24-BIT FLIGHT TEST DATA RECORDING FORMAT

H. L. Mills
K. D. Turver
Boeing Commercial Airplane Group
Flight Test Engineering
Seattle, Washington

ABSTRACT

Boeing Commercial Airplane Group's Flight Test Engineering organization is developing a new test data recording format to be used on the new model 777 airplane. ARINC 429, ARINC 629 and IRIG PCM data will be formatted for recording test data. The need to support a variety of data recorders, and three types of data, mandate the development of a new recording format. The format Flight Test chose is a variation of IRIG Standard 106-86, Chapter 8. The data from each channel is treated as a data packet, including time and channel ID, and then multiplexed into 24 bits. This allows a time accuracy of 10 microseconds and a minimum latency caused by multiplexing.

INTRODUCTION

The requirement to record many high speed ARINC 629, ARINC 429, and IRIG PCM data channels in support of testing the new model 777 airplane has resulted in a data rate beyond the capability of existing instrumentation tape recorders and ground based data systems. To add ARINC 629 data to the Flight Test Data System without a major change to the data base software, a new recording format must be developed. It must include several different types of data, real time monitor requirements, support multiple recording devices, and be easy to install and maintain on a test airplane.

CURRENT FORMATS

Flight Test currently uses IRIG PCM and a second format for recording ARINC 429 data. Both formats are recorded using six data tracks and one time track on an analog instrumentation recorder. The maximum combined bit rate of the six data tracks is six megabits per second. Time accuracy is less than 100 microseconds. Telemetry data is limited to any two of the six data tracks.

NEW FORMAT REQUIREMENTS

The recording format required for the 777 airplane test program must adhere to the following:

Digital test data recorder and instrumentation recorders.
A multiplexed data rate of 1 2 Mbits/sec. minimum.
Up to 31 channels of data.
One format for all flight test data systems.
Time accuracy of 10 microseconds.
Recording of data in increasing time order.
The selection of parameters from all data channels for telemetry.
Faster than real-time Playback on ground based data system.

FORMATS EVALUATED

Several recording methods where evaluated before the selection of a 24 bit format. The following approaches were given the most consideration.

1. Conventional PCM using commercially available multiplexers. This approach was complicated, time correlation was insufficient, the data rate was not flexible, and the equipment was large.

2. Packets made of one label word, two word-count words, three time words, and from one to 510 data words, are recorded on a PCM channel. A frame synchronization pattern is inserted at fixed intervals. Fill words are used when a packet exceeds the frame. To process data as it is extracted from the recorder it must be in increasing time order to minimize time skew between data. Due to the large packet size data is not in increasing time order. This approach does provide the best use of recorder bandwidth when six or more data words per label are recorded.

3. A 24-bit packet defines the channel, function and associated data word. This data word can contain data, minor time, status, label, frame synchronization pattern, or fill pattern. Channel zero is common to all other channels and contains major time and any other system information necessary.

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The 24-bit format (Figure 1) is similar to the IRIG Standard 106-86; Chapter 8, used to record MIL-STD-1553 data. To support 31 input channels, five bits are used. This leaves only three bits to define the function of a 1 6-bit data word.

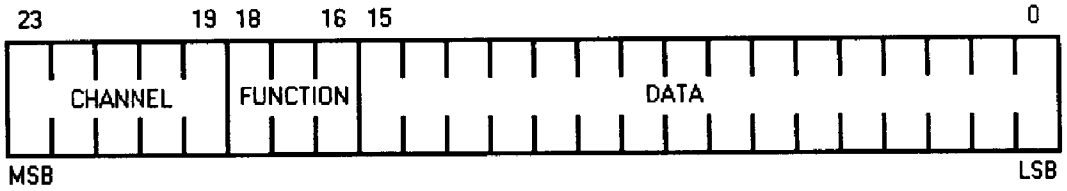

Figure 1

CHANNEL ID

The Channel ID(bits 19-23) identifies up to 31 data channels and one special function channel. Channel 0 is the special function channel and is used to record parameters common to all data channels. Some examples are Major Time, Airplane Number, Test Number, and year.

FUNCTION OF DATA

The function field(bits 16-18) define the information contained in the data field as follows:

Bit			Function
18	17	16	
0	0	0	Spare
0	0	1	Data
0	1	0	Minor Time
0	1	1	ARINC 629 Status
1	0	0	Label
1	0	1	Frame Synchronization Pattern
1	1	0	Spare
1	1	1	Fill Pattern

DATA

The Data field(bits 0-15) contain a 16-bit word defined by the Function bits and Channel ID bits. A database must be maintained to relate the Channel ID to a type of data and labels to a parameter.

TIME

Major time is recorded as a 32-bit integer divided into high order and low order words on channel zero using label zero. It identifies days of the year to a resolution of one hundredth of a second. Minor time is recorded on all channels and is relative to the last bit of the label with 1 microsecond resolution. The Minor time word is a 16-bit integer with a value of 0-9999 microseconds and is recorded between the label and first data word.

ARINC 629 STATUS

The ARINC 629 hardware sends a status word when an error occurs and the bus transmitter will truncate the data string. This status word must be included in the data string or the 24-bit decode process will interpret the short string as a recording error.

LABEL

The Label defines each word that follows it. Some labels have variable word lengths. In this case, the word after the label tells how many words follow the label.

FRAME SYNCHRONIZATION PATTERN

A 24-bit frame synchronization pattern occurs every 512 24-bit words to allow synchronization of a serial bit stream required by telemetry and continuous speed recorders. Disk drives and most digital data recorders have byte wide interfaces and do not require the use of frame synchronization patterns.

FILL

The provision for fill words is for applications that require a fixed bit rate. Telemetry and continuous speed recorders will use fill words.

MULTIPLEXING

Data sources can be organized as labels followed by a string of data words. IRIG PCM will have from 1 to 508 data words following the label. ARINC 429 will have 2 data words following a label. And ARINC 629 will have from 1 to 256 words following the label. Multiplexing these different data sources into a single data stream works like this. As each word arrives at the multiplexer it is encoded with its channel ID and Function and merged into the output data stream. This

keeps data in increasing time order. Minor time is added after each label. To find the time of any word in the multiplexed stream the word interval of that channel must be known. For example, the time of the fifth word after a label is found by combining Major time from channel 0 with the Minor time of the label and adding five times the word interval.

A limited bandwidth exists for telemetry data on an airplane. This format allows an output card in the multiplexer to select only the labels needed for telemetry and output those parameters to the telemetry hardware while a second output card is transferring all data to a recorder.

Because this format is a multiple of eight bits it can support parallel and serial interfaces. This allows the use of incremental tape drives, continuous speed tape drives, and disk drives.

CONCLUSION

This 24-bit format simplifies the recording, monitoring, and retrieval of Flight Test data. It allows a standard formatting of all types of data, supports a time accuracy of 10 microseconds, can be used for all types of recording devices, and allows the telemetry of selected parameters.

ACKNOWLEDGMENTS

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REFERENCES

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