MPQ6400

Low Quiescent Current Programmable-Delay Supervisory Circuit

AEC-Q100 Qualified

The Future of Analog IC Technology

DESCRIPTION

The MPQ6400 family is the microprocessor (µP) 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 MPQ6400DG-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 MPQ6400 has a very low quiescent current of 1.6µA typically, which makes it ideal suitable for battery-powered applications. It provides a precision reference to achieve ±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. MPQ6400 is available in 2mm×2mm 6-pin QFN package.

FEATURES

- Guaranteed Industrial/Automotive Temp Range Limits
- Fixed Threshold Voltages for Standard Voltage Rails From 0.9V to 5V and Adjustable Voltage From 0.4V are Available
- Low Quiescent Current: 1.6µA Typ
- Power-On Reset Generator with Adjustable Delay Time: 2.1ms to 10s
- High Threshold Accuracy: ±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
- 2×2mm QFN

APPLICATIONS

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

TYPICAL APPLICATION
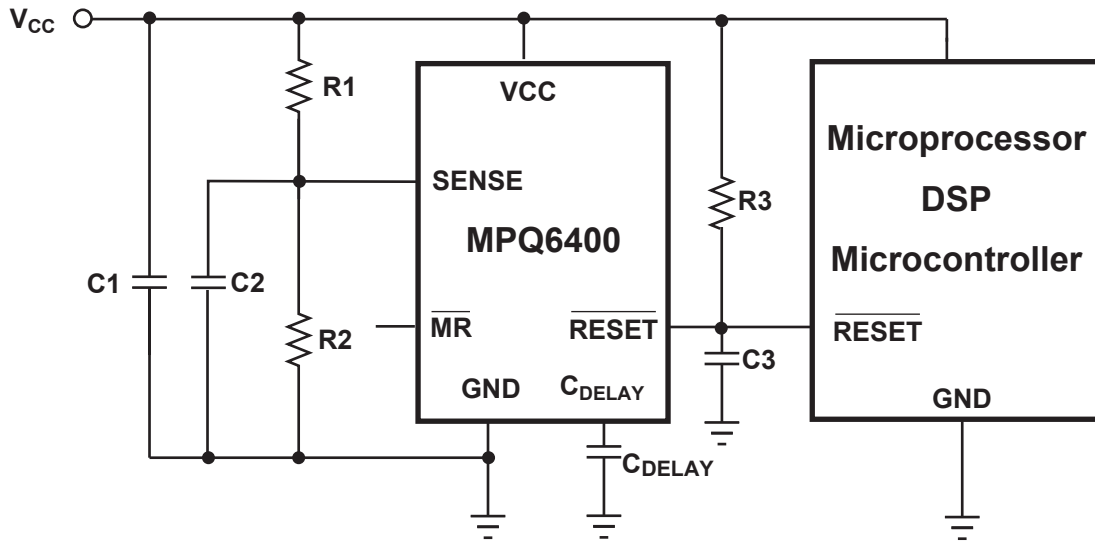
ORDERING INFORMATION

Part Number*	Package	T_J
MPQ6400DG-33**	QFN6 (2x2mm)	-40°C to +125°C
MPQ6400DG-33-AEC1	QFN6 (2x2mm)	-40°C to +125°C

*For Tape & Reel, add suffix –Z (e.g. MPQ6400DG–XX-Z);
For RoHS compliant packaging, add suffix –LF (e.g. MPQ6400DG–XX-LF–Z).
** Check factory for availability in other options.

PACKAGE REFERENCE

TOP VIEW

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VCC      1          6   RESET

SENSE    2          5   GND

C_DELAY  3          4   MR
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QFN6 (2 x 2mm)
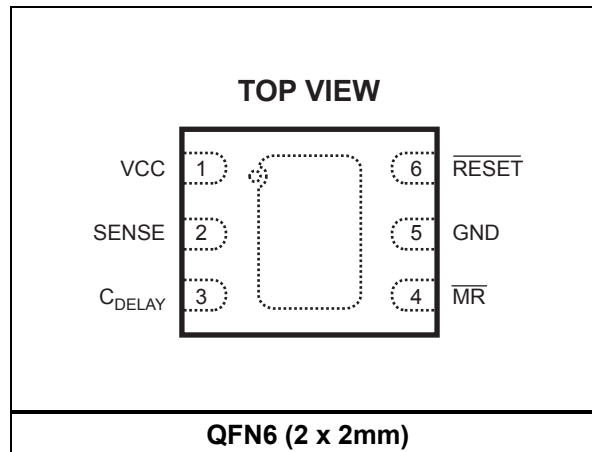
ABSOLUTE MAXIMUM RATINGS [1]

Supply Voltage V_{CC} .... -0.3 to 6.0V
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 +6.0V
RESET Current $I_{\overline{RESET}}$ 5mA
Continuous Power Dissipation $(T_A = +25°C)$ [2]
QFN6 (2mmx2mm) 2.5W
Junction Temperature..............................150°C
Lead Temperature ....260°C
Storage Temperature............... -65°C to +150°C

Recommended Operating Conditions [3]
Supply Voltage V_{CC} ....1.8V to 5.5V
Maximum Junction Temp. (T_J) .... +125°C

Thermal Resistance [4] θ_{JA} θ_{JC}
QFN6 (2x2mm) ....50 ...... 12 ... °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 θ_{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

$1.8V \leq V_{CC} \leq 5.5V$, R_3 = 100kΩ, C_3 = 47pF, T_J= -40°C to +125°C, Typical values are at T_j=+25°C, unless otherwise noted.

Parameters Sy	mbol	Condition	Min	Typ	Max	Units
Input Supply Range	V_{CC}		1.8		5.5	V
Supply Current (current into V_{CC} pin)	I_{CC}	V_{CC} = 3.3V, $\overline{RESET}$ not asserted. $\overline{MR}$, $\overline{RESET}$, C_{DELAY} open	1.6		5	µA
		V_{CC} = 5.5V, $\overline{RESET}$ not asserted.$\overline{MR}$, $\overline{RESET}$, C_{DELAY} open	1.85	15		µA
Low-level Output Voltage	V_{OL}	$1.3V \leq V_{CC} < 1.8V$, I_{OL} = 0.4mA			0.3	V
		$1.8V \leq V_{CC} \leq 5.5V$, I_{OL} = 1.0mA			0.4	V
Power-up Reset Voltage[5]		V_{OL} (max) = 0.2V, $I_{\overline{RESET}} = 15uA$ $T_{rise(Vcc)} \geq 15µs/V$			0.8	V
Negative-going Input Threshold Accuracy [7]	V_{IT}	-40°C to +85°C	-2.5	±1.0	1.5	%
		-40°C to +125°C	-3		1.7	
Hysteresis on V_{IT} Pin	V_{HYS}			1.5	4	V_{IT}%
$\overline{MR}$ Internal Pull-up Resistance	$R_{\overline{MR}}$	50		110		kΩ
Input Current at SENSE Pin	I_{SENSE}	Fixed versions V_{SENSE} = 6V	2.4			µA
$\overline{RESET}$ Leakage Current		$V_{\overline{RESET}}$ = 5.5V, $\overline{RESET}$ not asserted			500	nA
$\overline{MR}$ Logic Low Input	V_{IL}				0.25V_{CC}	V
$\overline{MR}$ Logic High Input	V_{IH}		0.7V_{CC}			V
SENSE Maximum Transient Duration	t_w	V_{IH} = 1.05 V_{IT}, V_{IL} = 0.95 V_{IT}	17.5			µs
$\overline{RESET}$ Delay Time	t_d	C_{DELAY} = Open	15	24	34	ms
		C_{DELAY} = V_{CC}[6]	230	380	530	ms
		C_{DELAY} = 150pF	1.3	2.1	3	ms
		C_{DELAY} = 10nF[6]	61	102	142	ms
$\overline{MR}$ to $\overline{RESET}$ Propagation Delay	t_{pHL1}	V_{IH} = 0.7 V_{CC}, V_{IL} = 0.25 V_{CC}	160			ns
High to Low Level $\overline{RESET}$ Delay, SENSE to $\overline{RESET}$	t_{pHL2}	V_{IH} = 1.05 V_{IT}, V_{IL} = 0.95 V_{IT}	17.5			µs

Note:
5) The lowest supply voltage (V_{CC}) at which $\overline{RESET}$ becomes active.
6) Guaranteed by design.
7) V_{SENSE} Falling Slowly

ORDERING INFORMATION

Product	Package	Top Mark	Nominal Supply Voltage	Threshold Voltage (VIT)
MPQ6400DG-33	QFN		3.3V	3.07V

PIN FUNCTIONS

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

DETAIL DESCRIPTION

The MPQ6400 product family asserts a $\overline{RESET}$ signal when either the SENSE pin voltage is lower than V_{IT} or the manual reset ($\overline{MR}$) is driven low. The MPQ6400-XX family, other than the MPQ6400DG-01, can monitor a fixed voltage from 0.9V to 5.0V. The MPQ6400DG-01 can monitor any voltage above 0.4V by adjusting the external resistor divider. After both the manual reset ($\overline{MR}$) and SENSE voltages exceed their thresholds, the $\overline{RESET}$ output remains asserted for a user's programmable delay time. Two fixed $\overline{RESET}$ delay times are user-selectable: 380ms delay time by connecting the C_{DELAY} pin to V_{CC}, and 24ms delay time by leaving the C_{DELAY} pin float. Any delay time from 2.1ms to 10s could be gotten by connecting a capacitor between C_{DELAY} and GND. The wide monitor voltage and programmable reset delay time make MPQ6400 product family suitable for a broad array of applications.
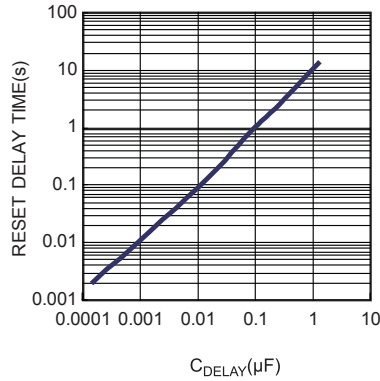
TYPICAL PERFORMANCE CHARACTERISTICS

V_{CC}=3.3V, R_3 = 100kΩ, C_3 = 47pF, T_A= -40°C to +125°C, Typical values are at T_A=+25°C, unless otherwise noted.
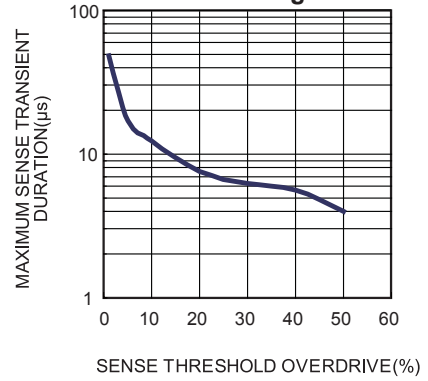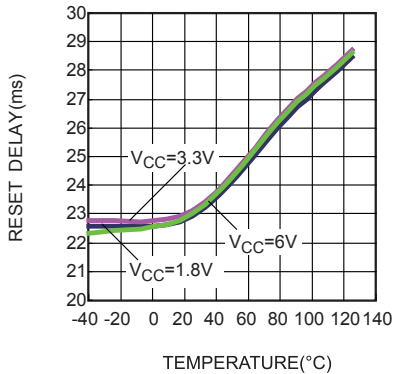
Supply Current vs. V_{CC}
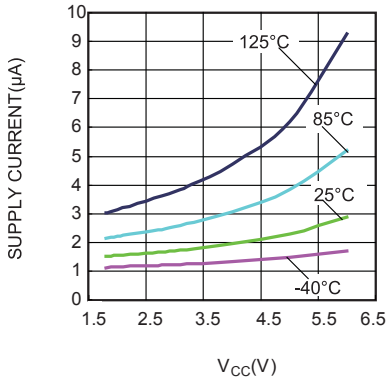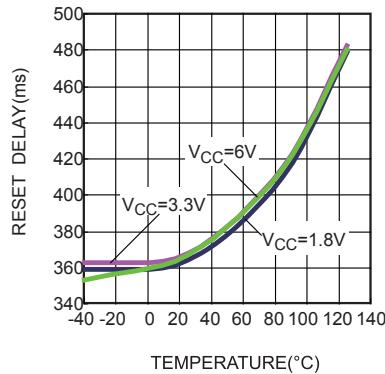
Reset Delay Time vs. C_{DELAY}

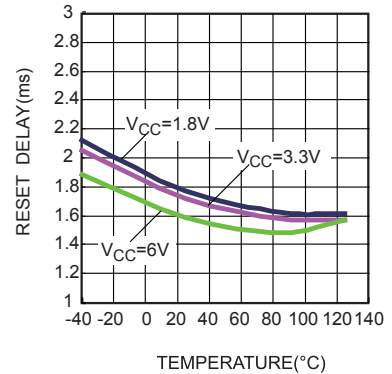### Maximum SENSE Transient Duration vs.SENSE Threshold Overdrive Voltage
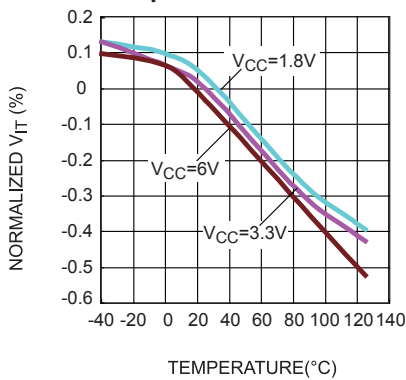
Reset Delay vs.Temperature
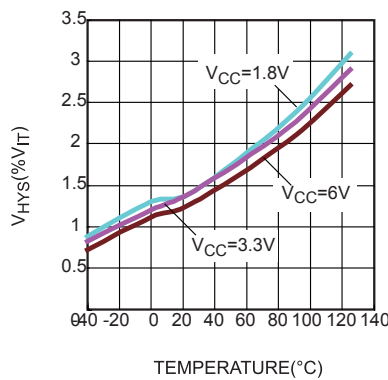(C_{DELAY}=open)

Reset Delay vs.Temperature
(C_{DELAY}=V_{CC})
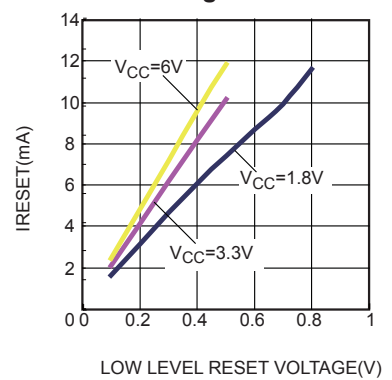
Reset Delay vs.Temperature
(C_{DELAY}=150pF Cap)

Normalized V_{IT} vs. Temperature

V_{HYS} vs. Temperature

$I_{\overline{RESET}}$ vs. Low Level Reset Voltage

FUNCTIONAL BLOCK DIAGRAM

Adjustable Voltage Version

Fixed Voltage Version
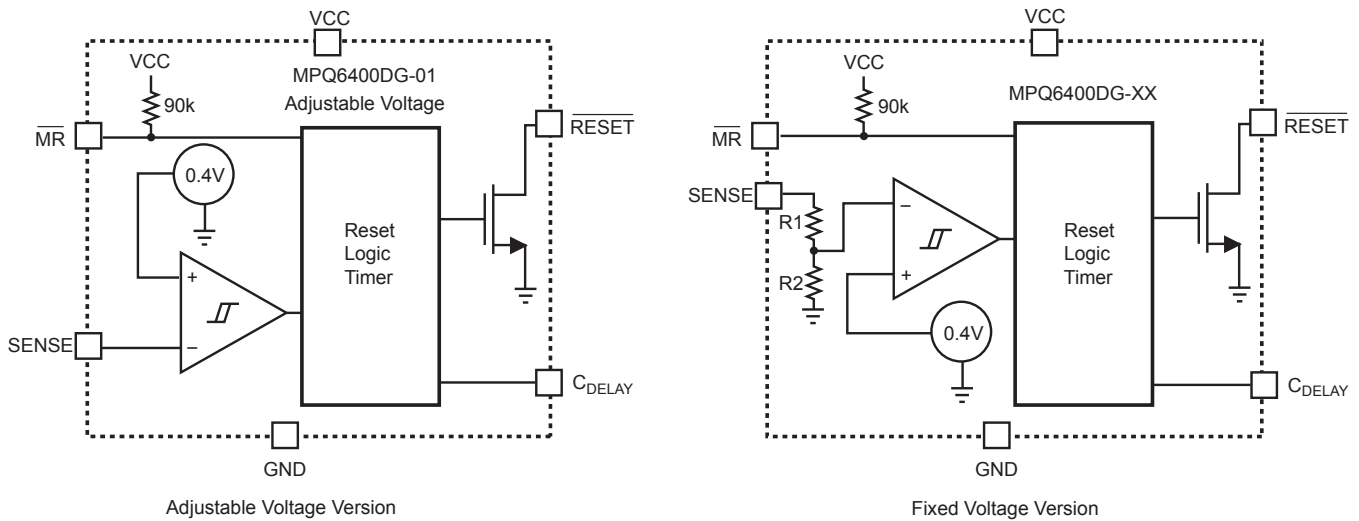
Figure 1—Functional Block Diagram
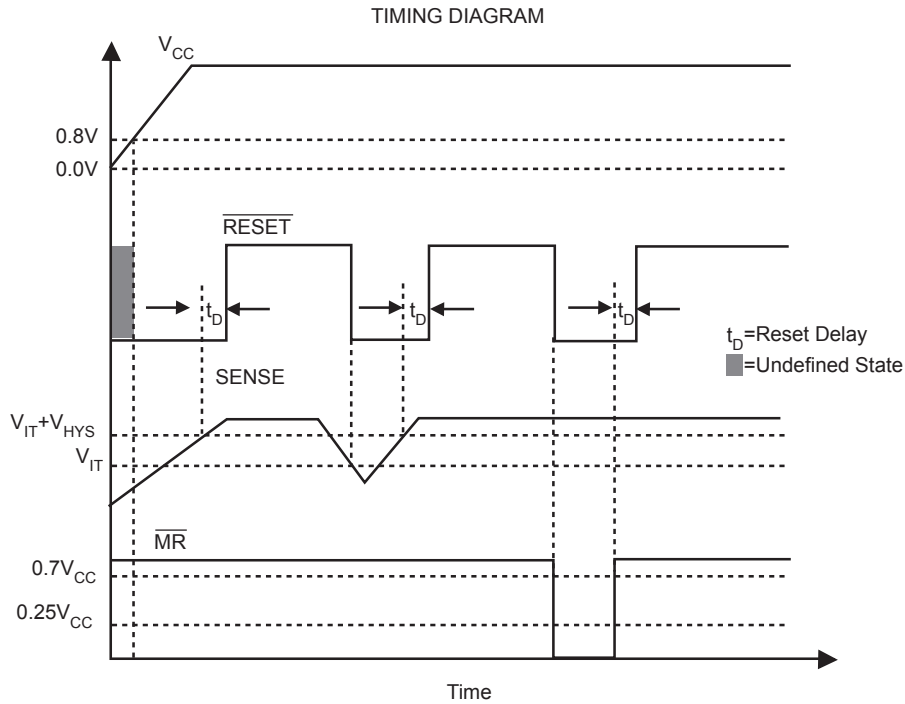
Figure 2—MPQ6400 Timing Diagram

TRUTH TABLE

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

APPLICATION INFORMATION

Reset Output Function

The M PQ6400 $\overline{\text{RESET}}$ 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. Th e voltage of reset signa l is allowed to be high er than V $_{CC}$ (up to 6 V) through a r esistor p ulling up from supply line. If the voltage is below 0.8V, $\overline{\text{RESET}}$ output is undefined. This co ndition ca n be ign ored generally because that most microprocessors do not function at this state. When both SENSE and $\overline{\text{MR}}$ are higher than their thr eshold voltage, $\overline{\text{RESET}}$ output hold s logic high . Once eith er of the tw o drops belo w their th reshold, $\overline{\text{RESET}}$ will be asserted.
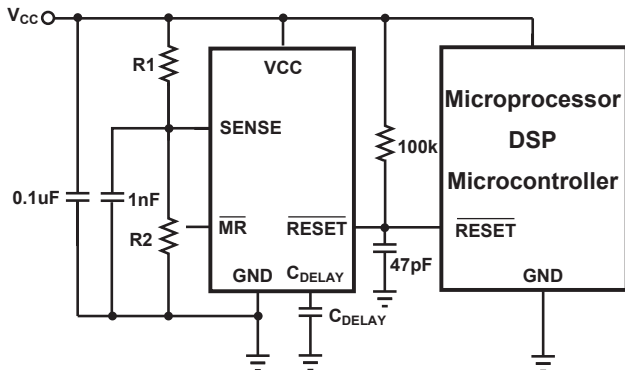

Figure 3—Typical Application of MPQ6400 with Microprocessor

From the p oint that $\overline{\text{MR}}$ is again logic high a nd SENSE is above V $_{IT}$ + V $_{HYS}$ (the threshold hysteresis), $\overline{\text{RESET}}$ will be driv en to a logic high after a re set delay tim e. The re set delay tim e is programmable by C $_{DELAY}$ pin. Due to the finite impedance of $\overline{\text{RESET}}$ pin, th e pull up resistor should be bigger than 10kΩ.

Monitor a Voltage

The SENSE input pin is conn ected to the monitored system volta ge directly or through a resistor network (on M PQ6400DG-01). When the voltage on the pin is below V $_{IT}$, $\overline{\text{RESET}}$ is asserted. A threshold hysteresis will prev ent the chip from responding perturbation on SENSE pin. A 1nF to 10nF bypass capacitor should be put on this pin to increase its im munity to noise. A t ypical application of the M PQ6400DG-01 is shown in Figure 4. T wo external resistor s fo rm a voltage

divider from m onitored voltage to GND. Its tap connects to the SENSE pin. The circuit can be used to monitor any voltage higher than 0.4V.
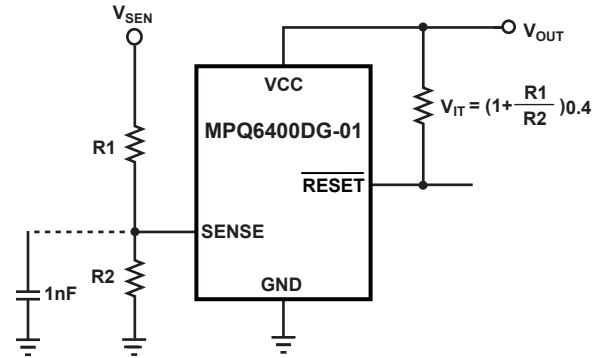

$$V_{IT} = (1+\frac{R1}{R2})0.4$$

Figure 4—MPQ6400DG-01 Monitoring a User-Defined Voltage

Monitor Multiple System Voltages

The m anual reset ($\overline{\text{MR}}$) can introduce another logic signal to control the $\overline{\text{RESET}}$. When $\overline{\text{MR}}$ is a logic low (0.25V_{CC}), $\overline{\text{RESET}}$ will be asserte d. After both SENSE and $\overline{\text{MR}}$ are above their thresholds, $\overline{\text{RESET}}$ will be driv en to a lo gic high af ter a reset delay time. The $\overline{\text{MR}}$ is internally connected to V_{CC} through a 90kΩ resistor so this pin can float. See how m ultiple system voltages are m onitored 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 90kΩ pull u p resistor. A logic-level FET can be used to minimize the leakage, as shown in Figure 6.
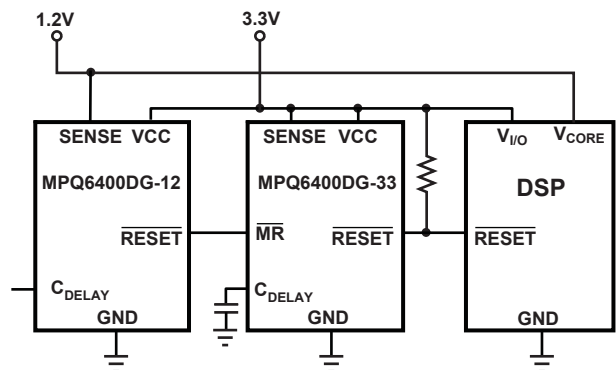

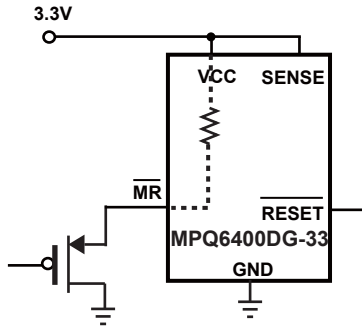**Figure 5— MPQ6400 Family Monitoring Multiple System Voltages**

3.3V

Figure 6—Minimizing I_{CC} When $\overline{MR}$ Signal isn't over V_{CC} by External MOSFET

Programmable Reset Delay Time

The reset delay tim e can be pro grammed b y C_{DELAY} configure. Whe n C_{DELAY} is connected to VCC through a resistor between 50k Ω a nd 200kΩ, the delay tim e is 380m s. When C_{DELAY} floated, the delay tim e is 24m s. In addition, a capacitor connected C_{DELAY} to GND could be used to get the user's program mable delay time from 2.1m s to 10s. The three configures can be found in Figure 7(a)(b)(c).
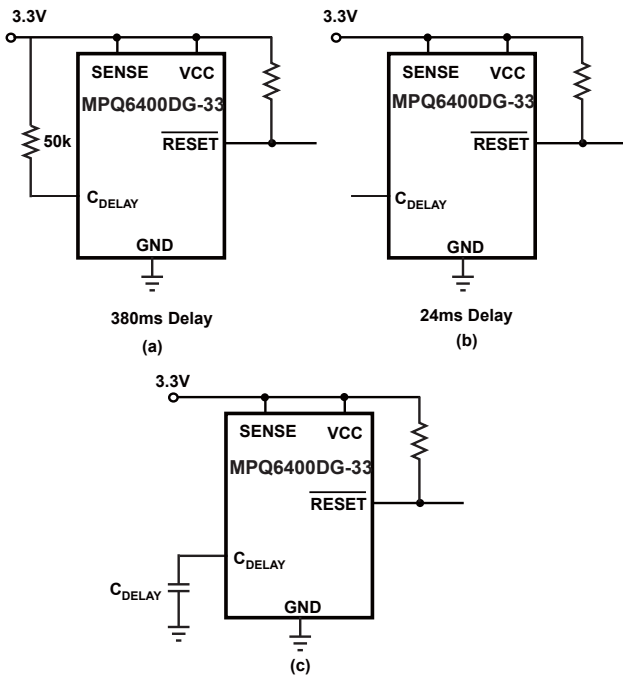
Figure 7—Programmable Configurations to the Reset Delay Time

The external capacitor C_{DELAY} must be larger than 150pF. For a given d elay tim e, the capacito r value can be calculated using the followin g equation:

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

The reset delay time is determined by the charge time of external capacitor. While SENSE is above V_{IT} and $\overline{MR}$ is a logic hig h, the internal 140nA current sour ce is enabled and star ts to charg e 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 th e delay tim e. A ceram ic capacitor with low leakage is stro ngly recommended.

SENSE Voltage Transients Immunity

The M PQ6400 can be im mune to SENSE pin short negative transient. The m aximum i mmune duration is 17us while overdrive is 5%. A shorter negative transient can not assert the $\overline{RESET}$ output. The effective d uration is r elative to t he threshold overdrive, as shown in Figure 8.
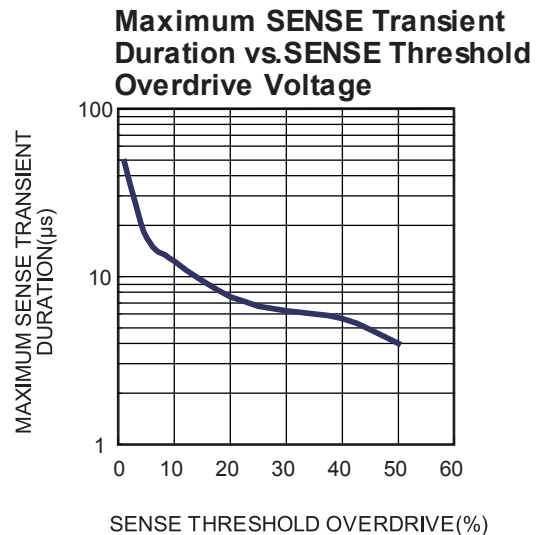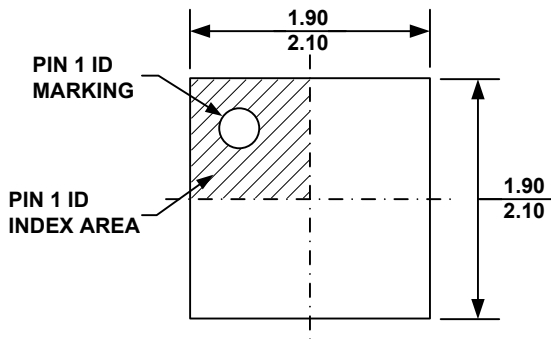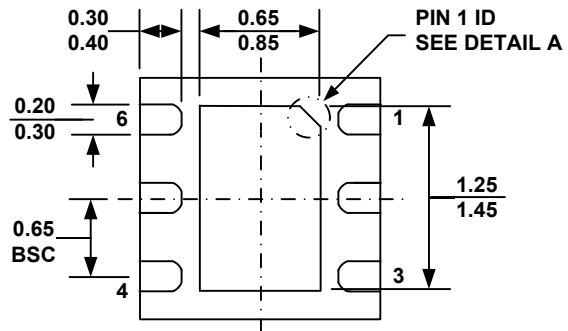

Figure 8—Maximum Transient Duration vs. Sense Threshold Overdrive Voltage

PACKAGE INFORMATION

QFN6 (2 x 2mm)

1.90
2.10

PIN 1 ID
MARKING

PIN 1 ID
INDEX AREA

1.90
2.10

TOP VIEW

0.30
0.40

0.65
0.85

PIN 1 ID
SEE DETAIL A

0.20
0.30

6

1

0.65
BSC

1.25
1.45

4

3

BOTTOM VIEW

0.80
1.00

0.20 REF

0.00
0.05
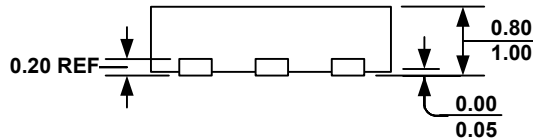
SIDE VIEW

PIN 1 ID OPTION A
0.30x45º TYP.
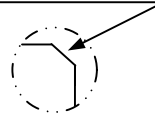
PIN 1 ID OPTION B
R0.20 TYP.

DETAIL A

1.90

0.70

0.70

0.25

0.65

1.40
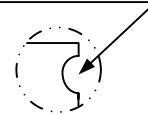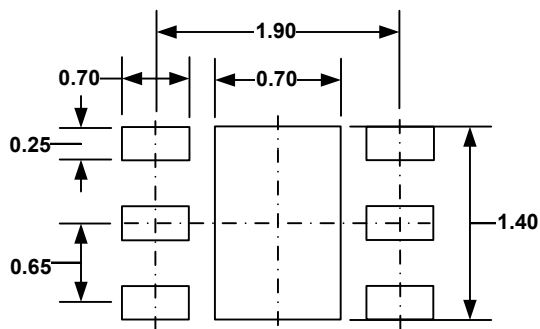
RECOMMENDED LAND PATTERN

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.