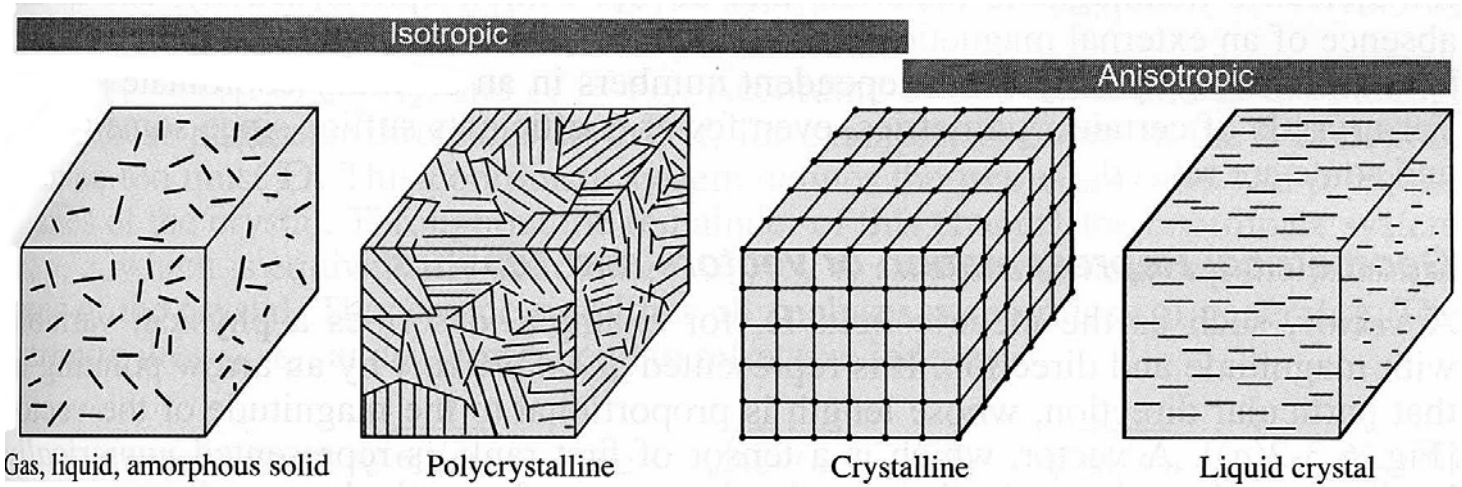
Different types of materials



Permittivity tensor

$$D_i = \sum_j \epsilon_{ij} E_j$$

$$\mathbf{D} = \boldsymbol{\epsilon}\mathbf{E}$$

Principal axes and principal refractive indexes

$$D_1 = \epsilon_1 E_1, \qquad D_2 = \epsilon_2 E_2, \qquad D_3 = \epsilon_3 E_3$$

$$n_1 = \sqrt{\epsilon_1/\epsilon_o}, \qquad n_2 = \sqrt{\epsilon_2/\epsilon_o}, \qquad n_3 = \sqrt{\epsilon_3/\epsilon_o}$$

Biaxial, uniaxial, and isotropic crystals

Biaxial crystal: All three principal refractive indexes are different.

Uniaxial crystal

$n_1 = n_2 = n_o$ Ordinary refractive index

$n_3 = n_e$ Extraordinary refractive index

$n_e > n_o$ Positive uniaxial

$n_e < n_o$ Negative uniaxial

Optic axis: *z* axis of a uniaxial crystal

Isotropic crystal $n_1 = n_2 = n_3$

Index ellipsoid

$$\mathbf{D} = \epsilon \mathbf{E}$$

$$\mathbf{E} = \epsilon^{-1} \mathbf{D}$$

$$\boldsymbol{\eta} = \epsilon_o \boldsymbol{\epsilon}^{-1}$$

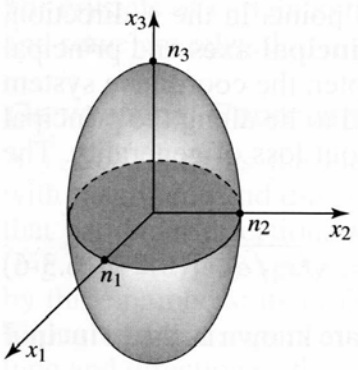
Electric impermeability tensor

$$\epsilon_o \mathbf{E} = \boldsymbol{\eta} \mathbf{D}$$

Index ellipsoid (optical indicatrix)

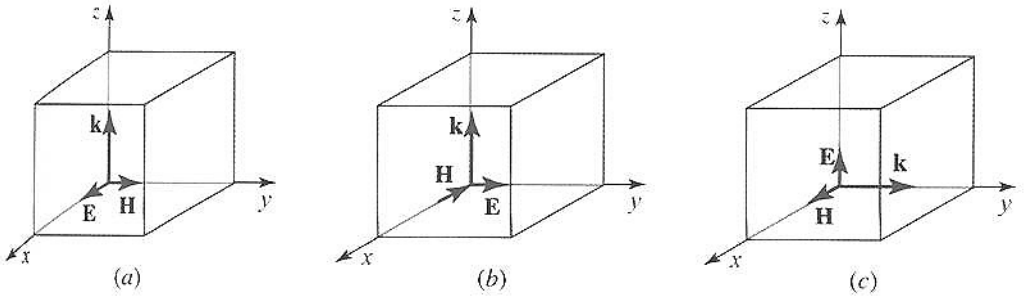
$$\sum_{ij} \eta_{ij} x_i x_j = 1, \qquad i, j = 1, 2, 3.$$

$$\frac{x_1^2}{n_1^2} + \frac{x_2^2}{n_2^2} + \frac{x_3^2}{n_3^2} = 1$$

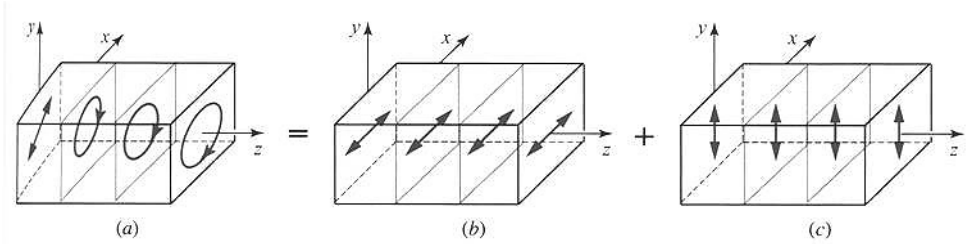


Propagation along a principal axis

Normal modes



Polarization along an arbitrary direction



Propagation in an arbitrary direction

Index-Ellipsoid Construction for Determining Normal Modes

Figure 6.3-6 illustrates a geometrical construction for determining the polarizations and refractive indexes n_a and n_b of the normal modes of a wave traveling in the direction of the unit vector $\hat{\mathbf{u}}$ in an anisotropic material characterized by the index ellipsoid:

$$\frac{x_1^2}{n_1^2} + \frac{x_2^2}{n_2^2} + \frac{x_3^2}{n_3^2} = 1.$$

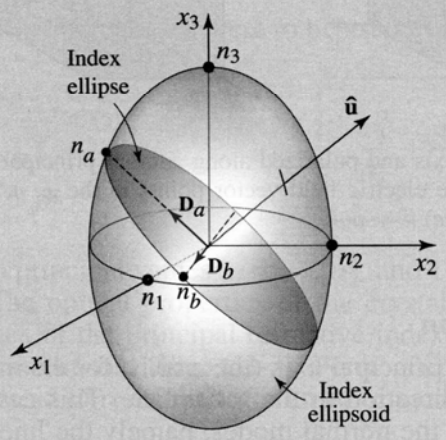
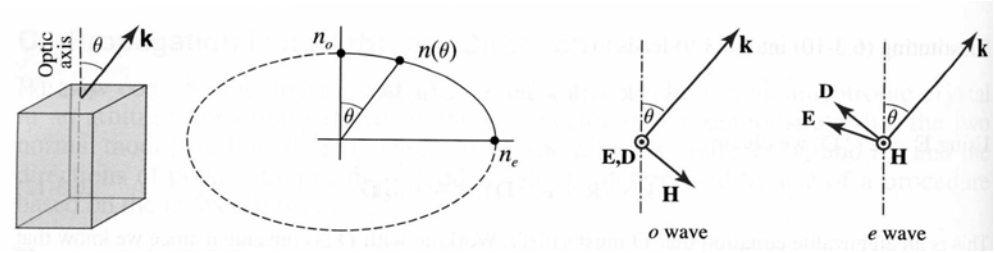


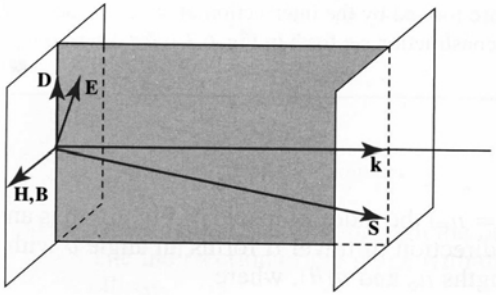
Figure 6.3-6 Determination of the normal modes from the index ellipsoid.

- Draw a plane passing through the origin of the index ellipsoid, normal to $\hat{\mathbf{u}}$. The intersection of the plane with the ellipsoid is an ellipse called the **index ellipse**.
- The half-lengths of the major and minor axes of the index ellipse are the refractive indexes n_a and n_b of the two normal modes.
- The directions of the major and minor axes of the index ellipse are the directions of the vectors $\mathbf{D}_a$ and $\mathbf{D}_b$ for the normal modes. These directions are orthogonal.
- The vectors $\mathbf{E}_a$ and $\mathbf{E}_b$ may be determined from $\mathbf{D}_a$ and $\mathbf{D}_b$ with the help of (6.3-5).

Uniaxial crystals

$$\frac{1}{n^2(\theta)} = \frac{\cos^2\theta}{n_o^2} + \frac{\sin^2\theta}{n_e^2}$$

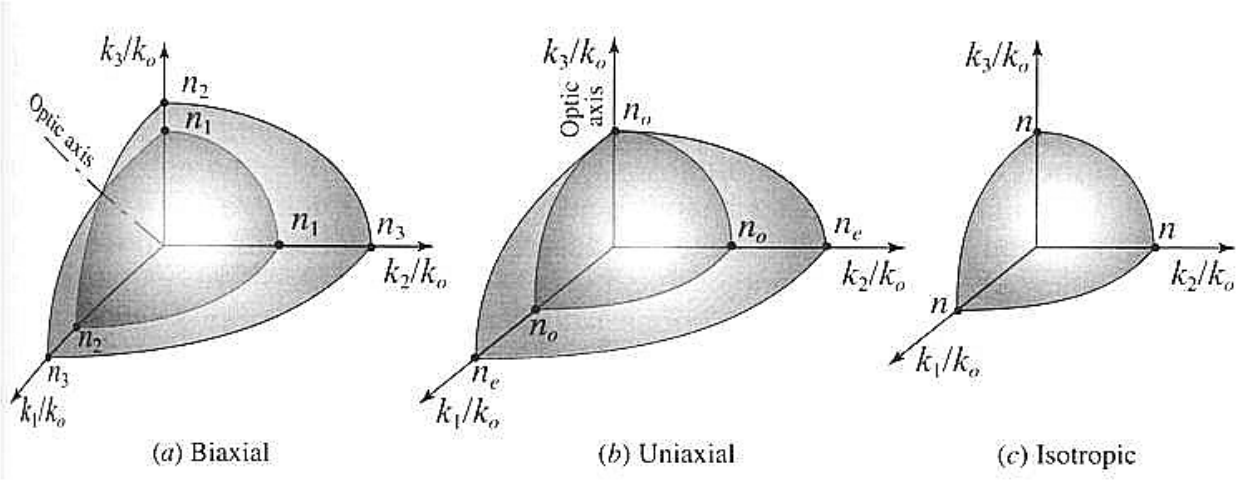




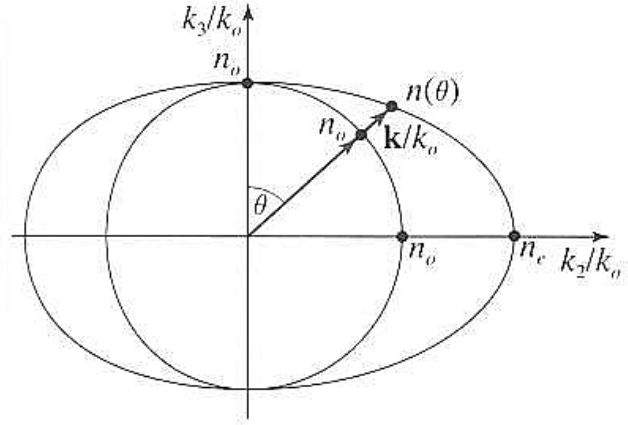
Dispersion relation and k surface

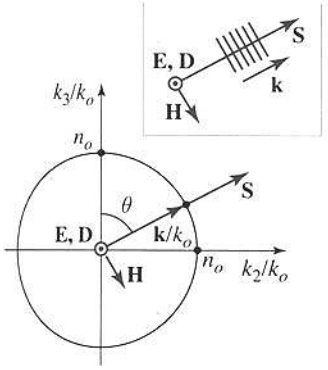
$$\mathbf{k} \times (\mathbf{k} \times \mathbf{E}) + \omega^2 \mu_o \epsilon \mathbf{E} = \mathbf{0}$$

$$\begin{bmatrix} n_1^2 k_o^2 - k_2^2 - k_3^2 & k_1 k_2 & k_1 k_3 \\ k_2 k_1 & n_2^2 k_o^2 - k_1^2 - k_3^2 & k_2 k_3 \\ k_3 k_1 & k_3 k_2 & n_3^2 k_o^2 - k_1^2 - k_2^2 \end{bmatrix} \begin{bmatrix} E_1 \\ E_2 \\ E_3 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$$

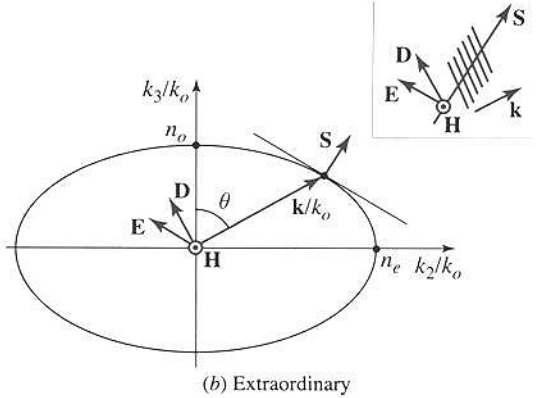


Uniaxial crystals





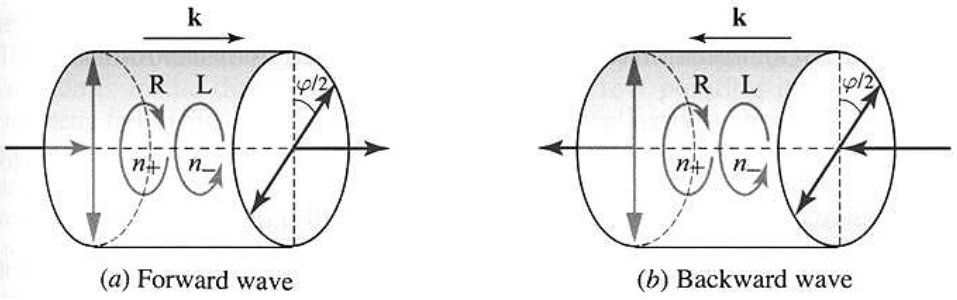
(*a*) Ordinary



(*b*) Extraordinary

Optical activity and magneto-optics

$$\rho = \frac{\pi}{\lambda_o}(n_- - n_+)$$

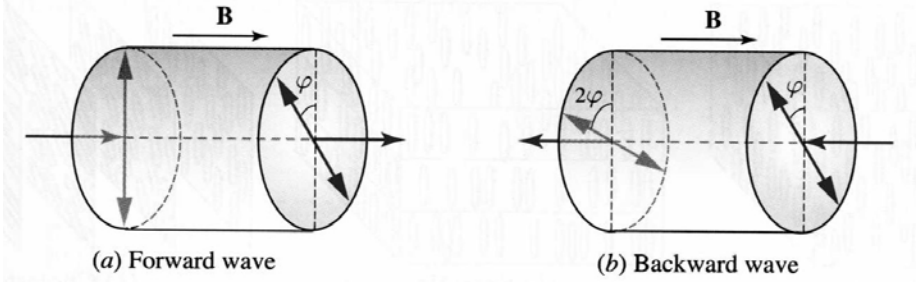


(a) Forward wave (b) Backward wave

$$\rho = \mathfrak{V}B$$

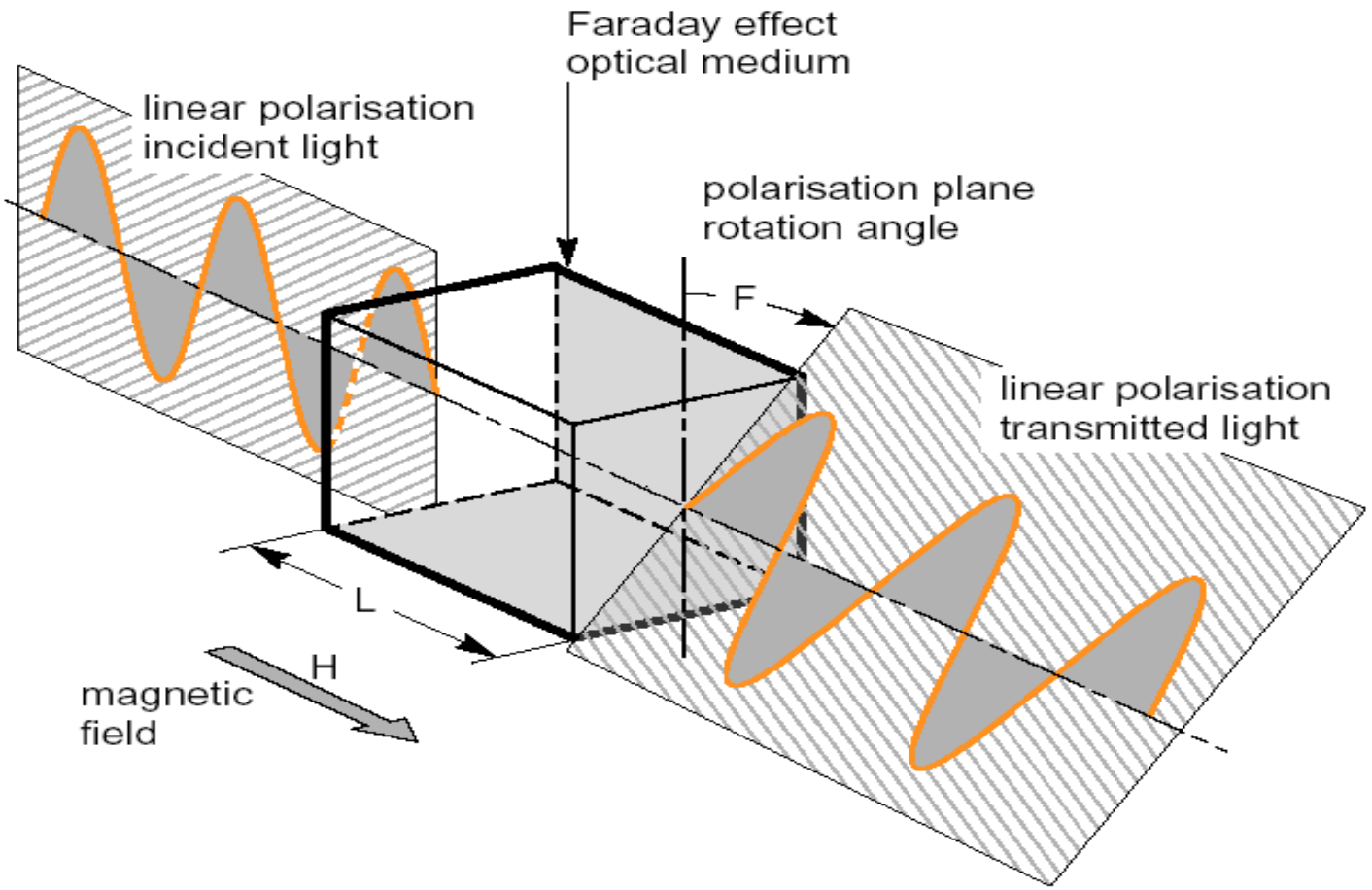
Faraday effect (Faraday rotation)

Verdet constant

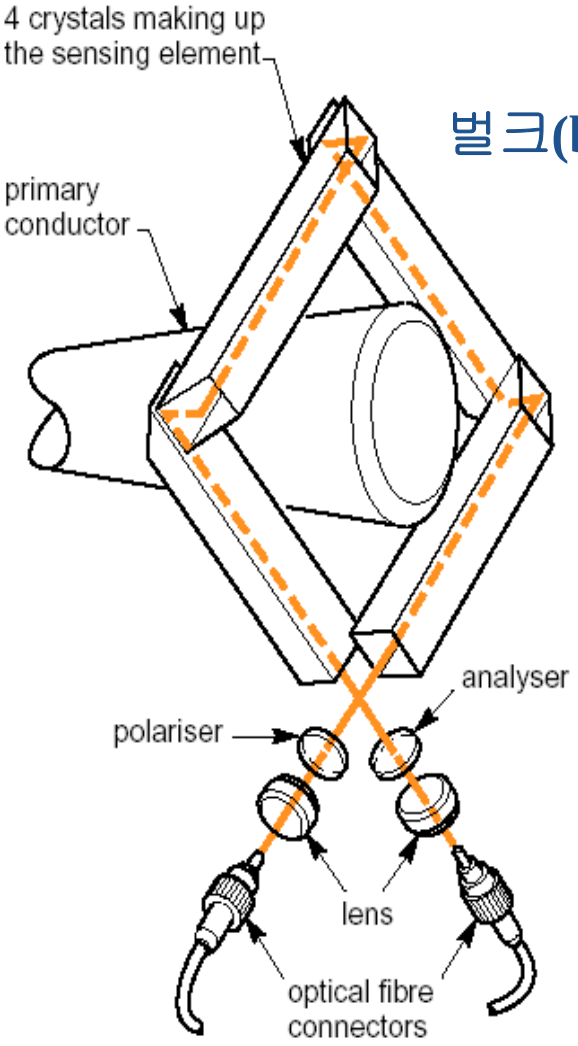


(a) Forward wave (b) Backward wave

편광 변화를 이용한 전류의 측정

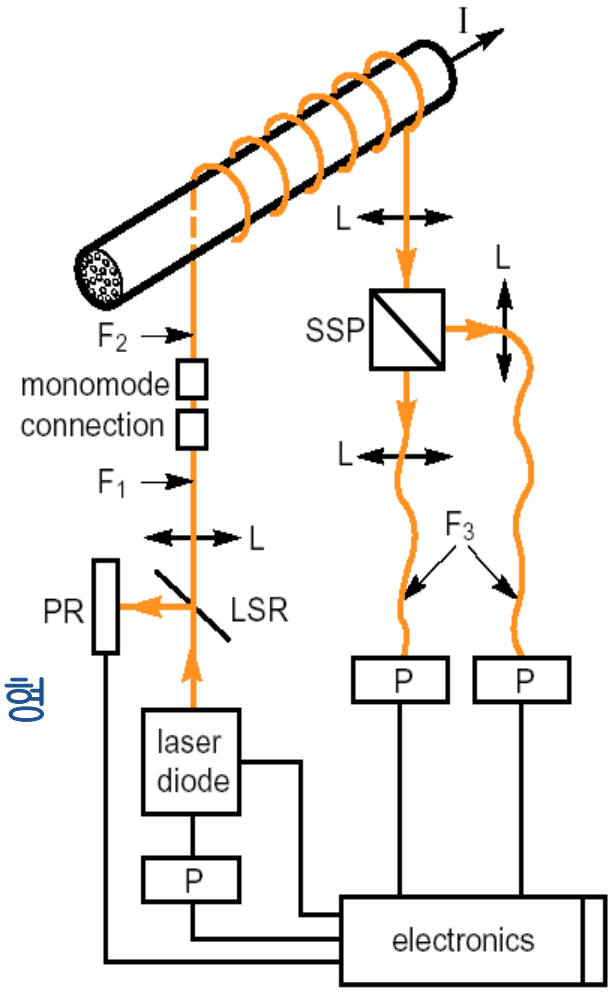


광 CT의 종류

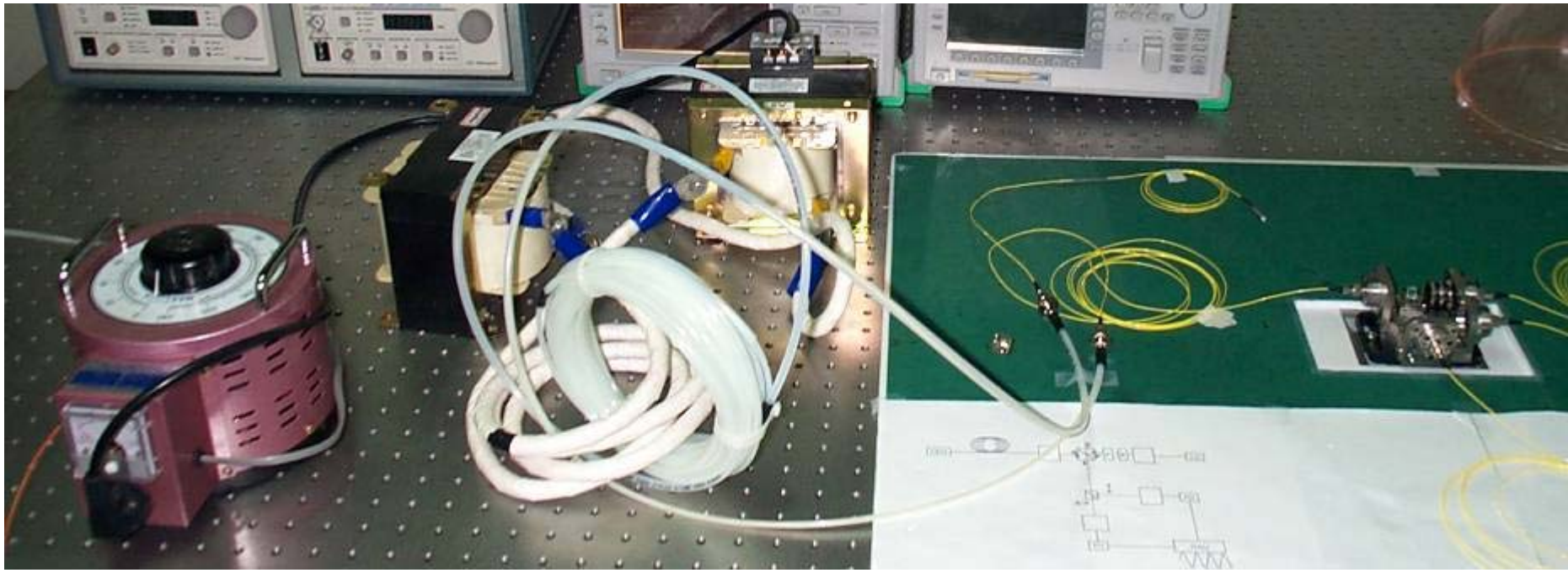


벌크(bulk)형

광섬유형



광 CT의 실험 Setup

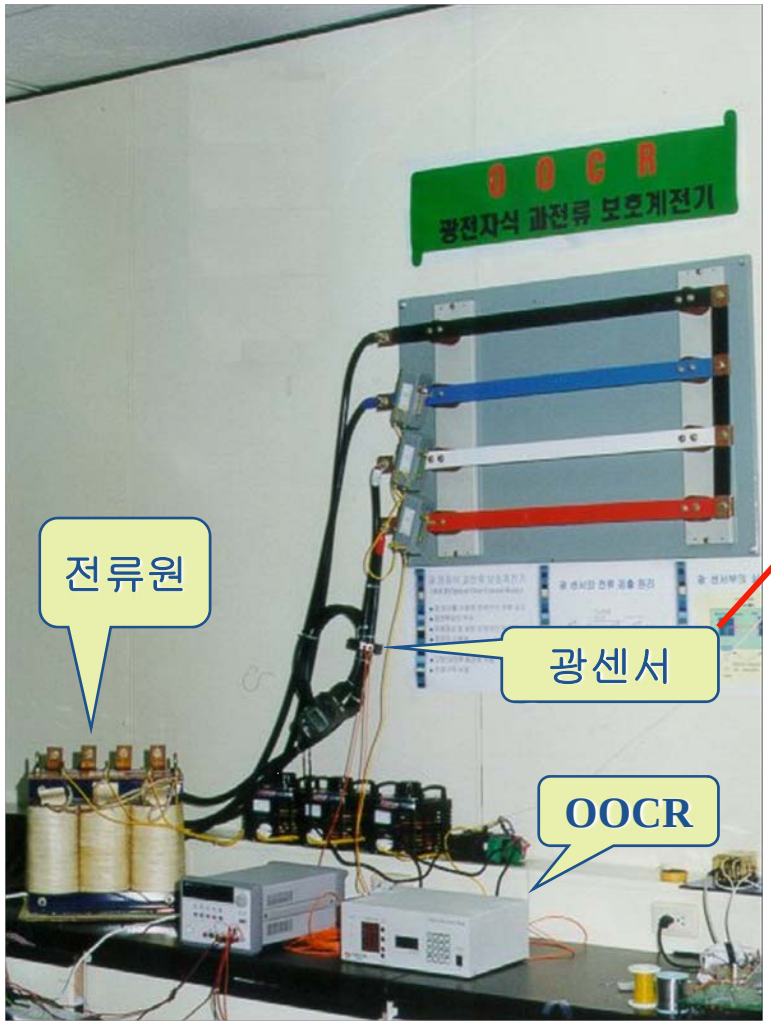


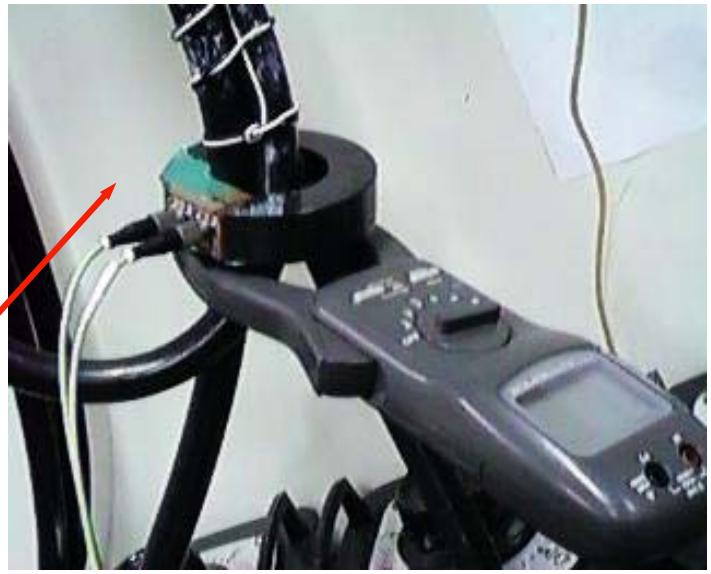
측정전류: 0~200 Ampere·Turns

광섬유 코일 회전 수 $N = 53$

56 twist/meter

광 CT를 이용한 과전류 보호계전기





한국전력 전력연구원