19-0622; Rev 0; 8/06

# Dual-/Triple-/Quad-Voltage, Capacitor-Adjustable, Sequencing/Supervisory Circuits



## General Description

The MAX16041/MAX16042/MAX16043 are dual-/triple-/quad-voltage monitors and sequencers that are offered in a small thin QFN package. These devices offer enormous design flexibility as they allow fixed and adjustable thresholds to be selected through logic inputs and provide sequence timing through small external capacitors. These versatile devices are ideal for use in a wide variety of multivoltage applications.

As the voltage at each monitored input exceeds its respective threshold, its corresponding output goes high after a propagation delay or a capacitor-set time delay. When a voltage falls below its threshold, its respective output goes low after a propagation delay. Each detector circuit also includes its own enable input, allowing the power-good outputs to be shut off independently. The independent output for each detector has an open-drain configuration capable of supporting voltages up to 28V, thereby allowing them to interface to shutdown and enable inputs of various DC-DC regulators. Each detector can operate independently as four separate supervisory circuits or can be daisy-chained to provide controlled power-supply sequencing.

The MAX16041/MAX16042/MAX16043 also include a push-pull reset function that deasserts only after all of the independently monitored voltages exceed their threshold. The reset timeout is internally fixed or can be adjusted externally. These devices are offered in a 4mm x 4mm TQFN package and are fully specified from -40°C to +125°C.

## Applications

Multivoltage Systems

DC-DC Supplies

Servers/Workstations

Storage Systems

Networking/Telecommunication Equipment

## Selector Guide

| PART | MONITORED VOLTAGES | INDEPENDENT OUTPUTS | $\overline{\text{RESET}}$ OUTPUT |
|---|---|---|---|
| MAX16041 | 2 | 2 (Open-drain) | Push-pull |
| MAX16042 | 3 | 3 (Open-drain) | Push-pull |
| MAX16043 | 4 | 4 (Open-drain) | Push-pull |

## Features

- ♦ **2.2V to 28V Operating Voltage Range**
- ♦ **Fixed Thresholds for 3.3V, 2.5V, 1.8V, 1.5V, and 1.2V Systems**
- ♦ **1.5% Accurate Adjustable Threshold Monitors Voltages Down to 0.5V**
- ♦ **2.7% Accurate Fixed Thresholds Over Temperature**
- ♦ **Fixed (140ms min)/Capacitor-Adjustable Delay Timing**
- ♦ **Independent Open-Drain Outputs/Push-Pull $\overline{\text{RESET}}$ Output**
- ♦ **Enable Inputs for Each Monitored Voltage**
- ♦ **9 Logic-Selectable Threshold Options**
- ♦ **Manual Reset and Tolerance Select (5%/10%) Inputs**
- ♦ **Small, 4mm x 4mm TQFN Package**
- ♦ **Fully Specified from -40°C to +125°C**

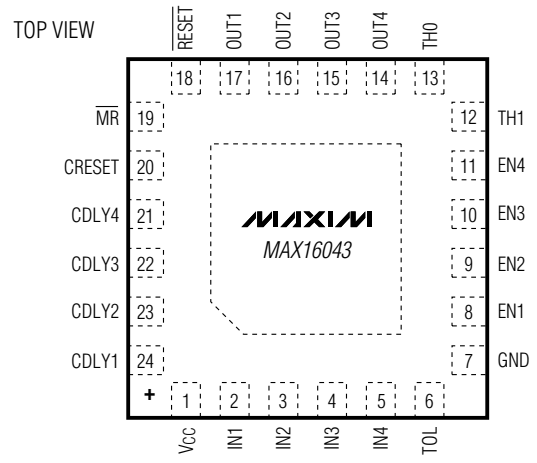
## Ordering Information

| PART* | TEMP RANGE | PIN-PACKAGE | PKG CODE |
|---|---|---|---|
| **MAX16041**TE+ | -40°C to +125°C | 16 TQFN | T1644-4 |
| **MAX16042**TP+ | -40°C to +125°C | 20 TQFN | T2044-3 |
| **MAX16043**TG+ | -40°C to +125°C | 24 TQFN | T2444-4 |

*+Denotes lead-free package.*

**For tape and reel, add a "T" after the "+." All tape and reel orders are available in 2.5k increments.*

## Pin Configurations




**TQFN (4mm x 4mm)**

*Pin Configurations continued at end of data sheet.*

# Dual-/Triple-/Quad-Voltage, Capacitor-Adjustable, Sequencing/Supervisory Circuits

## ABSOLUTE MAXIMUM RATINGS

(All voltages referenced to GND.)
$V_{CC}$ .....-0.3V to +30V
EN1–EN4 .....-0.3V to ($V_{CC}$ + 0.3V)
OUT1–OUT4 .....-0.3V to +30V
$\overline{RESET}$.....-0.3V to ($V_{CC}$ + 0.3V)
IN1–IN4.....-0.3V to ($V_{CC}$ + 0.3V)
$\overline{MR}$, TOL, TH1, TH0 .....-0.3V to ($V_{CC}$ + 0.3V)
CDLY1–CDLY4 .....-0.3V to +6V
CRESET .....-0.3V to ($V_{CC}$ + 0.3V)
Input/Output Current (all pins).....±20mA

Continuous Power Dissipation ($T_A$ = +70°C)
16-Pin TQFN (derate 25mW/°C above +70°C) .....2000mW
20-Pin TQFN (derate 25.6mW/°C above +70°C) .....2051mW
24-Pin TQFN (derate 27.8mW/°C above +70°C) .....2222mW
Operating Temperature Range .....-40°C to +125°C
Storage Temperature Range .....-65°C to +150°C
Junction Temperature.....+150°C
Lead Temperature (soldering, 10s) .....+300°C

*Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.*

## ELECTRICAL CHARACTERISTICS

($V_{CC}$ = 2.2V to 28V, $T_A$ = -40°C to +125°C, unless otherwise specified. Typical values are at $V_{CC}$ = 3.3V and $T_A$ = +25°C.) (Note 1)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| **SUPPLY** | | | | | | | |
| Operating Voltage Range | $V_{CC}$ | (Note 2) | | 2.2 | | 28.0 | V |
| Undervoltage Lockout | UVLO | (Note 2) | | 1.8 | 1.9 | 2.0 | V |
| Undervoltage-Lockout Hysteresis | $UVLO_{HYST}$ | $V_{CC}$ falling | | | 50 | | mV |
| $V_{CC}$ Supply Current | $I_{CC}$ | All OUT_ and $\overline{RESET}$ at logic-high (IN_ current excluded) | $V_{CC}$ = 3.3V | | 40 | 75 | µA |
| | | | $V_{CC}$ = 12V | | 47 | 75 | |
| | | | $V_{CC}$ = 28V | | 52 | 80 | |
| **INPUTS (IN_)** | | | | | | | |
| IN_ Thresholds (IN_ Falling) | $V_{TH}$ | 3.3V threshold, TOL = GND | | 2.970 | 3.052 | 3.135 | V |
| | | 3.3V threshold, TOL = $V_{CC}$ | | 2.805 | 2.888 | 2.970 | |
| | | 2.5V threshold, TOL = GND | | 2.250 | 2.313 | 2.375 | |
| | | 2.5V threshold, TOL = $V_{CC}$ | | 2.125 | 2.187 | 2.250 | |
| | | 1.8V threshold, TOL = GND | | 1.620 | 1.665 | 1.710 | |
| | | 1.8V threshold, TOL = $V_{CC}$ | | 1.530 | 1.575 | 1.620 | |
| | | 1.5V threshold, TOL = GND | | 1.350 | 1.387 | 1.425 | |
| | | 1.5V threshold, TOL = $V_{CC}$ | | 1.275 | 1.312 | 1.350 | |
| | | 1.2V threshold, TOL = GND | | 1.080 | 1.110 | 1.140 | |
| | | 1.2V threshold, TOL = $V_{CC}$ | | 1.020 | 1.050 | 1.080 | |
| Adjustable Threshold (IN_ Falling) | $V_{TH}$ | TOL = GND | | 0.492 | 0.5 | 0.508 | V |
| | | TOL = $V_{CC}$ | | 0.463 | 0.472 | 0.481 | |
| IN_ Hysteresis (IN_ Rising) | $V_{HYST}$ | | | | 0.5 | | % |
| IN_ Input Resistance | | Fixed threshold | | 500 | 918 | | kΩ |
| IN_ Input Current | $I_L$ | Adjustable threshold only ($V_{IN\_}$ = 1V) | | -100 | | +100 | nA |

## ELECTRICAL CHARACTERISTICS (continued)

($V_{CC}$ = 2.2V to 28V, $T_A$ = -40°C to +125°C, unless otherwise specified. Typical values are at $V_{CC}$ = 3.3V and $T_A$ = +25°C.) (Note 1)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| **CRESET AND CDLY_** | | | | | | |
| CRESET Threshold | $V_{TH-RESET}$ | CRESET rising, $V_{CC}$ = 3.3V | 0.465 | 0.5 | 0.535 | V |
| CRESET Charge Current | $I_{CH-RESET}$ | $V_{CC}$ = 3.3V | 380 | 500 | 620 | nA |
| CDLY_ Threshold | $V_{TH-CDLY}$ | CDLY_ rising, $V_{CC}$ = 3.3V | 0.95 | 1 | 1.05 | V |
| CDLY_ Charge Current | $I_{CH-CDLY}$ | $V_{CC}$ = 3.3V | 200 | 250 | 300 | nA |
| **DIGITAL LOGIC INPUTS (EN_, $\overline{MR}$, TOL, TH1, TH0)** | | | | | | |
| Input Low Voltage | $V_{IL}$ | | | | 0.4 | V |
| Input High Voltage | $V_{IH}$ | | 1.4 | | | V |
| TH1, TH0 Logic-Input Floating | | | | 0.6 | | V |
| TOL, TH1, TH0 Logic-Input Current | | $V_{TOL}$, $V_{TH1}$, $V_{TH0}$ = GND or $V_{CC}$ | -1 | | +1 | µA |
| EN_ Input Leakage Current | | $V_{EN\_}$ = $V_{CC}$ or GND | -100 | | +100 | nA |
| $\overline{MR}$ Internal Pullup Current | | $V_{CC}$ = 3.3V | 250 | 535 | 820 | nA |
| **OUTPUTS (OUT_, $\overline{RESET}$)** | | | | | | |
| Output Low Voltage (Open-Drain or Push-Pull) | $V_{OL}$ | $V_{CC}$ ≥ 1.2V, $I_{SINK}$ = 90µA | | | 0.3 | V |
| | | $V_{CC}$ ≥ 2.25V, $I_{SINK}$ = 0.5mA | | | 0.3 | |
| | | $V_{CC}$ ≥ 4.5V, $I_{SINK}$ = 1mA | | | 0.35 | |
| Output High Voltage (Push-Pull) | $V_{OH}$ | $V_{CC}$ ≥ 3V, $I_{SOURCE}$ = 500µA | 0.8 x $V_{CC}$ | | | V |
| | | $V_{CC}$ ≥ 4.5V, $I_{SOURCE}$ = 800µA | 0.8 x $V_{CC}$ | | | |
| Output Leakage Current (Open-Drain) | $I_{LKG}$ | Output not asserted low, $V_{OUT}$ = 28V | | | 1 | µA |
| Reset Timeout Period | $t_{RP}$ | CRESET = $V_{CC}$, $V_{CC}$ = 3.3V | 140 | 190 | 260 | ms |
| | | CRESET open | | 0.030 | | |
| **TIMING** | | | | | | |
| IN_ to OUT_ Propagation Delay | $t_{DELAY+}$ | IN_ rising, CDLY_ open | | 35 | | µs |
| | $t_{DELAY-}$ | IN_ falling, CDLY_ open | | 20 | | |
| IN_ to $\overline{RESET}$ Propagation Delay | $t_{RST-DELAY}$ | CRESET open, IN_ falling | | 35 | | µs |
| $\overline{MR}$ Minimum Input Pulse Width | | (Note 3) | 2 | | | µs |
| EN_ or $\overline{MR}$ Glitch Rejection | | | | 280 | | ns |
| EN_ to OUT_ Delay | $t_{OFF}$ | From device enabled to device disabled | | 3 | | µs |
| | $t_{ON}$ | From device disabled to device enabled (CDLY_ open) | | 30 | | |
| $\overline{MR}$ to $\overline{RESET}$ Delay | | $\overline{MR}$ falling | | 3 | | µs |

**Note 1:** Devices are production tested at $T_A$ = +25°C. Limits over temperature are guaranteed by design.

**Note 2:** Operating below the UVLO causes all outputs to go low. The outputs are guaranteed to be in the correct state for $V_{CC}$ down to 1.2V.

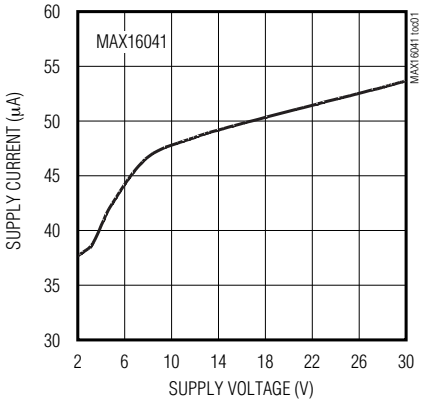
**Note 3:** To guarantee an assertion, the minimum input pulse width must be greater than 2µs.

# Dual-/Triple-/Quad-Voltage, Capacitor-Adjustable, Sequencing/Supervisory Circuits

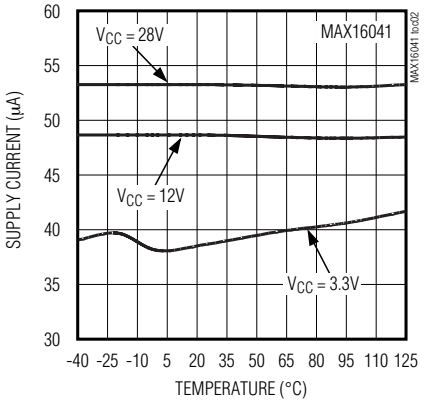
## Typical Operating Characteristics

($V_{CC}$ = 3.3V, $T_A$ = +25°C, unless otherwise noted.)

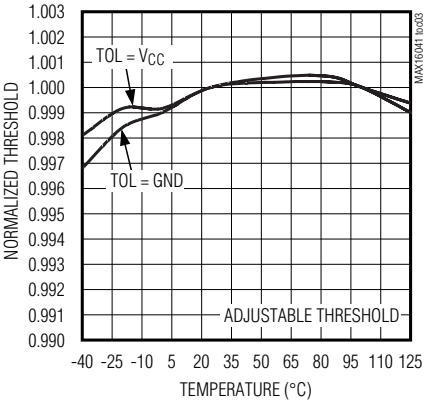
**SUPPLY CURRENT vs. SUPPLY VOLTAGE**



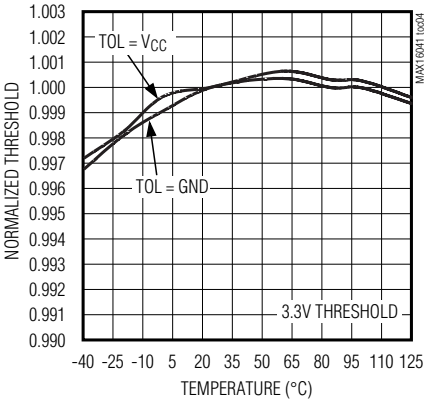

**SUPPLY CURRENT vs. TEMPERATURE**



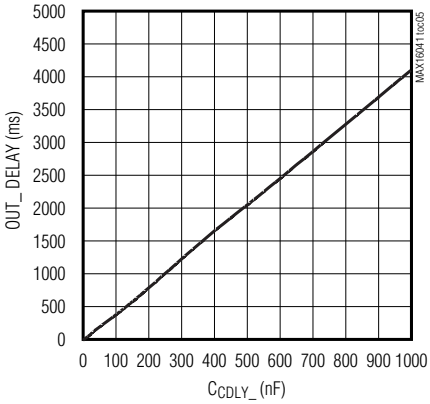

**NORMALIZED ADJUSTABLE THRESHOLD vs. TEMPERATURE**



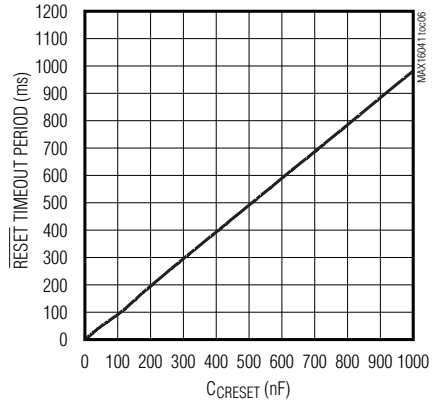

**NORMALIZED ADJUSTABLE THRESHOLD vs. TEMPERATURE**



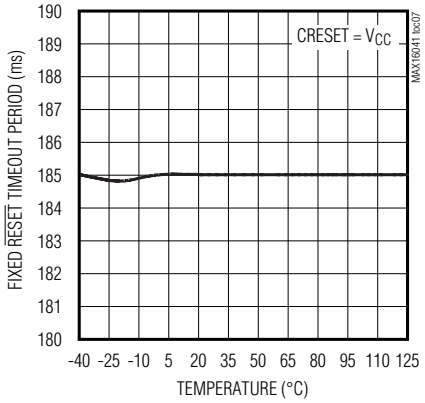

**OUT_ DELAY vs. $C_{CDLY\_}$**



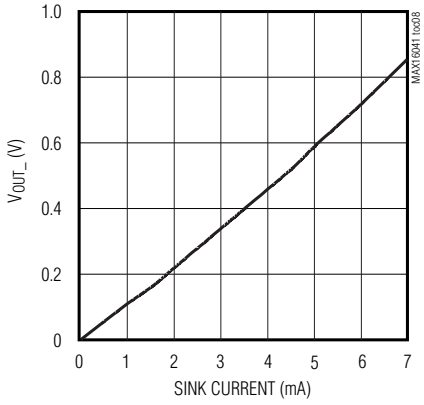

**$\overline{RESET}$ TIMEOUT PERIOD vs. $C_{CRESET}$**



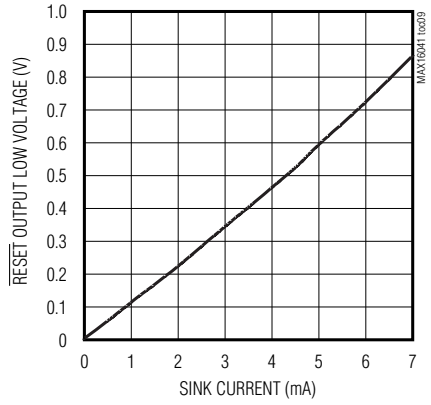

**FIXED $\overline{RESET}$ TIMEOUT PERIOD vs. TEMPERATURE**




**OUT_ LOW VOLTAGE vs. SINK CURRENT**



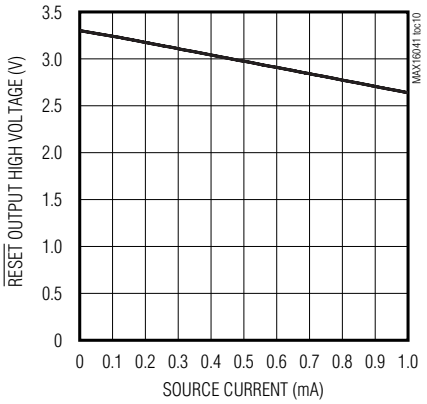

**$\overline{RESET}$ OUTPUT LOW VOLTAGE vs. SINK CURRENT**



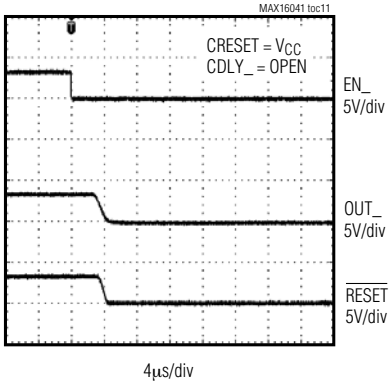
## Typical Operating Characteristics (continued)

($V_{CC}$ = 3.3V, $T_A$ = +25°C, unless otherwise noted.)

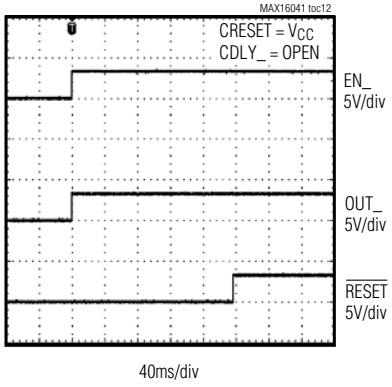
**$\overline{RESET}$ OUTPUT HIGH VOLTAGE vs. SOURCE CURRENT**



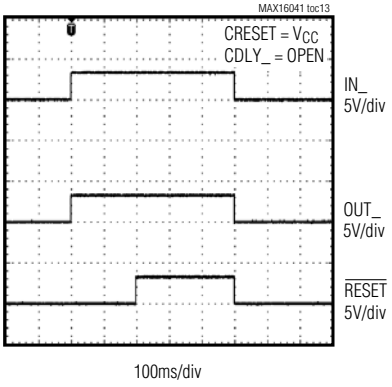

**ENABLE TURN-OFF**



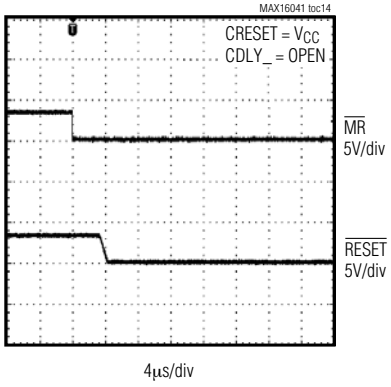

**ENABLE TURN-ON**



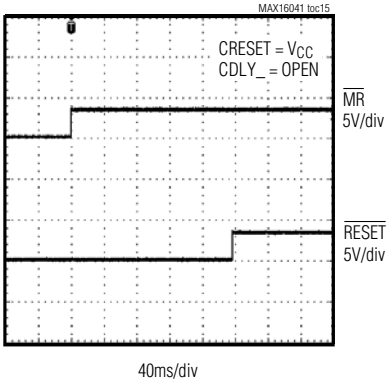

**$\overline{RESET}$ TIMEOUT DELAY**



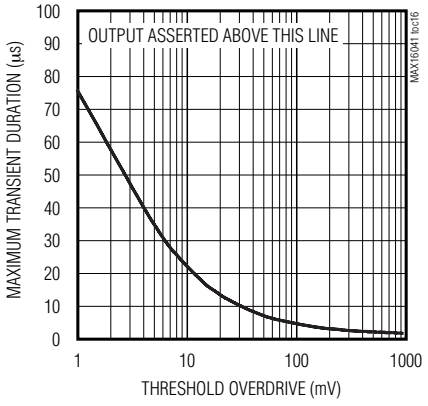

**$\overline{MR}$ FALLING vs. $\overline{RESET}$**




**$\overline{MR}$ RISING vs. $\overline{RESET}$**




**MAXIMUM TRANSIENT DURATION vs. THRESHOLD OVERDRIVE**



# Dual-/Triple-/Quad-Voltage, Capacitor-Adjustable, Sequencing/Supervisory Circuits

## Pin Description

| PIN | | | NAME | FUNCTION |
|---|---|---|---|---|
| MAX16041 | MAX16042 | MAX16043 | | |
| 1 | 1 | 1 | $V_{CC}$ | Supply Voltage Input. Connect a 2.2V to 28V supply voltage to power the device. All outputs are low when $V_{CC}$ is below the UVLO. For noisy systems, bypass $V_{CC}$ to GND with a 0.1µF capacitor. |
| 2 | 2 | 2 | IN1 | Monitored Input 1. When the voltage at IN1 exceeds its threshold, OUT1 goes high after the capacitor-adjustable delay period. When the voltage at IN1 falls below its threshold, OUT1 goes low after a propagation delay. |
| 3 | 3 | 3 | IN2 | Monitored Input 2. When the voltage at IN2 exceeds its threshold, OUT2 goes high after the capacitor-adjustable delay period. When the voltage at IN2 falls below its threshold, OUT2 goes low after a propagation delay. |
| — | 4 | 4 | IN3 | Monitored Input 3. When the voltage at IN3 exceeds its threshold, OUT3 goes high after the capacitor-adjustable delay period. When the voltage at IN3 falls below its threshold, OUT3 goes low after a propagation delay. |
| — | — | 5 | IN4 | Monitored Input 4. When the voltage at IN4 exceeds its threshold, OUT4 goes high after the capacitor-adjustable delay period. When the voltage at IN4 falls below its threshold, OUT4 goes low after a propagation delay. |
| 4 | 5 | 6 | TOL | Threshold Tolerance Input. Connect TOL to GND to select thresholds 5% below nominal. Connect TOL to $V_{CC}$ to select thresholds 10% below nominal. |
| 5 | 6 | 7 | GND | Ground |
| 6 | 7 | 8 | EN1 | Active-High Logic-Enable Input 1. Driving EN1 low causes OUT1 to go low regardless of the input voltage. Drive EN1 high to enable the monitoring comparator. |
| 7 | 8 | 9 | EN2 | Active-High Logic-Enable Input 2. Driving EN2 low causes OUT2 to go low regardless of the input voltage. Drive EN2 high to enable the monitoring comparator. |
| — | 9 | 10 | EN3 | Active-High Logic-Enable Input 3. Driving EN3 low causes OUT3 to go low regardless of the input voltage. Drive EN3 high to enable the monitoring comparator. |
| — | — | 11 | EN4 | Active-High Logic-Enable Input 4. Driving EN4 low causes OUT4 to go low regardless of the input voltage. Drive EN4 high to enable the monitoring comparator. |
| 8 | 10 | 12 | TH1 | Threshold Select Input 1. Connect TH1 to $V_{CC}$ or GND, or leave it open to select the input-voltage threshold option in conjunction with TH0 (see Table 2). |
| 9 | 11 | 13 | TH0 | Threshold Select Input 0. Connect TH0 to $V_{CC}$ or GND, or leave it open to select the input-voltage threshold option in conjunction with TH1 (see Table 2). |
| — | — | 14 | OUT4 | Output 4. When the voltage at IN4 is below its threshold or EN4 goes low, OUT4 goes low. |
| — | 12 | 15 | OUT3 | Output 3. When the voltage at IN3 is below its threshold or EN3 goes low, OUT3 goes low. |
| 10 | 13 | 16 | OUT2 | Output 2. When the voltage at IN2 is below its threshold or EN2 goes low, OUT2 goes low. |

## Pin Description (continued)

| PIN | | | NAME | FUNCTION |
|---|---|---|---|---|
| MAX16041 | MAX16042 | MAX16043 | | |
| 11 | 14 | 17 | OUT1 | Output 1. When the voltage at IN1 is below its threshold or EN1 goes low, OUT1 goes low. |
| 12 | 15 | 18 | $\overline{\text{RESET}}$ | Active-Low Reset Output. $\overline{\text{RESET}}$ asserts low when any of the monitored voltages (IN_) falls below its respective threshold, any EN_ goes low, or $\overline{\text{MR}}$ is asserted. $\overline{\text{RESET}}$ remains asserted for the reset timeout period after all of the monitored voltages exceed their respective threshold, all EN_ are high, all OUT_ are high, and $\overline{\text{MR}}$ is deasserted. |
| 13 | 16 | 19 | $\overline{\text{MR}}$ | Active-Low Manual Reset Input. Pull $\overline{\text{MR}}$ low to assert $\overline{\text{RESET}}$ low. $\overline{\text{RESET}}$ remains low for the reset timeout period after $\overline{\text{MR}}$ is deasserted (as long as all OUT_ are high). |
| 14 | 17 | 20 | CRESET | Capacitor-Adjustable Reset Delay Input. Connect an external capacitor from CRESET to GND to set the reset timeout period or connect to $V_{CC}$ for the default 140ms minimum reset timeout period. Leave CRESET open for internal propagation delay. |
| — | — | 21 | CDLY4 | Capacitor-Adjustable Delay Input 4. Connect an external capacitor from CDLY4 to GND to set the IN4 to OUT4 (and EN4 to OUT4) delay period. Leave CDLY4 open for internal propagation delay. |
| — | 18 | 22 | CDLY3 | Capacitor-Adjustable Delay Input 3. Connect an external capacitor from CDLY3 to GND to set the IN3 to OUT3 (and EN3 to OUT3) delay period. Leave CDLY3 open for internal propagation delay. |
| 15 | 19 | 23 | CDLY2 | Capacitor-Adjustable Delay Input 2. Connect an external capacitor from CDLY2 to GND to set the IN2 to OUT2 (and EN2 to OUT2) delay period. Leave CDLY2 open for internal propagation delay. |
| 16 | 20 | 24 | CDLY1 | Capacitor-Adjustable Delay Input 1. Connect an external capacitor from CDLY1 to GND to set the IN1 to OUT1 (and EN1 to OUT1) delay period. Leave CDLY1 open for internal propagation delay. |
| — | — | — | EP | Exposed Pad. EP is internally connected to GND. Connect EP to the ground plane. |

## Detailed Description

The MAX16041/MAX16042/MAX16043 are low-voltage, accurate, dual-/triple-/quad-voltage microprocessor (µP) supervisors in a small TQFN package. These devices provide supervisory and sequencing functions for complex multivoltage systems. The MAX16041 monitors two voltages, the MAX16042 monitors three voltages, and the MAX16043 monitors four voltages.

The MAX16041/MAX16042/MAX16043 offer independent outputs and enable functions for each monitored voltage. This configuration allows the device to operate as four separate supervisory circuits or be daisy-chained together to allow controlled sequencing of power supplies during power-up initialization. When all of the monitored voltages exceed their respective thresholds, an independent reset output deasserts to allow the system processor to operate.

These devices offer enormous flexibility as there are nine threshold options that are selected through two threshold-select logic inputs. Each monitor circuit also offers an independent enable input to allow both digital and analog control of each monitor output. A tolerance select input allows these devices to be used in systems requiring 5% or 10% power-supply tolerances. In addition, the time delays and reset timeout can be adjusted using small capacitors. There is also a fixed 140ms minimum reset timeout feature.

# Dual-/Triple-/Quad-Voltage, Capacitor-Adjustable, Sequencing/Supervisory Circuits

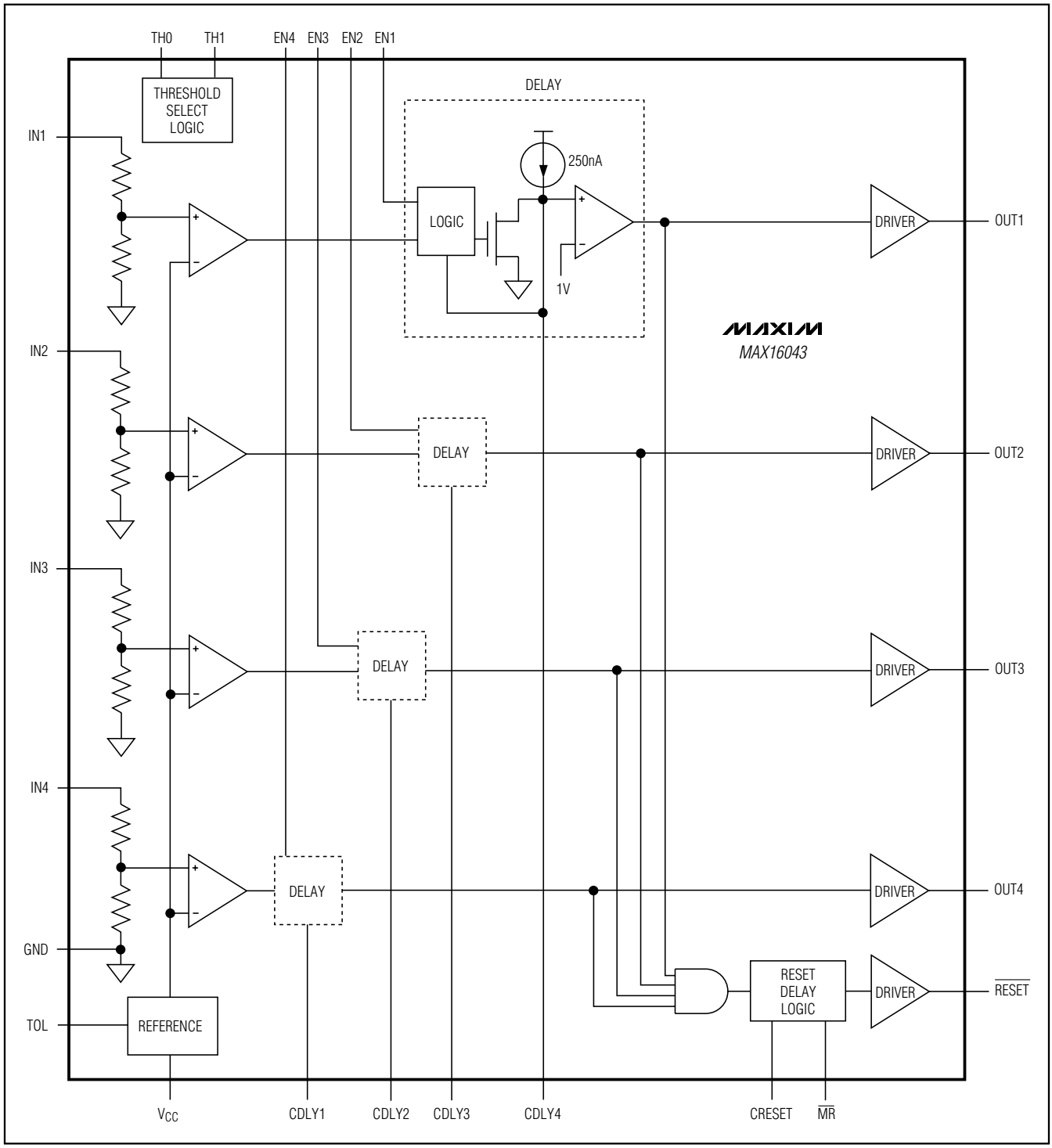



*Figure 1. MAX16043 Simplified Functional Diagram*

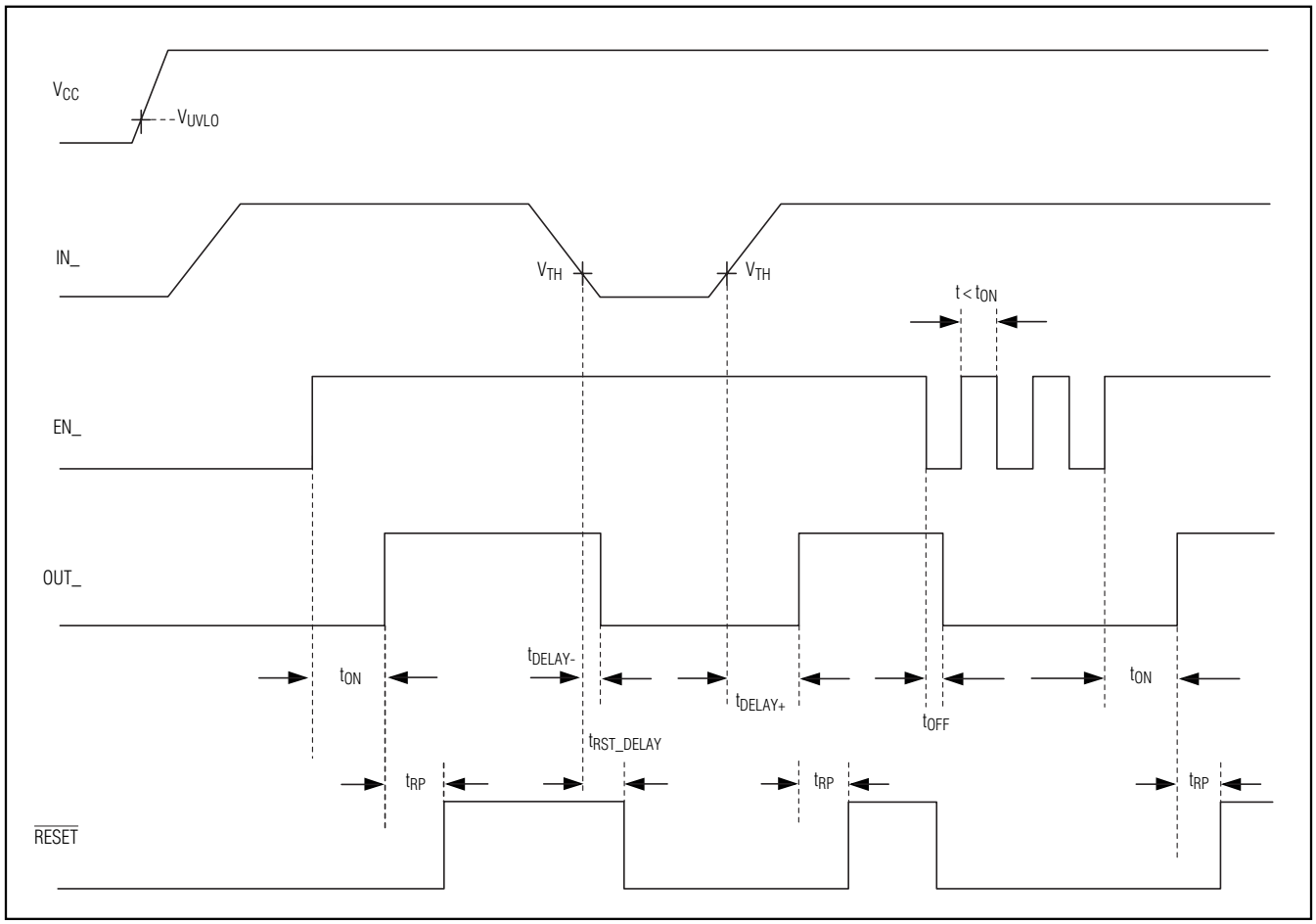



*Figure 2. Timing Diagram (CDLY_ Open)*

## Applications Information

### Tolerance

The MAX16041/MAX16042/MAX16043 feature a pin-selectable threshold tolerance. Connect TOL to GND to select the thresholds 5% below the nominal value. Connect TOL to $V_{CC}$ to select the threshold tolerance 10% below the nominal voltage. Do not leave TOL unconnected.

### Adjustable Input

These devices offer several monitoring options with both fixed and/or adjustable reset thresholds (see Table 2). For the adjustable threshold inputs, the threshold voltage ($V_{TH}$) at each adjustable IN_ input is typically 0.5V (TOL = GND) or 0.472V (TOL = $V_{CC}$). To monitor a voltage $V_{INTH}$, connect a resistive divider network to the circuit as shown in Figure 3 and use the following equation to calculate the threshold voltage:

$$V_{INTH} = V_{TH} \times \left(1 + \frac{R1}{R2}\right)$$

Choosing the proper external resistors is a balance between accuracy and power use. The input to the voltage monitor is a high-impedance input with a small 100nA leakage current. This leakage current contributes to the overall error of the threshold voltage where the output is asserted. This induced error is proportional to the value of the resistors used to set the threshold. With lower value resistors, this error is reduced, but the amount of power consumed in the resistors increases.

# Dual-/Triple-/Quad-Voltage, Capacitor-Adjustable, Sequencing/Supervisory Circuits

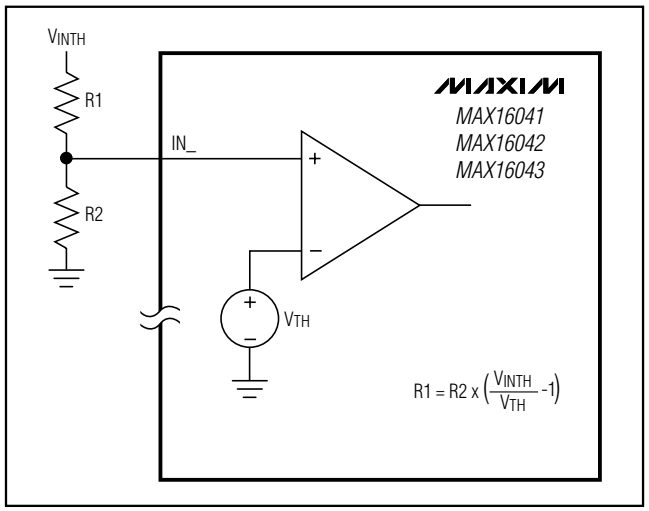



*Figure 3. Setting the Adjustable Input*

The following equation is provided to help estimate the value of the resistors based on the amount of acceptable error:

$$R1 = \frac{e_A \times V_{INTH}}{I_L}$$

where $e_A$ is the fraction of the maximum acceptable absolute resistive divider error attributable to the input leakage current (use 0.01 for ±1%), $V_{INTH}$ is the voltage at which the output (OUT_) should assert, and $I_L$ is the worst-case IN_ leakage current (see the *Electrical Characteristics*). Calculate R2 as follows:

$$R2 = \frac{V_{TH} \times R1}{V_{INTH} - V_{TH}}$$

### Unused Inputs

Connect any unused IN_ and EN_ inputs to $V_{CC}$.

### OUT_ Output

The MAX16041/MAX16042/MAX16043 feature open-drain outputs. An OUT_ goes low when its respective IN_ input voltage drops below its specified threshold or when its EN_ goes low (see Table 1). OUT_ goes high when EN_ is high and $V_{IN\_}$ is above its threshold after a time delay. Open-drain outputs require an external pullup resistor to any voltage from 0 to 28V.

## Table 1. Output State*

| EN_ | IN_ | OUT_ |
|---|---|---|
| Low | $V_{IN\_} < V_{TH}$ | Low |
| High | $V_{IN\_} < V_{TH}$ | Low |
| Low | $V_{IN\_} > V_{TH}$ | Low |
| High | $V_{IN\_} > V_{TH}$ | OUT_ = high impedance |

**When $V_{CC}$ falls below the UVLO, all outputs go low regardless of the state of EN_ and $V_{IN\_}$. The outputs are guaranteed to be in the correct state for $V_{CC}$ down to 1.2V.*

## Table 2. Input-Voltage Threshold Selector

| TH1/TH0 LOGIC | IN1 (ALL VERSIONS) (V) | IN2 (ALL VERSIONS) (V) | IN3 (MAX16042) (V) | IN4 (MAX16043) (V) |
|---|---|---|---|---|
| Low/Low | 3.3 | 2.5 | 1.8 | 1.5 |
| Low/High | 3.3 | 1.8 | Adj | Adj |
| Low/Open | 3.3 | 1.5 | Adj | Adj |
| High/Low | 3.3 | 1.2 | 1.8 | 2.5 |
| High/High | 2.5 | 1.8 | Adj | Adj |
| High/Open | 3.3 | Adj | 2.5 | Adj |
| Open/Low | 3.3 | Adj | Adj | Adj |
| Open/High | 2.5 | Adj | Adj | Adj |
| Open/Open | Adj | Adj | Adj | Adj |

### $\overline{\text{RESET}}$ Output

$\overline{\text{RESET}}$ asserts low when any of the monitored voltages (IN_) falls below its respective threshold, any EN_ goes low, or $\overline{\text{MR}}$ is asserted. $\overline{\text{RESET}}$ remains asserted for the reset timeout period after all of the monitored voltages exceed their respective thresholds, all EN_ are high, all OUT_ are high, and $\overline{\text{MR}}$ is deasserted. All devices have a push-pull, active-low reset output.

### Adjustable Reset Timeout Period (CRESET)

All of these parts offer an internally fixed reset timeout (140ms min) by connecting CRESET to $V_{CC}$. The reset timeout can also be adjusted by connecting a capacitor from CRESET to GND. When the voltage at CRESET reaches 0.5V, $\overline{RESET}$ goes high. When $\overline{RESET}$ goes high, CRESET is immediately held low.

Calculate the reset timeout period as follows:

$$t_{RP} = \frac{V_{TH\text{-}RESET}}{I_{CH\text{-}RESET}} \times C_{CRESET} + 30 \times 10^{-6}$$

where $V_{TH\text{-}RESET}$ is 0.5V, $I_{CH\text{-}RESET}$ is 0.5µA, $t_{RP}$ is in seconds, and $C_{CRESET}$ is in Farads. To ensure timing accuracy and proper operation, minimize leakage at $C_{CRESET}$.

### Adjustable Delay (CDLY_)

When $V_{IN}$ rises above $V_{TH}$ with EN_ high, the internal 250nA current source begins charging an external capacitor connected from CDLY_ to GND. When the voltage at CDLY_ reaches 1V, OUT_ goes high. When OUT_ goes high, CDLY_ is immediately held low. Adjust the delay ($t_{DELAY}$) from when $V_{IN}$ rises above $V_{TH}$ (with EN_ high) to OUT_ going high according to the equation:

$$t_{DELAY} = \frac{V_{TH\text{-}CDLY}}{I_{CH\text{-}CDLY}} \times C_{CDLY} + 35 \times 10^{-6}$$

where $V_{TH\text{-}CDLY}$ is 1V, $I_{CH\text{-}CDLY}$ is 0.25µA, $C_{CDLY}$ is in Farads, and $t_{DELAY}$ is in seconds. To ensure timing accuracy and proper operation, minimize leakage at CDLY.

### Manual-Reset Input ($\overline{MR}$)

Many µP-based products require manual-reset capability, allowing the operator, a test technician, or external logic circuitry to initiate a reset. A logic-low on $\overline{MR}$ asserts $\overline{RESET}$ low. $\overline{RESET}$ remains asserted while $\overline{MR}$ is low and during the reset timeout period (140ms fixed or capacitor adjustable) after $\overline{MR}$ returns high. The $\overline{MR}$ input has a 500nA internal pullup, so it can be left unconnected, if not used. $\overline{MR}$ can be driven with TTL or CMOS logic levels, or with open-drain/collector outputs. Connect a normally open momentary switch from $\overline{MR}$ to GND to create a manual-reset function. External debounce circuitry is not required. If $\overline{MR}$ is driven from long cables or if the device is used in a noisy environment, connect a 0.1µF capacitor from $\overline{MR}$ to GND to provide additional noise immunity.

### Pullup Resistor Values

The exact value of the pullup resistors for the open-drain outputs is not critical, but some consideration should be made to ensure the proper logic levels when the device is sinking current. For example, if $V_{CC}$ = 2.25V and the pullup voltage is 28V, keep the sink current less than 0.5mA as shown in the *Electrical Characteristics*. As a result, the pullup resistor should be greater than 56kΩ. For a 12V pullup, the resistor should be larger than 24kΩ. Note that the ability to sink current is dependent on the $V_{CC}$ supply voltage.

### Power-Supply Bypassing

The device operates with a $V_{CC}$ supply voltage from 2.2V to 28V. When $V_{CC}$ falls below the UVLO threshold, all the outputs go low and stay low until $V_{CC}$ falls below 1.2V. For noisy systems or fast rising transients on $V_{CC}$, connect a 0.1µF ceramic capacitor from $V_{CC}$ to GND as close to the device as possible to provide better noise and transient immunity.

### Ensuring Valid Reset Output with $V_{CC}$ Down to 0V

When $V_{CC}$ falls below 1.2V, the ability for the output to sink current decreases. To ensure a valid output as $V_{CC}$ falls to 0V, connect a 100kΩ resistor from $\overline{RESET}$ to GND.

### Typical Application Circuits

Figures 4 and 5 show typical applications for the MAX16041/MAX16042/MAX16043. In high-power applications, using an n-channel device reduces the loss across the MOSFETs as it offers a lower drain-to-source on-resistance. However, an n-channel MOSFET requires a sufficient $V_{GS}$ voltage to fully enhance it for a low $R_{DS\_ON}$. The application in Figure 4 shows the MAX16042 configured in a multiple-output sequencing application. Figure 5 shows the MAX16043 in a power-supply sequencing application using n-channel MOSFETs.

# Dual-/Triple-/Quad-Voltage, Capacitor-Adjustable, Sequencing/Supervisory Circuits

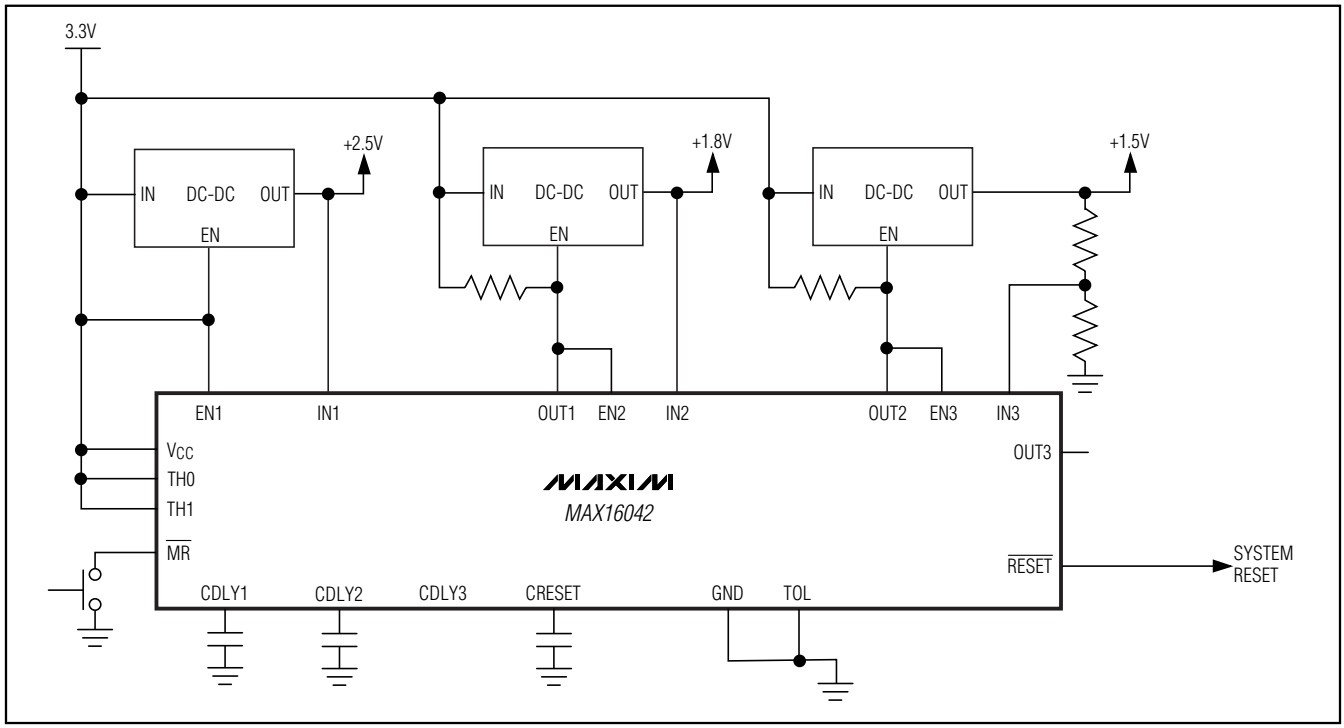



*Figure 4. Sequencing Multiple-Voltage System*

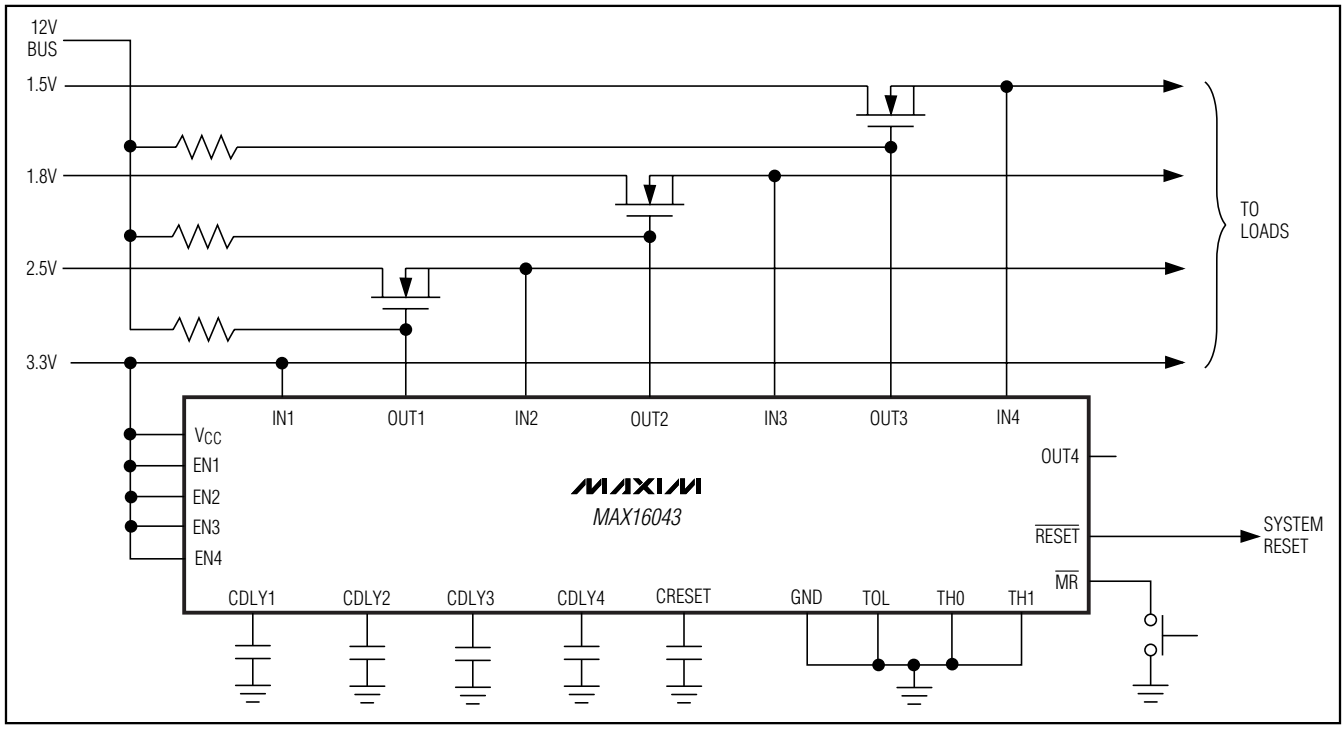
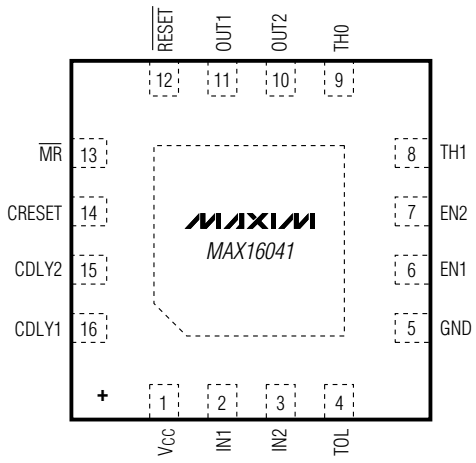


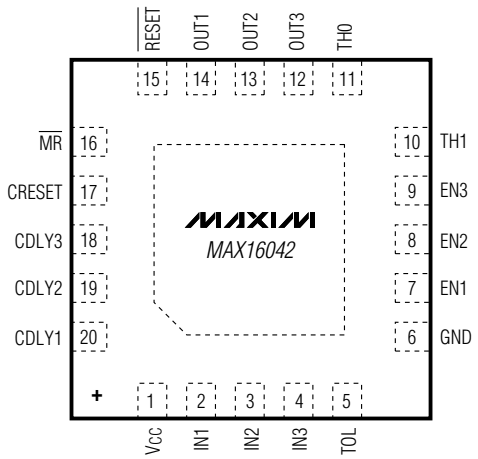

*Figure 5. Multiple-Voltage Sequencing Using n-Channel FETs*

## Pin Configurations (continued)

TOP VIEW




**TQFN**
**(4mm x 4mm)**




**TQFN**
**(4mm x 4mm)**

## Chip Information

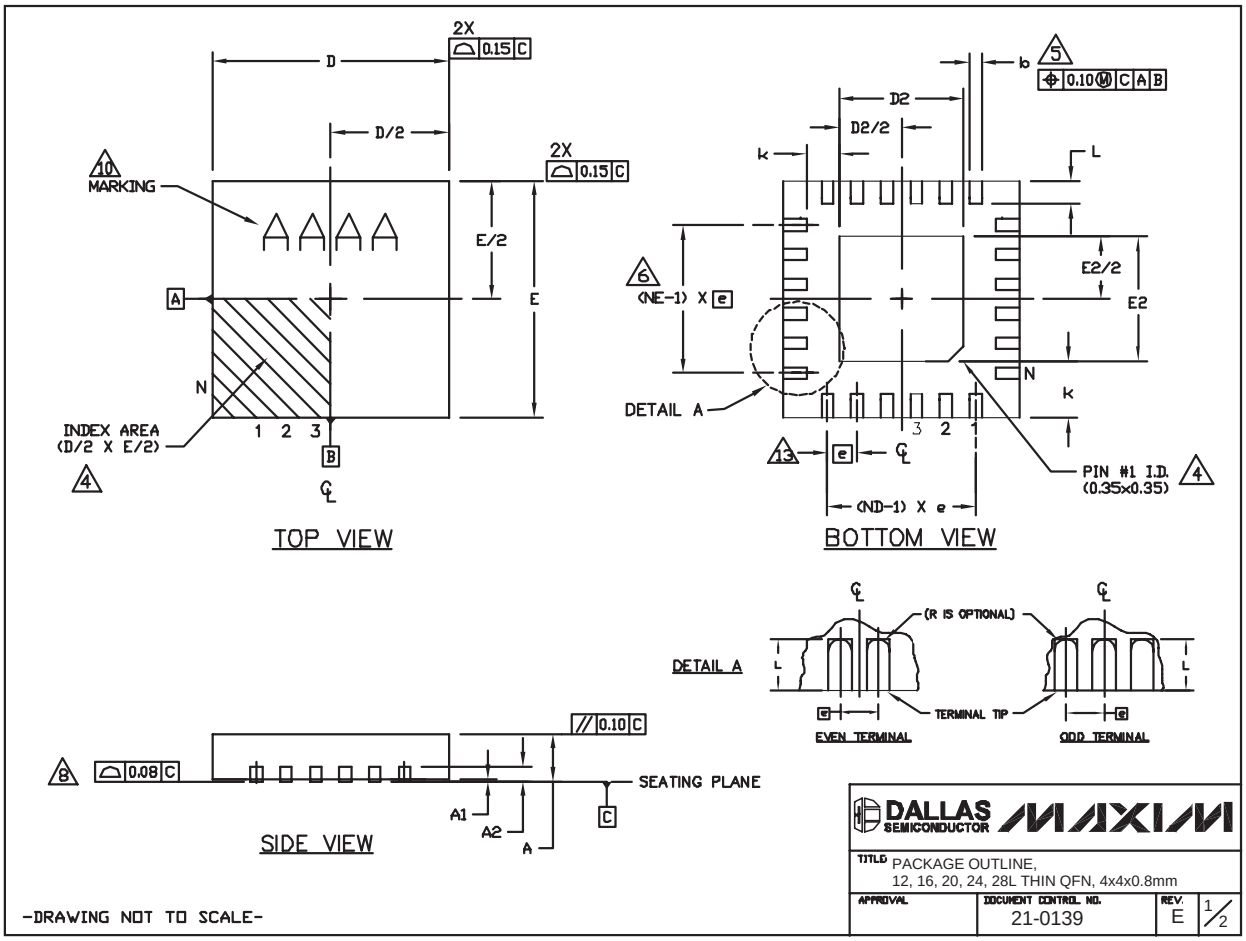
PROCESS: BICMOS

# Dual-/Triple-/Quad-Voltage, Capacitor-Adjustable, Sequencing/Supervisory Circuits

## Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information go to **www.maxim-ic.com/packages**.)

24L QFN THIN.EPS



## Package Information (continued)

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information go to **www.maxim-ic.com/packages**.)

| COMMON DIMENSIONS | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PKG | 12L 4x4 | | | 16L 4x4 | | | 20L 4x4 | | | 24L 4x4 | | | 28L 4x4 | | | |
| REF. | MIN. | NOM. | MAX. | MIN. | NOM. | MAX. | MIN. | NOM. | MAX. | MIN. | NOM. | MAX. | MIN. | NOM. | MAX. | |
| A | 0.70 | 0.75 | 0.80 | 0.70 | 0.75 | 0.80 | 0.70 | 0.75 | 0.80 | 0.70 | 0.75 | 0.80 | 0.70 | 0.75 | 0.80 | |
| A1 | 0.0 | 0.02 | 0.05 | 0.0 | 0.02 | 0.05 | 0.0 | 0.02 | 0.05 | 0.0 | 0.02 | 0.05 | 0.0 | 0.02 | 0.05 | |
| A2 | 0.20 REF | | | 0.20 REF | | | 0.20 REF | | | 0.20 REF | | | 0.20 REF | | | |
| b | 0.25 | 0.30 | 0.35 | 0.25 | 0.30 | 0.35 | 0.20 | 0.25 | 0.30 | 0.18 | 0.23 | 0.30 | 0.15 | 0.20 | 0.25 | |
| D | 3.90 | 4.00 | 4.10 | 3.90 | 4.00 | 4.10 | 3.90 | 4.00 | 4.10 | 3.90 | 4.00 | 4.10 | 3.90 | 4.00 | 4.10 | |
| E | 3.90 | 4.00 | 4.10 | 3.90 | 4.00 | 4.10 | 3.90 | 4.00 | 4.10 | 3.90 | 4.00 | 4.10 | 3.90 | 4.00 | 4.10 | |
| e | 0.80 BSC. | | | 0.65 BSC. | | | 0.50 BSC. | | | 0.50 BSC. | | | 0.40 BSC. | | | |
| k | 0.25 | - | - | 0.25 | - | - | 0.25 | - | - | 0.25 | - | - | 0.25 | - | - | |
| L | 0.45 | 0.55 | 0.65 | 0.45 | 0.55 | 0.65 | 0.45 | 0.55 | 0.65 | 0.30 | 0.40 | 0.50 | 0.30 | 0.40 | 0.50 | |
| N | 12 | | | 16 | | | 20 | | | 24 | | | 28 | | | |
| ND | 3 | | | 4 | | | 5 | | | 6 | | | 7 | | | |
| NE | 3 | | | 4 | | | 5 | | | 6 | | | 7 | | | |
| Jedec Var. | WGGB | | | WGGC | | | WGGD-1 | | | WGGD-2 | | | WGGE | | | |

| EXPOSED PAD VARIATIONS | | | | | | | |
|---|---|---|---|---|---|---|---|
| PKG. CODES | D2 | | | E2 | | | DOWN BONDS ALLOWED |
| | MIN. | NOM. | MAX. | MIN. | NOM. | MAX. | |
| T1244-3 | 1.95 | 2.10 | 2.25 | 1.95 | 2.10 | 2.25 | YES |
| T1244-4 | 1.95 | 2.10 | 2.25 | 1.95 | 2.10 | 2.25 | NO |
| T1644-3 | 1.95 | 2.10 | 2.25 | 1.95 | 2.10 | 2.25 | YES |
| T1644-4 | 1.95 | 2.10 | 2.25 | 1.95 | 2.10 | 2.25 | NO |
| T2044-2 | 1.95 | 2.10 | 2.25 | 1.95 | 2.10 | 2.25 | YES |
| T2044-3 | 1.95 | 2.10 | 2.25 | 1.95 | 2.10 | 2.25 | NO |
| T2444-2 | 1.95 | 2.10 | 2.25 | 1.95 | 2.10 | 2.25 | YES |
| T2444-3 | 2.45 | 2.60 | 2.63 | 2.45 | 2.60 | 2.63 | YES |
| T2444-4 | 2.45 | 2.60 | 2.63 | 2.45 | 2.60 | 2.63 | NO |
| T2844-1 | 2.50 | 2.60 | 2.70 | 2.50 | 2.60 | 2.70 | NO |

NOTES:

1. DIMENSIONING & TOLERANCING CONFORM TO ASME Y14.5M-1994.
2. ALL DIMENSIONS ARE IN MILLIMETERS. ANGLES ARE IN DEGREES.
3. N IS THE TOTAL NUMBER OF TERMINALS.
4. THE TERMINAL #1 IDENTIFIER AND TERMINAL NUMBERING CONVENTION SHALL CONFORM TO JESD 95-1 SPP-012. DETAILS OF TERMINAL #1 IDENTIFIER ARE OPTIONAL, BUT MUST BE LOCATED WITHIN THE ZONE INDICATED. THE TERMINAL #1 IDENTIFIER MAY BE EITHER A MOLD OR MARKED FEATURE.
5. DIMENSION b APPLIES TO METALLIZED TERMINAL AND IS MEASURED BETWEEN 0.25 mm AND 0.30 mm FROM TERMINAL TIP.
6. ND AND NE REFER TO THE NUMBER OF TERMINALS ON EACH D AND E SIDE RESPECTIVELY.
7. DEPOPULATION IS POSSIBLE IN A SYMMETRICAL FASHION.
8. COPLANARITY APPLIES TO THE EXPOSED HEAT SINK SLUG AS WELL AS THE TERMINALS.
9. DRAWING CONFORMS TO JEDEC MO220, EXCEPT FOR T2444-3, T2444-4 AND T2844-1.
10. MARKING IS FOR PACKAGE ORIENTATION REFERENCE ONLY.
11. COPLANARITY SHALL NOT EXCEED 0.08mm
12. WARPAGE SHALL NOT EXCEEND 0.10mm
13. LEAD CENTERLINES TO BE AT TRUE POSITION AS DEFINED BY BASIC DIMENSION "e", ±0.05.
14. NUMBER OF LEADS SHOWN ARE FOR REFERENCE ONLY

-DRAWING NOT TO SCALE-

DALLAS SEMICONDUCTOR MAXIM

| TITLE: PACKAGE OUTLINE, 12, 16, 20, 24, 28L THIN QFN, 4x4x0.8mm | | | |
|---|---|---|---|
| APPROVAL | DOCUMENT CONTROL NO. 21-0139 | REV. E | 2/2 |

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