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Virtual Lab 8: The Black Box

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Purpose:
- Characterize an unknown circuit from terminal measurements
- Gain additional experience with remote access

Equipment:
- HP 34401A Multimeter
- HP 54601A Oscilloscope with HP 54657A Measurement/Storage Module
- HP 8116A Pulse/Function Generator or HP 33120A Function/Arb Generator
- HP 6236B Triple-output Power Supply
- Connectix Video Camera
- Intel 100MHz Pentium computer, 32MB Ram with HPIB Card
- HP VEE for Windows software, Version 3.2
- Timbuktu (remote access) software
- QuickPICT software
- Text: Robert Helsel, "Graphical Programming: A Tutorial for HP VEE", Prentice Hall, 1995
- HP VEE executable file

Introduction:

A weather telemetry station is located in a remote location near the top of a mountain peak in the Rockies. Access is limited; much of the route is passable only with a 4-wheel drive vehicle, and the last half-mile can only be traveled by foot. The data from this station has been shown to be particularly valuable for predicting serious storms in populated areas about 50 miles to the west, so the weather service has made the operation of the station a high priority. It is costly and time-consuming to visit the station for service and maintenance, so the station is controlled and monitored remotely. However, a malfunction has recently been detected so plans are underway to send a team to repair the station. Because access is so difficult, it is important to pin-point the problem before-hand so that the repair team will be sure to have the necessary parts and equipment with them to perform the needed repair.

From preliminary measurements, it has been determined that the failure is in a telemetry input filter circuit. The circuit diagram of the filter is shown below:
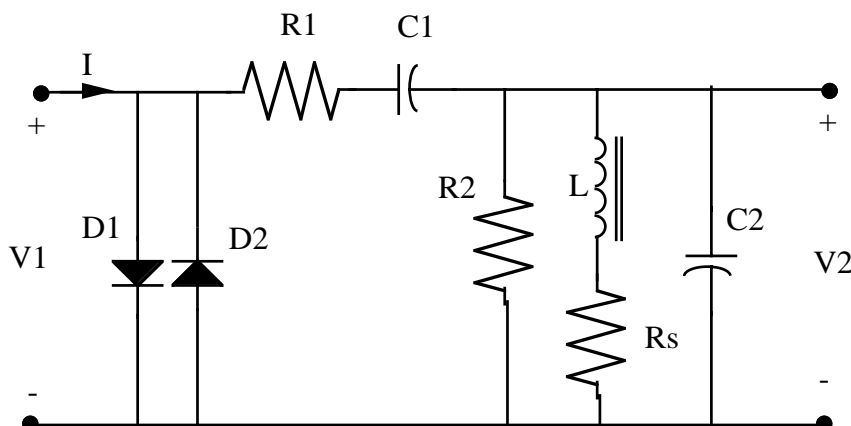
The component values are as follows:

- D1,D2: 1N4001 silicon diodes
- C1=C2=0.33 μF
- R1= R2=1K
- Rs= 3.7 Ω (series resistance of actual inductor; not physically a separate component)
- L= 1 mH

The purpose of the diodes is to protect other components in the system from voltage transients and static discharges. As long as the input voltage V1 is less than V_{on}, the diodes are off. When V1 exceeds V_{on} with either positive or negative polarity, one of the diodes turns on and clamps the input voltage at V_{on}. When the diodes are off, the circuit functions as a narrowband filter, so that |V2/V1| is maximum at the resonant frequency.
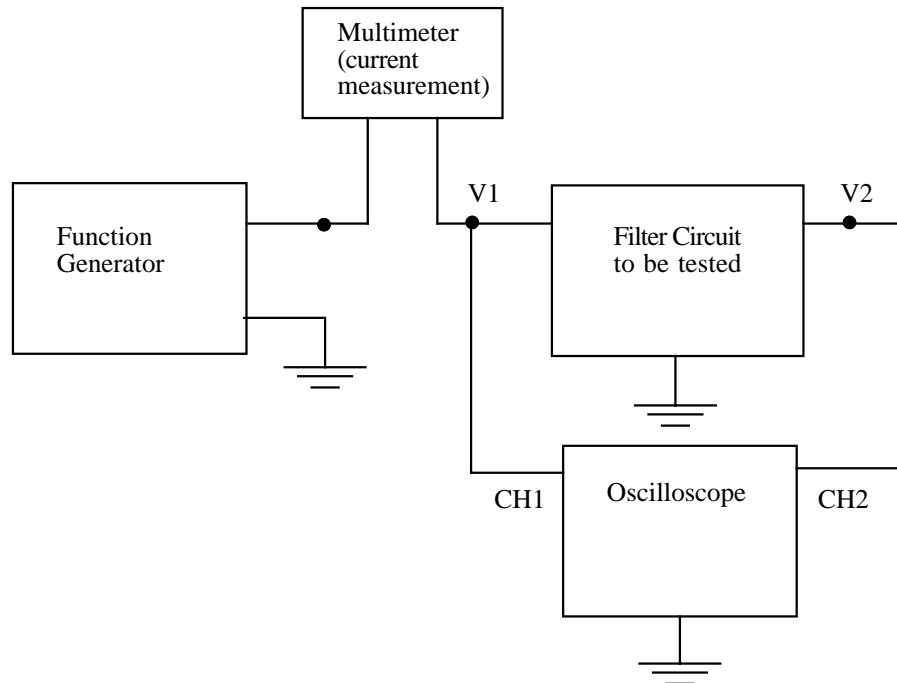
The specifications for the circuit are:

- Clamping voltage: ±0.6 V ±0.2 V
- Filter center frequency: 8.85 KHz ± 20%
- Filter bandwidth (full bandwidth at which |V2/V1| is down by 3 dB from the peak transmission): 1550 Hz ± 20%
- Insertion loss at filter center frequency: 10 dB ± 2dB

Procedure:

Part 1: Measurement Configuration

Of course, from a remote location it is not possible to measure everything that you might if you were there in person. Consequently you must work with the measurements that are accessible. The measurement configuration that is available remotely is shown in the figure below.

Part 2: Assignment

1. Design and construct a virtual instrument for testing the filter circuit as connected above. The virtual instrument should execute a sequence of steps to evaluate each of the specifications mentioned earlier. The program should be able to generate plots of I vs. V1 for DC inputs, and |V2/V1| vs. frequency for small-signal AC inputs. The program should have an easy-to-use interface panel, and should generate a report file with the following format:

FILTER TEST
===========================
day/mon/year   time AM/PM

Parameter	Value	Nominal	LowLim	HiLim	Result
+Vclamp (V)	0.65	0.6	0.48	0.72	PASS
-Vclamp (V)	-0.70	-0.6	-0.72	-0.48	PASS
Res. Freq.(Hz)	7.05k	8.85k	8k	12k	FAIL
Bandwidth (Hz)	1600	1550	1240	1860	PASS
Ins. Loss (dB)	10.9	10	12	8	PASS

2. Use the results of these measurements to determine which components in your circuit are defective. This may require analysis of the circuit. You are free to analyze the circuit by hand, or to use any design and simulation software that you prefer (e.g., SPICE).

Part 3: The Report

You must turn in a written report that has the following sections:

1. Cover page

   This page must have the lab number and title, your name(s), course number and title, semester and year, department (Electrical and Computer Engineering), and university (Carnegie Mellon University!!).

2. Introduction (begin on next page)

   Give some background on the problem. You may draw from the material in this lab handout, but you are also free to embellish as you are inspired. Conclude with summarizing what is in each section of your report. Point out the software that you are using to solve the problem (HP VEE and Timbuktu).

3. Program Description

   Organize your program so that the functional blocks can all be seen at once on the HP VEE screen (use UserObjects as necessary to simplify the highest level view). Capture the HP VEE screen and use this as a figure in your report. Add a description with words (a few paragraphs) explaining how the program works and referring to the major objects in the figure. You are not required to use veedoc, although you may if this is helpful.

4. Experimental Observations

   Describe your remote observations. Include the date and time of the observations, the name of the lab machine accessed, and the remote machine or location from which you accessed the experiment. Also include the report file showing the filter test results.

5. Analysis and Diagnosis

Describe your analysis of the filter test results along with any circuit simulation used to diagnose the circuit malfunction. Specify which component you think has failed and the nature of the failure (value high, low, open, short, etc.) based on your analysis.

6. Summary and Conclusions

Briefly summarize the original problem, the solution addressing the problem (design of a virtual instrument to test the filter), and the conclusions from the observations.

Grading

This lab is worth 10 points. The points will be distributed as follows:

Working program meeting the specifications:	5 pts
Report	5 pts
Proper format 1	
Grammar and style 1	
Analysis of data 2	
Correct Diagnosis 1	
Total	10 pts

Lab Logistics

Since you may find it helpful to consult some of the instrument reference manuals, you may design and program your virtual instrument either in the lab or remotely. However, the actual testing and diagnosis must be performed remotely. Parts will be distributed to enable you to breadboard the filter circuit to assist in program development. The six stations in the lab will be configured and equipped with filter circuits between 5:00pm Friday and Noon the following Monday on the following weekends: Nov. 16-17, Nov. 23-24, and Nov. 30-Dec. 1. All of the filter circuits will have a malfunction owing to a component that has failed or is out of spec, but not all of the circuits will have the same malfunction. You may choose to analyze the filter at any one of the stations. **Labs will be due Friday, Dec. 6.**

You should be able to:
• Demonstrate your test program with the circuit above assembled on a protoboard. The program should generate:

• I-V1 curve for DC applied to the filter input
• Graph of |V2/V1| vs. frequency for small AC inputs
• Output report file in a format similar to the above example

• Present a report containing your analysis of one of the "black box" filters, what component(s) you believe to be faulty, and how you arrived at that conclusion. Be sure to identify the filter tested by the name of the computer controlling the equipment.