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(DURIP) Instrumentation Support for High-Latitude Ionospheric Research and the Establishmen of a Dual Radar/Dual Frequency Observational Capability at the Millstone Radar Facility.

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John C. Foster

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Radar receiver and signal processing instrumentation was acquired and fabricated in order to establish a capability for dual 440 MHz and 1390 MHz radar operations at the M.I.T. Millstone Hill research facility. Hardware costs for a duplicate of the MIDAS radar processor were provided. This instrumentation enables a program of simultaneous, high-spatial resolution dual frequency observations of non-thermal and coherent radar backscatter from ionospheric plasma waves and turbulence at both F and E region heights. Simultaneous operation of the fully steerable Millstone Hill UHF and L-band radars in the incoherent scatter mode addresses the spatial homogeneity and simultaneity of ionospheric effects and processes.

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COMPLETED PROJECT SUMMARY

1. TITLE: (DURIP) Instrumentation Support for High-Latitude Ionospheric Research and the Establishment of a Dual Radar/Dual Frequency Observational Capability at the Millstone Radar Facility

2. PRINCIPAL INVESTIGATOR: Dr. J. C. Foster
M.I.T. Haystack Observatory
Westford, MA 01886

3. INCLUSIVE DATES: 1 December 1988 - 30 June 1991

4. GRANT NUMBER: AFOSR-89-0169

5. COSTS AND FY SOURCE: $62,235 FY 89

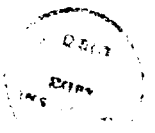
6. SENIOR RESEARCH PERSONNEL:
Dr. J. C. Foster

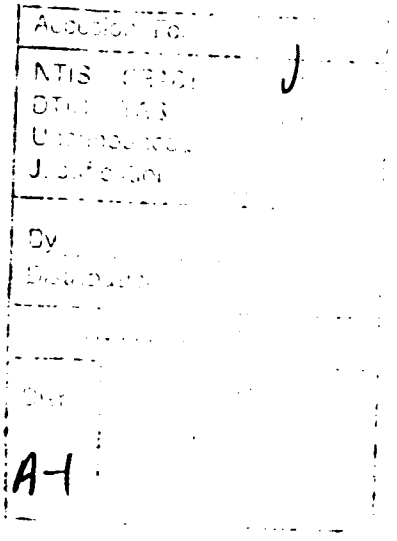
7. JUNIOR RESEARCH PERSONNEL:
Mr. A. D. Pailes

8. PUBLICATIONS: not applicable

9. ABSTRACT OF OBJECTIVES AND ACCOMPLISHMENTS:

Radar receiver and signal processing instrumentation was acquired and fabricated in order to establish a capability for dual 440 MHz and 1390 MHz radar operations at the M.I.T. Millstone Hill research facility. Hardware costs for a duplicate of the MIDAS radar processor were provided. This instrumentation enables a program of simultaneous, high-spatial resolution dual frequency observations of non-thermal and coherent radar backscatter from ionospheric plasma waves and turbulence at both *F* and *E* region heights. Simultaneous operation of the fully steerable Millstone Hill UHF and L-band radars in the incoherent scatter mode addresses the spatial homogeneity and simultaneity of ionospheric effects and processes.





FINAL SCIENTIFIC REPORT

submitted to the

Air Force Office of Scientific Research

by

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for

AFOSR-88-0169

(DURIP) INSTRUMENTATION SUPPORT FOR HIGH-LATITUDE IONOSPHERIC RESEARCH AND THE ESTABLISHMENT OF A DUAL RADAR/DUAL FREQUENCY OBSERVATIONAL CAPABILITY AT THE MILLSTONE RADAR FACILITY

in

Fiscal Years 1989 - 1991

Introduction

The MIDAS (Millstone Ionospheric Data Acquisition System) signal processing, radar control, and receiver system was developed under National Science Foundation support for use with the 440 MHz UHF Atmospheric Sciences radar at Millstone Hill. MIDAS has been designed as a highly modular system based on industry standards using "off-the-shelf" components wherever possible. The standards adopted were Ethernet and RS232 for communications between loosely coupled system modules, VME bus for communications between tightly coupled modules, Unix-based operating systems for the real-time system software and the C programming language. Hardware for a prototype MIDAS system and engineering and personnel costs associated with MIDAS design, fabrication, and testing have been provided by NSF. A block diagram of the MIDAS system hardware is presented in Figure 1.

Under this DURIP instrumentation grant, radar receiver and signal processing hardware, following the prototype design, has been acquired for a second MIDAS system for use with the M.I.T. Lincoln Laboratory L-band radar in order to establish a capability for dual 440 MHz and 1390 MHz radar operations at the M.I.T. Millstone Hill research facility. This instrumentation enables a program of simultaneous, high-spatial resolution dual frequency observations of non-thermal and coherent radar backscatter from ionospheric plasma waves and turbulence at both *F* and *E* region heights. Simultaneous operation of the fully steerable Millstone Hill UHF and L-band radars in the incoherent scatter mode addresses the spatial homogeneity and simultaneity of ionospheric effects and processes.

Instrumentation Acquired:

Under this DURIP award, funding was provided for the major system modules and electrical components of a second MIDAS receiver and processing system. All components were purchased, and fabrication and system integration has proceeded in parallel with the NSF-supported prototype system. Personnel costs associated with the fabrication, testing, and integration of the DURIP MIDAS system have been borne by the NSF and the schedule for this work has been set in accordance with the NSF program. The current schedule is for the DURIP MIDAS system to be fully operational and integrated into the Atmospheric Sciences system by mid-1992.

MIDAS system modules and components acquired under DURIP support are as follows.

Item	Cost	
Radar Processor		
Mercury 3232 Array Processor	18,360	
SUN 3E120 Computer cards	7,300	
Ironics IV1624A Controller	2,640	
VME Crate	6,400	
Total Pre-fabricated Radar Processor Modules		34,700
Receiver		
PTS 500 Frequency Synthesizer	8,000	
PTS 40 Frequency Synthesizer	8,000	
Datacom and RF Boards	6,300	
Total Pre-fabricated Receiver Modules		22,300
Electronics Components & Supplies		5,235
TOTAL DURIP Equipment		62,235

Research Projects using DURIP Instrumentation

a) As Proposed: The frequency dependence of coherent radar backscatter from *F* region ionospheric irregularities generated by current driven instabilities will be investigated in experiments using simultaneous observations with the Millstone Hill UHF and L-band radars. Recent UHF and VHF observations of this phenomena at auroral latitudes with the EISCAT radars further suggest that such frequency-dependent characteristics play an important role in understanding enhanced radar backscatter. Several specific projects using the DURIP instrumentation at Millstone Hill have already been proposed. A dual-radar/rocket research program has been proposed to NASA for 1995 to investigate this topic using a rocket-borne electron beam device to drive local currents and generate the phenomena of interest. Continued research on the occurrence and characteristics of the *F* region radar returns, making use of the DURIP equipment to help differentiate current driven instabilities from false returns, has been proposed to AFOSR for a three year period beginning in 1992. In addition, Dr. Keith M. Groves, a recent graduate of MIT whose area of specialization included this topic, plans to continue a research program in this area using the enhanced Millstone Hill facilities.

b) New Research Areas: *E* region plasma waves and turbulence are produced in the presence of intense ionospheric currents and heating. Initial studies using the narrow beam and great sensitivity of the Millstone Hill UHF radar will be extended to a program of dual frequency observations under a project proposed to AFOSR. The co-location of two large, fully steerable radars, as enabled by the DURIP instrumentation, has created a unique capability to investigate the processes which lead to intense clutter returns for VHF and UHF radars operating in the high-latitude environment. An additional capability of the DURIP equipment is to observe the coherent *E* region returns with one radar system while doing simultaneous incoherent scatter diagnostics of background plasma conditions using the other radar.

A second new research area utilizing the DURIP instrumentation is that of dual antenna UHF incoherent observations of ionospheric phenomena using the 68 m fixed and 46 m steerable antennas at Millstone Hill. Here the DURIP instrumentation creates the capability of receiving and integrating signals from both antennas simultaneously. Locally propagating phenomena, such as gravity waves, can best be diagnosed with such a technique. Dual antenna operations will also provide the capability of examining the spatial homogeneity and simultaneity of ionospheric phenomena.

Professional Personnel

Dr. J. C. Foster - Principal Investigator
Mr. A. D. Pailes - Electrical Engineering

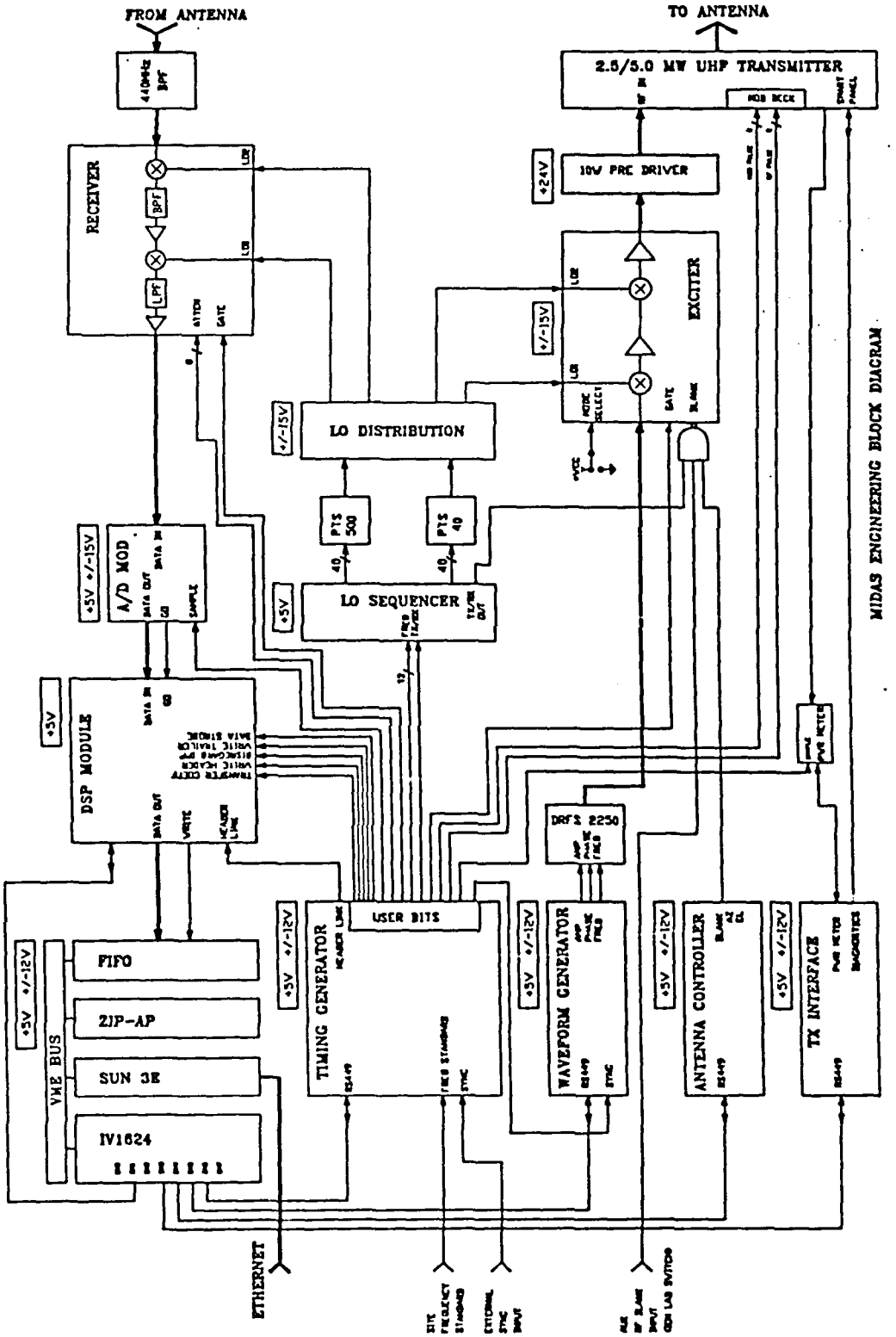

Fig. 1 Block diagram of MIDAS hardware.