TXE8124 24-Bit SPI Bus I/O Expander with Interrupt Output, Reset Input, and I/O Configuration Registers

1 Features

- Operating supply voltage range of 1.65V to 5.5V
- Low standby current consumption of 2.3µA typical
- SPI SCLK Frequency
  - 10MHz from 3.3V to 5.5V
  - 5MHz from 1.65V to 5.5V
- SPI daisy-chain supported
- SPI read and write with burst mode
- Multi-port SPI command to configure multiple ports simultaneously
- I_{OFF} supported input port pins
- Active-low reset input ($\overline{RESET}$)
- Open-drain active-low interrupt output ($\overline{INT}$)
  - Interrupt mask and status per I/O
  - Interrupt status per port
- Built-in fail-safe I/O feature
- Individual I/O configuration for
  - Input and Output function
  - Polarity inversion
  - Output push-pull and open-drain selection
  - Integrated pull-up or pull-down selection
  - Bus-hold feature to maintain last I/O state
  - Glitch filter enable selection
- Latched outputs with 10mA drive capability for directly driving LEDs
- Latch-up performance exceeds 100mA per JESD 78, class II
- ESD protection exceeds JESD 22
  - 2000V Human-body model (A114-A)
  - 1000V Charged-device model (C101)

2 Applications

- Industrial transportation
- Industrial automation
- Testing and measurement
- Factory automation & control
- Medical and healthcare
- Servers
- Routers (telecom switching equipment)
- Products with GPIO-limited processors

3 Description

The TXE8124 devices provide general purpose parallel input/output (I/O) expansion for the four wire Serial Peripheral Interface (SPI) protocol and is designed for 1.65V to 5.5V V_{CC} operation. The TXE8124 supports both standard point-to-point communication along with daisy-chaining of multiple devices.

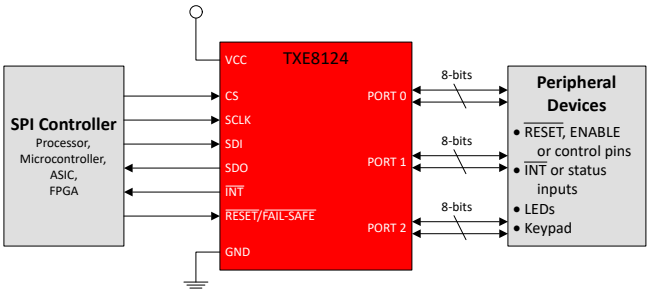
The device supports 10MHz from 3.3V to 5.5V and 5MHz from 1.65V to 5.5V. I/O expanders, such as the TXE8124, are designed for when additional I/Os are needed for switches, sensors, push-buttons, LEDs, and fans.

The TXE8124 devices has 3 I/O ports of 8 IOs each, which include additional features designed to enhance the I/O performance in terms of speed, power consumption, and flexibility. These include per I/O programmable open-drain or push-pull outputs, programmable pull-up and pull-down resistors, bus-hold latchable inputs, maskable interrupt, interrupt status register, glitch filter and a fail-safe register mode which is enabled by the $\overline{FAIL\text{-}SAFE}$ pin.

Package Information

PART NUMBER	PACKAGE(1)	PACKAGE SIZE(2)
TXE8124	(VSSOP, 32)	8mm x 5mm
	(VQFN, 32) (3)	5mm x 5mm

(1) For more information, see Section 11.
(2) The package size (length × width) is a nominal value and includes pins, where applicable.
(3) VQFN is in Preview status and subject to change.



Simplified Schematic

Table of Contents

4 Pin Configuration and Functions

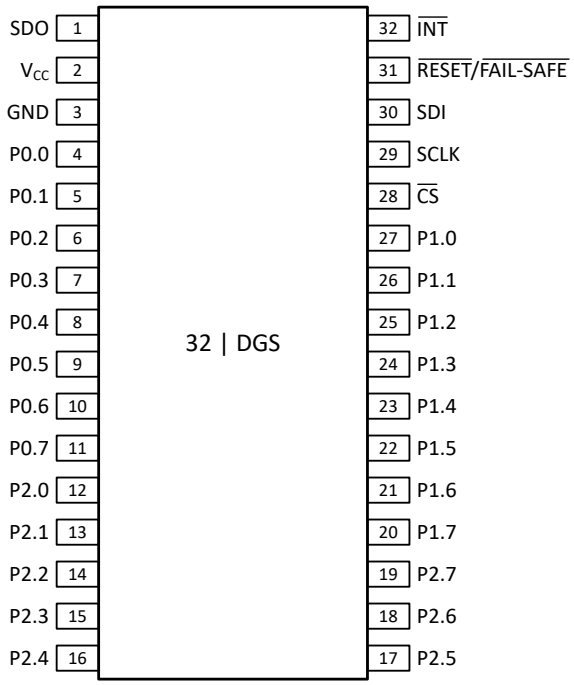


Figure 4-1. TXE8124 DGS (VSSOP) Package, 32-Pin (Top View)

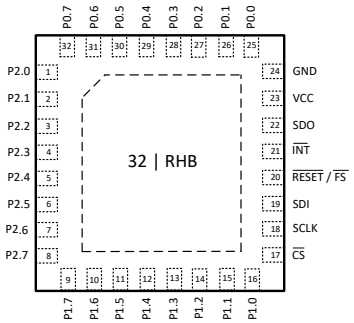


Figure 4-2. TXE8124 RHB (VQFN) Package, 32-Pin (Top View)

Table 4-1. Pin Functions

PIN			TYPE[1]	
NAME	DGS (VSSOP32)	RHB (VQFN)		
P2.0	12	1	I/O	P-port input/output. At power on, Port 2 - IO #0 is configured as an input
P2.1	13	2	I/O	P-port input/output. At power on, Port 2 - IO #1 is configured as an input
P2.2	14	3	I/O	P-port input/output. At power on, Port 2 - IO #2 is configured as an input
P2.3	15	4	I/O	P-port input/output. At power on, Port 2 - IO #3 is configured as an input
P2.4	16	5	I/O	P-port input/output. At power on, Port 2 - IO #4 is configured as an input
P2.5	17	6	I/O	P-port input/output. At power on, Port 2 - IO #5 is configured as an input
P2.6	18	7	I/O	P-port input/output. At power on, Port 2 - IO #6 is configured as an input
P2.7	19	8	I/O	P-port input/output. At power on, Port 2 - IO #7 is configured as an input
P1.7	20	9	I/O	P-port input/output. At power on, Port 1 - IO #7 is configured as an input
P1.6	21	10	I/O	P-port input/output. At power on, Port 1 - IO #6 is configured as an input
P1.5	22	11	I/O	P-port input/output. At power on, Port 1 - IO #5 is configured as an input
P1.4	23	12	I/O	P-port input/output. At power on, Port 1 - IO #4 is configured as an input
P1.3	24	13	I/O	P-port input/output. At power on, Port 1 - IO #3 is configured as an input
P1.2	25	14	I/O	P-port input/output. At power on, Port 1 - IO #2 is configured as an input
P1.1	26	15	I/O	P-port input/output. At power on, Port 1 - IO #1 is configured as an input
P1.0	27	16	I/O	P-port input/output. At power on, Port 1 - IO #0 is configured as an input
$\overline{CS}$	28	17	I	SPI chip select input. Internal pull-up resistor
SCLK	29	18	I	SPI serial clock input. Internal pull-down resistor
SDI	30	19	I	SPI serial data input.

Table 4-1. Pin Functions (continued)

PIN			TYPE[1]	
NAME	DGS (VSSOP32)	RHB (VQFN)		
$\overline{\text{RESET}}$/ $\overline{\text{FAIL-SAFE}}$	31	20	I	Active Low reset or fail-safe input. An external pull-up resistor connects to V_{CC}.
$\overline{\text{INT}}$	32	21	O	Open-Drain Interrupt output. An external pull-up resistor connects to V_{CC}.
SDO	1	22	O	SPI serial data output. Push-pull output
VCC	2	23	P	Supply voltage
GND	3	24	G	Ground
P0.0	4	25	I/O	P-port input/output. At power on, Port 0 - IO #0 is configured as an input
P0.1	5	26	I/O	P-port input/output. At power on, Port 0 - IO #1 is configured as an input
P0.2	6	27	I/O	P-port input/output. At power on, Port 0 - IO #2 is configured as an input
P0.3	7	28	I/O	P-port input/output. At power on, Port 0 - IO #3 is configured as an input
P0.4	8	29	I/O	P-port input/output. At power on, Port 0 - IO #4 is configured as an input
P0.5	9	30	I/O	P-port input/output. At power on, Port 0 - IO #5 is configured as an input
P0.6	10	31	I/O	P-port input/output . At power on, Port 0 - IO #6 is configured as an input
P0.7	11	32	I/O	P-port input/output. At power on, Port 0 - IO #7 is configured as an input

(1) I = Input, O = Output, I/O = Input or Output, G = Ground, P = Power

5 Specifications

5.1 Absolute Maximum Ratings

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

				MIN	MAX	UNIT
V_{CC}	Supply voltage			–0.5	6.5	V
V_I	Input voltage(2)			–0.5	6.5	V
V_O	Output voltage(2)			–0.5	6.5	V
I_{IK}	Input clamp current	$\overline{RESET}$, SCLK, SDI, $\overline{CS}$	V_I < 0		-20	mA
I_{OK}	Output clamp current	$\overline{INT}$, SDO	V_O < 0		-20	mA
I_{IOK}	Input-output clamp current	P0.0 - P2.7	V_O < 0 or V_O > V_{CC}		±20	mA
I_{OL}	Continuous output low current		V_O = 0 to V_{CC}		50	mA
I_{OH}	Continuous output high current		V_O = 0 to V_{CC}		–50	mA
I_{CC}	Continuous current through GND(3)				-200	mA
I_{CC}	Continuous current through V_{CC} (3)				160	mA
T_J	Junction temperature			-40	150	°C
T_{stg}	Storage temperature			-40	150	°C

(1) *Operation outside the Absolute Maximum Ratings may cause permanent device damage. Absolute Maximum Ratings do not imply functional operation of the device at these or any other conditions beyond those listed under Recommended Operating Conditions. If used outside the Recommended Operating Conditions but within the Absolute Maximum Ratings, the device may not be fully functional, and this may affect device reliability, functionality, performance, and shorten the device lifetime.*
(2) The input negative-voltage and output voltage ratings may be exceeded if the input and output current ratings are observed.
(3) The total current limits the number of channels that can run at full load.

5.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all pins(1)	±2000	V
		Charged device model (CDM), per ANSI/ESDA/JEDEC specification JS-002, all pins(2)	±1000	

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

5.3 Recommended Operating Conditions

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

			MIN	MAX	UNIT
V_{CC}	Supply voltage		1.65	5.5	V
V_{IH}	High-level input voltage	P Port	0.7 * V_{CC}	VCC	V
		SCLK, SDI, $\overline{CS}$, $\overline{RESET}$	0.7 * V_{CC}	VCC	V
V_{IL}	Low-level input voltage	P Port	-0.5	0.3 * V_{CC}	V
		SCLK, SDI, $\overline{CS}$, $\overline{RESET}$	-0.5	0.3 * V_{CC}	V
I_{OH}	High-level output current (V_{CC} ≥ 2.3V)	P Port		–10	mA
	High-level output current (V_{CC} < 2.3V)			-5	mA
I_{OL}	Low-level output current (V_{CC} ≥ 2.3V)			10	mA
	Low-level output current (V_{CC} < 2.3V)			5	mA
T_A	Ambient temperature		–40	130	°C

5.4 Thermal Information

THERMAL METRIC[1]		Package		UNIT
		DGS (VSSOP)	RHB (VQFN)	
		32 PINS	32 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	80.1	44.1	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	35.4	35.6	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	44.1	25.0	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	2.0	2.7	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	43.7	24.9	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	n/a	14.2	°C/W

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

5.5 Electrical Characteristics

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

PARAMETER			TEST CONDITIONS	V_{CC}	MIN	TYP	MAX	UNIT
V_{IK}	Input diode clamp voltage		I_I = –18mA		–1.2			V
V_{PORR}	Power-on reset voltage, V_{CC} rising		V_I = V_{CC} or GND, I_O = 0				1.35	V
V_{PORF}	Power-on reset voltage, V_{CC} falling				1.05			V
V_{OH}	High-level output voltage	P Port	I_{OH} = -4mA	V_{CC} = 1.65V	1.27			V
			I_{OH} = -8mA	V_{CC} = 2.3V	1.73			V
				V_{CC} = 3V	2.4			V
				V_{CC} = 4.5V	4.0			V
				V_{CC} = 5.5V	4.95			V
			I_{OH} = -10mA	V_{CC} = 3.3V	2.53			V
				V_{CC} = 5V	4.3			V
				V_{CC} = 5.5V	4.85			V
		SDO	I_{OH} = -3mA		VCC - 0.4			V
V_{OL}	Low-level output voltage	P Ports	I_{OL} = 4mA	V_{CC} = 1.65V			0.24	V
			I_{OL} = 8mA	V_{CC} = 2.3V			0.36	V
				V_{CC} = 3V			0.25	V
				V_{CC} = 4.5V			0.17	V
				V_{CC} = 5.5V			0.15	V
			I_{OL} = 10mA	V_{CC} = 3.3V			0.40	V
				V_{CC} = 5V			0.33	V
				V_{CC} = 5.5V			0.32	V
		SDO	I_{OL} = 3mA				0.4	V
I_{OL}	Low-level output current	$\overline{INT}$	V_{OL} = 0.4V		4			mA
I_I	Input leakage current	P Ports	V_I = V_{CC} or GND				±1	μA
			V_I = 3.6V	V_{CC} = 0V			±1	
		SDI, $\overline{RESET}$	V_I = V_{CC} or GND				±1	
		SCLK	V_I = GND				±1	μA
			V_I = V_{CC}				±65	μA
		$\overline{CS}$	V_I = V_{CC}				±1	μA
			V_I = GND				±65	μA

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

PARAMETER			TEST CONDITIONS	V_{CC}	MIN	TYP	MAX	UNIT
I_{CC}	Quiescent current	Standby mode	SDI, $\overline{CS}$ and $\overline{RESET}$ = V_{CC}, P port = V_{CC} or GND, I/O = inputs, I_O = 0mA, f_{SCLK} = 0MHz, –40°C < T_A ≤ 85°C, I/O resistors disabled	V_{CC} = 5.5V		2.3	8	µA
				V_{CC} = 3.6V		2	7.5	µA
				V_{CC} = 2.7V		1.8	7.2	µA
				V_{CC} = 1.65V to 1.95V		1.7	7	µA
			SDI, $\overline{CS}$ and $\overline{RESET}$ = V_{CC}, P port = V_{CC} or GND, I/O = inputs, I_O = 0mA, f_{SCLK} = 0MHz, –40°C < T_A ≤ 125°C, I/O resistors disabled	V_{CC} = 5.5V		2.3	26	µA
				V_{CC} = 3.6V		2	24	µA
				V_{CC} = 2.7V		1.8	23.6	µA
				V_{CC} = 1.65V to 1.95V		1.7	23.4	µA
	Active current	Active mode (5MHz)	SDI, $\overline{CS}$ and $\overline{RESET}$ = V_{CC}, P port = V_{CC} or GND, I/O = inputs, I_O = 0mA, f_{SCLK} = 5MHz, 100pF load on SDO –40°C < T_A ≤ 125°C, I/O resistors disabled	V_{CC} = 5.5V		150	170	µA
				V_{CC} = 3.6V		132	140	µA
				V_{CC} = 2.7V		127	135	µA
				V_{CC} = 1.65V to 1.95V		124	130	µA
		Active mode (10MHz)	SDI, $\overline{CS}$ and $\overline{RESET}$ = V_{CC}, P port = V_{CC} or GND, I/O = inputs, I_O = 0mA, f_{SCLK} = 10MHz, 100pF load on SDO –40°C < T_A ≤ 125°C, I/O resistors disabled	V_{CC} = 5.5V		292	350	µA
				V_{CC} = 3.6V		257	285	µA
				V_{CC} = 2.7V		240	270	µA
				V_{CC} = 1.65V to 1.95V		242	260	µA
I_{BHL}	Bus-hold low sustaining current		Ramp V_I from 0 to 0.3 × V_{CC}	V_{CC} = 1.65V			42	uA
				V_{CC} = 2.3V			62	uA
				V_{CC} = 3V			82	uA
				V_{CC} = 4.5V			125	uA
I_{BHH}	Bus-hold high sustaining current		Ramp V_I from V_{CC} to 0.7 × V_{CC}	V_{CC} = 1.65V			-32	uA
				V_{CC} = 2.3V			-52	uA
				V_{CC} = 3V			-72	uA
				V_{CC} = 4.5V			-115	uA
I_{BHLO}	Bus-hold low override current		Ramp V_I from 0 to V_{CC}	V_{CC} = 1.95V	170			uA
				V_{CC} = 2.7V	260			uA
				V_{CC} = 3.6V	340			uA
				V_{CC} = 5.5V	500			uA
I_{BHHO}	Bus-hold high override current		Ramp V_I from V_{CC} to 0	V_{CC} = 1.95V	-170			uA
				V_{CC} = 2.7V	-260			uA
				V_{CC} = 3.6V	-340			uA
				V_{CC} = 5.5V	-500			uA
$R_{pu(int)}$	internal pull-up resistance	$\overline{CS}$			70	100	140	kΩ
		P port			70	100	140	kΩ
$R_{pd(int)}$	internal pull-down resistance	P port			70	100	140	kΩ
		SCLK			70	100	140	kΩ
C_I	Input pin capacitance	SCLK	V_I = V_{CC} or GND				8	pF
		SDI					8	pF
		$\overline{CS}$					8	pF
		$\overline{RESET}$					8	pF

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

PARAMETER			TEST CONDITIONS	V_{CC}	MIN	TYP	MAX	UNIT
C_{IO}	Input-output pin capacitance	P port	V_{IO} = V_{CC} or GND				8.5	pF

5.6 Timing Requirements

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

			MIN	MAX	UNIT
$\overline{RESET}$					
t_w	Reset pulse duration, SDO C_{LOAD} = 100pF (Figure 6-1)		100		ns
t_{REC}	Reset recovery time, SDO C_{LOAD} = 100pF (Figure 6-1)			100	ns
t_{RESET}	Time to reset, SDO C_{LOAD} = 100pF (Figure 6-1)			80	ns
Power-On Reset					
t_{FT}	Fall rate (Figure 8-3) (Figure 8-4)		0.1	2000	ms
t_{RT}	Rise rate (Figure 8-3) (Figure 8-4)		0.1	2000	ms
t_{TRR_GND}	Time to re-ramp (when V_{CC} drops to GND) (Figure 8-3)		1		µs
t_{TRR_POR50}	Time to re-ramp (when V_{CC} drops to V_{POR_MIN} – 50mV) (Figure 8-4)		40		µs
V_{CC_GH}	Level that V_{CC} can glitch down to, but not cause a functional disruption when t_{VCC_GW} = 1µs (Figure 8-5)			1.2	V
t_{VCC_GW}	Glitch width that cannot cause a functional disruption when V_{CC_GH} = 0.5 × V_{CC} (Figure 8-5)			10	µs
Fail-safe IO					
fs_{EN}	Fail-safe IO enable time (100pF load) (Figure 6-2)	Ouput High in normal mode and Output Low in fail-safe mode		100	ns
		Output Low in normal mode and output high in fail-safe mode		100	ns
		Ouput high in normal mode and input in fail safe mode (500ohm pull down load)		70	ns
		Output low in normal mode and input in fail-safe mode (500ohm pull down load)		70	ns
fs_{DIS}	Fail-safe IO disable time (100pF load) (Figure 6-2)	Ouput High in normal mode and Output Low in fail-safe mode		100	ns
		Output Low in normal mode and output high in fail-safe mode		100	ns
		Input in normal mode and output high in fail-safe mode (500ohm pull down load)		110	ns
		Input in normal mode and output low in fail-safe mode (500ohm pull down load)		90	ns
Digital IO					
T_{GW}	Digital glitch filter width		70	230	ns

5.7 SPI Bus Timing Requirements

over operating free-air temperature range and SDO C_{LOAD} = 100pF (unless otherwise noted) (see (Figure 6-3))

		MIN	MAX	UNIT
SPI Bus - 10MHz				
f_{SCLK}	SPI clock frequency; 3.3V < V_{CC} < 5.5V		10	MHz
t_{CSS}	$\overline{CS}$ to SCLK Rise Setup Time	50		ns
t_{CSH}	SCLK Fall to $\overline{CS}$ De-asserted Hold Time	50		ns
t_{CSD}	$\overline{CS}$ Disable Time	50		ns
t_{DS}	SDI to SCLK Setup Time	10		ns
t_{DH}	SDI to SCLK Hold Time	10		ns
t_{LOW}	SCLK Low Time	45		ns
t_{HIGH}	SCLK High Time	45		ns
$t_{V\ (SDO)}$	SDO Valid Time		27	ns
$t_{DIS\ (SDO)}$	SDO Disable Time		50	ns
SPI Bus - 5MHz				
f_{SCLK}	SPI clock frequency; 1.65V < V_{CC} < 5.5V		5	MHz
t_{CSS}	$\overline{CS}$ to SCLK Rise Setup Time	50		ns
t_{CSH}	SCLK Fall to $\overline{CS}$ De-asserted Hold Time	100		ns
t_{CSD}	$\overline{CS}$ Disable Time	100		ns
t_{DS}	SDI to SCLK Setup Time	10		ns
t_{DH}	SDI to SCLK Hold Time	10		ns
t_{LOW}	SCLK Low Time	90		ns
t_{HIGH}	SCLK High Time	90		ns
$t_{V\ (SDO)}$	SDO Valid Time		54	ns
$t_{DIS\ (SDO)}$	SDO Disable Time		100	ns

5.8 Switching Characteristics

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

PARAMETER		FROM (INPUT)	TO (OUTPUT)	MIN	TYP	MAX	UNIT
t_{iv}	Interrupt valid time, INT C_{LOAD} = 100pF and R_{PU} = 4.7kΩ (Figure 6-4)	P port	$\overline{INT}$			0.2	µs
t_{ir}	Interrupt reset delay time, INT C_{LOAD} = 100pF and R_{PU} = 4.7kΩ (Figure 6-4)	SCLK	$\overline{INT}$			0.4	µs
t_{pv}	Output data valid time, SDO C_{LOAD} = 100pF (Figure 6-5)	SCLK	P port			100	ns
t_{ps}	Input data setup time, SDO C_{LOAD} = 100pF (Figure 6-5)	P port	SCLK	26			ns
t_{ph}	Input data hold time, SDO C_{LOAD} = 100pF (Figure 6-5)	SCLK	P port	2.5			ns

6 Parameter Measurement Information

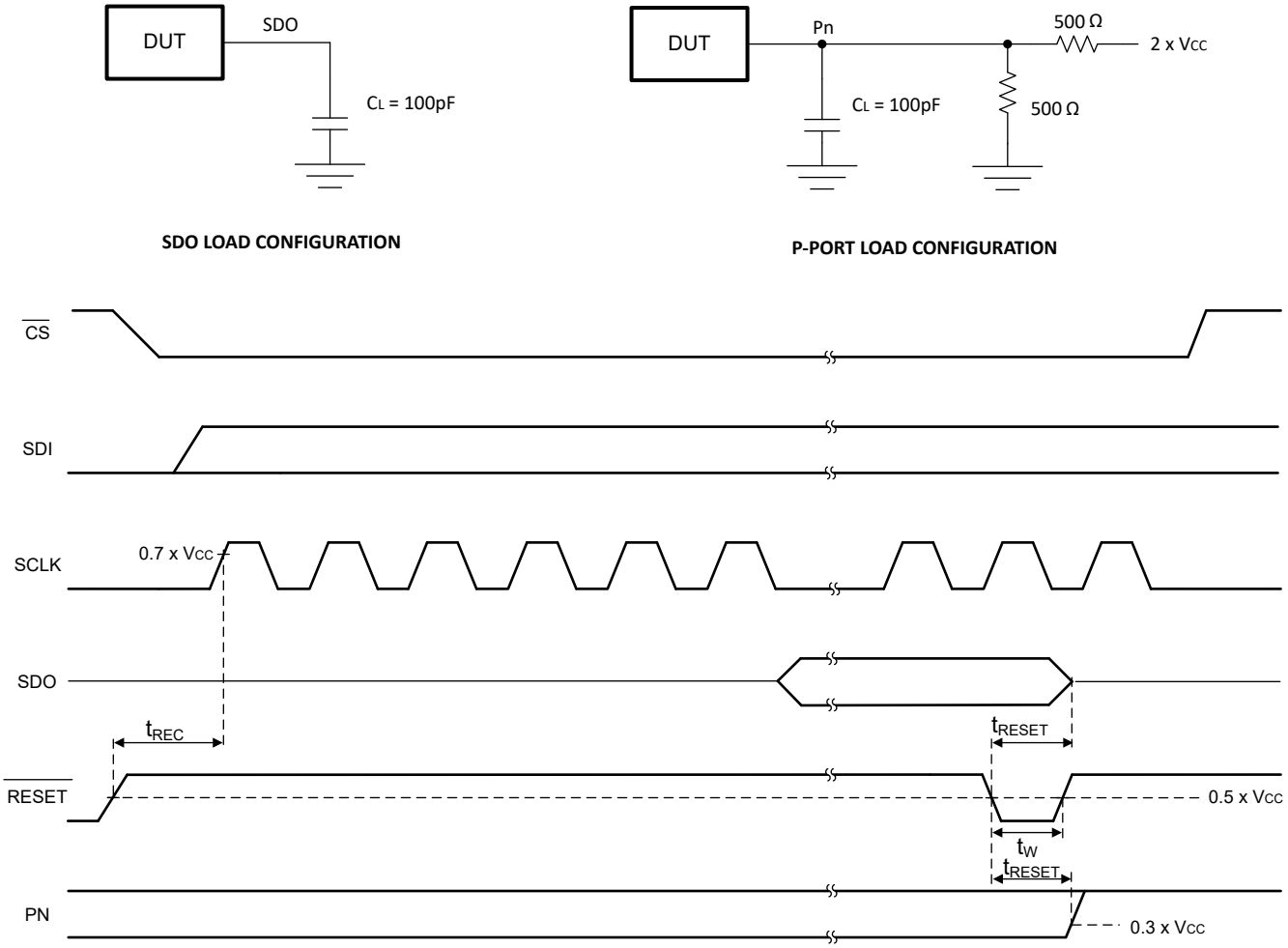


Figure 6-1. Reset Load Configuration

A. 1. C_L includes probe and jig capacitance.
2. All inputs are supplied by generators having the following characteristics: PRR ≤ 10MHz; Zo = 50Ω; tr/tf ≤ 10ns.
3. All parameters and waveforms are not applicable to all devices.

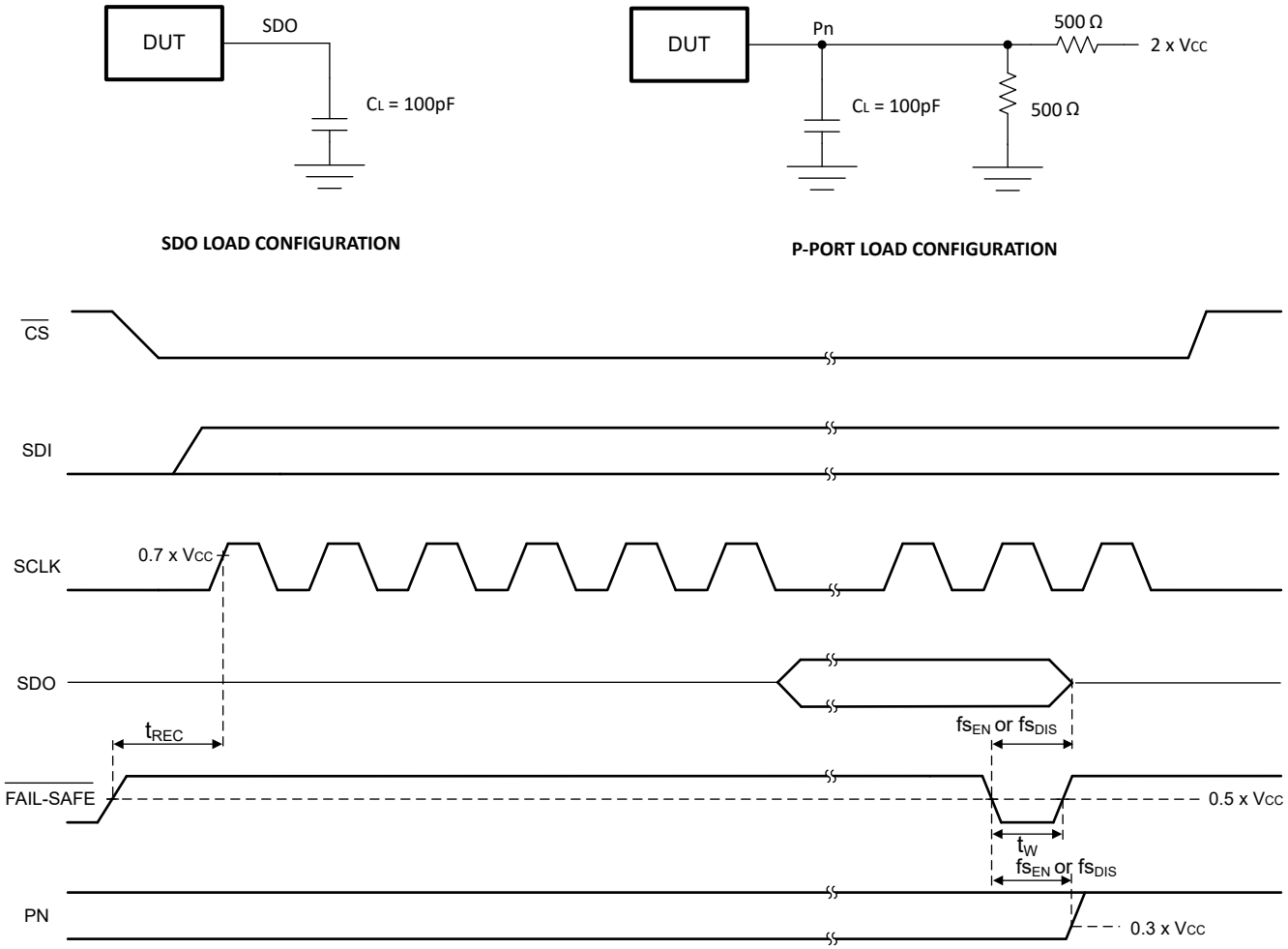
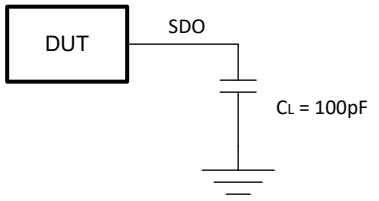


Figure 6-2. Fail-safe Load Configuration

A. 1. C_L includes probe and jig capacitance.
2. All inputs are supplied by generators having the following characteristics: PRR ≤ 10MHz; Zo = 50Ω; tr/tf ≤ 10ns.
3. FAIL-SAFE pin is a shared pin with RESET pin.
4. All parameters and waveforms are not applicable to all devices.



SDO LOAD CONFIGURATION

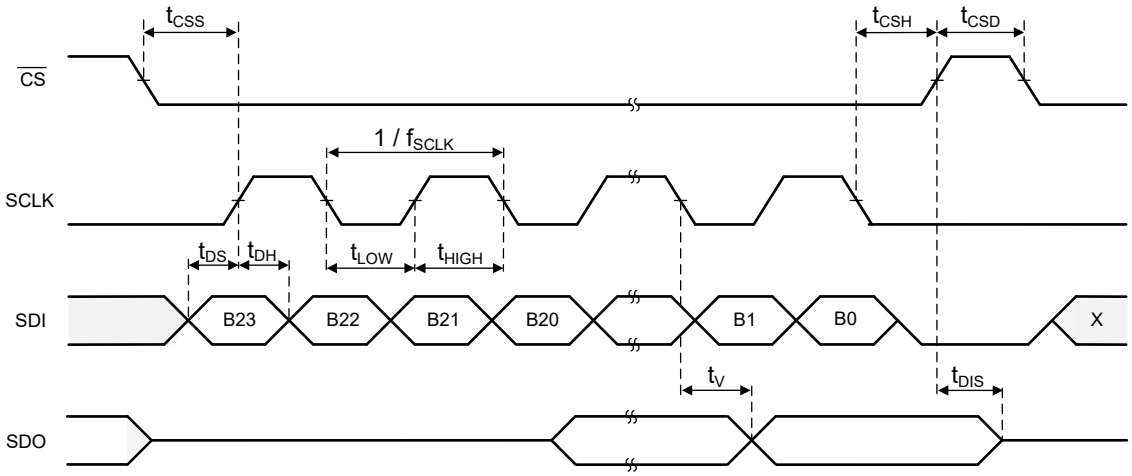
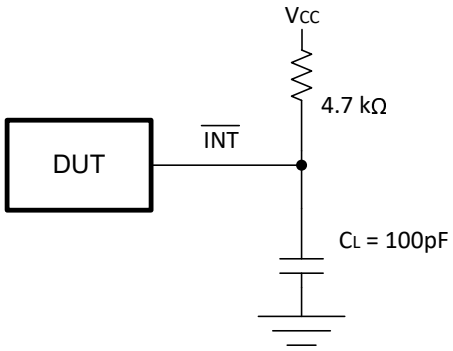


Figure 6-3. SPI Timing Diagram - Input

A. C_L includes probe and jig capacitance.



INTERRUPT LOAD CONFIGURATION

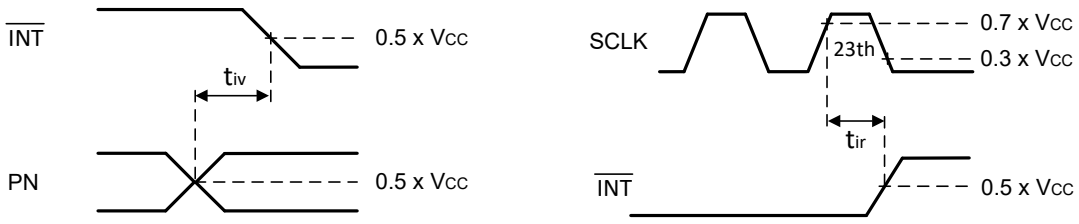
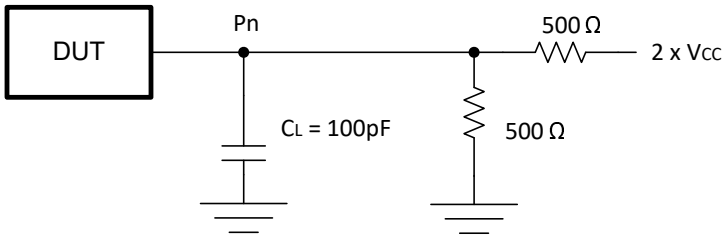


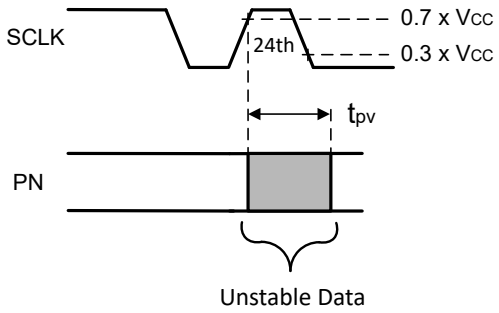
Figure 6-4. Interrupt Load Configuration

A. 1. C_L includes probe and jig capacitance.

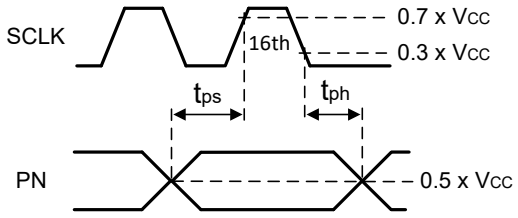
2. All inputs are supplied by generators having the following characteristics: PRR ≤ 10MHz; Zo = 50Ω; tr/tf ≤ 10ns.



P-PORT LOAD CONFIGURATION



WRITE MODE (R/$\overline{W}$ = 0)



READ MODE ($\overline{R}$/W = 1)

Figure 6-5. P-Port Load Configuration and Timing Waveforms

A. 1. C_L includes probe and jig capacitance.
2. t_{pv} is measured from 0.7 × V_{CC} on SCLK to 50 % I/O (Pn) output.
3. All inputs are supplied by generators having the following characteristics: PRR ≤ 10MHz; Zo = 50Ω; tr/tf ≤ 10ns.

7 Detailed Description

7.1 Overview

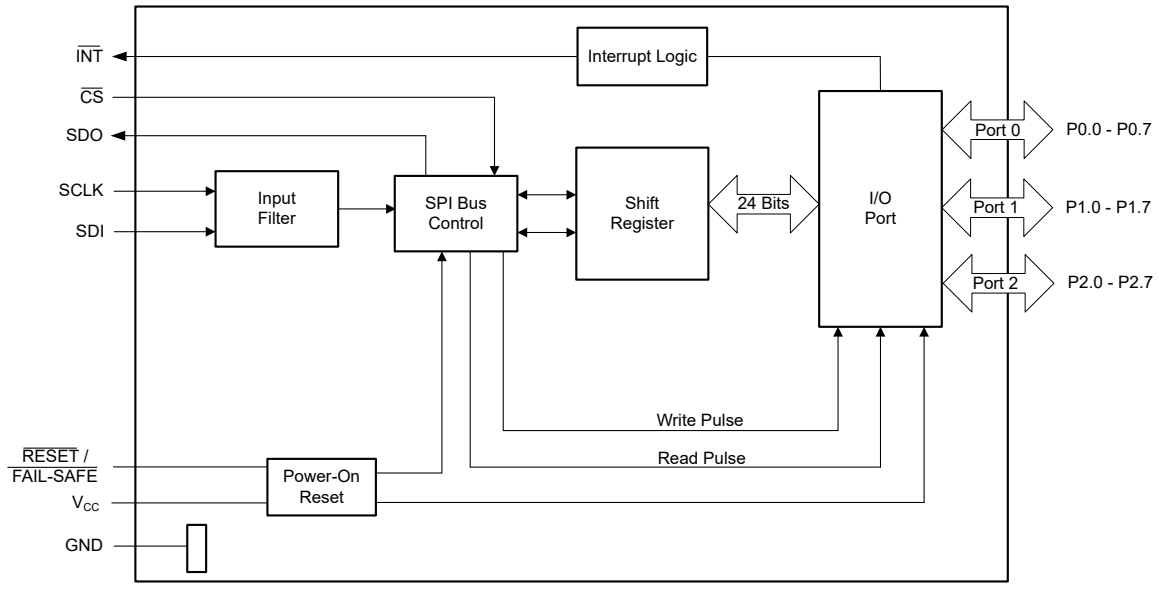
The TXE8124 digital core consists of 8-bit registers, which allow the user to configure the I/O port characteristics. At power on or after a reset, the I/Os are configured as inputs. However, the system controller can configure the I/Os as either inputs or outputs by writing to the direction configuration registers. The data for each input or output is kept in the corresponding Input Port or Output Port register. The polarity of the Input Port register can be inverted with the Polarity Inversion register. All registers, except software reset register, are readable by the system controller.

The TXE8124 has configurable I/O functionality which is specifically targeted to enhance the I/O ports. The configurable I/O features and registers include enabling or disabling pull-up and pull-down resistors, bus-hold latchable inputs, maskable interrupts, interrupt status register, and individual programmable open-drain or push-pull outputs. These configuration registers improve the I/O by increasing flexibility and allowing the user to optimize their design for power consumption and speed.

Other features of the device include an interrupt that is generated on the $\overline{INT}$ pin whenever an input port changes state. The device can be reset to its default state by applying a low logic level to the $\overline{RESET}$ pin, issuing a software reset command, or by cycling power to the device and causing a power-on reset. The TXE8124 open-drain interrupt ($\overline{INT}$) output is activated when any input state differs from the last read state and is used to indicate to the system controller that an input state has changed. The $\overline{INT}$ pin can be connected to the interrupt input of a processor. By sending an interrupt signal on this line, the device can inform the processor if there is incoming data on the remote I/O ports without having to communicate via the SPI bus. The device remains a simple target device.

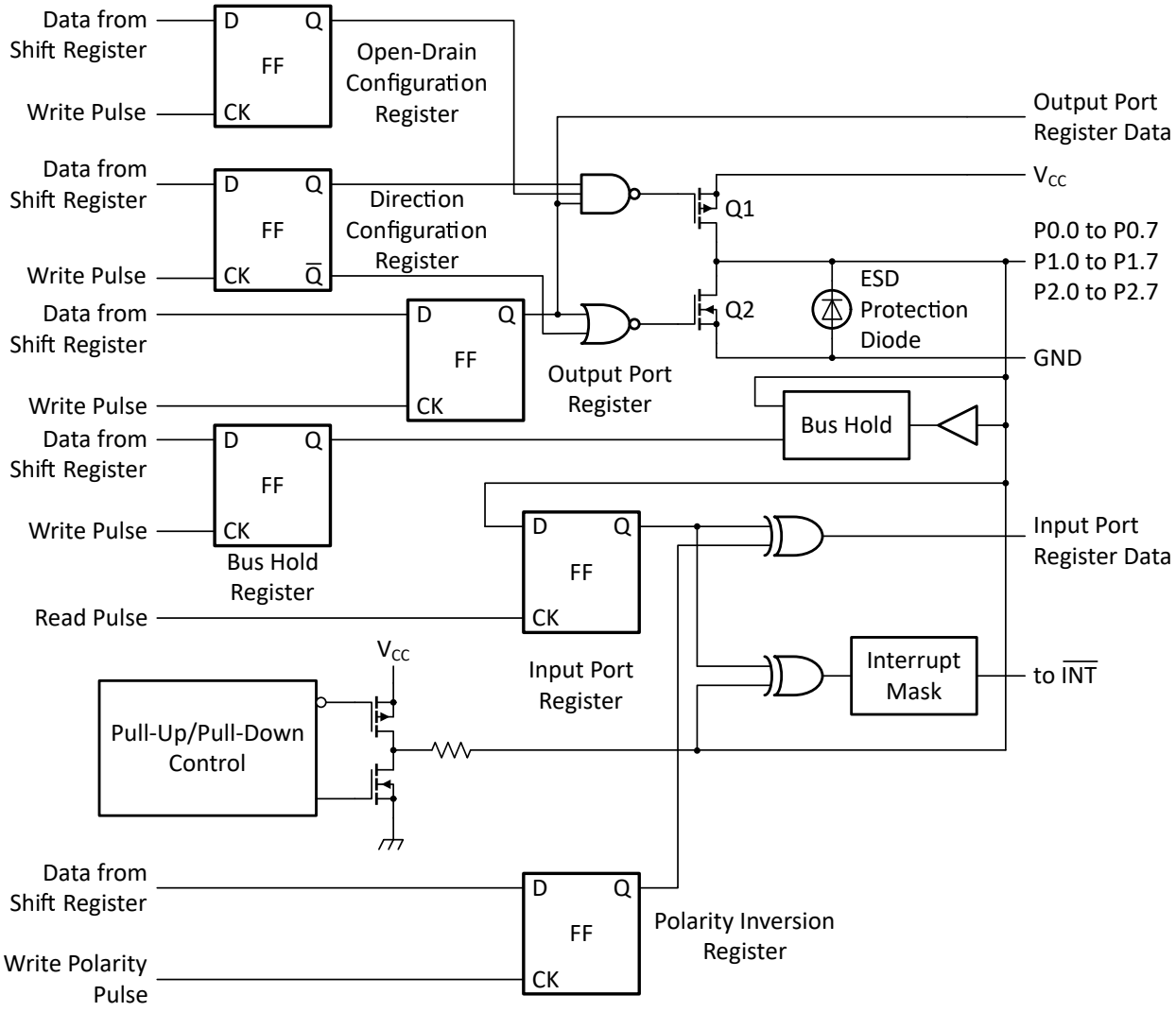
In the event of a timeout or other improper operation, the system controller resets the device by asserting a low on the $\overline{RESET}$ input pin or by cycling the power to the V_{CC} pin and causing a power-on reset (POR). A reset puts the registers in their default state and initializes the SPI state machine. The $\overline{RESET}$ feature and a POR cause the same reset/initialization to occur, but the $\overline{RESET}$ feature does so without needing to power down the device.

7.2 Functional Block Diagrams



A. All I/Os are set to inputs at reset.

Figure 7-1. Logic Diagram



A. On power up or reset, all registers return to default values.

Figure 7-2. Simplified Schematic of P0.0 to P2.7

7.3 Feature Description

7.3.1 I/O Port

When an I/O is configured as an input, FETs Q1 and Q2 are off (see Figure 7-2), which creates a high-impedance input.

If the I/O is configured as an output, Q1 or Q2 is enabled, depending on the state of the output port register. In this case, there are low-impedance paths between the I/O pin and either supply or GND. The external voltage applied to this I/O pin should not exceed the recommended levels for proper operation.

7.3.2 Interrupt Output ($\overline{INT}$)

The TXE8124 devices generate an interrupt on any rising or falling edge of an input I/O, provided that the interrupt for that I/O is not masked. When an input pin state is different than the input read register state, the corresponding interrupt flag bit is set, and the $\overline{INT}$ output is asserted. The $\overline{INT}$ pin is open-drain and requires an external pull-up resistor to V_{CC} use the interrupt feature, otherwise it may be left floating.

I/Os configured as outputs do not generate interrupts. Switching a pin from output to input may generate a fault interrupt if the actual pin level does not match the stored input port register value. If an I/O port was previsouly in

input state and detected an interrupt as switching to output, this won't clear the interrupt flag. It only masks the interrupt pin. Then when the port is reconfigured as input, the interrupt comes back.

With the following conditions, the interrupt status bits can be cleared and the $\overline{INT}$ pin de-asserted.

- Hardware reset from $\overline{RESET}$ pin - this de-asserts the interrupt temporarily as POR is going to assert the interrupt
- Entering fail-safe mode - this disables and de-assert the interrupt
- Reading Interrupt Flag Status Register
- Setting the corresponding bit as 1 in Interrupt Mask Register

There are four sources of interrupts in TXE8124:

1. **Smart Input Pin Interrupt**: Smart Interrupt is enabled or disabled at I/O port level by setting the corresponding port bit in the Smart Interrupt Register. If Smart Interrupt (the corresponding register bit as 0) is enabled and an interrupt is generated, the interrupt clears if the I/O state goes back to the intial logic state or it reads the Interrupt Flag Status Register. For example, if the Input Port Register is read and/or the I/O state goes back to the initial state, the interrupt is cleared even if there is no reading operation on the Interrupt Flag Status Register. Refer to Table 7-1 for the different interrupt clearing scenarios. To avoid missing the interrupt clear due to false IO toggle, it is strongly recommended to enable the glitch filter enable in the Input Glitch Filter Enable Register.
2. **Regular Input Pin Interrupt**: When Smart Interrupt is disabled (the corresponding register bit as 1) in the Smart Interrupt Register, the I/O state going back to the initial logic state cannot clear the interrupt, only reading the Interrupt Flag Status Register clears the interrupt.

Table 7-1. Interrupt Flag Clearing Scenarios for Smart Interrupt

Smart Interrupt	$\overline{CS}$ state when IO input changes	Interrupt flag clears
Disable	$\overline{CS}$ = High	$\overline{CS}$ to be low and SPI reading Interrupt Flag Status Register
Disable	$\overline{CS}$ = Low	Reading Interrupt Flag Status Register
Enable	$\overline{CS}$ = High	a. $\overline{CS}$ to be low and SPI reading Input Port Register b. IO state going back to the initial state c. $\overline{CS}$ to be low and SPI reading Interrupt Flag Status Register
Enable	$\overline{CS}$ = Low	a. Reading Input Port Register or IO states going back to the initial state will not clear the interrupt flag immediately. After $\overline{CS}$ becomes high and holds over 30ns, the interrupt flag is cleared. b. Reading Interrupt Flag Status Register

3. **POR Interrupt** : the POR fault bit is set in the Fault Status Register for each POR recovery, which also generates an interrupt. The interrupt is only cleared when the Fault Status Register is read.
4. **Fail-safe Redundancy Failure Interrupt**: When the fail-safe redundancy check is enabled, and if any fail-safe redundancy check failure occurs, a fail-safe sync fault bit is set in the Fault Status Register. This also generates an interrupt. The interrupt is only cleared when the Fault Status Register is read.

Interrupt Masking

Interrupts from all input I/Os are unmasked by default. To mask an interrupt, the corresponding I/O bit needs to be set in the interrupt mask register. The interrupt generated by POR recovery cannot be masked.

If the state of an input I/O is changed and the corresponding bit in the Interrupt mask register is set to 1, the interrupt is masked and the $\overline{INT}$ pin is not asserted. The corresponding bit in the interrupt flag status register also stays at 0 and is blocked by the interrupt mask bit.

The interrupts generated by fail-safe redundancy check fail is disabled if the fail-safe redundancy check enable bit is 0.

Multiple ports can be configured for interrupt masking at the same time by using multi port command.

7.3.3 Reset Input ($\overline{RESET}$)

The $\overline{RESET}$ input can be asserted to initialize the system while keeping the V_{CC} supply at its operating level. A reset can be accomplished by holding the $\overline{RESET}$ pin low for a minimum of t_W. The TXE8124 registers and SPI state machine are changed to their default state once $\overline{RESET}$ is set LOW. When $\overline{RESET}$ is set HIGH, the I/O levels at the P port can be changed externally or through the controller. This input requires a pull-up resistor to V_{CC}, if no active connection is used. When $\overline{RESET}$ is toggled the input port register is updated to reflect the state of the GPIO pins.

7.3.4 Bus Hold

TXE8124 supports bus hold (bus-keeper) function on all input I/Os which is very useful when the system has to go into low-power or standby state as external pull-up or pull-down correponding to the low-power state are no longer required. By default the feature is disabled and must be enabled through software programming.

On enabling the bus hold feature, the I/O holds the last known active level on the I/O. If the external device drives a logic 1, TXE8124 activates the internal bus hold pull-up. When the controller goes into low-power state making its output pins high-impedance, the internal bus hold pull-up holds the I/O high, thus avoiding a floating input. The same happens when the external device is drives a logic 0, with the TXE8124 activating the internal bus hold pull-down. This also ensures that the TXE8124 does not generate an interrupt due to noise on the floating inputs, as the device is held in the last known state.

When the bus hold feature is enabled, the external driver must ensure that the current sink or source (indicated by the + or - sign on the specification) due to leakage or other circuits on the board must meet the sustaining or override current. As an example, if the bus hold is activated in high state, then the external devices on the line must not source current from TXE8124 that exceeds the $I_{BHH(MAX)}$ limit. If the limit is exceeded, the voltage may drop below the $V_{IL(MAX)}$ on the corresponding port pin and trigger the bus-hold pull-down. Similalry, if the bus-hold has to be overriden, then the external devices must be able to sink $I_{BHO(MIN)}$ current from the TXE8124, to ensure that the device releases the bus-hold.

The software must ensure that the pull-up or pull-down selection must not be used along with the bus-hold feature to avoid additional leakage current in the device.

7.3.5 Fail-safe Mode

The SPI controller has the option to set TXE8124 to be in a fail-safe state by programing the Fail-safe Enable Register to enable this feature and change the functionality of the pin from reset to fail-safe.

This register can get cleared during a POR event or other fault scenarios. The SPI controller has to rewrite this register every time if there is a fault scenario which will generate an interrupt to the SPI controller. After the interrupt is generated, the SPI controller can read the Fault Status Register to understand the source of the interrupt.

The bit 0 in Fail-safe Enable Register must be 1 to configure TXE8124 to be fail-safe mode.

Two Device Configuration Registers have to be written to program I/O configuration to ensure redundancy. If either of these registers get corrupted, and the contents don’t match, an interrupt will be generated.

For example, if setting I/O pin P0.1 to be output and high under fail-safe mode, the sequence to configure fail-safe mode:

1. Configure bit 0 in the Fail-safe Enable Register 1 as 1
2. Configure bit 0 in the Fail-safe Enable Register 2 as 1

3. Set bit 1 (P0.1) in port 0 of Fail-safe Direction Configuration Register 1 for Port-0 to be 1
4. Set bit 1 (P0.1) in port 0 of Fail-safe Direction Configuration Register 2 for Port-0 to be 1
5. Set bit 1 (P0.1) in port 0 of Fail-safe Output Register 1 for Port-0 to be 1
6. Set bit 1 (P0.1) in port 0 of Fail-safe Output Register 2 for Port-0 to be 1
7. Set bit 0 in Fail-safe Redundancy Check Register to be 1
8. Assert $\overline{\text{RESET}}$/FAIL-SAFE pin

7.3.6 Software Reset Call

The software reset call is a SPI bus transaction to the TXE8124 device, to write to the software reset register, that instructs the device to be reset to the power-up default state. This allows customer application to reset the device without having to either power cycle the device or assert/de-assert the $\overline{\text{RESET}}$ pin. This is especially useful if the $\overline{\text{RESET}}$ pin is being used in fail-safe mode.

7.3.7 Daisy Chain

Multiple TXE8124 devices can be connected in a daisy chain configuration as shown in example implementation Figure 7-3, to expand the number of I/O ports supported. In the daisy chain mode of operation the SDO of the controller is connected to the SDI of the first TXE8124. The SDO of the first TXE8124 is in turn connected to the SDI of the next TXE8124. This connection can be done until the last TXE8124, where the SDO is connected to the SDI of the controller.

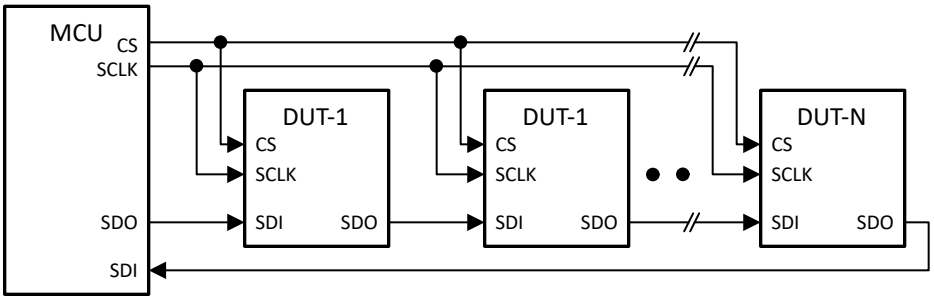


Figure 7-3. SPI Daisy Chain Diagram

The controller transmits a header to auto-configure the daisy chain of operation, followed by the register address of the devices in the chain with the register address of the farthest device in the chain (the device furthest from the controller's SDI and closest to the controller's SDO) first. The data is transmitted after the address with data for the furthest device first. When receiving the data from the furthest device is received first.

Refer to Figure 7-4 for the frames of daisy chained transaction. The same sequencing is repeated throughout the entire chain until the final device is reached.

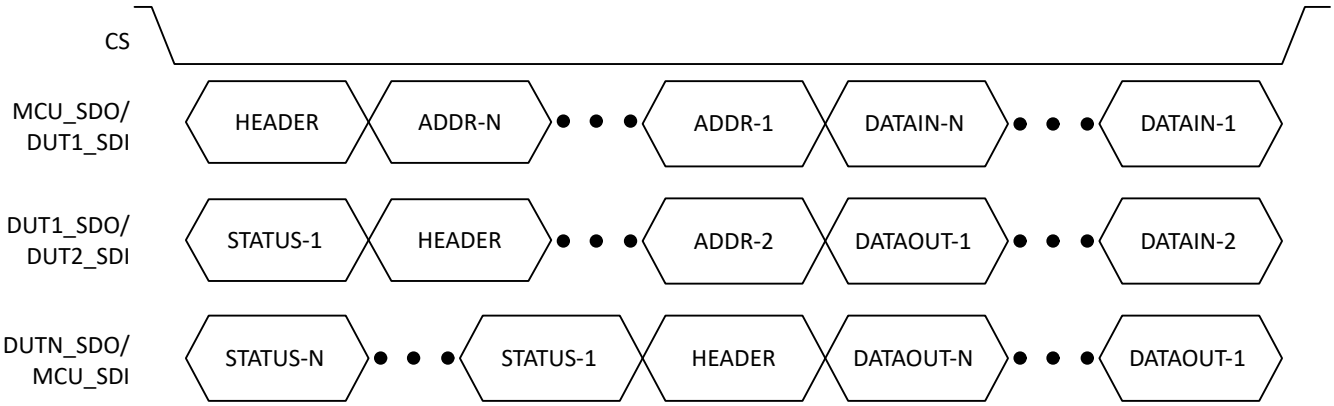


Figure 7-4. SPI Daisy Chain Data Frame

Header segment

Bit-15 and 14 in Header segment are the Header ID that is used by the device controller to detect that a header segment is being received. The Header ID bits have the value 01 to indicate this is a Header segment.

Bit-13 is reserved and bits 12 to 0 indicate the number of devices in the chain.

Address segment (Register Address)

Bit 15 indicates SPI mode of operation (1 = Read operation 0 = Write operation). Refer to the first and second byte in Figure 7-5 for the register address.

Status segment

Bit-15 and 14 indicate a status segment and set to 11 to indicate status segment. Bit 13 to 8 indicate the fault status register and bit 7 to 0 are always transmitted as 0.

7.3.8 Multi Port

As shown in Section 7.5.2, the LSB of the second byte enables the multi-port feature. When this bit is 1, each bit of the following write data byte on SDI refers to individual ports. So, LSB bit B0 refers to P0 port, B1 refers to P1 port, B2 refers to P2 port. All I/Os in a particular port will have the same configuration when multi-port programming is used. During a multi-port access, the SDO will output the first byte with fault status register value, followed by 0s for the data byte.

7.3.9 Feature Register Mapping

The TXE8124 device registers are implemented as a register bank, where the actual register address for a port is formed by concatenating the feature address, 0 and the port number as shown in Figure 7-5. This allows the customer software to configure or read a specific feature for all ports more effectively with a burst transfer.

Table 7-2 lists the registers as per the feature address and support for multi-port.

Table 7-2. TXE8124 Feature Map

FEATURE ADDRESS					REGISTER NAME	MULTI PORT	ACCESS
B20	B19	B18	B17	B16			
0	0	0	0	0	Scratch Register	No	RW
0	0	0	0	1	Device_ID	No	R
0	0	0	1	0	Input Port Register	Yes	R
0	0	0	1	1	Output Port Register	Yes	RW
0	0	1	0	0	Direction Configuration Register	Yes	RW
0	0	1	0	1	Polarity Inversion Register	Yes	RW
0	0	1	1	0	Push Pull / Open Drain Selection Register	Yes	RW
0	1	0	0	0	Pull Up or Pull Down Enable Register	Yes	RW
0	1	0	0	1	Pull Up or Pull Down Selection Register	Yes	RW
0	1	0	1	0	Bus Holder Register	Yes	RW
0	1	0	1	1	Smart Interrupt Register	No	RW
0	1	1	0	0	Interrupt Mask Register	Yes	RW
0	1	1	0	1	Input Glitch Filter Enable Register	No	RW
0	1	1	1	0	Interrupt Flag Status Register	No	R
0	1	1	1	1	Interrupt Port Status Register	No	R
1	0	0	1	0	Fail-safe Enable Register 1	No	RW
1	0	0	1	1	Fail-safe Enable Register 2	Yes	RW
1	0	1	0	0	Fail-safe Direction Configuration Register 1	Yes	RW
1	0	1	0	1	Fail-safe Direction Configuration Register 2	Yes	RW
1	0	1	1	0	Fail-safe Output Register 1	Yes	RW
1	0	1	1	1	Fail-safe Output Register 2	Yes	RW
1	1	0	0	0	Fail-safe Redundancy Check Register	No	RW

Table 7-2. TXE8124 Feature Map (continued)

FEATURE ADDRESS					REGISTER NAME	MULTI PORT	ACCESS
B20	B19	B18	B17	B16			
1	1	0	0	1	Fault Status Register	No	R
1	1	0	1	0	Software Reset Register	No	WO

7.4 Device Functional Modes

7.4.1 Power-On Reset

When powering the device from 0V is applied to V_{CC}, an internal power-on reset holds the TXE8124 in a reset condition until the supply has reached V_{POR}. At that time, the reset condition is released, and the TXE8124 registers and SPI state machine initializes to their default states. After that, V_{CC} must be lowered to below V_{PORF} for time $t_{TRR_POR_50}$and back up to the operating voltage for a power-reset cycle.

7.5 Programming

7.5.1 SPI Interface

The TXE8124 devices use a SPI interface to set device configurations, operating parameters and read out diagnostic information. The SPI protocol uses three inputs and one output; serial clock (SCLK), active LOW chip select ($\overline{CS}$), serial data in (SDI) and serial data out (SDO). $\overline{CS}$ must be driven low before clock pulses and data into the device. When $\overline{CS}$ is high, the device ignores all activity on SCLK and SDI.

The TXE8124 devices support SPI mode 0 (CPOL = 0, CPHA = 0). The clock (SCLK) is low when idle. Data is sampled on the rising edge of SCLK and changed on the falling edge.

Besides SPI bus with independent chip select, daisy chain configuration is also supported in TXE8124. It allows multiple peripherals to be connected in series, with the output of one device feeding into the input of the next. Daisy chain is benefitial to reduce the number of $\overline{CS}$ lines, as only one is needed for the entire chain. Data is shifted through all devices in the chain during each clock cycle.

7.5.2 SPI Data Format

The length of TXE8124 SPI data word is [16 + (N*8)] bits (N is the number of data bytes to write). For a single byte write or read, 24 bits of data are sent and received MSB first. SPI data must be stable during the rising edge of SCLK where it is sampled.

The data format on the SDI pin from the controller to TXE8124 is shown in Figure 7-5.

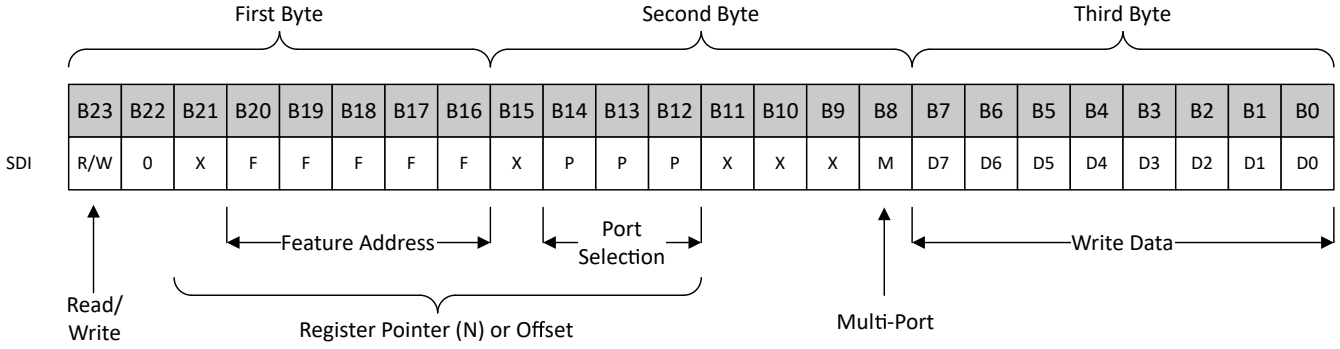


Figure 7-5. TXE8124 SPI SDI Data Frame Format

The first and second byte are mandatory portion of the frame. The B23 bit in the SDI frame is R/$\overline{W}$, where 1 is for a read operation and 0 is for a write operation. The B22 bit is always 0 for a point-to-point connection (non-daisy chain topology). B20 to B16 correspond to the feature register of the port. B14 to B12 are for selecting the port. The B8 bit is used for multi-port operation, and must be set to 1 only if the multi-port function is used. The bits B21 to B12 are referred to as the register pointer (or offset in the register table) for the device.

Third byte onwards, the 8-bit write data is shifted in and written to the register indicated by the register pointer. For single transfer N=1 while for a burst mode N>1. For a burst transfer, the register pointer is internally incremented and the shifted data written to the updated internal register pointer. Any bit which is not defined in the frame must be sent as 0 for future compatibility.

The data format on the SDO pin from the TXE8124 to the controller is shown in Figure 7-6.

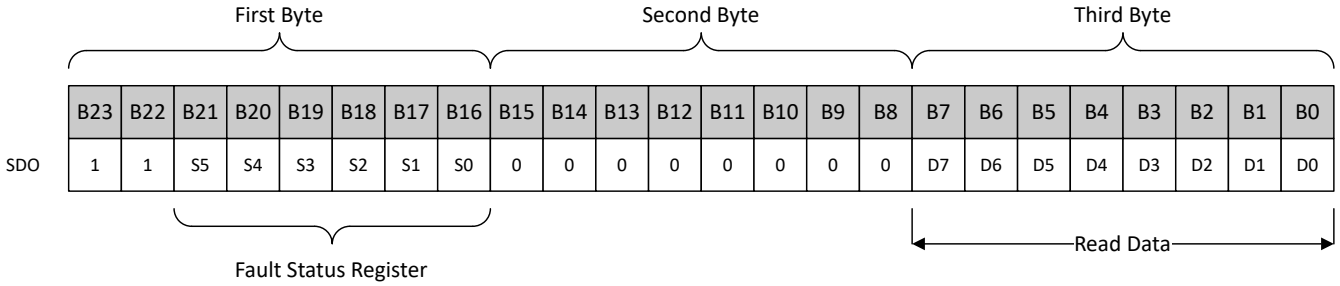


Figure 7-6. SPI SDO Data Format

The first and second byte are standard for any SPI bus communication operation. The B23 and B22 are set as 1 to indicate valid status. B21 to B16 are the status bit from the fault status register. The second byte is always set to 0. Third byte onwards the 8-bit read is shifted out for the register pointer shifted into the device on the SDI pin. For a burst transfer (N>1) the register pointer is internally incremented and the data shifted out.

7.5.3 Burst Mode

In Burst Mode Transactions, the initial register pointer is specified by the controller device and sent to the peripheral. For subsequent accesses, the register pointer is automatically incremented to the next valid address (second address byte) corresponding to the next port. This automatic address increment continues as long as the CS remains active low and SCLK pulses are received by the peripheral device.

As the burst mode transaction continues sequentially, the register pointer automatically advances the address. If there is no valid register corresponding to the updated register pointer or the register is a read-only type, the data written is ignored. Similarly on the SDO the peripheral will output 0s for a register which is not mapped in the address space of the device.

It is strongly recommended to use burst mode when configuring or accessing the same register for multiple ports together to improve the effective data throughput on the SPI bus.

7.5.4 SPI Write

SPI Write operation is used to send data from the controller device to the peripheral device. SPI write can be a single byte write as shown in Figure 7-7 or burst write as shown in Figure 7-8 where multiple bytes can be written to the device. The operation is performed over the SPI bus, where the controller device drives $\overline{CS}$ low, generates the serial clock (SCLK) and sends data to the peripheral. SPI Write is commonly used to configure peripherals, send control commands, or transfer data. During a SPI single write, the device sends the last data from the register indicated by the register pointer. On a SPI burst write, the address is automatically incremented and the device sends the last data from the updated register pointer.

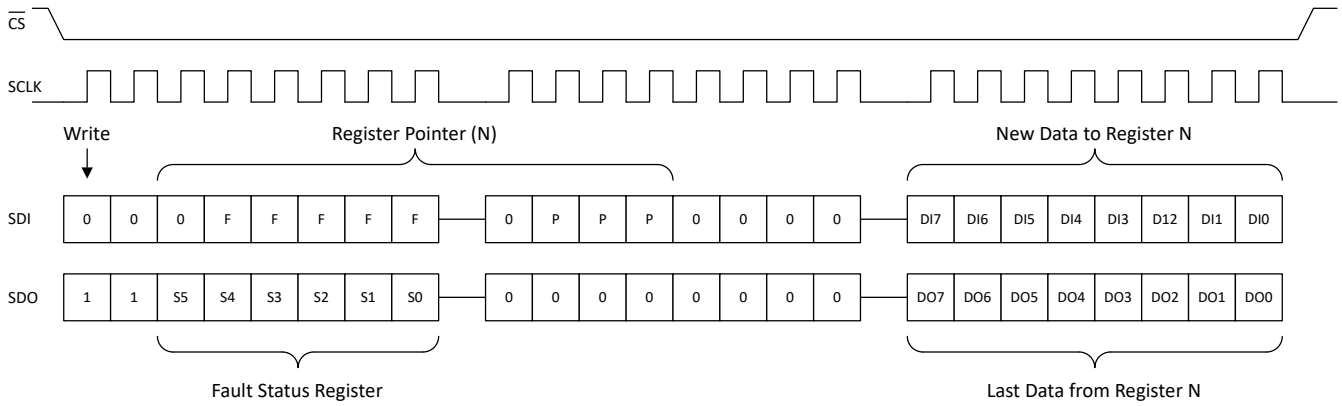


Figure 7-7. SPI Single Write

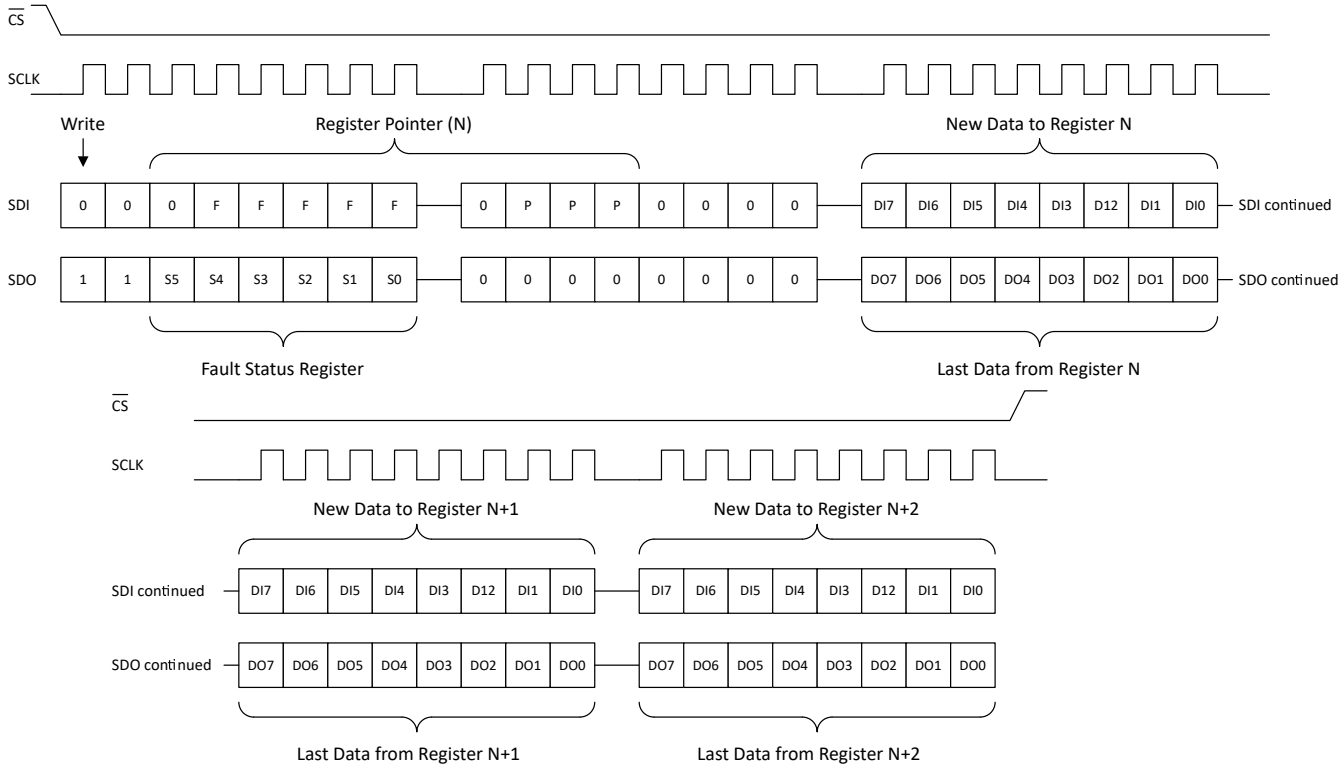


Figure 7-8. SPI Burst Write

SPI Write Steps

1. Drive $\overline{CS}$ low. This enables the internal shift register.
2. Shift 24 bits of data into the device in a MSB first fashion, MSB bit . Data must be stable during the rising edge of SCLK.
3. The MSB bit must be a '0' indicating it is a write operation.
4. On the SDO pin, the device sends the first 2 bits as 2’b11 (indicating it to be a status segment). followed by 6 bits are the Bit 5 to 0 of the Fault status register. The next 8 bits are all 0s followed by 8-bit current data in the register selected by register pointer.
5. After the last bit of data is transferred, drive SCLK low if there is no more data to be transferred.
6. The previous content of the register is sent out on SDO as the data byte is driven on SDI.
7. De-assert $\overline{CS}$ (drive it high) to end the write cycle.

7.5.5 SPI Read

The SPI Read operation for TXE8124 is used to retrieve data from a specific register in single read mode as shown in Figure 7-9 or sequential registers in burst mode as shown in Figure 7-10.

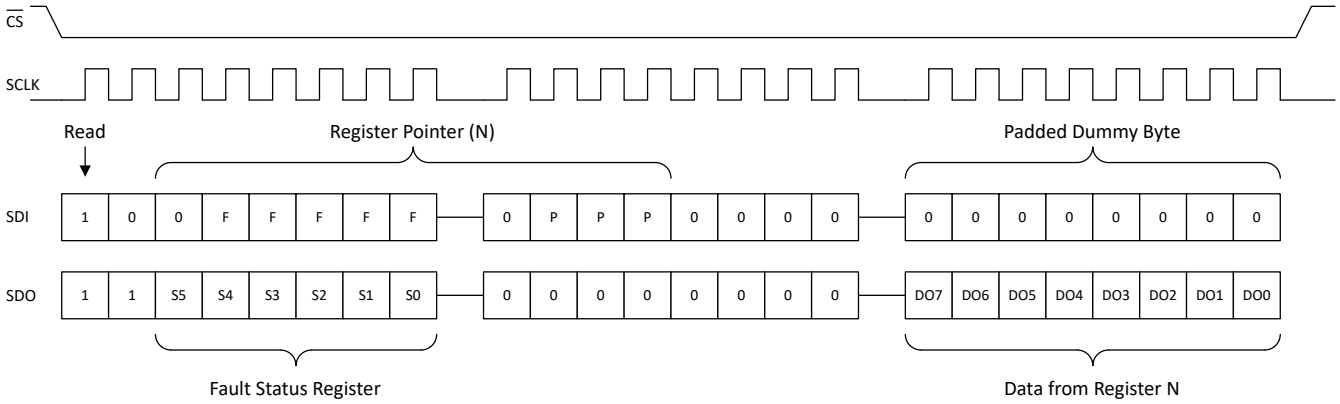


Figure 7-9. SPI Single Read

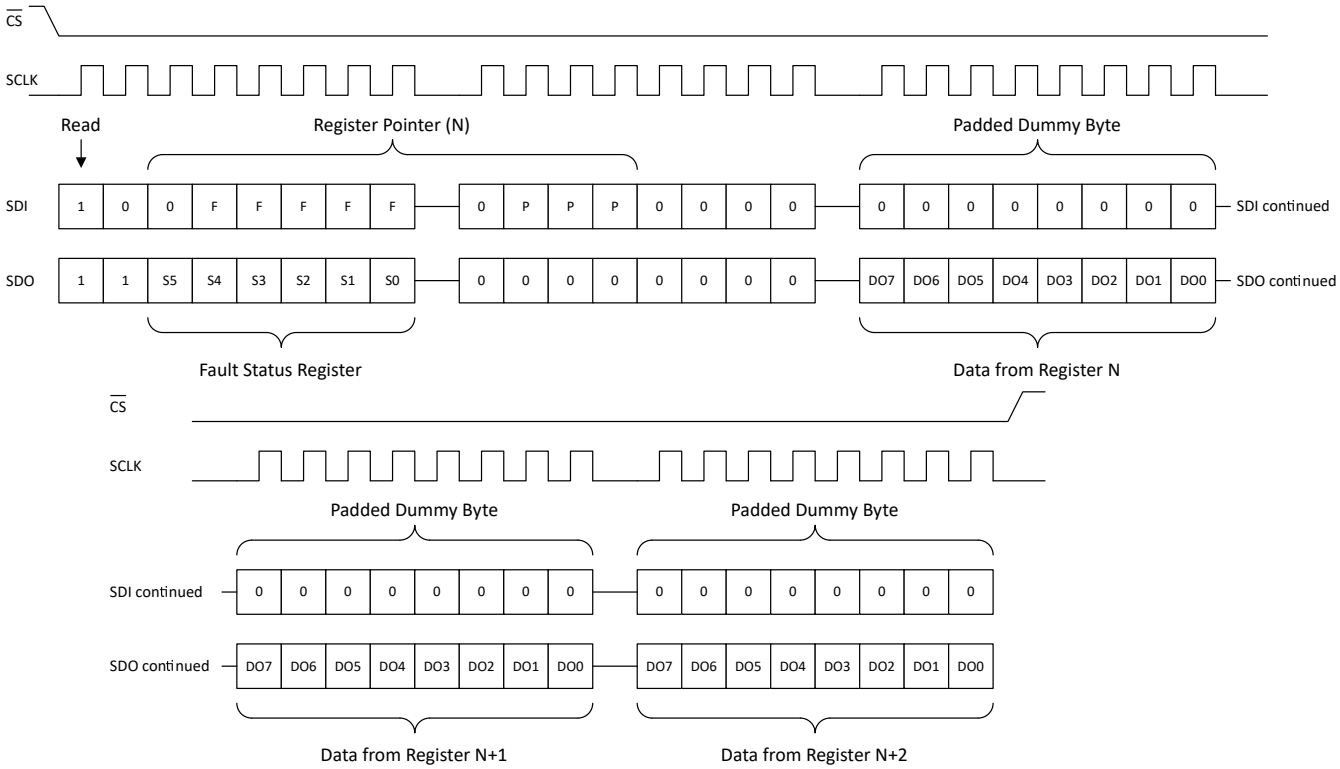


Figure 7-10. SPI Burst Read

SPI Read Operation Steps:

1. Drive $\overline{CS}$ low. This enables the internal shift register.
2. Shift 24 bits of data into the device in a MSB first fashion. Data must be stable during the rising edge of SCLK
3. The MSB bit must be a '1' indicating it is a read only transfer.
4. The third data byte is NOP (no operation) which is dummy data byte.
5. On the SDO pin the device sends the first 2 bits as 2’b11 (indicating it to be a status segment), followed by 6 bits that are the Bit 5 to 0 of Fault status register. The next 8 bits are all 0s followed by 8-bit current data in the register selected by register pointer.

6. After the last bit of data is transferred, drive SCLK low if there is no more data to be transferred.
7. De-assert $\overline{CS}$ (drive it high) to end the read cycle.

7.5.6 SPI Daisy Chain

In daisy chain mode of operation, the SPI transaction from the controller consists of 3 types of segments: Header (16-bit), Address (Nx16-bit) and Data (Nx8-bit). As the TXE8124 receives the same and transmits it to the next device in the chain, it appends a Status (16-bit) to the transaction, while removing the Address segment and replacing the Data segement that corresponds to its position in the chain.

Figure 7-11 shows an example of a daisy chain write for 2 devices in daisy chain. The header byte is transmitted with the chain length (CL) value of 2, followed by the address for DUT2, DUT1 and then the 8-bit data-in for DUT2, DUT1. As the first device shifts the data out, it transmits its status segement, followed by the original header, address for DUT2, data-out from DUT1 and data-in for DUT2. The final device in the chain sends its status, followed by status for DUT1 and finally data-out for DUT2, DUT1.

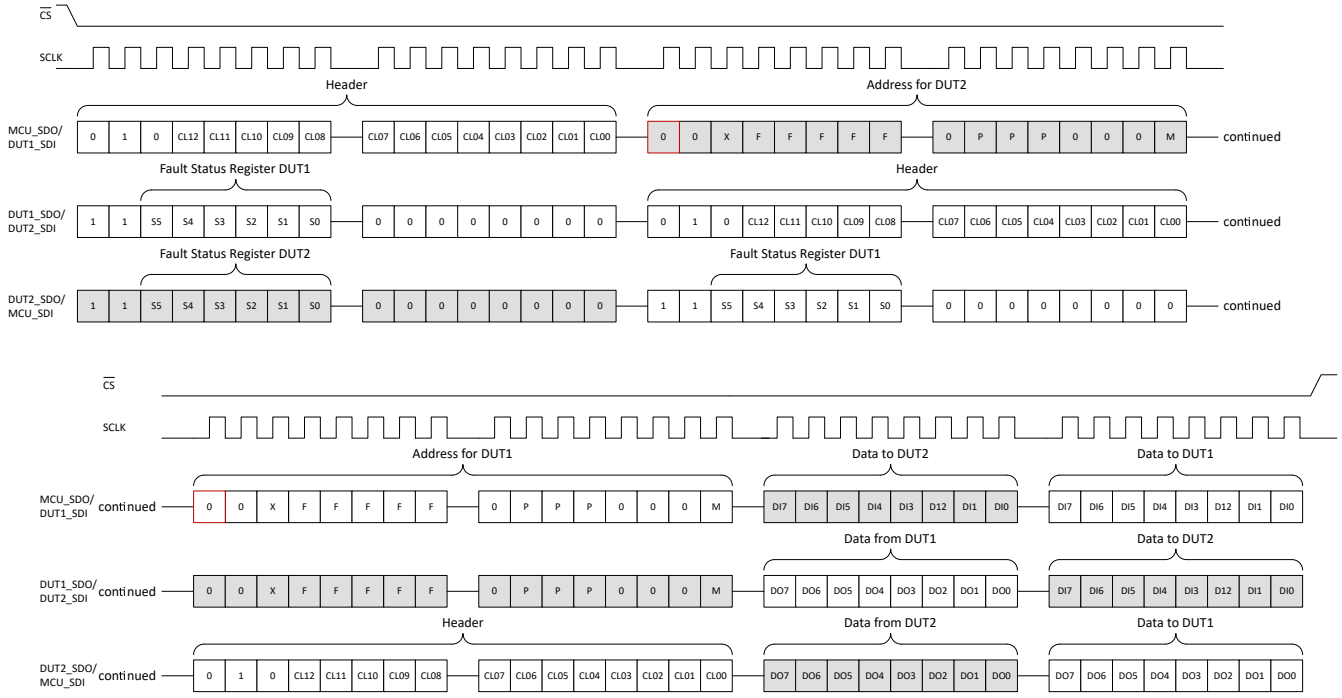


Figure 7-11. SPI Daisy Chain Write

Figure 7-12 shows an example of a daisy chain read for 2 devices in daisy chain. The header byte is transmitted with the chain length (CL) value of 2, followed by the address for DUT2, DUT1 and then the 8-bit dummy data-in for DUT2, DUT1. As the first device shifts the data out, it transmits its status segement, followed by the original header, address for DUT2, data-out from DUT1 and dummy data-in for DUT2. The final device in the chain sends its status, followed by status for DUT1 and finally data-out for DUT2, DUT1.

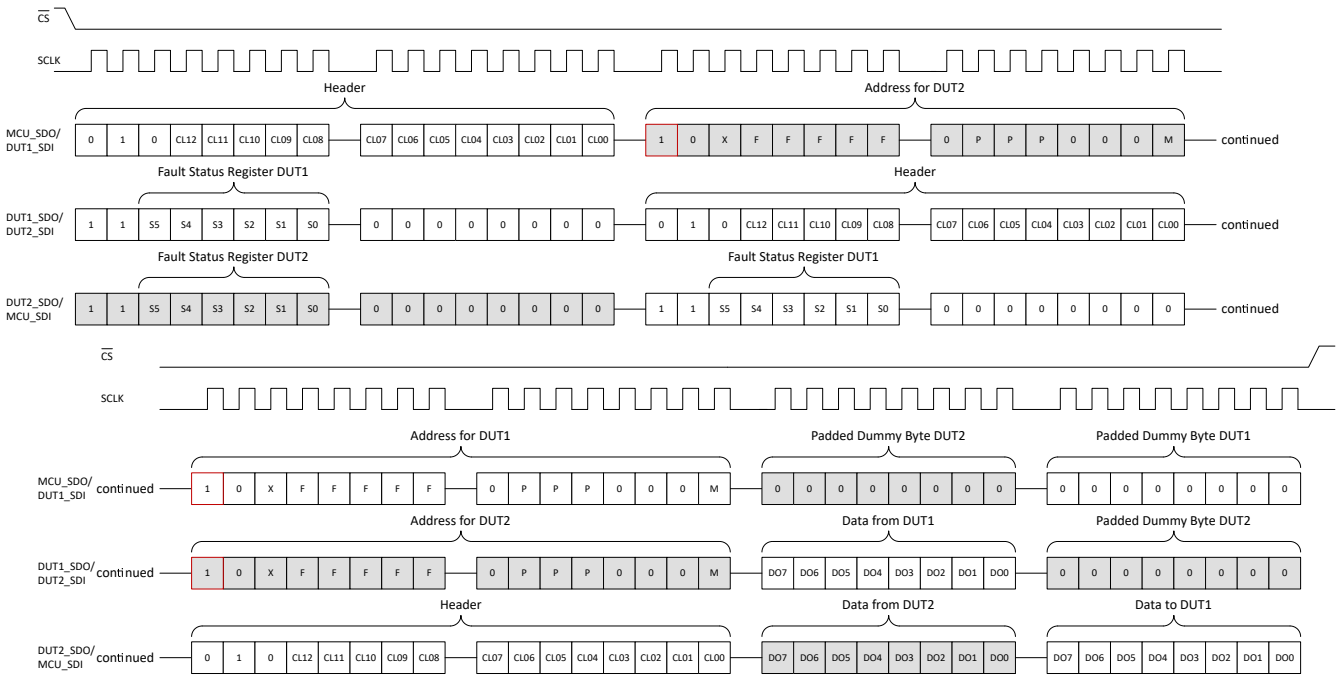


Figure 7-12. SPI Daisy Chain Read

7.6 TXE8124 Registers

Table 7-3 lists the memory-mapped registers for the TXE8124 registers. All register offset addresses not listed in Table 7-3 should be considered as reserved locations and the register contents should not be modified.

Table 7-3. TXE8124 Registers

Offset	Acronym	Register Name	Section
0h	Scratch_Register	Scratch Register	Section 7.6.1
10h	Device_ID_Register	Device ID Register	Section 7.6.2
20h + formula	Input_Port_Register_y	Input Port Register	Section 7.6.3
30h + formula	Output_Port_Register_y	Output Port Register	Section 7.6.4
40h + formula	Direction_Configuration_Register_y	Direction Configuration Register	Section 7.6.5
50h + formula	Polarity_Inversion_Register_y	Polarity Inversion Register	Section 7.6.6
60h + formula	Push_Pull/ Open_Drain_Selection_Register_y	Push Pull/Open Drain Selection Register	Section 7.6.7
80h + formula	Pull-up/Pull-down_Enable_Register_y	Pull-up/Pull-down Enable Register	Section 7.6.8
90h + formula	Pull-up/Pull-down_Selection_Register_y	Pull-up/Pull-down Selection Register	Section 7.6.9
A0h + formula	Bus_Holder_Register_y	Bus Holder Register	Section 7.6.10
B0h	Smart_Interrupt_Register	Smart Interrupt Register	Section 7.6.11
C0h + formula	Interrupt_Mask_Register_y	Interrupt Mask Register	Section 7.6.12
D0h + formula	Interrupt_Glitch_Filter_Enable_Register_y	Interrupt Glitch Filter Enable Register	Section 7.6.13
E0h + formula	Interrupt_Flag_Status_Register_y	Interrupt Flag Status Register	Section 7.6.14
F0h	Interrupt_Port_Status_Register	Interrupt Port Status Register	Section 7.6.15
120h	Fail-Safe_Enable_Register-1	Fail-safe Enable Register-1	Section 7.6.16
130h	Fail-Safe_Enable_Register-2	Fail-Safe Enable Register-2	Section 7.6.17
140h + formula	Fail-Safe_Direction_Configuration_Register-1_y	Fail-Safe Direction Configuration Register-1	Section 7.6.18
150h + formula	Fail-Safe_Direction_Configuration_Register-2_y	Fail-Safe Direction Configuration Register-2	Section 7.6.19
160h + formula	Fail-Safe_Output_Register-1_y	Fail-Safe Output Register-1	Section 7.6.20
170h + formula	Fail-Safe_Output_Register-2_y	Fail-Safe Output Register-2	Section 7.6.21
180h	Fail-Safe_Redundancy_Check_Register	Fail-Safe Redundancy Check Register	Section 7.6.22
190h	Fault_Status_Register	Fault Status Register	Section 7.6.23
1A0h	Software_Reset_Register	Software Reset Register	Section 7.6.24

Complex bit access types are encoded to fit into small table cells. Table 7-4 shows the codes that are used for access types in this section.

Table 7-4. TXE8124 Access Type Codes

Access Type	Code	Description
Read Type		

Table 7-4. TXE8124 Access Type Codes (continued)

Access Type	Code	Description
R	R	Read
Write Type		
W	W	Write
W1S	W 1S	Write 1 to set
Reset or Default Value		
-n		Value after reset or the default value
Register Array Variables		
i,j,k,l,m,n		When these variables are used in a register name, an offset, or an address, they refer to the value of a register array where the register is part of a group of repeating registers. The register groups form a hierarchical structure and the array is represented with a formula.
y		When this variable is used in a register name, an offset, or an address it refers to the value of a register array.

7.6.1 Scratch_Register (Offset = 0h) [Reset = 00h]

Scratch_Register is shown in Table 7-5.

Return to the Summary Table.

The scratch register is a test register to read/write code from/to a blank register and resolve any coding issues

Table 7-5. Scratch_Register Field Descriptions

Bit	Field	Type	Reset	Description
7-0	Scratch_Value	R/W	0h	8-bit scratch value

7.6.2 Device_ID_Register (Offset = 10h) [Reset = 01h]

Device_ID_Register is shown in Table 7-6.

Return to the Summary Table.

The device identification register that has the device ID.

Table 7-6. Device_ID_Register Field Descriptions

Bit	Field	Type	Reset	Description
7-0	Device_ID	R	1h	Device identification 0: TXE8116 1: TXE8124

7.6.3 Input_Port_Register_y (Offset = 20h + formula) [Reset = XXh]

Input_Port_Register_y is shown in Table 7-7.

Return to the Summary Table.

The input port register reflects the incoming logic level of the pins for the port, regardless of whether the configuration register defines the pin as an input or output. The input port registers are read only. Writes to these registers have no effect. The externally applied logic level determines the default value.

Offset = 20h + (y * 1h); where y = 0h to 2h

Table 7-7. Input_Port_Register_y Field Descriptions

Bit	Field	Type	Reset	Description
7	IPy.7	R	Xh	Py.7 input pin value
6	IPy.6	R	Xh	Py.6 input pin value
5	IPy.5	R	Xh	Py.5 input pin value
4	IPy.4	R	Xh	Py.4 input pin value
3	IPy.3	R	Xh	Py.3 input pin value
2	IPy.2	R	Xh	Py.2 input pin value
1	IPy.1	R	Xh	Py.1 input pin value
0	IPy.0	R	Xh	Py.0 input pin value

7.6.4 Output_Port_Register_y (Offset = 30h + formula) [Reset = 00h]

Output_Port_Register_y is shown in Table 7-8.

Return to the Summary Table.

The output port register reflect the outgoing logic levels of the pins Py.0 to Py.7, when defined as outputs by the configuration register. Bit values in the register have no effect on pins defined as inputs. Reads from the register reflect the value that is in the register and not the actual pin value.

Offset = 30h + (y * 1h); where y = 0h to 2h

Table 7-8. Output_Port_Register_y Field Descriptions

Bit	Field	Type	Reset	Description
7	OPy.7	R/W	0h	Py.7 output value
6	OPy.6	R/W	0h	Py.6 output value
5	OPy.5	R/W	0h	Py.5 output value
4	OPy.4	R/W	0h	Py.4 output value
3	OPy.3	R/W	0h	Py.3 output value
2	OPy.2	R/W	0h	Py.2 output value
1	OPy.1	R/W	0h	Py.1 output value
0	OPy.0	R/W	0h	Py.0 output value

7.6.5 Direction_Configuration_Register_y (Offset = 40h + formula) [Reset = 00h]

Direction_Configuration_Register_y is shown in Table 7-9.

Return to the Summary Table.

The direction configuration registers configure the direction of the I/O pins. If a bit in the register is set to 0, the corresponding port pin is enabled as a high-impedance input. If a bit in the register is set to 1, the corresponding port pin is enabled as an output.

Offset = 40h + (y * 1h); where y = 0h to 2h

Table 7-9. Direction_Configuration_Register_y Field Descriptions

Bit	Field	Type	Reset	Description
7	DIRy.7	R/W	0h	Py.7 configuration 0: Pin is in input mode 1: Pin is in output mode
6	DIRy.6	R/W	0h	Py.6 configuration 0: Pin is in input mode 1: Pin is in output mode
5	DIRy.5	R/W	0h	Py.5 configuration 0: Pin is in input mode 1: Pin is in output mode
4	DIRy.4	R/W	0h	Py.4 configuration 0: Pin is in input mode 1: Pin is in output mode
3	DIRy.3	R/W	0h	Py.3 configuration 0: Pin is in input mode 1: Pin is in output mode
2	DIRy.2	R/W	0h	Py.2 configuration 0: Pin is in input mode 1: Pin is in output mode
1	DIRy.1	R/W	0h	Py.1 configuration 0: Pin is in input mode 1: Pin is in output mode
0	DIRy.0	R/W	0h	Py.0 configuration 0: Pin is in input mode 1: Pin is in output mode

7.6.6 Polarity_Inversion_Register_y (Offset = 50h + formula) [Reset = 00h]

Polarity_Inversion_Register_y is shown in Table 7-10.

Return to the Summary Table.

The polarity inversion register allows polarity inversion of pins Py.0 to Py7, defined as inputs by the configuration register. If a bit in this register is set, the corresponding pin's polarity is inverted. If a bit in the register is cleared, the corresponding pin's polarity is retained.

Offset = 50h + (y * 1h); where y = 0h to 2h

Table 7-10. Polarity_Inversion_Register_y Field Descriptions

Bit	Field	Type	Reset	Description
7	PIy.7	R/W	0h	Py.7 polarity inversion 0: Polarity is unchanged 1: Polarity is inverted
6	PIy.6	R/W	0h	Py.6 polarity inversion 0: Polarity is unchanged 1: Polarity is inverted
5	PIy.5	R/W	0h	Py.5 polarity inversion 0: Polarity is unchanged 1: Polarity is inverted
4	PIy.4	R/W	0h	Py.4 polarity inversion 0: Polarity is unchanged 1: Polarity is inverted
3	PIy.3	R/W	0h	Py.3 polarity inversion 0: Polarity is unchanged 1: Polarity is inverted
2	PIy.2	R/W	0h	Py.2 polarity inversion 0: Polarity is unchanged 1: Polarity is inverted
1	PIy.1	R/W	0h	Py.1 polarity inversion 0: Polarity is unchanged 1: Polarity is inverted
0	PIy.0	R/W	0h	Py.0 polarity inversion 0: Polarity is unchanged 1: Polarity is inverted

7.6.7 Push_Pull/Open_Drain_Selection_Register_y (Offset = 60h + formula) [Reset = 00h]

Push_Pull/Open_Drain_Selection_Register_y is shown in Table 7-11.

Return to the Summary Table.

The push pull / open drain selection register is used to select the pin as push-pull or open-drain. When the bit is set, the corresponding pin is configured as open-drain (Q1 is disabled and Q2 is active). When the bit is cleared, the corresponding pin is configured as push-pull (Q1 and Q2 are active).

Offset = 60h + (y * 1h); where y = 0h to 2h

Table 7-11. Push_Pull/Open_Drain_Selection_Register_y Field Descriptions

Bit	Field	Type	Reset	Description
7	PPODy.7	R/W	0h	Py.7 output configuration bit 0: Pin is configured as output push-pull 1: Pin is configured as output open-drain
6	PPODy.6	R/W	0h	Py.6 output configuration bit 0: Pin is configured as output push-pull 1: Pin is configured as output open-drain
5	PPODy.5	R/W	0h	Py.5 output configuration bit 0: Pin is configured as output push-pull 1: Pin is configured as output open-drain
4	PPODy.4	R/W	0h	Py.4 output configuration bit 0: Pin is configured as output push-pull 1: Pin is configured as output open-drain
3	PPODy.3	R/W	0h	Py.3 output configuration bit 0: Pin is configured as output push-pull 1: Pin is configured as output open-drain
2	PPODy.2	R/W	0h	Py.2 output configuration bit 0: Pin is configured as output push-pull 1: Pin is configured as output open-drain
1	PPODy.1	R/W	0h	Py.1 output configuration bit 0: Pin is configured as output push-pull 1: Pin is configured as output open-drain
0	PPODy.0	R/W	0h	Py.0 output configuration bit 0: Pin is configured as output push-pull 1: Pin is configured as output open-drain

7.6.8 Pull-up/Pull-down_Enable_Register_y (Offset = 80h + formula) [Reset = 00h]

Pull-up/Pull-down_Enable_Register_y is shown in Table 7-12.

Return to the Summary Table.

The pull-up/pull-down enable register allows the user to enable or disable pull-up/pull-down resistors on the GPIO pins. Setting the bit enables the selection of pull-up/pull-down resistors on the pins. Clearing the bit disconnects the pull-up/pull-down resistors from the pins. The resistors are disabled when the corresponding pins are configured as outputs.

Offset = 80h + (y * 1h); where y = 0h to 2h

Table 7-12. Pull-up/Pull-down_Enable_Register_y Field Descriptions

Bit	Field	Type	Reset	Description
7	PEy.7	R/W	0h	Py.7 pull-up/pull-down enable 0: Pull-up/Pull-down is disabled on the pin 1: Pull-up/Pull-down is enabled on the pin
6	PEy.6	R/W	0h	Py.6 pull-up/pull-down enable 0: Pull-up/Pull-down is disabled on the pin 1: Pull-up/Pull-down is enabled on the pin
5	PEy.5	R/W	0h	Py.5 pull-up/pull-down enable 0: Pull-up/Pull-down is disabled on the pin 1: Pull-up/Pull-down is enabled on the pin
4	PEy.4	R/W	0h	Py.4 pull-up/pull-down enable 0: Pull-up/Pull-down is disabled on the pin 1: Pull-up/Pull-down is enabled on the pin
3	PEy.3	R/W	0h	Py.3 pull-up/pull-down enable 0: Pull-up/Pull-down is disabled on the pin 1: Pull-up/Pull-down is enabled on the pin
2	PEy.2	R/W	0h	Py.2 pull-up/pull-down enable 0: Pull-up/Pull-down is disabled on the pin 1: Pull-up/Pull-down is enabled on the pin
1	PEy.1	R/W	0h	Py.1 pull-up/pull-down enable 0: Pull-up/Pull-down is disabled on the pin 1: Pull-up/Pull-down is enabled on the pin
0	PEy.0	R/W	0h	Py.0 pull-up/pull-down enable 0: Pull-up/Pull-down is disabled on the pin 1: Pull-up/Pull-down is enabled on the pin

7.6.9 Pull-up/Pull-down_Selection_Register_y (Offset = 90h + formula) [Reset = 00h]

Pull-up/Pull-down_Selection_Register_y is shown in Table 7-13.

Return to the Summary Table.

The pull-up/pull-down selection register allows the user to configure each GPIO pin to have a pull-up or pull-down resistors. Setting the bit enables the pull-up resistors on the pins. Clearing the bit enables the pull-down resistors on the pins. If the pull-up/pull-down feature is disabled, then writing to the register will have no effect.

Offset = 90h + (y * 1h); where y = 0h to 2h

Table 7-13. Pull-up/Pull-down_Selection_Register_y Field Descriptions

Bit	Field	Type	Reset	Description
7	PUDy.7	R/W	0h	Py.7 pull-up/pull-down selection 0: Pull-down resistor is enabled on the pin 1: Pull-up resistor is enabled on the pin
6	PUDy.6	R/W	0h	Py.6 pull-up/pull-down selection 0: Pull-down resistor is enabled on the pin 1: Pull-up resistor is enabled on the pin
5	PUDy.5	R/W	0h	Py.5 pull-up/pull-down selection 0: Pull-down resistor is enabled on the pin 1: Pull-up resistor is enabled on the pin
4	PUDy.4	R/W	0h	Py.4 pull-up/pull-down selection 0: Pull-down resistor is enabled on the pin 1: Pull-up resistor is enabled on the pin
3	PUDy.3	R/W	0h	Py.3 pull-up/pull-down selection 0: Pull-down resistor is enabled on the pin 1: Pull-up resistor is enabled on the pin
2	PUDy.2	R/W	0h	Py.2 pull-up/pull-down selection 0: Pull-down resistor is enabled on the pin 1: Pull-up resistor is enabled on the pin
1	PUDy.1	R/W	0h	Py.1 pull-up/pull-down selection 0: Pull-down resistor is enabled on the pin 1: Pull-up resistor is enabled on the pin
0	PUDy.0	R/W	0h	Py.0 pull-up/pull-down selection 0: Pull-down resistor is enabled on the pin 1: Pull-up resistor is enabled on the pin

7.6.10 Bus_Holder_Register_y (Offset = A0h + formula) [Reset = 00h]

Bus_Holder_Register_y is shown in Table 7-14.

Return to the Summary Table.

The bus holder register enables or disables the bus-hold or bus-keeper function of the GPIO pins. The feature is available only when the pin is configured as an input pin. When the register bit is set, the corresponding input pin state holds the line at its last known logical state when the device driving the pin floats its output.

Offset = A0h + (y * 1h); where y = 0h to 2h

Table 7-14. Bus_Holder_Register_y Field Descriptions

Bit	Field	Type	Reset	Description
7	BHy.07	R/W	0h	Py.7 bus holder configuration 0: Bus hold on the pin is disabled 1: Bus hold on the pin is enabled
6	BHy.6	R/W	0h	Py.6 bus holder configuration 0: Bus hold on the pin is disabled 1: Bus hold on the pin is enabled
5	BHy.5	R/W	0h	Py.5 bus holder configuration 0: Bus hold on the pin is disabled 1: Bus hold on the pin is enabled
4	BHy.4	R/W	0h	Py.4 bus holder configuration 0: Bus hold on the pin is disabled 1: Bus hold on the pin is enabled
3	BHy.3	R/W	0h	Py.3 bus holder configuration 0: Bus hold on the pin is disabled 1: Bus hold on the pin is enabled
2	BHy.2	R/W	0h	Py.2 bus holder configuration 0: Bus hold on the pin is disabled 1: Bus hold on the pin is enabled
1	BHy.1	R/W	0h	Py.1 bus holder configuration 0: Bus hold on the pin is disabled 1: Bus hold on the pin is enabled
0	BHy.0	R/W	0h	Py.0 bus holder configuration 0: Bus hold on the pin is disabled 1: Bus hold on the pin is enabled

7.6.11 Smart_Interrupt_Register (Offset = B0h) [Reset = 00h]

Smart_Interrupt_Register is shown in Table 7-15.

Return to the Summary Table.

The register is used to enable or disable the smart interrupt function. When the bit is set to 0 (smart interrupt enabled), a state change in any input pin generates an interrupt and if the input goes back to its initial state, the interrupt is cleard.
When the bit is set to 1 (smart interrupt disabled), a state change in any input pin generates an interrupt and if the input goes back to its initial state, the interrupt is not cleared. A read of the interrupt status flag register will clear the interrupt.
This feature is enabled at the port level only.

Table 7-15. Smart_Interrupt_Register Field Descriptions

Bit	Field	Type	Reset	Description
7-3	RESERVED	R	0h	Do not use
2	SI.P2	R/W	0h	Smart Interrupt for Port 2 0: Enabled 1: Disabled
1	SI.P1	R/W	0h	Smart Interrupt for Port 1 0: Enabled 1: Disabled
0	SI.P0	R/W	0h	Smart Interrupt for Port 0 0: Enabled 1: Disabled

7.6.12 Interrupt_Mask_Register_y (Offset = C0h + formula) [Reset = FFh]

Interrupt_Mask_Register_y is shown in Table 7-16.

Return to the Summary Table.

The interrupt mask register enables or disable interrupt generation from pins. If the mask register bit is set, and the input state of a pin changes, then interrupt is not asserted. If the mask register bit is cleared, and the input state of a pin changes, then interrupt is asserted.

Offset = C0h + (y * 1h); where y = 0h to 2h

Table 7-16. Interrupt_Mask_Register_y Field Descriptions

Bit	Field	Type	Reset	Description
7	IMy.7	R/W	1h	Py.7 interrupt mask bit 0: Interrupt is not masked on state change of the pin 1: Interrupt is masked on state change of the pin
6	IMy.6	R/W	1h	Py.6 interrupt mask bit 0: Interrupt is not masked on state change of the pin 1: Interrupt is masked on state change of the pin
5	IMy.5	R/W	1h	Py.5 interrupt mask bit 0: Interrupt is not masked on state change of the pin 1: Interrupt is masked on state change of the pin
4	IMy.4	R/W	1h	Py.4 interrupt mask bit 0: Interrupt is not masked on state change of the pin 1: Interrupt is masked on state change of the pin
3	IMy.3	R/W	1h	Py.3 interrupt mask bit 0: Interrupt is not masked on state change of the pin 1: Interrupt is masked on state change of the pin
2	IMy.2	R/W	1h	Py.2 interrupt mask bit 0: Interrupt is not masked on state change of the pin 1: Interrupt is masked on state change of the pin
1	IMy.1	R/W	1h	Py.1 interrupt mask bit 0: Interrupt is not masked on state change of the pin 1: Interrupt is masked on state change of the pin
0	IMy.0	R/W	1h	Py.0 interrupt mask bit 0: Interrupt is not masked on state change of the pin 1: Interrupt is masked on state change of the pin

7.6.13 Interrupt_Glitch_Filter_Enable_Register_y (Offset = D0h + formula) [Reset = 00h]

Interrupt_Glitch_Filter_Enable_Register_y is shown in Table 7-17.

Return to the Summary Table.

The interrupt glitch filter register enables or disable the glitch filter on the I/O. If the bit is set to 1, the glitch filter for the corresponding pin is enabled. If the bit is set to 0, the glitch filter for the corresponding pin is disabled.

Offset = D0h + (y * 1h); where y = 0h to 2h

Table 7-17. Interrupt_Glitch_Filter_Enable_Register_y Field Descriptions

Bit	Field	Type	Reset	Description
7	GFy.7	R/W	0h	Py.7 glitch filter enable bit 0: Glitch filter is disabled 1: Glitch filter is enabled
6	GFy.6	R/W	0h	Py.6 glitch filter enable bit 0: Glitch filter is disabled 1: Glitch filter is enabled
5	GFy.5	R/W	0h	Py.5 glitch filter enable bit 0: Glitch filter is disabled 1: Glitch filter is enabled
4	GFy.4	R/W	0h	Py.4 glitch filter enable bit 0: Glitch filter is disabled 1: Glitch filter is enabled
3	GFy.3	R/W	0h	Py.3 glitch filter enable bit 0: Glitch filter is disabled 1: Glitch filter is enabled
2	GFy.2	R/W	0h	Py.2 glitch filter enable bit 0: Glitch filter is disabled 1: Glitch filter is enabled
1	GFy.1	R/W	0h	Py.1 glitch filter enable bit 0: Glitch filter is disabled 1: Glitch filter is enabled
0	GFy.0	R/W	0h	Py.0 glitch filter enable bit 0: Glitch filter is disabled 1: Glitch filter is enabled

7.6.14 Interrupt_Flag_Status_Register_y (Offset = E0h + formula) [Reset = 00h]

Interrupt_Flag_Status_Register_y is shown in Table 7-18.

Return to the Summary Table.

The interrupt status register is read only register bits used to identify the source of an interrupt. When read, a logic 1 indicates that the corresponding input pin was the source of the interrupt. A logic 0 indicates that the input pin is not the source of the an interrupt. When the corresponding bit in the interrupt mask register is set to 1 (masked), the interrupt status bit will return a logic 0.

Offset = E0h + (y * 1h); where y = 0h to 2h

Table 7-18. Interrupt_Flag_Status_Register_y Field Descriptions

Bit	Field	Type	Reset	Description
7	ISy.7	R	0h	Py.7 interrupt status bit 0: Pin is not the source of interrupt 1: Pin is the source of the interrupt
6	ISy.6	R	0h	Py.6 interrupt status bit 0: Pin is not the source of interrupt 1: Pin is the source of the interrupt
5	ISy.5	R	0h	Py.5 interrupt status bit 0: Pin is not the source of interrupt 1: Pin is the source of the interrupt
4	ISy.4	R	0h	Py.4 interrupt status bit 0: Pin is not the source of interrupt 1: Pin is the source of the interrupt
3	ISy.3	R	0h	Py.3 interrupt status bit 0: Pin is not the source of interrupt 1: Pin is the source of the interrupt
2	ISy.2	R	0h	Py.2 interrupt status bit 0: Pin is not the source of interrupt 1: Pin is the source of the interrupt
1	ISy.1	R	0h	Py.1 interrupt status bit 0: Pin is not the source of interrupt 1: Pin is the source of the interrupt
0	ISy.0	R	0h	Py.0 interrupt status bit 0: Pin is not the source of interrupt 1: Pin is the source of the interrupt

7.6.15 Interrupt_Port_Status_Register (Offset = F0h) [Reset = 00h]

Interrupt_Port_Status_Register is shown in Table 7-19.

Return to the Summary Table.

The register is used to identify the IO port for the interrupt source. If the value of the bit is 1, it indicates that the source of the interrupt is from the corresponding IO port. If the value is 0, it indicates that none of the input pins in the IO port generated an interrupt.

Table 7-19. Interrupt_Port_Status_Register Field Descriptions

Bit	Field	Type	Reset	Description
7-3	RESERVED	R	0h	Do not use
2	IPS.P2	R/W	0h	Interrupt Status for Port 2 0: No interrupt from Port 2 1: Interrupt from Port 2
1	IPS.P1	R/W	0h	Interrupt Status for Port 1 0: No interrupt from Port 1 1: Interrupt from Port 1
0	IPS.P0	R/W	0h	Interrupt Status for Port 0 0: No interrupt from Port 0 1: Interrupt from Port 0

7.6.16 Fail-Safe_Enable_Register-1 (Offset = 120h) [Reset = 00h]

Fail-Safe_Enable_Register-1 is shown in Table 7-20.

Return to the Summary Table.

This register reconfigures the reset pin as a fail-safe pin. The register is cleared on POR or fault condition as mentioned in the fault status register.
There are two fail-safe registers in the device that have to be written to program the I/O configuration with built-in redundancy. If the value in the two registers mismatch, it will generate an interrupt with fault status set accordingly.

Table 7-20. Fail-Safe_Enable_Register-1 Field Descriptions

Bit	Field	Type	Reset	Description
7-1	RESERVED	R	0h	Do not use
0	FS1EN	R/W	0h	Fail-Safe Enable bit 0: Disable 1: Enable

7.6.17 Fail-Safe_Enable_Register-2 (Offset = 130h) [Reset = 00h]

Fail-Safe_Enable_Register-2 is shown in Table 7-21.

Return to the Summary Table.

This register reconfigures the reset pin as a fail-safe pin. The register is cleared on POR or fault condition as mentioned in the fault status register.
There are two fail-safe registers in the device that have to be written to program the I/O configuration with built-in redundancy. If the value in the two registers mismatch, it will generate an interrupt with fault status set accordingly.

Table 7-21. Fail-Safe_Enable_Register-2 Field Descriptions

Bit	Field	Type	Reset	Description
7-1	RESERVED	R	0h	Do not use
0	FS2EN	R/W	0h	Fail-Safe Enable bit 0: Disable 1: Enable

7.6.18 Fail-Safe_Direction_Configuration_Register-1_y (Offset = 140h + formula) [Reset = 00h]

Fail-Safe_Direction_Configuration_Register-1_y is shown in Table 7-22.

Return to the Summary Table.

The fail-safe direction configuration register-1 configure the direction of the I/O pins when the device enters a fail-safe state. If a bit in these register is set to 0, the corresponding IO pin is enabled as a high-impedance input during fail-safe mode. If a bit is set to 1, the corresponding IO pin is enabled as an output during fail-safe mode. There are two registers per port, that have to be written to program the I/O configuration to ensure redundancy. If the registers mismatch, it will generate an interrupt with fault status set accordingly.

Offset = 140h + (y * 1h); where y = 0h to 2h

Table 7-22. Fail-Safe_Direction_Configuration_Register-1_y Field Descriptions

Bit	Field	Type	Reset	Description
7	FS1DIRy.7	R/W	0h	Py.7 fail-safe configuration bit 0: Pin is configured in input mode 1: Pin is configured in output mode
6	FS1DIRy.6	R/W	0h	Py.6 fail-safe configuration bit 0: Pin is configured in input mode 1: Pin is configured in output mode
5	FS1DIRy.5	R/W	0h	Py.5 fail-safe configuration bit 0: Pin is configured in input mode 1: Pin is configured in output mode
4	FS1DIRy.4	R/W	0h	Py.4 fail-safe configuration bit 0: Pin is configured in input mode 1: Pin is configured in output mode
3	FS1DIRy.3	R/W	0h	Py.3 fail-safe configuration bit 0: Pin is configured in input mode 1: Pin is configured in output mode
2	FS1DIRy.2	R/W	0h	Py.2 fail-safe configuration bit 0: Pin is configured in input mode 1: Pin is configured in output mode
1	FS1DIRy.1	R/W	0h	Py.1 fail-safe configuration bit 0: Pin is configured in input mode 1: Pin is configured in output mode
0	FS1DIRy.0	R/W	0h	Py.0 fail-safe configuration bit 0: Pin is configured in input mode 1: Pin is configured in output mode

7.6.19 Fail-Safe_Direction_Configuration_Register-2_y (Offset = 150h + formula) [Reset = 00h]

Fail-Safe_Direction_Configuration_Register-2_y is shown in Table 7-23.

Return to the Summary Table.

The fail-safe direction configuration register-2 configure the direction of the I/O pins when the device enters a fail-safe state. If a bit in these register is set to 0, the corresponding IO pin is enabled as a high-impedance input during fail-safe mode. If a bit is set to 1, the corresponding IO pin is enabled as an output during fail-safe mode. There are two registers per port, that have to be written to program the I/O configuration to ensure redundancy. If the registers mismatch, it will generate an interrupt with fault status set accordingly.

Offset = 150h + (y * 1h); where y = 0h to 2h

Table 7-23. Fail-Safe_Direction_Configuration_Register-2_y Field Descriptions

Bit	Field	Type	Reset	Description
7	FS2DIRy.7	R/W	0h	Py.7 fail-safe configuration bit 0: Pin is configured in input mode 1: Pin is configured in output mode
6	FS2DIRy.6	R/W	0h	Py.6 fail-safe configuration bit 0: Pin is configured in input mode 1: Pin is configured in output mode
5	FS2DIRy.5	R/W	0h	Py.5 fail-safe configuration bit 0: Pin is configured in input mode 1: Pin is configured in output mode
4	FS2DIRy.4	R/W	0h	Py.4 fail-safe configuration bit 0: Pin is configured in input mode 1: Pin is configured in output mode
3	FS2DIRy.3	R/W	0h	Py.3 fail-safe configuration bit 0: Pin is configured in input mode 1: Pin is configured in output mode
2	FS2DIRy.2	R/W	0h	Py.2 fail-safe configuration bit 0: Pin is configured in input mode 1: Pin is configured in output mode
1	FS2DIRy.1	R/W	0h	Py.1 fail-safe configuration bit 0: Pin is configured in input mode 1: Pin is configured in output mode
0	FS2DIRy.0	R/W	0h	Py.0 fail-safe configuration bit 0: Pin is configured in input mode 1: Pin is configured in output mode

7.6.20 Fail-Safe_Output_Register-1_y (Offset = 160h + formula) [Reset = 00h]

Fail-Safe_Output_Register-1_y is shown in Table 7-24.

Return to the Summary Table.

The fail-safe output register-1 configure the output level of the pins defined as output by the fail-safe configuration register. Bit values in the register have no effect on pins defined as input.
There are two registers per port, that have to be written to with the same output value to ensure redundancy. If the registers mismatch, it will generate an interrupt with fault status set accordingly.

Offset = 160h + (y * 1h); where y = 0h to 2h

Table 7-24. Fail-Safe_Output_Register-1_y Field Descriptions

Bit	Field	Type	Reset	Description
7	FS1OPy.7	R/W	0h	Py.7 fail-safe output value
6	FS1OPy.6	R/W	0h	Py.6 fail-safe output value
5	FS1OPy.5	R/W	0h	Py.5 fail-safe output value
4	FS1OPy.4	R/W	0h	Py.4 fail-safe output value
3	FS1OPy.3	R/W	0h	Py.3 fail-safe output value
2	FS1OPy.2	R/W	0h	Py.2 fail-safe output value
1	FS1OPy.1	R/W	0h	Py.1 fail-safe output value
0	FS1OPy.0	R/W	0h	Py.0 fail-safe output value

7.6.21 Fail-Safe_Output_Register-2_y (Offset = 170h + formula) [Reset = 00h]

Fail-Safe_Output_Register-2_y is shown in Table 7-25.

Return to the Summary Table.

The fail-safe output register-2 configure the output level of the pins defined as output by the fail-safe configuration register. Bit values in the register have no effect on pins defined as input.
There are two registers per port, that have to be written to with the same output value to ensure redundancy. If the registers mismatch, it will generate an interrupt with fault status set accordingly.

Offset = 170h + (y * 1h); where y = 0h to 2h

Table 7-25. Fail-Safe_Output_Register-2_y Field Descriptions

Bit	Field	Type	Reset	Description
7	FS2OPy.7	R/W	0h	Py.7 fail-safe output value
6	FS2OPy.6	R/W	0h	Py.6 fail-safe output value
5	FS2OPy.5	R/W	0h	Py.5 fail-safe output value
4	FS2OPy.4	R/W	0h	Py.4 fail-safe output value
3	FS2OPy.3	R/W	0h	Py.3 fail-safe output value
2	FS2OPy.2	R/W	0h	Py.2 fail-safe output value
1	FS2OPy.1	R/W	0h	Py.1 fail-safe output value
0	FS2OPy.0	R/W	0h	Py.0 fail-safe output value

7.6.22 Fail-Safe_Redundancy_Check_Register (Offset = 180h) [Reset = 00h]

Fail-Safe_Redundancy_Check_Register is shown in Table 7-26.

Return to the Summary Table.

The fail-safe redundancy check register is used to enable the check on the fail-safe redundant registers (fail-safe enable register, fail-safe direction configuration register and fail-safe output register).

Table 7-26. Fail-Safe_Redundancy_Check_Register Field Descriptions

Bit	Field	Type	Reset	Description
7-1	RESERVED	R	0h	Do not use
0	FSCHECKEN	R/W	0h	Fail-Safe Check Enable bit 0: Disable 1: Enable

7.6.23 Fault_Status_Register (Offset = 190h) [Reset = 01h]

Fault_Status_Register is shown in Table 7-27.

Return to the Summary Table.

The fault status register are set during fault conditions. Bit-0 is set to 1 for POR recovery. Bit-1 is set when the redundancy register has a mismatch. Bit-2 is set when the device is in fail safe mode. These flags are not cleared even if the fault condition goes away. They can only be cleared by performing a read of the fault status register.

Table 7-27. Fault_Status_Register Field Descriptions

Bit	Field	Type	Reset	Description
7-3	RESERVED	R	0h	Do not use
2	FSMODEACTIVE	R	0h	Fail Safe function is Active
1	REGMISMATCH	R	0h	Fail Safe function cleared due to register mismatch
0	POR	R	1h	POR recovery status

7.6.24 Software_Reset_Register (Offset = 1A0h) [Reset = 00h]

Software_Reset_Register is shown in Table 7-28.

Return to the Summary Table.

The register is used to trigger a software reset of the device. The register is auto-cleared when the reset state is entered.

Table 7-28. Software_Reset_Register Field Descriptions

Bit	Field	Type	Reset	Description
7-2	RESERVED	R	0h	Do not use
1	Register_Reset	R/W1S	0h	When set triggers reset of all registers
0	Device_Reset	R/W1S	0h	When set triggers reset of the full device

8 Application and Implementation

Note

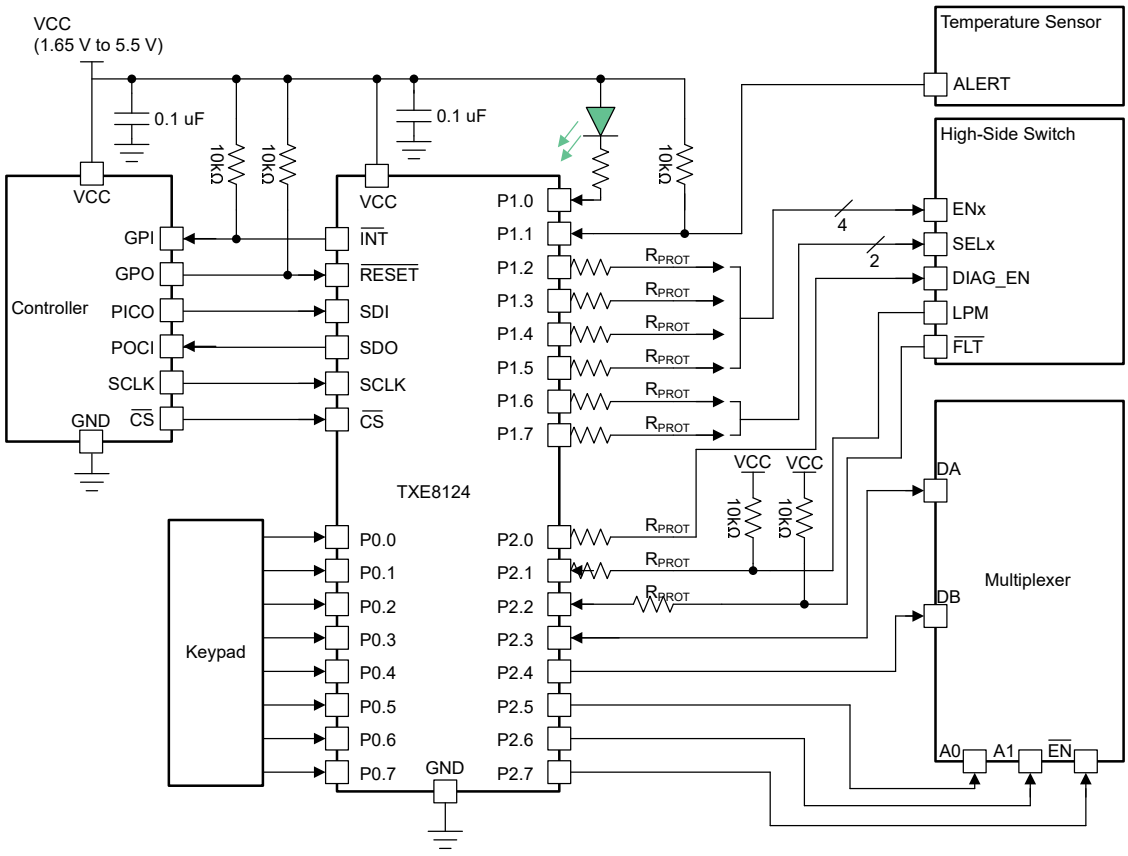
Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation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

8.1 Application Information

Applications of the TXE8124 use this device connected as a target to a SPI controller (processor), and the SPI bus may contain any number of other target devices. The TXE8124 is in a remote location from the controller, placed close to the GPIOs to which the controller needs to monitor or control.

8.2 Typical Application

Figure 8-1 shows an application in which the TXE8124 devices can be used.



A. P0.0 – P0.7, P1.0, P1.1, P2.1 – P2.3, are configured as inputs.
B. P1.2 – P1.7, P2.0, P2.4-P2.7, are configured as outputs.
C. Resistors are required for inputs (on P-port) that may float. If a driver to an input will never let the input float, a resistor is not needed. Outputs (in the P-port) do not need pullup resistors.

Figure 8-1. Typical Application Schematic

A sample application code example is shown below, that may be used for accessing the device.

```
uint32_t SPIExchangeData(uint32_t transmitData)
{
```

```
    uint32_t receiveData=0x0;

    for(int i = 23; i >= 0; i--)
    {
         // Shift out MSB first
         SPISendBit((transmitData >> i) & 0x01);
         receiveData |= SPIGetBit() << i;
    }

    return(receiveData);
}

uint32_t  SPITransmitReceive(uint32_t  RnW,  uint32_t  regPointer,  uint32_t  multiPort,  uint32_t
transmitData)
{
    uint32_t regWrData=0x0;
    uint32_t regRdData=0x0;

    regWrData = RnW          << 23 | \
                regPointer   << 12 | \
                mulitPort    << 8  | \
                transmitData << 0;

    regRdData = SPIExchangeData(regWrData);

    return(regRdData);
}
```

8.3 Power Supply Recommendations

8.3.1 Power-On Reset Requirements

In the event of a glitch or data corruption, TXE8124 can be reset to its default conditions by using the power-on reset feature. Power-on reset requires that the device go through a power cycle to be completely reset. This reset also happens when the device is powered on for the first time in an application.

The two types of power-on reset are shown in Figure 8-2 and Figure 8-3 .

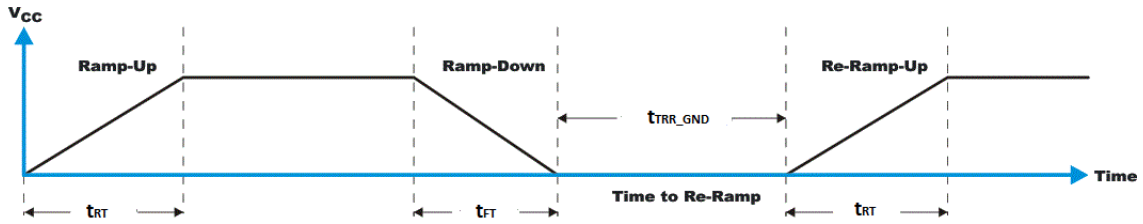


Figure 8-2. V_{CC} is lowered to 0V and then ramped up

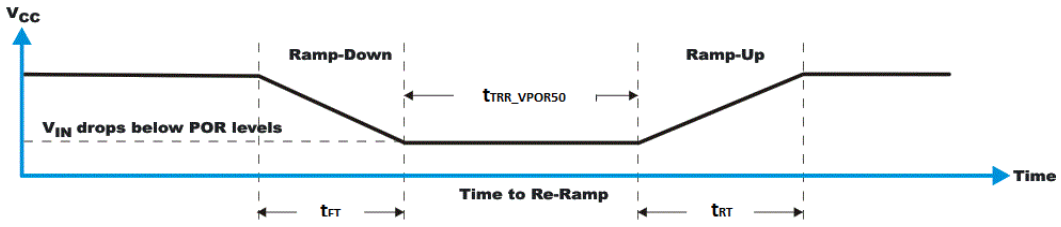


Figure 8-3. V_{CC} is lowered below the POR threshold, then ramped back up

Glitches in the power supply can also affect the power-on reset performance of this device. The glitch width (t_{VCC_GW}) and height (V_{CC_GH}) are dependent on each other. The bypass capacitance, source impedance, and device impedance are factors that affect power-on reset performance. Figure 8-4 provides more information on how to measure these specifications.

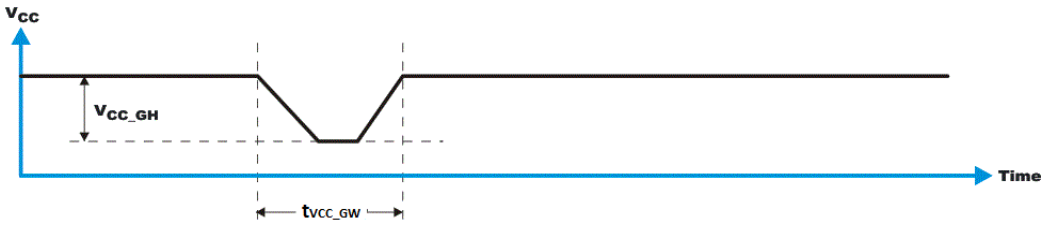


Figure 8-4. Glitch Width and Glitch Height

V_{POR} is critical to the power-on reset. V_{POR} is the voltage level at which the reset condition is released and all the registers and the SPI state machine are initialized to their default states. The value of V_{POR} differs based on the V_{CC} being lowered to or from 0. Figure 8-5 provides more detail on this specification.

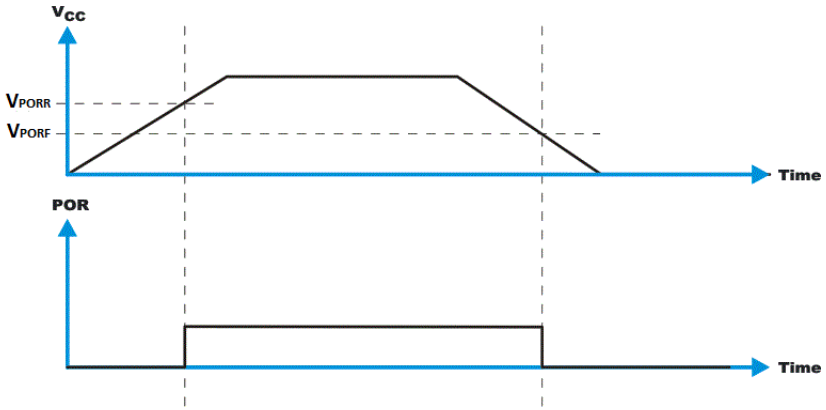


Figure 8-5. V_{POR}

8.4 Layout

8.4.1 Layout Guidelines

For printed circuit board (PCB) layout of the TXE8124, common PCB layout practices must be followed but additional concerns related to high-speed data transfer such as matched impedance and differential pairs are not a concern for SPI signal speeds.

In all PCB layouts, it is a best practice to avoid right angles in signal traces, to fan out signal traces away from each other upon leaving the vicinity of an integrated circuit (IC), and to use thicker trace widths to carry higher amounts of current that commonly pass through power and ground traces. By-pass and decoupling capacitors are commonly used to control the voltage on the supply pins, using a larger capacitor to provide additional power in the event of a short power supply glitch and a smaller capacitor to filter out high-frequency ripple. These capacitors must be placed as close to the TXE8124 as possible. These best practices are shown in Figure 8-6.

For the layout example provided in Figure 8-6, it is possible to fabricate a PCB with only 2 layers by using the top layer for signal routing and the bottom layer as a split plane for power and ground (GND). However, a 4 layer board is preferable for boards with higher density signal routing. On a 4 layer PCB, it is common to route signals on the top and bottom layer, dedicate one internal layer to a ground plane, and dedicate the other internal layer to a power plane. In a board layout using planes or split planes for power and ground, vias are placed directly next to the surface mount component pad which needs to attach to power or GND and the via is connected electrically to the internal layer or the other side of the board. Vias are also used when a signal trace needs to be routed to the opposite side of the board, but this technique is not demonstrated in Figure 8-6.

8.4.2 Layout Example

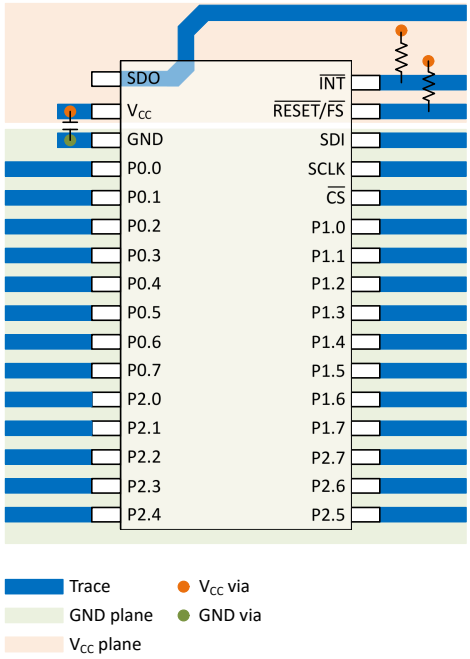


Figure 8-6. TXE8124 Layout

9 Device and Documentation Support

9.1 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. Click on *Notifications* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

9.2 Support Resources

TI E2E™ support forums are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

9.3 Trademarks

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

9.4 Electrostatic Discharge Caution

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

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

9.5 Glossary

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

10 Revision History

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

DATE	REVISION	NOTES
March 2026	*	Initial Release

11 Mechanical, Packaging, and Orderable Information

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

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package | Pins	Package qty | Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
TXE8124DGSR	Active	Production	VSSOP (DGS) | 32	5000 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	TE8124R
TXE8124RHBR	Active	Production	VQFN (RHB) | 32	5000 | LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	T8124R

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

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

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

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

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

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

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

OTHER QUALIFIED VERSIONS OF TXE8124 :

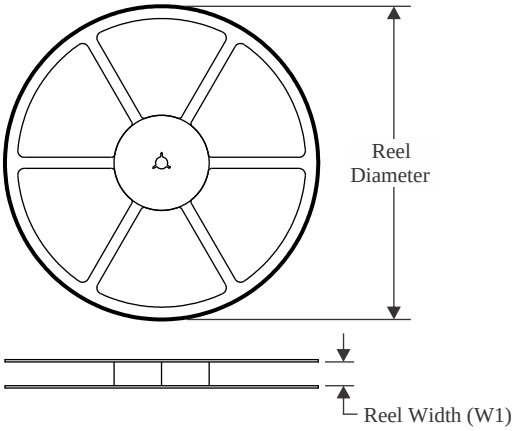
- Automotive : TXE8124-Q1

NOTE: Qualified Version Definitions:

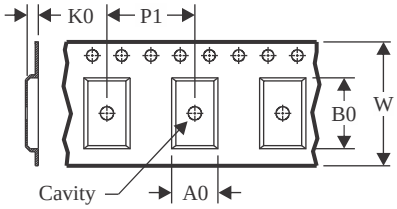
- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

TAPE AND REEL INFORMATION

REEL DIMENSIONS

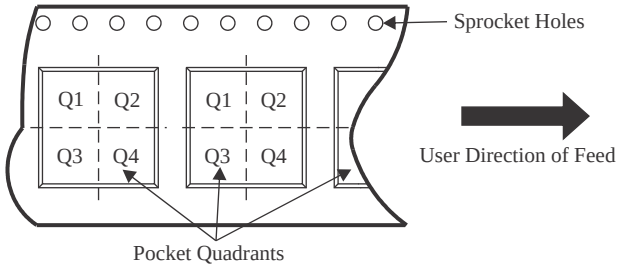


TAPE DIMENSIONS



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

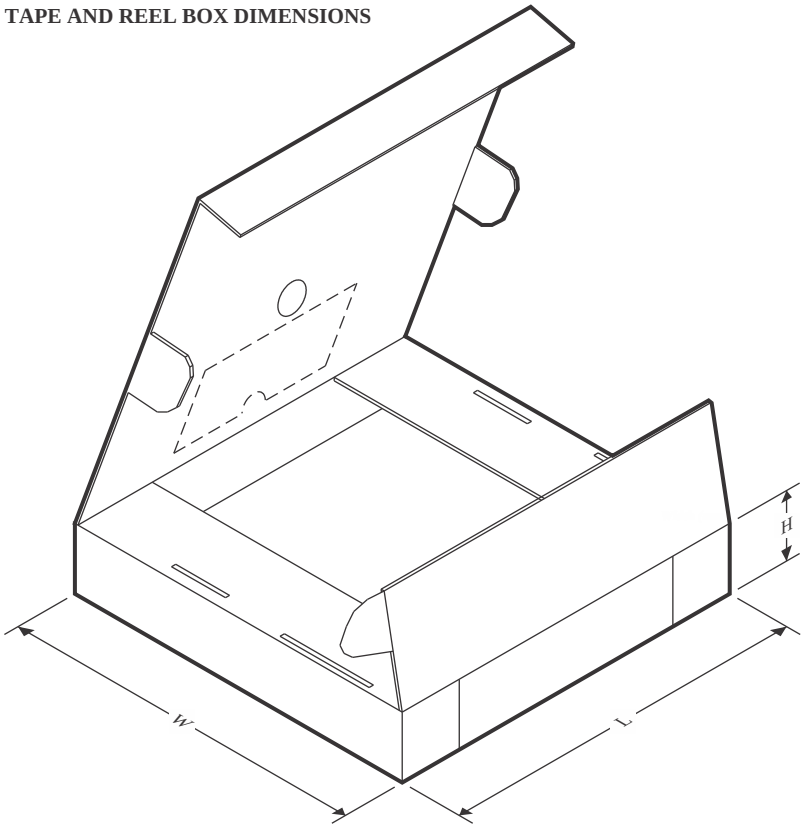
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

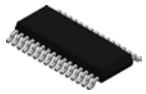
Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TXE8124DGSR	VSSOP	DGS	32	5000	330.0	16.4	5.65	8.4	1.45	8.0	16.0	Q1
TXE8124RHBR	VQFN	RHB	32	5000	330.0	12.4	5.3	5.3	1.1	8.0	12.0	Q2

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TXE8124DGSR	VSSOP	DGS	32	5000	353.0	353.0	32.0
TXE8124RHBR	VQFN	RHB	32	5000	367.0	367.0	35.0

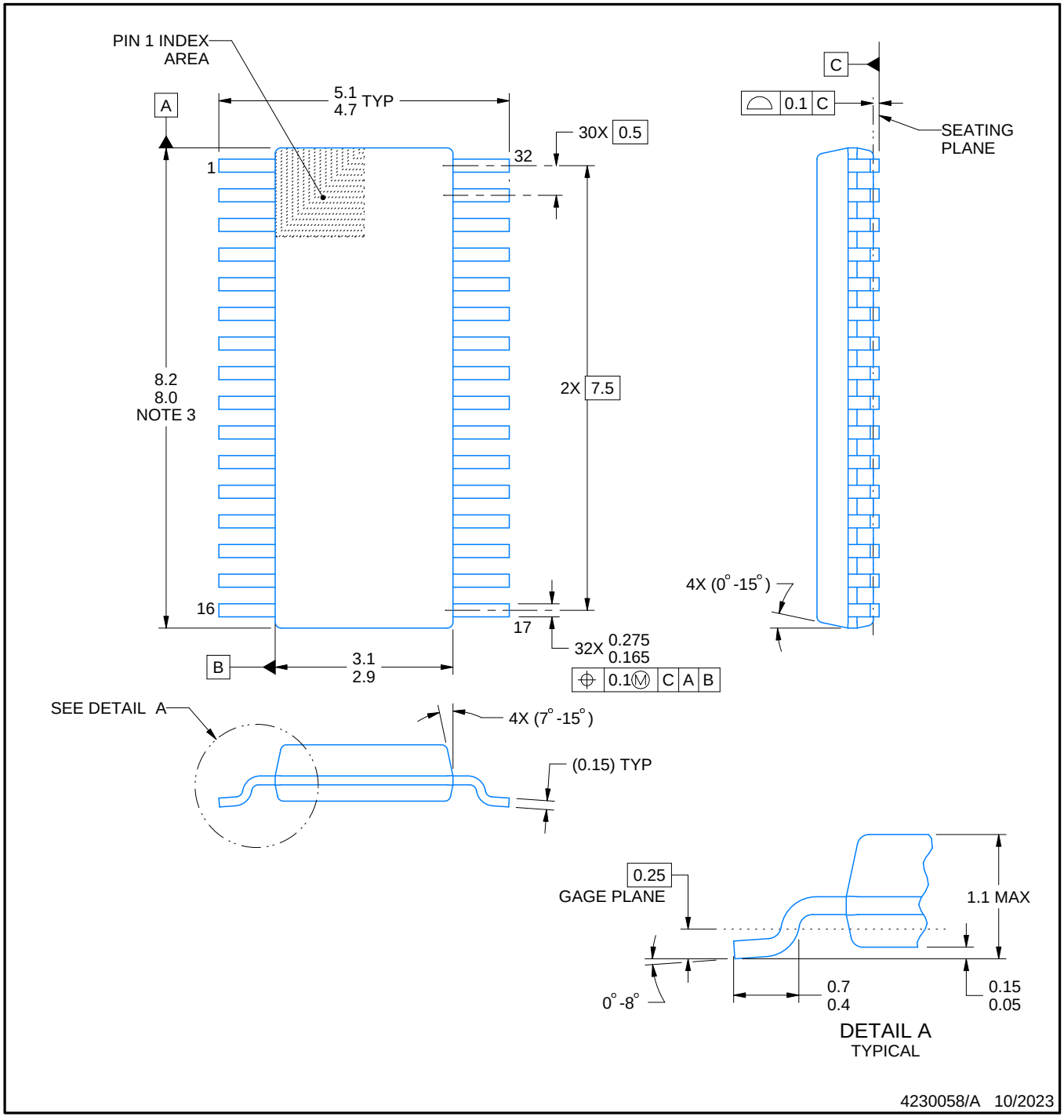


PACKAGE OUTLINE

DGS0032A

VSSOP - 1.1 mm max height

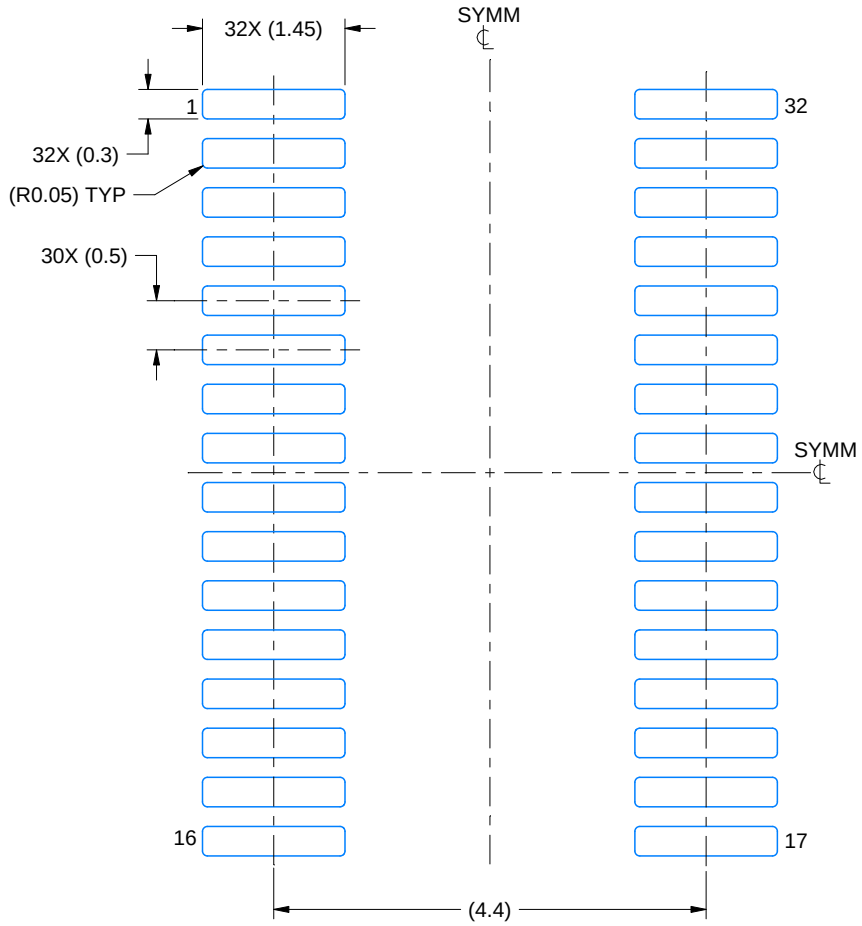
SMALL OUTLINE PACKAGE



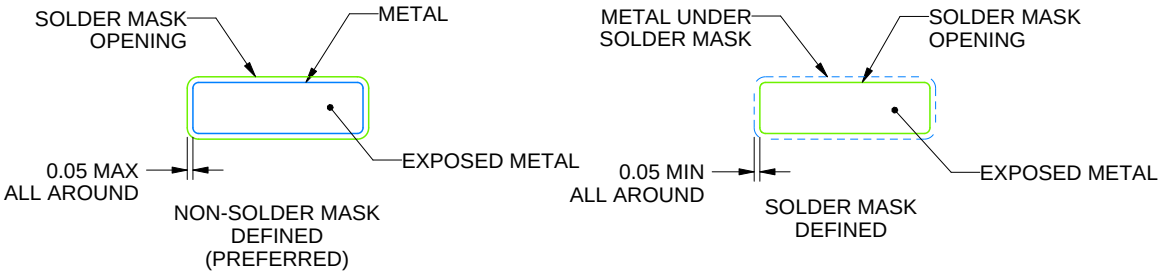
PowerPAD is a trademark of Texas Instruments.

NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. No JEDEC registration as of September 2020.
5. Features may differ or may not be present.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 13X

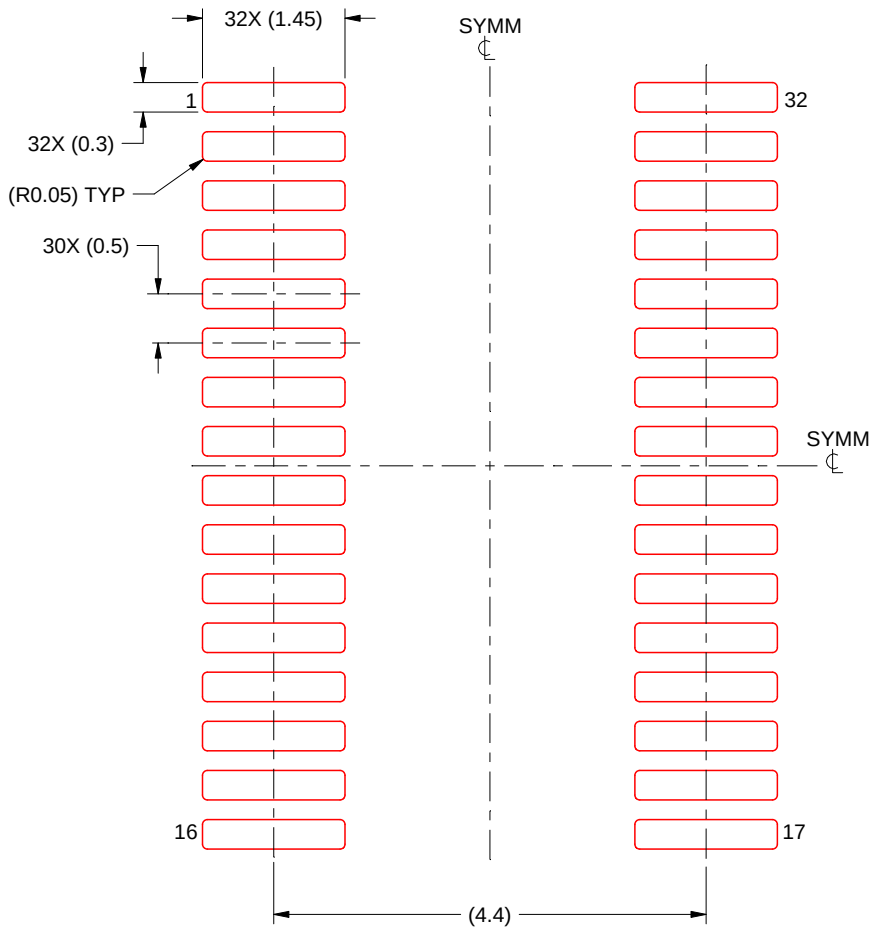


SOLDER MASK DETAILS

4230058/A 10/2023

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.
8. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature numbers SLMA002 (www.ti.com/lit/slma002) and SLMA004 (www.ti.com/lit/slma004).
9. Size of metal pad may vary due to creepage requirement.
10. Vias are optional depending on application, refer to device data sheet. It is recommended that vias under paste be filled, plugged or tented.



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE: 13X

4230058/A 10/2023

NOTES: (continued)

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

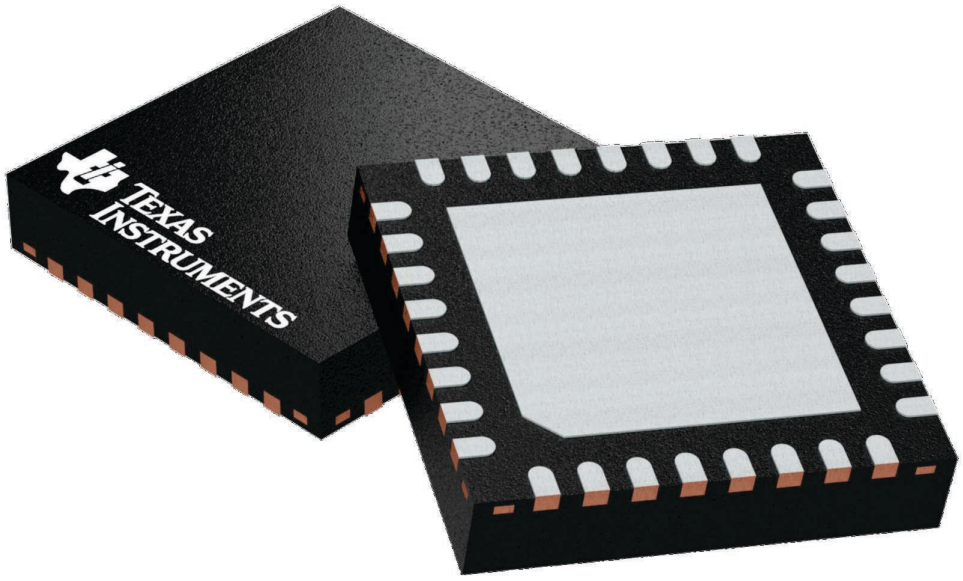
GENERIC PACKAGE VIEW

RHB 32

VQFN - 1 mm max height

5 x 5, 0.5 mm pitch

PLASTIC QUAD FLATPACK - NO LEAD



Images above are just a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.

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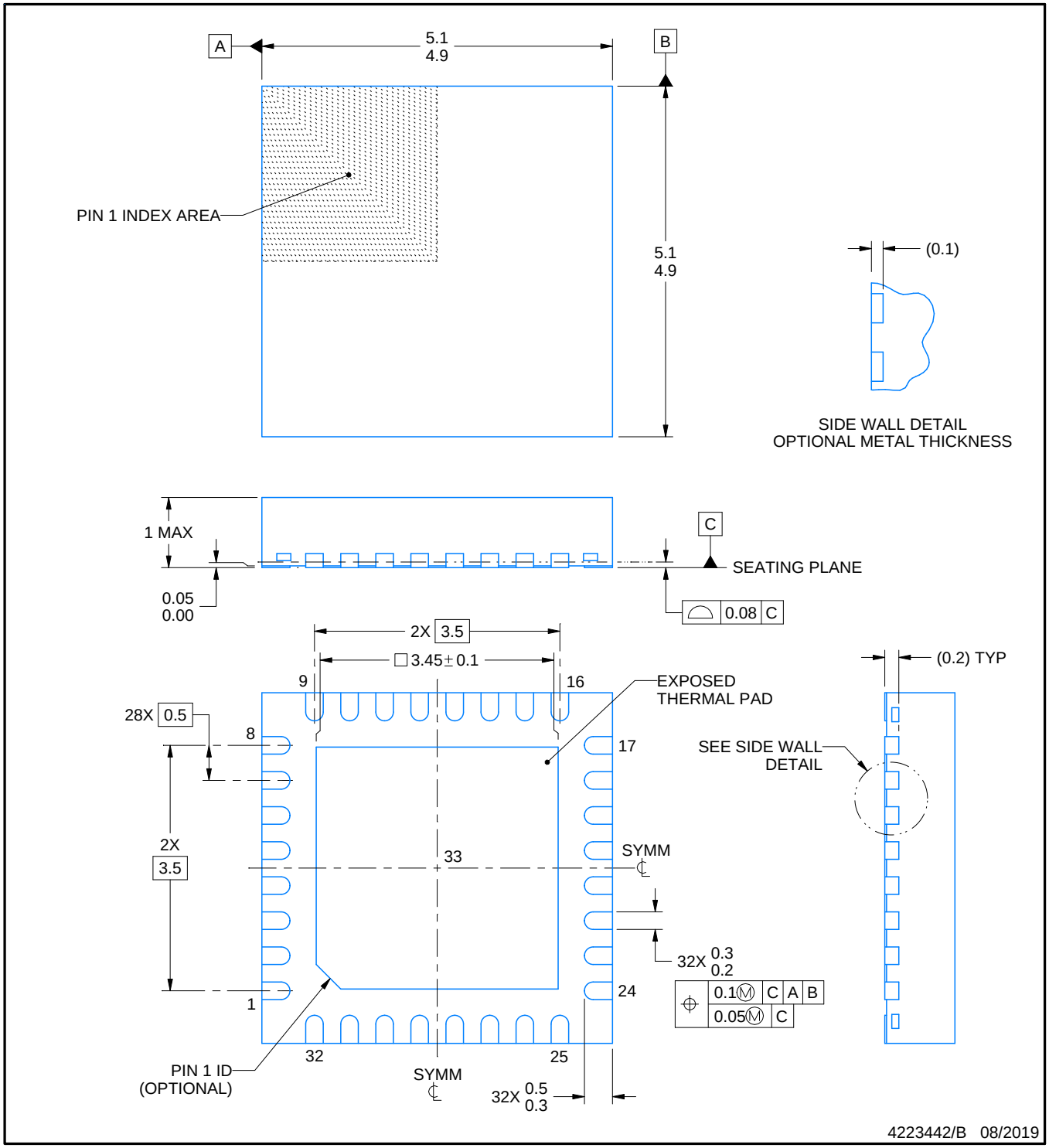
RHB0032E

PACKAGE OUTLINE

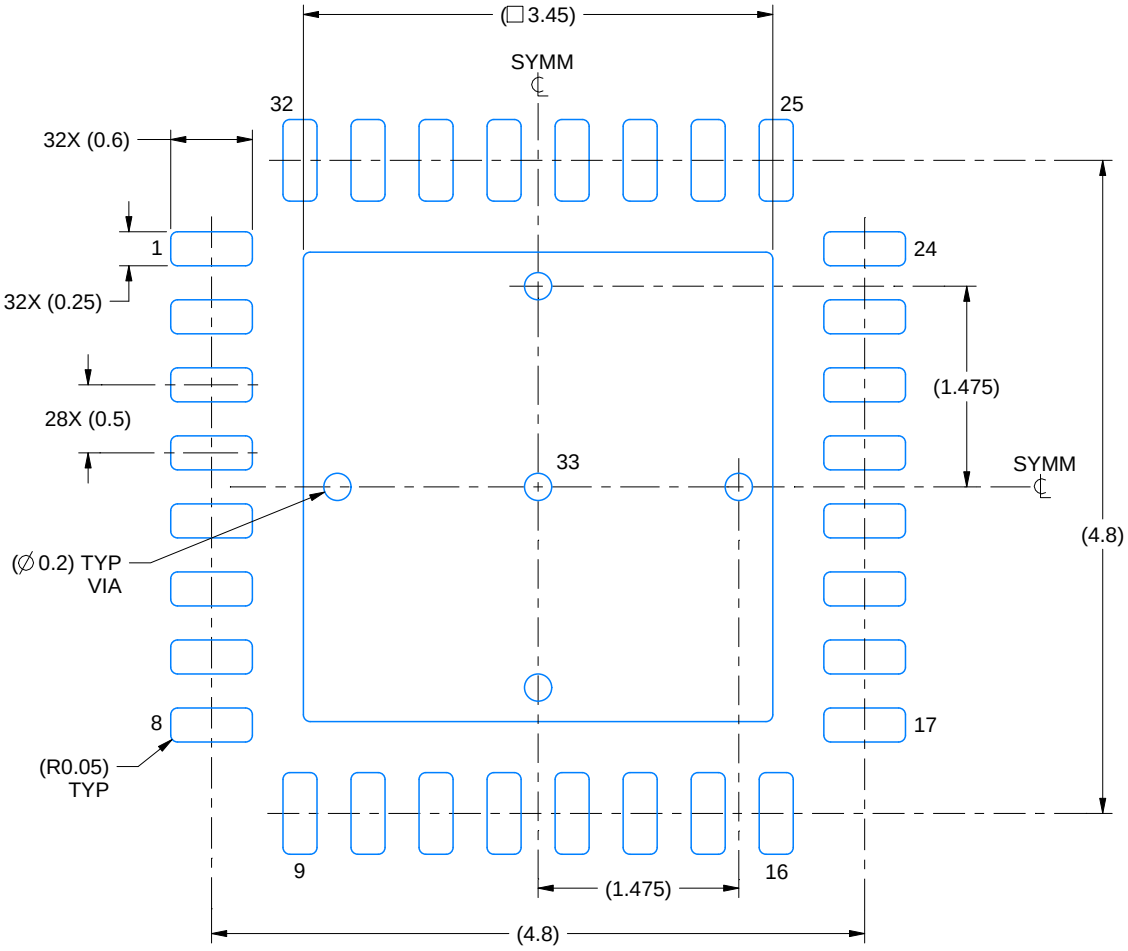
VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD

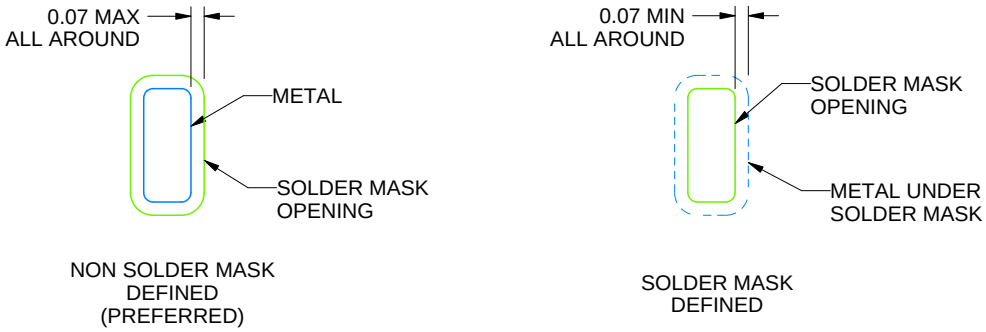


NOTES:

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
SCALE:18X

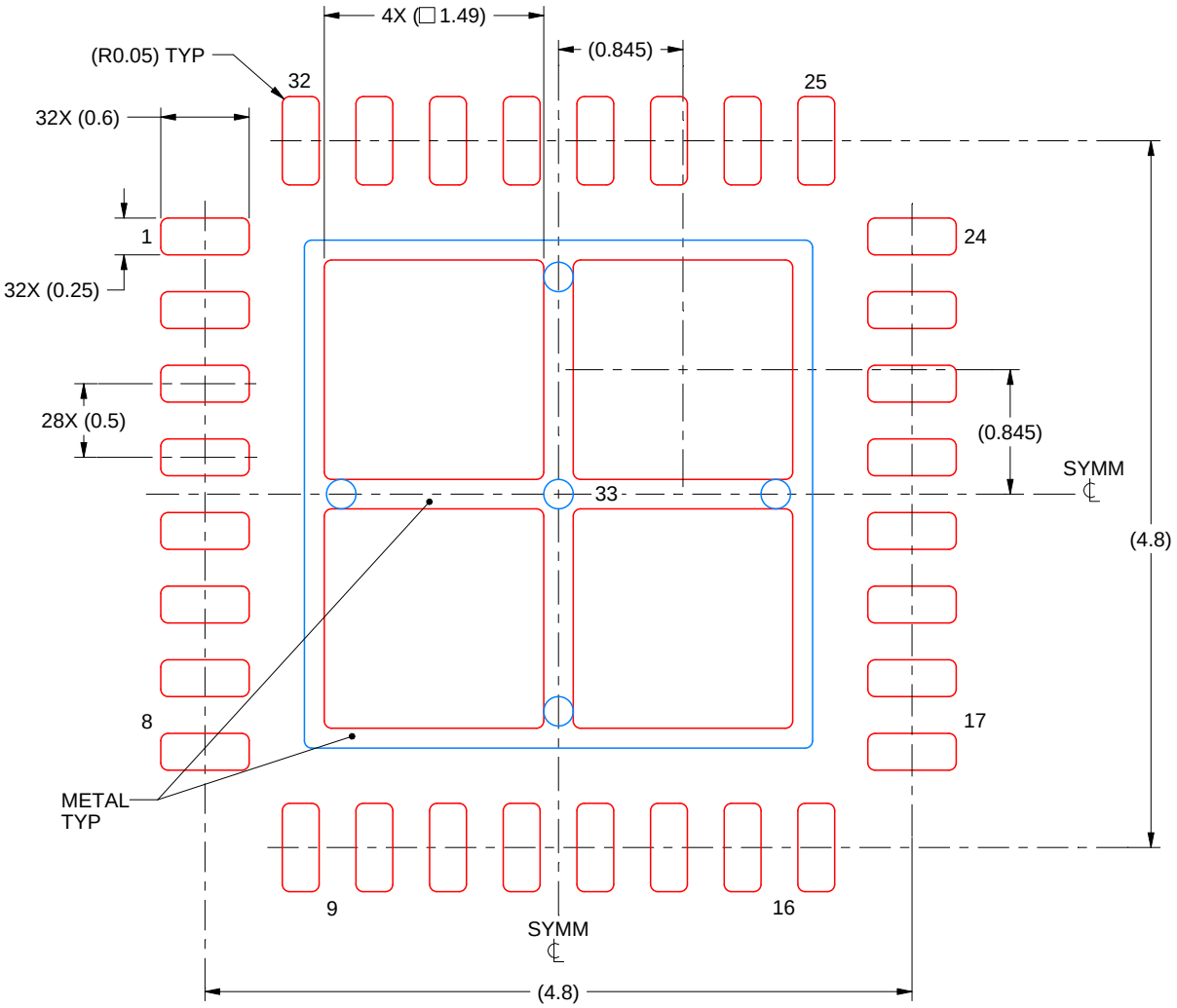


SOLDER MASK DETAILS

4223442/B 08/2019

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 33:
75% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE
SCALE:20X

4223442/B 08/2019

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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