5.2 Uniform Plane Wave in Lossless Dielectric

For a perfect or lossless dielectric the properties are given as, $\sigma = 0$, $\epsilon = \epsilon_o \epsilon_r$ and $\mu = \mu_o \mu_r$. In both free space medium and lossless dielectric medium $\sigma = 0$, so the analysis of the wave propagation is much similar in both cases. But as the permeability and permittivity values are different then expression in both cases gets varied.

The Velocity of propagation, $v = (1/\sqrt{(\mu \epsilon)})$

$$= (1/\sqrt{(\mu_o \mu_r \epsilon_o \epsilon_r)}) = 1/(\sqrt{(\mu_o \epsilon_o)} \sqrt{(\mu_r \epsilon_r)}) = 1/(\sqrt{(\mu_o \epsilon_o)}/ \sqrt{(\mu_r \epsilon_r)})$$

Therefore $v = c/ \sqrt{(\mu_r \epsilon_r)}$ m/s

The propagation constant,

$$\gamma = \sqrt{[jw\mu (\sigma + jw \epsilon)]} \text{ m}^{-1}$$

By substituting $\sigma = 0$, $\epsilon = \epsilon_o \epsilon_r$ and $\mu = \mu_o \mu_r$ in the above equation for a perfect or lossless dielectric, we get

$$\gamma = +/- jw \sqrt{(\mu\epsilon)} \text{ m}^{-1}$$

And also attenuation constant, $\alpha = 0$

The phase constant,

$$\beta = w \sqrt{(\mu \epsilon)} \text{ rad/m}$$

Intrinsic Impedance,

$$\eta = \sqrt{[(jw\mu) / (\sigma + jw \epsilon)]} \text{ ohms}$$

$$= \sqrt{(\mu_o/ \epsilon_o)} \sqrt{(\mu_r/ \epsilon_r)}$$

$$= \eta_o\sqrt{(\mu_r/ \epsilon_r)}$$

$$\eta = 377\sqrt{(\mu_r/ \epsilon_r)} \text{ ohms}$$