topology

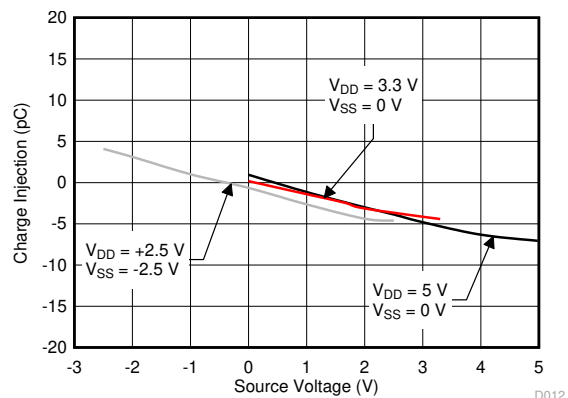


Figure 8-3. Charge Injection vs Source Voltage

8.4 Device Functional Modes

The select (SELx) pins are logic pins that control the connection between the source (SxA and SxB) and drain (Dx) pins of the TMUX113x devices. When a source pin is not selected that pin is in an open state (HI-Z). When a source pin is selected the switch conducts to drain. The logic control pins can be as high as 5.5V.

When the $\overline{\text{EN}}$ pin of the TMUX1133 is pulled low the SELx logic control inputs determine which source input is selected. When the $\overline{\text{EN}}$ pin is pulled high, all of the switches are in an open state regardless of the state of the SELx logic control inputs. The TMUX1134 SELx logic control inputs determine which source pin is connected to the drain pin for each channel.

The TMUX113x devices can be operated without any external components except for the supply decoupling capacitors. Unused logic control pins must be tied to GND or V_{DD} so that the device does not consume additional current as highlighted in [Implications of Slow or Floating CMOS Inputs](#). Unused signal path inputs (SxA, SxB, or Dx) should be connected to GND.

8.5 Truth Tables

[Table 8-1](#) and [Table 8-2](#) lists the truth tables for the TMUX1133 and TMUX1134 respectively.

Table 8-1. TMUX1133 Truth Table

EN	SEL1 ⁽¹⁾	SEL2	SEL3	Selected Source Pins Connected To Drain Pins
0	0	X	X	S1A to D1
0	1	X	X	S1B to D1
0	X	0	X	S2A to D2
0	X	1	X	S2B to D2
0	X	X	0	S3A to D3
0	X	X	1	S3B to D3
1	X	X	X	Hi-Z (OFF)

Table 8-2. TMUX1134 Truth Table

SEL1	SEL2	SEL3	SEL4	Selected Source Pins Connected To Drain Pins
0	X	X	X	S1B to D1
1	X	X	X	S1A to D1
X	0	X	X	S2B to D2
X	1	X	X	S2A to D2
X	X	0	X	S3B to D3
X	X	1	X	S3A to D3
X	X	X	0	S4B to D4
X	X	X	1	S4A to D4

(1) X denotes *do not 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

The TMUX11xx family offers ultra-low input/output leakage currents and low charge injection. These devices operate up to 5.5V, and offer true rail-to-rail input and output switching of both analog and digital signals. The TMUX113x devices have low on-capacitance which allows faster settling time when switching between inputs in the time domain. These features make the TMUX11xx devices a family of precision, high-performance switches and multiplexers for low-voltage applications.

9.2 Typical Application

Figure 9-1 shows an example circuit where the TMUX1133 or TMUX1134 can be used to minimize board space by integrating various applications into a multi-channel 2:1 (SPDT) switch. The application uses a 3-channel, or 4-channel SPDT switch to optimize the tradeoffs of system flexibility and board space.

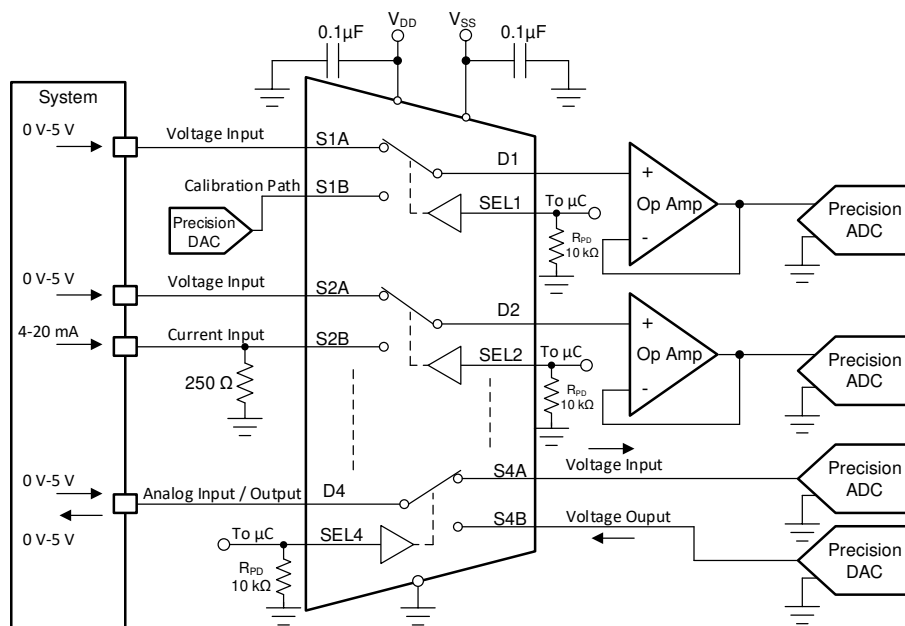


Figure 9-1. Multi-channel 2:1, Switching Applications

9.2.1 Design Requirements

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

Table 9-1. Design Parameters

PARAMETERS	VALUES
Supply (V_{DD})	5V
Input / Output Voltage range	0V to 5V
Input / Output Current range	4mA to 20mA
Control logic thresholds	1.8V compatible

9.2.2 Detailed Design Procedure

The TMUX113x devices can be operated without any external components except for the supply decoupling capacitors, however pull-down or pull-up resistors are recommended on the logic control inputs so that each channel is in a known state. All inputs passing through the switch must fall within the recommended operating conditions, including signal range and continuous current. For this design with a single supply of 5V the signal range can be 0V to 5V, and the maximum continuous current can be 30mA.

Industrial applications such as in factory automation and control; test and measurement benefit from using a multi-channel 2:1 switch, because it allows additional flexibility in the design.

A single 2:1 switch has numerous applications such as:

1. Switching between an analog signal path and a calibration path so that the system is calibrated across the life of a product or after installation.
2. Configuring a single channel to accept either a voltage or current input through software - allowing for system flexibility across applications where the end users input signals may differ.
3. Allowing a single channel to be configured as either an analog input or analog output. Providing additional control to a system while minimizing the number of physical connectors

Figure 9-1 shows how to configure a multi-channel analog switch to address these design implementations for additional control and flexibility in the system. The on-resistance of the TMUX113x devices is very low, 2Ω typical, and has a maximum on-leakage current of 2nA which allows the devices to be used in precision measurement applications. A system with a 4mA to 20mA signal can achieve >20bits of precision due to the extremely low leakage current of the TMUX113x devices.

9.2.3 Application Curve

The TMUX113x devices are capable of switching signals with minimal distortion because of the ultra-low leakage currents and low on-resistance. Figure 9-2 shows how the leakage current of the TMUX113x varies with different input voltages.

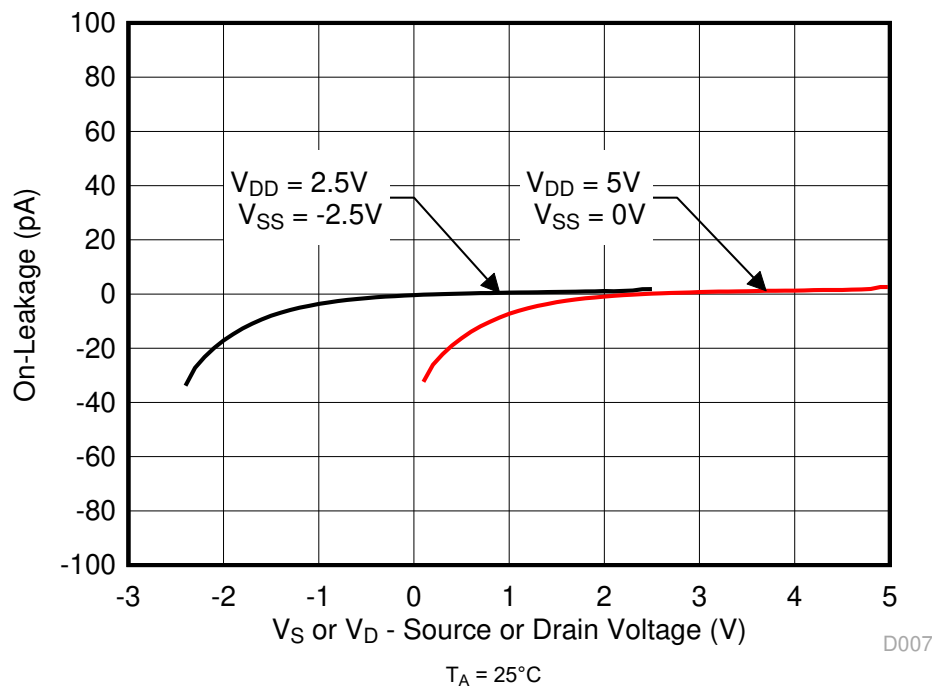


Figure 9-2. On-Leakage vs Source or Drain Voltage

9.3 Power Supply Recommendations

The TMUX113x devices operate across a wide supply range of 1.08V to 5.5V single supply, or $\pm 2.75\text{V}$ for dual supply applications. For single supply voltage applications V_{SS} must be connected to GND. Do not exceed the absolute maximum ratings because stresses beyond the listed ratings can cause permanent damage to the devices.

Power-supply bypassing improves noise margin and prevents switching noise propagation from the V_{DD} and V_{SS} supplies 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 from V_{DD} and V_{SS} 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 planes.

9.4 Layout

9.4.1 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 9-3](#) shows progressively better techniques of rounding corners. Only the last example (BEST) maintains constant trace width and minimizes reflections.

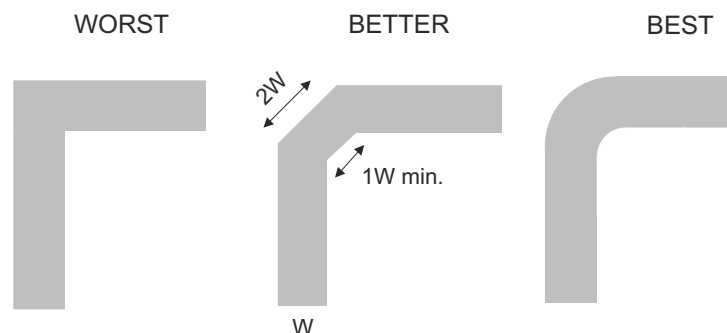


Figure 9-3. Trace Example

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 9-4](#) and [Figure 9-5](#) shows examples of a PCB layout with the TMUX1133 and TMUX1134 respectively. Some key considerations are:

- Decouple the V_{DD} and V_{SS} pins with a 0.1 μF capacitor, placed as close to the pin as possible. Ensure 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.

9.4.2 Layout Example

Figure 9-4 shows an example board layout for the TMUX1133.

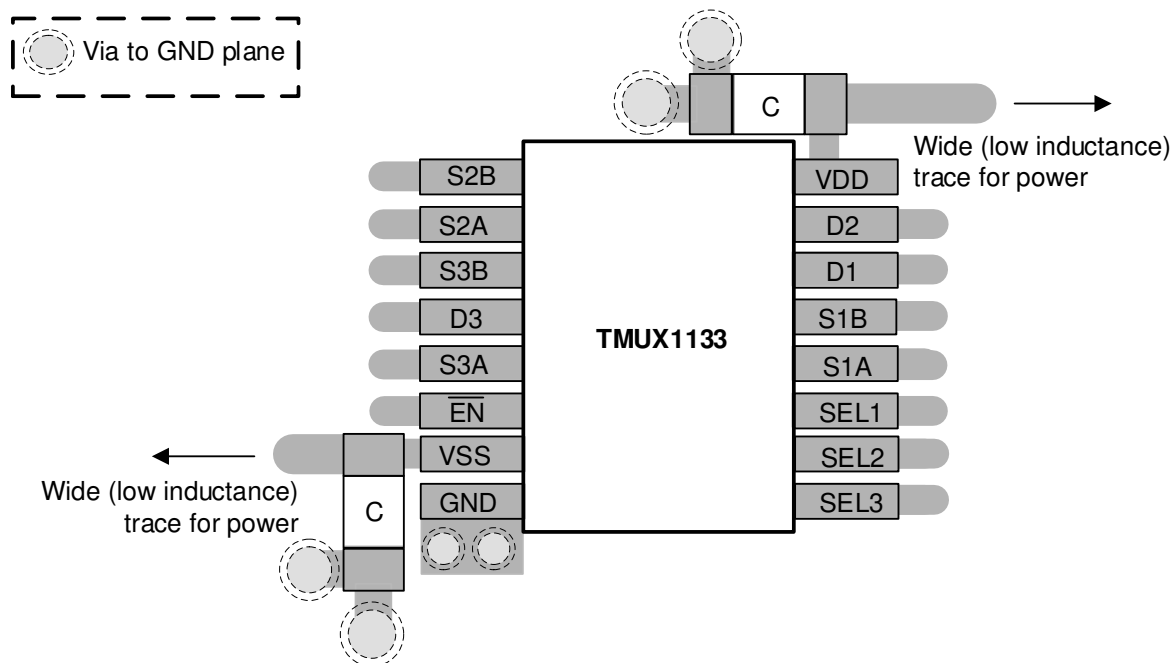


Figure 9-4. TMUX1133 Layout Example

Figure 9-5 shows an example board layout for the TMUX1134.

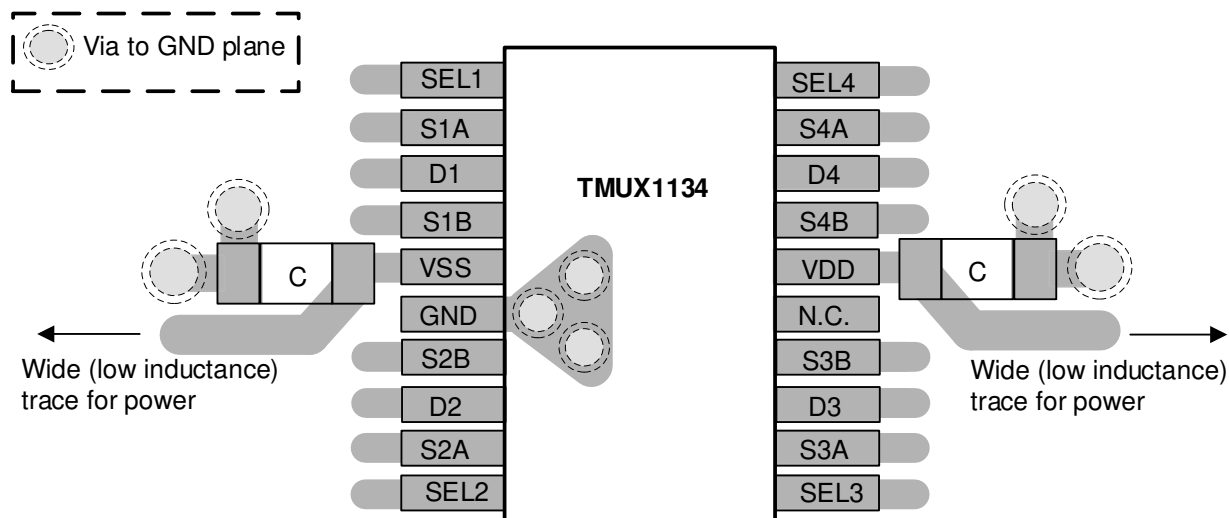


Figure 9-5. TMUX1134 Layout Example

10 Device and Documentation Support

10.1 Documentation Support

10.1.1 Related Documentation

For related documentation, see the following:

- Texas Instruments, [Ultrasonic Gas Meter Front-End With MSP430™ Reference Design](#).
- Texas Instruments, [True Differential, 4 x 2 MUX, Analog Front End, Simultaneous-Sampling ADC Circuit](#).
- Texas Instruments, [Improve Stability Issues with Low CON Multiplexers](#).
- Texas Instruments, [Simplifying Design with 1.8V logic Muxes and Switches](#).
- Texas Instruments, [Eliminate Power Sequencing with Powered-off Protection Signal Switches](#).
- Texas Instruments, [System-Level Protection for High-Voltage Analog Multiplexers](#).
- Texas Instruments, [QFN/SON PCB Attachment](#).
- Texas Instruments, [Quad Flatpack No-Lead Logic Packages](#).

10.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. Click on *Notifications* 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.

10.3 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.

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10.4 Trademarks

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10.5 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.

10.6 Glossary

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

11 Revision History

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

Changes from Revision A (August 2019) to Revision B (January 2024)	Page
• Edited Functional Block Diagram images to show logic state.....	1
• Updated Is or Id (Continuous Current) values.....	5
• Added Ipeak values to recommended operating conditions table.....	5

Changes from Revision * (June 2019) to Revision A (August 2019)	Page
• Changed the device From: <i>Advanced Information</i> To: <i>Production</i> data	1

12 Mechanical, Packaging, and Orderable Information

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

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package Pins	Package qty Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
TMUX1133PWR	Active	Production	TSSOP (PW) 16	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	TM1133
TMUX1133PWR.A	Active	Production	TSSOP (PW) 16	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	TM1133
TMUX1133PWRG4	Active	Production	TSSOP (PW) 16	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	TM1133
TMUX1133PWRG4.A	Active	Production	TSSOP (PW) 16	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	TM1133
TMUX1134PWR	Active	Production	TSSOP (PW) 20	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	TM1134
TMUX1134PWR.A	Active	Production	TSSOP (PW) 20	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	TM1134
TMUX1134PWRG4	Active	Production	TSSOP (PW) 20	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	TM1134
TMUX1134PWRG4.A	Active	Production	TSSOP (PW) 20	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	TM1134

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

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

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

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

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

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

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

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

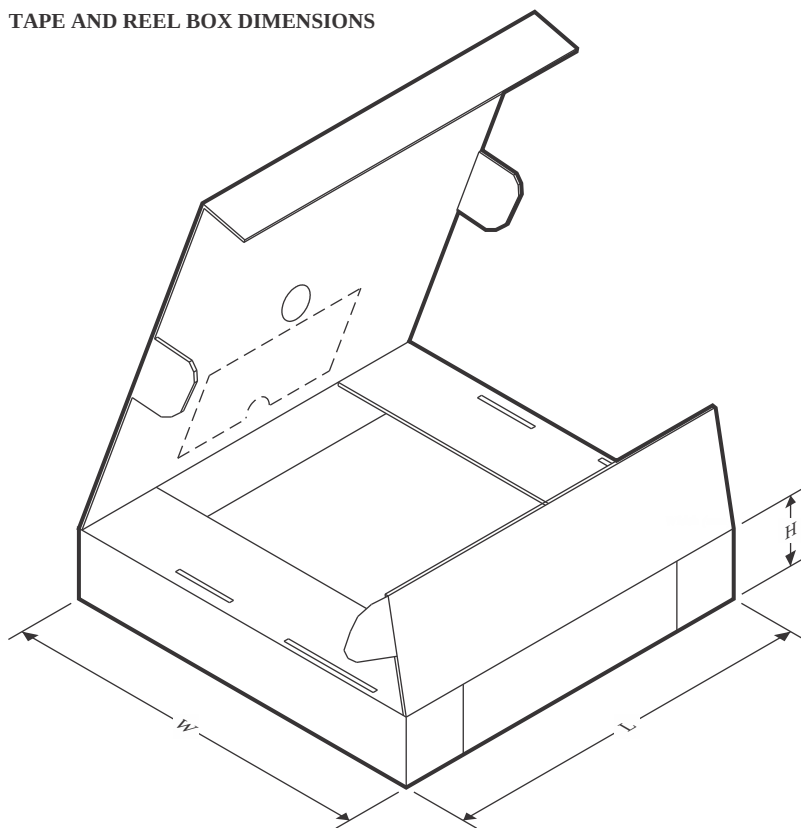
TAPE AND REEL INFORMATION



*All dimensions are nominal

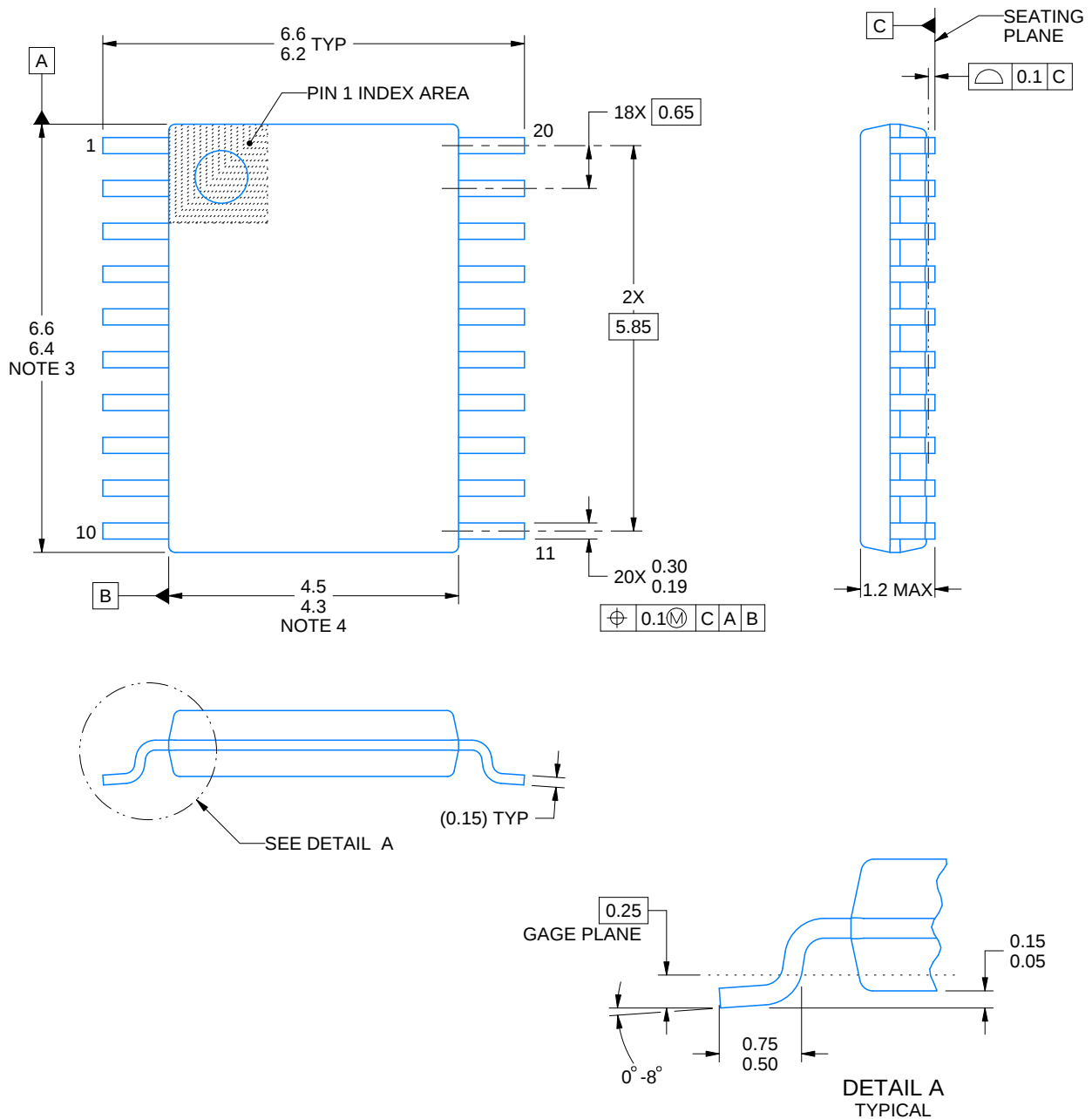
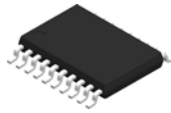
Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TMUX1133PWR	TSSOP	PW	16	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
TMUX1133PWRG4	TSSOP	PW	16	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
TMUX1134PWR	TSSOP	PW	20	2000	330.0	16.4	6.95	7.0	1.4	8.0	16.0	Q1
TMUX1134PWRG4	TSSOP	PW	20	2000	330.0	16.4	6.95	7.0	1.4	8.0	16.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TMUX1133PWR	TSSOP	PW	16	2000	353.0	353.0	32.0
TMUX1133PWRG4	TSSOP	PW	16	2000	353.0	353.0	32.0
TMUX1134PWR	TSSOP	PW	20	2000	353.0	353.0	32.0
TMUX1134PWRG4	TSSOP	PW	20	2000	353.0	353.0	32.0



4220206/A 02/2017

NOTES:

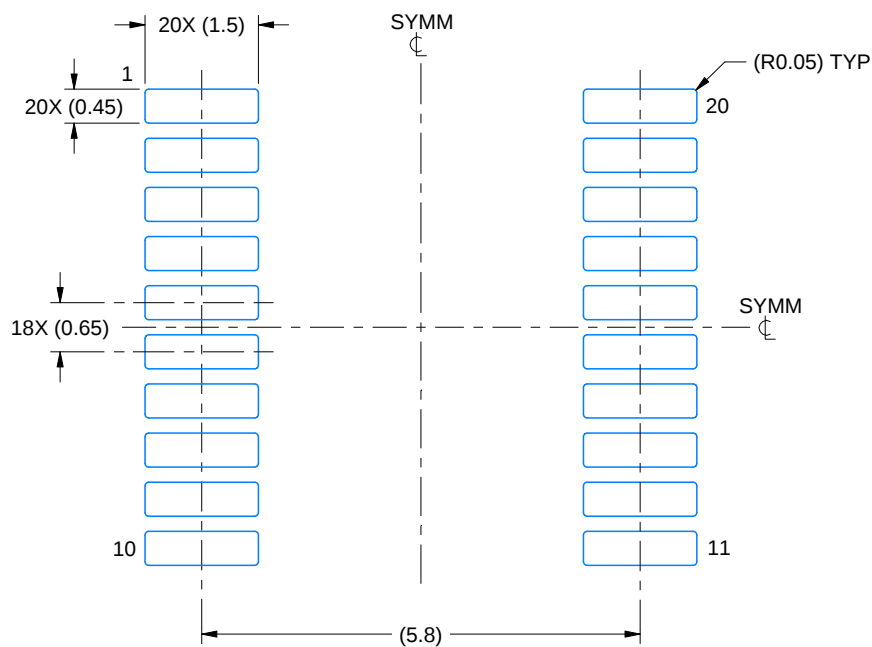
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or 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.

EXAMPLE BOARD LAYOUT

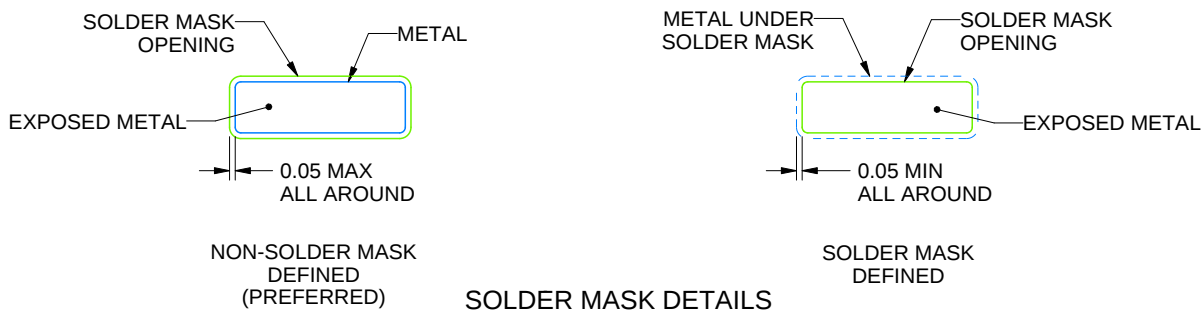
PW0020A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 10X



4220206/A 02/2017

NOTES: (continued)

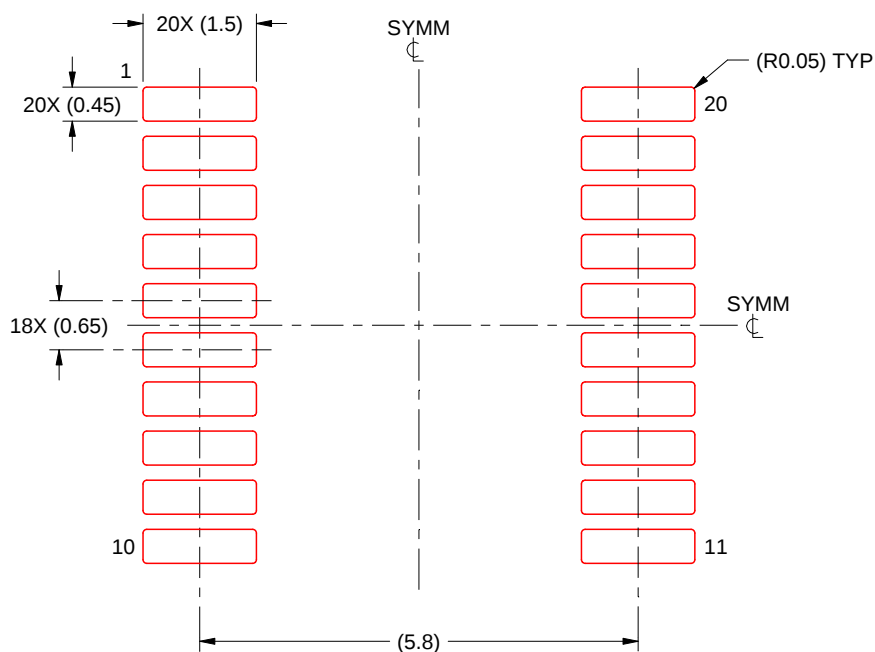
6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

PW0020A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE

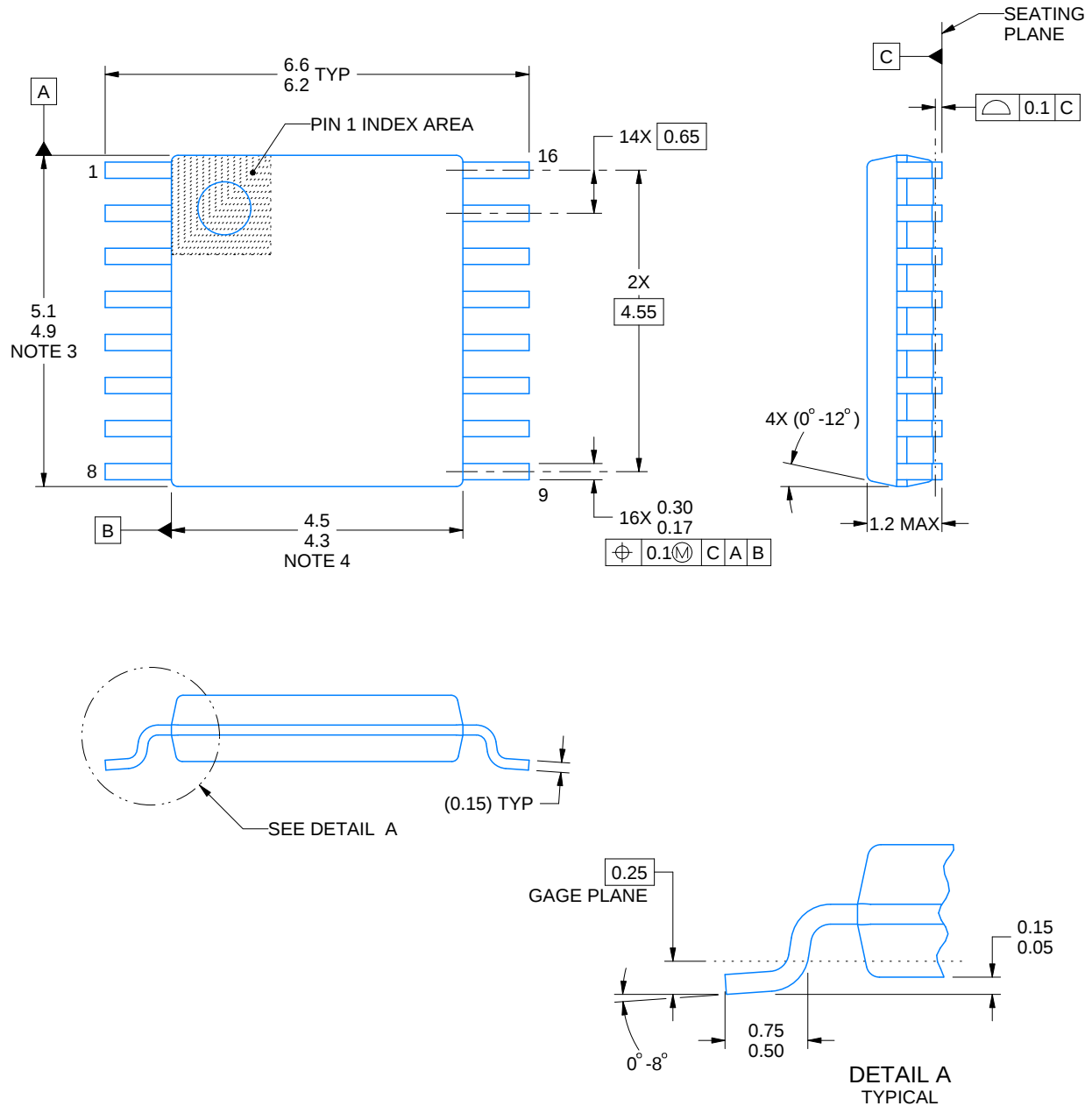
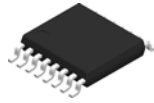


SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE: 10X

4220206/A 02/2017

NOTES: (continued)

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



4220204/B 12/2023

NOTES:

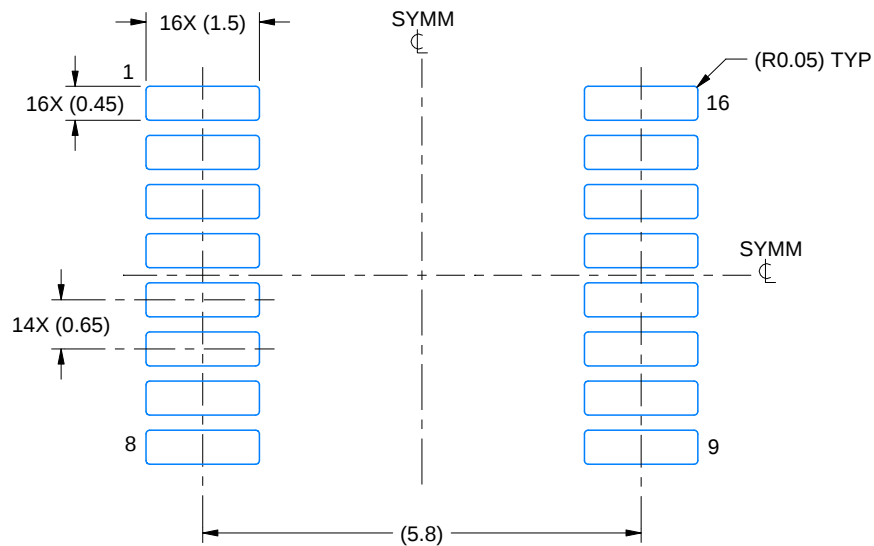
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or 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.

EXAMPLE BOARD LAYOUT

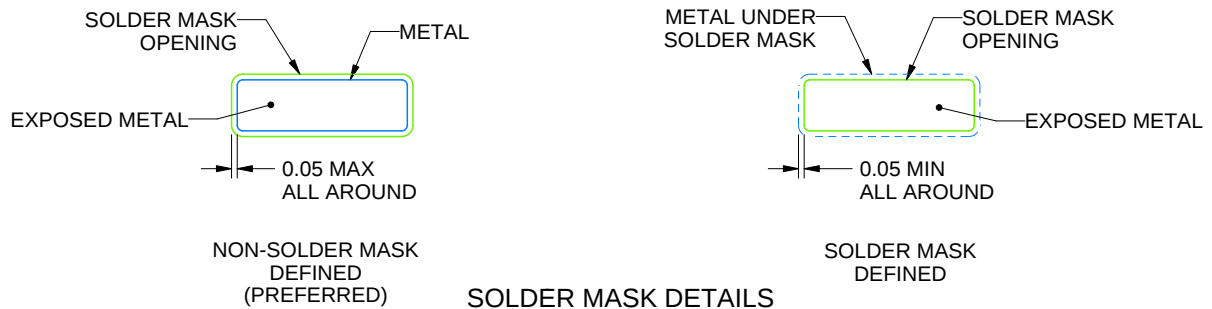
PW0016A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 10X



4220204/B 12/2023

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

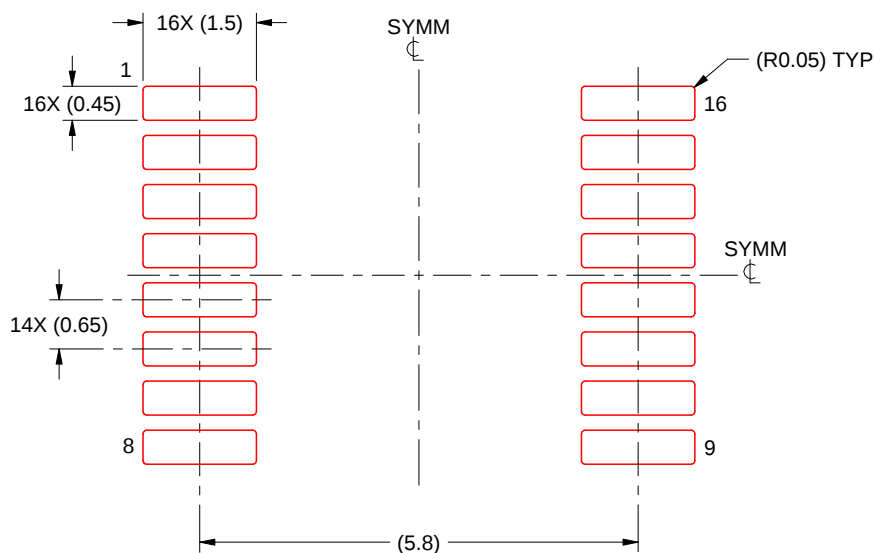
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

PW0016A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



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

4220204/B 12/2023

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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