

Microwave Journal interview with **Joseph Merenda**, Vice President of Engineering, Narda Microwave-East.



While miniaturization in general and MMICs in particular get center stage these days, microwave integrated circuit (MIC) technology continues to offer inherent benefits that are unachievable and/or unprofitable to pursue within the confines of a completely monolithic design. In this interview, Joe Merenda, Vice President of Engineering at Narda Microwave-East, points out that Narda (which delivered its first MIC over 25 years ago), is continually increasing MIC performance and functional integration while also reducing size, cost, and power consumption.

MWJ: Why do you think many people feel MIC technology hasn't advanced much over the years?

JM: One look at the catalogs of many microwave manufacturers tells the story. What you see are dozens or hundreds of product variations that began their lives as "specials" and remained in the catalog for years. However, the most exciting work is often performed for specific customers and doesn't wind up in a data sheet or catalog.

MWJ: This scenario doesn't seem to apply to Narda, which is actively promoting its advanced MIC technology.

JM: That's true. Our catalog certainly does contain hundreds of standard MIC products. But more importantly, we have recently launched a campaign to actively demonstrate the Narda engineering team's efforts to enhance our MIC technology. The results of this work include three families of advanced MIC product methodologies: Ultimate MICs, Multifunction MICs, and Surface Mount Technology. Our Ultimate MIC family combines multi-layer printed circuit fabrication with microwave hybrid manufacturing to yield very high levels of integration including digital signal processing, real time temperature compensation, and control functions. Our Multifunction MIC family uses new materials and attachment technologies to achieve superior electrical performance and compact size. Our Surface Mount Assemblies, targeted at operating frequencies up to 26 GHz, are well suited for high-volume low-cost applications. In every category, we are achieving higher levels of integration, performing more functions digitally, and reducing power consumption, size, weight, and manufacturing cost.

MWJ: What was the driving force behind all of this effort?

JM: Our customers have demonstrated that they want some or all of the improvements I just mentioned. Increasing complexity and performance requirements exceed the capability of traditional MIC techniques and are in conflict with constraints in size, weight, power consumption, and cost. At Narda, we recognize the incentive to rethink the way we

build MICs – material selection, electrical and mechanical design techniques, analog versus digital tradeoffs, and fabrication methods.

MWJ: Why did you focus on MIC rather than monolithic technology?

JM: For two reasons really. First, we have more than 25 years of experience in MIC development, so we knew – or thought we knew – what it could achieve. Second, at microwave and millimeter-wave frequencies, the MIC approach allows us to provide highly optimized solutions using a variety of commercially available RFICs and MMICs, as well as our own custom circuit designs. ASIC-type solutions are ill suited to our products because of high development costs and difficulty in modification or adaptation to new customer requirements. In contrast, our MIC technology offers adaptable, high performance solutions in a timely and cost effective manner.

MWJ: Give us an example of how your MICs are different?

JM: Generally speaking, a typical MIC is composed of thermally-matched carriers (CuMo, CuW, etc) that have a linear coefficient of expansion similar to that of GaAs along with high thermal conductivity. It's a proven approach that enables the interface between device and carrier to remain mechanically stable over the range of operating temperatures it will experience. However, the carriers, attached mechanically to the housing either with screws or silver epoxy, inevitably create interface discontinuities that dramatically reduce circuit performance if left uncorrected. Consequently, these discontinuities must be reduced in severity, or better yet, eliminated completely. This can be exceptionally difficult, particularly at millimeter-wave frequencies.

To address this issue, Narda adopted an approach that eliminates carriers in favor of alternative chip-to-housing attachment techniques. For instance, we utilize specialized housing materials that exhibit thermal conductivities similar to CuMo, weights similar to Al and expansion coefficients near that of GaAs. Among other advantages, our judicious choice of housing material achieves far more efficient space utilization, which in turn allows a greater number of functions to be incorporated into a given footprint. Moreover, the interface discontinuities that typically plague standard MIC fabrication techniques are reduced or eliminated. The benefits include easier product fabrication, simpler alignment procedures that eliminate the “tweaking” typically required for circuit optimization, and lighter weight.

MWJ: Is this the approach used in all of Narda's most advanced MIC designs?

JM: It's one of several approaches that are employed as dictated by the demands of the design. In products such as Narda's DCA Series 63-dB digitally-controlled attenuators, we achieve the same level of benefits as the method I just described by fundamentally changing the way assemblies of this type are constructed. The conventional approach to a MIC attenuator design employs channelized cavities that are machined into an aluminum housing. Substrates and components are then assembled into the RF cavities creating the

classic, high isolation MIC design. Typically, RF circuits are realized on one side of the assembly and the DC power, switching, and control circuits are on the other.

In our new approach, the RF cavities are machined all the way through the aluminum housing, eliminating the floor. The RF and DC circuitry is then fabricated as a separate, single, multi-layer printed circuit board with a metal core sandwiched between the RF and DC sections. When the circuit board is installed into the housing from the DC side into the channelized RF side, the metal core acts as the floor allowing us to maintain the same high level of isolation as the traditional method. DC and control connections between these two functional layers are made using isolated through-core vias. This eliminates the wires or feedthroughs that would otherwise be required, reduces the number of fabrication steps, and makes it possible to produce a highly compact and cost effective module.

MWJ: In what products is Narda using these techniques to fabricate extremely complex MIC subsystems?

JM: I think the best example is our Model 10512 linearized-VCO-based arbitrary FM waveform generator, because it's one of the most highly-integrated and challenging products we've produced, and is one of the flagships in our Ultimate MIC product line. The entire subsystem is enclosed in a 4 x 4 x 0.6 in. hermetically-sealed housing that weighs less than 14 oz. and requires less than 11 W of DC power. We designed it to satisfy the need for a flexible RF source that delivers performance and capabilities well beyond anything commercially available or achievable with analog techniques. Editor's note: A detailed description of the Model 10512 can be found on our website at <http://www.nardamicrowave.com/east/index.php?m=News>.

MWJ: What functions does the Model 10512 perform?

JM: It's a very versatile subsystem. The unit was originally designed to digitally generate uniformly-distributed, pseudo-random noise that can be applied to each of two independent carriers. The characteristics of the noise waveforms, including center frequency, video bandwidth, dispersion bandwidth (up to 400 MHz) and other parameters, are digitally controlled via the unit's parallel interface port. Each carrier's center frequency can be changed by up to 50 MHz in less than 100 ns. Two VCOs and a high-speed, PIN-diode-based SP2T switch allow us to toggle between the two carriers at the speed of the PIN switch, which is an order of magnitude faster than the frequency settling time of either VCO. Although the standard model is centered at 3 GHz, other frequencies are offered. The amplitude of each carrier is controlled using independent pHEMT-based, 63dB digitally controlled attenuators with 1dB step size. Settling time between any two attenuator states is less than 100 ns. Key advantages of our FPGA-based digital implementation include precise filtering and shaping of the modulation waveforms, enhanced VCO linearity, and temperature stability without the need for an oven. Since the unit incorporates non volatile memory and a programming port interface, it can also be re-customized to produce a broad array of user-defined waveforms without the need for disassembly or hardware rework.

MWJ: Please describe the way the Model 10512 is fabricated?

JM: The unit is partitioned into digital and analog sections. The digital section contains the FPGA, logic, and external interface circuitry, while the analog section contains the VCOs, digitally-controlled attenuators, gain stages, high-speed switch, and the output level control attenuator. A 0.04-in. housing septum separates and provides RF isolation between the analog and digital sections. Interconnection between the digital and RF circuits is accomplished using multi-pin PCB headers. The RF multilayer printed circuit board incorporates several unique features that minimize electrical discontinuities. We create the equivalent of single layer microstrip by removing portions of the dielectric material between the RF conductor and RF ground layers, forming pockets in the dielectric where microwave devices are placed. By choosing the thickness of the dielectric material to closely match the height of the microwave devices and by employing special processing steps to ensure that the pocket walls are free of plating, virtually discontinuity-free RF transitions are realized.

MWJ: Is Narda using other techniques beyond those you've just described?

JM: Yes. We focus strongly on improving our processes to ensure our continued ability to deliver products that meet or exceed our customer's demands at a competitive cost. The techniques we have developed are key enablers for a wide variety of products. For instance, we take advantage of these design methodologies in our Ka-band, 10-W solid state power amplifier, Ku-band and Ka-Band block up and down converters, and our series of variable phase and variable output power amplifiers in the 2.7 GHz to 43 GHz frequency range.

In the satellite communications ground terminal area, we have developed a line of frequency generators that are used as local oscillators in our microwave frequency converters and transceivers. Our quad-band downconverter, for example, uses a Narda-developed frequency generator that produces outputs at 6.3, 8.75, 9.6, 10.0, 10.5, 10.75, and 11.25 GHz from RF inputs of 5.0 and 6.3 GHz.

Other satellite communication products include the Model 15172 L-band transceiver that adapts military 70 MHz satellite communication modems to single-band, tri-band, or quad-band block converters that require L-band IF inputs and outputs. The L-band transceiver converts signals from the 70 MHz IF frequency to any L-band frequency from 950 MHz to 2 GHz with a 1 MHz step size. A 20-kHz step size option is also available. The Model 10516 Ka band/L band transceiver produces RF output power of +24 dBm from 27.99 to 28.35 GHz and has 37 dB of conversion gain. The receiver section has a noise figure of 6 dB and an adjustable gain range of 5 dB to 50 dB in 1 dB increments.

Our surface-mount technology exemplifies yet another technique that we make constant use of in our products. These techniques are particularly beneficial for applications that require high-volume, cost-effective solutions.

MWJ: Can you give us some examples of your SMT products?

JM: We exploit surface-mount technology in a variety of ways. We make use of custom-designed DC-to-40 GHz surface-mount packages within our connectorized MIC assemblies. Bare die is assembled into our surface-mount packages prior to module level integration. The packaged die are then assembled into our modules using standard low-cost, surface-mount manufacturing techniques. Our X-band, 50K noise temperature LNA and our oscillators for 10-Gb/s and 40-Gb/s fiber optic applications are examples of MIC modules that make use of this design technique. One such oscillator is a 39- to 44-GHz voltage-tunable dielectric resonator based design that is well suited for use as a clock source for OC-768 40-Gb/s fiber optic communication systems. This oscillator provides 51 MHz of linear electronic tuning range, exhibits very low jitter, and has phase noise at 44 GHz of -90 dBc/Hz at a 10 kHz offset.

The surface-mount manufacturing and design experience gained in our connectorized module designs has enabled the introduction of MIC modules in a surface-mount form factor. This is illustrated in our modulator driver amplifier products for both 100-Gb/s and 40-Gb/s fiber optic systems. At 10 Gb/s we offer 8-Vpp, duo-binary, and non-return to zero (NRZ) modulator driver amplifiers. At 40-Gb/s we offer 7-Vpp differential phase shift keying (DPSK) and 3-Vpp NRZ modulator driver amplifiers as a surface-mount module.

MWJ: Are there still advances in performance and functional integration that remain to be achieved with MIC technology?

JM: Absolutely. Our development work continues to show that the MIC has a long way to go before its full potential is realized. We will continue to advance our MIC technology at every level. This includes material selection, choice of components, exploitation of advances in computer-based modeling and analysis tools, and continued innovations in our fabrication process. The results of our efforts in this area will be reflected in the performance and reliability of Narda's next generation millimeter-wave products and systems.