Rectangular cavity has described by single scalar function Ax (x component of the magnetic vector potential). The wave equation becomes,

$$\Delta^2 Ax + K^2 Ax = 0$$

$$Ax = X(x)\ Y\ (y)\ Z(z)$$

The Eigen value equation is,

$$Kx^2 + Ky^2 + Kz^2 = K^2$$

Here Kx, Ky, Kz are the wave numbers along the x,y,z directions respectively. The electric field components inside the cavity are related to vector potential Ax.

$$\text{Ex} = -J\frac{1}{w\mu\varepsilon}\left(\frac{\partial^2}{\partial x^2} + K^2\right)Ax$$

$$\text{Ey} = -J\frac{1}{w\mu\varepsilon}\left(\frac{\partial^2 Ax}{\partial x\partial y}\right)Ax$$

$$\text{Ez} = -J\frac{1}{w\mu\varepsilon}\left(\frac{\partial^2 Ax}{\partial x\partial z}\right)$$

$$\text{Hx} = 0$$

$$\text{Hy} = \frac{1}{\mu}\left(\frac{\partial Ax}{\partial z}\right)$$

$$\text{Hz} = -\frac{1}{\mu}\left(\frac{\partial Ax}{\partial y}\right)$$

Applying harmonic functions in the equation (3.3) should derive the general solutions. That particular solutions depends on the boundary conditions. The boundary conditions are applied as per the x, y, and z coordinates where cavity is placed.

$$\text{Ey}(\text{x}' = 0, 0 \leq y' \leq L, 0 \leq z' \leq W) = \text{Ey}(\text{x}' = h, 0 \leq y' \leq L, 0 \leq z' \leq W) = 0$$

$$\text{Hy}(0 \leq x' \leq h, 0 \leq y' \leq L, z' = 0) = \text{Hy}(0 \leq x' \leq h, 0 \leq y' \leq L, z' = W) = 0$$

$$\text{Hz}(0 \leq x' \leq h, y' = 0, 0 \leq z' \leq W) = \text{Hy}(0 \leq x' \leq h, y' = L, 0 \leq z' \leq W) = 0$$

From this boundary conditions, we can simply derive the wave numbers,

$$\text{Kx} = \left(\frac{m\pi}{h}\right) \qquad m = 0, 1, 2 \ldots$$

$$\text{Ky} = \left(\frac{p\pi}{W}\right) \qquad p = 0, 1, 2 \ldots$$

$\text{Kz} = \left(\frac{n\pi}{L}\right)$ n = 0, 1, 2…

Here [m = n = p ≠ 0]. The equation (3.5) becomes,

$$Kx^2 + Ky^2 + Kz^2 = \left(\frac{m\pi}{h}\right)^2 + \left(\frac{p\pi}{W}\right)^2 + \left(\frac{n\pi}{L}\right)^2 = K^2 = w^2\mu\varepsilon$$

The resonant frequencies for the cavity are given by,

$$(\text{Fr})\ \text{mnp} = \frac{1}{2\pi\sqrt{\mu\varepsilon}}\sqrt{\left(\frac{m\pi}{h}\right)^2 + \left(\frac{p\pi}{W}\right)^2 + \left(\frac{n\pi}{L}\right)^2}$$

For dominant mode the equation (3.17) should get lowest resonant frequency at TM 010.

$$(\text{Fr})\ 010 = \frac{1}{2L\sqrt{\mu\varepsilon}} = \frac{v}{2L\sqrt{\varepsilon \text{r}}}$$