

### DESCRIPTION

The MP6400 family is the microprocessor ( $\mu$ P) supervisory circuit which can monitor and provide reset function for system voltages from 0.4V. When either the SENSE voltage falls below its threshold ( $V_{IT}$ ) or the voltage of manual reset ( $\overline{MR}$ ) is pulled to a logic low, the  $\overline{RESET}$  signal will be asserted. The reset voltage can be factory-set for standard voltage rails from 0.9V to 5V, while the MP6400DG(J)-01 reset voltage is adjustable with an external resistor divider. When SENSE voltage and  $\overline{MR}$  exceed their thresholds,  $\overline{RESET}$  is driven to a logic high after a user-programmable delay time.

The MP6400 has a very low quiescent current of 1.6 $\mu$ A typically, which makes it ideal suitable for battery-powered applications. It provides a precision reference to achieve  $\pm 1\%$  threshold accuracy. The reset delay time can be selected by a capacitor which is connected between  $C_{DELAY}$  and GND, allowing the user to select any delay time from 2.1ms to 10s. 380ms delay time is selected by connecting the  $C_{DELAY}$  pin to  $V_{CC}$ , while 24ms delay time by leaving the  $C_{DELAY}$  pin float. MP6400 is available in TSOT23 and 2mm $\times$ 2mm 6-pin QFN packages.

### FEATURES

- Fixed Threshold Voltages for Standard Voltage Rails From 0.9V to 5V and Adjustable Voltage From 0.4V are Available
- Low Quiescent Current: 1.6 $\mu$ A typ
- Power-On Reset Generator with Adjustable Delay Time: 2.1ms to 10s
- High Threshold Accuracy:  $\pm 1\%$  typ
- Manual Reset ( $\overline{MR}$ ) Input
- Open-Drain  $\overline{RESET}$  Output
- Immune to Short Negative SENSE voltage
- Guaranteed Reset Valid to  $V_{CC}=0.8V$
- 6 Pin TSOT23 and 2mm $\times$ 2mm QFN

### APPLICATIONS

- DSP or Micro controller Applications
- Laptop/Desktop Computers
- PDAs/Hand-Held Products
- Portable/Battery-Powered Products
- FPGA/ASIC Applications

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### TYPICAL APPLICATION



### ORDERING INFORMATION

Part Number*	Package	Top Marking	Free Air Temperature (T <sub>A</sub> )
MP6400DG-01	QFN6 (2x2mm)	5B	-40°C to +85°C
MP6400DG-09		AD	
MP6400DG-12		AC	
MP6400DG-15		Contact Factory	
MP6400DG-25		4V	
MP6400DG-30		Contact Factory	
MP6400DG-33		9R	
MP6400DJ-01		TSOT23-6	
MP6400DJ-09	AAG		
MP6400DJ-12	Contact Factory		
MP6400DJ-15	Contact Factory		
MP6400DJ-25	4V		
MP6400DJ-30	Contact Factory		
MP6400DJ-33	3S		

\*For Tape & Reel, add suffix -Z (e.g. MP6400DG-XX-Z);

For RoHS compliant packaging, add suffix -LF (e.g. MP6400DG-XX-LF-Z).

\* For other versions, contact factory for availability.

### PACKAGE REFERENCE



**ABSOLUTE MAXIMUM RATINGS** <sup>(1)</sup>

Supply Voltage $V_{CC}$ .....	-0.3 to 6.5 V
$C_{DELAY}$ Voltage $V_{CDELAY}$ .....	-0.3V to $V_{CC} + 0.3V$
SENSE Voltage $V_{SENSE}$ .....	-0.3V to 6V
All Other Pins .....	-0.3V to +6.5V
RESET Current $I_{RESET}$ .....	5mA
Continuous Power Dissipation ( $T_A = +25^{\circ}C$ ) <sup>(2)</sup>	
QFN6 (2mmx2mm) .....	2.5W
TSOT23-6 .....	0.57W
Junction Temperature .....	150°C
Lead Temperature .....	260°C
Storage Temperature.....	-65°C to +150°C

**Recommended Operating Conditions** <sup>(3)</sup>

Supply Voltage $V_{CC}$ .....	1.8V to 6V
Operating Junct. Temp ( $T_J$ ).....	-40°C to +125°C

**Thermal Resistance** <sup>(4)</sup>

	$\theta_{JA}$	$\theta_{JC}$
QFN6 (2mmx2mm) .....	50	12 ... °C/W
TSOT23-6 .....	220	110 .. °C/W

**Notes:**

- 1) Exceeding these ratings may damage the device.
- 2) The maximum allowable power dissipation is a function of the maximum junction temperature  $T_J(MAX)$ , the junction-to-ambient thermal resistance  $\theta_{JA}$ , and the ambient temperature  $T_A$ . The maximum allowable continuous power dissipation at any ambient temperature is calculated by  $P_D(MAX)=(T_J(MAX)-T_A)/\theta_{JA}$ . Exceeding the maximum allowable power dissipation will cause excessive die temperature, and the regulator will go into thermal shutdown. Internal thermal shutdown circuitry protects the device from permanent damage.
- 3) The device is not guaranteed to function outside of its operating conditions.
- 4) Measured on JESD51-7 4-layer board.

## ELECTRICAL CHARACTERISTICS

1.8V ≤ V<sub>CC</sub> ≤ 6V, R<sub>3</sub> = 100kΩ, C<sub>3</sub> = 47pF, T<sub>A</sub> = -40°C to +85°C, Typical values are at T<sub>A</sub> = +25°C, unless otherwise noted.

Parameters	Symbol	Condition	Min	Typ	Max	Units
Input Supply Range	V <sub>CC</sub>		1.8		6	V
Supply Current (current into V <sub>CC</sub> pin)	I <sub>CC</sub>	V <sub>CC</sub> = 3.3V, $\overline{\text{RESET}}$ not asserted. $\overline{\text{MR}}$ , $\overline{\text{RESET}}$ , C <sub>DELAY</sub> open		1.6	3.5	μA
		V <sub>CC</sub> = 6V, $\overline{\text{RESET}}$ not asserted. $\overline{\text{MR}}$ , $\overline{\text{RESET}}$ , C <sub>DELAY</sub> open		1.85	12	μA
Low-level Output Voltage	V <sub>OL</sub>	1.3V ≤ V <sub>CC</sub> < 1.8V, I <sub>OL</sub> = 0.4mA			0.3	V
		1.8V ≤ V <sub>CC</sub> ≤ 6V, I <sub>OL</sub> = 1.0mA			0.4	V
Power-up Reset Voltage <sup>(5)</sup>		V <sub>OL</sub> (max) = 0.2V, I <sub>RESET</sub> = 15μA, T <sub>rise(V<sub>CC</sub>)</sub> ≥ 15μs/V			0.8	V
Negative-going Input Threshold Accuracy	V <sub>IT</sub>	V <sub>SENSE</sub> falling slowly		±1.0	±2.0	%
Hysteresis on V <sub>IT</sub> Pin	V <sub>HYS</sub>			1.5	3.5	V <sub>IT</sub> %
$\overline{\text{MR}}$ Internal Pull-up Resistance	R <sub>MR</sub>		50	110		kΩ
Input Current at SENSE Pin	I <sub>SENSE</sub>	MP6400DJ-01 V <sub>SENSE</sub> = V <sub>IT</sub>	-25		+25	nA
		Fixed versions V <sub>SENSE</sub> = 6V		2.4		μA
$\overline{\text{RESET}}$ Leakage Current		V <sub>RESET</sub> = 6V, $\overline{\text{RESET}}$ not asserted			300	nA
$\overline{\text{MR}}$ Logic Low Input	V <sub>IL</sub>				0.25V <sub>CC</sub>	V
$\overline{\text{MR}}$ Logic High Input	V <sub>IH</sub>		0.7V <sub>CC</sub>			V
SENSE Maximum Transient Duration	t <sub>w</sub>	V <sub>IH</sub> = 1.05 V <sub>IT</sub> , V <sub>IL</sub> = 0.95 V <sub>IT</sub>		17.5		μs
$\overline{\text{RESET}}$ Delay Time	t <sub>d</sub>	C <sub>DELAY</sub> = Open	15	24	34	ms
		C <sub>DELAY</sub> = V <sub>CC</sub> <sup>(6)</sup>	230	380	530	ms
		C <sub>DELAY</sub> = 150pF	1.3	2.1	3	ms
		C <sub>DELAY</sub> = 10nF <sup>(6)</sup>	61	102	142	ms
$\overline{\text{MR}}$ to $\overline{\text{RESET}}$ Propagation Delay	t <sub>pHL1</sub>	V <sub>IH</sub> = 0.7 V <sub>CC</sub> , V <sub>IL</sub> = 0.25 V <sub>CC</sub>		160		ns
High to Low Level $\overline{\text{RESET}}$ Delay, SENSE to $\overline{\text{RESET}}$	t <sub>pHL2</sub>	V <sub>IH</sub> = 1.05 V <sub>IT</sub> , V <sub>IL</sub> = 0.95 V <sub>IT</sub>		17.5		μs

**Note:**

5) The lowest supply voltage (V<sub>CC</sub>) at which  $\overline{\text{RESET}}$  becomes active.

6) Guaranteed by design.

**STANDARD VERSIONS** <sup>(7)</sup>

Product	Package	Top Mark	Nominal Supply Voltage	Threshold Voltage (VIT)
MP6400DG-01	QFN	5B	Adjustable	0.4V
MP6400DJ-01	TSOT23	4B		
MP6400DG-09	QFN	AD	0.9V	0.84V
MP6400DJ-09	TSOT23	AAG		
MP6400DG-12	QFN	AC	1.2V	1.12V
MP6400DJ-12	TSOT23	Contact Factory		
MP6400DG-125	QFN	Contact Factory	1.25V	1.16V
MP6400DJ-125	TSOT23	Contact Factory		
MP6400DG-15	QFN	Contact Factory	1.5V	1.40V
MP6400DJ-15	TSOT23	Contact Factory		
MP6400DG-18	QFN	Contact Factory	1.8V	1.67V
MP6400DJ-18	TSOT23	Contact Factory		
MP6400DG-25	QFN	4V	2.5V	2.33V
MP6400DJ-25	TSOT23	4V		
MP6400DG-30	QFN	Contact Factory	3.0V	2.79V
MP6400DJ-30	TSOT23	Contact Factory		
MP6400DG-33	QFN	9R	3.3V	3.07V
MP6400DJ-33	TSOT23	3S		
MP6400DG-50	QFN	Contact Factory	5.0V	4.65V
MP6400DJ-50	TSOT23	Contact Factory		

**Note:**

7) In "MP6400DG(J)-\_\_", the "\_\_" are placeholders for the monitored voltage levels of the devices. Desired monitored voltages are set by the suffix found in ordering information.

## PIN FUNCTIONS

QFN Pin #	TSOT Pin #	Name	Description
6	1	$\overline{\text{RESET}}$	$\overline{\text{RESET}}$ is an open drain signal which will be asserted when the SENSE voltage drops below a preset threshold or when the manual reset ( $\overline{\text{MR}}$ ) pin drops to a logic low. The $\overline{\text{RESET}}$ delay time is programmable from 2.1ms to 10s by using external capacitors. A pull-up resistor bigger than 10k should be connected this pin to supply line, and the $\overline{\text{RESET}}$ outputting a higher voltage than $V_{\text{CC}}$ is allowable.
5	2	GND	Ground.
4	3	$\overline{\text{MR}}$	The manual reset ( $\overline{\text{MR}}$ ) can introduce another logic signal to control the $\overline{\text{RESET}}$ . It is internally connected to $V_{\text{CC}}$ through a 90k $\Omega$ resistor.
3	4	$C_{\text{DELAY}}$	Programmable reset delay time pin. When $C_{\text{DELAY}}$ connected to $V_{\text{CC}}$ through a resistor between 50k $\Omega$ and 200k $\Omega$ , a 380ms delay time is selected. When $C_{\text{DELAY}}$ floated, the delay time is 24ms. A capacitor bigger than 150pF connected $C_{\text{DELAY}}$ to GND could be used to get the user's programmable time from 2.1ms to 10s.
2	5	SENSE	SENSE pin is connected to the monitored system voltage. When the monitored voltage is below desired threshold, $\overline{\text{RESET}}$ is asserted.
1	6	$V_{\text{CC}}$	Supply voltage. A 0.1 $\mu\text{F}$ decoupling ceramic capacitor should be put close to this pin.

## DETAIL DESCRIPTION

The MP6400 product family asserts a  $\overline{\text{RESET}}$  signal when either the SENSE pin voltage is lower than  $V_{\text{IT}}$  or the manual reset ( $\overline{\text{MR}}$ ) is driven low. The MP6400 family can be monitored a fixed voltage from 0.9V to 5.0V, while the MP6400DG(J)-01 can monitor any voltage above 0.4V by adjusting the external resistor divider. After both the manual reset ( $\overline{\text{MR}}$ ) and SENSE voltages exceed their thresholds, the  $\overline{\text{RESET}}$

output remains asserted for a user's programmable delay time. Two fixed  $\overline{\text{RESET}}$  delay times are user-selectable: 380ms delay time by connecting the  $C_{\text{DELAY}}$  pin to  $V_{\text{CC}}$ , and 24ms delay time by leaving the  $C_{\text{DELAY}}$  pin float. Any delay time from 2.1ms to 10s could be gotten by connecting a capacitor between  $C_{\text{DELAY}}$  and GND. The wide monitor voltage and programmable reset delay time make MP6400 product family suitable for a broad array of applications.

## TYPICAL PERFORMANCE CHARACTERISTICS

$V_{CC}=3.3V$ ,  $R_3 = 100k\Omega$ ,  $C_3 = 47pF$ ,  $T_A= -40^{\circ}C$  to  $+85^{\circ}C$ , Typical values are at  $T_A=+25^{\circ}C$ , unless otherwise noted.

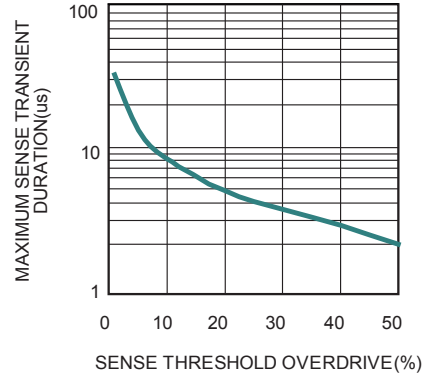
Supply Current vs.  $V_{CC}$



Reset Delay Time vs.  $C_{DELAY}$



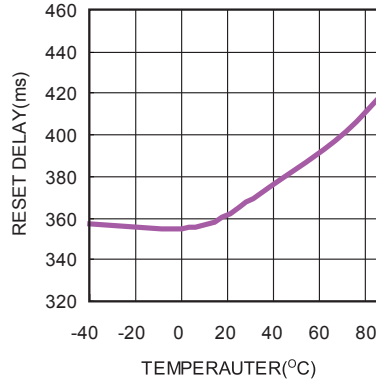
Maximum SENSE Transient Duration vs. SENSE Threshold Overdrive Voltage



Reset Delay vs. Temperature ( $C_{DELAY}=open$ )



Reset Delay vs. Temperature ( $C_{DELAY}=V_{CC}$ )



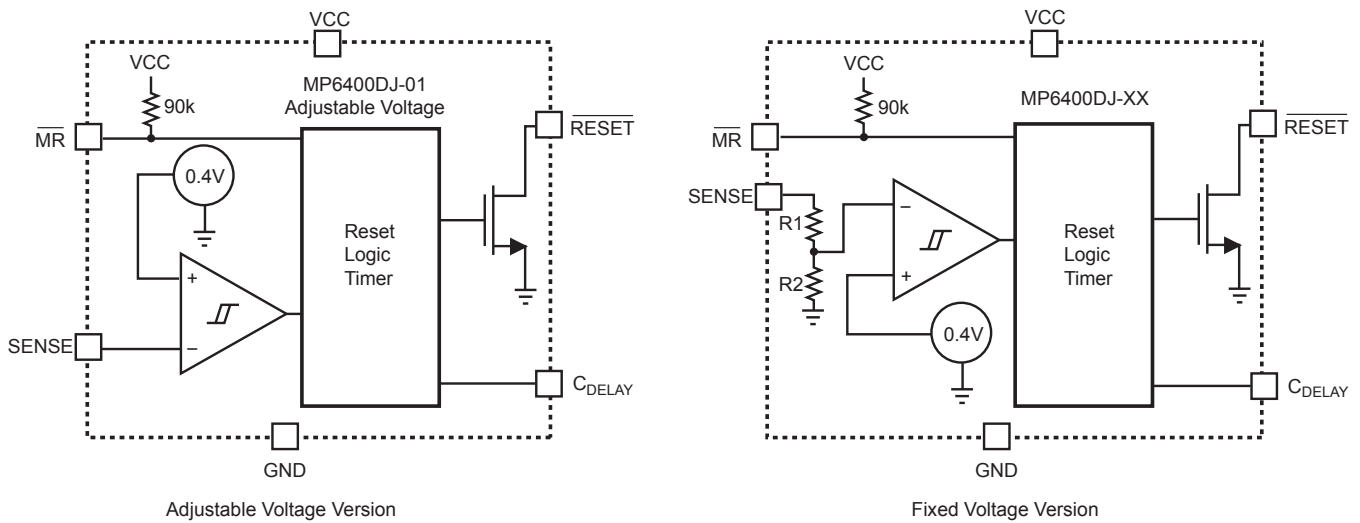
$V_{IT}$  vs. Temperature



$I_{RESET}$  vs. Low Level RESET Voltage



## FUNCTIONAL BLOCK DIAGRAM



**Figure 1—Functional Block Diagram**



**Figure 2—MP6400 Timing Diagram**

### TRUTH TABLE

$\overline{MR}$	$\text{SENSE} > V_{IT}$	$\overline{RESE}$
L	0	L
L	1	L
H	0	L
H	1	H



## APPLICATION INFORMATION

### Reset Output Function

The MP6400  $\overline{\text{RESET}}$  output is typically connected to the  $\overline{\text{RESET}}$  input of a microprocessor, as shown in Figure 3. When  $\overline{\text{RESET}}$  is not asserted, a pull up resistor must be connected to hold this signal high. The voltage of reset signal is allowed to be higher than  $V_{CC}$  (up to 6V) through a resistor pulling up from supply line. If the voltage is below 0.8V,  $\overline{\text{RESET}}$  output is undefined. This condition can be ignored generally because that most microprocessors do not function at this state. When both SENSE and  $\overline{\text{MR}}$  are higher than their threshold voltage,  $\overline{\text{RESET}}$  output holds logic high. Once either of the two drops below their threshold,  $\overline{\text{RESET}}$  will be asserted.



**Figure 3—Typical Application of MP6400 with Microprocessor**

From the point that  $\overline{\text{MR}}$  is again logic high and SENSE is above  $V_{IT} + V_{HYS}$  (the threshold hysteresis),  $\overline{\text{RESET}}$  will be driven to a logic high after a reset delay time. The reset delay time is programmable by  $C_{DELAY}$  pin. Due to the finite impedance of  $\overline{\text{RESET}}$  pin, the pull up resistor should be bigger than 10k $\Omega$ .

### Monitor a Voltage

The SENSE input pin is connected to the monitored system voltage directly or through a resistor network (on MP6400DJ-01). When the voltage on the pin is below  $V_{IT}$ ,  $\overline{\text{RESET}}$  is asserted. A threshold hysteresis will prevent the chip from responding perturbation on SENSE pin. A 1nF to 10nF bypass capacitor should be put on this pin to increase its immunity to noise. A typical application of the MP6400DJ-01 is shown in Figure 4. Two external resistors form a voltage divider from monitored voltage to GND. Its tap

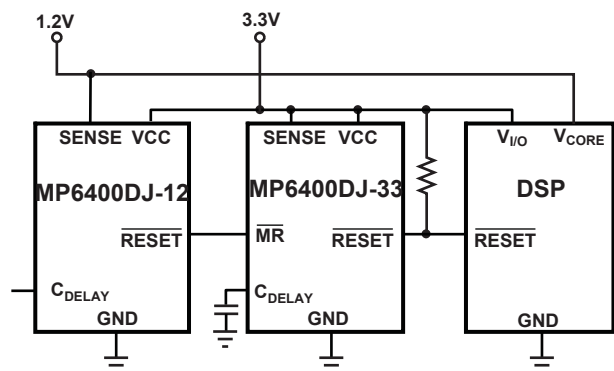
connects to the SENSE pin. The circuit can be used to monitor any voltage higher than 0.4V.



**Figure 4—MP6400DJ-01 Monitoring a User-Defined Voltage**

### Monitor Multiple System Voltages

The manual reset ( $\overline{\text{MR}}$ ) can introduce another logic signal to control the  $\overline{\text{RESET}}$ . When MR is a logic low ( $0.25V_{CC}$ ),  $\overline{\text{RESET}}$  will be asserted. After both SENSE and  $\overline{\text{MR}}$  are above their thresholds,  $\overline{\text{RESET}}$  will be driven to a logic high after a reset delay time. The  $\overline{\text{MR}}$  is internally connected to  $V_{CC}$  through a 90k $\Omega$  resistor so this pin can float. See how multiple system voltages are monitored by  $\overline{\text{MR}}$  in Figure 5. If the signal on  $\overline{\text{MR}}$  isn't up to  $V_{CC}$ , there will be an additional current through internal 90k $\Omega$  pull up resistor. A logic-level FET can be used to minimize the leakage, as shown in Figure 6.



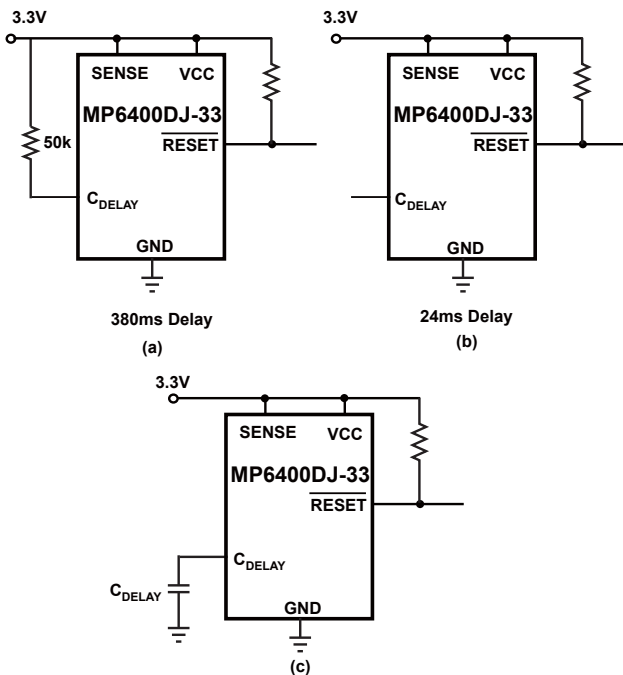
**Figure 5—MP6400 Family Monitoring Multiple System Voltages**



**Figure 6—Minimizing I<sub>CC</sub> When  $\overline{MR}$  Signal isn't over V<sub>CC</sub> by External MOSFET**

**Programmable Reset Delay Time**

The reset delay time can be programmed by C<sub>DELAY</sub> configure. When C<sub>DELAY</sub> is connected to VCC through a resistor between 50kΩ and 200kΩ, the delay time is 380ms. When C<sub>DELAY</sub> floated, the delay time is 24ms. In addition, a capacitor connected C<sub>DELAY</sub> to GND could be used to get the user's programmable delay time from 2.1ms to 10s. The three configures can be found in Figure 7(a)(b)(c).



**Figure 7—Programmable Configurations to the Reset Delay Time**

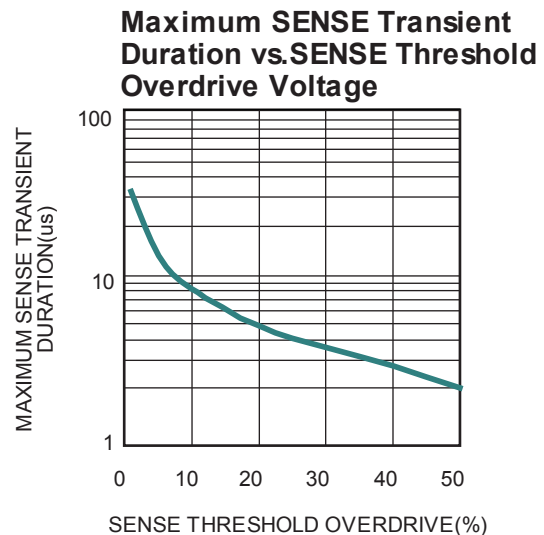
The external capacitor C<sub>DELAY</sub> must be larger than 150pF. For a given delay time, the capacitor value can be calculated using the following equation:

$$C_{DELAY} \text{ (nF)} = [t_D \text{ (s)} - 4.99 \times 10^{-4} \text{ (s)}] \times 107$$

The reset delay time is determined by the charge time of external capacitor. While SENSE is above V<sub>IT</sub> and  $\overline{MR}$  is a logic high, the internal 140nA current source is enabled and starts to charge the capacitor to set the delay time. When the capacitor voltage rises to 1.13V, the  $\overline{RESET}$  is de-asserted. The capacitor will be discharged when the  $\overline{RESET}$  is again asserted. Stray capacitance may cause errors of the delay time. A ceramic capacitor with low leakage is strongly recommended.

**SENSE Voltage Transients Immunity**

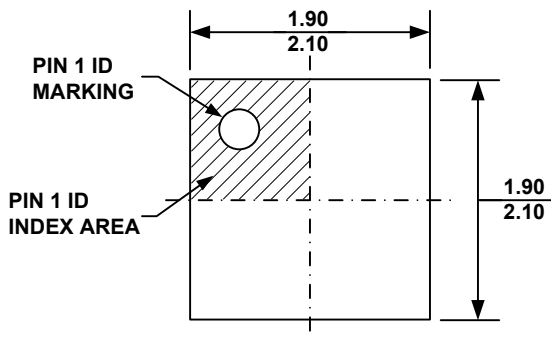
The MP6400 can be immune to SENSE pin short negative transient. The maximum immune duration is 17us while overdrive is 5%. A shorter negative transient can not assert the  $\overline{RESET}$  output. The effective duration is relative to the threshold overdrive, as shown in Figure 8.



**Figure 8—Maximum Transient Duration vs. Sense Threshold Overdrive Voltage**

**PACKAGE INFORMATION**

**QFN6 (2mm x 2mm)**



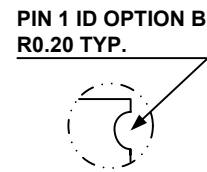
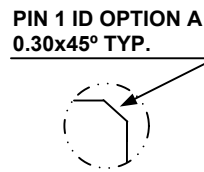
**TOP VIEW**



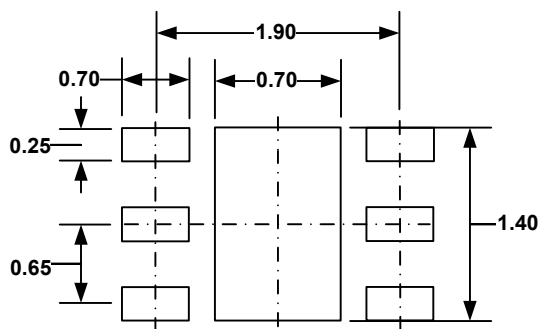
**BOTTOM VIEW**



**SIDE VIEW**



**DETAIL A**

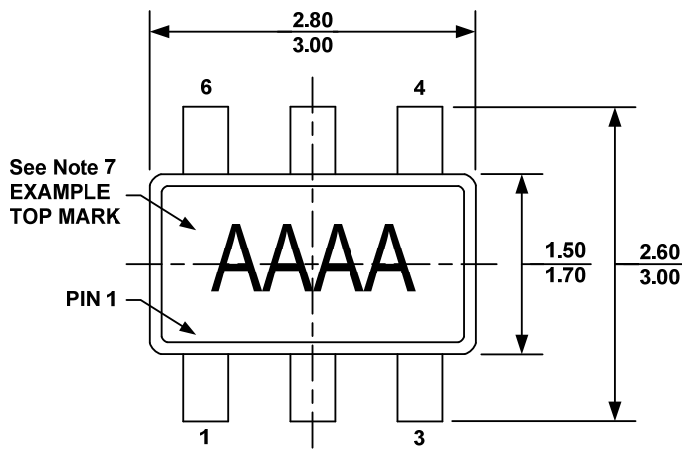


**RECOMMENDED LAND PATTERN**

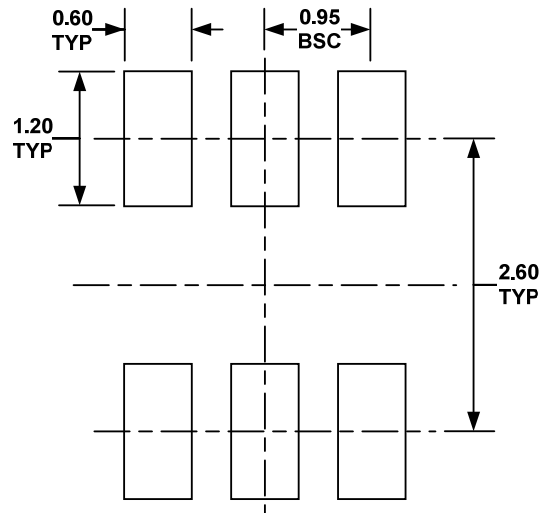
**NOTE:**

- 1) ALL DIMENSIONS ARE IN MILLIMETERS.
- 2) EXPOSED PADDLE SIZE DOES NOT INCLUDE MOLD FLASH.
- 3) LEAD COPLANARITY SHALL BE 0.10 MILLIMETER MAX.
- 4) JEDEC REFERENCE IS MO-229, VARIATION VCCC.
- 5) DRAWING IS NOT TO SCALE.

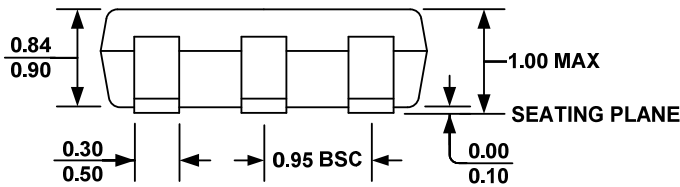
**TSOT23-6**



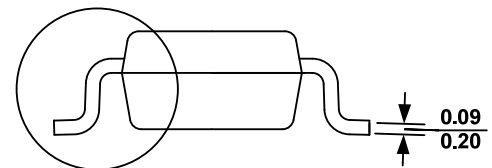
**TOP VIEW**



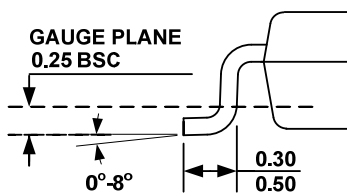
**RECOMMENDED LAND PATTERN**



**FRONT VIEW**



**SIDE VIEW**



**DETAIL "A"**

**NOTE:**

- 1) ALL DIMENSIONS ARE IN MILLIMETERS.
- 2) PACKAGE LENGTH DOES NOT INCLUDE MOLD FLASH, PROTRUSION OR GATE BURR.
- 3) PACKAGE WIDTH DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION.
- 4) LEAD COPLANARITY (BOTTOM OF LEADS AFTER FORMING) SHALL BE 0.10 MILLIMETERS MAX.
- 5) DRAWING CONFORMS TO JEDEC MO-193, VARIATION AB.
- 6) DRAWING IS NOT TO SCALE.
- 7) PIN 1 IS LOWER LEFT PIN WHEN READING TOP MARK FROM LEFT TO RIGHT, (SEE EXAMPLE TOP MARK)

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105318, г.Москва, ул.Щербаковская д.3, офис 1107, 1118, ДЦ «Щербаковский»

Телефон: +7 495 668-12-70 (многоканальный)

Факс: +7 495 668-12-70 (доб.304)

E-mail: [info@moschip.ru](mailto:info@moschip.ru)

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