Analog Engineer's Circuit

Isolated Current-Sensing Circuit With ±50-mV Input and Differential Output

Data Converters

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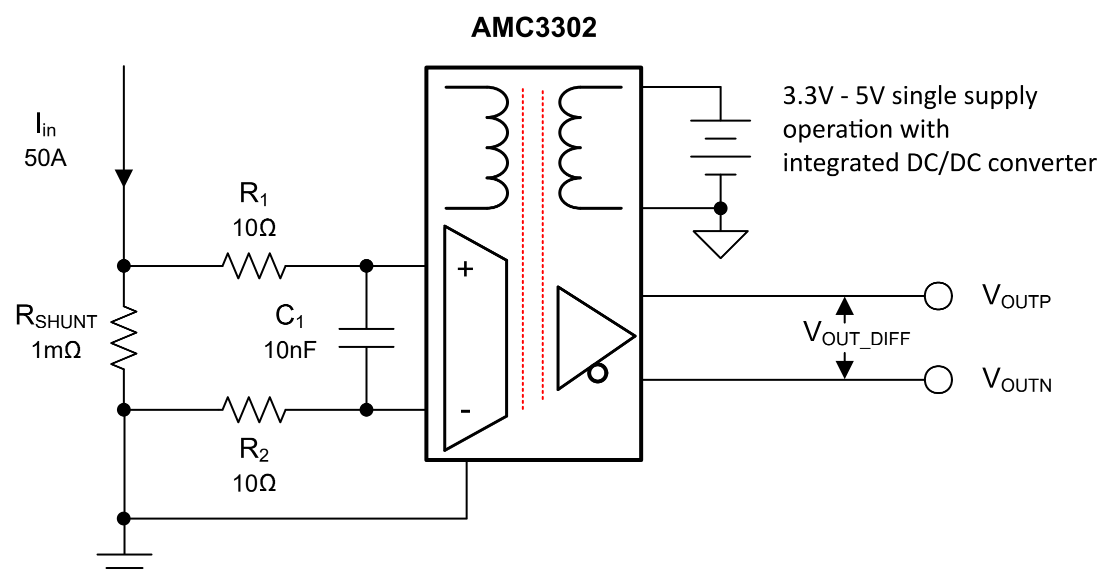
Design Goals

Current Source		Input Voltage		Output Voltage		Single Power Supply
$I_{IN\ MIN}$	$I_{IN\ MAX}$	$V_{IN\ DIFF,\ MIN}$	$V_{IN\ DIFF,\ MAX}$	$V_{OUT\ DIFF,\ MIN}$	$V_{OUT\ DIFF,\ MAX}$	V_{DD}
–50 A	50 A	–50 mV	50 mV	-2.05 V	2.05 V	5 V

Design Description

This isolated single-supply bidirectional current sensing circuit can accurately measure load currents from –50 A to 50 A. The linear range of the input is from –50 mV to 50 mV with a differential output swing of –2.05 V to 2.05 V and an output common-mode voltage (V_{CM}) of 1.44 V. The gain of the isolated amplifier circuit is fixed at 41 V/V. The design requires 1200-V working voltage to ensure operator safety in a high-voltage application.



Design Notes

1. The AMC3302 was selected due to its high accuracy, small input voltage range and the single, low-side power supply requirement of the application.
2. Select a low impedance, low-noise source for VDD which supplies the AMC3302.
3. For highest accuracy measurements, select a precision shunt resistor with a low temperature coefficient.
4. Select the current shunt resistor based on expected peak input current levels.
5. For continuous operation, do not run shunt resistors at more than two-thirds of the rated current under normal conditions as per IEEE standards. Further reducing the shunt resistance or increasing the rated wattage may be necessary for applications with stringent power dissipation requirements.

Design Steps

1. Determine the transfer equation given the input current range and the fixed gain of the isolation amplifier.

$$V_{OUT} = I_{in} \times R_{shunt} \times 41$$

2. Determine the maximum shunt resistor value.

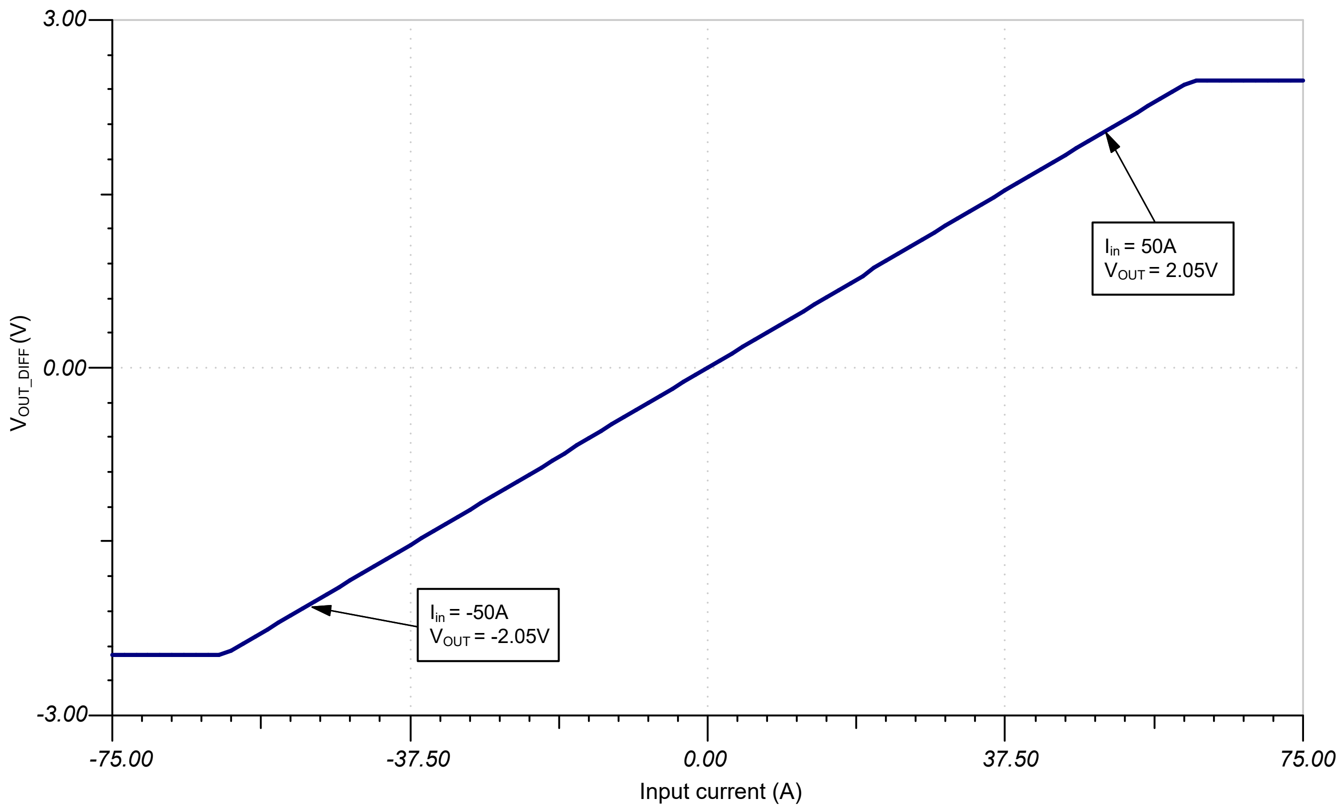
$$R_{shunt} = \frac{V_{inMax}}{I_{inMax}} = \frac{50\ mV}{50\ A} = 1\ m\Omega$$

3. Determine the minimum shunt resistor power dissipation.

$$Power\ R_{shunt} = {I_{inMax}}^2 \times R_{shunt} = 2500\ A \times 0.001\ \Omega = 2.5\ \mathrm{W}$$

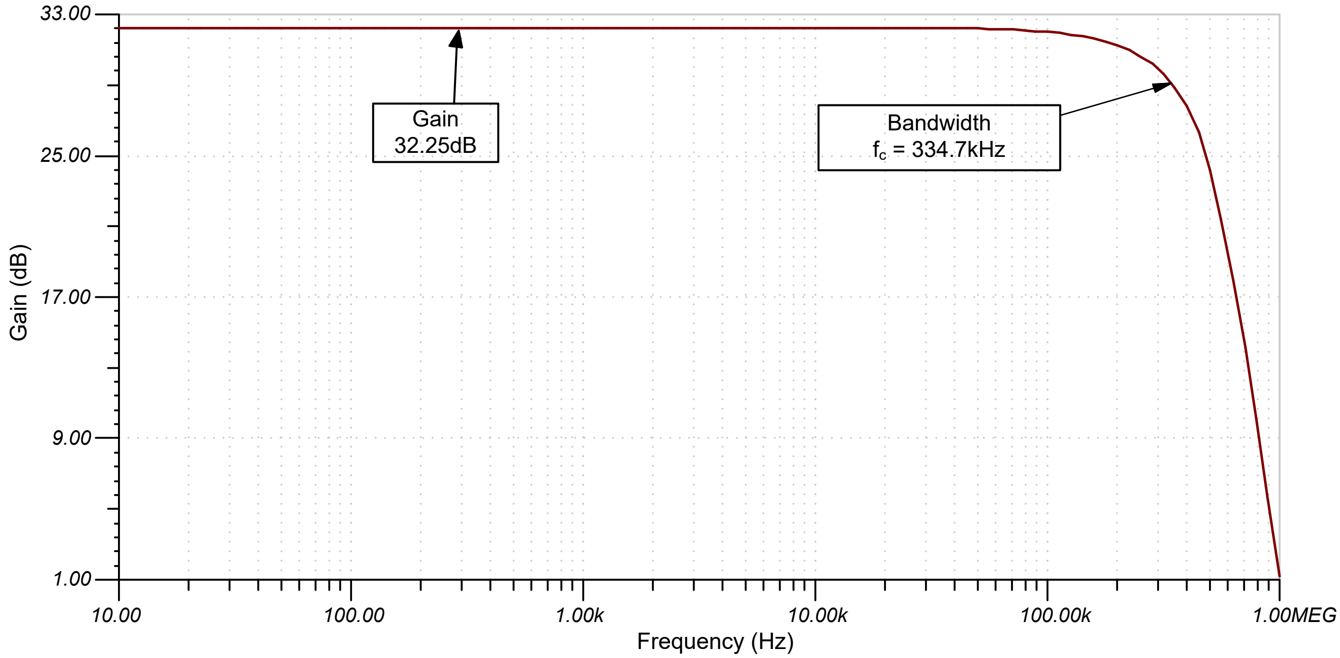
DC Transfer Characteristics

The following plots show the simulated DC characteristics of the AMC3302 differential output. The plot shows that the output is linear with a ±50 A input.



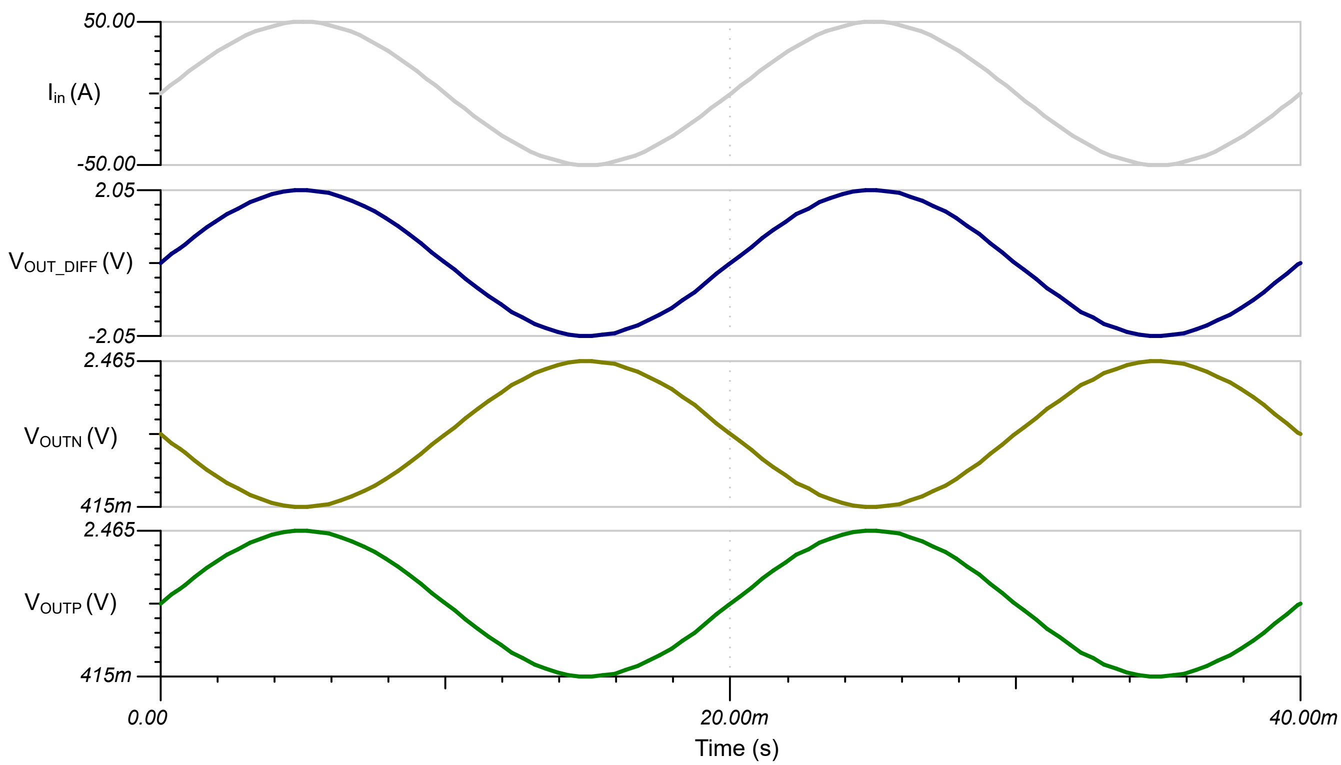
Closed Loop AC Simulation Results

The AC sweep shows the AC transfer characteristics of the differential output. Since the AMC3302 has a gain of 41 V/V, the gain of 33.25-dB shown in the following image is expected.



Transient Simulation Results

The following transient simulation shows the output signals of the AMC3302 from –50 A to 50 A. The differential output of the AMC3302 is ±2.05 Vpk-pk as expected.



Design References

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

Design Featured Isolation Amplifier

AMC3302	
Working voltage	1200 V_{RMS}
Gain	41 V/V
Bandwidth	340 kHz TYP
Linear input voltage range	±50 mV
AMC3302	

Design Alternate Isolation Amplifier

AMC3301	
Working voltage	1200 V_{RMS}
Gain	8.2 V/V
Bandwidth	334 kHz TYP
Linear input voltage range	±250 mV
AMC3301	

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