AN INEXPENSIVE DATA ACQUISITION SYSTEM FOR MEASURING TELEMETRY SIGNALS ON TEST RANGES TO ESTIMATE CHANNEL CHARACTERISTICS

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ABSTRACT

In an effort to determine a more accurate characterization of the multipath fading effects on telemetry signals, the BYU telemetering group is implementing an inexpensive data acquisition system to measure these effects.

It is designed to measure important signals in a diversity combining system. The received RF envelope, AGC signal, and the weighting signal for each beam, as well as the IRIG B time stamp will be sampled and stored.

This system is based on an 80x86 platform for simplicity, compactness, and ease of use. The design is robust and portable to accommodate measurements in a variety of locations including aircraft, ground, and mobile environments.

KEY WORDS

Data Acquisition, Channel Characterization, Forward Error Correction, Diversity Combining, Multipath Fading

INTRODUCTION

Multipath fading on telemetry channels is a problem on test ranges. Diversity combining systems have been implemented to overcome the effects of fading [2]. While effective, additional protection is provided by forward error correcting (FEC) codes. The choice of a suitable code depends strongly on the characteristics of the channel. The aeronautical fading channel model [3] is ideally suited to this application. This channel model is parameterized by several terms which have not been determined for test ranges. This paper describes a data acquisition system developed to measure signals required to determine the values of the parameters of the channel model.

This work represents part of a larger effort by the Brigham Young University telemetering group to study the application of FEC coding to test range systems. Nelson [4] investigated the fading properties of the weighting signal in the diversity combining system using data recorded at Tyndall AFB. However, use of the weighting signal alone to recover the envelope of the received signal requires solving a second order nonlinear differential equation with non-constant coefficients. Measuring the data directly is a more practical approach to solving the problem.

DESIGN REQUIREMENTS

The receiver, shown in Figure 1, provides 6 signals available in a typical RF diversity combining telemetering system. Fade rates above 10 kHz are rare, and most fade rates are less than 1 kHz [1]. For margin, the system will be required to sample each channel at a minimum rate of 50 ksamp/sec. Thus, an upper bound for the maximum fade rate that the system should be able to record is 25 kHz. Since the digital IRIG-B time code signal is pulse width modulated [5], it must also be sampled. Therefore, the required minimum overall sample rate is 350 ksamp/sec.

The system will be used in land and aircraft based platforms, requiring the system power supply must be functional at both 60 Hz and 400 Hz. Due to vibrations and shocks experienced by aircraft based platforms, the system must reliably write to a disk drive while retrieving data.

Additional requirements include

1. portability — Since the test ranges are widely separated, the acquisition equipment must be transported to test facilities as needed.

2. storage capacity — The length of data the system can store is limited by the size of the hard disk drive. To allow storage of data for multiple tests, exceeding the capacity of the drive, a mass storage device must be included in the system.

SYSTEM DESIGN

A versatile and inexpensive PC based system was chosen as the foundation for the design, as shown in Figure 2. It can be connected to a network and used as a signal processing station for off-line analysis. A 12 bit, 8 channel, 400 kHz data acquisition

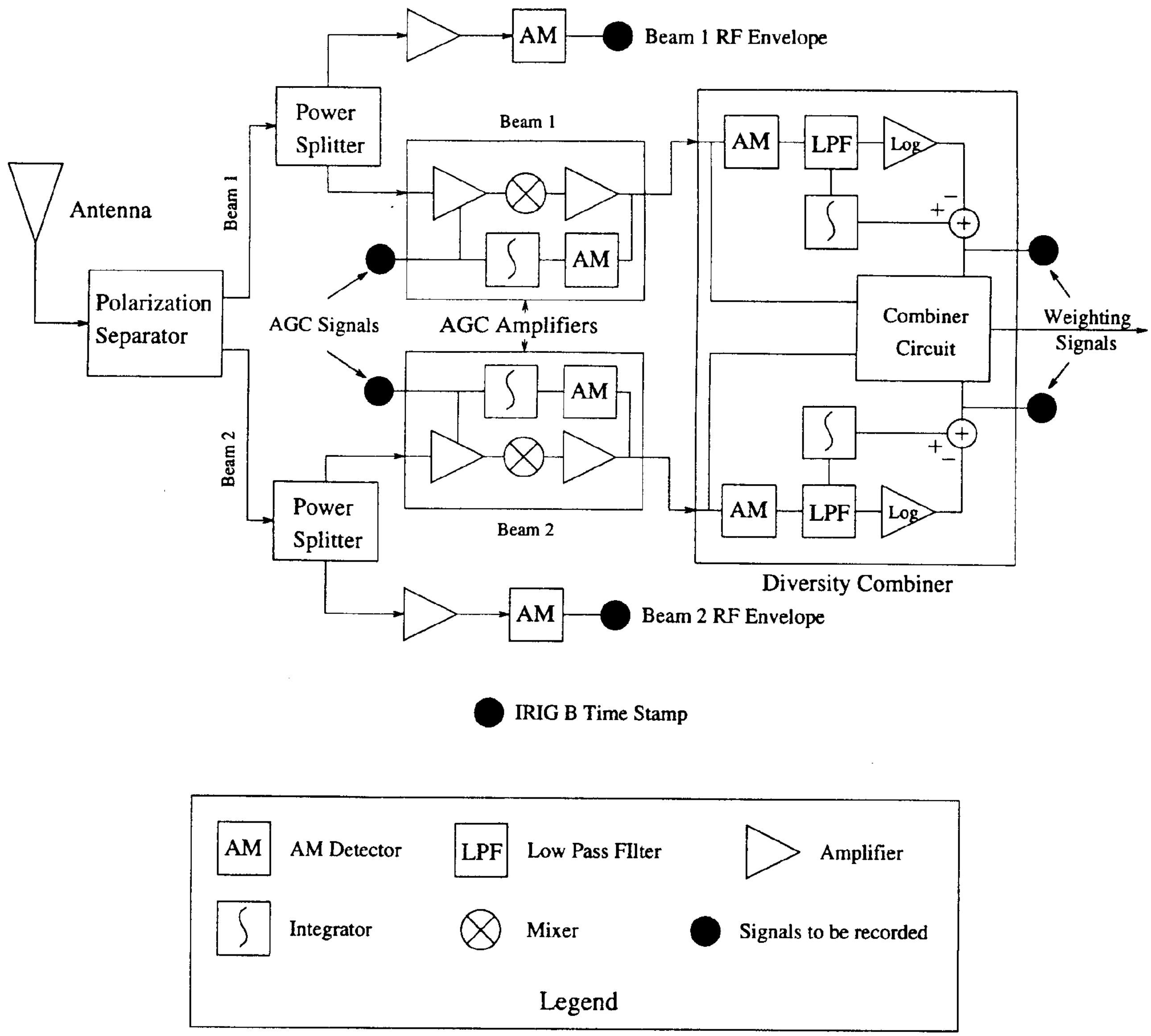

Figure 1: Receiver and Signals to be Recorded

card was chosen. This card is capable of sampling seven channels at a rate of 50 ksamp/sec each, meeting the design requirement. It can be reconfigured from software, allowing easy reconfiguring on site.

To facilitate later use of the system for data analysis and to assure its ability to transfer data quickly from the acquisition card, a fast (90 MHZ) processor on a PCI motherboard was chosen. A SCSI disk controller and a reasonably large 2.1 Gbyte hard drive with a low (8 ms) access time were also used. This results in a storage capacity of approximately 50 minutes of data.

A major problem in the design of the system was to assure that the data could be reliably transferred to disk while on an aircraft experiencing vibrations and sudden

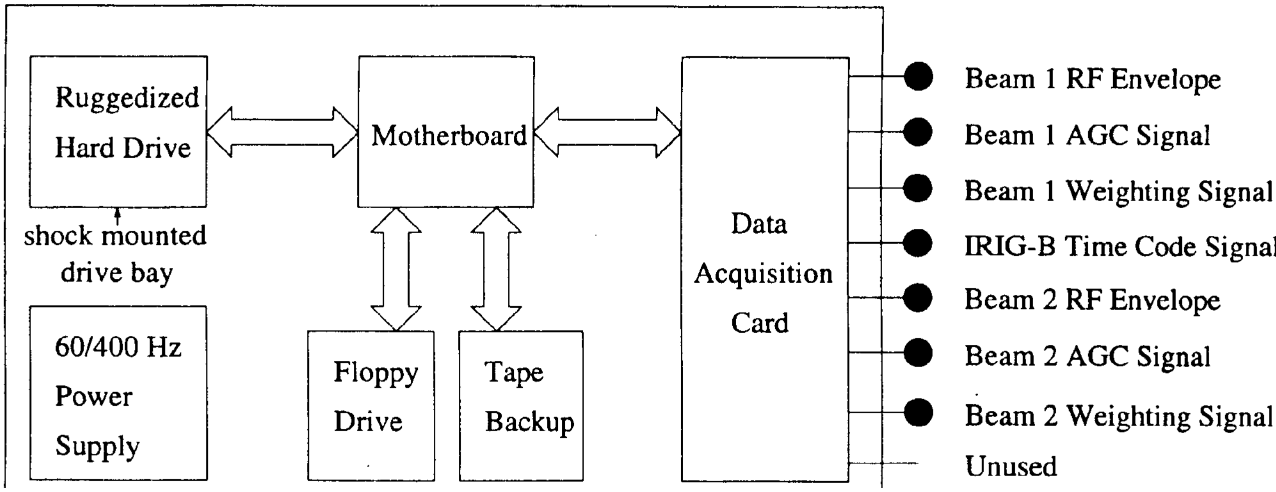

Figure 2: Block Diagram of Data Acquisition System

shocks. A rack-mount chassis with a shock mounted drive bay, able to withstand a 5 G shock, was chosen to protect against disk crashes. The chassis uses a power supply capable of operating at 400 Hz, allowing the system to operate on board aircraft.

A streaming tape backup system was included to augment the 2.1 Gbyte capacity of the hard drive, so that data from many tests can be recorded. This also facilitates long term storage and backup of the data.

The acquisition system is small and light enough to be transported on a commercial airline flight.

EXPECTED RESULTS

From the data acquired using this system, the parameters of the aeronautical fading channel will be determined for test ranges. The parameters are [3]:

1. Γ, the amplitude ratio of the specular reflected ray to direct signal component.

2. K, the power ratio of direct to diffuse signal components.

3. B_dT, the normalized fading bandwidth.

4. f_dT, the normalized Doppler shift.

Γ and K can be determined directly from the data, while B_dT and f_dT can be determined indirectly from the data. From these parameters and the correlation between the two beams, the statistical nature of the error bursts will be computed. The nature of the error bursts determines which FEC code is best suited for the channel. Thus, from the data recored using this system, the BYU telemetering group will be able to recommend an efficient FEC code for application to test ranges.

SUMMARY

The system described is a low cost, versatile, PC based data acquisition system. It is capable of measuring signals important to the characterization of multipath fading on telemetry channels. Measurements made with this system will be used to characterize the fading on test ranges so that an efficient coding scheme can be recommended to recover bits lost due to fading.

References

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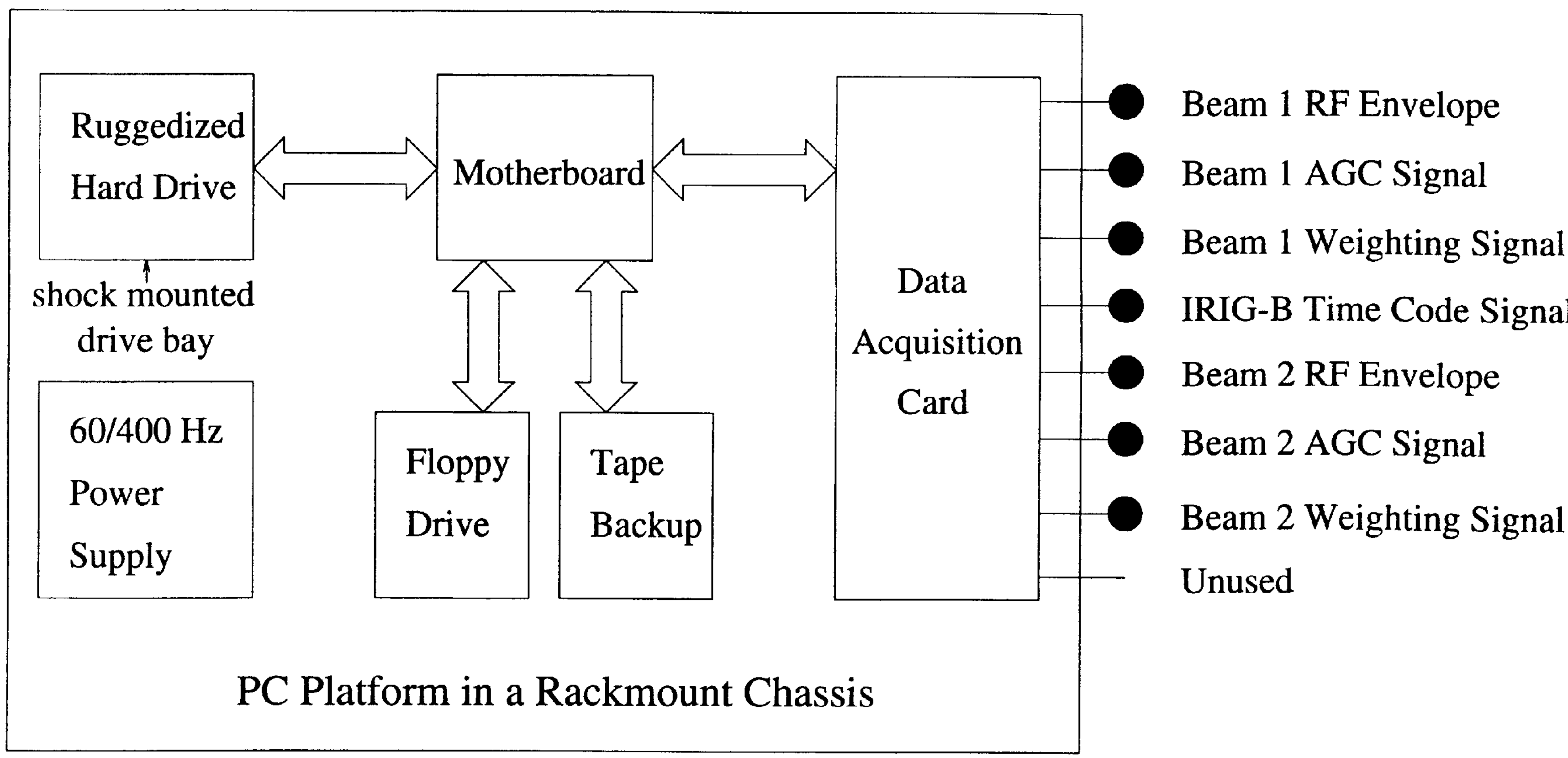
Ruggedized Hard Drive
shock mounted drive bay
60/400 Hz Power Supply
Motherboard
Floppy Drive
Tape Backup
Data Acquisition Card
Beam 1 RF Envelope
Beam 1 AGC Signal
Beam 1 Weighting Signal
IRIG-B Time Code Signal
Beam 2 RF Envelope
Beam 2 AGC Signal
Beam 2 Weighting Signal
Unused
PC Platform in a Rackmount Chassis