Lab 4: Diode Detector Lab

By: Cynthia Furse, Ray Woodward
ECE 6130 Wireless LAN Lab
Utah State University
USA

A diode detector is used to convert AC voltage to DC voltage. You will use this in your WLAN to measure the voltage after the filters to determine which frequency was passed (corresponding to a 1 or a 0).

Objective: Design, build, and test a diode detector

Equipment:

- Agilent 8510C Microwave Vector Network Analyzer
- TRL Calibration Kit
- Matlab

Prelab:
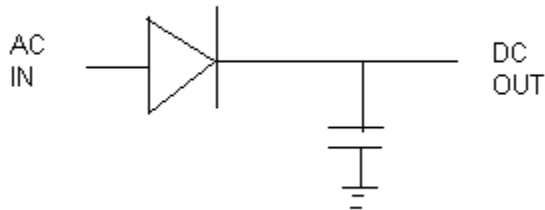
1. Detector design:

    a. Download the diode tutorial file (diodetut.pdf) and see addendum for diode data.

    b. Follow the steps outlined in the tutorial to simulate the diode circuit.

    c. Design a single stub matching network for the front of it using a parallel short-circuited stub. Do this for a 2.4 GHz detector, and repeat the process for a 2.6 GHz detector.

2. Detector Layout:

    a. Follow the steps in the tutorial to layout the design.

    Note: When you put a hole in your stub to make is a short circuited stub, be sure to put it right at the end of the stub (or make the stub just a little longer to allow space for the wire to be soldered). The location of the soldered pin is the "end" of the stub.

3. Prototyping:

    a. Solder on the diode and capacitor using the surface-mount soldering equipment.

    b. Solder wires through the holes from ground to make necessary short circuits using regular solder equipment.

Lab:

4. Test your circuit on the network analyzer.

    a. Measure S11 for the diode detector. It should be below -10 dB at the frequency you matched it for.

    b. Plot your expected and observed values on the same plot.

    c. IF your circuit does not work as expected

        1. Check the solder connections (touch them up with a hot soldering iron if needed)

        2. Remove the matching stubs (with exacto knife), measure the input impedance of the diode as done for the antenna in lab 2 (accounting for the length of the input lines). Use the new S-parameters in your ADS simulation, design new stubs, and try again.

5. Test your circuit with the signal generator.

    a. Solder a wire (about 2" long) to the end of your detector. You will connect this wire to a DC voltmeter. Connect the ground of the DC voltmeter to the bottom (ground plane) of your circuit board (just use an alligator clip to the edge of your board, being sure the top of the alligator clip is some distance from other parts of your circuit.).

    b. Disconnect one side of the circuit board holder from the network analyzer, and connect it to the signal generator. (No calibration is needed, this is just acting as a connector for your board.) Place the input of the diode detector in the circuit board holder. Turn on the signal generator, and give it a frequency of 2.4 or 2.6 GHz (depending on the detector) and a magnitude of 0 dB. You should see a voltage of about 1 V on the DC voltmeter.

Turn in

1. Design of single stub matching networks (Smith Charts or other method)

2. The layouts

3. ADS simulation results (S11)

4. Network analyzer results (S11)

5. Signal generator results (DC voltages)

6. Comments and summary on the diode detector and your results.

Addendum to Diode Detector Lab

Diode Data

!BEGIN ACDATA

\#   GHz   S   MA   R 50.0

!% F n11x n11y n21x n21y n12x n12y n22x n22y

1.75	0.9683	-23.8255	1.9259	-11.7179	0	0	1.0000	0
2.0	0.9683	-29.8098	1.9021	-14.6593	0	0	1.0000	0
2.4	0.9521	-35.1478	1.8610	-17.1282	0	0	1.0000	0
2.6	0.9529	-35.7572	1.8586	-17.4327	0	0	1.0000	0
3.0	0.8956	-44.0234	1.7578	-20.7357	0	0	1.0000	0

!END

Matlab Data

%Values read from network analyzer (ohms)
Z175in = 25-j*272.8;
Z2in=4.2-j*102.6;
Z24in=2.8379+j*57.205;
Z26in=4.6289+j*84.121;
Z3in =186+j*363.6;

%rotate values as needed for TRL calibration adjustment (values below line
%on smith chart)
gam175in=(Z175in-50)/(Z175in+50);   % (Zin-Zo)/(Zin+Zo)
gam2in=(Z2in-50)/(Z2in+50);
gam175in=gam175in*exp(2*j*pi/2);
gam2in=gam2in*exp(2*j*pi/2);
Z175in=50*(1+gam175in)/(1-gam175in);
Z2in=50*(1+gam2in)/(1-gam2in);

% total length of line - Thru_length/2 (mils)
L=1040

%wavelengths at each frequency (mils)
lam175=4235.704;
lam2 =3705.246;
lam24=3086.292;
lam26=2848.206;
lam3 =2467.231;

%reflection coefficients at input at each frequency Zo=50 ohms
gam175in=(Z175in-50)/(Z175in+50);   % (Zin-Zo)/(Zin+Zo)
gam2in=(Z2in-50)/(Z2in+50);
gam24in=(Z24in-50)/(Z24in+50);
gam26in=(Z26in-50)/(Z26in+50);
gam3in=(Z3in-50)/(Z3in+50);

```
%reflection coefficients at the load at each frequency
gam175L=gam175in*exp(2*j*L*2*pi/lam175);
gam2L=gam2in*exp(2*j*L*2*pi/lam2);
gam24L=gam24in*exp(2*j*L*2*pi/lam24);
gam26L=gam26in*exp(2*j*L*2*pi/lam26);
gam3L=gam3in*exp(2*j*L*2*pi/lam3);

%impedance at load (ohms)
Z175L=50*(1+gam175L)/(1-gam175L);
Z2L=50*(1+gam2L)/(1-gam2L);
Z24L=50*(1+gam24L)/(1-gam24L);
Z26L=50*(1+gam26L)/(1-gam26L);
Z3L=50*(1+gam3L)/(1-gam3L);

%transmission coefficient at the load
T175L=1+gam175L;
T2L=1+gam2L;
T24L=1+gam24L;
T26L=1+gam26L;
T3L=1+gam3L;

r2d=180/pi;     % conversion for radians to degrees

magr = [abs(gam175L); abs(gam2L); abs(gam24L); abs(gam26L); abs(gam3L)];
angr = [angle(gam175L)*r2d; angle(gam2L)*r2d; angle(gam24L)*r2d; angle(gam26L)*r2d;
angle(gam3L)*r2d];
magt = [abs(T175L); abs(T2L); abs(T24L); abs(T26L); abs(T3L)];
angt = [angle(T175L)*r2d; angle(T2L)*r2d; angle(T24L)*r2d; angle(T26L)*r2d; angle(T3L)*r2d];

%Mag[S11] Ang[S11(deg)] Mag[S21] Ang[S21(deg)] Mag[S12] Ang[S12(deg)] Mag[S22] ]
d = [magr angr magt angt zeros(size(magr)) zeros(size(magr)) ones(size(magr))]
```

% The formatting is not correct here. Cut and paste the d table into a notebook editor.
%You need to add a column of frequencies at the front and a column of zeros (AngS22) at the end:

%frequencies are: 1.75, 2.0, 2.4, 2.6, 3.0