HCNR201/200

High-Linearity Analog Optocouplers
Evaluation Board User's Manual

Hardware Guide

Description

The HCNR200/201 high-linearity analog optocoupler consists of a high-performance AlGaAs LED that illuminates two closely matched photodiodes. The input photodiode can be used to monitor, and therefore stabilize, the light output of the LED. As a result, the nonlinearity and drift characteristics of the LED can be virtually eliminated. The output photodiode produces a photocurrent that is linearly related to the light output of the LED. The close matching of the photodiodes and advanced design of the package ensure the high linearity and stable gain characteristics of the optocoupler.

The HCNR200/201 can be used to isolate analog signals in a wide variety of applications that require good stability, linearity, bandwidth and low cost. The HCNR200/201 is very flexible and, by appropriate design of the application circuit, is capable of operating in many different modes, including: unipolar/ bipolar, ac/dc and inverting/noninverting. The HCNR200/201 is an excellent solution for many analog isolation problems.

The HCNR201/200 evaluation board is to help designer quickly evaluate this high-linearity analog optocoupler. Figure 1 and 2 shows the schematic of this evaluation board, respectively. Besides the HCNR201/200, this evaluation board also consists of two op-amps at the input side and output side respectively. Refer to the Circuit Operation section to see how this circuit works in details. This evaluation board is immediately suitable for current-sensing applications in the motor control design. Though this evaluation board is designed for certain application, the versatile high-linearity analog optocoupler HCNR201/200 is suitable for many applications, such as voltage/current sensing, analog signal coupling.

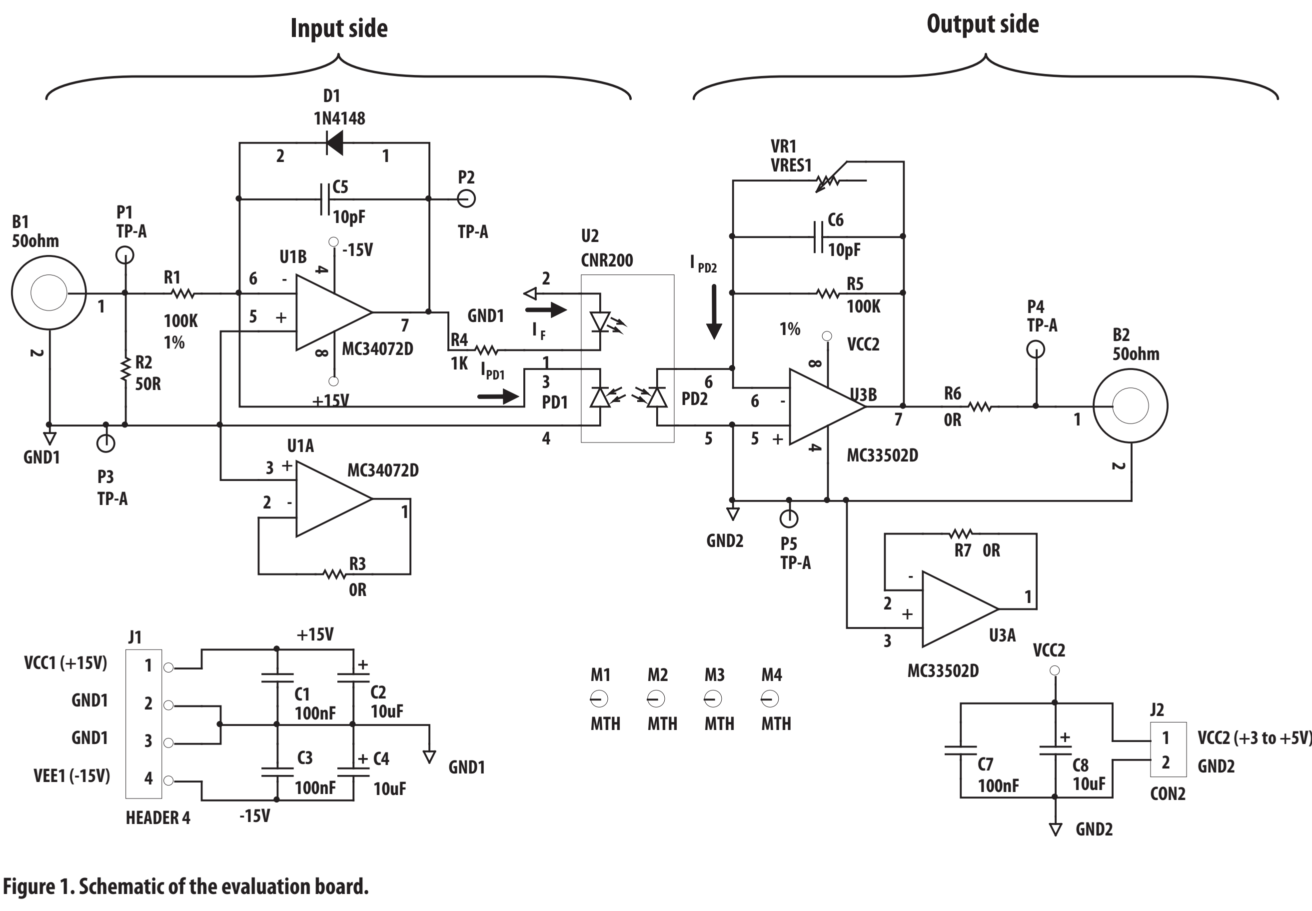

Figure 1. Schematic of the evaluation board.

Connecting and operating the evaluation board

1. Input side power supply: connect +15V power supply to connector J1-pin 1, -15V to J1-pin 4, and 0V to J1-pin 2 or 3. ±15V power supply is commonly available in a motor drive board. A user also can get these supplies from a bench power supply in a lab.
2. Output side power supply: connect power supply VCC2 to J2-pin 1 and GND2 of J2-pin 2 at the output side of the evaluation board. VCC2 takes a flexible supply ranges from 3V to 5V. This is to cater for either 3.3V or 5V MCU system at the motor controller board. The VCC2 can also be connected to a bench power supply.

A note on the input side and output side power supplies is that the two power supply systems are separated from each other in an actual application. However, this requirement is not always compulsory in the evaluation phase. For example, in order to measure circuit linearity on a bench, the isolation of the input side and output side power supplies is not a must. Another example is that when measuring input to output propagation delay, it is necessary to short GND1 and GND2 together to capture time delay on an oscilloscope.

3. Connect the input signal in either way of following:
   a. Input from the motor board. This input normally comes from a voltage node, which is either the DC supply bus in the voltage-sensing application, or from a power resistor in the current-sensing situation. In either case, the loading effect of resistor R2 on the board needs to taken into account. The loading effect can be neglected is the output impedance of the voltage node is very low compared to R2, or a user can simply remove R2 to avoid the loading effect.
   b. Input from a bench signal generator. A common signal generator has output impedance of 50Ω, which is terminated by R2.

   It is recommended to operated the HCNR201/200 in its linear range, which is 5 nA < I_{PD} < 50 µA. In this evaluation board, R1 of 100 kΩ is used as the input resistor. The photodiode input current range will be translated into input voltage range of 0.5 mV to 5 V. The effective upper limit of the input range is further limited be slightly below the VCC2 supply voltage.
4. Connect the output to the MCU control board if the input signal comes from a motor board as described in step 3-a, through a piece of wire. If the input signal comes from a signal generator, the output signal can be connected to an oscilloscope using a BNC cable.
5. Under typical room temperature of 25°C, at ±15V input side power supply and +5V output power supply, and using Lab bench-top equipments, in average the following measurement results can be obtained:
   - Input voltage range: 0.5 mV to 4.8 V.
   - Input to output voltage gain: 1.03 (at V_{IN} = 4 V).
   - -3dB bandwidth: 50 kHz.
   - Propagation delay at the -3dB bandwidth frequency: 3.5 µs.

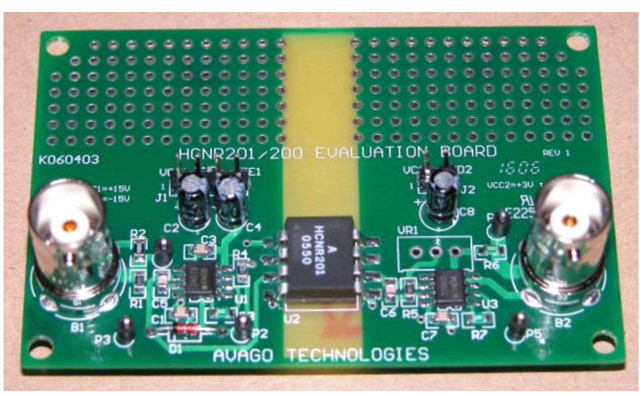

Figure 2. PCB of the evalution board.

Circuit Operation

The HCNR201 consists of an LED and two photodiodes. The LED and one of the photodiodes (PD1) is on the input side of the optoisolation barrier, and the other photodiode (PD2) is on the output side. The package is constructed so that each photodiode receives approximately the same amount of light from the LED. Feedback amplifier U1B is configured with PD1 to monitor the light output of the LED and automatically adjust LED current to compensate for any non-linearity. The output photodiode then converts the LED's stable, linear light output into a current, which is then converted back into a voltage by amplifier U3B.

Circuit operation may not be immediately obvious from inspecting Figure 1, particularly the input part of the circuit. Stated briefly, amplifier U1B adjusts LED forward current (I_F) such that the current in PD1 (I_{PD1}) is equal to V_{IN}/R1. Analysis of the input circuit reveals that increasing the input voltage increases the voltage at the inverting input terminal of U1B. Amplifier U1B amplifies that increase, causing I_F and I_{PD1} to increase. Given the way that PD1 is connected, I_{PD1} will pull the inverting input of the op-amp back toward ground. U1B will continue to increase IF until its inverting input voltage stabilizes near its ground reference voltage. Assuming that no current flows into the inputs of U1B, all of the current flowing through R1 will flow through PD1. Since the inverting input of U1B is at approximately 0 volts, the current through R1, and therefore I_{PD1}, is equal to V_{IN}/R1. Essentially, amplifier U1B adjusts IF such that $I_{PD1} = -V_{IN}/R1$.

Note that I_{PD1} depends only on the input voltage and the value of R1 and is independent of the optocoupler's characteristics. Also note that I_{PD1} is directly proportional to V_{IN}, giving a very linear relationship between the input voltage and the photodiode current. The physical construction of the optocoupler's package determines the relative amounts of light that fall on the two photodiodes and, therefore, the ratio of the photodiode currents. This results in a current, I_{PD2}, that is nearly equal to I_{PD1}. Amplifier U3B and resistor R5 form a trans-resistance amplifier that converts I_{PD2} back into a voltage, V_{OUT}, where $V_{OUT} = I_{PD2} \times R5$. Combining input and output equations results in an expression that relates the output voltage to the input voltage, $V_{OUT} / V_{IN} = (R5/R1)$. Therefore, with R1 = R5, the output signal closely matches the input.

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