

Technical Data:

VBMUE

Measurement Software for Calculation of Permittivity and Permeability

VBMUE is a Windows based an all inclusive program for the computation of complex permeability and permittivity from scatter parameters or SPARS.

The underlying assumption is that all four SPARS have been measured by a network analyzer such as Hewlett Packard HP-8510 and the I-Q, (In-phase and Quadrature phase), output has been saved as an ASCII file which can be read by a PC.

Since permeability and permittivity constitute two complex unknowns and SPARS provide three complex data points, (assuming that by the Reciprocity Theorem $S_{12}=S_{21}$), the measurement redundancy allows the computer to determine the phase reference from the measured data as long as the inputted phase reference is accurate within $1/8$ wavelength at the lowest frequency. The program will read the CITIFILE header format of the HP network analyzer and it can be customized to read any other header format which contains additional information such as the layer thickness. Such customization must be specified at the time of purchase.

VBMUE will compute complex permeability and permittivity for the following cases:

1. Single layer, normal incidence.

Such measurements are usually made in a coax fixture.

It is possible to make these measurements in a free space reflection/transmission facility, but in general scatter matrix measurements in free space are more complex.

One can always make S_{11} and S_{21} measurements and then define $S_{12}=S_{21}$ and $S_{22}=S_{11}$, but this necessitates accurate definition of phase reference which sometimes is difficult.

2. Single layer arbitrary angle of incidence TE and TM polarization modes.
3. Single layer in a rectangular waveguide operating in the dominant TE₁₀ mode.
4. All above with multiple layers, where the unknown layer is sandwiched between layers whose properties are known.

Chief application is the measurement of liquids which can be placed in a sample holder and materials such as paints which can be deposited on a substrate. The program assumes that the "known" layers are materials whose properties are frequency independent over the frequency range of interest. This is almost always the case with low loss materials which are commonly used for containers or substrates. A capability to read "known" material properties from the user specified material data base or files can be provided as an option.

Measured complex permeability and permittivity can be least square fitted (LSF'd) to a Debye and/or Lorentzian oscillator. This will allow the user to quantify the measured results in a concise way. The use of LSF Debye and/or Lorentzian oscillators are useful for a limited extrapolation of measured permeability and permittivity to frequencies outside the measured range.

Quite frequently segments of the measured data, particularly at the low and the high ends of the frequency band are clearly in error. With few clicks of the mouse, these questionable segments of measured data can be readily excluded from the Debye and Lorentzian analysis and make these representations more meaningful.

All inputted and computed parameters are automatically displayed by tables with vertical scroll bars and full screen graphics. To facilitate reading of graphics, pressing the left key of the mouse will display the x and y coordinates of the selected point. Graphics can be interactively customized by the user. The user can change scales, colors of the plots, fonts, labels, grid display and many other features.

With a click of the mouse all graphics can be printed or stored on the clipboard as bit maps which can then be scaled and pasted into slides and documents.

All computed information is automatically stored in ASCII files which can be easily ported to spread sheets, or incorporated into reports.

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 the Olectra Chart, Version 5.02 by KL Group. All files generated by the program are ASCII files. Below is an example of the main page of the VBMUE software after calculating the materials properties of a Teflon sample.

