Off-the-shelf radiation resilience: A case for RADHARD COTS

By Steve Edwards

Today's vehicle system designer must plan for the battlefield survivability of critical electronics during nuclear events. Electronic components deployed in space flight for flight-critical systems must be designed and hardened to continue to function while being exposed to high levels of gamma and neutron radiation for repeated or extended periods of time. In comparison, the radiation protection needed for electronic systems on ground vehicles – such as fire control systems and mission control computers – need not ensure continued functionality through nuclear events. Instead, there are many ground vehicle electronic systems that need only survive a nuclear event by detecting damaging levels of radiation, then shutting down and restarting after a specified period of time to then operate within higher levels of residual radiation. COTS components can mitigate these levels of battlefield radiation, achieving a satisfactory level of radiation resilience at a cost and complexity of 2 to 5 times less than that needed for space radiation hardening.

Radiation-resilient COTS

Radiation-resilient COTS products (or "RADHARD COTS") can address a large percentage of today's ground-based vehicle applications through a process that includes proper component selection, component and card-level testing, and evaluation. The harm to electronics depends on the density of the radiation created by a nuclear event in the form of gamma and neutron radiation. While there are always ambient (or background) levels of radiation present, they have no adverse effect on electronic circuitry. Today, most circuitry in COTS products is based on Complementary Metal Oxide Semiconductor (CMOS) technology.

Gamma radiation can cause an exposed powered CMOS circuit to upset or latchup. *Upset* is a condition where the device loses memory, changes state, or does not operate properly after the gamma dose. *Latchup,* the more damaging of the two, occurs when the parasitic Silicon-Controlled Rectifiers (SCRs) in the CMOS cells start conducting when exposed to a high gamma dose, resulting in a high current to the substrate and burnout. The typical latchup circumvention is to detect dangerous levels of gamma rays and turn off power to the circuitry before the latchup causes burnout. This can be done at the card or system (box) level. The traditional approach is to perform detection at the box level, protecting all cards in the system. If detection is done at the card level, all cards used in the system must have detection circuitry requiring the redesign of a portion of the cards used in the system.

Neutron radiation must also be mitigated. The CMOS devices are inherently resistant to most tactical neutron dose levels but can still experience upset. Neutron radiation can flip bits or flip the state of latches used in the circuitry. Compared to gamma radiation, which is gone quickly after a blast, neutron radiation lingers longer in the background radiation. Typical neutron-radiation circumvention includes providing Error Correction Code (ECC) on memories [especially Double Data Rate (DDR)], and parity bits or checksums to detect whether the accessed data is correct. If a transmission is bad, the system is allowed to request a retransmit or identify a failure and make the appropriate correction.

Getting to radiation resilience

Radiation resilience can be achieved with the proper selection of COTS components. The first step is for the system designer to review the system and hardware requirements to determine whether a RADHARD COTS product is suitable, rather than a more costly and complex radiation hardened product. For example, long-duration space applications are not generally well suited to RADHARD COTS.

BOM analysis and component selection

After the hardware requirements are determined for vehicle systems that might be exposed to nuclear radiation, the next step is to analyze the components used in the design, followed by proper component selection. Selection should be done to identify components that will not degrade when exposed to higher levels of radiation. Functionality such as ECC, parity, or checksums should be added to the system design to enable error detection and correction. Materials should also be analyzed for their suitability. For example, different types of optical fibers respond differently to nuclear events. Some fibers fail to function after exposure to radiation because the event detrimentally changes the structure of the fiber.

Lastly, radiation-resilient COTS components must be tested to ensure they will survive nuclear events. Increased customer requirements for ground vehicle programs have led Curtiss-Wright Controls Embedded Computing (CWCEC) to launch its RAD-HARD READY initiative and test radiation-resilient variants of standard VME and OpenVPX SBCs such as the SVME/DMV-183 at the White Sands Missile Range in New Mexico (Figure 1).

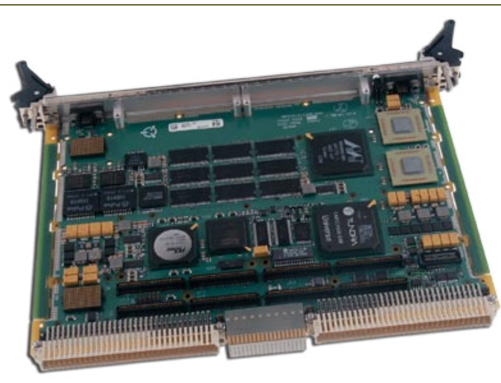

Figure 1 | The SVME/DMV-183 SBC from Curtiss-Wright Controls Embedded Computing

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