Maury Microwave & Rohde & Schwarz

SOLUTION PARTNER BROCHURE / 5G-003

Maury Microwave

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"Alone we can do so little; together we can do so much." – Helen Keller

I started working with Maury Microwave in 2005 and one of the things that has always impressed me was Maury's presence in the microwave and RF community, as a pioneer and innovator since its inception in 1957.

Our history is full of firsts: the first commercial connector gage kit, the first 40 GHz mode-free coaxial connector, the first VNA calibration kit, the first manual slide-screw impedance tuner, the first commercial automated slide-screw impedance tuner, and the first non-50Ω device characterization software, just to name a few.

But as much as we accomplished ourselves, it has been through partnerships that we have been able to best support our customers with the largest offering of validated turnkey solutions. With our partners, we have launched the industry's first and widest assortment of commercial vector-receiver load pull systems, open-loop active and hybrid-active load pull systems, mixed-signal active load pull systems, compact model extraction and refinement systems, sub-THz active load pull systems, and the list goes on!

Partnerships are and remain a cornerstone of our strategy, and as Helen Keller said, "alone we can do so little; together we can do so much." With that, I would like to introduce you to a selection of our best-in-class solutions that have been made possible through intimate relationships with our partners.

Finally, I would like to extend an invitation to visit Maury Microwave and witness our best-in-class solutions in person. We hope to see you soon!

Michael Howo, CEO

VNA load pull

Load pull is the art of presenting a set of controlled load impedances to a device under test (DUT) while measuring a multitude of parameters at each impedance state. By systematically varying the impedance, it is possible to characterize the performance of a device and design the ideal matching network for optimum realistic large-signal operating conditions.

Vector-receiver load pull, or VNA-based load pull, is a modern and efficient methodology for load pull measurements. Low-loss couplers are placed between the tuners and device under test and are connected to the receivers of a VNA, such as a Rohde & Schwarz's ZNA. Doing so allows the a- and b-waves to be measured at the DUT reference plane in real-time, presenting vector information not normally made available through traditional power-meter load pull techniques. Vector-receiver load pull allows the direct measurement of actual impedances presented to the DUT without any assumptions of pre-characterized tuner positioning or losses. The delivered input power is derived from the a- and b-waves with incredible accuracy, which results in properly-defined power added efficiency. Output powers at each frequency, fundamental and multiple harmonics, are made available, as are multi-tone carrier and intermodulation powers.

Measurement parameters include Zin, Pin,available, Pin,delivered, Pout, Gp, Gt, PAE, Eff, AM/PM, IMD, Pout@nF.

Benefits of using Rohde & Schwarz's ZNA with vector receiver load pull include industry-leading dynamic range and sweep speeds, resulting in fast and accurate load pull measurements.

Applications

- Amplifier design
- Model validation and extraction
- Reliability test (VSWR test)

Key Attributes

- High measurement frequencies
- Fast measurement speeds
- High measurement accuracy

Active and Hybrid-Active Load Pull

The goal of load pull is to measure the response of a device as a function of load impedance. Considering our DUT as a two-port device, the impedance we present toa DUT, ΓL , is nothing more than a2/b2, or the ratio between the reflected- and forward-traveling waves.

Instead of reflecting the original signal using a passive mechanical tuner, active load pull uses signal sources to inject a signal into the output of the DUT, thereby creating a2. Because a2 is no longer limited to a fraction of the original reflected signal, as is the case with the traditional passive mechanical tuner, external amplifiers may be used to increase a2 nearly indefinitely so that ΓL can touch the outer edges of the Smith Chart. In addition to gamma, the advantages of active load pull include speed, the ability to add active tuning loops for harmonic load pull, and easy integration for on-wafer measurements.

Hybrid-active load pull refers to a combination of active and passive tuning in the same system. Traditional passive mechanical tuners can be used to reflect high power at the fundamental frequency allowing a much smaller active injection signal, using much smaller amplifiers, to overcome losses and achieve ΓL=1. Additionally, since the powers at harmonic frequencies are often well below the power of the fundamental signal, less-expensive wideband amplifiers may be used with active tuning to accomplish active harmonic load pull with ΓL,nf=1. In both cases, only a low power is required for active tuning.

The Rohde & Schwarz ZNA combined with external signal generators with magnitude and phase control, and IVCAD measurement and modeling device characterization software provide a turnkey solution active and hybrid-active load pull measurements.

Applications

- On-wafer characterization
- Amplifier design (high efficiency including harmonics)

Key Attributes

- High tuning range at DUT reference plane
- Easy addition of harmonic tuning

Nonlinear Large Signal Analysis (LSA) and Behavioral Model Extraction

Nonlinear large signal analysis, also referred to as time-domain analysis and waveform engineering, is the analysis of currents and voltages at the device input and output terminals of a device under test in order to identify the DUT's mode of operation. This tool is useful in the study and design of advanced amplifier classes of operation including E, F, J and K and their inverses, which can be visualized by the shapes of the voltages and currents over time. LSA measurements are achieved by recording the phase dependency of harmonic content and allows a- and b-waves, voltage and current waveforms, and load lines to be displayed for each measurement state (impedance/power/bias), and can be de-embedded to the device reference plane.

LSA measurements can be used to extract measurement-based behavioral models, such as the enhanced poly-harmonic distortion (EPHD) models. EPHD models are ideal for modeling the behavior of unmatched transistor in which extrapolation of loading conditions may be required beyond those used in the modeling extraction process. These behavioral models can then be used in the efficient design of complex or multi-stage power amplifier circuits such as Doherty amplifiers.

The Rohde & Schwarz ZNA combined with the passive or active harmonic load pull and IVCAD measurement and modeling device characterization software provide a turnkey solution to extract EPHD behavior models and empower first-pass amplifier design.

These behavioral models can be used in the efficient design of complex or multi-stage power amplifier circuits such as Doherty amplifiers, and are compatible with common circuit simulators such as ADS and MWO.

Applications

- Model validation
- Behavioral model extraction
- Amplifier design (higher-order classes of operation)
- System design

Key Attributes

- Fast model extraction speed
- High accuracy interpolation and extrapolation

MMW and Sub-THz 50Ω Gain Compression and Active Load Pull Measurements

Performing mmWave and sub-THz device characterization can be challenging for several reasons. First, commercially available waveguide extenders between 110 GHz and 1.1 THz tend to have a fixed output power or a limited range of powers, which are set manually through an integrated or external variable attenuator. Second, passive load-pull is not readily available above 110 GHz. Even though passive mechanical tuners can be built at these higher frequencies, the ability to present high reflections (i.e., gammas and mismatches) at the DUT reference plane is limited by waveguide and probe losses between the tuner and DUT.

These challenges are addressed with MMW-STUDIO, a software module that works with waveguide-banded mmWave VNAs, adding accurate, repeatable and high-resolution power control. The software enables the direct measurement of vector-corrected power at the DUT reference plane, as well as controlling the power delivered to the DUT. This provides the capability to perform gain compression power sweep measurements over the available power levels and perform S-parameter measurements at any arbitrary power level.

MMW-STUDIO can also control the magnitude and phase of the signals delivered to the input and output of the DUT when used with a vector modulation unit (VMU). By setting arbitrary impedances, the system can perform active load-pull measurements, and measure Pout, Pin, Pavs, Gt, Gp, Eff, PAE, Vin, Vout, Iin, Iout at any controlled load impedance.

The Rohde & Schwarz ZNA combined with waveguide frequency extenders, Vertigo Technologies VMU and MMW-STUDIO millimeter-wave and sub-THz characterization software provide a turnkey solution for 50Ω gain compression and active load pull measurements up to 1.1 THz.

Applications

- Transistor characterization
- Model extraction and validation
- Amplifier/circuit design
- Robustness/mismatch test of circuits and systems

Key Attributes

- Measure S-parameters at user-specified power levels
- High-resolution power control for accurate and repeatable vector-corrected gain compression power sweep measurements
- Arbitrary impedance control/active load pull

Mobile Phone Testing Under Real World Conditions

Mobile phones must guarantee proper functioning in non-ideal real-world environments, such as a lost or damaged antenna, usage in a tunnel or locker, being held close to the body or in a pocket surrounded by coins, etc. Each of these scenarios can be regarded as non-ideal from an RF standpoint, meaning non-50 ohm. We can use a single tuner to vary the VSWR magnitude and phase seen by the antenna port of the phone and test its performance in transmit and receive mode.

The goal of load pull in the phone's transmit mode is to measure the output power as a function of VSWR magnitude and phase.

The goal of load pull in RX mode is the sensitivity measurement of the phone; at what power level will a user-specified bit-error rate (BER) or frame-error rate (FER) be achieved, as a function of VSWR magnitude and phase.

The Rohde & Schwarz CMU and CMW-series wideband radio communication testers combined with Maury's automated impedance tuners and AMTS automated mobile phone test platform empower the efficient test of mobile phones under real world conditions.

Applications

- Real-world validation of antenna mismatch
- Antenna design for mobile phones

Key Attributes

- Supports modern communications signals

Synchronized Pulsed IV and Pulsed S-Parameter Measurements

Synchronized pulsed IV and pulsed S-parameter measurements are the backbone of extraction compact transistor models.

Linear compact models are extracted using S-parameters to determine the extrinsic parasitic elements, from which the resulting data is used to extract frequency-independent intrinsic parameters.

Nonlinear model extraction uses pulsed IV measurements to study the effects of temperature-dependent performance in safe operating regions and to study the breakdown area of a transistor. Pulse widths and duty cycles are chosen to maintain quasi-isothermal operating conditions. Pulsed IV measurements are used to extract the current diodes, and synchronized pulsed IV/S-parameters to extract the nonlinear capacitance model.

Electro-thermal circuits are used to model transistor performance as a function of device temperature and device self-heating. A transistor's thermal resistance is extracted using the differentiation between continuous and short-pulsed bias conditions.

The Rohde & Schwarz ZNA combined with the AM3200 pulsed IV system and IVCAD measurement and modeling device characterization software provide a turnkey solution to extract compact transistor models for III-V and MOS technologies.

Applications

- Parametric analysis
- Compact model extraction

Key Attributes

- Turnkey solution with integrated pulsed modulators and receivers
- High dynamic range
- Fast sweep time

Measuring S-Parameters with Uncertainty

As new technologies emerge and are introduced as standards, the specifications and requirements for products get tighter, and the competitive landscape even fiercer. This puts the responsibility on engineers and designers to squeeze out every tenth of a dB of performance, and to publish ambitious specifications. This introduces a potential problem; how can one balance the desire to list aggressive specifications yet still have confidence that their products will meet the promised performance? And not only performance as measured by the designer but also by the end-user, today and over time.

Scientists have been investigating the sources of uncertainty in microwave and RF measurements and have proposed models and techniques to quantify the individual contributions. These contributions can be systematically determined and added as part of an overall S-parameters measurement.

Maury Microwave's Insight VNA calibration and S-parameter measurement software can be used with almost any Rohde & Schwarz 2-port or 4-port VNA to calibrate, validate and measure S-parameters with uncertainty. Individual uncertainty contributors such as the VNA, calibration kit, cable assemblies, connectors, and operator are quantified and shown real-time with the S-parameter measurements. Rohde & Schwarz' VNAs offer some of the industry's best-in-class uncertainty and result in more accurate S-parameter measurements. This empowers a designer to report a product's performance with uncertainties, and give both designers and end-users the confidence needed to ensure product performance over time.

Thanks to their low noise floor and improved drift, users can take advantage of Rohde & Schwarz' VNAs to achieve more accurate S-parameter measurements with reduced measurement uncertainties.

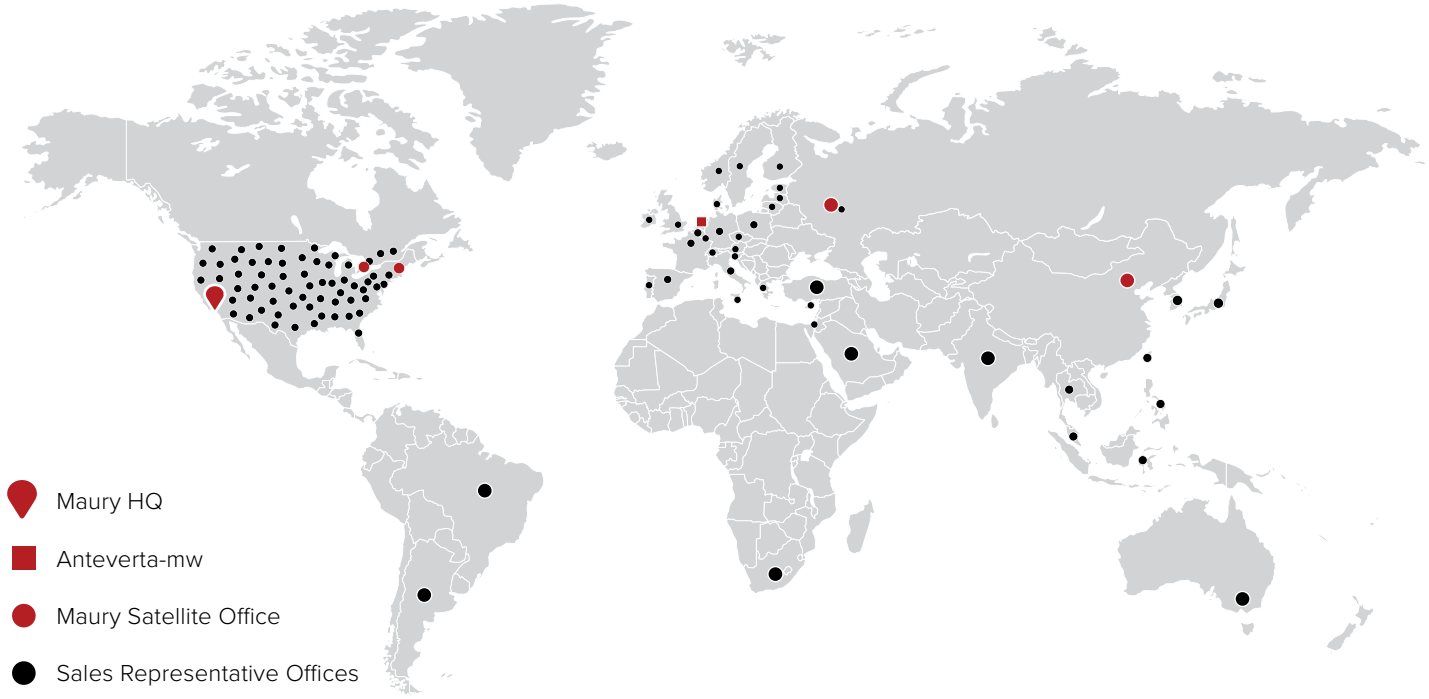
Applications

- Production test (pass/fail)
- Research and development

Key Attributes

- Support most R&S VNA models
- High measurement accuracy

Where You Can Find Us



Address

2900 Inland Empire Blvd

Ontario, CA 91764 USA

Social Media

Linkedin.com/company/maury-microwave

Twitter.com/MauryMicrowave

Youtube.com/MauryMicrowave

Contact Us

sales@maurymw.com

909 987 4715

www.maurymw.com

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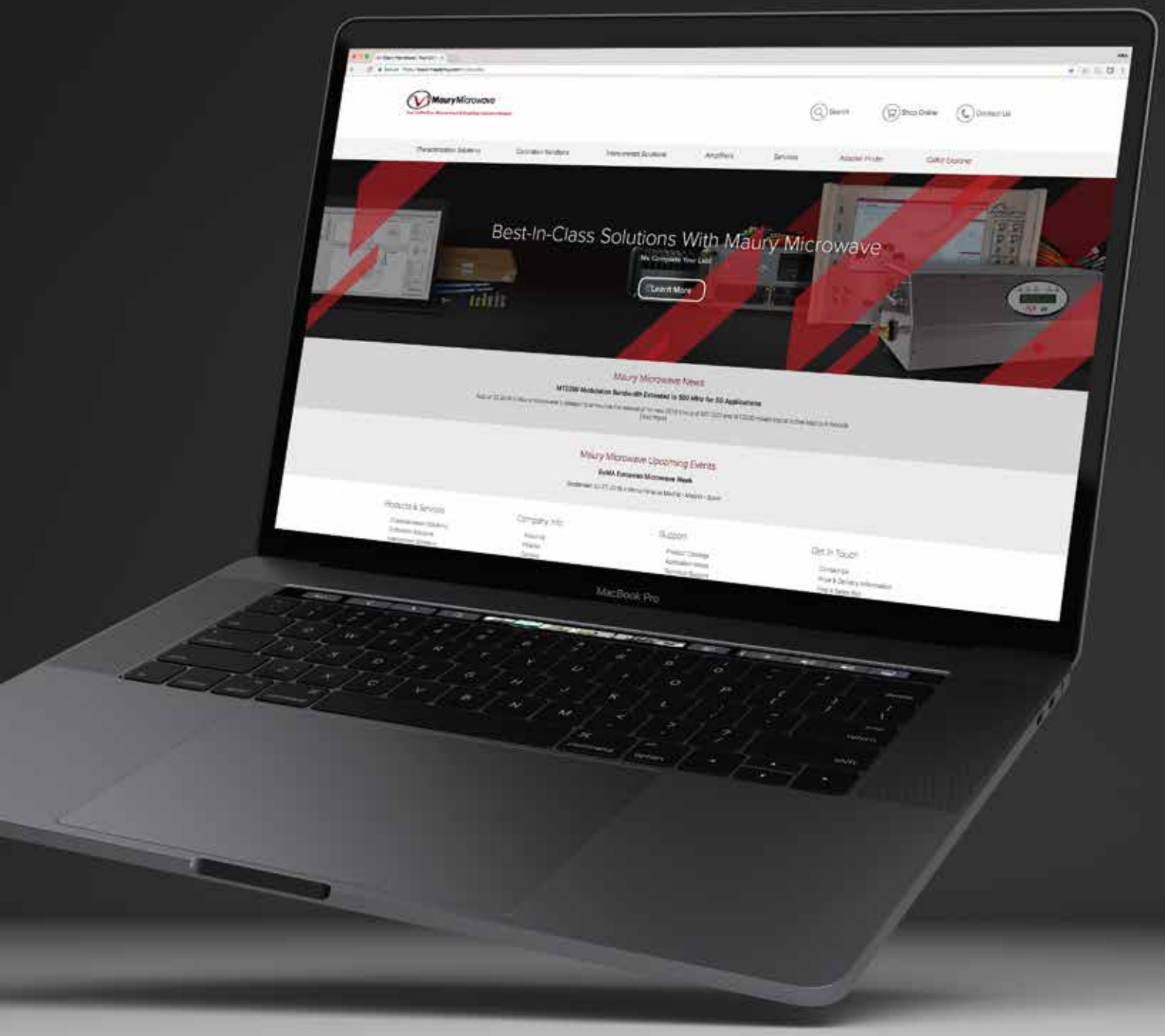

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CONTACT US:
W / maurymw.com
E / maury@maurymw.com
P / +1-909-987-4715
F / +1-909-987-1112
2900 Inland Empire Blvd
Ontario, CA 91764