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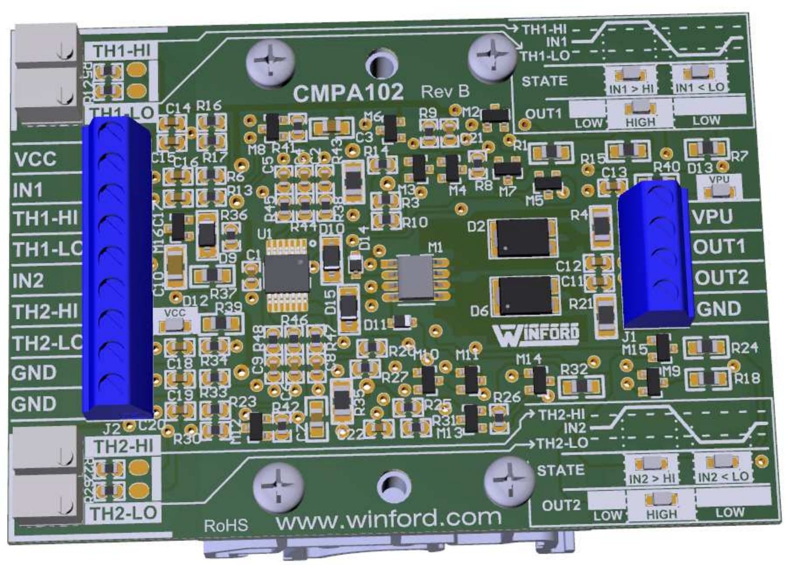
CMPA102 Datasheet

Overview

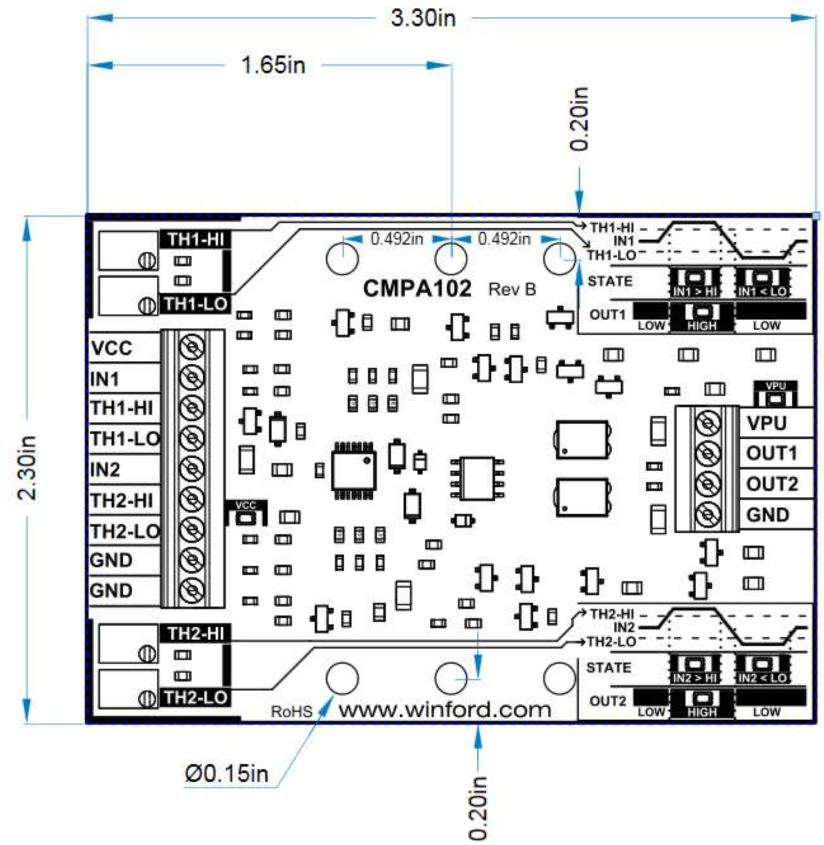
The CMPA102 comparator board provides two channels of comparator functions with a non-inverting open-drain protected output for each channel. Two potentiometers (trim-pots) are included on each channel in order to easily set independent rising and falling thresholds. Alternatively, threshold voltages can be provided externally by the user. Unlike traditional comparator circuits that use positive feedback to implement hysteresis, the hysteresis on the CMPA102 device is completely independent of the output-side supply voltage and load.

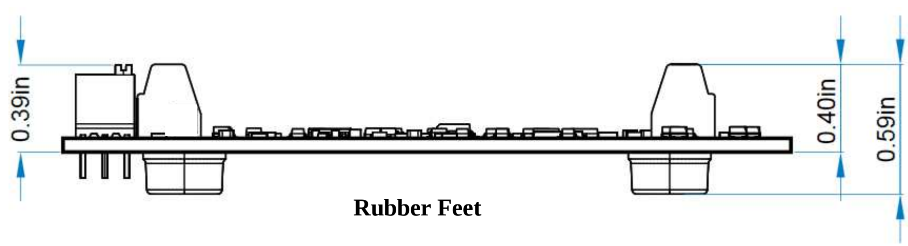
Rail-to-rail input stages maximize the voltage range allowed on the inputs without requiring resistor dividers. Both the input side and the output side are designed to interface with equipment using supply and logic voltages of anywhere from 3.3V to 24V, making it ideal for use in low-voltage embedded systems as well as industrial control applications. This robust design includes protected low-side output drivers that provide significant sink current capability. Reverse-polarity protection on inputs and outputs is also included. Terminal blocks provide easy access to the signals while maintaining a compact form factor.



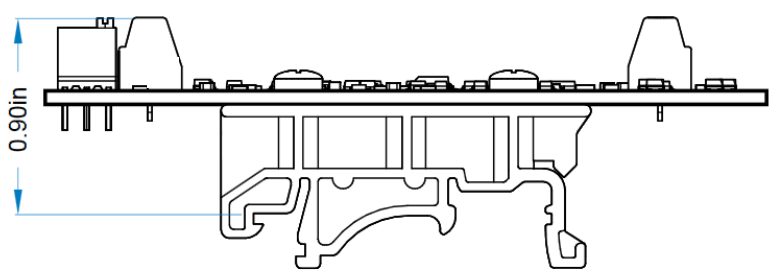
DIN Mounting Option Shown

Dimensions (typical shown)





Rubber Feet



DIN Clips

Part Number Ordering Information

CMPA102	-	
		1

1. Mounting Option

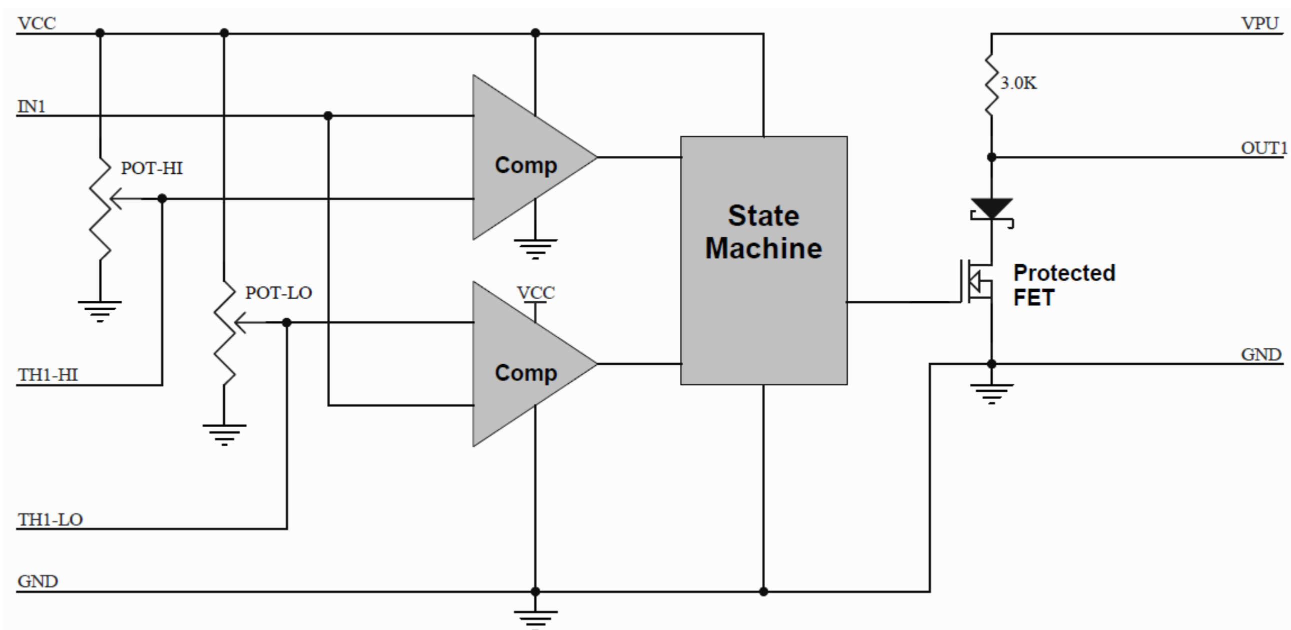
- **FT** Rubber Feet on bottom side of PCB
- **DIN** DIN Rail Mounting Clips

CMPA102 Stocked Part Numbers

The following part numbers represent standard options that are normally stocked:

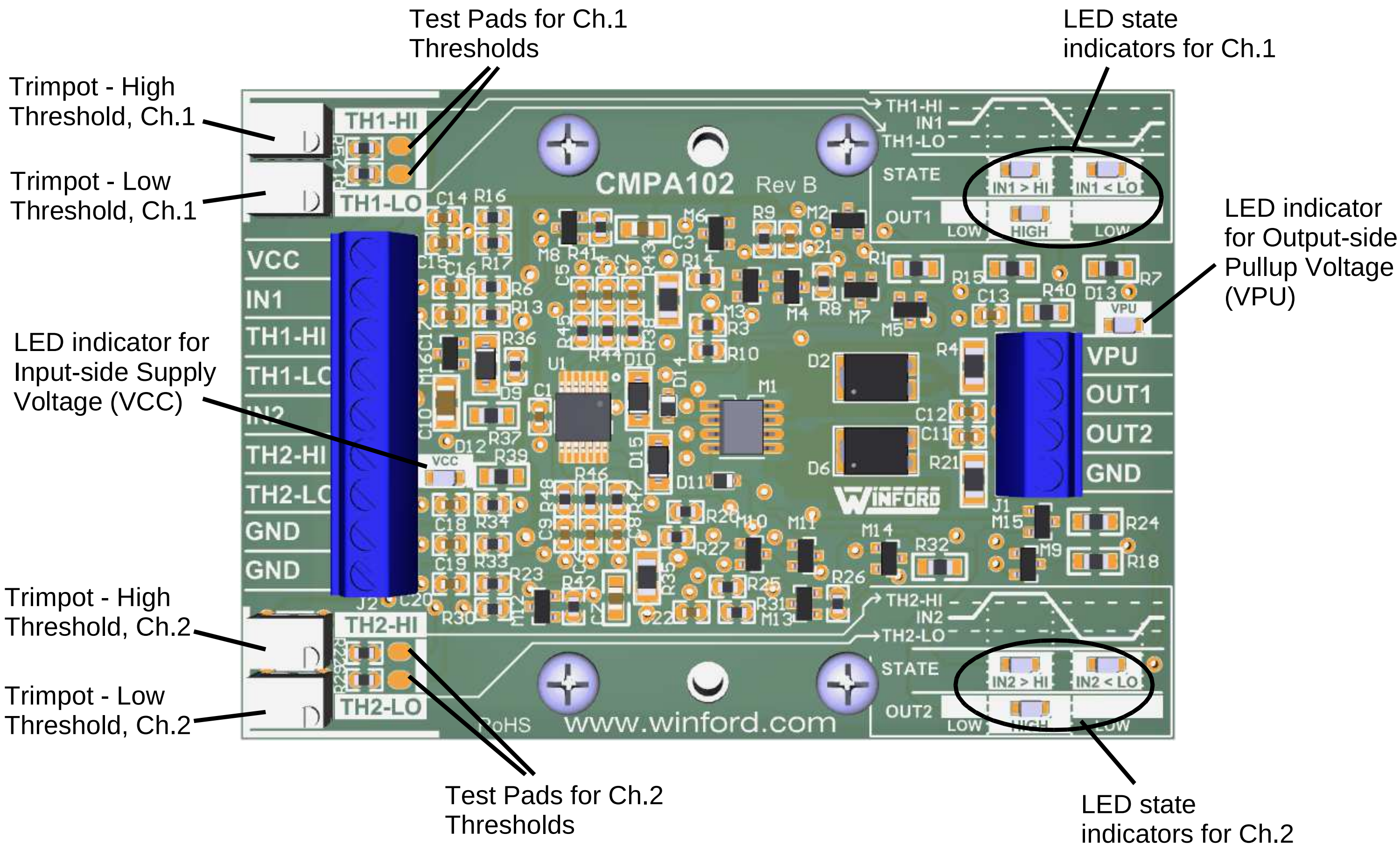
- CMPA102-FT
- CMPA102-DIN

Simplified Schematic Drawing (one channel)



Implementation is the same for both channels. Channel 1 is shown in the figure.

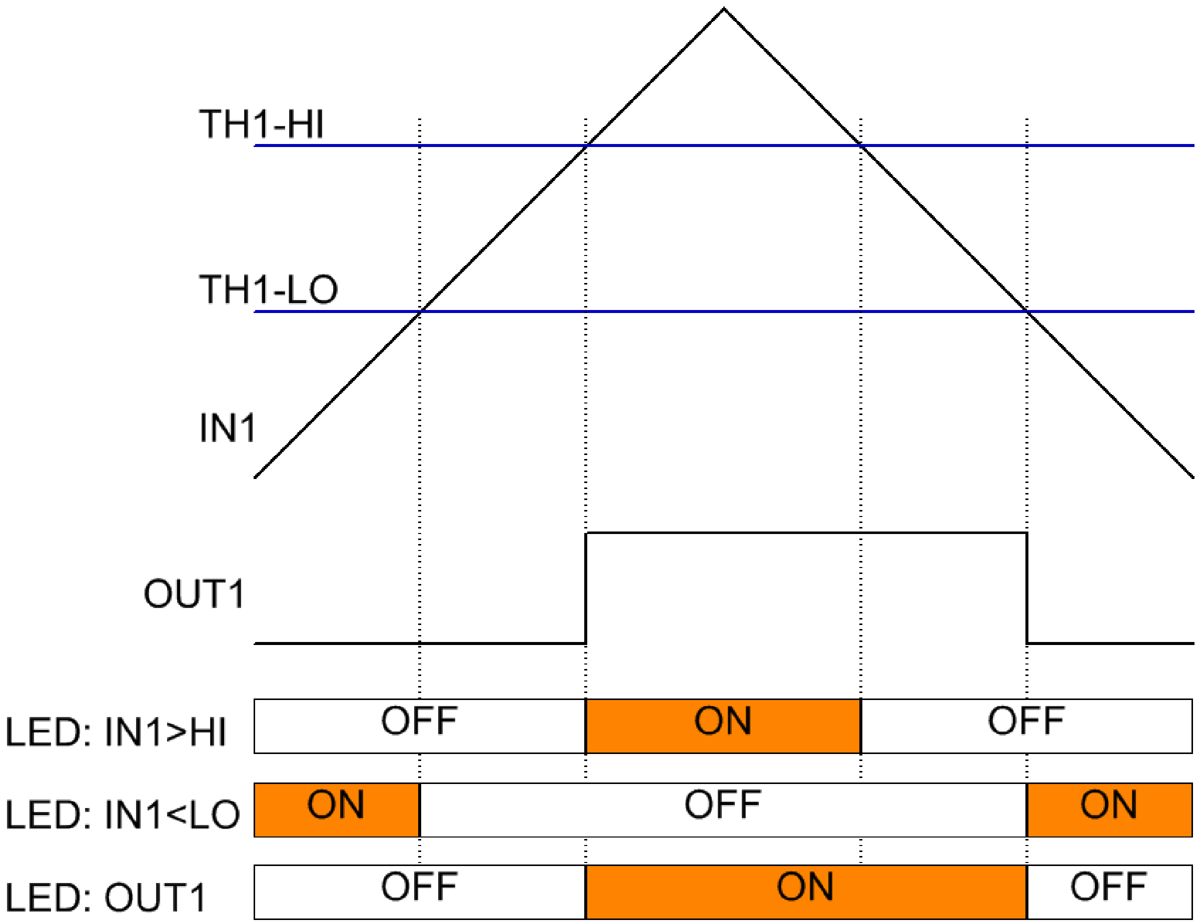
Detailed Description



SIGNAL	DESCRIPTION
VCC	Input-side Supply Voltage
IN1	Input signal for Channel 1
TH1-HI	Access point that allows the user to monitor Channel 1 high threshold set by the trim-pot. Alternatively, allows user to provide their own external threshold signal.
TH1-LO	Access point that allows the user to monitor Channel 1 low threshold set by the trim-pot. Alternatively, allows user to provide their own external threshold signal.
IN2	Input signal for Channel 2
TH2-HI	Access point that allows the user to monitor Channel 2 high threshold set by the trim-pot. Alternatively, allows user to provide their own external threshold signal.
TH2-LO	Access point that allows the user to monitor Channel 2 low threshold set by the trim-pot. Alternatively, allows user to provide their own external threshold signal.
GND	Ground reference (2 locations)

SIGNAL	DESCRIPTION
VPU	Output-side Pullup Voltage
OUT1	Open-drain output, Channel 1
OUT2	Open-drain output, Channel 2
GND	Ground reference

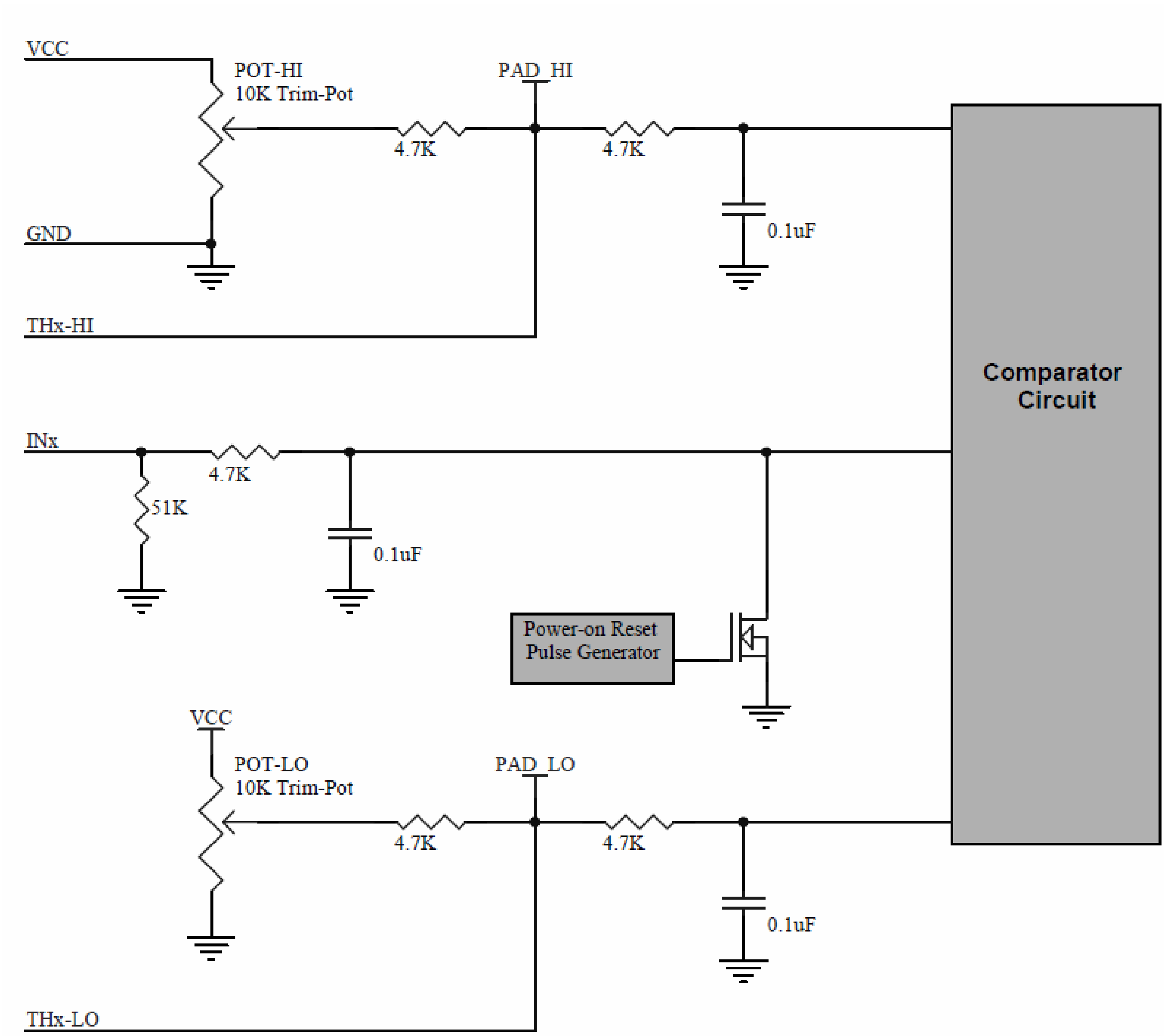
The following figure illustrates the basic behavior of the comparator function, with hysteresis defined by the two thresholds set by the user.   On each channel, three LEDs provide a visual indication of the output state as well as the value of the input signal compared to the threshold signals. Channel 1 is shown, and Channel 2 behaves in the same manner.



Output Signal and LED Indicators vs Input Signals

Input Stage for Each Channel

The following figure shows the circuitry associated with the input stage used for each channel.



Each pin on the terminal block also has a small capacitor (100pF) connected between the signal and ground in order provide a measure of ESD protection.

Setting the Thresholds Using the Trim-Pots

In many cases, the thresholds will be set using the 12-turn 10K trim-pots included on the board. With this option, each threshold will be a percentage of the input-side supply voltage (VCC). As the thresholds are being set by adjusting the trim-pots, the thresholds may be measured with a high-impedance instrument (e.g., voltmeter). This is accomplished by accessing the threshold signals at either the input-side terminal block or the test pads (located by the trim-pots).

In some cases, it may be easier to set the thresholds (using the trim-pots) by visually monitoring the state LEDs while a known input voltage is applied to IN1 / IN2. For example, assume that it is desired to set the Channel 1 low threshold to 5.5V. First, with the board powered up, apply 5.5V to IN1 and check the state of the LED marked "IN1<LO". If the LED is on, turn the TH1-LO trimpot counterclockwise (decreasing the threshold voltage) until the LED just turns off. On the other hand, if the LED is off to begin with, turn the

TH1-LO trimpot clockwise (increasing the threshold voltage) until the LED just turns on. If very precise threshold voltages are required, it is advisable to measure them with a voltmeter and adjust further if needed.

Setting the Thresholds Using External Signals

Since the threshold signals come out to the input-side terminal block, the thresholds may be set using external signals. Note that in this case each threshold signal should be supplied by a low-impedance source to ensure that the trim-pot does not excessively load the signal. Referring to the input stage schematic, it can be seen that signal loading is a function of the trim-pot position and the series 4.7K resistor. In order to minimize loading, it may be helpful to set the potentiometer to its middle position (50%). On the other hand, if using a signal source that does not have the capability to sink current (e.g., a typical linear regulator), it may be best to set the trimpot fully counterclockwise so that the signal source essentially sees a load of 4.7K to ground, ensuring that the trimpot will not tend to pull up the signal.

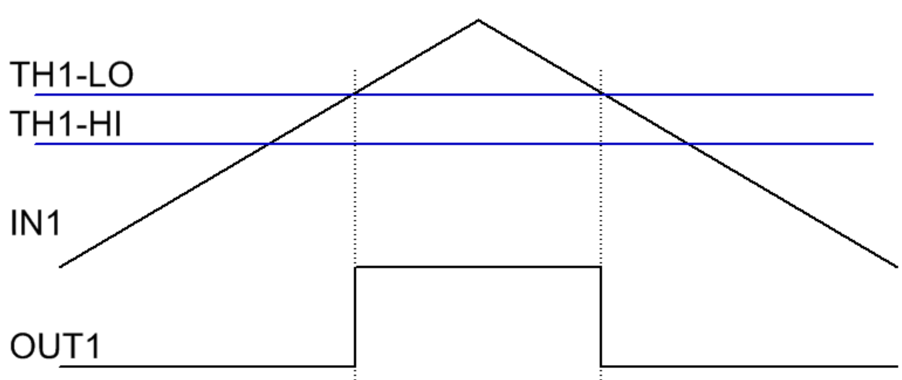
Rail-to-Rail Common-Mode Input Voltage Range

Those who are familiar with comparator ICs probably at some point have experienced some frustration with limitations associated with the common-mode input voltage range, especially when operating at a low supply voltage. For instance, when considering the LM2901 comparator IC (which is a fine device when used properly), it is clear that this device will operate at a supply voltage of 3.3V. However, it is important to note that the common-mode input voltage range for this operating condition is only 1.8V at room temp, and is only 1.3V across the temperature range for the device. In other words, for a given LM2901 comparator powered by 3.3V, one of its two inputs must stay below that 1.3V limit in order to achieve a guaranteed proper output state.

The inputs on the CMPA102 board do not have these limitations due to the rail-to-rail input stages that are implemented. All inputs may go all the way from ground to the VCC input-side supply rail. The only limitation is that in a typical application it is advisable to keep the threshold voltages at least 10mV from the supply rails to ensure that there is enough voltage differential to switch states when the input signal crosses a threshold voltage.

Option for No Hysteresis

There may be situations in which it is desired to have practically no hysteresis. This can be accomplished by setting the low threshold (TH1-LO, TH2-LO) to a voltage that is greater than the high threshold (TH1-HI, TH2-HI).



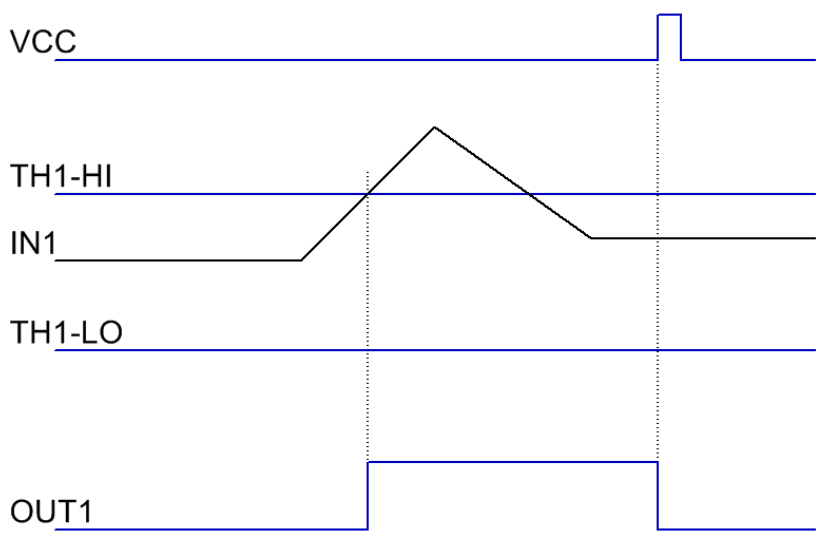
Output Signal vs Input Signals -- No Hysteresis

Option for Latching Output (high state)

There may be cases in which it is desired to have the output latch high when the high threshold is exceeded, with no option for the output to transition low other than by removing power from the board. For this case, set the low threshold (TH1-LO, TH2-LO) to ground reference by setting the low-threshold trim-pot fully counter-clockwise so that its output is zero, or by connecting the Thx-LO signal to ground at the input-side terminal block. Once high, the output will remain high as long as the input voltage is greater than the low threshold voltage, which has been set to ground in this case.

Be aware that this scheme assumes that the input signal (IN1, IN2) will not descend all the way to ground reference. If the low threshold voltage is at ground and the input signal is also at ground, the output state will not be deterministic (that is, it may switch low or it may remain high).

If it is desired to implement the output-high latching function while retaining the possibility of resetting it, then consider setting the low threshold to a small voltage (e.g., 0.1V) instead of setting it all the way down at ground. If the output latches high and the input later drops back into the region below the high threshold, reset can be accomplished by applying a fast positive step on the supply rail (rising step of 3V or more, for at least 20ms), as shown in the figure below.



Reset by Step-Up on VCC

Deterministic Startup: Power-On Reset

Like any comparator circuit that includes hysteresis, the output state is not strictly a function of the inputs only. This is apparent by noting that when the input signal (IN1, IN2) is between the threshold voltages, the output may be either high or low depending on the particular sequence of events that occurred previously. While this is normal and expected, it raises a question: If the input signal is between the threshold voltages during power-up, what will the initial output state be?

In order to ensure that the output state is deterministic for this power-up condition, the CMPA102 board includes a power-on reset function. As VCC ramps up, the input signal that is seen by the comparator IC gets pulled low for about 10ms. The output state is low for this condition. When the comparator's input signal is then released and rises to a value between the threshold voltages, the state machine clearly interprets this as a rising signal with an output state that is currently low, so the output state remains low. It will stay in this state until the signal at some point exceeds the high threshold.

If it is desired to take advantage of this power-on reset function, recommended maximum VCC ramp-up times should be observed as indicated in the table below.

VCC Voltage	Max Allowed VCC Ramp-Up Time to Ensure Reset
3.3V	1ms
5.0V	2ms
12V	5ms
24V	10ms

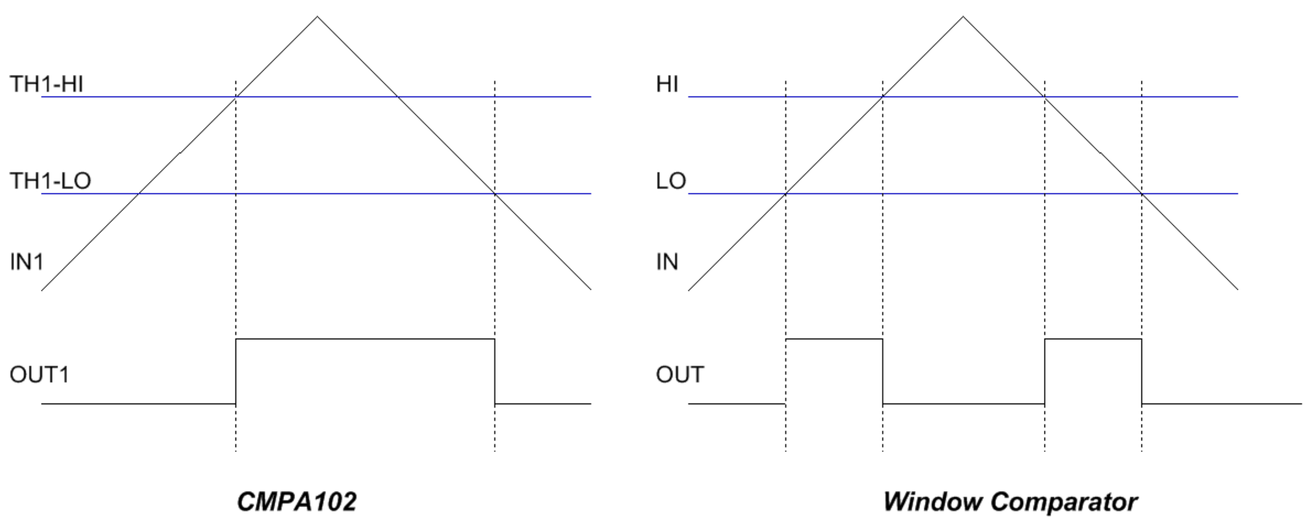
For normal operation, loading on each input signal (IN1, IN2) is approximately 51K. Note that during the brief power-up reset pulse period, loading on the input signal is approximately 4.7K.

Fast Step-Up on VCC and Power-On Reset Trigger

The power-on reset function engages when it sees a fast rising edge on the VCC supply line. During normal operation, it is assumed that VCC will be steady, or will be rising or falling relatively slowly (e.g., battery voltage dropping slowly over time). If using the CMPA102 in a system in which the VCC supply is very noisy (e.g., fast voltage steps of about 2V or more), there is the potential for the power-on reset generator to be triggered. Depending on the state of the system at the time that this happens, this could cause the output to switch unexpectedly. If using this device in a system with a very noisy VCC supply, please consult Winford Engineering to discuss the particulars of the application and determine the optimal solution.

Not a Window Comparator!

Since there are two input thresholds on each channel, there may be an initial impression that this device is a window comparator. To eliminate any confusion, please note that this device is not a window comparator. The diagram below illustrates the behavior of the CMPA102 and a window comparator.

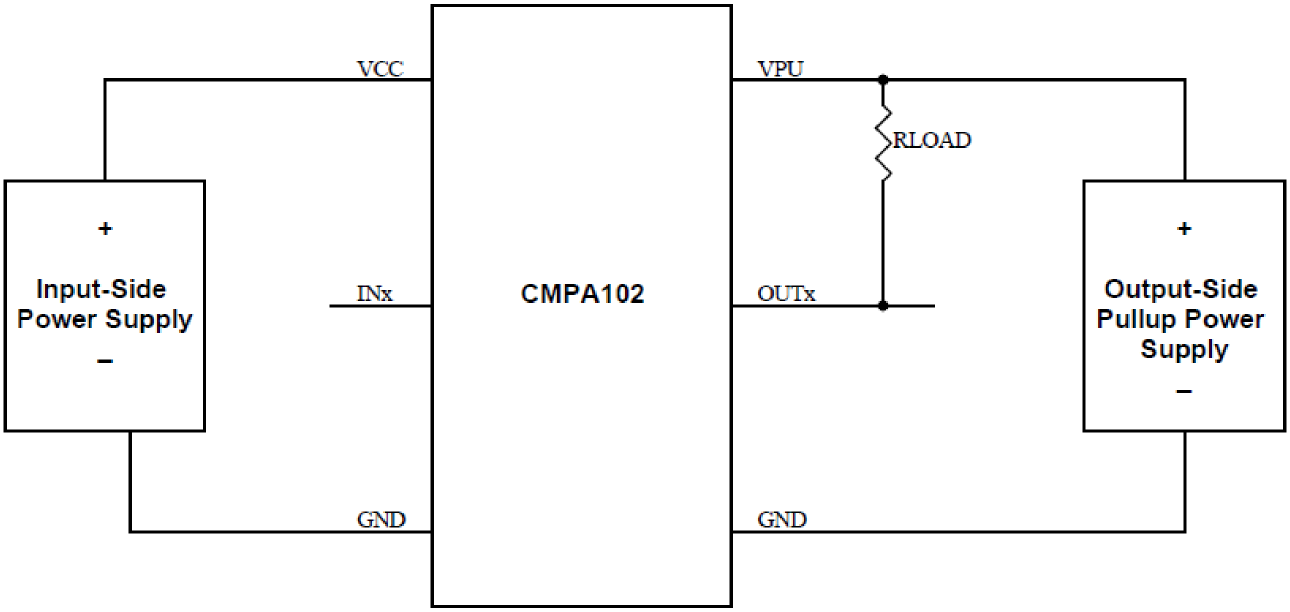


(It is feasible to use CMPA102 as the basis for a window comparator by using both channels and adding an external transistor. Contact Winford Engineering if more information is needed on this topic.)

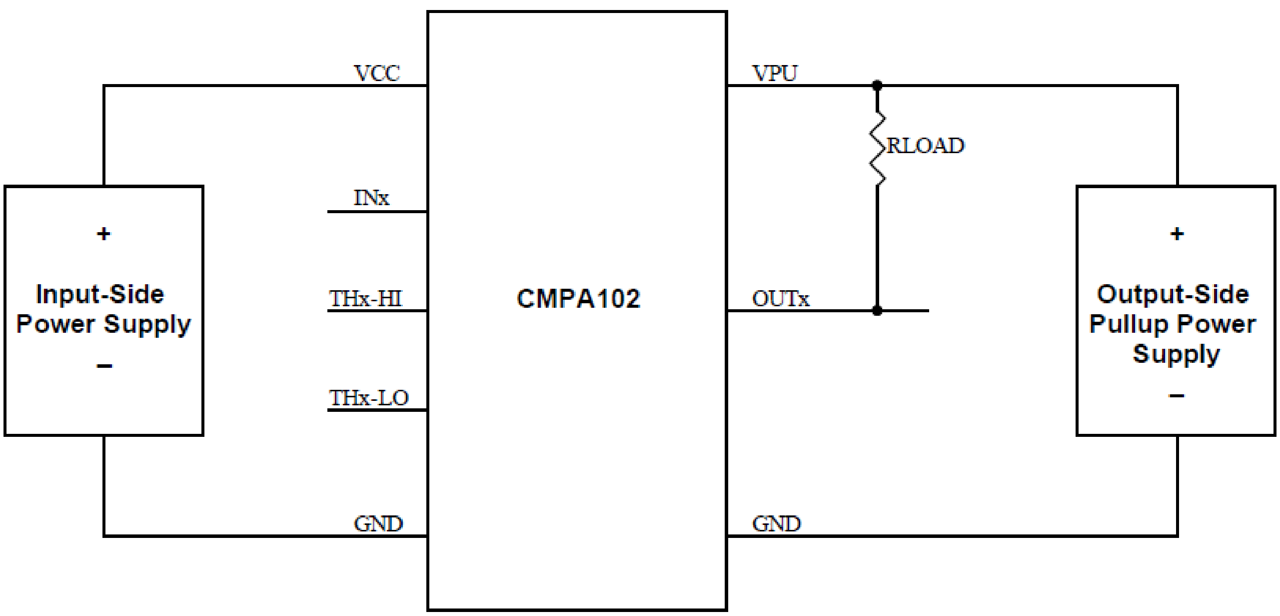
Operating Conditions

Ambient Temperature Range	–30°C to 85°C
Relative Humidity Range - not icing or condensing	5% to 85% RH

Configuration for Ratings / Specifications



The figure above applies for applications in which the potentiometers are used to set thresholds.



The figure above applies for applications in which the user provides thresholds externally.

Absolute Maximum Ratings (25 degC, all voltages relative to GND)

Specification	*Symbol*	*Min*	*Typ*	*Max*	*Unit*
Input Supply Voltage	VCC	-25		27.5	V
Input Signal Voltages	INx	-25		40V or VCC + 25 (whichever is less)	V
Threshold Voltages (externally applied), at VCC=24V, trim-pots in any position	THx-HI, THx-LO	-5		29	V
Threshold Voltages (externally applied), at VCC=12V, trim-pots in any position	THx-HI, THx-LO	-17		29	V
Threshold Voltages (externally applied), at VCC=3.3V, trim-pots in any position	THx-HI, THx-LO	-25		29	V
Output Supply Pull-Up Voltage	VPU	-30		30	V
Output Signal Voltages, at VPU=24V	OUTx	-6		30	V
Output Signal Voltages, at VPU=12V	OUTx	-18		30	V
Output Signal Voltages, at VPU=3.3V	OUTx	-26		30	V
Max rated sink current @ -30 degC VCC = 3.3V VCC = 5.0V VCC = 12V VCC = 24V	IOUTx			1.5 1.7 1.8 1.8	A A A A
Max rated sink current @ 25 degC VCC = 3.3V VCC = 5.0V VCC = 12V VCC = 24V	IOUTx			1.0 1.3 1.5 1.5	A A A A
Max rated sink current @ 85 degC VCC = 3.3V VCC = 5.0V VCC = 12V VCC = 24V	IOUTx			0.5 0.8 1.0 1.0	A A A A

Electrical Performance and Recommended Operating Conditions (at 25 degC, all voltages relative to GND)

Specification / Conditions	*Min*	*Typ*	*Max*	*Unit*
Input Supply Voltage (VCC)	3.2		25	V
Input Signal Range (INx)	0.0		VCC	V
Input Thresholds (THx-HI, THx-LO)	0.01		VCC – 0.01	V
Output Pull-up Voltage (VPU)	3.2		25	V

Specification / Conditions	***Min***	***Typ***	***Max***	***Unit***
Output Signal Range (OUTx)	0.0		VPU	V
Input signal current, INx = 3.3V, VCC > 3.3V (stable)		0.06		mA
Input signal current, INx = 5.0V, VCC > 5.0V (stable)		0.10		mA
Input signal current, INx = 12V, VCC > 12V (stable)		0.23		mA
Input signal current, INx = 24V, VCC > 24V (stable)		0.47		mA
Switch point for rising input signal, relative to THx-HI	-0.01		+0.01	V
Switch point for falling input signal, relative to THx-LO	-0.01		+0.01	V
Threshold signal at full counterclockwise trim-pot position (threshold set by trim-pot, THx-xx not connected to external circuitry)		0	0.01	V
Threshold signal at full clockwise trim-pot position (threshold set by trim-pot, THx-xx not connected to external circuitry)	VCC-0.01	VCC		V
Output OUTx Voltage, Low State (FET active) VPU = VCC = 3.3V RLOAD = 2.7 Ohms RLOAD = not present		0.60 0.15	0.85 0.30	V V
Output OUTx Voltage, Low State (FET active) VPU = VCC = 5.0V RLOAD = 3.5 Ohms RLOAD = not present		0.57 0.15	0.80 0.30	V V
Output OUTx Voltage, Low State (FET active) VPU = VCC = 12.0V RLOAD = 7.7 Ohms RLOAD = not present		0.55 0.17	0.80 0.32	V
Output OUTx Voltage, Low State (FET active) INx = Logic Low VPU = VCC = 24.0V RLOAD = 16 Ohms RLOAD = not present		0.55 0.17	0.80 0.35	V
Output OUTx Voltage, High State INx = Logic High VPU = 3.2V to 25V No external loading	VPU – 0.3	VPU		V

Screw Terminal Wire Sizes

- All Signals and Power: 16-26 AWG

Output Stage Component Details

The output stage for each channel is shown in the simplified schematic drawing shown previously in this document. Additional information is provided below.

Component	***Manufacturer***	***Manuf. Part Number***
Output Pull-up Resistor	(any)	3.0 kΩ
Output Low-Side Protected FET, Dual	ON Semiconductor	NCV8402AD
Output Diode (reverse-polarity protection)	Nexperia	PMEG045V100EPD

Each pin on the output-side terminal block also has a small capacitor (100pF) connected between the signal and ground in order to provide a measure of ESD protection.

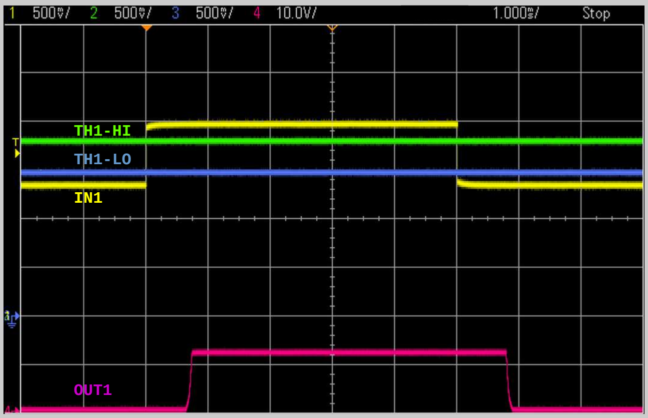
Note that the outputs are open-drain outputs. That is, each of the outputs is able to sink a significant amount of current, but can only source current thru its output pull-up resistor.

For a thorough understanding of the protection features included in the protected output FET (low-side driver), please refer to the ON Semiconductor datasheet for device NCV8402AD.

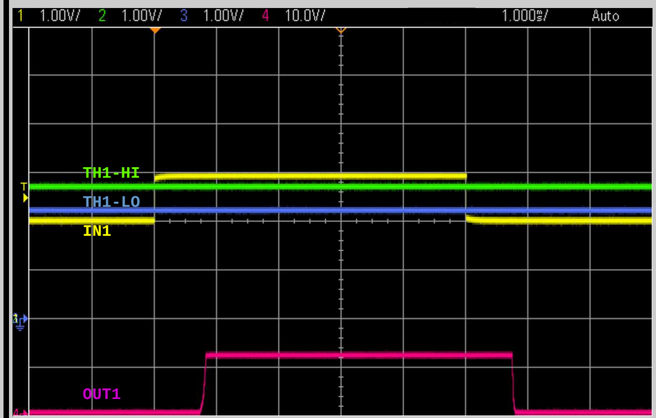
Timing Performance

For reference, typical output transition timing is provided below (for a single channel).

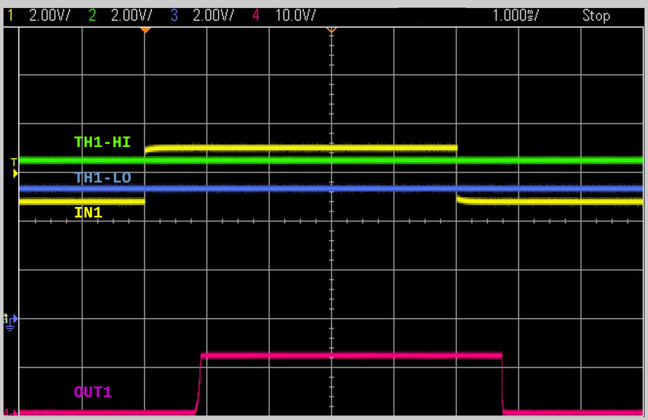
VCC = 3.3V, VPU = 12V, No External Loading



VCC = 5.0V, VPU = 12V, No External Loading



VCC = 12V, VPU = 12V, No External Loading



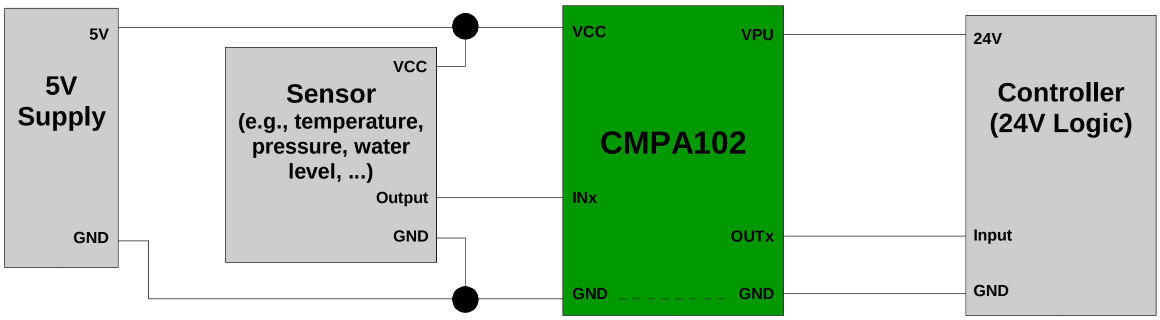
VPU = 24V, VPU = 12V, No External Loading

(Plot time scale: 1ms/div)

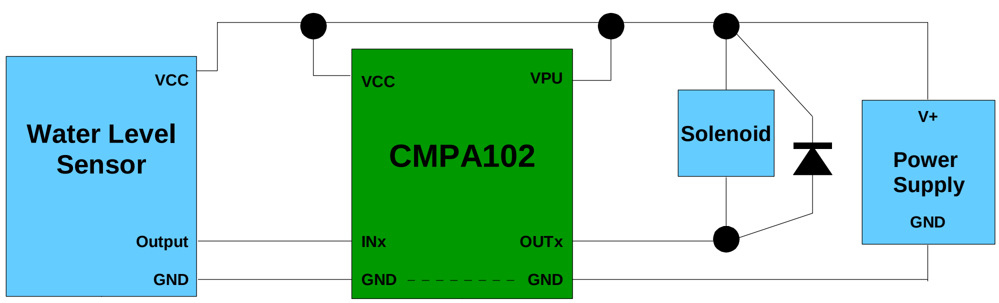
Note that timing will vary somewhat based on the application. If any particular timing parameter is critical for a given application, please consult Winford Engineering to discuss the specific operating conditions of the application.

Applications

On each channel, a digital output provides an indication of the value of an analog input signal relative to the analog thresholds. In addition, this product provides a method to perform logic level translation since it allows the input side and output side to use different supply voltages. The figure below shows a typical application in which the the CMPA102 is used to monitor an analog sensor operating at 5V and provide a digital indicator signal to a controller operating at 24V.



This product is also suitable for use as a low-side driver for a small DC motor, solenoid, heater element, relay coil, bulb, or similar. The figure below shows an example use case in which the CMPA102 is used to monitor the water level in a tank. When the water level drops below the THx-LO threshold set by the user, the OUTx output will go low, activating the solenoid which opens the water supply valve to allow more water to flow into the tank. The solenoid will remain activated until the level sensor's analog output exceeds the THx-HI threshold set by the user. In this particular application, both the input side and output side are operating at the same supply voltage, although other applications may be configured with separate supplies.



For this type of application in which the low-side output driver sinks additional current beyond the current flowing thru the output pull-up resistor, the user should note the electrical performance characteristics table in which max rated sink current is specified for various conditions. It is also advisable to include external clamping for inductive loads (e.g., diode placed across the load, as shown in the figure above).

System Analysis: Failure Modes & Effects

When designing any system, it is advisable to ensure that there is a thorough understanding of what will happen when each piece of the system fails. It is the responsibility of the system designer to ensure that the failure effects are understood, and that appropriate countermeasures or redundancies are implemented if warranted.

If there are additional questions about using this product in a particular application, please contact Winford Engineering for more information.

Notice

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Revision History

Date	Page #	Description
11/01/2019	7	Option for No Hysteresis: Corrected figure to show that transitions occur when input crosses TH1-LO (not TH1-HI)