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# A Summary of HF/VHF/UHF Technology Sessions at IMS2010

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The "below microwave" technologies in the HF, VHF and UHF bands remain very important for communications, broadcast, medicine, and industrial applications.

The IEEE Microwave Theory and Techniques Society's (MTT-S) International Microwave Symposium (IMS) was held in May at the Anaheim, CA Convention Center, and offered a full week of presentations from high level research to tutorial, as well as one of the largest commercial expositions of microwave and RF companies in the world.

Even though the symposium has the word *microwaves* in the title, there was plenty of material presented that was of interest to the sub-1000 MHz community (i.e., many readers of *High Frequency Electronics*), which is represented by one of the symposium's technical sub-committees, SC-18 HF-VHF-UHF Technology. If you find the electronics work that you are doing falls in this frequency range, don't toil in obscurity; consider submitting a paper for the IMS2011 to be held at the Baltimore, MD Convention Center, near the inner harbor. Details on the paper submission process can be found at the IMS2011 website

http://www.ims2011.org/

When submitting your paper, make sure you select the SC-18 subcommittee as your primary area of interest. Presentation formats are both formal PowerPoint-style presentations as well as poster format sessions (called the Interactive Forum at IMS).

Here is a wrap-up of the session on "Power Amplifier and Combiner Techniques for HF, VHF, and UHF."

The HF/VHF/UHF session at IMS 2010 was held on Wednesday afternoon and the associated interactive-forum session was held on Tuesday afternoon. Many unique and interesting systems operate in this frequency range, and many new circuit techniques first emerge at these frequencies before migrating to the microwave region.

**Robert Caverly of Villanova University opens the session on "Power Amplifier and Combiner Techniques for HF, VHF, and UHF" at IMS2010.**

The first paper was "Class-D Power Amplifier with RF Pulse-Width Modulation" by Fritz Raab from Green Mountain Radio Research Company. This paper presented a technique for directly modulating the duty ratio of a class-D RF-power amplifier (PA) in order to generate an amplitude-modulated signal. The end result is both good linearity and high efficiency. In contrast to delta-sigma modulation, the RF PWM technique produces a very clean spectrum. The prototype 200-W, 500-kHz amplifier maintains an average efficiency of 80 to 85% for a variety of signals

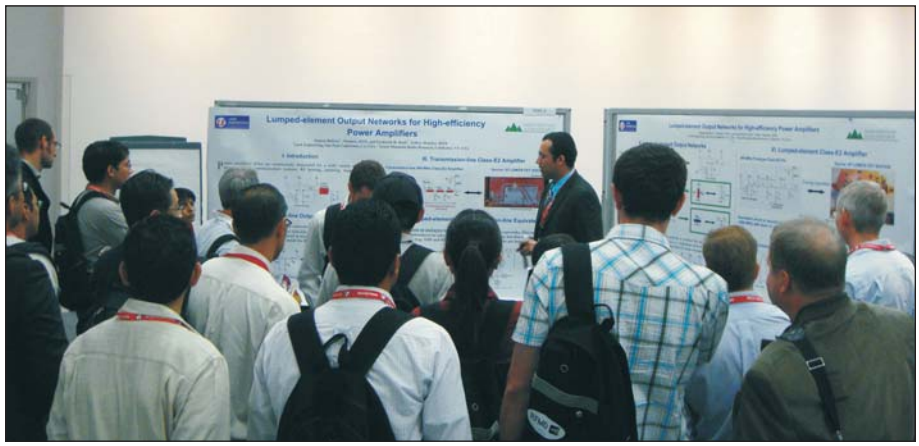
from CW to a ten-tone signal with a 10-dB peak-to-average ratio.

Marc Franco from RFMD presented the second paper, "An Efficient, 35 dBm, Inverse Class-F, UHF RF Power Amplifier." Marc described the the design, simulation and experimental verification of a 59% efficient, 35 dBm, inverse class-F power amplifier module. The module is based upon a GaAs HBT and includes all of the power supply decoupling and matching components, but occupies an area of only 10 $mm^2$. It operates achieves high linearity and good efficiency from 824 to 915 MHz. The simulation process produced a first-pass design success that required no further tuning or adjustment.

The third paper, "Switch-Controlled Multi-Octave Bandwidth Radial Power Divider/Combiner" was written by Young-Pyo Hong and several coauthors at the University of California San Diego. It describes a radial cavity power combiner whose operating band is shifted by the movement of cylindrical conductors and dielectric spacers. The combiner has two tuning positions, allowing it to operate from 400 to 2000 MHz with no more than 1 dB of loss.

Shigeru Hiura and several other engineers from the Toshiba Corporation gave the fourth paper, "High-Efficiency 400 W Power Amplifier with Dynamic Drain Voltage Control for 6 MHz OFDM Signal." The power amplifier uses an LDMOS FET operated as a linear amplifier. To improve efficiency, the drain supply voltage is toggled between 20 V and 40 V as required by the signal envelope. Tests with an OFDM signal with a 10-dB peak-to-average ratio produce an average efficiency of 34%, which is 15% higher than when the amplifier is operated from a fixed voltage.

The final paper, "100 W GaN HEMT Power Amplifier Module with >60% Efficiency over 100-1000 MHz Bandwidth" was presented by K. Krishnamurthy from RFMD in Charlotte, NC. This 2 × 2 inch power module incorporates four 30-W GaN HEMTs based upon GaN-on-Si technology. The four individual GaN-HEMT PAs are combined through a lossy broadband matching circuit to achieve operation from 100 to 1000 MHz. The module delivers a remarkable 104 to 121 W CW output power with 61.4 to 76.6% drain efficiency and 15.5 to 18.6 dB gain.




**Ramon Beltran presents his work on high efficiency amplifiers with lumped element matching networks at the IMS2010 Interactive Forum.**

One interactive-forum paper was "Second harmonic reduction in broadband VHF class E RF power amplifiers" by Kumar Narendra, Arturo Mediano, and other authors from Motorola Technology, Penang, Malaysia, University of Zaragoza, Spain, and University Science Malaysia. The class-E power amplifier they described offers efficiencies approaching 100%, but generates a strong second harmonic. This paper presented a broadband output circuit that provides 40-dB suppression of the second harmonic. The resultant PA produces 5.5 W from 134 to 174 MHz with an efficiency of 60% or better.

The second interactive-forum paper, presented by Ramon Beltran, was "Lumped-element Output Networks for High-efficiency Power Amplifiers." Transmission-line output networks are generally used to implement class-F and class-E power amplifiers at UHF and higher frequencies. However, the line spacing and quarter-wavelength stubs are often impractically large, especially at lower frequencies. This paper derives analogous lumped-element networks based upon Ts and series-tuned circuits. A prototype LDMOS class-E PA based upon this technique produces 10 W at 900 MHz with a drain efficiency of 73%.

Again, if your electronics work falls in this frequency range, consider publishing it at IMS2011! If your work is at HF, VHF, or UHF, we are looking forward to seeing your paper in December.

*To avoid confusion, remember that HF/VHF/UHF Technology subcommittee SC-18 is only for the International Microwave Symposium. This area of interest is also the realm of regular MTT committee MTT-17.*

## Author Information

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