MIC2776

Micropower Low Voltage Supervisor

Features

- User-Adjustable Input Can Monitor Supplies as Low as 0.3V
- ±1.5% Threshold Accuracy
- Separate V_{DD} Input
- Generates Power-On Reset Pulse (140 ms min.)
- Manual Reset Input
- Choice of Active-High, Active-Low or Open-Drain Active-Low Reset Output
- Inputs Can be Pulled Above V_{DD} (7V abs. max.)
- Open-Drain Output Can be Pulled Above V_{DD} (7V abs.max.)
- Ultra-Low Supply Current, 3.0 µA Typical
- Rejects Brief Input Transients
- Available in 5-Lead SOT-23 Package

Applications

- Monitoring Processor, ASIC, or FPGA Core Voltage
- Computer Systems
- PDAs/Handheld PCs
- Embedded Controllers
- Telecommunications Systems
- Power Supplies
- Wireless/Cellular Systems
- Networking Hardware

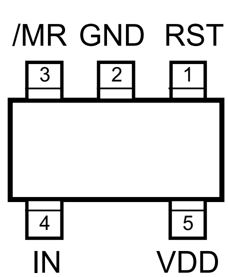
General Description

The MIC2776 is a power supply supervisor that provides undervoltage monitoring and power-on reset generation in a compact 5-lead SOT-23 package. Features include an adjustable undervoltage detector, a delay generator, a manual reset input, and a choice of active-high, active-low, or open-drain active-low reset output. The user-adjustable monitoring input is compared against a 300 mV reference. This low reference voltage allows monitoring voltages lower than those supported by previous supervisor ICs.

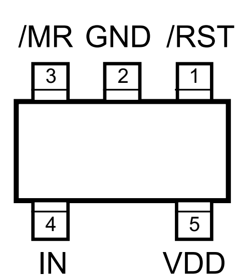
The reset output is asserted for no less than 140 ms at power-on and any time the input voltage drops below the reference voltage. It remains asserted for the timeout period after the input voltage subsequently rises back above the threshold boundary. A reset can be generated at any time by asserting the manual reset input, /MR. The reset output will remain active at least 140 ms after the release of /MR. The /MR input can also be used to daisy-chain the MIC2776 onto existing power monitoring circuitry or other supervisors. Hysteresis is included to prevent chattering due to noise. Typical supply current is a low 3.0 µA.

Package Types

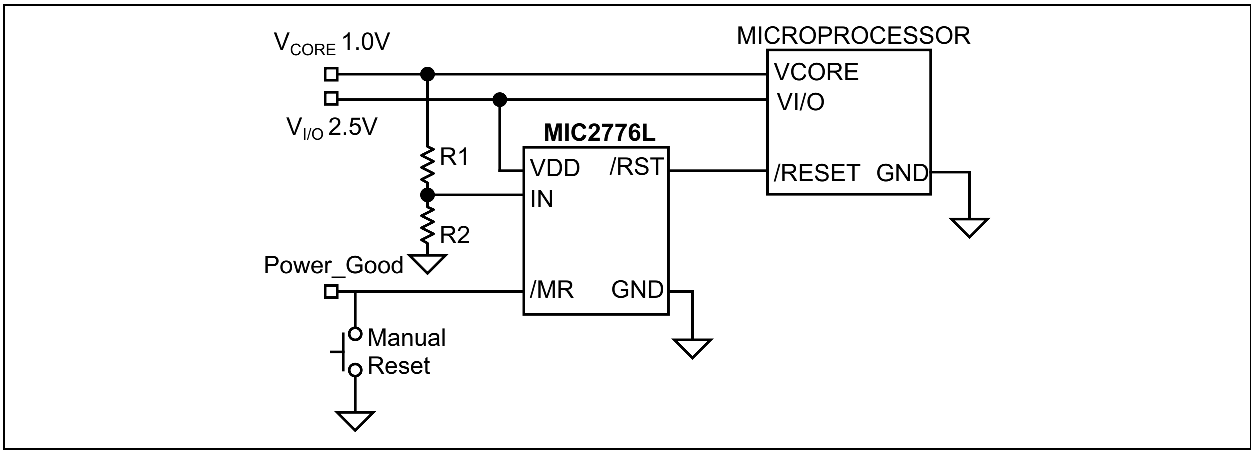
MIC2776
5-Lead SOT-23 (M5)
(Top View, “H” Version)



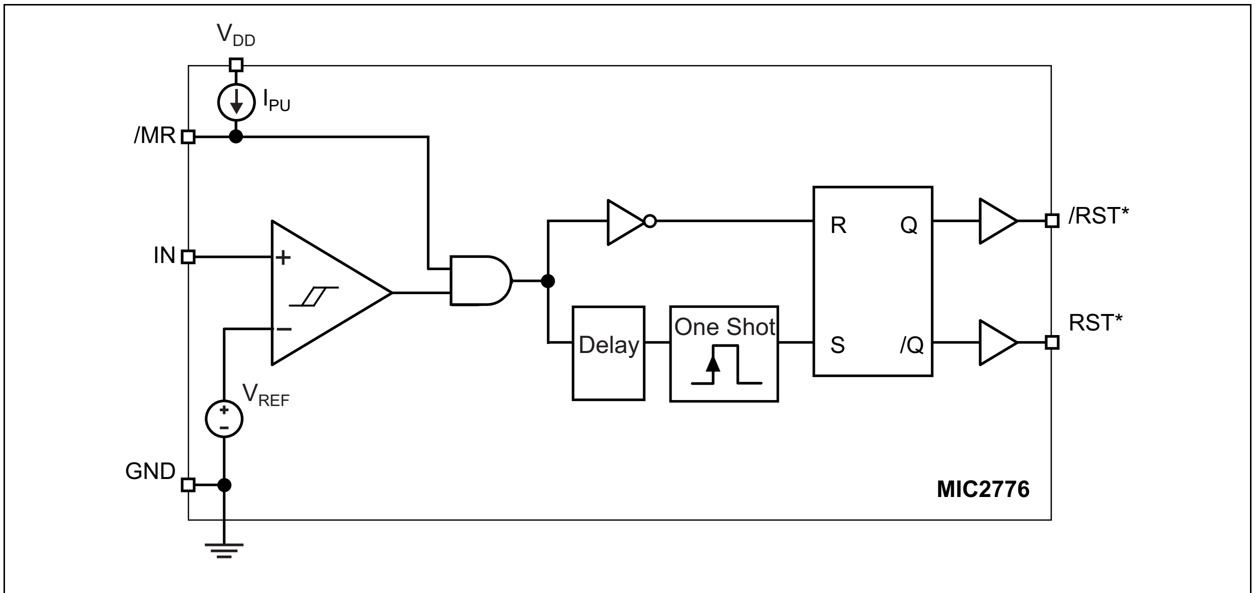
MIC2776
5-Lead SOT-23 (M5)
(Top View, “L” and “N” Versions)



Typical Application Circuit



Functional Block Diagram



* Pinout and polarity vary by device type.
See the Product Identification System section for more information.

1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Supply Voltage (V_{DD}) .... –0.3V to +7V
Input Voltages (V_{IN}, $V_{/MR}$) .... –0.3V to +7V
RST, /RST Current .... 20 mA
ESD Rating (Note 1) .... 1.5 kV

Operating Ratings ‡

Supply Voltage (V_{DD}) .... +1.5V to +5.5V
Input Voltages (V_{IN}, $V_{/MR}$) .... –0.3V to +6.0V
Output Voltages
$V_{/RST}$ (N Version) .... –0.3V to +6.0V
$V_{/RST}$, V_{RST} (H and L Versions) .... –0.3V to V_{DD} + 0.3V

† 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 recommended. Human body model, 1.5 kΩ in series with 100 pF.

ELECTRICAL CHARACTERISTICS

Electrical Characteristics: V_{DD} = 3.3V; T_A = +25°C, **bold** values valid for –40°C ≤ T_A ≤ +85°C, unless noted. Note 1

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Supply Current	I_{DD}	—	3.0	—	µA	V_{DD} = V_{IN} = 3.3V; /MR, RST, /RST open
IN, Undervoltage Detector Input						
Undervoltage Threshold	V_{REF}	**295**	300	**305**	mV	T_A = +25°C
Hysteresis Voltage	V_{HYST}	—	3	—	mV	—
Input Current	I_{IN}	—	5	—	pA	—
		—	—	**10**	nA	T_{MIN} ≤ T_A ≤ T_{MAX}
Reset Outputs (/RST, RST)						
Propagation Delay	t_{PROP}	—	20	—	µs	V_{IN} = ($V_{REF(MAX)}$ + 100 mV) to V_{IN} = ($V_{REF(MIN)}$ – 100 mV)
Reset Pulse Width	t_{RST}	**140**	—	**280**	ms	—
RST or /RST Output Voltage Low	V_{OL}	—	—	**0.3**	V	I_{SINK} = 1.6 mA; V_{DD} ≥ 1.6V
		—	—	**0.3**		I_{SINK} = 100 µA; V_{DD} ≥ 1.2V, Note 1
RST or /RST Output Voltage High (H & L Versions Only)	V_{OH}	**0.8VDD**	—	—	V	I_{SOURCE} = 500 µA; V_{DD} ≥ 1.5V
		0.8VDD	—	—		I_{SOURCE} = 10 µA; V_{DD} ≥ 1.2V, Note 1
Manual Reset Inputs (/MR)						
Input High Voltage	V_{IH}	**$0.7V_{DD}$**	—	—	V	1.5V ≤ V_{DD} ≤ 5.5V
Input Low Voltage	V_{IL}	—	—	**$0.3V_{DD}$**	V	1.5V ≤ V_{DD} ≤ 5.5V
Propagation Delay	t_{PROP}	—	5	—	µs	$V_{/MR}$ < V_{IL}
Minimum Input Pulse Width	t_{MIN}	—	33	—	ns	Reset occurs, $V_{/MR}$ < V_{IL}
Internal Pull-Up Current	I_{PU}	—	100	—	nA	—
Input Current, /MR	I_{IN}	—	100	—	nA	$V_{/MR}$ < V_{IL}

Note 1: V_{DD} operating range is 1.5V to 5.5V. Output is ensured to be asserted down to V_{DD} = 1.2V.

TEMPERATURE SPECIFICATIONS

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	—
Package Thermal Resistances						
Thermal Resistance, SOT-23 5-Ld	θ_{JA}	—	256	—	°C/W	—

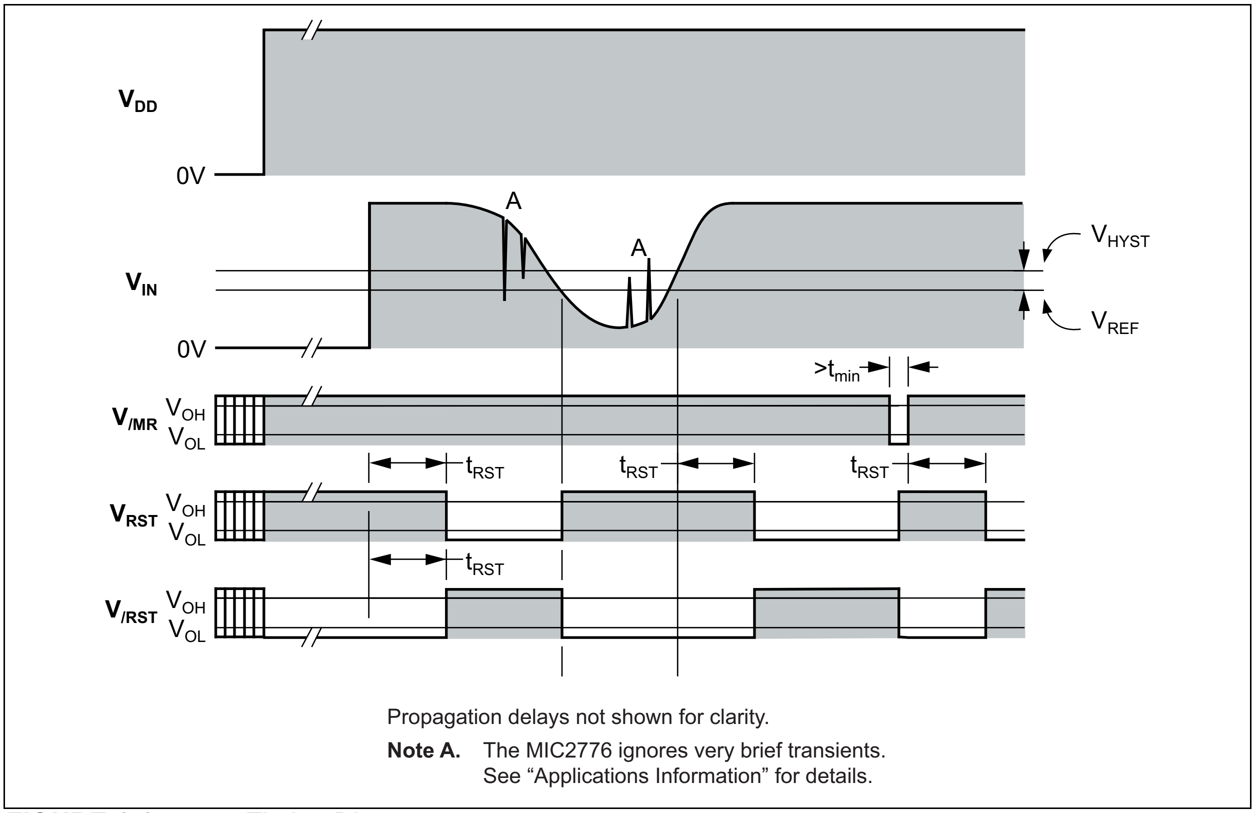


FIGURE 1-1: *Timing Diagram.*

2.0 PIN DESCRIPTIONS

The descriptions of the pins are listed in Table 2-1.

TABLE 2-1: PIN FUNCTION TABLE

Pin Number MIC2776H	Pin Number MIC2776L MIC2776N	Pin Name	Description
1	—	RST	Digital (Output): Asserted high whenever V_{IN} falls below the reference voltage. It will remain asserted for no less than 140 ms after V_{IN} returns above the threshold limit.
—	1	/RST	Digital (Output): Asserted low whenever V_{IN} falls below the reference voltage. It will remain asserted for no less than 140 ms after V_{IN} returns above the threshold limit. (Open-drain for "N" version.)
2	2	GND	Ground.
3	3	/MR	Digital (Input): Driving this pin low initiates an immediate and unconditional reset. Assuming IN is above the threshold when /MR is released (returns high), the reset output will be de-asserted no less than 140 ms later. /MR may be driven by a logic signal or a mechanical switch. /MR has an internal pull-up to V_{DD} and may be left open if unused.
4	4	IN	Analog (Input): The voltage on this pin is compared to the internal 300 mV reference. An undervoltage condition will trigger a reset sequence.
5	5	VDD	Analog (Input): Independent supply input for internal circuitry.

3.0 FUNCTIONAL DESCRIPTION

3.1 IN, Undervoltage Detector Input

The voltage present at the IN pin is compared to the internal 300 mV reference voltage. A reset is triggered if and when V_{IN} falls below V_{REF}. Typically, a resistor divider is used to scale the input voltage to be monitored such that V_{IN} will fall below V_{REF} as the voltage being monitored falls below the desired trip-point. Hysteresis is employed to prevent chattering due to noise.

3.2 RST, /RST Reset Output

Typically, the MIC2776 is used to monitor the power supply of intelligent circuits such as microcontrollers and microprocessors. By connecting the reset output of a MIC2776 to the reset input of a microcontrollers or microprocessor, the processor will be properly reset at power-on and during power-down and during brown-out conditions. In addition, asserting /MR, the manual reset input, will activate the reset function.

The reset outputs are asserted any time /MR is asserted or if V_{IN} drops below the threshold voltage. The reset outputs remain asserted for $t_{RST(MIN)}$ after V_{IN} subsequently returns above the threshold boundary and /MR is released. A reset pulse is also generated at power-on.

3.3 /MR, Manual Reset Input

The ability to initiate a reset via external logic or a manual switch is provided in addition to the MIC2776's automatic supervisory functions. Driving the /MR input to a logic low causes an immediate and unconditional reset to occur. Assuming V_{IN} is within tolerance when /MR is released (returns high), the reset output will be de-asserted no less than t_{RST} later. /MR may be driven by a logic signal, or mechanical switch. Typically, a momentary push-button switch is connected such that /MR is shorted to ground when the switch contacts close. The switch may be connected directly between /MR and GND. /MR has an internal 100 nA pull-up current to V_{DD} and may be left open if unused.

4.0 APPLICATION INFORMATION

4.1 Programming the Threshold Voltage

Referring to the Typical Application Circuit, the voltage threshold is calculated as follows:

EQUATION 4-1:

$$V_{TH} = V_{REF} \times \frac{R1 + R2}{R2}$$

Where:

V_{REF} = 0.300V

In order to provide the additional criteria needed to solve for the resistor values, the resistors can be selected such that the two resistors have a given total value, that is, R1 + R2 = R_{TOTAL}. Imposing this condition on the resistor values provides two equations that can be solved for the two unknown resistor values. A value such as 1 MΩ for R_{TOTAL} is a reasonable choice because it keeps quiescent current to a generally acceptable level while not causing any measurable errors due to input bias currents. The larger the resistors, the larger the potential errors due to input bias current (I_{IN}). The maximum recommended value of R_{TOTAL} is 3 MΩ.

Applying this criteria and rearranging the V_{TH} expression to solve for the resistor values gives:

EQUATION 4-2:

$$R2 = \frac{R_{TOTAL} \times V_{REF}}{V_{TH}}$$

$$R1 = R_{TOTAL} - R2$$

4.2 Application Example

Figure 4-1 illustrates a hypothetical MIC2776 application in which the MIC2776 is used to monitor the core supply of a high-performance CPU or DSP. The core supply, V_{CORE}, in this example is 1.0V ±5%. The main power rail and I/O voltage, $V_{I/O}$, is 2.5V ±5%. As shown in Figure 4-1, the MIC2776 is powered by $V_{I/O}$. The minimum value of $V_{I/O}$ is 2.5V – 5% = 2.375V; the maximum is 2.5V + 5% = 2.625V. This is well within the MIC2776's power supply range of 1.5V to 5.5V.

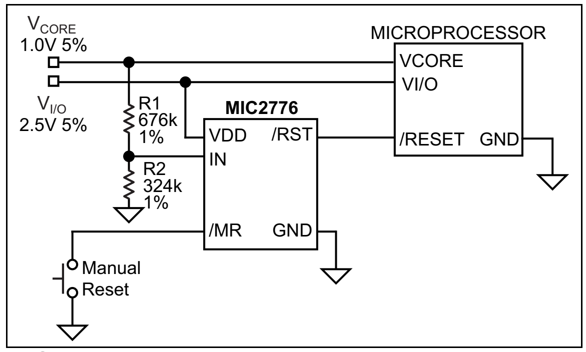


FIGURE 4-1: Example Design.

Resistors R1 and R2 must be selected to correspond to the V_{CORE} supply of 1.0V. The goal is to ensure that the core supply voltage is adequate to ensure proper operation, i.e., $V_{CORE} \geq (1.0V - 5\%) = 0.950V$. Because there is always a small degree of uncertainty due to the accuracy of the resistors, variations in the devices' voltage reference, etc., the threshold will be set slightly below this value. The potential variation in the MIC2776's voltage reference is specified as ±1.5%. The resistors chosen will have their own tolerance specifications. This example will assume the use of 1% accurate resistors. The potential worst-case error contribution due to input bias current can be calculated once the resistor values are chosen. If the guidelines above regarding the maximum total value of R1 + R2 are followed, this error contribution will be very small thanks to the MIC2776's very low input bias current.

To summarize, the various potential error sources are:

- Variation in V_{REF}: Specified at ±1.5%
- Resistor tolerance: Chosen by designer (typically ≤ ±1%)
- Input bias current, I_{IN}: Calculated once resistor values are known, typically very small

Taking the various potential error sources into account, the threshold voltage will be set slightly below the minimum V_{CORE} specification of 0.950V so that when the actual threshold voltage is at its maximum, it will not intrude into the normal operating range of V_{CORE}. The target threshold voltage will be set as follows:

Given that the total tolerance on V_{TH} is

EQUATION 4-3:

$$[\text{VREF tolerance}] + [\text{resistor tolerance}] =$$

$$\pm1.5\% + \pm1\% = \pm2.5\%$$

and $$V_{TH(MAX)} = V_{CORE(MIN)}$$

then $$V_{CORE(MIN)} = V_{TH} + 2.5\% V_{TH} = 1.025 V_{TH}$$

Therefore, solving for V_{TH} results in:

EQUATION 4-4:

$$V_{TH} = \frac{V_{CORE(MIN)}}{1.025} = \frac{0.950}{1.025} = 0.9268V$$

Solving for R1 and R2 using this value for V_{TH} and the equations above yields:

R1 = 676.3 kΩ ≈ 673 kΩ

R2 = 323.7 kΩ ≈ 324 kΩ

The resulting circuit is shown in Figure 4-1.

4.3 Input Bias Current Effects

Now that the resistor values are known, it is possible to calculate the maximum potential error due to input bias current, I_{IN}. As shown in the Electrical Characteristics table, the maximum value of I_{IN} is 10 nA. Note that the typical value is a much smaller 5 pA. The magnitude of the offset caused by I_{IN} is given by:

EQUATION 4-5:

$$V_{ERROR} = I_{IN(MAX)} \times (R1 \parallel R2)$$

$$V_{ERROR} = \pm 1 \times 10^{-8} A \times 2.189 \times 10^{5} \Omega$$

$$V_{ERROR} = \pm 2.189 \times 10^{-3} V$$

$$V_{ERROR} = \pm 2.189 mV$$

The typical error is about three orders of magnitude lower than this—close to 1 µV. Generally, the error due to input bias can be discounted. If it is to be taken into account, simply adjust the target threshold voltage downward by this amount and recalculate R1 and R2. The resulting value will be very close to optimal. If accuracy is more important than the quiescent current in the resistors, simply reduce the value of R_{TOTAL} to minimize offset errors.

4.4 Interfacing to Processors with Bidirectional Reset Pins

Some microprocessors have reset signal pins that are bidirectional, rather than input only. The Motorola 68HC11 family is one example. Because the MIC2776N's output is open-drain, it can be connected directly to the processor's reset pin using only the pull-up resistor normally required. See Figure 4-2.

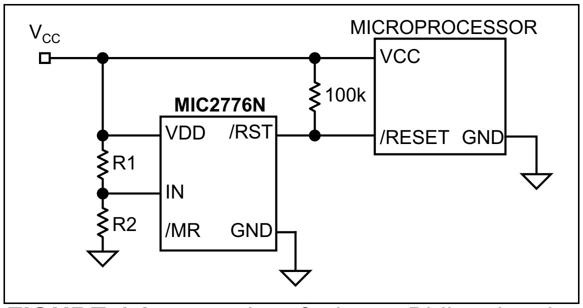


FIGURE 4-2: *Interfacing to Bidirectional Reset Pin.*

4.5 Transient Response

The MIC2776 is inherently immune to very short negative going glitches. Very brief transients may exceed the voltage threshold without tripping the output.

As shown in Figure 4-3, the narrower the transient, the deeper the threshold overdrive that will be ignored by the MIC2776. The graph represents the typical allowable transient duration for a given amount of threshold overdrive that will not generate a reset.

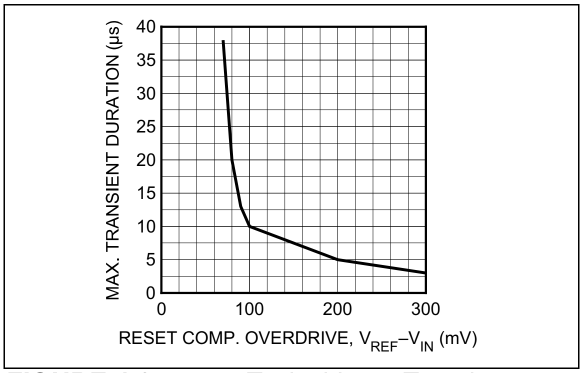


FIGURE 4-3: *Typical Input Transient Response.*

4.6 Ensuring Proper Operation at Low Supply

At levels of V_{DD} below 1.2V, the MIC2776L's /RST output driver cannot turn on sufficiently to produce a valid logic low on the /RST output. In this situation, other circuits driven by /RST could be allowed to float, causing undesired operation. In most cases, however, it is expected that the circuits driven by the MIC2776L will be similarly inoperative at $V_{DD} \leq 1.2V$.

If a given application requires that /RST be valid below V_{DD} = 1.2V, this can be accomplished by adding a pull-down resistor to the /RST output. A value of 100 kΩ is recommended as this is usually an acceptable compromise of leakage current and pull-down current. The resistor's value is not critical, however. See Figure 4-4.

The statements above also apply to the MIC2776H's RST output. That is, to ensure valid RST signal levels at V_{DD} < 1.2V, a pull-up resistor (as opposed to a pull-down) should be added to the RST output. A value of 100 kΩ is typical for this application as well. See Figure 4-5.

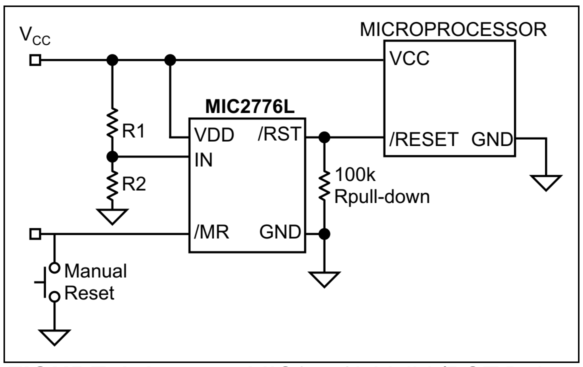


FIGURE 4-4: *MIC2776L Valid /RST Below 1.2V.*

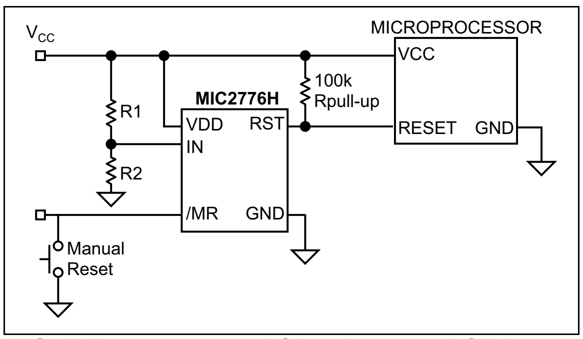


FIGURE 4-5: *MIC2776H Valid RST Below 1.2V.*

5.0 PACKAGING INFORMATION

5.1 Package Marking Information

5-Lead SOT-23* (Front)	Example	5-Lead SOT-23* (Back)	Example
XXXX	ULAA	NNN	DW4

Note: The Marking Code for the H version is ULAA; the marking code for the L version is UMAA; the marking code for the N version is UKAA.

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.

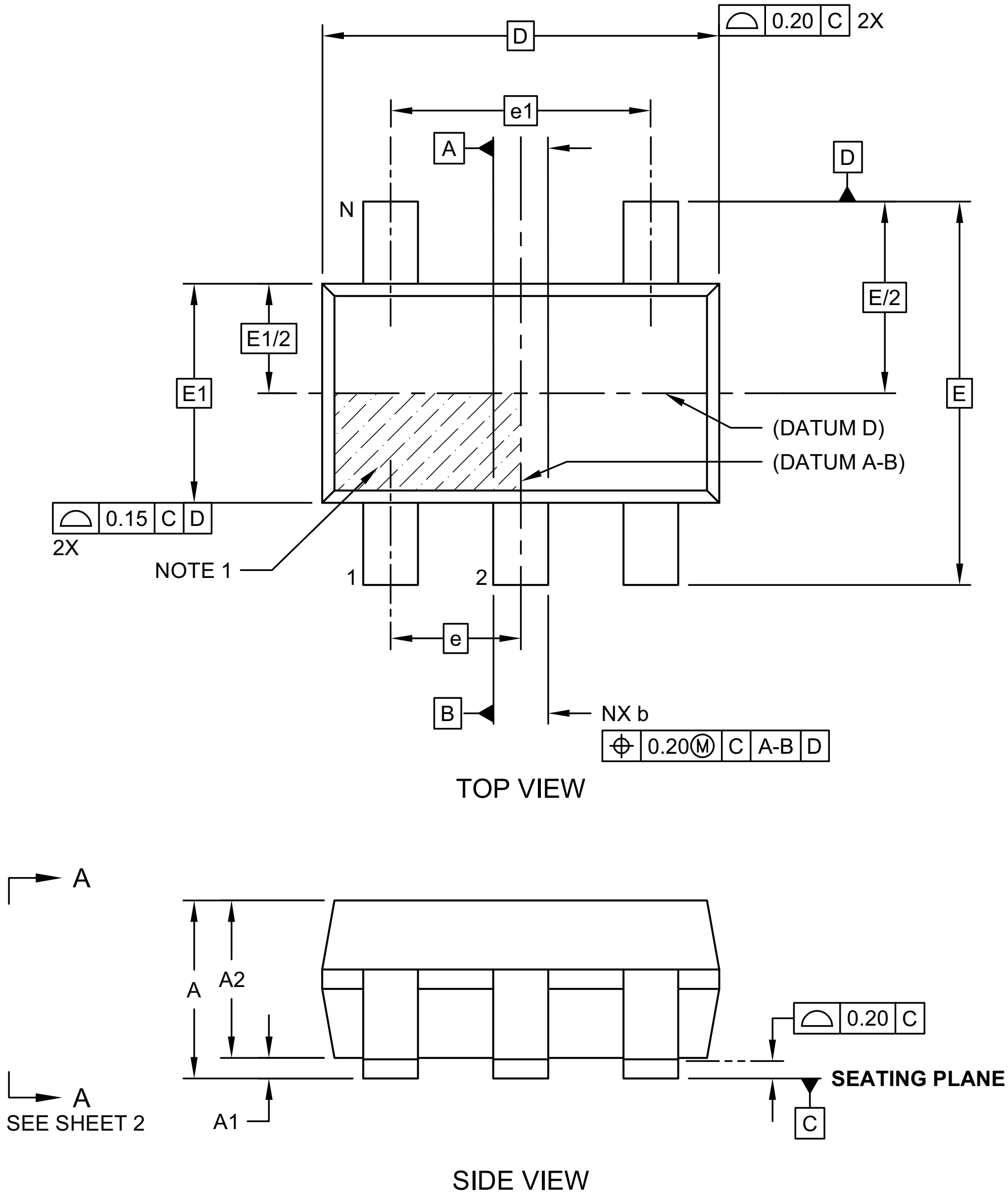
Underbar (_) symbol may not be to scale.

Note: If the full seven-character YYWWNNN code cannot fit on the package, the following truncated codes are used based on the available marking space:
6 Characters = YWWNNN; 5 Characters = WWNNN; 4 Characters = WNNN; 3 Characters = NNN;
2 Characters = NN; 1 Character = N

5-Lead SOT-23 Package Outline and Recommended Land Pattern

5-Lead Plastic Small Outline Transistor (6BX) [SOT23]

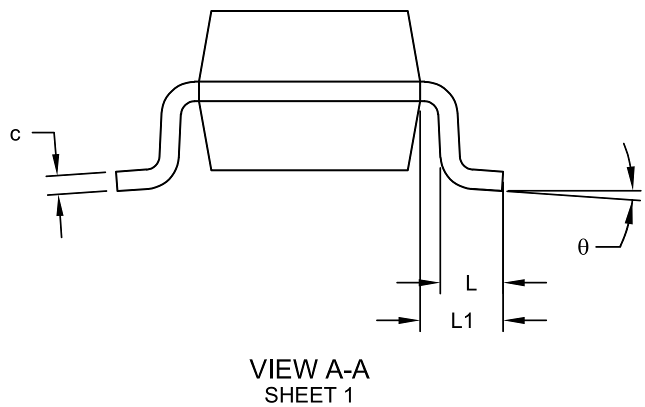
Note:	For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging

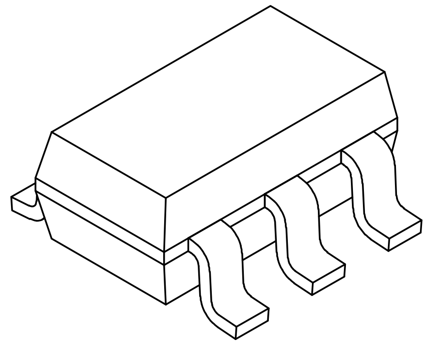


Microchip Technology Drawing C04-091-6BX Rev G Sheet 1 of 2

5-Lead Plastic Small Outline Transistor (6BX) [SOT23]

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





	Units	MILLIMETERS		
	Dimension Limits	MIN	NOM	MAX
Number of Pins	N		5	
Pitch	e		0.95 BSC	
Outside lead pitch	e1		1.90 BSC	
Overall Height	A	0.90	-	1.45
Molded Package Thickness	A2	0.89	-	1.30
Standoff	A1	-	-	0.15
Overall Width	E		2.80 BSC	
Molded Package Width	E1		1.60 BSC	
Overall Length	D		2.90 BSC	
Foot Length	L	0.30	-	0.60
Footprint	L1		0.60 REF	
Foot Angle	ϕ	0°	-	10°
Lead Thickness	c	0.08	-	0.26
Lead Width	b	0.20	-	0.51

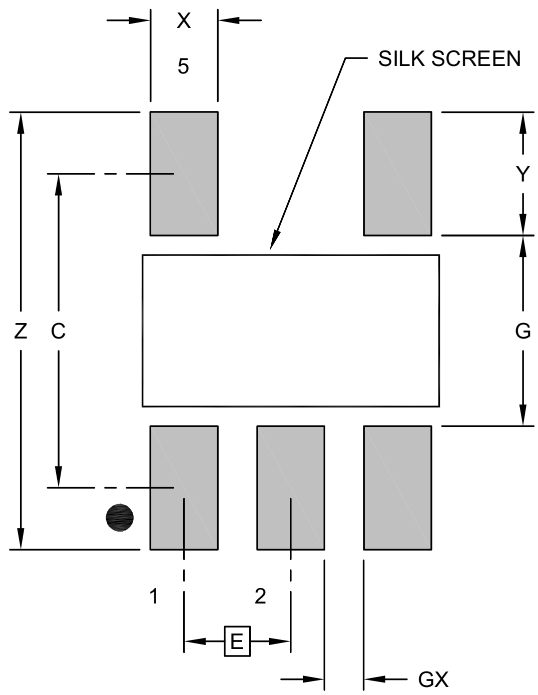
Notes:

1. Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.25mm per side.
2. Dimensioning and tolerancing per ASME Y14.5M
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.
   REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing C04-091-6BX Rev G Sheet 2 of 2

5-Lead Plastic Small Outline Transistor (6BX) [SOT23]

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



RECOMMENDED LAND PATTERN

Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Contact Pitch	E		0.95 BSC	
Contact Pad Spacing	C		2.80	
Contact Pad Width (X5)	X			0.60
Contact Pad Length (X5)	Y			1.10
Distance Between Pads	G	1.70		
Distance Between Pads	GX	0.35		
Overall Width	Z			3.90

Notes:

1. Dimensioning and tolerancing per ASME Y14.5M

   BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing No. C04-2091-6BX Rev G

NOTES:

APPENDIX A: REVISION HISTORY

Revision A (August 2022)

- Converted Micrel document MIC2776 to Microchip data sheet DS20006705A.
- Minor text changes throughout.

NOTES:

PRODUCT IDENTIFICATION SYSTEM

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

Part Number	X	-X	XX	-XX
Device	Reset Output	Temp. Range	Package	Media Type

Device:	MIC2776:	Micropower Low Voltage Supervisor
Reset Output:	N =	Open-Drain, Active-Low /RST
	H =	Active-High, Complementary RST
	L =	Active-Low, Complementary /RST
Temperature Range:	Y =	–40°C to +85°C
Package:	M5 =	5-Lead SOT-23
Media Type:	TR =	3,000/Reel
	TX =	3,000/Reel Reversed

Examples:

a) MIC2776N-YM5-TR: MIC2776, Open-Drain, Active-Low /RST, –40°C to +85°C Temp. Range, 5-Lead SOT-23, 3,000/Reel

b) MIC2776H-YM5-TR: MIC2776, Active-High, Complementary RST, –40°C to +85°C Temp. Range, 5-Lead SOT-23, 3,000/Reel

c) MIC2776L-YM5-TR: MIC2776, Active-Low, Complementary /RST, –40°C to +85°C Temp. Range, 5-Lead SOT-23, 3,000/Reel

d) MIC2776N-YM5-TX: MIC2776, Open-Drain, Active-Low /RST, –40°C to +85°C Temp. Range, 5-Lead SOT-23, 3,000/Reel Reversed

e) MIC2776L-YM5-TX: MIC2776, Active-Low, Complementary /RST, –40°C to +85°C Temp. Range, 5-Lead SOT-23, 3,000/Reel Reversed

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:

Note the following details of the code protection feature on Microchip products:

- Microchip products meet the specifications contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is secure when used in the intended manner, within operating specifications, and under normal conditions.
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- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of its code. Code protection does not mean that we are guaranteeing the product is "unbreakable" Code protection is constantly evolving. Microchip is committed to continuously improving the code protection features of our products.

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