National Aeronautics and
Space Administration

MSFC-STD-3631
BASELINE
EFFECTIVE DATE: July 19, 2011

George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

ES42

MSFC TECHICAL STANDARDS

MSFC ELECTRICAL INTEGRATION DOCUMENTATION STANDARD

BASELINE

Approved for Public Release; Distribution Unlimited

CHECK THE MASTER LIST— VERIFY THAT THIS IS THE CORRECT VERSION BEFORE USE

DOCUMENT HISTORY LOG

Status (Baseline/ Revision/ Cancelled)	Document Revision	Effective Date	Description
Baseline		7/19/2011	Baseline Release

FOREWORD

This standard specifies the requirements for the preparation of Electrical Integration drawings and associated lists for flight projects, flight vehicles, and electrical ground support equipment (EGSE) interfacing with flight hardware. This standard is intended for all MSFC programs/projects.

TABLE OF CONTENTS

1 SCOPE

This standard specifies the requirements for the Electrical Integration drawings and associated lists which include Cable Interconnect Diagrams (CID), Electrical System Schematics (ESS), Cable Harness Assembly drawings, and Grounding Diagrams. Electrical Integration drawings and associated lists shall disclose (directly or by reference) the electrical interconnect and grounding requirements for the overall avionics, power, and electrical systems within the end item. The CID depicts the assembly level cable harness interconnect requirements. The ESS is a detailed schematic depiction of the CID at the wiring level. The Cable Harness Assembly drawings are assembly drawings used for the manufacturing and testing of the individual cable harness assemblies. The Grounding Diagram is a schematic depiction of the overall grounding scheme from the primary source to the end sensors and effectors.

2 APPLICABLE DOCUMENTS

2.1 Documents

ASME Y14.2	Line Conventions and lettering
ASME Y14.5	Dimensioning and Tolerancing
ASME Y14.24	Types and Applications of Engineering Drawings
ASME Y14.34	Associated Lists
ASME Y14.44	Reference Designations for Electrical and Electronics Parts and Equipment
ASME Y14.100	Engineering Drawing Practices
Global Engineering	Global Drawing Requirements Manual Tenth Edition (ISBN: 1570530971)
IEEE Standard 315A	Graphic Symbols for Electrical and Electronics Diagrams

2.2 Order of Precedence

In the event of any conflict between the text of this standard and the references cited herein, the text of this specification shall take precedence. However, nothing in this text shall supersede applicable laws and regulations unless a specific exemption has been obtained.

3 ACRONYMS AND DEFINITIONS

3.1 Acronyms

CID	Cable Interconnect Diagram
DRD	Data Requirements Document
EGSE	Electrical Ground Support Equipment
EMC	Electromagnetic Compatibility
ESS	Electrical System Schematic
GN&C	Guidance Navigation and Control
ICD	Interface Control Document
MSFC	Marshall Space Flight Center
SOW	Statement of Work
TVC	Thrust Vector Control

3.2 Definitions

3.2.1 Acronym index. A table that documents and defines all acronyms used on the drawing.

3.2.2 Assembly. A number of basic parts or subassemblies (or any combination thereof) joined together to perform a specific function, and subject to disassembly without degradation of any of the parts.

3.2.3 Cable Harness. An electrical cable harness is a stand-alone electrical assembly. The assembly consists of wires, shields, cables, or any combination of these, all insulated and with at least one branch properly terminated to connectors, terminal lugs, or other suitable devices (for example heaters, thermostats, pig-tail terminated sensors, jiffy-junctions, bus couplers). Electrical cable harness assemblies are designed and built separately from the assemblies they are used to interconnect.

3.2.4 Command and Measurement Identifier index. A table that documents all commands and measurements used on a drawing and points to their location by page number and zone within the drawing. This index does not apply to data bus commands.

3.2.5 Connector index. A table that documents all connectors, by "P" and "J" reference designator, used on a drawing and points to their location by page number and zone within the drawing.

3.2.6 Design Activity. A design activity is an activity that has, or has had, responsibility for the design of an item. The activity may be Government, commercial or non-profit organization.

3.2.7 Reference designator index. A table that documents all cable harness and electronic assemblies on a drawing. This table lists all assemblies by reference designator and cross-references by part number.

3.2.8 Relay index. A table that documents all relays, by reference designator, on a drawing and points to their location by page number and zone.

3.2.9 Set. Units, necessary assemblies, subassemblies, and basic parts connected or associated together to perform an operational function.

3.2.10 Sheet index. A table which documents the contents of the drawing by sheet title.

3.2.11 Subassembly. Two or more basic parts which form a portion of an assembly or a unit, replaceable as a whole, but having a part or parts which are individually replaceable.

3.2.12 System. A combination of two or more sets (generally physically separated when in operation) and such other units, assemblies, and basic parts necessary to perform an operational function or functions.

3.2.13 Unit. A major building block for a set or system, consisting of a combination of basic parts, subassemblies, and assemblies packaged together as a physically independent entity.

3.2.14 Wiring. Electrical wiring is used to make the electrical connections between discrete electronic components (resistors, capacitors, transistors, heaters, thermostats, etc.) and subassemblies within assemblies. As opposed to the Cable Harness, wiring is not considered stand-alone. Electrical wiring is an inseparable part of the electrical design for the assembly on which it resides. The design for the electrical wiring of an assembly is governed by a wiring diagram or wire list and not an assembly drawing.

4 CABLE INTERCONNECT DIAGRAM (CID) REQUIREMENTS

The purpose of the CID is to define the electrical interconnection of all units and assemblies within the electrical system of a project, flight vehicle, or electrical ground support equipment (EGSE). The information contained within the CID is utilized primarily by the structural designers to perform routing and installation design of electrical cable harnesses. The CID is also used for system trouble-shooting, repair, procedure development, and documentation of the end item electrical system. As a deliverable product of the Configuration Management Data Requirements Document (DRD) of the contract Statement of Work (SOW), the CID officially documents the final, as-designed configuration of the electrical system it represents. The CID is maintained current for the life of the project.

4.1 Format

4.1.1 Drawing format, lettering size, and other formatting requirements shall be in accordance with Global Drawing Requirements Manual (10th Edition) and ASME Y14.100.

4.1.2 All engineering changes shall be incorporated into the final deliverable CID.

4.1.3 Each sheet of the CID shall be prepared on a standard D-size drawing format.

4.1.4 Electrical circuit symbols shall be in accordance with IEEE-STD-315A. Where circuit symbols have not been defined by IEEE-STD-315A, the symbol used must be defined in a drawing legend or in the notes section of the drawing.

4.1.5 Reference designations shall be assigned in accordance with ASME Y14.44 using the Unit Numbering Method.

4.1.6 Minimum font size shall be 12.

4.1.7 The CID shall be assigned one unique drawing number.

4.1.8 The sheets of the CID shall be numbered sequentially using whole numbers beginning with sheet 1.

4.2 Organization

4.2.1 Drawing complexity shall be simplified by minimizing off-page bubbles and crossing lines.

4.2.2 The CID shall contain the following:

a. Title
b. Notes
c. Last continued circuit symbol used (balloon, off-page bubble)
d. Sheet index[1]
e. Reference designator index
f. Connector index[1]
g. Acronym index when acronyms are used
h. Interconnection drawing sheets

Note 1: Not required for drawings less than 5 sheets in length.

4.3 Detail requirements

4.3.1 The CID shall depict all external interconnections of the end-item electrical system at the cable harness and electronic assembly level.

4.3.2 The CID shall show all system cable harnesses and identify their connectivity to electronic assemblies, components, sensors, end effectors, and all other electrical interfaces.

4.3.3 The CID may include cable harnesses internal to assemblies.

4.3.4 Wiring internal to assemblies shall not be shown.

4.3.5 Color shall not be used to convey information.

4.3.6 Lines shall be drawn either left to right or top to bottom remaining consistent throughout the CID.

4.3.7 “Line jumps” or other symbols shall not be used to indicate “no connection” at line crossings.

4.3.8 Branching cables from main trunks shall be shown as 90 degree arcs that indicate appropriate connectivity.

4.3.9 With the exception of cable harness assemblies, each electronic assembly shall be shown in its entirety in one location on the drawing.

4.3.10 External interface planes shall not be split on the drawing.

4.3.11 All electronic assemblies shall be depicted by a single, solid line (of heavier weight than cable harness lines) square or rectangle which represents the boundary of the assembly.

4.3.12 Electronic assemblies shall be identified by complete reference designator everywhere they appear within the schematic sheets.

4.3.13 Cable harnesses shall be identified with part number, reference designator, and EMC class.

4.3.14 Text shall not be placed in-line with cable harnesses.

4.3.15 The CID shall not depict physical placement, orientation, or other physical characteristics of components.

4.3.16 The controlling ICD for each external interface shown in the CID shall be indentified in the drawing notes.

4.3.17 When heaters or other discrete electronic components (for example, terminal lugs, bus couplers, thermostats, jiffy junctions) are designed as an integral part of a cable harness assembly, these components shall be shown on the CID interconnection drawing sheets.

4.3.18 Cable harness terminations to electronic assemblies or other components shall indicate the partial reference designation for both connectors of each mated connector pair (i.e. P1/J1) as long as they are shown along with their associated assembly.

5 ELECTRICAL SYSTEM SCHEMATIC (ESS) REQUIREMENTS

The purpose of the Electrical System Schematic (ESS) is to serve as a tool for performing system troubleshooting, repair, procedure development, and to document the implementation of safety hazard controls at the system level of a project, flight vehicle, or electrical ground support equipment (EGSE). The ESS depicts all electrical system wiring contained within the end item electrical system. As a deliverable product of the Configuration management Data Requirements Document (DRD) of the contract Statement of Work (SOW), the ESS officially documents the final, as-designed configuration of the electrical system it represents. The ESS is a schematic as opposed to a wiring diagram, and it is not intended to be used for manufacturing (wiring) of the components shown within its sheets.

5.1 Format

5.1.1 Drawing format, lettering size, and other formatting requirements shall be in accordance with Global Drawing Requirements Manual (10^{th} Edition) and ASME Y14.100.

5.1.2 All engineering changes shall be incorporated into the final deliverable ESS.

5.1.3 Each Sheet of the ESS shall be prepared on a standard D-size drawing format.

5.1.4 Minimum font size shall be 12.

5.1.5 The ESS shall be assigned one unique drawing number.

5.1.6 Electrical circuit symbols shall be in accordance with IEEE-STD-315A. Where circuit symbols have not been defined by IEEE-STD-315A, the symbol used must be defined in a drawing legend or in the notes section of the drawing.

5.1.7 Reference designations shall be assigned in accordance with ASME Y14.44 using the Unit Numbering Method.

5.1.8 The sheets of the ESS shall be numbered sequentially using whole numbers beginning with sheet 1.

5.2 Organization

5.2.1 The ESS shall be organized according to functional groups within the electrical system. (i.e. Power, TVC, GN&C, Range Safety)

5.2.2 The ESS shall contain the following:

a. Title
b. Notes
c. Last continued circuit symbol used (balloon, off-page/on-page bubble)
d. Sheet Index[1]
e. Command and Measurement Identifier Index[1]
f. Reference designator index
g. Connector index[1]
h. Relay index[1]
i. Acronym index when acronyms are used
j. Schematic sheets

Note 1: Not required for drawings less than 3 sheets in length.

5.3 Detail Requirements

5.3.1 The ESS shall show the internal wiring, shielding, and terminations of all electrical system cable harnesses.

5.3.2 Signal and power nomenclature shall be shown adjacent to all wiring within the ESS.

5.3.3 Unused wires shall be labeled as “Spare”.

5.3.4 Connector contacts shall be identified by letter or number.

5.3.5 Wiring internal to power distributors, junction boxes, and signal distributors (for example patch panels and 1553 couplers) shall be shown as a single line diagram in accordance with ASME Y14.24.

5.3.6 Where electronic assemblies do not serve a distribution role (for example C&DH, Flight Computer, Data Acquisition assemblies), only the interface circuitry shall be depicted as a single line diagram in accordance with ASME Y14.24.

5.3.7 Signal flow shall be drawn either left to right or top to bottom remaining consistent throughout the ESS.

5.3.8 Diagonal lines shall not be allowed, except when depicting the conductor breakout of a multi-conductor cable end.

5.3.9 Color shall not be used to convey information.

5.3.10 Text shall not be placed in-line with wires.

5.3.11 “Line jumps” or other symbols shall not be used to indicate “no connection” at line crossings.

5.3.12 Where crossing lines are connected to each other, the connection shall be depicted by a solid bubble.

5.3.13 Connectors or other electronic assemblies may be split between sheets on the drawing.

5.3.14 Break lines, in accordance with ASME Y14.2, shall be used to depict incomplete assemblies.

5.3.15 Electronic assemblies shall be identified by complete reference designator everywhere they appear within the schematic sheets.

5.3.16 Connectors on electronic assemblies may be identified by their partial reference designator as long as they are shown with their associated assembly.

5.3.17 The ESS shall not depict the physical placement, orientation, or other physical characteristics of components.

5.3.18 Discrete electronic components (for example, heaters, thermostats, sensors, jiffy junctions, relays, electromagnetic solenoids) mounted externally to electronic assemblies and structures shall be depicted in the ESS schematic sheets.

5.3.19 All safety and mission critical inhibits shall be shown where the inhibit function is implemented.

5.3.20 Amperage rating shall be shown adjacent to each circuit protection device.

5.3.21 The "state" of the system (i.e. powered, unpowered, prelaunch, etc.) depicted in the ESS shall be stated in a general note in the "Notes" section of the drawing.

5.3.22 System "state" terminology shall match that used in the project system definition documentation or Operational Data Book.

5.3.23 Contacts of latching relays shall be shown in their last-energized configuration as appropriate for the depicted "state" of the system.

5.3.24 Non latching (general purpose) relays shall be shown in the unpowered state.

5.3.25 Any "test-select" component values shall be identified by flag note which indicates where the actual installed component value can be found.

5.3.26 Command and Measurement System Identifiers shall be shown adjacent to each committed valve and each sensor that performs the particular command or measurement respectively.

5.3.27 The ESS shall show wire ID's if used in the equipment design documentation.

5.3.28 Rotational phases (A, B, C) shall be labeled for multi-phase AC power lines.

5.3.29 The controlling ICD for each external interface shown in the ESS shall be identified in the "Notes" section of the drawing.

6 CABLE HARNESS ASSEMBLY DRAWING REQUIREMENTS

A cable assembly drawing is prepared when the design activity has determined that a cable assembly is to be fabricated as a discrete item. This type of assembly drawing depicts an electrical cable assembly of defined length and establishes item identification for that assembly. The assembly consists of wires, shields, cables, or any combination of these, all insulated and with at least one branch properly terminated to connectors, terminal lugs, or other suitable devices (for example heaters, thermostats, pig-tail terminated sensors, jiffy-junctions, bus couplers) and is designed to be installed as a single unit for the interconnection of electrical or electronic equipment. The cable assembly drawing specifies all data required for the fabrication and test of a cable assembly to include potential information for installation at the next higher level. (for example, identification of pigtails)

6.1 Format

6.1.1 Drawing format, lettering size, and other formatting requirements shall be in accordance with Global Drawing Requirements Manual (10th Edition) and ASME Y14.100.

6.1.2 The cable assembly drawing shall be prepared on a standard D-size drawing format. Other formats may be acceptable upon NASA approval.

6.1.3 Each cable assembly shall be defined by a unique drawing number and serial number.

6.1.4 Minimum font size shall be 12.

6.1.5 Electrical circuit symbols shall be in accordance with IEEE-STD-315A. Where circuit symbols have not been defined by IEEE-STD-315A, the symbol used must be defined in a drawing legend or in the notes section of the drawing.

6.1.6 Each cable assembly and all terminations on the assembly shall be assigned reference designations.

6.1.7 Reference designations shall be assigned in accordance with ASME Y14.44 using the Unit Numbering Method.

6.1.8 Pigtails shall be labeled with appropriate nomenclature to facilitate installation at the next higher level.

6.1.9 Dimensioning and tolerancing shall be in accordance with ASME Y14.5.

6.1.10 Parts lists shall be in accordance with Global Drawing Requirements Manual (10th edition) and ASME Y14.34M.

6.1.11 Separate parts lists, if used, shall be prepared on a standard A-size drawing format.

6.1.12 Wire lists shall be in accordance with ASME Y14.34M.

6.1.13 Drawing notes shall define all design specifications and process specifications used for fabrication and test.

6.1.14 Altered Item Drawings shall be in accordance with Global Drawing Requirements Manual (10th Edition) and ASME Y14.24.

6.1.15 Source Control Drawings shall be in accordance with Global Drawing Requirements Manual (10th Edition) and ASME Y14.24.

6.1.16 Vendor Item Control Drawings shall be in accordance with Global Drawing Requirements Manual (10th Edition) and ASME Y14.24.

7 GROUNDING DIAGRAM REQUIREMENTS

The purpose for the Grounding Diagram (GD) is to document the implementation of the grounding and isolation requirements at the system level of a project, flight vehicle, or electrical ground support equipment (EGSE). The GD also serves as a tool for performing system troubleshooting and procedure development. The GD depicts all ground references within the end item electrical system. As a deliverable product of the configuration management Data Requirements Description (DRD) of the contract Statement of Work (SOW), the GD officially documents the final, as-designed grounding and isolation scheme of the end item it represents. The GD is a schematic as opposed to a wiring diagram, and it is not intended to be used for manufacturing (wiring) the components shown within its sheets.

7.1 Format

7.1.1 Drawing format, lettering size, and other formatting requirements shall be in accordance with Global Drawing Requirements Manual (10th Edition) and ASME Y14.100.

7.1.2 The grounding diagram shall be prepared on a standard D-size drawing format.

7.1.3 Minimum font size shall be 12.

7.1.4 Electrical circuit symbols shall be in accordance with IEEE-STD-315A. Where circuit symbols have not been defined by IEEE-STD-315A, the symbol used must be defined in a drawing legend or in the notes section of the drawing.

7.1.5 Reference designations shall be consistent with all electrical design documentation (CID and ESS).

7.2 Organization

7.2.1 The GD shall be organized according to functional groups within the end item electrical system.

7.2.2 The GD shall contain the following:

a. Title
b. Notes
c. Last continued circuit symbol used (balloon, off-page/on-page bubble)
d. Sheet index[1]
e. Reference designator index[1]
f. Acronym index[1]
g. Grounding Diagram sheets

Note 1: Not required for drawings less than 5 sheets in length.

7.3 Detail Requirements

7.3.1 Signal flow shall be drawn either left to right or top to bottom remaining consistent throughout the GD.

7.3.2 Diagonal lines shall not be allowed, except when depicting the conductor breakout of a multi-conductor cable end.

7.3.3 Color shall not be used to convey information.

7.3.4 Text shall not be placed in-line with wires.

7.3.5 “Line jumps” or other symbols shall not be used to indicate “no connection” at line crossings.

7.3.6 Where crossing lines are connected to each other, the connection shall be depicted by a solid bubble.

7.3.7 Break lines, in accordance with ASME Y14.2, shall be used to depict incomplete assemblies.

7.3.8 Electronic assemblies shall be identified by complete reference designator everywhere they appear within the schematic sheets.

7.3.9 Connectors on electronic assemblies may be identified by their partial reference designator as long as they are shown with their associated assembly.

7.3.10 Connector contacts shall be identified by letter or number.

7.3.11 The GD shall not depict the physical placement, orientation, or other physical characteristics of components.

7.3.12 The GD shall show the wiring/paths internal to all assemblies to a point sufficient to demonstrate the required DC isolation between the external returns and chassis.[1]

7.3.13 The GD shall show all paths less than or equal to program required DC isolation to the chassis.[1]

7.3.14 The GD shall show the paths to primary/secondary structure from the chassis (e.g. if chassis uses a direct connection or a ground strap).

7.3.15 The GD shall show all shield terminations including terminations through contacts noting the path to primary/secondary structure.

7.3.16 The GD shall document all intentional ground points to chassis.

7.3.17 Where common designs exist for end effectors and sensors, only one example is required to be shown (other locations noted) on the GD.

Notes:

1. The DC isolation requirement shall be taken from the project's governing requirements documentation.