Functional Safety Information

ADS7956-Q1
Functional Safety FIT Rate, FMD and Pin FMA

Table of Contents

Trademarks

1 Overview

This document contains information for ADS7956-Q1 (TSSOP package) to aid in a functional safety system design. Information provided are:

- Functional Safety Failure In Time (FIT) rates of the semiconductor component estimated by the application of industry reliability standards
- Component failure modes and their distribution (FMD) based on the primary function of the device
- Pin failure mode analysis (Pin FMA)

Figure 1-1 shows the device functional block diagram for reference.

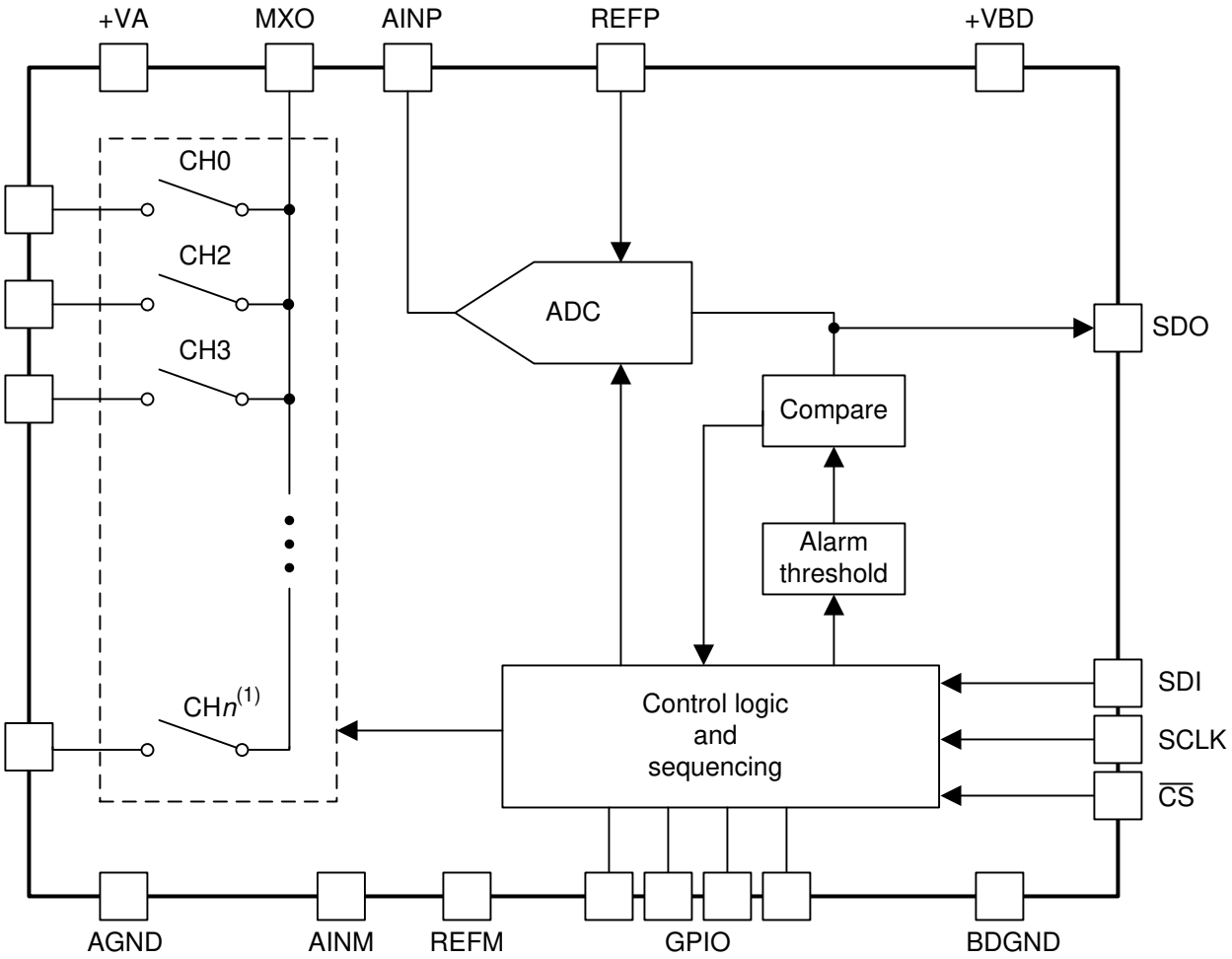

Figure 1-1. Functional Block Diagram

ADS7956-Q1 was developed using a quality-managed development process, but was not developed in accordance with the IEC 61508 or ISO 26262 standards.

2 Functional Safety Failure In Time (FIT) Rates

This section provides Functional Safety Failure In Time (FIT) rates for ADS7956-Q1 based on two different industry-wide used reliability standards:

- Table 2-1 provides FIT rates based on IEC TR 62380 / ISO 26262 part 11
- Table 2-2 provides FIT rates based on the Siemens Norm SN 29500-2

Table 2-1. Component Failure Rates per IEC TR 62380 / ISO 26262 Part 11

FIT IEC TR 62380 / ISO 26262	FIT (Failures Per 10^9 Hours)
Total Component FIT Rate	21
Die FIT Rate	2
Package FIT Rate	19

The failure rate and mission profile information in Table 2-1 comes from the Reliability data handbook IEC TR 62380 / ISO 26262 part 11:

- Mission Profile: Motor Control from Table 11
- Power dissipation: 21 mW
- Climate type: World-wide Table 8
- Package factor (lambda 3): Table 17b
- Substrate Material: FR4
- EOS FIT rate assumed: 0 FIT

Table 2-2. Component Failure Rates per Siemens Norm SN 29500-2

Table	Category	Reference FIT Rate	Reference Virtual T_J
5	CMOS, BICMOS Digital, analog / mixed	25 FIT	55°C

The Reference FIT Rate and Reference Virtual T_J (junction temperature) in Table 2-2 come from the Siemens Norm SN 29500-2 tables 1 through 5. Failure rates under operating conditions are calculated from the reference failure rate and virtual junction temperature using conversion information in SN 29500-2 section 4.

3 Failure Mode Distribution (FMD)

The failure mode distribution estimation for ADS7956-Q1 in Table 3-1 comes from the combination of common failure modes listed in standards such as IEC 61508 and ISO 26262, the ratio of sub-circuit function size and complexity and from best engineering judgment.

The failure modes listed in this section reflect random failure events and do not include failures due to misuse or overstress.

Table 3-1. Die Failure Modes and Distribution

Die Failure Modes	Failure Mode Distribution (%)
Incorrect channel selected	20%
Channel-channel short	20%
ADC output code bit error	15%
ADC gain out of specification	15%
ADC offset out of specification	15%
Communication error	15%

4 Pin Failure Mode Analysis (Pin FMA)

This section provides a Failure Mode Analysis (FMA) for the pins of the ADS7956-Q1. The failure modes covered in this document include the typical pin-by-pin failure scenarios:

- Pin short-circuited to Ground (see Table 4-2)
- Pin open-circuited (see Table 4-3)
- Pin short-circuited to an adjacent pin (see Table 4-4)
- Pin short-circuited to supply (see Table 4-5)

Table 4-2 through Table 4-5 also indicate how these pin conditions can affect the device as per the failure effects classification in Table 4-1.

Table 4-1. TI Classification of Failure Effects

Class	Failure Effects
A	Potential device damage that affects functionality
B	No device damage, but loss of functionality
C	No device damage, but performance degradation
D	No device damage, no impact to functionality or performance

Figure 4-1 shows the ADS7956-Q1 pin diagram. For a detailed description of the device pins please refer to the *Pin Configuration and Functions* section in the ADS7956-Q1 data sheet.

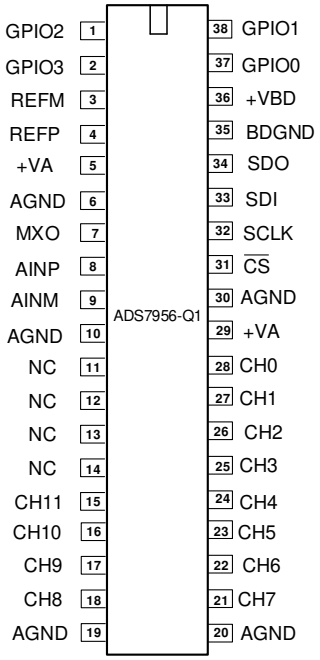

Figure 4-1. Pin Diagram

Following are the assumptions of use and the device configuration assumed for the pin FMA in this section:

- +VA and +VBD use the same supply voltage.
- AGND, REFM and BDGND use the same GND.
- RC filters on every analog input, CHx. Series resistors are sized to limit the input currents into the analog inputs to <10mA in all circumstances, e.g. also in case device is unpowered and input signal is applied.
- Device is the only slave on the SPI bus.

Table 4-2. Pin FMA for Device Pins Short-Circuited to Ground

Pin Name	Pin No.	Description of Potential Failure Effect(s)	Failure Effect Class
GPIO2	1	GPIO2 configured as digital output: GPIO2 stuck low. Increase in supply current when GPIO2 tries to drive high. Device damage may be plausible.	A
		GPIO2 configured as digital input: GPIO2 stuck low. Readback value of GPIO2 will be 0b.	B
GPIO3	2	GPIO3 configured as digital output: GPIO3 stuck low. Increase in supply current when GPIO3 tries to drive high. Device damage may be plausible.	A
		GPIO3 configured as digital input: GPIO3 stuck low. Readback value of GPIO3 will be 0b.	B
REFM	3	No effect. Normal operation.	D
REFP	4	Reference voltage to the ADC will be 0 V as REFP = REFM = Ground. Incorrect conversion result for all channels. Conversion result for all channels will be close to 0x3FF.	B
+VA	5	Device unpowered and not functional. Observe that the absolute maximum ratings for all pins of the device are met, otherwise device damage may be plausible.	A
AGND	6	No effect. Normal operation.	D
MXO	7	Conversion results for all channels will be close to 0x000. Multiplexer's analog inputs CH11-CH0 will be connected to Ground through MXO. Increase in current sourced from the analog inputs.	B
AINP	8	External amplifier used between MXO and AINP: Conversion results for all channels will be close to 0x000. External amplifier's output will be connected to Ground.	B
		MXO directly connected to AINP: Conversion results for all channels will be close to 0x000. Multiplexer's analog inputs CH11-CH0 will be connected to Ground through MXO and there will be increase in current sourced from the external circuits driving the analog inputs.	B
AINM	9	No effect. Normal operation.	D
AGND	10	No effect. Normal operation.	D
NC	11	No effect. Normal operation.	D
NC	12	No effect. Normal operation.	D
NC	13	No effect. Normal operation.	D
NC	14	No effect. Normal operation.	D
CH11	15	Conversion result for this analog input channel will be close to 0x000.	B
CH10	16	Conversion result for this analog input channel will be close to 0x000.	B
CH9	17	Conversion result for this analog input channel will be close to 0x000.	B
CH8	18	Conversion result for this analog input channel will be close to 0x000.	B
AGND	19	No effect. Normal operation.	D
AGND	20	No effect. Normal operation.	D
CH7	21	Conversion result for this analog input channel will be close to 0x000.	B
CH6	22	Conversion result for this analog input channel will be close to 0x000.	B
CH5	23	Conversion result for this analog input channel will be close to 0x000.	B
CH4	24	Conversion result for this analog input channel will be close to 0x000.	B
CH3	25	Conversion result for this analog input channel will be close to 0x000.	B
CH2	26	Conversion result for this analog input channel will be close to 0x000.	B
CH1	27	Conversion result for this analog input channel will be close to 0x000.	B
CH0	28	Conversion result for this analog input channel will be close to 0x000.	B
+VA	29	Device unpowered and not functional. Observe that the absolute maximum ratings for all pins of the device are met, otherwise device damage may be plausible.	A
AGND	30	No effect. Normal operation.	D
$\overline{CS}$	31	$\overline{CS}$ stuck low. No SPI communication with the device possible.	B
SCLK	32	SCLK stuck low. No SPI communication with the device possible.	B
SDI	33	SDI stuck low. Device configuration cannot be modified. Device will remain in previously configured state until reset condition occurs. Device will remain in default configuration after power-up.	B
SDO	34	SDO stuck low. No data readback possible from the device. Increase in supply current when device tries to drive SDO high. Device damage may be plausible.	A

Table 4-2. Pin FMA for Device Pins Short-Circuited to Ground (continued)

Pin Name	Pin No.	Description of Potential Failure Effect(s)	Failure Effect Class
BDGND	35	No effect. Normal operation.	D
+VBD	36	Digital interface not powered up. No SPI communication with device possible. Observe that the absolute maximum ratings for all pins of the device are met, otherwise device damage may be plausible.	A
GPIO0	37	GPIO0 configured as digital output: GPIO0 stuck low. Increase in supply current when GPIO0 tries to drive high. Device damage may be plausible.	A
		GPIO0 configured as digital input: GPIO0 stuck low. Readback value of GPIO0 will be 0b.	B
GPIO1	38	GPIO1 configured as digital output: GPIO1 stuck low. Increase in supply current when GPIO1 tries to drive high. Device damage may be plausible.	A
		GPIO1 configured as digital input: GPIO1 stuck low. Readback value of GPIO1 will be 0b.	B

Table 4-3. Pin FMA for Device Pins Open-Circuited

Pin Name	Pin No.	Description of Potential Failure Effect(s)	Failure Effect Class
GPIO2	1	GPIO2 configured as digital output: No logic signaling between GPIO2 and external circuit possible. Otherwise normal operation.	B
		GPIO2 configured as digital input: Readback value of GPIO2 will be unknown.	B
GPIO3	2	GPIO3 configured as digital output: No logic signaling between GPIO3 and external circuit possible. Otherwise normal operation.	B
		GPIO3 configured as digital input: Readback value of GPIO3 will be unknown.	B
REFM	3	Incorrect conversion result for all channels. The ADC reference will connect to ground internally through REFM pin ESD diode. Increased gain error for all channels due to reference voltage drop across ESD diode.	B
REFP	4	Incorrect and unknown conversion result for all channels. Unknown reference voltage to the ADC. The reference circuit may power-up through internal circuit to Power.	B
+VA	5	Device functionality unknown. Device unpowered and not functional if all external analog pins are held low. Observe that the absolute maximum ratings for all pins of the device are met, otherwise device damage may be plausible. Device may power up through internal ESD diodes to +VA if voltages above the device's power-on reset threshold are present on any of the analog pins.	A
AGND	6	Device functionality unknown. Device may be unpowered or connect to ground internally through alternate pin ESD diode and power up.	B
MXO	7	External amplifier used between MXO and AINP: Multiplexer's analog inputs CH11-CH0 cannot be connected to the external amplifier's input. Conversion results for all channels will depend on the output voltage of the amplifier driving AINP.	B
		MXO directly connected to AINP: Multiplexer's analog inputs CH11-CH0 cannot be connected to the ADC's input. Conversion results for all channels will be unknown.	B
AINP	8	Conversion results for all channels will be unknown.	B
AINM	9	Conversion results for all channels will be unknown.	B
AGND	10	Device functionality unknown. Device may be unpowered or connect to ground internally through alternate pin ESD diode and power up.	B
NC	11	No effect. Normal operation.	D
NC	12	No effect. Normal operation.	D
NC	13	No effect. Normal operation.	D
NC	14	No effect. Normal operation.	D
CH11	15	Conversion result for this analog input channel will be unknown.	B
CH10	16	Conversion result for this analog input channel will be unknown.	B
CH9	17	Conversion result for this analog input channel will be unknown.	B
CH8	18	Conversion result for this analog input channel will be unknown.	B
AGND	19	Device functionality unknown. Device may be unpowered or connect to ground internally through alternate pin ESD diode and power up.	B
AGND	20	Device functionality unknown. Device may be unpowered or connect to ground internally through alternate pin ESD diode and power up.	B
CH7	21	Conversion result for this analog input channel will be unknown.	B
CH6	22	Conversion result for this analog input channel will be unknown.	B
CH5	23	Conversion result for this analog input channel will be unknown.	B
CH4	24	Conversion result for this analog input channel will be unknown.	B
CH3	25	Conversion result for this analog input channel will be unknown.	B
CH2	26	Conversion result for this analog input channel will be unknown.	B
CH1	27	Conversion result for this analog input channel will be unknown.	B
CH0	28	Conversion result for this analog input channel will be unknown.	B
+VA	29	Device functionality unknown. Device unpowered and not functional if all external analog pins are held low. Observe that the absolute maximum ratings for all pins of the device are met, otherwise device damage may be plausible. Device may power up through internal ESD diodes to +VA if voltages above the device's power-on reset threshold are present on any of the analog pins.	A

Table 4-3. Pin FMA for Device Pins Open-Circuited (continued)

Pin Name	Pin No.	Description of Potential Failure Effect(s)	Failure Effect Class
AGND	30	Device functionality unknown. Device may be unpowered or connect to ground internally through alternate pin ESD diode and power up.	B
$\overline{CS}$	31	State of $\overline{CS}$ undetermined. No SPI communication with the device possible.	B
SCLK	32	State of SCLK undetermined. No SPI communication with the device possible.	B
SDI	33	State of SDI undetermined. Device configuration cannot be modified. Device will remain in previously configured state until reset condition occurs. Device will remain in default configuration after power-up.	B
SDO	34	No data readback possible from the device.	B
BDGND	35	Device functionality unknown. Digital interface may be unpowered or power up internally through alternate pin ESD diode to Ground. SPI communication may not be possible with the device.	B
+VBD	36	Digital interface not powered up if all external digital pins are held low. No SPI communication with device possible. Observe that the absolute maximum ratings for all pins of the device are met, otherwise device damage may be plausible. Digital interface may power up through internal ESD diodes to DVDD if voltages above the device's power-on reset threshold are present on any of the digital pins.	A
GPIO0	37	GPIO0 configured as digital output: No logic signaling between GPIO0 and external circuit possible. Otherwise normal operation.	B
		GPIO0 configured as digital input: Readback value of GPIO0 will be unknown.	B
GPIO1	38	GPIO1 configured as digital output: No logic signaling between GPIO1 and external circuit possible. Otherwise normal operation.	B
		GPIO1 configured as digital input: Readback value of GPIO1 will be unknown.	B

Table 4-4. Pin FMA for Device Pins Short-Circuited to Adjacent Pin

Pin Name	Pin No.	Shorted to	Description of Potential Failure Effect(s)	Failure Effect Class
GPIO2	1	GPIO3	GPIO2 configured as digital output and GPIO3 as digital output: Output voltage level unknown. Increase in supply current when GPIO2 tries to drive low and GPIO3 tries to drive high and vice versa. Device damage may be plausible.	A
			GPIO2 configured as digital output and GPIO3 as digital input: Readback value of GPIO3 will depend on the output drive on GPIO2.	B
			GPIO2 configured as digital input and GPIO3 as digital output: Readback value of GPIO2 will depend on the output drive on GPIO3.	B
			GPIO2 configured as digital input and GPIO3 as digital input: Readback value of GPIO2 and GPIO3 will be the same.	B
GPIO3	2	REFM	GPIO3 configured as digital output: GPIO3 stuck low. Increase in supply current when GPIO3 tries to drive high. Device damage may be plausible.	A
			GPIO3 configured as digital input: GPIO3 stuck low. Readback value of GPIO3 will be 0b.	B
REFM	3	REFP	Incorrect conversion result for all channels. Conversion result will be close to 0x3FF for all channels. Reference voltage to the ADC will be 0 V as REFP = REFM = Ground.	B
REFP	4	+VA	Incorrect conversion result for all channels. Higher gain error for all channels because reference to the ADC is different from the intended REFP voltage. Reference voltage out of specification in case +VA > 3 V.	B
+VA	5	AGND	Device unpowered and not functional. Observe that the absolute maximum ratings for all pins of the device are met, otherwise device damage may be plausible.	A
AGND	6	MXO	Conversion results for all channels will be close to 0x000. Multiplexer's analog inputs CH11-CH0 will be connected to Ground through MXO. Increase in current sourced from the analog inputs.	B
MXO	7	AINP	External amplifier used between MXO and AINP: The external amplifier is bypassed. Increased gain error in conversion results if the external amplifier is configured for gain > 1. Conversion results for all channels may have higher error if there are ADC input settling errors when driving AINP directly with MXO.	B
			MXO directly connected to AINP: No effect. Normal operation.	D
AINP	8	AINM	Conversion results for all channels will be close to 0x000.	B
AINM	9	AGND	No effect. Normal operation.	D
AGND	10	NC	No effect. Normal operation.	D
NC	11	NC	No effect. Normal operation.	D
NC	12	NC	No effect. Normal operation.	D
NC	13	NC	No effect. Normal operation.	D
NC	14	CH11	No effect. Normal operation.	D
CH11	15	CH10	Conversion results for CH11 and CH10 will be the same. The conversion results may be incorrect depending on the external drive circuits.	B
CH10	16	CH9	Conversion results for CH10 and CH9 will be the same. The conversion results may be incorrect depending on the external drive circuits.	B
CH9	17	CH8	Conversion results for CH9 and CH8 will be the same. The conversion results may be incorrect depending on the external drive circuits.	B
CH8	18	AGND	Conversion results for CH2 and CH1 will be the same. The conversion results may be incorrect depending on the external drive circuits.	B
AGND	19	–	Not considered. Corner pin.	–
AGND	20	CH7	Conversion result for CH7 will be close to 0x000.	B
CH7	21	CH6	Conversion results for CH7 and CH6 will be the same. The conversion results may be incorrect depending on the external drive circuits.	B
CH6	22	CH5	Conversion results for CH6 and CH5 will be the same. The conversion results may be incorrect depending on the external drive circuits.	B

Table 4-4. Pin FMA for Device Pins Short-Circuited to Adjacent Pin (continued)

Pin Name	Pin No.	Shorted to	Description of Potential Failure Effect(s)	Failure Effect Class
CH5	23	CH4	Conversion results for CH5 and CH4 will be the same. The conversion results may be incorrect depending on the external drive circuits.	B
CH4	24	CH3	Conversion results for CH4 and CH3 will be the same. The conversion results may be incorrect depending on the external drive circuits.	B
CH3	25	CH2	Conversion results for CH3 and CH2 will be the same. The conversion results may be incorrect depending on the external drive circuits.	B
CH2	26	CH1	Conversion results for CH2 and CH1 will be the same. The conversion results may be incorrect depending on the external drive circuits.	B
CH1	27	CH0	Conversion results for CH1 and CH0 will be the same. The conversion results may be incorrect depending on the external drive circuits.	B
CH0	28	+VA	Device configured for range 1: Conversion result for this analog input channel will be close to 0x3FF.	B
			Device configured for range 2: Conversion result for this analog input channel will correspond to (+VA / (2xVREF)) * 1023.	B
+VA	29	AGND	Device unpowered and not functional. Observe that the absolute maximum ratings for all pins of the device are met, otherwise device damage may be plausible.	A
AGND	30	$\overline{CS}$	$\overline{CS}$ stuck low. No SPI communication with the device possible.	B
$\overline{CS}$	31	SCLK	SPI communication corrupted. No SPI communication with the device possible.	B
SCLK	32	SDI	SPI communication corrupted. No SPI communication with the device possible.	B
SDI	33	SDO	SPI communication corrupted. No SPI communication with the device possible. Increase in supply current when host tries to drive SDI low while device tries to drive SDO high and vice versa. Device damage may be plausible.	A
SDO	34	BDGND	SDO stuck low. No data readback possible from the device. Increase in supply current when device tries to drive SDO high. Device damage may be plausible.	A
BDGND	35	+VBD	Digital interface not powered up. No SPI communication with device possible. Observe that the absolute maximum ratings for all pins of the device are met, otherwise device damage may be plausible.	A
+VBD	36	GPIO0	GPIO0 configured as digital output: GPIO0 stuck high. Increase in supply current when GPIO0 tries to drive low. Device damage may be plausible.	A
			GPIO0 configured as digital input: GPIO0 stuck high. Readback value of GPIO0 will be 1b.	B
GPIO0	37	GPIO1	GPIO0 configured as digital output and GPIO1 as digital output: Increase in supply current when GPIO0 tries to drive low and GPIO1 tries to drive high and vice versa. Device damage may be plausible.	A
			GPIO0 configured as digital output and GPIO1 as digital input: Readback value of GPIO1 will depend on the output drive on GPIO0.	B
			GPIO0 configured as digital input and GPIO1 as digital output: Readback value of GPIO0 will depend on the output drive on GPIO1.	B
			GPIO0 configured as digital input and GPIO1 as digital input: Readback value of GPIO0 and GPIO1 will be the same.	B
GPIO1	38	–	Not considered. Corner pin.	–

Table 4-5. Pin FMA for Device Pins Short-Circuited to supply

Pin Name	Pin No.	Description of Potential Failure Effect(s)	Failure Effect Class
GPIO2	1	GPIO2 configured as digital output: GPIO2 stuck high. Increase in supply current when GPIO2 tries to drive low. Device damage may be plausible.	A
		GPIO2 configured as digital input: GPIO2 stuck high. Readback value of GPIO2 will be 1b.	B
GPIO3	2	GPIO3 configured as digital output: GPIO3 stuck high. Increase in supply current when GPIO3 tries to drive low. Device damage may be plausible.	A
		GPIO3 configured as digital input: GPIO3 stuck high. Readback value of GPIO3 will be 1b.	B
REFM	3	Incorrect conversion result for all channels. The ADC reference will connect to ground internally through REFM pin ESD diode. Increased gain error for all channels due to reference voltage drop across ESD diode. Increase in supply current through ESD to Ground from REFM pin. Device damage may be plausible.	A
REFP	4	Incorrect conversion result for all channels. Higher gain error for all channels because reference to the ADC is different from the intended REFP voltage. Reference voltage out of specification in case +VA > 3 V.	B
+VA	5	No effect. Normal operation.	D
AGND	6	Device unpowered and not functional. Observe that the absolute maximum ratings for all pins of the device are met, otherwise device damage may be plausible.	A
MXO	7	Multiplexer's analog inputs CH11-CH0 will be connected to Power through MXO. Increase in current sinked by the external circuits driving the analog inputs. • Device configured for range 1: Conversion results for all channels will be close to 0x3FF. • Device configured for range 2: Conversion results for all channels will correspond to (+VA / (2xVREF)) * 1023.	B
AINP	8	If MXO is directly connected to AINP, multiplexer's analog inputs CH11-CH0 will be connected to Power through MXO and there will be increase in current sinked by the external circuits driving the analog inputs. • Device configured for range 1: Conversion results for all channels will be close to 0x3FF. • Device configured for range 2: Conversion results for all channels will correspond to (+VA / (2xVREF)) * 1023.	B
AINM	9	Conversion result for all channels will be close to 0x000.	B
AGND	10	Device unpowered and not functional. Observe that the absolute maximum ratings for all pins of the device are met, otherwise device damage may be plausible.	A
NC	11	No effect. Normal operation.	D
NC	12	No effect. Normal operation.	D
NC	13	No effect. Normal operation.	D
NC	14	No effect. Normal operation.	D
CH11	15	Device configured for range 1: Conversion result for this analog input channel will be close to 0x3FF.	B
		Device configured for range 2: Conversion result for this analog input channel will correspond to (+VA / (2xVREF)) * 1023.	
CH10	16	Device configured for range 1: Conversion result for this analog input channel will be close to 0x3FF.	B
		Device configured for range 2: Conversion result for this analog input channel will correspond to (+VA / (2xVREF)) * 1023.	
CH9	17	Device configured for range 1: Conversion result for this analog input channel will be close to 0x3FF.	B
		Device configured for range 2: Conversion result for this analog input channel will correspond to (+VA / (2xVREF)) * 1023.	
CH8	18	Device configured for range 1: Conversion result for this analog input channel will be close to 0x3FF.	B
		Device configured for range 2: Conversion result for this analog input channel will correspond to (+VA / (2xVREF)) * 1023.	
AGND	19	Device unpowered and not functional. Observe that the absolute maximum ratings for all pins of the device are met, otherwise device damage may be plausible.	A

Table 4-5. Pin FMA for Device Pins Short-Circuited to supply (continued)

Pin Name	Pin No.	Description of Potential Failure Effect(s)	Failure Effect Class
AGND	20	Device unpowered and not functional. Observe that the absolute maximum ratings for all pins of the device are met, otherwise device damage may be plausible.	A
CH7	21	Device configured for range 1: Conversion result for this analog input channel will be close to 0x3FF.	B
		Device configured for range 2: Conversion result for this analog input channel will correspond to (+VA / (2xVREF)) * 1023.	
CH6	22	Device configured for range 1: Conversion result for this analog input channel will be close to 0x3FF.	B
		Device configured for range 2: Conversion result for this analog input channel will correspond to (+VA / (2xVREF)) * 1023.	
CH5	23	Device configured for range 1: Conversion result for this analog input channel will be close to 0x3FF.	B
		Device configured for range 2: Conversion result for this analog input channel will correspond to (+VA / (2xVREF)) * 1023.	
CH4	24	Device configured for range 1: Conversion result for this analog input channel will be close to 0x3FF.	B
		Device configured for range 2: Conversion result for this analog input channel will correspond to (+VA / (2xVREF)) * 1023.	
CH3	25	Device configured for range 1: Conversion result for this analog input channel will be close to 0x3FF.	B
		Device configured for range 2: Conversion result for this analog input channel will correspond to (+VA / (2xVREF)) * 1023.	
CH2	26	Device configured for range 1: Conversion result for this analog input channel will be close to 0x3FF.	B
		Device configured for range 2: Conversion result for this analog input channel will correspond to (+VA / (2xVREF)) * 1023.	
CH1	27	Device configured for range 1: Conversion result for this analog input channel will be close to 0x3FF.	B
		Device configured for range 2: Conversion result for this analog input channel will correspond to (+VA / (2xVREF)) * 1023.	
CH0	28	Device configured for range 1: Conversion result for this analog input channel will be close to 0x3FF.	B
		Device configured for range 2: Conversion result for this analog input channel will correspond to (+VA / (2xVREF)) * 1023.	
+VA	29	No effect. Normal operation.	D
AGND	30	Device unpowered and not functional. Observe that the absolute maximum ratings for all pins of the device are met, otherwise device damage may be plausible.	A
$\overline{CS}$	31	$\overline{CS}$ stuck high. No SPI communication with the device possible. SDO will be Hi-Z.	B
SCLK	32	SCLK stuck high. No SPI communication with the device possible.	B
SDI	33	SDI stuck high. Device configuration cannot be modified. Device will remain in previously configured state until reset condition occurs. Device will remain in default configuration after power-up.	B
SDO	34	SDO stuck high. No data readback possible from the device. Increase in supply current when device tries to drive SDO low. Device damage may be plausible.	A
BDGND	35	Device unpowered and not functional. Observe that the absolute maximum ratings for all pins of the device are met, otherwise device damage may be plausible.	A
+VBD	36	No effect. Normal operation.	D
GPIO0	37	GPIO0 configured as digital output: GPIO0 stuck high. Increase in supply current when GPIO2 tries to drive low. Device damage may be plausible.	A
		GPIO0 configured as digital input: GPIO0 stuck high. Readback value of GPIO0 will be 1b.	B

Table 4-5. Pin FMA for Device Pins Short-Circuited to supply (continued)

Pin Name	Pin No.	Description of Potential Failure Effect(s)	Failure Effect Class
GPIO1	38	GPIO1 configured as digital output: GPIO1 stuck high. Increase in supply current when GPIO1 tries to drive low. Device damage may be plausible.	A
		GPIO1 configured as digital input: GPIO1 stuck high. Readback value of GPIO1 will be 1b.	B

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI’s products are provided subject to TI’s Terms of Sale or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI’s provision of these resources does not expand or otherwise alter TI’s applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265