AN OPEN ARCHITECTURE FOR MULTIPLEXING AND PROCESSING TELEMETRY DATA

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INTRODUCTION

Increased availability and falling prices now make modern high-speed digital recorders the ideal replacement for older analog recorders. Additional benefits include increased accuracy and reliability, as well as higher storage capacity, lower cost of media, and easy-to-use cartridge tapes.

Many applications require a method to multiplex multiple data sources in order to replicate the analog recorder's multiple track acquisition capability. High-speed multiplexing of multiple streams of synchronous data presents technical issues involving channel timing during data demultiplexing and reproduction. This paper will address this multiplexing/demultiplexing function as well as the ability to multiplex and record within a data analysis and display environment.

APPLICATION

Until now, approaches to high-speed multiplexer designs involved the use of proprietary multiplexer data formats, and the need to use expensive ground equipment to properly demultiplex the data prior to analysis. This paper discusses a new approach to capturing high-speed, multi-channel data in an open architecture, computer readable file format. The system described is the Intelligent Multiplexer (IMUX™) developed by VEDA SYSTEMS.

ARCHITECTURE

The architecture shown in the figure is a dual PCM stream configuration with a SCSI CD drive interface. Two PCM streams and time are multiplexed together over the high speed GME bus then sent over VME to a local 200 MHz processor with SCSI control (with the recorder I/O module). This processor provides the SCSI I/O interface, as well as performs data processing for display and analysis using Veda Systems' OMEGA Toolkit™ software.

For the purpose of this paper, the SCSI architecture will be used.

Other architectures are available, including a high speed DCRsi or VLDS interface. In these higher rate configurations, the VME bus would limit the data rate to tape, so IMUX includes a high speed Recorder I/O module that provides the interface between the GME bus and the specific recorder interface.

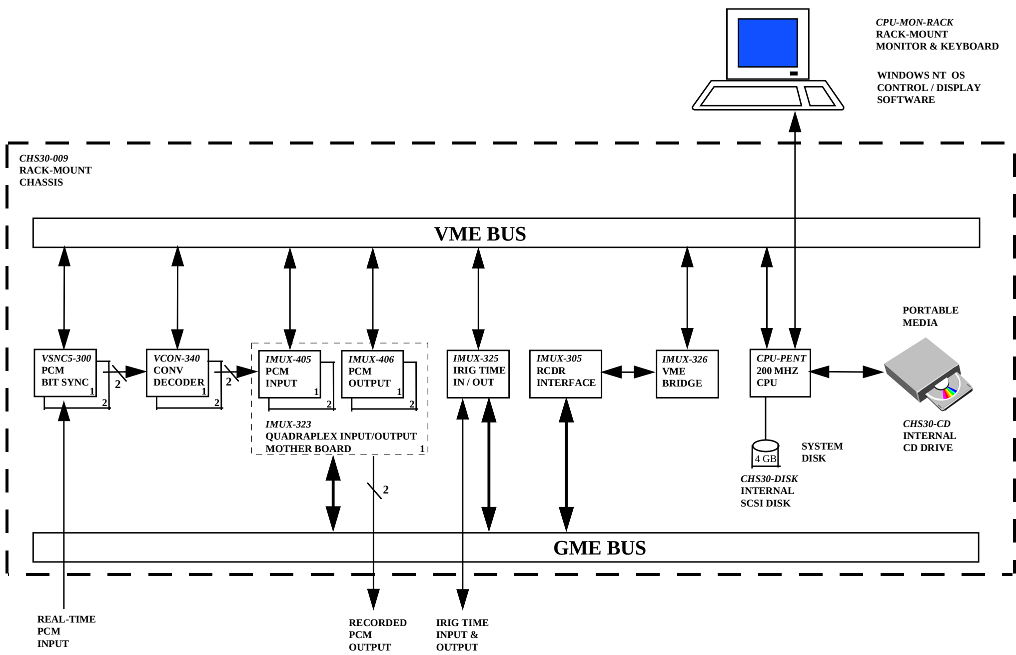
The IMUX platform supports any mix of data inputs. Up to sixty channels of analog, serial, parallel or message data may be input and multiplexed to an aggregate rate of 512 Mbps. IMUX data reproduction accuracy is extremely high, with selectable timing resolution better than one microsecond. IMUX provides the capability to output simultaneously all or selected channels to one or multiple recording devices through standard computer buses (SCSI) as well as other standard parallel interfaces such as DCRsi and VLDS.

IMUX provides high-fidelity reconstruction for individual channel timing and signal characteristics if required, but also allows immediate access to data parameters without the need for traditional demultiplexing and data reconstruction. IMUX stores data in a flexible computer readable file format. The IMUX archive format was designed for ease of reading and processing by any computer system. It is fully documented and is non-proprietary. This data can be read directly from tape and processed. Other formats, such as the newly defined standard based on CCSDS, are also supported by IMUX.

The IMUX hardware multiplexing function is based on our existing Series-30/OMEGA™ telemetry processing system architecture. Both products use the standard 6U VME module format. The same high-speed data bus used for multiplexing and transferring real-time data in our Series-30/OMEGA is also implemented in the IMUX architecture. This data bus is capable of transferring data at rates up to 128 MBytes per second, and is implemented on the user definable VME pins as described by VME bus standards.

IMUX I/O modules were designed using a common carrier module for all input types. This module has a standard 6U VME format. Customizing the system involves selecting various I/O modules which plug into the carrier module. This carrier module is referred to as the Quadraplex board and each one provides mounting areas for up to four I/O modules. Personality modules currently available include PCM, 1553, ARINC 429/629, analog, and discrete input and output modules.

Systems are then configured by selecting the number of I/O signals, desired I/O type, and recorder type.



ITAS SERIES-30 / IMUX BLOCK DIAGRAM

The primary functions of the Quadraplex board are to accept data as provided to it by the personality module and transfer this data to the high speed GME data bus during recording. During playback, the Quadraplex receives data from the high speed bus and delivers it to the personality module. This transfer is done in 16- to 40-bit transfers (depending on the data type), of which 8 bits are stream ID, and the remaining 8, 16, or 32 bits are data. The GME bus is a clock driven data bus running at 16 MHz. Arbitration and data transfers over the data bus are accomplished on a clock-cycle basis. Multiple devices transferring single parameters over this bus, with the bus requests being granted every cycle, provides an inherent data multiplexing function over this GME bus.

DEMULTIPLEXING ACCURACY

Statistical multiplexing of this kind does present some technical challenges with respect to demultiplexing. These types of issues are normally not as technically complex in other demultiplexing systems, such as voice multiplexers used in standard telecommunications systems, in which errors and minor skewing of data are not catastrophic. They do, however, become an issue in telemetry systems where time correlation between data steams and low bit errors is important. The IMUX design includes some very advanced demultiplexing methods to reconstruct the original signals with minimum inter-channel skew. This is done as follows:

The 16 MHz GME bus timing is used to derive the one microsecond time stamp used to time stamp the data file. This time is interlaced with the data transfers over this data bus and stored to the recorder device the same way. This data flow from the GME bus to archival device is a multiplexed parallel data stream that includes data, ID tags and time with microsecond accuracy. Individual data bandwidth is not fixed, therefore higher rate data will have more samples than lower rate data in any given time period.

During playback and data reconstruction, the data is read back by the processor and transferred to the Recorder I/O (RIO) board via the VME bridge module in the SCSI architecture. In other architectures, the RIO module receives data through its recorder interface. The RIO board has adequate buffering to allow for some elasticity in the read back function. In addition, the RIO board has control lines used to increase or decrease data flow from the recorder device based upon buffer fullness.

During playback, data is received by the RIO board. It locates the first time word from the tape, and sends it along with the data located between the first time word and the next time word over the GME bus to the appropriate modules. The RIO board has its own unique timing circuit which includes a microsecond counter. Using this counter, the RIO will synchronize its internal microsecond clock to the flow of time words from the recorder - releasing blocks of data between microsecond time stamps back onto the high-speed bus at exactly one microsecond intervals. The data between time stamps then hits the GME bus at the same microsecond rate that it was recorded. Thus, the initial stage of data smoothing takes place on the RIO card. The data flow to the GME bus is relatively smooth and closely resembles the original data flow as it occurred in real time. The second stage of smoothing takes place at the output cards. The output cards have some level of data buffering at the input and include a clock generator that is selected to clock the data out at the appropriate rate.

The interchannel skewing error introduced by the IMUX for PCM data is 40 bits, +/- 1 microsecond over the input range.

AN INTEGRATED APPROACH

As a result of using the Series-30/OMEGA telemetry processor architecture as the basis for the IMUX architecture, we can now offer many features not normally found in multiplexer recorder systems. Veda Systems has invested many years in the development of its core telemetry products. One such product is our OMEGA Toolkit™ processing, analysis and display software. Many features of this software are now available for use in an IMUX recording system.

One such feature is the Series-30/OMEGA software decommutation function. This function allows data to be read from the tape, decommutated, and processed using a standard COTS EU processor and the OMEGA Toolkit front-end processing software.

The ingestion of PCM data through a PCM input module mounted on a Quadraplex module is done by encapsulating the data into 32-bit words and transferring this data over the bus with an ID tag. This encapsulation is done with no attention given to word boundaries of the telemetry format, as opposed to a conventional hardware decommutator which performs a similar serial to parallel conversion, but does account for the word boundaries of the telemetry format. This encapsulated data is then transferred over the high speed data bus for output to a storage device.

Since the Series-30/OMEGA also uses this same data bus for high speed transfers, it's possible to transfer this IMUX acquired PCM data to a COTS processor, where this software decommutation and processing can be performed in real time. This means the Quadraplex module with PCM plug-in cards can now serve a dual purpose, in that it not only serves as the IMUX input module for recording the data, but also replaces a hardware decommutator card in an analysis system. Since OMEGA provides a method to read the GME data and feed this data into the OMEGA processing engine in real time, the ability to perform real-time display and analysis exists during the recording sessions, as well as post test from tape.

Users may now record data to tape and playback the digital data directly into this processing engine for display and analysis. There is no need to reconstruct (demultiplex) the original data streams and feed them through a telemetry front-end hardware suite.

The advantages are tremendous. Typical post analysis involves moving a tape to a demultiplexer or reproduce recorder, playing the data back and directing the data to a telemetry processing system. IMUX allows the user to simply move a cartridge tape from the recorder to a stand-alone workstation or processor for direct data access and analysis, obviating the need for a dedicated hardware suite of demultiplexers and front-end equipment for this post analysis function.

Although the OMEGA software decommutator was intended to provide the Series-30/OMEGA with a low cost decommutator capability in a telemetry processing system, we felt initially that software decoms could replace hardware in some systems with low data rates, with higher-rate systems still requiring a hardware decom function. Since the software decommutator was introduced three years ago, the processing rates of COTS processors used for decommutation have increased to the point where a single processor can now ingest, decommutate, and

process a stream of data up to a rate of 5 Mbps. Future advancements in COTS processors are sure to increase this rate.
The common IMUX and Series 30 form factor and bus structure means these two products can be combined in a single chassis for an integrated multiplexer recorder system with full analysis and display capability. For users with both requirements, this can greatly reduce card count and lower their system cost.

OMEGA software in a recording system will provide the following real-time and post analysis capabilities:

- Engineering unit conversion
- Derived parameter processing
- Application support through real-time data hooks
- Data compression
- Number conversion
- Limit/Alarm checking/notification
- Data logging
- Data display, including strip chart, bar chart, tabular numeric, and full Dataviews
- Network data distribution
- Local disk archive

In addition to real-time and post test processing, the use of software decommutators for acquiring and processing the multiplexed data opens many other doors for telemetry processing systems. Once there's no longer a need for retaining the synchronous attributes of PCM data for processing this data, as with hardware PCM decommutators, telemetry data can also be transferred to the processing engine in many ways. Data can be encapsulated in TCP/IP packets, ATM cells, standard disk files, and many other storage and transmission formats. Telemetry data can now enter the vast world of network data distribution and true distributed processing using COTS products.

This concept has been demonstrated by using a prerecorded disk archived file, and through TCP/IP socket connections, this file was read from disk on one computer, transferred to the soft decommutator through a network TCP/IP socket connection, and processed and displayed with OMEGA software.

TECHNOLOGICAL FALLOUT

Although the original IMUX design was intended to address the data recorder market--primarily to replace analog recorders--the product was then taken a step further by integrating the recording and processing environments into a full recording and analysis product. Use of standards in the system design also provides a complementary use for other technologies which can now be implemented into IMUX. Specifically, the introduction of high-speed networks for telemetry data transfer and public network distribution.

Through the use of available COTS network products, this same multiplexed data stream that is stored to an archival device can also be transmitted to standard network formats such as FDDI, T1, T2, DS-3, and ATM. Data can be captured at one location, multiplexed together, and transferred over the public network for distribution in real time to other locations around the world.

Once distributed to remote sites, the data can be processed using OMEGA Toolkit software. OMEGA Toolkit processing software is POSIX compliant, and can be installed on most platforms at these remote locations for ingesting the distributed data, and processing and displaying this data. Currently we are delivering the OMEGA Toolkit processing and display software on DEC, HP, SGI, Sun, and Pentium NT platforms.

As software decommutators are perfected by numerous vendors, and data analysis and display capabilities advance, the end users at remote areas will have many options to implement their own analysis system through the use of COTS software products and will no longer have their analysis requirements driven by the supplier of the data product.

One such product is currently under design. Veda Systems is under contract to deliver multiple IMUX units with a standard T2 telecom data link in lieu of the standard tape interface. These IMUX units will be used to transfer multiple streams of PCM telemetry launch data and time around the Kennedy Space Center and Patrick AFB.

CONCLUSION

The IMUX architecture provides applications beyond data multiplexing and recording. IMUX can be used in conjunction with VEDA SYSTEMS OMEGA Toolkit software for post-test data processing, and real-time recording session processing and display. OMEGA Toolkit is a full featured UNIX or Windows NT software suite that provides software decommutation of recorded data, as well as extensive graphical display and analysis tools. Tools are provided in the software so that users can access and process the data with their own or third-party software tools, providing true open-architecture flexibility.

As telecommunication products in the high-speed public network evolve, IMUX will also evolve into a high speed telecommunications device for public network distribution of telemetry data.