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Mission-critical, solid-state storage

By John Wemekamp

With the rapid growth in commercial markets for solid-state flash devices driving up capacity and as a result, driving the cost per megabyte rapidly downwards, embedded military computing systems are set to benefit as innovative designers find yet more applications and packaging formats to suit their special characteristics. Military applications span the complete spectrum of capacity and performance offered by today's high-density flash devices from mission data loaders, storage for application code, and virtual memory operating systems through to very high-capacity sensor data recorders, replacing traditional tape, hard disk, and DVD recording.

Mass storage for use in very rugged environments has always been costly compared to the equivalent commercial application, whether disk- or solid-state-based. Ruggedized disks are difficult to protect against the effects of shock, vibration, humidity, and high altitude, often requiring the creation of a benign local environment through mechanical isolation to ensure reliable, long-term operation. Flash is capable of withstanding these environments but, until recently, has not been cost effective for applications requiring many gigabytes of storage in extended temperature range form.

These rugged environments can typically be found in tracked vehicles, combat aircraft, helicopters, missiles, or Unmanned Aerial Vehicles (UAVs) where the extreme environmental conditions preclude the use of hard disks. Therefore, hard disks have seen limited deployment in such applications despite the advantages that their volume of storage would offer to applications such as artificial intelligence, command and control, digital mapping, distributed databases and target classification, or for the storage of an entire mission's signals intelligence sensor data. These classes of applications are being migrated into smaller and smarter vehicles, dealing with vastly increased volumes of data as sensor performance increases and with networks that connect them to other battlefield assets and sensors. This is making it imperative that solutions are developed to maintain the technology advantage on the battlefield. These applications for mass storage generally fall into three major categories:

- Real-time, deterministic embedded applications with access to very large local databases
- Virtual memory operating systems often used for command, control, and communications
- Collection and storage of mission sensor data and/or recording of mission performance, often used for later analysis or operator debriefing and training

Flash density has now increased to the point where 64 GB of Not AND type of logic gate (NAND) flash can be implemented on a single PMC/XMC mezzanine module, offering a choice of software access mechanisms such as a single RAID drive or a number of USB drives using off-the-shelf device drivers complementing the most popular real-time operating systems. With their easy integration into VMEbus systems, these products are ideally suited to the first two categories of application. SmartMedia flash page management can be used for wear leveling to ensure longer life in applications that frequently rewrite data by distributing the written blocks throughout the devices. Price points will continue to be eroded, making regular replacement with modules of increased capacity the norm for maintenance where overall rewrite life may be an issue. The Curtiss-Wright Controls Embedded Computing (CWCEC) PBOD, 64 GB product illustrated in Figure 1 is this kind of PMC/XMC flash module.

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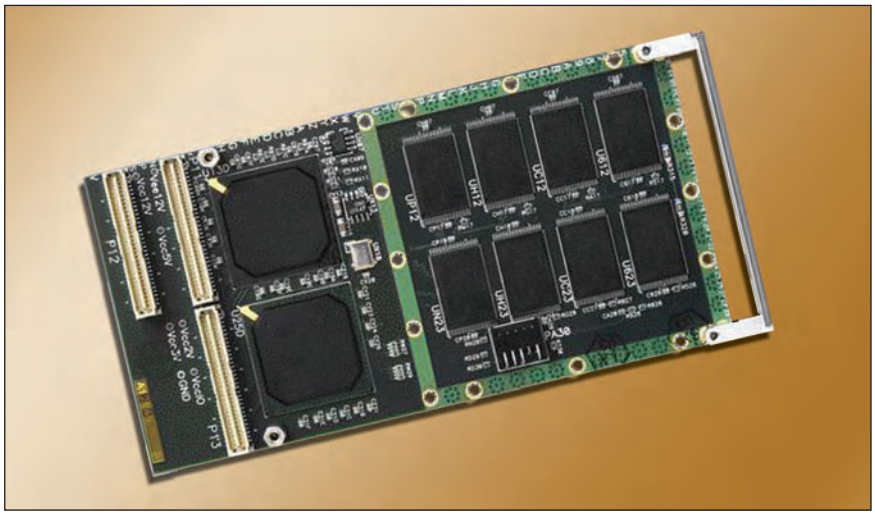

Figure 1

Due to the very high data rates produced by sensors such as radar, TV, intelligence gathering, and sonar, these types of data recording have been the preserve of very expensive, bulky systems using multiple hard disks or DVD drives. This limits their regular deployment to large platforms or specific experimental missions. For rugged systems, the price of flash will soon be competitive, and very high-capacity flash-based products will start to become available for these applications. Reductions in size and weight will be available at the same time, but many terabytes of flash will still be expensive and will occupy a relatively large space, making it unlikely that small platforms will adopt this type of sensor recording for regular operational use. However, the ability to record sensor data and human workload is an invaluable analysis tool to improve operational effectiveness.

Taking data *snapshots* triggered by discrete events is an innovative solution to the capacity and cost issues of continuous recording. A small, lightweight event recorder with up to 128 GB of flash can be implemented in a very rugged enclosure, affordable enough to be fitted to every platform from light armored vehicles to attack helicopters. Unlike a flight data recorder, which records all data leading up to a final catastrophic crash, an event recorder can capture shorter length data sets of critical information throughout a mission in the form of *snapshots*. CWCEC is developing such an event recorder using SATA flash technology, able to record numerous 15-second *snapshots* with input data rates up to 247 MBps. The CWCEC EDRxR Snapshot Event Recorder is illustrated in Figure 2.

Flash has become the mass memory of choice for military embedded computing requirements, particularly those based on the industry-standard VMEbus. Future increases in capacity and further cost erosion are guaranteed by the wealth of commercial applications using the technology. Flash operates over temperature extremes, is rugged, and for secure applications, can be wiped clean of readable data in a matter of seconds. Not only will flash replace traditional applications for recording and mass storage, but it also looks set to develop new uses as designers explore new packaging, data organization, speed, and retrieval mechanisms.

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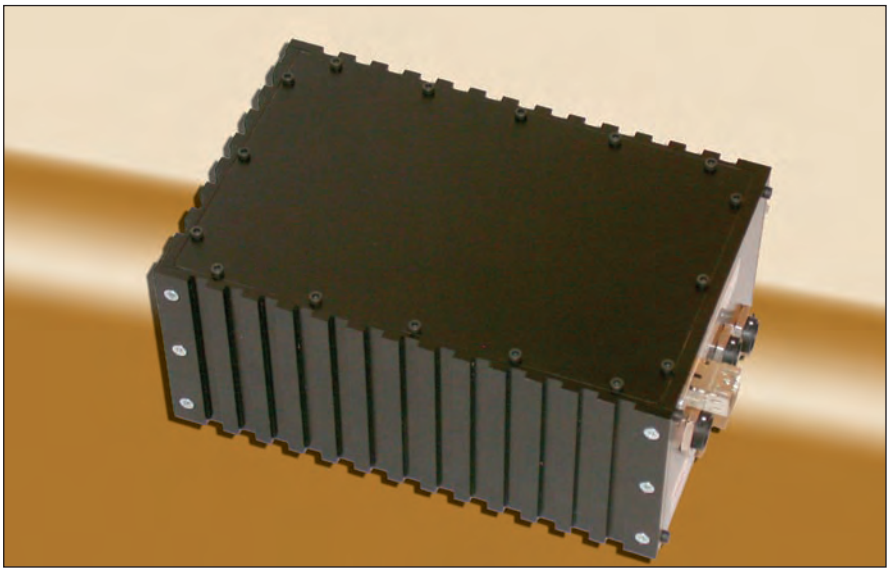

Figure 2