Microsoft Excel Based S-parameter Device Analysis Software

by Brianna Murphy, Ali Darwish, and Thomas Farmer
NOTICES

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Microsoft Excel Based S-parameter Device Analysis Software

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When collecting S-parameter data from a 2-port measurement device, such as a vector network analyzer (VNA), it is typically necessary to view this data on a computer other than the VNA for use in design or analysis of the measured device. To graphically view S-parameter data on a standard Microsoft Windows-based computer requires proprietary software, which typically requires licensing or installation. In an effort to eliminate the need for such proprietary software, a Microsoft Excel spreadsheet with built in macro software has been developed at the U.S. Army Research Laboratory (ARL) to read in and plot S-parameter data collected from a VNA. This technical report discusses the use, the design, and provides a listing of this macro-based software.
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1. Introduction

When using a network analyzer to analyze a 2-port device, S-parameter data is collected, typically in an ASCII file known as an S2P file. Several formats for this file exist. In the context of this report, we require the S2P file to be in the touchstone format, which was developed by EEsof in 1984. In order to analyze this data, it is necessary to import it into a software program to both plot and analyze the data. Typically the data plotted in linear representation as magnitude versus frequency or in a Smith chart representation. Typical analysis of S-parameters for transistor devices is the determination of $f_T$, $f_{MAX}$, and $g_m$. These plots and analysis are easily performed on some network analyzers and several proprietary or purchased licensed only software.

The purpose of this work was to create a Microsoft (MS) Excel program using the MS Excel macro scripting language to both plot and analyze S-parameter data from S2P files generated by network analyzers. The advantage of using MS Excel is that it allows engineers universal access to the plotting and analysis of S-parameters using any standard image computer equipped with MS Excel within the U.S. Army Research Laboratory, and possibly in a Department of Defense (DoD)-wide environment, to avoid the installation of proprietary or costly S-parameter analysis software.

2. User Manual

The following are the steps for using the program:

1. Open the S-parameter analyzer MS Excel Macro Workbook:
   - Filename: SParameter_Analyzer_v1.xlsm
   - At the time of this report was written, this file was located on the common RDRL-SER-E server share drive:
     - L:\Sparameter_Analysis_Software\Brianna_Murphys_Sparameter_Plotting_Tool\SParameter_Analyzer_v1.xlsm
   - A complete listing of the source code for this MS Excel Macro Workbook is in appendix A, so that the reader may create their own instance of this software in their own copy of MS Excel if L:\ drive access is not possible or the location listed above has expired.

2. The user is then prompted to select an .S2P file to be analyzed.
• Note: If the user chooses a file that is not an .S2P file, the program will not work.

3. Once the appropriate .S2P file is chosen, the program will process the S2P data
   • The original .S2P data file is not be manipulated or changed in any way.

4. Once the MS Excel macro has completed, there will be multiple sheets/tabs in a newly create MS Excel workbook:
   • The first sheet is a listing of the original .S2P data.
   • The second sheet is named Sparams_dB and includes the data with each column labeled. This sheet also has four extra columns that show the numerical data for 20*log(Magnitude) of the S11, S21, S21, and S22 magnitudes.
   • The third sheet has four S-parameter plots. Each of the two-port S-parameters has the logarithmic form of the magnitude plotted against frequency:
     – The plots are on top of one another, so the user must drag them apart to see all four S-parameters.

3. Structure of the MS Excel Macro Program

The MS Excel macro is split into several functions. The function at the top of the macro hierarchy is called **run_all_macros()** and is listed in figure 1. The functions or sub-routines called by this top function define the structure of this macro.

```
Sub run_all_macros()
    import_data_file
    analyze_data_dB
    add_sheet
    plot_S11
    plot_S21
    plot_S12
    plot_S22
End Sub
```

Figure 1. The **run_all_macros()** function.
As listed previously, the main macro function calls seven sub-routines to perform the tasks specified by their names. The following is a brief list of the functionality encapsulated by each sub-routine:

- **import_data_file**
  
  This sub-routine prompts the user for the .S2P file to import. Once the file is located, it creates a new MS Excel spreadsheet, then imports the ASCII-based data into that MS Excel spreadsheet.

- **analyze_data_dB**
  
  This sub-routine converts the magnitude of each S-parameter into dB, using the following MS Excel formula: $20 \times \log_{10}(B3)$. A new tab is created in the current MS Excel spreadsheet and the logarithmic form of the magnitude of each S-parameter is placed in this tab.

- **add_sheet**
  
  A new tab is created in the current MS Excel spreadsheet to hold the S-parameter plots.

- **plot_S11**
  
  An MS Excel XY-scatter plot of the logarithmic form of S11 versus the frequencies defined by the imported data is created and plotted in the new tab of the MS Excel spreadsheet.

- **plot_S21**
  
  An MS Excel XY-scatter plot of the logarithmic form of S21 versus the frequencies defined by the imported data is created and plotted in the new tab of the MS Excel spreadsheet.

- **plot_S12**
  
  An MS Excel XY-scatter plot of the logarithmic form of S12 versus the frequencies defined by the imported data is created and plotted in the new tab of the MS Excel spreadsheet.

- **plot_S22**
  
  An MS Excel XY-scatter plot of the logarithmic form of S22 versus the frequencies defined by the imported data is created and plotted in the new tab of the MS Excel spreadsheet.

A complete listing of each of these functions is given in the appendix. This section serves merely as an explanation of the programs hierarchy and flow.
4. Conclusions and Future Work

This program will allow all users to easily convert S-parameter data into graphs using MS Excel as opposed to using proprietary or costly S-parameter analysis software. Future work includes expanding this software into a more robust tool that will allow engineers future insight into the devices they are measuring.

Future improvements to this software include the following:

1. Auto-separating the four S-parameter plots.
2. Plotting the Smith chart representations of the imported S-parameter data.
3. Calculating H21 from the imported S-parameter data to plot $f_T$ for a single transistor.
4. Calculating the U-parameter from the imported S-parameter data to plot $f_{MAX}$ parameter for a single transistor.
5. Calculating the $g_m$ from the imported S-parameter data.
Appendix. Source Code Listing of the S-parameter Analysis Software

This is the complete source code listing of the S-parameter Analysis Software created in the Visual Basic Macro Scripting Language for MS Excel, version 2007.

This code can be copied and pasted into the macro section of an MS Excel spreadsheet and then saved as an .XLSM (macro-enabled workbook) file.

Afterwards, this .XLSM file can be opened and it will prompt to user for an .S2P file to analyze.

Sub run_all_macros()
' This Macro will call all the subsequent macros (consider in like main() in C)
'
' Import Data
import_data_file
'
' Analyze Data - Convert to dB
analyze_data_dB
add_sheet
plot_S11
plot_S21
plot_S12
plot_S22
End Sub

Sub import_data_file()
' This macro will import the S2P file and save it as an .XLSX file
'
' Prompt user for filename
Dim vFile As Variant
'
' Showing Excel Open Dialog Form
vFile = Application.GetOpenFilename("S2P files (*.S2P*)," & _
"*.S2P*", 1, "Select S2P File", "Open", False)
'
' Open S2P file and create new file
Workbooks.OpenText Filename:= _
vFile,
   Origin:=437, StartRow:=1, DataType:=xlDelimited, TextQualifier:= _
xlDoubleQuote, ConsecutiveDelimiter:=True, Tab:=False, Semicolon:=False, _
Comma:=False, Space:=True, Other:=False, FieldInfo:=Array(Array(1, 1), _
Array(2, 1), Array(3, 1), Array(4, 1), Array(5, 1), Array(6, 1), Array(7, 1),
Array(8, 1), _
Array(9, 1), Array(10, 1)), TrailingMinusNumbers:=True
' Save in .XLSX format
ActiveWorkbook.SaveAs vFile + ".xlsx", FileFormat:=51

Set dataWorkBook = ActiveWorkbook

Sub analyze_data_dB()
    '
    ' This macro will copy the imported S2P data into a separate tab, convert it to dB, and plot it
    '
    ' Copy data from one tab to a new tab
    Sheets.Copy After:=dataWorkBook.ActiveSheet

    ' rename new tab
    ActiveSheet.Name = "Sparams_dB"

    ' organize columns and rows
    Rows("1:3").Select
    Selection.Delete Shift:=xlUp
    Columns("A:A").Select
    Selection.Delete Shift:=xlToLeft
    Range("A1").Select
    ActiveCell.FormulaR1C1 = "Frequency"
    Range("B1").Select
    ActiveCell.FormulaR1C1 = "S11 Magnitude"
    Range("C1").Select
    ActiveCell.FormulaR1C1 = "S11 Phase"
    Range("D1").Select
    ActiveCell.FormulaR1C1 = "S21 Magnitude"
    Range("E1").Select
    ActiveCell.FormulaR1C1 = "S21 Phase"
    Range("F1").Select
    ActiveCell.FormulaR1C1 = "S12 Magnitude"
    Range("G1").Select
    ActiveCell.FormulaR1C1 = "S12 Phase"
    Range("H1").Select
    ActiveCell.FormulaR1C1 = "S22 Magnitude"
    Range("I1").Select
    ActiveCell.FormulaR1C1 = "S22 Phase"
    Range("A2").Select

    Columns("C:C").Select
    Selection.Insert Shift:=xlToRight, CopyOrigin:=xlFormatFromLeftOrAbove
    Columns("F:F").Select
    Selection.Insert Shift:=xlToRight, CopyOrigin:=xlFormatFromLeftOrAbove
    Columns("I:I").Select
    Selection.Insert Shift:=xlToRight, CopyOrigin:=xlFormatFromLeftOrAbove
    Columns("L:L").Select
    Selection.Insert Shift:=xlToRight, CopyOrigin:=xlFormatFromLeftOrAbove
    Range("A1").Select
    ActiveCell.FormulaR1C1 = "20log(S11)"
    Range("C1").Select
    ActiveCell.FormulaR1C1 = "=IF(ISBLANK(RC[-1])=TRUE,"" "",20*LOG10(RC[-1]))"
    Range("C2").Select
    Selection.AutoFill Destination:=Range("C2:C402")
    Range("C2:C402").Select
    Range("F1").Select
ActiveCell.FormulaR1C1 = "20log(S11)"
Range("F2").Select
ActiveCell.FormulaR1C1 = "=IF(ISBLANK(RC[-1])=TRUE,"" "",20*LOG10(RC[-1]))"
Range("F2").Select
Selection.AutoFill Destination:=Range("F2:F402")
Range("F2:F402").Select
Range("F2:F402").Select
ActiveCell.FormulaR1C1 = "20log(S12)"
Range("I2").Select
ActiveCell.FormulaR1C1 = "=IF(ISBLANK(RC[-1])=TRUE,"" "",20*LOG10(RC[-1]))"
Range("I2").Select
Selection.AutoFill Destination:=Range("I2:I402")
Range("I2:I402").Select
Range("I2:I402").Select
ActiveCell.FormulaR1C1 = "20log(S22)"
Range("L2").Select
ActiveCell.FormulaR1C1 = "=IF(ISBLANK(RC[-1])=TRUE,"" "",20*LOG10(RC[-1]))"
Range("L2").Select
Selection.AutoFill Destination:=Range("L2:L402")
Range("L2:L402").Select
Range("Q2").Select

End Sub

Sub add_sheet()
'
' This macro will add a new sheet to put the plots on

    Sheets.Add After:=Sheets(Sheets.Count)
ActiveSheet.Select
ActiveSheet.Name = "Sparam_plots"
    Sheets("Sparams_dB").Select
End Sub

Sub plot_S11()
'
' plot_S11 Macro
' Will plot graph of freq vs. 20log(S11)
'
    Range("A:A,C:C").Select
    Range("C1").Activate
Charts.Add
ActiveChart.ChartType = xlXYScatterSmooth
ActiveChart.SetSourceData Source:=Sheets("Sparams_dB").Range(_
    "A1:A405,C1:C405"), PlotBy:=xlColumns
ActiveChart.Location Where:=xlLocationAsObject, Name:="Sparam_plots"
With ActiveChart
    .HasTitle = True
    .ChartTitle.Characters.Text = "S11"
    .Axes(xlCategory, xlPrimary).HasTitle = True
    .Axes(xlCategory, xlPrimary).AxisTitle.Characters.Text = "Frequency"
    .Axes(xlValue, xlPrimary).HasTitle = True
    .Axes(xlValue, xlPrimary).AxisTitle.Characters.Text = "20log(S11)"
End With
End Sub

End Sub
Sub plot_S21()
     ' plot_S21 Macro
     ' Will plot graph of freq vs. 20log(S21)
        
        Range("A:A,F:F").Select
        Range("F1").Activate
        Charts.Add
        ActiveChart.ChartType = x1XYScatterSmooth
        ActiveChart.SetSourceData Source:=Sheets("Sparams_dB").Range( _
        "A1:A405,F1:F405"), PlotBy:=xlColumns
        ActiveChart.Location Where:=xlLocationAsObject, Name:="Sparam_plots"
        With ActiveChart
            .HasTitle = True
            .ChartTitle.Characters.Text = "S21"
            .Axes(xlCategory, xlPrimary).HasTitle = True
            .Axes(xlCategory, xlPrimary).AxisTitle.Characters.Text = "Frequency"
            .Axes(xlValue, xlPrimary).HasTitle = True
            .Axes(xlValue, xlPrimary).AxisTitle.Characters.Text = "20log(S21)"
        End With
    End Sub

Sub plot_S12()
     ' plot_S12 Macro
     ' Will plot graph of freq vs. 20log(S12)
        
        Range("A:A,I:I").Select
        Range("I1").Activate
        Charts.Add
        ActiveChart.ChartType = x1XYScatterSmooth
        ActiveChart.SetSourceData Source:=Sheets("Sparams_dB").Range( _
        "A1:A405,I1:I405"), PlotBy:=xlColumns
        ActiveChart.Location Where:=xlLocationAsObject, Name:="Sparam_plots"
        With ActiveChart
            .HasTitle = True
            .ChartTitle.Characters.Text = "S12"
            .Axes(xlCategory, xlPrimary).HasTitle = True
            .Axes(xlCategory, xlPrimary).AxisTitle.Characters.Text = "Frequency"
            .Axes(xlValue, xlPrimary).HasTitle = True
            .Axes(xlValue, xlPrimary).AxisTitle.Characters.Text = "20log(S21)"
        End With
    End Sub

Sub plot_S22()
     ' plot_S22 Macro
     ' Will plot graph of freq vs. 20log(S22)
        
        Range("A:A,L:L").Select
        Range("L1").Activate
        Charts.Add
        ActiveChart.ChartType = x1XYScatterSmooth
        ActiveChart.SetSourceData Source:=Sheets("Sparams_dB").Range( _
        "A1:A405,L1:L405"), PlotBy:=xlColumns
        ActiveChart.Location Where:=xlLocationAsObject, Name:="Sparam_plots"
        With ActiveChart
.HasTitle = True
.ChartTitle.Characters.Text = "S22"
.Axes(xlCategory, xlPrimary).HasTitle = True
.Axes(xlCategory, xlPrimary).AxisTitle.Characters.Text = "Frequency"
.Axes(xlValue, xlPrimary).HasTitle = True
.Axes(xlValue, xlPrimary).AxisTitle.Characters.Text = "20log(S22)"
End With
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