EEE YIR Draft
Title: NASA EEE Parts 2014 Year in Review
Summary: The NASA Electronic Parts and Packaging Program continued to support Electrical, Electronic and Electromagnetic Parts for the agency with an eventful year of workshops, innovations, testing and challenges.
Article:

The NASA Electronic Parts and Packaging Program (NEPP) continued Electrical, Electronic and Electromagnetic (EEE) parts evaluation and assurance activities for the agency with an eventful year of workshops, innovations, testing and challenges.

Workshops
NEPP hosted two successful workshops in 2014, their annual NEPP Electronics Technology Workshop (ETW) in June and the EEE Parts for Small Missions in September, both at NASA Goddard Space Flight Center (GSFC).

NEPP Co-Manager Ken LaBel calls the ETW "a program review on steroids."

"We basically present to the outside world a technical overview of our tasks — or the highlights of them at least — as well as have some invited technical talks that are of interest to folks with a common technical background area," said LaBel.

The 2014 ETW focused on NEPP's two main agency-wide efforts, EEE Parts assurance and evaluating new electronics technologies. The event was open to industry, universities and other government agencies. International participants could attend online. The presentation materials are available on the NEPP website. The 2015 ETW will be held June 23-26.

The EEE Parts for Small Missions workshop focused on CubeSats and small missions, which are particularly relevant in the current economic climate. The workshop was open to the national and international commercial industry, universities, and other government agencies, and had more than 300 registrants. Learn more about the workshop in the article, "The NEPP Program Hosts EEE Parts Workshop With Focus on Small Missions."

Innovations:
Class Y Update
Class Y, a new category specifically for non-hermetic microcircuits for use in aerospace applications, has been added to MIL-PRF-38535 for discrete microcircuits.

"We have traditionally used microcircuits that have been encapsulated in metal or ceramic packages which are hermetic — don't let air in or out," said NEPP Co-Manager Michael Sampson. "But the more advanced, newer technologies are becoming too complicated to package that way. Class Y is a process to allow qualification for space-use, non-hermetic complex packages, such as ceramic column grid arrays."

NEPP is now working with the first set of interested companies to qualify their parts for Class Y packaging. Read more about Class Y in the article, ["Class Y: A New Class of Microcircuits for Space and Military."]

Automotive Parts

NEPP, in conjunction with the Naval Surface Warfare Center, Crane Division, has been exploring the possibility of using commercial automotive parts — ceramic capacitors, plastic-encapsulated integrated circuits and discrete semiconductors in particular — for military and space use.

Why should we be looking to automotive parts for space use?

"[Automotive parts] are newer technology, more available and more affordable than most of the parts we have used traditionally," said Sampson. "The automotive parts have a well-documented qualification system and are used in high numbers in automobiles, where failure and other problems are fairly visible."

NEPP is currently looking at automobile Base Metal Electrode (BME) ceramic capacitors for space use, and the results seem promising. When NEPP first tested them over a decade ago, the BME capacitors failed under traditional lab test conditions. However, more recent test results have exceeded requirements for military qualification.

NEPP Evaluation Automotive Grade MLCCs Selected and Evaluation Plan

Parts were purchased through distributors as AEC Q-"XXX" Automotive Grade

Commodity	Test	Status	Comments
Ceramic Capacitors 3 Different Mfrs BME, 0805, 0.47uF, 50V	Construction Analysis	Complete	• *At their own discretion a manufacturer supplied devices made with "flexible termination"*
	Initial Parametric Measurements	Complete	• No Failures • *DWV known to produce negative cap shift* • *Mfrs recommend bake-out to restore cap*
	Life Test (2x Vrated, 125°C)	> 6000 Hrs Complete (Progressing to 10k hours)	• *1 lot exhibits 5 life test failures (120pc) up to 6000 hrs* • *2 failures at 3100 hrs; 3 failures at 4700 hrs* • 2 lots exhibit no life test failures up to ~5500 hrs
Integrated Circuits 2 Different Mfrs 1 digital IC (Diff Bus Driver; 1 linear IC (Comparator)	Construction Analysis	In Process	• *Corrosion on Terminals "As-Received" (Linear IC)* • Tg measurements complete • CSAM complete for digital IC • C/A to be performed at end of test
	Initial Parametric Measurements	In Process	• No Failures for digital IC • Linear IC to be tested 04/15
	Burn-In & Life Test	Begin 04/15	
Discrete Semiconductors	Construction Analysis	Awaiting input	Awaiting input
	Initial Parametric Measurements	Awaiting input	Awaiting input
	Burn-In & Life Test	Awaiting input	Awaiting input

NEPP Automotive Parts Test and Evaluation Plan

If NEPP is able to prove the reliability of automotive parts for use in space, there will be significant benefits. Automotive parts that are qualified by the Automotive Electronics Council undergo a series of critical stress test qualifications to ensure consistent performance and reliability; reliability problems are more likely to become public knowledge because of the large user base; and they are cost-competitive to commercial parts.

"Automotive parts are smaller, cheaper and higher-performance than most of the parts we're using on regular satellites," said Sampson.

Test Findings:
Plugging for Electronic Packages
One major finding from hermeticity testing of EEE Parts was proof that plugging of leak paths occurs.

Plugging in non-hermetic packages — an undesirable process that reduces the effective size of a leakage path in a hermetic part — is believed to occur when the package material corrodes and the corrosion expands and plugs up the fine leak path. Fine leak paths are typically very thin, with dimensions in the nanometer range.

"We didn't anticipate it — it has been known or suspected in the industry for years, but testing by NEPP actually proved that it does exist," said Sampson.

Plugging can be detrimental because it can create a seal that could temporarily allow an inherently non-hermetic package to pass testing. NEPP continues to investigate plugging and explore possible ways to improve detection.

Xilinx Virtex 5QV for Radiation
This year NEPP completed radiation testing on Xilinx's Virtex-5QV field-programmable gate array (FPGA). The Virtext-5QV is a commercial high-performance FPGA partially re-designed to improve radiation tolerance for space usage.

"We had gotten an agreement in place with Xilinx," said LaBel, "They provided samples and we provided testing… So it was a wonderful in-kind agreement that put no restrictions on us at all from accessibility of the data."

In exchange for the samples, NEPP provided independent testing on heavy ion single-event radiation performance; all other tests on these parts had been performed by the manufacturer.

Radiation can change the state of a memory cell, or, in extreme cases, cause hard failures, said LaBel. It was important, then, to provide independent testing to determine whether the hardening provided by Xilinx was sufficient for space-use. NEPP's testing focused on the practical space-application of the Virtex-5QV.

"We saw things we expected to see based on the manufacturer's testing, and we saw a few things they didn't because of the way we test," said LaBel. "We care about what happens that affects user designs; what does it mean to someone who is using the device with 3.9 billion transistors… Does it cause bad data or failure of the operation?"

Through their independent testing, NEPP is able to provide guidance for suitability and strategies for application, said Sampson.

Small Mission and CubeSat

In 2014, NEPP completed initial radiation tests on microprocessors, microcontrollers and power devices from CubeSat kit manufacturers, with mixed results.

According to LaBel, radiation responses vary widely in Commercial Off-The-Shelf parts.

"When you consider straightforward devices, like a capacitor, which in truth is never really straightforward, and these billion transistor FPGAs like the Xilinx device, there's this whole spectrum of complexity," he said. "The results we see span that complexity in terms of orders of magnitude of differences that we can see in things that are fairly similar."

The variation is caused by a number of factors, including the foundry process, the design rules established at the factory for that process, and the application circuitry embedded in the device. These factors can impact both radiation and reliability.

Other factors include complex packaging, which is often done at third party locations. "We're talking about packages with more than 1,500 pins on them. And the complexity is increasing," said LaBel.

CubeSat missions typically have relatively short lifespans and are set in more benign radiation orbits, which allow a certain tolerance for variance. However, NASA is looking at increasing CubeSat mission lengths and moving to more challenging environments. NEPP is working towards providing guidance for these more demanding mission requirements, which may address these variances.

Challenges:
Radiation Modeling and Testing Availability

While NEPP had many successes with radiation testing, they faced some new challenges in 2014 regarding radiation modeling and testing availability.

One challenge was the threatened closure of CREME96 and CREME-MC, a tool that is used by NASA and the entire aerospace industry as a standard process for radiation risk analysis. The website that was hosting the tool faced closure due to lack of government funding. NASA and other government agencies formed a team to keep the website active and to transition CREME to a government site.

"…We've managed to step in and bring community awareness to this, as well as working a transition plan," said LaBel.

Another challenge was the closure of the Indiana University Cyclotron Facility (IUCF), which had been the most highly used proton-testing site in the country. IUCF had started as a research facility, and then transitioned into a proton therapy medical facility that still allowed proton single event testing and research.

"The shutdown was announced in August, and the last beam for us testers was run in October 31," said LaBel. "We've formed and led an ad hoc team of multi-government agency support people to investigate other facilities…. We've done a large number of site visits to these alternate medical proton therapy sites, and the short answer is, we can likely get some beam time access at these sites, but it's not going to be a one-for-one replacement."

Part of the issue is that the proton beam is delivered to medical patients in a different manner than it is traditionally delivered to EEE parts. NEPP is running a series of tests to evaluate the implications of that difference. In addition, the multi-agency team is investigating long-term solutions for testing access, or even a replacement dedicated facility.

"We're not recommending that anyone go spend $5 million dollars right now [on a new facility]," said LaBel. "However, we are saying, in the near future at least, we can make relatively small investments to improve accessibility for the future."

Looking Ahead at 2015:
For 2015, NEPP is continuing their research and testing, as well as adapting to the changing economic climate.

"The goals this year are really in many ways a continuation of the work we've started," said LaBel. "I think the real thing we're trying to push for is how to be more cost effective in the current climes of cost-conscious missions."

NEPP hopes to achieve these goals by exploring more collaboration opportunities with other government agencies and military, investigating emerging commercial and military technologies, and constantly reevaluating current processes for efficiency and innovation opportunities.