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MIL-DTL-24784/20B (SH)
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ASSOCIATED DETAIL SPECIFICATION

DIGITAL SYSTEMS MANUAL REQUIREMENTS

This specification is approved for use by the Naval Sea Systems Command, Department of the Navy, and is available for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification sets forth content requirements for the preparation of technical manuals covering the installation, operation, maintenance, and parts support of complex digital systems.

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3 and 4 of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements documents cited in sections 3 and 4 of this specification, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DoDISS) and supplement thereto, cited in the solicitation (see 6.2).

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Sea Systems Command, ATTN SEA 05Q, 1333 Isaac Hull Ave SE Stop 5160, Washington Navy Yard DC 20376-5160 by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A AREA TMSS

SPECIFICATIONS

DEPARTMENT OF DEFENSE

MIL-DTL-24784	Manuals, Technical: General Acquisition and Development Requirements.
MIL-DTL-24784/7	Technical Repair Standards (TRS) for Hull, Mechanical, and Electrical (HM&E) Equipment, Electronic Equipment, and Ordnance Equipment.
MIL-DTL-24784/21	Digital Equipment Manual Requirements.

(Unless otherwise indicated, copies of the above specifications, standards, and handbooks are available from the Standardization Documents Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

2.2.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues are those cited in the solicitation (see 6.2).

NAVAL SEA SYSTEMS COMMAND (NAVSEA)

ST000-AG-IDX-010 TMDE	Test Measurement Diagnostics Equipment Index; Version 3.0

(Unless otherwise indicated, copies of the above specifications, standards, and handbooks are available from the Standardization Documents Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

DEFENSE LOGISTICS SERVICES CENTER (DLSC)

Cataloging Handbook H4/H8	Commercial and Government Entity (CAGE) Codes.

(Applications for copies should be addressed to the Defense Logistics Services Center, (ATTN: DLSC-JCC), Federal Center, Battle Creek, MI 49017-3084.)

2.3 Non-Government publications. The following document(s) form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted are those listed in the issue of the DoDISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DoDISS are the issues of the documents cited in the solicitation (see 6.2).

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 200	Reference Designations for Electrical and Electronics Parts and Equipment.
IEEE 315	Graphic Symbols for Electrical and Electronics Diagrams. (DoD adopted)

(Application for copies should be addressed to the Institute of Electrical and Electronics Engineers, Inc., 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331.)

INTERNATIONAL STANDARDS ORGANIZATION (ISO)

ISO 6829	Flowchart Symbols and Their Use in Micrographics.

(Application for copies should be addressed to the American National Standards Institute, 11 West 42nd Street, New York, NY 10036)

2.4 Order of precedence. In the event of a conflict between the text of this document and the references cited herein (except for related associated detail specifications), the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 General. The requirements for acquiring the product described herein shall consist of this document and MIL-DTL-24784.

3.2 Security classifications, distribution statement and destruction notice. The security classification, distribution statement and destruction notice shall be in accordance with MIL-DTL-24784.

3.3 Deliverable products and data items. Deliverable products and data items shall be in accordance with MIL-DTL-24784 (see 6.2).

3.3.1 Type style and size. Type style and sizes shall be comparable to those shown in MIL-DTL-24784 except for the styles and sizes listed in Table I:

TABLE I. Text size and style. (note 1)

USE	SIZE AND STYLE
Art callouts (pictorials, and so forth)	8 point
Art lettering	7 point
Circled keying numbers on FBD art	8 point
Circled keying numbers on pictorials	10 point
Art drawing sheet numbers, title blocks, main drawing number blocks, hardware boundary titles, and functional boundary titles	8 point
Running heads	10 point bold
Dangers (heading)	14 point bold
Warnings (heading)	14 point bold caps, boxed
Cautions (heading)	14 point bold caps, underlined
Notes (heading)	10 point caps
Rules	1 point

1 Text for notes, dangers, cautions, and warnings shall be short-measured; that is indented from left and right margins of overall text area.

3.4 Arrangement. Unless otherwise specified in the technical manual contract requirements (TMCR) (see 6.2), the manual shall be arranged in a standardized format [that is, front matter, technical content, appendices, glossaries, indices and Technical Manual Deficiency/Evaluation Report (TMDER)] and appropriately divided by volume, part, chapter and section in accordance with MIL-DTL-24784.

3.5 Format and preparation instructions. Unless otherwise specified in the TMCR, the writing style, safety precautions, tabular material, and numbering shall be in accordance with MIL-DTL-24784 and as follows (see 6.2).

3.5.1 Graphics. Unless otherwise specified in the TMCR (see 6.2), the preparation of illustrations, drawings, diagrams and sketches shall be in accordance with MIL-DTL-24784 and the following paragraphs.

3.5.1.1 Functional block diagrams (FBDs). A system of FBDs shall be used to depict the functional divisions of the system. (A functional division is defined as a function or a portion of a function that performs a particular task in relationship to the entire system.) The diagrams shall depict the system in an integrated manner; that is, a master FBD shall show each function of the system; primary FBDs shall show the functional divisions of the system; and third-level or lower-level FBDs shall show further functional subdivisions of complex subfunctions. The lowest level of FBD shall be directly linked to functional circuit diagrams (FCDs) (contained in Chapter 5) or to the hardware where the function is performed. This reference shall be by the hardware reference designator. The FBD/FCD structure and relationship is shown on figure 20-1.

a. Master FBD. The master FBD depicts the system functions and major signal paths within the system.

   1. Each major block on the master FBD shall represent a major functional element and shall be identified by functional and hardware boundary lines and descriptive names. These functional elements shall be connected by signal path and control lines, also identified with descriptive names.
   2. Functional boundaries shall be depicted with thin, solid lines; and hardware boundaries shall be depicted with thin, short-dash and long-dash lines. Signal and control lines shall be depicted with thin, solid lines; while data lines shall be depicted with thick, solid lines (see figure 20-2).
   3. Each block on the master FBD shall contain a circled number. The circled number corresponds to a brief paragraph (referred to as "keyed text") that describes the purpose and function of that block. The circled numbers shall start with the circle 1 in the first block at the top left of the FBD and progress in a logical manner (either by data flow, or top to bottom and left to right) on the FBD until all blocks are numbered. This "keyed text" paragraph will be located on a page facing the FBD to which it applies. In addition to the circled number, each block on the master FBD shall contain a reference to a primary FBD and the paragraph number of the paragraph that describes the block (not the keyed text paragraph).

b. Primary FBD. Primary FBDs shall contain system function and subfunction information. The primary FBD shall illustrate the interconnection of subfunctional elements in order to describe how the functions work within the system. They shall provide a reference to secondary diagrams and the paragraph number of the paragraph that describes the block (not the keyed text paragraph). The secondary diagrams may be FBDs or FCDs. If there are no secondary diagrams for reference, the reference shall be made directly to the hardware by reference designation.

   1. The primary FBD shall consist of the major functional divisions enclosed by the proper boundary lines (see figure 20-3). Each functional block shall be identified by a descriptive name and referenced to a keyed text paragraph on the facing page. The functional divisions shall be interconnected by signal path and control lines, each identified with a descriptive name and proper line weight (line weights shall be in accordance with 3.5.1.1.3). Primary FBDs may show equipment boundaries if appropriate to the function being shown. A direct relationship shall be maintained in regard to the number and nomenclature of interface lines between a primary FBD and other interfacing primary FBDs.

c. Secondary FBD. When the functional divisions represented on the primary FBD are sufficiently large, subfunctionalization is sometimes necessary. The secondary FBD provides the transition between the major functional elements on the primary FBD and the FCDs (see 3.5.1.3), or to actual hardware by reference designator where the function depicted is performed. The subfunctional segments illustrated on the secondary FBD must often be

further subdivided to effectively depict equipment operation. In this case, the secondary FBD provides the transition between the primary FBD and lower levels of FBDs (see figure 20-4).

1. The secondary and lower-level FBDs are generated by dividing the functional elements into discrete segment (subfunction) blocks. Each block shall be identified by a descriptive name and referenced to a keyed text paragraph on the facing page. The blocks shall also reference the paragraph number of the paragraph that describes the block (not the keyed text paragraph). These segments shall be interconnected in the same manner as the major blocks on the primary FBD; that is, with signal path and control lines identified by names and having the proper line weights. Each subfunctional block shall be identified by a descriptive name. A direct relationship shall be maintained in regard to the number and nomenclature of interface lines between a secondary FBD and other interfacing secondary FBDs. The lowest-level FBD block shall contain a reference to an FCD, or to the hardware reference designator where the function depicted is performed (see figure 20-5).

3.5.1.1.1 Power and grounding circuits. The following paragraphs describe the preparation of power and grounding circuit FBDs.

a. System power FBD. The system power FBD shall show the distribution of primary power from the power source to the various units comprising the system. The FBD shall be a part of the master FBD of the technical manual and shall reference the associated unit power and grounding FBDs and FCDs. Power conversion and distribution within the system units shall be shown by a separate power FBD for each unit unless the power circuits within the unit do not warrant a separate FBD because of their simplicity.
b. Unit power FBD. This FBD shall show the distribution of primary power and control power from the primary power source and associated interface units to the power elements within each unit. The FBD shall represent the power elements as functional blocks and shall show power conversion, power control monitoring and indicating between the unit power elements. The diagram shall be laid out in a logical left-to-right sequence to clearly define the power operations within the unit. Each functional block shall contain a reference to an FCD. This FBD shall be the last sheet(s) of the FBDs (see figure 20-6).

3.5.1.1.2 Requirements for preparing FBDs. A clear and complete referencing system is required for use on FBDs because of the interrelationship between FBDs and FCDs, and the interconnection between sheets of FBDs. The referencing system shall include all or a portion of the following reference information.

a. Signal names.

1. Signal names on FBDs shall be descriptive names. The Automated Interface Listing (AIL) (the wire lists for the system cabling), or their equivalent, shall be used as the source of signal names between units. Engineering schematics and cabling wire lists shall be used as the source of signal names internal to a unit.

2. Power-on reset signals on the data FBDs shall be shown entering from external to the function. No function block for power reset shall be shown on the data FBDs. The generation of the power-on reset shall be shown on the power and grounding FBDs.
3. All signal lines between functional blocks on the FBDs shall be identified by descriptive signal names. Signal lines that interface from one FBD sheet to another FBD sheet shall have the identical signal name on each sheet. Signal lines that are identified on different level FBDs (a signal level shown both on the primary FBD and on the secondary FBD) shall be identified by the same signal name.
4. Reference designations shall not be used as signal names except in cases where no other name exists.
5. The FBD number, sheet and zone shall be used to identify signal origins and destinations when referencing from one FBD to another.

b. Signal referencing for FBDs.

1. Signal referencing on the same sheet. An on-sheet reference to show a continuous line between two points shall be shown by a circle enclosing double capital letters with a lead arrow indicating direction. Zone reference shall not be used. (Letters to start with AA, then AB, AC, and so forth) (see figure 20-7).

    a) Signal lines shall show signal name on flow line before the reference symbol (see figure 20-7).
    b) An inverted triangle symbol shall not be used except for an A or B (primarily found on the power FCDs) to indicate grounds.

2. Signal referencing between two or more functional parts. To show a continuous line between two points on different sheets of a functional breakdown (a function broken into Parts 1 of 2, 2 of 2, and so forth), an irregular pentagon shall be used. Double capital letters starting with BA then BB, BC, and so forth, shall be enclosed within this symbol. Zone references shall be indicated (see figure 20-8).
3. Signal referencing between functions. Referencing between units shown on the diagram shall be accomplished at equivalent levels (that is, primary levels shall interface, second levels shall interface; however, a primary level shall not interface with a second level) (see figure 20-9).
4. Grouping of signals. Brackets may be used when all of a group of signals come from or go to the same zone on destination (see figure 20-6).

c. Diagram type. The diagram type (FBD or FCD) shall be included above the title block of the drawing or on sheet 1 only. The title block shall appear only on sheet 1. Sheets 2 and on shall not contain the diagram type block or the title block.
d. Equipment names. Equipment name or reference designation shall be used to identify hardware boundaries on the FBDs.
e. Function names. Each functional area of each unit shall be identified by a descriptive name. These functional areas shall then be further broken into subfunctions, each being assigned a descriptive name. Once a function name has been assigned, the identical name shall always

appear whether it appears on an FBD or on an FCD to identify the functional boundary. No two functional areas may be assigned the same name.

f. Diagram (drawing) numbers. In systems with fully implemented unit numbers, all FBDs shall be numbered FBDXXXX, where XXXX is equal to the unit number (that is: 1001, 1002, 1107, and so forth), except for the master FBD or FCD. The master FBD or FCD shall be numbered FBD0000 or FCD0000. For those cases where one FBD (or FCD) is used for multiple and identical units, the lowest unit number shall be used (that is, units 1071 and 1072 shall be FBD1071). In other systems, FBDs shall be numbered chronologically.

g. Sheet numbers. FBDs or FCDs having multiple sheets shall be assigned sheet numbers starting with one (1). The drawing sheet number and zone number shall be used to identify signal interconnections between sheets of the same FBD or FCD.

h. Zone numbers.

    1. The zone number and sheet number shall be used to identify signal interconnections between sheets of an FBD and when referencing between FBDs or from FBDs to FCDs and vice versa. Sheet and zone numbers shall be as shown on figure 20-10.
    2. Zone number references shall call out the drawing coordinates of the referenced detailed signal name rather than call out the drawing coordinates of the symbol itself. Brackets may be used when all of a group of signals come from or go to the same place.

i. Reference designations. Reference designations shall be used to correlate circuit symbols to actual hardware locations. All hardware boundaries, logic symbols, electrical symbols, and analog symbols shall be identified by the reference designations assigned to the hardware being depicted.

3.5.1.1.3 Diagram drafting requirements. This subsection defines the requirements for line weights, methods of depicting interconnecting lines, symbol sizes, lettering size, and notes in the preparation of FBDs.

a. Line weights. Hardware or functional boundaries and boundary titles shall be prepared as described in the following paragraphs.

    1. Hardware Boundary. A hardware boundary shall be a long-dash, short-dash light (0.005 inch) line. The length of the long-dash in relation to the length of the short-dash should be drawn so that the long-dash does not give the impression of a solid line. The hardware boundary title shall be positioned as illustrated on figure 20-11.
    2. Functional Boundary. A functional boundary shall be a solid medium (0.01 inch) line. The functional boundary title shall be positioned as illustrated on figure 20-12.

b. Interconnecting lines. Interconnecting (data, signal and control) lines shall be prepared in the following manner:

    1. Line bends shall be 90 degrees, unless a particular junction requires a different bend. Bend corners shall not be rounded.
    2. Line spacing shall be 0.125 inch minimum on a 9 by 15.75-inch master.

3. Data lines shall be single, solid heavy (0.02 inch) lines (see figure 20-13).
4. Signal and control lines shall be single, solid medium (0.01 inch) lines (see figure 20-12).
5. Signal lines that contain closely related information may be grouped into one line. However, care must be exercised to not group signal lines indiscriminately. Grouping of signal lines into one line is called a highway.
6. Highways shall be solid medium (0.01 inch) for signal and control lines, and heavy (0.02 inch) lines for data (see figure 20-13).

    a) Any changes in the flow direction of the basic highway shall be indicated by square corners [see figure 20-13, (a)(1)].
    b) Any input or output of a highway shall be indicated by a 45-degree connecting line. The direction of the angle implies flow direction [see figure 20-13, (a)(2)].
    c) The end points (a highway may have several) of a highway are indicated by square corners [see figure 20-13, (a)(3)].
    d) A highway does not necessarily contain a uniform number of signals over its entire length. Therefore, when a highway is identified by a name, that name applies to its entire length.
    e) Each individual signal contained within a highway shall be identified with a detailed signal name.
    f) The signal names used as inputs to a highway may be different from the highway signal name; for example, BIT 5 and BIT 4 may be individual inputs to a highway having a signal name of INTERFACE REG SET OUTPUT. There shall be a logical relationship between the input and highway signal names [see figure 20-13, (b)].
    g) The signal names used as outputs to a highway may be different from the highway signal name; for example, BIT 9 and BIT 8 may be individual outputs to a highway having a signal name of ADDRESS. There shall be a logical relationship between the highway signal name and the output [see figure 20-13, (c)].
    h) Highway inputs and outputs to logic symbols are illustrated on figure 20-13, (d). The input shall contain the input signal name and input pin number; the output shall contain the output pin number and signal name.
    i) Highway fan-outs and fan-ins shall have the highway signal name indicated above the signal line and the highway output or input signal names with its appropriate sheet and zone reference below the signal line [see figure 20-13, (e)].

c. Symbols. Symbols shall be prepared in the following manner:

1. FBD rectangular blocks shall be drawn as medium (0.01 inch) lines and, insofar as possible, conform to a 2-to-1 aspect ratio. Minimum block size shall be 0.05 inch by 1 inch. Insofar as possible, the block nomenclature shall be positioned as illustrated on figure 20-14, for ease of reading.
2. On-page and off-page connectors and miscellaneous symbols shall be drawn as medium (0.01 inch) lines and in accordance with the dimensions depicted on figure 20-15.

d. Lettering. Lettering shall be accomplished in the following manner:

1. All lettering on the diagrams shall be Letter Gothic. Letter style shall be vertical, uppercase Gothic (sans-serif) as illustrated by figure 20-16.
2. Lowercase lettering shall not be used for general lettering on a diagram. Lowercase letters shall be indicated as an underscored uppercase letter but may be used when:

    a) Lower case lettering appears on the physical part (such as connector pins).
    b) Symbols requiring lowercase letters are used on drawings.
    c) Signal names contain lowercase letters such as an abbreviation like "Db".

3. All lettering shall be placed on the diagrams in a position readable from either the bottom or right-hand side of the diagram.
4. Letter size, line spacing, and line weight shall be as follows:

    a) 8-point for drawing sheet number, title block, main drawing number block, circled keyed text reference number, hardware boundary titles, and functional boundary titles. Line spacing for 8-point type shall be 2 points (.028 inches) minimum.
    b) 7-point for all other format block areas and the field of the drawing. Line spacing for 7-point shall be 2 points (.028 inches) minimum.

e. Notes. Notes shall be included on the diagrams as appropriate. The notes shall be identified by Arabic numerals in consecutive numeric sequence starting with the number 1.

3.5.1.2 Flowchart development. The flowchart shall be developed using the following procedure and symbology.

a. General flow. The general flow of the flowchart shall be top-to-bottom and left-to-right. A portion of the flow may be contrary to the general flow if no intermediate blocks are involved (see figure 20-17).
b. Terminal blocks (see figure 20-18). These blocks are used to show the starting and ending points of a flow. START blocks shall have a vertical exiting line. EXIT and COMPLETE blocks shall have vertical or horizontal entry lines. The EXIT block shall be accompanied by text explaining the reason for the EXIT.
c. Annotation or comment block. These blocks are used to provide additional descriptive clarification, comments, or explanatory notes (see figure 20-19). The dashed line is connected to the dashed outline of the symbol corresponding to the data contained inside. This block is inserted with the dashed line intersecting flowchart flow at the point appropriate to the content of the block.
d. Process blocks. These blocks define an operation to be performed (see figure 20-20). These blocks shall have only one entry line and one exiting line. Entry lines and exiting lines shall be vertical or horizontal; however, entry lines shall never enter the bottom of a process block and exiting lines shall never leave the top of a process block. Process blocks shall never be used in place of decision blocks.
e. Decision blocks. These blocks are used to provide two or more paths resulting from specific condition related decisions (see figure 20-21). Decision blocks where the exiting line choice is dependent on a "yes" or "no" decision shall normally have only two exiting lines. These

blocks may have more than two exiting lines if each path is clearly defined by the decision required to select that path. There shall be only one entry line (either from the top or at the side) to a decision block. Entry and exiting lines shall not occupy the same side of a decision block. Exiting lines shall not occupy the top of a decision block. Exiting lines shall be labeled by decision criteria. Do not include question marks in decision blocks.

f. On-Page connectors. These connectors shall be used to join two ends of a line when it is inconvenient to draw a single continuous line between two points on a single sheet (see figure 20-22). These connectors shall be shown by a circle enclosing a capital letter. The letter used in the on-page connectors shall start with "A" and proceed alphabetically on each page. The same letter shall be used in the starting and ending connectors at both ends of an implied line of communication. The same letter shall be used in multiple starting connectors when their respective ending connectors are the same point. Connectors shall have exiting or entry lines consisting of vectored arrows which indicate that the connector is used as a starting or ending connector. A single arrowhead with multiple entry lines may be used when required to ensure clarity (see figure 20-23). The exiting from a starting connector and the entry line to an ending connector shall show the direction of the corresponding connector and path of the implied line between.

g. Off-Page connectors. These connectors shall be used to show flow continuity between sheets of the same figure or of different figures. These connectors shall be shown by an irregular pentagon enclosing a number and a capital letter (see figure 20-24). The number contained by the off-page connector shall indicate the destination sheet (for the output connector) and the origin sheet (for the input connector). The letters used in off-page connectors shall start with "A" and proceed alphabetically in each figure, using the same letter in the output and input connectors at each end of an implied line continuation. The same letter shall be used in multiple output connectors when their respective input connectors are the same point. The entry line to an output off-page connector shall enter the side of the connector opposite the point. The exiting line from an input off-page connector shall leave from the point of the connector. When off-page connectors are used to show flow continuity between figures, the figure number of the corresponding connector location shall be shown outside each off-page connector symbol (see figure 20-25). If more than one of the output connectors is located on another figure, two or more input connectors shall be placed at the entry point so that figure numbers of all output connectors are shown (see figure 20-25).

h. Arrowheads. Arrowheads shall be used to indicate the direction of flow. All block or connector entry lines shall have arrowheads. Arrowheads shall be used at all line intersections to clearly show direction of flow (see figure 20-26).

i. Line intersections. Lines shall not cross except when an intersection is intended. On-page connectors shall be employed to prevent line crossings where intersections are not intended (see figure 20-26).

3.5.1.3 FCDs. An FCD shows in symbolic form the interrelationship of the circuits required to perform a function. The FCD consists of symbols representing circuit modules and electrical parts complete with physical location and interconnection information. FCDs shall be prepared for control and indicator circuits, analog logic, and power and grounding circuits. See figure 20-27 for an example of an analog logic FCD. An explanation of power and grounding FCDs is

given in paragraph f.1 below. If FCDs are required for a unit having all three types of the above circuits, all circuits shall be shown on the same drawing numbered FCD.

a. Schematics are not required for unit wiring or similar interconnecting hardware devices because complete interconnecting information appears on the FCDs. Components such as switches, relays, terminating resistors, and so forth, mounted directly on the cabinet shall be shown in schematic form on the FCD using the rules for detailed FCDs (refer to paragraph e below).
b. Layout techniques. An FCD shall be prepared for each function defined on the lowest level of FBD where it is necessary to show circuits that are not located on pluggable modules and for the power and grounding circuits. Layout of the symbols on the FCD shall provide a left-to-right functional flow. Circuit symbols shall be functionally divided by thin lines in direct relationship to a functional block on a related FBD, and the functional division on the FCD shall be identified by the same function name. If the equipment is sufficiently complex, an FCD may consist of multiple sheets; then, functional flow shall be left-to-right from sheet to sheet. All inputs and outputs of the function depicted on the FCD shall be identified by signal names. Inputs shall be referenced to the source FCD and outputs shall be referenced to the destination FCD. For smaller systems or equipments, an FCD sheet may contain more than one function and possibly the entire equipment.
c. Analog functionalization. In analog functions, the FCD details the operating elements (emitter followers, amplifiers, and so forth) within the function using special block symbols or schematic symbols. The special block symbols shall be used to detail replaceable circuit elements or modules that are used as building blocks in the analog equipment.
d. Schematic symbols shall be used to detail circuits of assemblies or modules having replaceable parts. The resulting FCD may have both symbolic and electrical schematic characteristics with functional grouping techniques applied. Schematic representations on the FCD shall be formed using the rules set forth for detailed FCDs.
e. Detailed FCDs. Detailed FCD drawing techniques shall be used, where necessary, to show cabinet-mounted components such as switches, relays, termination resistors, and so forth, and for detailing circuits of assemblies or modules having replaceable parts. Separate detailed FCDs are required for the unique repairable circuits used as building blocks for analog equipment; one detailed FCD is required for each type of building block.

    1. Layout techniques. Detailed FCDs present all circuit information, including component values, test points, and sensors (see figure 20-28). Circuit parts shall be grouped functionally and arranged to make signal flow obvious from left-to-right and top-to-bottom. Emphasis should be placed on arranging the circuit parts to enhance functional understanding. One technique which simplifies the circuit presentation is to completely separate each power and ground connection. Common ground or return points should not be tied together merely to conserve symbols.

f. Power and grounding circuits. The following paragraphs describe the preparation of power and grounding circuit FCDs.

1. Unit power and grounding FCD. Unit power and grounding FCDs shall show the generation and distribution of power to all assemblies within the unit. All cable, connector, and pin numbers shall be shown except those listed on sheet 1 as unused. Cabinet-mounted parts shall be shown in schematic form. All power supplies and regulators that are packaged as complete assemblies shall be shown in symbolic form. Lowest level replaceable assemblies shall not be further detailed in detailed FCD form. Since a power and grounding FCD is a schematic diagram rather than a wiring diagram, it does not show routing of wires, but it must show the continuities that exist. Several types of circuit returns may exist in the system: (1) ground, (2) chassis or frame connection, and (3) common connections. Each of these grounds shall be shown by using symbols where it will simplify the FCD (see figure 20-29).

    a) Prime power inputs shall be shown on the left of the FCD and signal flow shall be left-to-right. Grounds shall be shown by using the symbols illustrated in IEEE 315. The layout of circuit parts shall follow a logical arrangement and be consistent with other unit-oriented power and grounding diagrams; for example, primary AC distribution, power control and indication, interlocks, gate monitoring and gate distribution. Also, unnecessary long lines shall be shortened to conserve space. The hardware boundaries can be distorted where necessary, to preserve smooth signal flow. Crossed lines and "doglegs" shall be kept to a minimum.
    b) Each relay and switch element or contact set shall be identified. If the switch is a front panel control, and it is accessible during normal equipment operation, the nomenclature of the switch exactly as it appears on the front panel shall be placed adjacent to the switch symbol. When multisection switches or relays have more than one element or contact set, the sets or elements shall be identified individually but with some alphanumeric relationship. It is desirable to align the contact sets if possible, but not at the expense of disturbing functional flow. Relays and switches shall not necessarily have their contact sets in the same functional area; often they will function in different circuits. When this occurs, the various sets of contacts and actuating elements shall be connected by a dashed line (if on different FCD sheets, sheet and zone references shall be used to connect the dashed line) to illustrate mechanical linkage. Spare contact sets of switches and relays shall not be shown on the body of the diagram.

3.5.1.3.1 Requirements for preparing FCDs. A clear and complete referencing system is required for use on FCDs because of the interrelationship between FBDs and FCDs, and the interconnection between sheets of FCDs. The referencing system shall include all or a portion of the following reference information:

a. Signal names.

    1. Major or important signal paths on an FCD shall be identified by descriptive signal names. All signal lines that interface between FCD sheets shall be identified by descriptive signal names. The signal name shall be identical on all FCD sheets. No signal name shall be used for more than one signal path.

2. Reference designations shall not be used as signal names except in cases where no other name exists (primarily on power FCDs).
3. The FBD or FCD number, sheet, and zone shall be used to identify signal origins and destinations when referencing from one FCD to another or from an FCD to an FBD.

b. Signal referencing for FCDs shall be in accordance with 3.5.1.1.2.
c. General format items. The following shall, at a minimum, be located on the FCD first sheet:

1. Notes that apply specifically to that FCD.
2. Special abbreviations (that is, P/O).
3. A note to explain the position (energized/de-energized, on/off) of any relays or switches shown on the FCD.
4. All assemblies shall reference an internal schematic when necessary for troubleshooting and maintenance.
5. Power and logic FCDs shall carry specific signal names on the flow lines. If signal names are not readily available, then the signal name may indicate a hardware destination point (that is, K3-82).

d. Diagram type, equipment names, and function names shall be in accordance with 3.5.1.1.2.
e. Key codes. In certain applications, both digital and analog modules shall be assigned key codes. Most key codes consist of three letters (KDM, KDN, and so forth). The logic or analog symbol on the FCD shall contain the key code for the circuit module (or portion of the circuit module) depicted. These key codes permit the users to locate a text description of circuit operations located in the technical manual.
f. Diagram (drawing) numbers, sheet numbers, and zone numbers shall be in accordance with 3.5.1.1.2.
g. Reference designations shall be in accordance with 3.6.6.3.2.
h. Test points. All monitored and nonmonitored test points shall be incorporated in all FCDs. These test points shall be shown as part of the circuitry they are testing and shall indicate the following information and parameters:

1. Test point number.
2. Test point operational connector pin (if applicable).
3. Circuitry associated with test point (for example, divider network).
4. Test point symbology per IEEE 315.

3.5.1.3.2 Diagram drafting requirements. This subsection defines the requirements for line weights, methods of depicting interconnecting lines, symbol sizes, lettering size, and notes in the preparation of FCDs (see 3.5.1.1.3 and the following).

a. FCD logic symbols shall be drawn as medium (0.01 inch) lines. Other symbols depicting assemblies shall be drawn rectangular and to the minimum size which will allow inputs and outputs to be depicted and include all reference data within the symbol. All like symbols shall be drawn to the same size. FCD logic symbol nomenclature shall be positioned as illustrated on figure 20-14 to ease reading.

b. FCD electrical and electronic graphic symbols shall be drawn as medium (0.01 inch) lines. Graphic symbol nomenclature shall be positioned to achieve the best clarity.
c. On-page and off-page connectors and miscellaneous symbols shall be drawn as medium (0.01 inch) lines and in accordance with the dimensions depicted on figure 20-15.

3.6 Technical contents for digital systems manuals.

3.6.1 Specific requirements. The manuals shall provide system and subsystem oriented instructions for operation, maintenance, installation, and testing. Detailed equipment data should be provided by reference to the equipment manuals (see MIL-DTL-24784 and MIL-DTL-24784/21). However, for this manual, the technical data shall be developed at the digital equipment level and be included for all digital equipment system and subsystem and interface components not covered by an equipment technical manual. The contents shall be arranged in chapters according to the following:

a. Chapter 1 - General information and safety precautions.
b. Chapter 2 - Scheduled maintenance.
c. Chapter 3 - Functional description.
d. Chapter 4 - Operation.
e. Chapter 5 - Fault-isolation.
f. Chapter 6 - System alignment.
g. Chapter 7 - System cabling.
h. Chapter 8 - Unit level maintenance.

3.6.2 Chapter 1, General information and safety precautions. All safety precautions necessary for the protection of personnel and the ship shall be included and cross-referenced as the initial paragraphs ahead of the introduction. These precautions shall be prepared as specified (see MIL-DTL-24784). The remaining content of this chapter shall be so that command level, supervisory personnel, and other users having a general interest in the equipment can easily and rapidly determine the purpose, physical and functional characteristics, and the operational capabilities of the digital system.

3.6.2.1 Safety precautions. This section shall describe the hazards associated with system operation and maintenance.

3.6.2.1.1 Introduction. This description shall orient system supervisory personnel, and shall include the following:

a. Purpose, scope, and organization of the system safety instructions.
b. Basic safety concepts.
c. Basic responsibilities for safety.

3.6.2.1.2 Electromagnetic radiation hazards and precautions. If applicable, describe the radiation hazards to topside personnel and the precautions to be taken. The hazards of radiation to flammable or explosive materials also shall be described. The description shall include discussions of the following:

a. Locations of topside and in board radiation hazardous areas.
b. Minimum safe distances on the axis of beam radiation.
c. Precautions to be taken when entering areas of radiation hazard (such as the wearing of copper-screen goggles).
d. The effect of radiation on flammable or explosive material such as induction of RF currents in metals, sparking, and the consequent possibility of igniting flammables or detonating explosives. The text shall be supported by one or more illustrations identifying the areas of radiation hazards and the location of antennas, and so forth.

3.6.2.2 Hazards to divers. When applicable, the description of hazards to divers shall include but shall not necessarily be limited to the following:

a. The nature and intensity of sound energy in water as related to divers.
b. Precautions to be taken when working near operating equipment.
c. Illustrations identifying the hazardous areas and locations of sonar domes.

3.6.2.3 System hazards and precautions. Descriptions of system hazards and precautions shall be included, addressed to system personnel and referenced to particular system equipments. The descriptions shall be organized to be consistent with the operation of the system. The descriptions shall supplement and extend equipment safety instructions to the system level, by warning of potential hazards that can be caused during operation or maintenance.

3.6.2.3.1 Operational safety summary. A summary shall be included which emphasizes the proper use of equipment controls, describes the hazards to operators, or as applicable, the hazards to persons in areas remote from the operation, and recommends precautions. An emergency operational routine shall be included which emphasizes the controls that permit immediate braking or de-energizing of the system.

3.6.2.3.2 Maintenance safety summary. A maintenance safety summary shall emphasize the proper use of controls, describe the hazards to maintenance personnel, potential damage to the equipment, and recommend precautions.

3.6.2.3.3 Hazardous components. Identify and briefly describe the hazardous components including radioactive devices and elements used with the system and summarize the general handling precautions for such components. The description of a hazardous component shall include brief statements as to the purpose, manner of functioning, nature of built-in safety devices, and nature of the hazardous element; it shall also indicate the relative sensitivity of the component to mechanical shock, vibration, electromagnetic and radioactive radiation, and electrostatic charges.

3.6.2.3.4 Introduction. The introduction shall define the system and its relationship with other systems. The mission of the system shall be stated. The text shall be supported by a diagram (see MIL-DTL-24784) showing the interrelationships of the system equipments (see figure 20-30). The major functional relationship and inputs and outputs to related systems shall be indicated.

3.6.2.3.5 Physical arrangement. System areas and compartments shall be described and the system equipment and units contained in the areas shall be listed. The physical arrangement description shall be supported by the following illustrations:

a. An inboard profile drawing of the ship or stations showing compartment locations and identifying topside equipment and equipment units comprising the system (see figure 20-31).
b. Separate illustrations of each compartment and area, identifying the listed system equipment (see figure 20-32). Other equipment, which is installed in the subject system compartments and areas, need not be listed in the text or called out in the illustrations if they do not directly affect the operation or maintenance of the subject system.

3.6.2.3.6 System equipment description. Each of the equipment comprising the system shall be identified and described. Descriptions of operator-attended equipment shall include general statements as to the nature and purpose of units and indicators. The text shall be supported by illustrations. All equipment shall be shown, whenever possible, in relative-scale proportion. An equipment may be separately illustrated with significant features called out, if such details are necessary for proper support of the text.

3.6.2.3.7 Associated system equipment. When required, descriptions and illustrations of associated system equipment shall be limited to the major units thereof. The descriptions shall be more condensed than those of subject system equipment; otherwise, the same requirements are applicable. In the descriptions, emphasis shall be placed on those associated systems equipments that constitute operational or functional interfaces with the subject system. Such units shall be included in the system illustrations.

3.6.2.3.8 Equipment illustrations. Equipment illustrations shall be in accordance with MIL-DTL-24784.

3.6.2.3.9 Reference data. Reference data, equivalent to the following, shall be included in tabular form:

a. Descriptive (identification plate data) which identifies manufacturer, type, model, part or identifying number (PIN), Joint Electronic Type Designation (when applicable), repairable identification code (RIC) and allowance parts list (APL), as applicable.
b. Functional characteristics, such as: power requirements, horsepower, pressure, capacity, modes of operation, power output, frequency, pulse characteristics, sensitivity, selectivity, including tolerances, where applicable.
c. Capabilities and limitations, such as: pounds of thrust, knots, turning radius, minimum and maximum ranges, degree of coverage, resolution, accuracy.

d. Rated outputs, such as: wattages, voltages, horsepower, gallons per minute.
e. Environmental characteristics, such as: ambient temperatures, heat dissipation per unit, humidity limits.

3.6.2.3.10 Equipment, accessories, and documents supplied. A tabular listing of all equipment and documents supplied shall be included. List the equipment, its units, and its accessories (special tools, test equipment, miscellaneous parts, and Government-furnished items) which form a part of, or are supplied with, the equipment. The table shall include the following:

a. Column 1, Quantity. This column shall contain the quantity of each unit and accessories supplied with the equipment.
b. Column 2, Item name or nomenclature. This column shall contain the official name (for example, pump, winch) or nomenclature (name and designation) of each component, unit or accessory.
c. Column 3, PIN number, RIC number, or unit number. This column shall contain the PIN, RIC, or unit number of each equipment unit or accessory.
d. Column 4, Overall dimensions. This column shall contain the crated (if available) and uncrated height, width, and depth in inches (or inches and centimeters) of each unit or accessory.
e. Column 5, Weight and volume. This column shall contain the crated (if available) and uncrated weight and volume in cubic feet of each unit and accessory.

3.6.2.3.11 Equipment and publications required but not supplied. A tabular listing of all test equipment and publications required but not supplied with the equipment or system shall be included. If a measurement requirement is established which cannot be satisfied by the subcategory (SCAT) codes listed in this guide, or alternate test procedures cannot be developed utilizing the listed SCAT request for assistance should be directed to:

Commander
Naval Sea Systems Command
Arlington, VA 22242-5160
ATTN: SEA 0415

The listing shall contain:

a. Column 1, SCAT code. When applicable, this column shall contain the four digit group of numbers, which is included in NAVSEA ST000-AG-IDX-010 TMDE used to identify a measurement requirement.
b. Column 2, Test equipment category. This column shall contain the item name of each item of equipment required.
c. Column 3, Representative test equipment model number. This column shall contain the model number of the standard or Substitute Standard General Purpose Electronic Test Equipment, listed in NAVSEA ST000-AG-IDX-010 TMDE, which can be used to satisfy the measurement parameters.

d. Column 4, Equipment test parameters. This column shall specify the range of test parameters which must be satisfied by this test equipment item (it shall not define the ranges of the test equipment model).
e. Column 5, Application. This column shall indicate the intended use of the test equipment (for example, scheduled maintenance, troubleshooting, corrective maintenance, or installation).

3.6.2.3.12 Field and factory changes. System and equipment changes (for example field changes, factory changes, engineering changes or notices, modifications, and so forth) shall be identified and included in separate tables. Field and factory changes shall be included as follows:

a. Column 1, Change number. This column shall list the change number for each field and factory change considered and included in the preparation of the manual.
b. Column 2, Nomenclature. This column shall list the equipment nomenclature and Government serial numbers of equipment affected by the change.
c. Column 3, Description. This column shall contain a brief statement identifying the change and its purpose.

3.6.2.3.13 Description of technical manual. A brief description of the technical manual and an introduction to the use of the data contained within shall be included.

3.6.3 Chapter 2, Scheduled maintenance. Chapter 2 shall contain all system schedule test procedures, together with necessary explanations and illustrations. It is intended that the engineering effort required to develop preventive maintenance data be expended only once and that the data, where applicable be used both in this chapter and in Logistic Support Analysis (LSA) or Maintenance Requirements Cards (MRC) where one or more of the latter three data items are required by the contract (see 6.2). The preparation of this chapter of the manual should therefore be delayed until completion of the LSA, or MRC; submissions of the manual draft copy for review should be marked "TO BE SUPPLIED UPON COMPLETION OF LSA". When the approved LSA, or MRC data is available, it shall be referenced in the manual. When included in the manual, such LSA, or MRC data shall be integrated with other technical data required by this specification to be in this chapter. Chapter 2 shall comprise the following:

a. Introduction.
b. Scheduled maintenance action index.
c. Scheduled test procedures.

When a separate depot-level manual is required (see 6.2), it shall include the information required by MIL-DTL-24784 and MIL-DTL-24784/7, as applicable.

3.6.3.1 Introduction. The introduction shall be an explanation of the purpose, scope, and arrangement of the scheduled maintenance material. When a preventive maintenance procedure is critical to the operation of the system and the schedule for servicing is absolute (not recommended), this information shall be conspicuously written as a CAUTION. The following statement shall be included:

"The scheduled maintenance instructions in this manual are intended to duplicate those furnished in the Planned Maintenance System (PMS). In case of conflicts, the PMS documentation takes precedence. Such conflicts should be reported immediately on the user comment sheet in accordance with the maintenance procedures for this manual."

3.6.3.2 Scheduled maintenance action index. This index shall include all scheduled performance procedures. The index shall be tests and preventive maintenance tabulated as follows:

a. Column 1, Periodicity. This column shall contain an alphanumeric list of all maintenance actions contained in the chapter. The following periodicity symbols, as appropriate, shall be used in the order of increasing periodicity as listed in Table II.

TABLE II. Periodicity symbols.

INTERVAL	SYMBOLS
Daily	D
Weekly	W
Monthly	M
Quarterly (3 months)	Q
Semiannually (6 months)	S
Annually	A
Overhaul cycle	C
As specified (explain circumstances)	R (note 1)

1. An R periodicity shall be preceded by a recommended calendar periodicity (for example, DR, WR, MR, and so forth).

b. Column 2, Maintenance action. This column shall list the maintenance action which corresponds to the periodicity number in column 1.
c. Column 3, Reference. This column shall state the paragraph number that contains the procedure listed in column 2.

3.6.3.3 Scheduled test procedures. Include the detailed procedures for setting up and performing complete system tests. Each procedure shall be numbered and titled to clearly define the test action and the output to be tested.

3.6.3.3.1 Scheduled performance tests. These tests shall contain step-by-step procedures necessary to verify that the equipment is operating within standards in all modes of operation and shall contain the following:

a. Safety precautions.
b. A list of tools and test equipment identified by type, manufacturer, and model number.
c. The title of the test to be performed.
d. The minimum rating of the technician expected to perform the task.
e. Preliminary setup data required to perform the test.
f. Detailed procedures for accomplishing the test. Procedures requiring lengthy and identical setup data may be presented in detail in one procedure and referenced in succeeding procedures.
g. Values or conditions, with tolerances, indicative of normal operation.
h. References to troubleshooting or corrective actions to be used if the test values are not within tolerances.
i. Illustrations to support the test.

3.6.4 Chapter 3, Functional description. Chapter 3 shall describe how the components or equipments comprising the system jointly perform major operations and functions, and how associated systems contribute to the performance of these major functions. Equipment or associated system interfaces shall be described only as necessary to identify the sources or destinations of system inputs and outputs (see figure 20-33). Descriptions shall not repeat the functional description provided in the equipment manuals or Chapter 8.

3.6.4.1 Method of presentation. The presentation shall first define how the system major functions meet the purpose of the system as described in 3.6.2. Each major function shall then be discussed separately at progressively increasing levels of detail. The description of the entire system shall be supported by a basic block diagram of the system (see figure 20-34). Where information can be presented better pictorially than by text, additional diagrams and other illustrations shall be used. Reference may be made to diagrams appearing in Chapter 5.

3.6.4.2 Introduction. The introduction shall describe the general approach that is used in the functional description. The introduction shall also describe briefly the interrelationship between the system and associated systems.

3.6.4.3 System function directory. A system function directory shall tabulate operation control functions and the signal data described in the detailed level of functional analysis (see 3.6.4.4). The tabulation shall include the following information, as applicable:

a. Official name of the function, colloquial name, and symbol.
b. Type of control or signal (ac frequency and voltage, dc polarity and voltage, hydraulic pressure, mechanical motion, synchro, and so forth).
c. The origin and termination of the control or signal.
d. Identify equipments (relay transmitters, coordinate converters, distribution boxes, switches, and the like) between the origin and termination of the output control or signal.
e. Figure numbers of illustrations on which the function is illustrated, including the fault-isolation diagrams in Chapter 5.

3.6.4.4 Functional description level.

3.6.4.4.1 First level of functional description. The first level of the description shall be confined to data, such as, origin of the function at an equipment control or sensor; transmission of the signal via intermediate equipment such as switchboards, relay transmitters, coordinate converters, and distribution boxes; and presentation of the function at terminal equipment. Control functions essential to the development of a signal shall be introduced and briefly described in their relationship to the signal. The description shall be supported by an FBD (see 3.5.1.1). Functions involving computations may be explained in mathematical terms, but at a level no higher than high school mathematics. The second level of analysis shall be supported by one or more diagrams.

3.6.4.4.2 Detailed (second) level of functional description. The detailed level description shall explain the system functions in terms directly related to the diagrams in Chapter 5. Data and control functions shall be described down to the level of an equipment or an equipment group.

3.6.4.5 Preparation of FBD associated keyed text. This subsection describes the requirements and method of presentation of the keyed text associated with each FBD.

a. Keyed text presents brief descriptions of each block on the FBD. The short (generally one to three sentences) paragraph is "keyed" to the FBD by a circled number. The first text paragraph shall describe the total FBD sheet. Each subsequent paragraph (circle one, circle two, circle three, and so forth) shall describe what that block does within the operation of the system.
b. The keyed text shall discuss, at an overview level, the purpose of each block (why it exists, and what it does). The keyed text shall not discuss circuit implementation, or how it works. When the same block appears on many levels of the FBD, the keyed text relating to the block shall be identical at all levels (see figures 20-35 through 20-37).

3.6.5 Chapter 4, Operations. Chapter 4 shall describe system operating situations, modes, and procedures. The descriptions shall be detailed to the level required for an understanding of the operational interfaces of the system equipments and associated systems. Illustrations shall be included when necessary for clarity (see figure 20-38). The various operating modes shall first be described to acquaint the operator with all equipment combinations that can be employed to effect a given mode of operation.

3.6.5.1 Preoperational conditions and setup. Specific preoperational conditions presumed to be in effect prior to system operation shall be established. A system readiness checkoff list of significant switch positions and indicator status shall be tabulated. For indicators such as dials, where a band of readings are possible, upper and lower limits shall be delineated. The initial conditions of associated system equipment that directly affect system operation shall be treated in a similar manner.

3.6.5.2 Operating modes. The primary operating mode shall be discussed in detail, and alternate modes shall be treated as modifications of the primary mode. Operating procedures common to all modes shall be detailed under the primary mode and referred to under the alternate modes,

with such modifications of procedure as may be necessary. Each mode shall be described in the logical sequence of major phases, events, options, supervisory commands and responsive actions, and the following:

a. Only those equipment operational controls and indicators having system significance shall be explained in the description. When controls must be actuated and indicators observed in a sequence to achieve system operation, the descriptions will cite each control and indicator with a number to indicate the position in the sequence.
b. Emphasis shall be placed, by the use of warnings on the safe operation of controls, which, if operated improperly, could result in hazards to personnel or damage to the equipment. Each control shall be followed by a brief description of its effects (equipment actuation or display indication, or both) at the operator station and at remote stations. The primary mode description shall be supported by both general and detailed illustrations.
c. Operational phases which involve operator judgment shall be illustrated by operational logic diagrams. The diagrams shall indicate the conditions that must be favorable prior to an operator action, or if unfavorable, indicate the alternate action. Illustrations showing dials, gauges, status lights, and so forth, which indicate the favorable or unfavorable conditions shall be included. Special procedures to be followed when an equipment failure may be bypassed (as separate from emergency procedures) shall also be described.

3.6.5.2.1 Normal operation. The duties of system operators shall be described in terms of general responsibility and specific step-by-step procedures (see MIL-DTL-24784) for operating the system in all of the primary modes. Descriptive words (such as switch, button, dial, or indicator) may be added to clarify the type of control involved, for example: "Press ACCESS button and observe channel spot." All system controls and indicators provided for the use of operators shall be covered. Controls and indicators provided only for maintenance and nonsystem application shall not be called out.

3.6.5.2.2 Emergency operation. Step-by-step procedures shall be provided for emergency operation of the system. If specially designated controls have been provided for emergencies, a short statement shall be included describing how they modify or otherwise affect normal system operation. Emergency procedures shall be supported by illustrations.

3.6.5.2.3 Special operation. Special operations such as test checkout, training, or evaluation exercises shall be described. Illustration support shall include block diagrams and pictorial diagrams.

3.6.6 Chapter 5, Fault-isolation. Chapter 5 shall provide a high level overview of troubleshooting methods, techniques, and procedures as well as detailed procedures, illustrations, and an explanation of the use of the information presented for the identification, isolation and correction of all system level and system interface related problems and casualties. The major objective of the system fault-isolation procedures shall be described. In addition, a brief description of each type of maintenance diagram shall be provided. This chapter shall also provide procedures for the identification of system level casualties caused by and which must be repaired at an individual equipment level and shall isolate these casualties to the applicable portion

of Chapter 8 or other equipment level manual for troubleshooting. Chapter 5 shall provide an index of system diagnostic callout fault groups. Chapter 5 shall provide system related maintenance data, including tools and test equipment descriptions, and safety precautions associated with maintenance. The material in Chapter 5 shall be presented in seven separate sections as described by the following:

a. Introduction
b. Tools and Test Equipment
c. Diagnostic Descriptions
d. Diagnostic Operating Procedures
e. System Troubleshooting
f. Fault Group Index
g. System FCDs

3.6.6.1 Safety precautions. A reference to the safety precaution data contained in Chapter 1 shall be included as the initial paragraph ahead of the introduction.

3.6.6.2 Introduction. The introduction shall provide an explanation of the purpose, scope, supersedure data, and application of Chapter 5, including the models, serial numbers, and configurations covered. The interface relationship of the technical manual to other referenced publications and the relationship of the equipment to referenced systems or other equipment shall also be included. Warranty and guarantee information shall be included, as applicable.

3.6.6.3 Tools and test equipment. This section shall consist of data associated with the system which has been found to be useful as reference data for maintenance purposes. General data presented shall include, but not be limited to: identification and description of general and special purpose tools and test equipment; and any other special system requirement which modifies general electronic system maintenance practices.

3.6.6.3.1 Tools and test equipment listing. Separate listings shall be provided as required to describe the system complement of general purpose tools and tool kits, consumable items, general purpose test equipment, special purpose tools and tool kits, and special purpose test equipments. Tools supplied as parts of hardware assemblies, such as cabinet wrenches, shall be included in the tool lists. Requirements for description will be dependent upon the determination that a listed item is categorized as general purpose type or special purpose type. Special tools and equipment are defined as those not listed in the Federal Supply Catalog. Notes explaining use of the tables and Stock Code Number column numbering system shall precede the first table for which a particular note is applicable.

a. General purpose tools shall be listed in tabular form with numbered items listed alphabetically by their official name or nomenclature. Descriptive text explaining the use of the table and the Stock Code Number column numbering system shall precede the first table. Separate tables shall be provided which list the items comprising tool kits or groups which may be acquired as a kit or set. Tables describing the contents of tool kits or sets shall include

identification data for the acquisition of the kit or set in the title of the table. For each listed item, the table shall include:

1. Item number reflecting the position of the item on the tables.
2. Item name consisting of the official name or nomenclature of the listed item.
3. Part number consisting of the manufacturer or contracting activity assigned number as it appears on the item.
4. Quantity of the items required for maintenance of the system.
5. National Stock Number of the item as it appears in the Federal Supply Catalog.
6. Contractor and Government Entity (CAGE) code consisting of the assigned CAGE code of the manufacturer or contracting activity of the listed item.
7. Stock Code Number consisting of an assigned number which indicates the procurement status of the listed item as follows:

    a) Item is supplied with the equipment.
    b) Item is supplied by the Navy Supply System.
    c) Item is available through the Navy Supply System.

A note explaining this coding system shall precede the first table where used.

8. Remarks and Descriptions consisting of the name or number of the unit for which the item is to be used, SCAT code number, equivalency data, description of use, and so forth, applicable to the listed item.

b. Consumable items shall be listed in tabular form with numbered items listed alphabetically by their official name or nomenclature. For each listed item, the table shall include data as described by paragraph (a) above.
c. General purpose test equipment shall be listed in tabular form with numbered items listed alphabetically by their official name or nomenclature. For each listed item, the table shall include data as described by paragraph (a) above.
d. Special purpose tools shall be presented in tabular form. Items included in the tables will be listed alphabetically by their official name or nomenclature. Separate tables shall be provided which list the items comprising tool kits or groups which may be acquired as a kit or set. Notes explaining the use of the tables and Stock Code Number lettering system shall precede the first table for which a particular note is applicable. Tables describing the contents of tool kits or sets shall contain identification data (the manufacturer's or other identification to be used in acquisition of the kit or set) in the title of the table. Special purpose items listed as parts of general purpose tool kits shall be included in the special purpose tools table; its inclusion as part of the kit or set shall be properly annotated. For each listed item, the table shall include:

1. Item number reflecting the position of the item on the table.
2. Item name consisting of the official name or nomenclature of the listed item.
3. Illustration number consisting of the number of illustration describing the item and its general use.

4. Quantity of the items required for maintenance of the system.
5. Manufacturer's part number consisting of the manufacturer's or the contracting activity's assigned part number as it appears on the item.
6. CAGE code consisting of the assigned CAGE code of the manufacturer or contracting activity of the listed item.
7. Stock code number consisting of an assigned number which indicates the acquisition status of the listed item as follows:

    a) Item is supplied with the equipment.
    b) Item is supplied by the manufacturer.
    c) Item is available from the manufacturer.

    A note explaining this coding system shall precede the first table where used.

8. Remarks and description consisting of the name or number of the unit for which the item is to be used, SCAT code number, equivalency data, description of use, reference to procedures requiring usage, and so forth, applicable to the listed item.

e. Special purpose test equipment shall be presented in tabular form with accompanying illustrations. Items included in the table will be listed alphabetically by their official name or nomenclature. For each listed item, the table shall include data as described in 3.6.6.3.1a.

3.6.6.3.2 Reference data. This section shall consist entirely of data associated with the system which has been found to be useful as reference data for maintenance purposes. Technical and informative data which enhances maintenance and repair of the system shall be included. This section shall be presented by tabular format with introductory text and illustrations. Use of text and illustration shall be kept to the minimum required to ensure understanding of the material in the tables. This section shall contain, but not be limited to, the following sections.

a. A list of redundant (identical) pluggable electronic components shall be provided to facilitate the interchange of parts in use within the system. The list of components shall appear in tabular form with items grouped by part number and arranged in alpha- numeric part number order. The list shall include reference designators for each part number listed. Reference designators shall be arranged in ascending order with the least critical component appearing first. A maximum of ten reference designators shall be listed for any component used more than ten times within the system. Nonpluggable items and items having minor degrading impact on the system shall not be listed (Example: indicator lamps and light bulbs). This table shall be titled "Component Interchangeability."
b. A list of Maintenance Assistance Modules (MAMs) shall provide a tabular listing of the system MAMs. This table shall be titled "Special Purpose Test Equipment - MAMs."

3.6.6.4 Diagnostic descriptions. This section shall identify and describe all performance monitoring and fault localization tests supporting the system.

3.6.6.5 Diagnostic operating procedures. Step-by-step procedures shall be provided for

operating all system diagnostic operating procedures.

3.6.6.6 System troubleshooting procedures. This section shall provide specific troubleshooting methods and procedures to direct fault identification and location, fault-isolation, and fault repair or correction at the system level. The procedures shall provide for the analysis of switching combinations and observable indications (dials, gauge lamps, and meters). The use of any required test equipment shall be described. The procedures shall support the fault logic diagrams (FLDs), FCDs, and sequenced switching diagrams (SSDs). The supporting diagrams shall be referenced by figure number. Prerequisite control settings, conditions, and tools and test equipment shall precede each procedure.

3.6.6.6.1 Maintenance concept. The beginning of the system troubleshooting section shall describe the maintenance concept for system fault detection, fault localization, and fault-isolation and repair. The section shall contain a flowchart to aid the maintainer by illustrating the philosophy behind the method used to troubleshoot casualties.

3.6.6.6.2 Maintenance concept flowchart. The flowchart shall illustrate the basic methodology of troubleshooting casualties. The philosophy or concept behind the troubleshooting method shall be shown by depicting generalized maintenance actions rather than specific tasks performed. Overall format of the flowchart shall be divided into Operational, Detection, Localization, and Isolation and Repair sections by use of labeled dashed lines. Each block of the flowchart shall contain a circled number that corresponds to a paragraph number of an accompanying narrative text that describes the content of that block. Block numbers shall be assigned sequentially and shall follow the top-to-bottom, left-to-right flow pattern used by the flowchart. The flowchart shall illustrate typical operations performed during the troubleshooting process in the sequence that they were performed. The flowchart shall represent sufficient examples of the hardware and software used with the system to illustrate the underlying troubleshooting philosophy. All inherent or built-in troubleshooting aids shall be illustrated. However, to minimize complexity, the flowchart shall not attempt to show all of the possible troubleshooting operations for every hardware and software combination. (see 3.5.1.2).

3.6.6.6.3 Maintenance concept flowchart definitions. This section shall describe each of the blocks of the maintenance concept flowchart and their content by use of narrative text presented in tabular form. The table shall consist of paragraphs referenced to the numbered block of the flowchart that is described. The table shall contain a separate sequentially numbered description for each block appearing on the maintenance concept flowchart.

3.6.6.6.4 FLDs. The FLDs shall be prepared in accordance with MIL-DTL-24784.

3.6.6.6.5 SSDs. SSDs may be used to step the technician through a sequence of events to support troubleshooting. SSDs are generally used when normal monitoring of events will miss symptoms that are significant to the troubleshooting process. This can be due to the speed that the events take place, the need for controlling operator actions or other circumstances that make a step-by-step monitoring of events useful to the troubleshooting process. SSDs are often used to

monitor weapon control functions, ensuring that the technician zeros in on the correct symptom rather than a symptom indirectly resulting from the actual problem.

3.6.6.7 Fault group index. The fault group index shall provide a list of suspected faulty assemblies and parts for a fault group number callout resulting from the performance of specific diagnostic fault detection routines performed at the system level. Use of this section shall enable maintainers to swap or replace suspected faulty parts identified by troubleshooting routines with the use of MAMs, replacements from the supply system, or redundant parts available within the system. The fault group index is used for repair of a failure. The fault group index shall consist of a list of callouts or typeouts which list the reference designator of suspected faulty part(s) causing the callout; and which references the entry point on the correct diagram for further troubleshooting of casualty. This section shall also contain references to available lists of swappable components and MAMs, supply data, and instructions for replacement or swapping of suspected faulty parts. This section shall consist of a tabular listing of data related to system troubleshooting routine callouts. The fault group index may be an automated printout if format and legibility are retained and reproduced copy is clear and useable. The fault group index shall contain an introduction describing the use of the table in narrative text. The fault group index shall contain the following parts:

a. Fault group number. This shall consist of a column of callouts or typeouts listed alphanumerically by unit number of the diagnostic test performed, and shall contain all callouts applicable to unit casualties. Entries shall be spaced to facilitate inclusion of all corresponding data in the other columns of the table.
b. Test. This column shall identify the diagnostic test number of the test that produced the fault group callout.
c. Unit. This column shall identify the unit that was tested.
d. Card type. This column shall identify the part number of the suspected faulty card.
e. Reference designator. This shall consist of a column of all suspected faulty components applicable to the corresponding fault group number. Entries shall be spaced one to a line of type and shall be ranked by highest-to-lowest probability of causing the fault group number callout, and pluggable components shall be listed preceding hard-wired components. The reference designator shall describe unit number, cabinet or section number, subassembly number, and component number.
f. Functional circuit diagram. This column shall identify the figure number of the FCD associated with the suspected faulty card.
g. Circuit tested. This column shall identify the circuit that was tested.
h. Notes or remarks. This shall consist of notes, remarks, comments or amplifying data related to repair of the casualty. (Examples of notes and data: Identification of Electrostatic Discharge (ESD) sensitive parts; reference to applicable Fault Group Replacement Instructions; and so forth).

3.6.6.7.1 Fault group replacement instructions. This section shall describe by procedural text, the approved instructions for replacement or swapping of components identified by the fault group index, including equipment lineups and restrictions and all applicable safety instructions. This section shall also contain narrative references to technical manual sections describing the

availability, location, and use of MAMs and redundant swappable components in use within the system.

3.6.6.8 System FCDs. FCDs shall be the most detailed part of the system of diagrams used to depict the functional divisions of the system. The FCDs shall be directly linked to the lowest level of FBDs contained in Chapter 3. This reference shall be by the hardware reference designator. More information about the FBD and FCD structure and relationship is discussed in 3.5.1.1 and 3.5.1.3 and shown on figure 20-1.

3.6.7 Chapter 6, Alignment procedures. Chapter 6 shall present the corrective adjustment procedures and support information necessary to restore electrical and mechanical alignment between the various system equipments. All values and tolerances shall be included. The alignment shall be cross-referenced to respective fault-isolation procedures and diagrams in Chapter 5. Alignment procedures shall include references to equipment publications where further procedures are required at the equipment level. The alignment procedures shall be presented in step-by-step form.

3.6.8 Chapter 7, System cabling. This chapter shall provide system cabling diagrams, listings and description tables which will support troubleshooting of the system and the interfaces to associated systems. Chapter 7 shall be structured to provide coverage for every class of ship for which the system configuration being covered by this manual is applicable.

3.6.8.1 System cabling diagram. The system cabling diagram shall illustrate the electrical interfaces between the system units and the interfaces between the system and other associated systems.

3.6.8.2 System interface listing. The system interface listing shall list all the system cables, by cable number, and provide a cross-reference to a cable description table which describes the cable. The listing shall also correlate the cable number with the cable drawing number and show which ship class(es) the cable is applicable to.

3.6.8.3 Cable description table. The cable description table shall define the electrical interfaces between units of the system and between the system and associated systems. A separate table shall be provided for each cable. The cable description table shall be in accordance with the following.

3.6.8.3.1 Header data. The first line of header data (the table title) contains the table number and system cable number. The second line (USABLE ON CODE) shall list a code which can be correlated with the class(es) of ship the cable is installed on. The third and fourth lines list the names of the units connected by the cable and correlate by physical position with the TO and FROM columns.

3.6.8.3.2 WXP1, EXP2, From and to columns. The headings of these columns shall show the

cable plug reference designators and their physical position shall correlate with the unit number's physical position. The entries within these columns refer to the pin numbers on the connectors and the signal flow.

3.6.8.3.3 Signal name column. This column shall give the name of the signal associated with a wire. The term "NOT USED" shall indicate an unwired connector pin. The term "SPARE" shall indicate a wire that can be used in the future (or in an emergency). The term "UNUSABLE SPARE" shall indicate a signal line not presently used but that cannot be used as a spare.

3.6.8.3.4 Signal characteristics column. This column shall describe the electrical characteristics of power and supply signals listed in the "SIGNAL NAME" column.

3.6.8.3.5 Comments column. This column shall contain grounding notes and other pertinent information. The comments column shall also contain general remarks such as revision dates for table entries and references to footnotes.

3.6.8.3.6 General table data. The general table data block at the bottom of each sheet shall contain information which applies to the entire table. This block shall show the manufacturer's code, the cable drawing number, the revision level, and the sheet number.

3.6.9 Chapter 8, Unit level maintenance procedures. Chapter 8 shall be prepared as Unit Level Maintenance manuals for each unit. The technical manual shall therefore contain a separate part of Chapter 8 for each (or like) units. Each Part of Chapter 8 will contain Sections 1-5. When a Chapter 8 part requires 2 or more physical binders, the section(s) contained in each binder shall be clearly listed on the cover and title page of that binder. Procedures shall be included for troubleshooting to the lowest replaceable unit designated as organizational level by the equipment maintenance plan of the unit described. Troubleshooting procedures shall be included for corrective action where the automatic diagnostic program recommendations fail to solve the problem and for any circuits not tested by an automatic diagnostic program. Applicable tools for performing each removal, replacement, or maintenance action shall be listed before each procedure.

3.6.9.1 Section 1, General information and safety precautions. All safety precautions necessary for the protection of personnel and the ship shall be included as part of the introduction, in accordance with 3.6.6.1.

3.6.9.1.1 Introduction. The introduction shall provide an explanation of the purpose, scope, supersedure data, and applicability of the technical manual, including the models, serial numbers, and configurations covered. The interface relationship of the technical manual to other referenced publications and the relationship of the equipment to referenced systems or other equipment shall also be included, warranty and guarantee information shall be included, as applicable.

3.6.9.2 Section 2, Functional description. Section 2 shall include a detailed analysis of the

principles of operations of the overall equipment and its functions. The required inputs and development of the equipment outputs in every mode of operation shall be described. The descriptions shall be presented in successive levels of increasing detail as follows:

a. Overall level (Level 1). The first level of description shall explain the equipment functions in terms directly related to the equipment primary FBD (see 3.5.1.1b). The primary FBD and associated keyed text (see 3.6.4.5) are located in section 2.
b. Detailed level (Level 2). The detailed level description shall explain the equipment functions in terms directly related to the secondary and lower level FBDs and FCDs (see 3.5.1.1b). The FBDs and associated keyed text (see 3.6.4.5) are located in section 2. The FCDs are located in section 3.

3.6.9.3 Section 3, Troubleshooting. Troubleshooting procedures and data shall contain all information necessary for a technician to locate a malfunction in the equipment. Troubleshooting shall be presented based on locating faults in a unit, assembly, subassembly, module, or piece part, depending on the maintenance concept for the level of maintenance being performed. When the troubleshooting concept limits the location of a fault to a repairable item (such as the unit, assembly, subassembly, or module) for organizational level maintenance, trouble- shooting procedures and data shall also be presented that will permit a repair of the item at the intermediate level maintenance facility. When more than one level of maintenance must be provided for, organizational- and intermediate-level troubleshooting procedures shall be separated such that the organizational-level troubleshooting procedures are identified as "Organizational-Level Troubleshooting Procedures" and are presented first. Intermediate-level troubleshooting procedures shall follow organizational-level procedures and shall be identified "Intermediate Level Procedures." Immediately following this title the following statement shall be included: "These procedures are authorized for Intermediate-Level (or higher) activities (tender, shore facility or depot)."

3.6.9.3.1 Trouble isolation and testing. This subsection shall contain all instructions and information necessary to locate troubles and conduct tests on each component, assembly, or subassembly of the equipment as follows:

a. Troubleshooting guides providing step-by-step procedures for logical isolation of faults. This information shall direct the technician to observe meters, fuses, circuit breakers, valves, and other available indicators which would indicate the presence of trouble.
b. Complete instructions on signal tracing for electrical circuit including the use of special test instruments and unusual servicing techniques.
c. Where appropriate because of equipment complexity, troubleshooting diagrams including schematics giving details of mechanical and electrical assemblies and relationship specified under the following paragraphs.

3.6.9.3.2 Malfunctions. This subsection shall contain all the information required to enable the technician to locate malfunctions in the equipment.

3.6.9.3.3 Introduction. The introduction shall explain the approach and logic of the

troubleshooting principles presented in the manual. The section shall describe the troubleshooting data in Chapter 8 and show how it relates to the data in Chapter 5.

3.6.9.3.4 Troubleshooting index. The troubleshooting index shall be presented in tabular form. The index shall list all equipment, major and supporting functions in alphabetical order, provide references to the technician to the appropriate procedures and diagrams that area to be used to troubleshoot a specific function (see MIL-DTL-24784).

3.6.9.3.5 Relay and lamp indices. These indices shall be prepared in tabular form for all relay coils and indicator lamps. The relay and lamp indices shall include the item reference designation, the functional name, energizing voltage, and a reference to the troubleshooting diagram(s). Any components which are part of a circuit card assembly that is a lowest replaceable unit shall not be listed on the component indices (see MIL-DTL-24784).

3.6.9.3.6 Protective device index. This index shall list all protective devices, such as fuses, circuit breakers, and so forth. The index shall include the item reference designation, front panel marking of the device, trip-out value of the circuit breaker and rating of fuses, name of the circuit protected and a reference to troubleshooting diagram(s) (see MIL-DTL-24784).

3.6.9.3.7 Maintenance turn-on procedure. Include a maintenance turn-on procedure to energize the equipment from the fully de-energized condition to full operation (see figure 20-39). This procedure shall enable the technician to determine which major function or supporting function is malfunctioning. Each step of the procedure shall include the action to be taken (STEP), the observation to be made (OBSERVE), and shall presume that normal conditions have been observed in previous steps. Reference shall be made to the procedure for troubleshooting or corrective action to be used (REFERENCE) if the observation is out of tolerance. Built-in monitors, such as meters, dials, lamps, and so forth, shall be used when possible for making observations, as opposed to the use of external test equipment. The procedure is complete when the equipment is fully energized and all switches and controls are positioned for proper operation.

3.6.9.3.8 Troubleshooting procedures. Specific troubleshooting methods and procedures shall be presented to direct fault identification, fault-isolation, and fault repair or correction, at the equipment level. The procedures shall provide for the analysis of switching combinations and observable indications (dials, gauge lamps, and meters). The use of any required test equipment shall be described. The procedures shall support the troubleshooting diagrams (see 3.6.9.3.9). The supporting diagrams shall be referenced by figure number. Prerequisite control settings, conditions, tools and test equipment, shall precede each procedure.

3.6.9.3.8.1 Fault group index. The fault group index shall provide a list of suspected faulty assemblies and parts for a fault group number callout resulting from the performance of specific diagnostic fault detection routines performed at the system level. Use of this section shall enable maintainers to swap or replace suspected faulty parts identified by troubleshooting routines with the use of MAMs, replacements from the supply system, or redundant parts available within the system. The fault group index is used for repair of a failure. The fault group index shall consist of a list of callouts or typeouts which list the reference designator of suspected faulty part(s)

causing the callout; and which references the entry point on the correct diagram for further troubleshooting of casualty. This section shall also contain references to available lists of swappable components and MAMs, supply data, and instructions for replacement or swapping of suspected faulty parts. This section shall consist of a tabular listing of data related to system troubleshooting routine callouts. The fault group index may be an automated printout if format and legibility are retained and reproduced copy is clear and useable. The fault group index shall contain an introduction describing the use of the table in narrative text. The fault group index shall contain the following parts:

a. Fault group number. This shall consist of a column of callouts or typeouts listed alphanumerically by unit number of the diagnostic test performed, and shall contain all callouts applicable to unit casualties. Entries shall be spaced to facilitate inclusion of all corresponding data in the other columns of the table.
b. Test. This column shall identify the diagnostic test number of the test that produced the fault group callout.
c. Unit. This column shall identify the unit that was tested.
d. Card type. This column shall identify the part number of the suspected faulty card.
e. Reference designator. This shall consist of a column of all suspected faulty components applicable to the corresponding fault group number. Entries shall be spaced one to a line of type and shall be ranked by highest-to-lowest probability of causing the fault group number callout, and pluggable components shall be listed preceding hard-wired components. The reference designator shall describe unit number, cabinet or section number, subassembly number, and component number.
f. Functional circuit diagram. This column shall identify the figure number of the FCD associated with the suspected faulty card.
g. Circuit tested. This column shall identify the circuit that was tested.
h. Notes and remarks. This shall consist of notes, remarks, comments or amplifying data related to repair of the casualty. (Examples of notes and data: Identification of ESD sensitive parts; reference to applicable Fault Group Replacement Instructions; and so forth).

3.6.9.3.8.2 Fault group replacement instructions. This section shall describe by procedural text, the approved instructions for replacement or swapping of components identified by the fault group index, including equipment lineups and restrictions and all applicable safety instructions. This section shall also contain narrative references to technical manual sections describing the availability, location, and use of MAMs and redundant swappable components in use within the system.

3.6.9.3.9 Troubleshooting diagrams. Troubleshooting diagrams shall consist of FLDs, secondary FBDs, FCDs, and so forth, as required to support the system maintenance concept. All diagram notes (general, apron, multiple page, and so forth), except for FBDs and FCDs, shall be developed in accordance with MIL-DTL-24784.

3.6.9.3.10 Secondary FBD, lowest-level FBD, and FCDs. Refer to Chapter 5 for a discussion of these diagrams.

3.6.9.3.11 Flow charts. Flow charts for digital devices shall be provided to support the explanation of machine instructions and test programs, and shall be in accordance with 3.5.1.2, ISO 6829, and MIL-DTL-24784.

3.6.9.3.12 Coding instruction sheets. Coding instruction sheets shall be provided for all programs. The listing shall contain all coding and address data as well as an adequate notes section to ensure understanding (see figure 20-40).

3.6.9.3.13 Test programs. Test programs with coding instruction sheets shall be developed and included on support troubleshooting procedures.

3.6.9.3.14 Troubleshooting dependency diagrams. FLDs (see 3.6.6.6.4) shall be provided to augment the troubleshooting procedures. Supporting information required to explain the use of the diagrams shall be provided in the text or general note.

3.6.9.4 Section 4, Corrective maintenance. This section shall contain instructions required to adjust and align the equipment; remove, repair, reinstall, and align all repairable parts, modules, subassemblies, and assemblies. The instructions shall identify the action to be accomplished; safety precautions to be observed; tools, parts, materials, and test equipment required; preliminary control settings; test equipment setup instructions; and step-by-step instructions, with supporting illustrations, to accomplish the maintenance task. Corrective maintenance instructions shall be provided for all items designated repairable irrespective of the maintenance concept unless this information is included in another technical manual and can be referenced.

3.6.9.4.1 Introduction. The introduction shall contain an explanation of the purpose, scope, and arrangement of the corrective maintenance data.

3.6.9.4.2 Adjustments and alignments. This subsection shall contain all information and procedures required to perform all necessary adjustments and alignments as follows:

a. Nonoperator type adjustments.
b. Alignments requiring external jigs, test equipment, or bench setups.
c. Alignments that are accomplished after a repair or replacement of a part or module.
d. Test equipment setup and other illustrations necessary to support the procedures.

3.6.9.4.3 Repair. The repair subsection shall contain all procedures required in the repair of assemblies and repairable parts. Repair procedures shall include but not be limited to the following:

a. Removal, disassembly, and inspection.
b. Repair or replacement of piece parts.
c. Cleaning, reassembly, adjustment, installation, calibration, and checkout.
d. Exploded views, sectional views, wiring diagrams, and photographs necessary to support the procedures.

e. Obvious repair actions such as soldering, use of multimeters, hand tools, and so forth, shall not be included except where these actions involve hazards to personnel or equipment.

3.6.9.4.4 Supporting illustrations and data. The use of clear, sharp illustrations to supplement description and maintenance coverage is required. Exploded views are required for parts location illustration. As a minimum, illustrations or sketches of the following shall, when applicable, be included:

a. Typical bearings for rotating or moving equipment.
b. Method of taking clearance measurements where required.
c. Typical mechanism for absorbing thrust where applicable.
d. Locking devices when applicable.
e. Typical seal assembly (pressure and vacuum seals or controlled leakage between rotor and casing).
f. Typical assembly of blading to rotor, with lock devices, where applicable.
g. Typical assembly of field poles, laminated core iron, electrical windings, commutator, slip rings, and brush rigging where applicable.
h. Equipment assembly with upper casing partially removed.
i. Series of illustrations showing installation of supervisory instruments (such as RTEs in bearings).

3.6.9.5 Section 5, Parts list. The parts list shall list and identify and shall reference or include an illustration that will show the location of all repair parts, including the attaching hardware required to support the maintenance concept. All mechanical parts subject to replacement, although not provisioned as a spare part, such as handles, slides, plates, covers, and so forth included in the Provisioning Documentation shall be included in the parts list and identified in the respective parts-location diagram. This chapter shall include:

a. Introduction.
b. Parts list (including attaching hardware).
c. List of manufacturers.
d. Parts location illustrations.

3.6.9.5.1 Introduction. The introduction shall contain an explanation of the scope and arrangement of the parts list. The following type of information shall be included:

a. Models of equipments and, where all equipment of a specific model do not have interchangeable parts, serial number of equipments covered.
b. Explanation of any special notes.
c. Explanation and instructions for using the list of common item descriptions.
d. Explanation and instructions for using the list of attaching hardware.
e. Explanation and instructions for using the parts list.
f. Explanation and use of the list of manufacturers.

3.6.9.5.2 Parts list requirements. The parts list shall be in tabular form in accordance with MIL-DTL-24784. The parts list shall be divided by major units. Each unit shall be arranged in numerical sequence (for example, unit 1 with its parts, and so forth, will precede unit 2 with its parts). All parts attached to the unit shall be listed first in alphanumerical order, followed by unit assemblies with parts and than subassemblies with parts, also listed in alphanumerical order. The list shall be arranged as follows:

Unit	1
(Cabinet parts)	1AT1
	1B1
	1C1
	1CR1
	1R1
	and so forth
Assembly	1A1
(Assembly parts)	1A1AT1
	1A1B1
	1A1C1
	1A1CR1
	1A1R1
	and so forth
Subassembly	1A1A1
(Subassembly parts)	1A1A1AT1
	1A1A1B1
	1A1A1C1
	1A1A1CR1
	1A1A1R1
	and so forth
Unit	2
	and so forth

3.6.9.5.3 Parts list format. All parts listings shall be prepared in tabular form with columns headed as follows (see MIL-DTL-24784).

a. Column 1, Reference designation. This column shall contain the reference designations of all parts listed in sequential order. Unit numbering method of assigning reference designations, in accordance with IEEE 200 shall be used to identify units, assemblies, subassemblies, and parts. Mechanical part numbers shall be assigned to mechanical parts subject to replacement, such as handles, slides, and so forth, that are included in the APL but not assigned mechanical part numbers in the engineering drawings. With the exceptions of screws, nuts, bolts, and other attaching hardware, every functioning part in the equipment shall have a reference

designator. When reference designations have been canceled for more than two consecutive items, only the first and last of the designations are to be listed, separated by the word "through". For example: 3A1R69 through A1R100 not used.

b. Column 2, Part name. This column shall contain the name of the part.
c. Column 3, Part number. This column shall contain the part number.
d. Column 4, CAGE code. This column shall contain the Contractor and Government Entity (CAGE) code of the manufacturer.
e. Column 5, figure reference. This column shall reference the parts location illustration in Section 4.
f. Column 6, Notes. This column shall contain equipment reference information such as serial number, model number, configuration data, and so forth.

3.6.9.5.4 List of common item descriptions. This list shall include the description of all identical parts that are used more than five times in the equipment. The description of each common item shall totally identify the item including manufacturing CAGE code and part number or military standard number. Like parts should be grouped and arranged in alphanumeric order. Item numbers shall be assigned consecutively, for example:

Item number	Description
1	CAPACITOR, FIXED,CERAMIC: DIELECTRIC 3PF, 500 VDCW; MIL type CCZ1UJ030C
2	CAPACITOR, FIXED GLASS: DIELECTRIC 5100 PF, + 1% 300 VDCW, mfr 86969, dwg 231B743H15.
3	RESISTOR, FIXED, COMPOSITION: 3000 ohms + 5% 1/2w; mfr 42384 dwg 4469D69
4	RESISTOR, FIXED, COMPOSITION: 4000 ohms + 5% 1/2w; MIL type RC20GF402J.

3.6.9.5.5 List of attaching hardware. A list shall be included that shows items of attaching hardware. Attaching hardware shall be listed alphanumerically and identified by an assigned letter. For example:

Letter code	Name and description
A	CAPSCREW, 1/4-28, UNF-2A, 1 in. lg, HEX HEAD, DRILLED HEAD, CRES MS51100-8,.
B	WASHER, FLAT, 0.750 in. ID, 0.312 in. OD, 0.066 in. thickness, STEEL, ROUND.,

Items used fewer than five times need not be included in the list of attaching hardware providing the item is completely identified in the parts list, following the part identification that is being attached.

3.6.9.5.6 List of manufacturers. The list of manufacturers shall contain the names, addresses,

and CAGE number of all manufacturers supplying items for the equipment as referenced in the parts list. The list shall be presented in numerical sequence by CAGE number. CAGE numbers shall be in accordance with Cataloging Handbook H4/H8.

3.6.9.5.7 Parts location illustrations. Illustrations shall be included to provide positive and rapid location of parts. Types of parts location illustrations include exploded views, when approved by the Government, engineering drawings and sectional views, printed-circuit boards, as applicable (see MIL-DTL-24784). (Suitable parts location illustrations located in other chapters of the manual may be referenced).

3.6.9.5.8 Criteria for illustrations. Items shall be called out by reference designator. Standard attaching hardware items (such as nuts, bolts, washers, screws) need not be called-out or illustrated, except when they are referenced in a procedure. Exploded views shall be supplied when required to support maintenance procedures in Section 4.

3.6.9.5.9 Exploded views. Exploded views for parts lists shall be prepared in accordance with MIL-DTL-24784.

3.6.9.5.10 Line drawings, engineering drawings, and photographs. Line drawings shall be used in lieu of photographs (see MIL-DTL-24784).

3.6.9.5.11 Printed circuit board. Printed-circuit board illustrations shall be prepared in accordance with MIL-DTL-24784.

4. VERIFICATION

4.1 Quality assurance provisions. The quality assurance requirements for delivery of book plans, review draft copies, preliminary technical manuals, final reproducible copy, technical manuals, replenishment materials, changes and revisions shall be in accordance with MIL-DTL-24784.

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When actual packaging of materiel is to be performed by DoD personnel, these personnel need to contact the responsible packaging activity to ascertain requisite packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activity within the Military Department or Defense Agency, or within the Military Department's System Command. Packaging data retrieval is available from the managing Military Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but it is not mandatory.)

6.1 Intended use. The technical manuals prepared to this specification are intended to be used for installation, operation, maintenance, repair, and parts support of digital systems. The technical manual will be used as a training document in the classroom and as a source for on-the-job training.

6.2 Acquisition requirements. Acquisition documents must specify the following:

a. Title, number, and date of the specification (or any TMCR referencing this specification).
b. Issue of DoDISS to be cited in the solicitation, and if required, the specific issue of individual documents referenced (see 2.2.1 and 2.3).
c. Deliverable products and data items (see 3.3).
d. Arrangement if other than standardized format (3.4)
e. When format and development instructions other than as specified in the MIL-DTL-24784 (see 3.5).
f. When preparation of illustrations, drawings, diagrams and sketches other than as specified in the MIL-DTL-24784 (see 3.5.1).
g. When LSA or MRC data is required or a depot level maintenance manual is to be acquired in accordance with MIL-DTL-24784/7 (see 3.6.3).
h. Packaging requirements (see 5.1).

6.3 Technical manual acquisition. This specification (or a TMCR based on this specification) must be listed on the Contract Data Requirements List (DD Form 1423) in order to acquire the technical manuals described by this specification. An alternate acquisition strategy should be devised by contracting officers for those solicitations or contracts which are exempted from using the Uniform Contract Line Item Numbering System (UCLINS).

6.4 Definitions. The words or phrases used throughout this specification are defined in MIL-DTL-24784.

6.5 Subject term (key word) listing.
Complex Digital Systems
Installation
Maintenance
Operation
Parts Support

6.6 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extent of the changes.

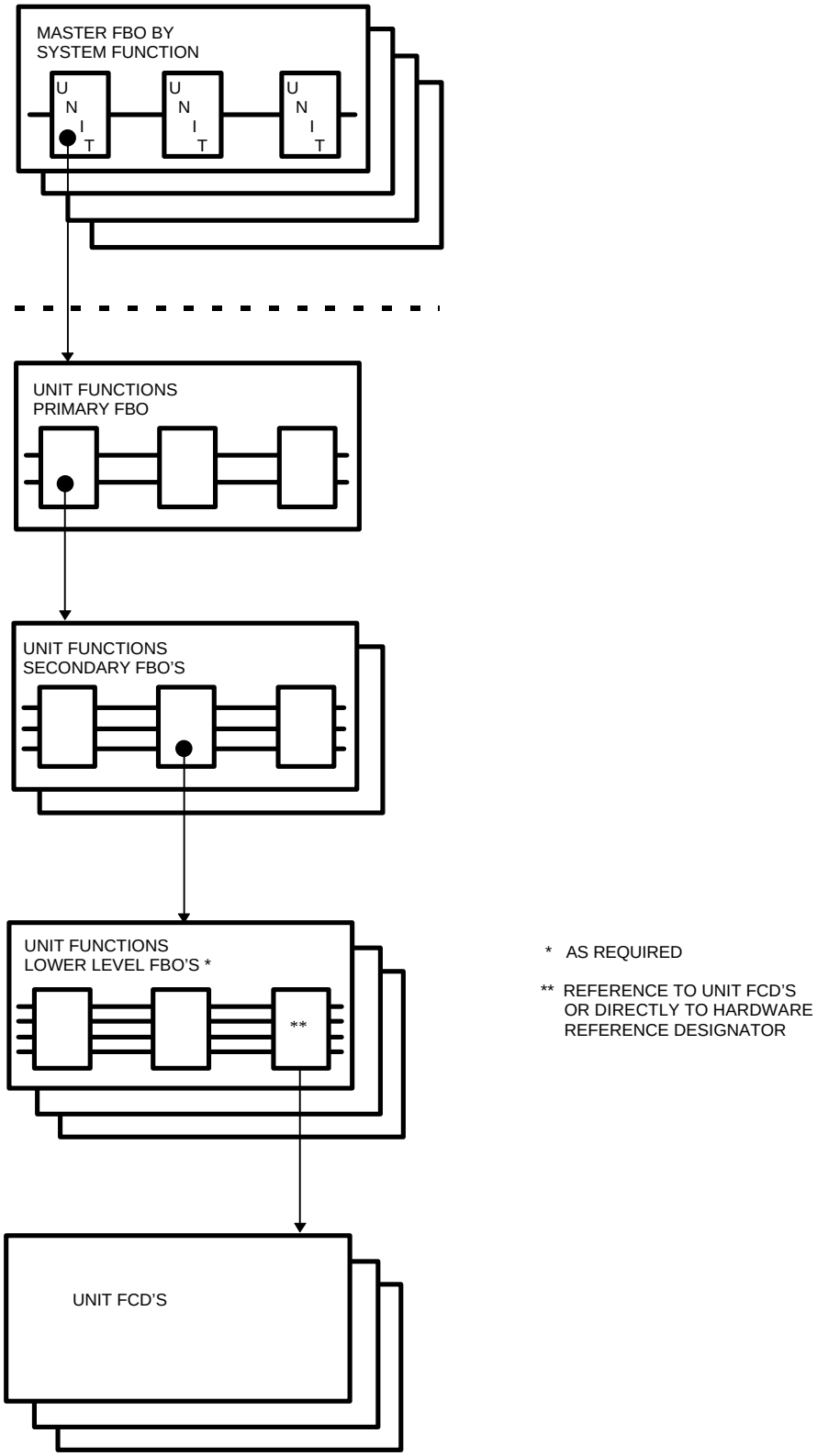


FIGURE 20-1. FBD/FCD structure and relationship. (Example)

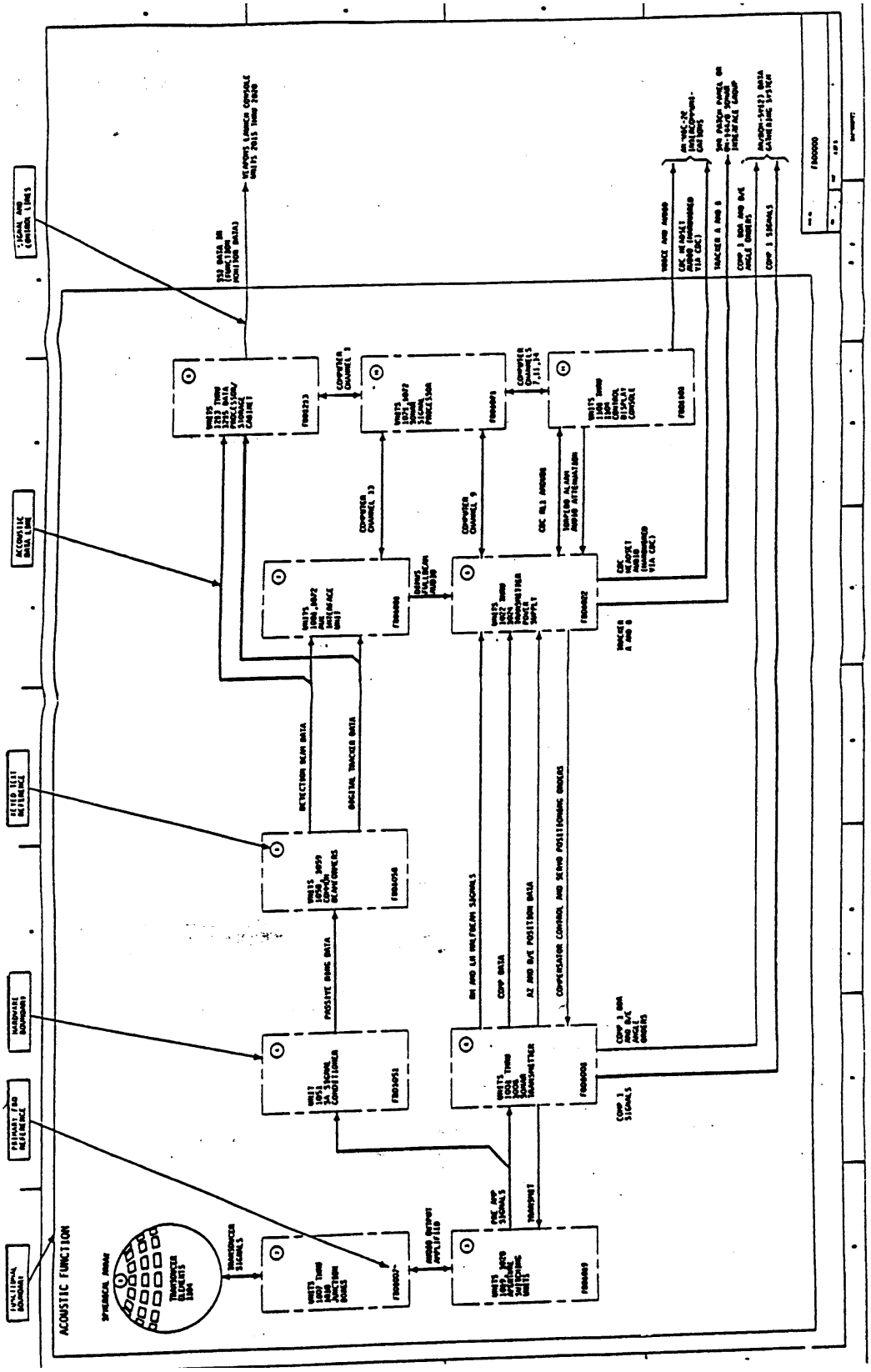


FIGURE 20-2. FBD, master. (Example)

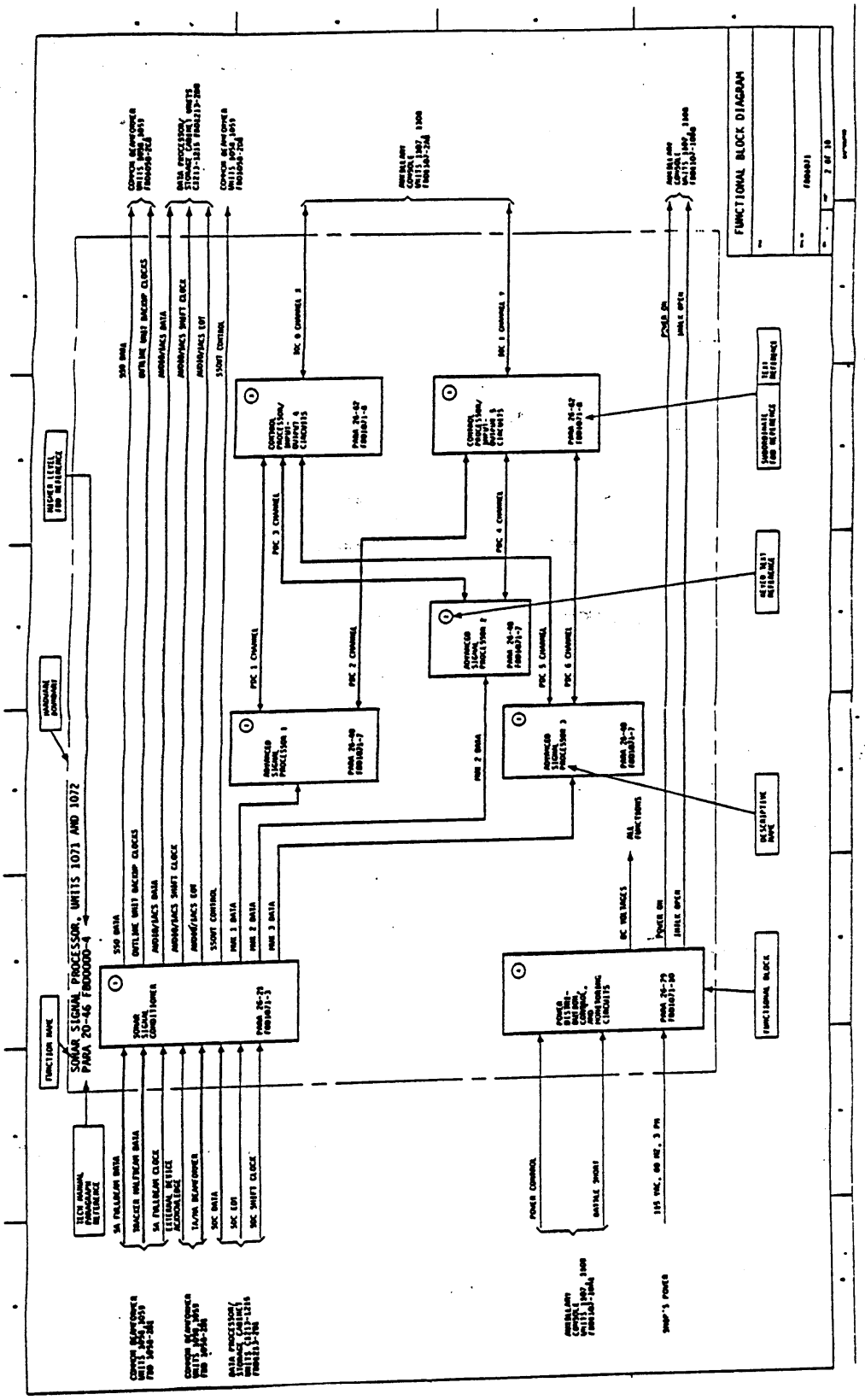


FIGURE 20-3. FBD, primary. (Example)

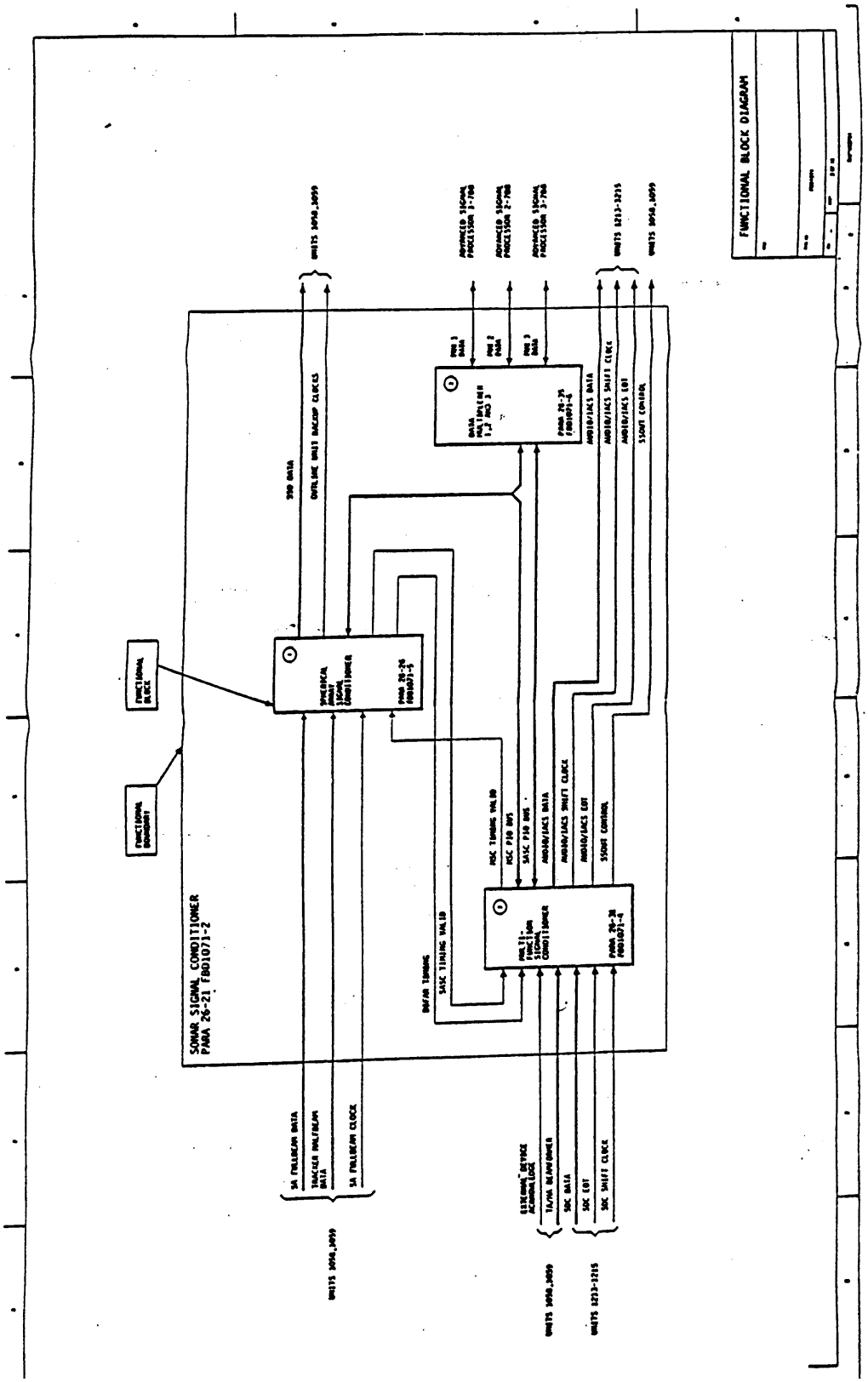


FIGURE 20-4. FBD, secondary. (Example)

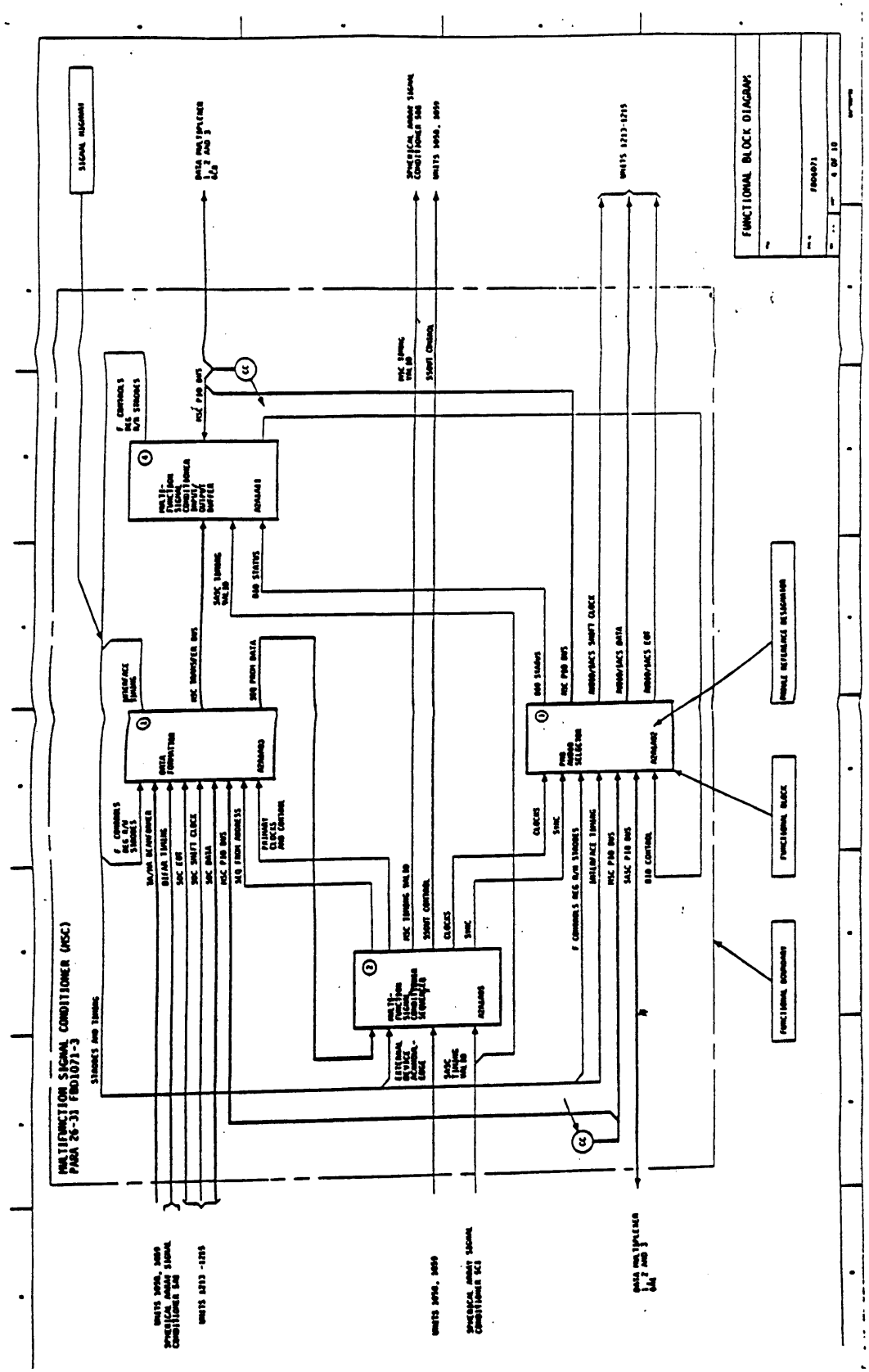


FIGURE 20-5. FBD, lowest - level. (Example)

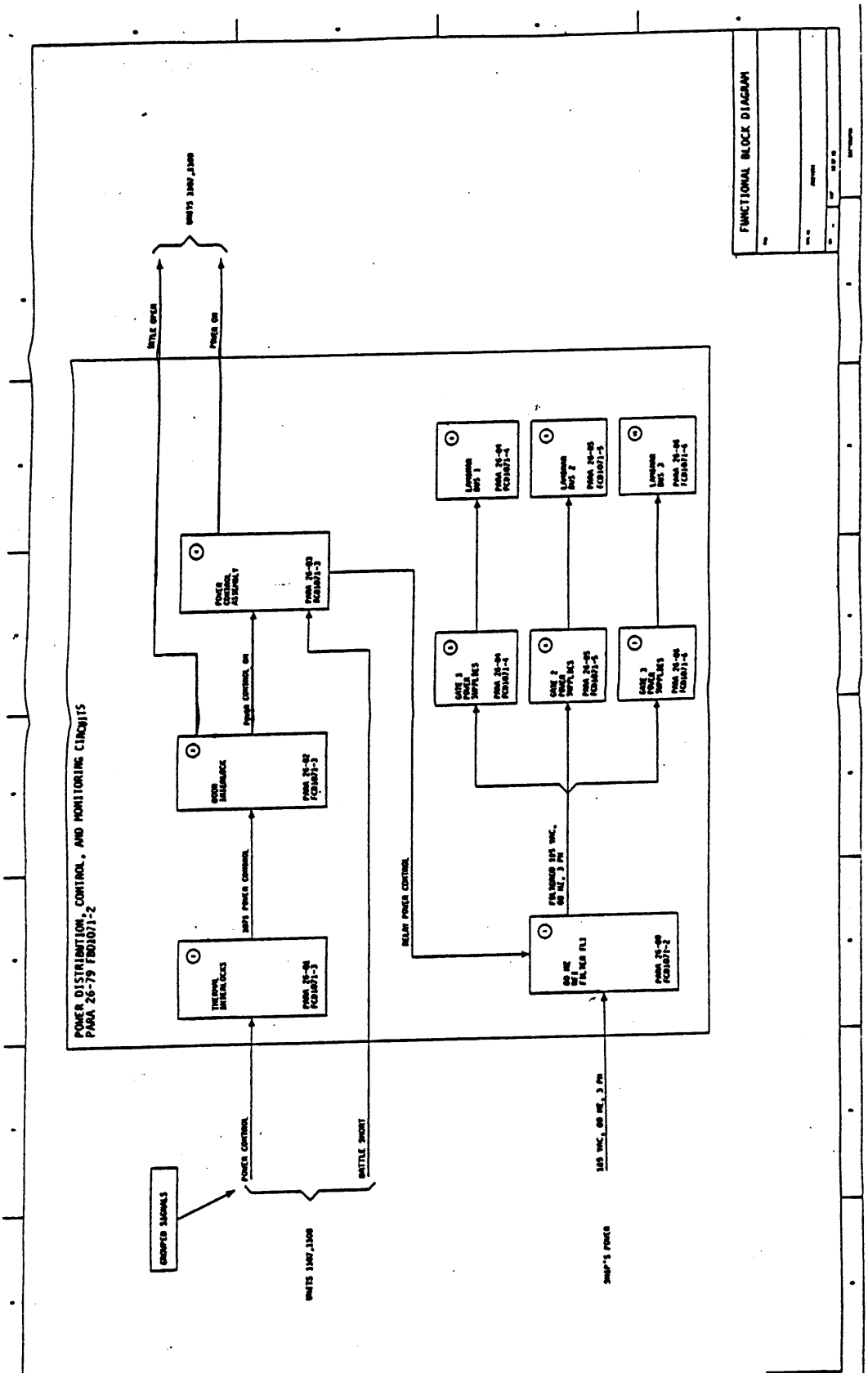


FIGURE 20-6. FBD, unit power. (Example)

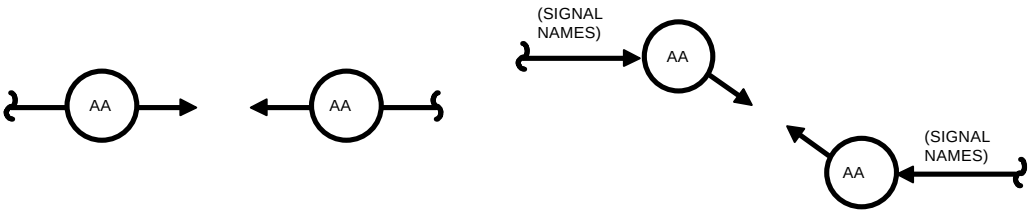


FIGURE 20-7 Signal referencing on the same sheet.

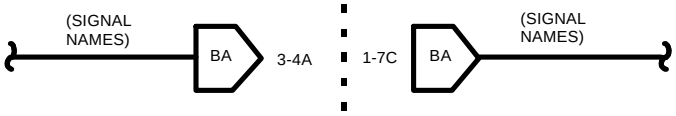


FIGURE 20-8. FBD signal referencing between two or more functional parts.

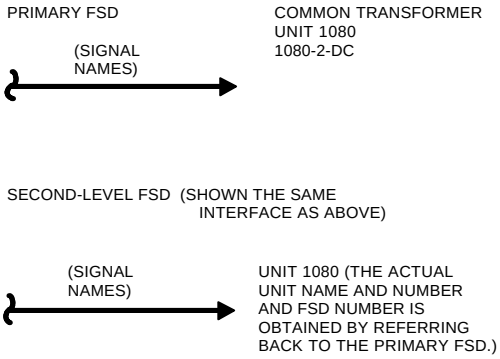


FIGURE 20-9. FBD referencing between units.

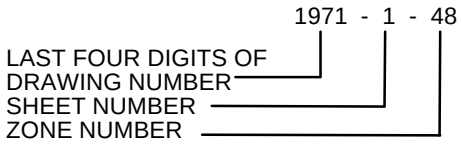


FIGURE 20-10. Zone numbers.

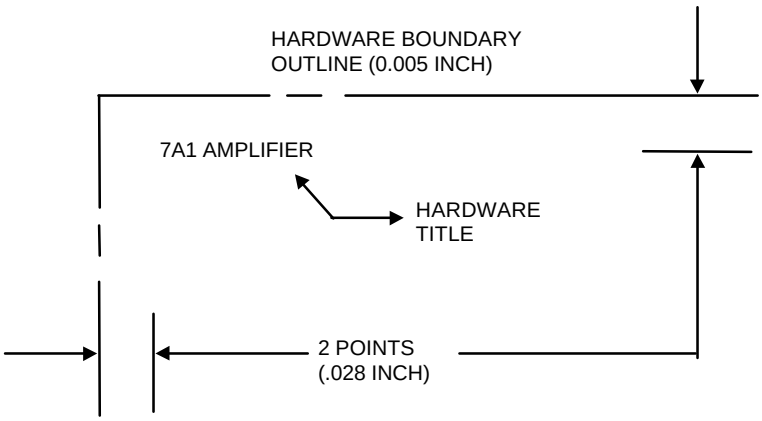


FIGURE 20-11. Hardware boundary.

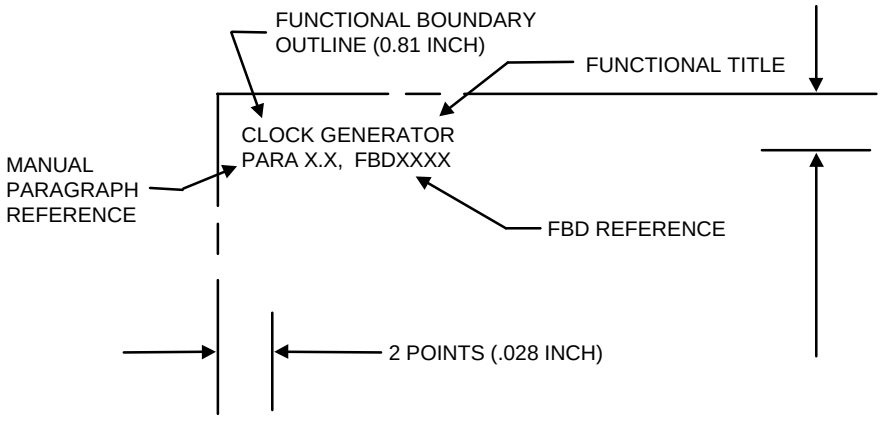


FIGURE 20-12. Functional boundary.

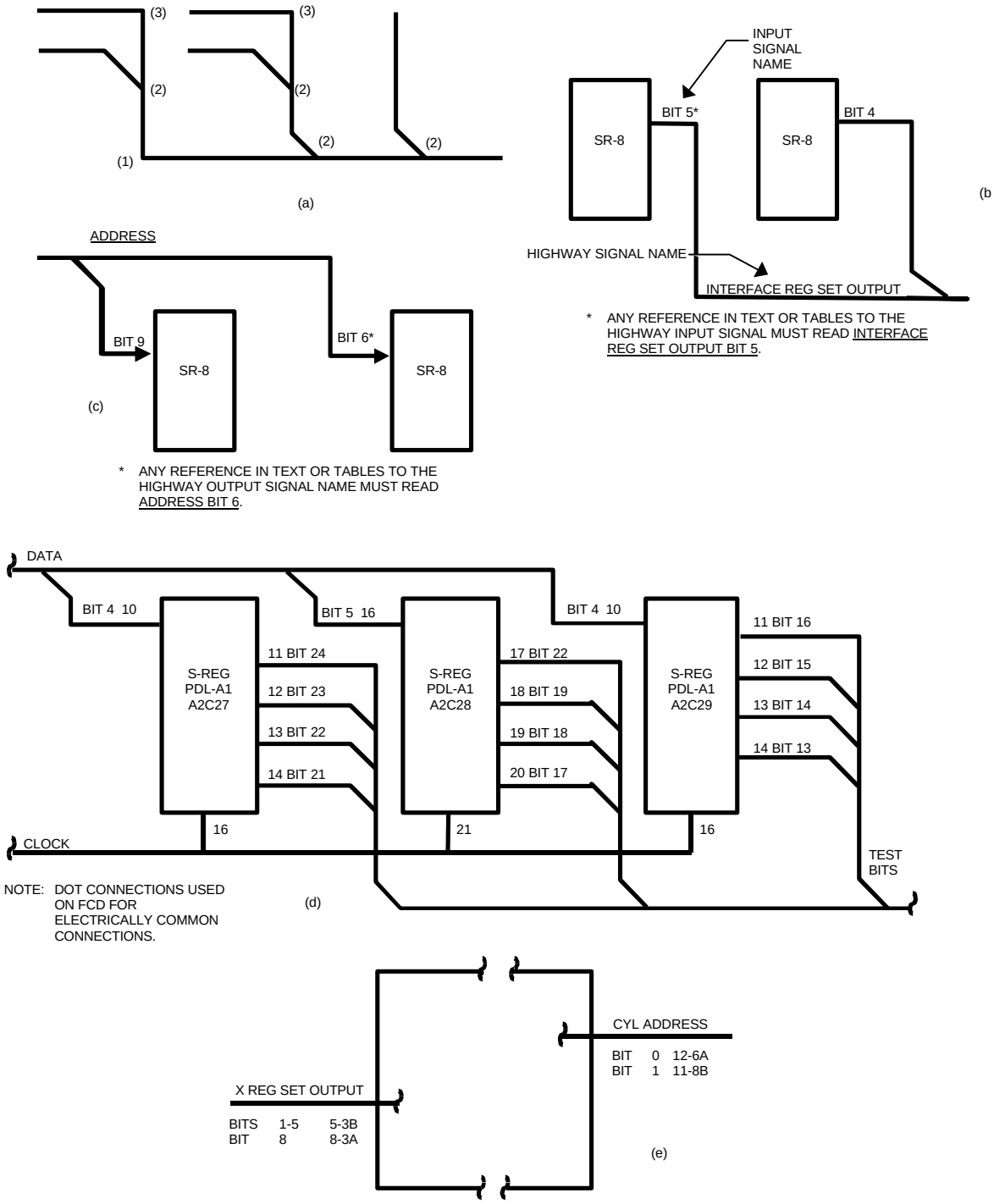


FIGURE 20-13. Interconnecting lines. (Example)

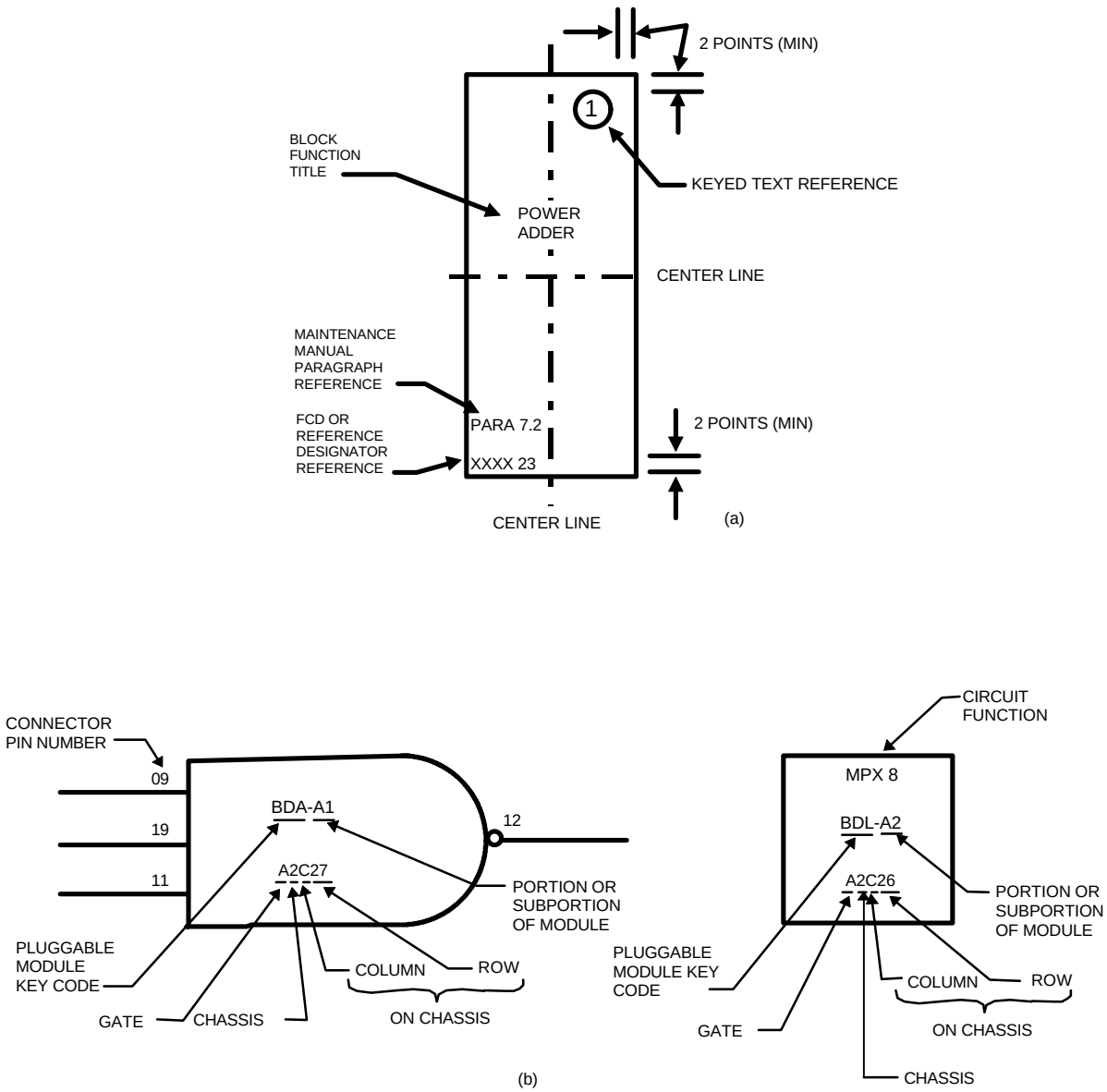


FIGURE 20-14. Symbols.

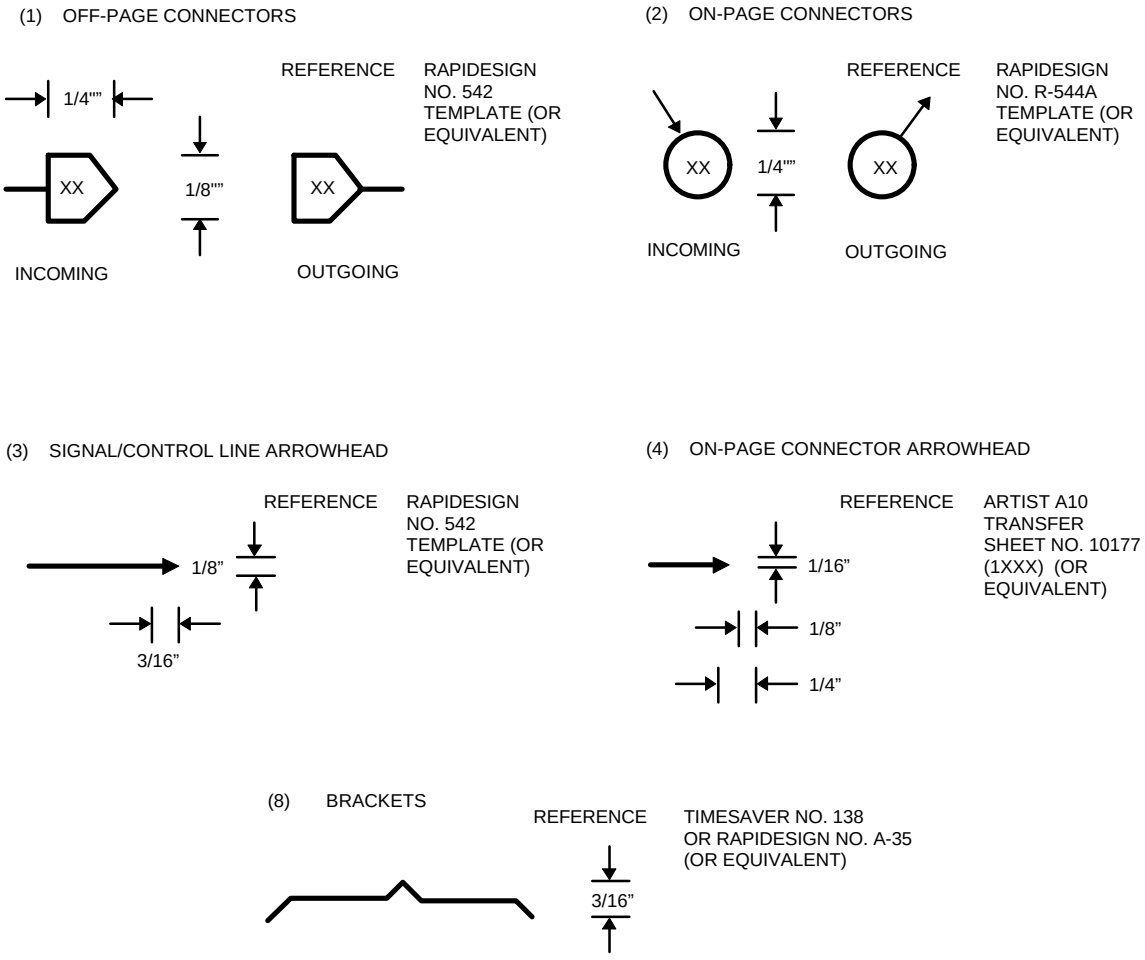


FIGURE 20-15. On-page and off-page connectors and miscellaneous symbols.

A B C D E F G H I J
K L M N O P Q R S T
U V W X Y Z
1 2 3 4 5 6 7 8 9 0

FIGURE 20-16. Lettering - gothic, vertical, sans serif.

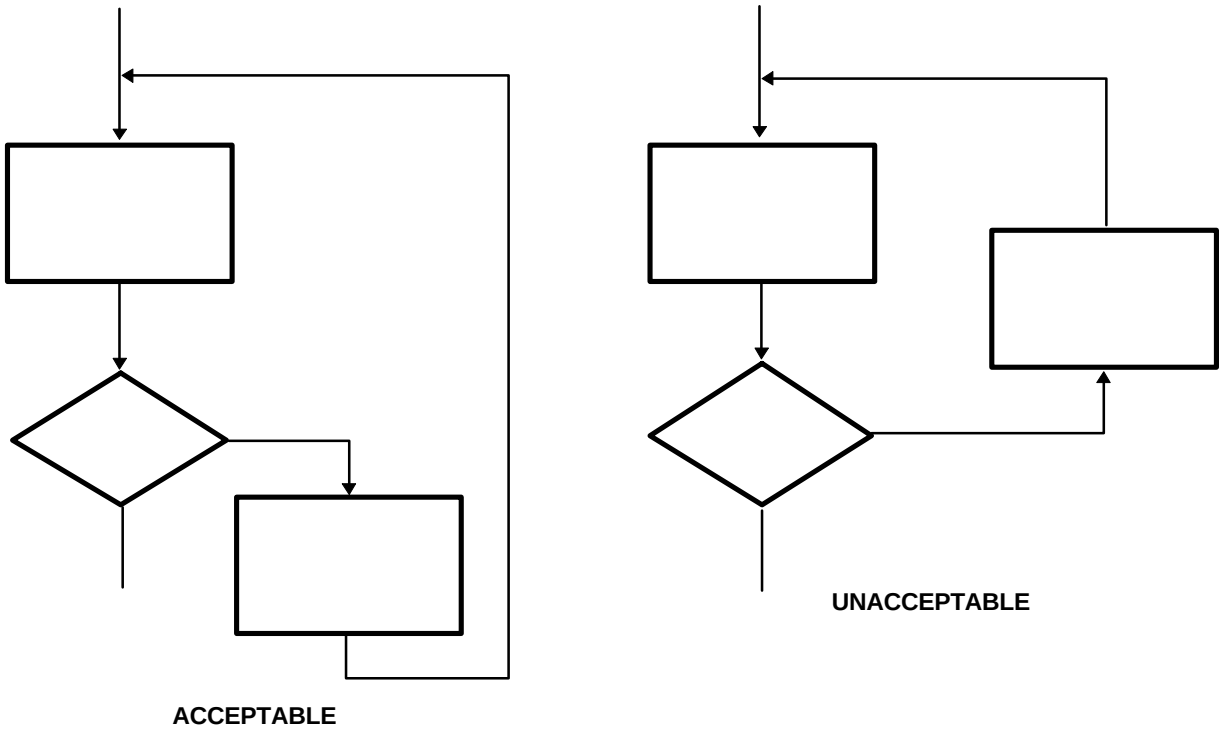


FIGURE 20-17. General flow.

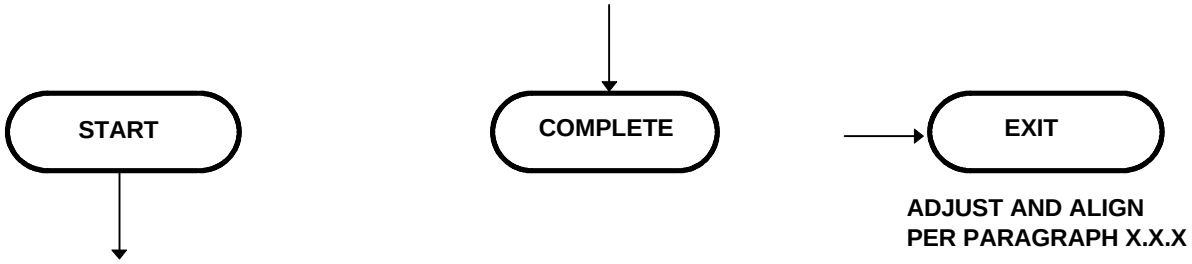


FIGURE 20-18. Terminal blocks

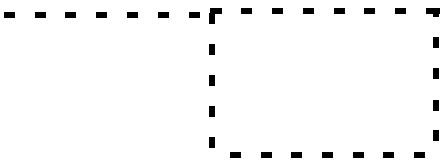


FIGURE 20-19. Annotation/comment block.

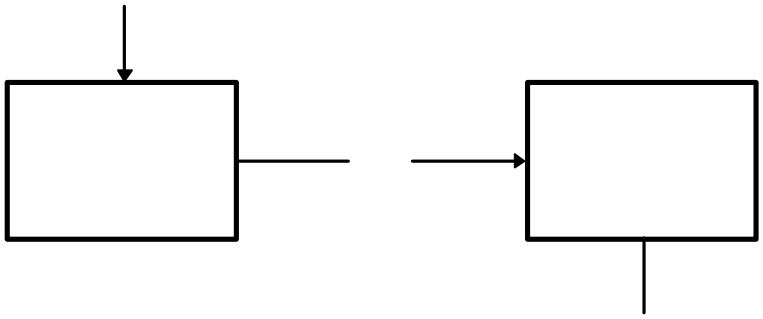


FIGURE 20-20. Process blocks.

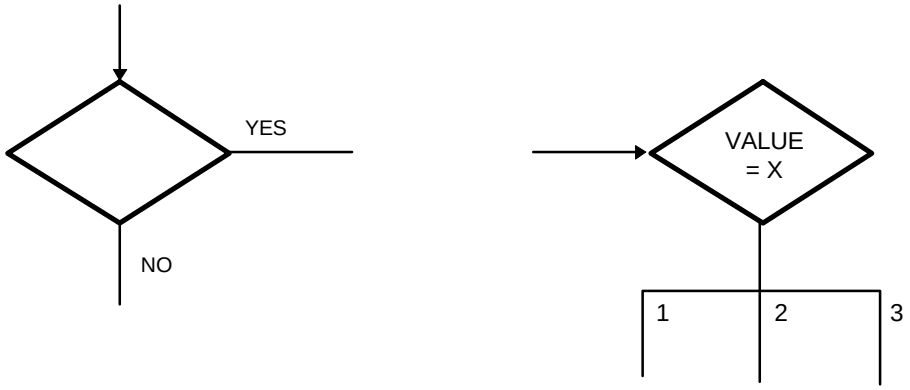


FIGURE 20-21. Decision blocks.

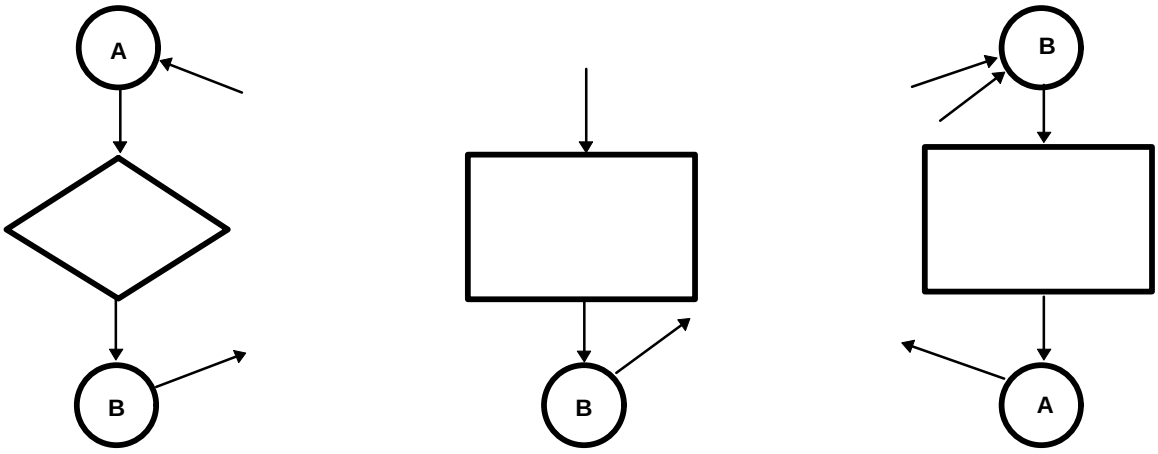


FIGURE 20-22. On-page connectors.

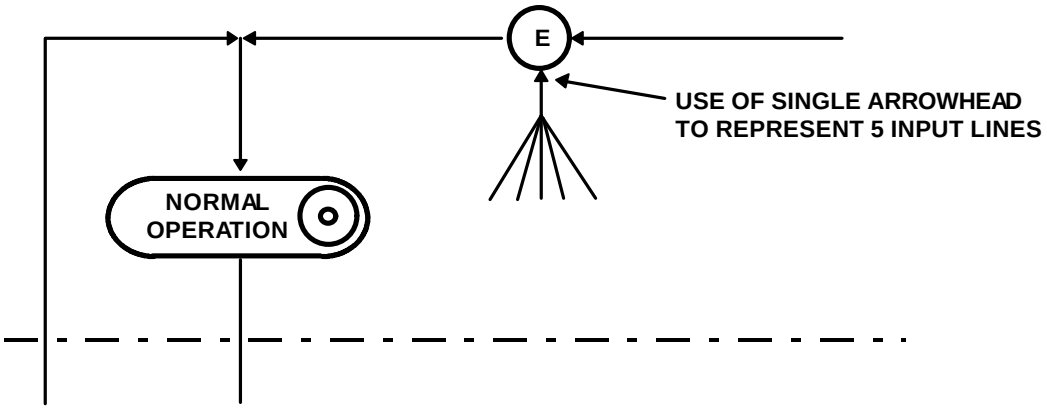


FIGURE 20-23. Multiple on-page connector varient.

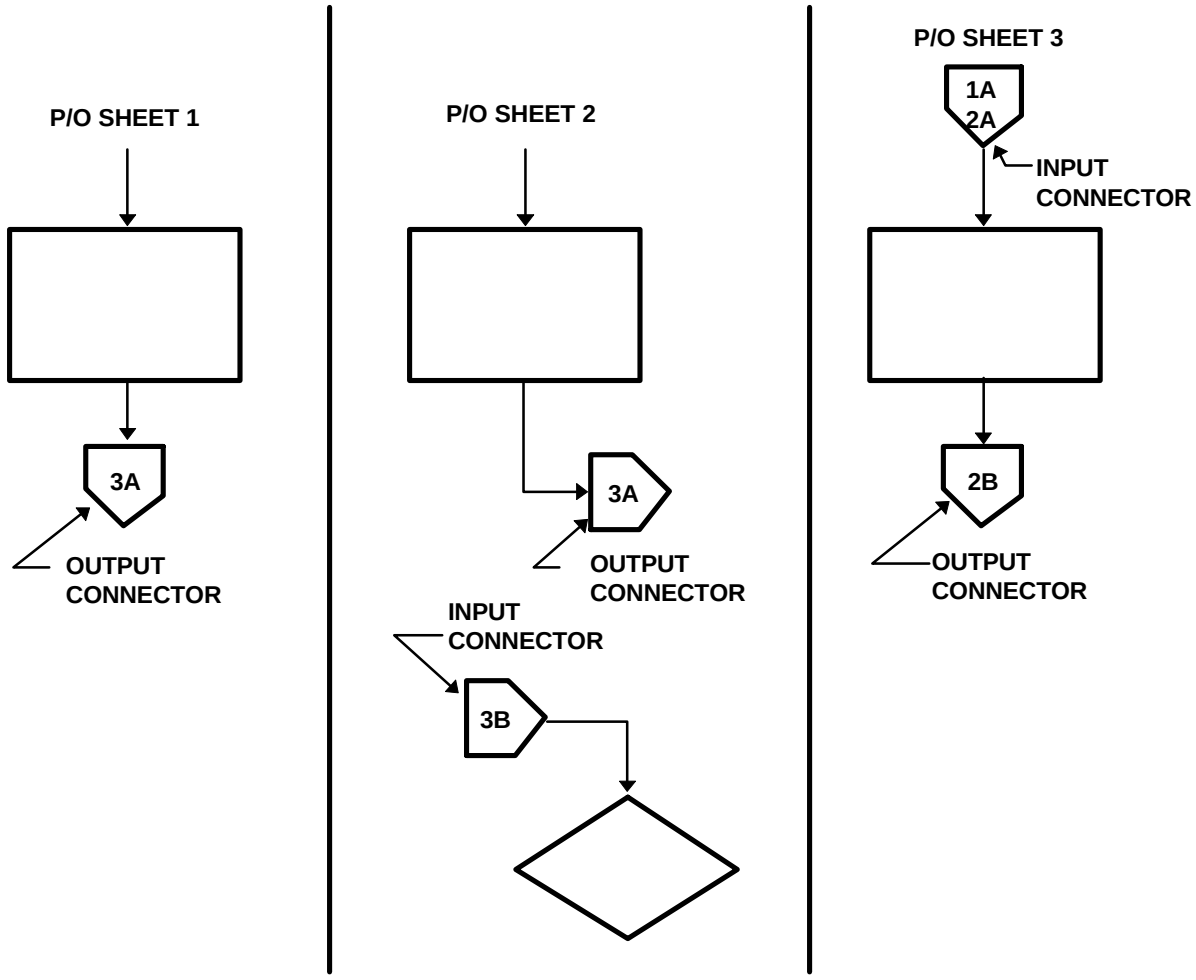


FIGURE 20-24. Off-page connectors.

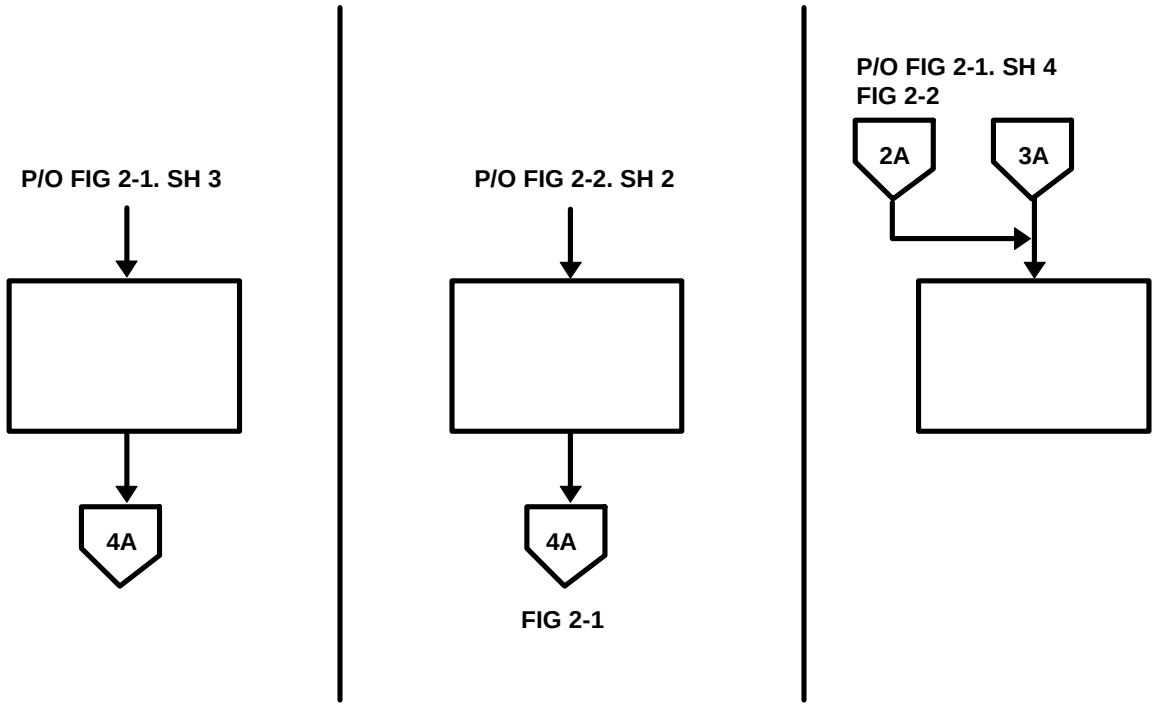


FIGURE 20-25. Use of multiple input off-page connectors.

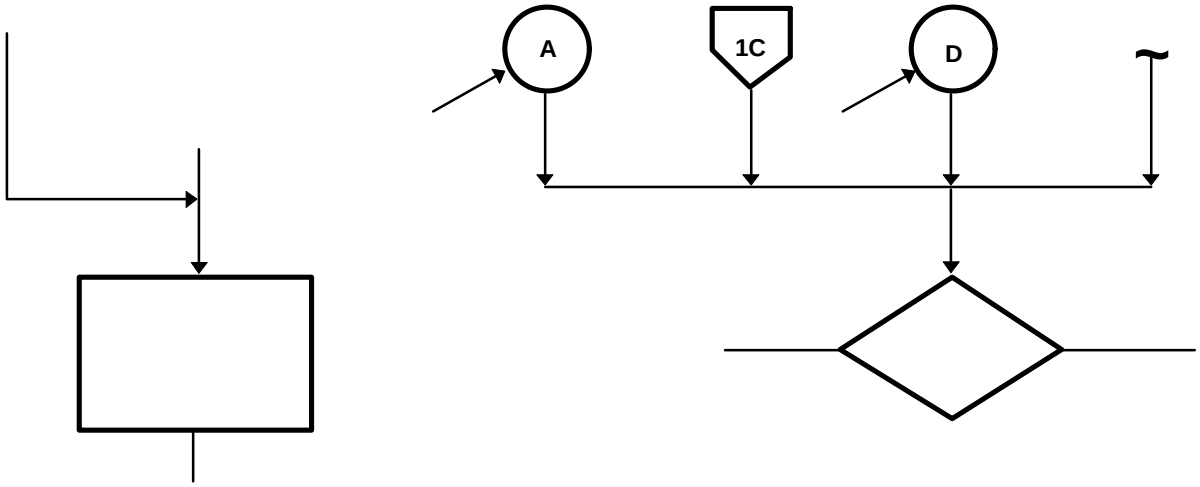


FIGURE 20-26. Line intersections.

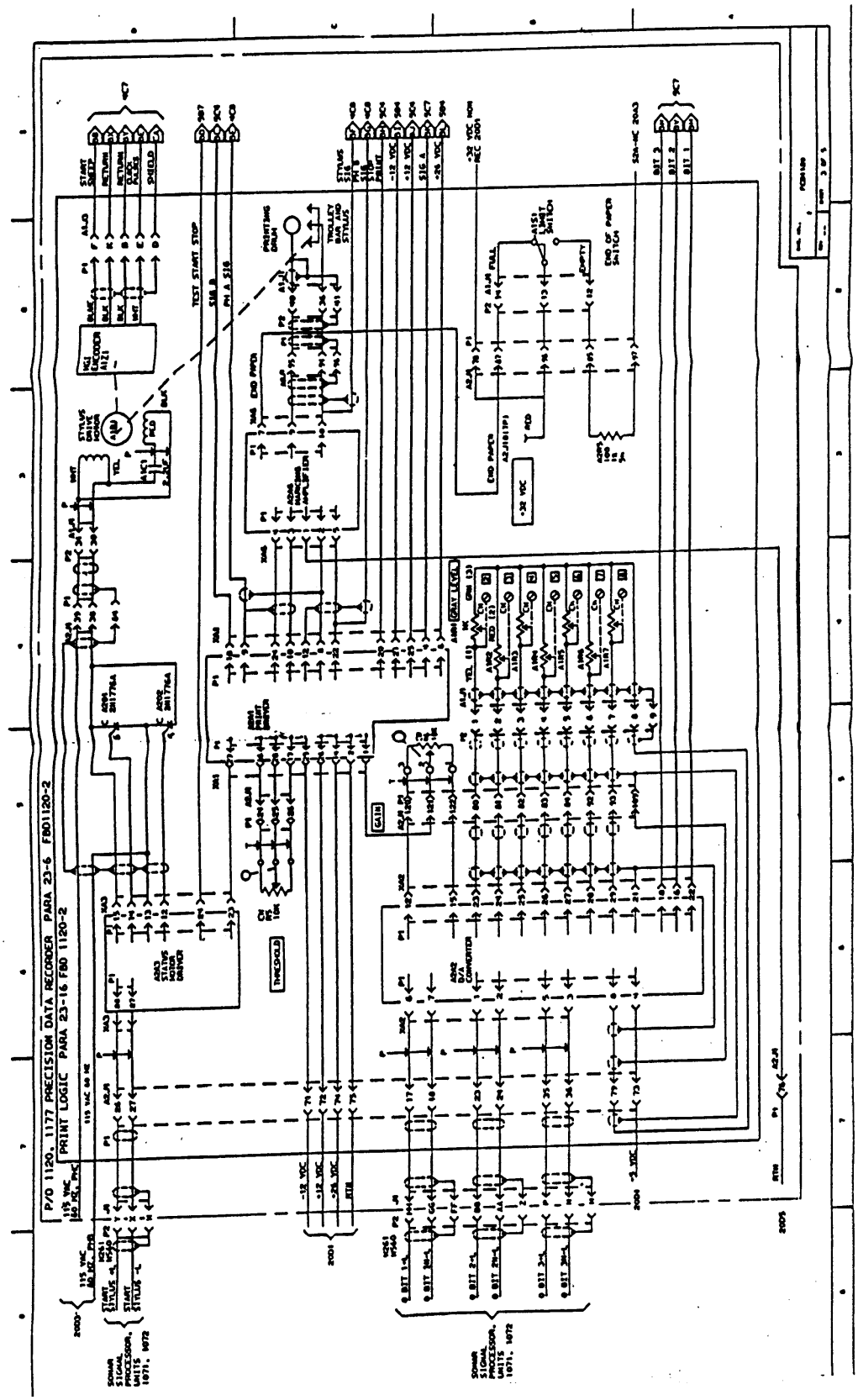


FIGURE 20-27. FCD, analog logic. (Example)

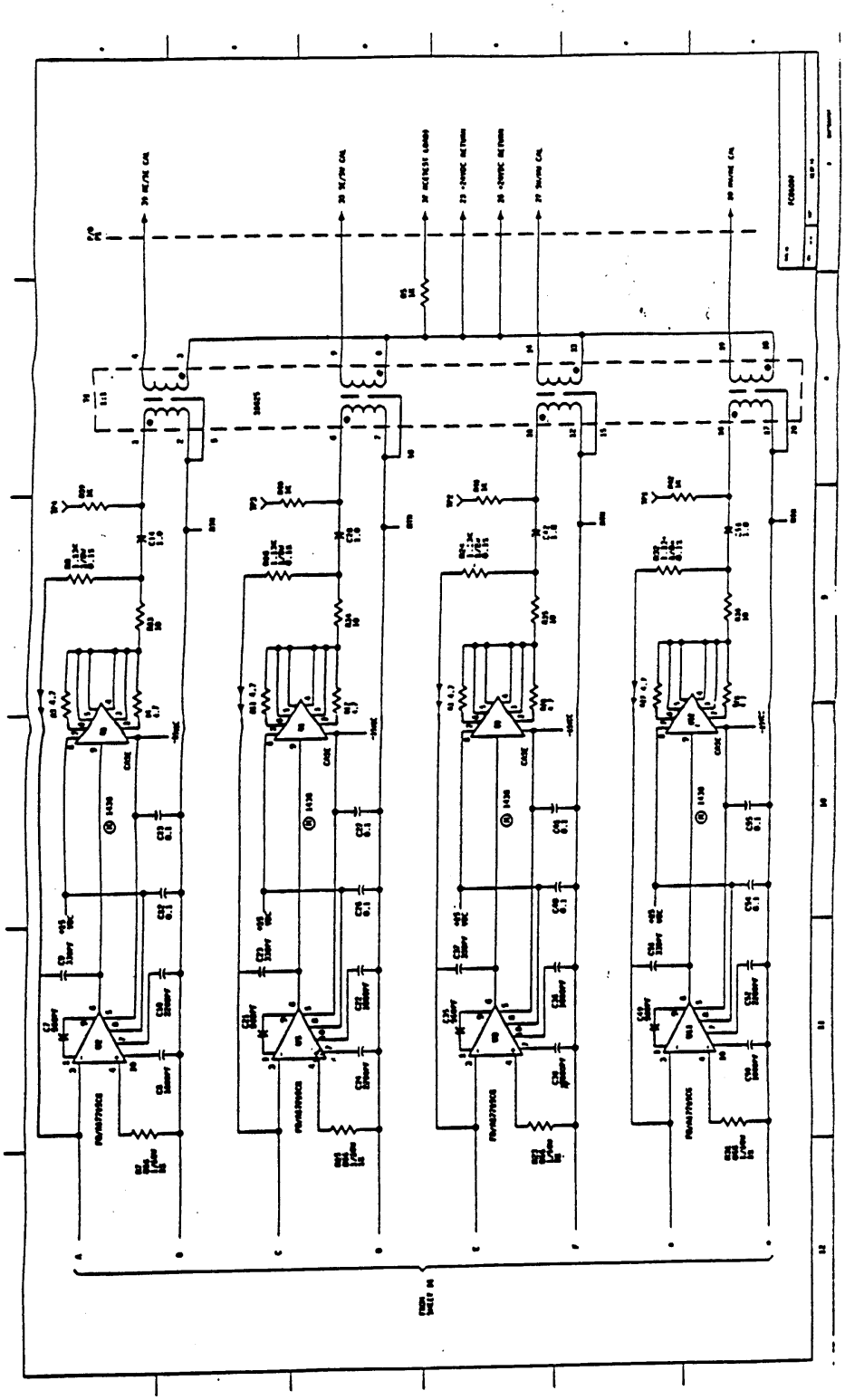


FIGURE 20-28. FCD, detailed. (Example)

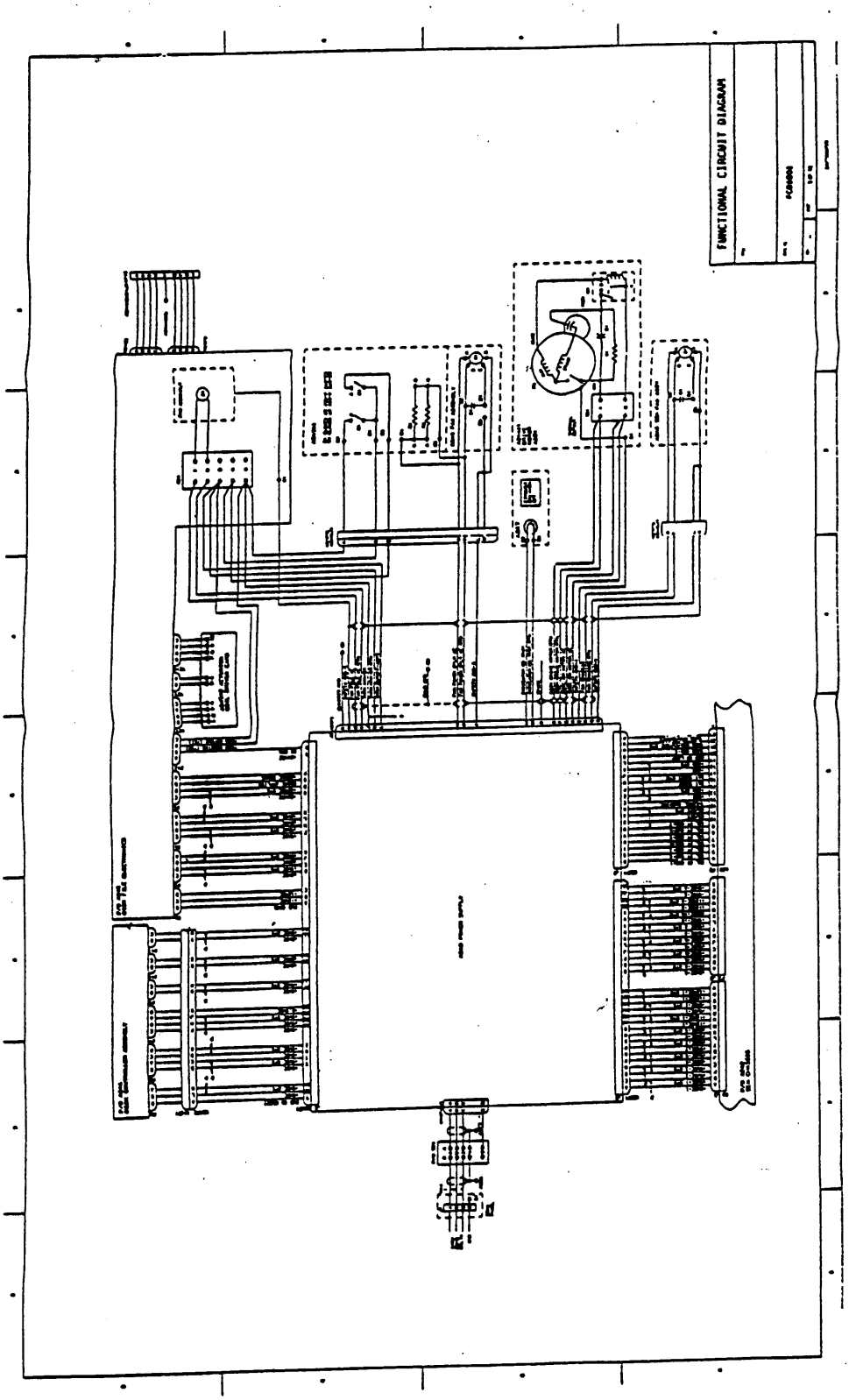


FIGURE 20-29. FCD, unit power and grounding. (Example)

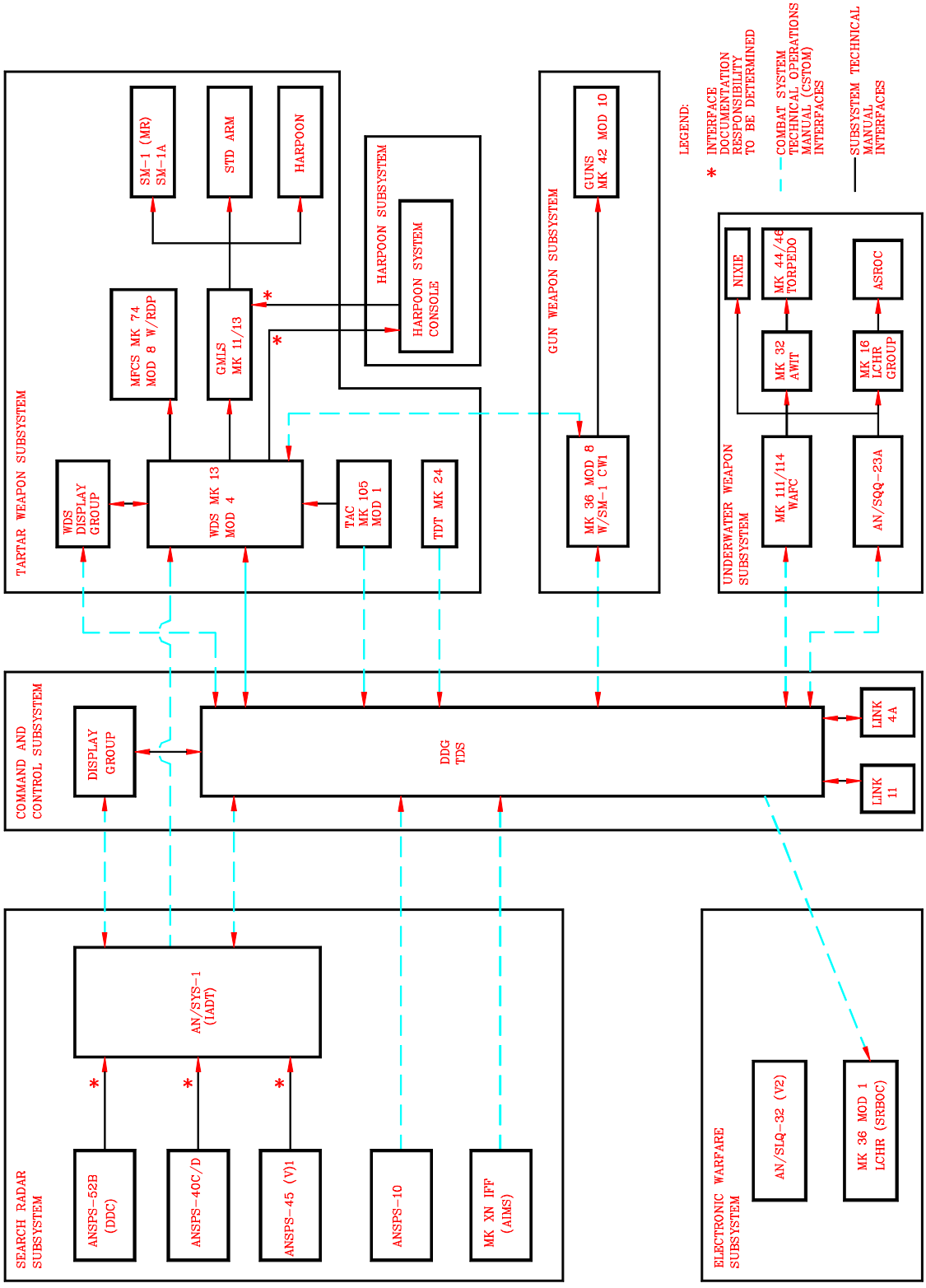


FIGURE 20-30. System block diagram interface documentation.

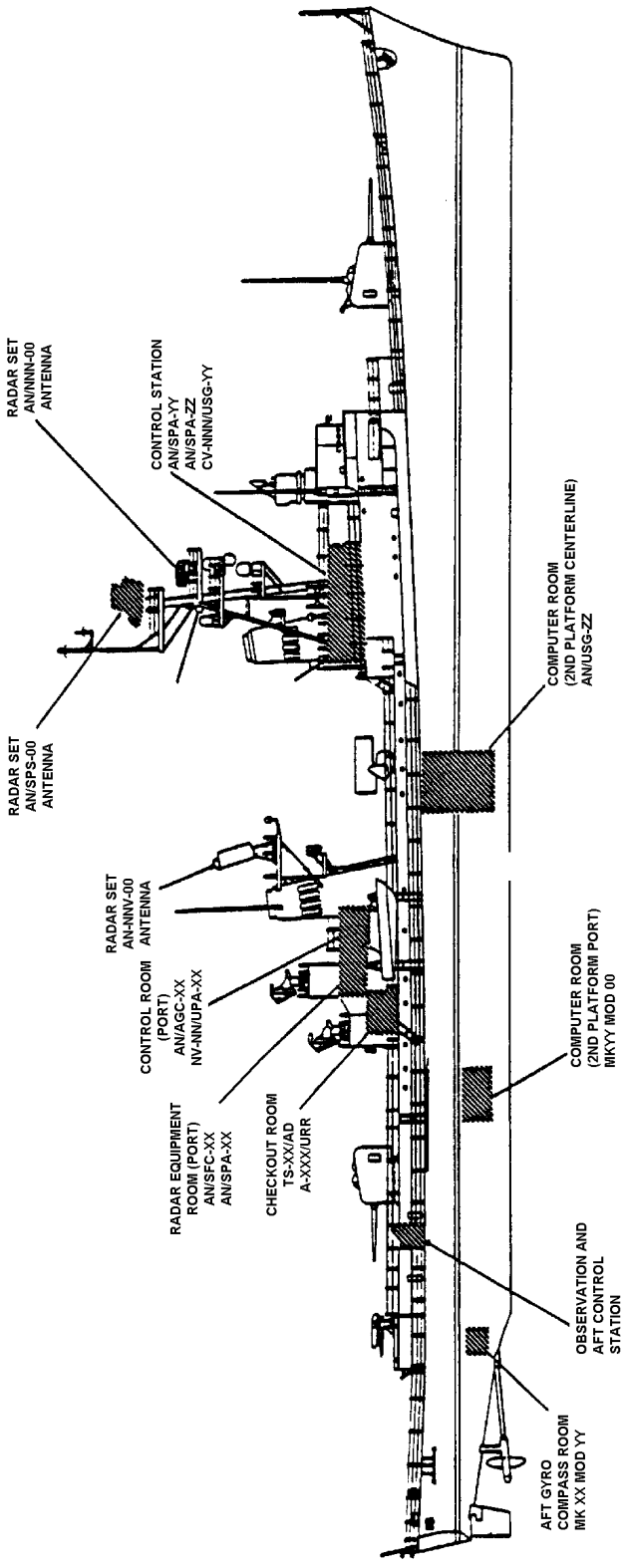


FIGURE 20-31. System compartments.

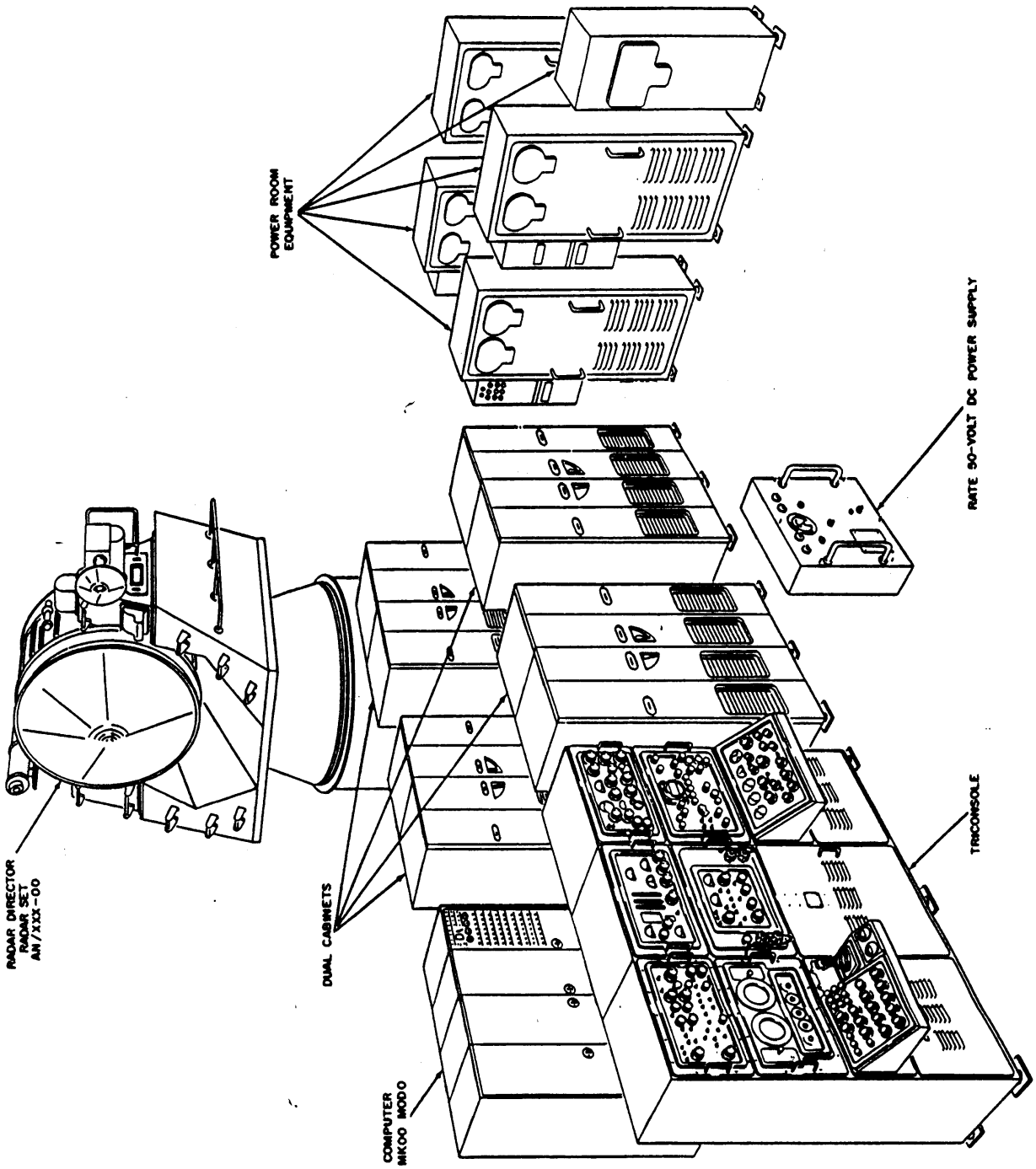


FIGURE 20-32. Compartment areas.

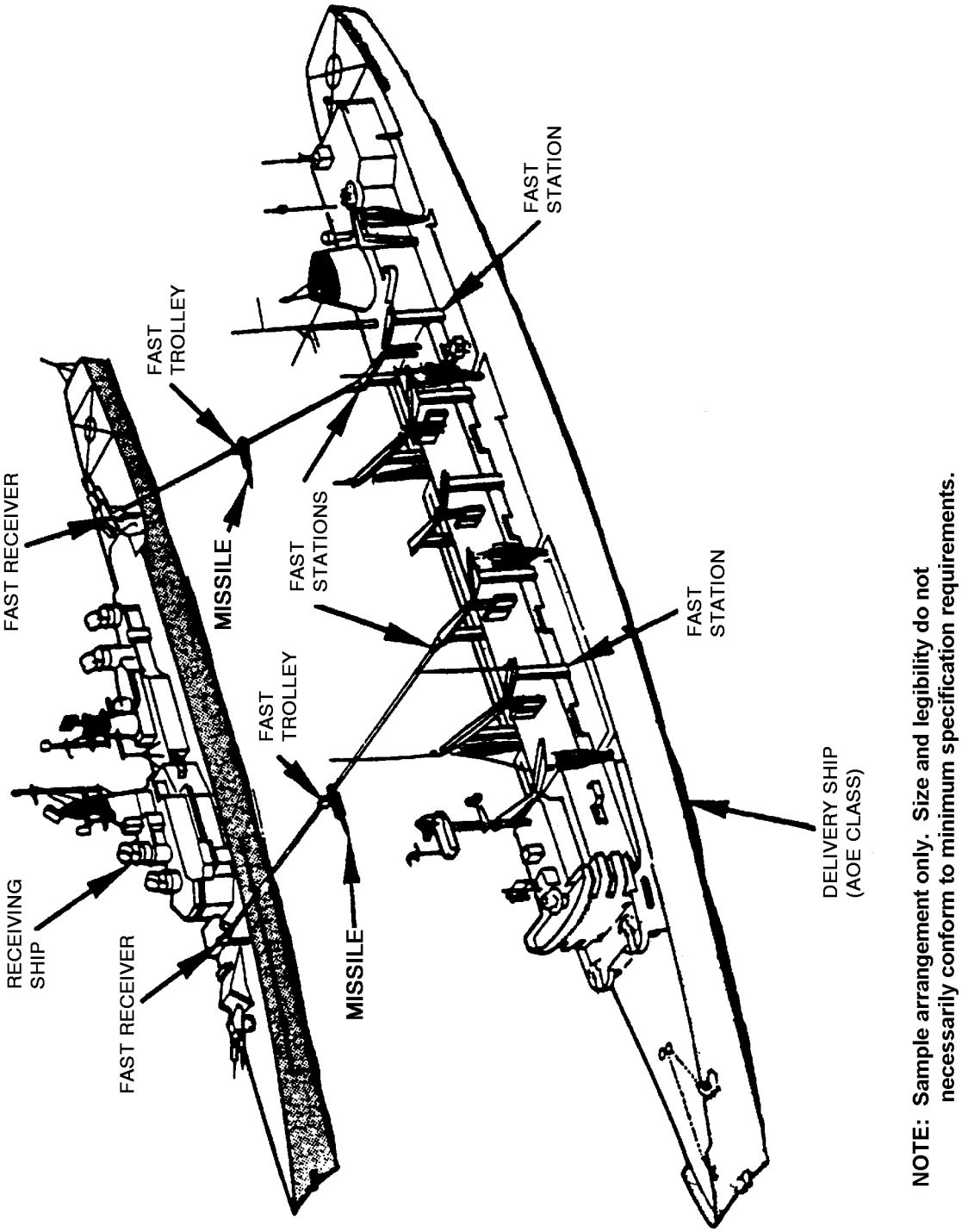


FIGURE 20-33. System illustration showing interface.

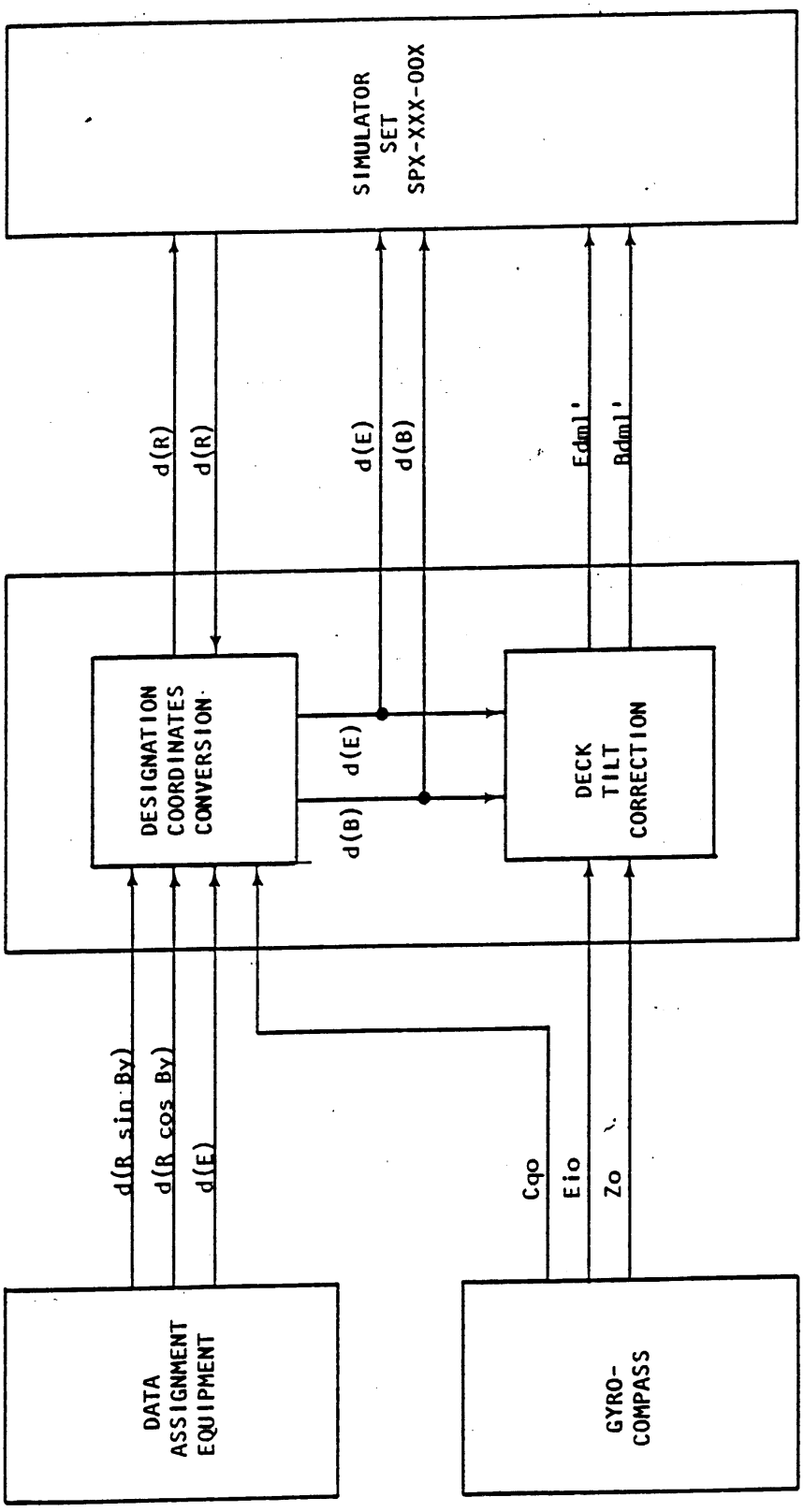


FIGURE 20-34. Functional block diagram (FBD), system.

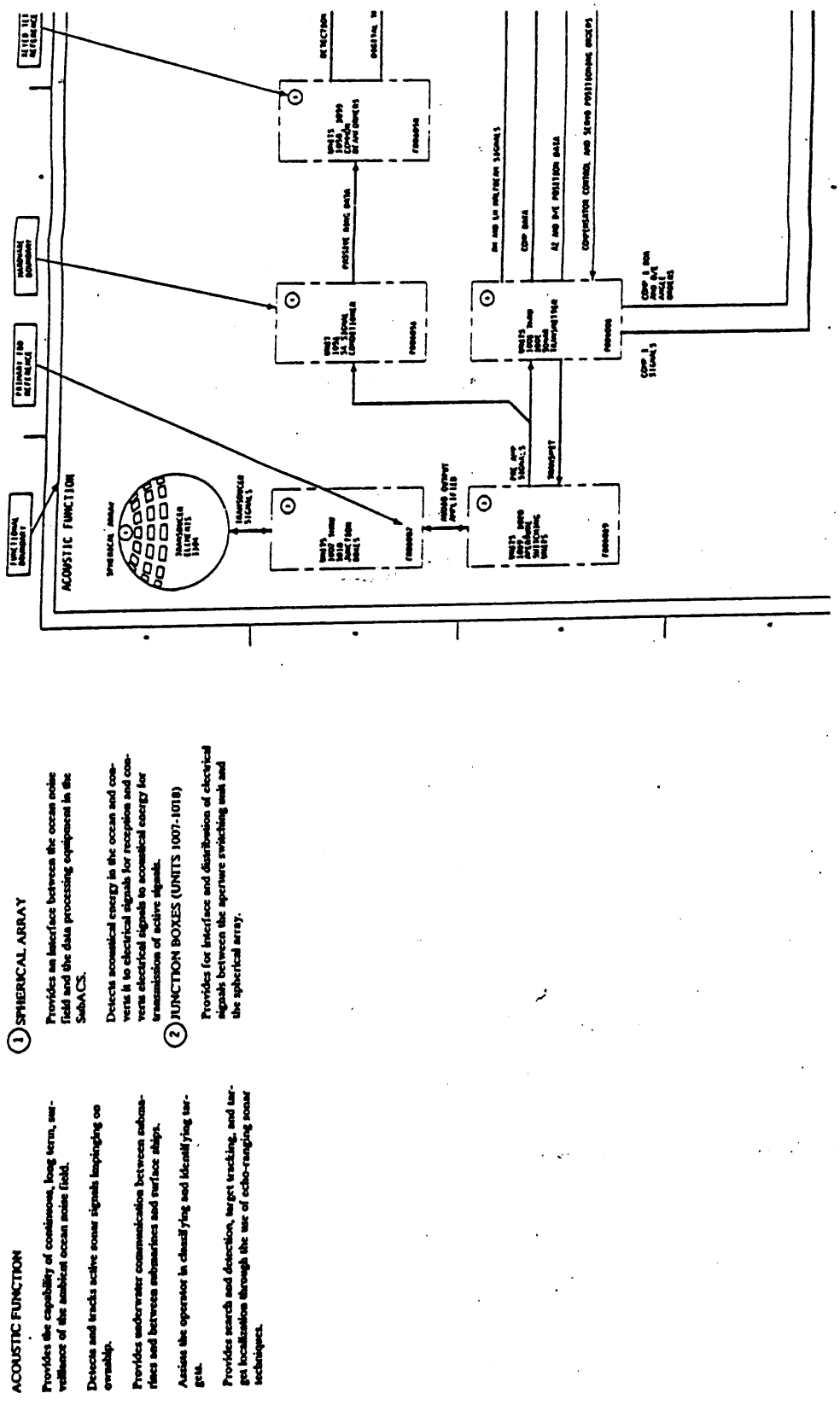
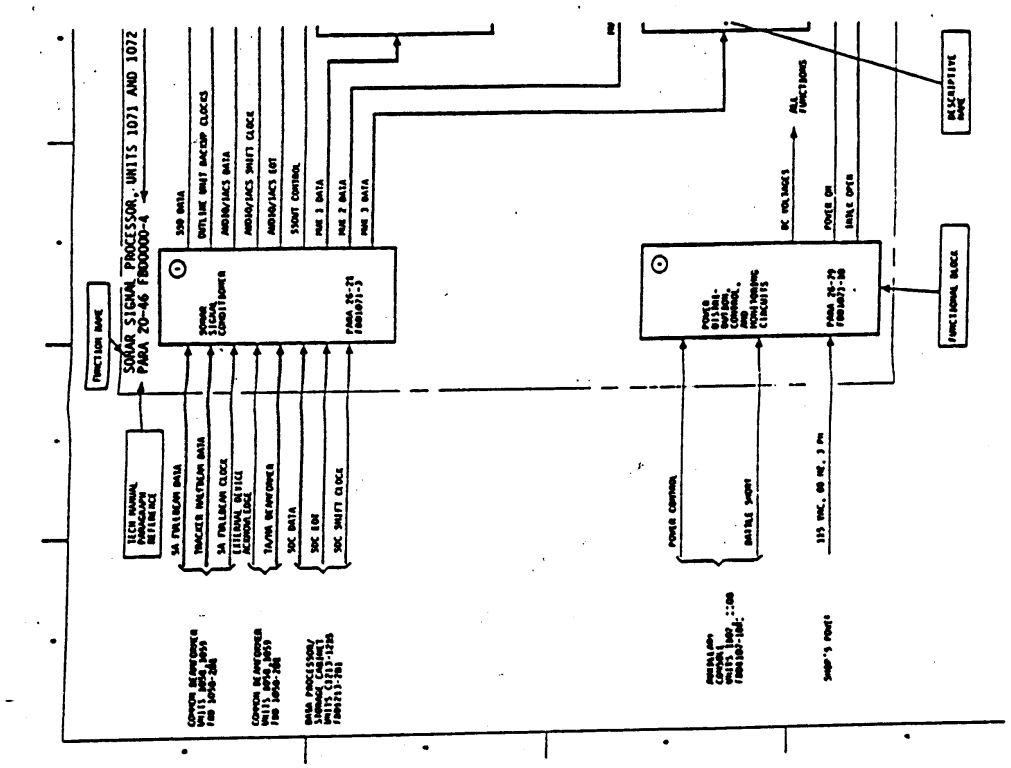


FIGURE 20-35. FBD, master, keyed text. (Example)



SONAR SIGNAL PROCESSOR, UNITS 1071 AND 1072

Provides a spectral analysis of passive sonar signals for the purpose of detecting sonar targets.

Computes the instantaneous position (angular displacement) of a target within a PNB tracker beam.

(1) SONAR SIGNAL CONDITIONER

Receives, selects and buffers spherical array and tracker beam data for transfer to the advanced signal processors.

Receives, selects and buffers towed array and hull array beam data for transfer to the advanced signal processors.

FIGURE 20-36. FBD, primary, keyed text. (Example)

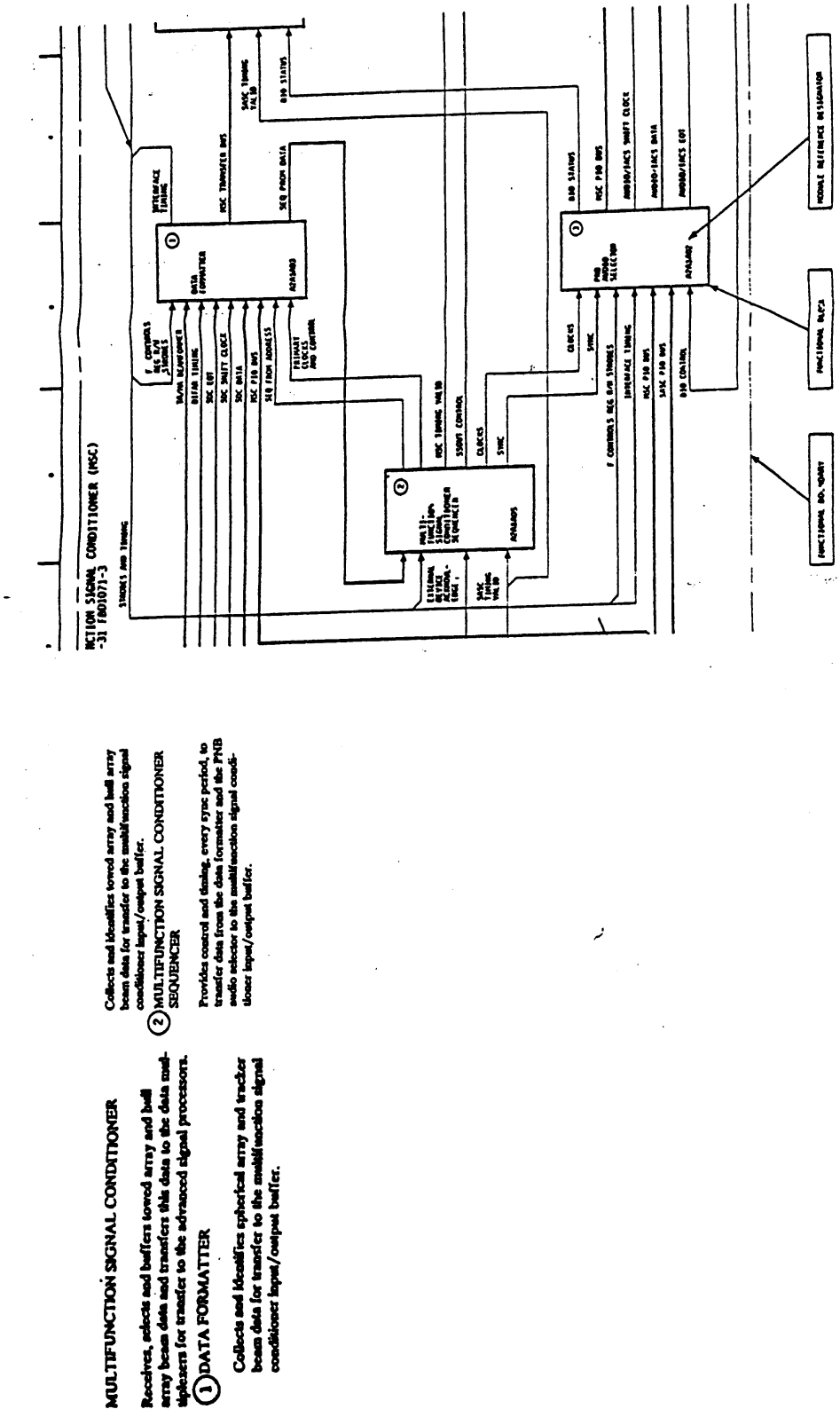


FIGURE 20-37. FBD, lowest - level, keyed text. (Example)

STEP	OBSERVE	REFERENCE
1. Preliminary Procedure.		
a. Position the following switches on rear deck assembly 1A210A1 as indicated. Switch — POSITION POWER — OFF BATTLE SHORT — OFF STOW — BRAKES APPLY		
b. Position POWER switch on console 1A220A20 (see figure 5-2) to OFF.		
c. Check to ensure that all chassis or subassemblies in the four compartments of electronic rack assembly, 1A70 are in the retracted position and all covers are secured.	Covers Secured	
d. Remove all obstructions from the rotational paths of the director main antenna assembly.	Director Clear	
2. Power off		
a. At power control panel perform the following.		
(1) Check convenience lamp indicators.	Lighted	Schematic, figure 5-233
e. At track meter panel, 1A340-02. check COOLANT FAILURES lamp.	Extinguished (Depress RESET button if lamp is lighted)	Relay diagram, figure 5-77, SH #(4B)

FIGURE 20-38. Operational procedure.

STEP	OBSERVE	REFERENCE
1. Preliminary Procedure.		
a. Position the following switches on rear deck assembly 1A210A1 as indicated. Switch — POSITION POWER — OFF BATTLE SHORT — OFF STOW — BRAKES APPLY		
b. Position POWER switch on console 1A220A20 (see figure 5-2) to OFF.		
c. Check to ensure that all chassis or subassemblies in the four compartments of electronic rack assembly, 1A70 are in the retracted position and all covers are secured.	Covers Secured	
d. Remove all obstructions from the rotational paths of the director main antenna assembly.	Director Clear	
2. Power off		
a. At power control panel perform the following.		
(1) Check convenience lamp indicators.	Lighted	Schematic, figure 5-233
e. At track meter panel, 1A340-02. check COOLANT FAILURES lamp.	Extinguished (Depress RESET button if lamp is lighted)	Relay diagram, figure 5-77, SH #(4B)

FIGURE 20-39. Maintenance turn-on procedure.

Table 6-1

LOC	MEMORY CONTENTS	LABEL	ORD	ADR	MOD	CONSTANT	S C L	NOTES
01443	000330700		FRS	030700				
01447	051510457		TMI	01457				
01453	034706277		TRA	06277				
01457	000077632		SET	37632				
01463	034706403		ORG	06403				
			ORG	06103				
06102	001037632	A1	STO	TEMPR	1			SAVE INSERTED NUMBER
06107	035106123		TMI	A3				-/- NEGATIVE INSERT
06113	014077763	A2	GET	ONE				KEY FOR FIX RESET
06117	035035357		STO	KTYPF				TYPE OF RESET KEY
06123	000077760	A3	GET	ZERO				
06127	035037633		STO	TEMPR	2			CLEAR RESET /NRS/ KEY
06122	000077632		GET	TEMPR	1			
06137	004706147		TRA	SUB 1				GO TO RESET NUMBER SUBROUTINE
06143	000706327		TRA	A14				
06137	055437634	SUB1	STV*	TEMPR	3			ENTRANCE - RESET NUMBER SUBRTN
06153	034313700	A4	PRS	1				
06157	035106243		IMI	RE13				CHECK LAST BCD BIT FOR SIGN
06163	034313700	A5	PRS	1				
06167	035106213		TMI	**5				CHECK 2ND BCD BIT FOR SIGN
06173	034333600	A6	FRS	2				CHECK 3RD AND 4TH BITS
06177	002206177		TMI	OUT				
06203	034077633	A7	GET	TEMPR	2			TEMPORARY RESET KEY
06207	002737634		TRA	TEMPR	3			EXIT - RESET NUMBER SUBROUTINE
06213	005077766	A8	EXT	MAXNO				
06217	034333600	FRS	FRS	2				CHECK 3RD AND 4TH BITS
06223	002206277		TMI	OUT				
06227	044041030	A0	GET			020000000		KEY TO RESET 2
06233	005477633	A10	ADD	TEMPR	2			
06237	005737344		TRA	TEMPR	3			EXIT - RESET NUMBER ROUTINE
06243	034313700	RE13	PRS					
06247	035106303		TMI	RE3				CHECK 2ND BIT FOR SIGN
06253	034077766	A11	EXT	MAXNO				
06257	034333600		FRS	2				CHECK 3RD AND 4TH BITS
06263	001106277		TMI	OUT				
06267	034077762	A12	GET	HALF				KEY TO RESET 1

FIGURE 20-40. Coding instruction sheet.

Custodian:
Navy -SH

Review Activity:
Navy - EC

Preparing activity:
Navy - SH
(Project TMSS-N326)

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.
2. The submitter of this form must complete blocks 4,5,6, and 7 and send to preparing activity.
3. The preparing activity must provide a reply within 30 days from receipt of the form.

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I RECOMMEND A CHANGE:	1. DOCUMENT NUMBER MIL-DTL-24784/20 (SH)	2. DOCUMENT DATE *(YYYYMMDD)* 15 February 2002

3. DOCUMENT TITLE HULL,
DIGITAL SYSTEMS MANUAL REQUIREMENTS

4. NATURE OF CHANGE *(Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed)*

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME *(Last, First, Middle Initial)*	b. ORGANIZATION	
c. ADDRESS *(Include Zip Code)*	d. TELEPHONE *(Include Area Code)* (1) Commercial (2) DSN *(if applicable)*	7. DATE SUBMITTED *(YYYYMMDD)*

8. PREPARING ACTIVITY

a. NAME SEA 05Q	b. TELEPHONE *(Include Area Code)* (1) Commercial (202) 781-3726 (2) DSN
c. ADDRESS *(Include Zip Code)* Commander, Naval Sea Systems Command ATTN: SEA 05Q, 1333 Isaac Hull Ave SE Stop 5160, Washington Navy Yard DC 20376-5160	IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT: Defense Standardization Program Office (DLSC-LM) 8725 John J. Kingman Road, Suite 2533, Fort Belvoir, VA 22060-6221 Telephone (703) 767-6888 DSN 427-6888