Technical Article

Improving IC Reliability for Harsh Design Environments

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It’s hard to believe that I’ve actually grown up with the integrated circuit (IC), which recently turned 50 years old (I pre-date that slightly … but hey, who’s counting). As a boy, I dreamed of Star Trek-like communicators and handheld medical scanners - as well as computers you could talk to that possessed seemingly endless information.

Well, it’s 2018 (so strange to write that) and much of the science fiction I dreamed about is now a reality. We see it in everyday appliances driven by powerful and reliable ICs. Our cellphones possess far more processing power than the computers that helped put astronauts on the moon and they provide instant access to any kind of entertainment or information we desire. ICs are embedded in devices and systems everywhere, many of which drive critical infrastructure such as power and water treatment plants. Unlike our cell phones, however, these devices and systems must continue working for years - sometimes in harsh conditions.

So how do you harden ICs against the environment where they are employed? First, you have to understand what causes them to fail. Because ICs are manufactured using high-energy processes, they are also susceptible to high energy. For example, running an IC at elevated junction temperatures will degrade the working life of the device. Another failure mechanism is metal migration caused by high current densities in the conductors used to connect the transistors.

These are just a few of the phenomena that can cause an IC to fail prematurely. There are many others, such as a mechanical package failure, tin whisker growth, electrostatic discharge damage ... the list goes on. As a designer looking at all of these failure mechanisms, it may feel difficult at times to ensure that your systems will operate throughout their intended lifespans. But actually, the semiconductor industry has made great strides in helping improve the quality and long-term reliability of ICs even in the harshest environments. Beyond simply improving the processes and design rules used to create ICs, standards have emerged that add additional testing to improve reliability. An example is Automotive Electronics Council (AEC)-Q100, which states how an IC is stressed during production testing. This helps ensure that the device will continue to operate once installed in a harsh environment. These devices can also be used in nonautomotive environments where higher reliability is required.

For the defense and space industry, it's a bit more difficult. The radiation that exists in space (as well as at high altitudes) can disrupt or damage ICs. As previously mentioned, high energy, such as high speed atomic particles and ionizing radiation, can wreak havoc on normal semiconductors. To mitigate failures in space and high-altitude applications, ICs are often modified to harden against this exposure and withstand extreme testing requirements such as the Qualified Manufacture List – Class V (QMLV) established by MIL-STD-883. Devices with this qualification are designed and tested to withstand high levels of radiation found in high orbits, or those installed in long-term missions (+15 years) that are exposed to continuous radiation. They can be very expensive due to the hermetic packages and extended testing required.

Device families such as Enhanced Plastic (EP) and Space Enhanced Plastic (SEP) are sophisticated alternatives. EP products follow a controlled baseline, only have gold bond wires and no pure tin that can cause whisker growth and extended temperature capability. Many of TI's components have an EP equivalent. For example, the TPS7A4001 is also available in EP as the TPS7A4001-EP. SEP devices add radiation testing and assurance so they can be used in applications such as cube satellites that sit in low Earth orbit (LEO) and have shorter operational lifespans (three years).

The IC has come a long way in its 50-plus years. Today's systems require long-lasting, reliable components. If you are designing a system that needs to be in service for extended periods of time or requires radiation tolerance, there are families of devices from Texas Instruments that are a good fit. For more information, check out my article in Electronic Design and browse our aerospace and defense web portal.

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