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The Final Report
for

THE DEVELOPMENT OF QUALITY STANDARDS FOR BIPOLAR LSI

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General Quality, Reliability and Maintainability (QRM) Requirements for Large Scale Integrated Devices

ABSTRACT

This volume contains recommended guidelines for reliability engineers and other prospective LSI users, which can be used to formulate meaningful quality assurance specifications for procurement of LSI devices. To this end, Volume II contains general Quality, Reliability and Maintainability (QR&M) requirements for large scale integrated devices.

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THE DEVELOPMENT OF QUALITY STANDARDS FOR BIPOLAR LSI

1.0 INTRODUCTION

1.1 SCOPE: This document provides guidelines for the preparation of quality, reliability and maintainability requirements for LSI devices.

1.2 PURPOSE: The purpose of this document is to outline and establish electrical tests, process controls, and process screening tests that should be applied to insure meeting of quality, reliability and maintainability requirements of LSI devices.

2.0 REFERENCE DOCUMENTS

MIL-STD-470	Maintainability Program Requirements (For Systems and Equipments)
MIL-STD-471	Maintainability Demonstration
MIL-STD-785A	Reliability Program for Systems and Equipment Development and Production
MIL-STD-790C	Reliability Assurance Program for Electronic Parts Specification
MIL-STD-810B	Environmental Test Methods
MIL-STD-883	Test Methods and Procedures for Microelectronics
MIL-M-38510	General Specification for Microcircuit Quality and Reliability Assurance
MIL-C-45662	Calibration System Requirements

3.0 GENERAL REQUIREMENTS

3.1 DOCUMENTATION

The contractor shall, as a part of his Quality, Reliability and Maintainability (QR&M) program, maintain as a minimum the following records which shall be made available upon request to the procuring activity for review:

a. Quality Reliability Assurance organizational structure, indicating lines of authority and responsibility

b. A list of test facilities used for qualification and quality conformance

c. Failure reports and analyses

d. Process and material control documents

e. Test conditions and results of qualification program

f. Lot traceability procedures

g. Equipment calibration records

h. Initial documentation and subsequent changes in designs, materials or processing.

3.2 DESIGN REQUIREMENTS

The contractor's design plan shall include the use of reliability oriented design techniques and shall incorporate utilization of statistical planning and analysis. This shall include application of methods such as analysis of parameter variance, worst case analysis, or other methods applicable to design, development, and production phases. The program shall also provide plans for reviews at appropriate stages to evaluate achievement of the QR&M Program Plan.

3.2.1 ELECTRICAL DESIGN REQUIREMENTS:

The electrical design analysis shall consider as a minimum the following:

a. Worst case input and output conditions

b. Internal power dissipation

c. Thermal stress (hot spots)

d. Reproducibility

e. Internal component or cell fan-in and fan-out

f. Electrical acceptance tests.

3.2.2 MECHANICAL DESIGN REQUIREMENTS:

The mechanical design analysis and testing shall consider as a minimum the following:

a. Heat sinking requirements

b. Techniques for mounting the LSI devices in the package

c. Capability of protecting the LSI device from expected environmental requirements

d. Materials and construction of the package

e. Hermeticity.

3.2.3 DESIGN REVIEWS:

Reviews shall be made at appropriate stages of development and production to evaluate achievement of the reliability requirements. The planned reviews should include, but not necessarily be limited to:

a. Current reliability estimates and achievements for each mode of operation, as derived from reliability analyses or test(s).

b. Potential design or production (derived from reliability analyses) problem areas, and control measures necessary to preserve the inherent reliability.

c. Failure mode(s) and effect(s) analyses

d. Corrective action on reliability critical items

e. Effects of engineering decisions, changes, and trade-offs upon reliability, producibility and electrical performance, within the functional model framework

f. Status of subcontractor and supplier reliability programs

g. Status and effect of previously approved design or process changes. The results of reliability reviews shall be documented.

4.0 QUALITY ASSURANCE PROGRAM

The contractor shall establish and maintain an effective QA program that is planned, integrated and developed in conjunction with other design, development and production functions to permit the most economical achievement of overall program objectives. The QA program shall include the management and technical resources, plans, procedures, schedule and controls for the work needed to assure achievement of quality requirements. The program shall be consistent with the severity of the requirements, the complexity of the design, the quantity to be delivered and the manufacturing techniques required. The program shall assure QRA participation throughout the design, development, and production steps to meet the overall objectives.

4.1 PROCESS CONTROL REQUIREMENTS

4.1.1 The QA plan shall identify Process Control procedures to be utilized during production to prevent process instability and to build in a high level of quality. It shall include a summary manufacturing flow diagram containing the following:

a. General manufacturing process operations

b. Manufacturing specification numbers where applicable.

c. Process Control inspection points and criteria where applicable

d. Screening tests and general test surveillance procedures.

4.1.2 In addition to the above, the QA plan shall include as a minimum procedures to accomplish the following tasks:

a. Process Control corrective action

b. Control of non-conforming material

c. Control of purchase and storage material

d. Control of finished goods inventory

e. Acceptance test control

f. Control of packing and shipping.

4.2 SCREENING TESTS DURING MANUFACTURE

Screening tests to be applied during manufacture shall be defined by the procuring activity and approved and implemented by the contractor to insure that the electrical and

mechanical requirements are met, and to eliminate possible early life failures. Typical screening tests to be considered are:

a. Precap visual inspection (for example see Appendix A)

b. Stabilization bake

c. Temperature cycling

d. Bond integrity tests

e. Hermeticity tests

f. Electrical acceptance tests at high and low temperature

g. Operating burn-in at high temperature.

In general, the test methods of MIL-STD-883 should be followed where applicable.

4.3 PROCESS MONITORING

In addition to the above process control screening tests, the contractor shall develop and incorporate plans to monitor the process. He shall, using customer approved sampling plans, perform as a minimum, the following tests:

a. Life tests

b. Thermal shock

c. Temperature cycling

d. Vibration

e. Shock

f. Hermeticity

g. Bond integrity.

Sampling evaluation, if approved by the procurement agency, may be performed on representative device types similar to those being procured at the discretion of the contractor.

5.0 RELIABILITY ASSURANCE PROGRAM

The contractor's proposed program plan shall detail how he plans to conduct a reliability program to demonstrate compliance with the requirements of the statement-of-work

contained in the request for proposal (quote), and in order to comply with applicable reliability program elements listed below in the detailed requirements. The plan shall be submitted as a separate and complete document within the contractor's proposal. The reliability program plan as approved by the procuring activity will be incorporated into the procurement document.

5.1 RELIABILITY TEST PLANS

An integrated test and demonstration plan shall be prepared and submitted for approval by the procuring activity. The plan shall include all reliability testing and longevity demonstration to be performed during the program. These tests shall be designed to make maximum use of data and reliability information from all relevant sources.

5.2 RELIABILITY DEMONSTRATION

A plan for formal demonstration of achieved reliability levels at specified points in time shall be prepared. It shall, as a minimum, include planned number of tests and test sequences, accept/reject criteria, and the associated confidence or risk levels. It shall be prepared and submitted for approval to the procuring activity. In addition to the above, the reliability demonstration plan shall describe how the results of related testing, yielding valid reliability data, will be integrated (including effects on confidence or risk levels) to yield an overall reliability and confidence level. Planned engineering tests and analysis, e.g., test-to-failure concepts shall be used as appropriate to supplement statistical reliability test plans. The milestone dates at which contract compliance is to be demonstrated shall be specified.

5.3 EQUIPMENT CONTROL

Each instrument or equipment used to manufacture, measure, or control the production of LSI devices or to measure the acceptability of parts under test shall be calibrated in accordance with MIL-C-45662. In addition, a scheduling system shall be maintained to assure that calibration is accomplished according to a pre-determined schedule, and that instruments due for calibration are removed from service on or before the calibration due date.

5.4 FAILURE AND DEFECT ANALYSIS PROGRAMS

The manufacturer shall describe and maintain failure and defect analysis programs which should result in corrective action to reduce part failures and defects to an acceptable level. Procedures for such analyses shall include the following:

a. Defect analysis of in-process material or parts when records indicate a critical process is not within the manufacturer's prescribed limits.

b. Failure analysis of sample parts which have failed during field use. If, subsequent to identification of a failure mechanism, failures attributed to the same mechanism occur on a series of parts, analysis is required as a minimum on the first two parts.

5.4.1 FAILURE REPORTING

The manufacturer shall describe and maintain a failure recording and reporting system for parts which have failed during quality conformance inspections or while in use in equipment. The system shall provide for at least the following:

a. The operating or test conditions under which the part failed, including environmental exposure levels, if known.

b. The source from which the failed part was received.

c. Verification of the reported condition of the failed part by the manufacturer's personnel responsible for production, inspection or engineering.

5.4.2 FAILURE AND DEFECT ANALYSIS RECORDS

The manufacturer shall establish a form to record the results of failure and defect analyses. Records shall be maintained which substantiate the failure and defect analyses performed and shall provide for at least the following:

a. The results of analyses.

b. The probable failure activating cause when possible.

c. Recommended corrective action, if any.

Failure analysis records shall be retained in files located in a central facility. Defect analysis records shall be held for the period determined by the manufacturer, subject to approval by the procurement agency.

5.4.3 CORRECTIVE PLAN-OF-ACTION

Where failures or defects are greater than the prescribed limits, the manufacturer shall prepare a plan or recommendation for corrective action. Corrective action

recommendations for performance failures shall include failure mode information when established and shall be supported by verifying data, or a proposed evaluation test plan. Corrective action affecting control procedures shall not be implemented for production until approved by qualified personnel responsible for the engineering, quality control, and reliability functions of the manufacturer.

6.0 MAINTAINABILITY PROGRAM

The contractor's proposed program plan shall detail how he plans an effective maintainability program to assure attainment of the contractual maintainability requirements. The program shall be consistent with the complexity of the design, the quantity to be delivered, and shall be progressively updated as design, development and fabrication proceeds. The program shall, as a minimum, include the following sections:

a. Maintainability analysis (MIL-STD-470)

b. Required depth and frequency of maintenance

c. Required support equipment/facilities required

d. Establish skill levels

e. Planned maintainability demonstration (MIL-STD-471).

7.0 PROGRAM REVIEW

The reliability program shall be planned and scheduled to permit the contractor and the procuring activity to review its status including results achieved at pre-planned steps or checkpoints. This review and assessment of reliability shall be conducted at major program points (in conjunction with system program reviews). As the program develops, reliability progress shall be assessed by the use of information such as predictions of reliability and results of reliability design reviews and tests. The procuring activity shall be supplied with the program review agenda at least 10 days prior to each contractually scheduled reliability program review, to permit participation by the procuring activity and possible additions to the agenda. The minutes of these reliability program reviews shall be supplied to the procuring activity as a part of the program documentation requirements.

APPENDIX

PRE-CAP VISUAL INSPECTION

PRE-CAP VISUAL INSPECTION

INTRODUCTION

Pre-cap visual inspection is a 100% QC inspection just prior to the package sealing operation. Due to the unique nature of the LSI process, and also the large sunk cost accrued at this point, QC does a 100% inspection of all the devices prior to sealing to detect any conceivable defects.

EQUIPMENT REQUIRED

A. Variable power microscope

B. Tweezers

C. Finger Cots

PROCEDURE

A. Material Flow: All manufacturing devices will be presented to the Quality Control Inspector before the package sealing operation. All devices which are rejected by the Quality Control Inspector will be 100% rescreened by qualified manufacturing personnel for all defects; not just those noted on the reject tag by the Quality Control Inspector. Rescreened devices will be resubmitted to the Quality Control Inspector for reinspection. Any device which is inadvertently sealed without having passed Quality Control pre-cap inspection will be held for Quality Control Engineering disposition.

B. Sampling: One hundred percent (100%) of all devices mounted on headers and ready for sealing shall pass through this inspection operation.

C. Inspection: Before performing any formal inspection on a device, first note the device type and any other pertinent information listed on the device traveler. Then, compare this data with the actual device. If any discrepancies exist, reject the device without any formal inspection. List the discrepancies on the reject tag and return the device to the responsible manufacturing foreman.

1.0 Inspect the devices for all defects listed in defect criteria (Attachment II).

1.1 All devices containing any major defects (Attachment II-A) will be rejected.

1.2 All minor defects (Attachment II-B) found will be recorded on the QC Daily Log and reported to the responsible manufacturing personnel.

2.0 If the device is accepted, stamp the traveler with the Quality Control stamp to denote acceptance.

3.0 If the device is rejected, fill out reject tag with the necessary information, noting especially the reason or reasons for rejection. Then, notify the responsible manufacturing foreman.

4.0 Record the results of all inspections on Quality Control Daily Logs (Attachment I).

ATTACHMENT I

QUALITY CONTROL DAILY LOG

DEVICE	NO.	DATE	TEST	DEFECTS	SUB.	PASS/FAIL

ATTACHMENT II

DEFECT CRITERIA

A. MAJOR DEFECTS (Any one will necessitate rejection of device)

1. Opens

   a. Broken bond wires

   b. Stitches pulled loose

   c. Ball pulled loose

   d. Wires missing

   e. Deep scratches - surface scratches which reduce the width of a gold lead or pad to <50% of original width.

2. Shorts

   a. Slack wire - bond wire of excessive length so that it contacts (or could easily contact) the lid, conducting surfaces, or other bonds.

   b. Tight wire - repair bonds that clear the slice surface by less than twice the wire diameter after 10 mils distance from the bond.

   c. Misplaced bond - bonds placed in such a manner as to short to other bond pads or conducting surfaces.

   d. Loose wire which shorts (or could easily short) bonds or other conducting surfaces together.

   e. Pigtail - wire tails longer than 3 mils attached to the final stitch bond.

3. Miswiring - any wiring which differs from the respective device wiring diagram.

4. Bond wire damage - nicks, scrapes, kinks or necking which reduces the wire diameter to <75% of its original diameter.

5. Malformed ball bond - bond wires emanating from the ball, off-center to the extent that the capillary imprint cannot be seen all around the ball.

6. Package defects - cuts, cracks, nicks, scratches or any other defects in the package that would cause an electrical, mechanical, or hermetic failure.

7. Others - any other defects of a major nature that could cause the device to malfunction.

B. **MINOR DEFECTS** (Not desirable, but will not reject a device)

1. Contamination-foreign materials and chemical stains which discolor the slice.

2. Scratches-surface scratches which do not cause shorts or opens and do not limit the width of a lead, pad, or bond wire to less than 50%.

3. Pulled second stitch-the lifting or complete removal of the second stitch (also, the lack of making the second stitch) without harming the first stitch.

4. Others-any other defects which do not reject the device, but are undesirable.