Figure 2. These **Voltage and Current Waveforms** occur at the terminals of the piezoelectric actuators.

timing drive current to opto-isolator U4, which, in turn, provides the switch-on signal for the triac gate.

Figure 2 illustrates the voltage and current waveforms at the terminals of the piezoelectric actuators. Suppose that C2 has been initially charged. At the beginning of the first half cycle, when a timing pulse occurs, the triac is turned on and current begins to flow from C2 through the triac and L2. When the magnitude of the current increases above the minimum hold current, the triac becomes latched on. The triac then continues to conduct until the current drops below the minimum hold current, which is essentially zero for the purpose of this application. The minimum hold current is reached and the triac turns off when the voltage on C2 reaches a negative peak near –450

V. The reversal of polarity is provided by L2. The precise magnitude of the peak reverse voltage is slightly less than |450 V| by an amount that depends on the energy lost in the various exchanges of energy involved in the reversal of polarity. While the triac remains off, C2 remains in its negatively charged state, in which only parasitic dielectric losses slowly reduce the magnitude of the voltage on C2.

At the beginning of the second half cycle, when the next timing pulse arrives, the process described in the preceding paragraph is repeated, except that the currents and voltages applied to C2 are reversed. Again, the difference between |450 V| and the magnitude of the peak voltage depends on the energy lost.

If the operation as described thus far were allowed to continue, the voltages

would continue to decay and operation would halt after a number of cycles. To enable continuous operation, it is necessary to replenish the energy lost. This is accomplished as follows: After the completion of the polarity reversal of the second half cycle and before the arrival of the next timing pulse, the replenish-control subcircuit senses the triac cutoff and turns on Q1 to recharge C2 to 450 V. At the chosen 20-Hz pump frequency, the triac-off time is long enough to enable C2 to be recharged to 450 V by use of relatively low charging current, provided that the energy lost is relatively low.

Because recharging is done only during the positive half cycle, a dc offset is induced in C2; however, this offset is typically a small fraction of the peak drive voltage and does not adversely affect the operation of the piezoelectric actuators. The advantage of recharging only during positive half cycle is that the circuit can be less complex and contain fewer components than would be needed for recharging during both half cycles.

This work was done by Chris Matice of Stress Engineering Services Inc., and Frank E. Sager and Bill Robertson of Oceaneering Space Systems for **Johnson Space Center**.

Title to this invention has been waived under the provisions of the National Aeronautics and Space Act {42 U.S.C. 2457(f)} to Oceaneering Space Systems. Inquiries concerning licenses for its commercial development should be addressed to:

Oceaneering Space Systems
16665 Space Center Blvd.
Houston, TX 77058-2268
Refer to MSC-22887, volume and number of this NASA Tech Briefs *issue, and the page number.*

Dual Common Planes for Time Multiplexing of Dual-Color QWIPs

With external control, commercial single-color readout integrated circuits could be used.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed improved method of externally controlled time multiplexing of the readouts of focal-plane arrays of pairs of stacked quantum-well infrared photodetectors (QWIPs) that operate in different wavelength bands is based on a dual-detector-common-plane circuit configuration. The method would be implemented in a QWIP integrated-circuit chip hybridized with a readout integrated-circuit (ROIC) chip.

There are alternative methods of multicolor readout, but they involve more on-chip circuitry and the attendant disadvantages of greater size, power dissipation, number of control signals, and complexity of circuitry on the QWIP and ROIC chips. To minimize size of, and power dissipation in, a multicolor pixel, one must minimize the number of transistors and control signals; this can be achieved only by time multiplexing of

colors in each pixel. The time multiplexing can be controlled by signals from external or internal circuitry. The proposed reliance on external control for time multiplexing would make it possible to use a commercial single-color ROIC with only minor modifications in the form of extra metallization for an additional detector common plane and for clocking bias potentials. (If, instead, one were to rely on internally controlled

multiplexing, it would be necessary to radically redesign the ROIC, at considerably greater development cost.) Other advantages of the external-control approach over the internal-control approach are greater flexibility and the possibility of using a technique, known as "skimming," for subtracting unwanted dark-, background-, and noise-current contributions from readout signals

The figure schematically depicts the circuitry in one pixel according to an internally controlled multiplexing scheme and according to the proposed externally controlled multiplexing scheme. In both schemes, the time multiplexing would be accomplished by switching

(clocking or ramping) the biases applied to the QWIPs via detector common planes. In the internal-control case, a bias signal would be applied via a single detector common plane and two internal electronic switches. In the proposed external-control case, bias signals would be applied via two detector common planes, without internal electronic switches. A previously unmentioned advantage of the external-control scheme shown in the figure is the need for only one indium bump (instead of two) in each pixel.

This work was done by Sir B. Rafol, Sarath Gunapala, Sumith Bandara, John Liu, and Jason Mumolo 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:

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Refer to NPO-30523, volume and number of this NASA Tech Briefs *issue, and the page number.*

MMIC Power Amplifier Puts Out 40 mW From 75 to 110 GHz
This amplifier operates over the full frequency band of the WR-10 waveguide.

NASA's Jet Propulsion Laboratory, Pasadena, California

A three-stage monolithic microwave integrated circuit (MMIC) W-band amplifier has been constructed and tested in a continuing effort to develop amplifiers as well as oscillators, frequency multipliers, and mixers capable of operating over wide frequency bands that extend above 100 GHz. There are numerous potential uses for MMICs like these in scientific instruments, radar systems, communication systems, and test equipment operating in this frequency range.

This amplifier can be characterized, in part, as a lower-frequency, narrower-band, higher-gain version of the one described in "Power Amplifier With 9 to 13 dB of Gain from 65 to 146 GHz" (NPO-20880), *NASA Tech Briefs*, Vol. 25, No. 1 (January 2001), page 44. This amplifier includes four InP high-electron-mobility transistors (HEMTs), each having a gate periphery of 148 μm. In the third amplifier stage, two of the HEMTs are combined in parallel to maximize the output power. The amplifier draws
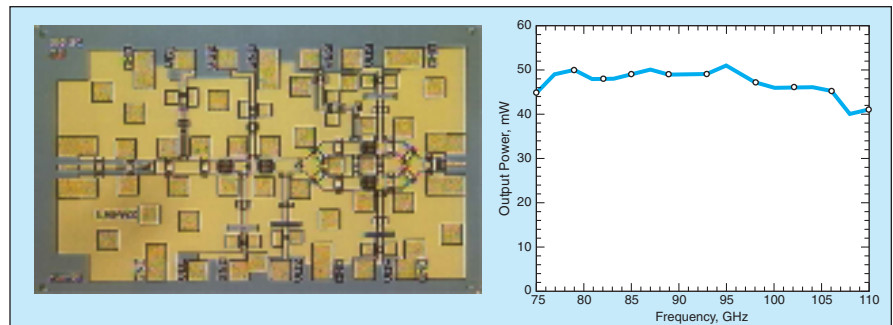
The **Amplifier Shown in the Photograph** was tested at a supply potential of 2.5 V, a gate bias potential of –0.05 V, and an input excitation power of 2 mW at frequencies from 75 to 110 GHz. The plot of output power vs. frequency can be characterized by a large-signal gain of about 13.5±0.5 dB. (Note: The amplifier is actually about 2 mm long.)

a current of 250 mA at a supply potential of 2.5 V.

In a test, this amplifier was driven by a backward-wave oscillator set to provide an input power of 2 mW. The output power of the amplifier was measured by a power meter equipped with a WR-10 waveguide sensor. As shown in the figure, the amplifier put out a power between 40 and 50 mW over the frequency

range of 75 to 110 GHz, which is the entire frequency band of the WR-10 waveguide. At the stated power levels, this amplifier offers a power-added efficiency of slightly more than 6 percent.

This work was done by Lorene Samoska of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1). NPO-30577*