Telemetry Recorders and Disruptive Technologies

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Abstract

Telemetry data recorders are not immune to the effects that a number of disruptive technologies have had on the telemetry industry. Data recorder designs today make use of data buses, storage types and graphical user interfaces that are constantly evolving based on the advances of personal computer and consumer electronics technologies. Many of these recorders use embedded designs that integrate disruptive technologies such as PCI Express for realtime data and signal processing, SATA interfaces for data storage and touchscreen technologies to provide an intuitive operator interface. Solid state drives also play a larger role in the latest recorder designs.

This paper will explore the effects of these technologies on the latest telemetry recorders in terms of the benefits to the users, cost of implementation, obsolescence management, and integration considerations. The implications of early adoption of disruptive technologies will also be reviewed.

Introduction

Telemetry data recorders are designed with a combination of established and leading-edge technologies that offer the telemetry community a versatile platform for the recording of data. Over time, however, even the most innovative of designs fall victim to the ever-changing technologies driven by the personal computer and consumer electronics industries. Many of these changes can be considered disruptive technologies.

A disruptive technology is one that improves a product in unexpected ways. More importantly, it is an innovation that can cause an upheaval for a particular market. Classical examples include the telephone or personal computer. In an effort to use the most modern and innovative designs, telemetry recorders utilize leading edge technologies that often fall into the disruptive category.

A Look at Telemetry Recorder Architectures

Telemetry data recorders were once known as "strip-chart recorders" due to the nature of the recording medium which was a continuous strip of paper on which signals were printed. The earliest recorders were galvanometer-based instruments. The microprocessor and the thermal array printhead were the main disruptive technologies behind the revolution in telemetry recording over 20 years ago. Today's telemetry recorders are open-platform devices where the digital data is stored electronically for the user to visualize, analyze and print if necessary.

The early microprocessor-based architectures of these telemetry recorders relied on dedicated electronics designed for specific functions. These functions included the signal conditioning of analog data, digital signal processing, bus management, user I/O, data storage, and print-specific functions. A typical block diagram is as follows:

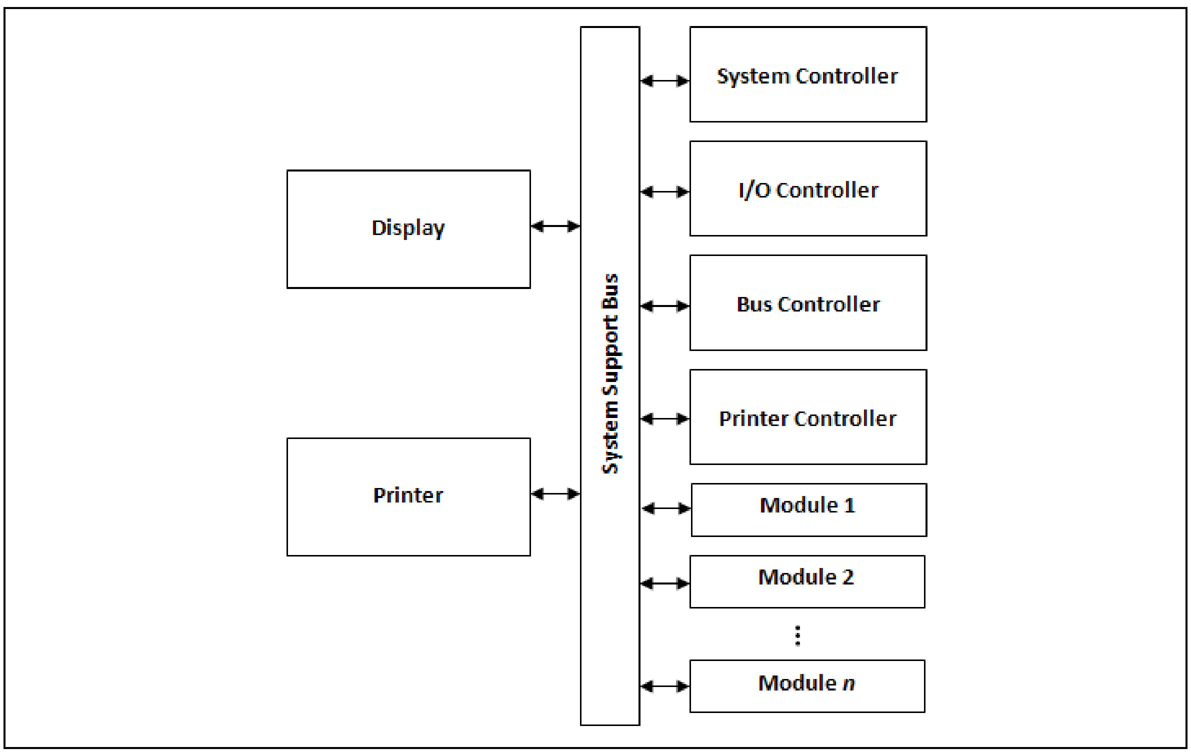

Figure 2: Block diagram of an early telemetry recorder design

The design of the modern telemetry recorder replaces many of these dedicated controllers with embedded PCs – or single-board computers (SBC) – that serve as the main system controller. This system controller is connected to a proprietary data acquisition controller A typical block diagram is shown below.

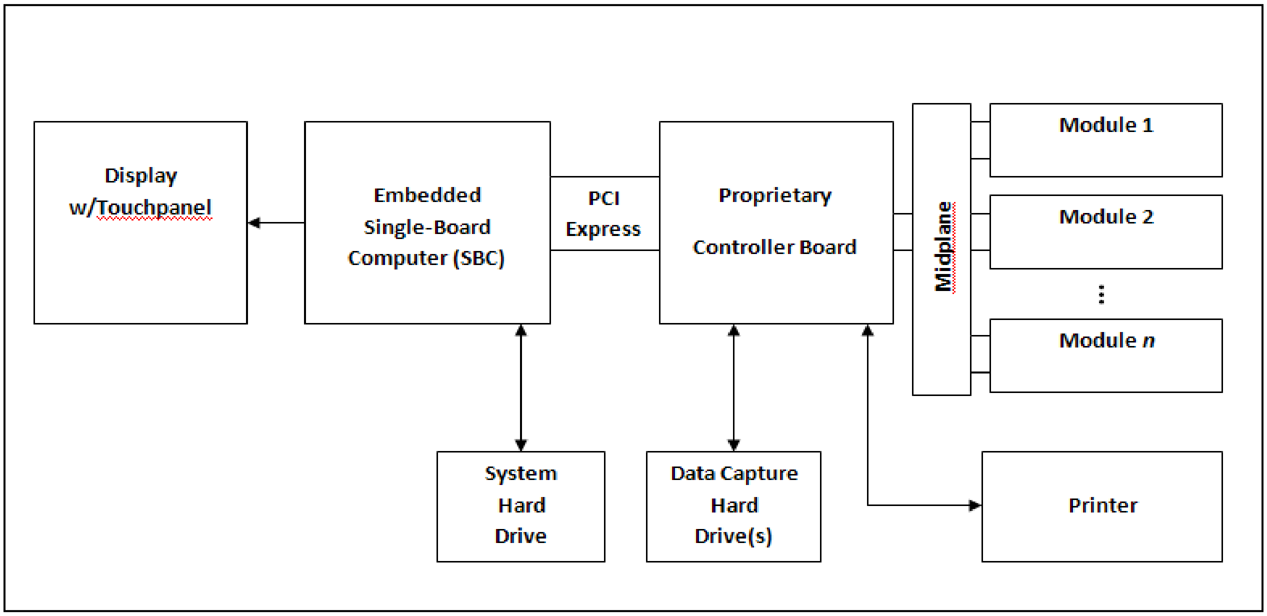

Figure 2: Block diagram of a current telemetry recorder design

There are many benefits to using an embedded design such as standard form factors, wide availability of suitable vendors, scalability, and a natural upgrade path for existing designs. The main drawback to the embedded design is the likelihood of a disruptive technology changing the basic system design. This is especially true of the communication interface between the embedded SBC and the data acquisition controller as well as the interface to the storage medium.

Disruptive Technologies

There have been many innovations in signal processing, recording technologies, data busses and drive interfaces that have proven to be disruptive to the design of the telemetry recorder. Because the designs today rely on the embedded SBC industry – which can change quickly based on technology advances – the telemetry data recorder is more susceptible to these disruptive technologies than previous generations of systems were.

The following sections focus on some of the innovations that have affected the telemetry data recorder.

PCI Express

One of the major design choices in the telemetry data recorder is the data link between the SBC and the proprietary controller board. Recorder designs have evolved from using SCSI to USB 2.0 for this communication. The latest product designs, however, utilize PCI Express (PCIe) for this interface. PCIe can be considered a disruptive technology due to the nature of the interconnect to the SBC.

PCIe was originally specified by Intel in 2004 as a new expansion card interface for PCs. A key reason for this innovation is that the older PCI interface was being taxed by graphics controllers and other devices in the traditional PC and more bandwidth was needed. PCIe is a high-speed serial interface, with up to 16 lanes for data links. Each lane is capable of a data rate of 250MB/s (v1.0). A 16-lane interface can transfer 6.4GB/s.

The PCIe interface is ideal for telemetry recorder designs, where moving large amounts of data quickly is crucial. The disruption occurs because of the different physical and interface characteristics of PCIe that required the redesign of the SBC and data recorder controllers.

Serial ATA

Another disruptive technology for the telemetry data recorder is the Serial ATA (SATA) interface. Telemetry data recorders rely on hard drives on which to record data. The standard interface for embedded SBCs for many years was the Parallel ATA (PATA) interface. While PATA proved to be successful as a hard drive interface, its limitations became apparent as drive technology improved and the demand for bandwidth increased. PATA uses a single-ended signaling method in which signal noise became a problem at higher bandwidths (greater than 100MB/s). PATA also uses 5V signal levels, which is increasingly being phased out in favor of lower voltages for both power and cooling considerations.

SATA offers a substantial improvement over the older PATA interface in terms of bandwidth, signal integrity, physical cabling, and power requirements. SATA uses low-voltage differential signaling (LVDS) with a level of 250mV. This offers the benefit of noise reduction, improved signal integrity, and the elimination of TTL-compatible (5V) signal levels.

The SATA interface also improves on the physical cable connections required to the hard drive. Where PATA utilized a 40-pin (80-wire) ribbon cable for data, SATA uses a 7-wire cable. The SATA cable can also be up to 1 meter in length, compare to the 18-inch maximum for the older PATA standard. These changes vastly improve the flexibility in cable routing in an integrated telemetry recorder.

Solid State Storage

While solid state storage has been used for many years for airborne telemetry recorders, the relatively recent innovations in NAND Flash technology have lead to the practical replacement of hard drives with solid state drives (SSD) in ground-based telemetry data recorders. In addition, the portable telemetry recorder can now be cost-effectively ruggedized for applications that require both onboard and lab-based data recording.

The consumer electronics industry was the catalyst for the development of NAND flash-based drives. NAND technology has faster program and erase times than its counterpart NOR memory technology. NAND provides over 5 Mbytes/s of sustained write performance. The block erase times are an impressive 2 ms for NAND versus 750 ms for NOR.[1] Because of this speed increase, NAND technology was used for a wide variety of removable media such as Secure Digital (SD) and Memory Stick. The USB-based flash drive, a truly disruptive technology for the PC industry, was also NAND-based.

One of the main concerns regarding the flash-based SSD from a data recording standpoint is the fact that the solid state drive technology has limitation on the number of read/write cycles. The telemetry recorder can write data to a hard drive at speeds of up to 32MB/s sustained. This volume of data can quickly fill even large hard drives, especially when using a pre-trigger FIFO mode of operation where the data can be constantly overwritten. SSD manufacturers, however, use intelligent wear-leveling technologies that distribute data evenly over each memory block of the flash device. This increases the write endurance of the SSD to a point where the useful life of the device is several years.

Touchscreen
The first telemetry data recorder with a touchscreen user interface was introduced to the telemetry community in 2000. The touch-panel graphical user interface (GUI) made an immediate impact on how the user interacted with the instrument and provided for intuitive customization of the front panel. With the increasing emphasis on touchscreen controls found in the consumer electronics industries, the innovation known as “multi-touch” is the latest disruptive technology.

Multi-touch technology is designed to sense more than one touch on the panel. This can be used for two or more fingers to make gestures on the screen such as a pinch, rotate, or swipe. For the telemetry recorder, these gestures could be used for zooming in on particular area of interest, rotating an on-screen control, or opening/closing files. Development is being pursued on larger multi-touch panels that would allow users access to these types of controls, leading to an entirely new way in which to visualize and analyze telemetry data.

Adoption of Disruptive Technologies

Whether or not to migrate to a new technology is a key decision that affects not only the instrumentation being updated, but also the integration of that system in a telemetry facility. Those innovations that can be absorbed by a change in the internal system design or architecture, with no effect on the end user or installation, are more practical to employ. The industry acceptance of a new technology can also be a factor in this decision. Consider the classic innovation adoption curve[2] in figure 3 shown below.

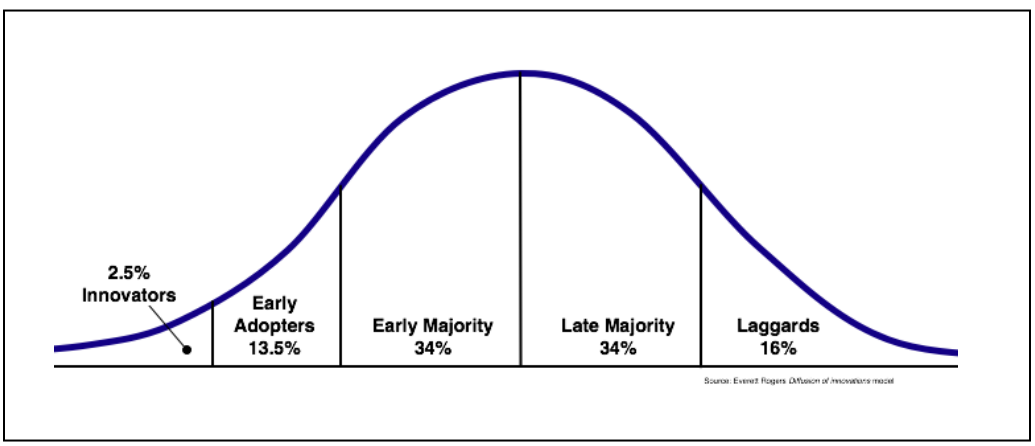

Figure 3: Rogers Innovation Adoption Curve

The innovators are those who would first employ a new technology, while the early adopters would follow their lead if the innovation proves somewhat successful. The early majority is more risk averse than the previous groups, but is willing to adopt the technology once proven. The late majority is more skeptical and will only move to a new technology when it is considered mainstream. The laggards are those who resist change and will only adopt when previous solutions are obsolete.

While this model is based on the sociology behind the consumer adoption of innovations, it is useful in discussing the implications of employing disruptive technologies. As the curve is traversed from left to right, the amount of risk is inversely proportional to the normalized value. The risks of innovators and early adopters of a new technology are higher cost, potential for the technology to not be fully developed, and the possibility of the stagnation of the innovation where it never enters the mainstream. The risk of the laggards is that the technology is no longer new and there is a real possibility that a newer technology is already being developed as a replacement.

For the telemetry community, system designers must weigh these risks when deciding on how and when a disruptive technology should be employed. The technical advantages of implementing a new technology often outweigh the risks, especially if the technology is a significant advancement for telemetry.

Obsolescence Management

One of the major implications of disruptive technologies for data recorders is the issue of obsolescence management. These recorders are often integrated into larger telemetry systems that require support for many years. The embedded industry is typically prepared to supply data recorder manufacturers and telemetry system integrators with the components that are specified into current designs, but the supplies are finite. Telemetry recorder designers must have obsolescence plans in place that not only support existing installations, but are able to offer drop-in replacements as necessary.

Disruptive technologies, by their nature, do not offer the telemetry manufacturer or system integrator an expected change. Rather, the unexpected must be dealt with by a combination of open communications with component vendors, direct involvement with procurement resources, and the constant education for engineers on the latest technologies. Obsolescence management tools are available that can help execute a robust plan that includes engineering, procurement, and production techniques to mitigate the impact of a required change.

Conclusion

The telemetry data recorder, as well as many other areas within telemetry, is susceptible to the impact of disruptive technologies. The benefits of implementing these innovations include increased performance, improved ease-of-use, new features/capabilities and an overall better product. The risks of using disruptive technologies include the cost of redesign, the possibility of increased product cost, the potential for technology stagnation and the risk of adopting a technology too early or too late.

Data recorders today strike a good balance between using both innovative and established technologies to provide the telemetry user a platform that is useful and productive. The identification and use of disruptive technologies must continue to play a role in order to provide for the current and future requirements for telemetry applications.

References

[1] Cooke, Jim, "Flash Memory 101: An Introduction to NAND Flash," CommsDesign, March 20, 2006.

[2] Rogers, Everett M., Diffusion of Innovations, Glencoe: Free Press. 1962.