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White Paper

System Approach to EMP Mitigation

The Need for EMP/HEMP Mitigation

The need for integrating EMP and HEMP mitigation into military communications electronics has been gaining much awareness from defense contractors and military officials over the past decade. While the threat of an EMP attack had already been recognized during the Cold War, commanding much attention and government resources, today our reliance on sophisticated electronic infrastructure increases the EMP danger even more.

"There is a 70 percent risk of an attack somewhere in the world with a weapon of mass destruction in the next decade", a survey of 85 arms experts predicted in June 2005.1 The survey executor, U.S. Senate Foreign Relations Committee Chairman Richard Lugar, describes the weapons of mass destruction (WMD) threat as "real and increasing over time."[1]

The Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP) Attack wrote in July 2004: "The high-altitude nuclear weapon-generated electromagnetic pulse (EMP) is one of a small number of threats that has the potential to hold our society seriously at risk and might result in defeat of our military forces." [3]

EMP Protection Applications

Today, MIL STD 188-125-1 designates "subscriber terminals and data processing centers, transmittingand receiving communications stations and relay facilities" as examples of applications which are included in EMP/HEMP requirements and applies to "both new construction and retrofit of existing facilities".4 This standard calls out for EMP mitigation for all military C4 (Command, Control, Communications andComputer) systems.

Fixed ground-based command, control, communications, computer and intelligence (FGBC4I) systems that require network interoperability during and after exposure to HEMP environments necessitate uniform and effective hardening, hardness verification, hardness maintenance as well as hardness surveillance. In critical time-urgent applications where some momentary upsets or damage are missionaborting, the hardening requirements include stringent shielding, point-of-entry (POE) protection, and special protective measures.[4]

Examples of applications currently utilizing EMP mitigation solutions include battleships, land vehicles,UAV, missile silos, satellites, and aircrafts. The attack of each of these military systems by enemy EMP strike would be catastrophic to our military efforts and national security.

EMP versus Common Electronic Transients

An electromagnetic pulse differs considerably from common electronic transients. Frank J. Gaffney, Jr., an expert in foreign relations, nuclear forces and arms control policy and former assistant secretary of defense for international security policy examines the science behind the electromagnetic pulse in simple terms.

"If it seems incredible that a single weapon could have such an extraordinarily destructive effect, consider the nature and repercussions of the three distinct components of an electromagnetic pulse: fast, medium and slow. The fast component [20/550 ns pulse] is essentially an electromagnetic shock-wave that can temporarily or permanently disrupt the functioning of electronic devices. In twenty-first century America,such devices are virtually everywhere, including in controls, sensors, communications equipment, protective systems, computers, cell phones, cars and airplanes. The extent of the damage induced by this fast component of EMP, is determined by the altitude of the explosion.

The medium-speed component [1.5/5000 μs pulse] of EMP covers roughly the same geographic area as the fast one, but the peak power level of its electrical shock is much lower. However, since it follows the fast component by a small fraction of a second, the medium-speed component has the potential to do extensive damage to systems whose protective and control features have been impaired or destroyed by the first onslaught.

The first two EMP components are followed by a third one - a slow component [0.2/25 s pulse] resulting from the expansion of the explosion's fireball in the Earth's magnetic field. It is this slow component - a pulse that lasts tens of seconds to minutes - which creates disruptive currents in electricity transmission lines, resulting in damage to electrical supply and distribution systems connected to such lines. Just as the second component compounds the destructive impact of the first, the third pulse causes even greater damage to power grids and related infrastructure.[5]"

The System Solution

An effective solution to mitigating EMP should consider the entire electronic system. This holistic approach includes four integrated elements - grounding, shielding, filtering and surge suppression.

Grounding

Proper grounding and a correct relationship between the neutral and the ground is not only essential to meet National Electric Code (NEC) requirements, but is imperative to achieve optimum performance of microprocessor based equipment such as computers, programmable logic controllers, communications systems and telemetry systems. By code (NEC), the neutral and ground may only be connected at one place, and the main distribution panel or a secondary transformer supplies the distribution system.

Many computer installations will even run two grounds – the safety ground (required by NEC) and a special insulated, isolated and dedicated computer quality ground, which is used as the zero reference for the computer's DC power supply and logic. These grounds, the neutral and the earth ground (ground rod), connect only at the required single point. Grounding can be considered the cornerstone for electrical safety, and in the context of military communications equipment we must install and maintain the lowest impedance ground possible.

Shielding

Surge events cause a magnetic field to be induced in conductors within a given radius, depending on the magnitude. Proper shielding of the sensitive electrical and electronic systems prevents the propagation of induced voltages and currents past or around the filtering of protection schemes employed.

Electromagnetic interference (EMI) shielding derives from Maxwell's equations which prove that the electric field over a closed surface is a function of the charge and that the magnetic field over a closed surface sums to zero. So with proper metallic sealing, the electric charge can be shunted to ground and a magnetic field cannot permeate into an electronic housing.

Proper metallic sealing, however, is a design engineering challenge, since even a small gap can lead to electromagnetic leaking from a surge environment into a protected electronic system Any conductor that enters a shelter or protected electronic system must employ fittings and coupling elements designed to prevent inadvertent gaps. Sub-assemblies should be utilized for the various points of entry and egress. Numerous regulatory agencies including FCC and CE post limits to the amount of EMI noise that can be emitted from a given electronic device. The practice of EMI reduction is widely practiced, and various connector products are readily available.

Filtering

Passive filter networks block out induced surge currents and voltages on data and power circuits for hardening electronics against lightning and EMP surge energy. This becomes extremely difficult with high frequency data circuits because the frequency content of the transient is similar to the data rate of the original signal.

Even with the use of inductive devices with large magnetic cores to prevent saturation at high frequencies and voltages, filter circuits are difficult to synthesize effectively. Filter elements can serve a vital role in cleaning up signals, providing common mode noise rejection and isolation between surge protection elements in a multi-stage protection scheme.

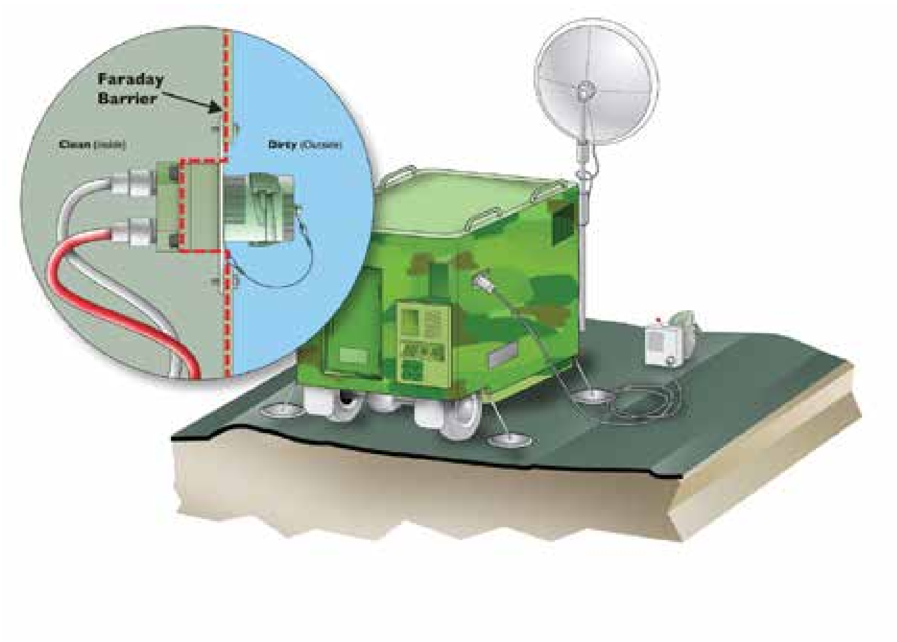
Surge Protection

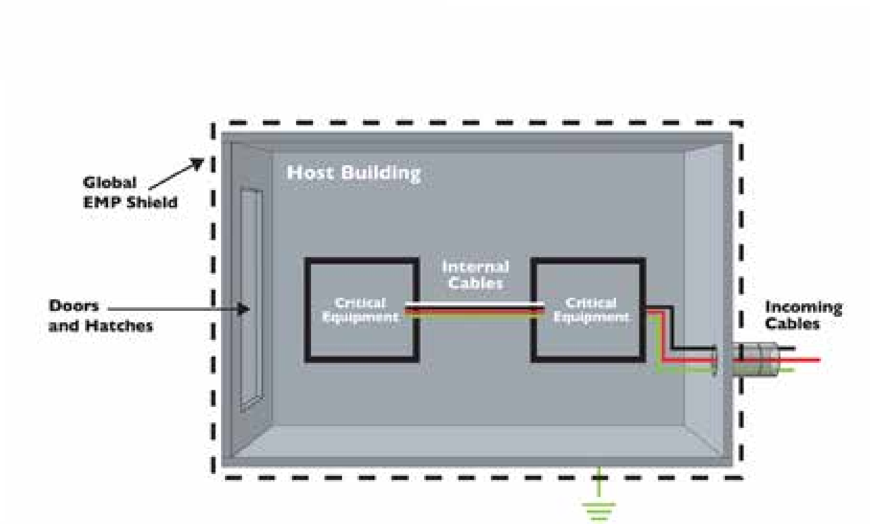
A voltage induced between conductors can drive a surge current into an electronic circuit, or conversely, a current induced onto a conductor can create a voltage across a series impedance as the current propagates into a circuit. It is virtually impossible to neutralize the current as it surges into an electronic circuit. Fusing elements and circuit breakers are too slow to prevent the current from flowing, and even if they were to open, the circuit is then nonfunctional until the interrupting device is reset. Effectively limiting the transient voltage near the sensitive electronics, however, is the key to mitigating transient damage.

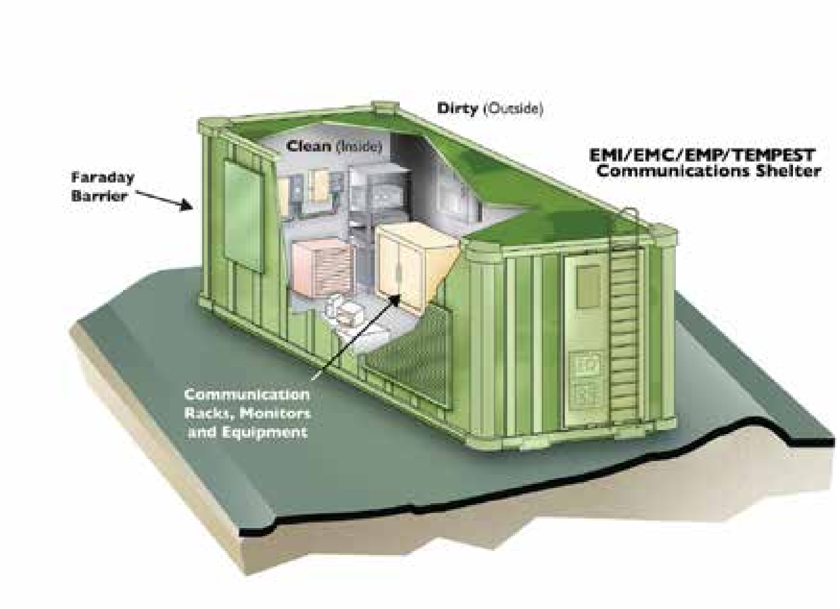
By utilizing non-degrading, fast-acting silicon avalanche suppressor diode (SASD) technology to clip off the voltage peak above the operating level, the entering surge current can be shunted away from the electronics either to ground, or back out on a safe current carrying conductor (neutral in the case of AC power). The lower the resulting voltage, the more current can be shunted. Nevertheless, the circuit topology becomes complex when considering the 20ns rise time associated with EMP strikes. Any series inductance incurred across the SASD component leads, circuit traces or grounding scheme will negatively affect the protection circuit.

Each specific system will have different characteristics and requirements, but these four elements – shielding, grounding, filtering and surge protection – remain inevitable to create a system that is effectively safeguarded from EMP. Since many variables, such as dimensions, the environment, materials, signal types, electronic configurations, points of entry (POE), cable lengths, connectors and other conditions affect the system design, equipment manufacturers and EMP mitigation experts need to work together to create an effective EMP protection solution.

Any military communications shelter or system demands a faraday barrier, or an intangible block from outside electronic dangers to achieve EMP protection. The points of entry should be minimized and protected. Transtector Systems has the capability to help accomplish this goal of system EMP mitigation.


Faraday
Barrier
Clean (Inside)
Dirty (Outside)


Global
EMP Shield
Host Building
Doors
and Hatches
Critical
Equipment
Internal
Cables
Critical
Equipment
Incoming
Cables


Dirty (Outside)
Clean (Inside)
Faraday
Barrier
EMI/EMC/EMP/TEMPEST
Communications Shelter
Communication
Racks, Monitors
and Equipment

References

1. "Experts warn of substantial risk of WMD Attack", Reuters, June, 22, 2005.

2. Arms Control Association web site, "The State of Nuclear Proliferation 2001", Retrieved March 10, 2006, from http://www.armscontrol.org/factsheets/statefct.asp

3. Report of the Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP) Attack, 2004, Dr. John S. Foster, Jr., et al.

4. Department of Defense Interface Standard: High-Altitude Electromagnetic Pulse (HEMP) Protection for Ground-Based C4I Facilities Performing Critical, Time-Urgent Missions, MIL STD 188-125-1, July 17, 1998.

5. "EMP: America's Achilles Heel", Imprimis, June 2005, Frank J. Gaffney, Jr.

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