A MODIFIED CAMAC SYSTEM FOR HIGH SPEED BURST DATA ACQUISITION

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INTRODUCTION

During the past decade there has been a growing interest in laser radar (LIDAR) instruments for the remote measurement of atmospheric constituents and pollutants. This interest is due to three distinct advantages of LIDAR systems.

1) Remote measurement removes the possibility of balloon-borne contaminants affecting the measurement.

2) The range-gating capability of pulsed LIDAR systems allows the determination of vertical and/or horizontal spatial profiles.

3) The LIDAR system is often times more sensitive than competing techniques.

Recently, engineers at NASA's Goddard Space Flight Center have developed a balloon borne LIDAR facility for the measurement of trace elements in the stratosphere. The goals of the first mission are the measurement of the hydroxyl radical (OH) and ozone (O₃). The hydroxyl radical has been recognized as a key component in the understanding of chemical processes in the upper atmosphere, and the amount of OH present in the atmosphere is intimately related to the incident solar flux and the local ozone concentration. The LIDAR system is designed to generate, in a single flight the altitude profile of the hydroxyl radical and ozone from 40 to 65 kilometers at intervals of 10 to 30 minutes throughout a full diurnal cycle.

The LIDAR techniques employed are differential absorption (DIAL) for the ozone measurement and laser-induced fluorescence for the OH measurements. The differential absorption technique relies on the back-scattering of laser light to generate the return signals. Remote induced fluorescents uses a tuned laser beam to excite atoms or molecules of a species which subsequently fluoresce. The intensity of the returned fluorescent energy can be related to the concentration of the fluorescent species.

The LIDAR facility transmits two, five nanosecond laser pulses at 282 nanometers and 354 nanometers respectively. It receives two backscatter returns of these same wavelengths plus an additional return at 310 nm due to OH fluorescence. The three UV returns are separated by an onboard spectrograph and relayed to three separate photomultipliers. Output from each photomultiplier tube is coupled to a fast A/D converter and to a photon counting system which permits operation over a wide range of signal background levels. Data from each shot as well as "housekeeping" information related to system environment is transmitted to the ground by a 50 Kbit telemetry system.

In order to spatially resolve the species concentration, one requires a detection circuit consisting of a series of sequentially clocked sampling gates permitting the acquisition of multiple range information from a single laser shot. Because of the falloff of the scattered or fluorescent return with the inverse square law of distance (+ time) the sampling intervals must be longer, (lower spatial resolution at greater ranges), to stay comfortably above the noise background.

As an illustration, a typical OH measurement cycle consists of the following sequence of events. The laser fires, emitting a pulse at 282 nanometers in resonance with an OH absorption. The counters begin to count as the UV pulse is transmitted from the telescope. Photons at 310 nm resulting from OH fluorescence are detected and counted. This process of counting and storing continues through all timed gates and an accumulated signal in each channel is then processed. The process consists of digitization and addition of samples for transmittal to the ground. After taking several samples at this wavelength the laser is detuned slightly off the OH absorption resonance and the measurements repeated. This second data set measures the general average background noise present at 310 nm. The amount of OH present is then related to the difference in signal return at 310 nm for the on and off resonance measurements.

Data System

To accomplish the scientific objectives stated above, it was necessary to develop a high speed data system that would meet the following requirements:

1) Simultaneous sampling of the three wavelengths, with high and low resolution capability.

2) Sampling rate would be 1 MHz on each channel, with no dead time.

3) A series of 300+ samples per channel would be acquired each 1/10 second.

4) Eight (8) bit resolution was required per sample.

5) Good RFI rejection (due to laser pulsing) was essential.

6) Buy before build philosophy.

7) One 50K bit/sec telemetry channel was available.

To obtain the required amount of data, and transmit it back to the ground station unaltered was impossible due to the bandwidth limitation of the telemetry channel. The requirement to start a new data sequence every 1/10 second, and collect 8 bit data from 6 channels for a period of 300 milliseconds, generated a total data sample of 14,400 bits which would have to be transmitted in ~99 milliseconds. To reduce the data rate without seriously degrading data resolution, and allow sufficient bandwidth for necessary payload housekeeping functions, would require data compaction and dynamic on board processing. To accomplish this and provide for control operations at the same time, it was decided to use a 16 bit LSI-11 microprocessor packaged in a CAMAC configuration.

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The acquisition of the data from each photomultiplier was also approached using CAMAC components. Connected to the output of each photomultiplier was a 10 bit high speed scaler, and a 10 bit transient digitizer. The scaler, sampling for 1 microsecond, produced an integrated sample per channel, while the transient digitizer which sampled for 15 picoseconds every microsecond, generated an instantaneous look at the variations in the event. All of the data thus generated must be appropriately compressed and transmitted to the ground station. Fig. #1 is the functional representation of the system. At the time of design and construction no zero dead time scalers existed in the CAMAC repertoire. Therefore, 5, 3 channel scalers were used in a sequential mode. Each scaler sampled for 1 microsecond, had 1 microsecond dead time and output data on each channel for 1 microsecond. Since it was impossible to process the data as it was acquired, three High Speed Cache (HSC) memories were constructed which received the data from the scalers and were read out at the end of the sample period by the microcomputer.

To control the sequencing of the scalers and loading of the high speed caches a special sequencer was designed. The design of the High Speed Crate Controller (HSCC) differentiates this CAMAC system from other standard systems. The HSCC sits in the center of the CAMAC Bus and cuts it in half. See Fig. #2. All devices to the right of the HSCC operate under the control of the LSI-11 and all CAMAC bus signals are standard. The right hand side of the HSCC is connected to the CAMAC bus and receives the commands as does any standard CAMAC module. However when the HSCC is commanded to run it operates the devices to its left without CAMAC bus intervention. The bus to the left uses the same CAMAC backplane but reassigns the functions such that all 6 channels can operate simultaneously. The HSCC generates the sequence control signals for the scalers acquired and directs the data flow to the proper cache. When the required number of data samples has been acquired and stored, the HSCC flags the microcomputer and opens the CAMAC bus to the Transient Digitizers and High Speed Caches thus enabling data to be output to the microcomputer and telemetry buffer.

Because there is more data than can be transmitted, the data is compacted by co-adding selected samples. The method is to transmit the first 30 samples directly, to sum two samples for the next 60 samples, sum 4 samples for the next 60 samples, etc. In this way, the resolution is high for the rapidly changing data and lower as the data decays. To further permit continuous operation the microcomputer and telemetry system jointly control a ping-pong buffer. The microcomputer loads one buffer while the telemetry reads the other.

SUMMATION

By using a mixture of standard and specially constructed CAMAC modules, it was possible to construct a High Speed Burst Data Acquisition System which exceeded the capabilities of a standard CAMAC system and at the same time keep costs and schedule within reasonable limits. The ability to split the CAMAC bus under program control allows for separate high speed data acquisition, and processing and control to occur simultaneously.

FLIGHT RESULTS

The LIDAR balloon package has been successfully flown from Palestine, Texas on October 20, 1980. All electronic systems were fully operational throughout the entire duration of the flight.