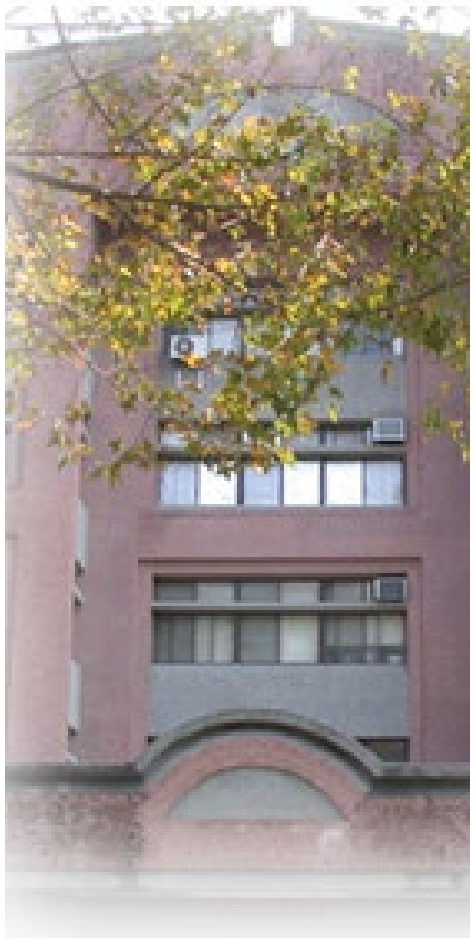
台大電機系 光電實驗



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實驗四. 電光調變器實驗

實驗六. 液晶與偏振實驗

實驗七. 光纖光學實驗

實驗八. 太陽能電池實驗

Optical Amplifier

Optical Amplifier :

Semiconductor Optical Amplifier

Raman Amplifier

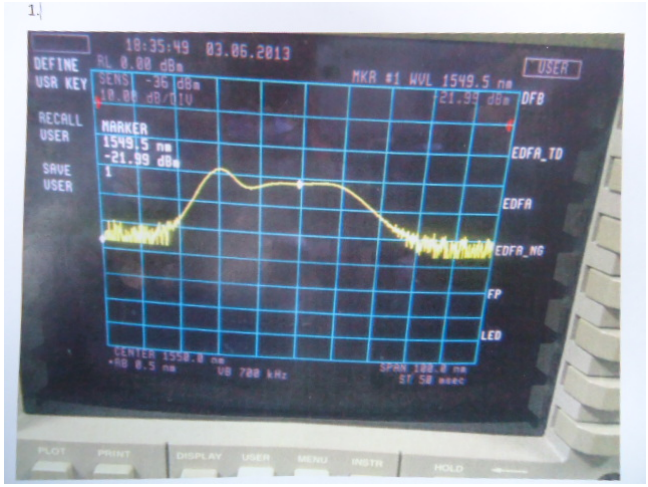
Erbium-Doped Fiber Amplifier (EDFA).

Experiment:

1. Gain Bandwidth （增益光譜）
2. Gain V.S. Pump Power
3. Gain Saturation
4. Noise Figure

注意事項

攜帶數位相機紀錄波型和數據



System setup

（基本配置圖 實驗配置圖）

Tunable lase

Power meter

Modulator

Optical Signal

Source

Optical Fiber

Electrical Signal In

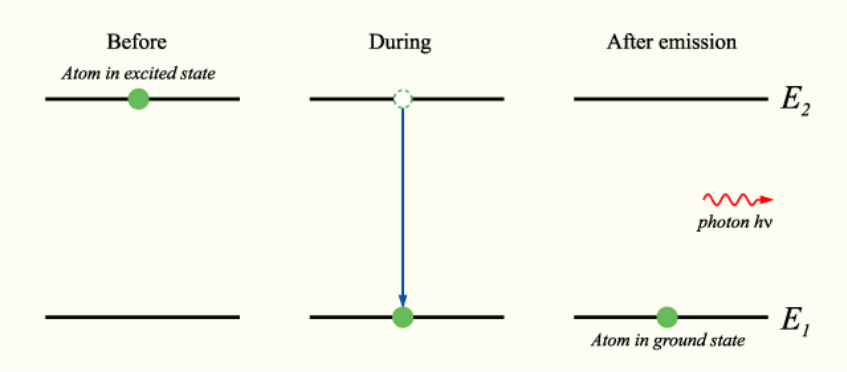
長程傳輸

EDFA

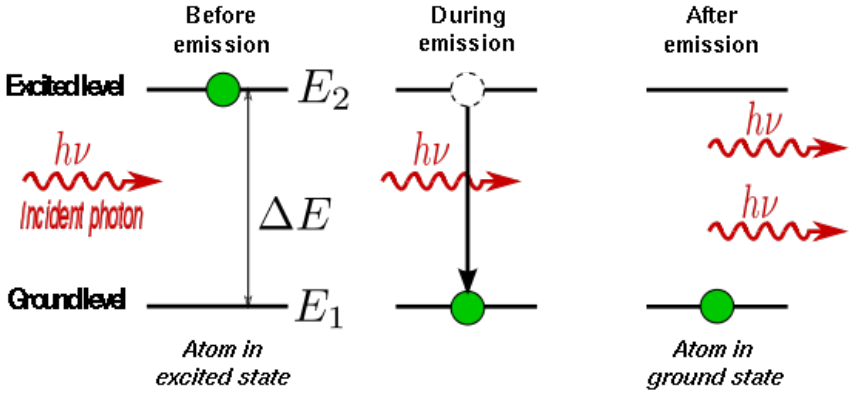
The basic principle of light emission

- EDFA (光學放大器）所使用到的兩種放光機制
- Interaction between light and atoms

Spontaneous emission



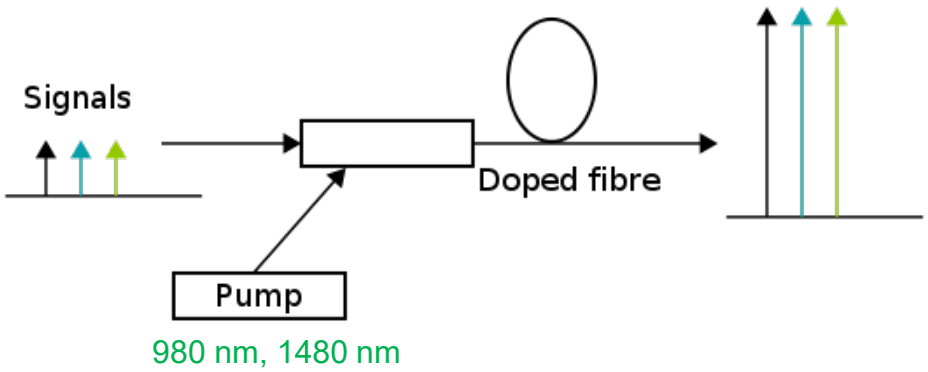
Stimulated emission

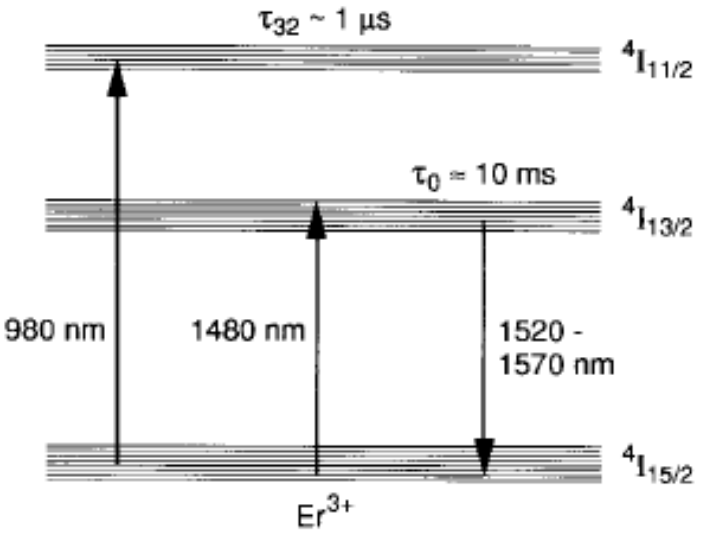


$$E_2 - E_1 = \Delta E = h\nu$$

- Optical amplifier：Amplify incident light through stimulated emission in most amplifiers.

- EDFA：Use erbium ions (Er^{3+}) fiber.
- Pump Wavelength : 980nm、1480nm
- Bandwidth : 1520nm~1570nm





- **Amplified Spontaneous Emission (ASE)** :

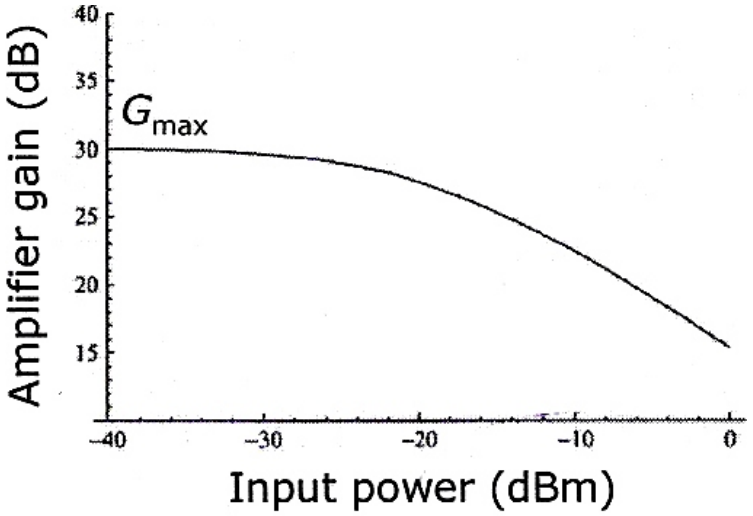
  The atoms can release their energy spontaneously without concerning with signal photon and it results in energy released with a random phase, polarization and direction. These random photons also become amplified by the same process. So ASE does not carry signal information. It contributes to noise and degrades the signal.

Gain saturation and SNR

- In the small signal regime,

$$P_{out} = P_{in} \times G_{\max}$$

As the input signal power increases, the gain will decrease as the EDFA reaches its saturation at a given pump power. This phenomenon is called EDFA gain saturation .



- The Signal-to-Noise Ratio (SNR) is defined as

$$SNR = \frac{average\ signal\ \ power}{noise\ \ power} = \frac{I_p^2}{\sigma^2}$$

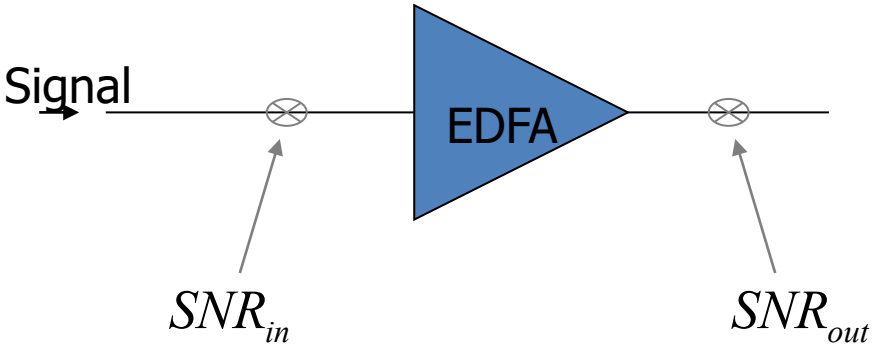
I_p *is the* average current, σ is the root-mean-square (RMS) value of the noise current.

- **Noise Figure(雜訊指數)：**
  To quantify the SNR degradation after the signal be amplified. It is the ratio of SNR_i to SNR_o.

$$F = \frac{SNR_{in}}{SNR_{out}}$$

- NF is commonly expresses in dB as

$$NF_{db} = 10 \bullet \log(NF)$$



- An NF approximation can be expressed as

$$NF = 2n_{sp}\frac{(G-1)}{G} + \frac{1}{G} \quad , \quad n_{sp} = \frac{P_{ASE}}{2h\nu B_o(G-1)}$$

- Here G is the gain of optical amplifier (linear unit), B_o is the optical bandwidth in Hz (the resolution of OSA), v is the frequency, h = 6.626×10^{-34} *J·S*, hv is photon energy, P_{ASE} is the amplified spontaneous emission noise power.
- n_{sp} is a constant called the spontaneous emission factor

實驗器材

- Tunable Laser (可調變雷射光源）

輸出光強度旋鈕

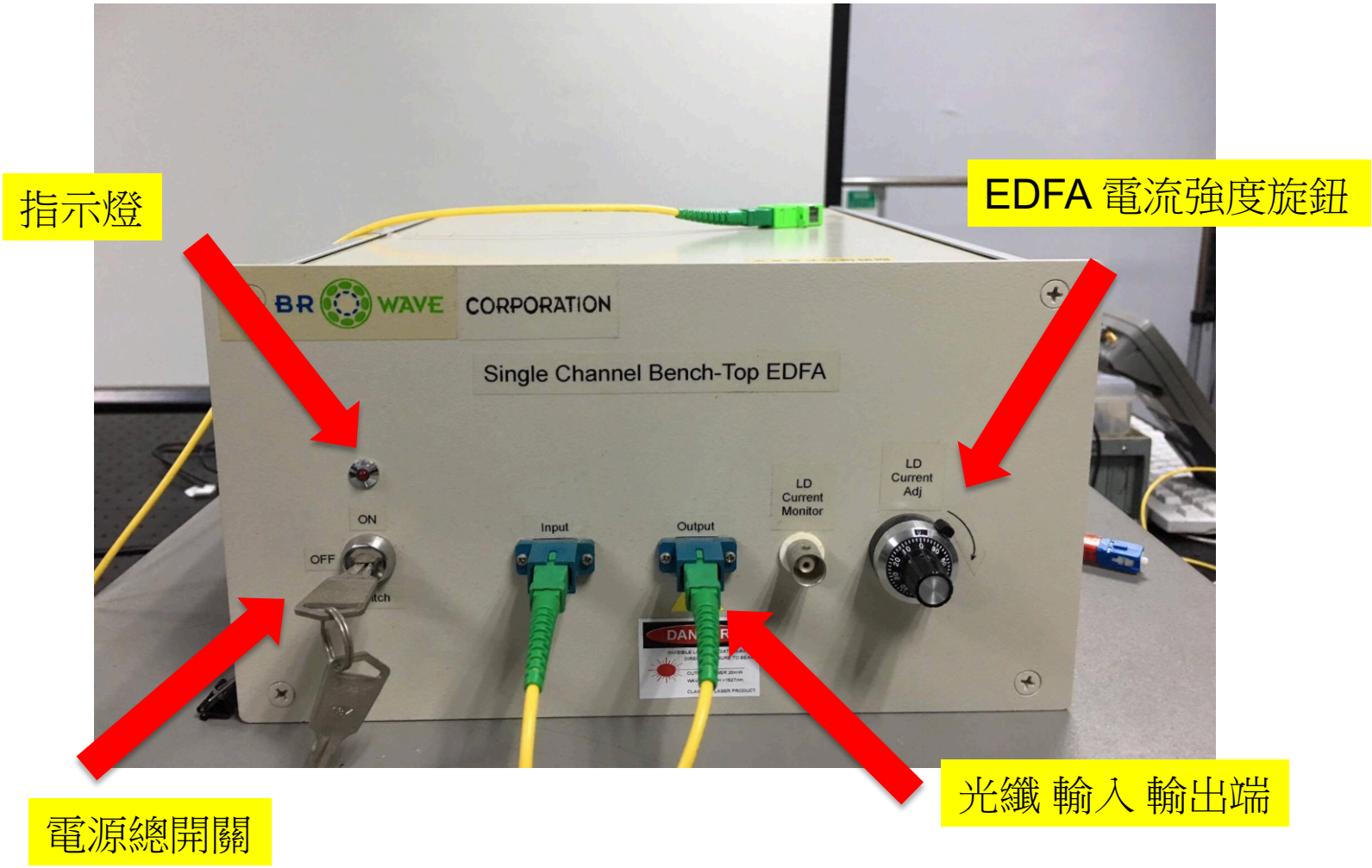
光訊號輸出鍵
on/off

電源總開關

指示燈 亮（輸出）
滅 （停止輸出）

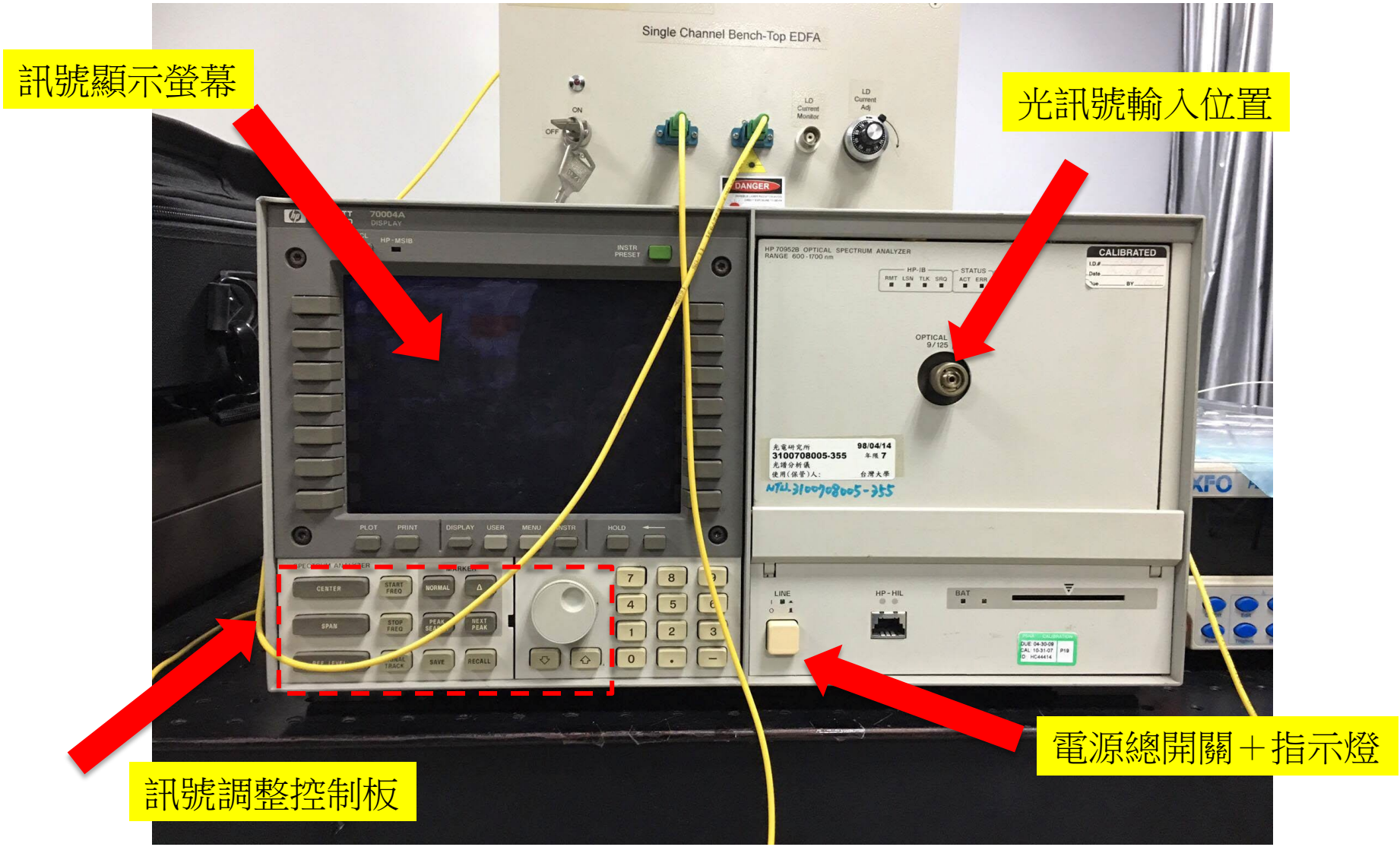
實驗器材

- EDFA (光學放大器)



實驗器材

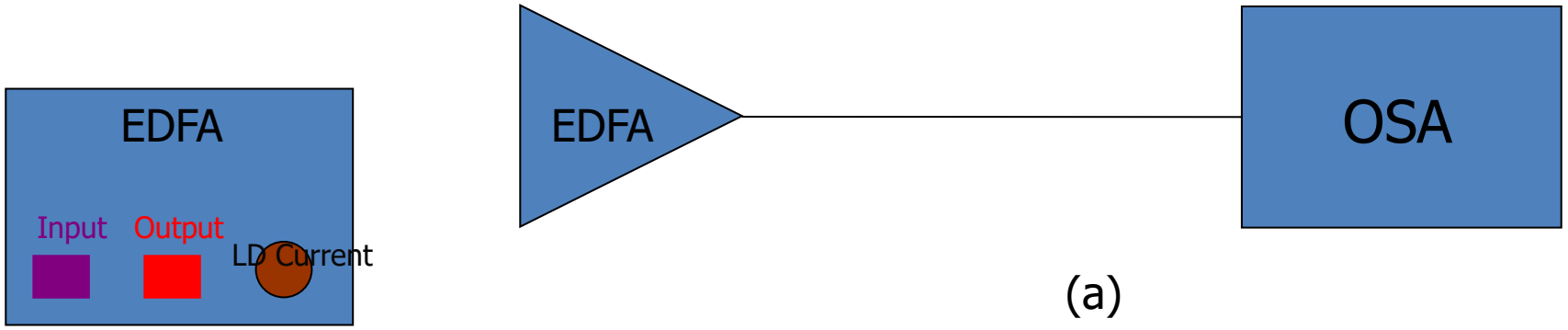
- OSA (光譜分析儀)



- 實驗步驟

1.Gain Bandwidth

- Figure (a), to measure spontaneous amplified emission (ASE), when the signal is not fed into EDFA. Connect EDFA output to OSA(Optical Spectrum Analyzer) through attenuator. In this setup, no signal is coupled into the fiber and only pump is. The output spectrum is ASE.

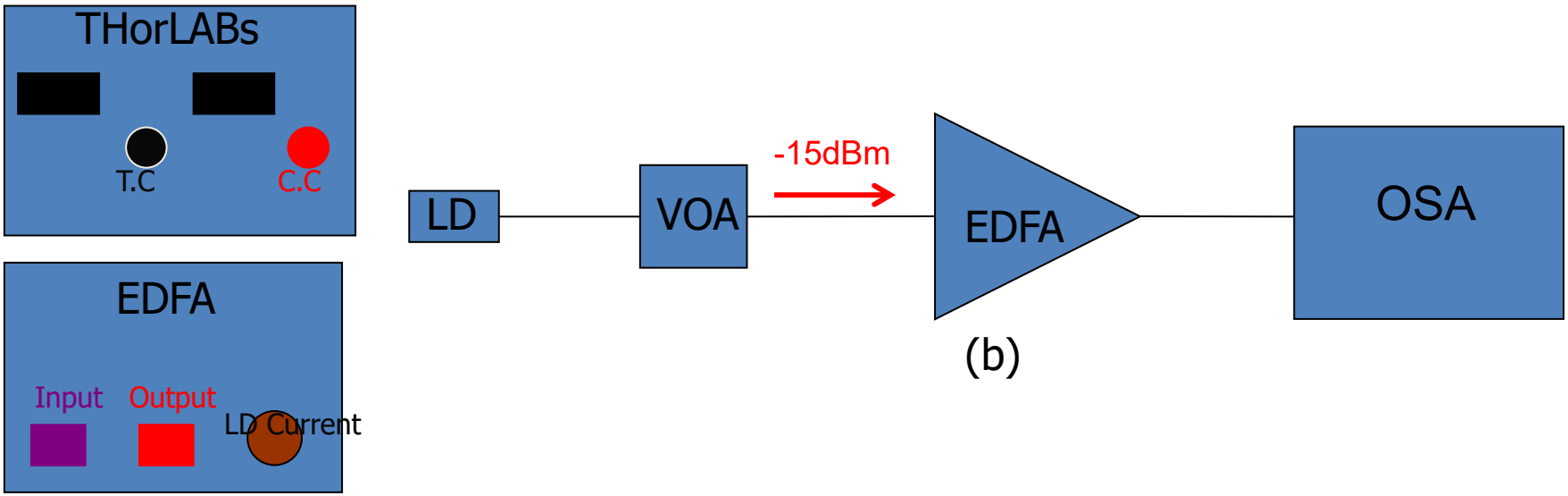


(a)

- 實驗步驟

2.Gain V.S. Pump Power

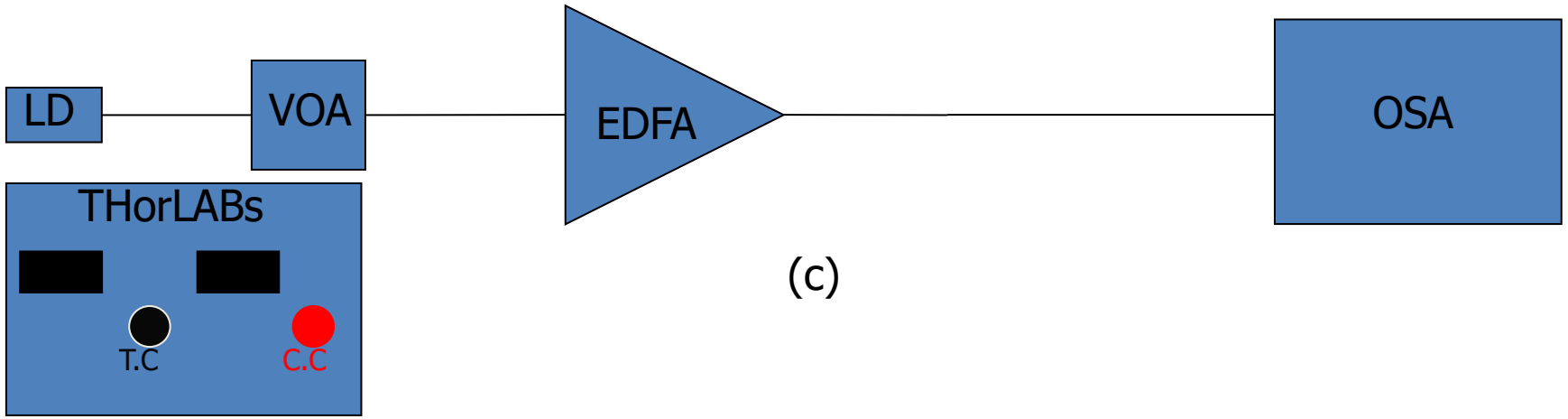
- Figure (b), Use the **variable optical attenuator** to set the fixed input power into the EDFA. To measure the signal gain versus the pump current, increase the EDFA pump current from 200mA to 400mA in 100mA increments while measuring optical output power.



- 實驗步驟

3.Gain Saturation

- Figure (c), Measure and record the EDFA output power for the input power levels from -30dBm to -5dBm, in step of 5dB, at different EDFA pump currents : 250. Plot the gain v.s. the input power and locate the input power with 3dB gain suppression. Compare the 3dB gain suppression input powers and the saturation output power level at the different pump current.



(c)

預報問題

- 說明EDFA架構與工作原理
- Optical Spectrum analyzer (OSA) 架構 應用 及工作原理

注意事項

攜帶數位相機紀錄波型和數據