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MIC2025/2075

Single-Channel Power Distribution Switch

Features

- 140 mΩ Maximum On-Resistance
- 2.7V to 5.5V Operating Range
- 500 mA Minimum Continuous Output Current
- Short-Circuit Protection with Thermal Shutdown
- Fault Status Flag with 3 ms Filter Eliminates False Assertions
- Undervoltage Lockout
- Reverse Current Flow Blocking (No “Body Diode”)
- Circuit Breaker Mode (MIC2075) Reduces Power Consumption
- Logic-Compatible Input
- Soft-Start Circuit
- Low Quiescent Current
- Pin Compatible with MIC2525
- UL File #E179633

Applications

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

General Description

The MIC2025 and MIC2075 are high-side MOSFET switches optimized for general-purpose power distribution requiring circuit protection.

The MIC2025/75 are internally current limited and have thermal shutdown that protects the device and load. The MIC2075 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.

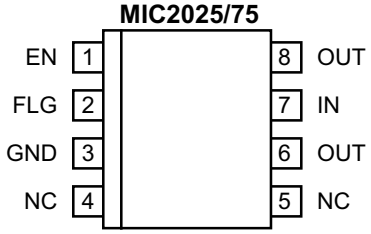
Both devices employ soft-start circuitry that minimizes inrush current in applications where highly capacitive loads are employed. A fault status output flag is provided that is asserted during overcurrent and thermal shutdown conditions.

The MIC2025/75 are available in the 8-Pin MSOP and 8-Pin SOIC packages.

Package Type

MIC2025/2075
8-Pin SOIC (YM)
8-Pin MSOP(YMM)

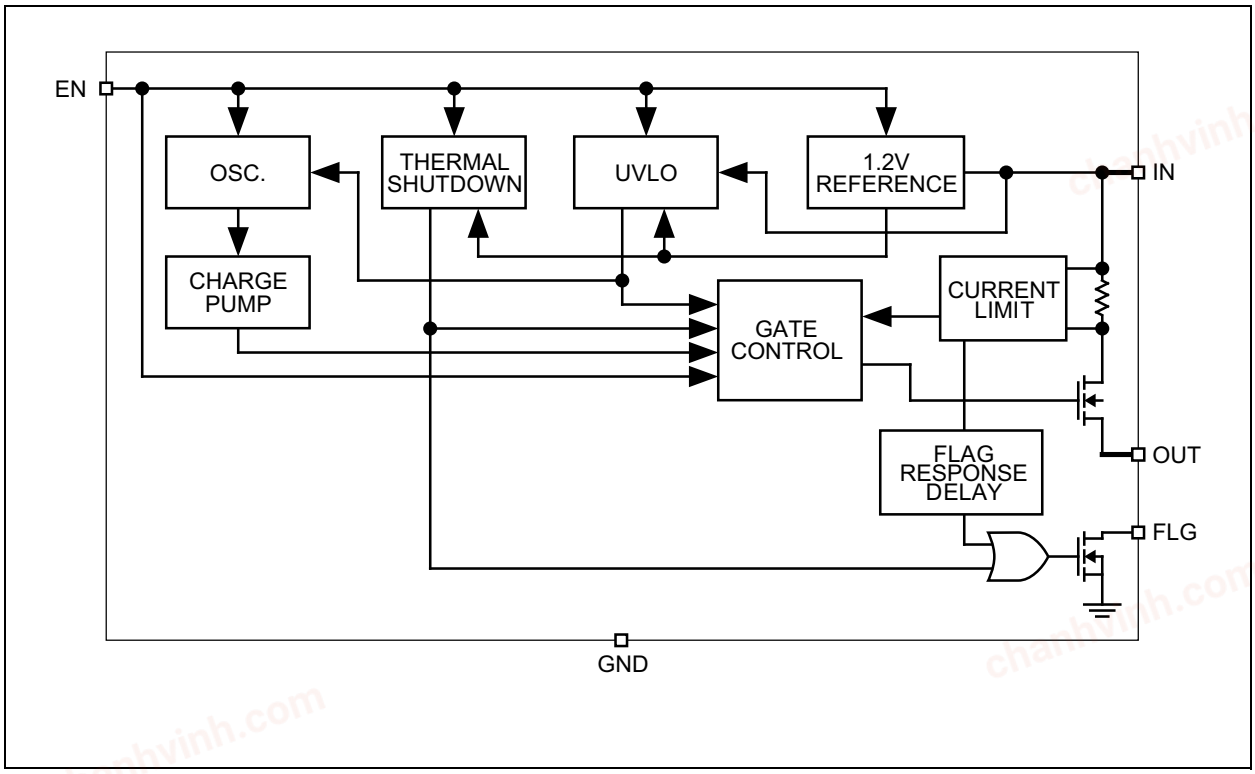
MIC2025/75



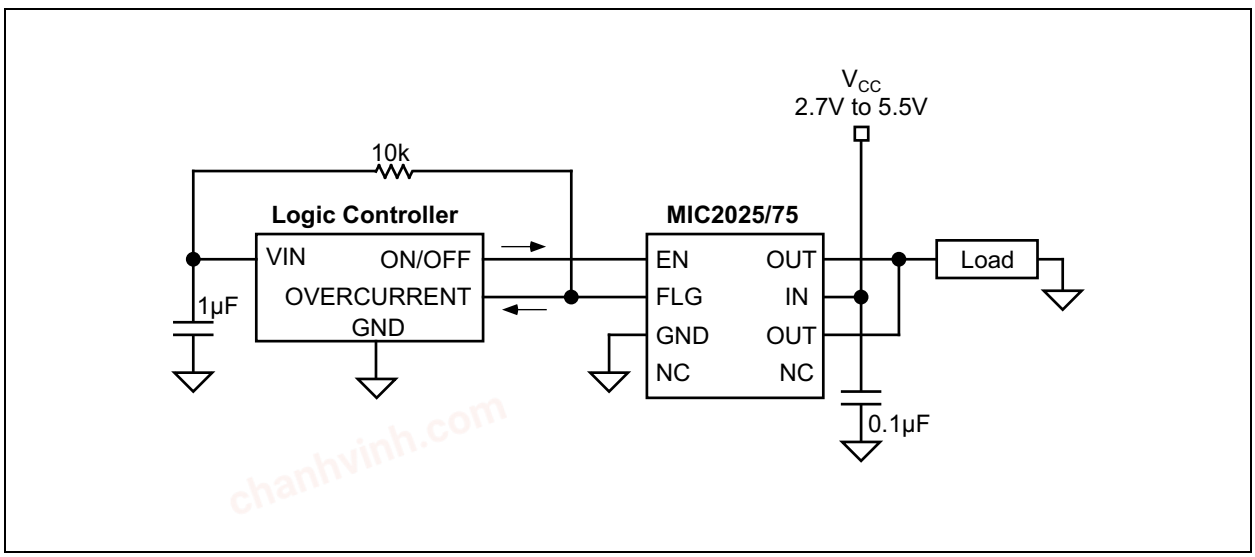
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Functional Block Diagram



Typical Application Circuit



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1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Supply Voltage (V_{IN}) ..... –0.3V to +6V
Fault Flag Voltage (V_{FLG}) ..... +6V
Fault Flag Current (I_{FLG}) ..... 25 mA
Output Voltage (V_{OUT}) ..... +6V
Output Current (I_{OUT}) ..... Internally Limited
Enable Input (I_{EN}) ..... –0.3V to V_{IN} + 3V
ESD Rating ..... (Note 1)

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. Specifications are for packaged product only.

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

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

TABLE 1-1: ELECTRICAL CHARACTERISTICS

Electrical Characteristics: V_{IN} = +5V; T_A = +25°C, **Bold** values indicate –40°C ≤ T_A ≤ +85°C; unless otherwise specified.

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Supply Current	I_{DD}	—	0.75	**5**	µA	MIC20x5-1, V_{EN} ≤ 0.8V (switch off), OUT = open
		—	0.75	**5**	µA	MIC20x5-2, V_{EN} ≥ 2.4V (switch off), OUT = open
		—	—	160	µA	MIC20x5-1, V_{EN} ≥ 2.4V (switch on), OUT = open
		—	—	160	µA	MIC20x5-2, V_{EN} ≤ 0.8V (switch on), OUT = open
Enable Input Voltage	V_{EN}	—	2.1	**2.4**	V	Low-to-High Transition
		0.8	1.9	—	V	High-to-Low Transition
Enable Input Hysteresis		—	200	—	mV	—
Enable Input Current	I_{EN}	**–1**	0.01	**1**	µA	V_{EN} = 0V to 5.5V
Control Input Capacitance	—	—	1	—	pF	—
Switch Resistance	$R_{DS(ON)}$	—	90	**140**	mΩ	V_{IN} = 5V, I_{OUT} = 500 mA
		—	100	**160**	mΩ	V_{IN} = 3.3V, I_{OUT} = 500 mA
Output Leakage Current	—	—	—	**10**	µA	MIC2025/2075 (output off)
OFF Current in Latched Thermal Shutdown	—	—	50	—	µA	MIC2075 (during thermal shutdown state)
Output Turn-On Delay	t_{ON}	**1**	2.5	**6**	ms	R_L = 10Ω, C_L = 1 µF, (see Timing Diagrams)
Output Turn-On Rise Time	t_R	**0.5**	2.3	**5.9**	ms	R_L = 10Ω, C_L = 1 µF, (see Timing Diagrams)
Output Turn-Off Delay	t_{OFF}	—	50	100	µs	R_L = 10Ω, C_L = 1 µF, (see Timing Diagrams)

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Electrical Characteristics: V_{IN} = +5V; T_A = +25°C, **Bold** values indicate –40°C ≤ T_A ≤ +85°C; unless otherwise specified.

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Output Turn-Off Fall Time	t_F	—	50	100	µs	R_L = 10Ω, C_L = 1 µF, (see Timing Diagrams)
Short-Circuit Output Current	I_{LIMIT}	0.5	0.7	1.25	A	V_{OUT} = 0V, enabled into short-circuit
Current-Limit Threshold (See Figure 2-22)	—	0.60	0.85	1.25	A	Ramped load applied to output
Short-Circuit Response Time	—	—	24	—	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
		1.5	3	8	ms	V_{IN} = 3.3V, apply V_{OUT} = 0V until FLG low
Undervoltage Lockout Threshold		**2.2**	2.5	**2.7**	V	V_{IN} Rising
		2.0	2.3	**2.5**	V	V_{IN} Falling
Error Flag Output Resistance		—	8	25	Ω	I_L = 10 mA, V_{IN} = 5V
		—	11	40	Ω	I_L = 10 mA, V_{IN} = 3.3V
Error Flag Off Current		—	—	10	µA	V_{FLAG} = 5V
Overtemperature Threshold		—	140	—	°C	T_J increasing
		—	120	—	°C	T_J decreasing

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TEMPERATURE SPECIFICATIONS (Note 1)

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Temperature Ranges						
Storage Temperature Range	T_S	–65	—	+150	°C	—
Ambient Temperature Range	T_A	–40	—	+85	°C	—
Junction Temperature Range	T_J	—	—	—	°C	Internally Limited
Package Thermal Resistances						
Thermal Resistance SOIC 8-LD	θ_{JA}	—	160	—	°C/W	—
Thermal Resistance MSOP 8-LD	θ_{JA}	—	206	—	°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}).

Test Circuit

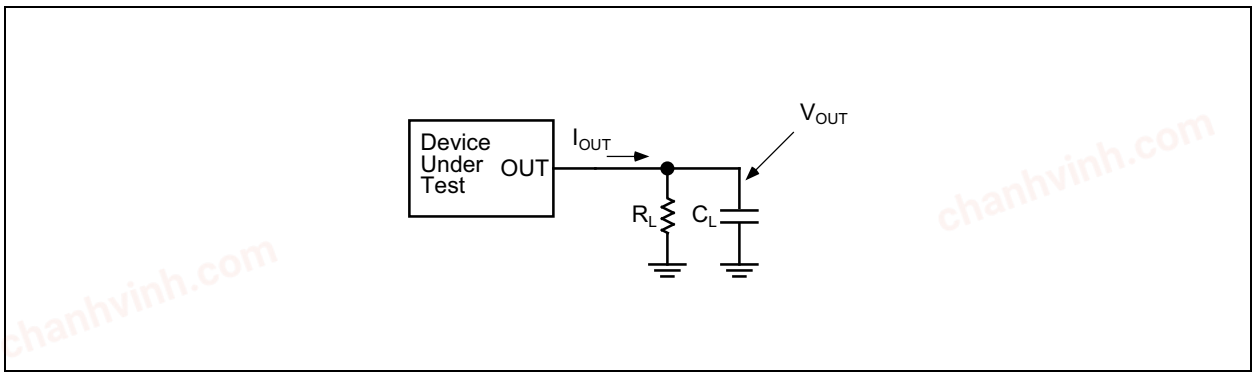


FIGURE 1-1: *MIC2025/2075 Test Circuit.*

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Timing Diagrams

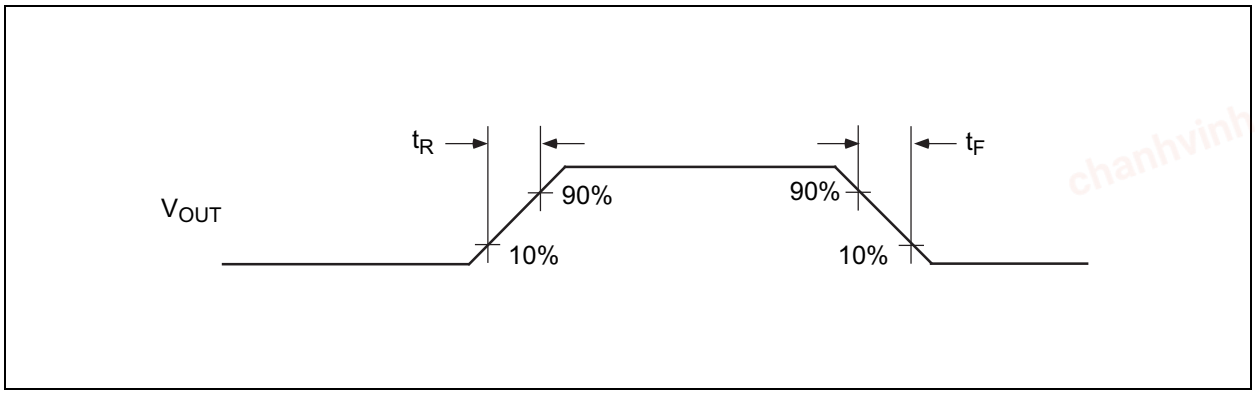


FIGURE 1-2: *Output Rise and Fall Times.*

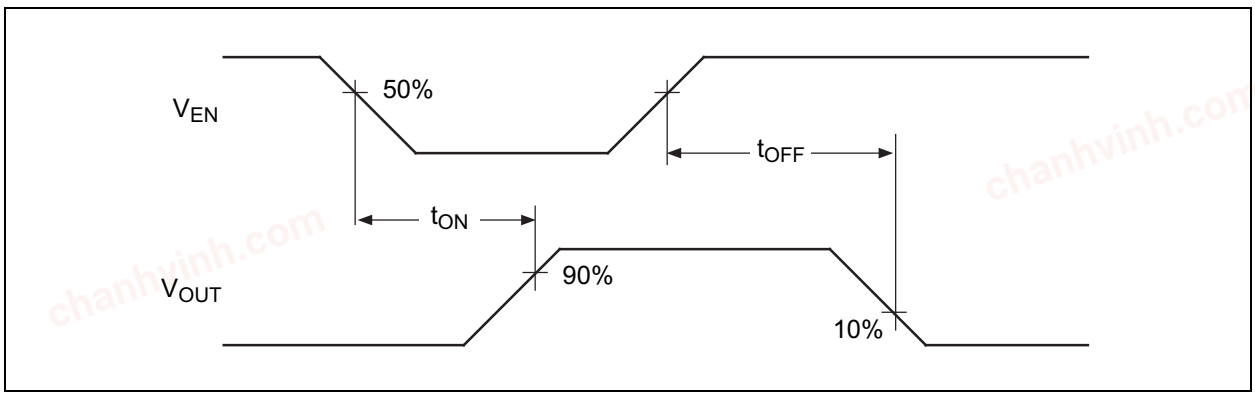


FIGURE 1-3: *Active-Low Switch Delay Time (MIC20x5-2).*

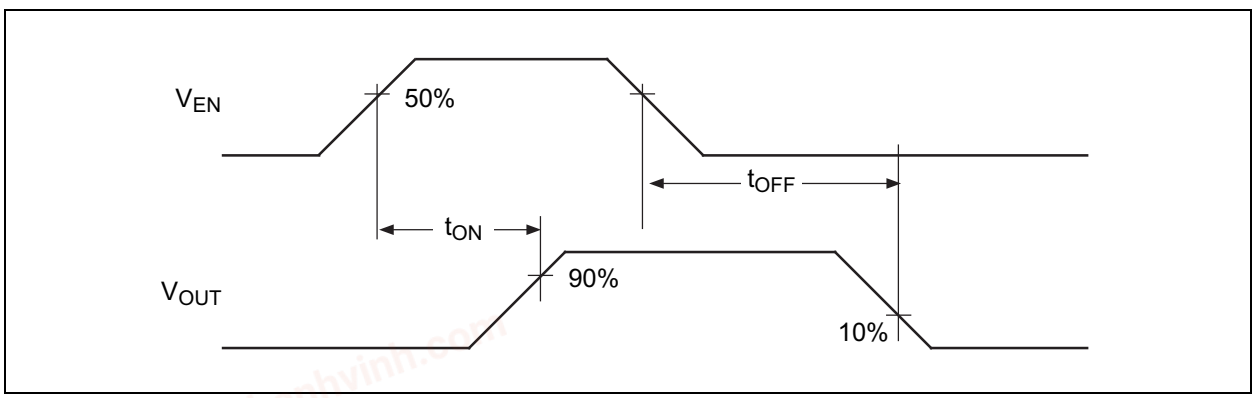


FIGURE 1-4: *Active-High Switch Delay Times (MIC20x5-1).*

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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.

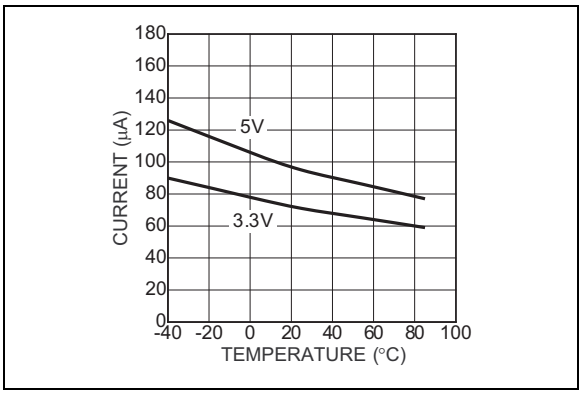


FIGURE 2-1: *Supply On-Current vs. Temperature.*

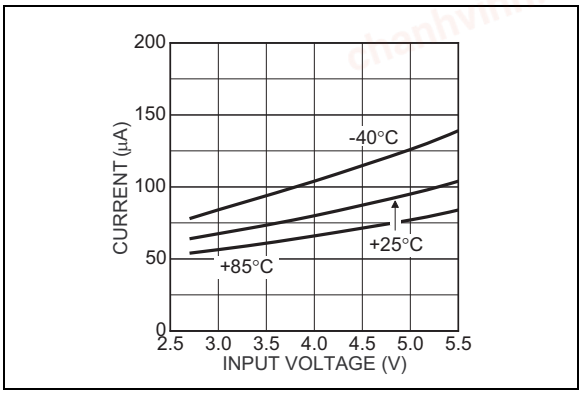


FIGURE 2-4: *Supply On-Current vs. Input Voltage.*

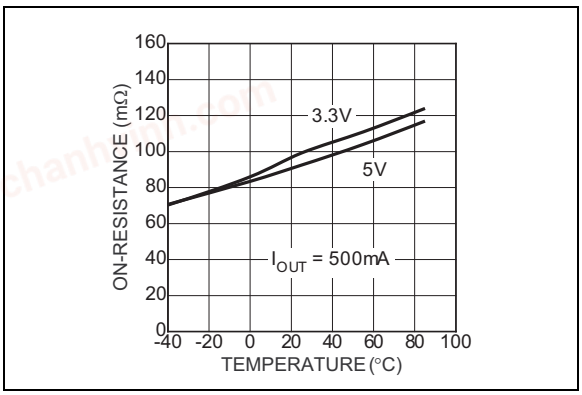


FIGURE 2-2: *On-Resistance vs. Temperature.*

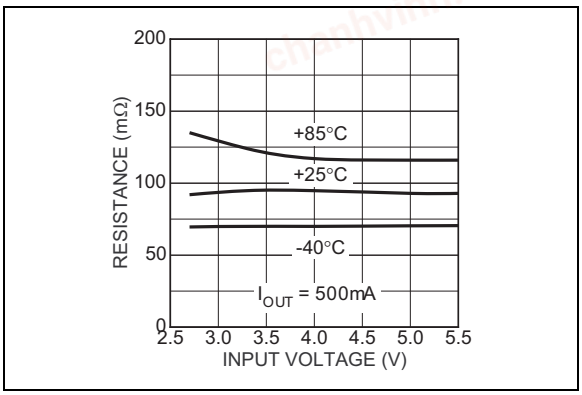


FIGURE 2-5: *On-Resistance vs. Input Voltage.*

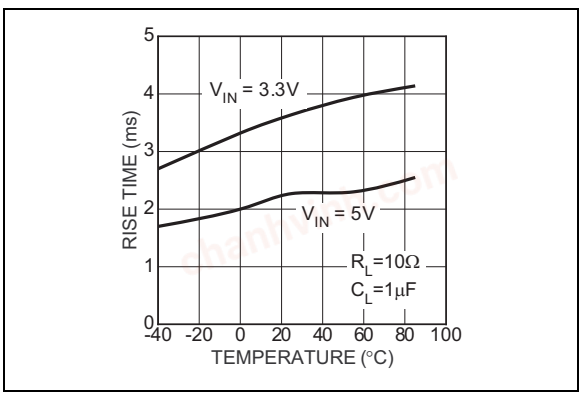


FIGURE 2-3: *Turn-On rise Time vs. Temperature.*

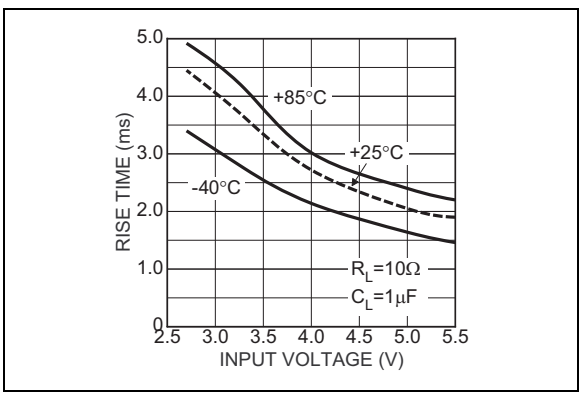


FIGURE 2-6: *Turn-On Rise Time vs. Input Voltage.*

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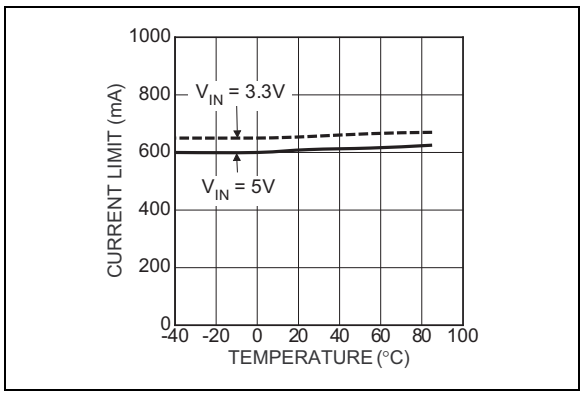


FIGURE 2-7: *Short-Circuit Current-Limit vs. Temperature.*

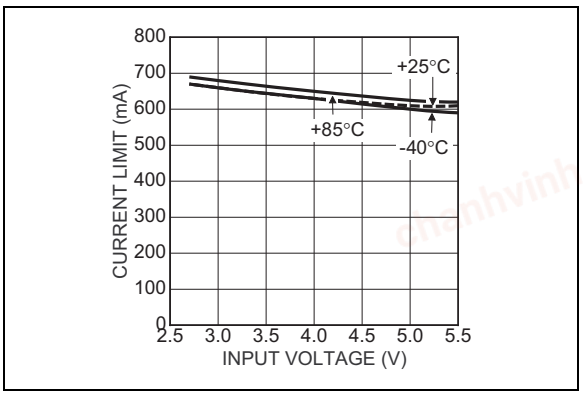


FIGURE 2-10: *Short-Circuit Current-Limit vs. Input Voltage.*

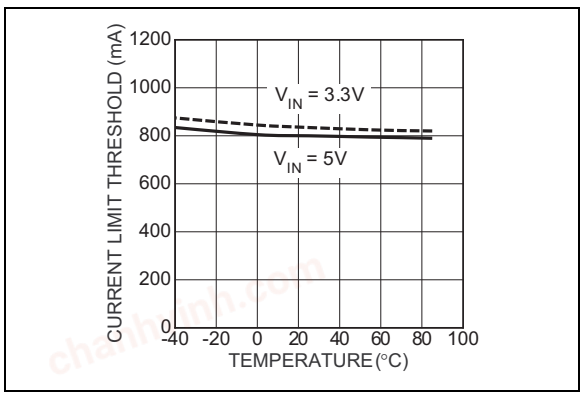


FIGURE 2-8: *Current-Limit Threshold vs. Temperature.*

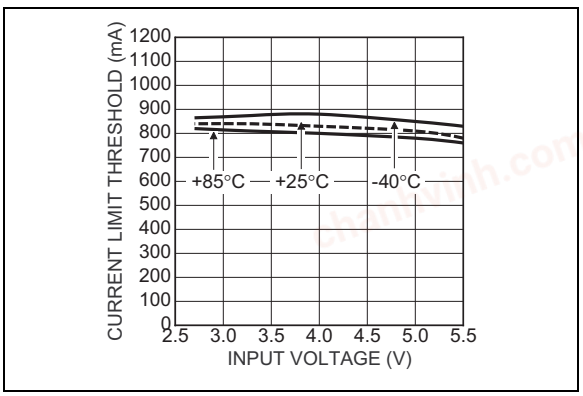


FIGURE 2-11: *Current-Limit Threshold vs. Input Voltage.*

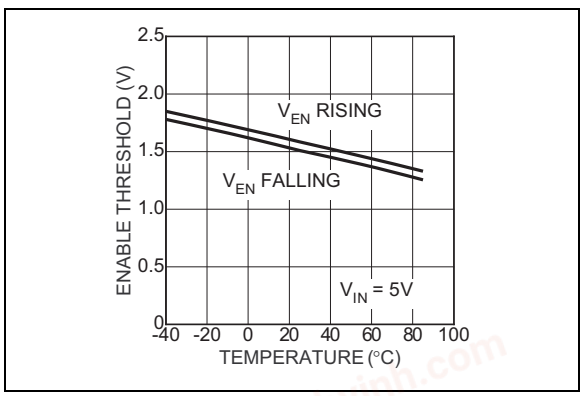


FIGURE 2-9: *Enable Threshold vs. Temperature.*

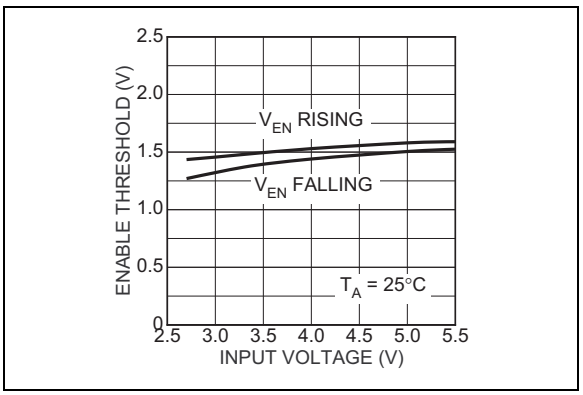


FIGURE 2-12: *Enable Threshold vs. Input Voltage.*

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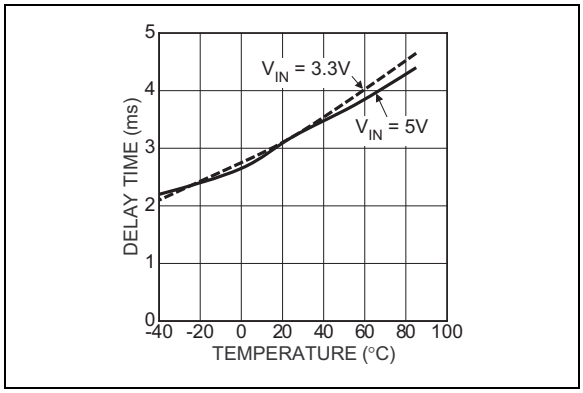


FIGURE 2-13: *Flag Delay vs. Temperature.*

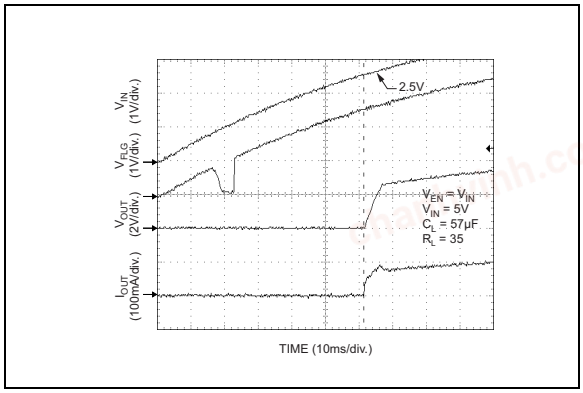


FIGURE 2-16: *UVLO V_{IN} Rising (MIC2025-1).*

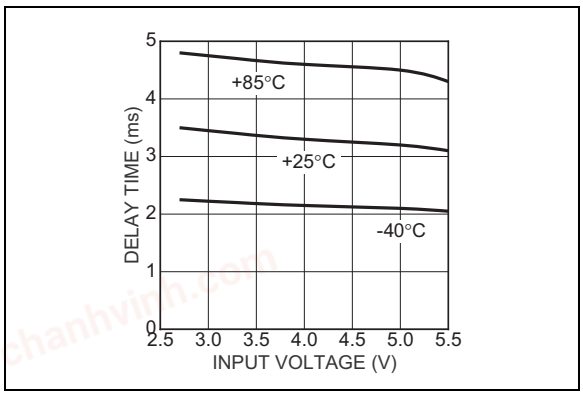


FIGURE 2-14: *Flag Delay vs. Input Voltage.*

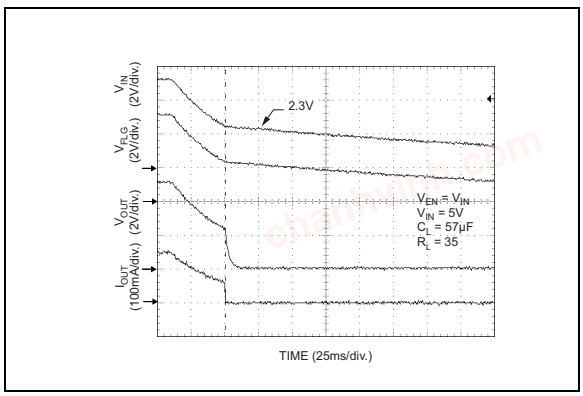


FIGURE 2-17: *UVLO V_{IN} Falling (MIC2025-1).*

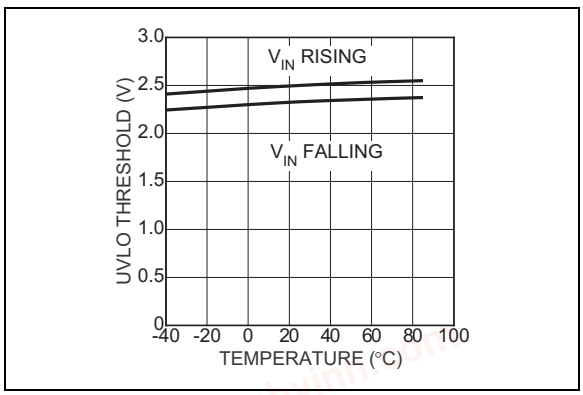


FIGURE 2-15: *UVLO Threshold vs. Temperature.*

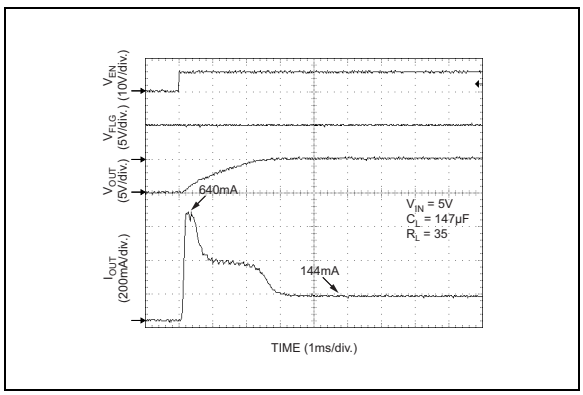


FIGURE 2-18: *Turn-On Response (MIC2025-1).*

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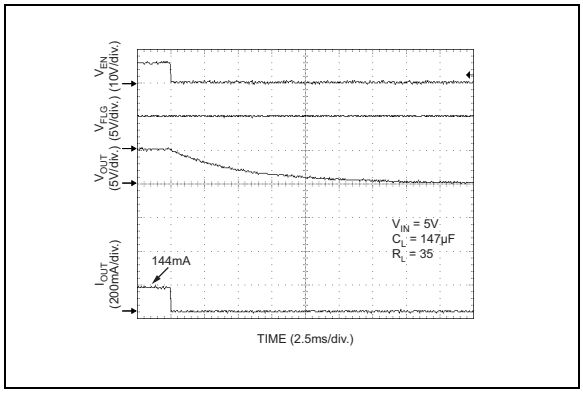


FIGURE 2-19: *Turn-Off Response (MIC2025-1).*

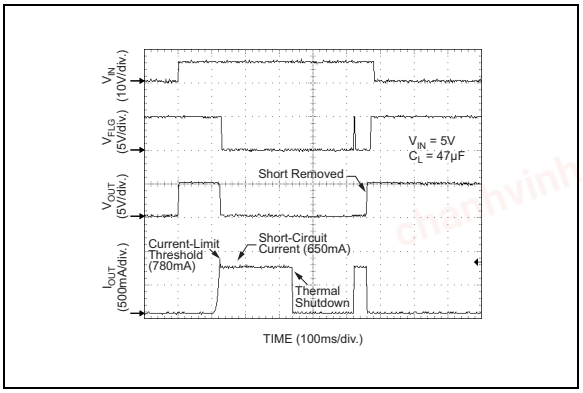


FIGURE 2-22: *Current-Limit Response (Ramped Load Into Short MIC2025-1).*

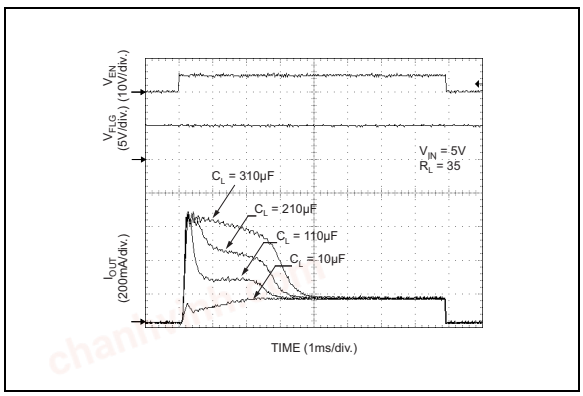


FIGURE 2-20: *In-Rush Current Response (MIC2025-1).*

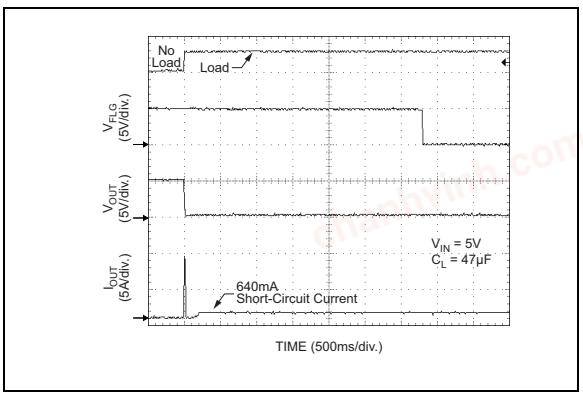


FIGURE 2-23: *Current-Limit Transient Response (Enable Into Short MIC2025-1).*

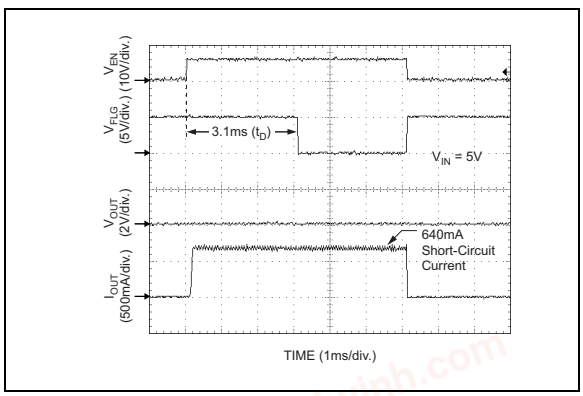


FIGURE 2-21: *Enable Into Short (MIC2025-1).*

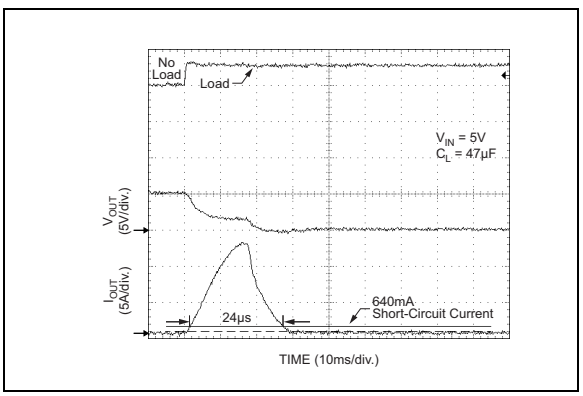


FIGURE 2-24: *Current-Limit Transient Response (MIC2025-1).*

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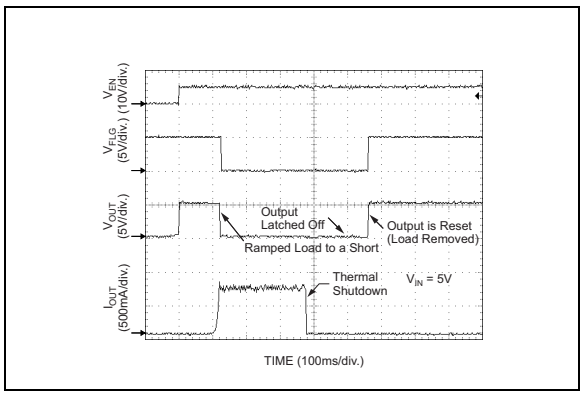


FIGURE 2-25: *Thermal Shutdown Response (Output Reset By Removing Load MIC2075-1).*

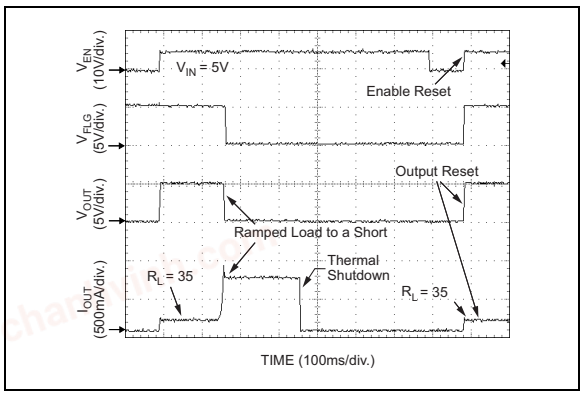


FIGURE 2-26: *Thermal Shutdown Response (Output Reset By Toggling Enable MIC2075-1).*

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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	EN	Switch Enable (Input): Active-high (-1) or Active-low (-2).
2	FLG	Fault Flag (Output): Active-low, open-drain output. Indicates overcurrent or thermal shutdown conditions. Overcurrent condition must exceed t_D in order to assert FLG.
3	GND	Ground.
4	NC	Not internally connected.
5	NC	Not internally connected.
6, 8	OUT	Supply (Output): Pins must be connected together.
7	IN	Supply voltage (Input).

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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, since 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 MIC2025/75 prevents 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. Thermal shutdown shuts off the output MOSFET and asserts the FLG output if the die temperature reaches 140°C. The MIC2025 will automatically reset its output should the die temperature cool down to 120°C. The MIC2025 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. If the MIC2075 goes into thermal shutdown, its output will latch off and 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 details.

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. The worst-case scenario of thermal shutdown is that of a short-circuit fault and is shown in Figure 2-25 and Figure 2-26.

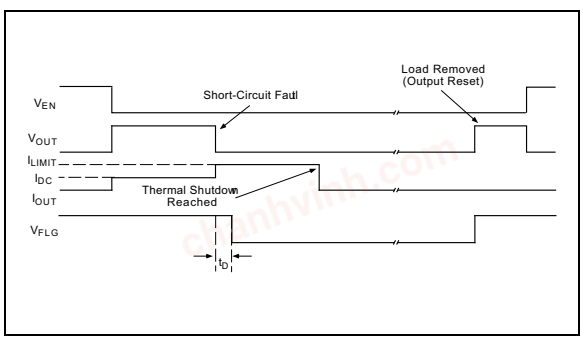


FIGURE 4-1: *MIC2075-2 Timing: Output Reset by Removing Load.*

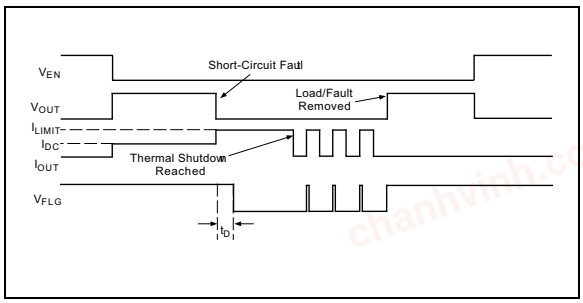


FIGURE 4-2: *MIC2025-2 Timing.*

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 and junction temperature are found in Equation 4-1 and Equation 4-2.

EQUATION 4-1:

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

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 Functional Block Diagram is virtual and has no voltage drop. The reaction to an overcurrent condition varies with three scenarios:

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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, reducing the output voltage. The FLG signal is asserted indicating an overcurrent condition. See Figure 2-21.

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. See Figure 2-23.

4.4.3 CURRENT-LIMIT RESPONSE - RAMPED LOAD

The MIC2025/75 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 until the current-limit threshold is exceeded. See Figure 2-22.

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. 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.

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5.0 APPLICATION INFORMATION

5.1 Supply Filtering

A 0.1 µF to 1 µF bypass capacitor positioned close to VIN 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 MIC2025/75 are ideal inrush current-limiters for hot plug applications. Due to their integrated charge pumps, the MIC2025/75 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. Equation 5-1 shows how the MIC2075 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. Since 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 Equation 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 MIC2025/75.

5.3 Universal Serial Bus (USB) Power Distribution

The MIC2025/75 are ideally suited for USB (Universal Serial Bus) 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). Equation 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. Equation 5-4 shows a bus-powered hub.

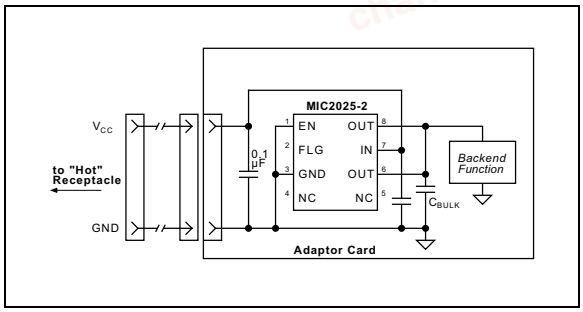


FIGURE 5-1: *Hot-Plug Application.*

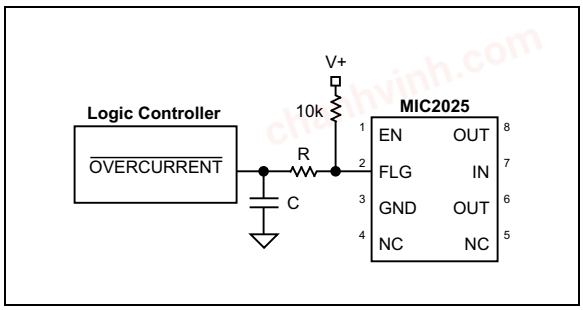


FIGURE 5-2: *Transient Filter.*

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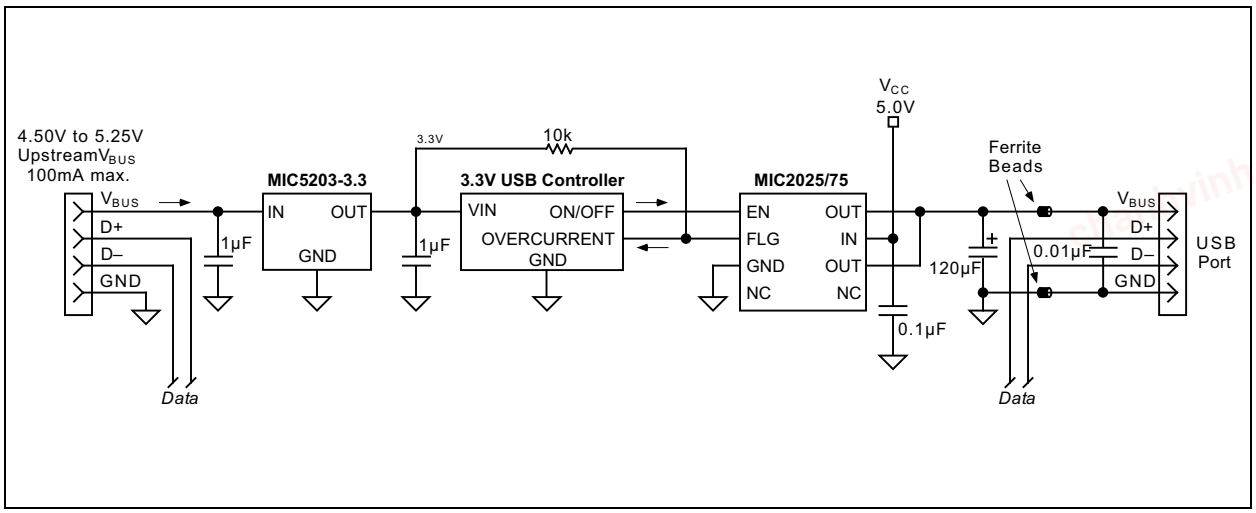


FIGURE 5-3: *USB Host Application.*

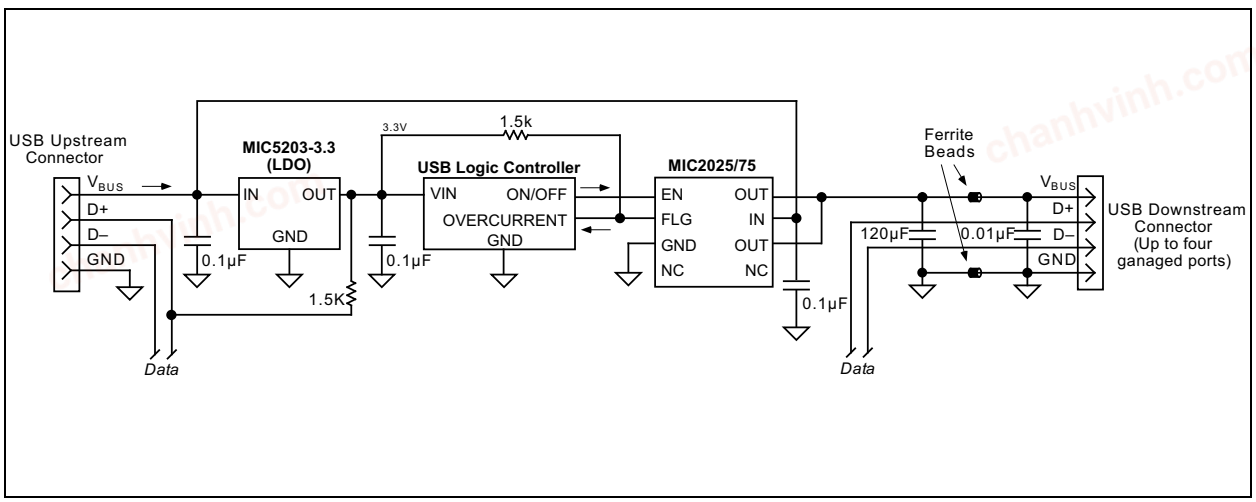


FIGURE 5-4: *USB Bus-Powered Hub.*

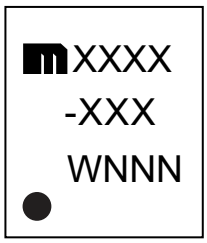
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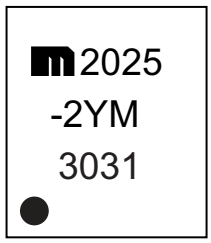
6.0 PACKAGING INFORMATION

6.1 Package Marking Information

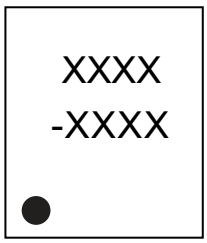
8-Lead SOIC*



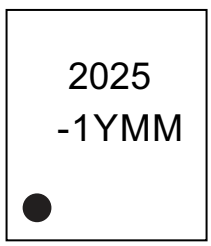
Example



8-Lead MSOP*



Example



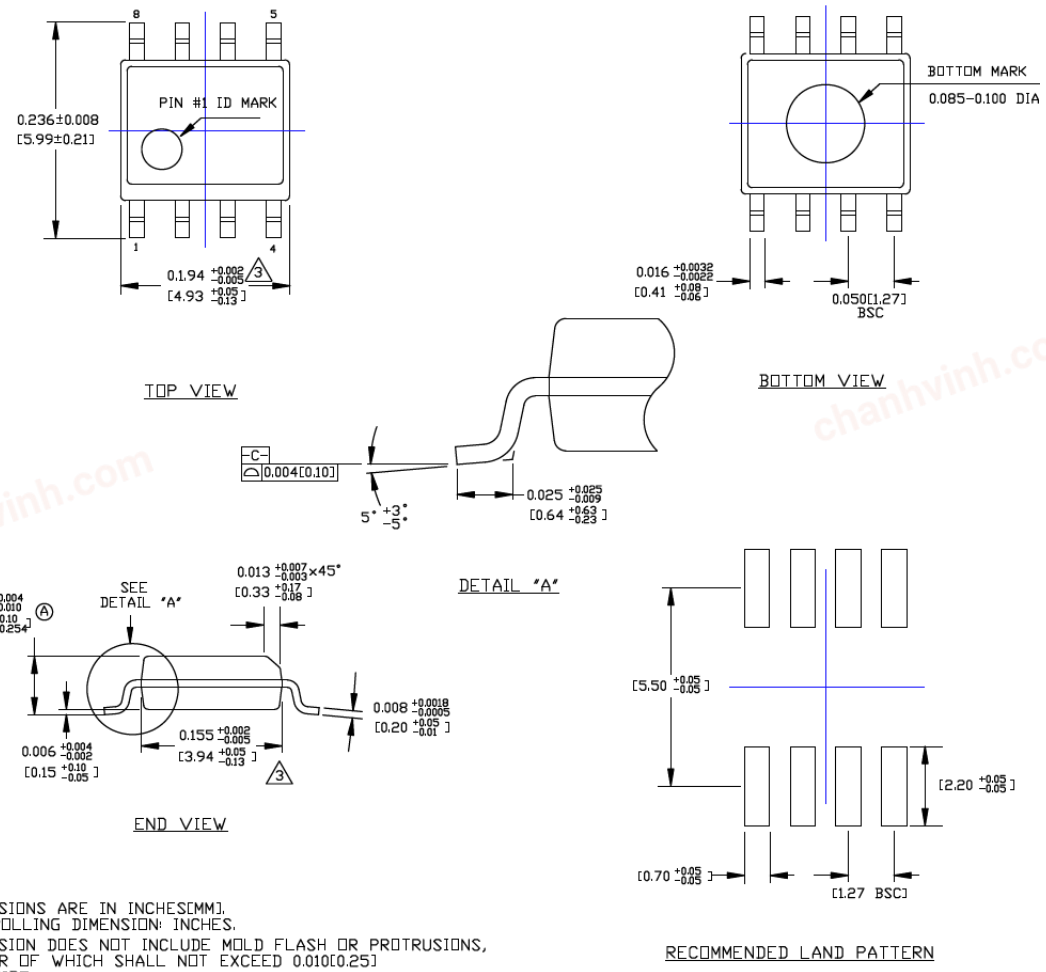
Legend:	XX...X	Product code or customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week ‘01’)
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC® designator for Matte Tin (Sn)
	*	This package 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.

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8-Lead SOIC-8 Package Outline and Recommended Land Pattern

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8 LEAD SOICN PACKAGE OUTLINE & RECOMMENDED LAND PATTERN

DRAWING #	SOICN-8LD-PL-1	UNIT	INCH [MM]



NOTES:
1. DIMENSIONS ARE IN INCHES[MM].
2. CONTROLLING DIMENSION: INCHES.
3. DIMENSION DOES NOT INCLUDE MOLD FLASH OR PROTRUSIONS, EITHER OF WHICH SHALL NOT EXCEED 0.010[0.25] PER SIDE.

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

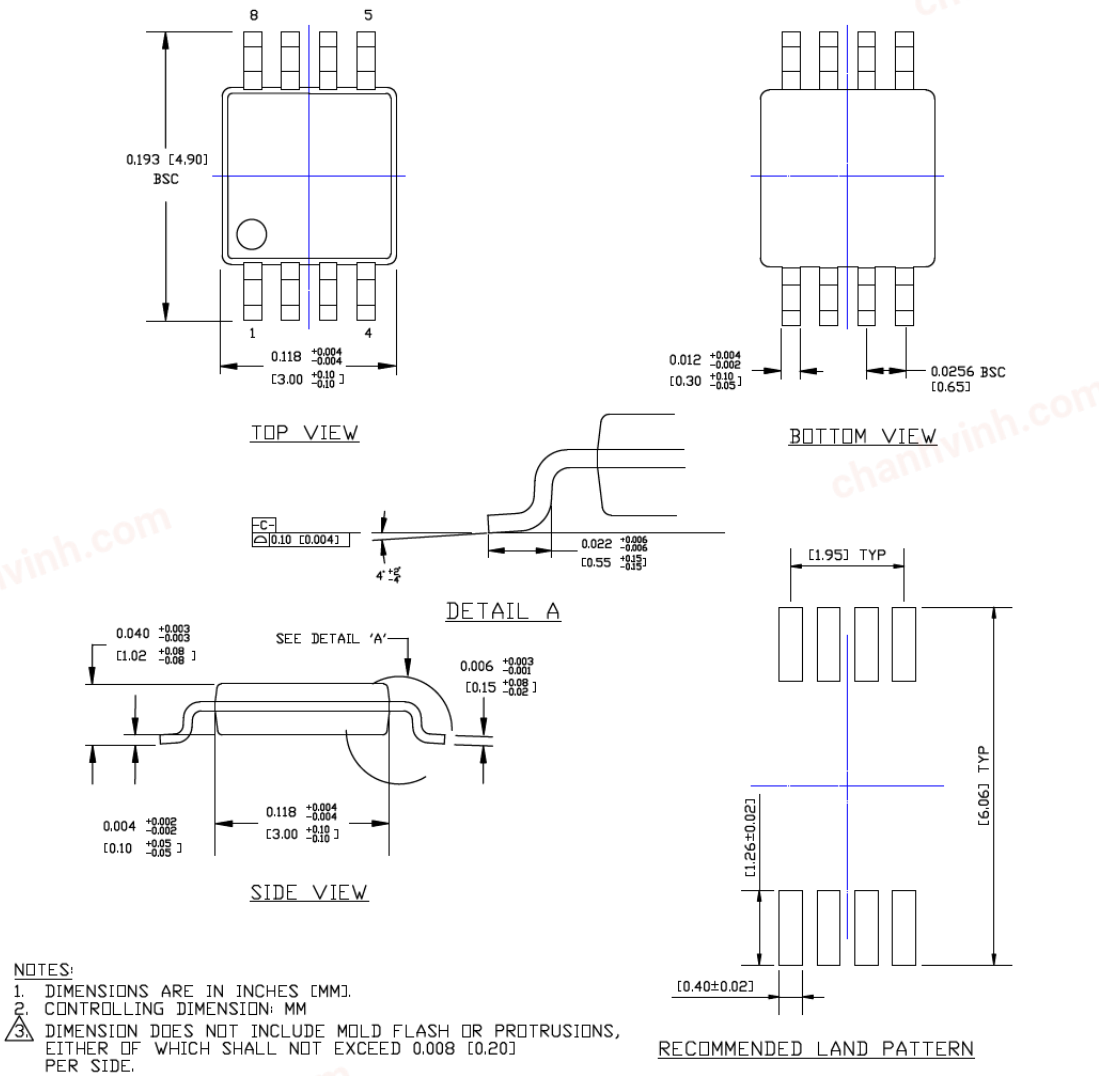
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8-Lead MSOP-8 Package Outline and Recommended Land Pattern

TITLE
8 LEAD MSOP PACKAGE OUTLINE & RECOMMENDED LAND PATTERN

DRAWING #	MSOP-8LD-PL-1	UNIT	INCH [MM]



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APPENDIX A: REVISION HISTORY

Revision A (June 2018)

- Converted Micrel document MIC2025/2075 to Microchip data sheet DS20006030A.
- Minor text changes throughout.

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NOTES:

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PRODUCT IDENTIFICATION SYSTEM

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

PART NO.	–X	X	XX	–XX
Device	Control/ Enable	Junction Temperature Range	Package	Media Type

Device:	MIC2025: MIC2075:	Single Channel Power Distribution Switch Single Channel Power Distribution Switch with Circuit Breaker Mode
Control/Enable:	1 = 2 =	Active-High Active-Low
Junction Temperature Range:	Y =	–40°C to +85°C (RoHs Compliant, Pb-Free, Halogen Free)
Package:	M = MM =	8-Lead SOIC 8-Lead MSOP
Media Type:	Blank = Blank = TR =	95/Tube 100/Tube 2,500/Reel

Examples:

a) MIC2025-1YM:	Single Channel Power Distribution Switch, Active-High Control Enable, –40°C to +85°C Temp. Range, 8-Lead SOIC Package, 95/Tube
b) MIC2025-2YMM:	Single Channel Power Distribution Switch, Active-Low Control Enable, –40°C to +85°C Temp. Range, 8-Lead MSOP Package, 100/Tube
c) MIC2025-1YM-TR:	Single Channel Power Distribution Switch, Active-High Control Enable, –40°C to +85°C Temp. Range, 8-Lead SOIC Package, 2,500/Reel
d) MIC2025-2YMM-TR:	Single Channel Power Distribution Switch, Active-Low Control Enable, –40°C to +85°C Temp. Range, 8-Lead MSOP Package, 2,500/ Reel
e) MIC2075-1YM	Single Channel Power Distribution Switch with Circuit Breaker Mode, Active-High Control Enable, –40°C to +85°C Temp. Range, 8-Lead SOIC Package, 95/Tube
f) MIC2075-1YM-TR:	Single Channel Power Distribution Switch with Circuit Breaker Mode, Active-High Control Enable, –40°C to +85°C Temp. Range, 8-Lead SOIC Package, 2,500/Reel
g) MIC2075-2YMM-TR:	Single Channel Power Distribution Switch with Circuit Breaker Mode, Active-Low Control Enable, –40°C to +85°C Temp. Range,8-Lead MSOP Package, 2,500/Reel

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