Prototype Parts of a Digital Beam-Forming Wide-Band Receiver

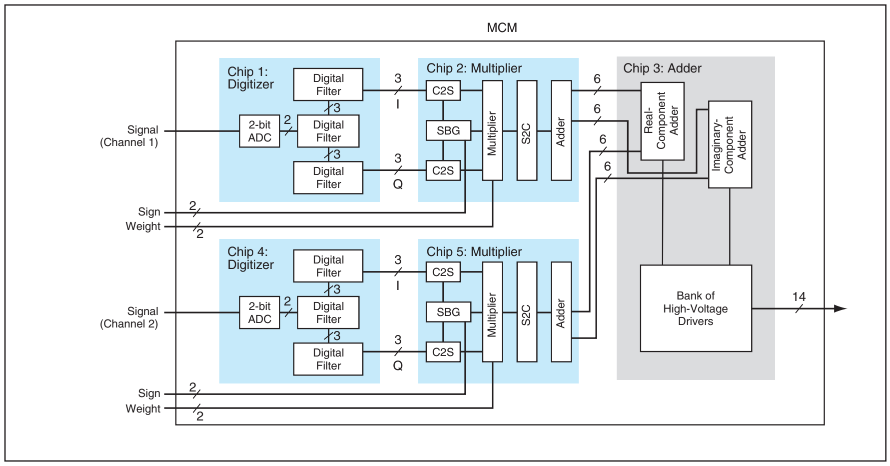
RSFQ circuits are used for digital processing at multigigahertz rates.

John H. Glenn Research Center, Cleveland, Ohio

Some prototype parts of a digital beam-forming (DBF) receiver that would operate at multigigahertz carrier frequencies have been developed. The beam-forming algorithm in a DBF receiver processes signals from multiple antenna elements with appropriate time delays and weighting factors chosen to enhance the reception of signals from a specific direction while suppressing signals from other directions. Such a receiver would be used in the directional reception of weak wide-band signals — for example, spread-spectrum signals from a low-power transmitter on an Earth-orbiting spacecraft or other distant source.

The prototype parts include superconducting components on integrated-circuit chips, and a multichip module (MCM), within which the chips are to be packaged and connected via special inter-chip-communication circuits. The design and the underlying principle of operation are based on the use of the rapid single-flux quantum (RSFQ) family of logic circuits to obtain the required processing speed and signal-to-noise ratio. RSFQ circuits are superconducting circuits that exploit the Josephson effect. They are well suited for this application, having been proven to perform well in some circuits at frequencies above 100 GHz. In order to maintain the superconductivity needed for proper functioning of the RSFQ circuits, the MCM must be kept in a cryogenic environment during operation.

The DBF and cryogenic aspects of the receiver design make it possible to overcome the limitations of both (1) the inherently narrow-band nature of analog beam-forming circuits in which the differential time delays needed for beam forming (including beam steering) are implemented via phase shifts and (2) the relatively slow speeds of room-temperature digital signal processors. A typical fully developed DBF receiver would have to contain more than two input-signal-processing channels for effectiveness in beam forming. For demonstrating feasibility at the present early stage of development, the prototype MCM is designed to accommodate two input-signal-processing channels.



Five Chips in a Multichip Module would perform various digital signal-processing functions for a two-channel DBF receiver. The blocks marked "C2S," "S2C," and "SBG" perform conversions between complementary and signed-binary representations of numbers, as needed because the filter and adder circuits work best in complementary code, while the multipliers work best in signed binary code.

The complete two-channel MCM would contain five chips: two analog-to-digital converter (ADC) chips, two multiplier chips, and an adder/driver chip (see figure). The ADC in each channel is designed to digitize the incoming signal to two bits at a sampling rate of 10 GS/s. The ADC chip includes a digital mixer and anti-aliasing filters that shift the signal frequency down to a bandwidth of 2.5 GHz and separate the signal into in-phase (I) and quadrature (Q) components. The multiplier in each channel is designed to introduce weighting and delay factors for steering. The adder portions of the adder/driver chip are designed to combine the I and Q signal components from the two channels. The driver portion is needed to amplify the outputs of the adders to avoid errors that could otherwise occur if one were to couple the low-level adder outputs directly to external room-temperature circuits.

This work was done by Steven B. Kaplan, Sergey V. Rylov, and Michael Pambianchi of HYPRES for **Glenn Research Center**.

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-16935.

High-Voltage Droplet Dispenser

Individual droplets are released on command.

John H. Glenn Research Center, Cleveland, Ohio

An apparatus that is extremely effective in dispensing a wide range of droplets has been developed. This droplet dispenser is unique in that it utilizes a droplet bias voltage, as well as an ionization pulse, to release a droplet. Apparatuses that deploy individual droplets have been used in many applications, including, notably, study of combustion of liquid fuels. Experiments on isolated droplets are useful in that they enable the study of droplet phenomena under well-controlled and simplified conditions.

In this apparatus, a syringe dispenses a known value of liquid, which emerges from, and hangs onto, the outer end of a flat-tipped, stainless steel needle. Somewhat below the needle tip and droplet is a ring electrode. A bias high voltage, followed by a high-voltage pulse, is applied so as to attract the droplet sufficiently to pull it off the needle. The voltages are such that the droplet and needle are negatively charged and the ring electrode is positively charged.

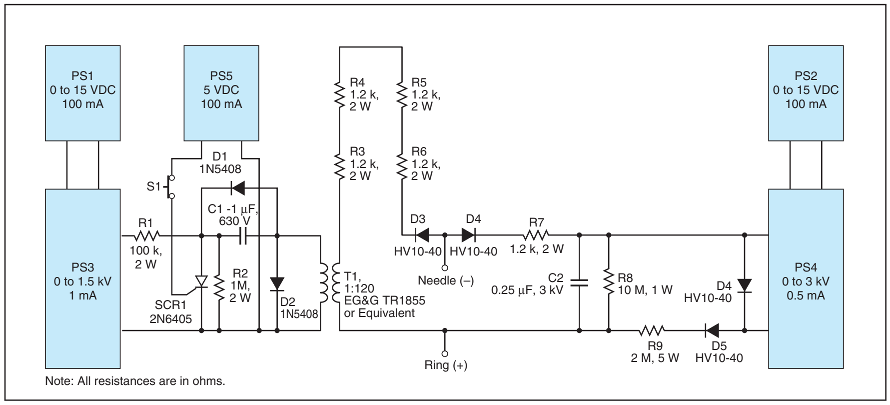
The droplet-dispenser circuit (see figure) includes power supply PS2, which energizes DC-to-DC converter PS4 to produce the bias voltage. A bias voltage of the order of 3 kV has been found to be effective. PS4 charges capacitor C2 through current-limiting resistor R9. Bleed resistor R8 discharges C2 for safety when the circuit is not in use. Diodes D5 and D6 protect PS4 from inductive voltage spikes. The droplet is charged via steering diode D4 and current-limiting resistor R7.

Power supply PS1 energizes DC-to-DC converter PS3 to charge capacitor C1 via current-limiting resistor R1. Charging C1 to 100 volts has been found to be effective. Bleeder resistor R2 discharges C1 for safety when the circuit is not in use. Silicon controlled rectifier SCR1 conducts when push-button switch S1 is closed momentarily, producing a microsecond pulse in the primary winding of transformer T1. Diodes D1 and D2 protect SCR1 from inductive spikes. When C1 has been charged to 100 V, a pulse of 12 kV is produced at the secondary winding of T1; however, the circuit is capable of generating a pulse of as much as 40 kV. The pulse provides ionization energy to the droplet via steering diode D3 and current-limiting resistors R3, R4, R5, and R6. This energy causes the release of the droplet. The four current-limiting resistors (instead of only one resistor with four times the resistance of one of them) are used here to enable this part of the circuit to withstand the high-voltage pulse.

Before the circuit is turned on, PS1 and PS2 are set to the minimum voltage levels. Then they are turned on along with PS5. Next, PS1 and PS2 are set to the desired voltage levels. Finally, S1 is closed momentarily to release the droplet. The circuit as described here was designed for manual control, but is readily adaptable to control by a microprocessor.

This work was done by Dennis J. Eichenberg of **Glenn Research Center.** *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-17190.



This **Electronic Circuit** of the high-voltage droplet dispenser generates a steady high bias voltage, upon which it superimposes a high-voltage pulse to release a droplet.

Network Extender for MIL-STD-1553 Bus

Long-distance communications and equipment tests can be effected through a single multicoupled source.

Lyndon B. Johnson Space Center, Houston, Texas

An extender system for MIL-STD-1553 buses transparently couples bus components at multiple developer sites. The bus network extender is a relatively inexpensive system that minimizes the time and cost of integration of avionic systems by providing a convenient mechanism for early testing without the need to transport the usual test equipment and personnel to an integration facility. This bus network extender can thus alleviate overloading of the test facility while enabling the detection of interface problems that can occur during the integration of avionic systems. With this bus extender in place, developers can correct and adjust their own hardware and software before products leave a development site. Currently resident at Johnson Space Center, the bus network extender is used to test the functionality of equipment that, although remotely located, is connected through a MIL-STD-1553 bus. Inasmuch as the standard bus protocol for avionic equipment is that of MIL-STD-1553, companies that supply MIL-STD-1553-compliant equipment to government or industry and that need long-distance communication support might benefit from this network bus extender.

The state of the art does not provide a multicoupler source for this purpose. Instead, the standard used by the military serves merely as an interface between a main computer in some device or aircraft and the subsystems of that device or aircraft — for example, a subsystem that controls wing flaps or ailerons. Unfortunately, the transmission distance of a state-of-the-art MIL-STD-1553 system is limited to 400 ft (122 m). The bus network extender eliminates this distance restriction by enabling the integrated testing of subsystems that are located remotely from each other, without having to physically unite those subsystems. Interlinking by use of the bus network extender is applicable to 90 percent of all required testing for the military; hence, it offers the potential for savings in cost and time. There is also potential for commercial applications in simulation and training and in the development of real-time systems.

The bus network extender enables long-distance communications by use of specified media and compliant equipment, while conforming to all rel-