MAX16160

High-Accuracy 4-Channel, Any-Input Supervisory Circuits

General Description

The MAX16160 precision, four-channel supervisory circuit is designed to maintain system integrity in multi-supply systems. The device monitors its own power supply voltage in addition to three other system supply voltages and asserts the reset output whenever any supply voltage falls below its reset threshold. After all of the supply voltages rise above their reset thresholds, the reset output remains asserted for the reset timeout period, and then deasserts.

During power-up, and before all of the input voltages exceed their trip thresholds, the reset output asserts low if any of the monitored inputs is greater than 1V. The open-drain output has a weak 18µA (typ) pullup to IN2/V_{CC}, eliminating the need for external pullup resistors.

The MAX16160 offers a wide range of threshold options. Input thresholds may be fixed or adjustable. Fixed reset voltage thresholds for IN1, IN3, IN4 are available from 0.5V to 5V in approximately 20mV increments. Reset voltage thresholds for IN2/V_{CC} are available from 1.76V to 5V in approximately 20mV increments.

The MAX16160 operates over the -40°C to +125°C temperature and is available in a small, 6-bump WLP and 6-pin SOT23 package.

Applications

- Telecommunications
- High-End Printers
- Desktop and Notebook Computers
- Data Storage Equipment
- Networking Equipment
- Industrial Equipment
- Set-Top Boxes
- Servers/Workstations

Benefits and Features

- Valid $\overline{\text{RESET}}$ Logic State for Any Input Above 1V
- ±1% Accuracy for All Inputs
- Low 17µA Supply Current
- Open-Drain $\overline{\text{RESET}}$ Output with 18µA Internal Pullup
- Immune to Short Monitored Supply Transients
- Internally Fixed/Adjustable Threshold Options
- -40°C to +125°C Operating Temperature Range
- Small, 6-Pin SOT23 Package and 6-Bump WLP

Ordering Information **appears at end of data sheet.**

Typical Operating Circuit
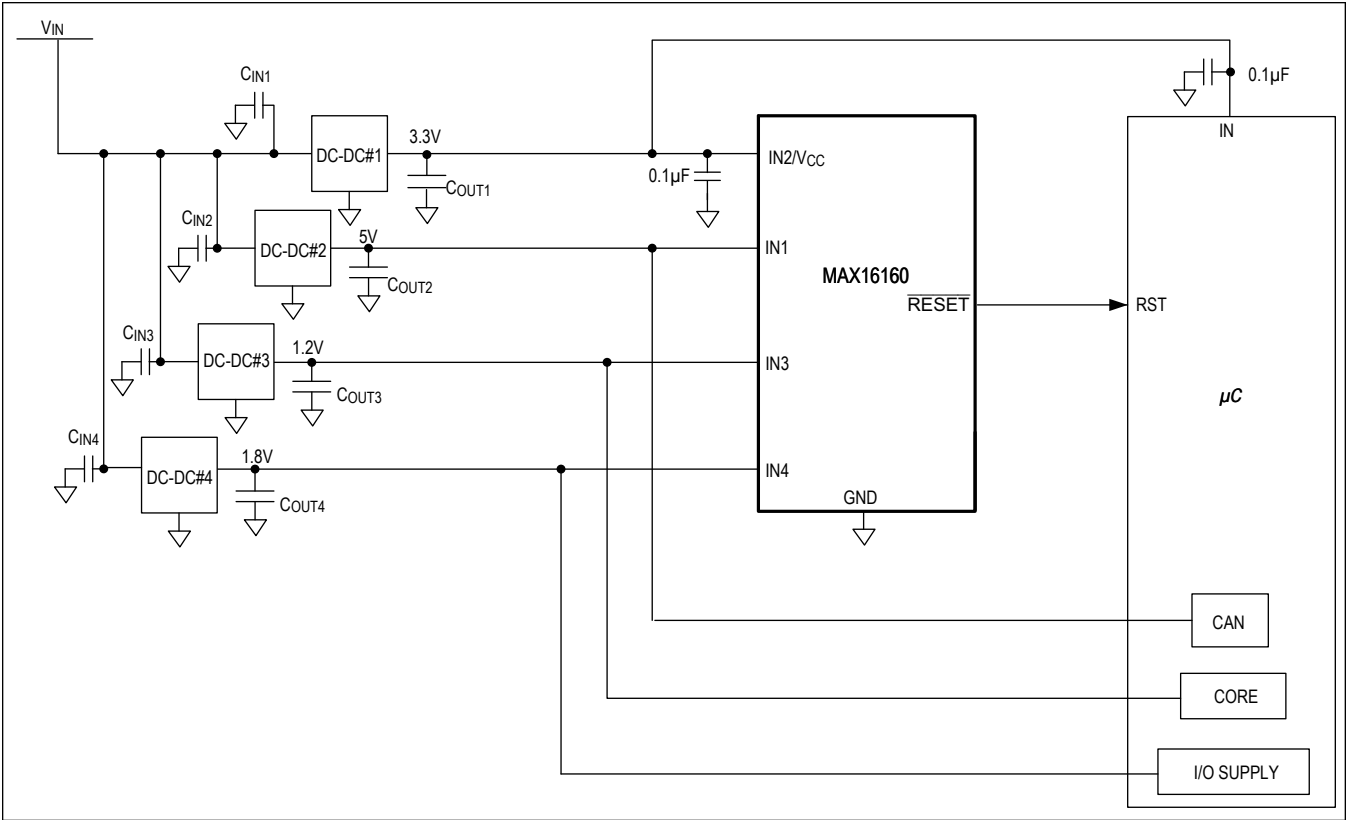
Absolute Maximum Ratings

IN1, IN2/V_{CC}, IN3, IN4 $\overline{RESET}$, to GND .... -0.3V to +6V
Continuous $\overline{RESET}$ Current 20mA
Continuous Power Dissipation (T_A = +70°C)
   SOT23, derate 8.7mW/°C above +70°C)..................... 696mW
   WLP, derate 10.51mW/°C above +70°C) 840mW

Operating Temperature Range ....-40°C to +125°C
Storage Temperature Range ....-65°C to +150°C
Junction Temperature ....+150°C
Lead Temperature (soldering, 10 seconds).....................+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

6 SOT23

Package Code	U6+1C
Outline Number	21-0058
Land Pattern Number	90-0175
Thermal Resistance, Four-Layer Board:	
Junction to Ambient (θ_{JA})	115°C/W
Junction to Case (θ_{JC})	80°C/W

6 WLP

Package Code	N60L1+1
Outline Number	21-100366
Land Pattern Number	
Thermal Resistance, Four-Layer Board:	
Junction to Ambient (θ_{JA})	95.15°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

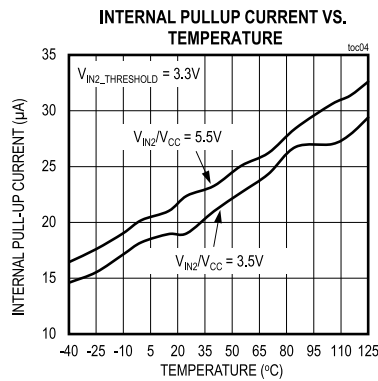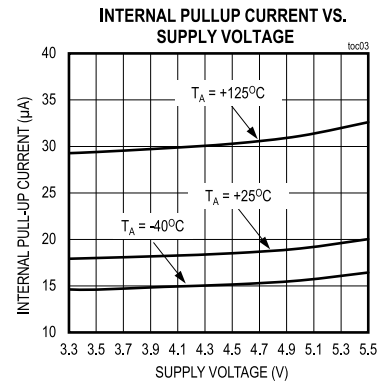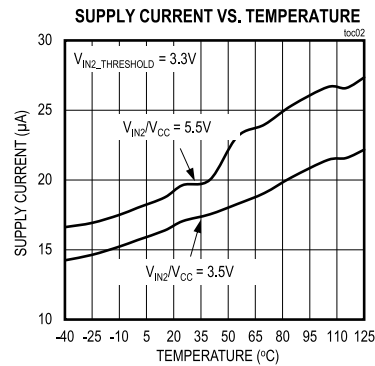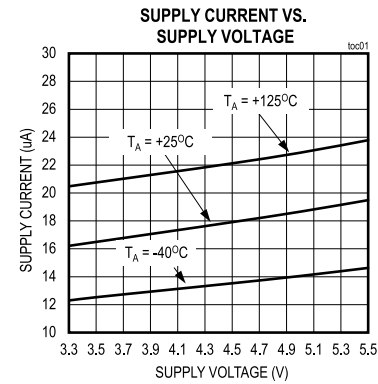(IN2/V_{CC} = 1.7V to 5.5V, T_A = -40°C to +125°C, unless otherwise noted. Typical values are at T_A = +25°C.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Operating Voltage Range	IN2/V_{CC}		1.7		5.5	V
	IN_	Reset output is guaranteed to be at known state	1			
Supply Current	I_{CC}	$\overline{RESET}$ not asserted	5	17	37	µA
IN_ Input Current	$I_{IN\_}$	IN1, IN3, IN4, fixed threshold inputs			2.3	µA
		IN1, IN3, IN4, adjustable threshold inputs			0.3	
Fixed Threshold Voltage Accuracy	V_{TH_ACC}	V_{IN1}, V_{IN2}/V_{CC}, V_{IN3}, V_{IN4} falling	-1		+1	%
Adjustable Input Threshold	$V_{TH\_}$	Adjustable thresholds options only. V_{IN2}/V_{CC} > V_{TH2}	0.6138	0.620	0.6262	V
IN1, IN3, IN4 Threshold Range		V_{IN2}/V_{CC} ≥ 1.7V, fixed threshold options only (Note 1)	0.52		5	V
Threshold Voltage Hysteresis	V_{HYS}	MAX16160___A		0.25		%
IN2/V_{CC} Threshold Range			1.76		5	V
Reset Output Voltage Low	V_{OL}	V_{IN2}/V_{CC} = 2.5V, I_{SINK} = 1.2mA,			0.4	V
		V_{IN2}/V_{CC} = 5V, I_{SINK} = 2mA			0.3	
		$V_{IN\_}$ = 1V, I_{SINK} = 50µA			0.3	
Reset Output Voltage High	V_{OH}	V_{IN2}/V_{CC} ≥ 2V, I_{SOURCE} = 6µA, $\overline{RESET}$ deasserted	0.8 x V_{IN2}/V_{CC}			V
Reset Threshold Temperature Coefficient	TCV_{TH}			60		ppm/°C
Reset Timeout Period Accuracy	t_{RP_ACC}	V_{IN2}/V_{CC} > V_{TH2}	-40		+30	%
Input to Reset Delay	t_{RD}	V_{IN2}/V_{CC}, V_{IN1}, V_{IN3}, V_{IN4} falling at 10mV/µs from (V_{TH} + 1%) to (V_{TH} - 1%)		20		µs
$\overline{RESET}$ Output Source Current	I_{OH}	V_{IN2}/V_{CC} ≥ 2V, $\overline{RESET}$ deasserted		18		µA

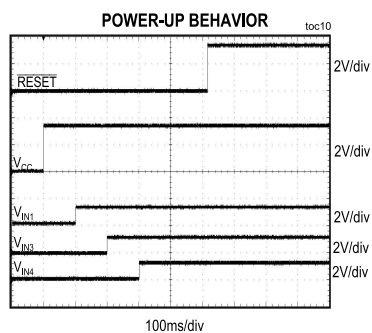**Note 1:** 100% production tested at T_A = +25°C. Limits over temperature guaranteed by design.

Typical Operating Characteristics
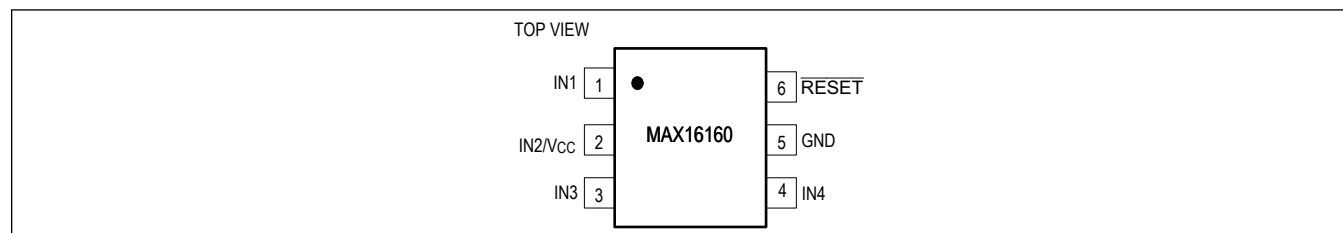
(V_{IN2}/V_{CC} = 3.3V, T_A = -40°C to +125°C.)

SUPPLY CURRENT VS. SUPPLY VOLTAGE
toc01

T_A = +125°C
T_A = +25°C
T_A = -40°C

SUPPLY CURRENT (µA)
SUPPLY VOLTAGE (V)

SUPPLY CURRENT VS. TEMPERATURE
toc02

$V_{IN2\_THRESHOLD}$ = 3.3V
V_{IN2}/V_{CC} = 5.5V
V_{IN2}/V_{CC} = 3.5V

SUPPLY CURRENT (µA)
TEMPERATURE (ºC)

INTERNAL PULLUP CURRENT VS. SUPPLY VOLTAGE
toc03

T_A = +125°C
T_A = +25°C
T_A = -40°C

INTERNAL PULL-UP CURRENT (µA)
SUPPLY VOLTAGE (V)

INTERNAL PULLUP CURRENT VS. TEMPERATURE
toc04

$V_{IN2\_THRESHOLD}$ = 3.3V
V_{IN2}/V_{CC} = 5.5V
V_{IN2}/V_{CC} = 3.5V

INTERNAL PULL-UP CURRENT (µA)
TEMPERATURE (ºC)

V_{CC} TO RESET OUTPUT DELAY VS. TEMPERATURE
toc05

V_{CC} TO RESET OUTPUT DELAY (µs)
TEMPERATURE (ºC)

NORMALIZED RESET TIMEOUT PERIOD VS. TEMPERTURE
toc06

NORMALIZED RESET TIMEOUT PERIOD
TEMPERATURE (ºC)

ADJUSTABLE INPUT VS. TEMPERATURE
toc07

$V_{IN\_}$ RISING
$V_{IN\_}$ FALLING

NORMALIZED THRESHOLD
TEMPERATURE (ºC)

NORMALIZED FIXED-INPUT THRESHOLD VS. TEMPERATURE
toc08

$V_{IN\_}$ RISING
$V_{IN\_}$ FALLING

NORMALIZED FIXED INPUT THRESHOLD
TEMPERATURE (ºC)

MAXIMUM TRANSIENT DURATION VS. RESET THRESHLD OVERDRIVE
toc09

FIXED THRESHOLD INPUTS
RESET OCCURS ABOVE THE CURVE

TRANSIENT DURATION (µs)
RESET THRESHOLD OVERDRIVE (mV)

Typical Operating Characteristics (continued)

(V_{IN2}/V_{CC} = 3.3V, T_A = -40°C to +125°C.)

POWER-UP BEHAVIOR

Pin Configurations

6 SOT23

TOP VIEW

```
        ┌──────────┐
IN1  [1]│  ●       │[6]  RESET
        │          │
IN2/VCC [2] MAX16160 [5]  GND
        │          │
IN3  [3]│          │[4]  IN4
        └──────────┘
```

6 WLP

TOP VIEW

```
          1         2         3

     ┌(RESET)  ( GND )  ( IN4 )
  A

              MAX16160

  B  ( IN1 )  (IN2/VCC) ( IN3 )
```

BUMP-SIDE DOWN
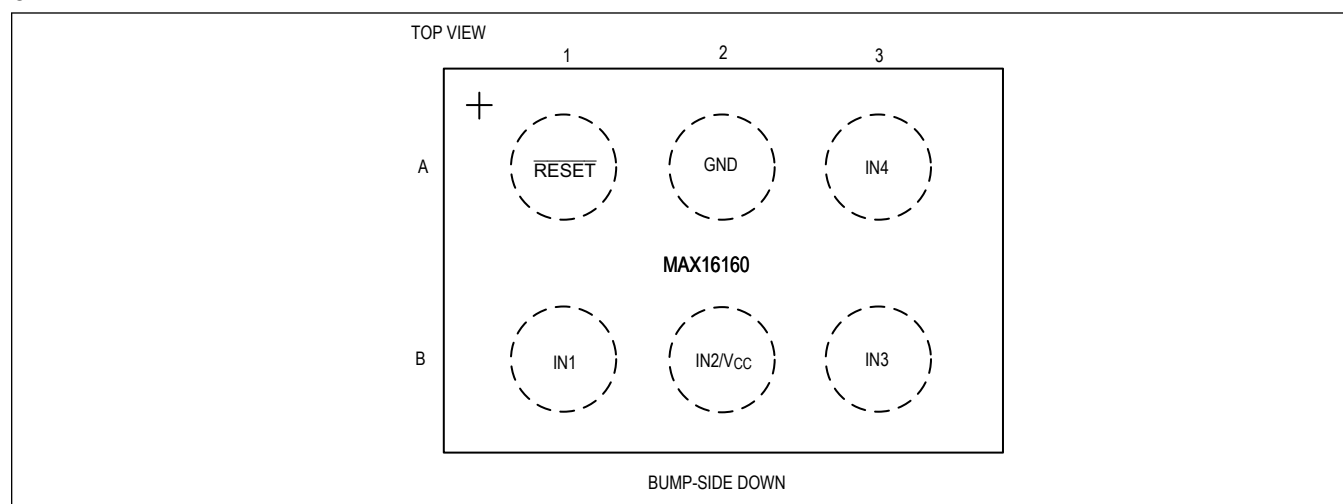
Pin Description

| PIN		NAME	FUNCTION
6 SOT23	6 WLP		
1	B1	IN1	Monitoring Input 1. When Input 1 has an internally fixed trip threshold, connect directly to the supply voltage to be monitored. When Input 1 is an adjustable input, connect to the supply voltage to be monitored through a resistive divider network. For better immunity to external noise, place a 0.1µF capacitor between IN1 and GND as close as possible to the MAX16160.
2	B2	IN2/V_{CC}	Supply Voltage. IN2/V_{CC} is the power supply input and the monitoring input. Bypass with a 0.1µF capacitor between IN2 and GND.
3	B3	IN3	Monitoring Input 3. When Input 3 has an internally fixed trip threshold, connect directly to the supply voltage to be monitored. When Input 3 is an adjustable input, connect to the supply voltage to be monitored through a resistive divider network. For better immunity to external noise, place a 0.1µF capacitor between IN3 and GND as close as possible to the MAX16160.
4	A3	IN4	Monitoring Input 4. When Input 4 has an internally fixed trip threshold, connect directly to the supply voltage to be monitored. When Input 4 is an adjustable input, connect to the supply voltage to be monitored through a resistive divider network. For better immunity to external noise, place a 0.1µF capacitor between IN4 and GND as close as possible to the MAX16160.
5	A2	GND	Ground
6	A1	$\overline{RESET}$	Active-Low, Open-Drain Reset Output. $\overline{RESET}$ asserts low when any input falls below its set threshold. $\overline{RESET}$ deasserts after the reset timeout period when all inputs rise above their set thresholds. $\overline{RESET}$ has a weak (18µA) internal pullup to IN2/V_{CC}.

Block Diagrams

Internally Fixed Threshold
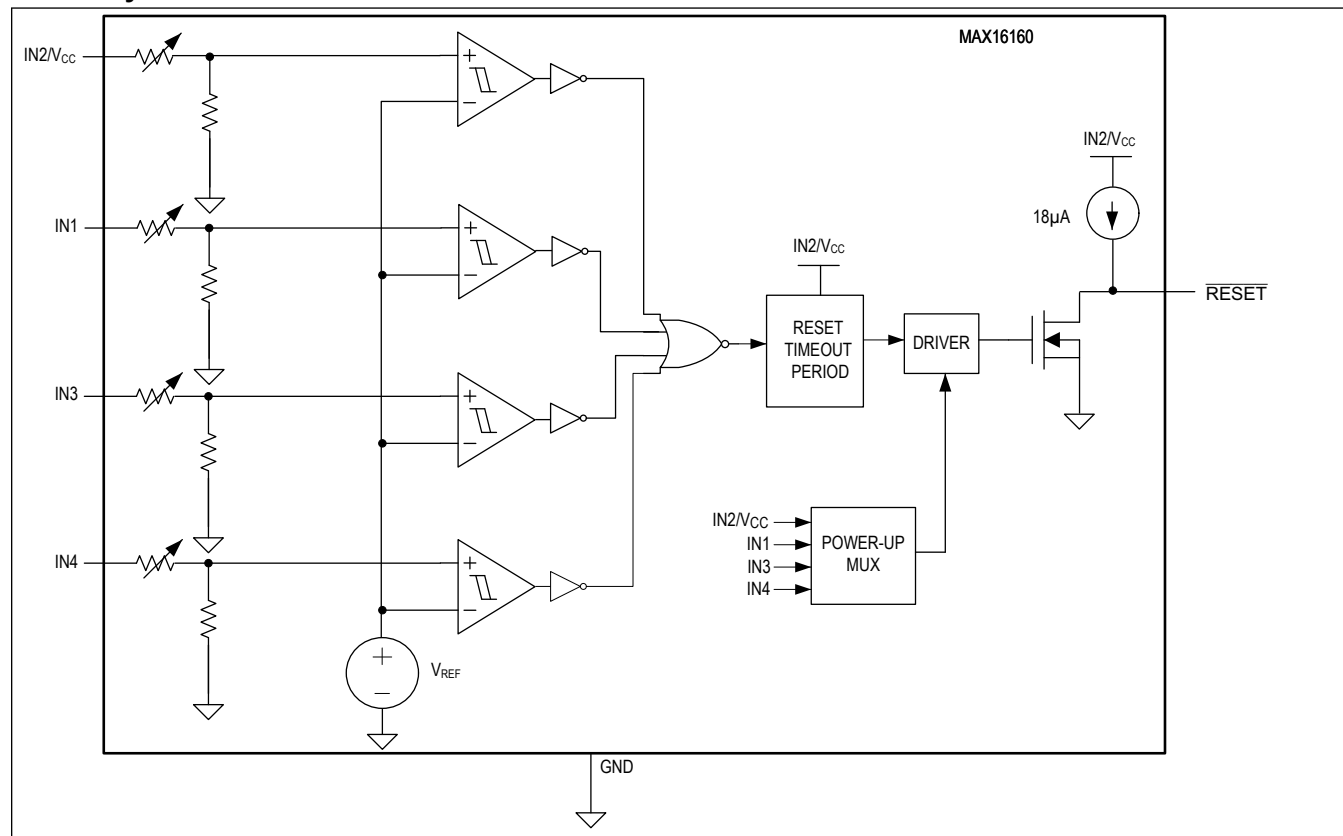
Block Diagrams (continued)

Adjustable Threshold
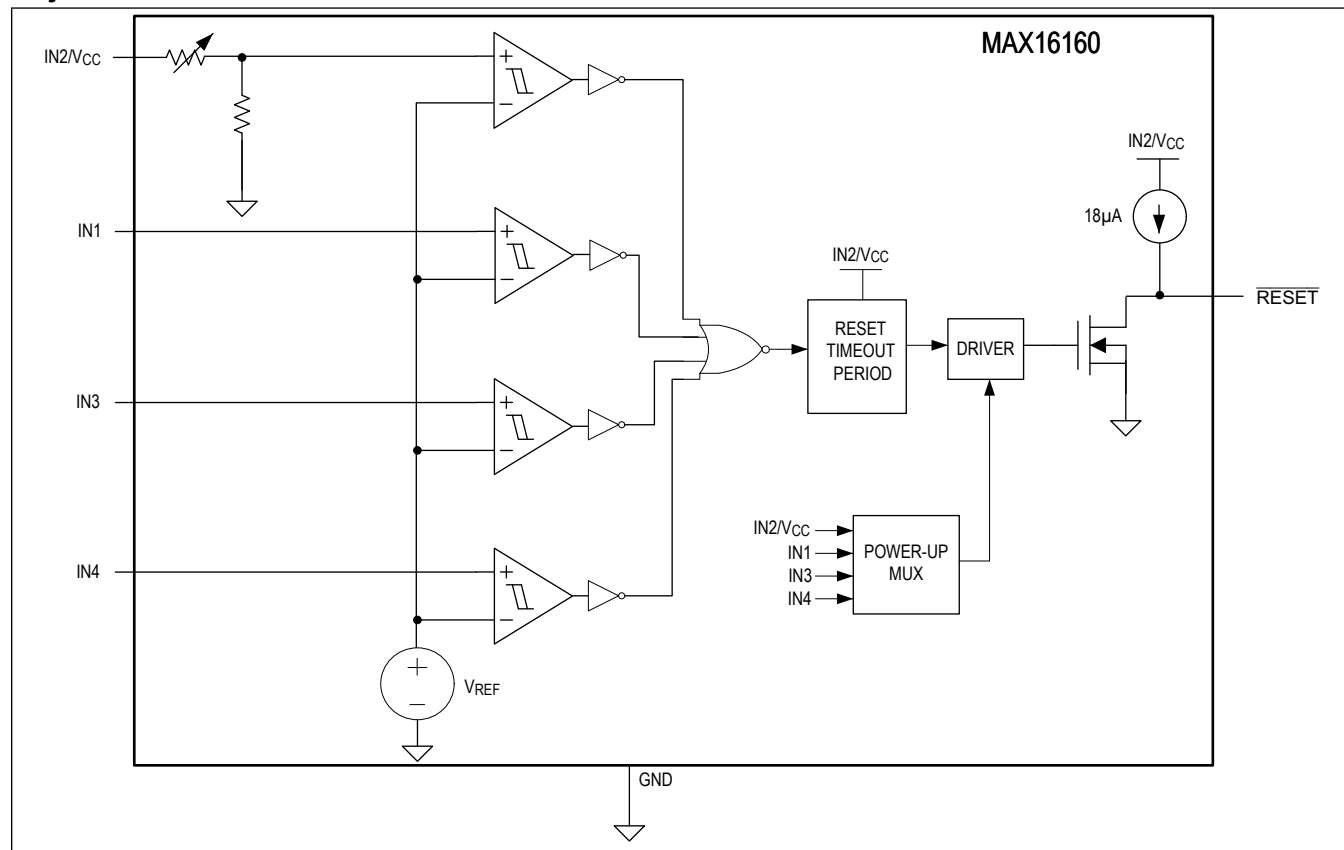
Detailed Description

The MAX16160 is high-accuracy, 4-channel supervisory circuit that monitors its own power input supply and three additional system supply voltages and asserts an active-low reset signal when any input voltage drops below its reset threshold. After all of the input voltages rise above their threshold voltages, the reset output remains asserted during the reset timeout period, and finally asserts after the timeout period ends. During power-up, before the inputs have reached their threshold voltages, the reset output ($\overline{\text{RESET}}$) asserts low when any of the monitoring inputs exceeds 1V (Figure 1).
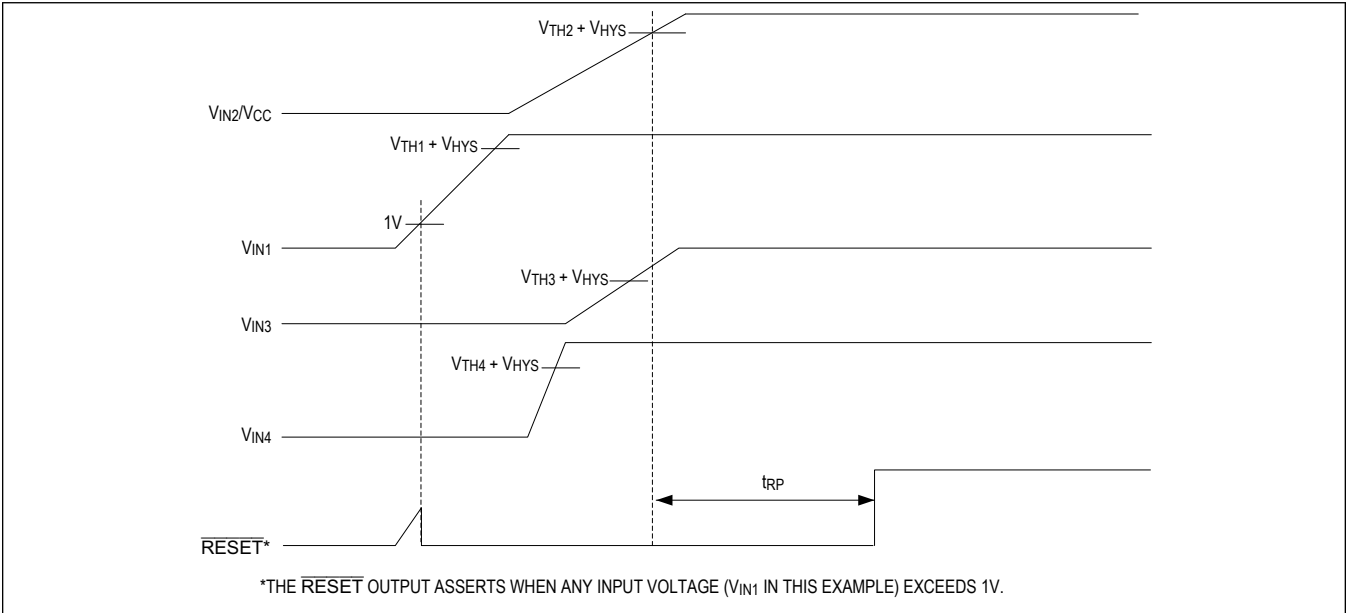

Figure 1. Power-Up Timing Characteristics

Reset Output

The MAX16160 features an active-low open-drain reset output ($\overline{\text{RESET}}$) that asserts low when any monitored input drops below its threshold voltage, $V_{TH\_}$. The reset output remains asserted as long as any of the monitoring inputs remains below its threshold voltage. When all inputs rise above their threshold voltages (plus the required hysteresis), the reset output remains asserted during the reset timeout period, and then deasserts. See Figure 2 for more details. Only one input voltage is shown; all others are assumed to be greater than their threshold voltages. Contact Maxim for reset timeout period options not listed in the *Ordering Information* table.
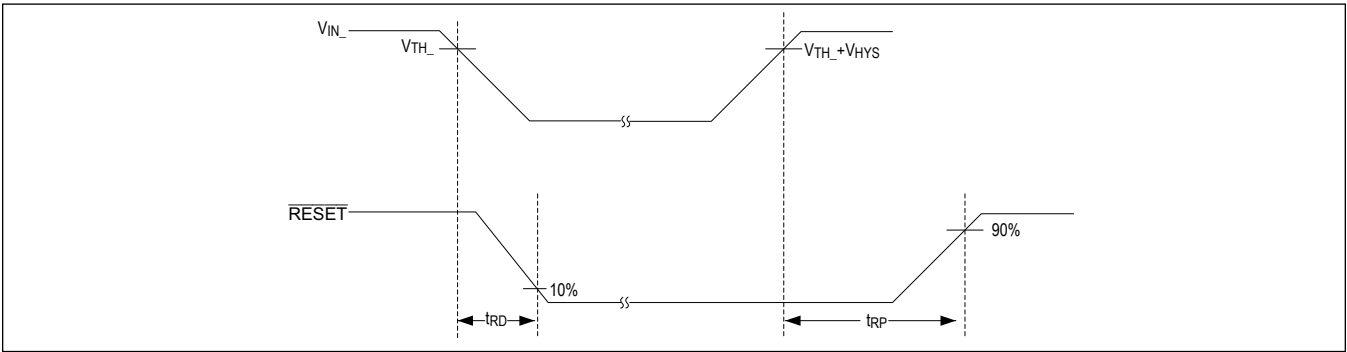

Figure 2. Reset Output Timing

An 18µA (typ) pullup current to IN2/V$_{CC}$ eliminates the need for an external pullup resistor in many cases. If a logic-high level different from IN2/V$_{CC}$ is needed, an external pullup resistor can be connected to a pullup voltage up to 5.5V. Internal circuitry prevents reverse current flow from the external pullup voltage to IN2/V$_{CC}$ (Figure 3).
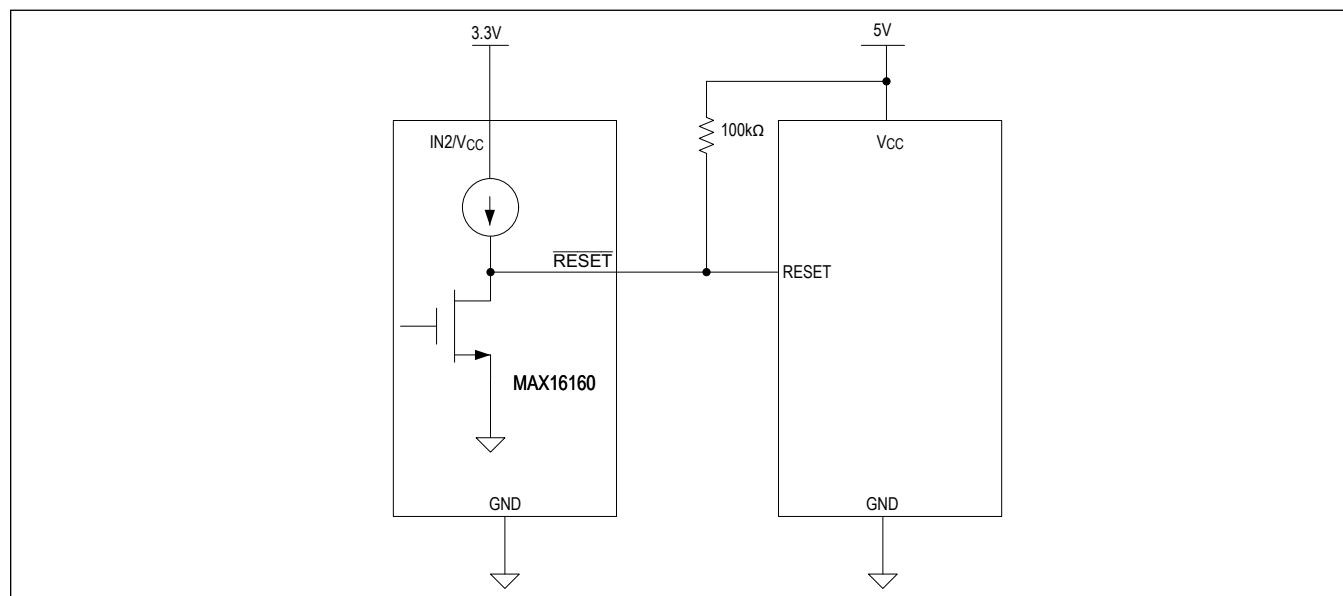

Figure 3. Interfacing to a Logic Supply Voltage Other Than IN2/V$_{CC}$

Input Hysteresis

The MAX16160 is immune to short IN_ transients. Each of the internal comparators are available with either 0.5% or 0.25% hysteresis with respect to the input threshold. Hysteresis provides immunity to input noise without significantly reducing the input threshold accuracy. See the *Maximum IN_ Transient Duration vs. Reset Threshold Overdrive* graph in the *Typical Operating Characteristics* section.

Input Thresholds

The MAX16160 monitors all inputs with ±1% accuracy across the full temperature and supply voltage ranges. The input thresholds (IN1/IN3/IN4) are available with values ranging from 0.5V to 5V in approximately 20mV increments. IN2/V$_{CC}$ input thresholds are available from 1.76V to 5V in approximately 20mV increments. All inputs except IN2/V$_{CC}$ are available as adjustable-threshold inputs (0.62V internal threshold) using an external resistor-divider. Contact Maxim for thresholds not listed in the *Ordering Information* table.

Applications Information

Adjustable Threshold Inputs (IN1, IN3, IN4)

The threshold voltage at each adjustable input is 0.62V (typ). To monitor a voltage > 0.62V, connect a resistor-divider network to the circuit, as shown in Figure 4. Use the following equations to calculate the resistor values.

$$V_{IN\_TH} = 0.62V \times \left(\frac{R1 + R2}{R2} \right)$$

or

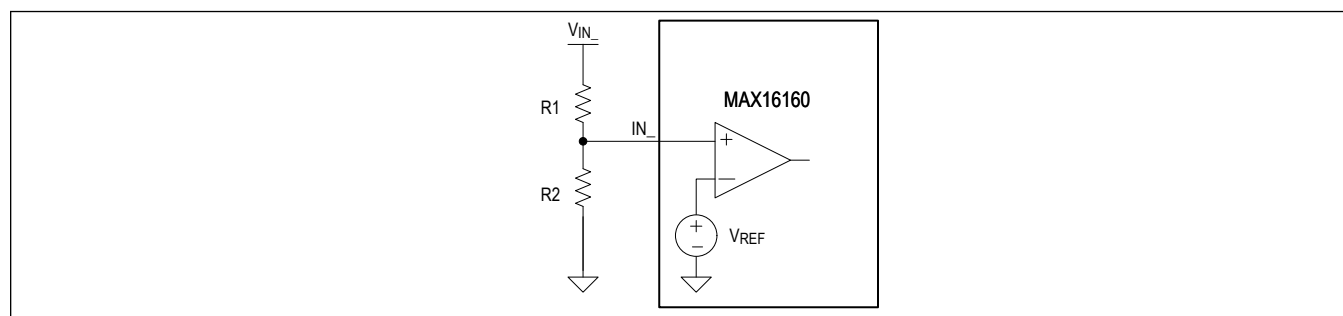$$R1 = R2 \left(\left(\frac{V_{IN\_TH}}{0.62V} \right) - 1 \right)$$

Figure 4. Adjustable Input Circuit

Adding Manual Reset Capability

Figure 5 shows an application circuit adding manual reset to the MAX16160. Depressing the pushbutton switch shorts the analog input to ground and initiates a reset output pulse. The switch must be open for at least reset timeout period (t_{RP}) in order to deassert the reset output. Use a small capacitor to improve noise immunity when using long leads from the pushbutton switch to the adjustable input.
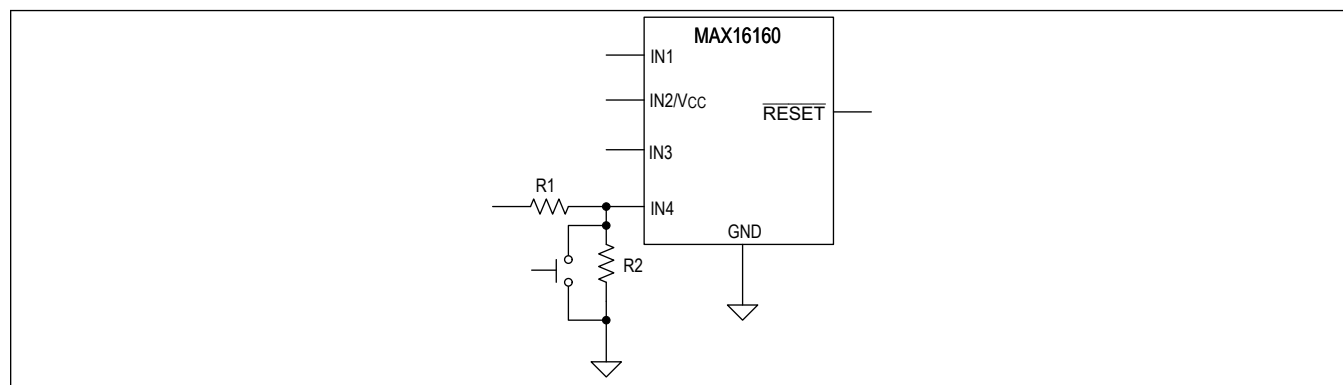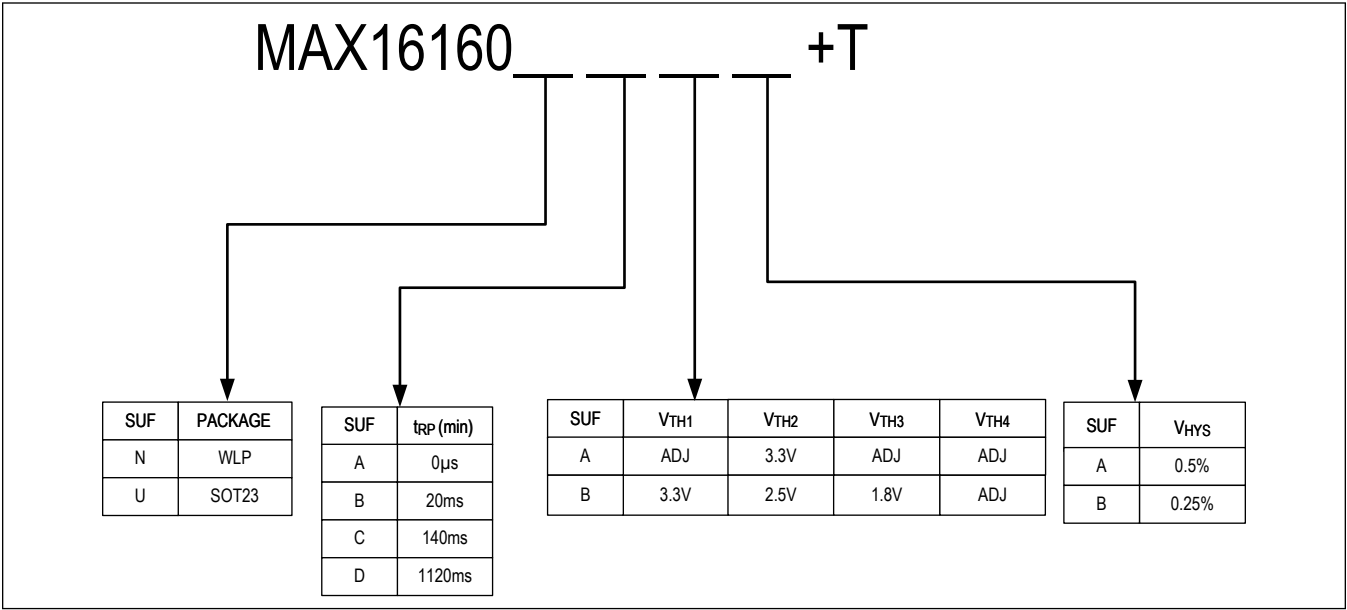

Figure 5. Adding Manual Reset Capability

Unused Inputs

Connect unused monitor inputs to a supply voltage greater in magnitude than their specified threshold voltages. For unused IN_ adjustable inputs, connect a 1MΩ series resistor between the unused input and IN2/V$_{CC}$ to limit the bias current. Do not connect unused monitor inputs to ground or allow them to float.
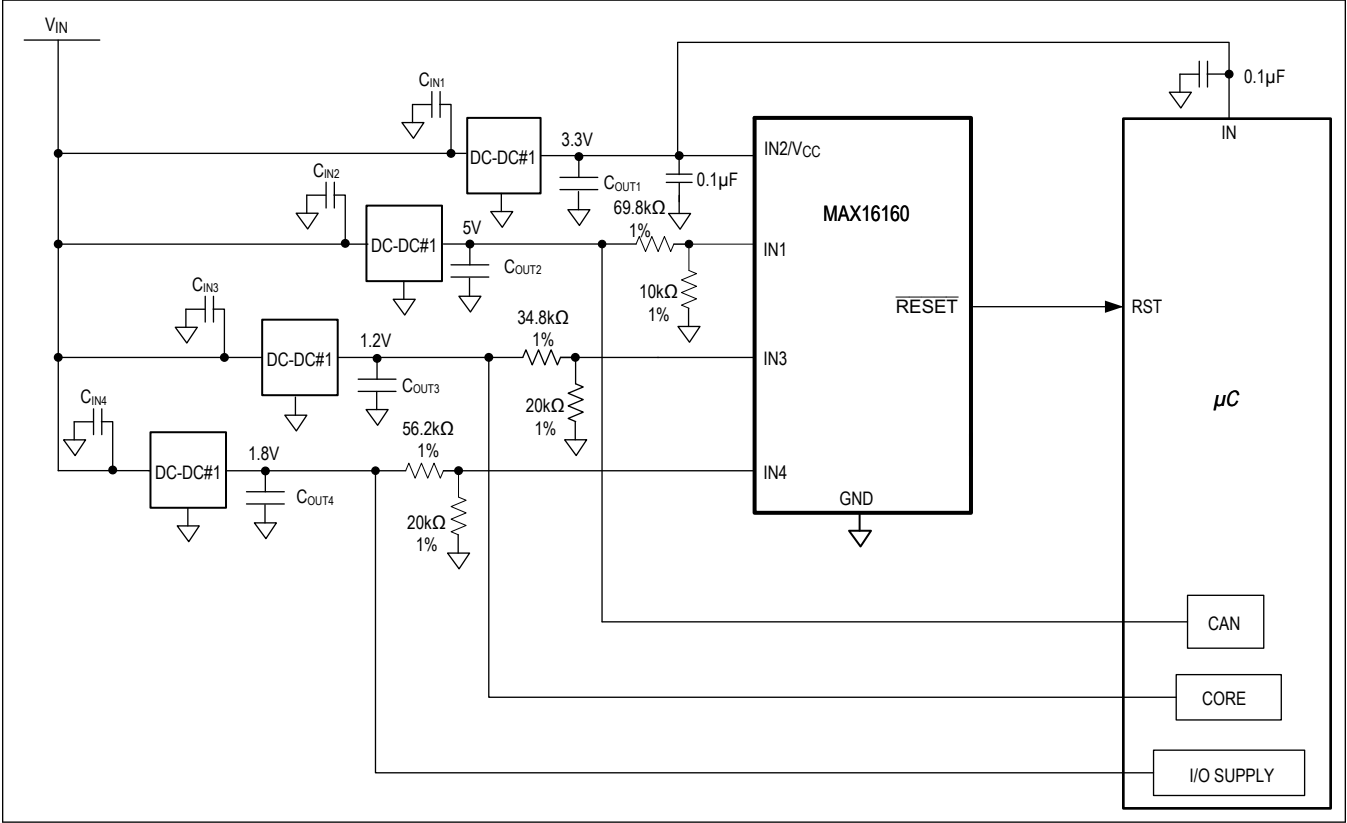
Power-Supply Bypassing

The MAX16160 operates from a 1.70V to 5.5V supply. Bypass IN2/V_{CC} to ground with a 0.1µF capacitor as close to the device as possible to improve transient immunity. For fast-rising V_{CC} transients, additional capacitance may be required.

Selector Guide

MAX16160__ __ __ __ +T

SUF	PACKAGE
N	WLP
U	SOT23

SUF	t_{RP} (min)
A	0µs
B	20ms
C	140ms
D	1120ms

SUF	V_{TH1}	V_{TH2}	V_{TH3}	V_{TH4}
A	ADJ	3.3V	ADJ	ADJ
B	3.3V	2.5V	1.8V	ADJ

SUF	V_{HYS}
A	0.5%
B	0.25%

Typical Application Circuit

Ordering Information

PART NUMBER	TEMPERATURE RANGE	PIN-PACKAGE
MAX16160UCAB+T	-40°C to +125°C	6 SOT23
MAX16160NCAB+T	-40°C to +125°C	6 WLP

Note: See the Selector Guide for reset timeout period, threshold voltage, and input hysteresis options. For additional options and future products, visit www.maximintegrated.com.

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

T = Tape-and-reel.

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	6/19	Initial release	—
1	8/19	Updated title of data sheet and *Ordering Information* table	1–17
2	12/20	Updated the *Pin Description* and *Ordering Information* tables	8, 17

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