The Continuing Evolution of Strip-Chart Emulation Software

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Abstract: The telemetry strip-chart recorder is evolving into a software-based visual display system. The challenge is to emulate the inherent capabilities of the strip-chart recorder while producing intuitive application software. The latest systems employ standard data protocols and include advancements in real-time visualization, data recording and peer-to-peer messaging.

Keywords: strip-chart, visual display, data recording, recorder

Introduction

The strip-chart recorder, for many decades an essential piece of telemetry instrumentation, is gradually being replaced at many facilities. Although the requirement for a continuous graphical representation of data has not changed, the medium on which it is represented has. Traditionally, waveforms were recorded on moving chart paper which was collected and analyzed at the end of a test. Many of these strip-chart recorders were controlled individually by flight test engineers or other operators using front-panel controls. The user interface was primarily made up of knobs, buttons and switches

Today's telemetry facilities are fast evolving into "glass rooms" where displays, keyboards and pointing devices are the user interface to the telemetry system. The latest generation of telemetry strip-chart recorders are well suited for this glass room, having large displays and touch-panel user interfaces themselves. However, the actual paper recording method is becoming less desired as a primary method of recording. Many facilities have turned to strip-chart recorder emulation software as a means of fulfilling the user requirements for time-plotted data.

A Continuing Evolution

The traditional strip-chart recorder has evolved over recent years into today's telemetry recorder-workstation. These instruments not only perform the traditional strip chart functions, but offer the flight test engineer a complete data collection and review workstation. They also offer complete customization of the data viewing and printing and also allow the user to define the control interface. Network interfaces allow it to be an integrated component of a larger telemetry system.

While the telemetry recorder-workstation is a fundamental piece of instrumentation, the display and visualization functions have taken on an even greater role in the modern telemetry facility. This has led to the development of strip-chart emulation software. There are different implementations of strip-chart emulation software. Some are basic and meant to be add-ons to existing telemetry software. The more advanced applications provide a realistic replication of an actual strip-chart recorder. The latest software applications have been developed in conjunction with the requirements and feedback of the telemetry community.

One of the critical advancements in technology that makes this type of software possible is the increased processing capability of the PC/workstation. Tasks that were once delegated to proprietary hardware such dedicated microcontrollers or DSPs can now be performed by the PC's main CPU. For strip-chart emulation software, the CPU can now perform min/max algorithms on incoming data, manipulation of scaling factors and interfacing to the display controller for real-time scrolling of waveforms.

A main benefit for telemetry facilities is that the strip-chart emulation software is an ideal fit for the "glass room". This type of installation utilizes high-end PC's and workstations along with the latest in display technologies in order to provide instant and timely information to the flight test engineer or other telemetry personnel. These rooms provide the ability to run several applications such as strip-chart emulation software, interactive display systems, and real-time video simultaneously. One console can now serve as the complete interface for the user.

Emulating the Strip-Chart Recorder

The goal for many telemetry installations is to provide a realistic replication of an actual strip-chart recorder. A typical example of a segment of the display can be seen in figure 1.

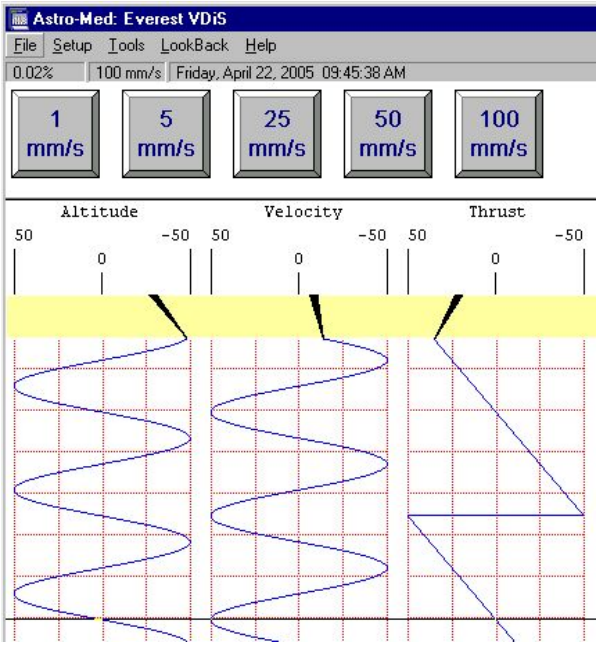

Figure 1: A segment of the strip-chart emulation display

The display includes real-time waveforms, grids and annotation similar to what can be seen on a paper chart. The waveforms are displayed in the traditional "waterfall" format - as if paper were being printed – which is the default telemetry visualization format. The default color choices match a traditional strip-chart recorder, but can easily be changed to suit a particular application or preference. Each channel can use a different color, for example, and the color of the waveform can be set to change based on the signal exceeding a pre-defined threshold. Grids can also be chosen to have various widths, number of divisions and colors. The design of the software is such that different tests or missions can easily utilize different display formats.

One of the most vital aspects of the strip-chart recorder in telemetry use was the ability to see the pens move so that the operator can react to an problem immediately. The latest strip-chart emulation applications include pen-tip simulation for precisely viewing the real-time point of writing. As seen in figure 1, the pens for each individual channel can be clearly viewed in real-time.

The design of the human machine interface is also an area of importance for emulating a strip-chart recorder. While traditional menu-based interfaces serve well for pre-mission setup, the user interface should consist of icons and software buttons that instantly perform their programmed function. The use of touchscreens was also a factor in the development of the user interface, as many installations are making use of this intuitive pointing method. The latest applications today offer users or facilities the ability to define different sets of on-screen controls in order to have a user interface that is application or test specific. Figure 2 is an example of a customized control panel.

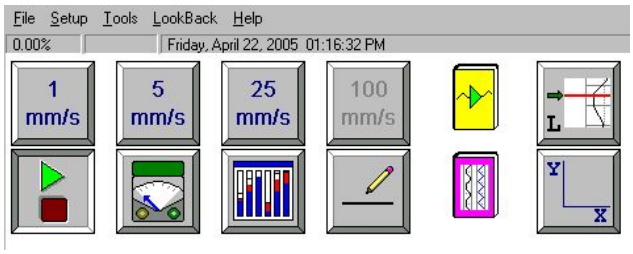

Figure 2: A customized control panel

Advancements have also been made in strip-chart emulation with the addition of customized overlay templates that can be superimposed on a scrolling chart. These are often used by flight test engineers to determine thresholds and other areas of interest based on their specific criteria. All of these features make the strip-chart emulation software a viable replacement for the legacy pen recorder.

The latest visual display software also has a "lookback" recording method where the user can review previous data that has already scrolled off of the display. This is analogous to being able to look back through a paper chart that has already been printed on a traditional strip-chart recorder. Figure 3 provides an illustration of this capability. The software keeps a running archive of previous data on the workstation hard drive that can be accessed at any point. Cursors can be used to make amplitude and timing measurements.

An additional benefit of the LookBack capability is that this data can also be reviewed after a test, facilitating post-mission analysis. Data files collected from a test can be also be stored for review at a later time. These files can also be sent to others interested in the outcome of a test.

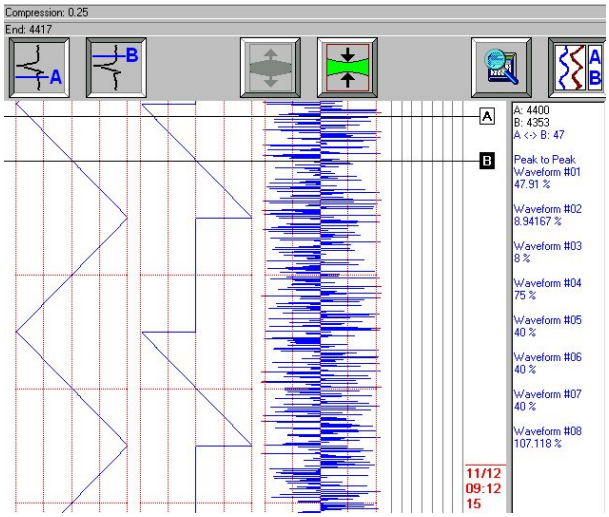

Figure 3: LookBack data review capability with cursors

Network Communications

One of the most important aspects of strip-chart emulation software is that it makes use of standardized interfaces and data protocols for communication. Unlike the venerable strip-chart recorder – which used analog inputs for data I/O – the latest visualization applications take advantage of the ubiquitous network interface. The Ethernet interface (10/100 BaseT) and TCP/IP protocol, established in almost all telemetry facilities, is utilized for both data and command communication. In addition, this network connectivity supports other protocols used for file transfer (FTP) and peer-to-peer communications. Figure 4 illustrates the different uses of Ethernet by the latest strip-chart emulation applications.

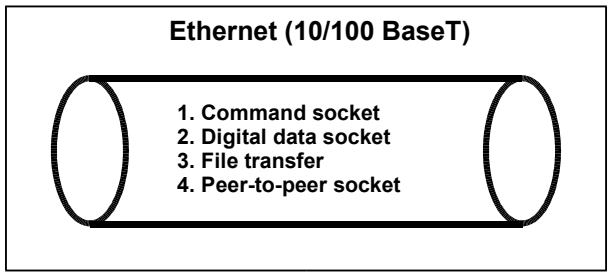

Figure 4: Uses of Ethernet for strip-chart emulation software

A higher-level data packet protocol is used to transmit data to the visual display software. This protocol is also used on current generation telemetry recorder-workstations and is quickly becoming a standard in many telemetry facilities. The protocol is also being implemented in dedicated network printers designed specifically for flight testing. The digital data packet protocol is optimized for strip-chart recorder data. Historically, thermal array telemetry recorders use a min/max algorithm on digitized data in order to reproduce a waveform on a chart. This algorithm was based on the fixed print cycle of a thermal printhead. Regardless of how fast the analog waveform was digitized, a min/max pair was derived for a given print cycle. In the latest strip-chart emulation software, the data to be displayed is also sent by the host using this method.

The min/max method requires the host to send line segments based on the minimum and maximum waveform values for a slice of time, or ΔT. The value of ΔT depends on the emulated chart speed of the display. The signal sample rates are set by the host in order to maintain the required bandwidth. By selecting an effective chart speed, the host can calculate a rate at which min/max pairs of data must be sent to the visual display software. The impact of transmission delays is minimal because the line segments are built in the host using a fixed time period that the strip-chart emulation software also uses to control the rate of the waveform display. The min/max method also offers the advantages of reduced bandwidth and glitch capture. The data packets containing the line segments can also include timing marks, an IRIG time stamp and grid information that provide the host with advanced control over the waveform display.

As a networked application, visual display software can also offer a telemetry facility the advantage of P2P communications between many different workstations. Using industry standard P2P technologies, the visual display software can communicate with other applications on the network. One capability is workgroup control where one user can coordinate and control multiple strip-chart emulation systems in a telemetry facility without the need for a host server. Chart marking, also known as highlight marking, is of specific importance to flight test engineers as they often need to mark an event as it occurs in realtime. The advantage of P2P in this case is that any other networked workstations running the visual display software will also be marked at the same time and location. Instant messaging, another P2P capability, can be used to facilitate communication between consoles during a mission.

Conclusion

The advances being made in strip-chart emulation software are a result of the changing needs of the telemetry community. Today's solutions fulfill the requirement for a software-based visual display solution with network connectivity. The similarity to traditional strip-chart recording systems make these applications intuitive to the end users and straightforward to implement in a telemetry installation. The added benefits such as peer-to-peer communication during a mission and post-mission data review and analysis make strip-chart emulation software an important tool for the modern telemetry facility.

Glossary

PC: personal computer
DSP: digital signal processor
CPU: central processing unit
I/O: input/output
TCP/IP: Transmission Control Protocol/Internet Protocol
FTP: File Transfer Protocol
IRIG: Inter-Range Instrumentation Group
P2P: peer-to-peer