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A HIGH POWER COHERENT 95 GHz RADAR (HIPCOR-95)

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ABSTRACT

The Georgia Tech Research Institute is developing, under contract with the U.S. Army Missile Command, a high power, wide bandwidth, coherent 95 GHz (HIPCOR-95) radar using a traveling wave tube amplifier (TWTA) and an extended interaction klystron amplifier (EIKA). The HIPCOR-95 radar has two modes of operation; a 80 watt peak power, 2 GHz bandwidth mode utilizing the TWTA, and a 1 kW peak power, 350 MHz bandwidth mode utilizing the EIKA. This paper describes the design and fabrication of the waveform signal generator, millimeter wave transmitter, and the polarization agility assembly, and the proposed data collection and processing hardware.

INTRODUCTION

The radar, designated as HIPCOR-95, was developed for the U.S. Army Missile Command, Research, Development and Engineering Center, Redstone Arsenal, Alabama.

This millimeter wave radar provides pulse-to-pulse frequency stepping in two power modes. The power output in the high power mode is 1,000 watts with a bandwidth of approximately 350 MHz, tunable between 94 GHz and 95 GHz. In the medium power mode, the peak power is 80 watts with a frequency stepping bandwidth of 2 GHz. Any bandwidth may be programmed into the radar between 93 and 95 GHz. In the wideband mode, off-line processing can yield range profile measurements with resolution down to 7.5 cm. The two operating modes are provided by using 1) a Varian extended interaction klystron amplifier (EIKA) in the high power mode and 2) a Hughes coupled cavity traveling wave tube amplifier (TWTA) in the medium power wideband mode.

The TWT is also used as a driver for the EIKA output stage. In addition to the power and bandwidth capabilities, the radar also has the ability to measure the full polarization scattering matrix of a given target by switching polarization on a pulse-to-pulse basis. The coherent radar receiver is a dual channel (co-polarized and cross-polarized) type with dual down conversion design incorperating both log and synchronous in-phase and quadrature detection. Key features of the radar given in Table 1.

TABLE 1. FEATURES OF THE HIPCOR-95 RADAR

Coherent:	In-Phase (I) & Quadrature (Q) Outputs
Polarization Agile (Transmit):	Horizontal/Vertical, Right/Left Circular
Dual Polarized (Receive):	Co-polarization, Cross-polarization
Operational Modes:	
High Power:	1 kW (2 kW Goal), 1 W Average
Moderate Power:	80 W, 0.1 W Average
Coherently Frequency Agile:	2 GHz Bandwidth at Moderate Power
Pulse Width:	50 ns, 100 ns
High Range Resolution:	0.5 ns (Off-line Processing) at Moderate Power
Multiple Range Samples:	1 per Channel (6 Total)

The simplified system block diagram in Figure 1 shows the signal generator, the MMW transmitter, the polarization agility assembly, and the proposed data collection system.

SIGNAL GENERATOR

The signal generator shown in Figure 2. consists of a multifrequency crystal oscillator, a high speed Comstron microwave synthesizer, a MMW upconverter, and several signal conditioning devices.

The crystal oscillator provides a highly stable 100 MHz reference for the synthesizer, internal timing signals for the microprocessor radar controller, and the reference for coherent detection.

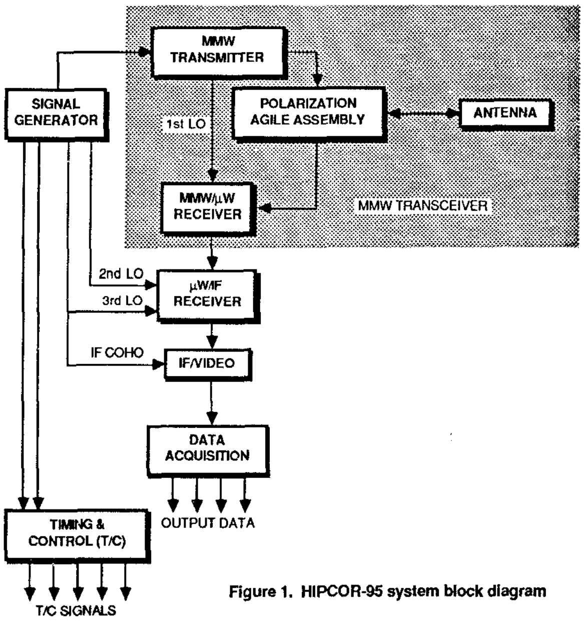

Figure 1. HIPCOR-95 system block diagram

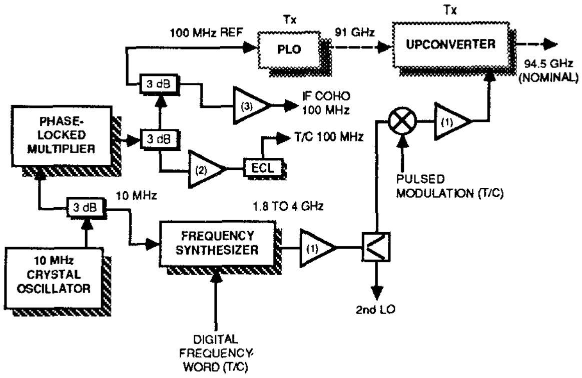

Figure 2. Signal generator block diagram

The Comstron frequency synthesizer provides step frequencies between 2 and 4 GHz to be up-converted to 93-95 GHz during the transmit time. The synthesizer then switches to a frequency 200 MHz below the transmit frequency during the receive time. This frequency stepping can be done at any rate up to the pulse repetition frequency. If polarization agility is in operation, the frequency would only be changed as each matrix is completed.

The millimeter wave up-converter mixes the output of a phase-locked 91 GHz oscillator and the pulse modulated and amplified 2-4 GHz signal from the synthesizer.

MMW TRANSCEIVER

The millimeter wave transceiver consists of the millimeter wave transmitter, the polarization agility assembly, the antenna, and the millimeter wave to microwave receiver. Figure 3 is a block diagram which shows the interconnection within the transceiver.

The transmitter is arranged to give two power-level/bandwidth combinations. The Hughes 982H TWT, when connected to the polarization agility assembly via the waveguide switch, yields approximately 80 watts peak RF power (2 GHz bandwidth) to the antenna and polarization assembly. The Varian VKB2449T1 EIKA produces approximately 1,000 watts peak power at a 350 MHz bandwidth when driven by a portion of the TWT output.

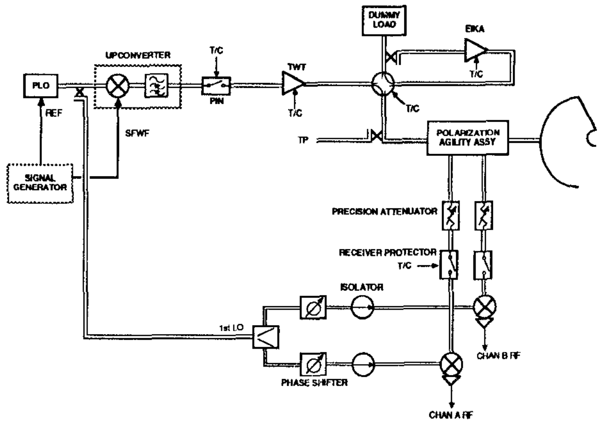

Figure 3. MMW transceiver block diagram

The polarization agility assembly contains an orthomode transducer to separate the parallel and orthogonal polarized received signals, along with a Faraday rotational device, a dielectric slab circular polarizer, and a circular scalar antenna feed horn to provide the capability of circular polarization. By appropriately energizing the magnet coil of the Faraday rotator, any polarization (linear, circular) can be obtained.

The millimeter wave to microwave receiver is the first down conversion mixer to combine the fixed 91 GHz signal with the frequency agile radar return signal. The resultant IF signal can have a bandwidth of up to 2 GHz. Two identical receivers are arranged to receive the parallel and orthogonal polarized components. Attenuators are located in each receiver path in order to allow precise calibration of the radar.

MICROWAVE/IF RECEIVER

The microwave/IF receiver shown in Figure 4 consists of the second down conversion mixer, the logarithmic IF amplifier/detector, and a linear IF amplifier with in-phase (I) and quadrature (Q) detection. This unit also contains various test points for maintenance and adjustment of the system.

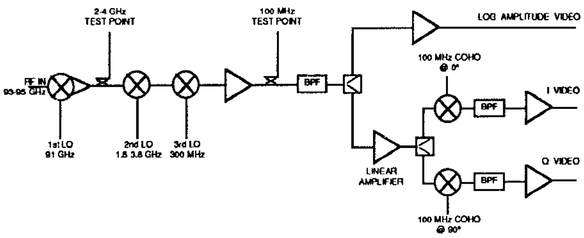

Figure 4. Simplified receiver block diagram

TIMING AND CONTROL

Timing and control of the radar is accomplished with a 68000 type microprocessor which is programmed with a desktop type "Apple" Macintosh computer. The microprocessor is clocked with the precision reference crystal oscillator. Timing of specific radar functions are controlled with digital divide circuits and adjustable delay lines. The program or mode of operation is loaded into the radar controller via a RS-232 interface to the Macintosh computer where frequency tables and operating parameters are set up. Operating scenarios will be stored on 3.5 inch micro diskettes. A local control panel is provided for testing and preliminary task setups.

DATA ACQUISITION RADAR CONTROL

The data acquisition system is broken into two units: one within the radar proper and one remotely located. The radar unit in Figure 5 consists of six video signal conditioning amplifiers, six microprocessor-controlled, range-gated fast track-and-hold units, and six 12-bit A/D converters with multiplex addressed buffer memory.

These digital words will be transmitted to the data acquisition computer via a high speed serial link. A block diagram of the data acquisition system/radar controller is given in Figure 6. The Macintosh computer is used as the input driver for the radar controller. Operating sequences, frequency, polarization, power, target range, and other parameters can be programmed and stored on disk for use in any given condition. The radar data are finally stored and or processed by the data acquisition computer where calibration and formatting will take place. No real-time processing is planned at this time.

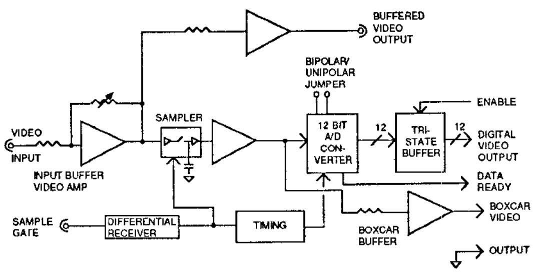

Figure 5. Data acquisition card - block diagram

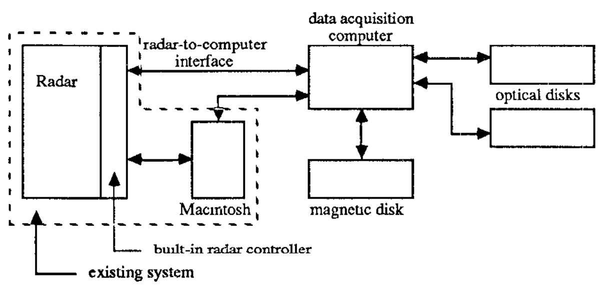

Figure 6. Data acquisition system block diagram

CONCLUSIONS

The HIPCOR-95 radar described will provide a means of evaluating coherency of a high power master-oscillator power amplifier (MOPA) transmitter using state-of-the-art millimeter wave transmitter tubes, the EIKA and TWTA, and waveguide components. Additionally, the power, range resolution (by using frequency step agility), and polarimetric processing available in this radar will provide a unique millimeter wave test bed for advanced target detection and classification evaluation. The radar will serve as an advanced tool for the collection of precision radar backscatter data.