Project 1 (*Due: February 22)*

RF Notch Filter

Trap for Unwanted Frequencies

For this project, students can work in groups of two to four. Hand in one report for each group.

Grading

1. Design Information (10 pts) _____

2. **Analysis of Design** (8 pts) _____

3. Frequency Response for Design (15 pts) _____

4. Performance of Design (10 pts) _____

5. Discussion (5 pts) _____

Task Breakdown (2 pts) _____

Total _____

Group Members:

1. _____

2. _____

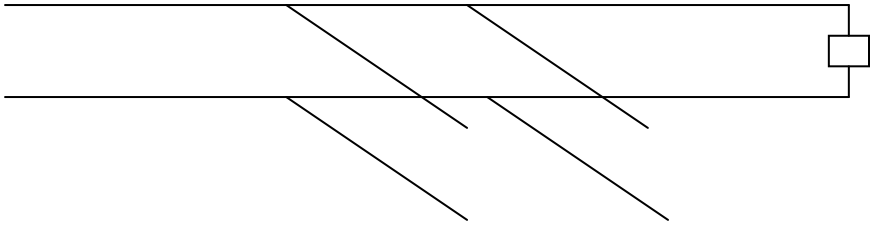
3. _____

4. _____

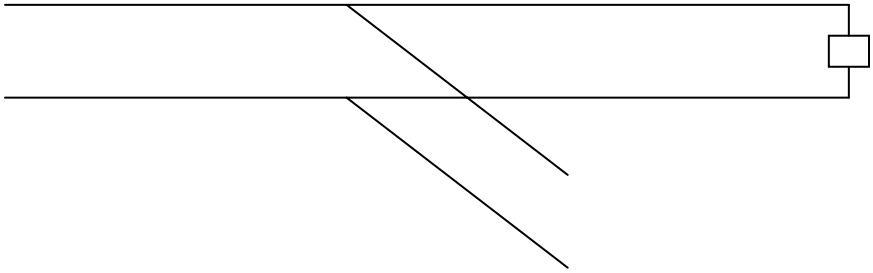
Filter

There are two general options shown generically below. We can either add a single open stub or a double open stub. The former is easier, but the latter generally does a better job of blocking a signal and, unfortunately, the signals from nearby channels.

Double Open Stub Tuning



Single Open Stub Tuning



Look to the Past: Those of you who know how this project was specified in the past will note that we have previously used either a short-circuited or an open-circuited line. The open-circuited line is easier to implement, since one only needs to cut a wire and leave it unconnected. However, even a small amount of open wire at the end of the line will act like an antenna. This is not necessarily a serious problem, so this time we will use an open stub. Those of you who have heard nothing about this project should look over the Fall '99 project write up, which can be found at the bottom of the course Project page. There is also a set of comments on this project which includes a lot of the important analysis steps for the channel blocker. This latter document should be read thoroughly.

Analysis Option 1: In the project from Fall '99, the channel blocker circuit was modeled using Matlab. You can use the program listing provided in the comments as a guide. The comments also include sample plots. Also, see the Matlab analysis document that you can link to from the project page.

Analysis Option 2: The traditional way to analyze stub filters is to use a Smith Chart. This is discussed in the text book and at the following sites on the web.

Smith Chart References:

- http://weewave.mer.utexas.edu/DPN_files/courses/363M/tuner_exmpl/dbl_tnr.html
- http://www.ee.surrey.ac.uk/Personal/D.Jefferies/stubs.html
- http://people.deas.harvard.edu/~jones/es151/pages/gallery/gallery.html
- http://www.eecs.umich.edu/emag/labmanual/EECS230_LE5.pdf

Analysis Option 3: Since transmission lines can be modeled using PSpice, you can do your analysis by downloading the student version of this excellent program. Please also see the PSpice analysis document linked to on the projects page. Your final analysis must be done with the lossy transmission line model. This is by far the most popular choice for this project, even though it has some limitations.

Overall Goals:

You must design two systems. Preferably, one should block a TV channel below 150MHz and one should block a channel above 300MHz. However, you can choose any two channels as long as they are not too close in frequency. Your lossy transmission line model must be correct at the frequency of interest for both cases. For the Matlab analysis option, your model should hold at all reasonable frequencies. For the PSpice option, there is no way to easily incorporate a frequency dependent resistance per unit length. Thus, you should do a complete frequency scan (covering the entire range of channel frequencies) for each of the two cases. This will help you to identify the range of validity of your two models.

Once the analysis has been done, you must build a channel blocker for the two TV channels (two F-type Tee connectors will be provided for each group and, we hope, some cable and connectors). You must test your final designs (for the two channels) and record the results (e.g. channels blocked and channels unaffected). Then, you must demonstrate its efficacy to a TA using the cable feed in the studio to the TV display and the spectrum analyzer.

Specific Tasks:

1. Provide all information on the parameters of the cables you are using and justify the accuracy of your numbers. Be sure that you include cable losses at the frequencies you wish to block. Fully document the sources of your information. (10 pts)

2. Qualitatively analyze the filter schemes (show your work). For example, show your hand calculations for the length of the open stub you plan to construct and predict the frequencies it will block. Check these frequencies against the list of CATV stations on campus to identify which signals will be affected. (This is what you were asked to do during the second pre-project day.) You should also set up and explain the more detailed analysis (using one of the three options) you will do for your designs at each frequency. *The purpose of this section is to show that you understand how to do the analysis. Thus, you should do some simple calculations and explain your approach, step-by-step. The results (plots) for your analysis are asked for in the next section.*
    a. Blocking a lower frequency cable TV station (your choice) while leaving as many other channels as possible unaffected.
        - **Design** (4 pts)
    b. Blocking a higher frequency cable TV station (your choice) while leaving as many other channels as possible unaffected.
        - **Design** (4 pts)

3. Do your full analysis first for lossless lines. Then repeat for lossy lines. *You must clearly annotate your plots so it is completely clear what information they contain.*
    a. For the Matlab analysis, you should produce a plot like the transmission coefficient plot on pages 5 and 8 of the project 2 comments (Fall '99) found on the course Project Webpage. (15 pts)

    b. For PSpice, you should produce a plot of the voltage vs. frequency at the load. In both cases, the frequency range should cover all cable TV frequencies for the TV channel blocker. (15 pts)

    c. For the Smith Chart approach, you will have to include all of your Smith Charts. The Smith Chart analysis must be done for at least 5 representative frequencies, including the specific frequencies of interest. *Note – this option probably requires the biggest time investment to learn. You should probably not try it unless you have had a little experience with Smith Charts before or unless you find graphical tools to be particularly useful.* (15 pts).

4. Build and test the TV channel blocker which must be turned in with your report and tested in class jointly with one of the course instructors. Testing should include connecting your blocker to the spectrum analyzer and recording changes in the observed spectrum. A simple way to do this is to photograph the display of the spectrum analyzer. However, a simple sketch is also fine. You should also connect your blocker to the cable line that feeds the VCR and observe changes in the display projected on the screens at the front of the room. Describe the changes you see.
    a. **Low Frequency Design** (5 pts)
    b. **High Frequency Design** (5 pts)

5. Discuss your results. What worked as expected? What did not? How close are the predictions of your model to the actual experimental results you obtained? (5 pts)

Task Breakdown: You must formally divide the work up in this project and assign each task to a member of your group. For example, one person can work on the report, one can build or test designs, one can do the analysis of your design and, most importantly, one can be responsible for coordinating all the tasks and making sure that everyone is on schedule. In your project report, you must clearly describe how you divided up the work and who did what. It is not acceptable to say that everyone did everything. A particular member of your group must be responsible for each task. (2 pts)

Suggestions: One thing that we all learn when working on projects is that everything will go better if one begins writing the report on day one. In this way, it is easy to see what yet needs to be done. Lay out the structure of the report and identify the person responsible for each section. Then the report writer will know who to bug to get things done on time. Also, the report writer needs to be sure that the report makes overall sense and does not appear to be a cut and paste job with no continuity. Be sure that you clearly identify the source of any significant information you have used. For example, you will obviously need the parameters for cables. What specification information did you use? If you used formulas from the book, lecture slides, class notes, other texts, etc. clearly indicate page numbers, etc. If you received help from anyone else (which is perfectly OK), make sure that you give them credit. You should not outsource your report, but you can really get help from anyone. *Finally, do not include plots generated from Matlab, PSpice, etc. without including a discussion of the information contained in the plot.* The easiest way to do this is to clearly label the plots with arrows and text boxes. The reader of your report should know exactly why the plot is included in your report and what it tells us.