HCNR201

High Bandwidth Evaluation Board

User Guide

Table of Contents

Chapter 1: Introduction

This HCNR201 High Bandwidth Evaluation Board User Guide provides the necessary information and instructions to effectively evaluate and utilize the Broadcom® HCNR201 high-linearity analog optocoupler in your applications. By following the guidelines outlined in this user guide, you can maximize the performance and reliability of their optical isolation systems.

1.1 Features

- **High bandwidth performance:** The evaluation board enables evaluation of the HCNR201's high bandwidth, making it suitable for applications requiring fast response times.
- **High-linearity analog optocoupler:** The HCNR201 optocoupler provides linear optical isolation and precise signal transmission, crucial for applications such as feedback control systems and isolation amplifiers.
- **Compact design:** The evaluation board features a compact layout, facilitating easy setup and integration into existing test environments.
- **Versatile connectivity:** Various input and output connectors are provided, ensuring compatibility with different signal sources and measurement equipment.

1.2 Applications

- **DC bus voltage sensing for WBG devices (ripple measurement):** Ideal for DC bus voltage sensing in wide band gap (WBG) devices, facilitating accurate measurement of voltage ripple to ensure stable and efficient operation.
- **DC current measurement (fast reaction time for SiC protection):** With its high bandwidth and fast reaction time, the evaluation board is well suited for DC current measurement, particularly in applications involving silicon carbide (SiC) protection, where rapid response is critical for effective overcurrent protection.

1.3 Warnings

Take special care to avoid risk of injury and life endangering. While operating the board, take the following safety precautions into considerations:

- If the board is powered up, do not touch the board, especially exposed metal parts.
- Pay attention to the maximum ratings.
- Use of a protection cover made of insulating materials is recommended.
- Whenever a change in the test setup is performed (for example, changing the probe position), turn off the power supply and ensure that the DC bus is fully discharged to avoid injuries and the destruction of the board.

NOTE: Normal static precautions must be taken when handling the board to prevent damage and/or degradation that might be induced by ESD.

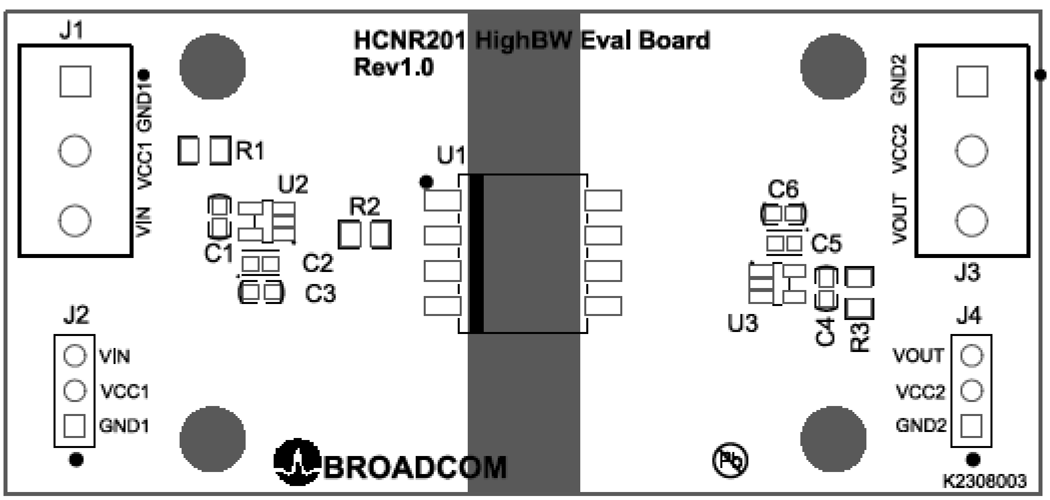
Chapter 2: Board Connections

2.1 Board Layout

The following figures detail the components and layout of the evaluation board, including connector locations and signal paths.

Figure 1: HCNR201 High Bandwidth Evaluation Board

Figure 2: HCNR201 High Bandwidth Evaluation Board Silk Screen Drawing



2.2 Setup Instructions

The following is a step-by-step guide for setting up the evaluation board, including connection to power sources and signal generators.

- Power supplies and ground connection:
  - Connect the power supplies V_{CC1}, GND1 (terminal block J1) and V_{CC2}, GND2 (terminal block J3) to a stable 5V power source, ensuring proper polarity and voltage levels.
  - Verify that the power supply meets the recommended operating conditions and key parameters as specified in Table 1.
- Signal input connection:
  - Connect the input signal source to the designated input terminals (V_{IN} – terminal block J1) on the evaluation board.
  - Ensure that the input signal meets the specified requirements, including amplitude (1Vp-p) and offset (1V), for optimal performance.
- Output signal connection:
  - Connect the output terminals (V_{OUT} – terminal block J3) of the evaluation board to the measurement equipment or the next stage of the circuitry.
  - Ensure proper grounding and shielding to minimize noise and interference in the output signal.

Instead of the terminal blocks (J1, J3), connections can also be made to the respective pin headers (J2, J4) if preferred.

ATTENTION: Before proceeding with operation, verify that all operating conditions, including power supply voltages and signal inputs, are within the recommended range. Failure to comply with operating conditions might result in suboptimal performance or damage to the evaluation board.

Chapter 3: Measurement

Once the board is connected and powered on, monitor the output signal using appropriate measurement equipment such as oscilloscopes or multimeters.

Analyze the output signal characteristics, including amplitude, frequency response, and linearity, to evaluate the performance of the evaluation board.

The following figures show the output response of the board in time and frequency domains respectively. At 1 MHz, the output gain remains at unity (Gain = 1). The propagation delay is ~125 ns.

Figure 3: Output Signal in Green vs Input Signal in Red (1 MHz, 1 Vpp, 1V Offset)

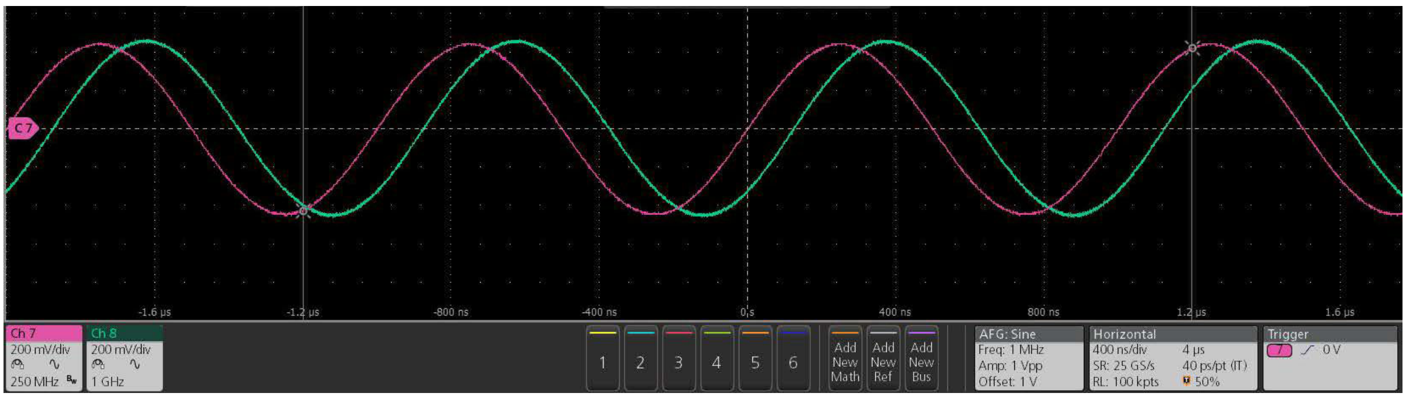
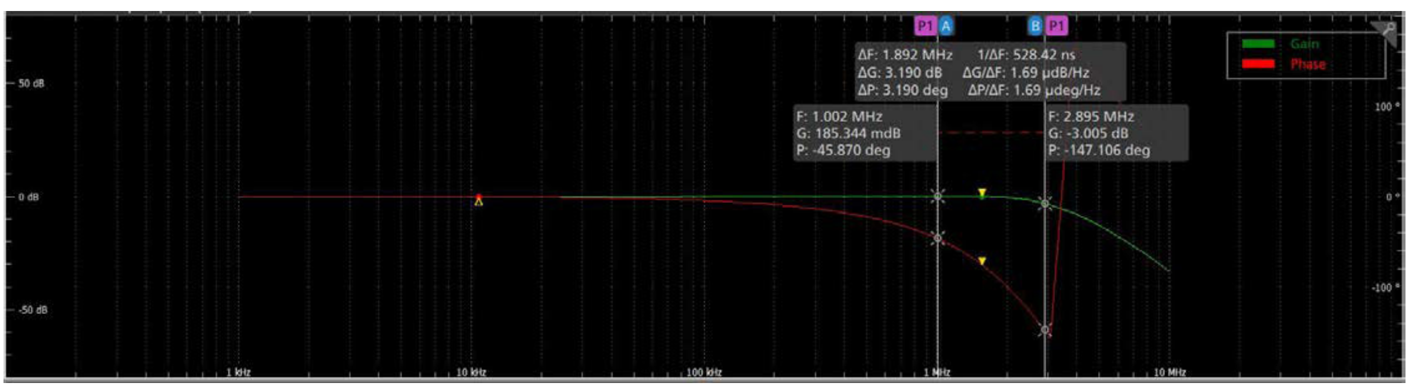


Figure 4: Bode Plot (–3 dB Bandwidth at 2.9 MHz)

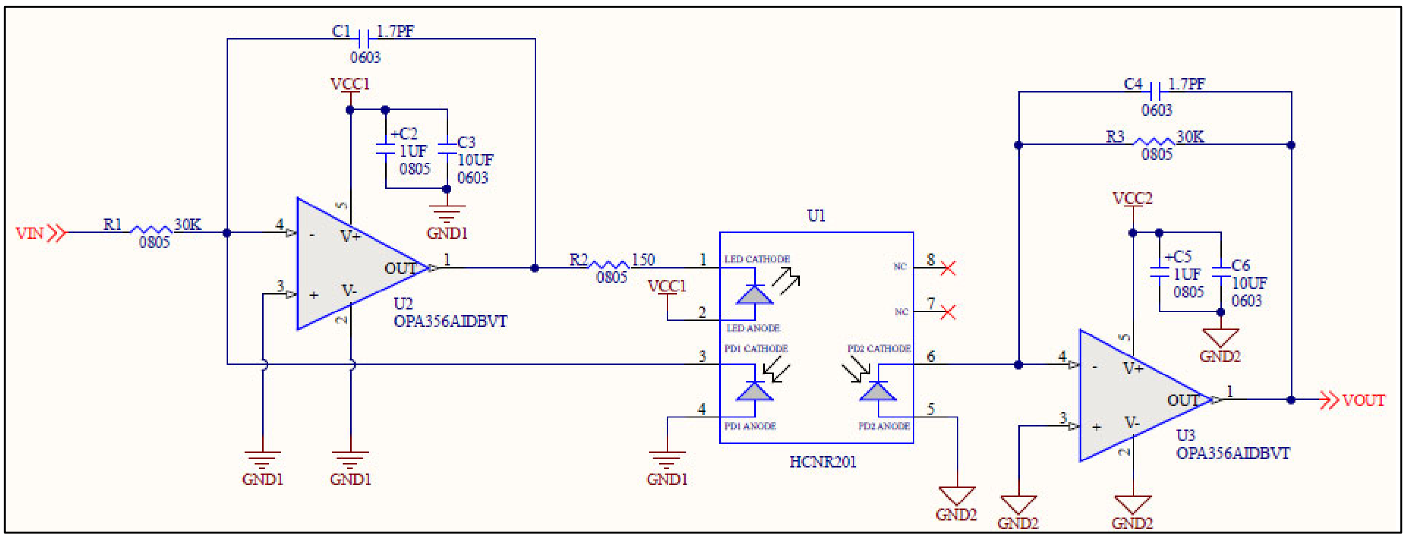


Chapter 4: Circuit Operation

The HCNR201 (U1) comprises an LED and two photodiodes, with the LED and one photodiode (PD1) situated on the input side of the optoisolation barrier, and the other photodiode (PD2) on the output side. The packaging ensures both photodiodes receive similar light levels from the LED.

In the circuit, the feedback amplifier U2, connected to PD1, monitors the LED light output and adjusts the LED current to counter any nonlinearity. PD2 then converts the LED's stable, linear light into current, which the amplifier U3 transforms back into voltage.

Figure 5: HCNR201 High Bandwidth Evaluation Board Schematic



Understanding the circuit's operation, especially its input section, might not be immediately evident from Figure 5. Briefly, U2 regulates the LED forward current (I_F) to maintain the PD1 current (I_{PD1}) at V_{IN}/R1. Increasing the input voltage raises the voltage at U2's inverting input, causing U2 to amplify this increase, leading to higher I_F and I_{PD1}.

Due to PD1's connection, I_{PD1} pulls U2's inverting input towards ground. U2 continues to increase IF until its inverting input stabilizes near ground reference voltage. Assuming no current flows into U1B's inputs, all R1 current flows through PD1, making $I_{PD1} = V_{IN}/R1$. Essentially, U2 adjusts I_F to make $I_{PD1} = –V_{IN}/R1$.

Note that I_{PD1} depends solely on input voltage and R1, irrespective of the optocoupler's characteristics. Additionally, I_{PD1} is directly proportional to V_{IN}, ensuring a highly linear relationship between input voltage and photodiode current.

The optocoupler's physical design determines the relative light falling on PD1 and PD2, resulting in nearly equal currents. Amplifier U3 and resistor R3 form a transimpedance amplifier, converting I_{PD2} to voltage ($V_{OUT} = I_{PD2} \times R3$). Combining input and output equations yields V_{OUT}/V_{IN} = (R3/R1), indicating that with R1 = R3, the output closely mirrors the input signal.

4.1 Components Selection

At the core of the evaluation board lies the HCNR201 high-linearity analog optocoupler, providing exceptionally linear optical isolation between input and output signals.

- Input signal resistor, R1

  To fully utilize the linearity range of I_{PD} < 50 µA, R1's value should be carefully selected. With the input signal (V_{IN}) ranging from 0.5V to 1.5V, a resistance of 30 kΩ yields a current range of 16 µA to 50 µA.

- Forward current limiting resistor, R2

  Considering the typical K1 value of 0.48%, representing I_{PD1}/I_F, peak I_F is expected to reach 10.4 mA. Thus, R2 should be selected to avoid limiting I_F below 10.4 mA and to ensure peak I_F remains within the absolute maximum ratings of 40 mA.

- Operational amplifiers, U2, U3

  The foremost consideration for U2 and U3 is selecting op amps with a wide bandwidth gain product, crucial for accommodating the high-frequency operation (1 MHz) demanded in this application. To meet this requirement, a pair of 200-MHz op amps has been carefully chosen. Because the circuit is unipolar, op amps with dual power supply rails are unnecessary.

- Op amp feedback resistor and capacitor pairs, R1//C1, R3//C4

  With R1's value determined, C1's value should allow a 3-dB cut-off frequency higher than 1 MHz. A combination of 30 kΩ and 1.7 pF achieves a theoretical cut-off of ~3 MHz. To maintain unity gain and ensure superior linearity performance, both RC pairs on input and output sides should be similar or symmetrical.

- Bypass capacitors, C2, C3, C5, C6

  These were implemented for the op amps based on the recommendations in the data sheet from the op amps.

4.2 Electrical Characteristics and Performance Parameters

The following tables provide the key electrical characteristics and performance parameters of the high bandwidth evaluation board and HCNR201 optocoupler.

Table 1: High Bandwidth Evaluation Board Key Parameters

Parameter	Value
Supply Voltages – V_{CC1}, V_{CC2}	4.5V to 5.5V
Input Signal Voltage Range	0.5V to 1.5V
Input to Output Voltage Gain	1.0 V/V (typ.)
–3-dB Signal Bandwidth	3 MHz (typ).

Table 2: HCNR201 Key Parameters

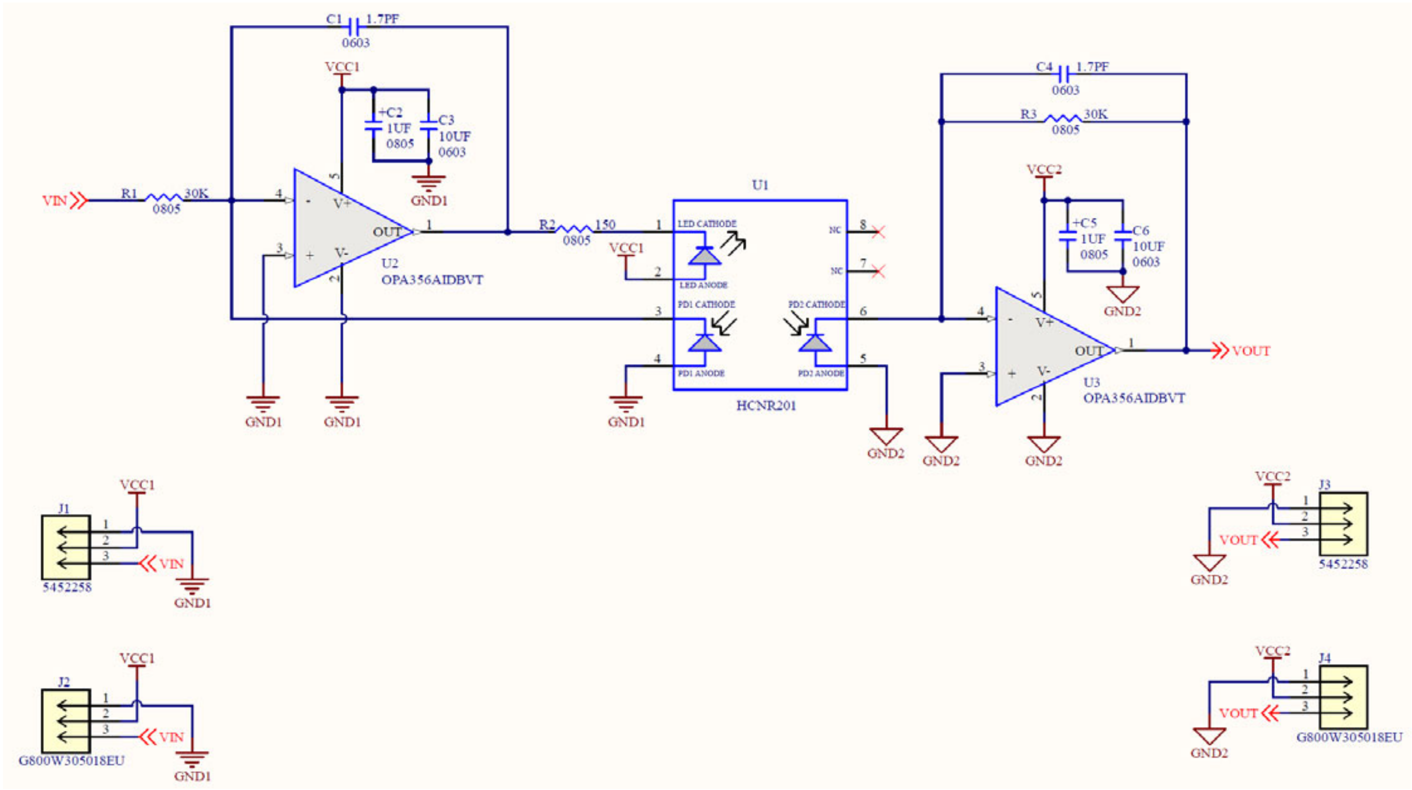
Parameter	Symbol	Device	Min.	Typ.	Max.	Unit	Test Conditions
Transfer Gain	K_3	HCNR201	0.95	1.00	1.05		5 nA < I_{PD} < 50 µA, 0V < V_{PD} < 15V
Input Photodiode Current Transfer Ratio (I_{PD1}/I_F)	K_1	HCNR201	0.36	0.48	0.72	%	I_F = 10 mA, 0V < V_{PD1} < 15V

Appendix A: Board Description

This section provides full schematics, layout, and bill of materials of the HCNR201 high bandwidth evaluation board. The information enables customers to modify, copy, and qualify the design for production, according to specific requirements.

A.1 Schematics

Figure 6: Full Schematic



A.2 Layout

Figure 7: Top Silkscreen

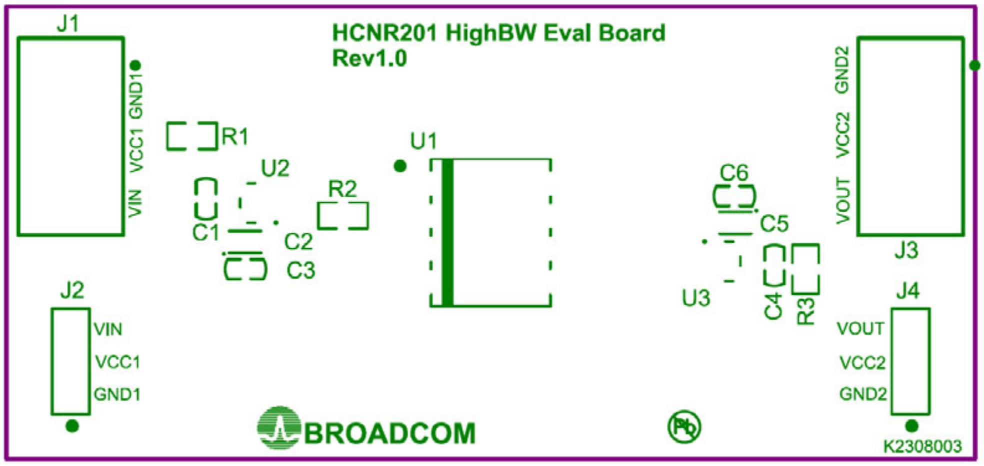


Figure 8: Top Layer

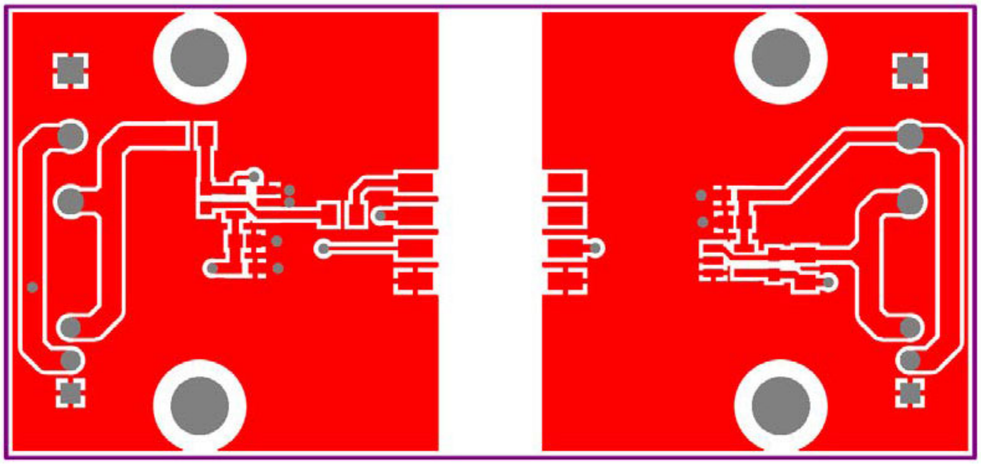
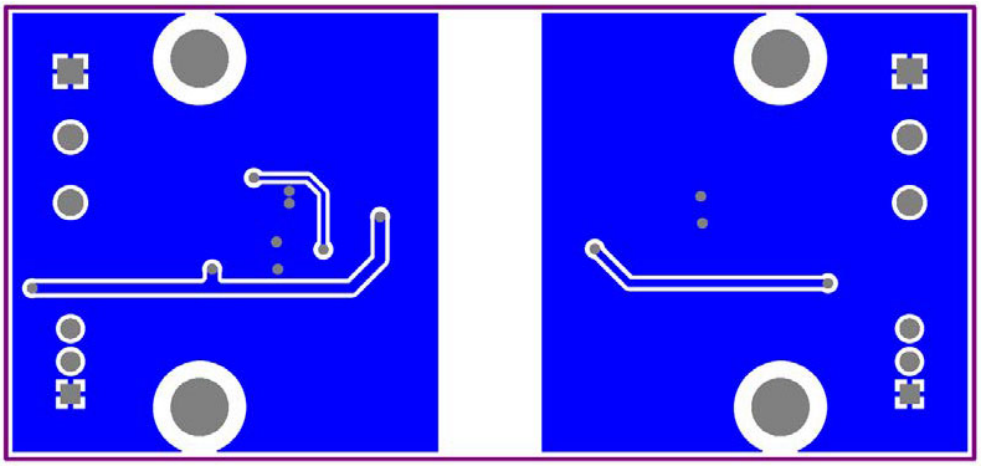


Figure 9: Bottom Layer



A.3 Bill of Materials

Table 3: Bill of Materials

Designator	Description	Manufacturer	Mfg. Part Number
C1, C4	CAP CER 1.7PF 50V C0G/NP0 0603	Kemet	CR06C179B5GAC
C2, C5	CAP TANT 1UF 20% 16V 0603	Vishay Sprague	TMCJ1C105MTRF
C3, C6	CAP0603 X7R 10UF 10% 10V	Cal-Chip Electronics	GMC10X7R106K10NT
J1, J3	TERM BLK 3P SIDE ENT 5.08MM PCB	Phoenix Contact	5452258
J2, J4	PIN HEADER 2.54MM PITCH STR,1X3P	Amphenol ICC	G800W305018EU
R1, R3	RES 30K OHM 0.1% 1/8W 0805	KOA Speer Electronics	RN73R2ATTD3002B25
R2	RES 150 OHM 5% 1/8W 0805	Yageo	RC0805JR-07150RL
U1	High-Linearity Analog Optocoupler	Broadcom	HCNR201
U2, U3	IC OPAMP VFB 1 CIRCUIT SOT23-5	Texas Instruments	OPA356AIDBVT

Revision History

HCNR201-UG100; March 4, 2024

Initial release.

BROADCOM®