PRODUCTIVITY IMPROVEMENTS FOR A GATED-CW RADAR

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ABSTRACT

This paper will describe new developments in a gated-CW radar that has been designed to improve the productivity and sensitivity of RCS measurements.

Improvements in data acquisition speeds result from the design of a fast synthesizer, a data acquisition co-processor and a pulse modulator. Each of these new products have been specifically designed to take advantage of the high speed capabilities of Scientific-Atlanta's Model 1795 Microwave Receiver. The RF sub-system has also been designed to permit continuous 2-18 GHz, full polarization data acquisitions. Critical RF components are now mounted at the feed in the chamber, improving the sensitivity and ringdown of the system.

Productivity in analysis activities has been improved by the use of a multi-tasking system controller which permits simultaneous use of the system for acquisitions, analysis, and plotting.

Keywords: RCS Measurements, Pulse Modulator, Radar

1. INTRODUCTION

As RCS targets become more sophisticated and their specifications more stringent, the data that is required to completely characterize a target has dramatically increased. There are more vehicle and component configurations of interest and the threat scenarios in terms of bands, polarizations, and aspects are also increasing.

Large bandwidths over small aspect increments are needed to achieve the cross range and down range resolution that is often required on these targets. These measurements may also need to be repeated at several elevations. RCS versus aspect measurements are being replaced by high resolution imaging measurements, placing a much larger data handling requirement on the system. Other measurements such as doppler for aircraft engines or helicopter rotors may also be needed.

In order to completely characterize these targets, RCS facilities often need to take data from 2 to 18 GHz with all four polarizations over a 360 degree rotation. These measurements can require the acquisition of enormous amounts of data. Many facilities are employing multiple work shifts in an effort to reduce their increasing backlogs because they are unwilling or unable to afford a second measurement facility. To stem the increasing demand on measurement facilities, a system is required that can improve the productivity of a facility beyond what is currently available in the market.

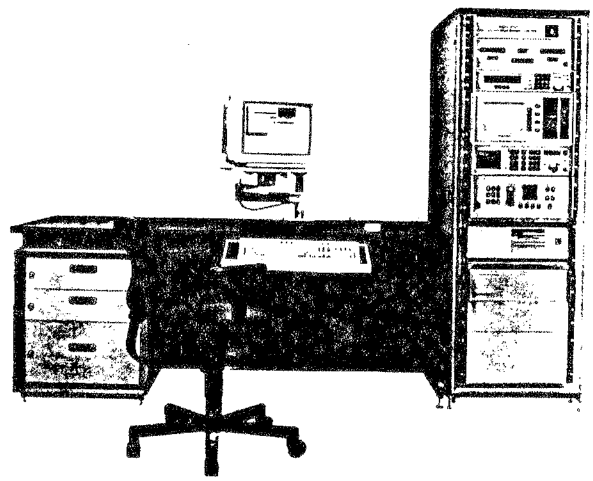

Figure 1: Scientific-Atlanta Model 2095 Microwave Measurement System

2. SCIENTIFIC-ATLANTA MODEL 2095 DESCRIPTION

The Scientific-Atlanta Model 2095 Microwave Measurement System has been designed for both antenna and radar cross section applications. It is a fully automated system capable of controlling, acquiring, and processing measurement data. The Model 2095 includes RF instrumentation, positioning control equipment and an acquisition and analysis workstation. For radar cross section measurements, a Model 1788 Pulse Modulator has been added to provide hardware gating.

The RF instrumentation includes the recently introduced Model 1795 Microwave Receiver and the Model 2180 Signal Source. The positioner is controlled by the Model 4131 Positioner Controller (single axis) or the Model 4139 Positioner Controller (3 axis.)

The acquisition/analysis system controller is configured on a Compaq 386 computer using the OS/2 operating system. An optional offline unix workstation is available. The controller includes a data acquisition co-processor to control acquisitions, synchronize system triggers, funnel and format data, and output parallel bus commands. The operator interface is configured in a user friendly format using windows with pull down graphics.

The pulse modulator employs hardware gating to improve sensitivity and dynamic range, clutter rejection, and increase data acquisition rates.

The Model 2095 Microwave Measurement System has been packaged in a single six foot rack enclosure enabling the system to be easily rolled into different chambers or transported to off-campus facilities. In addition to the console, a compact packaged remote RF unit is located at the feed to optimize RF sensitivity and ringdown. A workbench is also included to locate the monitor, keyboard and printer.

3. MODEL 2095 FEATURES

The Model 2095 is capable of taking data at a rate of 5000 points per second with frequency agility of 4750 frequencies per second. This system speed utilizes the maximum operating speed of Scientific-Atlanta's 1795 Microwave Receiver. An improved RF sub-system permits the system to take complete polarization data from 2-18 GHz in a single acquisition (optional .1 - 26.5 GHz). Specifications for the Model 2095 System for RCS applications are shown in Table 1.

TABLE 1

MODEL 2095 MICROWAVE MEASUREMENT SYSTEM FOR RCS APPLICATIONS SPECIFICATIONS

DESCRIPTION	SPECIFICATION
Frequency Range (Continuous Coverage)	2-18 GHz Standard .1-40 GHz Optional
Receive Sensitivity (10% Duty Cycle)	-132 dBm Max
Transmit Power	63 mW (Standard) 1 Watt (Optional) 20 Watts (Optional)
Measurement Speed	5000 Points/Second
Frequency Agility	100 Frequencies/Second (Std) 4750 Frequencies/Second (Opt.)
Dynamic Range	85 dB Min.
RF Rise/Fall Time	<2 ns
Pulsewidth (Tx/Rcv)	5-255 Ns
PRF	1-9.99 MHz
RF Isolation	> 140 dB
Antenna Interface	Single T/R or Bi-static; Dual Polarization
Measurement Mode	Full Polarization Matrix 2-18 GHz Continuous (Std) .1-26.5 GHz (Opt)
Measurement Time (256 x 256 Image)	12 Minutes (Std) .3 Minutes (Opt)

Radar receiver sensitivities have been increased to a maximum of -132 dBm with a dynamic range of greater than 85 dB. With the high transmit-receive isolation of Scientific-Atlanta's Model 1788 Pulse Modulator, 85 dB of dynamic range on the target is achievable. To improve system sensitivity in the transmit section, the Pulse Modulator has been designed to operate with a variable PRF of up to 9.99 MHz. RF transmit powers have been increased from a standard of 63 milliwatts to 1 Watt and 20 Watt versions. The variable PRF and optional transmit powers allows the user to select the highest possible duty cycle and transmit power for a specific range and required system sensitivity. Due to the high RF isolation of the Model 1788, transmit powers up to 20 Watts may be achieved with a monostatic (single T/R) antenna configuration.

Table 2 shows the improvements that have been realized through the new system design. The acquisition time for a typical image has dropped from 22 minutes to 18 seconds, while at the same time being capable of taking much more data, such as bandwidth and polarizations in the same acquisition. The improved RF system performance with higher transmit power, sensitivity, and dynamic range also highlight the differences in specifications.

TABLE 2

MODEL 2086 VS MODEL 2095 COMPARISON

DESCRIPTION	2086	2095
Sensitivity (.1 Duty Cycle)	-121 dBm	-132 dBm
Dynamic Range	65 dB	85 dB
Transmit Power	63 mW	63 mW or 1 W
Rise/Fall Time	<4 ns	<2 ns
PRF	Fixed 3.2 MHz	1-10 MHz
Antenna Interface	Bi-static	Mono/Bi-static
Polarizations	1	4
Acquisition Bandwidth	2-4, 4-8, 8-12, 12-18	2-18 GHz
Acq. Time (256 x 256 Image) (Single Polarization)	22 Min.	0.3 Min.

To achieve this performance, a new system had to be developed around Scientific-Atlanta's Model 1795 Microwave Receiver. The system development included a high speed synthesizer, a pulse modulator, and a streamlined data acquisition co-processor that could synchronize and manage data acquisitions at rates approaching 5 kHz. Each of these areas are discussed in detail in the following sections.

4. RF Instrumentation Acquisition Rates

Last year Scientific-Atlanta introduced the Model 1795 Microwave Receiver which had dramatically improved sensitivity and data acquisition speeds. The goal was to then to develop a new system around the Model 1795 that could take full advantage of its measurement speeds. The Model 1795 is capable of frequency stepping at a rate of 4750 frequencies per second. The measurement cycle includes approximately 180 μs for the measurement with a 30 μs window for parameter changes (such as frequency and polarization). To match the maximum frequency stepping rate of the receiver a new synthesizer must change frequencies in less than 30 μs, with up to 180 μs dwell time between steps. Constant improvements in the synthesizer technology now permit lower cost alternatives for high speed RCS measurement applications.

It should be noted that the measurement period for single frequency acquisitions is 200 μs. This rate is achieved when integrating, measuring multiple polarizations, or taking doppler measurements.

5. PULSE MODULATOR/RF UNIT

The remaining component of the RF system that has been designed is Scientific-Atlanta's Model 1788 Pulse Modulator. The Model 1788 was designed to optimize the productivity of the range facility by enabling the user to acquire data from 2-18 GHz with all four polarizations in a single acquisition. To provide the best system performance and flexibility, the Pulse Modulator has been modularized to work with a variety of configurations dependent upon location, transmit power, and number of antenna interfaces.

Figure 2 shows the block diagram of the Model 1788 in a direct illumination application where the instrumentation is located fairly close to the antenna. In this configuration, only the control unit is required and it contains the front panel controls, remote bus, and all RF timing/control circuits. In the figure, a single 2-18 GHz Remote RF unit is shown, but could be configured with up to three separate RF units for additional antenna interfaces (each RF can automatically address two dual polarized antennas). In all of these applications, the Remote RF unit has been designed to be mounted directly at the feed for optimum performance.

For typical compact range applications the RF hardware can be located some distance from the control room. To maintain the RF performance a remote version of the Model 1788 is also available. The timing unit is located in the chamber with the synthesizer and downconverter. In this configuration the control unit remains in the control room and contains front panel controls and performs data transfers to the timing unit located in the chamber. The timing unit contains all of the RF timing/control functions and pulse modulator. Packaging the pulse modulator in the timing unit (which is mounted adjacent to the synthesizer) instead of the RFU improves the isolation, and reduces the leakage requirements on cables and packaging.

Locating the RF critical components at the feed increases the effective transmit power at the antenna port as well as a lowering the noise figure. By designing the RF unit as compactly as possible and locating it directly at the feed, system ringdown is optimized. This is particularly important on very small ranges with low RCS targets. Having high PRF capabilities in an RCS system means little to the operator if the RF energy has not reached the noise floor by the time the target is reached.

The Model 1788 RF Unit has optional configurations to suit power levels and antennas required by the application. The unit can interface to a single 2-18 GHz antenna, or up to six antenna bands covering 2-18 GHz. The RFU configuration shown in Figure 2 can be used in ranges where minor field variations over frequency can be tolerated from the antenna. It also yields the lowest cost solution. The RF subsystem shown in Figure 3 provides a better illumination field with 2 antennas per octave band. This approach requires three separate RF units which automatically addresses up to two antennas per band. The three RF unit configuration also has the 2-18 GHz, full polarization measurement capability in a single acquisition. These switching functions are achieved without affecting the system acquisition speed by using the 20 μs window after each measurement.

All of the RF unit designs have been optimized in circuit and packaging design to provide the highest transmit/receive, and receiver on/off isolation possible (140 dB). These high isolation specifications are required for monostatic antenna operation, and also greatly improve acquisition times because the system is only required to sample over the target cell instead of the entire chamber. High isolation permits the system to operate with up to 20 Watts of transmit power without affecting the radar noise floor. For bi-static measurements the RF units have been designed with separate transmit and receive housings which can be separated and moved to different locations.

A variable PRF has also been incorporated into the Model 1788 Modulator. The variable rate from 1-9.99 MHz allows the user to optimize the system sensitivity through duty cycle factors, multiple-time-around range clutter, and PRF harmonics which can leak into the IF of the receiver.

This system design represents a quantum improvement in range productivity not just through higher data rates, but also because the Model 2095 Gated-CW measurement system is capable of acquiring more data (all four polarizations from 2-18 GHz) in a single set-up. This minimizes the need for stopping acquisitions, changing antennas, cables or pushing buttons to acquire another band or polarization.

6. DATA ACQUISITION CO-PROCESSOR

Many systems today are limited not by the RF instrumentation acquisition rates, but by the system controller which controls the timing, triggering, and data handling responsibilities. Figure 4 shows a block diagram of a system architecture designed to relieve the host controller of acquisition responsibilities that normally slow system speed. In addition to slowing the system data rate, acquisition tasks also prevent the host from handling other tasks such as data analysis or plotting.

The data acquisition co-processor receives a downloaded program from the host controller at the beginning of an acquisition. The downloaded program contains all of the information required for an acquisition (e.g. frequencies, polarization, angles, etc.). At this point the co-processor takes control of the acquisition and frees the host for other activities. Hardware in the co-processor checks status indicators in the instruments shown in Figure 4 and issues triggers to properly control the acquisition sequence. Data is transferred to the co-processor from the receiver and position indicator where it is buffered, formatted, correlated, and pipelined to the controller memory. The correlation routines are responsible for tagging receiver data with position and frequency information.

When the system is running a multi-aspect acquisition, the co-processor can be configured to process position data in two different ways. If position data is to be acquired and put into the data file, the co-processor will read the position data and generate record increments. For imaging applications where only even spacing is important, the co-processor can be configured to monitor a TTL Pulse that is generated by the position controller. This pulse is then used as the record increment for triggering the Model 1795 Receiver.

This co-processor architecture allows acquisition speeds for the measurement system to be limited only by the speed of the Model 1795 Receiver and the high speed synthesizer. In addition, the system is now capable of supporting a true multi-tasking environment where the user may analyze or plot data while simultaneously making a new acquisition.

7. HOST CONTROLLER

To reduce system cost and improve productivity, a Compaq 386 machine has been incorporated into the Scientific-Atlanta Model 2095. Productivity is improved because the operating system supports multi-tasking operations. The operator interface has been re-designed with windows to facilitate more efficient set-up of acquisitions, and analysis routines. A batch mode facilitates setting up pre-defined acquisitions, analysis, and plots to run unattended. This feature is especially useful in production environments. An Ethernet port is available for transferring data to a mainframe computer when the Compaq 386 analysis routines are not to be used.

8. CONCLUSIONS

The new Model 2095 Microwave Measurement System has been developed to enhance the productivity and sensitivity of RCS measurements. A new architecture was created to take advantage of Scientific-Atlanta's Model 1795 Receiver acquisition speeds. Faster synthesizers have been incorporated to frequency step rates consistent with the Model 1795 Receiver. A data acquisition co-processor was created, stream-lining data and control flow. A new pulse modulator was designed to enable the system to operate continuously from 2-18 GHz while taking all four polarizations. The RF unit was designed to be mounted at the feed, to improve sensitivity and ringdown.

The Model 2095 System has been engineered for outstanding measurement sensitivity and offers the range user excellent productivity advantages over other gated CW radar systems.

9. REFERENCES

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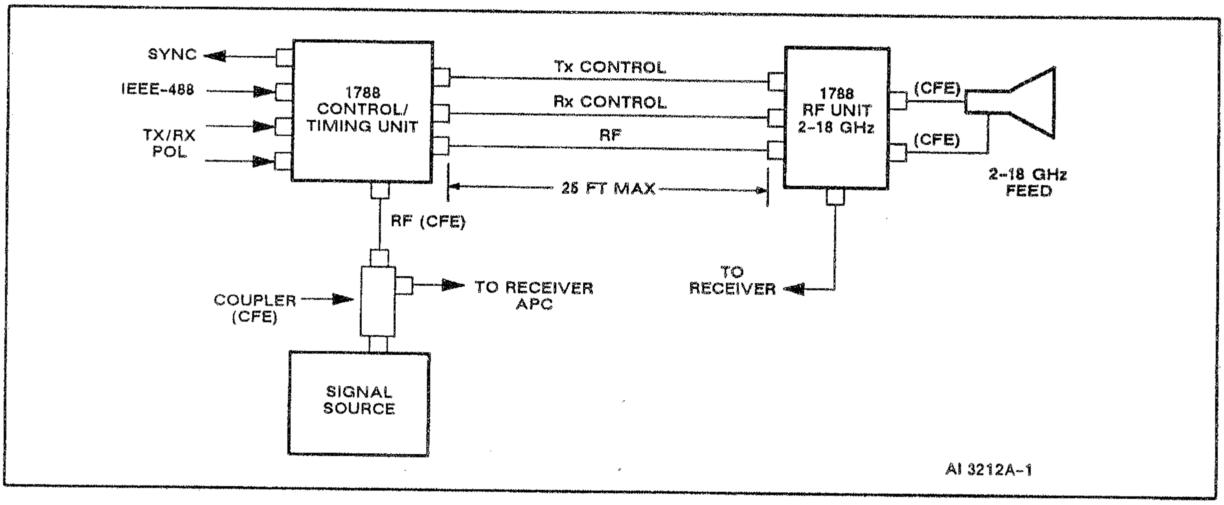

Figure 2: Single Control Unit 1788 Block Diagram

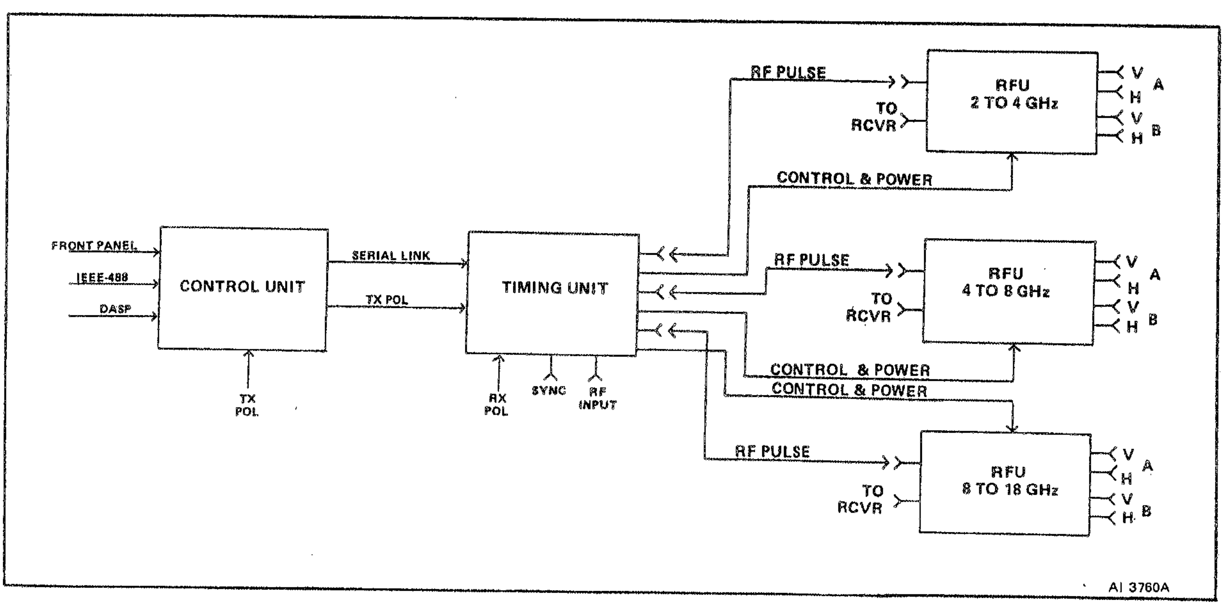

Figure 3: Separate Control and Timing Unit Block Diagram

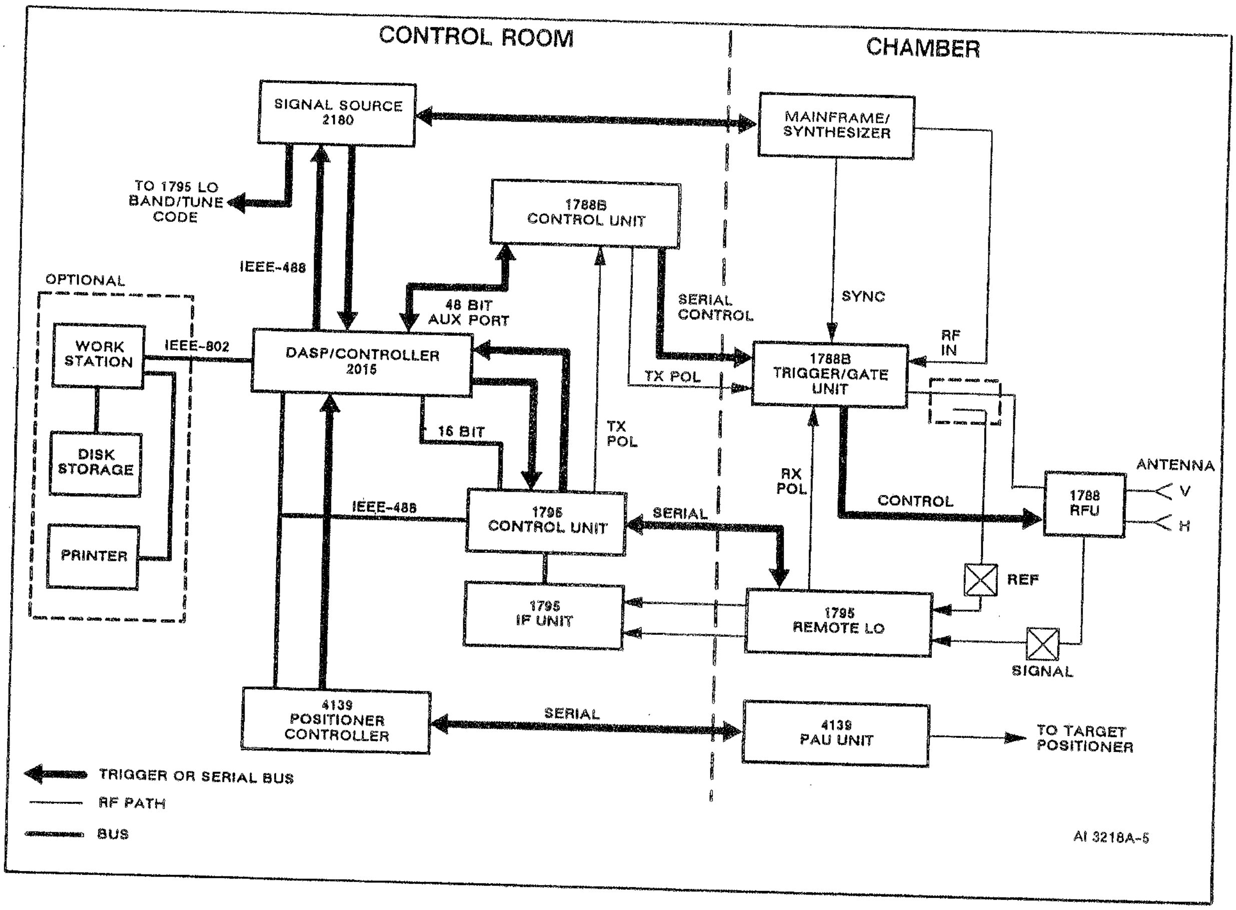

Figure 4: 2095 Block Diagram

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