3 V Dual-Loop 50 Mbps to 3.3 Gbps Laser Diode Driver

ADN2847

FEATURES
50 Mbps to 3.3 Gbps Operation
Single 3.3 V Operation
Typical Rise/Fall Time 80 ps
Bias Current Range 2 mA to 100 mA
Modulation Current Range 5 mA to 80 mA
Monitor Photodiode Current 50 μA to 1200 μA
Dual MPD Functionality for DWDM
50 mA Supply Current at 3.3 V
Closed-Loop Control of Power and Extinction Ratio
Full Current Parameter Monitoring
Laser Fail and Laser Degrade Alarms
Automatic Laser Shutdown, ALS
Optional Clocked Data
Supports FEC Rates
48-Lead (7 mm × 7 mm) LFCSP Package
32-Lead (5 mm × 5 mm) LFCSP Package
Available in Die Form

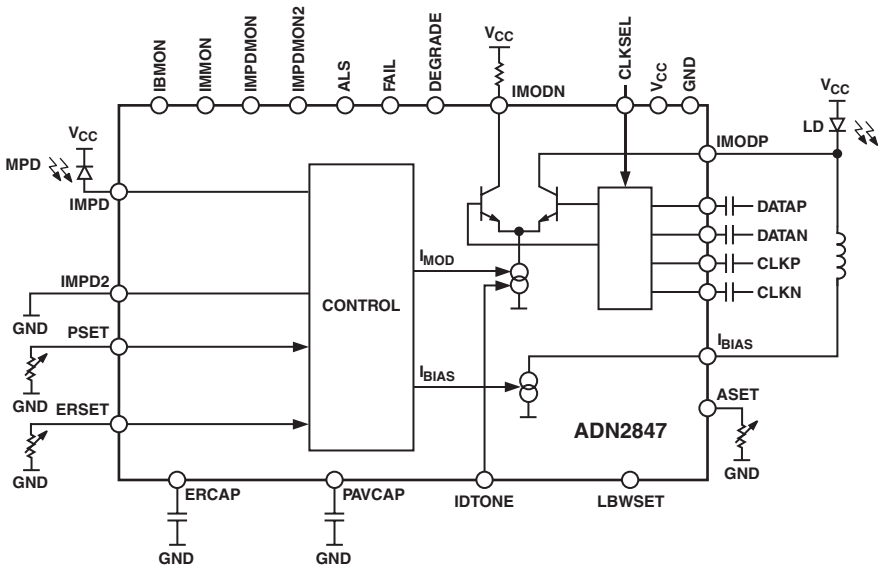
APPLICATIONS
SONET OC-1/3/12/48
SDH STM-0/1/4/16
Fibre Channel
Gigabit Ethernet
DWDM Dual MPD Wavelength Control

GENERAL DESCRIPTION

The ADN2847 uses a unique control algorithm to control both average power and extinction ratio of the laser diode, LD, after initial factory setup. External component count and PCB area are low as both power and extinction ratio control are fully integrated. Programmable alarms are provided for laser fail (end of life) and laser degrade (impending fail).

Optional dual MPD current monitoring is designed into the ADN2847 specifically for DWDM wavelength control.

FUNCTIONAL BLOCK DIAGRAM



REV. 0

One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106, U.S.A.
Tel: 781/329-4700 **www.analog.com**
Fax: 781/326-8703

ADN2847–SPECIFICATIONS

(V_{CC} = 3.0 V to 3.6 V. All specifications T_{MIN} to T_{MAX}, unless otherwise noted.[1] Typical values as specified at 25°C.)

Parameter	Min	Typ	Max	Unit	Conditions/Comments
LASER BIAS (BIAS)					
Output Current I_{BIAS}	2		100	mA	
Compliance Voltage	1.2		V_{CC}	V	
I_{BIAS} during ALS			0.1	mA	
ALS Response Time			5	µs	I_{BIAS} < 10% of nominal
CCBIAS Compliance Voltage	1.2		V_{CC}	V	
MODULATION CURRENT (IMODP, IMODN)[2]					
Output Current I_{MOD}	5		80	mA	
Compliance Voltage	1.5		V_{CC}	V	
I_{MOD} during ALS			0.1	mA	
Rise Time (See Figure 4 for Typical Distribution)[3]		80	120	ps	
Fall Time (See Figure 5 for Typical Distribution)[3]		80	120	ps	
Random Jitter[3]		1	1.5	ps	RMS
Pulsewidth Distortion[3]		15		ps	I_{MOD} = 40 mA
MONITOR PD (MPD, MPD2)					
Current	50		1200	µA	Average Current
Compliance Voltage			1.65	V	
POWER SET INPUT (PSET)					
Capacitance			80	pF	
Monitor Photodiode Current into RPSET Resistor	50		1200	µA	Average Current
Voltage	1.1	1.2	1.3	V	
EXTINCTION RATIO SET INPUT (ERSET)					
Allowable Resistance Range	1.2		25	kΩ	
Voltage	1.1	1.2	1.3	V	
ALARM SET (ASET)					
Allowable Resistance Range	1.2		25	kΩ	
Voltage	1.1	1.2	1.3	V	
Hysteresis		5		%	
CONTROL LOOP					Low Loop Bandwidth Selection
Time Constant		0.22		s	LBWSET = GND
		2.25		s	LBWSET = V_{CC}
DATA INPUTS (DATAP, DATAN, CLKP, CLKN)[4]					
V p-p (Single-Ended, Peak-to-Peak)	100		500	mV	Data and Clock Inputs Are
Input Impedance (Single-Ended)		50		Ω	AC-Coupled
t_{SETUP}[5] (See Figure 1)	50			ps	
t_{HOLD}[5] (See Figure 1)	100			ps	
LOGIC INPUTS (ALS, LBWSET, CLKSEL)					
V_{IH}	2.4			V	
V_{IL}			0.8	V	
ALARM OUTPUTS (Internal 30 kΩ Pull-Up)					
V_{OH}	2.4			V	
V_{OL}			0.8	V	
IDTONE					
Compliance Voltage		V_{CC} –1.5		V	
$\left(\frac{I_{OUT}}{I_{IN}}\right)Ratio$		2			
f_{IN}[6]	0.01		1	MHz	User to Supply Current Sink in the Range of 50 µA to 4 mA
IBMON, IMMON, IMPDMON, IMPDMON2					
IBMON, IMMON Division Ratio		100		A/A	
IMPDMON, IMPDMON2		1		A/A	
IMPDMON to IMPDMON2 Matching			2	%	I_{MPD} = 1200 µA
Compliance Voltage	0		V_{CC} –1.2	V	

Parameter	Min	Typ	Max	Unit	Conditions/Comments
SUPPLY					
I_{CC}[7]		50		mA	$I_{BIAS} = I_{MOD} = 0$
V_{CC}[8]	3.0	3.3	3.6	V	

NOTES
[1]Temperature range: –40°C to +85°C.
[2]The high speed performance for the die version of ADN2847 can be achieved when using the bonding diagram shown in Figure 3.
[3]Measured into a 25 Ω load using a 11110000 pattern at 2.5 Gbps.
[4]When the voltage on DATAP is greater than the voltage on DATAN, the modulation current flows in the IMODP pin.
[5]Guaranteed by design and characterization. Not production tested.
[6]IDTONE may cause eye distortion.
[7]I_{CCMIN} for power calculation on page 8 is the typical I_{CC} given.
[8]All V_{CC} pins should be shorted together.

Specifications subject to change without notice.

ABSOLUTE MAXIMUM RATINGS[1]

(T_A = 25°C, unless otherwise noted.)

V_{CC} to GND . . . . . 4.2 V
Digital Inputs (ALS, LBWSET, CLKSEL) . . –0.3 V to V_{CC} + 0.3 V
IMODN, IMODP . . . . . V_{CC} + 1.2 V
Operating Temperature Range
  Industrial . . . . . –40°C to +85°C
Storage Temperature Range . . . . . –65°C to +150°C
Junction Temperature (T_J max) . . . . . 150°C
48-Lead LFCSP Package
  Power Dissipation[2] . . . . . (T_J max – T_A)/θ_{JA} W
  θ_{JA} Thermal Impedance[3] . . . . . 25°C/W
  Lead Temperature (Soldering 10 sec) . . . . . 300°C
32-Lead LFCSP Package
  Power Dissipation[2] . . . . . (T_J max – T_A)/θ_{JA} W
  θ_{JA} Thermal Impedance[3] . . . . . 32°C/W
  Lead Temperature (Soldering 10 sec) . . . . . 300°C

NOTES
[1] Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those listed in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.
[2] Power consumption formulae are provided on page 8.
[3] θ_{JA} is defined when part is soldered on a 4-layer board.

ORDERING GUIDE

Model	Temperature Range	Package Description
ADN2847ACP-32	–40°C to +85°C	32-Lead LFCSP
ADN2847ACP-48	–40°C to +85°C	48-Lead LFCSP
ADN2847ACP-32-RL	–40°C to +85°C	32-Lead LFCSP
ADN2847ACP-32-RL7	–40°C to +85°C	32-Lead LFCSP
ADN2847ACP-48-RL	–40°C to +85°C	48-Lead LFCSP

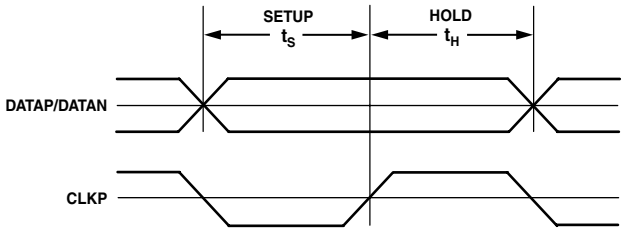


Figure 1. Setup and Hold Time

CAUTION

ESD (electrostatic discharge) sensitive device. Electrostatic charges as high as 4000 V readily accumulate on the human body and test equipment and can discharge without detection. Although the ADN2847 features proprietary ESD protection circuitry, permanent damage may occur on devices subjected to high energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.

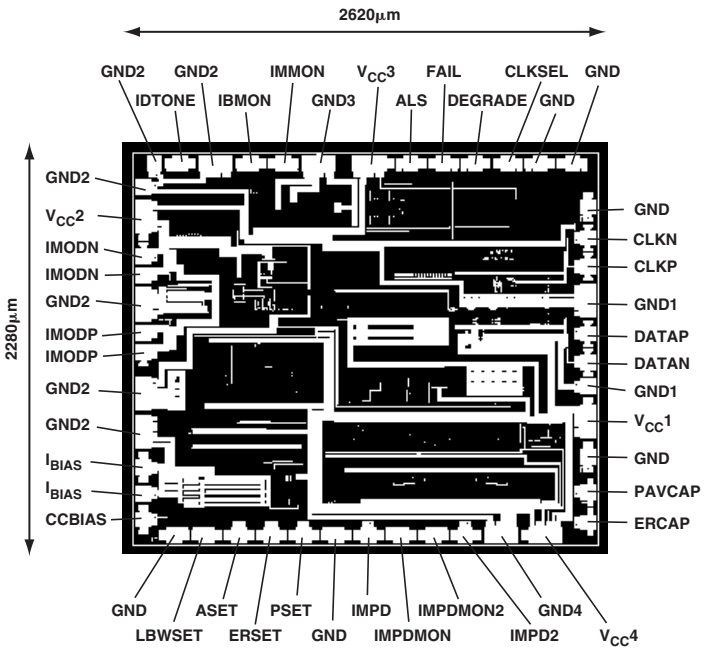


Figure 2. Metallization Photograph

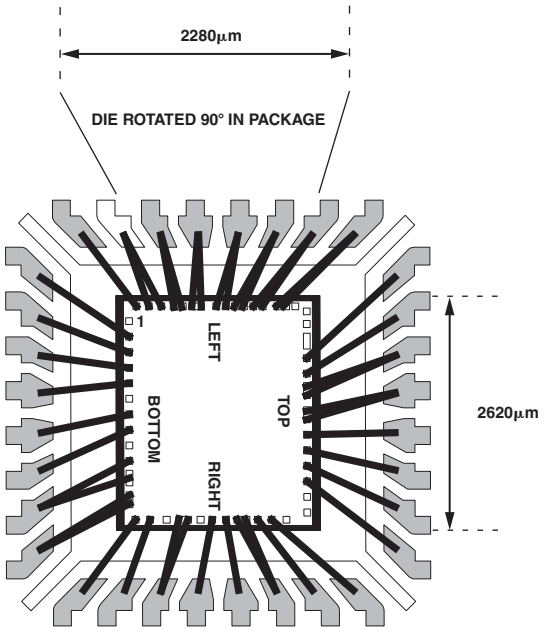


Figure 3. Bonding Diagram

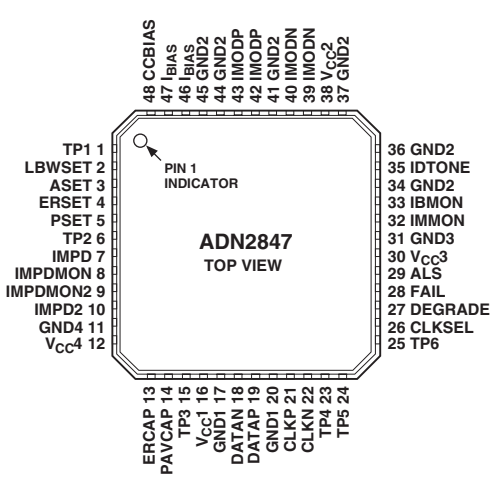
DIE PAD COORDINATES*

Pad Number	Pad Name	x[µm]	Y[µm]
1	TP1 (GND)	–996	1026
2	LBWSET	–996	853
3	ASET	–996	679
4	ERSET	–996	506
5	PSET	–996	332
6	TP2 (GND)	–996	159
7	IMPD	–996	–15
8	IMPDMON	–996	506
9	IMPDMON2	–996	–361
10	IMPD2	–996	–534
11	GND4	–996	–724
12	$V_{CC}4$	–995	–964
13	ERCAP	–925	–1191
14	PAVCAP	–777	–1191
15	TP3 (GND)	–606	–1191
16	$V_{CC}1$	–389	–1191
17	GND1	–200	–1191
18	DATAN	–70	–1191
19	DATAP	83	–1191
20	GND1	263	–1191
21	CLKP	442	–1191
22	CLKN	596	–1191
23	TP4 (GND)	762	–1191
24	TP5 (GND)	996	–1109
25	TP6 (GND)	996	–935
26	CLKSEL	996	–762
27	DEGRADE	996	–589
28	FAIL	996	–415
29	ALS	996	–242
30	$V_{CC}3$	996	–19
31	GND3	996	251
32	IMMON	996	441
33	IBMON	996	614
34	GND2	996	804
35	IDTONE	995	993
36	GND2	995	1133
37	GND2	867	1191
38	$V_{CC}2$	713	1191
39	IMODN	500	1191
40	IMODN	396	1191
41	GND2	242	1191
42	IMODP	88	1191
43	IMODP	–16	1191
44	GND2	–239	1191
45	GND2	–443	1191
46	I_{BIAS}	–633	1191
47	I_{BIAS}	–772	1191
48	CCBIAS	–912	1191

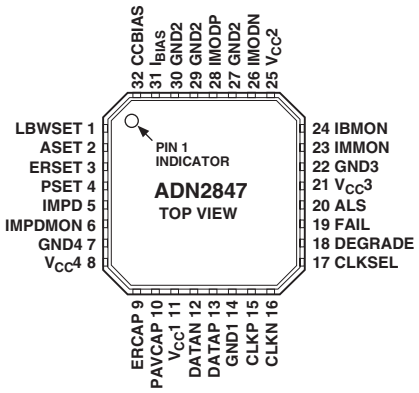
*With the origin in the center of the die (see Figure 2).

PIN CONFIGURATION

48-Lead LFCSP



32-Lead LFCSP



PIN FUNCTION DESCRIPTIONS

Pin Number			
48-Lead	**32-Lead**	**Mnemonic**	**Function**
1		TP1	Test Pin. In normal operation, TP1 = GND.
2	1	LBWSET	Select Low Loop Bandwidth
3	2	ASET	Alarm Current Threshold Setting Pin
4	3	ERSET	Extinction Ratio Set Pin
5	4	PSET	Average Optical Power Set Pin
6		TP2	Test Pin. In normal operation, TP2 = GND.
7	5	IMPD	Monitor Photodiode Input
8	6	IMPDMON	Mirrored Current from Monitor Photodiode
9		IMPDMON2	Mirrored Current from Monitor Photodiode2 (for Use with Two MPDs)
10		IMPD2	Monitor Photodiode Input 2 (for Use with Two MPDs)
11	7	GND4	Supply Ground
12	8	$V_{CC}4$	Supply Voltage
13	9	ERCAP	Extinction Ratio Loop Capacitor
14	10	PAVCAP	Average Power Loop Capacitor
15		TP3	Test Pin. In normal operation, TP3 = GND.
16	11	$V_{CC}1$	Supply Voltage
17		GND1	Supply Ground
18	12	DATAN	Data, Negative Differential Terminal
19	13	DATAP	Data, Positive Differential Terminal
20	14	GND1	Supply Ground
21	15	CLKP	Data Clock Positive Differential Terminal, Used if CLKSEL = V_{CC}
22	16	CLKN	Data Clock Negative Differential Terminal, Used if CLKSEL = V_{CC}
23		TP4	Test Pin. In normal operation, TP4 = GND.
24		TP5	Test Pin. In normal operation, TP5 = GND.
25		TP6	Test Pin. In normal operation, TP6 = GND.
26	17	CLKSEL	Clock Select (Active = V_{CC}), Used if Data Is Clocked into Chip
27	18	DEGRADE	DEGRADE Alarm Output
28	19	FAIL	FAIL Alarm Output
29	20	ALS	Automatic Laser Shutdown
30	21	$V_{CC}3$	Supply Voltage
31	22	GND3	Supply Ground
32	23	IMMON	Modulation Current Mirror Output
33	24	IBMON	Bias Current Mirror Output

PIN FUNCTION DESCRIPTIONS (continued)

Pin Number			
48-Lead	32-Lead	Mnemonic	Function
34		GND2	Supply Ground
35		IDTONE	IDTONE (Requires External Current Sink to Ground)
36		GND2	Supply Ground
37		GND2	Supply Ground
38	25	$V_{CC}2$	Supply Voltage
39	26	IMODN	Modulation Current Negative Output. Connect via a matching resistor to V_{CC}.
40	26	IMODN	Modulation Current Negative Output. Connect via a matching resistor to V_{CC}.
41	27	GND2	Supply Ground
42	28	IMODP	Modulation Current Positive Output. Connect to laser diode.
43	28	IMODP	Modulation Current Positive Output. Connect to laser diode.
44	29	GND2	Supply Ground
45	30	GND2	Supply Ground
46	31	I_{BIAS}	Laser Diode Bias Current
47	31	I_{BIAS}	Laser Diode Bias Current
48	32	CCBIAS	Extra Laser Diode Bias when AC-Coupled Current Sink

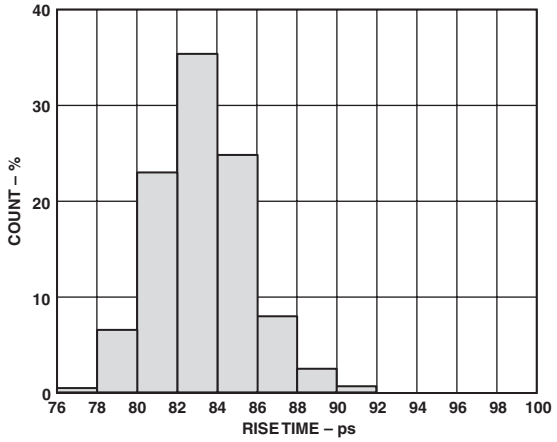


Figure 4. Rise Time Distribution Under Worst-Case Operating Conditions

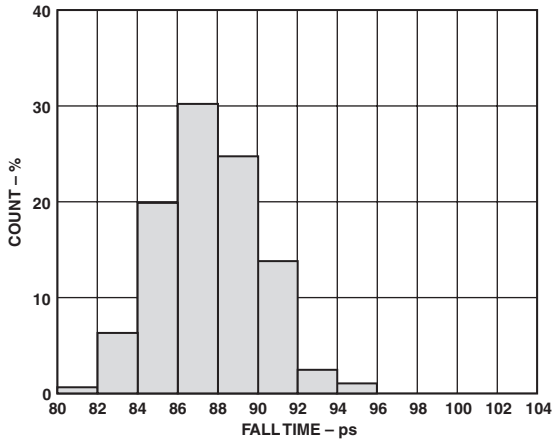


Figure 5. Fall Time Distribution Under Worst-Case Operating Conditions

GENERAL

Laser diodes have current-in to light-out transfer functions as shown in Figure 6. Two key characteristics of this transfer function are the threshold current, I_{TH}, and slope in the linear region beyond the threshold current, referred to as slope efficiency, LI.

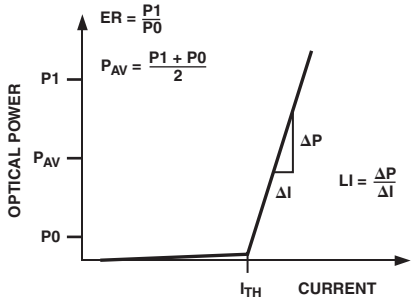


Figure 6. Laser Transfer Function

Control

A monitor photodiode, MPD, is required to control the LD. The MPD current is fed into the ADN2847 to control the power and extinction ratio, continuously adjusting the bias current and modulation current in response to the laser's changing threshold current and light-to-current slope efficiency.

The ADN2847 uses automatic power control, APC, to maintain a constant average power over time and temperature.

The ADN2847 uses closed-loop extinction ratio control to allow optimum setting of extinction ratio for every device. Thus SONET/SDH interface standards can be met over device variation, temperature, and laser aging. Closed-loop modulation control eliminates the need to either overmodulate the LD or include external components for temperature compensation. This reduces research and development time and second sourcing issues caused by characterizing LDs.

Average power and extinction ratio are set using the PSET and ERSET pins, respectively. Potentiometers are connected between these pins and ground. The potentiometer R_{PSET} is used to change the average power. The potentiometer R_{ERSET} is used to adjust the extinction ratio. Both PSET and ERSET are kept 1.2 V above GND.

The R_{PSET} and R_{ERSET} potentiometers can be calculated using the following formulas.

$$R_{PSET} = \frac{1.2V}{I_{AV}} (\Omega)$$

$$R_{ERSET} = \frac{1.2V}{\frac{I_{MPD\_CW}}{P_{CW}} \times \frac{ER-1}{ER+1} \times P_{AV}} (\Omega)$$

where:
I_{AV} is the average MPD current.
P_{CW} is the dc optical power specified on the laser data sheet.
I_{MPD_CW} is the MPD current at that specified P_{CW}.
P_{AV} is the average power required.
ER is the desired extinction ratio (ER = P1/P0).

Note that I_{ERSET} and I_{PSET} will change from device to device; however, the control loops will determine actual values. It is not required to know exact values for LI or MPD optical coupling.

Loop Bandwidth Selection
For continuous operation, the user should hardwire the LBWSET pin high and use 1 µF capacitors to set the actual loop bandwidth. These capacitors are placed between the PAVCAP and ERCAP pins and ground. It is important that these capacitors are low leakage multilayer ceramics with an insulation resistance greater than 100 GΩ or a time constant of 1000 sec, whichever is less.

Operation Mode	LBWSET	Recommended PAVCAP	Recommended ERCAP
Continuous 50 Mbps to 3.3 Gbps	High	1 µF	1 µF
Optimized for 2.5 Gbps to 3.3 Gbps	Low	22 nF	22 nF

Setting LBSET low and using 22 nF capacitors results in a shorter loop time constant (a 10× reduction over using 1 µF capacitors and keeping LBWSET high.)

Alarms
The ADN2847 is designed to allow interface compliance to ITU-T-G958 (11/94) section 10.3.1.1.2 (transmitter fail) and section 10.3.1.1.3 (transmitter degrade). The ADN2847 has two active high alarms, DEGRADE and FAIL. A resistor between ground and the ASET pin is used to set the current at which these alarms are raised. The current through the ASET resistor is a ratio of 100:1 to the FAIL alarm threshold. The DEGRADE alarm will be raised at 90% of this level.

Example:

$$I_{FAIL} = 50\ mA\ so\ I_{DEGRADE} = 45\ mA$$

$$I_{ASET} = \frac{I_{FAIL}}{100} = \frac{50\ mA}{100} = 500\ \mu A$$

$$^{*}R_{ASET} = \frac{1.2V}{I_{ASET}} = \frac{1.2}{500\ \mu A} = 2.4\ k\Omega$$

* The smallest valid value for R_{ASET} is 1.2 kΩ, since this corresponds to the I_{BIAS} maximum of 100 mA.

The laser degrade alarm, DEGRADE, is provided to give a warning of imminent laser failure if the laser diode degrades further or environmental conditions continue to stress the LD, such as increasing temperature.

The laser fail alarm, FAIL, is activated when the transmitter can no longer be guaranteed to be SONET/SDH compliant. This occurs when one of the following conditions arises:

- The ASET threshold is reached.
- The ALS pin is set high. This shuts off the modulation and bias currents to the LD, resulting in the MPD current dropping to zero. This gives closed-loop feedback to the system that ALS has been enabled.

DEGRADE will be raised only when the bias current exceeds 90% of ASET current.

Monitor Currents
IBMON, IMMON, IMPDMON, and IMPDMON2 are current controlled current sources from V_{CC}. They mirror the bias, modulation, and MPD current for increased monitoring functionality. An external resistor to GND gives a voltage proportional to the current monitored.

If the monitoring functions IMPDMON and IMPDMON2 are not required, the IMPD and IMPD2 pins must be grounded and the monitor photodiode output must be connected directly to the PSET pin.

Dual MPD DWDM Function (48-Lead LFCSP Only)
The ADN2847 has circuitry for a second monitor photodiode, MPD2. The second photodiode current is mirrored to IMPDMON2 for wavelength control purposes and is summed internally with the first monitor photodiode current for the power control loop. For single MPD circuits, the MPD2 pin is tied to GND.

This enables the system designer to use the two currents to control the wavelength of the laser diode using various optical filtering techniques inside the laser module.

If the monitor current functions IMPDMON and IMPDMON2 are not required, then the IMPD and IMPD2 pins can be grounded and the monitor photodiode output can be connected directly to PSET.

IDTONE (48-Lead LFCSP Only)
The IDTONE pin is supplied for fiber identification/supervisory channels or control purposes in WDM. This pin modulates the optical one level over a possible range of 2% of minimum I_{MOD} to 10% of maximum I_{MOD}. The level of modulation is set by connecting an external current sink between the IDTONE pin and ground. There is a gain of two from this pin to the I_{MOD} current.

Figure 9 shows how an AD9850/AD9851 or the AD9834 may be used with the ADN2847 to allow fiber identification.

If the ID_TONE function is not used, the IDTONE pin should be tied to V_{CC}. Note that using IDTONE during transmission may cause optical eye degradation.

Data, Clock Inputs
Data and clock inputs are ac-coupled (10 nF capacitors are recommended) and terminated via a 100 Ω internal resistor between DATAP and DATAN, and also between the CLKP and CLKN pins. There is a high impedance circuit to set the common-mode voltage that is designed to allow for maximum input voltage

headroom over temperature. It is necessary that ac coupling is used to eliminate the need for matching between common-mode voltages.

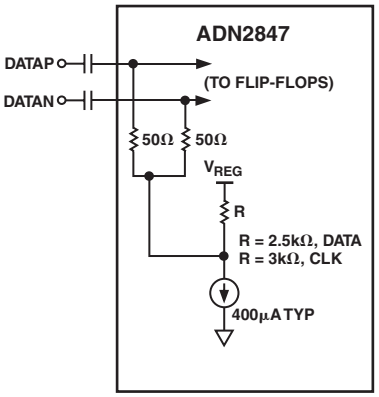


Figure 7. AC Coupling of Data Inputs

For input signals that exceed 500 mV p-p single ended, it is necessary to insert an attenuation circuit as shown in Figure 8.

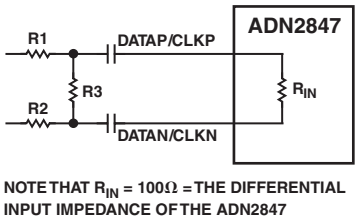


Figure 8. Attenuation Circuit

CCBIAS

When the laser is used in ac-coupled mode, the CCBIAS and I_{BIAS} pins should be tied together (Figure 12). In dc-coupled mode, CCBIAS should be tied to V_{CC}.

Automatic Laser Shutdown

The ADN2847 ALS allows compliance to ITU-T-G958 (11/94), section 9.7. When ALS is logic high, both bias and modulation currents are turned off. Correct operation of ALS can be confirmed by the FAIL alarm being raised when ALS is asserted. Note that this is the only time DEGRADE will be low while FAIL is high.

Alarm Interfaces

The FAIL and DEGRADE outputs have an internal pull-up resistor of 30 kΩ used to pull the digital high value to V_{CC}. However, the alarm can be overdriven with an external resistor allowing alarm interfacing to non-V_{CC} levels. **Non-V_{CC} alarm output levels must be below the V_{CC} used for the ADN2847.**

Power Consumption

The ADN2847 die temperature must be kept below 125°C. Both LFCSP packages have an exposed paddle, which should be connected in such a manner that is is at the same potential as the ADN2847 ground pins. The θ_{JA} for both packages is shown in the Absolute Maximum Ratings. Power consumption can be calculated using

$$I_{CC} = I_{CCMIN} + 0.3\ I_{MOD}$$

$$P = V_{CC} \times I_{CC} + \left(I_{BIAS} \times V_{BIAS\_PIN}\right) + I_{MOD}\left(V_{MODP\_PIN} + V_{MODN\_PIN}\right)/2$$

$$T_{DIE} = T_{AMBIENT} + \theta_{JA} \times P$$

Thus, the maximum combination of $I_{BIAS} + I_{MOD}$ must be calculated. Where:

I_{CCMIN} = 50 mA, the typical value of I_{CC} provided on page 3 with $I_{BIAS} = I_{MOD} = 0$

T_{DIE} = die temperature

$T_{AMBIENT}$ = ambient temperature

V_{BIAS_PIN} = voltage at I_{BIAS} pin

V_{MODP_PIN} = average voltage at IMODP pin

V_{MODN_PIN} = average voltage at IMODN pin

Laser Diode Interfacing

Many laser diodes designed for 2.5 Gbs operation are packaged with an internal resistor to bring the effective impedance up to 25 Ω in order to minimize transmission line effects. In high current applications, the voltage drop across this resistor combined with the laser diode forward voltage makes direct connection between the laser and the driver impractical in a 3 V system. AC coupling the driver to the laser diode removes this headroom constraint.

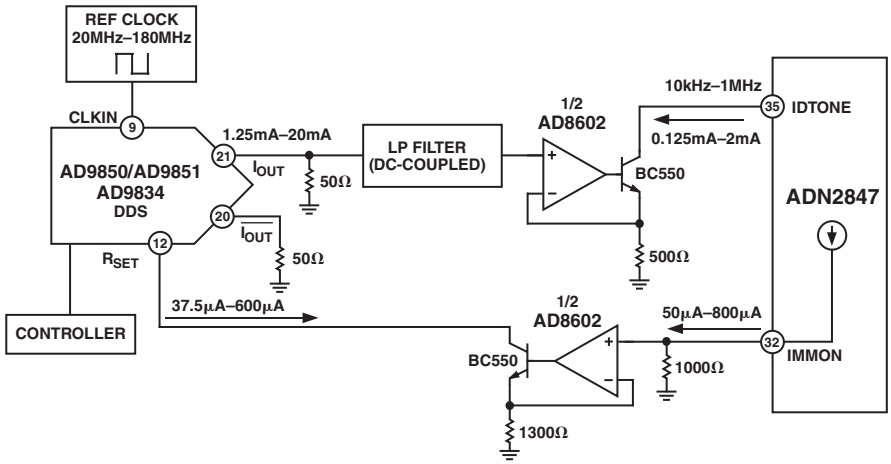


Figure 9. Application Curcuit to Allow Fiber Identification Using the AD9850/AD9851

Caution must be taken when choosing component values for ac coupling to ensure that the time constants (L/R and RC, see Figure 12) are sufficiently long for the data rate and expected number of CIDs (consecutive identical digits). Failure to do this could lead to pattern dependent jitter and vertical eye closure.

For designs with low series resistance, or where external components become impractical, the ADN2847 supports direct connection to the laser diode (see Figure 11). In this case, care must be taken to ensure that the voltage drop across the laser diode does not violate the minimum compliance voltage on the IMODP pin.

Optical Supervisor

The PSET and ERSET potentiometers may be replaced with a dual-digital potentiometer, the ADN2850 (see Figure 10). The ADN2850 provides an accurate digital control for the average optical power and extinction ratio and ensures excellent stability over temperature.

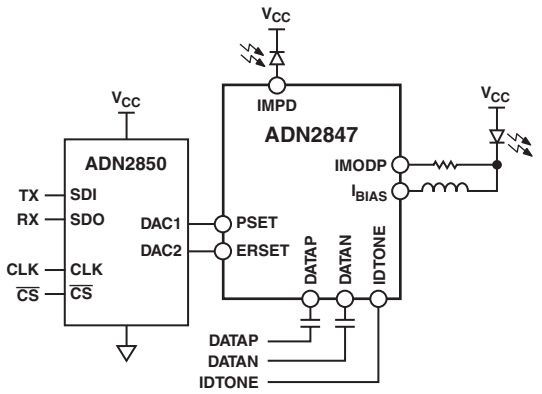


Figure 10. Application Using the ADN2850 a Dual 10-Bit Digital Potentiometer with an Extremely Low Temperature Coefficient as an Optical Supervisor

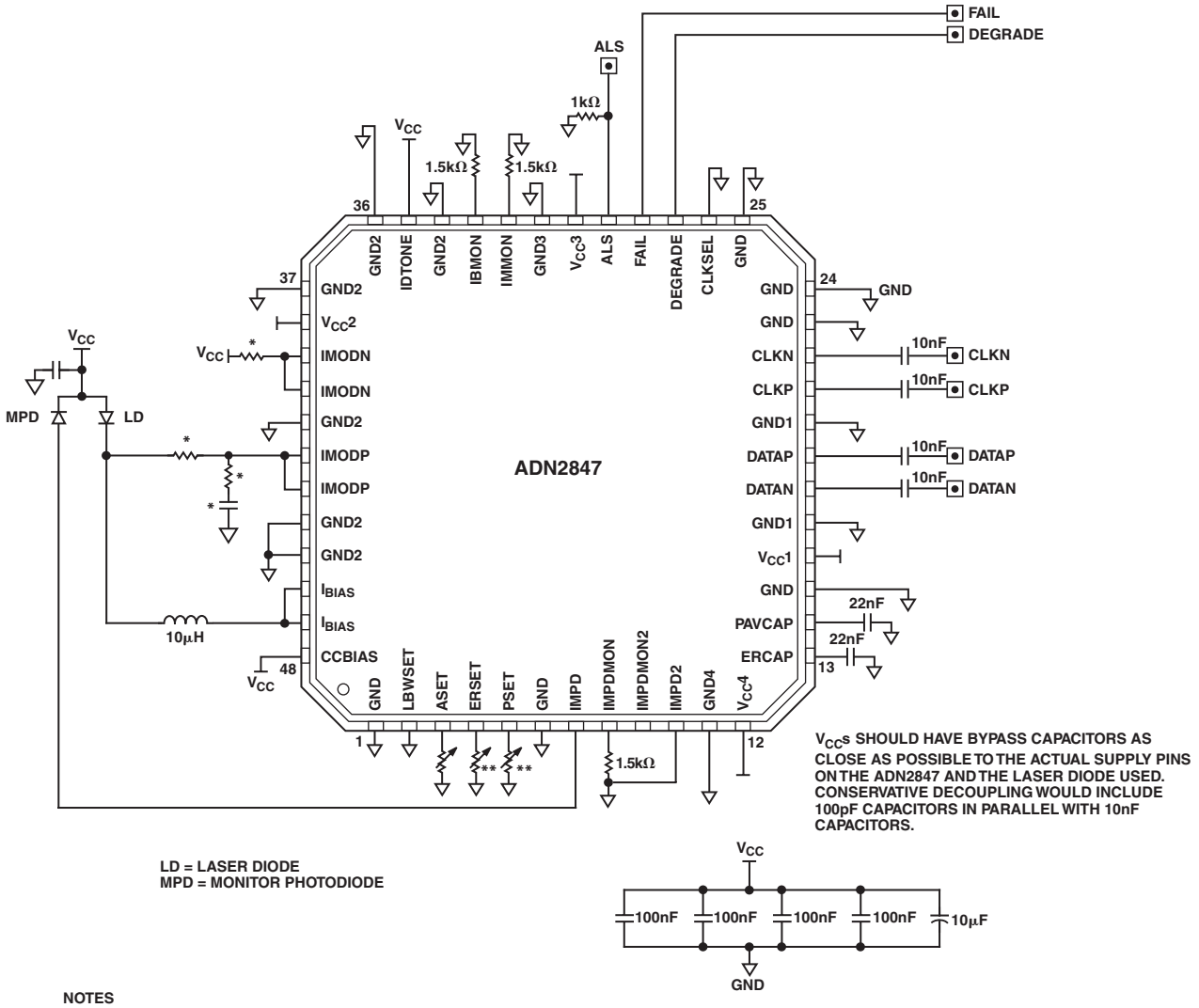


Figure 11. DC-Coupled 3.3 Gbps Test Circuit, Data Not Clocked

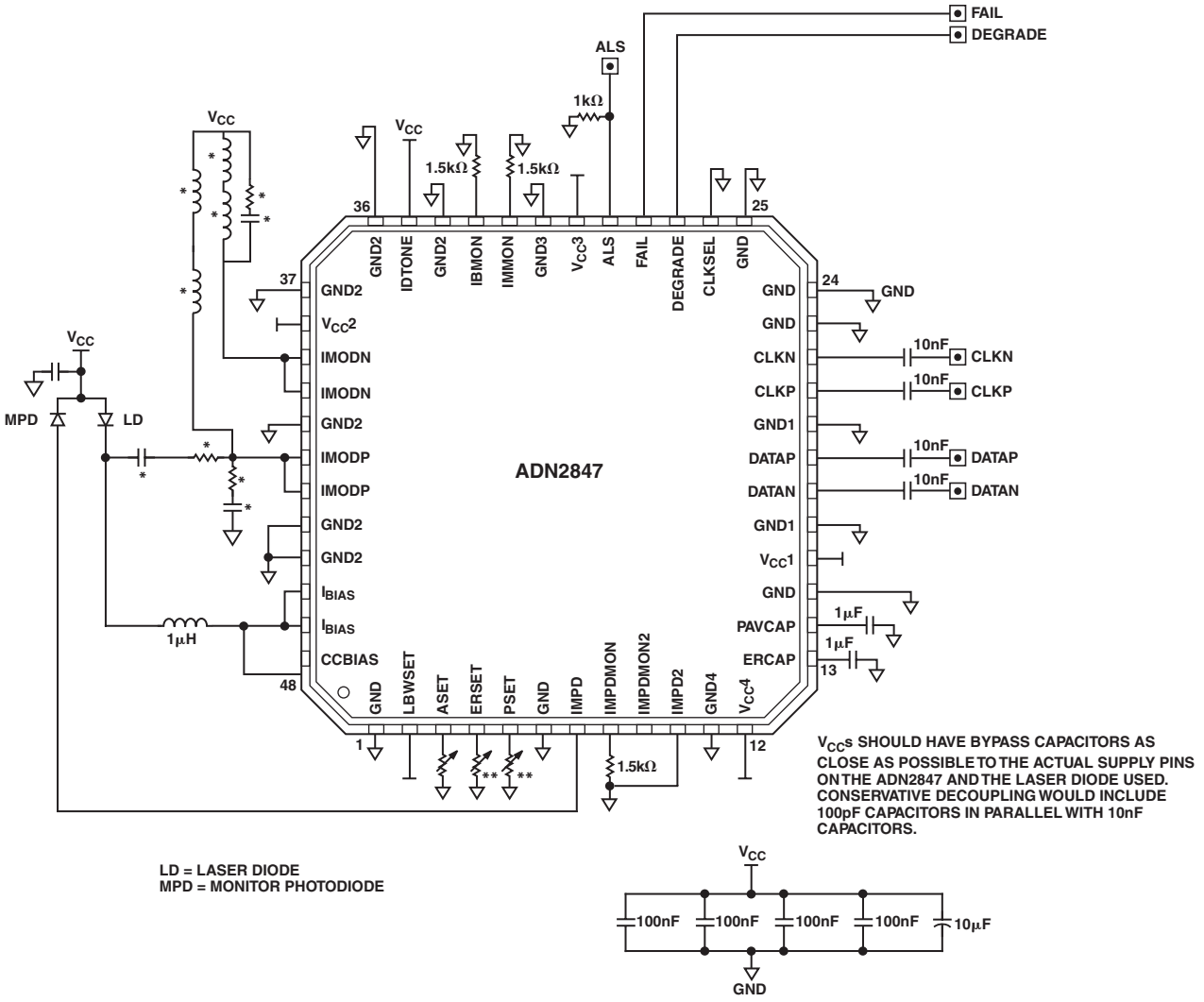


Figure 12. AC-Coupled 50 Mbps to 3.3 Gbps Test Circuit, Data Not Clocked

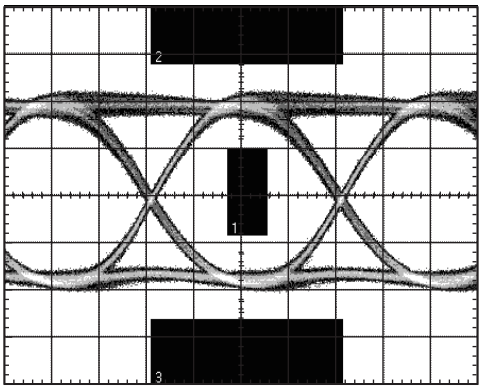


Figure 13. A 2.5 Gbps Optical Eye at 25°C. Average Power = 0 dBm, Extinction Ratio = 10 dB, PRBS 31 Pattern. Eye Obtained Using a DFB Laser.

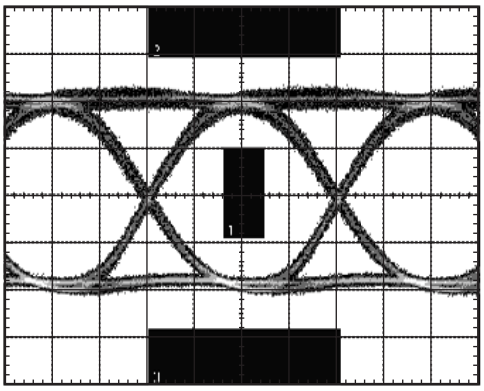
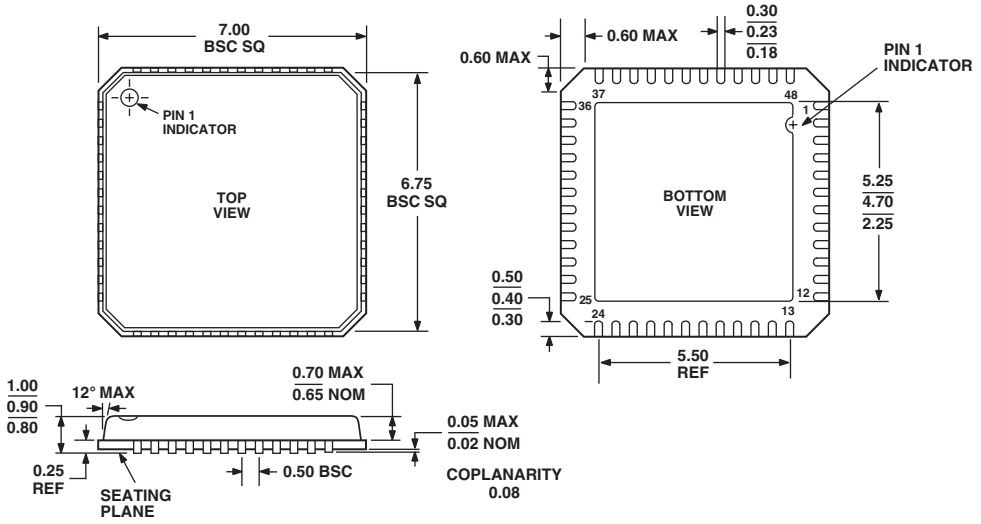


Figure 14. A 2.5 Gbps Optical Eye at 85°C. Average Power = 0 dBm, Extinction Ratio = 10 dB, PRBS 31 Pattern. Eye Obtained Using a DFB Laser.

OUTLINE DIMENSIONS

48-Lead Frame Chip Scale Package [LFCSP]
(CP-48)

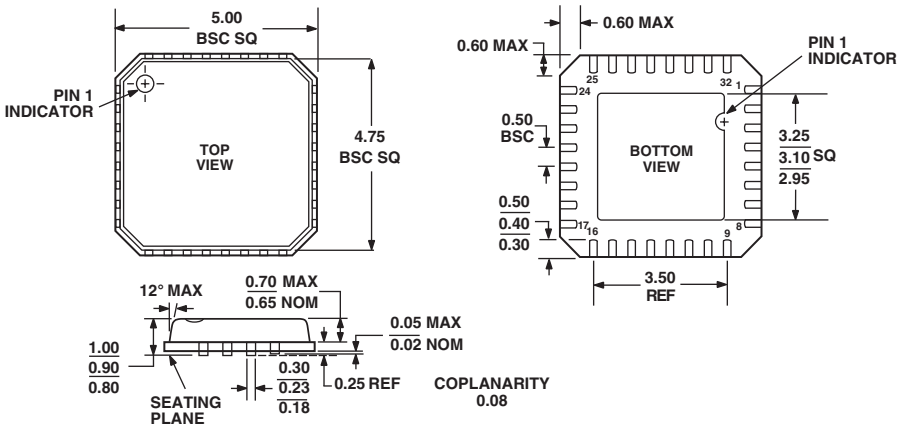
Dimensions shown in millimeters



COMPLIANT TO JEDEC STANDARDS MO-220-VKKD-2

32-Lead Frame Chip Scale Package [LFCSP]
(CP-32)

Dimensions shown in millimeters



COMPLIANT TO JEDEC STANDARDS MO-220-VHHD-2

C02745–0–1/03(0)

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