Air Force SBIR/STTR

# Innovation

Air Force SBIR/STTR Innovation Story

**SBIR Topic Number:**
AF05-012

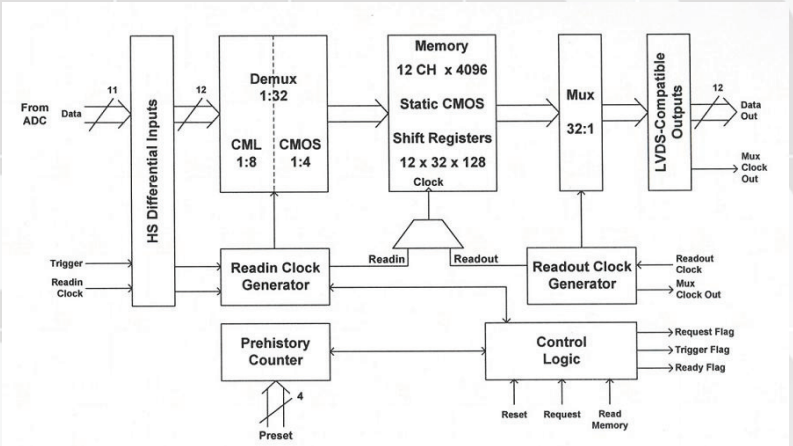
**SBIR Title:**
Compact Ultra-Wideband Target Identification

**Contract Number:**
FA9451-06-C-0036

**SBIR Company Name:**
Hittite Microwave Corporation, Chelmsford, MA

**Technical Project Office:**
AFRL Directed Energy Directorate, Kirtland AFB, NM

This Air Force SBIR/STTR Innovation Story is an example of Air Force supported SBIR/STTR technology that met topic requirements and has outstanding potential for Air Force and DoD.



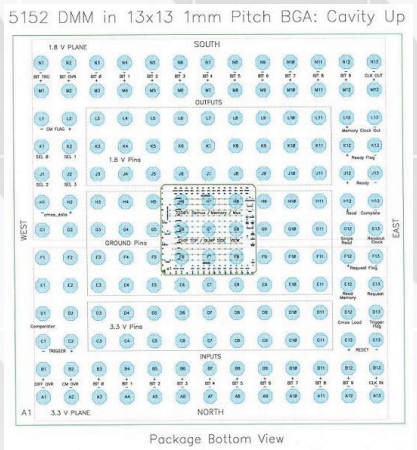




**Figure 1 (left): 12-Channel Demultiplexer/Memory/Multiplexer (DMM). Figure 2 (right): DMM in Ball Grid Array (BGA).**

## Ultra-Compact, Ultra-Wideband Transient Receiver/Digitizer

- The demultiplexer/memory/multiplexer (DMM) radio-frequency integrated circuit (RFIC) was specifically designed as an integral component of a hand-held or unmanned aerial vehicle (UAV)-borne Ultra-Wideband (UWB) Transient Receiver/Digitizer (R/D)
- The DMM chip captures and stores a 4096-word record of output from one ADC; its 12 channels will accommodate up to a 10-bit ADC plus over-range bit, with an additional channel dedicated to the Early-Time Trigger signal
- Compared to the custom DMM RFIC, the off-chip memory system requires 14x to 55x more power plus 154 square inches of multi-layer printed circuitry and $4573 in parts
- The DMM RFIC enables a new generation of UWB equipment to see through walls and foliage

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## Air Force Requirement

The demultiplexer/memory/multiplexer (DMM) radio-frequency integrated circuit (RFIC) was specifically designed as an integral component of a hand-held or unmanned aerial vehicle (UAV)-borne Ultra-Wideband (UWB) Transient Receiver/Digitizer (R/D). It acquires data directly from a high sampling rate (e.g., 6 giga samples per second (GS/s)) analog-to-digital converter (ADC), stores the data, then outputs the data at a slow rate (e.g., less than or equal to 250 mega samples per second (MS/s)) compatible with standard field-programmable gate arrays (FPGAs), digital signal processors (DSPs), etc. Since the UWB data of interest spans only 100 nanoseconds (ns), only a small memory is required.

## SBIR Technology

The custom DMM RFIC enables the ultra-low size, weight and power signal digitizers suitable for hand-held and UAV-borne equipment. An alternative to the DMM is to use commercial-off-the-shelf (COTS) demultiplexer (demux), memory, and multiplexer (mux) integrated circuits (ICs) on a printed-wiring board (PWB) to the maximum extent possible. Since no COTS demux will accept data clocked at 6 Gword/second, a custom demux is required. This custom demux can be realized as a stand-alone RFIC or it can be incorporated on the custom ADC RFIC. In fact, the ADC Hittite developed under a separate contract includes a demux on chip. Not including the custom demux, the complete off-chip memory system for each ADC dissipates 109 W (both during read-in and standby), occupies 156.2 inches, and costs $4,573 in parts alone. Clearly, a COTS-based DMM is not suitable for hand-held or UAV-borne equipment.

The DMM chip captures and stores a 4096-word record of output from one ADC. Its 12 channels will accommodate up to a 10-bit ADC plus over-range bit, with an additional channel dedicated to the Early-Time Trigger signal. It is designed to operate at read-in rates of up to 7 Gword/second. At the system command, it will then read these data out at a lower rate of up to 250 Mword/second. Besides the ADC, the DMM interfaces with a trigger comparator, a controller chip and a user output interface. The last two functions may be implemented in one FPGA.

The key design challenges for this chip were the high data capture rate and maximizing the stored data length within the constraints of a reasonable chip size and power. Demultiplexing of the high-speed data is required so that the complementary metal oxide semi-conductor (CMOS) memory block can operate at a significantly lower clock rate. Also, the proper operation and system control of the memory for both read-in and read-out functions, including a programmable pre-history controller, required a substantial memory control design. The data are multiplexed back to 12 channels for readout. A simplified block diagram of the DMM is shown in Figure 1 on Page 1.

Although the DMM is not yet packaged, work was done to define a ball grid array (BGA) package and pinout for it. A 13 x 13-ball or 14 x 14-ball BGA package with 1 millimeter (mm) ball spacing is recommended. (A 13 x 13-ball size is all that is required, but sockets for that size are uncommon.) Figure 2 shows the chip placed within a 13 x 13-ball, 1 mm BGA. This BGA is designed to be attached to a printed wiring board using conventional surface-mount technology.

The chip is powered by 3.3 V and 1.8 V supplies for the bipolar and CMOS sections of the chip, respectively. There is no negative supply. The total power dissipation during read-in is projected to be 8 W; the power during read-out may be less, depending on the read-out clock rate. Standby current is about 2 watts (W).

## Potential Application

The DMM RFIC provides the memory function required for hand-held and UAV-borne UWB equipment in a small, low-power form. Compared to the custom DMM RFIC (which includes the custom demux) housed in a 0.58" x 0.53" BGA, which dissipates 8 W during read-in and 2 W otherwise, the off-chip memory system requires 14x to 55x more power plus 154 square inches of multi-layer printed circuitry and $4573 in parts.

The DMM RFIC enables a new generation of UWB equipment to see through walls and foliage.

## Company Impact

The SBIR program has been a rewarding program for Hittite Microwave Corporation. The company has generated a number of commercial technologies and products via the SBIR program. Company sponsors have benefited from these numerous contributions

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