Lamp Code Speaker Transmission Line PhL 6.10.14

See comments at the end. For those reasons, I did not try to include this in lines doc!

Cord Technical Information

Insulation and Jacket Properties

PARAMETER	PVC	PE
Specific Gravity	1.37	0.92
Dielectric Constant		
(a) 60 Hz	6.0	2.26
(b) 1000 Hz	5.0	2.25

So ε = 5 or ε = 6 is reasonable!

lamp wire 2: d= 1 mm b = 3.0 mm PVC

Set G = 0. First compute R from $R = 1/(\pi a^2 \sigma)$:

```
b := 3e-3;
```

$$b := .003$$

```
a := 0.5e-3;
```

$$a := .0005$$

```
sigma := 5.71e7;
```

$$\sigma := .571\ 10^{8}$$

```
R := evalf(1/(Pi*a^2*sigma));
```

$$R := .02229841584$$

which is maybe 1 ohm for 45 meters of wire?? Seems low? Well agrees with "std compu power cables" so OK.

$$C = 2\pi\varepsilon \frac{1}{\xi_2 - \xi_1}$$

First get ξ for the left wire:

```
a_ := (1/2)*sqrt(b^2-4*a^2);
```

$$a_ := .001414213563$$

```
xi2 := arcsinh(a_/a);
```

$$\xi 2 := 1.762747174$$

Fine. Now here is C:

```
eps_rel := 5;
```

$$eps_rel := 5$$

```
eps0 := 8.85e-12;
```

$$eps0 := .885\ 10^{-11}$$

```
eps := eps_rel*eps0;
```

$$eps := .4425\ 10^{-10}$$

```
C := evalf(Pi*eps/xi2);
```

$$C := .7886296855\ 10^{-10}$$

So C = 79 pF per meter!

What about L?? We know that

$$L_e = \frac{\mu}{4\pi} K$$

$$C = 4\pi\varepsilon/K$$

$L_eC = \mu\varepsilon = \mu_0\varepsilon_0\varepsilon_{rel} = c^{-2}\,\varepsilon_{rel}$

```
c := 3e8;
```

$$c := .3\ 10^{9}$$

```
Le := (1/c^2)*eps_rel/C;
```

$$Le := .7044568138\ 10^{-6}$$

so we are talking 0.7 μH/meter which seems OK. This is 700 nH/meter.

Lets throw in $L_{int} = 2L_i = \mu_0/4\pi$ = 100 nH/m.

So ballpark maybe L = 800 nH/m. So we then have

$$G = 0$$

$$R = .04\ \Omega/m$$ for the sum of both wires

$$C = 79 \times 10^{-12}\ F/m$$

L = 800 x 10^{-9} H/m for the sum of both wires

By one estimate we have

```
Le := (1/c^2)*eps_rel/C;
```

$$Le := .7044568138\ 10^{-6}$$

```
Lint := 100e-9;
```

$$Lint := .100\ 10^{-6}$$

```
L := Le+Lint;
```

$$L := .8044568138\ 10^{-6}$$

```
Z0 := sqrt(L/C);
```

$$Z0 := 100.9984728$$

So I am getting 100 Ω as Z_0 as long as

ωL >> R

2πf >> (R/L)

f > (R/2πL);

```
fmin := evalf(R/(2*Pi*L));
```

$$fmin := 4411.552048$$

Ouch. So at 10 KHz maybe we get this real cable impedance.

What is δ? $\delta \equiv \sqrt{2/\omega\mu\sigma} = [\ 2/2\pi f\mu\sigma]^{1/2} = [\ 1/\pi f\mu\sigma]^{1/2}$

At 1 KHz I get δ = 2 mm while a = 0.5 mm, so not in skin limit.
At 4 Khz I get δ = 1 mm while a = 0.5 mm.

So I have several problems with this little calculation:

(1) the cable impedance is coming out at 100 ohms resistive for f >> 4.4 KHz
which does not match an 8 ohm speaker. At lower f the Z_0 is not resistive. People would be interested in low f for bass where power is high, but there we don't have a well-terminated transmission line.

(2) probably a speaker is an inductive load in general anyway and varying with ω.

(3) this is probably a terrible example of a transmission line and I would do well NOT to include it!!!