REAL-TIME TELEMETRY OF COMPLETE 1553 DATA BUSES

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ABSTRACT

As MIL-STD-1553 Multiplex Data Bus usage proliferates, the ability to remotely monitor bus traffic has become important. Common applications include flight testing of missiles and aircraft, and the field maintenance of vehicles. Due to the high data rate and asynchronous characteristics of the 1553 Data Bus, special problems exist in the acquisition and analysis of 1553 bus traffic. The acquisition of the complete bus traffic is especially important during system testing and diagnostic operations. Several approaches are being utilized today to transmit 1553 bus traffic. The first approach is an extension of the PCM technique in which all of the bus traffic, during a specific time window, is buffered and then output in a PCM style format. This has the advantage of being synchronous, but a significant amount of bus information is lost, primarily the protocol and bus timing. An alternative approach is to transmit raw unbuffered bus traffic. Bus timing and protocol are retained, but the telemetry signal is asynchronous. A third approach, developed by Loral Data Systems in conjunction with Loral Instrumentation, is a 1553 Data Acquisition System that retains bus timing and protocol and synchronizes the signal to a common clock.

INTRODUCTION

Over the past two decades the use of digital technology in aircraft avionics systems has greatly increased, as well as the volume of data processed and distributed among various subsystems. Large parallel bus wire bundles proved to be an inefficient way of interconnecting equipment onboard vehicles and aircraft. To solve these problems, a serial digital communication bus was developed. MIL-STD-1553 describes this bus.

The MIL-STD-1553 multiplex data bus provides an integrated, centralized system control and standard interface for all equipment connected to the bus. The initial specification was released in 1973 that describes the electrical requirements and message protocol. Additional stipulations were added in 1978.

In recent years we have seen an increase in the use of 1553 buses in new aircraft designs and programs to retrofit the bus into existing systems. In addition, the application of the multiplex bus in missile and ground based hardware is common today. With this increasing application of the 1553 bus standard into more complex systems, the need to acquire and analyze one hundred percent of the serial bus traffic has become evident, particularly in the validation and test phases of a program. Also, once a system has been deployed, the information on the entire bus can be utilized for maintenance and diagnostic procedures.

Since the multiplex bus is a one megabit, asynchronous data bus, the high speed and non-synchronous nature of the bus present particular problems in the acquisition and analysis of 1553 data.

REMOTE SERIAL DATA ACQUISITION

Traditionally, data acquisition systems have been totally selfcontained, utilizing independent transducers and sensors to gather test data. However, the accuracy and quality of data which is available today in many modern avionics subsystems is equal to or greater than that which can be gathered by independent telemetry hardware. With the integration of the 1553 serial bus into the vehicle, the test engineer has been given a valuable resource to gather quality data and reduce the total cost of the data acquisition system. It is common today for PCM multiplex hardware to monitor a 1553 data bus and insert selected data into the telemetry stream. This is often accomplished in a format which is compatible with the IRIG standards and hence existing ground equipment can handle the decommutation of the data. However, in many cases sampled data is inadequate to analyze the results of the test.

Several approaches are being utilized today to transmit the entire bus. The first approach is an extension of the PCM technique, in which all of the bus traffic during a specific time window is buffered and then output in a PCM style format. This has the advantage of being a clock synchronous transmission, but unfortunately much of the information on the bus has been lost. Since there are gaps in the bus traffic that are transmitted, the bus timing has been destroyed. Although the data can be captured using standard bit sync and frame sync hardware, the decommutation and tagging of the data is a problem. Standard 1553 instrumentation can no longer be used to identify the data. Mainframe host software can be generated to process the decom output and recover the data, but the high data rate makes this a difficult real time task that is not cost effective. However, the most important disadvantage of this technique is in the quality of the recovered information. The diffusion of the 1553 bus protocol to a PCM style format could make the analysis of test data impossible and, as a result, the data is of little or no value in solving problems.

Another approach is to simply transmit the raw asynchronous bus. This straight forward and simple approach is low cost and of course preserves the bus timing and protocol. In addition, the received data can be easily analyzed with standard 1553 instrumentation. However, since the multiplex bus is not synchronized to a common clock, the signal to noise performance of this link is poor when compared with a synchronous transmission. Hence, this technique would only be appropriate for special, controlled environments.

SYNCHRONIZED 1553 DATA

Systems are available today to capture and record the entire bus. These units operate as a passive bus monitor, synchronize the 1553 traffic to a clock and record the information on a high-density digital tape system. But in many applications it is not possible to record the information on the verhicle and, therefore, the data must be transmitted to a ground station or maintenance center.

The most effective approach for transmitting the 1553 bus is essentially the same technique used to record the data. A data acquisition package monitors the 1553 traffic and synchronizes the data to a common clock. The synchronized data is then code converted to provide sufficient transitions in the data, to insure good bit synchronizer performance, and then transmitted. The received data is interfaced to a bit synchronizer and converted back into 1553 format. This serial output can then be interfaced to standard instruments for recording, protocol testing, and data analysis. This approach has the distinct advantage of preserving the basic 1553 protocol and timing while gaining the benefits of transmitting synchronous data. Loral Data Systems has employed these principals in the design of an airborne data acquisition system known as the PCM-453.

AIRBORNE SYSTEM OVERVIEW

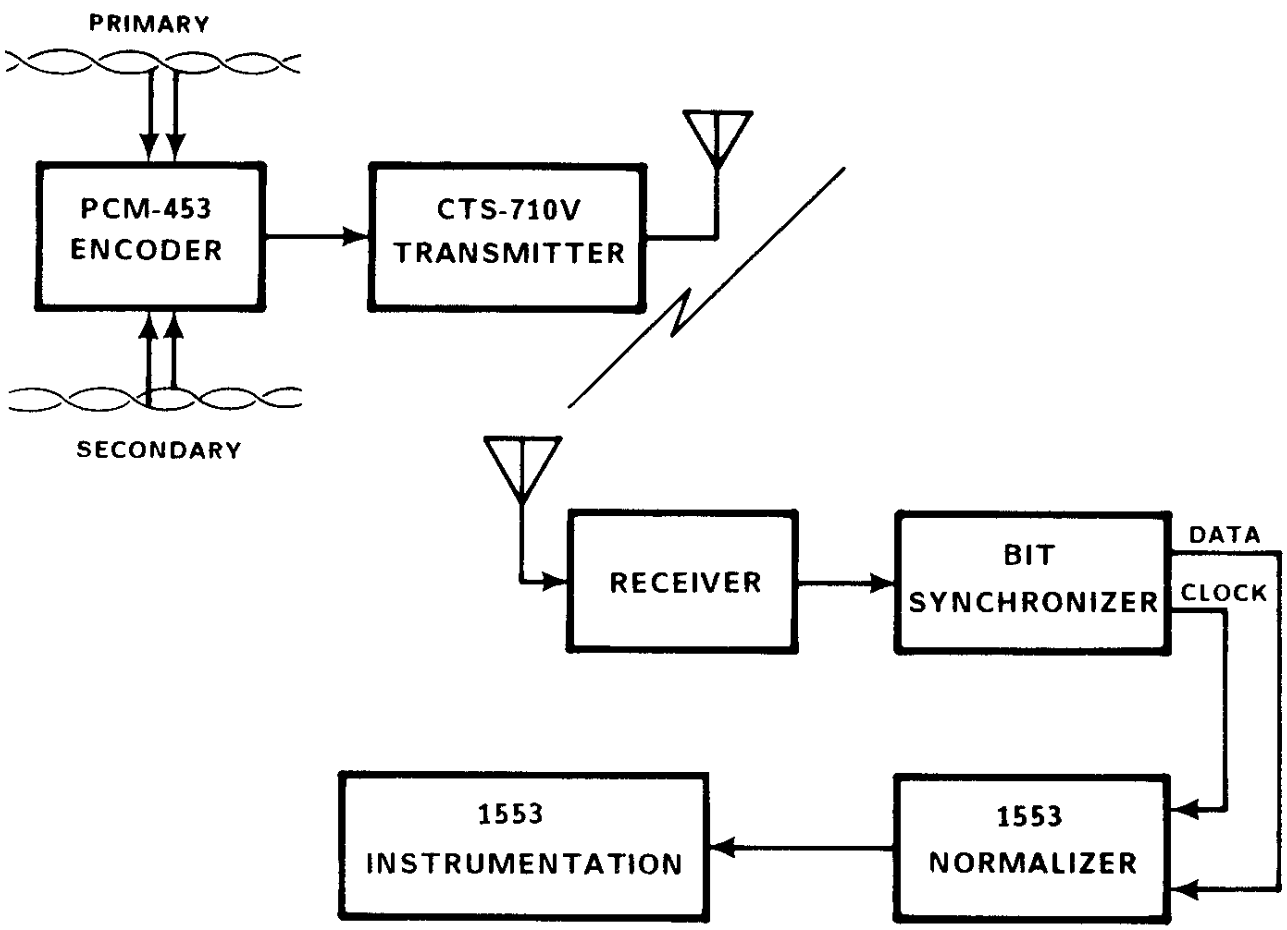
The basic airborne configuration consists of a PCM-453 Encoder with premod filter and FM Telemetry Transmitter. if necessary, optional encryption hardware can be utilized to secure the data link.

The PCM-453 transparently monitors the 1553 bus and synchronizes the data to a system clock. The output data rate is 2 Mbps with different output codes offered depending on the bandwidth available. Specifically, NRZ-L, RNRZ-L, BIO-L, and DM-M are the output options with RNRZ-L the recommended choice, because it provides suitable transition density for good bit synchronizer performance and requires a minimum transmitter bandwidth of approximately 1.5 MHz.

The PCM-453 is offered in three basic configurations. In the first configuration the Encoder continuously monitors both the primary and secondary buses and selects the active bus on a priority basis for output on a single telemetry channel. Thus, 1553 data is output from either the primary or secondary bus. In the case that both buses are active simultaneously, data from the primary bus is output.

A second configuration treats the bus data as the first configuration, but with the addition of a bus origination bit at the end of each 1553 message. This bit is set to true if the message originates on the secondary bus. The extra bit allows the decoder to identify the origin of each 1553 message and output the data on the appropriate bus.

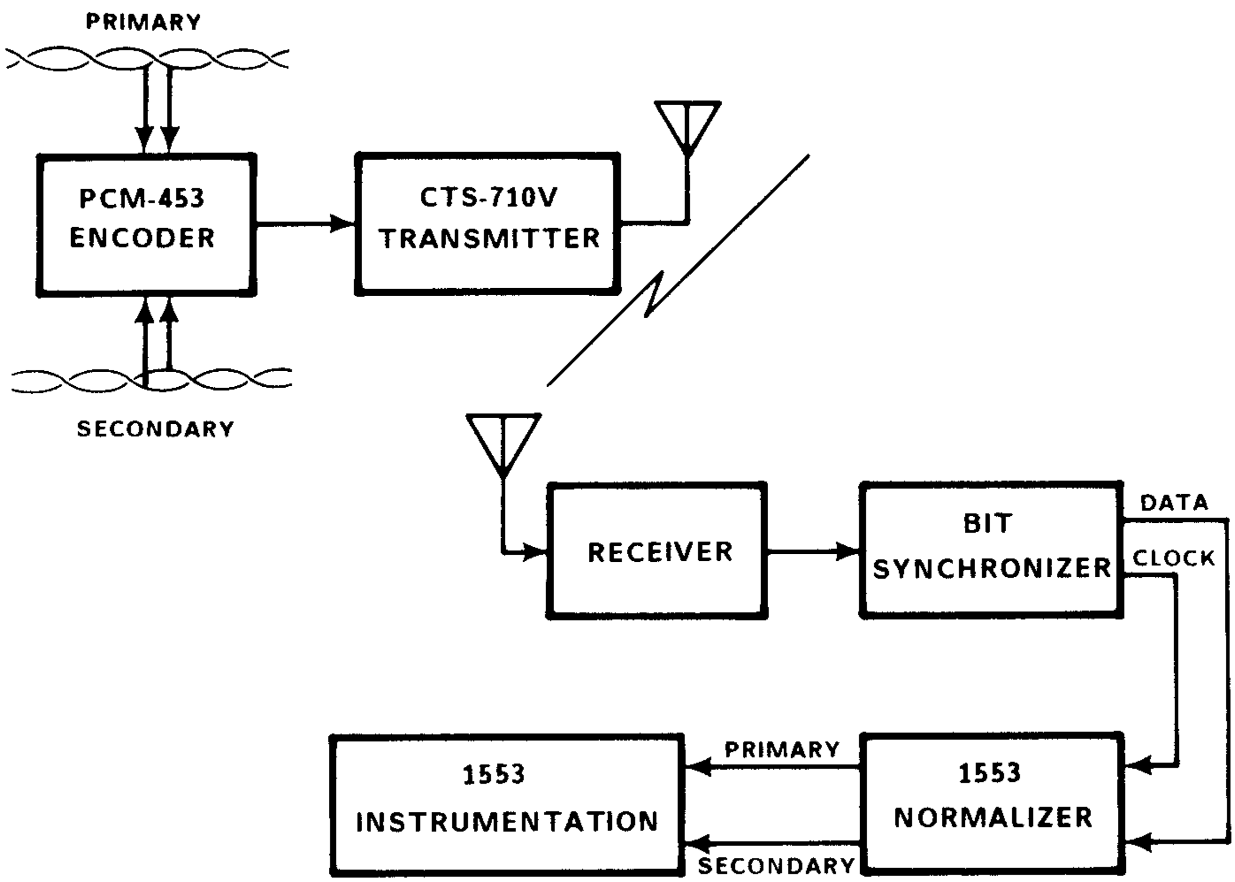
The third configuration involves the simultaneous, independent monitoring of both the primary and secondary buses. In this mode each 1553 data bus utilizes a separate transmission channel. A telemetry transmitter, with a wideband subcarrier, can be effectively used to achieve this result, or two separate transmitters may be utilized.



CONFIGURATION 1

PCM-453 encoder transparently monitors the primary and secondary bus and outputs data from the active bus. The data is treated as a 40 bit per word, 2 megabit per second NRZ-L data stream. The airborne package synchronizes the data to a common clock and code converts the information. This data stream is then used to modulate the transmitter.

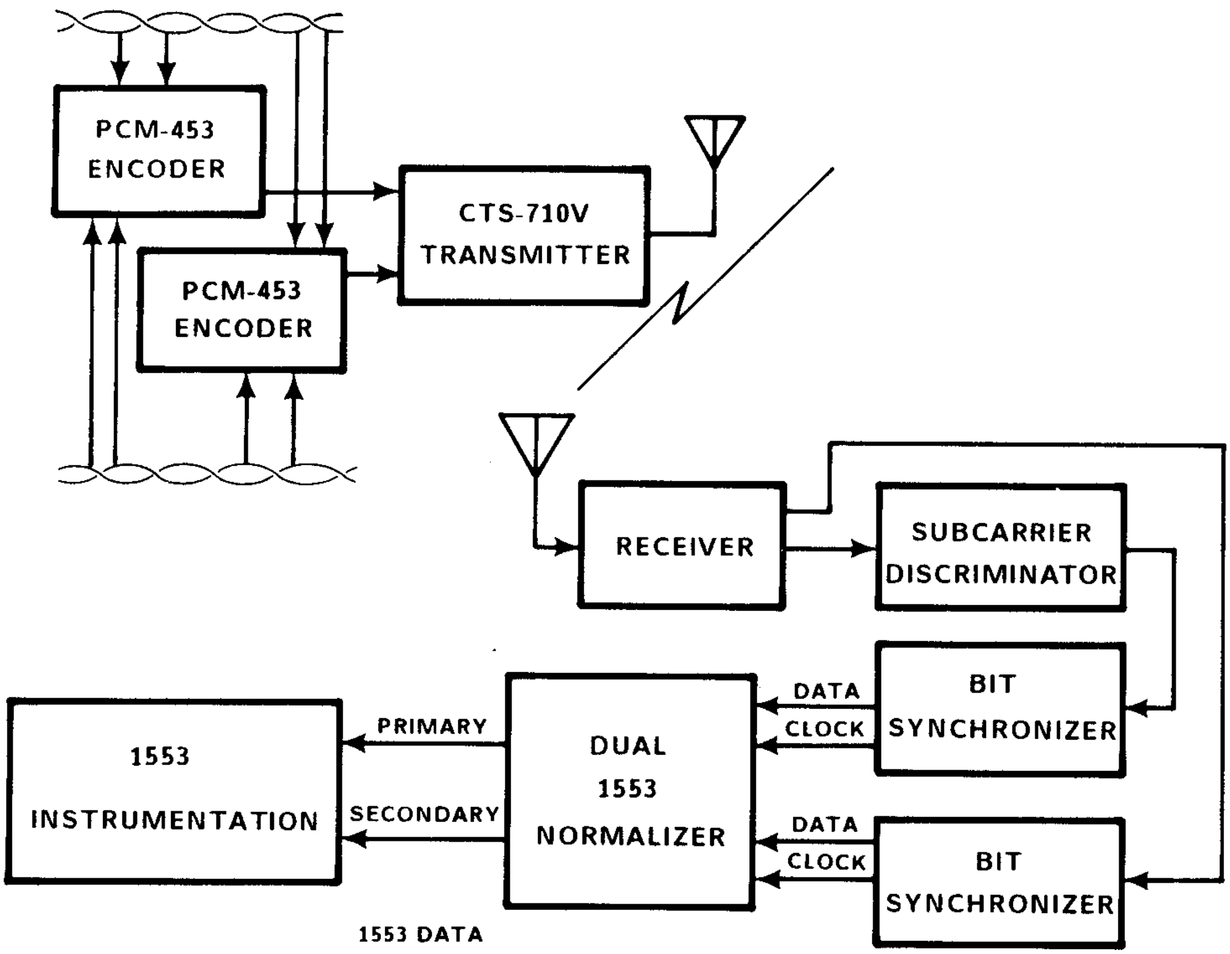
The received data is interfaced to a bit synchronizer and then converted back into 1553 data. Standard 1553 instrumentation is then available to inspect, process, and record the data.



CONFIGURATION 2

The PCM-453 encoder transparently monitors the primary and secondary bus and outputs the data, with the addition of a bus origination bit at the end of each message.

The extra bit allows the decoder to identify the origin of each message and output the data on the appropriate bus.



CONFIGURATION 3

Two airborne units are used to continuously monitor the primary and secondary buses. A telemetry transmitter with wideband subcarrier is used to output the data.

The dual decoder receives the independent data streams and clocks from the receiver/discriminator and bit synchronizers. The complete primary and secondary bus activity is then output for evaluation.

SYSTEM PERFORMANCE

Perfect conditions cannot be assumed in an operational environment. Excessive noise, environmental conditions and hardware failures can affect the bus operation. These conditions are difficult to detect unless the telemetry system is determined by how accurately the bus can be analyzed. In both the sampling and reformatting techniques, the bus timing and protocol are destroyed. By using the PCM-453 to monitor the traffic, the basic bus timing and protocol are preserved.

The bit error performance of the telemetry link is another major aspect that must be addressed. The bit error rate probability is substantially enhanced by synchronizing the asynchronous 1553 data bus, which translates directly into usable telemetry range.

GROUND INSTRUMENTATION

After the serial stream has been received and converted back into 1553 data, the information can be interfaced with standard 1553 instrumentation to record, examine and analyze the data. In January of 1980, Loral Instrumentation was contracted by the Systems Engineering Avionics Facility at Wright Patterson Air Force Base to develop a bus tester and analyzer to certify equipment compliant with MIL-STD-1553 A/B. The system was called Bus Tester IV and is sold commercially as the Serial Bus Analyzer (SBA 100). The SBA can simulate up to 32 remote terminals and the bus controller, as well as capture specific bus traffic. The system not only simulates normal activity, but can also create the full set of abnormal bus activity; introducing up to 17 error types and detecting these error conditions in actual bus activity. Thus, when interfaced to the received 1553 data, the SBA can monitor and examine the 1553 bus in the protocol domain.

In October of 1981, Loral Instrumentation introduced the Advanced Decom System (ADS 100) to address the real-time acquisition, processing, and distribution needs of the flight test community. The system is based on a bus structured, distributed processing architecture that currently has over 55 major assemblies and product options available. Realizing the need for 1553 data processing hardware, Loral Instrumentation recently developed a set of modules consistent with ADS data flow architecture to acquire 1553 data. These modules allow the user to apply the extensive processing and distribution capabilities of the ADS to 1553 data streams. The resulting system is known as the Serial Data Processor (SDP 100). Our objective is to give the SDP similar capabilities to a telemetry ground station and operate on the 1553 bus in the data domain. The functions of bit synchronization and normalization of the 1553 signal are included in the SDP system.

APPLICATIONS

The first application obviously is in the test phase of a development program. The PCM-453 can be utilized in place of or in addition to a standard PCM data link to send information to a ground station. Real-time processing, display, and storage of test data will be handled by a Serial Data Processor network.

In an operational scenario, the link can be utilized to maintain equipment in the field. Maintenance personnel and instrumentation can support vehicles deployed in the field from a central location. Diagnostics can be accomplished at the maintenance center on the information received via the 1553 telemetry link and coordinated through existing voice channels. Both the Serial Bus Analyzer and Serial Data Processor can be employed by maintenance personnel to diagnose any malfunctions. Once identified, maintenance personnel can guide field operators through removal and replacement of spares or dispatch the proper equipment from a central repair site. The concept is aimed at providing the maximum deployment of systems in the field.