APPENDIX A

Mathcad worksheets

As far as circuit modeling is concerned, Mathcad software eliminates most of the tedium involved in developing programs. It can handle tasks that include the calculation of values of circuit components, analysis of the response of the circuit model, analysis of test data to define the response of an assembly under test, and display a single graph showing the responses of model and hardware. This can all be done on the same worksheet; that is, without the need to invoke subroutines that are recorded on separate files. Moreover, the equations used in the computations are displayed in exactly the same way as they would appear in a textbook on circuit theory.

In a programming language, equations look something like:

$$\mathrm{x} = (-\mathrm{B} + \mathrm{SQRT}(\mathrm{B}^{**}2 - 4^{*}\mathrm{A}^{*}\mathrm{C}))/2^{*}\mathrm{A}$$

With Mathcad software, the same equation looks the same way as it does in a reference book:

$$x = \frac{-b + \sqrt{b^2 - 4 \cdot a \cdot c}}{2 \cdot a}$$

This makes the programs much easier to read and understand. Mathcad software also avoids the need to use a rigorous procedure to write a program. If the programmer gets the syntax wrong, the software refuses to accept the entry; and provides a message indicating what is wrong.

On a worksheet, the equations can be set out from left to right, top to bottom. Text can be included anywhere on the page.

Doubtless there are other software packages which provide the same sort of facility. However, for consistency in presentation, Mathcad is the one used here.

Since this software has been available for over a decade, there is a fair probability that the reader is already using it. If not, it should be fairly easy task to modify the programs in the worksheets of this document to convert them into programs which work with other software packages.

A few symbols in Mathcad have a special meaning:

$a := b + c$ ‘a’ is defined as the sum of b and c

$a = 2$ the value of ‘a’ is 2

If the 'equals' sign is in bold typeface, the software interprets this as the 'boolean equal' and returns a zero or a one.

The programming operator looks like that shown on Figure A.1:

$$\text{root}(a, b, c) = \left| \begin{array}{l} discr \leftarrow b^2 - 4 \cdot a \cdot c \\ num \leftarrow -b + \sqrt{discr} \\ denom \leftarrow 2 \cdot a \\ \dfrac{num}{denom} \end{array} \right.$$

Figure A.1 Simple Mathcad program.

The programming operator behaves like a function, taking input variables and returning an output. This output is the last variable to be declared. In the example above it is the value of the ratio of '*num*' divided by '*denom*'. The program can return a single variable, a vector, or an array.

Local variables defined in the function are not visible outside. However, variables declared in the worksheet above the program function are visible within the function.

Included in the software are a number of built-in functions. As far as circuit modeling is concerned, the most important is 'lsolve(M, $\mathbf{v}$)'. The argument 'M' is a square array, while '$\mathbf{v}$' is a vector. 'M' contains as many rows as there are elements in '$\mathbf{v}$'. This function returns a solution vector '$\mathbf{x}$' such that $M\mathbf{x} = \mathbf{v}$.

Another useful characteristic of the software is that it can distinguish between the 'j' operator as used with complex numbers and the variable 'j'. It can be defined as an imaginary number by typing the characters '1j'. It appears on the worksheet as 'j'.

It is also possible to intermingle text with variables. This facility is put to good use in defining the units appropriate to each variable. To avoid cluttering up the worksheets, this is usually restricted to places where a variable is defined or a final result is displayed.

Armed with this information, there should be no real problems in understanding the programs contained in the Mathcad worksheets of this book. Since the figures in the book which depict Mathcad worksheets have been hand-copied from copies of the actual worksheets, it is possible that errors have been introduced in the transcription process. Further errors could be introduced by the reader hand-copying the text onto his or her own computer. To prevent the chance of such errors creeping in, copies of the original Mathcad files are available in a zip folder which can be downloaded from www.designemc.info. These files can be run on any computer which has Mathcad version 15.0 (or higher) software installed.

The techniques described in the previous pages can be used to simulate the interference-coupling characteristics of any signal link. Every electrical or electronic system will have its own particular set of interference problems. It should be possible for individual designers to carry out tests and create circuit models of their own critical links. Such information can be shared. Mathcad users have access to PlanetPTC, a mix of dynamic channels that enables PTC customers and product development professionals to actively participate in exchanging ideas.

However, it does not really matter which software is used to carry out the calculations. The key feature of any circuit model is the fact that it is a shorthand method of defining a set of equations. It becomes possible to describe the hardware, the tests, the model, and to illustrate the results in a single report. There are many forums and many communities which can be used to publish such reports.