Aerospace & Defense Products Group
Automotive Grade COTS

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Agenda

- Corporate Overview & History
- Microchip Strengths
- Automotive Grade Products
- Automotive Grade Qualification
- Microchip Production Part Approval Process (PPAP) Overview
- Summary
- Acknowledgements
- Q&A

Corporate Overview

- **Leading provider of:**
  - **Hi performance, field programmable Microcontrollers and Digital Signal Controllers**
  - **Mixed-Signal, Analog & Interface Products**
  - **Non-volatile EEPROM & FLASH memory**
  - **High speed low power ADC**
  - **MEMS oscillators**
- **~ $3.3Billion revenue run rate**
- **~ 14,000 employees worldwide**
- **Headquartered near Phoenix in Chandler, AZ**
- **>100K Clients and >100K SKUs**

Microchip History

- 1987 – General Instrument spins-off microelectronics division
- 1989 – Microchip Technology formed from spin-off
- 1993 – Microchip Technology becomes a public company
  - Commercial microcontrollers and MCU related products
- 1998 – Microchip forms Automotive Products Group
  - The start of a large Commercial Off The Shelf (COTS) portfolio

Microchip – A Leading Provider of Microcontroller, Mixed-Signal, Analog and FLASH-IP Solutions

Microchip History

- **Starting in 2010, Microchip advanced its Mil / Aero product portfolio and capabilities with strategic acquisitions:**

- **2010 – SST – High Density FLASH-IP**
- **2011 – MMT – DLA Approved assembly and test**
- **2011 – LSS – High Speed ADC technology**
- **2013 – Novocell – NV Memory-IP**
- **2014 – Supertex – HV analog & mixed signal**
- **2015 – Micrel – Analog, power & mixed signal**
- **July 2015 – Microchip Aerospace & Defense Products Group**
- **April 2016 – Atmel**
  - **Rad hard & rad tolerant microprocessors & microcontrollers**

Microchip – 26 Years of Continuous Growth & Development with > 102 Continuous Quarters of Profitability

Strengths

Microchip Strengths

- **Unique Differentiators**
  - **Ease of Use – Long History & Reputation**
  - **Un-paralleled Product Support from Applications Teams and Reference Designs**
  - **Quality System and Test Flow Ensure Reliability**
  - **Own our Fabs – Tempe AZ & Gresham OR**
  - **Own our Assembly and Test - MTAI**
  - **Own Microchip-MMT = DLA Approved**
    - **Mil / Aero Hermetic Packaging & Test**
  - **“No EOL” Policy**
  - **Many Aerospace Design Partners**

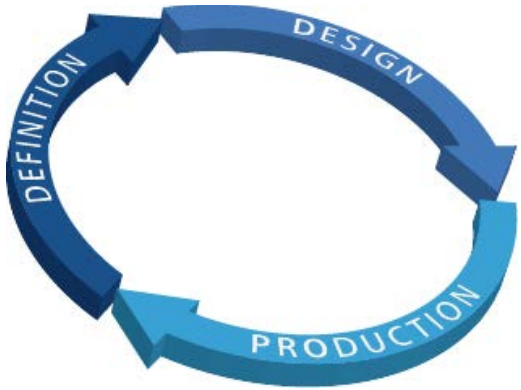
Microchip Strengths

- **Robust Quality Management System**
  - **TS-16949 deployed worldwide**
  - **“Most” products started with “intent” to be automotive grade**
- **Extensive Automotive Product Line**
  - **> 30 product families**
  - **> 750 individual products**
  - **> 1000 PPAPs**
- **Microchip - MMT – DLA Approved Assembly & Test:**
  - **MIL-PRF-38535 and MIL-STD 883 (Microcircuit)**
  - **MIL-PRF-19500 and MIL-STD-750 (Discrete)**
  - **MIL-PRF-38538 and MIL-STD-883 (MCM)**

World Class Quality & Reliability

Reliable Supply
- >99% On-time Delivery
- 6-8 Week Lead Times
- Longest Product Lifecycles
- More Than 20 Years Experience

Reliable Support
- Global Technical Support
- 1000+ Design Partners
- 80+ Distributors
- Global Training Network



Reliable Product
- Automotive Grade - PPAP
- Robust Quality Systems
- Thorough Test and Process Control

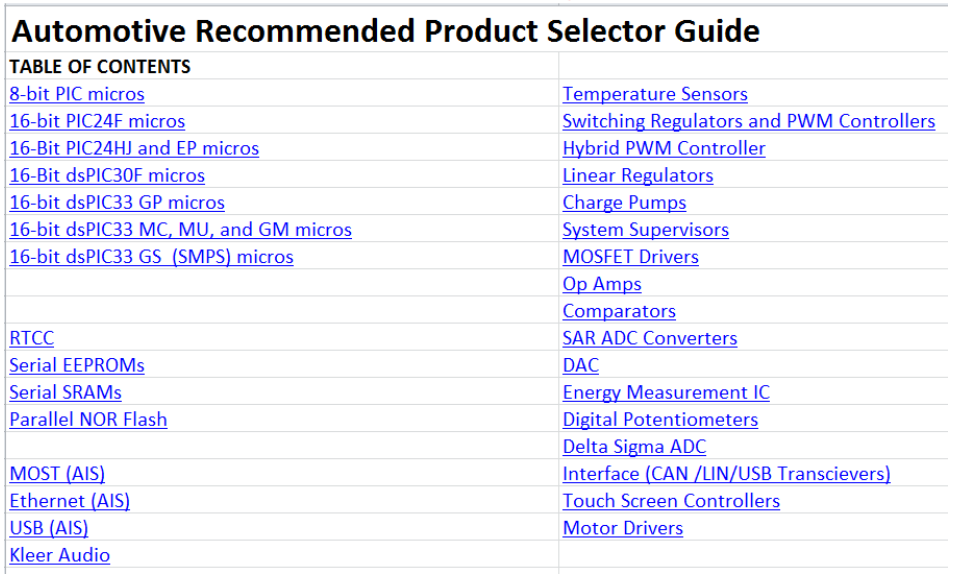
Here to help you throughout your product lifecycle

ADPG Product Portfolio

Automotive (COTS) Selector Guide

- **Automotive Grade AEC Q100 Qualified**
- **> 30 product families, > 750 part numbers**
  - **Note: Automotive grade products are not designed for an SEE or TID environment**
- **Complete Product Selector Guide available at:**
  www.microchip.com/aero

Table of Contents



Automotive Recommended Product Selector Guide

AEC

- The Automotive Electronics Council (AEC) was originally established by Chrysler, Ford, and GM in the mid-1990s
- The AEC developed part-qualification standard AEC-Q100
- Defines critical stress tests conducted to qualify an IC for automotive applications

http://www.aecouncil.com/Documents/AEC_Q100_Rev_G_Base_Document.pdf

Automotive Temp Grades

- AEC Q-100
  - Grade 0 (-40C to 150C)
    - H-Temp
  - Grade 1 (-40C to 125C)
    - E-Temp
  - Grade 2 (-40C to 105C)
    - V-Temp
  - Grade 3 (-40 to 85C)
    - I-Temp

Automotive Grade Qualification

- Qualification as an automotive grade part requires Advanced Product Quality Planning (APQP phase 4) and compliant to TS-16949
- APQP requires:
  - Planning and Definition
  - Product Design and Development
  - Process Design and Development
  - Product and Process Validation
  - Feedback, Assessment and Corrective Action
- APQP culminates in a submission as evidence that the product quality, as planned, was achieved.
- Compliance to TS-16949 = TS Yes (aka QS Yes)
  - ISO-9000 -> QS-9000 ->TS16949

Automotive Grade Qualification

Microchip offers multiple levels of compliance

- Commercial / Industrial with “intent” to be TS yes
- VAO = TS yes + No PPAP
- Vnn = TS yes + Essential Elements + No PPAP
- Vnn = TS yes + PPAP
- Other / custom = no limits, based on customer and business opportunity
  - i.e. – custom packaging, screening - MMT

What is a “VAO” part

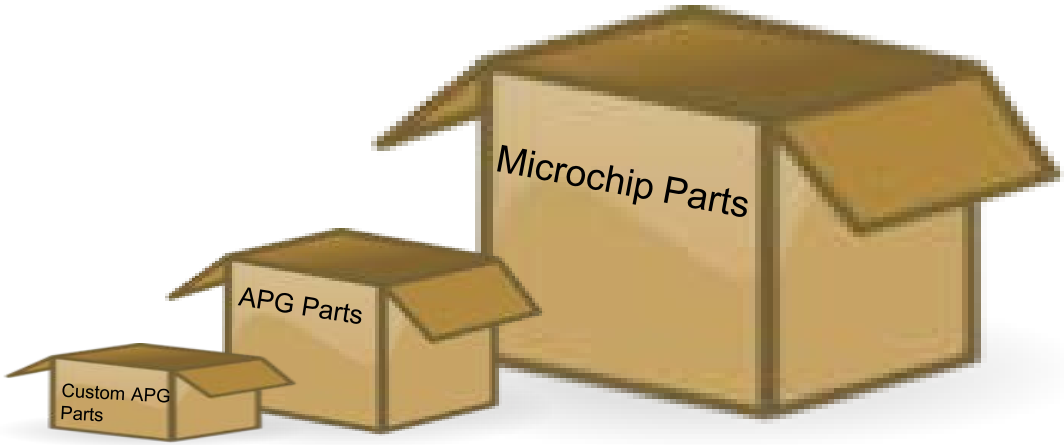
- Three letter extension added to standard part numbers
  - Example: PIC16F688T-I/SL → PIC16F688T-I/SLVAO
- Identifies standard AUTOMOTIVE parts
- “VAO” = only TS16949 compliant devices will be shipped
  - Wafers must meet minimum yield requirements
  - Limits imposed on allowable rework
  - Limited assembly site
  - Limited product/process changes
  - AEC-Q100 qualified
  - Improved cycle time for FA and root cause and corrective action on a failure (8D) support

“VAO” is NOT

- A special wafer fab process
- A special assembly or test process, but restricted
- An industry standard
  - Used by Microchip to identify Automotive parts
- Has no translation
  - 3 letters chosen at random

Automotive Grade (COTS) Customers

- **Must order "VAO" part number**
  - **COTS / automotive customers should not order standard parts**
- **Custom Automotive part numbers can be created for the following**
  - PPAPs
  - QTP
  - Customer request



Automotive PPAPs

Production Part Approval Process (PPAP) Overview

- PPAP is a series of documents formally approved by the supplier & customer through a Part Submission Warrant (PSW)
- PPAP highlights the proof or evidence collected through APQP and validated with results from the first trial run
- The trial run cannot be a prototype – it must represent the production environment with correct tools, machines, processes, personnel, and conditions that may affect quality
- PPAP is used in the automotive supply chain to establish confidence in the components suppliers and their production processes

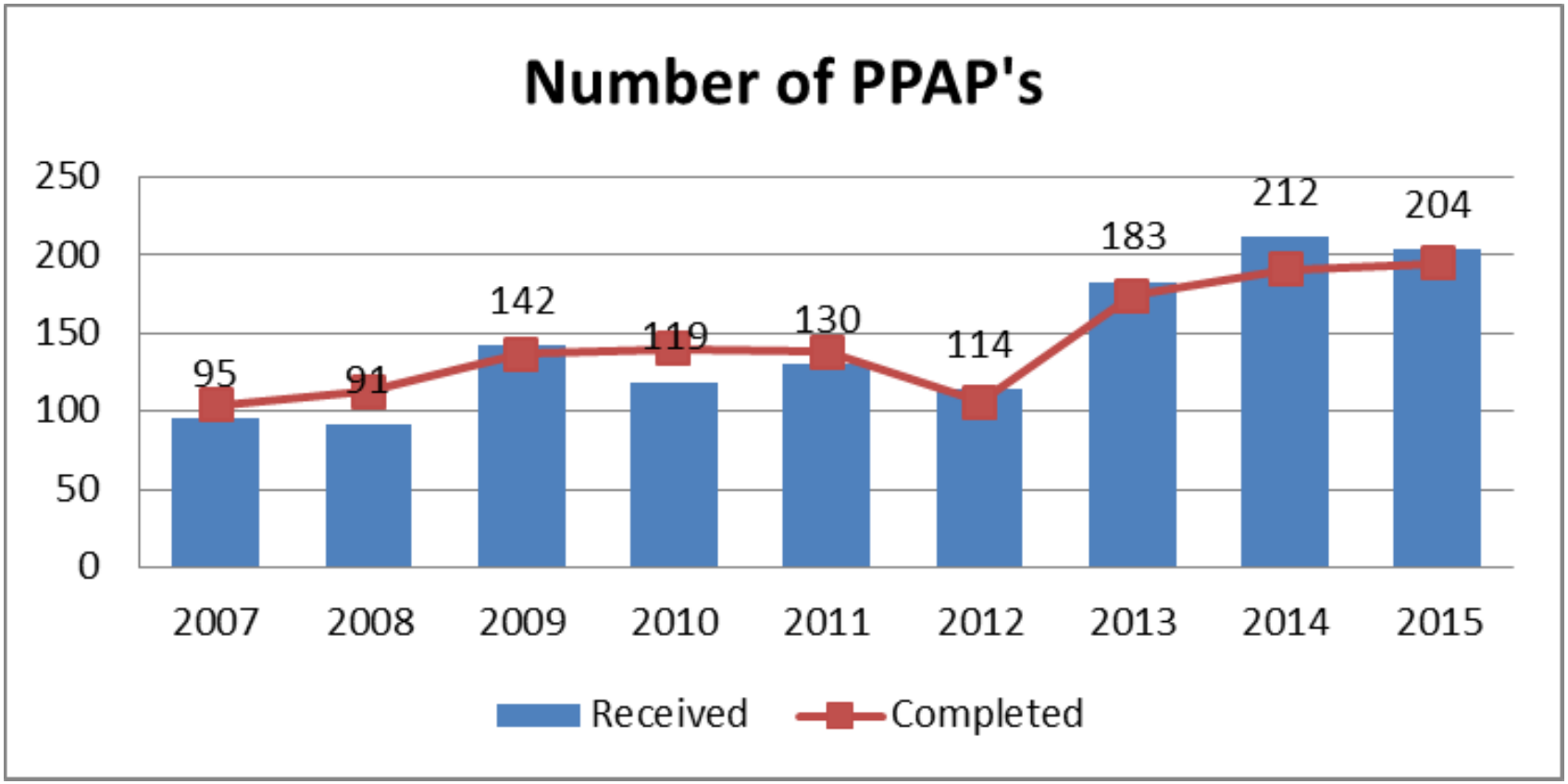
Main Contents of a PPAP

- **The contents of a PPAP are Client specific and subject to their Quality System**
- **The contents of a PPAP apply to the whole process**
  - **Design Records**
  - **Certificate of Design & Construction**
  - **Bonding Diagram**
  - **International Material Data System (IMDS)**
  - **Data Sheet**
  - **Customer Specification (if provided)**
  - **Design Process Failure Mode Effects Analysis (DFMEA)**
  - **Process Flow Diagrams**
  - **Process Failure Mode Effects Analysis (PFMEA)**
  - **Control Plans**
  - **Measurement System Analysis Studies (MSA)**
  - **Dimensional Results**
  - **Qualification AEC Q-100**
  - **Initial Process Studies (Cpks > 1.67)**
  - **Qualified Laboratory Documentation**
  - **Appearance Approval Report (ARR)**
  - **Part Submission Warrant (PSW)**

PPAP Part Numbers

- PPAP Custom Part Numbers (Vnn)
  - Unique part number for only one customer
  - Restricted manufacturing location
  - Restricted essential elements
  - Restricted test flow (if applicable)
  - Custom Product Change Notification (PCN)

Automotive PPAPs



Summary

- "Most" Microchip products are started with "intent" to be automotive grade
- Automotive grade products are not designed for an SEE or TID environment
- Microchip has an extensive AEC Q-100 product portfolio
- Microchip has a well established PPAP process with more than 1000 PPAPs of record
- "VAO" part numbers deliver a Q-100 part without PPAP
- "Vnn" part numbers MAY have an associated PPAP but these are customer specific part numbers
  - Future planning – utilize existing PPAP contents with a new part number for space customers

Acknowledgments

Microchip Technology would like to thank:

Ken LaBel, Mike Sampson and NASA GSFC for this opportunity to present at NEPP ETW

Thank You

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Q & A

BACKUP

Microchip - MMT History

- Founded in 1989 – spin-off from Philips Thailand
- 1990 – hermetic assembly operations start
- 1993 – plastic assembly operations start
- 2000 – transfer hermetic space assembly & test line
- 2001 – name change to Millennium Microtech
- 2006 – transferred hermetic MEMS production line
- 2007 – transferred metal can space assembly & test line
- 2011 – acquired by Microchip Technology
- 2014 – changed name to Microchip Technology Thailand LTD

http://www.mmt-technology.com/solution.html

AEC

Automotive Electronic Council

- **The Automotive Electronics Council (AEC) was originally established by Chrysler, Ford, and GM for the purpose of establishing common part-qualification and quality-system standards. From its inception, the AEC has consisted of two Committees: the Quality Systems Committee and the Component Technical Committee. Today, the committees are composed of representatives from the Sustaining Members (currently Autoliv, Bose Corporation, Continental Corporation, Cummins, Delphi Corporation, Denso International America, Gentex Corporation, Harman, Hella, John Deere Electronics Solutions (Phoenix International), Lear Corporation, Magna Electronics, TRW Automotive, Valeo, and Visteon Corporation) and other Technical, Associate, and Guest Members.**

AEC Documents

The following documents have been established by the AEC Component Technical Committee to define common electrical component qualification requirements. These documents contain detailed qualification and requalification requirements and include unique test methods and guidelines for the use of generic data. Components meeting these specifications are suitable for use in the harsh automotive environment without additional component level qualification testing. Suppliers may advertise components meeting these specifications without restrictions, but the specifications cannot be changed without the approval of the Sustaining Members (currently Autoliv, Bose Corporation, Continental, Cummins, Delphi, Denso International America, Gentex, Harman, Hella, John Deere Electronic Solutions (Phoenix International), Lear Corporation, Magna Electronics, TRW Automotive, Valeo, and Visteon).

Important: To view and download these documents free of charge simply click on the appropriate link.

- **AEC - Q100:** Failure Mechanism Based Stress Test Qualification For Integrated Circuits
  - **AEC - Q100 Rev - H:** Failure Mechanism Based Stress Test Qualification For Integrated Circuits (base document)
  - **AEC - Q100-001 - Rev-C**: Wire Bond Shear Test
  - **AEC - Q100-002 - Rev-E**: Human Body Model (HBM) Electrostatic Discharge Test
  - **[Decommissioned] AEC - Q100-003 - Rev-E**: Machine Model (MM) Electrostatic Discharge Test
  - **AEC - Q100-004 - Rev-D**: IC Latch-Up Test
  - **AEC - Q100-005 - Rev-D1**: Non-Volatile Memory Program/Erase Endurance, Data Retention, and Operational Life Test

Automotive PCNs

Automotive PCN

- **Previously**
  - Commercial PCNs handled by corporate
    - http://www.microchip.com/pagehandler/en-us/designsupport/pcn
  - Automotive PCNs were managed customer by customer using APG PE and FQE
- **PCN Group was formed to handle the increase in notifications for Automotive**
  - APG PE will participate in Control Change Board meetings
  - APG PE review and approve PCN prior to notification for automotive customers
- **Why?**
  - To ensure PPAP customers are notified and have an opportunity to approve prior to implementation
  - To show record of approval and due diligence of changes implemented to PPAPs

PPAPs and PCNs

- **PPAPs help identify the specific customer's PCN email and/or FQE location to be notified**
  - PCN address is a personal address, not company address
  - World wide customers may want every location ordering the device to be notified

Automotive PCN

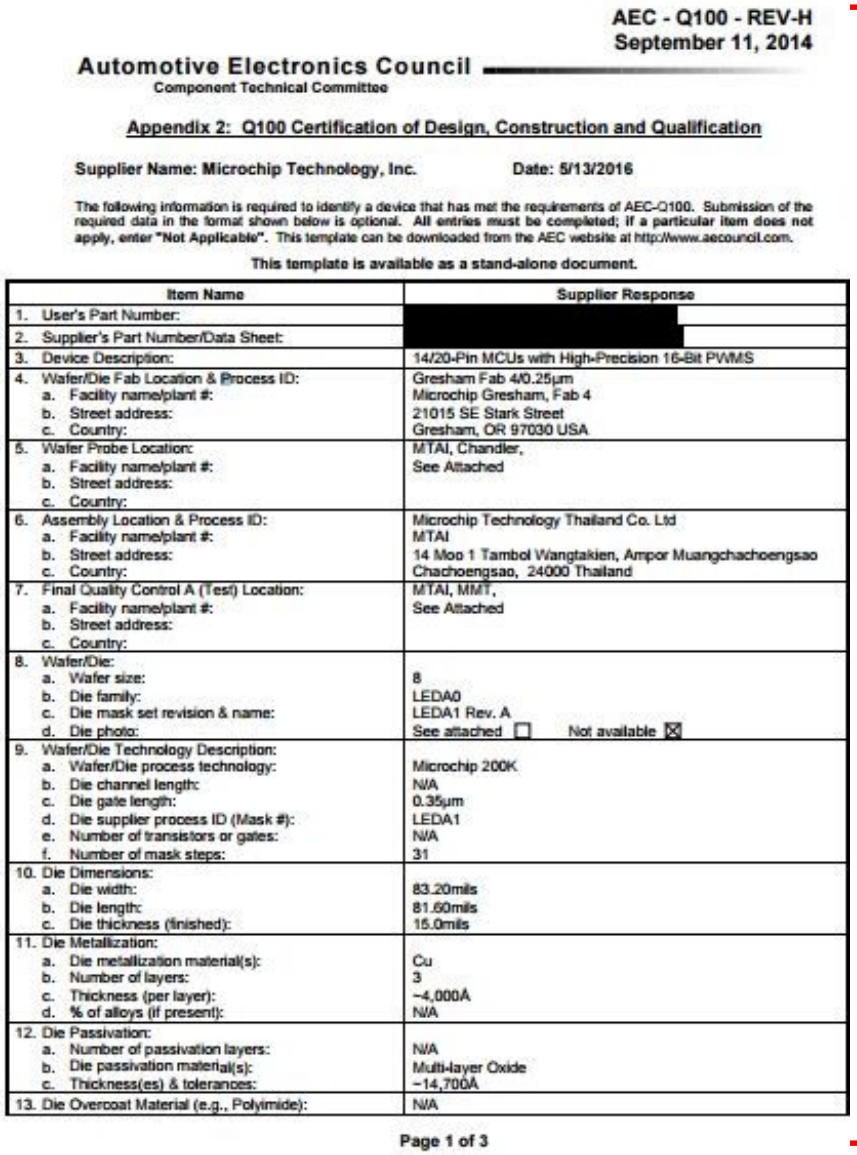
- **Four notifications will be sent out for every PCN**
  - Initial notification
    - No firm dates for samples, Q-100, PPAP
  - 2nd notification
    - Samples, Q-100, and PPAP available upon request
  - 3rd notification (45 days after 2nd notification)
  - Final notification (45 days after 3rd notification)
    - If no response, Microchip will automatically switch

Automotive PCN

- **PCN Support Emails**
  - PCN Approval
    - Automotive_PCN_Approval@Microchip.com
  - PCN Samples
    - Automotive_PCN_Samples@Microchip.com
  - PCN Questions
    - Automotive_PCN_Questions@Microchip.com

Example of PPAP

- 908 pages total
- Page 1 of 3 Certification of Design, construction and Qualification



AEC - Q100 - REV-H
September 11, 2014

Automotive Electronics Council
Component Technical Committee

Appendix 2: Q100 Certification of Design, Construction and Qualification

Supplier Name: Microchip Technology, Inc. **Date: 5/13/2016**

The following information is required to identify a device that has met the requirements of AEC-Q100. Submission of the required data in the format shown below is optional. All entries must be completed; if a particular item does not apply, enter "Not Applicable". This template can be downloaded from the AEC website at http://www.aecouncil.com.

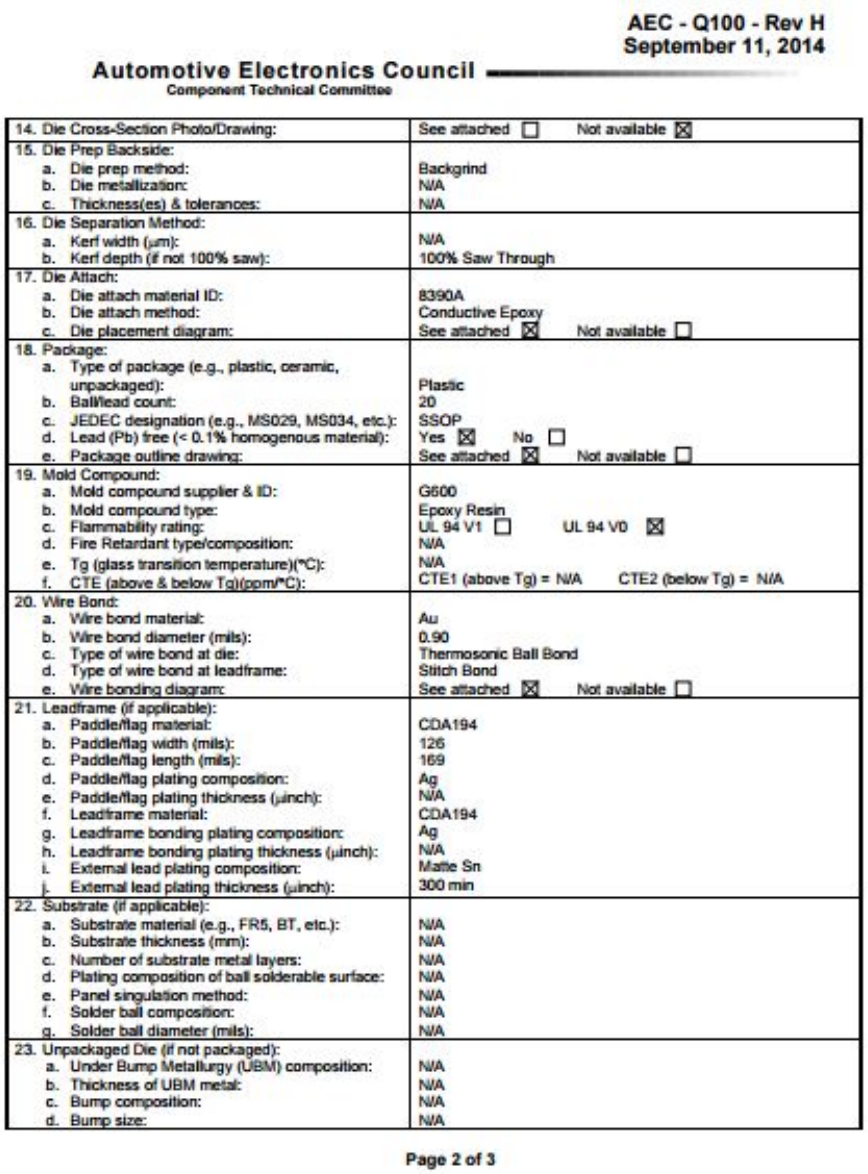
This template is available as a stand-alone document.

Item Name	Supplier Response
1. User's Part Number:	[redacted]
2. Supplier's Part Number/Data Sheet:	[redacted]
3. Device Description:	14/20-Pin MCUs with High-Precision 16-Bit PWMS
4. Wafer/Die Fab Location & Process ID: a. Facility name/plant #: b. Street address: c. Country:	Gresham Fab 4/0.25µm Microchip Gresham, Fab 4 21015 SE Stark Street Gresham, OR 97030 USA
5. Wafer Probe Location: a. Facility name/plant #: b. Street address: c. Country:	MTAI, Chandler, See Attached
6. Assembly Location & Process ID: a. Facility name/plant #: b. Street address: c. Country:	Microchip Technology Thailand Co. Ltd MTAI 14 Moo 1 Tambol Wangtakien, Ampor Muangchachoengsao Chachoengsao, 24000 Thailand
7. Final Quality Control A (Test) Location: a. Facility name/plant #: b. Street address: c. Country:	MTAI, MMT, See Attached
8. Wafer/Die: a. Wafer size: b. Die family: c. Die mask set revision & name: d. Die photo:	 8 LEDA0 LEDA1 Rev. A See attached ☐ Not available ☒
9. Wafer/Die Technology Description: a. Wafer/Die process technology: b. Die channel length: c. Die gate length: d. Die supplier process ID (Mask #): e. Number of transistors or gates: f. Number of mask steps:	 Microchip 200K N/A 0.35µm LEDA1 N/A 31
10. Die Dimensions: a. Die width: b. Die length: c. Die thickness (finished):	 83.20mils 81.60mils 15.0mils
11. Die Metallization: a. Die metallization material(s): b. Number of layers: c. Thickness (per layer): d. % of alloys (if present):	 Cu 3 ~4,000Å N/A
12. Die Passivation: a. Number of passivation layers: b. Die passivation material(s): c. Thickness(es) & tolerances:	 N/A Multi-layer Oxide ~14,700Å
13. Die Overcoat Material (e.g., Polyimide):	N/A

Page 1 of 3

Example of PPAP

- 908 pages total
- Page 2 of 3 Certification of Design, construction and Qualification



AEC - Q100 - Rev H
September 11, 2014

Automotive Electronics Council
Component Technical Committee

14. Die Cross-Section Photo/Drawing:	See attached ☐ Not available ☒
15. Die Prep Backside:	
a. Die prep method:	Backgrind
b. Die metallization:	N/A
c. Thickness(es) & tolerances:	N/A
16. Die Separation Method:	
a. Kerf width (µm):	N/A
b. Kerf depth (if not 100% saw):	100% Saw Through
17. Die Attach:	
a. Die attach material ID:	8390A
b. Die attach method:	Conductive Epoxy
c. Die placement diagram:	See attached ☒ Not available ☐
18. Package:	
a. Type of package (e.g., plastic, ceramic, unpackaged):	Plastic
b. Ball/lead count:	20
c. JEDEC designation (e.g., MS029, MS034, etc.):	SSOP
d. Lead (Pb) free (< 0.1% homogenous material):	Yes ☒ No ☐
e. Package outline drawing:	See attached ☒ Not available ☐
19. Mold Compound:	
a. Mold compound supplier & ID:	G600
b. Mold compound type:	Epoxy Resin
c. Flammability rating:	UL 94 V1 ☐ UL 94 V0 ☒
d. Fire Retardant type/composition:	N/A
e. Tg (glass transition temperature)(°C):	N/A
f. CTE (above & below Tg)(ppm/°C):	CTE1 (above Tg) = N/A CTE2 (below Tg) = N/A
20. Wire Bond:	
a. Wire bond material:	Au
b. Wire bond diameter (mils):	0.90
c. Type of wire bond at die:	Thermosonic Ball Bond
d. Type of wire bond at leadframe:	Stitch Bond
e. Wire bonding diagram:	See attached ☒ Not available ☐
21. Leadframe (if applicable):	
a. Paddle/flag material:	CDA194
b. Paddle/flag width (mils):	126
c. Paddle/flag length (mils):	169
d. Paddle/flag plating composition:	Ag
e. Paddle/flag plating thickness (µinch):	N/A
f. Leadframe material:	CDA194
g. Leadframe bonding plating composition:	Ag
h. Leadframe bonding plating thickness (µinch):	N/A
i. External lead plating composition:	Matte Sn
j. External lead plating thickness (µinch):	300 min
22. Substrate (if applicable):	
a. Substrate material (e.g., FR5, BT, etc.):	N/A
b. Substrate thickness (mm):	N/A
c. Number of substrate metal layers:	N/A
d. Plating composition of ball solderable surface:	N/A
e. Panel singulation method:	N/A
f. Solder ball composition:	N/A
g. Solder ball diameter (mils):	N/A
23. Unpackaged Die (if not packaged):	
a. Under Bump Metallurgy (UBM) composition:	N/A
b. Thickness of UBM metal:	N/A
c. Bump composition:	N/A
d. Bump size:	N/A

Page 2 of 3

Example of PPAP

- 908 pages total
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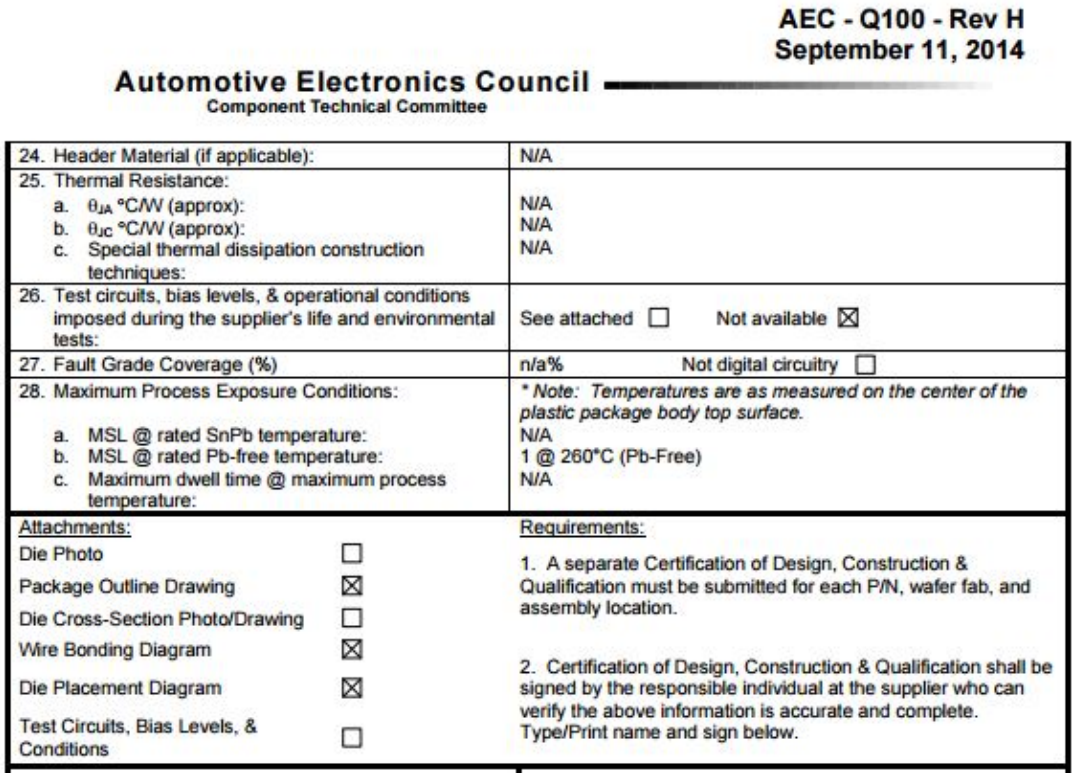

AEC - Q100 - Rev H
September 11, 2014

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24. Header Material (if applicable):	N/A
25. Thermal Resistance: a. θ_{JA} °C/W (approx): b. θ_{JC} °C/W (approx): c. Special thermal dissipation construction techniques:	 N/A N/A N/A
26. Test circuits, bias levels, & operational conditions imposed during the supplier's life and environmental tests:	See attached ☐ Not available ☒
27. Fault Grade Coverage (%)	n/a% Not digital circuitry ☐
28. Maximum Process Exposure Conditions: a. MSL @ rated SnPb temperature: b. MSL @ rated Pb-free temperature: c. Maximum dwell time @ maximum process temperature:	** Note: Temperatures are as measured on the center of the plastic package body top surface.* N/A 1 @ 260°C (Pb-Free) N/A

Attachments:		Requirements:
Die Photo	☐	1. A separate Certification of Design, Construction & Qualification must be submitted for each P/N, wafer fab, and assembly location.
Package Outline Drawing	☒	
Die Cross-Section Photo/Drawing	☐	
Wire Bonding Diagram	☒	2. Certification of Design, Construction & Qualification shall be signed by the responsible individual at the supplier who can verify the above information is accurate and complete. Type/Print name and sign below.
Die Placement Diagram	☒	
Test Circuits, Bias Levels, & Conditions	☐	

Vnn no PPAP

Essential Elements

- Defined by planning / engineer / customer request
- A sub-set of the 28 elements on the AEC certification sheets
- Control the locations (fab, assembly, probe, and final test), bonding diagram, test flow, and test platform

8D – Automotive Root Cause Analysis

- **8D = 8 Disciplines report for root cause and corrective action on a failure. Could be part failure, test escape, wrong labels, anything that was not what the Client expected.**

https://en.wikipedia.org/wiki/Eight_Disciplines_Problem_Solving

- **Eight Disciplines (8Ds) Problem Solving is a method developed at Ford Motor Company used to approach and to resolve problems, typically employed by engineers or other professionals. Focused on product and process improvement, its purpose is to identify, correct, and eliminate recurring problems. It establishes a permanent corrective action based on statistical analysis of the problem and on the origin of the problem by determining the root causes. Although it originally comprised eight stages, or 'disciplines', it was later augmented by an initial planning stage. 8D follows the logic of the PDCA cycle. The disciplines are:**
- **D0: Plan: Plan for solving the problem and determine the prerequisites.**
- **D1: Use a Team: Establish a team of people with product/process knowledge.**
- **D2: Describe the Problem: Specify the problem by identifying in quantifiable terms the who, what, where, when, why, how, and how many (5W2H) for the problem.**
- **D3: Develop Interim Containment Plan: Define and implement containment actions to isolate the problem from any customer.**
- **D4: Determine, and Verify Root Causes and Escape Points: Identify all applicable causes that could explain why the problem has occurred. Also identify why the problem was not noticed at the time it occurred. All causes shall be verified or proved. One can use five whys or Ishikawa diagrams to map causes against the effect or problem identified.**
- **D5: Verify Permanent Corrections (PCs) for Problem will resolve problem for the customer: Using pre-production programs, quantitatively confirm that the selected correction will resolve the problem. (Verify that the correction will actually solve the problem.)**
- **D6: Define and Implement Corrective Actions: Define and Implement the best corrective actions.**
- **D7: Prevent System Problems: Modify the management systems, operation systems, practices, and procedures to prevent recurrence of this and all similar problems.**
- **D8: Congratulate Your Team: Recognize the collective efforts of the team. The team needs to be formally thanked by the organization.**
- **8Ds has become a standard in the automotive,[1] assembly, and other industries that require a thorough structured problem solving process using a team approach.**

FIT rate link

http://www.microchip.com/reliabilityreport/Default.aspx