JAET

Journal homepage: http://jae-tech,com

Journal of Applied Engineering & Technology

ISSN : 2523-6032 ISSN-L : 2523-2924

Design of Receiver Preamplifier with Bandwidth Adjustment Capabilities

Javier Poncela González[1,*]

[1]Professor, Department of Communication Engineering, University of Malaga, Spain.
*Corresponding Author

Abstract: The challenge of communication world today is to create a new environment of wireless links using infrared. This challenge is during new innovation in the design of optical transceivers, because the received optical signal is very weak at the frond-end. This work is to design an infrared optical receiver with bandwidth adjustment capabilities. The measured result show a bandwidth can achieve between 10MHz to 100MHz.

Keywords: Bandwidth adjustment, Infrared, Optical receiver, Transimpedance Front-End

1. Introduction

The free-space propagation of light waves for infrared band as a transmission medium for communication is termed as Wireless infrared communications. The communication is performed between access point and base station. Optical communications is one of the cornerstones of today's revolution in information technology. The challenge of creating inexpensive links for wireless is driving new and efficient optical transceivers. The main challenge of designing an optical receiver is to maintain the high sensitivity and broad bandwidth for optical receiver [1]. However, maintaining both high bandwidth and high sensitivity for receiver are in conflicting with a capacitive device. Because the RC product, increases with load resistance and reduction in capacitance can be achieved by low capacitance photodiode at preamplifier stage [2-4].

2. Background and Literature Review

The optical receiver is comprised of many devices such as; photodetector, PIN Photodiode, Low impedance front end, High impedance font end and Transimpedance font end [5-6]. The received optical signal is converted into an electrical signal using photodetector. The photodetector also determines the performance of the system. The ream time photodetector has limited bandwidths with limited finite response times. In photodetector the PIN Photodiodes are commonly used. In PIN photodiodes a parallel junction resistance is used as differential resistance of the diode the standard range of resistance for high-quality diode in the reverse-bias mode is more than 106 Ω [7-8]. The impedance for the receiver is characterized using different front end configuration of receiver such as; Low impedance front end, High impedance font end and Transimpedance font end. Low Impedance Front-End is configured with a photodetector, a low input-impedance voltage amplifier, and a load resistor. The photodiode used in low impedance front receiver can be either AC coupled or DC coupled [9]. High Impedance Front-End is configured using a resistor for the development of voltage proportional to the light detector current [10-11]. In the high impedance front end receiver the resistance is too high along with high leakage current that prevents the modulated signal from ever being detected and due to this it is not recommended for long-haul optical communications [12]. The Transimpedance Front-End has a feedback resistor that converts the current to a voltage is connected from the output to the input of an inverting amplifier [13]. The one of the main advantage of using the Transimpedance Front-End is it can be used for canceling effect of the circuit wiring and diode capacitance [14].

*Corresponding author: javier@ic.uma.es

In the next the design of Receiver Preamplifier with Bandwidth Adjustment Capabilities is discussed for the optical receiver. The designed system is capable of providing the bandwidth variation and maintaining the receiver's sensitivity. The deigned system also provide the enhancement in the bandwidth variation with receiver's sensitivity compare to existing work.

3. Research Methodology

The designed receiver for bandwidth adjustment capabilities is designed using Multiple Stage Receivers using BJT and Bootstrapping Transimpedance Amplifier. In the next both of the receiver configuration are discussed.

3.1 Multiple Stage Receivers using BJT

In the Multiple Stage Receivers is designed using BJT transistors. The design of developed Multiple Stage Receivers using BJT is shown in Fig. 1. It is demonstrated in Fig.1 that Multiple Stage Receivers using BJT has multiple stages for the receivers using BJT. The designed Multiple Stage Receivers using BJT has high bandwidth for because of Transimpedance feedback design is developed using a single transistor gain stage. The voltage gain that can be developed in a single stage is relatively modest, and consequently the feedback resistor often limited to no more than 1kΩ [6]. So, for the low impedance load is to be presented the photodiode.

Q3 at emitter will introduce a peak in the voltage gain at the inverse of the ReCe constant. Capacitor C1, C2 and CL are in open circuit configuration at Dc analysis and short circuit at AC analysis. R1, R2 and R5 will limit the current before collector to emitter transistor.

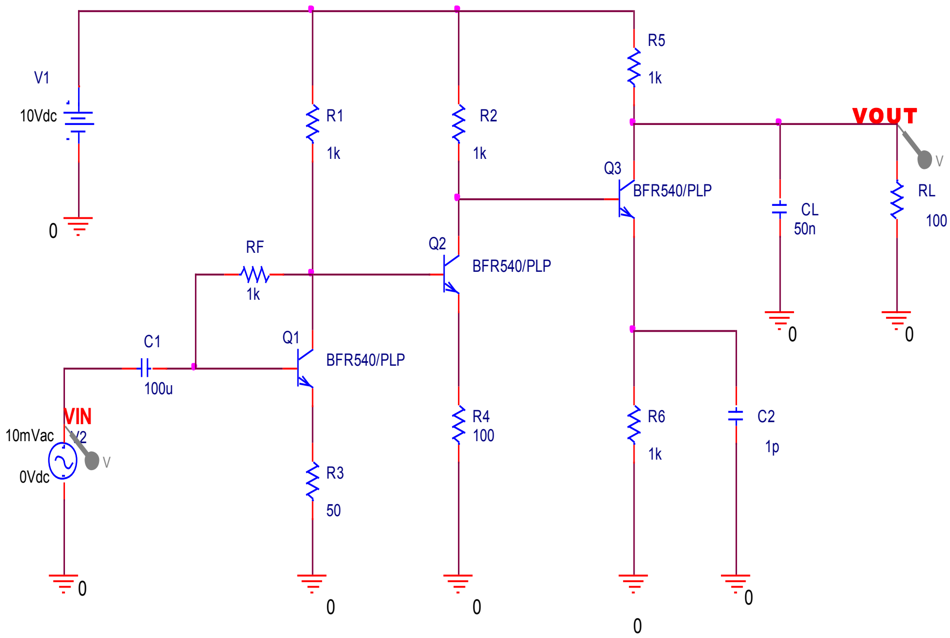

Fig. 1 - Multiple stage receiver using BJT.

The designed of Multiple Stage Receivers using BJT has multiple stages has also verified using simulated values gain for different capacitance value. Table 1 shows the simulated value and gain.

Table 1 shows the simulated value and gain of this circuit is 15.370 dB. The capacitor value is change from 1pF-250pF. When the capacitance value is increased, the cutoff frequency is decreased. In the next, the design of receiver using Bootstrapping Transimpedance Amplifier is discussed.

Table 1 – Simulated value of frequency, gain when the capacitance load (cl), is changed.

Capacitor CL (pF)	Frequency F(MHz)	Gain (dB)
250	8.317	15.370
200	13.709	15.370
150	19.999	15.370
100	35.892	15.370
50	53.334	15.370
10	90.991	15.370
1	120.54	15.370

3.2 Bootstrapping Transimpedance Amplifier

The Bootstrapping Transimpedance Amplifier is designed using detector that has range of 1mm for GaAs PIN photodiode as shown in Fig. 2. The Bootstrapping Transimpedance Amplifier is designed using bootstrapped common collector preamp that utilizes PIN-BJT. The preamplifier is configured using a Transimpedance due its high range, better sensitivity, and does not required equalization [8]. The most important of this circuit is it consists of a bootstrapping capacitor. Bootstrapping capacitor (C1) is used to limit the incoming signal and removed the signal which is greater than the photodiode bandwidth [8].

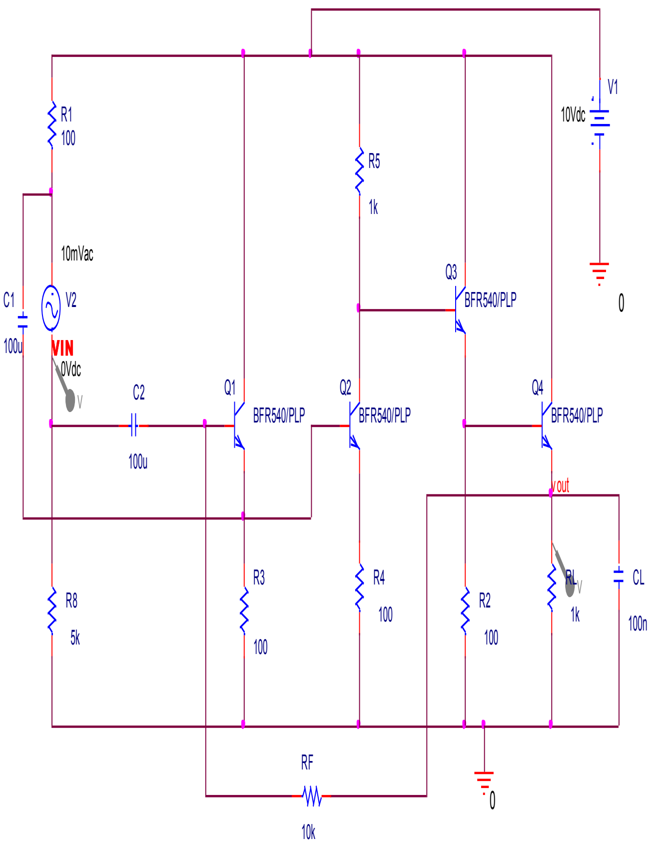

Fig. 2 - Bootstrapping Transimpedance Amplifier circuit.

It can be shown in Fig. 2 that the circuit has 2 stage of the preamplifier. The supply voltage for all stage is 10V. Capacitor C2 and C1 will be open circuit in dc analysis and short circuit in Ac analysis. Resistor R2, R3, R4 will function as stability circuit.

The designed of Bootstrapping Transimpedance Amplifier has multiple stages has also verified using simulated values gain for different capacitance value. Table 2 shows the simulated value and gain.

Table 1 – Simulated value of frequency, gain when the capacitance load (cl), is changed.

Capacitor CL (pF)	Frequency F(MHz)	Gain (dB)
250	58.354	18.090
200	67.872	18.090
150	79.247	18.090
100	94.134	18.090
50	108.751	18.090
10	110.610	18.090
1	112.501	18.090

Table 2 shows the simulated value of the circuit for frequency and gain when the capacitor C1 is changed. The capacitance value is changed from 250pF–1pF. The gain of this circuit is 18.090 dB. When the capacitance value is increased, the cutoff frequency is decreased. Therefore the relationship a capacitance is inversed proportionally with frequency. In the next section, the result of the designed optical receiver using Bootstrapping Transimpedance Amplifier and Multiple Stage Receivers using BJT are discussed.

4. Results and Discussion

The designed optical receiver is configured using Bootstrapping Transimpedance Amplifier and Multiple Stage Receivers using BJT. The simulation results in Fig. 3 to Fig. 7 show that the highest gain it can reach is 15.370dB and in real time the highest gain is 15.27dB. The cutoff frequency are adjustable using a capacitor. In this circuit, the capacitor is changed manually.

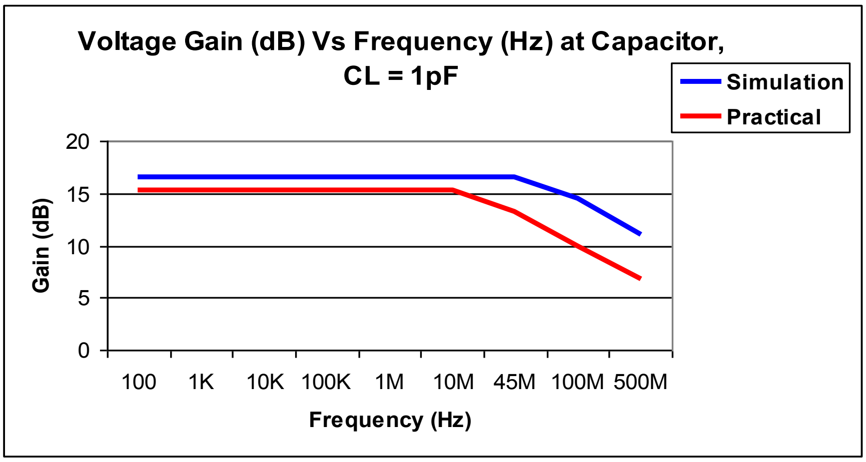

Fig. 3 - Voltage Gain (dB) Vs Frequency (Hz) at capacitor, CL=1pF

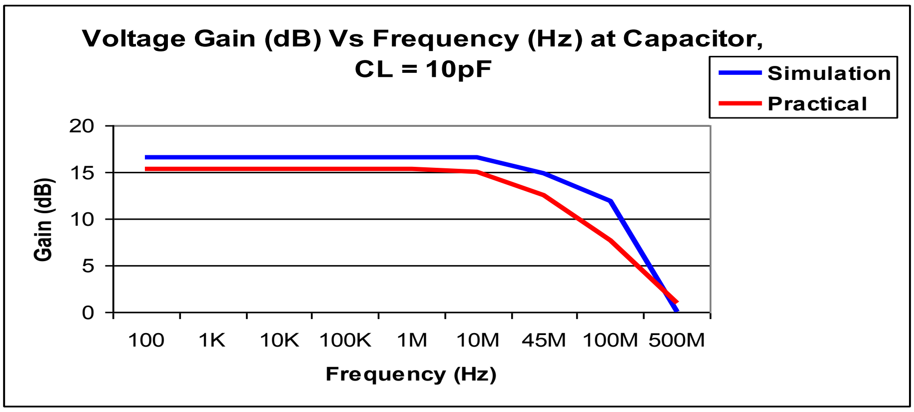

Fig. 4 - Voltage Gain (dB) Vs Frequency (Hz) at capacitor, CL=10pF

The capacitor value is change from 1pF-250pF. When the capacitance value is increased, the cutoff frequency decreased. Simulation and practical waveforms of the multiple stage receiver front ends amplifier are shown in Fig. 3 to Fig. 7.

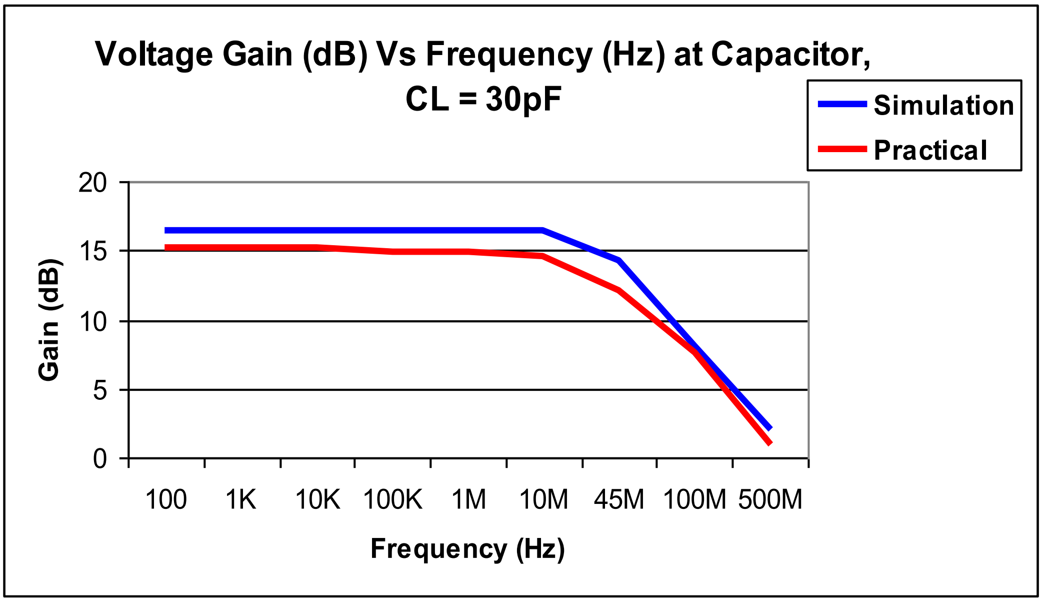

Fig. 5 - Voltage Gain (dB) Vs Frequency (Hz) at capacitor, CL=30pF

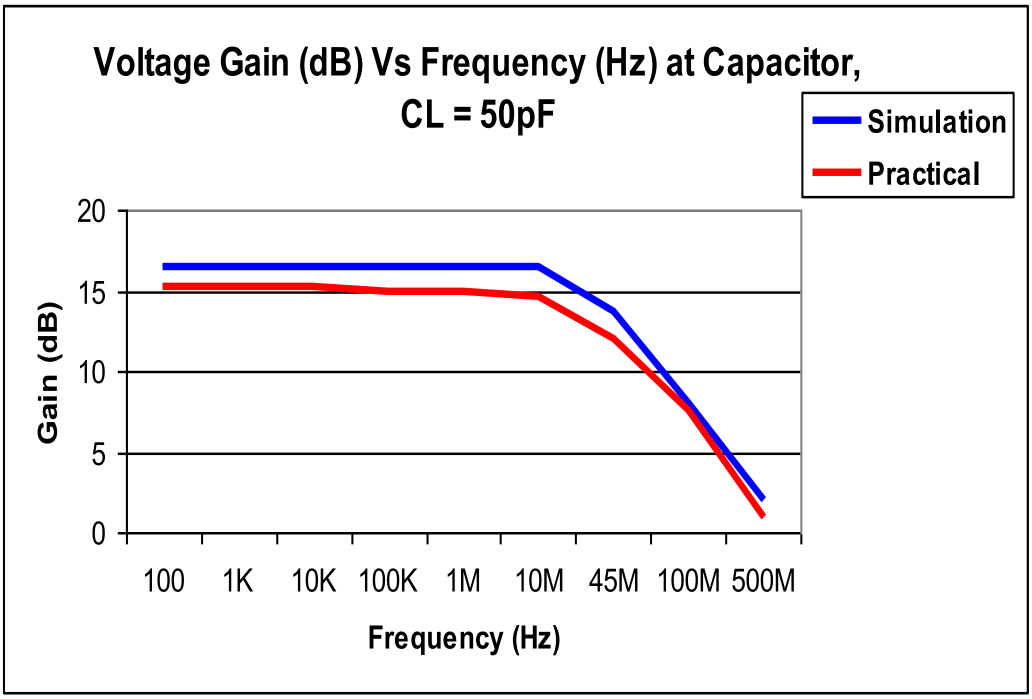

Fig. 6 - Voltage Gain (dB) Vs Frequency (Hz) at capacitor, CL=50pF

Several factors are identified as the causes for this difference. The equipment such as functioned generator, oscilloscope, and cable and receiver circuit have the noise. This noise has contributed to the difference of the result.

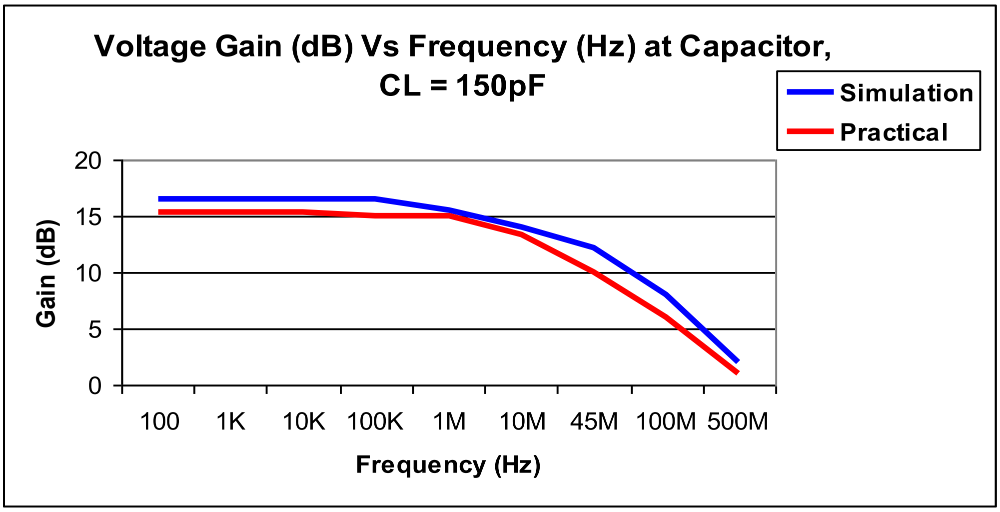

Fig. 7 - Voltage Gain (dB) Vs Frequency (Hz) at capacitor, CL=150pF

5. Conclusion

In conclusion, an optical receiver already designed to meet it early objective viz bandwidth adjustment capabilities. In designing and developing an optical receiver it needs strong fundamental theory and research. An optical receiver with bandwidth adjustment capabilities has three receiver front-end techniques which are low-impedance, high-impedance and transimpedance. The objective of an optical receiver is to design and achieve an adjustment bandwidth approximately between 10MHz to 100MHz. The capacitance value is changed from 250pF–1pF. The capacitor and inductor are the component which can be used to adjust the bandwidth of an amplifier.

References

[1] H. Kaushal and G. Kaddoum. (2017) "Optical communication in space: Challenges and mitigation techniques," IEEE Communications Surveys & Tutorials, 19, pp. 57-96.

[2] M.K.C Kamarudin. (2018). “CMOS Based SNR Measurement for Wireless Application,” J. of Applied Engineering & Technology Vol. 2 No. 1 (2018) p. 9-13.

[3] A. Rogalski, Z. Bielecki, and J. MIKOLAJCZYK. (2017). "Detection of optical radiation," Handbook of Optoelectronics: Concepts, Devices, and Techniques, 1.

[4] J.M. Fiber-optic communication Systems. New York: john Wiley & Sonc, Inc. 1997.

[5] A.A.Abdul. Rehman, “CMOS Amplifier Receiver with AGC Bandwidth Circuit,” J. of Applied Engineering & Technology Vol. 2 No. 1 (2018) p. 14-21

[6] Mitchell, A.f., and O’Mahoney, M.J.(1984) ‘The performance analysis of PIN bipolar receivers’, Er. Telecom Technol. J., 2, pp. 74-85.

[7] R. L. Aguiar, A. Tavares, J. L. Cura, E. De Vaaconcelos, L. N. Alves, R. Valadas, et al. (1999)"Considerations on the design of transceivers for wireless optical LANs,".

[8] J. J. Schentag, D. T. D'andrea, and F. V. Bright. (2015). "Device and method for monitoring and quantifying analytes," ed: Google Patents.

[9] J.P. Gonzále. (2017). “Adaptive Dynamic Filter using MOSFET Receiver,” J. of Applied Engineering & Technology Vol. 1 No. 1 (2017) p. 9-15.

[10] A. C. Farrell, P. Senanayake, X. Meng, N. Y. Hsieh, and D. L. Huffaker. (2017) "Diode characteristics approaching bulk limits in GaAs nanowire array photodetectors," Nano Letters, vol. 17, pp. 2420-2425, 2017.

[11] Idrus, S.M, Hafizah, N. and Azis, S.I.A. (2006). Performance Analysis of Bootstrap Transimpedance Amplifier for Large Windows Optical Wireless Receiver. RFM2006: Putrajaya.

[12] Emami, S., Doan, C. H., Niknejad, A. M., & Brodersen, R. W. (2007, February). A highly integrated 60GHz CMOS front-end receiver. In 2007 IEEE International Solid-State Circuits Conference. Digest of Technical Papers (pp. 190-191). IEEE.

[13] Samavati, H., Rategh, H. R., & Lee, T. H. (2000). A 5-GHz CMOS wireless LAN receiver front end. IEEE Journal of Solid-State Circuits, 35(5), 765-772.

[14] H.R.A. Rahman, Mohammad Faiz. (2017). “Amplitude and Frequency Shift Keying Infrared Transmitter,” J. of Applied Engineering & Technology Vol. 1 No. 1 (2017) p. 16-21.