APPLICATION NOTE

AB1432
50Mb/s fiber optic receivers

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Philips Semiconductors

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INTRODUCTION

This application brief describes the use of four Philips Semiconductors devices specifically designed for use as fiber optic receiver components.

In order to simplify the design process for a prospective user, two typical fiber optic receivers were designed, built and tested. The design criteria for these receivers is a maximum of 50Mb/s data rate non-return-to-zero (NRZ) format, optical wavelength of 850nm, and readily available components.

The two receivers are topologically similar; the difference between them is in performance, which will be pointed out in the specific discussion of each receiver. For ease of explanation, two sets of schematic diagrams are used. The first is a signal-only diagram used in the description of the circuit operation. The second, and complete set, shows the peripheral components and the power supply decoupling networks.

The choice of which preamplifier to use with which postamplifier is determined by the task to be accomplished. Selections were made for the two test receivers: One receiver combination (NE5211/NE5214) was chosen for long haul, i.e., greatest gain, and a short (2^7-1)-Pseudo Random Bit Sequence (PRBS). The other combination (NE5210/NE5217) was chosen for short haul, longer (2^{23}-1) PRBS operation. That is to say other combinations cannot exist; the choice is made dependent upon the application. The optical source used in the evaluation of the receivers is the transmitter, described in AB1121. SMA connectors were used throughout, with the exception of the step attenuator (see Figure 1 for complete test set-up description). The test set-up shown in Figure 1 provides measurement capability of optical power, Bit-Error-Rate (BER), and eye pattern (duty cycle distortion).

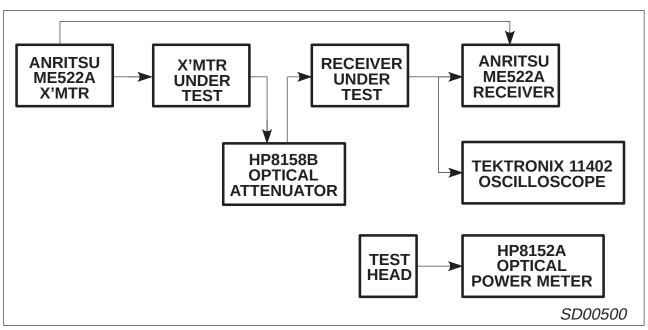


Figure 1. Test Set-Up

RECEIVER 1

The first receiver (Receiver 1) is shown in Figure 2. The optical signal is coupled to the PIN diode. Current flowing in the diode also flows into the input of the NE5211 preamplifier. The preamplifier is a fixed gain block that has a 28kΩ differential transimpedance and does a single-ended to differential conversion. With the signal in differential form, greater noise immunity is assured. The second stage, or postamplifier (NE5214), includes a gain block, auto-zero circuit, detection and limiting. The auto-zero circuit allows DC coupling of the preamplifier and cancels the signal dependent offset due to the optical-to-electrical conversion. The auto-zero capacitor must be 1000pF or greater for proper operation. The peak detector has an external threshold adjustment, R_{TH}, allowing the system designer to tailor the threshold to the individual's need. Hysteresis is included to minimize jitter introduced by the peak detector, and an external resistor, R_{HYS}, is used to set the amount of hysteresis desired. The output stage provides a single-ended TTL data signal with matched rise and fall times to minimize duty cycle distortion. The decoupling networks are shown in the complete schematic, Figure 3. Because this receiver has gain >100dB and very wide bandwidth, great care must be taken in both the physical layout and decoupling of the stages.

The printed circuit layout shown in Figure 4 may not be optimum; it serves only to demonstrate capability. For higher performance, a different layout and shielding between the detector leads and the preamplifier, and between the preamplifier and the postamplifier, may be in order. The decoupling networks cannot be disposed of; the value of the passive components may change to fit a particular need, but overall they are necessary. Another feature of all of the devices is the grounding pins which are available to separate input grounds and output grounds, high level grounds and low level grounds. These grounds need to be given careful consideration when laying out a circuit.

Results

Receiver 1 was built using the layout shown in Figure 4. Input power (P_{IN}) (minimum) was measured for PRBS lengths of 2^7-1 and 2^{23}-1 with the following conditions: BER = 10^{-9}, R_{TH} = 39kΩ, R_{HYS} = 5kΩ;

The results obtained were:
P_{IN} dBm optical = -32dBm for PRBS of 2^7-1,
P_{IN} dBm optical = -20dBm for PRBS of 2^{23}-1,

Actual eye patterns are shown in Figure 5a and b, for PRBS of 2^7-1,
P_{IN} dBm optical = -32dBm for PRBS of 2^{23}-1,
P_{IN} dBm optical = -20dBm, respectively.

To demonstrate threshold and hysteresis, a pair of curves were generated by measuring input power required for the signal to fall just below the threshold (signal loss), then measuring P_{IN} to just exceed the threshold (regain signal) for different valves of R_{TH}. The value of R_{HYS} is kept at a constant value of 5kΩ. These curves are shown in Figure 6.

Receiver 2

Receiver 2, Figure 7, is similar to Receiver 1, topologically. Optical power is coupled to the PIN photodetector diode, which is directly coupled to the NE5210. The NE5210 is a fixed 7kΩ differential transimpedance gain block with a differential output for noise immunity. The postamplifier, NE5217, is DC coupled to the preamplifier. The NE5217 also has an auto-zero circuit allowing direct coupling and cancellation of signal decoupling and cancellation of signal dependent offsets. The peak detector has its threshold externally adjustable by means of R_{TH}, and hysteresis for detector jitter reduction is adjustable using R_{HYS}. Curves are available in the data sheets for both R_{TH} and R_{HYS}. The NE5217 has a built-in Schmitt trigger, which requires coupling, capacitors, C_{S1} and C_{S2} as shown in Figure 7. The Schmitt trigger allows this device to function with longer PRBS NRZ signals by holding the last state until a change is made. The penalty is that an internal threshold is moved from 20mV to 400mV. The complete schematic is shown in Figure 8. The discussion of grounding and layout for Receiver 1 holds true for Receiver 2. A well through out layout will produce superior results.

Results

Receiver 2 was built using the layout shown in Figure 9. The same measurements were made as with Receiver 1. Input power minimum was measured for PRBS lengths of 2^7-1 and 2^{23}-1 with BER = 10^{-9}, R_{TH} = 39kΩ and R_{HYS} = 5kΩ.

The results obtained were:
P_{IN} dBm optical = -30dBm for PRBS of 2^7-1,
P_{IN} dBm optical = -21dBm for PRBS of 2^{23}-1,

Actual eye patterns are shown in Figure 10a and b, for PRBS of 2^7-1, and 2^{23}-1, respectively.

The curves showing power input (P_{IN}) required for the signal to fall just below the threshold (signal loss) and P_{IN} required to just exceed the threshold (regain signal) for different values of R_{TH}, are shown in Figure 11. The value of R_{HYS} is kept at a constant value of 5kΩ.

NOTE: Recall that the transimpedance of the NE5210 is 1/4 the transimpedance of the NE5211 when comparing the results.

CONCLUSION

Two 50Mb/s fiber optic receivers were presented along with full schematic diagrams and printed circuit layouts. Individual circuit descriptions were give, along with suggestions of how further performance improvement could be gained. Performance characteristics were shown for each circuit under actual operating conditions.

NOTE: The available bandwidth of both receivers is far greater than necessary for the applications shown. Capacitor C_1, shown in all schematic diagrams, serves to limit the overall bandwidth to 60MHz.

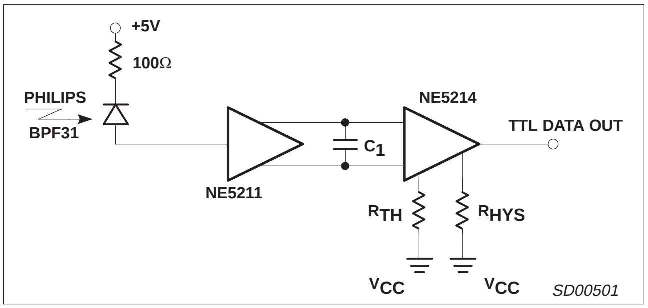


Figure 2.

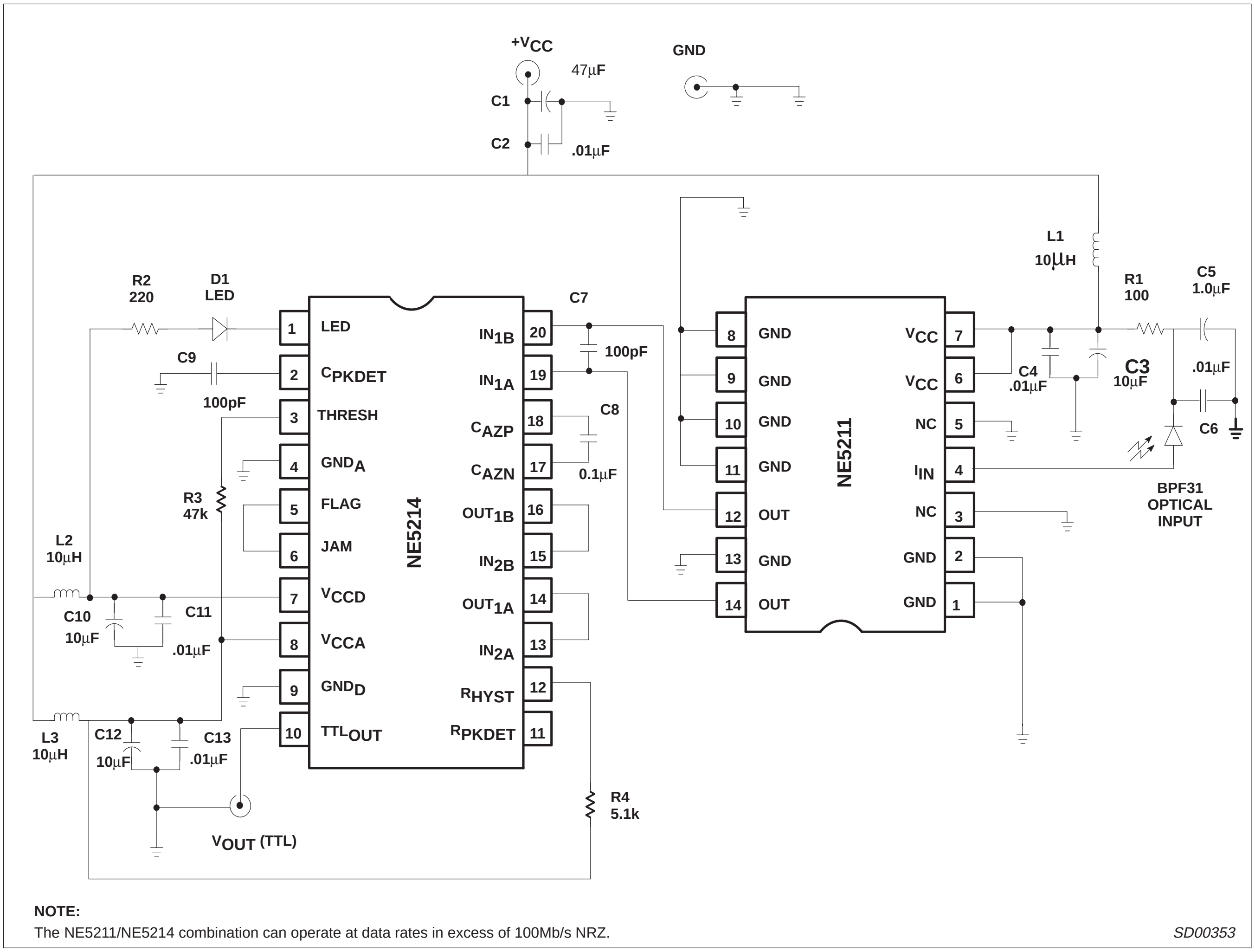


Figure 3. Eye Patterns for Receiver 1

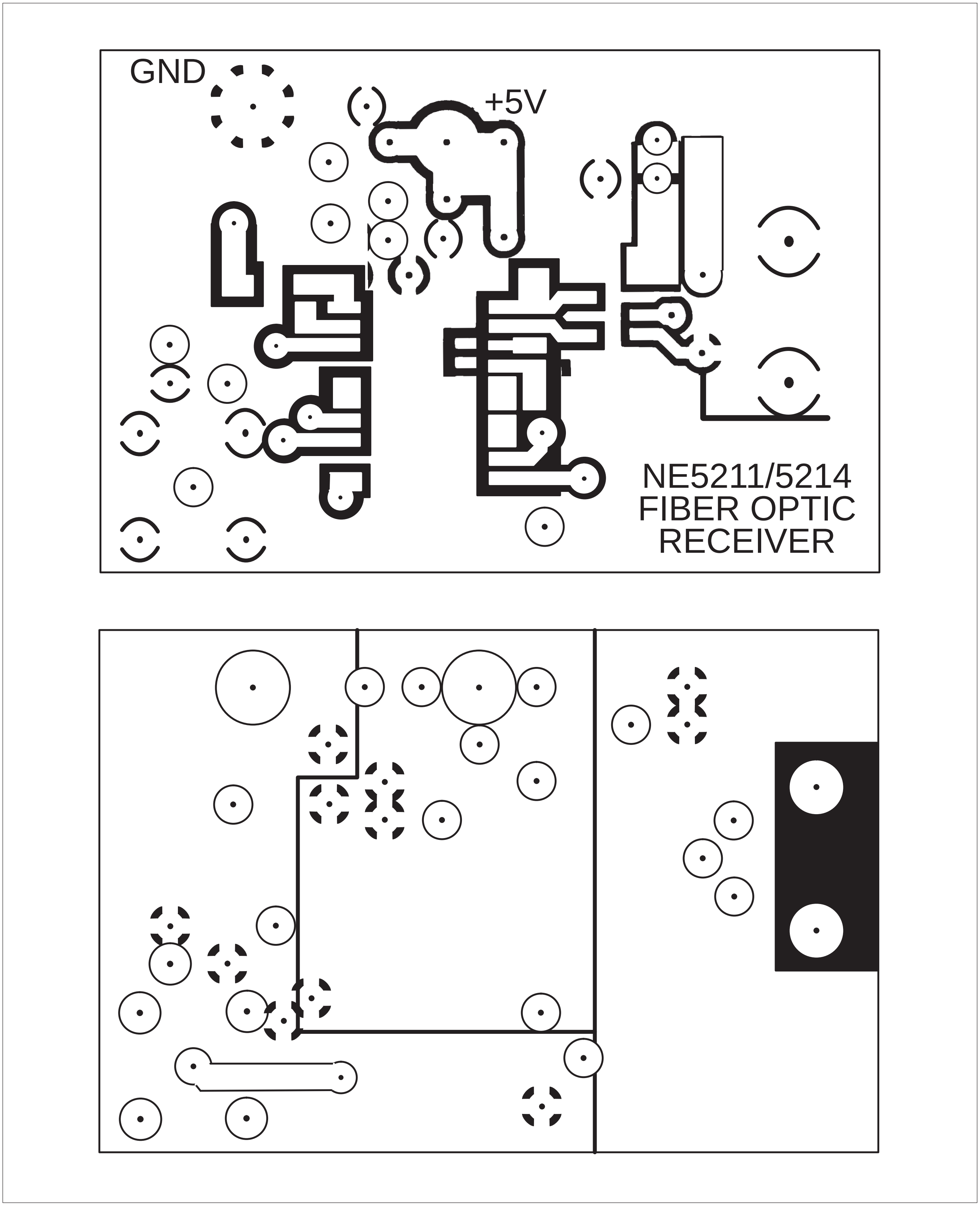
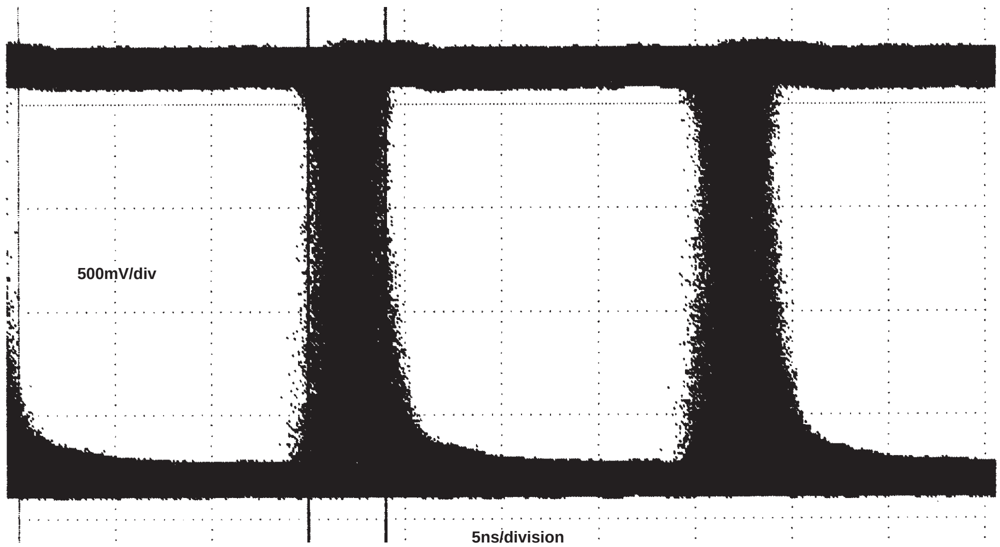
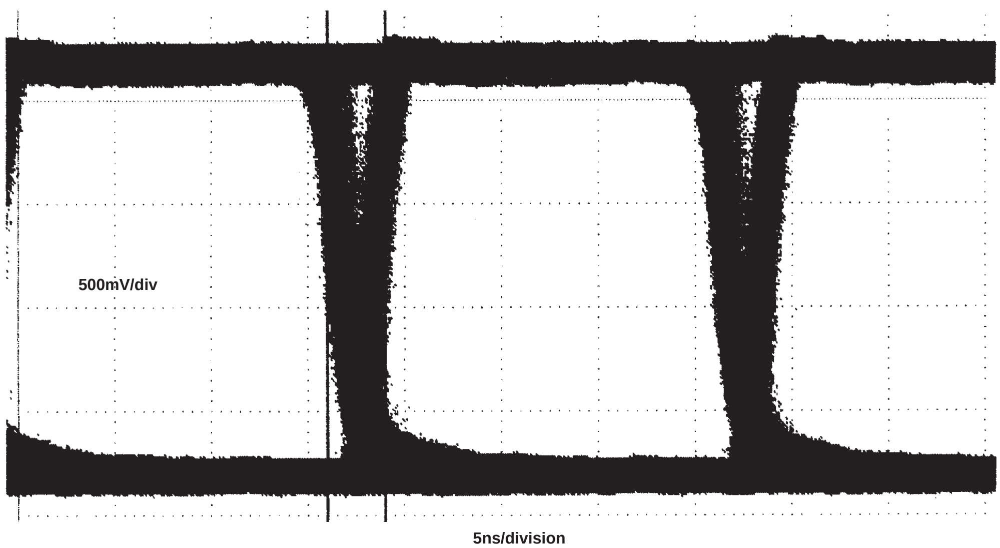


Figure 4. Eye Patterns for Receiver 1



a. PRBS of 2^7-1



b. PRBS of 2^{23}-1

SD00502

Figure 5. Eye Patterns for Receiver 1

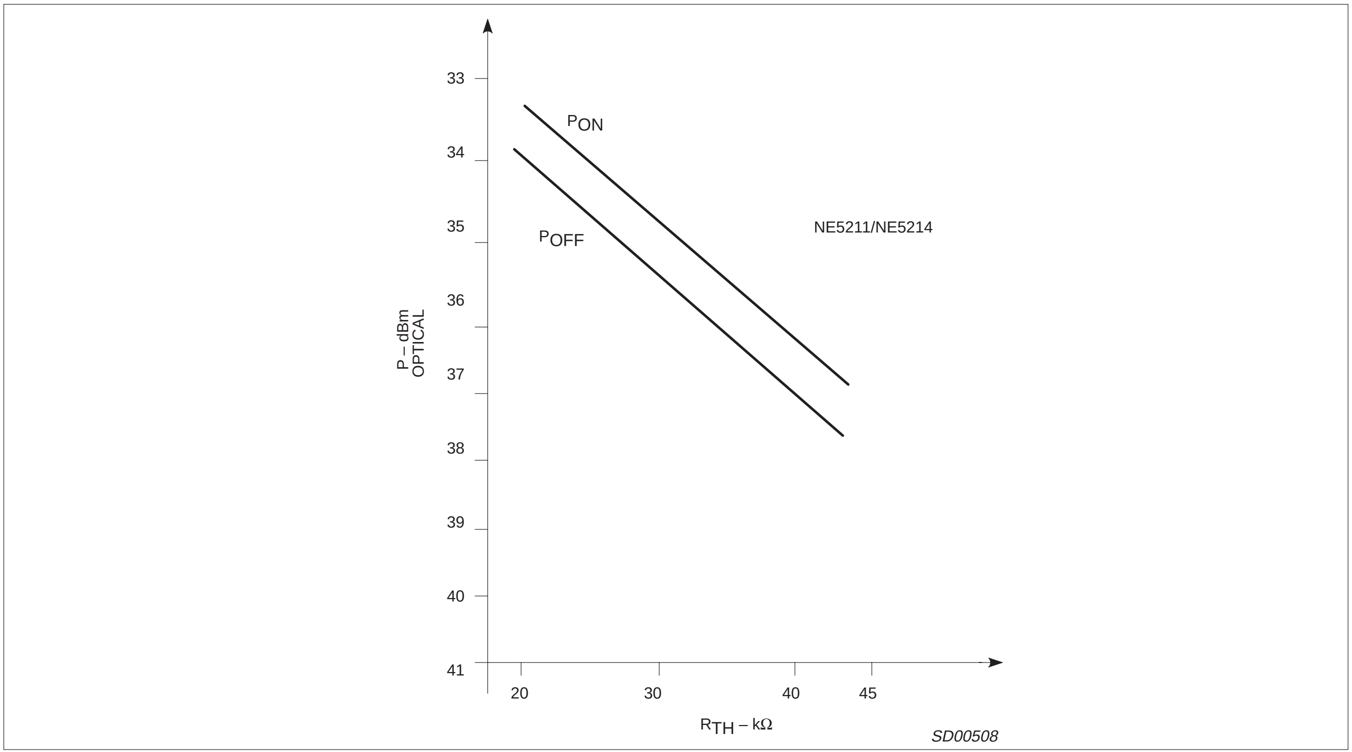


Figure 6. Eye Patterns for Receiver 1

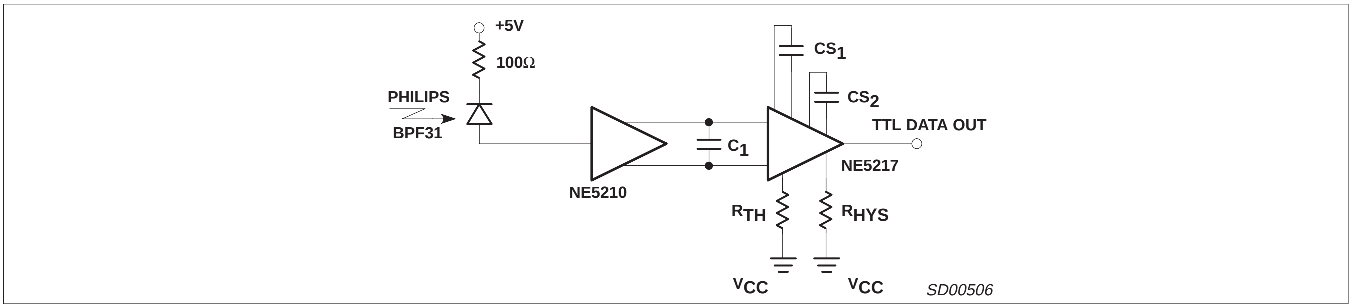


Figure 7. Eye Patterns for Receiver 1

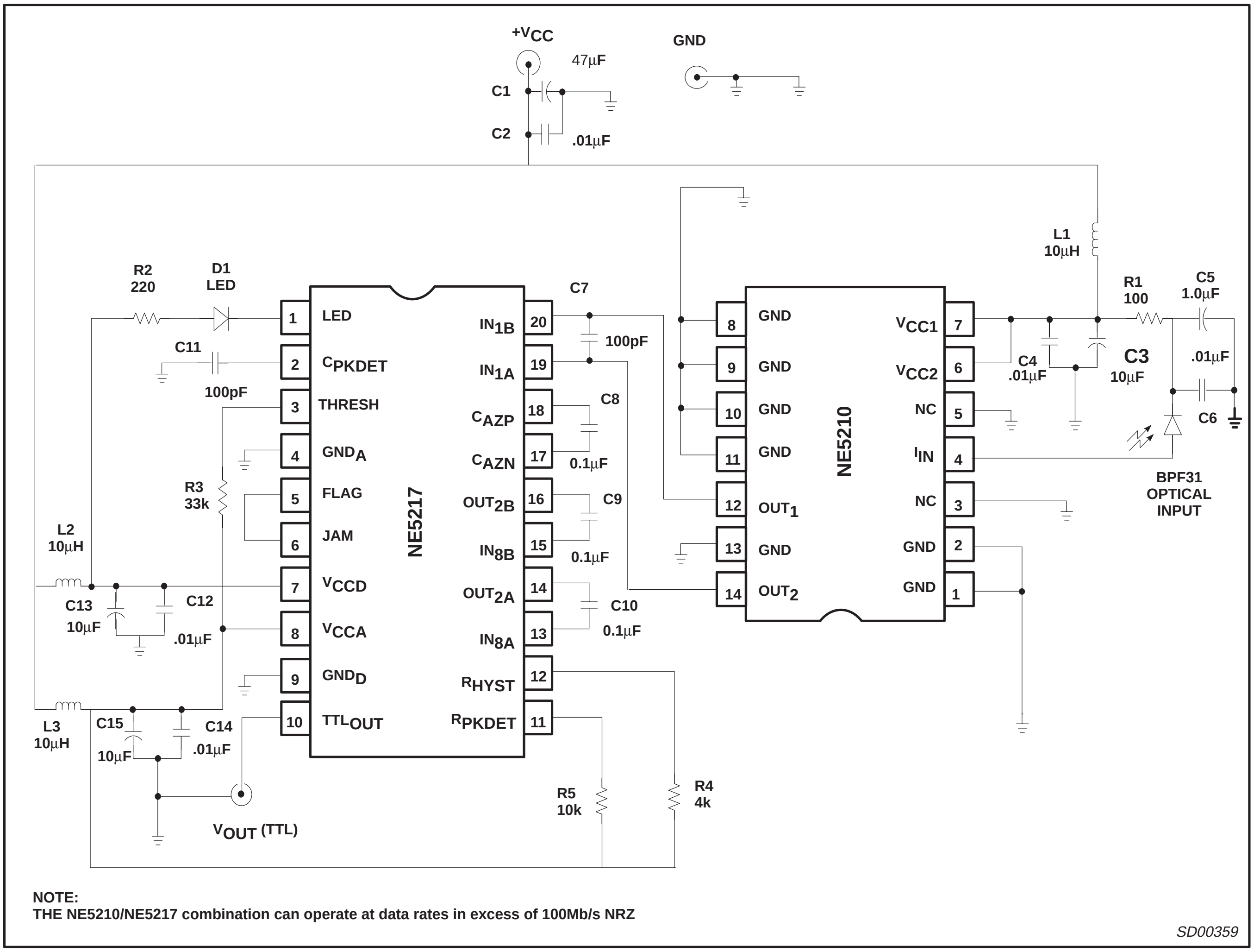
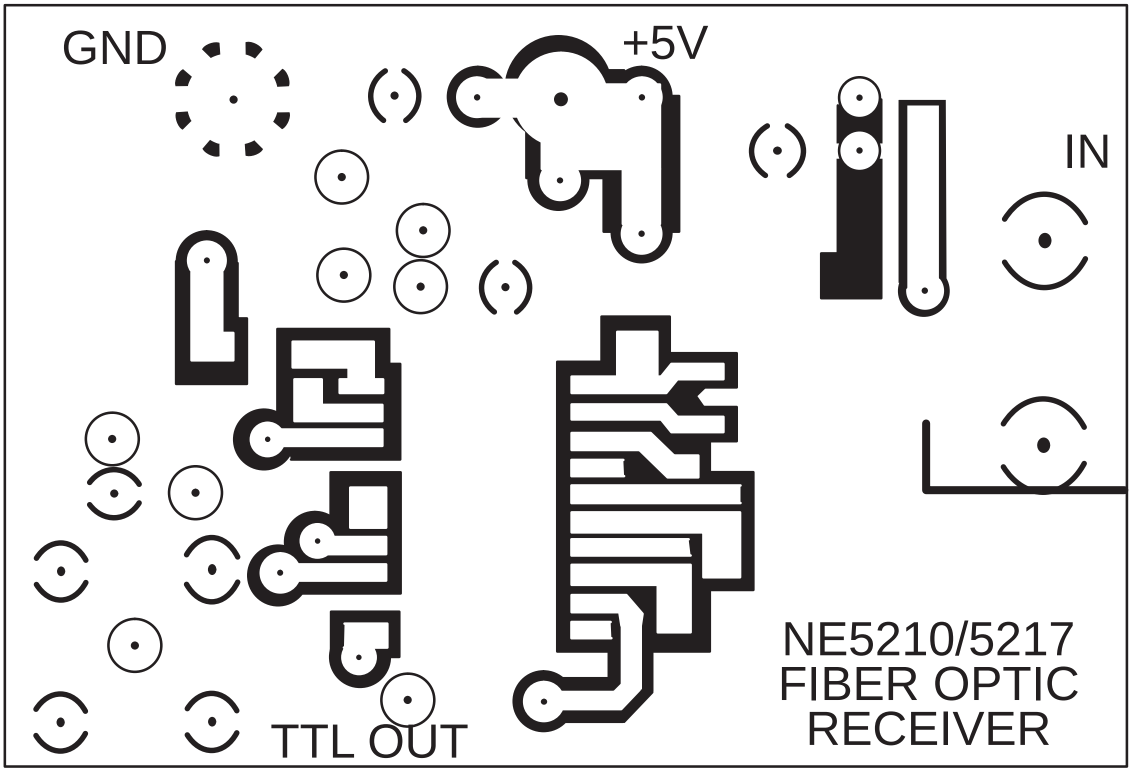
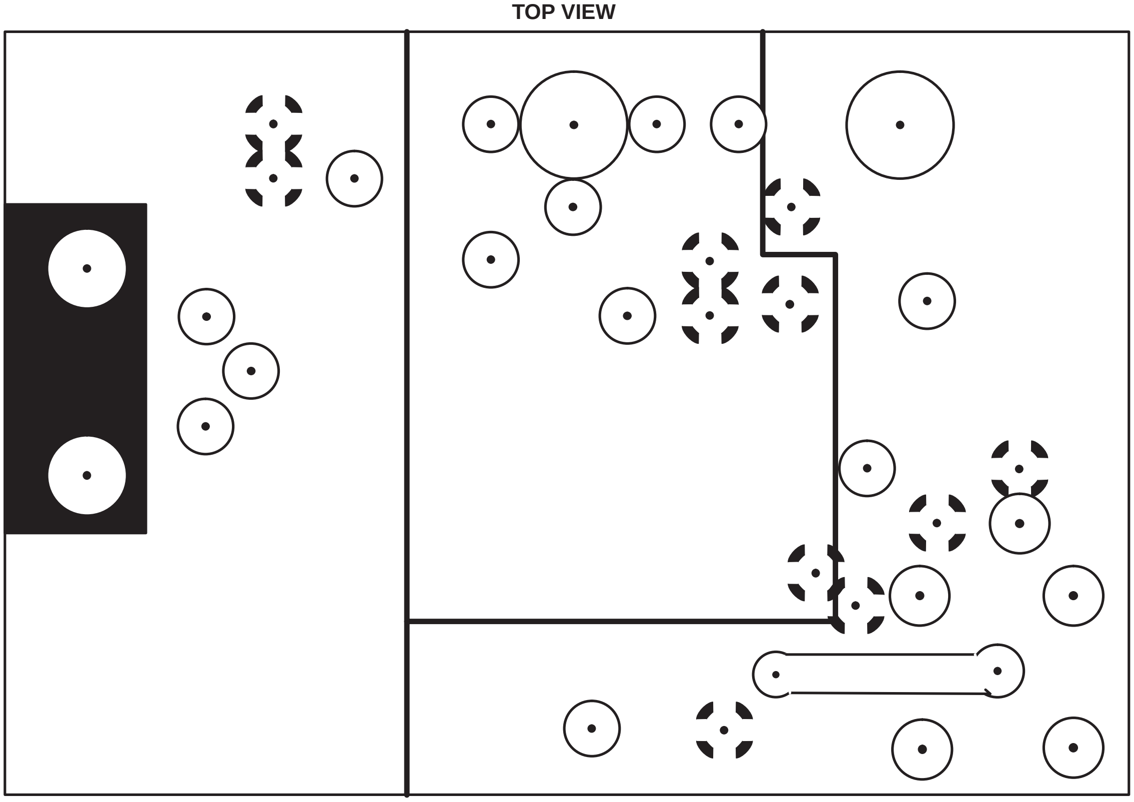


Figure 8. Eye Patterns for Receiver 1



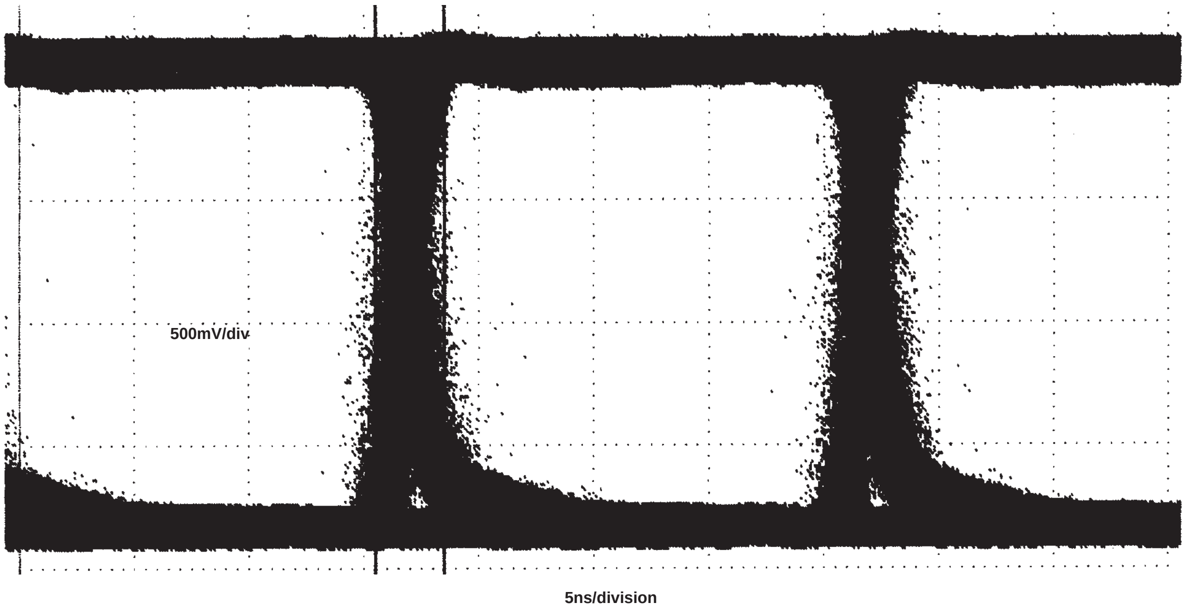
TOP VIEW



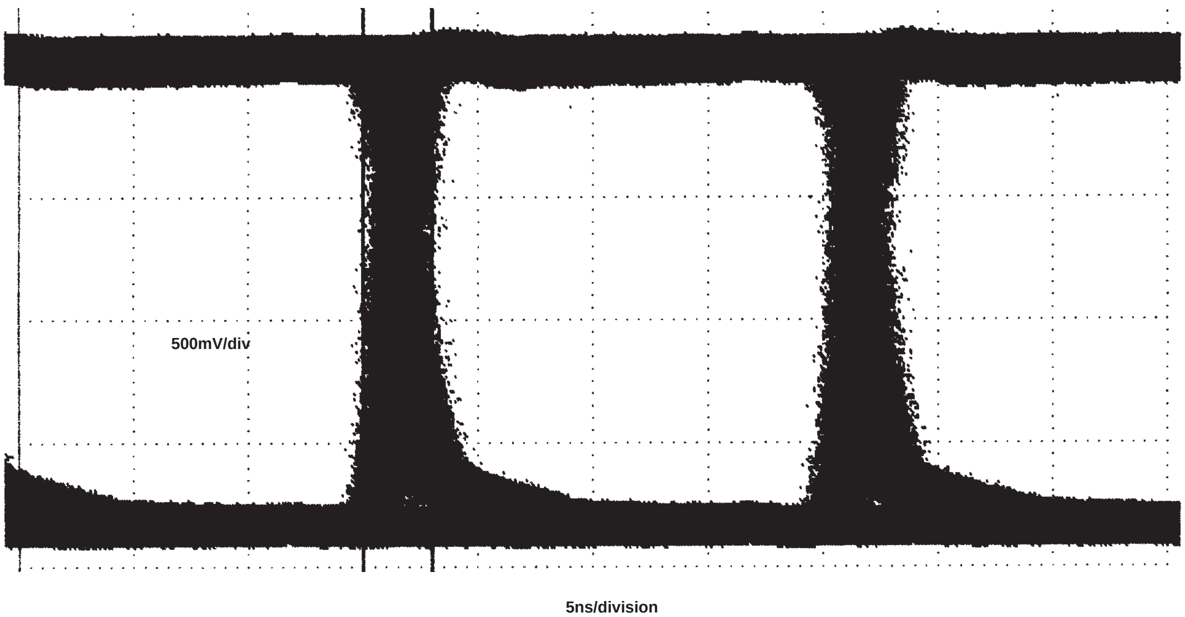
BOTTOM VIEW

SD00504

Figure 9. Eye Patterns for Receiver 1



a. PRBS of 2^7-1



b. PRBS of 2^{23}-1

SD00503

Figure 10. Eye Patterns for Receiver 2

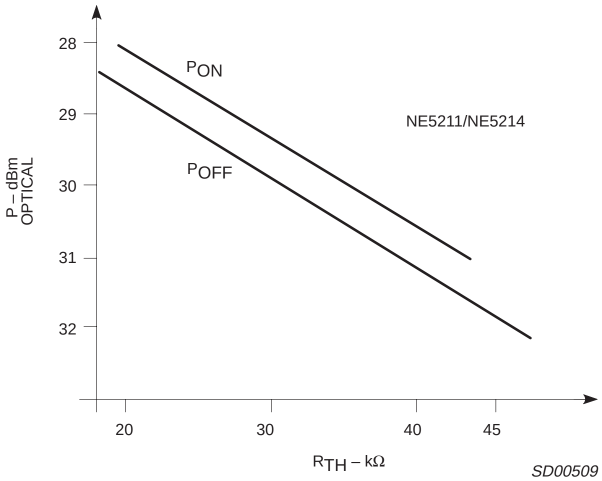

28
29
30
31
32
P – dBm
OPTICAL
PON
POFF
NE5211/NE5214
20
30
40
45
RTH – kΩ
SD00509

Figure 11.

NOTES

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Definitions

Short-form specification — The data in a short-form specification is extracted from a full data sheet with the same type number and title. For detailed information see the relevant data sheet or data handbook.

Limiting values definition — Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability.

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