MCP111/112

Micropower Voltage Detector

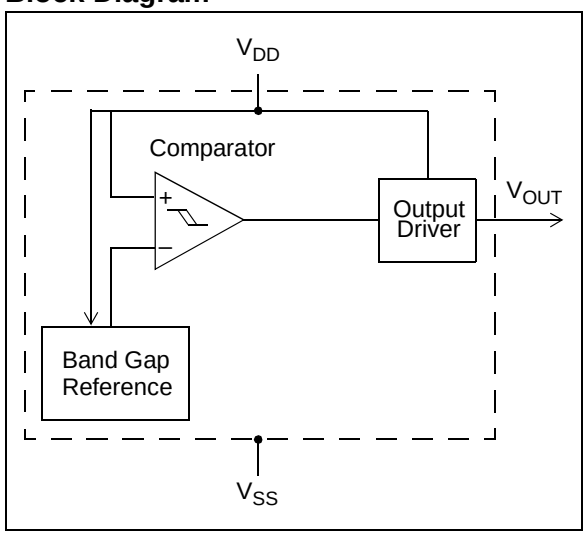
Features

- Ultra-low supply current: 1.75 µA (max.)
- Precision monitoring options of:
  - 1.90V, 2.32V, 2.63V, 2.90V, 2.93V, 3.08V, 4.38V and 4.63V
- Resets microcontroller in a power-loss event
- Active-low V_{OUT} pin:
  - **MCP111** active-low, open-drain
  - **MCP112** active-low, push-pull
- Available in SOT23-3, TO-92 and SC70 packages
- Temperature Range:
  - Extended: –40°C to +125°C (**except MCP1XX-195**)
  - Industrial: –40°C to +85°C (**MCP1XX-195 only**)

Applications

- Critical µC and µP Power-monitoring Applications
- Computers
- Intelligent Instruments
- Portable Battery-Powered Equipment

Block Diagram



Description

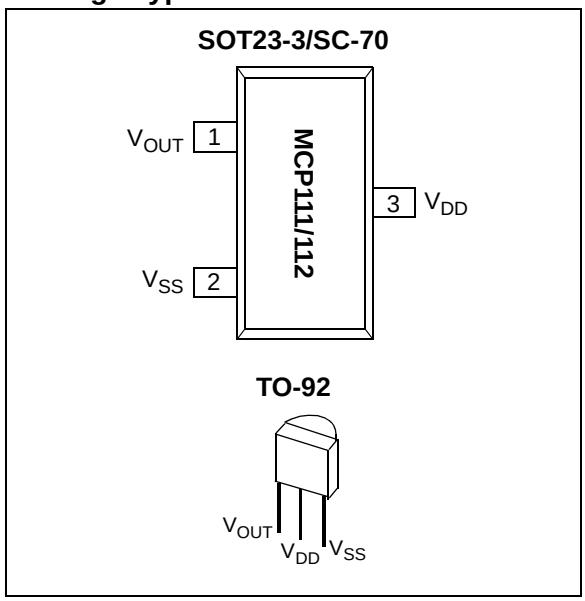
The MCP111/112 are voltage-detecting devices designed to keep a microcontroller in reset until the system voltage has reached, and stabilized, at the appropriate level for reliable system operation. These devices also operate as protection from brown-out conditions when the system supply voltage drops below a safe operating level. The MCP111 and MCP112 are available in eight different trip voltages.

The MCP111 has an open-drain output with an active-low pin (V_{OUT}). This device will assert V_{OUT} when the voltage on the V_{DD} pin is below the trip-point voltage.

The MCP112 has a push-pull output and will assert an active-low signal (V_{OUT} pin) when the voltage on the V_{DD} pin is below the trip-point voltage.

During operation, the output (V_{OUT}) remains at a logic-high as long as V_{DD} is greater than the specified threshold voltage. When V_{DD} falls below the voltage trip point, V_{OUT} is driven low.

Package Types



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1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings†

V_{DD} 7.0V
Input current (V_{DD}) . . . . . .10 mA
Output current ($\overline{RST}$) . . . . . .10 mA
Rated Rise Time of V_{DD} 100V/µs
All inputs and outputs w.r.t. V_{SS} . . . . . –0.6V to (V_{DD} + 1.0V)
Storage temperature . . . . . .–65°C to + 150°C
Ambient temp. with power applied . . . . . .–40°C to + 125°C
Maximum Junction temp. with power applied . . . . . .150°C
ESD protection on all pins . . . . . ≥ 2 kV

† **Notice:** Stresses above those listed under "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 listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

DC CHARACTERISTICS

Electrical Specifications: Unless otherwise indicated, all limits are specified for V_{DD} = 1V to 5.5V, R_{PU} = 100 kΩ (only **MCP111**), T_A = –40°C to +125°C.

Parameters		Sym	Min	Typ	Max	Units	Conditions
Operating Voltage Range		V_{DD}	1.0	—	5.5	V	
Specified V_{DD} Value to V_{OUT} low		V_{DD}	1.0	—		V	$I_{\overline{RST}}$ = 10 µA, $V_{\overline{RST}}$ < 0.2V
Operating Current		I_{DD}	—	< 1	1.75	µA	
V_{DD} Trip Point	**MCP1XX-195**	V_{TRIP}	1.872	1.900	1.929	V	T_A = +25°C **(Note 1)**
			1.853	1.900	1.948	V	T_A = -40°C to +85°C **(Note 2)**
	MCP1XX-240		2.285	2.320	2.355	V	T_A = +25°C **(Note 1)**
			2.262	2.320	2.378	V	**Note 2**
	MCP1XX-270		2.591	2.630	2.670	V	T_A = +25°C **(Note 1)**
			2.564	2.630	2.696	V	**Note 2**
	MCP1XX-290		2.857	2.900	2.944	V	T_A = +25°C **(Note 1)**
			2.828	2.900	2.973	V	**Note 2**
	MCP1XX-300		2.886	2.930	2.974	V	T_A = +25°C **(Note 1)**
			2.857	2.930	3.003	V	**Note 2**
	MCP1XX-315		3.034	3.080	3.126	V	T_A = +25°C **(Note 1)**
			3.003	3.080	3.157	V	**Note 2**
	MCP1XX-450		4.314	4.380	4.446	V	T_A = +25°C **(Note 1)**
			4.271	4.380	4.490	V	**Note 2**
	MCP1XX-475		4.561	4.630	4.700	V	T_A = +25°C **(Note 1)**
			4.514	4.630	4.746	V	**Note 2**
V_{DD} Trip Point Tempco		T_{TPCO}	—	±100	—	ppm/°C	
Threshold Hysteresis (min. = 1%, max = 6%)	**MCP1XX-195**	V_{HYS}	0.019	—	0.114	V	T_A = +25°C
	MCP1XX-240		0.023	—	0.139	V	
	MCP1XX-270		0.026	—	0.158	V	
	MCP1XX-290		0.029	—	0.174	V	
	MCP1XX-300		0.029	—	0.176	V	
	MCP1XX-315		0.031	—	0.185	V	
	MCP1XX-450		0.044	—	0.263	V	
	MCP1XX-475		0.046	—	0.278	V	

Note 1: Trip point is ±1.5% from typical value.
2: Trip point is ±2.5% from typical value.

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DC CHARACTERISTICS (CONTINUED)

Electrical Specifications: Unless otherwise indicated, all limits are specified for V_{DD} = 1V to 5.5V, R_{PU} = 100 kΩ (only **MCP111**), T_A = –40°C to +125°C.

Parameters	Sym	Min	Typ	Max	Units	Conditions
V_{OUT} Low-level Output Voltage	V_{OL}	—	—	0.4	V	I_{OL} = 500 µA, V_{DD} = $V_{TRIP(MIN)}$
V_{OUT} High-level Output Voltage	V_{OH}	V_{DD} – 0.6	—	—	V	I_{OH} = 1 mA, For only **MCP112** (push-pull output)
Open-Drain Output Leakage Current (**MCP111** only)	I_{OD}	—	0.1	—	µA	

Note 1: Trip point is ±1.5% from typical value.

2: Trip point is ±2.5% from typical value.

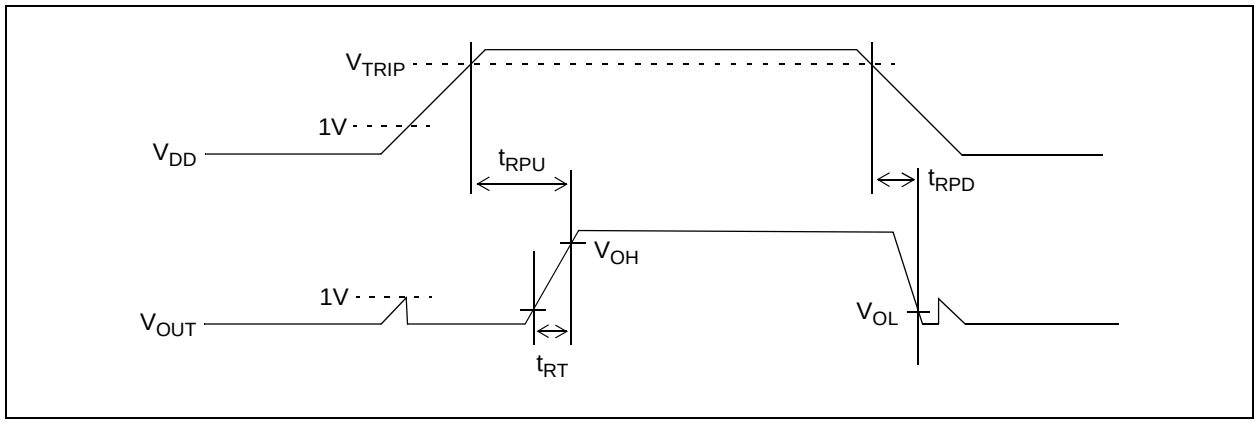


FIGURE 1-1: *Timing Diagram.*

AC CHARACTERISTICS

Electrical Specifications: Unless otherwise indicated, all limits are specified for V_{DD} = 1V to 5.5V, R_{PU} = 100 kΩ (only **MCP111**), T_A = –40°C to +125°C.

Parameters	Sym	Min	Typ	Max	Units	Conditions
V_{DD} Detect to V_{OUT} Inactive	t_{RPU}	—	90	—	µs	**Figure 1-1** and C_L = 50 pF **(Note 1)**
V_{DD} Detect to V_{OUT} Active	t_{RPD}	—	130	—	µs	V_{DD} ramped from $V_{TRIP(MAX)}$ + 250 mV down to $V_{TRIP(MIN)}$ – 250 mV, per **Figure 1-1**, C_L = 50 pF **(Note 1)**
V_{OUT} Rise Time After V_{OUT} Active	t_{RT}	—	5	—	µs	For V_{OUT} 10% to 90% of final value per **Figure 1-1**, C_L = 50 pF **(Note 1)**

Note 1: These parameters are for design guidance only and are not 100% tested.

TEMPERATURE CHARACTERISTICS

Electrical Specifications: Unless otherwise noted, all limits are specified for V_{DD} = 1V to 5.5V, R_{PU} = 100 kΩ (only **MCP111**), T_A = –40°C to +125°C.

Parameters	Sym	Min	Typ	Max	Units	Conditions
Temperature Ranges						
Specified Temperature Range	T_A	–40	—	+85	°C	**MCP1XX-195**
Specified Temperature Range	T_A	–40	—	+125	°C	Except **MCP1XX-195**
Maximum Junction Temperature	T_J	—	—	+150	°C	
Storage Temperature Range	T_A	–65	—	+150	°C	
Package Thermal Resistances						
Thermal Resistance, 3L-SOT23	θ_{JA}	—	336	—	°C/W	
Thermal Resistance, 3L-SC-70	θ_{JA}	—	340	—	°C/W	
Thermal Resistance, 3L-TO92	θ_{JA}	—	131.9	—	°C/W	

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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.

Note: Unless otherwise indicated, all limits are specified for V_{DD} = 1V to 5.5V, R_{PU} = 100 kΩ (only **MCP111**; see **Figure 4-1**), T_A = –40°C to +125°C.

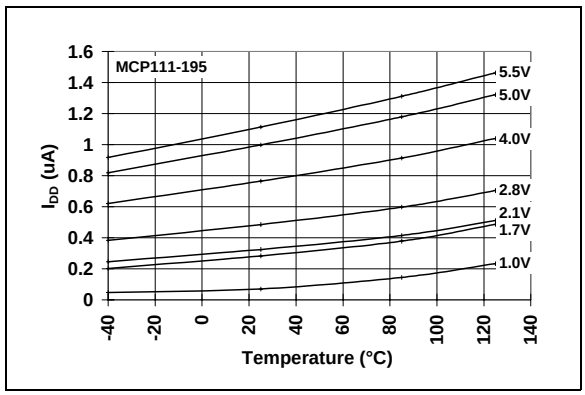


FIGURE 2-1: *I_{DD} vs. Temperature (**MCP111-195**).*

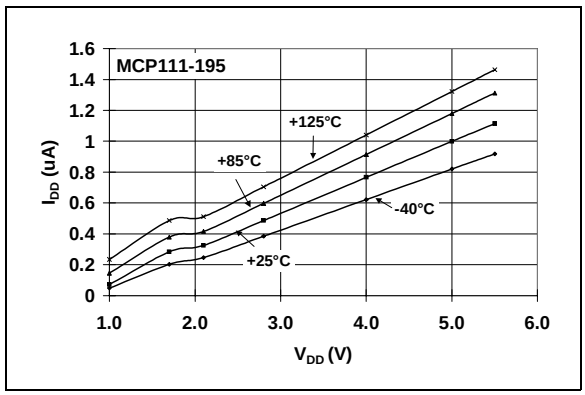


FIGURE 2-4: *I_{DD} vs. V_{DD} (**MCP111-195**).*

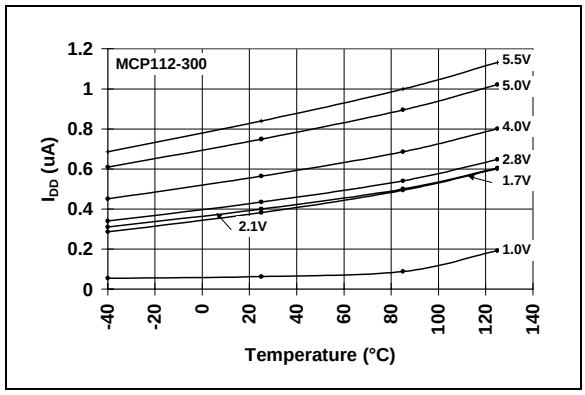


FIGURE 2-2: *I_{DD} vs. Temperature (**MCP112-300**).*

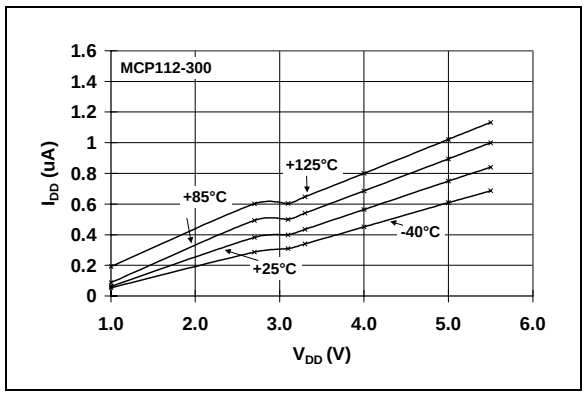


FIGURE 2-5: *I_{DD} vs. V_{DD} (**MCP112-300**).*

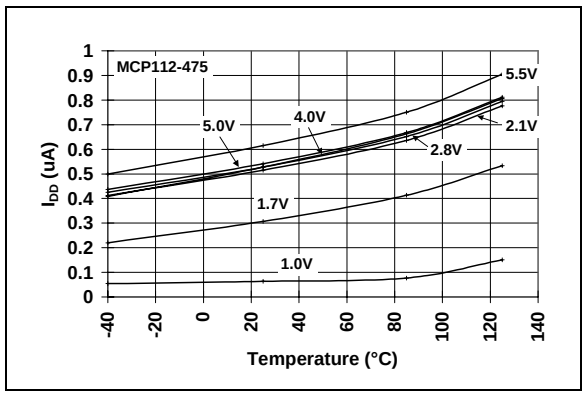


FIGURE 2-3: *I_{DD} vs. Temperature (**MCP112-475**).*

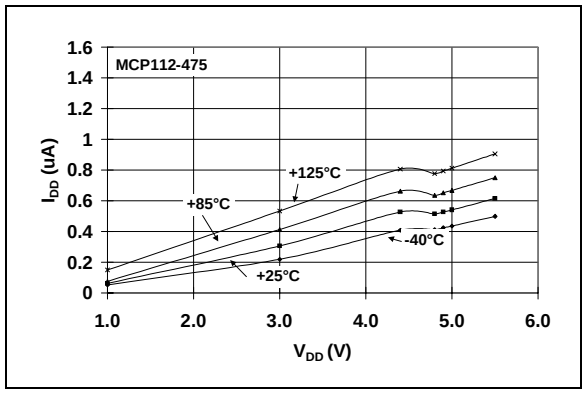


FIGURE 2-6: *I_{DD} vs. V_{DD} (**MCP112-475**).*

Note: Unless otherwise indicated, all limits are specified for V_{DD} = 1V to 5.5V, R_{PU} = 100 kΩ (only **MCP111**; see **Figure 4-1**), T_A = –40°C to +125°C.

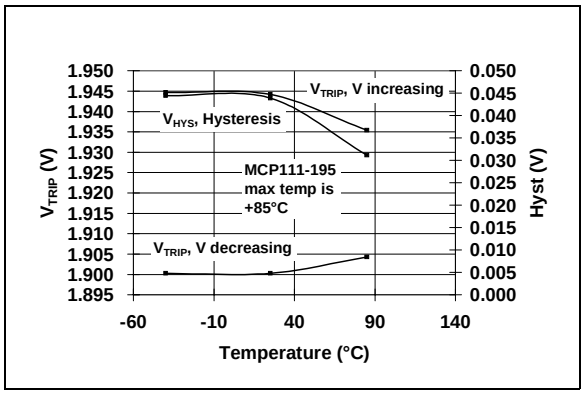


FIGURE 2-7: *V_{TRIP} and V_{HYST} vs. Temperature (**MCP111-195**).*

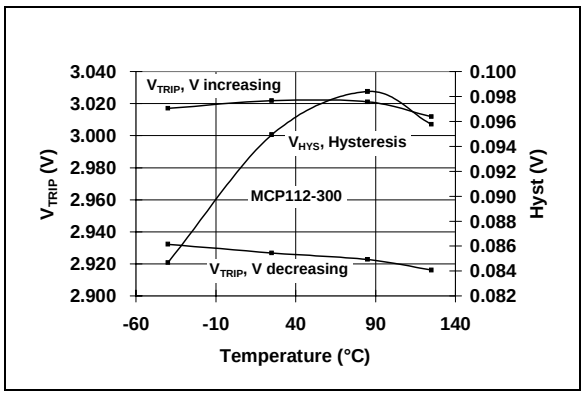


FIGURE 2-8: *V_{TRIP} and V_{HYST} vs. Temperature (**MCP112-300**).*

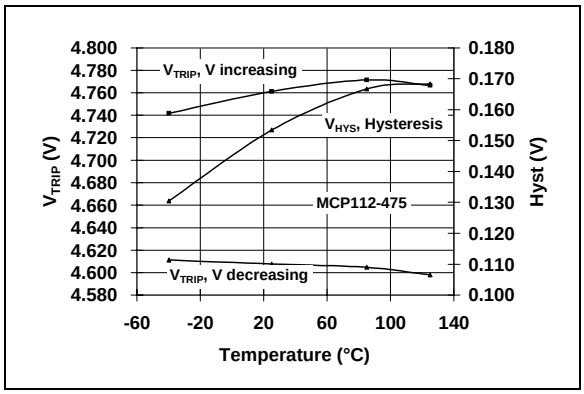


FIGURE 2-9: *V_{TRIP} and V_{HYST} vs. Temperature (**MCP112-475**).*

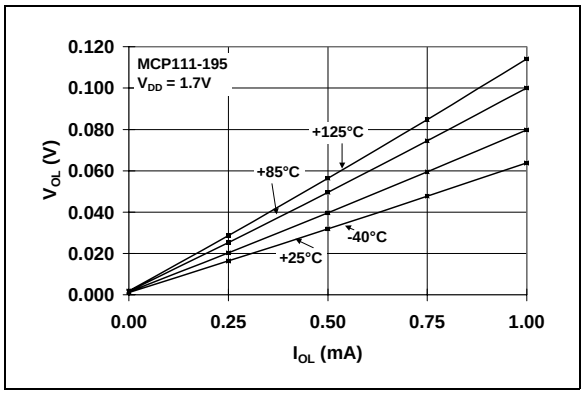


FIGURE 2-10: *V_{OL} vs. I_{OL} (**MCP111-195** @ V_{DD} = 1.7V).*

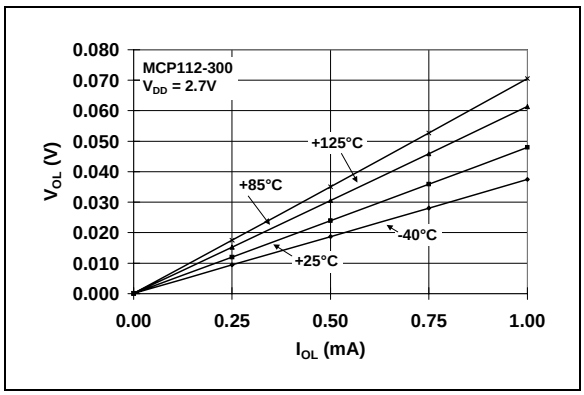


FIGURE 2-11: *V_{OL} vs. I_{OL} (**MCP112-300** @ V_{DD} = 2.7V).*

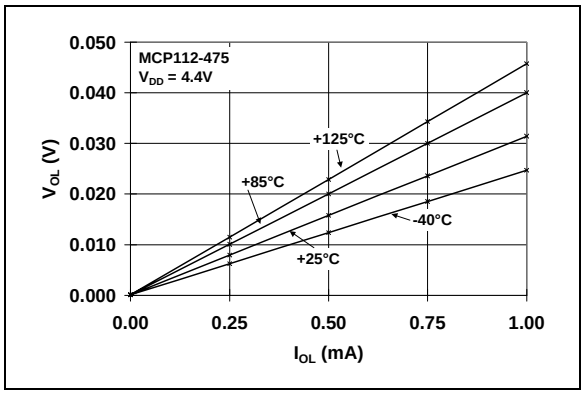


FIGURE 2-12: *V_{OL} vs. I_{OL} (**MCP112-475** @ V_{DD} = 4.4V).*

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Note: Unless otherwise indicated, all limits are specified for V_{DD} = 1V to 5.5V, R_{PU} = 100 kΩ (**only MCP111**; see **Figure 4-1**), T_A = –40°C to +125°C.

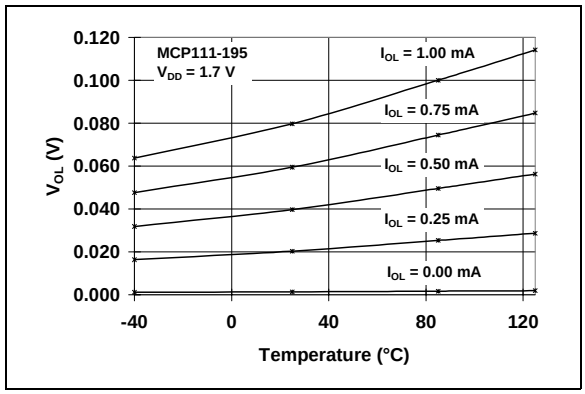


FIGURE 2-13: *V_{OL} vs. Temperature (**MCP111-195** @ V_{DD} = 1.7V).*

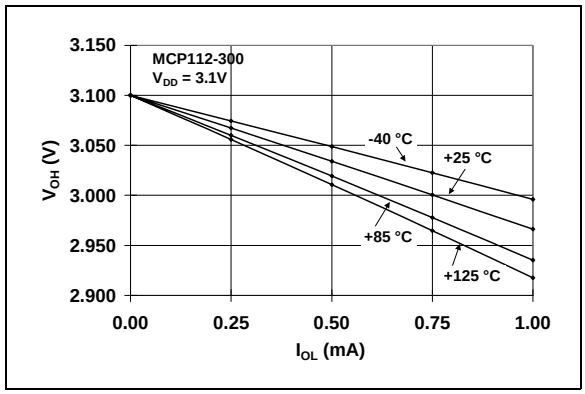


FIGURE 2-16: *V_{OH} vs. I_{OH} (**MCP112-300** @ V_{DD} = 3.1V).*

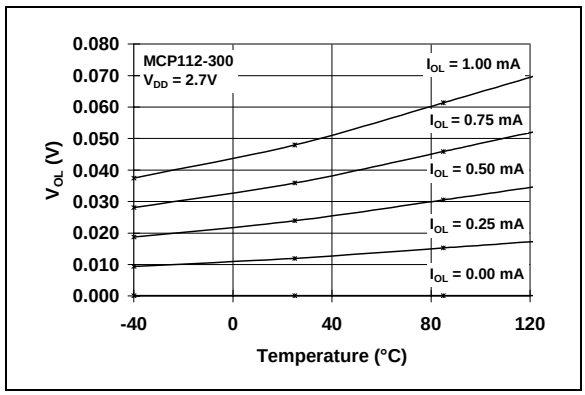


FIGURE 2-14: *V_{OL} vs. Temperature (**MCP112-300** @ V_{DD} = 2.7V).*

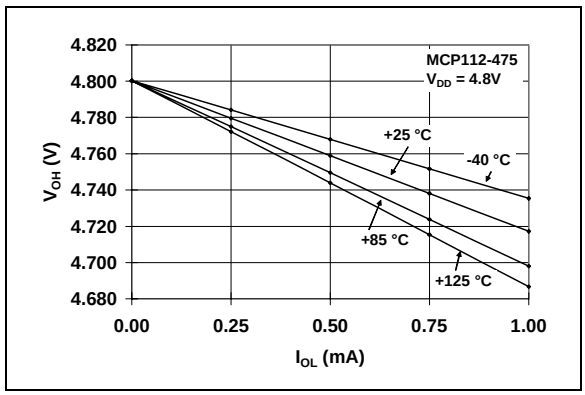


FIGURE 2-17: *V_{OH} vs. I_{OH} (**MCP112-475** @ V_{DD} = 4.8V).*

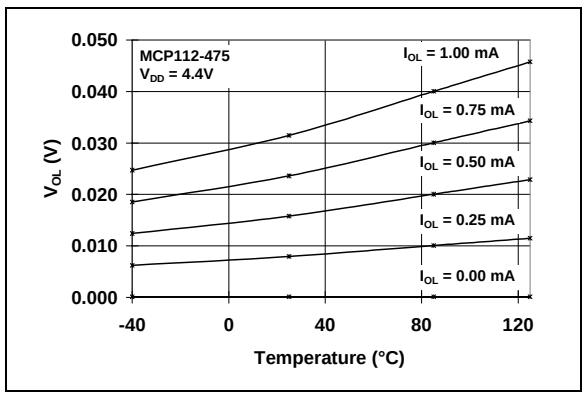


FIGURE 2-15: *V_{OL} vs. Temperature (**MCP112-475** @ V_{DD} = 4.4V).*

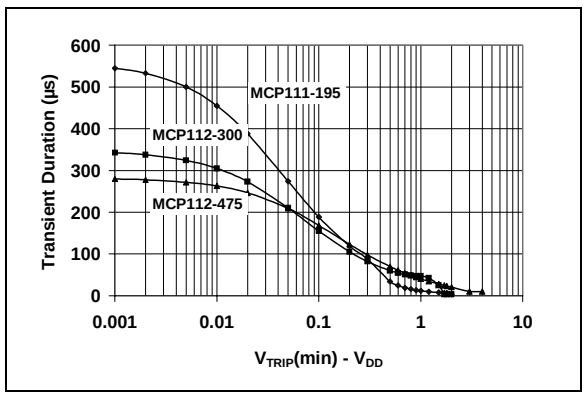


FIGURE 2-18: *Typical Transient Response (25 °C).*

Note: Unless otherwise indicated, all limits are specified for V_{DD} = 1V to 5.5V, R_{PU} = 100 kΩ (**only MCP111**; see **Figure 4-1**), T_A = –40°C to +125°C.

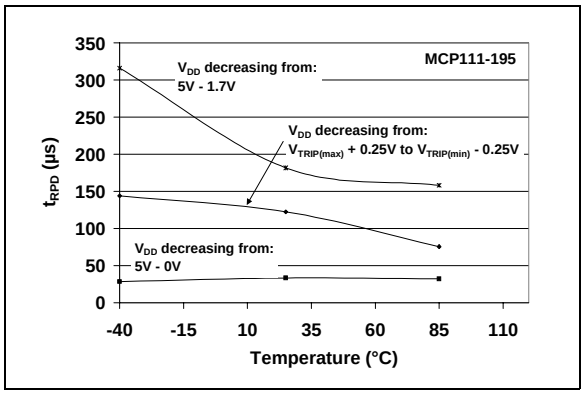


FIGURE 2-19: *t_{RPD} vs. Temperature (**MCP111-195**).*

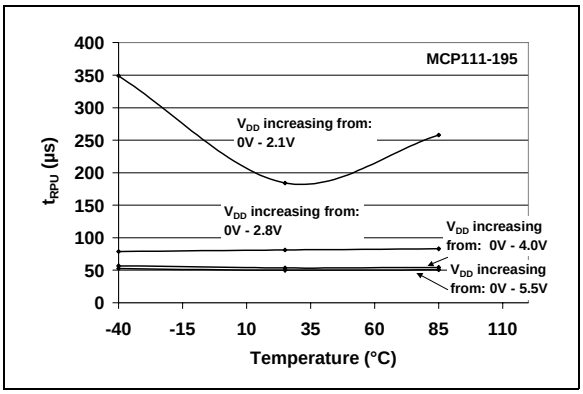


FIGURE 2-22: *t_{RPU} vs. Temperature (**MCP111-195**).*

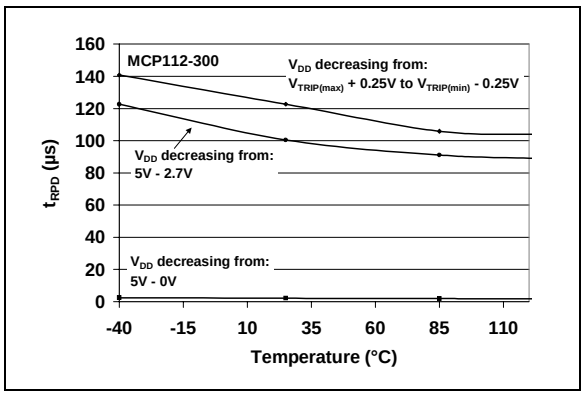


FIGURE 2-20: *t_{RPD} vs. Temperature (**MCP112-300**).*

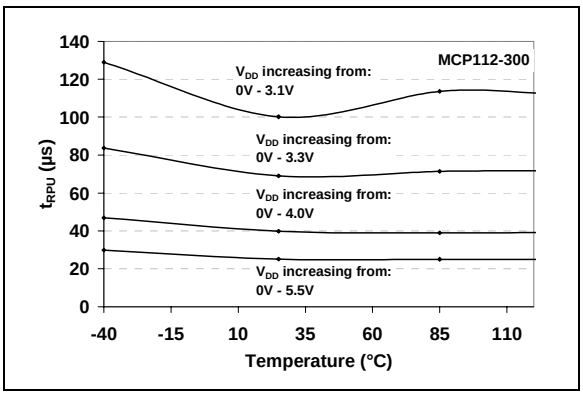


FIGURE 2-23: *t_{RPU} vs. Temperature (**MCP112-300**).*

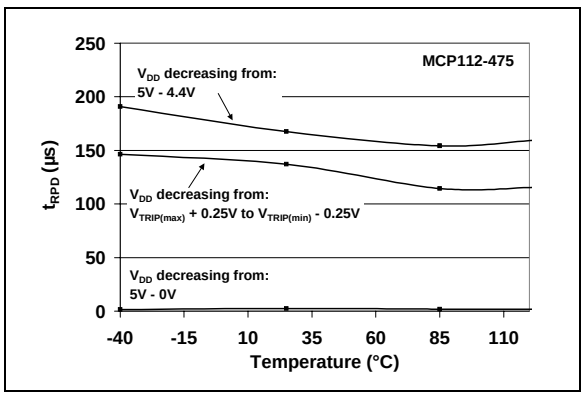


FIGURE 2-21: *t_{RPD} vs. Temperature (**MCP112-475**).*

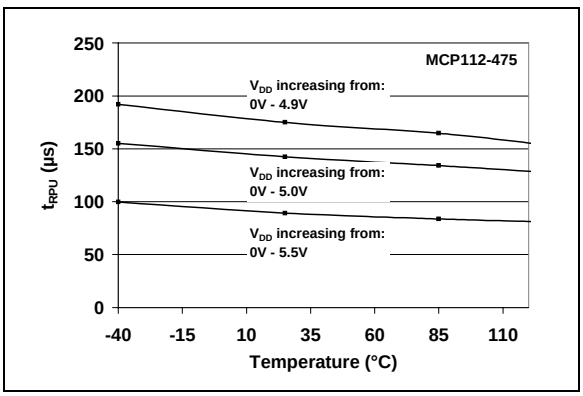


FIGURE 2-24: *t_{RPU} vs. Temperature (**MCP112-475**).*

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Note: Unless otherwise indicated, all limits are specified for V_{DD} = 1V to 5.5V, R_{PU} = 100 kΩ (**only MCP111**; see **Figure 4-1**), T_A = –40°C to +125°C.

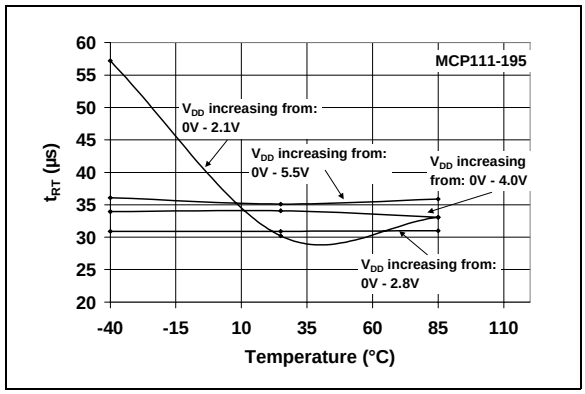


FIGURE 2-25: *t_{RT} vs. Temperature (**MCP111-195**).*

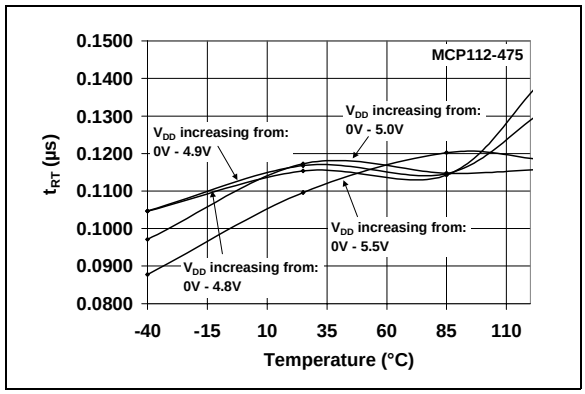


FIGURE 2-27: *t_{RT} vs. Temperature (**MCP112-475**).*

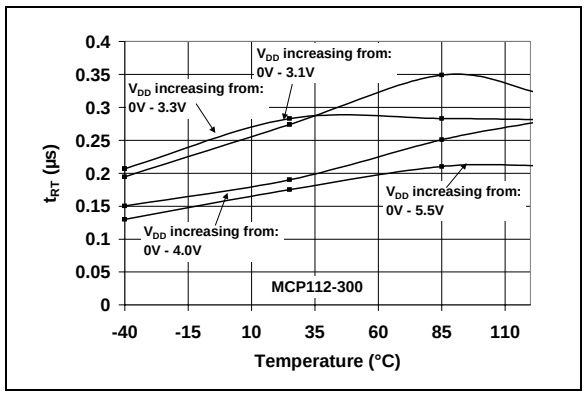


FIGURE 2-26: *t_{RT} vs. Temperature (**MCP112-300**).*

3.0 PIN DESCRIPTION

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

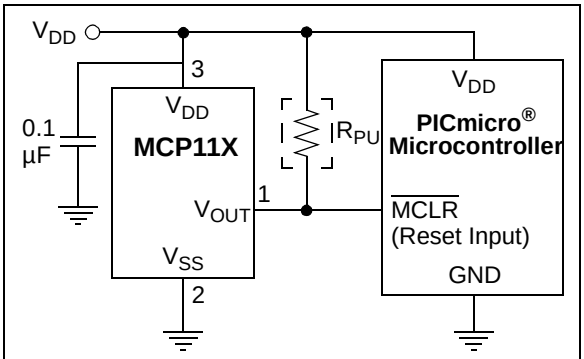
TABLE 3-1: PIN FUNCTION TABLE

Pin No.		Symbol	Function
SOT23-3 SC-70	T0-92		
1	1	V_{OUT}	**Output State** **V_{DD} Falling:** H = $V_{DD} > V_{TRIP}$ L = $V_{DD} < V_{TRIP}$ **V_{DD} Rising:** H = $V_{DD} > V_{TRIP} + V_{HYS}$ L = $V_{DD} < V_{TRIP} + V_{HYS}$
2	3	V_{SS}	Ground reference
3	2	V_{DD}	Positive power supply

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4.0 APPLICATION INFORMATION

For many of today's microcontroller applications, care must be taken to prevent low-power conditions that can cause many different system problems. The most common causes are brown-out conditions, where the system supply drops below the operating level momentarily. The second most common cause is when a slowly decaying power supply causes the microcontroller to begin executing instructions without sufficient voltage to sustain SRAM, thus producing indeterminate results. Figure 4-1 shows a typical application circuit.



Note 1: R_{PU} may be required with the MCP111 due to the open-drain output. Resistor R_{PU} is not required with the MCP112.

FIGURE 4-1: *Typical Application Circuit.*

4.1 V_{TRIP} Operation

The voltage trip point (V_{TRIP}) is determined on the falling edge of V_{DD}. The actual voltage trip point (V_{TRIPAC}) will be between the minimum trip point ($V_{TRIPMIN}$) and the maximum trip point ($V_{TRIPMAX}$). There is a hysteresis on this trip point to remove any "jitter" that would occur on the V_{OUT} pin when the device V_{DD} is at the trip point.

Figure 4-2 shows the state of the V_{OUT} pin as determined by the V_{DD} voltage. The V_{TRIP} specification is for falling V_{DD} voltages. When the V_{DD} voltage is rising, the V_{OUT} pin will not be driven high until V_{DD} is at V_{TRIP} + V_{HYS}.

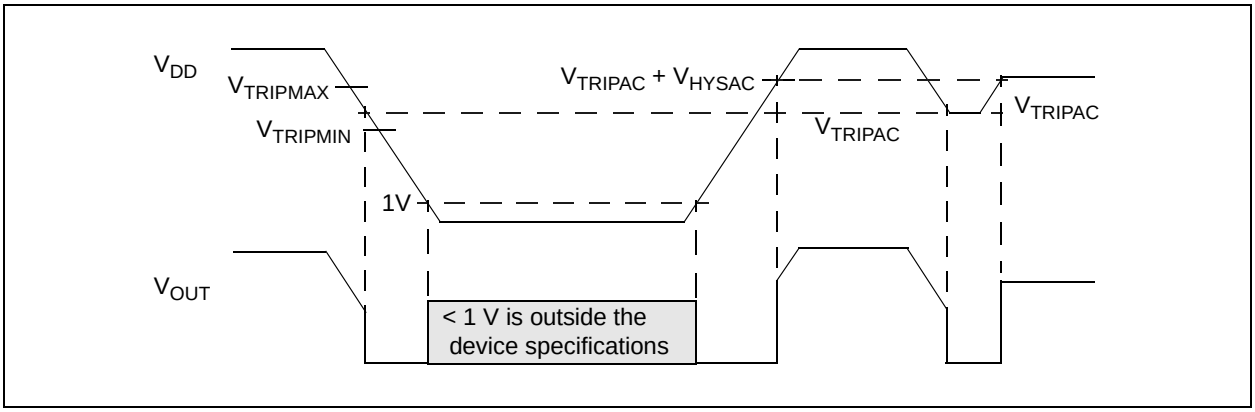


FIGURE 4-2: *V_{OUT} Operation as Determined by the V_{TRIP} and V_{HYS}.*

4.2 Negative Going V_{DD} Transients

The minimum pulse width (time) required to cause a reset may be an important criteria in the implementation of a POR circuit. This time is referred to as transient duration and is the amount of time needed for these supervisory devices to respond to a drop in V_{DD}. The transient duration time is dependant on the magnitude of $V_{TRIP} – V_{DD}$. Generally speaking, the transient duration decreases with increases in $V_{TRIP} – V_{DD}$.

Figure 4-3 shows a typical transient duration vs. reset comparator overdrive for which the MCP111/112 will not generate a reset pulse. It shows that the farther below the trip point the transient pulse goes, the duration of the pulse required to cause a reset gets shorter. Figure 2-18 shows the transient response characteristics for the MCP111/112.

A 0.1 µF bypass cap mounted as close as possible to the V_{DD} pin provides additional transient immunity (refer to Figure 4-1).

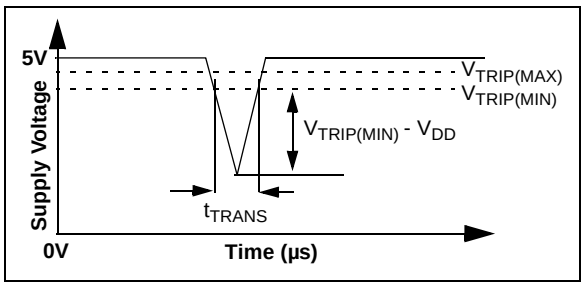


FIGURE 4-3: *Example of Typical Transient Duration Waveform.*

4.3 Effect of Temperature on Time-out Period (t_{RPU})

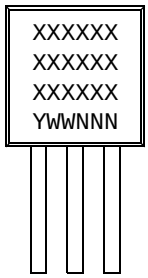
The time-out period (t_{RPU}) determines how long the device remains in the reset condition. This is affected by both V_{DD} and temperature. The graph shown in Figures 2-22, 2-23 and 2-24 show the typical response for different V_{DD} values and temperatures.

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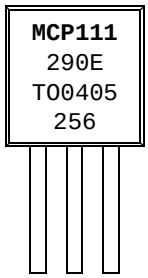
5.0 PACKAGING INFORMATION

5.1 Package Marking Information

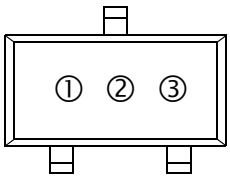
3-Lead TO-92



Example:



3-Pin SC-70

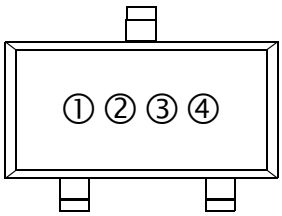


Top Side

Example:

Part Number	SC-70	Part Number	SC-70
MCP111T-195I/LB	EPN	**MCP112T-195I/LB**	ERN
MCP111T-240E/LB	EQN	**MCP112T-240E/LB**	ESN
MCP111T-270E/LB	EGN	**MCP112T-270E/LB**	EAN
MCP111T-290E/LB	EHN	**MCP112T-290E/LB**	EBN
MCP111T-300E/LB	EJN	**MCP112T-300E/LB**	ECN
MCP111T-315E/LB	EKN	**MCP112T-315E/LB**	EDN
MCP111T-450E/LB	ELN	**MCP112T-450E/LB**	EEN
MCP111T-475E/LB	EMN	**MCP112T-475E/LB**	EFN

3-Pin SOT-23B



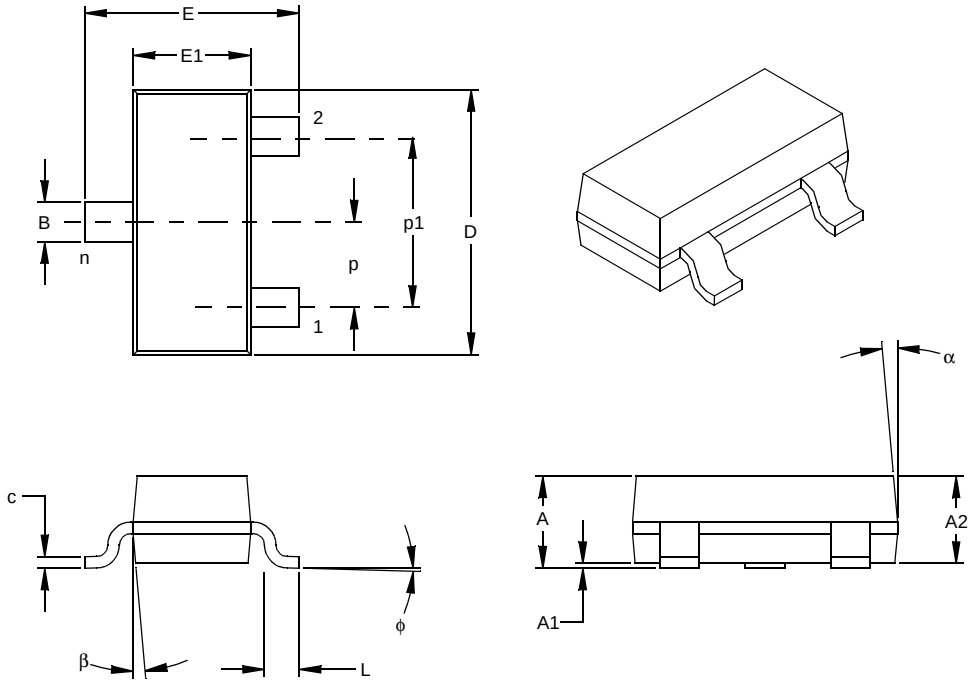
Example:

Part Number	SOT-23	Part Number	SOT-23
MCP111T-195I/TT	MPNN	**MCP112T-195I/TT**	MRNN
MCP111T-240ETT	MQNN	**MCP112T-240ETT**	MSNN
MCP111T-270E/TT	MGNN	**MCP112T-270E/TT**	MANN
MCP111T-290E/TT	NHNN	**MCP112T-290E/TT**	MBNN
MCP111T-300E/TT	MJNN	**MCP112T-300E/TT**	MCNN
MCP111T-315E/TT	MKNN	**MCP112T-315E/TT**	MDNN
MCP111T-450E/TT	MLNN	**MCP112T-450E/TT**	MENN
MCP111T-475E/TT	MMNN	**MCP112T-475E/TT**	MFNN

Legend:	1	Part Number + temperature range and voltage (two-digit code)
	2	Part Number + temperature range and voltage (two-digit code)
	3	Lot ID number
	4	Year and work week

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.

3-Lead Plastic Small Outline Transistor (TT) (SOT-23)



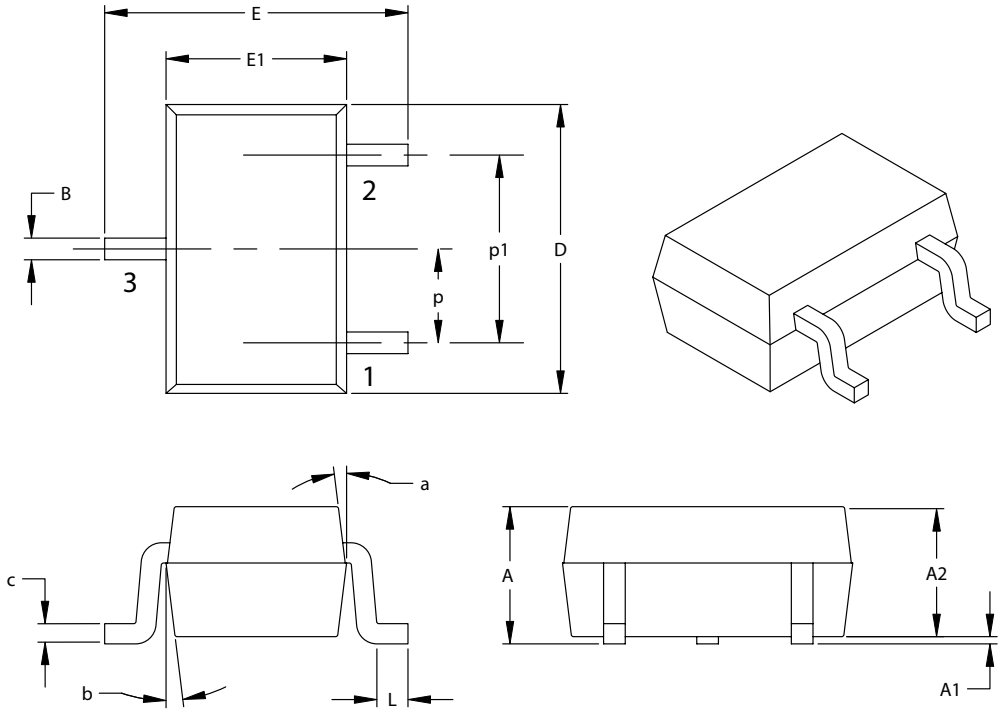
Units		INCHES*			MILLIMETERS		
Dimension Limits		MIN	NOM	MAX	MIN	NOM	MAX
Number of Pins	n		3			3	
Pitch	p		.038			0.96	
Outside lead pitch (basic)	p1		.076			1.92	
Overall Height	A	.035	.040	.044	0.89	1.01	1.12
Molded Package Thickness	A2	.035	.037	.040	0.88	0.95	1.02
Standoff §	A1	.000	.002	.004	0.01	0.06	0.10
Overall Width	E	.083	.093	.104	2.10	2.37	2.64
Molded Package Width	E1	.047	.051	.055	1.20	1.30	1.40
Overall Length	D	.110	.115	.120	2.80	2.92	3.04
Foot Length	L	.014	.018	.022	0.35	0.45	0.55
Foot Angle	ϕ	0	5	10	0	5	10
Lead Thickness	c	.004	.006	.007	0.09	0.14	0.18
Lead Width	B	.015	.017	.020	0.37	0.44	0.51
Mold Draft Angle Top	α	0	5	10	0	5	10
Mold Draft Angle Bottom	β	0	5	10	0	5	10

* Controlling Parameter
§ Significant Characteristic

Notes:
Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .010” (0.254mm) per side.
JEDEC Equivalent: TO-236
Drawing No. C04-104

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3-Lead Plastic Small Outline Transistor (LB) (SC-70)



Units		INCHES		MILLIMETERS*	
Dimension Limits		MIN	MAX	MIN	MAX
Number of Pins		3		3	
Pitch	p	.026 BSC.		0.65 BSC.	
Outside lead pitch (basic)	p1	.051 BSC.		1.30 BSC.	
Overall Height	A	.031	.043	0.80	1.10
Molded Package Thickness	A2	.031	.039	0.80	1.00
Standoff	A1	.000	.0004	0.00	.010
Overall Width	E	.071	.094	1.80	2.40
Molded Package Width	E1	.045	.053	1.15	1.35
Overall Length	D	.071	.089	1.80	2.25
Foot Length	L	.004	.016	0.10	0.41
Lead Thickness	c	.003	.010	0.08	0.25
Lead Width	B	.006	.016	0.15	0.40
Mold Draft Angle Top	a	8°	12°	8°	12°
Mold Draft Angle Bottom	b	8°	12°	8°	12°

*Controlling Parameter

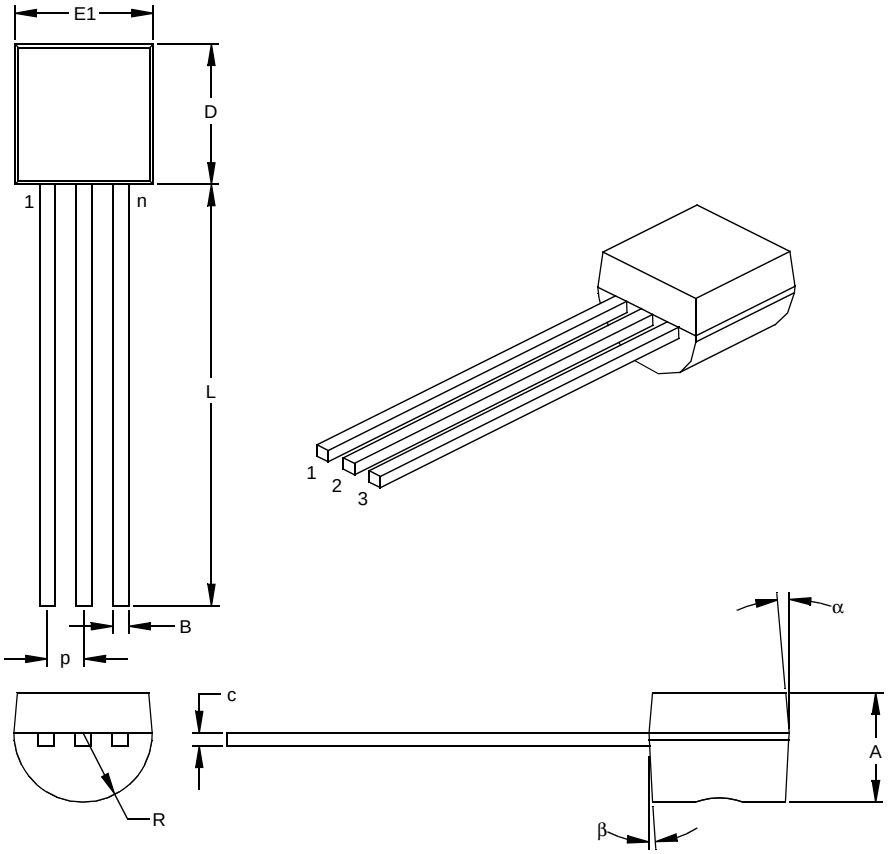
Notes:

Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .005" (0.127mm) per side.

JEITA (EIAJ) Equivalent: SC70

Drawing No. C04-104

3-Lead Plastic Transistor Outline (TO) (TO-92)



Units		INCHES*			MILLIMETERS		
Dimension Limits		MIN	NOM	MAX	MIN	NOM	MAX
Number of Pins	n		3			3	
Pitch	p		.050			1.27	
Bottom to Package Flat	A	.130	.143	.155	3.30	3.62	3.94
Overall Width	E1	.175	.186	.195	4.45	4.71	4.95
Overall Length	D	.170	.183	.195	4.32	4.64	4.95
Molded Package Radius	R	.085	.090	.095	2.16	2.29	2.41
Tip to Seating Plane	L	.500	.555	.610	12.70	14.10	15.49
Lead Thickness	c	.014	.017	.020	0.36	0.43	0.51
Lead Width	B	.016	.019	.022	0.41	0.48	0.56
Mold Draft Angle Top	α	4	5	6	4	5	6
Mold Draft Angle Bottom	β	2	3	4	2	3	4

*Controlling Parameter
Notes:
Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .010” (0.254mm) per side.
JEDEC Equivalent: TO-92
Drawing No. C04-101

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5.2 Product Tape and Reel Specifications

FIGURE 5-1: EMBOSSED CARRIER DIMENSIONS (8, 12, 16 AND 24 MM TAPE ONLY)

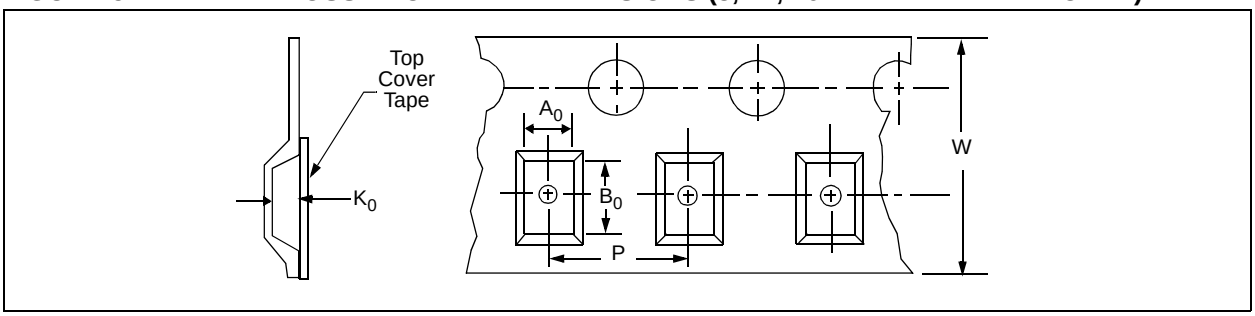


TABLE 1: CARRIER TAPE/CAVITY DIMENSIONS

Case Outline	Package Type		Carrier Dimensions		Cavity Dimensions			Output Quantity Units	Reel Diameter in mm
			W mm	P mm	A0 mm	B0 mm	K0 mm		
TT	SOT-23B	3L	8	4	3.15	2.77	1.22	3000	180
LB	SC-70	3L	8	4	2.4	2.4	1.19	3000	180

FIGURE 5-2: 3-LEAD SOT-23/SC70 DEVICE TAPE AND REEL SPECIFICATIONS

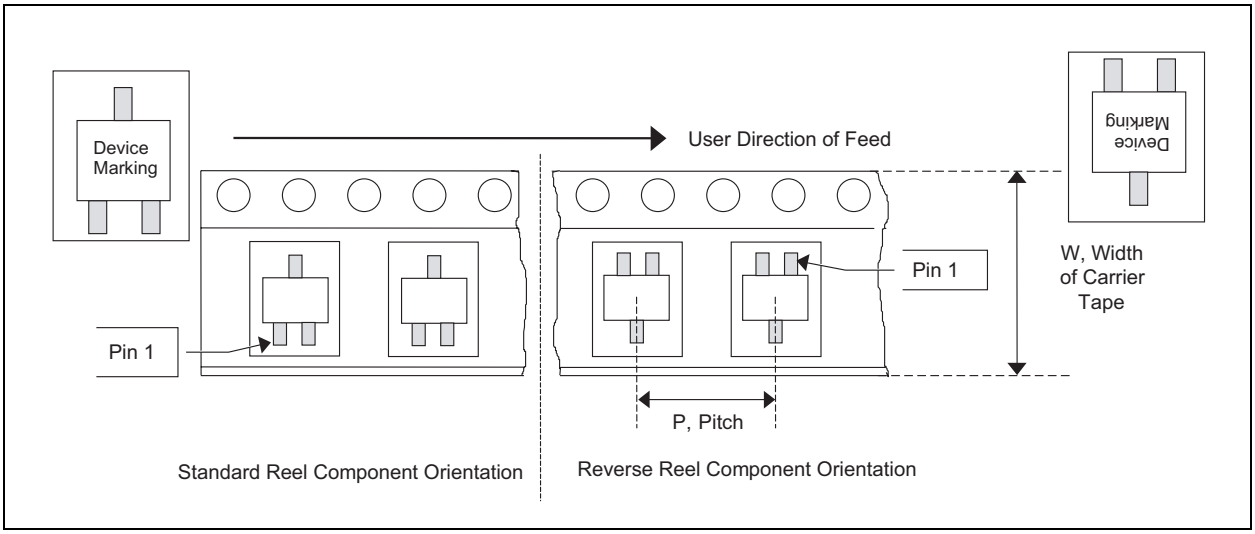
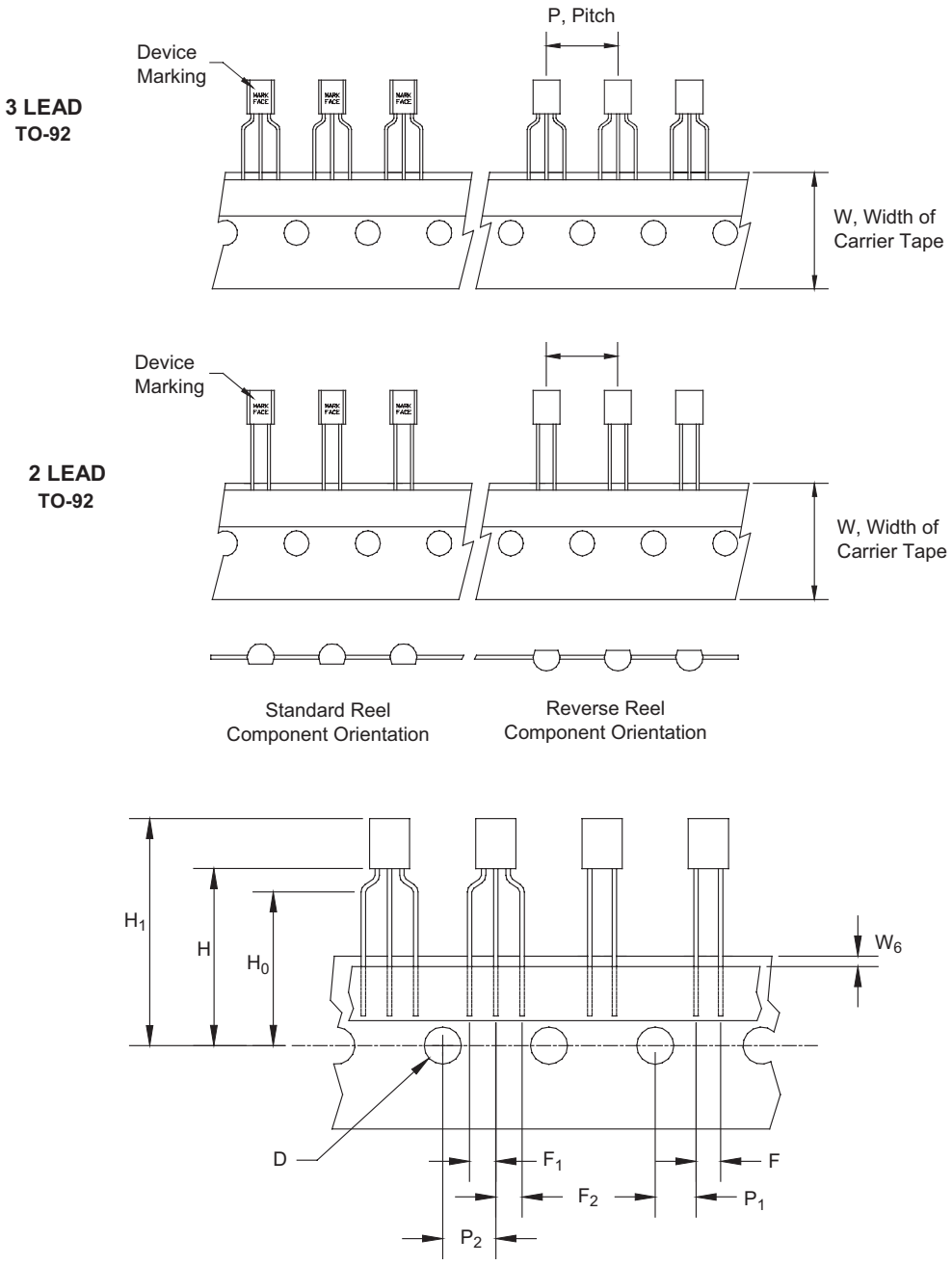


FIGURE 5-3: TO-92 DEVICES



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PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, refer to the factory or the listed sales office.

PART NO.	X	XXX	X	XX
Device	Tape/Reel Option	Monitoring Options	Temperature Range	Package

Device:	MCP111:	MicroPower Voltage Detector, open-drain
	MCP111T:	MicroPower Voltage Detector, open-drain (Tape and Reel)
	MCP112:	MicroPower Voltage Detector, push-pull
	MCP112T:	MicroPower Voltage Detector, push-pull (Tape and Reel)
Monitoring Options:	195 =	1.90V
	240 =	2.32V
	270 =	2.63V
	290 =	2.90V
	300 =	2.93V
	315 =	3.08V
	450 =	4.38V
	475 =	4.63V
Temperature Range:	I =	-40°C to +85°C (MCP11X-195 only)
	E =	-40°C to +125°C (Except MCP11X-195 only)
Package:	TT =	SOT-23B, 3-lead
	LB =	SC-70, 3-lead
	TO =	TO-92, 3-lead

Examples:

a) MCP111T-195I/TT: Tape and Reel, 1.95V option, open-drain, -40°C to +85°C, SOT-23B package.

b) MCP111T-315E/LB: Tape and Reel, 3.15V option, open-drain, -40°C to +125°C, SC-70-3 package.

c) MCP111-300E/TO: 3.00V option, open-drain, -40°C to +125°C, TO-92-3 package.

a) MCP112T-290E/TT: Tape and Reel, 2.90V option, push-pull, -40°C to +125°C, SOT-23B-3 package.

b) MCP112T-475E/LB: Tape and Reel, 4.75V option, push-pull, -40°C to +125°C, SC-70-3 package.

c) MCP112-450E/TO: 4.5V option, push-pull, -40°C to +125°C, TO-92-3 package.

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