```
H Constantes L

Date@D
a = 0.0371703894074700;
H frec=3 10^9; L
w = 2  Pi  frec;
alpha = N@Pi ê 2D;
μ = 1.25663706144  10^-6;
d = 0.002;
θi = N@Pi ê 12D;
θj = N@3  Pi ê 12D;
θk = N@5  Pi ê 12D;
θij = θj - θi;
θik = θk - θi;
θjk = θk - θj;
wi = 0.00433677096491318;
wj = 0.00433677096491318;
wk = 0.00433677096491318;
Δi = wi ê a;
Δj = wj ê a;
Δk = wk ê a;
εr = 4.2;
co = 299792458;
k = 2  Pi  frec  è!!!!!!
                 εr ë co;
wr = wi ê 4;
xr = wr ê 2;
ws = wr;
xs = 3  xr;
wp = wi ê 4;
xp = wr ê 2;
wq = wr;
xq = 3  xp;
nmax = 50
mmax = 50

82005, 4, 25, 0, 4, 2<

50

50
```

```
Needs@"NumericalMath`BesselZeros`"D

Date@D
nmaxx = 2  nmax + 1
mmaxx = 1  mmax

matrizbesel@nnn_, mmm_D := Module@8kl<,
 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, 25, 0, 19, 55<

101

50

82005, 4, 25, 0, 22, 29<

H Formulas L

Needs@"NumericalMath`BesselZeros`"D

Jns@ns_, eval_D := Module@8salida<,
  salida = BesselJ@ns, evalD
 D

Iij@ns_, m_, θi_, θj_, θij_, k_, Δi_, Δj_D :=
 ModuleA8num01, num02, den01, salida<,
  num01 = Sigma@nsD  HCos@ns  θijD + Cos@ns  Hθi + θjLDL;
                    ns                   ns
  num02 = CosAiijjii  HΔi − ΔjLE − CosAiijjii  HΔi + ΔjLE;
                    2                    2
  den01 =
                               HnsL^2
   HnsL^2  jHaL^2 − jjjjjjjjjjjjjjjjjjjjjjjjjjjjjjjjjjjjjj z  HHkmn@ns, mDêaL^2 − HkL^2L;
           k            Hkmn@ns, mDêaL^2 {
  salida = num01  num02êden01
 E

LimIij@ns_, m_, k_, Δi_, Δj_, a_D := Module@8num01, den01, salida<,
  num01 = Δj  Δi;
  den01 = HHaL^2L  HHkmn@ns, mDêaL^2 − HkL^2L;
  salida = num01êden01
```

```
 D

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

gr1@wr_, xr_, ns_, m_, a_D := Hkmn@ns, mD ê aL  Hxr - Hwr ê 2LL

gr2@wr_, xr_, ns_, m_, a_D := Hkmn@ns, mD ê aL  Hxr + Hwr ê 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, ns ê 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, mD ê aL^2 - HkL^2L
    HHJns@ns, kmn@ns, mDDL^2L;
  salida = num01 ê 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, mD ê aL^2 - HkL^2L
    HHJns@ns, kmn@ns, mDDL^2L;
  salida = num01 ê den01
 D

Iir@ns_, m_, Θi_, Δi_, wr_, xr_, alpha_, k_, a_D :=
 ModuleA8num01, den01, salida<,
  num01 = Sigma@nsD  Cos@ns  alphaD  Cos@ns  ΘiD
    Sin@ns  Δi ê 2D  Ins@wr, xr, ns, m, aD;
  den01 = ns  Hkmn@ns, mD ê aL  j HaL^2 - HnsL^2 y
                                k Hkmn@ns, mD ê aL^2 z{
    HHkmn@ns, mD ê aL^2 - HkL^2L  HJns@ns, kmn@ns, mDDL;
  salida = num01 ê den01
 E
```

```
LimIir@ns_, m_, Θi_, Δi_, wr_, xr_, alpha_, k_, a_D :=
 Module@8num01, den01, salida<,
  num01 = Sigma@nsD  HΔi ê 2L  Ins@wr, xr, ns, m, aD;
  den01 = Hkmn@ns, mD ê aL  HHaL ^ 2L
    HHkmn@ns, mD ê 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

        2  ą  w  μ  d  a²
Zx56 = ¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡  HSum@LimIij@0, m, k, Δj, Δk, aD, 8m, 1, mmax<D +
          alpha  wj  wk
    Sum@Iij@2  n, m, Θj, Θk, Θjk, k, Δj, ΔkD, 8n, 1, nmax<, 8m, 1, mmax<DL

        2  ą  w  μ  d  a²
Zx57 = ¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡  HSum@LimIij@0, m, k, Δi, Δk, aD, 8m, 1, mmax<D +
          alpha  wi  wk
    Sum@Iij@2  n, m, Θi, Θk, Θik, k, Δi, ΔkD, 8n, 1, nmax<, 8m, 1, mmax<DL

        2  ą  w  μ  d  a²
Zx55 = ¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡  HSum@LimIij@0, m, k, Δk, Δk, aD, 8m, 1, mmax<D +
          alpha  wk  wk
    Sum@Iij@2  n, m, Θk, Θk, 0, k, Δk, ΔkD, 8n, 1, nmax<, 8m, 1, mmax<DL

        2  ą  w  μ  d  a²
Zx66 = ¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡  HSum@LimIij@0, m, k, Δj, Δj, aD, 8m, 1, mmax<D +
          alpha  wj  wj
    Sum@Iij@2  n, m, Θj, Θj, 0, k, Δj, ΔjD, 8n, 1, nmax<, 8m, 1, mmax<DL

        2  ą  w  μ  d  a²
Zx67 = ¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡  HSum@LimIij@0, m, k, Δi, Δj, aD, 8m, 1, mmax<D +
          alpha  wi  wj
    Sum@Iij@2  n, m, Θi, Θj, Θij, k, Δi, ΔjD, 8n, 1, nmax<, 8m, 1, mmax<DL

         2  ą  w  μ  d
Zx12 = ¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡
        alpha  wr  ws
  HSum@Irs@0, m, wr, xr, ws, xs, alpha, k, aD, 8m, 1, mmax<D + Sum@Irs@
      2  n, m, wr, xr, ws, xs, alpha, k, aD, 8n, 1, nmax<, 8m, 1, mmax<DL


         2  ą  w  μ  d
Zx11 = ¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡
        alpha  wr  wr
  HSum@Irs@0, m, wr, xr, wr, xr, alpha, k, aD, 8m, 1, mmax<D + Sum@Irs@
      2  n, m, wr, xr, wr, xr, alpha, k, aD, 8n, 1, nmax<, 8m, 1, mmax<DL

         2  ą  w  μ  d
Zx22 = ¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡¡
        alpha  ws  ws
  HSum@Irs@0, m, ws, xs, ws, xs, alpha, k, aD, 8m, 1, mmax<D + Sum@Irs@
      2  n, m, ws, xs, ws, xs, alpha, k, aD, 8n, 1, nmax<, 8m, 1, mmax<DL
```

$$Zx13 = \frac{2\ a\ w\ \mu\ d}{alpha\ wr\ wp}$$

```
HSum@Irp@0, m, wr, xr, wp, xp, alpha, k, aD, 8m, 1, mmax<D + Sum@Irp@
    2  n, m, wr, xr, wp, xp, alpha, k, aD, 8n, 1, nmax<, 8m, 1, mmax<DL
```

$$Zx14 = \frac{2\ a\ w\ \mu\ d}{alpha\ wr\ wq}$$

```
HSum@Irp@0, m, wr, xr, wq, xq, alpha, k, aD, 8m, 1, mmax<D + Sum@Irp@
    2  n, m, wr, xr, wq, xq, alpha, k, aD, 8n, 1, nmax<, 8m, 1, mmax<DL
```

$$Zx23 = \frac{2\ a\ w\ \mu\ d}{alpha\ ws\ wp}$$

```
HSum@Irp@0, m, ws, xs, wp, xp, alpha, k, aD, 8m, 1, mmax<D + Sum@Irp@
    2  n, m, ws, xs, wp, xp, alpha, k, aD, 8n, 1, nmax<, 8m, 1, mmax<DL
```

$$Zx24 = \frac{2\ a\ w\ \mu\ d}{alpha\ ws\ wq}$$

```
HSum@Irp@0, m, ws, xs, wq, xq, alpha, k, aD, 8m, 1, mmax<D + Sum@Irp@
    2  n, m, ws, xs, wq, xq, alpha, k, aD, 8n, 1, nmax<, 8m, 1, mmax<DL
```

$$Zx15 = \frac{4\ a\ w\ \mu\ d\ a}{alpha\ wr\ wk}$$

```
HSum@LimIir@0, m, 0k, Dk, wr, xr, alpha, k, aD, 8m, 1, mmax<D + Sum@Iir@
    2  n, m, 0k, Dk, wr, xr, alpha, k, aD, 8n, 1, nmax<, 8m, 1, mmax<DL
```

$$Zx25 = \frac{4\ a\ w\ \mu\ d\ a}{alpha\ ws\ wk}$$

```
HSum@LimIir@0, m, 0k, Dk, ws, xs, alpha, k, aD, 8m, 1, mmax<D + Sum@Iir@
    2  n, m, 0k, Dk, ws, xs, alpha, k, aD, 8n, 1, nmax<, 8m, 1, mmax<DL
```

$$Zx16 = \frac{4\ a\ w\ \mu\ d\ a}{alpha\ wr\ wj}$$

```
HSum@LimIir@0, m, 0j, Dj, wr, xr, alpha, k, aD, 8m, 1, mmax<D + Sum@Iir@
    2  n, m, 0j, Dj, wr, xr, alpha, k, aD, 8n, 1, nmax<, 8m, 1, mmax<DL
```

$$Zx26 = \frac{4\ a\ w\ \mu\ d\ a}{alpha\ ws\ wj}$$

```
HSum@LimIir@0, m, 0j, Dj, ws, xs, alpha, k, aD, 8m, 1, mmax<D + Sum@Iir@
    2  n, m, 0j, Dj, ws, xs, alpha, k, aD, 8n, 1, nmax<, 8m, 1, mmax<DL
```

$$Zx17 = \frac{4\ a\ w\ \mu\ d\ a}{alpha\ wr\ wi}$$

```
HSum@LimIir@0, m, 0i, Di, wr, xr, alpha, k, aD, 8m, 1, mmax<D + Sum@Iir@
    2  n, m, 0i, Di, wr, xr, alpha, k, aD, 8n, 1, nmax<, 8m, 1, mmax<DL
```

$$Zx27 = \frac{4\ a\ w\ \mu\ d\ a}{alpha\ ws\ wi}$$

```
HSum@LimIir@0, m, 0i, Di, ws, xs, alpha, k, aD, 8m, 1, mmax<D + Sum@Iir@
```

```
2  n, m, θi, Δi, ws, xs, alpha, k, aD, 8n, 1, nmax<, 8m, 1, mmax<DL
```

2.4×10^{9}

5.75014×10^{7} ą

5.75014×10^{7} ą

5.75014×10^{7} ą

5.75014×10^{7} ą

5.75014×10^{7} ą

3.51532×10^{8} ą

3.53739×10^{8} ą

3.4934×10^{8} ą

3.53739×10^{8} ą

3.51532×10^{8} ą

3.51532×10^{8} ą

3.4934×10^{8} ą

-1.4262×10^{8} ą

-1.4173×10^{8} ą

-1.4262×10^{8} ą

-1.4173×10^{8} ą

-1.4262×10^{8} ą

-1.4173×10^{8} ą

```
Zx = 88Zx11, Zx12, Zx13,  Zx14, Zx15, Zx16, Zx17 <,
  8Zx12, Zx22, Zx23, Zx24, Zx25, Zx26, Zx27<,
  8Zx13,  Zx23, Zx11, Zx12, Zx17, Zx16, Zx15 <,
  8Zx14,  Zx24,  Zx12, Zx22, Zx27, Zx26, Zx25<,
  8Zx15,  Zx25,  Zx17, Zx27, Zx55, Zx56, Zx57<,
  8Zx16, Zx26, Zx16,  Zx26, Zx56, Zx66, Zx67<,
  8Zx17,  Zx27, Zx15, Zx25, Zx57, Zx67, Zx55<<

 Yx = N@Inverse@ZxDD ;
```

```
Y11 = Sum[Sum[Part[Yx, k, l], {l, 4}], {k, 4}];
Y12 = Sum[Part[Yx, k, 5], {k, 4}];
Y13 = Sum[Part[Yx, k, 6], {k, 4}];
Y14 = Sum[Part[Yx, k, 7], {k, 4}];
Y21 = Sum[Part[Yx, 5, l], {l, 4}];
Y22 = Part[Yx, 5, 5];
Y23 = Part[Yx, 5, 6];
Y24 = Part[Yx, 5, 7];
Y31 = Sum[Part[Yx, 6, l], {l, 4}];
Y32 = Part[Yx, 6, 5];
Y33 = Part[Yx, 6, 6];
Y34 = Part[Yx, 6, 7];
Y41 = Sum[Part[Yx, 7, l], {l, 4}];
Y42 = Part[Yx, 7, 5];
Y43 = Part[Yx, 7, 6];
Y44 = Part[Yx, 7, 7];

Y = {{Y11, Y12, Y13, Y14}, {Y21, Y22, Y23, Y24},
  {Y31, Y32, Y33, Y34}, {Y41, Y42, Y43, Y44}}

 Z = Inverse[Y]

 Id = {{1, 0, 0, 0}, {0, 1, 0, 0}, {0, 0, 1, 0}, {0, 0, 0, 1}};

 Zref = Id  50;

 S = (Z - Zref).Inverse[Z + Zref];
Prueba = Sum[Abs[Part[S, k, 1]]
         , {k, 4}]
Prueba = Sum[Abs[Part[S, 1, k]]
         , {k, 4}]
 20  Log[10, Abs[Part[S, 1, 1]]]
 20  Log[10, Abs[Part[S, 1, 2]]]
 20  Log[10, Abs[Part[S, 1, 3]]]
 20  Log[10, Abs[Part[S, 1, 4]]]
 20  Log[10, Abs[Part[S, 2, 1]]]
```

```
 20  Log@10, Abs@Part@S, 2, 2DDD
 20  Log@10, Abs@Part@S, 2, 3DDD
 20  Log@10, Abs@Part@S, 2, 4DDD
 20  Log@10, Abs@Part@S, 3, 1DDD
 20  Log@10, Abs@Part@S, 3, 2DDD
 20  Log@10, Abs@Part@S, 3, 3DDD
 20  Log@10, Abs@Part@S, 3, 4DDD
 20  Log@10, Abs@Part@S, 4, 1DDD
 20  Log@10, Abs@Part@S, 4, 2DDD
 20  Log@10, Abs@Part@S, 4, 3DDD
 20  Log@10, Abs@Part@S, 4, 4DDD

 Date@D

H Fin L
```

883.53739×10^8 ą, 3.51532×10^8 ą, 3.53739×10^8 ą,
  3.51532×10^8 ą, −1.4262×10^8 ą, −1.4262×10^8 ą, −1.4262×10^8 ą<,
 83.51532×10^8 ą, 3.4934×10^8 ą, 3.51532×10^8 ą, 3.4934×10^8 ą,
  −1.4173×10^8 ą, −1.4173×10^8 ą, −1.4173×10^8 ą<,
 83.53739×10^8 ą, 3.51532×10^8 ą, 3.53739×10^8 ą, 3.51532×10^8 ą,
  −1.4262×10^8 ą, −1.4262×10^8 ą, −1.4262×10^8 ą<,
 83.51532×10^8 ą, 3.4934×10^8 ą, 3.51532×10^8 ą, 3.4934×10^8 ą,
  −1.4173×10^8 ą, −1.4173×10^8 ą, −1.4173×10^8 ą<,
 8−1.4262×10^8 ą, −1.4173×10^8 ą, −1.4262×10^8 ą, −1.4173×10^8 ą,
  5.75014×10^7 ą, 5.75014×10^7 ą, 5.75014×10^7 ą<,
 8−1.4262×10^8 ą, −1.4173×10^8 ą, −1.4262×10^8 ą, −1.4173×10^8 ą,
  5.75014×10^7 ą, 5.75014×10^7 ą, 5.75014×10^7 ą<,
 8−1.4262×10^8 ą, −1.4173×10^8 ą, −1.4262×10^8 ą, −1.4173×10^8 ą,
  5.75014×10^7 ą, 5.75014×10^7 ą, 5.75014×10^7 ą<<

880. − 0.00925951 ą, 0. − 0.00760577 ą,
  0. − 0.00760642 ą, 0. − 0.00760577 ą<,
 80. − 0.00760577 ą, 0. + 0.013044 ą, 0. + 0.000851093 ą, 0. − 0.0326417 ą<,
 80. − 0.00760642 ą, 0. + 0.000851093 ą,
  0. − 0.0204503 ą, 0. + 0.000851093 ą<,
 80. − 0.00760577 ą, 0. − 0.0326417 ą, 0. + 0.000851093 ą, 0. + 0.013044 ą<<

880. + 522652. ą, 0. − 212047. ą, 0. − 212049. ą, 0. − 212047. ą<,
 80. − 212047. ą, 0. + 86045.4 ą, 0. + 86033.4 ą, 0. + 86067.3 ą<,
 80. − 212049. ą, 0. + 86033.4 ą, 0. + 86080.8 ą, 0. + 86033.4 ą<,
 80. − 212047. ą, 0. + 86067.3 ą, 0. + 86033.4 ą, 0. + 86045.4 ą<<

1.96939

1.96939

−3.83189

−7.09103

```
−7.09065

−7.09103

−7.09103

−10.1164

−17.3896

−1.6177

−7.09065

−17.3896

−1.14574

−17.3896

−7.09103

−1.6177

−17.3896

−10.1164

82005, 4, 17, 17, 12, 12<
```