RÜ 8

Dienstag, 31. Mai 2011
16:01

1.6

$R = 4\,m \qquad f = 60\,MHz$

$H_{11}^c \quad f_c(H_{11}) = \frac{c_0}{2\pi R / 1{,}8412} = 21{,}98\,MHz$

$H_{11}^s \quad ↯$ Randbedingungen $E_{tan} = 0$ für $\varphi = 0°$; $\varphi = 180°$

$E_{01} \quad ↯$ Randbedingungen

$H_{21}^c \quad f_c(H_{21}) = f_c(H_{11}) \cdot 1{,}6588 = 36{,}46\,MHz$

$H_{21}^s \quad ↯$ RB

$H_{01} \quad f_c(H_{01}) = f_c(H_{11}) \cdot 2{,}0811 = 45{,}74\,MHz$

$E_{11}^c \quad ↯$

$E_{11}^s \quad f_c(E_{11}) = f_c(H_{11}) \cdot 2{,}0811 = 45{,}74\,MHz$

$H_{31}^c \quad f_c(H_{31}) = 50{,}15\,MHz$

$H_{31}^s \quad ↯$

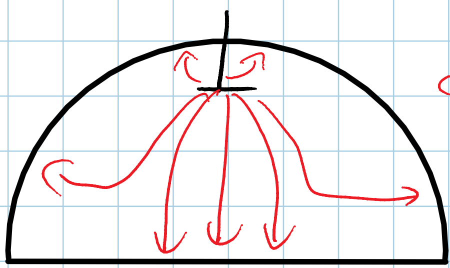
$E_{21}^c \quad ↯$

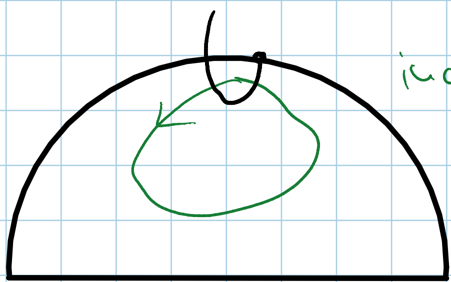
$E_{21}^s \quad f_c(E_{21}) = 61{,}3\,MHz \quad ↯$

Ausbreitungsfähige Moden bei $f = 60\,MHz$

$H_{11}^c \quad H_{21}^c \quad H_{01} \quad E_{11}^s \quad H_{31}^c$

6.1.2





$\Rightarrow$ E-Feld an Stelle $\varphi = 90°$ $\rho = R$ $z = 0$

anregen maximal und senkrecht zur Wand

$\Rightarrow$ nur H_{11}^c E_{11}^s H_{31}^c anregbar

6.1.3 $\quad \rho = 0 \Rightarrow E = 0$

$H_{21}^c \quad H_{01} \quad H_{31}^c$

6.2.1) $\beta_H = \beta_{H_{11}^c} = \frac{2\pi f}{c_0}\sqrt{1 - \left(\frac{f_c}{f}\right)^2}$

$= 1{,}1693\,m^{-1}$

$$\beta_E = \beta_{E_{11}^s} = \frac{2\pi f}{c_0}\sqrt{1-\left(\frac{f_c}{f}\right)^2}$$

$$= 0{,}8132\ m^{-1}$$

6.2.2) $\vec{E}(\rho=0,z) = \vec{E}_{H_{11}^c}(\rho=0,z) + \vec{E}_{E_{11}^s}(\rho=0,z)$

H_{11}^c $\quad E_0 = E_\rho(\varphi=90°, \rho=R, z=0)$

$$E_\varphi(\rho,\varphi,z) = -\frac{\omega\mu}{\beta} H_\rho(\rho,\varphi,z)$$

$$E_\rho(\rho,\varphi,z) = \frac{\omega\mu}{\beta} H_\varphi(\rho,\varphi,z)$$

$$E_z(\rho,\varphi,z) = 0$$

mit $\quad H_\rho(\rho,\varphi,z) = -j\frac{2\pi f}{\lambda_H p_{11}} J_1'\left(1{,}84\frac{\rho}{R}\right)\cos(\varphi)e^{-j\beta z}$

$$H_\varphi(\rho,\varphi,z) = j\frac{2\pi f}{\lambda_H \cdot p_{11}^2 \rho} J_1\left(1{,}84\frac{\rho}{R}\right)\sin(\varphi)e^{-j\beta z}$$

1.) Einspeisung bei $\rho=R \quad \varphi=90° \quad z=0$

$$\Rightarrow \cos(\varphi)=0$$

$$\Rightarrow H_\rho = E_\varphi = 0$$

$$E_\rho = \underbrace{j\frac{\omega\mu}{\beta}\frac{2\pi f}{\lambda_H p_{11}^2 R} J_1(1{,}84)}_{E_0}$$

2.) An der Stelle $\rho=0, \ z=0$

$$J_1(0)=0$$

$\Rightarrow H_\varphi = E_\rho = 0$

$$E_\varphi = +j \frac{\omega\mu}{\beta} \frac{2 = f}{\lambda_{1f} p_{11}} J_1'(0)$$

mit

$$E_\varphi = E_0 \, p_{11} \, R \, \frac{J_1'(0)}{J_1(1{,}84)}$$

mit $p_{11} = \frac{\eta_{11}'}{R}$

$$E_\varphi = E_0 \frac{\eta_{11}' J_1'(0)}{J_1(1{,}84)} \qquad \eta_{11}' = 1{,}841$$

$$= 1{,}582 \, E_0$$

$\underline{E_{11}^S}$

$$\vec{E}_z = \vec{g}_z \, e^{-j\beta z}$$

$$E_z = \underline{G} \, J_m(p \cdot \rho) \cos(m\varphi + \varphi_0) e^{-j\beta z}$$

$$\vec{E}_\rho = \vec{g}_\rho \, e^{-j\beta z}$$

$$E_\rho = -\frac{j\beta}{p^2} \underline{G} \, p \cdot J_m'(p \cdot \rho) \cos(m\varphi + \varphi_0) e^{-j\beta z}$$

$$E_\varphi = \frac{j\beta}{p^2} \underline{G} \frac{m}{\rho} J_m(p\rho) \sin(m\varphi + \varphi_0) e^{-j\beta z}$$

E_{11}^S: $m = 1 \qquad n = 1$

$p = 3 \qquad \rho_{32} \cdot \frac{1}{R}$

S: sinus   z abh. von sinus

$$\Rightarrow \varphi_0 = 90°$$

E_{11}^S:

$$E_z = \underline{S}\, J_1\left(3{,}822 \frac{\varrho}{R}\right) \sin(\varphi) e^{-j\beta z}$$

$$E_\varrho = -j\frac{\beta}{p_{11}^2} \underline{S}\, p_{11} J_1'\left(3{,}832 \frac{\varrho}{R}\right) \sin(\varphi)\, e^{-j\beta z}$$

$$E_\varphi = j\frac{\beta}{p_{11}} \underline{S}\, \frac{1}{\varrho} J_1\left(3{,}832 \frac{\varrho}{R}\right) \cos(\varphi)\, e^{-j\beta z}$$

1.) Einspeisung an $\varphi = 90°$, $\varrho = R$, $z = 0$

$$E_\varphi = 0$$

$$E_\varrho = \underbrace{-\frac{j\beta}{p_{11}^2} S\, p_{11} J_1'(3{,}832)}_{E_0}$$

2.) bei $\varrho = 0$, $z = 0$

$$E_\varphi = 0 \qquad (\text{da } J_1(0) = 0)$$

$$E_\varrho = -j\frac{\beta}{p_{11}^2} \underline{S}\, p_{11} J_1'(0)$$

$$= E_0 \cdot \frac{J_1'(0)}{J_1'(3{,}832)} = -1{,}2413\, E_0$$

$$\Rightarrow \vec{E}(\varrho = 0, z) = 1{,}582\, E_0\, e^{-j\beta_H z} - 1{,}2413\, E_0\, e^{-j\beta_E z}$$

2.3) Minima von $|\vec{E}(\varrho = 0, z)|$

$$|\vec{E}(\rho=0,z)| = |1{,}582\, E_0\, e^{-j\beta_H z} - 1{,}2413\, E_0\, e^{-j\beta_E z}|$$

$$= 1{,}582\, |E_0|\, \left|1 - \frac{1{,}2413}{1{,}582}\, e^{-j(\beta_E-\beta_H)z}\right|$$

$$\Rightarrow \quad z = \frac{n \cdot 2\pi}{-(\beta_E-\beta_H)} \text{ [m]} \qquad n \in \mathbb{N}$$

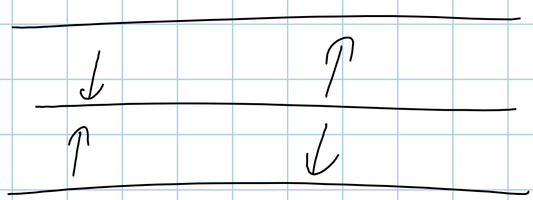
mit $\beta_E = 0{,}813$; $\beta_H = 1{,}1693$

$$z = 17{,}63\, n \text{ [m]} \qquad n \in \mathbb{N}$$

<u>2.4</u>) $V = \dfrac{|E_{max}|}{|E_{min}|}$ für $\rho=0$

$$\frac{|E_{max}|}{|E_{min}|} = \frac{|E_0|\cdot(1{,}582+1{,}2413)}{|E_0|\cdot(1{,}582-1{,}2413)} = 8{,}287$$

<u>2.5</u>)



Fahrdraht wirkt sich nur auf den E_m Wellentyp aus

$\rightarrow$ Wellentyp kurzgeschlossen bzw.

stark gedämpft

$\rightarrow$ V wird kleiner (bzw. im Idealfall gilt $V=1$)

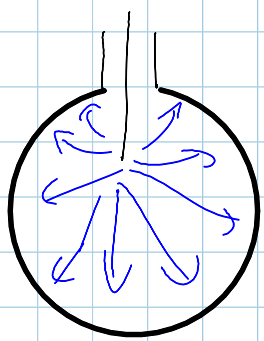
1.6 H08

6.1.1) $f_{cE0,1} \le f \le f_{cH1,1}$ | $k_{m,n} = \frac{\eta_{m,n}}{R}$

$$\frac{c_0\,2}{2\pi R}\cdot 2{,}405 \le f \le \frac{c_0}{2\pi R}\cdot 3{,}054$$ | $f^{H}_{c\,m,n} = k_{m,n}\cdot\frac{c}{2\pi}$

$3{,}828\,\text{GHz} \le f \le 4{,}861\,\text{GHz}$

6.1.2)



6.1.3)

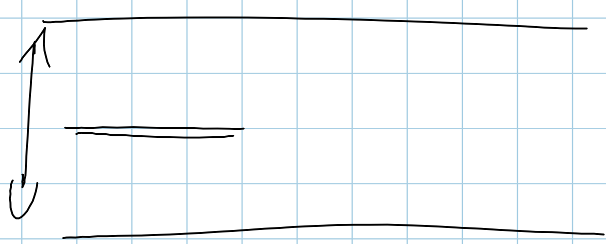
$E_{0,1}$

↳ drehsymmetrisch (Zuleitung für Radarsysteme)

$H_{1,1}$ SAT - Empfang

6.2)

D



$D = 3\,\text{cm}$ $\quad f_0 = 5\,\text{GHz}$

6.2.1)

6.2.1)

Rundhohlleiter

$\rightarrow f_{c\,H11}^{S,C} = p_{1,1}^{H} \frac{c}{2\pi} = 2{,}93\text{ GHz} < 5\text{ GHz}$ ✓

$f_{c\,E01} = p_{0,1}^{E} \frac{c_0}{2\pi} = 3{,}83\text{ GHz} < 5\text{ GHz}$ ✓

$f_{c\,H21}^{SC} = 4{,}86\text{ GHz}$ ✓

$f_{c\,H01} = f_{c\,E11}^{SC} = 6{,}1\text{ GHz}$ ↯

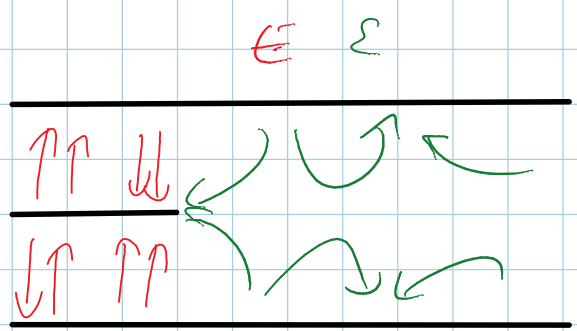
} 5 Moden

Koax

$TEM \rightarrow f_c = 0$ ✓

$\rightarrow H_{1,1} \rightarrow f_{c\,H1,1} = \frac{2\,c_0}{\pi\,(d_a + d_i)} = 6{,}37\text{ GHz}$ ✗ } Σ 1

6.2.2



die E_{01}-Welle (Feldlinien jeweils rotationssymmetrisch transversale Feldlinien sehr ähnlich)

6.2.3

$$Z_{F\,E0,1} = Z_0 \sqrt{1 - \left(\frac{f_{c0,1}}{f}\right)^2}$$

$$= 120\pi \sqrt{1-\left(\frac{3,83}{5}\right)^2}$$

$$= 242,35\,\Omega$$

$$\Rightarrow Z_{F\,H11}^{S,C} = Z_0 \cdot \frac{1}{\sqrt{1-\left(\frac{f_{c11}^{H}}{f}\right)^2}} = 665,24\,\Omega$$

6.3)

$d_a = 4\,cm$

$\frac{d_a}{d_i} = e = 2,7183$

$f_0 = 3\,GHz$

$E_{max} = 1\,kV/cm$

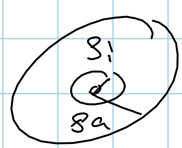
6.3.1)

$$f_{c\,H11}^{Koax} = \frac{c_0}{\lambda_{c\,H11}} = \frac{2c_0}{(d_i+d_a)\pi} \overset{!}{=} f_{c\,H21}^{Hohlle.} = \frac{c_0}{2\pi R}\, x'_{21}$$

$D = 8,56\,cm$

6.3.2)

$$\vec{E}_r = \frac{U}{r \ln \frac{\rho_a}{\rho_i}}$$



$$P = \frac{1}{2} \iint_A \vec{E}_r \times \vec{H}_\varphi^* \, dA$$

$$= \frac{1}{2} \int_{\rho_i}^{\rho_a} \int_0^{2\pi} |E|^2 \ldots \quad \frac{1}{\ldots} \int^{\rho_a} \int^{2\pi} |U|^2 \ldots$$

$$= \frac{1}{2} \int_0^{\rho_a} \int^{2\pi} \frac{|E|^2}{Z_{F0}} \rho \, d\rho \, d\varphi = \frac{1}{2} \int_{\rho_i}^{\rho_a} \int_0^{2\pi} \frac{|U|^2}{\cancel{\rho^2} \ln^2 \frac{\rho_a}{\rho_i}} \cancel{\rho} \, d\rho \, d\varphi$$

mit

$$\Rightarrow |E_{max}| = \frac{|U|}{\rho_i \ln \frac{\rho_a}{\rho_i}}$$

$$P = \frac{1}{2} \int_{\rho_i}^{\rho_a} \int_0^{2\pi} \frac{|E_{max}|^2 \rho_i^2 \cancel{\ln^2 \frac{\rho_a}{\rho_i}}}{\rho \cdot \cancel{\ln^2 \frac{\rho_a}{\rho_i}}} \, d\rho \, d\varphi$$

$$= \frac{1}{2} \int_{\rho_i}^{\rho_a} \int_0^{2\pi} \frac{|E_{max}|^2 \rho_i^2}{\rho} \, d\rho \, d\varphi = \pi \frac{|E_{max}|^2 \rho_i^2}{Z_{F0}} \ln \frac{\rho_a}{\rho_i}$$

$$= 4{,}51 \, kW$$