Optical Receivers

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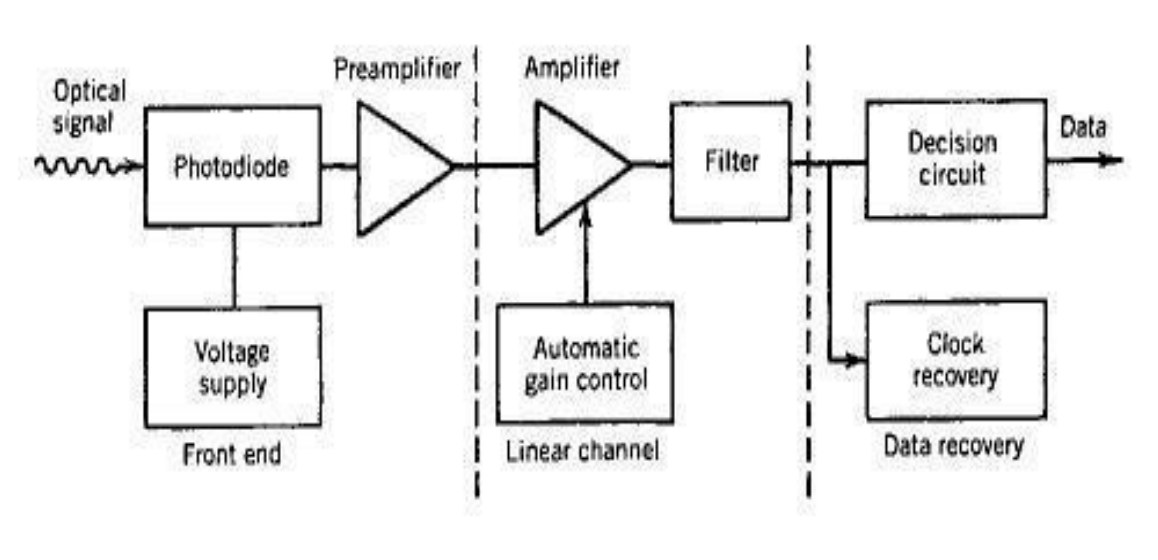
Three Components
Front End, Linear Channel, Data Recovery



Front-End Amplifier

-Emphasis on low-noise front-end amps.
-Maximize receiver sensitivity while maintaining a suitable bandwidth.
-3 classifications based on application:

High Impedance Amplifier
Low Impedance Amplifier
Transimpedance Amplifier

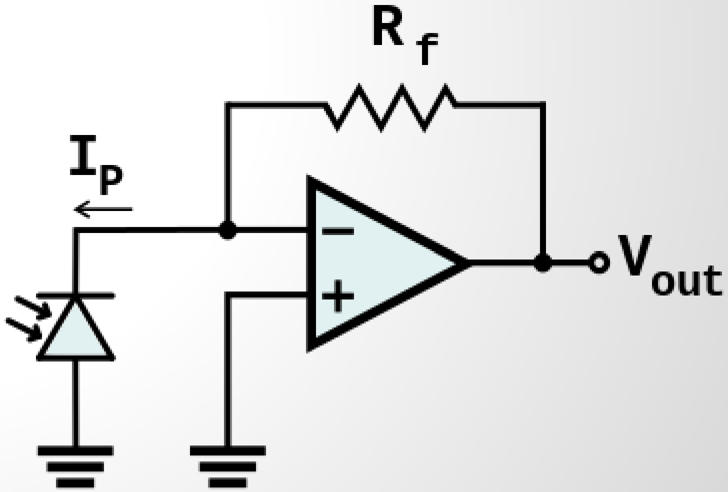
Hi/Low-Impedance Amps

-Familiar RF Amp w/ Photodiode
-Goal is to balance bandwidth and thermal noise with preamp Load Resistance.

Low-impedance: Wide BW, Low Sensitivity
High-impedance: High Sensitivity, Narrow BW

Transimpedance Amplifier

-Load Resistance used as Negative Feedback
-Allows for high load resistance (Wide BW) without increasing effective resistance seen by photodiode (Low Thermal Noise/High Sensitivity).



-Preferable for fiber optic transmission.

Linear Channel

Consists of a High-gain Amplifier and a LP filter.

-Amplifier's gain is automatically controlled in order to keep the output voltage fixed regardless of measured optical power at the receiver.

-LP Filter shapes the voltage pulse (to minimize noise), and defines receiver bandwidth.

-Equalization may be needed before amplifier if BW from front-end is limited (to minimize noise).

Clock and Data Recovery

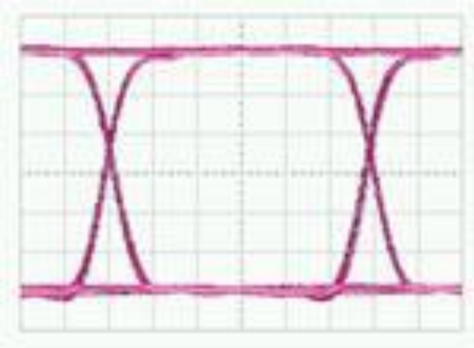
-Decision Circuit

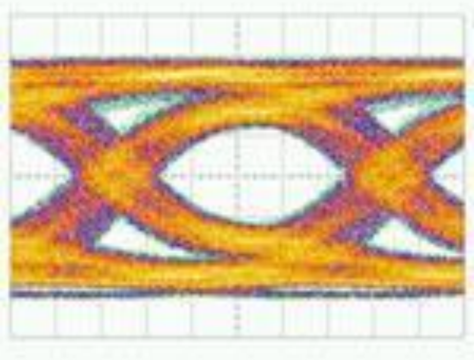
Samples the electric signal at a periodicity equal to the bit interval (using a clock) and compares it to a reference threshold voltage level, interpreting the signal as digital 1's and 0's.

Eye Diagrams and Errors

-Eye-Diagrams: Essential measurement tool for analysis of digital fiber optic transmission systems.
-Width of eye opening indicates the time interval in which the signal can be sampled without error due to interference from adjacent pulses (Intersymbol Interference).
-Height of eye opening indicates the Noise Margin, or the ratio of the peak signal voltage (V1) to the maximum signal voltage as measured from the threshold level (V2)

%Noise Margin = (V1/V2)*100





ISI Degradation

Consider an eye diagram in which the center opening is about 90% due to intersymbol interference(ISI) degradation. What is the ISI degradation in decibels?

Error Sources

-Photon Detection Quantum Noise: Arises in electronic devices because of the discrete nature of current flow in the device.

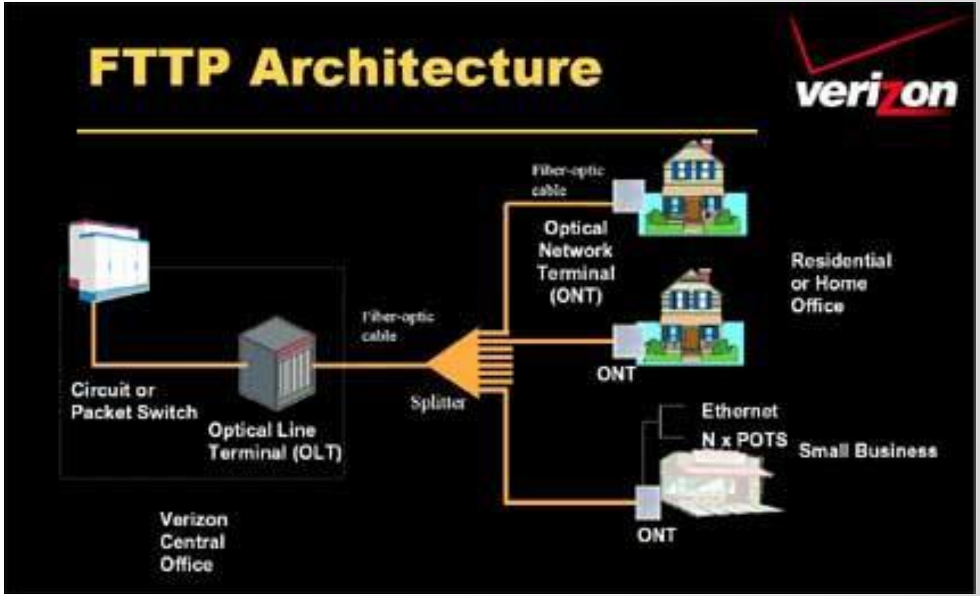
-Dark Current Noise: Arises from the current that continues to flow through the bias circuit of the device when no light is incident on the photodiode.

-Thermal Noise: Arises from the random motion of electrons in a conductor.

- Amplifier Noise: Noise gets amplified along with the signal.

Burst-Mode Receivers

-Demand for higher-capacity connections led to development of PON's (Passive Optical Networks), or FTTP (Fiber-to-the-Premises).
-No active components along the network transmission path.
-FTTP central office service examples: public telephone switches, video-on-demand servers, internet protocol routers, ethernet switches, asynchronous transfer mode (ATM) switches.



Burst-Mode Receivers

-Variations in distance between customers and service providers

=> Variations in optical power seen by receivers.

-Conventional Receivers can’t instantaneously handle rapidly changing signal amplitudes and clock phase alignments

=> Burst-Mode Receivers needed for FTTP networks.

-Overhead bits sent at the beginning of each packet burst indicate to burst-mode receivers the decision threshold and signal phase.

-Key requirements for Burst-Mode Receiver:

High Sensitivity, Wide Dynamic Range, Fast Response Time

Analog Receivers

-Example analog applications: 4kHz voice channels, microwave links operating in the multi-gigahertz region.
-Most common technique is amplitude modulation.
-Continuous signal => Receiver performance is in terms of signal-to-noise ratio (SNR).