Appendix A

Giles Model

The Giles model [1-2] is based on absorption and gain parameters that are proportional to the cross sections. The rate and propagation equations are solved by integrating the spectral evolution back and forth along the fiber until it converges.

The model uses the two-level approximation, which assumes that the lifetime of the pump level is much smaller than the lifetime of the metastable level:

$$N_t = N_1 + N_2 \tag{A1}$$

$$\frac{\partial N_2}{\partial t} = \sum_{K=1}^{K} I_K (N_1 \sigma_K^a - N_2 \sigma_K^e) - \frac{N_2}{\tau_2} \tag{A2}$$

where N_t = total ions density

N_i = ions density in ith level (i = 1,2)

σ_K^a = absorption cross sections of the beam

σ_K^e =emission cross sections of the beam

I_k = intensity of the kth beam

τ_2 = combined radiative and non-radiative decay time from level 2 to level 1.

The evolution of the power in each pump and signal beam is given by:

$$\frac{\partial P_{S,K}}{\partial z} = u_K \int (N_2 \sigma_K^e - N_1 \sigma_K^a) I_K \, dA \tag{A3}$$

where u_K = +1 for propagation in the positive z direction

= -1 for propagation in the negative z direction

$dA = r dr d\phi$ is the cylindrical coordinate system

Integrating the equation over the transverse plane yields:

$$\frac{\partial P_S(z)}{\partial z} = u_S P_S(z) (\overline{N}_2 \Gamma_{S,2} \sigma_S^e - \overline{N}_1 \Gamma_{S,1} \sigma_S^a) \tag{A4}$$

where $A_{eff} = \int \frac{N_t(r,\phi,z)dA}{N_t(0)}$, effective area of the dopant ions

$$\Gamma_{S,i} = \frac{A_{eff} \int I_K(r,\phi,z) N_i(r,\phi,z)dA}{P_S(z) \int N_i(r,\phi,z)dA}$$, overlap integral or confinement factor

The Giles model provides a full spectral solution. The propagation equations are integrated backs and forth along the fiber until the solution converges. For the Giles model, the propagation equations are rewritten in terms wavelength, λ, dependent absorption and emission coefficients:

$$\alpha(\lambda_K) = \Gamma(\lambda_K)\overline{N}_t \sigma_K^a(\lambda_K) \quad \text{(A5)}$$

$$g(\lambda_K) = \Gamma(\lambda_K)\overline{N}_t N_K^e(\lambda_K) \quad \text{(A6)}$$

$$\frac{\partial P_K(z)}{\partial z} = u_S P_S(z)(N_2 \alpha_K - N_1 g_K) \quad \text{(A7)}$$

Steady-state solution to the rate equation gives the average population inversion along the fiber:

$$N_2(z) = \frac{\frac{\tau_2}{A_{eff}} \sum \frac{P_K \alpha_K}{h\gamma_K}}{1 + \sum \frac{P_K}{P_K^{IS}}} \quad \text{(A8)}$$

where the intrinsic saturation power is given by:

$$P_K^{IS} = \frac{h\gamma A_{eff}}{\Gamma_{K,2} \tau_2 (\sigma_K^a + \sigma_K^e)}$$

References

[1] OptiAmplifier Manual

[2] C. R. Giles and E. Desurvire, "Modeling Erbium Doped Fiber Amplifiers," IEEE Photon. Technol. Lett., 9, pp. 271, 1991.

Appendix B

Theory of Regenerative Amplifier

The theory of regenerative amplifier derived here is basically based on the linear configuration developed R. Loudon et. al. [1]. The theory is also valid for ring configurations since interference effects were not taken into account. A similar result is also obtained in [2] and [3].

The intensity damping rates associated with the two couplers are given by

$$\gamma_1 = \frac{cT_1}{p} \qquad \text{and} \qquad \gamma_2 = \frac{cT_2}{p} \tag{B1}$$

where T_1 and T_2 are the transmitance of couplers C_1 and C_2, respectively (see Fig. 6.1) and p is the perimeter of the cavity. The total damping rate of the cavity field is then determined by

$$\gamma_c = \frac{1}{2}(\gamma_1 + \gamma_2) \tag{B2}$$

Applying an external signal of complex field $\boldsymbol{E}_{\text{in}}$ then excites the cavity field $\boldsymbol{E}$, giving the output field, from coupler C_2 as

$$\boldsymbol{E}_{out} = \sqrt{\gamma_1}\boldsymbol{E} \tag{B3}$$

The equation of motion for the cavity field $\boldsymbol{E}$, atomic population inversion D and dipole moment $\boldsymbol{d}$ are described by the Maxwell-Bloch equation

$$\dot{\boldsymbol{E}} + (\gamma_c + iw)\boldsymbol{E} = g\boldsymbol{d} + \sqrt{\gamma_2}\boldsymbol{E}_{in} \tag{B4}$$

$$\dot{D} + \gamma_{//}D = \gamma_{//}D_p - g(\boldsymbol{E}^{*}\boldsymbol{d} + \boldsymbol{E}\boldsymbol{d}^{*}) \tag{B5}$$

$$\dot{d} + (\gamma_{\perp} + iw)\boldsymbol{d} = g\boldsymbol{E}D \tag{B6}$$

Above the oscillating threshold, it is assumed that laser action occurs for a single mode of frequency w_L in resonance with the atomic transition. In the erbium-doped fiber lasers, the dipole moment decay rate $\gamma_\perp$ is much larger than the population inversion decay rate ($\gamma_\perp >> \gamma_{//} \approx \gamma_c$). Therefore, they are treated as class B lasers [4]. The laser pump is expressed in terms of the mean population inversion D_p that would be obtained in the absence of any cavity field, while coupling constant, g in Eq. (B4)-(B6) is from the interaction of the collective atomic dipole moment and cavity field.

Below threshold, there is only a single-frequency component in the cavity determined by the frequency of the input signal-frequency component in the input signal w_s. Thus, the input signal field takes the form

$$\boldsymbol{E}_{in} = \varepsilon_{in} \exp(-iw_s t) = \varepsilon_{in} \exp[-i(w_L + \Delta w)t] \tag{B7}$$

where $\Delta w = w_s - w_L$ represents the amount of detuning and ε_{in} is the amplitude of input signal.

Below threshold, there is no mean excitation of the image-frequency field and no modulation of the population inversion and the dipole moment in the cavity is just contributed from the input signal. Then, we have

$$\boldsymbol{E} = \boldsymbol{E}_s \exp[-i(w_L + \Delta w)t] \tag{B8}$$

$$\boldsymbol{d} = \boldsymbol{d}_s \exp[-i(w_L + \Delta w)t] \tag{B9}$$

$$D = D_p \tag{B10}$$

Thus, Eq. (B4) and (B6) reduce to

$$(\gamma_c + iw)\boldsymbol{E}_s = g\boldsymbol{d}_s + \sqrt{\gamma_2}\varepsilon_{in} \tag{B11}$$

$$\gamma_\perp \boldsymbol{d}_s = g\boldsymbol{E}_s D_p \tag{B12}$$

Sustituting Eq. (B12) into (B11) gives the solution

$$E_s = \frac{\sqrt{\gamma_2}\,\varepsilon_{in}}{\gamma_c(1-C)+i\Delta w} \tag{B13}$$

where $C = g^2 D_p/\gamma_c\gamma_\perp < 1$ below threshold.

The intensity gain is then given by

$$G(\Delta w) = \left(\frac{E_{out}}{\varepsilon_{in}}\right)^2 = \frac{\gamma_1\gamma_2}{\Delta w^2 + \gamma_c^{\,2}(1-C)^2} \tag{B14}$$

From Eq. (B14), it is seen that he maximum gain achieved at zero detuning $\Delta w = 0$.

References

[1] R. Loudon, M. Harris, and J. M. Voughan, "Laser-amplifier gain and noise," Phys. Rev. A, Vol. 18, 1993, 681.

[2] A. E. Siegman, "Lasers," Mill Valley, California, 1986.

[3] M. B. Spencer and W. E. Lamb, Jr., "Laser with a Transmitting Window," Phys. Rev. A, Vol. 5, 1972, 884.

[4] Ligua Luo, T. J. Tee, and P. L. Chu, "Chaotic behaviour in erbium-doped fiber-ring lasers," J. Opt. Soc. Am. B, Vol. 15, No. 3, 1998, 972.

Appendix C

Injection Locking Theory Based on Adler's Model

A standard method used to describe the injection locking phenomena is based on Adler's model [1]. This model explains very well the phenomena in the locking range. However, outside this locking range, there is no steady-state solution for the cavity phase, resulting in the limitation of the model [2].

In Adler's model, the eigenfield of the slave laser is given by

$$E_0(t) = \varepsilon_0(t)\, e^{j[w_0(t)+\phi_0(t)]} \tag{C1}$$

The injected signal from the master laser has the field in the same form

$$E_1(t) = \varepsilon_1(t)\, e^{j[w_1(t)+\phi_1(t)]} \tag{C2}$$

$\varepsilon_{0,1}(t)$ and $w_{0,1}$ represent the amplitude and angular frequency of the field of the slave laser and incident signal, respectively. Both the waves depend also on the phase $\phi_{0,1}(t)$.

Equations of time-evolution amplitude $\varepsilon_{0,1}(t)$ of the cavity signal are

$$\frac{d\,\varepsilon_0(t)}{dt} + \frac{(\gamma_c - \gamma_m)}{2}\varepsilon_0(t) = \gamma_e \varepsilon_1(t)\cos[\phi_0(t) - \phi_0(t)] \tag{C3}$$

$$\frac{d\,\phi_1(t)}{dt} + (w_1 - w_0) = -\frac{\gamma_e \varepsilon_1(t)}{\varepsilon_0(t)}\sin[\,\phi_0(t) - \phi_1(t)] \tag{C4}$$

where γ_c : cavity decay rate

γ_m : laser growth rate

γ_e : external decay rate

Solving phase equation (C4) under steady-state condition gives

$$(w_1 - w_0) = -\frac{\gamma_e \varepsilon_1}{\varepsilon_0}\sin[\phi_0 - \phi_1] \tag{C5}$$

But $$-1 \le \{ \sin[\phi_0 - \phi_1] \equiv \frac{(w_1 - w_0)}{\gamma_e} \frac{\varepsilon_0}{\varepsilon_1} \} \le 1$$

or $$-\frac{\gamma_e \varepsilon_0}{\varepsilon_1} \le w_1 - w_0 \le \frac{\gamma_e \varepsilon_0}{\varepsilon_1}$$

The full locking range centered at resonance atomic transition frequency w_0 is then given by

$$\Delta w = 2\gamma_e \sqrt{I_1/I_0} \qquad \text{(C6)}$$

where $I_{0,1} \alpha\ \varepsilon_{0,1}^2$.

The round-trip power decrease due to external coupling can be related to coupler reflectivity by

$$R = e^{-\gamma_e \tau} \qquad \text{(C7)}$$

where $\tau = n\iota/c$, round-trip time in the cavity length of ι and refractive index of n. This gives the external decay rate

$$\gamma_e = \frac{c}{\iota} \ln(\frac{1}{R}) \qquad \text{(C8)}$$

Substituting equation (C8) into (C6) and use the relation of $w = 2\pi v$, gives the full locking range

$$\Delta v = \frac{c \ln(\frac{1}{R})}{\pi \iota} \sqrt{P_1/P_0} \qquad \text{(C9)}$$

where the power ratio, P_1/P_0, is equivalence to I_1/I_0.

References

[1] A. E. Siegman, "Lasers," Mill Valley, California, 1986.

[2] P. Even, K. Ai Ameur and G. M. Stephan, " Modeling of an injected gas laser," Phy. Rev. A, Vol. 55, No. 2, 1997, 1441.

Appendix D

Publication List

International Journals

1. T. C. Teyo, M. K. Leong and H. Ahmad, "*Power Conversion Efficiency of Erbium doped Fibre Amplifiers With Optical Feedback*," accepted to be published in **J. Opt. Comm.**

2. T. C. Teyo, N. S. Mohd. Shah and H. Ahmad, "*Injection locking of erbium-doped fiber laser-amplifier*," **Microwave & Opt. Technol. Lett** , Vol. 36, No. 2, pp. 89-91, 2003.

3. T. C. Teyo, N. S. Mohd. Shah, P. Poopalan and H. Ahmad, "*Regenerative Erbium Doped Fibre Amplifier Subject to External Injection,*" **Opt. Comm.**, Vol. 203, No. 1-3, pp. 223-228, 2002.

4. T. C. Teyo, M. K. Leong and H. Ahmad, "*Noise Characteristics of Erbium-doped Fiber Amplifier With Different Optical Feedback Schemes*," **Opt. Comm.**, Vol. 207, No. 1-6, pp. 327-331, 2002.

5. Tuan Chin TEYO, Nor Shahida MOHD SHAH, Prabakaran POOPALAN and Harith AHMAD, "*Saturation Characteristics of Regenerative Erbium-Doped Fiber Amplifier*," **Jpn. J. Appl. Phys.**, Vol. 41, No. 7B, pp. L830 - L832, 2002.

6. Tuan Chin TEYO, Mun Kiat LEONG and Harith AHMAD, "*Noise Characteristics of Erbium-Doped Fiber Amplifier with Optical Counter-Feedback*," **Jpn. J. Appl. Phys.**, Vol. 41, No. 5A, Part 1, pp. 2949-2950, 2002.

7. Nor Shahida MOHD SHAH, Tuan Chin TEYO, Prabakaran POOPALAN and Harith AHMAD, "*Unidirectional and Bi-Directional Feedbacks Regenerative*

Erbium-Doped Fiber Amplifier," **Jpn. J. Appl. Phys.**, Vol. 41, No. 8B, Part 2, pp. L960-962, 2002.

8. S. W. HARUN, N. TAMCHEK, T. C. TEYO, P. POOPALAN and H. AHMAD, "*All optical gain-clamped L-band EDFA using a ring resonator*," **Indian J. Phys.**, 6B(2), pp. 103-105, 2002.

9. T. C. Teyo, N. S. Mohd. Shah and H. Ahmad, "*A Study of Laser SNR in an Erbium Doped Fiber Laser Subject to External Injection*," **Microwave & Opt. Technol. Lett**, Vol. 35, No. 1, pp. 40-42, 2002.

10. T. C. Teyo, N. S. Mohd. Shah, M. K. Leong, P. Poopalan and H. Ahmad, "*Comparison between Regenerative-Feedback and Cofeedback Gain-Clamped EDFA*," **IEEE Photon. Technol. Lett.**, Vol. 14, No. 9, pp. 1255-1257, 2002.

11. T. C. Teyo, M. K. Leong and H. Ahmad, "*Lasing wavelength dependence of gain clamped EDFA performance with different optical feedback schemes*," **Opt. & Laser Technol.**, Vol. 34, No. 6, pp. 497-500, 2002.

12. T. C. Teyo, V. Sinivasagam, M. K. Abdullah, and H. Ahmad, "*An Injection Locked Erbium-Doped Fibre Ring Laser*," **Opt. & Laser Technol**, Vol. 31, No. 7, pp. 493-496, 2000.

13. T. C. Teyo, P. Poopalan, A. Mahdi, and H. Ahmad, "*Properties of Laser and Amplified Signal in a Gain-clamped* Er^{3+}*-doped Fibre Amplifier System*," **Microwave & Opt. Technol. Lett.**, Vol.24, No. 6, pp. 418-420, 2000.

14. T. C. Teyo, P. Poopalan, and H. Ahmad, "*Regenerative Erbium-doped Fiber Ring Amplifier,*" **Electron. Lett.**, Vol. 35, No. 17, pp. 1471-1473, 1999.

International Conferences

1. T. C. Teyo, N. S. Mohd. Shah and H. Ahmad, "*Amplification bandwidth of below threshold regenerative erbium-doped fibre amplifiers*," Proc. 1st **International Conference on Optical Communications and Networks, ICOCN'2002**, pp. 80-81, Singapore.
2. N. S. Mohd. Shah, T. C. Teyo, and H. Ahmad, "*Power Stabilization of Erbium-Doped Fibre Laser by External Injection*," Proc. **ICOCN'2002**, pp. 167-168, Singapore.
3. K. F. Chang, P. Poopalan, *T. C. Teyo*, T. Subramaniam and H. Ahmad, "*Gain Enhancement in Double-Pass Erbium-Doped Fiber Amplifier*," Proc. **ICOCN'2002**, pp. 77-79, Singapore.
4. Nor Shahida Mohd. Shah, Tuan Chin Teyo and Harith Ahmad, "*Uni- and Bi-directional Feedbacks Regenerative EDFA operating Below Threshold*," 2002 IEEE International Conference on Semiconductor Electronics (**ICSE'02**).
5. N. S. Mohd Shah, T. C. Teyo, and H. Ahmad, "*Power Stabilization of Erbium-Doped Fibre Ring Laser Subjected to External Injection*," 2002 IEEE International Conference on Semiconductor Electronics (**ICSE'02**).
6. N. S. Mohd Shah, T. C. Teyo, P. Poopalan, H. Ahmad, "*Regenerative Erbium-Doped Fiber Ring Amplifier with Unidirectionaland Bi-directional Feedbacks*," Proc. The 2002 International Technical Conference on Circuits/Systems, Computers and Communications (**ITC-CSCC 2002**), Phuket, Thailand, pp. 540-541, 2002.
7. Teyo Tuan Chin, Prabakaran Poopalan, Thirumeni Subramaniam, and Harith Ahmad, "*Erbium-doped Fiber Ring Laser Subject to an External Injection*,"

Proc. 2nd East Asian Conference on Lightwave Systems, Lasers and Optoelectronics (**LiSLO'2001**), pp. 360-362.

8. Teyo Tuan Chin, M. K. Abdullah, F. Isnin, and H. Ahmad, "*Cavity Configuration Study of an EDFL System*," 1998 IEEE International Conference on Semiconductor Electronics (**ICSE'98**).

9. M. K. Abdullah, F. Isnin, V. Sinivasagam, T. C. Teyo, H. Ahmad, "*Back reflection and pump instability effects on a fiber laser system*", **ICSE'98**.

10. T. C. Teyo, M. K. Abdullah, F. Isnin, S. Vasagavijayan and H. Ahmad, "*Optimization of the Reflectivity in Erbium-Ytterbium Co-doped Fiber Laser Design for Maximum Output Power*," 1998 International Meeting on Frontier Physics (**IMFP'98**).

11. F. Isnin, M. K. Abdullah, T. C. Teyo, H. Ahmad, "*Back reflection studies of tunable fiber laser system*", **IMFP'98**.

12. H. Ahmad, M.K. Abdullah, M.S. Kassim, A. Mat. Hassan, M. A. Mahdi, P. Poopalan, S. Selvakennedy, N. Ismail, M. Ngadino, F. Isnin, T. C. Teyo and S. Vasagavijayan, "*Research in optical fibres devices at Telekom Malaysia Photonics Laboratory*," **IMFP'98**.

13. M. K. Abdullah, S. Vasagavijayan, T. C. Teyo, F. Isnin, and H. Ahmad, "*Erbium doped fiber lasers for optical communications*," **IMFP'98**.

Local Journals

1. T. C. Teyo, M. K. Leong, N. S. Mohd. Shah, P. Poopalan, S. W. Harun and H. Ahmad, "*Characterization of EDFA using Different Measurement Methods*," submitted to **Malaysian Journal of Science**.

2. S. W. Harun, N. Tamchek, T. C. Teyo, P. Poopalan and H. Ahmad, "*L-Band Ring Erbium-Doped Fiber Amplifier with Fiber Bragg Grating*," **Malaysian Journal of Science**, 21, pp. 115-121, 2002.

3. Teyo Tuan Chin, Thirumeni Subramaniam, Prabakaran Poopaan, and Harith Ahmad, " *A Study of the Optical Feedback Level in An Erbium-doped Fiber Laser System*," to be published in **J. Solid State Sc. and Technol**.

4. T. C. Teyo, N. S. Mohd. Shah and H. Ahmad, '*Lasing Threshold In Gain-Clamped Erbium-Doped Fiber Amplifier*," submitted to **J. Solid State Sc. and Technol.**

5. Teyo Tuan Chin, M. K. Abdullah, and H. Ahmad, "*Study of the Effects of Reflectivity in an EDFL System*," **J. Fizik Malaysia**, Vol. 22, No. 1&2, pp.5-14, 2001.

6 Teyo Tuan Chin, M. K. Abdullah, and H. Ahmad, "*Effects of Isolator in an Erbium-doped Fibre Ring Laser*," **J. Telekom**, Vol. 11, No. 1, pp. 70-72, 1999.

7. Teyo Tuan Chin, M. K. Abdullah, and H. Ahmad, "*A Study of the Effects of EDF Length in an EDFL System*," **J. Teknologi**, UTM, No. 31, pp. 65, 1999.

8. Teyo Tuan Chin, M. K. Abdullah and, H. Ahmad, "*Effects of Filter Positioning Study in an* Er^{3+}*-doped Fibre Ring Laser*," **Pertanika J. Sci. & Technol**. 9(2), pp. 189-195, 2001.

Local Conferences (With Proceeding)

1. <u>T. C. Teyo</u>, N. S. Mohd. Shah and H. Ahmad, "*Determination of Laser Threshold In Gain-Clamped Erbium-doped Fiber Amplifier Using Power Conversion Efficiency*," **Simposium Fisika National XIX**, Indonesia.
2. P. Poopalan, K. F. Chang, T. Subramaniam, <u>T. C. Teyo</u>, S. W. Harun and H. Ahmad, "*A High Clamped-Gain Double-Pass Erbium-Doped Fibre Amplifier*," **Simposium Fisika National XIX**, Indonesia.
3. N. S. Mohd Shah, F. R. Mahamad Adikan, <u>T. C. Teyo</u>, and H. Ahmad, "*Long Wavelength-Band Er^{3+}-Doped Fiber Amplifier Incorporating a Midway Isolator*," Proc. 2001 IEEE National Symposium on Microelectronics (**NSM'2001**), pp. 25-28.
4. K. F. Chang, P. Poopalan, <u>T. C. Teyo</u>, T. Subramaniam, and H. Ahmad, "*Gain Dependence of a Double-pass EDFA on Signal Wavelength*," Proc. **NSM'2001**, pp. 22-24.
5. <u>Teyo Tuan Chin</u>, Leong Mn Kiat, Nor Shahida Mohd Shah, Thirumeni Subramaniam, Prabakaran Poopaan, and Harith Ahmad, "*A Study of Different of Pumping Schemes in a Gain-clamped Erbium-doped Fiber Amplifier*," Proc. **NSM'2001**, pp. 98-101.
6. T. Subramaniam, <u>T. C. Teyo</u>, S. K. Low, M. A. Mahdi, P. Poopalan and H. Ahmad, "*Single to Dual Channel Erbium-Doped Fibre Amplifier Study*," Proc. **NSM'2001**, pp. 132-134.
7. <u>Teyo Tuan Chin</u> and Harith Ahmad, "*Gain and PCE of Erbium-doped Fiber Amplifier With Optical Feedback*" Proc. National Science Fellowship (**NSF**) Workshop 2001, pp. 170-172.

8. Sulaiman Wadi Harun, N. Tamchek, T. C. Teyo, P. Poopalan and H. Ahmad, "*Gain Improvement in L-Band EDFA by Adding an Under-pumped EDF*," Proc. **NSF** Workshop 2001, pp.142-144.

9. Teyo Tuan Chin, S. Vasagavijayan, F. Isnin, M. K. Abdullah, and H. Ahmad, "*Erbium-Ytterbium Co-doped Fiber Lasers and Cascaded Systems*," 1999 IEEE National Symposium on Microelectronics (**NSM'99**).

10. Teyo Tuan Chin, M. K. Abdullah, F. Isnin, S. Vasagavijayan and H. Ahmad, "*Optimization of the Reflectivity in Erbium Fiber Laser Design for Maximum Output Power*," 2nd National Conference on Telecommunications Technology (**NCTT'98**).

11. F. Isnin, M.K. Abdullah, T.C. Teyo, V. Sinivasagam, H. Ahmad, "*Side mode suppression ratio (SMSR) study of a tunable fiber laser*", **NCTT'98**.

Local Conferences (Without Proceeding)

1. Teyo Tuan Chin, Thirumeni Subramaniam, Prabakaran Poopaan, and Harith Ahmad, "*A Study of the Optical Feedback Level in An Erbium-doped Fiber Laser System*," The XVIII Regional Conference o Solid State Science and Technology (**MASS XVIII 2001**).

2. K. F. Chang, P. Poopalan, T. C. Teyo, T. Subamanam, and H. Ahmad, "*Double-Pass Erbium-Doped Fibre Amplifier*," National Physics Conference 2001 (**PERFIK 2001**).

3. K. F. Chang, P. Poopalan, T. C. Teyo, T. Subramaniam, and H. Ahmad, "*Automated Testing of EDFA Without Switches*," **PERFIK 2001**.

4. Leong Mun Kiat, Teyo Tuan Chin, Prabakaran Poopalan, and Harith Ahmad, "*Effect of Erbium-doped Fiber Amplifier with Optical Feedback*," **PERFIK 2001**.

5. Teyo Tuan Chin, S. Vasagavijayan, M. K. Abdullah, and H. Ahmad, "*Gain-Clamping in Erbium-Doped Fiber Amplifier*," 1999 National Physics Conference (**PERFIK'99**).