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Thermo-Optic Effects on Silica Based Microring Resonator (MRR).
Gain Characteristic in L-Band EDFA Threshold Pump Power in L-Band EDFA

Surabaya, May 23rd 2012
General Chairman SITIA 2012

Dr. Heri Suryoatmojo, ST., MT.
NIP. 198006032006041003

May 23rd 2012
at AJ Building, Dept. of Electrical Engineering Campus, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia

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PREFACE

Dear Collegues,

On behalf of Technical Program Committee and Organizing Committee of SITIA 2012, I am honored to welcome you to ***the 13th Seminar on Intelligent Technology and Its Applications (SITIA)***. This annual seminar is organized **by Electrical Engineering Departement, Institut Teknologi Sepuluh Nopember (ITS) Surabaya**. The objective of this seminar is to promote the fruitful growth of researches in various fields in Electrical Engineering and its related fields presented in international oral presentation, domestic oral presentation, and poster presentation. This seminar also provides forum for researchers, scientist, and engineers to exchange ideas and their current achievements.

This year we have received **127 paper submissions** from universities, research centers, and industries, the Technical Program Committee accepted **107 selected papers** that should be presented in this seminar. The accepted papers are categorized into five groups; **Computer Engineering and Telematics, Electronics, Power Systems, Telecommunications and Control Systems**. This number the continues attraction on this seminar as an important forum. The quality of papers incresed year by year.

At last, the success of this seminar is due to the hard effort of many people especially students of Electrical Engineering Departement of ITS which we gratefully acknowledge. We thank also to the authors whose papers are presented, the invited keynote speakers, and all parties that we are not able to mention here.

We wish you all can enjoy one day discussion through this seminar and could spend to enjoy the beauties of Surabaya City and ITS-Campus. We hope to meet you again in the next seminar, the 14th Seminar on Intelligent Technology and Its Application 2013.

Surabaya, May 23rd 2012

General Chairman of SITIA 2012

Dr. Heri Suryoatmojo

NIP. 198006032006041003

ISSN : 2252-8296

Schedule of SITIA 2012

07.30-08.00	Registration
08.00-08.05	Welcome Speech by MC
08.05-08.15	Opening Ceremony
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08.20-08.30	Welcome Speech: Head of Electrical Engineering Department, ITS **Dr. Tri Arief Sardjono, ST., MT.**
08.30-08.40	Welcome Speech : Rector of ITS **Prof. Dr. Ir. Triyogi Yuwono, DEA**
08.40-09.15	**1st Keynote Speaker:**
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	Discussion
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	Prof. Er Meng Joo **(Nanyang Technology University, Singapore)**
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Time	Room VII	Room VIII	Room IX	Room X	Room XI
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	103 106 107 126	067 070 071 116 124	044 077 084 096 102	034 040 078 098 123	036 052 126 109 110	112 119 120 015 025
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	Domestic	Domestic	Domestic	Domestic	Domestic	
	Telecommunications	Telecommunications, Control Systems	Power Systems	Power Systems	Power Systems, Control Systems, Electronics	
	065 068 069 072 022	108 122 047 049 101	076 075 088 092 113	086 093 111 127 087	114 024 115 053 056	

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1. Presentation must be in Bahasa Indonesia or English, but for international session, presentation must be in English.
2. Presenter must prepare his/her presentation in Microsoft Power Point file (*.ppt or *.pptx).
3. Presentation file must be submitted to Organizing Committee before starting presentation.
4. Each paper must be presented by one presenter only. If presenter would like to delegate another person to present his/her paper, he/she must contact the Organizing Committee first.
5. Presenter must use laptop provided by the Organizing Committee.
6. Each presenter will have maximum 15 minutes for presenting his/her presentation, including discussion time. The allocated time may vary depending on room capacity.
7. Organizing Committee may cut presentation or discussion when it exceeds the allocated presentation time.

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Thermo-Optic Effects On Silica Based Microring Resonator(MRR)

Amri Heryana[1], Ary Syahriar[1,2], Ahmad H. Lubis[1]
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Abstract - *Optical communication requires supporting components as on copper wire communications. One of optical component that has an important role in optical communications is the optical filter. In this paper the characteristics of microring resonator as an add/drop filter component were analyzed. Optical add/drop filter is necessary to transmit or drop the signals with the certain wavelengths in wavelength division multiplexing (WDM) communication system. In this research the characteristic of microring resonator including Free Spectral Range (FSR), Full Width Half Maximum (FWHM) and temperature effect are simulated using matlab programme. The simulation result present that the profile of transmission power from the microring resonator is depending on the coupling power ratio, with its on-off ratio is more than 20 dB. The profile of transmission power have 20 nm of FSR and 3.247 nm of FWHM. The simulation result in investigating the effect of temperature in microring resonator indicates that the shifted resonance wavelength is arised of about 5 nm by changing the temperature from 27 °C to 500 °C.*

Keywords : *Wavelength Division Multiplexing, optical add/drop filter, microring resonator, temperature effect of microring resonator.*

Paper ID: 068

Peningkatan QoS VoIP over WLAN (VoWLAN) 802.11 pada Protokol MAC 802.11

Mochamad Susantok[1], Wirawan[2], Achmad Affandi[3]
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Abstrak – *Jaringan wireless modern mampu memberikan layanan multimedia dengan baik. Wireless LAN (WLAN) mode infrastruktur yang saat ini sering digunakan awalnya didesain untuk jenis paket best effort seperti web, mail, dan ftp. Namun seiring dengan kebutuhan akan layanan multimedia yang semakin meningkat seperti VoIP, kehandalan sistem WLAN dalam memberikan kualitas VoIP yang terbaik terus menjadi topik yang menarik untuk diteliti. Heterogen trafik data dan suara yang dimulai dari 1-10 percakapan atau sampai 20 terminal voip serta pergerakan mobile user yang deterministic akan menjadi faktor penguji dalam penelitian ini. Penelitian ini menggunakan NS-2 sebagai environment simulasi untuk membandingkan performansi VoWLAN sebelum dan sesudah dilakukan peningkatan QoS. Peningkatan QoS VoWLAN dilakukan dengan mengatur parameter protokol MAC 802.11 pada VoIP dan AP node sehingga trafik voip lebih diprioritaskan daripada trafik best effort. Hasil pengukuran QoS didapatkan besar latency 72.3 – 84.4 ms sebelum dilakukan peningkatan QoS dan terjadi peningkatan di paket hilang dari 0.12 – 6.22 % menjadi 0 – 4.88 %.*

Kata Kunci : *Protokol MAC 802.11, QoS, VoWLAN, NS-2*

Thermo-Optic Effects On Silica Based Microring Resonator (MRR)

Amri Heryana[1)], Ary Syahriar[2)], Ahmad H. Lubis[3)]

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Abstract - *Optical communication requires supporting components as on copper wire communications. One of optical component that has an important role in optical communications is the optical filter. In this paper the characteristics of microring resonator as an add/drop filter component were analyzed. Optical add/drop filter is necessary to transmit or drop the signals with the certain wavelengths in wavelength division multiplexing (WDM) communication system. In this research the characteristic of microring resonator including Free Spectral Range (FSR), Full Width Half Maximum (FWHM) and temperature effect are simulated using matlab programme. The simulation result present that the profile of transmission power from the microring resonator is depending on the coupling power ratio, with its on-off ratio is more than 20 dB. The profile of transmission power have 20 nm of FSR and 3.247 nm of FWHM. The simulation result in investigating the effect of temperature in microring resonator indicates that the shifted resonance wavelength is arised of about 5 nm by changing the temperature from 27°C to 500°C.*

***Keywords**: Wavelength Division Multiplexing, optical add/drop filter, microring resonator, temperature effect of microring resonator.*

Introduction

Microring resonator (MRR) have the potential to be the basic building block of Photonic VLSI circuit. They have been used to build optical add/drop filters [1][2], modulators [3][4], dispersion compensators [5][6], time-delay elements [7] and sensors [8][9] amongst several other integrated photonic devices. One of the first papers dealing with the simulation of an integrated ring resonator for a bandpass filter has been published in 1969 by Marcatili [10]. The layout of the channel dropping filter which he proposed is shown in Figure 1. This can be regarded as the standard configuration for an integrated ring resonator channel dropping filter.

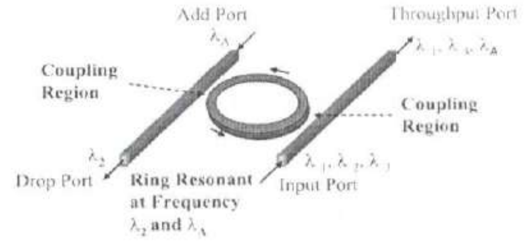

Figure 1 Ring resonator channel droping filter [10]

I. Characteristic Microring Resonator (MRR)

A simple MRR is created by taking one output of a generic directional coupler and feeding it back into one input as shown in Figure 2. Such a device exhibits a periodic cavity resonance when light traveling the ring acquires a phase shift corresponding to an integer multiple of 2π radians. The resonator is mathematically formulated from two components: a coupling strength and feedback path.

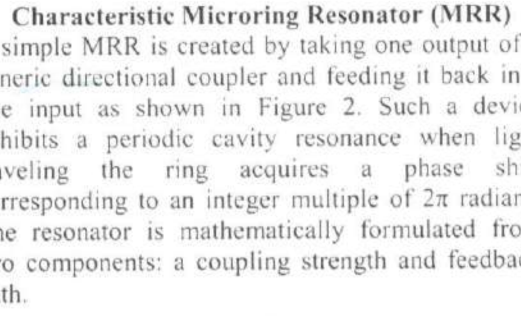

Figure 2. Model of a single ring resonator with one waveguide bus []

Light in the ring resonator filter are incorporated in the attenuation constant, the interaction can be described by the matric relation :

$$\begin{bmatrix} A \\ B \end{bmatrix} = \begin{bmatrix} t & jK \\ jK & t \end{bmatrix} \begin{bmatrix} A_0 \\ B_0 \end{bmatrix} \quad (1)$$

So we can get :

$$A = A_0 t + jB_0 K \quad (2.a)$$

$$B = jA_0 K + B_0 t \quad (2.b)$$

The complex mode amplitude E are normalized, so that their squared magnitude corresponds to the modal power. The coupler parameters t and K depend on the specific coupling mechanism used of the directional coupler. Whereby t is coefficient transmission and K is normalized coefficient coupling. The matrix is symmetric because the networks under consideration are reciprocal, therefore $t^2 + K^2 = 1$. K^2 is coupling power ratio and t^2 is transmission power ratio of the coupler.

We assumed that input/output and resonator waveguides have the same propagation constant β. When we denote the intensity attenuation coefficient of the ring waveguide as α, B_0 is expressed by :

$$B_0 = B \exp\left(-\frac{\alpha}{2}L - j\beta L\right) \tag{3}$$

Where $L = 2\pi R$, R is radii of ring.

By substituting equation (3) and (2), we get the amplitude transmittance of the optical MRR :

$$\frac{A}{A_0} = \frac{t - \exp\left(-\frac{\alpha}{2}L - j\beta L\right)}{1 - t\exp\left(-\frac{\alpha}{2}L - j\beta L\right)} \tag{4}$$

So from equation (4), the transmission power of the MRR is obtained as [11][12]:

$$P_T(\theta) = \left|\frac{A}{A_0}\right| = \frac{t^2 + t^2\gamma^2 - 2t^2\gamma\cos(\theta)}{1 - 2t^2\gamma\cos(\theta) + t^4\gamma^2} \tag{5}$$

Whereby:

$$\gamma = \exp(-\alpha\pi R) \tag{6}$$

$$\theta = \beta L \tag{7}$$

β is propagation constant $\beta = k_0 n_{eff}$ with $k_0 = \frac{2\pi}{\lambda}$, λ is wavelength of light.

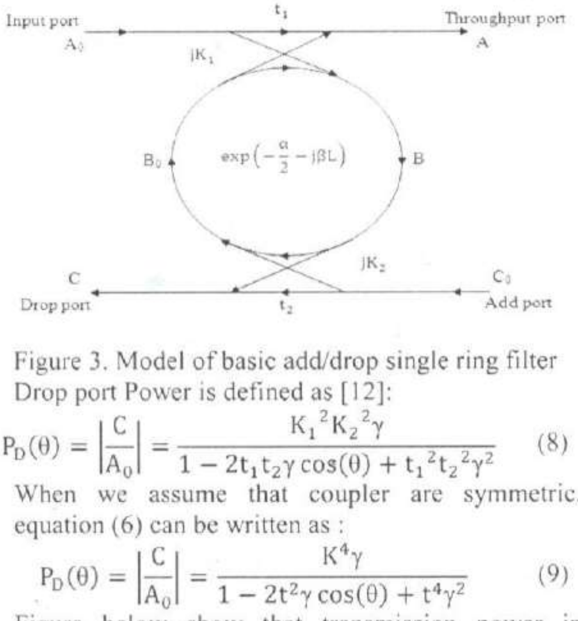

Figure 3. Model of basic add/drop single ring filter

Drop port Power is defined as [12]:

$$P_D(\theta) = \left|\frac{C}{A_0}\right| = \frac{K_1^2 K_2^2 \gamma}{1 - 2t_1 t_2 \gamma\cos(\theta) + t_1^2 t_2^2 \gamma^2} \tag{8}$$

When we assume that coupler are symmetric, equation (6) can be written as :

$$P_D(\theta) = \left|\frac{C}{A_0}\right| = \frac{K^4\gamma}{1 - 2t^2\gamma\cos(\theta) + t^4\gamma^2} \tag{9}$$

Figure below show that transmission power in throughput port using equation (5) and drop port using equation (9). Parameters used in this simulation are : width of core h = 2 μm, refractive index of core $n_1 = 1.468$, refractive index of cladding $n_0 = 1.458$ and radii of ring R = 12.5 μm.

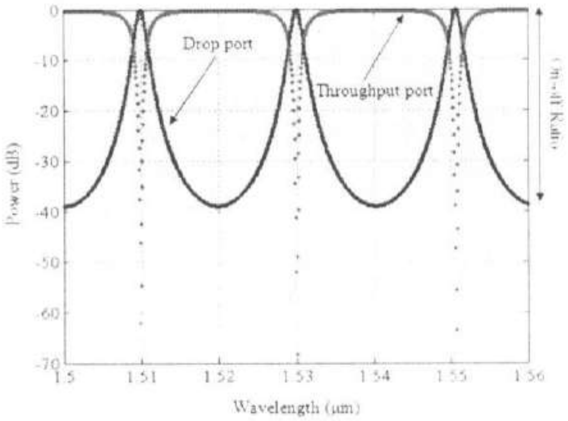

Figure 4. Power of throughput port and drop port of single MRR in dB.

Figure 4 is transmission power in dB at coupling power ratio $K^2 = 0.25$ when this condition produce sharper dropping channel more than 60 dB, filter response on-off ratio more than 30 dB. Free Spectral Range (FSR) equal 20 nm, it's star from 1.510 μm to 1.530 μm. And Full Width Half Maximum (FWHM) is 3.247 nm.

II. Thermo-Optic

The refractive index of the optical materials is not a constant parameter over temperature region in which the materials, such as crystals, semiconductors and glasses are used in different optical devices or systems. The variation of the refractive index with the temperature at a constants pressure is called the thermo-optic coefficient. It is denoted as $\frac{dn}{dT}$, where n is refractive index and T is temperature. Its unit is per degree order 10^{-3} to 10^{-6} °C^{-1} [13].

Typical value of $\frac{dn}{dT}$ for silica is 10^{-5} °C^{-1} [14]. Although the value is quite small, it is possible to measure with sufficient accuracy. The analyses of thermo-optic coefficients are essential to characterize the temperature-dependent nonlinear optical device, the optical devices, the optical fiber communication systems, semiconductor technology, and the ultrafast femtosecond technology.

The Sellmeier coefficients at any temperature T are computed from the room temperature Sellmeier equation and the smoothed $\frac{dn}{dT}$ values by calculating refractive indexes from the relations [15] :

$$nT = n_{T0} + (T - T_0)\frac{dn}{dT} \tag{10}$$

whereby, n_T is the refractive index at T temperature, n_{T0} is refractive index at room temperature, T_0 is room temperature and $\frac{dn}{dT}$ is thermo-optic coefficient. .

Figure 5 describes that refractive index rises due to the temperature. The used parameters are refractive index of silica n = 1.468, temperature T = 27 – 350 ^{o}C, and thermo-optic coefficient $\frac{dn}{dT} = 10^{-5}\ ^{o}C^{-1}$.

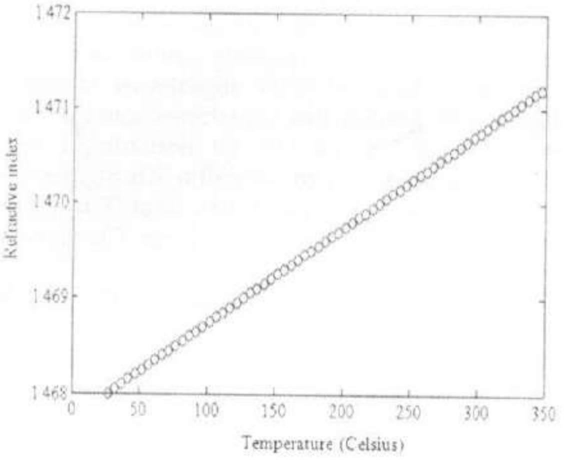

Figure 5. Refractive index as a function of temperature

We can observe that refractive index increases with temperature rise. The greater the temperature is given then it will increase the value of the refractive index.

When we get relationship of refractive index and temperature, the next step is analyze influence temperature to effective refractive index on optical waveguide. We assume that only the core is warming while not to cladding. Term of effective refractive index must be satisfied, that :

$$n_0 < n_{eff} < n_1$$

Following figure shows the relations of effective refractive index as a function of temperature.

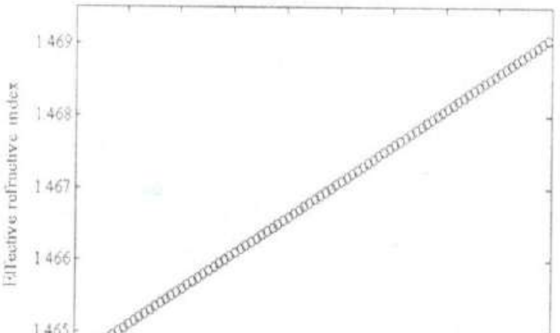

Figure 6. Effective refractive index as a function of temperature

Figure 6 shows that the temperature affects the value of effective refractive index. When the temperature is increased the value of effective refractive index will go up as well.

III. Thermo-Optic on Microring Resonator (MRR)

In thermo-optic base on MRR structure, we assume that only ring cavity is warming as illustrated in figure below :

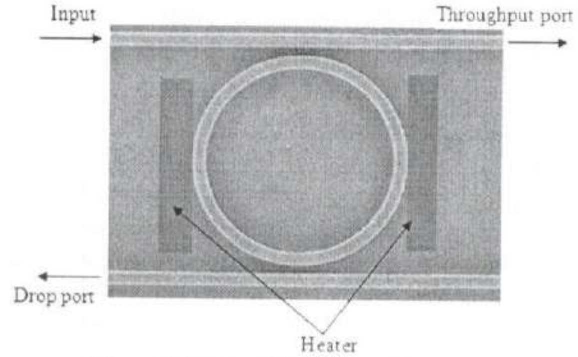

Figure 7. MRR with heater on ring cavity

The parameters in transmission of MRR that determines the resonance wavelength is theta [16] symbolized θ. Whereby :

$$\theta = \beta L$$
$$= k_o n_{eff} L$$

Since effective refractive index depends on temperature, then the propagation constant β is also dependent on temperature. Its mean that the transmission power of MRR influence to temperature exchange.

By using equation (5) which is combined by equation (10), we can simulate and observe the characteristics of transmission power of MRR as a function of temperature.

Figure 4.15 shows transmission power of MRR as a function of temperature. Parameters used as following : refractive index of cladding $n_0 = 1.458$, refractive index of core $n_1 = 1.468$, width of core h = 2 μm, radii of ring R = 12.5 μm, Coupling power ratio $K^2 = 0.25$, thermo-optic coefficient $\frac{dn}{dT} = 10^{-5}$ $^{o}C^{-1}$, $T_0 = 27\ ^{o}C$ and using several number of temperature they are 250 ^{o}C and 500 ^{o}C.

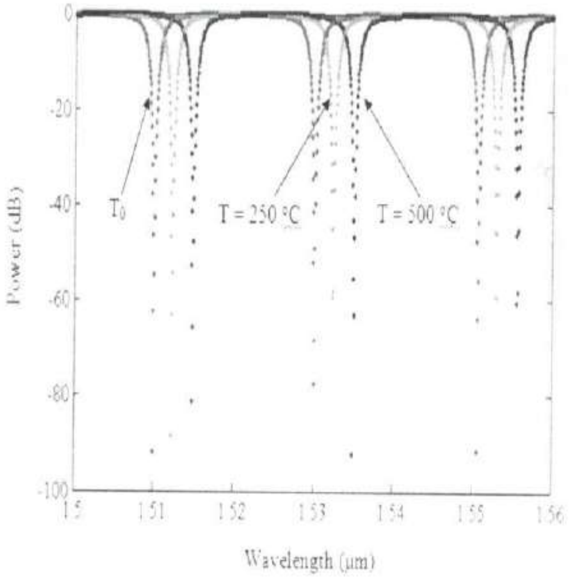

Figure 8. Power transmission of MRR as a function of temperature

By figure above we can observe that temperature influence the power transmission of MRR. Since effective refractive index depends on temperature then power transmission dependent as well. Its mean that temperature changes, it will change the resonance wavelength. When temperature increased the resonance wavelength will shifting. Wavelength shift (symbolized by $\Delta\lambda$) we get by resonance wavelength at T difference by resonance wavelength at T_0. At T equal 250 °C we get $\Delta\lambda$ several 2.5 nm whereas at T equal 500 °C produce $\Delta\lambda = 5$ nm.

IV. Conclusion

MRR can be used as add/drop filter. MRR is a narrow optical filter. This final project has demonstrated optical filter which has FSR several 20 nm, it is 1.51 μm – 1.53 μm. sharpness of transmission power depend on coupling power ratio K^2. When coupling power ratio 0.5 and more, transmission power very sharp. Whereas coupling power ratio less then 0.5, the transmission power is ramp and produce smaller FSR and wider FWHM. Radii of ring cause different resonance wavelength, but multiple radii produce smaller FSR in other word its produce much resonance wavelength or dropped channel.

In thermo-optic, refractive index depend on temperature. When temperature change then refractive index change as well. Since refractive index change it means the effective refractive index change also. In other word, the temperature affects the propagation constant β.

Temperature effect on ring cavity of MRR has been demonstrated in this final project. When the ring is warming the propagation constant in ring waveguide will change also. This condition cause the different resonance wavelength. By simulation result, increasing temperatur affect resonance wavelength shift $\Delta\lambda$. In this final project demonstrated that increasing temperature 500 °C produce $\Delta\lambda = 5$ nm.

V. Reference

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