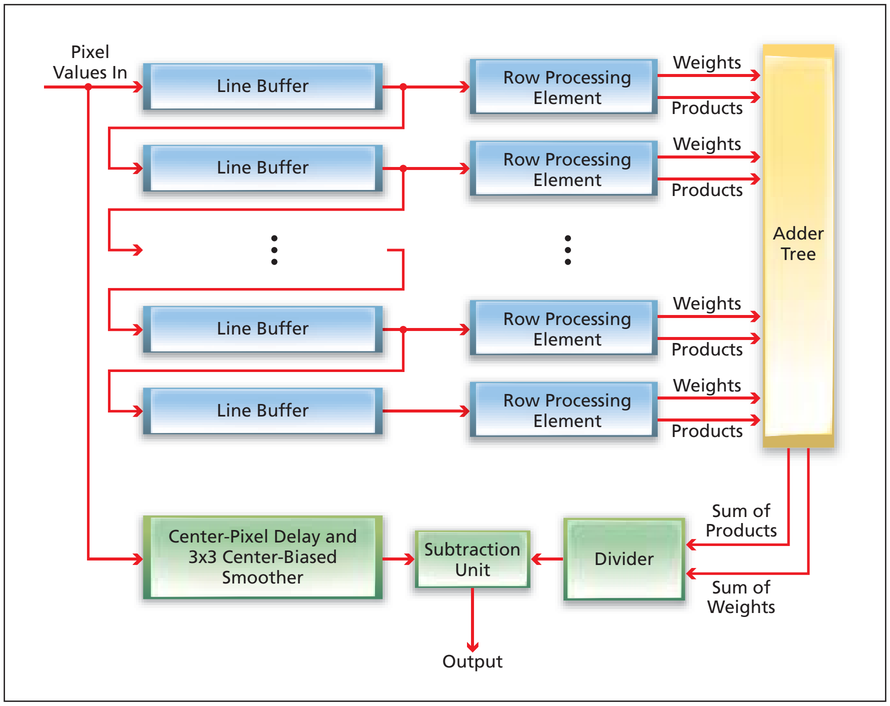


A **Bilateral Subtraction Filter** is implemented in an FPGA that performs parallel pipeline computations in a moving 9×9-pixel window.

used as an address in a lookup table. Each processing element has a lookup table, unique for its position in the window, containing the weight coefficients for the Gaussian function for that position. The pixel value is multiplied by the weight, and the outputs of the processing element are the weight and pixel-value·weight product. The products and weights are fed to the adder tree. The sum of the products and the sum of the weights are fed to the divider, which computes the sum of products ÷ the sum of weights. The output of the divider is denoted the bilateral smoothed image.

The smoothing function is a simple weighted average computed over a 3×3 subwindow centered in the 9×9 window. After smoothing, the image is delayed by an additional amount of time needed to match the processing time for computing the bilateral smoothed image. The bilateral smoothed image is then subtracted from the 3×3 smoothed image to produce the final output.

The prototype filter as implemented in a commercially available FPGA processes one pixel per clock cycle. Operation at a clock speed of 66 MHz has been demonstrated, and results of a static timing analysis have been interpreted as suggesting that the clock speed could be increased to as much as 100 MHz.

This work was done by Andres Huertas, Robert Watson, and Carlos Villalpando of Caltech and Steven Goldberg of Indelible Systems for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-45906

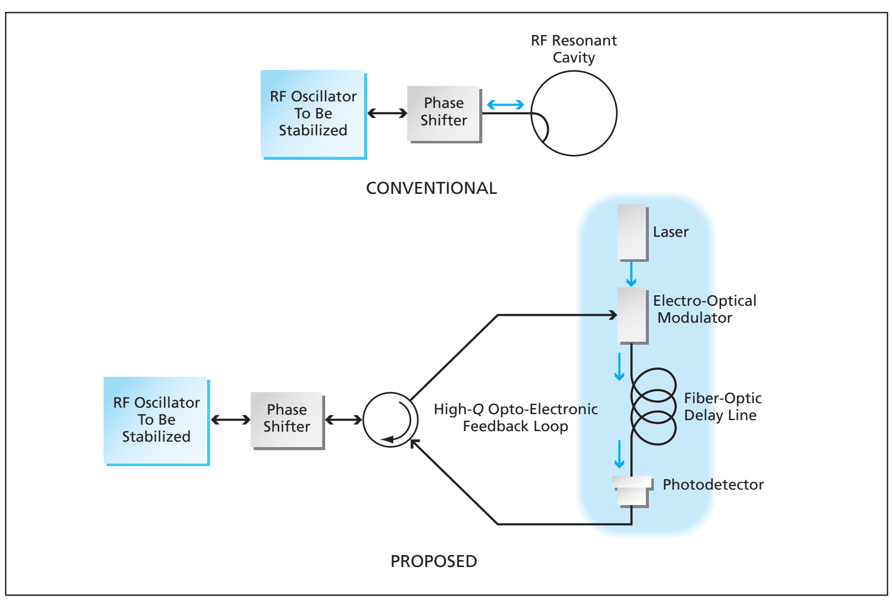
Simple Optoelectronic Feedback in Microwave Oscillators

Phase and frequency stability would be enhanced greatly.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed method of stabilizing microwave and millimeter-wave oscillators calls for the use of feedback in optoelectronic delay lines characterized by high values of the resonance quality factor (Q). The method would extend the applicability of optoelectronic feedback beyond the previously reported class of optoelectronic oscillators that comprise two-port electronic amplifiers in closed loops with high-Q feedback circuits.

The upper part of the figure illustrates the example of a typical free-running oscillator in a conventional form stabilized with an external metal radio-frequency (RF) resonant cavity. The oscillator could be of any of a variety of types, including those based on Gunn diodes, impact avalanche transit-time (IMPATT) diodes, klystrons, backward-wave tubes, and others. The maximum Q of a typical resonant metal cavity ranges from about 10^4 at an oscillation frequency of 10 GHz down to



A **High-Q Optoelectronic Delay Line** would be substituted for the RF resonant cavity of a conventional free-running oscillator stabilized with an external resonator.

10^3 at a frequency of 100 GHz and to even lower values at higher frequencies. In contrast, the maximum Q attainable in a resonator based on an optoelectronic delay line is of the order of 10^6 at a frequency of 10 GHz and increases with frequency.

The proposed method is partly similar to two older patented methods that involve the use of fiber-optic delay lines as RF-phase-noise discriminators. However, unlike those methods, the proposed method does not call for the generation of a low-frequency signal applied to a control port of the oscillator to be stabilized. Instead, the delayed RF signal would simply be returned to the oscillator, as described below.

The lower part of the figure shows an example of the same oscillator as before, but this time stabilized by use of optoelectronic feedback according to the proposed method. The RF signal from the oscillator would be fed through a circulator to an electro-optical modulator, which would modulate the RF signal onto a laser beam. After traveling the length of an optical fiber or other optical delay line, a photodetector would demodulate the signal. The RF output of the photodetector would be returned via the circulator to the oscillator.

The return of the delayed RF signal would enforce a steady phase in an otherwise noisy free-running oscillator, thereby suppressing phase noise in the oscillations. This stabilizing effect is expected as a consequence of the frequency-pulling effect or self-injection locking observed previously in oscillators equipped with high-Q external resonant cavities.

The original tunability of the free-running oscillator would be substantially preserved in the presence of optoelectronic stabilization, except as described next: Upon tuning of the oscillator, the frequency of the oscillator would not change continuously but would jump between successive resonances of the optoelectronic feedback loop. Typical frequency jumps would likely range from a few tens of kilohertz for a kilometer-long fiber-optic delay line up to a few gigahertz for an optical microresonator.

This work was done by Lute Maleki and Vladimir Iltchenko of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

Innovative Technology Assets Management
JPL
Mail Stop 202-233
4800 Oak Grove Drive
Pasadena, CA 91109-8099
(818) 354-2240
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Small X-Band Oscillator Antennas

In some applications, these compact units could be powered by solar cells.

John H. Glenn Research Center, Cleveland, Ohio

A small, segmented microstrip patch antenna integrated with an X-band feedback oscillator on a high-permittivity substrate has been built and tested (see Figure 1). The oscillator antenna is powered by commercial solar photovoltaic cells mounted nearby or on the same substrate. This oscillator antenna is a prototype for demonstrating the feasibility of such devices as compact, low-power-consumption building blocks of advanced, lightweight, phased antenna arrays that would generate steerable beams for communication and remote-sensing applications.

The solar-powered oscillator antenna includes a commercially available super-low-noise, high-frequency field-effect transistor integrated into the center of the segmented microstrip-patch antenna. Along with bias lines, a feedback loop, and other conductors that are parts of the oscillator antenna circuitry, the patch antenna was formed by etching the corresponding pattern out of a surface metal layer on the substrate, which is a commercial microwave laminate having a relative permittivity of 10.2 and a thickness of 0.635 mm. The oscillator antenna occupies an area of 5 by 6 mm on the substrate. The oscillator feedback path ex-

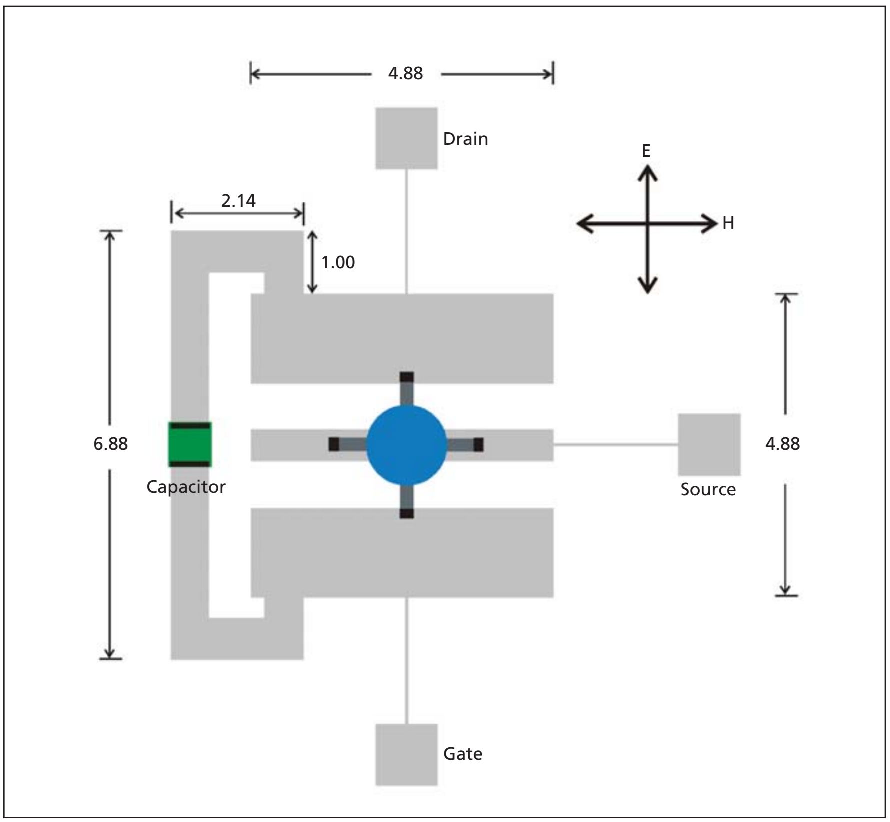

Figure 1. A **Schematic of Oscillator Antenna** is shown with feedback loop. The dimensions are in millimeters.