

decsystem20
POWER SYSTEM
SYSTEM DESCRIPTION

decsystem**20**
POWER SYSTEM
SYSTEM DESCRIPTION

1st Printing Jan.1976
2nd Printing Apr.1976

The drawing and specifications herein are the property of Digital Equipment Corporation and shall not be reproduced or copied or used in whole or in part as the basis for the manufacture or sale of equipment described herein without written permission

The material in this manual is for informational purposes and is subject to change without notice.

Digital Equipment Corporation assumes no responsibility for any errors which may appear in this manual.

Printed in U.S.A.

Copyright ©1976 by Digital Equipment Corporation

The following are trademarks of Digital Equipment Corporation, Maynard, Massachusetts:

DEC	DECtape	PDP
DECCOMM	DECUS	RSTS
DECsystem-10	DIGITAL	TYPESET-8
DECSYSTEM-20	MASSBUS	TYPESET-11
		UNIBUS

CONTENTS

	Page
CHAPTER 1 SYSTEM LEVEL DESCRIPTION	
1.1 PHYSICAL DESCRIPTION	PWR20/1-1
1.2 MAJOR COMPONENT FUNCTIONS AND LOCATIONS	PWR20/1-1
1.3 ELECTRICAL CHARACTERISTIC SUMMARY	PWR20/1-4
1.4 ELECTRICAL REQUIREMENTS	PWR20/1-4
1.5 ENGINEERING DRAWINGS	PWR20/1-13
 CHAPTER 2 INTERFACE LEVEL DESCRIPTION	
2.1 BLOCK DIAGRAM ANALYSIS	PWR20/2-1
2.2 BASIC OPERATION	PWR20/2-5
2.3 SWITCH PANEL	PWR20/2-6
2.3.1 System Connections	PWR20/2-8
2.3.2 Operation	PWR20/2-10
2.4 POWER-FAILURE PROTECTION	PWR20/2-10
2.5 AUTOMATIC RESTART	PWR20/2-12
 CHAPTER 3 UNIT LEVEL DESCRIPTION	
3.1 INTRODUCTION	PWR20/3-1
3.2 863 POWER CONTROL	PWR20/3-3
3.2.1 Block Diagram Analysis	PWR20/3-3
3.2.2 Detailed Circuit Description	PWR20/3-6
3.2.3 W7000 Auxiliary Power Supply	PWR20/3-21
3.2.4 W516 AC Low Voltage Detector	PWR20/3-24
3.2.5 G8017 Indicator Driver	PWR20/3-25
3.3 861-D POWER CONTROL	PWR20/3-28
3.3.1 Block Diagram Analysis	PWR20/3-28
3.3.2 Detailed Circuit Description	PWR20/3-30
3.3.3 Pilot Control Board Circuit Description	PWR20/3-33
3.4 H7420 POWER SUPPLY	PWR20/3-35
3.4.1 Detailed Circuit Description	PWR20/3-35
3.4.1.1 H7420 Step-Down Transformer	PWR20/3-35
3.4.1.2 H7420 +15 Volt Output	PWR20/3-37
3.4.1.3 H7420 Clock Output	PWR20/3-41
3.4.1.4 H7420 AC LO and DC LO Sensing Circuits	PWR20/3-41
3.5 H744 +5 VOLT REGULATOR	PWR20/3-46
3.5.1 Detailed Circuit Description	PWR20/3-46
3.5.1.1 H744 +5 V Regulator Circuit	PWR20/3-46
3.5.1.2 H744 Overcurrent Sensing Circuit	PWR20/3-51
3.5.1.3 H744 Overvoltage Crobar Circuit	PWR20/3-52
3.6 H745 -15 VOLT REGULATOR	PWR20/3-53
3.6.1 H745 Detailed Circuit Description	PWR20/3-53
3.6.1.1 H745 -15 Volt Regulator Circuit	PWR20/3-53
3.6.1.2 H745 Overcurrent Sensing Circuit	PWR20/3-58
3.6.1.3 H745 Overvoltage Protection	PWR20/3-58
3.7 H754 +20, -5 VOLT REGULATOR	PWR20/3-60
3.7.1 Detailed Circuit Description	PWR20/3-60
3.7.1.1 H754 +20, -5 V Regulator Circuit	PWR20/3-60

CONTENTS (Cont)

	Page
3.7.1.2	H754 Overcurrent Sensing Circuit PWR20/3-64
3.7.1.3	H754 Overvoltage Crobar Circuits PWR20/3-65
3.7.1.4	H754 Voltage Adjustments PWR20/3-66
3.8	H770 +15 VOLT REGULATOR PWR20/3-67
3.8.1	Detailed Circuit Description PWR20/3-67
3.8.1.1	H770 +15 V Regulator Circuit PWR20/3-67
3.8.1.2	H770 Overcurrent Sensing PWR20/3-72
3.8.1.3	H770 Overvoltage Crobar Circuit PWR10/3-73
3.9	H760 POWER SUPPLY PWR20/3-74
3.9.1	Detailed Circuit Description PWR20/3-74
3.10	CAPACITOR ASSEMBLY PWR20/3-78
3.10.1	Detailed Circuit Schematic PWR20/3-78
3.11	H761 SERIES PASS ASSEMBLY PWR20/3-80
3.11.1	Detailed Circuit Description PWR20/3-80
3.11.1.1	+10 V Reference (G8013) PWR20/3-82
3.11.1.2	-5.2 Vdc Controls (G8010) PWR20/3-85
3.11.1.3	-2.0 Vdc Controls (G8011) PWR20/3-87
3.11.1.4	-5.2 V Heat Sink Assembly PWR20/3-90
3.11.1.5	-2.0 V Heat Sink Assembly PWR20/3-92
3.11.1.6	DC Low Voltage Detector (G8014) PWR20/3-95
3.12	AIR FLOW SENSORS PWR20/3-97

ILLUSTRATIONS

Figure No.	Title	Page
1-1	Basic 2040 Configuration	PWR20/1-2
1-2	Front View – Power Supply and Cooling Assembly Locations	PWR20/1-5
1-3	Rear View – Power Supply and Cooling Assembly Locations	PWR20/1-6
1-4	CPU and I/O Cabinet Rear Door (Open)	PWR20/1-7
1-5	KL10-C Power Distribution System Block Diagram (System Level)	PWR20/1-8
2-1	KL10-C Power Distribution System Block Diagram (Interface Level)	PWR20/2-2
2-2	Front View of Switch Panel	PWR20/2-7
2-3	Switch Panel, External Connections	PWR20/2-9
3-1	KL10-C Power Distribution System Block Diagram (Unit Level)	PWR20/3-2
3-2	863 Power Control, Block Diagram	PWR20/3-4
3-3	863 Power Control Simplified Functional Schematic	PWR20/3-7
3-4	863 Power Control, Power Down Sequencing	PWR20/3-18
3-5	NE555 Timer, Simplified Block Diagram	PWR20/3-26
3-6	861-D Power Control, Block Diagram	PWR20/3-29
3-7	861-D Simplified Functional Schematic	PWR20/3-31
3-8	H7420 Power Supply, Simplified Schematic	PWR20/3-36
3-9	H7420 AC LO and DC LO Sensing Circuits, Simplified Diagram	PWR20/3-42
3-10	H7420 Power-Up and Power-Down Sequencing	PWR20/3-45
3-11	H744 Precision Voltage Regulator E1, Simplified Diagram	PWR20/3-47
3-12	H744 Regulator Waveforms	PWR20/3-50
3-13	H745 Precision Voltage Regulator E1, Simplified Diagram	PWR20/3-54

ILLUSTRATIONS (Cont)

Figure No.	Title	Page
3-14	H745 Regulator Waveforms	PWR20/3-57
3-15	H754 Precision Voltage Regulator E1, Simplified Diagram	PWR20/3-61
3-16	H770 Precision Voltage Regulator E1, Simplified Diagram	PWR20/3-68
3-17	H770 Regulator Waveforms	PWR20/3-71
3-18	H760A Power Supply, Simplified Schematic	PWR20/3-76
3-19	Distribution of Power to Fans in H760A and H760B	PWR20/3-77
3-20	Capacitor Discharge Curve	PWR20/3-79
3-21	H761 Regulated Series Pass Assembly, Simplified Diagram	PWR20/3-81
3-22	+10 V Reference, Simplified Schematic of \pm REF C Circuit	PWR20/3-84
3-23	Typical G8010 -5.2 Vdc Control Circuit, Simplified Schematic	PWR20/3-86
3-24	Typical G8011 -2.0 Vdc Control Circuit, Simplified Schematic	PWR20/3-88
3-25	Typical -5.2 V Heat Sink, Simplified Schematic	PWR20/3-91
3-26	Typical -2.0 Vdc Heat Sink, Simplified Schematic	PWR20/3-93
3-27	Air Flow Sensor Characteristics	PWR20/3-98

TABLES

Table No.	Title	Page
1-1	Power Supplies, Regulators and Controls	PWR20/1-3
1-2	KL10-C System Power Requirements	PWR20/1-9
1-3	Electrical Characteristics Summary	PWR20/1-10
1-4	Reference Drawings	PWR20/1-14

FOREWORD

This manual is a modularly-structured technical system description (operation theory) of the 2040 Power System. It is to be used with the DECsystem-20 KL-based documentation, as it serves as an integral part of a total documentation package.

A multi-level form of document structure is implemented in this manual; it exhibits an open-ended nature at each level that is suitable for future modular expansion. The structure comprises three presentation levels which provide a totally integrated Power System description:

System Level

Interface Level

Unit Level

Each level of presentation contains descriptions which differ in context and level of detail.

Section 1 describes the 2040 Power System on a system level. It describes a typical 2040 KL-based Processor and shows the physical location of each power supply, power controller and regulator. Also provided is a basic block diagram which shows the power system interconnections. The discussion includes what the power system consists of and what each component does. Electrical characteristics are tabulated and a list of all pertinent unit schematics is provided.

Section 2 discusses the power system on an interface level, based on a more detailed version of the block diagram provided in Section 1; major signals and voltages are introduced. The discussion at this level follows sequential (e.g., power/up down) operations through the block diagram. The level of text does not go beyond the level of the block diagram.

Section 3 describes the unit level theory. Here, the previously used system block diagram is further detailed to show all the signals and voltages produced. From this, detailed theory of each Power System component is provided; simplified block and schematic diagrams complement the text. All diagrams are compatible with those in the system and interface level descriptions.

Included in a series of KL-based documentation, this manual relates only to the 2040 Power System. For further information on the 2040 system, refer to the Introduction to KL-Based System Technical Description manual (EK-KL10-TD-002).

CHAPTER 1

SYSTEM LEVEL DESCRIPTION

This chapter briefly describes the KL-based 2040 Power System. A basic physical description is presented, where all major power components are defined and related through the use of block diagrams and tabular specifications.

1.1 PHYSICAL DESCRIPTION

The KL10-C Processor is used in all DECsystem-20 KL-based 2040 configurations. A typical system configuration (including the KL10-C Processor) is shown in Figure 1-1. The processor comprises three adjoining cabinets with self-contained power supplies. As viewed from the front, the left cabinet contains the PDP-11/40 Console Processor (front end) and peripherals, power controls and associated Floppy disk system; the center cabinet contains the input/output logic; and the right cabinet contains the Central Processing Unit.

The "stand-alone" DECwriter terminal has its own ac power cable, which connects to the 861 Power Control in the Console Processor cabinet. In general, KL10-C peripherals have independent power cables and connections. They are interconnected with the basic power control system via a common DEC Power Control Bus.

1.2 MAJOR COMPONENT FUNCTIONS AND LOCATIONS

Table 1-1 lists the power supplies, regulators and controls in the KL10-C Power System; the physical locations are shown in

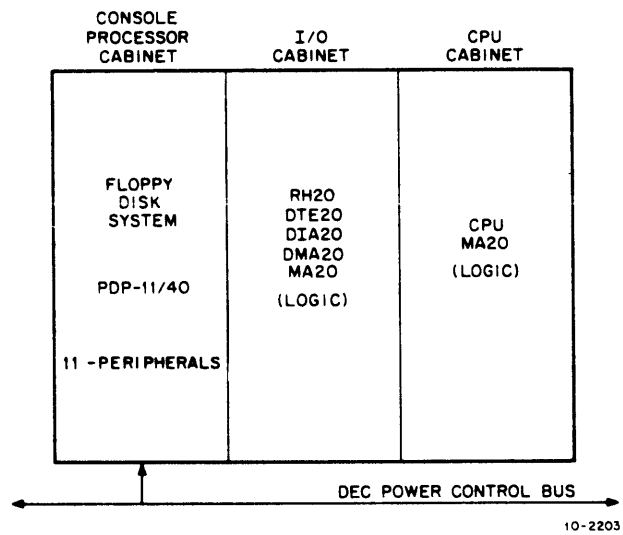


Figure 1-1 Basic 2040 Configuration

Table 1-1
Power Supplies, Regulators and Controls

Quantity	Assembly	Function
1	863D/E Power Control	Main Power Control for system
1	861D/E Power Control	Power control for console processor equipment
5 (7)*	H7420 Power Supply	Main power supplies for CPU, RH20, DTE20, DIA/DMA20, and MA20
1	H760 Power Supply	Power supply used with capacitor assembly (7009878) to provide -11 and ± 15 Vdc to the H761 Series Pass Assembly
1	H761 Series Pass Assembly	Regulated -5.2 and -2.0 Vdc to the CPU
15 (19)*	H744 Regulator	Regulated +5 Vdc to CPU, DTE20, DIA20, DMA20, and the MA20
1	H745 Regulator	Regulated -15 Vdc to DIA20 and DMA20
6 (12)*	H754 Regulator	+20, -5 Vdc to the MA20
1	H770 Regulator	+15 Vdc to air flow sensors
1	Switch Panel	Contains power on/off controls (normal and emergency) and bootstrap loading controls.

*If second MA20 is used, number in parentheses indicates new total number of that component used.

Figures 1-2 through 1-4. Some of the components are mounted on the inside-rear cabinet doors (Figure 1-4). The power supplies in the PDP-11/40 front end and associated Floppy disk system are not considered part of the 2040 Power System.

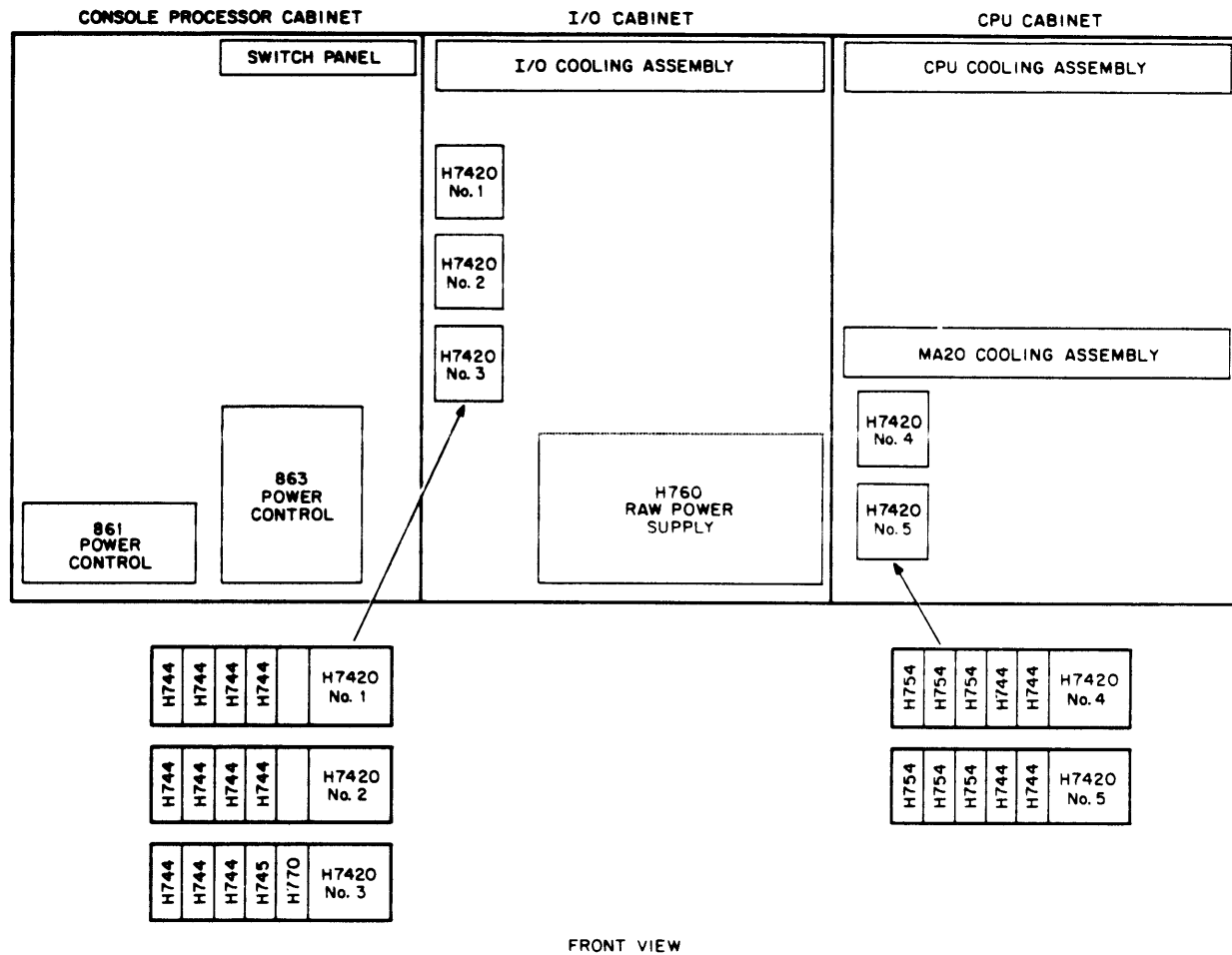
1.3 ELECTRICAL CHARACTERISTIC SUMMARY

Figure 1-5 is a block diagram showing the basic interconnections among the various 2040 Power System components. Input power requirements are listed in Table 1-2. Detailed electrical characteristics of each assembly are summarized in Table 1-3.

1.4 ELECTRICAL REQUIREMENTS

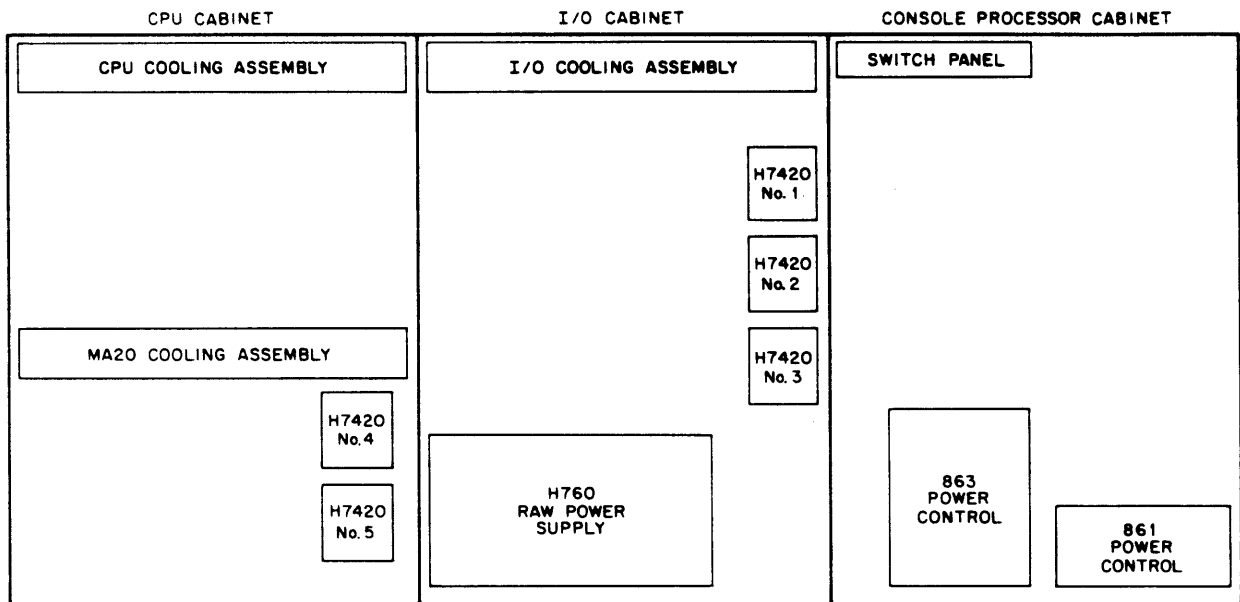
The KL10-C Processor operates with 120 or 240 Vac, 60/50 Hz, 3-phase, 5-wire power. Line voltage must be within +6, -12 percent of the nominal value and the line frequency should not vary more than 2 Hz. A basic KL10-C Processor requires approximately 21.6 KVA of input power (60 A @ 120 Vac, 30 A @ 240 Vac).

Primary power to the KL10-C Processor should be provided on a line separate from lighting, air conditioning, etc., so that computer operation is not affected by voltage surges or fluctuations. Primary power outlets at the computer site must be compatible with the KL10-C primary input connector. Refer to the DECsystem-10 Site Preparation Guide (EK-DEC10-SP-003) for additional information.



10 2204

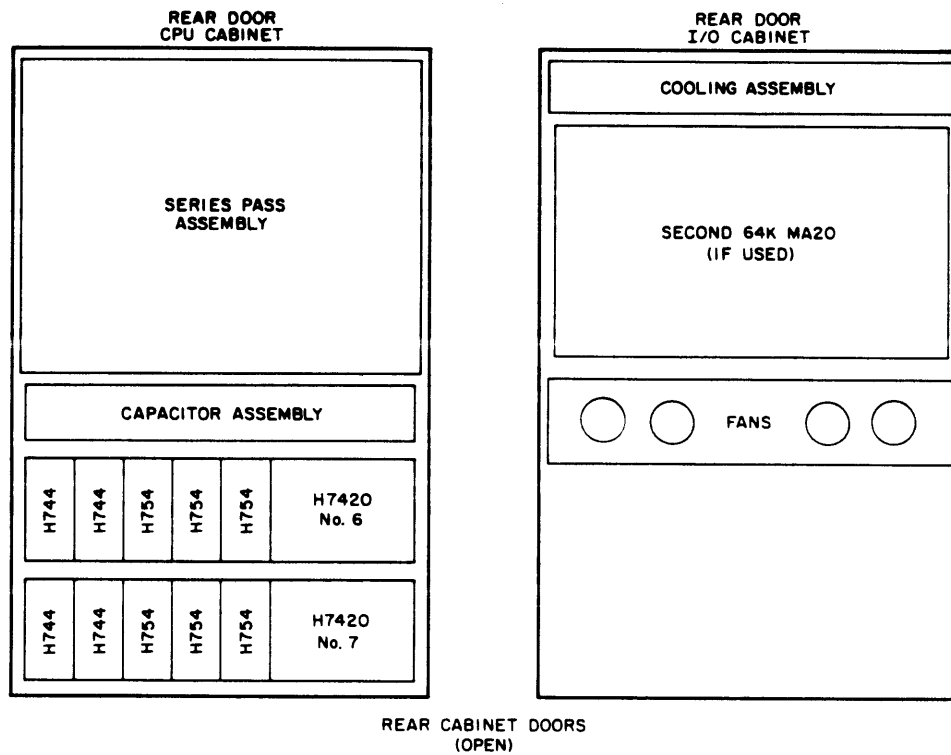
Figure 1-2 Front View - Power Supply and Cooling
Assembly Locations



REAR VIEW

10-2205

Figure 1-3 Rear View - Power Supply and Cooling
Assembly Locations



10-2206

Figure 1-4 CPU and I/O Cabinet Rear Doors (Open)

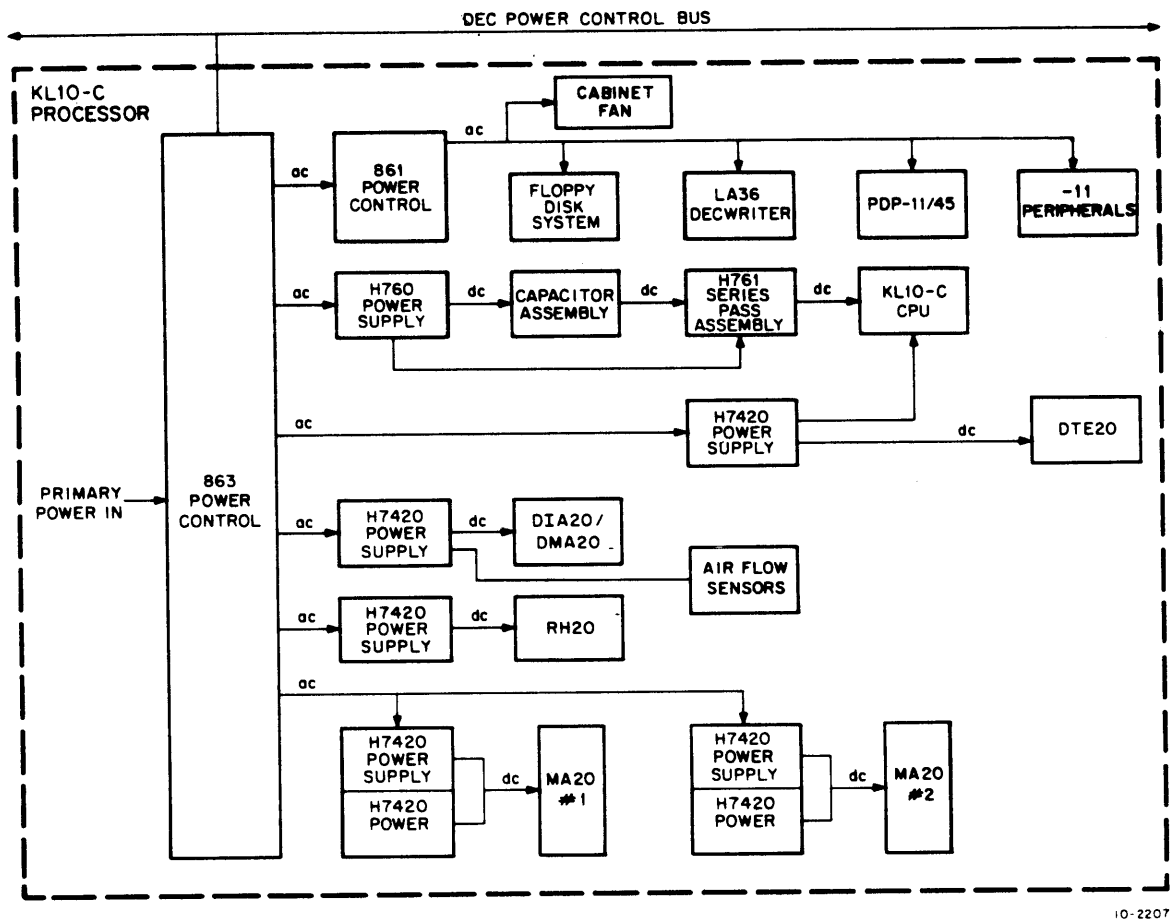


Figure 1-5 KL10-C Power Distribution System Block Diagram
(System Level)

Table 1-2
KL10-C System Power Requirements

Parameter	Value
Voltage:	KL10-CA 110/208 Vac KL10-CB 240/416 Vac
Input Connections:	3-phase, 5-wire
Current:	60A/phase (maximum – 60 Hz operation) 30A/phase (maximum – 50 Hz operation)
Input Frequency:	KL10-CA – 60 Hz \pm 1 Hz KL10-CB – 50 Hz \pm 1 Hz
Input Power:	21.6 KW
Cooling:	Forced Air

Table 1-3
Electrical Characteristics Summary

Qty	Assembly	DEC Type No.	Electrical Characteristics
1	863* Power Control	863	Input Requirements (Max) Voltage 90–132/180–264 Vac Phase 3-phase, 5-wire Frequency 47–63 Hz Current 75A/phase (CB)
	Includes:		
1	Power Distribution Panel		
1	Pilot Control Board		
1	Auxiliary Power Supply Board	W7000	
1	AC Low Voltage Detector Board	W516	
1	Power Control Logic Board	G8015	Output Power Outlets** Ten (8 Switched, 2 unswitched)
1	Indicator Driver Board	G8017	Control Element (Relay or Circuit Breaker) Switched { K1 30A CB3 15A CB4 15A CB5 15A CB6 15A CB7 15A CB8 15A CB9 15A Unswitched { CB2 30A CB10 15A
1	861 Power Control	861-D 861-E	Input Requirements (Max) Voltage 861-D: 90–135 Vac 861-E: 180–270 Vac Phase 861-D: Three 861-E: Three
	Includes:		
1	Pilot Control Board	5411522	Frequency 47–63 Hz Current 861-D: 24A/pole 861-E: 16A/pole Circuit Breaker 861-D: 30A/20A 861-E: 20A (CB1)

*Two models: 863D (120 Vac, 60 Hz) and 863E (240 Vac, 50 Hz)

**Same outlets have duplex connectors

Table 1-3 (Cont)
Electrical Characteristics Summary

Qty	Assembly	DEC Type No.	Electrical Characteristics
7	H7420 Power Supply	H7420-A H7420-B	Power Requirements
			Full Load 861-D: 2870 VA 861-E: 3830 VA
			No Load 861-D: 10VA 861-E: 10VA
			Output Power
			Outlets Six duplex (4 switched, 2 unswitched)
			Outlet Current 861-D: 12A/outlet, 16A/branch, 24A total Power Control
			861-E: 12A/outlet, 16A total Power Control
1	Includes: Power Control Board	5411086	Input Requirements (Max)
			Voltage H7420A: 120 Vac H7420B: 240 Vac
			Phase H7420A: Single H7420B: Single
			Frequency 47-63 Hz
			Current
			Circuit Breaker A A
			Power Requirements
			Full Load VA
			No Load VA
			Output Voltage
			DC +8 V @ 1A +15 V ± 1.5 V @ 3A
			AC Seven separate regulator outputs, 20-30 Vac (25 Vac ± 20%) @ A
			each; single 115 Vac convenience outlet
			Clock 0-5 V square wave at 47-63 Hz

Table 1-3 (Cont)
Electrical Characteristics Summary

Qty	Assembly	DEC Type No.	Electrical Characteristics
19	H744 Regulator	H744	<p>Input Requirements (Max)</p> <p>Voltage 20–30 Vac</p> <p>Phase Single</p> <p>Frequency 47–63 Hz</p> <p>Current 12A</p> <p>Fuse (F1) 15A</p> <p>Output Power</p> <p>Voltage 5 Vdc \pm 60 mV</p> <p>Current 25A</p> <p>Ripple 150 mV p-p (max)</p>
1	H745 Regulator	H745	<p>Input Requirements (Max)</p> <p>Voltage +15 Vdc \pm % 20–30 Vac</p> <p>Phase Single</p> <p>Frequency 47–63 Hz</p> <p>Current +15 Vdc @ A 20–30 Vac @ A</p> <p>Fuse (F1) 15A</p> <p>Output Power</p> <p>Voltage -15 Vdc \pm 50 mV</p> <p>Current 10A</p> <p>Ripple 450 mV p-p (max)</p>
12	H754 Regulator	H754	<p>Input Requirements (Max)</p> <p>Voltage 20–30 Vac</p> <p>Phase Single</p> <p>Frequency 47–63 Hz</p> <p>Current 8A</p> <p>Fuse (F1) 10A</p> <p>Output Power</p> <p>Voltage +20 Vdc \pm 5% -5 Vdc \pm 5%</p> <p>Current 8A @ +20 Vdc 1A @ -5 Vdc</p>
1	H770 Regulator	H770	<p>Input Requirements (Max)</p> <p>Voltage 20–30 Vac</p> <p>Phase Single</p> <p>Frequency 47–63 Hz</p> <p>Current 12A</p> <p>Fuse (F1) 15A</p> <p>Output Power</p> <p>Voltage +15 V \pm 3%</p> <p>Current 0–10A</p>

The KL10-C cabinet grounding point should be connected to the building ground point. Complete cabinet grounding information is provided in the Field Maintenance Print Set.

1.5 ENGINEERING DRAWINGS

Table 1-4 lists reference schematics and wiring interconnection diagrams contained in the Field Maintenance Print Set for the Power Distribution System units within the 2040 system configurations.

**Table 1-4
Reference Drawings**

Title	DEC Dwg. No.	No. of Sheets
863 Power Control, Detailed Schematic	D-CS-863-0-1	4
Auxiliary Power Supply (W7000), Detailed Schematic	D-CS-W7000-0-1	2
AC Low Voltage Detector (W516), Detailed Schematic	D-CS-W516-0-1	2
Indicator Driver (G8017), Detailed Schematic	D-CS-G8017-0-1	1
Power Control Logic (G8015), Detailed Schematic	D-CS-G8015-0-1	2
H7420 Power Supply, Detailed Schematic	D-CS-H7420-0-1	1
H7420 Power Control Board	C-CS-5411086-0-1	4
H744 Regulator (+5 Vdc), Detailed Schematic	D-CS-H744-0-1	1
H745 Regulator (-15 Vdc), Detailed Schematic	D-CS-H745-0-1	1
H754 Regulator (+20, -5 Vdc), Detailed Schematic	D-CS-H754-0-1	1
Switch Panel, Assembly Drawing	E-AD-7011639-0-0	1
Capacitor Assembly, Detailed Schematic	D-CS-7009878-0-1	1
+10 V Reference, Detailed Schematic	D-CS-G8013-0-1	2
-5.2 Vdc Control, Detailed Schematic	D-CS-G8010-0-1	1
-2.0 Vdc Control, Detailed Schematic	D-CS-G8011-0-1	1
-5.2 Vdc Heat Sink, Detailed Schematic	D-CS-7009405-0-1	1
-2.0 Vdc Heat Sink, Detailed Schematic	D-CS-7008404-0-1	1
DC Low Voltage Detector, Detailed Schematic	D-CS-G8014-0-1	1
H761 Power Diagram	D-IC-KL10-0-1	2

Table 1-4 (Cont)
Reference Drawings

Title	DEC Dwg. No.	No. of Sheets
H761 Detailed Interconnection Wiring Diagrams (H761-0-1 through H761-0-8)	D-IC-H761-0-	9
H770 Regulator (+15 Vdc), Detailed Schematic	D-CS-5411207-0-1	1

CHAPTER 2

INTERFACE LEVEL DESCRIPTION

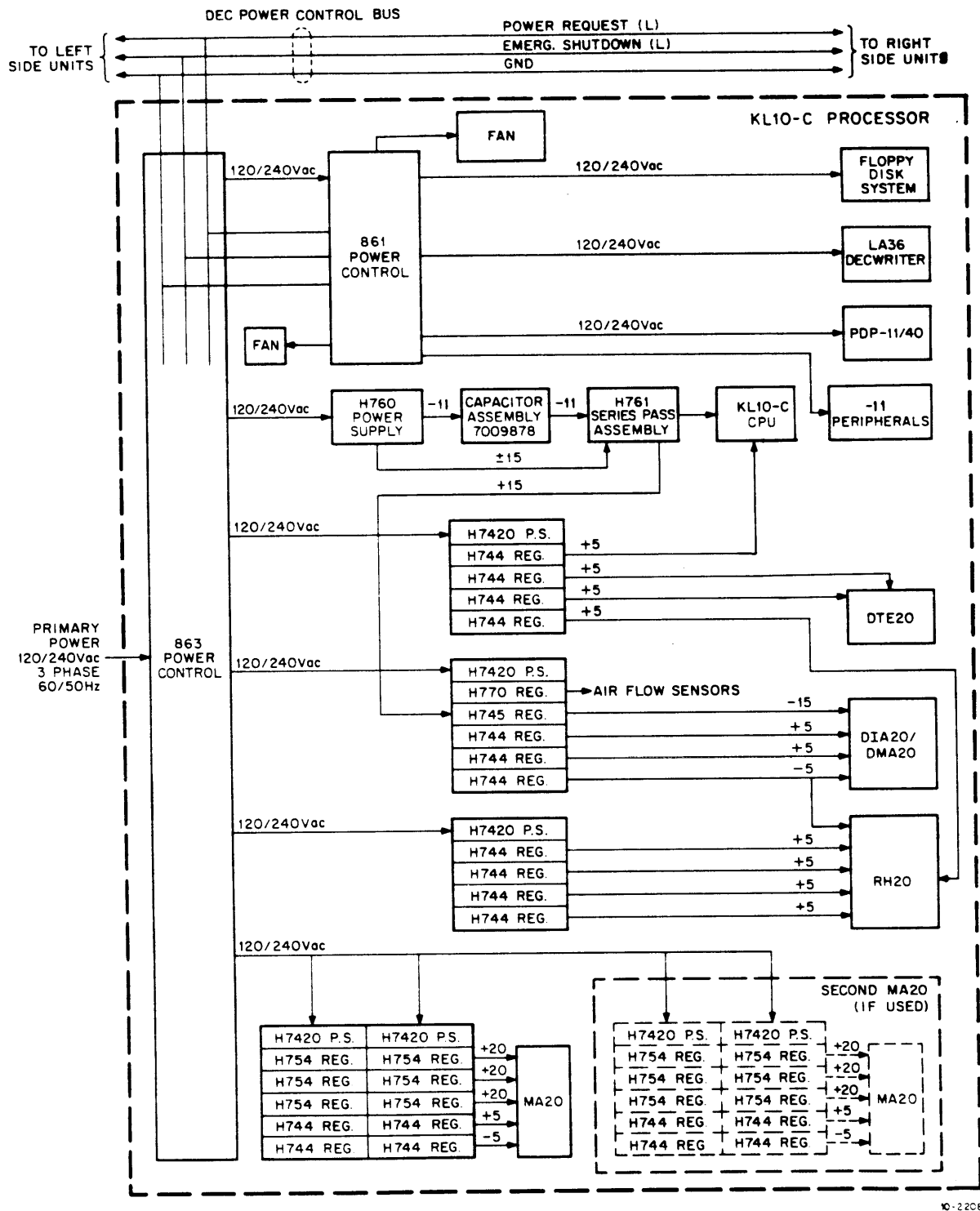
2.1 BLOCK DIAGRAM ANALYSIS

An Interface Level block diagram of the KL10-C Power Distribution system is shown in Figure 2-1. The 863-D Power Control controls application of ac power to the entire power system.

Power to the PDP-11/40, the DECwriter, and the Floppy Disk system is further controlled by the 861 Power Control, which receives its primary input from the 863. The 861 also controls ac power to the fans in the CPU Cabinet. The H7420 Power Supplies in this cabinet are identical to those in the I/O Cabinet. The additional power supplies and regulators powering the PDP-11/40 and Floppy Disk system are internal to those devices and are not considered part of the 2040 Power System; these supplies and regulators are not discussed further in this manual.

The Switch Panel is located in the same cabinet as the 863 Power Control. During normal operation, the system is turned on and off by means of a POWER ON switch on the Switch Panel. A separate switch removes power under emergency conditions.

DC power for the ECL logic in the Central Processing Unit (CPU) is furnished by a ferroresonant H760 Raw Power Supply, a Capacitor Assembly for energy storage, and an H761 Regulated Series Pass Assembly. The ferroresonant transformer primaries



10-2208

Figure 2-1 KL10-C Power Distribution System Block Diagram
(Interface Level)

are wired in a 3-phase delta, while the outputs are wired in a full-wave 3-phase star. The outputs of the ferroresonant supply are -11 V @ 490 A, and ± 15 V @ 2 A. The +15 V and -15 V outputs share a common winding. The input line tolerances are +10%, -30% of 120/240 nominal voltage. With the capacitor assembly added, the power supply is capable of 20 ms of energy hold-up when power is removed.

The H761 provides the major portion of the voltage regulation, as well as the sequencing of the -2.0 V, overvoltage protection, and current limiting. Within the H761, are control cards, circuit breakers, and heat sink assemblies to generate the -5.2 V and -2.0 V. The outputs of these regulators are $\pm 1\%$ overall tolerance and 25 mV between common voltage levels at the point of remote sensing. Regulation is performed by a linear regulator with a series pass transistor. The output maximum current level is 35 amperes for each regulator.

LEDs on the back of the H761 regulator control cards (G8010 and G8011) are used to indicate output voltage is present. The only indication that the regulator cards are not functioning correctly, other than tripped circuit breakers, is the LEDs being off. Each regulator card consists of three identical voltage regulators, although not all regulators on all cards are used.

Both POWER WARNING and CROBAR line pairs are connected to the CPU from the 863 Power Control. These line pairs are simply open (SIGNAL to RETURN) or shorted, depending on the state of

the relay contacts associated with the individual control relays. Before power is applied to the system, both sets of contacts are closed. Approximately 5 seconds after power is applied, both sets of contacts are opened, with CROBAR lagging POWER WARNING by 5 milliseconds. During power shut-down, CROBAR again lags POWER WARNING by 5 milliseconds. At least 13 seconds must elapse between power-down and the next power-up sequence.

The power supplies and regulators in the I/O Cabinet are similar to those in the CPU Cabinet. Type H770 and H745 regulators are added to the I/O Cabinet. The H770 has been designed for a higher degree of regulation than provided for by the power control board in the H7420. The +15 Vdc for the air flow sensors is furnished by the H770. The H745 supplies -15 Vdc to the DIA/DMA20 logic.

The CROBAR that is applied to the CPU is also applied to the H770. In this case, the CROBAR assures that approximately 5 seconds will elapse so that the cabinet fans can get up to speed before power is applied to the air flow sensors, thus avoiding accidentally initiating an Emergency Power Off sequence.

As shown in Figure 2-1, the DEC Power Control Bus is connected to both the 863 and the 861 Power Controls. An override switch is provided in the 863 for maintenance purposes. This switch overrides a fault condition so that the processor can be powered-up for troubleshooting.

2.2 BASIC OPERATION

Two types of power must be considered in an analysis of the KL10-C: switched primary power and unswitched primary power. The main input to the 863 is 120/208 Vac or 240/416 Vac, 3-phase (wye-connected). When the main circuit breaker on the 863 is closed, unswitched 120/240 Vac power is applied to various circuits inside the 863, and to one additional circuit breaker. Closing the circuit breaker applies 120/240 Vac to the unswitched convenience outlets and the 861 Power Control. The circuits inside the 863 include a W7000 Auxiliary Power Supply, a W516 AC Low Voltage Detector, a G8011 Indicator Driver with fault indicators, and G8015 Power Control Logic. These four circuits are active (and remain active) as long as the 863 main circuit breaker is closed.

To apply power to the system, it is necessary to close the POWER ON switch on the Switch Panel. Approximately 5 seconds after this switch is closed, the normally-closed CROBAR and POWER WARNING lines in the 863 are opened, removing the inhibit from the system logic (that is, the clock, the memory, and other circuits). Closing the POWER ON switch also energizes a power relay and two contactors in the 863. As a result, primary 120/240 Vac switched power is applied to a series of individual circuit breakers on the 863 front panel. When these individual circuit breakers are closed, primary ac power is applied to the rest of the system, as shown in Figure 2-1.

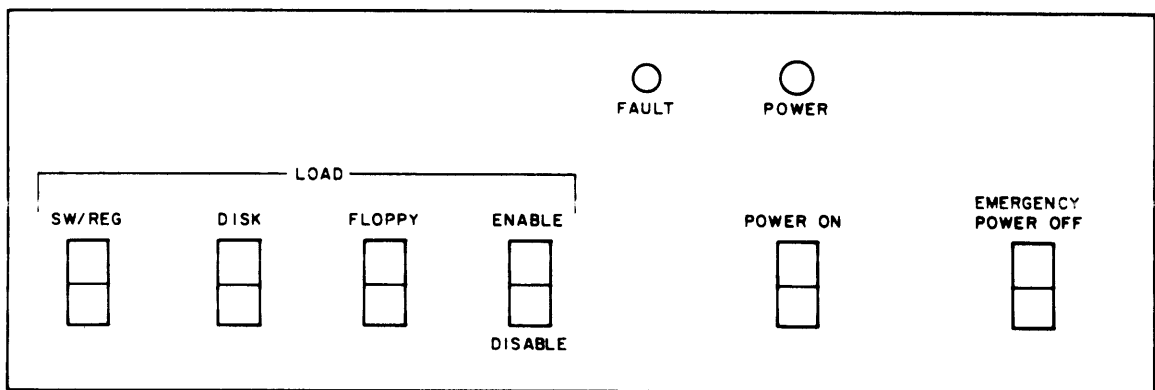
The application of primary power to the 863 is indicated by three orange-colored lamps on the 863 front panel, one for each of the three phases. When the POWER ON switch on the Switch Panel is closed, the red LED (POWER) next to the switch lights, indicating the application of switched power to the system.

Fault indicators (LEDs) are associated with both the 863 Power Control and the Switch Panel. If any one of several fault conditions prevails, the single orange-colored FAULT indicator on the Switch Panel lights. The system will automatically power-down and will remain down for at least 13 seconds. Eight fault conditions, in particular, are identified individually by LEDs on the front panel of the 863 Power Control. These EIGHT conditions are:

- (4) Insufficient air flow (four locations)
- (5) Overtemperature (unused)
- (6) Circuit breaker to CPU power is tripped
- (8) Cooling Assembly door open (two locations)

2.3 SWITCH PANEL

The Switch Panel is located in the front top area of the Console Processor Cabinet. Figure 2-2 shows a front view of the Switch Panel.



10-2237

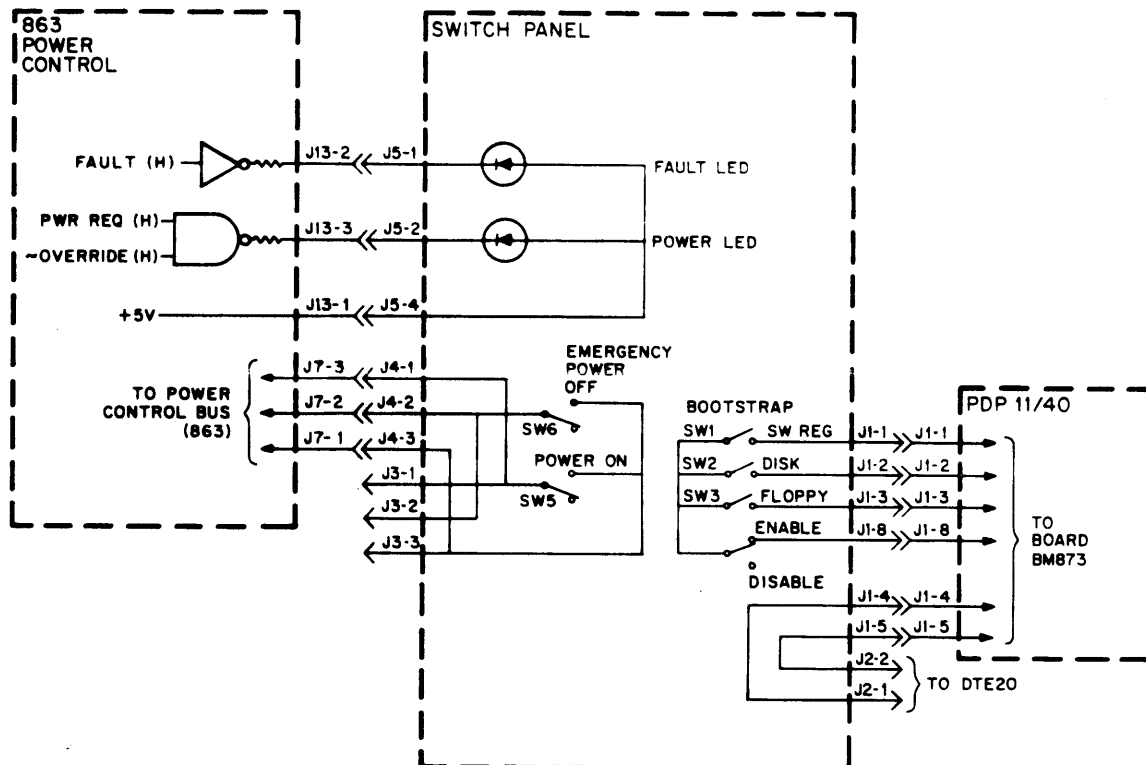
Figure 2-2 Front View of Switch Panel

The Switch Panel main functions are:

1. Normal application and removal of power to the system by means of the POWER ON-OFF switch with the associated red LED POWER indicator.
2. Emergency shutdown; EMERGENCY POWER OFF switch with the manual mechanical-reset-only feature.
3. Red system FAULT indicator (LED) for any one of eight (8) possible fault conditions related to power distribution.
4. BOOTSTRAP loading from disk, Floppy disk or the PDP-11/40 front panel (SWitch REGister). A separate switch enables or disables the bootstrap loading function.

2.3.1 System Connections

The Switch Panel is interfaced in the overall system as shown in Figure 2-3. A +5 Vdc LED source input line is connected between the 863 Power Control and the Switch Panel. The POWER LED lights when system power is applied through the POWER ON switch. The FAULT LED lights when a power-related fault occurs, as, for example, in the case of a series pass circuit breaker tripping or no air flow.



10-2232

Figure 2-3 Switch Panel, External Connections

2.3.2 Operation

Power is applied to the 2040 System when the POWER ON switch is actuated. The associated POWER indicator should light and the cabinet fans should be audible. If some type of maintenance problem exists and the override switch on the 863 Power Control is actuated, the POWER indicator blinks (at a 1 Hz rate).

A bootstrap program is loaded by actuating the appropriate Switch Panel momentary switches. For example, if the bootstrap program is to be loaded manually through the PDP-11/40 front panel, the following steps are performed:

1. Set the PDP-11/40 console switches to the desired settings for loading the bootstrap program.
2. Actuate the ENABLE switch; depress and hold it in.
3. Actuate the SW REG switch on the 2040 Switch Panel; depress and hold it in.
4. When the load has started, release both 2040 Switch Panel switches.

Once the program is running, it is not necessary to operate any other controls on the 2040 Switch Panel.

2.4 POWER-FAILURE PROTECTION

Whenever ac power drops below 95 Vac for 115 V (190 Vac for 230 V) or outside a limit of 47 to 63 Hz, as measured by dc power, a power-fail sequence is started.

The KL10 CPU senses the power drop and the 863 power control asserts POWER WARNING. A CONI APR reads the POWER WARNING signal into bit 30, setting the Power Line Flag. This APR interrupt begins the KL10 CPU power-fail sequence and allows the KL10 to begin an orderly shutdown, storing information and clearing memory.

Coincident with the KL10 CPU shutdown process is the PDP-11/40 front end shutdown process. The PDP-11/40 Central Processor (under the same above conditions) automatically traps to location 24 and the power-fail program (at that address) has 2 ms to save all volatile information (data in registers), and condition peripherals for power fail.

When power is restored, the PDP-11/40 processor traps to location 24 and executes the power up routine to restore the machine to its state prior to the power failure. The PDP-11/40 start-up routine includes reading the entire 20-microcode back into the KL10 CPU, as it is totally lost during the power failure. The KL10 CPU is then restored to its prior state and the system is again ready to function.

Refer to the Introduction to KL-based System Technical Description manual (EK-KL10-TD-002) for more detailed information.

2.5 AUTOMATIC RESTART

The only automatic restart feature present in the KL10-C is with the ac. During a power-failure, for example, if the ac comes back up, the power failure program automatically restarts. The power cannot, however, come back up for a minimum of 13 seconds (one shot timer disallows power coming back up for this period of time).

Only ac faults are restartable. All other faults are unrestartable; they must be dealt with manually. Refer to the Introduction to KL-based System Technical Description manual (EK-KL10-TD-002) for more detailed information.

CHAPTER 3

UNIT LEVEL DESCRIPTION

3.1 INTRODUCTION

This section describes, in detail, the operation of each major assembly in the 2040 Power System. A detailed block diagram of the KL10-C Power Distribution System (Figure 3-1) introduces the chapter. Here, all the major assemblies are identified and all the assembly interconnections are shown. Then, each major assembly component is further described in subsequent paragraphs. The descriptions are supported by simplified schematics and diagrams. Refer to the Field Maintenance Print Set for detailed schematic diagrams.

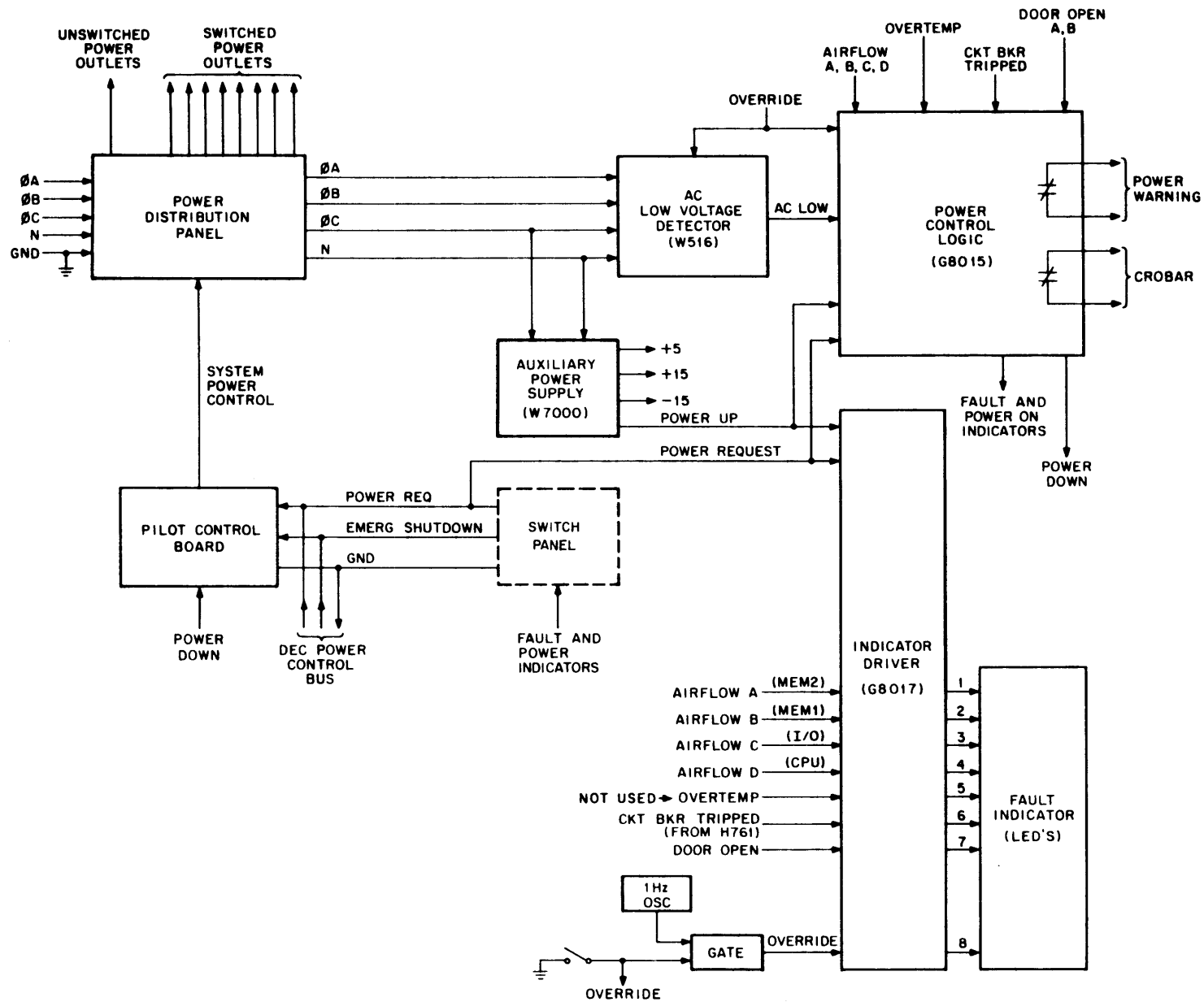
3.2 863 POWER CONTROL

The 863 Power Control controls application of ac power to the entire power system. Two versions of the power control are available: 863-D (120 Vac, 60 Hz) and 863-E (240 Vac, 50 Hz). A single detailed description (relative to both controls) is provided below.

3.2.1 Block Diagram Analysis

A block diagram of the 863 Power Control is shown in Figure 3-2. Major subassemblies include: a power distribution panel and associated pilot control board; an ac/dc low-voltage auxiliary power supply for internal usage; an ac low-voltage detector; power control logic and a bank of eight red fault indicators (LEDs) with associated flip-flop indicator drivers. An override circuit is provided for maintenance purposes. It prevents the machine from powering down during fault isolation. A 1 Hz oscillator provides blinking for two indicators when the override is enabled. One indicator is the OVERRIDE LED, located on the back of the 863. The other indicator is the POWER indicator located on the Switch Panel.

Operation of the 863 Power Control is summarized as follows: When the main circuit breaker on the power distribution panel is actuated, ac power is applied directly to the W7000 Auxiliary Power Supply and to the W516 AC Low Voltage Detector. AC power is also made available to circuit breakers that feed the unswitched power outlets (convenience outlets and the 861). Three lamps indicate the presence of phase A, B, and C power, respectively.



10-2194

Figure 3-2 863 Power Control, Block Diagram

Before the dc outputs of the auxiliary power supply reach rated value (+5, +15, -15 V), a POWER UP signal from that supply resets a fault flip-flop in the G8015 power control logic. The POWER UP signal also resets the five fault flip-flops (indicator storage) in the G8017 Indicator Drive. When the auxiliary power supply voltages reach rated value, the 863 Power Control is ready for operation.

Closing the POWER ON switch on the Switch Panel energizes a control relay and to ac contactors on the Pilot Control Board. As a result, 3-phase ac is applied to a series of circuit breakers on the power distribution panel (switched power outlets). These circuit breakers control primary ac power to the other power controls and supplies in the KL10-C Processor. Approximately 5 seconds after power is turned on, the normally-closed CROBAR and POWER WARNING lines in the Power Control Logic are opened. The KL10-C is now ready for operation.

The AC Low Voltage Detector continually senses the peak value of the 3-phase ac input to ensure the line voltage is within prescribed limits (e.g., greater than 90 volts for a 120 Vac, 60 Hz system). If the line voltage remains above the preset limit, the machine functions normally. However, if the line voltage drops below the preset limit, the 863 executes a power down sequence. A power down sequence also occurs if one of the fault sensors is actuated (e.g., if a cooling cabinet door is accidentally opened). Both CROBAR and POWER WARNING signals are

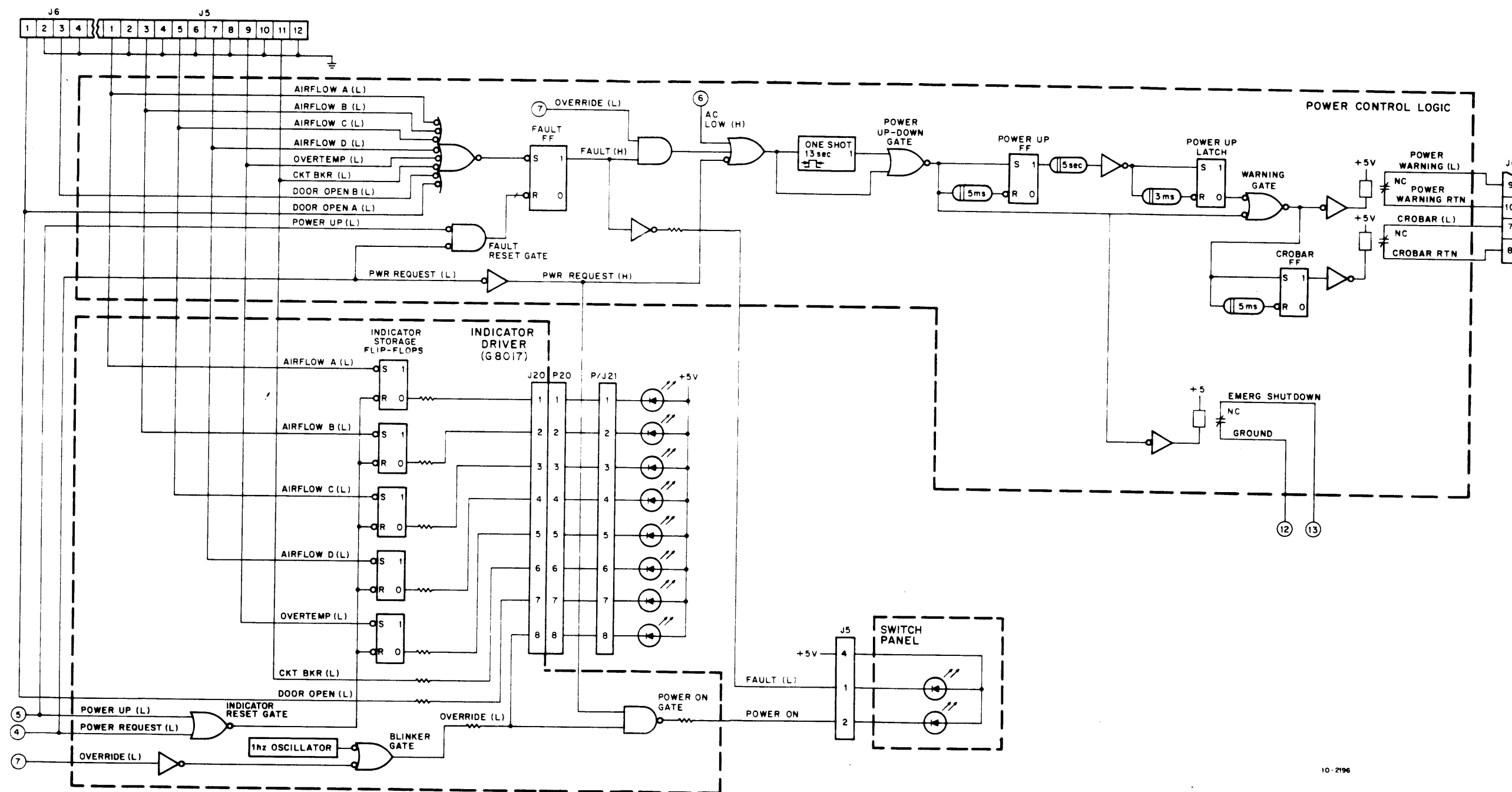
sent to the KL10-C CPU to indicate a powered-down condition (relay contacts are closed) during which time main power is removed from the system.

Timing in the Power Control logic ensures that at least 13 seconds will elapse between shutting down and powering up the system, either under normal operating conditions or when a fault is detected. If the EMERGENCY POWER OFF switch on the Switch Panel is activated, then power is immediately removed from only the switched outlets.

Two indicators on the Switch Panel are associated with the 863 Power Control. When the POWER ON switch on the Switch Panel is closed, the POWER light-emitting diode on the Switch Panel is activated. This LED remains activated until the POWER ON switch is opened. During an OVERRIDE condition, the POWER indicator blinks at a 1 Hz rate. The other LED on the Switch Panel specifies a FAULT condition, and remains illuminated as long as one of eight fault conditions exists: airflow sensors A, B, C, D; overtemperature; circuit breaker tripped in the H761 Pass Assembly; door open (A); and door open (B); (one of these is OVERRIDE).

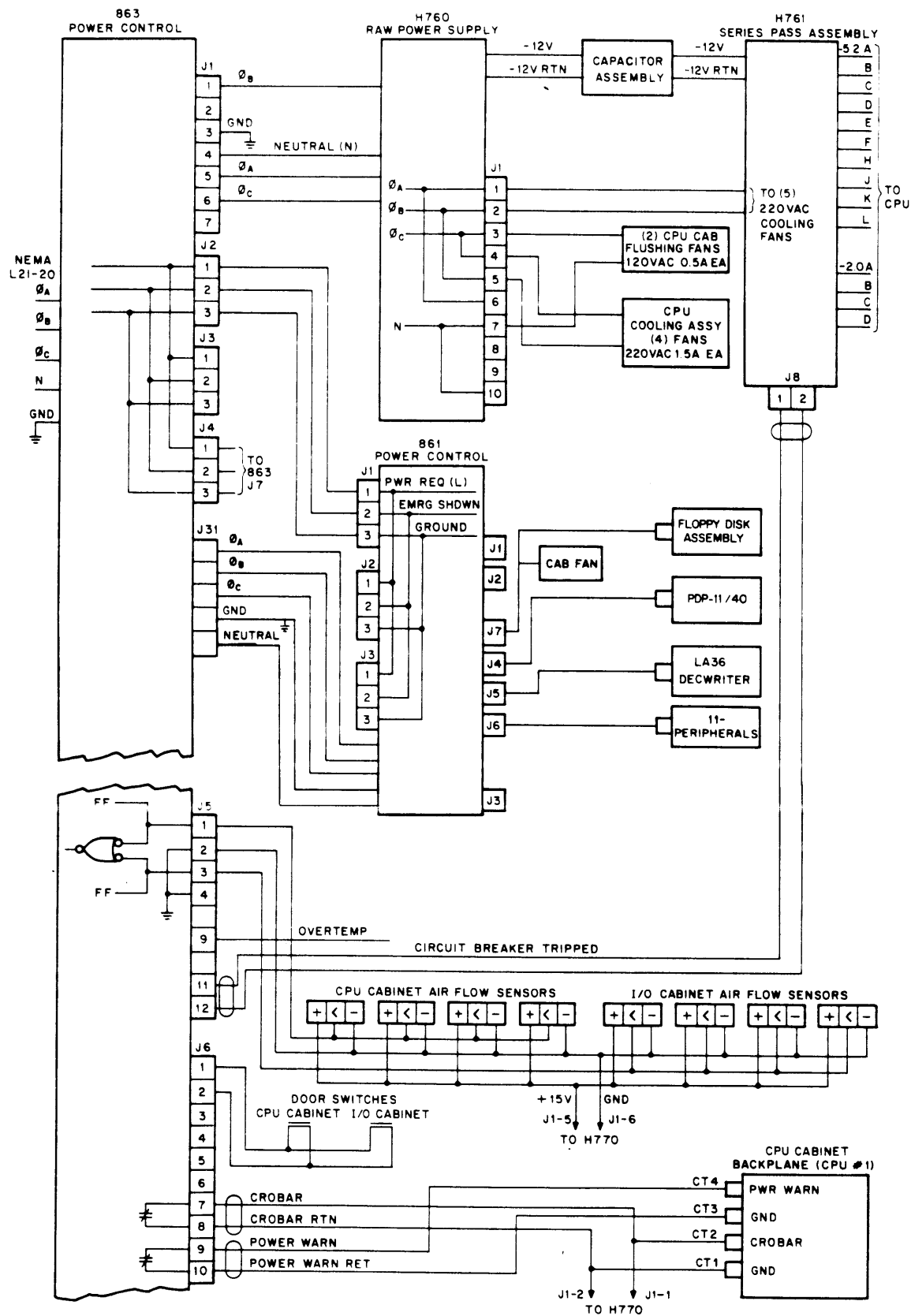
3.2.2 Detailed Circuit Description

Figure 3-3 is a simplified schematic diagram of the 863 Power Control. Refer also to drawing D-CS-863-0-1 in the Field Maintenance Print Set.



10-2196

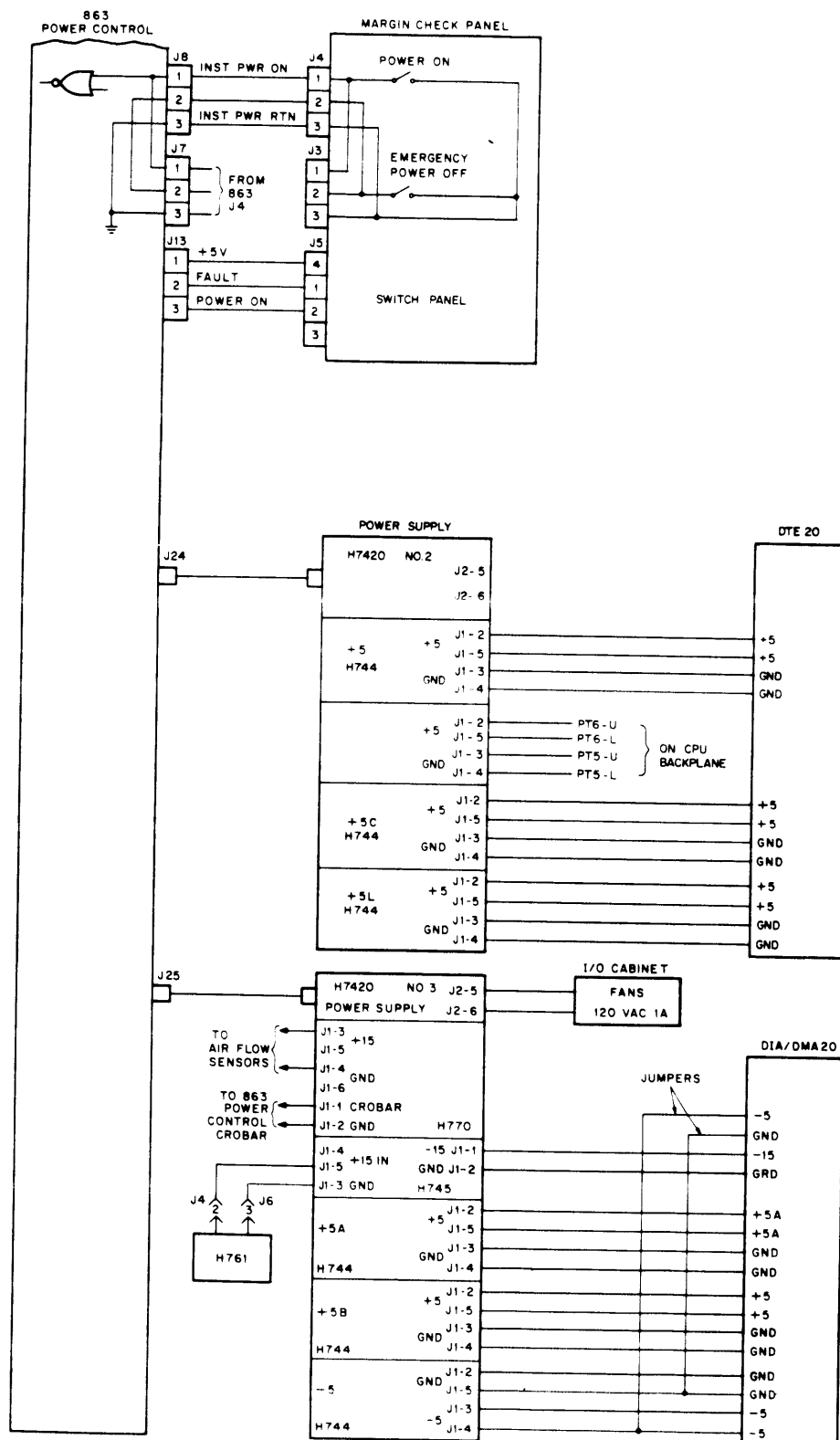
Figure 3-3 863 Power Control Simplified Functional Schematic (Sheet 3 of 7)



10-2197

Figure 3-3 863 Power Control Simplified Functional Schematic

(Sheet 4 of 7)



10-2198

Figure 3-3 863 Power Control Simplified Functional Schematic
(Sheet 5 of 7)

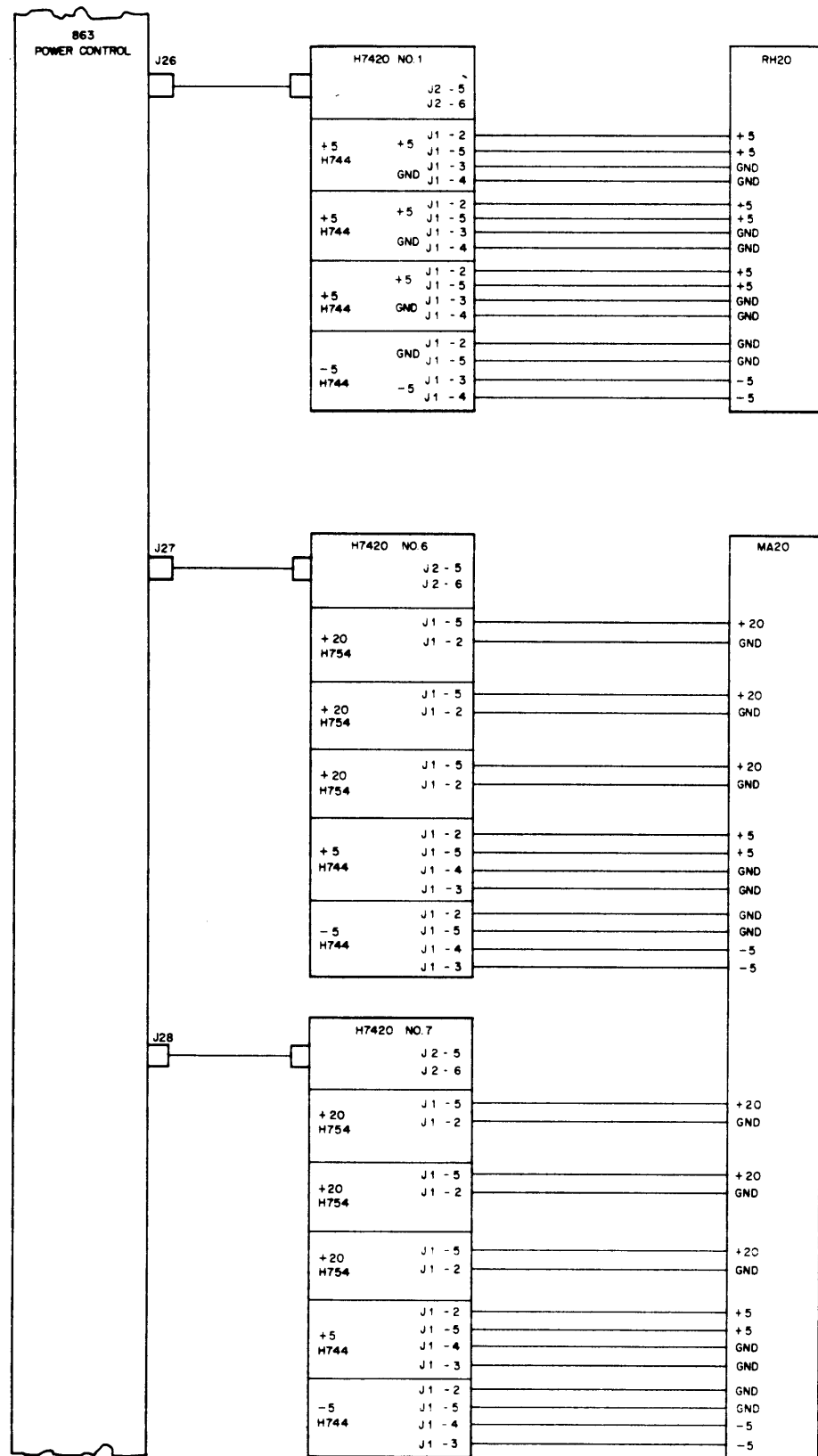
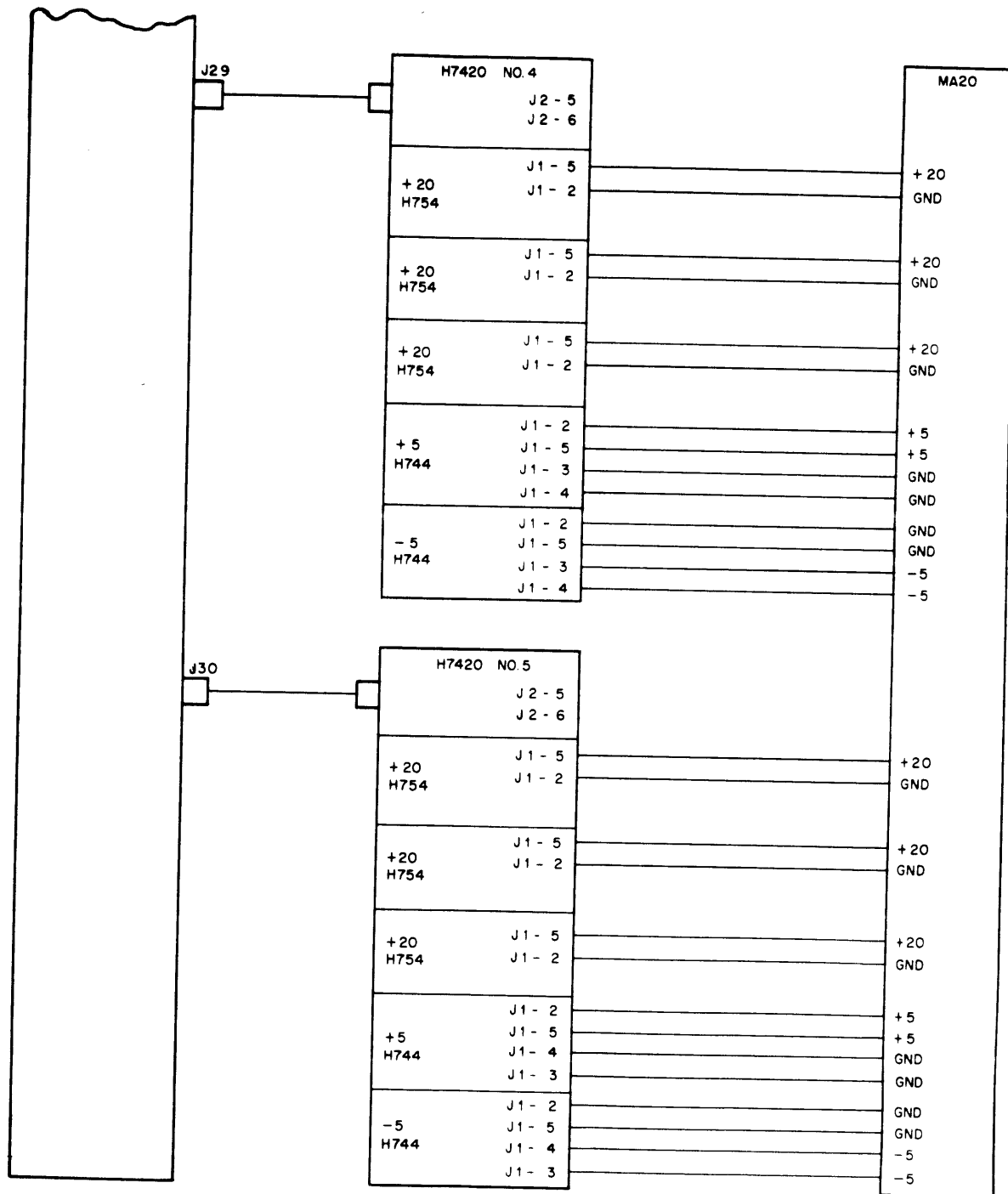


Figure 3-3 863 Power Control Simplified Functional Schematic



10-2200

Figure 3-3 863 Power Control Simplified Functional Schematic
(Sheet 7 of 7)

As shown in the illustration, primary ac 3-phase power is applied to the 863 Power Control via 75-ampere main circuit breaker CB1. Indicators 11, 12, and 13 are illuminated, indicating the presence of phases A, B, and C, respectively. For 120 Vac operation, resistors R1, R2, and R3 are shorted, so that each indicator is connected directly between its associated ac line and neutral. For 240 Vac operation, the jumpers are removed so that each indicator is connected in series with a 47K resistor between line and neutral. Three-phase ac is applied to unswitched outlet J23 via CB10 and to unswitched outlet J31.

Stepped-down ac is applied to the Auxiliary Power Supply via transformer T1. Jumpers are used for either 120 Vac or 240 Vac operation. For 120 Vac operation, jumpers are placed between pins J16-1 and J16-3, and between J16-2 and J16-4. For 240 Vac operation, only one jumper, between pins J16-2 and J16-3, is required.

Both 14 Vac and 30 Vac (phase C) are applied to full-wave bridge rectifiers in the W7000. The 15 Vac input provides a dc output of +18 V; the other bridge provides outputs of ± 30 Vdc. These dc voltages are applied to separate regulator circuits, yielding regulated outputs of +5 Vdc @ 1 A, +15 Vdc @ 50 mA, and -15 Vdc @ 100 mA. Before the regulator outputs reach rated value, however, the POWER UP output of the W7000 is high, resetting the Fault flip-flop in the power control logic as well as the five fault (indicator storage) flip-flops in the indicator driver.

When an R-S flip-flop in the indicator driver is reset, its associated LED is turned off. No storage flip-flops are associated with CKT BRK (circuit breaker tripped), DOOR OPEN, or OVERRIDE. If none of these three conditions exists, the input lines are high, and the associated fault indicators (LEDs 6, 7, and 8) are also turned off. When the W7000 Regulator outputs reach rated value, the POWER UP line goes low.

Three-phase ac is applied to the AC Low Voltage Detector by transformer T2, which has a wye-connected primary and a 3-phase secondary. The secondary feeds three full-wave rectifiers whose outputs are tied together to yield a dc component with superimposed 360 Hz ripple (for a 60 Hz primary). The peak value of the signal is compared with a reference. If the 3-phase ac input to the detector remains at its nominal value, the 5 usec one-shot is repeatedly triggered so that AC LOW remains low. This condition causes the output of the Power Up-Down gate in the power control logic to go high, thereby energizing the relay associated with the POWER DOWN line (contacts now open). As long as the POWER DOWN contacts are open, switched ac power can be applied to the main system. Approximately 5 seconds after POWER DOWN contacts are opened, the CROBAR and POWER WARNING contacts are opened.

When the POWER ON switch on the Switch Panel is closed (grounded), the POWER REQUEST line goes low. This signal is inverted and ANDed with OVERRIDE. If no override condition

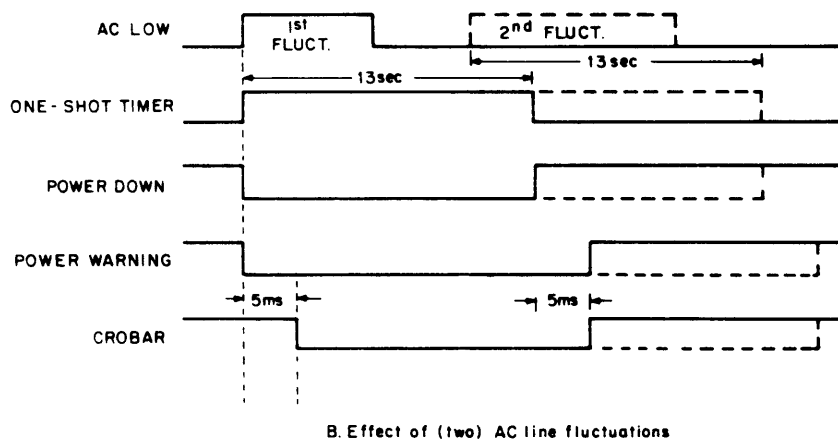
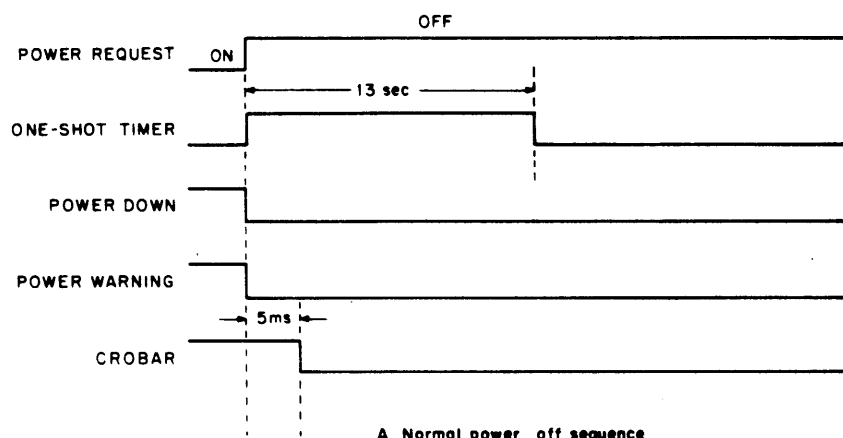
exists, both inputs to the POWER-ON gate are high, so that the output is low. This low output turns on the associated POWER indicator (LED) on the Switch Panel. POWER REQUEST (low) is ANDed with POWER UP (low) from the auxiliary power supply at the Fault Reset gate. Because both signals are low, the output of the associated AND gate is high. Therefore, the Fault flip-flop in the power control logic cannot be reset inadvertently while power is applied to the system. The same statement holds true for the R-S flip-flops that drive the indicator LEDs.

If the LOCAL-REMOTE switch on the pilot control board is in the REMOTE ON position, then the cathode of diode D1 is grounded through the POWER ON switch on the Switch Panel. In this case, +24 Vdc is applied to the center-tap of the pilot control relay on the pilot control board. The +24 Vdc comes from the full-wave rectifier (diodes D4, D5) which is transformer-coupled to the phase C primary input (path J9-3, J15-3, J16-3, J16-1 or J16-2). When the pilot control relay is energized, relay K3 on the power distribution panel is energized, so that main contactors K1 and K2 on the power distribution panel are also energized. This causes 3-phase ac power to be applied directly to jack J1 and, through circuit breakers, to the remaining switched power outlets (jacks J24 through J30). As long as no faults are detected and the input voltage is within specification, the 863 power control functions normally, supplying primary ac power to the remainder of the KL10-C Power System.

Switching the LOCAL-REMOTE switch on the pilot control board from the REMOTE ON position to the LOCAL ON position, grounds the cathode of diode D1 and has essentially the same effect as closing the POWER ON switch on the Switch Panel. In this case, primary power is made available to the switched power outlets. The POWER ON switch must be kept closed when the LOCAL-REMOTE switch is in the LOCAL ON position. Note also that the pilot control relay can be externally controlled by the DEC Power Bus.

Two ways of normally shutting down power to the system are used: opening main circuit breaker CB1 on the 863 Power Control; or opening the POWER ON switch on the Switch Panel. Opening CB1 removes all power from the system and closes the CROBAR and POWER WARNING lines to the CPU. Opening the POWER ON switch provides a predetermined power-down sequence, which is described as follows (see Figure 3-4 (A)):

When J8-1 goes high (PWR REQUEST high), the five Indicator Storage flip-flops are reset, the POWER indicator on the Switch Panel is extinguished, the 13-second one-shot in the power control logic is triggered, and the POWER DOWN and POWER WARNING lines are closed. Approximately 5 ms later, the CROBAR line is closed.



10-1853

Figure 3-4 863 Power Control, Power Down Sequencing

If the LOCAL-REMOTE switch on the pilot control board is in the REMOTE ON position, then the relay on that board will be de-energized, as will power relay K3 and contactors K1 and K2. This removes ac power from the switched outlets. Reapplying power to the switched outlets is not possible until the output of the 13-second one-shot in the power control logic returns to ground. While the output of that one-shot is high, the POWER DOWN relay will not be energized so that the POWER DOWN line will be closed, shorting pins J2-2 and J2-3 on the pilot control board. When these two pins are shorted, currents flow in opposite directions through the center-tapped coil of the relay on that board, preventing the relay from being energized. Closing the EMERGENCY POWER OFF switch on the Switch Panel grounds pin J2-2 and has the same effect as closing the POWER DOWN line.

If cooling air stops flowing at a given rate in a cabinet, a fault LED (No. 1, 2, 3, or 4) will light and the Fault flip-flop in the Power Control Logic will be set. If the override is disabled (high), then the FAULT indicator on the Switch Panel will light, the 13-second one-shot will be triggered and, at the same time, the POWER DOWN and POWER WARNING lines will be closed. Approximately 5 ms later, the CROBAR line closes. These three output lines remain closed as long as the one-shot is activated. Closing the POWER DOWN line de-energizes the relay on the Pilot Control Board and, therefore, removes ac power from the switched outlets.

If an overtemperature condition exists, or if a circuit breaker trips in the H761 Series Pass Assembly, or if a cooling cabinet door is open, a similar fault condition will exist as did for air flow. The main difference is that no indicator flip-flops are associated with CKT BKR and DOOR OPEN.

When an AC LOW condition (AC LOW line high) exists, the input to the 13-second one-shot in the power control logic is high (Figure 3-4 (B)). The one-shot is triggered and, at the same time, the output of the associated NOR gate (POWER UP-DOWN) is low. As a result, the POWER DOWN and POWER WARNING lines are closed. Approximately 5 ms later, the CROBAR line is closed. Closing the POWER DOWN line causes the relay of the pilot control board to be de-energized, removing ac power from the switched outlets.

Closing the OVERRIDE switch disables the power down circuits (POWER DOWN, POWER WARNING, and CROBAR) in the event of a fault condition. This enables the fault condition to be corrected while full power is still applied to the system. When the OVERRIDE switch is closed, it enables the output of the 1 Hz oscillator to be applied to the associated fault indicator (LED No. 8), providing a blinking light on the 863 Power Control. The output of the oscillator is also ANDed with the PWR REQUEST line, causing the POWER indicator on the Switch Panel to blink in a similar fashion. The OVERRIDE signal inhibits the AC LOW gate, so that the ac low voltage detector is inoperative (AC LOW line is kept low).

When the input line voltage to the ac low voltage detector drops below the preset value (nominally 90 Vac), the AC LOW signal goes high and the 863 Power Control executes a power-down sequence. The one-shot in the power control logic prevents power from coming back up for a period of 13 seconds. When the input line voltage returns to nominal value, the AC LOW signal goes low and the 863 executes a POWER-ON sequence. The POWER WARNING and CROBAR functions are dependent on the status of the AC LOW signal, and can automatically remove and reapply power to the CPU without the necessity of manually operating the POWER ON switch on the Switch Panel. By comparison, if one of the first seven fault conditions is present, the machine will power-down and cannot be powered up until the fault is actually corrected (or the machine placed in an override condition). The first five fault lamps on the indicator driver can be reset only by opening the POWER ON switch or the main circuit breaker (CB1).

3.2.3 W7000 Auxiliary Power Supply

The W7000 Auxiliary Power Supply board (see Figure 3-3, sheet 2 of 7), contains a +5 V regulator, a +15 V regulator, and a -15 V regulator. Each regulator operates in essentially the same manner. Consider the +5 V regulator first (i.e., the circuit comprising E6, Q9, Q12 and the external 2N3790 transistor). A reference voltage of approximately 5 Vdc is applied through a resistor divider to pin 3 of operational amplifier E6 from Zener diode D15 (5.1 Vdc). The negative input of the operational amplifier, pin 2 of E6, is tied to the +5 V output through sensing resistor R43.

When the +5 V output decreases, E6 drives Q9 on, thereby developing a base current for the external transistor. When that transistor is turned on, the +5 V output will be increased to the desired level.

Raw voltage for the +5 V regulator is obtained from the full-wave bridge comprising D1 to D4, which has a 15 Vac input. The external 30,000 uF capacitor provides filtering and energy hold-up (approximately 100 ms).

Transistor Q12 provides current limiting for the +5 V regulator and is used for detecting a shorted output. Overvoltage protection is provided by Q2, D19, C8 and R23. For example, if the series pass transistor (2N3790) becomes shorted, the +5 V output would rise toward approximately +15 Vdc. To protect the 863 Power Control logic, the SCR (Q2) would turn on, effectively shorting the output until the overvoltage condition is corrected.

The +15 V operational amplifier (E5) has a 5 V input which is obtained by means of a resistor divider tied to the +15 V output. If the +15 V output decreases, E5 turns on Q4 which, in turn, causes Q7 to draw more current, increasing the output. Raw dc voltage for the +15 V (and -15 V) regulators is obtained from the full-wave bridge comprising D5 through D8.

The -15 V operational amplifier (E2) has its reference (pin 3) tied to ground. A resistor divider between the +15 V and -15 V outputs determines the voltage on the negative input (pin 2) of E2. If the -15 V output decreases, the operational amplifier will turn on Q10, which will cause Q8 to turn on, increasing the -15 V output.

Transistor Q6, resistor R35, diode D21, Zener D16, and C22 comprise a power supply for producing +5 Vdc for the integrated circuits in the W7000; (the +5 V outputs of the W7000 cannot be used for this purpose). The base of Q6 (emitter follower) is at approximately 5.7 Vdc, but because of the drop across the base-to-emitter junction, the output is approximately +5 Vdc.

Detection logic is included in the W7000 to detect a decrease in the -15 V output. Pin 13 is the input to detector E3. When the -15 V output decreases, the -15 V side of R28 rises, so that the voltage at pin 13 of E3 also rises. When the input to E3 exceeds 2 volts, the output at pin 12 goes low, causing pins 12 and 13 of E4 to go low. Other inputs to E4 are the +5 V sensing circuit (D14, R11) and the +15 V sensing circuit (D20, R19, R12). When all of the inputs to E4 go high, the output of E4 (pin 8) goes low, so that pin 6 of E3 goes high and, therefore, pin 8 of E3 goes low. This is the normal output of E3 (POWER UP) after the voltages in W7000 have reached rated value.

If the input line voltage decreases, pin 8 of E4 will go high, so that pin 2 of E3 goes high. This causes output pin 4 of E3 to go low, which in turn shuts down the system.

E1 is an LM301 operational amplifier. Its basic function is to provide a time delay during the power-up sequence. This enables the POWER UP line to be initially high, to reset the 863 fault circuits, and then to go low after the W7000 voltages reach rated value. The LED (D24) lights as long as pin 8 of E4 is grounded, indicating a POWER UP condition. When pin 8 of E4 goes high, the LED is no longer lit.

3.2.4 W516 AC Low Voltage Detector

Diodes D11, D15, D16, D17, D18, and D19 form three full-wave rectifiers. The outputs are tied together to produce a dc component with a ripple of 360 Hz (for a 60 Hz primary). High-frequency noise is filtered by resistor R8 and capacitor C10. The input to pin 2 of E1 is attenuated by a resistor divider consisting of R10, R11, and R12. This dc input level is cancelled by Zener diodes D4 and D5 to the base of Q3. When the ripple goes positive, Q3 emitter goes positive also and turns on Q5. When Q5 turns on, capacitor C15 charges in a positive direction. At this point, pin 12 of E1 is essentially at ground. Pin 11 of E1 is at approximately 1 Vdc, as determined by voltage divider R32-R33. Pin 9 of E1 is now low, thereby inhibiting gate E1 at pin 5.

When the peak of the ripple voltage is reached, Q5 turns off, and its collector voltage rises to +5.7 Vdc. This allows pin 9 of E1 to go high, permitting the sampling of voltage on pin 2 of E1. If the voltage on pin 2 of E1 is greater than the voltage on pin 1, then one-shot E2 triggers, keeping the output of Q2 (AC LOW) low. At the negative transition time after the peak, Q4 discharges capacitor C15, and the cycle continues. As long as the input voltage remains within prescribed limits, C15 continues to charge and discharge, and one-shot E2 is continually triggered. If the input voltage drops below the prescribed limit, then E2 no longer triggers; AC LOW goes high, shutting down the system for at least 13 seconds.

3.2.5 G8017 Indicator Driver

A detailed schematic of the G8017 is shown in the Field Maintenance Print Set. The Indicator Driver is used to turn on various fault indicators when a malfunction occurs. The board contains an NE555 monolithic timing circuit (E2). When used as a highly stable oscillator, the free-running frequency and duty cycle are both accurately controlled with two external resistors and capacitor. The circuit can be triggered and reset on falling waveforms. A simplified block diagram of the NE555 is shown in Figure 3-5.

When power (V_{CC}) is first applied, capacitor C8 begins to charge through R10 and R11. When the capacitor voltage rises to a value greater than the threshold voltage (i.e., greater than

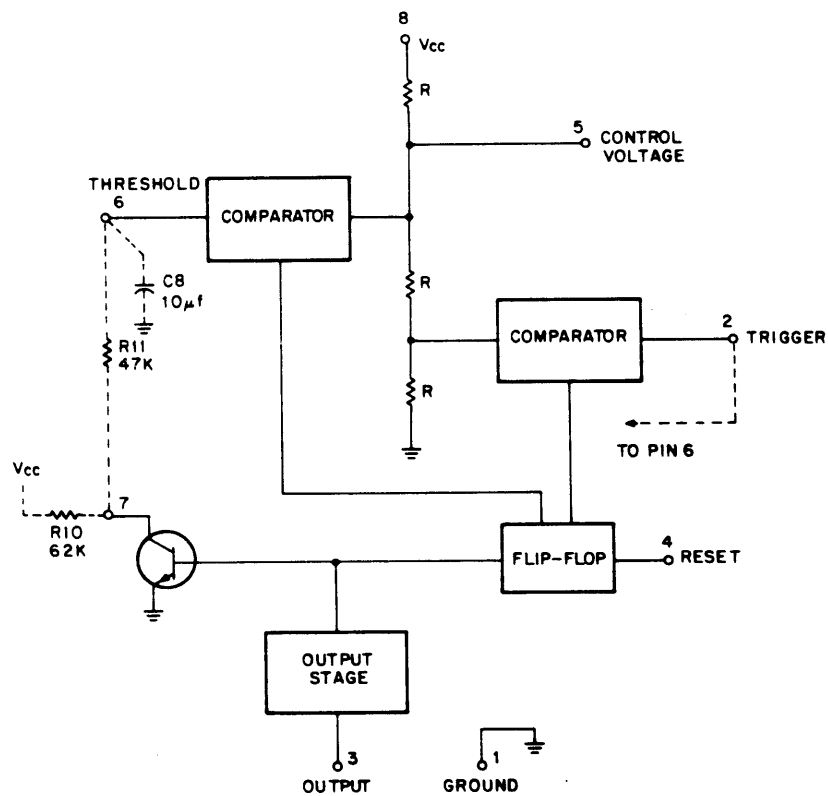


Figure 3-5 NE555 Timer, Simplified Block Diagram

approximately $2/3$ of V_{CC}), the capacitor is triggered, discharging C8 through the discharge transistor (pin 7). When the voltage across C8 is less than the trigger voltage (i.e., less than approximately $1/3$ of V_{CC}), the discharge transistor is cut off and C8 recharges through R10 and R11. In effect, the output at pin 3 is an exponential waveform rising and falling as C8 charges and discharges.

3.3 861-D POWER CONTROL

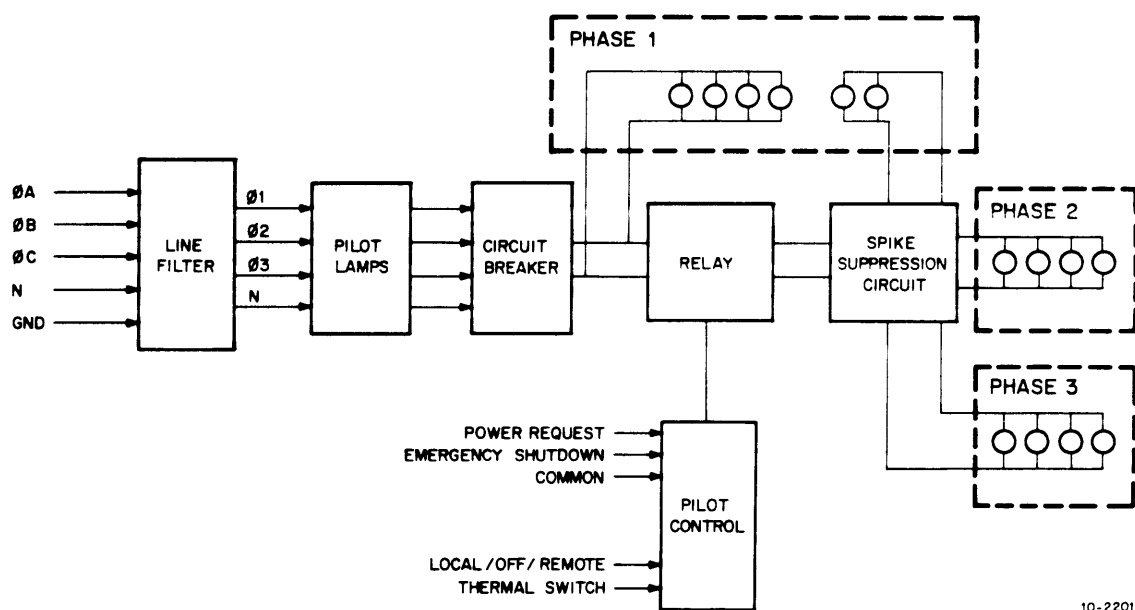
The 861-D Power Control controls application of ac power from the 863 Power Control to the 2040 front-end device power supplies and controllers (i.e., the PDP-11/40, LA36 DECwriter and Floppy Disk system).

3.3.1 Block Diagram Analysis

A block diagram of the 861-D Power Control is shown in Figure 3-6. Major sub-assemblies include a power line filter, circuit breaker and relay assembly, pilot control board, and switched (with spike suppression) and unswitched outlets. Four basic functions are performed:

1. Control large amounts of power by control signals of small power content;
2. Distribute primary power to controlled devices (front end power supplies and controls) conveniently;
3. Filter primary power to controlled devices; and
4. Remove primary power from controlled devices in case of overload or temperature conditions automatically.

Operation of the 861-D is summarized as follows: When the circuit breaker (CB7) is turned on, power is supplied to the unswitched outlets and to the switched outlets, when the LOCAL/OFF/REMOTE switch is in the LOCAL position. The circuit breaker opens automatically when an overload condition exists at a power outlet or within the power control.



10-2201

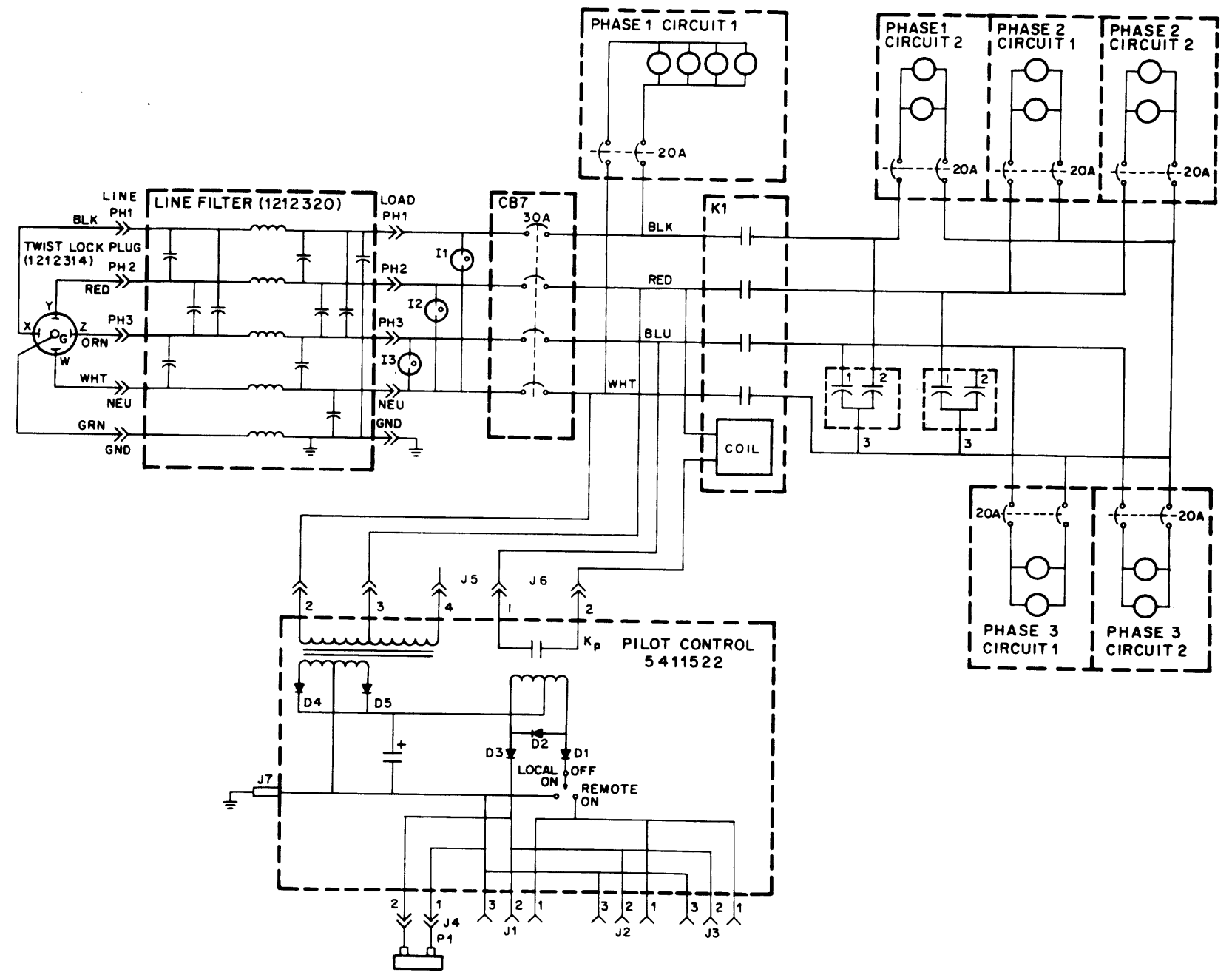
Figure 3-6 861-D Power Control, Block Diagram

The LOCAL/OFF/REMOTE switch provides the Remote Switching Bus with the means to control the power to the switched outlets. When the power controller is energized and the switch is in the OFF position, the switched outlets are disabled. When it is in the REMOTE position and connected to a bus where POWER REQUEST and EMERGENCY SHUTDOWN are in use, the switched outlets are enabled or disabled in accordance with conditions on the bus. When it is switched to the LOCAL position, the switched outlets are enabled only when the EMERGENCY SHUTDOWN signal is not asserted. All three pilot lamps (I1 - I3) are lighted whenever the controller input power cable is connected to the line mains, regardless of the position of the power control circuit breaker or LOCAL/OFF/REMOTE switch.

A thermally activated switch is provided to disable the controlled outlets in the event of an overtemperature condition at the power controller. The switch opens at 160° F and resets automatically when the ambient temperature at the power controller drops below 120° F.

3.3.2 Detailed Circuit Description

Figure 3-7 is a simplified schematic diagram of the 861-D Power Control. Refer also to drawing D-CS-861-D-1 in the Field Maintenance Print Set.



10-2202

Figure 3-7 861-D
Simplified Functional
Schematic

The 861-D Power Control is a 4-pole, 5-wire, 3-phase, 24 ampere, 120 Vac Power Control. Power is applied to the terminal block mounted on the power line filter. This filter contains 0.1 uF capacitors which connect between each side of the 120 Vac line and ground. Also contained in this filter are two chokes connected in series in each of the five lines. The capacitors provide low impedance paths to ground for high frequency line components; the chokes present a high impedance to these components. If voltage is present across the lines at the output of the line filter, the three indicators (from each phase to neutral) light. Each side of the line connects to a 30 ampere element of circuit breaker CB7. All loads connected to the power control (both switched and unswitched) are controlled by CB7. If the current through any line exceeds 30 amperes, CB7 trips, removing power from the load. Four power outlets (Phase 1) connect across the output of CB7. These outlets are energized whenever the circuit breaker is closed. The four output lines from CB7 each connect to a normally open contact on relay K1. The field coil associated with K1 is energized by 120 Vac from the output of CB7 if a relay on the pilot control board (K_p) is energized.

When K1 is energized, 120 Vac is applied across the remaining outlets. The capacitors connected across the relay lines reduce the amplitude of voltage spikes, when switching inductive loads, at the outputs of the control.

3.3.3 Pilot Control Board Circuit Description

Figure 3-7 shows the pilot control board simplified circuit schematic. The pilot control board contains the circuitry which allows remote turn-on and emergency turn-off of the switched power outlets in the 861-D Power Control. These functions are accomplished by controlling the voltage applied to the field coil of relay K1.

The circuit basically consists of a full-wave rectifier (D4, D5) loaded by the center-tapped field coil of a relay. Three control lines (J1, J2 and J3) connect to the board, as shown at the bottom of the figure. Pin 3 of each connector connects to the center-tapped secondary of the full-wave rectifier transformer. Pin 2 is the disable (Emergency Shutdown) line from the DEC power bus; pin 1 is the enable (Power Request) line from the DEC power bus. Two additional lines (from a thermal switch) are connected to J4-1 and J4-2, the lines associated with pins 3 and 2.

When the LOCAL/OFF/REMOTE switch is in the REMOTE position and pins 3 and 1 are connected, current flows through the lower portion of the center-tapped relay field coil and D1 to the full-wave rectifier transformer. This action closes relay K_p on the pilot control board and causes an energizing potential to be applied across the field coil associated with K1 in the power control.

This energizes the controlled outlets (Phase 2 and 3). When pins 3 and 2 are connected (Emergency Shutdown), current flows through the lower and upper halves of the center-tapped field coil in different directions before returning through D2 and D3 to the power supply transformer. The resultant current through the field coil is less than that required for holding the relay closed. Energizing potential, therefore, is not present at relay K1 and power is removed from the Phase 2 and 3 controlled outlets.

Diode D2 provides a current path in the lower section of the coil to prevent closing the relay in instances where pins 3 and 2 are connected but no connection exists between pins 1 and 3.

Closing the thermal switch (at J4) performs the same function as Emergency Shutdown (connects pins 2 and 3). This switch is exposed to the air ambient to the 861-D Power Control.

Temperatures above 160° F close the switch, disabling the 861-D and the rest of the system. The switch resets automatically when the temperature drops below 120° F.

Placing the LOCAL/OFF/REMOTE switch in the LOCAL ON position, provides a connection between pin 3 and the lower portion of the coil to energize K1, regardless of the state of the Power Request line on the DEC Power Bus. This switch position is normally used for maintenance purposes.

3.4 H7420 POWER SUPPLY

The H7420 Power Supply is used with type H744 (+5 V), H745 (-15 V), H754 (+20 V, -5 V), and H770 (+15 V) Regulators to supply the CPU, memory, and air flow sensors with dc power.

The H7420 is functionally divided into two major parts:

1. A step-down transformer for providing various ac voltages required by the fans, regulators and power control board.
2. A power control board that provides +8 V (not used in the KL10-C), +15 V, a line clock, AC LO and DC LO signals for power fail warning.

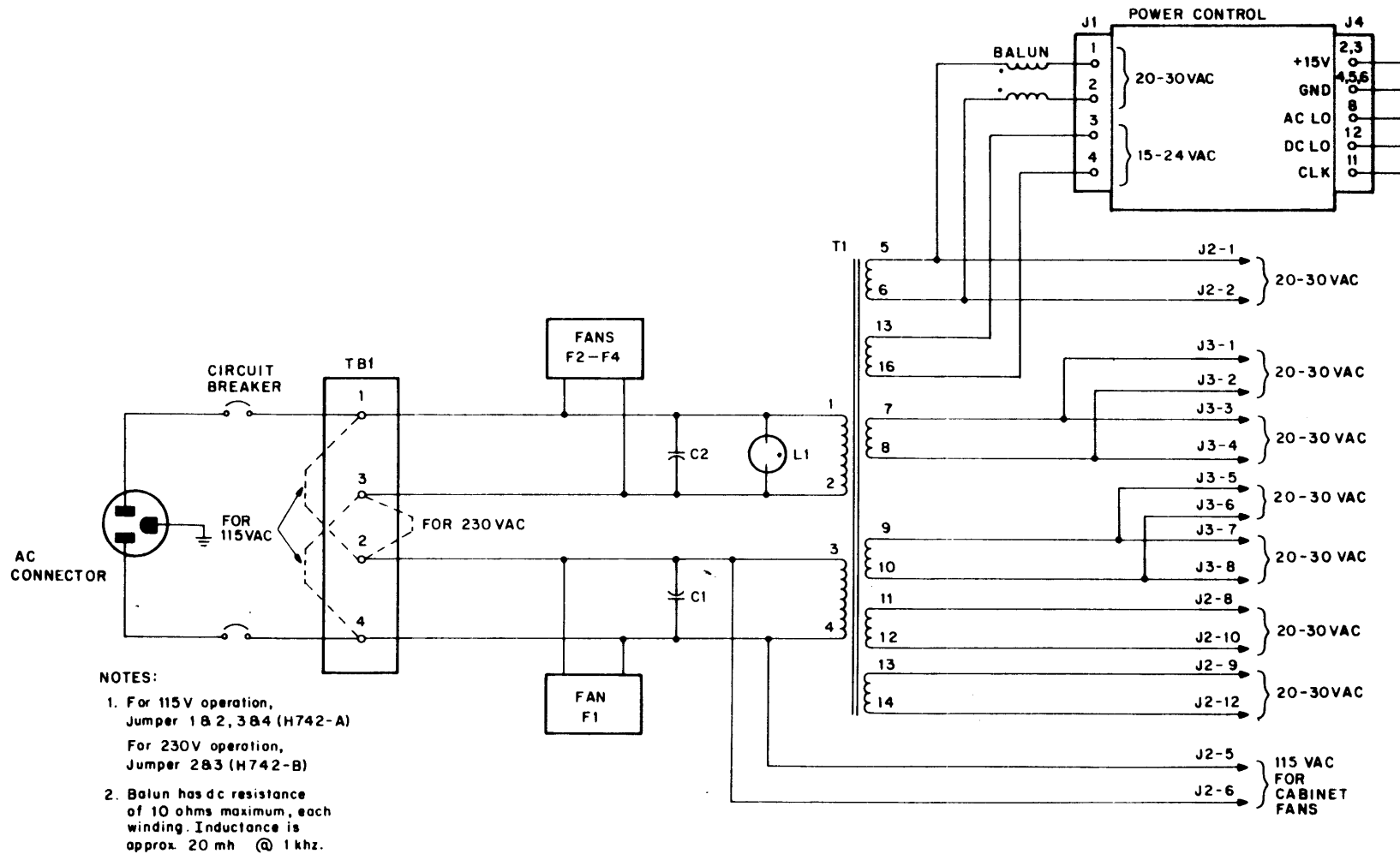
3.4.1 Detailed Circuit Description

Figure 3-8 is a simplified schematic diagram of the H7420 Power Supply. Refer also to drawing D-CS-H7420-0-1 in the Field Maintenance Print Set.

3.4.1.1 H7420 Step-Down Transformer

The H7420 Power Supply operates with either a 115 Vac or 230 Vac primary power input. Jumpers on terminal strip TB1 adapt the supply to the desired voltage, as shown.

.



10-1855

Figure 3-8 H7420 Power Supply, Simplified Schematic

Line power is applied through TB1 to the primary of transformer T1. The transformer secondaries provide 20-30 Vac and 15-24 Vac input power for the power control board, and 20-30 Vac for the regulators. Power to the H7420 cooling fan and three regulator fans is taken from the transformer primary; 115 Vac is provided for external (cabinet) fan operation with either 115 or 230 Vac prime power input.

A balun assembly is connected between the T1 secondary (terminals 5 and 6) and the 20-30 Vac input to the power control board (J1-1 and J1-2). The purpose of this BALanced to UNbalanced device is to filter out noise from the power line, thereby preventing inadvertent tripping of the power-fail circuits on the power control board.

3.4.1.2 H7420 +15 Volt Output

The power control board (refer to circuit schematic D-CS-5411086-0-1, sheet 4 of 4) of the H7420 power supply contains a +15 Vdc/+8 Vdc regulator. This switching regulator receives +25 to +45 Vdc from the rectified 20-to-33 Vac input (sheet 3 of 4).

Chip E1 is a precision voltage regulator. This DEC723 integrated circuit comprises a temperature-compensated voltage reference amplifier, error amplifier, series-pass power transistor, and current limiter; V_{OUT} (pin 10) is not used in this application.

The voltage applied to the base of the power transistor in E1 controls the current through that transistor, and subsequently controls the current flow through the other transistors (Q4, Q6, Q7) in the overall voltage regulator circuit.

Transistor Q7 is a pass transistor; Q4 is a pre-driver; and Q6 is a level shifter. Zener diode D17 is used with R11 to provide +15 Vdc for E1.

The output circuit of the regulator is standard for most switching regulators and consists of "free-wheeling" diode D12, choke L1, and output capacitor C10. These components make up the regulator output filter. Free-wheeling diode D12 is used to clamp the emitter of Q7 to ground when Q7 shuts off, thus providing a decay path for L1.

In operation, Q7 is turned on and off, generating a square-wave voltage which is applied across D12 at the input of the LC filter (L1, C10). This type of circuit is basically an averaging device, and the square-wave voltage appears as an average voltage at the output terminals. By varying the Q7 conduction period, the output (average) voltage may be varied or controlled, thus supplying regulation. The output voltage is sensed and sent back to E1, where it is compared with a fixed reference voltage. E1 turns pass transistor Q7 on and off, according to whether the output voltage level decreases or increases.

During one full operation cycle, the regulator operates as follows: Q7 is turned on and a high voltage (approximately +35 Vdc) is applied across L1. If the output is already at a +15 Vdc level, then a constant +20 Vdc is present across L1. This constant dc voltage causes a linear ramp of current to build up through L1. At the same time, output capacitor C10 absorbs this changing current and voltage, causing the output voltage (+15 V at this point) to increase. When the output (which is monitored by E1) reaches approximately +15.2 Vdc, E1 shuts off, turning Q7 off; the emitter of Q7 is clamped to ground. L1 current then decays through D12, which becomes forward biased by the back emf of L1. Pre-driver Q4 is used to increase the effective gain of Q7 to ensure Q7 can be turned on and off in a relatively short period.

Conversely, once Q7 is turned off and the output voltage begins to decrease, a predetermined value of approximately +14.8 Vdc is reached, causing E1 to turn on. This causes Q7 to conduct again, beginning another cycle of operation. Thus, a ripple voltage is superimposed on the output and is detected as predetermined maximum (+15.2 Vdc) and minimum (+14.8 Vdc) values by E1. When the maximum is reached, E1 turns Q7 off and when the minimum is reached, E1 turns Q7 on. This type of circuit action is also referred to as a "ripple regulator."

The overcurrent sensing circuit consists of Q1, Q2, D2, D1 and R1 through R6. Transistor Q2 is normally not conducting; however, when the output current exceeds approximately 4 amperes, the current sensed through R6, R5 and R4 in the RETURN line, turns Q2 on. When Q2 turns on, diode D1 is biased correctly; it draws current and shuts off the series pass transistor in E1, effectively shutting E1 off and stopping regulation. Also, as Q2 turns on, a voltage divider (R2, R1) turns on Q1. Transistor Q1 provides current to keep Q2 latched on. Now the +15 V line begins to decrease. When the base of Q1 reaches approximately 4 volts, Q1 shuts off, which turns Q2 off. This allows E1 to turn on again and begin a new cycle.

The overvoltage crowbar circuit consists of the following components: Zener diode D18, Q9, R37, R40, C13 and thyristor Q8.

Under normal conditions, the trigger input to the thyristor (Q8) is at ground because the voltage across Zener diode D18 is too small to cause D18 to conduct. As the +15 V line approaches +18 Vdc, Zener diode D18 conducts, clamping the base of Q9 to +18 V. The emitter of Q9 (through current sensing resistor R37) continues to rise. When the emitter/base junction becomes forward biased, Q9 begins to turn on and pass current. A voltage drop is created across R40. This draws gate current and triggers the thyristor, turning it on. The thyristor shorts the +15 V output line to ground and remains on until

capacitor C10 discharges.

3.4.1.3 H7420 Clock Output

The LT CL line clock output (refer to circuit schematic C-CS-5411086-0-1) is derived from one leg of full-wave rectifier bridge D11, R22 and Zener diode D19. The clock output is a 0-to-4 volt square wave at the line frequency of the input power source (47 to 63 Hz). The clock output is used in the KL10-C to drive the KW11-L Line Time Clock Option, which mounts in slot F03 of the PDP-11/40 processor backplane. Operation of the KW11-L option is described in the KW11-L Line Time Clock manual.

3.4.1.4 H7420 AC LO and DC LO Sensing Circuits

A simplified diagram of the power sensing circuits is shown in Figure 3-9. A detailed schematic is shown on D-CS-5411086-0-1, sheet 3 of 4). The AC LO and DC LO signals warn the processor when a power failure is imminent, allowing the processor time to perform a power fail sequence. If an ac power failure (line power or power supply failure) exists, AC LO is asserted on the bus; AC LO is then followed by DC LO. Sufficient time exists between these two signals to allow storage of volatile data and the conditioning of peripherals.

The 20-33 Vac input from the secondary of H7420 transformer T1 is rectified and filtered by diode pack D11 and C8. Both sensing circuits operate in a similar manner; each contains a differential amplifier, FET switches and associated circuits.

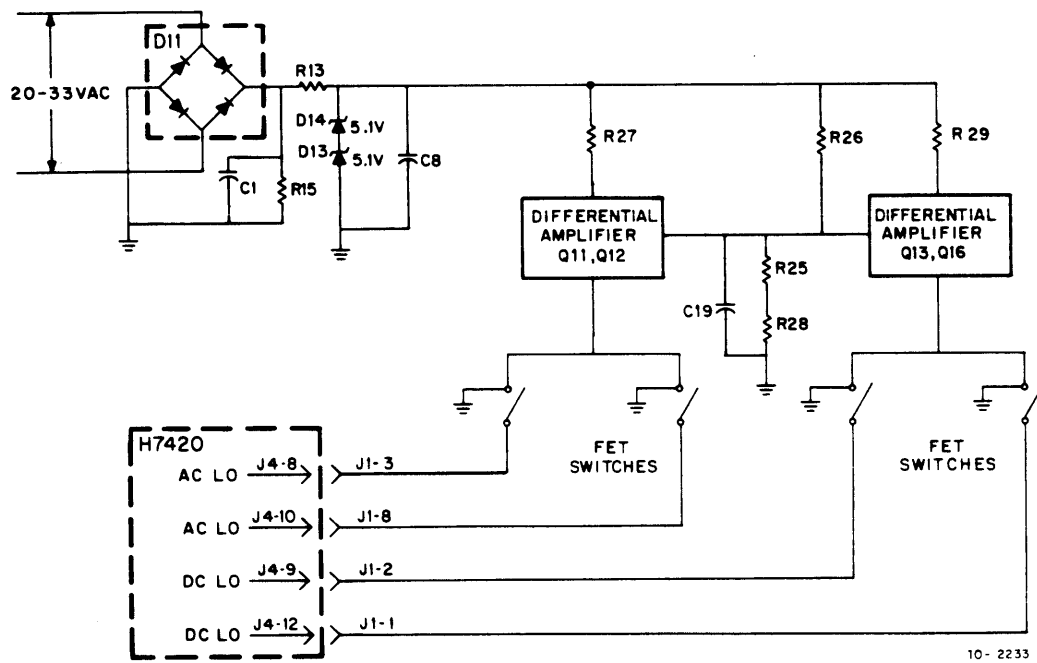
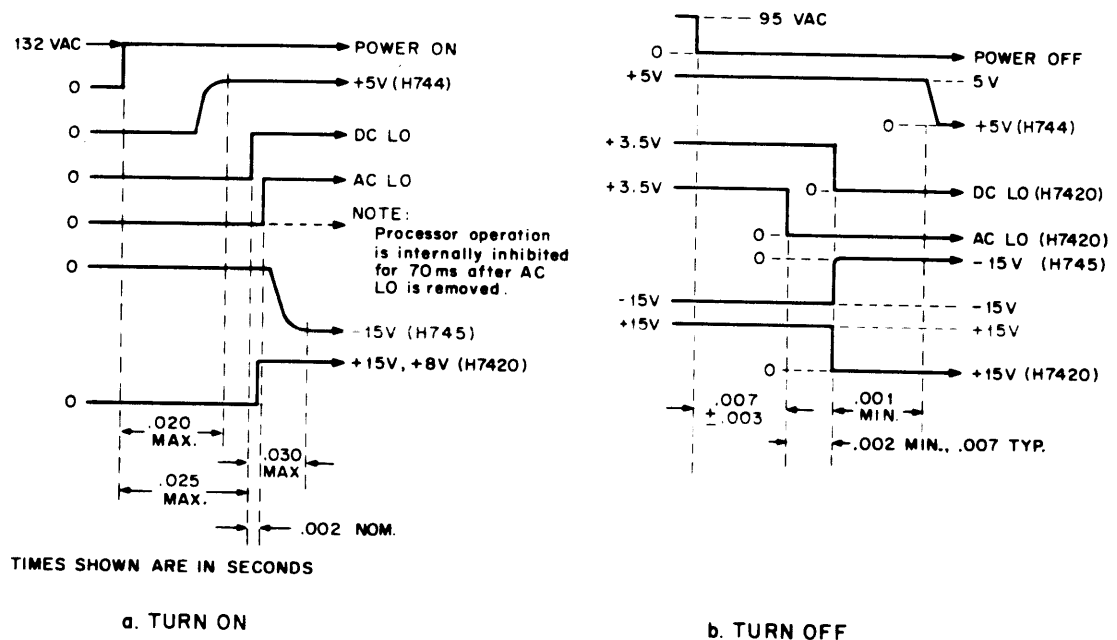


Figure 3-9 H7420 AC LO and DC LO Sensing Circuits,
Simplified Diagram

A common reference voltage (10.2 V) is derived by Zener diodes D13 and D14; resistor network R26, R25 and R28 places a fixed 4.3 Vdc (approximately) at the common base connection (Q13/Q12) between the two differential amplifiers. A major difference between the two amplifiers is that the base of Q11 in the AC LO circuit is at a slightly lower potential than that of Q16 in the DC LO differential amplifier circuit. The operation of both sensing circuits depends upon the voltage across C8. When AC LO is being sensed, capacitor C8 charges and discharges at a known rate whenever ac power is switched on or off. Thus, the voltage applied to the emitters of differential amplifier Q11/Q12 through R27 is a rising or falling waveform of known value. For example, when power fails or is shut down, the dc voltage decays at a known rate, as determined by the RC time constant. If the voltage decreases to approximately 20 Vdc, the base of Q11 becomes negative with respect to the base of Q12. The increased forward bias on Q11 causes it to conduct more and the resultant decrease in Q12 causes it to cut off. The removal of voltage at the collector of Q12 causes Q19 to conduct. This causes Q15 and Q18 to conduct, which grounds the AC LO lines (1 and 2) at pins 3 and 8. The AC LO signal is applied through the cable harness and processor backplane to the processor power fail initialize logic so that the power-fail sequence can be started.

The DC LO sensing circuit operates in a similar manner to the AC LO sensing circuit, with the primary difference being the voltage level at which it "trips."

For example, if the ac input starts to decrease as a result of either a power failure or shutdown, the AC LO lines are grounded before the DC LO lines are. As power is restored, the ground is removed from the DC LO lines before it is removed from the AC LO lines. The DC LO signal is also applied to the power-fail initialize logic. Figure 3-10 shows the H7420 power turn-on and turn-off sequences.



CP-2015

Figure 3-10 H7420 Power-Up and Power-Down Sequencing

3.5 H744 +5 VOLT REGULATOR

The H744 Regulator circuit is shown in the Field Maintenance Print Set (drawing D-CS-H744-0-1) and includes a regulator circuit, an overcurrent sensing circuit, and an overvoltage crobar circuit. The schematic shown is for a +5 Vdc Regulator, where output pins J1-2 and J1-5 provide +5 Vdc; pins J1-3 and J1-4 are grounded. To obtain a -5 Vdc regulated output at pins J1-3 and J1-4, pins J1-2 and J1-5 are grounded. The following paragraphs describe the positive regulator circuit, over-current sensing circuit and overvoltage crobar circuit.

3.5.1 Detailed Circuit Description

As shown in the schematic (D-CS-H744-0-1), the 20-30 Vac input from the associated H7420 Power Supply is rectified by full-wave bridge D1 to provide a dc voltage (24 to 40 Vdc, depending on line voltage) across filter capacitor C1 and bleeder resistor R1. This dc voltage is regulated by the circuit comprising transistors Q2 through Q5 and monolithic integrated circuit E1, which is a precision voltage regulator.

Filter capacitor C1 (31,000 uF) is used to obtain a delay of approximately 20 ms in the event of power failure.

3.5.1.1 H744 +5 V Regulator Circuit

Figure 3-11 is a simplified diagram of precision voltage regulator E1. This DEC723 integrated circuit comprises a temperature-compensated voltage reference amplifier, error amplifier, series-pass power transistor, and current limiter; V_{OUT} (pin 10) is not used in this application.

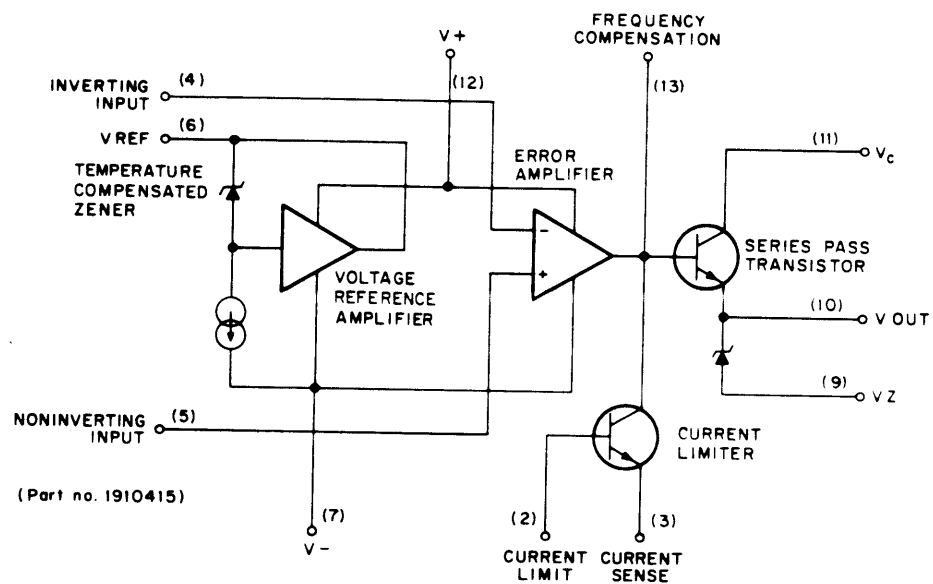


Figure 3-11 H744 Precision Voltage Regulator E1,
Simplified Diagram

The voltage applied to the base of the power transistor in E1 controls the current through that transistor, and subsequently controls the current flow through the other transistors (Q2 through Q5) in the overall voltage regulator circuit.

Q2 is a pass transistor; Q3 and Q4 are pre-drivers; and Q5 is a level shifter. Zener diode D2 is used with Q5 and R2 to provide +15 Vdc for E1. Most of the input voltage is absorbed across the collector-emitter of Q5. This is necessary because the raw input voltage is well above that required for E1 to operate. The +15 Vdc input to E1 is supplied while still retaining the ability to switch pass transistor Q2 on or off by drawing current down through the emitter of Q5.

The output circuit of the H744 Regulator is standard for most switching regulators and consists of "free-wheeling" diode D5, choke L1, and output capacitors C8 and C9. These components make up the regulator output filter. Free-wheeling diode D5 is used to clamp the emitter of Q2 to ground when Q2 shuts off, thus providing a decay path for L1.

In operation Q2 is turned on and off, generating a square-wave voltage which is applied across D5 at the input of the LC filter (L1, C8 and C9). This type of circuit is basically an averaging device, and the square-wave voltage appears as an average voltage at the output terminals.

By varying the Q2 conduction period, the output (average) voltage may be varied or controlled, thus supplying regulation. The output voltage is sensed and fed back to E1, where it is compared with a fixed reference voltage. E1 turns pass transistor Q2 on and off, according to whether the output voltage level decreases or increases. Defined upper and lower limits (see Figure 3-12) for the output are approximately +5.05 Vdc and +4.95 Vdc (i.e., 5 Vdc $\pm 1\%$).

During one full operation cycle, the regulator operates as follows: Q2 is turned on and a high voltage (approximately +30 Vdc) is applied across L1. If the output is already at a +5 Vdc level, then a constant +25 Vdc is present across L1. This constant dc voltage causes a linear ramp of current to build up through L1. At the same time, output capacitors C8 and C9 absorb this changing current and voltage, causing the output level (+5 V at this point) to increase. When the output (which is monitored by E1) reaches approximately +5.05 Vdc, E1 shuts off, turning Q2 off; the emitter of Q2 is clamped to ground. L1 current then decays through D5, which becomes forward biased by the back emf of L1. Pre-drivers Q3 and Q4 are used to increase the effective gain of Q2 to ensure that Q2 can be turned on and off in a relatively short period of time.

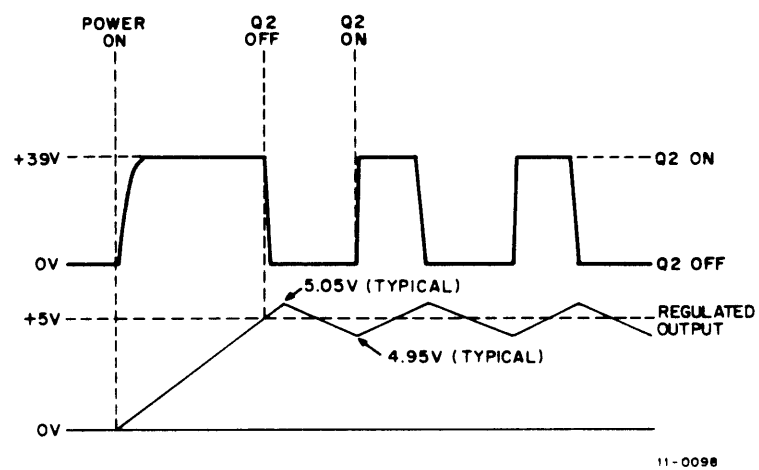


Figure 3-12 H744 Regulator Waveforms

Conversely, once Q2 is turned off and the output voltage begins to decrease, a predetermined value of approximately +4.95 Vdc is reached, causing E1 to turn on. This causes Q2 to conduct again, beginning another cycle of operation. Thus a ripple voltage is superimposed on the output and is detected as predetermined maximum (+5.05 Vdc) and minimum (+4.95 Vdc) values by E1. When +5.05 V is reached, E1 turns Q2 off and when +4.95 V is reached, E1 turns Q2 on. This type of circuit action is also referred to as a "ripple regulator."

3.5.1.2 H744 Overcurrent Sensing Circuit

The overcurrent sensing circuit consists of Q1, R3 through R6, R25, R26, Programmable UJT (PUT) Q7, and C4. Transistor Q1 is normally not conducting; however, if the output exceeds 30 amperes, the forward voltage across current sensing resistor R4 (0.02 ohms) is sufficient to turn Q1 on, causing C4 to begin charging. When C4 charges to a potential (present at the anode of PUT Q7) equal to the programmed fixed voltage at the gate to Q7, Q7 turns on. E1 is biased off, which turns pass transistor Q2 off. Thus, the output voltage is decreased as required to ensure that the output current is maintained below 35 amperes (approximately) and the regulator is "short-circuit" protected. The regulator continues to oscillate in this new mode until the overload condition is removed. Capacitor C4 then discharges until E1 is again allowed to turn on, and the cycle repeats.

3.5.1.3 H744 Overvoltage Crobar Circuit

The overvoltage crobar circuit consists of the following components: Zener diode D3, SCR D7, D8, R21, R22, R23, C7 and Q6.

Under normal conditions, the trigger input to the SCR (D7) is at ground because the voltage across Zener diode D3 is too small to cause D3 to conduct. As the +5 V line approaches +6 Vdc, Zener diode D3 conducts (D8 also), clamping the base of Q6 to 6 V. The emitter of Q6 (through current sensing resistor R21) continues to rise. When the emitter/base junction becomes forward biased, Q6 begins to turn on and pass current. A voltage drop is created across R23. It draws gate current and triggers the SCR (D7), turning it on. The SCR shorts the +5 V line to ground. The SCR remains on until capacitors C8 and C9 discharge.

3.6 H745 -15 VOLT REGULATOR

The H745 Regulator circuit is shown in the Field Maintenance Print Set (drawing D-CS-H745-0-1) and supplies regulated -15 volts. The following paragraphs describe the negative regulator circuitry.

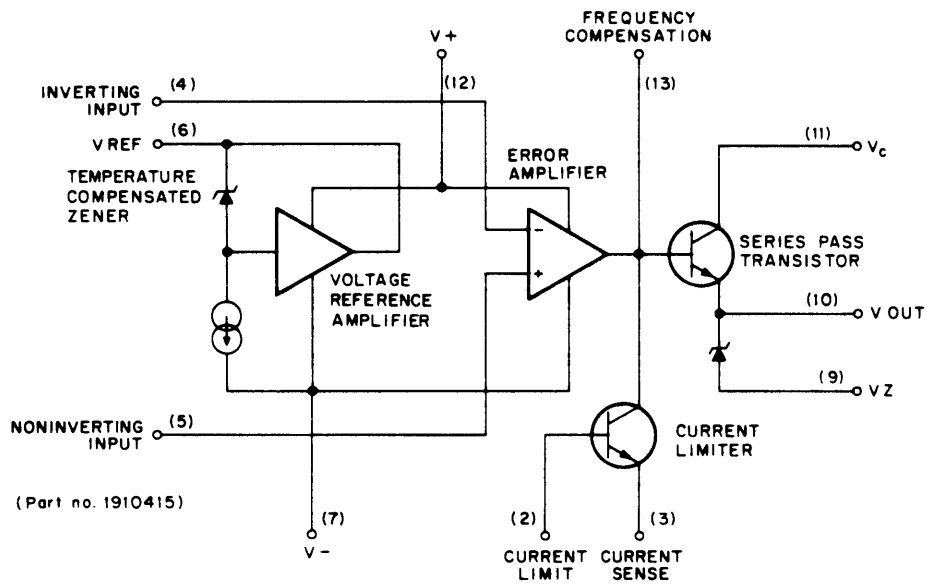
3.6.1 H745 Detailed Circuit Description

As shown in the schematic (D-CS-H745-0-1), the 20-30 Vac input from the associated H7420 Power Supply is rectified by full-wave bridge D1 to provide dc voltage (24 to 40 Vdc, depending on line voltage) across filter capacitor C1 and bleeder resistor R1. This dc voltage is regulated by the circuit comprising transistors Q2 through Q5 and monolithic integrated circuit E1, which is a precision voltage regulator.

Filter capacitor C1 (31,000 uF) is used to obtain a delay of approximately 20 ms in the event of a power failure.

3.6.1.1 H745 -15 Volt Regulator Circuit

Figure 3-13 is a simplified diagram of precision regulator E1. This DEC723 integrated circuit comprises a temperature-compensated voltage reference amplifier, error amplifier, series pass power transistor, and current limiter; V_{OUT} (pin 10) is not used in this application. The voltage applied to the base of the power transistor in E1 controls the current through that transistor, and subsequently controls the current flow through the other transistors (Q2 through Q5) in the overall voltage regulator circuit.



10-1976

Figure 3-13 H745 Precision Voltage Regulator E1,
Simplified Diagram

Transistor Q2 is a pass transistor; Q3 and Q4 are pre-drivers; and Q5 is a level shifter. Unlike the H744 Regulator, the H745 +15 V input required for correct E1 operation is derived from an external source; it is applied across C2 to E1. In addition, the inverting and noninverting inputs to E1 are reversed, as are the polarities of the various components. For example, Q5, which is used as a level shifter, is an NPN transistor in the +5 V H744 Regulator, but is a PNP in the H745 Regulator. This allows the H745 Regulator to operate below ground level (-15 Vdc). The output circuit of the H745 Regulator is standard for most switching regulators and consists of diode D4, choke L1 and output capacitors C8 and C9. These components make up the regulator output filter. Diode D4 is used to clamp the collector of Q2 to ground when Q2 shuts off, thus providing a decay path for L1.

Under normal conditions, regulator operation centers around linear regulator E1 and pass transistor Q2, which is controlled by E1. Transistor Q2 is turned on and off, generating a square-wave voltage which is applied across D4 at the input of the LC filter (L1, C8, and C9). This type circuit is basically an averaging device, and the square-wave voltage appears as an average voltage at the output terminals. By varying the Q2 conduction period, the output (average) voltage may be varied or controlled, thus supplying regulation. The output voltage is sensed and fed back to E1, where it is compared with a fixed reference voltage. E1 turns pass transistor Q2 on and off, according to whether the output voltage level increases or decreases.

Defined lower and upper limits (see Figure 3-14) for the output are approximately -15.15 Vdc and -14.85 Vdc (i.e., -15 Vdc $\pm 1\%$).

During one full operation cycle, the regulator operates as follows: Q2 is turned on and a high negative voltage (approximately -30 Vdc) is applied across L1. If the output is already at a -15 Vdc level, then a constant -15 Vdc is present across L1. This constant dc voltage causes a linear ramp of current to build up (more negative) through L1. At the same time, capacitors C8 and C9 absorb this changing current and voltage, causing the output level (-15 V at this point) to increase. When the output (which is monitored by E1) reaches approximately -15.15 Vdc, E1 shuts off, turning Q2 off; the collector of Q2 is clamped to ground. Choke L1 current then decays through D4, which becomes forward biased by the back emf of L1. Predrivers Q3 and Q4 are used to increase the effective gain of Q2 to ensure that Q2 can be turned on and off in a relatively short period of time.

Conversely, once Q2 is turned off and the output voltage begins to decrease (more positive), a predetermined value of approximately -14.85 Vdc is reached, causing E1 to turn on. This causes Q2 to conduct again, beginning another cycle of operation. Thus, a ripple voltage is superimposed on the output and is detected as predetermined maximum (-15.15 Vdc) and minimum (-14.85 Vdc) values by E1. When -15.15 V is reached, E1 turns Q2 off and when -14.85 V is reached, E1 turns Q2 on. This type of circuit action is also referred to as a "ripple regulator."

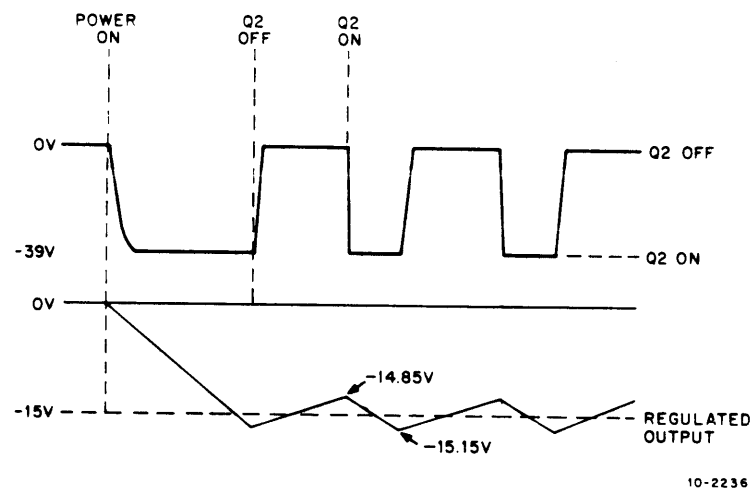


Figure 3-14 H745 Regulator Waveforms

3.6.1.2 H745 Overcurrent Sensing Circuit

The overcurrent sensing circuit consists of Q1, R2, R3, R18, R23, Programmable UJT (PUT) Q7 and C3. Transistor Q1 is normally not conducting; however, if the output exceeds 15 amperes, the forward voltage across current sensing resistor R2 (0.04 ohms) is sufficient to turn Q1 on, causing C3 to begin charging. When C3 charges to a potential (present at the gate of PUT Q7) equal to the anode potential of Q7, Q7 turns on. E1 is biased off, which turns pass transistor Q2 off. Thus, the output voltage is decreased as required to ensure that the output current is maintained below 10 amperes (approximately) and the regulator is "short-circuit" protected. The regulator continues to oscillate in this new mode until the overload condition is removed. Capacitor C3 then discharges until E1 is again allowed to turn on, and the cycle repeats.

3.6.1.3 H745 Overvoltage Protection

The overvoltage crobar circuit consists of the following components: Zener diode D6, SCR D5, R19, R20, R21, C7, C11, and Q6.

Under normal conditions, the trigger input to the SCR (D5) is close to -15 V because the voltage drop across Zener diode D6 is too small to cause D6 to conduct. As the -15 V line approaches -18 Vdc, Zener diode D6 conducts, clamping approximately 3 V at the base of Q6. The emitter (through current sensing resistor R19) appears to rise, although it is

the base that is actually becoming more negative as the -15 V line goes more negative. When the base/emitter junction of Q6 becomes biased correctly, Q6 turns on. A voltage drop is created across R21. It draws gate current and triggers the SCR (D5), turning it on. The SCR shorts the -15 V line to ground, stopping output. The SCR remains on until capacitors C8 and C9 discharge.

3.7 H754 +20, -5 VOLT REGULATOR

The H754 Regulator circuit is shown in the Field Maintenance Print Set (drawing D-CS-H754-0-1) and includes a regulator circuit, two shunt regulator circuits, an overcurrent sensing circuit and an overvoltage crobar circuit. With pin J1-2 grounded, pin J1-5 outputs +20 Vdc and pin J1-3 outputs -5 Vdc. The following paragraphs describe the regulator, shunt regulator, overcurrent sensing and overvoltage crobar circuitry.

3.7.1 Detailed Circuit Description

As shown in the schematic (D-CS-H754-0-1), the ac input (20-30 Vac) from an associated H7420 Power Supply connects to pins J1-7 and J1-8. In addition to providing full-wave rectification, this input circuit is a voltage doubler, boosting the rectified ac to approximately 50-60 Vdc. The dc voltage is regulated by the circuit comprising Q2, Q3, Q5 and monolithic integrated circuit E1, which is a precision voltage regulator.

3.7.1.1 H754 +20, -5 V Regulator Circuit

Figure 3-15 is a simplified diagram of precision voltage regulator E1. This DEC723 integrated circuit comprises a temperature-compensated voltage reference amplifier, error amplifier, series pass power transistor, and current limiter; V_{OUT} (pin 10) is not used in this application. The voltage applied to the base of the power transistor in E1 controls the current through that transistor, and subsequently controls the current flow through the other transistors (Q2, Q3, and Q5) in the overall voltage regulator circuit.

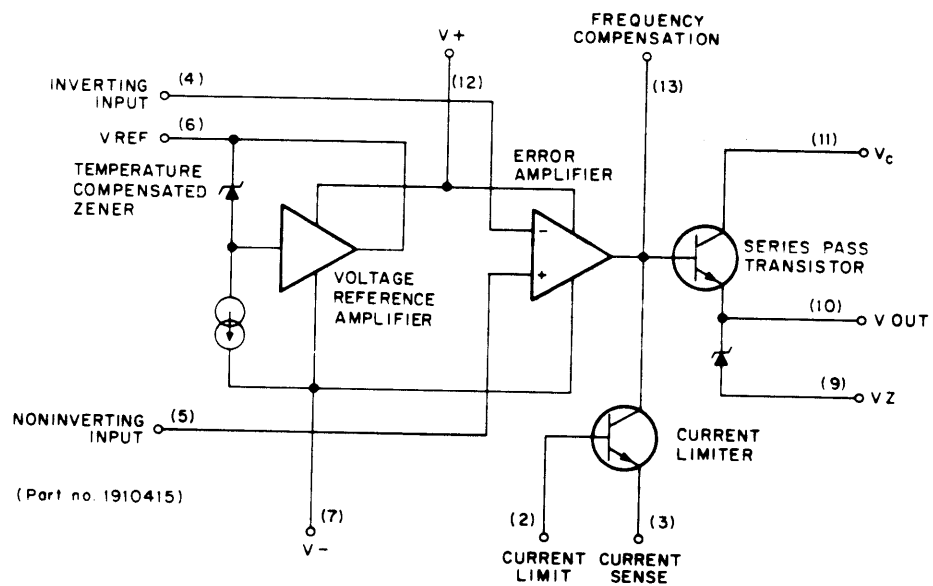


Figure 3-15 H754 Precision Voltage Regulator E1,
Simplified Diagram

Transistor Q2 is a pass transistor; Q3 is a pre-driver; and Q5 is a level shifter. Zener diode D3 is used with Q5 and R3 to provide +15 Vdc (V_C) for E1. Most of the input voltage is absorbed across the collector-emitter of Q5. This is necessary because the raw input voltage is well above that required for E1 to operate. The +15 Vdc input to E1 is supplied while still retaining the ability to switch pass transistor Q2 on and off by drawing current down through the emitter of Q5.

The output circuitry consists of two shunt regulator circuits: one for the +20 V output, the other for the -5 V output. The +20 V shunt regulator comprises transistors Q4, Q10, and Q11; the -5 V shunt regulator comprises transistors Q6 and Q9. Both Q10 and Q9 are pass transistors.

The basic regulator output is +25 V (-5 Vdc to +20 Vdc). The shunt regulators are connected across this output, with a connection to ground between pass transistors Q9 and Q10. Circuitry for this output consists of diode D6, choke L1 and output capacitors C9 and C16. These components make up the regulator output filter. Diode D6 is used to clamp the emitter of Q2 toward -5 V when Q2 shuts off, thus providing a decay path for L1.

In operation, Q2 is turned on and off, generating a square-wave voltage which is applied across D6 at the input of the LC filter (L1, C9 and C16). This type circuit is basically an averaging device, and the square-wave voltage (+25 V) appears as an average voltage at the input to the shunt regulators.

By varying the Q2 conduction period, the output (average) voltage may be varied or controlled, thus supplying regulation. The output voltage (+25 V) is sensed by E1, where it is compared with a fixed reference voltage. E1 turns pass transistor Q2 on or off, according to whether the output voltage level decreases or increases.

During one full operation cycle, the regulator operates as follows: Q2 is turned on and a high voltage (approximately 60 Vdc because of the voltage doubler input) is applied across L1. If the basic regulator output (before the two shunt regulators) is already at a +25 Vdc level (-5 V to +20 V), then a constant +35 Vdc is present across L1. This constant voltage causes a linear ramp of current to build up through L1. Coincident with this current build-up, output capacitors C9 and C16 absorb the changing current and voltage, causing the output level (+25 V at this point) to increase. When the output (which is monitored by E1) reaches approximately 26 Vdc, E1 shuts off, turning Q2 off; the emitter of Q2 is clamped toward -5 V. L1 current then decays through D6, which becomes forward biased by the back emf of L1. Pre-driver Q3 is used to increase the effective gain of Q2 to ensure that Q2 can be turned on and off in a relatively short period of time.

Conversely, once Q2 is turned off and the output voltage begins to decrease, a predetermined value of approximately 24 Vdc is reached, causing E1 to turn on.

This causes Q2 to conduct again, beginning another cycle of operation.

The voltages at the bases of Q6 and Q4 (in the two shunt regulator circuits) vary with respect to ground, depending on the relative amount of current drawn from the +20 V and -5 V regulator outputs. If the +20 V current increases while the -5 V current remains constant, the output voltage at the +20 V output tends to go more negative with respect to ground; this causes the -5 V output to go more negative also because the output of the basic regulator is fixed at +25 Vdc. This change is sensed at the bases of Q6 and Q4. Transistor Q6 conducts, causing Q9 to begin conducting, thus increasing the current between the -5 V and ground tabs until the balance between the +20 V and -5 V output is restored. When this condition is met, Q6 ends conducting; Q4 was not conducting during this period. If the -5 V current increases, transistors Q4 and Q10 conduct to balance the outputs.

3.7.1.2 H754 Overcurrent Sensing Circuit

The overcurrent sensing circuit consists of Q1, Programmable UJT (PUT) Q8, Q13, Q14, R4, and associated circuitry.

Transistor Q1 is normally not conducting; however, if the total peak current exceeds approximately 14 amperes, the forward voltage across current sensing resistor R4 (0.04 ohms) turns Q1 on.

This establishes a voltage across R7 and R38 sufficient to fire PUT Q8. The voltage on pin 4 of E1 is then pulled above the reference voltage (E1, pin 5), thereby shutting off Q2. Now diode D6 conducts and the current through R37 turns on Q14, which turns on Q13. This keeps Q8 on for a period determined by the output voltage and L1. In turn, this action allows the off-time of Q2 to be greater than the on-time. The off-time increases as the overload current increases, changing the duty cycle in proportion to the load. The output current is thus limited to approximately 10 amperes.

3.7.1.3 H754 Overvoltage Crobar Circuits

Two crobar circuits are employed in the H754: one for the +20 V regulator and one for the -5 V regulator.

The +20 V overvoltage crobar circuit consists of the following components: Zener diode D7, SCR D9, R23, R24, R25, C7 and Q7. Under normal conditions, the trigger input to the SCR (D9) is at -5 V because the voltage across Zener diode D7 is too small to cause D7 to conduct. As the +20 V line approaches +24 Vdc, Zener diode D7 conducts, clamping the base of Q7 to +24 V. The emitter (through current sensing resistor R23) continues to rise. When the emitter/base junction becomes biased properly, Q7 begins to turn on. A voltage drop is created across R25. It draws gate current and triggers the SCR (D9), turning it on. The SCR shorts the +20 V line to the -5 V line and, through D3, also shorts the +15 volt source to E1 and Q5.

When E1 loses +15 V (V_C), it shuts off which shuts off Q2, thus stopping output. The SCR remains on until the capacitor (C9) discharges.

The -5 V overvoltage crowbar circuit functions in a similar manner. Under normal conditions, Zener diode D14 does not conduct. As the -5 V line increases (more negative), D14 turns on and clamps the base of Q12. As the -5 V line continues to increase, Q12 begins to turn on. As Q12 turns on, a voltage drop is again created across R25. It triggers the SCR which then shorts the -5 V line to the +20 V line. The SCR remains on until the capacitor (C9) discharges.

3.7.1.4 H754 Voltage Adjustments

The +20 V adjustment (R17) is located on the side of the H754; the -5 V potentiometer (R21) is on the top, next to the connector. To set the output voltages, power down the system, disconnect the load, power up, adjust for a 25 V reading between the +20 and -5 V outputs with the 20 V potentiometer (R17). Then set the -5 V line between its output and ground. Power down, reconnect the load, power up, and check and adjust the outputs again. This procedure is necessary because the +20 V potentiometer (R17) actually sets the overall output of the H754 Regulator (i.e., 25 V, from +20 V to -5 V), while the -5 V adjustment (R21) controls the -5 V to ground output.

3.8 H770 +15 VOLT REGULATOR

The H770 Regulator circuit is shown in the Field Maintenance Print Set (drawing D-CS-5411207-0-1) and includes a remote on/off crobar circuit, a regulator circuit, an overcurrent sensing circuit and an overvoltage crobar circuit.

3.8.1 Detailed Circuit Description

As shown in the schematic (D-CS-5411207-0-1), the 20-30 Vac input from the associated H7420 Power Supply is rectified by full-wave bridge D1 to provide a dc voltage (24-40 Vdc, depending on line voltage) across filter capacitor C1 and bleeder resistor R1. This dc voltage is regulated by the circuit comprising Q3 through Q6 and monolithic integrated circuit E1, which is a precision voltage regulator.

Filter capacitor C1 (31,000 uF) is used to obtain a delay of approximately 20 ms in the event of a power failure.

3.8.1.1 H770 +15 V Regulator Circuit

Figure 3-16 is a simplified diagram of precision voltage regulator E1. This DEC723 integrated circuit comprises a temperature-compensated voltage reference amplifier, error amplifier, series-pass power transistor, and current limiter; V_{OUT} (pin 10) is not used in this application. The voltage applied to the base of the power transistor in E1 controls the current through that transistor, and subsequently controls the current flow through the other transistors (Q3 through Q6) in the overall voltage regulator circuit. Q3 is a pass-transistor; Q4 and Q5 are pre-drivers; and Q6 is a level shifter.

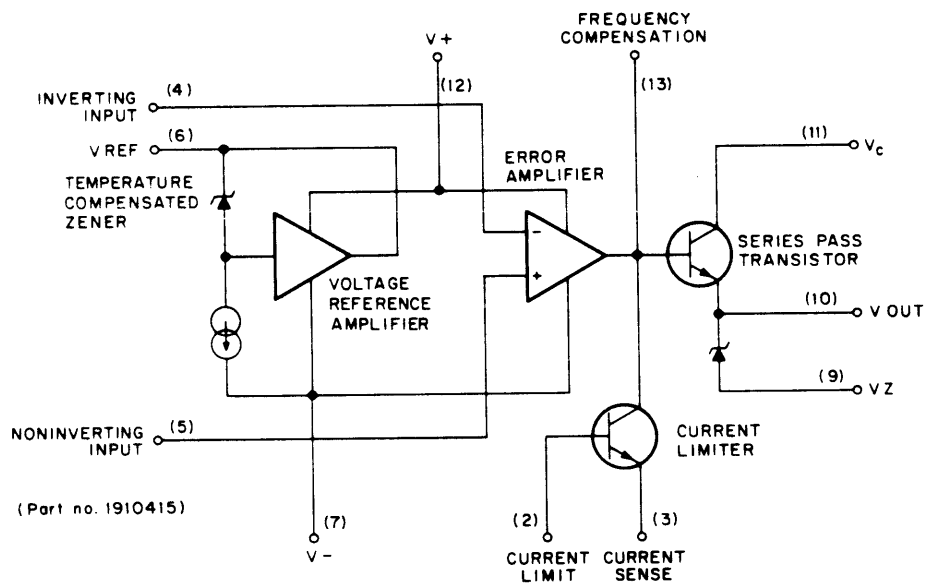


Figure 3-16 H770 Precision Voltage Regulator E1,
Simplified Diagram

Transistor Q2 is a switching transistor that controls the application of +15 Vdc to E1. Q2 turns on only after the 2040 System has been energized by the 863 Power Control for approximately five (5) seconds; this ensures the cooling fans are up to speed. When Q2 turns on, the +15 V derived from Zener diode D2 is passed to E1. However, most of this input voltage to E1 is absorbed across the collector/emitter of Q6. This is necessary because the raw input voltage is well above that required for E1 to operate. The +15 Vdc input to E1 is supplied while still retaining the ability to switch pass transistor Q3 on or off by drawing current down through the emitter of Q6.

Transistor Q8 provides remote turn-on for the crobar circuit. A ground at J1-1 turns Q8 off which, in turn, turns both Q2 and Q6 off. With Q6 off, Q3 is held off and no +15 Vdc regulated output appears at J1-3/J1-5. When the crobar signal is removed (i.e., an open at J1-1), Q8 is turned on, resulting in Q3 turning on; +15 V is applied to output pins J1-3/J1-5.

The output circuitry of the H770 Regulator is standard for most switching regulators and consists of "free-wheeling" diode D3, choke L1, and output capacitors C8 and C9. These components make up the regulator output filter. Free-wheeling diode D3 is used to clamp the emitter of Q3 to ground when Q3 shuts off, thus providing a decay path for L1.

In operation, Q3 is turned on and off, generating a square-wave voltage which is applied across D3 at the input of the LC filter (L1, C8 and C9). This type circuit is basically an averaging device and the square-wave voltage appears as an average voltage at the output terminals. By varying Q3 conduction period, the output (average) voltage may be varied or controlled, thus supplying regulation. The output voltage is sensed and fed back to E1, where it is compared with a fixed reference voltage. E1 turns pass transistor Q2 on and off, according to whether the output voltage level decreases or increases. Defined upper and lower limits (see Figure 3-17) for the output are approximately +15.45 Vdc and +14.55 Vdc (i.e., +15 Vdc $\pm 3\%$).

During one full operation cycle, the regulator operates as follows: Q3 is turned on and a high voltage (approximately +30 Vdc) is applied across L1. If the output is already at a +15 Vdc level, then a constant +15 Vdc is present across L1. At the same time, C8 and C9 absorb this changing current and voltage, causing the output level (+15 V at this point) to increase. When the output (which is monitored by E1) reaches approximately +15.45 Vdc, E1 shuts off, turning Q3 off; the emitter of Q3 is clamped to ground. L1 current then decays through D3, which becomes forward biased by the back emf of L1. Pre-drivers Q4 and Q5 are used to increase the effective gain of Q3 to ensure that Q3 can be turned on and off in a relatively short period of time.

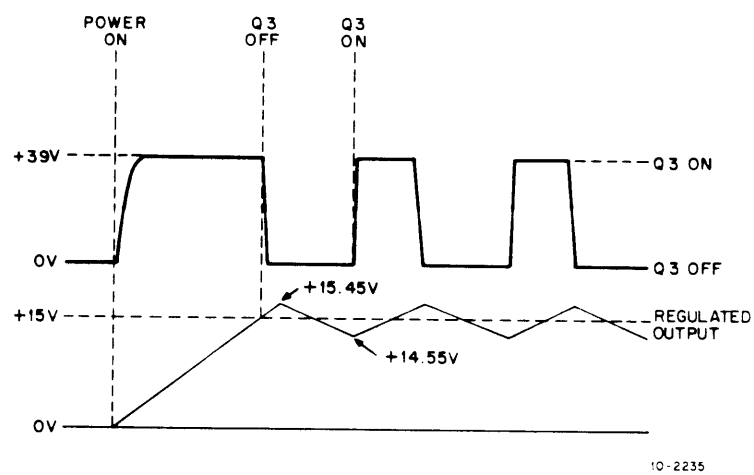


Figure 3-17 H770 Regulator Waveforms

Conversely, when Q3 is turned off and the output voltage begins to decrease, a predetermined value of approximately +14.45 Vdc is reached, causing E1 to turn on. This causes Q3 to conduct again, beginning another cycle of operation. Thus, a ripple voltage is superimposed on the output and is detected as predetermined maximum (+15.45 Vdc) and minimum (+14.55 Vdc) values by E1. When +15.45 V is reached, E1 turns Q3 off and when +14.55 V is reached, E1 turns Q3 on. This type of circuit is also referred to as a "ripple regulator."

3.8.1.2 H770 Overcurrent Sensing

The overcurrent sensing circuit consists of Q1, R3 through R5, R20 through R22, Programmable UJT (PUT) Q9, and C4. Transistor Q1 is normally not conducting; however, if the output exceeds 20 amperes, the forward voltage across current sensing resistor R4 (0.03 ohms) is sufficient to turn Q1 on, causing C4 to begin charging. When C4 charges to a potential (present at the anode of PUT Q9) equal to the programmed fixed voltage at the gate of Q9, Q9 turns on. E1 is biased off, which turns pass transistor Q3 off. Thus, the output voltage is decreased as required to ensure that the output current is maintained below 25 amperes (approximately) and the regulator is "short-circuit" protected. The regulator continues to oscillate in this new mode until the overload condition is removed. Capacitor C4 then discharges until E1 is again allowed to turn on, and the cycle repeats.

3.8.1.3 H770 Overvoltage Crobar Circuit

The overvoltage crobar circuit consists of the following components: Zener diode D5, SCR D4, D12, R13, R14, R15, C7 and Q7.

Under normal conditions, the trigger input to the SCR (D4) is at ground because the voltage across Zener diode D5 is too small to cause D5 to conduct. As the +15 V output line approximately +18.6 Vdc, Zener diode D5 conducts (D12 also), clamping the base of Q7 to +18.6 Vdc. The emitter of Q7 (through current sensing resistor R13) continues to rise. When the emitter-base junction becomes forward biased, Q7 begins to turn on and pass current. A voltage drop is created across R14. It draws gate current and triggers the SCR (D4), turning it on. The SCR shorts the +15 V line to ground. The SCR remains on until capacitors C8 and C9 discharge.

3.9 H760 POWER SUPPLY

Two models of the H760 Power Supply are available:

1. H760A - 120 Vac, 3-phase @ 60 Hz
2. H760B - 240 Vac, 3-phase @ 50 Hz

Basically, two main differences between the two power supply models exist:

H760A	H760B
Diode assembly fans obtain 208 Vac from phase A and phase B lines.	Diode assembly fans obtain 240 Vac from phase B and neutral lines.
Primary windings of transformers T1, T2 and T3 have connections at input terminals 1 and 2.	Primary windings of transformers T1, T2 and T3 have connections at input terminals 1 and 4, plus a jumper between terminals 2 and 3.

The H760A and H760B Power Supply schematics are shown in the Field Maintenance Print Set (drawings D-CS-H760A-0-1 and D-CS-H760B-0-1, respectively). The following paragraphs reference those schematics and some additional simplified drawings.

3.9.1 Detailed Circuit Description

Ferroresonant transformers are used to regulate changes in line voltage.

The transformer primaries are wired in a 3-phase delta, while the outputs are wired for 3-phase full-wave operation (see Figure 3-18). The outputs of the transformers are essentially square waves, which are diode rectified. Outputs of the H760A change by approximately 1.5 volts due to line (+10% - 30%) and load (25% - 100%) variations. With the Capacitor Assembly (7009878) added to the -11 Vdc output, the power supply is capable of a 20 ms energy holdup when input power is removed. The 20 ms holdup for the +15 Vdc outputs is provided by filter capacitors C1 and C2 (50,000 uF and 30,000 uF, respectively).

Figure 3-19 shows the distribution of power to the fans in the H760A and H760B. When the primary power input is 120 Vac, 60 Hz, then 208 Vac power is applied to the diode assembly fans in the H760A from the phase A and phase B lines. That identical voltage (208 Vac) is also applied to (through J1-1 and J1-2) to the fans in the CPU cabinet. Only 120 Vac is applied to the ceiling fans in the CPU cabinet via J1-3 and J1-7. In the case of the H760B, 240 Vac is applied to the diode assembly fans; 240 Vac is applied to the fans in the CPU cabinet (through J1-1 and J1-2); and 240 Vac is applied to the ceiling fans in the CPU cabinet.

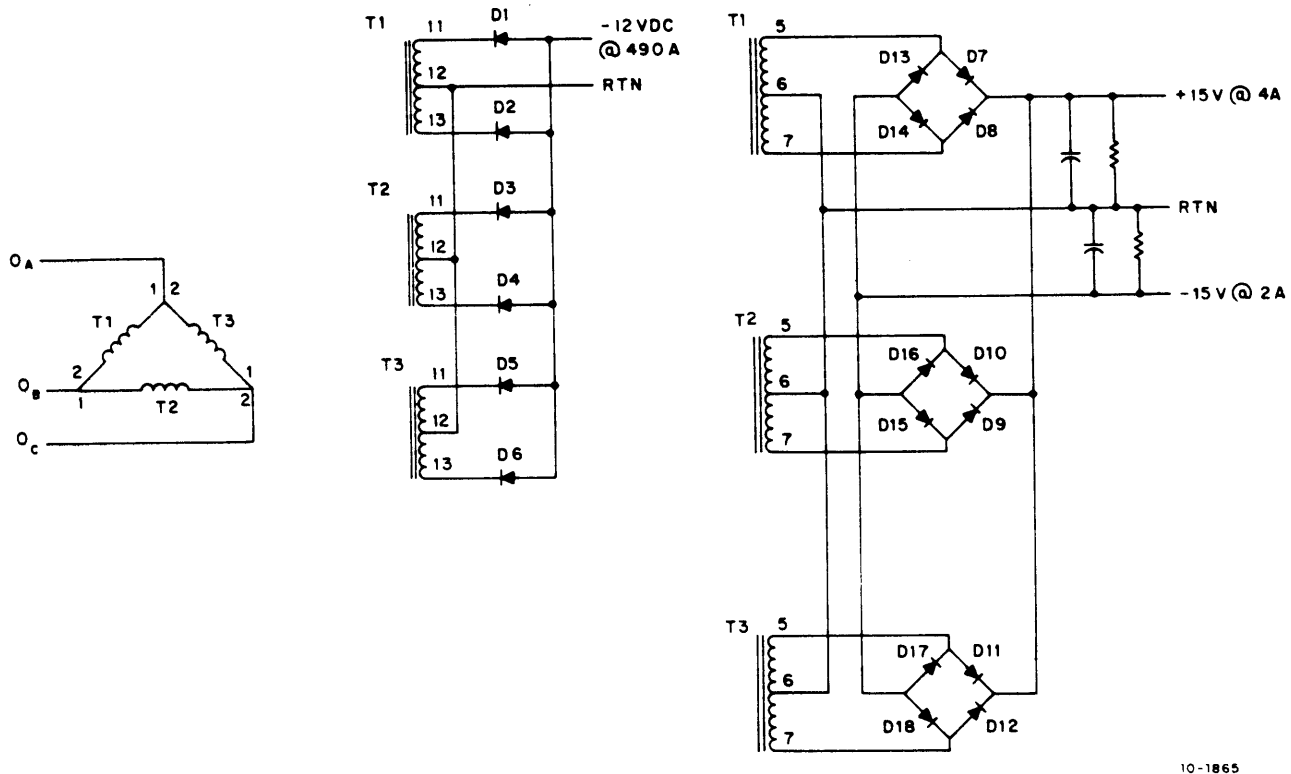
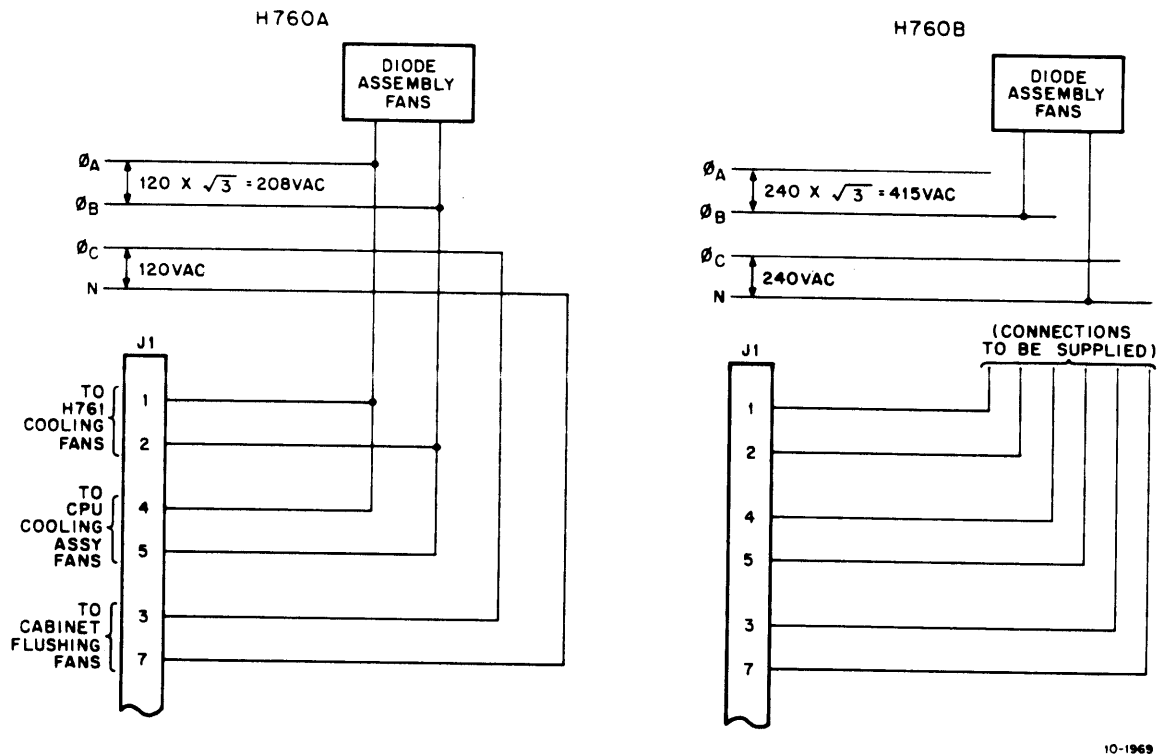


Figure 3-18 H760A Power Supply, Simplified Schematic



10-1969

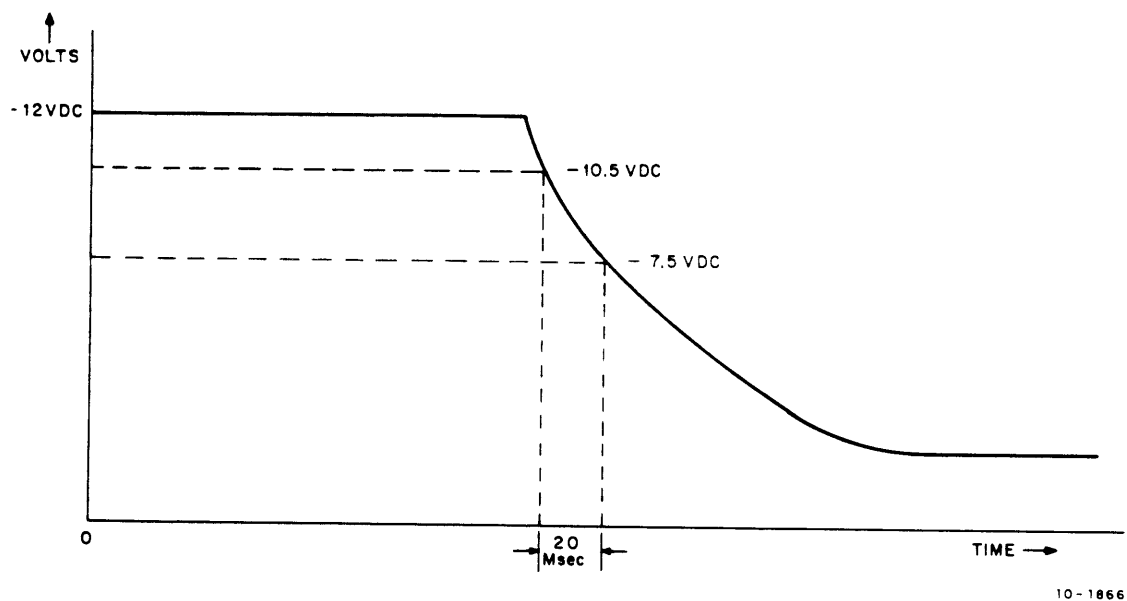
Figure 3-19 Distribution of Power to Fans in H760A and H760B

3.10 CAPACITOR ASSEMBLY

The Capacitor Assembly is shown in the Field Maintenance Print Set (E-AD-7009878-0-0 and D-CS-7009475-0-1). The following paragraphs reference the circuit schematic.

3.10.1 Detailed Circuit Schematic

The Capacitor Assembly is connected between the H760 Power Supply and the H761 Series Pass Assembly. Thirteen (13) 0.3 Farad capacitors are connected in parallel to achieve an overall capacitance of 3.9 Farads. The output voltage under full load is approximately -11 Vdc $\pm 10\%$ when the assembly is connected to the H761. When the input voltage to the Capacitor Assembly drops below this value (e.g., during normal shut-down or a power failure), the capacitors discharge exponentially through the parallel resistance load, which is only a fraction of an ohm (see Figure 3-20). A delay of 20 ms is thus obtained before the discharge voltage decays to a value of about -7.5 Vdc. During this 20 ms period, critical information may be appropriately stored in memory for reuse after power restoration.



10-1866

Figure 3-20 Capacitor Discharge Curve

3.11 H761 SERIES PASS ASSEMBLY

The function of the H761 is to convert the unregulated, single -11 Vdc input from the H760 and Capacitor Assembly (D-CS-7009475-0-1) into thirteen (13) separate, highly regulated negative outputs to the 2040 CPU. These outputs include nine (9) -5.2 Vdc lines and four (4) -2.0 Vdc lines, as shown in Figure 3-21.

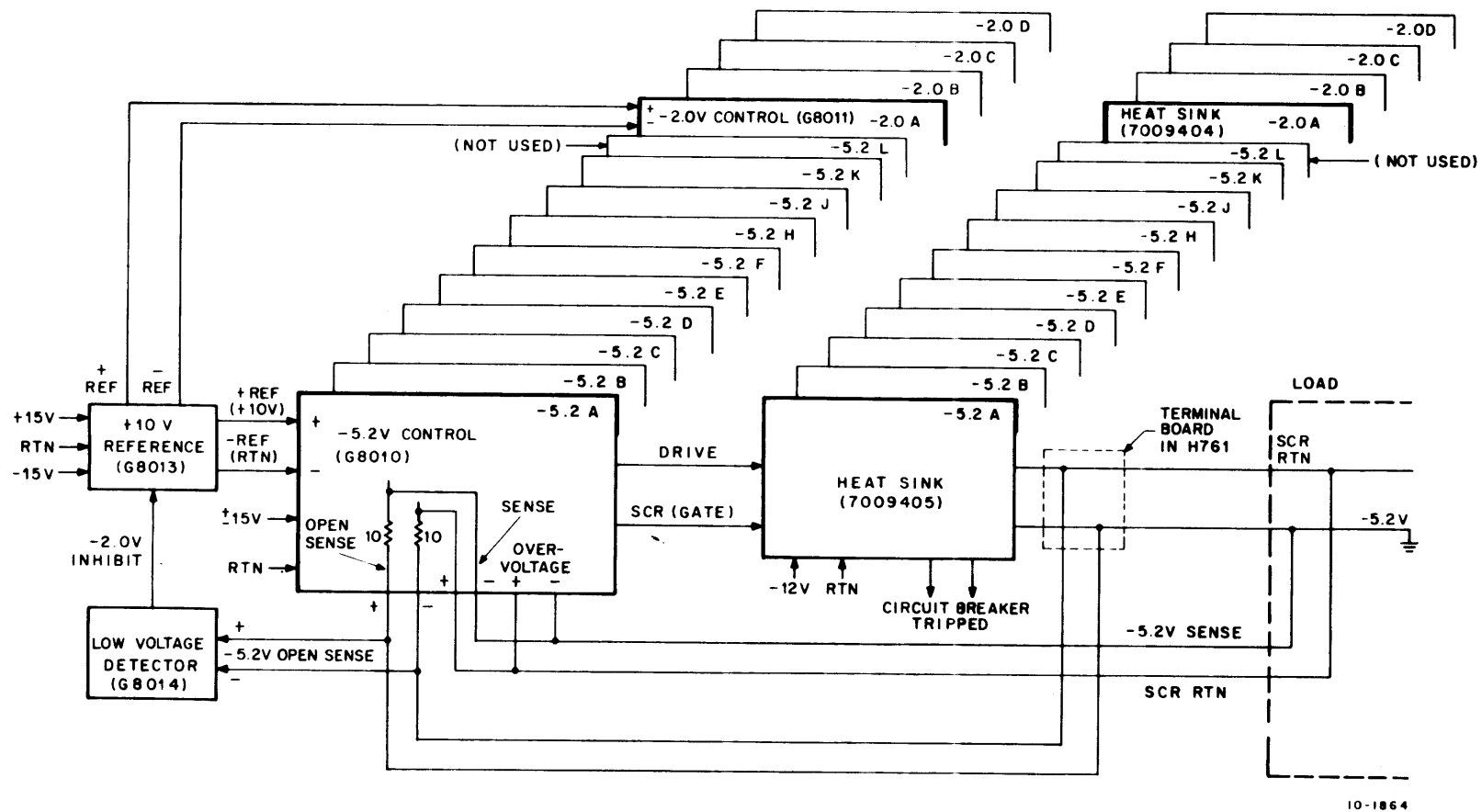
The -5.2 Vdc outputs are labelled A, B, C, D, E, F, H, J, and K; the -2.0 Vdc outputs are labelled A, B, C, and D.

3.11.1 Detailed Circuit Description

The H761 Series Pass Assembly comprises six subassemblies:

Quantity	Subassembly	Name
1	G8013	+10 V Reference (Quad)
3	G8010	-5.2 V Control (Triple)
2	G8011	-2.0 V Control (Triple)
3	7009405	-5.2 V Heat Sink Ass'y (Quad)
2	7009404	-2.0 V Heat Sink Ass'y (Dual)
1	G8014	DC Low Voltage Detector

The +15 Vdc from the H760 Power Supply is input to the +10 V Reference and to all of the -5.2 V and -2.0 V Control Circuits. The -12 Vdc from the Capacitor Assembly is input to each -5.2 V and -2.0 V Heat Sink.



A +10 V reference voltage is supplied to each -5.2 V and -2.0 V Control. The reference voltage to the -5.2 V Controls is labelled \pm REF B; the one to the -2.0 V Controls is labelled \pm REF C.

The outputs of each control circuit comprise a drive signal and an SCR gate, which are applied to an associated heat sink. The output of each heat sink is applied to the CPU (load). Because lines are tied from the load back to the -5.2 V and -2.0 V Controls, an overvoltage detector is present in each Control circuit that is tied directly to the sense lines. A set of "open sense" lines is connected between each heat sink output and its associated Control circuit. A 10 ohm resistor separates the sense and "open sense" lines. The purpose of the "open sense" lines is to protect the -5.2 V and -2.0 V regulators in the event a sense line is broken or disconnected at the load.

Direct connections are made between the "open sense" lines on the -5.2 V controls and the dc low voltage detector. A single output from the dc low voltage detector is fed back to the +10 V Reference. This output is an inhibit signal which ensures that the -2.0 V regulators are turned on and off at the proper time, with respect to the -5.2 V regulators.

3.11.1.1 +10 V Reference (G8013)

Two identical circuits are utilized on the G8013 +10 V Reference board, with outputs labelled \pm REF B and \pm REF C. In the 2040 system configuration, the \pm REF C output is applied to the -2.0 V Controls; the \pm REF B output is applied to the -5.2 V controls.

Consider the operation of the \pm REF C circuit, as shown in Figure 3-22. The reference output is +10 Vdc when +6.2 V appears on both pins 3 and 2 of E1 (i.e., when the differential input to E1 is approximately zero Volts). Pin 3 of E1 is at 6.2 V because of the Zener diode. If the reference voltage decreases, pin 2 of E1 drops below +6.2 V, and the output of E1 (pin 6) goes positive. This causes Q1 to conduct, thereby causing Q2 to conduct more, increasing the reference voltage and pulling up pin 2. If the reference voltage increases above +10 Vdc, pin 2 of E1 goes above +6.2 V. As a result, Q1 causes the reference voltage and the voltage on pin 2 of E1 to decrease to the desired level.

To properly sequence the -5.2 and -2.0 control voltages, it is necessary that the -2.0 V regulators be turned on after the -5.2 V regulators and off before the -5.2 V regulators. This is accomplished by means of the inhibit line which controls the operation of Q6. When the inhibit line is activated, Q6 is turned on, clamping the 6.2 V Zener, and effectively bringing the +10 V reference output to about 0.5 Volt. When the inhibit is removed, Q6 is turned off and the +10 V reference is applied to the -2.0 V Controls. The \pm REF B circuit, which furnishes a +10 V reference to the -5.2 Controls, has its inhibit line permanently grounded, so that the Q6 equivalent is always turned off. (See Section 3.11.1.6 for more details of inhibit operation).

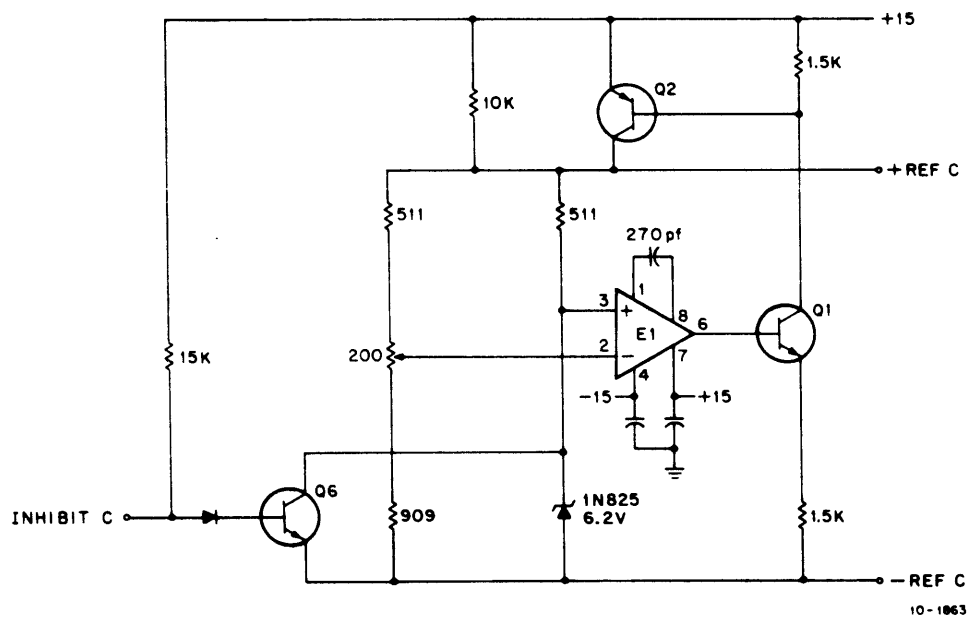


Figure 3-22 +10 V Reference, Simplified Schematic of +REF C Circuit

3.11.1.2 -5.2 Vdc Controls (G8010)

Referring to drawing D-CS-G8010-0-1, notice that there are three identical circuits on each subassembly. Three such subassemblies provide the nine -5.2 V regulator circuits necessary for 2040 operation. Each circuit includes a regulator and an overvoltage detector.

Refer to Figure 3-23, the -5.2 Vdc Control Circuit. The +REF point is at +10 Vdc, while the -SENSE point is at -5.2 Vdc. Pin 3 of E1 is at 0 Vdc because of the voltage dividing effect of the 10K and 5.2K resistors. Pin 2 of E1 is at ground because the -REF and +SENSE points are grounded. If the -5.2 V goes more negative, pin 3 of E1 goes more negative, and the E1 output (pin 6) follows. This causes Q2 to conduct less, thereby decreasing the current through Q1, which is the drive for the associated heat sink. If the -5.2 V goes less negative, the reverse occurs, and the current through Q1 increases. Thus, the drive current increases or decreases with fluctuations in the load.

Overvoltage detection is provided to protect against an inadvertent short circuit of a more negative supply to the -5.2 V lines. As the -0. V. (Minus Overvoltage) point goes more negative, the base of Q9 goes more negative, turning it on. The gate of the SCR in the associated heat sink goes more positive and turns on the SCR, thereby clamping the -5.2 V lines to approximately -1.5 Volts. The SCR remains on until the current through it is removed by tripping a circuit breaker in the H761 or in the supply shorted to it.

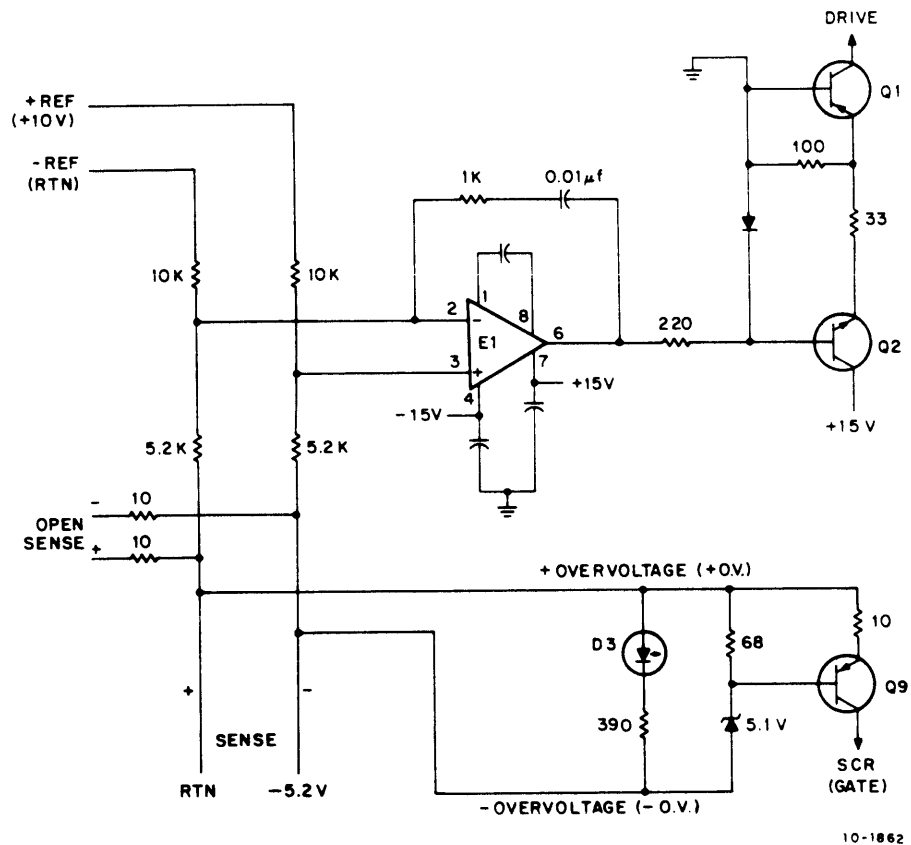


Figure 3-23 Typical G8010 -5.2 Vdc Control Circuit,
Simplified Schematic

The LED in the overvoltage circuit (diode D3) provides an indication that the supply has output voltage. It also aids in determining which module and which regulator has no output. As long as voltage is present at the associated output, the LED remains on.

If the sense leads are open, the output goes to maximum voltage (-11 V), tripping the overvoltage circuit. To prevent this, a 10 ohm resistor is added between each of the sense leads and the output of the heat sink. Thus, if a sense lead is broken or disconnected, the output of the supply only increases by approximately 300 mV.

3.11.1.3 -2.0 Vdc Controls (G8011)

Referring to drawing D-CS-G8011-0-1, notice that there are three identical circuits on each subassembly. Two such subassemblies provide the four (some remain unused) -2.0 V regulator circuits necessary for 2040 operation. Each circuit includes a regulator and an overvoltage detector.

Refer to Figure 3-24, the -2.0 Vdc Control Circuit. The +REF point is at +10 Vdc, while the -SENSE point is at -2.0 Vdc. Pin 3 of E1 is at 0 Vdc because of the voltage dividing effect of the 10K and 2K resistors. Pin 2 of E1 is at ground because the -REF and +SENSE points are grounded. If the -2.0 V goes more negative, pin 3 of E1 goes more negative, and the E1 output (pin 6) follows.

This causes Q2 to conduct less, thereby decreasing the current through Q1, which is the drive for the associated heat sink. If the -2.0 V goes less negative, the reverse occurs, and the current through Q1 increases. Thus, the drive current increases or decreases with fluctuations in the load.

Overvoltage detection is provided to protect against an inadvertent short circuit of a more negative supply to the -2.0 V lines. As the -0. V. (Minus Overvoltage) point goes more negative, the base of Q9 goes more negative, turning it on. The gate of the SCR in the associated heat sink goes more positive and turns on the SCR, thereby clamping the -2.0 V lines to approximately -1.5 Volts. The SCR remains on until the current through it is removed by tripping a circuit breaker in the H761 or in the supply shorted to it. The LED in the overvoltage circuit (diode D3) provides an indication that the supply has output voltage. It also aids in determining which module and which regulator has no output. The LED is continually on, as long as voltage is present at the associated output.

If the sense leads are open, the output goes to maximum voltage (-11 V), tripping the overvoltage circuit. To prevent this, a 10 ohm resistor is added between each of the sense leads and the output of the heat sink. Thus, if a sense lead is broken, or disconnected, the output of the supply increases by approximately 300 mV.

3.11.1.4 -5.2 V Heat Sink Assembly

A simplified schematic of one of the -5.2 V Heat Sink Assemblies (D-CS-7009405-0-1) is shown in Figure 3-25. Four identical circuits comprise the overall Assembly.

The drive output of the associated -5.2 V Control circuit is applied to Q2, which forms a power Darlington amplifier with Q3, Q4, Q5, and Q6. A decrease in current in Q2 causes the other four transistors to conduct less; thus, the -V.0. output goes more positive. Conversely, an increase in current in Q2 causes the -V.0. output to go more negative. Regulation is, therefore, a function of current in Q2.

In the event of an overvoltage condition, the SCR (D1) is turned on, effectively clamping the -V.0. output to -1.5 Vdc. The SCR remains on until power is removed.

Current limiting is performed in two steps. The main current limit is provided by a circuit breaker in the -11 V line. If the current increases to a point which is 110% to 125% of the rating of the circuit breaker, the breaker trips. When the breaker trips, the internal switch in the breaker closes, sending a ground signal to the 863 Power Control. This ground signal shuts off power to the H760 Power Supply and consequently to the H761.

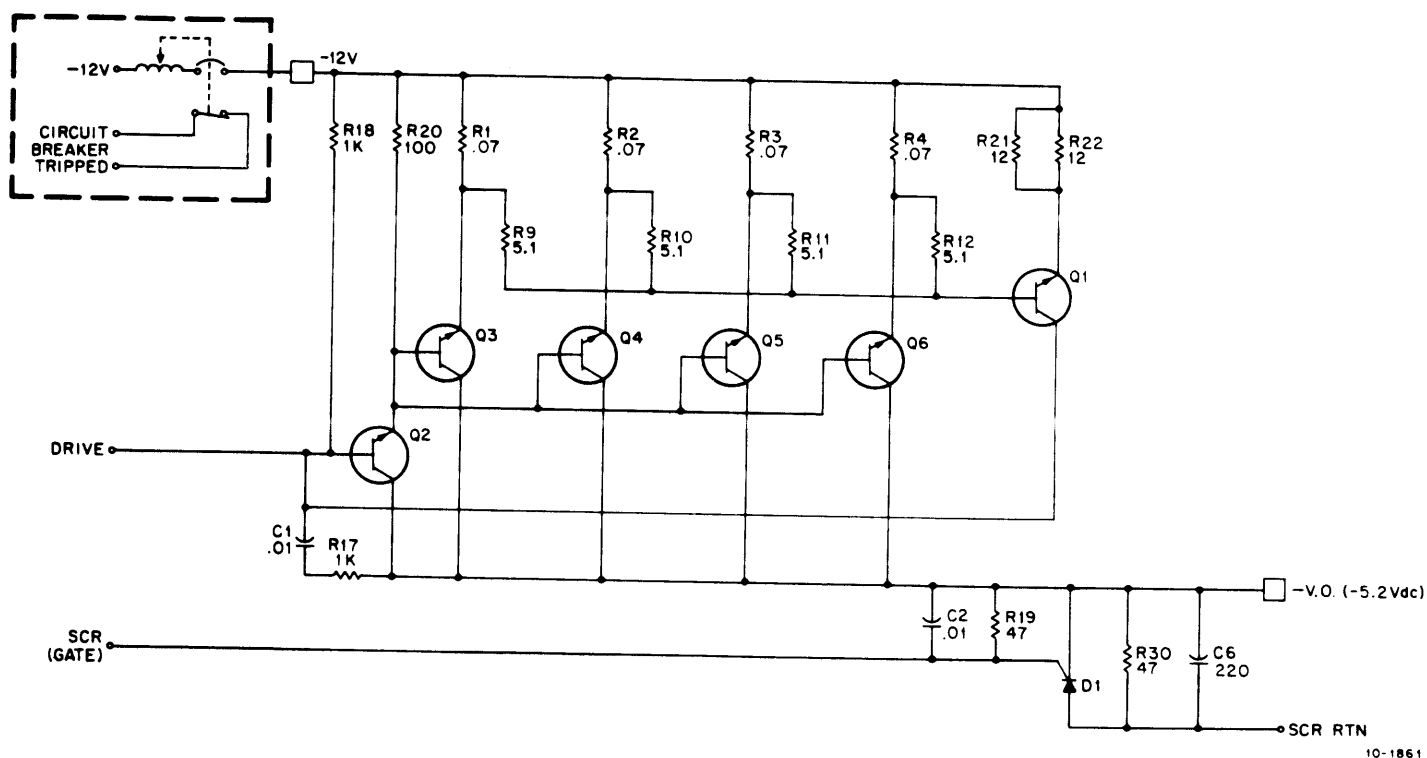


Figure 3-25 Typical -5.2 V Heat Sink, Simplified Schematic

The circuit breaker is a magnetic mechanical device and therefore is relatively slow (trip time at 500% of rating is 10 ms). During the time that the circuit breaker needs to trip under short-circuit conditions, the transistors could be damaged. Therefore, a faster current limiter is needed. The 5.1 ohm resistors, 12 ohm resistors, and Q1 form this circuit.

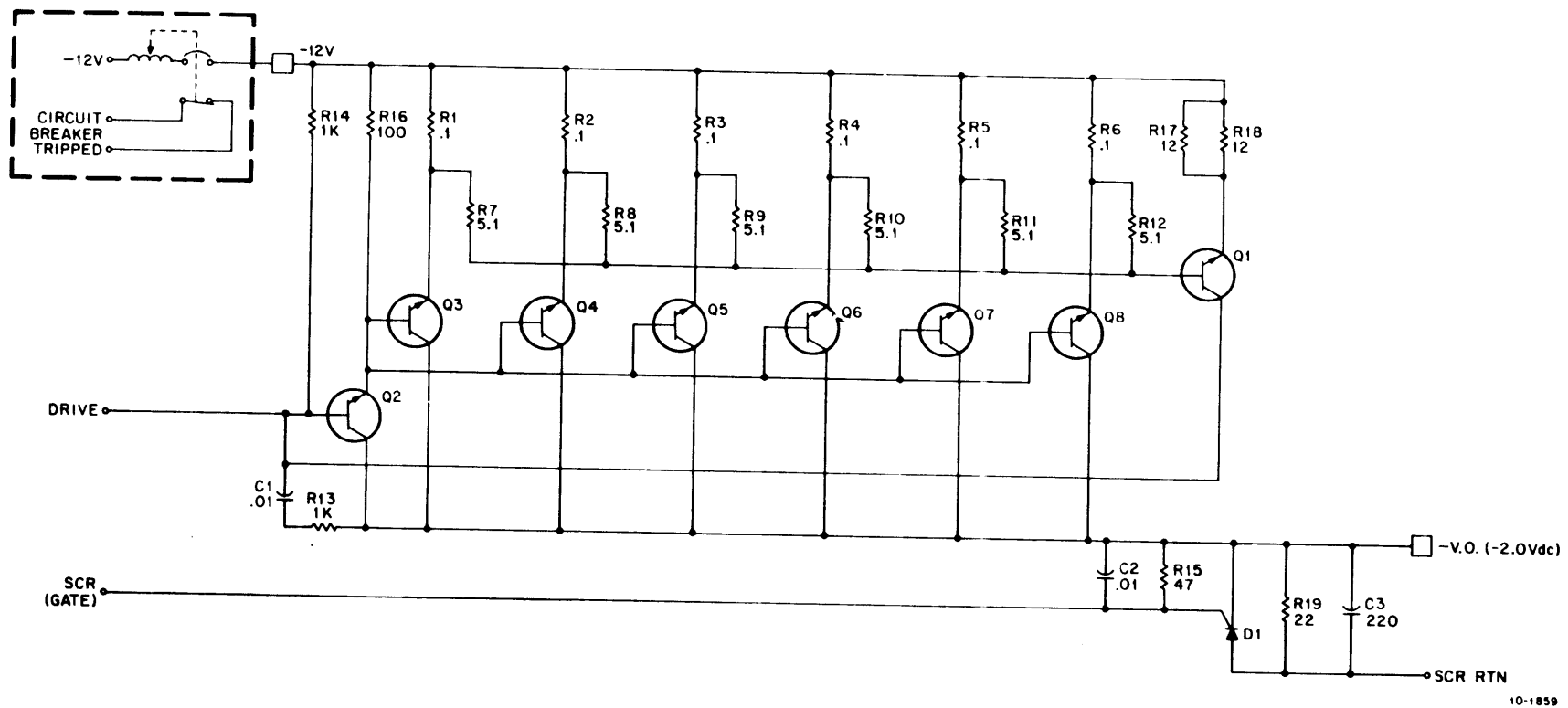
Current drawn by the Darlington is sensed through the 0.07 ohm resistors and then summed by the 5.1 ohm resistors. When the voltage across the 0.07 ohm resistors is above the V_{be} at Q1, Q1 conducts, decreasing the base drive to Q2. This causes Q3, Q4, Q5, and Q6 to conduct less, achieving current limiting. The circuit breaker is the main current limiter, while the transistor circuit provides transient current limiting. The 0.07 ohm resistors are current sensors and also ensure better sharing of current among Q3, Q4, Q5, and Q6.

The series combination of C1 and R17 minimizes parasitics; networks C2/R19 and C6/R30 are filters.

3.11.1.5 -2.0 V Heat Sink Assembly

A simplified schematic of one of the -2.0 V Heat Sink Assemblies (D-CS-7009494-0-1) is shown in Figure 3-26. Two identical circuits comprise the overall Assembly.

The drive output of the associated -2.0 V Control circuit is applied to Q2, which forms a power Darlington amplifier with Q3, Q4, Q5, Q6, Q7, and Q8.



10-1859

Figure 3-26 Typical -2.0 Vdc Heat Sink,
Simplified Schematic

The circuit is essentially the same as the -5.2 V Heat Sink, except for the addition of two transistors (Q7 and Q8) for power-dissipation purposes. Eight (8) volts is placed across the transistors in this configuration, versus five (5) volts in the -5.2 V Heat Sink. A decrease in current in Q2 causes the other six transistors to conduct less; thus, the -V.0. output goes more positive. Conversely, an increase in current in Q2 causes the -V.0. output to go more negative. Regulation is, therefore, a function of current in Q2.

In the event of an overvoltage condition, the SCR (D1) is turned on, effectively clamping the -V.0. output to -1.5 Vdc. The SCR remains on until power is removed.

Current limiting is performed in two steps. The main current limit is provided by a circuit breaker in the -11 V line. If the current increases to a point which is 110% to 125% of the rating of the circuit breaker, the breaker trips. When the breaker trips, the internal switch in the breaker closes, sending a ground signal to the 863 Power Control. This ground signal shuts off power to the H760 Power Supply and consequently to the H761.

The circuit breaker is a magnetic mechanical device and therefore is relatively slow (trip time at 500% of rating is 10 ms). During the time that the circuit breaker needs to trip under short-circuit conditions, the transistors could be damaged. Therefore, a faster current limiter is needed. The 5.1 ohm resistors, 12 ohm resistors, and Q1 form this circuit.

Current drawn by the Darlington is sensed through the 0.1 ohm resistors and then summed by the 5.1 ohm resistors. When the voltage across the 0.1 ohm resistors is above the V_{be} at Q1, Q1 conducts, decreasing the base drive to Q2. This causes Q3, Q4, Q5, Q6, Q7, and Q8 to conduct less, achieving current limiting. The circuit breaker is the main current limiter, while the transistor circuit provides transient current limiting. The 0.1 ohm resistors are current sensors and also ensure better sharing of current among Q3, Q4, Q5, Q6, Q7, and Q8.

The series combination C1 and R13 minimizes parasitics; networks C2/R15 and C3/R19 are filters.

3.11.1.6 DC Low Voltage Detector (G8014)

The G8014 DC Low Voltage Detector is shown in the Field Maintenance Print Set (D-CS-G8014-0-1). The following paragraphs reference the circuit schematic.

The primary function of this board is to provide an inhibit signal (labelled DC LOW) to the +10 V Reference so that the -2.0 Vdc regulators will be turned on after the -5.2 Vdc regulators, and off before the -5.2 Vdc regulators.

Power sequencing is accomplished by sensing the level of the -5.2 V outputs. When they are all more negative than -4.75 V, the -2.0 V outputs are allowed to turn on. Unused inputs to the detector are allowed to float.

If a -5.2 V output goes more positive than -4.75 V, the output of comparator E2 goes low and turns Q1 off. The collector of Q1 is tied into the base circuit of Q11 in Figure 3-22. Q1 turning off in the detector turns on Q11 in the +10 V Reference and shuts down the +10 V reference for the -2.0 Vdc regulators. When power is applied, Q1 in the detector is off until the -5.2 Vdc regulators are all more negative than -4.75 Vdc. Internal hysteresis eliminates any oscillation in the output of the comparator.

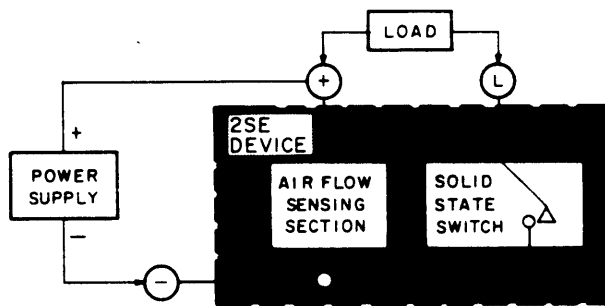
Supply voltages of +11 Vdc and -6.2 Vdc for operation of E2 and Q1 are provided by diodes D5, D6, and D7 on the detector board. The ± 15 V input to the diodes comes from the H760 Power Supply.

3.12 AIR FLOW SENSORS

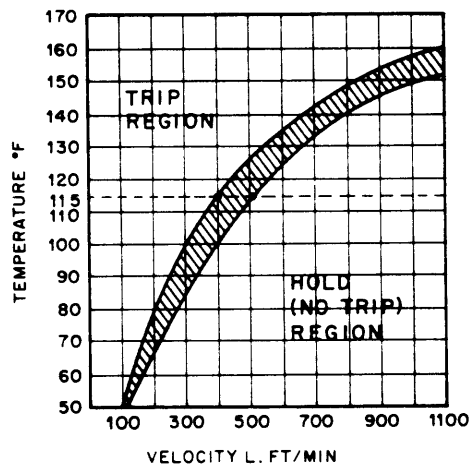
The 2040 System air flow sensors are solid-state vane switches approximately 3-1/2 inches (8.9 cm) long by 1/2 inch (1.27 cm) in diameter. They are positioned at various locations in both the CPU and I/O cabinets. A simplified wiring diagram and air-flow characteristics of a typical sensor are shown in Figure 3.27.

Sensing is accomplished using a positive temperature coefficient module sensor mounted in a protective housing in the head of a probe. This sensor has a low resistance as its temperature increases, until it reaches a critical point on its temperature/resistance curve. At this point, the resistance changes by several orders of magnitude for a correspondingly small change in temperature. A voltage applied across it causes it to self heat. As long as cooling air flows, the sensor is cooled sufficiently so that it remains stable at its low resistance point.

Below normal air flow, damage to the equipment can result. With cooling air reduced, less efficient heat transfer causes the stability to be disturbed, and the sensor module temperature begins to increase. At an elevated temperature, the module reaches the critical point, and resistance increases sharply. This rapid rise and subsequent current reduction is sensed and is used to trigger a gate in the 863 Power Control.



A. SIMPLIFIED WIRING DIAGRAM



B. AIR FLOW VERSUS TEMPERATURE

10-1860

Figure 3-27 Air Flow Sensor Characteristics

As shown in Figure 3-27 (b), the "tripping" region is to the left of the dashed curve, and the "non-tripping" or "hold" region is to the right of the dashed curve. For example, the sensor will indicate a problem if the temperature is 100° F and the air flow is 200 feet/minute. However, if the air flow is 500 feet/minute, the sensor will not indicate a fault.

Reader's Comments

DECSYSTEM-20 POWER SYSTEM
SYSTEM DESCRIPTION
EK-PWR20-SD-001

Your comments and suggestions will help us in our continuous effort to improve the quality and usefulness of our publications.

What is your general reaction to this manual? In your judgment is it complete, accurate, well organized, well written, etc.? Is it easy to use? _____

What features are most useful? _____

What faults do you find with the manual? _____

Does this manual satisfy the need you think it was intended to satisfy? _____

Does it satisfy *your* needs? _____ Why? _____

Would you please indicate any factual errors you have found. _____

Please describe your position. _____

Name _____ Organization _____

Street _____ Department _____

City _____ State _____ Zip or Country _____

CUT OUT ON DOTTED LINE

Fold Here -----

Do Not Tear - Fold Here and Staple -----

**FIRST CLASS
PERMIT NO. 33
MAYNARD, MASS.**

**BUSINESS REPLY MAIL
NO POSTAGE STAMP NECESSARY IF MAILED IN THE UNITED STATES**

Postage will be paid by:

Digital Equipment Corporation
Technical Documentation Department
146 Main Street
Maynard, Massachusetts 01754