TECH BRIEF

Teledyne e2v Microprocessors: High Reliability Differentiators

Nov 2019

TELEDYNE e2v
Everywhereyoulook™

ABSTRACT

Let's play a technical quizz today...are you ready?

Are you able to list the top requirements of critical heavy computing systems such as Avionics, Space & Defense systems in less than 15 seconds?

Did you answer some of the following: **Longevity, Reliability, Harsh environments compliancy, Extended Lifetime, ...?**

This looks like a good start!

For more than 35 years, Teledyne e2v has **successfully delivered generations of High Reliability Microprocessors, to worldwide Avionics, Space & Defense customers** including Airbus, Boeing, NASA, ESA,...

In this paper, we will first list the **top needs from Aerospace & Defense customers**, then detail how **Teledyne e2v Microprocessors are perfectly suited for those High Reliability requirements,** prior to **a deep dive into the qualification** of these High Reliability Microprocessors.

AVIONICS, SPACE & DEFENSE MARKETS COMPUTE INTENSIVE NEEDS

Electrical & Mechanical product integrity in Extended Temperature Ranges

Avionics, Space & Defense systems are designed **to work in more extreme environments** than daily objects such as our cars and mobile phones.

It is pretty easy to understand that **extension of temperature range is among the first requirements.** An aircraft cruising at an altitude of 10,000m / 35,000 feet or a satellite in the shadow of the earth are both exposed to temperature far below freezing. While the electronic systems are obviously well protected, they have to behave as predictably at very cold temperatures as at standard ones.
On the other side, systems must also be capable of functionning perfectly in very hot conditions: with high temperatures driven by the nature of their targeted application, elevated because of constrained environments such as on board enclosures or fanless designs often required for reliability reasons or to be sure that systems still work in the worst loading conditions.

This often leads to **electronic products designed and therefore qualified over a wide range of temperatures, such as -55C to 125C** (sometimes called **Military Grade)**, as shown on Figure 1.

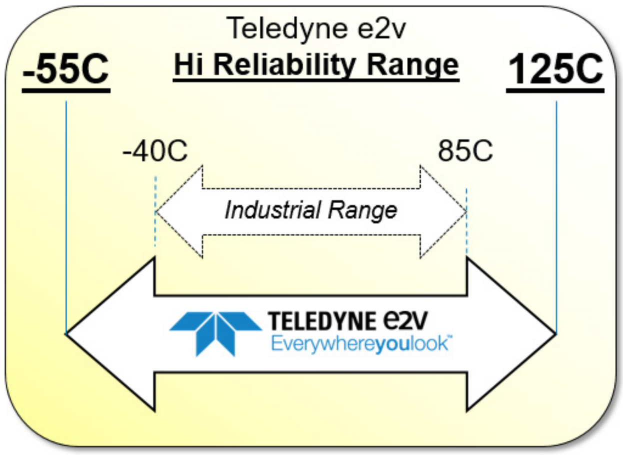

Fig. 1: Avionics, Space & Defense Temperature Requirements versus Industrial Grade.

Solder ball finishing

Solder ball finishing is also a key topic for Aerospace, Space & Defense customers. In integrated circuit packaging, the solder balls are the network of contacts underneath the device, aimed to be soldered to a printed circuit board (PCB).
Systems manufacturers had experience working with **tin-lead balls (also written Sn-Pb)** for many years; lead has indeed been widely believed to mitigate the formation of tin whiskers, though the precise mechanism is unknown.

These leaded ball are identified as Tin-Lead or SnPb, versus other type of balls not containing lead.
The Restriction of Hazardous Substances Directives (RoHS), limit the inclusion of lead in most consumer products and has triggered the **deployment of a tin-silver-copper solder process**, also called lead-free or RoHS.
Over the years, manufacturers of components such as Microprocessors, have supplied both leaded (Sn-Pb) and lead-free (RoHS) options, but **in the past ten years, the trend has been towards proposing only RoHS option.**

Since lead-free properties are less thoroughly known, they have been less popular in critical applications such as Aerospace, Space & Defense. Transition from leaded to lead-free solder naturally adds significant lead-time for customers to adopt the lead-free technology.

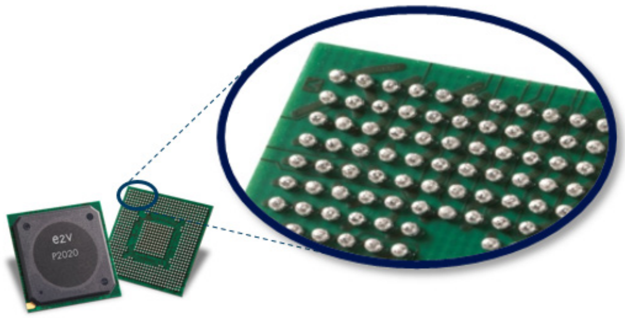

Fig. 2: Ball Finishing.

Today, the adoption rate for Lead-free is higher in Europe versus other US and Asia-Pacific regions, but yet very far from being 100% to date. In Avionics & Defense systems across Europe, the run rate for lead free is still not at 100%.
The adoption rate for Lead free devices is much lower in Avionics & Defense systems in both US & Asia.

Therefore there is a strong market requirement to continue manufacturing and qualifying components with leaded solder finishing.

Longevity

Longevity can either be seen as a key point for Avionics, Space & Defense systems, or a burden... and probably both.
Why ? Well... for the following reasons.

In Avionics, financial investments are very significant to manufacture safety critical systems; the overall lead time to manufacture, certify and have the system qualified by Aviation Authorities is very long (between 5 and 10 years). Therefore, once a system is qualified, Avionics manufacturers wish to re-use the system without any modification.

Translated into an electronic procurement world, this means being capable of sourcing devices over several decades, in order to keep manufacturing the same proven systems without any modification. Look around you and you will notice how old some aircrafts and aircraft models are and they operate without any compromise on security.

TELEDYNE E2V HIGH RELIABILITY MICROPROCESSORS QUALIFICATION

Teledyne e2v has been manufacturing High Reliability Microprocessors for more than 35 years, with the following key advantages for Avionics, Space & Defense customers:

- Extended Temperature Range: -55 to 125C
- Qualifications of both lead-free (RoHS) & Leaded (SnPb) solder ball product variants.
- Long Term Supply (15+ years).
- Teledyne e2v's product warranty in extended High Reliability domains.
- Last but not least: Aerospace Certification as per AS / EN / JIS Q 9100 (Grenoble, France).

Teledyne e2v's product qualification in High Reliability domains contains four major steps.

Let's dive into these steps.

Once the decision is taken to include a new product in our portfolio of High Reliability Microprocessors, Teledyne e2v follows these steps to assess and qualify the product.

1. Product Transfer

This first step is key to ensure that commercial Microprocessors can be extended over an Extended Temperature range.
The key enabling factor is the combination of access to the manufacturer's original test programs, as well as using the same testers; this will allow Teledyne e2v to guarantee the full functionality in High Reliability domains (-55/125C), with the **same test coverage** and **same test quality as the original manufacturer.**
Teledyne e2v has indeed continuously invested in its testing assets to qualify NXP microprocessors in High Reliability domains, from older generations to newer ones. Figure 3 highlights the **different testers that have been procured and used by Teledyne e2v over the years**, to ensure **both long term supply** as well as **introduction of new processor technologies**. Processor categories are also indicated with the associated testers.

2. Characterization

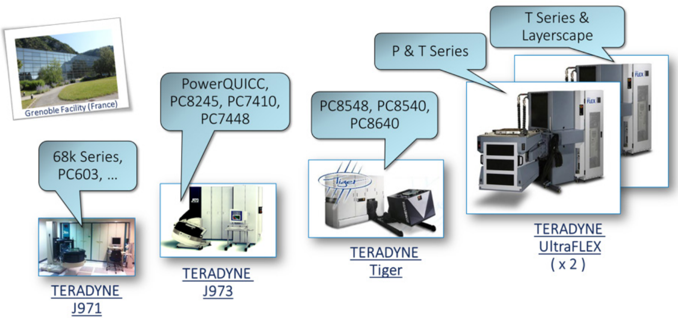

Fig. 3: Pictures of the testers.

The target of this important step is to determine how all the critical parameters (CPU frequency, voltage, power consumption, SERDES & PLL,...) will behave in an extended -55 to 125C domain.

- How much power will the device consume at 125C?
- Will the PLL lock above 105C and at -55C?
- Can the device run at maximum frequency at 125C?

The characterization step answers those questions, and **all actual data measured in the extended environment will be reported in the Teledyne e2v datasheet** when relevant for the user.

In parallel, characterization will actually allow Teledyne e2v **to ensure long term supply and with the robustness to manufacture and deliver products versus Time, Process adjustments,...**

Figure 4 highlights how the extended temperature range (105 to 125C) affects power consumption. The values obtained from Teledyne e2v characterization will be reflected in the product's datasheet.

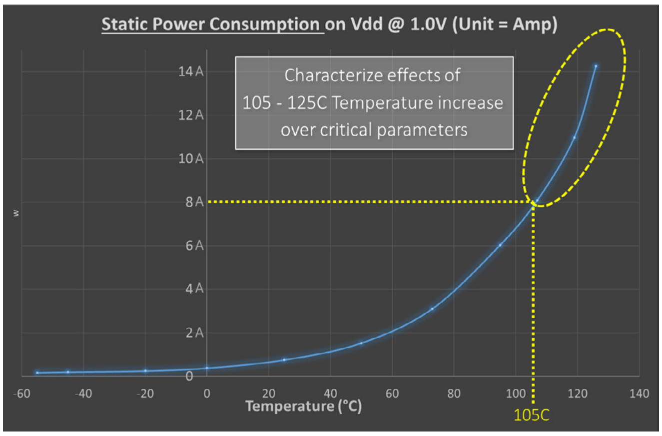

Fig. 4: Power Consumption versus Temperature.

On the other side, the next figure shows the CPU frequency versus supply voltage, in the extended Temperature range. The upper curve highlights that Vmin is crossing the min specification for Vid max, therefore the 1.8GHz frequency can not be guaranteed hence can not be manufactured in an extended temperature range. Teledyne e2v will instead manufacture the configuration to 1.6GHz since this frequency is compliant with the extended temperature range.

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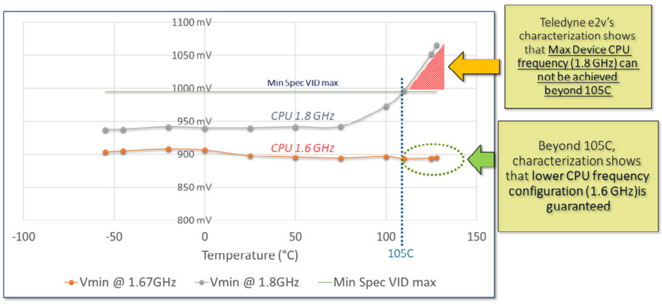

Fig. 5: CPU Frequency versus Supply voltage.

3. Deballing / Reballing

During this stage, Teledyne e2v duplicates the product configurations.

- The first configuration is the native one, i.e. with **lead-free (RoHS) solder ball**.
- The second configuration is the variant manufactured with **leaded (SnPb) solder ball.**

Such process could be easily described as just removing and replacing balls from one metal alloy to another one. However the exercise is quite complex, and the value brought to customers is very important. First because some microprocessor devices can include close to 2000 ball, and more importantly because **Teledyne e2v fully warrants the products' mechanical and electrical integrity after deballing and reballing.**

A customer handling this deballing / reballing operation by himself (probably via a third party) would indeed loose the original manufacturer product warranty.

Let us come back later on this during our case study below.

4. Qualification

This step is all about ensuring the product's reliability during its complete life cycle, through an accelerated aging process of the devices.

Figure 6 shows all major qualification steps that Teledyne e2v follows for its High Reliability microprocessors. A complete product qualification typically lasts between 4 and 6 months.
Seven successive steps are followed, involving four main activities:

- **Acoustic Microscopy**, to **check the device assembly** at T0. It is also used after other steps of the qualification to **check the integrity** of the device.
- **MSL** (Moisture Sensitivity Level tests) which actually **simulates three device reflows**.
- **Electrical tests at -55C, 25C and 125C** to verify device **performance** and to determine how the performance will evolve while the product ages.
- **Reliability Tests** involving **Humidity tests and Thermal cycles** also designed to monitor how the device will behave when it ages.

Naturally a product qualification will be performed on both product variants, i.e. the lead-free version as well as the leaded variant (deballed & reballed).

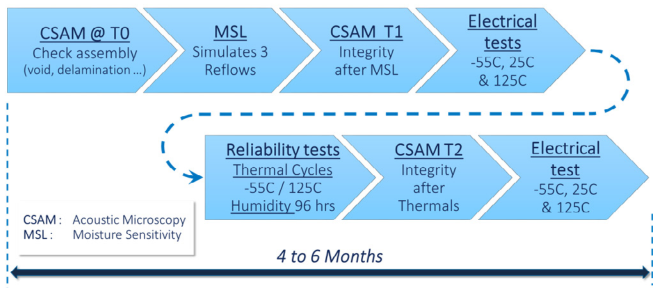

Fig. 6: Teledyne e2v Qualification flow.

A product will be deemed qualified only if it passes all of Teledyne e2v's Quality & Qualification criteria.

CASE STUDY - DEBALLING / REBALLING QUALIFICATION PROCESS

Let us now emphasize the importance of Acoustic Microscopy checks.
Let's consider a Microprocessor device that has been following a deballing / reballing to be available in a leaded (SnPb) option.
As the first step of the product qualification, an **acoustic microscopy check will be performed on the reballed leaded device.**

Figure 7 shows the same microprocessor product on which one part has gone through a Deballing / Reballing technical process «Option A» while the other has gone through a different Deballing / Reballing process «Option B».

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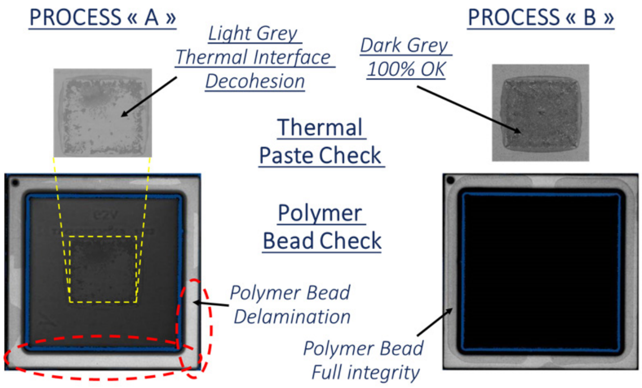

Fig. 7: Package assembly integrity check after Deballing / Reballing

Once the Teledyne e2v qualification starts, an acoustic microscopy check is performed on product A and product B.

- Option A: Acoustic Microscopy highlights that the device has been damaged during the Deballing / Reballing process. Some thermal paste is lacking as well as some of the polymer bead is delaminated.
- Option B: the results obtained are fine.

Conclusions:

- Teledyne e2v will proceed with process B.

- Process A will not be used since it does not allow Teledyne e2v to meet the product integrity requirements.

LEARN MORE:

> Teledyne e2v helps reduce power consumption in commercial processors.
> Teledyne e2v is introducing Quad ARM® Cortex® A72 for Space applications.
> Qormino packaged processing solutions will operate in a 100% Aerospace product application environment.
> Download our Space Flows Comparison Chart or order your free printed copy.

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