

## **STAINS 3.2**

### **Symbolic Two-Port Analysis via Internal Node Suppression**

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#### **Disclaimer of Warranty**

The author makes no warranties, express or implied, that the said program is free of error, or is consistent with any particular standard of merchantability, or that it will meet your requirements for any particular application. It should not be relied on for solving a problem whose incorrect solution could result in injury to a person or loss of property. If you use the program in such a manner, it is at your own risk. The author disclaims all liability for direct or consequential damages resulting from your use of the program.

## **1. INTRODUCTION**

STAINS32.XLS is an Excel 97 workbook that will allow you to obtain symbolic network functions in the "Sequence of Expressions" (SoE) form for any lumped, linear, time-invariant circuit. A copy of the software and many sample data files can be downloaded from the Web site: <http://services.eng.uts.edu.au/~benr/symbolic/index.htm>

A newer version of the program for Excel 2007 is available in STAINS32.XLSM.

There are two basic differences between STAINS32 and STAINS24:

1. STAINS32 can calculate symbolic network function sensitivities to parameter changes.
2. STAINS32 does not compact the Modified Node Admittance Matrix for circuits containing ideal op amps.

### **1.1. Theory**

The basic theory is described in the paper: F. Balik, B. Rodanski, "Calculation of Symbolic Sensitivities for Large-Scale Circuits in the Sequence of Expressions Form via the Transimpedance Method," *Analog Integrated Circuits and Signal Processing*, 40, pp. 265-276, 2004.

### **1.2. Software Requirements**

To run the program you will need a copy of Microsoft Excel 97 or higher, running on a PC or Mac (Mac version will require minor modifications due to different file management).

**IMPORTANT:** In Excel 97 the Add-Ins: 'Analysis ToolPack' and 'Analysis ToolPack - VBA' must be connected. To connect the required Add-Ins click on **Tools -> Add-Ins** on the Excel menu list and check appropriate check-boxes in the Add-Ins window.

In Excel 2007 the above is not necessary, but make sure that the reference to 'atpvbaen.xls' is enabled. To do that, go to the **Developer** tab on the Main Menu bar and click on Visual Basic icon. This will open the VBA window. Go to **Tools -> References** and check the box next to 'atpvbaen.xls'.

STAINS32 consists of two worksheets: "Data" and "Yn", three dialogue sheets: "NFS", "Piv", "Dly" and "Sns", and several Modules written in VBA (Visual Basic for Applications). The dialogue sheets are hidden and can be made visible by executing: **Format -> Sheet -> Unhide** from the Menu Bar. The VBA Modules can be accessed by executing: **Tools -> Macro -> Visual Basic Editor** from the Menu Bar. If you are not familiar with VBA, you need not concern yourself with the Modules, but if you know how to program in VBA, access to the source code will enable you to understand the operation of the program and even make your own changes.

### 1.3. Hardware Requirements

You must be able to run Excel 97 or higher, so the hardware requirements are the same as for the Microsoft Excel.

## 2. CIRCUIT DATA ENTRY

Circuit data is entered onto the worksheet called "Data".

### 2.1. General Data

In cell B2 (TileCell) enter any text you want to be the title of your circuit.

In cell B3 (NumOfNodesCell) enter the maximum node number of your circuit. (Nodes should be numbered by consecutive integers, starting from zero - the reference node.)

### 2.2. Component Data

Starting from row 6, under the appropriate headings, enter the component name, incident nodes and, optionally, its value. (The first letter of the name indicates the component type; you don't have to include the underscore; the entry is case-insensitive.) Component values are not used directly by STAINS2, but if you request the MATLAB files to be created, the values will be written to a file "circuit\_file\_name.DAT".

The following components are accepted by STAINS3:

#### 1. Resistor

R_name	n1	n2			value
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## 2. Capacitor

C_name	n1	n2			value
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## 3. Inductor

L_name	n1	n2			value
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## 4. Impedance

Z_name	n1	n2			value
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Note: Do not use names 'ZS' and 'ZL' for impedances; these names are reserved for source and load impedances, respectively.

## 5. Admittance

Y_name	n1	n2			value
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Note: Do not use names 'YS' and 'YL' for admittances; these names are reserved for source and load admittances, respectively.

## 6. Voltage-Controlled Voltage Source

E_name	n+	n-	n1	n2	value
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## 7. Voltage-Controlled Current Source

G_name	n+	n-	n1	n2	value
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## 8. Current-Controlled Voltage Source

H_name	n+	n-	n1	n2	value
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## 9. Current-Controlled Current Source

F_name	n+	n-	n1	n2	value
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In all four controlled source data, (n+, n-) represent controlled terminals (source) and (n1, n2) represent controlling terminals.

## 10. Ideal Op Amp (Nullor = Nullator + Norator)

N_name	n+	n-	n1	n2	
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In the ideal op amp data, (n+, n-) represent input nodes (noninverting, inverting), (n1, n2) represent output nodes; n2 is usually connected to ground (reference node). Input of an ideal op amp is modelled by the nullator, while the output is modelled by the norator.

### 2.3. Specifying Input and Output Ports

In order to calculate network functions, input and output ports must be specified. This is done by placing the following lines at the end of the component list:

inp	n1	n2			
out	n1	n2			

### 2.4. Saving Circuit Data

To save circuit data in a disc file, click on the "Save" button and select the name ("circuit\_file\_name") and location of your file from the "Save As" window. After saving, the full path to the data file will be displayed in cell B4 (DataFileCell).

The file "circuit\_file\_name.CIR" is saved as a plain ASCII file and can be viewed (and modified) with any text editor.

### 2.5. Loading Circuit Data

Previously saved data file can be loaded onto the spreadsheet "Data" by clicking on the "Open" button. An "Open" window will appear, from which a data file can be selected. Content of this file will replace all data on the input spreadsheet.

## 3. GENERATING A SEQUENCE OF EXPRESSIONS

To generate a network function in a sequence of expressions form, click on the "Run" button. The "Network Function Selection" dialogue box will appear. From the various options in this dialogue box you can select the required network function and the output format.

### 3.1. Selecting the Network Function

Currently only three network functions can be generated (all assume  $|Y_S| = |Y_L| = 0$ ):

Open-Circuit Voltage Ratio,  $T_v$ ,  
 Input Impedance,  $Z_{inp}$ ,  
 Input Admittance,  $Y_{inp}$ ,  
 Output Impedance,  $Z_{out}$ ,  
 Output Admittance,  $Y_{out}$ .

### 3.2. Selecting the Output Format

STAINS3 can generate two different output formats:

*Compact Sequence of Expressions* - sequence with the smallest number of arithmetic operations, but containing fractions (division operations). For example:

$$\begin{aligned}x_1 &= G_5 * G_3 / (G_6) \\x_2 &= -G_1 - s * C_1 - G_2 * x_1 / (s * C_2) \\x_3 &= -G_4 * G_8 / (x_2) \\T_v &= x_3 / (G_{11})\end{aligned}$$

*Matrix Only.* Only the Modified Node Admittance Matrix (MNAM) is displayed.

### 3.3. Sensitivity Calculations

STAINS32 can calculate symbolic network function sensitivity to a selected component. After clicking on the "Sensitivity" button in the Network Function Selection window, the Network Function Sensitivity window opens and the user can select a component from a drop down list.

### 3.4. Pivoting Criteria

The complexity of the final expression greatly depends on the pivoting criteria. At each elimination step the pivot is selected based on three criteria:

Minimum number of multiplications,  $N_{mult}$ ,  
Minimum number of fill-ins,  $N_{fill}$ ,  
Minimum number of flops,  $N_{flop}$ .

Each of these three criteria can be selected as a primary, secondary or tertiary criterion in any combination. To make a selection, click on the "Pivoting" button; the "Pivoting Criteria" dialogue box will appear from which you can select a desired combination. For most circuits the best results (shortest sequences) are obtained when the pivoting criteria are selected in the order above.

### 3.5. Creating MATLAB Files

When the "MATLAB Files" check box is checked, three text (plain ASCII) files may be created:

circuit_file_name.DAT -	with component data (values), when at least one circuit component was given a value on the "Data" spreadsheet,
circuit_file_name.NAM -	with the Compacted Modified Node Admittance Matrix (CMNAM),
circuit_file_name.SEQ -	with the required sequence of expressions.

The text files can be used for further processing by MATLAB or any other math software  
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package.

### **3.6. Animation**

Checking this option will enable you to view the creation of the CMNAM. The node admittance matrix is formulated using the element stamp approach. As the program scans the data file, element stamps will appear in the matrix one by one. To slow down or speed up the animation, select the delay time (in milliseconds) in the "Animation Delay" window.

## **4. SAMPLE DATA FILES**

A number of sample data files can be downloaded from:

<http://services.eng.uts.edu.au/~benr/symbolic/index.htm>

Select "STAINS" under "SOFTWARE" heading.