Evaluation of the Reflection Coefficient of Microstrip Elements for Reflectarray Antennas

NASA's Jet Propulsion Laboratory, Pasadena, California

Basis functions were studied and identified that provide efficient and accurate solutions for the induced patch currents and the reflection phase in microstrip reflectarrays. The integral equation of an infinite array of microstrip elements in the form of patches or crossed dipoles excited by a uniform plane wave is solved by the method-of-moments. Efficient choices of entire domain basis functions that yield accurate results have been described.

The results showed that an optimum choice would be a sinusoidal basis function with a built-in edge condition along the current flow direction, and uniform current across the current flow direction for a rectangular or square patch. For a dipole, the optimum choice is a sinusoidal basis function without the edge condition along the dipole, and uniform with the edge condition across. The code employing these basis functions was substantially faster than the commercial code HFSS, and it was significantly more accurate than previously developed method-of-moments code.

It was determined that the optimum choice is one basis function for each of the two induced currents in a square or rectangular patch, and one basis function for each dipole. For very thin substrates, there was a need to have 32 basis functions to produce accurate solutions.

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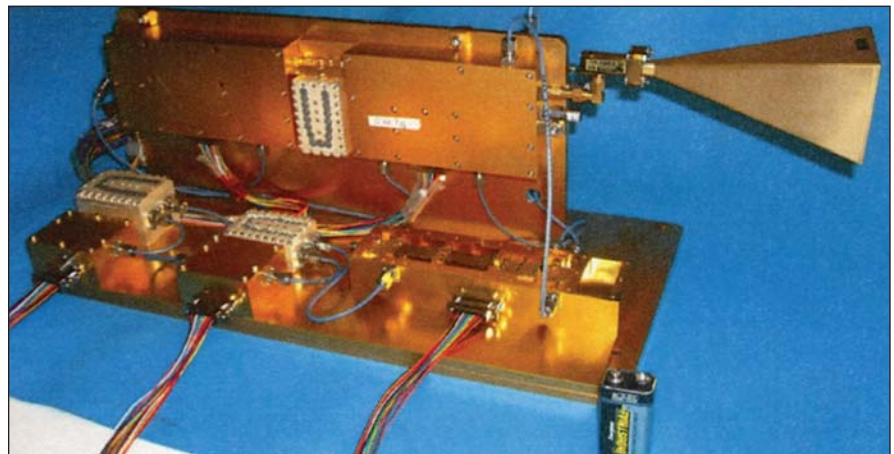
Miniaturized Ka-Band Dual-Channel Radar

This smaller, higher-bandwidth system can be used for interferometry, ocean surface height monitoring, and various military applications.

NASA's Jet Propulsion Laboratory, Pasadena, California

Smaller (volume, mass, power) electronics for a Ka-band (36 GHz) radar interferometer were required. To reduce size and achieve better control over RF-phase versus temperature, fully hybrid electronics were developed for the RF portion of the radar's two-channel receiver and single-channel transmitter. In this context, fully hybrid means that every active RF device was an open die, and all passives were directly attached to the subcarrier. Attachments were made using wire and ribbon bonding. In this way, every component, even small passives, was selected for the fabrication of the two radar receivers, and the devices were mounted relative to each other in order to make complementary components isothermal and to isolate other components from potential temperature gradients. This is critical for developing receivers that can track each other's phase over temperature, which is a key mission driver for obtaining ocean surface height.

Fully hybrid, Ka-band (36 GHz) radar transmitter and dual-channel receiver were developed for spaceborne radar interferometry. The fully hybrid fabrication enables control over every aspect

The fully integrated **Ka-Band Dual-Channel Radar** with horn antenna. The transmitter electronics are shown along the baseplate, while the dual receivers are mounted on the vertical plate. The last stage of the transmitter is left open to show the subcarriers.

of the component selection, placement, and connection. Since the two receiver channels must track each other to better than 100 millidegrees of RF phase over several minutes, the hardware in the two receivers must be "identical," routed the same (same line lengths), and as isothermal as possible. This level of design freedom is not possible with packaged components, which include many internal passive, unknown internal connection lengths/types, and often a single orientation of inputs and outputs.

The last item is key to fabricating a dual-channel receiver, where one wants components from the two channels to be isothermal, and therefore mounted back-to-back, while also having the routing as similar as possible. This

drives the design to be mirrored, where the two channels are fabricated back-to-back, achieving direct mechanical interface to improve the isothermal performance, which drives RF phase balance. This back-to-back design forces components to have a "left" and "right" handed version, which is not typically possible for packaged components, but with full design control of hybrid design, this is achievable. The radar was designed to have a series of separate subcarriers, which could be hermetically sealed individually, which is much easier than sealing the entire unit. Also, in the event of late component failure, rather than losing or reworking the entire unit, the subcarrier can easily be replaced by another qualified subcarrier.

This new instrument is a smaller, higher-bandwidth dual-channel interferometer with 500-MHz bandwidth at Ka-band (35.5 to 36 GHz), as compared to the prior instrument WSOA (Wide Swath Ocean Altimeter), which was Ku-band (13.275 GHz) with 80-MHz bandwidth. The new instrument has six-fold improvement in resolution capability, and better control of factors that contribute to RF phase stability.

Continuous-Integration Laser Energy Lidar Monitor

The integrator can be used in developing pulsed lasers for space-based lidar and ground-based laser applications.

Goddard Space Flight Center, Greenbelt, Maryland

This circuit design implements an integrator intended to allow digitization of the energy output of a pulsed laser, or the energy of a received pulse of laser light. It integrates the output of a detector upon which the laser light is incident. The integration is performed constantly, either by means of an active integrator, or by passive components. If an active integrator is used, closed-loop dc biasing is added with a time constant much longer than the laser pulse width. The output of the integrator goes to a track-and-hold amplifier (THA), using a zero-potential switch topology. The track/hold control is derived from timing information obtained either by a threshold comparator on the detector, or a peak detector. Laser pulses of varying widths can be accommodated by adjusting the characteristics of the timing control circuitry. The output of the THA is available for digitization at a later time. Bandwidth limiting can be used in the signal path as necessary, depending on the noise characteristics of the signal.

Prior integration techniques utilize threshold comparators to "start" and "stop" the integration. Some implementations require reset circuitry, which can create offset at the output. Starting and stopping the integration usually involves clipping off the beginning and/or end of the signal; this introduces greater errors as the signal amplitude decreases. Also, as the signal speed increases, the comparator speed must increase, and thus its power consumption rises. As the signal (pulse) gets narrower, the comparator delay time may cut off significant portions of the signal unless electronic delay is introduced. This adds complexity, mass, and timing uncertainty.

The advantage of this integration technique is that it does not depend on exact threshold adjustment to start or stop the integrator, nor does it require the use of switches to discharge the integration capacitor. Further, there is no pedestal introduced in the integrator.

This circuit is intended to implement an integrator that does not require time gating, delay, or reset circuitry, in order to avoid the limitations that these elements impose. The integrator is part of a pulsed laser energy monitor. This implementation of a continuous integrator is designed to be used in a laser transmit energy monitor.

The final design had the ability to integrate pulses down to 50 mV at 4.5 ns, and 250 mV at 3 ns, with 0.8-percent electrical accuracy.

Miniaturized Airborne Imaging Central Server System

This imaging server can be used for natural disaster response and for locating new sources of spring water.

Goddard Space Flight Center, Greenbelt, Maryland

In recent years, some remote-sensing applications require advanced airborne multi-sensor systems to provide high performance reflective and emissive spectral imaging measurement rapidly over large areas. The key or unique problem of characteristics is associated with a black box back-end system that operates a suite of cutting-edge imaging sensors to collect simultaneously the high throughput reflective and emissive spectral imaging data with precision georeference. This back-end system needs to be portable, easy-to-use, and reliable with advanced onboard processing.

The innovation of the black box back-end is a miniaturized airborne imaging central server system (MAICSS). MAICSS integrates a complex embedded system of systems with dedicated power and signal electronic circuits inside to serve a suite of configurable cutting-edge electro-optical (EO), long-wave infrared (LWIR), and medium-wave infrared (MWIR) cameras, a hyperspectral imaging scanner, and a GPS and inertial measurement unit (IMU) for atmospheric and surface remote sensing. Its compatible sensor packages include NASA's 1,024×1,024 pixel LWIR quantum well in-