Smart Sensing Systems
Pushing Technology Frontiers

Activity Report

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Doc. No.: 2407-SD-SMK-01

Report Title: Software Development optimizing part of the frequency locking LabVIEW program.
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Description: A MATLAB program was developed to determine the voltage at which the minimum S22 parameter occurs at a particular frequency. Several changes were made to the original LabVIEW program to accommodate the new MATLAB code.
Objective: - *To develop and test a MATLAB code to determine the voltage at which the minimum s22 parameter occurs with fewer voltage setting points compared to the original available code.* - *To make changes to the LabVIEW program accommodating the new MATLAB code.*

1. *Design Basis and the MATLAB Code Flow Chart*

This section discusses the basis the code uses to determine the voltage at which the minimum voltage occurs. The original LabVIEW program sweeps the voltage from 0 V to 5 V in a step size of 0.1 V. Taking 51 voltage setting points to finally determine the voltage at which the minimum S22 parameter occurs.

The developed MATLAB code uses the fact that the absolute minimum of any given data, the slope must alternate from negative to positive. The detailed algorithm of the code is depicted in the flow chart shown in figure 1. Note that if the minimum S22 occurs at voltages below 0.6 V, the code follows a sightly different methodology.

2. *Simulation programs*

2.1 MATLAB Code

The MATLAB code is given below.

```
clc;clear;
sample = load('data_out_850M.txt');
[C, B ] = min(sample(:,2)); range = 0;
V = linspace(0,5, 4);
n0 = find(V(1));n1 = find(V(2));n2 = find(V(3));
n3 = find(V(4));
reading_1(1) = sample(n0,2);  % set v = 0 V
reading_1(2) = sample(n1,2); % set v = 1.25 V
reading_1(3) = sample(n2,2); % set v = 2.5V
reading_1(4) = sample(n3,2); % set v =  V

difference_1st = abs(reading_1(2) - reading_1(1));
difference_2nd = abs(reading_1(3) - reading_1(2));
difference_3rd = abs(reading_1(4) - reading_1(3));

% Checks if the minimum s22 parameter occurs at large voltages (V> 0.6V)

if (difference_1st>0.1)
||(difference_2nd>0.1)||(difference_3rd>0.1)||(difference_4th>0.1)||(difference_5th>0.1)
```

```
diff = [ difference_1st difference_2nd difference_3rd];
A = sort(diff,"descend");
 % Determines the range within which the minimum voltage occurs
if ((A(1) == difference_1st) && (A(2) == difference_2nd)) || ((A(2) ==difference_1st) && (A(1) ==
difference_2nd))
    range = [n0 n2];
elseif   ((A(1) == difference_2nd) && (A(2) == difference_3rd)) || ((A(2) == difference_2nd) && (A(1) ==
difference_3rd))
    range = [n1 n3];
end
if (range ==0)
    if (A(1) == difference_1st)
        range = [n0 n1];
    elseif (A(1) == difference_2nd)
        range = [n1 n2];
    elseif (A(1) == difference_3rd)
        range = [n2 n3 ];
    end
 end
k = 5;
reading_1(5) = sample(range(1),2);  % for example: set v = 3.5 V
reading_1(6) = sample(range(1)+k,2); % set v = 1.5 V
reading_1(7) = sample(range(1)+2*k,2); % set v = 3.5 V
reading_1(8) = sample(range(2),2); % set v = 5 V

% The minimum s22 occurs where the consecutive diffrences alternate from (-) to (+)
k =0;j=0;
while(j<=18)
    voltage_setting_point = range(1) +k;
    reading_2(j+1) = sample(voltage_setting_point, 2);
    reading_2(j+2) = sample(voltage_setting_point+1, 2);
    if (j ==17)
        reading_2(21) = sample(range(2),2);
    else
        reading_2(j+3) = sample(voltage_setting_point+2, 2);
    end
    n_t_diff_1st = reading_2(j+2) - reading_2(j+1);
    n_t_diff_2nd = reading_2(j+3) - reading_2(j+2);
    if (n_t_diff_1st <-0.0001 ) && (n_t_diff_2nd >0.0001 )
        fprintf('The minimum s22 parameter occurs at %1.1f V, The number of voltage settings = %d
\n',sample(voltage_setting_point+1,1), numel(reading_1)+numel(reading_2))
        fprintf('\n The actual minimum s22 parameter occurs at %1.1f V \n ',sample(B,1))
        break;
    end
    k =k+1;j=j+1;
end
```

```
% Calculates the difference to determine the minimum voltage
% Taking into account small voltages
else
  n = [1 4];
  for j = 1:2
    for kk= 1:8
    reading(kk) = sample(kk,2);   % Sets the voltage to 0-0.8V  , V(1)
    end
  diff_1st = (reading(n(j)+1) - reading(n(j)));
  diff_2nd = (reading(n(j)+2) - reading(n(j)+1));
  diff_3rd = (reading(n(j)+3) - reading(n(j)+2));
  diff_4th = (reading(n(j)+4) - reading(n(j)+3));

    if (diff_1st <-0.0001 ) && (diff_2nd >0.0001 )
      fprintf('The minimum s22 parameter occurs at %1.1f V, The number of voltage settings = %d
\n',sample(j+1,1),numel(reading)+numel(reading_1))
      fprintf('\nThe actual minimum s22 parameter occurs at %1.1f V \n', sample(B,1))
      break;
    elseif (diff_2nd <-0.0001 ) && (diff_3rd > 0.0001)
      fprintf('The minimum s22 parameter occurs at %1.1f V, The number of voltage settings = %d
\n',sample(j+2,1), numel(reading)+numel(reading_1))
      fprintf('\nThe actual minimum s22 parameter occurs at %1.1f V \n', sample(B,1))
      break;
    elseif (diff_3rd <-0.0001 ) && (diff_4th > 0.0001)
      fprintf('The minimum s22 parameter occurs at %1.1f V, The number of voltage settings = %d
\n',sample(j+3,1), numel(reading )+numel(reading_1))
      fprintf('\nThe actual minimum s22 parameter occurs at %1.1f V \n', sample(B,1))
      break;
    end
  end
end
```

2.2 LabVIEW program

The portion of the block diagram of the original LabVIEW program for determining the minimum s22 voltage is shown in figure 2. Several changes were made to the program as the MATLAB block for processing the data is changed. The new block diagram is shown in figure 3.

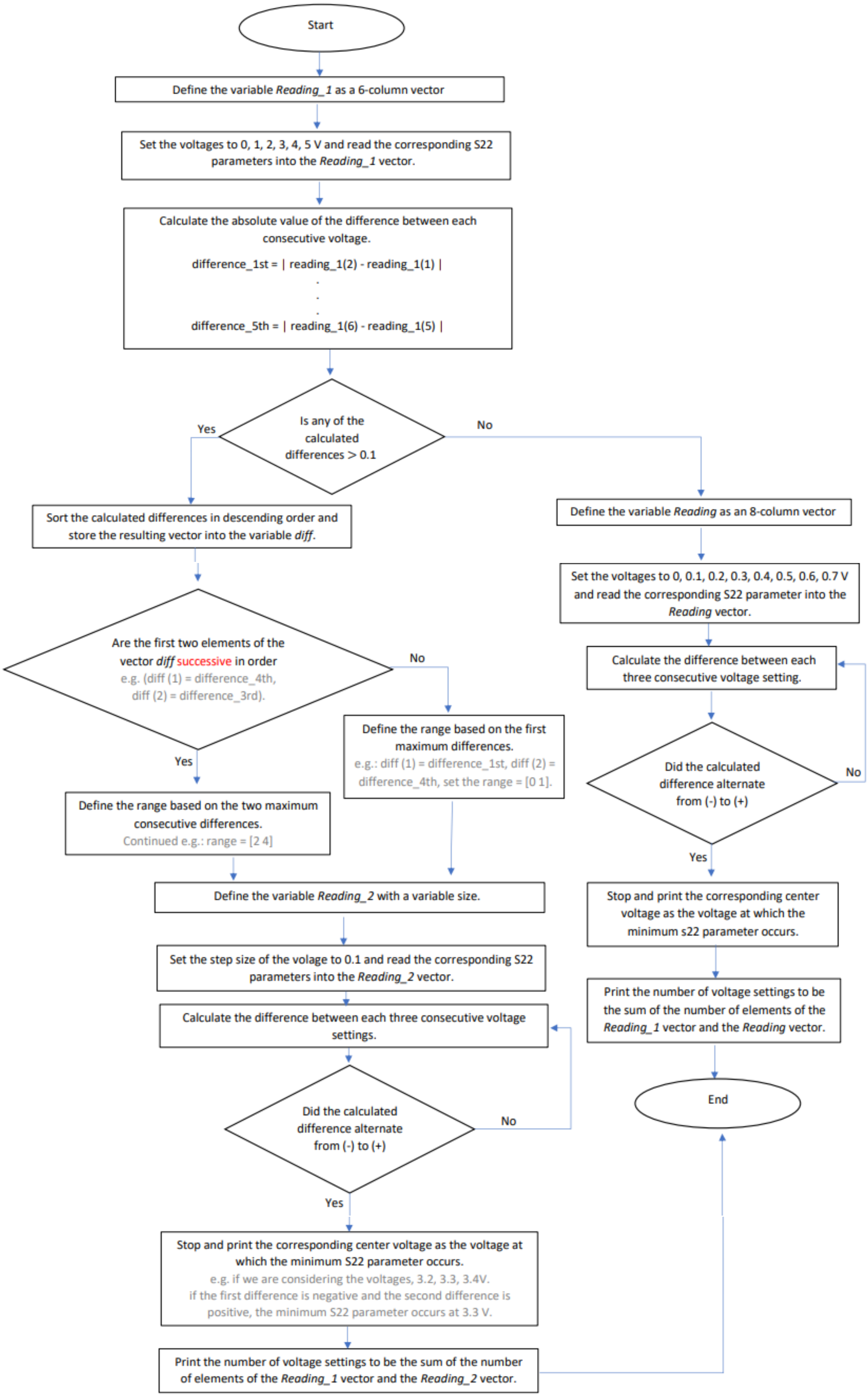
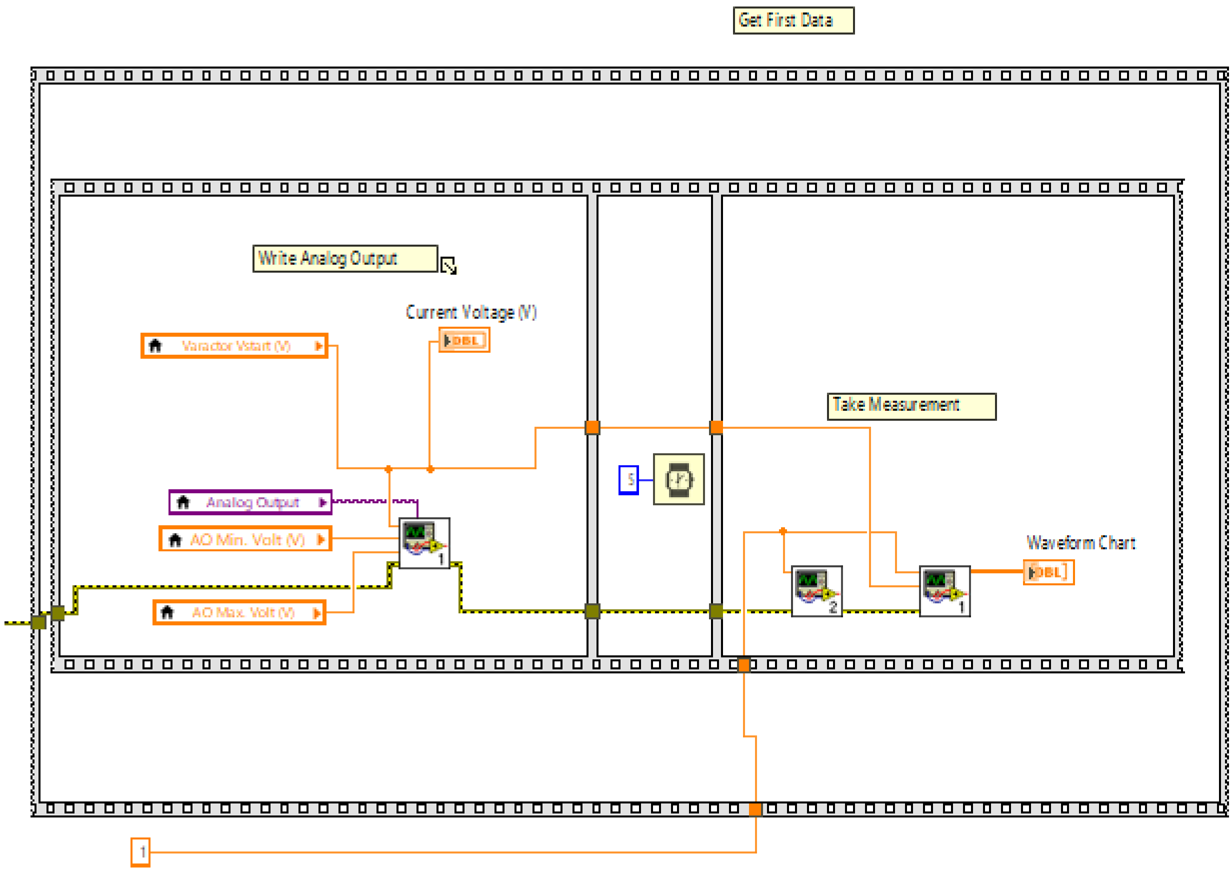
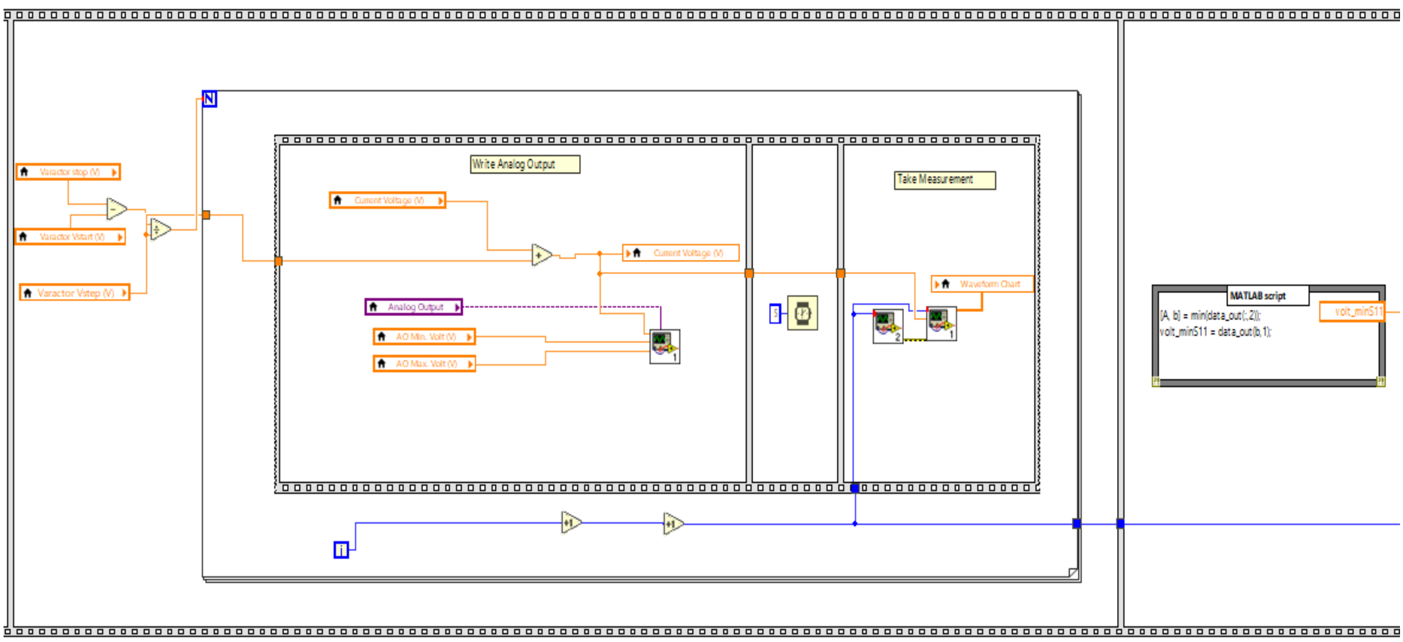


Figure 1. MATLAB code flow chart.

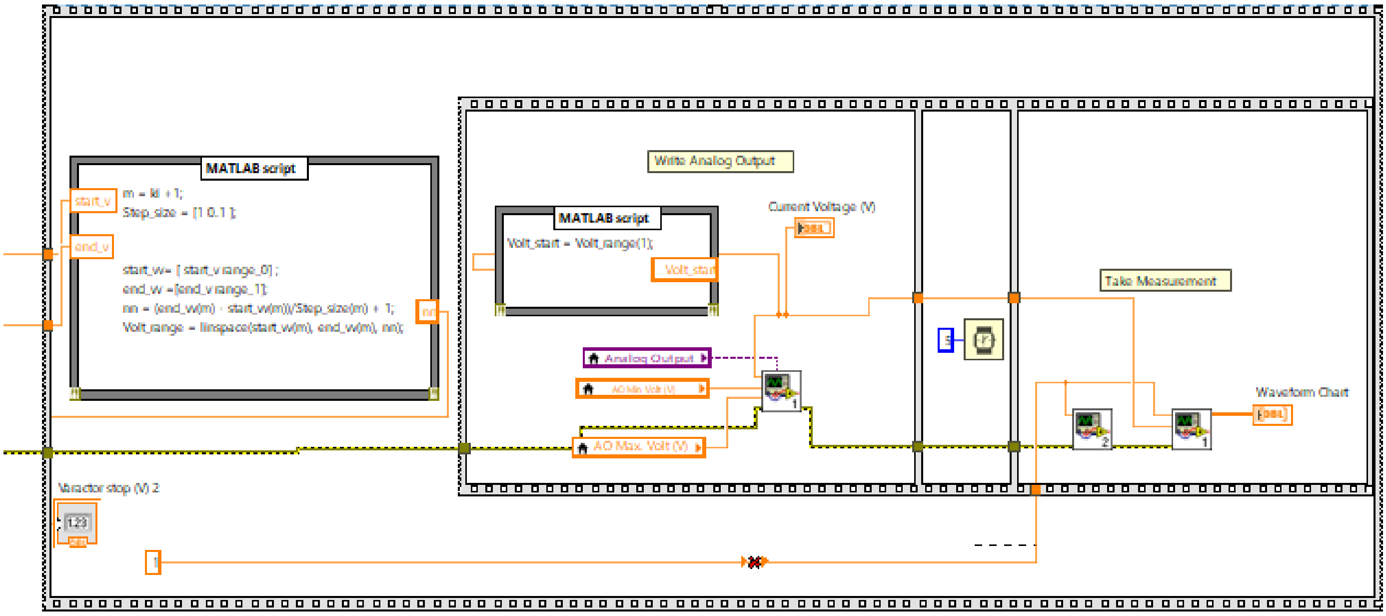


a.

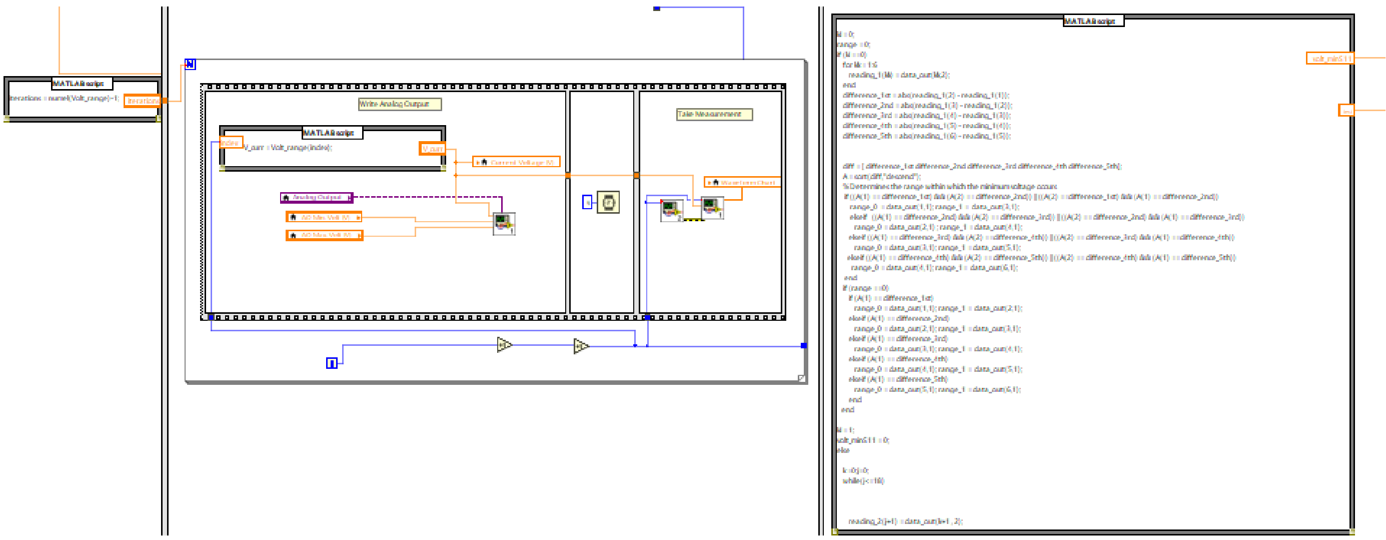


b.

Figure 2. Original LabVIEW program. (a) part 1 of the original program, (b) part 2 of the original program.



a.



b.

Figure 3. Modified LabVIEW program. (a) part 1 of the modified program, (b) part 2 of the modified program.

3. Results

The results obtained are summarized in this section.

3.1 MATLAB Simulation Results

The MATLAB code results based on data samples at f = 900 MHz, 850MHz, 780MHz, 700MHz, 600MHz, and 570MHz, respectively, are shown in figure 4. The maximum number of voltage settings achieved is **27**, while the minimum is **12**.

```
The minimum s22 parameter occurs at 4.0 V, The number of voltage settings = 18

 The actual minimum s22 parameter occurs at 4.0 V
```

```
The minimum s22 parameter occurs at 2.8 V, The number of voltage settings = 16

 The actual minimum s22 parameter occurs at 2.8 V
```

```
The minimum s22 parameter occurs at 1.4 V, The number of voltage settings = 12

 The actual minimum s22 parameter occurs at 1.4 V
```

```
The minimum s22 parameter occurs at 0.1 V, The number of voltage settings = 14

The actual minimum s22 parameter occurs at 0.1 V
```

```
The minimum s22 parameter occurs at 3.9 V, The number of voltage settings = 27

 The actual minimum s22 parameter occurs at 3.9 V
```

```
The minimum s22 parameter occurs at 2.2 V, The number of voltage settings = 20

 The actual minimum s22 parameter occurs at 2.2 V
```

Figure 4. MATLAB results.

3.2 LabVIEW Program Results

The modified LabVIEW code was tested and could successfully determine the voltage at which minimum S22 parameter occurs for multiple frequencies (Saguri needed the VNA before I could document the results).