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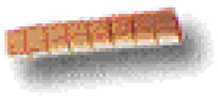

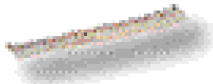

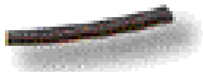

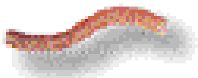

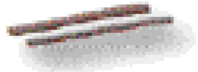

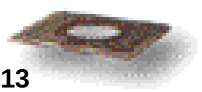

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ELECTRO-MAGNETIC PULSE (EMP)

By: Ron Brewer

In 1962, as part of the "Fishbowl" series of tests, the United States detonated a 1.4-megaton device, known as Starfish Prime, approximately 250 miles over the Johnston Atoll. An unexpected side effect of the detonation was the disruption of power, telephone, and radio communications in the Hawaiian Islands, which are located about 800 miles northeast of the Johnston Atoll. This disruption was caused by a high-intensity electromagnetic impulse created during the detonation.

Any time energy is released in an explosion, either nuclear or non-nuclear, a short-duration electromagnetic pulse is created by the ejection of free electrons from the surrounding molecules. The thermal-nuclear device, however, has significantly more energy, and in addition to thermal energy, also releases neutron, gamma, and x-ray radiation. The high energy gamma and x-ray radiation produce free electrons by both Compton and photoelectric effects from any surrounding molecules, including the shielding materials. These moving Compton electrons and photoelectrons create the high level transient electromagnetic field normally referred to as EMP.

Shielding for space craft and ground based systems that are located close to the detonation site is difficult because of the high levels of neutrons and gamma radiation. Ordinary shield materials do not impede neutrons and the gamma radiation produces free electrons, through Compton scattering, directly from the shield material. These free electrons produce an Electromagnetic Pulse internal (IEMP) to the equipment. The estimated magnitude of the IEMP is typically less than 1000 V/m. The gamma radiation from a device detonated at an altitude below about 20 miles is absorbed by the atmosphere and IEMP ceases to be a problem for ground based equipments when the separation distance from the detonation site is increased to approximately 10 miles.

In the case of a high altitude nuclear detonation, however, the gamma and x-ray radiation ejects free electrons from the surrounding air molecules. The distribution to these electrons is asymmetrical because of the varying density of the Earth's atmosphere. The path of these electrons is modified by interaction with the Earth's magnetic field and the electron velocity is accelerated, creating a coherent transverse current which produces a high-level EMP field. The amount of energy that results can produce peak EMP field intensities in the order of 50,000 V/m or more within a few nanoseconds which covers a frequency range from 1 kHz up to about 100 MHz. This field strength is 100,000 to 20,000,000, times greater than the levels required for radio communications, and is capable of causing both transient disruptions and permanent damage to electronic systems and equipment. The EMP standard environment is described in MIL-STD-2169. A system or equipment hardened to meet this standard EMP environment is expected to operate in any EMP environment without malfunction.

Any metallic surface or conductor associated with the system can act as a collector of electromagnetic energy, which is then coupled into the system. The greater the coupling area, the greater the magnitude of the coupled energy. Typical coupling levels into a ground based system, for the standard environment, are approximately 1000 Amperes for long overhead or buried line penetrations, 100 Amperes for shorter lines, and 10 Amperes for direct field penetrations into partially shielded conductors. The coupling effects of high altitude electromagnetic pulses (HEMP) at the system level are minimized by reducing the exposed collector areas and through the use of circumvention, circuit desensitization, and fault-tolerant software techniques, along with amplitude and frequency limiting. Circumvention techniques require special circuitry that senses the presence of an electromagnetic pulse and stops the operation of the system until the possibility of disruption has ended. Circumvention, circuit desensitization, and fault-tolerant software techniques must be designed into the system initially and are not normally used for retrofit of existing systems.

HEMP hardening of existing systems relies primarily on amplitude and frequency limiting through the use of shielded cables and enclosures, transient limiters, and filtering. Shielding works well for this application because there is essentially no gamma or x-ray radiation present at the shield. Shielding by enclosure is normally used for ground based facilities, systems, and equipment. Shields must be designed to handle surface currents of 1000 amperes or more combined with electric field intensities of 50,000 V/m (214 dBuV/m). This typically requires a solid skin enclosure with very low transfer impedance having attenuation values of 80-100 dB. Because of the high levels of attenuation required, and depending on the sensitivity of the equipment, this shielding is often multilayered. All penetrations of the shield must be protected and all removable panels and doors must be gasketed. The preferred RF gasket type for EMP shield protection is either the Beryllium Copper spring finger or Beryllium Copper flat spiral spring because of their low RF impedance and high current carrying characteristics. Cable shielding, on the other hand, is not as effective in reducing HEMP coupling as is the use of fiber optic signal transmission. Fiber optics, however, cannot be used for primary input power or for RF signal transmission from antenna systems. These cable and antenna systems must be hardened by using transient protectors to limit the amplitude, and either low-pass or band-pass filters to limit the frequency range of the coupled energy. Cable shields must have circumferential terminations.

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