MIC2026/MIC2076

Dual-Channel Power Distribution Switch

Features

- 140 mΩ Maximum On-Resistance per Channel
- 2.7V to 5.5V Operating Range
- 500 mA Minimum Continuous Current per Channel
- Short-Circuit Protection with Thermal Shutdown
- Thermally Isolated Channels
- Fault Status Flag with 3 ms Filter Eliminates False Assertions
- Undervoltage Lockout
- Reverse Current Flow Blocking (No “Body Diode”)
- Circuit Breaker Mode (MIC2076)
- Logic-Compatible Inputs
- Soft-Start Circuit
- Low Quiescent Current
- Pin-Compatible with MIC2526
- UL File #E179633

Applications

- USB Peripherals
- General Purpose Power Switching
- ACPI Power Distribution
- Notebook PCs
- PDAs
- PC Card Hot Swap

General Description

The MIC2026 and MIC2076 are high-side MOSFET switches optimized for general-purpose power distribution that requires circuit protection.

The MIC2026/76 are internally current limited and have thermal shutdown that protects the device and load.

The MIC2076 offers “smart” thermal shutdown that reduces current consumption in fault modes. When a thermal shutdown fault occurs, the output is latched off until the faulty load is removed. Removing the load or toggling the enable input will reset the device output.

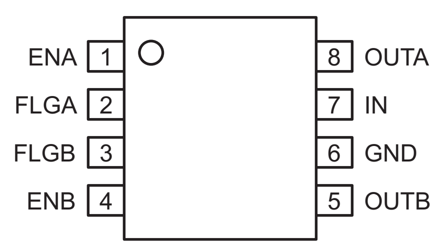
Both devices employ soft-start circuitry that minimizes inrush current in applications where highly capacitive loads are employed.

A fault status output flag is asserted during overcurrent and thermal shutdown conditions. Transient faults are internally filtered.

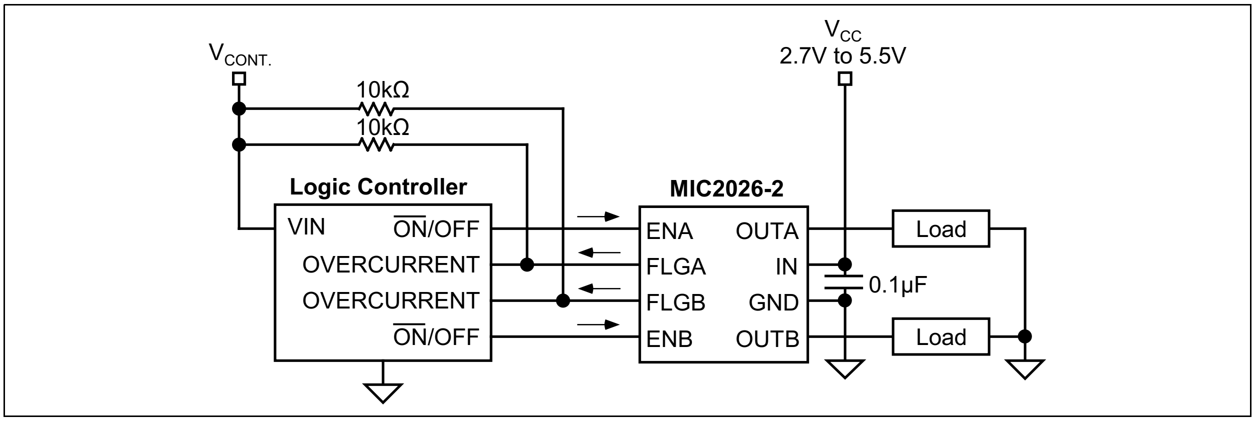
The MIC2026/76 are available in an 8-pin SOIC package.

Package Type

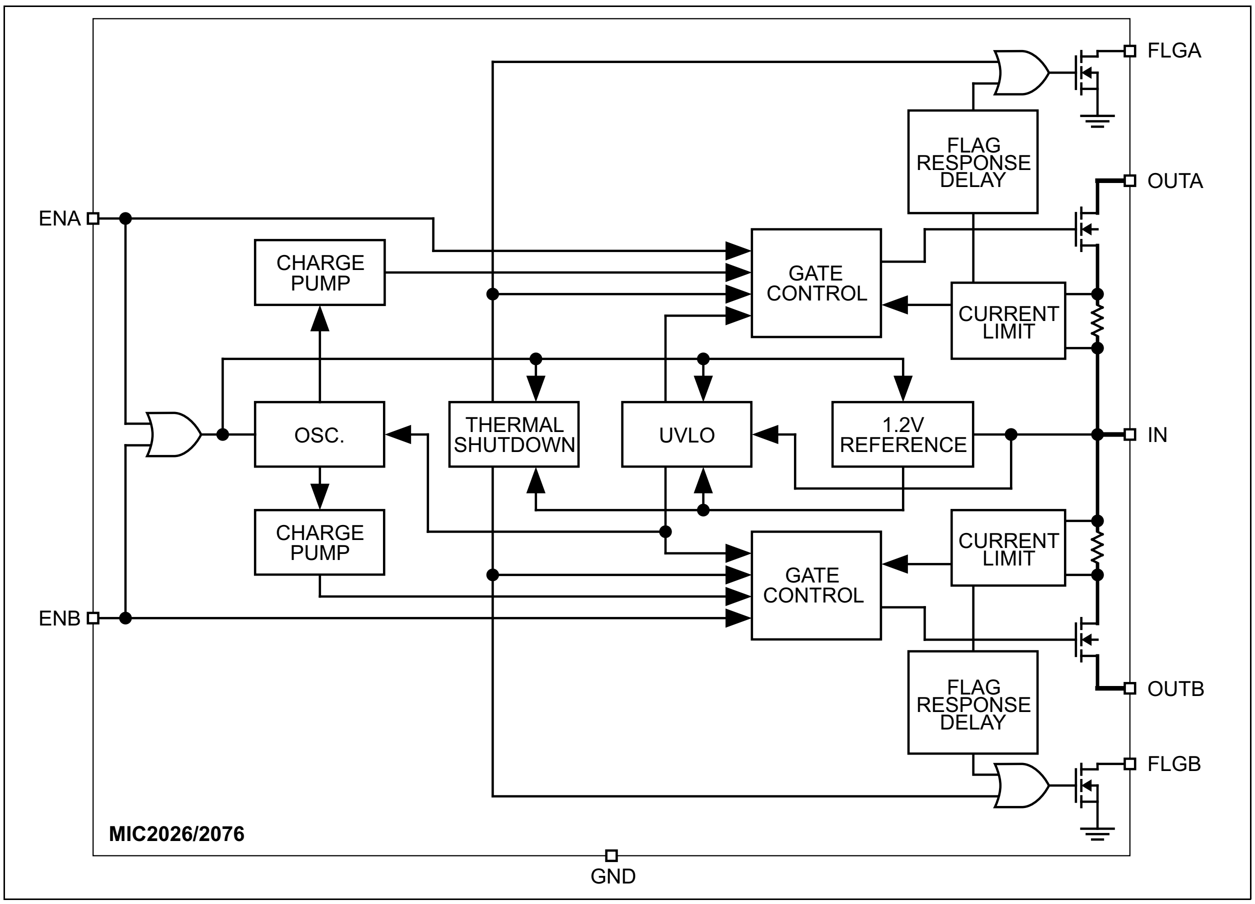
MIC2026/MIC2076
8-Lead SOIC (M)
(Top View)



Typical Application Circuit



Functional Block Diagram



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Supply Voltage (V_{IN}) .... –0.3V to +6.0V
Fault Flag Voltage (V_{FLG}) .... +6.0V
Fault Flag Current (I_{FLG}) .... 25 mA
Output Voltage (V_{OUT}) .... +6.0V
Output Current (I_{OUT}) .... Internally Limited
Enable Input Voltage (V_{EN}) .... –0.3V to V_{IN} + 0.3V
ESD Rating (Note 1) .... 1 kV (HBM)
200V (MM)

Operating Ratings ††

Supply Voltage (V_{IN}) .... +2.7V to +5.5V

† Notice: Stresses above those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operational sections of this specification is not intended. Exposure to maximum rating conditions for extended periods may affect device reliability.

†† Notice: The device is not guaranteed to function outside its operating ratings.

Note 1: Devices are ESD sensitive. Handling precautions are recommended.

ELECTRICAL CHARACTERISTICS

Electrical Characteristics: V_{IN} = +5V; T_A = +25°C, **bold** values valid for –40°C ≤ T_A ≤ +85°C, unless noted. Note 1

Parameter	Sym.	Min.	Typ.	Max.	Units	Conditions
Supply Current	I_{DD}	—	0.75	5	µA	MIC20x6-1, V_{ENA} = V_{ENB} ≤ 0.8V (switch off), OUT = open
		—	9.5	**20**		MIC20x6-2, V_{ENA} = V_{ENB} ≥ 2.4V (switch off), OUT = open
		—	100	160		MIC20x6-1, V_{ENA} = V_{ENB} ≥ 2.4V (switch on), OUT = open
		—	100	160		MIC20x6-2, V_{ENA} = V_{ENB} ≤ 0.8V (switch on), OUT = open
Enable Input Threshold	V_{EN}	—	1.7	**2.4**	V	Low-to-high transition
		0.8	1.45	—		High-to-low transition
Enable Input Hysteresis		—	250	—	mV	—
Enable Input Current	I_{EN}	**–1**	0.01	**1**	µA	V_{EN} = 0V to 5.5V
Enable Input Capacitance		—	1	—	pF	—
Switch Resistance	$R_{DS(ON)}$	—	90	**140**	mΩ	V_{IN} = 5V, I_{OUT} = 500 mA
		—	100	**170**		V_{IN} = 3.3V, I_{OUT} = 500 mA
Output Leakage Current	—	—	—	**10**	µA	MIC20x6-1, V_{ENx} ≤ 0.8V; MIC20x6-1, V_{ENx} ≥ 2.4V, (output off)
OFF Current in Latched Thermal Shutdown		—	50	—	µA	MIC2076 (during thermal shutdown state)

Note 1: Specification for packaged product only.

2: If there is a fault on one channel, that channel will shut down when the die reaches approximately 140°C. If the die reaches approximately 160°C, both channels will shut down, even if neither channel is in current limit.

ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Characteristics: V_{IN} = +5V; T_A = +25°C, **bold** values valid for –40°C ≤ T_A ≤ +85°C, unless noted. Note 1

Parameter	Sym.	Min.	Typ.	Max.	Units	Conditions
Output Turn-On Delay	t_{ON}	—	1.3	**5**	ms	R_L = 10Ω, C_L = 1 µF, see Timing Diagrams
Output Turn-On Rise Time	t_R	**0.5**	1.15	**4.9**	ms	R_L = 10Ω, C_L = 1 µF, see Timing Diagrams
		—	1.75	—		R_L = 10Ω, C_L = 1 µF, see Timing Diagrams
Output Turn-Off Delay	t_{OFF}	—	35	**100**	µs	R_L = 10Ω, C_L = 1 µF, see Timing Diagrams
Output Turn-Off Fall Time	t_F	—	32	**100**	µs	R_L = 10Ω, C_L = 1 µF, see Timing Diagrams
Short-Circuit Output Current	I_{LIMIT}	0.5	0.9	1.25	A	V_{OUT} = 0V, enabled into short-circuit
Current Limit Threshold	—	0.65	1.0	1.25	A	Ramped load applied to output
Short-Circuit Response Time	—	—	20	—	µs	V_{OUT} = 0V to I_{OUT} = I_{LIMIT} (short applied to output)
Overcurrent Flag Response Delay	t_D	**1.5**	3	**7**	ms	V_{IN} = 5V, apply V_{OUT} = 0V until FLG low
		—	3	—		V_{IN} = 3.3V, apply V_{OUT} = 0V until FLG low
Undervoltage Lockout Threshold	—	**2.2**	2.4	**2.7**	V	V_{IN} rising
		2.0	2.15	**2.5**		V_{IN} falling
Error Flag Output Resistance	—	—	10	**25**	Ω	I_L = 10 mA, V_{IN} = 5V
		—	15	**40**		I_L = 10 mA, V_{IN} = 3.3V
Error Flag Off Current	—	—	—	10	µA	V_{FLAG} = 5V
Overtemperature Threshold (Note 2)	—	—	140	—		T_J increasing, each switch
		—	120	—		T_J decreasing, each switch
		—	160	—		T_J increasing, both switches
		—	150	—		T_J decreasing, both switches

Note 1: Specification for packaged product only.

2: If there is a fault on one channel, that channel will shut down when the die reaches approximately 140°C. If the die reaches approximately 160°C, both channels will shut down, even if neither channel is in current limit.

TEMPERATURE SPECIFICATIONS

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Temperature Ranges						
Operating Ambient Temperature Range	T_J	–40	—	+85	°C	Note 1
Storage Temperature Range	T_S	–65	—	+150	°C	—
Package Thermal Resistance						
Thermal Resistance, SOIC 8-Ld	θ_{JA}	—	160	—	°C/W	—

Note 1: The maximum allowable power dissipation is a function of ambient temperature, the maximum allowable junction temperature and the thermal resistance from junction to air (i.e., T_A, T_J, θ_{JA}). Exceeding the maximum allowable power dissipation will cause the device operating junction temperature to exceed the maximum +85°C rating. Sustained junction temperatures above +85°C can impact the device reliability.

Test Circuit

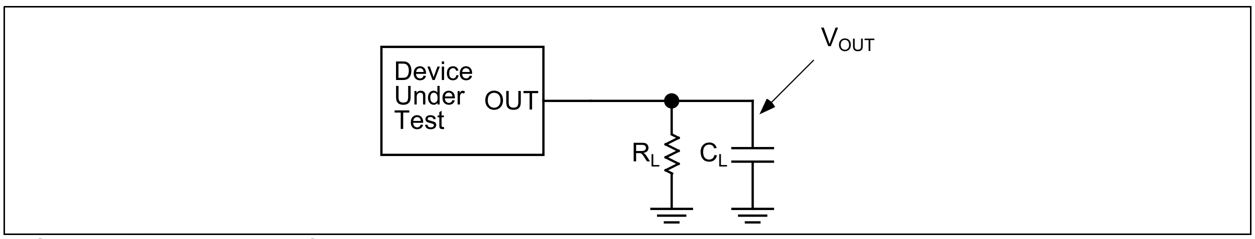


FIGURE 1-1: *Test Circuit.*

Timing Diagrams

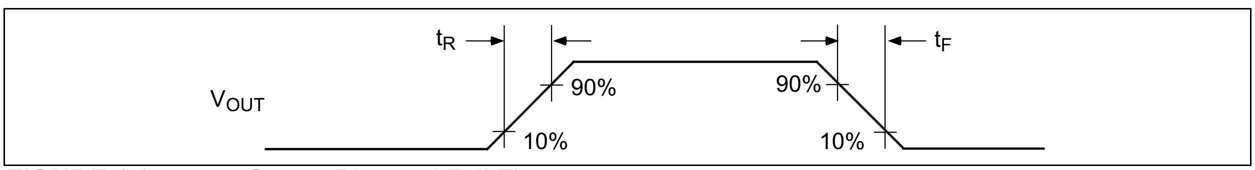


FIGURE 1-2: *Output Rise and Fall Times.*

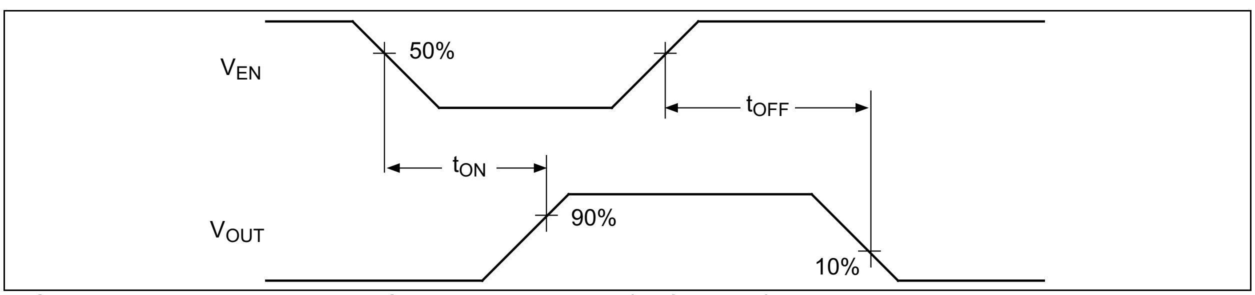


FIGURE 1-3: *Active-Low Switch Delay Times (MIC20x6-2).*

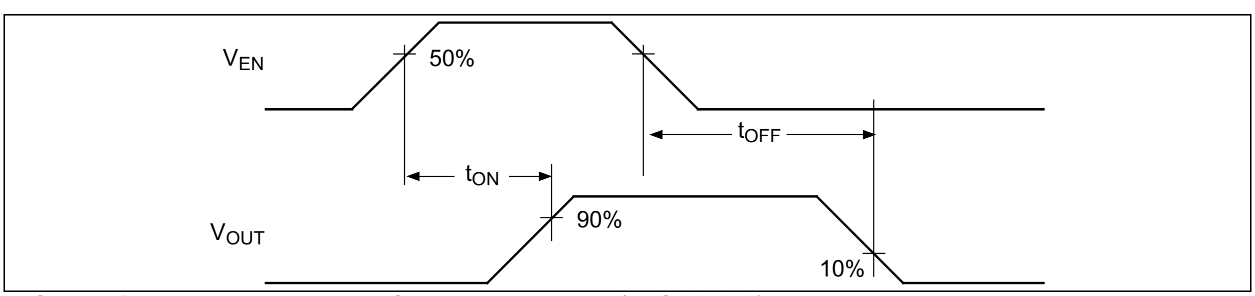


FIGURE 1-4: *Active-High Switch Delay Time (MIC20x6-1).*

2.0 TYPICAL PERFORMANCE CURVES

Note: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g., outside specified power supply range) and therefore outside the warranted range.

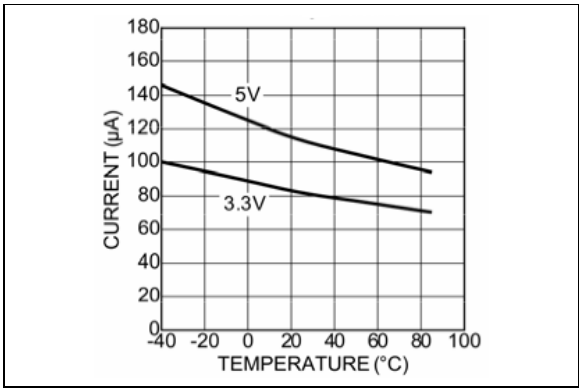


FIGURE 2-1: *Supply On-Current vs. Temperature.*

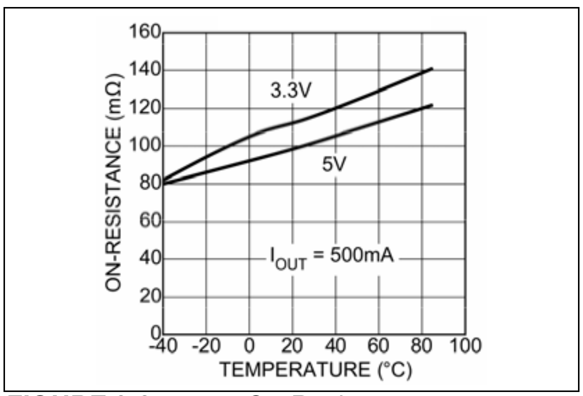


FIGURE 2-2: *On-Resistance vs. Temperature.*

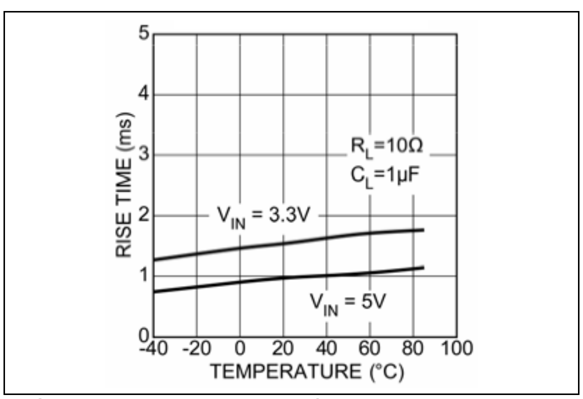


FIGURE 2-3: *Turn-On Rise Time vs. Temperature.*

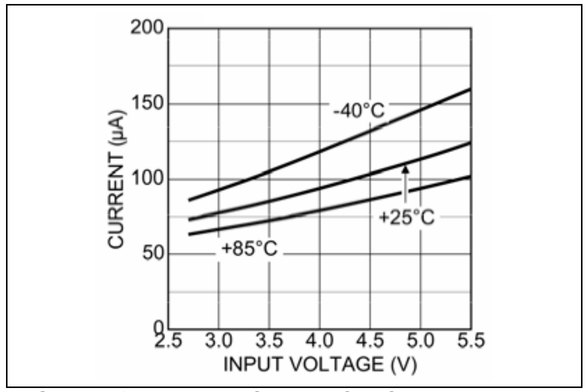


FIGURE 2-4: *Supply On-Current vs. Input Voltage.*

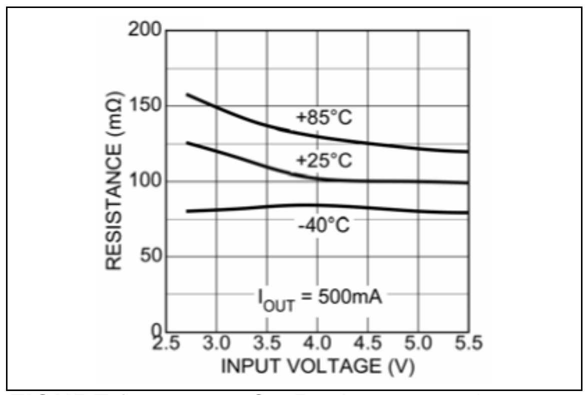


FIGURE 2-5: *On-Resistance vs. Input Voltage.*

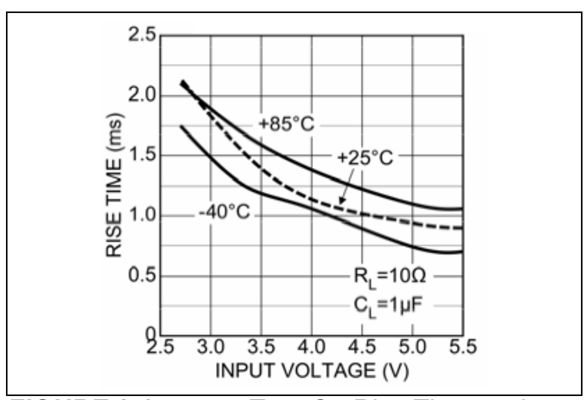


FIGURE 2-6: *Turn-On Rise Time vs. Input Voltage.*

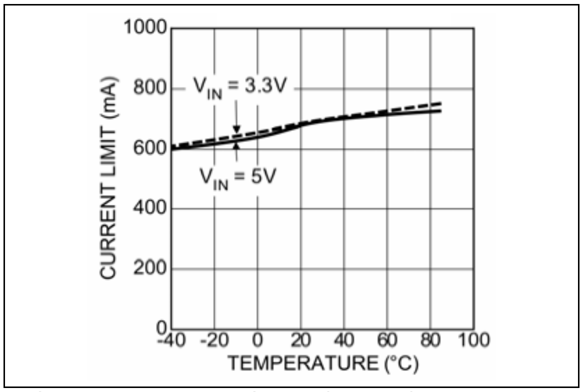


FIGURE 2-7: *Short-Circuit Current Limit vs. Temperature.*

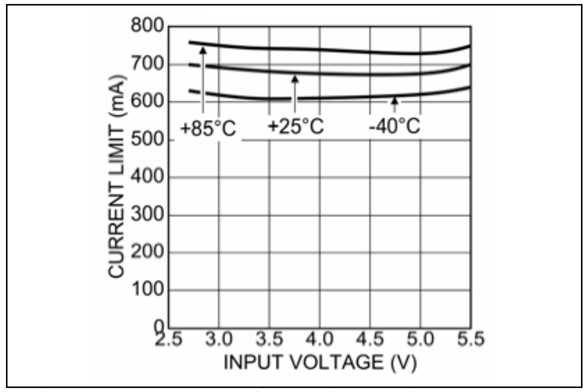


FIGURE 2-10: *Short-Circuit Current Limit vs Input Voltage.*

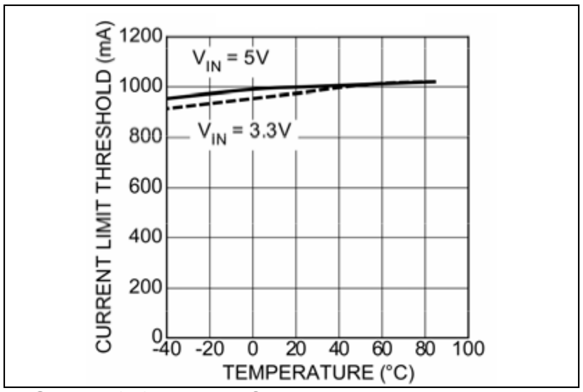


FIGURE 2-8: *Current-Limit Threshold vs. Temperature.*

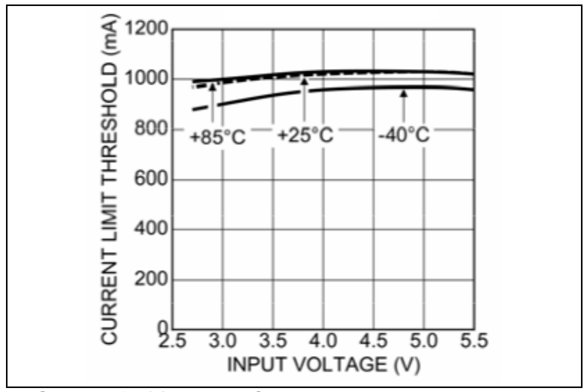


FIGURE 2-11: *Current Limit Threshold vs. Input Voltage.*

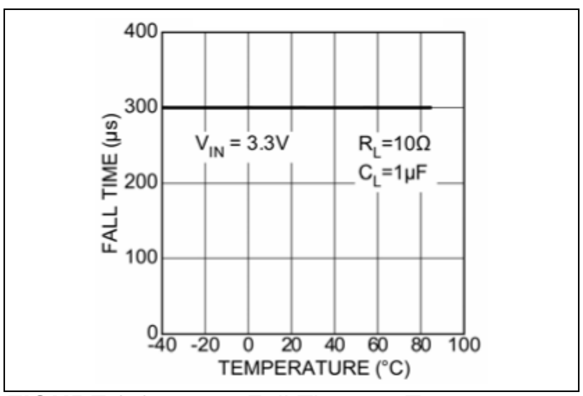


FIGURE 2-9: *Fall Time vs. Temperature.*

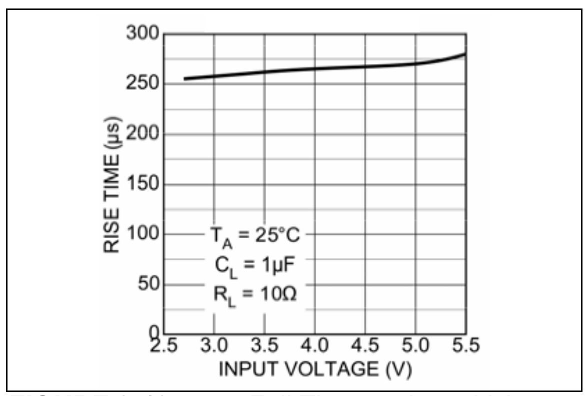


FIGURE 2-12: *Fall Time vs. Input Voltage.*

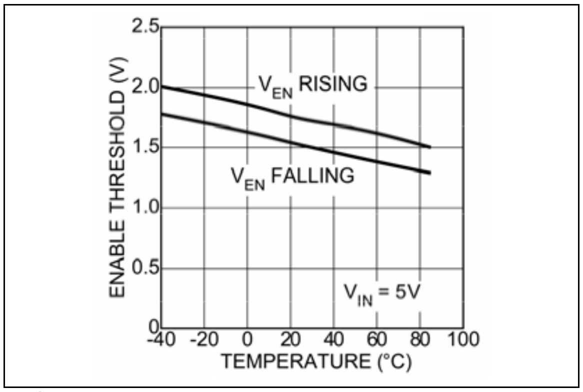


FIGURE 2-13: *Enable Threshold vs. Temperature.*

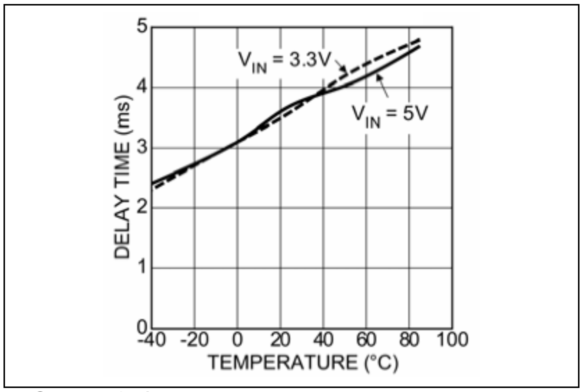


FIGURE 2-14: *Flag Delay vs. Temperature.*

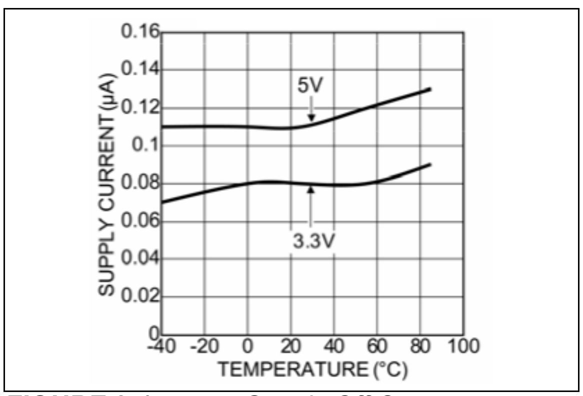


FIGURE 2-15: *Supply Off Current vs. Temperature.*

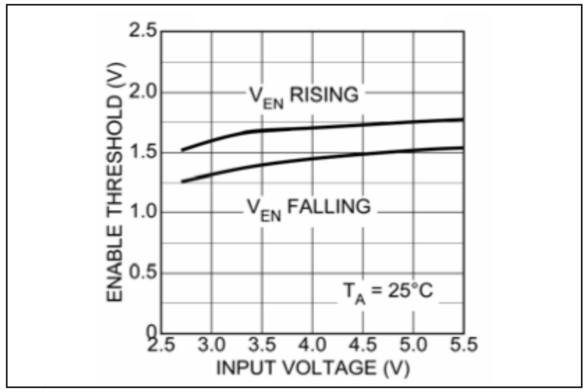


FIGURE 2-16: *Enable Threshold vs. Input Voltage.*

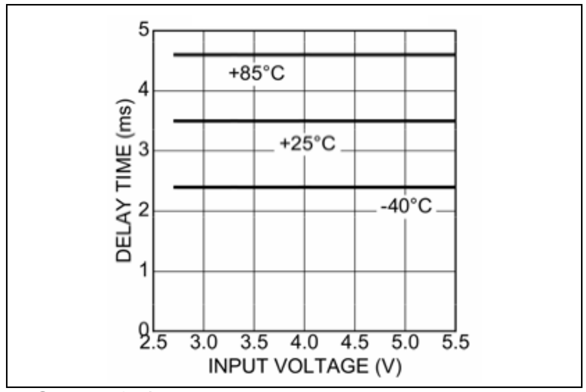


FIGURE 2-17: *Flag Delay vs. Input Voltage.*

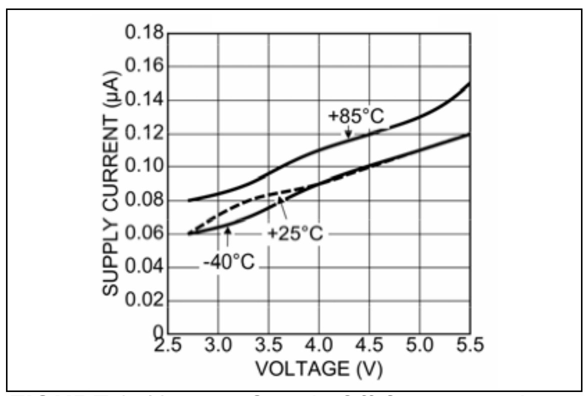


FIGURE 2-18: *Supply Off Current vs. Input Voltage.*

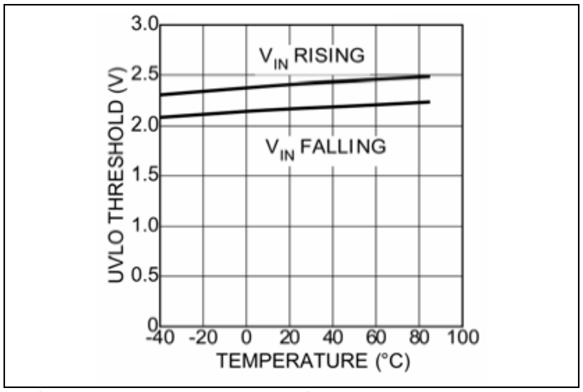


FIGURE 2-19: *UVLO Threshold vs. Temperature.*

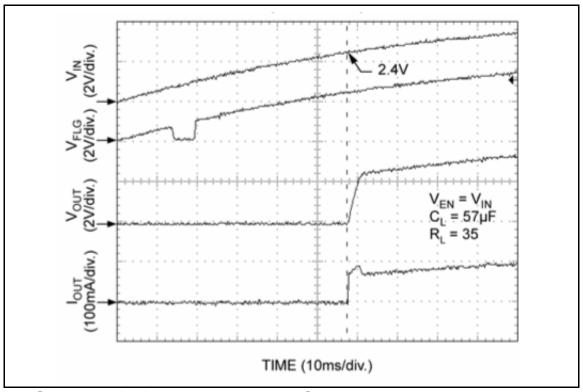


FIGURE 2-20: *UVLO, V_{IN} Rising (MIC2026-1).*

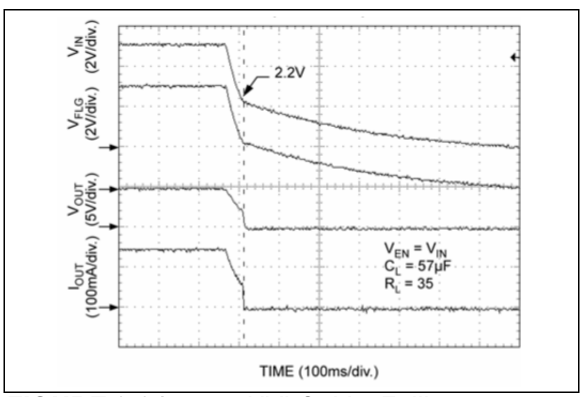


FIGURE 2-21: *UVLO, V_{IN} Falling (MIC2026-1).*

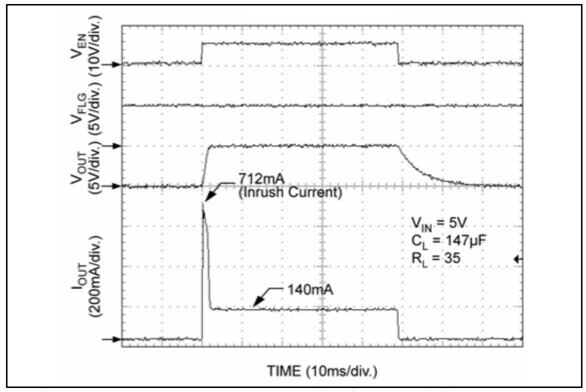


FIGURE 2-22: *Turn-On/Turn-Off (MIC2026-1).*

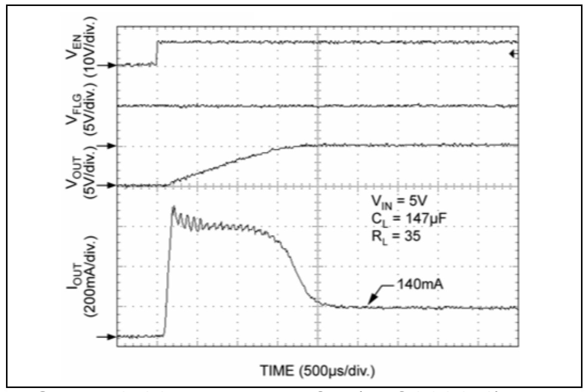


FIGURE 2-23: *Turn-On (MIC2026-1).*

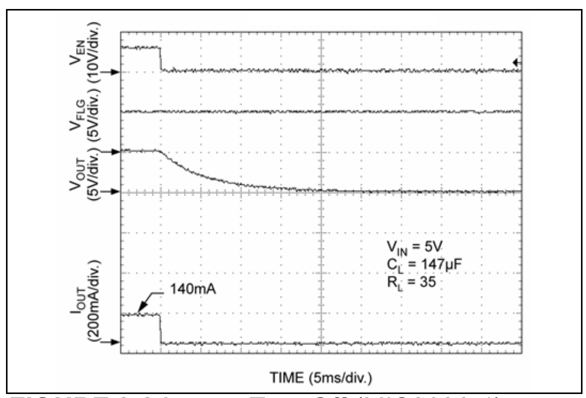


FIGURE 2-24: *Turn-Off (MIC2026-1).*

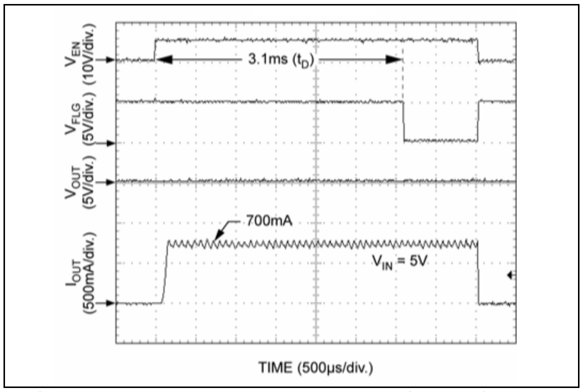


FIGURE 2-25: *Enabled into Short-Circuit (MIC2026-1).*

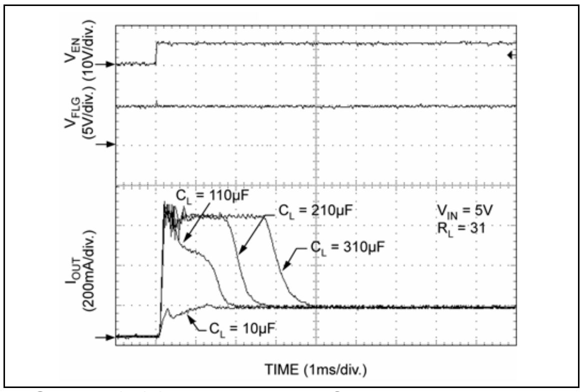


FIGURE 2-26: *Inrush Current Response (MIC2026-1).*

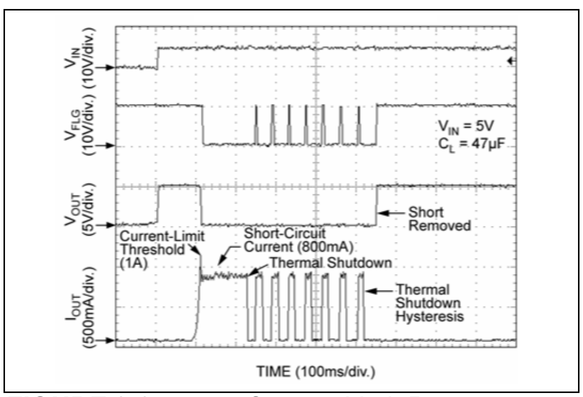


FIGURE 2-27: *Current-Limit Response (Ramped Load, MIC2026-1).*

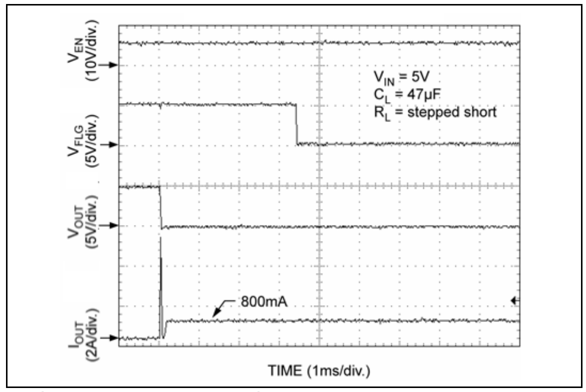


FIGURE 2-28: *Current-Limit Response (Stepped Short, MIC2026-1).*

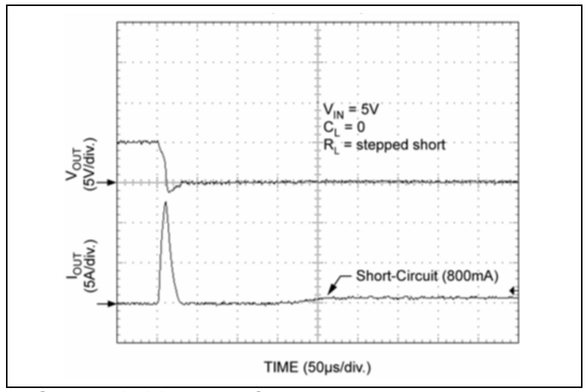


FIGURE 2-29: *Current-Limit Response (MIC2026-1).*

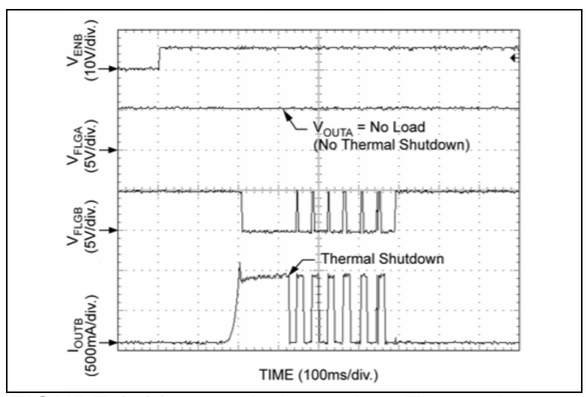


FIGURE 2-30: *Independent Thermal Shutdown (MIC2026-1).*

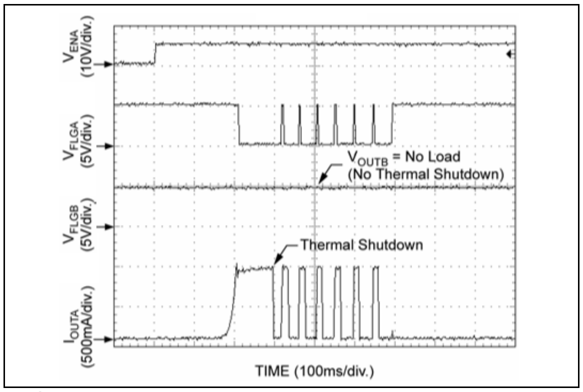


FIGURE 2-31: *Independent Thermal Shutdown (MIC2026-1).*

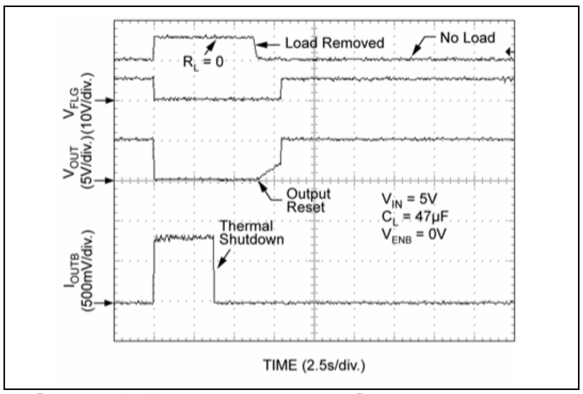


FIGURE 2-32: *Thermal Shutdown (MIC2076-2, Output Latched Off).*

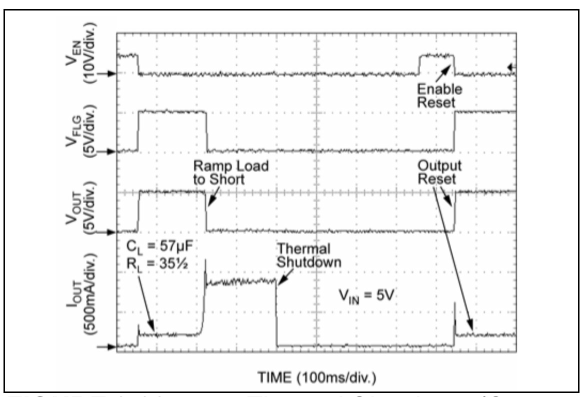


FIGURE 2-33: *Thermal Shutdown (Output Reset by Toggling Enable, MIC2076-2).*

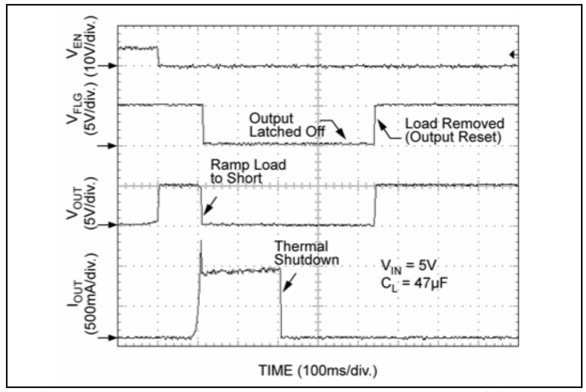


FIGURE 2-34: *Thermal Shutdown (Output Reset by Removing Load, MIC2076-2).*

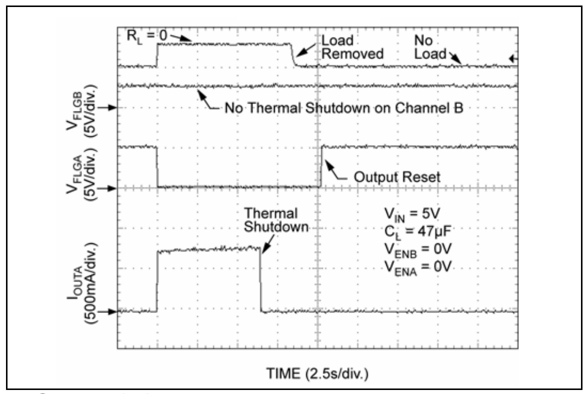


FIGURE 2-35: *Independent Thermal Shutdown (MIC2076-2).*

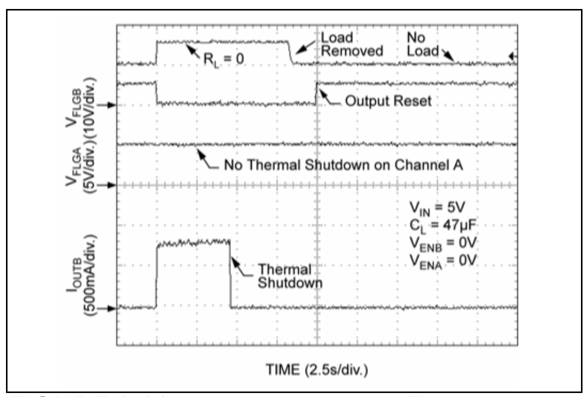


FIGURE 2-36: *Independent Thermal Shutdown (MIC2076-2).*

3.0 PIN DESCRIPTIONS

The descriptions of the pins are listed in Table 3-1.

TABLE 3-1: PIN FUNCTION TABLE

Pin Number	Pin Name	Description
1	ENA	Switch A Enable (Input): Logic-compatible, enable input. Active-high (MIC20x6-1) or active-low (MIC20x6-2).
2	FLGA	Fault Flag A (Output): Active-low, open-drain output. Indicates overcurrent or thermal shutdown conditions. Overcurrent conditions must last longer than t_D in order to assert FLGA.
3	FLGB	Fault Flag B (Output): Active-low, open-drain output. Low indicates overcurrent or thermal shutdown conditions. Overcurrent conditions must last longer than t_D in order to assert FLGB.
4	ENB	Switch B Enable (Input): Logic-compatible enable input. Active-high (MIC20x6-1) or active-low (MIC20x6-2).
5	OUTB	Switch B (Output)
6	GND	Ground
7	IN	Input: Switch and logic supply input.
8	OUTA	Switch A (Output)

4.0 FUNCTIONAL DESCRIPTION

4.1 Input and Output

IN is the power supply connection to the logic circuitry and the drain of the output MOSFET. OUT is the source of the output MOSFET. In a typical circuit, current flows from IN to OUT toward the load. If V_{OUT} is greater than V_{IN}, current will flow from OUT to IN, because the switch is bidirectional when enabled. The output MOSFET and driver circuitry are also designed to allow the MOSFET source to be externally forced to a higher voltage than the drain ($V_{OUT} > V_{IN}$) when the switch is disabled. In this situation, the MIC2026/76 prevent undesirable current flow from OUT to IN.

4.2 Thermal Shutdown

Thermal shutdown is employed to protect the device from damage should the die temperature exceed safe margins due mainly to short circuit faults. Each channel employs its own thermal sensor. Thermal shutdown shuts off the output MOSFET and asserts the FLG output if the die temperature reaches 140°C and the overheated channel is in current-limit. The other channel is not affected. If, however, the die temperature exceeds 160°C, both channels will be shut off. Upon determining a thermal shutdown condition, the MIC2076 will latch the output off. In this case, a pull-up current source is activated. This allows the output latch to automatically reset when the load (such as a USB device) is removed. The output can also be reset by toggling EN. Refer to Figure 4-1 for timing details.

The MIC2026 will automatically reset its output when the die temperature cools down to 120°C. The MIC2026 output and FLG signal will continue to cycle on and off until the device is disabled or the fault is removed. Figure 4-2 depicts typical timing.

Depending on PCB layout, package, ambient temperature, etc., it may take several hundred milliseconds from the incidence of the fault to the output MOSFET being shut off. This time will be shortest in the case of a dead short on the output.

4.3 Power Dissipation

The device's junction temperature depends on several factors such as the load, PCB layout, ambient temperature, and package type. Equations that can be used to calculate power dissipation of each channel and junction temperature are found in this section.

EQUATION 4-1:

$$P_D = R_{DS(ON)} \times I_{OUT}^2$$

Total power dissipation of the device will be the summation of P_D for both channels. To relate this to junction temperature, the following equation can be used:

EQUATION 4-2:

$$T_J = P_D \times \theta_{JA} + T_A$$

Where:
T_J = Junction temperature.
T_A = Ambient temperature.
θ_{JA} = The thermal resistance of the package.

4.4 Current Sensing and Limiting

The current-limit threshold is preset internally. The preset level prevents damage to the device and external load, but still allows a minimum current of 500 mA to be delivered to the load.

The current-limit circuit senses a portion of the output MOSFET switch current. The current-sense resistor shown in the block diagram is virtual and has no voltage drop. The reaction to an overcurrent condition varies with three scenarios:

4.4.1 SWITCH ENABLED INTO SHORT-CIRCUIT

If a switch is enabled into a heavy load or short-circuit, the switch immediately enters into a constant-current mode that reduces the output voltage. The FLG signal is asserted, indicating an overcurrent condition.

4.4.2 SHORT-CIRCUIT APPLIED TO ENABLED OUTPUT

When a heavy load or short-circuit is applied to an enabled switch, a large transient current may flow until the current-limit circuitry responds. Once this occurs, the device limits current to less than the short-circuit current-limit specification.

4.4.3 CURRENT-LIMIT RESPONSE: RAMPED LOAD

The MIC2026/76 current-limit profile exhibits a small foldback effect of about 200 mA. Once this current-limit threshold is exceeded, the device switches into a constant-current mode. It is important to note that the device will supply current up to the current-limit threshold.

4.5 Fault Flag

The FLG signal is an N-channel open-drain MOSFET output. FLG is asserted (active-low) when either an overcurrent or thermal shutdown condition occurs. In the case of an overcurrent condition, FLG will be asserted only after the flag response delay time, t_D, has elapsed. This ensures that FLG is asserted only upon valid overcurrent conditions and that erroneous error reporting is eliminated. For example, false overcurrent conditions can occur during hot plug events when a highly capacitive load is connected and causes a high transient inrush current that exceeds the current-limit threshold for up to 1 ms. The FLG response delay time t_D is typically 3 ms.

4.6 Undervoltage Lockout

Undervoltage lockout (UVLO) prevents the output MOSFET from turning on until V_{IN} exceeds approximately 2.5V. Undervoltage detection functions only when the switch is enabled.

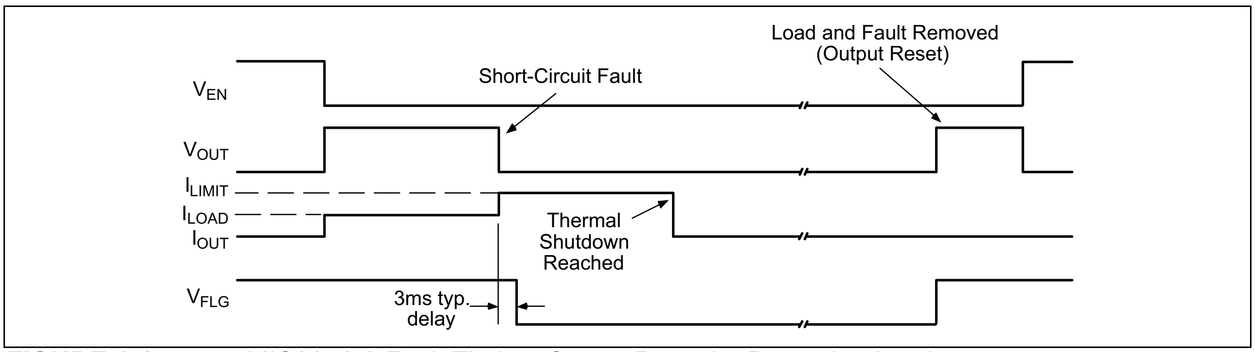


FIGURE 4-1: *MIC2076-2 Fault Timing: Output Reset by Removing Load.*

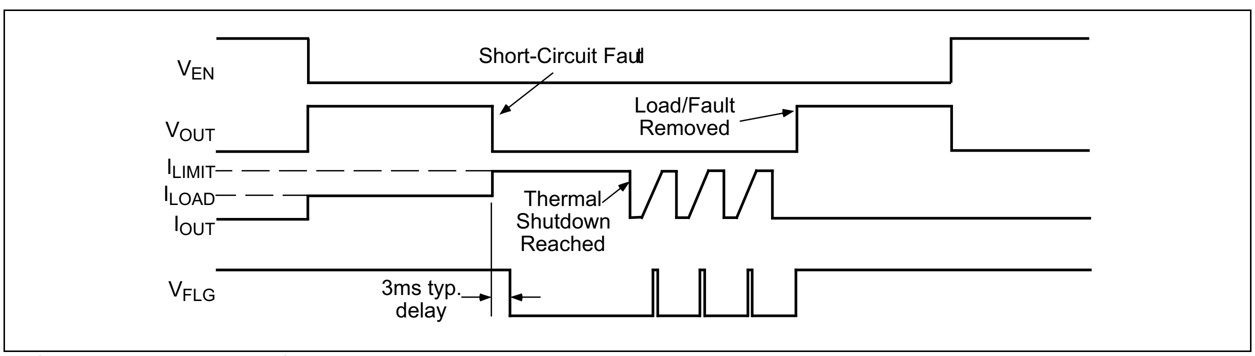


FIGURE 4-2: *MIC2026-2 Fault Timing.*

5.0 APPLICATION INFORMATION

5.1 Supply Filtering

A 0.1 µF to 1 µF bypass capacitor positioned close to V_{IN} and GND of the device is strongly recommended to control supply transients. Without a bypass capacitor, an output short may cause sufficient ringing on the input (from supply lead inductance) to damage internal control circuitry.

5.2 Printed Circuit Board Hot-Plug

The MIC2026/76 are ideal inrush current limiters for hot plug applications. Due to their integrated charge pumps, the MIC2026/76 present a high impedance when off and slowly become a low impedance as their integrated charge pumps turn on. This “soft-start” feature effectively isolates power supplies from highly capacitive loads by reducing inrush current. Figure 5-1 shows how the MIC2076 may be used in a card hot-plug application.

In cases of extremely large capacitive loads (>400 µF), the length of the transient due to inrush current may exceed the delay provided by the integrated filter. Because this inrush current exceeds the current-limit delay specification, FLG will be asserted during this time. To prevent the logic controller from responding to FLG being asserted, an external RC filter, as shown in Figure 5-2, can be used to filter out transient FLG assertion. The value of the RC time constant should be selected to match the length of the transient, less $t_{D(MIN)}$ of the MIC2026/76.

5.3 Universal Serial Bus (USB) Power Distribution

The MIC2026/76 are ideally suited for Universal Serial Bus (USB) power distribution applications. The USB specification defines power distribution for USB host systems such as PCs and USB hubs. Hubs can either be self-powered or bus-powered (that is, powered from the bus). Figure 5-3 shows a typical USB Host application that may be suited for mobile PC applications employing USB. The requirement for USB host systems is that the port must supply a minimum of 500 mA at an output voltage of 5V ±5%. In addition, the output power delivered must be limited to below 25 VA. Upon an overcurrent condition, the host must also be notified. To support hot-plug events, the hub must have a minimum of 120 µF of bulk capacitance, preferably low ESR electrolytic or tantalum. Please refer to Application Note 17 for more details on designing compliant USB hub and host systems.

For bus-powered hubs, USB requires that each downstream port be switched on or off under control by the host. Up to four downstream ports each capable of supplying 100 mA at 4.4V minimum are allowed. In addition, to reduce voltage droop on the upstream V_{BUS}, soft-start is necessary. Although the hub can consume up to 500 mA from the upstream bus, the hub must consume only 100 mA max at start-up, until it enumerates with the host prior to requesting more power. The same requirements apply for bus-powered peripherals that have no downstream ports. Figure 5-4 shows a bus-powered hub.

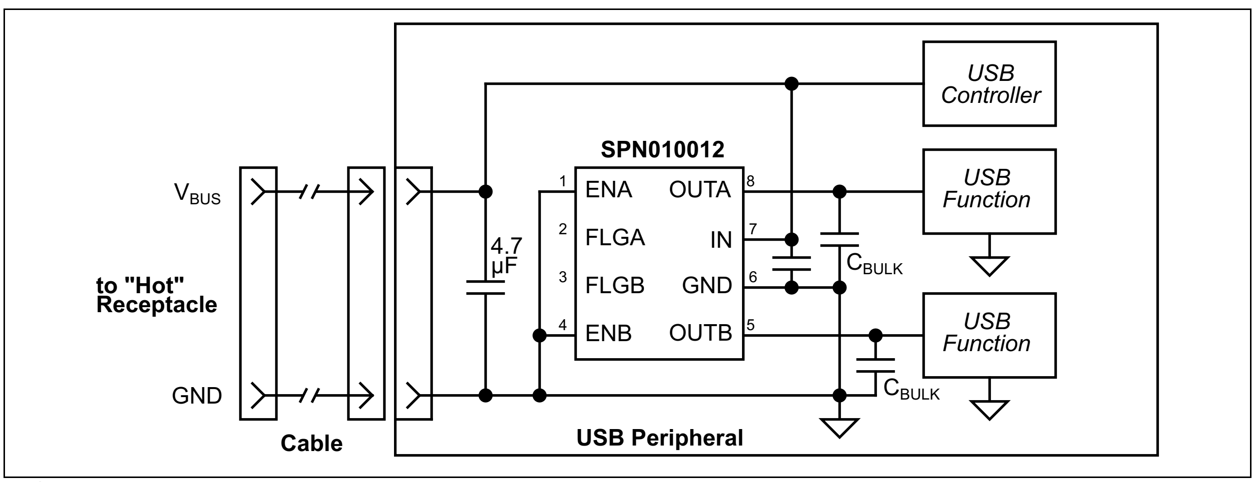


FIGURE 5-1: Hot-Plug Application.

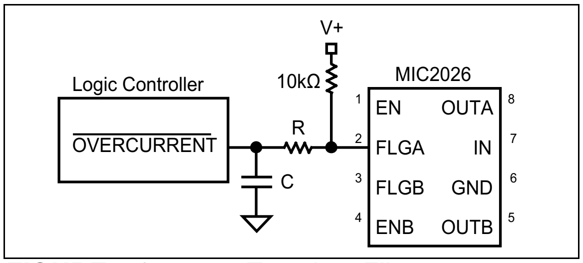


FIGURE 5-2: *Transient Filter.*

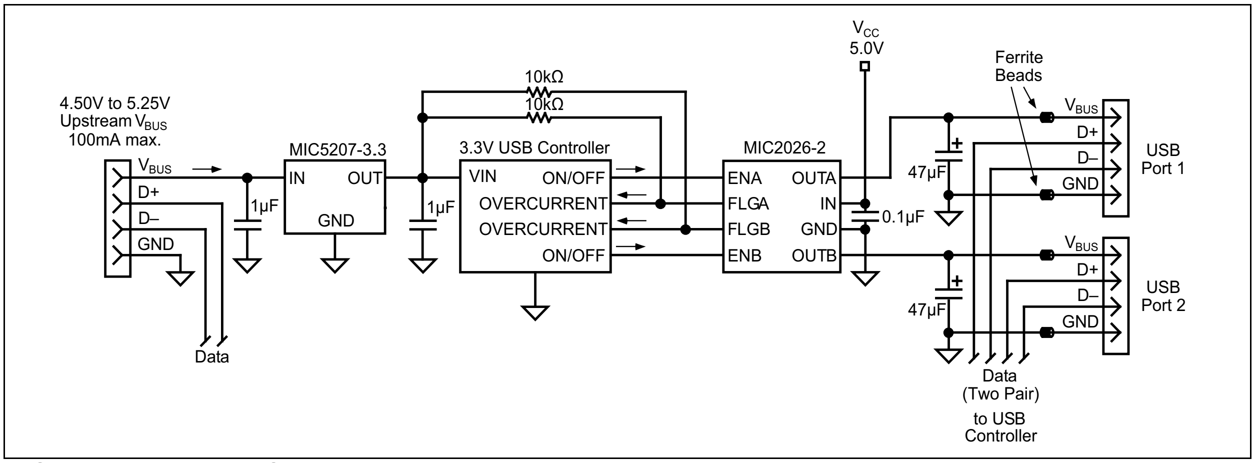


FIGURE 5-3: *USB Two-Port Host Application.*

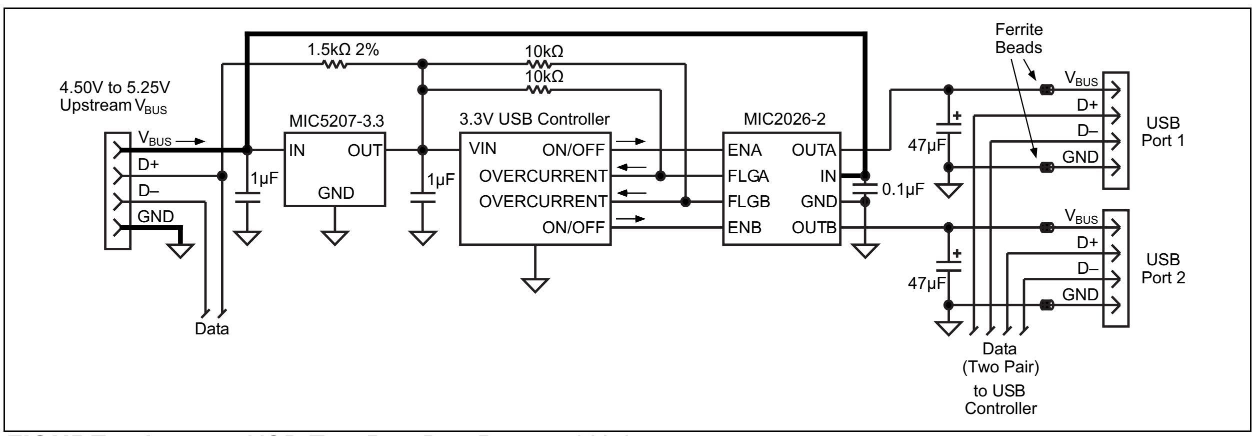
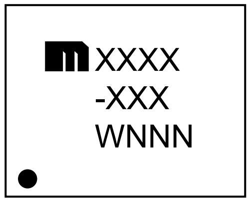


FIGURE 5-4: *USB Two-Port Bus-Powered Hub.*

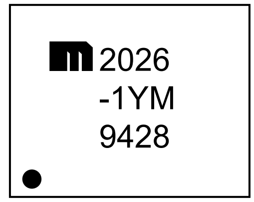
6.0 PACKAGING INFORMATION

6.1 Package Marking Information

8-Lead SOIC*



Example



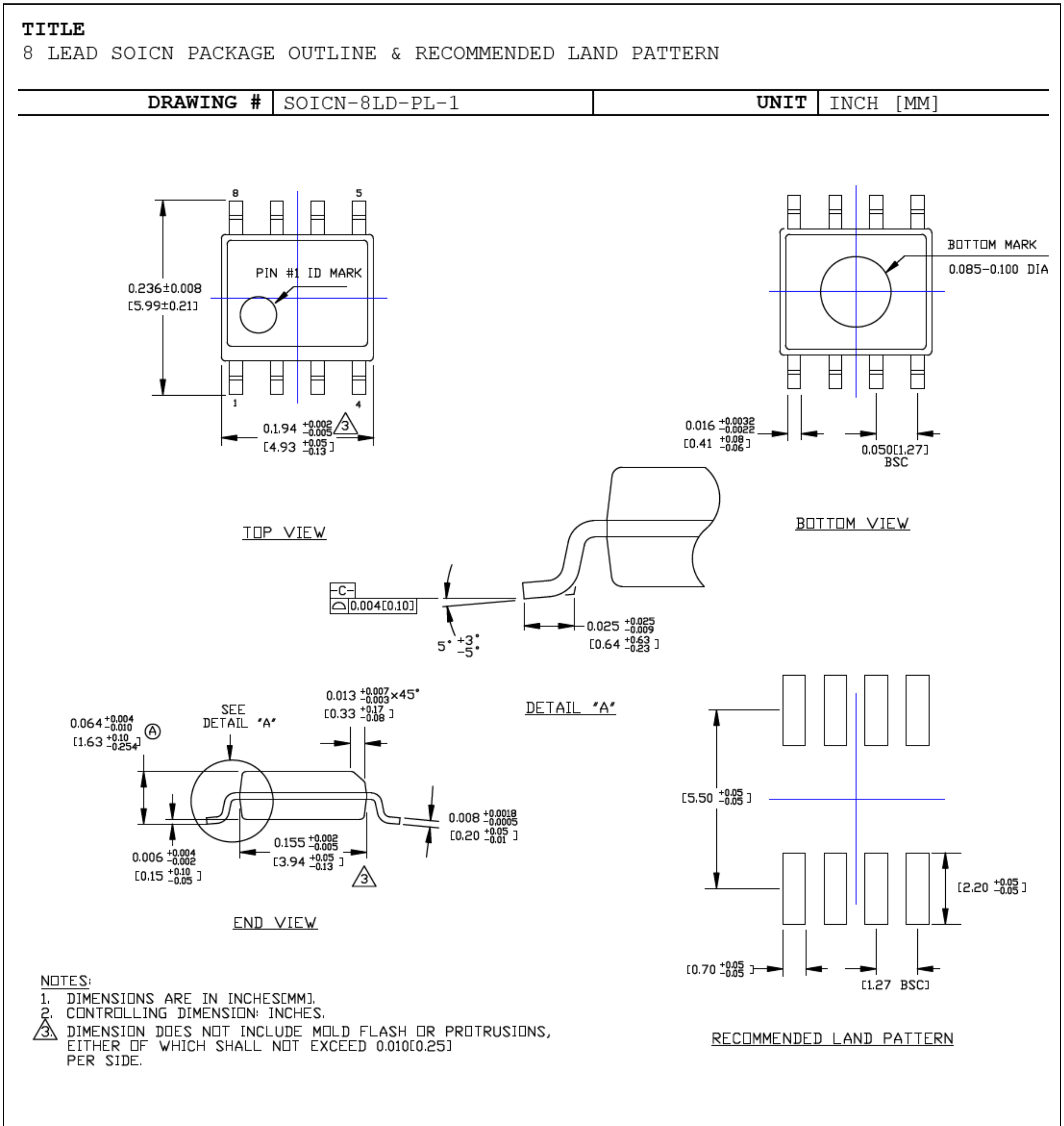
Note that MIC20x6-2 has a top marking that reflects -2YM on the middle line.

Legend:	XX...X	Product code or customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week ‘01’)
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC® designator for Matte Tin (Sn)
	*	This package is Pb-free. The Pb-free JEDEC designator ((e3)) can be found on the outer packaging for this package.
	●, ▲, ▼	Pin one index is identified by a dot, delta up, or delta down (triangle mark).

Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information. Package may or may not include the corporate logo.

Underbar (_) and/or Overbar (‾) symbol may not be to scale.

8-Lead SOIC Package Outline and Recommended Land Pattern



Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging.

APPENDIX A: REVISION HISTORY

Revision A (November 2020)

- Converted Micrel document MIC2026/MIC2076 to Microchip data sheet template DS20006443A.
- Minor grammatical text changes throughout.
- All reference to the PDIP package once available for this device has been removed.

NOTES:

PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, contact your local Microchip representative or sales office.

Device	-X	X	X	-XX
Part No.	Enable	Temp. Range	Package	Media Type

Device:	MIC2026: MIC2076:	Dual-Channel Power Distribution Switch Dual-Channel Power Distribution Switch with Something
Enable:	-1 = -2 =	Active-High Active-Low
Temperature Range:	Y =	–40°C to +85°C
Package:	M =	8-Lead SOIC
Media Type:	<blank>= TR =	95/Tube 2,500/Reel

Examples:

a) MIC2026-1YM: MIC2026, Active-High Enable, –40°C to +85°C, 8-Lead SOIC, 95/Tube

b) MIC2026-1YM-TR: MIC2026, Active-High Enable, –40°C to +85°C, 8-Lead SOIC, 2,500/Reel

c) MIC2026-2YM: MIC2026, Active-Low Enable, –40°C to +85°C, 8-Lead SOIC, 95/Tube

d) MIC2026-2YM-TR: MIC2026, Active-Low Enable, –40°C to +85°C, 8-Lead SOIC, 2,500/Reel

e) MIC2076-1YM: MIC2076, Active-High Enable, –40°C to +85°C, 8-Lead SOIC, 95/Tube

f) MIC2076-1YM-TR: MIC2076, Active-High Enable, –40°C to +85°C, 8-Lead SOIC, 2,500/Reel

g) MIC2076-2YM: MIC2076, Active-Low Enable, –40°C to +85°C, 8-Lead SOIC, 95/Tube

h) MIC2076-2YM-TR: MIC2076, Active-Low Enable, –40°C to +85°C, 8-Lead SOIC, 2,500/Reel

Note 1: Tape and Reel identifier only appears in the catalog part number description. This identifier is used for ordering purposes and is not printed on the device package. Check with your Microchip Sales Office for package availability with the Tape and Reel option.

NOTES:

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