

TPS3704x 四通道/三通道/双通道/单通道窗口或标准电压监控器

1 特性

- 专为高性能和安全性而设计：
 - 输入电流 (4 通道) : $I_{DD} = 15\mu\text{A}$ (最大值)
 - 高阈值精度 : $\pm 1\%$ (最大值)
 - 内置精密迟滞 : $V_{HYS} (V_{IT} > 800\text{mV}) = 0.75\%$ (典型值)
- 符合功能安全标准
 - 专为功能安全应用开发
 - 有助于进行 IEC 61508 系统设计的文档
 - 系统可满足 SIL 3 等级要求
 - 硬件可满足 SIL 1 等级要求
 - 自检 - 手动设置
- 适用于多种应用：
 - 四通道、三通道、双通道或单通道电压监控器
 - TPS37044、3、2、1 : 4、3、2、1 - 通道
 - 输入电压范围 : $V_{DD} = 1.7\text{V}$ 至 6V
 - (UV/OV) 阈值精度 : $\pm 0.1\%$ (典型值)
 - 每个通道均可独立配置 : 窗口、UV 或 OV
 - 窗口公差 : $\pm 3\%$ 至 $\pm 11\%$ (可编程为非对称)
 - 高阈值分辨率 :
 - $V_{IT} \leq 0.8\text{V}$: 20mV 阶跃
 - $V_{IT} > 0.8\text{V}$: 0.5% 或 20mV 阶跃二者中的较小者
 - 每个通道的阈值电压 V_{IT} 均可独立设置
 - 所有通道上的按钮监视器
 - 复位延时时间 (t_D) : 固定延时时间选项
 - Options: 23 个固定时间选项, 范围为 $20\mu\text{s}$ (最小值) 至 1200ms (最大值)
 - 温度范围 : -40°C 至 $+125^\circ\text{C}$
- 多种输出拓扑：
 - TPS3704xxxO : 漏极开路, 低电平有效 (RESET)
 - TPS3704xxxL : 推挽, 低电平有效 ($\overline{\text{RESET}}$)
 - TPS3704xxxH : 推挽, 高电平有效 (RESET)

2 应用

- 工厂自动化
- 楼宇自动化
- 医疗
- 电机驱动器
- 电网基础设施
- 无线基础设施
- 数据中心和企业计算

3 说明

TPS3704x 是一款低功耗精密窗口或标准电压监控器, 可配置为四通道、三通道、双通道或单通道。各通道的阈值精度为 $\pm 1\%$ 。该器件采用 8 引脚 (1.6mm x 2.9mm) SOT-23 封装, 可实现小尺寸解决方案。TPS3704x 支持精确阈值检测并具有高分辨率, 非常适合采用低电压电源轨且电源容差裕度非常小的系统。内置低阈值迟滞和固定复位延迟 (t_D 可选范围为 $20\mu\text{s}$ 至 1200ms), 可防止在监控多个电压轨时发出虚假复位信号。

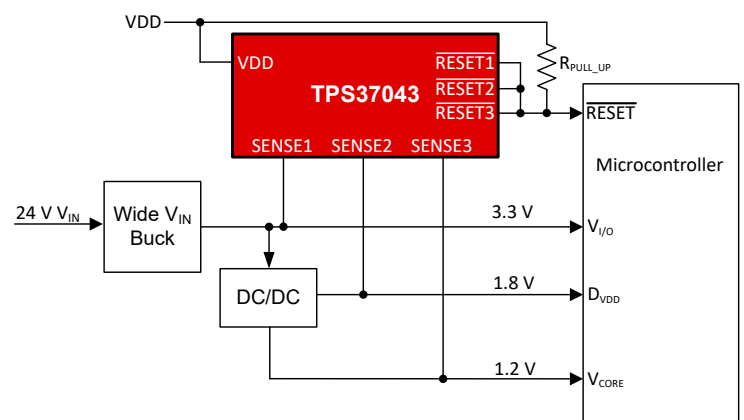
TPS3704x 无需任何外部电阻器来设置过压和欠压复位阈值, 因此进一步优化了整体精度、成本和解决方案尺寸, 提高了安全系统的可靠性。

独立的 VDD 和 SENSEx 引脚支持监控 VDD 以外的轨电压, 也可用作按钮输入。SENSEx 引脚支持使用可选的外部电阻器。TPS3704x 上的所有通道均可自定义为自己的过压和欠压窗口检测, 其上限和下限阈值公差可为对称或非对称式。

器件信息

器件型号	封装 (1)	封装尺寸 (标称值)
TPS3704x	DDF (8 引脚 SOT-23)	1.6mm x 2.9mm

(1) 如需了解所有可用封装, 请参阅数据表末尾的可订购产品附录。



典型应用电路



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4 Revision History

注：以前版本的页码可能与当前版本的页码不同

Changes from Revision B (November 2021) to Revision C (September 2022)	Page
• 添加了“功能安全”信息.....	1
• Added Manual Self-Test Option Section.....	24

Changes from Revision A (July 2021) to Revision B (November 2021)	Page
• 将“预告信息”更改为“量产数据”.....	1

5 Device Nomenclature

图 5-1 shows the device naming nomenclature to compare the different device variants. See 表 12-1 for a more detailed explanation. See 表 12-2 for the available device variants.

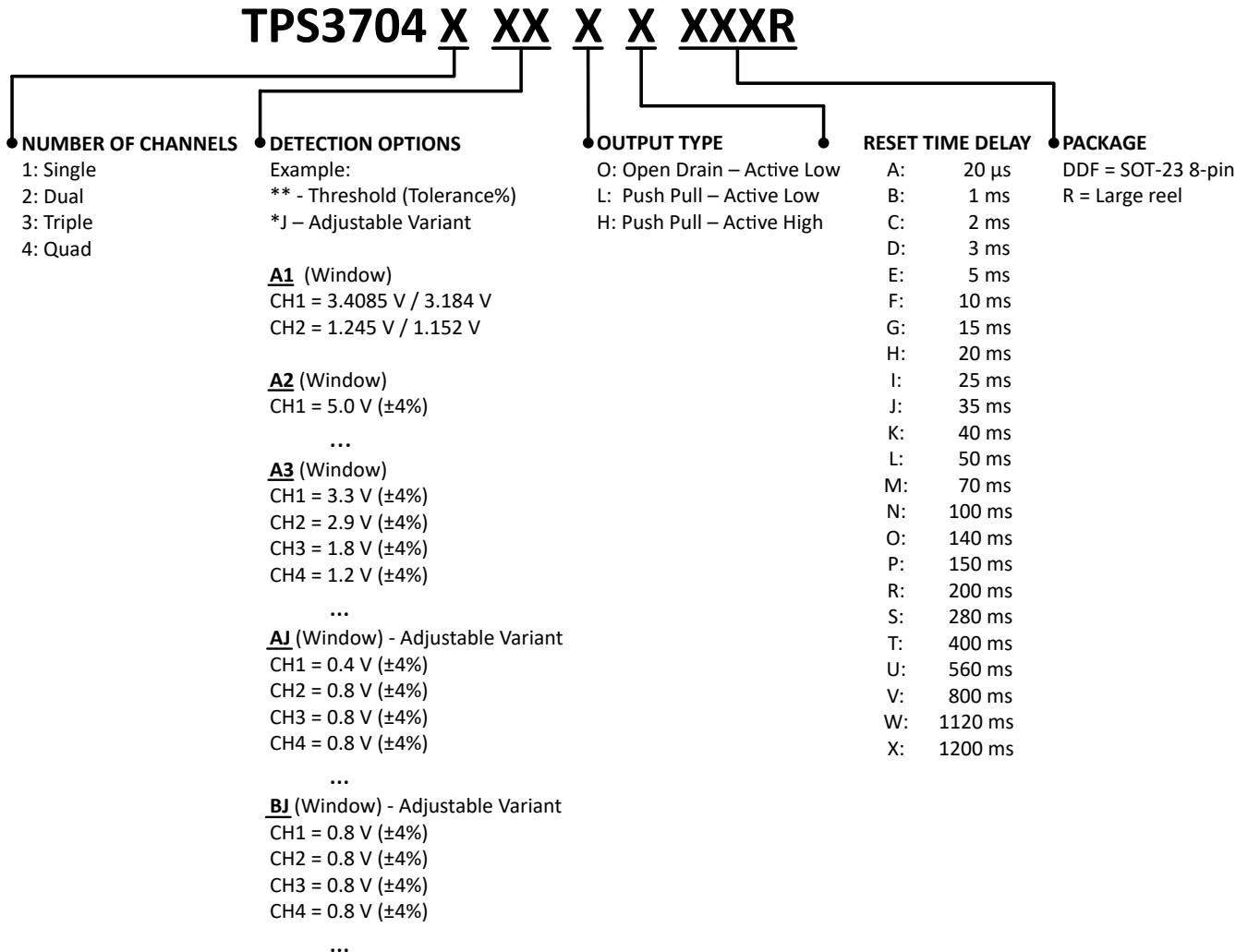
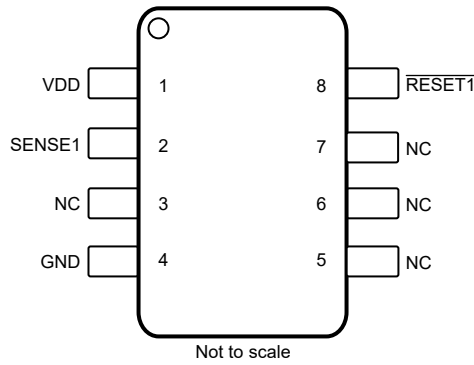
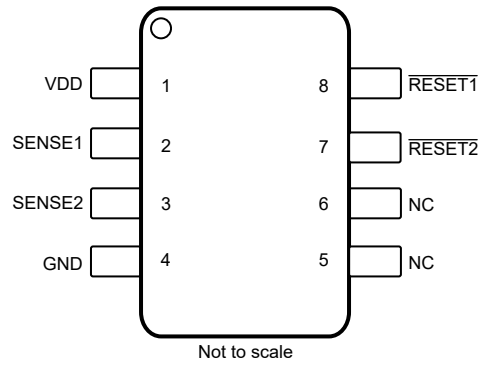


图 5-1. Device Naming Nomenclature

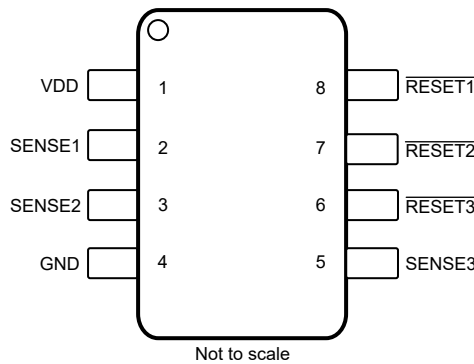
6 Pin Configuration and Functions



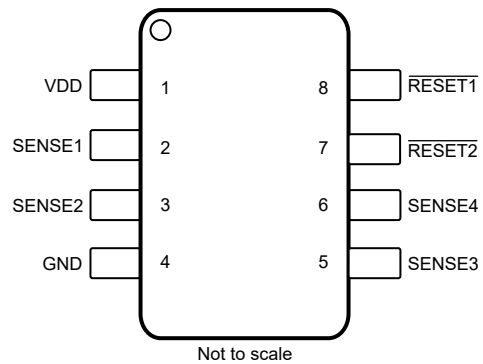
**图 6-1. SOT-23 8-PIN DDF Package
TPS37041
(Top View)**



**图 6-2. SOT-23 8-PIN DDF Package
TPS37042
(Top View)**



**图 6-3. SOT-23 8-PIN DDF Package
TPS37043
(Top View)**



**图 6-4. SOT-23 8-PIN DDF Package
TPS37044
(Top View)**

表 6-1. Pin Functions

NAME	PIN				I/O	DESCRIPTION
	TPS37041	TPS37042	TPS37043	TPS37044		
VDD	1	1	1	1	I	Supply Input. Bypass with a 0.1 μ F capacitor to GND.
SENSE1	2	2	2	2	I	Connect directly to monitored voltage. RESET1/RESET1 is asserted when SENSE1 falls outside of window threshold. No external capacitor is required for this SENSE1 pin. For TPS37044 (quad version) RESET1/RESET1 asserts when either SENSE1 or SENSE2 falls outside of window threshold. For noisy applications, placing a 10 nF to 100 nF ceramic capacitor close to this pin may be needed for optimum performance. If the input pin is not being used, it can be left floating.
SENSE2	-	3	3	3	I	Connect directly to monitored voltage. RESET2/RESET2 is asserted when SENSE2 falls outside of window threshold. No external capacitor is required for SENSE2 pin. For TPS37044 (quad version) RESET1/RESET1 asserts when either SENSE1 or SENSE2 falls outside of window threshold. For noisy applications, placing a 10 nF to 100 nF ceramic capacitor close to this pin may be needed for optimum performance. If the input pin is not being used, it can be left floating.
SENSE3	-	-	5	5	I	Connect directly to monitored voltage. RESET3/RESET3 is asserted when SENSE3 falls outside of window threshold. No external capacitor is required for SENSE3 pin. For TPS37044 (quad version) RESET2/RESET2 asserts when either SENSE3 or SENSE4 falls outside of window threshold. For noisy applications, placing a 10 nF to 100 nF ceramic capacitor close to this pin may be needed for optimum performance. If the input pin is not being used, it can be left floating.
SENSE4	-	-	-	6	I	Connect directly to monitored voltage. For TPS37044 (quad version) RESET2/RESET2 asserts when either SENSE3 or SENSE4 falls outside of window threshold. For noisy applications, placing a 10 nF to 100 nF ceramic capacitor close to this pin may be needed for optimum performance. If the input pin is not being used, it can be left floating.
RESET1 / RESET1	8	8	8	8	O	RESET1/RESET1 asserts when SENSE1 falls outside of the overvoltage or undervoltage threshold window. RESET1/RESET1 stays asserted for the reset timeout period after SENSE1 fall back within the window threshold. Active-low, open-drain reset output, requires an external pullup resistor. For TPS37044, RESET1/RESET1 asserts when either SENSE1 or SENSE2 fall outside of the window threshold. The pin can be left floating if it is unused.
RESET2 / RESET2	-	7	7	7	O	RESET2/RESET2 asserts when SENSE2 falls outside of the overvoltage or undervoltage threshold window. RESET2/RESET2 stays asserted for the reset timeout period after SENSE2 fall back within the window threshold. Active-low, open-drain reset output, requires an external pullup resistor. For TPS37044, RESET2/RESET2 asserts when either SENSE3 or SENSE4 fall outside of the window threshold. The pin can be left floating if it is unused.
RESET3 / RESET3	-	-	6	-	O	RESET3/RESET3 asserts when SENSE3 falls outside of the overvoltage or undervoltage threshold window. RESET3/RESET3 stays asserted for the reset timeout period after SENSE3 fall back within the window threshold. Active-low, open-drain reset output, requires an external pullup resistor. The pin can be left floating if it is unused.
GND	4	4	4	4	-	Ground
NC	3, 5, 6, 7	5, 6	-	-	-	No Connect

7 Specifications

7.1 Absolute Maximum Ratings

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

		MIN	MAX	UNIT
Voltage	V _{DD}	-0.3	6.5	V
	V _{RESET1} , V _{RESET2} , V _{RESET3}	-0.3	6.5	V
	V _{SENSE1} , V _{SENSE2} , V _{SENSE3} , V _{SENSE4}	-0.3	6.5	V
Current	I _{RESET1} , I _{RESET2} , I _{RESET3} SINK		±20	mA
Temperature ⁽²⁾	Continuous total power dissipation	See the Thermal Information		
	Operating junction temperature, T _J	-40	150	°C
	Operating free-air temperature, T _A	-40	150	°C
	Storage temperature, T _{stg}	-65	150	°C

- (1) Stresses beyond values listed under Absolute Maximum Ratings (AMR) 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 Conditions. Exposure to AMR-rated conditions for extended periods may affect device reliability.
- (2) As a result of the low dissipated power in this device, it is assumed that T_J = T_A.

7.2 ESD Ratings

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

7.3 Recommended Operating Conditions

		MIN	NOM	MAX	UNIT
V _{DD}	Supply pin voltage	1.7		6.0	V
V _{SENSE1,2,3,4}	Input pin voltage	0		6.0	V
V _{RESET1} , V _{RESET2} , V _{RESET3}	Output pin voltage	0		6.0	V
I _{RESET1} , I _{RESET2} , I _{RESET3} SINK	Output pin current sink	0.3		5	mA
T _A	Operating free air temperature	-40		125	°C

7.4 Thermal Information

THERMAL METRIC ⁽¹⁾		TPS3704x	
		DDF	UNIT
		PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	121.5	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	60.6	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	42.3	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	2.2	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	42.1	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	N/A	°C/W

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

7.5 Electrical Characteristics

At $1.7\text{ V} \leq V_{DD} \leq 6.0\text{ V}$, $\overline{\text{RESETx}}$ Voltage ($V_{\overline{\text{RESETx}}}$) = $10\text{ k}\Omega$ to V_{DD} , $\overline{\text{RESETx}}$ load = 10 pF , and over the operating free-air temperature range of -40°C to 125°C , unless otherwise noted. Typical values are at $T_A = 25^\circ\text{C}$, typical conditions at $V_{DD} = 3.3\text{ V}$.

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{DD}	Supply Voltage		1.7		6.0	V
UVLO	Under Voltage Lockout ⁽¹⁾	V_{DD} falling below 1.7 V	1.2	1.4	1.6	V
UVLO(HYS)	UVLO Hysteresis ⁽²⁾	V_{DD} rising below 1.7 V		65		mV
V_{POR}	Power on reset voltage ⁽³⁾	$V_{OL(MAX)} = 0.3\text{ V}$, $I_{OUT} = 15\text{ }\mu\text{A}$			0.7	V
V_{IT} Range	Threshold Programming Range		0.4		5.55	V
$V_{IT-(UV)}$	UV accuracy (25°C)			0.1		%
$V_{IT+(OV)}$	OV accuracy (25°C)			0.1		%
TOL_min	Tolerance Programming minimum			3		%
TOL_max	Tolerance Programming maximum			11		%
THR RES Low	Threshold Programming Resolution Low	$V_{IT} \leq 0.8\text{ V}$		20		mV / step
THR RES Mid	Threshold Programming Resolution Mid	$0.8\text{ V} < V_{IT} \leq 4.0\text{ V}$		0.5		% / step
THR RES High	Threshold Programming Resolution High	$V_{IT} > 4.0\text{ V}$		20		mV / step
V_{IT}	Accuracy for absolute threshold including tolerance	$V_{IT} < 0.8\text{ V}$	-1.6		1.6	%
V_{IT}	Accuracy for absolute threshold including tolerance	$V_{IT} = 0.8\text{ V} - 5.55\text{ V}$	-1		1	%
V_{HYS}	$V_{IT} < 0.80\text{ V}$		1.1	1.4	1.7	%
V_{HYS}	$V_{IT} \geq 0.80\text{ V}$		0.40	0.75	1	%
I_{DD}	TPS3704x	$V_{DD} \leq 6.0\text{ V}$		5.5	15	μA
I_{SENSEX}	Input current, SENSEx pin	$V_{SENSEX} = 5.5\text{ V}$		1	2.5	μA
I_{SENSE_ADJ}	Input current, SENSE pin (Bypass internal resistor divider)- Adjustable version	$V_{SENSEX} = 5.5\text{ V}$			350	nA
V_{OL}	Low level output voltage	$V_{DD} = 1.7\text{ V}$, $I_{SINK} = 0.4\text{ mA}$			300	mV
V_{OL}	Low level output voltage	$V_{DD} = 2\text{ V}$, $I_{SINK} = 3\text{ mA}$			300	mV
V_{OL}	Low level output voltage	$V_{DD} = 6.0\text{ V}$, $I_{SINK} = 5\text{ mA}$			300	mV
$I_{(lkg)}$	Open drain output leakage current	$V_{DD} = V_{\overline{\text{RESETx}}} = 6.0\text{ V}$			350	nA

(1) $\overline{\text{RESETx}}$ pin is driven low when V_{DD} falls below UVLO.

(2) Hysteresis is with respect of the tripoint ($V_{IT-(UV)}$, $V_{IT+(OV)}$).

- (3) V_{POR} is the minimum V_{DD} voltage level for a controlled output state. Slew rate = 100 mV / μ s.

7.6 Timing Requirements

At $1.7\text{ V} \leq V_{DD} \leq 6.0\text{ V}$, $\overline{\text{RESETx}}$ voltage ($V_{\overline{\text{RESETx}}}$) = $10\text{ k}\Omega$ to V_{DD} , $\overline{\text{RESETx}}$ load = 10 pF , and over the operating free-air temperature range of -40°C to 125°C , unless otherwise noted. Typical values are at $T_A = 25^\circ\text{C}$, typical conditions at $V_{DD} = 3.3\text{ V}$.

PARAMETER		TEST CONDITIONS	MIN	NOM	MAX	UNIT
t_D	Reset release time delay	Fixed delay option $t_D < 4\text{ ms}$, overdrive = 10%	-40	t_D	40	%
t_D	Reset release time delay	Fixed delay option $t_D > 5\text{ ms}$, overdrive = 10%	-30	t_D	30	%
t_{PD}	Propagation detect delay ⁽¹⁾	Fixed time delay $t_D > 1\text{ ms}$, overdrive 10%			10	μs
$t_{GI(VIT-)}$	Glitch Immunity Undervoltage (5% overdrive) ⁽²⁾			2		μs
$t_{GI(VIT+)}$	Glitch Immunity Overvoltage (5% overdrive) ⁽²⁾			2		μs
t_R	Ouptut rise (Push-Pull) ^{(2) (3)}			25		ns
t_R	Output rise time (Open-Drain) ^{(2) (3)}			2.2		μs
t_F	Output fall time ^{(2) (3)}			0.2		μs
t_{STRT}	Startup delay ⁽⁴⁾			1		ms

- (1) t_{PD} measured from threshold trip point ($V_{IT-(UV)}$ or $V_{IT+(OV)}$) to $\overline{\text{RESETx}}$ V_{OL} voltage
- (2) 5% Overdrive from threshold. Overdrive % = $[(V_{SENSEX} - V_{IT}) / V_{IT}]$; Where V_{IT} stands for $V_{IT-(UV)}$ or $V_{IT+(OV)}$
- (3) Output transitions from V_{OL} to V_{OH} or ($V_{\overline{\text{RESETx}}}$) for rise times and V_{OH} or ($V_{\overline{\text{RESETx}}}$) to V_{OL} for fall times.
- (4) During the power-on sequence, V_{DD} must be at or above $V_{DD(MIN)}$ for at least $t_{STRT} + t_D$ before the output is in the correct state. when V_{DD} is between $V_{DD(MIN)}$ and V_{POR} the $\overline{\text{RESETx}}$ pin will be engaged

7.7 Timing Diagrams

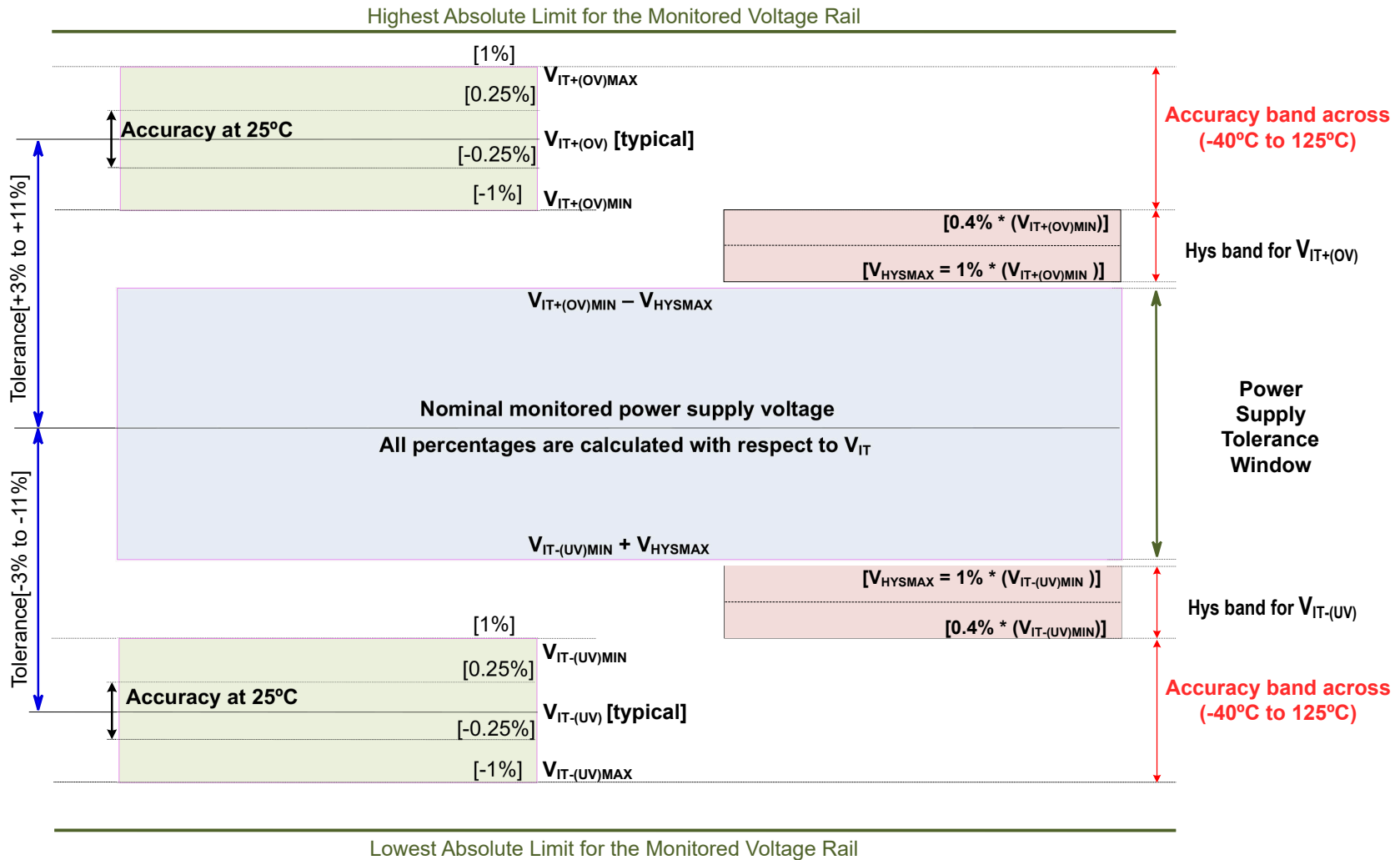
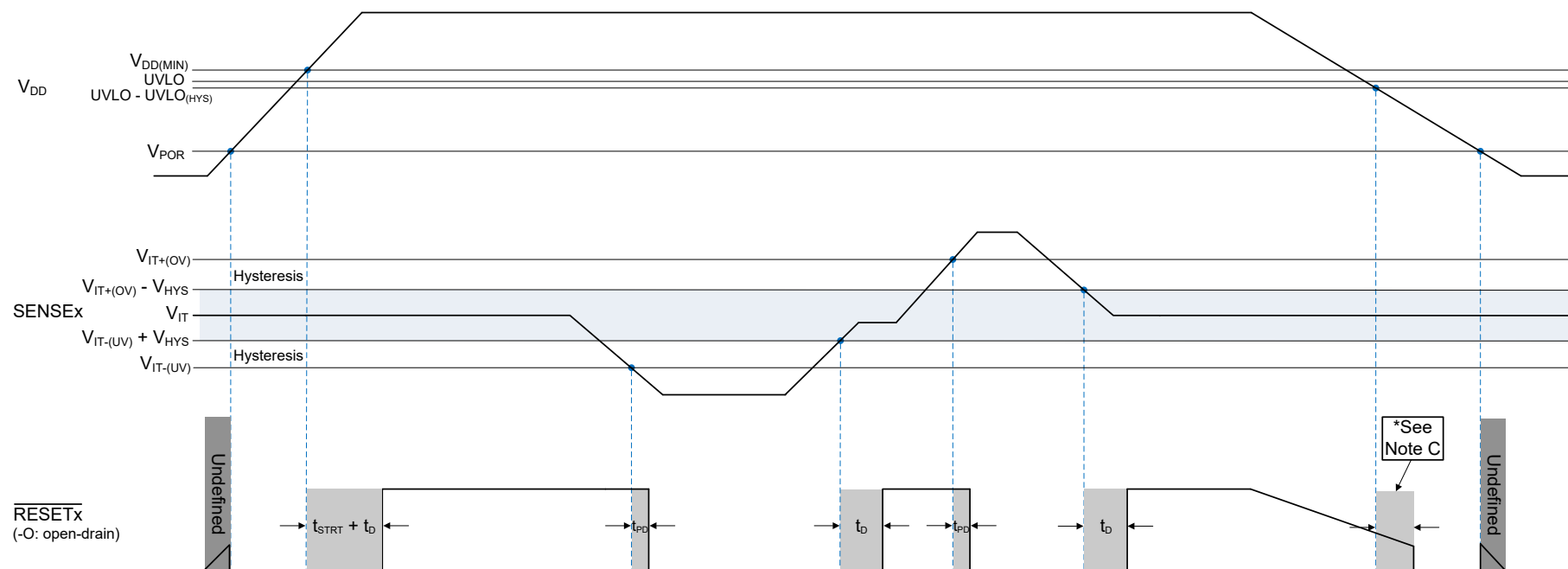


图 7-1. Voltage Threshold and Hysteresis Accuracy



- A. Open-Drain timing diagram assumes the \overline{RESETx} / RESETx pin is connected via an external pull-up resistor to VDD.
- B. Be advised that [Figure 7-2](#) shows the VDD falling slew rate is slow or the VDD decay time is much larger than the propagation detect delay (t_{PD}) time.
- C. \overline{RESETx} /RESETx is asserted after a time delay, typical value of 100 μ s, when VDD goes below the $UVLO - UVLO_{(HYS)}$ threshold.

图 7-2. SENSEx Timing Diagram

7.8 Typical Characteristics

Typical characteristics show the typical performance of the TPS3704x device. Test conditions are $T_A = 25^\circ\text{C}$, $V_{DD} = 3.3\text{ V}$, and $R_{\text{pull-up}x} = 10\text{ k}\Omega$, $C_{\text{LOAD}} = 50\text{ pF}$, unless otherwise noted.

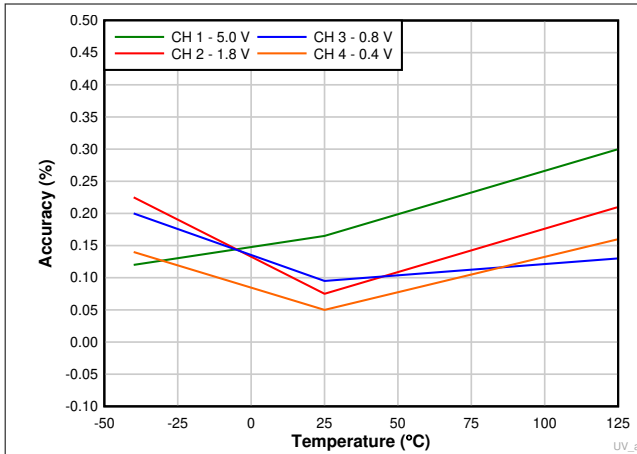


图 7-3. Undervoltage Accuracy vs Temperature

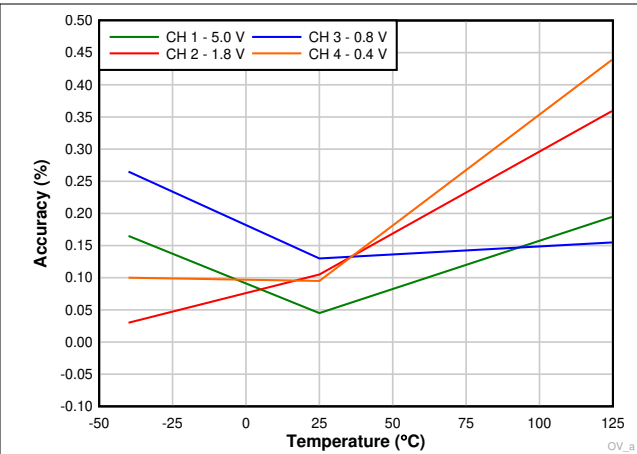


图 7-4. Overvoltage Accuracy vs Temperature

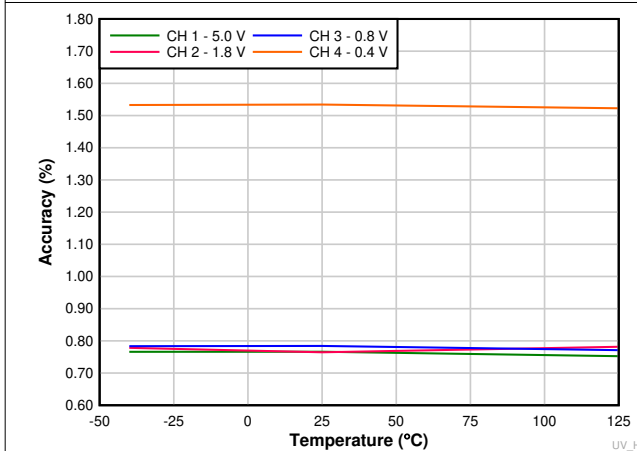


图 7-5. Undervoltage Hysteresis Voltage Accuracy vs Temperature

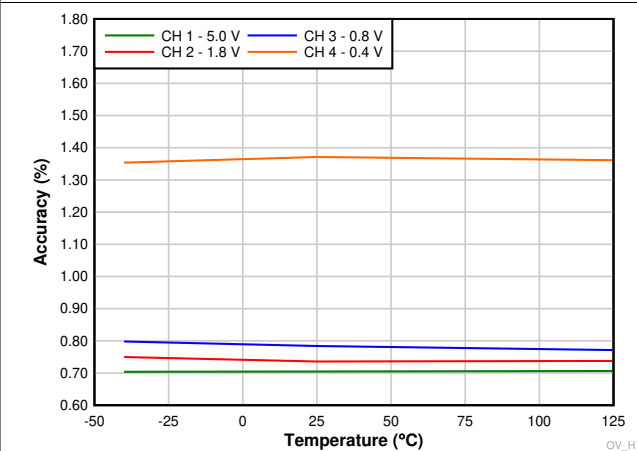


图 7-6. Overvoltage Hysteresis Voltage Accuracy vs Temperature

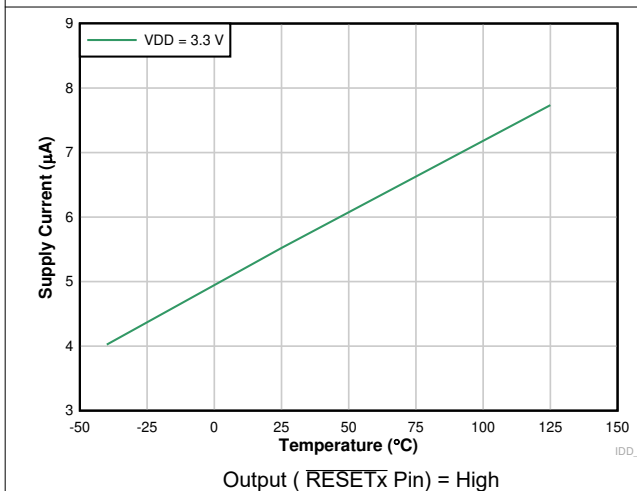


图 7-7. Supply Current vs Temperature

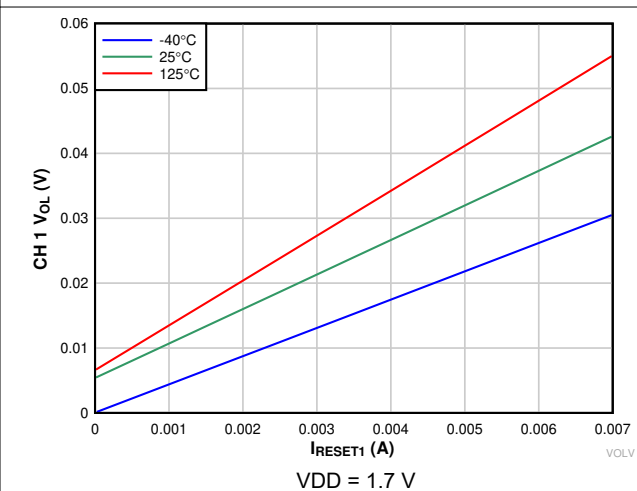


图 7-8. Low-Level CH 1 Output Voltage vs $\overline{\text{RESET1}}$ Current

7.8 Typical Characteristics (continued)

Typical characteristics show the typical performance of the TPS3704x device. Test conditions are $T_A = 25^\circ\text{C}$, $V_{DD} = 3.3\text{ V}$, and $R_{\text{pull-up}x} = 10\text{ k}\Omega$, $C_{\text{LOAD}} = 50\text{ pF}$, unless otherwise noted.

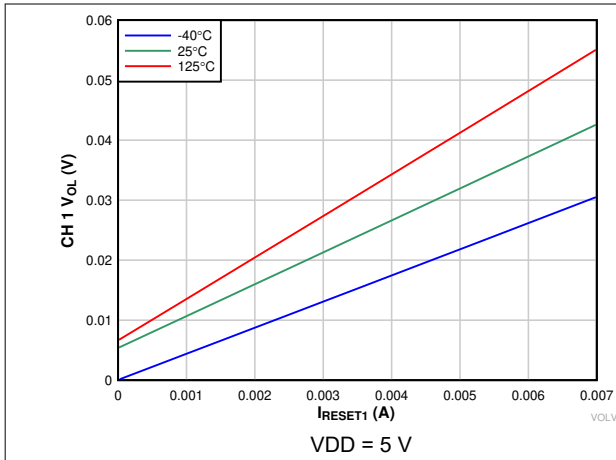


图 7-9. Low-Level CH 1 Output Voltage vs $\overline{\text{RESET1}}$ Current

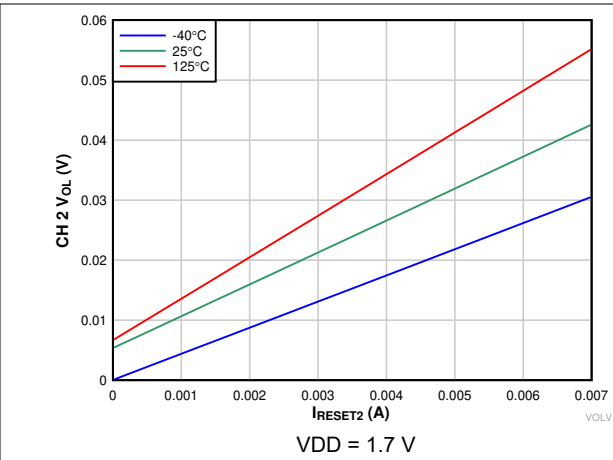


图 7-10. Low-Level CH 2 Output Voltage vs $\overline{\text{RESET2}}$ Current

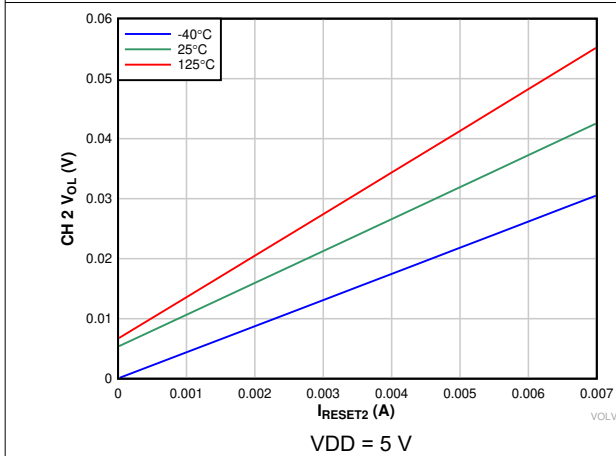


图 7-11. Low-Level CH 2 Output Voltage vs $\overline{\text{RESET2}}$ Current

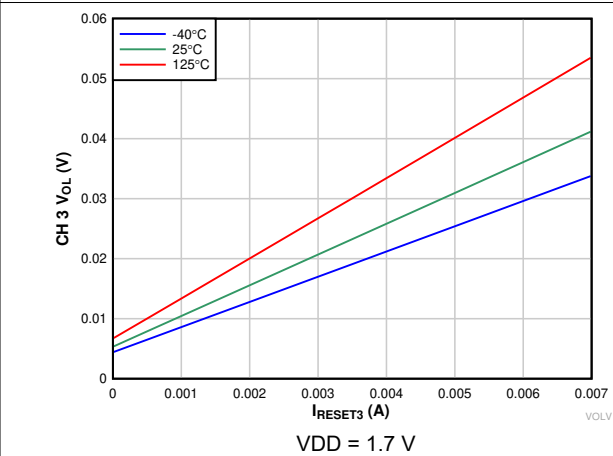


图 7-12. Low-Level CH 3 Output Voltage vs $\overline{\text{RESET3}}$ Current

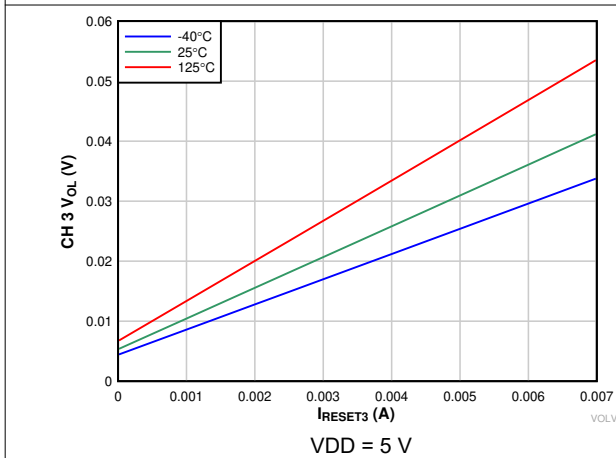


图 7-13. Low-Level CH 3 Output Voltage vs $\overline{\text{RESET3}}$ Current

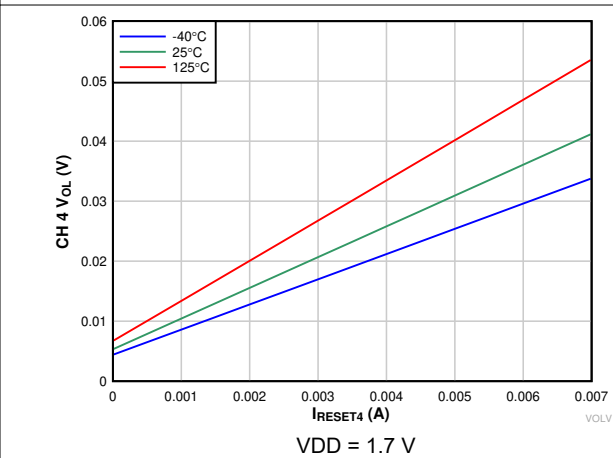


图 7-14. Low-Level CH 4 Output Voltage vs $\overline{\text{RESET4}}$ Current

7.8 Typical Characteristics (continued)

Typical characteristics show the typical performance of the TPS3704x device. Test conditions are $T_A = 25^\circ\text{C}$, $V_{DD} = 3.3\text{ V}$, and $R_{\text{pull-up}x} = 10\text{ k}\Omega$, $C_{\text{LOAD}} = 50\text{ pF}$, unless otherwise noted.

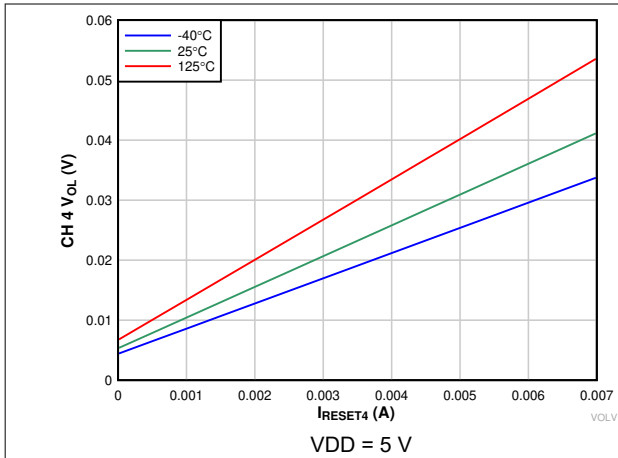


图 7-15. Low-Level CH 4 Output Voltage vs RESET4 Current

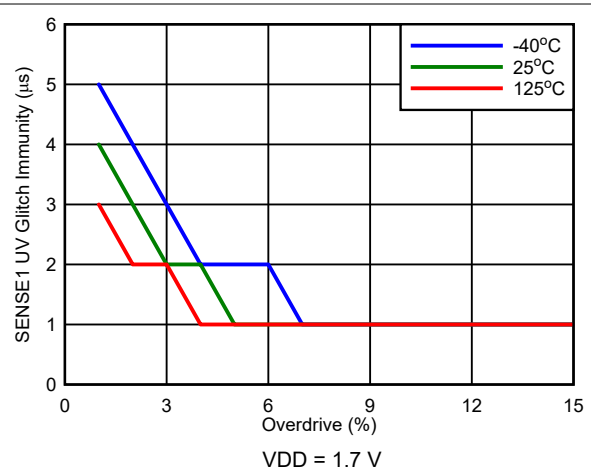


图 7-16. SENSE1 Glitch Immunity (V_{IT-}) vs Overdrive

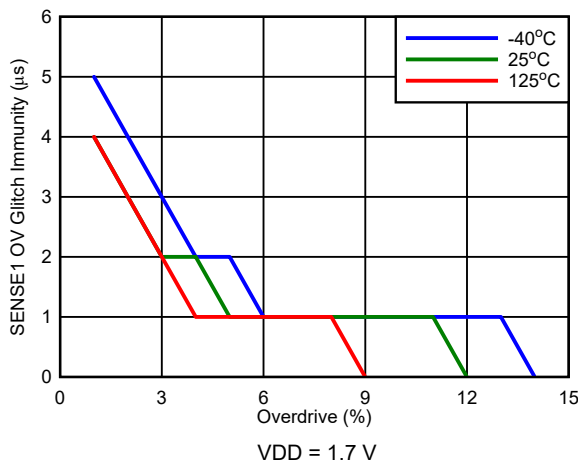


图 7-17. SENSE1 Glitch Immunity (V_{IT+}) vs Overdrive

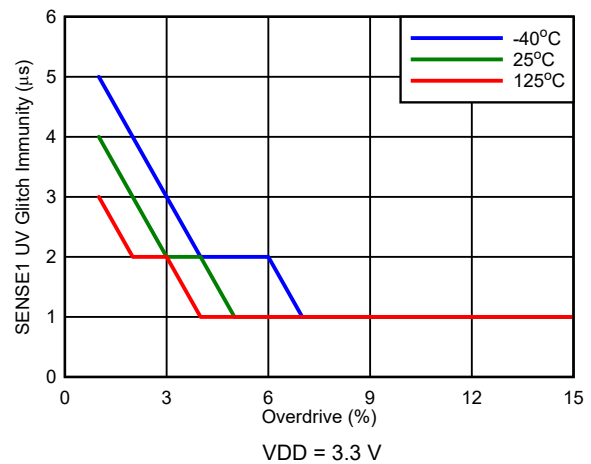


图 7-18. SENSE1 Glitch Immunity (V_{IT-}) vs Overdrive

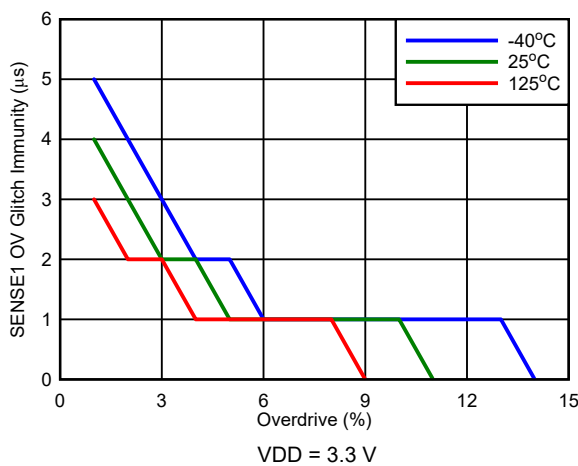


图 7-19. SENSE1 Glitch Immunity (V_{IT+}) vs Overdrive

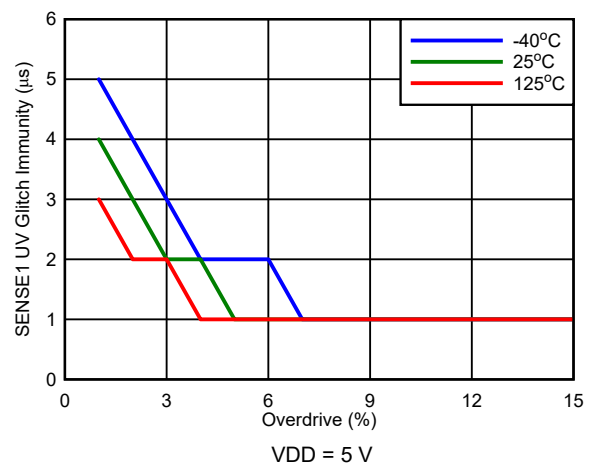


图 7-20. SENSE1 Glitch Immunity (V_{IT-}) vs Overdrive

7.8 Typical Characteristics (continued)

Typical characteristics show the typical performance of the TPS3704x device. Test conditions are $T_A = 25^\circ\text{C}$, $V_{DD} = 3.3\text{ V}$, and $R_{\text{pull-up}x} = 10\text{ k}\Omega$, $C_{\text{LOAD}} = 50\text{ pF}$, unless otherwise noted.

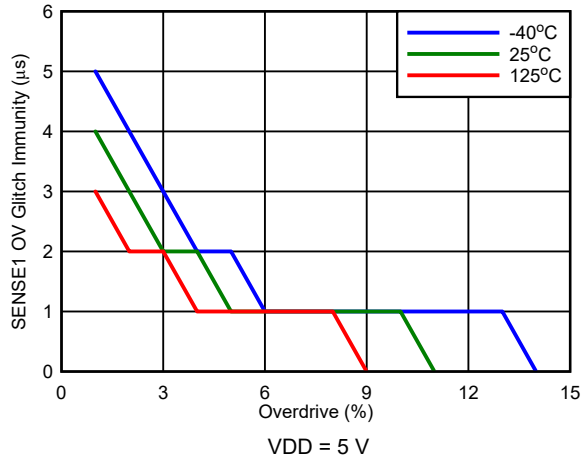


图 7-21. SENSE1 Glitch Immunity (V_{IT+}) vs Overdrive

8 Detailed Description

8.1 Overview

TPS3704x is a family of quad, triple, dual, and single precision voltage supervisors where each channel has overvoltage and undervoltage detection capability. The TPS3704x features a highly accurate window threshold voltage where the upper and lower thresholds can be customized for symmetric or asymmetric tolerances. The reset signal for the TPS3704x is asserted, with a fault detection time delay ($t_{PD} = 10 \mu s$ maximum), when the sense voltage is outside of the overvoltage and undervoltage thresholds.

TPS3704x includes the resistors used to set the overvoltage and undervoltage thresholds internal to the device. These internal resistors allow for lower component counts and greatly simplifies the design because no additional margins are needed to account for the accuracy of external resistors. The level of integration in the TPS3704x enables a total small solution size for any application.

The TPS3704x is capable to monitor any voltage rail with high resolution ($V_{IT} \leq 0.8 V$: 20 mV steps / $V_{IT} > 0.8 V$: 0.5% or 20 mV steps whichever is lower). Each channel in the TPS3704x can be configured independently as a window, OV or UV supervisor. Also, the V_{IT} threshold voltage for each channel can be asymmetric. For example, a channel that is configured as an overvoltage supervisor can be setup with a +5% tolerance whereas an undervoltage channel supervisor can be programmed with a -4% tolerance. If a window supervisor is configured, the voltage threshold tolerance can either be symmetrical or asymmetrical.

The TPS3704x includes fixed reset time delay (t_D) options ranging from 20 μs to 1200 ms and can monitor up to four channels while maintaining an ultra-low I_Q current of 15 μA (maximum).

8.2 Functional Block Diagram

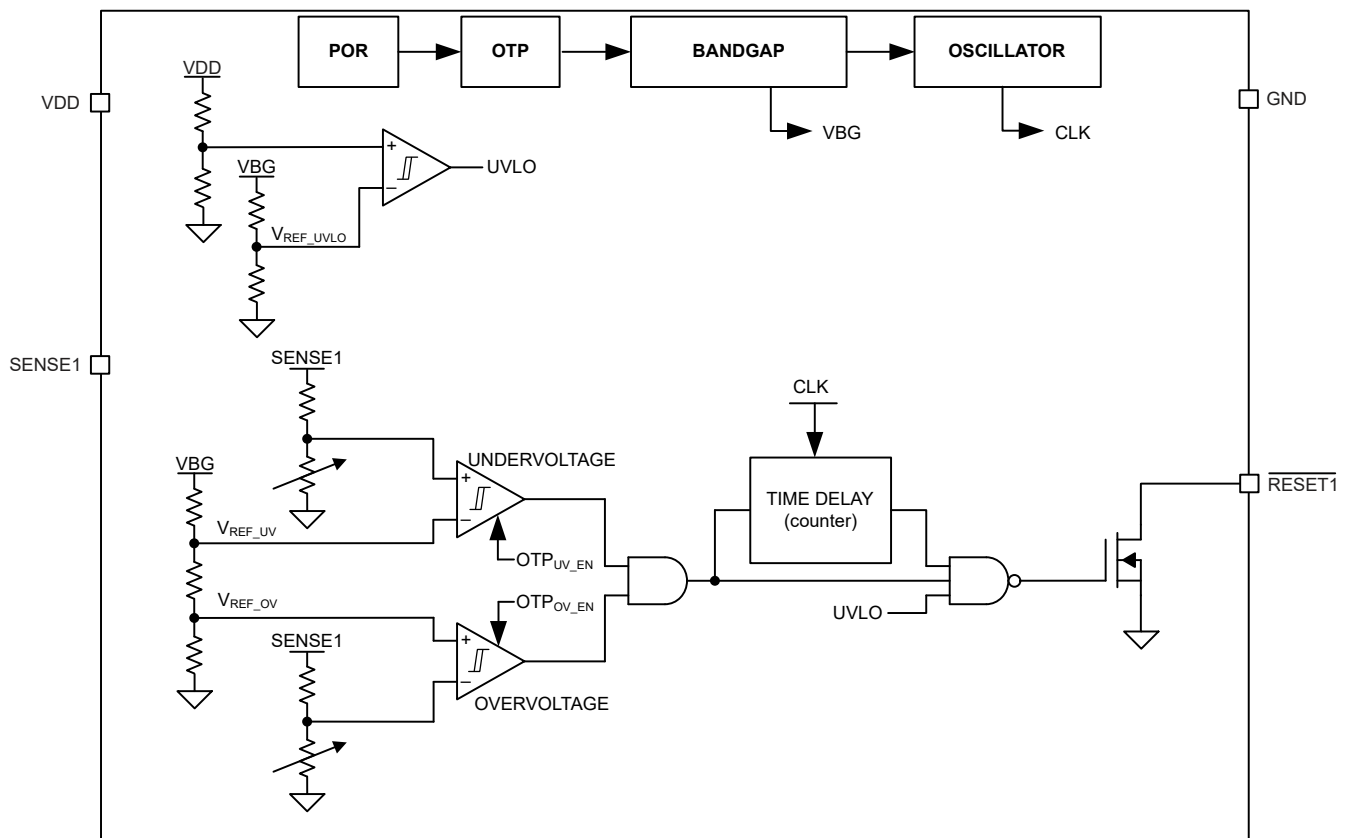


图 8-1. TPS37041 Single-Channel Functional Block Diagram

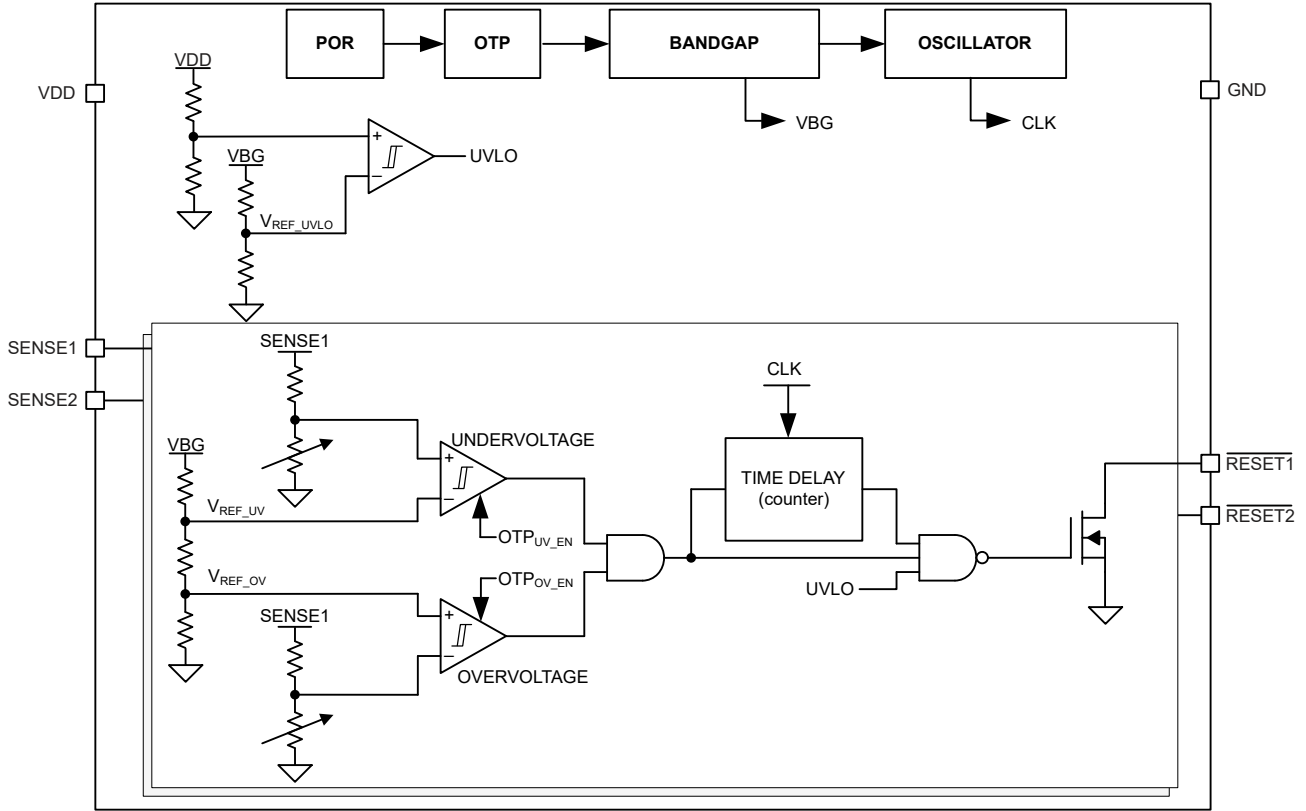


图 8-2. TPS37042 Dual-Channel Functional Block Diagram

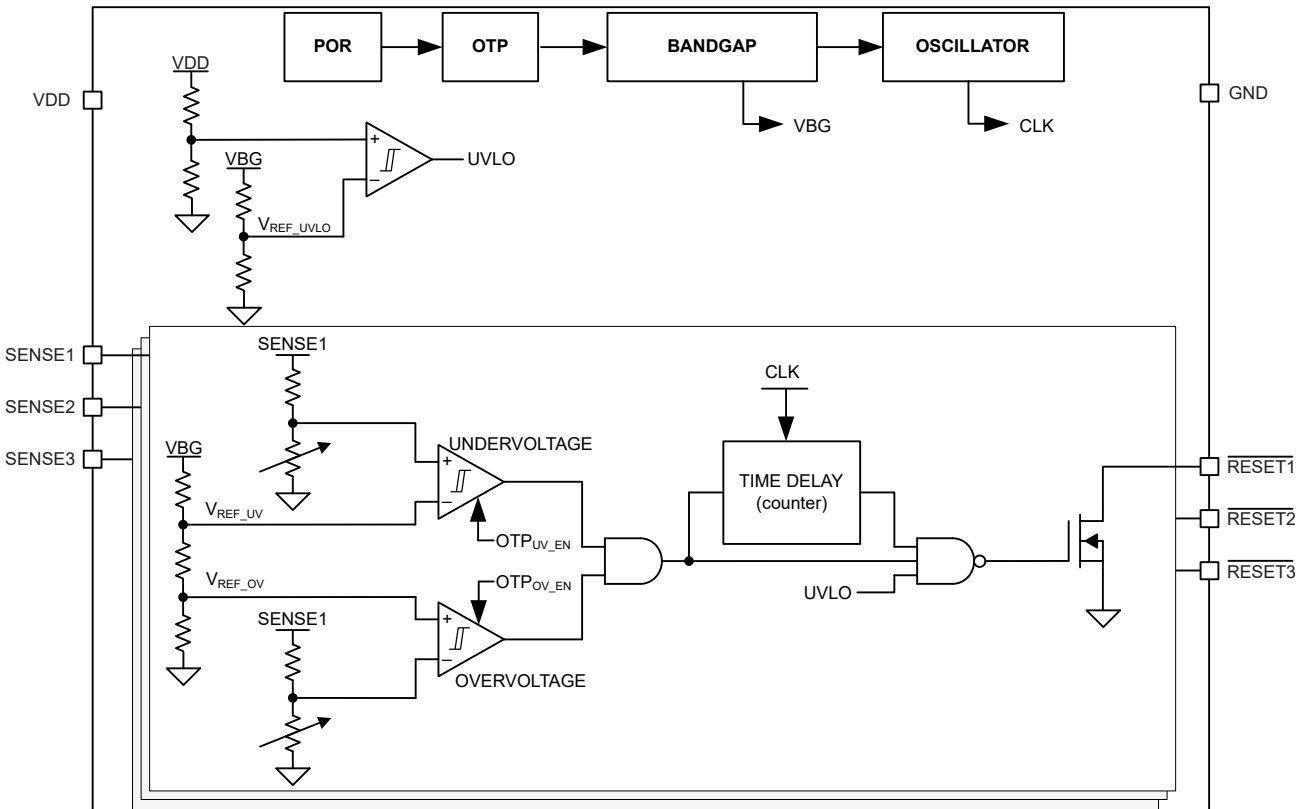


图 8-3. TPS37043 Triple-Channel Functional Block Diagram

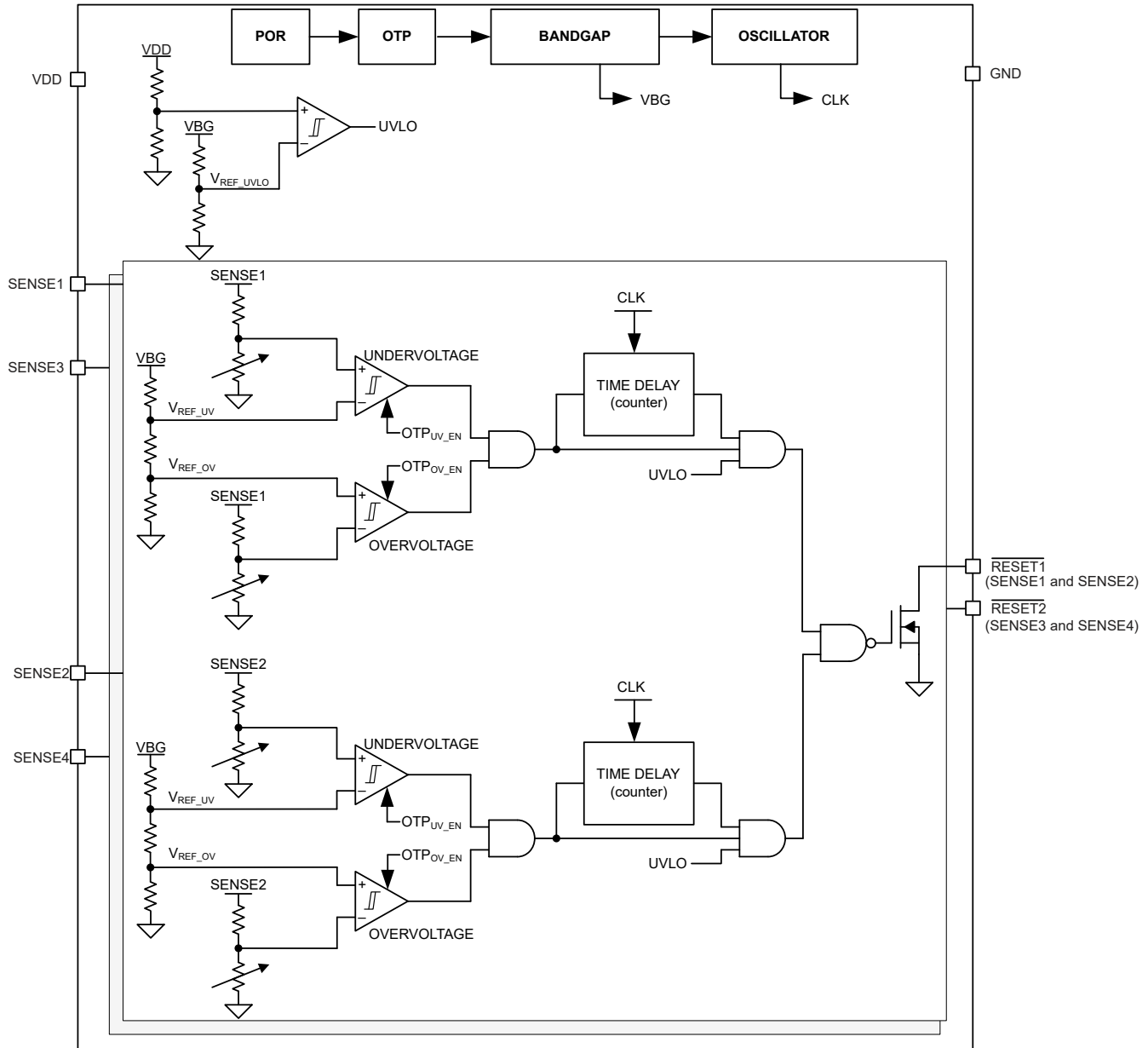


图 8-4. TPS37044 Quadruple-Channel Functional Block Diagram

*For available voltages, window tolerance, time delays, and UV/OV threshold options, see 表 12-2.

8.3 Feature Description

8.3.1 VDD

The TPS3704x is designed to operate from an input voltage supply range between 1.7 V to 6 V. The SENSE_x pins is monitored by the internal comparator. VDD also functions as the supply for the internal bandgap, internal regulator, state machine, buffers and other control blocks. The reset signal is at a known state when $V_{DD} > V_{POR}$. Undervoltage lockout forces the reset output to be asserted when VDD falls below the minimum VDD voltage.

VDD capacitor is not required for this device; however, if the input supply is noisy, then it is good design practice to place a 0.1 μ F to 1 μ F bypass capacitor between the VDD pin and the GND pin to ensure enough charge is available for the device to power up correctly. VDD needs to be at or above $V_{DD(MIN)}$ for start-up delay ($t_{STRT} + t_D$) to begin and for the device to be fully functional.

8.3.2 SENSEx Input

The SENSEx input can monitor supply rails from 0 V to 5.55 V, regardless of the device supply voltage used. The SENSEx pins are used to monitor critical voltage rails or push-button inputs. If the voltage on this pin drops below $V_{IT-(UV)}$ or goes above $V_{IT+(OV)}$, then $\overline{\text{RESETx}}/\text{RESETx}$ is asserted. When the voltage on the SENSEx pin rises above the positive threshold voltage $V_{IT-(UV)} + V_{HYS}$ or goes below the negative threshold voltage $V_{IT+(OV)} - V_{HYS}$,

$\overline{\text{RESETx}}/\text{RESETx}$ deasserts after the set $\overline{\text{RESETx}}/\text{RESETx}$ delay time. The internal comparators have built-in hysteresis to ensure well-defined $\overline{\text{RESETx}}/\text{RESETx}$ assertions and deassertions even when there are small changes on the voltage rail being monitored.

The TPS3704x combines comparators with a precision reference voltage and a trimmed resistor divider. This configuration optimizes device accuracy because all resistor tolerances are accounted for in the accuracy and performance specifications. The TPS3704x device is relatively immune to short transients on the SENSEx pin. Although not required in most cases, for noisy applications, good analog design practice is to place a 10-nF to 100-nF bypass capacitor at the SENSEx inputs to reduce sensitivity to transient voltages on the monitored signals.

8.3.2.1 Immunity to SENSEx Pins Voltage Transients

The TPS3704x is immune to short voltage transient spikes on the input SENSEx pins. Sensitivity to transients depends on both transient duration and overdrive (amplitude) of the transient.

Overdrive is defined by how much the V_{SENSEx} exceeds the specified threshold, and is important to know because the smaller the overdrive, the slower the response of the ($\overline{\text{RESETx}}/\text{RESETx}$) outputs. Threshold overdrive is calculated as a percent of the threshold in question, as shown in [方程式 1](#):

$$\text{Overdrive \%} = |(V_{\text{SENSEx}} - (V_{IT-(UV)} \text{ or } V_{IT+(OV)})) / V_{IT} (\text{Nominal}) \times 100\%| \quad (1)$$

where:

- V_{SENSEx} is the voltage at the SENSEx pin
- $V_{IT} (\text{Nominal})$ is the nominal threshold voltage
- $V_{IT-(UV)}$ and $V_{IT+(OV)}$ represent the actual undervoltage or overvoltage tripping voltage

8.3.2.1.1 SENSEx Hysteresis

Overvoltage and undervoltage comparators include built-in hysteresis that provides noise immunity and ensures stable operation. For example, if the voltage on the SENSEx pin falls below $V_{IT-(UV)}$ or above $V_{IT+(OV)}$, then $\overline{\text{RESETx}}/\text{RESETx}$ is asserted. When the voltage on the SENSEx pin is between the positive and negative threshold voltages, $\overline{\text{RESETx}}/\text{RESETx}$ deasserts after the set $\overline{\text{RESETx}}/\text{RESETx}$ delay time. [图 8-5](#) shows the relation between $V_{IT-(UV)}$, $V_{IT+(OV)}$ and the hysteresis voltage (V_{HYS}).

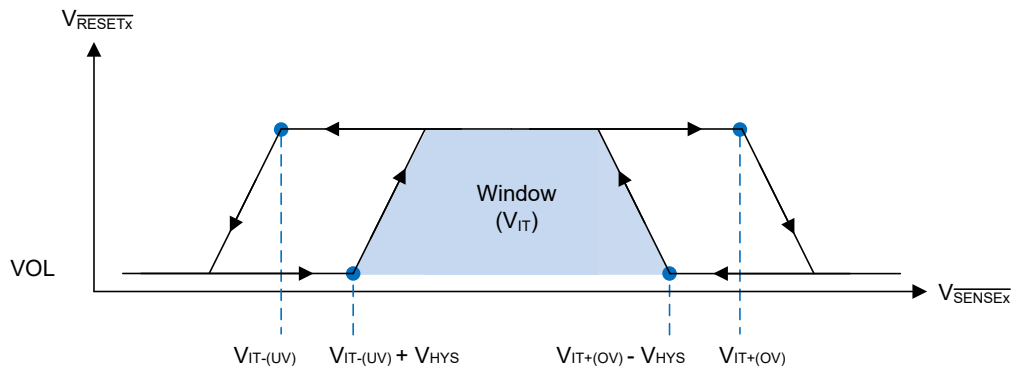


图 8-5. SENSEx Pin Hysteresis

8.3.3 RESET \bar{x} /RESET x

In a typical TPS3704x application, the RESET \bar{x} /RESET x output is connected to a reset or enable input of a processor [such as a digital signal processor (DSP), application-specific integrated circuit (ASIC), or other processor type] or the enable input of a voltage regulator [such as a DC-DC converter or low-dropout regulator (LDO)].

The TPS3704x has open drain active low outputs that requires an external pull-up resistor to hold these lines high to the required voltage logic. Connect the external pull-up resistor to the proper voltage rail to enable the output to be connected to other devices at the correct interface voltage levels. To ensure proper voltage levels, give some consideration when choosing the external pull-up resistor values. The external pull-up resistor value is determined by V_{OL} , output capacitive loading, and output leakage current. These values are specified in 节 7.5. The open drain output can be connected as a wired-OR logic with the other RESET \bar{x} /RESET x open drain pins.

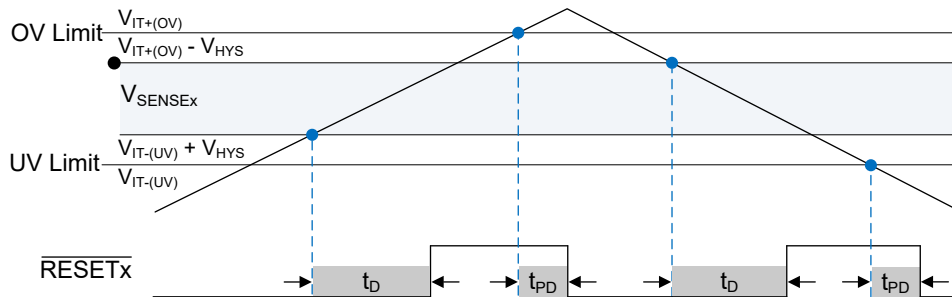


图 8-6. RESET x output

8.4 Device Functional Modes

表 8-1. Functional Mode Truth Table

DESCRIPTION	CONDITION	V _{DD} PIN	OUTPUT RESET \bar{x} / (RESET x) PIN
Normal Operation	$V_{IT-(UV)} < SENSEx < V_{IT+(OV)}$	$V_{DD} > V_{DD(MIN)}$	High / (Low)
Normal Operation (UV Only)	$SENSEx > V_{IT-(UV)}$	$V_{DD} > V_{DD(MIN)}$	High / (Low)
Overshoot detection	$SENSEx > V_{IT+(OV)}$	$V_{DD} > V_{DD(MIN)}$	Low / (High)
Undervoltage detection	$SENSEx < V_{IT-(UV)}$	$V_{DD} > V_{DD(MIN)}$	Low / (High)
UVLO engaged	$V_{IT-(UV)} < SENSEx < V_{IT+(OV)}$	$V_{POR} < V_{DD} < UVLO$	Low / (High)

8.4.1 Normal Operation ($V_{DD} > V_{DD(MIN)}$)

When the voltage on V_{DD} is greater than $V_{DD(MIN)}$ for approximately ($t_{STRT} + t_D$), the RESET \bar{x} /RESET x output state will correspond to the SENSE x pin voltage with respect to the threshold limits, when SENSE x voltage is outside of threshold limits the RESET \bar{x} /RESET x voltage will be asserted.

8.4.2 Undervoltage Lockout ($V_{POR} < V_{DD} < UVLO$)

When the voltage on V_{DD} is less than the device UVLO voltage but greater than the power-on reset voltage (V_{POR}), the RESET \bar{x} /RESET x pin will be asserted, regardless of the voltage on SENSE x pin.

8.4.3 Power-On Reset ($V_{DD} < V_{POR}$)

When the voltage on V_{DD} is lower than the required voltage (V_{POR}) to internally pull the asserted output to GND, RESET \bar{x} /RESET x signal is undefined and is not to be relied upon for proper device function.

9 Application and Implementation

备注

以下应用部分中的信息不属于 TI 器件规格的范围，TI 不担保其准确性和完整性。TI 的客户应负责确定器件是否适用于其应用。客户应验证并测试其设计，以确保系统功能。

9.1 Application Information

9.1.1 Voltage Threshold Accuracy

Voltage monitoring requirements vary depending on the voltage supply tolerance of the device being powered. Due to the high precision of the TPS3704x ($\pm 1\%$ maximum), the device allows for a wider supply voltage margins and threshold headroom for tight tolerance applications.

For example, take a DC/DC regulator providing power to a core voltage rail of an MCU. The MCU has a tolerance of $\pm 5\%$ of the nominal output voltage of the DC/DC. The user sets an ideal voltage threshold of $\pm 4\%$ which allows for $\pm 1\%$ of threshold accuracy. Since the TPS3704x threshold accuracy is $\pm 1\%$, the user has more supply voltage margin which can allow for a relaxed power supply design. This gives flexibility to the DC/DC to use a smaller output capacitor or inductor because of a larger voltage window for voltage ripple and transients. There is also headroom between the minimum system voltage and voltage tolerance of the MCU to ensure that the voltage supply will never be in the region of potential failure of malfunction without the TPS3704x asserting a reset signal.

图 9-1 illustrates the supply undervoltage margin and accuracy of the TPS3704x for the example explained above. Using a low accuracy supervisor will eat into the available budget for the power supply ripple and transient response. This gives less flexibility to the user and a more stringent DC/DC converter design.

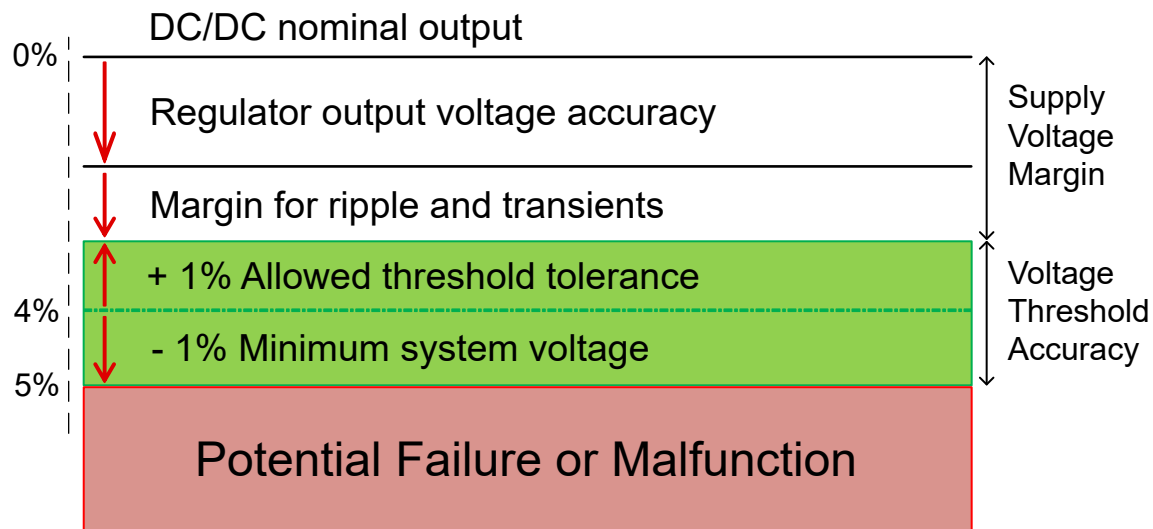


图 9-1. TPS3704x Voltage Threshold Accuracy

9.1.2 Adjustable Voltage Thresholds

The TPS3704x maximum accuracy (1%) allows for adjustable voltage thresholds using external resistors without adding major inaccuracies to the device. In case that the desired monitored voltage is not available, external resistor dividers can be used to set the desired voltage thresholds. 图 9-2 illustrates an example of how to adjust the voltage threshold with external resistor dividers. The resistors can be calculated depending on the desired voltage threshold and device part number. TI recommends using an adjustable voltage threshold device variant because of the bypass mode of internal resistor ladder.

For example, consider a 2.0 V rail being monitored (V_{MON}) using the TPS3704 0.8 V adjustable variant. Using 方程式 2, $R_1 = 15\text{ k}\Omega$ given that $R_2 = 10\text{ k}\Omega$, $V_{MON} = 2\text{ V}$, and $V_{SENSE1} = 0.8\text{ V}$. This device is typically meant to monitor a 0.8 V rail with $\pm 4\%$ voltage thresholds. This means that the device undervoltage threshold ($V_{IT-(UV)}$) and overvoltage threshold ($V_{IT+(OV)}$) is 0.768 V and 0.832 V respectively. Using 方程式 2, $V_{MON} = 1.92\text{ V}$ when $V_{SENSE1} = V_{IT-(UV)}$. This can be denoted as V_{MON-} , the monitored undervoltage threshold where the device will assert a reset signal. Using 方程式 2 again, the monitored overvoltage threshold (V_{MON+}) = 2.08 V when $V_{SENSE1} = V_{IT+(OV)}$. If a wider tolerance or UV only threshold is desired, use a device variant shown on 表 12-2 to determine what device part number matches your application.

$$V_{SENSE1} = V_{MON} \times (R_2 / (R_1 + R_2)) \quad (2)$$

There are inaccuracies that must be taken into consideration while adjusting voltage thresholds. Aside from the tolerance of the resistor divider, there is an internal resistance of the SENSE1 pin that may affect the accuracy of the resistor divider. Although expected to be very high impedance, users are recommended to calculate the values for design specifications. The internal sense resistance R_{SENSE1} can be calculated by the sense voltage V_{SENSE1} divided by the sense current I_{SENSE1} as shown in 方程式 4. V_{SENSE1} can be calculated using 方程式 2 depending on the resistor divider and monitored voltage. I_{SENSE1} can be calculated using 方程式 3.

$$I_{SENSE1} = [(V_{MON} - V_{SENSE1}) / R_1] - (V_{SENSE1} / R_2) \quad (3)$$

$$R_{SENSE1} = V_{SENSE1} / I_{SENSE1} \quad (4)$$

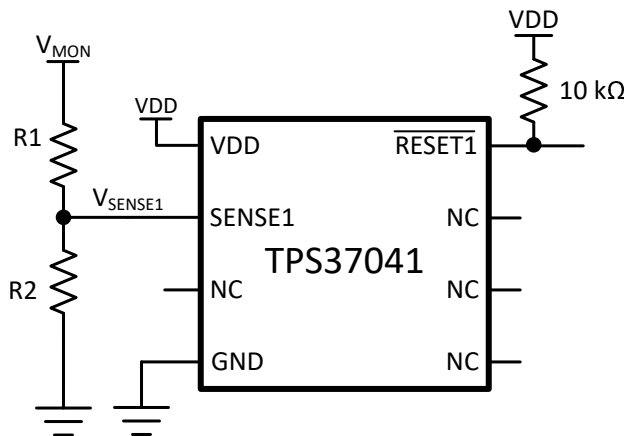


图 9-2. Adjustable Voltage Threshold with External Resistor Dividers

9.2 Typical Application

9.2.1 Design 1: Multi-Rail Window Monitoring for Microcontroller Power Rails

A typical application for the TPS37042 is shown in [图 9-3](#). The TPS37042 is used to monitor two PMIC voltage rails that powers the core and I/O voltage of the microcontroller that requires accurate reset delay and voltage supervision. It utilizes the TPS37042 to monitor the core voltage rail of a MCU similar to the circuit below.

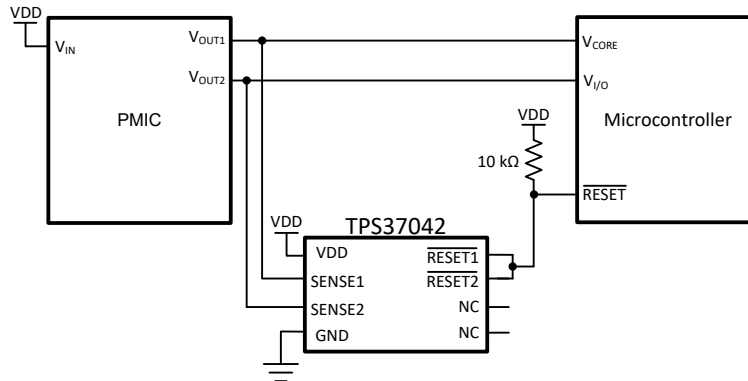


图 9-3. TPS37042 Dual-Channel Monitoring Two Microcontroller Power Rails

9.2.1.1 Design Requirements

表 9-1. Design Requirements

PARAMETER	DESIGN REQUIREMENT	DESIGN RESULT
Monitored rails	3.3-V _{I/O} nominal, with alerts if outside of ±8% of 3.3 V (including device accuracy), 10 ms reset delay	Worst case V _{IT+(OV)} = 3.533 V (7.06%) Worst case V _{IT-(UV)} = 3.071 V (-6.94%)
	1.2-V _{CORE} nominal, with alerts if outside of ±5% of 1.2 V (including device accuracy), 10 ms reset delay	Worst case V _{IT+(OV)} = 1.2484 V (4.03%) Worst case V _{IT-(UV)} = 1.1524 V (-3.97%)
Output logic voltage	5-V CMOS	5-V CMOS
Maximum system supervision current consumption	25 μA	5.5 μA (15 μA max)

9.2.1.2 Detailed Design Procedure

Determine which version of the TPS3704x best suits the monitored rail (V_{MON}) and window tolerances found on [表 12-2](#). The TPS3704x allows overvoltage and undervoltage monitoring for precise voltage supervision of common rails between 0.4 V and 5.55 V. This application calls for very tight monitoring of the rail with only ±5% of variation allowed on the 1.2-V_{CORE} rail. To ensure this requirement is met, the TPS37042 was chosen for its ±3% thresholds. The 3.3-V_{I/O} is more flexible and can operate up to 8% variance. Since the TPS3704x comes in various tolerance options, the ±6% thresholds can be chosen for this voltage rail. To calculate the worst-case for V_{IT+(OV)} and V_{IT-(UV)}, the accuracy must also be taken into account. The worst-case for V_{IT+(OV)} and V_{IT-(UV)} can be calculated shown in [方程式 5](#) and [方程式 6](#) respectively:

$$V_{IT+(OV-Worst\ Case)} = V_{MON} \times (1 + \%Threshold) \times (1 + \%Accuracy) = 1.2 \times (1.03) \times (1.01) = 1.2484\text{ V} \quad (5)$$

$$V_{IT-(UV-Worst\ Case)} = V_{MON} \times (1 - \%Threshold) \times (1 - \%Accuracy) = 1.2 \times (0.97) \times (0.99) = 1.1524\text{ V} \quad (6)$$

Hysteresis is also needed to be taken into account when determining the OV and UV thresholds such that the release point after the fault is higher than the power supply tolerance limits. Refer to [图 7-1](#) for more details.

When the outputs switch to a high impedance state, the rise time of the $\overline{\text{RESET}}/\text{RESET}$ pin depends on the pull-up resistance and the capacitance on that node. Choose pull-up resistors that satisfy both the downstream timing requirements and the sink current required to have a V_{OL} low enough for the application; 10 kΩ to 1 MΩ resistors are a good choice for low-capacitive loads.

9.2.2 Design 2: Manual Self-Test Option for Enhanced Functional Safety Use Cases

图 9-4 displays a self-test scheme where a manual self-test function can be implemented. Any SENSEx pin can be reserved and used to trigger a fault to be observed at the output, thus pre-checking the TPS3704 for fault detection. TPS3704 is a functional safety compliant multichannel supervisor and enables applications such as factory automation and motor drive achieve IEC 61508 requirements and industrial safety integrity levels. This example uses a TPS37044F, configured for separate undervoltage and overvoltage (UV/OV) outputs where the SENSE4 thresholds are set at 5.5 V for OV and 2 V for UV.

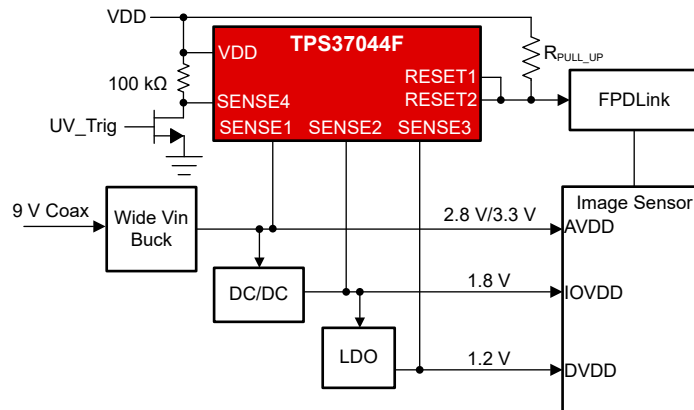


图 9-4. TPS37044F Quad-Channel Monitoring With Manual Self-Test Option for Functional Safety

9.2.2.1 Design Requirements

表 9-2. Design Requirements

PARAMETER	DESIGN REQUIREMENT	DESIGN RESULT
Monitored rails	3.3-V AVDD nominal, with alerts if outside of $\pm 4\%$ of 3.3 V (including device accuracy), 10-ms reset delay	Worst case $V_{IT+(OV)} = 3.432 \text{ V (+4\%)}$ Worst case $V_{IT-(UV)} = 3.168 \text{ V (-4\%)}$
	1.8-V IOVDD nominal, with alerts if outside of $\pm 4\%$ of 1.8 V (including device accuracy), 10-ms reset delay	Worst case $V_{IT+(OV)} = 1.872 \text{ V (+4\%)}$ Worst case $V_{IT-(UV)} = 1.728 \text{ V (-4\%)}$
	1.2-V DVDD nominal, with alerts if outside of $\pm 4\%$ of 1.2 V (including device accuracy), 10-ms reset delay	Worst case $V_{IT+(OV)} = 1.248 \text{ V (+4\%)}$ Worst case $V_{IT-(UV)} = 1.152 \text{ V (-4\%)}$
SENSE4 (Self-test Option)	100-k Ω pullup resistor to VDD with NFET pulldown transistor to GND	UV_Trig = High - causing SENSE4 pin going low UV_Trig = Low - in normal operation
Output logic voltage	5-V CMOS	5-V CMOS
Max system IDD current	25 μA	5.5 μA (20 μA maximum)

9.2.2.2 Detailed Design Procedure

图 9-4 shows a self-test scheme where a manual self-test function can be implemented. SENSE4 has an overvoltage (OV) threshold that is set at 5.5 V and the undervoltage (UV) threshold set at 2 V. SENSE4 can be connected via a 100-k Ω resistor to VDD. The self-test setup gives the added benefit of a built-in overvoltage detector for the rail powering the TPS37044F. From a functional safety perspective, a voltage supervisor cannot be considered reliable if the supervisor is operating outside its recommended operated limits.

To trigger a manual self-test, pull UV_Trig high to cause SENSE4 to be logic low, therefore triggering an undervoltage (UV) fault. The UV fault appears at RESET2 as an asserted low signal. By tying both reset outputs to an NMI or interrupt input of the processor, this self-test option scheme serves as a purpose to ensure that RESET2, of the TPS37044F is operating properly. For more information on functional safety, see the [Functional Safety Manual](#).

9.2.3 Application Curves

These application curves were taken with the TPS3704Q1EVM. Please see the [TPS3704Q1EVM User Guide](#) for more information.

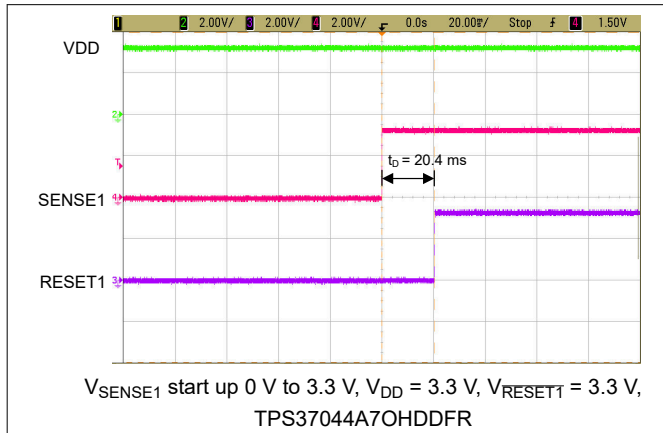


图 9-5. TPS37044 SENSE1 Start Up Function

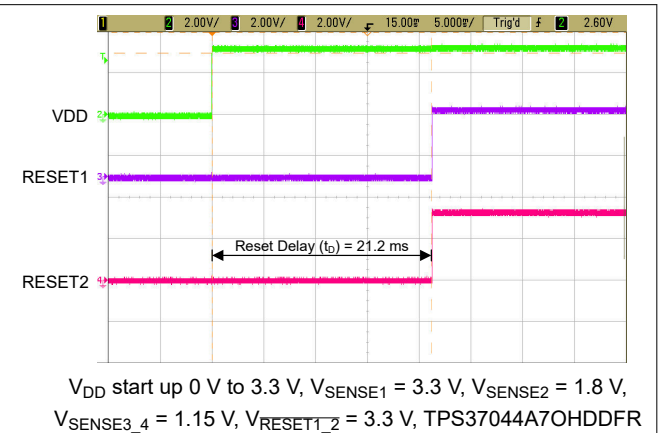


图 9-6. TPS37044 VDD Start Up Function

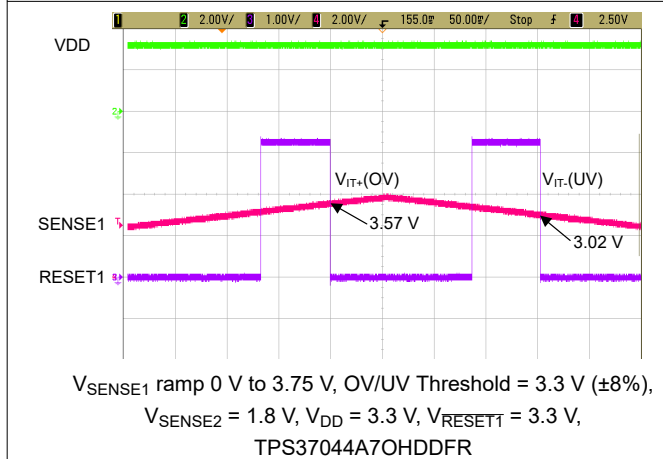


图 9-7. TPS37044 Overvoltage and Undervoltage Function

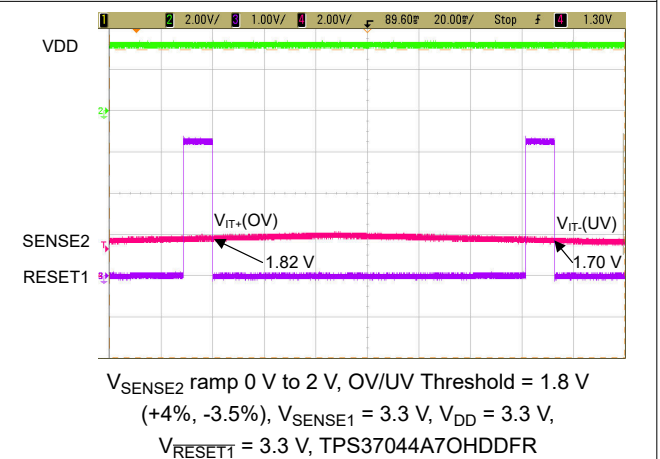


图 9-8. TPS37044 Overvoltage and Undervoltage Function

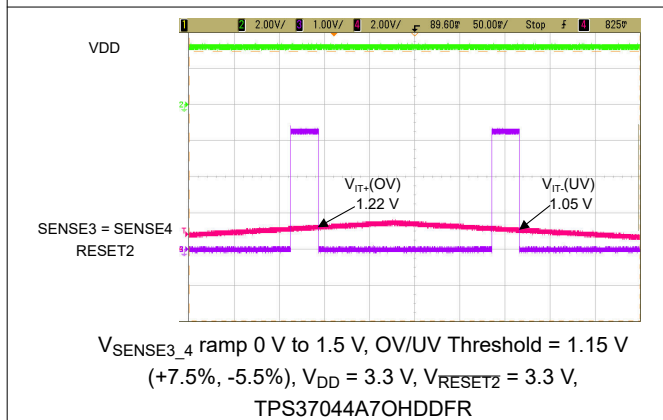


图 9-9. TPS37044 Overvoltage and Undervoltage Function

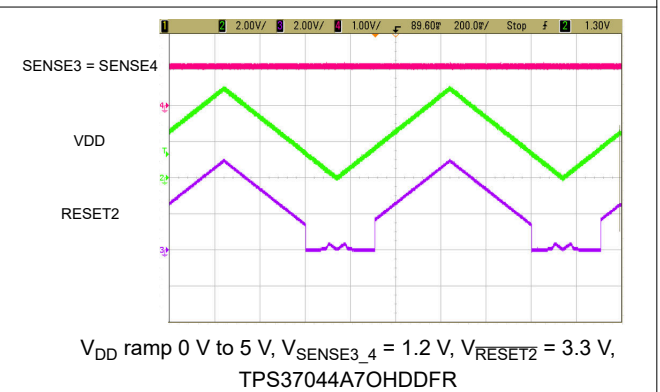
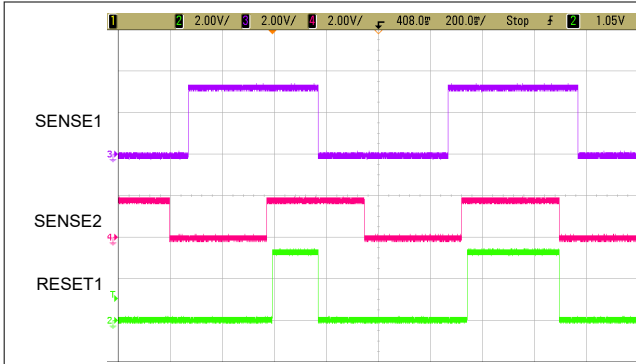
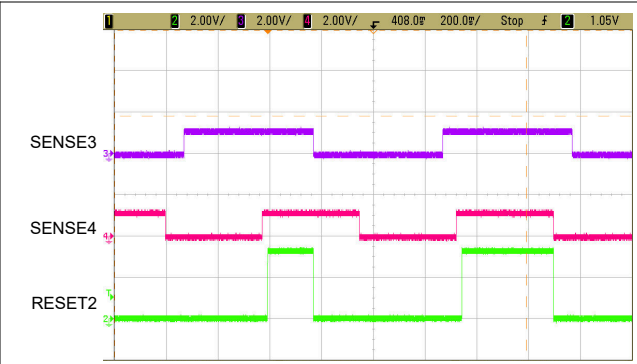


图 9-10. TPS37044 VDD Ramp Up Function



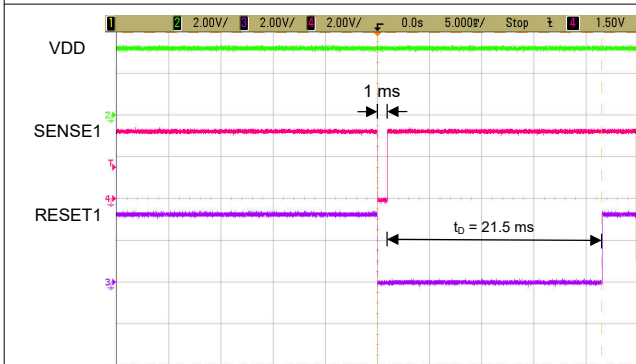
V_{SENSE1} toggling 0 V to 3.3 V [OV/UV Threshold = 3.3 V ($\pm 8\%$)], V_{SENSE2} toggling from 0 V to 1.8 V [OV/UV Threshold = 1.8 V (+4%, -3.5%)], $V_{DD} = 3.3$ V, $V_{RESET1} = 3.3$ V, TPS37044A7OHDDFR

图 9-11. TPS37044 SENSE 1 and SENSE 2 Toggling



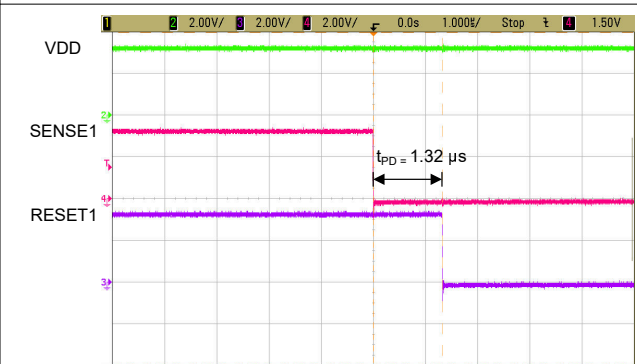
V_{SENSE3} toggling 0 V to 1.15 V [OV/UV Threshold = 1.15 V (+7.5%, -5.5%)], V_{SENSE4} toggling from 0 V to 1.15 V [OV/UV Threshold = 1.15 V (+7.5%, -5.5%)], $V_{DD} = 3.3$ V, $V_{RESET1} = 3.3$ V, TPS37044A7OHDDFR

图 9-12. TPS37044 SENSE 3 and SENSE 4 Toggling



$V_{SENSE1} = 3.3$ V, $V_{SENSE1} = 0$ V via push-button for 1 ms, $V_{DD} = 3.3$ V, $V_{RESET1} = 3.3$ V, TPS37044A7OHDDFR

图 9-13. TPS37044 SENSE1 Push-Button Monitoring Function with Reset Time Delay



V_{SENSE1} toggling from 3.3 V to 0 V, $V_{DD} = 3.3$ V, V_{RESET1} toggling from 3.3 V to 0 V, TPS37044A7OHDDFR

图 9-14. TPS37044 SENSE1 Propagation Delay Function

10 Power Supply Recommendations

10.1 Power Supply Guidelines

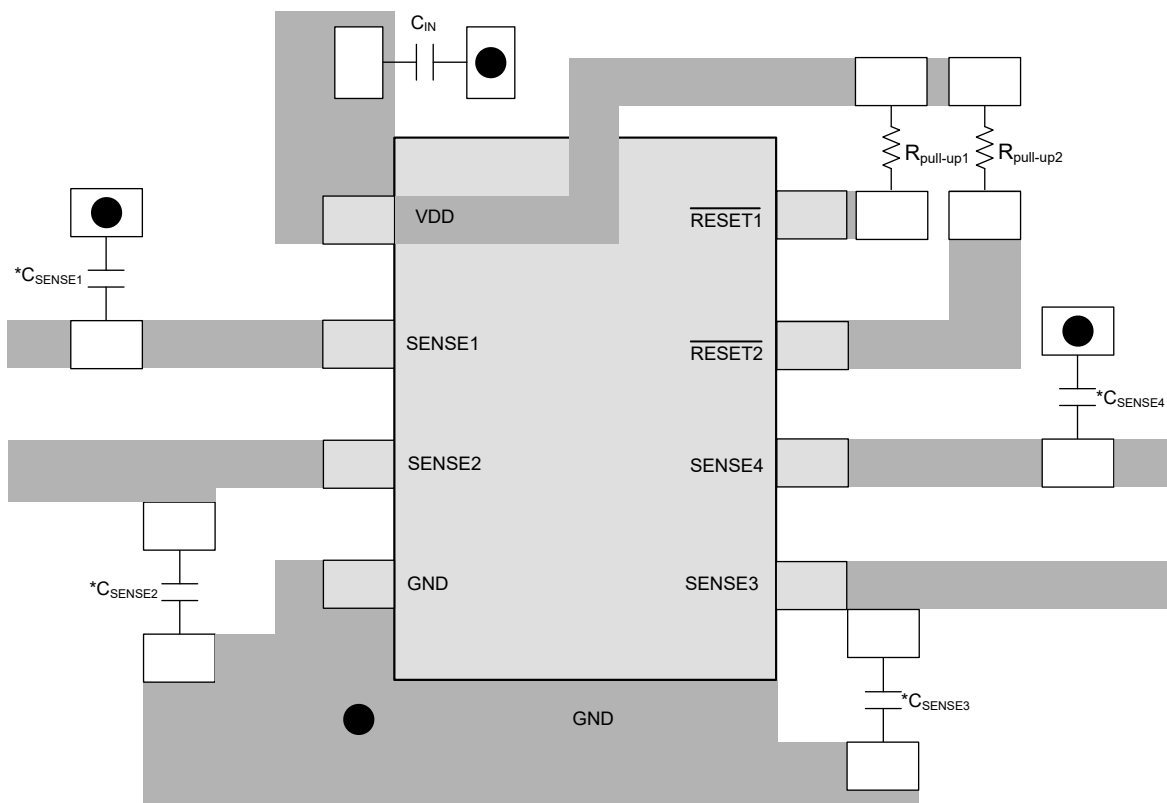
This device is designed to operate from an input supply with a voltage range between 1.7 V to 6 V. It has a 6.5 V absolute maximum rating on the VDD pin. It is good analog practice to place a 0.1 μ F to 1 μ F capacitor between the VDD pin and the GND pin depending on the input voltage supply noise. If the voltage supply providing power to VDD is susceptible to any large voltage transient that exceed maximum specifications, additional precautions must be taken. See [SNVA849](#) for more information.

11 Layout

11.1 Layout Guidelines

- Place the external components as close to the device as possible. This configuration prevents parasitic errors from occurring.
- Avoid using long traces for the VDD supply node. The VDD capacitor, along with parasitic inductance from the supply to the capacitor, can form an LC circuit and create ringing with peak voltages above the maximum VDD voltage.
- Avoid using long traces of voltage to the sense pin. Long traces increase parasitic inductance and cause inaccurate monitoring and diagnostics.
- If SENSEx capacitors (C_{SENSEx}) are used, place the capacitors as close as possible to the SENSEx pins to further improve the noise immunity on the SENSEx pins. Placing a 10 nF to 100 nF capacitors between the SENSEx pins and GND can reduce the sensitivity to transient voltages on the monitored signal.
- 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 absolutely necessary.

11.2 Layout Example



- Vias used to connect pins for application-specific connections
- * C_{SENSEx} capacitors can be added for improve noise immunity

图 11-1. Recommended Layout

12 Device and Documentation Support

12.1 Device Nomenclature

图 5-1 在 节 5 和 表 12-1 显示了如何根据器件的零件号解码器件的功能，如 表 12-2 所示。

表 12-1. Device Naming Convention

DESCRIPTION	NOMENCLATURE	VALUE
Generic Part number	TPS3704x	TPS3704x
Channel Option	1	One-channel option
	2	Dual-channel option
	3	Triple-channel option
	4	Quad-channel option
Detection Options	Ax, Bx, Cx,...	Please refer to 表 12-2
Variant code (Output Topology)	O	Open-Drain, Active-Low
	L	Push-Pull, Active-Low
	H	Push-Pull, Active-High
Reset Time Delay Option	A	20 μ s reset time delay
	B	1 ms reset time delay
	C	2 ms reset time delay
	D	3 ms reset time delay
	E	5 ms reset time delay
	F	10 ms reset time delay
	G	15 ms reset time delay
	H	20 ms reset time delay
	I	25 ms reset time delay
	J	35 ms reset time delay
	K	40 ms reset time delay
	L	50 ms reset time delay
	M	70 ms reset time delay
	N	100 ms reset time delay
	O	140 ms reset time delay
	P	150 ms reset time delay
	R	200 ms reset time delay
	S	280 ms reset time delay
	T	400 ms reset time delay
	U	560 ms reset time delay
V	800 ms reset time delay	
W	1120 ms reset time delay	
X	1200 ms reset time delay	
Package	DDF	SOT-23 8-pin (1.6 mm \times 2.9 mm)
Reel	R	Large Reel

表 12-2. Device Threshold Table

ORDERABLE PART NAME	VARIANT	NUM OF CHAN.	RESET TIME	SENSE1	SENSE2	SENSE3	SENSE4
TPS37044BJOFDDFR	TPS37044	4	10 ms	0.8 V (±4%)	0.8 V (±4%)	0.8 V (±4%)	0.8 V (±4%)

12.2 接收文档更新通知

要接收文档更新通知，请导航至 ti.com 上的器件产品文件夹。点击 [订阅更新](#) 进行注册，即可每周接收产品信息更改摘要。有关更改的详细信息，请查看任何已修订文档中包含的修订历史记录。

12.3 支持资源

[TI E2E™ 支持论坛](#) 是工程师的重要参考资料，可直接从专家获得快速、经过验证的解答和设计帮助。搜索现有解答或提出自己的问题可获得所需的快速设计帮助。

链接的内容由各个贡献者“按原样”提供。这些内容并不构成 TI 技术规范，并且不一定反映 TI 的观点；请参阅 TI 的 [《使用条款》](#)。

12.4 Trademarks

TI E2E™ is a trademark of Texas Instruments.

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12.5 Electrostatic Discharge Caution



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

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

12.6 术语表

[TI 术语表](#) 本术语表列出并解释了术语、首字母缩略词和定义。

13 Mechanical, Packaging, and Orderable Information

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

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
TPS37044BJOFDDFR	ACTIVE	SOT-23-THIN	DDF	8	3000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	4BJOF	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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OTHER QUALIFIED VERSIONS OF TPS3704 :

- Automotive : [TPS3704-Q1](#)

NOTE: Qualified Version Definitions:

- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

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
TPS37044BJOFDDFR	SOT-23-THIN	DDF	8	3000	180.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3

TAPE AND REEL BOX DIMENSIONS


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPS37044BJOFDDFR	SOT-23-THIN	DDF	8	3000	210.0	185.0	35.0

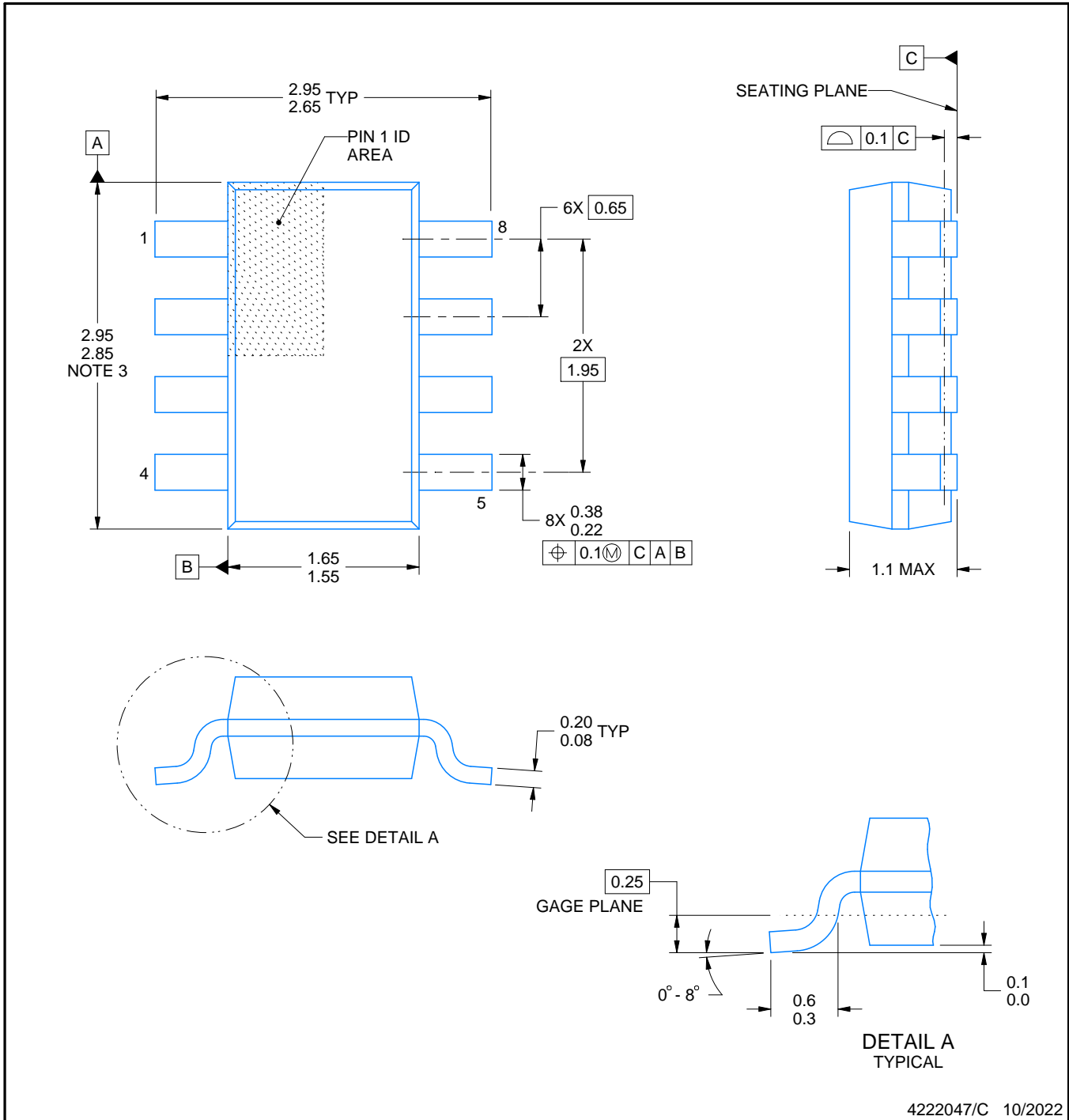
DDF0008A



PACKAGE OUTLINE

SOT-23 - 1.1 mm max height

PLASTIC SMALL OUTLINE



NOTES:

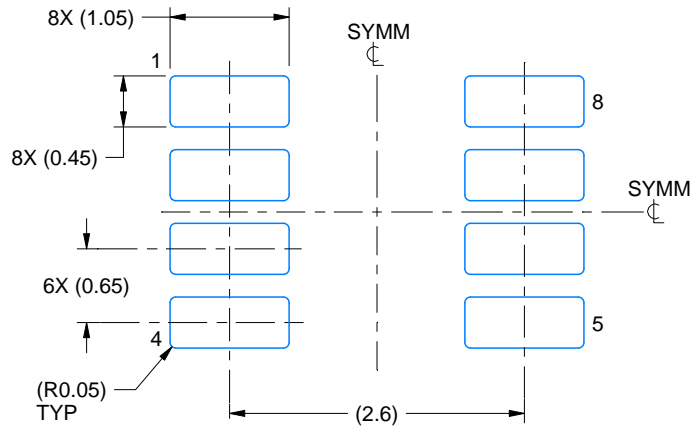
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.

EXAMPLE BOARD LAYOUT

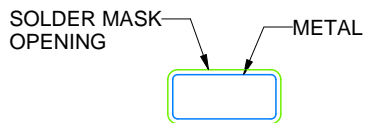
DDF0008A

SOT-23 - 1.1 mm max height

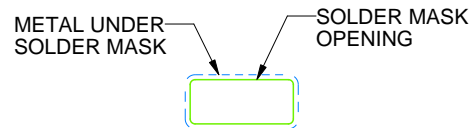
PLASTIC SMALL OUTLINE



LAND PATTERN EXAMPLE
SCALE:15X



NON SOLDER MASK
DEFINED



SOLDER MASK
DEFINED

SOLDER MASK DETAILS

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NOTES: (continued)

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

EXAMPLE STENCIL DESIGN

DDF0008A

SOT-23 - 1.1 mm max height

PLASTIC SMALL OUTLINE



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE:15X

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NOTES: (continued)

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

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