Application Note

1 Gb/s Datacom TIAs

Rev 1

RELEVANT PRODUCTS

- AMT121302
- AMT128502A
- AMT128503
- AMT8504

INTRODUCTION

Anadigics offers two types of packaged optical receivers for the gigabit data communications market. The first type is a PIN photodetector and preamplifier (AMT121302) integrated in a TO package. These use an InGaAs photodetector and are intended for the long wavelength region of operation (1300 to 1550nm). The second type, which is used for short wavelength (850nm) applications, is a monolithically integrated Metal-Semiconductor-Metal (MSM) photodetector and preamplifier (AMT128502, AMT128503, and AMT8504). Having the MSM photodetector and preamplifier integrated on the same die provides optimal performance and allows the use of a large area detector (100µm).

FUNCTIONAL DESCRIPTION

Figure 1 shows the functional block diagram of the integrated detector preamplifiers (IDPs). The device is comprised of a photodetector, a feedback network around two gain stages, automatic gain control and a differential, source follower, output buffer.

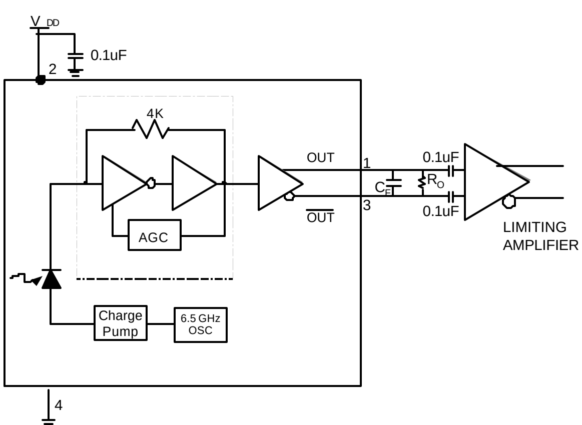


Figure 1: Application Schematic

Integrated DC to DC Converter

A unique feature of the optical receivers is the use of an integrated, microwave negative voltage generator to reverse bias the photodetector. The oscillation frequency for the negative voltage generator is set much higher than the bit rate of operation of the device and can be set up to 10GHz. In these devices the oscillator frequency is set to 6.5 to 7.5 GHz. The negative bias voltage, combined with the positive input offset voltage of the preamplifier, insures that the photodetector will operate in a low capacitance region thus providing the highest possible performance.

Output Filter Design

In most cases the negative voltage generator is transparent to the system design, however, a wide band, low pass filter at the output of the device should remove any fundamental or harmonic feed-through from the oscillator.

A recommended circuit to reduce any possible feed-through from the oscillator is also shown in Figure 1.

C_F is a single pole noise capacitor, determined from the following equation:

$$C_F = \frac{1}{2\pi f_c R}$$

Where f_c = desired cutoff frequency
R = 50 Ω

R_O (100Ω) is required only when using high input resistance (not 50Ω) post amplifiers.

The output filter can also be used to improve the receiver sensitivity. Since the noise performance of the receiver is strongly related to the bandwidth, which varies due to supply voltage, temperature and die lot, the output filter can be used to limit the bandwidth and reduce the noise. A higher order filter, as shown in Figure 2, improves the filter roll-off at the expense of higher complexity. A Bessel or Thompson filter is recommended because if its flat group delay response which will introduce minimal intersymbol interference.

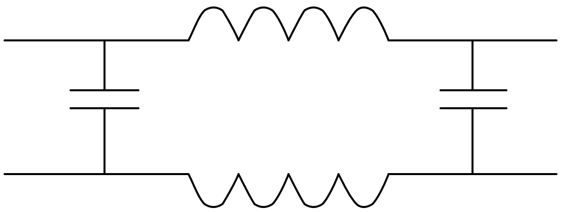


Figure 2: Three-Pole Bessel Filter

Noise Equivalent Power

Noise equivalent power (NEP) is a way of quantifying the noise characteristic of the receiver. The measurement setup used to measure these parameters is shown in Figure 3.

The NEP is defined as the receiver output noise voltage, V_n(rms), referred to the optical input through the responsivity (R) of the device:

$$NEP = V_n/R$$

Assuming a 50Ω output impedance, the output noise voltage can be calculated from the output noise power, P_n(rms):

$$V_n = \sqrt{(P_n \times 50)}$$

The output noise power of the device is measured without any optical input. A low pass filter can be used to limit the noise to the bandwidth of interest. The loss (L) through the 180° coupler is added to the noise power and the gain (G) of the amplifier is subtracted off of the measured noise.

The sensitivity for a bit error rate (BER) of 10^{-12} can be calculated from the NEP as follows:
Sensitivity (dBm) = $10\log_{10}(7000 \times NEP)$

Typical values of P_n, V_n, R, NEP and sensitivity for the AMT121302 and AMT128503 are given in Table 1.

The sensitivity calculated from the NEP will result in a more optimistic value than that obtained from an actual BER measurement. This is due to the fact that other circuit and system parameters are not accounted for; these include optical coupling efficiency, time jitter, intersymbol interference (ISI), transmitter extinction ratio and source intensity noise.

Stressed Eye Sensitivity Measurement

According to the IEEE Std 802.3z, a 1000BASE-SX receiver must have a minimum stressed eye sensitivity of –13.5 dBm (with 50µm MMF) and a 1000BASE-LX receiver must have a minimum stressed eye sensitivity of -14.4 dBm, at a BER of 10^{-12}.

The sensitivity of an Anadigics AMT128503T46 IDP was tested using both a non-stressed and stressed eye. The test setup for measuring the sensitivity is shown in Figure 4.

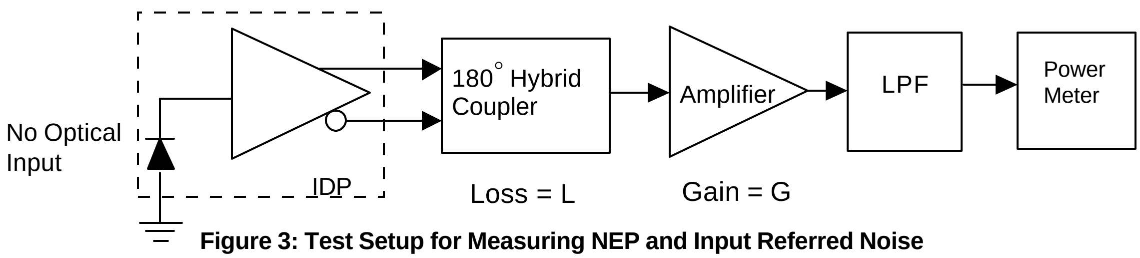


Figure 3: Test Setup for Measuring NEP and Input Referred Noise

Table 1: Typical NEP and Sensitivity

Part	P_n (nW rms)	V_n (µV rms)	R (V/W)	NEP (µW rms)	Sensitivity (dBm)
AMT121302	4.5	473	3300	0.14	-30
AMT128503	11.2	749	1500	0.5	-24.5

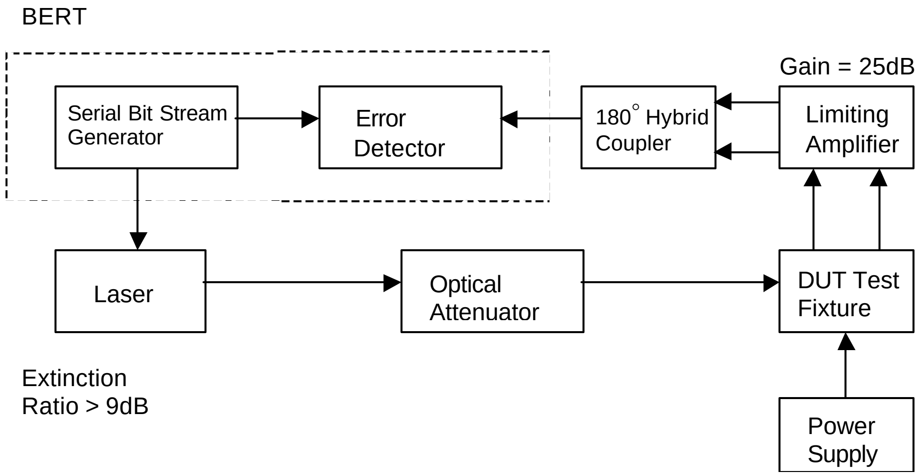


Figure 4: Test Setup for Measuring Sensitivity

The extinction ratio of the optical signal used in the measurement was 11.58 dB. The eye diagrams at the output of the laser and at the output of the hybrid coupler are shown in Figure 5 and Figure 6 respectively. Using a 2^7-1 PRBS, the sensitivity was measured to be –23.25 dBm for a BER of 10^{-10}.

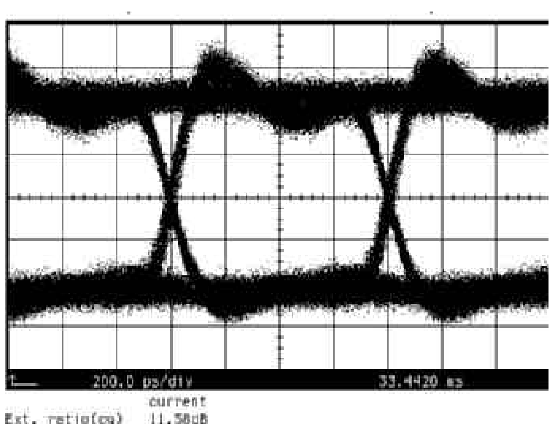


Figure 5: Optical Non-Stressed eye

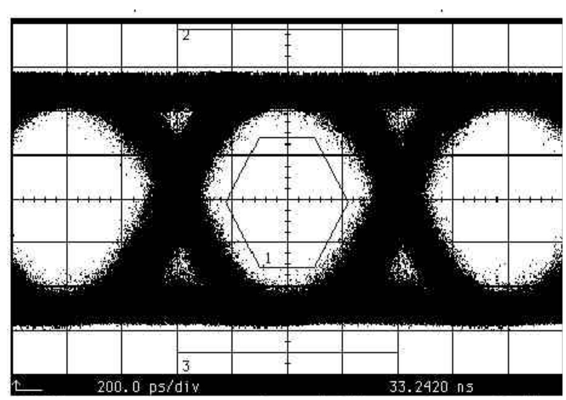
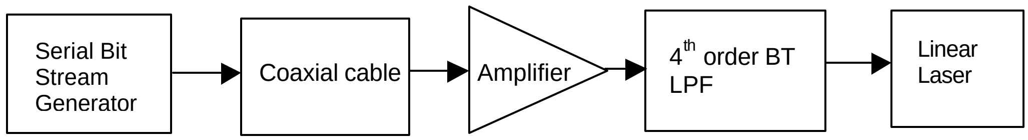


Figure 6: Non-Stressed Device Output

As outlined in the 802.3z standard, the block diagram of the equipment used to create the stressed eye is shown in Figure 7. The output of the laser goes to the optical attenuator and the rest of the equipment, as shown in Figure 4, is used to measure the sensitivity



Equipment List

Amplifier:	Picosecond Pulse Labs Model 5824
LPF:	Picosecond Pulse Labs Model 5915/467
Linear Laser:	Lawrence Labs Model FOT-850-10M/4G-50/125

Figure 7: Equipment for Generating the Stressed Eye

The extinction ratio of the stressed eye optical signal was 11.67dB; the jitter was greater than 100 ps and the eye closure was 2.3 dB. The eye diagrams at the output of the laser and at the output of the hybrid coupler are shown in Figure 8 and Figure 9 respectively.

Using a 2^7-1 PRBS, the sensitivity was measured to be –19.2 dBm for a BER of 10^{-10}. For a BER of 10^{-12}, a 1 dB penalty can be added. This gives the transceiver a design margin of almost 5 dB.

Similar tests were made for the AMT121302T46 IDP and the stressed eye sensitivity was measured between –23 and –24 dBm. This results in a transceiver design margin of 9 dB.

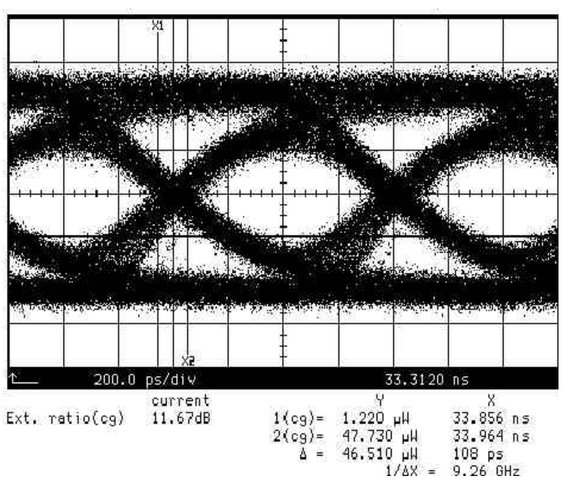


Figure 8: Optical Stressed Eye

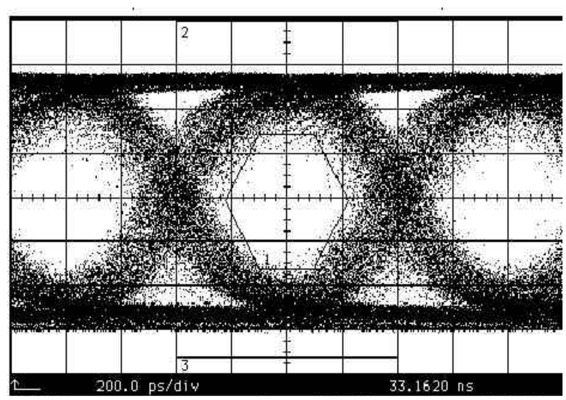


Figure 9: Stressed Eye, AMT128503T46 Output

Optical Sub-Assembly Design

When designing an optical sub-assembly to house a ball lens TO can, the placement of the receiver optical ferrule, with respect to the TO can, to achieve maximum output voltage is desired. Measurements were made to determine the z-height, that is, the distance from the bottom of the ferrule to the top of the TO can (Figure 10) and the position of optimal response with respect to the center of the TO can (Figure 11). Table 2 lists the average, minimum, maximum and standard deviation (σ) of the z-height for a PIN IDP and an MSM IDP in a TO-46L package.

Part	Average (mm)	Min.(mm)	Max.(mm)	σ (mm)
PIN IDP	2.0	1.8	2.2	0.05
MSM IDP	1.8	1.75	1.87	0.04

Table 2: Z-Height for PIN and MSM IDPs

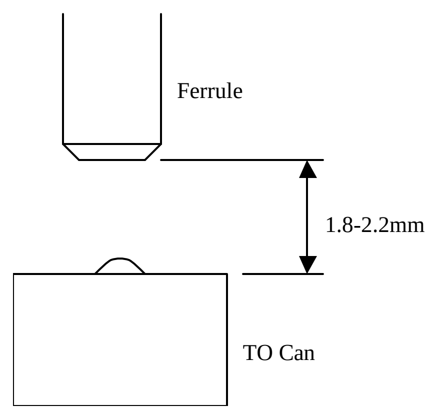


Figure 10: Z height for AMT121302T46L

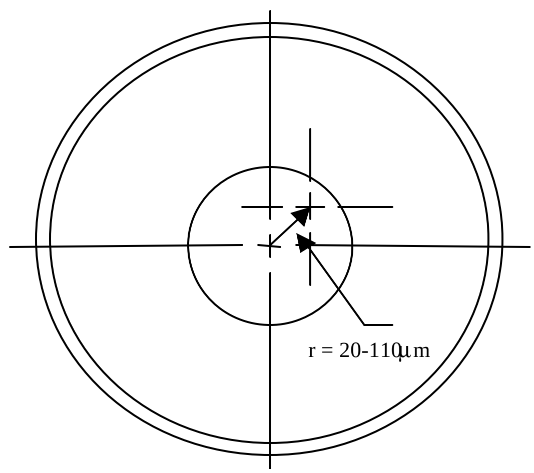


Figure 11: Distance from the center of the can to point of optimal response (r)

It was found that the distance from the center of the can to the point of optimal response, r, varied from 20 to 110µm, with an average of 57µm. This range will be typical for both PIN and MSM IDPs.

NOTES

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ANADIGICS, Inc.
141 Mount Bethel Road
Warren, New Jersey 07059, U.S.A.
Tel: +1 (908) 668-5000
Fax: +1 (908) 668-5132

URL: http://www.anadigics.com
E-mail: Mktg@anadigics.com