EE5801 EMC

Tutorial 6 – Cables and Cabling

1.
The magnetic field strength from an infinitely long current-carrying straight wire is

$$H = \frac{I}{2\pi r} \tag{1}$$

where I is the current, r is the distance between the observation point and the wire.

From (1), the magnetic field strength at point $(x, 0)$ for the case in Fig. 1 is

$$\begin{aligned} H &= \frac{I}{2\pi(x-d)} - \frac{I}{2\pi(x+d)} \\ &= \frac{I}{\pi}\frac{d}{(x^2-d^2)} \\ &\approx \frac{I}{\pi}\frac{d}{x^2} \text{ for } x \gg d \end{aligned} \tag{2}$$

Therefore, when $x \gg d$, H is inversely proportional to x^2 and is proportional to d.

The significance of (2) is that when the two wires are close to each other, H is much smaller compared to that of single wire/or two wires far apart.

2.
i) To calculate the spacing between the cables and the ground plane in earth,

$$h = \delta = \frac{1}{\sqrt{\pi f \mu \sigma}} = \frac{1}{\sqrt{\pi \times 50 \times 4 \times 4\pi \times 10^{-7} \times 10}} \approx 11.3 \text{ m} \tag{3}$$

The mutual inductance between the two cables is

$$\begin{aligned} M &= \frac{\mu_0 \mu_\mathrm{r}}{4\pi} \ln\left[1 + \left(\frac{2h}{d}\right)^2\right] \cdot l \\ &= 4 \times 10^{-7} \times \ln[1 + (2 \times 11.3)^2] \cdot 300 \\ &= 7.49 \times 10^{-4}\, H \end{aligned} \tag{4}$$

Hence, the induced voltage on the second cable is

$$\begin{aligned} V_\mathrm{N} &= \omega M I \\ &= 2 \times \pi \times 50 \times 7.49 \times 10^{-4} \times 63000 \\ &\approx 14824 \text{ V} \end{aligned} \tag{5}$$

ii) As can be seen from the mutual inductance formula, the inducted voltage can be reduced by reducing h and/or increasing d.

a) to reduce h, we can increase the conductivity;
b) to increase d, we can increase cable separation.