worksheet 7.4 page 1

$$data := \begin{pmatrix} 1 & 400 & 0.4 \\ 2 & 400 & 0.4 \\ 3 & 400 & 1 \\ 4 & 395 & 1.9 \\ 5 & 390 & 3.4 \\ 6 & 390 & 5.9 \\ 6.5 & 385 & 8.4 \\ 7 & 385 & 14.5 \\ 7.5 & 380 & 26 \\ 7.83 & 360 & 36 \\ 8 & 350 & 31.5 \\ 8.5 & 345 & 16.5 \\ 9 & 345 & 10.5 \\ 10 & 345 & 6.2 \\ 11 & 345 & 6 \\ 12 & 345 & 4.4 \\ 13 & 340 & 3.4 \\ 14 & 340 & 3 \\ 15 & 330 & 3 \\ 16 & 330 & 2.4 \\ 17 & 320 & 1.4 \\ 18 & 315 & 2.2 \\ 19 & 310 & 3.4 \\ 19.6 & 305 & 4.2 \end{pmatrix}$$

column 1: frequency, MHz
column 2: channel 1 voltage, mV
column 3: channel 2 voltage, mV

Yt is the admittance derived from test results

From figure 7.2.7:-

$R1 := 300\ \Omega$ $\quad$ $R2 := 51\ \Omega$

$R3 := 50\ \Omega$ $\quad$ $R4 := 850\ \Omega$

$L1 := 200 \cdot 10^{-6}\ \ H$ $\quad$ $C1 := 60 \cdot 10^{-12}\ \ F$

$Turns := 10$

$s := 1 .. rows(data)$ $\quad$ $f_s := data_{s,1} \cdot 10^6$

$$Ytest(s) := \left| \begin{array}{l} Vch1 \leftarrow data_{s,2} \cdot 10^{-3} \\ Vin \leftarrow \dfrac{51+50}{50} \cdot Vch1 \\ Vch2 \leftarrow data_{s,3} \cdot 10^{-3} \\ \omega \leftarrow 2 \cdot \pi \cdot f_s \\ Z1 \leftarrow R4 + \dfrac{1}{j \cdot \omega \cdot C1} \\ Y2 \leftarrow \dfrac{1}{R1} + \dfrac{1}{R2} + \dfrac{1}{R3} + \dfrac{1}{j \cdot \omega \cdot L1} + \dfrac{1}{Z1} \\ Isec \leftarrow \left|Y2\right| \cdot Vch2 \\ Iprim \leftarrow Isec \cdot Turns \\ \dfrac{Iprim}{Vin} \end{array} \right.$$

$Yt_s := Ytest(s)$

Figure 7.4.2 Using test data to calculate the admittance characteristic worksheet 7.4 page 2

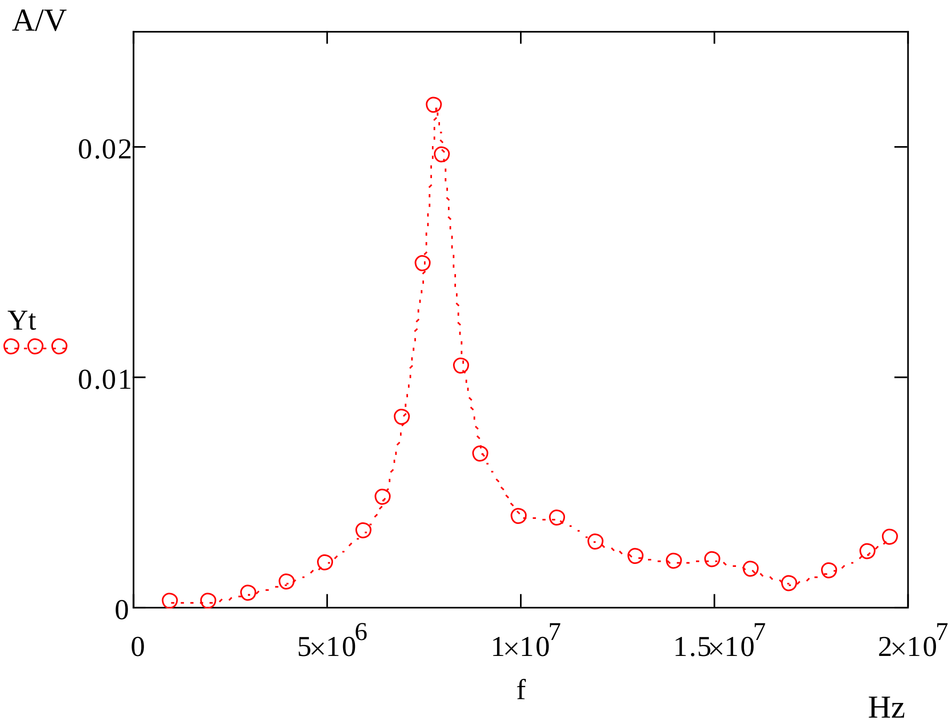

Figure 7.4.3 Admittance of conductor, derived from test results

$\varepsilon_o := 8.854 \cdot 10^{-12}$ F/m $\mu_o := 4 \cdot \pi \cdot 10^{-7}$ H/m $\mu_r := 1$ $c := 3 \cdot 10^8$ m/s

$\rho := 1.7 \cdot 10^{-8}\ \Omega\ \ m$ — resistivity of copper

$l := 7.5\ m$ — length of monopole

$r := 0.5 \cdot 10^{-3}\ m$ — from micrometer measurement of conductor diameter

$$Fx := \frac{4 \cdot \rho}{\mu_o \cdot \pi \cdot r^2} = 6.89 \times 10^4$$

crossover frequency.
See equation (2.5.14)

$$Lp := \frac{\mu_o \cdot \mu_r \cdot l}{2 \cdot \pi} \cdot \ln\left(\frac{l}{r}\right) = 1.442 \times 10^{-5}$$

equation (2.3.2)

$$\frac{Lp}{2} = 7.212 \times 10^{-6}$$

inductive component value
for model

$fq := 7.83 \cdot 10^6\ \ Hz$ — from taulated data

$v := 4 \cdot l \cdot fq$ $v = 2.349 \times 10^8$ — equation (2.3.10)

$$\varepsilon_r := \left(\frac{c}{v}\right)^2 = 1.631$$

equation (2.3.11)

$$Cp := \frac{2 \cdot \pi \cdot \varepsilon_o \cdot \varepsilon_r \cdot l}{\ln\left(\frac{l}{r}\right)} \qquad Cp = 7.077 \times 10^{-11}$$

equation (2.3.1)

$Rrad := 73\ \ \Omega$ — equation (5.1.3)

$Vsource := 1\ V$ — allows admittance value to be calculated

$$Rss := \frac{\rho \cdot l}{\pi \cdot r^2} = 0.162$$

steady state resistance
see equation (2.5.11)

$Gp := 0\ S$ — good quality insulation assumed.

$Rsource := 1\ \Omega$ — guess-value for impedance of current transformer

Figure 7.4.5 Calculating values for components of circuit model

$i := 1 .. 200$ $\quad\quad$ $F_i := i \cdot 10^5$ Hz

$$
\mathrm{Ymodel}(i, \mathrm{Vsource}) := \left|
\begin{array}{l}
Rp \leftarrow Rss \cdot \sqrt{1 + \dfrac{F_i}{Fx}} \\
\omega \leftarrow 2 \cdot \pi \cdot F_i \\
\theta \leftarrow \sqrt{(Rp + j \cdot \omega \cdot Lp) \cdot (Gp + j \cdot \omega \cdot Cp)} \\
Zo \leftarrow \sqrt{\dfrac{Rp + j \cdot \omega \cdot Lp}{Gp + j \cdot \omega \cdot Cp}} \\
Z1 \leftarrow Zo \cdot \tanh\left(\dfrac{\theta}{2}\right) \\
Z2 \leftarrow Zo \cdot \mathrm{csch}(\theta) \\
Z3 \leftarrow 2 \cdot Z1 + 2 \cdot Z2 + Rrad + Rsource \\
\dfrac{Vsource}{|Z3|}
\end{array}
\right.
$$

$Ym_i := \mathrm{Ymodel}(i, \mathrm{Vsource})$

Figure 7.4.7 Calculating the admittance of circuit model over a range of frequencies

$Cp = 7.077 \times 10^{-11}$ F $\quad Lp = 1.442 \times 10^{-5}$ H $\quad Fx = 6.89 \times 10^{4}$ Hz

$Rrad = 73$ Ω $\quad Rsource = 1$ Ω $\quad Rss = 0.162$ Ω

$Vsource = 1$ Ω

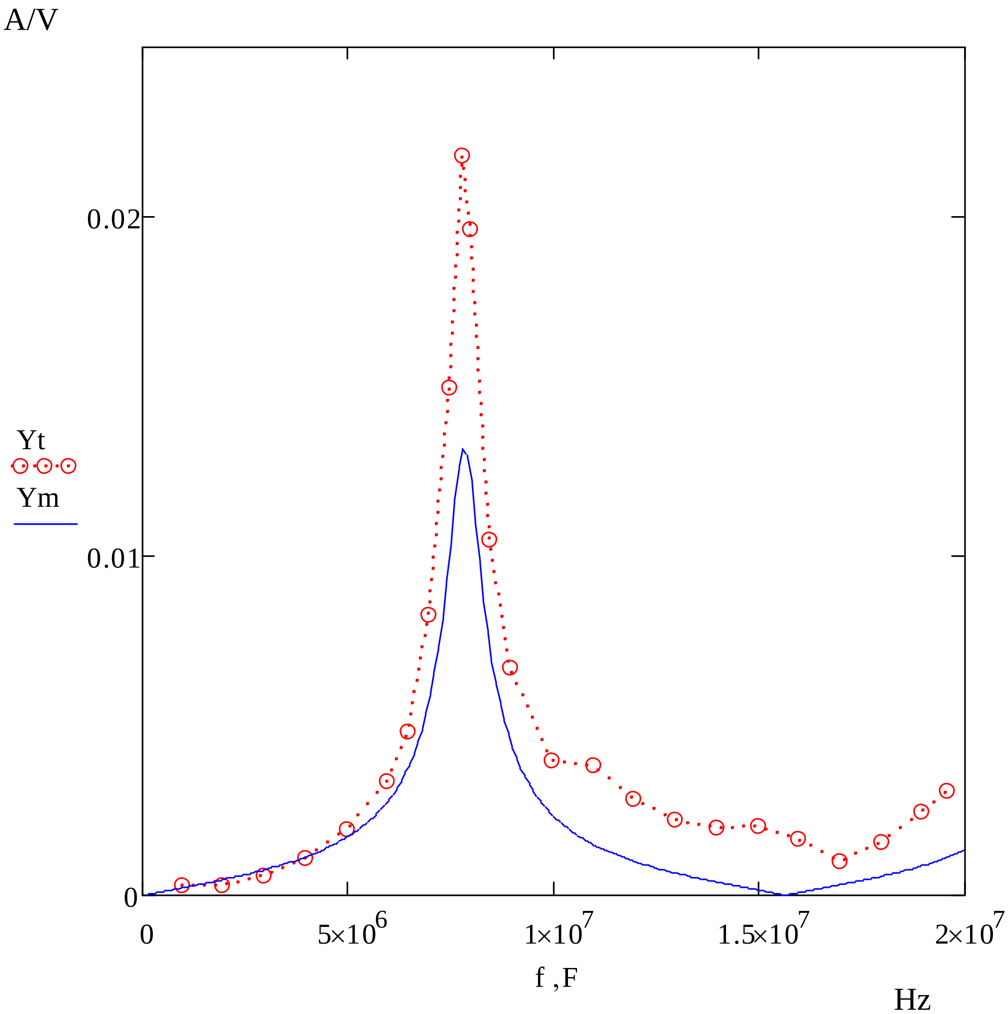

Figure 7.4.8 Comparing response of the test with that of the initial circuit model

worksheet 7.4 page 6 $Vsource := 1.65$ V $Ym_i := Ymodel(i, Vsource)$

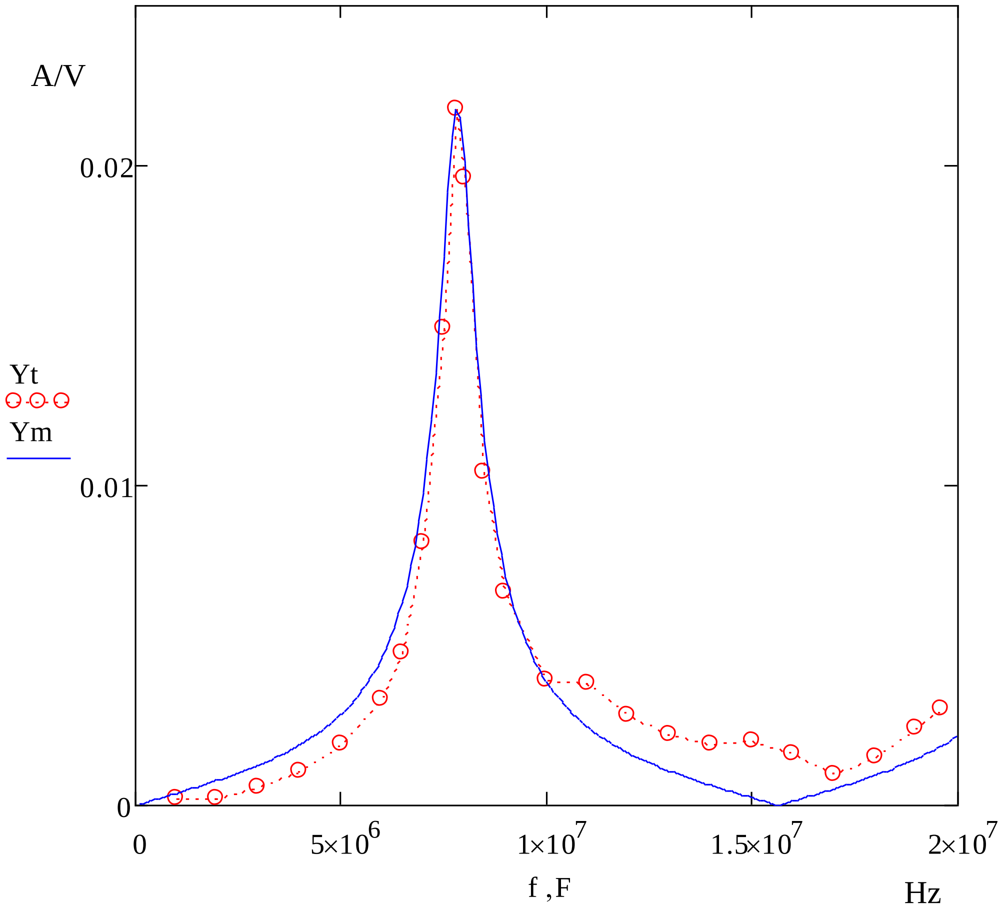

Figure 7.4.9 Response of model, taking into account stored energy