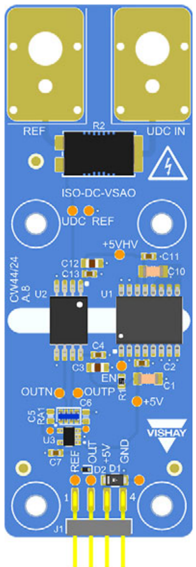
Reference Design
Isolated DC Voltage Sensing Using the VIA2000SD



LINKS TO ADDITIONAL RESOURCES

- ISO-DC-VSAO

FEATURES

- DC voltage measurements up to 1000 V_{RMS}
- Maximum working isolation voltage of 1200 V_{RMS}
- Isolated single-ended analog output
- Low temperature offset and GAIN drift
- Large bandwidth of 290 kHz

KEY COMPONENTS

- VIA2000SD
- CDHV
- ACAS

APPLICATIONS

- Motor control applications
- Power supplies
- Battery monitoring systems
- Charging stations
- EV powertrains

DESCRIPTION

This reference design focuses on the voltage sensing solutions used in high DC voltage applications, in which an isolated high voltage sensing circuit is a must.

This application is based on the VIA2000SD isolation amplifier and a CDHV voltage divider. The high voltage input (UDC_IN to REF) is scaled down to +2000 mV (UDC to REF) using a set of CDHV resistors. This reduced voltage is then fed into the VIA2000SD isolation amplifier, which produces an isolated, amplified analog signal at its output (OUT_P to OUT_N). The differential output signal, with a common-mode voltage of 1.44 V, is accessible via pin headers labeled OUT_P and OUT_N, allowing users to connect a differential ADC or to use it for other prototyping needs. This differential output is converted to a single-ended output, providing an output in the range from 0 V to 2.5 V (OUT to GND), which is ready to be interfaced by a single-ended ADC or multimeter.

To allow the lowest possible thermal drift, the differential to single-ended conversion stage is based on the ACAS resistor network, providing well-matched resistance values over a wide range of temperatures.

OVERALL SYSTEM BLOCK DIAGRAM

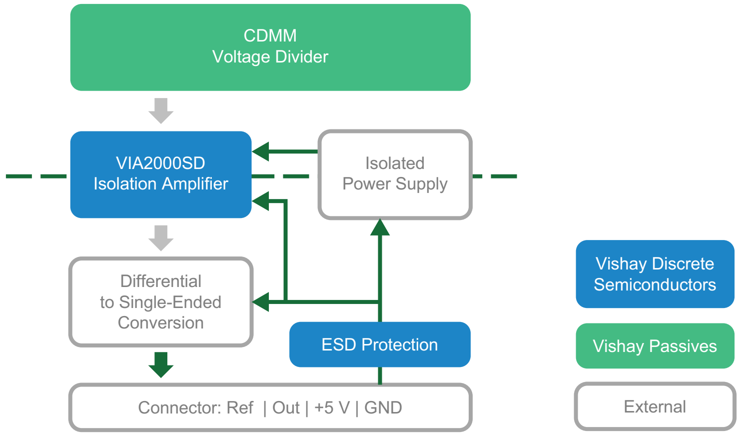


Fig. 1 - Overall System Block Diagram

APPLICATION DESCRIPTION

This application comprises a few stages that work together to provide an accurate isolated current measurement. In the following subsections, these stages are briefly explained.

Voltage Sensing Stage

In this design, the CDHV voltage divider is used to step down the input voltage to a voltage level that matches the input voltage range of the isolation amplifier.

The CDHV resistor is built with thick film technology, supports high voltages up to 1500 V, and offers precision up to ± 0.5 % with low TCR tracking of 10 ppm/°C. It is sulfur-resistant (EIA 977 test condition A), features automotive-compliant terminations, and is AEC-Q200 qualified. Additionally, it provides a wide range of resistance values and ratios.

Isolation Amplifier and Single-Ended Conversion

The voltage across the voltage divider from the voltage sensing stage is fed to the isolation amplifier (VIA2000SD). The VIA2000SD is a high performance isolation amplifier designed for precise isolated voltage sensing with differential output. It utilizes proprietary capacitive isolation technology and supports a single-ended input signal range from 0.02 V to 2 V. With its high input impedance, the device is ideal for measurements across high voltage potential dividers.

In this application the VIA2000SD is adjusted to have a fixed gain of $GAIN_{VIA} = 1$. The output of the VIA2000SD is then fed to a simple "differential to a single-ended" conversion circuit with a fixed gain of $GAIN_{DSC} = 1$.

GAIN Calculation

This section details the GAIN calculation required to confirm that the voltage output from the voltage divider matches the maximum input voltage range of the isolation amplifier. Proper GAIN adjustment is essential to ensure that the current signal is accurately represented within the amplifier's input range. If the input signal exceeds this range, the output voltage of the isolation amplifier will become non-linear or clipped.

The following calculation applies to the available reference design and can be adapted to specific customer needs. By following the outlined procedures, you can achieve accurate and reliable current sensing, which is crucial for the effective operation of your electronic applications.

The overall GAIN can be calculated using the following equation:

$$GAIN = GAIN_{VD} \times GAIN_{VIA} \times GAIN_{DSC}$$

Where:

$GAIN_{VD}$: is the voltage divider GAIN = 0.002 (-54 dB)

$GAIN_{VIA}$: is the isolation amplifier GAIN = 1 (0 dB)

$GAIN_{DSC}$: is the differential to single-ended GAIN = 1 (0 dB)

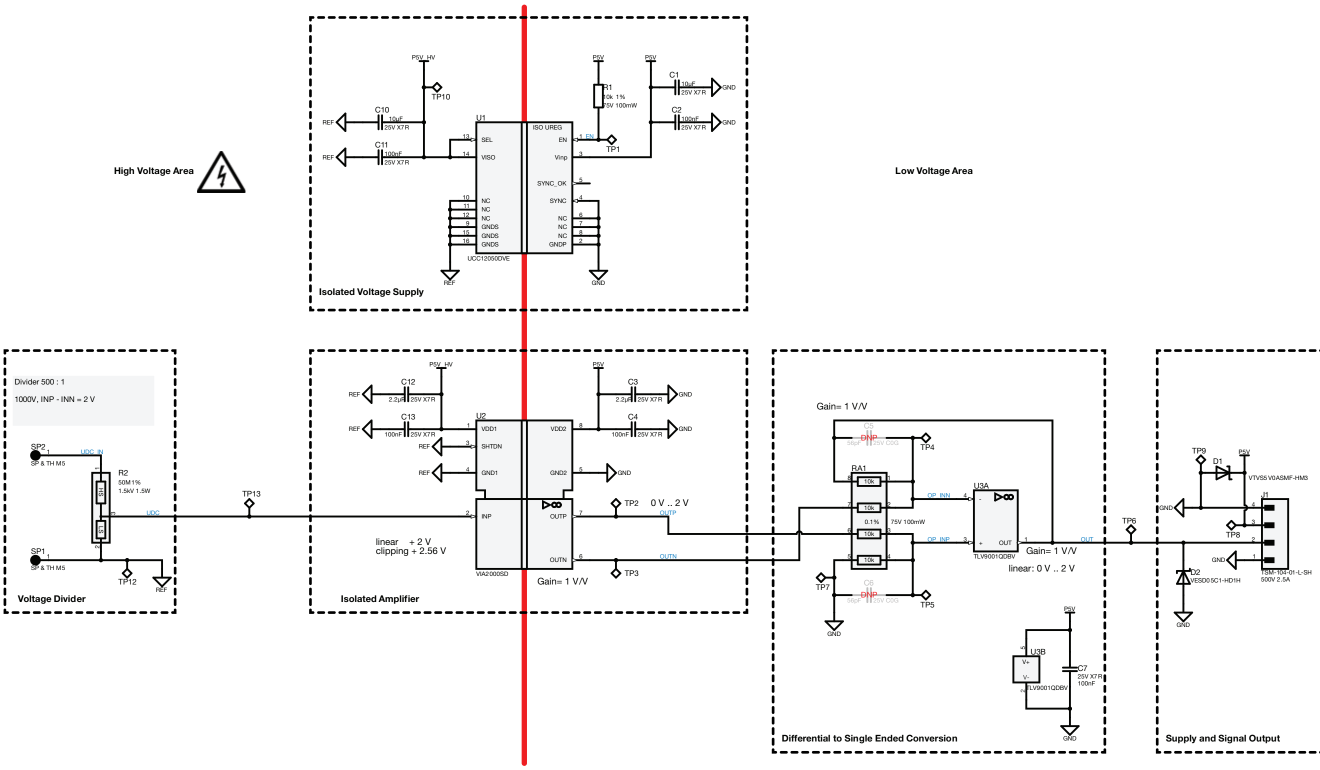


Fig. 2 - Schematic

Total GAIN

$$\text{GAIN} = \text{GAIN}_{\text{VD}} \times \text{GAIN}_{\text{VIA}} \times \text{GAIN}_{\text{DSC}}$$

$$\text{GAIN}_{\text{VD}} = \frac{1\ \text{V}}{500\ \text{V}} \times 1 \times 1$$

$$\text{GAIN}_{\text{VD}} = 0.002 = \frac{1\ \text{V}}{500\ \text{V}}$$

Measured output voltage vs. input voltage is shown in the following figure:

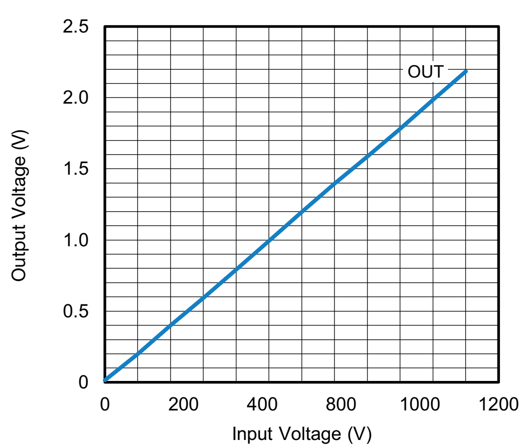


Fig. 3 - Output Voltage vs. Input Voltage

The figure shows the measured gain of the isolated amplifier together with the differential to single-ended conversion (without voltage divider) versus frequency. For total GAIN, the gain of the voltage divider (-54 dB) must be added.

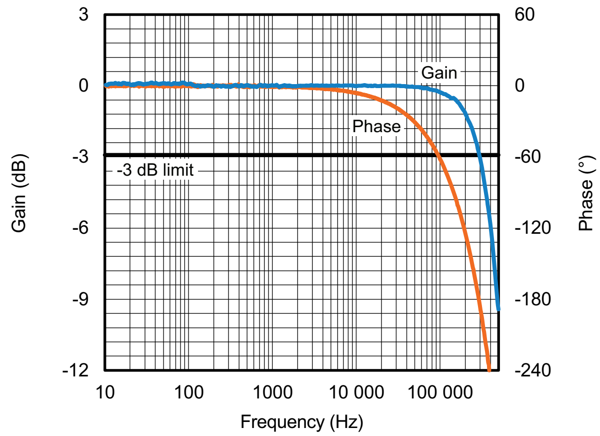


Fig. 4 - GAIN of Isolated Amplifier and Differential to Single-Ended Conversion vs. Frequency

PIN CONFIGURATION

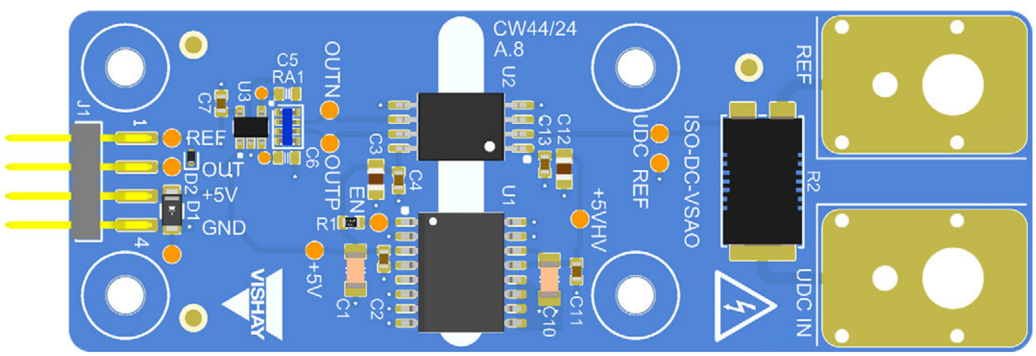


Fig. 5 - Pin Configuration

PIN DESCRIPTION		
PIN NUMBER	**SYMBOL**	**DESCRIPTION**
HV1	UDC_IN	HV DC voltage input: ± 1000 V max.
HV2	REF	Reference point DC input
1	REF	Reference output: GND
2	OUT	Single-ended output: 0 V to 2.5 V
3	+5 V	DC supply input / V_{DD2} (+5 V)
4	GND	Ground level / GND_2

DIMENSIONS in millimeters

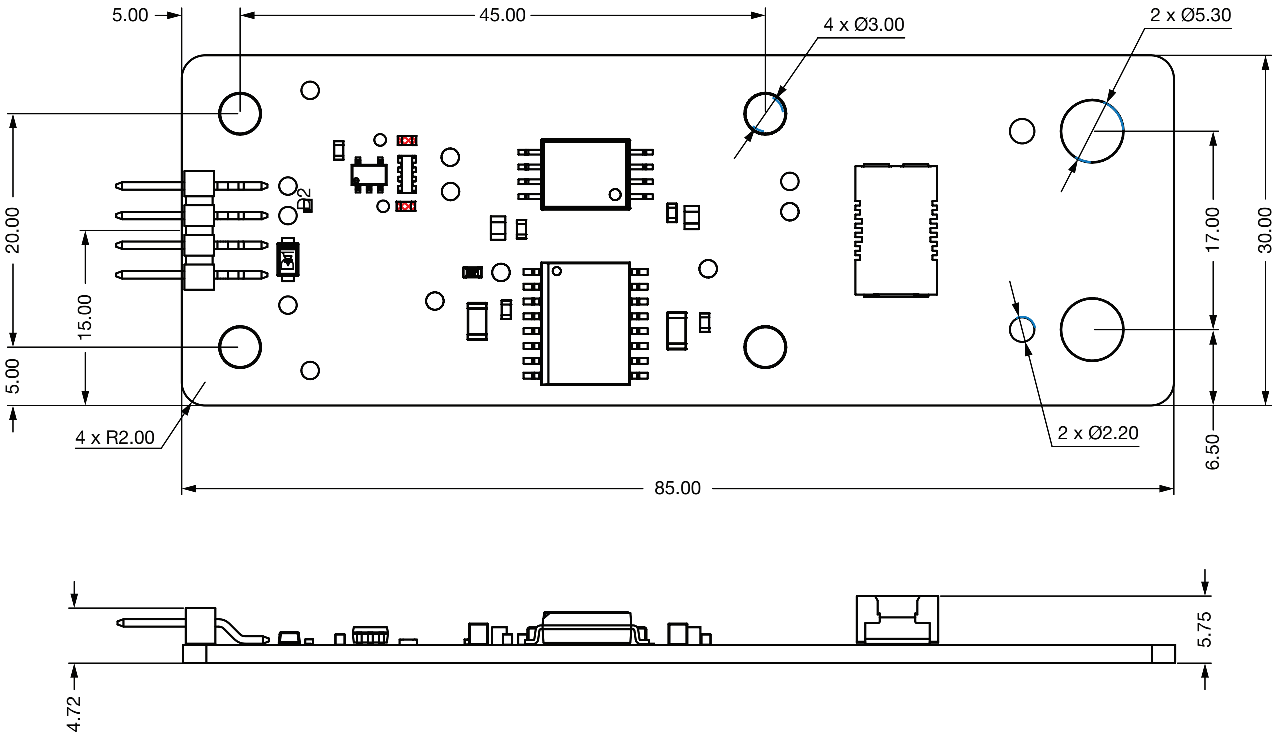


Fig. 6

ABSOLUTE MAXIMUM RATINGS

ABSOLUTE MAXIMUM RATINGS (T_{amb} = 25 °C, unless otherwise specified)		
ELECTRICAL PARAMETER	**LIMITS**	**UNIT**
HV U_{AC} to ref.	1280	V
V_{CC} to GND	-0.3 to +6.0	V
OUT to GND	0 to 2.56	V
Ambient temperature	-40 to +125 (1)	°C
Storage temperature	-55 to +125	°C
Current consumption	600	mA

Note

- Limited by capacitors C1, C10; all other components 125 °C

ELECTRICAL CHARACTERISTICS (T_{amb} = 25 °C, unless otherwise specified)					
PARAMETER		**MIN.**	**TYP.**	**MAX.**	**UNIT**
DC supply		4.0	5.0	5.5	V
HV UAC_IN to REF	linear range	-	-	1000	V
	before clipping	-	-	1280	V
Reference output		-	GND	-	V
Single-ended output		0	-	2.5	V
Output bandwidth		-	290	-	kHz
Current consumption		-	65	300	mA
Power consumption		-	300	1500	mW

SAFETY AND INSULATION RATINGS				
PARAMETER	**TEST CONDITION**	**SYMBOL**	**VALUE**	**UNIT**
Maximum rated withstanding isolation voltage		V_{ISO}	5000	V_{RMS}
Maximum transient isolation voltage		V_{IOTM}	7071	V_{peak}
Maximum repetitive isolation voltage		V_{IORM}	1697	V_{peak}
Maximum working isolation voltage	AC voltage	V_{IOWM}	1200	V_{RMS}
	DC voltage		1697	V_{DC}

Note

- Isolation from component datasheets, not measured in system.

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