

Isolated Undervoltage and Overvoltage Detection Circuit



Data Converters

Scott Cummins

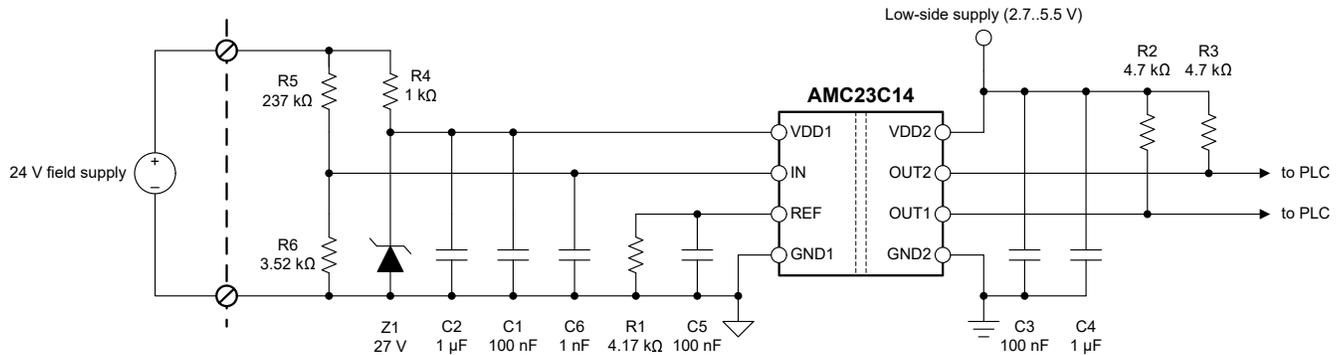
Design Goals

Overvoltage Level	Undervoltage Level	Low-Side V _{DD}	High-Side V _{DD}	Transient Response Time
28.8 V	20.4 V	2.7 V–5.5 V	24 V	360 ns

Design Description

This high-speed, isolated undervoltage and overvoltage detection circuit is implemented with a dual isolated window comparator with an adjustable threshold (AMC23C14). This circuit is designed for industrial field-supply applications where the controller-side must detect whether the remote module supply voltage is in a valid range.

The AMC23C14 is selected for its robust reinforced isolation with a high CMTI of 100 kV/μs (minimum), the adjustable dual window comparator thresholds, a wide high-side supply voltage range (3 V to 27 V), and the extended industrial temperature range (–40°C to +125°C).



Undervoltage and Overvoltage Detection Circuit Schematic

Design Notes

1. To minimize errors, choose precision resistors for the voltage divider (R_5 and R_6) and the threshold-setting resistor (R_1).
2. The AMC23C14 is powered from the field supply and is protected against voltage > 30 V (absolute maximum supply) by a Zener diode and shunt resistor.
3. Select the voltage divider and threshold-setting resistors based on the desired operating voltage range.

Design Steps

1. Determine the voltage divider ratio needed to trip the fixed internal 300-mV threshold when the power supply exceeds the minimum valid operating voltage of 20.4 (24 V – 15%). Size the total resistance of the voltage divider to set its current at 100 μ A when the V_{supp} is at the desired operating voltage of 24 V.

$$IN = V_{supp} \left(\frac{R_6}{R_5 + R_6} \right)$$

$$300 \text{ mV} = 20.4 \text{ V} \left(\frac{R_6}{R_5 + R_6} \right)$$

$$V_{supp} = 100 \mu\text{A} \times (R_5 + R_6)$$

$$24 \text{ V} = 100 \mu\text{A} \times (R_5 + R_6)$$

Solving the system of equations results in $R_5 = 236 \text{ k}\Omega$, $R_6 = 3.52 \text{ k}\Omega$.

- Using the [Analog Engineer's Calculator](#), the closest E96 resistor value is 237 k Ω and 3.48 k Ω .
2. Size the threshold-setting resistor to trip the adjustable-threshold comparator when the power supply exceeds 28.8 V (24 V + 20%).

$$IN = V_{supp} \left(\frac{R_6}{R_5 + R_6} \right)$$

$$IN = 28.8 \text{ V} \left(\frac{3.52 \text{ k}\Omega}{237 \text{ k}\Omega + 3.52 \text{ k}\Omega} \right)$$

$$IN = 0.42 \text{ V}$$

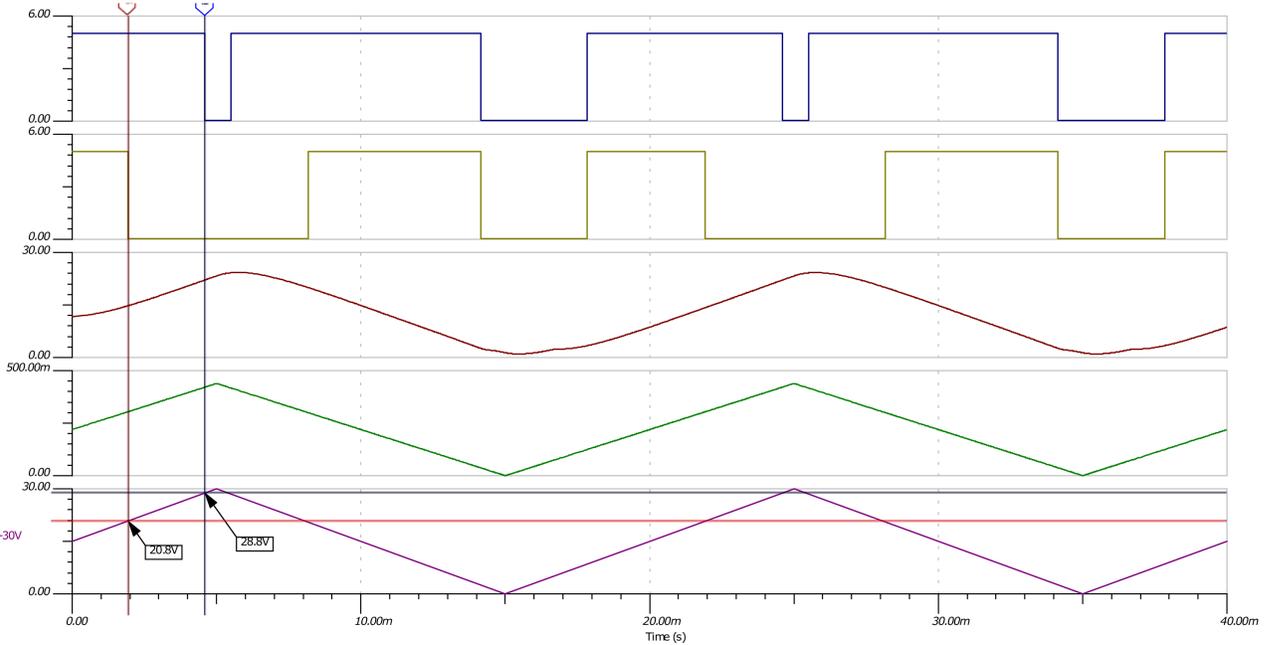
$$V_{ref} = IN$$

$$R_1 = \frac{V_{ref}}{I_{ref}} = \frac{0.42 \text{ V}}{100 \mu\text{A}} = 4.2 \text{ k}\Omega$$

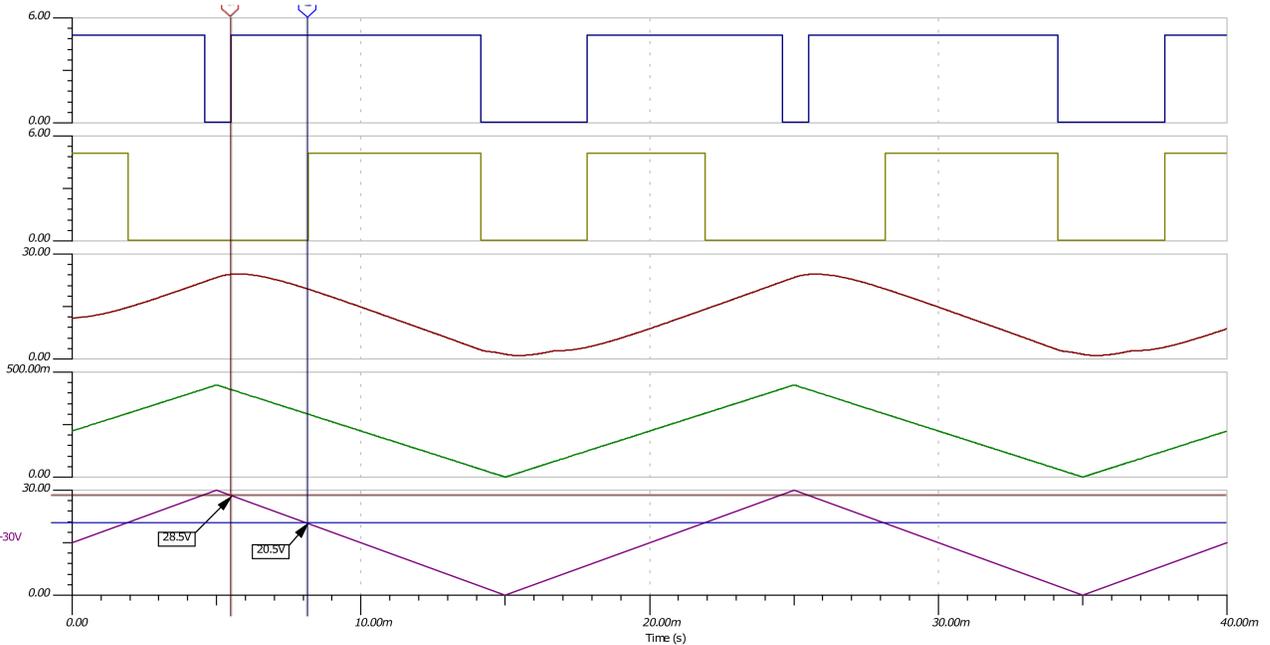
3. Select a 27-V Zener diode to protect the AMC23C14 from voltages greater than the recommended operating supply voltage.

Design Simulations

The following images are SPICE simulation waveforms of the undervoltage and overvoltage detection circuit. Included is the VDD1 input, which shows the Zener diode protects the VDD1 input from voltages outside of its operating range. [SPICE Simulation of the Undervoltage and Overvoltage Detection Circuit - Rising](#) shows the Spice simulation with the output trigger points on a rising input voltage. [SPICE Simulation of the Undervoltage and Overvoltage Detection Circuit - Falling](#) shows a similar image but with the output trigger points on a falling input voltage. Comparing the two figures, the trigger points differ by 0.3 V with the falling voltage input having a lower trigger value.



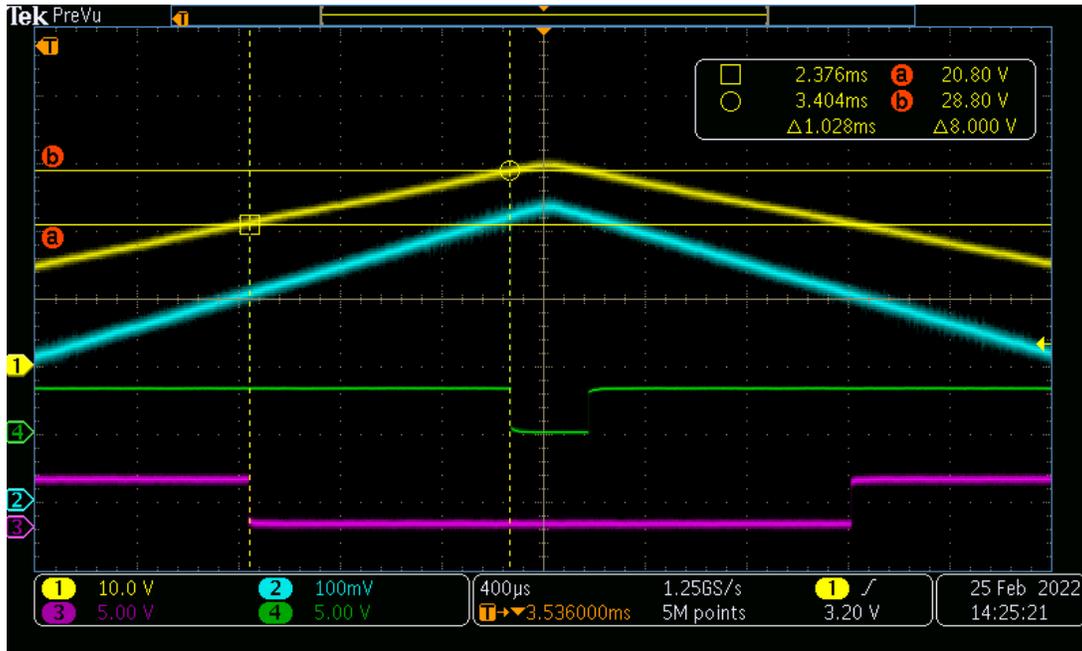
SPICE Simulation of the Undervoltage and Overvoltage Detection Circuit - Rising



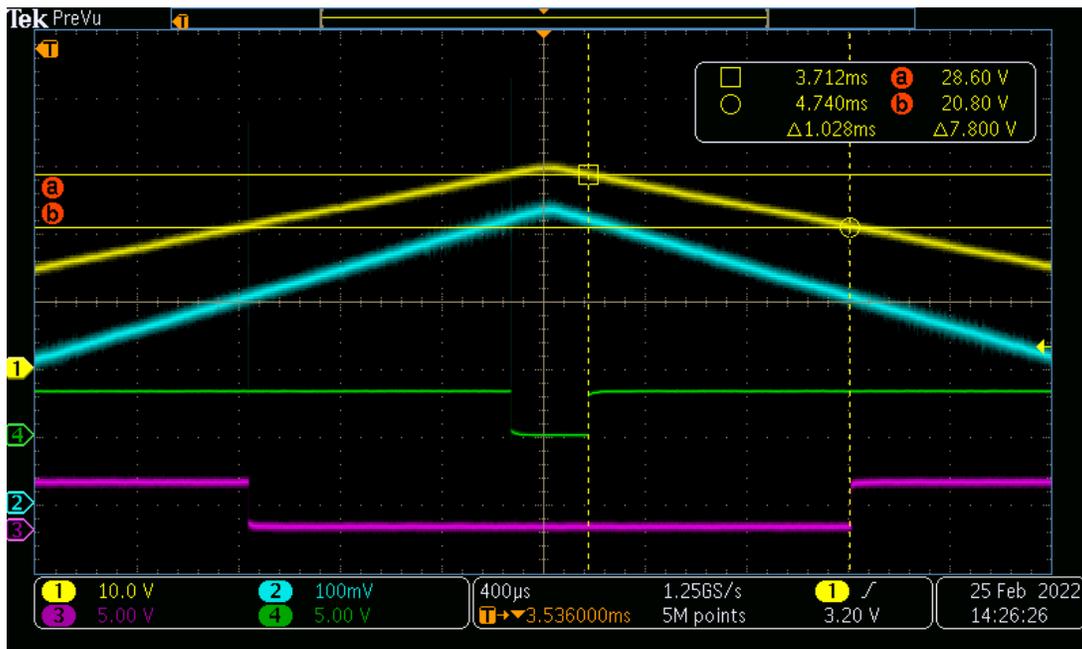
SPICE Simulation of the Undervoltage and Overvoltage Detection Circuit - Falling

Measured Response

The following images show the measured output of the undervoltage and overvoltage detection circuit, comparing the outputs to the V_{supp} voltage (trace 1). The AMC23C14 has open-drain outputs that are normally pulled up to V_{DD2} , and is driven low when the input voltage exceeds the threshold voltage of each comparator. In these measurements $OUT1$ (trace 3) transitions low if V_{supp} exceeds 28.8 V, and $OUT2$ transitions low if V_{supp} exceeds 20.8 V. Component variations and the comparator hysteresis can affect the trip thresholds, but in this case the trip point is within less than 1% of the desired values. The voltage thresholds vary slightly if V_{supp} is rising or falling. The second waveform depicts this with $OUT1$ tripping at 28.6 V instead of 28.8 V.



Waveform Capture With V_{supp} Increasing

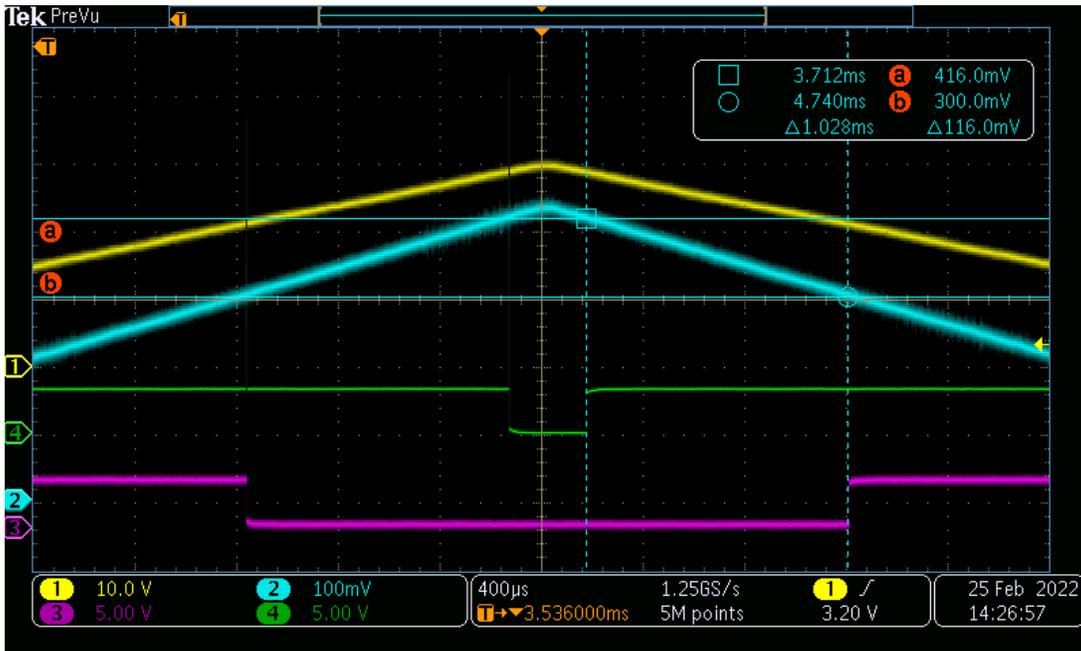


Waveform Capture With V_{supp} Decreasing

The following images show the measured output of the undervoltage and overvoltage detection circuit, comparing the AMC23C14 outputs to the VIN voltage (trace 2). These measurements confirm that the comparator trip thresholds match the desired values set by the internal comparator threshold at 300 mV, and the externally set threshold at 420 mV as defined in the equation in step 2 of the Design Steps section.



Waveform of IN When V_{supp} is Increasing



Waveform of IN When V_{supp} is Decreasing

Design Featured Device

Device	Key Features	Device Link
AMC23C14	<ul style="list-style-type: none"> • Wide high-side supply range: 3 V to 27 V • Low-side supply range: 2.7 V to 5.5 V • Dual window comparator: <ul style="list-style-type: none"> – Window comparator 1: ± 20-mV to ± 300-mV adjustable threshold – Window comparator 2: ± 300-mV fixed threshold • Supports positive-comparator mode: <ul style="list-style-type: none"> – Cmp0: 600-mV to 2.7-V adjustable threshold – Cmp2: 300-mV fixed threshold – Cmp1 and Cmp3: Disabled • Reference for threshold adjustment: 100 μA, $\pm 2\%$ • Trip threshold error: $\pm 1\%$ (max) at 250 mV • Propagation delay: 290 ns (typ) • High CMTI: 15 kV/μs (min) • Open-drain outputs • Safety-related certifications: <ul style="list-style-type: none"> – 7000-V_{pk} reinforced isolation per DIN VDE V 0884-11 – 5000-V_{RMS} isolation for 1 minute per UL1577 • Fully specified over the extended industrial temperature range: -40°C to $+125^{\circ}$C 	Device: AMC23C14 Similar Devices: Isolated amplifiers

Design References

See [Analog Engineer's Circuit Cookbooks](#) for TI's comprehensive circuit library.

Texas Instruments, [AMC23C14 AMC23C14 Dual, Fast Response, Reinforced Isolated Window Comparator With Adjustable Threshold](#) data sheet

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