

H Constantes L

```
Date@D
a = 0.0371703894074700;
H freq=2.4 10^9 L
w = 2 Pi freq;
alpha = N@Pi^2 D;
μ = 1.25663706144 10^-6;
d = 0.002;
i = N@Pi^8 D;
j = N@3 Pi^8 D;
ij = j - i;
wi = 0.00433677096491318;
wj = 0.00433677096491318;
i = wi^a;
j = wj^a;
r = 4.2;
co = 299792458;
k = 2 Pi freq^r / co;
wr = wi^4;
xr = wr^2;
ws = wr;
xs = 3 xr;
wp = wi^4;
xp = wr^2;
wq = wr;
xq = 3 xp;
nmax = 50
mmax = 50
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82005, 4, 24, 17, 49, 39<

50

50

Needs@"NumericalMath`BesselZeros`"D

Date@D

nmaxx = 2 nmax + 1

mmaxx = 1 mmax

matrizbesel@nnn_, mmm_D := Module@8k1<,

If@nnn ~ 0, BesselJPrimeZeros@nnn, 82, mmm + 1<D,

BesselJPrimeZeros@nnn, 81, mmm<DD

D

autoderiv@nnn_D := matrizbesel@nnn, mmaxxD

autovalbesel = Array@autoderiv, 8nmaxx<, 80<D ;

kmn@ns_, mt_D := Part@autovalbesel, ns + 1, mtD

Date@D

82005, 4, 24, 17, 52, 26<

101

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82005, 4, 24, 17, 54, 40<

H Formulas L

Needs@"NumericalMath`BesselZeros`"D

Jns@ns_, eval_D := Module@8salida<,

salida = BesselJ@ns, evalD

D

Iij@ns_, m_, i_, j_, ij_, k_, i_, j_D :=

ModuleA8num01, num02, den01, salida<,

num01 = Sigma@nsD H Cos@ns ijD + Cos@ns H i + jLDL ;

num02 = CosA $\frac{ns}{2}$ H i - jLE - CosA $\frac{ns}{2}$ H i + jLE ;

den01 =

$$HnsL^2 \int_k^j HaL^2 - \frac{HnsL^2}{Hkmn@ns, mDê aL^2} H Hkmn@ns, mDê aL^2 - HkL^2L ;$$

salida = num01 num02 ê den01

E

LimIij@ns_, m_, k_, i_, j_, a_D := Module@8num01, den01, salida<,

num01 = j i ;

den01 = H HaL^2L H Hkmn@ns, mDê aL^2 - HkL^2L ;

salida = num01 ê den01

```

D
Sigma@n_D := If@n == 0, 1, 2D

gr1@wr_, xr_, ns_, m_, a_D := Hkmn@ns, mDê aL Hkr - Hwrê 2LL
gr2@wr_, xr_, ns_, m_, a_D := Hkmn@ns, mDê aL Hkr + Hwrê 2LL

Ins@wr_, xr_, ns_, m_, a_D := Module@8tempin1, tempin2, salida<,
  tempin1 = NIntegrate@BesselJ@0, tD,
  8t, gr1@wr, xr, ns, m, aD, gr2@wr, xr, ns, m, aD<D;
  tempin2 = N@Sum@HBesselJ@2 k + 1, gr2@wr, xr, ns, m, aDD -
  BesselJ@2 k + 1, gr1@wr, xr, ns, m, aDDL, 8k, 0, nsê 2 - 1<DD;
  salida = tempin1 - 2 tempin2
D

T1@ns_, alpha_D := HCos@ns alphaDL ^ 2

T2@ns_, alpha_D := Cos@ns alphaD

Irs@ns_, m_, wr_, xr_, ws_, xs_, alpha_, k_, a_D :=
Module@8num01, den01, salida<,
  num01 = Sigma@nsD T1@ns, alphaD
  Ins@wr, xr, ns, m, aD Ins@ws, xs, ns, m, aD;
  den01 = HHkmn@ns, mDL ^ 2 - HnsL ^ 2L HHkmn@ns, mDê aL ^ 2 - HkL ^ 2L
  HHJns@ns, kmn@ns, mDDL ^ 2L;
  salida = num01ê den01
D

Irp@ns_, m_, wr_, xr_, wp_, xp_, alpha_, k_, a_D :=
Module@8num01, den01, salida<,
  num01 = Sigma@nsD T2@ns, alphaD
  Ins@wr, xr, ns, m, aD Ins@wp, xp, ns, m, aD;
  den01 = HHkmn@ns, mDL ^ 2 - HnsL ^ 2L HHkmn@ns, mDê aL ^ 2 - HkL ^ 2L
  HHJns@ns, kmn@ns, mDDL ^ 2L;
  salida = num01ê den01
D

Iir@ns_, m_, i_, i_, wr_, xr_, alpha_, k_, a_D :=
ModuleA8num01, den01, salida<,
  num01 = Sigma@nsD Cos@ns alphaD Cos@ns iD
  Sin@ns iê 2D Ins@wr, xr, ns, m, aD;
  den01 = ns Hkmn@ns, mDê aL  $\int_0^i$  HaL ^ 2 -  $\frac{HnsL^2}{Hkmn@ns, mDê aL^2}$ 
  HHkmn@ns, mDê aL ^ 2 - HkL ^ 2L HHJns@ns, kmn@ns, mDDL;
  salida = num01ê den01
E

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LimIir@ns_, m_, i_, i_, wr_, xr_, alpha_, k_, a_D :=
Module@8num01, den01, salida<,
  num01 = Sigma@nsD H i ê 2L Ins@wr, xr, ns, m, aD;
  den01 = Hkmn@ns, mDê aL HHaL ^ 2L
    Hkmn@ns, mDê aL ^ 2 - HkL ^ 2L HJns@ns, kmn@ns, mDDL;
  salida = num01 ê den01
D

H Impedancias Extendidas L
ClearAll@"frec"D
frec = 2.4 10^9
Date@D

Zx56 = 
$$\frac{2 \alpha w U d a^2}{\alpha w_i w_j} \text{HSum@LimIij@0, m, k, i, j, aD, 8m, 1, mmax<D +}$$

  Sum@Iij@2 n, m, i, j, ij, k, i, jD, 8n, 1, nmax<, 8m, 1, mmax<DL

Zx55 = 
$$\frac{2 \alpha w U d a^2}{\alpha w_j w_j} \text{HSum@LimIij@0, m, k, j, j, aD, 8m, 1, mmax<D +}$$

  Sum@Iij@2 n, m, j, j, 0, k, j, jD, 8n, 1, nmax<, 8m, 1, mmax<DL

Zx12 = 
$$\frac{2 \alpha w U d}{\alpha w_r w_s} \text{HSum@Irs@2 n, m, wr, xr, ws, xs, alpha, k, aD,}$$

  8n, 0, nmax<, 8m, 1, mmax<DL

Zx11 = 
$$\frac{2 \alpha w U d}{\alpha w_r w_r} \text{HSum@Irs@2 n, m, wr, xr, wr, xr, alpha, k, aD,}$$

  8n, 0, nmax<, 8m, 1, mmax<DL

Zx22 = 
$$\frac{2 \alpha w U d}{\alpha w_s w_s} \text{HSum@Irs@2 n, m, ws, xs, ws, xs, alpha, k, aD,}$$

  8n, 0, nmax<, 8m, 1, mmax<DL

Zx13 = 
$$\frac{2 \alpha w U d}{\alpha w_r w_p} \text{HSum@Irp@2 n, m, wr, xr, w_p, x_p, alpha, k, aD,}$$

  8n, 0, nmax<, 8m, 1, mmax<DL

Zx14 = 
$$\frac{2 \alpha w U d}{\alpha w_r w_q} \text{HSum@Irp@2 n, m, wr, xr, w_q, x_q, alpha, k, aD,}$$

  8n, 0, nmax<, 8m, 1, mmax<DL

H
Zx23 = 
$$\frac{2 \alpha w U d}{\alpha w_s w_p} \text{HSum@Irp@2 n, m, ws, xs, w_p, x_p, alpha, k, aD,}$$

  8n, 1, nmax<, 8m, 1, mmax<DL L
Zx23 = Zx14

```

Zx24 = $\frac{2 \text{ á w U d}}{\text{alpha ws wq}}$ HSum@Irp@2 n, m, ws, xs, wq, xq, alpha, k, aD,
 8n, 0, nmax<, 8m, 1, mmax<DL

Zx15 = $\frac{4 \text{ á w U d a}}{\text{alpha wr wj}}$
 HSum@LimIir@0, m, j, j, wr, xr, alpha, k, aD, 8m, 1, mmax<D+Sum@Iir@
 2 n, m, j, j, wr, xr, alpha, k, aD, 8n, 1, nmax<, 8m, 1, mmax<DL

Zx25 = $\frac{4 \text{ á w U d a}}{\text{alpha ws wj}}$
 HSum@LimIir@0, m, j, j, ws, xs, alpha, k, aD, 8m, 1, mmax<D+Sum@Iir@
 2 n, m, j, j, ws, xs, alpha, k, aD, 8n, 1, nmax<, 8m, 1, mmax<DL

Zx16 = $\frac{4 \text{ á w U d a}}{\text{alpha wr wi}}$
 HSum@LimIir@0, m, i, i, wr, xr, alpha, k, aD, 8m, 1, mmax<D+Sum@Iir@
 2 n, m, i, i, wr, xr, alpha, k, aD, 8n, 1, nmax<, 8m, 1, mmax<DL

Zx26 = $\frac{4 \text{ á w U d a}}{\text{alpha ws wi}}$
 HSum@LimIir@0, m, i, i, ws, xs, alpha, k, aD, 8m, 1, mmax<D+Sum@Iir@
 2 n, m, i, i, ws, xs, alpha, k, aD, 8n, 1, nmax<, 8m, 1, mmax<DL

Date@D

2.4×10^9

82005, 4, 14, 14, 30, 54<

$5.75014 \times 10^7 \text{ á}$

$5.75014 \times 10^7 \text{ á}$

$3.51532 \times 10^8 \text{ á}$

$3.53739 \times 10^8 \text{ á}$

$3.4934 \times 10^8 \text{ á}$

$3.53739 \times 10^8 \text{ á}$

$3.51532 \times 10^8 \text{ á}$

$3.51532 \times 10^8 \text{ á}$

$3.4934 \times 10^8 \text{ á}$

$-1.4262 \times 10^8 \text{ á}$

$-1.4173 \times 10^8 \text{ á}$

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-1.4262 × 108 á
-1.4173 × 108 á
82005, 4, 14, 14, 37, 30<

Zx = 88Zx11, Zx12, Zx13, Zx14, Zx15, Zx16 <, 8Zx12, Zx22, Zx14,
      Zx24, Zx25, Zx26<, 8Zx13, Zx14, Zx11, Zx12, Zx16, Zx15 <,
      8Zx14, Zx24, Zx12, Zx22, Zx26, Zx25<, 8Zx15, Zx25, Zx16,
      Zx26, Zx55, Zx56<, 8Zx16, Zx26, Zx15, Zx25, Zx56, Zx55<< ;

Yx = N@Inverse@ZxDD

      4 4
Y11 = , , HPart@Yx, k, 1DL ;
      k=1 l=1

      4
Y12 = , Part@Yx, k, 5D ;
      k=1

      4
Y13 = , Part@Yx, k, 6D ;
      k=1

      4
Y21 = , HPart@Yx, 5, 1DL ;
      l=1
Y22 = Part@Yx, 5, 5D ;
Y23 = Part@Yx, 5, 6D ;

      4
Y31 = , HPart@Yx, 6, 1DL ;
      l=1

Y32 = Part@Yx, 6, 5D ;

Y33 = Part@Yx, 6, 6D ;

Y = 88Y11, Y12, Y13<, 8Y21, Y22, Y23<, 8Y31, Y32, Y33<<

Z = Inverse@YD

Id = 881, 0, 0<, 80, 1, 0<, 80, 0, 1<<

Zref = Id 50

S0 = HZ - ZrefL.HInverse@HZ + ZrefL DL

      3
Prueba1 = , Abs@Part@S0, k, 1DD
      k=1

      3
Prueba2 = , Abs@Part@S0, 1, kDD
      k=1

```

Part@S0, 1, 1D

20 Log@10, Abs@Part@S0, 1, 1DDD
 20 Log@10, Abs@Part@S0, 1, 2DDD
 20 Log@10, Abs@Part@S0, 1, 3DDD
 20 Log@10, Abs@Part@S0, 2, 1DDD
 20 Log@10, Abs@Part@S0, 2, 2DDD
 20 Log@10, Abs@Part@S0, 2, 3DDD
 20 Log@10, Abs@Part@S0, 3, 1DDD
 20 Log@10, Abs@Part@S0, 3, 2DDD
 20 Log@10, Abs@Part@S0, 3, 3DDD

Date@D

H Fin L

880. - 0.136946 á, 0. + 0.0430231 á, 0. + 0.112699 á,
 0. - 0.0186175 á, 0. - 0.000689848 á, 0. + 0.000705659 á<,
 80. + 0.0430231 á, 0. - 0.0492054 á, 0. - 0.0186175 á,
 0. + 0.021049 á, 0. - 0.00152742 á, 0. - 0.00734008 á<,
 80. + 0.112699 á, 0. - 0.0186175 á, 0. - 0.136946 á,
 0. + 0.0430231 á, 0. + 0.00070566 á, 0. - 0.000689848 á<,
 80. - 0.0186175 á, 0. + 0.021049 á, 0. + 0.0430231 á,
 0. - 0.0492054 á, 0. - 0.00734008 á, 0. - 0.00152742 á<,
 80. - 0.000689848 á, 0. - 0.00152742 á, 0. + 0.00070566 á,
 0. - 0.00734008 á, 0. + 0.160011 á, 0. - 0.181829 á<,
 80. + 0.000705659 á, 0. - 0.00734008 á, 0. - 0.000689848 á,
 0. - 0.00152742 á, 0. - 0.181829 á, 0. + 0.160011 á<<

880. - 0.00718442 á, 0. - 0.00885169 á, 0. - 0.00885169 á<,
 80. - 0.00885169 á, 0. + 0.160011 á, 0. - 0.181829 á<,
 80. - 0.00885169 á, 0. - 0.181829 á, 0. + 0.160011 á<<

880. + 522652. á, 0. - 212047. á, 0. - 212047. á<,
 80. - 212047. á, 0. + 86052. á, 0. + 86054.9 á<,
 80. - 212047. á, 0. + 86054.9 á, 0. + 86052. á<<

881, 0, 0<, 80, 1, 0<, 80, 0, 1<<

8850, 0, 0<, 80, 50, 0<, 80, 0, 50<<

880.664278 + 0.231636 á, -0.413715 + 0.285271 á, -0.413715 + 0.285271 á<,
 8-0.413715 + 0.285271 á, -0.506415 + 0.293308 á, 0.486762 + 0.409923 á<,
 8-0.413715 + 0.285271 á, 0.486762 + 0.409923 á, -0.506415 + 0.293308 á<<

1.70857

1.70857

0.664278 + 0.231636 á

-3.05464

-5.97671

-5.97671

-5.97671

-4.65357

-3.92573

-5.97671

-3.92573

-4.65357

82005, 4, 14, 14, 37, 30<