



# 2.7V to 16.5V Hot Swap Controller with Tracking or Slew Rate Control

Preliminary Technical Data

ADM1173

## FEATURES

- Allows Safe Board Insertion and Removal from a Live Backplane
- Controls Supply Voltages from 2.7 V to 16.5V
- Adjustable Analog Current Limit with Circuit Breaker
- Fast Response Limits Peak Fault Current
- Automatic Retry or Latch-Off On Current Fault
- Adjustable Voltage Slew Rate Control
- Charge Pumped Gate Drive for External N-FET Switch
- TIMER pin allows control over timing functions
- Undervoltage Lockout
- 8-pin TSOT Package

## APPLICATIONS

- Hot Swap Board Insertion – Line Cards, Raid systems
- Electronic Circuit Breaker
- Industrial High Side Switch/Circuit Breaker

## GENERAL DESCRIPTION

The ADM1173 is a Hot Swap controller that allows a board to be safely inserted and removed from a live backplane.

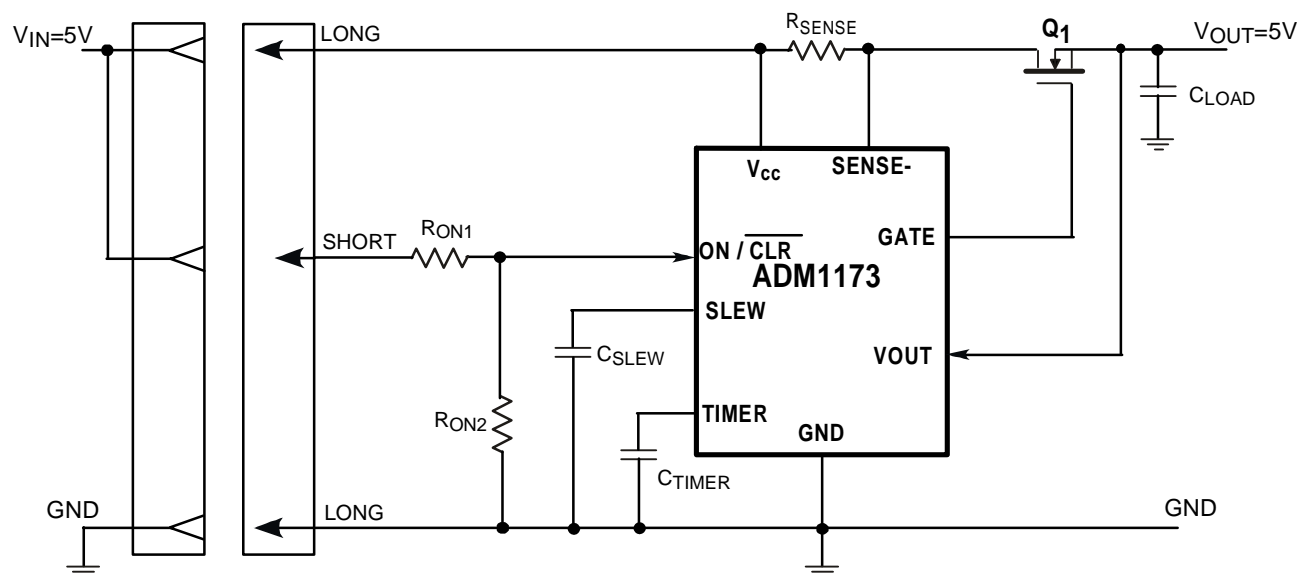
An internal charge pumped driver controls the GATE of an external high side N-channel FET for a supply voltage ranging from 2.7V to 16.5V. The ADM1173 provides the initial timing cycle and allows the GATE to be ramped up at an adjustable rate. The Slew rate of the Output is controlled a capacitor or supply on the SLEW pin.

The ADM1173 features a fast current limit loop providing active current limiting together with a circuit breaker timer. The signal at the ON pin turns the part on and off and is also used for the reset function.

A capacitor connected to the TIMER pin gives the user control over the duty cycle of the PWM retry ratio during current fault. This part is available in two options: the ADM1173-1 will automatic retry for over-current fault and the ADM1173-2 will latch-off for an over-current fault.

The ADM1173 is packaged in an 8-lead TSOT package.

## APPLICATIONS DIAGRAM



### Rev.PrE

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One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106, U.S.A.  
Tel: 781.329.4700  
Fax: 781.326.8703  
www.analog.com  
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## SPECIFICATIONS

Table 1.  $V_{CC} = 2.7V$  to  $16V$ ,  $T_A = -40^{\circ}C$  to  $+85^{\circ}C$ , Typical Values at  $T_A = 25^{\circ}C$  unless otherwise noted.

Parameter	Min	Typ	Max	Units	Conditions
<b>V<sub>CC</sub> Pin</b>					
Operating Voltage Range, $V_{CC}$	2.7		16.5	V	$V_{CC}$ Rising
Supply Current, $I_{CC}$		0.65	1.0	mA	
Undervoltage Lockout, $V_{UVLO}$	2.4	2.525	2.65	V	
Undervoltage Lockout Hysteresis, $V_{UVLOHYS}$		25		mV	
<b>ON Pin</b>					
ON Pin Input Current, $I_{INON}$	-100	0	100	nA	ON rising
On Pin Threshold, $V_{ON}$	1.26	1.3	1.34	V	
ON Pin Threshold Hysteresis, $V_{ONHYS}$		80		mV	
<b>RS- Pin</b>					
Hot Swap Voltage	2.7		16.5	V	$V_{SENSE} = V_{CC}$ , $V_{HOTSWAP} = 0.6V$ , Note $V_{SENSE} = V_{CC}$ , $V_{HOTSWAP} > 2.2V$ $V_{CB} = (V_{CC} - V_{SENSE})$ , $V_{HOTSWAP} = 0.6V$ $V_{CB} = (V_{CC} - V_{SENSE})$ , $V_{HOTSWAP} > 2.2V$ $V_{HOTSWAP} = 0.6V$ , Note $V_{HOTSWAP} > 2.2V$
RS- Pin Input Current, $I_{INSENSE}$	TBD	-200	TBD	$\mu A$	
	10	20	30	$\mu A$	
Circuit Breaker Limit Voltage, $V_{CB}$	34	47	60	mV	
	44	47	53	mV	
Over Current Limit Voltage, $V_{OC}$	40	53	66	mV	
	50	53	59	mV	
<b>GATE Pin</b>					
GATE Drive Voltage, $V_{GATE}$	5	6.5	10	V	$V_{GATE} = V_{CC}$ , $V_{CC} = 2.7V$
GATE Drive Voltage, $V_{GATE}$	6	8	12	V	$V_{GATE} = V_{CC}$ , $V_{CC} = 5V$
GATE Drive Voltage, $V_{GATE}$	5	6.5	10	V	$V_{GATE} = V_{CC}$ , $V_{CC} = 16.5V$
<b>Gate Pullup Current</b>	10	12	14	$\mu A$	$V_{GATE} = 0V$
<b>Gate Pulldown Current</b>		2		mA	$V_{GATE} = 3V$ , $V_{CC} > UVLO$
<b>Gate Pulldown Current</b>		25		mA	$V_{GATE} = 3V$ , $V_{CC} < UVLO$
<b>TIMER Pin</b>					
TIMER Pin Pull-Up Current, $I_{TIMERUP}$	-4	-5	-6	$\mu A$	Initial Cycle, $V_{TIMER} = 1V$
	-48	-60	-72	$\mu A$	During Current Fault, $V_{TIMER} = 1V$
TIMER Pin Pull-Down Current, $I_{TIMERDN}$		2	2.5	$\mu A$	After Current Fault, $V_{TIMER} = 1V$
		100		$\mu A$	Normal Operation, $V_{TIMER} = 1V$
TIMER Pin Threshold High, $V_{TIMERH}$	1.235	1.3	1.365	V	TIMER rising
TIMER Pin Threshold Low, $V_{TIMERL}$	0.18	0.2	0.22	V	TIMER falling
<b>C<sub>SLEW</sub> Pin</b>					
Slew up Current		-10		$\mu A$	$V_{SLEW}/V_{OUTFB}$
Slew down Current		10		$\mu A$	
Tracking Gain		1		V/V	
Tracking Accuracy	-100		100	mV	
Minimum Tracking Voltage		0.1		V	
Maximum Tracking voltage		$V_{CC} - 0.1$		V	
Slew Rate	100		1000	V/s	
<b>V<sub>OUTFB</sub> Pin</b>					
Input Current	-100		100	$\mu A$	
Voltage Range	0		$V_{CC}$	V	

## Absolute Maximum Ratings

Parameter	Rating
V <sub>CC</sub> Pin	20V
RS+, RS- Pins	-0.3V to 20V
TIMER Pin	-0.3V to (V <sub>CC</sub> + 0.3V)
Slew Pin	-0.3 to 20V
ON Pin	-0.3V to 20V
GATE Pin	V <sub>CC</sub> + 11V
Power Dissipation	TBD
Storage Temperature	-65°C to +125°C
Operating Temperature Range	-40°C to +85°C
Lead Temperature Range (10 sec)	300°C
Junction Temperature	150°C

## HOT CIRCUIT INSERTION

When circuit boards are inserted into live backplanes, the supply bypass capacitors can draw large transient currents from the backplane power bus as they charge. Such transient currents can cause permanent damage to connector pins, glitches on the system supply or reset other boards in the system.

The ADM1173 is designed to turn a printed circuit board's supply voltage ON and OFF in a controlled manner, allowing the circuit board to be safely inserted into or removed from a live backplane. The ADM1173 can reside either on the backplane or on the daughter board for hot circuit insertion applications.

## OVERVIEW

The ADM1173 is designed to operate over a range of supplies from 2.7V to 16.5V. Upon insertion, an undervoltage lockout circuit determines if sufficient supply voltage is present. When the ON pin goes high an initial timing cycle assures that the board is fully seated in the backplane before the FET is turned on. A single timer capacitor sets the periods for all of the timer functions. After the initial timing cycle the ADM1173 can either start up in current limit or with a lower load current. Once the external FET is fully enhanced and the supply has ramped up, the ADM1173 monitors the load current through an external sense resistor. Overcurrent faults are actively limited to  $47\text{mV}/R_{\text{SENSE}}$  for a specified circuit breaker timer limit. The ADM1173-1 will automatically retry after a current limit fault while the ADM1173-2 latches off. The ADM1173-1 timer function limits the retry duty cycle to 3.8% for FET cooling.

## UNDervOLTAGE LOCKOUT

An internal undervoltage lockout (UVLO) circuit resets the ADM1173 if the  $V_{\text{CC}}$  supply is too low for normal operation. The UVLO has a low-to-high threshold of 2.525V, a 25mV hysteresis. Above 2.525V supply voltage, the ADM1173 will start if the ON pin conditions are met.

## ON FUNCTION

The ON pin is the input to a comparator which has a low-to-high threshold of 1.3V, an 80mV hysteresis and a high-to-low glitch filter of 30 $\mu\text{s}$ . A low input on the ON pin resets the ADM1173 TIMER status and turns off the external FET by pulling the GATE pin to ground. A low-to-high transition on the ON pin starts an initial cycle followed by a start-up cycle. The output will then start to rise at a rate determined by the slew rate of the SLEW pin. A 10k pull-up resistor connecting the ON pin to the supply is recommended. The 10k resistor

shunts any potential static charge on the backplane and reduces the overvoltage stress at the ON pin during live insertion.

Alternatively, an external resistor divider at the ON pin can be used to program an undervoltage lockout value higher than the internal UVLO circuit. An RC filter can be added at the ON pin to increase the delay time at card insertion if the internal glitch filter delay is insufficient.

## GATE FUNCTION

During hot insertion of the PCB, an abrupt application of supply voltage charges the external FET drain/gate capacitance. This can cause an unwanted gate voltage spike. An internal circuit holds GATE low before the internal circuitry wakes up. This reduces the FET current surges substantially at insertion. The GATE pin is held low in reset mode and during the initial timing cycle. In the start-up cycle the GATE pin is pulled up by a 12 $\mu\text{A}$  current source. During an over-current fault condition, the error amplifier servos the GATE pin to maintain a constant current to the load until the circuit breaker trips. When the circuit breaker trips, the GATE pin shuts down abruptly.

## SLEW RATE CONTROL

The slew rate of a rising or falling supply can be controlled by an external capacitor on the SLEW pin. Alternatively, this pin can be overdriven with a supply which will result in the output following this supply. This enables the ADM1173 to behave as a voltage tracker.

## CURRENT LIMIT CIRCUIT BREAKER FUNCTION

The ADM1173 features a current limiting circuit breaker. When there is a sudden load current surge, such as a low impedance fault, the bus supply voltage can drop significantly to a point where the power to an adjacent card is affected, causing system malfunctions. The ADM1173 fast response current sense amplifier instantly limits current by reducing the external FET GATE pin voltage. This minimizes the bus supply voltage drop and permits power budgeting and fault isolation without affecting neighboring cards. A compensation circuit should be connected to the GATE pin for current limit loop stability.

### CALCULATING CURRENT LIMIT

The nominal fault current limit is determined by a sense resistor connected between  $V_{CC}$  and the SENSE pin as given by the equation below:

$$I_{LIMIT(NOM)} = V_{CB(NOM)} / R_{SENSE} \quad (1)$$

The minimum load current is given by Equation 2:

$$I_{LIMIT(MIN)} = V_{CB(MIN)} / R_{SENSE(MAX)} \quad (2)$$

The maximum load current is given by Equation 3:

$$I_{LIMIT(MAX)} = V_{CB(MAX)} / R_{SENSE(MIN)} \quad (3)$$

Note: The power rating of the sense resistor should be rated at the fault current level.

For proper operation, the minimum current limit must exceed the circuit maximum operating load current with margin. The sense resistor power rating must exceed  $V_{CB(MAX)}^2 / R_{SENSE(MIN)}$ .

### TIMER FUNCTION

The TIMER pin handles several key functions with an external capacitor,  $C_{TIMER}$ . There are two comparator thresholds: COMP1 (0.2V) and COMP2 (1.3V). The four timing current sources are:

- 5 $\mu$ A pull-up
- 60 $\mu$ A pull-up
- 2 $\mu$ A pull-down
- 100 $\mu$ A pull-down

The 100 $\mu$ A is a non-ideal current source approximating a 7k resistor below 0.4V.

### INITIAL TIMING CYCLE

When the card is being inserted into the bus connector, the long pins mate first which brings up the supply  $V_{IN}$  at time point 1 of Figure 1. The ADM1173 is in reset mode as the ON pin is low. GATE is pulled low and the TIMER pin is pulled low with a 100 $\mu$ A source. At time point 2, the short pin makes contact and ON is pulled high. At this instant, a start-up check requires that the supply voltage be above UVLO, the ON pin be above 1.3V and the TIMER pin voltage be less than 0.2V. When these three conditions are fulfilled, the initial cycle begins and the TIMER pin is pulled high with 5 $\mu$ A. At time point 3, the TIMER reaches the COMP2 threshold and the first portion of the initial cycle ends. The 100 $\mu$ A current source then

pulls down the TIMER pin until it reaches 0.2V at time point 4. The initial cycle delay (time point 2 to time point 4) is related to  $C_{TIMER}$  by equation:

$$t_{INITIAL} \sim 272.9 \times C_{TIMER} \text{ ms/uF} \quad (4)$$

When the initial cycle terminates, a start-up cycle is activated and the GATE pin ramps high. The TIMER pin continues to be pulled down towards ground.

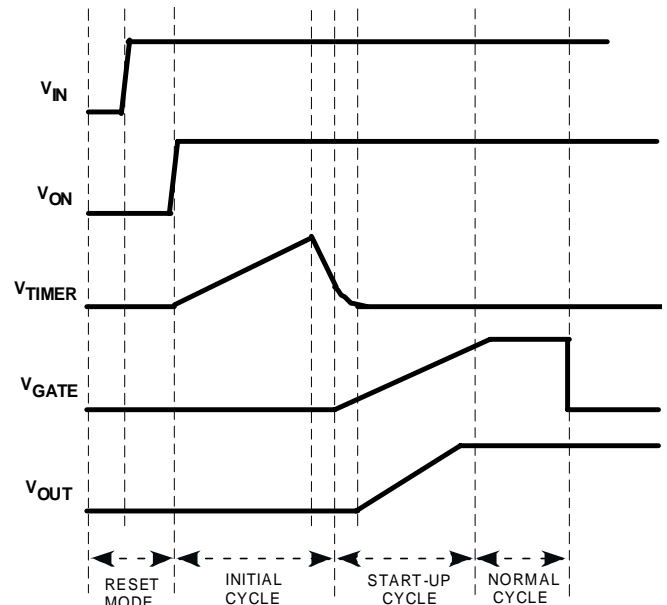


Figure 1: Normal Start-up

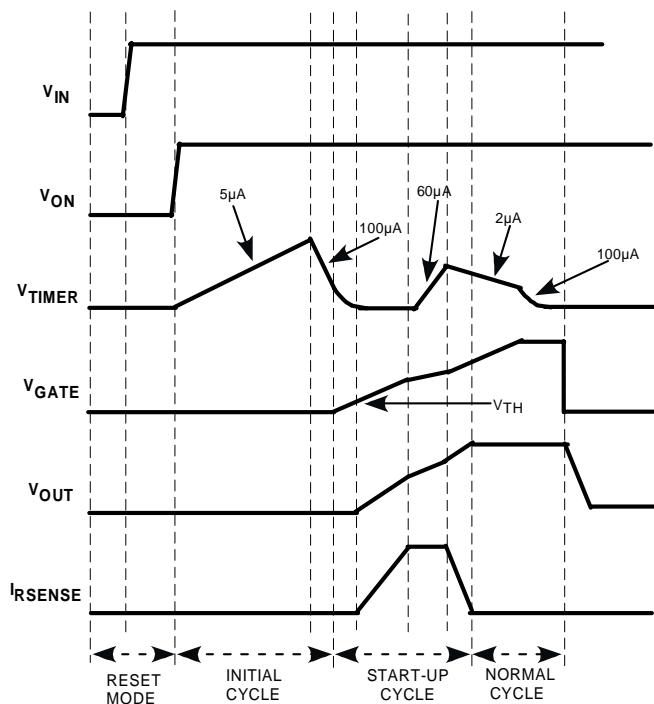


Figure 2: Current Limiting at Start-up

### KELVIN SENSE RESISTOR CONNECTION

When using a low-value sense resistor for high current measurement the problem of parasitic series resistance can arise. The lead resistance can be a substantial fraction of the rated resistance making the total resistance a function of lead length. This problem can be avoided by using a Kelvin sense connection. This type of connection separates the current path through the resistor and the voltage drop across the resistor. Figure 18 below shows the correct way to connect the sense resistor between the VCC and RS- pins of the ADM1173.

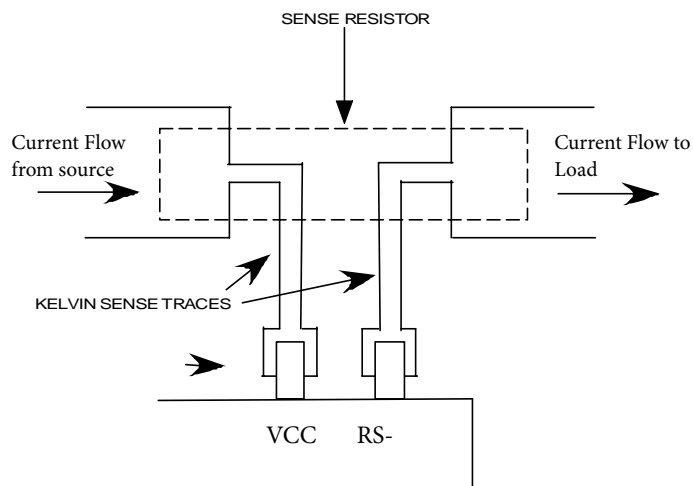
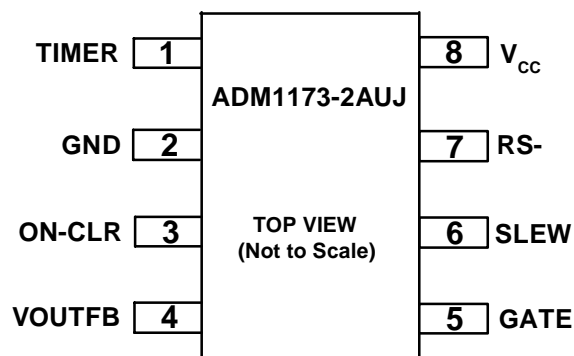
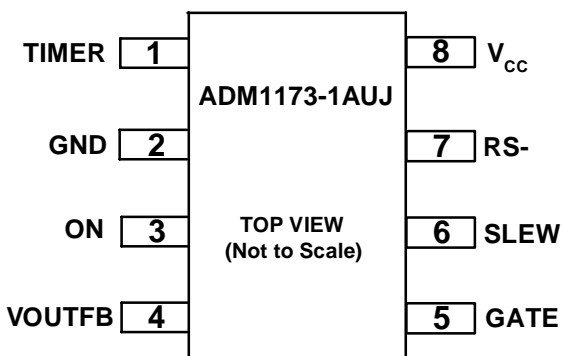


Figure 2: Current Sense Kelvin connection

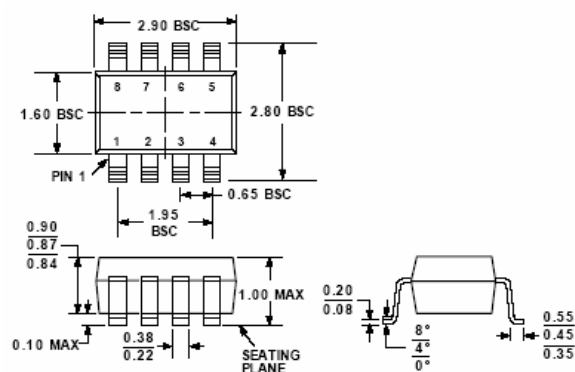
## PIN CONFIGURATIONS



## PIN FUNCTIONAL DESCRIPTIONS

Pin No.	Name	Description
1	TIMER	Timer Input Pin. An external capacitor $C_{\text{TIMER}}$ sets a 272.9ms/ $\mu\text{F}$ initial timing delay and a 21.7ms/ $\mu\text{F}$ circuit breaker delay. The GATE pin turns off whenever the TIMER pin is pulled beyond the upper threshold, such as for overvoltage detection with an external zener.
2	GND	Chip Ground Pin
3	UP/STOP ON (ON-CLR)	Input Pin. The ON pin comparator has a low-to-high threshold of 1.3V with 80mV hysteresis and a glitch filter. When the ON pin is low, the ADM1173 is reset. When the ON pin goes high, the GATE turns on after the initial timing cycle. On the ADM1173-2, a rising edge on this pin has the added function of clearing a fault and restarting the device
4	VOUTFB	Monitors the Source of the external FET
5	GATE	GATE Output Pin. This pin is the high side gate drive of an external N-channel FET. An internal charge pump provides a 12 $\mu\text{A}$ pull-up current with Zener clamps to RS+ and ground. In overload, the error amplifier (EA) controls the external FET to maintain a constant load current.
6	SLEW	Connect to an external capacitor to control the slew rate of the of the GATE at turn on and turn-off.
7	RS-	Current Limit Sense Input Pin. A sense resistor between the Vcc and RS- pins sets the analog current limit. In overload, the EA controls the external FET gate to maintain the SENSE voltage at 50mV. When the EA is maintaining current limit, the TIMER circuit breaker mode is activated. The current limit loop/circuit breaker mode can be disabled by connecting the Vcc pin and RS- pin together.
8	V <sub>CC</sub>	Positive Supply Input Pin. The operating supply voltage range is between 2.7V to 16.5V. An undervoltage lockout (UVLO) circuit with a glitch filter resets the ADM1173 when a low supply voltage is detected.

# OUTLINE DIMENSIONS



COMPLIANT TO JEDEC STANDARDS MO-193BA

Figure 3. 8-Lead TSOT Package (UJ-8)—Dimensions shown in millimeters

## ESD CAUTION

ESD (electrostatic discharge) sensitive device. Electrostatic charges as high as 4000 V readily accumulate on the human body and test equipment and can discharge without detection. Although this product features proprietary ESD protection circuitry, permanent damage may occur on devices subjected to high energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.



Table 2. Ordering Guide

Part Number	Version	Temperature Package	Package Description	Package Outline
ADM1173-1AUJ	Automatic Retry Version	−40°C to +85°C	TSOT	UJ-8
ADM1173-2AUJ	Latched Off Version	−40°C to +85°C	TSOT	UJ-8