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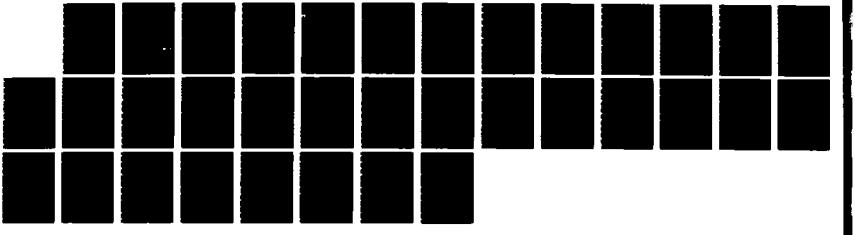

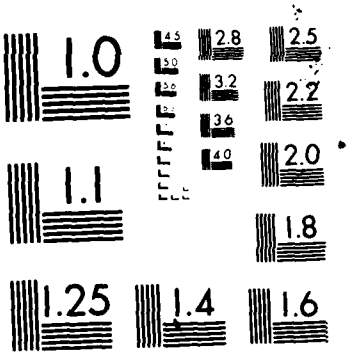

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Organization for Industrial Research, Inc.

240 Bear Hill Road
Waltham, MA 02154

(617) 890-4030

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This document is a report of the requirements for a Group Technology Electronics Classification and Coding System (ECACS). The report outlines a methodology for code development, identifies implications of these activities for an ECACS and defines a general structure for the code. Specific characteristics which should be captured by an ECACS are delineated.

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Organization for Industrial Research, Inc.

240 Bear Hill Road
Waltham, Massachusetts 02154 USA
Telephone: (617) 890-4030

Report DAAK10-80-C-0189

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Requirements Definition

Peter Chevalier, Cece Menkin
Organization for Industrial Research, Inc.
240 Bear Hill Road
Waltham, MA. 02154

5 April 1982

Final Report

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Prepared for

DEPARTMENT OF THE ARMY
U.S. Army Armament R&D Command
Dover, New Jersey 07801

TABLE OF CONTENTS

Section 2

BACKGROUND

The Organization for Industrial Research is a company committed to the philosophy of Group Technology. However, OIR believes in realistic and practical applications of Group Technology within manufacturing environments and has over fifty American customers and seventy installations of its systems as confirmation of its philosophy and approach.

OIR strongly believes in an integrated approach to CAD and CAM systems. Over ten years of practical, on-site experience has unequivocally demonstrated the benefits of an integrated systems approach rather than numerous systems in isolation. Group Technology can become "glue" technology and be the essential ingredient in achieving integration of CAD and CAM systems. OIR has shown that a Group Technology classification and coding system can become the common denominator among different CAD/CAM systems and applications. The MICLASS code is at the core of all OIR systems.

An important part of the many Group Technology system implementations OIR performs, is code design and development. Each application of an OIR system requires the development of a specific code for a particular environment, in addition to OIR's standard Group Technology Classification and Coding System. This specific code is an extension of the standard code. In this way, each company can make best use of proven, industry wide data captured in the standard section of the code, yet still have a section of the code specific to its own needs and requirements.

Additionally, OIR has developed other types of Group Technology Classification and Coding Systems for different applications (i.e. Purchased Parts Coding System). These coding systems have been in direct response to client requests.

Code development can be an extremely time consuming task requiring a highly labor intensive effort. OIR has significantly reduced the time and manpower requirements for this task by using:

- inhouse expertise gained through years of experience;
- computerized Group Technology analysis programs.

Contract No. DAAK10-80-C-0189 required OIR to define the fundamentals of a Group Technology Electronics Classification and Coding System. This Requirements Definition document will identify the primary and secondary characteristics for an ECACS.

OIR developed this report based on survey and interview data, consultation with a panel of electronics experts and its own extensive experience with Group Technology code development.

Section 1

INTRODUCTION

Contract NO. DAAK10-80-C-0189 was awarded by the Tri-Service Manufacturing Technology Program through the Department of the Army, U.S. Army Armament R & D Command, Dover, New Jersey to the Organization for Industrial Research, Inc. (OIR). The goal of this contract was to develop the fundamentals of a Group Technology Electronics Classification and Coding System (ECACS) including a Requirements Definition. This report is the Requirements Definition document and is the second section of the contract final report.

The information found in this report is based on data collected by OIR by surveying manufacturers within the electronics industry. Information regarding the survey process, survey findings, survey data analysis and conclusions can be found in Report DAAK10-80-C-0189, "Fundamentals of a Group Technology Classification and Coding System: Summary of Survey Findings".

Section 3

ECACS: GENERAL CONSIDERATIONS

OIR has developed a methodology for the development of Group Technology Coding Systems based upon our years of experience with this activity. There are certain general considerations which must be reviewed before actual code development is begun. In order to develop a classification and coding system for electronics the following must be considered:

- applications.
- existing software utility programs.
- code format and layout.

3.1 Applications

The development of a classification and coding system cannot begin until there is a clear understanding of how the code will be used. The nature of the application/s of the code will govern the information a coding system should capture.

OIR's first activity in a code development project is to identify the potential applications which will use the coding system. It is essential to realistically identify as many possible applications which will eventually use the coding system even though some of these applications will take place in the future.

A classification and coding system should not be developed in isolation. OIR has reviewed many coding systems developed at various companies and found mostly simple codes for isolated applications. The isolated application approach to code development leads to a system which quickly becomes too limited and often has to be replaced.

Often, a company will abandon the code and not expend additional man-hours developing a new replacement code. These experiences have created some skepticism regarding the usefulness of coding systems.

OIR is strongly committed to the philosophy of creating an integrated applications database which is accessed by the code number. Therefore, it is essential to develop a classification and coding system which captures the necessary information for multiple applications. Development of a coding system for one application should not create obstacles for the use of that code in other applications. The format and layout of the code will also be influenced by the potential applications. The code structure should be able to adapt to changes in technology - a most important consideration for the electronics industry.

Therefore, OIR in the survey and interview phase of this project thoroughly investigated the potential applications of an ECACS with professionals in the electronics industry. The following potential applications were identified:

3.1.1 Design Applications

- Design Retrieval - ability to quickly retrieve preferred reference design for review and possible re-use. This would enable a company to make optimal use of CAD systems and improve designer productivity.

- Design Documentation Support
  - creation of a preferred components file/listing (including specifications) which could be accessed by using the code number for immediate data retrieval. Additionally, an alternate components program could be used when a designer would need to identify an equivalent component when the preferred one was unavailable. This application would provide immediate data retrieval and eliminate time-consuming clerical search activities for the designer.
  - development of an automated program for creating design specifications, storing previously used specifications and retrieval of design specifications. (Design specifications could include function specs for an assembly, component specs,etc.)

3.1.2 Manufacturing Applications

- Automated production specification generation.
  - This would include process documentation and test specification. Inherent in the program would be the ability to create, store and retrieve data necessary to support these documentation activities. Once again past proven experience in the form of preferred reference production specs could be quickly retrieved for re-use either as is, or in an edited version, thereby, improving manufacturing engineering productivity.
- Automated Components Inventory Listing.
- Automated Component Status Specification.
  - This would identify parts obsolescence and parts performance data; also vendor performance. The code number would provide quick determination of alternates. Obsolescence planning and second sourcing would be enhanced in this application.

After applications have been identified, OIR reviews these applications to determine which one offers the greatest potential return on investment. The inital code development will specifically address that application but the final code will be structured so as to accommodate future applications.

An additional factor identified which must be considered when developing a Group Technology code for electronics is the particular area of electronics manufacture (electronics family) where the code will be used. The survey and interview data indicating the following families would be best suited for the application of an ECACS in both design and manufacturing:

- PCB,
- PCBA,
- Elec/Mechanical,
- Wired/Assembly,
- Discretes (all types of individual components).

3.1.3 Implications for an ECACS

After reviewing the data regarding potential applications, an ECACS should:

- capture both design and manufacturing information so as to be useful to multiple users. Design information can be captured by approximately 4-6 characteristics. Manufacturing information can be captured by approximately 10-25 characteristics because of the greater detail necessary for manufacturing applications.
- facilitate the integration of CAD/CAM systems and the integration of databases by becoming the common means of accessing these systems.
- be structured with enough flexibility to keep pace with changing technology.
- be a comprehensive structure so as to cover all areas of electronics manufacture (all the families).

3.2 Existing Software Utility Programs

A classification and coding system only becomes effective when coupled with good software utility programs. Utility programs together with required data files will build the integrated applications database. Developing a classification and coding system which can use well chosen, proven software utility programs can eliminate the costly and time consuming development effort required to create software programs in-house.

Therefore, after potential applications have been identified, OIR's next task in code development is to review all relevant existing software utility programs. Once a decision is made regarding existing programs, the code must be structured so its format and layout are compatible with the existing software programs. Additionally, this focuses the code development team on the concept of creating an integrated applications database and the means of accessing it.

Some examples of software utility programs which would be considered follow. This is not an inclusive listing.

- Standardized Retrieval Program
  A standardized retrieval module which allows for fast, first line retrieval. This is a necessity given that if you have a code number and unlimited time you can find anything. However, the advantage of a code number coupled with a good retrieval system is immediate access to desired data.

- Software Communication Program
  A program designed to be the link between data retrieval and data handling. This is the software that allows you to use the "do" systems more effectively (i.e. MIGRAPHICS facilitates the activities of a CADD system).

- Data Handling Programs
  A standard "do" modules which handles retrieved data for a specific application (computer aided process planning). The code number could directly access such a program (i.e. MIPLAN Process Planning Systems).

- Analysis Programs
  A standard program which will perform a statistical analysis of data for a particular application (i.e. The MIGROUP System does statistical analysis for Group Technology applications).

3.2.1 Implications for an ECACS

Before the development of an electronics classification and coding system begins, a thorough review of appropriate existing software programs should be completed. During the on-site interview process OIR did not discover any standardized utility programs in use at the ten electronics manufacturers visited. However, OIR is aware that a more intensive review is necessary.

3.3 ECACS Code Format and Layout

Even though survey data did not identify existing software programs compatible with a Group Technology Electronics Classification and Coding System, OIR has used its own MIGROUP System - Group Technology Analysis Programs - in all of its code development projects. The MIGROUP Software enables OIR to significantly reduce the time and manpower requirements necessary to perform the activities of code development. Therefore, OIR recommends the use of MIGROUP or an equivalent system to do the analysis necessary for the development of an ECACS.

3.3.1 Implications for an ECACS

The Group Technology Classification and Coding System for Electronics should be a numeric code with a maximum of thirty digits so that it will be compatible with existing Group Technology analysis program software. If this structure is used it will greatly facilitate the code development process.

Section 4

GROUP TECHNOLOGY CODE DEVELOPMENT

After potential applications and support software programs have been identified, actual code development activities begin.

4.1 Code Development Start-up Activities

During a typical code development project, OIR performs the following activities during project start-up.

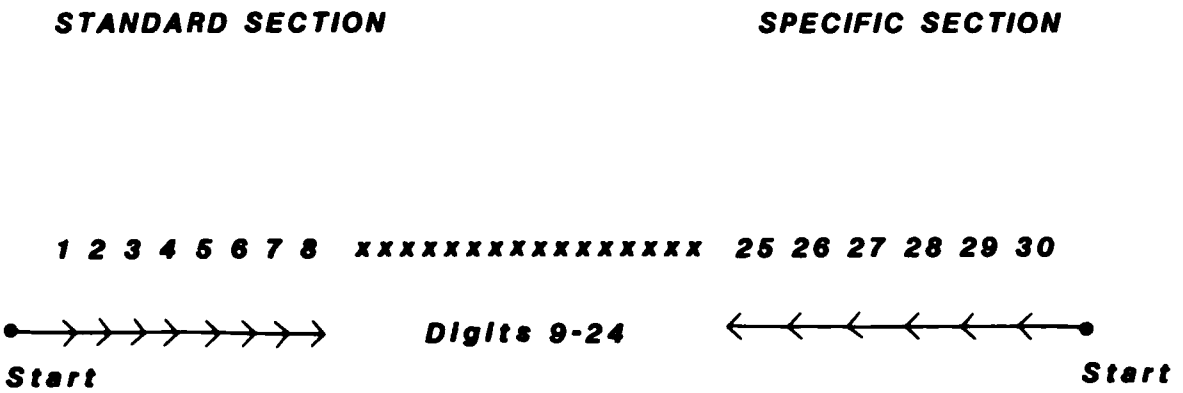
- Review potential applications, support software and any other requirements for the code.
- Determine the particular characteristics and information the code should capture.
- Determine level of detail (for information) to be captured by the code.
  The level of detail depends on:
  - total number of items to be coded (100 items require less detail than 100,000 items).
  - type of application:
    design retrieval requires less detail in the code than shop floor analysis or process plan retrieval.
  - type of coding system:
    coding system for 50 parts in each sub-assembly requires more than a coding system for 50 sub-assemblies in a few final assemblies.

4.2 Code Structure Development

Upon completion of these start-up activities, OIR begins to develop the actual code. OIR splits the code structure into two sections:

- A standard section which carries the general information which applies to every item to be coded;
- and a specific section which carries the information which is specific to only one item grouping. In the case of an ECACS, the specific section of the code would capture information pertaining to one electronics family grouping (i.e. IC's, Hybrids, etc.) only. Each electronics family will have a separate specific section of the code.

The following illustration depicts OIR's method of code development.



The code is developed by beginning with a limited number of digits for the standard section. The standard section of the code will perform an initial split of the data in order to define broad family groups. The standard section of an ECACS will begin to define the electronics family groups (i.e. PWB, wired/assy, etc.) in this initial split of the data. A relatively small standard code section will be developed (4-6 digits only).

OIR then begins to develop a specific section of the code for each of the groups defined in the initial split of the data. The specific section of the code in an ECACS will capture information relevant to a particular family grouping. For example, the Integrated Circuit family specific code section will capture lead configuration, type of packaging, type by funtion, circuit performance, etc. Again, it is recommended at this level of development to keep each specific section of the code simple (4 digits).

Development of the standard and specific sections of the code begins at the end digits (OIR's standard code structure is 30 digits) and develops towards the center. The x's in the diagram represents spaces held for undefined digits.

The coding system that is developed during this phase of the project should allow for the eventual expansion of the standard and specific sections of the code. OIR's methodology facilitates that expansion requirement.

4.2.1 Implications for ECACS

OIR recommends that the above methodology be used to develop the ECACS as it insures the flexibility necessary for code expansion, during development as well as actual application.

The first cut at developing an ECACS should yield:

- a maximum of eight digits for the standard section of the code;
- and a maximum of 4 digits for each specific section of the code.

Note: Digit development includes the definition of all appropriate values for these digits.

4.3 Group Technology Analysis of Code Structure

The next step in code development is to use this initial coding system to code a random sample of items (1000) within the chosen area of application thus creating a database for the coded items (ECACS - code 1000 components). OIR then uses the MIGROUP Group Technology Analysis programs to determine the effectiveness and completeness of the code structure.

At the same time an analysis database is built that contains "raw data". This analysis database serves two purposes:

- Researches the effectiveness of the ECACS for retrieval of meaningful clusters of raw data. This simulates the effectiveness of the code as "glue" for applications databases.
- Researches whether the correct balance has been established between compressed data (or ECACS) and raw data. The ECACS should only contain the minimum amount of meaningful characteristics that enables the user to access a border set of "raw" data.

The MIGROUP System (or equivalent Group Technology analysis program) is used to:

- perform a specific analysis of the code for redundancy of information captured by the digits. Often in the initial structuring of a coding system, the same information is captured by various digits. This analysis identifies those cases. The code is more clearly defined so that redundancy is eliminated by further compression of the code structure. After all, a code structure is a compressed version of much greater amounts of raw data.

- perform an analysis to determine code utilization. This analysis checks the combination of key characteristics to determine if looking at these groupings will yield the specific information needed for a specific application. The characteristics captured by the initial code structure can be very general in nature and if examinedsingly will not yield information to point to a specific item. However, when key characteristics are grouped they should identify specific items. Eventually similiarities in design and function will be identified by grouping digits. This analysis reviews the code to insure that it can be used to satisfy application requirements.

- perform an analysis of the code structure to determine if and how the code needs expansion. This analysis will reveal if the code needs more detail in order to split the data into coherent and cohesive groups. This analysis will direct the further resolution of the code structure by identifying details about the characteristics necessary to describe these data groups.

The development of a coding system is an iterative process. The basic methodology set forth above is repeated until the code structure performs according to the requirements necessary for the application.

4.3.1 Implications for ECACS

In order to develop a Group Technology Electronics Classification and Coding System with industry-wide appeal and application, OIR recommends the following:

- The code structure should be comprehensive enough to cover all areas of electronics manufacture (all electronics family grouping - see Section 5). The code should be structured to capture information useful in design, manufacture and test.
- The code should be capable of expansion and/or change to reflect the changing technology within electronics.
- The code should be developed so as to be compatible with existing software programs to the degree possible. The ECACS can become a strong force in the integration of isolated CAD and CAM Systems.

- The MIGROUP Group Technology Analysis Programs or equivalent should be used to structure and develop the code. This will ensure the development of a code which can work with existing group technology applications software.
- The code should be as simple and compressed as possible to facilitate use. Coding should be done interactively using the terminal. Training and use of the code should be user friendly.

Section 5

ECACS: STANDARD SECTION OF CODE

Based upon survey and interview data, the following information should be captured in the Standard Section of an Electronics Classification and Coding System.

5.1 Family Categories

The following family categories were identified as primary, discrete areas (functional grouping) within electronics manufacturing.

- Packaging (panels, covers, chassis, etc.)
- Wired Assemblies (cables, harnesses, point to point)
- Printed Wiring Boards
- Discrete Components
- Integrated Circuits
- Hybrid Microelectronics
- Wire Wound Magnetic Components
- Electronic Assemblies
- Electro-Magnetic Assemblies
- Electro-Optics
- Hardware

Definitions for these families can be found in the Glossary (Appendix A).

5.2 General Characteristics

An ECACS should capture the following general characteristics in the Standard Section of the code. These characteristics apply to all components to be coded. This information is necessary for design, manufacture and test engineering and has been identified as of primary importance by all respondents. The characteristics are listed in order of importance.

1. Function
2. Dimensional Parameters
3. Electronic Parameters/Specifications
4. Tolerances
5. Test Criteria
6. Annual Quantity

5.2.1 Function

This is the most important characteristic to be captured in the code. Functional description of the component will quickly split the database into manageable sections

for quick search and retrieval routines. This description will reflect the family groups delineated above. OIR estimates it will take 1-2 digits for the functional description.

Additionally components to be coded will need functional descriptions particular to family grouping. These characteristics will be captured in the specific section of the code.

5.2.2 The Remaining Characteristics

- Dimensional Parameters (dimensions)
- Electronic Parameters/Specifications (wattage, voltage, impedence)
- Tolerances
- Test Criteria
- Annual Quantity

are self explanatory and were universally identified by electronics manufacturers as crucial information.

These characteristics are necessary for design, manufacturing applications (i.e. automated insertion vs manual) and testing.

5.3 Additional Concerns

As a result of OIR's on-site interviews with electronics professionals some additional topics of concern were identified. These concerns were raised at each company visited and should be explored fully during the development of an ECACS.

5.3.1 Obsolescence

The electronics industry is driven by a constantly changing technology. The nature of technological advances often is reflected in component, sub-assembly and process obsolescence. Most electronics engineers were concerned with capturing data about obsolescence and being able to quickly retrieve this data.

Additionally, obsolescence presents real concerns for components inventory control, product reliability and maintenance and carrying costs of inventory and finished goods.

At this time, OIR believes the area of obsolescence needs further exploration in order to decide the best way to handle the problem. Two solutions are readily apparent:

- develop a code structure which would capture this characteristic in the standard section of code.
- develop a separate data file for obsolescence which could be accessed by the code number.

Obsolescence data would be a separate file.

The question of obsolescence must be investigated in greater detail prior to making such a decision.

5.3.2 Reliability

During the interview sessions, a substantial number of electronics professionals identified a need to code reliability data. Component reliability affects end product quality and performance and substantially impacts the rigor of the testing procedures a company establishes as standards.

Electronics industry personnel would like to capture the following reliability data:

- history of component performance
- testing standards
- vendor reliability

Reliability data may be captured in some other digits in the electronics code structure through review of performance parameters, tolerances and testing procedures. This is a good example of the need to perform a Group Technology analysis of the code structure during development. The analysis will provide information on whether reliability information is captured, where it is captured and if the code needs more detail for this characteristic.

5.4 Recommendations

In order to develop the standard section fo an ECACS, OIR recommends:

- capturing information about six general characteristics:
  - Function,
  - Dimensional Parameter,
  - Electronics Parameters/Specifications,
  - Tolerances,
  - Test Criteria,
  - Annual Quantity.
- creating a code structure of a maximum of eight digits to describe these characteristics.

- performing a Group Technology analysis of the code structure during development using the MIGROUP System or equivalent.
- further investigations into applications, existing software programs and issues of reliability and obsolescence.

Section 6

ECACS: SPECIFIC SECTION OF THE CODE

The specific section of an ECACS will be developed for each of the main functional categories defined in the standard section of the code. Characteristics will be captured which are category specific.

The following sections of this report outline the information to be captured by an ECACS for each main functional category. This outline was developed as a result of the survey/interview data analysis and review by the project team.

The primary and secondary characteristics must be captured for both design and manufacturing applications.

The delineation of types of testing required are of primary interest for manufacturing applications.

6.1 Functional Category: Packaging

- Primary Characteristics
  - Shape
  - Shape Elements (holes, slots, etc.)
  - Material
  - Surface Treatments
- Secondary Characteristics
  - Position of Shape Elements
  - Quantity of Shape Elements
  - Major Machining Operations
  - Major Fabrication Operations
- Types of Testing
  - Dimensional Analysis
  - Metallurgical/Material Evaluation
  - Stress/Strength Analysis
  - Color, Texture (Aesthetic Evaluation)
  - Static Dissipation
  - EMI Shielding

6.2 Functional Category: Wired Assemblies

- Primary Characteristics
  - Number of Conductors
  - Size of Conductors
  - Type of End Terminations
  - Type of Insulation
  - Number of Branches
  - Type (e.g. flat, ribbon, coax)

- Secondary Characteristics
  - Type of Base Material
  - Type of Surface Plating
  - Shielding
  - End Product Destination
  - Machine Operations
  - Manual Operations
  - Coating/Encapsulation
  - Joining Processes

- Types of Testing
  - Dimensional
  - Opens/Shorts Testing
  - Impedence Testing
  - Hi-Pot Testing

6.3 Functional Category: Printed Wiring Boards (PWB)

- Primary Characteristics
  - Type of Base Material
  - Type of Conductive Material
  - Number of Layers
  - Types of Layers

- Secondary Characteristics
  - Shape
  - Conductor Electrical Characteristics
  - Environment Requirements
  - Printed Circuitry Processes
  - Hole Information (size, quantity, etc.)
  - Plating Information
  - Masking and Coating

- Types of Testing
  - Bond Evaluation (layer)
  - Bond Evaluation (conductor)
  - Metallurgical Evaluation of Plating Quality
  - Dimensional
  - Electrical Testing
  - Micro Sectioning

6.4 Functional Category: Discrete Component

- Primary Characteristics
  - Type of Package
  - Lead Configuration
  - Component Type
- Secondary Characteristics
  - Environmental Specifications
  - Adjustability
- Types of Testing
  - Parametric
  - Functional
  - Dimensional
  - Environmental

6.5 Functional Category: Integrated Circuits

- Primary Characteristics
  - Type of Packaging
  - Lead Arrangements
  - Type by Function
- Secondary Characteristics
  - Scale of Integration (LSI,SSI, etc.)
  - Circuit Performance
  - Number of Leads
  - Environmental Requirements
- Types of Testing
  - Parametric Testing
  - Functional Testing
  - Pattern Sensitivity Testing
  - Burn-In
  - Dynamic

6.6 Functional Category: Hybrid Micro Electronics

- Primary Characteristics
  - Type of Packaging
  - Lead Arrangement
- Secondary Characteristics
  - Number of Leads
  - Internal Circuit Types
  - Number of Internal Elements
  - Lead Related Dimensions
  - Environmental Specifications
- Types of Testing
  - Physical Characteristics
  - Parametrics
  - Functional Testing
  - Static Testing

6.7 Functional Category: Wire Wound Magnetic Components

- Primary Characteristics
  - Shape
  - Function
  - Winding Wire Data
  - Lamination Data
  - Type of Shielding/Sleeving
- Secondary Characteristics
  - Adjustability
  - External Lead Data
  - Machine Processes
  - Major Fabrications Operations
  - Coating/Encapsulation
- Types of Testing
  - Induction
  - Impedence
  - Coupling
  - Load Effects
  - Excitation Current
  - Permeability
  - Voltage/Current/Frequency Data
  - Hi-Pot
  - Dimensions
  - Resistance

6.8 Functional Category: Electronic Assemblies (EA)

- Primary Characteristics
  - Shape
  - Function
  - Type of Composite Components
  - Major Fabrication Operations
- Secondary Characteristics
  - Component Spacing Information
  - Special Packaging
  - Environmental Requirements
  - Coat/Encapsulation
- Types of Testing
  - Functional Testing
  - In Circuit Testing
  - Parametrics
  - Dynamic Testing
  - In-Product Substitution
  - Environmental Chamber

6.9 Functional Category: Electro-Mechanical Assemblies

- Primary Characteristics
  - Shape
  - Function/s
  - Type of Electronic Components
  - Quantity of Electronic Components
  - Major Assembly Operations
- Secondary Characteristics
  - Type of Mechanical Components
  - Quantity of Mechanical Components
  - Type of Electro-Optical Components
  - Quantity of Electro-Optical Components
  - Major Machining Operations
  - Coating/Encapsulation
  - Joining Processes
- Types of Testing
  - Functional Testing
  - Parametrics

6.10 Functional Category: Electro-Optics

- Primary Characteristics
  - Type of Packaging
  - Lead Configuration
  - Coupling Techniques
  - Performance/Optical Parameter

- Secondary Characteristics
  - All characteristics offered for review were considered of primary importance in Electro-Optics.

- Types of Testing
  - Dimensional
  - Signal Transmission
  - Parametrics

6.11 Functional Category: Hardware

- Primary Characteristics
  - Type of Hardware
  - Shape
  - Base Material
  - Surface Treatment
  - Custom or Standard

- Secondary Characteristics
  - Mounting Technique
  - Machining Operations
  - Fabrication Operations

- Types of Testing
  - Dimensional
  - Metalurgical/Material
  - Aesthetics
  - Plating Analysis

APPENDIX A

GLOSSARY

1. PACKAGING	Packaging encompasses the elements (components/assemblies) which are required to create a "black box" which will contain electronic components, (i.e. panels, covers, chassis, etc.).
2. WIRED ASSEMBLIES	An assembly consisting of multiconductor grouping of wires, point to point wiring, etched/additive wire assemblies, and/or flexible printed cables.
3. PRINTED WIRING BOARDS (PWB)	A completely processed conductor pattern(s) all formed on a common base.
4. DISCRETE COMPONENT	Any passive or active electronic component, other than integrated circuits and hybrid microelectronics. (e.g. capacitors, resistors, switches, diodes, transistors, etc.).
5. INTEGRATED CIRCUITS	A complex electronic semiconductor circuit, packaged as an individual component.
6. HYBRID MICRO ELECTRONICS	A packaging technique that interconnects passive and/or semiconductor devices within a single package.
7. WIRE WOUND MAGNETIC COMPONENTS	Any device which acts or reacts due to the electromagnetic field induced by current flowing through wire windings. This shall include transformers, actuators, rotary components and coils.
8. ELECTRONIC ASSEMBLIES (EA)	A final assembly or second level assembly which includes a printed circuit board. These shall contain electronic, mechanical, and/or optical components.

9. ELECTRO-MECHANICAL ASSEMBLIES	A final or secondary level assembly which performs an electronic function, but is manufactured using basically mechanical operations such as staking, riviting, screws, bolting and hard mounting of electronic or optical components.
10. ELECTRO-OPTICS	Electronic device or assembly which integrates electrical and optical signal carrying medium.
11. HARDWARE	Various electro-mechanical and mechanical components utilized in the different categories of assemblies (e.g. knobs, dials, connectors, etc.).

END

11-86

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