DESIGN FOR MANUFACTURABILITY

DEFINITION

INTRODUCTION

COMPETITION AND VULNERABILITY PROBLEMS WITHOUT DFM MANUFACTURABILITY THE EARLY EFFECTS OF DESIGN

DESIGN PHILOSOPHY

TRADITIONAL DESIGN CONSIDERATIONS
FACTORY DESIGN CONSIDERATIONS
SOCIAL DESIGN CONSIDERATIONS
MARKETING DESIGN CONSIDERATIONS
ENVIRONMENTAL DESIGN
CONSIDERATIONS
DFM VERSUS DESIGN FREEDOM
UNDERSTANDING MANUFACTURING

IMPLEMENTING DFM

WHAT DFM PROGRAMS ACCOMPLISH
ORGANIZING A DFM PROGRAM
SOURCES OF DFM INFORMATION
STRUCTURING DFM INFORMATION
CHECKLISTS
DESIGN TEAMS
ENCOURAGING DFM

THE BENEFITS OF DFM

ASSEMBLY COST SAVINGS
PART FABRICATION COST SAVINGS
WORK-IN-PROCESS INVENTORY SAVINGS
MARKET FLEXIBILITY AND DELIVERY
FINISHED GOODS INVENTORY SAVINGS
MATERIALS OVERHEAD SAVINGS
MACHINERY UTILIZATION SAVINGS
FLOOR SPACE SAVINGS
QUALITY COST SAVINGS
DEVELOPMENT COST SAVINGS
PRODUCTS SOONER TO MARKET
SUPERIOR PRODUCT DESIGN
CONCLUSIONS

CONCURRENT ENGINEERING

DESIGN FOR MANUFACTURABILITY

DFM/A PRINCIPLES
DEVELOPING GUIDELINES
SUPPLIERS INVOLVEMENT
DFM/A ANALYSIS TOOLS
INTEGRATING DFM WITH CAD

DESIGN FOR QUALITY

QUALITY FUNCTION DEPLOYMENT TAGUCHI QUALITY ENGINEERING BENCHMARKING

DESIGN FOR THE LIFE CYCLE

DESIGN FOR TESTABILITY/INSPECTABILITY DESIGN FOR RELIABILITY DESIGN FOR MAINTAINABILITY AND SERVICEABILITY

DESIGN FOR COST

ENABLING TECHNOLOGY

DIGITAL PRODUCT MODELS AND DATA MANAGEMENT DESIGN AND ANALYSIS

PROCESS DESIGN DATA INTERCHANGE

CONCURRENT ENGINEERING AND THE ORGANIZATION

PRODUCT DEVELOPMENT TEAMS
ORGANIZATION STRUCTURE
TEAM OPERATION

IMPROVING THE DEVELOPMENT PROCESS

RESOURCE PLANNING STREAMLINING THE DEVELOPMENT PROCESS

SUMMARY

MANAGEMENT INVOLVEMENT IN DFM

MANAGEMENT FRAMEWORKS

ARCHITECTURE

MANUFACTURABILITY PROCESS

MANAGEMENT'S CONCERNS
WITH MANUFACTURABILITY
PERFORMANCE

PROCESS INTEGRATION

MANAGEMENT INTERESTS IN THE DESIGN

CHAPTER 4

TEAM BUILDING AND TRAINING

WHERE TO BEGIN

TOOLS TO CONSIDER

START A PILOT PROJECT

TEAM SELECTION AND TRAINING

DEFINE CORPORATE OBJECTIVES

EDUCATE

IMPLEMENTATION

ASSESSMENT

INTERNALLY PUBLICIZE

ACCOMPLISHMENTS

INSTITUTIONALIZE

DEVELOPING AN INTERNAL DFM MANUAL

HOW SHOULD THE DFM MANUAL BE PRESENTED?

WHAT SHOULD BE IN A DFM MANUAL

HOW TO CREATE A DFM MANUAL

HUMAN PERFORMANCE IMPROVEMENT AND TRAINING IN DFM

PLANT MODERNIZATION EFFECTS ON HUMAN PERFORMANCE DFM AND HUMAN FACTORS ENGINEERING HUMAN LEARNING PRINCIPLES SYSTEMS BASED TRAINING SUMMARY

JUSTIFICATION OF DFM

INTRODUCTION

THE BEST TIME FOR DFM
COSTS FOR DFM USE
OTHER IMPORTANT FEATURES OF DFM

VIEWPOINTS FOR DFM

THE MACRO PERSPECTIVE
TYPES OF COST
OTHER SIGNIFICANT
COST ESTIMATING CONCEPTS

COMPUTER APPLICATIONS

OTHER SIGNIFICANT COST ESTIMATING CONCEPTS

COST ESTIMATING

TECHNICAL ESTIMATES
HISTORICAL DATA
PREDETERMINED TIME STANDARDS
ELEMENTAL STANDARD DATA
METHODS FOR DETERMINING
RELEVANT COSTS

TRADITIONAL JUSTIFICATION

DEALING WITH INTANGIBLES

STEP 1-FIND THE FACTORS IMPORTANT TO THE COMPANY IN MAKING A DECISION CONCERNING PRIORITIES STEP 2-RANK THE FACTORS ACCORDING TO IMPORTANCE STEP 3-SELECT A RATING SYSTEM FOR HOW IMPROVEMENTS WILL AFFECT EACH FACTOR

STEP 4-DEVELOP WEIGHTS FOR EACH FACTOR THAT WILL BE USED IN DECIDING PRIORITIES STEP 5-DEVELOP A CONSISTENT APPROACH TO DECIDE PRIORITY OF IMPROVEMENTS

USING QUALITY TOOLS IN DFM

BASIC CONCEPTS

DEFINITIONS OF KEY TERMS THE DEMING PROCESS MANAGEMENT CYCLE

A PROCESS VIEW OF DFM ACTIVITIES

QUALITY TOOLS

STRUCTURED PLANNING METHODS
QUALITY FUNCTION DEPLOYMENT
PROCESS DOCUMENTATION AND
ANALYSIS
STATISTICAL METHODS
BENCHMARKING

QUALITY TOOLS IN THE DESIGN STAGE

PLAN

DO

STUDY

ACT

QUALITY TOOLS IN THE TRANSITION STAGE

PLAN

DO

STUDY

ACT

QUALITY TOOLS IN THE PRODUCTION OPERATIONS STAGE

PLAN

DO

STUDY

ACT

SUMMARY

COMPUTER-AIDED TECHNOLOGY

CHAPTER CONTENTS:

INTRODUCTION

THE USE OF COMPUTER-AIDED ENGINEERING, DESIGN AND MANUFACTURING TOOLS IN DFM

USING STANDARD PARTS AND COMPONENTS

DESIGNING FOR A MINIMUM NUMBER OF PARTS

DESIGNING PARTS FOR MULTIPLE USES

DESIGNING MULTIFUNCTIONAL PARTS

AVOIDING SEPARATE FASTENERS

DEVELOPING MODULAR DESIGNS

MINIMIZING MODELS AND MOCKUPS
DEALING WITH FLEXIBLE COMPONENTS

MINIMIZING NEW PROCEDURES AND PROCESSES

PRODUCING PROCESS-DRIVEN DESIGNS

MINIMIZING MANUFACTURING COSTS DESIGNING-IN COMPLIANCE FEATURES

MINIMIZING COMPONENT HANDLING EFFECTIVE MODEL CONSTRUCTION METHODS

DESIGNING FOR MANUFACTURE, FABRICATION AND ASSEMBLY PUTTING IT ALL TOGETHER

RAPID PROTOTYPING

BENEFITS OF SOLID MODELING AND RAPID PROTOTYPING
STEREOLITHOGRAPHY
CRITERIA FOR STEREOLITHOGRAPHY
RESIN SELECTION
SOLID GROUND CURING
SELECTIVE LASER SINTERING
BALLISTIC PARTICLE MANUFACTURING
FUSED DEPOSITION MODELING

LAMINATED OBJECT MANUFACTURING SIMULTANEOUS IRRADIATION OF CONSTRAINED POLYMERS 3-AXIS DESKTOP MODELING SYSTEM

DESIGN FOR ASSEMBLY

RELATING DFA TO DFM

DFA ANALYSIS
WHY IS DFA IMPORTANT?

GETTING STARTED: DEVELOP THE TEAM

MANAGEMENT MUST BE ON YOUR SIDE ENCOURAGE A CREATIVE CLIMATE SELECT A MANUFACTURING SITE AND DECIDE ON THE PROCESS THE TEAM OWNS THE PRODUCT SELECT AND APPLY DFA TOOLS

APPLYING THE DFA PROCESS

PRODUCT GOALS
ESTABLISH DFA PRINCIPLES
APPLY MECHANICAL DFA PRINCIPLES
USE DFA METRICS

IMPROVING PRODUCT SERVICEABILITY

INCLUDE FIELD SERVICE ADVICE
DFA REDESIGN APPROACHES
THE DIFFERENCE BETWEEN DFA AND DFS
DFS CONSIDERATIONS

RECYCLABILITY

WHO IS DOING IT CONSIDERATIONS

PRELIMINARY DESIGN ISSUES

CREATIVE THINKING IN DFM/A

WHAT IS CREATIVITY?
WHAT IS CREATIVE THINKING?
WHAT IS CREATIVE PROBLEM SOLVING?
WHY AREN'T ENGINEERS CREATIVE?

ROADBLOCKS TO CREATIVE THINKING

PERCEPTUAL ROADBLOCKS EMOTIONAL ROADBLOCKS CULTURAL ROADBLOCKS HABITUAL BLOCKS

DEVELOPING CREATIVE THINKING

THE CREATIVE ENVIRONMENT
VERTICAL (CONVERGENT) THINKING
LATERAL (DIVERGENT) THINKING
LATERAL THINKING VERSUS
VERTICAL THINKING
ACTIVATING LATERAL THINKING

CREATIVE PROBLEM SOLVING TECHNIQUES

INDIVIDUAL TECHNIQUES GROUP TECHNIQUES

APPLYING CREATIVE PROBLEM SOLVING TO DFM/A

CREATIVE THINKING IN DFA
CREATIVE THINKING IN
PROCESS SELECTION
CREATIVE THINKING IN
MATERIAL SELECTION

CREATIVE THINKING IN MATERIAL AND PROCESS SELECTION

CONCEPTUAL DESIGN

GENERAL METHODS FOR CONCEPTUAL DESIGN FACILITATION OF CONCEPTUAL DESIGN BY COMPUTERS

FUNCTIONAL EFFICIENCY TECHNIQUES FOR ASSURING ECONOMICAL DFM

THE CONCEPT OF FUNCTION
RELATIONSHIPS AMONG FUNCTIONS
FEATURE FUNCTIONS VERSUS
SYSTEM FUNCTIONS

THE QUANTIFICATION OF FUNCTION FUNCTIONAL DESIGN EFFICIENCY EXAMPLE OF USING FUNCTIONAL EFFICIENCY FOR DESIGN REVIEW

A CONCEPTUAL DESIGN SYSTEM

METHODOLOGY FOR BUILDING A
CONCEPTUAL DESIGN SYSTEM
SPECIFICATION OF REQUIREMENTS
AND FUNCTIONS
REPRESENTATION OF
SPECIFIED FUNCTIONS
DESIGN SYNTHESIS
ARCHITECTURE OF THE SYSTEM FOR
CONCEPTUAL DESIGN
SUMMARY

APPLICATIONS OF ARTIFICIAL INTELLIGENCE IN DFM

INTRODUCTION
THE NATURE OF ARTIFICIAL
INTELLIGENCE (AI)
SELECTING AN APPROPRIATE
APPLICATION
SUGGESTIONS FOR DFM EXPERT SYSTEM
APPLICATIONS
SUGGESTIONS FOR DFM NEURAL
NETWORK APPLICATIONS

GENERAL PRODUCT DESIGN

IMPACT OF DESIGN CONCEPT AND EARLY PROJECT DECISIONS

NATURE OF DESIGN GUIDELINES

COST COMMITMENT
DESIGN FLEXIBILITY
HOW A DESIGN IS DETERMINED
CONCURRENT DESIGN
MANUFACTURING COST
TECHNOLOGY OF THE PROJECT

DESIGN PROCESS ELEMENTS

AND TECHNIQUES

QUALITY CONTROL
CONTINUOUS IMPROVEMENT
TEAM PERSONNEL
SUPPORT FUNCTIONS
SAFETY

WASTE GENERATION AND DISPOSITION

EVALUATING MANUFACTURABILITY OF CONCEPTUAL DESIGNS

INTRODUCTION
MEASUREMENT OF MANUFACTURABILITY
THE MANUFACTURABILITY RATING
TECHNIQUE—BASELINE
BASELINE EVALUATION OF
MANUFACTURABILITY
APPLICABILITY

SUMMARY

PRODUCIBILITY

INTRODUCTION
NEEDS ANALYSIS
PRODUCIBILITY BACKGROUND
THE DESIGN-MATERIAL-PROCESS TRILOGY
EVALUATION
A PRODUCIBILITY MODEL
PRODUCIBILITY METRICS
SUMMARY

PRODUCIBILITY ASSESSMENT FOR DOD CONTRACTS

PA FOR DECISION MAKERS AND MANAGERS PA TOOLS FOR ENGINEERS

GEOMETRIC TOLERANCING STRUCTURE AND LANGUAGE FOR CONCURRENT ENGINEERING (CE)

INTRODUCTION

PRODUCT DEFINITION

THE LANGUAGE OF CONCURRENT ENGINEERING—Y14.5M CONCURRENT ENGINEERING TOOLING AND FUNCTIONAL GAGING SUMMARY

ENVIRONMENTALLY RESPONSIBLE PRODUCT DESIGN

INTRODUCTION SUMMARY

HUMAN FACTORS ISSUES IN PRODUCT DESIGN

PRODUCT USABILITY
PRODUCT SAFETY AND LIABILITY
QUALITY CONTROL AND INSPECTION
PRODUCT ASSEMBLY
MAINTENANCE
IMPACT OF EQUIPMENT RELIABILITY
WORKSTATION DESIGN AND
OPERATOR TRAINING

DESIGN FOR SERVICEABILITY

THE EFFECT OF DESIGN ON SERVICE DESIGN CONSIDERATIONS FOR SERVICEABILITY AN IDEAL TO STRIVE FOR

SUMMARY

DESIGN CRITERIA FOR PRODUCT AND PACKAGE

PRODUCT DESIGN MATERIAL TYPE

MATERIAL SIZE PRODUCT SHAPE

PACKAGE DESIGN

MATERIAL TYPE

MATERIAL THICKNESS

PACKAGE SHAPE PACKAGE SEAL

SUPPLIER CERTIFICATION

INTRODUCTION

APPROACH

DESIGN OF THE CERTIFICATION PROGRAM SUPPLIER CRITERIA

INITIAL CONTACT

PLANT VISIT

IMPLEMENTATION

AWARD

MAINTENANCE OF CERTIFICATION

SUMMARY

MACHINING

SIMPLIFYING MACHINING IN THE DESIGN STAGE

GENERAL MACHINING CONSIDERATIONS

MATERIAL CONSIDERATIONS

DIMENSIONAL TOLERANCES AND

SURFACE ROUGHNESS

SURFACE FINISH

THE RELATIONSHIP OF CLOSE TOLERANCES AND FINE FINISHES TO PRODUCTION COST

TURNING

MILLING

DRILLING

PRODUCTION GRINDING

HONING

GEAR DESIGN

GEOMETRIC DIMENSIONING AND TOLERANCING GAGE DESIGN METALWORKING FLUID SELECTION

NONTRADITIONAL MACHINING

LASER MACHINING WATERJET AND ABRASIVE WATERJET MACHINING

ABRASIVE FLOW MACHINING

ULTRASONIC MACHINING

ELECTROCHEMICAL MACHINING

PHOTOCHEMICAL MACHINING

FLEXIBLE MANUFACTURING CELLS AND SYSTEMS

FLEXIBLE MANUFACTURING CELLS FLEXIBLE MANUFACTURING SYSTEMS

FORMING

METAL FORMING METHODS

STAMPING DESIGN FOR ECONOMY OF TOOLING PREFERRED CONDITIONS FOR PUNCHED HOLES PREFERRED TRIM DIE CONDITIONS

WELD FLANGES

PRACTICAL TOLERANCES
TOOLING DESIGN
MATERIAL COMPATIBILITY WITH
PRESSWORKING LUBRICANTS
LUBRICANT CLEANING AND
FINISHING REQUIREMENTS
STRUCTURE OF PRESSWORKING
LUBRICANTS

WATER-BASED PRESSWORKING LUBRICANTS FINISHING OPERATIONS

FINEBLANKING

CORNER RADII AND EDGE ROLL
CHARACTERISTICS
MATERIALS, THICKNESS AND
SIZE OF PARTS
TOLERANCES, EDGE SURFACE
CONDITIONS AND FLATNESS
HOLE DIAMETERS, CROSSSECTIONS AND OFFSETS
SEMI-PIERCING (EXTRUSIONS)—
FORMING AND BENDING
PROGRESSIVE TOOLING—
COINING AND FORMING
FORMING AND DRAWING

ROLL FORMING

BENDING RADIUS
DISCONTINUED BEND LINES
WIDTH OF FLAT ELEMENTS
EFFECT OF SECONDARY OPERATIONS IN
THE ROLL FORMING LINE
MATERIAL TO BE FORMED
TOLERANCES
INTERACTION OF ROLL DESIGN WITH
FORMED MATERIAL
MATERIAL HANDLING, PACKAGING,
ASSEMBLY AND ERECTION
CONSIDERATIONS

PRECISION FORMING

DESIGN IMPLICATIONS OF THE PROCESS UPSETTING

METAL FLOW PRINCIPLES

UPSETTING

FORWARD EXTRUSION BACKWARD EXTRUSION

DRAWING

COINING

SHEAR FORMING

NOSING/FLARING

BENDING

METAL SPINNING

THE SPINNING PROCESS
ADVANTAGES OF METAL SPINNING
TOLERANCES
SURFACE FINISH
GEOMETRIES
MATERIALS

CONVENTIONAL PIPING DESIGN FOR BEND FABRICATION

BENDING APPROACH

DESIGN CONSIDERATIONS

MATERIAL

CLAMPING LENGTHS

PRESSURE DIE AND PUSHWAY LENGTHS

COMPOUND BENDS

OPTIMUM RADII

POST-BEND TREATMENT

EQUIPMENT SPACING

PIPE RACK SPACING

PIPE HANGER LOCATIONS

FIELD WELDS

LUBRICANTS

ANCHORS

TUBE FABRICATING AND BENDING

BEND CONFIGURATION (ENVELOPE)
ENDFORMING
ATTACHMENTS (WELDMENTS)
OTHER CONSIDERATIONS

CAD APPLICATIONS IN SHEET METAL CUTTING, PUNCHING AND BENDING

CAD MODELING OF SHEET METAL PARTS
COST ESTIMATING
NC SHEET METAL SOFTWARE

FORGINGS

WHY SELECT FORGINGS?
TYPES OF FORGINGS
IMPRESSION DIE FORGINGS
OPEN-DIE FORGINGS
SEAMLESS ROLLED RINGS
SPECIAL PROCESSES FOR
NEAR NET SHAPE FORGING
COLD FORGING PROCESSES—
DESIGN CONSIDERATIONS
SUMMARY

CASTING

CONCEPTUAL FRAMEWORK
ALLOY CHARACTERISTICS AND DESIGN
DEVELOPING A MODEL
SOLIDIFICATION SHRINKAGE
JUNCTION DESIGNS
SOFT VERSUS HIGHLY
CONFIGURED SHAPES
SLAG AND DROSS
INFINITELY VARIABLE SHAPES
SIMPLIFYING TOOLING
DESIGN AND SECONDARY OPERATIONS
CASTING DRAWINGS, DIMENSIONS AND
TOLERANCES

FINISHING AND COATING

DESIGN GUIDELINES FOR PAINTED PARTS

PAINTING TECHNOLOGY DESIGN SPECIFICS

POWDER COATING

PART GEOMETRY
COATING CHARACTERISTICS
FIXTURING REQUIREMENTS
SUBSTRATES
FILM CHARACTERISTICS
PERFORMANCE

ELECTROCHEMICAL METALLIZING

BATH ELECTROPLATING
THERMAL SPRAY METALLIZING
WELDING
ELECTROCHEMICAL METALLIZING
SUMMARY

THERMAL SPRAY COATING

MATERIALS COMMONLY COATED
FINISHING AND SEALING
SHAPE CAPABILITIES
ADVANTAGES OF
THERMAL SPRAY COATINGS
APPLICATIONS
DESIGNING PARTS FOR
THERMAL SPRAY COATINGS

HEAT TREATING

PART DESIGN FOR INDUCTION HEAT TREAT MEASUREMENT TECHNIQUES STATISTICAL PROCESS CONTROL PART MATERIAL

FASTENING AND JOINING

FASTENERS

FASTENER SELECTION
SYSTEM SELECTION
THE IMPORTANCE OF THREADED JOINT QUALITY IN DESIGN FOR SERVICEABILITY
THE BOLTED JOINT
BASIC CHARACTERISTICS
OF THE BOLTED JOINT
BOLTED JOINT FAILURE MECHANISMS
THE IMPORTANCE AND DIFFICULTY OF CORRECT ASSEMBLY
SUMMARY

ADHESIVE ASSEMBLY

ADVANTAGES AND LIMITATIONS OF ADHESIVES

SURFACE PREPARATION BOND LINE DESIGN ASSEMBLY METHODS

TESTING

CONCLUSIONS DFM AND STRUCTURAL ADHESIVES MANUFACTURING WITH ADHESIVES

WELDED ASSEMBLIES

RESISTANCE SPOT WELDING
PROJECTION WELDING
ARC WELDING
ROBOTIC AND AUTOMATED WELDING
LASER BEAM WELDING

MATERIALS

PLASTIC PRODUCTS

FAILURE ANALYSIS— WHY PRODUCTS FAIL

SUPPLIER CHECKLIST

PROTOTYPING

CLASSIFICATION OF PLASTICS

MATERIAL SELECTION

PRODUCT DESIGN CONSIDERATIONS

TYPICAL DESIGN

CONCERNS AND LIMITATIONS

SHRINKAGE

SECONDARY OPERATIONS

SURFACE PREPARATION

DECORATIVE PROCESSES

SUMMARY

COMPOSITES

LIQUID COMPOSITES MOLDING FIBER COMPOSITES SHEET MOLDING COMPOUNDS MOLDED COMPOSITE GEARS

CERAMICS

ENGINEERED CERAMICS

POWDER METALLURGY

POWDER FORGING METAL INJECTION MOLDING

ADVANTAGES AND LIMITATIONS OF PM COMPARING PM WITH OTHER PROCESSES

PM MATERIALS

PM DESIGN

TOOLING CONSIDERATIONS

SHAPES

DESIGN FOR ELECTRONIC ASSEMBLY

INTRODUCTION

OVERVIEW

THE MERGER OF TECHNOLOGY AND BUSINESS
LOOKING BEYOND TRADITIONAL SOURCES FOR NEW PRODUCTIVITY

SALES AND EMPLOYMENT TRENDS

BUSINESS DRIVERS THE TECHNOLOGY DRIVERS

PRINTED WIRE ASSEMBLY (PWA)

DEVELOPMENT
LEVELS OF TECHNOLOGY
GLOBAL USE OF PACKAGE TYPES
CHOICES

BALANCING TECHNOLOGY

A GUIDE TO FINDING THE BALANCE DESIGNING IN THE QUALITY

INDUSTRY PREFERRED COMPONENTS

STANDARDIZATION

COST-EFFICIENT PRINTED WIRE BOARDS DESIGN FEATURES FOR PREFERRED PRINTED WIRE ASSEMBLY PROCESSES OTHER ABILITIES TO CONSIDER

THE NEED TO DESIGN FOR MANUFACTURABILITY

SUCCESSFUL DESIGN
BEFORE DFM—VALUE ENGINEERING

PRINTED WIRING ASSEMBLY TECHNOLOGIES

THROUGH-HOLE TECHNOLOGY SURFACE MOUNT TECHNOLOGY

THE RULES OF DFM

USE STANDARD PARTS
DESIGN FOR EASE OF ORIENTATION

DETERMINE PROCESS CAPABILITIES ELIMINATE MULTIPLE SOLDER AND CLEANING STEPS

ELIMINATE ADJUSTMENTS

MINIMIZE THE NUMBER
OF DIFFERENT PARTS
PUBLISH UP-TO-DATE
DFM DESIGN GUIDELINES
DESIGN FOR VARIABILITY
IDENTIFY DEFECT RATES BY CAUSE

IMPLEMENTING DFM

PEOPLE PARTICIPATION
PREDICTIVE TOOLS
MANAGEMENT COMMITMENT

AUTOMATING THE DFM PROCESS

PROCESS EXAMPLE
SUITABLE PARTS AND MATERIALS

DESIGN FOR TESTABILITY

HOW (AND WHY) CIRCUITS ARE TESTED

KEY TESTABILITY TECHNIQUES TESTABILITY DEFINITIONS REQUIREMENTS FOR DESIGNERS RELIABILITY CALCULATIONS GOALS FOR TESTABILITY JUSTIFYING TESTABILITY

TESTABILITY SUCCESS

AWARENESS

TESTABILITY BENEFITS
TESTABILITY TRENDS FOR THE FUTURE
IMPLEMENTING A STANDARD TEST
STRATEGY FOR ELECTRONIC PRINTED
CIRCUIT BOARDS

STANDARD TEST ARCHITECTURE

BI-DIRECT CELL MODES OF OPERATION
TEST ACCESS PORT
TAP INSTRUCTIONS
DESIGN PROCESS
ATPG AND PARTIAL SCAN
TESTABILITY RULES AND GUIDELINES
ECONOMICS OF TEST GENERATION
TEST MIGRATION

DESIGN FOR RELIABILITY

GUIDELINES FOR DFR
PROBABILISTIC DESIGN APPROACH
METHODS AND TOOLS FOR DFR
MAINTAINING RELIABILITY
DURING PRODUCTION
SUMMARY