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Designing and simulation of MEMS based Coaxial cable for Different Impedances

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Abstract - **Coaxial cable is the type of cylindrical shape wave guide cannel used in telecommunications for transmitting information signals for larger distance. They are basically governed by electromagnetic theory. The frequency range of these EM wave cables are more than the frequency range of other cables. The main application of coaxial cable is in the transmission of video signals over a long distance without any disturbance. A method is proposed here to find out the variation of impedance of a dielectric filled transmission cable (Coaxial Cable). This paper provides the theoretical and practical measures and its comparison by using different dielectric filled coaxial cables. This paper gives the composite solution, which involves a method of cable design for different applications, using geometry size and operating frequency, in order to study the variation of characteristic impedance with respect to dielectric material variation. This work is simulated using MEMS COMSOL MULTIPHYSICS Tools.**

Keywords: MEMS, Wave Guide Channel, EM Waves, Impedance, Video Signals.

1. INTRODUCTION

This piece of work focuses on the coax cable, its usefulness and observational parts when buying coax cable. Examining the impedance about coax cable is the major criteria while buying the cable. The basic components of a coaxial cable, from the inside out, are center conductor, dielectric, one or more shield layers and jacket (figure 1). A significant part of the cost to manufacturer coaxial cables is the outer conductor, or shield. Depending on the cable construction, the shield may use braided bare- or tinned copper wires, a conductive foil tape such as aluminum, a corrugated or smooth solid copper or aluminum tube outer conductor or some combination. It is intuitive that the more shield coverage, the better. Some shield types, such as a tubular or wrapped shield, completely enclose the dielectric and center conductor.

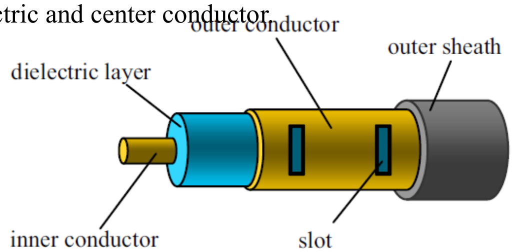

Fig 1: Coax Cable outlook.

2. CONSTRUCTION:

The center conductor may be made of various materials and constructions. Most common constructions are solid or seven-strand conductors. Solid conductors are used in permanent, infrequently handled or low flex applications and stranded conductors are used in flexible cable applications. Common materials include copper, tinned or silver plated copper, copper clad steel and copper clad aluminum. Plated copper is used to aid in solder ability of connectors or to minimize corrosion effects. Because of a phenomena known as skin-effect, copper clad materials may be used in higher frequency applications (> 50 MHz) to improve tensile strength and reduce weight and cost. (Skin-effect is the result of higher frequency signals propagating along the outermost surface, or skin, of the conductor.)

The insulation, or dielectric material, is used to provide separation between the conductors. It is desirable that the material has stable electrical characteristics (dielectric constant and dissipation factor) across a broad frequency range. The most common materials used are polyethylene (PE), polypropylene (PP), fluorinated ethylene propylene (FEP), and polytetrafluoroethylene (PTFE). PE and PP are desirable in lower cost, power, and temperature range applications (PE is 85C, PP is 105C)1. FEP and PTFE are for higher power and temperature range applications

(200C)1, and offer some additional environmental resistance properties. However, they are also much higher in cost. The materials may be used in their natural form (solid), or injected with air bubbles (foam or cellular) to improve the dielectric constant and electrical properties of the material and cable. Some designs also incorporate a mono-filament or disc designs sometimes referred to as air gap.

3.DESIGNING METHODOLOGY:

1. MODEL WIZARD

Selection of 2D, physical parameters and mode analysis

2. GLOBAL DEFINATION

Table 1: Choosing the parameters

Name	Expression	Description
r_i	0.5[mm]	Coax inner radius
r_o	3.43[mm]	Coax outer radius
eps_r	2.4	Relative dielectric constant
Z0_analytic	(Z0_const/(2*pi*sqrt(eps_r)))*log(r_o/r_i)	Characteristic impedance, analytic

Click geometry and select circle and thus locate the object type In the material section choose the material required Define the variables required in the model couplings and thus click on the boundaries required

3. MESH 1

Triangular meshing is selected for the entire space

4.RESULT

By the selection of dielectric material for designing the coaxial cable impedance is calculated.

4. PARAMETERS

Impedance

The impedance of a coaxial line (over about 1 MHz) depends only on the type of dielectric used, or by the dielectric constant εr, and the ratio between the diameter of the inner conductor and the inner diameter of the outer screen (not the size) and it is independent of the length and frequency. But why are there 50Ω and 75Ω cables.

Cut-off frequency - max optimal frequency

The cut-off frequency of a coaxial cable is not to be confused with the maximum frequency where it is "convenient" to use a particular cable. A given cable makes sense to be used up to a certain frequency - "operating frequency". Even at 20 GHz, are used handy-form cables 10 to 30 cm long for internal interconnections, it will not be possible to use the same cable for antenna connection, 10 or 20 m at the same frequency, since for such long distances the attenuation would be too high, these cables are not suitable for outdoor use. When choosing a cable is often not considered the factor of insulation that depends on the shielding of the outer conductor. The cut-off frequency represents instead the maximum absolute frequency of use, and over of that there are various resonances that change the phase and amplitude in the propagation of electromagnetic waves in the cable itself. The propagation in a coaxial cable is defined as TEM (Transversal Electric and Magnetic Field), the electric and magnetic field lines are perpendicular to the cable. Beyond the cut-off frequency strange resonances appear in the propagation and they produce phenomena not easily foreseeable. The cut-off frequency is inversely proportional to the size of the cable, it is actually a much higher value of the maximum optimal frequency except for the semi-rigid cables. since due to their design and very good quality they can be used up to their cut-off frequency. For very high frequencies it is better to use small diameter cables considering also the attenuation.`

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Table 2: Insulation V/s Different cable for designing cut-off frequency.

Max cut-off frequency and max optimal frequency suggested for some coaxial cables

Type	RG 58	RG 223 (double shield)	RG 213	RG 214 (double shield)	RG 316	RG 316 (double shield)	RG 142 (double shield)	UT 141 Multiflex 141	UT 086 Multiflex 86
cut-off freq.	~ 20 GHz	~ 20 GHz	~ 12 GHz	~ 12 GHz	~ 30 GHz	~ 30 GHz	~ 20 GHz	33 GHz	40 GHz
max optimal freq	100-1000 MHz	3 - 6 GHz	2 - 4 GHz	4 - 8 GHz	2 - 3 GHz	3 - 6 GHz	4 - 8 GHz	26 GHz	33 GHz
	Ø 5 mm		Ø 10 mm		Ø 2,5 - 3 mm		Ø 5 mm	Ø 4 mm	Ø 3 mm
	polyethylene insulation				teflon insulation				

5. PARTICULARITIES AND APPLICATIONS

A) rigid, semirigid, hand-formable coaxial cables

- large impedance selection: 12.5, 25, 35, 50, 70 and 75Ω
- low loss and very good impedance precision typ. ± 1 Ω low return loss even at microwave frequencies
- good repeatability, aging and phase stability
- typical temperature range -40 / + 160 °C
-

B) flexible teflon cables

- low loss and good impedance precision typ. ± 2 Ω up to 3 GHz , they can be used up to 6 GHz
- typical temperature range -40 / + 160 °C and up to 200 °C only for RG 115 type
-

C) flexible polyethylene cables

- specifications are very good if compared with the low price, they are widely used in HF - VHF and video
- good shielding for double shield models min. 80 dB up to 6 GHz for RG 223 and 214 while for single shield models min. 40 dB up to 2 GHz for RG 58 and 213
- for laboratory usage up to 1 GHz

D) foam cables

- they are the cables with the lowest loss but also with less flexibility and not suitable for lab or professional usage
- if braid shielded they are quite flexible
- corrugated types are suitable only for antenna connection with very low insertion loss
- usable up to 3 GHz , max 6 GHz

E) super-flexible micro-porous teflon cables

- they are definitely the most efficient and sophisticated among all cables but also the most expensive, they are used exclusively in labs even up to 100 GHz
- they are used also for flexible wirings on over 10 GHz radio links

6. RESULT & CONCLUSION

Simulations Result

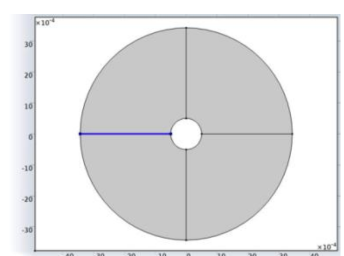

Fig2 :4 interior boundaries connect two conductors

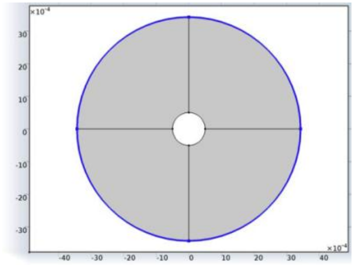

Fig3 :Outer conductor boundaries

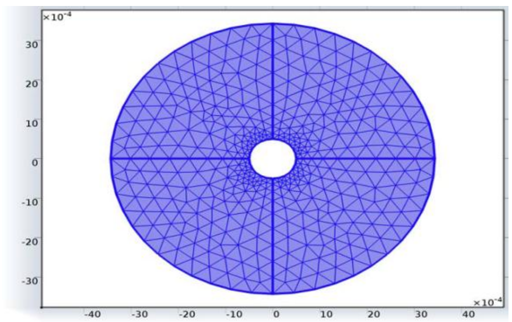

Fig 4: Triangular Meshing Screen

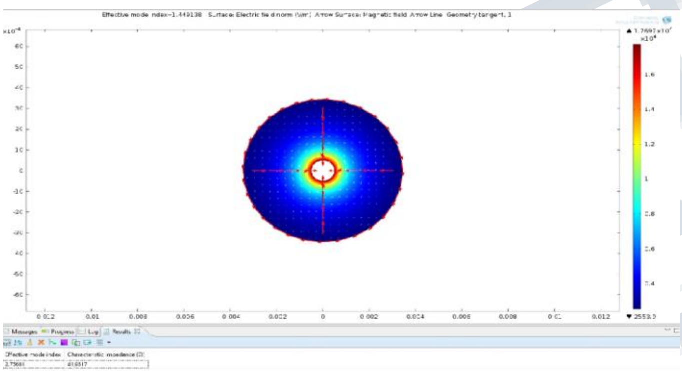

Fig 5: Output of Z0 after Studying the Design Z0= 41.9 for Glass

CONCLUSION

Hopefully this chapter has given you a brief overview of coaxial cable and a better insight to the relevant design properties. When choosing a cable for your application, work backwards from the end-need requirements. What is the specific application? Do you know what impedance is required? What is the frequency of interest? What is the loss budget (how much cable attenuation loss is allowed)? How long is the cable run length? Indoor or outdoor? Are there agency requirements (UL, NEC, AWM, MIL-Spec, etc.)? What connector type will be used? These few questions should help you easily identify an appropriate coaxial cable.

Table3: Dielectric Materials and their constant with calculated impedances:

materials	Dielectric constant	Characteristic impedance (ohm)
Glass	7.6	41.9
Teflon	2.1	79.677
Paper	3.0	66.662
Foam	4.6	53.835

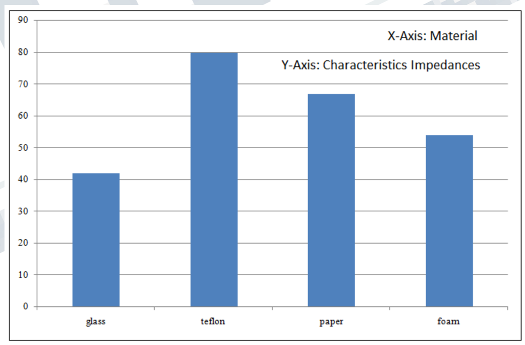

Fig 6: Output XY bargraph of Design using different dielectric materials

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