



Due 6 February 2008 at 6:00 pm

Pre-Project 1

Project 1 involves designing and building a simple CATV channel blocker. In the first session on 6 February, you will investigate the performance of some sample open-circuit stubs as blockers. You do not need to build anything at this point, but some simple analysis is necessary.

Some background information and general TV history resources:

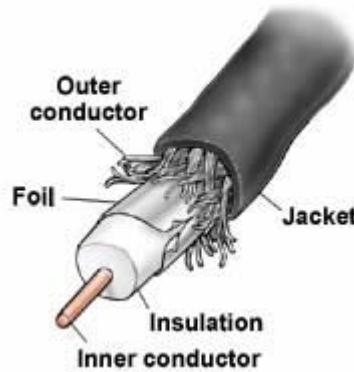
1. List of significant historical events in TV history:
http://en.wikipedia.org/wiki/List_of_%27years_in_television%27
2. Alan B. Dumont, RPI grad who built the first practical TV:
http://en.wikipedia.org/wiki/Allen_B._DuMont (check out the link to Rensselaer on this page for some very interesting info)
3. Television History, the first 75 years: <http://www.tvhistory.tv/>
4. The history of TV: <http://inventors.about.com/library/inventors/bltelevision.htm>
5. Radio and television history sites: <http://www.rtvf.unt.edu/links/histsites.htm>
6. Media History: <http://www.mediahistory.umn.edu/teevee.html>

Television channel frequencies:

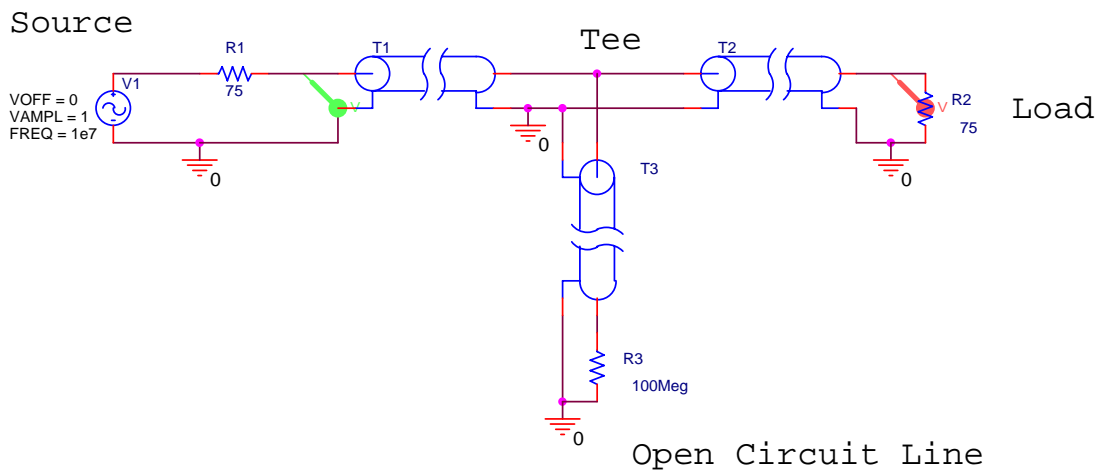
1. <http://www.arrl.org/tis/info/catv-ch.html>
2. <http://www.atxnetworks.com/qrf/catvfrq1.htm>
3. <http://www.tvtower.com/Commercial%20Television%20Frequencies.html>
4. <http://www.w4zt.com/freqs/catv.html>
5. <http://www.turnkey.net/CATV%20frequencies.htm>
6. <http://www.chem.hawaii.edu/uham/catvfreq.html>

Coaxial Cable Information

1. <http://www.ocarc.ca/coax.htm>
2. http://www.rfcafe.com/references/electrical/coax_chart.htm
3. <http://www.phptr.com/articles/article.asp?p=169518&seqNum=2&rl=1>
4. http://en.wikipedia.org/wiki/Coaxial_cable
5. http://www.pfm.howard.edu/infosys/choosing_correct_cable.pdf
6. http://www.signalengineering.com/ultimate/coax_basics.html
7. <http://www.educyclopedia.be/electronics/cablingrf.htm>
8. <http://www.zianet.com/ebear/coaxlist.html>
9. <http://www.epanorama.net/documents/wiring/coaxcable.html>
10. <http://www.timesmicrowave.com/cgi-bin/calculate.pl>



Filter



Introduction

The purpose of this project is to build a simple device that blocks the signal at a particular frequency while passing a signal at a second frequency. No active or lumped circuit elements will be used for this purpose. Rather, this will be accomplished by adding a stub-type tuner to the cable that brings the signal to the load. A picture of a standard triple-stub tuner (it has three shorted stubs with the ability to adjust the length of the stub) is shown in the following picture.



The basic principle of this signal blocker is relatively simple. The input cable (T1 in the figure above) is interrupted with a Tee coupler to which is connected a short piece of cable (T3 above) with no load (open circuited line). The input impedance of this extra piece of cable adds in parallel to the input impedance of the cable that runs from the Tee



to the load (T2 above). Assuming that the cable is properly matched to the load, the input impedance of this cable will be equal to the characteristic impedance of the cable. In this case, the impedance of the cable and the load is 75 ohms (as in a TV system). Since the input impedance Z_{in} is a function of the electrical length of the cable (through the terms like $\tan\beta d$ where d is the length), the Z_{in} of the open-circuited cable will change with frequency. If the length of this cable is properly selected, the signal from one frequency will be reflected from the Tee while the signals from other frequencies will not be reflected. A crude explanation of how this can work can be made by looking just at two frequencies where Z_{in} is either very small or very large.

For example, assume that the extra piece of cable has a length $= d$. Also, assume that it is insulated with polyethylene $\epsilon_r = 2.26$. Then the velocity of propagation on the line is $v = 2 \times 10^8$ m/s. In the simulation of this line, one can either reduce the expression for Z_{in} for an open circuit load or just use a very large value for Z_L . To be as general as possible, we should choose the latter approach, because there will always be some loss in a real

transmission line. Then $Z_{in} = Z_o \frac{Z_L + jZ_o \tan \beta d}{Z_o + jZ_L \tan \beta d} \approx -jZ_o \cot \beta d$, where we have

assumed that the transmission line is ideal and therefore lossless. When this is very large ($\cot\beta d \rightarrow \infty$), adding it in parallel to the cable will have no effect. When this is very small ($\cot\beta d \rightarrow 0$), adding it in parallel to the cable will look like a short circuit, which is as large an impedance mismatch as can be obtained. The input signal will see a short-circuit load at the frequency where $\cot\beta d \rightarrow 0$ and the signal at that frequency will be reflected from the Tee and not make it to the load.

Why would we want to do this? First, assume that the system of interest is the cable TV system in your residence. Let us assume that you would like to block one of the channels coming in for some reason. You can select the parameters of the open circuited stub (as such short cables are called) to short out the signal at the frequency of the unwanted channel. If you do this correctly, you will leave the other channels largely unaffected. Information on the frequencies of cable TV channels can be found on our Supplementary Materials Webpage and using the links on the first page of this document. Second, assume that you are doing some kind of an RF (Radio Frequency) experiment involving a low power signal at 144MHz. For example, moon bounce experiments are done at this frequency. Unfortunately, the signal is very small coming back from the moon and there is a lot of power in the FM broadcast band near 100MHz. This FM station power, if detected by your receiver can saturate the front-end amplifier so it is not able to amplify the signal you sent to the moon. To avoid this problem, you can filter out or block the FM signals before they get to your amplifier so it is able to respond to the signal at 144MHz. There is also an extensive description of eliminating AM band frequencies at <http://www.dxing.com/tnotes/tnote06.pdf>. Third, you may be operating some kind of wireless system where there is a lot of noise generated (by a motor or some other system) at several harmonics of 6kHz. Again, to block out the noise, you can use some kind of filter. The simple, single open stub configuration shown above is probably the simplest way to build such a filter.



Tasks for the Pre Project:

1. There is quite a large collection of open-circuit stubs in JEC 4107. You should perform simple analysis for and test at least two of these stubs. The two stubs must be of significantly different lengths. You may have trouble with one of the stubs, so it is recommended that you consider 3 stubs and choose the two with the best performance. Also, it is a good idea to test each of the three stubs to be sure it is indeed an open circuit. You can do this with the multimeter by measuring the resistance from the input end. Note the number of each stub you are using. If it does not have a number, then you should check with the TA to see that it has one.

Measure the length of the three stubs

- i. Stub 1 _____
- ii. Stub 2 _____
- iii. Stub 3 _____

2. Test the three stubs with the spectrum analyzer. Record the frequencies where the minima in signal level are observed. For the short stubs, there will probably be only one frequency in the CATV frequency band. However, for the longer cables there can be several. If you have access to a camera, plan to take a photo of the screen of the spectrum analyzer that shows the minimas for CATV frequencies

What are the frequencies of the minimas for the three stubs

- i. Stub 1 _____, _____, _____, _____
- ii. Stub 2 _____, _____, _____, _____
- iii. Stub 3 _____, _____, _____, _____

3. Test the three stubs with the TV signal that can be observed through the VCR and video projector. Indicate the channel numbers where the strongest impact on signal quality is observed. Obviously, you should look up the frequencies of the minimas you observed in part 2 before testing the stubs with the TV signal.

What are the channels with the worst signal for the three stubs

- i. Stub 1 _____, _____, _____, _____
- ii. Stub 2 _____, _____, _____, _____
- iii. Stub 3 _____, _____, _____, _____

4. One of the problems in implementing this idea with any old stub is that you may not know the propagation velocity of the cable. All CATV cables are 75 Ohms, but some have a velocity factor of 85%, some 67%, and some near one or the other of these values. The most common value is near one of these two values (82-85%) or (66-70%). Based on the length of the cable and the frequency being blocked, determine which of the two velocity factors holds for your three stubs. This is where doing three stubs comes in handy, because sometimes it is quite difficult to answer this question. For the pre-project, you are only to do the best possible job for each of the three stubs.

5. Analyze the three stubs using PSpice, setting up the configuration shown on page 2. If you have the velocity and length correct, your analysis should be consistent with your data. Note where you find such consistency and where you do not.

Remember that exact agreement is not necessary.



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