

Space: the next frontier

They are out there, and they are watching us. According to some estimates there are over 2200 satellites currently above the earth performing tasks which include giving us directions when we are driving; helping to predict crop yields, monitoring the ice-caps and providing security for critical infrastructure. Even further afield, spacecraft are watching our planetary neighbours. Charcroft Electronics tells us more

Perhaps the most iconic of these unmanned spacecraft are Voyager 1 and Voyager 2. Despite the fact that they were launched in 1977 on a five-year mission to study Jupiter and Saturn, they have continued to send data back to Earth for nearly 40 years. And this raises two of the most critical challenges in near-space design: longevity and reliability.

Whilst the military sector faces similar challenges their task is made considerably easier by the fact that they can bring their equipment back to earth for a refit or repair. With some notable exceptions, this is simply not an option for most space-bound systems.

This fact changes the game for space designers. Even the most basic electronic component, such as a resistor or capacitor, must be able to withstand the extremes of temperature, shock and vibration that are part of the normal operating conditions in space. This makes the rated shelf-life and reliability of a component critical.

That is why individual component or lot-based testing is such as (an) essential requirement in space design. It is also why many component datasheets include the phrase; "A range of screening options is available." This simple phrase has far-reaching implications which can make or break a mission.

The design methodology for space-grade systems is similar to that used by earth-bound equipment with one critical difference: rather than use the same parts throughout the design stages, space-qualified components are reserved for the final production build. In the earlier stages of the design the bread-boards will be populated with mil-spec parts which offer the same performance characteristics without the guaranteed longevity needed in the field. The final build will typically use space-grade or fully-approved European Space Agency (ESA) parts, and even these can be

subjected to additional custom test procedures to ensure longevity and reliability.

Beyond space-grade testing: ceramic capacitors

Take ceramic capacitors, for example. In addition to the stringent standard tests required to gain space-grade approval, custom tests performed by the manufacturer can include tests for humidity steady-state voltage; Destructive Physical Analysis (DPA); X-RAY fluorescence (XRF) analysis; and hot IR testing at 125°C for COG dielectric, or 85°C for XSR dielectric capacitors. Surprisingly, a Certificate of Conformity for the lead (Pb) content of the component can also be optional. A simple omission in the procurement process can mean that the lack of this vital document could compromise the validity of the component and even the entire build.

A new frontier for tantalum capacitors

Tantalum capacitors can also be taken beyond the limits of conventional space-grade approvals. A process methodology, developed by KEMET, improves the quality and reliability of the dielectric by reducing the contaminants and hidden defects which can cause failures in the field. This F1 Technology uses a sequence of process methodologies to minimise the oxygen and carbon content in the anodes which can lead to the crystallisation of the anodic oxide dielectric.

The technology has been shown to produce parts which show no degradation in a 2000 hour, accelerated life test at 85°C and at 1.32x the capacitors' rated voltage. In comparison, standard tantalum capacitors show 1.5 orders of magnitude degradation in leakage current.

Another screening technique which identifies hidden defects in the dielectric of tantalum capacitors is Simulated Breakdown Screening (SBDS). A low breakdown voltage (BDV) reveals defects in the dielectric, whereas a high BDV

indicates a stronger dielectric which should provide a lower risk of failure in the field.

As a non-destructive test, SBDS can be applied to a batch of capacitors to select out only those which have the strongest dielectric. Compared to a standard Weibull test, which grades parts with voltages down to 1.25x the rated voltage, SBDS testing can select out parts with a minimum BDV of 2x the rated voltage.

Space-grade discrete semiconductors

Additional manufacturer-based testing options can also be applied to discrete semiconductors. These optional

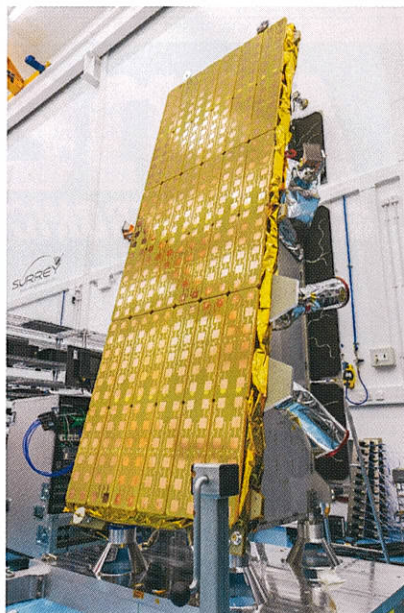


GPS satellite

tests for MIL-PRF-approved parts include electrical tests as well as short- or long-term environmental and endurance tests in response to thermal shock, temperature cycling, steady-state and intermittent operation, vibration and corrosion. Scanning electron microscopy, radiography and a total-dose radiation testing can also be added to the testing arsenal which can help to ensure the fail-free operation of components in space applications.

The cost vs reliability trade-off

Of course, additional testing does add both time and cost to the design cycle so balancing this against the planned operational life of a satellite is matter of skill and expertise. With Low-Earth Orbit (LEO) and geo-stationary satellites weighing from 1kg to above 4000kg, and life expectancy

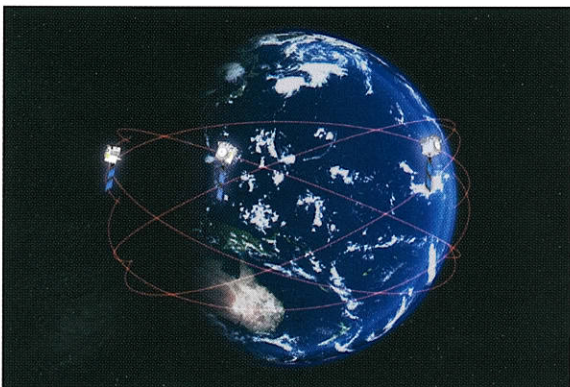


Radar platform for earth observation. Image courtesy of Surrey Satellite Technology Ltd

of between five to 15 years, this trade-off must be made on a case-by-case basis.

Despite the challenges of designing and operating products in space, this is a sector which continues to expand as designers and component manufacturers find more ways to ensure component longevity. So satellites and spacecraft, of all shapes and sizes, look set to continue to watch over us and our neighbouring planets in this solar system and beyond.

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Satellites monitor the Earth from Low Earth Orbits (LEO): Image courtesy of Surrey Satellite Technology Ltd