

TMUX6136 $\pm 16.5V$ 、低静電容量、低リーク電流の 高精度デュアル SPDT スイッチ

1 特長

- 広い電源電圧範囲: $\pm 5V \sim \pm 16.5V$ (デュアル)、 $10V \sim 16.5V$ (シングル)
- すべてのピンで、JEESD78 Class II Level A 準拠の $100mA$ を満たすラッチアップ性能
- 小さいオン容量: $5.5pF$
- 低い入力リーク: $0.5pA$
- 少ない電荷注入: $-0.4pC$
- レール・ツー・レール動作
- 低オン抵抗: 120Ω
- 高速な遷移時間: $66ns$
- ブレイク・ビフォー・メイクの切り替え動作
- SELx ピンを内蔵プルダウンにより V_{DD} に接続可能
- ロジック・レベル: $2V \sim V_{DD}$
- 低消費電流: $17\mu A$
- 人体モデル (HBM) ESD 保護: すべてのピンで $\pm 2kV$
- 業界標準の TSSOP パッケージ

2 アプリケーション

- ファクトリ・オートメーションと産業プロセス制御
- プログラマブル・ロジック・コントローラ (PLC)
- アナログ入力モジュール
- ATE 試験装置
- デジタル・マルチメータ
- バッテリ・モニタリング・システム

3 概要

TMUX6136 は、独立して選択可能な 2 つの SPDT スイッチを備えた相補型金属酸化膜半導体 (CMOS) アナログ・スイッチです。このデバイスは、デュアル電源 ($\pm 5V \sim \pm 16.5V$)、シングル電源 ($10V \sim 16.5V$)、非対称電源のいずれでも正常に動作します。デジタル選択ピン (SELx) は、スレッシュホールドが TTL (Transistor-Transistor Logic) 互換で、TTL/CMOS ロジックの互換性が保証されます。

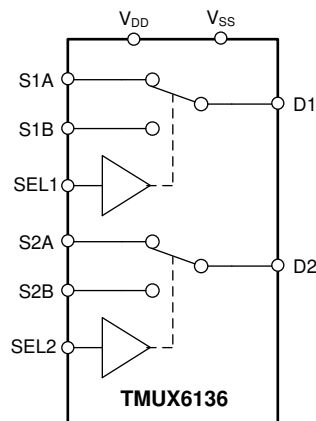
TMUX6136 は 2 つの入力 (Sx) の 1 つを、SELx ピンのステータスに応じて、共通の出力 (D) に切り替えます。各スイッチはオン位置において、どちらの方向にも同程度に導電性が高く、電源電圧までの入力信号範囲をサポートします。オフ状態では、電源電圧までの信号レベルがブロックされます。すべてのスイッチは、Break-Before-Make (BBM) スイッチング動作を行います。

TMUX6136 は、テキサス・インスツルメンツの高精度スイッチおよびマルチプレクサ・ファミリの製品です。このデバイスはリーク電流と電荷注入が非常に小さいため、高精度の測定アプリケーションに使用可能です。また、このデバイスはスイッチがオフ位置のとき、電源電圧までの信号レベルをブロックすることで、絶縁性能も非常に優れています。消費電流が $17\mu A$ と小さいため、携帯用アプリケーションで使用できます。

パッケージ情報 (1)

部品番号	パッケージ	本体サイズ (公称)
TMUX6136	PW (TSSOP, 16)	5.00mm × 4.40mm

(1) 利用可能なパッケージについては、データシートの末尾にあるパッケージ・オプションについての付録を参照してください。



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概略回路図



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4 Revision History

資料番号末尾の英字は改訂を表しています。その改訂履歴は英語版に準じています。

Changes from Revision * (November 2018) to Revision A (October 2022)	Page
• 文書全体にわたって表、図、相互参照の採番方法を更新.....	1
• Updated the <i>Transition-Time Measurement Setup</i> figure	13

5 Pin Configuration and Functions

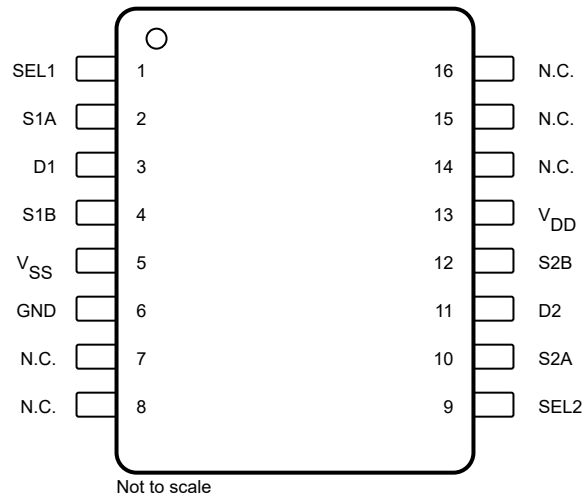


图 5-1. PW Package, 16-Pin TSSOP (Top View)

表 5-1. Pin Functions

PIN		TYPE ⁽¹⁾	DESCRIPTION
NAME	NO.		
SEL1	1	I	Select line 0
S1A	2	I/O	Source pin 1A. Can be an input or output.
D1	3	I/O	Drain pin D1. 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. In single-supply applications, this pin can be connected to ground. For reliable operation, connect a decoupling capacitor ranging from 0.1 μ F to 10 μ F between V _{SS} and GND.
GND	6		Ground (0 V) reference
N.C.	7, 8, 14, 15, 16	No Connect	No internal connection
SEL2	9	I	Select line 1
S2A	10	I/O	Source pin 2A. Can be an input or output.
D2	11	I/O	Drain pin D2. Can be an input or output.
S2B	12	I/O	Source pin 2B. Can be an input or output.
V _{DD}	13	P	Positive power supply. This pin is the most positive power-supply potential. For reliable operation, connect a decoupling capacitor ranging from 0.1 μ F to 10 μ F between V _{DD} and GND.

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

6 Specifications

6.1 Absolute Maximum Ratings

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

		MIN	MAX	UNIT
V _{DD} to V _{SS}	Supply voltage		36	V
V _{DD} to GND		-0.3	18	V
V _{SS} to GND		-18	0.3	V
V _{DIG}	Digital input pin (SEL1, SEL2) voltage	GND -0.3	V _{DD} +0.3	V
I _{DIG}	Digital input pin (SEL1, SEL2) current	-30	30	mA
V _{ANA_IN}	Analog input pin (Sx) voltage	V _{SS} -0.3	V _{DD} +0.3	V
I _{ANA_IN}	Analog input pin (Sx) current	-30	30	mA
V _{ANA_OUT}	Analog output pin (D) voltage	V _{SS} -0.3	V _{DD} +0.3	V
I _{ANA_OUT}	Analog output pin (D) current	-30	30	mA
T _A	Ambient temperature	-55	140	°C
T _J	Junction temperature		150	°C
T _{stg}	Storage temperature	-65	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.

6.2 ESD Ratings

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

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

6.3 Thermal Information

THERMAL METRIC ⁽¹⁾		TMUX6136	UNIT
		PW (TSSOP)	
		16 PINS	
R _{θJA}	Junction-to-ambient thermal resistance	111.0	°C/W
R _{θJC(top)}	Junction-to-case (top) thermal resistance	41.7	°C/W
R _{θJB}	Junction-to-board thermal resistance	57.2	°C/W
Ψ _{JT}	Junction-to-top characterization parameter	4.1	°C/W
Ψ _{JB}	Junction-to-board characterization parameter	56.6	°C/W
R _{θJC(bot)}	Junction-to-case (bottom) thermal resistance	N/A	°C/W

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

6.4 Recommended Operating Conditions

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

		MIN	NOM	MAX	UNIT
V_{DD} to V_{SS} ⁽¹⁾	Power supply voltage differential	10		33	V
V_{DD} to GND	Positive power supply voltage (single supply, $V_{SS} = 0$ V)	10		16.5	V
V_{DD} to GND	Positive power supply voltage (dual supply)	5		16.5	V
V_{SS} to GND	Negative power supply voltage (dual supply)	-16.5		-5	V
V_S ⁽¹⁾	Source pins voltage	V_{SS}		V_{DD}	V
V_D	Drain pin voltage	V_{SS}		V_{DD}	V
V_{DIG}	Digital input pin (SEL1, SEL2) voltage	0		V_{DD}	V
I_{CH}	Channel current ($T_A = 25^\circ\text{C}$)	-25		25	mA
T_A	Ambient temperature	-40		125	$^\circ\text{C}$

(1) V_{DD} and V_{SS} can be any value as long as $10\text{ V} \leq (V_{DD} - V_{SS}) \leq 33\text{ V}$.

6.5 Electrical Characteristics (Dual Supplies: ± 15 V)

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

PARAMETER		TEST CONDITIONS	TEST CONDITIONS	MIN	TYP	MAX	UNIT
ANALOG SWITCH							
V_A	Analog signal range		$T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$	V_{SS}		V_{DD}	V
R_{ON}	On-resistance	$V_S = 0\text{ V}$, $I_S = 1\text{ mA}$			120	135	Ω
					140	160	Ω
		$V_S = \pm 10\text{ V}$, $I_S = 1\text{ mA}$	$T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$		210	Ω	
		$T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$		245	Ω		
ΔR_{ON}	On-resistance mismatch between channels	$V_S = \pm 10\text{ V}$, $I_S = 1\text{ mA}$			2.5	6	Ω
			$T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$		9	Ω	
			$T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$		11	Ω	
R_{ON_FLAT}	On-resistance flatness	$V_S = -10\text{ V}$, 0 V , $+10\text{ V}$, $I_S = 1\text{ mA}$			23	33	Ω
			$T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$		35	Ω	
			$T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$		37	Ω	
R_{ON_DRIFT}	On-resistance drift	$V_S = 0\text{ V}$		0.42			$\%/^\circ\text{C}$
$I_{S(OFF)}$	Source off leakage current ⁽¹⁾	Switch state is off, $V_S = +10\text{ V}$ / -10 V , $V_D = -10\text{ V}$ / $+10\text{ V}$		-0.05	0.005	0.05	nA
		Switch state is off, $V_S = +10\text{ V}$ / -10 V , $V_D = -10\text{ V}$ / $+10\text{ V}$	$T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$	-0.17		0.1	nA
		Switch state is off, $V_S = +10\text{ V}$ / -10 V , $V_D = -10\text{ V}$ / $+10\text{ V}$	$T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$	-1		0.25	nA
$I_{D(ON)}$	Drain on leakage current	Switch state is on, $V_S = +10\text{ V}$ / -10 V , $V_D = -10\text{ V}$ / $+10\text{ V}$		-0.06	0.008	0.06	nA
			$T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$	-0.25		0.15	nA
			$T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$	-1.6		0.4	nA
DIGITAL INPUT (SELx pins)							
V_{IH}	Logic voltage high			2			V
V_{IL}	Logic voltage low					0.8	V

6.5 Electrical Characteristics (Dual Supplies: ±15 V) (continued)

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

PARAMETER		TEST CONDITIONS	TEST CONDITIONS	MIN	TYP	MAX	UNIT
$R_{PD(SELx)}$	Pull-down resistance on SELx pins				6		M Ω
POWER SUPPLY							
I_{DD}	V_{DD} supply current	$V_A = 0\text{ V}$ or 3.3 V , $V_S = 0\text{ V}$	$T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$		17	21	μA
			$T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$			22	μA
			$T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$			23	μA
I_{SS}	V_{SS} supply current	$V_A = 0\text{ V}$ or 3.3 V , $V_S = 0\text{ V}$	$T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$		8	10	μA
			$T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$			11	μA
			$T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$			12	μA

 (1) When V_S is positive, V_D is negative, and vice versa.

6.6 Switching Characteristics (Dual Supplies: ±15 V)

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
t_{TRAN}	Transition time	$V_S = 10\text{ V}$, $R_L = 300\ \Omega$, $C_L = 35\text{ pF}$		66	78	ns
		$V_S = 10\text{ V}$, $R_L = 300\ \Omega$, $C_L = 35\text{ pF}$, $T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$			107	ns
		$V_S = 10\text{ V}$, $R_L = 300\ \Omega$, $C_L = 35\text{ pF}$, $T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$			117	ns
t_{BBM}	Break-before-make time delay	$V_S = 10\text{ V}$, $R_L = 300\ \Omega$, $C_L = 35\text{ pF}$, $T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$	20	40		ns
Q_J	Charge injection	$V_S = 0\text{ V}$, $R_S = 0\ \Omega$, $C_L = 1\text{ nF}$		-0.4		pC
O_{ISO}	Off-isolation	$R_L = 50\ \Omega$, $C_L = 5\text{ pF}$, $f = 1\text{ MHz}$		-85		dB
X_{TALK}	Channel-to-channel crosstalk	$R_L = 50\ \Omega$, $C_L = 5\text{ pF}$, $f = 1\text{ MHz}$ (Inter-channel: S1x and S2x)		-105		dB
		$R_L = 50\ \Omega$, $C_L = 5\text{ pF}$, $f = 1\text{ MHz}$ (Intra-channel: SxA and SxB)		-92		dB
I_L	Insertion loss	$R_L = 50\ \Omega$, $C_L = 5\text{ pF}$, $f = 1\text{ MHz}$		-7		dB
ACPSRR	AC Power Supply Rejection Ratio	$R_L = 10\text{ k}\Omega$, $C_L = 5\text{ pF}$, $V_{PP} = 0.62\text{ V}$ on V_{DD} , $f = 1\text{ MHz}$		-59		dB
		$R_L = 10\text{ k}\Omega$, $C_L = 5\text{ pF}$, $V_{PP} = 0.62\text{ V}$ on V_{SS} , $f = 1\text{ MHz}$		-59		dB
BW	-3dB Bandwidth	$R_L = 50\ \Omega$, $C_L = 5\text{ pF}$		670		MHz
THD	Total harmonic distortion + noise	$R_L = 10\text{ k}\Omega$, $C_L = 5\text{ pF}$, $f = 20\text{ Hz}$ to 20 kHz		0.08		%
C_{IN}	Digital input capacitance	$V_{\text{IN}} = 0\text{ V}$ or V_{DD}		1.5		pF
$C_{\text{S(OFF)}}$	Source off-capacitance	$V_S = 0\text{ V}$, $f = 1\text{ MHz}$		2.4	3.3	pF
$C_{\text{S(ON)}}$, $C_{\text{D(ON)}}$	Source and drain on-capacitance	$V_S = 0\text{ V}$, $f = 1\text{ MHz}$		5.5	7.5	pF

6.7 Electrical Characteristics (Single Supply: 12 V)

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

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT		
ANALOG SWITCH									
V_A	Analog signal range			V_{SS}		V_{DD}	V		
R_{ON}	On-resistance	$V_S = 10\text{ V}$, $I_S = 1\text{ mA}$			235	345	Ω		
			$T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$			400	Ω		
			$T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$			440	Ω		
ΔR_{ON}	On-resistance mismatch between channels	$V_S = 10\text{ V}$, $I_S = 1\text{ mA}$			4	12	Ω		
			$T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$			19	Ω		
			$T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$			23	Ω		
R_{ON_DRIFT}	On-resistance drift	$V_S = 0\text{ V}$			0.47		%/ $^\circ\text{C}$		
$I_{S(OFF)}$	Source off leakage current ⁽¹⁾	Switch state is off, $V_S = 10\text{ V}$ / 1 V , $V_D = 1\text{ V}$ / 10 V			-0.03	0.005	0.03	nA	
			$T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$			-0.1		0.07	nA
			$T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$			-0.8		0.2	nA
$I_{D(ON)}$	Drain on leakage current	Switch state is on, $V_S =$ floating, $V_D = 1\text{ V}$ / 10 V			-0.04	0.01	0.04	nA	
			$T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$			-0.16		0.09	nA
			$T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$			-1.2		0.3	nA
DIGITAL INPUT (SELx pins)									
V_{IH}	Logic voltage high			2			V		
V_{IL}	Logic voltage low					0.8	V		
$R_{PD(SELx)}$	Pull-down resistance on SELx pins				6		M Ω		
POWER SUPPLY									
I_{DD}	V_{DD} supply current	$V_A = 0\text{ V}$ or 3.3 V , $V_S = 0\text{ V}$			13	16	μA		
			$T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$			17	μA		
			$T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$			18	μA		

(1) When V_S is positive, V_D is negative, and vice versa.

6.8 Switching Characteristics (Single Supply: 12 V)

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

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
t_{TRAN}	Transition time	$V_S = 8\text{ V}$, $R_L = 300\ \Omega$, $C_L = 35\text{ pF}$			72	84	ns
		$V_S = 8\text{ V}$, $R_L = 300\ \Omega$, $C_L = 35\text{ pF}$, $T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$				117	ns
		$V_S = 8\text{ V}$, $R_L = 300\ \Omega$, $C_L = 35\text{ pF}$, $T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$				128	ns
t_{BBM}	Break-before-make time delay	$V_S = 8\text{ V}$, $R_L = 300\ \Omega$, $C_L = 35\text{ pF}$, $T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$		20	40		ns
Q_J	Charge injection	$V_S = 6\text{ V}$, $R_S = 0\ \Omega$, $C_L = 1\text{ nF}$			-0.7		pC
O_{ISO}	Off-isolation	$R_L = 50\ \Omega$, $C_L = 5\text{ pF}$, $f = 1\text{ MHz}$			-85		dB
X_{TALK}	Channel-to-channel crosstalk	$R_L = 50\ \Omega$, $C_L = 5\text{ pF}$, $f = 1\text{ MHz}$ (Inter-channel: S1x and S2x)			-110		dB
		$R_L = 50\ \Omega$, $C_L = 5\text{ pF}$, $f = 1\text{ MHz}$ (Intra-channel: SxA and SxB)			-95		dB
I_L	Insertion loss	$R_L = 50\ \Omega$, $C_L = 5\text{ pF}$, $f = 1\text{ MHz}$			-13		dB
ACPSRR	AC Power Supply Rejection Ratio	$R_L = 10\text{ k}\Omega$, $C_L = 5\text{ pF}$, $V_{PP} = 0.62\text{ V}$, $f = 1\text{ MHz}$			-58		dB
BW	-3dB Bandwidth	$R_L = 50\ \Omega$, $C_L = 5\text{ pF}$			650		MHz

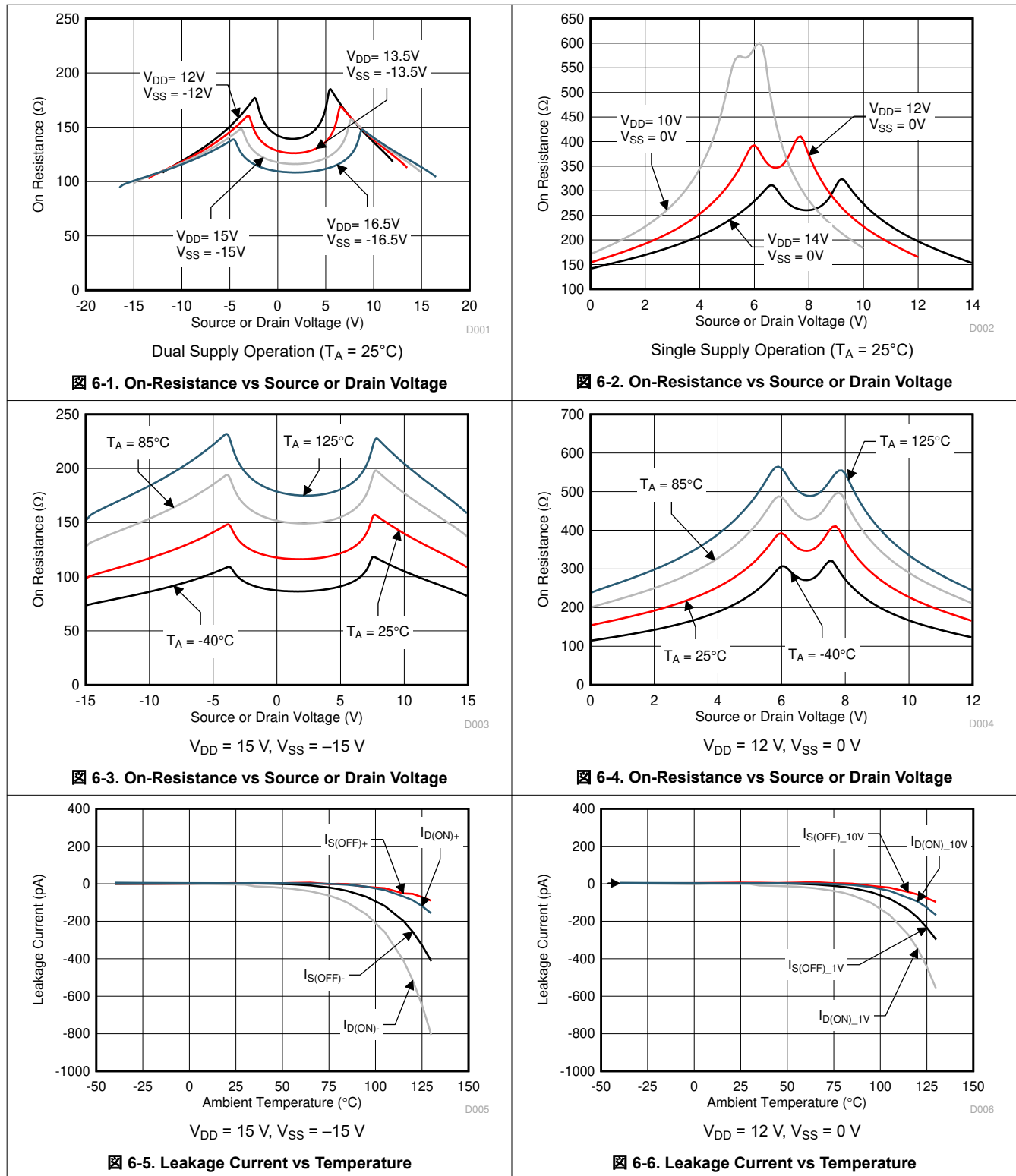
6.8 Switching Characteristics (Single Supply: 12 V) (continued)

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
C_{IN}	Digital input capacitance	$V_{IN} = 0\text{ V}$ or V_{DD}		1.7		pF
$C_{S(OFF)}$	Source off-capacitance	$V_S = 6\text{ V}$, $f = 1\text{ MHz}$		2.6	3.7	pF
$C_{S(ON)}$, $C_{D(ON)}$	Source and drain on-capacitance	$V_S = 6\text{ V}$, $f = 1\text{ MHz}$		6.3	8.5	pF

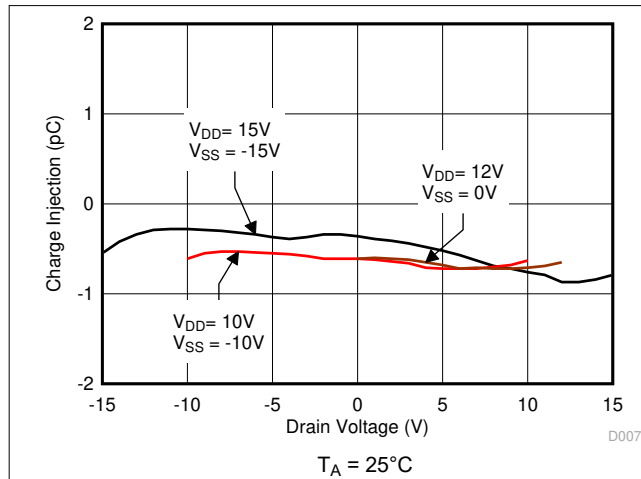
Typical Characteristics

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

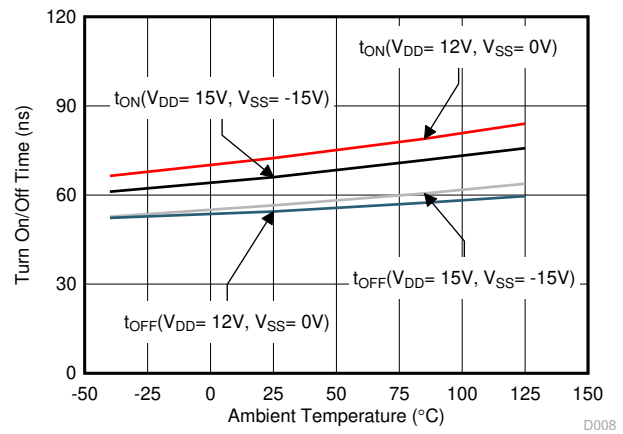


Typical Characteristics

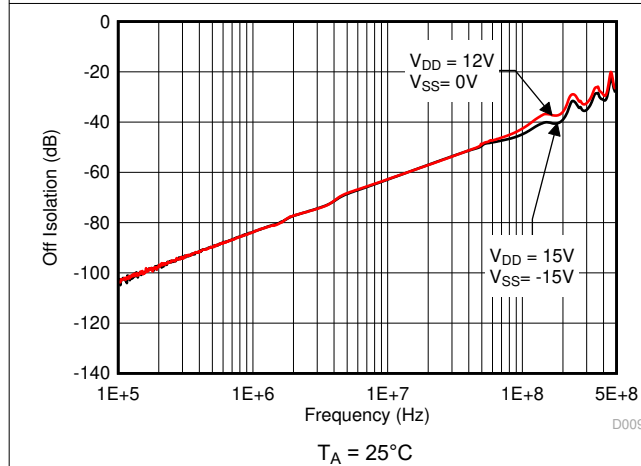
at $T_A = 25^\circ\text{C}$, $V_{DD} = 15\text{ V}$, and $V_{SS} = -15\text{ V}$ (unless otherwise noted)



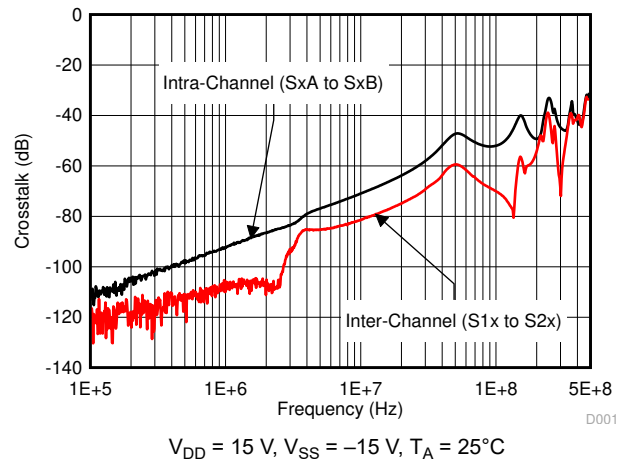
6-7. Charge Injection vs Source Voltage



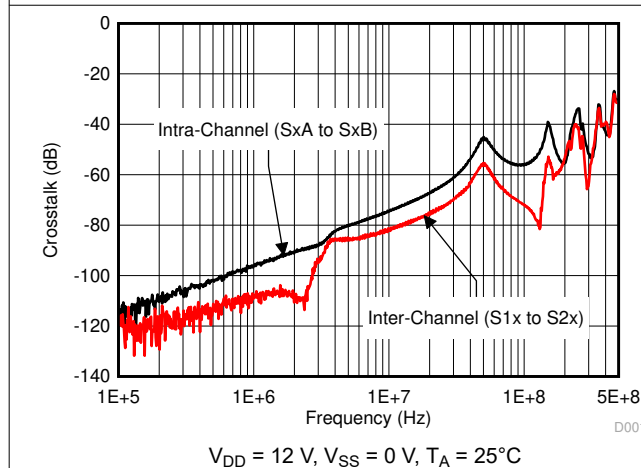
6-8. Transition Times vs Temperature



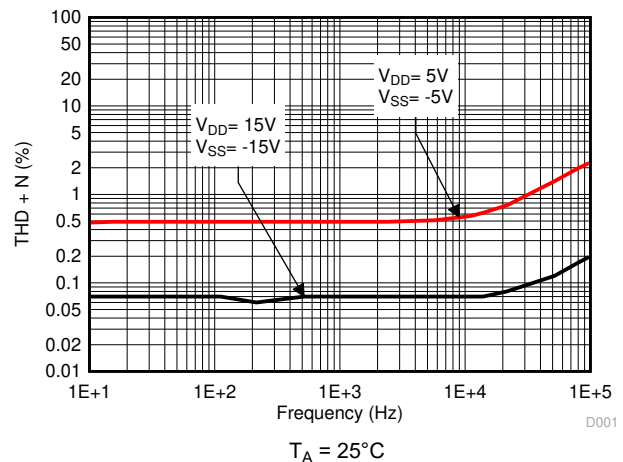
6-9. Off Isolation vs Frequency



6-10. Crosstalk vs Frequency



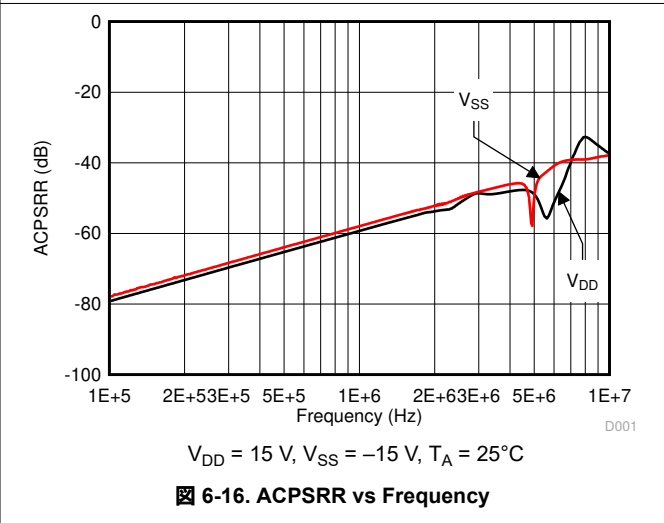
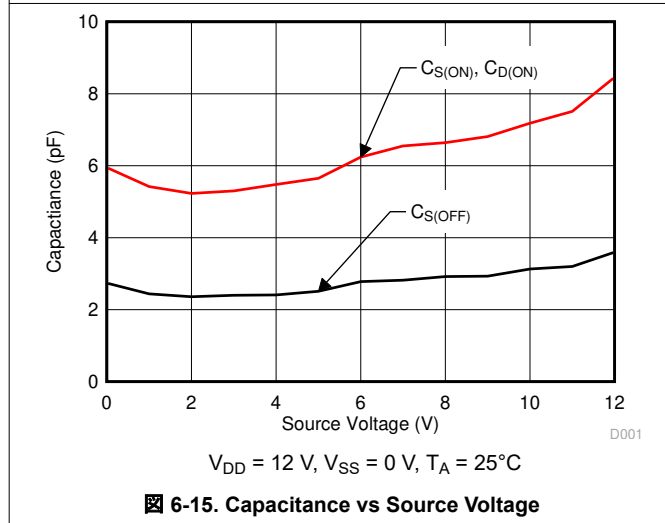
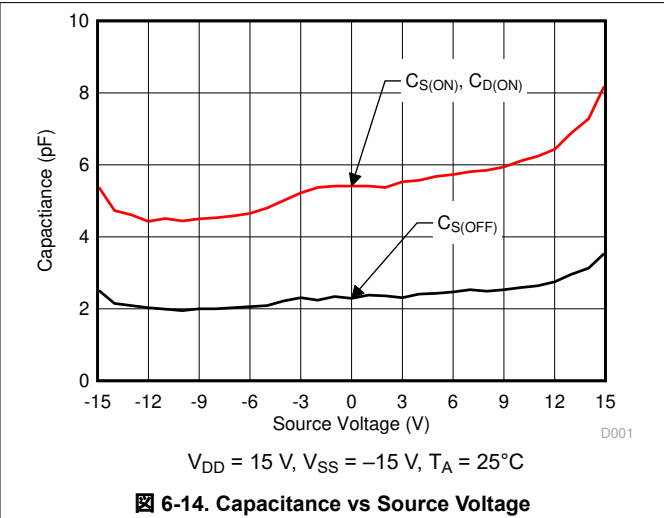
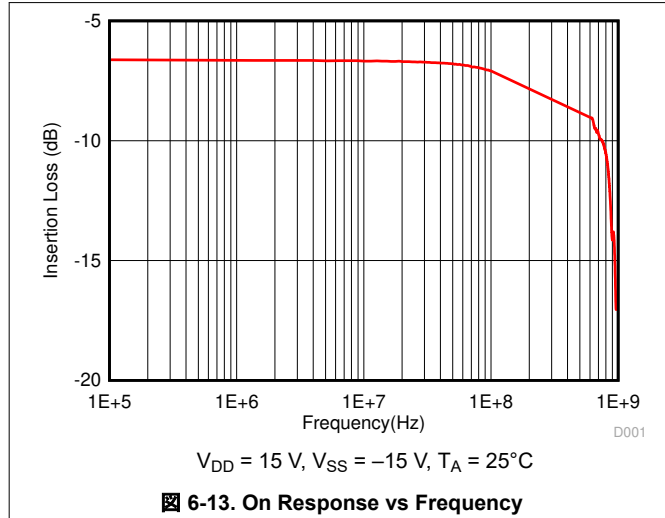
6-11. Crosstalk vs Frequency



6-12. THD+N vs Frequency

Typical Characteristics

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



7 Detailed Description

7.1 Overview

7.1.1 On-Resistance

The on-resistance of the TMUX6136 is the ohmic resistance across the source (Sx) and drain (D) pins of the device. The on-resistance varies with input voltage and supply voltage. The symbol R_{ON} is used to denote on-resistance. The measurement setup used to measure R_{ON} is shown in [Figure 7-1](#). Voltage (V) and current (I_{CH}) are measured using this setup, and R_{ON} is computed as shown in [Equation 1](#).

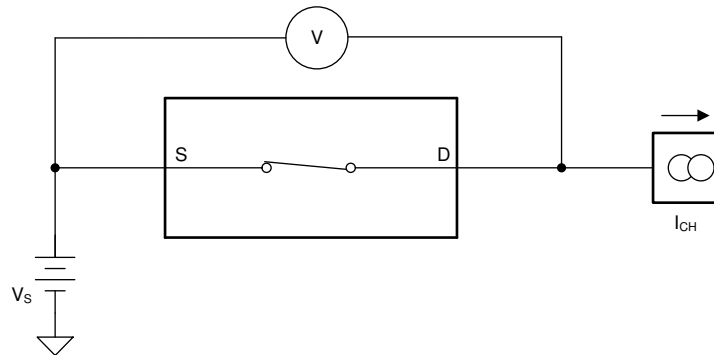


Figure 7-1. On-Resistance Measurement Setup

$$R_{ON} = V / I_{CH} \tag{1}$$

7.1.2 Off-Leakage Current

Source off-leakage current is defined as the leakage current that flows into or out of the source pin when the switch is in the off state. This current is denoted by the symbol $I_{S(OFF)}$. Drain off-leakage measurement is not characterization since the drain pin is always connected to one of the two source pins.

The setup used to measure both off-leakage currents is shown in [Figure 7-2](#).

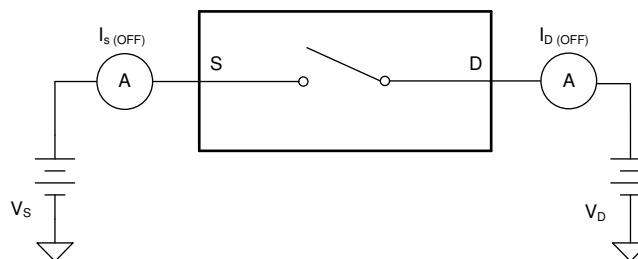


Figure 7-2. Off-Leakage Measurement Setup

7.1.3 On-Leakage Current

On-leakage current is defined as the leakage current that flows into or out of the drain pin when the switch is in the on state. The source pin is left floating during the measurement. [Figure 7-3](#) shows the circuit used for measuring the on-leakage current, denoted by $I_{D(ON)}$.

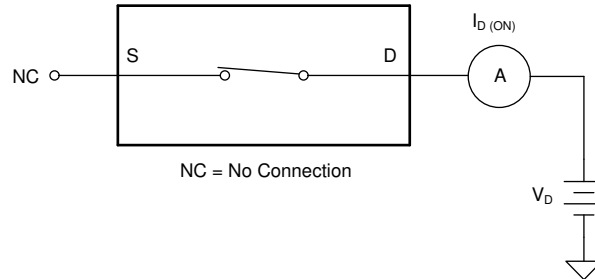


Figure 7-3. On-Leakage Measurement Setup

7.1.4 Transition Time

Transition time is defined as the time taken by the output of the TMUX6136 to rise or fall to 90% of the transition after the digital address signal has fallen or risen to 50% of the transition. [Figure 7-4](#) shows the setup used to measure transition time, denoted by the symbol t_{TRAN} .

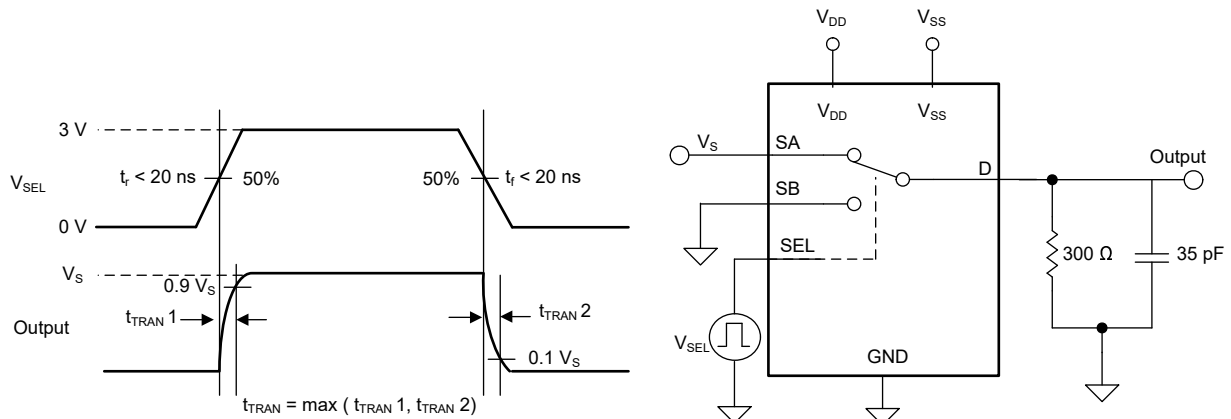

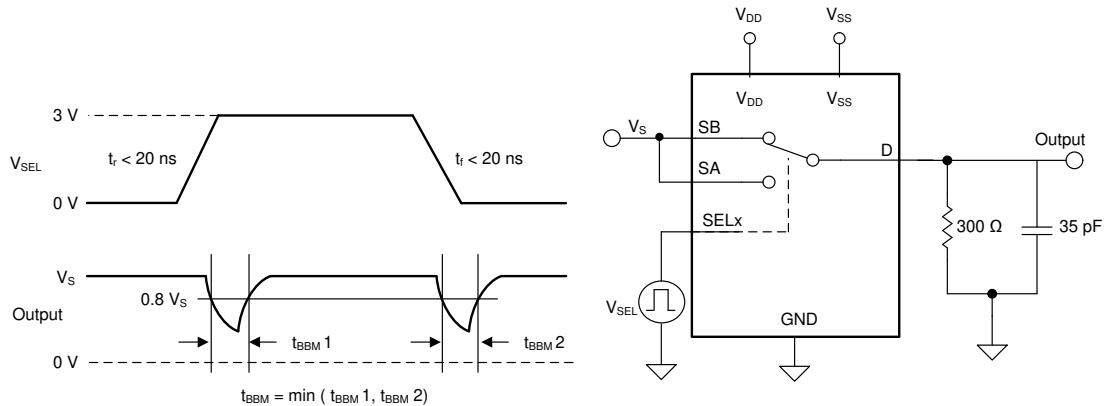


Figure 7-4. Transition-Time Measurement Setup


7.1.5 Break-Before-Make Delay

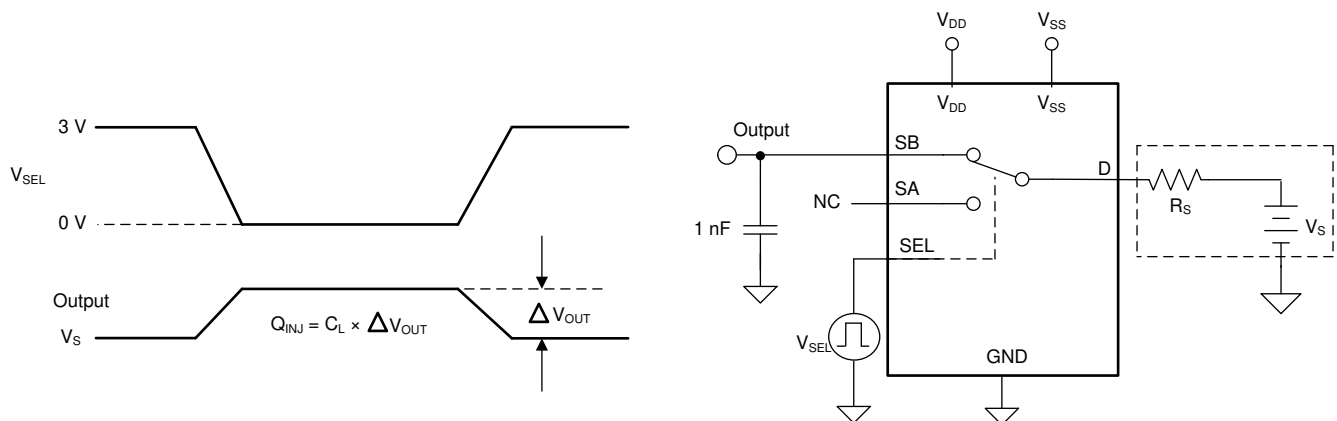
Break-before-make delay is a safety feature that prevents two inputs from connecting when the TMUX6136 is switching. The TMUX6136 output first breaks from the on-state switch before making the connection with the next on-state switch. The time delay between the *break* and the *make* is known as break-before-make delay.  7-5 shows the setup used to measure break-before-make delay, denoted by the symbol t_{BBM} .



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


7.1.6 Charge Injection

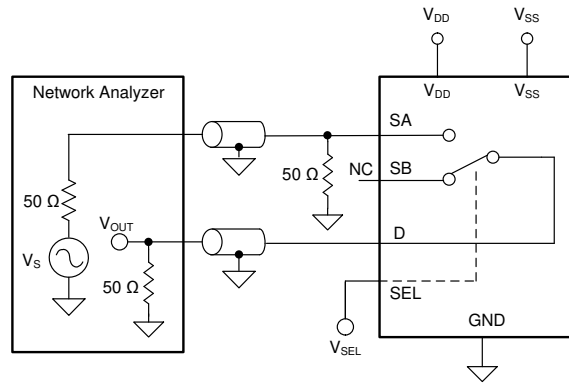
The TMUX6136 have a simple transmission-gate topology. Any mismatch in capacitance between the NMOS and PMOS transistors results in a charge injected into the drain or source during the falling or rising edge of the gate signal. The amount of charge injected into the source of the device is known as charge injection, and is denoted by the symbol Q_{INJ} .  7-6 shows the setup used to measure charge injection from drain (D) to source (Sx).



 7-6. Charge-Injection Measurement Setup

7.1.7 Off Isolation

Off isolation is defined as the voltage at the drain pin (D) of the TMUX6136 when a $1-V_{RMS}$ signal is applied to the source pin (Sx) of an off-channel.  7-7 shows the setup used to measure off isolation. Use 式 2 to compute off isolation.



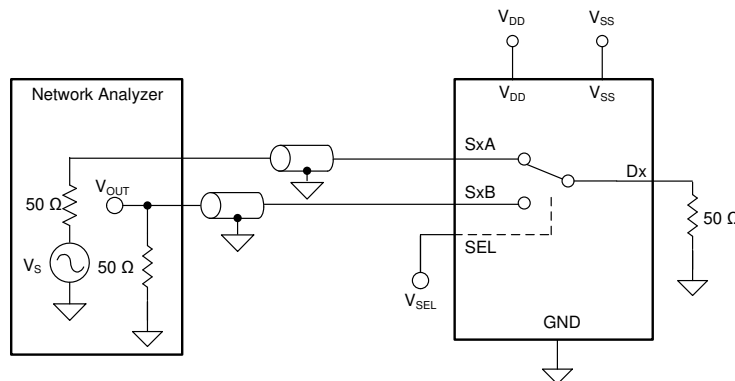
7-7. Off Isolation Measurement Setup

$$\text{Off Isolation} = 20 \cdot \text{Log} \left(\frac{V_{\text{OUT}}}{V_{\text{S}}} \right) \quad (2)$$

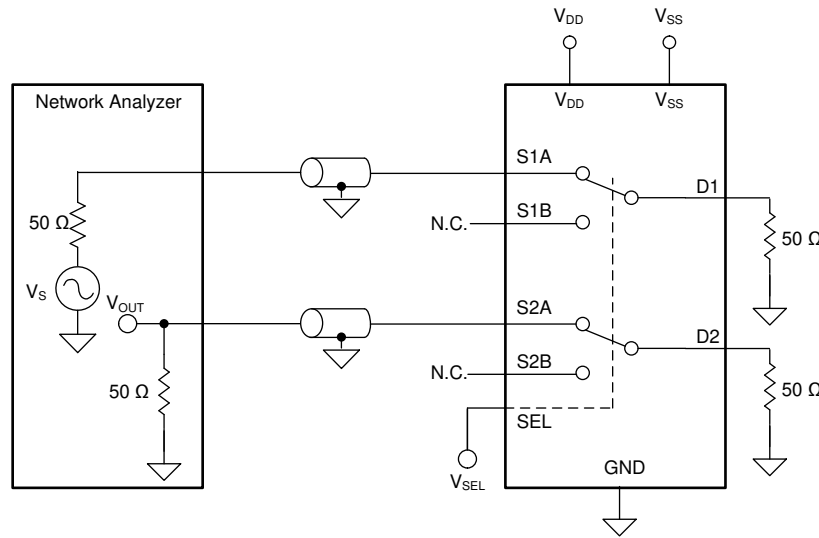
7.1.8 Channel-to-Channel Crosstalk

There are two types of crosstalk that can be defined for the TMUX6136:

1. Intra-channel crosstalk: the voltage at the source pin (Sx) of an off-switch input, when a 1-VRMS signal is applied at the source pin of an on-switch input in the same channel, as shown in [7-8](#).
2. Inter-channel crosstalk: the voltage at the source pin (Sx) of an on-switch input, when a 1-VRMS signal is applied at the source pin of an on-switch input in a different channel, as shown in [7-9](#).



7-8. Intra-Channel Crosstalk Measurement Setup

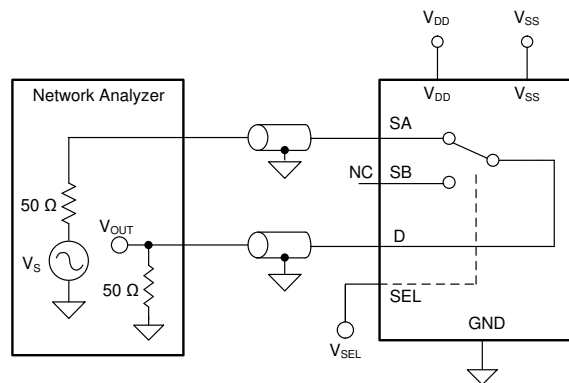


7-9. Inter-Channel Crosstalk Measurement Setup

$$\text{Channel-to-Channel Crosstalk} = 20 \cdot \text{Log} \left(\frac{V_{\text{OUT}}}{V_s} \right) \tag{3}$$

7.1.9 Bandwidth

Bandwidth is defined as the range of frequencies that are attenuated by < 3 dB when the input is applied to the source pin (Sx) of an on-channel, and the output is measured at the drain pin (D) of the TMUX6136. [7-10](#) shows the setup used to measure bandwidth of the mux. Use [4](#) to compute the attenuation.

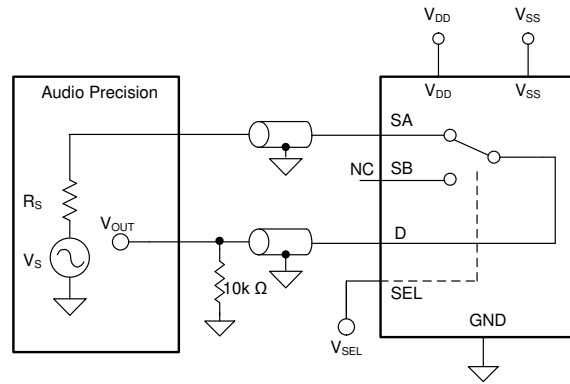


7-10. Bandwidth Measurement Setup

$$\text{Attenuation} = 20 \cdot \text{Log} \left(\frac{V_2}{V_1} \right) \tag{4}$$

7.1.10 THD + Noise

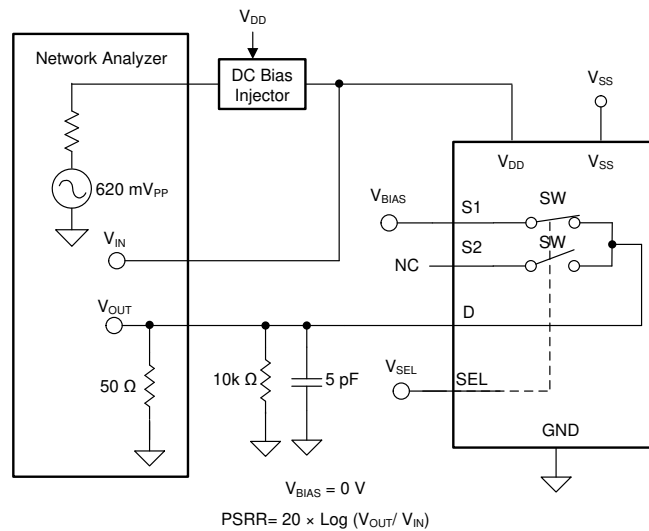
The total harmonic distortion (THD) of a signal is a measurement of the harmonic distortion, and is defined as the ratio of the sum of the powers of all harmonic components to the power of the fundamental frequency at the mux output. The on-resistance of the TMUX6136 varies with the amplitude of the 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.



7-11. THD+N Measurement Setup

7.1.11 AC Power Supply Rejection Ratio (AC PSRR)

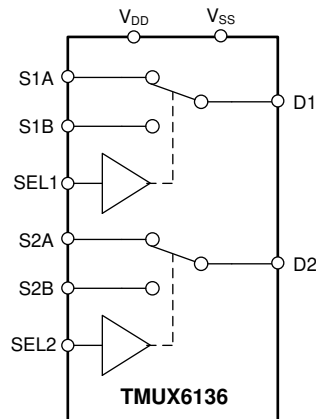
AC PSRR measures the ability of a device to prevent noise and spurious signals that appear on the supply voltage pin from coupling to the output of the switch. The DC voltage on the device supply is modulated by a sine wave of 620 mV_{PP}. The ratio of the amplitude of signal on the output to the amplitude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



7-12. AC PSRR Measurement Setup

For a top-level block diagram of the TMUX6136, see [セクション 7.2](#). The TMUX6136 is a 4-channel, single-ended, analog multiplexer. Each channel is turned on or turned off based on the state of the address lines and enable pin.

7.2 Functional Block Diagram



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7.3 Feature Description

7.3.1 Ultralow Leakage Current

The TMUX6136 provides extremely low on- and off-leakage currents. The TMUX6136 is capable of switching signals from high source-impedance inputs into a high input-impedance op amp with minimal offset error because of the ultralow leakage currents. [Figure 7-13](#) shows typical leakage currents of the TMUX6136 versus temperature.

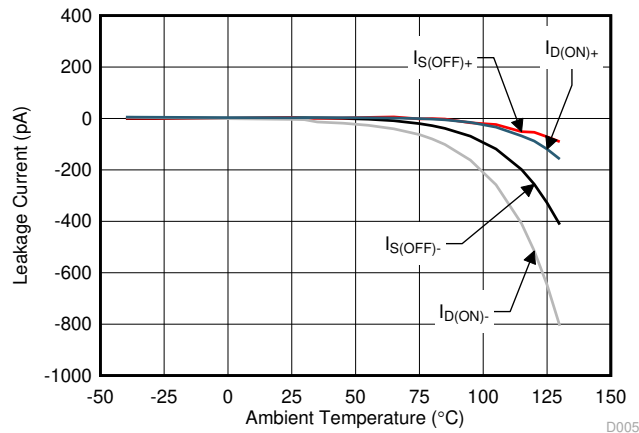


Figure 7-13. Leakage Current vs Temperature

7.3.2 Ultralow Charge Injection

The TMUX6136 is implemented with simple transmission gate topology, as shown in [Figure 7-14](#). Any mismatch in the stray capacitance associated with the NMOS and PMOS causes an output level change whenever the switch is opened or closed.

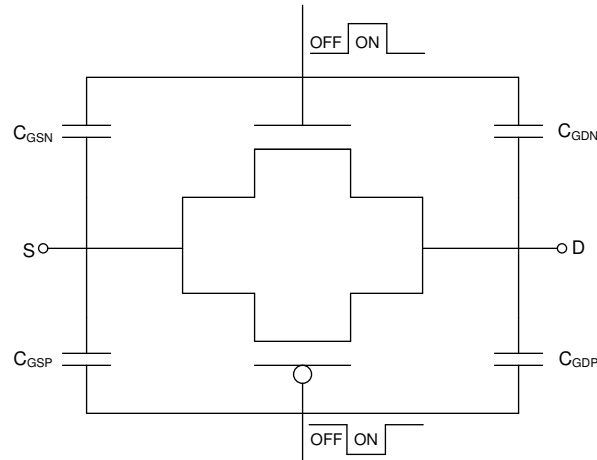


图 7-14. Transmission Gate Topology

The TMUX6136 utilizes special charge-injection cancellation circuitry that reduces the drain (D)-to-source (Sx) charge injection to as low as -0.4 pC at $V_S = 0 \text{ V}$, as shown in 图 7-15.

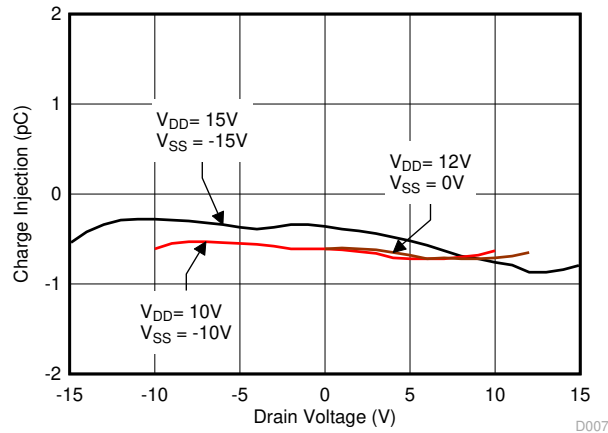


图 7-15. Charge Injection vs Drain Voltage

7.3.3 Bidirectional and Rail-to-Rail Operation

The TMUX6136 conducts equally well from source (Sx) to drain (D) or from drain (D) to source (Sx). Each TMUX6136 channel has very similar characteristics in both directions. The valid analog signal for TMUX6136 ranges from V_{SS} to V_{DD} . The input signal to the TMUX6136 swings from V_{SS} to V_{DD} without any significant degradation in performance.

7.4 Device Functional Modes

7.4.1 Truth Table

表 7-1. TMUX6136 Truth Table

SELx	Switch A (S1A to D1 or S2A to D2)	Switch B (S1B to D1 or S2B to D2)
0	OFF	ON
1	ON	OFF

8 Application and Implementation

注

以下のアプリケーション情報は、TI の製品仕様に含まれるものではなく、TI ではその正確性または完全性を保証いたしません。個々の目的に対する製品の適合性については、お客様の責任で判断していただくこととなります。お客様は自身の設計実装を検証しテストすることで、システムの機能を確認する必要があります。

8.1 Application Information

The TMUX6136 offers outstanding input and output leakage currents and ultralow charge injection. The device operates up to 33 V (V_{DD} to V_{SS} dual supply) or 16.5 V (V_{DD} single supply), and offers true rail-to-rail input and output. The on-capacitance of the TMUX6136 is low. These features make the TMUX6136 a precision, robust, high-performance analog multiplexer for high-voltage, industrial applications.

8.2 Typical Application

One example of the TMUX6136 precision performance to take advantage of is the implementation of parametric measurement unit (PMU) in the semiconductor automatic test equipment (ATE) application. The PMU is frequently used to characterize and measure the digital pin's DC characteristics of a device under test (DUT). Among all the PMU's capabilities, force voltage measure current (FVMC) and force current measure voltage (FCMV) are the two most typical configurations in DC characterizations.

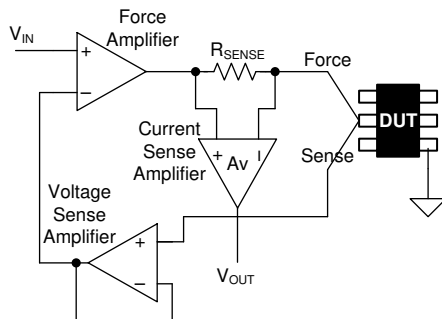


図 8-1. FVMC Measurement in PMU

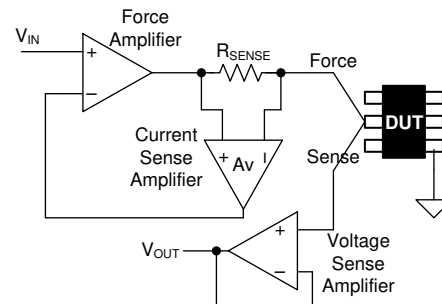


図 8-2. FCMV Measurement in PMU

図 8-1 shows a simplified diagram of the PMU in FVMC configuration. The control loop consists of the force amplifier with the voltage sense amplifier (unity gain in this example) making up the feedback path. Current flowing through the DUT is measured by sensing the current flowing through a sense resistor (R_{SENSE}) in series with the DUT. The current sense amplifier with a gain of A_v generates a voltage (V_{OUT}) at its output and the voltage can then be measured by an ADC. The voltage produced at the DUT pin stays at the input voltage level (V_{IN}) as long as the force amplifier does not rail out (for example, $I_{DUT} \times R_{SENSE} \times A_v$ stays within the input voltage range of the force amplifier). Depending on the level of the DUT current to be measured, different gain settings need to be configured for the current sense amplifier.

図 8-2 shows a simplified diagram of the PMU in FCMV mode. The voltage V_{IN} is now converted to a current through the following relationship:

$$\text{Force Current} = V_{IN} / (R_{SENSE} \times A_v) \quad (5)$$

The control loop consists of the force amplifier with the current sense amplifier making up the feedback path. The voltage at the DUT is sensed across the voltage sense amplifier (unity gain in this example) and presented at the output for sample.

8.2.1 Design Requirements

The goal of this design example is to simplify the FVMC and FCMV functions of a PMU design using a SPDT switch. The FVMC configuration is useful to test a device being used as a power supply, or in continuity or

leakage testing. In this configuration, the input voltage is directly applied to the DUT pin, and the current into or out of the DUT pin is converted to a voltage by a sense resistor and measured by an analog to digital converter (ADC). In the FCMV mode, an input current is forced to the DUT and the produced voltage on the DUT pin is directly measured. In this example, the PMU design is required to meet the following specifications:

- Force voltage range: –15 volts to +15 volts
- Force current range: $\pm 5 \mu\text{A}$ to $\pm 50 \text{ mA}$
- Measure voltage range: –15 volts to +15 volts
- Measure current range: $\pm 5 \mu\text{A}$ to $\pm 50 \text{ mA}$

In addition to the voltage and current requirements, fast throughput is also a key requirement in ATE because it relates directly to the cost of manufacturing the DUT.

8.2.2 Detailed Design Procedure

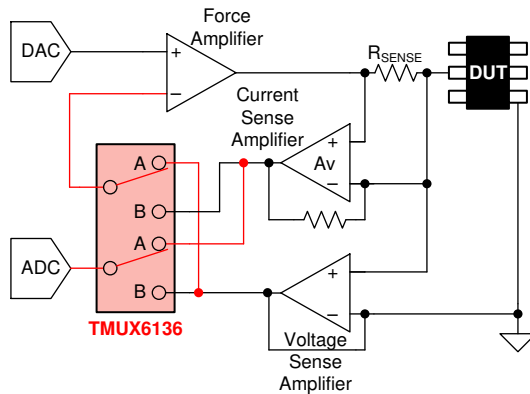


FIG 8-3. FVMC Implementation in PMU Using the TMUX6136

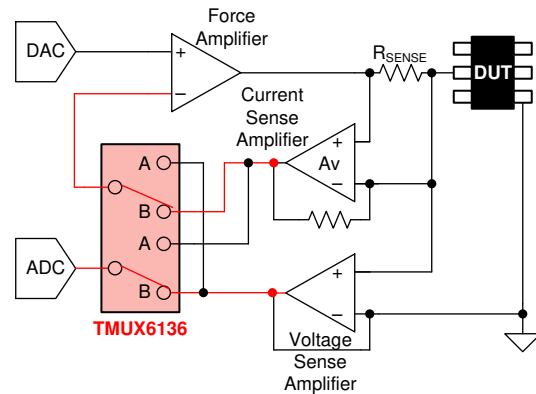
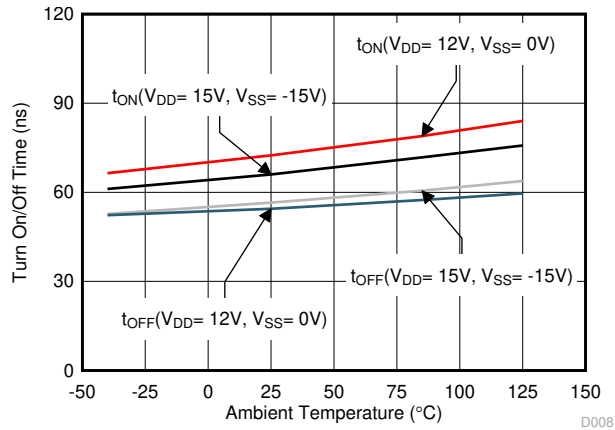


FIG 8-4. FCMV Implementation in PMU Using the TMUX6136

The implementation of the FVMC and FCMV modes can be combined with the use of a dual SPDT switch such as the TMUX6136. FIG 8-3 and FIG 8-4 shows simplified diagrams of such implementations. In the FVMC mode, the switch is toggled to position A and this allows the voltage sense amplifier to become part of the feedback loop and the voltage output of the current sense amplifier to be sampled by the ADC. In the FCMV mode, the switch is toggled to position B, and this allows the current sense amplifier to become part of the feedback loop and the voltage output of the voltage sense amplifier to be sampled by the ADC.

8.2.3 Application Curve

The fast transition time of the TMUX6136 and low input or output parasitic capacitance help minimize the settling time, making the TMUX6136 an excellent candidate to implement the FVMC and FCMV functions of the PMU. [8-5](#) shows the plot for the transition time versus temperature for the TMUX6136.



8-5. Transition Time vs Temperature for TMUX6136

9 Power Supply Recommendations

The TMUX6136 operates across a wide supply range of ± 5 V to ± 16.5 V (10 V to 16.5 V in single-supply mode). The device also performs well with unsymmetric supplies such as $V_{DD} = 12$ V and $V_{SS} = -5$ V. For reliable operation, use a supply decoupling capacitor ranging between 0.1 μ F to 10 μ F at both the V_{DD} and V_{SS} pins to ground.

10 Layout

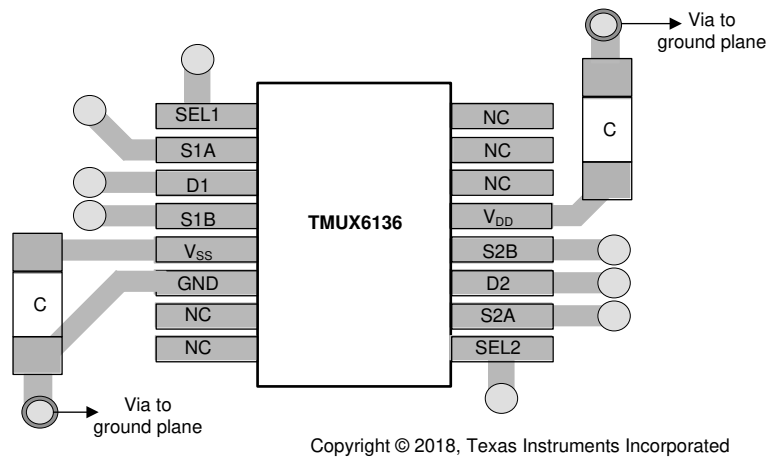
10.1 Layout Guidelines

☒ 10-1 shows an example of a PCB layout with the TMUX6136.

Some key considerations are as follows:

1. Decouple the V_{DD} and V_{SS} pins with a 0.1- μF capacitor, placed as close to the pin as possible. Make sure that the capacitor voltage rating is sufficient for the V_{DD} and V_{SS} supplies.
2. Keep the input lines as short as possible.
3. Use a solid ground plane to help distribute heat and reduce electromagnetic interference (EMI) noise pickup.
4. Do not run sensitive analog traces in parallel with digital traces. Avoid crossing digital and analog traces if possible, and only make perpendicular crossings when necessary.

10.2 Layout Example



☒ 10-1. TMUX6136 Layout Example

11 Device and Documentation Support

11.1 Documentation Support

11.1.1 Related Documentation

For related documentation, see the following:

- Texas Instruments, [ADS8664 12-Bit, 500-kSPS, 4- and 8-Channel, Single-Supply, SAR ADCs with Bipolar Input Ranges](#)
- Texas Instruments, [OPA192 36-V, Precision, Rail-to-Rail Input/Output, Low Offset Voltage, Low Input Bias Current Op Amp with e-Trim™](#)

11.2 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.

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11.5 Electrostatic Discharge Caution



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

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

11.6 Glossary

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

12 Mechanical, Packaging, and Orderable Information

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

PACKAGING INFORMATION

Orderable 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
TMUX6136PWR	ACTIVE	TSSOP	PW	16	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	MUX6136	Samples

(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.

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TAPE AND REEL INFORMATION

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TMUX6136PWR	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)
TMUX6136PWR	TSSOP	PW	16	2000	356.0	356.0	35.0



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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



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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.

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

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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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