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MAX16136

High-Precision Supervisory ICs with Window Watchdog and Overvoltage Indicator

General Description

The MAX16136, a low voltage, ±1% accurate window-detector supervisor circuit monitors a single system supply voltage and the integrity of code execution by a microprocessor or microcontroller. This device features an active-low, open-drain output that asserts whenever the monitored supply rail falls outside of the factory-trimmed undervoltage/overvoltage window threshold. The reset output remain asserted for the programmed reset timeout period after the monitored supply voltage falls within the undervoltage/overvoltage window threshold.

The MAX16136 offers factory-trimmed voltage thresholds from 0.5V to 5V in approximately 20mV increment. A variety of factory trimmed undervoltage/overvoltage thresholds from ±4% to ±11% are available to accommodate different supply voltages and tolerances.

A window-watchdog timer circuit monitors microprocessor or microcontroller activity. During normal operation, the microprocessor or microcontroller must repeatedly toggle the watchdog input (WDI) low within the fast watchdog timeout (t_{WD_F}) and slow watchdog timeout (t_{WD_S}). If the microcontroller or microprocessor does not toggle WDI within the window-timeout period, the supervisor asserts the watchdog output ($\overline{WDO}$) to signal that the system is not executing code as expected. The watchdog output pulse can be used to reset the microprocessor or microcontroller, or it may be used to interrupt the system to warn of execution errors.

In addition, the MAX16136 features an overvoltage fault output ($\overline{OV}$) that latches low when the monitored rail exceeds the overvoltage threshold. The latched output can be cleared by pulling $\overline{CLR}$ low.

The MAX16136 is available in a small, 2mm x 2mm, 8-pin TDFN side-wettable package with exposed pad and operates over the automotive temperature range of -40°C to +125°C.

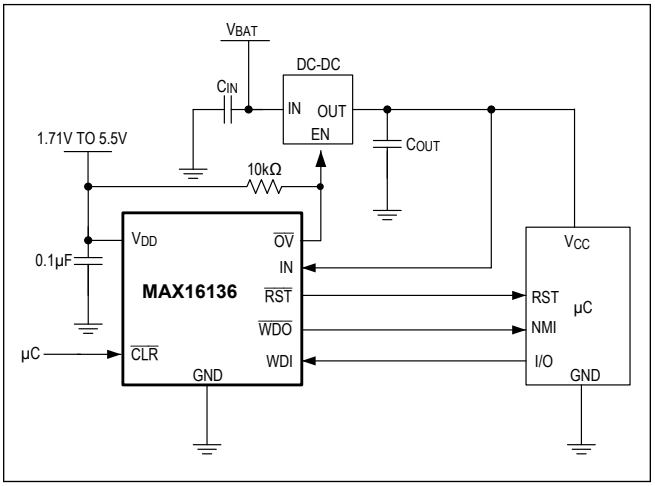
Applications

- Advanced Driver-Assistance Systems (ADAS)
- Automotive
- Multivoltage ASICs
- Servers
- Storage Equipment

Benefits and Features

- ±1% Accuracy
- Enables ASIL Compliance at System Level
  - FMEDA Results Available upon Request
- 0.5V to 5V Threshold Range with 20mV Increments
- ±4% to ±11% Undervoltage/Overvoltage Thresholds
- Latched Overvoltage Fault Output
- Clear Fault Input
- 5µs Overvoltage Fault Delay
- Window Watchdog Timeout
- Factory-Set Reset Timeout
- Open-Drain Reset Output
- 8-Pin TDFN Side-Wettable Package
- -40°C to +125°C Operating Temperature Range

Typical Application Circuit



Ordering Information appears at end of data sheet.

19-100580; Rev 2; 12/21

Absolute Maximum Ratings

V_{DD} to GND ..... -0.3V to +6V
IN, WDO, RST, CLR, OV, WDI to GND ..... -0.3V to +6V
Input/Output Continuous Current, WDO, RST, CLR, OV, WDI ..... ±20mA
Continuous Power Dissipation (T_A = +70°C)
TDFN (derate 11.7mW/°C above 70°C) 937.9mW
Operating Temperature Range ..... -40°C to +125°C
Junction Temperature ..... +150°C
Soldering Temperature (Reflow) ..... +260°C
Storage Temperature Range ..... -65°C to +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.

Package Information

8 TDFN

Package Code	T822Y+3C
Outline Number	**21-100185**
Land Pattern Number	**90-100070**
Thermal Resistance, Four-Layer Board:	
Junction to Ambient (θ_{JA})	85.3°C/W
Junction to Case (θ_{JC})	8.9°C/W

For the latest package outline information and land patterns (footprints), go to ***www.maximintegrated.com/packages***. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

Package thermal resistances were obtained using the method described in JEDEC specification JESD51-7, using a four-layer board. For detailed information on package thermal considerations, refer to ***www.maximintegrated.com/thermal-tutorial***.

Electrical Characteristics

(V_{DD} = 1.71V to 5.5V. T_A = T_J = -40°C to +125°C, unless otherwise noted. Typical values are at T_A = +25°C under normal conditions, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
POWER SUPPLY						
Operating Voltage Range	V_{DD}	Comparators functional	1.71		5.5	V
		Output guaranteed to be at known state	1.1			
Supply Current	I_{DD}	$\overline{RST}$, $\overline{OV}$, $\overline{WDO}$ not asserted		15	35	µA
Undervoltage Lockout Threshold	V_{UVLO}	V_{DD} rising	1.3	1.50	1.68	V
Undervoltage Lockout Hysteresis	V_{UVLO_HYS}	V_{DD} falling		47		mV
INPUT VOLTAGE (IN)						
Nominal Input Threshold Voltage Range	V_{IN_NOM}		0.5		5	V
Nominal Input Threshold Voltage Programming Step	$V_{IN\_NOM\_STEP}$			20		mV
Undervoltage/ Overvoltage Programming Range	TOL	Reset occurs when V_{IN_NOM} falls outside of V_{IN_NOM} x (1 ± TOL)	±4		±11	% of V_{IN_NOM}
INPUT THRESHOLD ACCURACY						
Undervoltage Threshold Accuracy	V_{UVTH_A}	All V_{IN_TH} setting, V_{IN_NOM} falling, V_{UVTH} = V_{IN_NOM} x ($\overline{1}$ - TOL%)	-1		+1	%
Overvoltage Threshold Accuracy	V_{OVTH_A}	All V_{IN_TH} setting, V_{IN_NOM} rising, V_{OVTH} = V_{IN_NOM} x ($\overline{1}$ + TOL%)	-1		+1	%
Undervoltage/ Overvoltage Hysteresis	V_{HYS}			0.25		$\%V_{TH}$
Input Current	I_{IN}			1.3	5	µA
Overvoltage Fault-to-$\overline{OV}$ Assert Delay	$t_{OV\ DLY}$	(V_{OVTH} - 1%) to (V_{OVTH} + 1%)		5		µs
$\overline{OV}$ Fault Glitch Immunity		V_{OVTH} + 5%		200		ns
$\overline{RST}$ Leakage Current		$V_{\overline{RST}}$ = $V_{\overline{OV}}$ = $V_{\overline{WDO}}$ = 5.5V		0.01	1	µA
CLEAR INPUT ($\overline{CLR}$)						
$\overline{CLR}$ Input Glitch Immunity			50			ns
$\overline{CLR}$ Minimum Input Pulse Width	t_{CLR}	(*Note 1*) (*Note 2*)	0.4			µs
$\overline{CLR}$ Internal Pullup Resistance				50		kΩ
WATCHDOG						
Fast Watchdog Timeout Accuracy	t_{WD_F}	V_{DD} = 3.3V (*Note 3*)	-20		+20	%
Slow Watchdog Timeout Accuracy	t_{WD_S}	V_{DD} = 3.3V (*Note 3*)	-20		+20	%
Minimum Watchdog Input Pulse		After $\overline{WDO}$ asserts	24			µs

Electrical Characteristics (continued)

(V_{DD} = 1.71V to 5.5V. T_A = T_J = -40°C to +125°C, unless otherwise noted. Typical values are at T_A = +25°C under normal conditions, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
$\overline{WDO}$ Pulse Duration	t_{WDOF}	WDI Input signal period < t_{WD_F}			50		ms
	t_{WDOS}	WDI Input signal period > t_{WD_S}			100		
RESET OUTPUT ($\overline{RST}$)							
Reset Timeout Period Accuracy	t_{RP}	From time V_{IN} enters overvoltage/undervoltage threshold-window to time $\overline{RST}$ goes high, V_{DD} = 3.3V		-20		+20	%
IN-to-$\overline{RST}$ Propagation Delay	t_D	(V_{OVTH} - 1%) to (V_{OVTH} + 1%)			5		µs
IN-to-$\overline{RST}$ Reset Propagation Delay	t_D	(V_{UVTH} + 1%) to (V_{UVTH} - 1%)			15		µs
INPUT VOLTAGE (WDI, $\overline{CLR}$)							
WDI, $\overline{CLR}$ Input Voltage Low						0.3 x V_{DD}	V
WDI, $\overline{CLR}$ Input Voltage High				0.7 x V_{DD}			V
WDI, $\overline{CLR}$ Leakage Current				-1		+1	µA
OUTPUT VOLTAGE ($\overline{RST}$, $\overline{WDO}$, $\overline{OV}$)							
Output Voltage Low	V_{OL}	$\overline{RST}$, $\overline{OV}$, $\overline{WDO}$	V_{DD} = 5V, I_{SINK} = 3mA		0.1	0.3	V
			V_{DD} = 1.71V, I_{SINK} = 8µA		0.1	0.3	
		$\overline{RST}$	V_{DD} = 1.1V, I_{SINK} = 8µA		0.1	0.3	

Note 1: Minimum pulse required to clear $\overline{OV}$ latched state. No overvoltage fault present and $\overline{RST}$ = high.

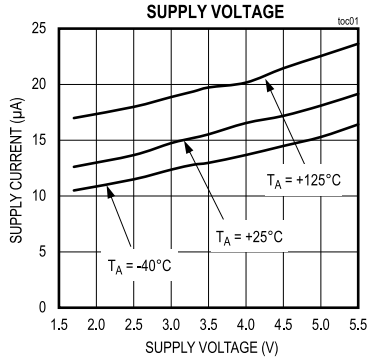
Note 2: Pulling $\overline{CLR}$ low for a pulse width duration t_{CLR} > 5µs asserts $\overline{RST}$. A consecutive series of pulses on $\overline{CLR}$ with low pulse width duration of t_{CLR} > 5µs must be separated by high pulse width duration > t_{RP} for valid reset operation.

Note 3: The margin for error will be an additional ±30µs due to the internal synchronization logic.

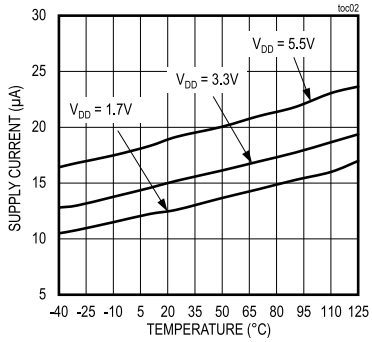
Typical Operating Characteristics

(V_{DD} = 1.71V to 5.5V, T_A = -40°C to +125°C, Typical values are at V_{DD} = 3.3V, unless otherwise specified.)

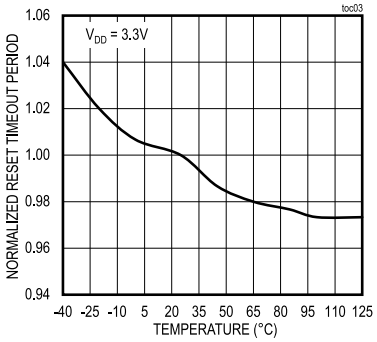
SUPPLY CURRENT vs. SUPPLY VOLTAGE



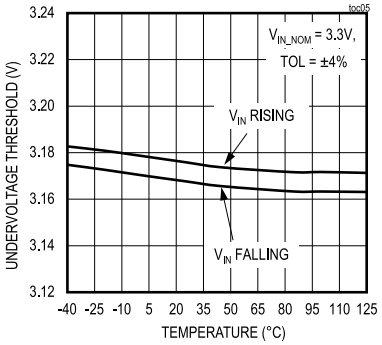
SUPPLY CURRENT vs. TEMPERATURE



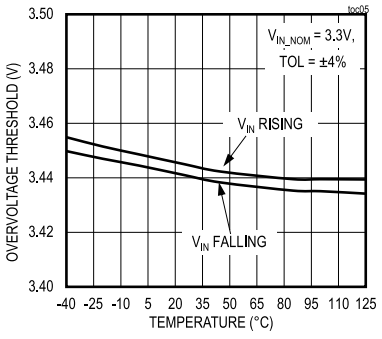
NORMALIZED RESET TIMEOUT PERDIOD PERIOD vs. TEMPERATURE



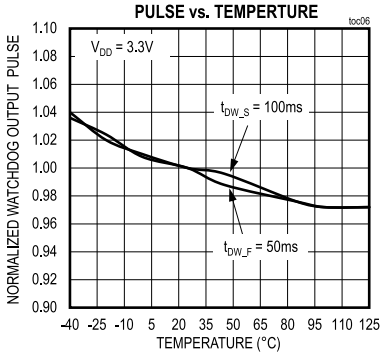
UNDERVOLTAGE THRESHOLD vs. TEMPERATURE



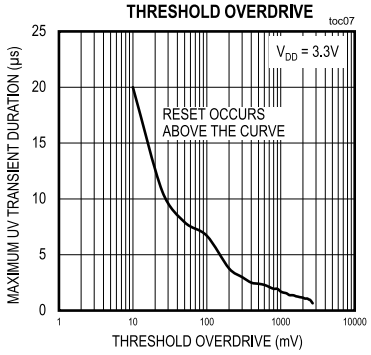
OVERVOLTAGE THRESHOLD vs. TEMPERATURE



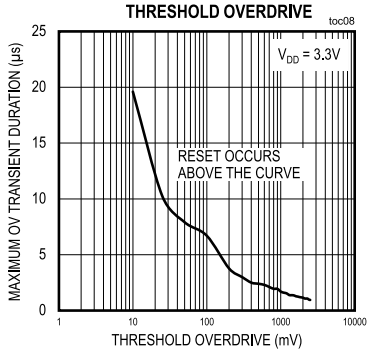
NORMALIZED WATCHDOG OUTPUT PULSE vs. TEMPERTURE



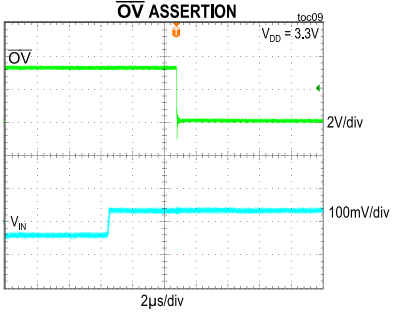
MAXIMUM UV TRANSIENT DURATION vs. THRESHOLD OVERDRIVE



MAXIMUM OV TRANSIENT DURATION vs. THRESHOLD OVERDRIVE

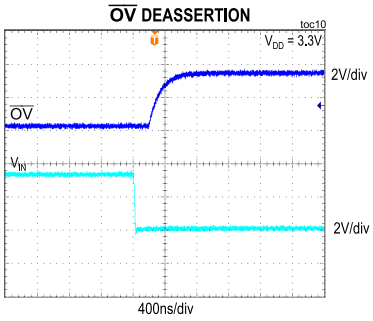


OVERVOLTAGE EVENT TO $\overline{OV}$ ASSERTION



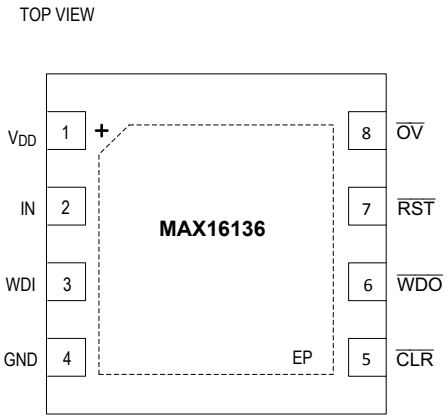
Typical Operating Characteristics (continued)

(V_{DD} = 1.71V to 5.5V, T_A = -40°C to +125°C, Typical values are at V_{DD} = 3.3V, unless otherwise specified.)



Pin Configuration

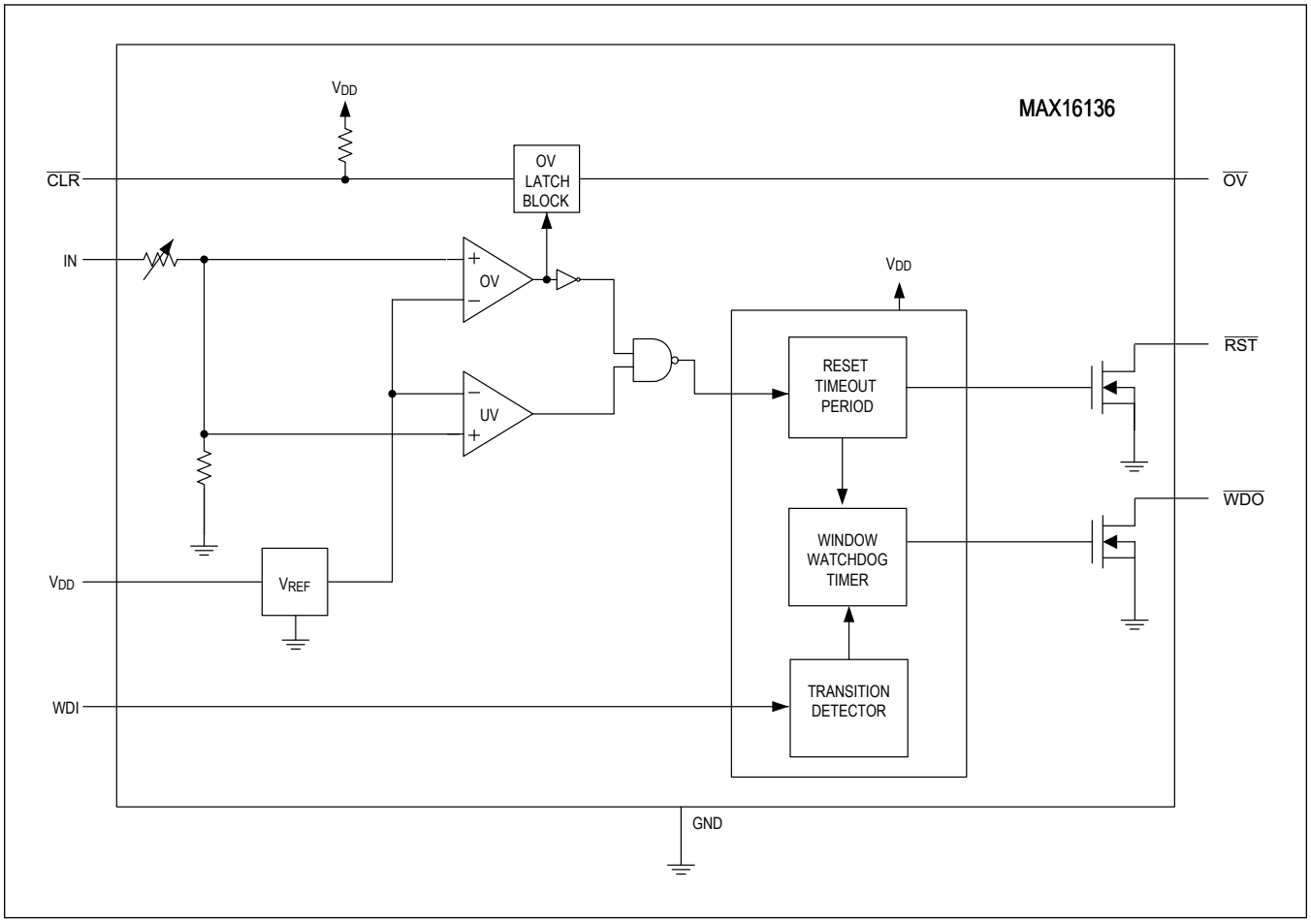
8 TDFN



Pin Description

PIN	NAME	FUNCTION
1	V_{DD}	Supply Input. Bypass V_{DD} to ground with a 0.1µF capacitor.
2	IN	Monitoring Input. IN monitors for undervoltage/overvoltage faults with respect to nominal input threshold. When V_{IN} falls outside the the undervoltage/overvoltage thresholds window, $\overline{RST}$ asserts and stays asserted for reset timeout period after V_{IN} falls within undervoltage/overvoltage thresholds window.
3	WDI	Watchdog Input. The internal watchdog timer clears to zero on the falling edge of WDI or when $\overline{RST}$ goes high. If WDI sees another falling edge within the factory-trimmed watchdog window, $\overline{WDO}$ will remain de-asserted. Transitions outside this window, either faster or slower, will cause $\overline{WDO}$ to pulse low. WDI must not be left floating. Connect to ground with 100kΩ resistor to ensure proper device operation. See *Window Watchdog Operation* for more detail.
4	GND	Ground
5	$\overline{CLR}$	Clear Input. Pull $\overline{CLR}$ low for a pulse duration of t_{CLR} to clear the overvoltage fault output at ($\overline{OV}$) after the overvoltage condition is removed. $\overline{CLR}$ has a 50kΩ internal pull up to V_{DD}.
6	$\overline{WDO}$	Open-Drain Watchdog Output. $\overline{WDO}$ asserts low for 50ms when two consecutive falling transitions on WDI are shorter than t_{WD_F}. $\overline{WDO}$ asserts low for 100ms when two consecutive falling transitions on WDI is longer than t_{WD_S}. See *Window Watchdog Operation* for more detail.
7	$\overline{RST}$	Open-Drain Reset Output. $\overline{RST}$ asserts low when V_{IN} falls outside of the undervoltage/overvoltage threshold's window. The reset output deasserts after the reset timeout period when V_{IN} enters the undervoltage/overvoltage threshold's window.
8	$\overline{OV}$	Overvoltage Fault Output. $\overline{OV}$ latches low when the voltage at IN exceeds the overvoltage threshold setting. To clear the latch, pull $\overline{CLR}$ low for t_{CLR} pulse width duration.
-	EP	Exposed pad. Connect EP to GND to improve heat dissipation capability. Add thermal vias below the exposed pad.

Internal Block Diagram



Detailed Description

The MAX16136 is a high-accuracy supervisory circuit that monitors a single system-supply voltage for factory-trimmed undervoltage/overvoltage window-threshold settings between ±4% to ±11% input tolerance. A reset output ($\overline{RST}$) asserts when the input voltage exceeds the selected tolerance levels and stays asserted for the reset timeout period after the supply voltage falls back within the selected undervoltage/overvoltage window threshold. An overvoltage fault output ($\overline{OV}$) latches low when the supply voltage exceeds the overvoltage threshold level. The latched output can be cleared by pulling the clear input ($\overline{CLR}$) low for t_{CLR} pulse duration. See the *Electrical Characteristics* for more detail.

The MAX16136 includes a window-watchdog timer circuit that monitors microprocessor or microcontroller activity (Figure 1). During normal operation, the microprocessor or microcontroller toggles the watchdog input (WDI) low within the factory-set window of operation. If the watchdog input is strobed faster than the fast watchdog timeout period, the watchdog output ($\overline{WDO}$) pulses low for 50ms (typ). If the watchdog input is strobed slower than the slow watchdog timeout period, the watchdog output pulses low for 100ms (typ).

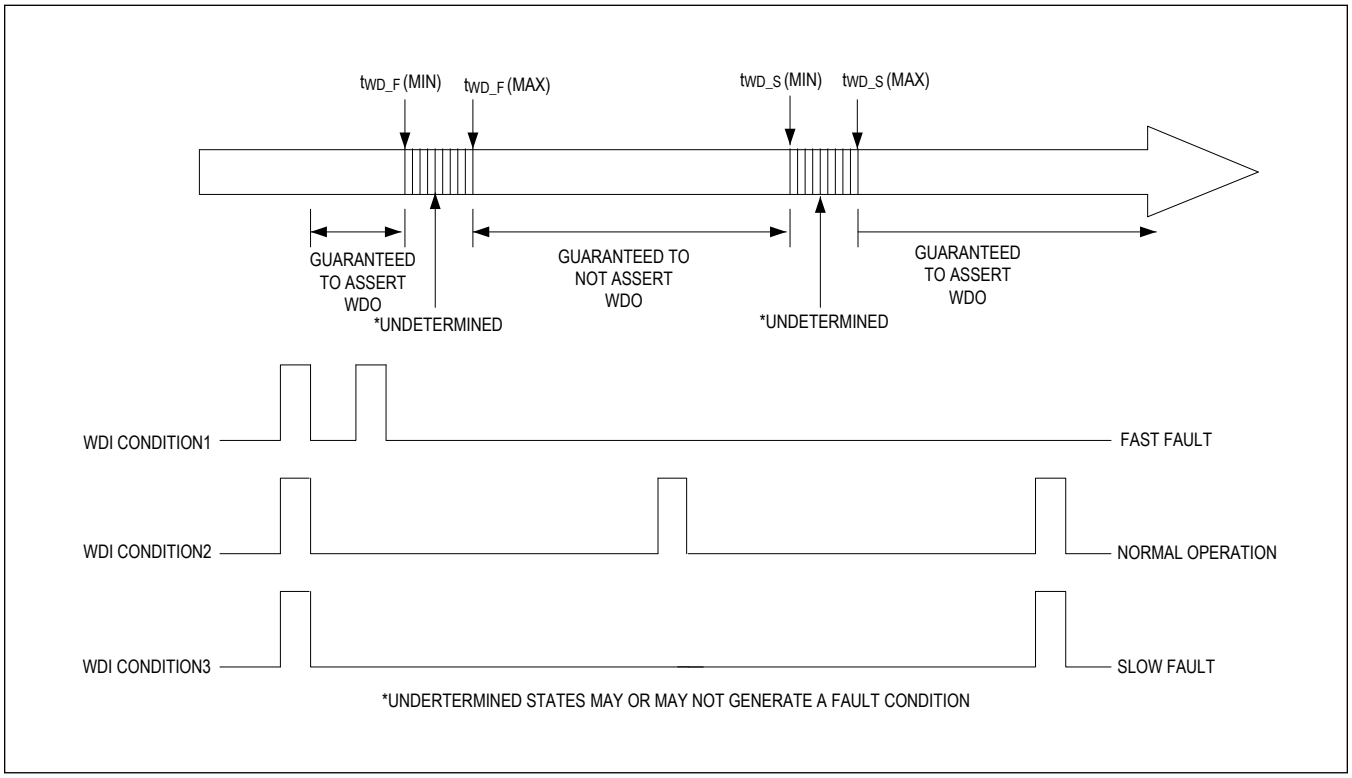


Figure 1. MAX16136 Detailed Watchdog Input Timing Relationship

Nominal Input Threshold Range

The MAX16136 offers a wide range of thresholds for monitoring system voltages from 0.5V to 5V in approximately 20mV increments. Each threshold is factory-trimmed for undervoltage/overvoltage threshold-window between ±4% to ±11% symmetrically with respect to nominal input threshold voltage. Contact Maxim sales for options not listed in the *Ordering Information* table.

Undervoltage/Overvoltage Thresholds

The MAX16136 monitors supply voltage for undervoltage/overvoltge faults with respect to nominal input voltage with ±1% accuracy over the operating temperature and supply ranges. The undervoltage and overvoltage thresholds are factory-trimmed from ±4% to ±11% in ±1% increments. Contact Maxim for threshold not listed in the *Ordering Information* table.

Undervoltage/Overvoltage Threshold Hysteresis

The MAX16136's monitoring input (IN) features undervoltage/overvoltage threshold hysteresis that provides immunity to short input transients. The input hysteresis is factory-set to either 0.25% or 0.5% and is applicable to both undervoltage and overvoltage thresholds. Contact Maxim for hysteresis option not listed in the *Ordering Information* table.

Overvoltage Fault Output($\overline{OV}$)

The MAX16136 features an open-drain, active-low overvoltage fault output ($\overline{OV}$) that asserts low 5µs after input voltage exceeds the overvoltage threshold level. $\overline{OV}$ is a latched output and can be cleared by pulling $\overline{CLR}$ input low for t_{CLR} pulse width duration. See Figure 2 for more detail.

Clear Input ($\overline{CLR}$)

The MAX16136 provides an active-low input ($\overline{CLR}$) to clear the latched overvoltage fault output ($\overline{OV}$). Pulling $\overline{CLR}$ low for t_{CLR} pulse duration clears the overvoltage fault after the overvoltage condition is removed. See the *Electrical Characteristics* for more detail. The MAX16136 ignores any activity on $\overline{CLR}$ input while the device is in an overvoltage condition. See Figure 2 for the timing diagram.

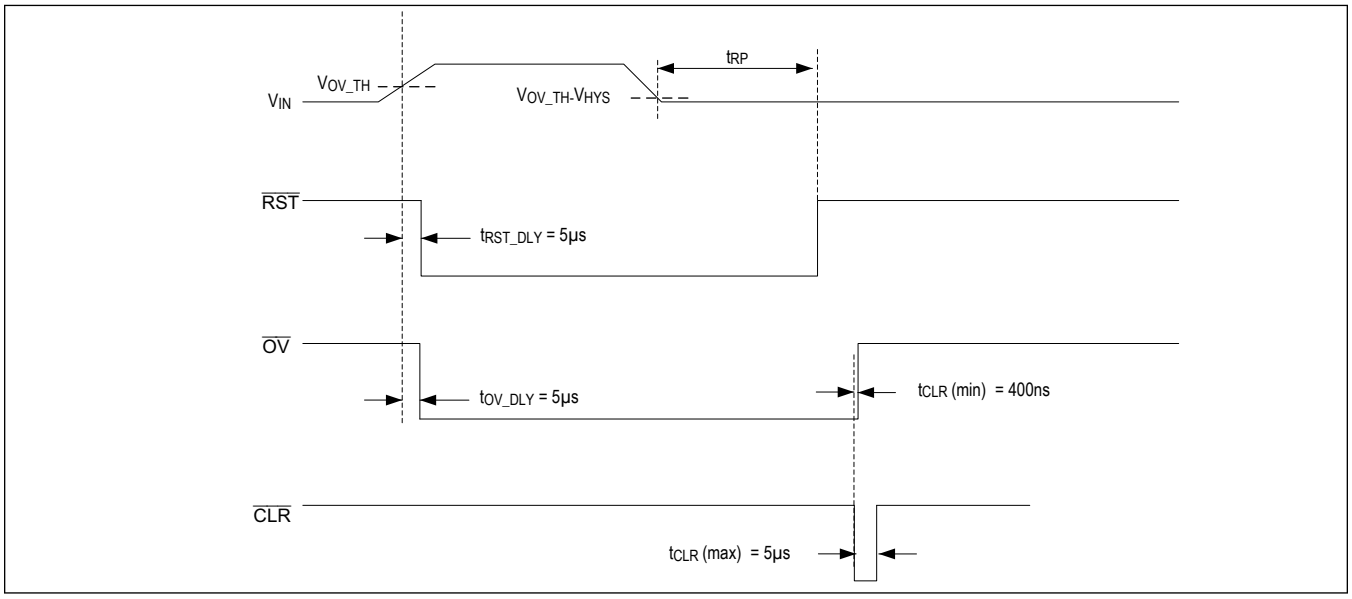


Figure 2. Clear Input Timing Diagram

Note: Pulling $\overline{CLR}$ low for a pulse width duration (t_{CLR}) > 5µs asserts $\overline{RST}$. A consecutive series of pulses on $\overline{CLR}$ with a low pulse width duration of t_{CLR} > 5µs must be separated by a high pulse width duration > t_{RP} for a valid reset output.

Window Watchdog Operation

The MAX16136 offers a window-watchdog circuit for monitoring the microprocessor or microcontroller activity. During normal operation the microprocessor or microcontroller repeatedly toggles the watchdog input WDI low. If the signal on WDI has two consecutive falling edges too close to each other ($t_{WD} < t_{WD\_F}$), the watchdog output, $\overline{WDO}$ pulses low for 50ms. If the signal on WDI has two consecutive falling edges too far apart ($t_{WD} > t_{WD\_S}$) the watchdog output pulses low 100ms. Two falling transitions within fast watchdog timeout and slow watchdog timeout window clears the watchdog timer and keeps the watchdog output deasserted. See Figure 3, Figure 4, Figure 5, and Table 1 for more detail. Contact Maxim for a watchdog timeout not listed in Table 1.

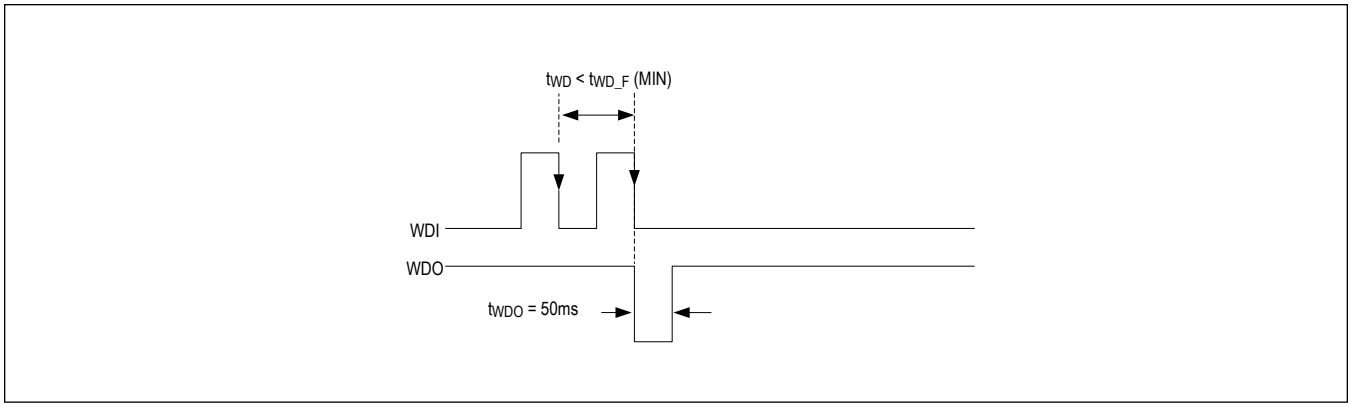


Figure 3. Fast Watchdog Fault Timing Characteristics

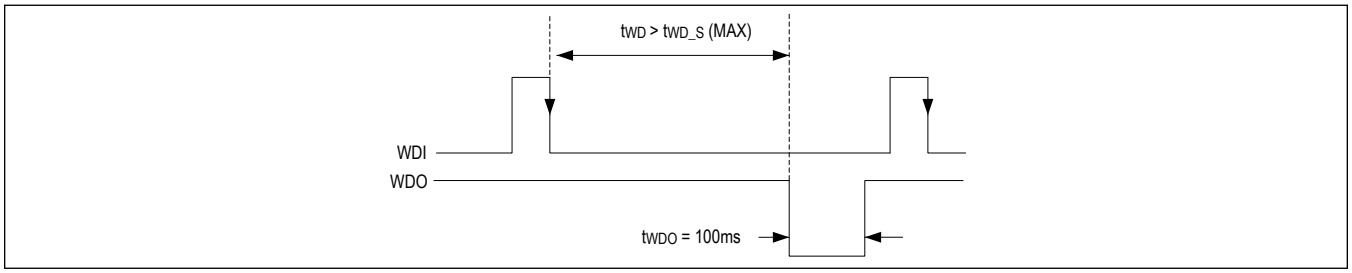


Figure 4. Slow Watchdog Timing Characteristics

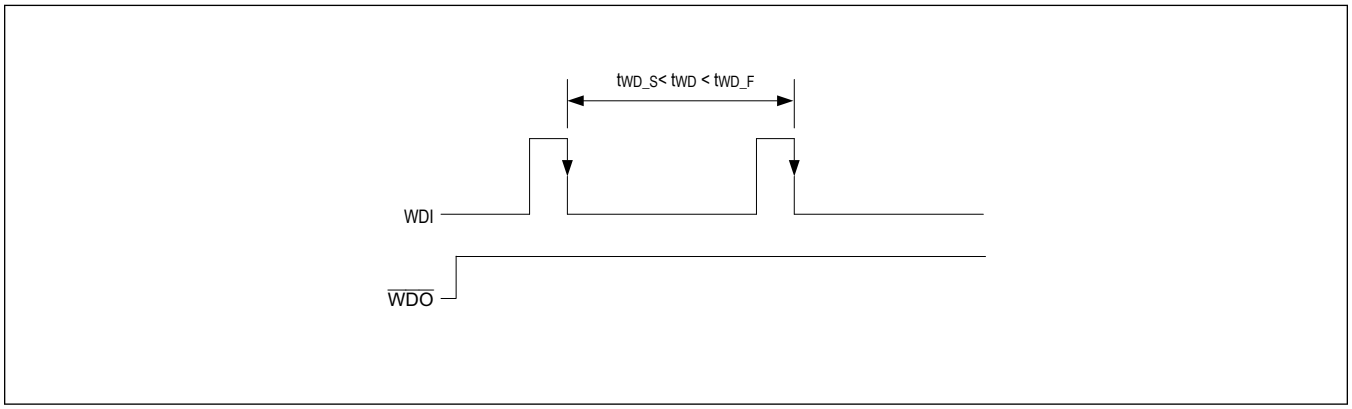


Figure 5. Normal Watchdog Operation (No Watchdog Output Pulse)

Table 1. Window Watchdog Available Options

OPTIONS	FAST WD TIMEOUT PERIOD (ms)	SLOW WD TIMEOUT PERIOD (ms)
1	1	10
2	2	20
3	4	40
4	8	80
5	16	160
6	32	320
7	64	640
8	128	1280
9	256	2560
10	512	5120
11	1024	10240
12	2048	20480
13	4096	40960

Reset Output

The MAX16136 offers an active-low, open-drain reset output ($\overline{RST}$) that asserts low when the supply voltage falls outside of the undervoltage/overvoltage window threshold. The reset output deasserts after the selected reset timeout period when the supply voltage falls back within the undervoltage/overvoltage window threshold. See Table 2 for more details. Contact Maxim for reset timeout period options not listed in Table 2.

Table 2. Reset Timeout Period Available Options

OPTIONS	RESET TIMEOUT PERIOD (ms)
1	1
2	5
3	10
4	15
5	20
6	50
7	100
8	150
9	200
10	250
11	300
12	500
13	750
14	1000
15	1500

Applications Information

Setting Input Thresholds

The MAX16136 monitors a system supply voltage for undervoltage/overvoltage window-threshold. Depending on the system supply tolerance requirement, the undervoltage/overvoltage thresholds can be factory-trimmed from ±4% to ±11%. The tolerance setting is symmetrical with respect to the selected nominal input threshold voltage (V_{IN_NOM}). A detailed calculation of how to determine the undervoltage/overvoltage threshold levels with ±1% threshold accuracy for 3.3V ±5% supply voltage is presented here:

V_{IN_NOM} = 3.3V

TOL = ± 5%

$V_{UVTH} = V_{IN\_NOM} (1 - 5\%) = 3.3V (1 - 0.05) = 3.3V - 0.165V = 3.135V$

$V_{OVTH} = V_{IN\_NOM} (1 + 5\%) = 3.3V (1 + 0.05) = 3.3V + 0.165V = 3.465V$

Where V_{IN_NOM} is the selected nominal input threshold voltage, TOL is the input tolerance, V_{UVTH} is undervotlage threshold voltage, and V_{OVTH} is the overvoltage threshold voltage.

The MAX16136 monitors the supply voltage with ±1% accuracy over the operating temperature and supply range. The accuracy range for the 3.3V ±5% is shown below:

$V_{UVTH\_A} = V_{UVTH} (1 \pm 1\%) = 3.135V (1 \pm 0.03135V) = 3.135V \pm 0.03135V$

$V_{OVTH\_A} = V_{OVTH} (1 \pm 1\%) = 3.465V (1 \pm 0.03465V) = 3.465V \pm 0.03465V$

Where V_{UVTH_A} is the undervoltage threshold accuracy range and V_{OVTH_A} is the overvoltage threshold accuracy range. See Figure 6 for details.

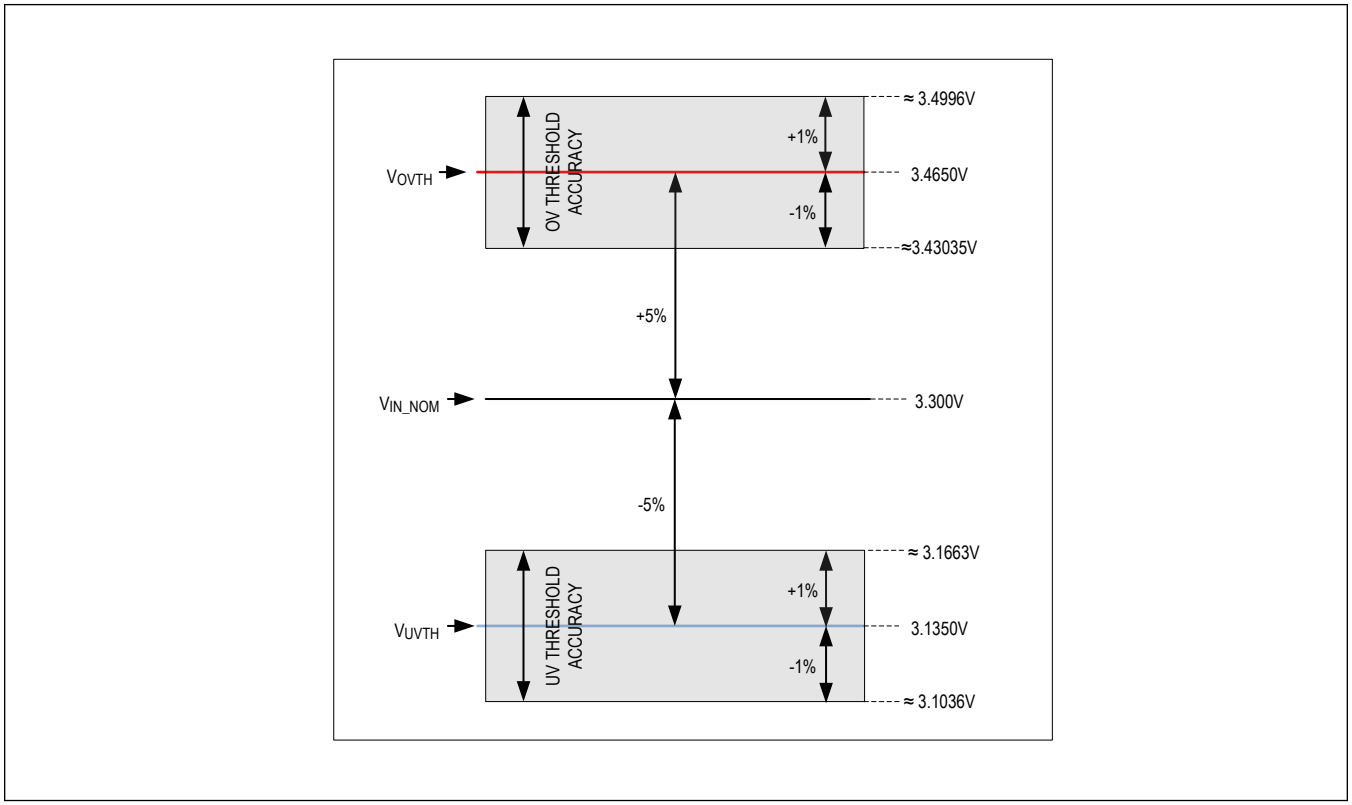


Figure 6. Undervoltage/Overvoltage Threshold Accuracy

Power Supply Bypassing/Noise Immunity

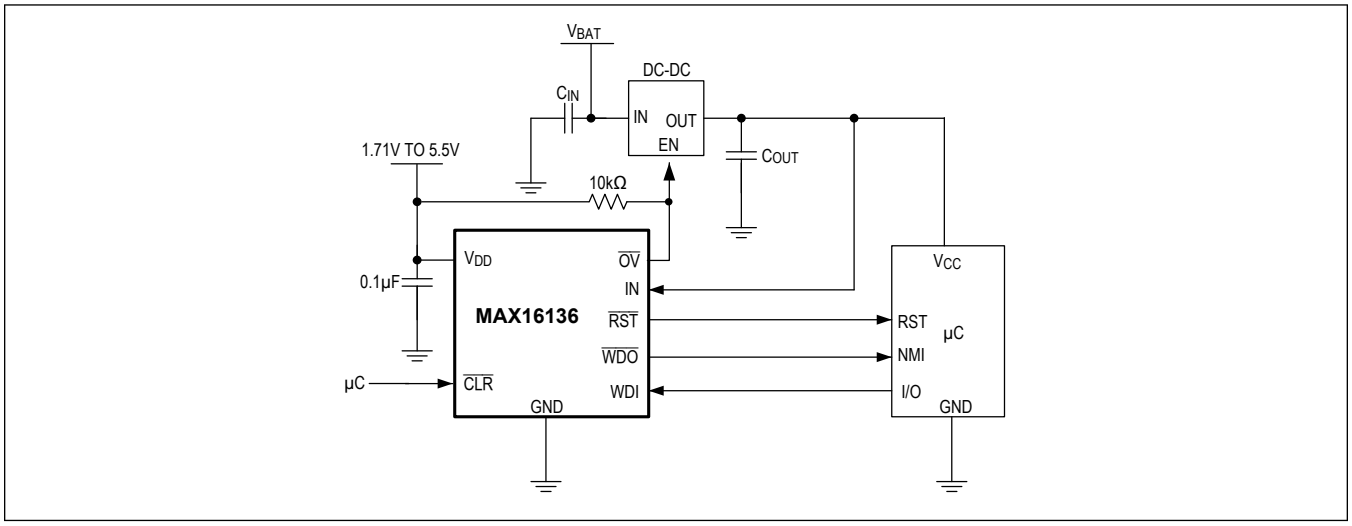
The MAX16136 operates from a 1.71V to 5.5V input supply range. An undervoltage lockout ensures that the outputs are in the correct states when the UVLO is exceeded. Bypass V_{DD} to ground with a 0.1µF capacitor as close to the device as possible. The additional capacitor improves transient immunity. For proper operation, limit V_{DD} noise within 200mV peak-to-peak.

Selector Guide Table

Table 3. Selector Guide

PART NUMBER	THRESHOLD VOLTAGE (V)	TOLERANCE (%)	HYSTERESIS (%)	RESET TIMEOUT (ms)	WINDOW WATCHDOG TIMEOUT (ms/ms)
MAX1613600/ VY+T	3.3	±4	±0.25	10	8/80
MAX1613601/ VY+T	1.0	±4	±0.25	20	32/320
MAX1613602/ VY+T	3.3	±4	±0.25	1	16/160
MAX1613603/ VY+T	5.0	±4	±0.25	10	8/80

Typical Application Circuit



Ordering Information

PART NUMBER	TEMP RANGE	PIN-PACKAGE
MAX1613600/VY+T	-40°C to +125°C	8 TDFN
MAX1613601/VY+T*	-40°C to +125°C	8 TDFN
MAX1613602/VY+T*	-40°C to +125°C	8 TDFN
MAX1613603/VY+T	-40°C to +125°C	8 TDFN

/V Denotes automotive grade.

Y Denotes side-wettable package.

+Denotes a lead(Pb)-free/RoHS-compliant package.

T = Tape and reel.

**Future product—contact factory for availability.*

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	6/19	Initial release	—
1	6/21	Updated General Description, Pin Configuration, and Pin Description; added Table 1 and Table 2	1, 6, 7, 10–14
2	12/21	Updated Table 3 and *Ordering Information* table	14, 15