PARTS APPLICATION HANDBOOK STUDY

NASA CONTRACT NAS8-32662

FINAL REPORT

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GENERAL ELECTRIC

PREFACE

The work described in this report was performed by the Components Engineering Unit of General Electric Aerospace Electronics Systems Department during the period between October, 1977 to February, 1978. The work was performed for the National Aeronautics and Space Administration (NASA), George C. Marshall Space Flight Center under contract no. NAS8-32662.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDICES

SECTION I - INTRODUCTION

1.0 OBJECTIVES

The objectives of this contract were to determine and define the requirements for a NASA application handbook for standard electronic parts similar to those listed in MIL-STD-975. This study concentrated on identifying in detail the type of information that designers and parts engineers need and expect in a parts application handbook for the effective application of standard parts on NASA projects.

2.0 BACKGROUND

In the past, the major NASA projects would generate their own documentation covering the selection and application of parts. Some of these examples are: Goddard Application Notes, Boeing Handbook of EEE, Parts Application Data funded by the LBJ Space Center, and the LVP Approved Parts List & Detailed Parts Requirement by General Dynamics funded by Lewis Research Center. In addition to this list, other government agencies have worked on or are working on these types of handbooks (e.g., proposed MIL-STD-1547).

Of course, if a central controlled application standardization handbook could be agreed upon by NASA lead centers and contractors, NASA would reap the benefits of a central controlled application/ standardization handbook. Those benefits would be cost saving due to the standardization of parts and the handbook itself.

Improvement in circuit performance and reliability would also be felt by NASA since the Design Engineers would have readily available to them the type of information needed to make performance/reliability design trade-offs early in their design.

3.0 APPROACH

The approach taken on this study was to visit the appropriate NASA centers and typical NASA contractors to discuss with designated Design and Parts Engineers their need for parts application information. Table I-1 lists the facilities visited and the dates of the visits.

Prior to these visitations, a questionnaire was sent to each of the facilities. These questions then were reviewed in detail with those in attendance at each visitation. It should be noted that at these meetings there was a lack of Design Engineers in attendance. A trip report was written on each visitation identifying those in attendance and a summary of their answers to the questionnaire. These trip reports are found in Appendix "A" of this report and a consensus summary of the answers to the questions can be found in Appendix "B". It should be remembered that this is a consensus summary and that the answers represent just that. For example, the answers given to the question "Would a separate document, with catalog type of data presented in it increase Design Engineering usage of MIL-STD-975" ranged from 1) Yes! Without this type of information, do not even issue the handbook to 2) No! The Design Engineers will still go to their own source of information (vendor catalogs). However, the consensus of those questioned was: Yes, it would help encourage use of standard parts and could be the most used part of the manual.

These face to face meetings, along with GE/AESD's vast experience in standardization parts program, were used as the primary source in determining and defining the requirement of the proposed NASA Application/Standardization Handbook.

VISITATIONS

FACILITY	DATE
AMES RESEARCH CENTER	12/01/77
BENDIX GUIDANCE SYSTEMS	11/02/77
BOEING AEROSPACE CORP.	12/12/77
GENERAL DYNAMICS	11/30/77
GE SPACE CENTER, VALLEY FORGE	11/03/77
GODDARD SPACE FLIGHT CENTER	11/10/77
JET PROPULSION LABORATORY	11/29/77
LANGLEY RESEARCH CENTER	11/11/77
LBJ SPACE CENTER	10/31/77
LEWIS RESEARCH CENTER	11/02/77
LOCKHEED MISSILES & SPACE CORP.	12/01/77
MARSHALL SPACE FLIGHT CENTER	10/18/77
MARTIN MARIETTA CO.	12/13/77
NASA HEADQUARTERS, WASHINGTON, DC	10/18/77
RCA, ASTRO ELECTRONICS DIVISION	11/02/77
SAMSO AEROSPACE CORP.	12/05/77
TELEDYNE	11/29/77
U.S. NAVY PRINTING SERVICE	11/10/77

TABLE I - 1

4.0 SUMMARY

This summary subsection is broken down into two categories 4.1 and 4.2. 4.1 addresses the Statement of Work tasks A through H, and 4.2 is a summary of the conclusion that GE/AESD arrived at on completion of this contract.

4.1 STATEMENT OF WORK TASKS A THROUGH H

A. Determine the optimum parts application data coverage needed by NASA Hardware Designer.

- Data catalog type of information is the Hardware Designer's foremost need. This information should include the form, fit, and function of the specific Standard Parts. In addition, minimum/maximum characterization charts of parameters performance on specific devices should also be a major part of the Data Catalog information (e.g. H_{FE} vs. I_C, output voltage of a regulator vs. temp., I_{IB} vs. temp. for Op-Amps, etc.).

- Reliability derating information is required by the designer so that he knows how these restrictions will affect his design using this specific device.

- Application TIPs (problems) of each specific device on the Standard Parts List (MIL-STD-975) should be made known to the designer. This information would cover subjects such as, Ringing Op-Amps, to Secondary Breakdown Problems of Power Transistors.

- The Hardware Designer should be informed through a handbook, the whys and hows of a Standard Parts Program. This could be used by the Parts/Reliability Engineer as a constant example to the Design Engineer on the virtues of a Standard Parts Program.

- The Standard Parts List used by NASA should be up-dated frequently. Once a parts list becomes obsolete, the designer will stop using it and will very unlikely ever go back to it.

B. Perform the necessary tasks to identify and specify all meaningful parts data in one place versus providing bare minimum data with references to obtain the remaining data.

- Only the following subjects have been identifed as requiring bare minimum data with reference to other publication. All other subjects shall have the meaningful part data in the handbook.

    - Storage Life Consideration
    - Radiation Consideration

C. Define the expected experience level of the projected users of the Parts Application/Standardization Handbook.

- The expected experience level of the projected user will vary depending on which category, (general technical information or catalog data information) one is addressing.

- For the general technical volumes the material in these would be useful for a range of users from the new engineer, small contractors, reliability engineers, to the parts specialist and experienced designer. However, it should be noted that the experienced designer would use these volumes at a minimum. The Catalog Data Information volume then would be used exclusively by all hardware designers. Therefore, the format of this volume should be optimum with the hardware designer in mind.

D. Define the data bank information necessary to support preparation and update the Parts Application Handbook, and estimate the cost of maintaining the data bank.

- Existing parts manual
- Contractor experience
- Industry experience
- GIDEP
- Existing NASA publications (i.e., Application TIPS)
- Cost of maintenance (25 - 50K). This estimate is based on the assumption that this information is being maintained by someone that is already staffed to maintain existing handbook.

E. Define the optimum publication, format, release, and update mechanism for dissemination of the Parts Application Handbook.

- Binding of the handbook should be a combination of loose leaf and perfect binding, e.g.,

Transistors and Diodes	Perfect Binding
Microcircuits	Perfect Binding
General & Digital	Perfect Binding
Linear, Hybrid, A/D's & D/A's	Perfect Binding
Memories	Perfect Binding
Microprocessors	Perfect Binding
Capacitors	Perfect Binding
Resistors	Perfect Binding
Data Catalog Volume	Loose Leaf
Volume IV	Loose Leaf

- The relationship between the handbook and the Catalog Data Volume should be such that up-dating is primarily done to the Catalog Volume.

- Initially, the handbook should only cover the five commodities in MIL-STD-975. However, these commodities should be more fully covered, (e.g, Memories should be included under Microcircuits.).

- Among the users interviewed, up-dating is key to the success of the handbook. NASA should be prepared to up-date sections of the handbook/catalog annually.

- Handbook should be released through the Military System but be expedited.

- Handbook and catalog would be four volumes:

  Volume I - Main General Section, Capacitors & Resistors

  Volume II - Transistors, Diodes, Microcircuits

  Volume III - Relays, Switches, Magnetics, Connectors, Circuit Interrupt Devices, Motors, Filters, Crystals, Delay Lines, Microwave Devices

  Volume IV - Catalog Data

- Format should be Dewey Decimal System with each commodity section and subsection breakdown the same.

F. Predict or forecast the quantity of changes that will occur as a result of technology changes over the next ten years.

- Frequency of revisions depends on commodity and which volume

Volume I & II

Capacitors	- Twice in the first three years, then every three years after
Resistors	- Every three years
Transistors	- Twice in the first three years, then every three years after
Diodes	- Every three years
Microcircuits	- Yearly basis for the next ten years

- Volume III

Relays Switches Magnetics Connectors Circuit Interrupt Devices Motors Filters Crystals Delay Lines Microwave Devices	One year after initial release, then every three years after

- Volume IV

Capacitors & Resistors	- Same as above
Transistors & Diodes	- Yearly
Microcircuits	- Semi-annually

G. Scope - The usage and distribution requirements of the Parts Application Handbook

- The Catalog Data Volume will be used exclusively by the Hardware Designer. Therefore, this volume must be distributed down to the Hardware Designer at the NASA lead centers at the NASA's contractor's facilities.

- The General Technical Volumes should be generated with all wide range of users in mind from the new designer to the experienced designer. The new designer will continually reference this volume where the experienced designer will reference them only on the commodities he is not intimate with. The distribution of these volumes would be throughout the Parts, Reliability, and Engineering functions.

- Distribution through the MIL-SPEC System should be made available. However, the lead centers and key contractors should get an advance copy along with a presentation explaining the objectives of the handbook.

H. Define method of publication, e.g., hard copy book style, throw-away catalog style, loose leaf notebook with revision pages, microfiche, computer storage with CRT terminals.

- The contractor shall write and edit a four volume part standardization/application handbook on electronic parts. This handbook as delivered to NASA, should be of high quality similar to that described in Section 6 of DOD Document 4120.3-M so as to be ready for Brinting by the government agencies chosen by NASA. Each volume should fit into a three inch ring binder with room for expansion of one inch. Printing can be done on both sides of the paper used.

- The space of the margins and the layout of each sheet should be such that the handbook can be used and be legible if bound in a three ring notebook type of binder or stapled together.

4.2 SUMMARY OF GE/AESD's CONCLUSIONS

Table I-2 shows GE/AESD's conclusions at the completion of this contract. The over-whelming conclusion is that the majority of the lead centers and contractors see a need for a handbook that covers both data catalog type of information for the designer and general technical information for all functions.

GE/AESD'S CONCLUSION

- Binding of the handbook should be a combination of loose leaf and perfect binding

e.g.:	Transistors & Diodes	Perfect Binding
	Microcircuits	Perfect Binding
	General & Digital	Perfect Binding
	Linear, Hybrid, A/D's & D/A's	Perfect Binding
	Memories	Perfect Binding
	Microprocessors	Perfect Binding
	Capacitor	Perfect Binding
	Resistors	Perfect Binding
	Data Catalog Volume	Loose Leaf
	Volume III	Loose Leaf

- The relationship between the handbook and the Catalog Data Volume should be such that up-dating is primarily done to the catalog volume

- Initially, the handbook should only cover the five commodities in MIL-STD-975. However, these commodities should be more fully covered. (e.g, Memories should be included under Microcircuits.)

- Among the users interviewed, up-dating is key to the success of the Handbook. NASA should be prepared to up-date sections of the Handbook/Catalog annually.

- Handbook should be released through the Military System but be expedited.

- Handbook and catalog would be four volumes:

  Volume I - Main General Section, Capacitors and Resistors

  Volume II - Transistors, Diodes, Microcircuits

  Volume III - Relays, Switches, Magnetics, Connectors, Circuit Interrupt Devices, Motors, Filters, Crystals, Delay Lines, Microwave Devices

  Volume IV - Catalog Data

- Handbook should be designed for use as a guide and should not be a mandatory requirement because of the problems with auditing.

TABLE I - 2

GE/AESD's CONCLUSION

- Radiation and storage life information should be covered in a general way with reference to detailed sources.
- There is a need for a complete separate radiation document.
- MIL-STD-975 is not complete enough. Should have more specific types within a commodity. Also, more commodities should be covered.
- MIL-STD-975 requires re-formating and up-grading.
- Main usage of the Handbook would be by the Component Engineer/ Reliability followed closely by the Design Engineer. However, it will be the main responsibility of Components Engineering/Reliability to assure Design is compliant to the handbook.
- The Catalog Data volume format should be optimum for the Hardware Designer.

CATALOG DATA VOLUME/CONCLUSIONS

- Catalog data formating of military parts would be beneficial and increase the Design Engineering usage of MIL devices and standardization.
- Catalog document should be broken down into families and then listed numerically - TTL-5400, 5401, etc.
- Individual data sheets should have design and reliability data only.
- Data sheet should include key parameters worst case over the full MIL temperature range, package outline, reliability derating and reference to the Military Specifications covering that device. In addition, characterization charts of parameters performance on the specific devices should be included (ie., H_{FE} vs. temp., H_{FE} vs. I_C, regulator output voltage vs. temp. Op-Amps I_{IB} vs. temp., etc.)

TABLE I-2

SECTION II - GENERAL TECHNICAL VOLUME

1.0 INTRODUCTION AND OBJECTIVES

The study program revealed that there is a need for a general technical handbook. This should contain design, application, and reliability information of a general nature and not related to a specific device.

Such a handbook should serve a primary purpose of improving the utilization of NASA standard parts on NASA projects. This volume would also assist all functions (Design Engineers, Part Engineers, Reliability Engineers, etc.) to better understand the NASA part selection and application philosophy.

The information contained in this handbook should be very broad, so that a complete understanding of proper design and application of various components is available in a single source. This should reduce the effort required to search out information necessary for proper part selection and application of component parts.

To gain maximum usage, the study program revealed, that this volume should be aimed at a broad spectrum of engineers. There was a feeling at many locations (first expressed by a Design Engineer at Goddard) that this would be a convenient reference for new Design Engineers, who have little practical parts experience. This would allow them to benefit from the years of experience accumulated by others. Several other respondents felt that there are many small contractors who do not have part specialists who would benefit from a single source of information that explained the Standard Parts Program, Parts Application and selection criteria and certain other reliability information.

At the same time, the study revealed that this handbook would be an important reference for experienced Design Engineers, Reliability Engineers, Parts Engineers, etc. One large company Parts Engineer felt that this handbook could also benefit large contractors in areas not covered by MIL-STD-975 where there is limited day to day experience (indicators, etc.). This handbook should serve as a standardizaton tool for these contractors to assure that similar application and derating criteria is used.

The study revealed that this volume should cover information on devices not included in the present revision of MIL-STD-975. Inclusion of sections on other commodities would increase the acceptance and usage of the handbook, and therefore indirectly increase its usage for commodities that are included in MIL-STD-975.

However, if priorities are necessary, the commodities already in MIL-STD-975 should be given the first attention. Although this volume should serve as a technical companion to a catalog volume of NASA standard parts, it would be very beneficial to include information on commodities for which no NASA standard parts have been established.

The study also revealed that for this handbook to be effective it must enjoy sufficient updating to remain current and to include the latest trends and technologies. The frequency of updating would be dependant on the commodity as follows:

Capacitors	- twice in the first three years then every three years after
Resistors	- every three years
Transistors	- twice in the first three years then every three years after
Diodes	- every three years
Microcircuits	- yearly basis for the next ten years

2.0 ORGANIZATION

These volumes of the handbook should be organized so that the first section is a main general section. This should include information on NASA parts philosophy and other application, reliability, design, etc. information that is common to all parts. The attached Table II-1 gives an outline of the type of information that should be included in this section. A sample of this type of information is the Impact of Non-Standard Parts shown in Appendix C.

Each commodity should have its own unique section that contains information that is peculiar to that commodity. Each commodity section should be subdivided in a manner similar to that shown in Table II-2.

The Commodity General Section would contain information common to the different types of devices within that commodity. An outline of the kind of information to be included in this subsection is included in Table II-3. Suggested Indexes for each commodity in MIL-STD-975 are shown in Appendix D. Examples of information that should be included in the Commodity General Subsections are shown in Appendix E.

Each device type within a commodity has special characteristics and considerations that should be covered separately. These sections should also include device types that should not be used by NASA, with details on why these parts are not satisfactory. Table II-4 gives a suggested outline of the material that should be included in these specific subsections. Examples of the type of material included in these specific commodity subsections is shown in Appendix F.

BREAKDOWN OF THE SPECIFIC COMMODITIES

CAPACITORS	TRANSISTORS	DIODES	RESISTORS	MICROCIRCUITS
General	General	General	General	General
Ceramic-Including Chips	Switching	Microwave	Fixed Composition	Digital
Mica & Glass	Power	Rectifier & Power	Fixed Film	Linear
Paper, Plastic, & Metalized Film	SCR	Switching	Fixed Wire-Wound	Hybrid
Tantalum Foil	FET	Voltage Reference	Variable Composition	Memories
Tantalum Solid-Including Chips	Unijunction	Voltage Regulator	Variable Film	D/A's A/D's
Tantalum Wet Slug	Microwave	Voltage Variable Capacitors	Variable Wire-Wound	Microprocessors
Aluminum			Thermal	
Variable				

TABLE II-1

MAIN GENERAL SECTION

- General Parts Program
  - Standard Parts Selection
    - Advantages -
      - Cost
      - Reliability
      - Documentation
      - Delivery
      - Availability
      - Available Test Data
      - Standard Screening
      - Inspection Procedures
      - Quantity Procurements
  - Standard Parts Lists
    - Equipment Standardization
    - Part Selecting Made Easy
    - Qualified Sources
  - Reliability Prediction
    - HBK-217
    - Derating
  - Failure Analysis
    - Procedures
    - Part Design
    - Part Workmanship
    - Part Application
    - Part Handling
  - Corrective Action
    - Eliminate or Reduce Future Failure
    - Improved Reliability
    - Necessary to Meet MTBF Requirements
  - Part Evaluation (Non-Standard Parts)
    - Early detection of problems
  - Corrective Action
    - Assurance of Spec Conformance
    - Source Selection
  - Source Evaluation
    - Survey Facility
    - Search Available Data

TABLE II-2

- Distributor Procurement
  - Disadvantages -
    - Lot Traceability
    - Corrective Action Problems
  - Advantages
    - Availability

- Non-Standard Part Usage
  - Specification Costs
    - Engineering Costs
    - Drawing Preparation Costs
    - Drawing Distribution
    - Drawing Revisions
  - Inspection Costs
    - New Procedures, Programs
    - Additional Lots
  - Procurement Costs
    - Smaller Quantities
    - Separate Purchase Orders
    - Lack of Purchase Agreement
      - Reduce Quantity of Standard Part
  - Non-Standard Part Submitted
    - Costly
    - Time Consuming
  - Schedule
    - Delivery
    - Availability
    - Availability Life Cycle
  - Logistics Costs
    - Field Support
    - Space Part Costs
  - Evaluation Costs
    - Testing
    - Report
    - Corrective Actions
  - Source Limitation
    - Often Single Source
    - Non-Competitive
    - Delivery Problems
    - Availability Problems
  - Alternate Source Costs
    - Investigation
    - Drawing Changes
    - Source Evaluation
    - Part Evaluation
  - Reliability
    - Limited Part Experience
    - More Problems
    - Higher Failure Rate

TABLE II-2

Introduction
  Objective
    Standardization
    Reliability
    Reduce Part Selection Effort
    New Engineers Experience
    Small Contractor Experience

  Limitation
    Restricted Commodities

  Organization
    Description

Index
  Contents

References
  General Specifications

TABLE II-2

COMMODITY GENERAL SECTION

- Introduction
  - Different Types
  - Basic Usage

- General Definitions
  - Definitions
  - Abbreviations
  - Symbols

- General Construction (where applicable)
  - Cross Section

- General Device Characteristics
  - Basic Processes
  - Package Designs
  - Contact Arrangements
  - Seals
  - Junction Protection
  - Examples

- General Parameter Information
  - Selection
    - Electrical
    - Mechanical
    - Environmental
    - Reliability
  - Electrical Considerations
    - Voltage
    - Current
    - Power
    - Frequency
    - Etc.
  - Mechanical Considerations
    - Packaging
    - Mounting
    - Connectors
  - Environmental Considerations
    - Temperature
    - Humidity
    - Vibration
    - Shock
    - Acceleration
    - Barometric Pressure
    - Radiation
  - Special Considerations (aging, life, etc.)

TABLE II-3

- General Guides and Charts
  - Family Comparisons
  - Special Comparisons
- General Reliability Considerations
  - Failure Modes
  - Failure Mechanism
  - Failure Analysis
  - Corrective Action
  - Application Considerations
  - DeRating Philosophy
    - Voltage
    - Current
    - Power
    - Etc.
  - Reliability Prediction
    - Screening
      - Burn-In
      - DPA
    - Handling
    - Radiation Consideration
    - Storage Life Consideration

TABLE II-3

SPECIFIC COMMODITY SECTION

Introduction
- Classes
- Usage
- Definitions

Usual Applications
- Class I (example, General Purpose)
- Class II (example, temperature compensated)

Physical Construction
- Cross Section Detail
- Description

Electrical Characteristics
- Voltage
- Current
- Power
- Frequency

Environmental Considerations

Reliability Considerations
- Failure Modes
- Failure Mechanism
- Screening
- Reliability Derating
- Special Considerations

TABLE II-4

3.0 SUMMARY

The survey concluded that this General Component Application Volume would be an important part of the NASA parts program. By providing the information described earlier, it would make it more obvious to the designer why the NASA Standard parts should be selected and would explain the pitfalls of using non-standard parts. This volume would help assure uniform part application and derating procedures between different NASA contractors. In the same vein, since this would provide a single source for part experience on all types of components, it should reduce the volume of part problems resulting from inexperience. These volumes would provide the technical foundation if a volume giving a catalog portrayal of NASA Standard Parts is added. While a catalog of NASA Standard Parts would be aimed at Design Engineers, the general volumes would be of value to all engineers and specialists.

SECTION III - DATA CATALOG VOLUME

1.0 INTRODUCTION & OBJECTIVES

The subject of providing a data catalog volume to the designers was first suggested by NASA headquarters during our visitation. It was felt that the designers shy away from using the Military Specifications due to the fact that they are too clumsy to be used as a readily available design reference. Therefore, most designers go directly to a vendor's catalog for his basic design information. This source of information is not an ideal source when designing high-rel hardware, since this information does not even cover all the necessary parameter limits over the military temperature range and in many cases just gives typical values for key design parameters.

Therefore, if a data catalog volume, covering the devices listed in MIL-STD-975, was issued by NASA with the salient features of a vendor's catalog data sheet, the Design Engineer would then have a readily, convenient design source to use that represents the military device available to him. The consensus of those visited during this contract indicated that they believed a data catalog volume would help encourage use of standard parts on NASA projects and would be the most used part of the handbook by Design Engineering.

It is apparent then that this volume format and information obtained in it should be optimized for the designer's requirements.

The information to be presented in this volume should be obtained from:

1) The present Military Device Specifications
2) Completed NASA Parts Study Program
3) Vendor's Data
4) NASA TIPs.

5) GIDEP Reports

6) Other government sponsored parts study program similar to GE/AESD's Electrical Specification of Linear Integrated Circuits - Contract # F30602-74-C-0127 for RADC.

Of course, the first priority of this volume is to cover the commodities and part types that are listed in MIL-STD-975. After these are completed and evaluated for acceptance, then other commodities and parts types within the original five commodities should be added.

2.0 ORGANIZATION

This volume should be organized so that the first section explains the objectives and limitation of this volume. The sections following the introduction section should have only appropriate application design information obtained in them. The format should be optimized with the hardware designer in mind.

Each commodity section should be broken down into families of devices and listed numerically. A few examples are:

<u>Microcircuits</u>
- TTL - 5400, 5401, 5410, etc.
- CMOS - 4000A, 4001A, 4002A, 4006A, etc.

<u>Transistors</u>
- Low Power NPN - JANTXV2N2219A, 2N2222A, etc.
- Low Power PNP - JANTXV2N2905A, 2N2907A, etc.

For each device listed in MIL-STD-975, there should be a data sheet written with the following minimal information.

- Electrical performance characteristics of key design parameters over the military temperature range. This information would be a summary of that specified on the military specification covering this device.

- Reliability derating information so that the designers would know early in his design how these restrictions would affect his design using this specific device.

- Application problems associated with a specific device should be noted on that data sheet covering that device. The GIDEP reports along with NASA TIPs reports would be the main source for this type of information. This information would cover such subjects as, Ring Op-Amps, to Secondary Breakdown Problems of Power Transistors.

- Minimum/maximum characterization curves on key parameters should also be included in this volume. These curves would be similar to those found in vendor's catalogs (see Appendix G) however, in most cases they would have to be a minimum/maximum envelope type of curve in order to reflect all the different process steps and geometry that the various suppliers employ. Appendix H has some examples of those type of charts that would be part of each data sheet. These examples were lifted out of GE/AESD's final report on Electrical Specification of Linear Integrated Circuit on Contract # F30602-74-C-0127 for RADC.

The data used to generate these charts should be obtained from data collected on NASA Parts Study Program and other government sponsored parts study programs.

- General description of the package configuration should also be included.

Appendix G is a simulated example of what a data sheet might look like in this volume.

3.0 SUMMARY

One of the major conclusions of this survey was that a data catalog volume on the parts listed in MIL-STD-975 was needed and that its implementation would encourage standardization by the Hardware Designers. This volume should include only information that is optimized for the designer and its format should be similar to that found in supplier's catalogs.

This volume of the handbook should have first priority since it will play a major role in standardization on NASA projects.

APPENDIX "A"

TRIP REPORTS ON VISITATIONS

GENERAL ELECTRIC

AEROSPACE ELECTRONIC SYSTEMS

TRAVELER:	PLACE VISITED:	DATE.
D. M. Cole	Ames Research Center, Moffet Field, CA	12/5/77
ACCOMPANIED BY:	COPIES OF THIS REPORT TO:	
-	J. Donnelly N. Scianna T. Pover G. Snider	
OBJECT OF VISIT:		DATE OF VISIT:
Discuss requirements for NASA Component Application Manual		12/1/77

TRIP REPORT

Persons Contacted:

Fred DeMuth - Chief R&QA Office
Stu Johnson - Component Engineering Leader

A contract (NAS8-32662) to investigate the need for and the content of a proposed Component Application Manual has been awarded to General Electric. As part of this study contract, several NASA installations and NASA contractors are being visited. This visit to NASA- Ames is one of those visits.

It was Ames belief that a manual would be beneficial to NASA, however, up-dating of the manual is key to it being continuously accepted. Also, the manual should cover more part types within the commodities presently covered by MIL-STD-975, (e.g., memories under microcircuits).

During this visit, a list of questions aimed at defining the requirement for this manual were discussed. This list of questions had been mailed to the respondent a few weeks before this visit. Attached is a summary of these questions and the response from this organization.

ORIGINAL PAGE IS
OF POOR QUALITY

AES 255 (6-70)

1. <u>What sources presently do you use for your required design and reliability information?</u>

   <u>ANS:</u> Presently use Ames -PPL, MIL-STD-1470, MIL-HNDBK-217B, MIL-STD-198 & 199, MIL-STD-975.

2. <u>Do you see this manual primarily as a design manual or a standardization manual?</u>

   <u>ANS:</u> This should be primarily a design manual.

3. <u>How should the manual be bound? Loose leaf, perfect binding, etc.?</u>

   <u>ANS:</u> Loose leaf for ease of up-dating. Up-date services is critical to the acceptance of this manual.

4. <u>Should the sections be assigned priority and each released as they are completed; or should the manual be released when totally completed?</u>

   <u>ANS:</u> Release when totally completed.

5. <u>How should this document be released? e.g., through the Mil-Standard System, part of each RFP, etc.</u>

   <u>ANS:</u> Through the Military Standard System

6. <u>Should the manual include both the military and equivalent vendor designation on the standard parts list?</u>

   <u>ANS:</u> Yes, absolutely.

7. <u>Should a pictorial cross section of each part type within a commodity be included?</u>

   <u>ANS:</u> Yes! Have found it very useful in the past.

8. <u>Should a typical process flow chart for each commodity be part of the manual?</u>

   <u>ANS:</u> No! There are too many variations between the different vendor's process flows; and in addition, typical flow charts are too general to be of any assistance to Component Engineering or Reliability.

9. <u>Should radiation be part of the manual? If so, rate the importance of the different radiation effects to the system design</u>.

   <u>ANS:</u> Only general information should be included with reference to detailed reports where available.

10. Should reliability stress limits (derating criteria) be part of the standard parts list?

ANS: Derating should be in both the application manual and the parts list. Derating criteria should be in both this manual and the part list (MIL-STD-975). However, the manual should also give the rational on how and why the derating criteria limit were established.

11. Should relative price information be included?

ANS: Relative price only, comparing cost of the different types of construction in a commodity (e.g. Resistor: Carbon vs. wire-wound).

12. Is non-operating information a consideration? How long: 2 years, 5 years, 10 years, longer -- years?

ANS: Yes, however, only in a general way.

13. Should the different grades of devices referenced in MIL-STD-975 have different reliability stress limits?

ANS: No! The only difference between the different grades of devices should be the 100% screen criteria.

14. How many grades of parts should there be?

ANS: Three (3). One lower grade than presently in MIL-STD-975.

15. Do you feel that this manual will be used mainly by Design Engineering, Reliability or Program functions?

ANS: 1) Reliability/Parts Engineering
2) Programs
3) Design Engineering

16. What present MIL-STD information should be included in this manual?

ANS: Selection guides of MIL-STD-198 and MIL-STD-199. Some of the information in MIL-STD-1470B.

17. Should ALERTS and a summary of each of them be included? If so, how far back should the ALERTS go?

ANS: Not directly. They should be reviewed and information pertaining to device/technology/application weakness should be included in each commodity section where appropriate.

18. How should each of the commodities be broken down; by function or construction?

ANS: Similar to that shown by GE/AESD

19. Would a separate document, with catalog type of data presented in it, increase Design Engineering usage of MIL-STD-975?

ANS: Yes! This is the type of information the designer needs and uses in performing his job. The military scatters this information all over and does not put it in a format that the designer is accustomed to.

20. Is catalog data formating of Military Spec Parts referenced in MIL-STD-975 desirable?

ANS: Yes.

D. M. Cole
Advance Components Engineering
MD 747
EX 5296

GENERAL ELECTRIC

AEROSPACE ELECTRONIC SYSTEMS

TRAVELER:	PLACE VISITED:	DATE
George Snider	Bendix Guidance Systems Div., Teterboro, NJ	11/08/77

ACCOMPANIED BY:	COPIES OF THIS REPORT TO:
-	D. Cole J. Donnelly T. Poyer N. Scianna

OBJECT OF VISIT:	DATE OF VISIT
Discuss Requirements for NASA Component Application Manual	11/2/77

Person Visited: George Kramer, Manager Parts Engineering.

A contract (NASS-32662) to investigate the need for and the content of a proposed Component Application Manual has been awarded to General Electric. As part of this study contract, several NASA installations and NASA contractors are being visited. This visit to Bendix is one of those visits.

During this visit a list of questions aimed at defining the requirements for this manual were discussed. This list of questions had been mailed to the respondant a few days before the visit. Attached is a summary of these questions and the responses from this organization.

TRIP REPORT

ORIGINAL PAGE IS
OF POOR QUALITY

ES 255 (6-70)

What sources presently do you use for your required design and reliability information?

ANS: MIL-STD-975, supplemented by PPL 13 and Goddard Specification 85M03936. Bendix standard parts lists are used when contracts permit. Also when contracts permit the order of precedance of MIL-E-5400 etc is used (including MIL-STD-454). In addition part selection specs such as MIL-STD-198 and MIL-STD-1132 are used.

The feeling is that MIL-STD-975 is inadequate because it does not cover enough part types.

Do you see this manual as a design manual or standardization?

ANS: Standardization. Should include a standardization list with supporting application information that could be edited by individual contractor parts engineers, before supplying to design engineers; the manual should be used by a parts engineer who interprets for design engineers. It should be design oriented for standardization purposes.

How should this manual be bound?

ANS: Bound by section with an interim amendment sheet. Each amendment shuuld include all previous amendments to the latest revision of the section so that there would never be more than one amendment per section. All sections could be placed in a common binder.

How should this document be released?

ANS: MIL standard system provides easier access. Is available to all, whether a contract is available or not. This system also provides for better review and update.

However, NASA system would be faster, but access is usually very limited. Therefore there is a slight preference for the MIL-STD system.

Should the manual include both the military and an equivalent vendor designation on the standard parts list?

ANS: Yes, should be able to recognize part easily. This should be generic where practical. The complete ordering reference should be included along with any additional ordering instructions. This would allow the list to be used by requisition writers.

Should a pictoral cross section of each part type within a commodity be included?

ANS: For parts engineer use only as part of explanatory information. Not useful to other people. A dimensional case outline should be made easily available, perhaps in an appendix.

Should a typical process flow chart for each commodity be included?

ANS: Not in part selection section. Could be helpful for failure analysis and destructive physical analysis if included in a different section.

Should radiation consideration be part of the manual?

ANS: Yes, whatever is known. Should be available for lookup by the design engineer.

Should reliability stress limits (derating criteria) be part of the standard parts test?

ANS: This should be a separate section of its own. This should include general guidelines. It should include graphical presentation of effect of derating on random failure rates.

Should relative price information be included?

ANS: No, there are too many more important factors for designers to consider.

Is shelf life information a consideration?

ANS: Yes. Worst case end of life tolerance under both operating and storage conditions should be included.

Should the different grade of devices have different reliability stress limits?

ANS: Generally no. However, different categories of equipment are designed differently in some cases.

How many grades of parts should there be?

ANS: Two. Ground equipment should not be included, since it is not part of MIL-STD-975.

Do you feel that this manual will be used mainly by Design Engineering, Reliability or Program Functions?

ANS: Hard to rank. But probably Reliability, Design and Programs in that order.

What present MIL-STD information should be included in the manual?

ANS: Should include many categories not covered by MIL-STD-975. (e.g. Relays, Switches, Connectors) Should cover all parts DESC controls. There is a need for attention to optical components. We should refer to MIL-STDs called out in MIL-STD-454.

Should ALERTS and a summary of each of them be included?

ANS: No, not directly. Information learned from them could be included in application information. Information over two years old would be of little value.

How should commodities be broken down?

ANS: Similar to setup shown, although some types shown may not be satisfactory for NASA use. Hybrids should be a separate section.

How should book be organized?

ANS: Six section format of mil specification should be used. (e.g. 1-Scope, 2-Applicable Documents, 3- Requirements, etc.) Main writeup should be under general section as above. Specific information for each commodity should be in appendix (e.g. Appendix A for Transistors, Appendix B for Diodes, etc.) Information could then be easily found by appendix and page (e.g. A-21).

George A. Snider
Components Engineering
x5478

GENERAL ELECTRIC

AEROSPACE ELECTRONIC SYSTEMS

TRAVELER:	PLACE VISITED:	DATE:
George Snider	Boeing Aerospace Corp. Seattle, Washington	1/6/78
ACCOMPANIED BY:	COPIES OF THIS REPORT TO:	
-	D. Cole, T. Poyer, N. Scianna	

OBJECT OF VISIT:	DATE OF VISIT:
Discuss Requirements for NASA Component Application Manual	12/12/77

Person Visited: Leo Buldhaupt, Component Engineering Supervisor

A contract (NAS8-32662) to investigate the need for and the content of a proposed Component Application Manual has been awarded to General Electric. As part of this study contract, several NASA installations and NASA contractors are being visited. This visit to Boeing Aerospace Corp. is one of those visits.

During this visit, a list of questions aimed at defining the requirement for this manual were discussed. This list of questions had been mailed to the respondent a few days before the visit. Attached is a summary of these questions and the response from this organization.

In addition to Mr. Buldhaupt, Bill Rumpza, Manager of Parts Engineering for all of Boeing Aerospace, was originally scheduled to participate in this meeting. However, because the flight to Seattle was 4½ hours late (malfunctioning aircraft), Mr. Rumpza was not available either the evening of 12/12 or on 12/13. Therefore, an evening meeting was held with Mr. Buldhaupt, who was a very knowledgeable substitute.

Mr. Buldhaupt felt that one of the biggest problems would be to define future NASA needs and to aim the catalog at these needs. He felt that such a definition should be obtained from NASA headquarters.

TRIP REPORT

AES 255 (6-70)

<u>What sources presently do you use for your required design and reliability information?</u>

ANS: Boeing PPL which lists parts by different reliability categories. This PPL has been in existence for 5-6 years and has a semi-annual update. This document lists key parameters, outline and mounting dimensions, and relative price information. The PPL is also on their computer for easy access.
Parts Specialists are also a primary source of information.
The Boeing Design Manual which is used in conjunction with the Boeing Airplane Co. (commercial aircraft) is also a source of this information. This manual was originated in 1964, is frequently updated and is somewhat like the General Electric CTS Manual.

<u>Do you see this manual primarily as a design manual or a standardization manual?</u>

ANS: The basic manual would supply detail for design for smaller subcontractors who do not have part specialists. It should not force design criteria on major contractors who have their own parts capability.
A second smaller manual should help standardization on <u>all</u> contractors by providing basic derating and design criteria.
This would mean essentially two levels for different type users.

<u>How should the manual be bound?</u>

ANS: The basic manual should be bound while the secondary manual should be loose leaf. Microfilm should be investigated in addition to loading on a central computer with each user having terminal access.

<u>How should this document be released?</u>

ANS: Stay away from Mil Spec system. Distribution should be farmed out to an independent agency or contractor. Coordination of changes could be a serious problem.

<u>Should the manual include both the military and an equivalent vendor designation on the standard parts list?</u>

ANS: Yes.

<u>Should a pictorial cross section of each part type within a commodity be included?</u>

ANS: Not necessary in manual for large contractors but should be helpful in manual for small contractors.

Should a typical Process Flow Chart for each commodity be included?

ANS: No, this information is too apt to be incorrect or out-of-date.

Should radiation consideration be part of the manual?

ANS: This would depend on future NASA goals. For outer space probes this information would be helpful and would make this a problem that could be treated like other environments.

Should reliability stress limits (derating criteria) be part of the standard parts list?

ANS: Yes, to provide standardization between contractors.

Should relative price information be included?

ANS: It should be relative with an explanation, should be very general and not specific. But because cost trade-offs are often important it should be included.

Is shelf life information a consideration?

ANS: Yes, this information is now lacking in industry. The duration would depend on future NASA requirements.

Should the different grades of devices have different reliability stress limits?

ANS: No! More effort should be devoted to making certain that more critical parts are properly applied and operated within their "design range". Too much derating could cause parts to operate below their design range and introduce new problems. Therefore, more attention to part application and selection of the correct part for the application is necessary.

How many grades of parts should there be?

ANS: Three, dependent on criticality of mission.

Do you feel that this manual will be used mainly by Design Engineering, Reliability or Program functions?

ANS: Small contractor designers, other designers, and Parts Reliability people in that order.

What present MIL-STD information should be included in the manual?

ANS: Only where necessary.

Should ALERTS and a summary of each of them be included?

ANS: Generally no, too often problem is already solved but may be important in rare cases.

How should commodities be broken down?

ANS: As shown in GE answer, each commodity should be broken down according to the common way it is handled in the industry. There is a need for more commodities. Information on little used parts (indicators, etc.) would be of more value to larger contractors.

How should the book be organized?

ANS: Should be three different manuals. One would cover complete Component Application Data etc. for use by small contractors. A second would be a more concise manual containing basic parameter information of value to large contractors who have Component Engineers. The third would be a manual dealing with "off the shelf" equipment such as vendor designed test equipment for use on NASA applications.

Would a separate document, with catalog type of data presented in it, increase Design Engineering usage of MIL-STD-975?

ANS: Yes, would help encourage use of standard parts, should be certain that all important parameters are included.

Is catalog data formating of MIL Spec parts referenced in MIL-STD-975 desirable?

ANS: Yes, would also reduce use of vendor catalog data.

George A. Snider
Advance Components Engineering

GENERAL ELECTRIC

AEROSPACE ELECTRONIC SYSTEMS

TRAVELER: George Snider	PLACE VISITED: General Electric Space Center, Valley Forge, Pa.	DATE 11/9/77
ACCOMPANIED BY: -	COPIES OF THIS REPORT TO: D. Cole, T. Poyer, J. Donnelly, N. Scianna	
OBJECT OF VISIT: Discuss Requirements for NASA Components Application Manual		DATE OF VISIT 11/03/77

Person Visited: A. C. Meyers, Manager Parts Engineering

A contract (NASS-32662) to investigate the need for and the content of a proposed Component Application Manual has been awarded to General Electric. As part of this study contract, several NASA installations and NASA contractors are being visited. This visit to GE, Valley Forge is one of those visits.

During this visit a list of questions aimed at defining the requirements for this manual were discussed. This list of questions had been mailed to the respondant a few days before the visit. Attached is a summary of these questions and the response from this organization.

Mr. Meyers was very time limited during this discussion because of last minute urgent conflicts. This reduced the amount of time available to discuss thoroughly his reply to questions.

TRIP REPORT

ES 255 (6-70)

What sources presently do you use for your required design and reliability information?

ANS: MIL-Handbook 217B, GIDEP, Standards Handbook, PPL-13.

Do you see this manual primarily as a design manual or a standardization?

ANS: Design manual that should contain information not in catalogs, such as duty cycle information (short intermittent time ratings etc.). It should contain unusual application phenomena and contain a lot of curves (e.g. Cornell-Dubilier thermal analysis curve for capacitors). This should be aimed primarily for Design Engineers with small contractors who co not have their own Parts Engineers.

How should this manual be bound?

ANS: Ring notebook with individual sheets. The notebook should be able to be set up for groups of commodities so that each person could get only information he needs.

How should this document be released?

ANS: DESC is too slow.

NASA is hard to get sufficient quantities of information unless they restructure. There is almost a need to know somebody.

The best answer would be to contract somebody to maintain a distribution list and distribution. There should also be direction on who to contact for error correction.

Should the manual include both the military and an equivalent vendor designation on the standard parts list?

ANS: It could be similar to PPL-13, but should also include more limited use parts. Presently only the easier decisions are shown.

Should a pictorial cross-section of each part type within a commodity be included?

ANS: Not necessary for Design Engineers. Environmental information is more important. This information should be in a separate DPA manual.

Should a typical process flow chart for each commodity be included?

ANS: Not necessary for designer. It clutters up the book and a good parts man should know the information.

Should radiation considerations be part of the manual?

ANS: Not in this manual, there is too much conflicting information on the subject. This should be a separate manual.

Should reliability stress limits (derating criteria) be part of the standard parts list?

ANS: PPL 13 has derating criteria. However a separate section on derating would be good. End of life, worst case analysis, transient information should be included. Information on how to derate current, voltage and power should be in manual.

Should relative price information be included?

ANS: No

Is shelf life information a consideration?

ANS: Yes, up to 10 years.

Should the different grade of devices have different reliability stress limits?

ANS: Same as GE, Utica reply.

How many grades of parts should there be?

ANS: Three - super critical, critical, non-critical.

Do you feel that this manual will be used mainly by Design Engineering, Reliability or Program Functions?

ANS: Mostly by Design Engineering, especially at smaller companies with little or no Parts Engineering support. There would be limited use by Reliability and almost no use by Programs.

<u>What present MIL-STD information should be included in the manual?</u>

<u>ANS:</u> The QPL status of parts should be reflected along with the probability of non-QPL parts obtaining qualification.

<u>Should ALERTS and a summary of each of them be included?</u>

<u>ANS:</u> No! Already have the GIDEP ALERT Summary. In addition, information over two years old has no value.

<u>How should commodities be broken down?</u>

<u>ANS:</u> Same as shown, except not enough commodities. GE Valley Forge Space Center is experiencing a majority of problems with electro-mechanical parts. These and magnetic components should be covered.

<u>How should format of book be organized?</u>

<u>ANS:</u> Similar to that shown, except a section on capacitor chips should be included.

George A. Snider
Components Engineering
x5478

GENERAL ELECTRIC

AEROSPACE ELECTRONIC SYSTEMS

TRAVELER: G. Snider	PLACE VISITED: Goddard Space Flight Center, Greenbelt, MD	DATE 11/17/
ACCOMPANIED BY: -	COPIES OF THIS REPORT TO: D. Cole, J. Donnelly, T. Poyer, N. Scianna	
OBJECT OF VISIT: Discuss Requirements for NASA Component Manual		DATE OF VISI 11/10/77

Persons Visited: John Adolphson
Mike Baluck
C. B. House
A. Luuchick
Walt Paraby
D. E. Stillwell

A contract (NAS8-32662) to investigate the need for and the content of a proposed Component Application Manual has been awarded to General Electric. As part of this study contract, several NASA installations and NASA contractors are being visited. This visit to Goddard Space Flight Center is one of those visits.

During this visit a list of questions aimed at defining the requirement for this manual were discussed. This list of questions had been mailed to the respondent a few days before the visit. Attached is a summary of these questions and the responses from this organization.

We were fortunate that Mr. Adolphson had requested that several other parts and design people attend this meeting.

TRIP REPORT

ES 255 (6-70)

<u>What sources presently do you use for your required design and reliability information?</u>

<u>ANS:</u> NASA Newsletter, NASA Application Notes, design experience and Parts Engineer consultation.

<u>Do you see this manual primarily as a design manual or a standardization?</u>

<u>ANS:</u> Design manual aimed at assisting standardization efforts.

<u>How should the manual be bound?</u>

<u>ANS:</u> Bound by section with amendments to each section.

<u>How should this document be released?</u>

<u>ANS:</u> Through "STAR" - NASA Scientific and Technical Information Facility.

<u>Should the manual include both the military and an equivalent vendor designation on the standard parts list?</u>

<u>ANS:</u> Yes, because some MIL designations are not self obvious.

<u>Should a pictorial cross section of each part type within a commodity be included?</u>

<u>ANS:</u> No, except would be useful in explaining what is accomplished by screening.

<u>Should a typical Process Flow Chart for each commodity be included?</u>

<u>ANS:</u> That is not necessary for designers. All necessary information could be narrative.

<u>Should radiation consideration be part of the manual?</u>

<u>ANS:</u> Yes, people should be made aware of what parts experience radiation problems, what toal dosage causes problems, and what parameters are affected.

<u>Should reliability stress limits (derating criteria) be part of the standard parts list?</u>

<u>ANS:</u> This manual should explain reasons for derating, with guide lines and typical information. It should explain what happens to parameters, how it helps performance (including precautions on over derating). It should not conflict with PPL-13.

Should relative price information be included?

ANS: Yes, but be sure to compare "apples". This also should include delivery information and affect of offshore manufacturers.

Is shelf life information a consideration?

ANS: Yes, what parts are affected. What the affect is. How to check old parts and determine if they are still good.

Should the difference grades of devices have different reliability stress limits?

ANS: No. This is not the reason for the differentiation, but is a reliability consideration.

How many grades of parts should there be?

ANS: Three, with the third class being higher reliability commercial parts, which are manufactured with good process controls and would include unscreened military parts.

Do you feel that this manual will be used mainly by Design Engineering, Reliability or Program functions?

ANS: Equally by Design Engineering and Reliability, with little if any use by Programs.

What present MIL-STD information should be included in the manual?

ANS: Reference to MIL-STD-975, other PPL's and NASA documents with comments. It should not include QPL information.

Should ALERTS and a summary of each of them be included?

ANS: No, except major problems and significant trends that have been digested could be in part application sections along with how to avoid the problems.

How should commodities be broken down?

ANS: Similar to that shown. Subcategories could include CMOS, NMOS. The breakdown should include all parts on the PPL-13 and should also include ceramic chips.

How should book be organized?

ANS: Similar to breakdown shown. Except that it should be expanded to more commodities (as should MIL-STD-975). This book should include all kinds of application information that would be useful to new designers. It should help give new designers the benefit of many years experience. Information should also be included on lead materials.

Would a separate document, with catalog type of data presented in it, increase Design Engineering usage of MIL-STD-975?

ANS: No. Vendor catalogs serve this purpose.

Is catalog data formating of MIL Spec parts referenced in MIL-STD-975 desirable?

ANS: No, would refer to vendor catalogs.

George A. Snider
Components Engineering

ORIGINAL PAGE IS
OF POOR QUALITY

GENERAL ELECTRIC

AEROSPACE ELECTRONIC SYSTEMS

TRAVELER:	PLACE VISITED:	DATE:
D. Cole	Jet Propulsion Lab., California	12/15/77

ACCOMPANIED BY:	COPIES OF THIS REPORT TO:
-	T. Poyer, N. Scianna, G. Snider

OBJECT OF VISIT:	DATE OF VISIT
Discuss Requirements for NASA Component Application Manual	11/29/77

TRIP REPORT

Persons Visited: Dick Scott - Supervisor, Component Engineering
Jack Wilson - Component Engineering Leader

A contract (NASS-32662) to investigate the need for and the content of a proposed Component Application Manual has been awarded to General Electric. As part of this study contract, several NASA installations and NASA contractors are being visited. This visit to JPL is one of those visits.

J. Wilson and D. Scott were identified by the contract office, (MSFC/NASA), as the key contact at the Jet Propulsion Laboratory. A list of questions aimed at defining the requirements for the NASA Component Application Manual was discussed. Attached is a summary of these questions and their responses.

Prior to the discussion of the questions, both gentlemen indicated that a manual of this type would be useful and should be generated.

AES 255 (6-70)

What sources presently do you use for your required design and reliability information?

ANS: Jet Propulsion Laboratory's own PPL and MIL-STD-975. However, due to lack of availability of grade 1 parts on MIL-STD-975, this specification is limited in use.

Do you see this manual primarily as a design manual or a standardization manual?

ANS: Standardization manual.

How should the manual be bound? Loose leaf, perfect binding, etc.?

ANS: Loose leaf due to ease of up-dating.

Should the sections be assigned priority and each released as they are completed; or should the manual be released when totally completed?

ANS: Assigned priorities:

1) Microcircuits
2) Transistors/Diodes
3) Capacitors
4) Resistors

How should this document be released? e.g., through the Mil-Standard System, part of each RFP, etc.

ANS: FCC type of release in order to have Design Engineers accept it. MIL-System will turn-off the Design Engineer.

Should the manual include both the military and equivalent vendor designation on the standard parts list?

ANS: Yes.

Should a pictorial cross-section of each part type within a commodity be included?

ANS: Desirable. However,more part types should be covered than presently in MIL-STD-975.

Should a typical process flow chart for each commodity be part of the manual?

ANS: No! Marginal value at best.

Should radiation be part of the manual? If so, rate the importance of the different radiation effects to the system design.

ANS: Yes! However, total dose is the only interest.

Should reliability stress limits (derating criteria) be part of the standards parts list?

ANS: Yes! Each NASA Center today has their own limits and none are the same. This would then be used as the standard for all Centers. Also curves and a detailed explanation on how the limits were established should be included.

Should relative price information be included?

ANS: No! Changes too rapidly.

Is non-operating information a consideration? How long: 2 years, 5 years, 10 years, longer -- years?

ANS: In a general way only.

Should the different grades of devices referenced in MIL-STD-975 have different reliability stress limits?

ANS: No.

How many grades of parts should there be?

ANS: Four(4). One lower and one higher than presently in MIL-STD-975.

Do you feel that this manual will be used mainly by Design Engineering, Reliability, or Program functions?

ANS:
1) Component Engineering
2) Reliability Engineering
3) Design Engineering
4) Programs.

What present MIL-STD information should be included in this manual?

ANS: None, all out-dated.

Should ALERTS and a summary of each of them be included? If so, how far back should the ALERTS go?

ANS: No! Too broad. Should be reviewed for major confirmed problems and corrective action. These problems should be addressed in the Reliability section of each commodity.

How should each of the commodities be broken down; by function or construction?

ANS: Similar to that shown by GE/AESD.

Would a separate document, with catalog type of data presented in it, increase Design Engineering usage of MIL-STD-975?

ANS: Yes! This would be a major step in the right direction.

Is catalog data formating of Military Spec Parts referenced in MIL-STD-975 desirable?

ANS: Yes!

D. M. Cole
Advance Components Engineering
MD 747
EX 5296

GENERAL ELECTRIC

AEROSPACE ELECTRONIC SYSTEMS

TRAVELER: George Snider	PLACE VISITED: Langley Research Center, Hampton, Virginia	DATE: 11/22/7
ACCOMPANIED BY: -	COPIES OF THIS REPORT TO: D. Cole, T. Poyer, J. Donnelly, N. Scianna	
OBJECT OF VISIT: Discuss Requirements for NASA Component Application Manual		DATE OF VIS 11/11/7

Persons Visited: Hugh Milteer, Manager Electronic Reliability Office
Harry Ricker, Consultant

A contract (NAS8-32662) to investigate the need for and the content of a proposed Component Application Manual has been awarded to General Electric. As part of this study contract, several NASA installations and NASA contractors are being visited. This visit to NASA, Langley Research Center, is one of those visits.

During this visit a list of questions aimed at defining the requirement for this manual were discussed. This list of questions had been mailed to the respondent a few days before the visit. Attached is a summary of these questions and the response from this organization.

There was a belief that there should be no manual at all and that NASA should not spend money on this effort. However, there was a strong desire to have a catalog section as discussed later in this report.

TRIP REPORT

:S 255 (6-70)

1. What sources presently do you use for your required design and reliability information?

   ANS: Vendor catalog data, technical publications (maintain a complete file), ALERT System, GIDEP System, project generated information (Viking, etc.), part manufacturers.

2. Do you see this manual primarily as a design manual or a standardization?

   ANS: Design supplement and guideline for new engineers and small companies.

3. How should manual be bound?

   ANS: Economics dictate loose leaf.

4. How should this document be released?

   ANS: Released to centers for implementation. After centers use it, the Parts Steering Committee could determine how to implement. It was suggested that all centers obtain a copy of the G.E. Manual and see how much it is used, before expanding distribution. Contractors would not have time to read the manual if required in contracts and would be afraid of not adhering strictly to the book. Do not mix with MIL-Std System.

5. Should the manual include both the military and an equivalent vendor designation on the standard parts list?

   ANS: Agree with GE answer. In addition, all references to contractor numbers on any program should include generic or vendor reference.

6. Should a pictorial cross section of each part type within a commodity be included?

   ANS: Probably not. It should not be similar to NASA-SP6507 and should be used only when it pertains to application information. This would not normally be needed by designers. As a sidelight, MIL-Specs should require construction analysis as part of QPL procedure.

7. Should a typical process flow chart for each commodity be included?

ANS: No.

8. Should radiation consideration be part of the manual?

ANS: No! After Jupiter, emphasis has diminished. Where a problem exists with a given part, attention to the problem could be given to the extent of encouraging a search elsewhere for information.

9. Should reliability stress limits (derating criteria) be part of the standard parts list?

ANS: No! This is already in MIL-STD-975 and Handbook 217. Inclusion in this book could be implied as a contract requirement.

10. Should relative price information be included?

ANS: Yes, differences between different reliability levels at a given quantity.

11. Is shelf life a consideration?

ANS: Where it is a consideration for a given part, it should be stated as applicable.

12. Should the different grades of devices have different reliability stress limits?

ANS: No, levels talk about assurance that different things have been done to the part.

13. How many grades of parts should there be?

ANS: None. Application notebook should apply to all parts the same way, therefore a grade differential is not necessary.

14. Do you feel that this manual will be used mainly by Design Engineering, Reliability or Program functions?

ANS: Almost equal between Design and Reliability with no Program usage. Work is often initiated by Reliability but must be implemented by the Designer.

15. What present MIL-STD information should be included in the manual?

    ANS: Mil Specs information should be related to describe what additional information is available in them.

16. Should ALERTS and a summary of each of them be included?

    ANS: No. Parts Engineers should keep active file of ALERTS. If an ALERT relates to application of a part, information gained from it could be included. Information should be kept as long as applicable since many parts in use have been made for several years.

17. How should commodities be broken down?

    ANS: As shown and as applicable to parts shown in standard parts list.

18. How should book be organized?

    ANS: Book should have a preface explaining when, where, and how to use and limitations, etc. It should not cover NASA Preferred Parts, otherwise the breakdown should be as shown.

19. Would a separate document, with catalog data presented in it increase Design Engineering usage of MIL-STD-975?

    ANS: Yes! It would be a big scope item, but could be a big advantage and time saver. It would be a good way of keeping everyone up to date. This should be self-sufficient and be kept condensed. This is the single most important reason for having a manual.

20. Is catalog data formating of MIL-Spec parts referenced in MIL-STD-975 desirable?

    ANS: Yes, as explained in 19 above.

George A. Snider

George A. Snider
Components Engineering
x5478

GENERAL ELECTRIC

AEROSPACE ELECTRONIC SYSTEMS

TRAVELER:	PLACE VISITED:	DATE:
D. M. Cole	LBJ Space Center, Houston, Texas	11/8/77
ACCOMPANIED BY: --	COPIES OF THIS REPORT TO: T. Poyer, N. Scianna	
OBJECT OF VISIT: Discuss NASA's Parts Application Manual		DATE OF VISIT: 10/31/77

TRIP REPORT

Personnel Contacted:

Mr. T. Edward - Safety & Reliability Mgr.
LBJ Space Center/NASA

Mr. - Roquemore - Component Engineer
LBJ Space Center/NASA

Mr. B. Dugdale
Boeing Rel. & Q.A. Shuttle Mgr.

Mr. L. Hamiter
Component Chief, MSFC/NASA

Accomplishments:

Prior to meeting with Boeing, the NASA personnel and I held a discussion on the pros and cons of a NASA Application Manual. Mr. Edward indicated that the shuttle parts have already been selected, and on future programs, NASA's/LBJ Space Center plans to procure more and more off-the-shelf black boxes, therefore, a need for an Application/Standardization Manual for their use is minimized in his opinion.

In meeting with Boeing personnel, the same impression concerning a need for a Manual was given. However, it was not as strong an impression as given by Mr. Edward. On many occasions, Mr. Dugdale of Boeing made reference to a 1974 Manual that his group generated in hopes of assisting engineering in selecting and using standard devices. A copy of this Manual was given to me to carry back.

Both Boeing and LBJ Space Center-NASA indicated that they presently are not using MIL-STD-975 or plan to in the near future. They feel that it should be expanded and made to be more helpful to the Design Engineer.

Attached is the list of questions asked of the LBJ Space Center and Boeing personnel and their answers.

ES 255 (6-70)

1. What sources presently do you use for your required design and reliability information?

   A handbook generated by Boeing in 1974 for the LBJ Space Center.

2. Do you see this Manual primarily as a Design Manual or a Standardization Manual?

   As a Design Manual.

3. How should the Manual be bound - Loose leaf, perfect binding, etc.?

   Loose leaf or a combination of loose leaf, perfect binding.

4. Should the sections be assigned priority and each released as they are completed; or should the Manual be released when totally completed?

   If only the present devices referenced in MIL-STD-975 are covered by the Manual, then the way the Manual is released in sections or as a whole does not concern the LBJ Space Center. However, if memories are to be covered, then they should be released first.

5. How should this document be released? e.g. Through the Mil-Standard System, part of each RFP, etc.?

   Through the military documentation out of Philadelphia.

6. Should the Manual include both the military and equivalent vendor designation on the standard parts list?

   No. Some designers might interpret this as saying that the military and vendor commercial parts are equal in performance.

7. Should a pictorial cross-section of each part type within a commodity be included?

   Yes. Have found it useful, in the past, using the cross-section generated by Lockheed for AMES/NASA.

8. Should a typical process flow chart for each commodity be part of the manual?

   Questionable at best, since there is a large variation between the different vendor's process flow.

9. Should radiation be part of the Manual? If so, rate the importance of the different radiation effects to the system design.

   There is not a need at the L.B.J. Space Center for this type of information.

10. Should reliability stress limits (derating criteria) be part of the standard parts list?

    Yes!

11. Should relative price information be included?

    No!

12. Is non-operating information a consideration? How long: two years, five years, ten years, longer _____ years?

    Should be mentioned wherever there is evidence of a problem.

13. Should the different grades of devices referenced in MIL-STD-975 have different reliability stress limits?

    No. Same derating should be used throughout NASA.

14. How many grades of parts should there be?

    Same number as there are in MIL-STD-975.

15. Do you feel that this manual will be used mainly by Design Engineering, Reliability, or Program functions?

    The order of usage by function as they see it is:
    Reliability/Component Engineers
    Design Engineers
    Program personnel

16. What present MIL-STD information should be included in this Manual?

    MIL-STD-198 & 199 type of information should be included.

17. Should alerts and a summary of each of them be included? If so, how far back should the alerts go?

    No. Alerts should be reviewed for pertinent information and that information included in the Manual as general information.

18. How should each of the commodities be broken down: by function or construction?

    The same as shown by GE/AESD.

19. Would a separate document, with catalog type of data presented in it increase Design Engineering usage of MIL-STD-975?

    Would be useful in increasing the Design Engineer use of MIL-STD-975.

20. Is catalog data formating of Military Spec Parts referenced in MIL-STD-975 desirable?

    Yes!

D. M. Cole
Advance Components Engineering
MD 747
EX 5296

GENERAL ELECTRIC

AEROSPACE ELECTRONIC SYSTEMS

TRAVELER:	PLACE VISITED:	DATE
D. Cole	Lewis Research Center, Cleveland	11/14/77
ACCOMPANIED BY:	COPIES OF THIS REPORT TO:	
-	T. Poyer, N. Scianna, G. Snider	

OBJECT OF VISIT:	DATE OF VISIT:
Discuss Requirements for NASA Component Application Manual	11/02/77

Person Visited: Joseph Kimmel

A contract (NASS-32662) to investigate the need for and the content of a proposed Component Application Manual has been awarded to General Electric. As part of this study contract, several NASA installations and NASA contractors are being visited. This visit to RCA is one of those visits.

Mr. J. Kimmel was identified by the contracting office, (MSFC/NASA), as the key contact at Lewis Research Center since he is their representative on NASA's Parts Steering Committee. A list of questions aimed at defining the requirements for the NASA Component Application Manual was discussed. Attached is a summary of these questions and the responses from Mr. Kimmel.

TRIP REPORT

AES 255 (6-70)

<u>What sources presently do you use for your required design and reliability information?</u>

Ans: Goddard Application Notes, Mil-Std-1470, Mil-Std-975 and vendors' contacts. However, feel that this military specification referenced are out of date; and therefore, are only used occasionally. Mil-Std-975 should be upgraded to cover more part types even in the commodities covered.

<u>Do you see this manual primarily as a design manual or a standardization manual?</u>

Ans: Design manual similar to the Goddard Application notes.

<u>How should the manual be bound - loose leaf, perfect binding, etc?</u>

Ans: Loose leaf, due to the ease of up-dating. Mr. Kimmel felt that most military specifications, once issued, are not kept current as required because of the cost involved in printing, etc.

<u>How should this document be released? e.g., through the Mil-Standard System, part of each RFP, etc.?</u>

Ans: Felt that the Mil-Standard system would be best since it would make it available to all, whether on contract or not.

<u>Should the manual include both the military and equivalent vendor designation on the standard parts list?</u>

Ans: The question requires a different answer for each of the commodities:

1) Capacitors, Resistors - No! The designers recognize and understand the military designation.
2) Transistors and Diodes - No! The military designation includes the vendor/generic designation (e.g., JAN-TX 2N _____, 1N _____.)
3) Microcircuits - Yes! The designer cannot relate the slash-sheet number to a vendor designation readily.

<u>Should a pictorial cross section of each part type within a commodity be included?</u>

Ans: Yes! Have found the NASA-SP6507 document useful in the part.

Should a typical process flow chart for each commodity be part of the manual?

Ans: Yes. But would emphasize the word typical and assure that those using the manual would understand that it is only a typical process flow.

Should radiation be part of the manual? If so, rate the importance of the different radiation effects to the system design.

Ans: Yes. However, the only concern is total Dose Hardness. The degree of degradation and what parameters are affected should be covered in a general way. (eg. a set of curves.)

Should reliability stress limits (derating criteria) be part of the standard parts list?

Ans: No. It should be a separate section/subsection of this proposed manual. The information covered should be similar to that in Mil-Std-975.

Should relative price information be included?

Ans: No!! NASA is too far removed for this type of information to be accurate or timely.

Is non-operating information a consideration?

Ans: No.

Should the different grades of devices referenced in Mil-Std-975 have different reliability stress limits?

Ans: Yes. Reliability stress limits should be based on the mission length.

How many grades of parts should there be?

Ans: Three. There should be a lower grade of part added to Mil-Std-975. There never should be more than three grades.

Do you feel that this manual will be used mainly by design engineering, reliability or program functions?

Ans: The main usage would be by Reliability/Component Engineering with Design Engineering a close second. Program people would only use this manual during the proposal phase.

What present Mil-Std information should be included in this manual?

Ans: Mil-Std-1470, Mil-Std-198 and the Goddard Application notes should be reviewed for pertinent information that should be included in this manual.

Should ALERTS and a summary of each of them be included?

Ans: No, not directly. ALERTS should be reviewed and information pertaining to device/technology weakness should be included in each commodity section where appropriate.

How should each of the commodities be broken down: by function or construction?

Ans: Similar to the breakdown shown.

Would a separate document, with catalog type of data presented in it, increase Design Engineering usage of Mil-Std-975?

Ans: Would help in increasing the Design Engineer's use of Mil-Std-975.

Is catalog data formating of Military Spec Parts referenced in Mil-Std-975 desirable?

Ans: Yes.

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Advance Components Engineering
MD 747
Ex 5296

GENERAL ELECTRIC

AEROSPACE ELECTRONIC SYSTEMS

TRAVELER: George A. Snider	PLACE VISITED. Marshall Space Flight Center, Huntsville, Ala.	DATE. 11/28/
ACCOMPANIED BY: Dale Cole	COPIES OF THIS REPORT TO. D. Cole, T. Poyer, J. Donnelly, N. Scianna	
OBJECT OF VISIT: Discuss study contract requirements for NASA Component Application Manual.		DATE OF VIS 10/18/77

Persons Visited:

Leon Hamiter
Porter Dunlap
A. M. Holliday
Mike Nowarowski
Phil Villella

A contract (NAS8-32662) to investigate the need for and the content of a proposed component application manual has been awarded to General Electric by Marshall Space Flight Center. The object of this trip was to present to the contracting agency the plan for fullfilling the contract requirement and obtain recommendations for carrying out this plan.

TRIP REPORT

A presentation was made by Dale Cole that outlined the significant elements of this plan. The schedule was discussed and was satisfactory. As part of the program several NASA installations and contractors are to be visited to collect opinions on the need for and content of the manual. The list of such contacts was reviewed and some minor changes were made and agreed upon.

A list of questions that pertained to the content were reviewed and these questions and answers were as follows:

What type of required design and/or reliability information is essential for this manual?

ANS: Component application and reliability information.

In designing, do you use data sheet information?

ANS: Only with NASA approval.

Is this type of information required in the manual?

ANS: No - MIL-STD-975 information only.

S 255 (6-70)

How should manual be bound?

ANS. After discussion of ineffective updating by sheet it was decided that perfect binding by section would be a good approach.

How should this document be released?

ANS. Opinion was that DOD distribution would be most practical.

Should the manual include both the military and an equivalent vendor designation on the standard parts list?

ANS. Yes, for clarity

Should a pictorial cross section of each part type within a commodity be included?

ANS. Yes, to understand part problems.

Should a typical process flow chart for each commodity be included?

ANS. No, too difficult to keep up to date, value is questionable.

Should radiation consideration be part of the manual?

ANS. Yes, difficult to scope, should therefore be limited to total dose information.

Should reliability stress limits (derating criteria) be part of the standard parts list?

ANS. No, belongs in MIL-STD-975.

Should relative price information be included?

ANS. No, too many variables.

Is shelf life a consideration?

ANS. Should be considered where practical.

Should the different grades of devices have different reliability stress limits?

ANS. Could not be defined without additional investigation.

How many grades of parts should there be?

ANS. Three, the present two with one more lower grade.

Do you feel this manual will be used mainly by Design Engineering, Reliability or Program functions?

ANS. Reliability, Programs and Design Engineering in that order.

What present MIL-STD information should be included in the manual?

ANS. None, except to reference specifications by commodity.

Should ALERTS and a summary of each of them be included?

ANS. No, only information of application nature in general writeup.

How should commodities be broken down?

ANS. As shown with minor modifications.

How should book be organized?

ANS. As shown, with addition to General Section to include Impact of Nonstandard Part Usage.

George A. Snider
Components Engineering
x5478

GENERAL ELECTRIC

AEROSPACE ELECTRONIC SYSTEMS

TRAVELER:	PLACE VISITED:	DATE:
George Snider	Martin Marietta Co., Denver, Colo.	1/5/78
ACCOMPANIED BY:	COPIES OF THIS REPORT TO:	
-	D. Cole, T. Poyer, N. Scianna	

OBJECT OF VISIT:	DATE OF VISIT:
Discuss Requirements for NASA Component Application Manual	12/13/77

Person Visited: William Grimes, Component Engineer

A contract (NAS8-32662) to investigate the need for and the content of a proposed Component Application Manual has been awarded to General Electric. As part of this study contract, several NASA installations and NASA contractors are being visited. This visit to Martin Marietta Co. is one of those visits.

During this visit a list of questions aimed at defining the requirement for this manual were discussed. This list of questions had been mailed to the respondent a few days before the visit. Attached is a summary of these questions and the response from this organization.

Mr. E. P. Carter was also scheduled to participate in this meeting, however because of an unscheduled customer visit, he was not available on arrival.

TRIP REPORT

<u>What sources presently do you use for your required design and reliability information?</u>

<u>ANS:</u> In-house test reports, vendor test reports, other contractor (JPL, etc.) test reports, own Parts Engineers.

<u>Do you see this manual primarily as a design manual or a standardization?</u>

<u>ANS:</u> Design manual used by designers for general information including derating, etc. Would be consulted before talking to Parts Engineers and would therefore reduce the effort required of Parts Engineers. It would be of even more value to small contractors.

<u>How should the manual be bound?</u>

<u>ANS:</u> Bound by section in <u>one</u> large book.

<u>How should this document be released?</u>

<u>ANS:</u> Should be released as a MIL-STD to make it more accessible and easier to order.

<u>Should the manual include both the military and an equivalent vendor designation on the standard parts list?</u>

<u>ANS:</u> Yes! Martin Marietta uses as much of generic number as possible in drawing numbers.

<u>Should a pictorial cross section of each part type within a commodity be included?</u>

<u>ANS:</u> Yes, gives the designer a better understanding of part limitations. Many designers <u>are</u> interested. Information should be represented as typical.

<u>Should a typical process flow chart for each commodity be included?</u>

<u>ANS:</u> Yes, would be of interest to Reliability Engineers.

<u>Should radiation consideration be part of the manual?</u>

<u>ANS:</u> Yes. Dose rate affect of atmospheric radiation, derating, etc. Nuclear radiation affect is generally classified.

Should reliability stress limits (derating criteria) be part of the standard parts list?

ANS: Yes, designer needs this information. Helps standardize between contractors on same program.

Should relative price information be included?

ANS: No, changes too rapidly.

Is shelf life information a consideration?

ANS: Yes, important in stored programs such as Minuteman, etc. Designers should know affect for at least 5 years.

Should the different grades of devices have different reliability stress limits?

ANS: Yes, there should be different stress limits because of different application criticality.

How many grades of parts should there be?

ANS: Three (3), add ground equipment to present MIL-STD-975 classifications.

Do you feel that this manual will be used mainly by Design Engineering, Reliability or Program functions?

ANS: Design Engineering, Reliability Engineering, and Parts Engineering in that order.

What present MIL-STD information should be included in the manual?

ANS: The manual should be complete and not reference other documents except where necessary.

Should ALERTS and a summary of each of them be included?

ANS: Yes, they are helpful to parts specialists and in some cases to designers. Aerospace Corp. has ALERTS loaded on computer, separated by commodity.

How should commodities be broken down?

ANS: Should be broadly described by construction and then by function. Electro-Mechanical parts such as circuit interrupting devices and connectors should be added.

How should the book be organized?

ANS: As shown on GE Figure 2-1 except that each section should contain most of the general information.

Would a separate document, with catalog type of data presented in it, increase Design Engineering usage of MIL-STD-975?

ANS: Yes, would be very helpful and would reduce the use of obsolete catalog information. Aerospace Corp. is generating a similar book as MIL-STD-1547 for SAMSO.

Is catalog data formating of Mil Spec parts referenced in MIL-STD-975 desirable?

ANS: Yes, would give actual vendor data.

George A. Snider
Components Engineering
MD 747
EX 5218

GENERAL ELECTRIC

AEROSPACE ELECTRONIC SYSTEMS

TRAVELER: George Snider	PLACE VISITED: RCA, Astro-Electronic Division, Princeton, NJ	DATE: 11/9/77
ACCOMPANIED BY: -	COPIES OF THIS REPORT TO: D. Cole, J. Donnelly, T. Poyer, N. Scianna	
OBJECT OF VISIT: Discuss Requirements for NASA Component Application Manual		DATE OF VISIT: 11/2/77

Person Visited: Val Monshow, Mgr. Reliability Engineering
Rick Fletcher, Semiconductor Reliability Engr.
Rodger Luckenbaugh, Electromechanical Reliability Engineer.

A contract (NASS-32662) to investigate the need for and the content of a proposed Component Application Manual has been awarded to General Electric. As part of this study contract, several NASA installations and NASA contractors are being visited. This visit to RCA is one of those visits.

During this visit a list of questions aimed at defining the requirement for this manual were discussed. This list of questions had been mailed to the respondent a few days before the visit. Attached is a summary of these questions and the responses from this organization.

Mr. Monshow because of last minute conflicts was present for only a small part of the meeting.

TRIP REPORT

ES 255 (6-70)

What sources presently do you use for your required design and reliability information?

ANS: MIL-STD-975, PPL-13, RCA DPPL-1971202, RCA Screening Spec. 1846684, RCA Manual for Design and Application Information, RCA Book of Application Notes for Preferred Parts and vendor catalogs. RCA has a group preferred parts list and a division preferred parts list.

Do you see this manual primarily as a design manual or a standardization?

ANS: A design guideline. Should not be a rehash of present known information. Would be for Parts Engineers, not Design Engineers. Therefore information should consist of new trends, results of burn-in accumulated by manufacturers, QPL status of different vendors, line certification, etc. It should be used to augment present procedures. MIL-STD 975 needs more frequent updating and should be expended to LSI and MSI.

How should the manual be bound?

ANS: Replaceable by complete section. Each section should be complete enough so that engineers interested in only certain commodities could get only that information.

How should this document be released?

ANS: DESC is easier to use, but slow on new trend information. NASA is faster, but much harder to get information.

Should the manual include both the military and an equivalent vendor designation on the standard parts list?

ANS: Yes, and where no QPL source exists suggested source should be given (those most likely to obtain QPL)

Should a pictorial cross section of each part type within a commodity be included?

ANS: Yes, including materials used and exploded views of critical areas.

Should a typical process flow chart for each commodity be included?

ANS: Yes, primarily for reliability and parts people. Process descriptions should be included.

Should radiation consideration be part of the manual?

ANS: Yes, a general guidance chart relating dose level to a point of concern. Beyond that, a band of curves showing what degradation occurs should be given. Also, parts application and shielding information should be included.

Should reliability stress limits (derating criteria) be part of the standard parts list?

ANS: Yes, but should be a self contained document. How failure rate changes with derating should be explained. A matrix should show how failure rate varies with derating, temperature etc. Information should be for reliability engineers, as this would be a dangerous two edged sword in the hands of a design engineer.

Should relative price information be included?

ANS: No!!

Is shelf life information a consideration?

ANS: No problems have been experienced resulting from storage of up to 8 years. It is probably not worth cost of developing information. However, storage procedures, end of life tolerances (after storage and/or operating) would be helpful for 2, 5, 7 and 10 years.

Should the different grades of devices have different reliability stress limits?

ANS: Critical and non-critical parts have same screening but different derating. There should be no double relaxation. This is a tricky subject for which RCA does not like to be told how to handle.

How many grades of parts should there be?

ANS: Two, critical and non-critical with more attention to critical parts.

Do you feel that this manual will be used mainly by Design Engineering, Reliability Engineering or Program Functions?

ANS: The main usage would be by Reliability Engineering. It should be a new source of information to fill voids on information not presently available. This manual would also be used by Design Engineering, but only as a guideline with no mandatory rules. Program people would use this manual only during proposal and testing phases.

What present MIL-STD information should be included in the manual?

ANS: QPL status with results of specific vendor QPL tests. Prospective sources should be given where QPL does not exist. Should include a current HOT section updated frequently.

Should ALERTS and a summary of each of them be included?

ANS: Should not be a repeat of GIDEP summary. Could include a review of other manufacturers to determine if problem exists elsewhere.

How should commodities be broken down?

ANS: As shown except monolithic and hybrid should be separate sections.

How should book be organized?

ANS: Similar to that shown. Computer loading should be investigated. Each commodity section should be as self sufficient as possible.

George A. Snider

George A. Snider
Components Engineering
x5478

GENERAL ELECTRIC

AEROSPACE ELECTRONIC SYSTEMS

TRAVELER:	PLACE VISITED:	DATE:
D. M. Cole	SAMSO/Aerospace Corp., Los Angeles, CA	12/5/77
ACCOMPANIED BY: -	COPIES OF THIS REPORT TO: J. Donnelly, N. Scianna, T. Poyer, G. Snider	
OBJECT OF VISIT: Discuss requirements for NASA Component Application Manual		DATE OF VISIT: 11/30-12/1/77

TRIP REPORT

Persons Contacted:

A. Barofsky - Supervisor, MTS Group
A. Carlan - MTS Parts Engineer
S. Cohen - MTS Parts Engineer
J. Eagan - Manager, Aerospace Component Engineering
G. Lindsay - Parts Engineer, SAMSO Parts Working Group

A contract (NAS8-32662) to investigate the need for and the content of a proposed Component Application Manual has been awarded to General Electric. As part of this study contract, SAMSO was identified by NASA to be visited by General Electric in order to discuss their requirements concerning this type of manual.

SAMSO believes that there is a need for this type of manual, and infact are generating a similar manual to be released under the military number MIL-STD-1547. This document is not as complete as the NASA document is visioned and is going to be tied to SAMSO MIL-STD-1546 which is solely a SAMSO document. However, SAMSO/Aerospace showed interest in working with the contractors that generate the NASA Application Manual.

During this visit, a list of questions aimed at defining the requirements for this manual were discussed. This list of questions had been mailed to the respondent a few weeks prior to this visit. Attached is a summary of these questions and the response from this organization.

AES 255 (6-70)

1. What sources presently do you use for your required design and reliability information?

   ANS: Presently using the rough draft of SAMSO's MIL-STD-1547 ("Technical Requirements for Parts, Material & Processes"), and MIL-HNDBK-217B. It is anticipated that MIL-STD-1547 will be released within the next month.

2. Do you see this manual primarily as a design manual or a standardization manual?

   ANS: Primarily a design guideline manual and a checklist for standardization.

3. How should the manual be bound? Loose leaf, perfect binding, etc.?

   ANS: Loose leaf for ease of up-dating. Frequency of up-dating will be critical to the acceptance of the manual.

4. Should the sections be assigned priority and each released as they are completed; or should the manual be released when totally completed?

   ANS: Yes! Priorities should be assigned and each section released when completed. Microcircuits should be the first one completed. In addition, other commodities than those specified in MIL-STD-975 should be covered.

5. How should this document be released? e.g., through the Mil-Standard System, part of each RFP, etc.

   ANS: Through the Military System. If the proper emphasis is placed on this document, the turn around time for release and up-dating can be reasonable.

6. Should the manual include both the military and equivalent vendor designation on the standard parts list?

   ANS: Yes.

7. Should a pictorial cross section of each part type within a commodity be included?

   ANS: Yes! Per family type, (DTL, TTL, CMOS, etc.). This is most useful to the reliability and component engineer when a problem arises.

8. Should a typical process flow chart for each commodity be part of the manual?

   ANS: No! Too much detail.

9. Should radiation be part of the manual? If so, rate the importance of the different radiation effects to the system design.

   ANS: Yes. Interested in the complete radiation spectron.

10. Should reliability stress limits (derating criteria) be part of the standard parts list?

    ANS: Yes!

11. Should relative price information be included?

    ANS: No! Always changing and very vendor related.

12. Is non-operating information a consideration?
    How long: 2 years, 5 years, 10 years, longer -- years?

    ANS: Yes! But believe that this subject must be treated very carefully and address the subject in general terms.

13. Should the different grades of devices referenced in MIL-STD-975 have different reliability stress limits?

    ANS: Yes. The different stress limit should reflect the different missions.

14. How many grades of parts should there be?

    ANS: Three (3) grades with the third grade being better than present Class "C".

15. Do you feel that this manual will be used mainly by Design Engineering, Reliability or program functions?

    ANS: If required by contract to use, the main user will be Design Engineering. However, if not required, than Components Engineering/ Reliability will be the main users.

16. What present MIL-STD information should be included in this manual?

    ANS: None.

17. Should ALERTS and a summary of each of them be included? If so, how far back should the ALERTS go?

    ANS: Review ALERTS for information pertaining to device/technology weakness which should be included in each commodity section where appropriate.

18. <u>How should each of the commodities be broken down; by function or construction?</u>

<u>ANS:</u> Similar to that shown by GE/AESD.

19. <u>Would a separate document, with catalog type of data presented in it increase Design Engineering usage of MIL-STD-975?</u>

<u>ANS:</u> No! Design Engineers should be forced to use the slash sheets.

20. <u>Is catalog data formating of Military Spec Parts referenced in MIL-STD-975 desirable?</u>

<u>ANS:</u> No! Same answer as question 19.

D. M. Cole

D. M. Cole
Advance Components Engineering
MD 747
EX 5296

GENERAL ELECTRIC

AEROSPACE ELECTRONIC SYSTEMS

TRAVELER:	PLACE VISITED:	DATE:
D. M. Cole	Teledyne, Northridge, California	12/19/77

ACCOMPANIED BY:	COPIES OF THIS REPORT TO:
--	J. Donnelly N. Scianna T. Poyer G. Snider

OBJECT OF VISIT:	DATE OF VISIT:
Discuss Requirements for NASA Component Manual	11/29/77

A contract (NAS8-32662) to investigate the need for and the content of a proposed Component Application Manual has been awarded to General Electric. As part of this study contract, several NASA installations and NASA contractors are being visited. This visit to Teledyne is one of those visits.

A few weeks prior to this visitation, a list of questions aimed at defining the requirements for this manual was sent to Teledyne. These questions were discussed at this visitation and attached is a summary of their response.

Dale M. Cole
Advance Components Engineering
MD 747
EX 5296

TRIP REPORT

AES 255 (6-70)

What sources presently do you use for your required design and reliability information?

ANS: GIDEP, MIL-HNDB-217B, MIL-STD-975. However, this manual should not just copy military specification over again.

Do you see this manual primarily as a design manual or a standardization manual?

ANS: Design Manual! Used as guideline for the designer.

How should the manual be bound?

ANS: Completely loose leaf for ease of up-dating.

Should the sections be assigned priority and each released as they are completed; or should the manual be released when totally completed?

ANS: Sections assigned priorities with the order being:
1) Transistors
2) Microcircuits
3) Capacitors
4) Diodes
5) Resistors

How should this document be released - e.g., through the Mil-Standard System, part of each RFP, etc.?

ANS: Mil-Standard System.

Should the manual include both the military and equivalent vendor designation on the standard parts list?

ANS: Yes. It is a must in the microcircuit area. Also, resistors and capacitors need this in the slash sheet area.

Should a pictorial cross-section of each part type within a commodity be included?

ANS: Yes, similar to NASA-SP6507

Should a typical process flow chart for each commodity be part of the manual?

ANS: Yes, for Space Programs.

Should radiation be part of the manual? If so, rate the importance of the different radiation effects to the system design.

ANS: Yes, document all that is known in a separate section.

Should reliability stress limits (derating criteria) be part of the standard parts list?

ANS: NASA needs one derating policy for all centers. If this cannot be accomplished through this manual, at least the philosophy behind derating can be explained and the key derating parameters can be identified.

Should relative price information be included?

ANS: No.

Is non-operating information a consideration? How long: 2 years, 5 years, 10 years, longer ---years?

ANS: Yes, for selected component like carbon resistors.

Should the different grades of devices referenced in MIL-STD-975 have different reliability stress limits?

ANS: No! Nobody would pay attention to this; they would only screen the part different.

How many grades of parts should there be?

ANS: One grade for space.

Do you feel that this manual will be used mainly by Design Engineering, Reliability or Program functions?

ANS: Design Engineering with Component Engineering and Reliabilty a close second.

What present MIL-STD information should be included in this manual?

ANS: None! This manual should not be a warmed-up Military specification.

Should ALERTS and a summary of each of them be included? If so, how far back should the ALERTS go?

ANS: Yes, three years with corrective action.

How should each of the commodities be broken down; by function or construction?

ANS: Similar to that shown by G.E.

Would a separate document, with catalog type of data presented in it, increase Design Engineering usage of MIL-STD-975?

ANS: Yes.

GENERAL ELECTRIC

AEROSPACE ELECTRONIC SYSTEMS

TRAVELER: George Snider	PLACE VISITED: U.S. Navy Printing Service, Washington Navy Yard, Washington, DC	DATE. 11/17/7
ACCOMPANIED BY: -	COPIES OF THIS REPORT TO: D. Cole, J. Donnelly, T. Poyer, N. Scianna	
OBJECT OF VISIT: Discuss Printing and Distribution Requirements for Proposed NASA Component Application Manual		DATE OF VISIT. 11/10/77

Persons Visited: Harold Burby, Head, Naval Printing Service
Don Lee

A contract (NAS8-32662) to investigate the need for and the content of a proposed Component Application Manual has been awarded to General Electric. One of the objects of this contact was to determine the best methods of printing, binding and distribution of this manual. This visit to the Naval Printing Service was to help accomplish this objective.

Our normal location for obtaining Military Specifications is the DOD, Philadelphia Printing Service. By contacting Theodore Kimelheim at that location, it was learned that the best information would be obtained by contacting Harold Burby at the U.S. Naval Printing Service in Washington, D.C., who has chief responsibility for decisions on publications printed for the Department of Defense. Therefore, this visit was arranged with him.

Discussion with Mr. Burby and Mr. Lee indicated that they would be willing to accept a contract to print and distribute the manual, however they were surprised that NASA would not want to do it themselves.

The book can be bound in almost any manner, however perfect binding would be more expensive.

Printing is usually prepared and accomplished according to a known standard such as Navy specification EMSSO-GB-1 (copy to be supplied to GE). Their opinion was that NASA must have their own specification (probably controlled by Goddard Space Flight Center) which they would be able to adhere to.

This was the first time they had been involved in project as exploratory in nature, as usually the printing specification has already been selected by the contractor. They suggested that before a specification is selected, that NASA be questioned on whether they require their own specification.

TRIP REPORT

AES 255 (6-70)

Most sheets have a trim size of 7-7/8 inches by 10-1/4 inches, but specification would cover how camera ready copies would be prepared, how they would be captioned, artist preparation etc.

Distribution and printing would actually take place at one of several DOD printing facilities. In our case, the most likely facility would be the Naval Publication Printing Service Office, Brooklyn, New York. However, they felt that NASA may want to use their own printing service. At the time of printing, they felt the details could be worked out with the actual printing service.

George A. Snider
Components Engineerin g

APPENDIX "B"

CONSENSUS SUMMARY OF POTENTIAL USER SURVEY QUESTIONS

CONSENSUS SUMMARY OF POTENTIAL USER SURVEY QUESTIONS

What sources do you presently use for your required design and reliability information?

ANS: Goddard Application Notes
Parts Engineer Consultation
Alert System
GIDEP
Mil-Hbk-217
Mil-Std-975
Mil-Std-1470
Mil-Std-198 & 199
User Preferred Parts Lists
User Parts Manuals
PPL 13

Do you see this as a design manual or standardization manual?

ANS: Design manual that would assist standardization efforts. This would be of special benefit to small contractors and new engineers.

How should this manual be bound?

ANS: Concern was over ease and cost of updating. There was a slight preference for complete loose leaf construction with many respondents feeling strongly that users would be more apt to keep books up-to-date if bound by section. Some respondents also felt that if bound by section, each section could have a single amendment generated between revisions.

How should this document be released?

ANS: The general consensus was that the Mil Spec System would be the most practical and accessible. However, there were some strong objections based on slowness and difficulty of updating through this system and that maybe it should be contracted to a separate publisher.

Should the manual include both Military and an equivalent vendor designation on the Standard Parts List?

ANS: Yes.

Should a pictorial cross section of each part type within a commodity be included?

ANS: Yes, would be helpful to both parts and design engineers. However, a few felt this to be useless information.

Should a typical process flow chart for each commodity be included?

ANS: The majority felt this information would not be accurate and/or current and should not be included.

<u>Should radiation consideration be part of the manual?</u>

ANS: The majority felt that information affecting general parts past performance and how it was affected should be included.

<u>Should reliability stress limits (derating criteria) be part of the Standard Parts List?</u>

ANS: Although there was some opposition, the majority felt that this was necessary to standardize between users.

<u>Should relative price information be included?</u>

Ans: Most respondents felt this would not be very accurate.

<u>Is shelf life information a consideration?</u>

ANS: The majority believed this should be included in general terms.

<u>Should the different grades of devices have different reliability stress limits?</u>

ANS: There was much disagreement on this. However, a slight majority seems to be against this for different reasons, including the possiblity of over derating to a point of decreased reliability.

<u>How many grades of parts should there be?</u>

ANS: Most felt there was a need for three classes: two the same as in Mil-Std-975 and one lower class.

<u>Do you feel that this manual will be used mainly by Design Engineering, Reliability or Program Functions?</u>

ANS: The answer varied between respondents. But it appears to be a close contest with Parts Engineers, Reliability Engineers, and Design Engineers finishing in that order. There was also an expression that Design Engineers with small contractors and new engineers would benefit the most.

<u>What present Mil-Std information should be included in the manual?</u>

ANS: Generally, as <u>little</u> as necessary.

<u>Should ALERTS and a summary of each of them be included?</u>

ANS: Most felt that this should not be included except where necessary to demonstrate application information.

<u>How should commodities be broken down?</u>

ANS: Similar to the breakdown shown on the GE chart.

<u>How should the book be organized?</u>

ANS: Similar to method shown on GE chart except that more commodities should be added.

<u>Would a separate document, with catalog type of data presented in it, increase Design Engineering usage of Mil-Std-975?</u>

ANS: Yes, would help encourage use of standard parts. It could be the most used part of the manual.

<u>Is catalog data formating of Mil Spec parts referenced in Mil-Std-975 desirable?</u>

ANS: Yes, for same reasons as above answer.

APPENDIX C

IMPACT OF NON-STANDARD PARTS

1. INTRODUCTION

In the selection of a part for a given application, the Design Engineer considers suitability of the part for the application. Items considered include electrical and mechanical characteristics, environmental capability, reliability, availability, purchase cost, and other apparent factors. However, there are various intangibles, particularly in the area of cost, which are frequently overlooked or are afforded only cursory attention. The major reason for the limited attention to these intangibles is attributed to the lack of definitive data in this area.

This section discusses various costs incurred by the specification of new parts.

2. TYPICAL COSTS

AES experience has shown that typical costs involved in the specification of a new nonstandard part are as indicated in Table 1. This shows that the cost incurred by the call-out of a nonstandard part ranges from --- for lamps to as high as for linear integrated circuits. It must be remembered that AESD's system requirements are normally military in nature and therefore these costs are higher than those in a commercial manufacturers house. These are only the basic costs of introducing a new part into tthe GE-AES inventory. Additional considerations to which it is not possible to apply a cost figure at this time include the following:

a). Stocking costs including handling, storage space, storage facilities, inventory control, etc.

b). Problems entailed by having only a single source.

c). Problems of schedule slippage, expediting, and decreased vendor response on problems with special parts.

d). Additional failure analysis activity entailed by new, unproven parts.

2. <u>TYPICAL COSTS</u> (Continued)

e). Increased cost due to small procurement quantities. This cost is estimated to average an additional 40 percent over the purchase cost of larger quantity standard parts.

Also not included in the basic costs of Table 1 are the logistics cost which must be borne in maintaining supplies of the new parts for field maintenance. Estimates of the paper cost alone for the introduction of a new part in the military logistics system range from $1000 to $5000.

The constribution of the various areas of activity to the costs of new parts are discussed in more detail in paragraph 3 of this Section.

3. DETAILED COSTS (Continued)

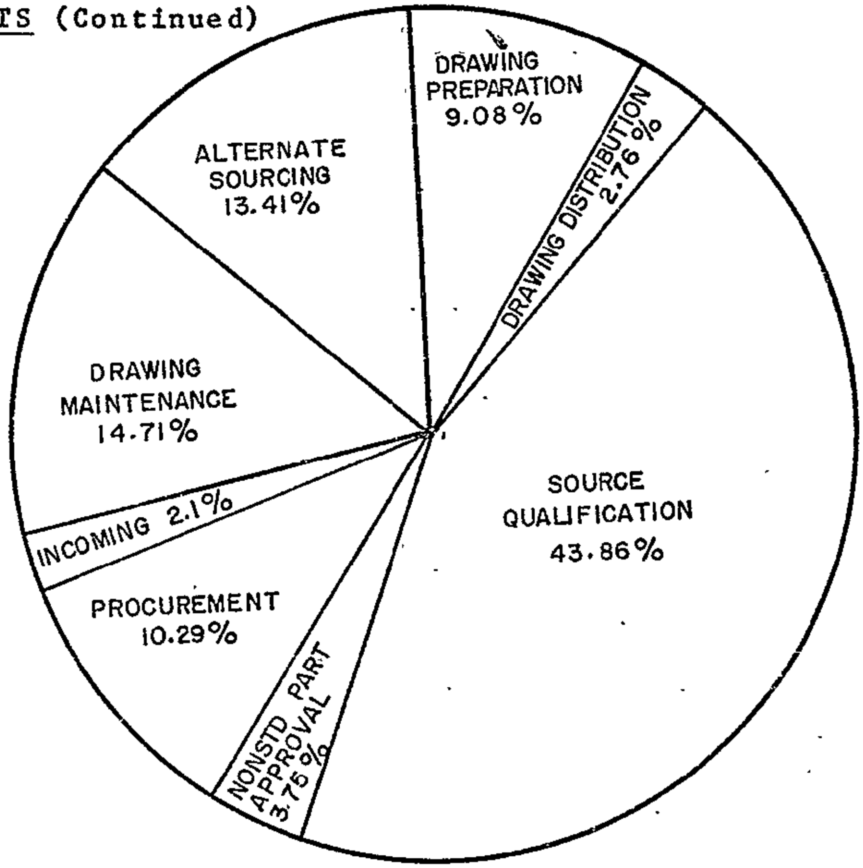

Figure 1. New Part Activities

The relative contribution of each of these activities will, of course, vary among the various part types.

APPENDIX D

SUGGESTED INDEX FOR EACH COMMODITY

SECTION CONTENTS

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SECTION CONTENTS

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SECTION CONTENTS

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SECTION CONTENTS

SECTION CONTENTS

SECTION CONTENTS

SECTION CONTENTS

SECTION CONTENTS

Section

SECTION CONTENTS

SECTION CONTENTS (Continued)

SECTION CONTENTS

SECTION CONTENTS

SECTION CONTENTS

SECTION CONTENTS

SECTION CONTENTS

SECTION CONTENTS

SECTION CONTENTS

SECTION CONTENTS

APPENDIX E

COMMODITY GENERAL INFORMATION

COMMODITY GENERAL INFORMATION

5. GENERAL PARAMETER INFORMATION (Continued)

Insulation resistance. Insulation resistance (IR) is expressed in megohms or megohm-microfarads for capacitors with conventional dielectric, and in terms of leakage current, usually microamperes for electrolytics. The effects of this parameter may be significant in timing and coupling applications, or where voltage division action occurs. Leakage current increases with temperature. Figure 3 shows typical comparative values for various dielectric materials.

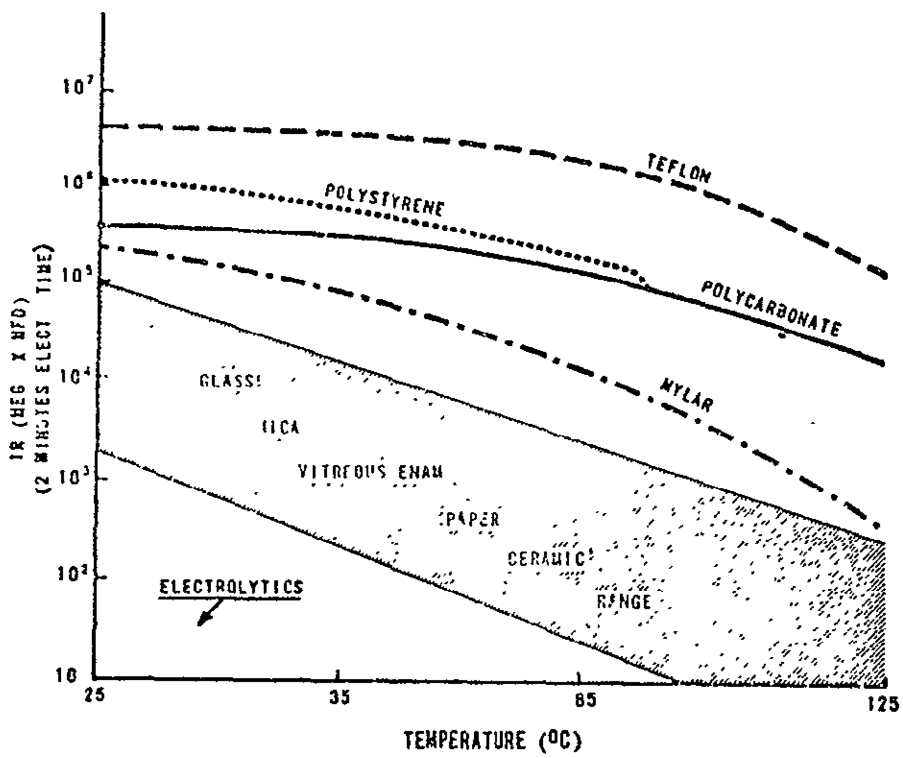


Figure 3. Typical Values of Insulation Resistance vs. Temperature

Dissipation Factor (DF) or Equivalent Series Resistance (ESR). Dissipation factor is a function of capacitance, ESR, and frequency. Unless otherwise specified, DF is measured at the following frequencies:

5. GENERAL PARAMETER INFORMATION (Continued)

It also follows that if a capacitor is operated at a frequency higher than its resonant frequency, it will no longer be a capacitor to the circuit, but will appear as an inductor.

Since there are so many variables affected by frequency, no attempt to present comparative values will be made here. As a guide for general areas of frequency applications for different types of capacitors, Figure 4 can be used for an initial approximation. Specific computations and/or measurements should be used to finalize any particular application.

Figure 4 reflects a frequency range of most efficient application based on normal design values and criteria. Both upper and lower limits of frequency usage can be extended somewhat by special design and construction techniques, as shown by the dashed areas.

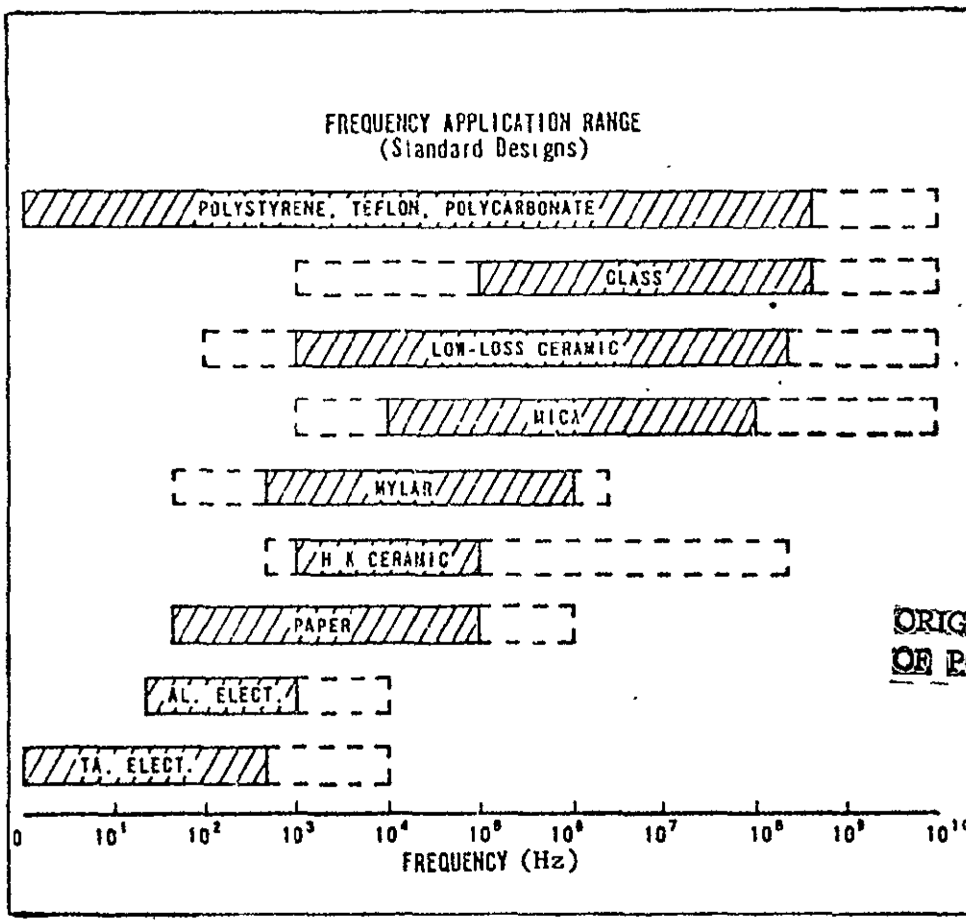
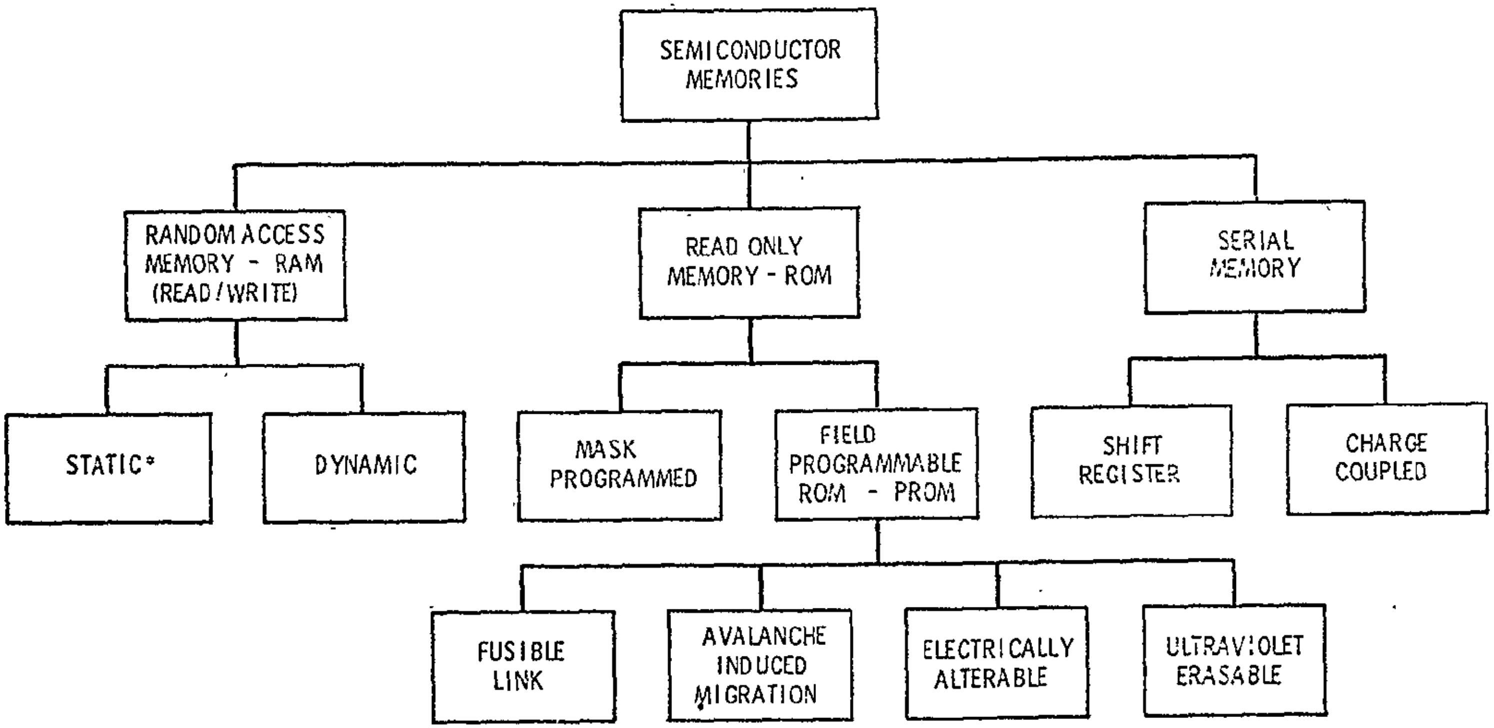


Figure 4. Frequency Application Range (Standard Designs)

1. INTRODUCTION (Continued)



*SOME STATIC RAMS ARE ACTUALLY QUASI-STATIC. THAT IS, THE MEMORY CELL IS STATIC, BUT READ/WRITE OPERATIONS REQUIRE A CLOCKED CHIP ENABLE

FIGURE 1. SEMICONDUCTOR MEMORY FAMILY

1. INTRODUCTION AND BASIC FABRICATION (Continued)

Aside from the fact that the mesa structure lends itself to a mass fabrication wafer process, such devices have some important electrical advantages. Among the advantages are: high voltage breakdown, increased structural strength, and high gain in the gigahertz frequency spectrum.

The principal disadvantage of the basic mesa transistor is an increase in VCE (SAT) in a switching circuit. A further disadvantage is a high reverse leakage characteristic caused by the exposed base-collector junction that occurred at wafer separation.

Recent progress in the fabrication process has developed an epitaxial mesa transistor. As illustrated in Figure 3 the high resistivity part of the collector region is grown on top of a low resistivity wafer. This process overcomes the high VCE (SAT) and retains all the advantages of high gain, excellent frequency response, and high breakdown voltage.

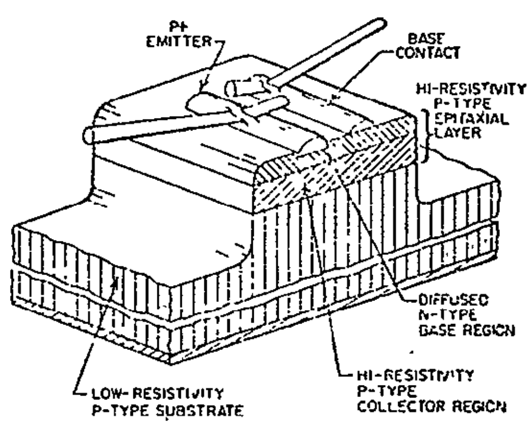


Figure 3. The Epitaxial Mesa Structure

Yet, there still remained a drawback. The exposed collector-base junction restricts the application where high reverse leakage current is critical.

Planar Construction. Advancements in the wafer mass fabrication technique have developed the epitaxial planar transistor. The planar transistor, see figure 4, like the mesa, begins with a low-resistivity substrate, capped by an epitaxial layer, and then by a very thin film of silicon dioxide, SiO_2. As can be seen the base-collector region is not exposed and the junction is said to be passivated.

1. INTRODUCTION AND BASIC FABRICATION (Continued)

Discussion of Basic Construction

The quality of transistors is presently high, largely because of improvements in manufacturing techniques. Several different methods of fabrication have been developed and three will be discussed: Mesa, Planar, and Annular (which is a modification to the planar process). These methods represent structural techniques which have provided the industry with devices for highly diversified applications.

Mesa Construction. A major breakthrough in high-frequency transistor design came with the developement of the mesa structure.

In the basic mesa transistor fabrication process, see Figure 2 below, the collector region is lightly doped resulting in high-resistivity material, either p or n type, depending on the desired transistor structure.

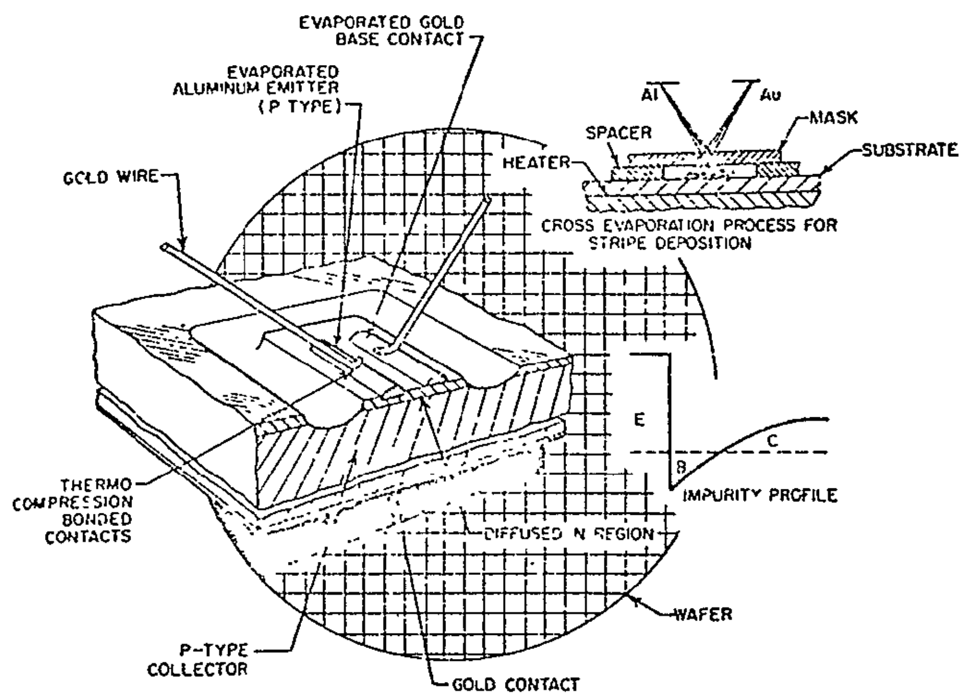


Figure 2. The Basic Mesa Structure

Due to the fabrication of transistors in a wafer form a separation process is employed that minimizes ragged breaks that would possibly produce loose material which would adhere to the edges and short out the base to collector junction. Accordingly, an etching process is employed to form a moat around the active area of each transistor, leaving sort of a mesa, or plateau.

5. ELECTRICAL CHARACTERISTICS

Characteristics of recommended switching transistors are shown in Table 5, paragraph 22.1.8.

The parameters of interest may be separated into static and transient groupings. This is, of course, somewhat arbitrary in that the same parameters may be in both aspects of the device behavior, but is convenient for purposes of discussion.

Static Parameters of Switching Transistors

Leakage current along with current gains, determines to a large extent the minimum off current, I_o, of the collector. The physical nature of I_{CO} is discussed in paragraph 22.0.5. In this section, only the manner in which it influences the circuit designer will be discussed.

Minimum Off Current, I_{CBO}. I_{CBO} is defined as the d-c collector current when the collector junction is reverse biased and the emitter is open-circuited. Its value is determined by the voltage applied and the temperature at which it is measured as is indicated in Figure 33. As the curves indicate, I_{CBO} essentially varies exponentially with temperature and above the "knee" of the voltage curve tends to follow an exponential variation with voltage.

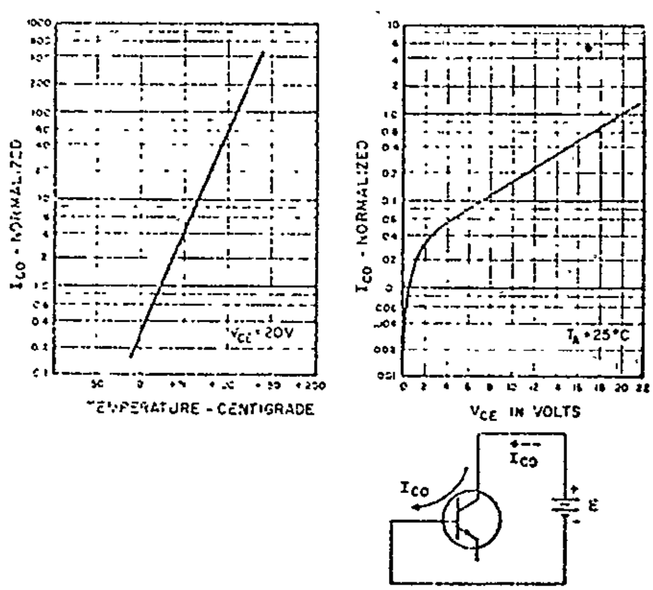


Figure 33. Behavior of I_{CBO} With Temperature and Voltage

Another alternative is the use of 1 mil gold wire thermocompression bonds to gold metallization on the die. The strength and stability of gold wire is achieved without the plague problems; however, few manufacturers have parts available with gold/gold interconnections. Where available, this system should be used.

The majority of suppliers use AuAl or AlAl interconnect schemes. Double post bonds are recommended for either system to provide good adhesion to the post. Gold ball thermocompression bonds and ultrasonic aluminum chisel bonds are the only acceptable means of bonding the wire to the die. Wire quality and material content, and metallization thickness and texture, must be controlled by the manufacturer for reliable bonding. Bond location and adequate pad size also are important controlling factors in reliable interconnects.

Lifted Die Mechanisms - Excessive voids in the eutectic bond or undue mechanical stress can cause die to lift off the header. In parts with dielectrically isolated collectors or gates, ceramic insulators which do not have adequate mechanical support to the header can break die during mechanical stress and result in opens.

Lifted Die Detection Methods - Parts which have marginal die attachments can usually be detected through X-ray of the die header assembly, looking for voids. Power pulse V_{CE} (SAT) measurements will also detect such defects.

Lifted Die Minimization - Die and insulators should be firmly attached to header rather than suspended from the leads. Ceramic temperature coefficients should be matched closely to Si to preclude cracking due tc thermal expansion.

Metallization Failure Mechanisms - Metallization opens are usually a problem only in expanded contact devices since current is carried from the die to the wire bond by paths of metallization. Scratches due to improper die handling and missing metallization due to photolithography defects are commonly the source of open metallization paths. Aluminum can also migrate from thinned areas to create voids. This is a problem in rf and power devices where metallization cross-sectional area and current requirements cause excessive current densities in the Al film. Improper alloying (sintering) of the Al film to the silicon and SiO_2 surfaces results in peeling and lifting of the metallization. This also can be a problem in direct contact devices. Another mechanism is failure of the metallization to make contact with silicon due to an incomplete etch of the SiO_2 at the window, or growth of SiO_2 at the interface of the Si and Al. Molygold metallization system failures are sometimes caused by excessive undercutting of the moly during etching or inadequate alloying of the moly.

Metallization Failure Detection Methods - A pre-cap visual inspection will detect open or degraded metallization fingers in uncapped parts. Electrical testing will reveal those sealed parts having open metallization paths. Metal voiding due to migration can be discovered by a forward burn-in at rated current. Several integrated circuit users require sample SEM inspection of each wafer to determine adequate metal coverage over oxide cuts.

9. GENERAL RELIABILITY CONSIDERATIONS (Continued)

Application Considerations

Operating temperature is a major factor in transistor reliability and will be the major portion of this write-up on general application considerations. Heat degrades bulk characteristics and has a degenerative run-away effect on junction characteristics. Localized hot spots resulting from impurity in materials, and localized high current densities frequently causes anomalies in performance. Material and process control during manufacture of a part can partially alleviate these problems, but cannot remove the need for rigorous temperature control in final application.

Figure 36 illustrates a portion of the thermal spectrum. Temperature scales appear in degrees Centigrade and degrees Fahrenheit. This illustration is attempting to show in pictorial terms, the present semiconductor storage, operating, and circuit design limits.

Melting point temperatures of a variety of metals used in the transistor fabrication are also shown. Many other materials important to semiconductor manufacture do not appear because of space limitations.

It can readily be seen from Figure 36 that in any circuit design involving semiconductors, consideration of temperature is vital. Therefore, reliable operation of a transistor over a wide temperature range requires that bias voltage and current remain reasonably stable.

As temperature limits are increased, reliability is more difficult to "design in" using germanium devices; therefore due to wide temperature ranges required in military applications, germanium transistors should not be used.

3. GENERAL DEFINITIONS (Continued)

Conversion Rate - The number of conversions an A/D converter is capable of making per second, usually expressed in MHz or kHz.

Conversion Time - The time a converter uses for one complete conversion.

Gain (Scale Factor) Error - The difference between a measured output and the ideal output in a D/A converter.

Glitch - When turn-off times and turn-on times of bit switches are not precisely equal, a spike (or glitch) is induced in the output. The magnitude of this spike is dependent upon the amount of mismatch in the switching times.

Least Significant Bit (LSB) - The bit which corresponds to the smallest analog increment is called the least significant bit (LSB). In an 8-bit converter, for example, it represents $(1/2)^8$, or 1/256 the total analog range.

Linearity - The linearity of a converter can be described as the deviation from the "best straight line" value for any given bit.

Monotonicity - The output of a converter is monotonic when it moves in an increasing direction in response to an increasing input stimulus.

Most Significant Bit (MSB) - The Bit which carries the most weight (1/2 of the analog range, by definition) is called the most significant bit (MSB).

Offset Binary Code - The only differences between the offset binary code and the binary code is as follows. In offset binary 000....0 corresponds to the most negative analog value (-Full Scale), 1111....1 corresponds to the most positive analog value (+Full Scale), and 1000....0 corresponds to zero analog value.

Offset Error - The amount which must be compensated for (by actual adjustment) for the "all bits off" condition.

Quantization Uncertainty - For a given digital code there is a range of analog values associated with it. The mid-point of this range is usually specified as being the value associated with the digital code. However, since the range is 1 LSB wide, the uncertainty is $\pm$ 1/2 LSB.

Relative Accuracy - This is the deviation of actual analog values from nominal analog values for a given digital input.

Resolution - The resolution of a converter is the ratio of the value of the LSB to the full analog range, or $(1/2)^n$ where n is the number of bits.

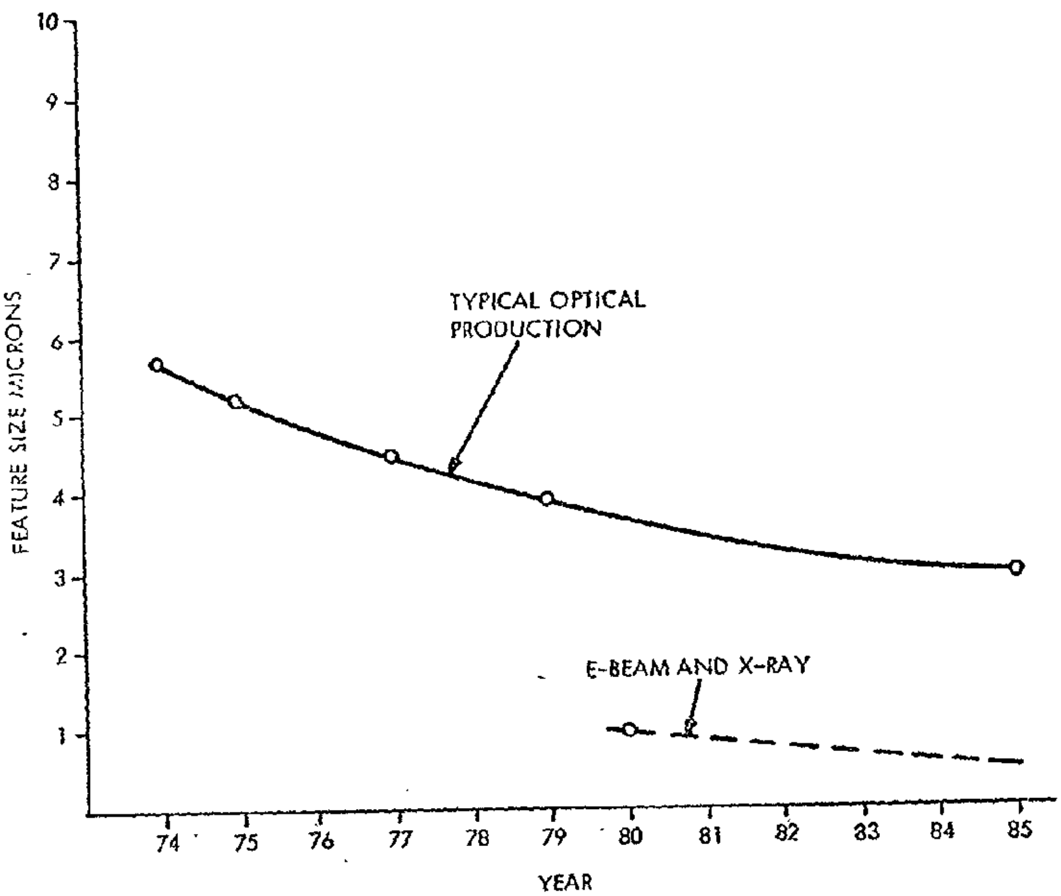


Figure A-3. Impact of E-Beam and X-Ray on Microelectronics Chip Die Feature Size

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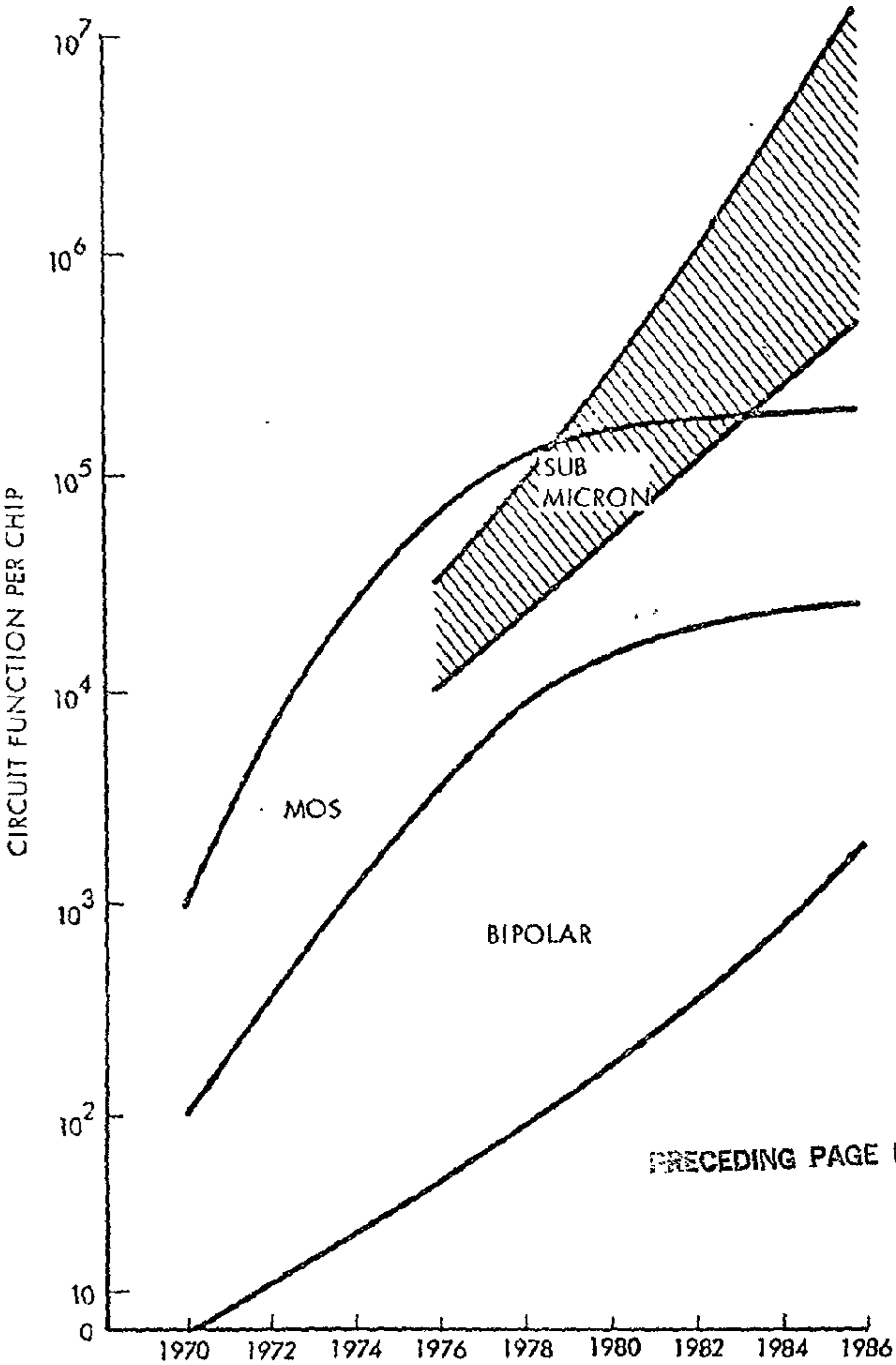

Figure A-4. Anticipated Microelectronics Circuit Density vs. Time

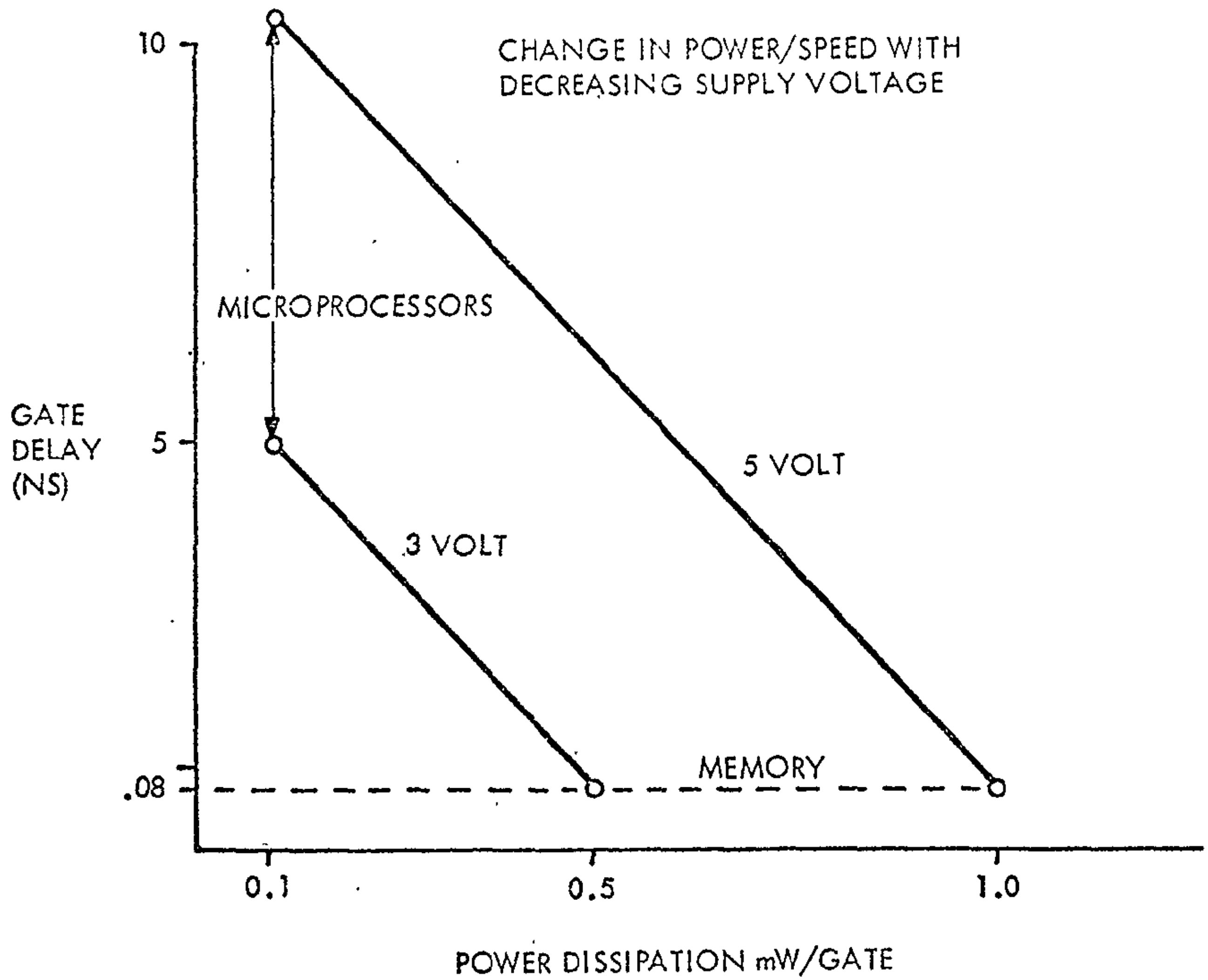

Figure A-5. Microprocessor/Memory Change in Power/Speed vs. Decreasing Power Supply Voltage

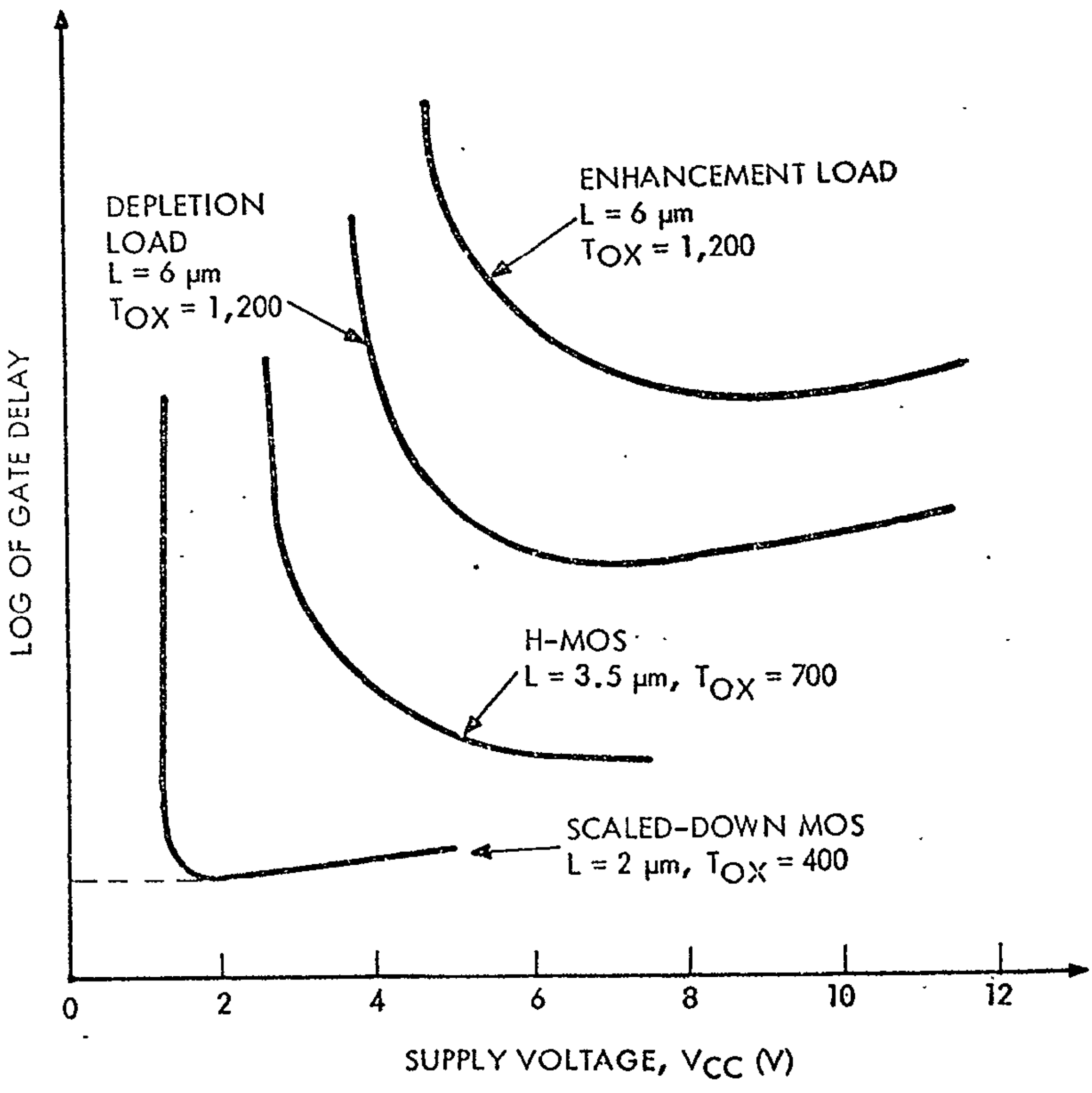

Figure A-6. MOS Process: Gate Delay vs. Supply Voltage

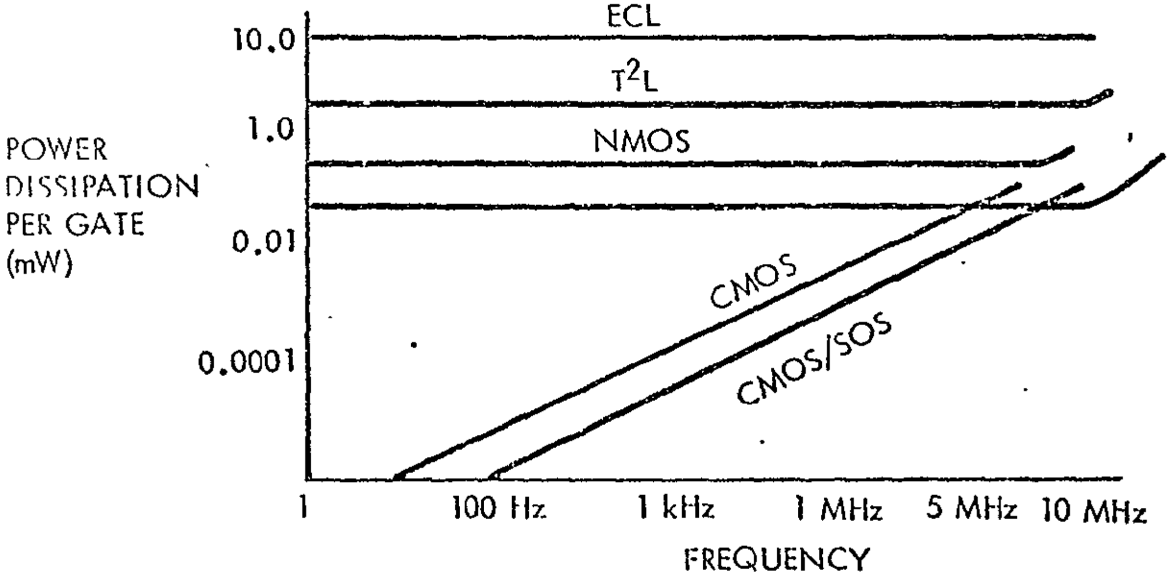

Figure A-7. Power Dissipation per Gate vs. Frequency for Various Microelectronics Technologies

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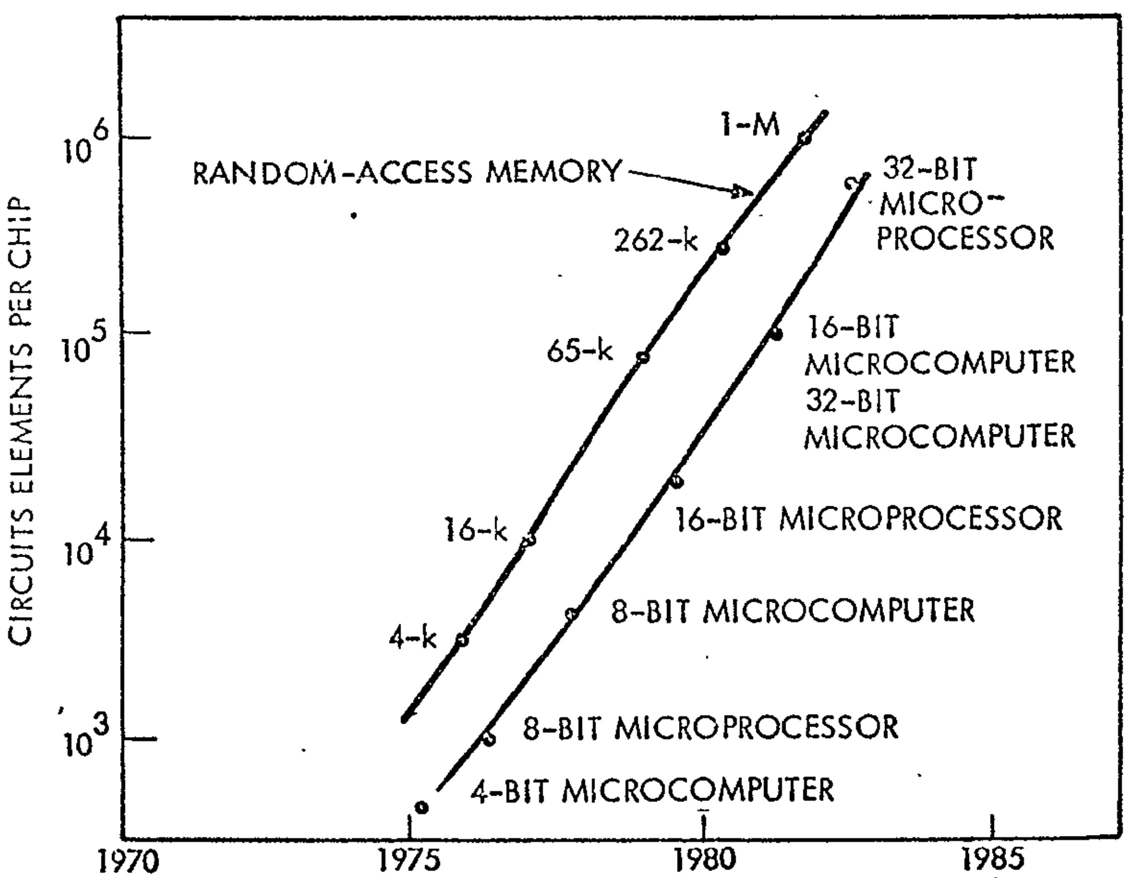
	RANDOM-ACCESS MEMORY		MICROPROCESSOR		MINIMUM LINE WIDTH (MILS)
	CHIP SIZE (X 1,000 MIL^2)	BIT DENSITY (X 1,024 BIT)	CHIP SIZE (X 1,000 MIL^2)	WORD LENGTH (BITS)	
1976	32	16	52	8 & 16	0.2
1979-1980	32	64	50	16	0.07
	50	256	60	32	0.04
1981-1983	45	256	55	32	0.03
	60	1,024	65	32	0.02



. RADIATION INFORMATION

TYPICAL GENERAL RADIATION INFORMATION

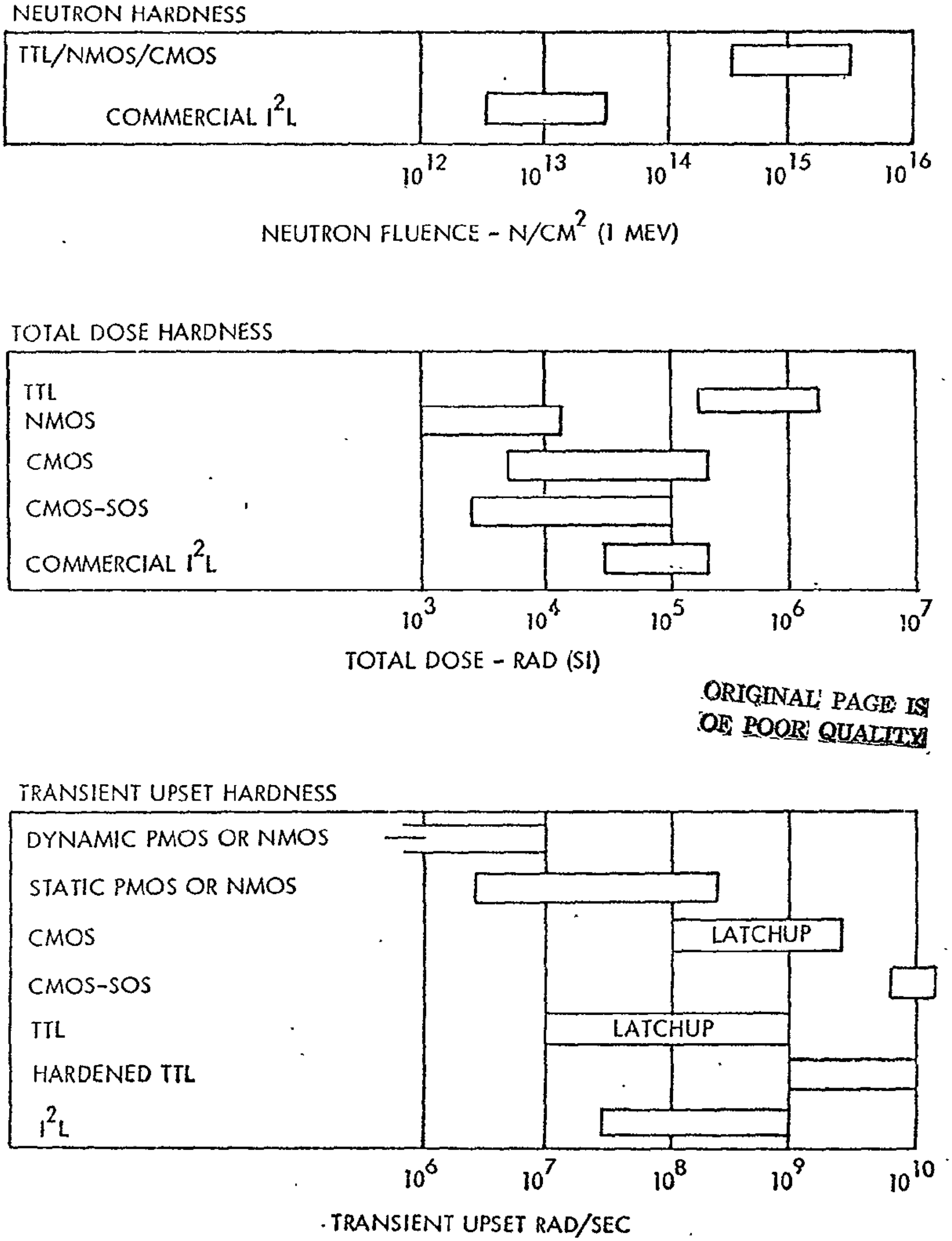


Figure A-9. Radiation Hardness Comparison of Various Microelectronics Technologies

TOTAL PARTS PROGRAM

6. INCOMING TESTING (Continued)

Rejection	Percent of Total Rejected Transistors* (4.6)	Diodes* (4.3)	IC's* (4.8)
Marking	24.1	20.7	20.9
Carrier Mounting	14.9	0	29.4
Leads Damaged	2.30	5	8.1
Lead Plating	14.0	12.2	9.8
Leads Contaminated	24.1	20.7	11.5
Wrong Part	8.1	17.3	7.7
Dimensions	1.0	17.2	1.0
De-Cap	11.6	6.9	11.6
Supplier Data (10% Log Jeopardy)	0	0	0

*Total percent rejected

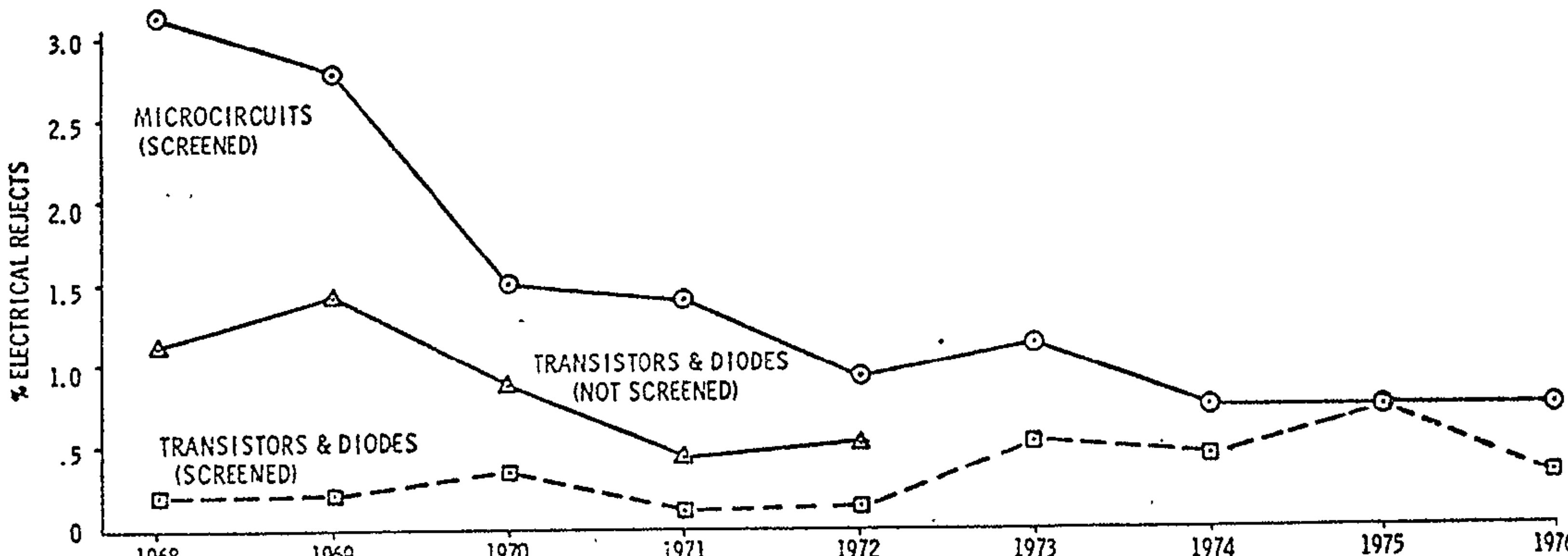
Figure 1b. Incoming Mechanical Rejection

Failure Analysis and Corrective Action

The improvement of equipment reliability is highly dependent on the determination of equipment failure causes and the analysis of these failures to determine appropriate corrective action. Under the formal program at GE/AESD, failed parts, along with failure commitances, are submitted to the Measurement and Analysis Laboratory of Component Engineering. Here, the ports are tested to verify the reported failure and analyzed to determine the cause of the failure.

GENERAL ELECTRIC

INCOMING TEST PERFORMANCE



	1968	1969	1970	1971	1972	1973	1974	1975	1976
UNSCREENED	410,000	228,000	126,000	70,000	6,000	—	—	—	—
SCREENED	122,000	160,000	99,000	190,000	212,708	135,000	232,000	144,000	155,092
MICRO	438,000	389,000	302,000	380,000	556,000	128,000	198,000	407,000	403,684
TOTAL	970,000	777,000	527,000	640,000	774,000	263,000	430,000	551,000	558,776

GENERAL ELECTRIC

MICROCIRCUITS
SUPPLIER FAULTS FAILURE MECHANISMS
1970-1976

(PERCENT)

	1970	1971	1972	1973	1974	1975	1976
CRACKED DIE	-	-	44.4	3.3	1.5	-	-
METALIZATION	8.5	3.1	3.6	9.9	4.6	7.9	5.0
WIRE BOND	33.9	23.4	11.7	13.2	25.0	21.1	12.5
PACKAGE	3.8	5.5	9.7	17.6	14.1	-	30.0
DIFFUSION	20	46.9	12.6	19.8	17.4	5.3	22.5
CONTAMINATION	14.6	4.7	8.7	25.2	10.9	7.9	2.5
OTHER	3.8	3.9	7.1	9.9	25.0	10.5	7.5
DIE BOND	15.4	12.5	2.2	1.1	1.5	-	-
MARKING	-	-	-	-	-	2.6	-
VENDOR TEST PROCEDURE	-	-	-	-	-	34.2	20.0
OXIDE DEFECT	-	-	-	-	-	10.5	-
NO. FAILURES	130	128	196	91	64	38	40

APPENDIX F

ELECTRICAL CHARACTERISTICS

USUAL APPLICATIONS & CHARACTERISTICS

RELIABILITY CONSIDERATIONS

ELECTRICAL CHARACTERISTICS

5. ELECTRICAL CHARACTERISTICS (Continued)

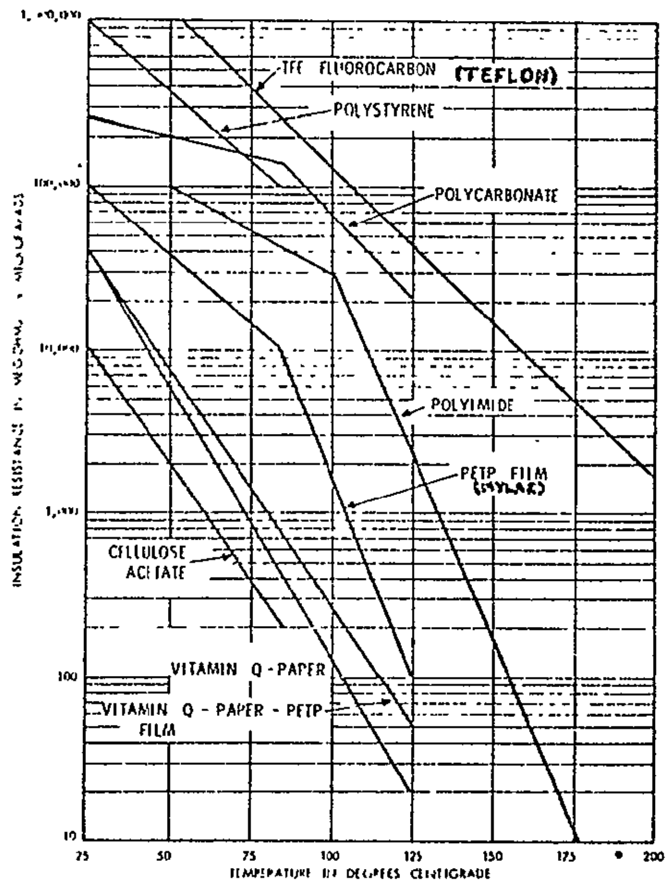
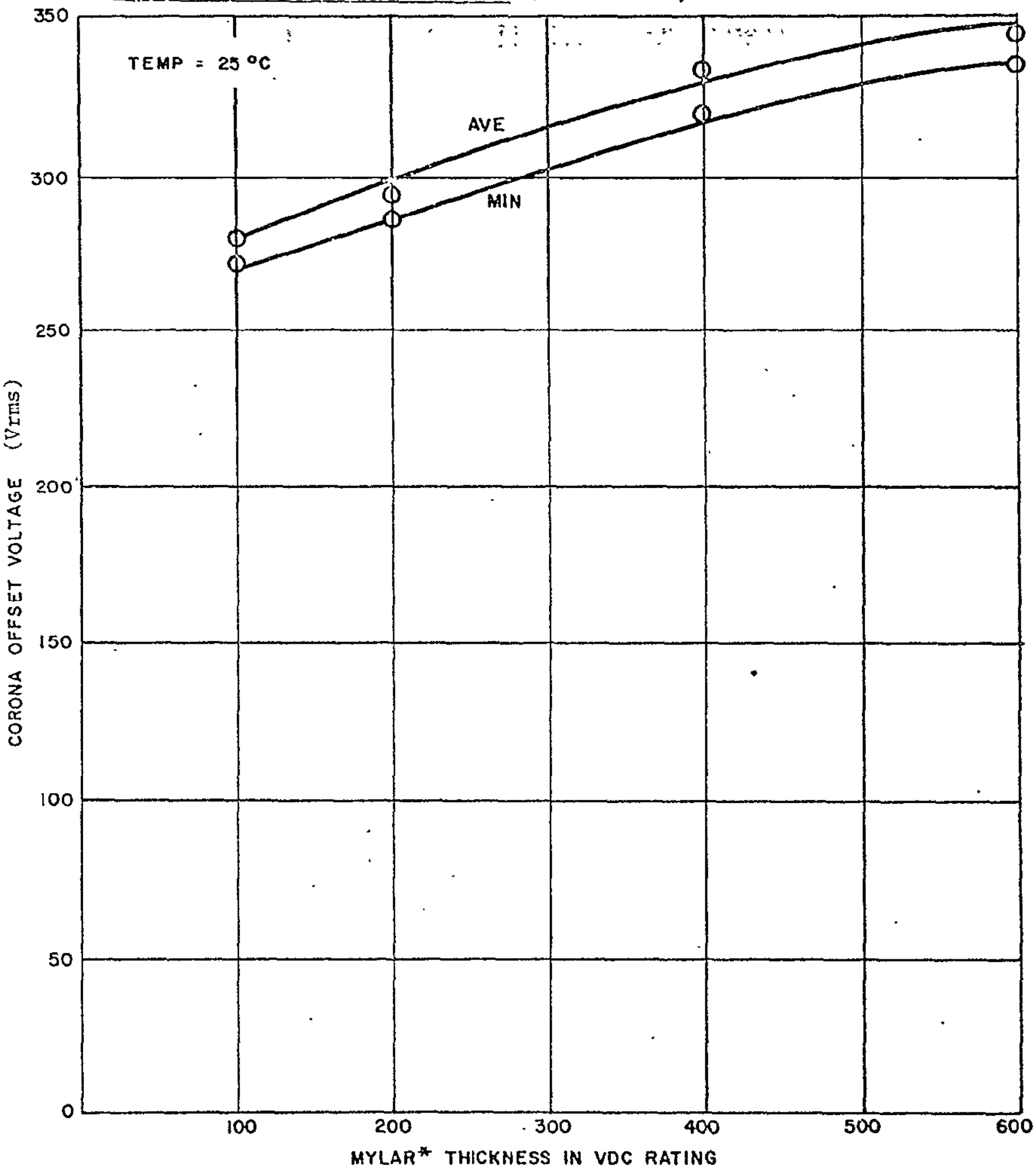


Figure 4. Insulation Resistance vs. Temperature for Various Dielectrics

A-C Operation

As with all capacitor types, the main factors to be considered in a-c applications of paper and plastic capacitors are two: corona and internal heat rise. This presumes, of course, that the capacitor is being operated within the limits of its voltage rating. It should be noted that corona is not strictly an a-c phenomenom, but other factors in a-c applications generally control the capacitor design parameters such that a-c corona does not become of critical concern except in special cases. In a-c applications, corona considerations must always be factored in because of the relatively low voltages at which a-c corona is initiated.

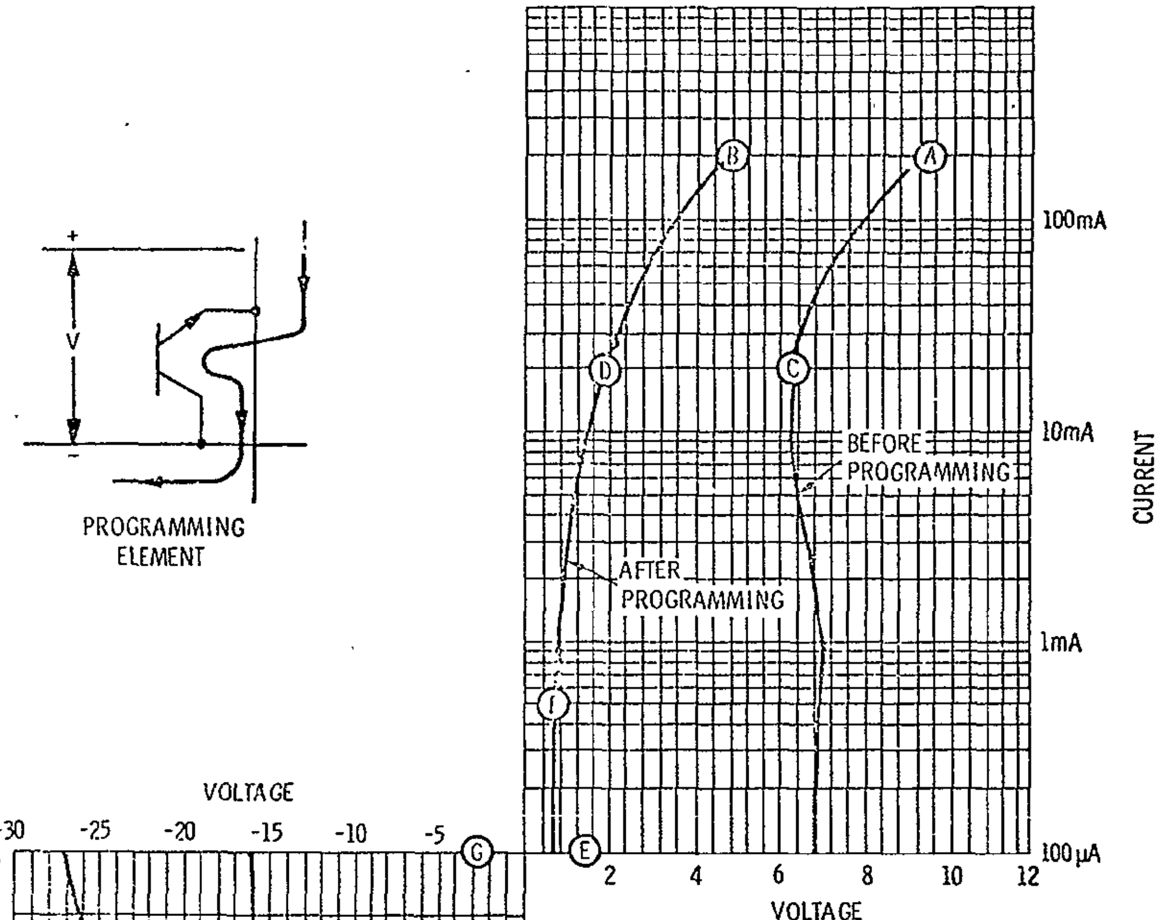
5. ELECTRICAL CHARACTERISTICS (Continued)

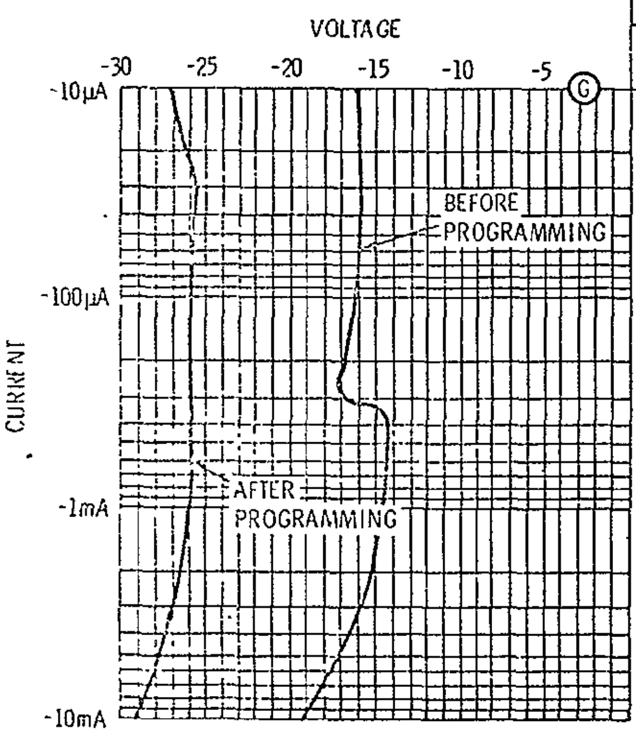


* Registered Trademark, Dupont Co.

Figure 5. Corona Offset Voltage vs. Vdc Rating

5. ELECTRICAL CHARACTERISTICS (Continued)





(A) Unprogrammed element at 200mA programming current

(B) Programmed element at 200mA programming current

(C) Unprogrammed element at 20mA sense current

(D) Programmed element at 20mA sense current

(E) Selected unprogrammed element under operating voltage condition (current is typically $< 1uA$)

(F) Selected programmed element under operating current and voltage conditions

(G) Unselected programmed or unprogrammed element under operating voltage condition (current is typically $\ll 1uA$)

FIGURE 20

AIM Element, Voltage/Current Characteristics

5. ELECTRICAL CHARACTERISTICS (Continued)

FIGURE 17c

Blown Poly-Silicon Fuse

Avalanche Induced Migration (AIM)

A different approach to a programmable element was developed and patented by Intersil, Inc. The technique is referred to a Avalanche Induced Migration (AIM).

A schematic representation of an AIM programming element and matrix are shown in Figure 18. Instead of a fusible link in series with a diode, the AIM element is a standard vertical NPN structure with its base open. Programming the element is achieved by applying pulses (reverse bias) between the emitter and collector. The programming pulses are of sufficient magnitude to eventually cause aluminum to spike (migrate) from the emitter to the base region due to the avalanche (secondary) breakdown conditions. (See Figure 18.) The resulting E-B short creates a diode.

5. ELECTRICAL CHARACTERISTICS (Continued)

Whether the switches are closed (logic "0") or open (logic "1") is determined at the metalization step during fabrication. Once the user has determined his bit pattern, this information is conveyed to the semiconductor manufacturer who then makes the necessary masks for that bit pattern.

Metalization is deposited over the entire silicon chip and is selectively etched away (after the mask step) where it is not wanted. Hence, these ROMs are referred to as mask programmable ROMs.

Manufacturers can fabricate ROM wafers up to this final mask step and store them. Then, the delivery cycle can be cut to 4 - 8 weeks for new patterns. In general, a mask set for a ROM costs the user from $750 to $1250 in non-recurring cost. Amortized over a large quantity of devices, this cost becomes negligible.

Since single transistor (diode) cells can be made extremely small, ROMs are presently available in sizes up to 16,384 (16K) bits. 32K and 64K bit devices are either in the planning stages or in engineering development.

Programmable Read Only Memories (PROMs)

In contrast to mask programmed ROMs, there is a class of devices known as field programmable ROMs, or PROMs. Instead of being programmed during the manufacturing cycle, they are programmed by the user. PROMs are especially useful during the design stages of a system when bit patterns are subject to change due to design iterations or where the quantity required for production is moderate. Of course, once bit patterns are firmly estalbished, and device quantities are large enough, it would be more practical and economical to switch to ROMs for the production phase of a product line.

PROM technologies are quite numerous. On one hand, there are PROMs in which the data bits are permanently programmed. A more recent development are alterable PROMs. Each technology will be discussed separately.

5. <u>ELECTRICAL CHARACTERISTICS</u> (Continued)

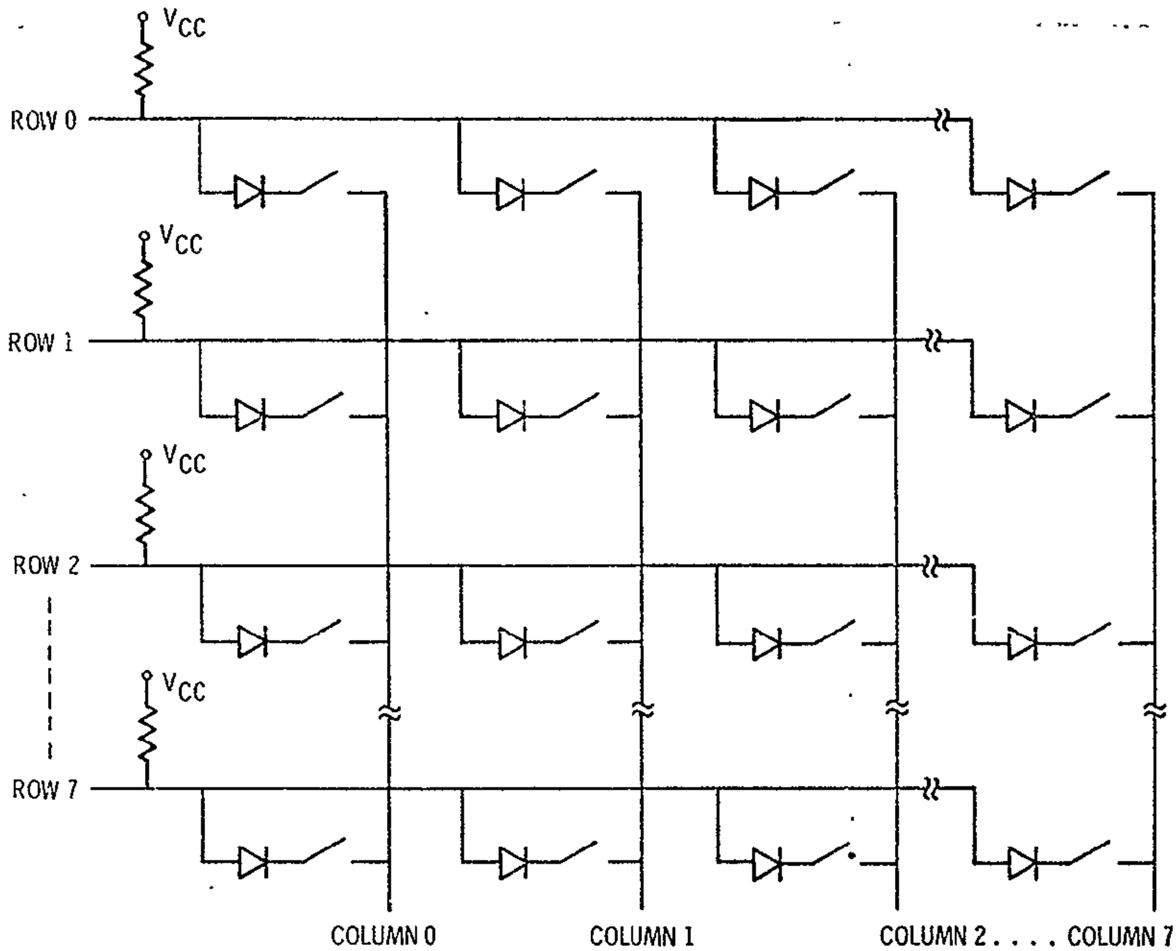


FIGURE 15c

A Portion of the 8 x 8 Storage Matrix

<u>Fusible Link</u>

The first PROMs ever manufactured were of the fusible link variety. Referring to Figure 16, a link of nichrome with a resistance on the order of a few hundred ohms, is deposited in series with each diode in the matrix, thus, a conductive path between rows (x_n) and columns (y_n) exists for an unprogrammed fusible link PROM. Each bit, therefore, is at a logic "0" level.

The value of h_{FE} is usually measured at a voltage between collector and emitter which is rather close to the saturation voltage as this represents a minimum value. Speaking loosely, h_{FE} is not a very strong function of collector-emitter voltage outside of saturation. It is, however, a rather strong function of junction temperature and of collector current. Figure 36 is a set of typical curves for h_{FE} as a function of I_C for the 2N914. Each curve is associated with a different temperature.

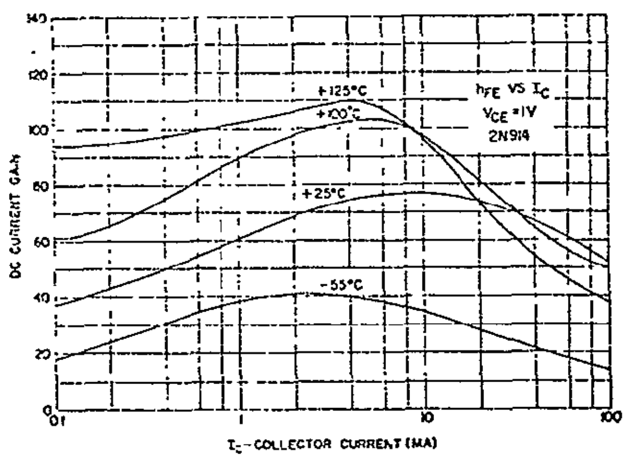


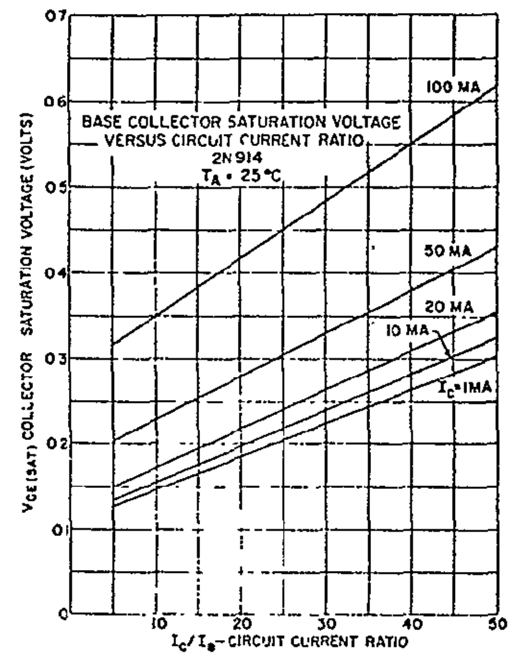
Figure 36. Variation of h_{FE} With Temperature and Current

The most important feature is that over most of the current range, the gain decreases with decreasing temperature. Obviously, this rule cannot be applied indiscriminately. The reverse begins to be true beyond 10 milliamperes and 100°C. A second feature of interest is that the gain has a definite maximum which may be quite broad (at room temperature for example) or rather sharp (at 125°C). The collector current at which this maximum occurs is a function of the junction temperature. It follows that the selection of operating "on" current to be used should take into consideration the temperature range over which the circuit will be expected to operate.

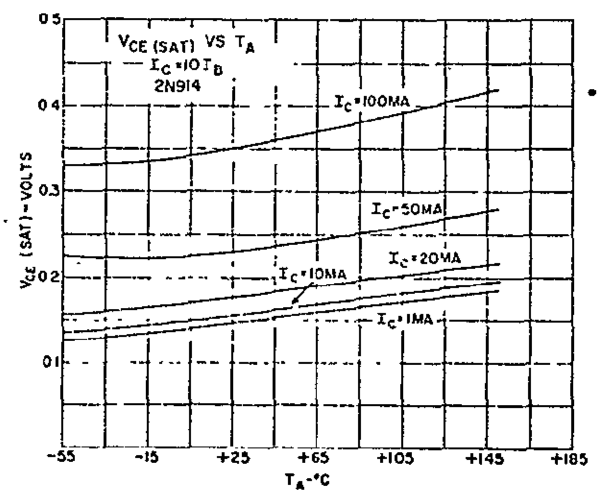
It sometimes happens that a decreasing gain with increasing temperature is desirable. Magnetic cores, for example, often require less drive at high temperatures than at low. Generally, however, this characteristic cannot be controlled sufficiently well to be useful.

Collector Saturation Voltage, $V_{CE(SAT)}$. The collector saturation voltage is the parameter that effectively limits how closely the transistor approximates a closed switch. Figure 37 shows how this parameter varies with temperature, current ratio and collector current.

5. ELECTRICAL CHARACTERISTICS (Continued)



(A)



(B)

Figure 37. Variations in $V_{CE(SAT)}$ With Temperature, Collector Current, and Force Gain

In the first set of curves the temperature is held constant while the circuit current ratio is increased (or I_B decreased) and the saturation voltage changes linearly. The fact that the saturation voltage changes with the circuit current ratio makes the concept of $r_{(SAT)}$ as

5. ELECTRICAL CHARACTERISTICS

Characteristics of recommended switching transistors are shown in Table 5, paragraph 22.1.8.

The parameters of interest may be separated into static and transient groupings. This is, of course, somewhat arbitrary in that the same parameters may be in both aspects of the device behavior, but is convenient for purposes of discussion.

Static Parameters of Switching Transistors

Leakage current along with current gains, determines to a large extent the minimum off current, I_o, of the collector. The physical nature of I_{CO} is discussed in paragraph 22.0.5. In this section, only the manner in which it influences the circuit designer will be discussed.

Minimum Off Current, I_{CBO}. I_{CBO} is defined as the d-c collector current when the collector junction is reverse biased and the emitter is open-circuited. Its value is determined by the voltage applied and the temperature at which it is measured as is indicated in Figure 33. As the curves indicate, I_{CBO} essentially varies exponentially with temperature and above the "knee" of the voltage curve tends to follow an exponential variation with voltage.

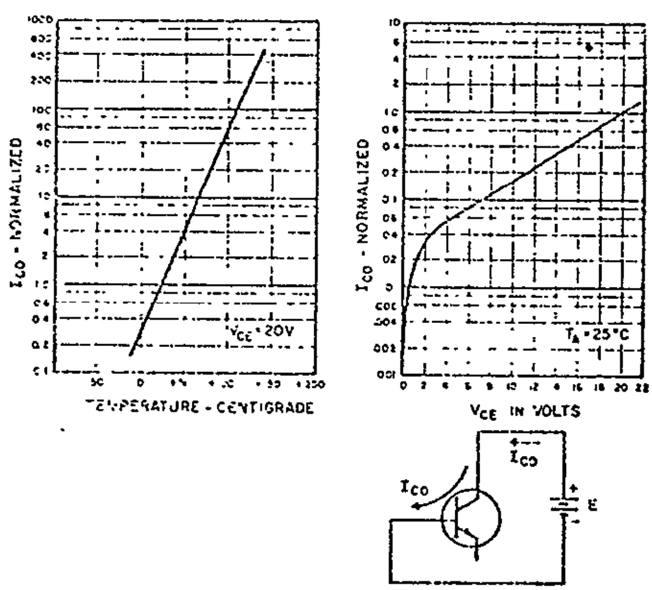


Figure 33. Behavior of I_{CBO} With Temperature and Voltage

. USUAL APPLICATIONS & CHARACTERISTICS

2. USUAL APPLICATIONS AND CHARACTERISTICS (Continued)

FIGURE 14. 6800 ARCHITECTURE/INSTRUCTION SET (Continued)

ACCUMULATOR AND MEMORY INSTRUCTIONS

		ADDRESSING MODES															BOOLEAN/ARITHMETIC OPERATION	COND CODE REG.					
		IMMED			DIRECT			INDEX			EXTND			IMPLIED			(All register labels refer to contents)	5	4	3	2	1	0
OPERATIONS	MNEMONIC	OP	~	#	OP	~	#	OP	~	#	OP	~	#	OP	~	#		H	I	N	Z	V	C
Add	ADDA	8B	2	2	9B	3	2	AB	5	2	BB	4	3				A + M → A	↕	•	↕	↕	↕	↕
	ADDB	CB	2	2	DB	3	2	EB	5	2	FB	4	3				B + M → B	↕	•	↕	↕	↕	↕
Add Acmltrs	ABA													1B	2	1	A + B → A	↕	•	↕	↕	↕	↕
Add with Carry	ADCA	89	2	2	99	3	2	A9	5	2	B9	4	3				A + M + C → A	↕	•	↕	↕	↕	↕
	ADCB	C9	2	2	D9	3	2	E9	5	2	F9	4	3				B + M + C → B	↕	•	↕	↕	↕	↕
And	ANDA	84	2	2	94	3	2	A4	5	2	B4	4	3				A · M → A	•	•	↕	↕	R	•
	ANDB	C4	2	2	D4	3	2	E4	5	2	F4	4	3				B · M → B	•	•	↕	↕	R	•
Bit Test	BITA	85	2	2	95	3	2	A5	5	2	B5	4	3				A · M	•	•	↕	↕	R	•
	BITB	C5	2	2	D5	3	2	E5	5	2	F5	4	3				B · M	•	•	↕	↕	R	•
Clear	CLR							6F	7	2	7F	6	3				00 → M	•	•	R	S	R	R
	CLRA													4F	2	1	00 → A	•	•	R	S	R	R
	CLRB													5F	2	1	00 → B	•	•	R	S	R	R
Compare	CMPA	81	2	2	91	3	2	A1	5	2	B1	4	3				A − M	•	•	↕	↕	↕	↕
	CMPB	C1	2	2	D1	3	2	E1	5	2	F1	4	3				B − M	•	•	↕	↕	↕	↕
Compare Acmltrs	CBA													11	2	1	A − B	•	•	↕	↕	↕	↕
Complement, 1's	COM							63	7	2	73	6	3				M̄ → M	•	•	↕	↕	R	S
	COMA													43	2	1	Ā → A	•	•	↕	↕	R	S
	COMB													53	2	1	B̄ → B	•	•	↕	↕	R	S
Complement, 2's	NEG							60	7	2	70	6	3				00 − M → M	•	•	↕	↕	①	②
(Negate)	NEGA													40	2	1	00 − A → A	•	•	↕	↕	①	②
	NEGB													50	2	1	00 − B → B	•	•	↕	↕	①	②
Decimal Adjust, A	DAA													19	2	1	Converts Binary Add of BCD Characters into BCD Format	•	•	↕	↕	↕	③
Decrement	DEC							6A	7	2	7A	6	3				M − 1 → M	•	•	↕	↕	4	•
	DECA													4A	2	1	A − 1 → A	•	•	↕	↕	4	•
	DECB													5A	2	1	B − 1 → B	•	•	↕	↕	4	•
Exclusive OR	EORA	88	2	2	98	3	2	A8	5	2	B8	4	3				A⊕M → A	•	•	↕	↕	R	•
	EORB	C8	2	2	D8	3	2	E8	5	2	F8	4	3				B⊕M → B	•	•	↕	↕	R	•
Increment	INC							6C	7	2	7C	6	3				M + 1 → M	•	•	↕	↕	⑤	•
	INCA													4C	2	1	A + 1 → A	•	•	↕	↕	⑤	•
	INCB													5C	2	1	B + 1 → B	•	•	↕	↕	⑤	•
Load Acmltr	LDAA	86	2	2	96	3	2	A6	5	2	B6	4	3				M → A	•	•	↕	↕	R	•
	LDAB	C6	2	2	D6	3	2	E6	5	2	F6	4	3				M → B	•	•	↕	↕	R	•
Or, Inclusive	ORAA	8A	2	2	9A	3	2	AA	5	2	BA	4	3				A + M → A	•	•	↕	↕	R	•
	ORAB	CA	2	2	DA	3	2	EA	5	2	FA	4	3				B + M → B	•	•	↕	↕	R	•
Push Data	PSHA													36	4	1	A → M_{SP}, SP − 1 → SP	•	•	•	•	•	•
	PSHB													37	4	1	B → M_{SP}, SP − 1 → SP	•	•	•	•	•	•
Pull Data	PULA													32	4	1	SP + 1 → SP, M_{SP} → A	•	•	•	•	•	•
	PULB													33	4	1	SP + 1 → SP, M_{SP} → B	•	•	•	•	•	•
Rotate Left	ROL							69	7	2	79	6	3				M	•	•	↕	↕	⑥	↕
	ROLA													49	2	1	A	•	•	↕	↕	⑥	↕
	ROLB													59	2	1	B (C ← b7 ← b0)	•	•	↕	↕	⑥	↕
Rotate Right	ROR							66	7	2	76	6	3				M	•	•	↕	↕	⑥	↕
	RORA													46	2	1	A	•	•	↕	↕	⑥	↕
	RORB													56	2	1	B (C → b7 → b0)	•	•	↕	↕	⑥	↕
Shift Left, Arithmetic	ASL							68	7	2	78	6	3				M	•	•	↕	↕	⑥	↕
	ASLA													48	2	1	A	•	•	↕	↕	⑥	↕
	ASLB													58	2	1	B (C ← b7 ← b0 ← 0)	•	•	↕	↕	⑥	↕
Shift Right, Arithmetic	ASR							67	7	2	77	6	3				M	•	•	↕	↕	⑥	↕
	ASRA													47	2	1	A	•	•	↕	↕	⑥	↕
	ASRB													57	2	1	B (b7 → b0 → C)	•	•	↕	↕	⑥	↕
Shift Right, Logic	LSR							64	7	2	74	6	3				M	•	•	R	↕	⑥	↕
	LSRA													44	2	1	A	•	•	R	↕	⑥	↕
	LSRB													54	2	1	B (0 → b7 → b0 → C)	•	•	R	↕	⑥	↕
Store Acmltr	STAA				97	4	2	A7	6	2	B7	5	3				A → M	•	•	↕	↕	R	•
	STAB				D7	4	2	E7	6	2	F7	5	3				B → M	•	•	↕	↕	R	•
Subtract	SUBA	80	2	2	90	3	2	A0	5	2	B0	4	3				A − M → A	•	•	↕	↕	↕	↕
	SUBB	C0	2	2	D0	3	2	E0	5	2	F0	4	3				B − M → B	•	•	↕	↕	↕	↕
Subtract Acmltrs	SBA													10	2	1	A − B → A	•	•	↕	↕	↕	↕
Subtr with Carry	SBCA	82	2	2	92	3	2	A2	5	2	B2	4	3				A − M − C → A	•	•	↕	↕	↕	↕
	SBCB	C2	2	2	D2	3	2	E2	5	2	F2	4	3				B − M − C → B	•	•	↕	↕	↕	↕
Transfer Acmltrs	TAB													16	2	1	A → B	•	•	↕	↕	R	•
	TBA													17	2	1	B → A	•	•	↕	↕	R	•
Test Zero or Minus	TST							6D	7	2	7D	6	3				M − 00	•	•	↕	↕	R	R
	TSTA													4D	2	1	A − 00	•	•	↕	↕	R	R
	TSTB													5D	2	1	B − 00	•	•	↕	↕	R	R
																		H	I	N	Z	V	C

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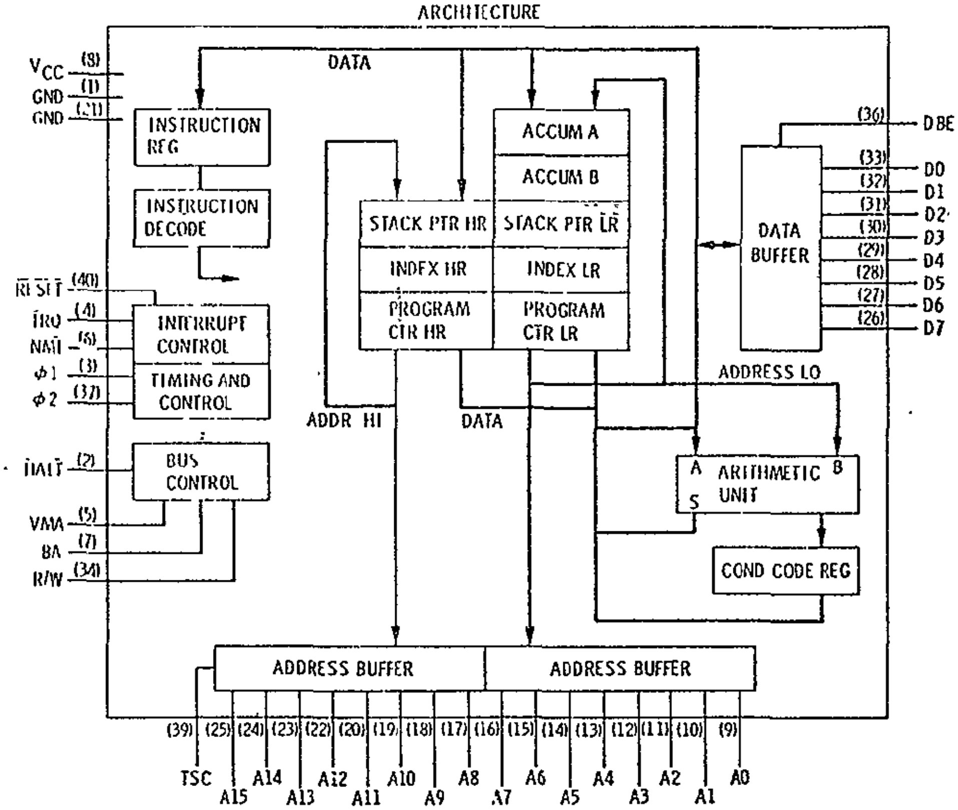
2. USUAL APPLICATIONS AND CHARACTERISTICS (Continued)

FIGURE 14. 6800 ARCHITECTURE/INSTRUCTION SET



JUMP AND BRANCH INSTRUCTIONS

		RELATIVE			INDEX			EXTND			IMPLIED				COND. CODE REG. 5	4	3	2	1	0
OPERATIONS	MNEMONIC	OP	~	#	OP	~	#	OP	~	#	OP	~	#	BRANCH TEST	H	I	N	Z	V	C
Branch Always	BRA	20	4	2										None	•	•	•	•	•	•
Branch If Carry Clear	BCC	24	4	2										C = 0	•	•	•	•	•	•
Branch If Carry Set	BCS	25	4	2										C = 1	•	•	•	•	•	•
Branch If = Zero	BEQ	27	4	2										Z = 1	•	•	•	•	•	•
Branch If ≥ Zero	BGE	2C	4	2										N ⊕ V = 0	•	•	•	•	•	•
Branch If > Zero	BGT	2E	4	2										Z + (N ⊕ V) = 0	•	•	•	•	•	•
Branch If Higher	BHI	22	4	2										C + Z = 0	•	•	•	•	•	•
Branch If ≤ Zero	BLE	2F	4	2										Z + (N ⊕ V) = 1	•	•	•	•	•	•
Branch If Lower Or Same	BLS	23	4	2										C + Z = 1	•	•	•	•	•	•
Branch If < Zero	BLT	2D	4	2										N ⊕ V = 1	•	•	•	•	•	•
Branch If Minus	BMI	2B	4	2										N = 1	•	•	•	•	•	•
Branch If Not Equal Zero	BNE	26	4	2										Z = 0	•	•	•	•	•	•
Branch If Overflow Clear	BVC	28	4	2										V = 0	•	•	•	•	•	•
Branch If Overflow Set	BVS	29	4	2										V = 1	•	•	•	•	•	•
Branch If Plus	BPL	2A	4	2										N = 0	•	•	•	•	•	•
Branch To Subroutine	BSR	8D	8	2										See Special Operations	•	•	•	•	•	•
Jump	JMP				6E	4	2	7E	3	3				See Special Operations	•	•	•	•	•	•
Jump To Subroutine	JSR				AD	8	2	BD	9	3				See Special Operations	•	•	•	•	•	•
No Operation	NOP										02	2	1	Advances Prog. Cntr. Only	•	•	•	•	•	•
Return From Interrupt	RTI										3B	10	1		(10)					
Return From Subroutine	RTS										39	5	1	See Special Operations	•	•	•	•	•	•
Software Interrupt	SWI										3F	12	1	See Special Operations	•	•	•	•	•	•
Wait for Interrupt	WAI										3E	9	1	See Special Operations	•	(11)	•	•	•	•

INDEX REGISTER AND STACK MANIPULATION INSTRUCTIONS

		IMMED			DIRECT			INDEX			EXTND			IMPLIED			BOOLEAN/ARITHMETIC OPERATION	COND. CODE REG. 5	4	3	2	1	0
POINTER OPERATIONS	MNEMONIC	OP	~	#	OP	~	#	OP	~	#	OP	~	#	OP	~	#	BOOLEAN/ARITHMETIC OPERATION	H	I	N	Z	V	C
Compare Index Reg	CPX	8C	3	3	9C	4	2	AC	6	2	BC	5	3				$X_H - M, X_L - (M+1)$	•	•	(7)	↕	(8)	•
Decrement Index Reg	DEX													09	4	1	$X - 1 \rightarrow X$	•	•	•	↕	•	•
Decrement Stack Pntr	DES													34	4	1	$SP - 1 \rightarrow SP$	•	•	•	•	•	•
Increment Index Reg	INX													08	4	1	$X + 1 \rightarrow X$	•	•	•	↕	•	•
Increment Stack Pntr	INS													31	4	1	$SP + 1 \rightarrow SP$	•	•	•	•	•	•
Load Index Reg	LDX	CE	3	3	DE	4	2	EE	6	2	FE	5	3				$M \rightarrow X_H, (M+1) \rightarrow X_L$	•	•	(9)	↕	R	•
Load Stack Pntr	LDS	8E	3	3	9E	4	2	AE	6	2	BE	5	3				$M \rightarrow SP_H, (M+1) \rightarrow SP_L$	•	•	(9)	↕	R	•
Store Index Reg	STX				DF	5	2	EF	7	2	FF	6	3				$X_H \rightarrow M, X_L \rightarrow (M+1)$	•	•	(9)	↕	R	•
Store Stack Pntr	STS				9F	5	2	AF	7	2	BF	6	3				$SP_H \rightarrow M, SP_L \rightarrow (M+1)$	•	•	(9)	↕	R	•
Indx Reg → Stack Pntr	TXS													35	4	1	$X - 1 \rightarrow SP$	•	•	•	•	•	•
Stack Pntr → Indx Reg	TSX													30	4	1	$SP + 1 \rightarrow X$	•	•	•	•	•	•

2. USUAL APPLICATIONS AND CHARACTERISTICS (Continued)

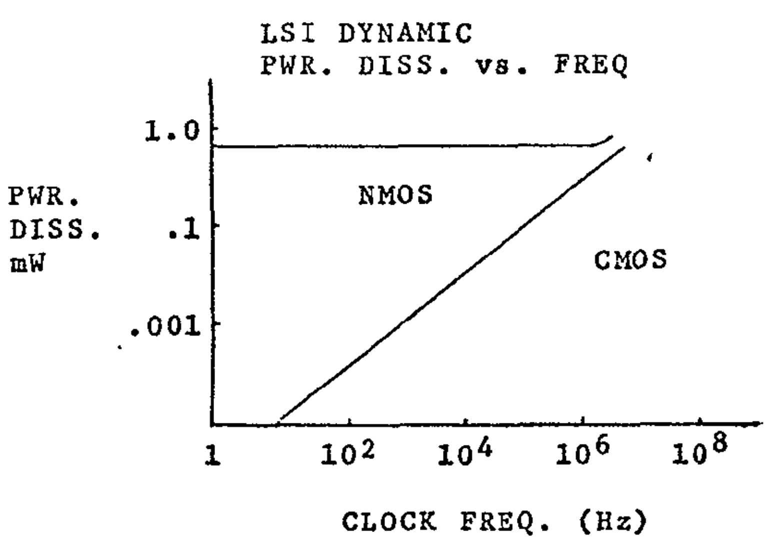
8/12 BIT FIXED INSTRUCTION SET MICROPROCESSOR (Continued)

A very important feature of two of these technologies (NMOS and CMOS) is that microprocessors become available with a wide operating temperature range. Several manufacturers offer devices which will operate to spec from -55°C to +125°C (full Mil temp. range). This has significant influence of acceptance and implementation of microprocessors in both the automotive and military industries. The following microprocessors are available full military temperature range devices:

TYPE	# BITS	VENDOR	TECHNOLOGY
8080A (9080A)	8	INTEL (AMD)	NMOS
IM6100 (HM6100)	12	INTERSIL (HARRIS)	CMOS
CD 1802	8	RCA (HUGHES)	CMOS
Z80	8	ZILOG (MOSTEK)	NMOS

By comparing this list to the announced microprocessors (Table II), it is apparent that not all manufacturers producing NMOS microprocessors, have elected to supply MIL temperature range parts. This requires tighter controls of the NMOS process, resulting in higher costs. By contrast, the inherent characteristics of CMOS are such that full MIL range devices are a natural result of the process. Of course, in CMOS, the mixing of two dissimilar dopants (P&N material) also required tight process control. Which MOS process a manufacturer picks depends on what is envisioned as the wave of the future. NMOS appears to have taken the lead.

The significant differences between these two technologies is: power consumption and mode of operation. NMOS microprocessors are dynamic devices, i.e., they must be continuously clocked or data will be lost. There is, therefore, a minimum clock frequency. CMOS is static. The clock can be stopped and data will be retained as long as power is applied. Acquiescent current for CMOS is very low, therefore, power consumption is low. Figure 12 compares some of the main features of CMOS and NMOS microprocessors.



	NMOS	CMOS
AREA/GATE MIL^2	6-8	10-30
MINIMUM FREQ.	500KHz	DC
NOISE IMMUNITY	5%	45%
POWER SUPPLY	5V	3 to 15V

FIGURE 12

2. USUAL APPLICATIONS (Continued)

Greater design and circuit flexibility is achieved by permitting the operating frequency of the circuit to be controlled rather than fixed by the supply voltage as in the circuit of Figure 6. With the voltage divider, P, the voltage across the reactor can be varied to produce a variable output frequency.

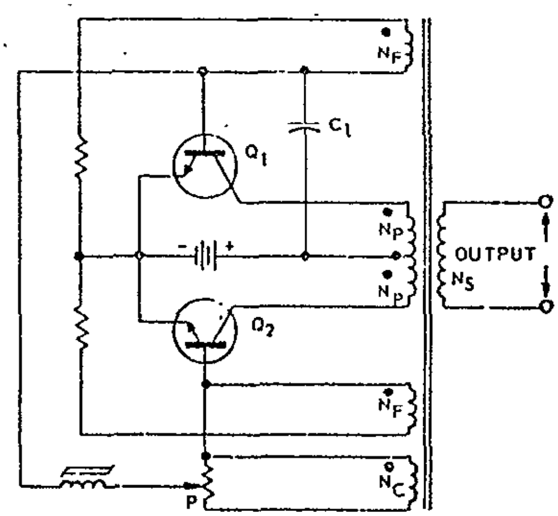


Figure 8. Saturable Reactor Controlled Inverter

The design of this type of circuit is relatively simple. The output transformer must be selected to support the highest input voltage at the lowest desired frequency without saturating. This precaution will insure that the oscillation is always under the control of the frequency locking reactor circuit. The voltage supplied by the resistive divider to the saturable reactor should be at least equal to twice the voltage supplied by the feedback windings. The circuit will operate with lower voltages applied to the reactor; however, more reliable operation is achieved at the higher voltage. In calculating the turns required on the reactor, the total voltage appearing across the output terminals of the reactor as well as the voltage supplied by the resistive divider network must be considered.

Tests of the improved circuit indicate that the transistor switching time can be reduced to less than one-half that obtained with the basic circuit and that the dissipation occurring during the switching transient can be reduced to about one-fourth the value obtained with a saturated output transformer. The described circuit has been constructed in power ratings up to 500 va. Variable frequency converters have been built to operate over frequency ranges of 10 Hz to 1 KHz and up to frequencies of 20 KHz. These inverters are used to supply power to motors, electronic equipment and a variety of other loads.

2. USUAL APPLICATIONS AND CHARACTERISTICS (Continued)

FIGURE 19. TMS9900 ARCHITECTURE/INSTRUCTION SET (Continued)

INSTRUCTION EXECUTION TIMES

INSTRUCTION	CLOCK CYCLES C	MEMORY ACCESS M	ADDRESS MODIFICATION† SOURCE	DEST
A	14	4	A	A
AB	14	4	B	B
ABS (MSB = 0)	12	2	A	–
(MSB = 1)	14	3	A	–
AI	14	4	–	–
ANDI	14	4	–	–
B	8	2	A	–
BL	12	3	A	–
BLWP	26	6	A	–
C	14	3	A	A
CB	14	3	B	B
CI	14	3	–	–
CKOF	12	1	–	–
CKON	12	1	–	–
CLR	10	3	A	–
COC	14	3	A	–
CZC	14	3	A	–
DEC	10	3	A	–
DECT	10	3	A	–
DIV (ST4 is set)	16	3	A	–
DIV (ST4 is reset)*	92-124	6	A	–
IDLE	12	1	–	–
INC	10	3	A	–
INCT	10	3	A	–
INV	10	3	A	–
Jump (PC is changed)	10	1	–	–
(PC is not changed)	8	1	–	–
LDCR (C = 0)	52	3	A	–
(1≤C≤8)	20+2C	3	B	–
(9≤C≤15)	20+2C	3	A	–
LI	12	3	–	–
LIMI	16	2	–	–
LREX	12	1	–	–
RESET function	26	5	–	–
LOAD function	22	5	–	–
Interrupt context switch	22	5	–	–
LWPI	10	2	–	–
MOV	14	4	A	A
MOVB	14	4	B	B
MPY	52	5	A	–
NEG	12	3	A	–
ORI	14	4	–	–
RSET	12	1	–	–
RTWP	14	4	–	–
S	14	4	A	A
SB	14	4	B	B
SBO	12	2	–	–
SBZ	12	2	–	–
SETO	10	3	A	–
Shift (C≠0)	12+2C	3	–	–
(C=0, Bits 12–15 of WR0=0)	52	4	–	–
(C=0, Bits 12–15 of WR0=N≠0)	20+2N	4	–	–
SOC	14	4	A	A
SOCB	14	4	B	B
STCR (C=0)	60	4	A	–
(1≤C≤7)	42	4	B	–
(C=8)	44	4	B	–
(9≤C≤15)	58	4	A	–
STST	8	2	–	–
STWP	8	2	–	–
SWPB	10	3	A	–
SZC	14	4	A	A
SZCB	14	4	B	B
TB	12	2	–	–
X **	8	2	A	–
XOP	36	8	A	–
XOR	14	4	A	–
Undefined op codes 0000-01FF, 0320-033F, 0C00-0FFF, 0780-07FF	6	1	–	–

INSTRUCTIONS BY MNEMONIC

MNEMONIC	OP CODE	FORMAT	RESULT COMPARED TO ZERO	STATUS AFFECTED	INSTRUCTIONS
A	A000	1	Y	0-4	ADD (WORD)
AB	B000	1	Y	0-5	ADD (BYTE)
ABS	0740	6	Y	0-4	ABSOLUTE VALUE
AI	0220	8	Y	0-4	ADD IMMEDIATE
ANDI	0240	8	Y	0-2	AND IMMEDIATE
B	0440	6	N		BRANCH
BL	0680	6	N	-	BRANCH AND LINK (W11)
BLWP	0400	6	N		BRANCH LOAD WORKSPACE POINTER
C	8000	1	N	0-2	COMPARE (WORD)
CB	9000	1	N	0-2,5	COMPARE (BYTE)
CI	0280	8	N	0-2	COMPARE IMMEDIATE
CKOF	03C0	7	N	-	EXTERNAL CONTROL
CKON	03A0	7	N	-	EXTERNAL CONTROL
CLR	04C0	6	N		CLEAR OPERAND
COC	2000	3	N	2	COMPARE ONES CORRESPONDING
CZC	2400	3	N	2	COMPARE ZEROES CORRESPONDING
DEC	0600	6	Y	0-4	DECREMENT (BY ONE)
DECT	0640	6	Y	0-4	DECREMENT (BY TWO)
DIV	3C00	9	N	4	DIVIDE
IDLE	0340	7	N	-	COMPUTER IDLE
INC	0580	6	Y	0-4	INCREMENT (BY ONE)
INCT	05C0	6	Y	0-4	INCREMENT (BY TWO)
INV	0540	6	Y	0-2	INVERT (ONES COMPLEMENT)
JEQ	1300	2	N		JUMP EQUAL (ST2=1)
JGT	1500	2	N	-	JUMP GREATER THAN (ST1=1)
JH	1B00	2	N	-	JUMP HIGH (ST0=1 AND ST2=0)
JHE	1400	2	N		JUMP HIGH OR EQUAL (ST0 OR ST2=1)
JL	1A00	2	N		JUMP LOW (ST0 AND ST2=0)
JLE	1200	2	N		JUMP LOW OR EQUAL (ST0=0 OR ST2=1)
JLT	1100	2	N		JUMP LESS THAN (ST1 AND ST2=0)
JMP	1000	2	N	-	JUMP UNCONDITIONAL
JNC	1700	2	N	-	JUMP NO CARRY (ST3=0)
JNE	1600	2	N		JUMP NOT EQUAL (ST2=0)
JNO	1900	2	N	-	JUMP NO OVERFLOW (ST4=0)
JOC	1800	2	N	-	JUMP ON CARRY (ST3=1)
JOP	1C00	2	N	-	JUMP ODD PARITY (ST5=1)
LDCR	3000	4	Y	0-2,5	LOAD CRU
LI	0200	8	N	0-2	LOAD IMMEDIATE
LIMI	0300	8	N	12-15	LOAD IMMEDIATE TO INTERRUPT MASK
LREX	03E0	7	N	12-15	EXTERNAL CONTROL
LWPI	02E0	8	N	-	LOAD IMMEDIATE TO WORKSPACE POINTER
MOV	C000	1	Y	0-2	MOVE (WORD)
MOVB	D000	1	Y	0-2,5	MOVE (BYTE)
MPY	3800	9	N	-	MULTIPLY
NEG	0500	6	Y	0-4	NEGATE (TWO'S COMPLEMENT)
ORI	0260	8	Y	0-2	OR IMMEDIATE
RSET	0360	7	N	12-15	EXTERNAL CONTROL
RTWP	0380	7	N	0-6,12-15	RETURN WORKSPACE POINTER
S	6000	1	Y	0-4	SUBTRACT (WORD)
SB	7000	1	Y	0-5	SUBTRACT (BYTE)
SBO	1D00	2	N		SET CRU BIT TO ONE
SBZ	1E00	2	N		SET CRU BIT TO ZERO
SETO	0700	6	N		SET ONES
SLA	0A00	5	Y	0-4	SHIFT LEFT (ZERO FILL)
SOC	E000	1	Y	0-2	SET ONES CORRESPONDING (WORD)
SOCB	F000	1	Y	0-2,5	SET ONES CORRESPONDING (BYTE)
SRA	0800	5	Y	0-3	SHIFT RIGHT (MSB EXTENDED)
SRC	0B00	5	Y	0-3	SHIFT RIGHT CIRCULAR
SRL	0900	5	Y	0-3	SHIFT RIGHT (LEADING ZERO FILL)
STCR	3400	4	Y	0-2,5	STORE FROM CRU
STST	02C0	8	N		STORE STATUS REGISTER
STWP	02A0	8	N		STORE WORKSPACE POINTER
SWPB	06C0	6	N	-	SWAP BYTES
SZC	4000	1	Y	0-2	SET ZEROES CORRESPONDING (WORD)
SZCB	5000	1	Y	0-2,5	SET ZEROES CORRESPONDING (BYTE)
TB	1F00	2	N	2	TEST CRU BIT
X	0480	6	N	-	EXECUTE
XOP	2C00	9	N	6	EXTENDED OPERATION
XOR	2800	3	Y	0-2	EXCLUSIVE OR

ILLEGAL OP CODES: 0000-01FF, 0320-033F, 0780-07FF, 0C00-0FFF

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$$T = t_{c(\phi)} \quad (C + W \cdot M)$$

where:

T = total instruction execution time;

$t_{c(\phi)}$ = clock cycle time;

C = number of clock cycles for instruction execution plus address modification;

W = number of required wait states per memory access for instruction execution plus address modification;

M = number of memory accesses.

*Execution time is dependent upon the partial quotient after each clock cycle during execution

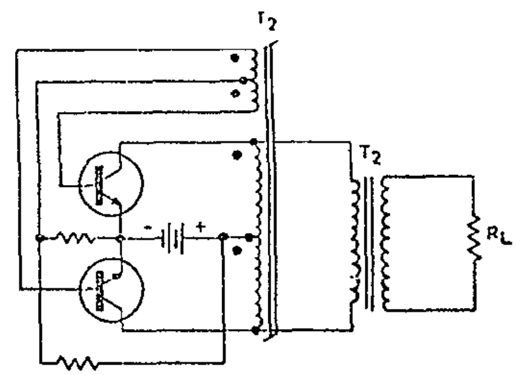
**Execution time is added to the execution time of the instruction located at the source address minus 4 clock cycles and 1 memory access time.

†The letters A and B refer to the respective tables that follow.

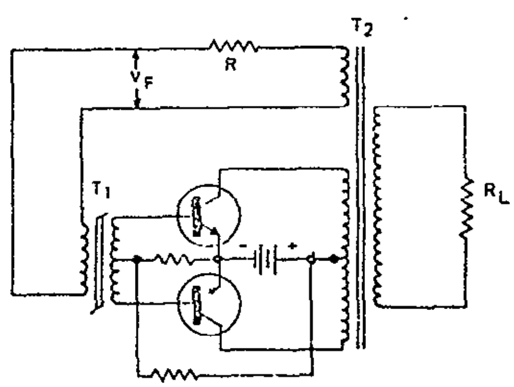
2. USUAL APPLICATIONS (Continued)

Two Transformer Inverters

Other methods of obtaining high output power are the two transformer inverters shown in Figure 9. In these circuits only the small driver transformers, T_1, saturate, which significantly reduces the magnetizing currents which the transistors must switch in the basic one transformer inverter. The use of normal core material in the nonsaturating output transformer reduces transformer cost and increases efficiency.



(a). Two Transformer Inverter



(b). Two Transformer Inverter with Frequency Control

Figure 9.

Frequency control may be accomplished as shown in Figure 9b where voltage V_F is regulated to provide constant frequency or varied to provide variable frequency. The circuits of Figure 10 are recommended to decrease transistor switching time and thereby reduce collector dissipation.

2. USUAL APPLICATIONS (Continued)

Audio Amplifier

The most important requirements of an audio power amplifier are that it should provide power gain over a wide band of frequencies and with minimum distortion. These requirements are met by operating the transistors in the active region. The choice of circuit and operating mode will depend upon the requirements of the application.

In the Class A mode, the transistor is biased to some quiescent operating point, with no signal applied. The a-c signal then swings the operating point on either side of the quiescent point so that ideally, the output collector current is a faithful but amplified reproduction of the input base current. (See Figure 2, page 3.) Since the quiescent operating point must allow the collector current to swing both positively and negatively, it is usually located near the midpoint of the load line. Consequently, for the transformer-coupled Class A amplifier, the quiescent power dissipation in the transistor is equal to the battery input power:

$$P_{BATT} = V_{CC} I_Q$$

where V_{CC} is the supply voltage and I_Q is the quiescent current. Since the operating point swings both positively and negatively with signal, it is apparent that the average input power remains constant in the Class A amplifier. The maximum transistor dissipation occurs at the zero signal or quiescent condition and the maximum ideal efficiency, which occurs at maximum signal, is 50 percent. Because of the relatively high quiescent power dissipation and low efficiency, Class A amplifiers are usually limited to low power levels.

In the Class B mode the quiescent point bias is zero, so that the zero signal power dissipation in the transistor is zero. The a-c signal swings the operating point alternately into the active region and into the cut-off region. Since conduction occurs for only 180 degrees of the a-c cycle, it is necessary to operate the transistors in pairs in a push-pull circuit as shown in Figure 11. The two transistors are driven in a split-phase source (in this case a center-tapped transformer) and conduct alternately.

In Class B operation, the maximum ideal efficiency is 78 percent. The maximum power output obtainable for Class B is five times the dissipation rating of the individual transistors. In contrast, the power obtainable in Class A is only one-half the dissipation rating. These factors make Class B operation the best choice for high power, high efficiency applications.

RELIABILITY CONSIDERATIONS

7. RELIABILITY CONSIDERATIONS (Continued)

Secondary Breakdown

No designer of power circuits can consider a design sufficiently reliable unless the circuit has been checked to insure that the transistors will not undergo secondary breakdown. Operating within the power-temperature ratings and insuring against thermal runaway will not alone guarantee circuit reliability.

Figure 34 shows a sketch of the voltage-current characteristic of a transistor operating in the reverse breakdown mode. Note that at low collector currents, the voltage across the device exceeds the open base breakdown rating. The peak of the curve and the negative resistance region has been termed the first breakdown, or the normal breakdown, and is a result of avalanche action in the transistor. However, as current in the avalanche mode is increased to higher values, a critical current (I_m) is reached at which the voltage across the device drops to a very low level. This behavior is aptly called secondary breakdown.

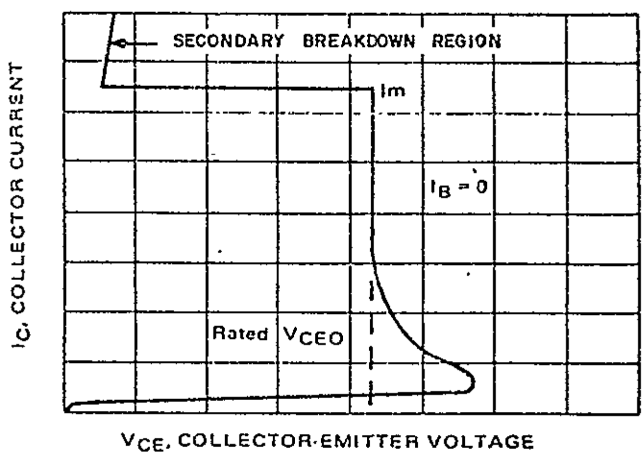


Figure 34. Manifestation of Secondary Breakdown in a Transistor

Transistors need not be operating in avalanche breakdown in order to encounter secondary breakdown. Figure 35 shows a family of collector curves, and the locus of critical or trigger currents at which the transistor enters secondary breakdown. Note that as collector voltage is increased, maximum current occurs at lower currents and becomes extremely low as the emitter-base junction becomes reverse biased. It has also been found that the amount of time a power pulse is applied at a particular operating point also determines whether or not secondary breakdown will occur. The observed behavior is a result of "hot spots" forming in the device as a result of non-uniform current density.

Studs - Galled or stripped threads, irregular or hollow surfaces on base of stud, and improper attachment of ceramic insulator (for dielectrically isolated devices) result in failures of stud mounted devices. The latter two usually cause a marked increase in thermal impedance of the device resulting in overheating and die failure. Damaged threads usually result in broken studs when proper torque is applied, or in insufficient torque due to added mechanical resistance.

Seals - Cracks and bubbles around the external leads result in loss of hermeticity. The effects of contaminated ambient have been discussed previously.

Part Marking - Soluble inks, smeared or smudged marking, or absence of marking afford loss of traceability of screened, qualified parts. It is essential that a part be uniquely marked to indicate that it was screened to preclude installation of an unqualified, unscreened part. Use of insoluble inks is mandatory. All part marking is to be stamped on the can. No tags on leads or cans which may outgas in the using hardware or otherwise degrade part are to be used. An external visual of all parts will eliminate such defects.

Figure 35 shows the distribution of failure mechanisms as seen in the industry. This information was taken from RADC Technical Report #TR-68-315.

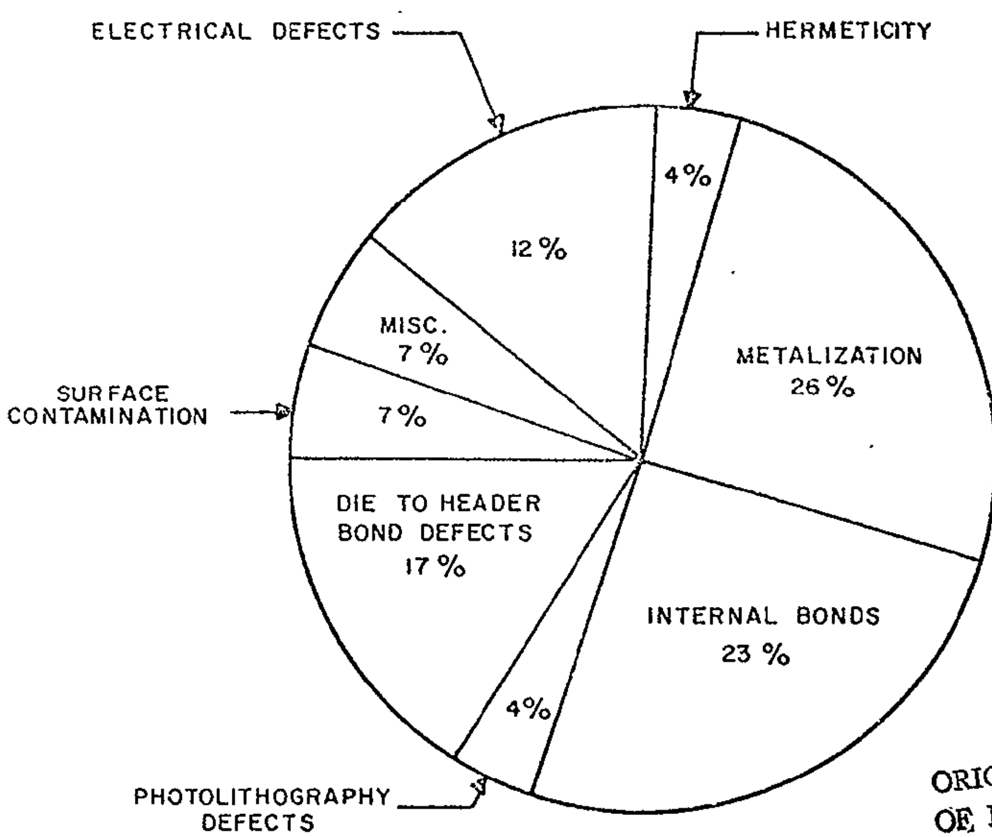


Figure 35. Distribution of Failure Mechanisms Seen in Industry

7. RELIABILITY CONSIDERATIONS (Continued)

There is good reason to believe that if it were possible to remove the current within a few microseconds after the onset of secondary breakdown, no particular harm would come to the transistor. Indeed, under much less than these ideal conditions, it has been possible to observe devices being switched in and out of secondary breakdown. It was proposed, at one time, that secondary breakdown might be used as a possible mode of operation for generation of very fast pulses. This application, however, proves to be not practical because it is difficult to control, and most devices will short when held in secondary breakdown for any appreciable time.

The current at which secondary breakdown occurs decreases markedly with increases in collector-emitter voltage when operating in the normal active region mode. The curves of Figure 36 illustrate this behavior and are typical for most types of semiconductors.

The reason for collector voltage being an important variable is that as collector voltage is increased, the base width is reduced, thereby accentuating current crowding effects because the higher electric field caused by the shorter path reduces the current spreading or fan out. As might be inferred, transistors with narrow base widths (i.e. higher f_t) will encounter secondary breakdown at lower power levels than lower frequency devices, other conditions being equal.

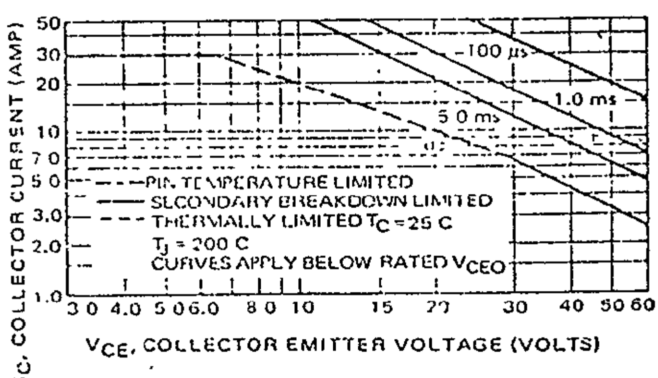


Figure 36. Example of an Active Region Safe Operating Area

Because of the secondary breakdown problem, many vendors of power transistors have come out with "safe operating area charts" as shown in Figure 36. The solid lines show secondary breakdown limitations while the dotted lines represent thermal limitations. For this transistor family, d-c currents above 30 A cause excessive emitter pin temperatures*; therefore, operation above 30 Adc is not recommended. Above 6.5 volts, the allowable d-c current is junction temperature limited. If the case temperature (T_c) is 25°C, then power dissipation (P_D) must not exceed 200 watts. The d-c curve also shows that the d-c power level must be lowered from the 200 W level as voltage

* On low-level devices, I_C is limited by the bonding wire at low values of V_{CE}.

7. RELIABILITY CONSIDERATIONS (Continued)

point can spend a given time at any one point on the curve or that it may travel along the curve for the same given time.

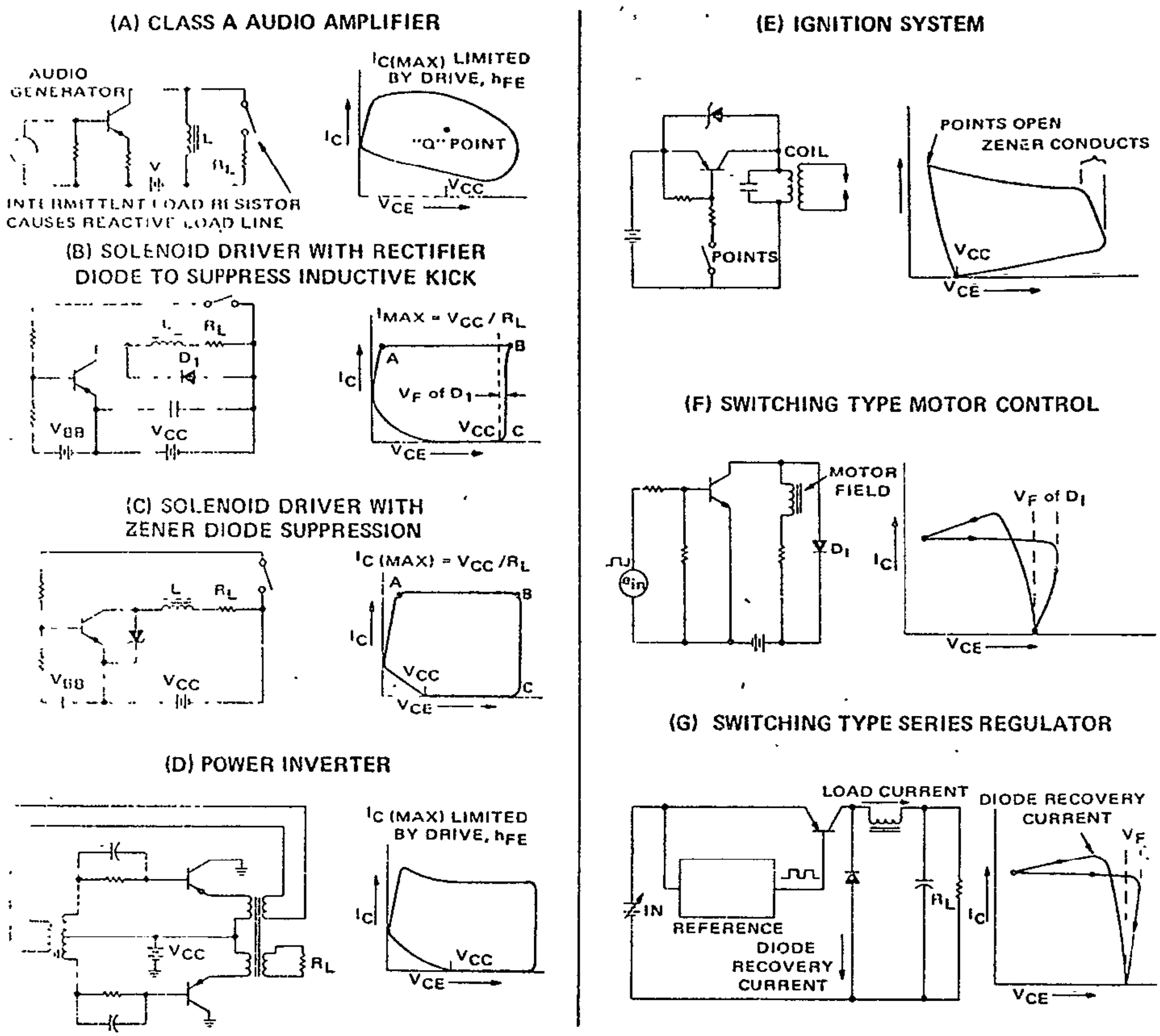


Figure 38. Examples of Circuits and Their Typical Load Lines

Power Transistor Cooling

Transistors with power ratings greater than one watt are usually provided with a large, flat surface that can be clamped against a metal exchanger. The purpose of the heat exchanger is to transfer the heat to a larger surface from which it can then be dispersed by a cooling medium. The heat must pass through several "thermal impedances"

APPENDIX G

SIMULATED EXAMPLE OF A DATA SHEET

1. Part Type: NPN, general purpose amplifier and switching transistor.

Commercial
Designation: 2N2222A

Military
Designation: JANTXV2N2222A - covered by MIL-S-19500/255 Rev. E
Amendment 4

2. Physical Characteristics
2.1 Physical Arrangement - Figure 1

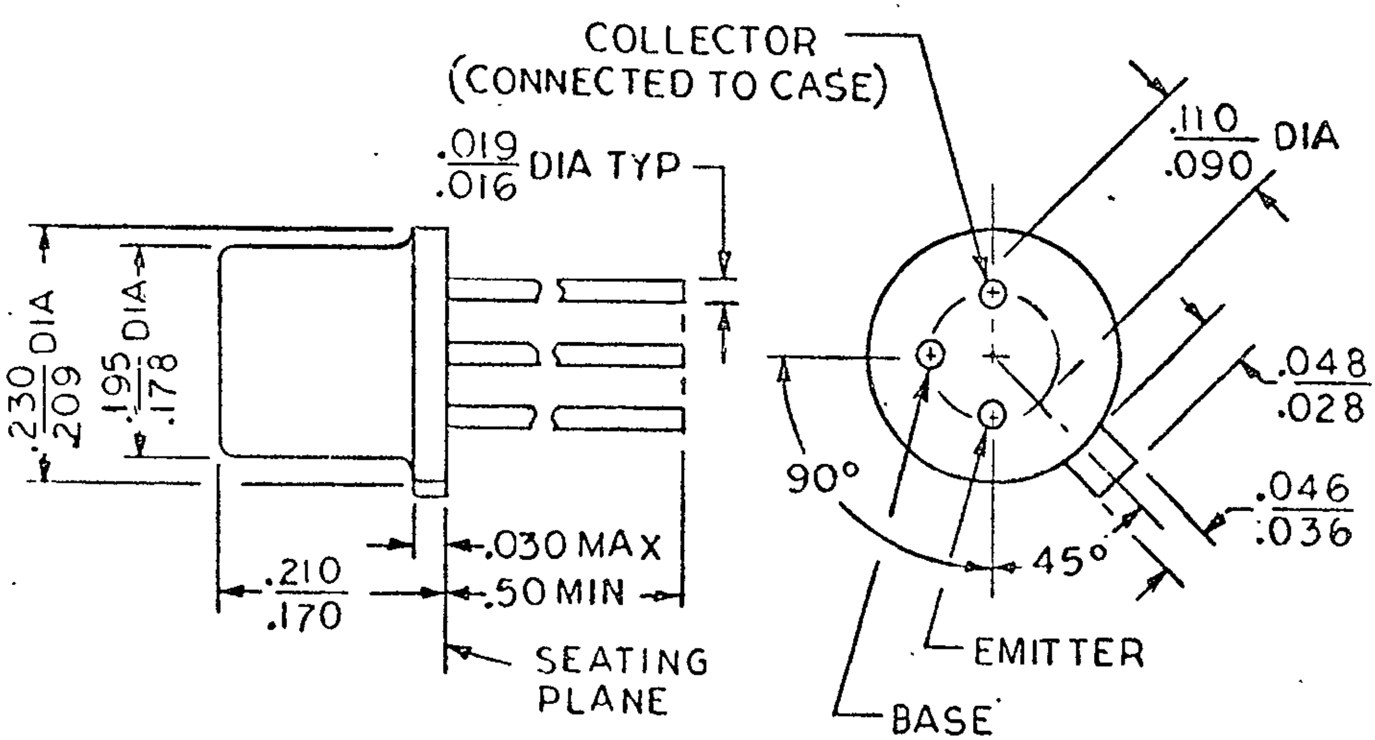


FIGURE 1 PHYSICAL ARRANGEMENT OF JANTXV2N2222A (TO-18)

2.2 Lead Material & Finish

Lead materials shall be Kovar or Alloy 52. Lead finish shall be gold-or-tin plated. Where a choice of lead material and lead finished is desired, it shall be specified in the contract or order.

2.3 Thermal Resistance

Θ_{J-A} = 3.3mW/°C
Θ_{J-C} = 12 mW/°C

3. Functional Characteristics

3.1 Absolute Maximum Ratings (see paragraph 3.2)

Collector to Base Voltage (V_{CBO}) 75Vdc
Collector to Emitter Voltage (V_{CEO})...............50Vdc
Emitter to Base Voltage (V_{EBO}).................... 6Vdc
Collector Current (I_C)..........................800madc
Power Dissipation:
Case Temp.= 25°C 1.8W
Ambient Temp. = 25°C 5W

Operating Junction Temperature ....-65°C to 200°C

3.2 Derating

The following derating criteria shall be used in the application of this device on NASA programs

3.2.1 Maximum dc collector current: 0.6Adc.
3.2.2 Maximum collector to emitter voltage: 37 Vdc
3.2.3 Maximum collector to base voltage: 56Vdc
3.2.4 Junction temperature shall not exceed +125°C in the application. For the purpose of calculation, device shall be derated linearly 3.33mW/°C for $T_A > 25°C$ and 12.0mW/°C for $T_C > 25°C$

3.2.5 End of Life: The following end-of-life criteria shall be used:

Parameter	End-of-Life Tolerance (EOLT)
a. Current Gain (h_{FE})	± 25% of Specified Values
b. Leakage Currents	+100% of Specified Maximum
c. Sustaining Voltage	- 20% of Specified Minimum
d. Saturation Voltage	+ 10% of Specified Maximum
e. Capacitance	+ 10% of Specified Maximum
f. Pulse Response	+ 25% of Specified Maximum

3.2.6 Application Problems:

Devices employing internal wedge wire bonds should not be used in circuit operation upon 100K_{HZ}.

3.3 Electrical Performance Characteristics
(T_A = -55 to + 125°C unless otherwise specified)

Test	Symbol	Conditions	Limits Min	Limits Max	Units
D.C. Current Gain	H_{FE}	V_{CE} = 10Vdc I_C = .1mAdc	50	-	-
		V_{CE} = 10Vde I_C = 1.0mAdc	75	-	-
		V_{CE} = 10Vdc I_C = 10mAdc	100	-	-
		V_{CE} = 10Vdc I_C = 150mAdc	100	300	-
		V_{CE} = 10Vdc I_C = 500mAdc	300	-	-
High Frequency Current Gain	h_{fe}	f = 100mHz V_{CE} = 20 Vde I_C = 20 mAdc	2.5	-	-
Output Capacitance	C_{ob}	100KHz $<$ f $<$ 1MHz V_{CB} = 10Vdc I_E = 0	-	8	pf
Switching Turn-on	t_{on}	Fig. 1	-	35	nsec.
Turn-off	t_{off}	Fig. 2	-	300	nsec
Turn-on + Turn-off	$t_{on}+t_{off}$	Fig. 3	-	18	nsec

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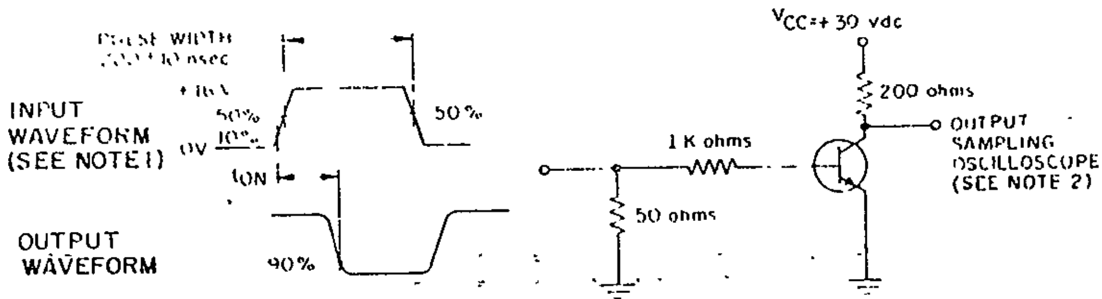


FIGURE 1 Saturated turn-on switching-time test circuit.

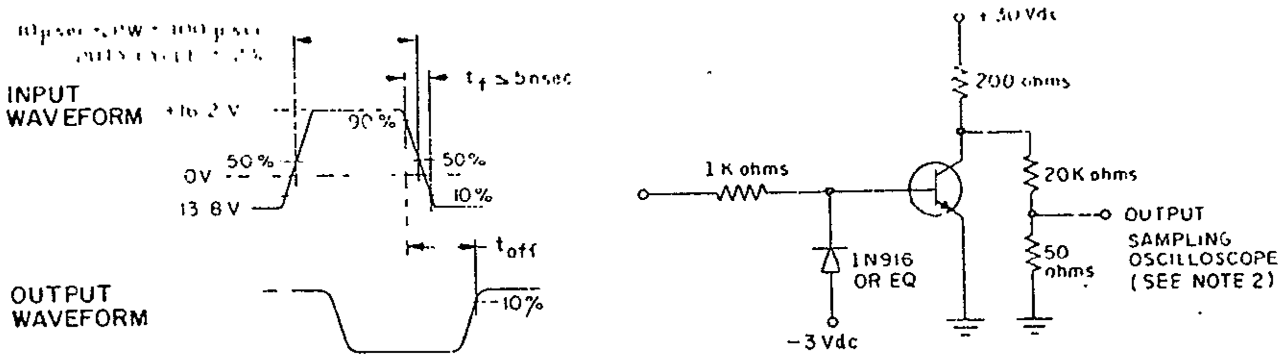


FIGURE 2 Saturated turn-off switching-time test circuit.

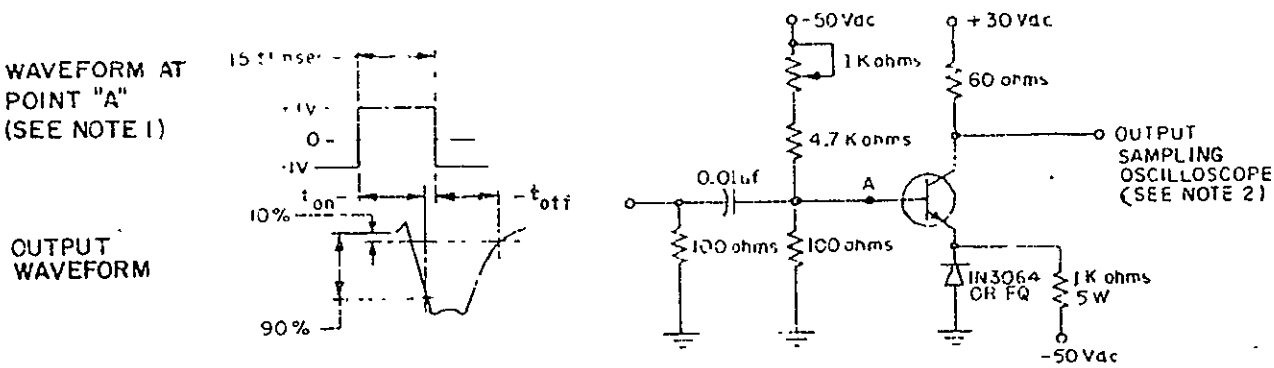
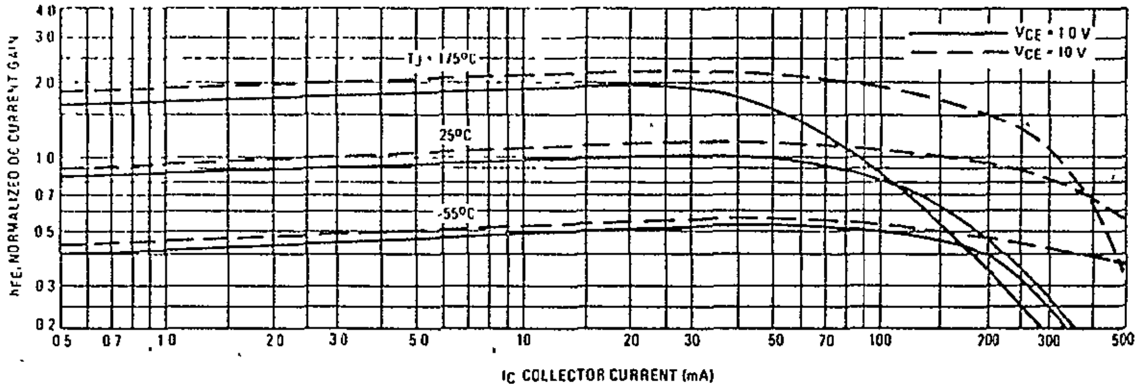


FIGURE 3 Non-saturated-switching-time test circuit.

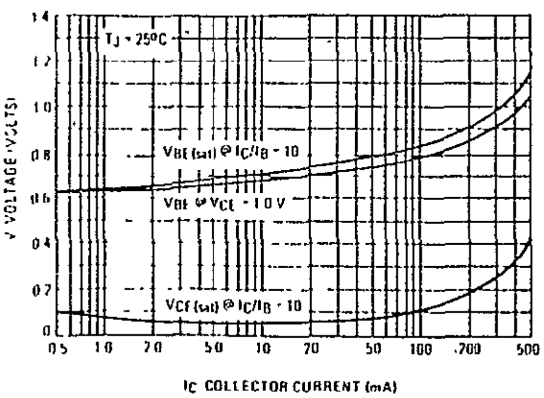
NOTES

1. The rise time (t_r) of the applied pulse shall be $\leq$ 2.0 nanoseconds, duty cycle $\leq$ 2%, and the generator source impedance shall be 50 ohms.
2. Sampling Oscilloscope $Z_{in} \geq 100$ K ohms, $C_{in} \leq 12$ pf, Rise time $\leq$ 5 nsec.

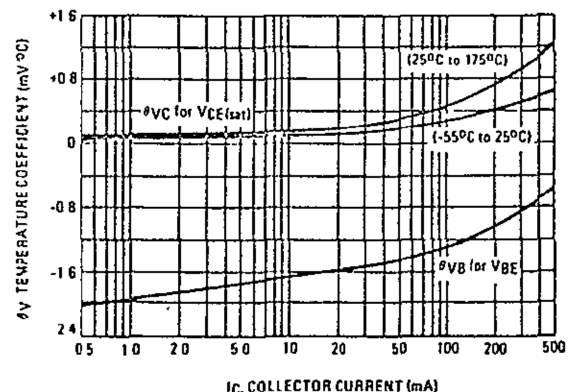
NORMALIZED DC CURRENT GAIN



"ON" VOLTAGES



TEMPERATURE COEFFICIENTS

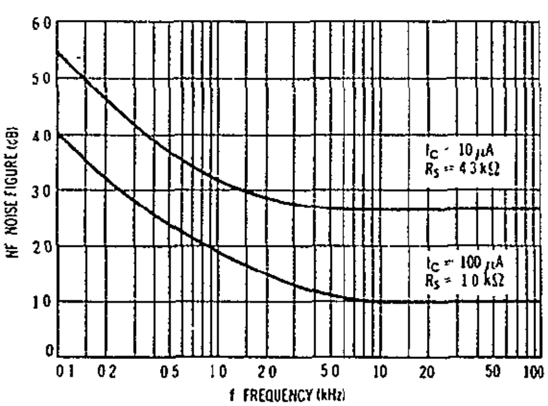


ORIGINAL PAGE IS OF POOR QUALITY

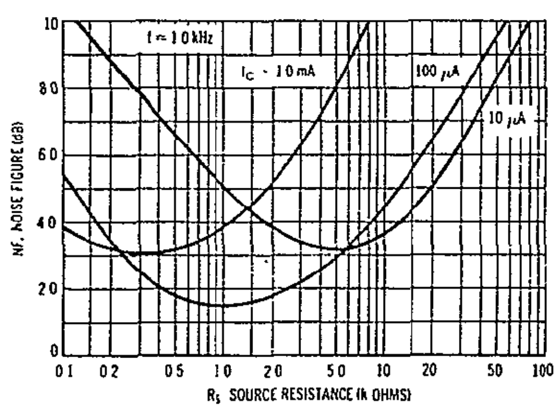
NOISE FIGURE

V_{CE} = 10 V, T_A = 25°C

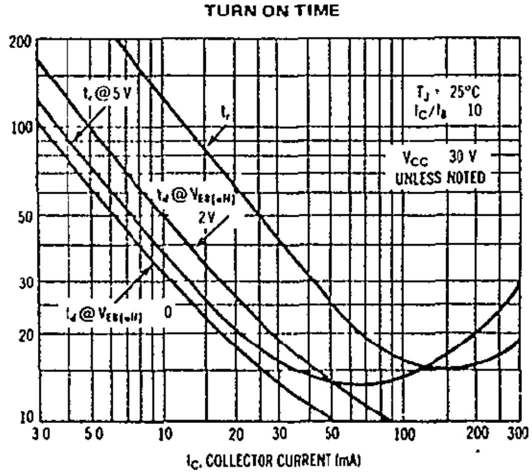
FREQUENCY EFFECTS



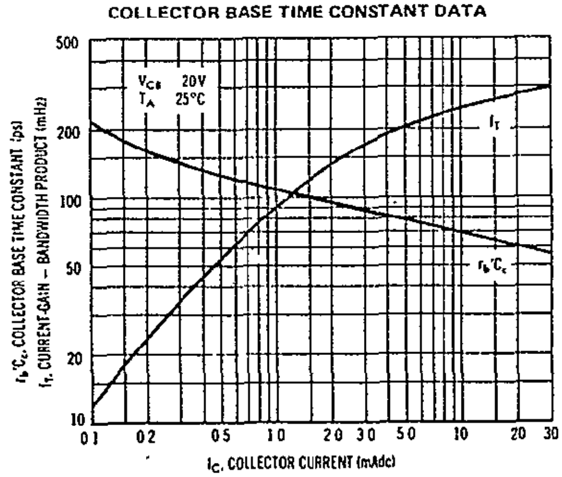
SOURCE RESISTANCE EFFECTS



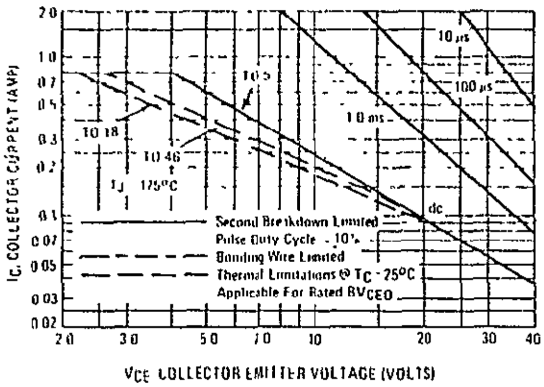
TURN ON TIME



CURRENT-GAIN–BANDWIDTH PRODUCT AND COLLECTOR BASE TIME CONSTANT DATA



ACTIVE-REGION SAFE OPERATING AREAS

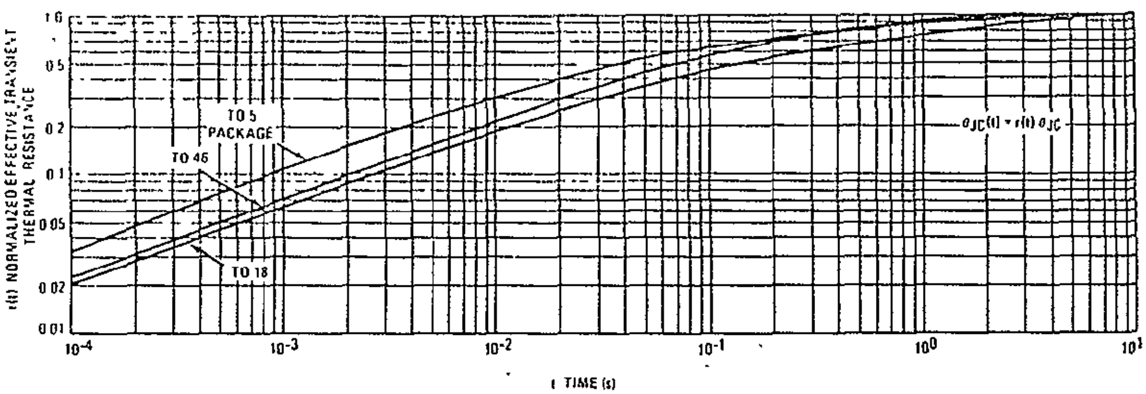


This graph shows the maximum I_C-V_{CE} limits of the device both from the standpoint of thermal dissipation (at 25°C case temperature), and secondary breakdown For case temperatures other than 25°C, the thermal dissipation curve must be modified in accordance with the derating factor in the Maximum Ratings table

To avoid possible device failure, the collector load line must fall below the limits indicated by the applicable curve Thus, for certain operating conditions the device is thermally limited, and for others it is limited by secondary breakdown

For pulse applications, the maximum I_C-V_{CE} product indicated by the dc thermal limits can be exceeded Pulse thermal limits may be calculated by using the transient thermal resistance curve of Figure 19.

THERMAL RESPONSE



APPENDIX H

EXAMPLE OF MINIMUM/MAXIMUM CHARTS

4.3.3 Current Limiting - I_{CL}

The current limiting point of the voltage regulator is determined by the value of R_{11} (nominally 0.3Ω) and the turn on threshold of Q_{15}. (Refer to circuit schematic in Figure 4-2). This mechanism is intended strictly to prevent short duration overloads from damaging the series pass element. [Long term overloads, which raise T_j significantly, are handled by the thermal shutdown element.]

Figure 4-10 is a plot of typical peak load current vs input to output voltage differential, with junction temperature remaining constant. The figure is valid for the entire regulator family, regardless of nominal V_{OUT}.

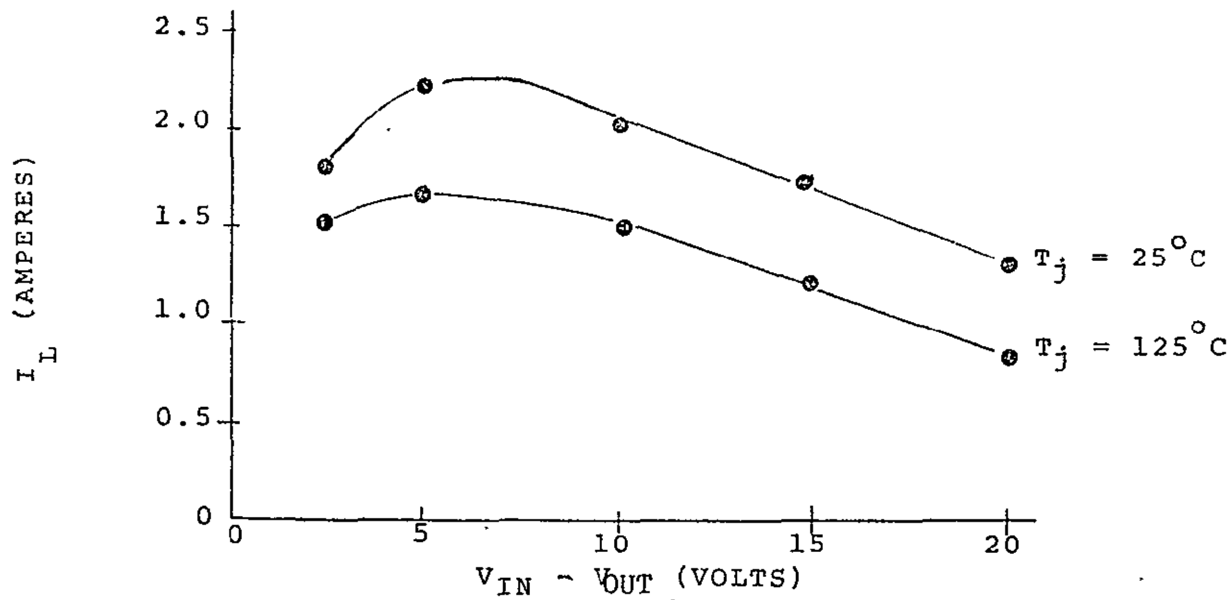


Figure 4-10 Typical Peak Load Current vs. Input-Output Voltage Differential

Since the peak current appeared to be at its greatest when $V_{IN} - V_o \approx 5V$, the test conditions were specified as such. The test circuit is shown in Figure 4-11.

The base of the external transistor is driven with a pulse whose amplitude is sufficient to achieve I_{CL} max. For example, I_{CL} max for the TO-3 case is 3.0 amperes, therefore the pulse amplitude is $3.0V + V_{BE}$ (external transistor). The measurement is conducted at a 2% duty cycle to prevent any thermal effects from becoming a factor. Data on I_{CL} is recorded in Table C-5 of Appendix C.

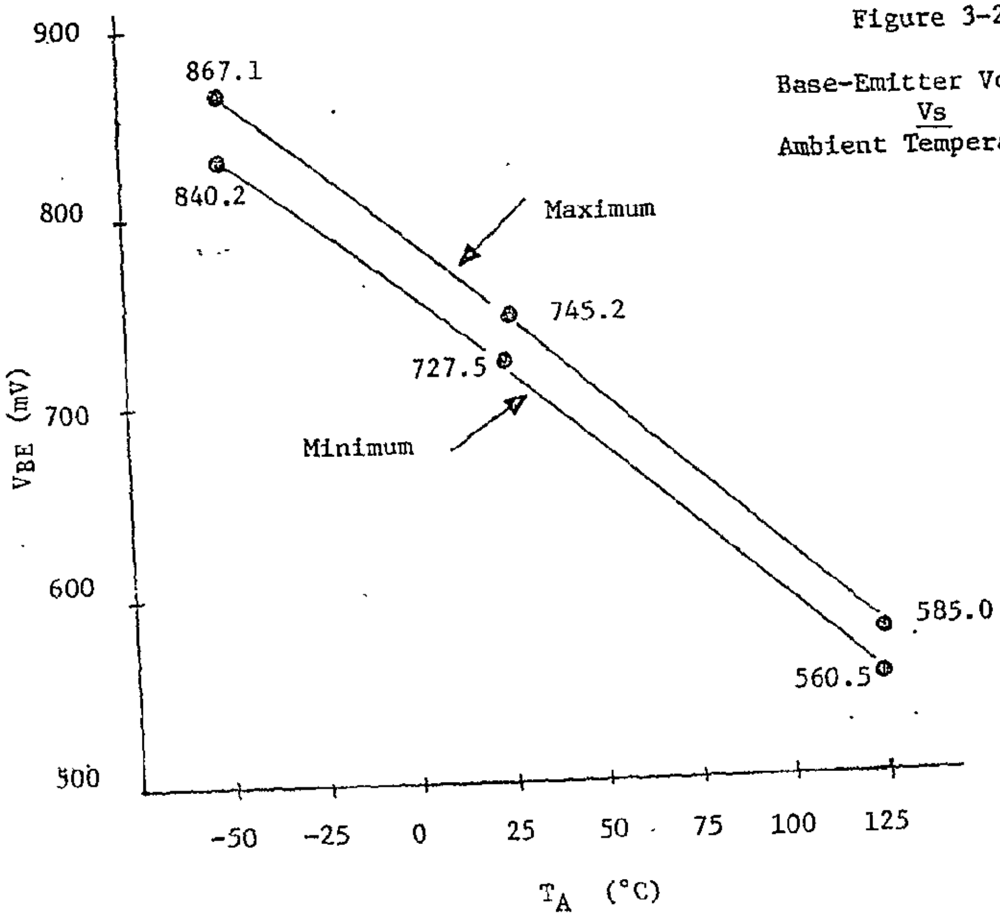


Figure 3-2

Base-Emitter Voltage
Vs
Ambient Temperature

WORST CASE

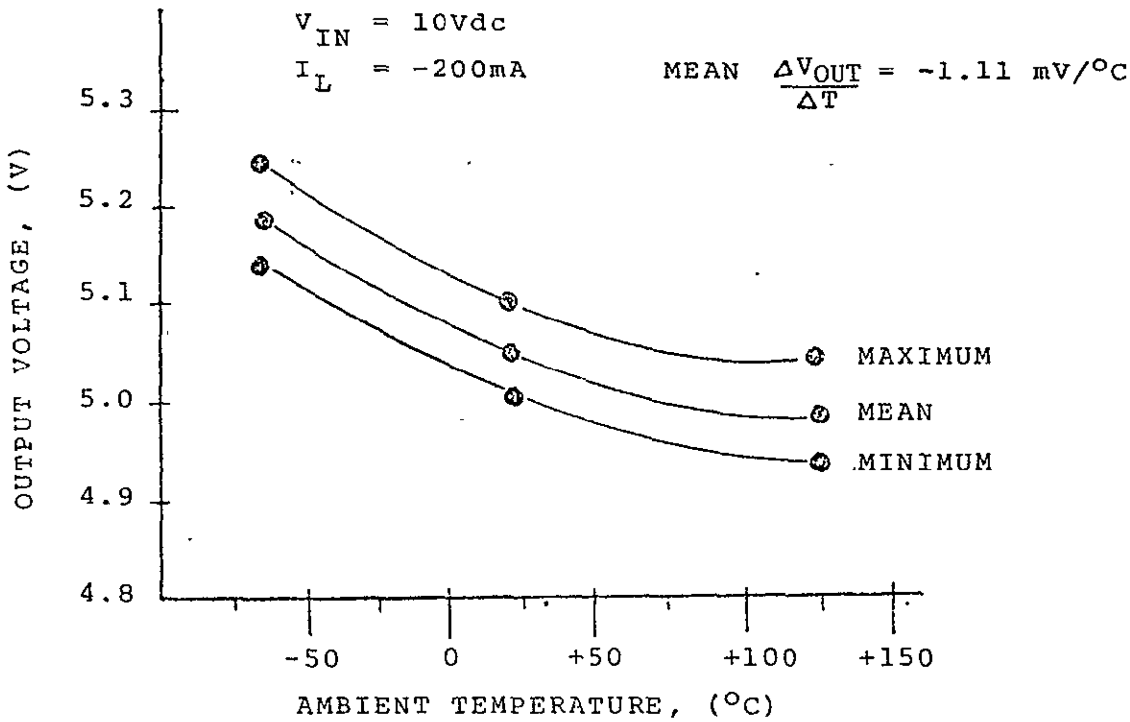
$\Delta V_{BE}/\Delta T$ = 560.5-745.2(mV)/125-25°C = -1.847 mV/°C

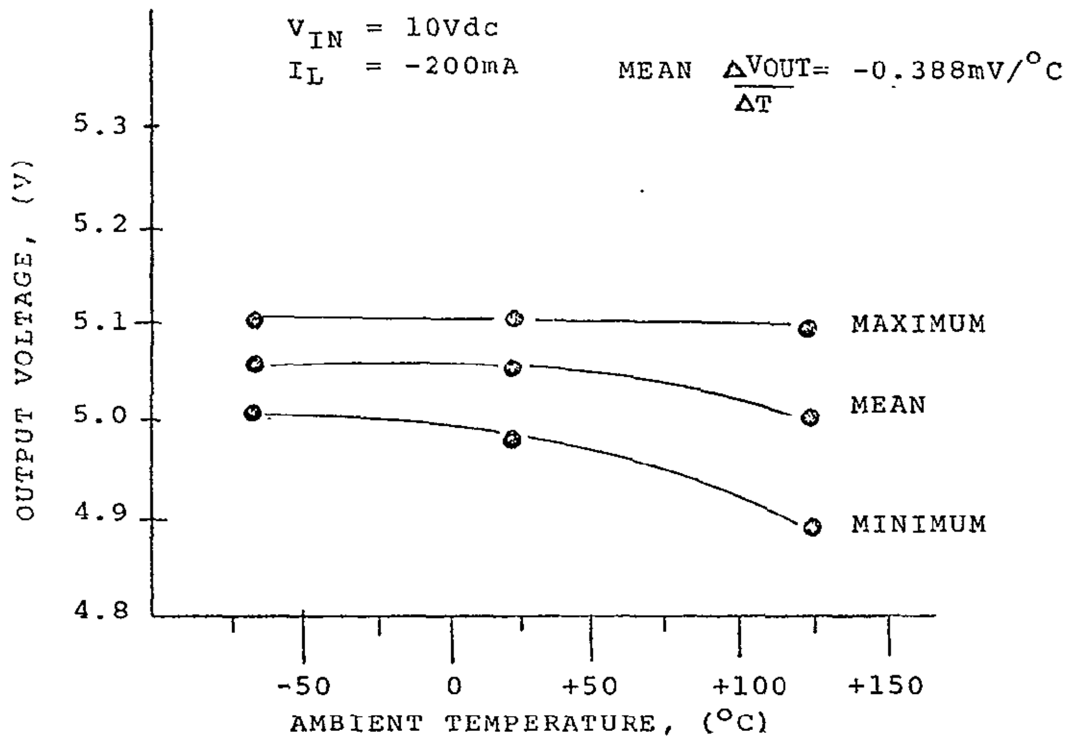
$\Delta V_{BE}/\Delta T$ = 727.5-867.1(mV)/25-(-55)°C = -1.745 mV/°C

The offset voltage, ($|V_{BEQA}-V_{BEQB}|$), for any given transistor pair is nominally $\leq$ 1.0 mV at T_A =25°C and $\leq$ 2.0 mV at T_A = -55°C and T_A = 125°C. The temperature coefficient of offset voltage $|\Delta(V_{BEQA}-V_{BEQB})/\Delta T|$ nominally runs $\approx$10 uV/°C. The values in Table B-2 show a range 0.0 to 20 uV/°C for 25°C $\leq T_A \leq$ 125°C and 3.75 to 32.5 uV/°C for -55°C $\leq T_A \leq$ 25°C.

Measurements conducted at the temperature extremes probably are less accurate than room temperature measurements due to added contact resistance of sockets/plugs in the cable assembly from the temperature chamber to the test fixture. Condensation of moisture at T_A = -55°C contributed to the measurement problem.

5 V Regulators





Figures 4-6a and 4-6b Output Voltage vs. Ambient Temperature

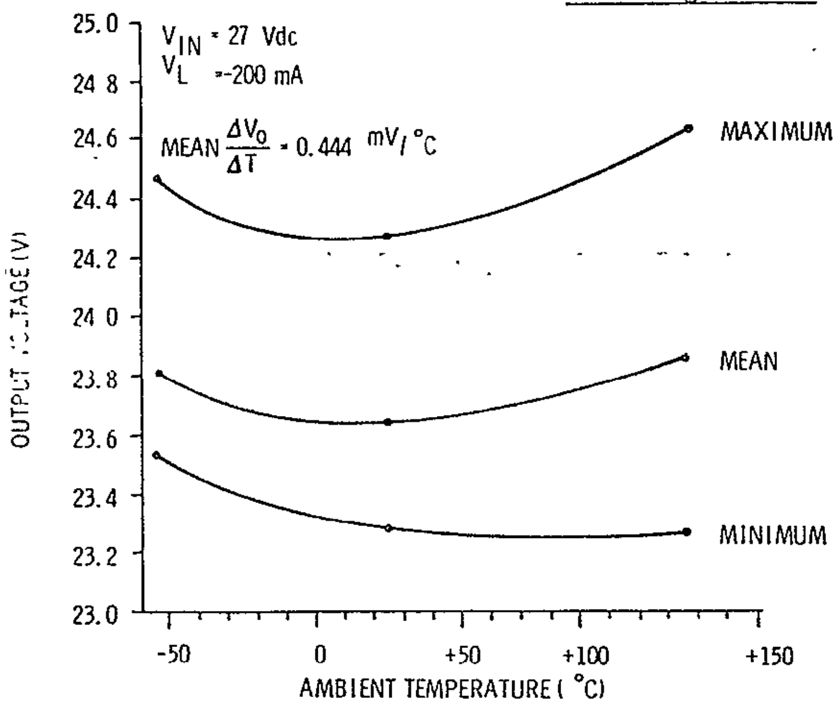


Figure 4-6e Output Voltage vs. Temperature

SUPPLIER G

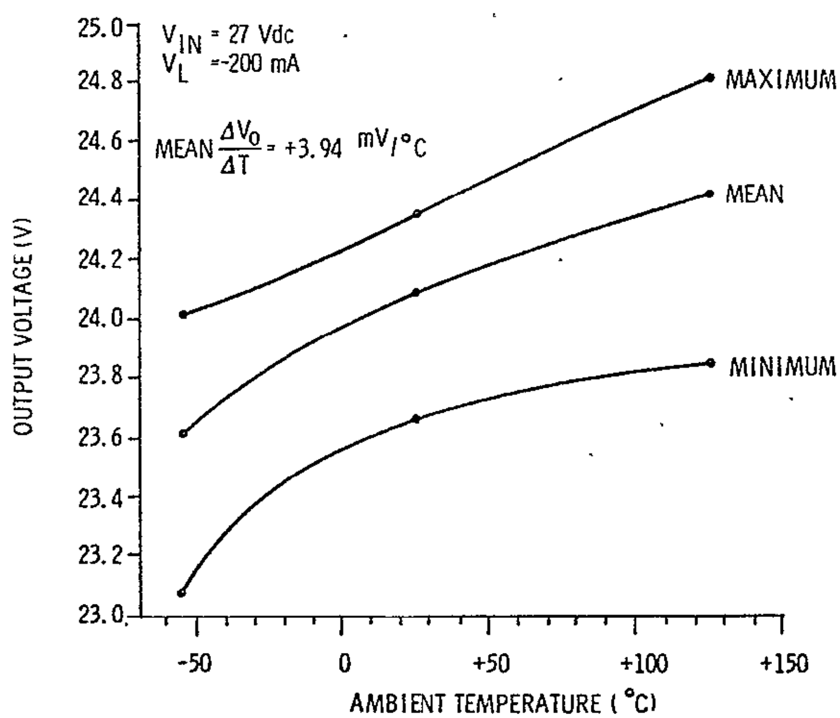


Figure 4-6f Output Voltage vs. Temperature

GENERAL ELECTRIC