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Implementation of Aerospace Qualified Electronic Component Requirements

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Introduction

In 1994, a paradigm shift occurred with the defense community due to the concept of “Defense Acquisition Reform”. In the years that followed the industry has looked for viable ways to procure commercial-off-the-shelf (COTS) components while still ensuring that these components meet critical performance, reliability, and safety requirements.

GEIA-STD-0002-1 Aerospace Qualified Electronic Component (AQEC) Requirements, jointly developed by the aerospace and semiconductor industries, defines the minimum requirements for commercial-off-the-shelf (COTS) components used in military, avionic, aerospace, and other rugged operating environments where high-reliability and long service life are required.

This paper will present the TI approach to AQEC certification, qualification of TI AQEC products, and the process monitors in place to ensure AQEC component quality and reliability.

Development of the AQEC Standard

The aerospace and semiconductor device industries needed a structured approach to share information about COTS components and to assess the suitability of using these components in rigorous applications. A working group of avionics manufacturers, airframe integrators, integrated circuit manufacturers, DoD end users, and representatives from multiple government and industry agencies was formed. The working group then defined a challenging set of goals:

- Establish a forum to promote interaction between the aerospace and semiconductor industries
- Eliminate or minimize the need for up-rating or up-screening of components
- Ensure parts are characterized and qualified for use in avionics
- Establish adequate configuration controls and change notification
- Assure part availability – reduce DMSMS issues
- Enable users to better understand component limitations (such as operating conditions, performance, operating life, and production longevity) to facilitate component selection and design trade-offs
- Ensure AQEC parts are automatically approved per IEC62239 and EIA4899

GEIA-STD-0002-1

The AQEC standard defines the minimum set of requirements and/or the information provided by the part manufacturer that will allow a COTS component to be designated AQEC by the manufacturer. This includes:

- Each component is designed, fabricated, assembled, and tested in accordance with the component manufacturer's requirements for standard data book components
- Qualification requirements and quality systems include the manufacturer's standards, operating procedures, and technical specifications
- Functional parameters are specified on manufacturer's data sheet
- Data is published regarding parametric limits versus application environmental conditions that would be of particular interest to users who need to make tradeoffs among characteristics. This includes temperature, power, frequency, and timing while still operating within the manufacturer's recommended operating conditions
- Published roadmap information to assist the system designer in anticipating future device parametric shifts and/or obsolescence and making provisions for them within the design or in planning ahead for revisions to the design
- Access to die and package related testing to facilitate characterization of parts for some applications
- Access to reliability data for life cycle environmental and operational stresses
- Access to steady-state life Failures-in-Time (FIT) data
- Lead finish indicated by an easily identified part number

TI AQEC Implementation

Texas Instruments elected to certify the entire Enhanced Products (EP) line to GEIA-STD-0002-1 Aerospace Qualified Electronic Component (AQEC) Requirements. Therefore each TI EP product must complete device, device family, and/or package family qualifications prior to release.

The TI Quality System Manual is available on the TI website www.ti.com for customer reference.

Compliance with GEIA-STD-0002-1

GEIA-STD-0002-1 defines several required processes including:

- AQEC Performance
- AQEC Qualification
- AQEC Documentation
- AQEC Last-time Buy Notification
- Termination Materials
- Qualify System Certification
- AQEC Quality Assurance
- AQEC Product Change Notification
- Obsolescence Management

The core portions of these requirements will be discussed below.

Texas Instruments is a certified ISO-9000:2000 manufacturer offering a broad cross-section of integrated circuits (microcircuits) on a worldwide scale using numerous wafer fabrication and assembly test facilities. All of these operations are governed by the TI Quality System Manual (QSM). The QSM establishes minimum standards for all TI business units. Each business unit defines, within the guidelines of the applicable QSM, a qualification and reliability monitoring program. These programs and other detailed specifications comprise the TI Quality Systems Standards (QSS). Qualification and reliability monitoring programs are established based on complexity of the technology and the requirements of major end customer requirements. The test methods used by TI are defined in detail in the QSS specification for each test.

Texas Instruments performs qualification and reliability monitoring at several levels. In general, a new process or device technology is extensively qualified as standalone entity. Variations of existing processes or technologies do not receive as extensive a qualification. For example, the release of a new family of digital signal processors using a new wafer fabrication process would receive a different level of qualification than the release of a die revision of an existing product. A new package technology qualification would differ from the release of a qualified die into an existing package. After initial qualification, various quality and reliability monitors are performed. In the wafer fab, wafer level reliability monitors are performed to ensure that the wafer fab processes are in control and producing die to the wafer fabrication baseline. In the assembly sites, package related testing is performed to ensure that the assembly process is in control and producing reliably devices. Periodic early failure rate and life test monitors are performed. Monitors for leading edge technologies are more extensive than those performed for mature technologies.

TI has standalone specifications governing HiRel Product Definition, Release and Change Control as well as a specific Enhanced Products Release Requirements document. EP devices are individually evaluated prior to release identify and verify the performance in all environmental conditions identified in the data sheet. The datasheet identifies any known environmental or performance limitations.

A stand-alone datasheet is provided for all EP products and is available on the TI web site www.ti.com/ep. The generic part type contains the suffix "-EP". A DSCC VID is assigned for EP products and is an orderable part number on the TI web. In addition material content is available on-line and/or upon request for all EP products. TI EP devices do not utilize lead finishes containing more than 97% tin. Most are Nickel-Palladium-Gold with Ball Grid Arrays utilizing Tin-Lead solder balls.

TI provides enhanced Process Change Notification for EP products with 180-day notification prior to implementation of a change. This is through the TI electronic PCN system. A published TI PCN is automatically picked up by the GIDEP systems.

While AQEC requires manufactures to provide an estimate of the actual expected production life for devices with expected production of less than 5 years, the TI EP policy is to review expected product lifetime and not release sunset devices or technologies.

Enhanced Products (EP) Minimum Qualification Requirements

As previously mentioned each TI EP product must complete device, device family, and/or package family qualifications prior to release.

Description	Condition	Sample Size	Test Method
<i>Electromigration</i>	Maximum Recommended Operating Conditions	N/A	Per TI Design Rules
<i>Wire Bond Life</i>	Maximum Recommended Operating Conditions	N/A	Per TI Design Rules
<i>Electrical Characterization</i>	TI Data Sheet	50 units/lot	N/A
<i>Electrostatic Discharge Sensitivity</i>	HBM MM	3 units/voltage	EIA/JESD22-A114 EIA/JESD22-A115
<i>Latch-up</i>	Per Technology	5/0 units/lot	EIA/JESD78
<i>Physical Dimensions</i>	TI Data Sheet	5/0	EIA/JESD22- B100
<i>Thermal Impedance</i>	Theta-JA on board	Per Pin-Package	EIA/JESD51
<i>Bias Life Test</i>	125°C / 1000 hours or equivalent	116/0	JESD22-A108*
<i>Biased Humidity</i>	85°C / 85% / 1000 hours or HAST 130°C / 85% / 96 hours	77/0	JESD22-A101* JESD22-A110
<i>Autoclave</i>	121 °C @ 2 atmospheres absolute for 96 hours	77/0	JESD22-A102*
<i>Temperature Cycle</i>	-65 °C to +150 °C non-biased for 1,000 cycles	77/0	JESD22-A104*
<i>Solder Heat</i>	260 °C for 10 seconds	22/0	JESD22-B106
<i>Resistance to Solvents</i>	Ink symbol only	12/0	JESD22-B107
<i>Solderability</i>	Condition A (steam age for 8 hours)	22/0	ANSI/J-STD-002-92
<i>Flammability</i>	Method A / Method B	5/0	UL-1964
<i>Bond Strength</i>	-	76/0 wires	ASTM F-459
<i>Die Shear</i>	-	5/0	TM 2019
<i>High Temp Storage</i>	150 °C / 1,000 hours	45/0	JESD22-A103-A*
<i>Moisture Sensitivity</i>	Surface Mount Only	12/0	J-STD-020-A*

* Precondition performed

Process Reliability Monitors

Periodic life test monitors are performed for each technology from each wafer fab. This consists of steady state life test for 1,000 hours at 125°C or equivalent. Package related monitors are determined performed by each assembly facility as dictated by the complexity of the technology and major end customer requirements.

Periodic environmental monitors are conducted by package type and assembly facility. These include Biased Humidity (85°C/85%RH/1K hours) or HAST (130°C/85%RH/96 hours), Autoclave or unbiased HAST, Temperature Cycle (-65°C/+150°C/500 cycles), and High Temp Storage (150°C/1K hours)

An example EP reliability report can be found under www.ti.com/ep

Each TI wafer fab establishes or adopts controlled specifications to define wafer level reliability controls, procedures, and tests. These specifications additionally contain any variable information that is unique to that wafer fab/product family. In general these procedures address metallization, protective overcoat, multilevel/interlevel dielectrics, and gate/storage dielectrics. The specific areas vary depending on process technology such as bipolar or CMOS.

Typical Wafer Level Reliability Monitor Program

Control Point	Test	Sample Point	Sample Size/Frequency	Control Method
Metal	Visual	Post etch	Each lot	Lot accept
	Thickness	Post deposition	Each run	SPC
	SEM step coverage	Post sinter	1 wafer/deposition system and/or prod family/week	Monitor
Field oxide	Phosphorus level	Post metal etch or post emitter diffusion	1 wafer/week	Monitor
	C-V test	Finished wafer	Each lot	Monitor
Interlevel Oxide (ILO)	Integrity	Post via etch	1 wafer/reactor/week or 1 wafer/ILO structure/week	Monitor
	Thickness	Post deposition	1 pilot/reactor/run	SPC
	Visual	Post etch	Each lot	Lot accept
	Wt % phosphorus (doped ILO/ MLO)	Post deposition	3 pilots/reactor/week	Monitor
Gate oxide	C-V test	Post oxidation	1 pilot/furnace/week	Monitor
Glassivation	Visual	Post etch	Each lot	Lot accept
	Thickness	Post deposition	Each run	SPC
	Refractive index	Post deposition	Each run	Monitor
	Integrity	Post etch	1 wafer/reactor/week or 1 wafer/deposition type/week	Monitor

Conclusion

The use of AQEC certified devices facilitates the insertion of state-of-the-art technology providing the defense and avionic manufacturer with a strategic competitive advantage.

Texas Instruments HiRel Products brings to the table a level of expertise in dealing with high reliability components and customer specific requirements that few suppliers can provide. The quality system developed and put in place fully meets the requirements for delivery of a reliable, quality product. This is not due to independent audits or certifications, but is directly attributable to years of commitment to quality, reliability, and service. TI remains committed to serving the HiRel, Defense, & Aerospace marketplace and continues to work with customers to provide them with the high quality products they have come to expect from Texas Instruments.