Çankaya University – ECE Department – ECE 572

2012 Spring Term **02.03.2012**

Experiment : Finding beta and propagating modes of the fibre

Experiment coded in MATLAB is given on course webpage, ece572.cankaya.edu.tr.

1. Download the experiment file into your computer.
2. Run the file, observe the OPs. Try to follow what is intended and what is happening
3. This experiment is intended to find the propagation constants (β) and identify the propagating modes in a step index fibre. For this purpose, the characteristic equation (CE) is written for both HE_{vm} - EH_{vm} and TE_{0m} – TM_{0m}. Note that the first (and in case of TM_{0m} the second as well) lines are in the original form of CE, but they create singularities due to zero crossings of Bessel functions in the denominator. Hence, they are eliminated by multiplying both sides of the equation by the Bessel function of the denominator. These are the forms used to plot both graphs .
4. In the first graph, we see in 3D the plot of CE. This picture helps us identify the zero crossings (zeros, m) of CE at selected v parameter for all modes in question. The second graph (contour plot) displays the zero crossing more clearly on a two dimensional plane and is merely the contour plot of the first graph with constant V circles added.
5. By incrementing v in the range 1 to 8, find the HE_{vm} and EH_{vm} modes for V values up to 10. Identify these modes one by one and their cut-off V values. Tabulate these results in your lab notebook.
6. By the other CE equations (further down) in the programme, find the TE_{0m} and TM_{0m} modes for V values up to 10. Identify these modes one by one and their cut-off V values. Tabulate these results in your lab notebook.
7. Find and compare the beta values from the graphs produced by this m file, Fig. 2.18 of Keiser (pasted below) and Fig. 2.5 of Agrawal (pasted below). Repeat this exercise for at least 3 different V values and 10 modes.

Sample calculation for β : Relevant equations and numeric settings are shown below

$V = ak\left(n_1^2 - n_2^2\right)^{0.5}$, $n_1 = 1.5,\ n_2 = 1.47,\ \lambda = 1.55$ μm, $k = 2\pi/\lambda = 4.0537\times10^6$

$k_1 = 2\pi n_1/\lambda = 6.0805\times10^6,\ k_2 = 2\pi n_2/\lambda = 5.9589\times10^6$

$$\beta = \left(\frac{w_n^2}{a^2} + k_2^2\right)^{0.5} = \left(k_1^2 - \frac{u_n^2}{a^2}\right)^{0.5}$$ Beta calculation from the graph given by m file of MATLAB

$\beta = k\times$ the normalized value read from the vertical axis of Fig. 2.18 of Keiser $= k\left(\frac{n_1 - n_2}{9}\times \text{intersection} + n_2\right)$

$\beta = k\left[b\left(n_1 - n_2\right) + n_2\right]$ Beta calculation from Fig. 2.5 of Agrawal

Now, take $V = 4$, thus $a = V/\left[k\left(n_1^2 - n_2^2\right)^{0.5}\right] = 3.3058\times10^{-6}$ m , then by selecting TE_{01} mode (relevant graph pasted below) and calculating from the relevant intersections of the graphs, we find

$$\beta = \left(\frac{w_n^2}{a^2} + k_2^2 \right)^{0.5} = 6.0146 \times 10^6, \quad \beta = \left(k_1^2 - \frac{u_n^2}{a^2} \right)^{0.5} = 6.0124 \times 10^6 \quad \text{from the graph of m file}$$

$$\beta = k\left(\frac{n_1 - n_2}{9} \times \text{intersection} + n_2 \right) = k\left(\frac{n_1 - n_2}{9} \times 4.1 + n_2 \right) = 6.0143 \times 10^6 \quad \text{from Fig. 2.18 of Keiser}$$

$$\beta = k\left[b\left(n_1 - n_2\right) + n_2 \right] = k\left[0.48\left(n_1 - n_2\right) + n_2 \right] = 6.0173 \times 10^6 \quad \text{from Fig. 2.5 of Agrawal}$$

8. Include your general comments for the experiment

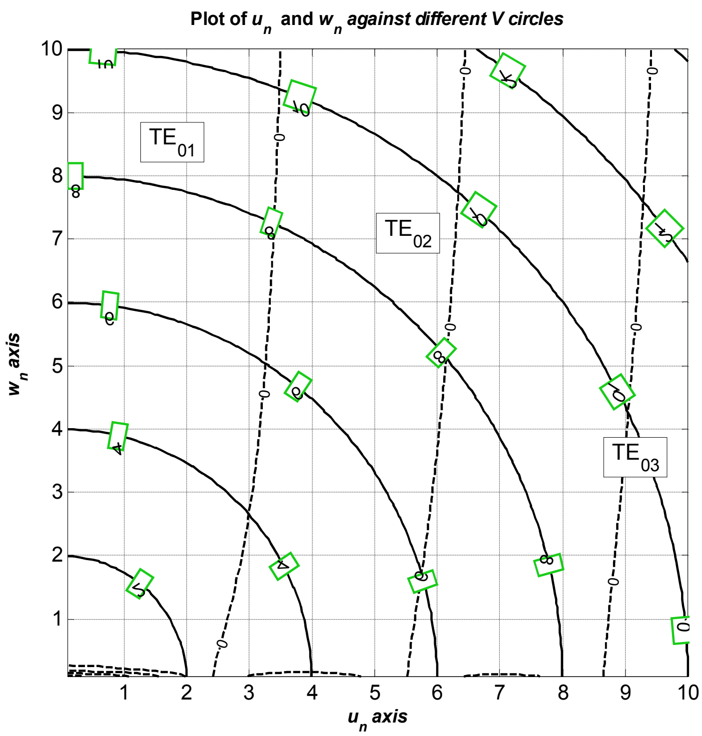

Fig. From the m file used for sample calculation above.

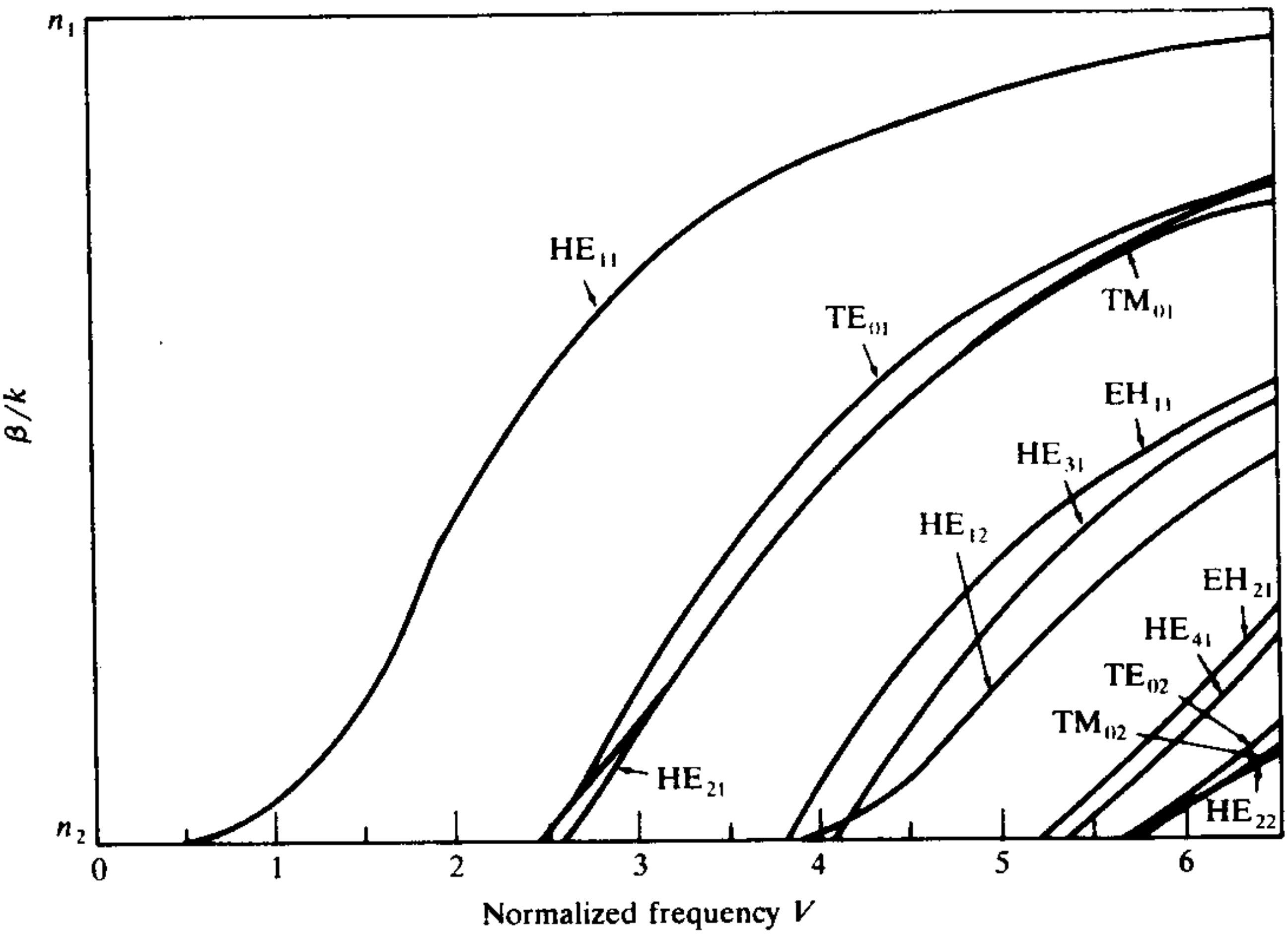

Fig. 2.18 of Keiser

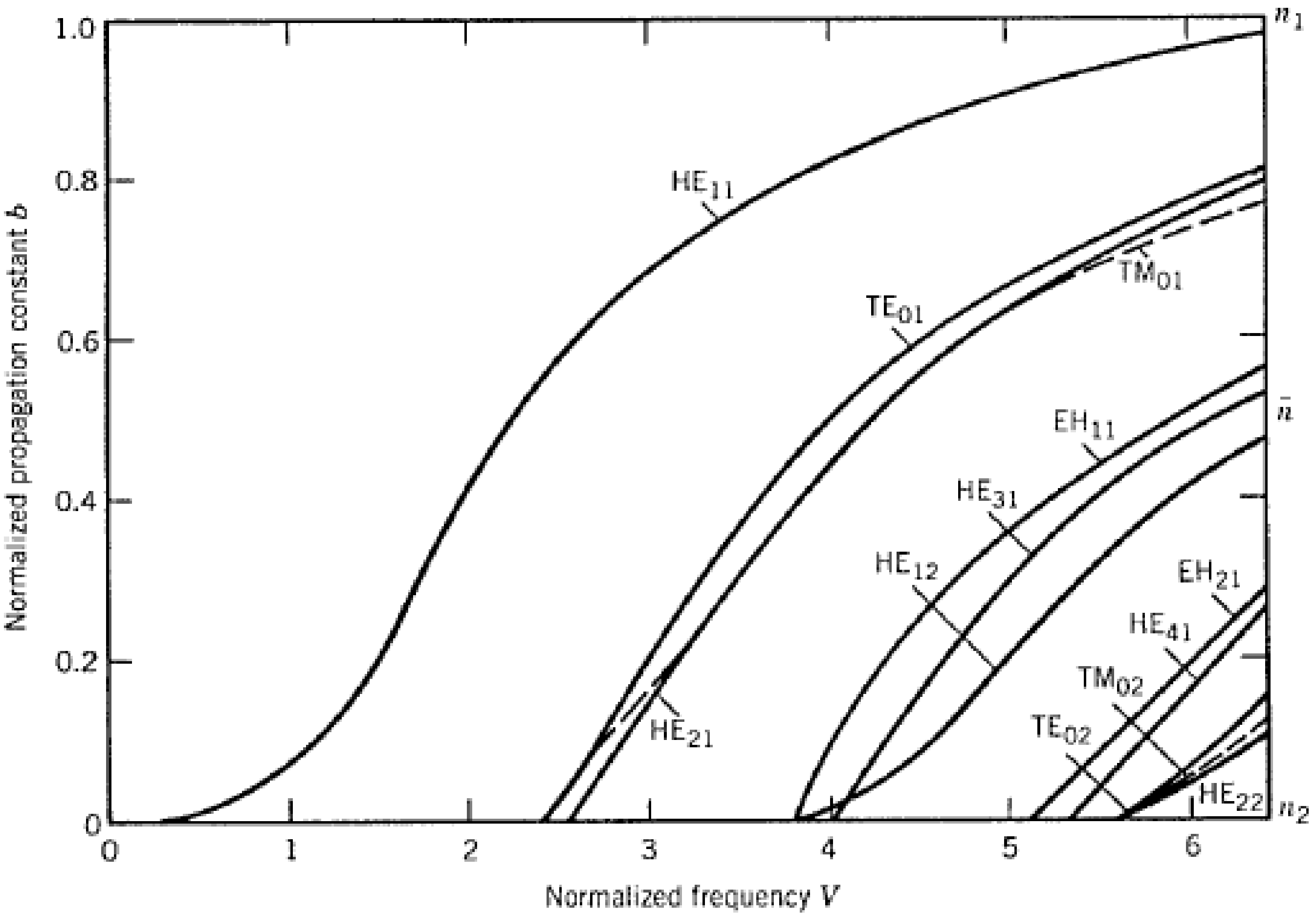

Fig. 2.5 of Agrawal