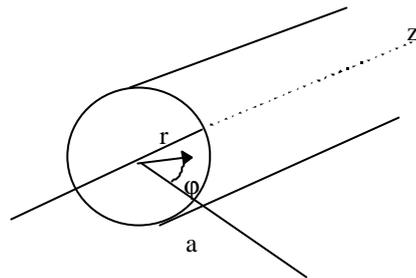


8.1.1 Rundhohlleiter

Anwendung

- bei Antennen z.B. wenn zirkular polarisierte Welle zu Antenne geführt werden muß.
- TE_{0n} - Welle hat extrem geringe Dämpfung
- wegen der geringeren Dämpfung bei Resonatoren

Die Lösung der Wellengleichung in Zylinderkoordinaten führt auf die sog. Zylinderfunktionen, von denen uns die Bessel-Funktionen bereits bekannt sind. (Abb. ..)



Die Moden werden durch die Knotenflächen in der Winkelfunktion (Index m) und der Radialfunktion (Index n) gekennzeichnet.

TM-Wellen: ($H_z = 0$)

Randbedingungen $H_n = 0$ bei $r = a \Leftrightarrow J_m(\mathbf{b}a) = 0$

Die 1.te Nullstelle der m -ten Besselfunktion wird mit j_{mn} bezeichnet:

$$J_m(\mathbf{b}_{gr,mn}a) = J_m(j_{mn}) = 0 \Rightarrow$$

$$\mathbf{b}_{gr,mn} = \frac{j_{mn}}{a} \quad m = 1,2,3,\dots \quad n = 1,2,3,\dots$$

$$\mathbf{b}_H^2 = \mathbf{b}_0^2 - \mathbf{b}_{gr,mn}^2$$

$$E_z = \hat{E} \cdot J_m\left(\frac{j_{mn}}{a}r\right) \cos(m\mathbf{j}) e^{j(\mathbf{w}t - \mathbf{b}_H \cdot \mathbf{z})}$$

$$E_r = -\hat{E} \frac{j\mathbf{b}_H}{\mathbf{b}_{gr,mn}} J_m'\left(\frac{j_{mn}}{a}r\right) \cos(m\mathbf{j}) e^{j(\mathbf{w}t - \mathbf{b}_H \cdot \mathbf{z})}$$

$$E_{\mathbf{j}} = \hat{E} \frac{j\mathbf{b}_H^n}{\mathbf{b}_{gr,mn}^2} J_m\left(\frac{j_{mn}}{a}r\right) \sin(m\mathbf{j}) e^{j(\mathbf{w}t - \mathbf{b}_H \cdot \mathbf{z})}$$

$$H_{\mathbf{j}} = \frac{E_r}{Z_{TM}}$$

$$H_r = -\frac{E_{\mathbf{j}}}{Z_{TM}}$$

$$Z_{TM} = \frac{\mathbf{b}_H}{\mathbf{w}\epsilon}$$



TE-Wellen :

Hier ist die Randbedingung $E_{\theta} = 0$ bei $r = a$ zu erfüllen. Das führt auf $\Leftrightarrow J'_m(\mathbf{b}a) = 0$
 Die 1.te Nullstelle der Ableitung der n-ten Besselfunktion wird mit j'_{nl} bezeichnet:

$$J'_m(\mathbf{b}_{gr,mn}a) = J'_m(j'_{mn}) = 0 \Rightarrow$$

$$\mathbf{b}_{gr,mn} = \frac{j'_{mn}}{a} \quad m = 1,2,3,\dots \quad n = 1,2,3,\dots$$

$$\mathbf{b}_H^2 = \mathbf{b}_0^2 - \mathbf{b}_{gr,mn}^2$$

$$H_z = \hat{H} \cdot J_m\left(\frac{j'_{mn}}{a}r\right) \cos(m\mathbf{j}) e^{j(\omega t - \mathbf{b}_H \cdot z)}$$

$$E_r = \hat{H} \frac{j\omega m \mathbf{b}_H}{\mathbf{b}_{gr,mn}^2} J_m\left(\frac{j'_{mn}}{a}r\right) \sin(m\mathbf{j}) e^{j(\omega t - \mathbf{b}_H \cdot z)}$$

$$E_{\mathbf{j}} = \hat{H} \frac{j\omega m}{\mathbf{b}_{gr,mn}} J'_m\left(\frac{j'_{mn}}{a}r\right) \cos(m\mathbf{j}) e^{j(\omega t - \mathbf{b}_H \cdot z)}$$

$$H_{\mathbf{j}} = \frac{E_r}{Z_{TE}}$$

$$H_r = -\frac{E_{\mathbf{j}}}{Z_{TE}}$$

$$Z_{TE} = \frac{\omega m}{\mathbf{b}_H}$$

aus Ramo [7]:

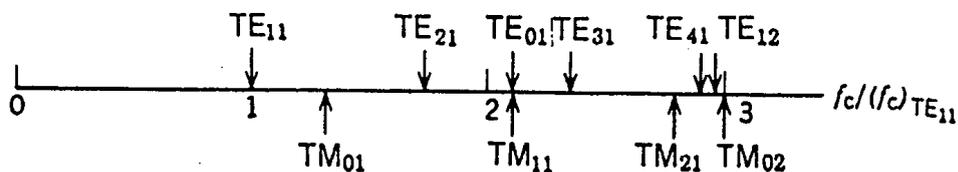


FIG. 8.9b Relative cutoff frequencies of waves in a circular guide.



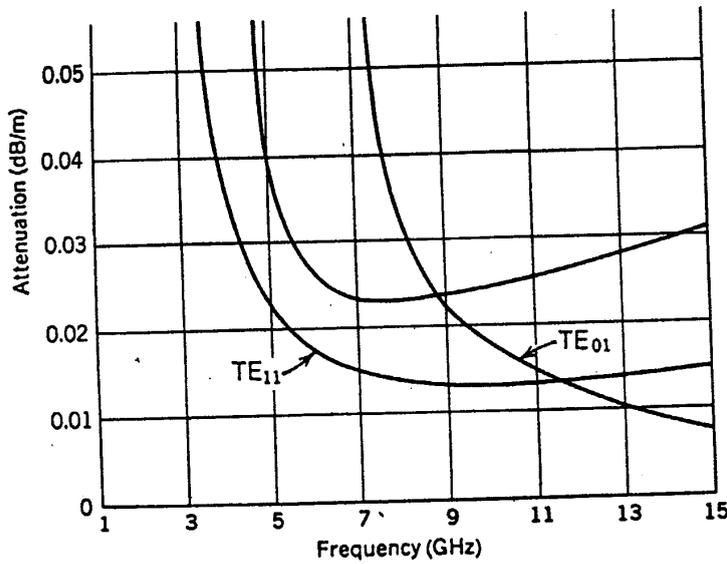
Rambo [7]

Table 8.9
Summary of Wave Types for Circular Guides*

Wave Type	TM_{01}	TM_{11}	TM_{12}	TE_{01}	TE_{11}
Field distributions in cross-sectional plane, at plane of maximum transverse fields					
Field distributions along guide					
Field components present	E_z, E_r, H_θ	E_z, E_r, H_θ	$E_z, E_r, E_\theta, H_r, H_\theta$	H_z, H_r, E_θ	$H_z, H_r, H_\theta, E_r, E_\theta$
p_{cut} or p_{cut}	2.405	5.52	3.83	3.83	1.84
$(k_c)_{cut}$	$\frac{2.405}{a}$	$\frac{5.52}{a}$	$\frac{3.83}{a}$	$\frac{3.83}{a}$	$\frac{1.84}{a}$
$(k_c)_{cut}$	2.616	1.164	1.040	1.040	3.410
$(k_c)_{cut}$	$\frac{0.393}{a\sqrt{\mu r}}$	$\frac{0.877}{a\sqrt{\mu r}}$	$\frac{0.009}{a\sqrt{\mu r}}$	$\frac{0.009}{a\sqrt{\mu r}}$	$\frac{0.203}{a\sqrt{\mu r}}$
Attenuation due to imperfect conductors	$\frac{R_s}{a^2} \frac{1}{\sqrt{1 - (k_c/f)^2}}$	$\frac{R_s}{a^2} \frac{1}{\sqrt{1 - (k_c/f)^2}}$	$\frac{R_s}{a^2} \frac{1}{\sqrt{1 - (k_c/f)^2}}$	$\frac{R_s}{a^2} \frac{(k_c/f)^2}{\sqrt{1 - (k_c/f)^2}}$	$\frac{R_s}{a^2} \frac{1}{\sqrt{1 - (k_c/f)^2}} \left[\left(\frac{k_c}{f}\right)^2 + 0.42 \right]$

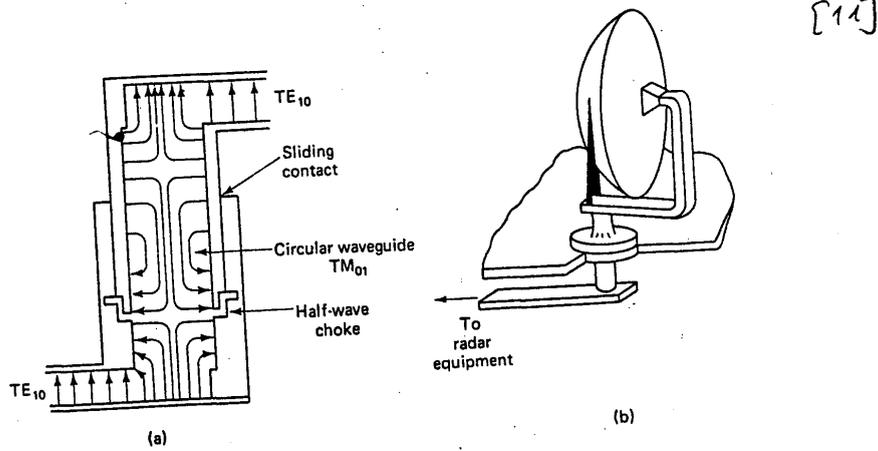
* Electric field lines are shown solid and magnetic field lines are dashed.

Rambo [7]



19c Attenuation due to copper losses in circular waveguides; diameter = 2 in.





Sinnema: Figure 7-27 Rotary joint (a) used in radar application (b).

Ramo [7]

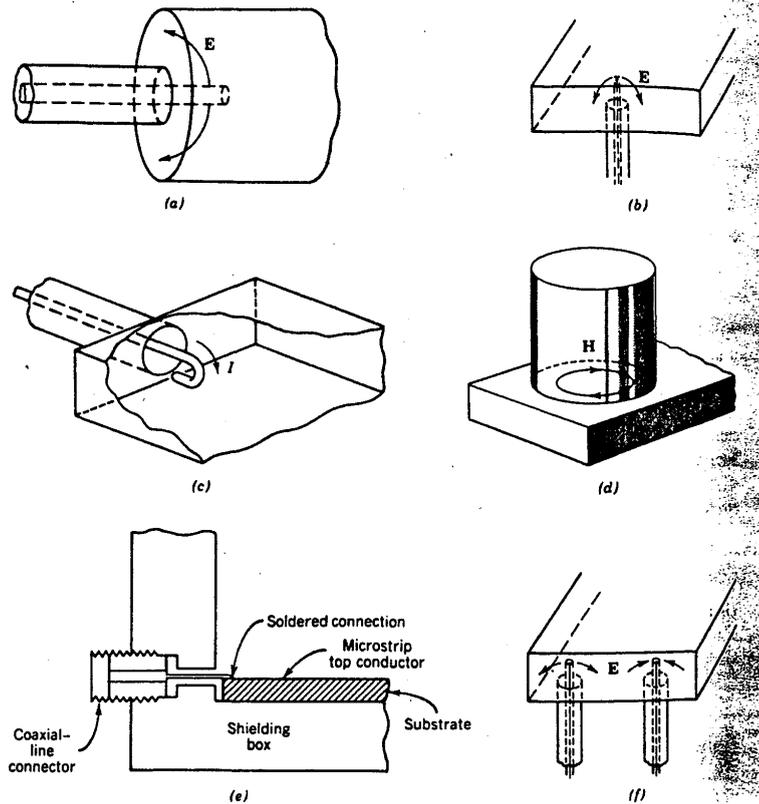


FIG. 8.11 (a) Antenna in end of circular guide for excitation of TM_{01} wave. (b) Antenna in bottom of rectangular guide for excitation of the TE_{10} wave. (c) Loop in end of rectangular guide for excitation of TE_{10} wave. (d) Junction between circular guide (TM_{01} wave) and rectangular guide (TE_{10} wave); large-aperture coupling. (e) Coaxial line coupling to microstrip. (f) Excitation of the TE_{20} wave in rectangular guide by two oppositely phased antennas.

