Holt Integrated Circuits
Device Reliability Report

For

Second Quarter 2019

09/30/2019

Document Number: QR-1915, Revision 1.0

Approved by:

Scott Paladichuk
Director of Quality

The Reliability and Quality Program

Introduction

This report summarizes Holt Integrated Circuits Product Reliability & Quality. To ensure that the highest possible product reliability standards are achieved and sustained, Holt Integrated Circuits maintains an active Product Reliability Monitoring Program. Reliability is defined as product performance to specification over time in response to specified environmental stress conditions. The goal of our reliability program is to be able to provide our customers insight into the robustness of the product being evaluated.

Reliability Qualification Program

The qualifications of new wafer process, packages, and devices are designed to ensure that products meet the internal requirements of Holt Integrated Circuits specification QSP-4.10.105 “Product Qualification Procedure” before transfer to production. The reliability stress tests are conducted in accordance to the conditions given in Table 1 – Table 3.

Reliability Monitor Program

Each quarter, Holt selects a set of representative products and subjects them to the stress tests previously used for their reliability qualification. These products are selected using criteria that include volume, complexity, assembly source, and specific customer requirements. The testing in Table 4 – Table 5 is performed to ensure that the reliability of a technology continues to meet its initial qualification specifications. This data is accumulated over several quarters to determine reliability trends in fab technologies, design rules, and assembly processes. Additionally, this data allows customers to predict the expected reliability performance of their overall system.

Additional Qualification Data

Qualification by Similarity (QBS): These are general guidelines for a product using the similar/same materials and processing since they most likely will contain the same level of random defects regardless of the final product. Product to product differences such as lead count and or die dimensions vs. package dimensions are addressed by selecting the 'worst case' package (with respect to these attributes).

Average Outgoing Quality Program

Average Outgoing Quality (AOQ)

Three elements of product quality are reported – manufacturing quality, electrical quality, and mechanical/visual quality. Any failures drive corrective actions and process/product improvements.

Manufacturing Quality is estimated by measuring early life failure rates from $\leq$ 168hrs of HTOL derived from product and product monitor results.

Electrical Quality is measured by taking a sample (monitor) of production parts and retesting the sample to the datasheet limits. This sample method identifies defects introduced at the test process step or that have escaped the test process.

Visual/Mechanical Quality is estimated by sample inspection of the completed product prior to final pack. Inspection items cover a broad range and include mark, count, label, moisture barrier bag visual, lead location, part placement, and many other general workmanship items required for customer satisfaction.

Average Outgoing Quality Data

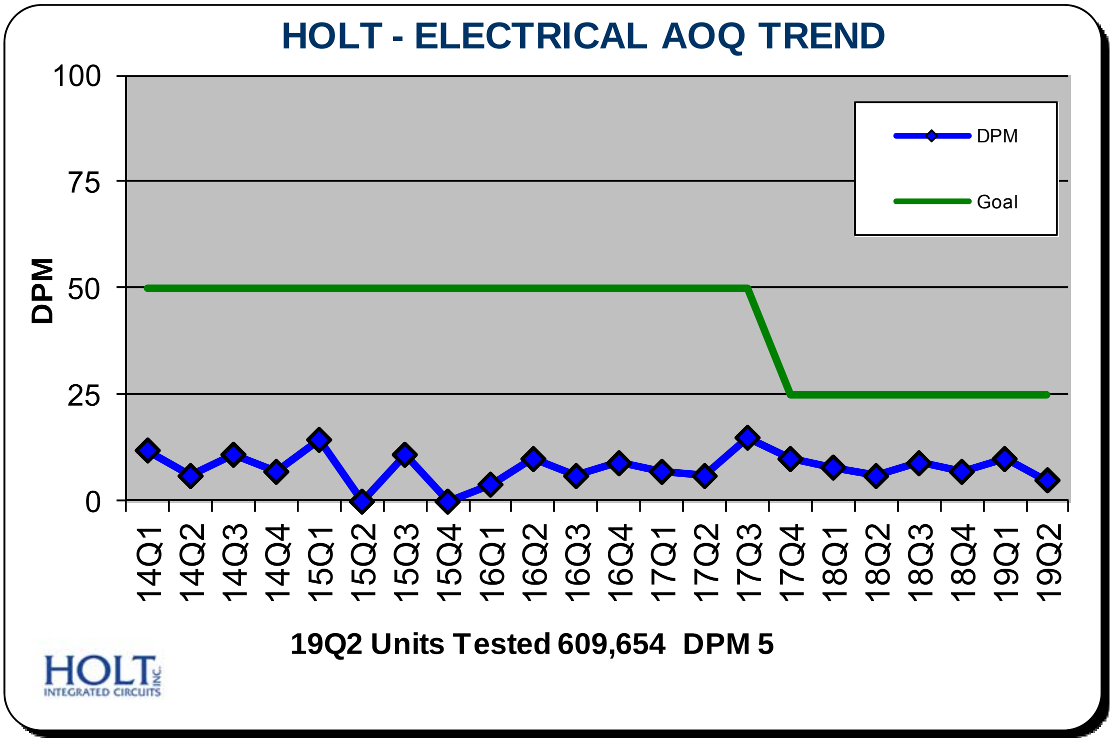
Results Manufacturing AOQ

Early Life Failure Rate AOQ for Q1 2009 – Q2 2019

Technology	Number of Units Tested	Equivalent Device Hours at 55°C	Failure	FIT [(a)]	FIT Goal
4.0um CMOS	597,723	1.39E+10	232	17.1	<50
1.5um CMOS	199,896	4.64E+09	94	21.0	<50
1.0um CMOS-SOI	2,608	6.05E+07	0	15.1	<50
0.8um CMOS	27,706	6.43E+08	15	26.3	<50
0.6um CMOS-SOI(b)	73,068	1.69E+09	60	37.0	<50
0.35um CMOS	13,910	3.23E+08	5	19.5	<50

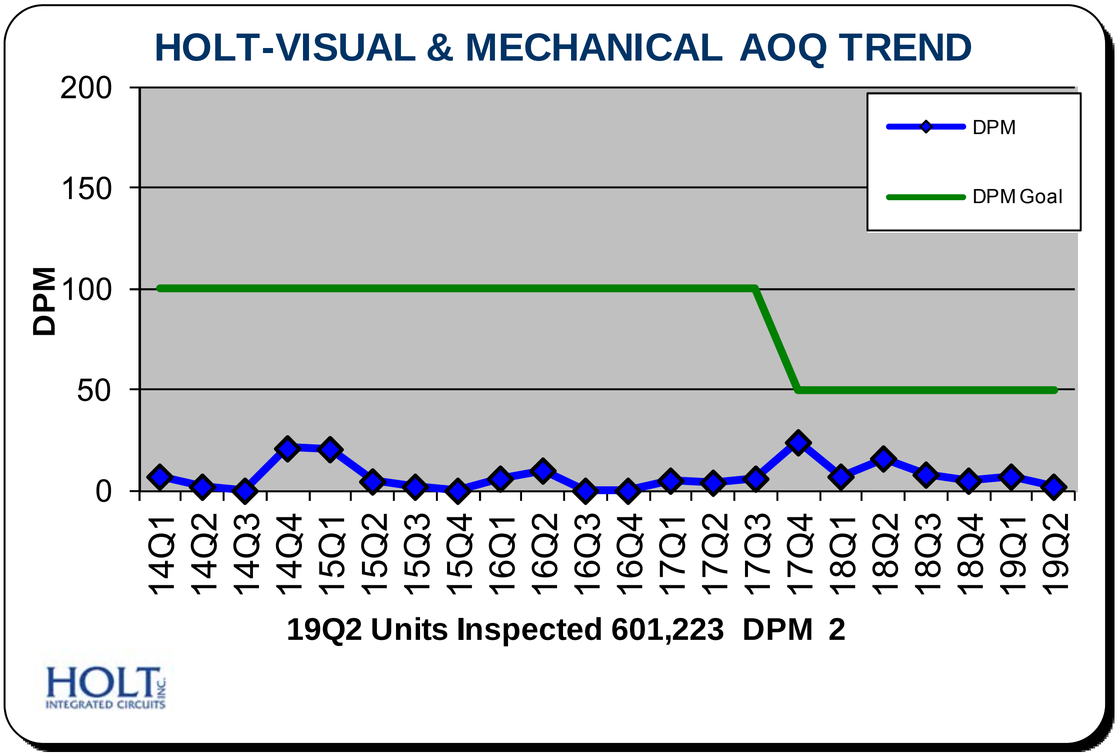
Note: **a.** FIT is calculated based on 0.8ev, 60%C.L. and T_j of 55°C
b. The FIT rate for this process is based on foundry process monitoring data and ongoing reliability monitoring

Results Electrical and Mechanical/Visual AOQ



19Q2 Units Tested 609,654 DPM 5

Figure 2 –Electrical AOQ



19Q2 Units Inspected 601,223 DPM 2

Figure 3 – Visual & Mechanical AOQ

Product Qualification

Table 1 – Wafer Process Qualification

Reliability Test	Test Conditions	Industry Standard	Accept Criteria Fail/SS
High Temperature Operating Life (HTOL)	Static Operating Condition, Tj ≥+125 °C, Vcc ≥ Vccmax, 168, 500, & 1000 Hrs	JESD22-A108	0/45
Highly-Accelerated Stress Test (HAST)	+130 °C 85%RH, 2atm, 96 Hrs. Biased, Vccmax	JESD22-A110	0/45
Temperature Cycle (TC)	-65°C to +150 °C, 500 & 1000 cycles	JESD22-A104	0/45
Autoclave	+121 °C 100%RH, 2atm, 96 Hrs. Unbiased	JESD22-A102	0/45
High Temperature Storage Life (HTS)	Ta ≥+150°C, 500 & 1000 Hrs.	JESD22-A103	0/45

Table 2 – Nonhermetic Package/Assembly Qualification

Reliability Test	Test Conditions	Industry Standard	Accept Criteria Fail/SS
MSL Preconditioning	IPC/JEDEC J-STD-020	JESD22-A113	Classification
Holt Plastic Package Qual	Holt Specification	AN-400	0/3
Highly-Accelerated Stress Test (HAST)	+130 °C, 85%RH, 2atm, 96 Hrs. Biased, Vccmax	JESD22-A110	0/45
Temperature Cycle (TC)	-65°C to +150 °C, 500 & 1000 cycles	JESD22-A104	0/45
Autoclave	+121 °C 100%RH, 2atm, 96 Hrs. Unbiased	JESD22-A102	0/45
High Temperature Storage Life (HTS)	Ta ≥+150°C, 500 & 1000 Hrs.	JESD22-A103	0/45

Notes: Package preconditioning is performed prior to HAST, TC, Autoclave, and HTS tests

Table 3 – Device Qualification

Reliability Test	Test Conditions	Industry Standard	Accept Criteria Fail/SS
High Temperature Operating Life (HTOL)	Static Operating Condition, Tj ≥+125 °C, Vcc ≥ Vccmax, 168, 500, & 1000 Hrs	JESD22-A108	0/45
Electrostatic Discharge Human Body Model (ESD_HBM)	Ta =+25°C	JESD22-A114	Classification
Latch-up (LU)	Current Injection, ±100mA	JESD78	0/6
Lightning Induced Transient Susceptibility(a)	Pin Injection, Level 3, WF 3, 4, 5B	RTCA/DO-160G Section 22	Classification

Note: a. This test only applies to products described in Holt Application Note AN-300

Reliability Monitor Program

Table 4 – Wafer Process Monitor

Reliability Test	Test Conditions	Industry Standard	SS/Process Family/Quarter
High Temperature Operating Life (HTOL)	Static Operating Condition, Tj ≥+125 °C, Vcc ≥ Vccmax, 168, 500, & 1000 Hrs	JESD22-A108	45

Table 5 – Package/Assembly Monitor

Reliability Test	Test Conditions	Industry Standard	SS/Pkg Family/Quarter
Highly-Accelerated Stress Test (HAST)	+130 °C, 85%RH, 2atm, 96 Hrs. Biased, Vccmax	JESD22-A110	45
Temperature Cycle (TC)	-65°C to +150 °C, 500 & 1000 cycles	JESD22-A104	45
Autoclave	+121 °C 100%RH, 2atm, 96 Hrs. Unbiased	JESD22-A102	45
High Temperature Storage Life (HTS)	Ta ≥+150°C, 500 & 1000 Hrs.	JESD22-A103	45

Note: Package preconditioning is performed prior to HAST, TC, Autoclave, and HTS tests

Q2 2019 Reliability Monitor Data

See Table 8 – Table 14 for Cumulative Data

Table 6 – Test Results for Q2 2019 Reliability Process Monitor

Reliability Test	4.0um CMOS		1.5um CMOS		0.6um CMOS-SOI		0.35um CMOS		0.18um CMOS	
	Sample Size	Failure	Sample Size	Failure	Sample Size	Failure	Sample Size	Failure	Sample Size	Failure
High Temperature Operating Life (HTOL)	45	0	45	0	45	0	45	0	45	0

Table 7 – Test Results for Q2 2019 Reliability Package Monitor

Reliability Test	SOIC-8HN		TSSOP-20HS		QFN-44PCS		MQFP-52PQS	
	Sample Size	Failure	Sample Size	Failure	Sample Size	Failure	Sample Size	Failure
High Accelerated Stress Test (HAST)	45	0	45	0	45	0	0	0
Temperature Cycle (TC)	45	0	45	0	45	0	45	0
Autoclave	45	0	45	0	45	0	90	0
High Temperature Storage (HTS)	45	0	45	0	45	0	45	0

Data Summaries for Q1 2001 – Q2 2019

Results by Process Technology

HTOL Results by Process for Q1 2001- Q2 2019

Technology	Number of Units Tested	Equivalent Device Hours at 55°C	Failure	FIT [a]	MTBF[b]
4.0um CMOS	4526	6.96E+08	1	2.9	3.44E+08
1.5um CMOS	3409	5.57E+08	1	3.6	2.75E+08
1.0um CMOS-SOI	1035	1.50E+08	0	6.1	1.64E+08
0.8um CMOS	1842	3.12E+08	0	2.9	3.41E+08
0.6um CMOS-SOI(c)	3755	1.05E+09	3	4.0	2.50E+08
0.35um CMOS(c)	2478	3.93E+08	1	5.1	1.94E+08
0.18um CMOS	642	9.31E+07	0	9.8	1.02E+08

Note:
a. FIT is calculated based on 0.8ev, 60%C.L. and T_j of 55°C
b. MTBF is calculated as MTBF= 10E+09/FIT Rate.
c. The FIT rate for this process is based foundry process qualification data and ongoing reliability monitoring.

Failure Rate Determination

The Failure Rate is usually expressed in FIT (Failure In Time) units. One FIT means 1 failure per 1 billion device hours.

$$\text{Failure Rate} = \lambda = \frac{\chi^2(\alpha, df)}{2t}$$

Where:
λ = failure rate
χ^2 = Chi-square function
α = (100 – confidence level)/ 100
df = degrees of freedom = 2f + 2
f = number of failures
t = device hours (no. of devices x no. of hours x acceleration factor)

The Acceleration Factor is calculated using the Arrhenius relationship

$$AF = \exp [E_a/k (1/T_1 - 1/T_2)]$$

Where:
E_a = The Activation Energy of the defect mechanism.
K= Boltzmann's constant = $8.62\text{x}10^{-5}$ eV/Kelvin.
T_1 is the operating temperature of the device at use conditions in degrees Kelvin.
T_2 is the operating temperature of the device under stress in degrees Kelvin.

Results by Package Type

Table 9 – 8HN, 8HNE, 14HN, 14HNE, 16HN, 16HNE, 16HW, 16HWE, 18HW, 20HW, 20HWE, 24HW, 28HW (SOIC)

Reliability Test	Number of Units Tested	Failures	Percentage Failures/Total Units x 100	Total Device Hrs/ Cycles
High Accelerated Stress Test (HAST)	2,656	0	0	261,906
Temperature Cycle (TC)	3,390	0	0	3,390,000
Autoclave	2,530	0	0	297,645
High Temperature Storage (HTS)	2,701	0	0	2,664,685
Holt Incoming QA Plastic Monitor	6,262	0	0	900,864

Table 10 – 20HS, 24HS, 24HT, 38HS (TSSOP)

Reliability Test	Number of Units Tested	Failures	Percentage Failures/Total Units x 100	Total Device Hrs/ Cycles
High Accelerated Stress Test (HAST)	1,125	0	0	108,000
Temperature Cycle (TC)	1,395	0	0	1,395,000
Autoclave	1,215	0	0	125,280
High Temperature Storage (HTS)	1,230	0	0	1,230,045
Holt Incoming QA Plastic Monitor	1,056	0	0	152,064

Table 11 – 20J, 28J, 44J (PLCC)

Reliability Test	Number of Units Tested	Failures	Percentage Failures/Total Units x 100	Total Device Hrs/ Cycles
High Accelerated Stress Test (HAST)	3,105	0	0	298,080
Temperature Cycle (TC)	2,956	0	0	2,956,000
Autoclave	1,973	1	0.05%	215,328
High Temperature Storage (HTS)	1,995	0	0	1,996,013
Holt Incoming QA Plastic Monitor	3,734	0	0	537,696

Table 12 – 16PCS(1), 24PCS, 32PCS(7), 40PCS, 44PCS, 48PCS6, 48PCS7, 64PCS (QFN)

Reliability Test	Number of Units Tested	Failures	Percentage Failures/Total Units x 100	Total Device Hrs/ Cycles
High Accelerated Stress Test (HAST)	705	0	0	67,680
Temperature Cycle (TC)	1,630	0	0	1,630,000
Autoclave	1,946	0	0	208,416
High Temperature Storage (HTS)	1,410	0	0	1,410,535
Holt Incoming QA Plastic Monitor	1,260	0	0	181,440

Table 13 – 32PTQS, 44PTQS, 48PQS, 52PTQS, 64PTQS, 80PTQS, 100PQS, 128PQS (LQFP)

Reliability Test	Number of Units Tested	Failures	Percentage Failures/Total Units x 100	Total Device Hrs/ Cycles
High Accelerated Stress Test (HAST)	945	0	0	97,650
Temperature Cycle (TC)	1,080	0	0	1,125,000
Autoclave	1,025	0	0	115,680
High Temperature Storage (HTS)	995	0	0	1,040,670
Holt Incoming QA Plastic Monitor	1,153	0	0	166,032

Table 14 – 44PQS, 44PMQS, 52PQS, (MQFP)

Reliability Test	Number of Units Tested	Failures	Percentage Failures/Total Units x 100	Total Device Hrs/ Cycles
High Accelerated Stress Test (HAST)	1,845	1	0.05%	177,120
Temperature Cycle (TC)	2,385	0	0	2,385,000
Autoclave	1,800	0	0	181,440
High Temperature Storage (HTS)	1,790	1	0.06%	1,790,545
Holt Incoming QA Plastic Monitor	3,361	0	0	483,984

Table 15 – 32PQS, 64PQS, (TQFP)

Reliability Test	Number of Units Tested	Failures	Percentage Failures/Total Units x 100	Total Device Hrs/ Cycles
High Accelerated Stress Test (HAST)	180	0	0	17,280
Temperature Cycle (TC)	405	0	0	405,000
Autoclave	505	0	0	48,480
High Temperature Storage (HTS)	405	0	0	405,000
Holt Incoming QA Plastic Monitor	364	0	0	52,416

Revision History

Date	Revision	Comments
09/30/19	1.0	Initial Document