

Theory of Optical Modes in Step Index Fibers

Number of Guided Modes in Optical Fibers

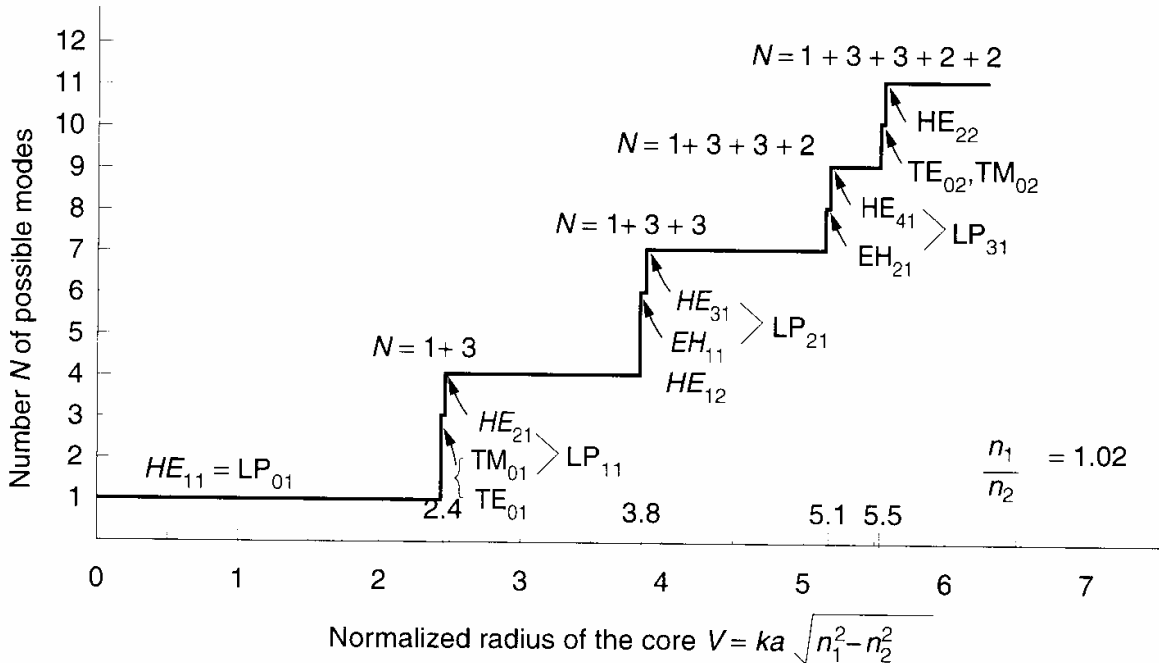


Figure 11.18 Number of possible modes in the step-index fiber as a function of the normalized radius of the core.

The fiber single mode when the normalized frequency $V < 2.4$.

When there are many modes: $\# \text{ of modes} \approx \frac{V^2}{2}$

The Normalized Propagation Constant

The normalized propagation constant (also called the normalized propagation parameter) is defined by

$$b \equiv \frac{\left(\frac{\beta}{k_0}\right)^2 - n_2^2}{n_1^2 - n_2^2} = \frac{n_{eff}^2 - n_2^2}{n_1^2 - n_2^2},$$

where n_1 is the refractive index of the fiber core and n_2 is the refractive index of the fiber cladding. This formula can also be used to define a normalized propagation constant for other optical waveguides.

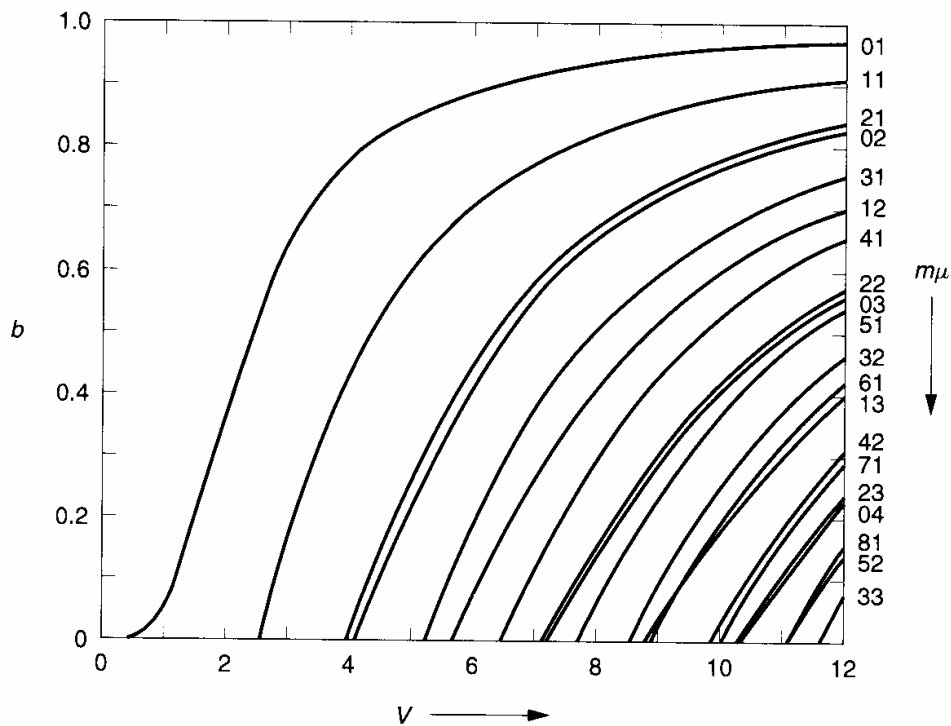


Figure 11.19 Normalized propagation parameter b as a function of the normalized frequency V for $LP_{m\mu}$ modes, which consists of $HE_{m+1\mu}$ and $EH_{m-1\mu}$ for $m > 1$; and $HE_{2\mu}$, $TM_{0\mu}$, $TE_{0\mu}$ for $m = 1$; and $HE_{1\mu}$ for $m = 0$. (After D. Gloge [20].)

From *Elements of Photonics, Volume II*, Iizuka

Propagation Constant vs. Normalized Frequency for the "True" Modes

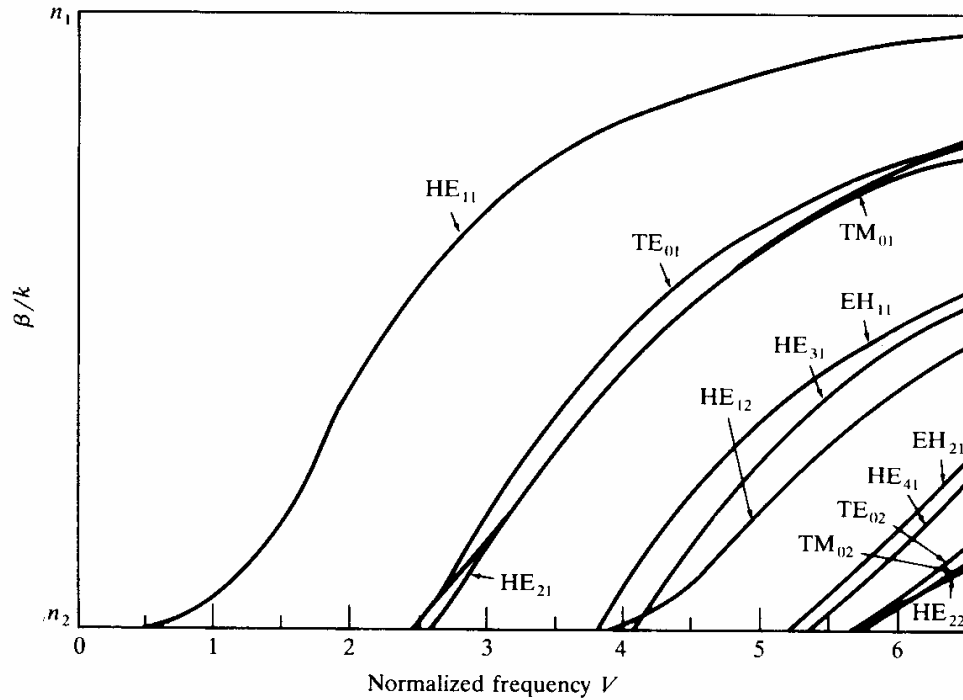


FIGURE 2-18

Plots of the propagation constant (in terms of β/k) as a function of V for a few of the lowest-order modes.

From Optical Fiber Communications, 2nd Ed., Gerd Keiser