Space/Satellite glossary of terms

VICOR

Bragg curve

A nonlinear energy loss peaking as the charged particle stops. It is a function of the material, the particle and its energy. A high energy particle exhibits lower LET than the same lower energy particle.

Coronal mass ejections

Proton rich plasma ejected due to magnetic field changes in the sun, speed 250~3000km/s, hrs to days to reach earth.

Fluence

Number of particles received per unit area [n/cm^2] or flux integrated over time [flux x s].

Flux

Number of particles per unit area per second [n/cm^2–s].

Gamma rays

High energy photons, electromagnetic waves, capable of ionizing matter that are generated by radioactive decay (^{60}Co sources are commonly used for TID testing).

Geostationary equatorial orbit (GEO)

GEO describes a specified orbit around the earth that is at a defined distance at 22,236 miles (35,786km) away from earth. It is also defined by several other parameters including velocity (11,052km/hr) and complete orbital rotation (24hr). GEO satellites are designed to match the speed of the earth's rotation to maintain its position over a specific point on earth. Many GEO satellites are exposed to greater levels of radiation and must be designed to withstand harsher design environments than LEO of MEO satellites. GEO satellites are also designed to have a longer operational life because of their intended applications like weather tracking and global telecommunications.

Highly elliptical orbit (HEO)

Unlike LEO or MEO, which are more concentric, HEO are highly eccentric and as a result are used far less often for traditional satellite applications like constellation communications networks. Highly inclined HEO satellites can appear to have long dwell times over high latitude locations which is better suited for communications at those high latitudes than GEO orbits.

Ionizing radiation

Subatomic particles (protons, electrons, neutrons, ions) or electromagnetic waves (x-rays or gamma rays) that have sufficient energy to ionize atoms by freeing electrons from them.

Linear energy transfer (LET)

The amount of energy that an ionizing particle transfers to the material traversed per unit distance [MeV/cm]. It is a function of the material density and is often expressed as the derived units [MeV•cm^2/mg] for silicon.

Low earth orbit (LEO)

LEO describes a specified orbit around the earth at a defined distance of 1,200 miles (2,000km) or less away from earth. It is also defined by several other parameters including velocity (25 – 28km/hr) and complete orbital rotation (128 minutes or less). Because of its lower orbit LEO satellites typically have a much smaller "earth footprint" which translates into a smaller serviceable area.

Medium earth orbit (MEO)

MEO describes a specified orbit around the earth that is situated between the LEO and GEO orbits at a defined distance between 1,200 miles (2,000km) and 22,236 miles (35,786km) or less away from earth. It is also defined by several other parameters including velocity (28km/hr to 11,052km/hr) and complete orbital rotation (2 to 24hrs). Because of its increasing altitude away from the earth MEO has a bigger "earth footprint" compared to LEO satellites which results in a larger serviceable area.

Rad

Radiation absorbed dose = .01 gray (SI)

Radiation hardened electronics (Rad-Hard)

Radiation-hardened electronics are electronic components that are designed, manufactured and tested to survive in specified radiation environments. Rad hard electronics are typically tested to high levels of total ionizing dose (TID), neutron or proton displacement damage (DD) and single event effects (SEE) to simulate the environment they will be exposed to. Typically rad-hard components are used in the design of spacecraft, nuclear reactors and particle accelerators where they will be exposed to high levels of radiation.

Rad-hard components typically undergo specific screening to meet established government standards which often require hermetic packaging to achieve long life. Because of their expected higher reliability and extended operational service life these devices are routinely used by space agencies, private spaceflight companies, the defense community, and research scientists.

Radiation tolerant electronics

Radiation-tolerant electronics are electronic components that are designed, manufactured and tested to withstand the negative effects of radiation up to a certain specified level. A key distinction to make is that rad-tolerant parts are not the same as rad-hard parts. Rad-tolerant parts cannot withstand the same levels of radiation rad-hard parts can. However, they are designed to operate in environments that include lower levels of radiation unlike commercial-off-the-shelf (COTS) products that have no radiation rating associated with them. With lower orbits, shorter mission times and reduced reliability requirements rad tolerant components are increasingly being utilized in LEO and MEO satellites.

Single event burn-out (SEB)

Triggering of the parasitic bipolar structure in a MOSFET power transistor, accompanied by regenerative feed-back, avalanche and high current condition. SEB is potentially destructive unless suitably protected. Typically, a particle fluence of 1E5 ions/cm^2 is used for SEB testing.

Single event effect (SEE)

A single energetic ionizing particle striking a sensitive node in a circuit and causing a measurable soft or hard error. Single events cause ionization and therefore contribute to TID which may be a factor during testing.

Single event functional interrupt (SEFI)

A soft error that causes the component to reset, lock-up, or otherwise malfunction. SEFI typically occur in complex devices with built-in state/control sections like in modern memories (SDRAM, DRAM, NOR- and NAND-Flash, etc.), all types of processors, FPGA or ASICs, or mixed-signal devices. Two main types of SEFI are distinguished depending on the actions required to restore operability: reset by software or by power cycling. The stored data may or may not be lost. Typically, a particle fluence of 1E7 ions/cm^2 is used for SEFI testing.

Single event gate rupture (SEGR) or single event dielectric rupture (SEDR)

Destructive rupture of a gate oxide or any dielectric layer by a single ion strike. This leads to leakage currents under bias and can be observed in power MOSFETs, linear integrated circuits (with internal capacitors), or as stuck bits in digital devices. Typically, a particle fluence of 1E5 ions/cm^2 is used for SEGR testing.

Single event latch-up (SEL)

A permanent and potentially destructive state of the device under ionizing particle exposure whereby a parasitic thyristor structure is triggered by an ion strike and a low impedance, high current path is created. This is common in CMOS circuits and may be destructive if the current is too high. This high current state is latched and can be reset by removal of power. Typically, a particle fluence of 1E5 ions/cm^2 is used for SEL testing at the highest rated temperature of the device.

Single event transient (SET)

A temporary voltage excursion (voltage spike) at a node in a logic, or linear, integrated circuit. Caused by a single energetic particle strike. This is a type of soft error.

Single event upset (SEU)

The change of state of one or more transistors due to a single particle. The change of state may result in a logic or memory error. A single event upset is non-destructive and the logic element can be rewritten or reset. This is a type of soft error. Typically, a particle fluence of 1E7 ions/cm^2 is used for SEU testing.

Solar flares

Intermittent eruption of electromagnetic energy from the sun typically associated with coronal mass ejections. The electromagnetic radiation covers all wavelengths from radio waves to gamma rays. Solar flare frequency varies over an 11-year cycle.

Solar wind

Charged particles consisting mostly of protons, electrons and alpha particles with trace amounts of heavier ions continuously emitted from the sun, speed 300~700km/s.

Threshold LET (LETth) or onset LET

The minimum LET sufficient to cause an effect. In device testing a particle fluence of 1E7 ions/cm^2 is often used to ensure adequate coverage of the sensitive nodes.

Total ionizing dose (TID)

A measure of long-term radiation absorbed dose. TID is measured in units of rad or gray.