DATA ACQUISITION SYSTEM CENTRAL MULTIPLEXER

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ABSTRACT

The Central Multiplexer is a versatile data multiplexer designed to address emerging test requirements for recording data from many sources on digital rotary head recorders at high data rates. A modular design allows easy reconfiguration for airborne or laboratory use; simultaneous data input from 63 sources of data in any combination of PCM commutators, ARINC 429 buses, ARINC 629 buses, MIL- STD-1553 buses, and general-purpose high-speed serial data packets; simultaneous, independent programmable outputs to high-speed digital data recorders, quick-look displays, and engineering monitor and analysis systems; and setup and control from a remote panel, a dumb terminal, a laptop personal computer, a standalone test system, or a large control computer.

INTRODUCTION

Test and certification of the next generation of commercial aircraft require expanded capabilities in airborne data systems used by flight test organizations. More data sources with higher data sampling rates demand data acquisition systems with increased real-time processing capabilities, recording rates, and recording capacities. Additionally, ARINC 629 buses introduce message-oriented protocols that cannot be easily handled by existing PCM systems. Loral, in cooperation with a major airframe manufacturer, has developed the system shown in Figure 1 to satisfy these growing requirements

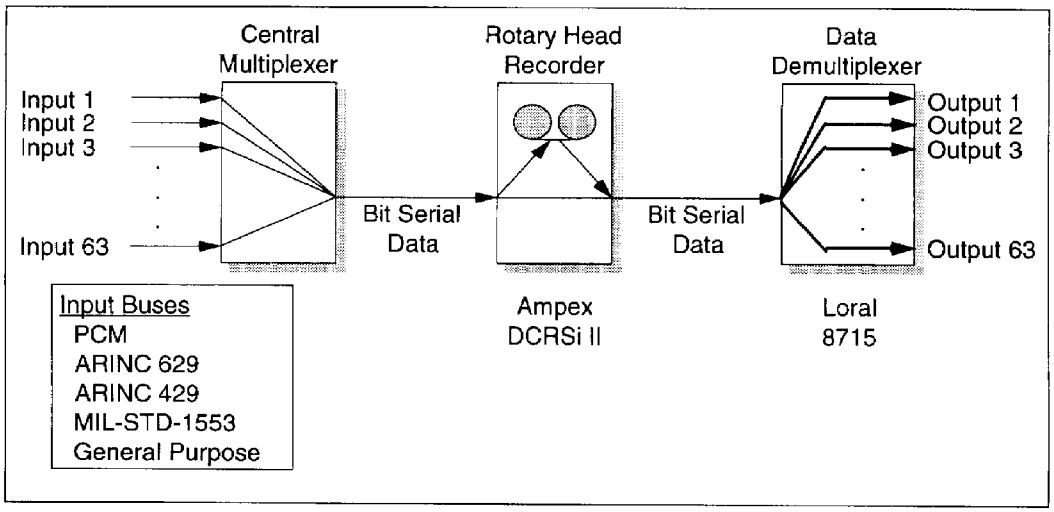

Figure 1. System Overview

Up to 63 data inputs from any combination of IRIG 106 PCM streams [1], ARINC 429 buses [2], ARINC 629 buses [3], and remote data multiplexers are accepted by a Central Data Multiplexer at combined rates up to 10 Mwords/second, then merged into any of several data streams which can be recorded on commercially available rotary head digital recorders and analyzed in real time by the Loral O/S90 telemetry system.

The Central Data Multiplexer can be set up and checked out using a laptop computer. Checkout displays include hardware configuration information, system operational status, data activity on each board, a log of protocol errors detected in the data, snapshots of user-selected data in real time, user-selected data played back from tape, and health test results. The user can enable/disable input from any source, and set data compression controls for each output independently. Data recording formats are compact, and data from different sources is kept in time sequence within a 1 microsecond resolution either synchronized to an internal clock or to a user-supplied IRIG B serial clock [4]. Comprehensive built-in testing and data simulation is provided to diagnose and repair problems. The Central Multiplexer can also be used to efficiently collect information about intermittent problems on airplanes that are in service. The unit may be configured to control output to tape by monitoring data conditions. When the airplane is operating under conditions producing the problem, the recorder is turned on; when the conditions end, the recorder is turned off. In this mode, data of interest can be recorded for several weeks without an operator on hand.

The Central Multiplexer operates in an airborne environment. It meets DO-160 environmental requirements [5], and has been designed for FAA approval as nonessential equipment on scheduled commercial flights. Normal operation continues through power interruptions up to 200 msec, and operation is automatically resumed

after longer interruptions. All active setup information is available in nonvolatile memory. The multiplexer architecture is modular, allowing input and output modules to be reconfigured as required. Modules processing new input or output protocols can be added in a straightforward manner.

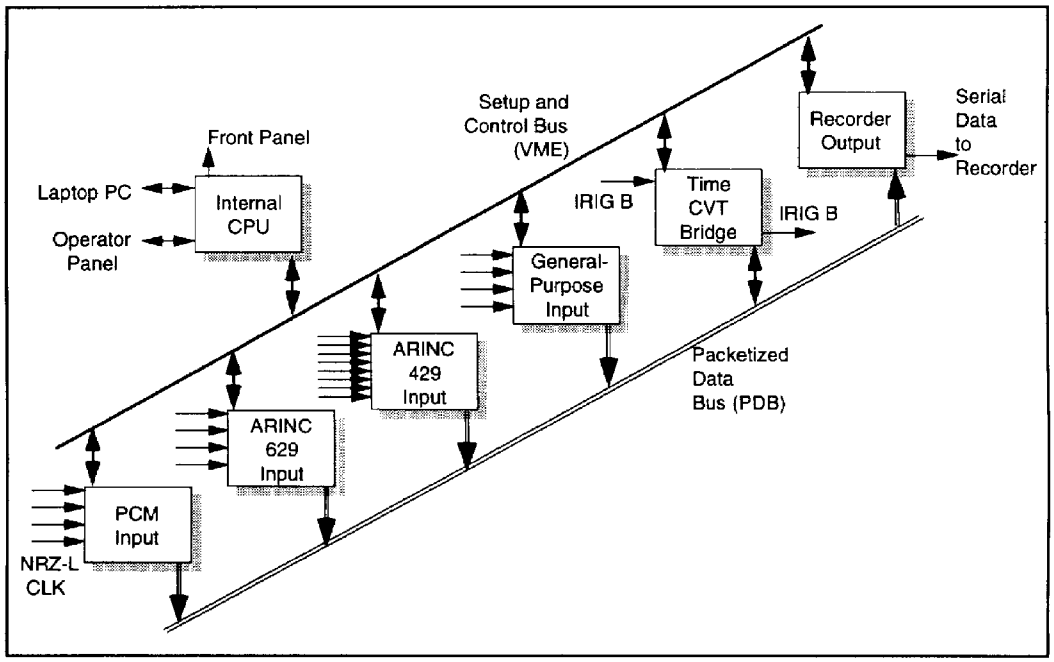

Figure 2. Overview of Central Multiplexer

A rich assortment of features addresses many user concerns, helping the operator perform his work quickly with a minimum of problems. Features include built-in diagnostics using internal data simulators, interactive setup menus, interactive status displays, error logging and display, validation of data written to tape, uninterrupted operation through short power dropouts, automatic resumption of operation after long power interruptions, an embedded general-purpose setup and control processor, and independent setup and data buses.

The Central Multiplexer has been designed and tested for operation in flight environments, including high and low temperature, altitude, vibration, humidity, lightening transients, power transients, and EMC standards. It is being used by a major aircraft manufacturer for flight qualification of new and redesigned planes.

DATA INPUTS

All inputs have a common functional design to give the operator a predictable "look and feel." Each input is set up independently by interactive menus or by program control. The control processor saves setup parameters in nonvolatile memory, and restores the setup automatically during the power-up sequence. Each input circuit

checks for data protocol errors, embedding an error marker in the data, and queuing an error message for display to the operator upon error detection. The embedded error marker immediately precedes the bad data word, punctuating the separation between good data and bad data for downstream processing functions. The input circuit organizes incoming data into word string packets that consist of source ID, word string label, microsecond time stamp, and associated data words. Examples of word string packets are shown in Figure 3 and include PCM minor frames, MIL-STD-1553 messages, and ARINC 629 word strings.

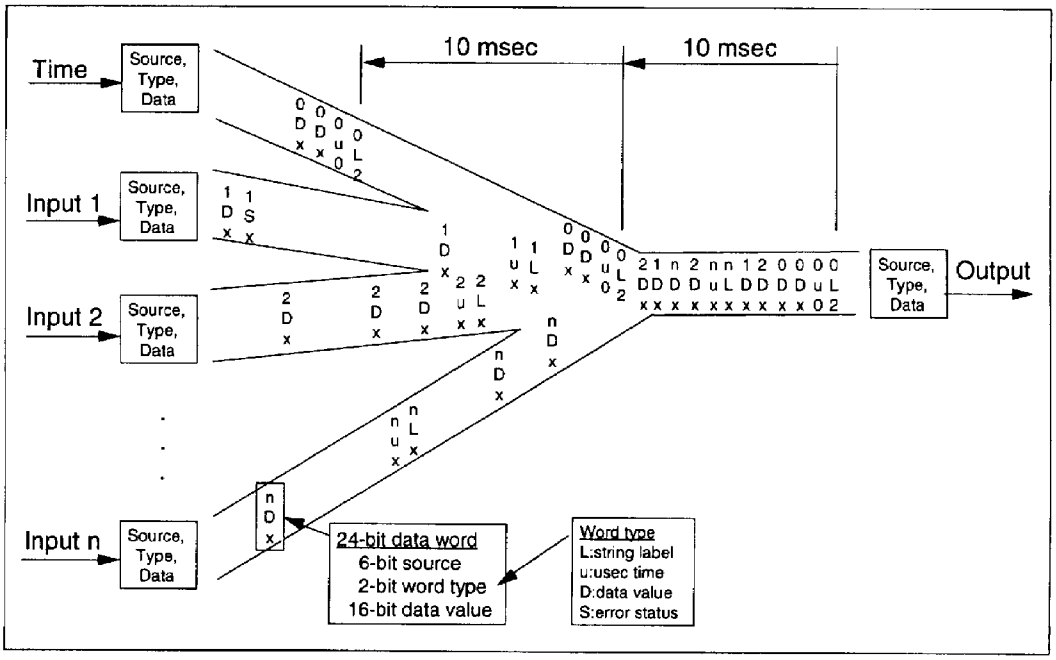

Figure 3. Example of Multiplexed Data

Data from each source is put into a standard 24-bit format similar to the PCM format for MIL-STD-1553 data [1]. Six bits designate that the data came from one of 63 data sources, two bits specify word type (string label, microsecond time stamp, data value, or error status word), and 16 bits contain data. This word string format definition allows data from many sources to be multiplexed into a single data stream, and later demultiplexed with no loss of information. The input circuits arbitrate access to the data bus and ensure time ordering of data words from different sources within one microsecond.

Each input circuit performs a functional self-test using built-in diagnostics that include on-board data simulators as controlled sources of data. The simulator data patterns check both error-free and error detection processing. The self-test runs under operator or remote computer control with test results returned for display.

TIME

Time input is amplitude-modulated serial IRIG B time. If the time input signal is not present, internally generated time is used. The time translator/generator places a time of year word string in the data stream every ten milliseconds, providing absolute time correlation to other data collection systems with an accuracy of one microsecond.

The time information embedded in the data stream specifies the time of each data word with a accuracy of one microsecond. The demultiplexer in Loral's 8715 processor uses the embedded time to reconstruct data time profiles reproduced from the Ampex DCRSi incremental recorder.

DATA OUTPUT

The output circuit receives the multiplexed data stream from the data bus, accepts selected word strings for output as programmed by the operator, and transmits the data to a tape recorder. During bursts of activity when data rates can exceed tape throughput rates, the output function can buffer 128K words of data without loss. During setup and checkout of the system, the operator can play data from tape and monitor the results on the Central Multiplexer data display.

CONCLUSION

The limitations of PCM on new aircraft have become substantial. New technologies use packet-oriented protocols that do not lend themselves to PCM formats and protocols. Flight test engineers need to collect data from several different buses at the same time. The Central Multiplexer solves many of the problems faced by today's flight test engineers, and offers innovative solutions that push into the next generation of flight test systems.

REFERENCES

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