

Optical Channel Identification on the ADN284x Laser Drivers (Part I)

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INTRODUCTION

This application note describes the optical channel identification feature implemented on the Analog Devices’ ADN284x series of laser drivers. It is the first in a series of three notes:

- Part I discusses the theory of operation and the implementation of the optical channel identification feature.
- Part II explains design considerations for the external circuitry needed to use the ADN284x series of laser diode drivers in a dc-coupled laser configuration.
- Part III explains design considerations for the external circuitry needed to use the ADN284x series of laser diode drivers in an ac-coupled laser configuration.

THEORY OF OPERATION

In most cases, a digital communications channel can be identified by organizing the digital information in packets or frames, and by adding to each a header that contains an identification sequence unique for each packet, frame, or channel. To identify the channel, it is necessary to extract the identification sequence. This usually involves the use of expensive equipment, especially at high data rates. If there is no need for a full interpretation of the digital data transmitted in the channel, the easiest way to implement a channel identification scheme is to add a pilot signal with known parameters (e.g., amplitude, frequency, phase, or shape) to the digital data. In optical transmitters, the pilot signal is added by changing the current flowing through the laser diode, as shown in Figure 1.

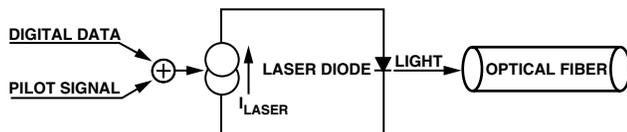


Figure 1. Optical Channel Identification

Figure 2 shows the optical signal before and after the pilot signal was added.

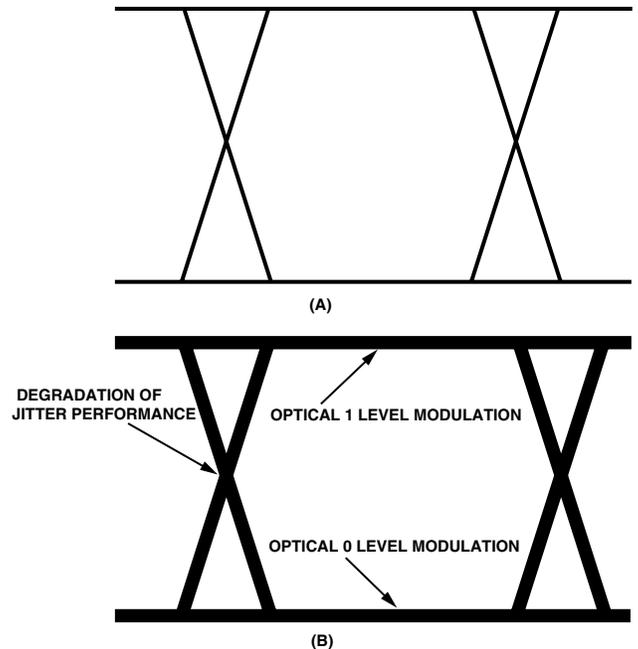


Figure 2. Optical Signal Before (A) and After (B) Pilot Signal Insertion

Figure 2 illustrates the visible degradation of the optical signal that occurs when the pilot tone is inserted. This degradation is due to

- Modulation of the optical 1 and 0 levels, which decreases the vertical eye opening. Because the definition of the extinction ratio is $P1/P0$, the modulation of the optical 0 level by the pilot signal will cause higher variations in extinction ratio than the optical 1 level modulation.
- The jitter performance being degraded by modulating the rising and falling edge with the pilot signal.

The optical channel identification is called ID_TONE in the ADN284x laser driver family and is based on the pilot tone principle. However, to reduce the optical eye distortion, the pilot signal is induced on the optical 1 level, thereby minimizing eye degradation caused by the jitter and extinction ratio variations related to modulation.

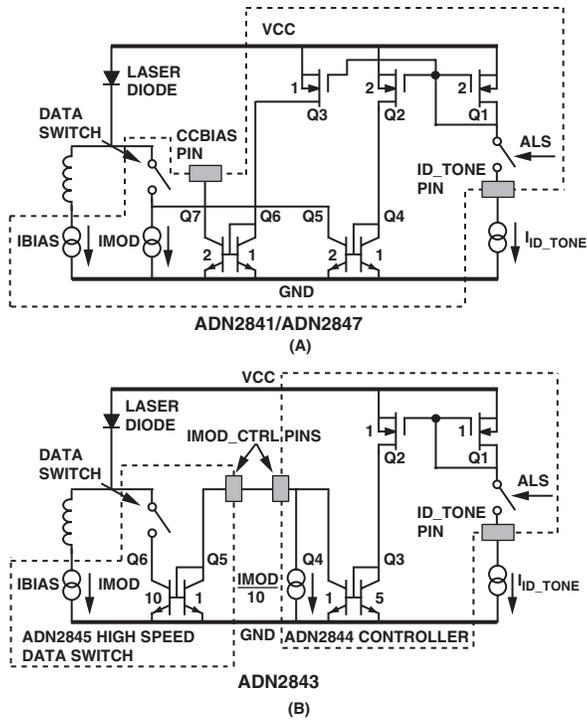


Figure 3. Optical Channel Identification on the ADN284x

Figure 3 shows a simplified version of the implementation of the optical channel identification feature on both single-chip and chipset LDDs. For the single-chip LDDs, this feature is available on the 48-lead LFCSP versions only. Note that using this feature during data transmission will cause distortions in the optical eye.

Figure 3 (A) shows the implementation of the ID_TONE feature on the ADN2841/ADN2847. To implement this feature, the user must connect a current sink to the ID_TONE pin. The shape and frequency of the I_{ID_TONE} signal will be reflected on the optical 1 level.

In normal operation, the I_{ID_TONE} current is applied to Q1. Beside each transistor there is a number that reflects the area of the drain or collector. It is easy to observe that Q1–Q2 and Q4–Q5 are used as current mirrors with a 1:1 gain for Q1–Q2 and 2:1 for Q4–Q5. Therefore, the collector current of Q5 is twice the I_{ID_TONE} current. This current is added to the modulation current, and when the high speed data switch is on, the optical 1 level is modulated by the collector current of Q5.

Similarly, Q1–Q3 and Q6–Q7 are also current mirrors. The gains of these current mirrors are 2:1 for Q1–Q3 and 1:2 for Q6–Q7. The collector current of Q7 is available at the CCBIAS pin and is used to cancel the optical 0 level modulation when the laser is used in an ac-coupled configuration.

The switch in series with Q1’s drain is driven by the ALS pin. When ALS is low, the switch is closed and the ID_TONE feature is enabled. If ALS is set high, the switch is opened,

cancelling the collector currents for Q5 and Q7. Note that when ALS is asserted, the bias and modulation current sources, IBIAS and IMOD, are turned off by additional circuitry not shown in Figure 3.

Figure 3 (B) shows the implementation of the ID_TONE feature on the ADN2843 chipset. The circuit is similar to Figure 3 (A); the only difference is that the CCBIAS and the associated current mirror are missing. This is because the ADN2843 is intended to be copackaged with the laser, eliminating the need to ac couple lasers. Consequently, the ID_TONE feature will not function correctly if the ADN2843 chipset is used with an ac-coupled laser.

The data sheet specifications for the ID_TONE include the following:

- I_{OUT}/I_{IN} ratio. This specification is the ratio between I_{ID_TONE} and the collector current of Q5. It equals 2 (see Figure 3).
- f_{IN} . This specification is the allowable frequency range for the external current sink connected to the ID_TONE pin. The frequency range is limited at the low end by the bandwidth of the control loops. If the frequency of the ID_TONE current is less than the lower limit specified, the ID_TONE disturbs the normal operation of the control loops, causing instability (oscillations), or even cancellation of added ID_TONE current by the control loops. The data sheet lower limit specification ensures that the normal operation of the control loops will not be affected by the use of the ID_TONE function. The upper end of the frequency range is due to bandwidth limitations of transistors Q1 – Q7, providing an overall –3 dB bandwidth of ≈ 1 MHz. The spacing between two adjacent ID_TONE current frequencies used in a multichannel system is given by the selectivity of the block that extracts the required signal at the receiver side. The modulation depth on the optical 1 is given by the sensitivity at the receive end.
- Compliance Voltage. This specification is defined as the voltage between the ID_TONE pin and GND. When the ID_TONE pin is tied to V_{CC} , there is no current flowing into the current mirrors built with Q1–Q7, thus the ID_TONE function is disabled. This configuration is recommended when the ID_TONE function is not used. When the function is used, the voltage on the ID_TONE pin should not go below $V_{CC} - 1.5$ V for the allowable current range on the external current sink; otherwise, the internal current mirrors will not work properly.

Note that the external current sink must have a proper dc component to minimize distortion.

In practice, the laser diode drivers operate in two main configurations: dc-coupled and ac-coupled. The following sections explain how the ID_TONE function works and how to configure the driver for proper operation.

DC-Coupled Mode

In this configuration, the laser diode should be connected to the laser driver as shown in Figure 4.

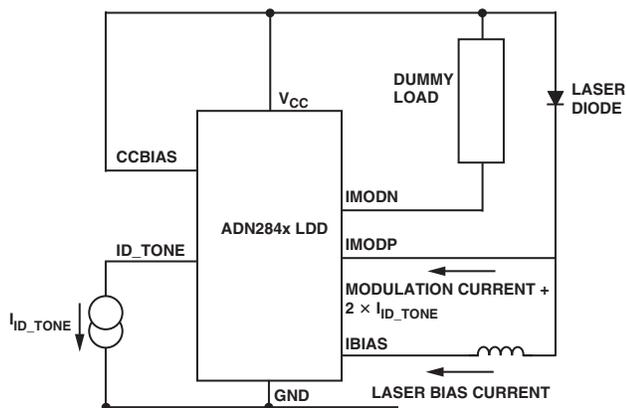


Figure 4. ADN284x LDD Used in DC-Coupled Configuration

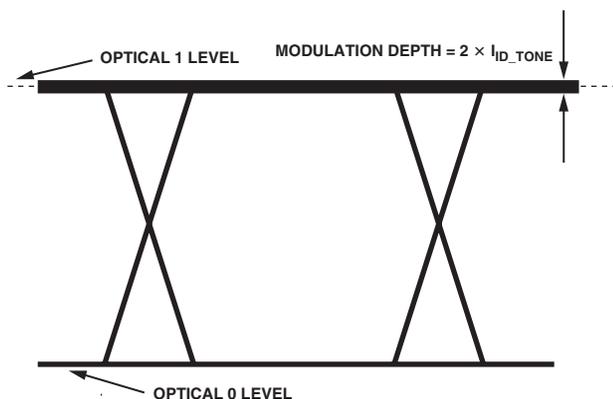


Figure 5. Optical Eye with ID_TONE Modulation for DC-Coupled Laser

Note that when the ADN2843 chipset is used, the CCBIAS pin is missing and the user should connect the ADN2844 controller and the ADN2845 high speed data switch as shown in the data sheet.

When the laser is dc-coupled, the optical 0 level is established by the bias current, and the modulation current and the ID_TONE current are directed into the dummy load by the high speed switch.

The optical 1 level is established by the summation of the bias, modulation, and ID_TONE currents. Therefore, the optical eye will have the ID_TONE signal only on the optical 1 level (see Figure 5). The modulation depth is adjustable by changing the amount of current applied to the ID_TONE pin.

AC-Coupled Mode

In this configuration, the laser diode should be connected to the laser driver as shown in Figure 6. The output of the high speed switch is connected to the laser's cathode

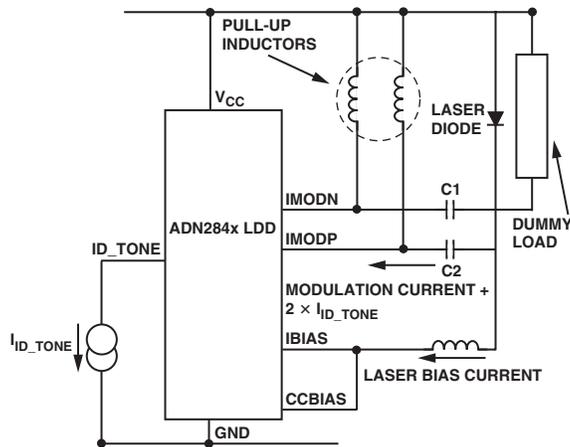


Figure 6. ADN284x LDD Used in AC-Coupled Configuration

through a capacitor, C2 in this case. This requires the use of inductors to provide a dc bias for the IMODP and IMODN pins. The coupling capacitor, C1, and the dummy load are intended to provide a balanced load for both outputs of the high speed switch (IMODP/IMODN), but they can be omitted. The eye diagram will look the same as the dc-coupled configuration; however, it is necessary to connect the CCBIAS pin to the IBIAS pin or the eye will appear as shown in Figure 7.

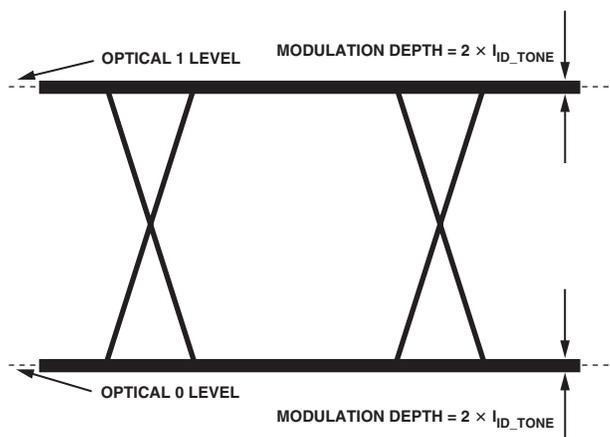


Figure 7. Optical Eye with ID_TONE Modulation for AC-Coupled Laser without CCBIAS Pin Tied to the Bias Line

The modulation depth of $2 \times I_{ID_TONE}$ in dc-coupled mode is reduced to I_{ID_TONE} , and is present on both the optical 1 and 0 levels in ac-coupled mode, thereby increasing optical eye distortion. To fix this issue, the optical 0 level must be shifted up with a current equal to I_{ID_TONE} . This is achieved by connecting CCBIAS to the IBIAS pin. This pin provides a current equal to I_{ID_TONE} (see Figure 3), which restores the eye to the desired shape, as in the dc-coupled mode (see Figure 5). Note that when the ADN2843 chipset (which does not have the CCBIAS pin) is used and the ID_TONE function is employed, the optical eye will look like Figure 7.

