

Embeddable Digital Video Recorders

A primer for OEMs

by Jim Lamberson, Senior Design Engineer, Sensoray

Abstract

A digital video recorder (DVR) is a required component in many types of equipment. In the past, original equipment manufacturers (OEMs) have often satisfied this requirement by building into their equipment DVRs which are not intended for embedding. Unfortunately, this strategy has resulted in high overall cost, convoluted hardware and wiring, and poor quality control. This article discusses these issues and introduces a new class of DVR that is specifically designed to solve these problems.

Introduction

Many OEMs design and build equipment which, as part of its larger purpose, must record video in a digital format. Often such equipment has no internal computer, so it must include a standalone DVR to meet this requirement.

This has historically been a problem for OEMs, because unlike many other components used in their equipment, which are engineered for embedding, there were no off-the-shelf, OEM embeddable DVRs. The obvious solution, designing and building a proprietary DVR, is prohibitively expensive unless manufacturing volume is high and, even then, mandates specialized in-house expertise and a level of vertical integration that often is ill-matched to the business model.

To work around this problem, OEMs would in many cases purchase inexpensive consumer DVRs, dismantle them, discard the case and other unnecessary parts, and secure the remaining power supply and other essential pieces into the OEM equipment in as professional a manner as possible. One of those pieces, the control keypad, typically would be mounted in a custom panel opening or, alternatively, discarded and replaced by an OEM-designed custom keypad.

This workaround resulted in low material cost but exacted a heavy toll in other ways. In particular, OEMs were perpetually re-designing their equipment, because it's not at all uncommon for consumer DVR designs to change – or worse, for models to be discontinued – virtually overnight and without warning. Also, the workaround only provided a partial solution because consumer DVRs lack many of the video-processing functions required by OEM equipment, such as text/graphics overlays and screenshot capture. To satisfy these requirements and others, additional components had to be purchased and integrated into the equipment, or the requirements had to be relaxed, or both.

Fortunately there is now a practical alternative to this workaround, because a new class of DVR has emerged which is specifically engineered for embedding in OEM equipment. These devices, known as *embeddable DVRs*, are industrial quality, OEM configurable units, which are endowed with comprehensive repertoires of video processing functions. They are robust, small and lightweight, and designed to be easily integrated into OEM equipment. Perhaps most importantly, embeddable DVRs have excellent long-term availability, which makes it possible for OEMs to break free of endless re-design cycles so they can focus on more profitable endeavors.

User Interface

Control device

Embeddable DVRs (eDVRs) are available in a variety of shapes and sizes and have widely varying features and capabilities, but they all share a number of distinguishing characteristics.

One of the most obvious features of an eDVR is what it *doesn't* have: a built-in keypad. There are several compelling reasons for this. A keypad must be located where it can be easily accessed by the equipment operator – a requirement which may be impossible to satisfy if the keypad is built into the DVR. Also, OEMs must be free to choose the keypad or other type of control device that best suits their needs, or to omit control devices altogether if one is not needed. An example of the latter is a turnkey eDVR that automatically starts recording when powered up.

On the other hand, when it comes to supporting external keypads and control devices, eDVRs are usually quite accommodating. Most eDVRs provide an interface for an external custom keypad, or for an external standard keyboard, or both. In either case, the control device connects to the eDVR via detachable cable, which allows it to be placed exactly where it's needed.

All OEMs strive to give their equipment a professional look and feel. This is often achieved, in part, by using an aesthetically pleasing, custom keypad which matches the equipment's color theme. Obviously, keypad color doesn't matter to an eDVR, but other keypad attributes do matter: every keypad has a unique layout and unique key functions that are tailored to the equipment. To support these variations, eDVRs typically provide a means for OEMs to define key functionality and to logically map keypad switches to particular eDVR connector pins.



Figure 1: Solid-state eDVR keypad with capacitive touch keys and cutouts for USB storage media (Sensoray 4011TB)

Video output

Keypads and other control devices comprise only one part of the eDVR user interface (UI). The other part of the UI is the video monitor or, more specifically, interactive menus that appear on the monitor. These eDVR-generated menus provide operator feedback, visual access to the eDVR's file system, and other information. Every OEM system is different, so eDVRs usually allow the OEM to customize the menu system, create a startup splash screen, and modify eDVR behavior in other ways to bring about a unique user experience.

When menus are not displayed, an eDVR will stream live video, playback video, or captured JPEG screenshots to the monitor. In many cases, a menu will consist of a concise, small amount of information that need not cover the entire display area. eDVRs take advantage of this by continuing to show areas of the video that are not masked by the menu, for the benefit of the operator.

eDVRs do not have a built-in video monitor because this would violate a primary tenet of eDVRs: maximum OEM flexibility. In fact, in some applications the video monitor is not even physically attached to the main body of the OEM equipment. It's common, for example, for OEM equipment to allow the use of a portable viewing device such as a phone, laptop or tablet, to enable the operator to easily move around while viewing video.

To facilitate this, many eDVRs support wireless operation via a WiFi adapter plugged into one of the eDVR's USB ports. Taken to the limit, this allows an eDVR to be operated without a monitor or keypad.



Figure 2: Left: This eDVR was configured for wireless operation by simply attaching a WiFi adapter (Sensoray 4011 eDVR with WA0001 WiFi adapter). Right: A Samsung tablet computer displays eDVR video conveyed via WiFi.

Mechanical attributes

eDVRs are usually supplied as bare circuit boards without an enclosure (though optional enclosures are often available). This is by far the most popular configuration used by OEMs, for several reasons. Since the eDVR will be built into OEM equipment, this eliminates the cost of an unnecessary enclosure. Also, it allows the use of high density, board-mounted (vs. bulkhead) connectors, which are ideally-suited to space-limited, internal equipment wiring. The eDVR's reduced footprint allows it to fit into handheld and other compact OEM equipment, and its weight contribution is minimized, which is essential in airborne and other applications where low mass is critical.

Mechanical designers will appreciate how easy it is to integrate eDVRs into OEM equipment. An eDVR is not mechanically bound to its control device, so it can be located at any convenient location inside the equipment where space permits. And since the eDVR is specifically designed for OEM embedding, it provides well-defined mount points that facilitate secure mounting in conformance with industry standards.

Some eDVRs are specifically designed for front panel mounting (see Figure 3). These devices facilitate front panel mounting in two ways: they offer a simple and straightforward means for direct panel mounting and they provide built-in, panel-aligned connectors for removable storage devices. When these eDVRs are mounted in the prescribed manner, the storage device connectors are directly exposed to equipment operators through panel openings. Consequently, it's not necessary to run an intermediate cable from the eDVR to a separate, panel-mounted storage media connector, and the expense and space required for such cables is eliminated.



Figure 3: Left: This compact (3 x 3.5 x 1”) eDVR assembly is engineered for direct front panel mounting, with two USB media ports accessible through openings in the integrated keypad. Right: The assembly flush-mounted in a panel cutout (Sensoray 4012DEMOKIT).

Data storage

Every eDVR requires a storage device for recordings but storage devices, like keypads, are not built into eDVRs, for many of the same reasons. Depending on the application, an eDVR may record to a fixed storage device embedded in the OEM equipment, or to a removable storage device, or to both. In the case of removable media, the media port must be accessible to the operator, which may mandate placing it some distance away from the eDVR. Furthermore, the requirements for storage device type and capacity will vary depending on the bit rate, record count and size, vibration tolerance, and other factors.

To address these concerns, eDVRs provide standardized interfaces for storage devices, thus affording OEMs the freedom to choose their preferred storage medium. Most eDVRs provide at least one USB port, which may be connected to a USB SSD/hard disk or removable USB flash stick. Some eDVRs also include a socket for a MicroSD card, which often is preferable to a bulkier SSD/hard disk when fixed, internal storage is needed.

The media storage system is also flexible in another very important way: eDVRs are able to perform multiple, simultaneous data transfers to/from a storage device. This is essential, because it allows an eDVR to record the live stream – without interruption – while it simultaneously captures screenshots in JPEG format.

Furthermore, this capability is not limited to a single storage device; eDVRs can simultaneously access multiple multiple storage devices. A typical application of this is to record the live stream to a user-accessible, removable storage device while, at the same time, recording an archive copy to an embedded storage device. Also, this allows the eDVR to copy recordings from one device to another (e.g., from internal to removable storage). Physically, this is made possible by the availability of

multiple storage media ports on the eDVR. For example, panel-mountable eDVRs (see Figure 3) usually provide an internal-facing port for an embedded storage device in addition to one or more exposed ports for removable media.

Video overlays

A common requirement for eDVRs is to superimpose the current time and date onto the live video prior to recording it, so as to visually mark the video with its creation time. To satisfy this requirement, eDVRs provide a real-time clock, which keeps track of the time and date, and a tightly-coupled video overlay engine. The overlay engine automatically superimposes the time and date – accurate to one video frame time – as text on the video.



Figure 4: eDVR screenshot, showing two lines of text overlay. Top line: date/time from eDVR clock. Bottom line: camera position from eDVR's incremental encoder interface.

At this point I briefly digress to mention the obvious: time and date overlays are worthless if the clock has not been correctly set. It's unreasonable to expect the operator to set the clock each time the equipment is turned on as this would be a nuisance at best, and potentially very costly if the operator forgets to do it. To circumvent this, eDVRs include a built-in, replaceable battery that keeps the clock ticking while the equipment is turned off.

Often it's necessary to overlay other, custom text on the video. For example, equipment operators may need to enter a job title, location, comments and other information, and have these data visually recorded at the beginning of a job. Typically, eDVRs allow custom overlay data to be entered via a standard keyboard, which may be plugged into any available USB port on the eDVR.

Whenever video is overlaid, there is a risk that important image features may be obscured by the overlays. eDVRs mitigate this risk by allowing the operator to control the transparency of overlays, and to position overlay elements such as date and time, camera position, and custom text, anywhere in the video frame.

Finally there is the matter of company and product branding. Most eDVRs allow the OEM to create a splash screen, which the eDVR will automatically display when the equipment is turned on. Also, eDVRs typically allow OEMs to overlay company logos and other graphic elements on the video.

Incremental encoders

Some of the most popular uses of eDVRs involve remote camera operation wherein the camera is located some distance away from, and moving relative to the eDVR. Widespread examples of this include pipeline and underwater inspection, surveying and monitoring.

In such applications, the eDVR is usually required to overlay the camera's position on the recorded video. To make this possible, the OEM will mechanically couple a rotary incremental encoder to the camera's cable reel (or to a non-slip cable guide pulley). As the camera moves, the reel is rotated as necessary to keep tension on the cable. The encoder rotates with the reel, causing it to transmit signals that indicate camera position changes.

With an incremental encoder in place, it's a simple matter for the OEM to procure an appropriate incremental encoder interface, integrate that interface into the OEM equipment, and arrange for the encoder counts to be sampled, converted to distance units and overlaid on the video. I'm joking, of course; nothing in the previous sentence is simple, as anyone who has implemented this will tell you.

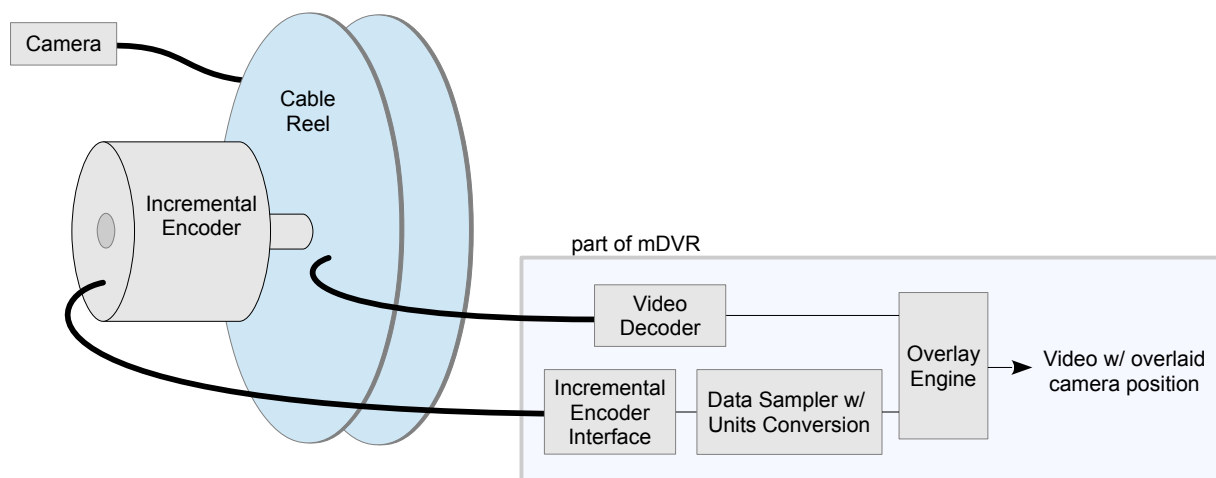


Figure 5: Some eDVRs have a built-in incremental encoder interface

Fortunately, eDVR manufacturers have recognized that this is a common requirement and responded by offering eDVRs with a built-in incremental encoder interface. When this feature is available, the eDVR will automatically fetch samples from the encoder interface at the video frame rate, calculate distance, and overlay the distance on the video in real-time. The OEM need only supply an incremental encoder and connect it to the eDVR.

Video resolution

I've saved for last what is often the first thing considered by OEMs. The decision to use high definition vs. standard definition (HD vs. SD) depends on several factors. Foremost among these is cost: HD devices tend to be pricier than SD equivalents. This is particularly true for SDI devices, which are otherwise suitable for remote camera operation over short distances (up to 100 meters with heavy coaxial cable). Unfortunately, the less-expensive HDMI and DVI standards are inherently incompatible with long cable runs and, even when short cables are used, employ bulky cables and connectors that are impractical in space-limited equipment. Consequently, SD has historically been used in equipment that does not absolutely require HD – until now.

Recently, analog HD technology has become available that allows HD video up to 1080p30 to be conveyed over coaxial cable of significant length (up to 1,500 feet). The technology was initially adopted for use in high volume security applications, which led to a proliferation of inexpensive analog HD cameras.

The explosive growth of analog HD has found its way into eDVRs. Modern eDVRs are now available that will accommodate both analog HD and composite SD cameras, resulting in HD video system costs that are only marginally higher than those of SD equipment.

These eDVRs offer a number of interesting possibilities. For example, OEMs can now easily develop equipment that provides a customer upgrade path or OEM migration path from SD to HD cameras. Also, they allow standardized hardware to be used in different equipment versions with different resolutions. In some cases there may be no technical performance benefit at all to HD – its sole advantage may be to allow the OEM to tout HD capability and thereby establish a competitive marketing edge.



Figure 6: This ultra-tiny eDVR records analog HD or SD to USB and/or MicroSD (Sensoray 4031)

Summary

I've glossed over or entirely neglected some important features of eDVRs. For example, eDVRs are designed to be powered by the types of batteries and low-voltage power supplies commonly found in OEM equipment. They typically capture audio as well as video, compress these to AAC and H.264, respectively, and store the combined A/V in MP4 format. Speaking of compression, eDVRs usually allow attributes such as bit rate, GOP size, and frame rate to be tuned to the application. Importantly, eDVRs are not merely OEM configurable; they often can be factory-customized to satisfy extraordinary OEM requirements.

Hopefully, I've enlightened and given hope to OEMs who have struggled with unwieldy DVR kludges, who can now take advantage of the simple, elegant, and cost-effective solution offered by eDVRs.