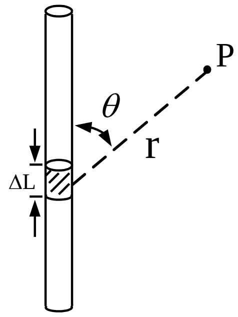
# Biot-Savart 畢奧特-薩爾發定律

1. 導體某一段ΔL 對外一點之磁場強度 $H_P = \dfrac{I \cdot \Delta L \cdot \sin\theta}{4\pi r^2}$

證明：




P 處放置一單位磁極 M，距 r 米處之球型表面磁通密度 $B = \dfrac{M}{4\pi r^2}$

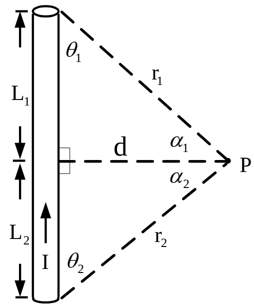
載 I 安培導體置於球表面其受力為

$$F = B \cdot I \cdot \Delta L \cdot \sin\theta = \frac{M}{4\pi r^2} I \cdot \Delta L \cdot \sin\theta$$

$$H_P = \frac{F}{M} = \frac{I \cdot \Delta L \cdot \sin\theta}{4\pi r^2}$$

2. 有限長度導體對外一點之磁場強度 $H_P = \dfrac{I}{4\pi R}\left(\sin\alpha_1 + \sin\alpha_2\right)$

證明：




$$l = R\cot\theta$$

$$dl = R\csc^2\theta d\theta$$

$$H_P = \int \frac{I \cdot \sin\theta}{4\pi r^2} dl = \int_{\theta_2}^{\theta_1} \frac{I \cdot \sin\theta \cdot R\csc^2\theta}{4\pi (R/\sin\theta)^2} d\theta = \int_{\theta_2}^{\theta_1} \frac{I \cdot \sin\theta}{4\pi R} d\theta = \frac{I}{4\pi R}[\cos\theta_1 + \cos\theta_2]$$

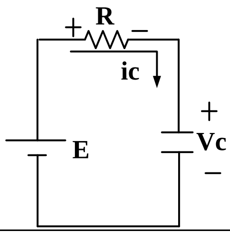
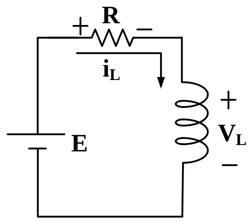
$$= \frac{I}{4\pi R}[\sin\alpha_1 + \sin\alpha_2]$$

3. 無限長導線對外一點之磁場強度 $H_P = \dfrac{I}{2\pi R}$

4. 圓形線圈

$$H_P = \frac{I \cdot \Delta L \cdot \sin\theta}{4\pi r^2} = \frac{I \cdot 2\pi r \cdot \sin 90^\circ}{4\pi r^2} = \frac{I}{2r} \text{(單匝)}$$

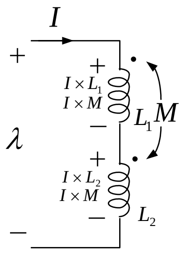
$$H_P = \frac{NI}{2r} \text{(N匝)}$$

| | 電場 | 磁場 |
|---|---|---|
| 庫侖定律 | $\vec{F} = K\frac{Qq}{d^2}$<br>$(K = \frac{1}{4\pi\epsilon_0\epsilon_r} = 9 \times 10^9(\epsilon_0 = 8.85 \times 10^{-12}))$ | $\vec{F} = K\frac{Mm}{d^2}$<br>$(K = \frac{1}{4\pi\mu_0\mu_r} = 6.33 \times 10^4(\mu_0 = 4\pi \times 10^{-7}))$ |
| 強度 | $\vec{E} = \frac{F}{q} = K\frac{q}{d^2}$ | $\vec{H} = \frac{F}{m} = K\frac{M}{d^2}$ |
| 動勢 | $V = \frac{W}{q} = \frac{F \cdot d}{q} = K\frac{q}{d}$ | $Ƒ = \frac{W}{m} = K\frac{M}{d}$ |
| 高斯定律 | $\Phi$(庫侖) = q(庫侖)[MKS]<br>$\Phi$(線) = $4\pi$q(靜庫)[CGS] | $\varphi$(韋伯) = m(韋伯)[MKS]<br>$\varphi$(線) = $4\pi$m(靜磁)[CGS] |
| 密度 | $D = \frac{\Phi}{A} = \epsilon E$ | $B = \frac{\phi}{A} = \mu H$ |
| 定律 | $V = IR$ | $Ƒ = NI = \phi Ɍ = Hl \ (Ɍ = \frac{l}{\mu A})$ |
| 結構 | $R = \rho\frac{l}{A}$ $\quad C = \epsilon\frac{A}{d}$ $\quad Ɍ = \frac{l}{\mu A}$ | |
| 公式 | $Q = CV = It$ | $\lambda = LI = N\phi = Et\ (E = N\frac{\Delta\phi}{\Delta t})$ |
| 電路分析 | $i_C = C\frac{dv_c}{dt}$<br> | $v_L = L\frac{di_L}{dt}$<br> |
| 能量 | $W = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C}$ | $W = \frac{1}{2}\lambda I = \frac{1}{2}N\phi I = \frac{1}{2}LI^2$ |
| 單位換算 | 1 牛頓(Nt) = $10^5$ 達因(dyne)<br>1 庫侖(C) = $3 \times 10^9$ 靜庫(S.C.)<br>1 伏特(V) = $\frac{1}{300}$ 靜伏(S.V.)<br>1 焦耳(J) = $10^7$ 爾格(erg) | 1 韋伯(wb) = $10^8$ 馬克斯威爾(Maxwell)<br>= $10^8$ 線(line) = $\frac{1}{4\pi} \times 10^8$ 靜磁<br>1 $wb/m^2$ = 1 特斯拉(Tesla) = $10^4$ 高斯(Gauss) |

考慮互感之等效電感量計算

將磁通鏈λ類比為電壓V，電感類比為電阻，利用驅動點阻抗法觀念，求串聯及並聯考慮互感等效電感值。

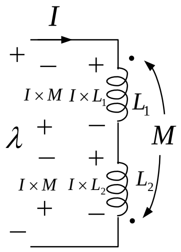
1. 串聯互助




$$\lambda = I\times L_1 + I\times M + I\times L_2 + I\times M$$

$$\frac{\lambda}{I} = L_T = L_1 + L_2 + 2M$$

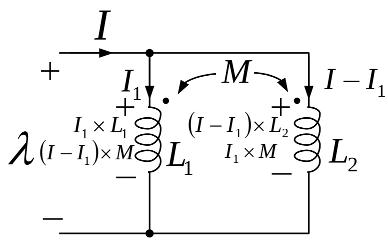
2. 串聯互消




$$\lambda = I\times L_1 - I\times M + I\times L_2 - I\times M$$

$$\frac{\lambda}{I} = L_T = L_1 + L_2 - 2M$$

3. 並聯互助

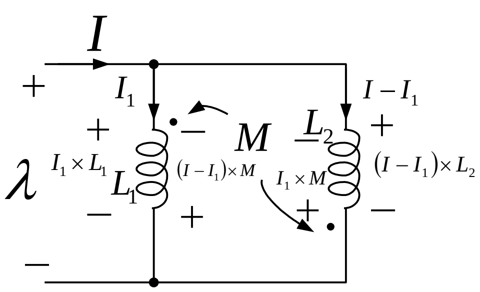



$$\begin{cases} \lambda = I_1\times L_1 + M\times(I-I_1) \text{..........................................} (1) \\ I_1\times L_1 + M\times(I-I_1) = M\times I_1 + L_2\times(I-I_1) \text{..................} (2) \end{cases}$$

$$(2)\text{式整理} \Rightarrow I_1 = \frac{L_2 - M}{L_1 + L_2 - 2M}$$

$$\text{帶入}(1)\text{式} \Rightarrow \frac{\lambda}{I} = L_T = \frac{L_1\times L_2 - M^2}{L_1 + L_2 - 2M}$$

4. 並聯互消

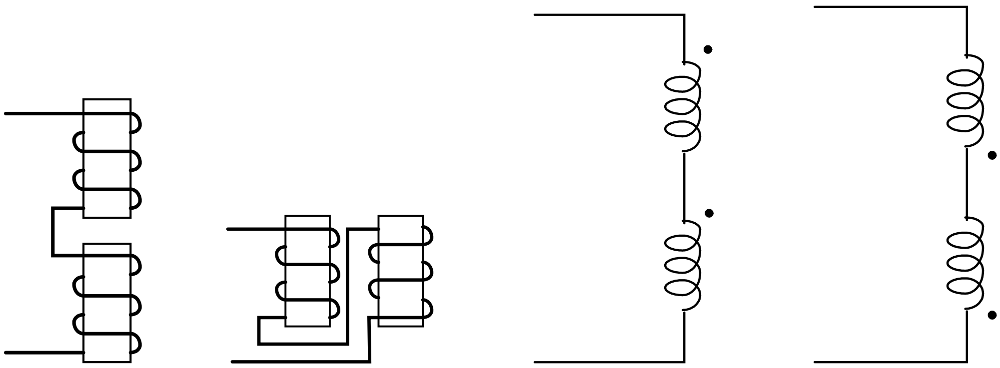



$$\begin{cases} \lambda = I_1\times L_1 - M\times(I-I_1) \text{..........................................} (1) \\ I_1\times L_1 - M\times(I-I_1) = L_2\times(I-I_1) - M\times I_1 \text{..................} (2) \end{cases}$$

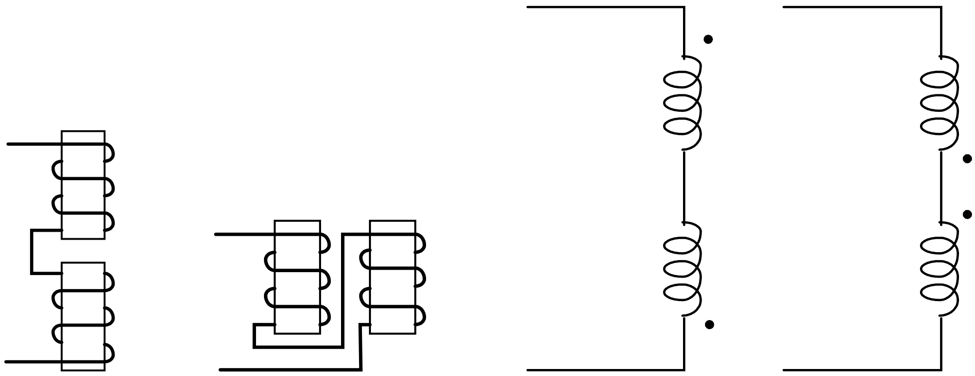
$$(2)\text{式整理} \Rightarrow I_1 = \frac{L_2 + M}{L_1 + L_2 + 2M}$$

$$\text{帶入}(1)\text{式} \Rightarrow \frac{\lambda}{I} = L_T = \frac{L_1\times L_2 - M^2}{L_1 + L_2 + 2M}$$

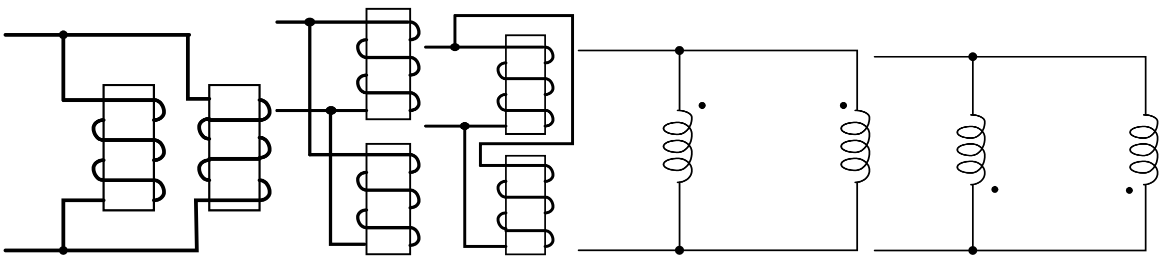
5.　串聯互助型式的電路連接與電路符號



6.　串聯互消型式的電路連接與電路符號



7.　並聯互助型式的電路連接與電路符號



8.　並聯互消型式的電路連接與電路符號