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Potential Failure Mode and Effects Analysis (FMEA)

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POTENTIAL FAILURE MODE AND EFFECTS ANALYSIS (FMEA)

Contents

1 Introduction

An FMEA is an anticipatory thought process designed to utilize as much knowledge and experience of an organization as possible toward the end of addressing potential issues defined in a new project. The objective is to reduce the probability that a customer is exposed to a potential product and or process problem by performing a thorough risk analysis.

A collection of subject matter experts from a number of various disciplines should be brought together to think about potential problems that could occur in a product and or process sometime in the future. Individuals do not necessarily have to be directly involved with the product and or the process; experience in a particular discipline may be of greater value than direct knowledge of the product and or the process. Ideally, representatives of the entire supply chain including customers and suppliers should also be contributors in the process.

Because of the need to continually improve whenever possible, there is a need for using FMEA as a disciplined technique to identify and help eliminate potential concerns.

It is meant to be a "before-the-event" action, not an "after-the-fact" exercise. To achieve the greatest value, the FMEA should be performed before a failure mode has been unknowingly planned into a product (DFMEA) and or process (PFMEA). Up front time spent in performing a comprehensive FMEA, when product and or process changes can be most easily and inexpensively implemented, will alleviate late change crises.

The outcome of the FMEA procedure should be a list of defined actions that will either prevent the occurrence of a problem through a design or process change, or improve the chances of detection of a problem through monitoring, if it does occur in the future. Actions are prioritized and decisions made as to which actions will have resources assigned for implementation.

It is not appropriate to compare one groups FMEA numerical rating with another groups FMEA, as each group’s knowledge and experience are unique. Since an FMEA procedure anticipates the future the numerical rating is a subjective value not an objective value.

A regular FMEA review can be conducted any time a change is being made to a product design and or to a process or new knowledge about risks is generated by learning from field failures. An FMEA can also reduce or eliminate the chance of implementing a corrective change that could create an even larger concern. Properly applied, it is an interactive process that is never ending.

POTENTIAL FAILURE MODE AND EFFECTS ANALYSIS (FMEA)

(From JEDEC Board Ballot JCB-97-23 and JCB-05-50, formulated under the cognizance of JC-14.3 Committee on Silicon Devices Reliability Qualification and Monitoring.)

1 Scope

This publication applies to electronic components and subassemblies product and or process development, manufacturing processes and the associated performance requirements in customer applications. These areas should include, but are not limited to: package design, chip design, process development, assembly, fabrication, manufacturing, materials, quality, service, and suppliers, as well as the process requirements needed for the next assembly. The publication covers the types of FMEAs described in Table 1.

The purpose of this document is to establish a minimum guideline for the application of Failure Mode and Effects Analysis techniques to improve quality, reliability, and/or consistency of electronic components subassemblies by continually evaluating the product and or process against potential failure modes. OEMs must provide suppliers with their manufacturing processes, their use conditions on the failed parts, and their failure experience(s). Suppliers must seek continuous improvement and have the responsibility of developing and improving the elements of FMEA.

Table 1 — Types of FMEAs

	DFMEA	**PFMEA**
Element to be assessed	Elements of a product (function / module)	Process steps of a production process or design flow
Potential failure modes	Deviations caused by the production and/or design process	Deviations in the process
Potential effects of the failures	Deviations from product specifications	Deviations from the process requirements

2 Terms and definitions

The following are the terms included in the body of the text. Definitions marked by an asterisk (*) are taken from EIA 557, General Standard for Statistical Process Control (SPC). They are replicated here for completeness.

characteristic*: A distinguishing feature of a process or its output on which variables or attributes data can be collected.

control*: A corrective action process based on feedback.

design of experiments (DOE): An efficient method of experimentation that identifies factors that affect the mean and variation with minimum testing.

2 Terms and definitions (cont'd)

failure: (1) The loss of the ability of a component to meet the electrical or physical performance specifications that (by design or testing) it was intended to meet.
(2) A component that has failed.

failure mode and effects analysis (FMEA): A systematized group of activities intended to recognize, evaluate, and prioritize the potential failure of a product or process and its effects, and to identify actions that could eliminate or reduce the chance of the potential failure occurring, listed in the order of effect on the customer**.**

node*: A definable point in the process at which form, fit, or function is altered.

Pareto analysis: A technique for problem-solving in which all potential problem areas or sources of variation are ranked according to their contribution.

potential cause of failure: A property, characteristic, or occurrence that could lead to a failure, described in terms of something that can be corrected or controlled.

potential failure mode: The manner in which the process could potentially fail to meet the process requirements and/or design intend. It is a description of the nonconformance at that specific operation. It can be a cause associated with a potential failure mode in a subsequent (downstream) operation or an effect associated with a potential failure in a previous (upstream) operation. However, when the "Failure Mode and Effect Analysis" (FMEA) is prepared, the assumption should be made that the incoming part(s)/material(s) are correct.

process*: (1) A combination of people, procedures, methods, machines, materials, measurement equipment, and/or environment for specific work activities to produce a given product or service.
(2) A repeatable sequence of activities with measurable inputs and outputs.

process change: A change in processing that could alter the capability of the process to meet the design requirements or durability of the product.

3 FMEA requirements

Experts from all disciplines are needed to properly assess the product(s) and or process(es) under consideration. A collection of subject matter experts from a number of various disciplines should be brought together to think about potential problems that could occur in a product and or process sometime in the future. Individuals do not necessarily have to be directly involved with the product and or the process; experience in a particular discipline may be of greater value than direct knowledge of the product and or the process. Ideally, representatives of the entire supply chain including customers and suppliers should also be contributors in the process.

3 FMEA requirements (cont'd)

3.1 Creation process

A design FMEA should begin with a block diagram of the product this allows the participants to envision how various components or sub-assemblies will interact. The effects identified on an appropriate process FMEA can be used as input to a design FMEA to help identify objective values for occurrence and detection based on historical data.

A process FMEA should begin with a flow diagram that shows the association of each operation (see Annex B for an example). When a process and or a product is being modified or a sub process added, it is not necessary to start the FMEA from the beginning, it is more appropriate to start by using an existing FMEA and concentrate on the new topics.

The block diagram or flow chart is then used to assist the group to anticipate potential problems in a structured way; this can be conducted through various brainstorming techniques. If applicable, FMEAs of design or process blocks could be reused from other FMEAs. All areas must be considered including design, materials, manufacturing, delivery etc. For each potential problem the group must then identify what the effect will be and to attach a subjective value to each item that is based on how severe they think the potential effects are.

Continuing the thought process, a potential cause of each of the problems must be defined and a determination of how often they may occur. Using their experience the group must determine how good they believe existing procedural or process controls will be for both preventing the problem but also detecting the problem if it does occur.

Using the numerical values that were determined for the severity, the possible number of occurrences and the ability to detect the problem, a prioritization of the risk of each problem can be made by calculating the Risk Priority Number (RPN)

Starting with the potential problems with the highest severity number the group then determines what actions can be taken to improve prevention or detection. When action for the high severity items have been identified the group should continue to identify actions to prevent or detect those items with the highest RPN The action list then allows resources to be allocated and objectives to be set that will help to reduce the potential risk to the customer in the future.

When the actions have been implemented and the results have been evaluated the RPNs should be recalculated, determination of actions for those items with the highest severity numbers and RPNs may have to be repeated until the problems are solved.

In order to facilitate documentation of the analysis of potential failures and their consequences, an example process FMEA form was developed and is included as Annex A. The use of a software tool for creation and documentation of the FMEA is recommended. Choose the software that makes most use to the team.

Application of the FMEA form is described below. Examples of a PFMEA and DFMEA are shown in Annex B and C.

3.2 FMEA identification

3.2.1 FMEA document number and date

FMEA document number, which may be used for tracking. The date the original FMEA was compiled, and the latest revision date.

3.2.2 Technology/Process/Product

The intended technologies and products that will utilize and/or be affected by the design/process being analyzed.

3.3 Process / Product function/requirements

3.3.1 PFMEA

A simple description of the process or operation being analyzed (e.g., diffusion, etching, joining, reflow, turning, drilling, tapping, welding, assembling). Indicate as concisely as possible the purpose of the process or operation being analyzed. Where the process involves numerous operations (e.g., assembling) with different potential modes of failure, it may be desirable to list the operations as separate processes.

3.3.2 DFMEA

A basic description of the design or product being analyzed can be divided in these major categories (e.g., product construction, design features and specifications, material, use environment). Indicate as concisely as possible the objective of the application and expected end use environment that may potentially affect product performance.

For each category, indicate areas with potential failures based on the deviations from each steps in the major categories, assessing severity and potential effects, and ability to detect them. As an example, during Design phase, significant impact could occur if drawing specifications were improperly documented or this step was overlooked or occurred out of process flow.

Downstream effects could be very severe affecting other processes and have a profound effect on product performance, quality and reliability. Finally, product responses from use environment should also be analyzed for completeness. An illustration of functions within each category is shown below:

Construction - process definition and sequence, interaction, and interdependencies, equipment, tools definition and capability, training and operator dependencies, in-line quality metrics, outgoing inspection requisites should be part of the PFMEA.

Design - drawing creation and verification, feature definition and prototype validation, dimensional and tolerance analysis, documentation and revision control, design-for-manufacturability (DFM) and design-for-testability (DFT) conformance.

Materials - Bill of Material generation, parts drawings, material properties and fact sheet, material availability and cost, supplier base evaluation.

3 FMEA requirements (cont'd)

3.3.2 DFMEA (cont'd)

Use environment - climatic, thermal, and mechanical effects, conformance to marketing requirements.

3.4 List of potential failure modes

List the potential failure modes for the particular operation in terms of a component, subsystem, system or process characteristic. The assumption is made that the failure could potentially occur. This list must address:

1) How can the process/part fail to meet requirements/expectations (e.g., bent leads, shorted output, excess leakage, inoperational, open, intermittent open, parametric shift, poor appearance, unstable, noisy, etc.)?

2) What is the anticipated impact on the customer independent of specification compliance? The customer(s) in this context could be the next operation, subsequent operations or locations, the dealer, and/or the product owner. Each must be considered when assessing the potential effect of a failure.

3.5 Description of the potential effects of each failure

Describe the effects of each failure in terms of what the customer(s) might notice or experience.

1) For the end user, the effects should always be stated in terms of product or system performance, such as:

   - inoperative
   - no impact
   - application dependent

This list must be as detailed as the technology and or the product requires. For example:

A shift in the common mode rejection ratio of an operational amplifier may cause few problems, while a shift in the input offset voltage will bring down many applications.

2) If the customer is the next operation or subsequent operation(s)/location(s) the effects should be stated in terms of process/operation performance such as:

   - does not fit
   - excessive effort required
   - increased yield loss
   - damages equipment
   - endangers operator/user

This must be as detailed as the technology and or product requires.

3 FMEA requirements (cont'd)

3.6 Comparison and review

A comparison of similar processes and or products a review of customer (end user and subsequent operation) claims relating to similar components will be performed and documented.

3.7 Quantification of the potential effect(s) of failure: Severity (S)

An assessment of the seriousness of the effect of the potential failure mode to the customer should be performed and documented.

The assessment of the severity should focus on consequences for the external customer. Topics from internal customer point of view could be added. The consequences include all type of problems at the customer production line or in the field, economical or legal.

3.7 Quantification of the potential effect(s) of failure: Severity (S) (cont'd)

Severity applies to the effect only. If the customer affected by a failure mode is the assembly plant or the product user, assessing the severity may lie outside the immediate process engineer's/team's field of experience/knowledge. In these cases, design engineer, subsequent manufacturing or assembly plant process engineer, and/or customer should be consulted.

The severity assessment will be made based upon the characteristics of the failure mode, not on the probability of occurrence of the failure mode. For details of the assessment metric see Annex D.

3.8 Potential cause(s)/mechanism(s) of failure

List, to the extent possible, every conceivable failure cause assignable to each potential failure mode. Many causes however are not mutually exclusive, and to correct or control the cause, a design of experiments, for example, may be considered to determine which root causes are the major contributors and which can be most easily controlled. The causes should be described so that remedial efforts can be aimed at those causes which are pertinent.

An example of typical failure causes includes:

- Improper diffusion
- Over/under etch
- Improper alignment
- Improper heat treatment - time, temperature
- Improper contaminant control
- Improper resist removal
- Part missing or dislocated
- Design failure

NOTE Ambiguous phrases (e.g., operator error, design error, machine malfunction) should not be used.

3 FMEA requirements (cont'd)

3.9 Quantification of the Occurrence (O) of the failure

Occurrence is how frequently the specific failure cause/mechanism is projected to occur. The cause gives the main information on the occurrence. The occurrence is determined as the probability PO that a failure occurs at the process step or product module under discussion. The lowest possible value for the O-Rate is the inverse of the sample size inspected. The probability values (O-Rate) could be transferred to the standard FMEA-Matrix by using the data in Annex F. If available from a similar process, statistical data should be used to determine the occurrence ranking. In all other cases, a subjective assessment can be made (see Annex F). For a detailed description of capability/performance analysis refer to publications such as the EIA557.

EXAMPLE A 10% resistor that is out of tolerance is much less likely to cause a customer impact than a 1% that is out of tolerance.

3.10 Current process controls

List the controls that either prevent to the extent possible the failure mode from occurring or detect the failure mode should it occur. They can be process controls such as fixture error-proofing or Statistical Process Control (SPC), or can be post-process evaluation. The evaluation may occur at the suspect operation or at subsequent operations that may detect the subject failure mode. Indicate whether the control is preventive (P) or detection (D)

3.11 Quantification of the Detection (D) probability of the failure

Assess the probability that the proposed process controls will detect the failure mode, before the part or component leaves the manufacturing or assembly location. Assume the failure has occurred and then assess the capabilities of all current process controls to prevent shipment of the part having this failure mode or defect. D can be calculated by using the inverse value, the escape rate, the probability that the defective part leaves the process under assessment. For example: the overall escape rate of a failure occurring in the FE production line is the product of the escape rates of all measurements sensitive to the discussed failure mode and following the failed process step:

$ER = ER_{PCM} \times ER_{Wafer\text{-}Test} \times ER_{Product\text{-}Test1} \times \ldots$ (assembled IC's)

$ER = ER_{PCM} \times ER_{Wafer\text{-}Test}$ (for Bare Die deliveries with wafer test)

The probability values (ER: Escape-Rate) could be transferred to the standard FMEA-Matrix by using annex G.

Do not automatically presume that the detection ranking is low or the escape rate is high because the occurrence is low (e.g., when control charts are used), but do assess the ability of the controls to detect low frequency failure modes or prevent them from going further in the process.

If available from a similar process or product, statistical data should be used to determine the occurrence ranking. In all other cases, a subjective assessment can be made (see Annex G).

3 FMEA requirements (cont'd)

3.11 Quantification of the Detection (D) probability of the failure (cont'd)

Random quality checks are unlikely to detect the existence of an isolated defect and should not influence the detection ranking. Sampling done on a statistical basis is a valid detection control. For details see Annex C.

Evaluate the likelihood that the defect will be detected by controls before next or subsequent process, or before part or component leaves the manufacturing or assembly location.

EXAMPLE An open address line on a DRAM will result in addressing errors that are difficult to detect, causing data errors. An open V_{CC} line will cause an inoperational device that can easily be detected and repaired. An open discrete capacitor used for decoupling, on the other hand, is frequently transparent to the customer.

3.12 Quantification of the overall risk by the Risk Priority Number (RPN)

A process shall be implemented for the purpose of ranking the customer risk. This process shall be based upon the multiplicative product of the severity, occurrence, and detection ranking numbers. It should be used to rank order the concerns in the process (e.g., in Pareto fashion). For higher RPNs the team must undertake efforts to reduce the risk through corrective action(s). When ranking the concerns the initial focus should be on those with high severity numbers followed by those with high occurrence numbers. If a concern has a high severity number but low RPN, it may be given a higher priority ranking than a concern with a higher RPN but low severity number.

3.13 Recommended action(s)

When the failure modes have been rank ordered by RPN, corrective action should be first directed at the highest ranked concerns and highest ranked severity items. If, for example, the causes are not fully understood, a recommended action might be determined by a statistical designed experiment (DOE). The intent of any recommended action is to reduce the severity or risk priority ranking by reducing the severity, occurrence, and/or detection rankings. If no actions are recommended for a specific cause, then this must also be documented. In all cases where the effect of an identified potential failure mode could be a hazard to manufacturing/assembly personnel, corrective actions should be taken to prevent the failure mode by eliminating or controlling the cause(s), or appropriate operator protection should be specified.

The need for taking specific, positive corrective actions with quantifiable benefits, recommending actions to other activities and following-up all recommendations cannot be overemphasized. A thoroughly thought out and well developed FMEA will lead to positive corrective actions. It is the responsibility of all initiators and affected activities to implement effective follow-up programs to address all recommendations.

3 FMEA requirements (cont'd)

3.13 Recommended action(s) (cont'd)

The following actions should be considered:

- To reduce the probability of occurrence, process and/or design revisions are required.
- An action-oriented study of the process using statistical methods could be implemented with an ongoing feedback of information to the appropriate operations for continuous improvement and defect prevention.

Only a design revision can bring about a reduction in the severity ranking.

To increase the probability of detection, process and/or design revisions are required. Generally, improving detection controls is costly and ineffective for quality improvements. Increasing quality controls inspection frequency is not positive corrective action and should only be utilized as a temporary measure; permanent corrective action is required. In some cases, a design change to a specific part may be required to assist in the detection. Changes to the current control system may be implemented to increase this probability. Emphasis must, however, be placed on preventing defects (e.g., reducing the occurrences) rather than detecting them.

An example would be the use of statistical process control and process improvement rather than random quality checks or associated inspection.

3.14 Responsibility (for the recommended action) and target completion date

The organization and individual responsible for the recommended action and the target completion date must be documented.

3.15 Actions taken

After an action has been implemented, document a brief description of the action and effective date.

3.16 Resulting RPN

After corrective actions have been identified/implemented, allow for a period of stabilization then review and revise the resulting occurrence, severity, and detection and risk priority numbers.

3.17 Classification

If other criteria are used to classify process, component, subsystem, or system characteristics such as critical, key, major or significant (e.g., JESD29, EIA557, etc.) these classifications should also be documented as part of the FMEA.

4 Follow-up

The FMEA is a living document and should always reflect the latest design level, as well as the latest relevant actions, including those occurring after the start of production. If new aspects are detected by analysis of failures in the field the affected FMEA has to be reviewed and can be updated if required. This review should include both preventive and corrective analysis.

Annex A Template for Potential Failure Mode and Effects Analysis

POTENTIAL
FAILURE MODE AND EFFECTS ANALYSIS
☐ PROCESS FMEA ☐ Design FMEA
Company:

FMEA date (Orig.) _____ (Rev) _____ Technology/Process/Product _____
Prepared by (core team members):

Process/ Product Function Requirements	Potential Failure Modes	Potential Effect(s) of Failure	Sev	Class	Potential Cause(s)/ Mechanism(s) of Failure	Occur	Current Design or Process Controls (preventive:P detection:D)	Detec	RPN	Recommended Action(s)	Responsibility & Target Completion Date	Action Results				
												Actions Taken	Sev	Occ	Det	RPN

Annex B Example PFMEA

POTENTIAL
FAILURE MODE AND EFFECTS ANALYSIS
X PROCESS FMEA ☐ Design FMEA
Company: ABC, Site adress

FMEA date (Orig.) 2004-06-30 (Rev) _____ Technology/Process/Product Smart-Power-CMOS-12-A
Prepared by (core team members): A. Bman, C. Dman, E. Fman

Process/ Product Function Requirements	Potential Failure Modes	Potential Effect(s) of Failure	Sev	Class	Potential Cause(s)/ Mechanism(s) of Failure	Occur	Current Design or Process Controls (preventive:P detection:D)	Detec	RPN	Recommended Action(s)	Responsibility & Target Completion Date	Action Results				
												Actions Taken	Sev	Occ	Det	RPN
Gate Poly (d,Rs)	Rs too high	Contact-R increased	5		Failure during dope process (t,T,conc)	5	Inline Rs (D)	3	75							
					Unwanted interface layer	4	EOL measurement (D)	4	80							
		R-Poly increased	6		Failure during dope process (t,T,conc)	5	Inline Rs (D)	3	90							
					Thickness too high	4	Inline d(poly)(D)	3	72							
		Gate RC increased	5		Failure during dope process (t,T,conc)	5	Inline Rs (D)	3	75							
					Thickness too high	4	Inline d(poly)(D)	3	60							
					Unwanted interface layer	4	EOL measurement (D)	4	80							
Spacer (Leak < x mA/µm)	Too narrow	Leak > x mA/µm	7		Step coverage spacer oxide unstable	6	EOL measurement (D)	6	252	Change deposition process	C. Dman 2004-07-31	Stable step coverage by new process	7	2	6	84

Annex C Example DFMEA

POTENTIAL
FAILURE MODE AND EFFECTS ANALYSIS
☐ PROCESS FMEA ☒ Design FMEA
Company: : ABC, Site adress

FMEA date (Orig.) 2004-11-30 (Rev) _____ Technology/Process/Product TL1234 High-Side -Switch
Prepared by (core team members):U. Vson, W. Xson, Y. Zson

Process/ Product Function Requirements	Potential Failure Modes	Potential Effect(s) of Failure	Sev	Class	Potential Cause(s)/ Mechanism(s) of Failure	Occur	Current Design or Process Controls (preventive:P detection:D)	Detec	RPN	Recommended Action(s)	Responsibility & Target Completion Date	Action Results				
												Actions Taken	Sev	Occ	Det	RPN
Pad 12 bonded with two parallel wires	One wire missing	Slow signal due to RC	6		Bonding process fail	3	Final Test if sum of RC already high (D)	10	180	Change to single thick wire	Y. Zson	Thick wire for pad 12	6	3	1	18
		Reduced lifetime of single wire (fail in field)	8		Bonding process fail or mechanical overstress	3	no	10	240	Change to single thick wire	Y. Zson	Thick wire for pad 12	8	3	1	18
	Bond ball lifted (intermittend)	Slow signal due to RC	6		Bonding process fail	3	Final Test if sum of RC already high (D)	10	180	Change to single thick wire and improve bonding process	Y. Zson, U.Vson	Thick wire for pad 12 with new bonding process	6	1	10	60
		Reduced lifetime if open (fail in field)	8		Bonding process fail or mechanical overstress	3	no	10	240	Change to single thick wire and improve bonding process	Y. Zson, U.Vson	Thick wire for pad 12 with new bonding process	8	1	10	80
Power line for 100 mA	Line too narrow by design	Thermal overstress causing opens	9		Wrong line width calculation	2	no	10	180	Add reliability simulation to design flow	A. Designer	DFR design flow implemented	9	1	2	36

Annex D Severity Metric

S	Effect	Effect Description	Customer Effect	Required action in case of occurrence at the customer
1	None*	No real effect.	will not notice the failure	none
2	Very Minor	Low influence on product or subsequent processes. Spec is not violated	Will probably notice the failure. No influence on customers processes	Minor adjustments at vendor to be checked.
3	Minor	Influence on product or subsequent processes. Spec is not violated	Will notice the failure. No influence on customers processes	Adjustments at vendor to be checked.
4	Very Low	Influence on product or subsequent processes detected during processing. Spec is not violated	Slight annoyance or made uncomfortable. Potential influence on customers processes.	Electrical or mechanical adjustment at vendor or change at customer's production process.
5	Low	Influence on product or subsequent processes detected at incoming inspection or prior to use. Spec is not violated	Moderate annoyance or made uncomfortable. Potential influence on customers processes.	Electrical or mechanical adjustment at vendor or change at customer's production process.
6	Moderate	Influence on product or subsequent processes detected at subsequent production line or in the field. Spec is not violated	Annoyance or made uncomfortable. Potential influence on customers processes.	Electrical or mechanical adjustment at vendor or change at customer's production process.
7	High	Failure causing problems (deterioration) of the product and is detected at the incoming inspection, prior to use or during processing. Spec is violated	Dissatisfied by out-of-spec-product.	Implementation of containment and corrective actions at vendor required.
8	Very High	Failure causing problems (deterioration) of the product and is detected at subsequent production line or in the field. Spec is violated	Dissatisfied by out-of-spec-product in the field.	Implementation of containment and corrective actions at vendor required.
9	Hazardous with warning	Failure effects safe operation with respect to production equipment and rest of the system and compliance with government regulations.	End user highly dissatisfied. Customer economically affected. May endanger operator (also at vendor) or user with warning.	Product should be recalled from the field.
10	Hazardous without warning	Failure effects safe operation with respect to human health and environmental safety and compliance with government regulations.	End user highly dissatisfied. Customer economically strongly affected. May endanger operator (also at vendor) or user without warning.	Product shall be recalled from the field.

* This class of potential fails should only be included in the FMEA as an exception (e.g. if occurrence is high and detectability is low and severity might change to higher values for other application areas).

Annex E Examples of assessment ranges for PFMEAs

To guarantee the consistency of different FMEAs detection ranges for different methods used in the production and design process are given. Depending on different boundary conditions the numbers could be different from the examples given, but it should be assured that under identical conditions the same numbers are used.

Table E.1 — Detection ranges for methods used in a production process (PFMEA)

Detection Method	D min	D max
Online at process	1	1
Control of inline data immediately after process	1	2
Special analysis after process	2	3
Control of inline data later in process	3	4
Special analysis later in process	3	5
Control by operator later in process (subjective)	5	6
Electrical test for all wafers at 5 sites (100% measurement → (D-1)	5	5
Functional or prefuse test at the product	5	5
Functional test after burn in	6	7
WLR monitoring	8	9
Product reliability monitoring	8	10
D can change drastically from the values in Table E.1 if different sampling is applied or the method is not sensitive to the failure mode under discussion, e.g. special measurements / sampling instead 100% test add one, subjective control instead of automatic testing add two		

Annex F Occurrence Rankings

Table F.1 — Occurrence rankings based on statistical data

Ranking	Meaning	O-Rate
1	unlikely	< 10 ppm
2	Only isolated fails	100 ppm
3	Only isolated fails in similar cases	500 ppm
4	Occasional fails	0.1 %
5	Occasional fails	0.2 %
6	Occasional fails	0.5 %
7	Repeated fails	1 %
8	Repeated fails	2 %
9	Fail almost inevitable	5 %
10	Fail almost inevitable	> 10 %

Table F.2 — Occurrence rankings (subjective)

Ranking	Meaning	Probability
1	Failure is unlikely.	Remote
2	Only isolated fails associated with almost identical cases	Very low
3	Only isolated failures associated with similar cases	low
4-6	Generally associated with processes similar to previous processes that have experienced occasional failures, but not in major proportions	moderate
7-8	Generally associated with processes similar to previous processes that have often failed (Repeated fails).	High
9-10	Failure is almost inevitable	Very high

Annex G Detectability Rankings

Table G.1 — Detection rankings based on statistical data

Ranking	Meaning	Probability
1	Almost certainty	< 10 ppm
2	Almost certainty	100 ppm
3	Good chance	500 ppm
4	Good chance	0.1 %
5	Likely	0.2 %
6	Likely	0.5 %
7	May be	1 %
8	May be	2 %
9	Probably not, but may be by customer	5 %
10	no	> 10 %

Table G.2 — Detection rankings (subjective)

Ranking	Meaning	Probability
1	Controls will almost certainly detect the existence of a defect. (Process automatically prevents further processing.)	Very high
2	Controls have a good chance of detecting a defect. (Process automatically detects failure.)	high
3-4	Controls may detect the existence of a defect	moderate
5-6	Controls have a poor chance of detecting the existence of a defect.	low
7-8	Controls probably will not detect the existence of a defect.	Very low
10	Absolute certainty of non detection: Controls will not or can not detect the existence of a defect.	no

Annex H (informative) Difference between JEP131 and JEP131A

This table briefly describes most of the changes made to entries that appear in this publication, JEP131A, compared to its predecessor, JEP131 (February 1998). If the change to a concept involves any words added or deleted (excluding deletion of accidentally repeated words), it is included. Some punctuation changes are not included.

Page	Description of change
All	Renumbered document to conform with the JEDEC Style Manual, JM7
i	**Introduction:** New topics added covering the objective, the team, the outcome, handling of results, review and introducing product (DFMEA).
1	**Scope**: Several terms added: “product and or”, “requirements”, “package design, chip design”. “process requirements neede” replaces “instead of area responsible”. In second paragraph added “and or process”.
1	Added **Table 1**
1	**Terms and definitions. Deleted the following:** definition for characterization and common cause, control limits, control plans, critical failure mechanism, design intent, design life, design validation/verification (DV), failure kinetics, failure mechanism from fabrication process, failure mechanism from assembly, long-term capability, nonconformity, parameter, pareto, potential physical failure mechanism, product capability study, product performance, and quality function deployment (QFD)
2	**failure mode and effect analysis (FMEA):** minor editorial changes
2	**Pareto analysis**: new
2	**potential cause of failure**: new text
2	**potential failure mode**: in alphabetic order, minor editorial changes
2	FMEA Requirements: new text
3	**3.1 Creation process**: new text, replaces old 5.3
4	**3.2 FMEA identification**: new structure of clauses
4	**3.2.1**: replaces old 5.1
4	**3.2.2**: replaces old 5.2, “Product” added to the header
4	**3.3 Process / Product function / requirements**: new structure of clauses
4	**3.3.1**: replaces old 5.4
4	**3.3.2 DFMEA**: new clause
5	**3.4**: replaces old 5.5, minor editorial changes
5	**3.5**: replaces old 5.6, “and or product” added.
5	**3.5**: first and last example of old 5.6 shifted to other clauses, at 2) “endanger operator/user” added
6	**3.6**: replaces old 5.7, “and or product” added.
6	**3.7**: replaces old 5.8.1, “Quantification of the potential effect(s) of failure:” added to the headline, second to fourth sentence added. Last sentence added to introduce Annex D. Last sentence and criteria list of old 5.8.1 deleted.
6	**3.8**: replaces old 5.9, “and or product” added.
6	typical failure causes: “design failure” added
7	**3.9**: replaces old 5.8.2, “Quantification of the … of the failure:” added to the headline, second to fifth sentence added to introduce annex F. Last sentence and criteria list of old 5.8.2 deleted. Example from old 5.6 added.
7	**3.10**: Last sentence added

Annex H (informative) Difference between JEP131 and JEP131A (cont'd)

7, 8	**3.11**: replaces old 5.8.3, "Quantification of the …probability of the failure:" added to the headline, "D can be…using annex G" and "If available…occurrence ranking." added to introduce annex G and ER. Last sentence added. Last sentence and criteria list of old 5.8.3 deleted. Example from old 5.6 added.
8	**3.12**: replaces old 5.8.4, "ranking" and R replaced by "number" and N in the headline and text. Last two sentences changed.
8	**3.13**: replaces old 5.11, RPR replaced by RPN in the text.
9	**3.14**: replaces old 5.12
9	**3.15**: replaces old 5.13
9	**3.16**: replaces old 5.14, last word change "rankings" to "numbers".
9	**3.17**: replaces old 5.15
10	**Follow –up**: last two sentences new
11	**Annex A**: add "Template" to title, new template has identifier for process or design FMEA, company name, product function (1st col), "design or" (8th col), RPN instead of RPR
12	**Annex B**: add "Example PFMEA" to title, new example
13	**Annex C**: new, old annex C deleted
14	**Annex D**: new
15	**Annex E**: new
16	**Annex F**: new
17	**Annex G**: new

Standard Improvement Form **JEDEC JEP131A**

The purpose of this form is to provide the Technical Committees of JEDEC with input from the industry regarding usage of the subject standard. Individuals or companies are invited to submit comments to JEDEC. All comments will be collected and dispersed to the appropriate committee(s).

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