

A NEW GENERATION OF DATA RECORDERS

BASED ON DLT TECHNOLOGY

by

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OVERVIEW

The Digital Linear Tape (DLT) drive has become an attractive alternative to other small/medium-format cassette mechanisms for data capture and storage applications. But to transplant such a device from its benign office habitat into a product capable of performing reliably in a wide spectrum of field and platform environments is an engineering task fully as difficult and complex as designing an environmentally robust recorder from scratch. This paper discusses the problems which must be overcome, citing practical examples of analogue and digital DLT-based data recorders which are now entering service for telemetry, intelligence gathering, anti-submarine warfare and related applications.

INTRODUCTION

For many years, designers of low and medium-capacity data recorders have frequently incorporated proprietary 'off-the-shelf' tape drives into their products as a means of reducing development time and unit cost. The S-VHS format, for example, is widely accepted as an excellent medium for many general purpose data recording applications. But now manufacturers are turning to newer recording formats to satisfy user demands for higher data rates and bandwidths in compact packages, greater storage per cassette and – most important – a more 'plug-and-play' approach to computer interfacing. The continuing long-term availability of professional grade S-VHS mechanisms and spares must also be considered.

In 1997 Avalon Electronics Ltd conducted a thorough review of the available alternatives, drawing on more than 15 years experience in the design and manufacture of BETA, VHS and S-VHS based data recorders for government and industrial applications. Eventually DLT was selected for several important reasons. The format has been in service for more than six years and is widely used and supported throughout the computer world. It exhibits a clear technology migration path – originally at 12 Mbits/sec, now at 40 Mbits/sec and with further advances anticipated in the future. The media is rated for more than half a million passes and 20 years of archival storage. Drives and media are freely available from a number of sources (Figures 1 & 2) and, based on the company's own in-

house testing, great confidence can be placed on the long-term robustness and reliability of the mechanisms themselves.



Figure 1. Proprietary DLT peripheral.

There are advantages too from the system designer's standpoint. Storage capacity is outstanding – 280 Gigabits in a cassette about half the size of a typical S-VHS cassette. The drive can be specified with an integral SCSI interface. Unlike rotary recorders, the multi-track linear format offers a true 'read-after-write' capability including the ability to rewrite a bad block, virtually eliminating the possibility of recorded errors. Its high speed searching is a valuable feature for operational data recording and analysis applications, while the buffered input/output capability readily supports fixed rate, variable rate and 'burst' data transfer modes. The in-built directory structure also offers the ability to include file management features not normally found in data recorders.



Figure 2. DLT drive mechanism.

ENGINEERING FOR RELIABILITY

Experience has taught us that the task of creating a reliable recording system around a transport designed originally for another application is fully as difficult and as complex as designing an environmentally robust recorder from scratch. In the case of adapting a computer peripheral, the problems fall into the following general categories:

In the computer room, archival devices such as DLT drives are used virtually only in a 'write-only' mode. With luck, they seldom if ever have to replay data, and only then if the primary source should fail. Even then, there may yet be alternative sources. Conversely, the data recorder will typically be the primary and perhaps only means of storage at the point of acquisition. Scientific or tactical data not properly recorded may be expensive or even impossible to recreate. The modes of data transfer also differ significantly. The computer drive controls the flow of data using 'handshaking' routines with which it can start and stop the process as required. The data recorder on the other hand generally has little or no control over the data flow and must capture whatever appears at its input – and for as long as necessary.

Overall data integrity is an aspect which is often overlooked when personal computers (PC) or peripherals are adapted for field use. Some simplistic attempts to wrap unsophisticated data capture electronics around this type of device have resulted in spectacular failure in the rough and tumble of an operational environment. It is unlikely that the basic DLT drive itself will produce errors, but the data recorder user needs error performance from input to output. There are many applications today, involving encrypted data for example, where a single bit error can render the entire data set useless. System control (both internal and external) will invariably require additional software and firmware. Since users have come to expect the same 'plug-and-play' functionality they get from say a new printer, it is essential that all new software be structured, implemented and tested in a thoroughly professional and rigorous manner. Among the many differences, one similarity between peripherals and their data recording cousins is that both must be developed to appeal to the broadest possible marketplace (although the relative production volumes will no doubt vary greatly). In the latter case, this means designing for 'worst case' environments. Baseline parameters for Avalon recorders typically include: operating temperature range 0 and 50°C, humidities to 80% and the ability to withstand, as a minimum, the levels of shock and vibration commensurate with hard mounting in military transport aircraft. The ability to accept a wide range of less than ideal power sources is also a primary requirement, as is the capability to optionally provide harsh environment packaging compliant with appropriate Mil Stds .

Other critical areas affecting reliability include: the correct choice of construction methods, materials, connectors and wiring, careful attention to electro-magnetic compatibility, the provision of adequate mechanical and thermal isolation and appropriate strategies for heat dissipation.

For a new product to be truly successful, it is also important that it should be easy to integrate and use while at the same time addressing both current and future operational requirements. Figure 3 shows the classical digital data recording model. The source sends the recorder a data stream, the recorder is started and the data is recorded. Sometime later, the recording is replayed into some form of analyser – typically a computer. The data may be serial or parallel, one stream or several, but the model is essential the same. Traditional data recorders are notoriously difficult to integrate into a computer controlled environment. For this reason, the concept of 'handshaking' was developed to accommodate situations in which the computer is unable to process an uncontrolled

continuous data stream. This was often a somewhat crude ON/OFF affair rather than the elegant interactive techniques found in the computer world. A further refinement to some traditional data recorders has been the addition of the 'data-on-demand' output clock provided by the computer, but in many projects this recorder/computer interface (often mission specific) has been a significant element of the overall cost – as much as 50% in some notable cases.

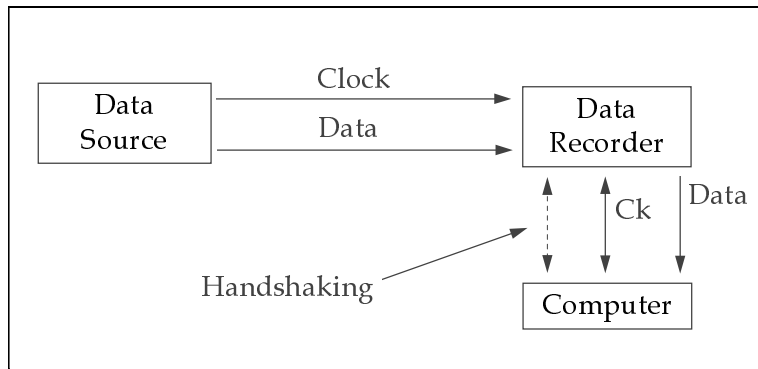


Figure 3. Classical Data Recording Model.

The use of a DLT drive with its built-in SCSI bus enables this problem to be solved in a very elegant way (Figure 4). Put simply, the proprietary DLT drive together with its read/write electronics and SCSI bus form the heart of the data collection system. A high speed PCI Pentium processor with SCSI interface connects to the drive while a data interface communicates with the outside world. The Pentium converts the incoming data into a SCSI bit stream which is recorded on the DLT drive *in its native format*. The system architecture is such that a range of single and multi-channel, interfaces (analogue and/or digital) are possible. In this way, the computer compatibility problem is solved, not at the interface between the reproducer and the computer, but right at the initial data collection stage. By recording data in SCSI format, the unit is as easy to integrate and use as any other SCSI compatible device. The analysis computer connects directly to the unit's own external SCSI port while data can still be output in its original form (analogue or digital) via the data interface if required.

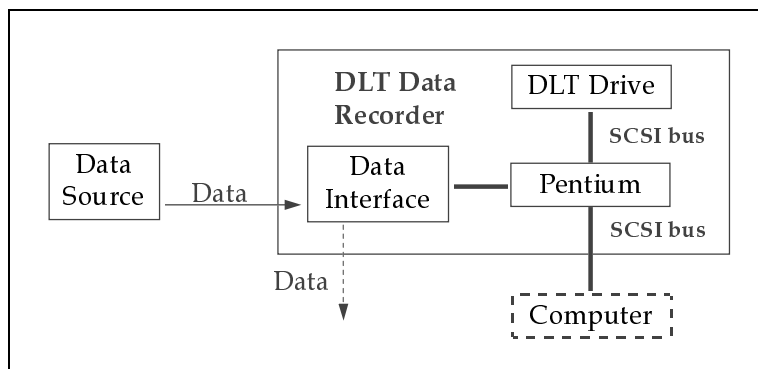


Figure 4. DLT Recorder Architecture.

In practical terms, the original peripheral (Figure 1) is stripped of all unwanted sub-assemblies and the resulting 'bare-bones' drive is anti-vibration mounted into a closed compartment at the top front of the recorder case (Figure 5). To reduce size and weight the drop-down loading door doubles as an integral control and display panel. The electronic modules are mounted in a separate compartment to the rear, the exact function of the recorder being determined by which modules are installed and activated. Finally, a fan is mounted to the central bulkhead to draw cooling air in through the rear of the unit, across the electronics modules and over a Peltier device fitted to the base of the tape drive compartment before being exhausted via a front panel mounted grill located below the control panel. A proprietary high grade, line tolerant power supply is used.

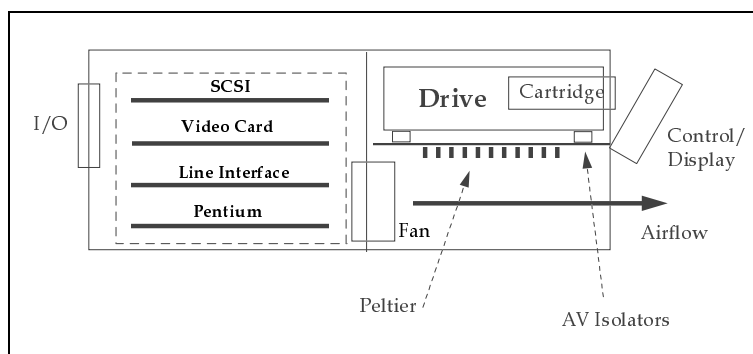


Figure 5. DLT Physical Layout.

A large input/output buffer (part of the data interface) is used to decouple the fast start/stop tape drive from 'real world' continuous (or discontinuous) data rates during recording, while allowing the analysis device to transfer data at its optimum rate during replay. The entire complex interaction is controlled by the Pentium and is completely transparent to the user. A powerful input-to-output error detection and correction strategy is used which, in effect, wraps around the DLT drives native error correction system. The 12 or 40 Megabit/sec maximum transfer rate is carefully selected to take full advantage of the drive's inherent 'read-after-write' (detection) and 'rewrite' (correction) capability, ensuring that data finally recorded to tape is virtually certain to be error free.

All new software is written and tested using a highly structured approach at all stages. Control programs are contained in non-volatile RAM and can be updated or modified via the unit's standard RS-232 port. A modem can be fitted within the recorder for remote control, interrogation or fault finding using a simple communications package such as Microsoft[®] 'Terminal'. The company places software revisions on-line for users to download.

Building on nearly 1 million hours of actual field experience with BETA, VHS and S-VHS based products, further important strategies are employed to maximise overall system reliability. All unnecessary packaging and sub-assemblies are discarded. All plastic and other components constructed from materials not permitted aboard aircraft or submarines are replaced with compliant equivalents. The tape drive is isolated both physically and thermally, and fitted with its own Peltier temperature control system, in order to protect the system's weakest link – the tape itself. The layout is structured to include a simple, yet very positive heat dissipation system while all connectors, cable runs, clamps, hardware and other components are carefully selected for their reliability in a worst case operational scenario.

TYPICAL CHARACTERISTICS

The first data recorders to use DLT technology are now entering service. A brief overview of their capabilities may give a useful idea of what is already possible using the DLT approach.

Telecommunications Recorders

For example, 12 and 40 Mbits/sec (nominal) recorders designed for high rate telecommunications applications (Figure 6) offers the following performance:

12 Mbit/sec Mainframe: >5 hours of 1 x E2 (8.448 Mbits/sec), HDB3 encoded (CEPT 2)

>5 hours of 4 x E1 (2.048 Mbits/sec), HDB3 (CEPT 1)

>7 hours of 1 x T2 (6.321 Mbits/sec), B6ZS (DS2)

>7 hours of 4 x T1 (1.544 Mbits/sec). B8ZS (DS1)

>20 hours of 1 x E1 (2.048 Mbits/sec), HDB3 (CEPT 1)

>28 hours of 1 x T1 (1.544 Mbits/sec). B8ZS (DS1)

40 Mbit/sec Mainframe: >2 hours of 1 x E3 (34.368 Mbits/sec), HDB3 (CEPT3)

>2 hours of 16 x E1 (2.048 Mbits/sec), HDB3 (CEPT 1)

>36 hours of 1 x E1 (2.048 Mbits/sec), HDB3 (CEPT 1)

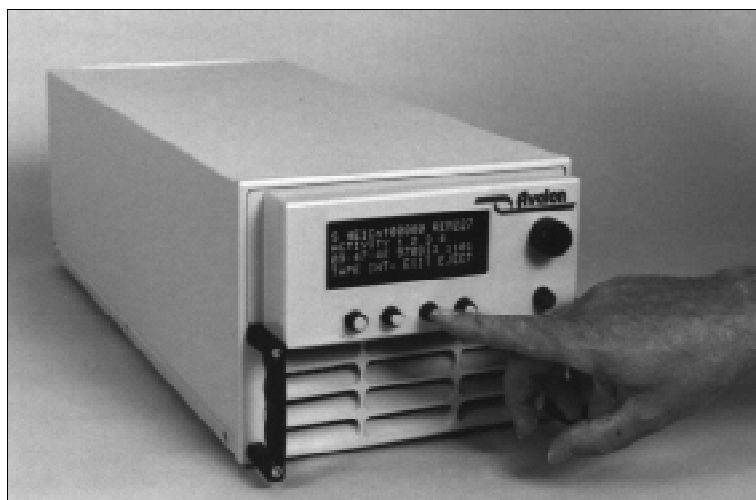


Figure 6. Communications Recorder

The input-to-output error rate is better than 1×10^{-14} while the system's Mean Time Between Failures (MTBF) is rated at better than 12,500 hours. Since the input/output interface is modular, considerable flexibility exists in the type and number of data

channels which can be recorded. In addition, a two-channel interceptor can be built into each system with which any two time slots from any tributary can be monitored and output in analogue or digital form. Optional CCITT compatible multiplexers can also be used independently to multiplex and demultiplex signals from one standard to another.

Digital/Analogue Data Recorders

DLT-based recorders also exist for conventional digital and analogue data acquisition applications (Figure 7). Again, taking advantage of the modular approach to input/output data interfacing, considerable flexibility exists in terms of the number and types of data which can be used for recording. Both the 12 and 40 Mbit/sec variants house up to six data modules which can be selected and operated in any combination via the unit's front panel, provided the aggregate maximum data rate is not exceeded. Analogue data is digitised with either 8 or 16 bit sampling and analogue and digital modules can be used in parallel.



Figure 7. Digital/Analog Recorder

Typical performance of combined digital/analogue systems:

- | | |
|--------------------|---|
| Recording Duration | >1.9 hours at 40 Mbits/sec
>3.5 hours at 12 Mbits/sec |
| Digital modules: | 1 ch. I/O, up to 40 Mbits/sec
4 ch. I/O, 0.05 to 8 Mbits/sec (asynchronous)
8 ch. I/O, 0 to 9600 baud (asynchronous)
8 ch. I/O, 0 to 5 Mbits/sec (synchronous) |
| Analogue modules: | 4 ch. I/O, 1xDC-2 MHz / 2xDC-1 MHz / 4xDC-500 kHz
(8 bit resolution) 8 ch. Input-only, DC-40 kHz
8 ch. Output-only, DC-40 kHz |

Analogue modules: 4 ch. I/O, 1xDC-1 MHz / 2xDC-500 kHz / 4xDC-250 kHz
(16 bit resolution) 8 ch. Input-only, DC-40 kHz
8 ch. Output-only, DC-40 kHz

When the recorder is waiting in 'stand-by' mode, the buffer holds a minimum of 9 seconds of data (longer for lower data rates) so that when the RECORD command is given this 'pre-event' data is automatically captured to tape.

SUMMARY

The introduction of DLT-based technology has yielded a number of important opportunities for users of small, compact data recorders:

- 2 hour recording duration at 40 Mbits/sec
- 280 Gigabits/cassette
- Direct computer connectivity via SCSI without special interfaces
- Outstanding input/output flexibility
- Inherently robust construction
- Long term availability of products and spares
- Inexpensive to purchase and use

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