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Band Pass Filters with Low Pass and High Pass Filters Integrated With Operational Amplifiers in Advanced Integrated Communication Circuits

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Abstract-This paper has presented band pass filters with low pass and high pass filters integrated with operational amplifiers in advanced integrated communication circuits over wide range of the affecting parameters. Filter gain, filter bandwidth, and filter resonance frequency are the major interesting parameters in the current study. Filter circuit can be designed over optical transmission spectrum regions.

Keywords: Operational amplifiers, Band pass filters, Low pass filters, Filter gain, Filter bandwidth, and High pass filters

I. INTRODUCTION

The most important consideration in choosing a filter type is the intended use of the filter. For example, if the requirement is to attain optimum behavior with square-wave signals, together with good frequency limiting, then the Bessel low-pass filter is the logical choice [1, 2]. This filter provides the least overshoot as a response to transients, when compared with Tschebyscheff or Butterworth low-pass filters. The disadvantage of this filter is the less abrupt kink in the amplitude frequency response. If, however, square-wave behavior is of less importance than the attenuation of sine-wave signals, then the decision will be in favor of Tschebyscheff or Butterworth filters. From the cutoff frequency onward, the Tschebyscheff filter has a strongly accentuated reduction in amplification. However, the amplitude frequency response within the pass band is not monotone, but instead features ripples with constant amplitude. The higher the permitted ripple of the order in question, the greater the attenuation above the cutoff frequency. The advantage of the greater reduction in amplification must be set against the higher ripple before the cutoff frequency [3]. In contrast, the Butterworth filter features an almost linear amplitude frequency response up to the cutoff frequency. It is used mainly when a minimum distortion of the input signal is required; only the part of the signal above the cutoff frequency will be attenuated [4].

Continuing the discussion of Op Amps, the next step is filters. There are many different types of filters, including low pass, high pass and band pass. We will discuss each of the following filters in turn and how they are used and constructed using Op Amps [5]. When a filter contains a device like an Op Amp they are called active filters. These active filters differ from passive filters (simple RC circuits) by the fact that there is the ability for gain depending on the configuration of the elements in the circuit. There are some problems encountered in active filters that need to be overcome. The first is that there is still a gain bandwidth limitation that arises. The second is the bandwidth in general. In a high pass filter there is going to be high frequency roll off due to the limitations of the Op Amp used. This is very hard to overcome with conventional op amps. The mathematical operations discussed in the previous lab (the integrator and differentiator) are both types of active filters. As for now, the discussion will focus mainly on the low pass (LP), high pass (HP) and band pass (BP) filters. There is also a band stop filter that can be created from the band pass filter with a simple change of components [6].

II. MODELING ANALYSIS

The final type of filter to be discussed here is that of a band pass filter. The band pass filter takes advantage of the low pass configuration as well as the high pass configuration. The two of these combine to for a range of frequencies that is called the pass band. Below the lower cutoff frequency the signals are stopped as well as above the higher cutoff frequency. The difference between these two frequencies is called the bandwidth of the filter [6].

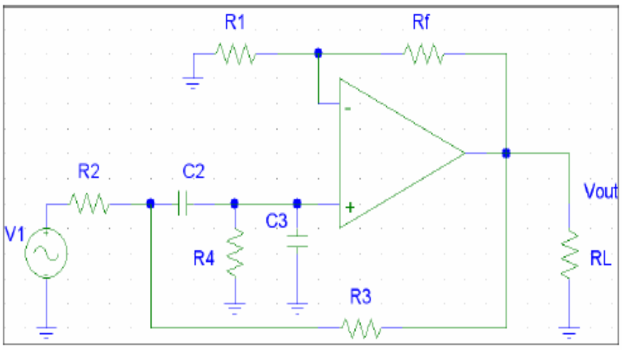

Fig. 1: Band Pass filter with low pass and high pass connections [7].

The logic behind the cutoff frequencies is a little misleading. The lower cutoff frequency is controlled by the high pass filter part of the band pass filter. On the same type of idea, the upper cutoff frequency is controlled by the low pass filter part of the band pass filter. The circuit shown in Figure 6 is that of a basic pass band filter. Notice the combination of the low pass and high pass connections. The combination of a 1st order HP and a 1st order LP creates a 2nd order band pass. If the trend were to continue a 2nd order HP and a 2nd order LP create a 4th order band pass. Based on the corner or cutoff frequency chosen and the values of resistors available, the values of the capacitors can be calculated [8]:

$$C_1 = \frac{0.9076\lambda_c}{2\pi c\ R} \quad (1)$$

$$C_2 = \frac{0.6809\lambda_c}{2\pi c\ R} \quad (2)$$

Where c is the speed of light ($3x10^8$ m/sec), R is the resistance and λ_c is the corner wavelength. These values again arise from the transfer function and then solving for each of the coefficients. To obtain a higher order filter the cascade technique will have to be used. Therefore to make a 4th order high pass (HP) filter two 2nd order HP filters need to be cascaded [9]:

$$R_1 = \frac{1.1017\lambda_c}{2\pi c\ C} \quad (3)$$

$$R_2 = \frac{1.4688\lambda_c}{2\pi c\ C} \quad (4)$$

To obtain a higher order filter the cascade technique will have to be used. Therefore to make a 4th order band pass (BP) filter two 2nd order BP filters need to be cascaded, therefore the resonant frequency can be given by [10]:

$$f_0(BPF) = \frac{1}{2\pi\sqrt{R_1 R_2 C_1 C_2}} \quad (5)$$

The lower and higher frequencies of BP filters can be described by the following formula [11, 12]:

$$f_L = \frac{1}{2\pi R_2 C_1} \quad (6)$$

$$f_H = \frac{1}{2\pi R_1 C_2} \quad (7)$$

Therefore the bandwidth and gain of BP filters integrated with operation amplifiers can be given by [13]:

$$BW_{(BPF)} = f_H - f_L \quad (8)$$

$$G = \frac{R_2}{R_1\left(1 + C_1/C_2\right)} \quad (9)$$

III. Simulation Results and Performance Analysis

The model has presented low pass, high pass and band pass filters integrated with operational amplifiers in advanced integrated circuits under the set of the wide range of the operating parameters as shown in Table 1 is listed below.

Table 1: Proposed operating parameters in [2, 5, 12, 15].

Operating parameters	Value
Near infrared corner wavelength, λ_{cNIR}	1200 nm-2000 nm
Resistance, R	1 MΩ-10 MΩ
Capacitance, C	10 pF-100 pF

Based on the model equations analysis, assumed set of the operating parameters as listed in the Table 1 above, and based on the series of the Figs. (2-9), the following facts are assured:

i) Figs. (2, 3) have assured that near infrared wavelength increases this leads to increase in filter capacitance values and decreases with increasing filter resistances values at the assumed set of the operating parameters.

ii) Figs. (4, 5) have assured that near infrared wavelength increases this leads to increase in filter resistance values and decreases with increasing filter capacitance values at the assumed set of the operating parameters.

iii) Figs. (6-9) have indicated that the filter resonance frequency, filter bandwidth, and lower and higher filter frequencies decreases with increasing near infrared operating optical signal wavelength. As well as the filter gain increases with increasing near infrared operating optical signal wavelength.

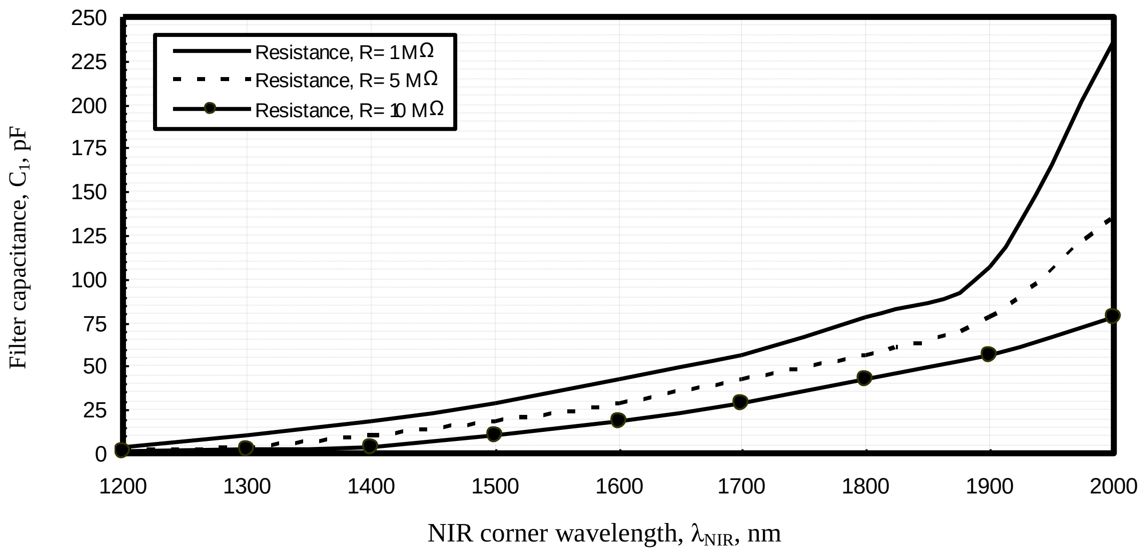

Fig. 2. Filter capacitance versus near infrared corner wavelength and filter resistance at the assumed set of the operating parameters.

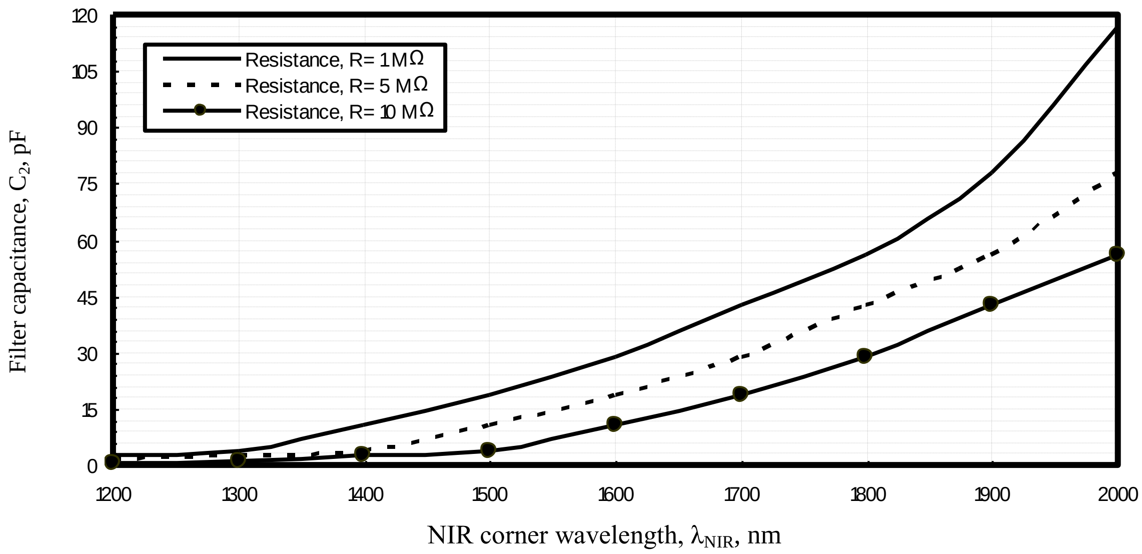

Fig. 3. Filter capacitance versus near infrared corner wavelength and filter resistance at the assumed set of the operating parameters.

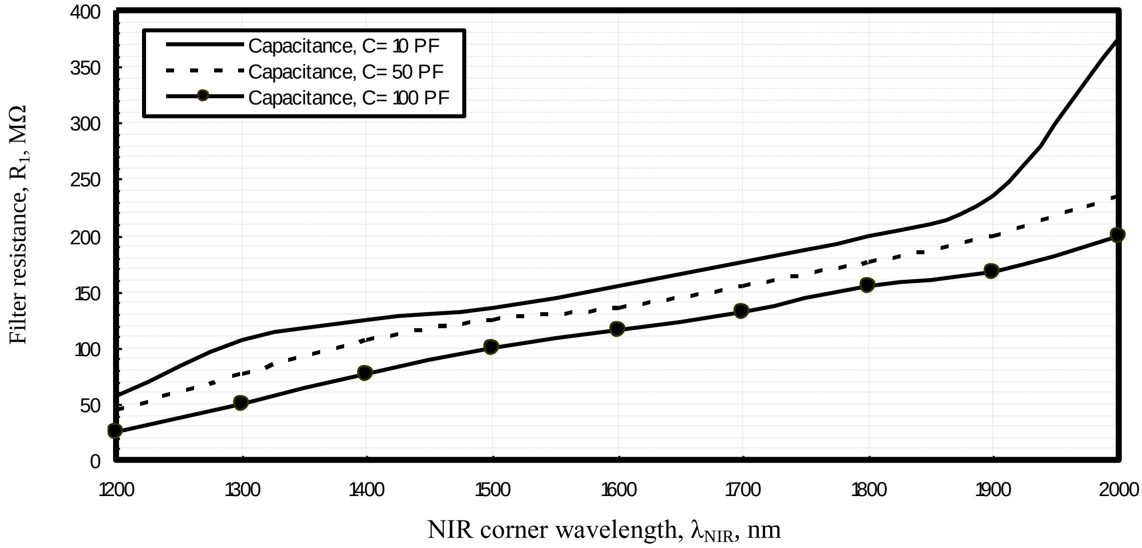

Fig. 4. Filter resistance versus near infrared corner wavelength and filter capacitance at the assumed set of the operating parameters.

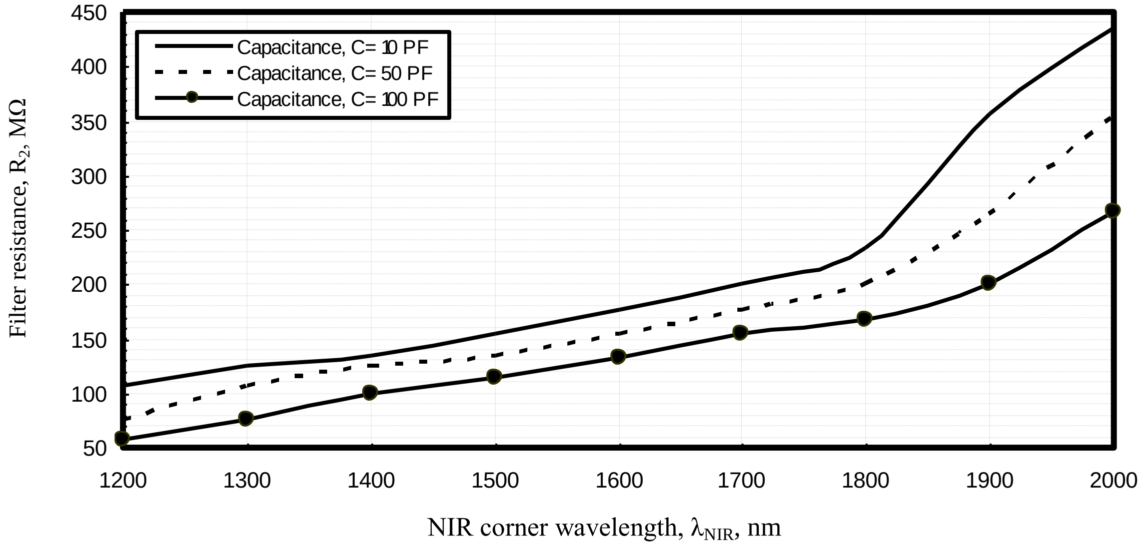

Fig. 5. Filter resistance versus near infrared corner wavelength and filter capacitance at the assumed set of the operating parameters.

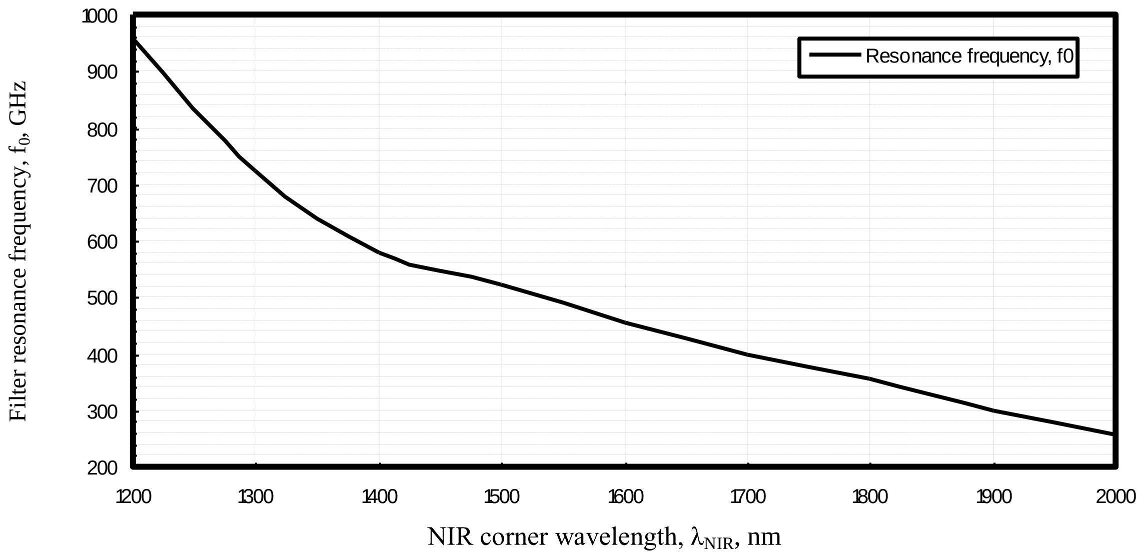

Fig. 6. Filter resonance frequency versus near infrared corner wavelength at the assumed set of the operating parameters.

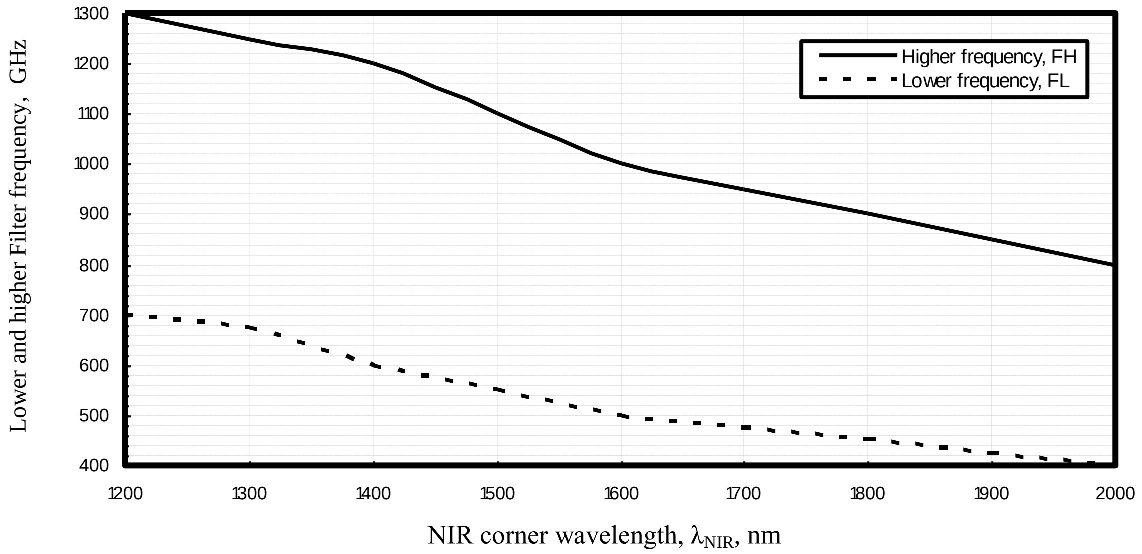

Fig. 7. Lower and higher Filter frequencies versus near infrared corner wavelength at the assumed set of the operating parameters.

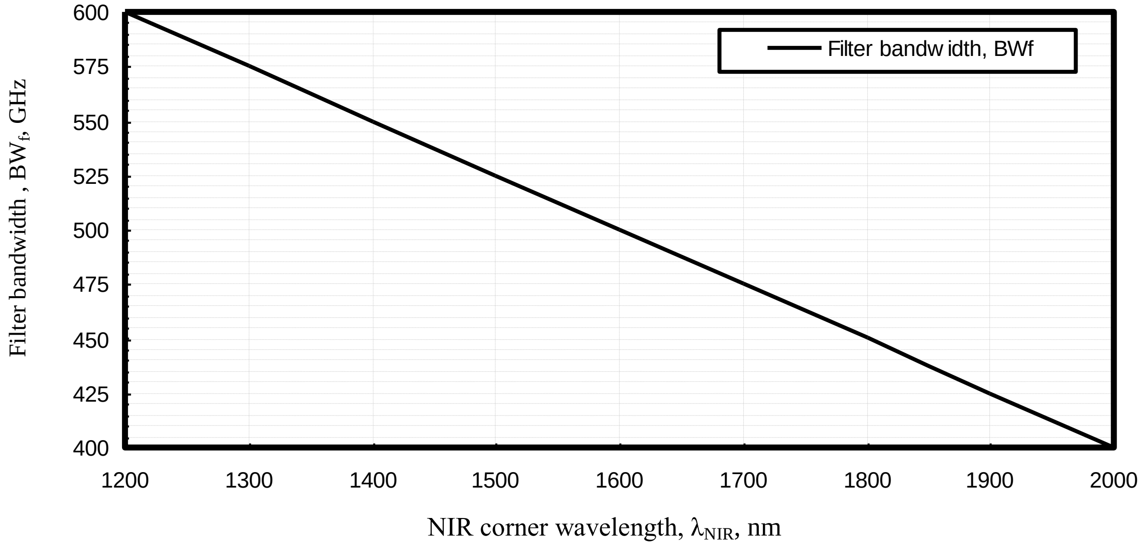

Fig. 8. Filter bandwidth versus near infrared corner wavelength at the assumed set of the operating parameters.

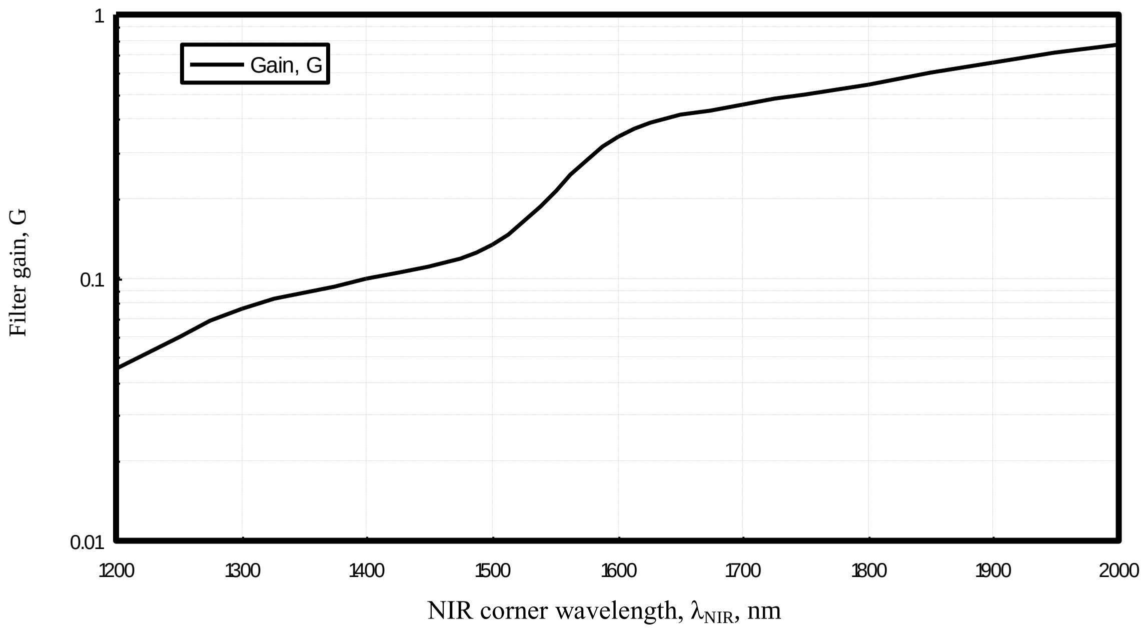

Fig. 9. Filter gain versus near infrared corner wavelength at the assumed set of the operating parameters.

IV. Conclusions

In a summary, the model has been investigated based on the different filters types categories with the integration role of operational amplifiers in advanced optical communication systems over wide range of the affecting parameters. It is theoretically found that the increased operating optical signal wavelength, this results in the increased of filter gain and the decreased of filter resonance frequency, lower and higher filter frequencies, and filter resonance frequency. It is our success to design the filters circuits with operational amplifiers under study considerations.

References

[1] M. S. Joung, J. Kim, J. S. Park, J. B. Lim, and H. G. Cho, "A Novel Defected Ground Structure and Its Application to A Microwave Oscillator" 33th European Microwave conference, pp.781-784, Oct.2003

[2] Abd El-Naser A. Mohammed, Mohamed M. E. El-Halawany, Ahmed Nabih Zaki Rashed, and Mohamoud M. Eid "Optical Add Drop Multiplexers with UW-DWDM Technique in Metro Optical Access Communication Networks," Nonlinear Optics and Quantum Optics, Vol. 44, No. 1, pp. 25–39, 2012.

[3] J. S . Park, J-S. Yun, and D. Ahn, "A design of the Novel Coupled Line Band Pass Filter Using Defected Ground Structure With Wide Stop Band Performance," IEEE Trans. On Microwave Theory and Techniques, Vo1. 50, No.9, Sept. 2003.

[4] J.S. Park, "An Equivalent Circuit and Modeling Method for Defected Ground Structure and its Application to the Design of Microwave Circuits," Microwave Journal, Nov. 2003.

[5] D. Ahn, J. Park, C. Kim, Y. Qian, and T. Itoh, "A design of the Low Pass Filter Using the Novel Microstrip Defected Ground Structure" IEEE Trans. Microwave Theory Tech., 2001, Vol.49, No. 1, p. 86 - 93. 2002.

[6] Ahmed Nabih Zaki Rashed, "High reliability optical interconnections for short range applications in high performance optical communication systems," Optics and Laser Technology, Elsevier Publisher, Vol. 48, pp. 302–308, 2013.

[7] M. Makimoto and S. Yamashita, "Microwave Resonators and Filters for Wireless Communications Theory and Design" Berlin, Germany, Springer, Verlag, 2001.

[8] S. Cohn , "Parallel Coupled Transmission Line Resonator Filter", IRE Trans., IEEE Trans., Microwave Theory and Techniques, Vol. 6, pp.223-231, 1958.

[9] C. Chang and T. Itoh, "A modified Parallel Coupled Filter Structure that Improves the Upper Stop Band Rejection and Response Symmetry", IEEE Trans., Microwave Theory and Techniques, Vol.39, pp.310-313, 1991.

[10] D. Ristau, H. Ehlers, T. Gross, and M. Lappschies, "Optical Broadband Monitoring of Conventional and Ion Processes," Appl. Opt., Vol. 45, pp. 1495-1501, 2006.

[11] Ahmed Nabih Zaki Rashed, "Performance signature and optical signal processing of high speed electro-optic modulators," accepted for publication in Optics Communications, Elsevier Publisher, 2013.

[12] B. J. Chang and C. D. Leonard, "Dichromated Gelatin for the Fabrication of Holographic Optical Elements", Appl. Opt., Vol. 18, pp. 2407–2417, 1979.

[13] S. James, L. Dockney, and P. Tatam, "Photorefractive Volume Holographic Demodulation of in Fiber Bragg Grating Sensors", IEEE Photonics Technology Letters, Vol. 8, No. 5, pp. 664 – 666, 1996.

[14] J. Manuel Russo and R. K. Kostuk, "PQ/PMMA Holographic Filters for OCDMA Over CWDM Applications", Proc. SPIE 7049, 2008.

[15] Ahmed Nabih Zaki Rashed, "Optical Fiber Communication Cables Systems Performance Under Harmful Gamma Irradiation and Thermal Environment Effects," accepted for publication in IET Communications, IET Publisher, 2013.

[16] C. Dai, L. Liu, D. Liu, Z. Chai, and Z. Luan, "Optimizations for the Uniformity of the Non Volatile Volume Grating in Doubly Doped $LiNbO_3$ Crystals", Optics Communications, Vol. 248, pp. 27–33, 2005.

[17] L. B. Glebov, "Photosensitive Glass for Phase Hologram Recording", Glastech. Ber. Glass Sci. Technol. 71C, pp. 85-90, 1998.

[18] V. Smirnov, J. Lumeau, S. Mokhov, B. Ya. Zeldovich and L.B. Glebov, "Ultra Narrow Bandwidth Moiré Reflecting Bragg Gratings Recorded in Photo Thermo Refractive Glass", Optics Letters, Vol. 35, No. 4, pp. 592–594, 2010.

Author's Profile

Dr. Ahmed Nabih Zaki Rashed was born in Menouf city, Menoufia State, Egypt country in 23 July, 1976. Received the B.Sc., M.Sc., and Ph.D. scientific degrees in the Electronics and Electrical Communications Engineering Department from Faculty of Electronic Engineering, Menoufia University in 1999, 2005, and 2010 respectively. Currently, his job carrier is a scientific lecturer in Electronics and Electrical Communications Engineering Department, Faculty of Electronic Engineering, Menoufia university, Menouf. Postal Menouf city code: 32951, EGYPT. His scientific master science thesis has focused on polymer fibers in optical access communication systems. Moreover his scientific Ph. D. thesis has focused on recent applications in linear or nonlinear passive or active in optical networks. His interesting research mainly focuses on transmission capacity, a data rate product and long transmission distances of passive and active optical communication networks, wireless communication, radio over fiber communication systems, and optical network security and management. He has published many high scientific research papers in high quality and technical international journals in the field of advanced communication systems, optoelectronic devices, and passive optical access communication networks. His areas of interest and experience in optical communication systems, advanced optical communication networks, wireless optical access networks, analog communication systems, optical filters and Sensors. As well as he is editorial board member in high academic scientific International research Journals. Moreover he is a reviewer member in high impact scientific research international journals in the field of electronics, electrical communication systems, optoelectronics, information technology and advanced optical communication systems and networks.