

## AUTOMATED TUNER SYSTEM AIDS IMD TESTING

Based on electromechanical impedance tuners, this system automatically measures a wide range of output parameters.

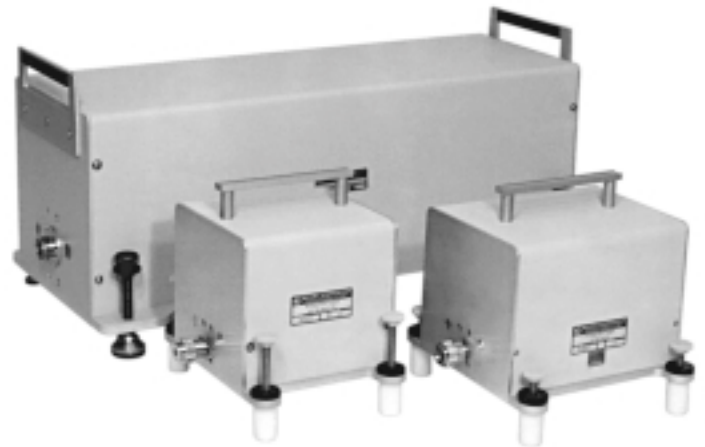
**Impedance tuners**, such as the MT980 series mechanical tuners from **Maury Microwave Corporation** (Ontario, California) can now be combined with power characterization software and test software for automated two-tone intermodulation distortion (IMD) testing. This program, which is Microsoft Window® compatible for use on personal computers, quickly delivers a variety of additional measured parameters, such as output power, available gain, and power-added efficiency. The automated system can also be used to measure device response to swept- and fixed-power inputs at user-selected source and load impedances.

Such electromechanical slide-screw tuners (**Figure 1**) have been used in the past for characterizing the noise and nonlinear parameters of active devices<sup>1,2</sup> but the units are just as suitable for IMD measurements. The tuners are based on a coaxial slide-screw design which utilizes a slab line as the primary transmission structure. The slab line is inherently broadband and the use of two permanently-mounted tuning probes provides for a typical matching capability often exceeding 20:1 (equivalent VSWR) over very broad frequency ranges of generally a decade or more.

Tuners are available from 0.25 to 110 GHz. The tuner is a non-contacting design; that is, even though it is capable of generating very high mismatches, the probe does not contact the center conductor or the side walls. This improves performance, extends operating life, and allows for high-speed tuning.

Load and source pull measurements require moving the appropriate tuner to a variety of positions to establish known terminating conditions. In IMD and power characterization, development of parameter contours requires that source and load tuner(s) be moved to many different, pre-characterized positions. Measured results, therefore, are highly dependent upon the repeatability of these tuners.

The repeatability of these tuners, such as the 0.4 to 4.0 GHz model MT981B unit, is specified at -50 dB,



**Figure 1:** Slide-screw electromechanical tuners in the MT980 series cover bands from 0.2 to 50 GHz. Other tuners in the MT979 series go as high as 110 GHz.

although the actual measured repeatability of the tuner is better than -60 dB. Repeatability is defined as the worst-case vector difference between the measured value at a given tuner position and a reference value stored in memory.

Two-tone IMD generally refers to the spurious mixing products generated by the nonlinearity of an active device when simultaneously stimulated by two signals. Intermodulation distortion (which results from mixing the fundamental frequency of one signal with the second harmonic of another signal) is particularly troublesome because the difference signal is often in close proximity to the frequency of the fundamental signal, which can cause adjacent-channel interference in a communication system.

The Automated Tuner System (**ATS**) and IMD software simplify the process of measuring IMD (**Figure 2**). Because the IMD software is appended to an existing power-characterization program, the IMD results are available along with any of the standard power parameters, including available input power, measured input current and voltage, delivered input power, carrier power, measured output current and voltage, delivered output power, intermodulation power, transducer gain, carrier-to-intermodulation ratio, and power gain. The system even includes the means by which the user can actually define an output function, such as power-added efficiency.



## System Calibration

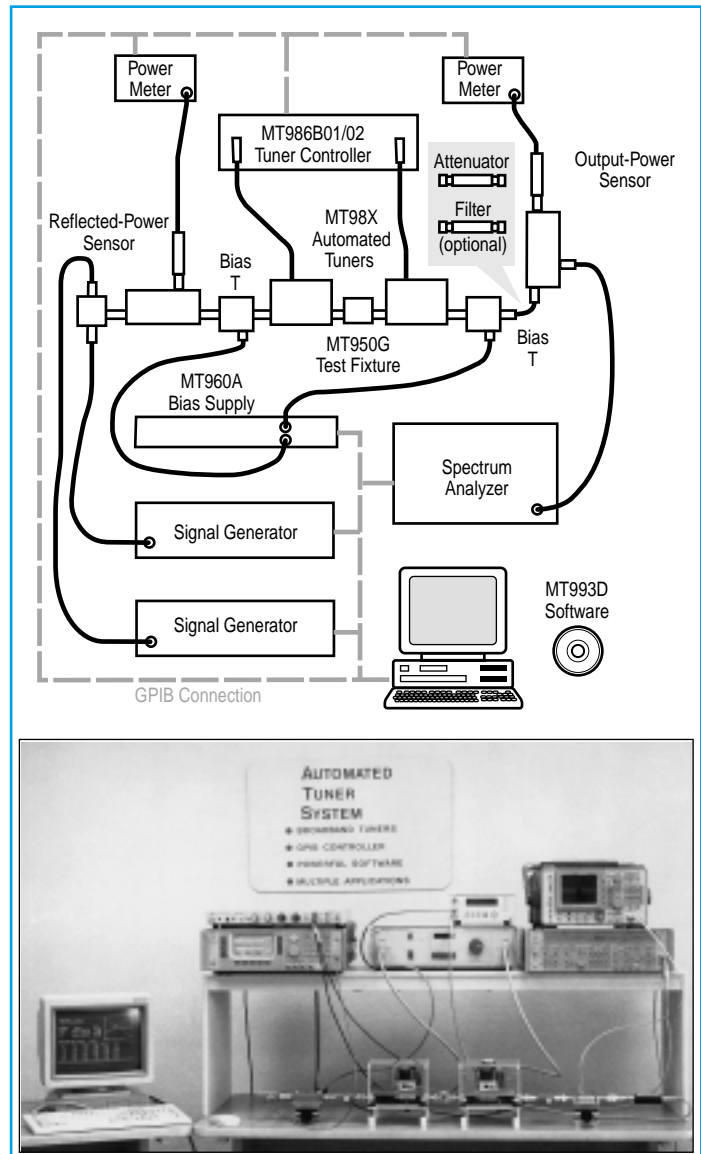
Prior to system calibration and measurement, the S-parameters of all elements are characterized over the measurement frequency range and stored. The software incorporates several vector network analyzer drivers, a general purpose S-parameter measurement program, and a module for both automatic and manual characterization of the tuners to facilitate generation of these files. If the measurement results are to be de-embedded (i.e., referenced to the Device Under Test (DUT) interfaces), the test fixture containing the DUT can be defined in the form of models of the input and output halves (such as with a model MT950 test fixture) or S-parameter files. This latter feature accommodates on-wafer measurements since the files can be made up of the S-parameters of the input and output probes.

Optional output filters and attenuators can be used to prevent harmonics from affecting the power-meter measurements and to avoid overdriving the output-power sensor. The transmission characteristics of these elements must be accounted for by inclusion in the tuner characterization or adjustment of the output-power sensor efficiency file.

The system is calibrated by inserting a pre-characterized in-circuit throughline in the fixture and measuring the output power over a range of input powers with the tuners in the matched position. This data is then used to calibrate the output coupler/spectrum analyzer and determine the available power. Moving the source tuner to a variety of positions then permits calibration of the input coupler. During measurements, this information is used to determine the reflected and, therefore, the delivered power. Once calibration is complete, the system may be used for load and source pull measurements or swept- and single-power measurements at user-selected source/load impedances.

At the completion of the calibration process, the user can select a measurement frequency and a specific DUT.

A PC computer display screen shows the types of measurements available and the measurement parameters, which can be selected by a mouse. The



**Figure 2:** The slide-screw tuners form the heart of an automated IMD test system.

distribution of available impedances is shown at both the source and load DUT interfaces. Cursors show the user-selectable, current-terminating impedances used for a swept or single-point measurement, as well as the DUT  $S_{11}$  and  $S_{22}$  conjugates, which are convenient when searching for impedances for a given optimum parameter value. If the stability factor ( $k$ ) of the DUT is less than unity, the regions of potential device instability are shown on both source- and load-impedance plots. When the mouse pointer is within the boundary of one



of the Smith charts, its position is continuously displayed directly below the chart.

The IMD-measurement software display permits a good deal of user interaction. In addition to setting up the conditions for a pull measurement, the operator can determine device performance at specific terminating conditions (e.g., determination of the compromise in device performance when the optimum terminating conditions for two parameters are not coincident and it is necessary to terminate the device at some intermediate position) and verify the results of a pull measurement.

A load or source pull measurement is made by varying the appropriate impedance (load or source) and measuring the effect on the desired parameter. Through the use of a random contouring algorithm, these data can be used to develop contours of constant carrier power, power-added efficiency, and intermodulation power.

The measurement frequency, available input power, and source termination are set by the user from the opening measurement display. The readouts on the left of the screen also show the parameter optimum, the reflection coefficient for the optimum, and the contour scaling. The number of contours and the step size are all controllable by the user. The program also permits adjustment of the contour resolution. Of course, finer resolution results in smoother contours, but takes longer to calculate than coarser resolution.

The software also has a swept power mode which provides for measurements over a range of input powers. The input and output terminating conditions can be set from the opening measurement display or simply left at the optimum positions established by the pull measurements.

The software instrument library contains a wide variety of all instruments required for power and IMD measurements; however, occasionally the user may wish to use an instrument (a special bias supply, signal source, spectrum analyzer, etc.) not represented in the supported list. All instrument control is by means of drivers incorporated in small, stand-alone modules. The Microsoft® Visual C++ source code for these modules is available and can

be edited by the user. Drivers for instruments not supported in the standard software can be easily developed by using an existing driver as a template. The new drivers can then be activated in the configuration file that establishes the measurement setup in the software.

The software also incorporates the means by which the user can write a function (using any of the measured or calculated values in the program) and define a scalar output. The user-defined function can be used to develop a specific output required for a unique application. A typical user-defined function would be simple efficiency which may be required for historical comparison purposes, but has been largely displaced by power-added efficiency.

**Maury Microwave Corporation, 2900 Inland Empire Blvd., Ontario, California 91764; TEL: (909) 987-4716, FAX: (909) 987-1112.**

## References

1. R. D. Pollard et al., "Programmable Tuner System Characterizes Gain and Noise," *Microwaves & RF*, Vol. 26, No. 5 May 1987.
2. W. E. Pastori and G. R. Simpson, "ATS for Power and Noise Characterization Using PC-AT Based Software," *Microwave Journal*, Vol. 36, No. 5, January 1993.
3. W. E. Pastori "Programmable Tuner Commands Impedance from 4 to 26.5 GHz," *Microwaves & RF*, Vol. 28, No. 6, June 1989.

Reprinted With Revisions From  
*Microwaves & RF*  
August 1994