Functional Safety Information

TUSB4020BI-Q1
Functional Safety FIT Rate, FMD and Pin FMA

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Trademarks

1 Overview

This document contains information for the TUSB4020BI-Q1 (HTQFP 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.

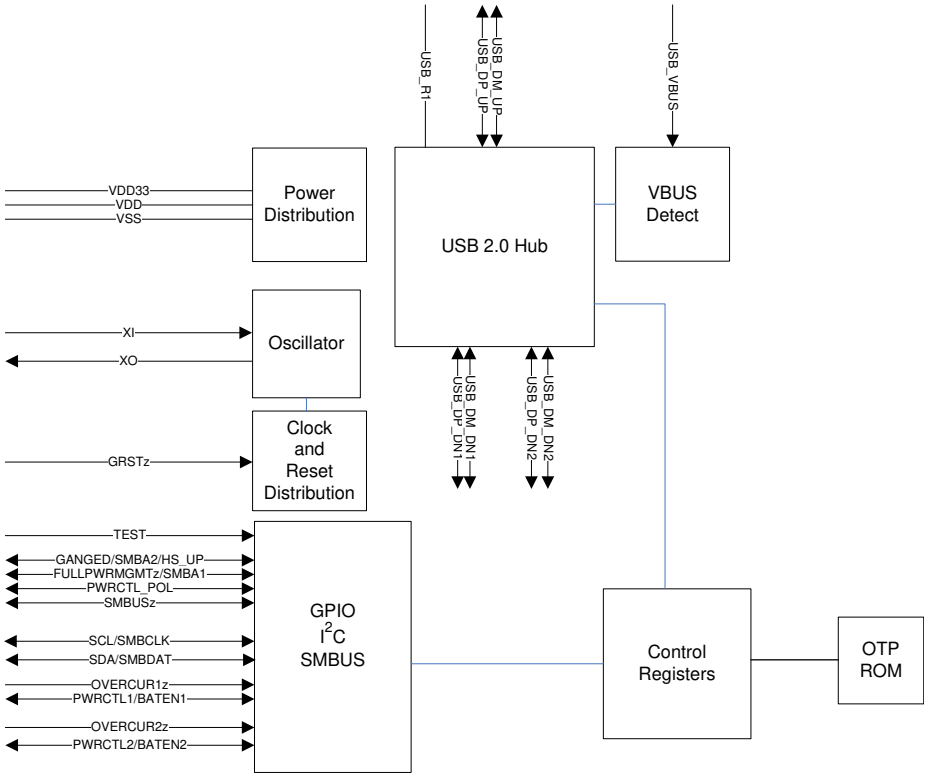

Figure 1-1. Functional Block Diagram

The TUSB4020BI-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 the TUSB4020BI-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	35
Die FIT rate	3
Package FIT rate	32

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: Passenger compartment from table 11
- Power dissipation: 345 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, or mixed ≤ 50V supply	70 FIT	70°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 the TUSB4020BI-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 resulting from misuse or overstress.

Table 3-1. Die Failure Modes and Distribution

Outputs of the TUSB4020BI-Q1	Function	Die Failure Modes	Failure Mode Distribution (%)
USB2 Upstream	Communication	Upstream communication error	18
USB Downstream 1	Communication	Downstream 1 communication error	18
USB Downstream 2	Communication	Downstream 2 communication error	18
Both USB Downstream 1 and 2	Communication	Both downstream 1 and 2 communication error	2
USB Downstream 1	Charging control	Downstream 1 charging error	14
USB Downstream 2	Charging control	Downstream 2 charging error	14
Both USB Downstream 1 and 2	Charging control	Both downstream 1 and 2 charging error	2
I^2C/SMBus	Communication	I^2C/SMBus control communication error	14

4 Pin Failure Mode Analysis (Pin FMA)

This section provides a failure mode analysis (FMA) for the pins of the TUSB4020BI-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 VDD (see Table 4-5)
- Pin short-circuited to VDD33 (see Table 4-6)

Table 4-2 through Table 4-6 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 TUSB4020BI-Q1 pin diagram. For a detailed description of the device pins, see the *Pin Configuration and Functions* section in the TUSB4020BI-Q1 data sheet.

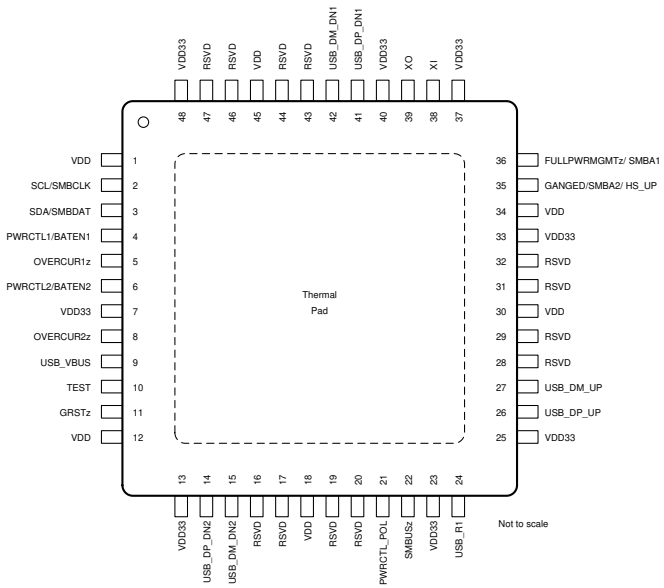

Figure 4-1. Pin Diagram

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

- Device is configured for power managed downstream ports
- Device battery charging support is enabled
- All device downstream ports are connected to a USB receptacle.
- Device Upstream port is connected to a USB2 Host controller.
- 5V BUS is present on upstream port.

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

Pin Name	Pin No.	Description of Potential Failure Effects	Failure Effect Class
VDD	1	Device can get damaged	A
SCL/SMBCLK	2	Device not functional (I2C and SMBus not functional)	B
SDA/SMBDAT	3	Device not functional (I2C and SMBus not functional)	B
PWRCTL1/BATEN1	4	USB2 downstream port 1 BC1.2 not functional. Also port power not functional	B
OVERCUR1Z	5	Device always communicates to system an overcurrent condition. Device never enables VBUS on the downstream port.	B
PWRCTL2/BATEN2	6	USB2 downstream port 2 BC1.2 not functional. Also port power not functional	B
VDD33	7	Device can get damaged	A
OVERCUR2Z	8	Device always communicates to system an overcurrent has occurred. Device never enables VBUS on downstream port 2.	B
USB_VBUS	9	VBUS on hub's upstream port is never detected. No communication with USB devices connected to Hub's downstream port 1 and 2 occurs.	B
TEST	10	No effect. Normal operation.	D
GRSTz	11	Device is held in reset and not functional	B
VDD	12	Device can get damaged	A
VDD33	13	Device can get damaged	A
USB_DP_DN2	14	Downstream port 2 not functional	B
USB_DM_DN2	15	Downstream port 2 not functional	B
RSVD	16	No effect. Normal operation.	D
RSVD	17	No effect. Normal operation.	D
VDD	18	Device can get damaged	A
RSVD	19	No effect. Normal operation.	D
RSVD	20	No effect. Normal operation.	D
PWRCTL_POL	21	No impact to functionality if external VBUS power switch enable polarity is active high. If polarity is active low, then VBUS for hub's downstream ports 1 and 2 are not enabled.	B
SMBUSz	22	No effect if system intends to use hub in SMBus mode. If system intends to use hub in I2C mode, then I2C mode is not enabled.	B
VDD33	23	Device can get damaged	A
USB_R1	24	Device not functional	B
VDD33	25	Device can get damaged	A
USB_DP_UP	26	Upstream port not functional	B
USB_DM_UP	27	Upstream port not functional	B
RSVD	28	No effect. Normal operation.	D
RSVD	29	No effect. Normal operation.	D
VDD	30	Device can get damaged	A
RSVD	31	No effect. Normal operation.	D
RSVD	32	No effect. Normal operation.	D
VDD33	33	Device can get damaged	A
VDD	34	Device can get damaged	A
GANGED/SMBA2/ HSUP	35	SMBus target address can be incorrect causing SMBus operation to fail.	B
FULLPWRMGMTz/ SMBA1	36	SMBus target address can be incorrect causing SMBus operation to fail.	B
VDD33	37	Device can get damaged	A
XI	38	XI is input for oscillator. Without a clock, device is not functional.	B
XO	39	No impact to functionality if external clock is provided to XI. If external crystal is used, then device is not functional.	B
VDD33	40	Device can get damaged	A
USB_DP_DN1	41	Downstream port 1 not functional	B
USB_DM_DN1	42	Downstream port 1 not functional	B
RSVD	43	No effect. Normal operation.	D
RSVD	44	No effect. Normal operation.	D
VDD	45	Device can get damaged	A
RSVD	46	No effect. Normal operation.	D
RSVD	47	No effect. Normal operation.	D
VDD33	48	Device can get damaged	A
Thermal pad	49	No effect. Normal operation.	D

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

Pin Name	Pin No.	Description of Potential Failure Effects	Failure Effect Class
VDD	1	Device unpowered. Device not functional.	B
SCL/SMBCLK	2	SMBus and load from an external I2C EEPROM not functional.	B
SDA/SMBDAT	3	SMBus and load from an external I2C EEPROM not functional.	B
PWRCTL1/BATEN1	4	Battery charge support for downstream port 1 is disabled. There is no VBUS control.	B
OVERCUR1Z	5	Device has internal pull-up resistor. Overcurrent detection not functional.	B
PWRCTL2/BATEN2	6	Battery charge support for downstream port 2 is disabled. There is no VBUS control.	B
VDD33	7	Device unpowered. Device not functional.	B
OVERCUR2Z	8	Device has internal pull-up resistor. Overcurrent detection not functional.	B
USB_VBUS	9	VBUS on hub's upstream port never detected. No communication with USB devices connected to Hub's DFP can occur.	B
TEST	10	No effect. Normal operation. Device has a internal pull-down.	D
GRSTz	11	Device has internal pull-up resistor. No effect. Normal operation.	D
VDD	12	Device unpowered. Device not functional.	B
VDD33	13	Device unpowered. Device not functional.	B
USB_DP_DN2	14	Downstream port 2 not functional.	B
USB_DM_DN2	15	Downstream port 2 not functional.	B
RSVD	16	No effect. Normal operation.	D
RSVD	17	No effect. Normal operation.	D
VDD	18	Device unpowered. Device not functional.	B
RSVD	19	No effect. Normal operation.	D
RSVD	20	No effect. Normal operation.	D
PWRCTL_POL	21	Device has internal pull-down. No effect if system requires VBUS power switch enable polarity to be active high.	B
SMBUSz	22	No effect if system intends to use hub in I2C mode. If system intends to use hub in SMBus mode, then SMBus not functional.	B
VDD33	23	Device unpowered. Device not functional.	B
USB_R1	24	Device not functional.	B
VDD33	25	Device unpowered. Device not functional.	B
USB_DP_UP	26	Hub upstream communication not functional. All USB2 downstream ports of hub also not functional.	B
USB_DM_UP	27	Hub upstream communication not functional. All USB2 downstream ports of hub also not functional.	B
RSVD	28	No effect. Normal operation.	D
RSVD	29	No effect. Normal operation.	D
VDD	30	Device unpowered. Device not functional.	B
RSVD	31	No effect. Normal operation.	D
RSVD	32	No effect. Normal operation.	D
VDD33	33	Device unpowered. Device not functional.	B
VDD	34	Device unpowered. Device not functional.	B
GANGED/SMBA2/ HSUP	35	Pin has an internal pull-up resistor. Floating pin causes device to operate in Ganged power switch mode instead of per port power switch.	B
FULLPWRMGMTz/ SMBA1	36	Pin has an internal pull-up resistor. Floating pin causes device to operation without downstream port power management.	B
VDD33	37	Device unpowered. Device not functional.	B
XI	38	XI is input for oscillator. Without a clock, device is not functional.	B
XO	39	Device functional if clock provided to XI pin. If external crystal is used, then device is not functional	B
VDD33	40	Device unpowered. Device not functional.	B
USB_DP_DN1	41	USB2 downstream port 1 not functional.	B
USB_DM_DN1	42	USB2 downstream port 1 not functional.	B
RSVD	43	No effect. Normal operation.	D
RSVD	44	No effect. Normal operation.	D
VDD	45	Device unpowered. Device not functional.	B
RSVD	46	No effect. Normal operation.	D
RSVD	47	No effect. Normal operation.	D
VDD33	48	Device unpowered. Device not functional.	B
Thermal pad	49	Thermal performance degraded. Thermal pad is also used for device ground and leave floating can cause device to not function.	B

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

Pin Name	Pin No.	Description of Potential Failure Effects	Failure Effect Class
VDD	1	I2C and SMBus not functional.	B
SCL/SMBCLK	2	I2C and SMBus not functional.	B
SDA/SMBDAT	3	I2C and SMBus not functional.	B
PWRCTL1/BATEN1	4	I2C and SMBus not functional. Downstream port 1 VBUS control not functional.	B
OVERCUR1Z	5	Overcurrent for downstream port 1 not functional.	B
PWRCTL2/BATEN2	6	Downstream port 2 VBUS control not functional.	B
VDD33	7	Device not functional.	B
OVERCUR2Z	8	Overcurrent for downstream port 2 not functional	B
USB_VBUS	9	Device not functional.	B
TEST	10	Device not functional.	B
GRSTz	11	Device not functional.	B
VDD	12	Device can get damaged.	A
VDD33	13	Device can get damaged.	A
USB_DP_DN2	14	Downstream port 2 not functional.	B
USB_DM_DN2	15	Downstream port 2 not functional.	B
RSVD	16	Downstream piort 2 not functional.	B
RSVD	17	No effect. Normal operation.	D
VDD	18	No effect. Normal operation.	D
RSVD	19	No effect. Normal operation.	D
RSVD	20	Device not functional.	B
PWRCTL_POL	21	Device not functional.	B
SMBUSz	22	Device not functional.	B
VDD33	23	Device can get damaged.	A
USB_R1	24	Device can get damaged.	A
VDD33	25	Device can get damaged.	A
USB_DP_UP	26	Device can get damaged.	A
USB_DM_UP	27	Upstream port not functional.	B
RSVD	28	Upstream port not functional.	B
RSVD	29	Device can get damaged.	A
VDD	30	Device can get damaged.	A
RSVD	31	Device can get damaged.	A
RSVD	32	Device can get damaged.	A
VDD33	33	Device can get damaged.	A
VDD	34	Device can get damaged.	A
GANGED/SMBA2/ HSUP	35	Device not functional.	B
FULLPWRMGMTz/ SMBA1	36	Device not functional.	B
VDD33	37	Device can get damaged.	A
XI	38	Device can get damaged.	A
XO	39	Device can get damaged.	A
VDD33	40	Device can get damaged.	A
USB_DP_DN1	41	Downstream port 1 not functional.	B
USB_DM_DN1	42	Downstream port 1 not functional.	A
RSVD	43	Downstream port 1 not functional.	A
RSVD	44	No effect. Normal operation.	D
VDD	45	No effect. Normal operation.	D
RSVD	46	No effect. Normal operation.	D
RSVD	47	Device can get damaged.	A
VDD33	48	Device can get damaged.	A
Thermal pad	49	Device can get damaged.	A

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

Pin Name	Pin No.	Description of Potential Failure Effects	Failure Effect Class
VDD	1	No effect. Normal operation.	D
SCL/SMBCLK	2	Device not functional.	B
SDA/SMBDAT	3	Device not functional.	B
PWRCTL1/BATEN1	4	Downstream port 1 power control not functional.	B
OVERCUR1Z	5	Device overcurrent detection behavior can be indeterminate since VDD is between VIL and VIH.	B
PWRCTL2/BATEN2	6	Downstream port 2 power control not functional.	B
VDD33	7	Device can get damaged.	A
OVERCUR2Z	8	Device overcurrent detection behavior can be indeterminate since VDD is between VIL and VIH.	B
USB_VBUS	9	Device can get damaged.	A
TEST	10	Device behavior can be indeterminate since device can enter an internal test mode.	B
GRSTz	11	Device can be in an indeterminate state because device was not reset properly.	B
VDD	12	No effect. Normal operation.	D
VDD33	13	Device can get damaged.	A
USB_DP_DN2	14	Downstream port 2 not functional.	B
USB_DM_DN2	15	Downstream port 2 not functional.	B
RSVD	16	No effect. Normal operation.	D
RSVD	17	No effect. Normal operation.	D
VDD	18	No effect. Normal operation.	D
RSVD	19	No effect. Normal operation.	D
RSVD	20	No effect. Normal operation.	D
PWRCTL_POL	21	Device not functional.	B
SMBUSz	22	Device not functional.	B
VDD33	23	Device can get damaged.	A
USB_R1	24	Device not functional.	B
VDD33	25	Device can get damaged.	A
USB_DP_UP	26	Upstream port not functional.	B
USB_DM_UP	27	Upstream port not functional.	B
RSVD	28	Device can get damaged.	A
RSVD	29	Device can get damaged.	A
VDD	30	No effect. Normal operation.	D
RSVD	31	Device can get damaged.	A
RSVD	32	Device can get damaged.	A
VDD33	33	Device can get damaged.	A
VDD	34	No effect. Normal operation.	D
GANGED/SMBA2/ HSUP	35	Device not functional.	B
FULLPWRMGMTz/ SMBA1	36	Device not functional.	B
VDD33	37	Device can get damaged.	A
XI	38	Device not functional.	B
XO	39	Device not functional.	B
VDD33	40	Device can get damaged.	A
USB_DP_DN1	41	Downstream port 1 not functional.	B
USB_DM_DN1	42	Downstream port 1 not functional.	B
RSVD	43	No effect. Normal operation.	D
RSVD	44	No effect. Normal operation.	D
VDD	45	No effect. Normal operation.	D
RSVD	46	No effect. Normal operation.	D
RSVD	47	No effect. Normal operation.	D
VDD33	48	Device can get damaged.	A
Thermal pad	49	Device can get damaged.	A

Table 4-6. Pin FMA for Device Pins Short-Circuited to VDD33

Pin Name	Pin No.	Description of Potential Failure Effects	Failure Effect Class
VDD	1	Device can get damaged.	A
SCL/SMBCLK	2	Device not functional.	B
SDA/SMBDAT	3	Device not functional.	B
PWRCTL1/BATEN1	4	Downstream port 1 power control not functional.	B
OVERCUR1Z	5	Overcurrent detection for downstream port 1 not functional	B
PWRCTL2/BATEN2	6	Downstream port 2 power control not functional.	B
VDD33	7	No effect. Normal operation.	D
OVERCUR2Z	8	Overcurrent detection for downstream port 1 not functional	B
USB_VBUS	9	Device can get damaged.	A
TEST	10	Device not functional.	B
GRSTz	11	Device not functional.	B
VDD	12	Device can get damaged.	A
VDD33	13	No effect. Normal operation.	D
USB_DP_DN2	14	Downstream port 2 not functional.	B
USB_DM_DN2	15	Downstream port 2 not functional.	B
RSVD	16	Device can get damaged.	A
RSVD	17	Device can get damaged.	A
VDD	18	Device can get damaged.	A
RSVD	19	Device can get damaged.	A
RSVD	20	Device can get damaged.	A
PWRCTL_POL	21	No effect if system requires VBUS power switch enable polarity to be active low. For active high polarity, VBUS power control not functional.	B
SMBUSz	22	No effect if system intends to use hub in I2C mode. If system intends to use hub in SMBus mode, then SMBus not functional.	B
VDD33	23	No effect. Normal operation.	D
USB_R1	24	Device can get damaged.	A
VDD33	25	No effect. Normal operation.	D
USB_DP_UP	26	Upstream port not functional.	B
USB_DM_UP	27	Upstream port not functional.	B
RSVD	28	Device can get damaged.	A
RSVD	29	Device can get damaged.	A
VDD	30	Device can get damaged.	A
RSVD	31	Device can get damaged.	A
RSVD	32	Device can get damaged.	A
VDD33	33	No effect. Normal operation.	D
VDD	34	Device can get damaged.	A
GANGED/SMBA2/ HSUP	35	Device not functional	B
FULLPWRMGMTz/ SMBA1	36	Device not functional	B
VDD33	37	No effect. Normal operation.	D
XI	38	Device can get damaged.	A
XO	39	Device can get damaged.	A
VDD33	40	No effect. Normal operation.	D
USB_DP_DN1	41	Downstream port 1 not functional.	B
USB_DM_DN1	42	Downstream port 1 not functional.	B
RSVD	43	Device can get damaged.	A
RSVD	44	Device can get damaged.	A
VDD	45	Device can get damaged.	A
RSVD	46	Device can get damaged.	A
RSVD	47	Device can get damaged.	A
VDD33	48	No effect. Normal operation.	D
Thermal pad	49	Device can get damaged.	A

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