Analog Engineer's Circuit

Isolated Overcurrent Protection Circuit

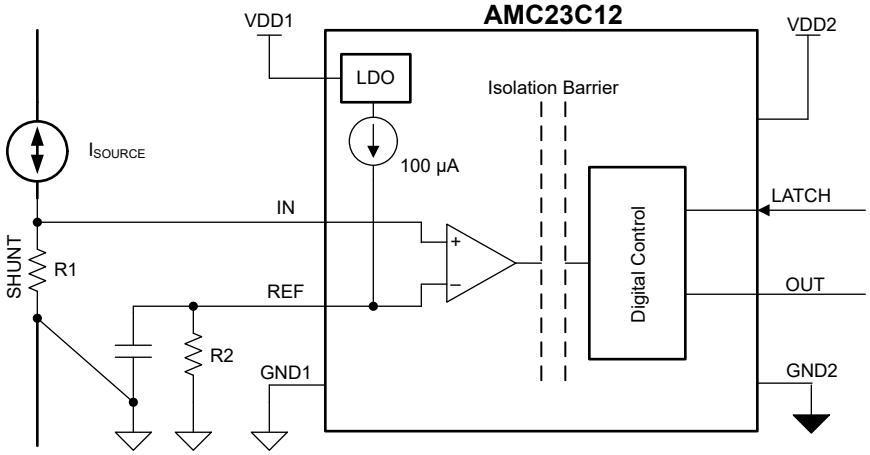
Data Converters

Design Goals

Nominal Current	Overcurrent Level	High-Side Supply	Low-Side Supply	Transient Response Time
50 A	55 A	3 V–27 V	2.7 V–5.5 V	≤ 1000 ns

Design Description

This high-speed, isolated bidirectional overcurrent detection circuit is implemented with the AMC23C12. The AMC23C12 features an isolated window comparator and an adjustable threshold level via a fixed internal precision current source and user-selectable resistor. This circuit is designed for fast detection of overcurrent situations allowing the controller to disable pulse width modulation (PWM) control of high-speed switches used in motor control, traction inverter, and other industrial control systems.



Overcurrent Protection Circuit Schematic

Design Notes

1. To minimize errors, choose a precision shunt resistor (R_1) and the threshold-setting resistor (R_2).
2. The AMC23C12 is powered from the gate-drive supply or high-side auxiliary source up to 27 V.
3. Select the shunt resistor and threshold-setting resistors to match the nominal current and overcurrent limits using the window comparator mode of operation.

Design Steps

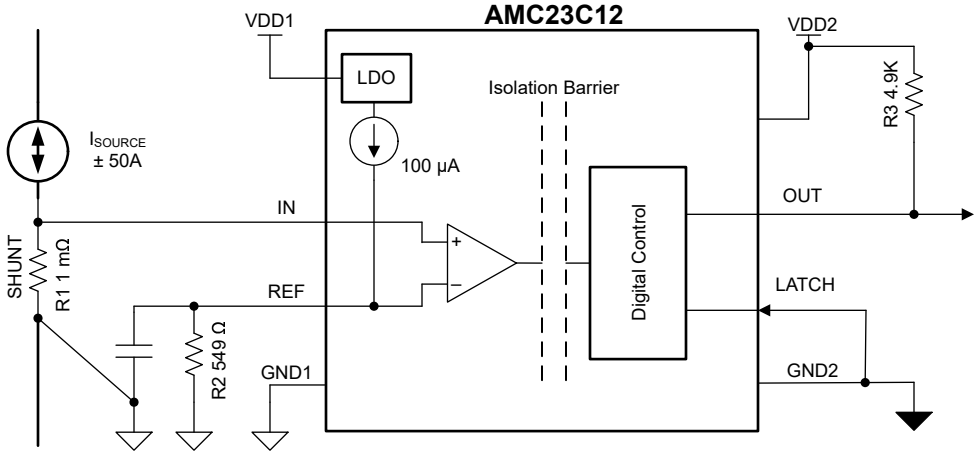
1. Determine the size of the shunt resistor based on the nominal current level. The shunt resistor is sized to allow 50 mV at the input pin.

$$R_1 = \left(\frac{50\ \ mV}{50\ \ A}\right) = 1.0\ \ m\Omega$$

2. Determine the value of R2 based on the desired current trip level using the internal 100-µA source and the desired trip level of 55 A with a 1-mΩ shunt for 55 mV at the input to the window comparator.

$$R_2 = \left(\frac{55\ \ mV}{100\ \ \mu A}\right) = 550\ \ \Omega$$

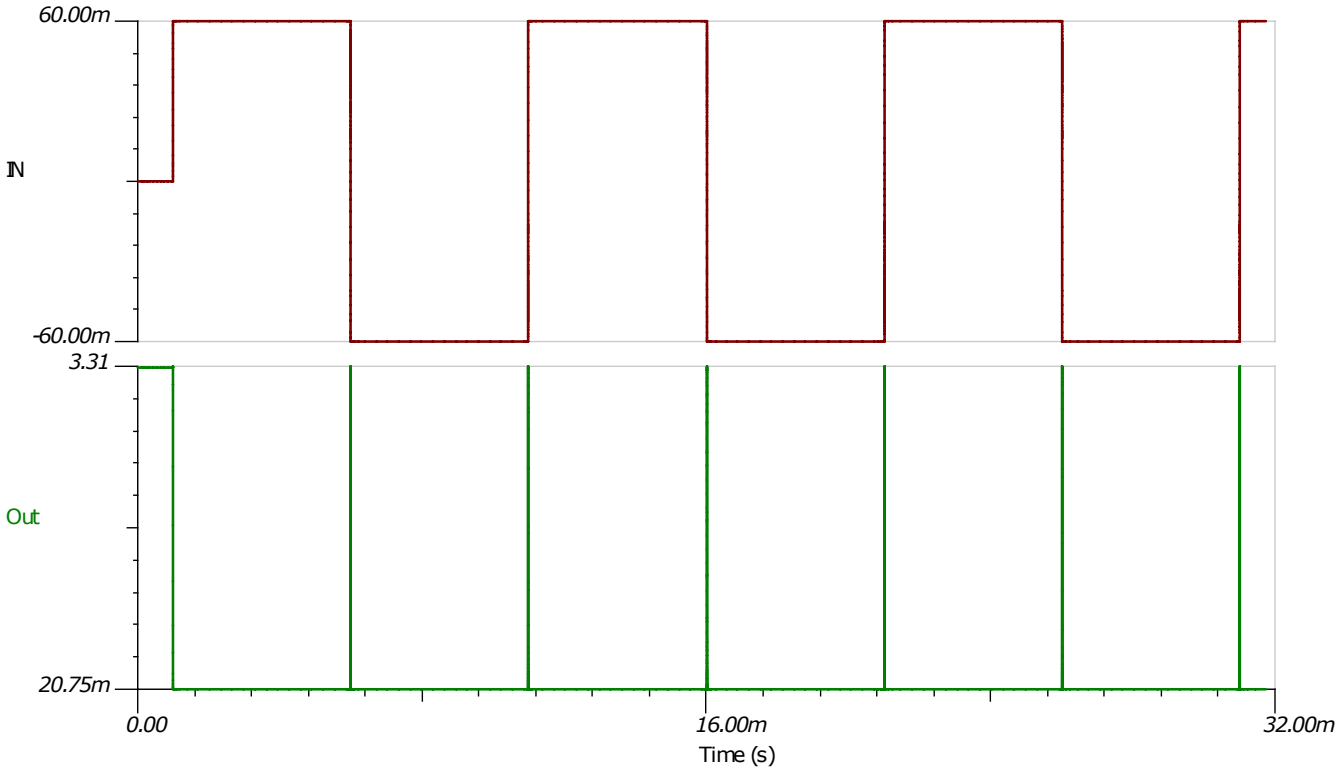
   - Using the Analog Engineers Calculator, the closest E96 resister value to 550 Ω is 549 Ω.
3. Optional - select a 27-V Zener diode to protect the AMC23C12 from voltages greater than the recommended operating supply voltage.



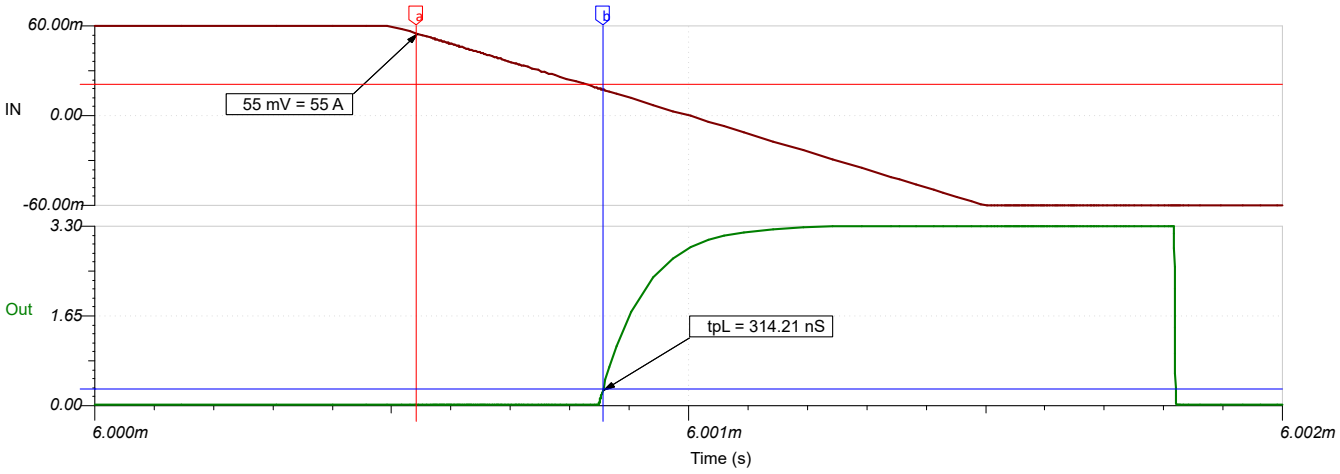
Revised Overcurrent Protection Schematic

Design Simulations

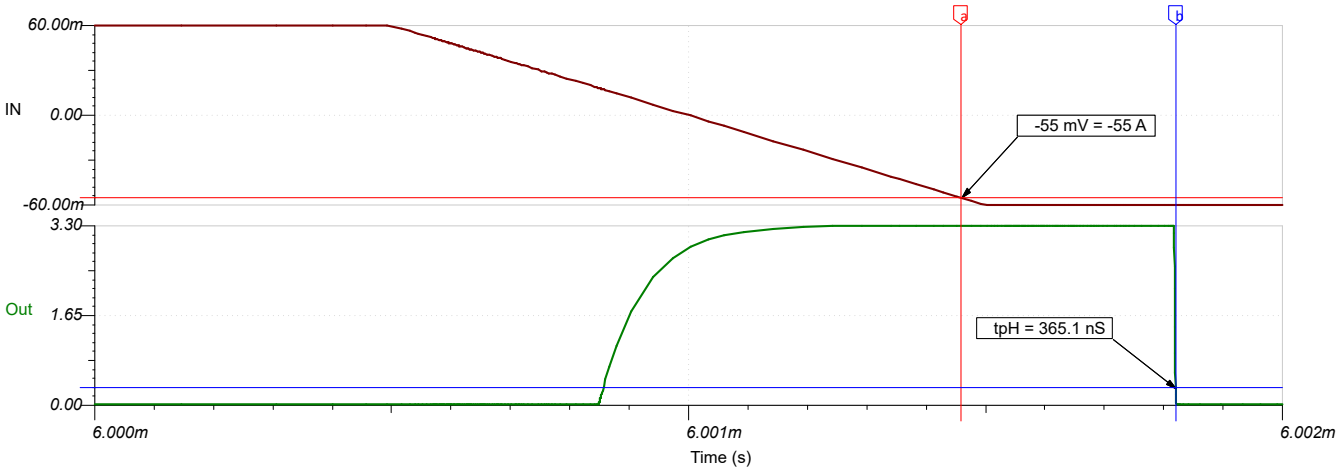
The following images are SPICE simulations of the overcurrent protection circuit. The simulations show the time until the edges trigger which is approximately 360 ns.



Transient Response of Overcurrent Protection Simulation



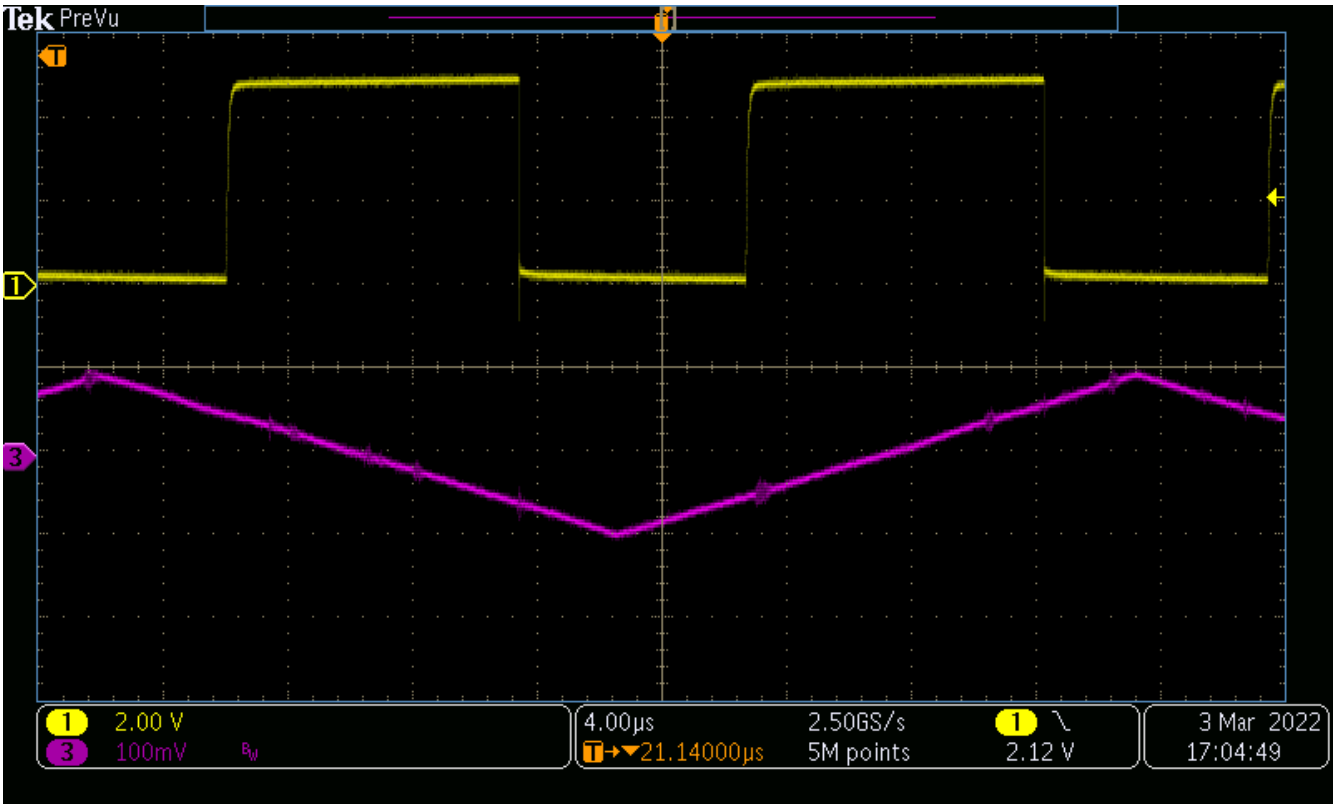
Transient Response of Overcurrent Protection Simulation - Rising



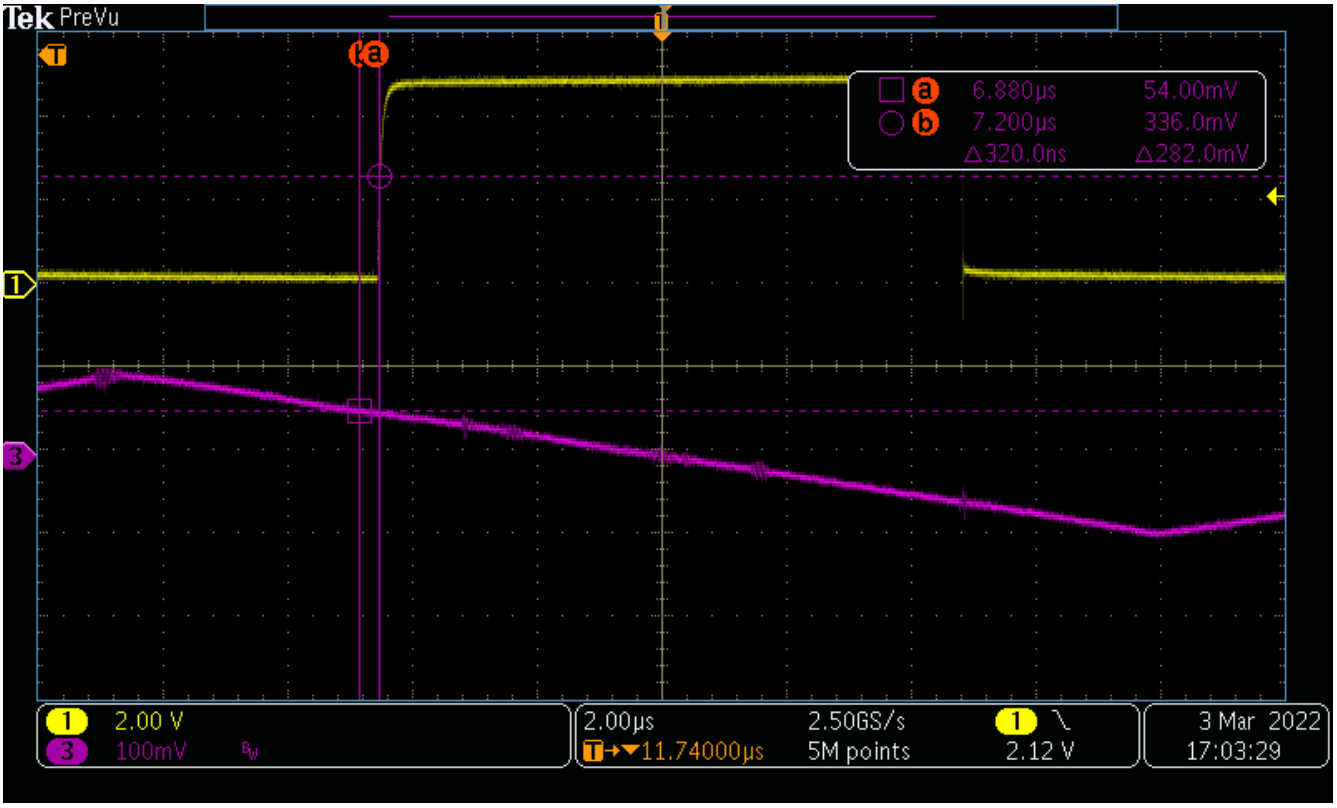
Transient Response of Overcurrent Protection Simulation - Falling

Design Results

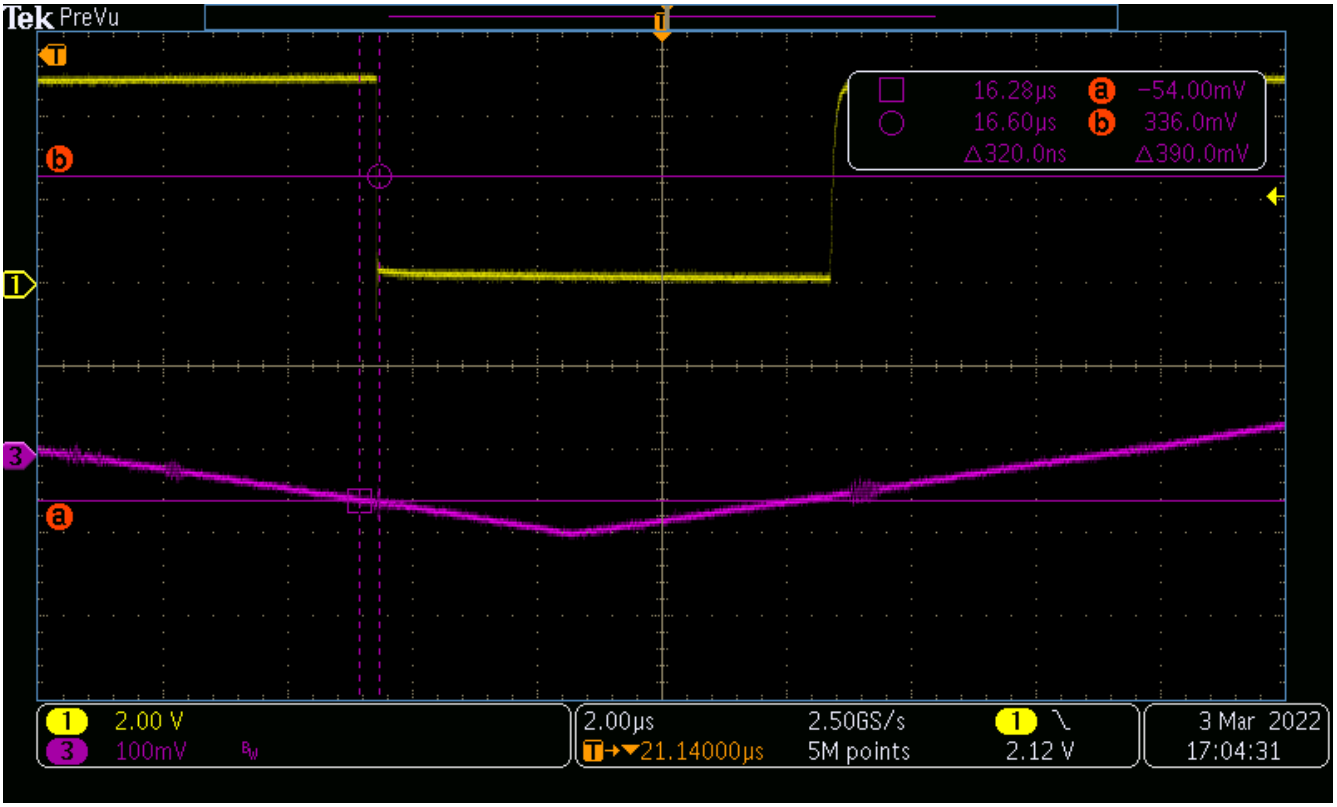
The following images are the waveform captures of the physical circuit. Overcurrent Protection Circuit Waveform shows the output on line 1 with relation to input on line 3. Overcurrent Protection Circuit Waveform - Rising shows the rising edge of the output line 1 and the time delay from the triggered current to the output. Overcurrent Protection Circuit Waveform - Falling shows the falling edge of the output line 1 and the time delay from the triggered current to the output.



Overcurrent Protection Circuit Waveform



Overcurrent Protection Circuit Waveform - Rising



Overcurrent Protection Circuit Waveform - Falling

Design Featured Devices

Device	Key Features	Device Link
AMC23C12	• Wide high-side supply range: 3 V to 27 V • Low-side supply range: 2.7 V to 5.5 V • Adjustable threshold: – Window-comparator mode: ±20 mV to ±300 mV – Positive-comparator mode: 600 mV to 2.7 V • Reference for threshold adjustment: 100 µA, ±2% • Trip threshold error: ±1% (max) at 250 mV • Propagation delay: 290 ns (typ) • High CMTI: 55 kV/µs (min) • Open-drain output with optional latch mode • Safety-related certifications: – 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°C	Device: AMC23C12 Similar Devices: Isolated amplifiers

Design References

See Analog Engineer's Circuit Cookbooks for TI's comprehensive circuit library.

Texas Instruments, *AMC23C12 Fast Response, Reinforced Isolated Window Comparator With Adjustable Threshold and Latch Function* data sheet

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