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$$data1 := \begin{pmatrix} 1 & 420 & 0.4 \\ 2 & 420 & 0.4 \\ 3 & 420 & 0.8 \\ 4 & 420 & 1.4 \\ 5 & 435 & 2.4 \\ 6 & 350 & 3.8 \\ 6.5 & 365 & 5.8 \\ 7 & 370 & 11 \\ 7.38 & 370 & 15 \\ 7.5 & 370 & 14 \\ 7.7 & 365 & 11 \\ 8 & 365 & 7.6 \\ 9 & 365 & 3.6 \\ 10 & 360 & 2 \\ 11 & 360 & 1.8 \\ 12 & 360 & 1.8 \\ 13 & 360 & 1.8 \\ 14 & 355 & 1.6 \\ 15 & 360 & 1 \\ 16 & 375 & 2.6 \\ 17 & 320 & 2 \\ 18 & 270 & 1 \\ 19 & 280 & 1 \\ 19.8 & 285 & 1 \end{pmatrix}$$

column 1: frequency, MHz
column 2: peak-to-peak voltage at channel 1, mV
column 3: peak-to-peak voltage at channel 2, mV

components of model of current transformer.
See figure 7.2.7:-

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

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

$L1 := 200\cdot 10^{-6}\ H$

$C1 := 60\cdot 10^{-12}\ F$

$Turns := 10$

$s := 1 .. rows(data1)$ $\qquad$ $f1_s := data1_{s,1}\cdot 10^6$

$$YTt_s := \left| \begin{array}{l} Vch1 \leftarrow data1_{s,2}\cdot 10^{-3} \\ Vin \leftarrow \dfrac{51+50}{50}\cdot Vch1 \\ Vch2 \leftarrow data1_{s,3}\cdot 10^{-3} \\ \omega \leftarrow 2\cdot\pi\cdot f1_s \\ Z1 \leftarrow R4 + \dfrac{1}{j\cdot\omega\cdot C1} \\ Y2 \leftarrow \dfrac{1}{R1} + \dfrac{1}{R2} + \dfrac{1}{R3} + \dfrac{1}{j\cdot\omega\cdot L1} + \dfrac{1}{Z1} \\ Isec \leftarrow |Y2|\cdot Vch2 \\ Iprim \leftarrow Isec\cdot Turns \\ Yt \leftarrow \dfrac{Iprim}{Vin} \end{array} \right.$$

$$data := \begin{pmatrix} 1 & 420 & 2.8 \\ 2 & 420 & 6.4 \\ 3 & 420 & 11 \\ 4 & 430 & 20.5 \\ 5 & 460 & 60 \\ 5.2 & 480 & 88 \\ 5.5 & 420 & 135 \\ 5.7 & 325 & 110 \\ 6 & 330 & 63.5 \\ 7 & 370 & 25 \\ 8 & 380 & 18.5 \\ 9 & 375 & 5.2 \\ 10 & 375 & 3.6 \\ 11 & 380 & 1.8 \\ 12 & 375 & 0.6 \\ 13 & 380 & 3 \\ 14 & 380 & 6.6 \\ 15 & 390 & 11.5 \\ 15.5 & 405 & 17 \\ 16 & 415 & 26 \\ 16.5 & 395 & 43 \\ 16.8 & 325 & 47 \\ 17 & 280 & 44 \\ 18 & 270 & 20 \\ 19 & 290 & 11.5 \\ 19.8 & 295 & 8.2 \end{pmatrix}$$

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

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

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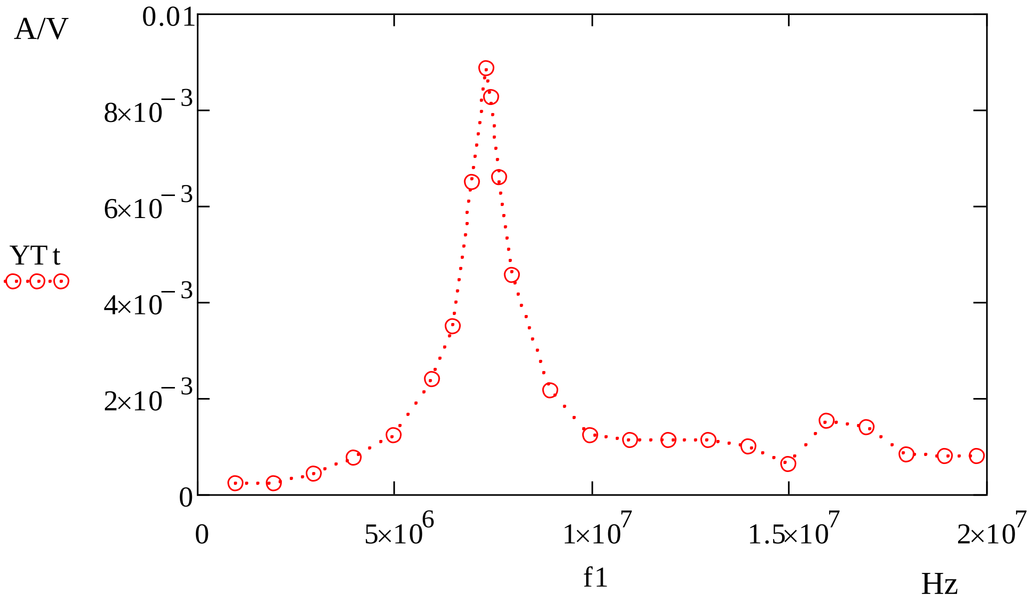

Figure 7.5.2 Results of radiated emission test

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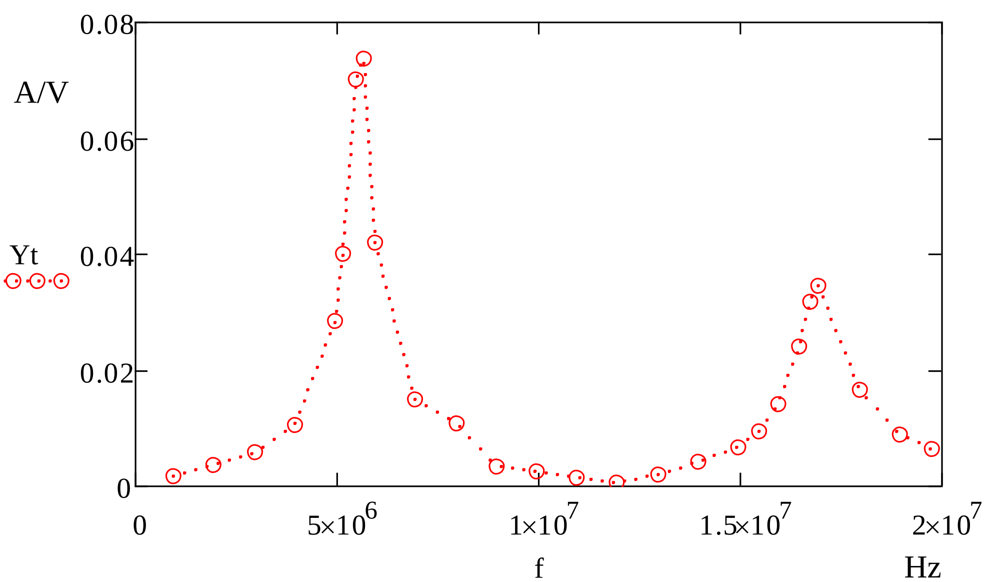

Figure 7.5.4 Results of wire-to-wire coupling test

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$\rho := 1.7\cdot 10^{-8}\ \Omega\ \ m$ $\mu_o := 4\cdot\pi\cdot 10^{-7}\ H/m$ $\mu_r := 1$

$r11 := 0.48\cdot 10^{-3}\ m$ $r22 := r11$ Radii of conductors

$r12 := 1.95\cdot 10^{-3}\ m$ Spacing between conductors. See figure 2.7.4

$l := 7.5\ m$ half the length of the cable

$Ra := 0.75\ \Omega$ Steady state resistance of length *l* of the cable.
Value selected during analysis.

$$Rss := \begin{pmatrix} Ra \\ Ra \\ 0 \end{pmatrix}$$

Placing steady state resitance values in the vector Rss.
Conductor 3 represents the environment

$$Fx := \frac{4\cdot\rho}{\mu_o\cdot\pi\cdot r11^2} = 7.476\times 10^4\ \ Hz$$

Frequency at which skin-effect starts to modify resistance.
See equation (2.5.14)

$$Lc_1 := \frac{\mu_o\cdot\mu_r\cdot l}{2\cdot\pi}\cdot\ln\left(\frac{r12}{r11}\right)$$

$$Lc_2 := \frac{\mu_o\cdot\mu_r\cdot l}{2\cdot\pi}\cdot\ln\left(\frac{r12}{r22}\right)$$

$$Lc_3 := \frac{\mu_o\cdot\mu_r\cdot l}{2\cdot\pi}\cdot\ln\left(\frac{l}{r12}\right)$$

Calculating inductance values for the circuit model and placing these values in a three-element vector.
See equation set (5.2.9)

$$\frac{Lc}{2} = \begin{pmatrix} 1.051\times 10^{-6} \\ 1.051\times 10^{-6} \\ 6.191\times 10^{-6} \end{pmatrix}\ H$$

Values of inductors of circuit model

$$\frac{Rss}{2} = \begin{pmatrix} 0.375 \\ 0.375 \\ 0 \end{pmatrix}\ \Omega$$

Values of resistors of circuit model

$Rrad := 50\ \Omega$

Radiation resistance.
Value selected during analysis
Initially set at 73 ohm

Figure 7.5.7 Calculation of values for resistors and inductors.

$\varepsilon_o := 8.854 \cdot 10^{-12}$ F/m

$c := 3 \cdot 10^8$ m/s

$fqa := 5.66 \cdot 10^6$ Hz

The frequency at which the peak occurs in test of wire-to-wire coupling.

$va := 4 \cdot l \cdot fqa = 1.698 \times 10^8$

Velocity of propagation of electromagnetic wave along transmission line. See equation (2.3.10)

$$\varepsilon_{ra} := \left(\frac{c}{va}\right)^2$$

Relative permittivity of dielectric of cable, acting as a transmission line. See equation (2.3.11)

$\varepsilon_{ra} = 3.122$

Value of relative permittivitty to be used to define capacitor values for conductors

$fqb := 7.55 \cdot 10^6$ Hz

The frequency at which the peak occurs in radiated emission test.

$vb := 4 \cdot l \cdot fqb = 2.265 \times 10^8$

Velocity of propagation of electromagnetic wave along cable. See equation (2.3.10)

$$\varepsilon_{rb} := \left(\frac{c}{vb}\right)^2$$

Relative permittivity of dielectric of cable when it is acting as an aerial. See equation (2.3.11)

$\varepsilon_{rb} = 1.754$

Value of relative permittivity to be used to define capacitor value for monopole.

$$Cc_1 := \frac{2 \cdot \pi \cdot \varepsilon_o \cdot \varepsilon_{ra} \cdot l}{\ln\left(\frac{r12}{r11}\right)}$$

$$Cc_2 := Cc_1$$

Calculating capacitance values for the circuit model and placing these values in a three-element vector. See equation set (5.2.10)

$$Cc_3 := \frac{2 \cdot \pi \cdot \varepsilon_o \cdot \varepsilon_{rb} \cdot l}{\ln\left(\frac{l}{r12}\right)}$$

$$Cc = \begin{pmatrix} 9.291 \times 10^{-10} \\ 9.291 \times 10^{-10} \\ 8.867 \times 10^{-11} \end{pmatrix}$$

Values of capacitors of circuit model

Figure 7.5.8 Calculating values for the capacitors

$i := 1..200$ $\quad F_i := i \cdot 10^5$ Hz $\quad$ Defining the frequency range for the model

$$
\begin{array}{l}
\mathrm{Zbranch}(s) := \left|
\begin{array}{l}
\omega \leftarrow 2 \cdot \pi \cdot F_s \\
\text{for } k \in 1..3 \\
\quad \left|
\begin{array}{l}
Rc_k \leftarrow Rss_k \cdot \sqrt{1 + \dfrac{F_s}{Fx}} \\
\theta \leftarrow \sqrt{(Rc_k + j \cdot \omega \cdot Lc_k) \cdot j \cdot \omega \cdot Cc_k} \\
Zo \leftarrow \sqrt{\dfrac{Rc_k + j \cdot \omega \cdot Lc_k}{j \cdot \omega \cdot Cc_k}} \\
z_{1,k} \leftarrow Zo \cdot \tanh\left(\dfrac{\theta}{2}\right) \\
z_{2,k} \leftarrow Zo \cdot \mathrm{csch}(\theta)
\end{array}
\right. \\
z
\end{array}
\right.
\end{array}
$$

copy of function introduced in figure 4.3.4

Equations for loop impedances, derived from inspection of figure 7.5.6

$$
\mathrm{Zloop}(s) := \left|
\begin{array}{l}
Z \leftarrow \mathrm{Zbranch}(s) \\
Z11 \leftarrow 2 \cdot (Z_{1,1} + Z_{2,1} + Z_{1,3} + Z_{2,3}) + Rrad \\
Z12 \leftarrow -2 \cdot (Z_{1,3} + Z_{2,3}) - Rrad \\
Z22 \leftarrow 2 \cdot (Z_{1,2} + Z_{2,2} + Z_{1,3} + Z_{2,3}) + Rrad \\
\begin{pmatrix} Z11 & Z12 \\ Z12 & Z22 \end{pmatrix}
\end{array}
\right.
$$

$$
V := \begin{pmatrix} 1 \\ 0 \end{pmatrix} V \qquad YTm_i := \left|
\begin{array}{l}
Z \leftarrow \mathrm{Zloop}(i) \\
I \leftarrow \mathrm{lsolve}(Z, V) \\
|I_1 - I_2|
\end{array}
\right.
$$

calculating response of transfer admittance for radiated emission from the cable.

$$
Ym_i := \left|
\begin{array}{l}
Z \leftarrow \mathrm{Zloop}(i) \\
I \leftarrow \mathrm{lsolve}(Z, V) \\
|I_2|
\end{array}
\right.
$$

calculating response of admittance of open-circuit transmission line

Figure 7.5.9 The main program; calculating the response of the circuit model.

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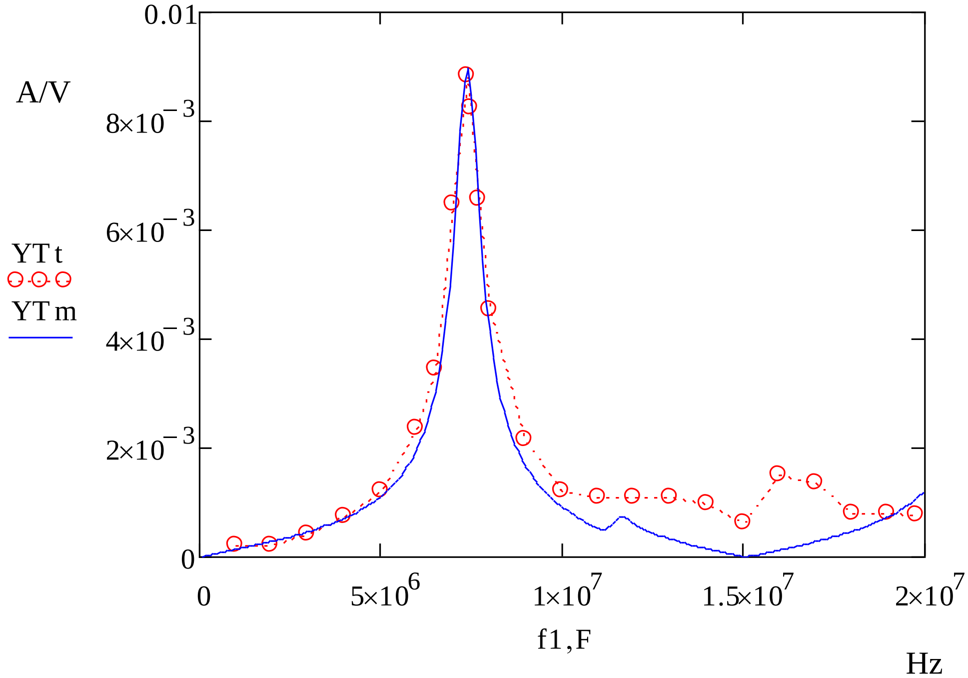

Figure 7.5.10 Radiated emission of cable and model.

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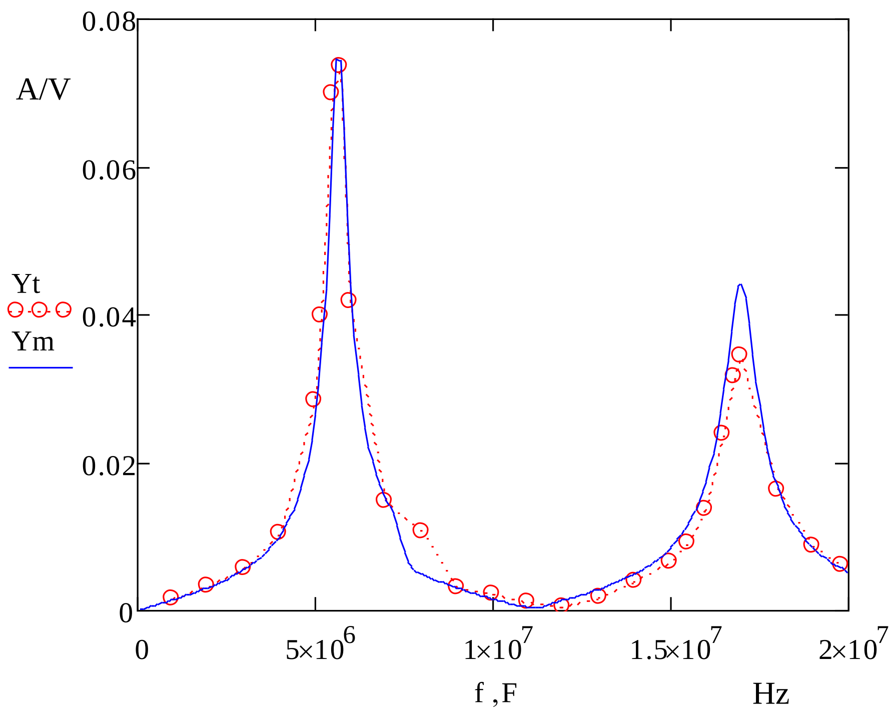

Figure 7.5.11 Transmission line responses of cable and model.