Technical Data: VBROP

MuEps SOFTWARE

Software & Training services for measurement, prediction, and design of electromagnetic materials.

Software for Optimization of Microwave Absorbing and Transmitting Stackups

VBROP, (Visual Basic Ram/Radome Optimization Program), is a very versatile WINDOWS based optimizer of multi-layered stacks for minimum reflection for absorbers or maximum transmission for radomes at specified frequencies, angle of incidence and polarization. The user may also select to maximize reflection or minimize transmission.

VBROP will optimize the stack by searching out optimum values of layer thicknesses and layer electrical properties. The user can also slave thicknesses and electrical properties of one layer to another through a linear relationship: slave=a*master where a and b are user specified constants.

Types of materials that VBROP handles are:

1. Materials with frequency independent properties.

2. Materials whose permeability and permittivity as a function of frequency is specified in a database or in a data file.

3. R-films specified by ohms/square and transmission phase at 2 and 18 GHZ. (Since transmission phase of R-films is usually quite linear, this is a convenient way to specify properties of the substrate. In R-films, phase is usually a minor player in RAM design and a reasonable estimate is normally adequate for design purposes.)

4. R-films specified by transmission dB loss and phase at 2 and 18 GHZ. (Since R-films normally have a nearly flat db response and linear phase response, this is a convenient way to characterize R-films which have been fabricated and measured in a microwave tunnel.)

5. Materials which exhibit constant conductivity over the frequency range of interest such as lossy honeycombs. These materials are specified by the imaginary part of permittivity at 10 GHZ and the real part of permittivity at 2 and 18 GHZ. It assumes linear variation of the real part of permittivity with frequency.

   This is a reasonable approximation for such items as a lossy honeycomb and it is useful for preliminary deign to determine what type of loading is needed. However for final design, measured permittivity should be used.

6. Electric permittivity described in terms of Debye oscillator. Useful for representing artificial dielectrics loaded with non-conductive or semi-conductive particles. Can also be used to represent most materials including frequency independent materials, R-films and lossy

honeycombs.

7. Electric permittivity described in terms of Lorentzian oscillator. Useful for representing artificial dielectrics loaded with metallic particles.

8. Fiber loaded matrix. Layer properties are specified by fiber volume fraction, fiber axial ratio, fiber conductivity and the dielectric constant of the matrix. Maxwell Garnett equations are used to compute permittivity.

9. Superset of the fiber loaded matrix described above. The additive particles are one or two species of coated and uncoated ellipsoids. Electrical properties of the coat and the core of the ellipsoidal particles may be specified by real and imaginary permittivity or real permittivity and resistivity in ohms*cm, or by Debye or Lorentzian parameters, or with material data base files.

10. A composite layer, (a graded layer or a stack of several layers) which is defined by its scatter parameters S11, S21 and S22 vs. frequency for a specified angle of incidence. (It is assumed S12 = S21).

    It is also useful for integrating circuit analog sheets into a multilayered design. Scatter parameters of the composite layer, which contains the CA sheets, are first computed with a periodic moment method program such as PMM developed by the Ohio State University. VBROP can read PMM output files directly, so it is easy to for the user to tweak the PMM input file manually, run PMM, and then run VBROP to optimize the stack with composite layers whose scatter properties have been defined by PMM. (Since CA properties are impacted by adjacent layers, it is necessary to include at least a part of adjacent layers into a composite layer whose properties are then computed by PMM.)

11. Layers whose electrical permittivity and magnetic permeability are defined by Debye or Lorentzian parameters. It is useful for theoretical explorations.

12. Layers whose magnetic permeability is defined by Debye or Lorentzian parameters and electric permittivity is assumed to be constant over the frequency range of interest. It is useful for some theoretical explorations and it is also a good approximation for many magram materials.

13. Impedance sheets specified by complex ohms/square at some frequency. The main purpose of this layer type is for

exploratory investigations of single frequency or narrow band designs since the reactance varies with frequency.

14. Artificial dielectrics consisting of one or two species of metallic or non-metallic ellipsoidal particles dispersed in a matrix. Nonmetallic particles may be coated or uncoated. Permittivity is computed with Maxwell Garnett equations.

For each frequency, the user defines design goals in terms of desired DB reflection or transmission and weight, (relative emphasis), at each frequency of interest. Frequencies at which optimization takes place need not be uniformly spaced.

Optimization is performed for a specified angle of incidence and the TE or TM or both. If both polarizations are specified, VBROP will try, at each frequency, to reduce reflection (or maximize transmission) of the TE or the TM mode, whichever is worse

Results of a single optimization run depend on initial values of layer parameters and do not guarantee that the resulting design is the best in the specified design space.

Monte Carlo capability allows the user to search for best designs in the design space by running a large number (up to 5000) of optimizations from randomly picked points in the design space. All computed designs are sorted according to their Figure of Merit and are saved and displayed for further consideration.

Gaussian analysis is used to simulate the impact of manufacturing tolerances on design performance. To simulate quality control inspection, random number generator produces truncated Gaussian distribution where a perturbation of any design variable which exceeds one standard variation is rejected.

With Gaussian analysis, the user can run a large number of cases, (up to 5000), and obtain a statistical summary and evaluation of design performance. (1000 cases takes typically less than 10 seconds on a Pentium 300 computer.) Up to 100 worst cases (those with the lowest Figure of Merit) are stored and may be interactively displayed, compared with the nominal design values, and examined to determine what combination of perturbed parameters contributed to the degraded performance. Similarly, perturbations which result in the lowest and the highest db reflection at each frequency are also stored for further examination by the user.

The user can display power dissipation in the stack for each layer at each frequency. This feature is useful in providing physical insight into design performance. It is essential in the design of high power absorbers or radomes, where thermal considerations must be taken into account to avoid damage to the absorber.

If the design is for non-normal angle of incidence, power dissipation by TE and TM modes are separately displayed.

VBROP features very extensive interactive capabilities. The user may change values of all material parameters, (fixed and variable), and immediately observe the effect of such change on the stack performance.

By clicking the mouse on a given variable the user can interactively increment or decrement that variable by a specified amount and observe the impact of these changes.

In addition to material variables, the user can also interactively adjust DB goals and weights and all material parameters which are held constant during the optimization process. For instance, in the case of frequency independent materials, the only variable is the layer thickness. However the user can interactively modify the layer's complex permeability or permittivity which are kept constant during optimization.

The user can sweep all material variables through five user designated increments and display a table of DB loss vs. frequency. Sweep is particularly useful in defining the design manufacturing tolerances.

Very extensive on-screen two and three-dimensional graphics greatly facilitate design analysis and evaluation. The user can interactively customize such items as fonts, grids, axis scales, and titles. All graphics can be bitmapped to the Windows Clipboard for further customization and inclusion into reports.

Graphics occupy the upper left corner of the screen and most graphics can also be displayed as full screen graphics with a header, footer and annotation on the current stack configuration. Full screen graphics are stamp dated and have provision for a user defined logo or project identification.

Extensive numerical tables are displayed in grids with scroll bars so that the amount of information in a table is not limited by the size of the grid or the screen. All important numerical data can be optionally written to ASCII tables for possible inclusion in reports or for data transfer to such programs as Microsoft EXCELL for the generation of customized data displays.

At any point during the design cycle the user can update the Input file to reflect the current stack configuration and design performance.

All ASCII files with numerical data generated by the program automatically include the updated Input File. This allows the ASCII file to be the Input File which uses the same stack configuration which was present when that data was generated.

A number of diagnostic features are included so that the user has significant capabilities to identify probable causes if the performance of the manufactured stack differs substantially from the design values. For instance, the user can request that VBROP reproduces the measured reflection and/or transmission db loss. By examining the resulting values of selected variables, the user is provided with valuable clues as to where the problem may be.

User's Manual is integrated into the program and may be interactively consulted by clicking the mouse. The Manual is displayed with Window's WordPad or Microsoft Word.

User's Manual figures may be interactively displayed with Microsoft PowerPoint.

Every attempt was made to make VBROP as intuitive and easy to learn and used as possible. It is assumed that the user has some basic knowledge of DOS and/or WINDOWS needed for handling files and directories.

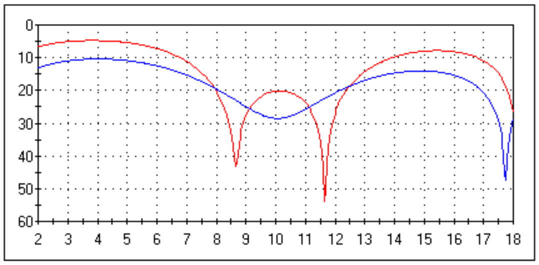
User interface is written in Microsoft Visual Basic Version 6. Virtually all mathematical computations are performed by FORTRAN subroutines embedded in DLL, the Dynamically Linked Library. Fortran compiler is the Microsoft Power Station 4. Graphics are Olectra Chart, Version 5.02 by KL Group in Toronto, Canada. Input file and all files generated by the program are ASCII files.

Below is the standard screen of VBROP. The results of a design optimized for a 40 degree angle of incidence at both polarizations.

VBROP VERSION 6.1 - STEVEN WEISBROD - SEPTEMBER 2004 - FILE C:\VBROP\RADOME.INP

Exit ROP | OpenInp | EditInp | UpdateInp | DBR | DBT | PHR | PHT | POL_AR | DbGoals ON | Large Plots

DBR VS FGHZ; AOI = 40.00 — TE — TM



Monte Carlo Search For Optimal Designs

Number Of Iterations = 50 | 2**N Scaling Factor = 32

Iteration Number = 00050; Last FOM = 95.938; Best FOM = 95.972

Run Monte Carlo | Stop Monte Carlo Run | Top Menu

☐ Save Results Of This Monte Carlo Search To An Ascii File.

To load a Monte Carlo run, click on the desired column in the bottom table. The selected run, shown in pink, is now the current run. To generate a repeating sequence of random numbers, enter number of iterations as a negative number.

CURRENT STACK CONFIGURATION. --- STACK IS TERMINATED BY AIR.

VAR #	LAYER #	TYPE	PAR	VALUE	LO-LIM	HI-LIM	STEP	% RANGE	T-IN	LBS/SQFT	STATUS
1	1	FIM	T-IN	0.0282	0.0010	0.2500	0.0050	10.9187	0.0282	0.0940	MASTER
2	2	FIM	T-IN	0.1524	0.0100	0.5000	0.0020	29.0584	0.1524	0.2540	MASTER
3	3	FIM	T-IN	0.2481	0.0010	0.2500	0.0050	99.2470	0.2481	0.8271	FREE
4	4	FIM	T-IN	0.1524	0.0100	0.5000	0.0000	29.0584	0.1524	0.2540	SL2M02
5	5	FIM	T-IN	0.0282	0.0010	0.2500	0.0000	10.9187	0.0282	0.0940	SL2M01

Total Thickness = 0.6093

Weight per sq.ft. = 1.5230

Note: Steps for OPSQ, FRES, and AXR are in % of VAR.

DBLOSS, DBGOALS AND WEIGHTS VS FGHZ; FOM = 95.972

FGHZ	2.000	3.000	4.000	5.000	6.000	7.000	8.000	9.000	10.000	11.000	12.000	13.000	14.000	15.000	16.000	17.000	18.000
DBGOAL	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WEIGHT	0.000	0.000	0.000	0.000	0.000	0.000	-1.000	-1.000	-1.000	-1.000	-1.000	0.000	0.000	0.000	0.000	0.000	0.000
DBR-TE	6.675	5.085	4.765	5.391	7.217	11.148	20.126	27.804	20.183	23.707	26.972	14.255	9.748	7.992	8.134	10.951	26.815
DBR-TM	13.093	10.979	10.376	10.888	12.481	15.298	19.539	24.949	28.508	25.767	20.763	16.924	14.682	14.030	15.335	20.702	28.707
DBT-TE	1.082	1.651	1.809	1.534	0.979	0.427	0.135	0.109	0.151	0.136	0.140	0.317	0.657	0.935	0.915	0.559	0.220
DBT-TM	0.242	0.395	0.461	0.423	0.317	0.206	0.135	0.112	0.114	0.131	0.168	0.234	0.307	0.342	0.306	0.224	0.208
POL-AR	1.132	1.163	1.168	1.151	1.114	1.066	1.019	1.015	1.034	1.050	1.079	1.117	1.145	1.151	1.133	1.114	1.165

AOI = 40.00

POL = EM

TOTAL T-IN & LBS.

	T-TIN	LBS
LO-LIM	0.000	0.000
HI-LIM	0.000	0.000
WEIGHT	0.00	0.00

50 HIGHEST FOMS FOUND BY THE MONTE CARLO SEARCH

#	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
FOM	95.972	95.972	95.970	95.953	95.953	95.949	95.948	95.945	95.944	95.943	95.943	95.943	95.942	95.942	95.942	95.942	95.942	95.941	95.941	95.941	95.941
TTIN	0.6093	0.6093	0.6097	0.6144	0.6143	0.6146	0.5774	0.5783	0.5783	0.5761	0.5762	0.5769	0.5765	0.5761	0.5767	0.5770	0.5771	0.5754	0.5771	0.5753	0.5771