Introduction to EXCEL

A spreadsheet design and a brief outline of some useful features of EXCEL are given.

Spreadsheet organization

Although you may be inclined to think of a spreadsheet as a single-page item, the terminology used here is that *spreadsheet* refers to a collection of *worksheets.* The various worksheets talk to each other as arranged by the spreadsheet designer. We might call this network the spreadsheet *architecture.* We will use the architecture shown in the flowchart of Figure 1.

Spreadsheet Architecture

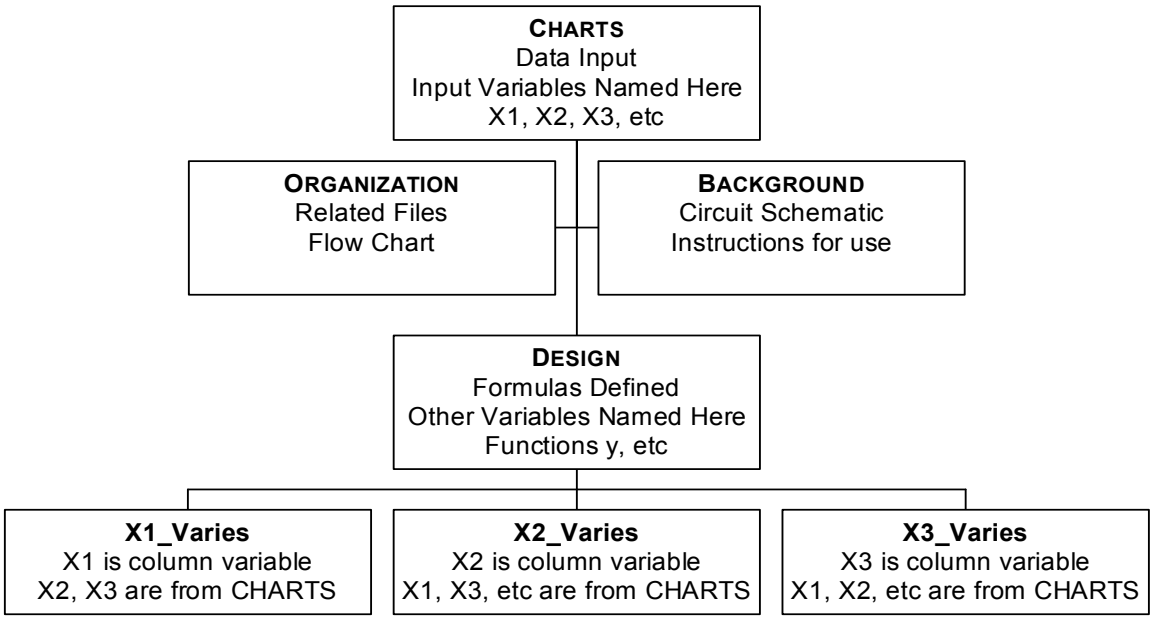

FIGURE 1
Example of spreadsheet organization

According to this architecture, data is input to the spreadsheet on worksheet CHARTS. This data is communicated to the workhorse worksheets called X1_VARIES, X2_VARIES, etc. Using one data entry point insures that all worksheets are using the same data: if data is entered on each worksheet separately, a lot of time will be spent comparing worksheets to see if they all are on the same page (excuse the terminology).

Another reason to use data entry on one page is convenience. On CHARTS the input data can be changed and it is piped immediately to the other worksheets where the calculations on those worksheets are immediately updated. We will place charts on the CHARTS worksheet that report the results of the calculations on the worksheets X1_VARIES, X2_VARIES, etc. Then, as soon as the input data is changed on CHARTS, the graphs on CHARTS are immediately updated so we can see exactly the effect of our changes. As a result, we can play with the input data and get a feel for what happens to the results when the input is changed. We gain intuition this way about how the system works.

The flowchart of Figure 1 is created using the EXCEL feature INSERT/PICTURE /ORGANIZATION CHART. It is pasted on a worksheet. Then the name of the worksheet is changed to ORGANIZATION, by right clicking on the worksheet tab at the lower left, and using the menu of Figure 2 below.

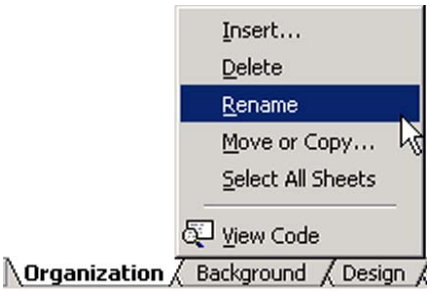

FIGURE 2
Renaming the worksheet with the name ORGANIZATION

CHARTS worksheet

We set up an input data worksheet by renaming one of the worksheets CHARTS, just as in Figure 2. Then on CHARTS we set up an INPUT DATA box. We highlight the variable values (1, 2, 3) and the variable names (X_1, X_2, X_3) and select the menu INSERT/NAME/CREATE, as shown in Figure 3. The CREATE NAMES menu appears and we click OK. Cells I8, I9 and I10 then are named X_1, X_2 and X_3.

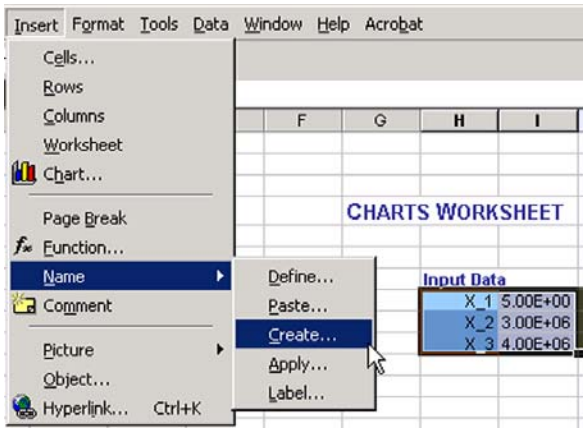

FIGURE 3
Making the input data X_1, X_2, and X_3 NAMED VARIABLES

Using NAMED VARIABLES enables transfer of Information from the input on CHARTS to the other worksheets. Now that variables X_1 etc have been defined, they are recognized on *all* the other worksheets in this spreadsheet. Hence, a change in the value of X_1 on CHARTS is piped immediately to all the other worksheets.

An underscore is used in naming X_1, etc because EXCEL sometimes uses names like X1, X2, etc as *cell names*, so we cannot use these names as variables too. I can't be bothered to remember which names fall into this category, so I use an underscore for all subscripts.

DESIGN worksheet

The DESIGN worksheet uses the input data to calculate the functions that depend on these variables. For the sake of illustration we will suppose that EQ. 1 below gives the function we want to explore:

EQ. 1

$$y = \frac{x_2^2}{x_1}\,\ell n(x_3)\,.$$

For this case the DESIGN worksheet is shown in Figure 4.

By doing a complete calculation on this worksheet, we can check that everything is working before we proceed. In a circuit design, we might calculate Q-point currents and voltages, specifications, small-signal parameters or what have you. With all the formulas here, we then can construct further worksheets simply by copying the columns on DESIGN and using EDIT/PASTE SPECIAL with the TRANSPOSE box checked to paste rows on another worksheet. See Figure 5 below.

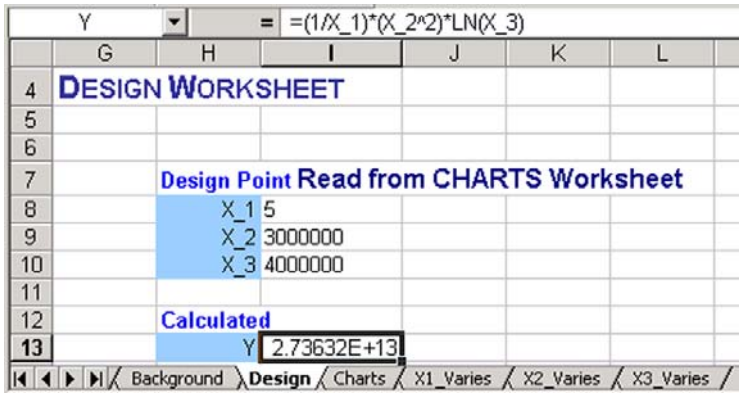

FIGURE 4

DESIGN worksheet showing calculation of function y

FIGURE 5

Preparing to copy the formulas from DESIGN onto another worksheet like X1_VARIES checking the TRANSPOSE box

For example, copying the columns H8:I13 in Figure 4 and pasting into a blank worksheet, we obtain Figure 6 below.

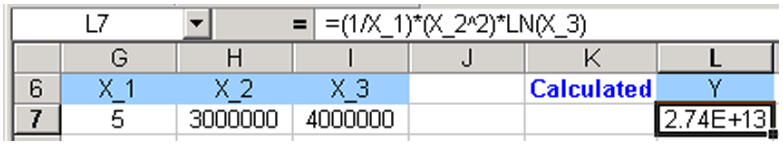

FIGURE 6

Result of PASTE SPECIAL with TRANSPOSE selected

Deleting columns H to K, we produce the first rows in a spreadsheet where x_1 will be the variable, as discussed next.

Calculating output: X1_VARIES, X2_VARIES and X3_VARIES worksheets

We name three other worksheets as X1_VARIES, X2_VARIES, and X3_VARIES. On these worksheets we want to explore the dependence of our functions on X_1, X_2, and X_3. In our case, these functions will be circuit properties, like resistor values, currents, bandwidths or whatnot.

Thus, on worksheet X1_VARIES we want to use fixed values of x_2 and x_3, but allow x_1 to change. Therefore, we import the values of x_2 and x_3 from CHARTS, but we implement x_1 as a column variable. To do this, we enter the values we want to consider in a column under heading X_1. Then we highlight the x_1 column and its name, and again use INSERT/NAME/CREATE, as shown in Figure 7. When we do this, the variable name X_1 from CHARTS is overridden, and the column variable X_1 replaces the CHARTS variable X_1 *only on this worksheet.*

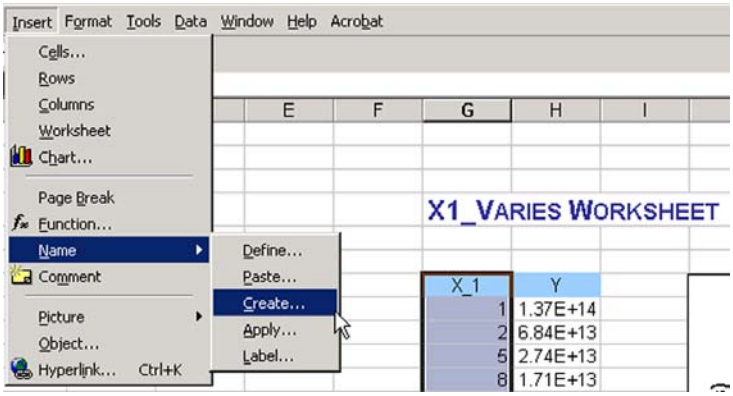

FIGURE 7

Naming X_1 as a COLUMN VARIABLE

Now we fill in the y-values by setting the cursor in the lower right corner of the first y-entry to obtain a plus sign as in Figure 8. We hold down the left mouse button and pull the cursor down to the end of the column, filling the formula for y all the way down.

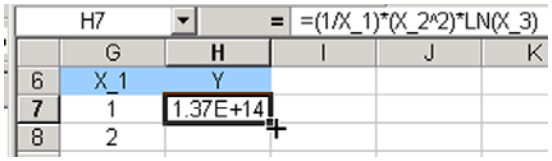

FIGURE 8

Setup to fill in formula for y; cursor set at lower right corner transforms to a + sign

Next we name Y as a column variable, the same way as Figure 7. If we now highlight the Y-column (without its name) we obtain the results shown in Figure 9 below.

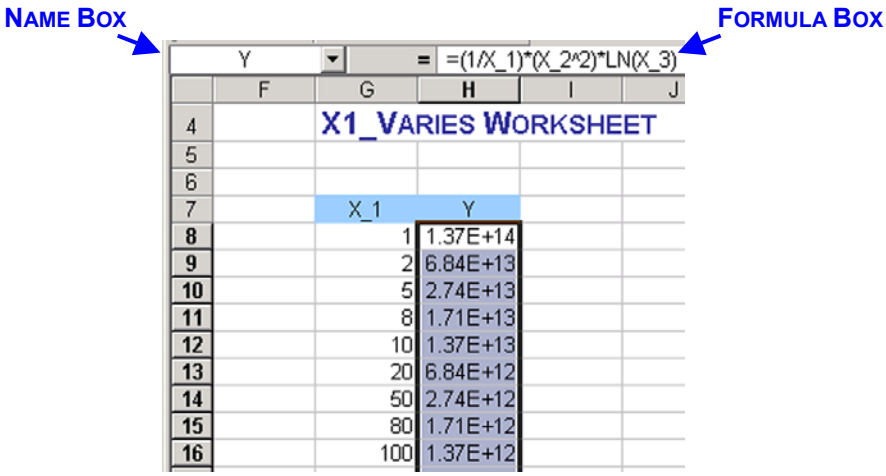

FIGURE 9

The column variable Y as a function of X_1; the name of the output column Y appears in the NAME BOX, and the formula of EQ. 1 for Y appears in the FORMULA BOX

In EXCEL there is a precedence list for the order of arithmetic operations. However, to avoid learning this order, I just use parentheses to insure the order is what I expect. So in the formula for Y, I have introduced parentheses around (X_2^2), just to be sure that the power 2 is used for X_2 and not the power 2*LN(X_3).

Graphing output

To plot the dependence of Y upon X_1, we simply highlight the values in the X_1 and Y columns and invoke the CHART WIZARD, as shown in Figure 10 below.

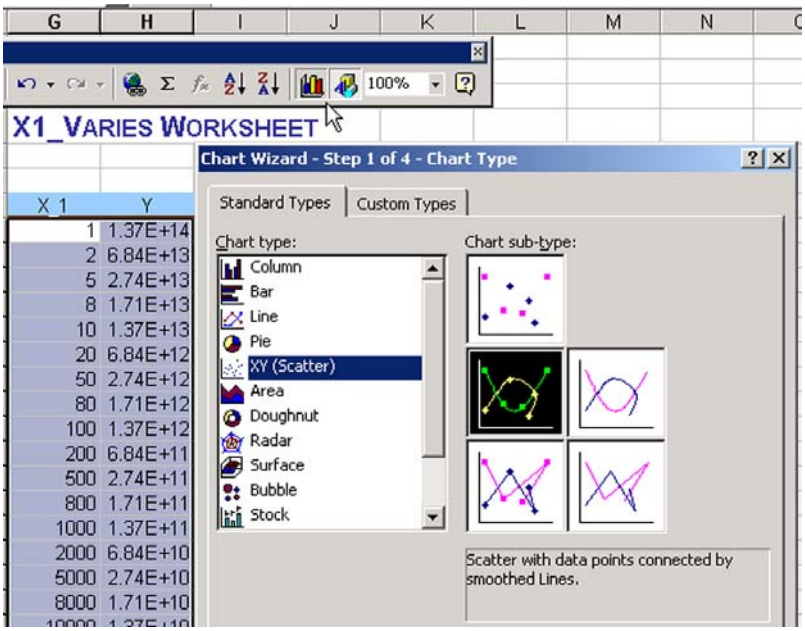

FIGURE 10

Using the CHART WIZARD (see cursor pointer) to obtain an xy (scatter) chart of Y vs. X_1

The initial plot is not very pretty, as shown in Figure 11.

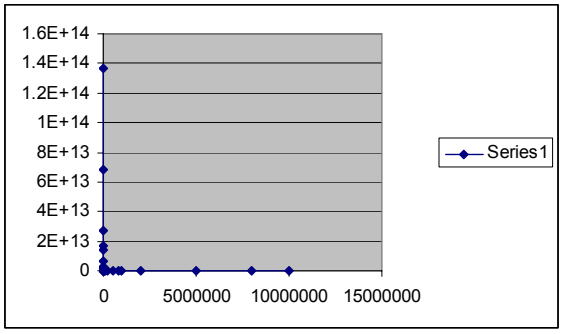

FIGURE 11

The initial xy-plot of Y vs. X_1

There are a number of menus that can be exercised to improve the plot's appearance. But for our purposes, you can simply copy the final chart in the EXCEL file, shown in Figure 12 below, onto your worksheets and the formatting is complete without any fiddling. In case you want to change formatting, some of these menus follow.

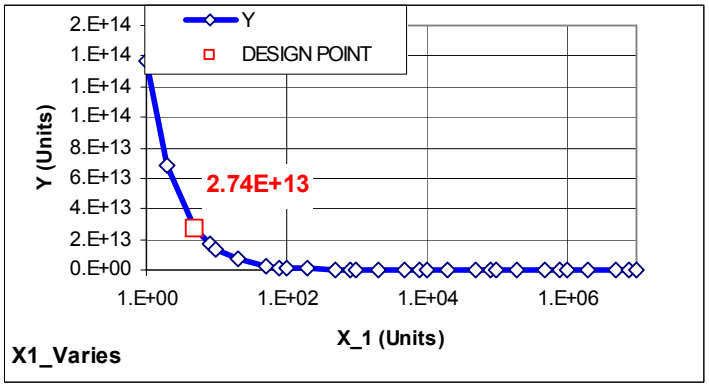

FIGURE 12

Formatted version of chart

We make the x-axis logarithmic by right clicking on the x-axis labels and selecting FORMAT AXIS. Choosing the SCALE tab, we elect LOGARITHMIC. See Figure 13 below.

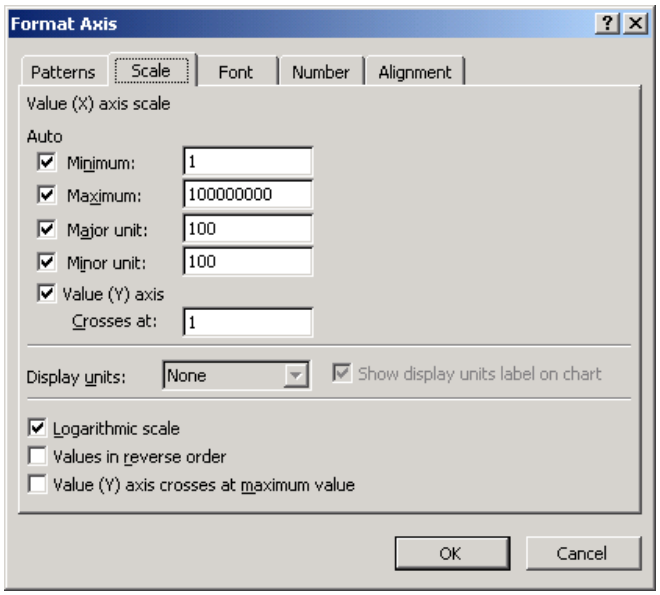

FIGURE 13

Making the x-axis logarithmic by checking the LOGARITHMIC SCALE box.

The label "X1_Varies" in the lower left can be inserted using the option for a chart title, accomplished by right clicking on the chart and filling out the menu of Figure 14 below.

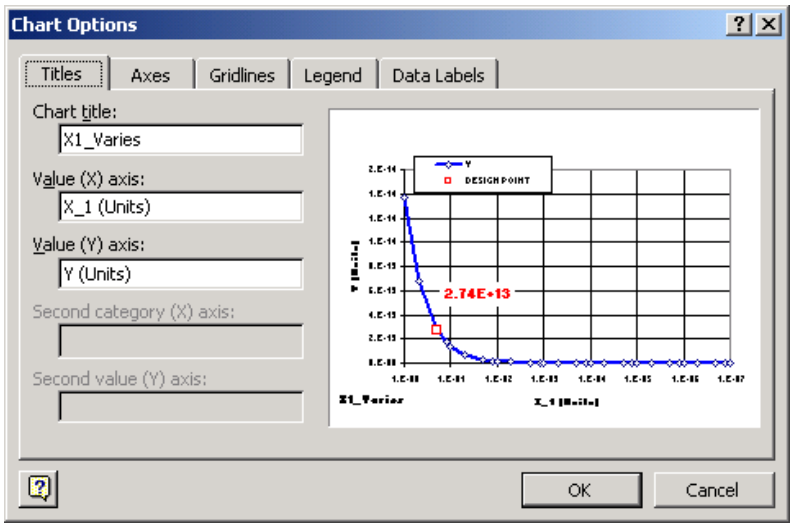

FIGURE 14

CHART OPTIONS menu for filling in the title and the axis labels

To get a white background, we right click on the background and select FORMAT PLOT AREA to obtain the menu of Figure 15. We select a white background.

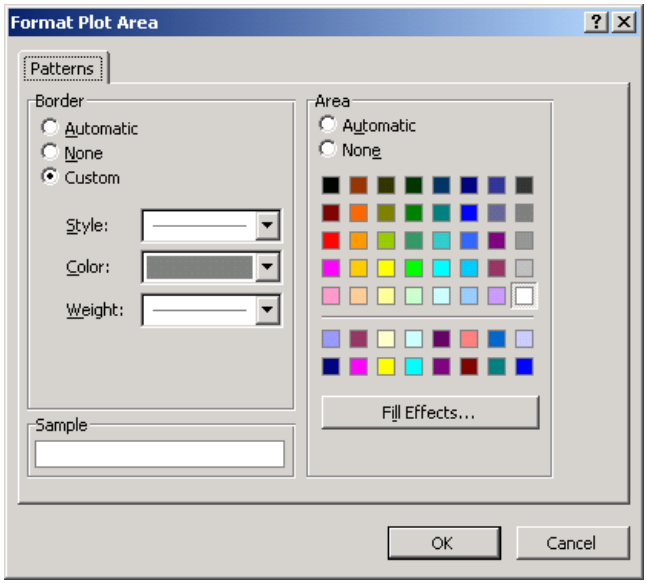

FIGURE 15

Setting a white background for the plot by clicking on the white square at the lower right of the color palette

The labels used for the axes are set by right-clicking on the axis and filling in the menu of Figure 16.

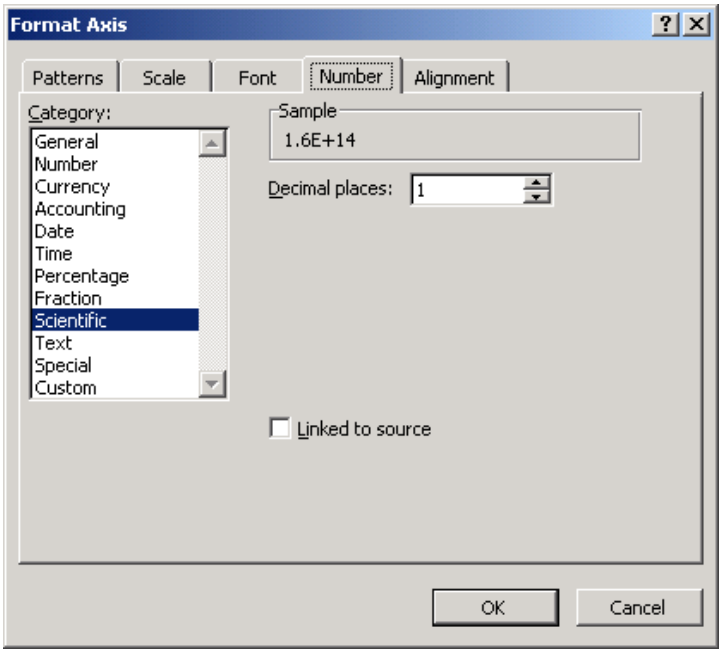

FIGURE 16

The FORMAT AXIS menu for setting the number format on the axis; the SCALE tab allows setting the scale as log or linear and the max and min number on the scale

The colors and symbols used for the curve itself are set by right clicking on the curve and filling in the menu of Figure 17 below.

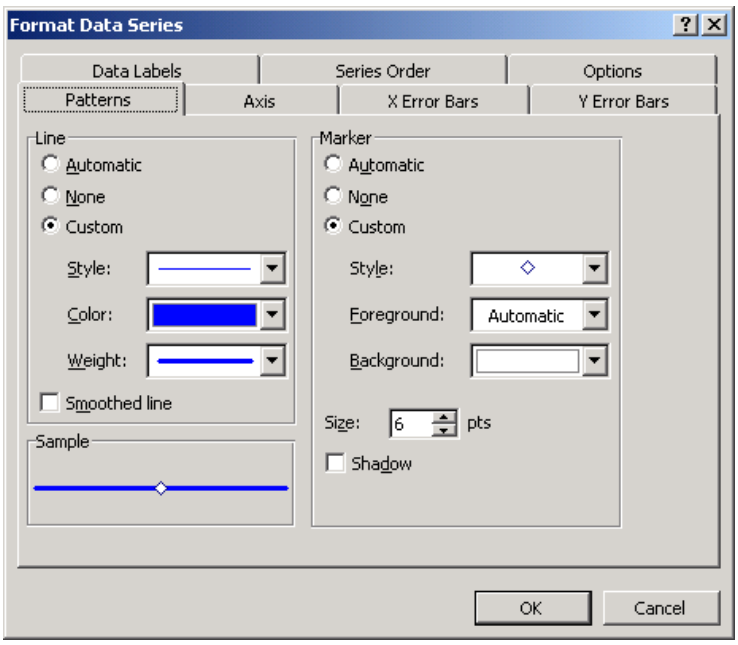

FIGURE 17

The FORMAT DATA SERIES menu for setting the weight, color, and symbol used on curves

The name of the curve that appears in the legend is set by right clicking on the chart and selecting the SOURCE DATA menu of Figure 18. The name used in the legend is entered in the NAME box. In this case, the cursor was placed in the NAME box, and then clicked on the label Y (shown in a dashed box), causing the name of the curve to be taken as the entry in cell X1_Varies!H7 (in the NAME box, X1_Varies! refers to the worksheet, H7 to the cell).

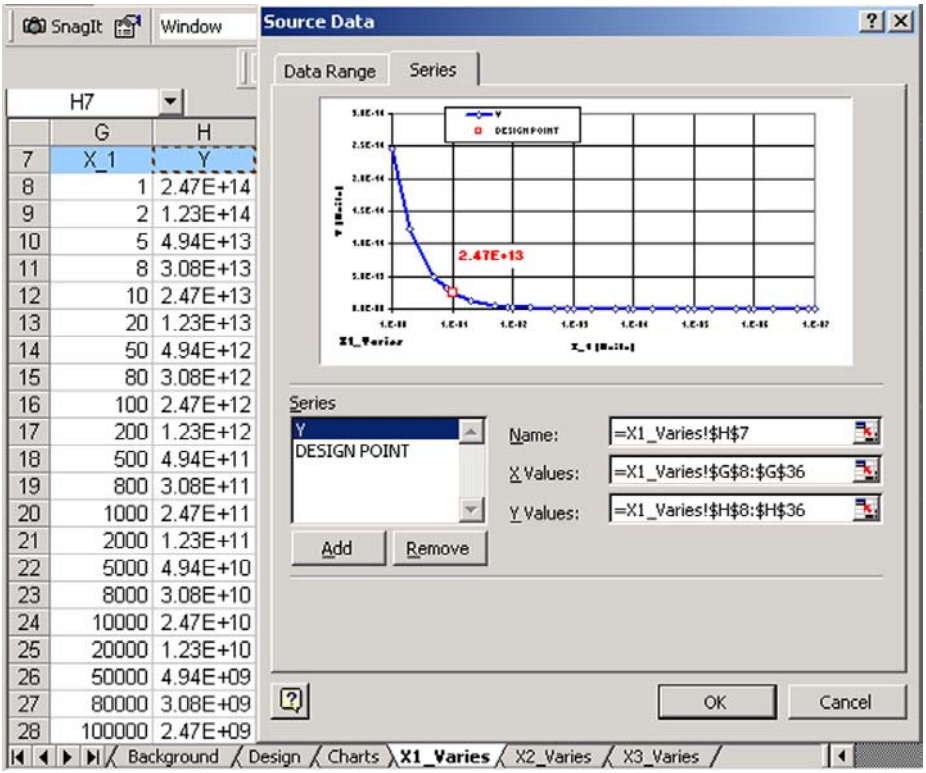

FIGURE 18

Setting the name that labels the curve in the legend

Adding additional curves

The menu of Figure 18 can be used to add other curves to the plot as well. Simply click the ADD button and fill in the NAME, X VALUES AND Y VALUES. For each box in turn, first clear the box, then put the cursor in the box, and then highlight the cells you want in that box.

Adding the Design Point

The DESIGN POINT shows the value of y at the selected (x_1, x_2, x_3) on the DESIGN worksheet. For a spreadsheet set up for a circuit design, this would be the values of the circuit parameters for the design we are looking at, and the curves would show us how the circuit specification y would change if we moved this design point.

The DESIGN POINT is a data series with only one point. The origin of the data for this point is found by clicking on DESIGN POINT in the SERIES window of Figure 18. Right clicking on the data point and selecting FORMAT SERIES produces the FORMAT DATA SERIES menu of Figure 19. The PATTERNS tab allows us to choose the symbol and line weight to attach to this series. Right clicking on the label on the chart allows us to format the label using the menu of Figure 20.

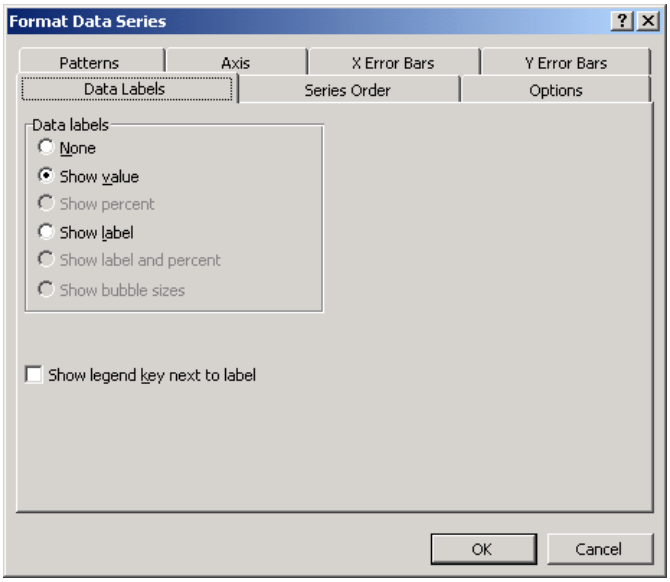

FIGURE 19

Selecting the SHOW VALUE data point label

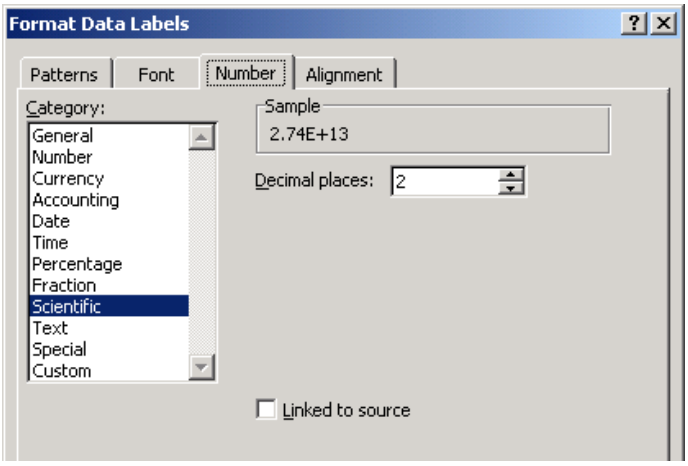

FIGURE 20

Formatting the data labels

Creating other worksheets by copying

We can repeat the procedure used for X1_VARIES for the other worksheets X2_VARIES and X3_VARIES. To simplify the process of making these other worksheets, we use the menu EDIT/MOVE OR COPY SHEET to make a copy of worksheet X1_VARIES, as shown in Figure 21.

Another approach is to position the cursor over the name tab and hold Ctrl+Shift. An icon showing a page with a +sign appears above the cursor. Drag it to the right of the name tab and release the keys. A copy of the worksheet appears.

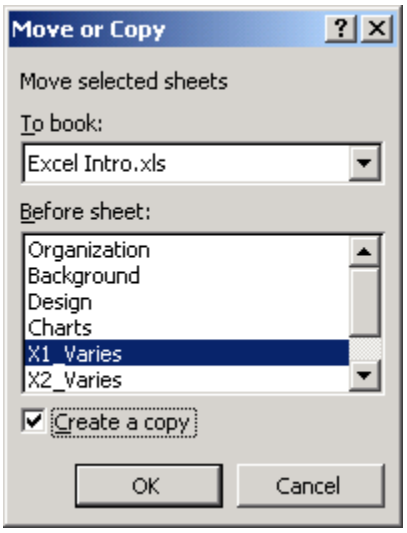

FIGURE 21

Creating a copy of the worksheet X1_VARIES with the CREATE A COPY box checked

We then rename the copied worksheet as X2_Varies. On this new worksheet, we set the column variable name to X_2, and use INSERT/NAME/CREATE to name this column and the Y-column. We edit the *x*-axis label and the title of the chart to refer to X_2.

Now we have to set X_1 to the value on CHARTS. Because we copied this worksheet from the worksheet X1_VARIES, the variable X_1 presently refers to the column variable, not to CHARTS. We use the menu INSERT/NAME/DEFINE and select variable X_1, as shown in Figure 22. The box at the bottom of this menu shows that X_1 refers to worksheet X2_Varies.

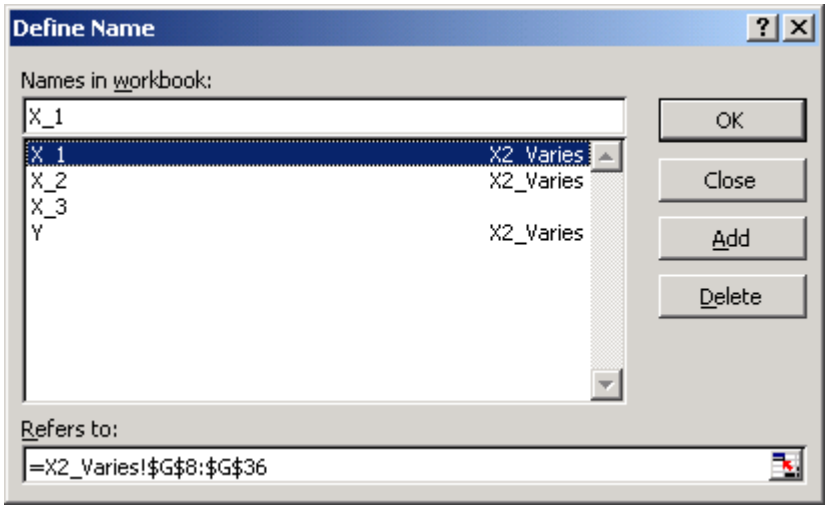

FIGURE 22

Preparing to delete the reference of variable X_1 to worksheet X2_VARIES

We hit the DELETE button. Now we highlight X_1 again, with the results shown in Figure 23. The box at the bottom of the menu shows variable X_1 now refers to the worksheet CHARTS, as we wish.

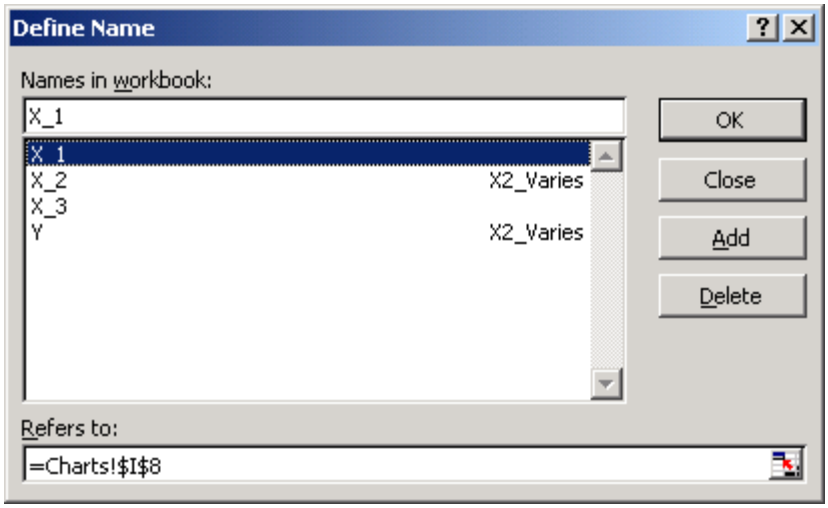

FIGURE 23

After DELETE, the variable X_1 on worksheet X2_VARIES now refers to CHARTS worksheet, as desired on worksheet X2_VARIES

The new X2_VARIES worksheet looks like Figure 24. The formula in the Y-column uses named variables, so it automatically picks up the correct values for X_1, X_2 and X_3. The chart automatically refers to the correct columns, so we do not need to redo the chart beyond editing the title and axis label, and in this case changing the x-axis from logarithmic to linear.

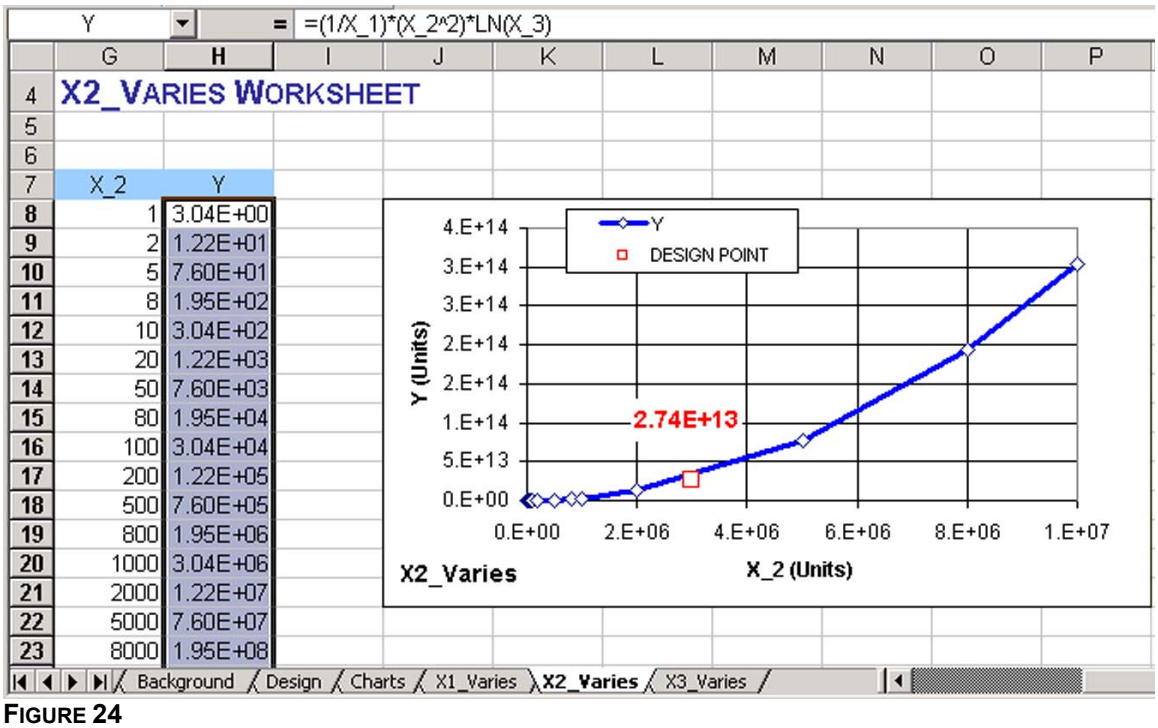

FIGURE 24

New X2_VARIES worksheet

Reporting back to CHARTS

The plots of Figure 12 and Figure 24 as well as the plot from X3_VARIES can be copied and pasted on the CHARTS worksheet. Then we can see what the functional dependence of Y looks

like for whatever values of X_1, X_2 and X_3 we choose to input. The CHARTS worksheet looks like Figure 25.

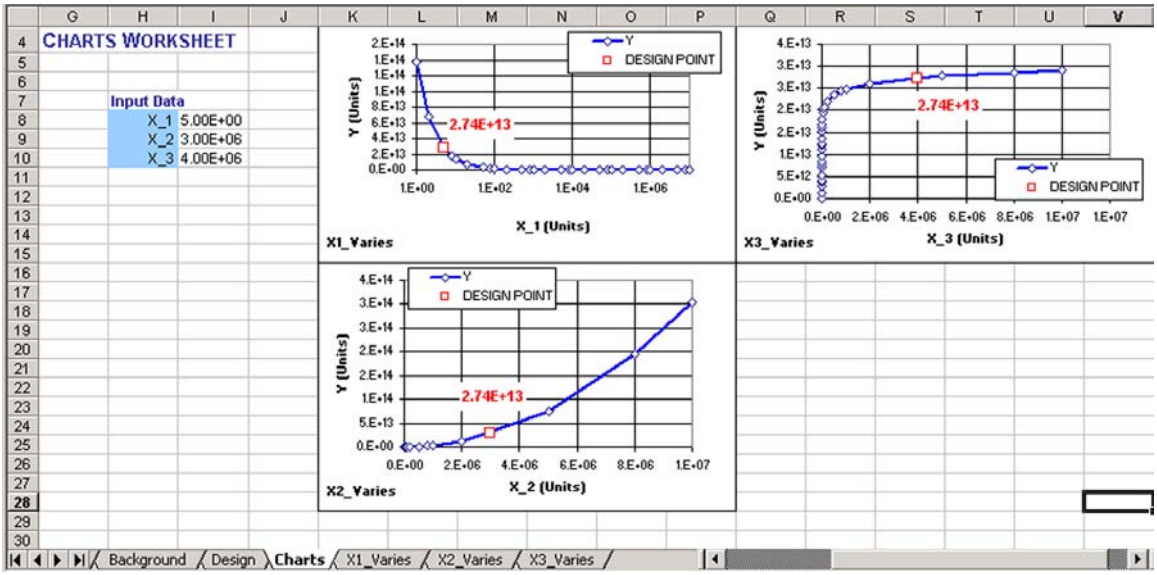

FIGURE 25

Final form of CHARTS worksheet

Exercises

1. Add charts to worksheet chart with logarithmic scales for both *x*- and *y*-axes: paste copies of each chart next to the existing chart, right click on each axis to get the FORMAT AXIS menu, choose the SCALE tab and check the LOGARITHMIC SCALE box. On the *y*-axis change the CROSSES AT box to the value 1E-300 to force the labeling of the x-axis to the bottom of the *y*-axis.

   An annoying feature of log plots in EXCEL is the warning menu of Figure 26 that pops up whenever a negative or zero value is amongst the values plotted. One way to avoid this problem is to make a new Y column for log plots that checks for negative values and marks them as not available. For example, next to the existing Y-column, make a "Y for Log" column that has this entry: =IF(Y<=0,#N/A,Y). This statement is interpreted as follows: if the value of Y is less than or equal to zero, enter #N/A (not available); otherwise enter the value of Y. Then use this "Y for Log" column as the plotted *y*-values for the log plots.

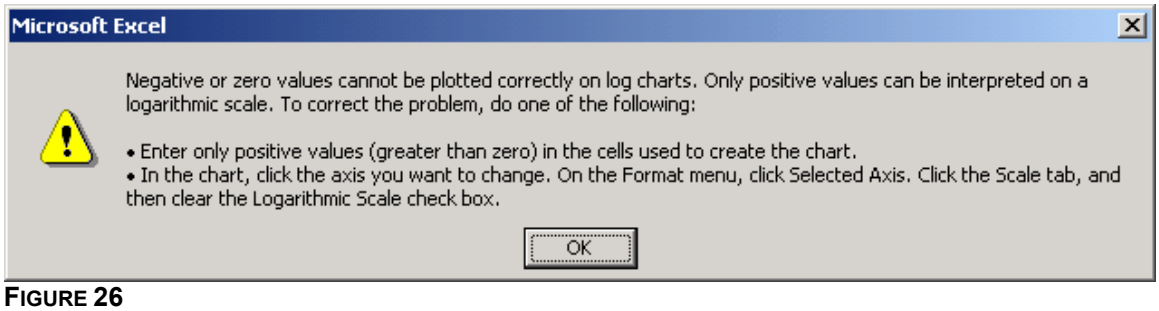

FIGURE 26

The annoying warning that crops up when using log plots in EXCEL: this menu has to be repeatedly "okayed" to proceed with any work; and every time the worksheet reevaluates because of some change, this menu pops up again

2. Suppose that particular values X_1C, X_2C, and X_3C have been identified for comparison with other choices. We want to add curve Y_{23} = (1/X_1)*(X_2C^2)*ℓn(X_3C) to the plot on

worksheet X1_Varies, Y_{13} = (1/X_1C)*(X_2^2)*ln(X_3C) to the plot on worksheet X2_Varies, and Y_{12} =(1/ X_1C)*(X_2C^2)*ln(X_3) to the plot on worksheet X3_Varies. These plots with the extra curves are to replace the charts presently on the CHARTS worksheet too, and the values of X_1C, X_2C and X_3C are to be named input variables on CHARTS, similar to X_1, X_2, and X_3. Make these changes to the spreadsheet. For illustration, use X_1C = 5, X_2C = 4E6, X_3C = 5E6.

References

For a complete owner's manual for EXCEL see

1. Craig Stinson and Mark Dodge, *Microsoft EXCEL Version 2002 Inside Out*, Microsoft Press, 2001.

For an older but very step-by-step introduction to using EXCEL, see

2. William J. Orvis, *EXCEL for Scientists and Engineers*, Second Edition, Sybex, 1996