Electronic Circuits for Avago POF Components

Application Note 5341

Transmitter (LED)

Basic Circuit for LED Driver

The emitter is stimulated into emission by current flowing in the forward direction. There are several possibilities for the design of the driver circuit, which has the task of adjusting and stabilizing the current flow. In Figure 1 the basic types of driver circuits are given.

In the simplest example (Figure 1a) the emitter diode is connected in series with a resistance R_S to the supply voltage V_S. The current If is dependent of the forward voltage V_f of the diode:

$$I_f = (V_S - V_f)/R_S$$

The diode may also be driven using the output transistor of a TTL gate or a separate driver transistor (Figure 1b), in which case the collector-emitter voltage should be taken into account. In this configuration the current let through by the transistor is given as:

$$I_f = (V_S - V_f - V_{ce})/R_S$$

In order to keep the current and thus the optical power constant, it is preferable to control the current flow (Figure 1c). For this example as with the others, it is necessary to ensure than sufficient voltage is provided.

One of the diagrams in the emitter data sheet shows the dependency of the forward voltage Vf on the current. Since Vf may reach 3 V for currents of 300 mA for example, the maximum duty cycle may be limited by the supply voltage.

Another important parameter when dimensioning the driver is the permissible pulse load. It is clear from the relevant diagram in the data sheet, that in regard to power loss, peak currents of up to 1 A are possible for short duty cycles. Whether this peak current can be used, depends on the available supply voltage.

LED Driver with NAND Gates

A very cost effective and often used circuit for high speed applications is LED driver with NAND Gates like 74 ACTQ00. It is possible to realize a simple peaking with this circuit:

Readily available 74ACT logic gates can be used to implement a shunt drive configuration to current-modulate the LED. A current of 60 mA is typically required to drive the LED. Ordinary bipolar TTL gates generally do not have sufficient capability to sink and source 60 mA. A simple high-speed LED driver can be constructed by connecting the active output of 74ACT logic to the LED as shown in Figure 2. In this configuration the pull-up transistor turns the LED off, and the pull-down transistor turns the LED on.

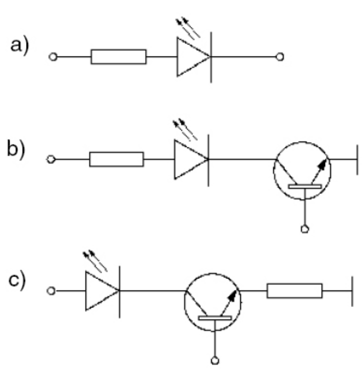

Figure 1. Basic Types of LED Driver Circuits

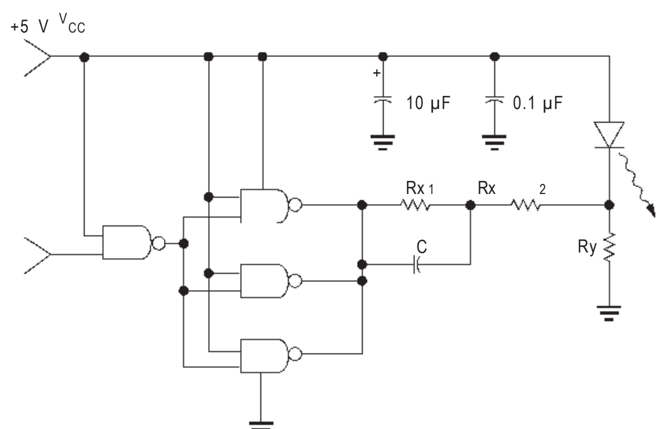

Figure 2. LED Driver with NAND Gates

Special Driver Circuits

Philips NE5300

Reviewing the specifications of NE5300 indicates that it has several desirable characteristics which make it suitable as an LED driver with TTL interface. The totem pole output on NE5300 is capable of sourcing > 60 mA and sinking, 120 mA of current from the low impedance load. The electrical rise and fall times are less than 2 ns and the t_{PLH} and t_{PHL} are fairly matched. The NE5300 from Philips Semiconductors has several attributes which make it suitable for this application. At V_O = 1.5 V, the output resistance is about 23 Ω. The slope of the sourcing and sinking currents extended to zero output current switched between the supply rails is very linear which improves the incident wave switching performance. The unique design of the totem pole output eliminates output current spiking or current feedthrough. The NE5300 also has a patented low impedance voltage reference (LIVR) for input speed up and output noise immunity improvement. There is also a patented active pull-off (APO) circuit consisting of a dynamic base discharge and quiescent pull-off network for the output pull-down transistor. This network eliminates any totem pole feedthrough currents.

MC2042-4 (Microcosm Communications Ltd.)

The MC2042-4 (Microcosm Communications Ltd.) is a full custom CMOS IC designed for high-speed LED drive in low-cost optical fiber based transmission systems. Depending on the LED used, datarates to 300 Mbps can be achieved.

The LED drive current is set by resistor. To improve LED ‘on’ time, a pre-emphasis circuit is included, which may be set via a simple RC network.

To minimize the effects of temperature on LED output power, LED drive temperature compensation can be set by resistor over a 500 - 10,000 ppm/° C range.

Differential Pseudo-ECL (PECL) data on the input pins can be shaped, if desired, by the differential voltage on the Pulse Width Adjust (PWA) pins. This adjustment is continuous over a +/-500 ps range. In addition, the V_{bb} output pin allows single-ended input to the MC2042-4 and provides compatibility with industry-standard FO modules.

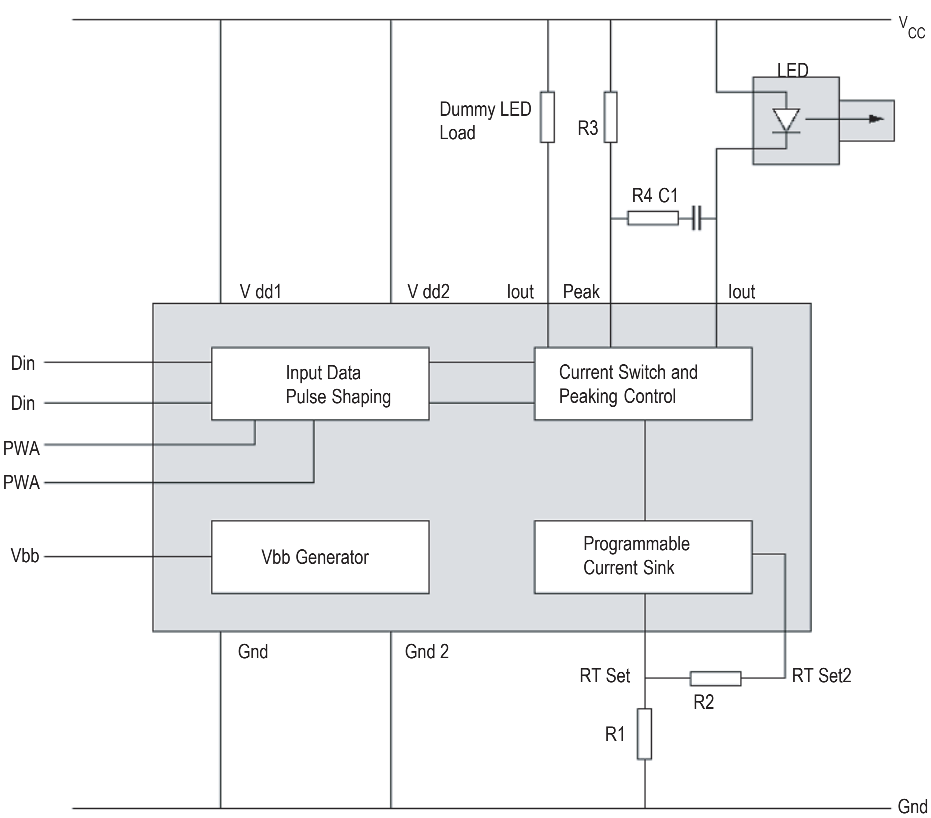

Figure 3. LED Driver from Microcosm

Detectors

At the other end of the link is the detector, which serves to convert the optical signal back to an electrical signal. The detector must be able to accept highly attenuated power down in the nanowatt levels. Subsequent stages of the receiver amplify and reshape the electrical signal back into its original shape. Some detector packages have a preamplifier built in to boost the signal immediately.

Detectors operate over a wide range of wavelengths and at speeds that are usually faster than the LEDs. The most important figure of merit for a detector is its sensitivity: what is the weakest optical power it can convert without error? The signal received must be greater than the noise level of the detector. Any detector has a small bit of fluctuating current running through it; this minuscule current is noise spurious, unwanted current. The minimum power received by the detector must still be enough to ensure that the detector can clearly distinguish between the signal and the underlying noise. This is expressed as a signal-to-noise ratio or a bit error rate. SNR is a straightforward comparison of the signal level and the noise level, while the bit error rate is a more statistical approach to determining the probability of noise causing a bit to be lost or misinterpreted.

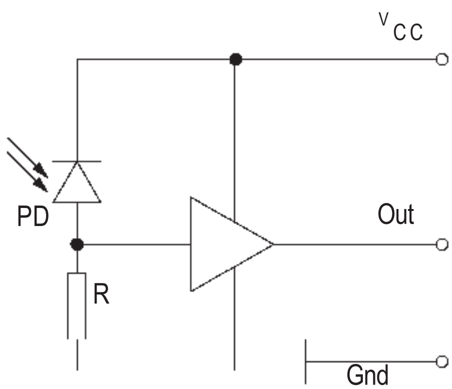

Figure 4. Basic Circuit for Optical Receiver

Photodiode SFH250

The photodiode SFH250 normally driven with reverse voltage of several V has a switching time of 10 ns (with 50 Ω and V_r 10 V), which makes it a very fast easy available detector. When driving a load of greater than 200... 1000 Ω, the capacitance (depending on V_r) of the diode also determines the switching time. Since the photodiode is a current-source there is a resistor R needed to get a voltage which can be amplified with a following preamp as shown in Figure 4. Also Silicon Bipolar MMIC-Amplifier from Infineon like BGA318 or BGA420 can be used. In this case R is not needed and the photodiode can be directly connected with the amplifier input. 200...300 MHz bandwidth can be achieved.

Usually, a transimpedance-amplifier (TIA) is applied. A resistor in the amplifier's feedback loop determines the current / voltage conversion. To avoid pulse disturbance, the amplifier has to offer a linear performance over the entire power-range of the received light.

The preamp is followed by a postamp in order to achieve a logic level. This postamp is a comparator or limiting amplifier as shown in Figure 5.

There is an important difference in coupling preamp and postamp. If there is a DC coupling as shown in figure any data without restrictions can be received. Due to the critical matching of Vref to the preampout the sensitivity is not so high.

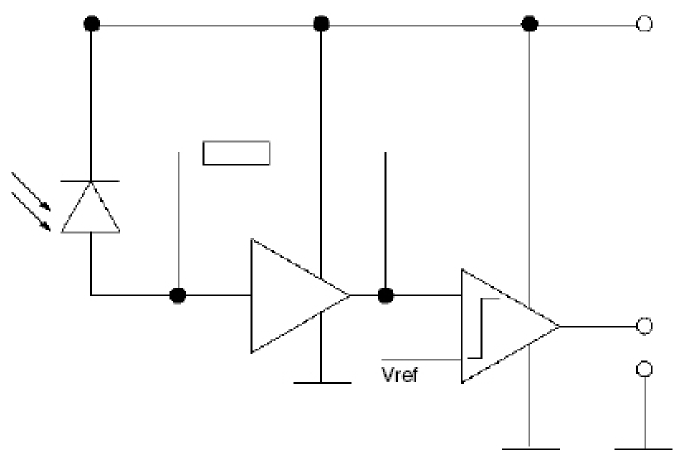

Figure 5. DC Coupled Optical Receiver (SFH551/1)

Integrated Digital Receiver SFH551/1

Infineon offers for datarates up to 5 Mbit/s the SFH551/1. This integrated optical receiver works like a receiver figure and comprises the following units:

The preamplifier converts the photocurrent into voltage.

The comparator following the signal path works "digital". Here, the preamplifier's output voltage is compared to a reference voltage and the decision to set the output 'high' or 'low' is made.

AC Coupled Optical Receiver

The function of AC coupled optical receiver is shown in Figure 6.

The sensitivity of such receivers can be very high if there is a continuos data stream and data are balanced coded.

Examples for Practical Realizations

There are a lot of preamps available on the market.

As first example the preamp AD801 5 from Analog Devices is shown here

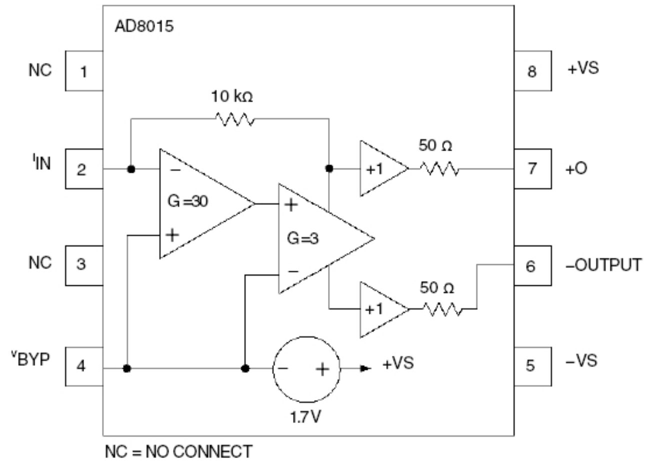

Figure 7. Preamp AD8015

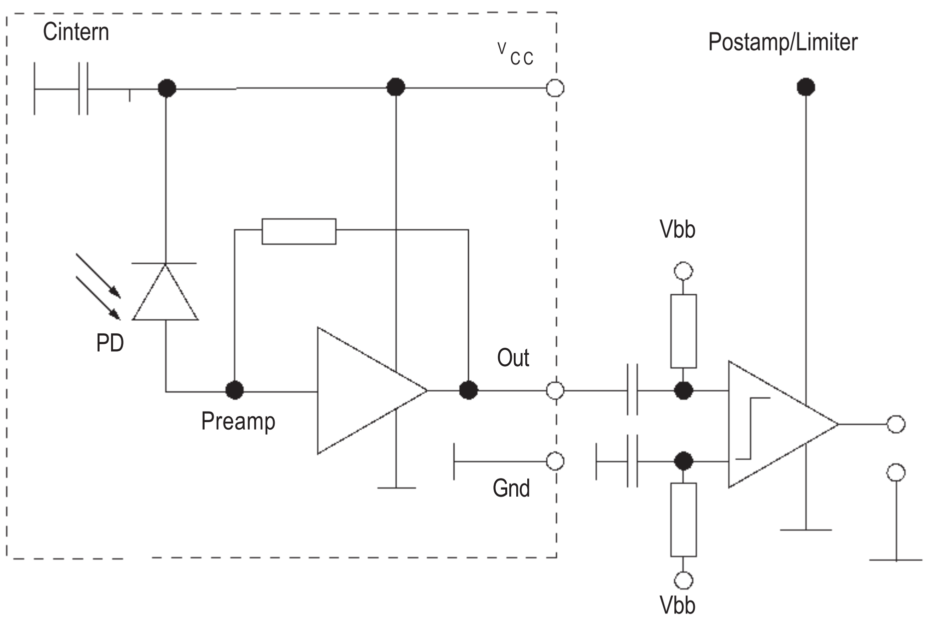

Figure 6. Basic Circuit for AC Coupled Optical Receiver

Features

- Low Cost, Wide Bandwidth, Low Noise
- Bandwidth: 240 MHz
- Pulse Width Modulation: 500 ps
- Rise Time/Fall Time: 1.5 ns
- Input Current Noise: 3.0 pA/ÖHz @ 100 MHz
- Total Input RMS Noise: 26.5 nA to 100 MHz
- Wide Dynamic Range
- Optical Sensitivity: -36 dBm @ 155.52 Mbps
- Peak Input Current: 6350 mA
- Differential Outputs
- Low Power: 5 V @ 25 mA
- Wide Operating Temperature Range: -408°C to +858°C

Application

- Fiber Optic Receivers: SONET/SDH, FDDI, Fibre Channel
- Stable Operation with High Capacitance Detectors
- Low Noise Preamplifiers
- Single-Ended to Differential Conversion
- I-to-V Converters

This preamp - originally designed for low capacitance photodiodes - can also be used in combination with the SFH250.

With the SFH250 (0.35 A/W) and the preamp AD8015 the following signal can be achieved.

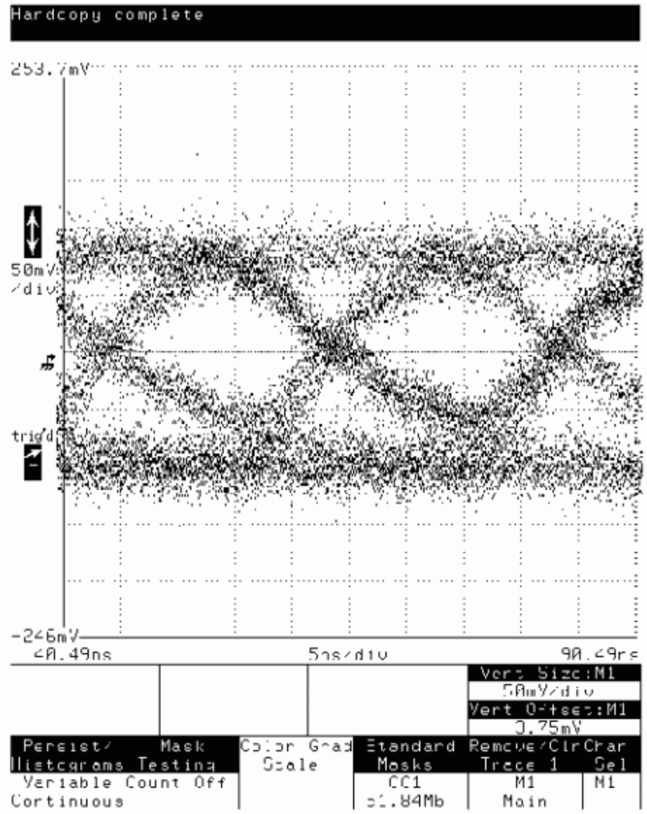

Figure 8. Eye Diagram at Preamp Output Working with Minimum Optical Power

Notes:

1. Photocurrent (average) 0.5 µA Optical power 1.4 µW or - 28.5 dBm
2. Signal good for BER < 10exp-9

Microcosm Transimpedance Amplifier IC MC2207

Low-Cost Transimpedance Amplifier IC for Fiber Optic Applications at 155 Mbps.

Main Features

- Low-cost, easy-to-use, CMOS transimpedance amplifier. Designed to be used in, e.g. ATM, FDDI and numerous other data or telecom applications operating up to 120 MHz/1 55 Mbps.
- Min. 120 MHz bandwidth.
- -34 dBm sensitivity, -11 dBm saturation @ 155 Mbps (BER 10-9) with 0.9 A/W PIN.
- Minimum 16 kΩ differential transimpedance.
- Single +5 V or +3.3 V operation.

General Description

The MC2207 is a next-generation, high performance linear transimpedance amplifier available in die form. It is designed to be mounted with a silicon or InGaAs photodetector for optical communications, and is particularly easy to use relative to earlier TZ Amplifiers, as no decoupling is required inside the Pin-Preamp case.

It operates from a single +5 V or +3.3 V supply, and reverse biases the photodetector to approximately -1.6 V. The photodetector dictates the optimum operating wavelengths.

The MC2207 has a differential output.

Please also see the other MC200x TZ amplifier IC's for applications from 155 Mbps to > 1 Gbps.

Some Examples for Postamp:

- Microcosm MC2045-2
- Philips NE5214
- Linear Technology: LT1016

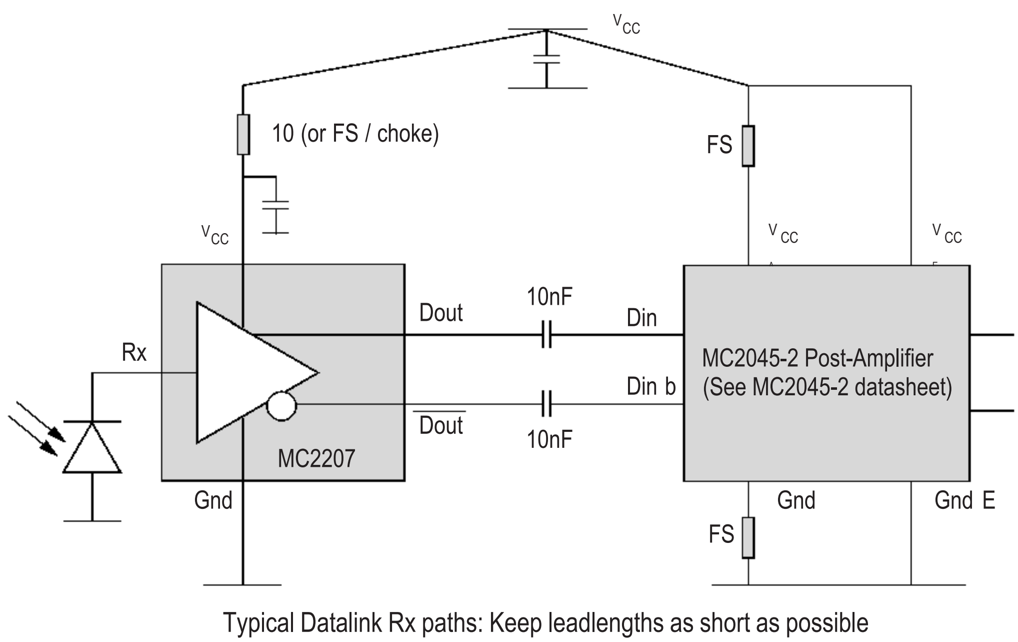

Figure 9. Pin-Preamp Connected with Postamp

Disclaimer

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Due to technical requirements components may contain dangerous substances. For information on the types in-question please contact your nearest Avago Technologies Office.

Avago Technologies Components may only be used in life-support devices or systems with the express written approval of Avago Technologies, if a failure of such components can reasonably be expected to cause the failure of that life-support device or system, or to affect the safety or effectiveness of that device or system. Life support devices or systems are intended to be implanted in the human body, or to support and/or maintain and sus-tainand/or protect human life. If they fail, it is reasonable to assume that the health of the user or other persons maybe endangered.

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