TPS389C03-Q1 マルチチャネル過電圧および低電圧 I²C プログラマブル電圧スーパーバイザおよびモニタ、Q&A ウォッチドッグ付き

1 特長

- ASIL-D 機能安全準拠
  - ISO 26262 システムの設計に役立つ資料
  - ASIL D までの決定論的対応能力
  - ASIL D までのハードウェア機能
- 以下の結果で AEC-Q100 認定済み:
  - デバイス温度グレード 1:-40℃～+125℃
  - デバイス HBM ESD 分類レベル 2
  - デバイス CDM ESD 分類レベル C7B
- SoC ソフトウェアの動作を監視する Q&A ウォッチドッグ
  - I²C によりプログラム可能な OPEN/CLOSE ウォッチドッグ・タイミング (1ms～864ms)
  - SoC 起動初期化によるスタートアップ遅延 (2ms～3.46s)
  - WDO アサート前のプログラム可能な最大違反カウント (最大 7)
  - ウォッチドッグ・ディスエーブル・ピン (WDE)
- 最新の SoC を監視
  - 3 チャネル、3 個のリモート・センス付き (TPS389C03-Q1)
  - 入力電圧範囲:2.6V～5.5V
  - 低電圧誤動作防止 (UVLO):2.6V
  - 高いスレッショルド精度:
  - ±5mV (-40℃～+125℃)
  - 電圧読み出し用の ADC を内蔵
  - 固定ウィンドウのスレッショルド・レベル
    - 0.2V～1.475V、5mV ステップ
    - その他の範囲は 20mV ステップ
- 小さなソリューション・サイズとわずかな部品コスト
  - 3mm × 3mm の QFN パッケージ
  - 調整可能な電圧スレッショルド・レベル (I²C 利用)
  - 調整可能なグリッチ耐性とヒステリシス・レベル (I²C 利用)
- 安全アプリケーション向けに設計
  - エラー信号モニタ (ESM)
    - I²C によりプログラム可能な ESM 遅延 (1ms～864ms)
  - 巡回冗長性検査 (CRC)
  - パケット・エラー・チェック (PEC)
  - アクティブ Low、オープン・ドレインの NIRQ、NRST、WDO 出力

2 アプリケーション

- 先進運転支援システム (ADAS)
- センサ・フュージョン
  - レベル 3～レベル 5 自律プラットフォーム

3 概要

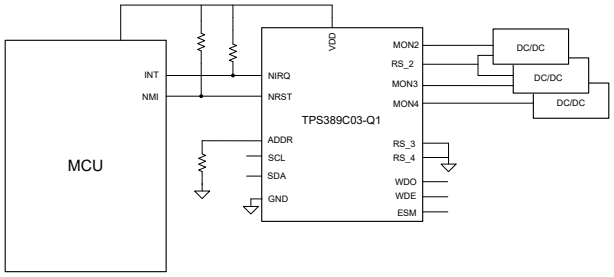
TPS389C03-Q1 デバイスは、一体型マルチチャネルのウィンドウ モニタ リセット IC で、3 つのリモート センス ピンを搭載し、16 ピンの 3mm × 3mm QFN パッケージで供給されます。

この高精度のマルチチャネル電圧スーパーバイザは、低電圧電源レールで動作する、電源誤差の余地が小さいシステムに理想的です。内部的なグリッチ耐性およびノイズ・フィルタにより、信号エラーによる誤ったリセットも回避されます。この TPS389C03-Q1 デバイスは、外付け抵抗なしで過電圧および低電圧リセットのスレッショルドを設定できるため、総合的な精度、コスト、ソリューション・サイズをさらに最適化でき、安全性システムの信頼性も向上します。I²C 機能により、スレッショルド、リセット遅延、グリッチ・フィルタ、ピン機能を柔軟に選択できます。このデバイスには、CRC エラー・チェック機能と、電圧読み出しを行うための内蔵 ADC が搭載されており、冗長なエラー・チェックが可能です。このデバイスには、Q&A ウォッチドッグとエラー信号モニタが組み込まれており、独立したウォッチドッグ・イネーブルとウォッチドッグ出力があります。

製品情報

部品番号	パッケージ (1)	本体サイズ (公称)
TPS389C03-Q1	WQFN (16)	3mm × 3mm

(1) 利用可能なすべてのパッケージについては、このデータシートの末尾にある注文情報を参照してください。



TPS389C03-Q1 回路例

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4 Device Comparison

図 4-1 shows the device nomenclature of the TPS389C03-Q1. Contact TI sales representatives or go online to TI's E2E forum for details and availability of other options; minimum order quantities apply.

See 図 4-1 for more information regarding the device ordering codes. 表 10-1 and show how to decode the function of the device based on the part number.

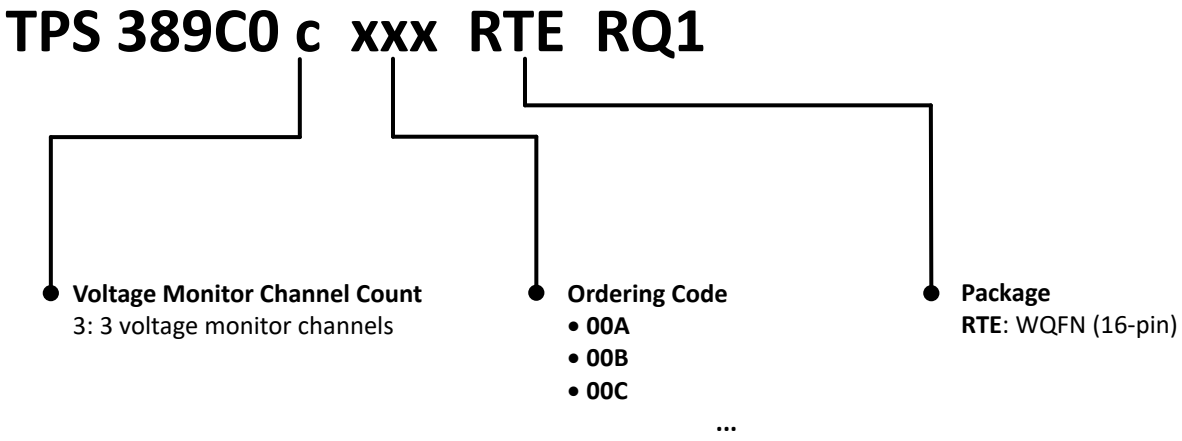


図 4-1. TPS389C03-Q1 Device Nomenclature

5 Pin Configuration and Functions

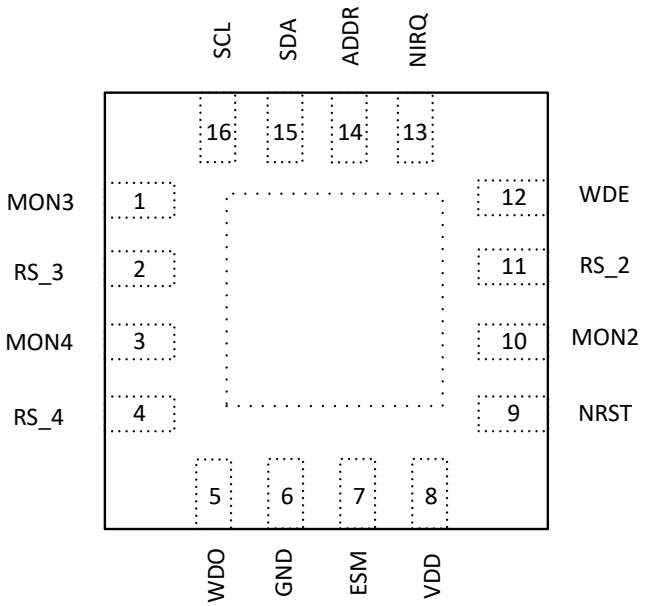


図 5-1. RTE Package
16-Pin WQFN
TPS389C03-Q1 Top View

表 5-1. Pin Functions

PIN		I/O	DESCRIPTION
NO.	TPS389C03-Q1 NAME		
1	MON3	I	Voltage monitor channel 3
2	RS_3	I	Remote sense for channel 3
3	MON4	I	Voltage monitor channel 4
4	RS_4	I	Remote sense for channel 4
5	WDO	O	Open drain pin for Watch Dog errors
6	GND	-	Power ground
7	ESM	I	Error signal monitor
8	VDD	-	Power supply rail
9	NRST	O	Open drain Reset pin
10	MON2	I	Voltage monitor channel 2
11	RS_2	I	Remote sense for channel 2
12	WDE	I	Watch dog enable
13	NIRQ	O	Active-low open-drain interrupt output
14	ADDR	I	I^2C address select pin
15	SDA	I/O	I^2C data pin
16	SCL	I	I^2C clock pin
17	GND	-	Exposed power ground pad

6 Specifications

6.1 Absolute Maximum Ratings

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

		MIN	MAX	UNIT
Voltage	VDD	–0.3	6	V
Voltage	NIRQ,NRST,WDO,ESM,WDE	–0.3	6	V
Voltage	SCL,SDA	–0.3	VDD+0.3	V
Voltage	ADDR	–0.3	2	V
Voltage	MONx	–0.3	6	V
Current	NIRQ,NRST,WDO		±10	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	125	°C
	Storage temperature, T_{stg}	-65	150	°C

(1) Stresses beyond values listed under Absolute Maximum Ratings 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 absolute-maximum-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 $T_J = T_A$.

6.2 ESD Ratings

				VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 (1)		±2000	V
		Charged-device model (CDM), per AEC Q100-011	All pins	±500	
			Corner pins	±750	

(1) AEC Q100-002 indicates that HBM stressing shall be in accordance with the ANSI/ESDA/JEDEC JS-001 specification

6.3 Recommended Operating Conditions

		MIN	NOM	MAX	UNIT
VDD	Supply pin voltage	2.6		5.5	V
NIRQ,NRST,WDO,ESM,WDE	Pin voltage	0		5.5	V
$I_{NIRQ,NRST,WDO}$	Pin Currents	0		±5	mA
ADDR	Address pin voltage	0		1.8	V
MONx	Monitor Pins	0		5.5	V
SCL,SDA	Pin Voltage	0		VDD	V
R_{UP} (1)	Pull-up resistor (Open Drain config)	1		100	kΩ
T_J	Junction temperature (free-air temperature)	-40		125	℃

6.4 Thermal Information

THERMAL METRIC[1]		TPS389C03-Q1 RTE (WQFN) PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	53.4	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	51.4	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	17.2	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	0.3	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	20.7	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	3.9	°C/W

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

6.5 Electrical Characteristics

At 2.6 V ≤ VDD≤ 5.5 V, NIRQ Voltage = 10 kΩ to V_{DD}, NIRQ 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_J = 25°C, typical conditions at VDD= 3.3 V.

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
COMMON PARAMETERS						
VDD	Input supply voltage		2.6		5.5	V
VDD_{UVLO}	Rising Threshold		2.67		2.81	V
	Falling Threshold		2.48		2.6	V
V_{POR}	Power on Reset Voltage [2]				1.65	V
I_{DD_Active}	Supply current into VDD pin	VDD≤5.5V		1550	2000	µA
V_{MONX}	MON voltage range		0.2		5.5	V
I_{MONX}	Input current MONx pins	V_{MON}=5V			20	µA
VMON_LF	1x mode (No scaling)		0.2		1.475	V
	4x mode		0.8		5.5	V
VMON_HF	1x mode (No scaling)		0.2		1.475	V
	4x mode		0.8		5.5	V
Threshold Granularity_LF	1x mode (No scaling)			5		mV
	4x mode			20		mV
Threshold Granularity_HF	1x mode (No scaling)			5		mV
Threshold Granularity_HF	4x mode			20		mV
Accuracy_HF	VMON	0.2V≤V_{MONX}≤1.0V	–6		6	mV
		1.0V<V_{MONX}≤1.475V	-7.5		7.5	mV
		1.475V<V_{MONX}≤2.95V	-0.6		0.6	%
		V_{MONX}>2.95V	-0.7		0.7	%
V_{HYS_HF}	Hysteresis on UV,OV pin(Hysteresis is with respect of the tripoint ((UV),(OV)) [1]	0.2V≤V_{MONX}≤1.475V		5	11	mV
		1.475V<V_{MONX}≤2.95V		9	16	
		VMONX>2.95V		17	28	mV
MON_OFF	OFF Voltage threshold	Monitored falling edge of V_{MON}	140		215	mV
NIRQ	On resistance- when asserted Low	Open Drain		12	17	Ω
V_{OL}	Low level output voltage-NIRQ	NIRQ, 5.5V/5mA			100	mV

6.5 Electrical Characteristics (続き)

At 2.6 V ≤ VDD≤ 5.5 V, NIRQ Voltage = 10 kΩ to V_{DD}, NIRQ 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_J = 25°C, typical conditions at VDD= 3.3 V.

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$I_{lkg(OD)}$	Open-Drain output leakage current-NIRQ	NIRQ pin in High Impedance,VNIRQ= 5.5, Not asserted			90	nA
NRST	On resistance- when asserted Low	Open Drain		10	15	Ω
V_{OL}	Low level output voltage-NRST	NRST , 5.5V/5mA			100	mV
$I_{lkg(OD)}$	Open-Drain output leakage current-NRST	NRST pin in High Impedance,VNRST= 5.5, Not asserted			600	nA
WDO	On resistance- when asserted Low	Open Drain		12	17	Ω
V_{OL}	Low level output voltage-WDO	WDO , 5.5V/5mA			100	mV
$I_{lkg(OD)}$	Open-Drain output leakage current-WDO	WDO pin in High Impedance,VNRST= 5.5, Not asserted			500	nA
ESM_L	Logic Low Input				0.24 x VDD	V
ESM_H	Logic High Input	VDD>4.5	0.55 x VDD			V
		VDD<4.5	0.6 x VDD			V
Ilkg(ESM)	Leakage current	ESM=5.5V			75	µA
WDE_L	Logic Low Input				0.36	V
WDE_H	Logic High Input		1.26			V
Ilkg(WDE)	Leakage current	WDE=5.5V			5	µA
I_{ADDR}	ADDR pin current			20		µA
I2C ADDR	(Hex format)	R=5.36k		0x30		
		R=16.2k		0x31		
		R=26.7k		0x32		
		R=37.4k		0x33		
		R=47.5k		0x34		
		R=59.0k		0x35		
		R=69.8k		0x36		
		R=80.6k		0x37		
TSD	Thermal Shutdown			155		℃
TSD Hys	Thernal Shutdown Hysterisis			25		℃
RS	Remote sense range		-100		100	mV
ADC SPECIFICATION						
Vin	Input Range		0.2		5.5	V
Resolution	1x mode	0.2V≤VMON≤1.475V		5		mV
	4x mode	VMON>1.475V		20		mV
f_S	Sample Rate			125		ksps
Accuracy_LF	VMON,1x mode	0.2V≤VMON≤1.475V	-12		+12	mV
	VMON, 4x mode	VMON>1.475V	-40		+40	mV
I2C ELECTRICAL SPECIFICATIONS						
V_{HYS_LF}	Hysteresis LF Faults, 1x mode	0.2V≤VMON≤1.475V		10	15	mV
	Hysteresis LF Faults, 4x mode	VMON>1.475V		40	55	mV
C_B	Capacitive load for SDA and SCL				400	pF
SDA,SCL	Low Threshold	DEV_CONFIG.SOC_IF=0			0.84	V

6.5 Electrical Characteristics (続き)

At 2.6 V ≤ VDD≤ 5.5 V, NIRQ Voltage = 10 kΩ to V_{DD}, NIRQ 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_J = 25°C, typical conditions at VDD= 3.3 V.

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
SDA,SCL	High Threshold	DEV_CONFIG.SOC_IF=0	2.31			V

(1) Hysteresis is with respect of the tripoint ($V_{IT-(UV)}$, $V_{IT+(OV)}$).
(2) V_{POR} is the minimum V_{DDX} voltage level for a controlled output state.

6.6 Timing Requirements

At 2.6 V ≤ VDD ≤ 5.5 V, NIRQ Voltage = 10 kΩ to VDD, NIRQ 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_J = 25°C, typical conditions at VDD = 3.3 V.

			MIN	NOM	MAX	UNIT
COMMON PARAMETERS						
t_{BIST}	POR to ready with BIST, TEST_CFG.AT_POR=1	includes OTP load			12	ms
tNBIST	POR to ready without BIST, TEST_CFG.AT_POR=0	includes OTP load			2	ms
BIST	BIST time,TEST_CFG.AT_POR=1 or TEST_CFG.AT_SHDN=1				10	ms
t_{I2C_ACT}	I2C active from BIST complete				0	µs
t_{NRST}	Fault detection to NRST assertion latency				25	µs
t_{WDO}	Fault detection to WDO assertion latency				25	µs
t_{NIRQ}	Fault detection to NIRQ assertion latency (except OV/UV faults)				25	µs
$t_{PD\_NIRQ\_1X}$	HF fault Propagation detect delay (default deglitch filter) includes digitial delay	VIT_OV/UV +/- 100mV			650	ns
$t_{PD\_NIRQ\_4X}$	HF fault Propagation detect delay (default deglitch filter) includes digitial delay	VIT_OV/UV +/- 400mV			750	ns
t_D	RESET time delay	I2C Register time delay =000		200		µs
		I2C Register time delay =001		1		ms
		I2C Register time delay =010		10		ms
		I2C Register time delay =011		16		ms
		I2C Register time delay =100		20		ms
		I2C Register time delay =101		70		ms
		I2C Register time delay =110		100		ms
		I2C Register time delay =111		200		ms

6.6 Timing Requirements (続き)

At 2.6 V ≤ VDD ≤ 5.5 V, NIRQ Voltage = 10 kΩ to VDD, NIRQ 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_J = 25°C, typical conditions at VDD = 3.3 V.

			MIN	NOM	MAX	UNIT
t_{D_WD}	WDO delay	I2C Register time delay =000		200		µs
		I2C Register time delay =001		1		ms
		I2C Register time delay =010		10		ms
		I2C Register time delay =011		16		ms
		I2C Register time delay =100		20		ms
		I2C Register time delay =101		70		ms
		I2C Register time delay =110		100		ms
		I2C Register time delay =111		200		ms
$t_{debounce\_ESM}$	Debounce time	I2C Register time delay =00		10		µs
		I2C Register time delay =01		25		
		I2C Register time delay =10		50		
		I2C Register time delay =11		100		
t_{GI_R}	UV & OV debounce range via I2C	FLT_HF(N)	0.1		102.4	µs

6.6 Timing Requirements (続き)

At 2.6 V ≤ VDD ≤ 5.5 V, NIRQ Voltage = 10 kΩ to VDD, NIRQ 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_J = 25°C, typical conditions at VDD = 3.3 V.

			MIN	NOM	MAX	UNIT
I2C TIMING CHARACTERISTICS						
f_{SCL}	Serial clock frequency	Standard mode			100	kHz
f_{SCL}	Serial clock frequency	Fast mode			400	kHz
f_{SCL}	Serial clock frequency	Fast mode +			1	MHz
t_{LOW}	SCL low time	Standard mode	4.7			µs
t_{LOW}	SCL low time	Fast mode	1.3			µs
t_{LOW}	SCL low time	Fast mode +	0.5			µs
t_{HIGH}	SCL high time	Standard mode	4			µs
t_{HIGH}	SCL high time	Fast mode +	0.26			µs
$t_{SU;DAT}$	Data setup time	Standard mode	250			ns
$t_{SU;DAT}$	Data setup time	Fast mode	100			ns
$t_{SU;DAT}$	Data setup time	Fast mode +	50			ns
$t_{HD;DAT}$	Data hold time	Standard mode	10		3450	ns
$t_{HD;DAT}$	Data hold time	Fast mode	10		900	ns
$t_{HD;DAT}$	Data hold time	Fast mode +	10			ns
$t_{SU;STA}$	Setup time for a Start or Repeated Start condition	Standard mode	4.7			µs
$t_{SU;STA}$	Setup time for a Start or Repeated Start condition	Fast mode	0.6			µs
$t_{SU;STA}$	Setup time for a Start or Repeated Start condition	Fast mode +	0.26			µs
$t_{HD:STA}$	Hold time for a Start or Repeated Start condition	Standard mode	4			µs
$t_{HD:STA}$	Hold time for a Start or Repeated Start condition	Fast mode	0.6			µs
$t_{HD:STA}$	Hold time for a Start or Repeated Start condition	Fast mode +	0.26			µs
t_{BUF}	Bus free time between a STOP and START condition	Standard mode	4.7			µs
t_{BUF}	Bus free time between a STOP and START condition	Fast mode	1.3			µs
t_{BUF}	Bus free time between a STOP and START condition	Fast mode +	0.5			µs
$t_{SU;STO}$	Setup time for a Stop condition	Standard mode	4			µs
$t_{SU;STO}$	Setup time for a Stop condition	Fast mode	0.6			µs
$t_{SU;STO}$	Setup time for a Stop condition	Fast mode +	0.26			µs
trDA	Rise time of SDA signal	Standard mode			1000	
trDA	Rise time of SDA signal	Fast mode	20		300	ns
trDA	Rise time of SDA signal	Fast mode +			120	ns
tfDA	Fall time of SDA signal	Standard mode			300	ns
tfDA	Fall time of SDA signal	Fast mode	1.4		300	ns
tfDA	Fall time of SDA signal	Fast mode +	6.5		120	ns
trCL	Rise time of SCL signal	Standard mode			1000	ns
trCL	Rise time of SCL signal	Fast mode	20		300	ns
trCL	Rise time of SCL signal	Fast mode +			120	ns
tfCL	Fall time of SCL signal	Standard mode			300	ns
tfCL	Fall time of SCL signal	Fast mode	6.5		300	ns
tfCL	Fall time of SCL signal	Fast mode +	6.5		120	ns
tSP	Pulse width of SCL and SDA spikes that are suppressed	Standard mode, Fast mode and Fast mode +			50	ns

7 Detailed Description

7.1 Overview

The TPS389C03-Q1 family of devices has three channels that can be configured for over voltage, under voltage or both in a window configuration. The TPS389C03-Q1 features a highly accurate window threshold voltages (up to ±5 mV) and a variety voltage thresholds which can be factory configured or set on boot up by I2C commands.

The TPS389C03-Q1 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 TPS389C03-Q1 is designed to assert active low output signals (NIRQ and/or NRST) when the monitored voltage is outside the safe window. The default configuration has the interrupts enabled for over voltage and under voltage faults, sequence timeout set for 1 ms, BIST enabled at POR, and over voltage and under voltage debounce set for 102.4 µs.

7.2 Functional Block Diagram

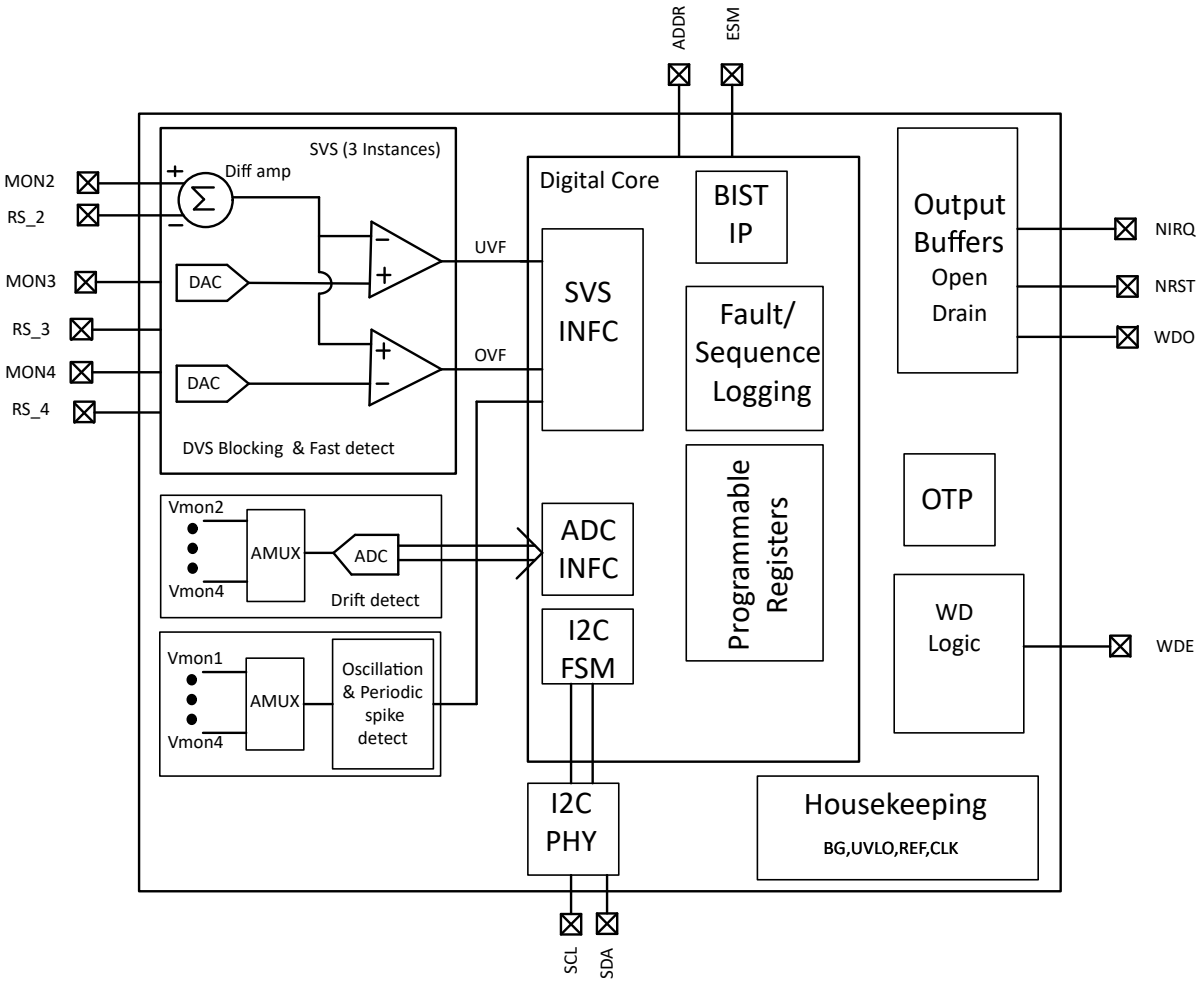


図 7-1. TPS389C03-Q1 Block Diagram

7.3 Feature Description

7.3.1 I²C

The TPS389C03-Q1 device follows the I²C protocol (up to 1MHz) to manage communication with host devices such as an MCU or System on Chip (SoC). I²C is a two wire communication protocol implmented using two signals, clock (SCL) and data (SDA). The host device is primary controller of communication. TPS389C03-Q1 device responds over the data line during read or write operation as defined by I²C protocol. Both SCL and SDA signals are open drain topology and can be used in a wired-OR configuration with other devices to share the communication bus. Both SCL and SDA pins need an external pull up resistance to supply voltage (10kΩ recommended).

図 7-2 shows the timing relationship between SCL and SDA lines to transfer 1 byte of data. SCL line is always controlled by host. To transfer 1 byte data, host needs to send 9 clocks on SCL. 8 clocks for data and 1 clock for ACK or NACK. SDA line will be controlled by either host or TPS389C03-Q1 device based on the read or write operation. 図 7-3 and 図 7-4 highlight the communication protocol flow and which device controls SDA line at various instances during active communication.

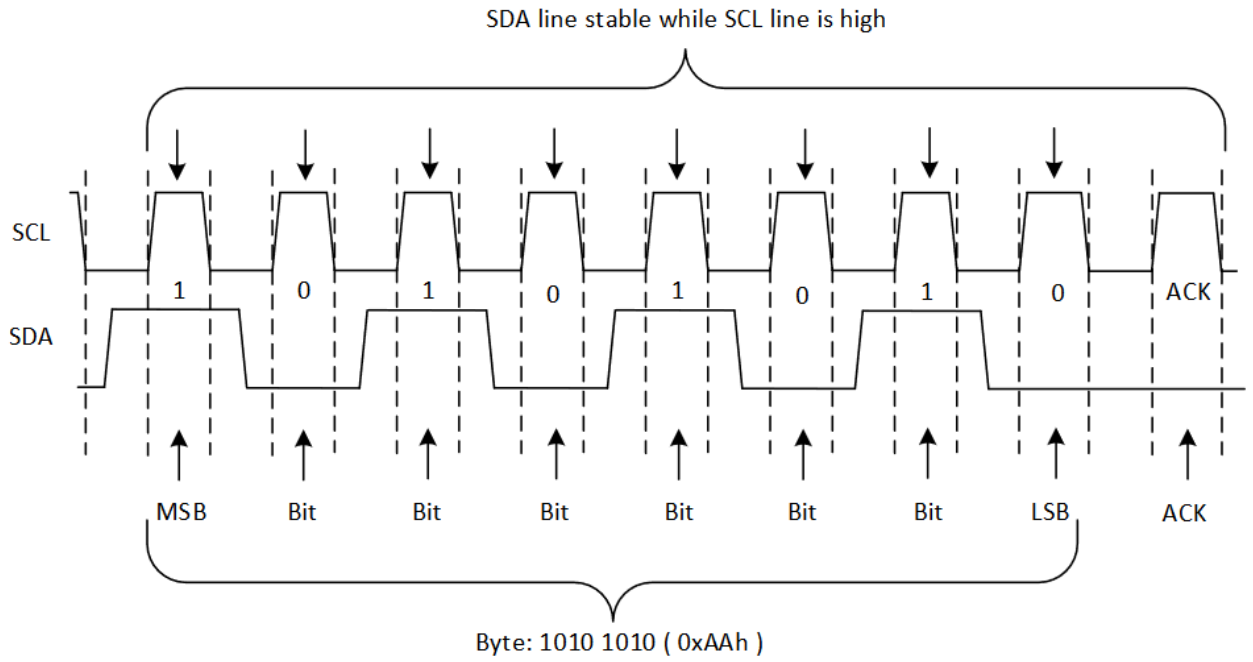


図 7-2. SCL to SDA timing for 1 byte data transfer

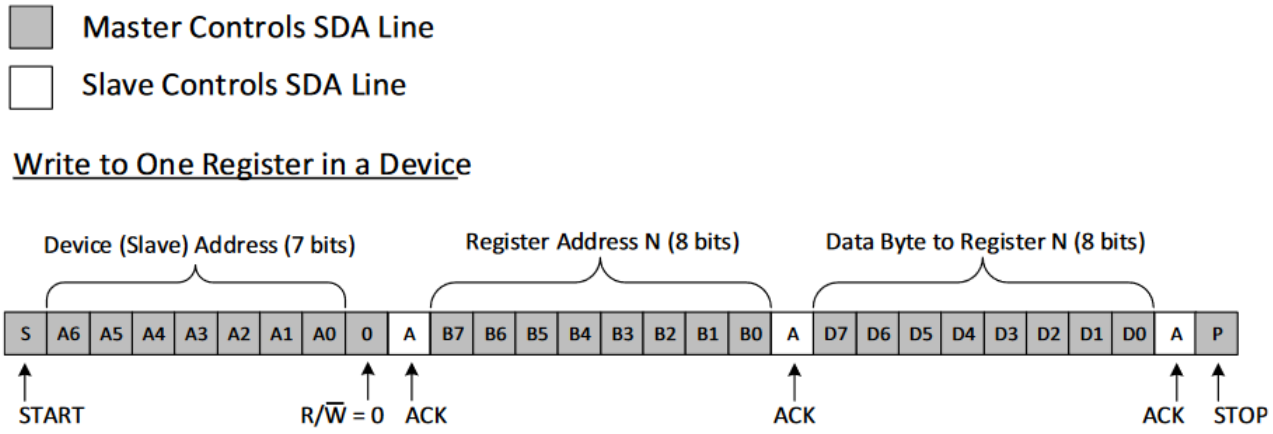


図 7-3. I²C write protocol

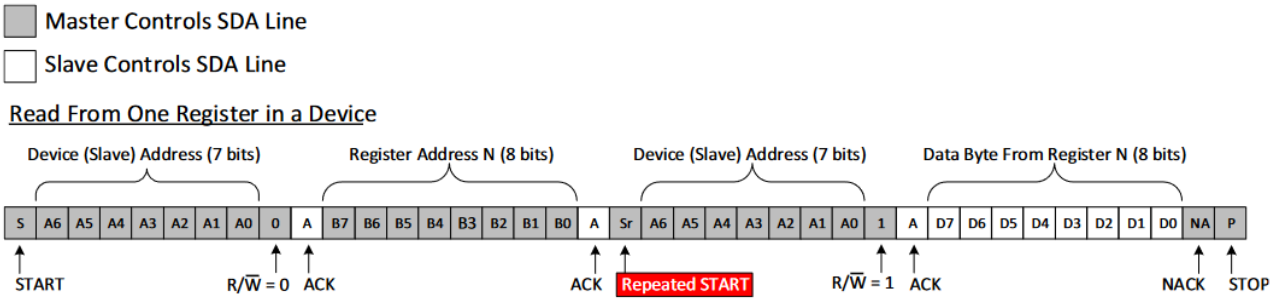


図 7-4. I²C read protocol

Before initiating communication over I²C protocol, host needs to confirm the I²C bus is available for communication. Monitor the SCL and SDA lines, if any line is pulled low, the I²C bus is occupied. Host needs to wait until the bus is available for communication. Once the bus is available for communication, the host can initiate read or write operation by issuing a START condition. Once the I²C communication is complete, release the bus by issuing STOP command. 図 7-5 shows how to implement START and STOP condition.

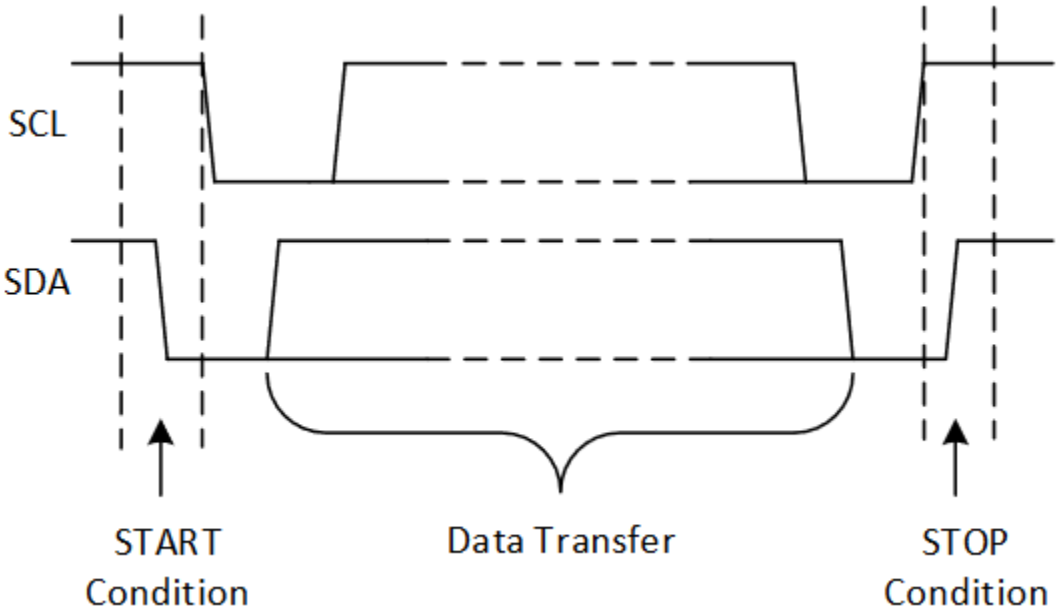


図 7-5. I²C START and STOP condition

The SDA line may get stuck in logic low level if required number of clocks are not provided by the host. In this scenario, host should provide multiple clocks on SCL line until the SDA line goes high. After this event, host should issue I²C stop command. This will release the I²C bus and other devices can use the I²C bus.

表 7-1 shows the different functionality available when programming with I²C.

表 7-1. User Programmable I²C Functions

FUNCTIONS	DESCRIPTION
Thresholds for OV/UV- HF	Adjustable in 5 mV steps from 0.2 V to 1.475 V and 20 mV steps from 0.8 V to 5.5 V
Thresholds for OV/UV - LF	Adjustable in 5 mV steps from 0.2 V to 1.475 V and 20 mV steps from 0.8 V to 5.5 V
Voltage Monitoring scaling	1 or 4
Glitch immunity for OV/UV- HF	0.1 us to 102.4 us
Low Frequency Cutoff filter	250 Hz to 4 kHz
Enable sequence timeout	1 ms to 4 s
Packet error checking for I²C	Enabling or Disabling
Force NIRQ/NRST/WDO assertion	Controlled by I²C register
Individual channel MON	Enable or Disable
Interrupt disable functions	BIST, PEC, TSD, CRC
ESM Threshold	1 ms to 864 ms
ESM Debounce	10 us to 100us
Reset Delay	200 us to 200 ms
MAX Violation Count	0 to 7
Watchdog Startup Delay Multiplier	0 to 7
Watchdog Open and Close Window Times	1 ms to 864 ms
Watchdog Output Delay	200 us to 200 ms (only applicable for non-latched WDO)
OV/UV/ESM/WDT	Mappable individually to NIRQ, NRST, and WDO

7.3.2 Maskable Interrupt (AMSK)

In the case of power up, AMSK_ON register applies. AMSK_ON masks interrupts until the MON voltage crosses the UVLF threshold or sequence timeout expires whichever is sooner. In the case of power down AMSK_OFF register applies. AMSK_ON masks interrupts until the MON voltage is below the OFF threshold and then the OVLF interrupts are active.

表 7-2 summarizes the auto-mask operation for power up and power down.

表 7-2. Auto-Mask Operation for the Power Up and Power Down

TRANSITION	AUTO-MASK APPLIED	AUTO-MASK APPLIES TO	AUTO-MASK INACTIVE	INTERRUPTS ACTIVE FOR MON CHANNELS NOT IN AUTO-MASK
Power Up	AMSK_ON	IEN_UVLF, IEN_UVHF, IEN_OVHF	SEQ_TOUT expires or rail crosses UVLF	At Power Up
Power Down	AMSK_OFF		Auto-mask active in transition until SEQ_TOUT expires	Until SEQ_TOUT expires

7.3.3 VDD

The TPS389C03-Q1 is designed to operate from an input voltage supply range between 2.6 V to 5.5 V. An input supply capacitor is not required for this device; however, if the input supply is noisy good analog practice is to place a 1-µF capacitor between the VDD pin and the GND pin.

V_{DD} needs to be at or above $V_{DD(MIN)}$ for at least the start-up delay (t_{SD}+ t_D) for the device to be fully functional.

7.3.4 MON

The TPS389C03-Q1 combines two comparators with a precision reference voltage and a trimmed resistor divider per monitor (MON) channel. This configuration optimizes device accuracy because all resistor tolerances are accounted for in the accuracy and performance specifications. Both comparators also include built-in hysteresis that provides noise immunity and provides stable operation.

Each MON channel can be configured for Low Frequency (LF) and High Frequency (HF) fault detection. HF fault detection uses a comparator for UV and OV measurements referenced to the threshold voltage. A debounce filter for glitch immunity can be configured for HF faults using the FLT_HF registers in BANK1 associated with each MON channel.

LF fault detection measures the voltage through an ADC that can be used to monitor voltage drift. The LF detection thresholds can be configured for various purposes. For example, the OVLF threshold can be set lower than the OVHF threshold for drift monitoring. Alternatively, the OVLF threshold can be set to overlap with the OVHF threshold for redundancy. LF and HF faults are configured using the UV_HF, OV_HF, UV_LF, and OV_LF registers in BANK1. Each MON channel has unique UV_HF, OV_HF, UV_LF, and OV_LF registers. The diagram shown in 図 7-6 illustrates an example of how the LF and HF faults can be configured.

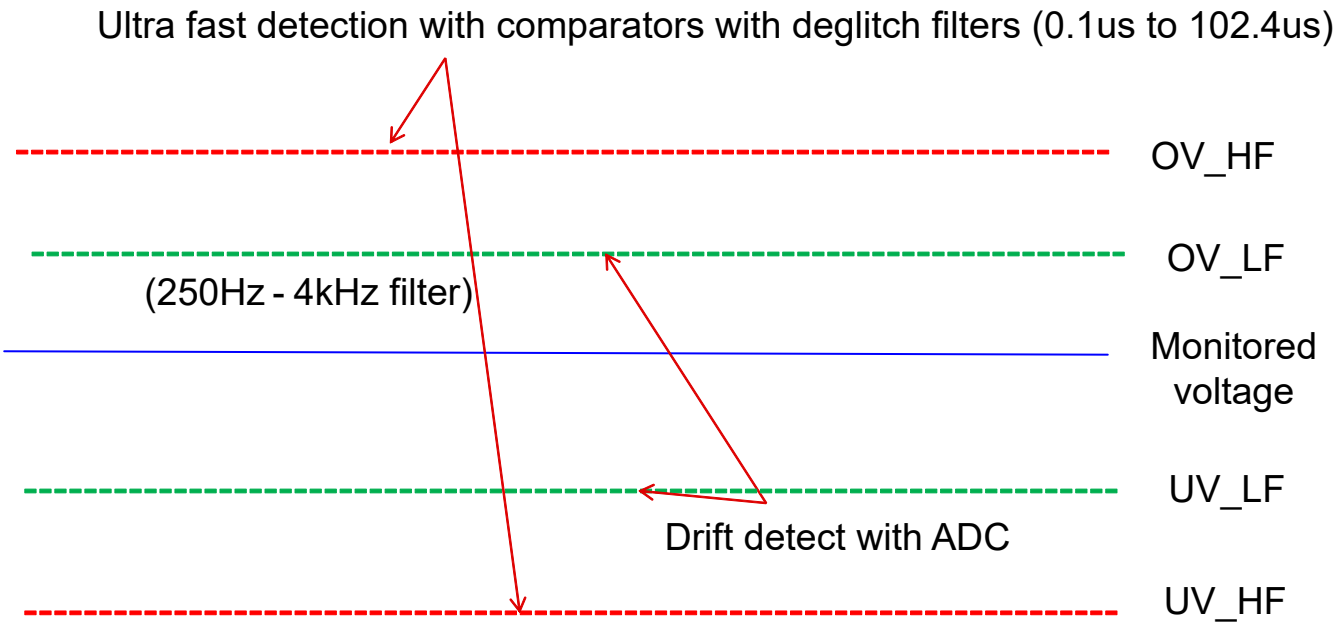


図 7-6. MON Channel State Diagram

Although not required in most cases, for noisy applications good analog design practice is to place a 1-nF to 10-nF bypass capacitor at the MON input to reduce sensitivity to transient voltages on the monitored signal. Specific debounce times or deglitch times can also be set independently for each MON via I^2C registers

When monitoring VDD supply voltage, the MON pin can be connected directly to VDD. The outputs NIRQ and NRST are high impedance when voltage at the MON pin is between upper and lower boundary of threshold.

The MON channel settings can be adjusted by using the associated registers listed in the register maps found in セクション 8. Using the register maps, the code example in 図 7-7 demonstrates how MON2 can be reconfigured.

```
ADDR 30
//              Go to Bank 1
WR F0 01
//              Check UVHF,OVHF thresholds for MON2 and MON3
RD 30 //MON2 UVHF
RD 31 //MON2 OVHF
RD 40 //MON3 UVHF
RD 41 //MON3 OVHF
//              Check UVLF,OVLF thresholds for MON2 and MON3
RD 32 //MON2 UVHF
RD 33 //MON2 OVHF
RD 42 //MON3 UVHF
RD 43 //MON3 OVHF
//             Example change OVHF threshold MON2 to 5.5V
WR 31 EB
//             Example change OVHF threshold MON2 to 5.48V
WR 31 EA
//             Example change OVHF threshold MON2 to 5.44V
WR 31 E8
//        Telemetry read the voltages being monitored
//              Go to Bank 0
WR F0 00
RD 41 // MON2 Voltage
RD 42 // MON3 Voltage
//     Simulate an OV fault on MON2
//              Go to Bank 1
WR F0 01
WR 31 C8 // Change OVHF threshold to 4.8V
//    NIRQ,NRST asserts (depends on mapping)
//    Clearing OVHF fault MON2
//              Go to Bank 0
WR F0 00
RD 16 // 02 READ SINCE OVHF on MON2
WR 16 02 // WRITE 1(bit 2) to clear
```

図 7-7. MON2 Setting Software Example

7.3.5 NRST

The NRST pin features a programmable reset delay time that can be adjusted from 0.2 ms to 200 ms when using TI_CONTROL register. NRST is an open-drain output that should be pulled up through a 1-kΩ to 100-kΩ pullup resistor. When the device is powered up and POR is complete, NRST is asserted low until the BIST is complete. After the BIST, NRST remains high (not asserted) until it is triggered by a mappable fault condition. An NRST_MISMATCH fault will be asserted if the NRST pin is pulled to an unexpected state. For example, if the NRST pin is in a high-impedence state (logic high) and is externally pulled low, then an NRST_MISMATCH fault will assert. During an NRST toggle NRST mismatch will be active after 2µs, NRST must exceed 0.6*VDD to be considered in a logic high state.

NRST is mappable to the watchdog fault, and the ESM fault when using the IEN_VENDOR register. If NRST is mapped to the ESM fault, the NRST pin will be asserted following the ESM delay and will be de-asserted after the reset delay (t_D). If NRST is mapped to the watchdog fault, the NRST pin will be asserted during a watchdog fault and de-assert following the reset delay (t_D).

NRST is also mappable to the OVHF and UVHF faults using the FC_LF[n] registers. If a monitored voltage falls or rises outside of the programmed OVHF and UVHF thresholds, then NRST is asserted, driving the NRST pin low. When the monitored voltage comes back into the valid window, a reset delay circuit is enabled that holds NRST low for a specified reset delay period (t_D).

The t_D period is determined by the RST_DLY[2:0] value found in the TI_CONTROL register. When the reset delay has elapsed, the NRST pin goes to a high-impedance state and uses a pullup resistor to hold NRST high. The pullup resistor must be connected to the proper voltage rail to allow other devices to be connected at the correct interface voltage. To ensure proper voltage levels, give some consideration when choosing the pullup resistor values. The pullup resistor value is determined by output logic low voltage (VOL), capacitive loading, and leakage current.

7.3.6 NIRQ

In a typical TPS389C03-Q1 application, the NIRQ output is connected to a reset or enable input of a processor [such as a digital signal processor (DSP) or application-specific integrated circuit (ASIC), or other processor type].

The TPS389C03-Q1 has an open drain active low output that requires a pull-up resistor to hold these lines high to the required voltage logic. Connect the 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 pull-up resistor values. The pull-up resistor value is determined by V_{OL}, output capacitive loading, and output leakage current. These values are specified in セクション 6. The open drain output can be connected as a wired-OR logic with other open drain signals such as another TPS389C03-Q1 NIRQ pin.

7.3.7 ADC

The ADC used in the TPS389C03Q-1 runs on a 1MHz clock with an effective sampling rate of 1/8 MHz (= 125 kHz). Initially, the ADC records with a resolution of 12 bits (1LSB = 0.41667mV) which is later round off to 8-bit data for I^2C transaction. (1LSB = 5mV) The ADC uses ping-pong architecture in which it requires 2us for both sampling and conversion per channel with a total of 2 sampling channels. While CH0 performs coarse conversion, CH1 does fine conversion and vice versa.

Digitized 8-bit data is updated once the fine conversion is completed, which occurs once every 8 µs. Each I^2C transaction initiated for reading 8-bit MON_LVL data (the ADC data of a particular channel), 8-bit data is paused from updating until the I^2C transaction completes.

Voltage scaling is done using a resistor ladder, but for differential mode channels, a chopping circuit is used to get the average of both of the voltages (VMON + VMON_RS)/2 since VMON_RS can be negative and can't be converted into an ADC code. VMON – VMON_RS is calculated digitally by subtracting ((VMON + VMON_RS) /2) from VMON and then multiplying by 2.

The MONX channels can be configured in 1x (0.2V to 1.475V) or 4x mode (0.8V to 5.5V). For differential mode channels configured in 1x mode, (MON1 and MON2) the ADC range is limited up to 1.7V. To configure an ADC channel above 1.7 V, please use 4x mode.

Real time voltage measurements use.

$$V_{lvl} = ((ADC[7:0] * 5mV) + 0.2) * (VRANGE\_MULT) \quad (1)$$

1. ADC[7:0] is translated to a corresponding decimal value. The value of ADC[7:0] corresponding to MON2-MON4 can be read from BANK0, registers 0x41 to 0x43 found in セクション 8.1.1.
2. VRANGE_MULT corresponds to the selected monitor voltage multiplier set in BANK1, register 0x1F of セクション 8.1.2.
3. VRANGE_MULT is set to a decimal 1 or 4 value depending on monitored value.

7.3.8 Packet Error Checking (PEC)

TPS389C03-Q1 supports Packet Error Checking (PEC) as a way to implement Cyclic Redundancy Checking (CRC). With the initial value of CRC set to 0x00, the PEC uses a CRC-8 represented by the polynomial:

$$C(x) = x^2 + x^2 + x + 1 \quad (2)$$

The PEC calculation includes all bytes in the transmission, including address, command and data. The PEC calculation does not include ACK or NACK bits or START, STOP or REPEATED START conditions. If PEC is enabled, and the TPS389C03-Q1 is transmitting data, then the TPS389C03-Q1 is responsible for sending the PEC byte. If PEC is enabled, and the TPS389C03-Q1 is reveiving data from the MCU, then the MCU is responsible for sending the PEC byte.

- If PEC is enabled by EN_PEC, and the PEC byte is present in the write transaction, the device will NACK and assert NIRQ if PEC byte is incorrect.
- If PEC is enabled by EN_PEC, and the PEC byte is not present in the write transaction.
  - If REQ_PEC = 0, missing PEC is treated as good PEC and register write succeeds. NIRQ is not asserted.
  - If REQ_PEC = 1, missing PEC is treated as incorrect PEC and register write fails. NIRQ is asserted.

7.3.9 Q&A Watchdog

The Question and Answer Watchdog requires specific data to be sent from the MCU to the TPS389C03-Q1 within a specific time interval.

The TPS389C03-Q1 generates questions for the MCU to read during the OPEN and CLOSE windows. Questions are read as the combination of ANSW_CNT[1:0] and TOKEN[3:0] status bits found in the WD_STAT_QA register in BANK0. After reading a question, the MCU calculates the Reference Answer using the logic equations shown in 図 7-8 and responds by writing the 8-bit answer into the WDT_ANSWER register in BANK1. A code example for Reference Answer calculation is shown in 図 7-11. For a typical application, changing the value of FDBK[1:0], found in the WDT_QA_CFG register in BANK1, from the default value of FDBK[1:0] = 00b is not required. However, FDBK[1:0] can be changed if a different Reference Answer calculation is needed. Question generation and answer calculations are explained in more detail in セクション 7.3.9.1.

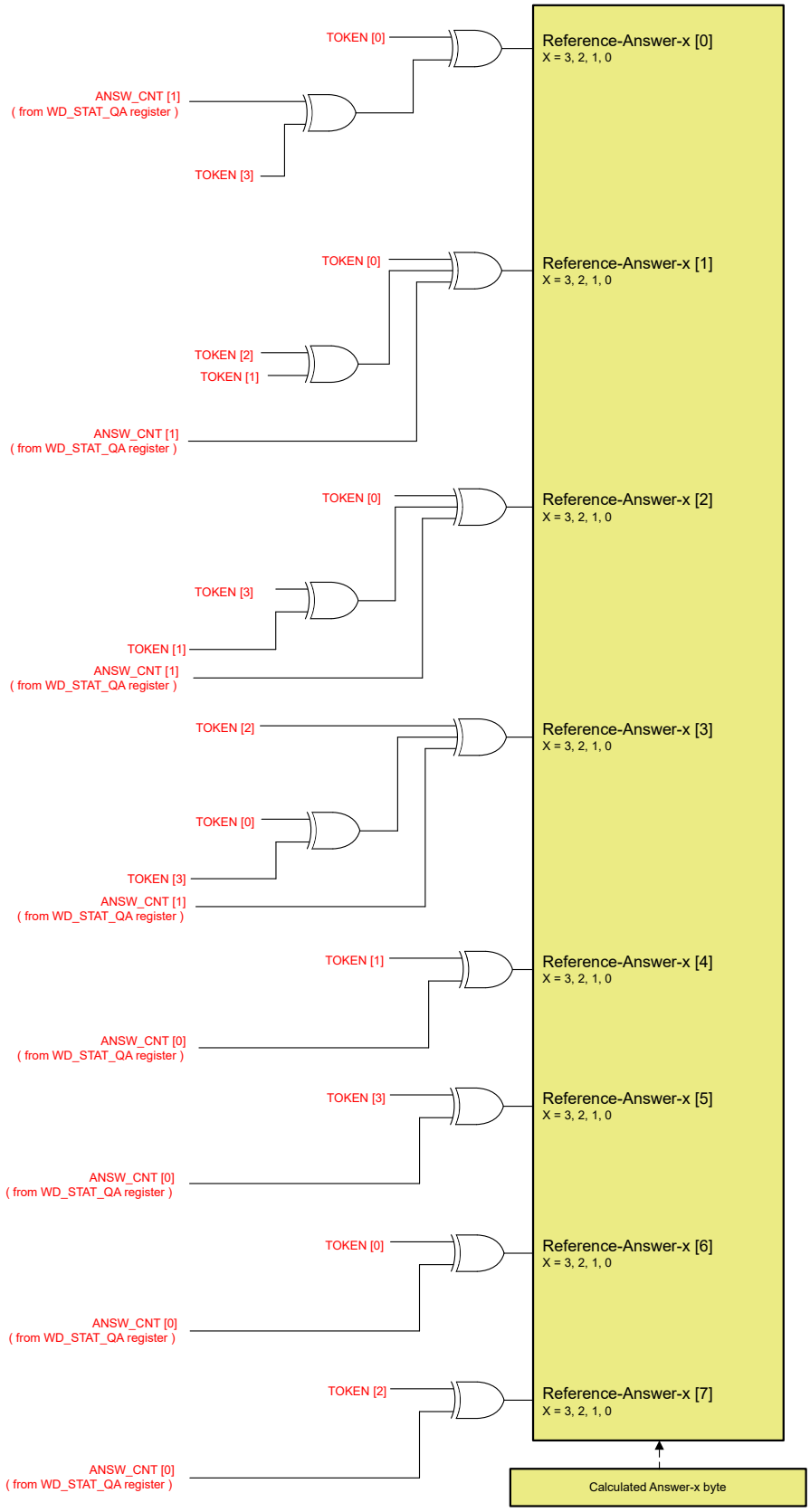


図 7-8. Watchdog Answer Calculation for FDBK[1:0] = 00b

During one “event,” the TPS389C03-Q1 generates three questions within the CLOSE window and one question within the OPEN window. The MCU must correctly read and answer all three questions within the specified CLOSE window and the question within the specified OPEN window for a “good event” to occur. At the start of an event, ANSW_CNT[1:0] = 11b. A correctly answered question decrements ANSW_CNT[1:0] to generate the next question. Once a good event occurs, ANSW_CNT[1:0] is reset to ANSW_CNT[1:0] = 11b, and the value of TOKEN[3:0] changes to generate a new set of questions for the next event.

An incorrectly answered question increments the violation count, resets the ANSW_CNT[1:0] to ANSW_CNT[1:0] = 11b, and restarts the CLOSE window. The maxmimum violation count, MAX_VIOLATION_COUNT[2:0], is programmed using the WDT_CFG register in BANK1. When the violation count reaches its maximum value, the TPS389C03-Q1 WDO (latched) low, and may assert NIRQ and NRST low depending on the fault mapping. A good event decrements the violation count if the violation count is not already equal to zero. When the watchdog enters the Idle state, the violation count is reset. When the the watchdog enters the suspend state, the violation count remains unchanged. The watchdog state diagram is illustrated in 図 7-20.

Within an event, the CLOSE window time is a fixed value, and does not change if all three questions are answered faster than the set time. For example, if the CLOSE window time is set to 10 ms, and the three questions are correctly answered in 5 ms, then the TPS389C03-Q1 will wait the remaining 5 ms before transitioning to the OPEN window. During the OPEN window, if the question is answered faster than the selected OPEN window time, then the TPS389C03-Q1 automatically transitions on to the next event's CLOSE window. An incorrectly answered question within either the CLOSE or OPEN windows results in the TPS389C03-Q1 restarting the CLOSE window.

7.3.9.1 Question and Token Generation

A question is presented to the MCU as a combination of the TOKEN[3:0] and the ANSW_CNT[1:0] status bits found in the WD_STAT_WA register. ANSW_CNT[1:0] has a default value of ANSW_CNT[1:0] = 11b and is decremented when a question is answered correctly. The value of ANSW_CNT[1:0] is reset to ANSW_CNT[1:0] = 11b when a question is answered incorrectly or a good event is completed.

The watchdog uses the Token Counter (TOKEN_CNT[3:0] bits 図 7-10) and a Linear Feedback Shift Register (LFSR) to generate the 4-bit TOKEN[3:0]. The LFSR architecture can be configured using POLY[1:0] in the WDT_QA_CFG register in BANK1 as shown in 図 7-10. In a typical application, it is not necessary to change the value of POLY[1:0] from the default 00b. However, POLY[1:0] can be configured if a different LFSR architecture is required. The diagram illustrated in 図 7-9 represents how questions are generated by the watchdog.

During the watchdog startup state, the LFSR is set with the initial value SEED[3:0], which is located in the WDT_QA_CFG register in BANK1. SEED[3:0] has a default value of 0000b.

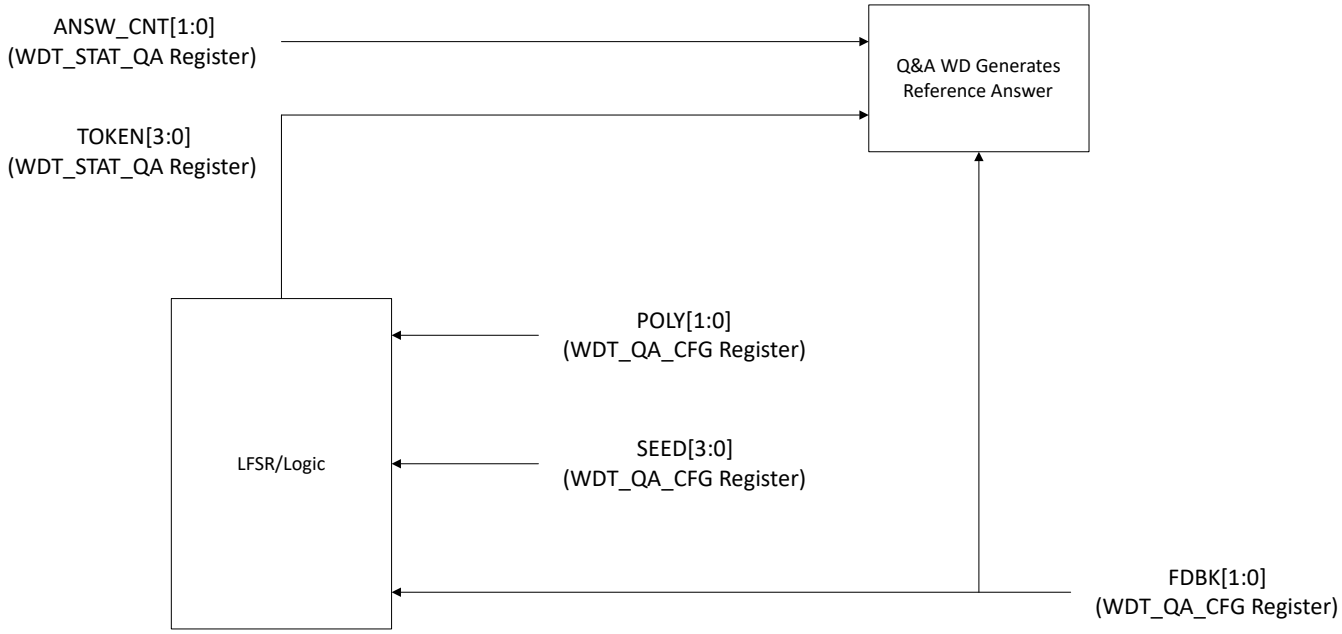
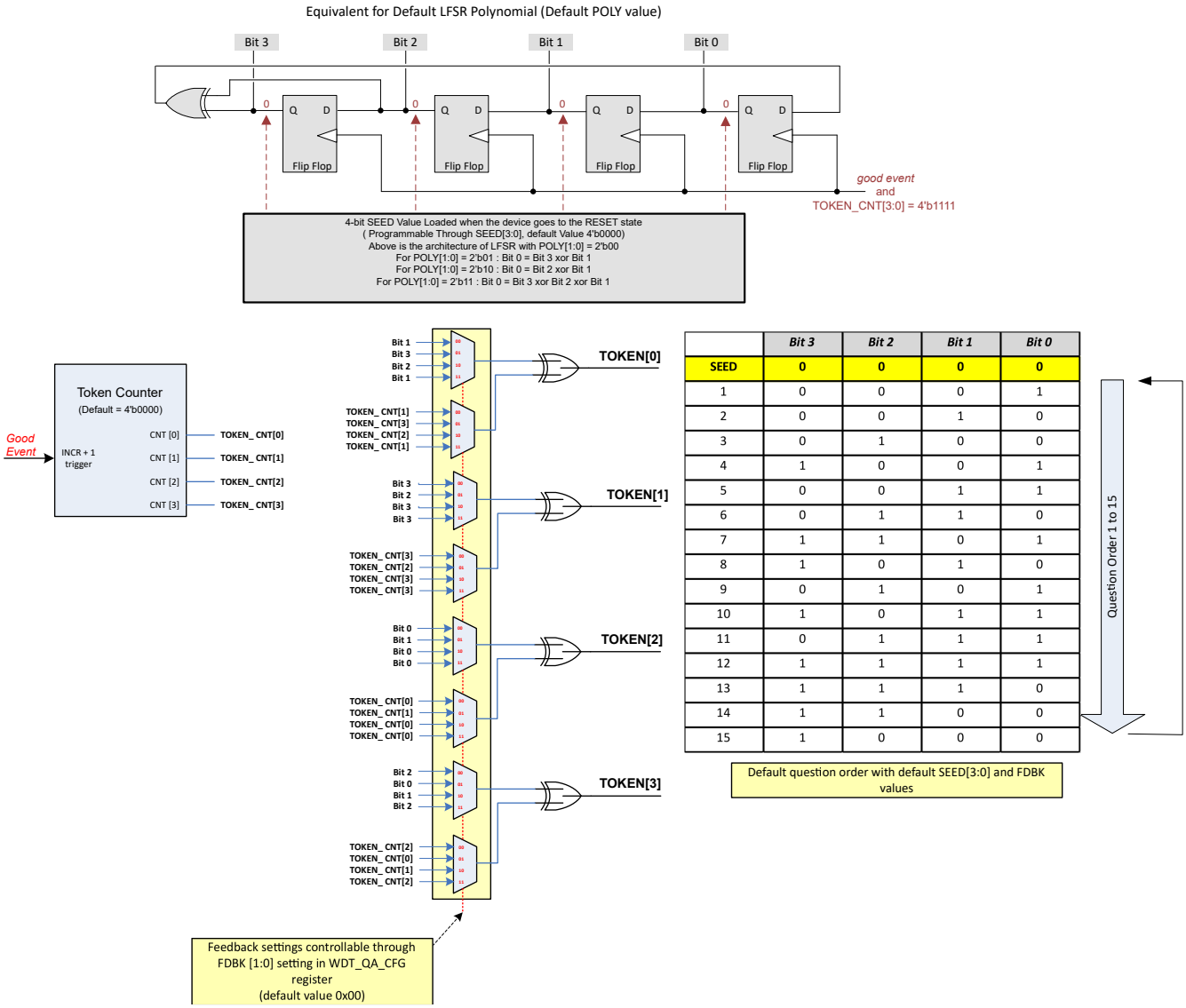


図 7-9. Watchdog Question Generation

At the end of a good event, the Token Counter is incremented, and the value of TOKEN[3:0] will change as a result of the mux and logic combinations shown in 図 7-10.



	Bit 3	Bit 2	Bit 1	Bit 0
SEED	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	1	0	0
4	1	0	0	1
5	0	0	1	1
6	0	1	1	0
7	1	1	0	1
8	1	0	1	0
9	0	1	0	1
10	1	0	1	1
11	0	1	1	1
12	1	1	1	1
13	1	1	1	0
14	1	1	0	0
15	1	0	0	0

A. A value of 0000b is a special seed and equates to 0001b, including the default loading of 0000b during power up.

図 7-10. Watchdog Question and Token Generation

Once the Token Counter has reached the maximum value of 1111b, the counter will reset and provide a clock pulse to the LFSR. The clock pulse will left shift the value stored in the LFSR, which changes the value of the TOKEN[3:0]. During the special case of SEED[3:0] = 0000b, Bit 0 of the LFSR will be incremented the first time the Token Counter resets. Subsequent Token Counter resets will provide the typical clock pulse that left-shifts the LFSR. While left shifting, the value of seed will cycle through values 1 to 15 as listed in 図 7-10.

The mux devices that generate TOKEN[3:0] are configured using FDBK[1:0] (WDT_QA_CFG register in BANK1). It is not necessary to change the value of FDBK[1:0] from the default value of 00b, and it is important to note that changing FDBK[1:0] also changes the logic equations required to calculate the reference answer. The different reference answer logic equations are listed below:

For FDBK[1:0] = 00b :

- Reference-Answer[0] = TOKEN[0] XOR (TOKEN[3] XOR ANSW_CNT[1])
- Reference-Answer[1] = TOKEN[0] XOR (TOKEN[1] XOR TOKEN[2]) XOR ANSW_CNT[1]
- Reference-Answer[2] = TOKEN[0] XOR (TOKEN[3] XOR TOKEN[1]) XOR ANSW_CNT[1]
- Reference-Answer[3] = TOKEN[2] XOR (TOKEN[0] XOR TOKEN[3]) XOR ANSW_CNT[1]

- Reference-Answer[4] = TOKEN[1] XOR ANSW_CNT[0]
- Reference-Answer[5] = TOKEN[3] XOR ANSW_CNT[0]
- Reference-Answer[6] = TOKEN[0] XOR ANSW_CNT[0]
- Reference-Answer[7] = TOKEN[2] XOR ANSW_CNT[0]

For FDBK[1:0] = 01b :

- Reference-Answer[0] = TOKEN[1] XOR (TOKEN[2] XOR ANSW_CNT[1])
- Reference-Answer[1] = TOKEN[1] XOR (TOKEN[1] XOR TOKEN[1]) XOR ANSW_CNT[1]
- Reference-Answer[2] = TOKEN[3] XOR (TOKEN[2] XOR TOKEN[1]) XOR ANSW_CNT[1]
- Reference-Answer[3] = TOKEN[1] XOR (TOKEN[3] XOR TOKEN[3]) XOR ANSW_CNT[1]
- Reference-Answer[4] = TOKEN[0] XOR ANSW_CNT[0]
- Reference-Answer[5] = TOKEN[2] XOR ANSW_CNT[0]
- Reference-Answer[6] = TOKEN[3] XOR ANSW_CNT[0]
- Reference-Answer[7] = TOKEN[1] XOR ANSW_CNT[0]

For FDBK[1:0] = 10b :

- Reference-Answer[0] = TOKEN[2] XOR (TOKEN[1] XOR ANSW_CNT[1])
- Reference-Answer[1] = TOKEN[2] XOR (TOKEN[0] XOR TOKEN[1]) XOR ANSW_CNT[1]
- Reference-Answer[2] = TOKEN[1] XOR (TOKEN[1] XOR TOKEN[1]) XOR ANSW_CNT[1]
- Reference-Answer[3] = TOKEN[0] XOR (TOKEN[2] XOR TOKEN[3]) XOR ANSW_CNT[1]
- Reference-Answer[4] = TOKEN[2] XOR ANSW_CNT[0]
- Reference-Answer[5] = TOKEN[1] XOR ANSW_CNT[0]
- Reference-Answer[6] = TOKEN[2] XOR ANSW_CNT[0]
- Reference-Answer[7] = TOKEN[0] XOR ANSW_CNT[0]

For FDBK[1:0] = 11b

- Reference-Answer[0] = TOKEN[3] XOR (TOKEN[0] XOR ANSW_CNT[1])
- Reference-Answer[1] = TOKEN[3] XOR (TOKEN[3] XOR TOKEN[1]) XOR ANSW_CNT[1]
- Reference-Answer[2] = TOKEN[1] XOR (TOKEN[0] XOR TOKEN[1]) XOR ANSW_CNT[1]
- Reference-Answer[3] = TOKEN[3] XOR (TOKEN[1] XOR TOKEN[3]) XOR ANSW_CNT[1]
- Reference-Answer[4] = TOKEN[3] XOR ANSW_CNT[0]
- Reference-Answer[5] = TOKEN[0] XOR ANSW_CNT[0]
- Reference-Answer[6] = TOKEN[1] XOR ANSW_CNT[0]
- Reference-Answer[7] = TOKEN[3] XOR ANSW_CNT[0]

Example code for answer calcultion when FDBK[1:0] = 00b is included in 図 7-11.

Expression:

```
Locals.Answer[7] = Locals.WDT_status_Bin[2] ^ Locals.WDT_status_Bin[4],
Locals.Answer[6] = Locals.WDT_status_Bin[0] ^ Locals.WDT_status_Bin[4],
Locals.Answer[5] = Locals.WDT_status_Bin[3] ^ Locals.WDT_status_Bin[4],
Locals.Answer[4] = Locals.WDT_status_Bin[1] ^ Locals.WDT_status_Bin[4],
Locals.Answer[3] = Locals.WDT_status_Bin[2] ^( Locals.WDT_status_Bin[0] ^ Locals.WDT_status_Bin[3])^ Locals.WDT_status_Bin[5],
Locals.Answer[2] = Locals.WDT_status_Bin[0] ^( Locals.WDT_status_Bin[3] ^ Locals.WDT_status_Bin[1])^ Locals.WDT_status_Bin[5],
Locals.Answer[1] = Locals.WDT_status_Bin[0] ^( Locals.WDT_status_Bin[2] ^ Locals.WDT_status_Bin[1])^ Locals.WDT_status_Bin[5],
Locals.Answer[0] = Locals.WDT_status_Bin[0] ^( Locals.WDT_status_Bin[3] ^ Locals.WDT_status_Bin[5]),

Locals.Final_Answer = 128* Locals.Answer[7] + 64*Locals.Answer[6]+32*Locals.Answer[5]  + 16*Locals.Answer[4]+8*Locals.Answer[3]  + 4*Locals.Answer[2]+2*Locals.Answer[1]  + Locals.Answer[0],



Locals.Question[4*Locals.X + 0] = Locals.REG_READ[0],
Locals.Answer_val [4*Locals.X + 0] = Locals.Final_Answer
```

図 7-11. Watchdog Answer Calculation Code for FDBK[1:0] = 00b

7.3.9.2 Q&A Watchdog Open and Close Window Delay

Open and Close window delay can be adjusted through register 0xAC and 0xAB repectively. During a reset event, the Open and Close window delays do not change from the programmed value (default OTP or user changes). 表 7-3 lists delay time and associated register value.

表 7-3. Open and Close Window Delay

Reg Value	Time	Notes
0-31	1-32 ms	1 ms steps
32-63	34-96 ms	2 ms steps
64-255	100-864 ms	4 ms steps

The startup delay is calculated using the WDT_Startup_DLY_MULTIPLIER[2:0] (register 0xAA), Close window delay, and the Open window delay. It is important to note that changing either the Close window delay or the Open window delay will change the resulting startup delay. Use 式 3 to calculate total startup delay.

$$t_{Startup} = (WDT\_Startup\_DLY\_MULTIPLIER+1)*(WDT\_OPEN+WDT\_CLOSE) \quad (3)$$

7.3.9.3 Q&A Watchdog Status Register

Read status register 0x37 to determine watchdog state of operation. 表 7-4 provides the operating state with its associated value. Bits ST_WDUV and ST_WDEXP of register 0x37 are cleared when read.

表 7-4. Q&A Watchdog Operating State

OPERATING STATE	STATE DESCRIPTION	VALUE
IDLE	WD is wating for a fault to be cleared or WDE is low. The violation count is reset.	0x00
OPEN	WD open window.	0x01
CLOSE	WD close window.	0x02
START UP	WD startup window.	0x03
SUSPEND	WDE is high and another fault has asserted output pins unrelated to the WD, or I^2C MR bit is set to 1. Violation count remains unchanged.	0x04

7.3.9.4 Q&A Watchdog Timing

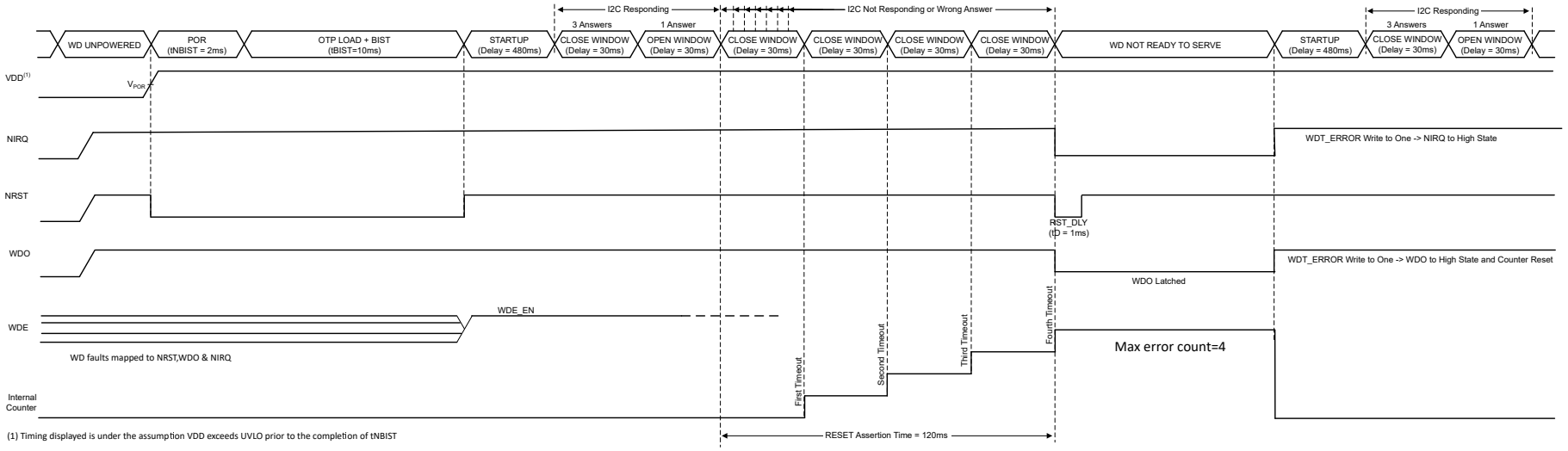


図 7-12. TPS389C03 CLOSE Window Error WDO Latched

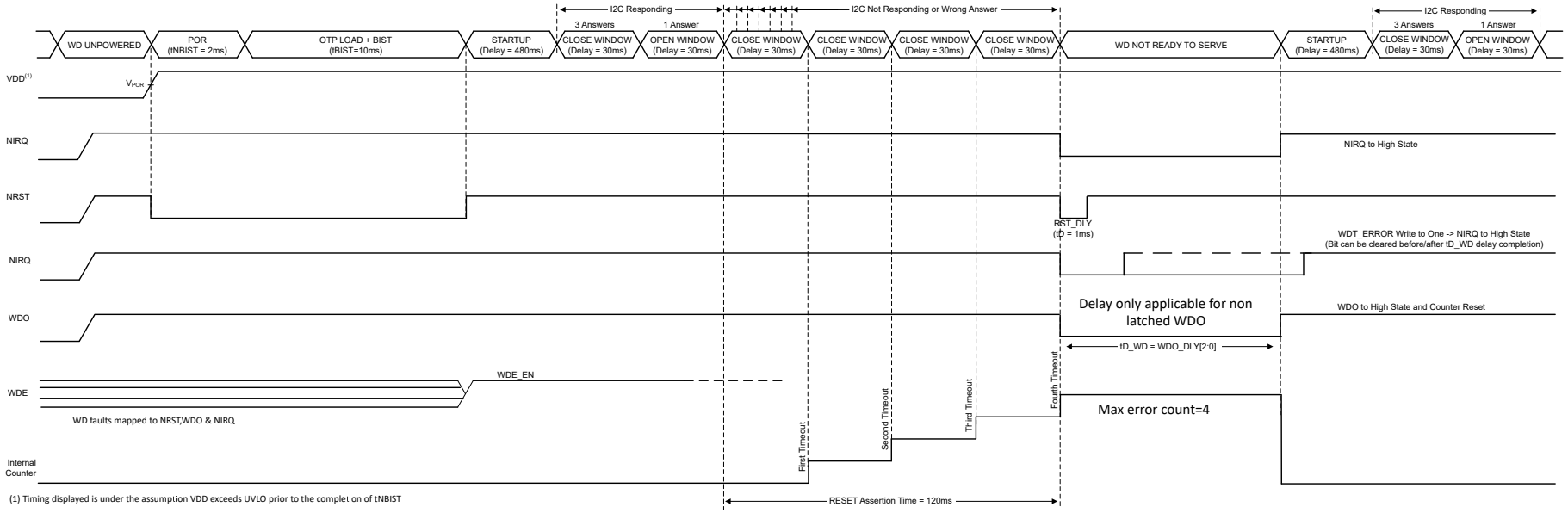


図 7-13. TPS389C03 CLOSE Window Error WDO Delay

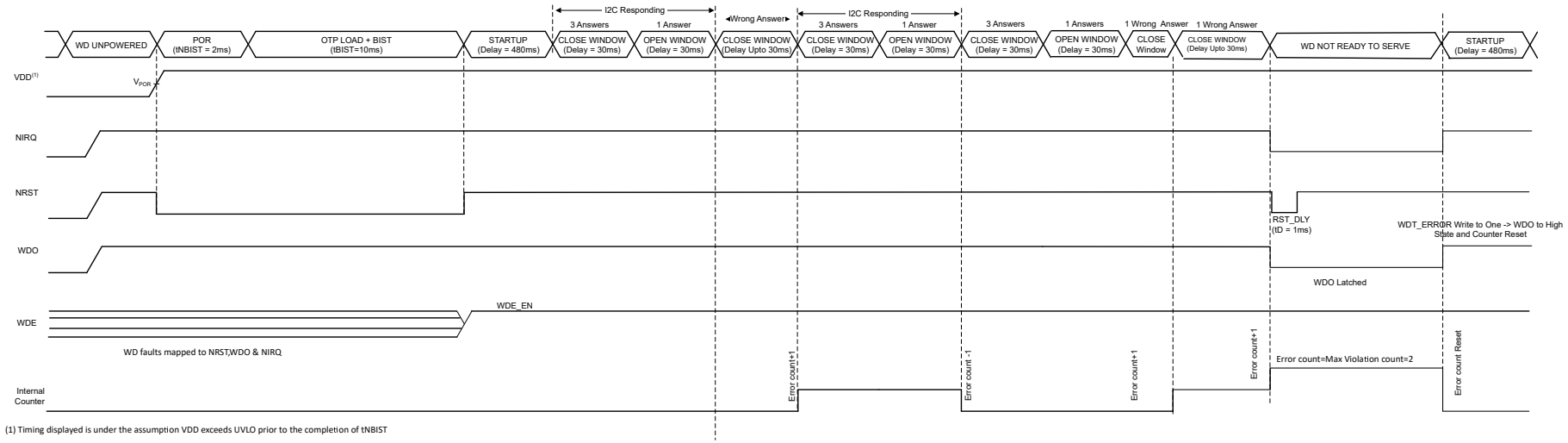


図 7-14. TPS389C03 CLOSE Window Error WDO Delay with Max Violation Count Reached

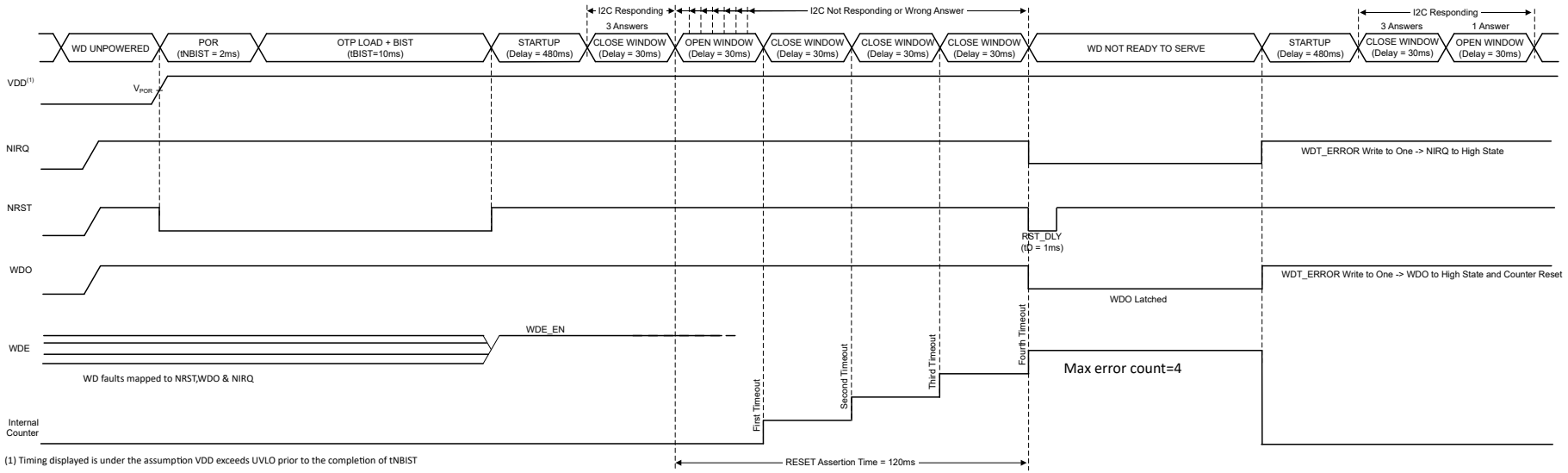


図 7-15. TPS389C03 OPEN Window Error WDO Latched

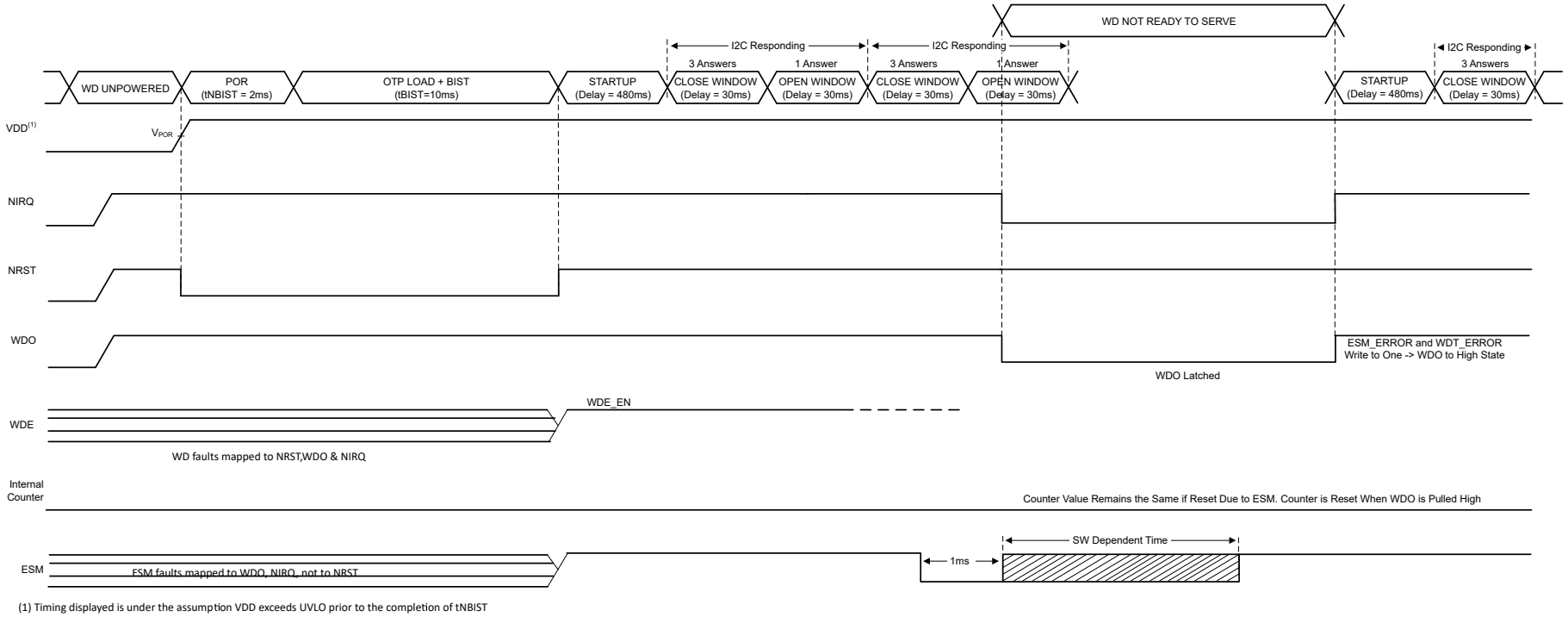
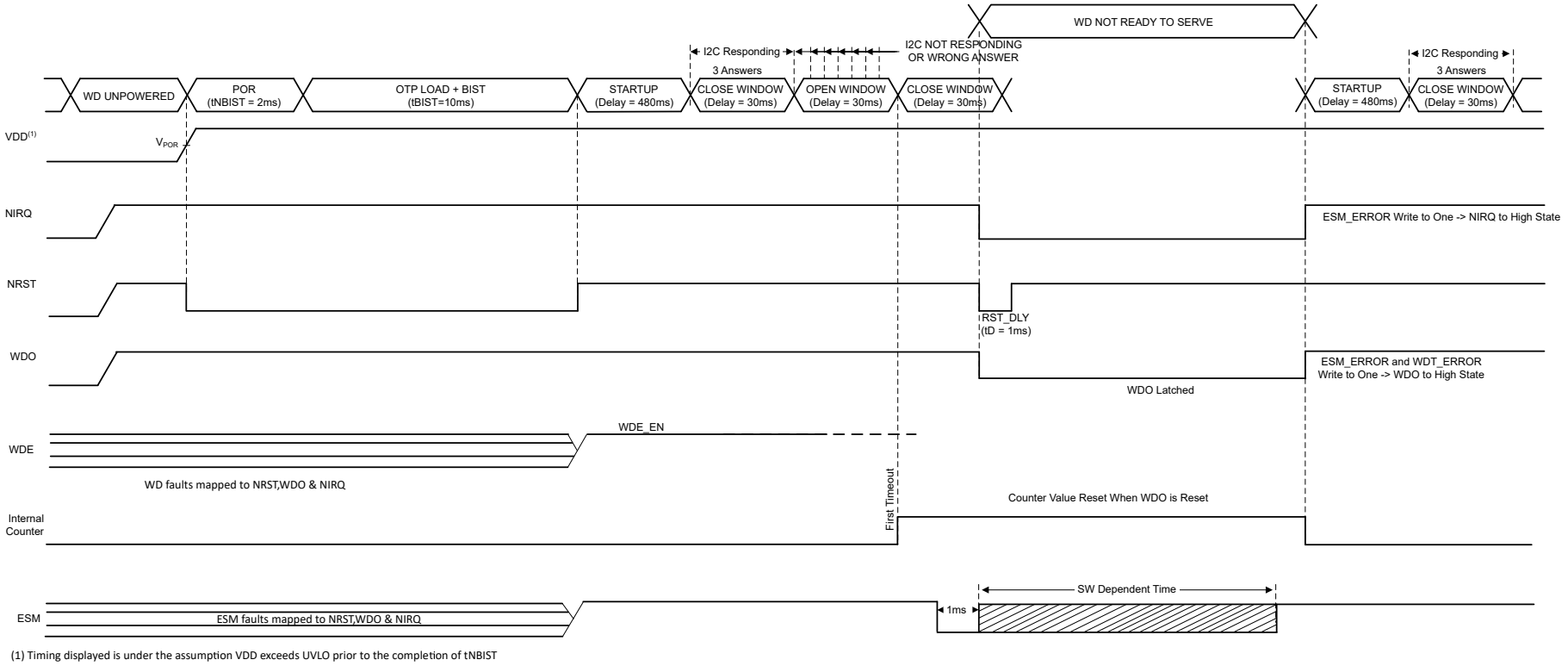


図 7-16. TPS389C03 ESM Error with No WD Faults



(1) Timing displayed is under the assumption VDD exceeds UVLO prior to the completion of tNBIST

図 7-17. TPS389C03 ESM Error After WD Time-out

7.3.9.5 Q&A Watchdog State Machine and Test Program

The flowchart shown in 図 7-18 and 図 7-19 describes the operation of the Q&A watchdog with an MCU. The associated state machine diagram drawn in 図 7-20 is referenced to 表 7-4 and describes the transition between states for the Q&A watchdog.

The single test program in 図 7-21 to 図 7-23 demonstrates how the watchdog can be tested.

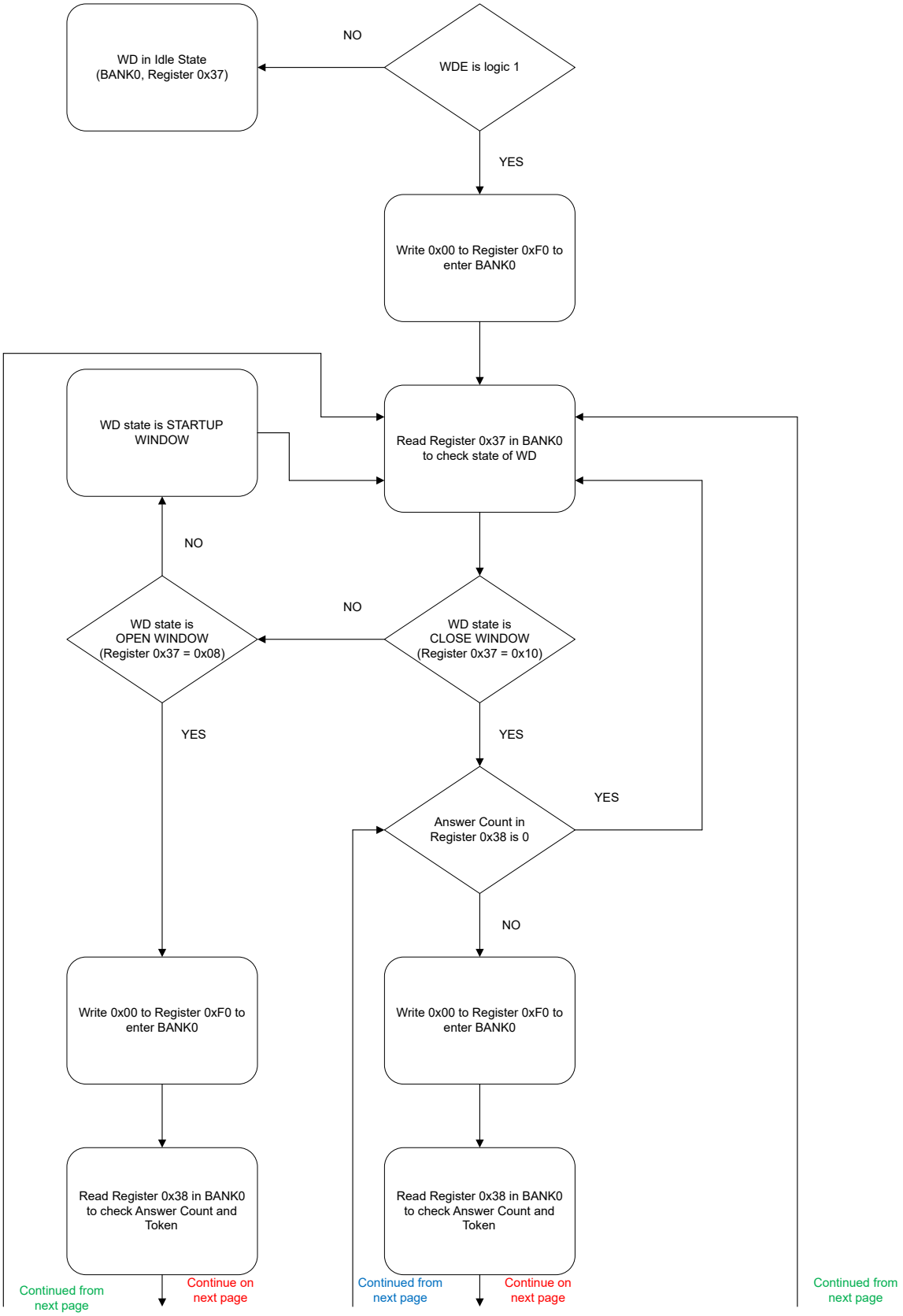


図 7-18. Q&A Watchdog Operation Flowchart Page 1

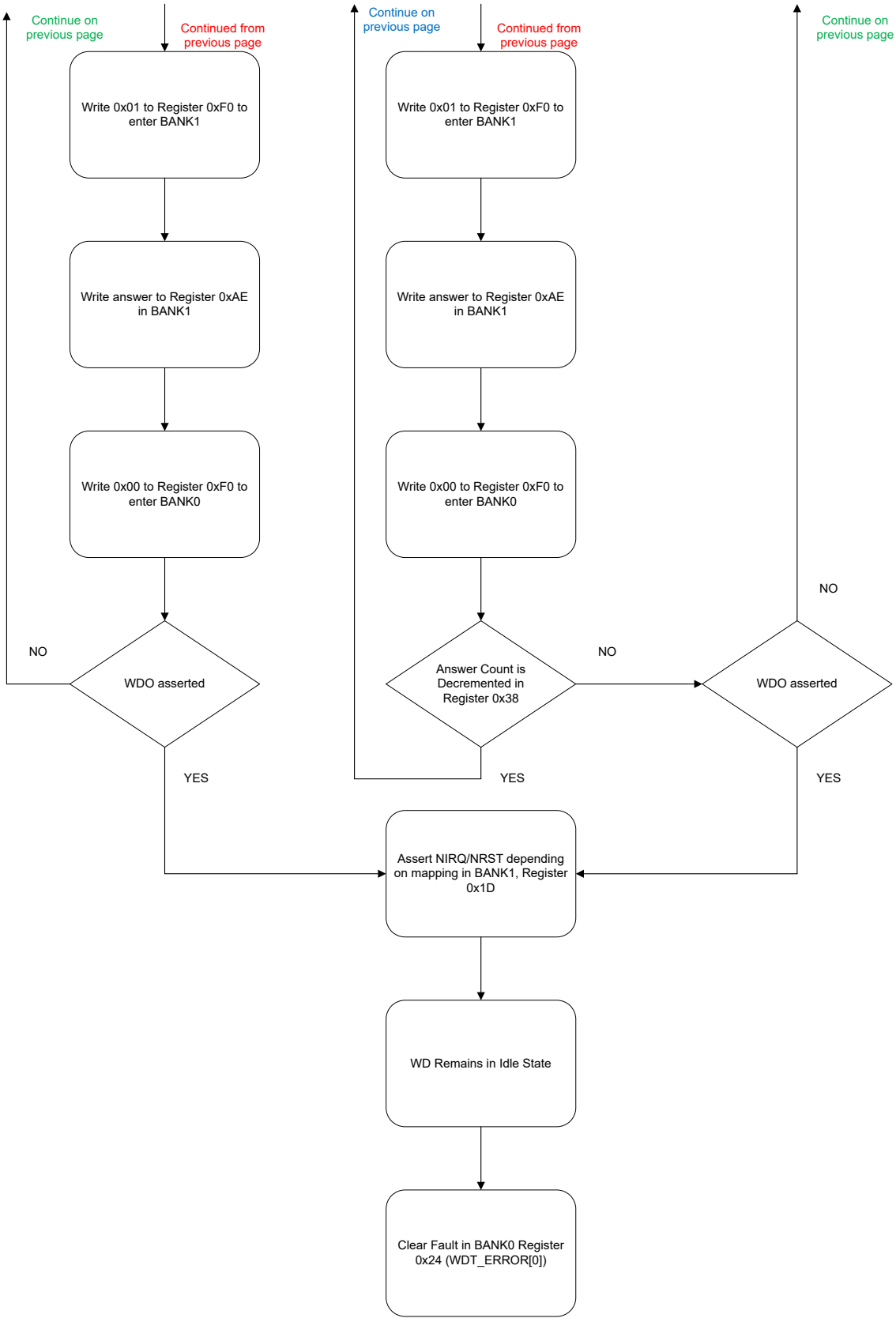


図 7-19. Q&A Watchdog Operation Flowchart Page 2

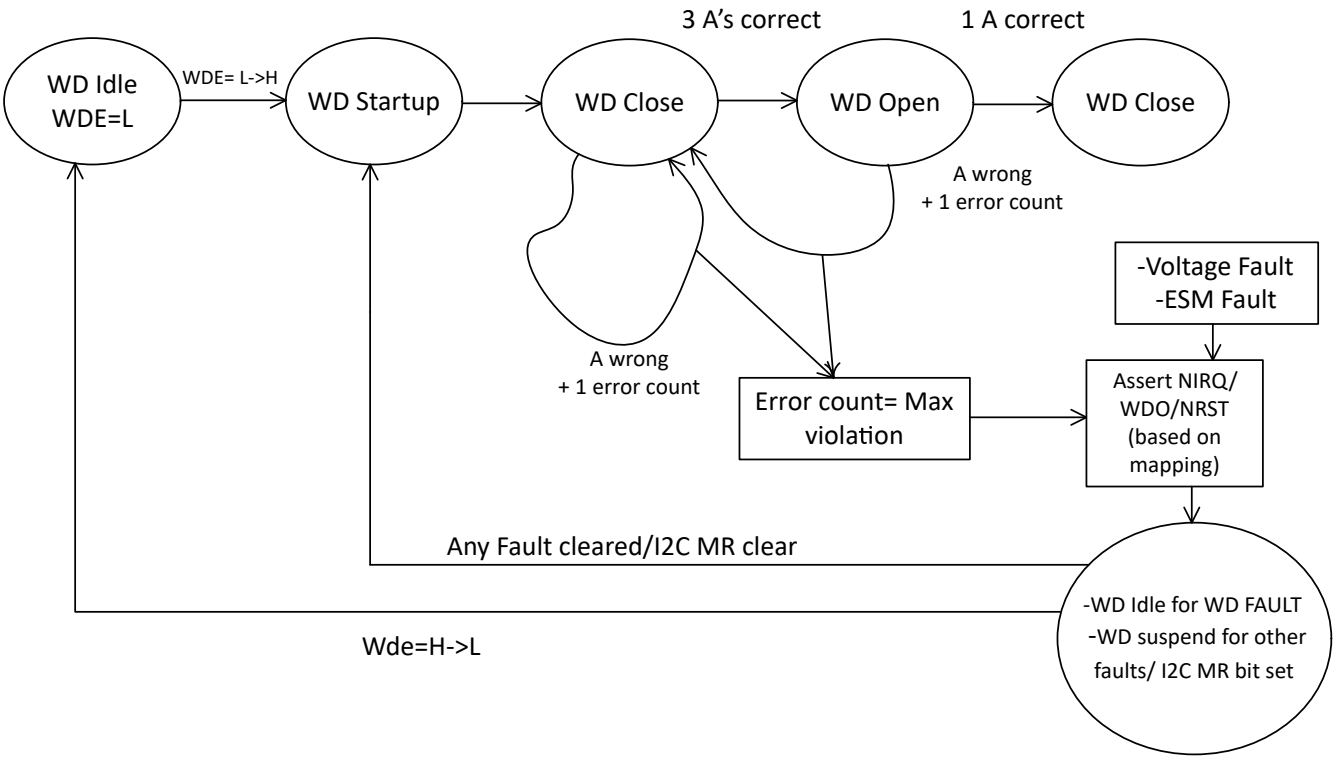


図 7-20. Q&A Watchdog State Diagram

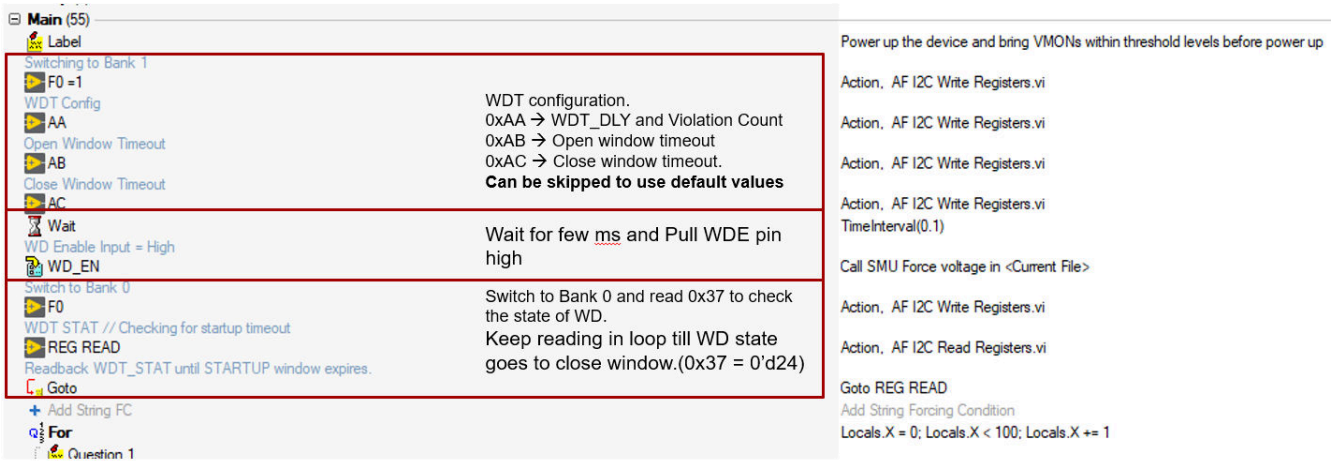


図 7-21. Q&A Watchdog Test Program Page 1

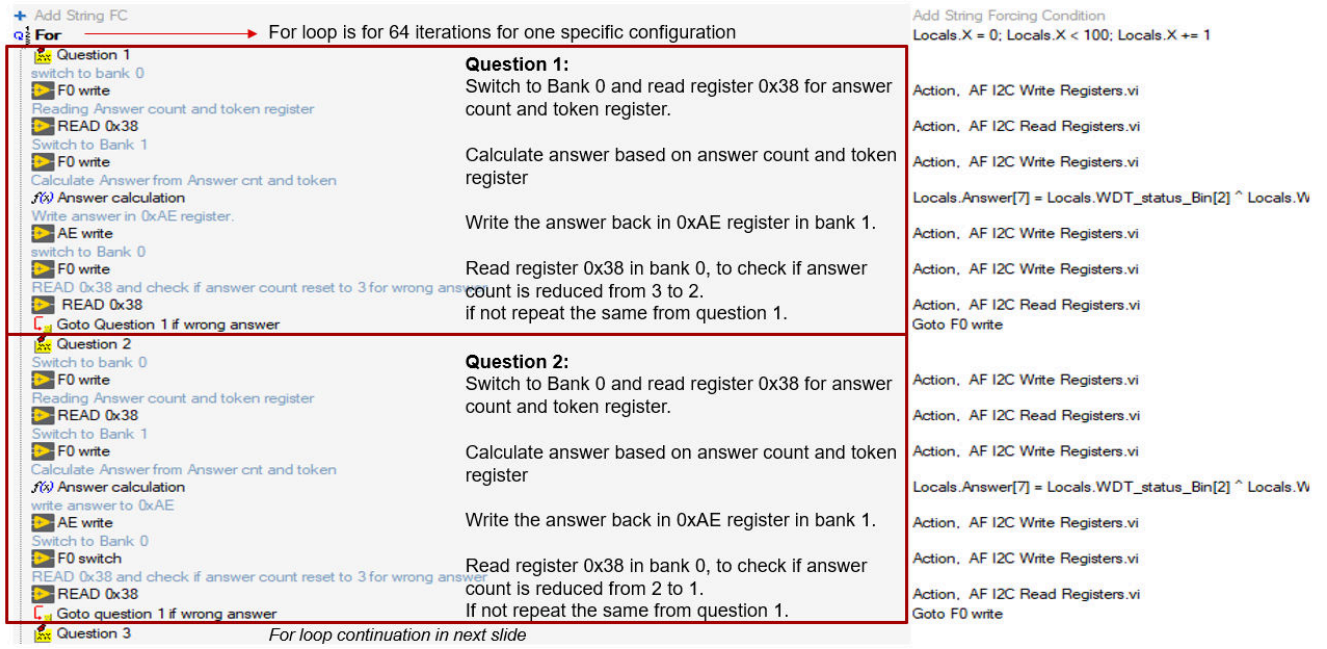


図 7-22. Q&A Watchdog Test Program Page 2

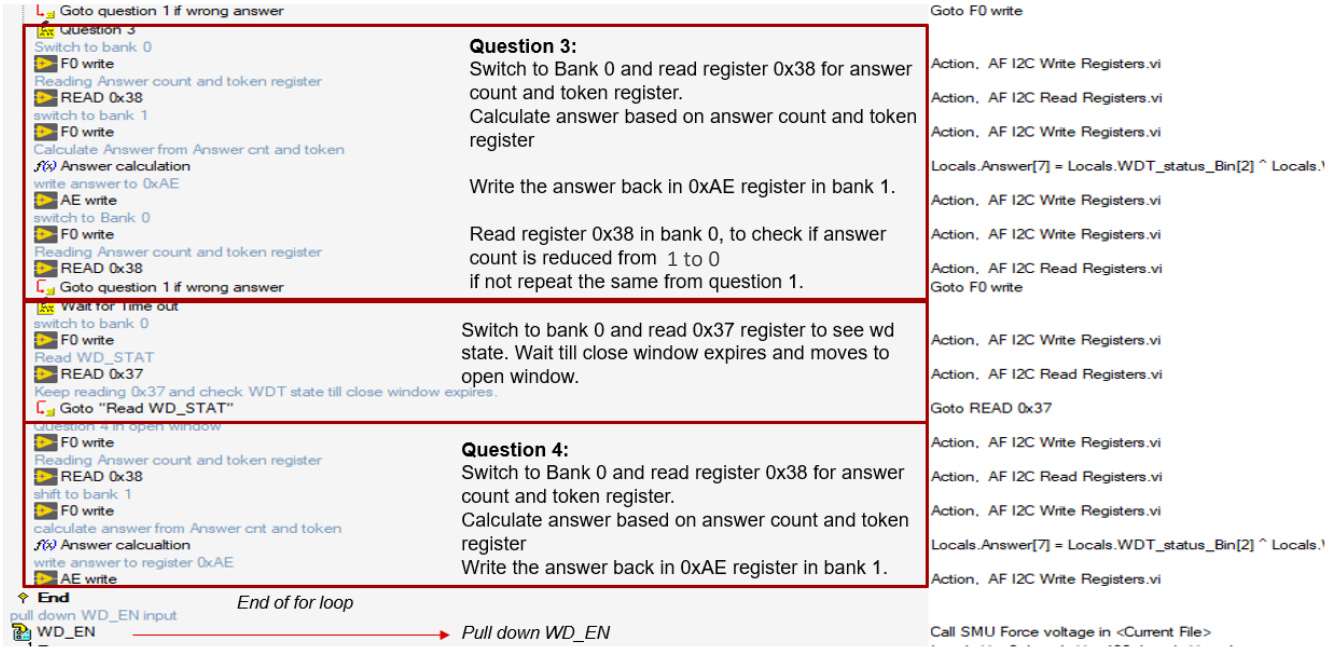


図 7-23. Q&A Watchdog Test Program Page 3

7.3.10 Error Signal Monitoring (ESM)

The Error Signal Monitoring (ESM) pin is used to monitor the error output of the SOC or microcontroller. The internal types of errors that need to happen to assert the ESM pin low can be configured in the microcontroller. Once the ESM pin is asserted low, the actions or results of the microcontroller cannot be relied on. The ESM pin has a programmable threshold delay (Bank 1_0x09E_Threshold) to prevent unintended false trips. The ESM pin also has a configurable debounce (Bank 1_0x09F_ESM_DEB). When the ESM pin of TPS389C03-Q1 is asserted low an ESM_ERROR will be flagged by a bit located in the INT_VENDOR register. The ESM pin is

pulled low by default through an internal 100k pull-down resistance, thus an ESM_ERROR will be flagged by default if no external source is applied to the ESM pin. Note the pull down resistor is only active when VDD has been applied, otherwise the pin is left floating.

表 7-5. ESM Threshold Delay Time

REG VALUE	TIME	NOTES
0-31	1-32 ms	1 ms steps
32-63	34-96 ms	2 ms steps
64-255	100-864 ms	4 ms steps

The configurations listed in 表 7-6 to 表 7-12 demonstrate how TPS389C03-Q1 responds when mapped to different fault outputs such as NRST, NIRQ and WDO. Faults mapped to NIRQ are always latched. Faults mapped to WDO can be latched or have an associated WDO delay based on the OTP setting. If the ESM function is being used as a reset method, then it is recommended to map ESM to WDO to avoid NRST toggling. If WDE is pulled low in operation, it is recommended to have ESM fault mapped only to NIRQ.

When ESM is mapped to WDO, an ESM fault, with the resulting WDO assertion, will not be flagged in the WDT_ERROR bit. However, it is recommended to write 1 to the WDT_ERROR bit and the ESM_ERROR bit found in the INT_VENDOR (セクション 8.1.1.9) register to clear all of the latched outputs. The WDO output can also be deasserted by toggling the WDE pin.

表 7-6. ESM Mapped to WDO, NIRQ, and NRST

	WDE	WDO	NIRQ	NRST
ESM fault	High	After ESM delay, WDO asserted and ESM fault set. I2C write to clear and deassert.	After ESM delay, NIRQ asserted and ESM fault set. I2C write to clear and deassert.	After ESM delay, NRST asserted and deasserted after reset delay. ESM pin state not checked until WDO is deasserted.
	Low	ESM fault not asserted WDO.	After ESM delay, NIRQ asserted and ESM fault set. I2C write to clear and deassert.	After ESM delay, NRST asserted and deasserted after reset delay. ESM pin state checked after ESM delay. If ESM stays low, NRST will toggle.

表 7-7. ESM Mapped to NIRQ and NRST

	WDE	WDO	NIRQ	NRST
ESM fault	High	Not asserted.	After ESM delay, NIRQ asserted and ESM fault set. I2C write to clear and deassert.	After ESM delay, NRST asserted and deasserted after reset delay. ESM pin state checked after ESM delay. If ESM stays low, NRST will toggle.
	Low	Not asserted.	After ESM delay, NIRQ asserted and ESM fault set. I2C write to clear and deassert.	After ESM delay, NRST asserted and deasserted after reset delay. ESM pin state checked after ESM delay. If ESM stays low, NRST will toggle.

表 7-8. ESM Mapped to WDO and NIRQ

	WDE	WDO	NIRQ	NRST
ESM fault	High	After ESM delay, WDO asserted and ESM fault set. I2C write to clear and deassert.	After ESM delay, NIRQ asserted and ESM fault set. I2C write to clear and deassert.	Not asserted.
	Low	Not asserted.	After ESM delay,NIRQ asserted and ESM fault set. I2C write to clear and deassert.	Not asserted.

表 7-9. ESM Mapped to WDO and NRST

	WDE	WDO	NIRQ	NRST
ESM fault	High	After ESM delay, WDO asserted and ESM fault set. I2C write to clear and deassert.	Not asserted.	After ESM delay, NRST asserted and deasserted after reset delay. ESM pin state not checked until WDO is deasserted.
	Low	Not asserted.	Not asserted.	After ESM delay, NRST asserted and deasserted after reset delay. ESM pin state checked after ESM delay. If ESM stays low NRST will toggle.

表 7-10. ESM Mapped to NRST

	WDE	WDO	NIRQ	NRST
ESM fault	High	Not asserted.	Not asserted.	After ESM delay, NRST asserted and deasserted after reset delay. ESM pin state checked after ESM delay. If ESM stays low NRST will toggle.
	Low	Not asserted.	Not asserted.	After ESM delay, NRST asserted and deasserted after reset delay. ESM pin state checked after ESM delay. If ESM stays low NRST will toggle.

表 7-11. ESM Mapped to NIRQ

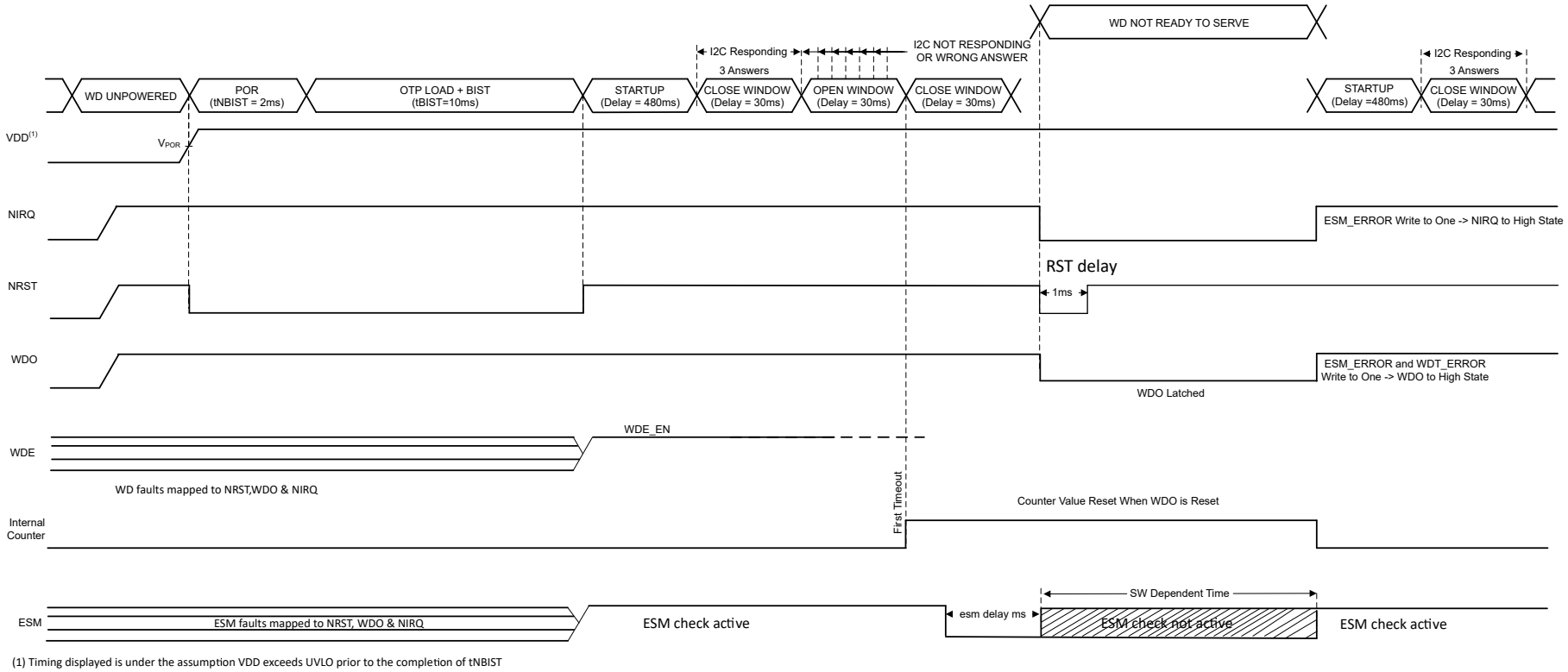
	WDE	WDO	NIRQ	NRST
ESM fault	High	Not asserted.	After ESM delay, NIRQ asserted and ESM fault set. I2C write to clear and deassert.	Not asserted.
	Low	Not asserted.	After ESM delay, NIRQ asserted and ESM fault set. I2C write to clear and deassert.	Not asserted.

表 7-12. ESM Mapped to WDO

	WDE	WDO	NIRQ	NRST
ESM fault	High	After ESM delay, WDO asserted and ESM fault set. I2C write to clear and deassert.	Not asserted.	Not asserted.
	Low	ESM fault not asserted WDO.	Not asserted.	Not asserted.

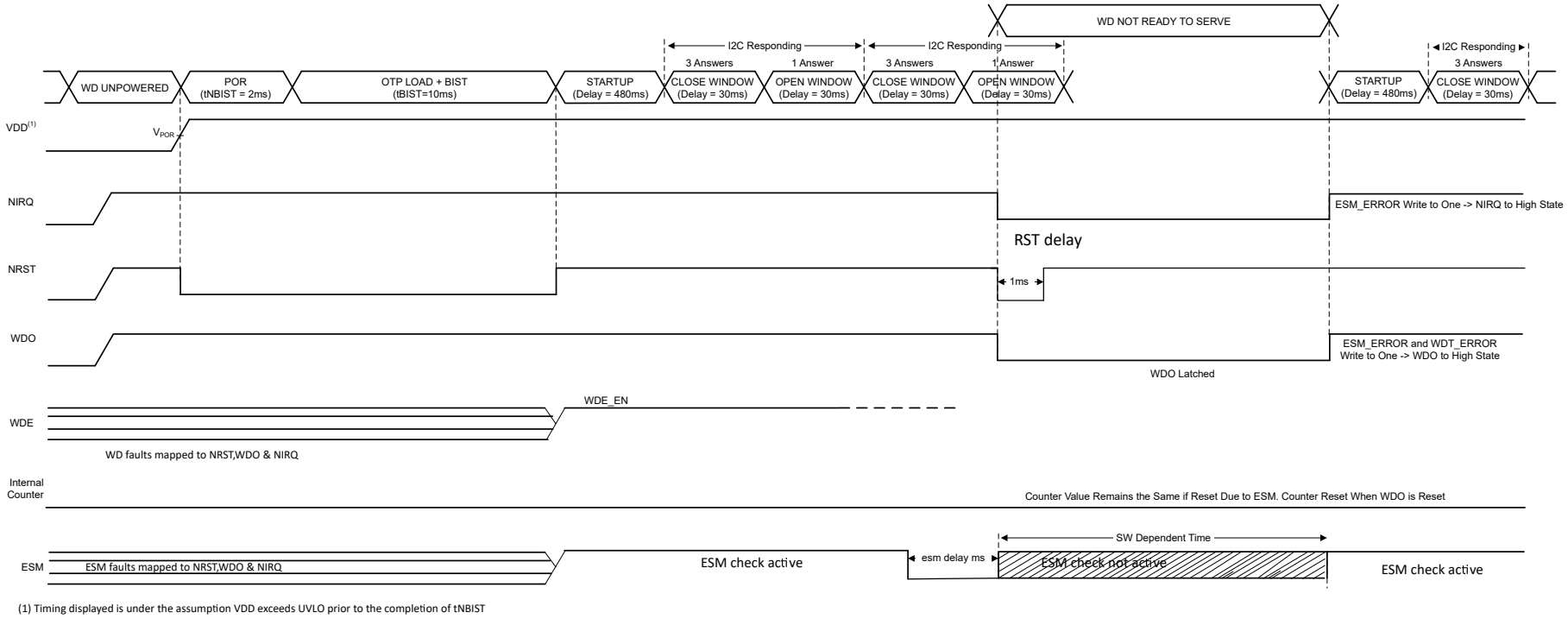
7.3.10.1 ESM Timing

The timing diagrams starting from 図 7-24 to 図 7-27 show the behavior for a latched WDO fault pin. Faults mapped to NRST have an associated reset delay based on (Bank 1_0x9F_RST_DLY). For each diagram, the assumed system configuration is that once the microcontroller is reset, it restarts with ESM fault cleared or ESM pin high.



(1) Timing displayed is under the assumption VDD exceeds UVLO prior to the completion of tNBIST

図 7-24. WD Error Followed by ESM Fault (WD Enabled)



(1) Timing displayed is under the assumption VDD exceeds UVLO prior to the completion of tNBIST

図 7-25. ESM Fault (WD Enabled)

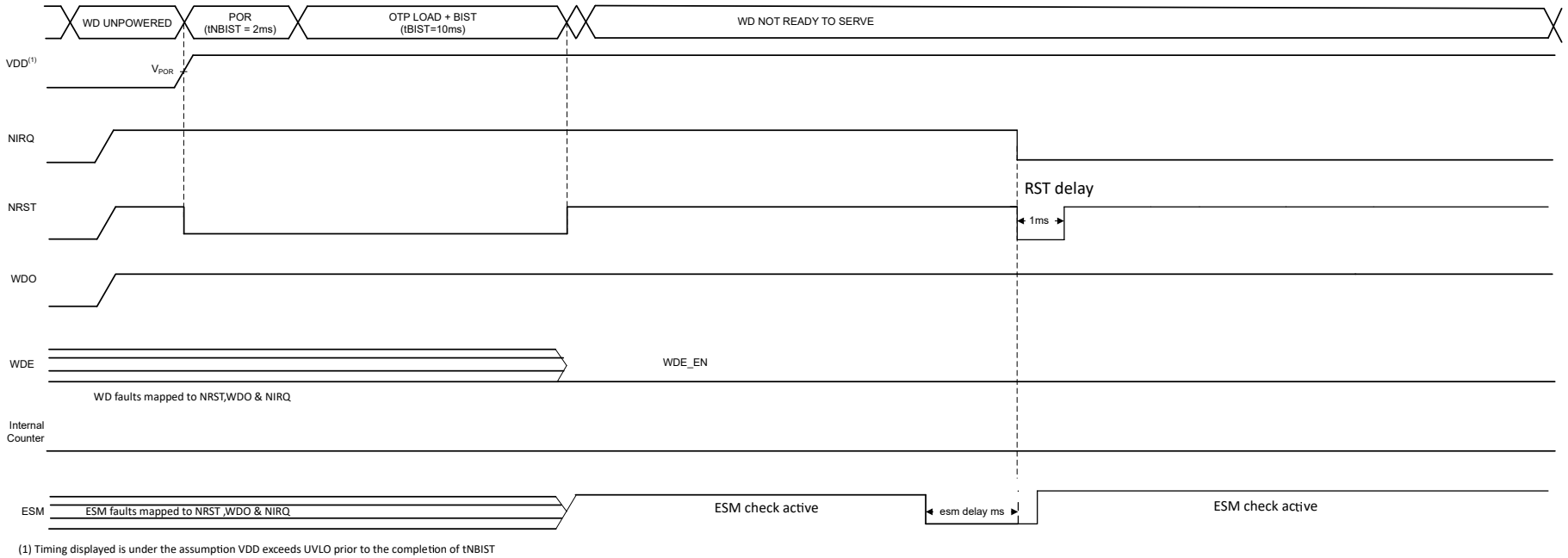


図 7-26. Transient ESM Fault (WD Disabled)

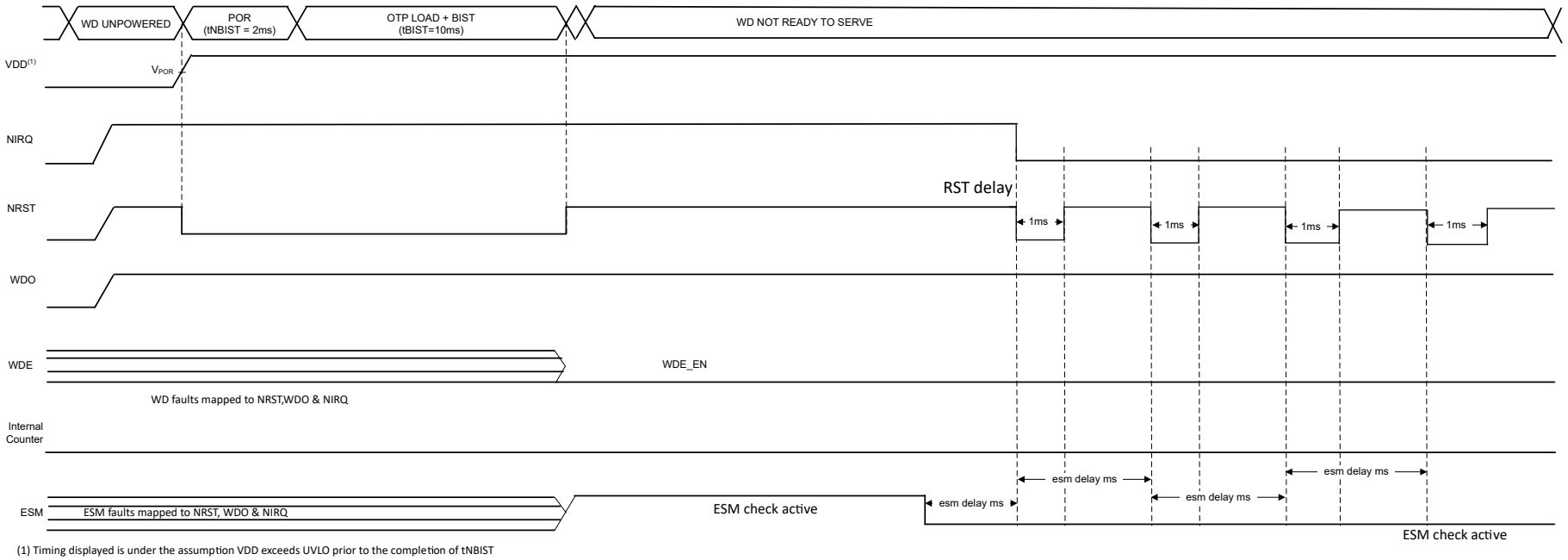


図 7-27. Permanent ESM Fault (WD Disabled)

7.4 Device Functional Modes

The TPS389C03-Q1 has three key functional modes that the device may enter over the course of operation. When no power is applied to the device, it will be in the OFF state where the monitoring channels and the watchdog will be inactive. Once VDD is greater than UVLO, the device will enter the ACTIVE state after the BIST and OTP loading have finished. During the ACTIVE state, the device will be capable of full monitoring and the watchdog will be active. If a BIST failure, double-error detect (DED) during the OTP loading, thermal shutdown, or an address pin fault occurs, the device will enter the FAILSAFE mode. Once in FAILSAFE, NRST and NIRQ are asserted low. To leave the FAILSAFE state, power to the TPS389C03-Q1 must be cycled. Reading register 0x30 in BANK0 provides information on the state of the device. See セクション 8.1.1.10 for details. The state diagram drawn in 図 7-28 follows the progression through each state.

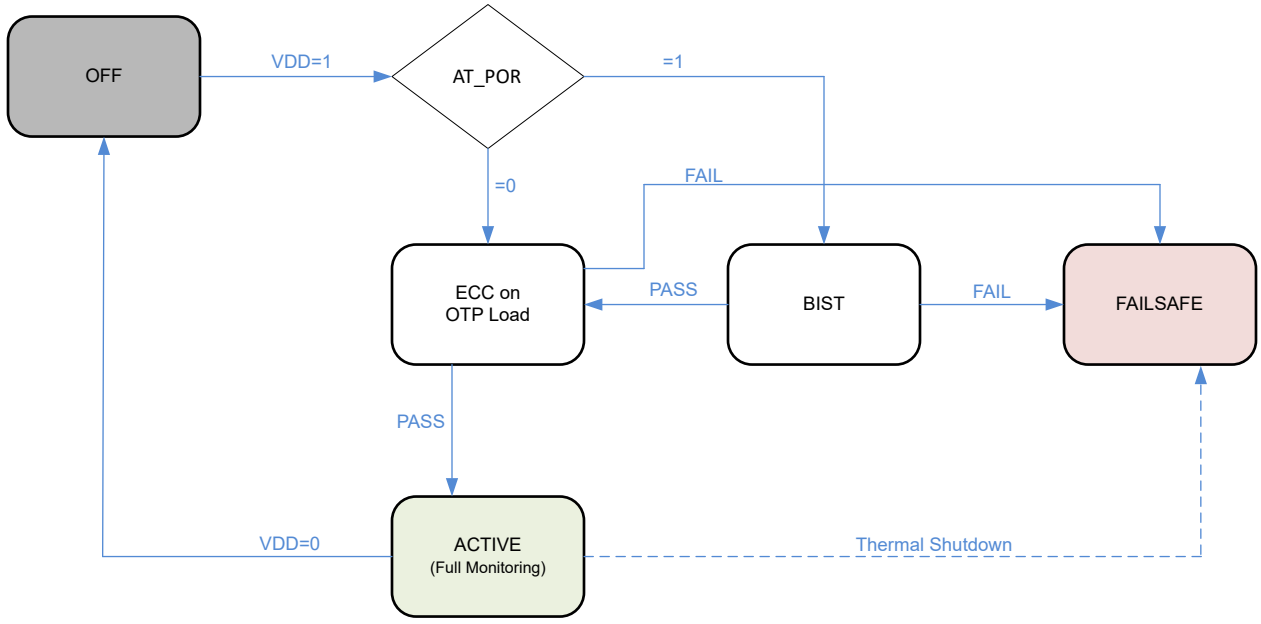


図 7-28. TPS389C03-Q1 State Diagram

7.4.1 Built-In Self Test and Configuration Load

Built-In Self Test (BIST) is performed at Power On Reset (POR), if TEST_CFG.AT_POR=1.

Configuration load from OTP is assisted by ECC (supporting SEC-DED). This is to protect against data integrity issues and to maximize system availability.

During BIST, NIRQ is de-asserted (asserted in case of failure), input pins are ignored, and the I^2C block is inactive with SDA and SCL de-asserted. The BIST includes device testing to meet the Technical Safety Requirements. Once BIST is completed without failure, I^2C is immediately active and the device enters the ACTIVE state after loading the configuration data from OTP. If BIST fails and/or ECC reports Double-Error Detection (DED), NIRQ is asserted low, NRST is asserted low, the device enters FAILSAFE state, and a best effort attempt is made to keep I^2C active. The TEST_INFO register found in セクション 8.1.1.11 provides information on the test coverage and results.

The detailed behavior upon success/failure of the BIST is controlled by INT_TEST and IEN_TEST registers. Reporting of the BIST results is carried out through:

- NIRQ pin: pulled low depending on the test result and BIST_C and BIST bits in IEN_TEST
- I_BIST_C and BIST bits in INT_TEST register depending on IEN_TEST settings
- VMON_STAT.ST_BIST_C register bit
- TEST_INFO[3:0] register bits

7.4.1.1 Notes on BIST Execution

Upon POR the TPS389C03-Q1 needs to make a decision whether to run BIST or not, based on the value of the TEST_CFG.AT_POR register bit. Assuming that ECC on this register is performed after BIST has checked the ECC logic itself, it is not possible to guarantee its data integrity before running BIST.

BIST can be triggered manually during normal operation by writing 1 to the ENTER_BIST bit found in BANK1 Register 0x9F. It is not reccomended to use BIST when faults are asserted by the TPS389C03-Q1.

7.4.2 TPS389C03-Q1 Power ON

When the TPS389C03-Q1 is powered ON, BIST is optionally executed (depending on TEST_CFG.AT_POR register bit); I^2C and fault reporting (through NIRQ) become active as soon as BIST is complete and configuration is loaded from OTP (assisted by ECC, supporting SEC-DED).

The details of the configuration load ECC and BIST results are reported are reported in TEST_INFO register.

Upon detection of the VDD rising edge past UVLO, the TPS389C03-Q1 starts the sequence timeout timer. The UV faults are masked until the sequence timeout has expired.

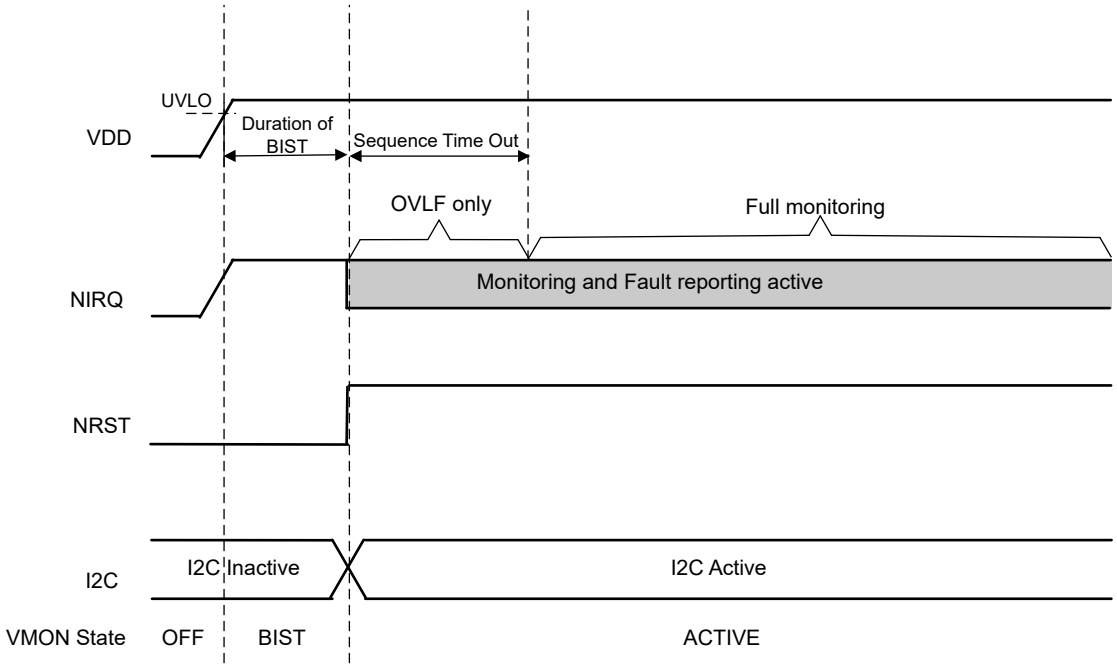


図 7-29. TPS389C03-Q1 Power ON Signaling and Internal States

BIST completion can be detected through interrupt or register polling:

- Interrupt: INT_TEST.I_BIST_C flag is set and NIRQ is asserted if IEN_TEST.BIST_C=1
- Polling: VMON_STAT register can be polled to read the ST_BIST_C bit

8 Register Maps

8.1 Registers Overview

The register map is designed to support up to 3 channels through register banks, with the following organization:

- Bank 0 - Status Register Set Summary
  - Vendor info and usage registers (bank independent)
  - Interrupt registers
  - Status registers
  - Bank selection register (bank independent)
  - Protection registers (bank independent)
  - Device configuration registers (bank independent)
- Bank 1 - Configuration Register Set Summary
  - Vendor info and usage registers (bank independent)
  - Control registers (device global registers)
  - Monitor configuration registers (channel specific registers)
  - Sequence configuration registers (both device global and channel specific registers)
  - Bank selection register (bank independent)
  - Protection registers (bank independent)
  - Device configuration registers (bank independent)

Bank independent registers are accessible at the same address irrespective of the current bank selection. Access to other registers requires the proper bank being selected.

All registers are 8-bit wide, and are loaded at boot with the default value described here or with the OTP value programmed at the factory. Unused registers addresses are reserved for future use and support up to 3 channels.

Write accesses to protected registers (see PROT1/2 details), invalid registers, or valid registers with invalid data, should be NACK'd.

If the default value found in the register map is listed as "X", then the value can be found in TPS389C0300CRTERQ1 OTP Configuration.

8.1.1 BANK0 Registers

表 8-1 lists the memory-mapped registers for the BANK0 registers. All register offset addresses not listed in 表 8-1 should be considered as reserved locations and the register contents should not be modified.

表 8-1. BANK0 Registers

Offset	Acronym	Register Name	Section
10h	INT_SRC	Global Interrupt Source Status register.	Go
11h	INT_MONITOR	Voltage Monitor Interrupt Status register.	Go
12h	INT_UVHF	High Frequency channel Under-Voltage Interrupt Status register.	Go
14h	INT_UVLF	Low Frequency channel Under-Voltage Interrupt Status register.	Go
16h	INT_OVHF	High Frequency channel Over-Voltage Interrupt Status register	Go
18h	INT_OVLF	Low Frequency channel Over-Voltage Interrupt Status register	Go
22h	INT_CONTROL	Control and Communication Interrupt Status register.	Go
23h	INT_TEST	Internal Test and Configuration Load Interrupt Status register.	Go
24h	INT_VENDOR	Vendor Specific Internal Interrupt Status register.	Go
30h	VMON_STAT	Status flags for internal operations and other non critical conditions.	Go
31h	TEST_INFO	Internal Self-Test and ECC information.	Go
32h	OFF_STAT	Channel OFF status.	Go
37h	WDT_STAT	Watchdog Status	Go
38h	WD_STAT_QA	Watchdog Answer Count and Token	Go
41h	MON_LVL[2]	Channel 2 voltage level.	Go
42h	MON_LVL[3]	Channel 3 voltage level.	Go
43h	MON_LVL[4]	Channel 4 voltage level.	Go
F0h	BANK_SEL	Bank Select.	Go
F1h	PROT1	Locks or unlocks register changes. Must match PROT2.	Go
F2h	PROT2	Locks or unlocks register changes. Must match PROT1.	Go
F3h	PROT_MON	Locks MON registers in tandem with PROT1 and PROT2.	Go
F9h	I2CADDR	I2C Address	Go
FAh	DEV_CFG	Status of I2C interface voltage levels.	Go

Complex bit access types are encoded to fit into small table cells. 表 8-2 shows the codes that are used for access types in this section.

表 8-2. BANK0 Access Type Codes

Access Type	Code	Description
Read Type		
R	R	Read
Write Type		
W	W	Write

表 8-2. BANK0 Access Type Codes (続き)

Access Type	Code	Description
W1C	W 1C	Write 1 to clear
Reset or Default Value		
-n		Value after reset or the default value

8.1.1.1 INT_SRC Register (Offset = 10h) [Reset = 00h]

INT_SRC is shown in 表 8-3.

Return to the Summary Table.

Global Interrupt Source Status register.

表 8-3. INT_SRC Register Field Descriptions

Bit	Field	Type	Reset	Description
7	F_OTHER	R	0h	Vendor internal defined faults. Details reported in INT_Vendor. Represents ORed value of all bits in INT_Vendor. 0 = No Vendor defined faults detected 1 = Vendor defined faults detected
6-3	RSVD	R	0h	RSVD
2	TEST	R	0h	Internal test or configuration load fault. Details reported in INT_TEST. Represents ORed value of all bits in INT_TEST. 0 = No test/configuration fault detected 1 = Test/configuration fault detected
1	CONTROL	R	0h	Control status or communication fault. Details reported in INT_CONTROL. Represents ORed value of all bits in INT_CONTROL. 0 = No status or communication fault detected 1 = Status or communication fault detected
0	MONITOR	R	0h	Voltage monitor fault. Details reported in INT_MONITOR. Represents ORed value of all bits in INT_MONITOR. 0 = No voltage fault detected 1 = Voltage fault detected

8.1.1.2 INT_MONITOR Register (Offset = 11h) [Reset = 00h]

INT_MONITOR is shown in 表 8-4.

Return to the Summary Table.

Voltage Monitor Interrupt Status register.

表 8-4. INT_MONITOR Register Field Descriptions

Bit	Field	Type	Reset	Description
7-4	RSVD	R	0h	RSVD
3	OVLF	R	0h	Over-Voltage Low Frequency Fault reported by ADC based measurement. Details reported in INT_OVLF. Represents ORed value of all bits in INT_OVLF. 0 = No OVLF fault detected 1 = OVLF fault detected
2	OVHF	R	0h	Over-Voltage High Frequency Fault reported by comparator based monitoring. Details reported in INT_OVHF. Represents ORed value of all bits in INT_OVHF. 0 = No OVHF fault detected 1 = OVHF fault detected

表 8-4. INT_MONITOR Register Field Descriptions (続き)

Bit	Field	Type	Reset	Description
1	UVLF	R	0h	Under-Voltage Low Frequency Fault reported by ADC based measurement. Details reported in INT_UVLF. Represents ORed value of all bits in INT_UVLF. 0 = No UVLF fault detected 1 = UVLF fault detected
0	UVHF	R	0h	Under-Voltage High Frequency Fault reported by comparator based monitoring. Details reported in INT_UVHF. Represents ORed value of all bits in INT_UVHF. 0 = No UVHF fault detected 1 = UVHF fault detected

8.1.1.3 INT_UVHF Register (Offset = 12h) [Reset = 00h]

INT_UVHF is shown in 表 8-5.

Return to the Summary Table.

High Frequency channel Under-Voltage Interrupt Status register.

表 8-5. INT_UVHF Register Field Descriptions

Bit	Field	Type	Reset	Description
7-4	RSVD	R/W1C	0h	RSVD
3	F_UVHF[4]	R/W1C	0h	Under-Voltage High Frequency Fault for MON4. Trips if MON4 High Frequency signal goes below UVHF[4]. 0 = MON4 has no UVHF fault detected (or interrupt disabled in IEN_UVHF register) 1 = MON4 has UVHF fault detected The recovery of the fault condition does NOT clear the bit. It can only be cleared by the host with a write-1-to-clear. Write-1-to-clear will clear the bit only if the UVHF fault condition is also removed (MON4 High Frequency signal is above UVHF[4]).
2	F_UVHF[3]	R/W1C	0h	Under-Voltage High Frequency Fault for MON3. Trips if MON3 High Frequency signal goes below UVHF[3]. 0 = MON3 has no UVHF fault detected (or interrupt disabled in IEN_UVHF register) 1 = MON3 has UVHF fault detected The recovery of the fault condition does NOT clear the bit. It can only be cleared by the host with a write-1-to-clear. Write-1-to-clear will clear the bit only if the UVHF fault condition is also removed (MON3 High Frequency signal is above UVHF[3]).
1	F_UVHF[2]	R/W1C	0h	Under-Voltage High Frequency Fault for MON2. Trips if MON2 High Frequency signal goes below UVHF[2]. 0 = MON2 has no UVHF fault detected (or interrupt disabled in IEN_UVHF register) 1 = MON2 has UVHF fault detected The recovery of the fault condition does NOT clear the bit. It can only be cleared by the host with a write-1-to-clear. Write-1-to-clear will clear the bit only if the UVHF fault condition is also removed (MON2 High Frequency signal is above UVHF[2]).
0	RSVD	R/W1C	0h	RSVD

8.1.1.4 INT_UVLF Register (Offset = 14h) [Reset = 00h]

INT_UVLF is shown in 表 8-6.

Return to the Summary Table.

Low Frequency channel Under-Voltage Interrupt Status register.

表 8-6. INT_UVLF Register Field Descriptions

Bit	Field	Type	Reset	Description
7-4	RSVD	R/W1C	0h	RSVD
3	F_UVLF[4]	R/W1C	0h	Under-Voltage Low Frequency Fault for MON4 . Trips if MON4 Low Frequency signal goes below UVLF[4]. 0 = MON4 has no UVLF fault detected (or interrupt disabled in IEN_UVLF register) 1 = MON4 has UVLF fault detected The recovery of the fault condition does NOT clear the bit. It can only be cleared by the host with a write-1-to-clear. Write-1-to-clear will clear the bit only if the UVLF fault condition is also removed (MON4 Low Frequency signal is above UVLF[4]).
2	F_UVLF[3]	R/W1C	0h	Under-Voltage Low Frequency Fault for MON3. Trips if MON3 Low Frequency signal goes below UVLF[3]. 0 = MON3 has no UVLF fault detected (or interrupt disabled in IEN_UVLF register) 1 = MON3 has UVLF fault detected The recovery of the fault condition does NOT clear the bit. It can only be cleared by the host with a write-1-to-clear. Write-1-to-clear will clear the bit only if the UVLF fault condition is also removed (MON3 Low Frequency signal is above UVLF[3]).
1	F_UVLF[2]	R/W1C	0h	Under-Voltage Low Frequency Fault for MON2. Trips if MON2 Low Frequency signal goes below UVLF[2]. 0 = MON2 has no UVLF fault detected (or interrupt disabled in IEN_UVLF register) 1 = MON2 has UVLF fault detected The recovery of the fault condition does NOT clear the bit. It can only be cleared by the host with a write-1-to-clear. Write-1-to-clear will clear the bit only if the UVLF fault condition is also removed (MON2 Low Frequency signal is above UVLF[2]).
0	RSVD	R/W1C	0h	RSVD

8.1.1.5 INT_OVHF Register (Offset = 16h) [Reset = 00h]

INT_OVHF is shown in 表 8-7.

Return to the Summary Table.

High Frequency channel Over-Voltage Interrupt Status register

表 8-7. INT_OVHF Register Field Descriptions

Bit	Field	Type	Reset	Description
7-4	RSVD	R/W1C	0h	RSVD
3	F_OVHF[4]	R/W1C	0h	Over-Voltage High Frequency Fault for MON4. Trips if MON4 High Frequency signal goes above OVHF[4]. 0 = MON4 has noOVHF fault detected (or interrupt disabled in IEN_OVHF register) 1 = MON4 has OVHF fault detected The recovery of the fault condition does NOT clear the bit. It can only be cleared by the host with a write-1-to-clear. Write-1-to-clear will clear the bit only if the OVHF fault condition is also removed (MON4 High Frequency signal is below OVHF[4])
2	F_OVHF[3]	R/W1C	0h	Over-Voltage High Frequency Fault for MON3. Trips if MON3 High Frequency signal goes above OVHF[3]. 0 = MON3 has no OVHF fault detected (or interrupt disabled in IEN_OVHF register) 1 = MON3 has OVHF fault detected The recovery of the fault condition does NOT clear the bit. It can only be cleared by the host with a write-1-to-clear. Write-1-to-clear will clear the bit only if the OVHF fault condition is also removed (MON3 High Frequency signal is below OVHF[3])

表 8-7. INT_OVHF Register Field Descriptions (続き)

Bit	Field	Type	Reset	Description
1	F_OVHF[2]	R/W1C	0h	Over-Voltage High Frequency Fault for MON2. Trips if MON2 High Frequency signal goes above OVHF[2]. 0 = MON2 has no OVHF fault detected (or interrupt disabled in IEN_OVHF register) 1 = MON2 has OVHF fault detected The recovery of the fault condition does NOT clear the bit. It can only be cleared by the host with a write-1-to-clear. Write-1-to-clear will clear the bit only if the OVHF fault condition is also removed (MON2 High Frequency signal is below OVHF[2])
0	RSVD	R/W1C	0h	RSVD

8.1.1.6 INT_OVLF Register (Offset = 18h) [Reset = 00h]

INT_OVLF is shown in 表 8-8.

Return to the Summary Table.

Low Frequency channel Over-Voltage Interrupt Status register

表 8-8. INT_OVLF Register Field Descriptions

Bit	Field	Type	Reset	Description
7-4	RSVD	R/W1C	0h	RSVD
3	F_OVLF[4]	R/W1C	0h	Over-Voltage Low Frequency Fault for MON4. Trips if MON4 Low Frequency signal goes above OVLF[4]. 0 = MON4 has no OVLF fault detected (or interrupt disabled in IEN_OVLF register) 1 = MON4 has OVLF fault detected The recovery of the fault condition does NOT clear the bit. It can only be cleared by the host with a write-1-to-clear. Write-1-to-clear will clear the bit only if the OVLF fault condition is also removed (MON4 Low Frequency signal is below OVLF[4]).
2	F_OVLF[3]	R/W1C	0h	Over-Voltage Low Frequency Fault for MON3. Trips if MON3 Low Frequency signal goes above OVLF[3]. 0 = MON3 has no OVLF fault detected (or interrupt disabled in IEN_OVLF register) 1 = MON3 has OVLF fault detected The recovery of the fault condition does NOT clear the bit. It can only be cleared by the host with a write-1-to-clear. Write-1-to-clear will clear the bit only if the OVLF fault condition is also removed (MON3 Low Frequency signal is below OVLF[3]).
1	F_OVLF[2]	R/W1C	0h	Over-Voltage Low Frequency Fault for MON2. Trips if MON2 Low Frequency signal goes above OVLF[2]. 0 = MON2 has no OVLF fault detected (or interrupt disabled in IEN_OVLF register) 1 = MON2 has OVLF fault detected The recovery of the fault condition does NOT clear the bit. It can only be cleared by the host with a write-1-to-clear. Write-1-to-clear will clear the bit only if the OVLF fault condition is also removed (MON2 Low Frequency signal is below OVLF[2]).
0	RSVD	R/W1C	0h	RSVD

8.1.1.7 INT_CONTROL Register (Offset = 22h) [Reset = 00h]

INT_CONTROL is shown in 表 8-9.

Return to the Summary Table.

Control and Communication Interrupt Status register.

表 8-9. INT_CONTROL Register Field Descriptions

Bit	Field	Type	Reset	Description
7-5	RSVD	R/W1C	0h	RSVD
4	F_CRC	R/W1C	0h	Runtime register CRC Fault: 0 = No fault detected (or IEN_CONTROL.RT_CRC is disabled) 1 = Register CRC fault detected The recovery of the fault condition does NOT clear the bit. It can only be cleared by the host with a write-1-to-clear. Write-1-to-clear will clear the bit. The bit will be set again during next register CRC check if the same fault is detected
3	F_NIRQ	R/W1C	0h	Interrupt pin fault (fault bit always enabled; no enable bit available): 0 = No fault detected on NIRQ pin 1 = Low resistance path to supply detected on NIRQ pin The recovery of the fault condition does NOT clear the bit. It can only be cleared by the host with a write-1-to-clear. Write-1-to-clear will clear the bit only if the NIRQ fault condition is also removed.
2	F_TSD	R/W1C	0h	Thermal Shutdown fault: 0 = No TSD fault detected (or IEN_CONTROL.TSD is disabled) 1 = TSD fault detected The recovery of the fault condition does NOT clear the bit. It can only be cleared by the host with a write-1-to-clear. Write-1-to-clear will clear the bit only if the TSD fault condition is also removed
1	RSVD	R/W1C	0h	RSVD
0	F_PEC	R/W1C	0h	Packet Error Checking fault: 0 = PEC mismatch has not occurred (or IEN_CONTROL.PEC is disabled) 1 = PEC mismatch has occurred, or VMON_MISC.REQ_PEC=1 and PEC is missing in a write transaction The recovery of the fault condition does NOT clear the bit. It can only be cleared by the host with a write-1-to-clear. Write-1-to-clear will clear the bit. The bit will be set again during next I2C transaction if the same fault is detected.

8.1.1.8 INT_TEST Register (Offset = 23h) [Reset = 00h]

INT_TEST is shown in 表 8-10.

Return to the Summary Table.

Internal Test and Configuration Load Interrupt Status register.

表 8-10. INT_TEST Register Field Descriptions

Bit	Field	Type	Reset	Description
7-4	RSVD	R/W1C	0h	RSVD
3	ECC_SEC	R/W1C	0h	ECC single-error corrected on OTP configuration load: 0 = No single-error corrected (or IEN_TEST.ECC_SEC is disabled) 1 = Single-error corrected Write-1-to-clear will clear the bit. The bit will be set again during next OTP configuration load if the same fault is detected.
2	ECC_DED	R/W1C	0h	ECC double-error detected on OTP configuration load: 0 = No double-error detected on OTP load 1 = Double-error detected on OTP load The fault bit is always enabled (there is no associated interrupt enable bit). The device will move to failsafe mode on double error detection.
1	BIST_Complete_INT	R/W1C	0h	Indication of Built-In Self-Test complete: 0 = BIST not complete (or IEN_TEST.BIST_C is disabled) 1 = BIST complete Write-1-to-clear will clear the bit. The bit will be set again on completion of next BIST execution

表 8-10. INT_TEST Register Field Descriptions (続き)

Bit	Field	Type	Reset	Description
0	BIST_Fail_INT	R/W1C	0h	Built-In Self-Test fault: 0 = No BIST fault detected (or IEN_TEST.BIST is disabled) 1 = BIST fault detected Write-1-to-clear will clear the bit. The bit will be set again during next BIST execution if the fault is detected

8.1.1.9 INT_VENDOR Register (Offset = 24h) [Reset = 00h]

INT_VENDOR is shown in 表 8-11.

Return to the Summary Table.

Vendor Specific Internal Interrupt Status register.

表 8-11. INT_VENDOR Register Field Descriptions

Bit	Field	Type	Reset	Description
7	RSVD	R/W1C	0h	RSVD
6	LDO_OV_Error	R/W1C	0h	Internal LDO Overvoltage error. 0 = No internal LDO overvoltage fault detected 1 = Internal LDO overvoltage fault detected The recovery of the fault condition does NOT clear the bit. It can only be cleared by the host with a write-1-to-clear. Write-1-to-clear will clear the bit only if the LDO fault condition is also removed.
5	NRST_MISMATCH	R/W1C	0h	Designates error due to drive state and read back. During an NRST toggle NRST mismatch will be active after 2µs, NRST must exceed 0.6*VDD to be considered in a logic high state. 0 = No fault detected on NRST pin 1 = Error due to drive state and read back. The recovery of the fault condition does NOT clear the bit. It can only be cleared by the host with a write-1-to-clear. Write-1-to-clear will clear the bit only if the NRST fault condition is also removed.
4	Freq_DEV_Error	R/W1C	0h	Designates internal frequency errors. 0 = No internal frequency fault detected 1 = Internal frequency fault detected The recovery of the fault condition does NOT clear the bit. It can only be cleared by the host with a write-1-to-clear. Write-1-to-clear will clear the bit only if the frequency fault condition is also removed.
3	SHORT_DET	R/W1C	0h	Address pin short detect. 0 = No address pin short fault detected 1 = Address pin short fault detected The recovery of the fault condition does NOT clear the bit. It can only be cleared by the host with a write-1-to-clear. Write-1-to-clear will clear the bit only if the address pin short fault condition is also removed.
2	OPEN_DET	R/W1C	0h	Address pin open detect. 0 = No address pin open fault detected 1 = Address pin open fault detected The recovery of the fault condition does NOT clear the bit. It can only be cleared by the host with a write-1-to-clear. Write-1-to-clear will clear the bit only if the address pin open fault condition is also removed.
1	ESM_ERROR	R/W1C	0h	Indication of ESM fault. 0 = No ESM fault detected 1 = ESM fault detected The recovery of the fault condition does NOT clear the bit. It can only be cleared by the host with a write-1-to-clear. Write-1-to-clear will clear the bit only if the ESM fault condition is also removed.

表 8-11. INT_VENDOR Register Field Descriptions (続き)

Bit	Field	Type	Reset	Description
0	WDT_ERROR	R/W1C	0h	Indication of Watchdog fault. 0 = No Watchdog fault detected 1 = Watchdog fault detected The recovery of the fault condition does NOT clear the bit. It can only be cleared by the host with a write-1-to-clear. Write-1-to-clear will clear the bit only if the Watchdog fault condition is also removed.

8.1.1.10 VMON_STAT Register (Offset = 30h) [Reset = 7Eh]

VMON_STAT is shown in 表 8-12.

Return to the Summary Table.

Status flags for internal operations and other non critical conditions.

表 8-12. VMON_STAT Register Field Descriptions

Bit	Field	Type	Reset	Description
7	FAILSAFE	R	0h	1 = Device in FAILSAFE state
6	ST_BIST_C	R	1h	Built-In Self-Test state: 0 = BIST not complete 1 = BIST complete
5	ST_VDD	R	1h	Status VDD
4	ST_NIRQ	R	1h	Status NIRQ pin
3	RSVD	R	1h	RSVD
2	ACTIVE	R	1h	1 = Device in ACTIVE state
1	RSVD	R	1h	RSVD
0	RSVD	R	0h	RSVD

8.1.1.11 TEST_INFO Register (Offset = 31h) [Reset = 00h]

TEST_INFO is shown in 表 8-13.

Return to the Summary Table.

Internal Self-Test and ECC information.

表 8-13. TEST_INFO Register Field Descriptions

Bit	Field	Type	Reset	Description
7-6	RSVD	R	0h	RSVD
5	ECC_SEC	R	0h	Status of ECC single-error correction on OTP configuration load. 0 = no error correction applied 1 = single-error correction applied
4	ECC_DED	R	0h	Status of ECC double-error detection on OTP configuration load. 0 = no double-error detected 1 = double-error detected
3	BIST_VM	R	0h	Status of Volatile Memory test output from BIST. 0 = Volatile Memory test pass 1 = Volatile Memory test fail
2	BIST_NVM	R	0h	Status of Non-Volatile Memory test output from BIST. 0 = Non-Volatile Memory test pass 1 = Non-Volatile Memory test fail
1	BIST_L	R	0h	Status of Logic test output from BIST. 0 = Logic test pass 1 = Logic test fail

表 8-13. TEST_INFO Register Field Descriptions (続き)

Bit	Field	Type	Reset	Description
0	BIST_A	R	0h	Status of Analog test output from BIST. 0 = Analog test pass 1 = Analog test fail

8.1.1.12 OFF_STAT Register (Offset = 32h) [Reset = 00h]

OFF_STAT is shown in 表 8-14.

Return to the Summary Table.

Channel OFF status.

表 8-14. OFF_STAT Register Field Descriptions

Bit	Field	Type	Reset	Description
7-4	RSVD	R	0h	RSVD
3	MON[4]	R	0h	Represents the OFF status of each channel: 0 = channel 4 is NOT OFF 1 = channel 4 is OFF (below OFF threshold)
2	MON[3]	R	0h	Represents the OFF status of each channel: 0 = channel 3 is NOT OFF 1 = channel 3 is OFF (below OFF threshold)
1	MON[2]	R	0h	Represents the OFF status of each channel: 0 = channel 2 is NOT OFF 1 = channel 2 is OFF (below OFF threshold)
0	RSVD	R	0h	RSVD

8.1.1.13 WDT_STAT Register (Offset = 37h) [Reset = 00h]

WDT_STAT is shown in 表 8-15.

Return to the Summary Table.

Watchdog Status

表 8-15. WDT_STAT Register Field Descriptions

Bit	Field	Type	Reset	Description
7-6	RSVD	R	0h	RSVD
5-3	WD_STATE	R	0h	Represents Watchdog state. 000 = WD Idle state 001 = WD Open state 010 = WD Close state 011 = WD Startup state 100 = WD suspend state
2	ST_WDEXP	R	0h	Will flag if close window expires before writing 3 answers or if open window expires. 1 = close window or open window expired (bit clears when read)
1	RSVD	R	0h	RSVD
0	ST_WDUV	R	0h	Will flag if an extra answer in close window (4 answers in close window) OR a wrong answer in close window OR a wrong answer in open window. 1 = extra or wrong answer (bit clears when read)

8.1.1.14 WD_STAT_QA Register (Offset = 38h) [Reset = 3Ch]

WD_STAT_QA is shown in 表 8-16.

Return to the Summary Table.

Watchdog Answer Count and Token

表 8-16. WD_STAT_QA Register Field Descriptions

Bit	Field	Type	Reset	Description
7-6	RSVD	R	0h	RSVD
5-4	ANSW_CNT[1:0]	R	3h	Represents Answer count in real time
3-0	TOKEN[3:0]	R	Ch	Represents Token in real time. Enabling the watchdog sets the Token value to 0.

8.1.1.15 MON_LVL[2] Register (Offset = 41h) [Reset = 00h]

MON_LVL[2] is shown in 表 8-17.

Return to the Summary Table.

Channel 2 voltage level.

表 8-17. MON_LVL[2] Register Field Descriptions

Bit	Field	Type	Reset	Description
7-0	ADC[7:0]	R	0h	Represents MON2 voltage telemetry value in hex

8.1.1.16 MON_LVL[3] Register (Offset = 42h) [Reset = 00h]

MON_LVL[3] is shown in 表 8-18.

Return to the Summary Table.

Channel 3 voltage level.

表 8-18. MON_LVL[3] Register Field Descriptions

Bit	Field	Type	Reset	Description
7-0	ADC[7:0]	R	0h	Represents MON3 voltage telemetry value in hex

8.1.1.17 MON_LVL[4] Register (Offset = 43h) [Reset = 00h]

MON_LVL[4] is shown in 表 8-19.

Return to the Summary Table.

Channel 4 voltage level.

表 8-19. MON_LVL[4] Register Field Descriptions

Bit	Field	Type	Reset	Description
7-0	ADC[7:0]	R	0h	Represents MON4 voltage telemetry value in hex

8.1.1.18 BANK_SEL Register (Offset = F0h) [Reset = 00h]

BANK_SEL is shown in 表 8-20.

Return to the Summary Table.

Bank Select.

表 8-20. BANK_SEL Register Field Descriptions

Bit	Field	Type	Reset	Description
7-1	RSVD	R/W	0h	RSVD
0	BANK_Select	R/W	0h	Represents bank selection. 0 = Bank 0 1 = Bank 1

8.1.1.19 PROT1 Register (Offset = F1h) [Reset = 00h]

PROT1 is shown in 表 8-21.

Return to the Summary Table.

Locks or unlocks register changes. Must match PROT2.

表 8-21. PROT1 Register Field Descriptions

Bit	Field	Type	Reset	Description
7-6	RSVD	R/W	0h	RSVD
5	WRKC	R/W	0h	Represents Protection from writes for WRKC group. Both PROT1 and PROT2 need to be set for protection. 0 = Changes to register are possible 1 = Changes to register are not possible
4	RSVD	R/W	0h	RSVD
3	CFG	R/W	0h	Represents Protection from writes for CFG group. Both PROT1 and PROT2 need to be set for protection. 0 = Changes to register are possible 1 = Changes to register are not possible
2	IEN	R/W	0h	Represents Protection from writes for IEN group. Both PROT1 and PROT2 need to be set for protection. 0 = Changes to register are possible 1 = Changes to register are not possible
1	MON	R/W	0h	Represents Protection from writes for MON group. Both PROT1 and PROT2 need to be set for protection. 0 = Changes to register are possible 1 = Changes to register are not possible
0	RSVD	R/W	0h	RSVD

8.1.1.20 PROT2 Register (Offset = F2h) [Reset = 00h]

PROT2 is shown in 表 8-22.

Return to the Summary Table.

Locks or unlocks register changes. Must match PROT1.

表 8-22. PROT2 Register Field Descriptions

Bit	Field	Type	Reset	Description
7-6	RSVD	R/W	0h	RSVD
5	WRKC	R/W	0h	Represents Protection from writes for CFG group. Both PROT1 and PROT2 need to be set for protection. 0 = Changes to register are possible 1 = Changes to register are not possible
4	RSVD	R/W	0h	RSVD

表 8-22. PROT2 Register Field Descriptions (続き)

Bit	Field	Type	Reset	Description
3	CFG	R/W	0h	Represents Protection from writes for CFG group. Both PROT1 and PROT2 need to be set for protection. 0 = Changes to register are possible 1 = Changes to register are not possible
2	IEN	R/W	0h	Represents Protection from writes for IEN group. Both PROT1 and PROT2 need to be set for protection. 0 = Changes to register are possible 1 = Changes to register are not possible
1	MON	R/W	0h	Represents Protection from writes for MON group. Both PROT1 and PROT2 need to be set for protection. 0 = Changes to register are possible 1 = Changes to register are not possible
0	RSVD	R/W	0h	RSVD

8.1.1.21 PROT_MON Register (Offset = F3h) [Reset = 1Fh]

PROT_MON is shown in 表 8-23.

Return to the Summary Table.

Locks MON registers in tandem with PROT1 and PROT2.

表 8-23. PROT_MON Register Field Descriptions

Bit	Field	Type	Reset	Description
7-4	RSVD	R/W	1h	RSVD
3	MON[4]	R/W	1h	Protects MON4 from writes along with PROT1 and PROT2. 0= Changes are possible 1= Changes are not possible
2	MON[3]	R/W	1h	Protects MON3 from writes along with PROT1 and PROT2. 0= Changes are possible 1= Changes are not possible
1	MON[2]	R/W	1h	Protects MON2 from writes along with PROT1 and PROT2. 0= Changes are possible 1= Changes are not possible
0	RSVD	R/W	1h	RSVD

8.1.1.22 I2CADDR Register (Offset = F9h) [Reset = 30h]

I2CADDR is shown in 表 8-24.

Return to the Summary Table.

I2C Address

表 8-24. I2CADDR Register Field Descriptions

Bit	Field	Type	Reset	Description
7	RSVD	R/W	0h	RSVD
6-3	ADDR_NVM[3:0]	R	6h	Represents I2C address from internal OTP. Default value of 30 hex. Also the default I2C address for fail safe mode if I2C communication fails
2-0	ADDR_STRAP[2:0]	R	0h	Represents I2C address from resistor value on ADDR pin.

8.1.1.23 DEV_CFG Register (Offset = FAh) [Reset = 00h]

DEV_CFG is shown in 表 8-25.

Return to the Summary Table.

Status of I2C interface voltage levels.

表 8-25. DEV_CFG Register Field Descriptions

Bit	Field	Type	Reset	Description
7-0	RSVD	R	0h	RSVD

8.1.2 BANK1 Registers

表 8-26 lists the memory-mapped registers for the BANK1 registers. All register offset addresses not listed in 表 8-26 should be considered as reserved locations and the register contents should not be modified.

表 8-26. BANK1 Registers

Offset	Acronym	Register Name	Section
10h	VMON_CTL	VMON device control register.	Go
11h	VMON_MISC	Miscellaneous VMON configurations.	Go
12h	TEST_CFG	Built-In Self Test (BIST) execution configuration.	Go
13h	IEN_UVHF	High Frequency channel Under-Voltage Interrupt Enable register	Go
14h	IEN_UVLF	Low Frequency channel Under-Voltage Interrupt Enable register.	Go
15h	IEN_OVHF	High Frequency channel Over-Voltage Interrupt Enable register.	Go
16h	IEN_OVLF	Low Frequency channel Over-Voltage Interrupt Enable register.	Go
1Bh	IEN_CONTROL	Control and Communication Fault Interrupt Enable register.	Go
1Ch	IEN_TEST	Internal Test and Configuration Load Fault Interrupt Enable register	Go
1Dh	IEN_VENDOR	Vendor Specific Internal Interrupt Enable register.	Go
1Eh	MON_CH_EN	Channel Voltage Monitoring Enable.	Go
1Fh	VRANGE_MULT	Channel Voltage Monitoring Range/Scaling.	Go
30h	UV_HF[2]	Channel 2 High Frequency channel Under-Voltage threshold.	Go
31h	OV_HF[2]	Channel 2 High Frequency channel Over-Voltage threshold.	Go
32h	UV_LF[2]	Channel 2 Low Frequency channel Under-Voltage threshold.	Go
33h	OV_LF[2]	Channel 2 Low Frequency channel Over-Voltage threshold.	Go
34h	FLT_HF[2]	Channel 2 UV and OV debouncing for High Frequency thresholds comparator output.	Go
35h	FC_LF[2]	Channel 2 Low Frequency Path G(s) Cutoff Frequency (-3 dB point). The register changes the filter properties of the programmable LPF such that the total frequency response G(s) meets these cutoff frequencies.	Go
40h	UV_HF[3]	Channel 3 High Frequency channel Under-Voltage threshold.	Go
41h	OV_HF[3]	Channel 3 High Frequency channel Over-Voltage threshold.	Go
42h	UV_LF[3]	Channel 3 Low Frequency channel Under-Voltage threshold.	Go
43h	OV_LF[3]	Channel 3 Low Frequency channel Over-Voltage threshold.	Go
44h	FLT_HF[3]	Channel 3 UV and OV debouncing for High Frequency thresholds comparator output.	Go

表 8-26. BANK1 Registers (続き)

Offset	Acronym	Register Name	Section
45h	FC_LF[3]	Channel 3 Low Frequency Path G(s) Cutoff Frequency (-3 dB point). The register changes the filter properties of the programmable LPF such that the total frequency response G(s) meets these cutoff frequencies.	Go
50h	UV_HF[4]	Channel 4 High Frequency channel Under-Voltage threshold.	Go
51h	OV_HF[4]	Channel 4 High Frequency channel Over-Voltage threshold.	Go
52h	UV_LF[4]	Channel 4 Low Frequency channel Under-Voltage threshold.	Go
53h	OV_LF[4]	Channel 4 Low Frequency channel Over-Voltage threshold.	Go
54h	FLT_HF[4]	Channel 4 UV and OV debouncing for High Frequency thresholds comparator output.	Go
55h	FC_LF[4]	Channel 4 Low Frequency Path G(s) Cutoff Frequency (-3 dB point). The register changes the filter properties of the programmable LPF such that the total frequency response G(s) meets these cutoff frequencies.	Go
9Eh	ESM	ESM threshold time for asserting a fault.	Go
9Fh	TI_CONTROL	Manual BIST/WD EN/Manual Reset via I2C/ESM deglitch/Reset delay	Go
A1h	AMSK_ON	Auto-mask UVLF, UVHF, and OVHF interrupts on power up transitions.	Go
A2h	AMSK_OFF	Auto-mask UVLF, UVHF, and OVHF interrupts on power down transitions.	Go
A5h	SEQ_TOUT_MSB	Timeout for UV faults during powerup and power down.	Go
A6h	SEQ_TOUT_LSB	Timeout for UV faults during powerup and power down.	Go
A8h	SEQ_UP_THLD	Threshold at which AMSK is released (VMON considered on) for power up.	Go
A9h	SEQ_DN_THLD	Threshold at which AMSK is released (VMON considered off) for power down.	Go
AAh	WDT_CFG	Max violation count for WD and Delay multiplier for Start Up Window.	Go
ABh	WDT_CLOSE	Close Window Time.	Go
ACh	WDT_OPEN	Open Window Time.	Go
ADh	WDT_QA_CFG	Feedback/Poly/Seed for Watchdog.	Go
AEh	WDT_ANSWER	Answer for the Watchdog.	Go
F0h	BANK_SEL	Bank Select.	Go

Complex bit access types are encoded to fit into small table cells. 表 8-27 shows the codes that are used for access types in this section.

表 8-27. BANK1 Access Type Codes

Access Type	Code	Description
Read Type		
R	R	Read
Write Type		

表 8-27. BANK1 Access Type Codes (続き)

Access Type	Code	Description
W	W	Write
Reset or Default Value		
-n		Value after reset or the default value

8.1.2.1 VMON_CTL Register (Offset = 10h) [Default = 20h]

VMON_CTL is shown in 表 8-28.

Return to the Summary Table.

VMON device control register.

表 8-28. VMON_CTL Register Field Descriptions

Bit	Field	Type	Default	Description
7-5	RSVD	R/W	1h	RSVD
4	FORCE_WDO_LOW	R/W	0h	Force assertion of WDO
3	RESET_PROT	R/W	0h	Reset_Prot = read 0, write 1 to clear Protection registers
2-1	RSVD	R/W	0h	RSVD
0	FORCE_NIRQ_LOW	R/W	0h	Force assertion of NIRQ

8.1.2.2 VMON_MISC Register (Offset = 11h) [Default = X]

VMON_MISC is shown in 表 8-29.

Return to the Summary Table.

Miscellaneous VMON configurations.

表 8-29. VMON_MISC Register Field Descriptions

Bit	Field	Type	Default	Description
7	RSVD	R/W	X	RSVD
6-4	WDO_DLY[2:0]	R/W	X	WDO_Delay (not applicable for latched WDO)
3-2	RSVD	R/W	X	RSVD
1	REQ_PEC	R/W	X	Require PEC. 0 = PEC not required 1 = PEC required
0	EN_PEC	R/W	X	Enable PEC. 0 = PEC not enabled 1 = PEC enabled

8.1.2.3 TEST_CFG Register (Offset = 12h) [Default = X]

TEST_CFG is shown in 表 8-30.

Return to the Summary Table.

Built-In Self Test (BIST) execution configuration.

表 8-30. TEST_CFG Register Field Descriptions

Bit	Field	Type	Default	Description
7-3	RSVD	R/W	X	RSVD

表 8-30. TEST_CFG Register Field Descriptions (続き)

Bit	Field	Type	Default	Description
2	AT_SHDN	R/W	X	Run BIST at SHDN
1	AT_POR[1]	R/W	X	Run BIST at POR, 2nd bit for redundancy
0	AT_POR[0]	R/W	X	Run BIST at POR

8.1.2.4 IEN_UVHF Register (Offset = 13h) [Default = X]

IEN_UVHF is shown in 表 8-31.

Return to the Summary Table.

High Frequency channel Under-Voltage Interrupt Enable register

表 8-31. IEN_UVHF Register Field Descriptions

Bit	Field	Type	Default	Description
7-4	RSVD	R/W	X	RSVD
3	MON[4]	R/W	X	enabling uvhf for channel 4, Disable=0, Enable=1
2	MON[3]	R/W	X	enabling uvhf for channel 3, Disable=0, Enable=1
1	MON[2]	R/W	X	enabling uvhf for channel 2, Disable=0, Enable=1
0	RSVD	R/W	X	RSVD

8.1.2.5 IEN_UVLF Register (Offset = 14h) [Default = X]

IEN_UVLF is shown in 表 8-32.

Return to the Summary Table.

Low Frequency channel Under-Voltage Interrupt Enable register.

表 8-32. IEN_UVLF Register Field Descriptions

Bit	Field	Type	Default	Description
7-4	RSVD	R/W	X	RSVD
3	MON[4]	R/W	X	enabling uvlf for channel 4, Disable=0, Enable=1
2	MON[3]	R/W	X	enabling uvlf for channel 3, Disable=0, Enable=1
1	MON[2]	R/W	X	enabling uvlf for channel 2, Disable=0, Enable=1
0	RSVD	R/W	X	RSVD

8.1.2.6 IEN_OVHF Register (Offset = 15h) [Default = X]

IEN_OVHF is shown in 表 8-33.

Return to the Summary Table.

High Frequency channel Over-Voltage Interrupt Enable register.

表 8-33. IEN_OVHF Register Field Descriptions

Bit	Field	Type	Default	Description
7-4	RSVD	R/W	X	RSVD
3	MON[4]	R/W	X	enabling ovhf for channel 4, Disable=0, Enable=1
2	MON[3]	R/W	X	enabling ovhf for channel 3, Disable=0, Enable=1
1	MON[2]	R/W	X	enabling ovhf for channel 2, Disable=0, Enable=1
0	RSVD	R/W	X	RSVD

8.1.2.7 IEN_OVLF Register (Offset = 16h) [Default = X]

IEN_OVLF is shown in 表 8-34.

Return to the Summary Table.

Low Frequency channel Over-Voltage Interrupt Enable register.

表 8-34. IEN_OVLF Register Field Descriptions

Bit	Field	Type	Default	Description
7-4	RSVD	R/W	X	RSVD
3	MON[4]	R/W	X	enabling ovlf for channel 4, Disable=0, Enable=1
2	MON[3]	R/W	X	enabling ovlf for channel 3, Disable=0, Enable=1
1	MON[2]	R/W	X	enabling ovlf for channel 2, Disable=0, Enable=1
0	RSVD	R/W	X	RSVD

8.1.2.8 IEN_CONTROL Register (Offset = 1Bh) [Default = X]

IEN_CONTROL is shown in 表 8-35.

Return to the Summary Table.

Control and Communication Fault Interrupt Enable register.

表 8-35. IEN_CONTROL Register Field Descriptions

Bit	Field	Type	Default	Description
7-5	RSVD	R/W	X	RSVD
4	RT_CRC_Int	R/W	X	Register Run time CRC error Interrupt. Disable=0, Enable = 1
3	RSVD	R/W	X	RSVD
2	TSD_INT	R/W	X	Thermal shutdown Interrupt. Disable=0, Enable = 1

表 8-35. IEN_CONTROL Register Field Descriptions (続き)

Bit	Field	Type	Default	Description
1	RSVD	R/W	X	RSVD
0	PEC_INT	R/W	X	PEC Error Interrupt. Disable=0, Enable = 1

8.1.2.9 IEN_TEST Register (Offset = 1Ch) [Default = X]

IEN_TEST is shown in 表 8-36.

Return to the Summary Table.

Internal Test and Configuration Load Fault Interrupt Enable register

表 8-36. IEN_TEST Register Field Descriptions

Bit	Field	Type	Default	Description
7-4	RSVD	R/W	X	RSVD
3	ECC_SEC	R/W	X	SEC Error Interrupt. Disable=0, Enable = 1
2	RSVD	R/W	X	RSVD
1	BIST_Complete_INT	R/W	X	BIST complete Interrupt. Disable=0, Enable = 1
0	BIST_Fail_INT	R/W	X	BIST Fail Interrupt. Disable=0, Enable = 1

8.1.2.10 IEN_VENDOR Register (Offset = 1Dh) [Default = X]

IEN_VENDOR is shown in 表 8-37.

Return to the Summary Table.

Vendor Specific Internal Interrupt Enable register.

表 8-37. IEN_VENDOR Register Field Descriptions

Bit	Field	Type	Default	Description
7-6	RSVD	R/W	X	RSVD
5	NRST_MISMATCH	R/W	X	NRST mismatch Interrupt. Disable=0, Enable = 1
4	ESM_TO_WDO	R/W	X	Maps ESM fault to WDO. Not mapped=0 Mapped = 1
3	ESM_TO_NIRQ	R/W	X	Maps ESM fault to NIRQ. Not mapped=0 Mapped = 1
2	WDT_TO_NIRQ	R/W	X	Maps Watchdog fault to NIRQ. Not mapped=0 Mapped = 1
1	ESM_TO_NRST	R/W	X	Maps ESM fault to NRST. Not mapped=0 Mapped = 1

表 8-37. IEN_VENDOR Register Field Descriptions (続き)

Bit	Field	Type	Default	Description
0	WDT_TO_NRST	R/W	X	Maps Watchdog fault to NRST. Not mapped=0 Mapped = 1

8.1.2.11 MON_CH_EN Register (Offset = 1Eh) [Default = X]

MON_CH_EN is shown in 表 8-38.

Return to the Summary Table.

Channel Voltage Monitoring Enable.

表 8-38. MON_CH_EN Register Field Descriptions

Bit	Field	Type	Default	Description
7-4	RSVD	R/W	X	RSVD
3	MON[4]	R/W	X	Enables channel 4 monitoring. Enabled = 1, Disabled = 0
2	MON[3]	R/W	X	Enables channel 3 monitoring. Enabled = 1, Disabled = 0
1	MON[2]	R/W	X	Enables channel 2 monitoring. Enabled = 1, Disabled = 0
0	RSVD	R/W	X	RSVD

8.1.2.12 VRANGE_MULT Register (Offset = 1Fh) [Default = X]

VRANGE_MULT is shown in 表 8-39.

Return to the Summary Table.

Channel Voltage Monitoring Range/Scaling.

表 8-39. VRANGE_MULT Register Field Descriptions

Bit	Field	Type	Default	Description
7-4	RSVD	R/W	X	RSVD
3	MON[4]	R/W	X	Scalar for MON_4. 1x =0, 4x = 1
2	MON[3]	R/W	X	Scalar for MON_3. 1x =0, 4x = 1
1	MON[2]	R/W	X	Scalar for MON_2. 1x =0, 4x = 1
0	RSVD	R/W	X	RSVD

8.1.2.13 UV_HF[2] Register (Offset = 30h) [Default = X]

UV_HF[2] is shown in 表 8-40.

Return to the Summary Table.

Channel 2 High Frequency channel Under-Voltage threshold.

表 8-40. UV_HF[2] Register Field Descriptions

Bit	Field	Type	Default	Description
7-0	THRESHOLD[7:0]	R/W	X	Undervoltage threshold for High Frequency component of monitored channel. The 8-bit value interpretation depends on the scaling setting in register VRANGE_MULT. With scaling = 1x, the 8-bit value represents the range 0.2 V to 1.475 V with 1 LSB = 5 mV. With scaling = 4x, the 8-bit value represents the range 0.8 Vto 5.9 V with 1 LSB = 20 mV.

8.1.2.14 OV_HF[2] Register (Offset = 31h) [Default = X]

OV_HF[2] is shown in 表 8-41.

Return to the Summary Table.

Channel 2 High Frequency channel Over-Voltage threshold.

表 8-41. OV_HF[2] Register Field Descriptions

Bit	Field	Type	Default	Description
7-0	THRESHOLD[7:0]	R/W	X	Overvoltage threshold for High Frequency component of monitored channel. The 8-bit value interpretation depends on the scaling setting in register VRANGE_MULT. With scaling = 1x, the 8-bit value represents the range 0.2 V to 1.475 V with 1 LSB = 5 mV. With scaling = 4x, the 8-bit value represents the range 0.8 Vto 5.9 V with 1 LSB = 20 mV.

8.1.2.15 UV_LF[2] Register (Offset = 32h) [Default = X]

UV_LF[2] is shown in 表 8-42.

Return to the Summary Table.

Channel 2 Low Frequency channel Under-Voltage threshold.

表 8-42. UV_LF[2] Register Field Descriptions

Bit	Field	Type	Default	Description
7-0	THRESHOLD[7:0]	R/W	X	Undervoltage threshold for Low Frequency component of monitored channel. The 8-bit value interpretation depends on the scaling setting in register VRANGE_MULT. With scaling = 1x, the 8-bit value represents the range 0.2 V to 1.475 V with 1 LSB = 5 mV. With scaling = 4x, the 8-bit value represents the range 0.8 Vto 5.9 V with 1 LSB = 20 mV.

8.1.2.16 OV_LF[2] Register (Offset = 33h) [Default = X]

OV_LF[2] is shown in 表 8-43.

Return to the Summary Table.

Channel 2 Low Frequency channel Over-Voltage threshold.

表 8-43. OV_LF[2] Register Field Descriptions

Bit	Field	Type	Default	Description
7-0	THRESHOLD[7:0]	R/W	X	Overvoltage threshold for Low Frequency component of monitored channel. The 8-bit value interpretation depends on the scaling setting in register VRANGE_MULT. With scaling = 1x, the 8-bit value represents the range 0.2 V to 1.475 V with 1 LSB = 5 mV. With scaling = 4x, the 8-bit value represents the range 0.8 Vto 5.9 V with 1 LSB = 20 mV.

8.1.2.17 FLT_HF[2] Register (Offset = 34h) [Default = X]

FLT_HF[2] is shown in 表 8-44.

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Channel 2 UV and OV debouncing for High Frequency thresholds comparator output.

表 8-44. FLT_HF[2] Register Field Descriptions

Bit	Field	Type	Default	Description
7-4	OV_DEB[3:0]	R/W	X	Overvoltage comparator output debounce time (dont assert until output is stable for debounce time) for High Frequency monitoring path. 0000b = 0.1 µs 1000b = 25.6 µs 0001b = 0.2 µs 1001b = 51.2 µs 0010b = 0.4 µs 1010b = 102.4 µs 0011b = 0.8 µs 1011b = 102.4 µs 0100b = 1.6 µs 1100b = 102.4 µs 0101b = 3.2 µs 1101b = 102.4 µs 0110b = 6.4 µs 1110b = 102.4 µs 0111b = 12.8 µs 1111b = 102.4 µs
3-0	UV_DEB[3:0]	R/W	X	Undervoltage comparator output debounce time (dont assert until output is stable for debounce time) for High Frequency monitoring path. 0000b = 0.1 µs 1000b = 25.6 µs 0001b = 0.2 µs 1001b = 51.2 µs 0010b = 0.4 µs 1010b = 102.4 µs 0011b = 0.8 µs 1011b = 102.4 µs 0100b = 1.6 µs 1100b = 102.4 µs 0101b = 3.2 µs 1101b = 102.4 µs 0110b = 6.4 µs 1110b = 102.4 µs 0111b = 12.8 µs 1111b = 102.4 µs

8.1.2.18 FC_LF[2] Register (Offset = 35h) [Default = X]

FC_LF[2] is shown in 表 8-45.

Return to the Summary Table.

Channel 2 Low Frequency Path G(s) Cutoff Frequency (-3 dB point). The register changes the filter properties of the programmable LPF such that the total frequency response G(s) meets these cutoff frequencies.

表 8-45. FC_LF[2] Register Field Descriptions

Bit	Field	Type	Default	Description
7-5	RSVD	R/W	X	RSVD
4	ovhf_to_nrst	R/W	X	Maps Channel 2 ovhf fault to NRST Not mapped = 0, Mapped = 1

表 8-45. FC_LF[2] Register Field Descriptions (続き)

Bit	Field	Type	Default	Description
3	uvhf_to_nrst	R/W	X	Maps Channel 2 uvhf fault to NRST Not mapped = 0, Mapped = 1
2-0	Cut_off_Freq[2:0]	R/W	X	Channel 2 Cut of frequency for LF faults filter 000 =Invalid 001 =Invalid 010 =250Hz 011 = 500Hz 100 = 1kHz 101 = 2kHz 110 =4kHz 111 = Invalid

8.1.2.19 UV_HF[3] Register (Offset = 40h) [Default = X]

UV_HF[3] is shown in 表 8-46.

Return to the Summary Table.

Channel 3 High Frequency channel Under-Voltage threshold.

表 8-46. UV_HF[3] Register Field Descriptions

Bit	Field	Type	Default	Description
7-0	THRESHOLD[7:0]	R/W	X	Undervoltage threshold for High Frequency component of monitored channel. The 8-bit value interpretation depends on the scaling setting in register VRANGE_MULT. With scaling = 1x, the 8-bit value represents the range 0.2 V to 1.475 V with 1 LSB = 5 mV. With scaling = 4x, the 8-bit value represents the range 0.8 Vto 5.9 V with 1 LSB = 20 mV.

8.1.2.20 OV_HF[3] Register (Offset = 41h) [Default = X]

OV_HF[3] is shown in 表 8-47.

Return to the Summary Table.

Channel 3 High Frequency channel Over-Voltage threshold.

表 8-47. OV_HF[3] Register Field Descriptions

Bit	Field	Type	Default	Description
7-0	THRESHOLD[7:0]	R/W	X	Overvoltage threshold for High Frequency component of monitored channel. The 8-bit value interpretation depends on the scaling setting in register VRANGE_MULT. With scaling = 1x, the 8-bit value represents the range 0.2 V to 1.475 V with 1 LSB = 5 mV. With scaling = 4x, the 8-bit value represents the range 0.8 Vto 5.9 V with 1 LSB = 20 mV.

8.1.2.21 UV_LF[3] Register (Offset = 42h) [Default = X]

UV_LF[3] is shown in 表 8-48.

Return to the Summary Table.

Channel 3 Low Frequency channel Under-Voltage threshold.

表 8-48. UV_LF[3] Register Field Descriptions

Bit	Field	Type	Default	Description
7-0	THRESHOLD[7:0]	R/W	X	Undervoltage threshold for Low Frequency component of monitored channel. The 8-bit value interpretation depends on the scaling setting in register VRANGE_MULT. With scaling = 1x, the 8-bit value represents the range 0.2 V to 1.475 V with 1 LSB = 5 mV. With scaling = 4x, the 8-bit value represents the range 0.8 Vto 5.9 V with 1 LSB = 20 mV.

8.1.2.22 OV_LF[3] Register (Offset = 43h) [Default = X]

OV_LF[3] is shown in 表 8-49.

Return to the Summary Table.

Channel 3 Low Frequency channel Over-Voltage threshold.

表 8-49. OV_LF[3] Register Field Descriptions

Bit	Field	Type	Default	Description
7-0	THRESHOLD[7:0]	R/W	X	Overvoltage threshold for Low Frequency component of monitored channel. The 8-bit value interpretation depends on the scaling setting in register VRANGE_MULT. With scaling = 1x, the 8-bit value represents the range 0.2 V to 1.475 V with 1 LSB = 5 mV. With scaling = 4x, the 8-bit value represents the range 0.8 Vto 5.9 V with 1 LSB = 20 mV.

8.1.2.23 FLT_HF[3] Register (Offset = 44h) [Default = X]

FLT_HF[3] is shown in 表 8-50.

Return to the Summary Table.

Channel 3 UV and OV debouncing for High Frequency thresholds comparator output.

表 8-50. FLT_HF[3] Register Field Descriptions

Bit	Field	Type	Default	Description
7-4	OV_DEB[3:0]	R/W	X	Overvoltage comparator output debounce time (dont assert until output is stable for debounce time) for High Frequency monitoring path. 0000b = 0.1 µs 1000b = 25.6 µs 0001b = 0.2 µs 1001b = 51.2 µs 0010b = 0.4 µs 1010b = 102.4 µs 0011b = 0.8 µs 1011b = 102.4 µs 0100b = 1.6 µs 1100b = 102.4 µs 0101b = 3.2 µs 1101b = 102.4 µs 0110b = 6.4 µs 1110b = 102.4 µs 0111b = 12.8 µs 1111b = 102.4 µs

表 8-50. FLT_HF[3] Register Field Descriptions (続き)

Bit	Field	Type	Default	Description
3-0	UV_DEB[3:0]	R/W	X	Undervoltage comparator output debounce time (dont assert until output is stable for debounce time) for High Frequency monitoring path. 0000b = 0.1 µs 1000b = 25.6 µs 0001b = 0.2 µs 1001b = 51.2 µs 0010b = 0.4 µs 1010b = 102.4 µs 0011b = 0.8 µs 1011b = 102.4 µs 0100b = 1.6 µs 1100b = 102.4 µs 0101b = 3.2 µs 1101b = 102.4 µs 0110b = 6.4 µs 1110b = 102.4 µs 0111b = 12.8 µs 1111b = 102.4 µs

8.1.2.24 FC_LF[3] Register (Offset = 45h) [Default = X]

FC_LF[3] is shown in 表 8-51.

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Channel 3 Low Frequency Path G(s) Cutoff Frequency (-3 dB point). The register changes the filter properties of the programmable LPF such that the total frequency response G(s) meets these cutoff frequencies.

表 8-51. FC_LF[3] Register Field Descriptions

Bit	Field	Type	Default	Description
7-5	RSVD	R/W	X	RSVD
4	ovhf_to_nrst	R/W	X	Maps Channel 3 ovhf fault to NRST Not mapped = 0, Mapped = 1
3	uvhf_to_nrst	R/W	X	Maps Channel 3 uvhf fault to NRST Not mapped = 0, Mapped = 1
2-0	Cut_off_Freq[2:0]	R/W	X	Channel 3 Cut of frequency for LF faults filter 000 =Invalid 001 =Invalid 010 =250Hz 011 = 500Hz 100 = 1kHz 101 = 2kHz 110 =4kHz 111 = Invalid

8.1.2.25 UV_HF[4] Register (Offset = 50h) [Default = X]

UV_HF[4] is shown in 表 8-52.

Return to the Summary Table.

Channel 4 High Frequency channel Under-Voltage threshold.

表 8-52. UV_HF[4] Register Field Descriptions

Bit	Field	Type	Default	Description
7-0	THRESHOLD[7:0]	R/W	X	Undervoltage threshold for High Frequency component of monitored channel. The 8-bit value interpretation depends on the scaling setting in register VRANGE_MULT. With scaling = 1x, the 8-bit value represents the range 0.2 V to 1.475 V with 1 LSB = 5 mV. With scaling = 4x, the 8-bit value represents the range 0.8 Vto 5.9 V with 1 LSB = 20 mV.

8.1.2.26 OV_HF[4] Register (Offset = 51h) [Default = X]

OV_HF[4] is shown in 表 8-53.

Return to the Summary Table.

Channel 4 High Frequency channel Over-Voltage threshold.

表 8-53. OV_HF[4] Register Field Descriptions

Bit	Field	Type	Default	Description
7-0	THRESHOLD[7:0]	R/W	X	Overvoltage threshold for High Frequency component of monitored channel. The 8-bit value interpretation depends on the scaling setting in register VRANGE_MULT. With scaling = 1x, the 8-bit value represents the range 0.2 V to 1.475 V with 1 LSB = 5 mV. With scaling = 4x, the 8-bit value represents the range 0.8 Vto 5.9 V with 1 LSB = 20 mV.

8.1.2.27 UV_LF[4] Register (Offset = 52h) [Default = X]

UV_LF[4] is shown in 表 8-54.

Return to the Summary Table.

Channel 4 Low Frequency channel Under-Voltage threshold.

表 8-54. UV_LF[4] Register Field Descriptions

Bit	Field	Type	Default	Description
7-0	THRESHOLD[7:0]	R/W	X	Undervoltage threshold for Low Frequency component of monitored channel. The 8-bit value interpretation depends on the scaling setting in register VRANGE_MULT. With scaling = 1x, the 8-bit value represents the range 0.2 V to 1.475 V with 1 LSB = 5 mV. With scaling = 4x, the 8-bit value represents the range 0.8 Vto 5.9 V with 1 LSB = 20 mV.

8.1.2.28 OV_LF[4] Register (Offset = 53h) [Default = X]

OV_LF[4] is shown in 表 8-55.

Return to the Summary Table.

Channel 4 Low Frequency channel Over-Voltage threshold.

表 8-55. OV_LF[4] Register Field Descriptions

Bit	Field	Type	Default	Description
7-0	THRESHOLD[7:0]	R/W	X	Overvoltage threshold for Low Frequency component of monitored channel. The 8-bit value interpretation depends on the scaling setting in register VRANGE_MULT. With scaling = 1x, the 8-bit value represents the range 0.2 V to 1.475 V with 1 LSB = 5 mV. With scaling = 4x, the 8-bit value represents the range 0.8 Vto 5.9 V with 1 LSB = 20 mV.

8.1.2.29 FLT_HF[4] Register (Offset = 54h) [Default = X]

FLT_HF[4] is shown in 表 8-56.

Return to the Summary Table.

Channel 4 UV and OV debouncing for High Frequency thresholds comparator output.

表 8-56. FLT_HF[4] Register Field Descriptions

Bit	Field	Type	Default	Description
7-4	OV_DEB[3:0]	R/W	X	Overvoltage comparator output debounce time (dont assert until output is stable for debounce time) for High Frequency monitoring path. 0000b = 0.1 µs 1000b = 25.6 µs 0001b = 0.2 µs 1001b = 51.2 µs 0010b = 0.4 µs 1010b = 102.4 µs 0011b = 0.8 µs 1011b = 102.4 µs 0100b = 1.6 µs 1100b = 102.4 µs 0101b = 3.2 µs 1101b = 102.4 µs 0110b = 6.4 µs 1110b = 102.4 µs 0111b = 12.8 µs 1111b = 102.4 µs
3-0	UV_DEB[3:0]	R/W	X	Undervoltage comparator output debounce time (dont assert until output is stable for debounce time) for High Frequency monitoring path. 0000b = 0.1 µs 1000b = 25.6 µs 0001b = 0.2 µs 1001b = 51.2 µs 0010b = 0.4 µs 1010b = 102.4 µs 0011b = 0.8 µs 1011b = 102.4 µs 0100b = 1.6 µs 1100b = 102.4 µs 0101b = 3.2 µs 1101b = 102.4 µs 0110b = 6.4 µs 1110b = 102.4 µs 0111b = 12.8 µs 1111b = 102.4 µs

8.1.2.30 FC_LF[4] Register (Offset = 55h) [Default = X]

FC_LF[4] is shown in 表 8-57.

Return to the Summary Table.

Channel 4 Low Frequency Path G(s) Cutoff Frequency (-3 dB point). The register changes the filter properties of the programmable LPF such that the total frequency response G(s) meets these cutoff frequencies.

表 8-57. FC_LF[4] Register Field Descriptions

Bit	Field	Type	Default	Description
7-5	RSVD	R/W	X	RSVD
4	ovhf_to_nrst	R/W	X	Maps Channel 4 ovhf fault to NRST Not mapped = 0, Mapped = 1

表 8-57. FC_LF[4] Register Field Descriptions (続き)

Bit	Field	Type	Default	Description
3	uvhf_to_nrst	R/W	X	Maps Channel 4 uvhf fault to NRST Not mapped = 0, Mapped = 1
2-0	Cut_off_Freq[2:0]	R/W	X	Channel 4 Cut of frequency for LF faults filter 000 =Invalid 001 =Invalid 010 =250Hz 011 = 500Hz 100 = 1kHz 101 = 2kHz 110 =4kHz 111 = Invalid

8.1.2.31 ESM Register (Offset = 9Eh) [Default = X]

ESM is shown in 表 8-58.

Return to the Summary Table.

ESM threshold time for asserting a fault.

表 8-58. ESM Register Field Descriptions

Bit	Field	Type	Default	Description
7-0	THRESHOLD[7:0]	R/W	X	Threshold value representing the ESM delay time (1ms to 864ms)

8.1.2.32 TI_CONTROL Register (Offset = 9Fh) [Default = X]

TI_CONTROL is shown in 表 8-59.

Return to the Summary Table.

Manual BIST/WD EN/Manual Reset via I2C/ESM deglitch/Reset delay

表 8-59. TI_CONTROL Register Field Descriptions

Bit	Field	Type	Default	Description
7	ENTER_BIST	R/W	X	Manual BIST. 1 = Enter BIST
6	WDT_EN	R/W	X	Watchdog EN to be used along with hardware WD_EN pin. 1 = Watchdog Enabled, 0 = Watchdog Disabled
5	I2C_MR	R/W	X	Manual Reset. 1 = Assert NRST low
4-3	ESM_DEB[1:0]	R/W	X	ESM debounce filter 00 = 10µs 01 = 25µs 10 =50µs 11 =100µs
2-0	RST_DLY[2:0]	R/W	X	Reset delay 000 =200µs 001 =1ms 010 =10ms 011 = 16ms 100 = 20ms 101 = 70ms 110 =100ms 111 = 200ms

8.1.2.33 AMSK_ON Register (Offset = A1h) [Default = X]

AMSK_ON is shown in 表 8-60.

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Auto-mask UVLF, UVHF, and OVHF interrupts on power up transitions.

表 8-60. AMSK_ON Register Field Descriptions

Bit	Field	Type	Default	Description
7-4	RSVD	R/W	X	RSVD
3	MON[4]	R/W	X	Automask at power on for MON 4. 0 = Disabled 1 = Enabled
2	MON[3]	R/W	X	Automask at power on for MON 3. 0 = Disabled 1 = Enabled
1	MON[2]	R/W	X	Automask at power on for MON 2. 0 = Disabled 1 = Enabled
0	RSVD	R/W	X	RSVD

8.1.2.34 AMSK_OFF Register (Offset = A2h) [Default = X]

AMSK_OFF is shown in 表 8-61.

Return to the Summary Table.

Auto-mask UVLF, UVHF, and OVHF interrupts on power down transitions.

表 8-61. AMSK_OFF Register Field Descriptions

Bit	Field	Type	Default	Description
7-4	RSVD	R/W	X	RSVD
3	MON[4]	R/W	X	Automask at power off for MON 4. 0 = Disabled 1 = Enabled
2	MON[3]	R/W	X	Automask at power off for MON 3. 0 = Disabled 1 = Enabled
1	MON[2]	R/W	X	Automask at power off for MON 2. 0 = Disabled 1 = Enabled
0	RSVD	R/W	X	RSVD

8.1.2.35 SEQ_TOUT_MSB Register (Offset = A5h) [Default = X]

SEQ_TOUT_MSB is shown in 表 8-62.

Return to the Summary Table.

Timeout for UV faults during powerup and power down.

表 8-62. SEQ_TOUT_MSB Register Field Descriptions

Bit	Field	Type	Default	Description
7-0	MILLISEC[15:8]	R/W	X	Sequence time out MSB

8.1.2.36 SEQ_TOUT_LSB Register (Offset = A6h) [Default = X]

SEQ_TOUT_LSB is shown in 表 8-63.

Return to the Summary Table.

Timeout for UV faults during powerup and power down.

表 8-63. SEQ_TOUT_LSB Register Field Descriptions

Bit	Field	Type	Default	Description
7-0	MILLISEC[7:0]	R/W	X	Sequence time out LSB

8.1.2.37 SEQ_UP_THLD Register (Offset = A8h) [Default = X]

SEQ_UP_THLD is shown in 表 8-64.

Return to the Summary Table.

Threshold at which AMSK is released (VMON considered on) for power up.

表 8-64. SEQ_UP_THLD Register Field Descriptions

Bit	Field	Type	Default	Description
7-4	RSVD	R/W	X	RSVD
3	MON[4]	R/W	X	AMSK releases at UVLF or OFF threshold for MON_4. 0 = off threshold, 1 = UVLF threshold
2	MON[3]	R/W	X	AMSK releases at UVLF or OFF threshold for MON_3. 0 = off threshold, 1 = UVLF threshold
1	MON[2]	R/W	X	AMSK releases at UVLF or OFF threshold for MON_2. 0 = off threshold, 1 = UVLF threshold
0	RSVD	R/W	X	RSVD

8.1.2.38 SEQ_DN_THLD Register (Offset = A9h) [Default = X]

SEQ_DN_THLD is shown in 表 8-65.

Return to the Summary Table.

Threshold at which AMSK is released (VMON considered off) for power down.

表 8-65. SEQ_DN_THLD Register Field Descriptions

Bit	Field	Type	Default	Description
7-4	RSVD	R/W	X	RSVD
3	MON[4]	R/W	X	AMSK releases at UVLF or OFF threshold for MON_4. 0 = off threshold, 1 = UVLF threshold
2	MON[3]	R/W	X	AMSK releases at UVLF or OFF threshold for MON_3. 0 = off threshold, 1 = UVLF threshold
1	MON[2]	R/W	X	AMSK releases at UVLF or OFF threshold for MON_2. 0 = off threshold, 1 = UVLF threshold
0	RSVD	R/W	X	RSVD

8.1.2.39 WDT_CFG Register (Offset = AAh) [Default = X]

WDT_CFG is shown in 表 8-66.

Return to the Summary Table.

Max violation count for WD and Delay multiplier for Start Up Window.

表 8-66. WDT_CFG Register Field Descriptions

Bit	Field	Type	Default	Description
7	RSVD	R/W	X	RSVD
6-4	MAX_VIOLATION_COUNT	R/W	X	Max violation count for Watchdog 000 =0 001 =1 010 =2 011 = 3 100 = 4 101 = 5 110 = 6 111 = 7
3	RSVD	R/W	X	RSVD
2-0	WDT_Startup_DLY_MULTIPLIER[2:0]	R/W	X	Watchdog Startup delay multiplier 000 =0 001 =1 010 =2 011 = 3 100 = 4 101 = 5 110 = 6 111 = 7

8.1.2.40 WDT_CLOSE Register (Offset = ABh) [Default = X]

WDT_CLOSE is shown in 表 8-67.

Return to the Summary Table.

Close Window Time.

表 8-67. WDT_CLOSE Register Field Descriptions

Bit	Field	Type	Default	Description
7-0	CLOSE[7:0]	R/W	X	Close window time (1ms to 864ms)

8.1.2.41 WDT_OPEN Register (Offset = ACh) [Default = X]

WDT_OPEN is shown in 表 8-68.

Return to the Summary Table.

Open Window Time.

表 8-68. WDT_OPEN Register Field Descriptions

Bit	Field	Type	Default	Description
7-0	OPEN[7:0]	R/W	X	Open window time (1ms to 864ms)

8.1.2.42 WDT_QA_CFG Register (Offset = ADh) [Default = 00h]

WDT_QA_CFG is shown in 表 8-69.

Return to the Summary Table.

FeedbackPolt/Seed for Watchdog.

表 8-69. WDT_QA_CFG Register Field Descriptions

Bit	Field	Type	Default	Description
7-6	FDBK[1:0]	R/W	0h	Feedback used for computing answer
5-4	POLY[1:0]	R/W	0h	Poly used for computing answer
3-0	SEED[3:0]	R/W	0h	Seed used for computing answer

8.1.2.43 WDT_ANSWER Register (Offset = AEh) [Default = 00h]

WDT_ANSWER is shown in 表 8-70.

Return to the Summary Table.

Answer for the Watchdog.

表 8-70. WDT_ANSWER Register Field Descriptions

Bit	Field	Type	Default	Description
7-0	ANSWER[7:0]	R/W	0h	Answer

8.1.2.44 BANK_SEL Register (Offset = F0h) [Default = 00h]

BANK_SEL is shown in 表 8-71.

Return to the Summary Table.

Bank Select.

表 8-71. BANK_SEL Register Field Descriptions

Bit	Field	Type	Default	Description
7-1	RSVD	R/W	0h	RSVD
0	BANK_Select	R/W	0h	Represents bank selection. 0 = Bank 0 1 = Bank 1

9 Application and Implementation

注

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

9.1 Application Information

Modern SOC and FPGA devices typically have multiple power rails to provide power to the different blocks within the IC. Accurate voltage level and timing requirements are common and must be met to provide proper operation of these devices. By utilizing TPS389C03-Q1 along with a multichannel voltage sequencer, the power up and power down sequencing requirements as well as the core voltage requirements of the target SOC or FPGA device can be met. This design focuses on meeting the timing requirements for an SOC by using the TPS389C03-Q1.

9.2 Typical Application

9.2.1 Automotive Multichannel Sequencer and Monitor

A typical application for the TPS389C03-Q1 is shown in 図 9-1. TPS389C03-Q1 is used to provide the proper voltage monitoring for the target SOC device. A mulitchannel voltage monitor TPS389C03-Q1 is used to monitor the voltage rails as these rails power up and power down to ensure that the correct sequence occurs in both occasions. A safety microcontroller is also used to provide ACT, NIRQ, and I^2C commands to the TPS389C03-Q1 and sequencer. The ACT signal from the safety microcontroller determines when the TPS389C03-Q1enters into ACTIVE or SHDN states while the NIRQ pin of the TPS389C03-Q1 acts as an interrupt pin that is set when a fault has occurred. The host microcontroller can clear the fault by writing 1 to the affected register. The power rails for the safety microcontroller are not shown in 図 9-1 for simplicity.

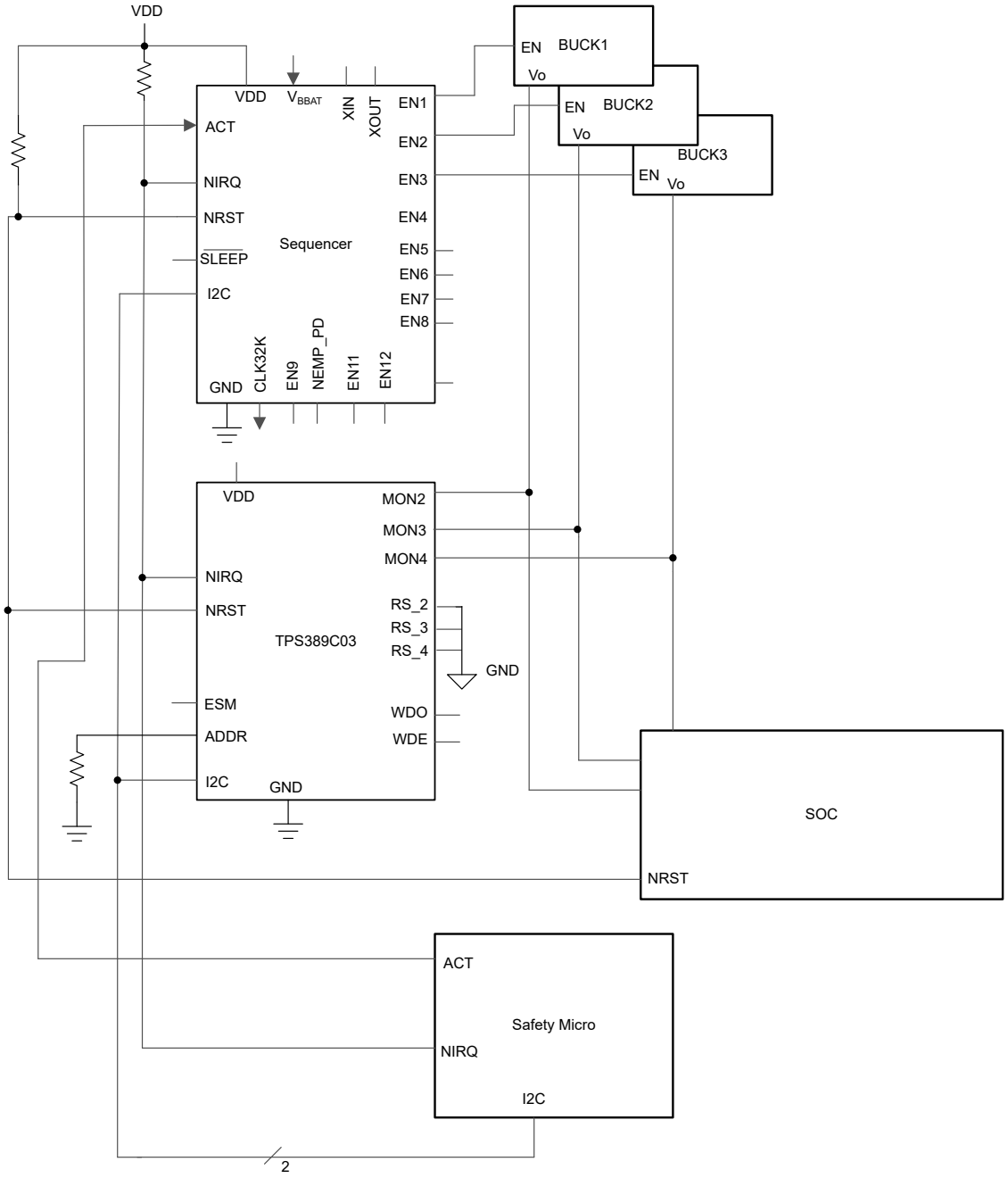


図 9-1. TPS389C03-Q1 Voltage Monitor Design Block Diagram

9.2.2 Design Requirements

- Three different voltage rails supplied by DC/DC converters need to be properly monitored in this design.
- All detected failures in sequencing should be reported via an external hardware interrupt signal.
- All detected failures should be logged in internal registers and be accessible to an external processor via I^2C.

9.2.3 Detailed Design Procedure

- TPS389C03-Q1 device option comes preprogrammed with default values for over voltage, under voltage.
- NIRQ pin requires a pull up resistor in the range of 1 kΩ to 100 kΩ.
- NRST pin requires a pull up resistor in the range of 1 kΩ to 100 kΩ.
- WDO pin requires a pull up resistor in the range of 1 kΩ to 100 kΩ.
- SDA and SCL lines require pull up resistors in the range of 10 kΩ.
- The safety microcontroller is used to clear fault interrupts reported through the NIRQ interrupt pin and the INT_SCR1 and INT_SCR2 registers. The interrupt flags can only be cleared by the host mircontroller with a write-1-to-clear operation; interrupt flags are not automatically cleared if the fault condition is no longer present.

9.2.4 Application Curves

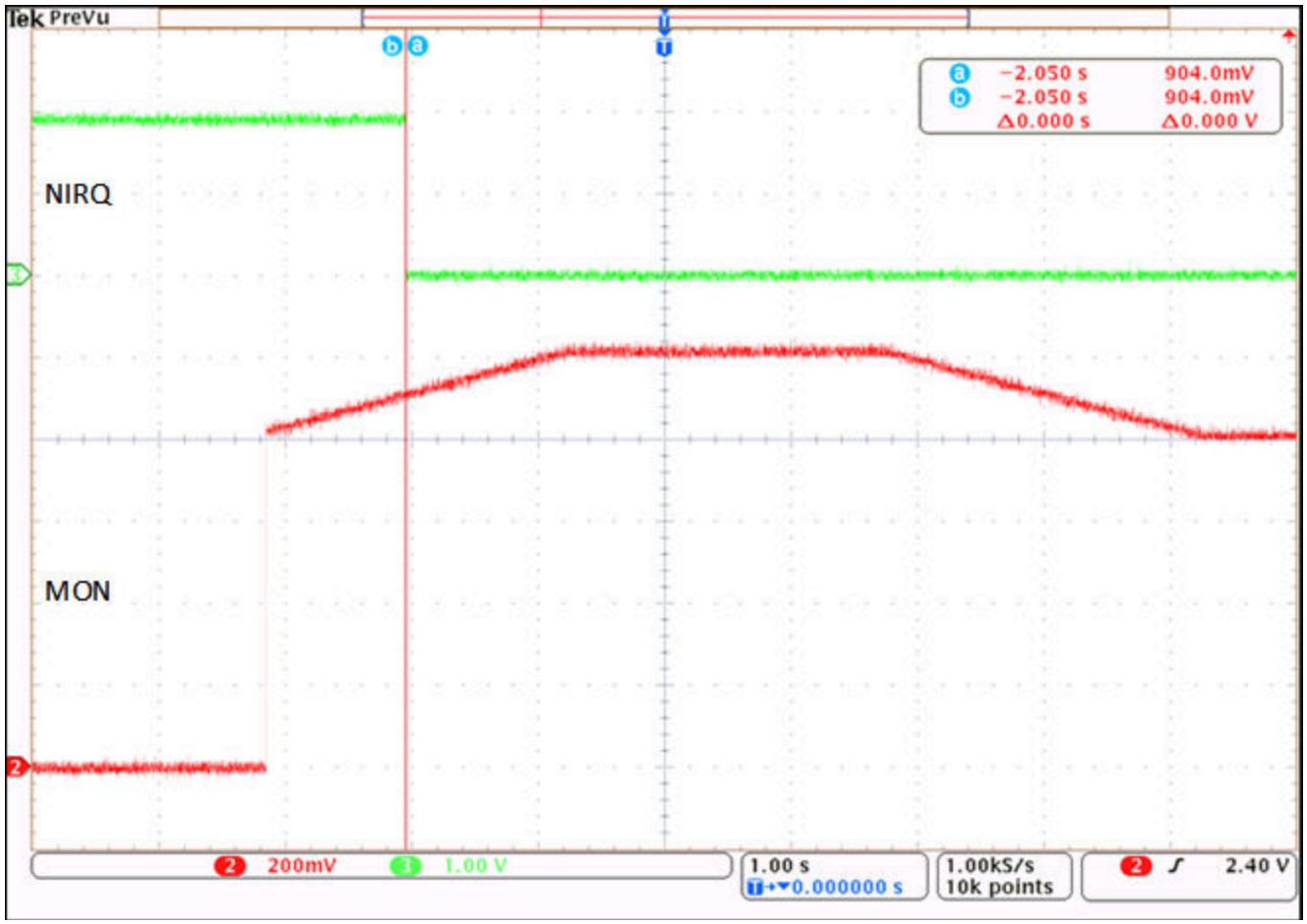


図 9-2. NIRQ Triggered After an Overvoltage Fault

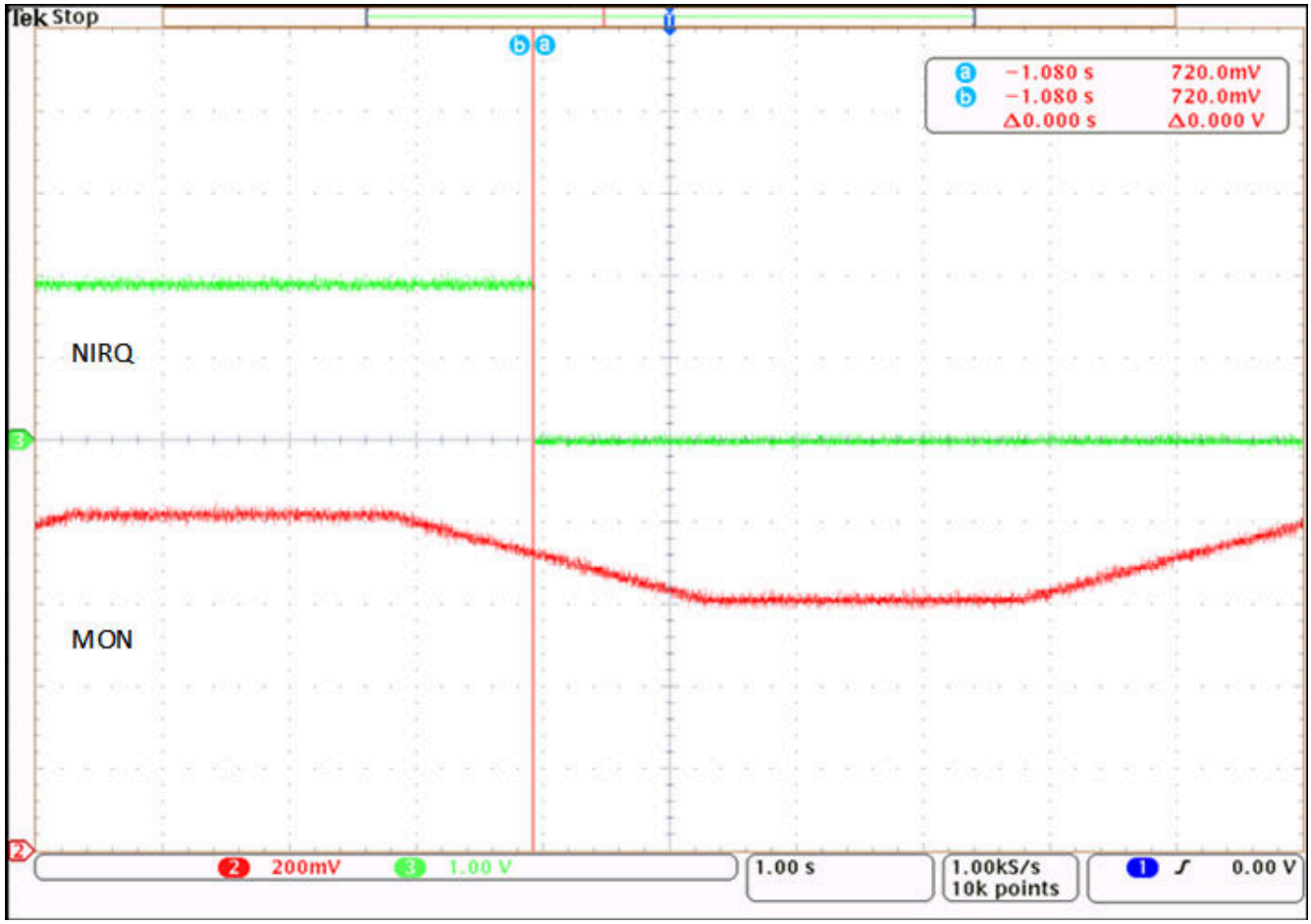


図 9-3. NIRQ Triggered After an Undervoltage Fault

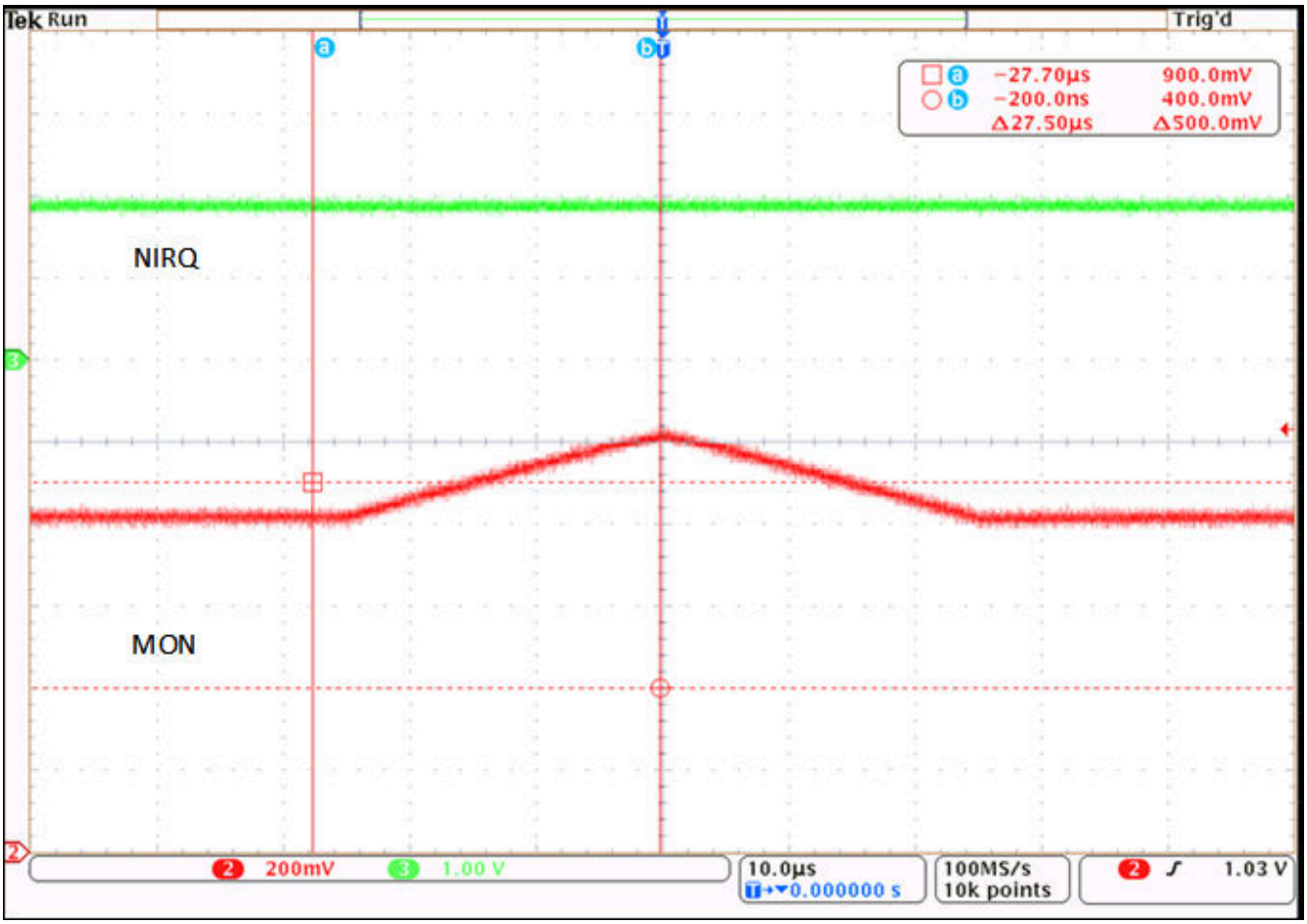


図 9-4. NIRQ Not Triggered on Overvoltage Fault with 51.2 us OV Debounce Filter

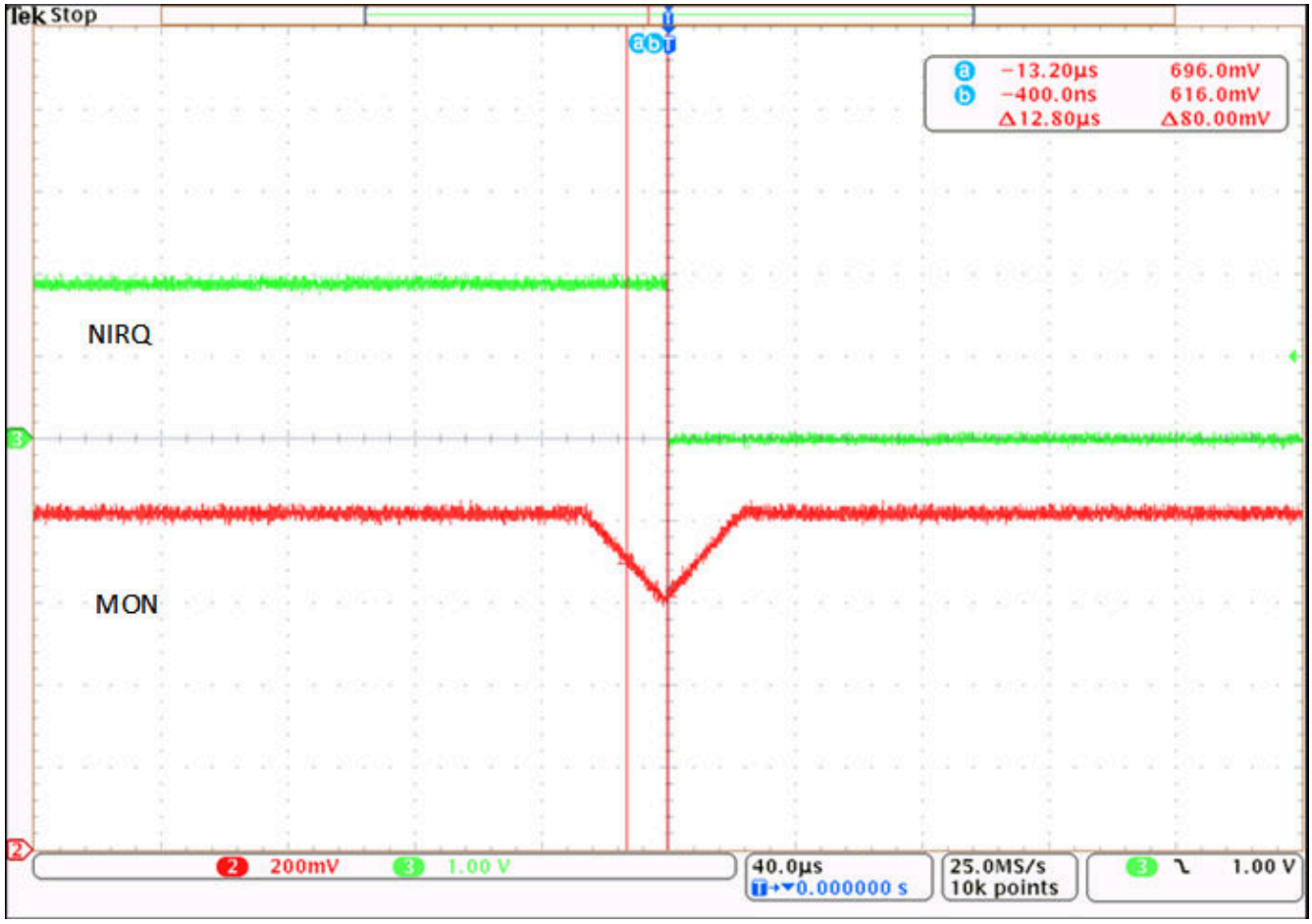


図 9-5. NIRQ Triggered on Undervoltage Fault with 12.8 us UV Debounce Filter

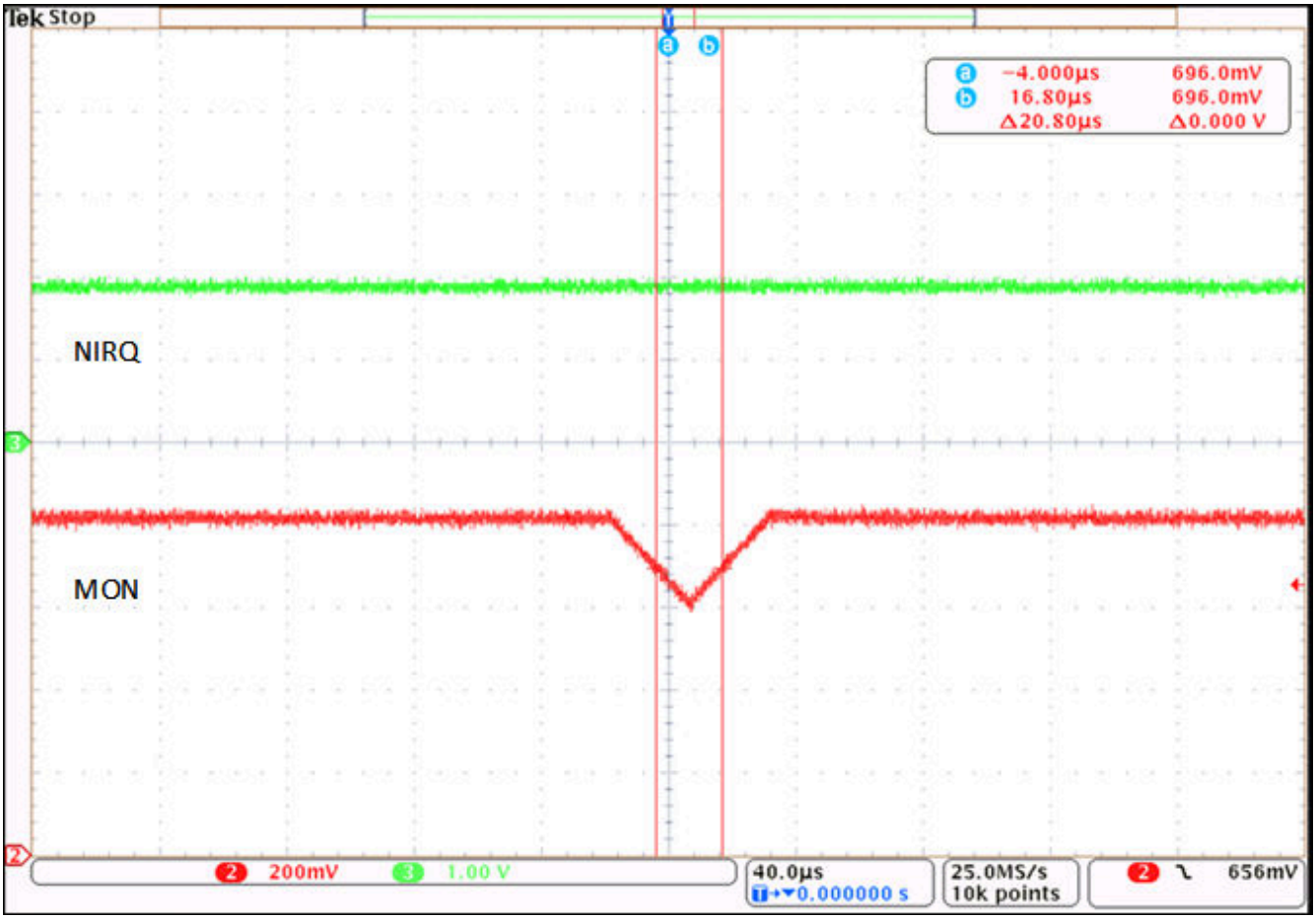


図 9-6. NIRQ Not Triggered on Undervoltage Fault with 25 us UV Debounce Filter

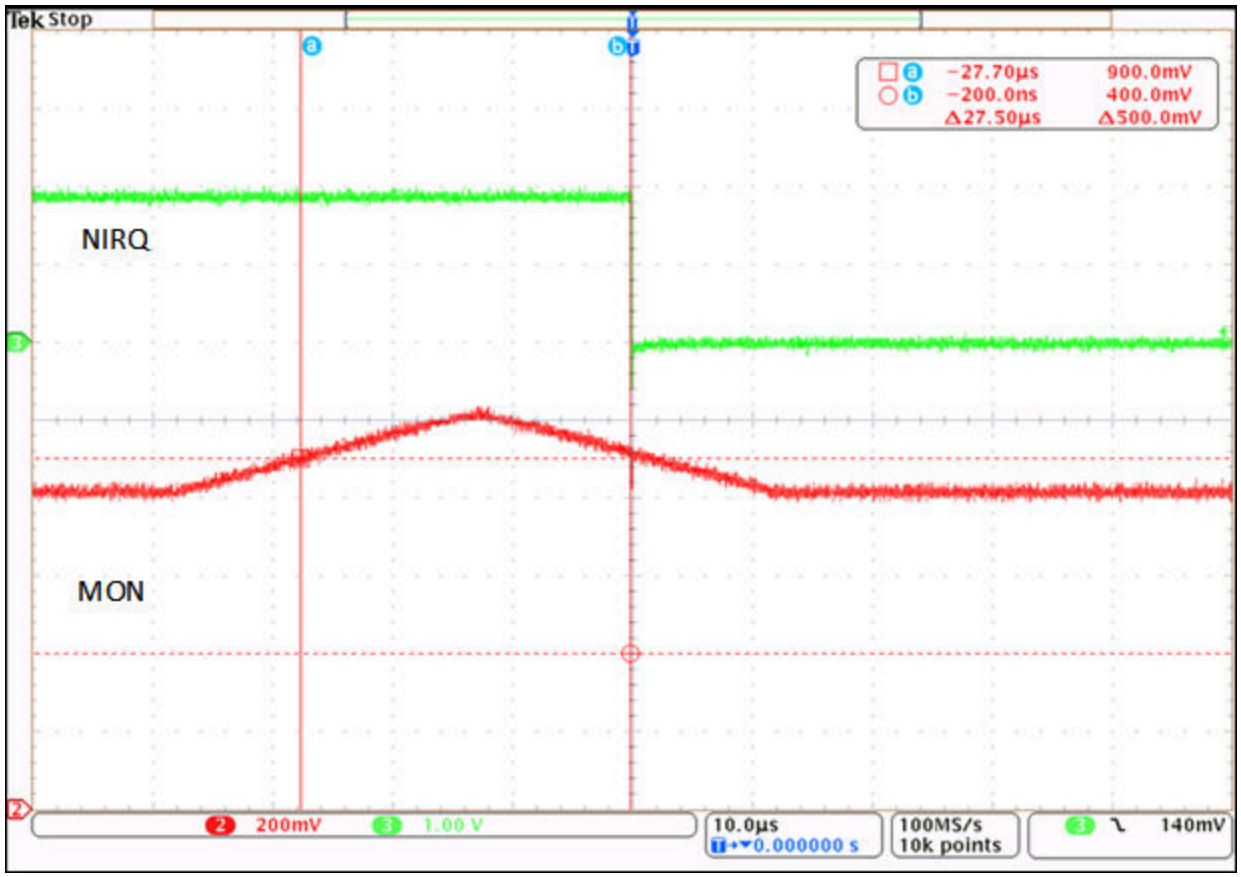


図 9-7. NIRQ Triggered on Overvoltage Fault with 25 us OV Debounce Filter

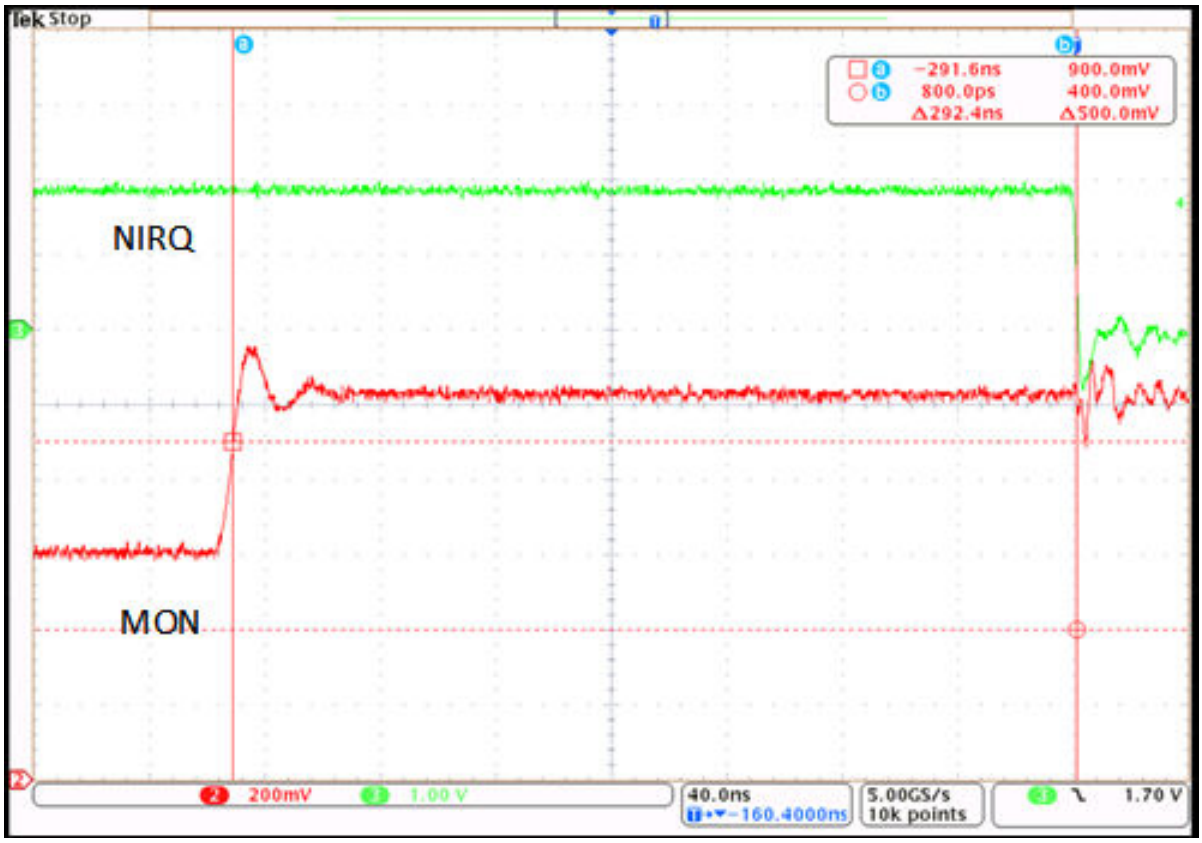


図 9-8. NIRQ Propogation Delay Resulting from Overvoltage Fault

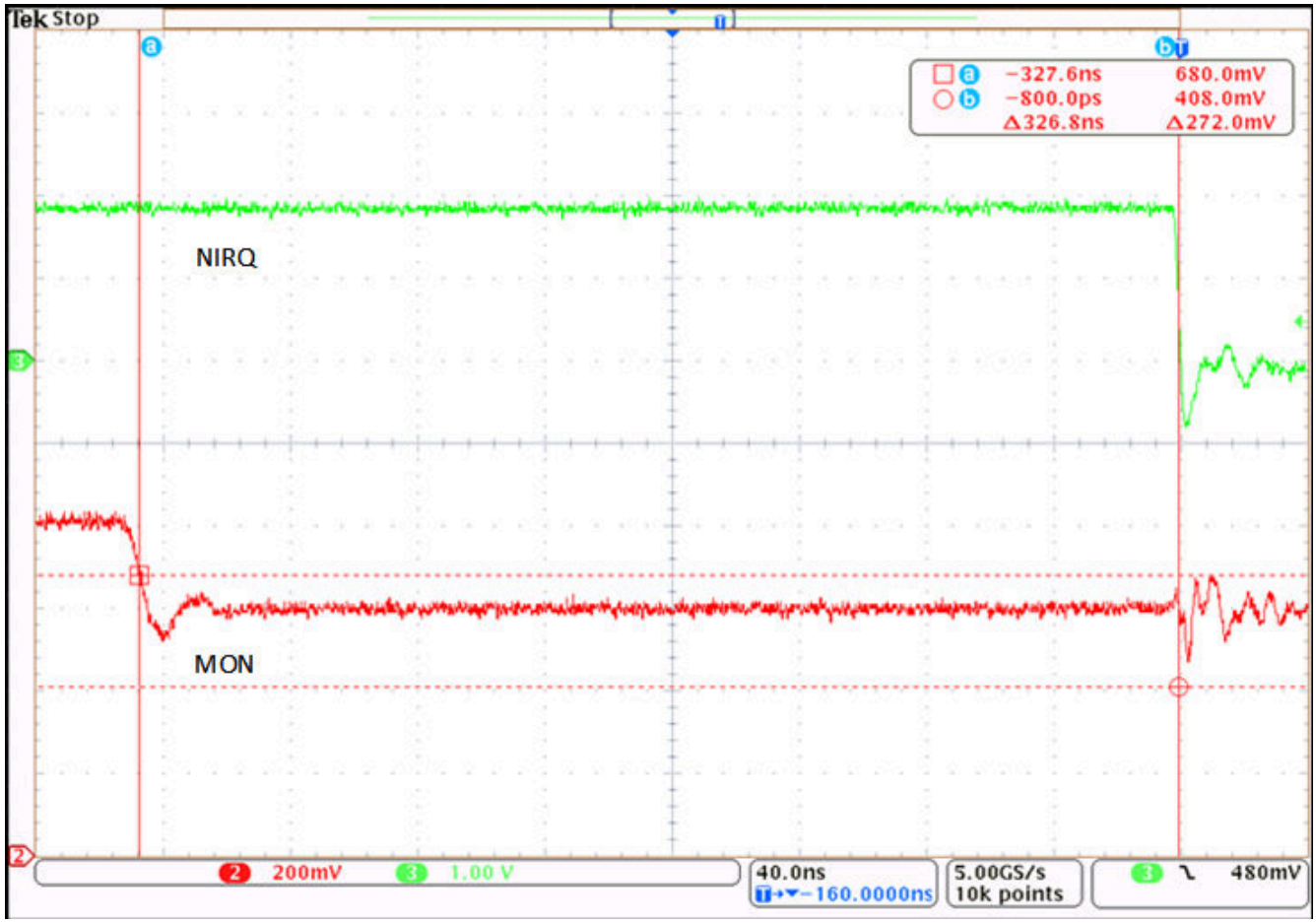


図 9-9. NIRQ Propogation Delay Resulting from Undervoltage Fault

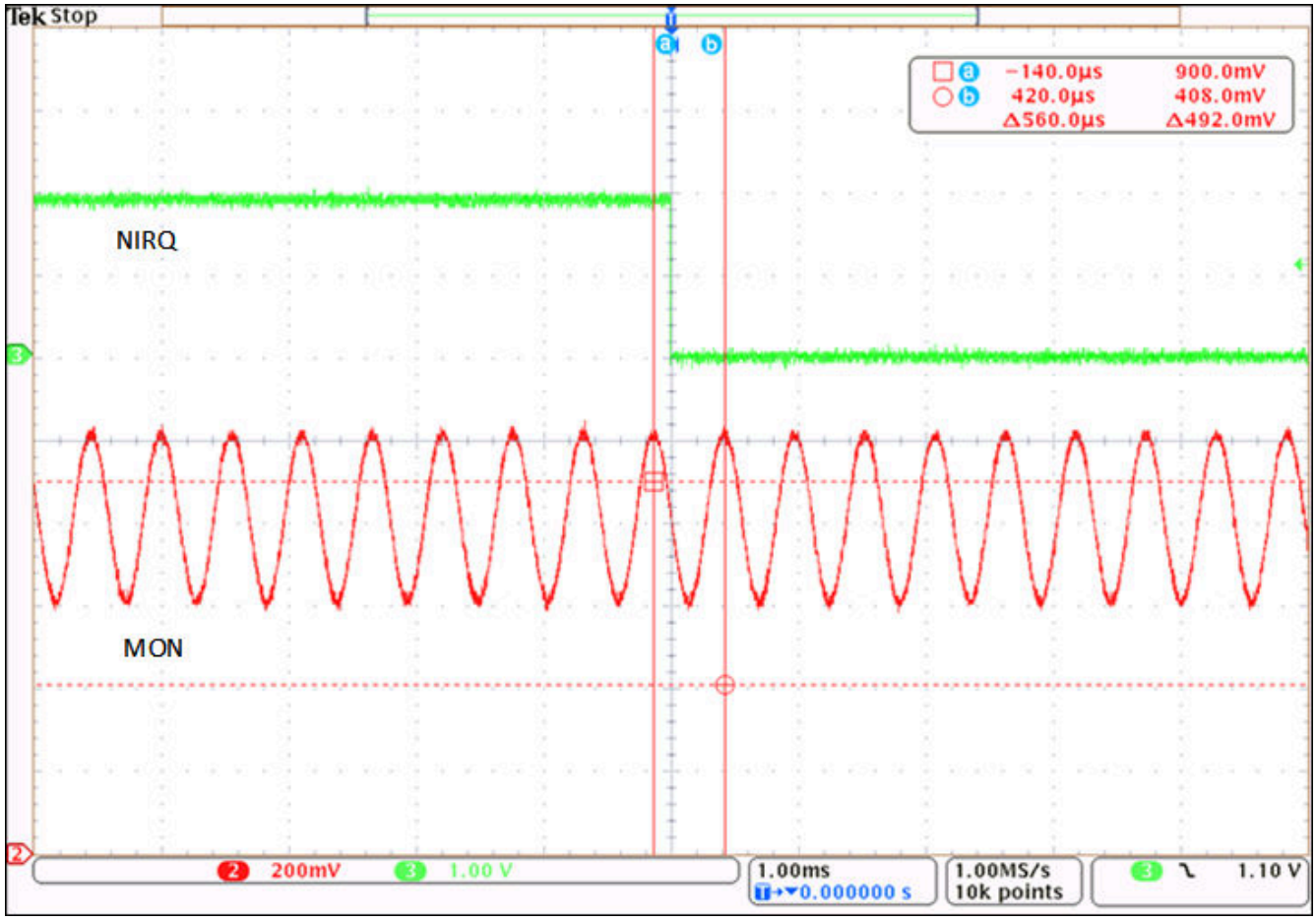


図 9-10. 1 kHz Low Pass Filter Setting. NIRQ Triggered at 1.8 kHz Signal with a 0.8 V DC Component and 200 mVp-p AC Signal. OV and UV Thresholds Set to 0.9V and 0.7V. Reduced the Frequency From 2 kHz Until the NIRQ Pin Went Low.

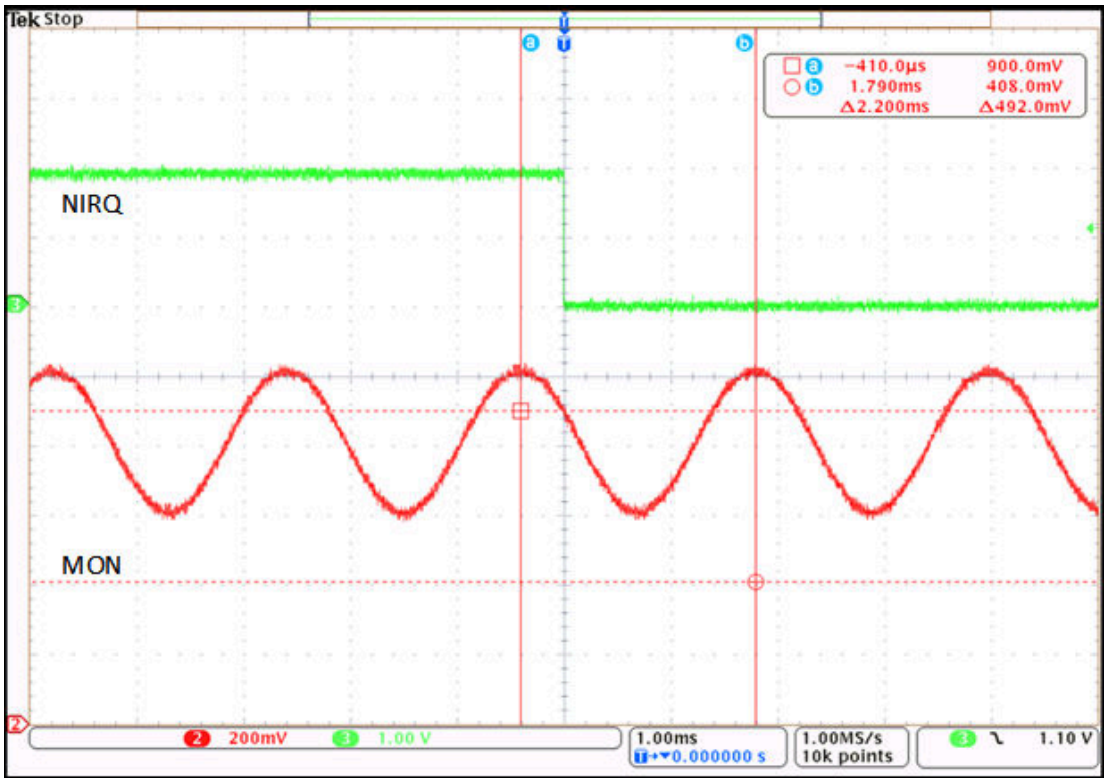


図 9-11. 250 Hz Low Pass Filter setting. NIRQ Triggered at 455 Hz Signal With a 0.8 V DC Component and 200 mVp-p AC Signal. OV and UV Thresholds Set to 0.9V and 0.7V. Reduced the Frequency From 500 Hz Until the NIRQ Pin Went Low.

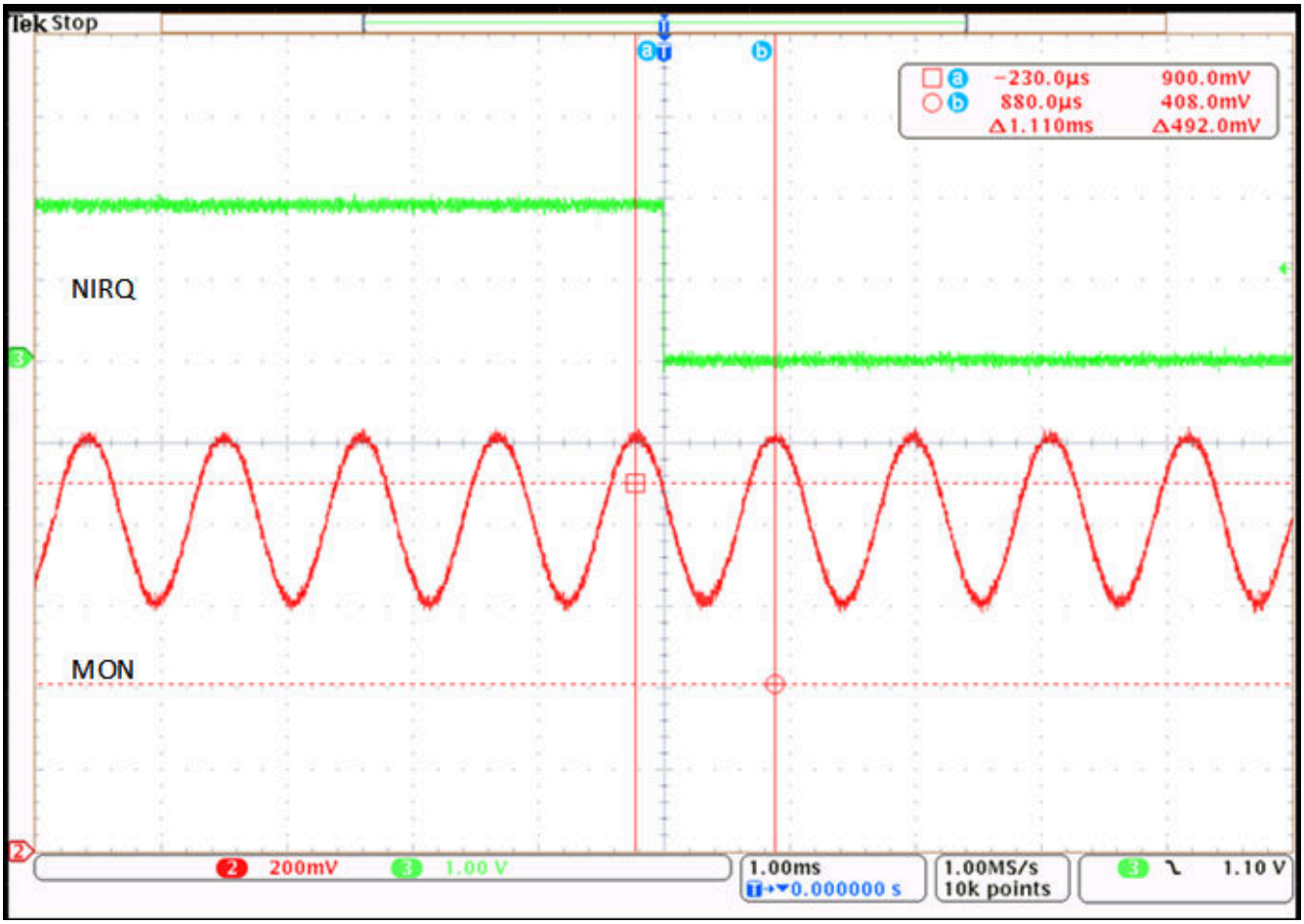


図 9-12. 500 Hz Low Pass Filter Setting. NIRQ Triggered at 0.9 kHz Signal With a 0.8 V DC Component and 200 mVp-p AC Signal. OV and UV Thresholds Set to 0.9V and 0.7V. Reduced the Frequency From 1 kHz Until the NIRQ Pin Went Low.

9.3 Power Supply Recommendations

9.3.1 Power Supply Guidelines

This device is designed to operate from an input supply with a voltage range between 2.6V to 5.5 V. It has a 6-V absolute maximum rating on the VDD pin. It is good analog practice to place a 0.1-µF to 1-µF 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.

9.4 Layout

9.4.1 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 MON pin. Long traces increase parasitic inductance and cause inaccurate monitoring and diagnostics.

- If differential voltage sensing is required for MON2 and/or MON3 and/or MON4 route RS_2,3,4 pin to the point of measurement. If RS_2,3,4 are not routed to the point of measurement, then route RS_2,3,4 to the GND pin of the device.
- 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.
- For logic pins such as WD_EN and ESM, make sure the correct pull-up/down voltage is applied as per device logic levels for the associated functionality.
- For open-drain outputs like WDO, NIRQ, and NRST, select a pull-up resistor value such that the absolute maximum ratings of the device are not violated.

9.4.2 Layout Example

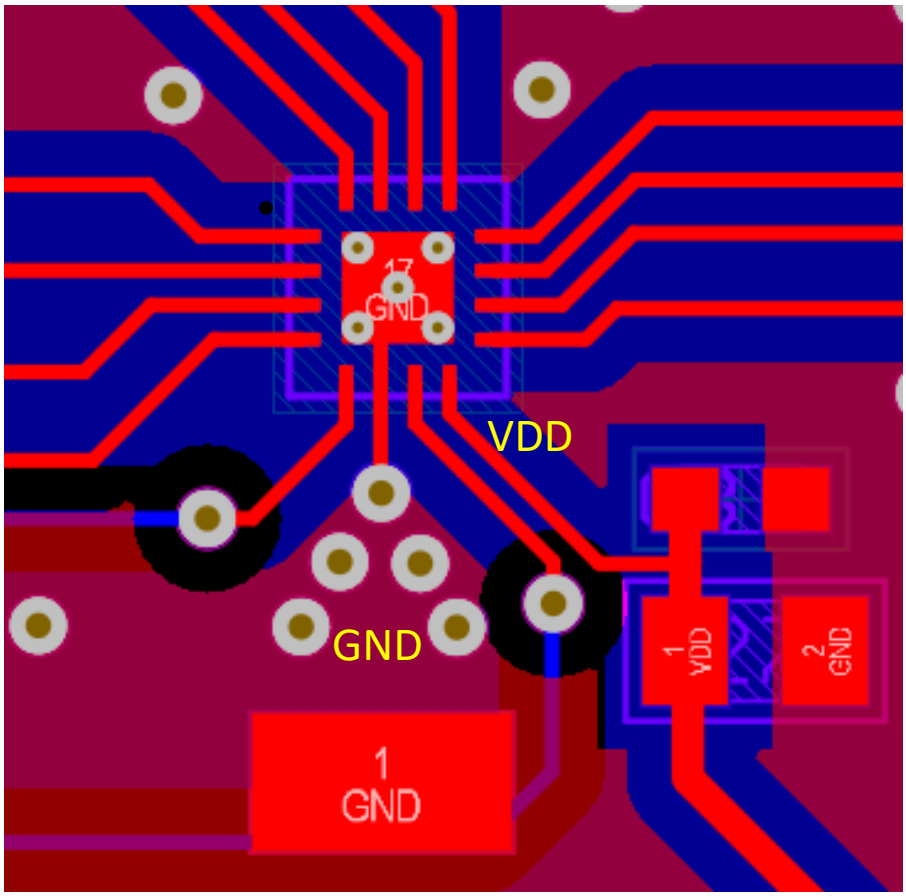


図 9-13. Recommended Layout

10 Device and Documentation Support

10.1 Device Nomenclature

表 10-1 shows how to decode the function of the device based on the part number.

表 10-1. Device Thresholds

ORDERING CODE	Description
TPS389C0300CRTERQ1	3 Monitors, Q&A Watchdog, ESM

表 10-2. TPS389C0300CRTERQ1 OTP Configuration

ADDR	DATA	Configuration Description
0x00	0x28	DEVICE_MODEL[7:3] and VENDOR_ID[2:0]
0x01	0x43	SILICON_REV[7:6] and OTP_REV[5:0]
0x02	0xF1	Channels disabled. MON2, 3, 4 enabled.
0x11	0x0C	WDO_DLY not applicable for latched WDO configuration
0x12	0x03	BIST at POR
0x13	0x06	Enable UVHF Mon2,3
0x14	0x06	Enable UVLF Mon2,3
0x15	0x06	Enable OVHF Mon2,3
0x16	0x06	Enable OVLF Mon2,3
0x1B	0x04	Thermal Shut Down Interrupt Enable
0x1C	0x01	Bist Fail Interrupt
0x1D	0x25	NRST MISMATCH, WDT → NIRQ, WDT → NRST
0x1E	0x06	Enable Mon2,3
0x1F	0x06	Mon2,3 x4 Scaling
0x30	0xBC	4.56V UVHF Threshold Mon2
0x31	0xE8	5.44V OVHF Threshold Mon2
0x32	0xBC	4.56V UVLF Threshold Mon2
0x33	0xE8	5.44V OVLF Threshold Mon2
0x34	0xAA	102.4 µs De-Bounce
0x35	0x1C	O VHF → NRST, UVHF → NRST, 1 kHz LF Cutoff
0x40	0x6F	3.02 V UVHF Threshold Mon3
0x41	0x8C	3.6 V OVHF Threshold Mon3
0x42	0x6F	3.02 V UVLF Threshold Mon3
0x43	0x8C	3.6 V OVLF Threshold Mon3
0x44	0xAA	102.4 µs De-bounce
0x45	0x1C	O VHF → NRST, UVHF → NRST, 1 kHz LF Cutoff
0X9E	0x01	ESM Threshold = 2 ms
0X9F	0x59	Reset Delay 1 ms, WD EN
0xA1	0x06	AMSK ON MON2,3
0xA2	0x06	AMSK OFF MON2,3
0xA5,6	0x00	SEQ Timeout = 1 ms
0xA8	0x06	SEQ UP Mon2,3 UVLF
0xA9	0x06	SEQ DOWN Mon2,3 UVLF

表 10-2. TPS389C0300CRTERQ1 OTP Configuration (続き)

ADDR	DATA	Configuration Description
0xAA	0x27	WD Violation Count = 2, WD Delay = 7
0xAB	0x1D	WD Close = 30 ms
0xAC	0x1D	WD Open = 30 ms
0xFA	0x00	3.3V I2C interface

10.2 Documentation Support

10.3 ドキュメントの更新通知を受け取る方法

ドキュメントの更新についての通知を受け取るには、www.tij.co.jp のデバイス製品フォルダを開いてください。[通知] をクリックして登録すると、変更されたすべての製品情報に関するダイジェストを毎週受け取ることができます。 変更の詳細については、改訂されたドキュメントに含まれている改訂履歴をご覧ください。

10.4 サポート・リソース

テキサス・インスツルメンツ E2E™ サポート・フォーラムは、エンジニアが検証済みの回答と設計に関するヒントをエキスパートから迅速かつ直接得ることができる場所です。既存の回答を検索したり、独自の質問をしたりすることで、設計で必要な支援を迅速に得ることができます。

リンクされているコンテンツは、各寄稿者により「現状のまま」提供されるものです。これらはテキサス・インスツルメンツの仕様を構成するものではなく、必ずしもテキサス・インスツルメンツの見解を反映したものではありません。テキサス・インスツルメンツの使用条件を参照してください。

10.5 Trademarks

テキサス・インスツルメンツ E2E™ is a trademark of Texas Instruments.
すべての商標は、それぞれの所有者に帰属します。

10.6 静電気放電に関する注意事項

この IC は、ESD によって破損する可能性があります。テキサス・インスツルメンツは、IC を取り扱う際には常に適切な注意を払うことを推奨します。正しい取り扱いおよび設置手順に従わない場合、デバイスを破損するおそれがあります。

ESD による破損は、わずかな性能低下からデバイスの完全な故障まで多岐にわたります。精密な IC の場合、パラメータがわずかに変化するだけで公表されている仕様から外れる可能性があるため、破損が発生しやすくなっています。

10.7 用語集

テキサス・インスツルメンツ用語集　　この用語集には、用語や略語の一覧および定義が記載されています。

11 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 C (May 2023) to Revision D (October 2023)	Page
• 量産データのリリース	1

12 Mechanical, Packaging, and Orderable Information

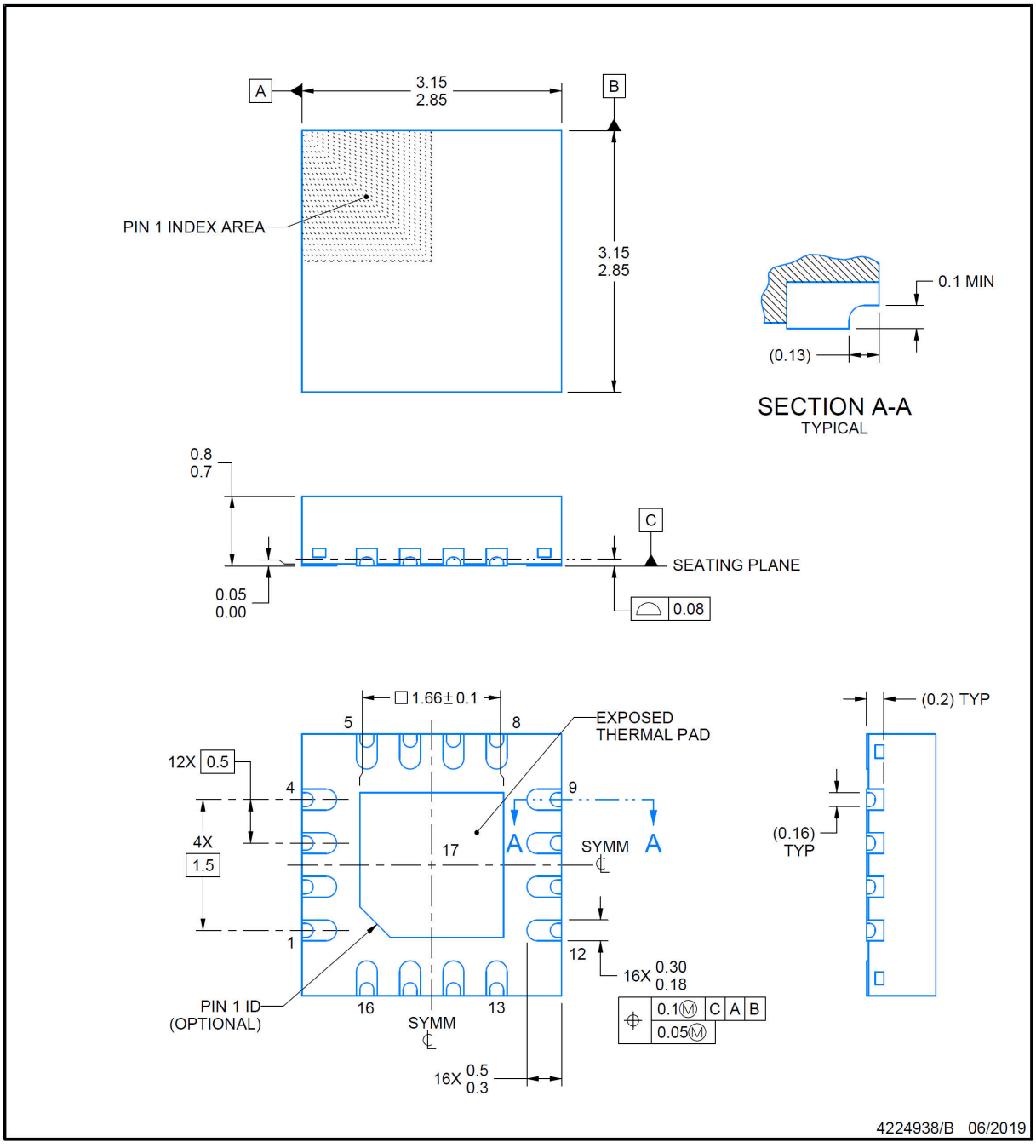
The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand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

PACKAGE OUTLINE

RTE0016K

WQFN - 0.8 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



NOTES:

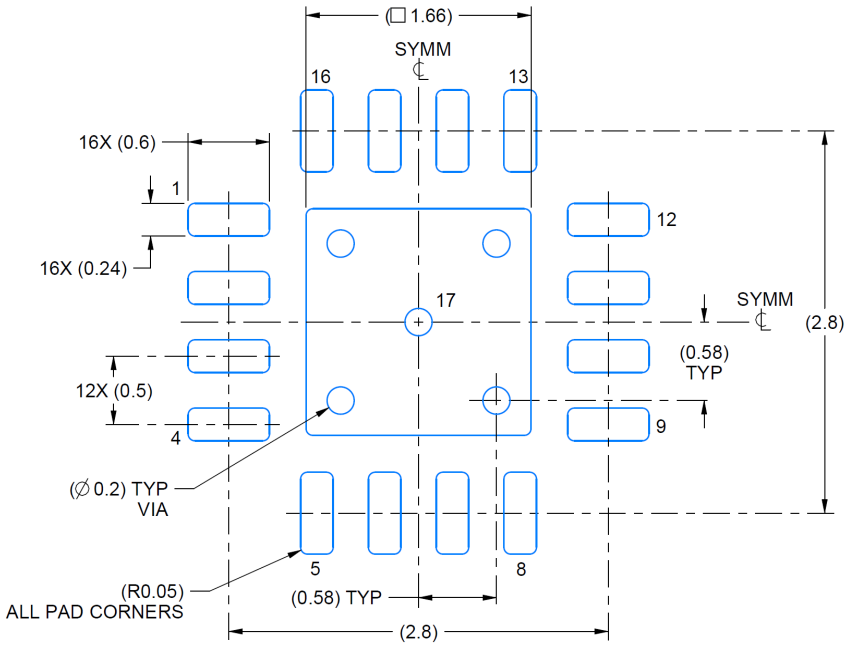
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.

EXAMPLE BOARD LAYOUT

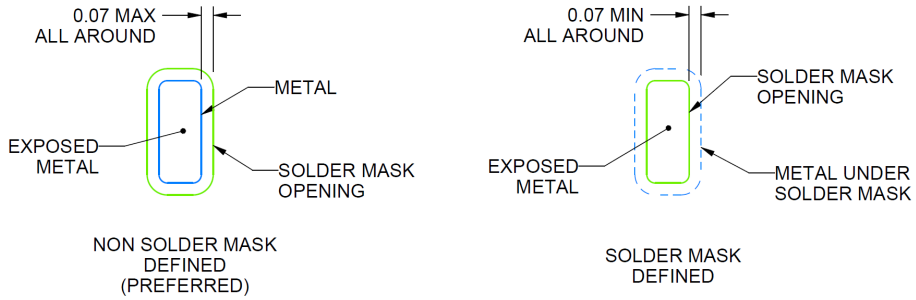
RTE0016K

WQFN - 0.8 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:20X



SOLDER MASK DETAILS

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NOTES: (continued)

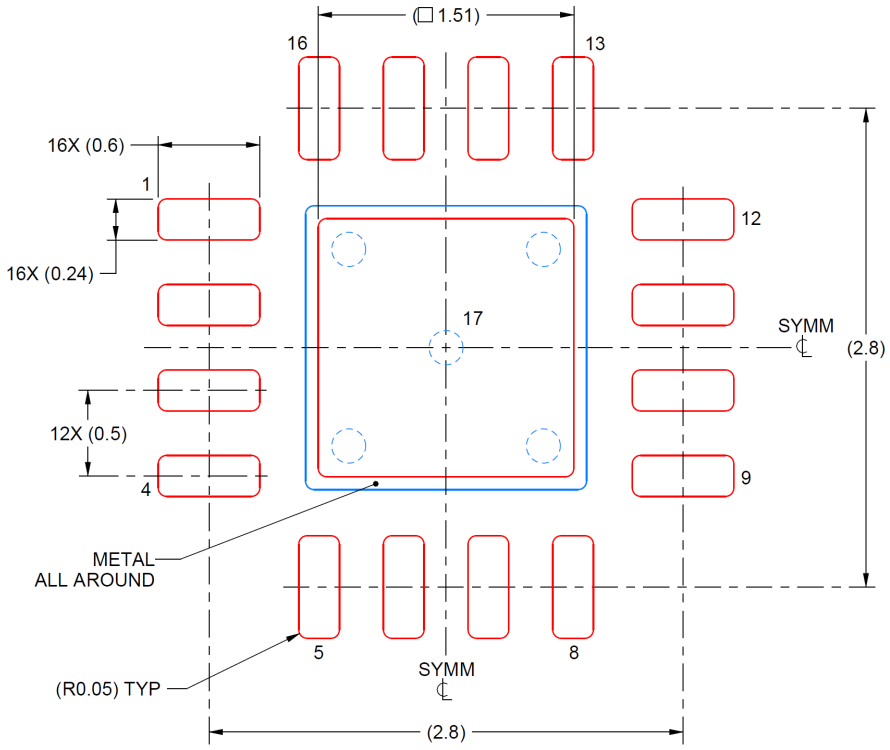
4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.

EXAMPLE STENCIL DESIGN

RTE0016K

WQFN - 0.8 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD 17:
84% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE
SCALE:25X

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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.

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
TPS389C0300CRTERQ1	ACTIVE	WQFN	RTE	16	3000	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	C030Q	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.

GENERIC PACKAGE VIEW

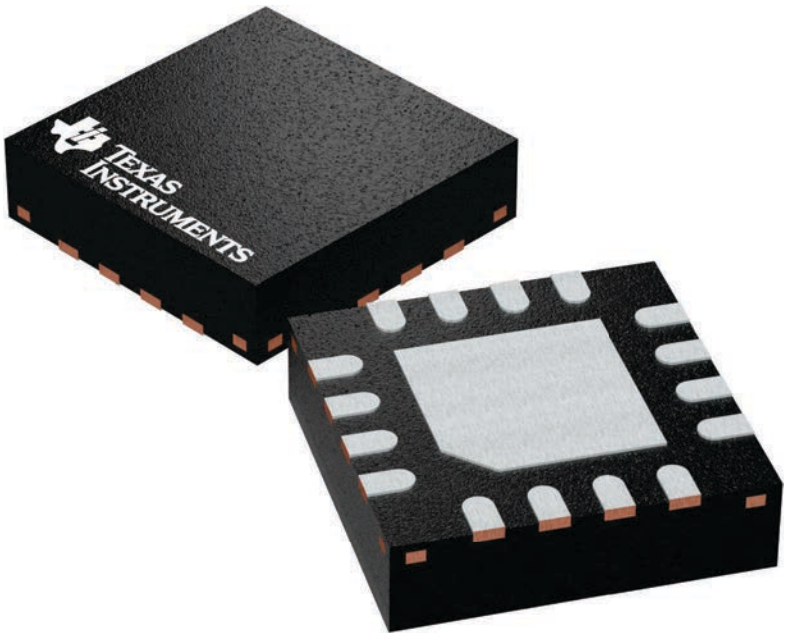
RTE 16

WQFN - 0.8 mm max height

3 x 3, 0.5 mm pitch

PLASTIC QUAD FLATPACK - NO LEAD

This image is a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.

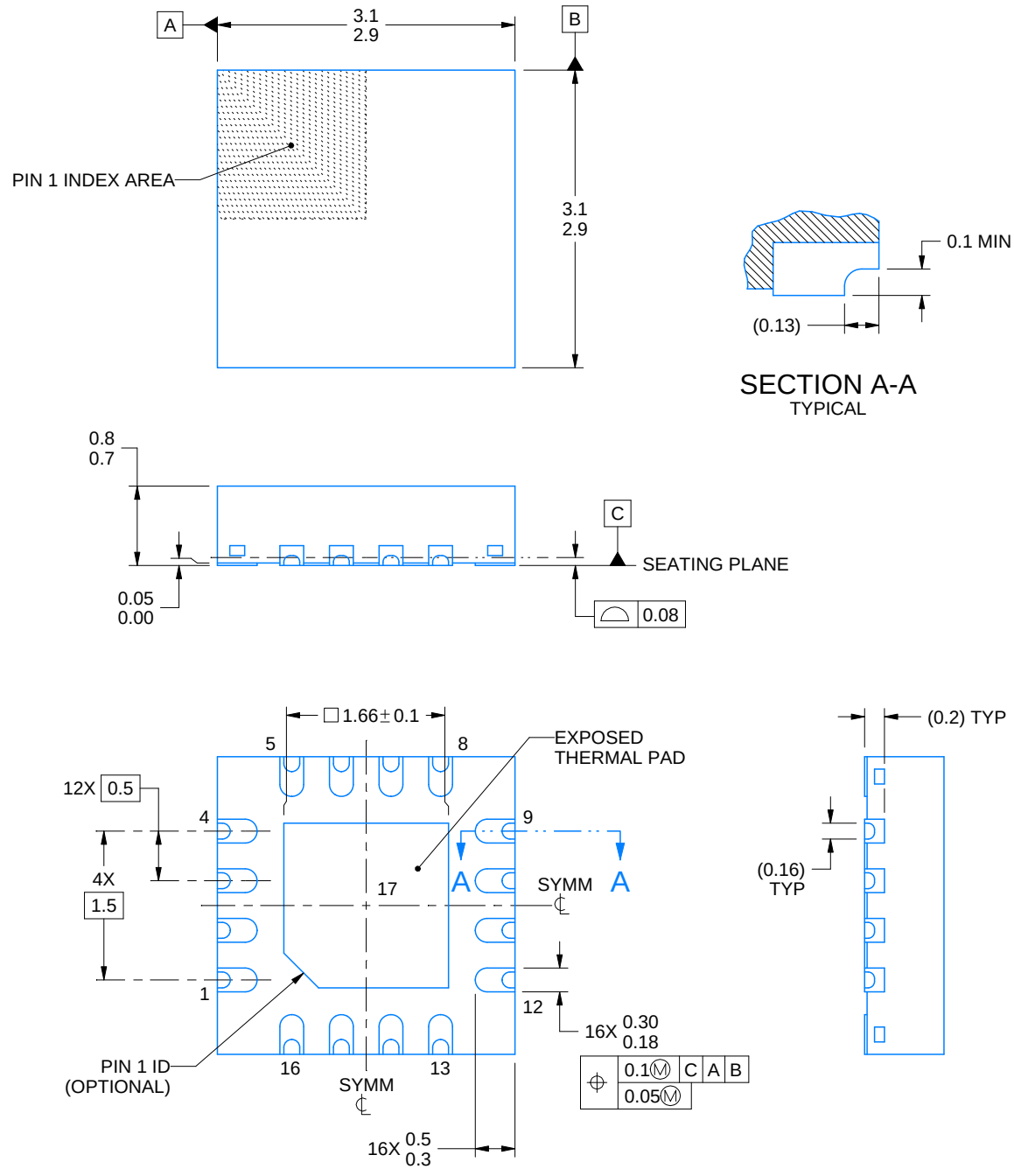


RTE0016K

PACKAGE OUTLINE

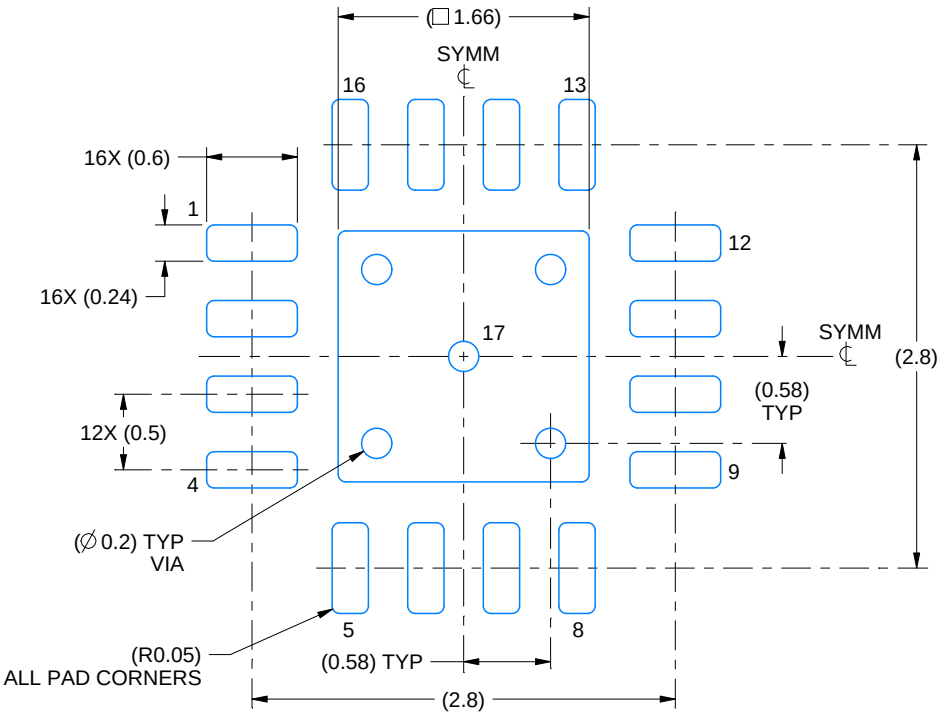
WQFN - 0.8 mm max height

PLASTIC QUAD FLATPACK - NO LEAD

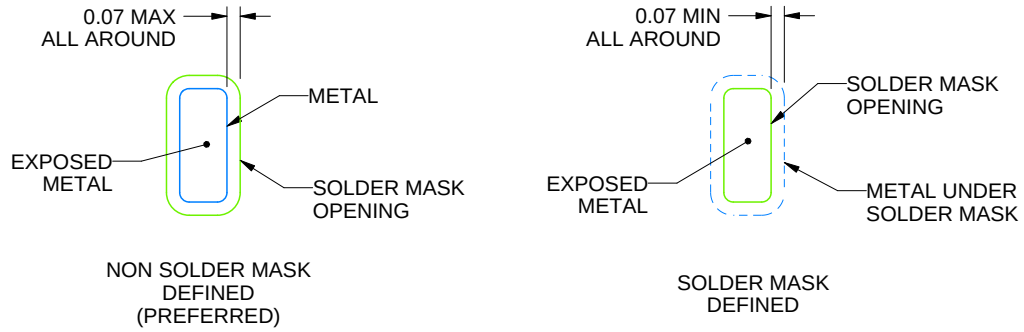


NOTES:

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. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:20X



SOLDER MASK DETAILS

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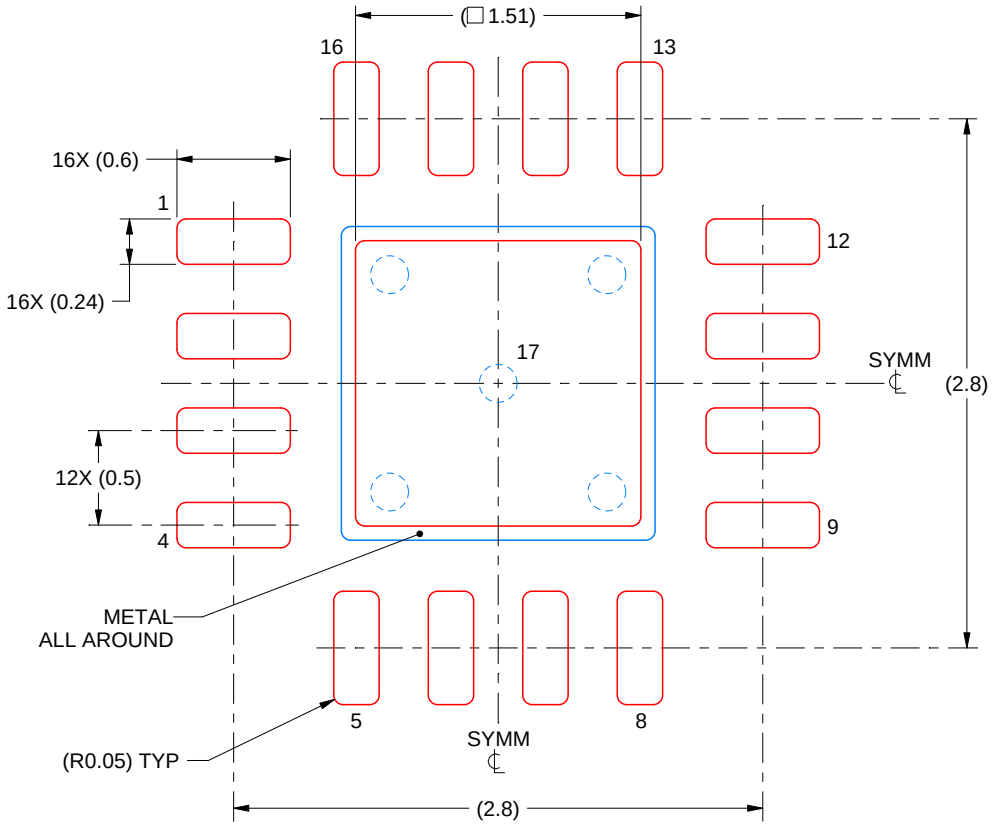
NOTES: (continued)

4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD 17:
84% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE
SCALE:25X

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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.

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