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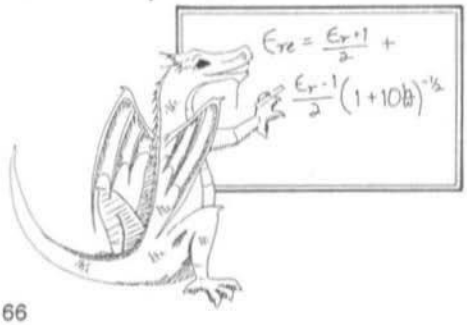
PUFF - A CAD Program for Microwave Stripline Circuits.

Back at the beginning of 1990 the authors Richard Compton (Cornell University), Scott W. Wedge (Hughes Aircraft Company) and David Rutledge (California University of technology) brought out version 1.5 of a remarkable versatile software package. Named after Puff, the magic dragon in the Peter, Paul and Mary song, the software was conceived especially for educational use. It was first used on microwave engineering courses at Caltech and at Los Angeles university; later it spread to many other universities and colleges and was also put to practical use by engineers and scientists. More than 6,000 copies were sent out worldwide of the first version alone.



PUFF represents an interactive circuit design environment for producing stripline and microstripline circuitry. Written in Turbo-PASCAL, it is fast, easy to learn and simple to use. Components are placed on the screen with cursor-key movements, followed by analyses in the time or frequency domain at the touch of a key. The results of the simulation can be seen as a plot, in a Smith diagram or in tabular form. Fig.1 shows the PUFF working screen with a simple example:

Top left is a square circuit board with four connections. At port 1 we have a an angled piece of 50-ohm stripline, next a quarter-wavelength piece with Z=87 ohms, and finally a 4mm-long 150-ohm resistor, connected to ground at the far end.

Below this we have (in this case) letters a to f representing components at our disposal (tline = transmission line; device = a FET on this occasion; clines = couples lines). The design impedance is indicated (50 ohms here) and the design frequency (5GHz this time).

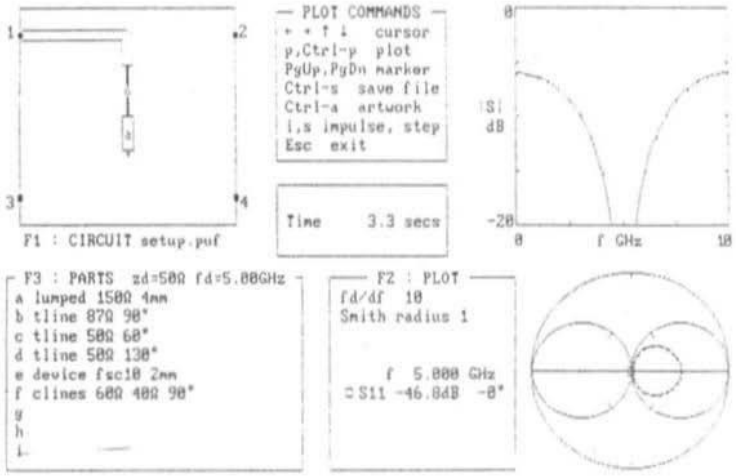


Fig.1 Screen shot of the Program in use

At top centre we have the commands at our immediate disposal. These vary according to whether we are working on a layout (f1), carrying out a simulation (f2) or arranging components (f3).

Top right we see the plotted results of the simulation -frequency response, impulse results or behaviour over time. Below is the Smith diagram for the S parameters selected.

Right in the middle is the time taken for the last calculation, below this the legend for scaling the Smith diagram, the design frequency and the measured value at the design frequency (which is not readable on the plot in the example).

After playing with the examples supplied and mastering the method of operation, you are ready to enter some values of your own. The printed circuit board can be altered according to material (thickness and Er) , dimensions, number and location of ports; the resulting solution can be re-worked to suit components already to hand or a particular frequency required. PUFF calculates all dimensions and avoids crossings of tracks or drawing outside the edge of the board.

Striplines or microstriplines (they should not be confused!) can be characterised by impedance and electrical length.

Concentrated components are SMD-resistors, -capacitors or -inductors. They are entered with their value and mechanical length. PUFF understands four units for impedance or admittance: ohms, Siemens, Z and Y. Reactance values require a "j" prefix or suffix, with the unit for an impedance following; for example 25johms and 0.5jZ specify a reactance of 25 ohms at the design frequency fd.

Devices are components with several ports, defined by S parameters. In the example we have an FSC10 FET from Fujitsu, with S parameters from 0 to 12GHz.

If you are happy with the results of your simulation, you can print out the enlarged layout, photograph and print it to the right scale and produce the PCB by photo-chemical methods.

At Caltech students have a two-hour practice session where they use PUFF to produce the following: solutions to a design exercise, producing film and PCBs, checking PCB track widths with a microscope, introducing

concentrated components and "devices", checking circuitry on a test station, and finally comparing simulation and actual results, which usually turn out very good.

The exercises are: a coupler, a low-pass filter, a band-pass filter, a low-noise FET amplifier and a FET oscillator. Fig.2 shows the comparison of a low-pass filter calculated by PUFF (solid and pecked lines) and the values measured (dots and crosses).

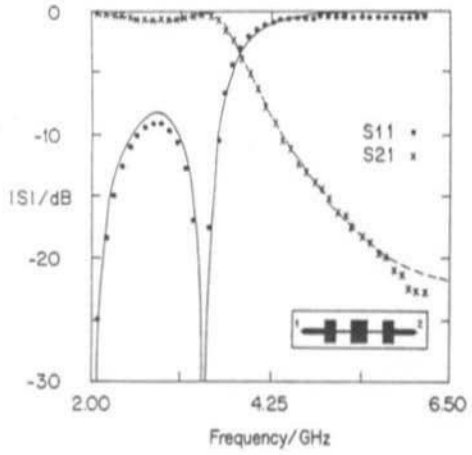


Fig.2 Comparison of calculated and actually measured values

PUFF does not contain an automatic optimisation procedure. The authors have, however, devoted a lot of effort into making it as fast as possible for users to check their circuits manually.

All measurements are given in mm, frequencies in GHz, and characteristics in the form of S parameters. <CTRL>-P is the command for printing a layout, enlarged to a (selectable) scale "p", on an IBM Proprinter. Naturally only the tlines and clines are printed, and bends are automatically chamfered (compensated).

Hardware requirements are IBM PC, XT, AT or compatible with EGA graphics. Slow computers should have a maths co-processor fitted, while on faster models the emulation built into the software works fast enough.

The finer details of the program are too varied to mention all of them here: with the 5.25" 360k floppy you get a neatly printed handbook with 36 pages and many illustrations. Fig's.1 and 2 in this article came from this handbook. The handbook is remarkably clearly written and easy to understand. Studying it is just as much a pleasure as working with PUFF is. The manual also contains a short tutorial with formulas and diagrams on dimensioning striplines, together with comprehensive references and keyword index. It is clear that extremely experienced college tutors have worked on PUFF and its manual!

Even if PUFF is no substitute for advanced (and expensive) microwave design programs, it is no plaything either and clearly more than "just" educational software. In the USA the software and manual cost just $10! Ordering information (mention size of disk required) from:

PUFF Distribution, Electrical Engineering M/S 116-81, California Institute of Technology, Pasadena, CA 91125, USA.

I would like to offer sincere thanks to Carl G. Lodstroem, SM6MOM/W6. Carl aroused my appetite for this software, obtained it for me and also supplied a disk full of "devices" - a whole host of transistors by HP and Motorola!

VHF COMMUNICATIONS has placed a trial order of the PUFF software packages, prices yet to be announced. For further information on availability and prices please contact KM Publications direct at the address shown on the inside front cover of this magazine.