36V, Overcurrent-Protection, Current Sense Comparator

Features

- Wide Common-Mode Range: 0 V to 36 V
- Selectable Response Times:
  - 10 µs, 50 µs, 100 µs
- Programmable Threshold:
  - Adjust Using a Single Resistor
  - Programmable from 0 mV to 250 mV
- Accuracy:
  - Offset Voltage: 180 µV (Typical)
  - Offset Voltage Drift: 1.61 µV/°C (Maximum)
- Selectable Hysteresis:
  - 2 mV, 4 mV, 8 mV
- Active Quiescent Current: 310 µA (Maximum)
- Selectable Disable Mode
  - Disabled Quiescent Current: 2 µA
  - Disabled Input Bias Current: 80 nA
- Open-Drain Output with Latch Mode

Applications

- Overcurrent Protection
- Computers
- Servers
- Telecom Equipment
- Power Supplies

Description

The device is a current-sensing comparator that detects overcurrent by measuring the voltage developed across a shunt resistor and comparing the voltage to the threshold voltage. The device measures this differential voltage signal on common-mode voltages which can vary from 0 V up to 36 V, independent of the supply voltage. The device features an adjustable threshold range that can be set by a single external resistor or an external voltage source at the limit terminal.

An open-drain alert output on the device can be configured to operate in either direct mode where the output status follows the input state, or in a latched mode where the alert output is cleared when the latch is cleared. The response time setting of the device is selectable, which enables overcurrent alerts to be issued in 10 µs, 50 µs, and 100 µs.

The device operates from a single 2.7-V to 5.5-V supply, drawing a supply current of 270 µA. The device is specified over the extended operating temperature range from −40°C to +125°C and is available in the DFN2×2-10 and MSOP10 packages.

Typical Application Circuit

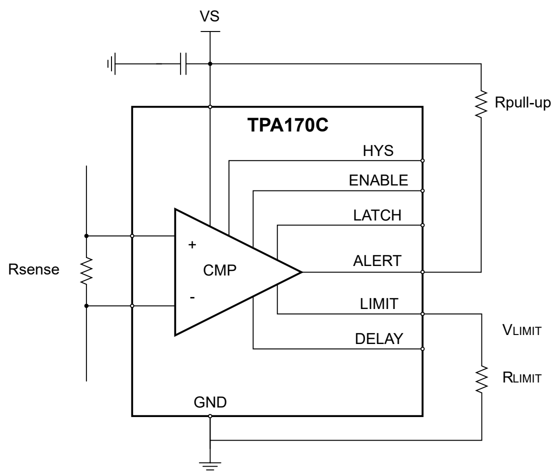
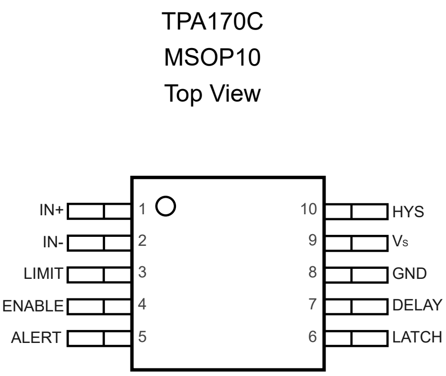


Table of Contents

Revision History

Date	Revision	Notes
2024-10-18	Rev.A.0	Initial version.
2024-12-18	Rev.A.1	The following updates are all about the new datasheet formats or typos, and the actual product remains unchanged. • Updated the Tape and Reel Information.

Pin Configuration and Functions



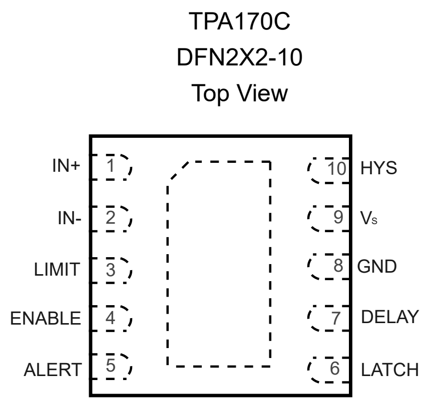


Table 1. Pin Functions

Pin No.	Name	I/O	Description
1	IN+	Analog I	Connected to the supply side of the shunt resistor.
2	IN−	Analog I	Connected to the load side of the shunt resistor.
3	LIMIT	Analog I	Alert threshold limit input.
4	ENABLE	Digital I	Enable or disable selection input.
5	ALERT	Digital O	Over limit alert, active-low, and open-drain output.
6	LATCH	Digital I	Transparent or latch mode selection input.
7	DELAY	Digital I	Response time selection input.
8	GND	Power Supply	Ground.
9	V_S	Power Supply	Power supply, 2.7 V to 5.5 V.
10	HYA	Digital I	Hysteresis setting input.
	Thermal Pad		This pad can be connected to GND or left floating.

Specifications

Absolute Maximum Ratings (1)

Parameter		Min	Max	Unit
V_S	Supply Voltage		6.5	V
Analog Input, IN+, IN−	Differential (IN+) − (IN−)	−40	40	V
	Input Common Voltage	GND − 0.3	40	V
	Input Current: IN+, IN−	−10	+10	mA
T_J	Maximum Junction Temperature		150	°C
T_A	Operating Temperature Range	−40	125	°C
T_{STG}	Storage Temperature Range	−65	150	°C
T_L	Lead Temperature (Soldering, 10 sec)		260	°C

(1) Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

ESD, Electrostatic Discharge Protection

Symbol	Parameter	Condition	Minimum Level	Unit
HBM	Human Body Model ESD	ANSI/ESDA/JEDEC JS-001 (1)	2	kV
CDM	Charged Device Model ESD	ANSI/ESDA/JEDEC JS-002 (2)	1.5	kV

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

Recommended Operating Conditions

Parameter		Min	Typ	Max	Unit
V_{CM}	Common-Mode Input Voltage	0	12	36	V
V_S	Supply Voltage	2.7	3.3	5.5	V
	Delay Setting		100		μs
T_A	Operating Temperature Range	−40	25	125	°C

Thermal Information

Package Type	θ_{JA}	θ_{JC}	Unit
MSOP10	175.5	54.6	°C/W
DFN2×2-10	58.9	89.7	°C/W

Electrical Characteristics

All test conditions: V_S = 3.3 V, T_A = 25°C, V_{IN} = V_{IN+} − V_{IN-} = 0 V, V_{CM} = 12 V, delay = 100 μs, unless otherwise noted.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Input						
V_{OS}	Input Offset Voltage	Delay = 100 μs	−650	180	950	μV
		Delay = 50 μs	−800	50	850	μV
		Delay = 10 μs	−1150	−380	450	μV
V_{OS} TC	Input Offset Voltage Drift (1)	−40°C to 125°C		1	2	μV/°C
V_{CM}	Common-Mode Input Range	−40°C to 125°C	0		36	V
CMRR	Common-Mode Rejection Ratio	−40°C to 125°C, V_{CM} = 0 V to 36 V	100	120		dB
V_{IN}	Differential Input Voltage	V_{IN} = V_{IN+} − V_{IN-}	0		250	mV
I_B	Input Bias Current (2)			10	80	nA
		Disable mode		10	80	nA
I_{OS}	Input Offset Current			±0.1		μA
I_{LIMIT}	Limit Threshold Output Current		19.85	20	20.15	μA
		−40°C to 125°C	19.75		20.25	μA
PSRR	Power Supply Rejection Ratio	V_S = 3 V to 5.5 V, −40°C to 125°C			340	μV/V
Output						
t_p	Alert Propagation Delay	Delay = open, Overdrive = 1 mV		10		μs
		Delay = GND, Overdrive = 1 mV		50		μs
		Delay = V_S, Overdrive = 1 mV		100		μs
HYS	Hysteresis	HYS = open		2		mV
		HYS = GND		4		mV
		HYS = V_S		8		mV
V_{IH}	High-Level Input Voltage	Latch, enable	1.4		6	V
		Delay, hysteresis	V_S − 0.5		6	V
V_{IL}	Low-Level Input Voltage	Latch, enable			0.4	V
		Delay, hysteresis			0.5	V
V_{OL}	Alert Low-Level Output Voltage	I_{OL} = 3 mA		120	400	mV
	Alert Terminal Leakage Input Current	V_{OH} = 3.3 V		0.1	0.2	μA
	Digital Leakage Input Current	0 ≤ Input Voltage ≤ V_S		0.8	1	μA
Power Supply						
V_S	Supply Voltage	−40°C to 125°C	2.7		5.5	V
I_Q	Quiescent Current	V_{SENSE} = 0 mV, T_A = 25°C		270	310	μA

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
		V_{SENSE} = 0 mV, T_A = −40°C to 125°C			320	µA
		V_{SENSE} = 0 mV, disable mode, HYS = 2 mV		1.4	2	µA
Timing Requirements						
	Start-up Time			40		µs
	Enable Time			35		µs
	Disable Time			15		µs

(1) Provided by bench tests and design simulation.
(2) The current flowing into the pins is considered positive.

Typical Performance Characteristics

All test conditions: T_A = 25°C, V_S = 3.3 V, V_{IN+} = 12 V, alert pull-up resistor = 10 kΩ, delay = 100 µs, unless otherwise noted.

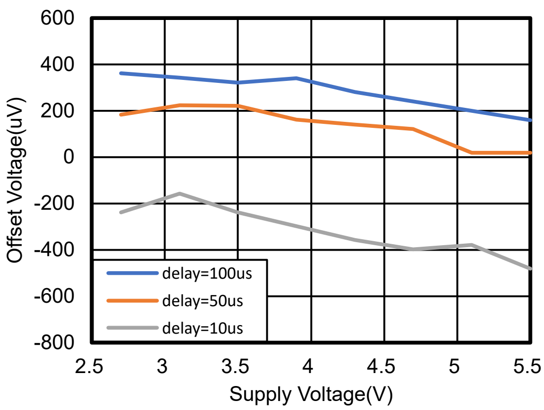


Figure 1. Input Offset Voltage vs. Supply Voltage

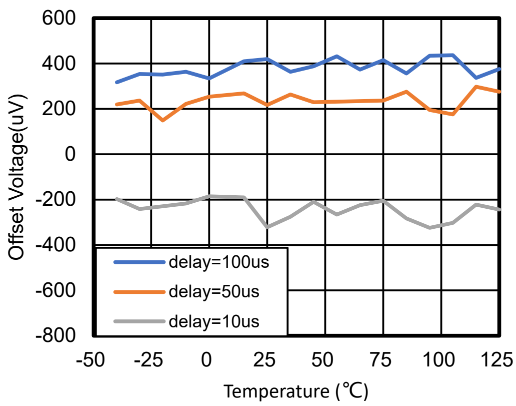


Figure 2. Input Offset Voltage vs. Temperature

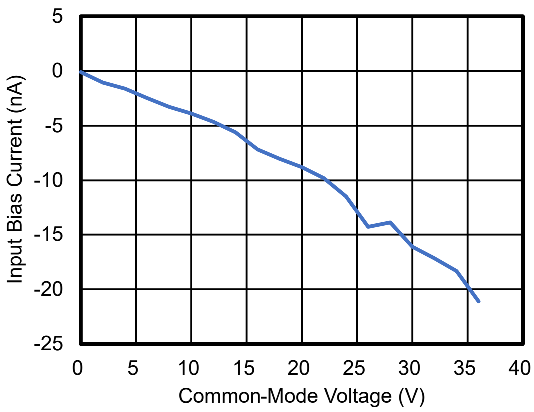


Figure 3. Input Bias Current vs. Common-Mode Voltage (Enabled)

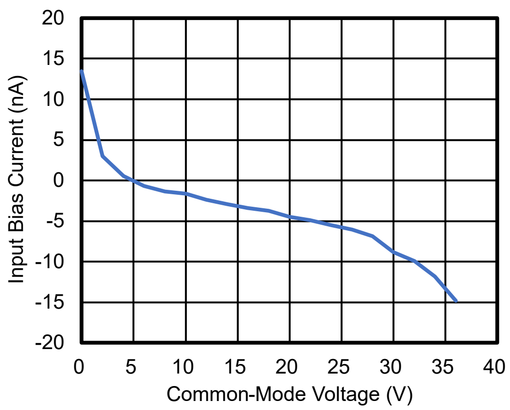


Figure 4. Input Bias Current vs. Common-Mode Voltage (Disabled)

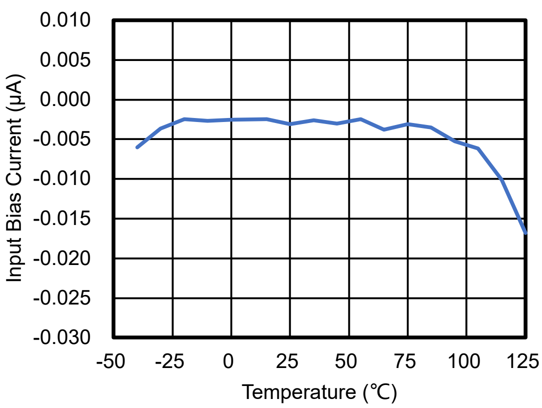


Figure 5. Input Bias Current vs. Temperature (Enabled)

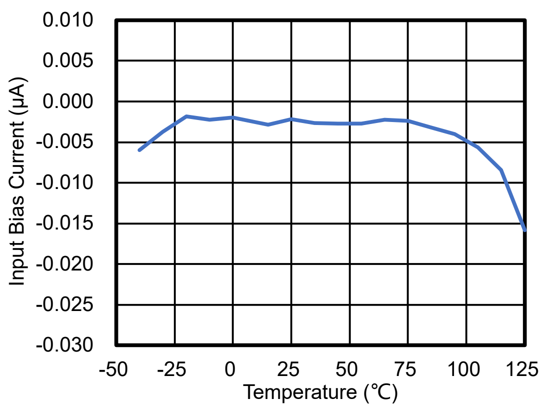


Figure 6. Input Bias Current vs. Temperature (Disabled)

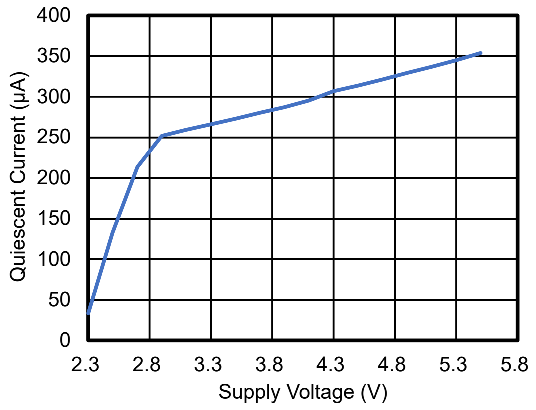


Figure 7. Quiescent Current vs. Supply Voltage (Enabled)

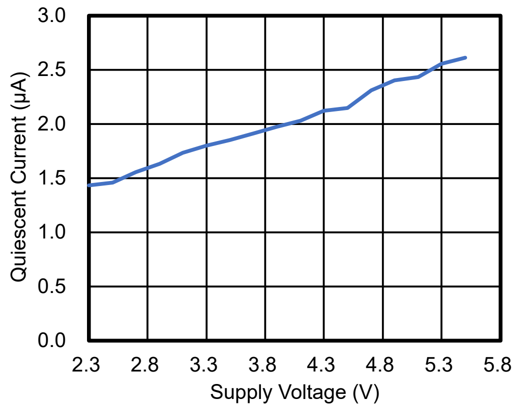


Figure 8. Quiescent Current vs. Supply Voltage (Disabled)

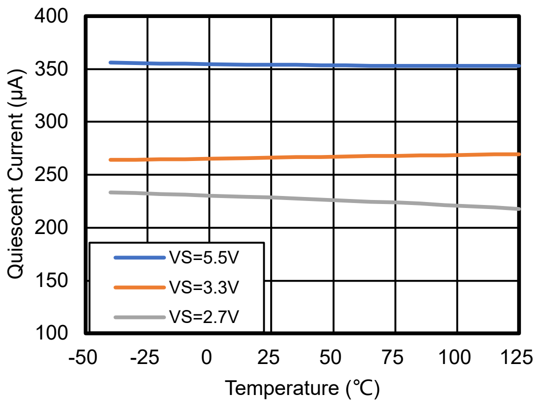


Figure 9. Quiescent Current vs. Temperature (Enabled)

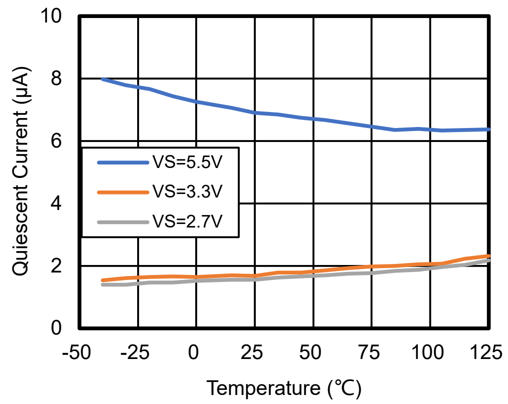
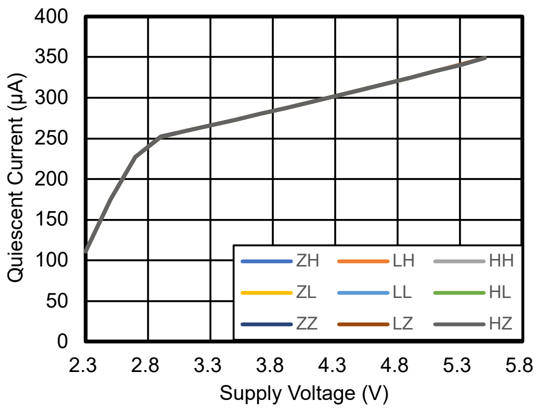


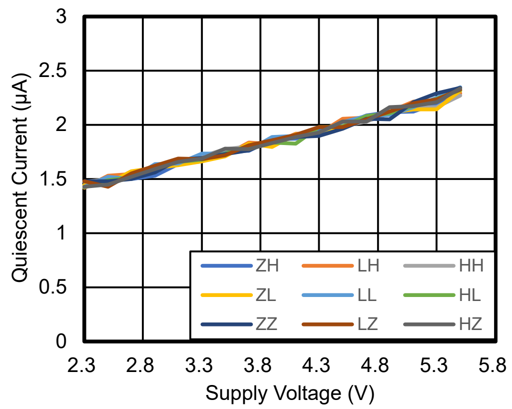
Figure 10. Quiescent Current vs. Temperature (Disabled)



Z = Floating, L = Low, H = High

HYS – Delay

Figure 11. Quiescent Current vs. HYS and Delay Settings (Enabled)



Z = Floating, L = Low, H = High

HYS – Delay

Figure 12. Quiescent Current vs. HYS and Delay Settings (Disabled)

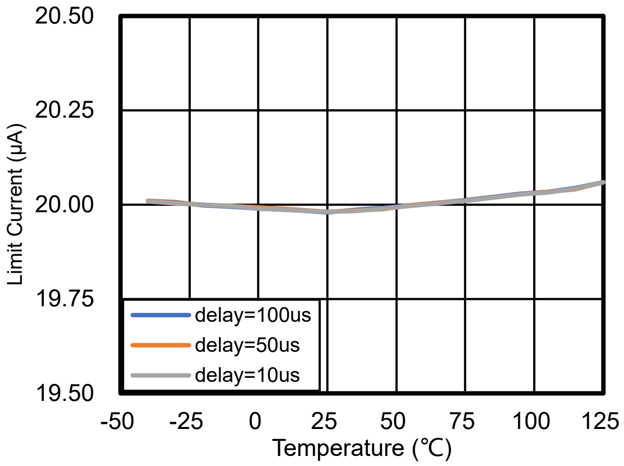


Figure 13. Limit Current Source vs. Temperature

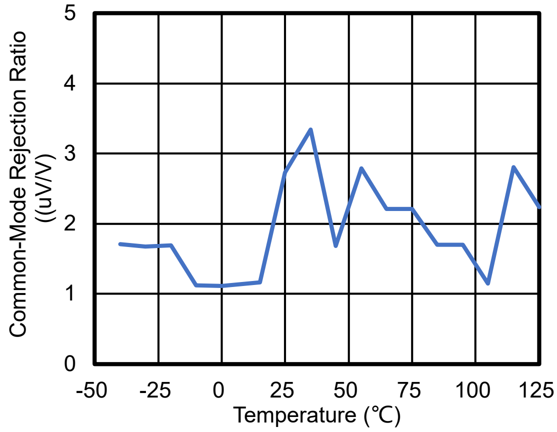


Figure 14. Common-Mode Rejection Ratio vs. Temperature

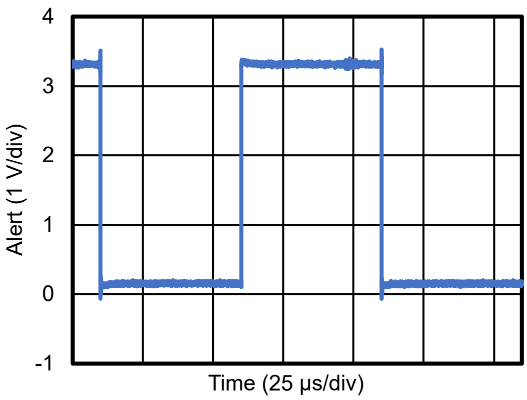


Figure 15. Alert Step Response

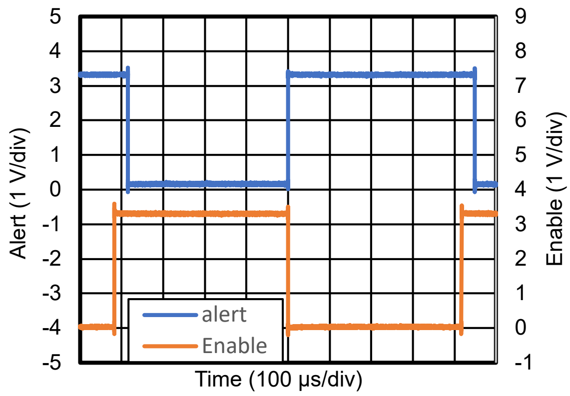


Figure 16. Alert Response (Disable to Enable)

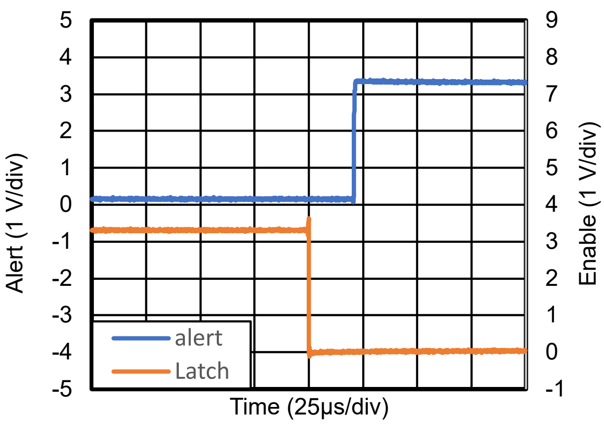


Figure 17. Alert Response (Latch Mode to Transparent Mode)

Detailed Description

Overview

The TPA170C is a comparator for current sensing applications. The device can operate on a supply voltage from 2.7 V to 5.5 V and offer a 36-V common-mode voltage range. The output function is present at the alert terminal. The alert terminal is an open-drain output. This terminal needs to be pulled up to the supply voltage by a resistor. A 10-kΩ resistor is recommended.

The TPA170C compares the differential mode input voltage with the threshold voltage. The alert terminal is pulled low when the differential mode input voltage exceeds the threshold. The threshold voltage can be configured by adding a resistor between the limit terminal and GND. The alert terminal keeps a high level with the input voltage below the threshold. Such alert terminal output behaviors make the device especially suitable for overcurrent detection. The 250-mV differential mode input range offers a wide range of detection.

Feature Description

Current Limit Threshold Setting

The comparison threshold voltage is set by the voltage at the limit terminal. There are two ways to set the threshold (V_{LIMIT}). One is to apply a certain voltage by connecting an external voltage source at the limit terminal, and the other is to add a resistor R_{LIMIT} between the limit terminal and GND. An internal 20-μA current source flows out from the limit terminal, which creates a voltage dropout (20 μA × R_{LIMIT}) as the comparison threshold on R_{LIMIT}.

Delay Setting

The delay terminal determines the delay time when the input voltage exceeds the threshold before the alert terminal turns low. There are three selections for delay time configurations, including 10 μs, 50 μs, and 100 μs, giving users a more flexible response time during the overcurrent detection for system designs.

The device has a comparison window in which it continuously detects the input voltage. The comparison window maintains the delay time setting by the delay terminal. For example, when the delay time is 10 μs, the input voltage needs to exceed the threshold for 10 μs to make the alert terminal turn to a low level. If there is a voltage below the threshold in the comparison window, the output alert can not be triggered, and the alert terminal keeps high. The 50-μs and 100-μs delay time effects are similar to those in the 10-μs delay time settings. The comparison window maintains for 50 μs or 100 μs depending on the 50-μs or 100-μs delay settings.

The comparison window not only exists in alert-triggered events but also functions in alert recovery. The input voltage needs to be lower than the threshold successively during the delay time to make the alert terminal return to a high level. Such recovery behavior is the characteristic in the transparent mode. The transparent mode is introduced in Alert Mode.

The delay time is set by connecting the delay terminal to the supply voltage or GND, or is left floating. The relationship between the delay terminal connection and delay time is shown in Table 2. When the delay time is 100 μs or 50 μs, it is not recommended to add a resistor between the delay terminal and the supply voltage or GND.

Table 2. Delay Setting

Delay Terminal Connection	Delay Time (μs)
Supply Voltage	100
GND	50
Floating	10

Hysteresis Setting

The hysteresis voltage (V_{HYS}) is set by the HYS terminal. V_{HYS} influences the recovery threshold. When the input voltage is lower than the recovery threshold (V_{LIMIT} − V_{HYS}), the alert event is removed, and the alert terminal returns to a high level. The combination of V_{LIMIT} and V_{HYS} contributes to the alert terminal behavior as the input voltage changes. This feature is represented in Figure 18.

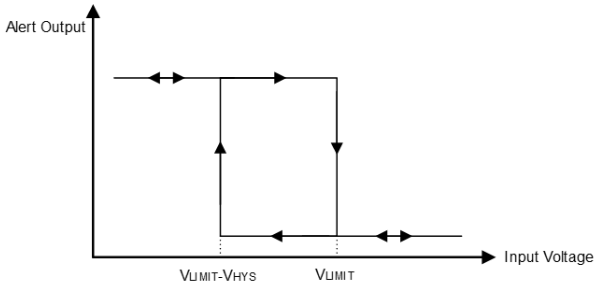


Figure 18. Hysteresis Feature

There are three V_{HYS} voltages including 8 mV, 4 mV, and 2 mV by connecting the HYS terminal to the supply voltage, or GND, or left floating. Three V_{HYS} voltage selections help users recognize overcurrent events disappeared in different applications. When the hysteresis voltage is 8 mV or 4 mV, it is not recommended to add a resistor between the HYS terminal and the supply voltage or GND. The relationship between the HYS terminal and V_{HYS} is shown in Table 3.

Table 3. Hysteresis Settings

HYS Terminal Connection	Hysteresis Voltage (mV)
Supply Voltage	8
GND	4
Floating	2

Disable Mode

The enable terminal determines whether the device is enabled or not. The device is disabled when the enable terminal keeps low. The power consumption is about 2 µA in the disable mode, offering benefits for battery-powered scenarios. The time is in microseconds when the state of the device changes between the enable mode and disabled mode, giving a short time to function normally. The relationship between the enable mode and the enable terminal is shown in Table 4.

Table 4. Enable and Disable Mode Settings

Enable Mode	Enable Terminal State
Enable Mode	High
Disable Mode	Low

Alert Mode

The alert mode consists of the transparent mode and the latch mode. The alert mode is determined by the latch terminal. The selection of the alert mode influences the alert terminal behaviors when the input voltage changes.

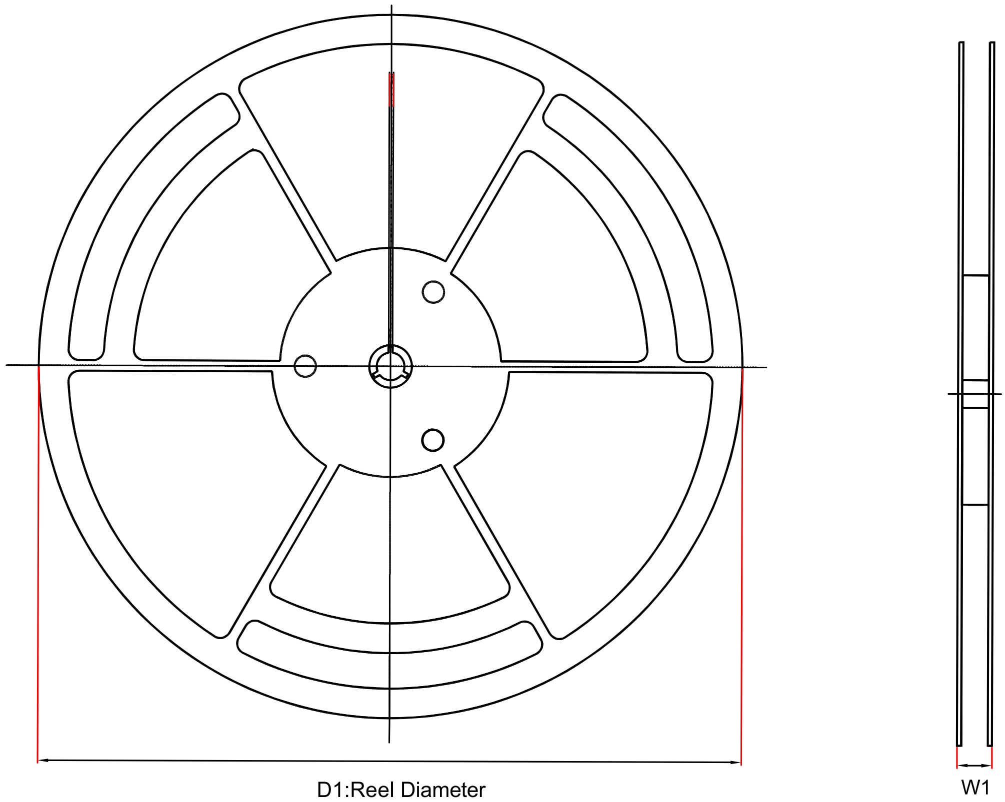
The device is configured in the transparent mode when the latch terminal is kept low. In the transparent mode, the alert terminal is pulled low when the input voltage exceeds V_{LIMIT}, and returns to a high level with the input voltage below V_{LIMIT} − V_{HYS}. Both of the two input voltage behaviors that cause changes in the alert terminal state must meet the delay time requirement in comparison window settings. Otherwise, the alert terminal keeps its state unchanged.

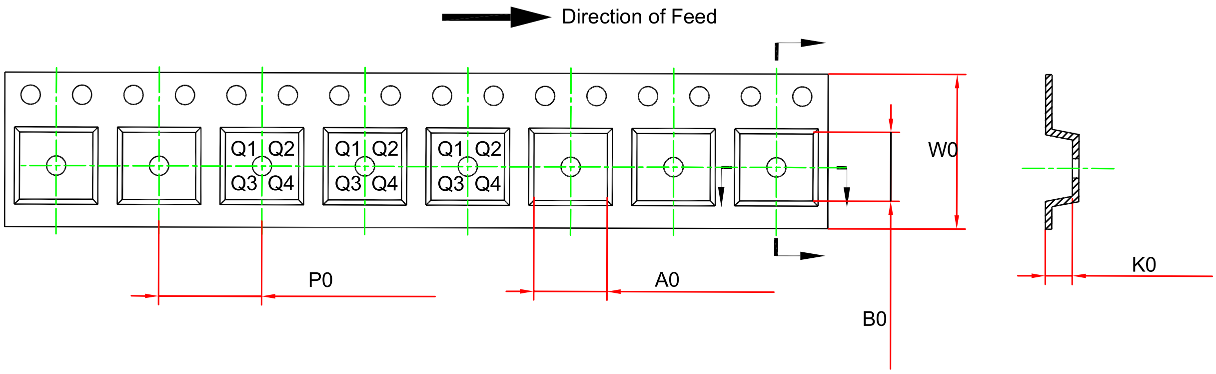
The device is configured to latch mode when the latch terminal is kept high. The difference between the transparent mode and latch mode is the alert terminal behavior when the input voltage is below the threshold. In the latch mode, the alert terminal is pulled low when the input voltage exceeds V_{LIMIT}, but it does not return to a high level with the input voltage below $V_{LIMIT} - V_{HYS}$. This feature in the latch mode helps users capture any overcurrent events in the system, while such events vanish in the transparent mode. To make the alert terminal return to a high level, the device must be in the transparent mode and the input voltage is below the $V_{LIMIT} - V_{HYS}$. Keep the latch terminal low for at least 2 μs to exit the latch mode.

Power Supply Recommendations

To realize better noise decouple performance on the power supply, place the power supply bypass capacitor as close as possible to the supply and the ground terminal. A 0.1-μF capacitor is recommended. Additional bypass capacitors get better noise suppression on the power supply.

Tape and Reel Information





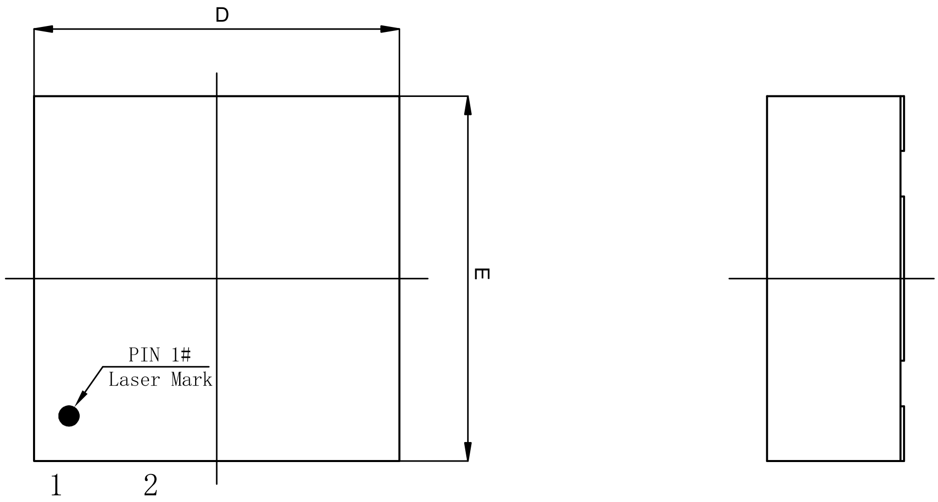
Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm) (1)	B0 (mm) (1)	K0 (mm) (1)	P0 (mm)	W0 (mm)	Pin1 Quadrant
TPA170C-DFFR-S	DFN2x2-10	180	12.5	2.3	2.3	1.1	4	8	Q2
TPA170C-VS2R-S	MSOP10	330	17.6	5.3	3.4	1.4	8	12	Q1

(1) The value is for reference only. Contact the 3PEAK factory for more information.

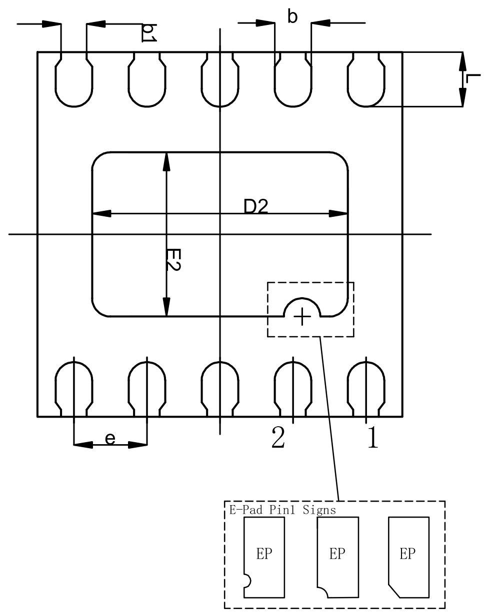
Package Outline Dimensions

DFN2×2-10

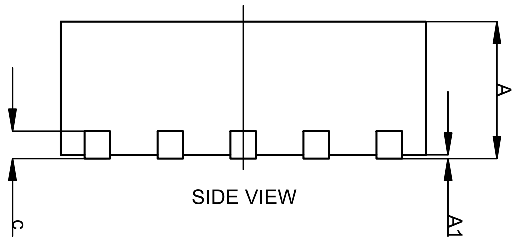
Package Outline Dimensions DFF(DFN2X2-10-A)



TOP VIEW



BOTTOM VIEW



SIDE VIEW

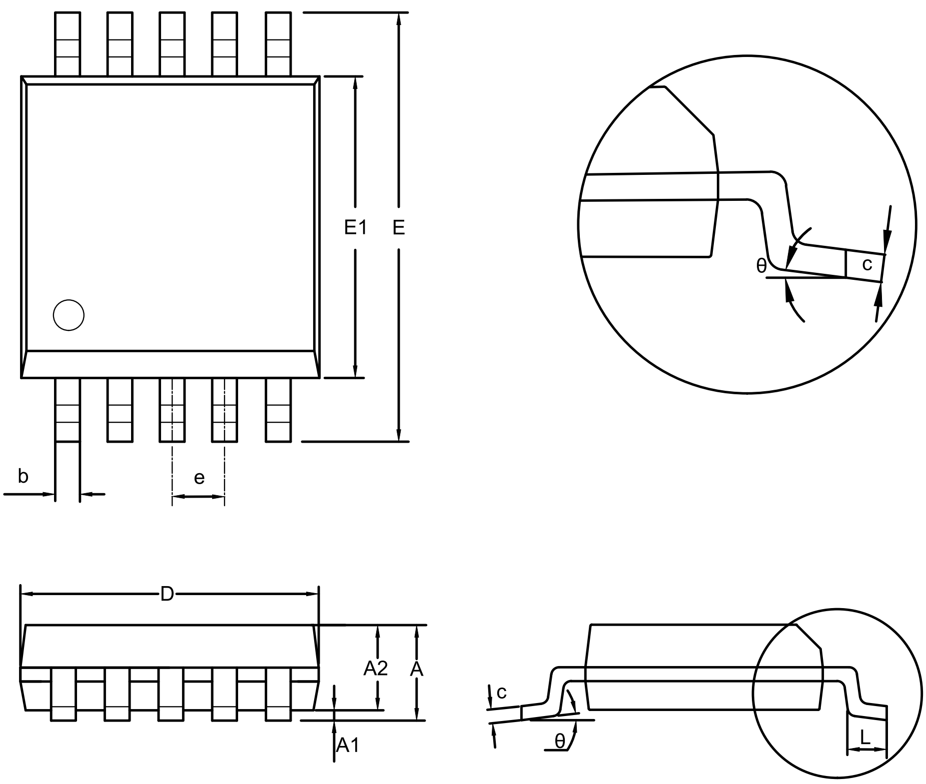
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
b	0.150	0.250	0.006	0.010
c	0.150	0.250	0.006	0.010
D	1.900	2.100	0.075	0.083
D2	1.300	1.500	0.051	0.059
E	1.900	2.100	0.075	0.083
E2	0.800	1.000	0.031	0.039
e	0.400 BSC		0.016 BSC	
L	0.250	0.350	0.010	0.014

NOTES

1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.
3. The many types of E-pad Pin1 signs may appear in the product.

MSOP10

Package Outline Dimensions VS2(MSOP-10-A)



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.800	1.100	0.031	0.043
A1	0.050	0.150	0.002	0.006
A2	0.750	0.950	0.030	0.037
b	0.180	0.280	0.007	0.011
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	4.700	5.100	0.185	0.201
E1	2.900	3.100	0.114	0.122
e	0.500 BSC		0.020 BSC	
L	0.400	0.800	0.016	0.031
θ	0	8°	0	8°

NOTES

1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

Order Information

Order Number	Package	Marking Information	MSL	Transport Media, Quantity	Eco Plan
TPA170C-DFFR-S	DFN2×2-10	70C	MSL1	Tape and Reel, 3,000	Green
TPA170C-VS2R-S (1)	MSOP10	A170C	MSL1	Tape and Reel, 3,000	Green

(1) Future Product.

Green: 3PEAK defines "Green" to mean RoHS compatible and free of halogen substances.

IMPORTANT NOTICE AND DISCLAIMER