An Update on New Tunable Technologies

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Electronically tunable circuits have been around for a long time, including those tuned with varactor diodes, or stepped to various values using, PIN diodes, PN junction diodes or FET switches. Variable inductances using variable-permeability magnetic cores are also in use. And of course, tunable filters and oscillators using YIG technology are commonplace.

Also, electro-mechanically tuned circuits using motorized control of adjustable components, or relay-switched stepped values have been used for certain high power and exceptionally low loss applications. Each of the above methods has its strengths and weaknesses in performance, size, cost and reliability.

New tunable technologies are being developed that can achieve the required performance with smaller size and lower power consumption, and in most case, fabrication that is compatible with high levels of integration. These include thin film ferroelectric-dielectric composite devices using barium strontium titanate (BST), various MEMS chip-scale technologies, and improvements in semiconductor-switched technologies. There is also work on gallium nitride (GaN) varactors, which have much higher breakdown voltages that silicon devices.

At this time, all methods being readied for production involve tunable capacitance, although research is underway into inductors that use ferroelectric materials.

Demand for New Tunable Solutions

Although tunable functions are available with established technologies, there are two primary application areas that are driving development of new products: higher performance in consumer wireless devices, and wide-range tunability in frequency-agile, adaptive-bandwidth military systems.

In wireless communications, greatly increased capacity is required to meet demand for broadband services with high download speed. Tunable devices can save power and space by eliminating individual switched filters for the various wireless bands and auxiliary services such as TV, GPS, WiFi and Bluetooth. In base stations, high power tunable technology can maintain efficiency in frequency-agile transmitters, and improve interference rejection—and thus, sensitivity—in receivers. In addition, phase shifters will be needed for the control of smart antenna systems.

Military needs for tunable technologies are extensive. Communications is evolving toward adaptive, reconfigurable systems that can operate at various frequencies, bandwidth and modulation formats as required by the particular data being transmitted. Fuzing and countermeasures systems require security, frequency agility, and resistance to jamming and interference. These functions are greatly enhanced by fast tunable circuits in both the radio circuitry and antennas.

Wireless base station and most military RF and microwave systems require tunable circuits to handle significant power levels, which has been the greatest challenge when the design objective is for small size, light weight and lower design complexity. Much of the research currently being funded through wireless industry and military sources addresses high power technology. As one example, a recent technical paper described thermal evaluation of a BST tunable capacitor at a power level of 50 watts in the 1-3 GHz frequency range.

The following news items describe some of the work currently in progress.

Business and Research News

WiSpry and IBM Collaborate to Develop MEMS Tunable Mobile Front-End Technology

WiSpry, Inc. (www.wispry.com), has announced that it is working with **IBM** (www.ibm.com) to develop MEMS process technology and manufacture its tunable RF product roadmap. This development includes WiSpry's current generation of tunable impedance matching products, slated for production with a major tier-one OEM this fall, as well as future generations of highly integrated products for the entire mobile terminal front-end.

Enabled by proprietary micro-electromechanical machine systems (MEMS), WiSpry's tunable RF devices deliver new levels of performance, providing over 3 dB of link resilience as well as increased talk or web access time on a mobile device. IBM's standard 0.18 micron process allows WiSpry to integrate new functions, providing a smaller footprint and lowering BOM costs. WiSpry's monolithic integration is targeted towards high-growth applications such as 3G multi-mode, multi-band mobile wireless devices; broadband communications, and 4G LTE terminals and infrastructure equipment.

nGimat Awarded an Air Force Contract for Multilayered Tunable Dielectrics at High Power

nGimat (www.ngimat.com) has been awarded a Small Business Innovation Research (SBIR) Phase II from the **U.S. Air Force** (www.af.mil) to continue the development of nanostructured multilayered tunable dielectric materials for high frequency high power microwave applications. These materials have high dielectric permittivity, low dielectric loss, high dielectric strength, and large nonlinear response to electric field

The development of electronic devices that are robust, highly efficient, compact, and powerful with wide operational frequency range is critical for enabling precision effects and full battle-space awareness for the U.S. military. High performance tunable dielectric materials are needed with high dielectric permittivity, low dielectric loss, high dielectric strength, and large nonlinear response to electric field. However, existing dielectric materials cannot meet these requirements completely.

In this Phase II effort, nGimat will further optimize the novel nanostructured multilayered dielectric materials and related process technique, design non-linear transmission line structures, and scale up to large wafer size. nGimats proprietary Combustion Chemical Vapor Deposition (CCVD) technique will be utilized to produce the proposed dielectric materials with controlled layer thickness and stacking periods and with improved electrical properties over existing dielectric materials.

MEMtronics in Second Year of DARPA Contract

In June 2009, MEMtronics Corporation received a development contract from the Defense Advance Research Projects Agency (DARPA) entitled “Reliable MEMS Ka-band Tunable Filters.” The company is now in the second year of this 24-month contract. The project’s focus is development and demonstration of high-performance tunable filters for military radar and communications systems.

“These circuits take advantage of MEMtronics’ developments in radio frequency microelectromechanical systems (RF MEMS) technology, which have been demonstrated to operate with lower loss, less power consumption, and improved linearity compared to conventional electronics technology,” said Dr. Chuck Goldsmith, MEMtronics president.

This contract is an extension of a previous SBIR award by DARPA that MEMtronics successfully completed last year. This phase of the program will build upon last year’s development to produce working prototypes with the necessary form, fit, and function for integration into radar systems.

GaN Varactor Development

The Center for Wireless Communications (CWC) at the **University of California, San Diego** (www-cwc.ucsd.edu/) is developing high power varactors for adaptive base stations. The objective of this research project is to develop microwave circuits for use in base station RF front-ends, with the use of novel varactor diodes which provide high Q (>100) in high power, high voltage (>100V) operation. The circuits will include adaptive filters and adaptive load modulation circuits for use with transmitters, as well as band-select filters that can be connected to the antenna. The varactors are being fabricated with GaN, which exhibits a figure of merit for varactors 40× better than that of silicon, as a result of the high breakdown electric field of the material. The work is funded in part by a 2009 UC Discovery grant.