Electronics/Computers

Micro Sun Sensor for Spacecraft

NASA's Jet Propulsion Laboratory, Pasadena, California

A report describes the development of a compact micro Sun sensor for use as a part of the attitude determination subsystem aboard future miniature spacecraft and planetary robotic vehicles. The prototype unit has a mass of only 9 g, a volume of only 4.2 cm^3, a power consumption of only 30 mW, and a 120° field of view. The unit has demonstrated an accuracy of 1 arcminute. The unit consists of a multiple-pinhole camera: A micromachined mask containing a rectangular array of microscopic pinholes, machined utilizing the microectromechanical systems (MEMS), is mounted in front of an active-pixel sensor (APS) image detector. The APS consists of a 512×512-pixel array, on-chip 10-bit analog to digital converter (ADC), on-chip bias generation, and on-chip timing control for self-sequencing and easy programmability. The digitized output of the APS is processed to compute the centroids of the pinhole Sun images on the APS. The Sun angle, relative to a coordinate system fixed to the sensor unit, is then computed from the positions of the centroids.

This work was done by Sohrab Mobasser, Carl Liebe, Youngsam Bae, Jeffrey Schroeder, and Chris Wrigley of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1)*
NPO-30867

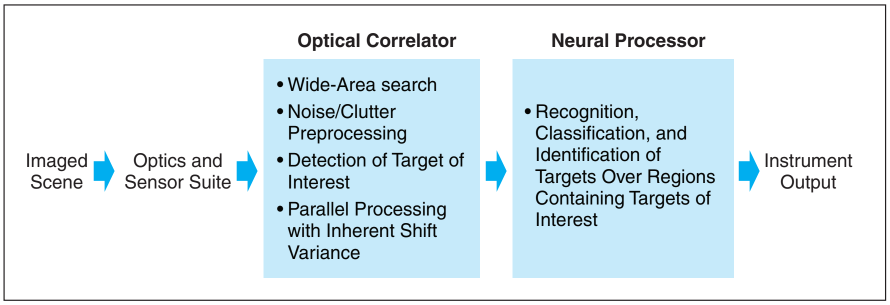
Passive IFF: Autonomous Nonintrusive Rapid Identification of Friendly Assets

Targeting decisions could be made with speed needed in urgent situations.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed optoelectronic instrument would identify targets rapidly, without need to radiate an interrogating signal, apply identifying marks to the targets, or equip the targets with transponders. The instrument was conceived as an identification, friend or foe (IFF) system in a battlefield setting, where it would be part of a targeting system for weapons, by providing rapid identification for aimed weapons to help in deciding whether and when to trigger them. The instrument could also be adapted to law-enforcement and industrial applications in which it is necessary to rapidly identify objects in view.

The instrument would comprise mainly an optical correlator and a neural processor (see figure). The inherent parallel-processing speed and capability of the optical correlator would be exploited to obtain rapid identification of a set of probable targets within a scene of interest and to define regions within the scene for the neural processor to analyze. The neural processor would then concentrate on each region selected by the optical correlator in an effort to identify the target. Depending on whether or not a target was recognized by comparison of its image data with data in an internal database on which the neural processor was trained, the processor would generate an identifying signal (typically, "friend" or "foe"). The time taken for this identification process would be less than the time needed by a human or robotic gunner to acquire a view of, and aim at, a target.



An **Optical Correlator and a Neural Processor**, each performing a different portion of the overall target-identification task, would generate a signal indicative of the identity of a target (e.g., "friend" or "foe") in a fraction of a second.

An optical correlator that has been under development for several years and that has been demonstrated to be capable of tracking a cruise missile might be considered a prototype of the optical correlator in the proposed IFF instrument. This optical correlator features a 512-by-512-pixel input image frame and operates at an input frame rate of 60 Hz. It includes a spatial light modulator (SLM) for video-to-optical image conversion, a pair of precise lenses to effect Fourier transforms, a filter SLM for digital-to-optical correlation-filter data conversion, and a charge-coupled device (CCD) for detection of correlation peaks. In operation, the input scene grabbed by a video sensor is streamed into the input SLM. Precomputed correlation-filter data files representative of known targets are then downloaded and sequenced into the filter SLM at a rate of 1,000 Hz. When there occurs a match between the input target data and one of the known-target data files, the CCD detects a correlation peak at the location of the target. Distortion-invariant correlation filters from a bank of such filters are then sequenced through the optical correlator for each input frame. The net result is the rapid preliminary recognition of one or a few targets.

The output of the optical correlator would be fed to the neural processor for classification and identification of the preliminarily recognized targets. The neural processor could contain one or more analog and/or digital artificial neural networks, which are well suited for identification of targets by virtue of their fault tolerance and their capabilities for adaptation, classification of patterns, and complex learning. An analog neural processor with a parallel configuration that has been demonstrated to be capable of classifying hyperspectral images and patterns may be suitable as a prototype neural processor for this instrument.

This work was done by Philip Moynihan, Robert Van Steenburg, and Tien-Hsin Chao of Caltech for **NASA's Jet Propulsion Laboratory.** *Further information is contained in a TSP (see page 1)*
NPO-30326

Finned-Ladder Slow-Wave Circuit for a TWT

Impedance and gain per unit length are increased.

John H. Glenn Research Center, Cleveland, Ohio

A finned-ladder structure has been invented in an effort to improve the design of the slow-wave circuit of a traveling-wave tube (TWT). The point of departure for the design effort was a prototype TWT that contains a ring-plane slow-wave circuit (see Figure 1). The design effort was a response to the observation that despite the high-power capabilities of the ring-plane TWT, its requirement for a high supply voltage and its low bandwidth have made it unacceptable for use outside a laboratory setting.

Modifications of the ring-plane slow-wave circuit were proposed on the basis of the physics of interaction of the electromagnetic field with this circuit and with the electron beam. The effects of each proposed modification were analyzed by use of the Solution of Maxwell's Equations by the Finite-Integration-Algorithm (MAFIA) computer program — a powerful, modular electromagnetic-simulation code for the computer-aided design and analysis of two- and three-dimensional electromagnetic devices, including magnets, radio-frequency cavities, waveguides, and antennas. For each trial design, MAFIA was used to calculate frequency-vs.-phase dispersion characteristics, and attenuation and small-signal gain vs. frequency. Also calculated were values of the beam on-axis interaction impedance, which is a measure of the strength of interaction between a radio-frequency wave and the electron beam. A nominal operating frequency of 32 GHz was used in the design calculations and numerical simulations of performance.

The modifications that were adopted included an increase in the inner diameter of the outer barrel, introduction of slots into the planes that support the rings, and the addition of metal loading fins. Figure 2 depicts the finned-ladder slow-wave structure that was adopted as a result of the iterated modifications and computations.

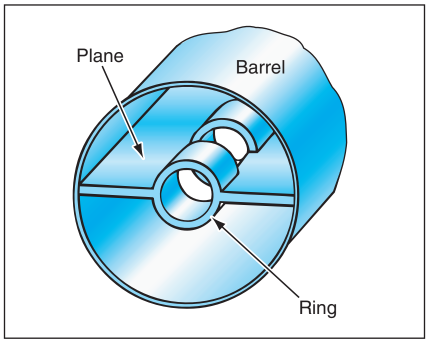


Figure 1. A **Prototype Ring-Plane Circuit** was modified to obtain a finned-ladder circuit.

The simulations showed that the finned-ladder structure can be expected to exhibit radio-frequency output power of 20 W (corresponding to efficiency of 20.2 percent) and on-axis interaction impedance of 120 Ω at an applied potential of 6.8 kV and nominal operating frequency of 32 GHz, with a half-power bandwidth of greater than 3 percent. The computed gain, efficiency, and on-axis interaction impedance are greater than those of prior TWTs that contain helical and coupled-cavity slow-wave structures, and the applied potential is low, relative to that of a TWT containing a ring-plane slow-wave structure. Moreover, because of the greater gain per unit length of the finned-ladder structure (relative to helical and coupled-cavity structures), slow-wave circuits needed to obtain a given amount of gain could be made significantly shorter.

The overall dimensions of the designed the finned-ladder structure are a diameter of 0.093 in. (2.36 mm) and length of 2 in. (50.8 mm). Because of their smallness, it would not be possible to fabricate the disks of the finned-ladder structure by conventional machining. Instead, it has been proposed to fabricate them by batch chemical milling and/or micro-electrical-discharge machining. The circuit and spacer disks would be stacked alternately and diffusion-bonded to form the all-metal periodic finned-ladder circuit structure.

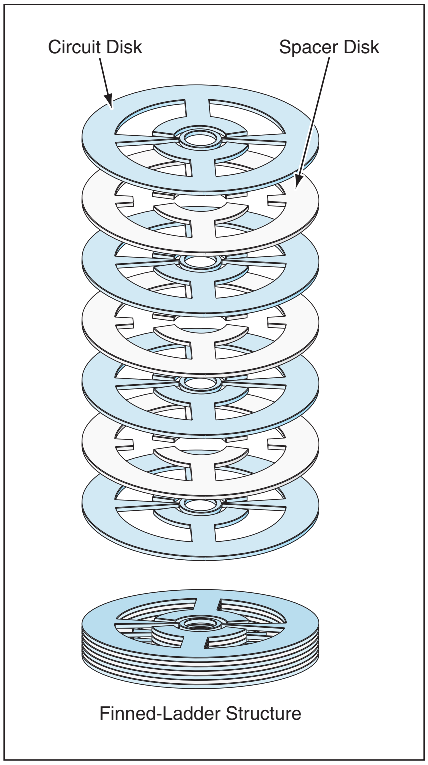


Figure 2. A **Finned-Ladder Circuit** has an all-metal structure comprising circuit and spacer disks. Numerical simulations show that the finned-ladder circuit offers advantages over prior slow-wave circuits.

This work was done by Jeffrey D. Wilson and Edwin G. Wintucky of **Glenn Research Center** *and Carol L. Kory of Analex Corp. Further information is contained in a TSP (see page 1)*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-17257.