HOSPIRA

TECHNICAL SUPPORT OPERATIONS
ELECTRONIC TECHNICAL SERVICE MANUAL

Plum A+
Infusion Pump

EPS-95150-005 (Rev. 07/04)

Hospira

For use with the following list numbers:

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	60529-04 Veterinary Pump			

Technical Service Manual

Hospira

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Section 1
INTRODUCTION

The Plum A+™ Infusion System is an advanced medication management system designed to meet the growing demand for hospital wide, alternate site, and home healthcare device standardization. Advanced clinical capabilities, field-upgradable architecture on a plug-and-play platform, and productive communications featuring barcode scanning make the Plum A+ a convenient and cost-effective multipurpose, multimode, flexible infusion system.

1.1
SCOPE

This manual is organized into 11 sections:

- ❏ Section 1 Introduction
- ❏ Section 2 Warranty
- ❏ Section 3 System Operating Manual
- ❏ Section 4 Theory of Operation
- ❏ Section 5 Maintenance and Service Tests
- ❏ Section 6 Troubleshooting
- ❏ Section 7 Replaceable Parts and Repairs
- ❏ Section 8 Specifications
- ❏ Section 9 Drawings
- ❏ Section 10 Index
- ❏ Technical Service Bulletins

If a problem in device operation cannot be resolved using the information in this manual, contact Hospira *(see Section 6.1, Technical Assistance)*.

Specific instructions for operating the device are contained in the *Plum A+ System Operating Manual*. Provision is made for the inclusion of the system operating manual in *Section 3* of this manual.

✎ **Note:** Figures are rendered as graphic representations to approximate actual product. Therefore, figures may not exactly reflect the product.

1.2 CONVENTIONS

The conventions listed in *Table 1-1, Conventions*, are used throughout this manual.

Table 1-1. Conventions

Convention	Application	Example
Italic	Reference to a section, figure, table, or publication	*(see Section 6.1, Technical Assistance)*
[ALL CAPS]	In-text references to keys and touchswitches	[START]
ALL CAPS	Screen displays	CASSETTE TEST IN PROGRESS
Bold	Emphasis	**CAUTION: Use proper ESD grounding techniques when handling components.**

Throughout this manual, warnings, cautions, and notes are used to emphasize important information as follows:

WARNING: A WARNING CONTAINS SPECIAL SAFETY EMPHASIS AND MUST BE OBSERVED AT ALL TIMES. FAILURE TO OBSERVE A WARNING MAY RESULT IN PATIENT INJURY AND BE LIFE-THREATENING.

CAUTION: A CAUTION usually appears in front of a procedure or statement. It contains information that could prevent hardware failure, irreversible damage to equipment, or loss of data.

Note: A note highlights information that helps explain a concept or procedure.

1.3 COMPONENT DESIGNATORS

Components are indicated by alpha-numeric designators, as follows:

Battery	**BT**	Diode	**D**	Resistor	**R**
Capacitor	**C**	Fuse	**F**	Switch	**SW**
Crystal	**Y**	Integrated Circuit	**U**	Transistor	**Q**

The number following the letter is a unique value for each type of component (e.g., R1, R2).

Note: Alpha-numeric designators may be followed with a dash (-) number that indicates a pin number for that component. For example, U15-13 is pin 13 of the encoder chip [U15] on the interface PWA.

1.4 ACRONYMS AND ABBREVIATIONS

Acronyms and abbreviations used in this manual are as follows:

A	Ampere
AC	Alternating current
A/D	Analog-to-digital
ADC	Analog-to-digital converter
APP	Air, pressure, and pin
BCR	Barcode reader
CCA	Clinical care area
CCFT	Cold cathode fluorescent tube
CMOS	Complementary metal-oxide semiconductor
CPU	Central processing unit
DAC	Digital-to-analog converter
DC	Direct current
DIP	Dual in-line package
DMA	Direct memory access
DMM	Digital multimeter
DPM	Digital pressure meter
ECG	Electrocardiograph
EEG	Electroencephalogram
EEPROM	Electrically erasable/programmable read-only memory
EMG	Electromyogram
EMI	Electromagnetic interference
ESD	Electrostatic discharge
ETO	Ethylene oxide
FPGA	Field programmable gate array
FSR	Force sensing resistor
hr	Hour
Hz	Hertz
ID	Identification
I/O	Input/output
IPB	Illustrated parts breakdown
IV	Intravenous
KB	Kilobyte
Kg	Kilogram
kHz	Kilohertz
KVO	Keep vein open

lbs	Pounds
LCD	Liquid crystal display
LED	Light emitting diode
L/S	Line select
mA	Milliampere
MB	Megabyte
mcg	Microgram
MHz	Megahertz
min	Minute
mL	Milliliter
mL/hr	Milliliter per hour
mmHg	Millimeter of mercury
MMIO	Memory-mapped input/output
MOSFET	Metal-oxide semiconductor field-effect transistor
ms	Millisecond
mV	Millivolt
N/A	Not applicable
ng	Nanogram
Op-amp	Operational amplifier
PROM	Programmable read-only memory
psi	Pounds per square inch
PVT	Performance verification test
PWA	Printed wiring assembly
PWM	Pulse width modulator
RAM	Random-access memory
rms	Root-mean-square
RTC	Real-time clock
SCC	Serial communication controller
SCP	Serial communication port
SLA	Sealed lead acid
SMT	Surface mount technology
SPI	Serial peripheral interface
SRAM	Static random access memory
TQFP	Thin quad flat pack
V	Volt
V_{AC}	Volts AC
V_{CC}	Collector supply voltage
VCO	Voltage-controlled oscillator
V_{DC}	Volts DC

VSC 5 V_{DC} supply circuitry
VSO Voltage sweep oscillator
VTBI Volume to be infused
WDI Watchdog input
µA Microampere
µL Microliter
µV Microvolt
µsec Microsecond

1.5 USER QUALIFICATION

The Plum A+ is intended for use at the direction or under the supervision of licensed physicians or certified healthcare professionals who are trained in the use of the pump and the administration of parenteral and enteral fluids and drugs, and whole blood or red blood cell components. Training should emphasize preventing related IV complications, including appropriate precautions to prevent accidental infusion of air. The epidural route can be used to provide anesthesia or analgesia.

1.6 ARTIFACTS

Nonhazardous, low-level electrical potentials are commonly observed when fluids are administered using infusion devices. These potentials are well within accepted safety standards, but may create artifacts on voltage-sensing equipment such as ECG, EMG, and EEG machines. These artifacts vary at a rate that is associated with the infusion rate. If the monitoring machine is not operating correctly or has loose or defective connections to its sensing electrodes, these artifacts may be accentuated so as to simulate actual physiological signals. To determine if the abnormality in the monitoring equipment is caused by the pump instead of some other source in the environment, set the pump so that it is temporarily not delivering fluid. Disappearance of the abnormality indicates that it was probably caused by electronic noise generated by the pump. Proper setup and maintenance of the monitoring equipment should eliminate the artifact. Refer to the appropriate monitoring system documentation for setup and maintenance instructions.

1.7 INSTRUMENT INSTALLATION PROCEDURE

CAUTION: Infusion pump damage may occur unless proper care is exercised during product unpacking and installation. The battery may not be fully charged upon receipt of the infusion pump. Do not place the infusion pump in service if it fails the self test.

CAUTION: Infusion pump performance may be degraded by electromagnetic interference (EMI) from devices such as electrosurgical units, cellular phones, and two-way radios. Operation of the infusion pump under such conditions should be avoided.

The instrument installation procedure consists of unpacking, inspection, and self test.

Note: Do not place the infusion pump in service if the battery is not fully charged. To make certain the battery is fully charged, connect the infusion pump to AC power for six hours *(see Section 8, Specifications)*.

1.7.1 UNPACKING

Inspect the shipping container as detailed in *Section 1.7.2, Inspection*. Use care when unpacking the infusion pump. Retain the packing slip and save all packing material in the event it is necessary to return the Plum A+ to the factory. Verify the shipping container contains a copy of the system operating manual.

1.7.2 INSPECTION

Inspect the infusion pump shipping container for shipping damage. Should any damage be found, contact the delivering carrier immediately.

CAUTION: Inspect the infusion pump for evidence of damage. Do not use the pump if it appears to be damaged. Should damage be found, contact Hospira *(see Section 6.1, Technical Assistance)*.

Inspect the infusion pump periodically for signs of defects such as worn accessories, broken connections, or damaged cable assemblies. Also inspect the infusion pump after repair or during cleaning. Replace any damaged or defective external parts.

1.7.3
SELF TEST

CAUTION: Do not place the infusion pump in service if the self test fails.

CAUTION: Certain peripheral module assembly list numbers are not compatible with older versions of the Plum A+ device. Refer to *Table 1-2, List Numbers*, for pump configuration and module compatibility.

Table 1-2. List Numbers

Device Configuration List Number	Compatible Module List Number
11973-04-07	12380-04; 12102-04
11971-04-01/02	12393-04; 12101-04
11971-04-higher	12393-04; 12101-04; 12680-04
12391-04-01/02	12393-04; 12101-04; 12680-04
60529-04-01 (Veterinary Pump)	60530-04 (Veterinary Pump only)

Note: *Figure 1-1, LCD and Keypad*, and *Figure 1-2, LCD and Keypad (MedNet)*, represent domestic devices only. International devices vary by country of origin.

Note: If an alarm condition occurs during the self test, cycle the power and repeat the self test. If the alarm condition recurs, note the message and take corrective action *(see Section 6, Troubleshooting)*. Repeat the self test. If the alarm condition recurs, remove the Plum A+ infusion system from service and contact Hospira.

Note: Screen representations are examples only, and do not necessarily reflect the most current software version.

To perform the self test, refer to *Figure 1-1* or *Figure 1-2*, and proceed as follows:

1. Connect the AC power cord to a grounded AC outlet. Verify the charging/line indicator **CHARGE** illuminates and an alarm beep sounds.
2. Without a cassette installed, press [ON/OFF] to turn on the pump.
3. The LCD screen briefly displays the **SELF TEST** screen. Verify the screen display matches *Figure 1-1* or *Figure 1-2*.

   Note: If the **SELF TEST** screen does not appear, contact Hospira.

4. After the self test is complete, the message “INSERT PLUM SET CLOSE LEVER” appears. Press the decimal [.] key, then [START].

   Note: The Plum A+ infusion system equipped with the MedNet™ accessory may display a clinical care area (CCA) screen before the “INSERT PLUM SET CLOSE LEVER” message appears.

5. Using the [SELECT] arrow keys, select **Set Time and Date**, and press the [CHOOSE] softkey.
6. Verify the time and date. To set the time and date, refer to *Section 1.8.3, Setting the Time and Date*.
7. Press [ON/OFF] to exit the **SET TIME AND DATE** screen.

8. Press [ON/OFF] to turn the pump back on.
9. Open the cassette door and insert a primed cassette. Close the cassette door. The cassette test is complete when the “CASSETTE TEST IN PROGRESS” message disappears.

Note: On version 11.3, or on a device equipped with the MedNet accessory, the message “MECHANISM INITIALIZATION IN PROGRESS” will briefly appear prior to the “CASSETTE TEST IN PROGRESS” message.

10. If previously entered programming exists, the “CLEAR SETTINGS?” message appears. Press the [YES] softkey to clear the settings.

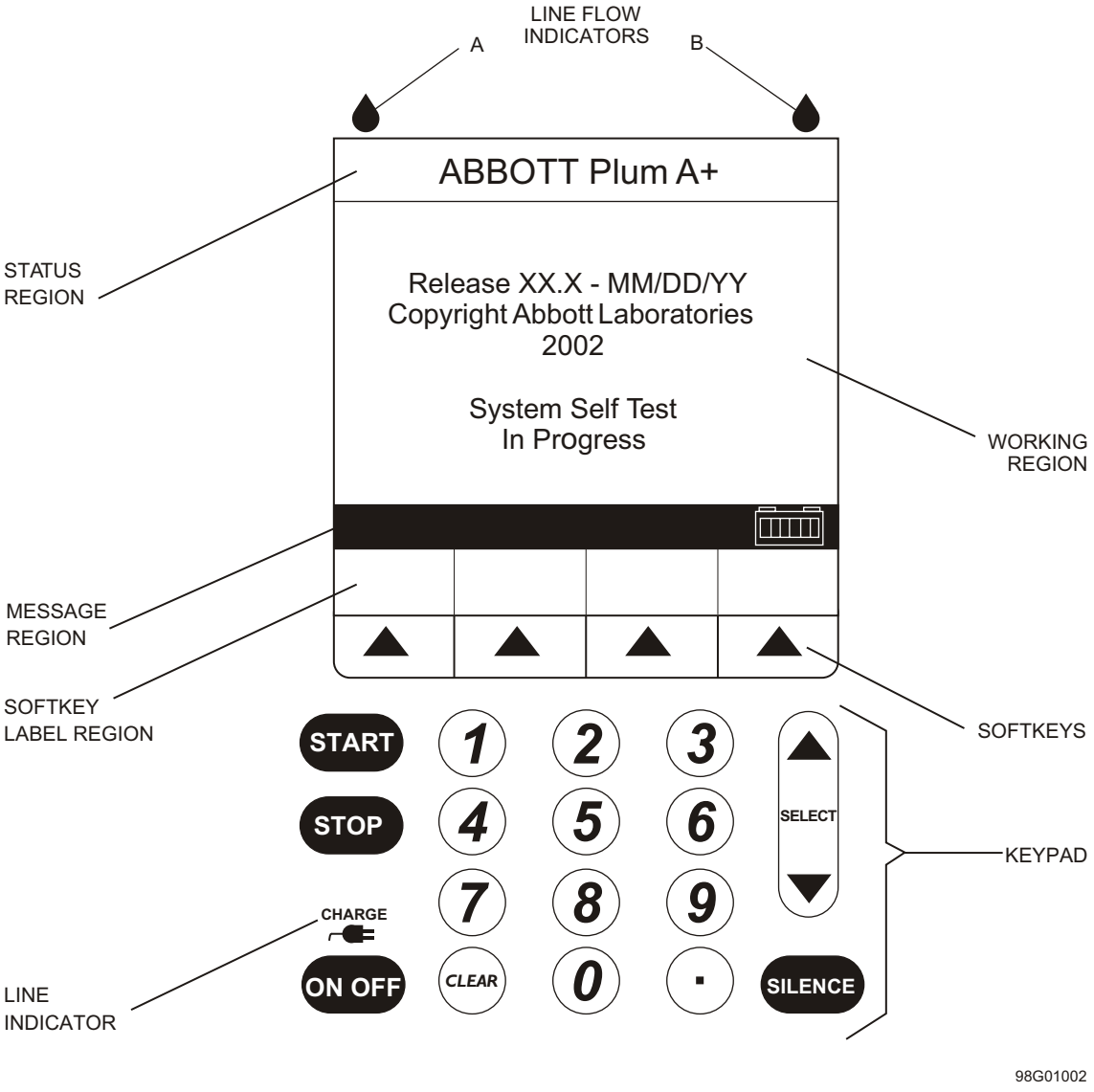

Figure 1-1. LCD and Keypad

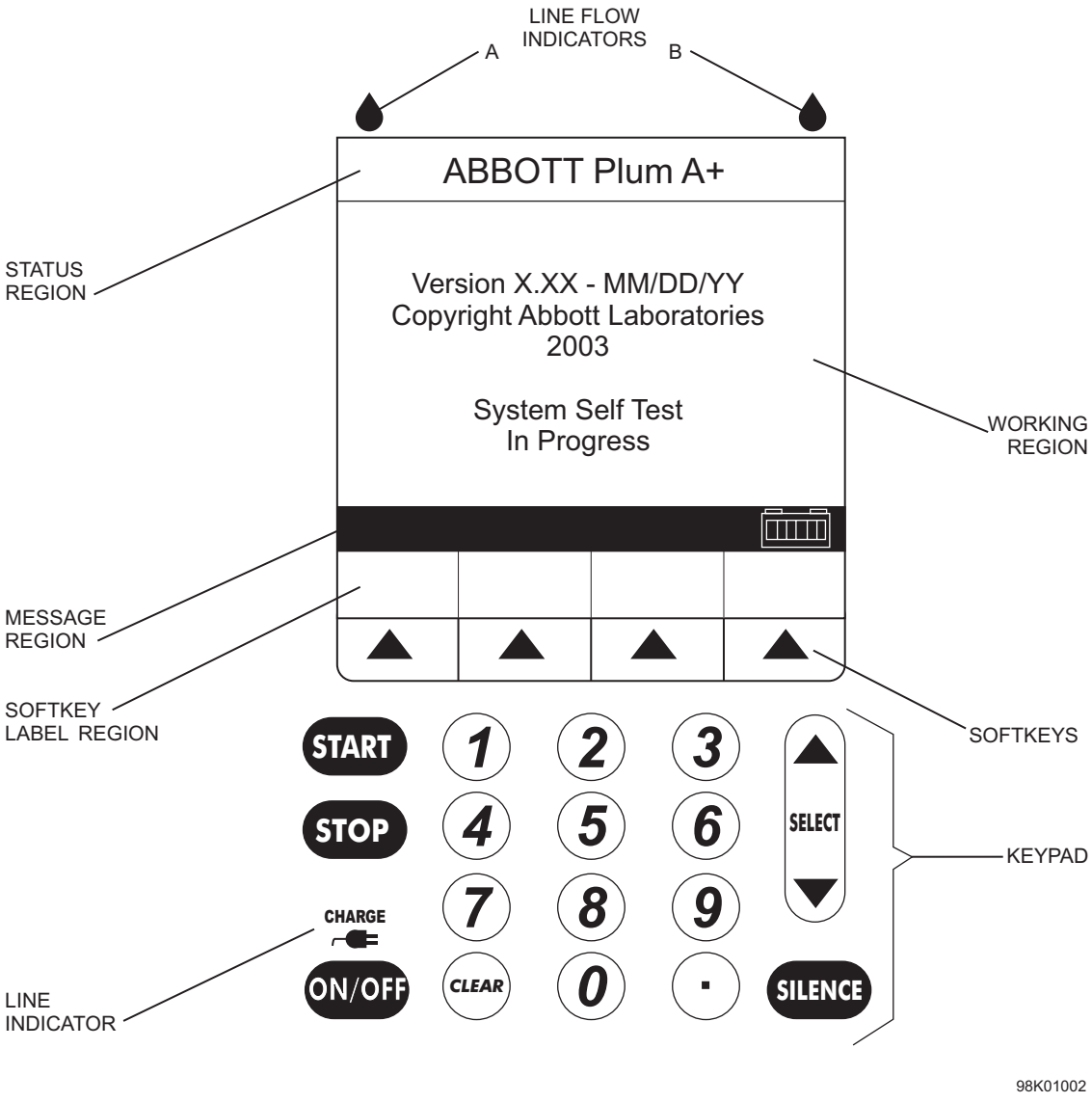

Figure 1-2. LCD and Keypad (MedNet)

1.8
BIOMED SETTINGS

The biomed settings screens contain the following options that can be changed or reviewed by qualified personnel:

- ❑ IV parameters
- ❑ Alarms log
- ❑ Set time and date

Note: All Plum A+ infusion devices (new or refurbished) are shipped with factory settings *(see Table 1-3, System Configuration Data)*.

Note: Biomed screens do not time out for the **Infuser Idle** alarm or **No Action** alarm.

Note: The battery will not be detected in the biomed service mode *(see Section 6.2.2, Error Codes Requiring Technical Service)*.

Note: The Plum A+ infusion system equipped with the MedNet accessory will not display the **IV Parameters** screen. IV parameters must be set through the MedNet accessory.

To access the biomed settings, refer to *Figure 1-1* or *Figure 1-2*, then proceed as follows:

1. Open the door and press [ON/OFF] to turn on the pump.
2. After the self test is complete, the message “INSERT PLUM SET CLOSE LEVER” appears. Press the decimal [.] key, then [START], and verify the **BIOMED SETTINGS** screen is displayed *(see Figure 1-3, Biomed Settings)*.

Note: The Plum A+ infusion system equipped with the MedNet accessory may display a CCA screen before the “INSERT PLUM SET CLOSE LEVER” message appears. Choose a CCA to access the biomed mode on a device equipped with Mednet.

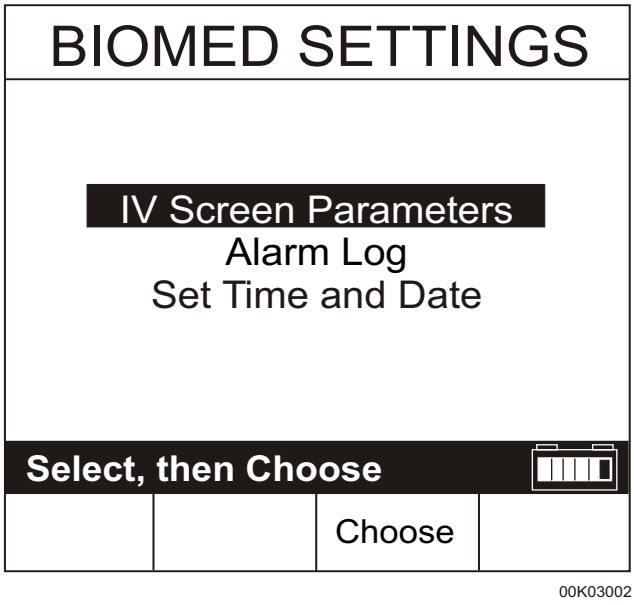

Figure 1-3. Biomed Settings

Table 1-3. System Configuration Data

Data	Options Range	Factory Setting
Maximum macro IV mode delivery rate	0.1 - 99.9 mL/hr and 100 - 999 mL/hr	999 mL/hr
Macro distal occlusion alarm (pressure level)	1 to 15 psi	6.0 psi
Deliver together enable	Concurrent or Piggyback	Piggyback
Delayed start/standby enable	Yes or No	Yes
Continue rate	Rate or KVO	KVO
Nurse callback default	Yes or No	No
Time	(24 hr) 00:00 - 23:59 in one minute increments	Factory time
Date	1/1/2002 - 12/31/2098	Factory date

Note: Standby is available only with software version 11.3 or higher.

1.8.1
IV PARAMETERS

Refer to *Figure 1-4, IV Parameters (Software Version 10.3)*, or *Figure 1-5, IV Parameters (Software Version 11.3)*. The IV parameters screen contains the following:

- ❏ Common IV parameters
- ❏ Default units/drug (software version 11.3 only)
- ❏ Macro IV parameters

To change the IV parameters, refer to *Figure 1-3*, and *Figure 1-4* or *Figure 1-5*, then proceed as follows:

1. Access the biomed settings screen as described in *Section 1.8*.
2. Using the [SELECT] arrow keys, select **IV Screen Parameters**, and press [CHOOSE] *(see Figure 1-3)*.

Note: The Plum A+ infusion system equipped with the MedNet accessory will not display the **IV Parameters** screen.

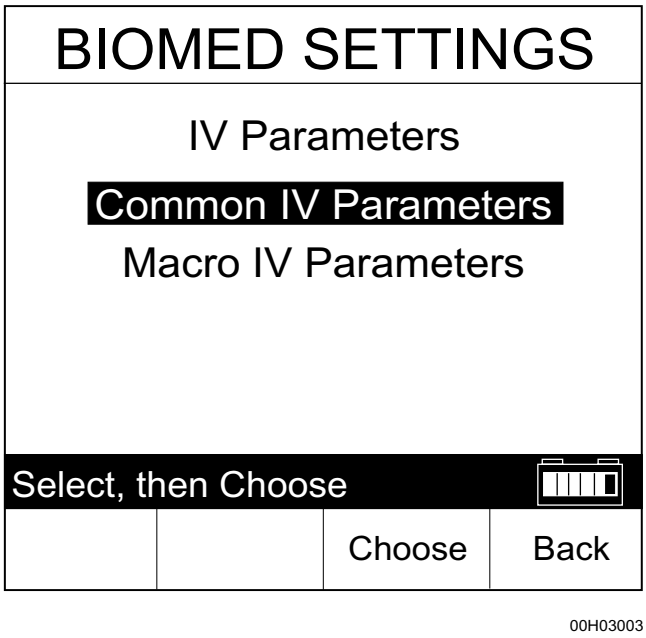

Figure 1-4. IV Parameters (Software Version 10.3)

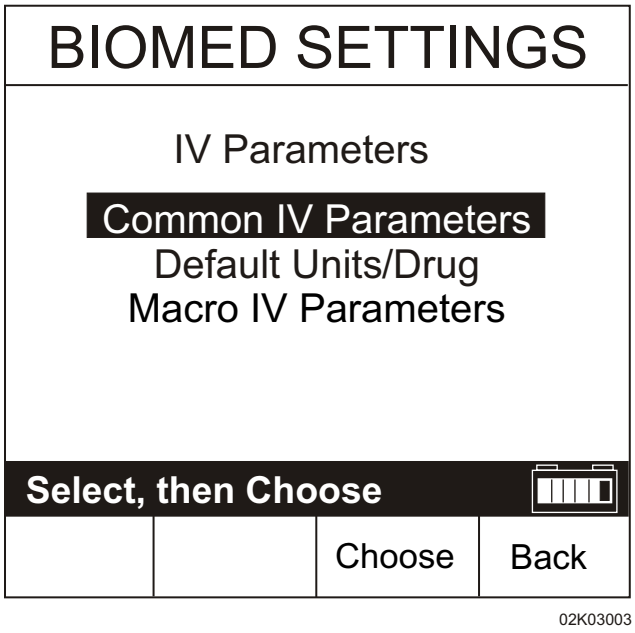

Figure 1-5. IV Parameters (Software Version 11.3)

1.8.1.1 COMMON IV PARAMETERS

To view common IV parameters, refer to *Figure 1-4* or *Figure 1-5*, then proceed as follows:

1. Access the IV parameters screen as described in *Section 1.8.1*.
2. Using the [SELECT] arrow keys, select **Common IV Parameters**, and press [CHOOSE].
3. Verify the **COMMON IV PARAMETERS** screen is displayed *(see Figure 1-6* or *Figure 1-7)*.
4. Using the [SELECT] arrow keys, select the desired parameter to be changed.
5. Using the [CHANGE VALUE] softkey, select the desired value.
6. Repeat Steps 4 and 5 for each parameter to be changed.

   Note: In version 11.3 only, when **Standby** mode is disabled, **Delay** mode is also disabled.

7. If there are no other changes to the common IV parameters, press the [CANCEL/BACK] softkey.
8. Verify the **IV PARAMETERS** screen is displayed.
9. If there are no other changes, press the [BACK] softkey to return to the main biomed settings screen, or press [ON/OFF] to power off the infusion device.

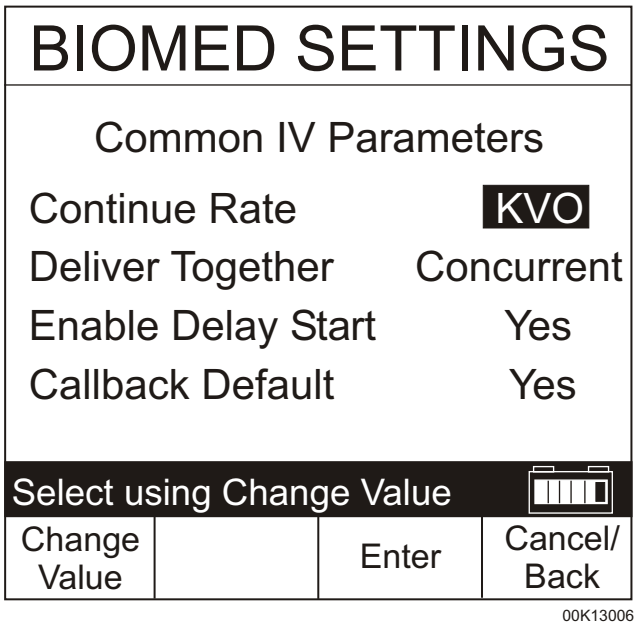

Figure 1-6. Common IV Parameters (Software Version 10.3)

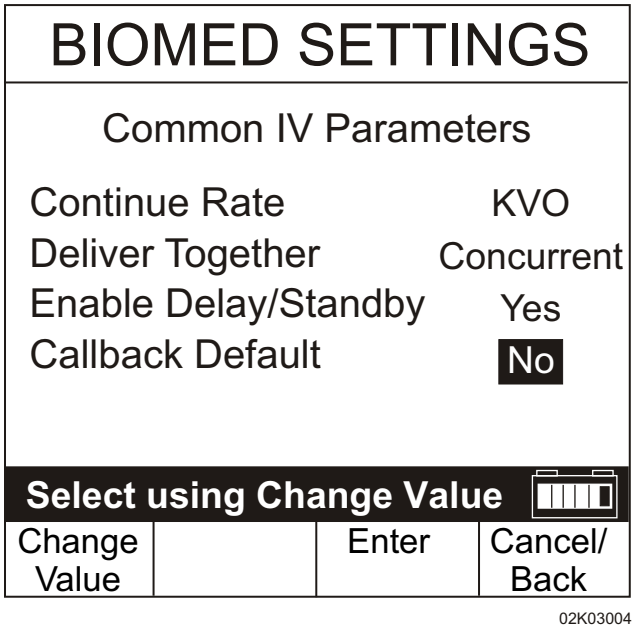

Figure 1-7. Common IV Parameters (Software Version 11.3)

1.8.1.2
DEFAULT UNITS/DRUG

Note: For default drug settings, refer to the system operating manual.

To review or change the default units/drug, refer to *Figure 1-8, Default Units/Drug*; *Figure 1-9, Dose Units for Drug*; and *Figure 1-10, Conc Units for Drug*, then proceed as follows:

1. Access the biomed settings screen as described in *Section 1.8*.
2. Access the IV parameters screen as described in *Section 1.8.1*.
3. Using the [SELECT] arrow keys, select **Default Units/Drug**, and press [CHOOSE].
4. Verify the **DEFAULT UNITS/DRUG** screen is displayed *(see Figure 1-8)*.
5. Using the [SELECT] arrow keys and the [PAGE UP] and [PAGE DOWN] softkeys, select the desired drug and press [ENTER].
6. Verify the **DOSE UNITS FOR DRUG** screen is displayed *(see Figure 1-9)*.
7. Using the [SELECT] arrow keys and the [PAGE UP] and [PAGE DOWN] softkeys, select the desired dose units, and press [CHOOSE].
8. Verify the **CONC UNITS FOR DRUG** screen is displayed *(see Figure 1-10)*.
9. Using the [SELECT] arrow keys, select the desired **Drug Conc in Container**, and press [CHOOSE].
10. Verify the **DEFAULT UNITS/DRUG** screen is displayed.
11. Repeat Steps 6 through 10 for each desired drug.
12. If there no other changes, press [CANCEL/BACK] to return to the main biomed settings screen, or power off the infusion device by pressing [ON/OFF].

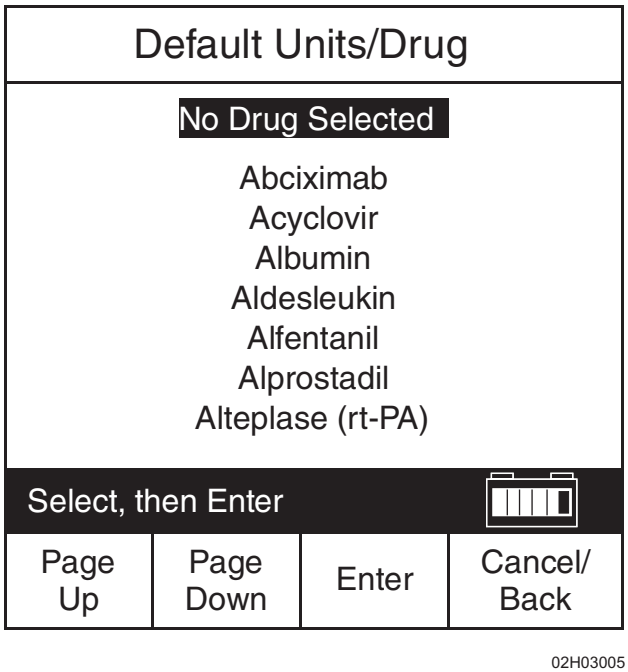

Figure 1-8. Default Units/Drug

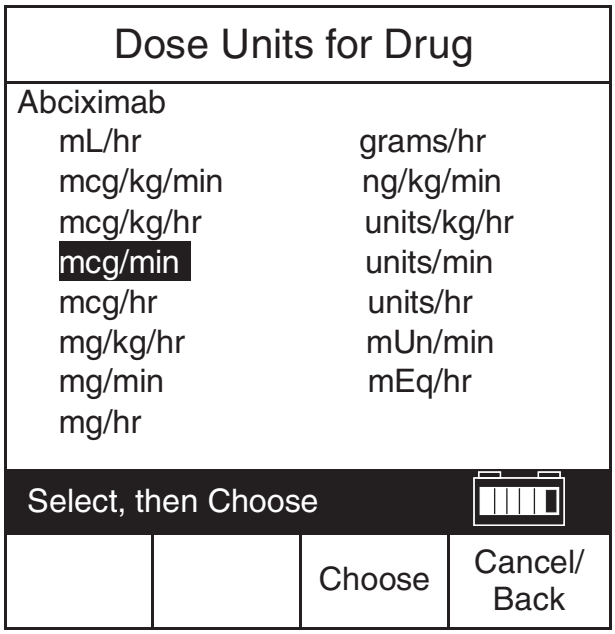

Figure 1-9. Dose Units for Drug

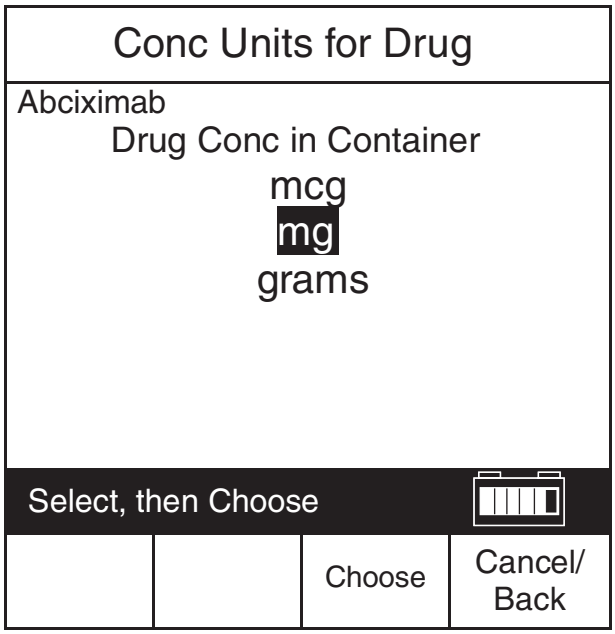

Figure 1-10. Conc Units for Drug

1.8.1.3
MACRO IV PARAMETERS

Note: This section is not applicable for infusion devices equipped with the MedNet accessory.

To review or change the macro IV parameters, refer to *Figure 1-3* and *Figure 1-11, Macro IV Parameters*, then proceed as follows:

1. Access the biomed settings screen as described in *Section 1.8*.
2. Access the IV parameters screen as described in *Section 1.8.1*.
3. Using the [SELECT] arrow keys, select **Macro IV Parameters**, and press [CHOOSE].
4. Verify the **MACRO IV PARAMETERS** screen is displayed *(see Figure 1-11)*.
5. Using the [SELECT] arrow keys, select the parameter to be changed.
6. Using the numeric keypad, enter the desired value for the parameter selected.
7. Repeat Steps 5 and 6 for each parameter to be changed.
8. If there are no other changes, press [CANCEL/BACK] to return to the IV parameters screen, or press [ON/OFF] to power off the infusion device.

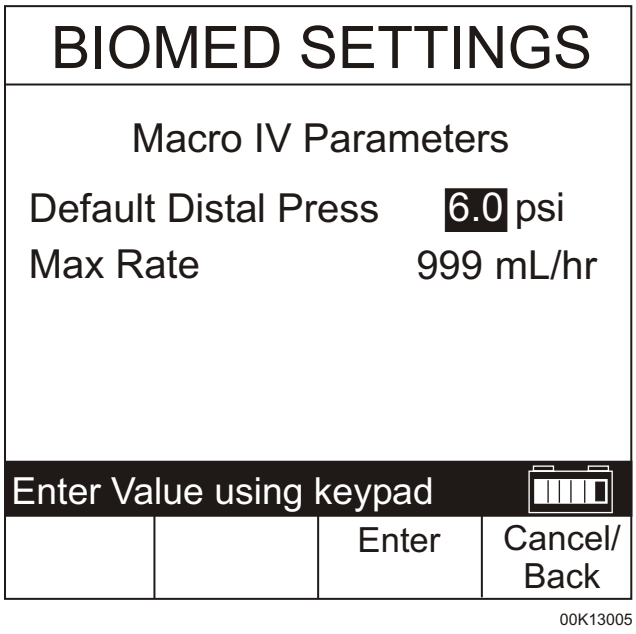

Figure 1-11. Macro IV Parameters

1.8.2
ALARMS LOG

To view the alarms log, refer to *Figure 1-3* and *Figure 1-12, Alarms Log*, then proceed as follows:

1. Access the biomed settings screen as described in *Section 1.8*.
2. Using the [SELECT] arrow keys, select **Alarms Log**, and press [CHOOSE].
3. Use the [PAGE UP] and [PAGE DOWN] softkeys to view the alarms log.
4. Press [BACK] to exit the alarms log and return to the main biomed settings screen.

Note: The alarms log will retain the latest 40 alarm and malfunction codes, listed in order from the most current to the oldest.

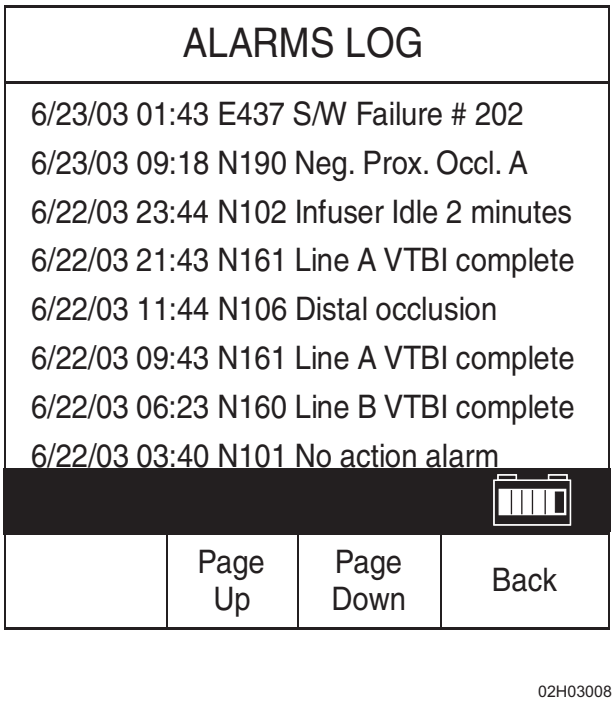

Figure 1-12. Alarms Log

1.8.3
SETTING THE TIME AND DATE

Note: The Plum A+ will automatically display February 29 on leap years.

Note: Daylight savings and time zone changes must be made manually.

Note: All Plum A+ infusion devices (new or refurbished) are shipped with factory settings *(see Table 1-3)*.

To set the time and date, refer to *Figure 1-3* and *Figure 1-13, Setting the Time and Date*, then proceed as follows:

1. Access the biomed settings screen as described in *Section 1.8*.
2. Using the [SELECT] arrow keys, select **Set Time and Date**, and press [CHOOSE].
3. Using the [SELECT] arrow keys, select the parameter to be changed.
4. Using the numeric keypad, enter the desired value.
5. Repeat Steps 3 and 4 for each parameter to be changed.
6. Verify the time and date are correct, then press [ENTER] to return to the biomed settings screen.
7. If there are no other changes to the biomed settings, press [ON/OFF] to power off the device.

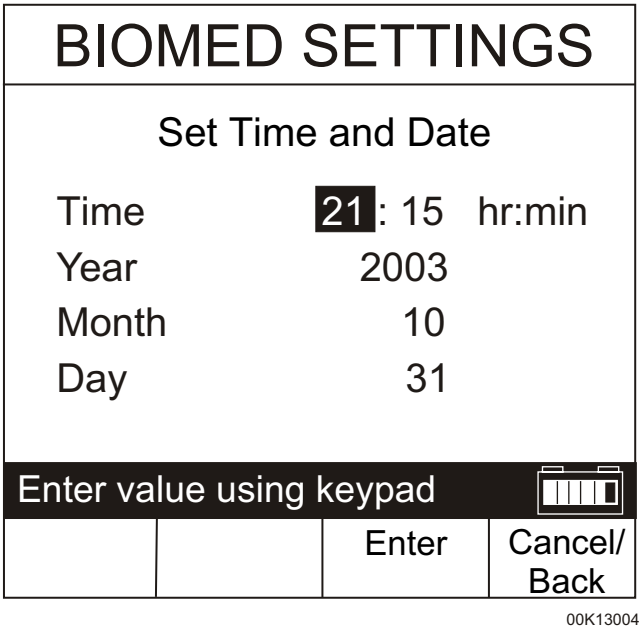

Figure 1-13. Setting the Time and Date

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Section 2

WARRANTY

Subject to the terms and conditions herein, Hospira, Inc., herein referred to as Hospira, warrants that (a) the product shall conform to Hospira's standard specifications and be free from defects in material and workmanship under normal use and service for a period of one year after purchase, and (b) the replaceable battery shall be free from defects in material and workmanship under normal use and service for a period of 90 days after purchase. Hospira makes no other warranties, express or implied, as to merchantability, fitness for a particular purpose, or any other matter.

Purchaser's exclusive remedy shall be, at Hospira's option, the repair or replacement of the product. In no event shall Hospira's liability arising out of any cause whatsoever (whether such cause be based in contract, negligence, strict liability, other tort, or otherwise) exceed the price of such product, and in no event shall Hospira be liable for incidental, consequential, or special damages or losses or for lost business, revenues, or profits. Warranty product returned to Hospira must be properly packaged and sent freight prepaid.

The foregoing warranty shall be void in the event the product has been misused, damaged, altered, or used other than in accordance with product manuals so as, in Hospira's judgment, to affect its stability or reliability, or in the event the serial or lot number has been altered, effaced, or removed.

The foregoing warranty shall also be void in the event any person, including the Purchaser, performs or attempts to perform any major repair or other service on the product without having been trained by an authorized representative of Hospira and using Hospira documentation and approved spare parts. For purposes of the preceding sentence, "major repair or other service" means any repair or service other than the replacement of accessory items such as batteries, flow detectors, detachable AC power cords, and patient pendants.

In providing any parts for repair or service of the product, Hospira shall have no responsibility or liability for the actions or inactions of the person performing such repair or service, regardless of whether such person has been trained to perform such repair or service. It is understood and acknowledged that any person other than a Hospira representative performing repair or service is not an authorized agent of Hospira.

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Section 3

SYSTEM OPERATING MANUAL

A copy of the system operating manual is included with every Plum A+ infusion system. Insert a copy here for convenient reference. If a copy of the system operating manual is not available, contact Hospira Technical Support Operations *(see Section 6.1, Technical Assistance)*.

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Section 4

THEORY OF OPERATION

This section describes the Plum A+ infusion system theory of operation. Related drawings are provided in *Section 9, Drawings*. The theory of operation details the general description, electronic subsystem overview, printed wiring assemblies, remote mounted peripherals, and mechanical overview of the infusion pump.

4.1 GENERAL DESCRIPTION

The infusion pump includes the following features:

- Dose calculation
- Loading dose
- Multi-step programming
- Therapy selection
- Nurse call
- Delayed start setting
- Standby mode
- Drug label library
- Piggyback and concurrent delivery modes
- Titration
- 0.1-99.9 mL/hr flow rate range for both lines (in 0.1 mL/hr increments)
- 100-999 mL/hr flow rate range for both lines (in 1.0 mL/hr increments)
- Anti free-flow protection
- Air removal/backpriming
- Battery gauge
- Long battery life (6 hours) for emergency backup and temporary portable operation
- Air detection (proximal and distal)
- Serial communication
- Alarm history
- Plug-in barcode reader for drug identification
- Volumes infused (A, B, total volumes)
- KVO at dose end (1.0 mL/hr or less depending on delivery rate) or continue rate to continue
- Variable distal pressure setting
- Nonpulsatile volumetric accuracy
- Microprocessor control
- Large LCD
- Panel back illumination on mains power
- Lockout switch
- Standard fullfill, partfill, syringe, and vial use
- Enteral and parenteral fluid delivery
- Blood and blood product delivery
- Wide range of standard and specialty administration sets

Alarms include the following:

- Distal occlusion
- Proximal occlusion
- Proximal air-in-line
- Distal air-in-line
- Low battery
- Door open while pumping
- Lockout violation
- VTBI complete
- Valve/cassette test failure
- Nurse call
- No action alarm
- Infuser idle for two minutes

4.2 ELECTRONIC SUBSYSTEM OVERVIEW

This section describes the function and electronic circuitry of three main subsystems in the infusion pump: CPU subsystem, power supply subsystem, and mechanism subsystem. Schematic diagrams of subsystem PWAs are in *Section 9, Drawings*.

Note: An asterisk (*) denotes an active low or negative true logic signal.

4.2.1 CPU SUBSYSTEM

The CPU subsystem contains the main microcontroller, which is responsible for controlling the display/keyboard interface, external communications interfaces, barcode reader interface, and system management *(see Figure 9-12, Peripheral PWA Schematic, and Figure 9-13, CPU PWA Schematic)*.

The CPU subsystem provides the following functions:

- External memory devices access
- LCD interfaces
- Real-time clock generator interface
- System watchdog
- Analog-to-digital and digital-to-analog converter interface
- Keypad interfaces
- Control and monitor status signals, such as LEDs, audible alarms, volume control, nurse call switch, and lockout switch
- Serial communication with host computer (DataPort) and barcode reader
- Power supply subsystem interface
- Mechanism subsystem interface

4.2.1.1
CPU

The central processing unit (CPU) is a Motorola MC68302. The CPU has a closely coupled 16 bit data bus and 24 bit address bus; MC68000 microprocessor core; a system integration block for peripherals; and an RISC communications processor. The MC68302 is packaged in a 144 pin thin quad flat pack (TQFP) package and operates from a 3.3 V_{DC} power supply.

The on-chip peripheral devices are isolated from the system through the dual port RAM. The 1152 byte dual port RAM has 576 bytes of system RAM and 576 bytes of parameter RAM, which contains various peripheral registers, parameters, and the buffer descriptors for each of the three serial communication controller (SCC) channels and the serial communication port (SCP) channels. The 24 bit address bus is capable of accessing up to 16 MB of data.

4.2.1.2
SYSTEM MEMORY ADDRESS MAP

The CPU has a 24 bit address bus when combined with UDS*/A0. The address bus is a bi-directional, three state bus capable of addressing 16 MB of data that is configured as 16 bits per word (including the IMP internal address space).

Each of the four programmable chip-select lines has two registers that define the starting address of a particular address space and the block size.

4.2.1.3
PROGRAMMABLE READ-ONLY MEMORY

The CPU subsystem has two 512 K x 8 bit programmable read-only memory (PROM) memory devices, which provide a total of 1024 KB. The PROM space is expandable up to 2 MB. The PROM memory devices operate off the 3.3 V_{DC} supply.

The CPU chip-select 0 pin (CS0*), is connected to the PROM chip-enable (CE*) pin (signal CSROM*). This special chip-select signal can support bootstrap operation after reset. The interface to the CPU is the 16 bit data bus, and a 19 bit address bus. The address bus is connected to the ADDR<19:1> lines, and the data bus is connected to the DATA<15:0> lines.

4.2.1.4
STATIC RANDOM ACCESS MEMORY

There are two 512 K x 8 bit CMOS static random access memory (SRAM) devices, which provide a total of 1024 KB of data memory. During an SRAM read or write cycle, the chip-enable (CE*) is controlled by the CPU chip-select pin 1 (CS1*, signal name (CSRAM*)). The SRAM space is expandable up to 2 MB. The SRAM operates off the 3.3 V_{DC} supply.

The CPU subsystem includes the additional SRAM for video buffer and real-time clock *(see Section 4.2.1.6, LCD Controller, and Section 4.2.1.9, Real-Time Clock)*.

4.2.1.5
CONTROL LOGIC

The CPU PWA uses field programmable gate arrays (FPGA), which are high density, high speed, I/O intensive general purpose devices. They are used to implement all the digital control functions, including: memory-map address decoding; memory read-write enable; direct memory access (DMA) request; I/O status signals; chip-select control; motor control; sensor select; and power up/system reset control.

4.2.1.6
LCD CONTROLLER

The liquid crystal display (LCD) controller is used to interface the LCD to the CPU. The device displays layered text and graphics, scrolls the display in any direction, and partitions the display into multiple screens. It stores bit-mapped graphic data in external frame buffer memory. The display controller functions include: transferring data from the controlling microprocessor to the buffer memory, reading memory data, converting data to display pixels, and generating timing signals for the buffer memory and LCD panel.

The LCD controller accesses 32 KB of frame buffer SRAM (video) via the controller's video address and data busses (VA<14:0> and VD<7:0>). The LCD controller external clock frequency is 8 MHz.

The interface to the CPU is through the lower 8 bits of the data bus, which is connected to DATA<7:0> lines, address line A1, and LCD chip-select signal CSLCD* (CS2*). This controller is also configured as 8080 family compatible interface device with all the control signals, such as WRLCD* (WR*) and RDLCD* (RD*), generated by the FPGA logic.

The LCD controller and the display memory are operated off the 3.3 V_{DC} supply. The output signal levels are shifted up to 5 V_{DC} by buffers for interface with the 5 V_{DC} LCD panel.

4.2.1.7
LCD BACKLIGHT CONTROL

The LCD panel is backlit by a cold cathode fluorescent tube (CCFT) lamp. The CCFT lamp requires 300 V_{rms} to operate; a current controlled DC-to-AC voltage inverter circuit is used to deliver a current regulated sine wave to the lamp. A switching regulator regulates the CCFT current by monitoring feedback pin 3, and varies its output duty cycle to drive a DC/AC inverter. Intensity control is achieved by superimposing a DC control signal with the feedback signal. The DC control signal is sourced by a voltage divider consisting of a digitally controlled non-volatile potentiometer and three series diodes.

The CPU can adjust LCD backlight intensity by selecting the digitally controlled non-volatile potentiometer and controlling TUBU/D and TUBINC* signals. The potentiometer has a five bit up/down counter with non-volatile memory. It is used to store one of 31 settings of the potentiometer. Each count represents 323 Ω with a range of 323 to 10 KΩ The current counter value is stored in non-volatile memory after CSTUB* is returned high while the TUBINC* input is also high. The current counter value is not stored if CSTUB* is returned high and TUBINC* is low. The CCFT intensity is directly proportional to the CCFT current, where 0 mA_{rms} is minimum intensity and 5 mA_{rms} is maximum intensity. The CCFT current is inversely proportional to the counter value.

4.2.1.8
LCD CONTRAST CONTROL

A digitally adjustable LCD bias supply is used to control the LCD contrast over a range of -24 to -8 V_{DC}. It is digitally adjustable in 64 equal steps by an internal digital-to-analog converter (DAC). The CPU provides two signals, LCDADJ (ADJ) and LCDCTL (CTL), to interface with this device. On power up or after a reset, the counter sets the DAC output to the mid-range value.

Each rising edge of LCDADJ increments the DAC output. When incremented beyond full scale, the counter rolls over and sets the DAC to the minimum value. Therefore, a single pulse applied to LCDADJ increases the DAC set point by one step, and 63 pulses decrease the set point by one step.

4.2.1.9
REAL-TIME CLOCK

The watchdog timekeeper chip includes a complete real-time clock/calendar (RTC), watchdog timer, alarm, and interval timer. The time/date information includes hundredths of seconds, seconds, minutes, hours, day, date, month, and year. The date at the end of the month is automatically adjusted for months with less than 31 days, including correction for leap year. The watchdog timekeeper operates in either 24-hour or 12-hour format with an AM/PM indicator. The device can be programmed to set up an interval timer, and it can generate an alarm every day, hour, or minute. These alarm functions may be used to schedule real-time related activities. A parallel resonant 32,768 Hz crystal oscillator drives the internal time base.

The external interface is a separate (non-multiplexed) 8 bit data bus and 6 bit address bus, with a contiguous address space of 64 bytes. When system power is turned off, a battery voltage input is available, which makes the RTC data non-volatile. The address bus is connected to the ADDR<6:1> lines, and the data bus is connected to DATA<7:0> lines. Since the CPU accesses are 16 bits wide, the RTC data is on the lower byte of the word.

The RTC chip-enable pin (CE*) is active low enabled for read and write operations. It is driven by the FPGA control logic, chip-select RTC signal (CSRTC*), which involves address decoding circuitry *(see Section 4.2.1.2)*.

4.2.1.10
VOLTAGE MONITOR WATCHDOG TIMER

It is important to protect the system during power transitions, and the CPU is reset after the V_{CC} power supply is applied. The microprocessor supervisory circuit generates an automatic reset output during power up, power down, or brownout conditions. When the V_{CC} falls below the reset threshold voltage of 2.90 V_{DC}, the reset signal (RESET*) goes low and holds the microprocessor in reset for approximately 200 ms after V_{CC} rises above the threshold. The supervisory circuit includes a chip-select inhibit circuit, which is used to disable access to the real-time clock's non-volatile SRAM during power transitions and power down mode.

This device also provides a watchdog timer function to monitor the activity of the microprocessor. To service the watchdog timer immediately after reset, the device has a longer time-out period (1.6 second minimum) right after a reset. The normal time-out period (70 ms minimum) is effective after the first transition of watchdog input (WDI) after RESET* is inactive. If the microprocessor does not toggle WDI within the time-out period, both RESET* and watchdog out (WDO*) outputs are asserted low. The RESET* remains active low for a minimum of 140 ms and it resets the CPU. The WDO* remains low as long as the WDI remains either high or low for longer than the watchdog time-out period. After a reset, the software reads this memory-mapped bit to determine if the latest reset was a watchdog time-out.

4.2.1.11
ANALOG-TO-DIGITAL CONVERTER

The analog-to-digital converter (ADC) monitors the proximal pressure sensor, distal pressure sensor, proximal air sensor, distal air sensor, battery charge/discharge current, battery voltage, buzzer test signal, LCD contrast voltage, CCFT test signal, and two chopper motor drive reference voltages. The ADC is an advanced 10 bit accurate, 11 channel, switched-capacitor, successive-approximation device. It has three inputs and a three-state output (chip-select, I/O clock, address input, and data out) that provide a direct four-wire interface to the serial communication port of the CPU. The ADC is designed to be used in conjunction with multiple serial devices on a common bus; consequently, the data-out pin is driven only when the chip-select (CS*) pin is asserted. *Figure 4-1, Serial Interface to ADC*, illustrates the serial interface between the ADC and the CPU.

In addition to a high-speed ADC and versatile control capability, this device has an on-chip 14 channel multiplexer that can select any one of 11 analog inputs or any one of three internal self test voltages. The sample-and-hold function is automatic. The end-of-conversion (EOC) output goes high to indicate that conversion is complete. The CPU polls the EOC signal.

Channel selection and conversion results are transferred through the SCP pins. A serial transfer synchronizing clock (SPCLK) must be fed into the I/O clock input pin when the CS* pin is driven low. The address to be converted is serially transmitted into the address pin, and the conversion results are serially shifted out the data-out pin. Typical access time is 21 µsec. The APP PWA is the source of the 2.5 V_{DC} reference voltage.

The analog inputs are selected by the channel multiplexer according to the input address *(see Table 4-1, Analog Inputs)*. The input multiplexer is a break-before-make type to reduce input-to-input noise injection resulting from channel switching.

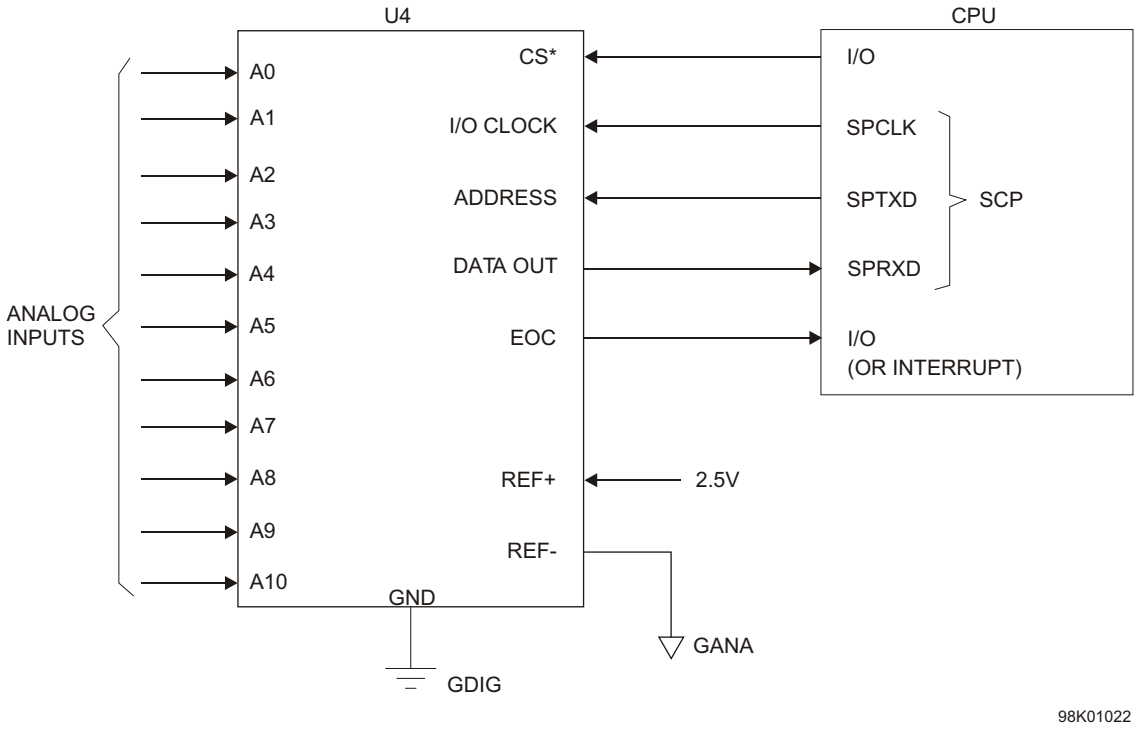

Figure 4-1. Serial Interface to ADC

Table 4-1. Analog Inputs			
Signal Name	**Analog Input**	**Address (hex)**	**Description**
PRPRS	A0	$00	Proximal pressure sensor
DIPRS	A1	$01	Distal pressure sensor
PXAIR	A2	$02	Proximal air sensor
DIAIR	A3	$03	Distal air sensor
IBATT	A4	$04	Battery current
VBATT	A5	$05	Battery voltage
BUZTST	A6	$06	Buzzer test voltage
LCDTST	A7	$07	LCD contrast test voltage
TUBTST	A8	$08	CCFT intensity test voltage
MI_STA	A9	$09	Motor current A control
MI_STB	A10	$0A	Motor current B control
		$0B	$(V_{ref(+)} - V_{ref(-)}) / 2$
		$0C	$V_{ref(-)}$
		$0D	$V_{ref(+)}$

4.2.1.12
DIGITAL-TO-ANALOG CONVERTER

The dual 8 bit digital-to-analog converter (DAC) generates two analog signals to control the phase A and phase B motor coil currents. The interface between the DAC device and the CPU is the 8 bit data bus, which is connected to DATA15:8. All the control signals for this DAC are generated by FPGA logic devices. Buffer amplifier/ground compensation circuits (U6 and U7) condition the DAC outputs.

4.2.1.13
FRONT PANEL KEYPAD MATRIX

A 5 x 5 membrane switch keypad matrix is located on the front panel. The keypad column lines (COL4:0) are driven by open collector type memory mapped input ports, while the keypad row lines (ROW4:0), are read by memory mapped input ports. The keypad strobing, scanning, and switch de-bouncing is accomplished by software. The keypad interface is designed with ESD protection *(see Table 4-2, Keypad Map)*.

Table 4-2. Keypad Map

	COL 0	COL 1	COL 2	COL 3	COL 4
Row 4	Softkey 1	Softkey 2	Softkey 3	Softkey 4	
Row 3	Start	1	2	3	[▲]
Row 2	Stop	4	5	6	
Row 1		7	8	9	[▼]
Row 0	On/Off	Clear	0	.	Silence

4.2.1.14
FRONT PANEL [ON/OFF] KEY

The [ON/OFF] key on the front panel provides a start up (STRTUP) signal to wake up the power supply when the system is shutdown. When activated during normal operation, the [ON/OFF] key interrupts (STRUPD*) the CPU, signaling a request for shutdown.

4.2.1.15
FRONT PANEL LED INDICATORS

The CPU drives the three light emitting diode (LED) indicators embedded in the front panel. Two memory mapped I/O signals activate the two LED lights used to indicate which channel is in delivery mode (LEDAE*, LEDBE*). The AC power on LED indicates the status of AC power (LEDAC) and that the system is in the battery charge mode. A buffered AC on signal (BACON) drives the LED and is active only when AC power is present.

4.2.1.16
KEYPAD LOCKOUT INTERFACE

A lockout switch (SW1) on the peripheral PWA indicates the front panel keypad is locked. A memory mapped input port (LOTSW*) reads the switch. The switch serves as a lockout request and software performs the lockout.

4.2.1.17
NURSE CALL INTERFACE

A nurse call relay switch on the peripheral PWA indicates alarm conditions to a remote operator. A memory-mapped output signal (NURSE) activates the relay during alarm conditions. The relay has both normally open and normally closed contacts. A jumper on the peripheral board selects the contact type. The factory setting is normally open.

4.2.1.18
AUDIBLE INDICATORS

There are two audible indicators on the CPU subsystem. A loud, main audible indicator is mounted on the main chassis. This main alarm is used for alerting the operator to alarm conditions. A keypad beeper (LS1), with lower power and a distinctly different tone, is used to provide audible feedback to the operator. The keypad beeper is driven by a memory-mapped output (KEYALM). It is used to indicate keypad activation, and confirmation to the operator.

The main alarm has an adjustable volume control on the peripheral PWA (R2), mounted on the rear of the instrument. The main alarm can be activated by either a memory-mapped control (MAINALM), the reset pulse(s), or by a power failure alarm latch. The main alarm will sound a chirp for every reset pulse sent by the watchdog timer IC. Continuous chirping indicates a stuck processor.

The alarm is activated continuously during power failure. If the control software does not shut down power in a proper sequence, a latch on the CPU PWA (U2), powered by a backup supply (0.1 F supercap), will activate a continuous alarm. This continuous alarm sounds until either the backup supply is discharged or the user resets the latch by pressing the front panel [ON/OFF] key. Reliable operation of the main alarm is assured by software monitoring of a buzzer test signal (FBUZTST) via the ADC.

4.2.1.19
BARCODE READER INTERFACE

Note: This section is not applicable to devices equipped with the MedNet accessory.

The CPU communicates with a barcode wand that is connected to the peripheral PWA from the rear of the infusion device. The barcode wand reads and decodes a Code 128 barcode symbology and outputs the barcode data via an RS-232 port using an asynchronous, serial ASCII format.The software controls power to the barcode reader and to the interface circuits via memory-mapped outputs BARPWR and COMPWR*. The barcode reader is isolated from the main system by an optical data path on the peripheral PWA (U10, U11, and U13) and an isolated power supply (U3 and T1).

4.2.1.20
DATAPORT INTERFACE

The CPU communicates with an external computer by way of a DataPort interface. The DataPort interface provides for remote monitoring of up to 15 pumps using a host computer with a modified RS-232-D serial interface. Pumps are either connected directly to the host or in a daisy chain configuration using junction boxes that provide a 5 bit hard ID via DIP switches on the junction box. The DIP switches are buffered (peripheral PWA U8) and read by the CPU via the memory-mapped input/output (MMIO) port.

The DataPort system conforms to the EIA-232-D standard, with the following exceptions:

- DataPort uses non-standard DB-15 and 6 pin modular connectors in addition to the standard DB-25 and DB-9 connectors
- With DataPort, more than one pump is allowed on the line
- The minimum line impedance is 2 KΩ (EIA-232-D standard: 3 KΩ min.)
- The maximum line impedance is 30 KΩ (EIA-232-D standard: 7 KΩ max.)
- The maximum line capacitance is 13 nF (EIA-232-D standard: 2,500 pF)

The communications default is 1200 BAUD, no parity, 8 data bits and 1 stop bit. The Plum A+ BAUD rate is selectable (1200, 2400, 4800, and 9600). The data format on the serial port is a 10 bit frame with asynchronous start and stop. The CTS line is held high and the RTS line is disconnected.

The DataPort is isolated from the main system by an optical data path on the peripheral PWA (U10, U11, and U13) and an isolated power supply (U3 and T1).

4.2.1.21
POWER SUPPLY INTERFACE

The CPU subsystem interfaces the power supply subsystem by providing the MMIO signals needed for power control and battery management. Additionally, the CPU subsystem measures the battery terminal voltage and charge/discharge current via the ADC *(see Table 4-3, CPU-Power Supply Interface)*.

Table 4-3. CPU-Power Supply Interface

Signal Name	Type	Description
PWRHLD	D, O	Holds system power on
STRTUP	A, I	Startup pulse from the [ON/OFF] key
STRUPD*	D, I	Digital startup pulse, used as interrupt to the CPU
V3_3	P	3.3 volt system power
V5_0/VANA	P	5.0 volt analog and interface power
VMOT	P	Raw, unregulated charger voltage or battery voltage
V2_7	P	2.7 volt backup power for RTC and non-volatile SRAM
VSC	P	Full time 5 volt supply, backed up by supercap
V12_0	P	12 volt, low current supply for audio alarm

Table 4-3. CPU-Power Supply Interface		
Signal Name	**Type**	**Description**
OVRVLT*	D, I	Signal that indicates overvoltage, regulation problem on the power supply main regulator
BACON	D, I	Buffered AC on signal
IBATT	A, I	Voltage proportional to integration of battery charge/discharge current
VBATT	A, I	Divided battery terminal voltage
CHG*	D, O	Battery charger enable
VFLOAT*	D, O	Set the main regulator voltage to battery float charge level
ITGRST	D, O	Reset the charge current integrator

Legend: P = Power; A = Analog; D = Digital; I = Input; O = Output

4.2.1.22 MECHANISM INTERFACE

The CPU subsystem provides the MMIO ports for interface to the mechanism subsystem, in addition to the analog interface mentioned in the ADC and DAC sections *(see Section 4.2.1.11 and Section 4.2.1.12)*. Refer to *Table 4-4* for CPU-mechanism interface signals.

Table 4-4. CPU-Mechanism Interface Signals		
Signal Name	**Type**	**Description**
MI_STA	A, O	Motor current set for phase A
MI_STB	A, O	Motor current set for phase B
GDAC	A, O	Ground signal from chopper (for compensation)
M_PHA	D, O	Motor phase A
M_PHB	D, O	Motor phase B
M_SEL1, M_SEL0	D, O	Motor select bits
FLCAME	D, O	I/O and L/S cam flag sensors enable
FLPINE	D, O	L/S pin motion detectors enable
FLPLE	D, O	Plunger motor sensor pair enable
FLLS_C	D, I	Flag, L/S valve cam sensor
FLIO_C	D, I	Flag, I/O valve cam sensor
FLLS_A	D, I	Flag, L/S valve A pin detector
FLLS_B	D, I	Flag, L/S valve B pin detector
FLPLRO	D, I	Flag, plunger rotation sensor

Table 4-4. CPU-Mechanism Interface Signals		
Signal Name	**Type**	**Description**
FLPLTR	D, I	Flag, plunger translation sensor
PXPRE	D,O	Proximal pressure sensor enable
PXPRS	A, I	Proximal pressure sensor
DIPRE	D, O	Distal pressure sensor enable
DIPRS	D, O	Distal pressure sensor
PXARE	D, O	Proximal air sensor enable
PXAIR	A, I	Proximal air sensor
DIARE	D, O	Distal air sensor enable
DIAIR	A, I	Distal air sensor
CASPR*	D, I	Cassette present
CASS2*, CASS1*, CASSO*	D, I	Cassette type coding: Macro (111), Micro (010); all others are invalid
SPCLK	D, O	SCP clock output
SPRXD	D, I	SCP receive data
SPTXD	D, O	SCP transmit data
CSSEP*	D, O	Chip select, EEPROM
V5_0	P	5.0 volt supply for interface power
V3_3	P	3.3 volt supply for logic power
GDIG	P	Digital ground
VANA	P	5.0 volt supply for analog power
GANA	P	Analog ground
VMOT, GMOT	P	Motor power is directly from power supply PWA
V2_5	A, I	Reference voltage for ADC and DAC

Legend: P = Power; A = Analog; D = Digital; I = Input; O = Output

4.2.2
POWER SUPPLY SUBSYSTEM

The power supply subsystem provides DC power to system circuits and interface software controlled power and battery management *(see Figure 9-11, Power Supply PWA Schematic (110 V) and Figure 9-17, Power Supply PWA Schematic (220 V))*.

The power supply subsystem provides for the following functions:

- Main switching regulator
- AC power detection
- Main regulator fault detection
- System power (secondary regulators)
- Auxiliary supplies
- Power control
- Battery charging circuitry
- Battery terminal voltage measurement
- Battery charge/discharge current measurement

4.2.2.1
MAIN SWITCHING REGULATOR (110 V_{AC})

The main source of power for the Plum A+ 110 V_{AC} is the AC line. The main switching regulator is a pulse width modulated, AC-to-DC converter which provides the system an isolated DC voltage of 6.74 V_{DC} (or 7.35 V_{DC} in battery charger boost mode). The main regulator is preceded by: line fuses F1 and F2, surge suppressor VR1, and a line filter (T3, T4, C54-56). The bridge rectifier U14 and capacitors C52 and C53 provide the DC voltage required for the switching circuit. Voltage regulator U13 provides the pulse width modulator (PWM) device U12 startup supply voltage. After startup, supply voltage for U12 is supplied by half wave rectifier circuitry CR14, R76, and C51.

The PWM oscillation frequency is approximately 40 kHz, determined by external resistor R72 and capacitor C45. U12 controls the power delivered by varying the duty cycle of the power metal-oxide-semiconductor field-effect transistor (MOSFET) Q9, which drives T2. A half-wave rectifier (CR9 and C37-C41) rectifies the transformer's secondary voltage, which provides the raw DC voltage for the battery charger and system power. There are three feedback mechanisms that maintain control: a main loop for normal control, a secondary loop for overvoltage protection, and a current limit loop.

4.2.2.2
MAIN SWITCHING REGULATOR (220 V_{AC})

The main source of power for the Plum A+ 220 V_{AC} is the AC line, at 230 V ±15% AC. The main switching regulator is a pulse width modulated, AC-to-DC converter which provides the system an isolated DC voltage of 6.74 V_{DC} (or 7.35 V_{DC} in battery charger boost mode). The main regulator is preceded by: line fuses F1 and F2, surge suppressor VR1, and a line filter (T3, T4, C55). The bridge rectifier U14 and capacitors C52 and C17 provide the DC voltage required for the switching circuit. Voltage regulator U16, Q12 and associated components provide the PWM device U12 startup and operating supply voltage. The DC source is supplied by the half wave rectifier circuitry CR18 and C84.

The PWM oscillation frequency is approximately 18 kHz, determined by external resistor R72 and capacitor C45. U12 controls the power delivered by varying the duty cycle of the power MOSFET Q9, which drives T2. A half-wave rectifier (CR9) rectifies the transformer's secondary voltage, which provides the raw DC voltage for the battery charger and system power. There are three feedback mechanisms that maintain control: a main loop for normal control, a secondary loop for overvoltage protection, and a current limit loop.

4.2.2.2.1
Main Loop (110 V_{AC} and 220 V_{AC})

The main loop uses an optical feedback path to regulate the charger voltage (BATPOS) at 6.9 V_{DC} (except during boost charge, when the limit is raised to 7.5 V_{DC} by software control of the VFLOAT* line). A shunt regulator and opto-isolator provide feedback to the PWM error amplifier.

4.2.2.2.2
Secondary Loop (110 V_{AC} and 220 V_{AC})

Diode CR10 and opto-isolator U10 provide overvoltage protection. CR10 conducts and activates U10 when secondary voltage exceeds approximately 10 V_{DC}. The duty cycle of U12 is reduced until the excessive voltage is removed.

4.2.2.2.3
Current Limit Loop (110 V_{AC} and 220 V_{AC})

The current limit loop is activated when the primary current, sensed by R71 (R71 and R85 for 220 V), exceeds 3.0 A (5.3 A for 220 V). Resistor R70 and capacitor C46 filter the voltage across R71 and feed it back to the current sense input (1.5 V_{DC} threshold) of U12. The duty cycle of U12 is reduced until the excessive load is removed.

4.2.2.3
MAIN REGULATOR FAULT DETECTION (110 V_{AC} AND 220 V_{AC})

If the switching regulator's main loop fails, the secondary voltage limit loop takes over. However, the battery charger and motors must be disabled, and an alarm must be generated. A comparator is used to monitor the raw DC (+BUSS) for overvoltage. A 3.3 V_{DC} logic signal (OVRVLT*) is provided to the CPU subsystem.

4.2.2.4
SYSTEM POWER (110 V_{AC})

Along with the unregulated VMOT supply, a secondary switching regulator provides system power. The secondary switching regulator includes IC U4, transformer T1, and transistors Q4 and Q5. The regulator is a triple output, wide supply range, fly-back converter that provides regulated 3.3 V_{DC}, 5.0 V_{DC}, and 12.0 V_{DC} outputs from the five winding transformer T1. The regulator operates over an input range of 4 to 10 V_{DC} and provides output current limit as well as voltage overshoot limit. Primary feedback is metered through a bias arrangement on transistor Q3. A Schottky rectifier diode CR4 provides feedback in the event of V3_3 or V12_0 failure, and transistor Q10 provides feedback in the event of V5_0 failure. The positive terminal of the battery provides the raw DC voltage, VMOT, for the motors and backlight of the display.

4.2.2.5
SYSTEM POWER (220 V_{AC})

Along with the unregulated VMOT supply, a secondary switching regulator provides system power. The secondary switching regulator includes IC U4, transformer T1, and transistors Q4 and Q5. The regulator is a triple output, wide supply range, fly-back converter that provides regulated 3.3 V_{DC}, 5.0 V_{DC}, and 12.0 V_{DC} outputs from the five winding transformer T1. The regulator operates over an input range of 4 to 10 V_{DC} and provides output current limit as well as voltage overshoot limit. Primary feedback is provided by R27 sense resistor and low pass filter R23 and C7 to U4, LTC187 sense input. The positive terminal of the battery provides the raw DC voltage, VMOT, for the motors and backlight of the display.

4.2.2.6
AUXILIARY SUPPLIES (110 V_{AC} AND 220 V_{AC})

The power supply subsystem provides full time 5.0 and 2.7 V_{DC} supplies, which are active when battery or AC voltage is present. The full time 5.0 V_{DC} supply (VSC) uses a linear low dropout voltage regulator U6, whose power source is directly from the battery and is backed up by a 0.1 F capacitor. VSC is used for the ON/OFF switch and a power failure alarm latch. The full time 2.7 V_{DC} supply (V2_7) is derived from VSC and is used to supply the ultra-low current needed to power the real-time clock and non-volatile SRAM during shutdown.

4.2.2.7
POWER CONTROL (110 V_{AC} AND 220 V_{AC})

The infusion pump will operate in one of three modes: normal, standby, or shutdown. During normal operation, the user interface is active and either on battery or AC line power. During standby mode the user interface is inactive while the CPU is still operating, servicing the battery management and waiting for a startup interrupt. Shutdown mode is when system power is off. Shutdown mode only occurs during battery operation; otherwise, +BUSS holds the system power on.

The infusion pump is activated when the [ON/OFF] key is pressed or the AC line is plugged in. The [ON/OFF] key activates the STRTUP signal, triggering a three second one-shot circuit (C3, R10, CR1, and Q1) that will temporarily turn the system power on. This three second one-shot period allows the CPU enough time to power up, initialize, and turn on the PWRHLD signal. The CPU monitors the STRTUP signal, via interrupt, to signal a user request for turning off the infuser.

Figure 4-2, System Startup and Shutdown Timing, Battery Powered illustrates the system startup/shutdown sequence while battery powered. System power is always on while AC powered.

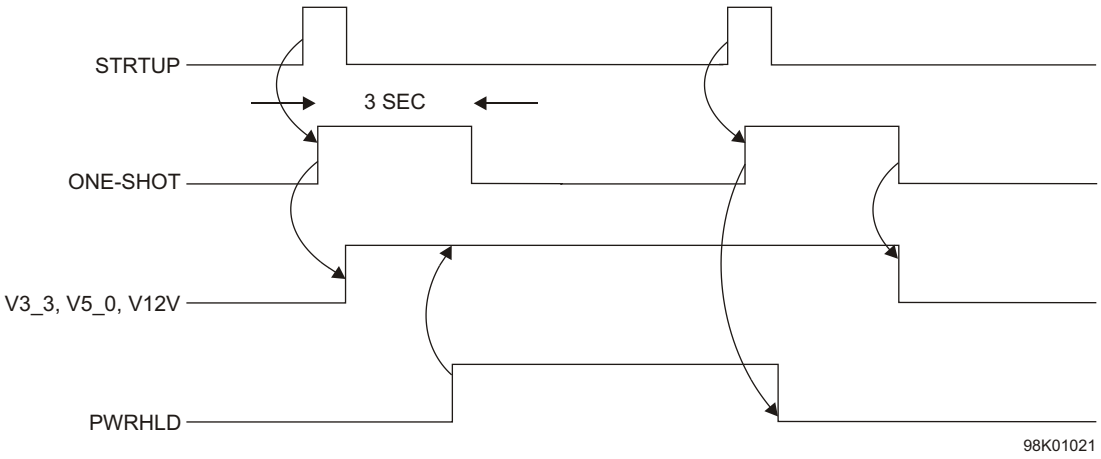

Figure 4-2. System Startup and Shutdown Timing, Battery Powered

4.2.2.8
BATTERY VOLTAGE MEASUREMENT (110 V_{AC} AND 220 V_{AC})

The battery terminal voltage (BATPOS - BATNEG) is measured with a differential amplifier consisting of U1, R1, R2, R4, R7, and R8. It has a gain of 0.317 to generate a single ended VBATT signal. The VBATT signal is then provided to the CPU A/D converter as input for the battery management algorithms.

4.2.2.9
BATTERY CHARGE/DISCHARGE CURRENT MEASUREMENT (110 V_{AC} AND 220 V_{AC})

The battery management algorithms measure battery charge/discharge current for battery capacity estimation and charger control. The charge/discharge current is measured by integrating the voltage across current sense resistor R57. An operational amplifier (op-amp) integrator circuit, consisting of U2, C5, R12, R13, R19, and R20, provides a voltage proportional to the integration of battery current (IBATT) over a CPU controlled measurement period. The IBATT signal is fed to the CPU A/D converter, where it is sampled at the end of the measurement period. The battery management algorithm further accumulates the charge/discharge current for battery capacity estimation. The op-amp integrator is reset by the CPU system at the beginning of each measurement period by parallel analog switches U3, controlled by the CPU's ITGRST signal. The battery management algorithm periodically calibrates the op-amp integrator.

4.2.2.10
BATTERY CHARGER (110 V_{AC} AND 220 V_{AC})

The software battery management algorithm controls the battery charger. The charging scheme is a current limit/two stage voltage limit charger. The charge current is limited to 1.3 A and the voltage is limited to either 6.74 V_{DC} or 7.35 V_{DC}.

The source of the charge current is power MOSFET transistor Q7 operating in the linear mode. Charge current passes through a current sense resistor R57, where it develops a feedback signal for the charger control amplifier consisting of U7, Q6, and associated parts. The feedback signal is compared against a 2.5 V_{DC} voltage reference U8. A .5 A fuse (F4) protects against damage due to a short circuit. The battery management algorithm maintains on/off control of the charger by the charger enable signal CHG*. When set high, CHG* activates a comparator U7, which overrides the feedback signal and disables the charger. Excessive voltage on the BATNEG terminal indicates that there is a shorted battery cell, and will disable the charger through the same comparator.

4.2.3
MECHANISM SUBSYSTEM

The mechanism subsystem includes the electronics and electromechanical components that interface with the Plum A+ pumping mechanism *(see Figure 9-14, Driver PWA Schematic and Figure 9-15, Switch PWA Schematic)*. Refer to *Table 4-4* for mechanism interface signals.

The mechanism subsystem provides the following functions:

- Chopper motor drive for three stepper motors (plunger, L/S valve, I/O valve)
- Four motor position sensors (flag detectors)
- Precision voltage reference
- Two air sensors (distal, proximal)
- Two pressure sensors (distal, proximal)
- Cassette presence and type detection
- Serial electrically erasable PROM (EEPROM)

4.2.3.1
MOTORS/MOTOR DRIVE

The Plum A+ infusion system uses three stepper motors for pumping: one for fluid displacement and two for cassette valve actuation. The stepper motors are driven, under step-by-step control from software, by a unipolar chopper drive.

4.2.3.1.1
Stepper Motors

Each motor is named by its function:

- Plunger motor for driving the plunger screw
- I/O valve motor for moving the input-output valve pins
- L/S valve motor for moving the line select valve pins A and B

All three motors are four phase stepper types. One electrical revolution is accomplished after four motor steps (phases) are completed. The step-angle (the number of steps per shaft revolution) resolutions are 3.6° /step (100 steps/rev) for the plunger motor, and 7.5° /step (48 steps/rev) for the I/O and L/S valve motors.

The unipolar motor windings have a center tap connected on each of the two coils as shown in *Figure 4-3, Stepper Motor Coils*. Unidirectional current enters the center tap and is steered to one end of the coil or the other end by the driver electronics, creating positive or negative flux lines in the motor coil. With two coils each with a choice of flux polarity, four electrical combinations or phases are possible.

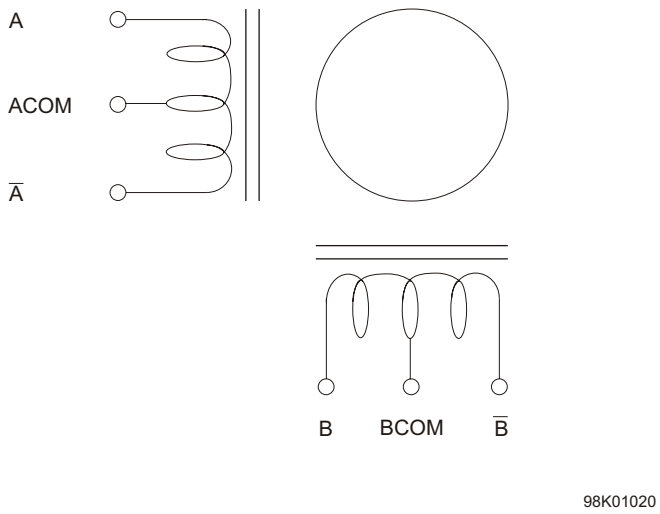

Figure 4-3. Stepper Motor Coils

4.2.3.1.2
Chopper Motor Drive

The Plum A+ stepper motor drive is a chopper drive, which is a pulse width modulation of the coil current in each motor winding. Current is switched on and off to maintain a predetermined coil current independent of supply voltage and motor speed. The motor winding inductance acts as a filter to smooth out the switching currents, slowing the current rise when turned on and storing a decaying current when turned off.

Each motor coil is modulated independently, allowing different coil currents in the two motor windings. The coil current is sensed and compared to a reference input for each winding. Modulation circuits correct for any error between the sensed current and the reference. This reference input can be changed to set a different coil current.

4.2.3.2
MOTOR POSITION SENSORS

Motor position is estimated by counting the motor steps, relative to a position reference. Optical switches and flags serve as position references, which are used to find the motor home positions and to verify proper motion. Flag positions are anticipated by software. Optical switch flag sensors are used for tracking:

- Plunger motor rotational position (coupler flag)
- Plunger translational (linear) position
- I/O valve motor rotational position (cam flag)
- L/S valve motor rotational position (cam flag)

Each optical switch consists of an infrared LED, which shines through a rectangular aperture, across a slot, to illuminate a photo-transistor. The photo-transistor is activated as long as the beam is on and not blocked (by a flag in the slot). The optical switches are distributed throughout the mechanism, near their associated flags. The motor rotational optical switches (U5, U9, and U10) are mounted on the driver PWA along with the control circuitry. The plunger translational optical switch is mounted remotely on the switch PWA. The switches are used intermittently to save power.

There are two control signals that enable associated switch pairs:

- FLCAME flag valve motor cam sensor enable
- FLPLE flag plunger motor rotation and translation sensors enable

Each of these control signals enables a constant current source which turns on the associated switch's infrared LEDs. The photo transistor states are sensed by Schmidt trigger inverters (U11 on driver PWA) which provide a 3.3 volt logic high when the optical path is blocked or a logic low when the optical path is clear. The Schmidt trigger output is high when the sensor is disabled.

The following output signals are provided to the CPU subsystem:

- FLIO_C flag I/O valve motor cam sensor
- FLLS_C flag L/S valve motor cam sensor
- FLPLRO flag plunger motor rotation sensor
- FLPLTR flag plunger motor transition sensor

4.2.3.3
V2_5 REFERENCE VOLTAGE

A precision 2.50 V_{DC} reference voltage is generated on the APP PWA for use by the pressure sensor excitation circuits, the air sensor amplifier circuits, and the ADC and DAC reference voltage. The precision 2.50 V_{DC} reference (U1) is buffered by a voltage follower (U3). The signal name is V2_5.

4.2.3.4
AIR SENSORS

The mechanism subsystem includes two air sensors, used to detect air passage into (proximal) or out of (distal) the cassette. Both sensors are piezoelectric crystal transmitter receiver pairs. Liquid between the transmitter and receiver will conduct the ultrasonic signal, while air will not *(see Figure 4-4, Air Sensor Block Diagram)*.

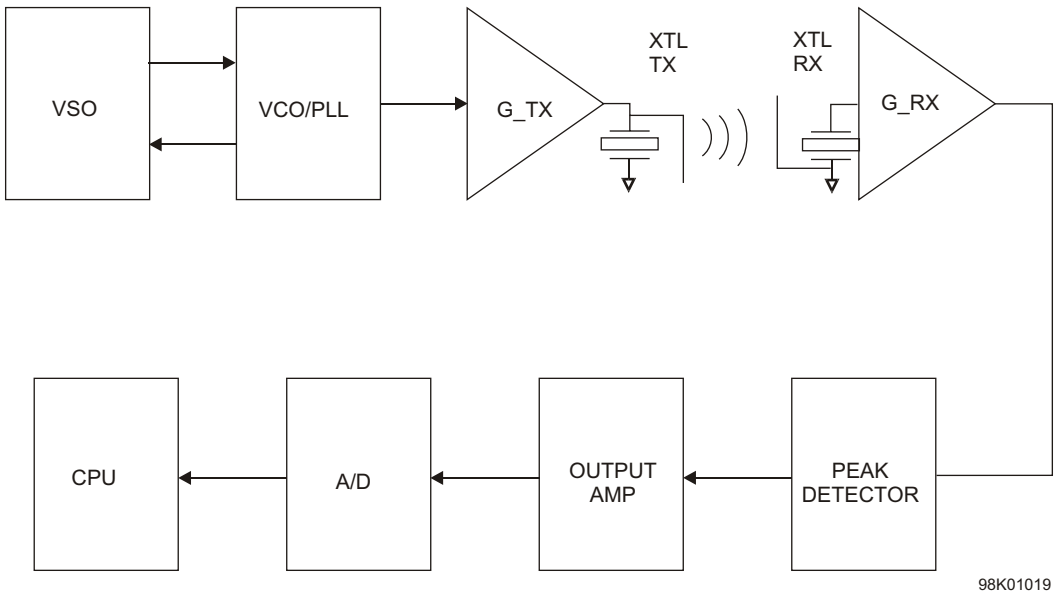

Figure 4-4. Air Sensor Block Diagram

4.2.3.4.1
Transmitter Circuitry

The transmitter circuitry consists of a voltage sweep oscillator (VSO), a voltage-controlled oscillator (VCO), and a transmitter amplifier, and are located on the APP PWA.

The voltage sweep oscillator circuit (U10B, R24, C12, and part of U9) oscillates at approximately 12 kHz at 50 percent duty cycle. The output of the sweep oscillator is between +2 V_{DC} and +3 V_{DC}, and is used to sweep the VCO. The VCO sweeps through the sensor's peak coupling frequency, which is between 3.0 and 6.0 MHz. A resistor and capacitor (R28 and C13) are used to configure the VCO center frequency. The VCO is enabled when the CPU asserts either DIARE or PXARE control signals.

The transmitter amplifier consists of a push-pull, emitter-follower, complementary pair of transistors (Q15 and Q16). The transmitter amplifier drives both proximal and distal sensors simultaneously.

4.2.3.4.2
Receiver Circuitry

When the cassette's test port is filled with fluid, the transmitted signal will be coupled to an identical piezoelectric crystal, where it is amplified and detected by the receiver circuitry. The receiver circuitry consists of an amplifier, a peak detector, and an adjustable gain buffer stage. There is a separate, symmetrical receiver circuit for each channel (proximal and distal). Component references (called out in this design description) will be made to the distal channel only.

The first amplifier includes two, directly coupled common emitter stages (Q5 and Q7), biased from the V2_5 supply. DIARE and PXARE are used to enable the distal and proximal sensors, respectively.

The detector stage consists of an emitter follower (Q3), charging a 400 µsec time constant, refreshed every 40 µsec (twice per VCO sweep).

The peak detector output is buffered by an op-amp (U7) configured as a basic non-inverting amplifier with a trimming potentiometer (R31) for gain adjustment. Each sensor has an independent gain adjustment. The two air sensor, gain-trimming potentiometers are accessible for calibration in an assembled mechanism.

These final signals are read by the CPU subsystem via the ADC:

- PXAIR Proximal air sensor output
- DIAIR Distal air sensor output

4.2.3.5
PRESSURE SENSORS

The mechanism subsection contains two strain gauge-type pressure sensors, one at the proximal and the other at the distal cassette ports. Electrically, the strain gauge is a Wheatstone bridge made of four strain gauge resistors. When the bridge is electrically excited, the bridge will output a millivolt level signal proportional to the applied pressure. The output signal is amplified and offset adjusted before being read by the ADC. Each pressure sensor circuit includes an excitation voltage supply, sensor amplifiers, and a low pass filter.

The pressure sensor circuitry is on the APP PWA. Each of the two channels has an identical topology, but different gain and filter response. Component references are made to the distal channel only. A block diagram of this circuit is shown in *Figure 4-5, Pressure Sensor Excitation and Amplifier Block Diagram*.

Note: Component references are made to the distal channel only.

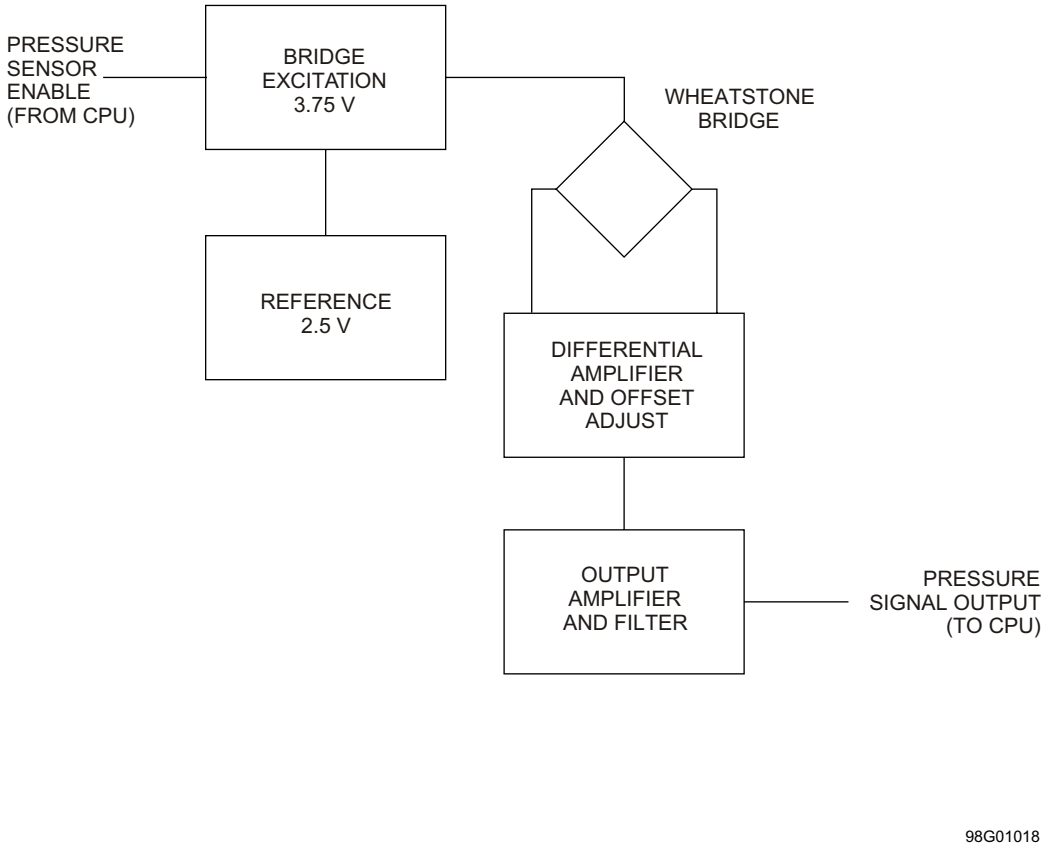

Figure 4-5. Pressure Sensor Excitation and Amplifier Block Diagram

4.2.3.5.1

Bridge Excitation Supply

The bridge excitation voltage is 3.75 V_{DC}, and is derived from the 2.5 V_{DC} reference signal (V2_5), gained 1.5 times by amplifier (U8A, Q13). The CPU subsystem may independently enable power to each pressure sensor bridge.

These enable signals are active high 3.3 volt logic level inputs:

- PXPRE Proximal pressure sensor enable
- DIPRE Distal pressure sensor enable

4.2.3.5.2
Amplifier and Low Pass Filter

The pressure sensor amplifiers include a high gain differential pre-amplifier (U4), followed by a second stage non-inverting amplifier (U6B) with low gain. A trimming potentiometer (R48) is adjusted to minimize any offset in the impedance of the bridge.

A two-pole filter is used to filter the pressure signals. The first pole is formed by a capacitor (C39, multiplied by 230 due to Miller effect) and a Thevenin resistance (seen at U4-2). The second pole is the RC filter at the ADC input, which is located on the CPU PWA.

These output signals to the A/D converter in the CPU PWA are:

- PXPRS Proximal pressure signal
- DIPRS Distal pressure signal

4.2.3.6
PRESSURE SENSOR CALIBRATION

Pressure sensors are calibrated for offset and gain during mechanism calibration. A trimming potentiometer is used to adjust the initial, zero pressure offset. The proximal and distal pressure sensors have independent offset adjustments.

The final system gain (cassette pressure to corrected amplifier output) is adjusted in software. During mechanism calibration, each channel's gain (amplifier output/cassette pressure) will be measured, and stored in the serial EEPROM on the driver PWA.

4.2.3.7
CASSETTE TYPE/PRESENCE SELECTION

The mechanism subsystem includes one force sensing resistor (FSR) switch, which is coupled to the cassette and is used for cassette present detection.

The FSR is a polymer thick film device, which exhibits a decrease in resistance with any increase in force applied to the active surface. The FSR is arranged in a voltage divider configuration with a fixed resistor, followed by a comparator with hysteresis. The comparator circuits are located on the CPU PWA. The comparators (CPU PWA: U8 and associated passives) are designed to trip as the FSR's resistance falls below 120 KΩ.

4.2.3.8
SERIAL EEPROM

The driver PWA holds the 8 K x 8 bit, serial EEPROM, which is used to store event, alarm, malfunction, and calibration data specific to the pumping mechanism. It is accessed through a serial peripheral interface (SPI) compatible interface, which is a high-speed serial interface to the CPU. The CPU PWA accesses this device through its SCP serial interface. This interface is a subset of the SPI, and consists of clock (SPCLK), data in (SPRXD), and data out (SPTXD) pins. This device is in the driver PWA to allow the calibration data to stay with the mechanism.

4.3 PRINTED WIRING ASSEMBLIES

The Plum A+ electronics are packaged into six printed wiring assemblies (PWA) and several remote mounted peripherals *(see Section 4-4, Remote Mounted Peripherals)*. The following sections provide a brief description of the functional interfaces of each PWA.

4.3.1 POWER SUPPLY PWA

The power supply PWA *(see Figure 9-11 and Figure 9-17)* contains the following functions of the power supply subsystem:

- Main switching regulator
- AC power detection
- Main regulator fault detection
- System power
- Auxiliary supplies
- Power control
- Battery management

The power supply is a four layer PWA, with primarily surface mount technology (SMT) components. The board is fully testable from the bottom side. An insulating tape covers the back of the power supply PWA. Open system troubleshooting should be done under battery power. If connection to the AC line is required, an isolation transformer should be used since AC line potentials are present on the power supply PWA.

See *Section 4.2.2* for a functional description, and refer to *Table 4-5* for power supply PWA interface connections.

Table 4-5. Power Supply PWA Interface Connections

Connector	Type	Interface
P2	30 pin receptacle	Board-to-board connection to CPU PWA
J16	4 pin header	Motor power connection to driver PWA
J21	3 pin receptacle	AC power cord connection
J22	2 pin header	Battery cable connection

4.3.2 PERIPHERAL PWA

The peripheral PWA *(see Figure 9-12)* contains part of the CPU subsystem circuitry, including system program and data memories (PROM and SRAM), external communication interface circuits, and rear instrument user controls. The peripheral PWA is designed to be field replaceable, to facilitate software upgrades or additional external interfaces.

The peripheral PWA is a four layer PWB, including one ground plane, one power plane, and two signal layers. In its initial configuration, all of the components are mounted on the top side.

See *Section 4.2.1* for a functional description, and refer to *Table 4-6* for peripheral PWA interface connections.

Table 4-6. Peripheral PWA Interface Connections

Connector	Type	Interface
P1	96 pin receptacle	Board-to-board connection to CPU PWA
J26	15 pin D-sub	DataPort
J27	9 pin D-sub	Barcode reader connection
J28	3 pin phone jack	Nurse call jack

4.3.3 CPU PWA

The CPU PWA *(see Figure 9-13)* contains most of the CPU subsystem functions, with the exception of main memory and communications ports, which are located on the peripheral PWA. The CPU PWA also accommodates system interconnect.

The CPU PWA is an eight layer PWB, with one ground plane, one power plane, and six signal layers. The CPU PWA primarily contains SMT components. Most of the components are on the top side, while the bottom side holds wave-solder compatible SMT resistors and capacitors.

See *Section 4.2.1* for a functional description, and refer to *Table 4-7* for CPU PWA interface connections.

Table 4-7. CPU PWA Interface Connections		
Connector	**Type**	**Interface**
J7	96 pin header	Connection to peripheral PWA (CPU bus, rear panel I/O, and communication ports)
J2	30 pin header	Connection to power supply PWA
J3	50 pin SMT	Ribbon cable connection to driver PWA (mechanism)
J4	21 pin header	Front panel connector (keypad, LEDs, on/off switch)
J5	14 pin SMT	Flat flex cable to LCD panel
J6	4 pin header	Lock box connector
J20	4 pin header	CCFT backlight connector
J24	2 pin header	Main audible alarm connector

4.3.4 DRIVER PWA

The driver PWA *(see Figure 9-14)* contains the mechanism subsystem's motor drive circuitry, motor position sensors, and serial EEPROM. The driver PWA is mounted in the mechanism sub-chassis.

The driver PWA is a four layer PWB, with one ground plane, one power plane and two signal layers. The driver PWA primarily uses SMT components. Most of the components are located on the top side of the board, while the bottom side holds wave-solder compatible resistors and capacitors.

See *Section 4.2.3* for a functional description, and refer to *Table 4-8* for driver PWA interface connections.

Table 4-8. Driver PWA Interface Connections		
Connector	**Type**	**Interface**
J7	6 pin header	Plunger motor
J8	6 pin header	Input/output motor
J9	6 pin header	Line select motor
J10	20 pin SMT	Flat flex cable to APP PWA
J11	50 pin header	Ribbon cable to CPU PWA
J12	6 pin SMT	FSR flex circuit
J13	4 pin header	Motor power from power supply PWA
J14	8 pin SMT	Flat flex cable to switch PWA

4.3.5
SWITCH PWA

The switch PWA *(see Figure 9-15)* contains the plunger translation position sensor, which is one of six position sensors in the system. The switch PWA is located at the side of the mechanism sub-chassis, and connects to the driver PWA.

4.3.6
APP PWA

The APP (air, pressure, and pin) PWA *(see Figure 9-16)* is mounted in the mechanism sub-chassis. The APP PWA contains the following mechanism subsystem circuitry:

- Proximal and distal air sensors and circuitry
- Proximal and distal pressure sensor amplifiers and excitation
- V2_5 precision voltage reference
- Pin detector optical switch module

The APP board is a four layer PWB, with one ground plane, one power plane and two signal layers. The APP PWA uses SMT components, mounted on both sides of the board. The air sensors and the pin detector module are board mounted.

See *Section 4.2.3* for a functional description, and refer to *Table 4-9* for APP PWA interface connections.

Table 4-9. APP PWA Interface Connections

Connector	Type	Interface
J15	20 pin SMT	Flat flex cable to driver PWA
J11	10 pin SMT	Pressure sensor connector

4.4
REMOTE MOUNTED PERIPHERALS

The following sections describe the major remote mounted peripherals.

4.4.1
LCD

The infusion pump uses a graphic LCD module with a CCFT. The CCFT provides a backlight source for the LCD. The LCD requires a nominal -16 V_{DC} supply for contrast control, which is controlled by the CPU. The pump's graphic display data is shifted out to the LCD by the CPU LCD controller, which interfaces directly with the CPU *(see Section 4.2.1.6)*. The display is configured as a 240 x 240 dot matrix with a viewing angle of approximately 60 degrees.

4.4.2
SEALED LEAD ACID BATTERY

The infusion pump uses a nominal 6.0 V_{DC} rechargeable sealed lead acid (SLA) battery with a 4.0 amp-hour capacity.

4.4.3
BARCODE READER WAND

Note: This section is not applicable to devices equipped with the MedNet accessory.

The barcode reader (BCR) wand connects to the BCR port J27 on the peripheral PWA *(see Figure 9-12)*. The BCR wand interfaces through the infusion pump's optically isolated, TTL logic level, asynchronous interface. The BCR wand is also capable of interfacing at RS-232 levels. The infusion pump provides an isolated +5.0 V_{DC} regulator to power the BCR wand. When the LED at the tip of the BCR wand is swiped across a barcode label, the reflected light is scanned and processed. After a successful scan, the data is sent over the communication interface to the CPU.

4.5
MECHANICAL OVERVIEW

The principal mechanical elements of the infusion pump include the cassette and the mechanism assembly. When a cassette is locked into the operating position and the [ON/OFF] switch is pressed, the infusion pump performs a self test to verify the integrity of the internal systems. The operation of the mechanism assembly moves a plunger, causing a pumping action. A valve motor selects the A or B valve, depending on the command. An additional valve motor alternately opens and closes an inlet valve and outlet valve to control fluid flow through the cassette pumping chamber.

The following sections detail the cassette and the mechanism assembly.

4.5.1
CASSETTE

The cassette operates on a fluid displacement principle to volumetrically deliver fluid *(see Figure 4-6, Major Elements of the Dual-Channel Cassette, and Figure 4-7, Fluid Path in the Cassette)*. Refer to the system operating manual for a description of the major cassette functions.

The pumping cycle begins when the outlet valve is opened and the inlet valve is closed. The plunger extends to deflect the cassette diaphragm and expel fluid. At the end of the pumping stroke, the outlet valve is closed, the inlet opens, the appropriate A or B valve opens, and the plunger retracts to allow fluid to refill the pumping chamber. After the pumping chamber is filled, the inlet and outlet valves are reversed, the A and B valves are closed, and the cycle repeats.

The cassette contains two chambers: an upper air trap chamber and a pumping chamber. The two chambers are separated by an inlet valve *(see Figure 4-6 and Figure 4-7)* and operate together to detect air. The air trap chamber receives fluid from the intravenous (IV) container through either the A or B valve. The air trap chamber collects air bubbles from the IV line and container to prevent them from entering the pumping chamber and can collect a substantial amount of air.

A proximal air-in-line sensor (bubble detector) is located between the A/B valves and the upper air-trap chamber. The proximal air-in-line sensor detects air entering the upper air-trap chamber and initiates an audible alarm if the predetermined air collection threshold is exceeded. Similarly, a second air-in-line sensor located distal to the pumping chamber initiates an audible alarm if a predetermined amount of air is detected. The infusion pump expels air from the cassette.

The pumping chamber receives fluid from the upper air-trap chamber through an inlet valve. A pressure sensor located in the upper air-trap chamber monitors pressure on the proximal side of the cassette. When the diaphragm covering the pumping chamber is deflected by the plunger, the pumping chamber expels fluid through an outlet valve. A pressure sensor located distal to the pumping chamber monitors pressure on the distal side of the cassette.

A flow regulator is incorporated into the cassette distal end. This flow regulator is used to manually control flow when the cassette is not inserted in the infusion pump. When the cassette is properly inserted into the pump and the door is closed, a mechanism opens the flow regulator to allow the pump to control fluid flow. When the door is opened, the same mechanism closes the flow regulator to disable fluid flow.

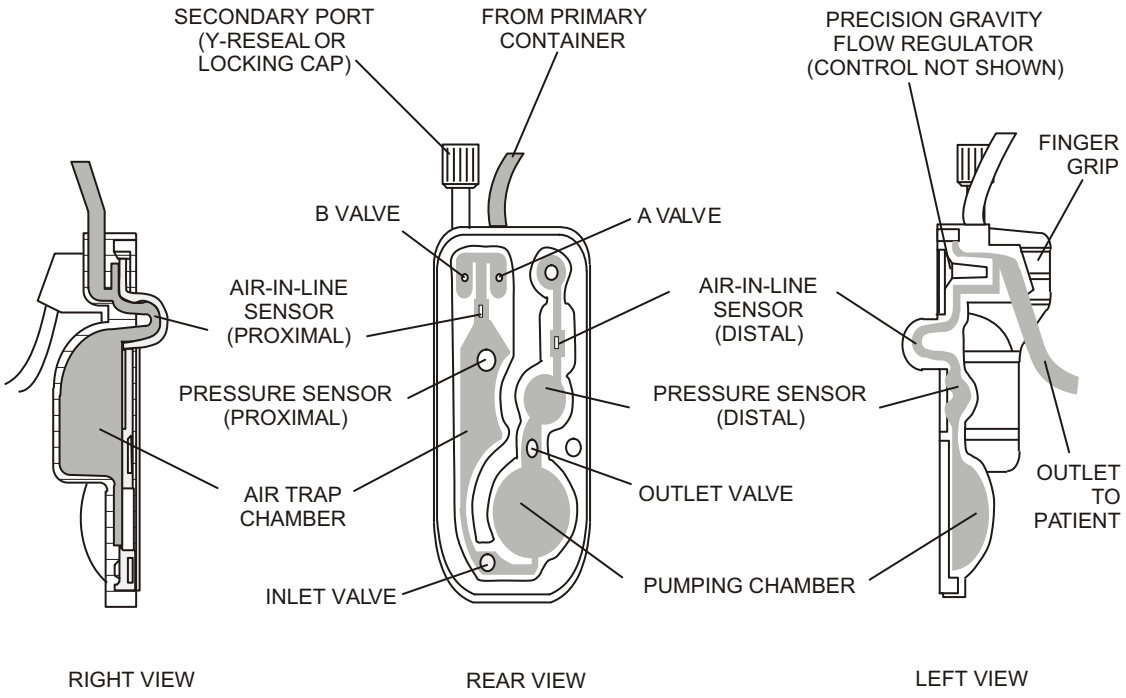

Figure 4-6. Major Elements of the Dual-Channel Cassette

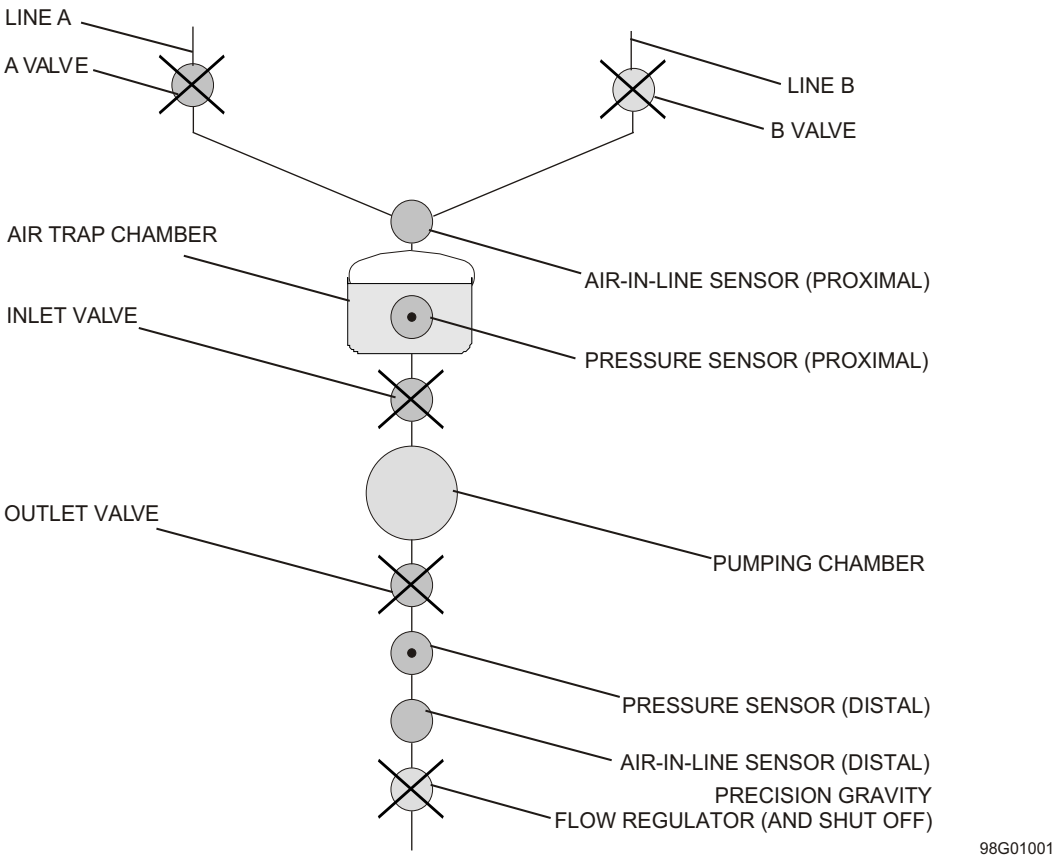

Figure 4-7. Fluid Path in the Cassette

4.5.2 MECHANISM ASSEMBLY

The mechanism assembly is a fully self-contained unit consisting of the motor and valve assemblies, A/B valve subsystem, inlet/outlet valve subsystem, plunger drive subsystem, air bubble (ultrasonic) sensor assemblies, cassette door, and pressure sensor assemblies. The motor and valve assemblies, A/B valve subsystem, inlet/outlet valve subsystem, and plunger drive subsystem are detailed in the following sections.

During pump operation, the mechanism assembly plunger motor drives a lead screw that is coupled to the plunger. The motor action and lead screw move the plunger forward to cause the delivery of approximately 0.33 mL of fluid per cycle. The plunger motion is synchronized to the valve motors to provide controlled fluid delivery.

4.5.2.1 MOTOR AND VALVE ASSEMBLIES

The mechanism assembly pumping action is controlled by three stepper motors. The first stepper motor, in conjunction with an associated valve assembly, activates the A or the B valve of the cassette, depending on the command. The second stepper motor alternately opens and closes the inlet and outlet valve to control fluid delivery through the cassette pumping chamber. A third stepper motor controls plunger movement.

4.5.2.2
A/B VALVE SUBSYSTEM

The A/B valve subsystem includes a motor designed to rotate a cam *(see Figure 4-8, Mechanism Valve Pins and Sensor Locations)*. When the cam is positioned at top-dead-center (home position), both valves are closed. Clockwise rotation (when viewed from the motor side) from the home position opens the A valve, while the B valve remains closed. Counterclockwise rotation opens the B valve, while the A valve remains closed.

The A/B valve subsystem consists of a stepper motor with attached cam and integral cam flag, A and B rockers and valve pins, and a pin detector assembly. The cam flag passes through an interrupter module as it rotates with the cam. Valve home position is determined by this cam flag/interrupter module combination through predetermined factory calibration data. During operation, if the cam flag passes through the interrupter module at the incorrect time sequence, a motor phase loss is detected. The rocker is the connecting link between the cam and the valve pin.

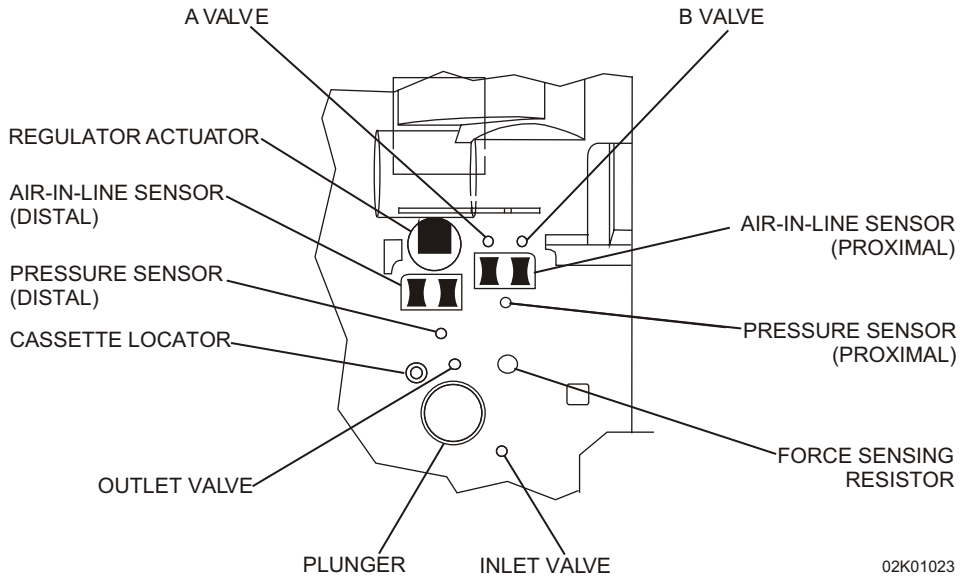

Figure 4-8. Mechanism Valve Pins and Sensor Locations

4.5.2.3
INLET/OUTLET VALVE SUBSYSTEM

The inlet/outlet valve subsystem is similar in function and build to the A/B valve subsystem *(see Section 4.5.2.2)*.

4.5.2.4
PLUNGER DRIVE SUBSYSTEM

The main components of the plunger drive subsystem are: plunger, lead screw and coupler, and stepper motor. When the pump is turned on, the plunger moves from the retracted, PARK position to the HOME position. The cassette diaphragm is engaged. The stepper motor rotates approximately 1 2/3 revolutions per pump cycle to permit a 0.33 mL fluid displacement every pump cycle. The stepper motor then reverses and the plunger returns to HOME position. This cycle repeats for the duration of fluid administration.

The screw/coupler assembly links the motor and the plunger. This assembly includes a flag that passes through an interrupter module. This screw/coupler, flag/interrupter module combination is used in conjunction with predetermined factory calibration data to determine the plunger position. During operation, if the screw/coupler flag passes through the interrupter module at the incorrect time sequence, a motor phase loss is detected.

Section 5

MAINTENANCE AND SERVICE TESTS

A complete maintenance program promotes infusion pump longevity and trouble-free instrument operation. Such a program should include routine maintenance, periodic maintenance inspection, and following any repair procedure, performance verification testing.

5.1 ROUTINE MAINTENANCE

Routine maintenance consists of basic inspection and cleaning procedures. As a minimum requirement, inspect and clean the infusion pump after each use. In addition, establish a regular cleaning schedule for the device.

5.1.1 INSPECTION

Inspect the infusion pump periodically for signs of defects such as worn accessories, broken instrument connections, or damaged cables. In addition, inspect the infusion pump after repair or during cleaning. Replace any damaged or defective external parts. See *Section 5.2.2, Inspection*, for a detailed list of areas to be inspected.

5.1.2 CLEANING

The following procedures are designed to maintain the infusion pump, sustain system longevity, and promote trouble-free instrument operation.

Follow hospital protocol for establishing the infusion pump cleaning schedule.

WARNING: DISCONNECT THE INFUSION PUMP FROM AC POWER PRIOR TO CLEANING THE INSTRUMENT. FAILURE TO COMPLY WITH THIS WARNING COULD RESULT IN ELECTRICAL SHOCK.

CAUTION: Do not immerse the infusion pump in liquids. Immersion could damage the instrument. Do not allow liquids to enter the infusion pump electronics compartment.

CAUTION: Do not spray cleaning solutions toward any openings in the device.

CAUTION: Certain cleaning and sanitizing compounds may slowly degrade components made from some plastic materials. Using abrasive cleaners or cleaning solutions not recommended by Hospira may result in product damage and, potentially, void the product warranty. Do not use compounds containing combinations of isopropyl alcohol and dimethyl benzyl ammonium chloride.

CAUTION: Clean the exposed surfaces of the infusion pump with a soft, lint-free cloth dampened with one of the cleaning solutions listed in *Table 5-1, Cleaning Solutions*, or a mild solution of soapy water. Remove soap residue with clear water. Do not use solvents that are harmful to plastic, such as isopropyl alcohol or acetone. Do not use abrasive cleaners.

CAUTION: To avoid damage to the device, cleaning solutions should be used only as directed in *Table 5-1*. The disinfecting properties of cleaning solutions vary; consult the manufacturer for specific information.

Table 5-1. Cleaning Solutions

Cleaning Solution	Manufacturer	Preparation
Coverage™ HB	Steris Corporation	Per manufacturer's recommendation
Dispatch™	Caltech Industries	Per manufacturer's recommendation
Formula C™	JohnsonDiversey	Per manufacturer's recommendation
Manu-Klenz®	Steris Corporation	Per manufacturer's recommendation
Precise™	Caltech Industries	Per manufacturer's recommendation
Sporicidin®	Sporicidin International	Per manufacturer's recommendation
Household bleach	Various	Per hospital procedures; do not exceed one part bleach in ten parts water

5.1.3 SANITIZING

Sanitize the external surfaces of the infusion pump using a cleaning solution listed in *Table 5-1*.

Note: Not all cleaning solutions are sanitizers. Check product labeling.

CAUTION: Do not sterilize the infusion pump using heat, steam, ethylene oxide (ETO), or radiation. These methods may cause the instrument to malfunction.

5.2 PERFORMANCE VERIFICATION TEST

The performance verification test (PVT) consists of the tests described in the following sections. The PVT can be used for diagnostic purposes during the troubleshooting of a malfunctioning infusion pump. The PVT should be used for performance verification before an infusion pump is placed back in service after repair. If any malfunction is detected as a result of the PVT, refer to *Table 6-3, Troubleshooting with the PVT*.

Note: Perform the PVT exactly as described in this manual to assure effective and reliable product evaluation information.

5.2.1 EQUIPMENT REQUIRED

The PVT requires the following equipment (or equivalents):

- ❑ Graduated cylinder, 25 mL, with 0.2 mL graduations (Type A)
- ❑ Sterile water or tap water in an IV bag/container
- ❑ Digital pressure meter (DPM), 0 to 50 psi (Fluke® Biomedical DPM3)
- ❑ Three-way stopcock, latex-free (List No. 3233-01, or equivalent)
- ❑ IV Set (List No. 11419, or equivalent)
- ❑ 21-gauge butterfly needle, latex-free (List No. 4492-01, or equivalent), or 18-gauge blunt cannula
- ❑ Safety analyzer (Fluke Biomedical 232D)
- ❑ Digital multimeter (DMM) (Fluke 187, or equivalent) (optional)
- ❑ Barcode directory (optional)
- ❑ Nurse call test cable (P/N 561-88416-001, or equivalent) (optional)

5.2.2 INSPECTION

Inspect the infusion pump periodically for signs of defects such as worn accessories or damaged cables. Also, inspect the infusion pump after repair or during cleaning. Replace any damaged or defective external parts.

Inspect the following areas for missing or damaged parts:

- Labels
- AC power cord
- Velcro® retainer straps
- Rubber foot pads
- Door assembly and handle
- Keypad
- External screws
- Pole clamp assembly
- Front and rear enclosures
- Battery access cover
- LCD
- LEDs

5.2.3
TEST SETUP

WARNING: A PATIENT SHOULD NEVER BE CONNECTED TO THE INFUSION PUMP DURING DEVICE TESTING.

To set up the infusion pump for the PVT, proceed as follows:

1. Confirm the infusion pump and appropriate accessories are assembled.
2. Hang two sterile water containers at a height of 18 ± 6 inches (46 ± 15.3 cm) above the pumping chamber of the device.
3. Connect the infusion pump to AC power. Conduct all tests with the pump connected to AC power unless otherwise specified.
4. Press [ON/OFF] to turn on the pump.
5. Verify the infusion pump is in the **unlocked** mode. Toggling the [LOCKOUT] switch alternates between **unlocked** [DOWN] and **locked** [UP] modes.
6. Press [ON/OFF] to turn off the pump.

5.2.4
SELF TEST

CAUTION: Do not place the infusion pump in service if the self test fails.

Note: If an alarm condition occurs during the self test, cycle the power and repeat the self test. If the alarm condition recurs, note the message and take corrective action *(see Section 6, Troubleshooting)*. Repeat the self test. If the alarm condition recurs, remove the Plum A+ infusion system from service and contact Hospira.

Note: Screen representations are examples only, and do not necessarily reflect the most current software version.

To perform the self test, refer to *Figure 5-1, LCD and Keypad*, or *Figure 5-2, LCD and Keypad (MedNet)*, then proceed as follows:

1. Connect the AC power cord to a grounded AC outlet. Verify the charging/line indicator **CHARGE** illuminates and an alarm beep sounds.
2. Without a cassette installed, press [ON/OFF] to turn on the pump.
3. The LCD screen briefly displays the **SELF TEST** screen. Verify the screen display matches *Figure 5-1* or *Figure 5-2*.

   Note: If the **SELF TEST** screen does not appear, contact Hospira.

4. After the self test is complete, the message “INSERT PLUM SET CLOSE LEVER” appears. Press the decimal [.] key, then [START].

   Note: The Plum A+ infusion system with the MedNet accessory may display a clinical care area (CCA) screen before the “INSERT PLUM SET CLOSE LEVER” message appears.

5. Using the [SELECT] key, select **Set Time and Date**. Press the [CHOOSE] softkey.

6. Verify the time and date. To set the time and date, refer to *Section 1.8.3, Setting the Time and Date*.
7. Press [ON/OFF] to exit the **SET TIME AND DATE** screen.
8. Press [ON/OFF] to turn the pump back on.
9. Open the cassette door and insert a primed cassette. Close the cassette door. The cassette test is complete when the "CASSETTE TEST IN PROGRESS" message disappears.

   Note: On version 11.3, or on a device equipped with the MedNet accessory, the message "MECHANISM INITIALIZATION IN PROGRESS" will briefly appear prior to the "CASSETTE TEST IN PROGRESS" message.

10. If previously entered programming exists, the "CLEAR SETTINGS?" message appears. Press the [YES] softkey to clear the settings.

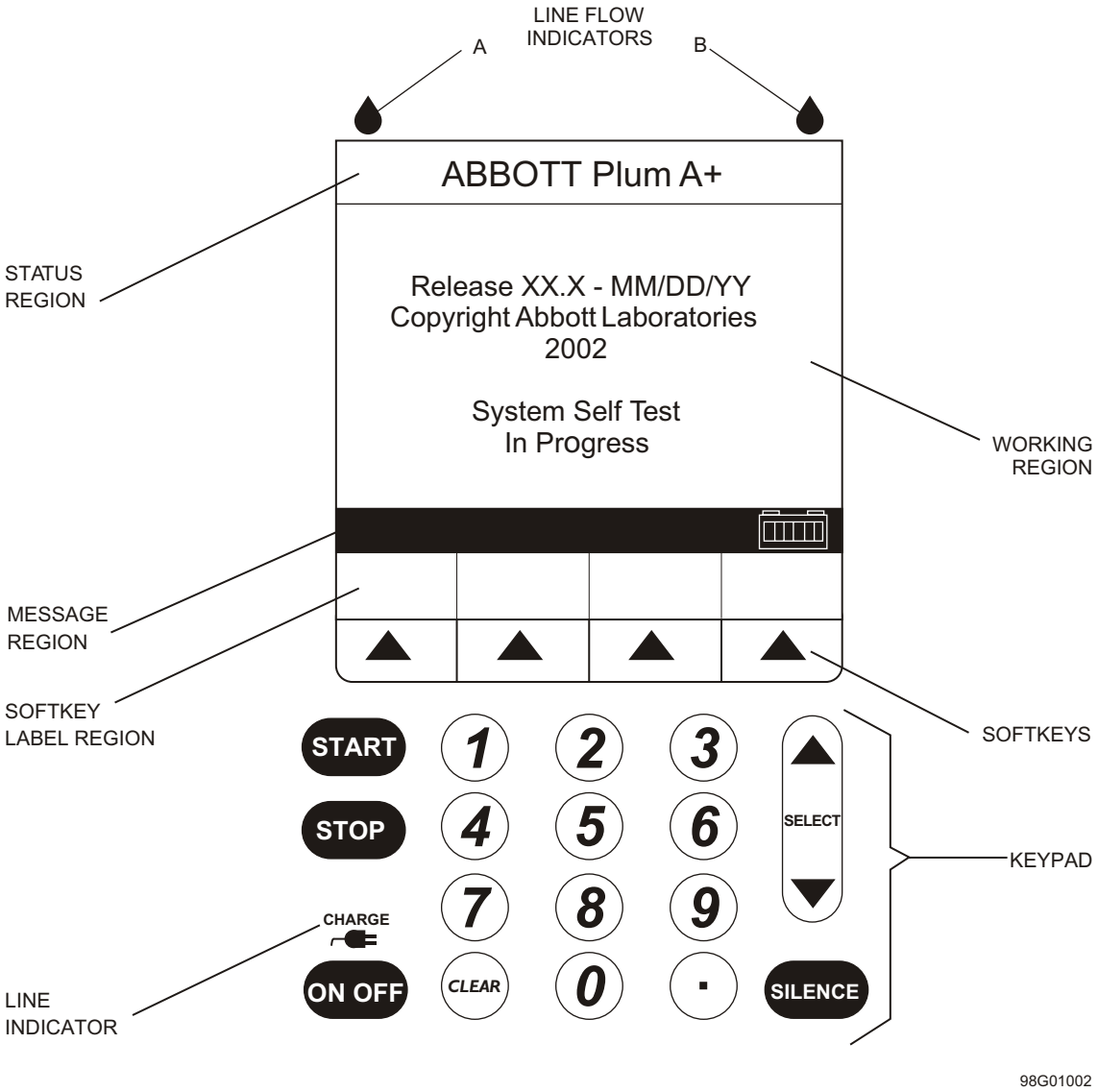

Figure 5-1. LCD and Keypad

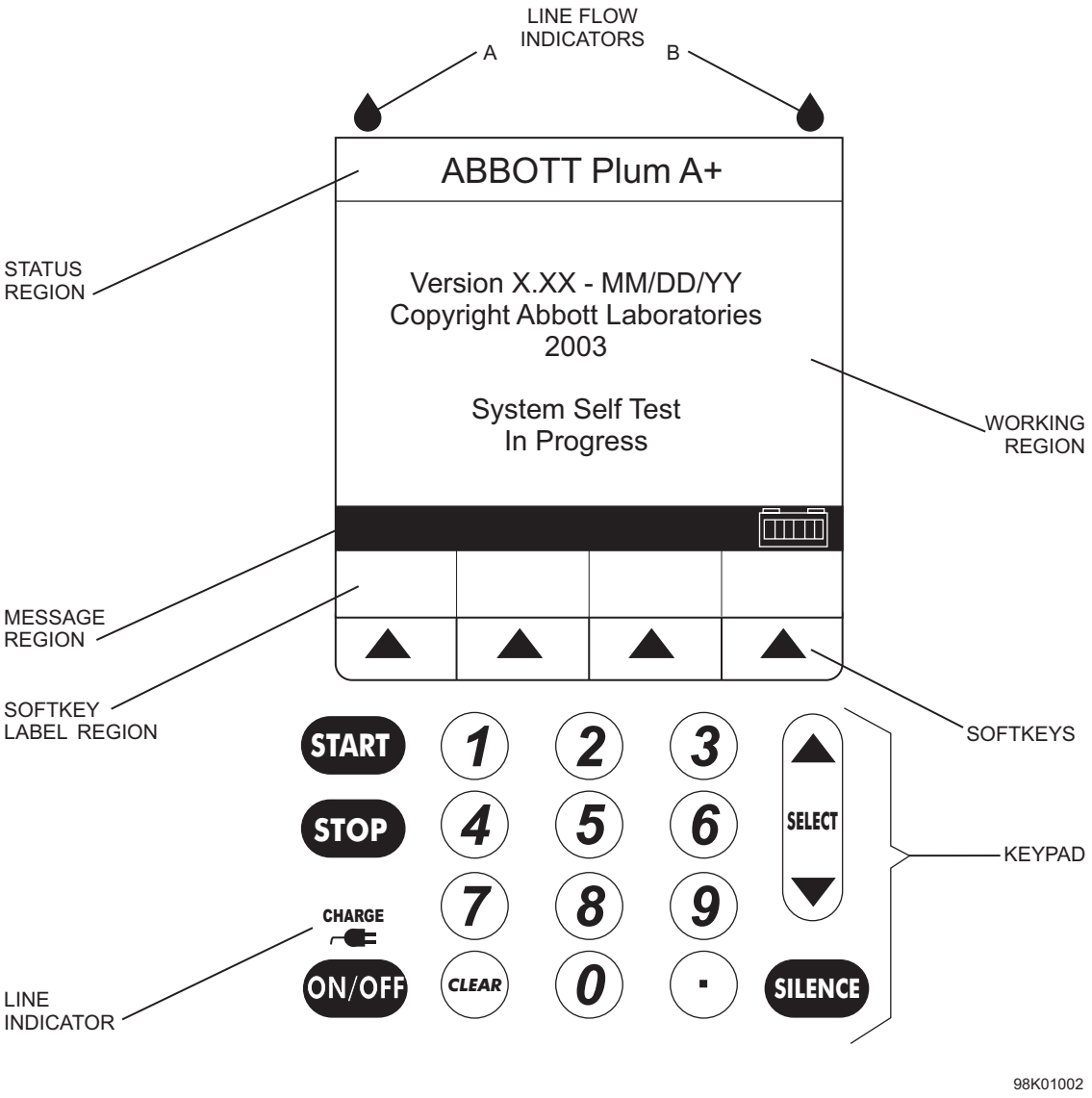

Figure 5-2. LCD and Keypad (MedNet)

5.2.5 CASSETTE ALARM TEST

To perform the cassette alarm test, proceed as follows:

1. Verify the infusion pump is on. Insert an empty cassette and close the door.
2. Verify the “CASSETTE TEST FAIL” message is flashing on the display and the alarm sounds after the cassette test is complete.
3. Open the door and remove the cassette.
4. Press [ON/OFF] to turn off the pump.

5.2.6 FREE FLOW TEST

To perform the free flow test, proceed as follows:

1. With a primed cassette installed, press [ON/OFF] to turn on the pump.
2. After the self test, press [YES] to clear settings.
3. Place the distal end of tubing into a collection container a minimum of 36 inches below the cassette.
4. With the cassette door closed, check the distal end of the tubing for fluid flow. Verify a minimal flow of fluid occurs (a few drops maximum).
5. Open the cassette door and check the distal end of the tubing for fluid flow. Verify a minimal flow of fluid occurs (a few drops maximum).

   Note: A small amount of fluid may be expelled from the cassette when opening or closing the door.

6. Close the cassette door.

5.2.7 DISPLAY TEST

To perform the display test, refer to *Figure 5-1* or *Figure 5-2*, then proceed as follows:

1. Verify the LCD backlight is illuminated and the display is clearly legible at eye level from approximately 18 inches.
2. With the pump in the **DELIVERY** screen, press the [OPTIONS/VOL INF] softkey to select the **OPTIONS** screen.
3. Using the [SELECT] key, select **Lighting/Contrast**, and press [CHOOSE].
4. Press the [DECREASE SETTING] and [INCREASE SETTING] softkeys to change backlight intensity. Verify backlight intensity decreases and increases.
5. Using the [SELECT] key, select **Display Contrast**.
6. Press [DECREASE SETTING] and [INCREASE SETTING] to change display contrast. Verify the display contrast decreases and increases.
7. Press the [CANCEL] softkey to return to the **OPTIONS** screen.
8. Press the [BACK] softkey to return to the **DELIVERY** screen.

5.2.8 KEYPAD VERIFICATION/FUNCTIONAL TEST

Note: To perform the keypad verification/functional test on a device equipped with the MedNet accessory, see *Section 5.2.9*.

To perform the keypad verification/functional test, refer to *Figure 5-1*, then proceed as follows:

1. With the pump in the **DELIVERY** screen, press the [A] softkey to select line A.
2. Verify the **PROGRAM** screen is displayed.
3. Using the numeric keypad, enter a rate of 123 mL/hr.
4. Using the [SELECT] key, select **VTBI**.

5. Using the numeric keypad, enter a VTBI of 4567 mL.
6. Press [START]. Verify fluid is pumping, the message “PUMPING” is displayed in the line A status bar, and the line A LED flashes.
7. Press [STOP], then press and hold the [BACKPRIME] softkey.
8. Verify the “BACKPRIMING” and “RELEASE BACKPRIME TO STOP” messages are displayed, and verify the pump is actually backpriming.
9. Release the [BACKPRIME] softkey, press [START], and verify normal pumping operation.
10. Press the [B] softkey.
11. Verify **PIGGYBACK** is the displayed delivery mode. If necessary, change the delivery mode by pressing the [CHANGE MODE] softkey.
12. Using the [SELECT] key, select **Rate**.
13. Using the numeric keypad, enter a rate of 890 mL/hr.
14. Using the [SELECT] key, select **VTBI**.
15. Using the numeric keypad, enter a VTBI of 2.0 mL.
16. Press [START] and verify fluid is pumping. Verify the message “PUMPING” is displayed in the line B status bar, the line B LED flashes, and line A goes into **Delayed** mode.
17. After 20 seconds, verify pumping has switched to line A.
18. Press [STOP].
19. Press [OPTIONS/VOL INF]. Select **Volume Infused** and press [CHOOSE].
20. Using the [SELECT] key, select line A.
21. Press the [CLEAR] key. Verify the line A volume is 0.0 mL and press [ENTER].

5.2.9 KEYPAD VERIFICATION/FUNCTIONAL TEST (MEDNET)

Note: Plum A+ devices equipped with the MedNet accessory may display override messages or hard limit restrictions, dependent on the current CCA selected. Select a different CCA, if necessary, to complete the keypad verification/functional test.

To perform the keypad verification/functional test on a device equipped with the MedNet accessory, refer to *Figure 5-2* and *Figure 5-3, MedNet Program Screen*, then proceed as follows:

1. With the pump in the **DELIVERY** screen, press the [A] softkey to select line A.
2. Verify the **PROGRAM** screen is displayed.
3. Using the numeric keypad, enter a rate of 123 mL/hr.
4. Using the [SELECT] key, select **VTBI**.
5. Using the numeric keypad, enter a VTBI of 4567.
6. Press [START] and verify the “CONFIRM PROGRAM?” message is displayed. If rate and VTBI are correct, press [YES] *(see Figure 5-3)*.
7. Verify fluid is pumping, the message “PUMPING” is displayed in the line A status bar, and the line A LED flashes.
8. Press [STOP], then press and hold the [BACKPRIME] softkey.
9. Verify the “BACKPRIMING” and “RELEASE BACKPRIME TO STOP” messages are displayed, and verify the pump is actually backpriming.

10. Release the [BACKPRIME] softkey, press [START], and verify normal pumping operation.
11. Press the [B] softkey.
12. Verify **PIGGYBACK** is the displayed delivery mode. If necessary, change the delivery mode by pressing the [CHANGE MODE] softkey.
13. Using the [SELECT] key, select **Rate**.
14. Using the numeric keypad, enter a rate of 890 mL/hr.
15. Using the [SELECT] key, select **VTBI**.
16. Using the numeric keypad, enter a VTBI of 2.0 mL.
17. Press [START} and verify the “CONFIRM PROGRAM?” message is displayed. If rate and VTBI are correct, press [YES] *(see Figure 5-3)*.
18. Verify fluid is pumping, the message “PUMPING” is displayed in the line B status bar, and the line B LED flashes.
19. After 20 seconds, verify pumping has switched to line A.
20. Press [STOP].
21. Press [OPTIONS/VOL INF]. Select **Volume Infused** and press [CHOOSE].
22. Using the [SELECT] key, select line A.
23. Press the [CLEAR] key. Verify line A volume is 0.0 mL and press {ENTER].

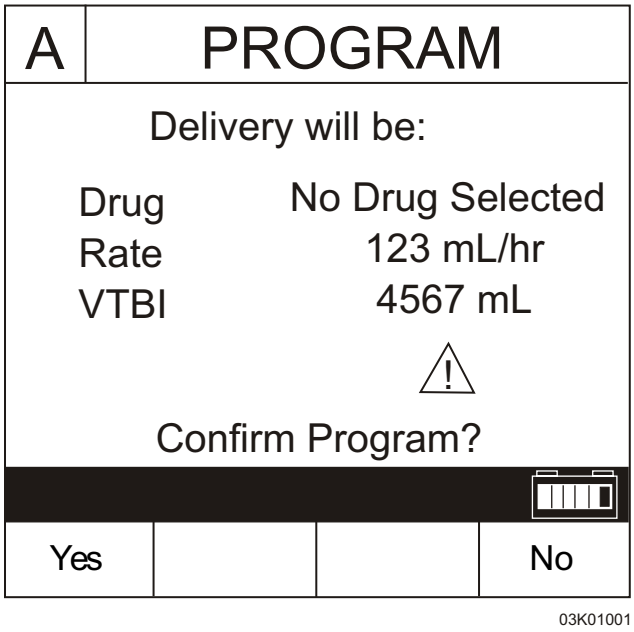

Figure 5-3. MedNet Program Screen

5.2.10
ALARM LOUDNESS TEST

Note: To perform the alarm loudness test on a device equipped with the MedNet accessory, see *Section 5.2.11*.

To perform the alarm loudness test, refer to *Figure 5-4, Rear Enclosure and Peripheral Assemblies*, then proceed as follows:

1. Press the [A] softkey to select line A.
2. Using the numeric keypad, enter a rate of 400 mL/hr and a VTBI of 1 mL, then press [START].
3. Verify the alarm sounds when the dose has been delivered.
4. Turn the volume control knob between HIGH and LOW. The volume control knob is found on the peripheral assembly. Verify the alarm loudness changes.
5. Press the [SILENCE] key, and verify the alarm is silenced.
6. Press [STOP].

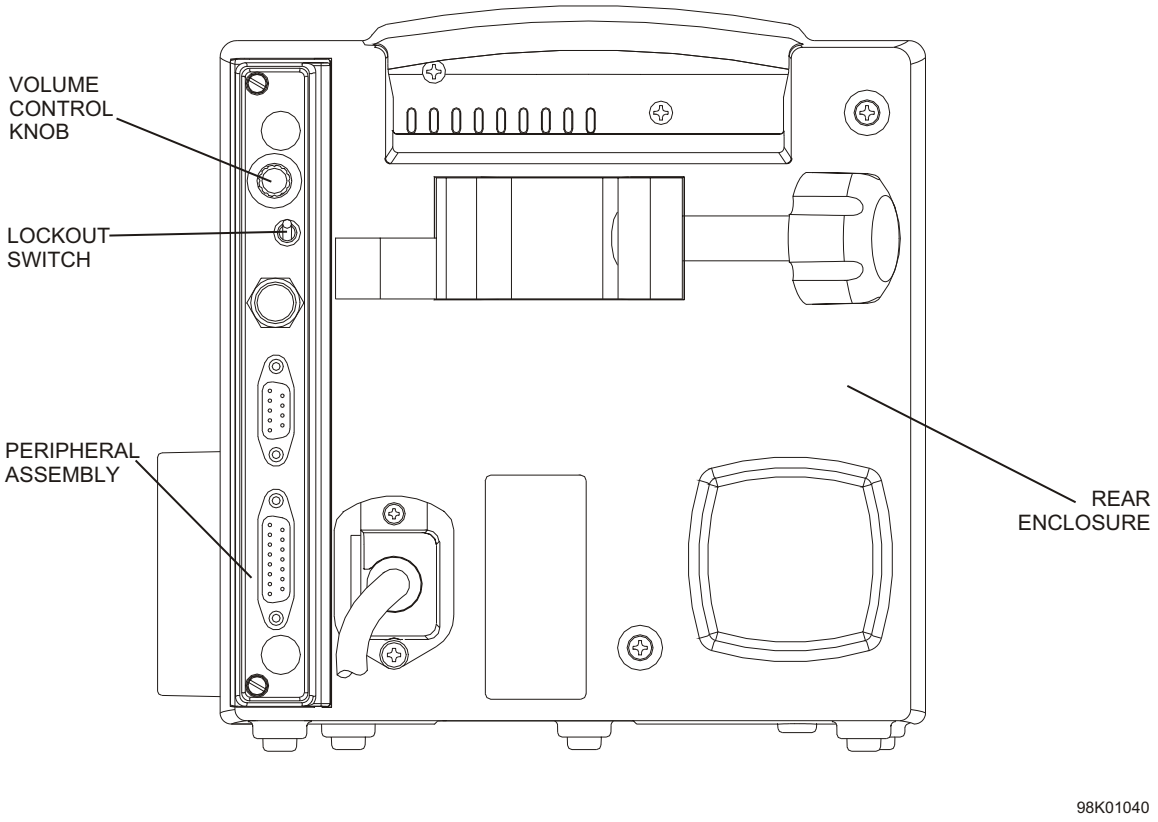

Figure 5-4. Rear Enclosure and Peripheral Assemblies

5.2.11
ALARM LOUDNESS TEST (MEDNET)

To perform the alarm loudness test on a device equipped with the MedNet accessory, refer to *Figure 5-3* and *Figure 5-4*, then proceed as follows:

1. Press the [A] softkey to select line A.
2. Using the numeric keypad, enter a rate of 400 mL/hr and a VTBI of 1 mL.
3. Press [START] and verify the "CONFIRM PROGRAM?" message is displayed. If rate and VTBI are correct, press [YES] *(see Figure 5-3)*.
4. Verify fluid is pumping, the message "PUMPING" is displayed in the line A status bar, and the line A LED flashes.
5. Verify the alarm sounds when the dose has been delivered.
6. Turn the volume control knob between HIGH and LOW. The volume control knob is found on the peripheral assembly. Verify the alarm loudness changes.
7. Press the [SILENCE] key, and verify the alarm is silenced.
8. Press [STOP].

5.2.12
LOCKOUT SWITCH TEST

Note: To perform the lockout switch test on a device equipped with the MedNet accessory, see *Section 5.2.13*.

To perform the lockout switch test, refer to *Figure 5-4*, then proceed as follows:

1. Press the [A] softkey to select line A.
2. Using the numeric keypad, enter a rate of 400 mL/hr and a VTBI of 50 mL.
3. Press [START], and verify the pump is operating.
4. Toggle the lockout alarm switch up (ON) to engage the alarm. The lockout switch is located on the peripheral assembly.
5. Press any key except [STOP], and verify an alarm sounds and the "HARD LOCKOUT ENABLED" message is displayed. Verify the pump continues to operate until [STOP] is pressed.
6. Press [STOP] and verify the "HARD LOCKOUT VIOLATION" message appears.
7. Toggle the lockout alarm switch down (OFF). Verify the "HARD LOCKOUT VIOLATION" message disappears and the alarm stops.
8. Press [START].
9. Open the door and verify the "DOOR OPEN WHILE PUMPING" message is displayed and the audio alarm activates.
10. Close the cassette door.
11. Press [NO] at the "CLEAR SETTINGS?" prompt.

5.2.13
LOCKOUT SWITCH TEST (MEDNET)

To perform the lockout switch test on a device equipped with the MedNet accessory, refer to *Figure 5-3* and *Figure 5-4*, then proceed as follows:

1. Press the [A] softkey to select line A.
2. Using the numeric keypad, enter a rate of 400 mL/hr and a VTBI of 50 mL.
3. Press [START] and verify the "CONFIRM PROGRAM?" message is displayed. If rate and VTBI are correct, press [YES] *(see Figure 5-3)*.
4. Verify fluid is pumping, the message "PUMPING" is displayed in the line A status bar, and the line A LED flashes.
5. Toggle the lockout alarm switch up (ON) to engage the alarm. The lockout switch is located on the peripheral assembly.
6. Press any key except [STOP], and verify an alarm sounds and the "HARD LOCKOUT ENABLED" message is displayed. Verify the pump continues to operate until [STOP] is pressed.
7. Press [STOP] and verify the "HARD LOCKOUT VIOLATION" message appears.
8. Toggle the lockout alarm switch down (OFF). Verify the "HARD LOCKOUT VIOLATION" message disappears and the alarm stops.
9. Press [START].
10. Open the door and verify the "DOOR OPEN WHILE PUMPING" message is displayed and the audio alarm activates.
11. Close the cassette door.
12. Press [NO] at the "CLEAR SETTINGS?" prompt.

5.2.14
PROXIMAL OCCLUSION TEST

Note: To perform the proximal occlusion test on a device equipped with the MedNet accessory, see *Section 5.2.15*.

To perform the proximal occlusion test, proceed as follows:

1. Press the [A] softkey to select line A.
2. Using the numeric keypad, enter a rate of 400 mL/hr and a VTBI of 50 mL.
3. Press [START].
4. After several pumping cycles, clamp line A tubing proximal to the cassette. Verify the "PROX OCCL A/AIR" message flashes and the alarm sounds before three pumping cycles are completed.
5. Press the [SILENCE] key and verify the alarm stops while the message on the display continues to flash.
6. Unclamp the proximal line and press [START]. Verify pumping resumes.
7. Press [STOP].

5.2.15
PROXIMAL OCCLUSION TEST (MEDNET)

To perform the proximal occlusion test on a device equipped with the MedNet accessory, refer to *Figure 5-3*, then proceed as follows:

1. Press the [A] softkey to select line A.
2. Using the numeric keypad, enter a rate of 400 mL/hr and a VTBI of 50 mL.
3. Press [START] and verify the "CONFIRM PROGRAM?" message is displayed. If rate and VTBI are correct, press [YES] *(see Figure 5-3)*.
4. Verify fluid is pumping, the message "PUMPING" is displayed in the line A status bar, and the line A LED flashes.
5. After several pumping cycles, clamp line A tubing proximal to the cassette. Verify the "PROX OCCL A/AIR" message flashes and the alarm sounds before three pumping cycles are completed.
6. Press the [SILENCE] key and verify the alarm stops while the message on the display continues to flash.
7. Unclamp the proximal line and press [START]. Verify pumping resumes.
8. Press [STOP].

5.2.16
PROXIMAL AIR-IN-LINE TEST

Note: To perform the proximal air-in-line test on a device equipped with the MedNet accessory, see *Section 5.2.17*.

To perform the proximal air-in-line test, refer to *Figure 5-5, Special Cassettes with Bubble Sensor Tips Removed,* then proceed as follows:

1. Install the special cassette marked **proximal**, and close the cassette door.

   Note: Confirm the special cassette proximal bubble sensor tips are removed *(see Figure 5-5)*.

2. Press [YES] to clear settings.
3. Press the [A] softkey to select line A.
4. Using the numeric keypad, enter a rate of 400 mL/hr and a VTBI of 50 mL.
5. Press [START].
6. Before 1 mL of fluid is delivered, verify the alarm sounds and the "PROX AIR A. BACKPRIME" message is flashing on the display.
7. Press [STOP], open the door, and remove the special cassette.

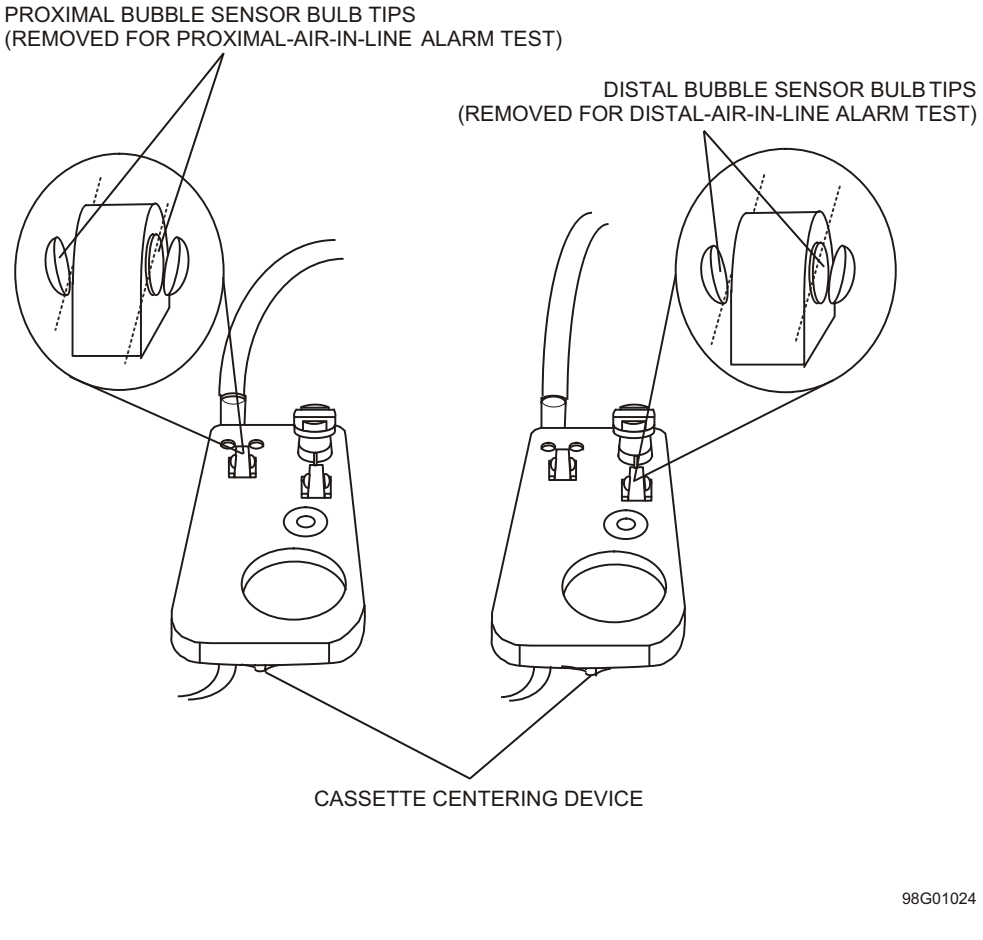

Figure 5-5. Special Cassettes with Bubble Sensor Tips Removed

5.2.17
PROXIMAL AIR-IN-LINE TEST (MEDNET)

To perform the proximal air-in-line test on a device equipped with the MedNet accessory, refer to *Figure 5-3* and *Figure 5-5*, then proceed as follows:

1. Install the special cassette marked **proximal**, and close the cassette door.

   Note: Confirm the special cassette proximal bubble sensor tips are removed *(see Figure 5-5)*.

2. Press [YES] to clear settings.
3. Press the [A] softkey to select line A.
4. Using the numeric keypad, enter a rate of 400 mL/hr and a VTBI of 50 mL.
5. Press [START] and verify the “CONFIRM PROGRAM?” message is displayed. If rate and VTBI are correct, press [YES] *(see Figure 5-3)*.

6. Verify fluid is pumping, the message “PUMPING” is displayed in the line A status bar, and the line A LED flashes.
7. Before 1 mL of fluid is delivered, verify the alarm sounds and the “PROX AIR A. BACKPRIME” message is flashing on the display.
8. Press [STOP], open the door, and remove the special cassette.

5.2.18 DISTAL AIR-IN-LINE TEST

Note: To perform the distal air-in-line test on a device equipped with the MedNet accessory, see *Section 5.2.19*.

To perform the distal air-in-line alarm test, refer to *Figure 5-5*, then proceed as follows:

1. Install the special cassette marked **distal**, and close the cassette door.

   Note: Confirm the special cassette distal bubble sensor tips are removed *(see Figure 5-5)*.

2. Press [YES] to clear settings.
3. Press the [A] softkey to select line A.
4. Using the numeric keypad, enter a rate of 400 mL/hr and a VTBI of 50 mL.
5. Press [START].
6. Before 1 mL of fluid is delivered, verify the alarm sounds and the “DISTAL AIR” message is flashing on the display.
7. Press [STOP], open the door, and remove the special cassette.

5.2.19 DISTAL AIR-IN-LINE TEST (MEDNET)

To perform the distal air-in-line test on a device equipped with the MedNet accessory, refer to *Figure 5-3* and *Figure 5-5*, then proceed as follows:

1. Install the special cassette marked **distal**, and close the cassette door.

   Note: Confirm the special cassette distal bubble sensor tips are removed *(see Figure 5-5)*.

2. Press [YES] to clear settings.
3. Press the [A] softkey to select line A.
4. Using the numeric keypad, enter a rate of 400 mL/hr and a VTBI of 50 mL.
5. Press [START] and verify the “CONFIRM PROGRAM?” message is displayed. If rate and VTBI are correct, press [YES] *(see Figure 5-3)*.
6. Verify fluid is pumping, the message “PUMPING” is displayed in the line A status bar, and the line A LED flashes.
7. Before 1 mL of fluid is delivered, verify the alarm sounds and the “DISTAL AIR” message is flashing on the display.
8. Press [STOP], open the door, and remove the special cassette.

5.2.20
DISTAL OCCLUSION TEST

Note: To perform the distal occlusion test on a device equipped with the MedNet accessory, see *Section 5.2.21*.

To perform the distal occlusion test, refer to *Figure 5-6, Distal Occlusion Test Setup*, then proceed as follows:

1. Install the cassette and connect the distal tubing to the DPM through a three-way stopcock as illustrated in *Figure 5-5*. Close the cassette door.

   Note: A reflux valve may be attached between the stopcock and the DPM to keep moisture out of the DPM.

   Note: The height of the DPM must be 0 ± 12 inches from the midline of the pumping chamber.

2. Press [ON/OFF] to turn on the pump.
3. Press [YES] to clear settings.
4. Press [OPTIONS/VOL INF] to select the **OPTIONS** screen.
5. Using the [SELECT] key, select **Pressure/Post Infusion Rate**, and press [CHOOSE].
6. Verify the distal pressure limit is set at 6.0 psi. If the pressure limit is not 6.0 psi, use the numeric keypad to enter 6.0, and press [ENTER].
7. Press the [A] softkey to select line A.
8. Using the numeric keypad, enter a rate of 40 mL/hr and a VTBI of 50.0 mL.
9. Open the three-way stopcock to air.
10. Press [START] and allow the infusion pump to stabilize for one minute. Verify all air is cleared from the tubing.
11. Set the three-way stopcock to measure pressure.
12. Verify the distal occlusion audible alarm occurs at 6.0 ±3.0 psi. Verify the **DISTAL OCCLUSION** message is flashing on the screen.
13. Open the three-way stopcock to air.
14. Open and close the door. Press [NO] at the “CLEAR SETTINGS?” prompt.
15. Press [OPTIONS/VOL INF] to select the **OPTIONS** screen.
16. Using the [SELECT] key, select **Pressure/Post Infusion Rate** and press [CHOOSE].
17. Using the [SELECT] key, select **Distal Pressure Limit**.
18. Using the numeric keypad, enter 10.0 psi, and press [ENTER].
19. Set the three-way stopcock to measure pressure, then press [START].
20. Verify the distal occlusion audible alarm occurs at 10.0 ±3.0 psi. Verify the **DISTAL OCCLUSION** message is flashing on the screen.
21. Open the door and remove the cassette.

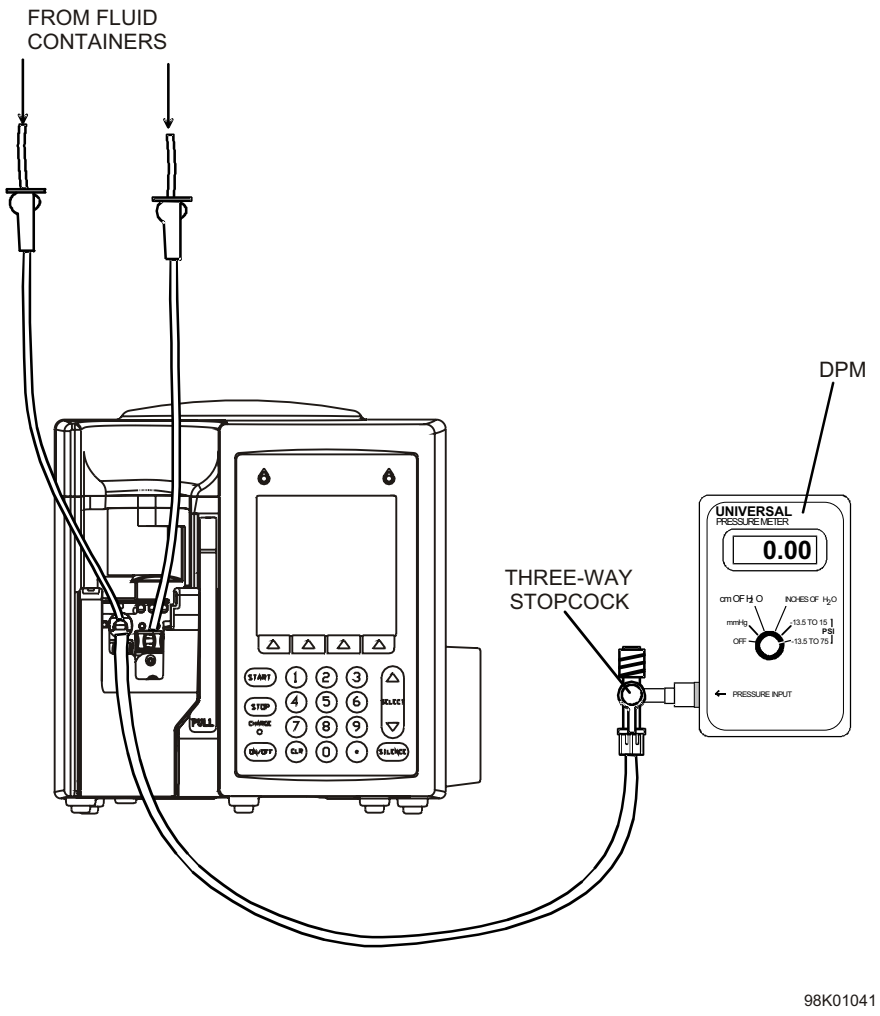

Figure 5-6. Distal Occlusion Test Setup

5.2.21
DISTAL OCCLUSION TEST (MEDNET)

To perform the distal occlusion test on a device equipped with the MedNet accessory, refer to *Figure 5-3* and *Figure 5-6*, then proceed as follows:

1. Install the cassette and connect the distal tubing to the DPM through a three-way stopcock as illustrated in *Figure 5-6*. Close the cassette door.

   Note: A reflux valve may be attached between the stopcock and the DPM to keep moisture out of the DPM.

   Note: The height of the DPM must be 0 ± 12 inches from the midline of the pumping chamber.

2. Press [ON/OFF] to turn on the pump.

3. Press [YES] to clear settings.
4. Press [OPTIONS/VOL INF] to select the **OPTIONS** screen.
5. Using the [SELECT] key, select **Pressure/Post Infusion Rate**, and press [CHOOSE].
6. Verify the distal pressure limit is set at 6.0 psi. If the pressure limit is not 6.0 psi, use the numeric keypad to enter 6.0, and press [ENTER].
7. Press the [A] softkey to select line A.
8. Using the numeric keypad, enter a rate of 40 mL/hr and a VTBI of 50.0 mL.
9. Open the three-way stopcock to air.
10. Press [START] and verify the "CONFIRM PROGRAM?" message is displayed. If rate and VTBI are correct, press [YES] *(see Figure 5-3)*.
11. Verify fluid is pumping, the message "PUMPING" is displayed in the line A status bar, and the line A LED flashes.
12. Set the three-way stopcock to measure pressure.
13. Verify the distal occlusion audible alarm occurs at 6.0 ±3.0 psi. Verify the **DISTAL OCCLUSION** message is flashing on the screen.
14. Open the three-way stopcock to air.
15. Open and close the door. Press [NO] at the "CLEAR SETTINGS?" prompt.
16. Press [OPTIONS/VOL INF] to select the **OPTIONS** screen.
17. Using the [SELECT] key, select **Pressure/Post Infusion Rate** and press [CHOOSE].
18. Using the [SELECT] key, select **Distal Pressure Limit**.
19. Using the numeric keypad, enter 10.0 psi, and press [ENTER].
20. Set the three-way stopcock to measure pressure, then press [START].
21. Verify the distal occlusion audible alarm occurs at 10.0 ±3.0 psi. Verify the **DISTAL OCCLUSION** message is flashing on the screen.
22. Open the door and remove the cassette.

5.2.22 DELIVERY ACCURACY TEST

Note: Accuracy testing is for informational purposes only, and is not to be used as a re-release test. If there is any concern as to infusion pump accuracy, contact Hospira.

CAUTION: Do not remove the protective cover from the 21-gauge needle.

Note: To perform the delivery accuracy test on a device equipped with the MedNet accessory, see *Section 5.2.23*.

To perform the delivery accuracy test, proceed as follows:

1. Install an 18-gauge blunt cannula or a 21-gauge needle to the distal end of the tubing. Verify the fluid container is 18 to 24 inches above the pumping chamber. Verify all lines are unclamped.
2. Place the distal output end of tubing into the graduated cylinder.
3. Press the [A] softkey to select line A.
4. Using the numeric keypad, enter a rate of 200 mL/hr and a VTBI of 10 mL, and press [START].
5. Press the [B] softkey to select line B.

6. Verify the pump is in the **PIGGYBACK** delivery mode. If necessary, change the delivery mode by pressing [CHANGE MODE].
7. Using the numeric keypad, enter a rate of 200 mL/hr and a VTBI of 10 mL.
8. Press [START], and verify the pump switches to line B.
9. Verify the "KVO" message flashes on the display and an audible alarm sounds when total delivery is complete on line A.
10. Press [STOP] and verify the volume delivered is 20 mL ± 1.0 mL.

5.2.23 DELIVERY ACCURACY TEST (MEDNET)

Note: Accuracy testing is for informational purposes only, and is not to be used as a re-release test. If there is any concern as to infusion pump accuracy, contact Hospira.

CAUTION: Do not remove the protective cover from the 21-gauge needle.

To perform the delivery accuracy test on a device equipped with the MedNet accessory, refer to *Figure 5-3* and *Figure 5-6*, then proceed as follows:

1. Install an 18-gauge blunt cannula or a 21-gauge needle to the distal end of the tubing. Verify the fluid container is 18 to 24 inches above the pumping chamber. Verify all lines are unclamped.
2. Place the distal output end of tubing into the graduated cylinder.
3. Press the [A] softkey to select line A.
4. Using the numeric keypad, enter a rate of 200 mL/hr and a VTBI of 10 mL.
5. Press [START] and verify the "CONFIRM PROGRAM?" message is displayed. If rate and VTBI are correct, press [YES] *(see Figure 5-3)*.
6. Verify fluid is pumping, the message "PUMPING" is displayed in the line A status bar, and the line A LED flashes.
7. Press the [B] softkey to select line B.
8. Verify the pump is in the **PIGGYBACK** delivery mode. If necessary, change the delivery mode by pressing [CHANGE MODE].
9. Using the numeric keypad, enter a rate of 200 mL/hr and a VTBI of 10 mL.
10. Press [START] and verify the "CONFIRM PROGRAM?" message is displayed. If rate and VTBI are correct, press [YES] *(see Figure 5-3)*.
11. Verify fluid is pumping, the message "PUMPING" is displayed in the line B status bar, and the line B LED flashes.
12. Verify the "KVO" message flashes on the display and an audible alarm sounds when total delivery is complete on line A.
13. Press [STOP] and verify the volume delivered is 20 mL ± 1.0 mL.

5.2.24
BARCODE READER WAND TEST

Note: The barcode reader wand test may be bypassed if the barcode reader function is not used.

1. Remove the plastic cover from the 9-pin connector on the peripheral assembly, and connect the barcode reader wand to the 9-pin connector.
2. Insert a primed cassette and close the door.
3. Press [ON/OFF] to turn on the infusion pump. Press [YES] to clear settings.
4. Using the numeric keypad, set the rate to 100 mL and the VTBI to 50 mL.
5. Verify the "WAND ACTIVE" message appears on the display.
6. Scan a barcode label from the barcode directory, and verify the corresponding drug name is displayed.

5.2.25
NURSE CALL TEST

Note: The nurse call test may be bypassed if the nurse call function is not used.

To perform the nurse call test, attach the nurse call test cable and proceed as follows:

1. Set the primary delivery rate to 400 mL/hr, and the primary dose limit to 1 mL.
2. Connect the DMM to the nurse call test cable.
3. Press [START] and verify pumping action.
4. After "DOSE END" and "KVO" appear on the display, observe a short circuit on the DMM (approximately 1 Ω on a scale of 0 to 100 Ω).

5.2.26
ELECTRICAL SAFETY TEST

To perform the electrical safety test, proceed as follows:

1. Connect the infusion pump AC power cord to a safety analyzer.
2. Connect the safety analyzer ground lead to the ground test-point located on the rear of the pump.
3. Check the leakage current with the safety analyzer. Leakage current (both open and closed ground) must not exceed 100 microamperes AC_{rms}.
4. Measure the resistance of the AC connector ground lug with the safety analyzer. Resistance should not exceed 0.1 Ω.

5.2.27
END OF THE PVT

If all performance verification tests have been successful, proceed as follows:

1. Press [OPTIONS/VOL INF]. Select **Volume Infused** and press [CHOOSE].
2. Press [CLEAR] to clear the volume infused.
3. Press [ENTER].
4. Press the [A] softkey.
5. Press the [CLEAR PROGRAM] softkey.

   Note: The [CLEAR PROGRAM] softkey is not present on devices equipped with the MedNet accessory.

6. Press [YES] at the “CLEAR LINE A SETTINGS?” prompt.
7. Press the [CANCEL/BACK] softkey to return to the delivery screen.
8. Press the [B] softkey.
9. Press the [CLEAR PROGRAM] softkey.

   Note: The [CLEAR PROGRAM] softkey is not present on devices equipped with the MedNet accessory.

10. Press [YES] at the “CLEAR LINE B SETTINGS?” prompt.
11. Reset the infusion pump to the original configuration.
12. Turn off the pump and return it to service.

Note: If any tests fail, refer to *Section 6*, or contact Hospira.

5.3
PERIODIC MAINTENANCE INSPECTION

Periodic maintenance inspections should be performed per hospital procedures for compliance to accreditation requirements. It is recommended that JCAHO and/or hospital protocol be followed for establishing an infusion pump periodic maintenance inspection schedule. Product specifications for this inspection are listed in *Section 8, Specifications*.

To perform the periodic maintenance inspection, complete the PVT in *Section 5.2*.

5.4
BATTERY OPERATION OVERVIEW

The Plum A+ is intended to operate on battery power on an exception basis only, such as emergency backup or temporary portable operation. Examples of emergency backup include AC power failure or inadvertent disconnection of the AC power cord. An instance of temporary portable operation includes patient transfer from one location to another.

The infusion pump should be connected to AC power whenever possible to allow the battery to remain fully charged. The line power indicator turns off and the **BATTERY** legend illuminates when the infusion pump is operating on battery power. The backlight extinguishes after one minute of pump operation on battery power.

Factors that most commonly affect battery life are the depth and frequency of discharge and the length of the recharge period. As a general rule, the more often the battery is discharged and recharged, the sooner it will need replacement. The primary cause of damage is leaving the battery in a less than fully charged state for any period of time. Battery damage can occur in a matter of hours and cause a permanent loss of battery capacity. The amount of lost capacity depends on the degree of discharge, the storage temperature, and the length of time the battery was stored in a discharged state.

Note: A permanently damaged battery cannot be recharged to full capacity.

When the battery discharges below the acceptable level while the infusion pump is operating, the alarm sounds and the **LOW BATTERY** message displays. Although it is not recommended to continue operating the device on battery power at this point, the battery continues providing power until discharged. At this point, the infusion pump enters the battery discharged mode, a continuous audible alarm sounds and, after three minutes, operation ceases.

CAUTION: As soon as the LOW BATTERY alarm occurs, connect the infusion pump to AC power.

Recharging occurs any time the infusion pump is connected to AC power. It is recommended that the pump be connected to AC power whenever practical to maximize available battery charge during transport or ambulation. The device does not have to be on for the battery to recharge. Recharging while the infusion pump is operating is rate dependent.

Note: The infusion pump should be operated on battery power for six continuous hours at least once every six months for optimum battery performance and life.

Section 6

TROUBLESHOOTING

This section contains information on technical assistance, alarm messages and error codes, and troubleshooting procedures for the Plum A+ infusion system.

6.1 TECHNICAL ASSISTANCE

For technical assistance, product return authorization, and to order parts, accessories, or manuals within the United States, contact Hospira Technical Support Operations.

1-800-241-4002

For additional technical assistance, technical training, and product information, visit the website at **www.hospira.com.**

Send all authorized, prepaid returns within the United States to the following address:

Hospira, Inc.
Technical Support Operations
755 Jarvis Drive
Morgan Hill, California 95037

For technical assistance, product return authorization, and to order parts, accessories, or manuals from outside the United States, contact the nearest Hospira sales office.

6.2 ALARM MESSAGES AND ERROR CODES

Under most alarm conditions the infusion pump ceases normal operation, generates an audible alarm, and displays an alarm message or error code on the LCD screen.

There are two types of alarm conditions:

- alarm codes that can be cleared by the operator
- error codes that require qualified service personnel

See *Table 6-1, Operational Alarm Messages and Corrective Actions*, and *Table 6-2, Error Codes Requiring Technical Service*.

6.2.1
OPERATIONAL ALARM MESSAGES

Table 6-1 lists infusion pump alarm codes that can be cleared by the operator. Also listed in *Table 6-1* are the alarm messages, descriptions, possible causes, and corrective actions.

Note: Operational alarm messages are displayed on the LCD screen. Associated error codes are displayed in the alarms log *(see Section 1.8.2)*.

Note: Air-in-line on either line applies to both lines.

Table 6-1. Operational Alarm Messages and Corrective Actions

Alarm Code	Alarm	Description	Possible Cause	Corrective Action
N100 or **E100** (URC)	Unrecognizable cassette	Incorrect cassette type	An incorrect cassette is inserted	Insert proper cassette
N101 or **E101** (NAA)	No action alarm	No operator action and no delivery for two minutes during delivery parameters entry	Interruption of a partial change to a program	Complete programming of the pump
N102 or **E102** (RL)	Infuser idle 2 minutes	Infuser in reset or idle for over two minutes	Programming set without start for two minutes	Press [START]
N103 or **E103** (SEEP CRC)	NV RAM lost thrpy data	Therapy data is lost	Infuser did not complete the previous non-volatile memory write successfully	Re-enter all programmed data
N104 or **E104** (NC2)	Nurse Callback B	Delivery line B has changed (if alarm is enabled)	End of delivery step on line B other than VTBI complete while callback is enabled	Press [SILENCE]
N105 or **E105** (NC1)	Nurse Callback A	Delivery line A has changed (if alarm is enabled)	End of delivery step on line A other than VTBI complete while callback is enabled	Press [SILENCE]
N160 or **E160** (VTB2)	Line B VTBI complete	Programmed volume to be infused completed on line B	VTBI is complete on line B	Press [SILENCE] and replace IV bag, and restart line B

Table 6-1. Operational Alarm Messages and Corrective Actions

Alarm Code	Alarm	Description	Possible Cause	Corrective Action
N161 or **E161** (VTB1)	Line A VTBI complete	Programmed volume to be infused completed on line A	VTBI is complete on line A	Press [SILENCE] and replace IV bag, and restart line A
N180 or **E180** (OD1)	Distal Occl	Peak distal occlusion, non-delivery	Distal occlusion detected during non-delivery	Backprime the cassette and restart pump
N181 or **E181** (OD1)	Distal Occl	Negative distal occlusion, non-delivery	Distal occlusion detected during non-delivery	Backprime the cassette and restart pump
N182 or **E182** (OP2)	Prox. Occl B/Air or Prox. Occl B	Negative proximal occlusion B, non-delivery	Proximal occlusion detected on line B during non-delivery	Backprime the cassette and restart line B or Stop all lines, backprime the cassette, and restart all lines
N183 or **E183** (OP2)	Prox. Occl B/Air or Prox. Occl B	Peak proximal occlusion B, non-delivery	Proximal occlusion detected on line B during non-delivery	Backprime the cassette and restart line B or Stop all lines, backprime the cassette, and restart all lines
N184 or **E184** (OP1)	Prox. Occl A/Air or Prox. Occl A	Negative proximal occlusion A, non-delivery	Proximal occlusion detected on line A during non-delivery	Backprime the cassette and restart line A or Stop all lines, backprime the cassette, and restart all lines
N185 or **E185** (OP1)	Prox. Occl A/Air or Prox. Occl A	Peak proximal occlusion A, non-delivery	Proximal occlusion detected on line A during non-delivery	Backprime the cassette and restart line A or Stop all lines, backprime the cassette, and restart all lines
N186 or **E186** (OD1)	Distal Occl	Peak distal occlusion, delivery	Distal occlusion detected during delivery	Fix occlusion (closed clamps; kinked tubing) and restart pump

Table 6-1. Operational Alarm Messages and Corrective Actions

Alarm Code	Alarm	Description	Possible Cause	Corrective Action
N187 or **E187** (OD1)	Distal Occl	Negative distal occlusion, delivery	Distal occlusion detected during delivery	Fix occlusion (closed clamps; kinked tubing) and restart pump
N188 or **E188** (OP2)	Prox. Occl B	Negative proximal occlusion B, delivery	Proximal occlusion detected during delivery on line B	Fix occlusion (closed clamps; kinked tubing) and restart line B or Stop all lines, fix occlusion (closed clamps; kinked tubing), and restart pump
N189 or **E189** (OP2)	Prox. Occl B	Peak proximal occlusion B, delivery	Proximal occlusion detected during delivery on line B	Fix occlusion (closed clamps; kinked tubing) and restart line B or Stop all lines, fix occlusion (closed clamps; kinked tubing), and restart pump
N190 or **E190** (OP1)	Prox. Occl A	Negative proximal occlusion A, delivery	Proximal occlusion detected during delivery on line A	Fix occlusion (closed clamps; kinked tubing); restart line A or Stop all lines, fix occlusion (closed clamps; kinked tubing), and restart pump
N191 or **E191** (OP1)	Prox. Occl A	Peak proximal occlusion A, delivery	Proximal occlusion detected during delivery on line A	Fix occlusion (closed clamps; kinked tubing) and restart line A or Stop all lines, fix occlusion (closed clamps; kinked tubing), and restart pump

Table 6-1. Operational Alarm Messages and Corrective Actions

Alarm Code	Alarm	Description	Possible Cause	Corrective Action
N230 or **E230** (APT)	Prox. Air Total	Proximal air-in-line total	500 µL of air has entered the cassette	Backprime the cassette and restart pump or Remove and manually reprime the cassette and restart pump
N231 or E231 (APB)	Prox. Air on B, Backprime	Proximal air-in-line on line B	500 µL of air has entered the cassette on line B	Backprime the cassette and restart line B or Remove and manually reprime the cassette and restart pump
N232 or **E232** (APA)	Prox. Air on A, Backprime	Proximal air-in-line on line A	500 µL of air has entered the cassette on line A	Backprime the cassette and restart line A or Remove and manually reprime the cassette and restart pump
N233 or **E233** (ADC)	Distal Air Cumulative	Distal air cumulative	500 µL of air detected in the last 5.3 mL of fluid delivered	Remove and manually reprime the cassette and restart pump
E234 or **E234** (ADB)	Distal Air Bolus	Distal air bolus	100 µL bolus of air detected at distal sensor	Remove and manually reprime the cassette and restart pump
N250 or **E250** (DCO1)	Door opened while pumping	Door opened while pumping	Door opened while pumping	Turn off the pump or Insert the cassette and close the door
N251 or **E251** (CS1)	Valve/Cass Test Fail	Valve/cassette test failure	Valve/cassette fails the leak test	Replace cassette and retest or Backprime and retest
N252 or **E252** (BDP)	Depleted Battery	Discharged battery	The battery is discharged to the recommended maximum discharge condition	Connect the pump to AC power or Recharge or replace the battery

Table 6-1. Operational Alarm Messages and Corrective Actions				
Alarm Code	**Alarm**	**Description**	**Possible Cause**	**Corrective Action**
N253 or **E253** (LOV)	Lockout Violation	Lockout violation	The use of the [STOP] key or an attempt to open the door while lockout switch is locked	Unlock the lockout switch
N254 or **E254** (FPL)	Lockout Enabled	Keypad locked	Any action not resulting in stopping of the delivery while the lockout switch is locked	Unlock the lockout switch

6.2.2
ERROR CODES REQUIRING TECHNICAL SERVICE

Table 6-2 lists infusion pump error codes that require technical service. Also listed in *Table 6-2* are malfunction descriptions, possible causes, and corrective actions.

Table 6-2. Error Codes Requiring Technical Service			
Error Code	**Malfunction**	**Possible Cause**	**Corrective Action**
E300	ADC failure	Analog to digital converter failure	Replace CPU PWA *(see Section 7.2.13.3)* Reset time and date, if required *(see Section 1.8.3)*
E301	Audio alarm failure	Piezo is off but sensed on or Piezo is on but sensed off	Turn power off, then on, to reset the pump Replace CPU PWA *(see Section 7.2.13.3)* Reset time and date, if required *(see Section 1.8.3)*
E302	Backlight failure	Backlight (CCFT tube) is not at the expected range	Turn power off, then on, to reset the pump Replace display/CPU assembly *(see Section 7.2.13.2)* Reset time and date, if required *(see Section 1.8.3)*

Table 6-2. Error Codes Requiring Technical Service

Error Code	Malfunction	Possible Cause	Corrective Action
E320	Battery charge current out of range	Battery charge current is out of range after 8 hours	Replace battery *(see Section 7.2.4)* Replace power supply PWA *(see Section 7.2.13.1)* Reset time and date, if required *(see Section 1.8.3)*
E321	Battery not charging	Battery charging timed out Complete battery discharge has occurred	Charge battery for additional 8 hours Replace power supply PWA *(see Section 7.2.13.1)* Reset time and date, if required *(see Section 1.8.3)*
E322	Battery current calibration value out of range	Battery integrator calibration value is out of range	
E323	Battery trickle charge current out of range	Battery trickle charge current is out of range	
E324	Supply overvoltage	An overvoltage condition is detected in the charging circuit	
E325	Battery overvoltage	An overvoltage condition is detected in the battery	
E326	Battery disconnected	Battery disconnected while pump is powered on	Check for loose battery connections Replace battery *(see Section 7.2.4)* Reset time and date, if required *(see Section 1.8.3)*
E327	Brownout condition	Brownout condition detected	Replace power supply PWA *(see Section 7.2.13.1)* Reset time and date, if required *(see Section 1.8.3)*
E340	Critical instruction failure	Power-up CPU register test failed (no malfunction message displayed)	Replace CPU PWA *(see Section 7.2.13.3)* Reset time and date, if required *(see Section 1.8.3)*
E341	Critical data memory failure	Critical data memory failure	Replace mechanism assembly *(see Section 7.2.13.5)* Reset time and date, if required *(see Section 1.8.3)*

Table 6-2. Error Codes Requiring Technical Service

Error Code	Malfunction	Possible Cause	Corrective Action
E342	Display failure	Defective display	Replace display/CPU assembly *(see Section 7.2.13.2)* Reset time and date, if required *(see Section 1.8.3)*
E343	Distal air sensor failure 1	With the cassette removed, the distal air sensor self test detects liquid	Replace mechanism assembly *(see Section 7.2.13.5)* Reset time and date, if required *(see Section 1.8.3)*
E344	Distal air sensor failure 2	With the cassette inserted, the distal air sensor self test detects sensor out of range	
E345	Distal pressure sensor failure 1	Distal air sensor failed while pump is OFF	
E346	Distal pressure sensor failure 2	Distal air sensor failed while pump is ON	
E347	Hardware watchdog failure	Hardware watchdog failure	Replace CPU PWA *(see Section 7.2.13.3)* Reset time and date, if required *(see Section 1.8.3)*
E371	I/O valve motor failure 1	I/O valve motor malfunction if a total of four resynchronizations failed	Replace mechanism assembly *(see Section 7.2.13.5)* Reset time and date, if required *(see Section 1.8.3)*
E372	I/O valve motor failure 2	I/O valve motor malfunction if three consecutive resynchronizations failed	
E373	L/S valve motor failure 1	L/S valve motor malfunction if a total of four resynchronizations failed	
E374	L/S valve motor failure 2	L/S valve motor malfunction if three consecutive resynchronizations failed	
E375	Motor position sensor failure	Motor position sensor failure	
E376	Plunger synch failure 1	Plunger malfunction when resynchronization has failed a total of four times	
E377	Plunger synch failure 2	Plunger malfunction when three consecutive resynchronizations failed	

Table 6-2. Error Codes Requiring Technical Service

Error Code	Malfunction	Possible Cause	Corrective Action
E378	I/O valve phase loss	Generic I/O valve failure	Turn power off, then on, to reset infusion pump Replace mechanism assembly *(see Section 7.2.13.5)* Reset time and date, if required *(see Section 1.8.3)*
E379	L/S valve phase loss	Generic L/S valve failure	Turn power off, then on, to reset infusion pump Replace mechanism assembly *(see Section 7.2.13.5)* Reset time and date, if required *(see Section 1.8.3)*
E380	Plunger motor phase loss	Generic plunger motor failure	
E430	Proximal air sensor failure 1	Proximal air sensor ongoing test detects liquid with cassette removed	Replace mechanism assembly *(see Section 7.2.13.5)* Reset time and date, if required *(see Section 1.8.3)*
E431	Proximal air sensor failure 2	Proximal air sensor self test detects liquid with cassette removed	
E432	Proximal pressure sensor 1	Proximal pressure sensor failed while pump is OFF	
E433	Proximal pressure sensor 2	Proximal pressure sensor failed while pump is ON	
E434	RAM failure	RAM failure	Replace CPU PWA *(see Section 7.2.13.3)* Turn power off, then on, to reset infusion pump Reset time and date, if required *(see Section 1.8.3)*
E435	RTC failure	Real-time clock failure	
E436	ROM failure	ROM checksum failure	
E437	Software failure	Generic software failure	
E438	Stack out-of-range failure	Stack out-of-range failure	
E439	Stuck key	A key is sensed as pressed for over two minutes	Replace display/CPU assembly *(see Section 7.2.13.2)* Reset time and date, if required *(see Section 1.8.3)*
E440	Power hold stuck	Power hold signal stuck Power cannot be turned off	

Table 6-2. Error Codes Requiring Technical Service

Error Code	Malfunction	Possible Cause	Corrective Action
E441	Valve self test failure	I/O or L/S valve self test failed	Replace mechanism assembly *(see Section 7.2.13.5)* Reset time and date, if required *(see Section 1.8.3)*
E443	LCD failure	LCD bias is out of range	Replace display/CPU assembly *(see Section 7.2.13.2)* Reset time and date, if required *(see Section 1.8.3)*
E444	CPU timebase inaccurate	CPU timer 2 and RTC measured times disagree	Replace CPU PWA *(see Section 7.2.13.2)* Reset time and date, if required *(see Section 1.8.3)*
E445	RTC memory failure	Real-time clock memory is corrupt	Turn power off, then on, to reset infusion pump Reset time and date, if required *(see Section 1.8.3)*
E446	CPU timer failure	CPU timer 1 and timer 2 measured times disagree	Replace CPU PWA *(see Section 7.2.13.3)* Reset time and date, if required *(see Section 1.8.3)*
E447	Battery ADC reading failure	16 consecutive readings have been either all 0 or the max value	
E448	SEEP write failure	SEEP data write failed	
E449	SEEP calibration data corrupted	Calibration data block corrupted	
E450	MMIO port read/write failure	I/O port read/write failure	Replace CPU PWA *(see Section 7.2.13.3)* Reset time and date, if required *(see Section 1.8.3)*
E451	Inaccurate delivery	Over/under delivery detected	Turn power off, then on, to reset infusion pump Reset time and date, if required *(see Section 1.8.3)*
E452	Software failure	Miscellaneous software failures	

Table 6-2. Error Codes Requiring Technical Service			
Error Code	**Malfunction**	**Possible Cause**	**Corrective Action**
E453	Two SEEP CRC errors	NVRAM data block corrupted	Turn power off, then on, to reset infusion pump Replace CPU PWA *(see Section 7.2.13.3)* Reset time and date, if required *(see Section 1.8.3)*
E454	NVRAM over capacity	Software trying to write into non-existent NVRAM space	
E455	Invalid device configuration	Incorrect flash memory on peripheral board	Turn power off, then on, to reset infusion pump Replace peripheral assembly *(see Section 7.2.6)*
E456	Invalid drug library	A download was started and not completed successfully	Reload library *(see System Operating Manual)*
E457	Drug library corrupted	CRC failure on drug library	Reload library *(see System Operating Manual)*

Note: The following error codes are not generated in the biomed service mode *(see Section 1.8)*:

E320	**E323**	**E326**	**E346**	**E373**	**E376**	**E379**	**E431**	**E441**
E321	**E324**	**E343**	**E371**	**E374**	**E377**	**E380**	**E432**	**E447**
E322	**E325**	**E345**	**E372**	**E375**	**E378**	**E430**	**E433**	

Note: Some error codes include sub-ID codes. These sub-ID codes are intended for Hospira internal use only, and should be included when contacting Hospira Technical Support Operations *(see Section 6.1)*.

6.3 TROUBLESHOOTING PROCEDURES

This section details recommended procedures for problems not associated with malfunction alarms. Before performing any troubleshooting procedure, turn the infusion pump off, then on. Allow the self test to complete and proceed as follows:

1. If a malfunction exists, carefully inspect the infusion pump for damage as described in *Section 5.2.2*.
2. If an infusion pump inspection has not disclosed a malfunction, perform the PVT in *Section 5.2*. Refer to *Table 6-3, Troubleshooting with the PVT*, for section reference, probable cause, and corrective actions.
3. If, after completing Steps 1 and 2, a malfunction has not been located, or if the infusion pump persistently fails, contact Hospira Technical Support Operations.

Table 6-3. Troubleshooting with the PVT

Test Failure	Probable Cause	Corrective Action
Self test *(Section 5.2.4)*	Cassette not properly installed	Reseat cassette
	Defective CPU PWA	Replace CPU PWA *(see Section 7.2.13.3)*
Cassette alarm test *(Section 5.2.5)*	Cassette not properly seated	Reseat cassette
	Defective cassette	Replace cassette
Free flow test *(Section 5.2.6)*	Cassette not properly seated	Reseat cassette
	Defective cassette	Replace cassette
	Defective or dirty valve pins	Clean valve pins
		Replace mechanism assembly *(see Section 7.2.13.5)*
Display test *(Section 5.2.7)*	Defective display/CPU assembly	Replace display/CPU assembly *(see Section 7.2.13.2)*
Keypad verification/ functional test *(Section 5.2.8)*	Defective display/CPU assembly	Replace display/CPU assembly *(see Section 7.2.13.2)*
Alarm loudness test *(Section 5.2.10)*	Defective CPU	Replace CPU PWA *(see Section 7.2.13.3)*
	Defective peripheral PWA	Replace peripheral PWA *(see Section 7.2.6)*
	Defective piezo alarm assembly	Replace piezo alarm assembly *(see Section 7.2.13.4)*
Lockout switch test *(Section 5.2.12)*	Defective peripheral PWA	Replace peripheral PWA *(see Section 7.2.6)*

Table 6-3. Troubleshooting with the PVT

Test Failure	Probable Cause	Corrective Action
Proximal occlusion test *(Section 5.2.14)*	Closed proximal clamp	Open clamp
	Cassette not properly primed	Re-prime cassette
	Defective cassette	Replace cassette
	Dirty sensor pin	Clean sensor pin
	Defective APP PWA	Replace mechanism assembly *(see Section 7.2.13.5)*
Proximal air-in-line test *(Section 5.2.16)*	Defective special cassette	Replace special cassette
	Dirty sensors	Clean sensors
	Defective APP PWA	Replace mechanism assembly *(see Section 7.2.13.5)*
Distal air-in-line test *(Section 5.2.18)*	Defective special cassette	Replace special cassette
	Dirty sensors	Clean sensors
	Defective APP PWA	Replace mechanism assembly *(see Section 7.2.13.5)*
Distal occlusion test *(Section 5.2.20)*	Cassette not properly primed	Re-prime cassette
	Defective cassette	Replace cassette
	Dirty sensor pin	Clean sensor pin
	Defective APP PWA	Replace mechanism assembly *(see Section 7.2.13.5)*
Delivery accuracy test *(Section 5.2.22)*	Set not properly primed	Re-prime cassette
	Damaged or faulty cassette	Replace cassette
	Defective mechanism assembly	Replace mechanism assembly *(see Section 7.2.13.5)*
Electrical safety test *(Section 5.2.24)*	Defective AC power cord	Replace AC power cord *(see Section 7.2.5)*

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Section 7

REPLACEABLE PARTS AND REPAIRS

This section itemizes all parts and subassemblies of the Plum A+ infusion system that are repairable within the scope of this manual. In addition, this section details replacement procedures for all listed parts.

7.1 REPLACEABLE PARTS

Replaceable parts for the Plum A+ are itemized in the spare parts price list and are identified in *Figure 9-1, Illustrated Parts Breakdown*. *Table 9-2, IPB for the Infusion Pump*, identifies each part by an index number that correlates to *Figure 9-1*.

To request a copy of the current spare parts price list, contact Hospira Technical Support Operations *(see Section 6.1, Technical Assistance)*, or to view the catalog online, visit the website at:

www.hospiraparts.com

For convenient reference, insert a copy of the spare parts price list here.

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7.2 REPLACEMENT PROCEDURES

This section contains safety and equipment precautions, required tools and materials, and step-by-step procedures for replacing parts in the infusion pump. Unless otherwise stated, always perform the PVT after a replacement procedure.

7.2.1 SAFETY AND EQUIPMENT PRECAUTIONS

Before opening the front enclosure of the infusion pump, take all necessary precautions for working on high-voltage equipment.

WARNING: POSSIBLE EXPLOSION HAZARD EXISTS IF THE INFUSION PUMP IS SERVICED IN THE PRESENCE OF FLAMMABLE ANESTHETICS.

WARNING: UNLESS OTHERWISE INDICATED, DISCONNECT THE INFUSION PUMP FROM AC POWER BEFORE PERFORMING ADJUSTMENT OR REPLACEMENT PROCEDURES.

CAUTION: Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store PWAs in antistatic bags before placing them on any surface.

7.2.2 REQUIRED TOOLS AND MATERIALS

The following tools and materials, or equivalents, are required for the replacement procedures in this section. In addition, the beginning of each procedure lists tools and materials recommended for that specific procedure.

- ❑ Set of standard and metric nutdrivers
- ❑ Set of flat blade screwdrivers
- ❑ Set of Phillips® screwdrivers
- ❑ Set of box wrenches
- ❑ Set of open end wrenches
- ❑ Long needle nose pliers
- ❑ Wide-head pliers
- ❑ Custom nutdriver (P/N 519-95056-001)
- ❑ Diagonal cutters
- ❑ X-acto® knife
- ❑ Tweezers
- ❑ Wire stripper
- ❑ Electrician's knife
- ❑ Permanent marker
- ❑ Mild solvent
- ❑ Lint-free cloth

7.2.3
RUBBER FOOT PAD REPLACEMENT

Recommended tools for this procedure are an X-acto knife, mild solvent, and lint-free cloth.

The replacement part for this procedure is:

Pad, Rubber Foot

To replace the rubber foot pad, refer to *Figure 7-1, Bottom View of the Infusion Pump*, then proceed as follows:

1. Press [ON/OFF] to turn off the infusion pump, and disconnect the pump from AC power.
2. Place the pump on its side.
3. Using the X-acto knife, remove the rubber foot pad and scrape the enclosure recess to remove adhesive residue.

   Note: Each adhesive-backed rubber foot pad is bonded in its recess. Do not damage the recess.
4. Using mild solvent and a lint-free cloth, clean any adhesive residue from the enclosure recess.
5. Remove the protective backing from the self-adhesive surface of the replacement foot pad and press the pad in place.
6. After approximately five minutes, verify the foot pad is secure.

Replacement of a rubber foot pad is routine maintenance and no verification procedure is normally required. However, if the infusion pump may have been damaged during a rubber foot pad replacement, perform the PVT in *Section 5.2*.

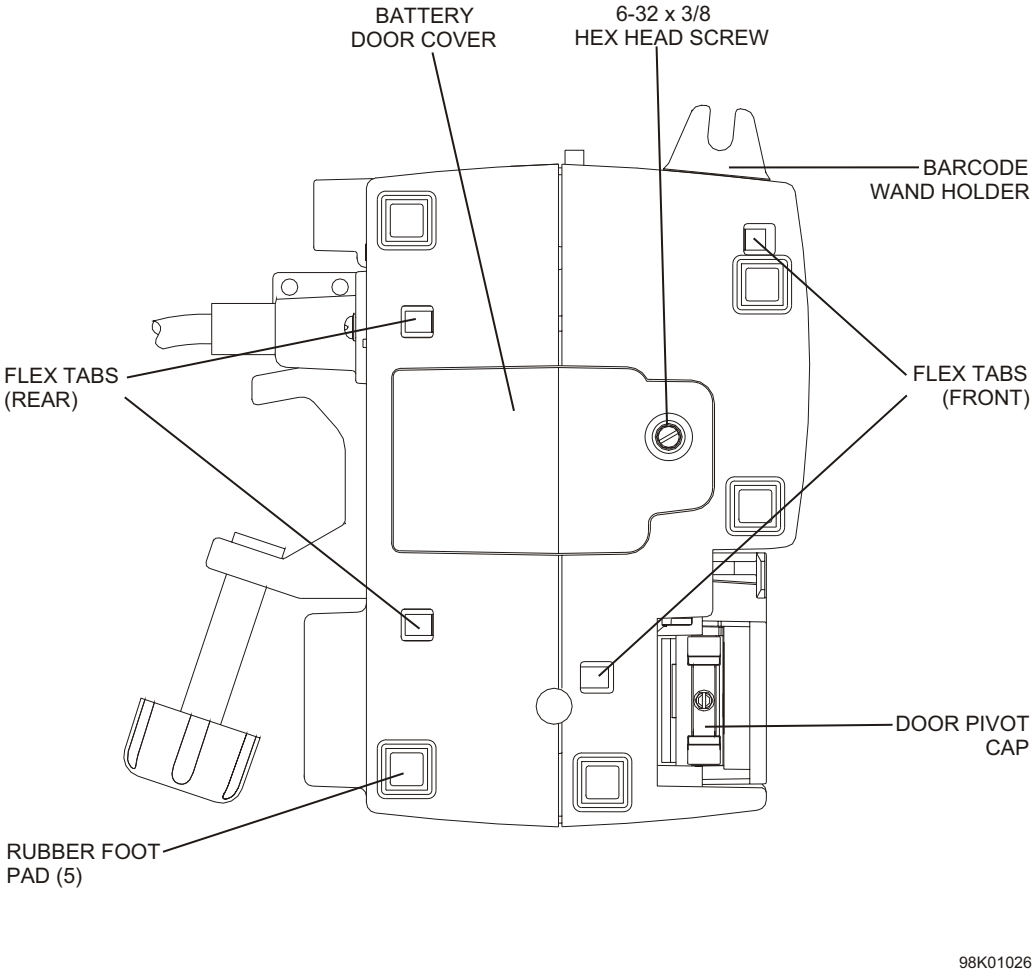


Figure 7-1. Bottom View of the Infusion Pump

7.2.4 BATTERY, BATTERY DOOR, AND BATTERY DOOR PAD REPLACEMENT

Recommended tools for this procedure are a medium size flat blade screwdriver, an X-acto knife, mild solvent, and a lint-free cloth.

The replacement parts for this procedure are:

Assembly, Battery, with Wire Harness
Door, Battery
Pad, Battery Door
Screw, 6-32 x 3/8, Hex Head, Slotted, with Washer

To replace the battery, battery door, and battery door pad, refer to *Figure 7-1* and *Figure 9-7*, then proceed as follows:

1. Press [ON/OFF] to turn off the infusion pump, and disconnect the pump from AC power.
2. Place the pump on its side.

3. Using the flat blade screwdriver, remove the 6-32 screw that attaches the battery door to the pump, and remove the door.
4. Inspect the battery door and door pad for damage. Replace the door, if necessary.
5. If the battery door pad is defective, remove it and clean the door with mild solvent. Dry the battery door thoroughly, and install the replacement pad on the door.
6. Disconnect the battery harness from the charger circuit cable. Carefully pull the battery harness wires and connector outside the enclosure, and remove the battery.
7. Connect the replacement battery harness to the charger circuit cable, and insert the replacement battery into the enclosure.

   Note: The cable connectors are keyed so that cables cannot be connected incorrectly.

   Note: Confirm the battery harness is not pinched between the battery and the enclosure.

8. Replace the battery door using the screw that was removed in Step 3.

To verify successful replacement of the battery, press [ON/OFF] with the infusion pump disconnected from AC power, and verify the front panel battery symbol illuminates.

Replacement of the battery door and battery door pad is routine maintenance and no verification procedure is normally required. However, if the infusion pump may have been damaged during these procedures, perform the PVT in *Section 5.2*.

7.2.5
AC POWER CORD, POWER CORD RETAINER, AND VELCRO RETAINER STRAP REPLACEMENT

The recommended tool for this procedure is a No. 2 Phillips screwdriver.

The replacement parts for this procedure are:

Cordset, AC Power, Hospital Grade, Detachable
Retainer, AC Power Cord
Strap, Velcro, AC Power Cord
Screw, 4-40 x 1/4, Pan Head, Phillips
Screw, 6-32 x 5/8, Pan Head, Phillips, with Washer
Screw, Jack, 4-40 x 7/16
Washer, Lock, #4

To replace the AC power cord, power cord retainer, and Velcro retainer strap, refer to *Figure 7-2, AC Power Cord, Power Cord Retainer, and Velcro Retainer Strap*, then proceed as follows:

1. Press [ON/OFF] to turn off the infusion pump, and disconnect the pump from AC power.
2. Using the Phillips screwdriver, remove the two screws from the AC power cord retainer.
3. Unplug the power cord, and slide the plug through the retainer.
4. Remove the Velcro strap from the power cord. Inspect the Velcro strap for wear and replace the strap, if necessary. Attach the strap to the replacement power cord.

5. Install the replacement AC power cord in the exact reverse order of removal.
6. Connect the infusion pump to AC (mains) power. Press [ON/OFF] and verify the pump powers on.

To verify successful AC power cord, power cord retainer, and Velcro retainer strap replacement, perform the PVT in *Section 5.2*.

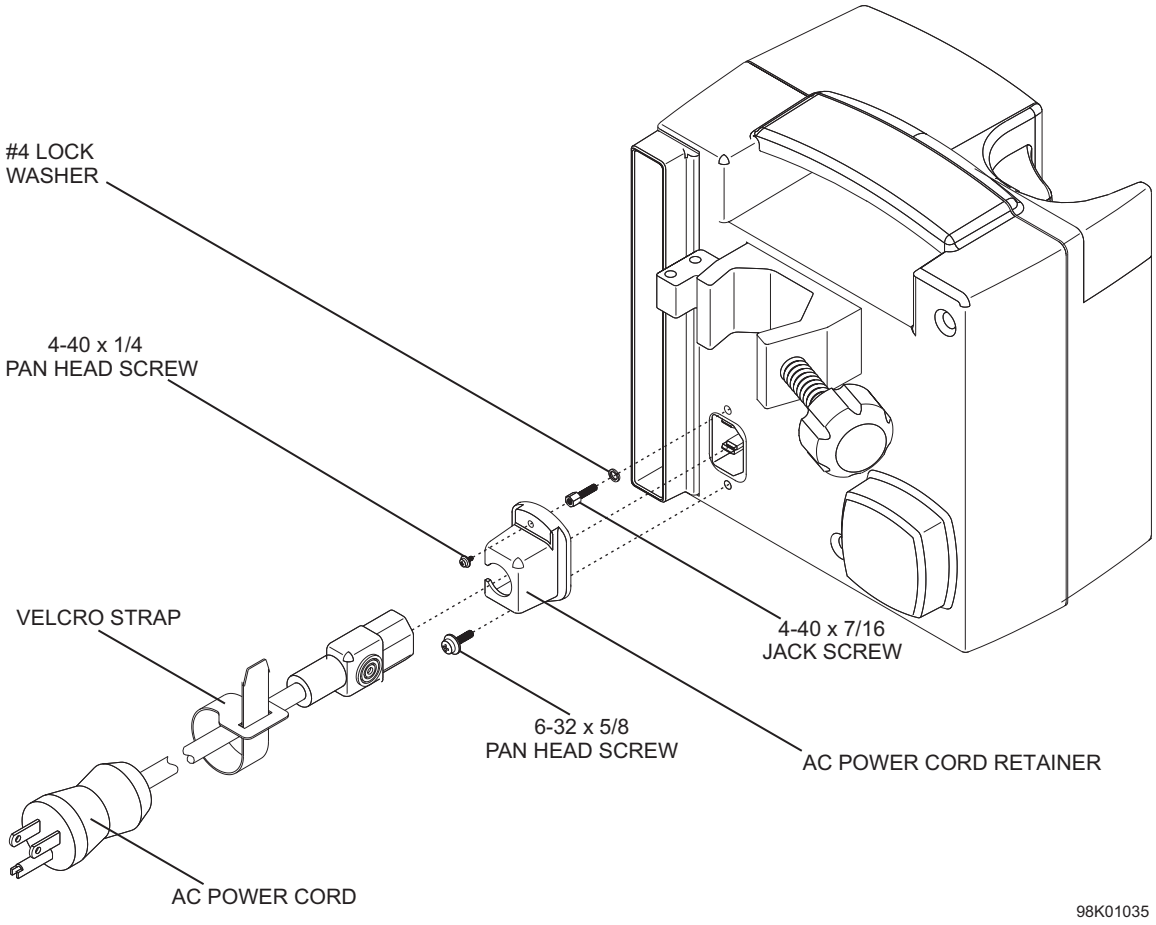


Figure 7-2. AC Power Cord, Power Cord Retainer, and Velcro Retainer Strap

7.2.6 PERIPHERAL ASSEMBLY REPLACEMENT

The recommended tool for this procedure is a No. 2 Phillips screwdriver.

The replacement parts for this procedure are:

Assembly, Peripheral
Cover, Peripheral Assembly
Screw, 4-40 x 1/4, Pan Head, Square Cone, Phillips

CAUTION: Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store the PWA in an antistatic bag before placing it on any surface.

CAUTION: Certain peripheral assembly list numbers are not compatible with older versions of the Plum A+ device. Refer to *Table 1-2, List Numbers*, for pump configuration and module compatibility.

Note: Replacing the peripheral PWA does not change the existing biomed settings.

To replace the peripheral assembly, refer to *Figure 7-3, Rear View of the Infusion Pump*, and *Figure 7-4, Peripheral Assembly Replacement*, then proceed as follows:

1. Press [ON/OFF] to turn off the infusion pump, and disconnect the pump from AC power.
2. Carefully set the infusion pump face down.
3. Using the No. 2 Phillips screwdriver, remove the two 4-40 screws from the peripheral assembly.
4. Carefully pull the assembly away from the pump.

   Note: When removing the peripheral assembly, note the placement guides the peripheral PWA rests between.

5. Install the replacement peripheral assembly in the exact reverse order of removal.

   Note: Verify the peripheral assembly is placed properly between the guides and fits correctly into the CPU PWA.

To verify successful peripheral assembly replacement, perform the PVT in *Section 5.2*.

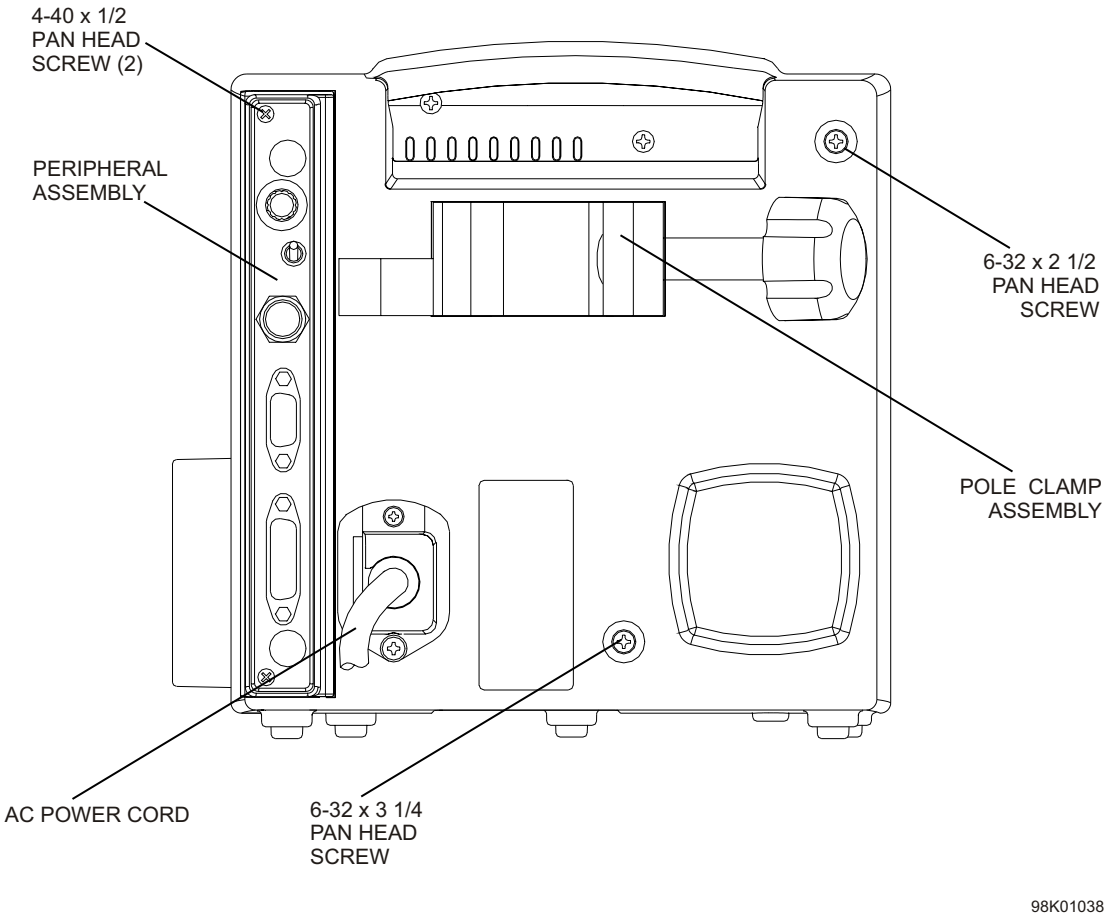


Figure 7-3. Rear View of the Infusion Pump

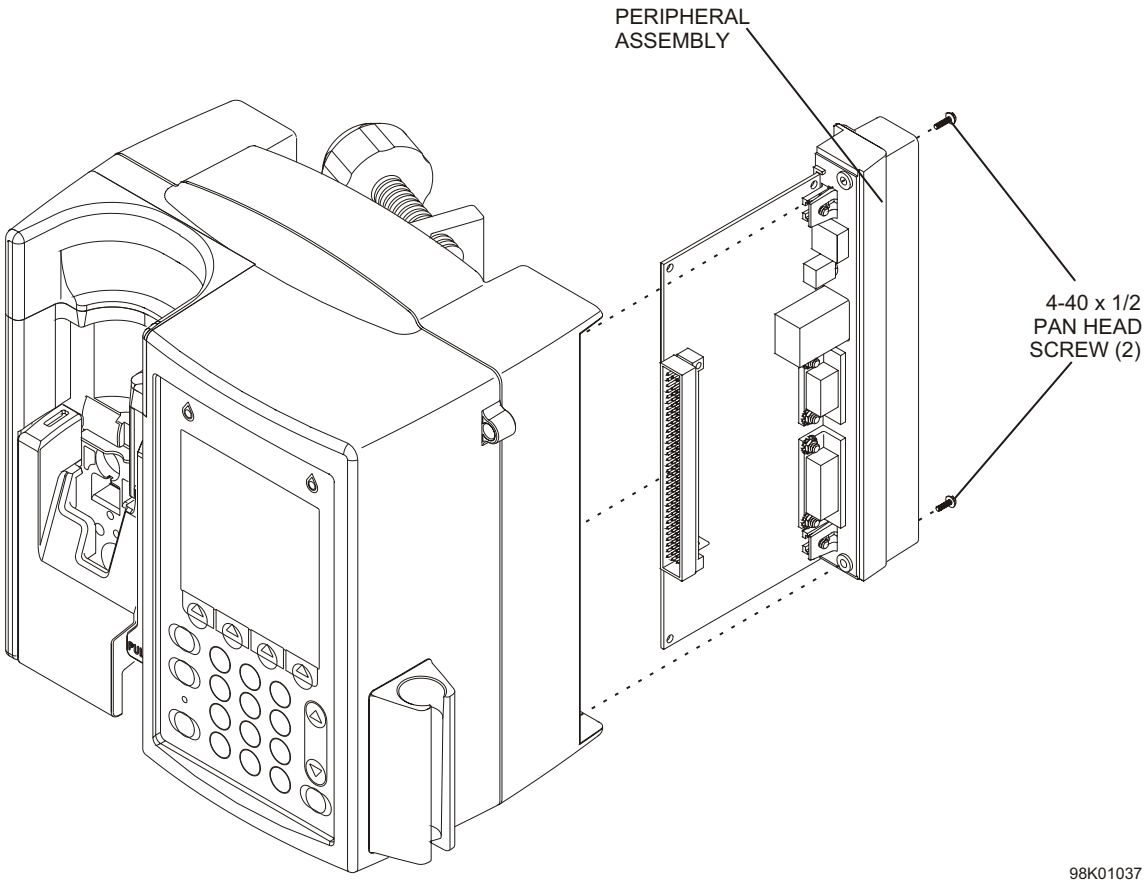


Figure 7-4. Peripheral Assembly Replacement

7.2.7
PERIPHERAL ASSEMBLY COMPONENT REPLACEMENT

Peripheral assembly component replacement includes the replacement of the volume control knob and the peripheral assembly cover.

CAUTION: Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store the PWA in an antistatic bag before placing it on any surface.

To replace the peripheral assembly components, refer to *Figure 7-5, Peripheral Assembly Components*, then proceed as detailed in the following sections.

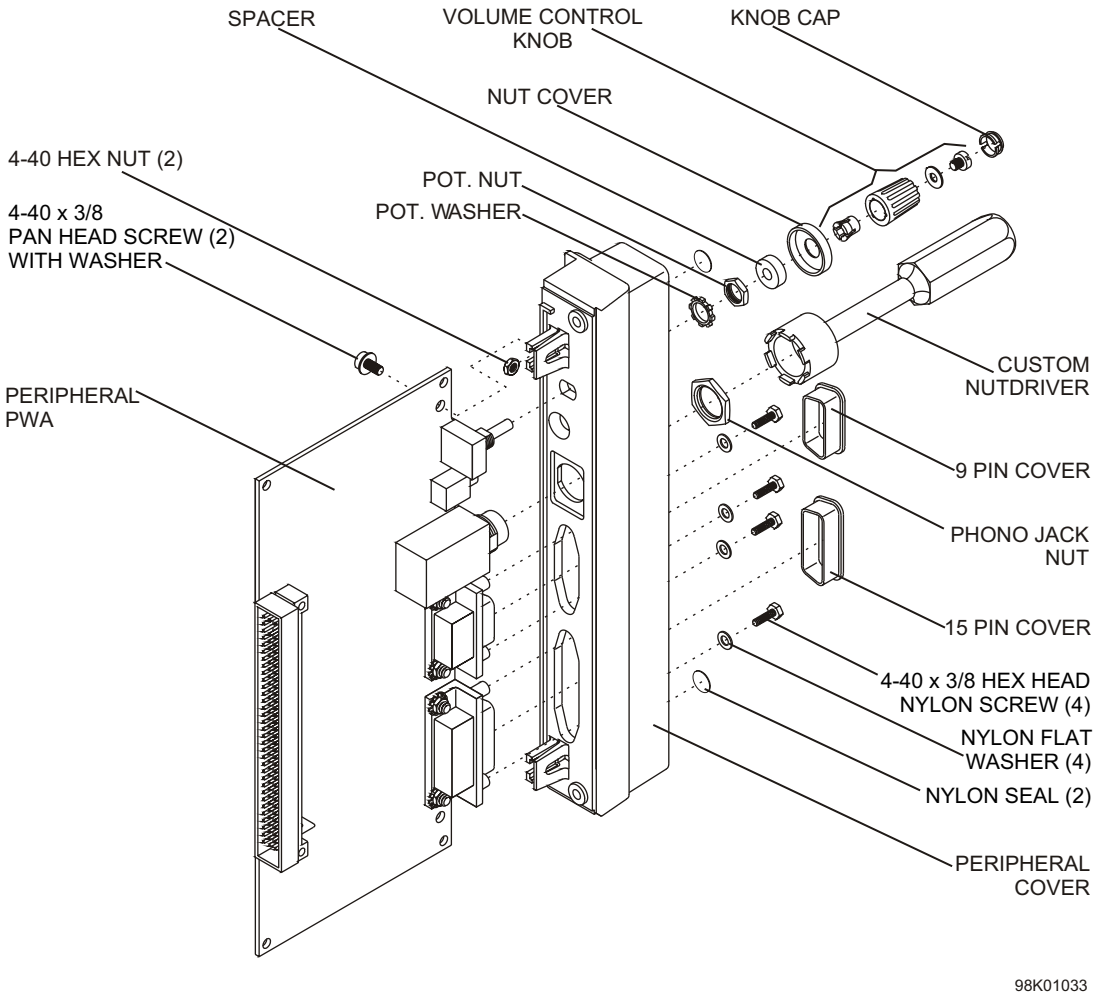


Figure 7-5. Peripheral Assembly Components

7.2.7.1 VOLUME CONTROL KNOB REPLACEMENT

Recommended tools for this procedure are an X-acto knife, a medium size flat blade screwdriver, and long needle nose pliers.

The replacement parts for this procedure are:

Knob, Volume Control
Cap, Knob
Cover, Nut
Spacer, Nylon

To replace the volume control knob, refer to *Figure 7-5*, then proceed as follows:

1. Remove the peripheral assembly as described in *Section 7.2.6*.
2. Using the X-acto knife, lift the volume control knob end cap away from the gray knob, exposing a flat head screw.

3. Using the flat blade screwdriver, remove the screw securing the knob.
4. Using long needle nose pliers, remove the knob and spacer.
5. Install the replacement volume control knob in the exact reverse order of removal.
6. Replace the peripheral assembly in the exact reverse order of removal.

To verify successful volume control knob replacement, perform the PVT in *Section 5.2*.

7.2.7.2
PERIPHERAL ASSEMBLY COVER REPLACEMENT

Recommended tools for this procedure are a 5/16 nutdriver, custom nutdriver, long needle nose pliers, and a No. 2 Phillips screwdriver.

CAUTION: Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store the PWA in an antistatic bag before placing it on any surface.

The replacement parts for this procedure are:

Cover, Peripheral Assembly
Cover, 9 Pin
Cover, 15 Pin
Seal, Nylon
Screw, 4-40 x 3/8, Hex Head, Nylon
Screw, 4-40 x 3/8, Pan Head, Phillips, with Washer
Nut, 4-40, Hex
Washer, Flat, .128 Dia., Nylon

To replace the peripheral assembly cover, refer to *Figure 7-5*, then proceed as follows:

1. Remove the peripheral assembly as described in *Section 7.2.6*.
2. Remove the volume control knob as described in *Section 7.2.7.1*.
3. Using the 5/16 nutdriver, remove the nut securing the potentiometer to the peripheral cover. Remove the washer with needle nose pliers.
4. Using the custom nutdriver, remove the nut securing the phono jack to the peripheral cover.
5. Remove and inspect the covers from the 9 pin and 15 pin connectors, and replace, if necessary.
6. Using the Phillips screwdriver, remove the two 4-40 screws securing the peripheral PWA to the cover.
7. Install the replacement peripheral cover in the exact reverse order of removal.
8. Replace the volume control knob in the exact reverse order of removal.

To verify successful peripheral assembly cover replacement, perform the PVT in *Section 5.2*.

7.2.8
SEPARATING THE FRONT ENCLOSURE ASSEMBLY, REAR ENCLOSURE ASSEMBLY, AND MAIN CHASSIS ASSEMBLY

The recommended tools for this procedure are a No. 2 Phillips screwdriver, medium size flat blade screwdriver, and 3/16 nutdriver.

CAUTION: Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store PWAs in antistatic bags before placing them on any surface.

To separate the front enclosure assembly, rear enclosure assembly, and main chassis assembly, refer to *Figure 7-6, Separating the Front Enclosure, Main Chassis, and Rear Enclosure*, then proceed as follows:

1. Remove the battery door and battery as described in *Section 7.2.4*.
2. Remove the AC power cord and retainer as described in *Section 7.2.5*.
3. Using the 3/16 nutdriver, remove the 4-40 jack screw and lock washer *(see Figure 7-2)*.
4. Remove the peripheral assembly as described in *Section 7.2.6*.
5. Using the Phillips screwdriver, remove the remaining two 6-32 screws from the upper right corner and lower center of the rear enclosure.
6. Carefully place the pump face down.
7. Using the flat blade screwdriver, depress the two flex tabs that secure the rear enclosure while lifting up the rear enclosure *(see Figure 7-1)*. Remove the rear enclosure.
8. Using the Phillips screwdriver, remove the two 6-32 screws in the pump handle area, and remove the shoe from the front enclosure.
9. Carefully place the pump face up.
10. Using the flat blade screwdriver, depress the flex tab that secures the front enclosure while lifting up the front enclosure. Remove the front enclosure.

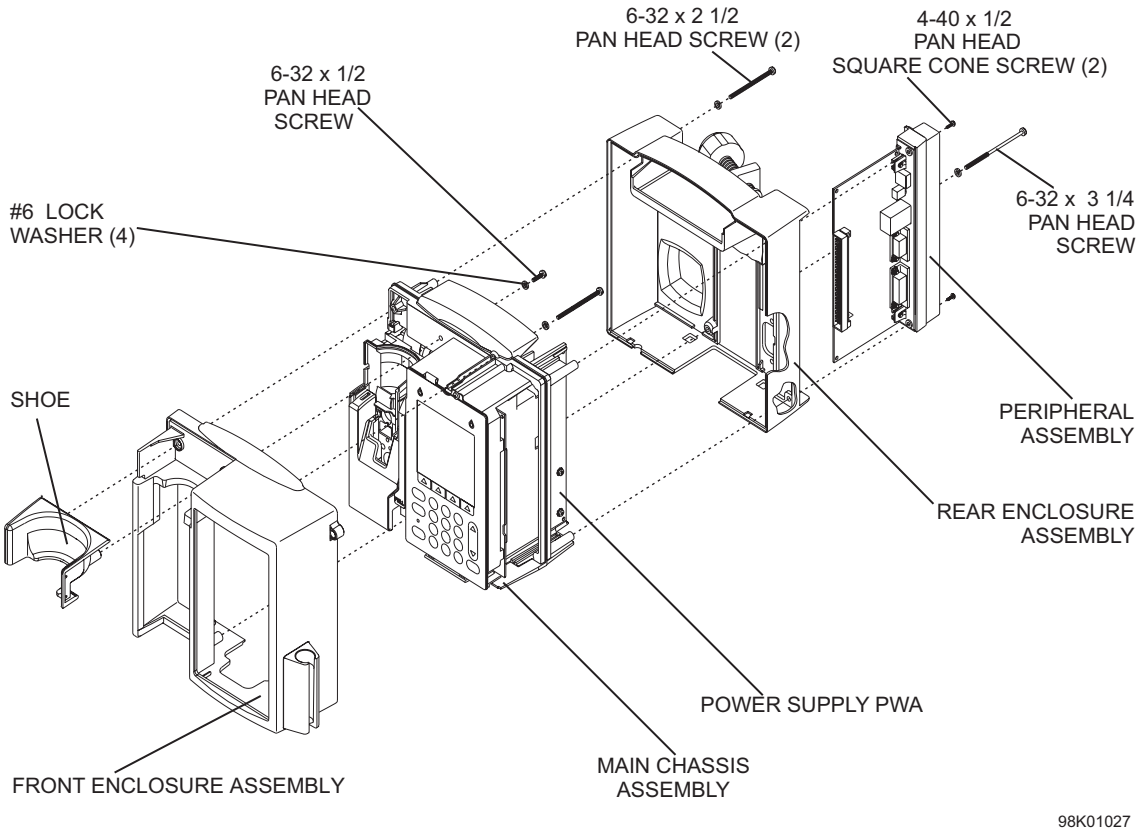


Figure 7-6. Separating the Front Enclosure, Main Chassis, and Rear Enclosure

7.2.9
FRONT ENCLOSURE, REAR ENCLOSURE, OR MAIN CHASSIS REPLACEMENT

There are no recommended tools for this procedure.

Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store PWAs in antistatic bags before placing them on any surface.

The replacement parts for this procedure are:

Enclosure, Front
Enclosure, Rear
Chassis, Main
Shoe, Front Enclosure
Screw, 6-32 x 1/2, Pan Head, Phillips
Screw, 6-32 x 2 1/2, Pan Head, Phillips
Screw, 6-32 x 3 1/4, Pan Head, Phillips
Washer, Lock, Helical, #6

To replace the front enclosure, rear enclosure, or main chassis, refer to *Figure 7-6*, then proceed as follows:

1. Separate the front enclosure assembly, rear enclosure assembly, and main chassis assembly as described in *Section 7.2.8*.
2. To replace the front enclosure, remove the specific components described in *Section 7.2.10, Front Enclosure Assembly Component Replacement*.
3. To replace the rear enclosure, remove the specific components described in *Section 7.2.11, Rear Enclosure Assembly Component Replacement*.
4. To replace the main chassis, remove the specific components described in *Section 7.2.13, Main Chassis Assembly Component Replacement*.
5. Reassemble the front enclosure assembly, rear enclosure assembly, or main chassis assembly components *(see Section 7.2.10, Section 7.2.11, and Section 7.2.13)*.

   Note: Assure the CPU/driver cable is positioned completely above and to the side of the battery enclosure prior to joining the rear enclosure assembly to the main chassis assembly.

6. Join the front enclosure assembly, main chassis assembly, and rear enclosure assembly in the exact reverse order of separation.

To verify successful front enclosure, rear enclosure, or main chassis replacement, perform the PVT in *Section 5.2*.

7.2.10
FRONT ENCLOSURE ASSEMBLY COMPONENT REPLACEMENT

Front enclosure assembly component replacement includes the replacement of the barcode reader wand holder, shoe gaskets, and front/rear enclosure gaskets.

To replace the front enclosure assembly components, refer to *Figure 7-7, Front Enclosure Assembly Components*, then proceed as detailed in the following sections.

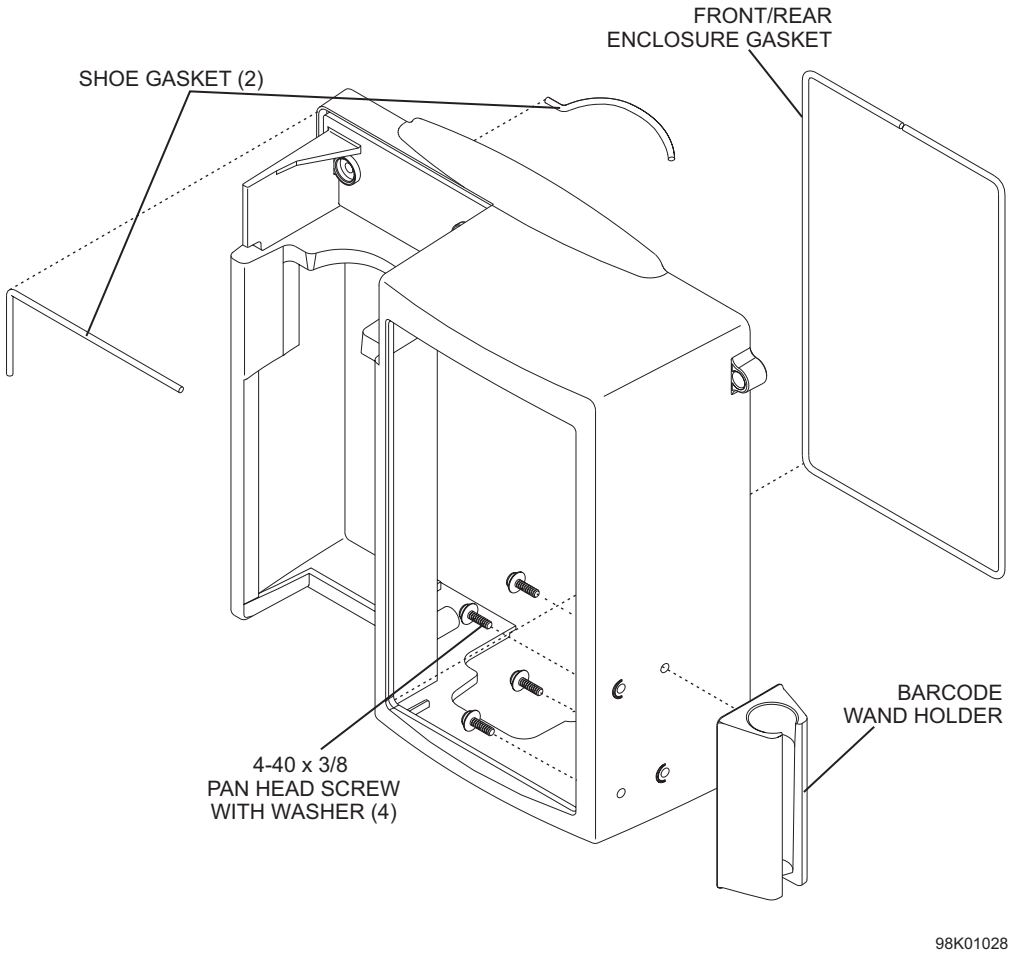


Figure 7-7. Front Enclosure Assembly Components

7.2.10.1

BARCODE READER WAND HOLDER REPLACEMENT

The recommended tool for this procedure is a No. 2 Phillips screwdriver.

The replacement parts for this procedure are:

Holder, Barcode Reader Wand

Screw, 4-40 x 3/8, Pan Head, Phillips, with Washer

To replace the barcode reader wand holder, refer to *Figure 7-7*, then proceed as follows:

1. Separate the front enclosure assembly, rear enclosure assembly, and main chassis assembly as described in *Section 7.2.8*.
2. Using the Phillips screwdriver, remove the four 4-40 screws securing the barcode reader wand holder to the front enclosure.
3. Install the replacement barcode reader wand holder in the exact reverse order of removal.

To verify successful barcode reader wand holder replacement, perform the PVT in *Section 5.2*.

7.2.10.2
SHOE GASKET REPLACEMENT

There are no recommended tools for this procedure.

The replacement part for this procedure is:

Gasket, Shoe

To replace the shoe gaskets, refer to *Figure 7-7*, then proceed as follows:

1. Separate the front enclosure assembly, rear enclosure assembly, and main chassis assembly as described in *Section 7.2.8*.
2. Remove the shoe gaskets from the front and back of the front enclosure assembly as shown in *Figure 7-7*.
3. Install the replacement shoe gaskets in the exact reverse order of removal.

To verify successful shoe gasket replacement, perform the PVT in *Section 5.2*.

7.2.10.3
FRONT/REAR ENCLOSURE GASKET REPLACEMENT

There are no recommended tools for this procedure.

The replacement part for this procedure is:

Gasket, Front/Rear Enclosure

To replace the front/rear enclosure gaskets, refer to *Figure 7-7*, then proceed as follows:

1. Separate the front enclosure assembly, rear enclosure assembly, and main chassis assembly as described in *Section 7.2.8*.
2. Remove the front/rear gasket from the front enclosure assembly.
3. Install the replacement front/rear gasket in the exact reverse order of removal.

To verify successful front/rear enclosure gasket replacement, perform the PVT in *Section 5.2*.

7.2.11
REAR ENCLOSURE ASSEMBLY COMPONENT REPLACEMENT

Rear enclosure assembly component replacement includes the replacement of the following:

- Pole clamp extrusion, backing plate, and insulation tape
- Pole clamp shaft/knob assembly and the pole clamp shaft tip
- Rear enclosure and handle gaskets

To replace the rear enclosure assembly components, refer to *Figure 7-8, Rear Enclosure Assembly Components*, then proceed as detailed in the following sections.

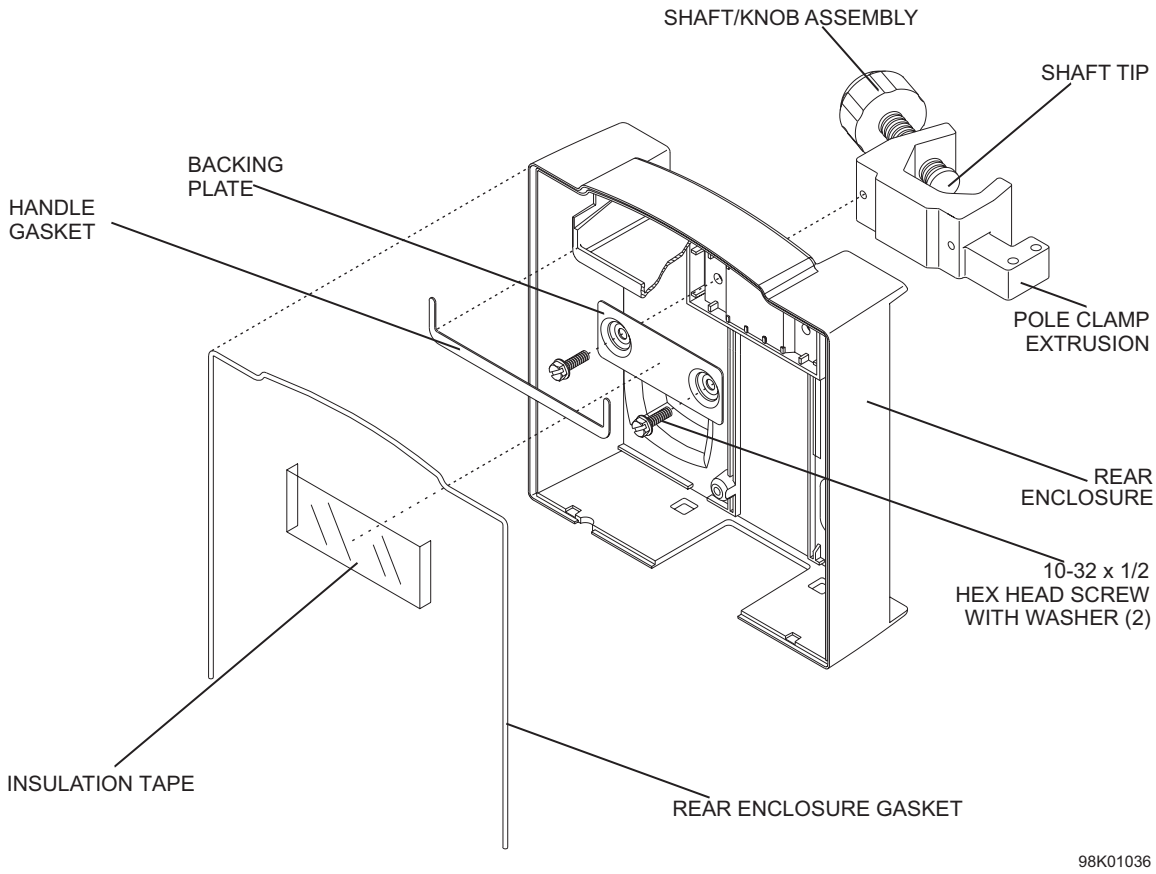


Figure 7-8. Rear Enclosure Assembly Components

7.2.11.1

POLE CLAMP EXTRUSION, BACKING PLATE, AND INSULATION TAPE REPLACEMENT

Recommended tools for this procedure are a medium size flat blade screwdriver and mild solvent.

The replacement parts for this procedure are:

Plate, Backing, Pole Clamp
Extrusion, Pole Clamp
Tape, Insulation
Screw, 10-32 x 1/2, Hex Head, Slotted, with Washer

To replace the pole clamp extrusion, pole clamp backing plate, and insulation tape, refer to *Figure 7-8*, then proceed as follows:

1. Separate the rear enclosure assembly as described in *Section 7.2.8*.
2. Grasp the insulation tape and remove it from the pole clamp backing plate.
3. Using mild solvent, clean the pole clamp backing plate and dry it thoroughly.

4. Using the flat blade screwdriver, remove the two 10-32 hex screws securing the pole clamp backing plate to the pole clamp extrusion, and remove the backing plate and pole clamp from the rear enclosure assembly.
5. Install the replacement pole clamp extrusion into the rear enclosure assembly.
6. Install the replacement pole clamp backing plate against the pole clamp extrusion, using the two screws that were removed in Step 4.
7. Completely cover the pole clamp backing plate with the replacement insulation tape. Press firmly to adhere the insulation tape to the backing plate.

   CAUTION: Make sure the insulation tape covers the entire backing plate. If the backing plate is exposed, the power supply PWA may be damaged when power is applied to the infusion pump.

To verify successful pole clamp extrusion, backing plate, and insulation tape replacement, perform the PVT in *Section 5.2*.

7.2.11.2

POLE CLAMP SHAFT/KNOB ASSEMBLY AND SHAFT TIP REPLACEMENT

The recommended tool for this procedure is wide-head pliers.

The replacement parts for this procedure are:

Assembly, Shaft/Knob, Pole Clamp

Tip, Shaft, Pole Clamp

To replace the pole clamp shaft/knob assembly and the pole clamp shaft tip, refer to *Figure 7-8*, then proceed as follows:

1. Turn the pole clamp shaft/knob assembly counterclockwise to remove it from the pole clamp extrusion, and loosen the pole clamp shaft tip from the shaft/knob assembly.
2. Turn the pole clamp shaft/knob assembly back into the pole clamp extrusion. Using the wide-head pliers, remove the pole clamp shaft tip and replace the tip, if necessary.

   Note: The pole clamp shaft tip has a long shaft that is pressed into the threaded pole clamp shaft/knob assembly.
3. Install the replacement pole clamp shaft/knob assembly into the pole clamp extrusion by turning the shaft/knob assembly clockwise into the extrusion until the threaded portion is visible.
4. Press the pole clamp shaft tip into the screw hole recess on the shaft/knob assembly and turn the shaft/knob assembly clockwise until the shaft tip is secure against the pole clamp extrusion.

Replacement of the pole clamp shaft/knob assembly and the pole clamp shaft tip is routine maintenance and no verification procedure is normally required. However, if the infusion pump may have been damaged during the replacement procedure, perform the PVT in *Section 5.2*.

7.2.11.3
REAR ENCLOSURE AND HANDLE GASKETS REPLACEMENT

There are no recommended tools for this procedure.

The replacement parts for this procedure are:

Gasket, Rear Enclosure
Gasket, Handle

To replace the rear enclosure and handle gaskets, refer to *Figure 7-8*, then proceed as follows:

1. Separate the rear enclosure assembly and main chassis assembly as described in *Section 7.2.8*.
2. Remove the rear enclosure and handle gaskets from the rear enclosure assembly.
3. Install the replacement gaskets in the exact reverse order of removal.

To verify successful rear enclosure and handle gaskets replacement, perform the PVT in *Section 5.2*.

7.2.12
MINIPOLE ASSEMBLY REPLACEMENT

The minipole assembly attaches to the infusion pump through two holes in the heatsink and is held in place by a cotter ring. This cotter ring passes through a hole near the end of the longer of the two vertical rods on the bag hanger and prevents the removal of the minipole assembly from the holes in the pole clamp *(see Figure 7-9, Minipole Assembly)*.

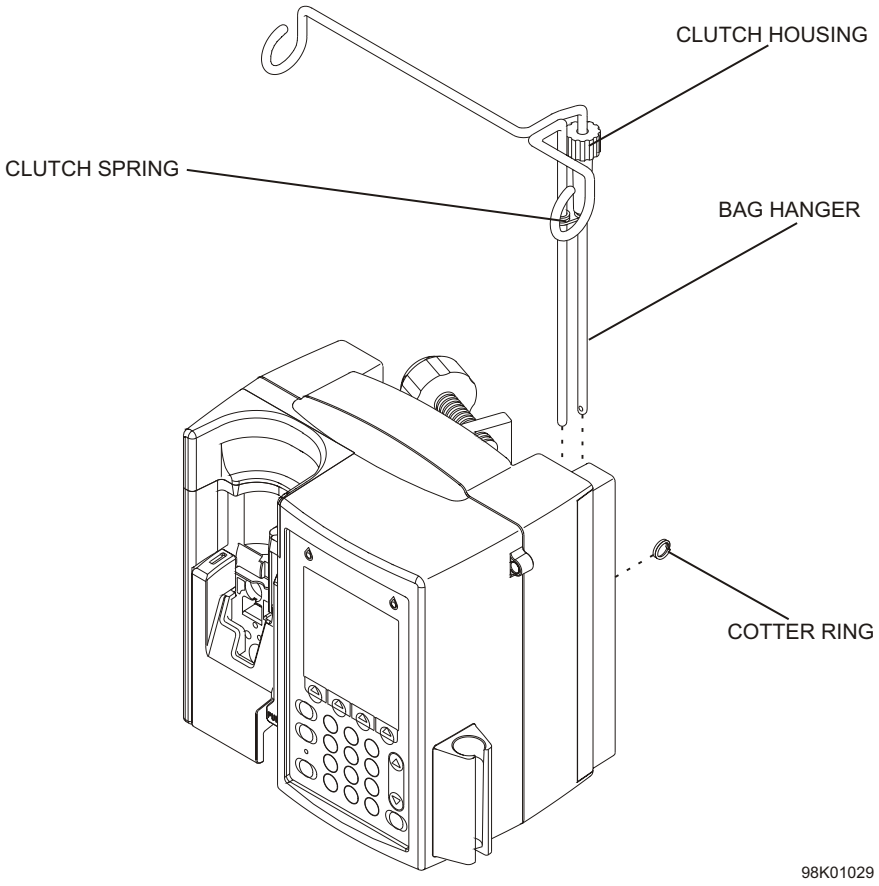


Figure 7-9. Minipole Assembly

7.2.12.1

COTTER RING REPLACEMENT

There are no recommended tools for this procedure.

The replacement part for this procedure is:

Ring, Cotter, Minipole

To replace the cotter ring, refer to *Figure 7-9*, then proceed as follows:

1. Place the infusion pump face down on a soft surface.
2. Grasp the cotter ring with thumb and finger. Twist, rotate, and remove the cotter ring from the rod hole.
3. Replace the cotter ring in exact reverse order of removal.

Replacement of the cotter ring is routine maintenance and no verification procedure is normally required. However, if the infusion pump may have been damaged during the replacement procedure, perform the PVT as described in *Section 5.2*.

7.2.12.2
BAG HANGER REPLACEMENT

There are no recommended tools for this procedure.

The replacement part for this procedure is:

Hanger, Bag, Minipole

To replace the bag hanger, refer to *Figure 7-9*, then proceed as follows:

1. Remove the cotter ring as described in *Section 7.2.12.1*.
2. Remove the bag hanger from the pole clamp rod holes.
3. Insert the replacement bag hanger in the pole clamp rod holes.
4. Insert the cotter ring.

Replacement of the bag hanger is routine maintenance and no verification procedure is normally required. However, if the infusion pump may have been damaged during the replacement procedure, perform the PVT in *Section 5.2*.

7.2.12.3
CLUTCH HOUSING REPLACEMENT

There are no recommended tools for this procedure.

The replacement part for this procedure is:

Housing, Clutch, Minipole

To replace the clutch housing, refer to *Figure 7-9*, then proceed as follows:

1. Remove the bag hanger from the infusion pump as described in *Section 7.2.12.2*.
2. Turn the clutch housing knob counterclockwise to loosen the clutch spring, and slide the knob and spring downward to remove them.
3. Work the clutch spring free from the clutch housing hole and install it into the replacement clutch housing.
4. Install the replacement clutch housing by turning the clutch housing knob counterclockwise and sliding it up the short rod. Confirm the clutch spring slides up the long rod.
5. Install the cotter ring.

Replacement of the clutch housing is routine maintenance and no verification procedure is normally required. However, if the infusion pump may have been damaged during the replacement procedure, perform the PVT in *Section 5.2*.

7.2.12.4
CLUTCH SPRING REPLACEMENT

There are no recommended tools for this procedure.

The replacement part for this procedure is:

Spring, Clutch, Minipole

To replace the clutch spring, refer to *Figure 7-9*, then proceed as follows:

1. Remove the clutch housing as described in *Section 7.2.12.3*.
2. Work the clutch spring free from the clutch housing hole and install the replacement clutch spring.

Replacement of the clutch spring is routine maintenance and no verification procedure is normally required. However, if the infusion pump may have been damaged during the replacement procedure, perform the PVT in *Section 5.2*.

7.2.13
MAIN CHASSIS ASSEMBLY COMPONENT REPLACEMENT

Main chassis assembly component replacement includes the replacement of the following:

- Power supply PWA
- Display/CPU assembly
- CPU PWA
- Piezo alarm assembly
- Mechanism assembly
- Cassette door
- Fluid shield
- Opener handle assembly

CAUTION: Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store PWAs in antistatic bags before placing them on any surface.

To replace the main chassis assembly components, refer to *Figure 7-10, Main Chassis Components*, then proceed as detailed in the following sections.

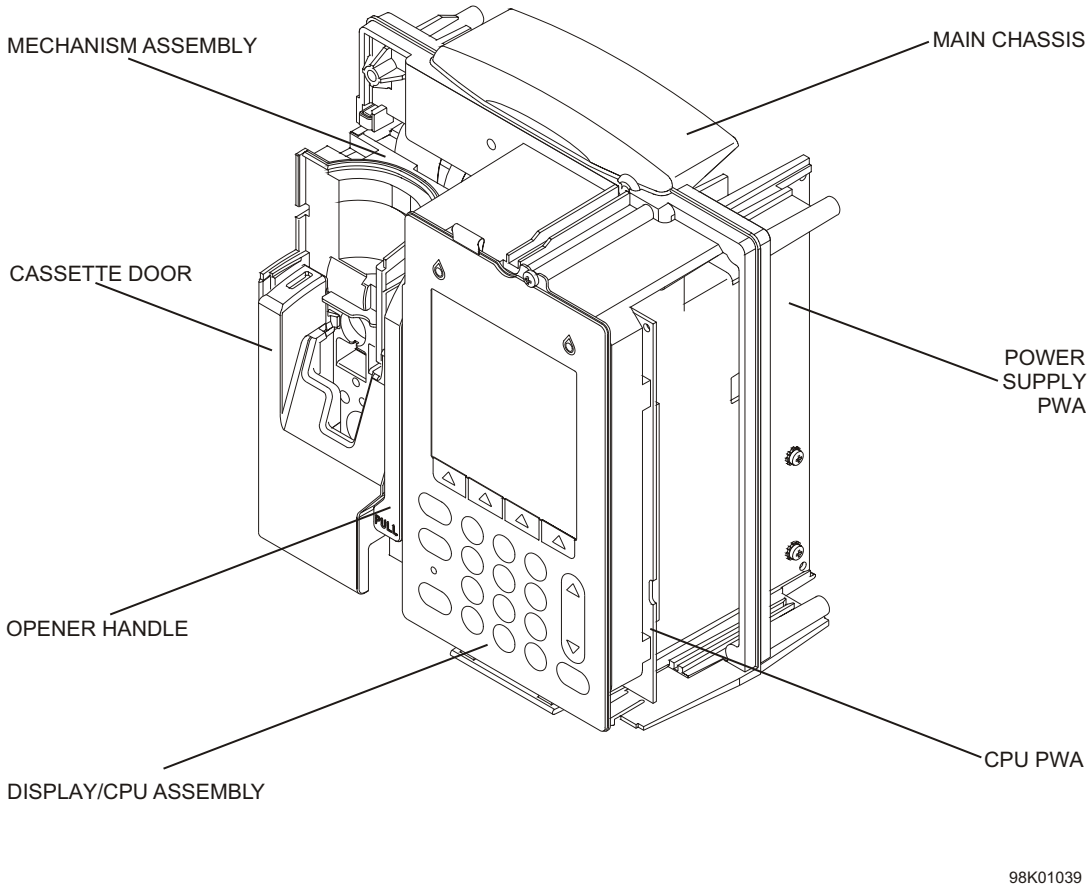


Figure 7-10. Main Chassis Components

7.2.13.1
POWER SUPPLY PWA REPLACEMENT

The recommended tool for this procedure is a medium size flat blade screwdriver.

The replacement parts for this procedure are:

PWA, Power Supply
Cable, Power Supply PWA/Battery
Cable, Power Supply PWA/Driver PWA

CAUTION: Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store the PWA in an antistatic bag before placing it on any surface.

Note: This procedure applies to 110 V_{AC} and 220 V_{AC} PWAs.

To replace the power supply PWA, refer to *Figure 7-10*, then proceed as follows:

1. Separate the rear enclosure assembly from the main chassis as described in *Section 7.2.8*.
2. Remove the power supply/battery cable from J22 on the power supply PWA.

3. Remove the power supply/mechanism cable from J16 on the power supply PWA.
4. Remove the power supply PWA by sliding the board away from the CPU PWA.
5. Install the replacement power supply PWA in the exact reverse order of removal.

Note: Verify the replacement power supply PWA connects to the CPU PWA correctly to avoid misalignment.

Note: If an alarm sounds, press the [ON/OFF] key to deactivate the alarm.

To verify successful power supply PWA replacement, perform the PVT in *Section 5.2*.

7.2.13.2
DISPLAY/CPU ASSEMBLY REPLACEMENT

The recommended tools for this procedure are a No. 2 Phillips screwdriver and a medium size flat blade screwdriver.

The replacement parts for this procedure are:

Assembly, Display/CPU
Cable, CPU PWA/Driver PWA
Screw, 4-40 x 3/8, Hex Head, Slotted, with Washer

CAUTION: Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store the PWA in an antistatic bag before placing it on any surface.

To replace the display/CPU assembly, refer to *Figure 7-10*, *Figure 7-11, Display/CPU Assembly and Piezo Alarm Assembly Replacement*, and *Figure 7-12, CPU PWA Replacement*, then proceed as follows:

1. Separate the front enclosure assembly, rear enclosure assembly, and main chassis assembly as described in *Section 7.2.8*.
2. Remove the power supply PWA as described in *Section 7.2.13.1*.
3. Using the Phillips screwdriver, remove the 4-40 screw securing the display/CPU assembly to the main chassis.
4. Carefully disconnect the ribbon cable from the display assembly. Place the display assembly with the keypad face down.
5. Using the flat blade screwdriver, remove the two 4-40 hex screws securing the splashguard and piezo alarm assembly.
6. Disconnect the piezo alarm assembly from the CPU PWA at J24.
7. Turn the CPU PWA as shown in *Figure 7-12*.
8. Disconnect the CPU/mechanism cable from J3.
9. Install the replacement display/CPU assembly in the exact reverse order of removal.

To verify successful display/CPU assembly replacement, perform the PVT in *Section 5.2*.

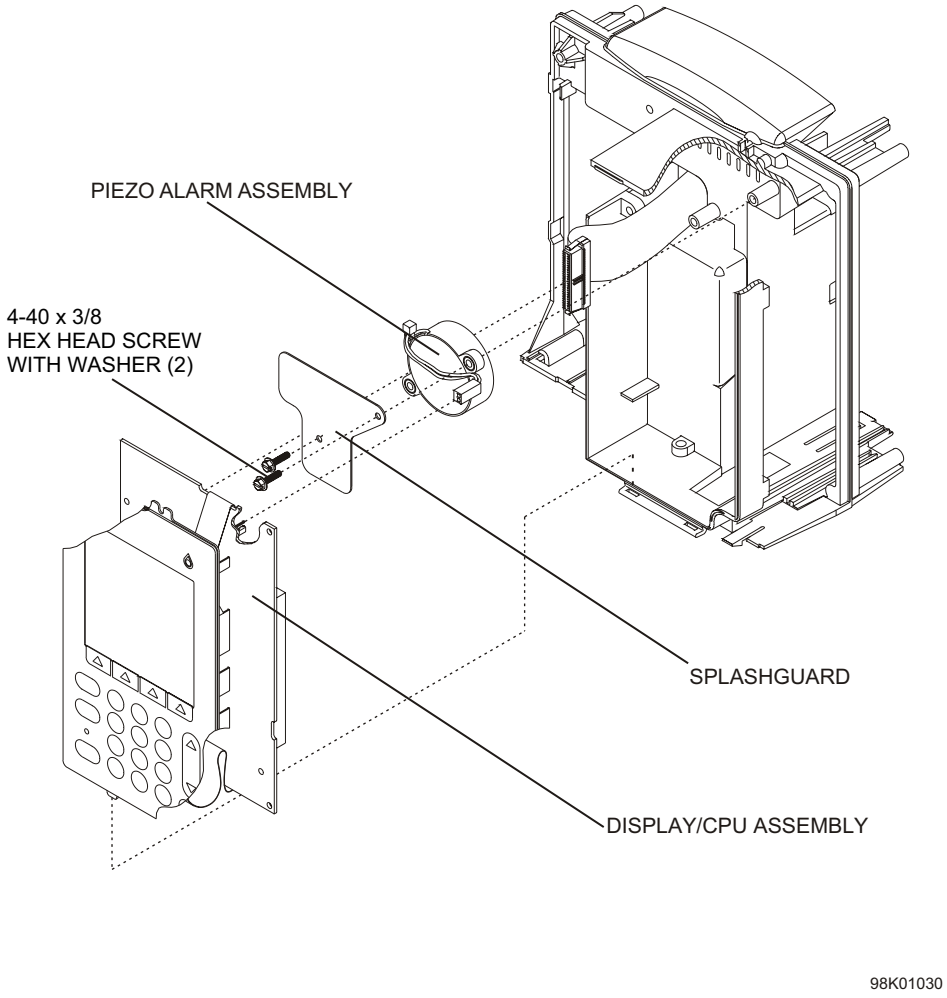


Figure 7-11. Display/CPU Assembly and Piezo Alarm Assembly Replacement

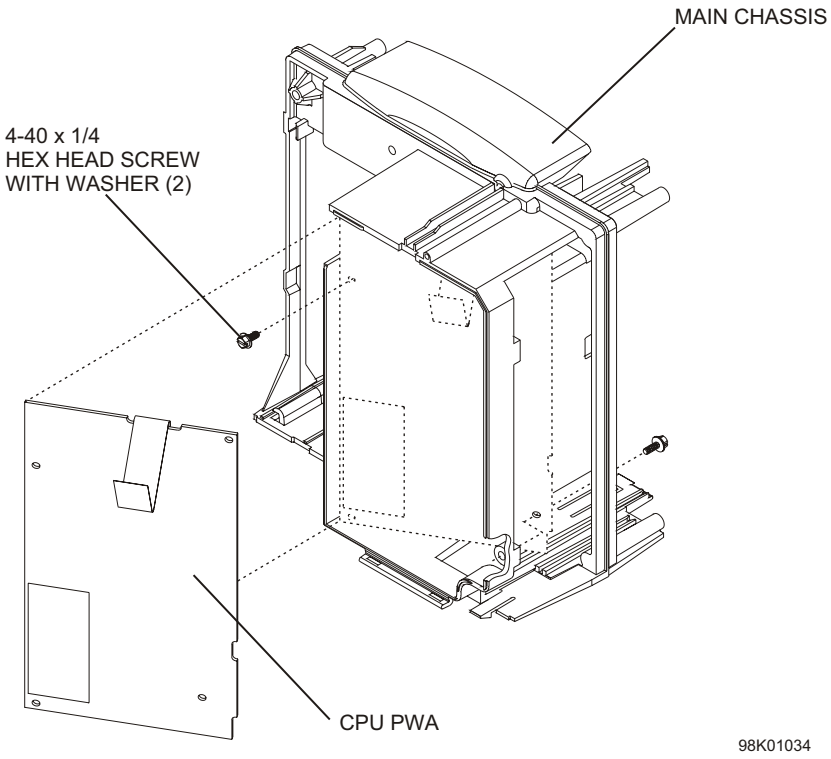


Figure 7-12. CPU PWA Replacement

7.2.13.3

CPU PWA REPLACEMENT

The recommended tool for this procedure is a medium size flat-blade screwdriver.

The replacement parts for this procedure are:

PWA, CPU

Screw, 4-40 x 1/4, Hex Head, Slotted, with Washer

CAUTION: Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store the PWA in an antistatic bag before placing it on any surface.

To replace the CPU PWA, refer to *Figure 7-11* and *Figure 7-12*, then proceed as follows:

1. Separate the front enclosure assembly, rear enclosure assembly, and main chassis assembly as described in *Section 7.2.8*.
2. Remove the power supply PWA as described in *Section 7.2.13.1*.
3. Remove the display/CPU assembly as described in *Section 7.2.13.2*.
4. Disconnect the keypad ribbon cable from J4.
5. Disconnect the display cable from J20.
6. Using the flat blade screwdriver, remove the two 4-40 hex screws.
7. Install the replacement CPU PWA in the exact reverse order of removal.
8. Reassemble the display/CPU assembly and power supply PWA in the exact reverse order of removal.

To verify successful CPU PWA replacement, perform the PVT in *Section 5.2*.

7.2.13.4
PIEZO ALARM ASSEMBLY REPLACEMENT

The recommended tool for this procedure is a medium size flat blade screwdriver.

The replacement parts for this procedure are:

Assembly, Piezo Alarm
Splashguard
Screw, 4-40 x 3/8, Hex Head, Slotted, with Washer

CAUTION: Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store the PWA in an antistatic bag before placing it on any surface.

To replace the piezo alarm assembly, refer to *Figure 7-11*, then proceed as follows:

1. Separate the front enclosure assembly, rear enclosure assembly, and main chassis assembly as described in *Section 7.2.8*.
2. Remove the power supply PWA as described in *Section 7.2.13.1*.
3. Remove the display/CPU assembly as described in *Section 7.2.13.2*.
4. Using the flat blade screwdriver, remove the two 4-40 hex screws securing the splash guard and piezo alarm to the main chassis.

   Note: Note the alignment of the piezo alarm assembly connecting wires, and verify the replacement assembly is aligned the same way.
5. Install the replacement piezo alarm assembly in the exact reverse order of removal.
6. Reassemble the display/CPU assembly and power supply PWA in the exact reverse order of removal.

To verify successful piezo alarm assembly replacement, perform the PVT in *Section 5.2*.

7.2.13.5
MECHANISM ASSEMBLY REPLACEMENT

The recommended tools for this procedure are a medium size flat blade screwdriver, No. 2 Phillips screwdriver, and diagonal cutters.

The replacement parts for this procedure are:

Assembly, Mechanism
Screw, 4-24 x 1/4, Pan Head, Phillips
Screw, 6-32 x 3/8, Hex Head, Slotted, with Washer
Bumper, Mechanism Chassis
Tie, Cable

Note: Replacing the mechanism changes the biomed settings to those stored in the mechanism.

To replace the mechanism assembly, refer to *Figure 7-13, Mechanism Assembly Replacement*, then proceed as follows:

1. Separate the front enclosure assembly, rear enclosure assembly, and main chassis assembly as described in *Section 7.2.8*.

2. Using diagonal cutters, cut the cable tie that secures the power supply/driver cable.
3. Using the flat blade screwdriver, remove the 6-32 hex screw securing the mechanism assembly to the main chassis assembly.
4. Remove and inspect the two mechanism chassis bumpers and replace, if necessary.
5. Slide the mechanism assembly away from the main chassis assembly.
6. Unlock and disconnect the CPU/driver cable from J11 on the mechanism assembly, and remove the mechanism assembly.
7. Install the replacement mechanism assembly in the exact reverse order of removal.
8. Replace the cable tie.

To verify successful mechanism assembly replacement, perform the PVT in *Section 5.2*.

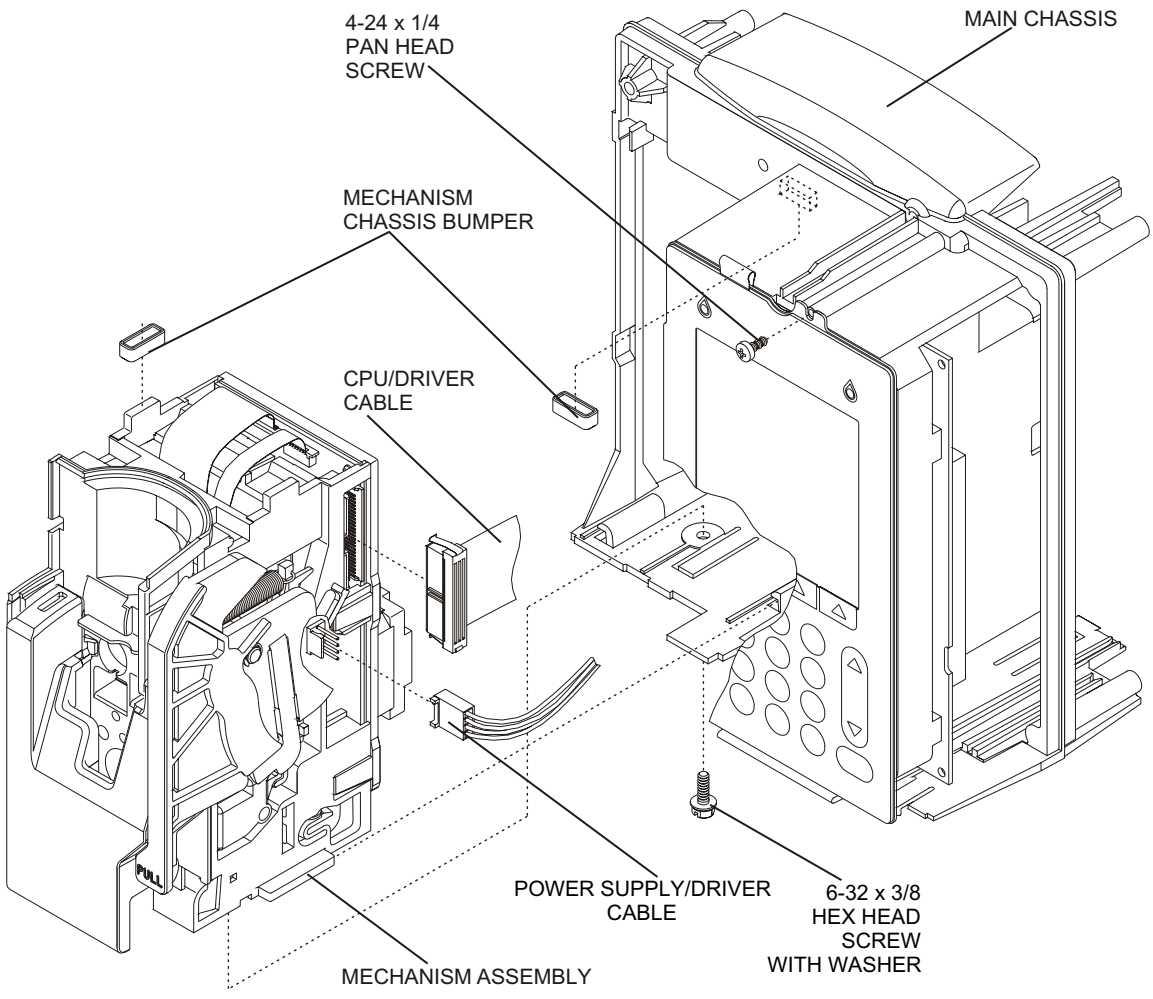


Figure 7-13. Mechanism Assembly Replacement

7.2.13.6
CASSETTE DOOR AND FLUID SHIELD REPLACEMENT

Recommended tools for this procedure are a medium size flat-blade screwdriver and long needle nose pliers.

The replacement parts for this procedure are:

Assembly, Cassette Door
Assembly, Fluid Shield
Cap, Door Pivot
Screw, 4-40 x 3/8, Hex Head, Slotted, with Washer

To replace the cassette door and fluid shield, refer to *Figure 7-14, Fluid Shield Replacement*, and *Figure 7-15, Cassette Door and Opener Handle Replacement*, then proceed as follows:

1. Separate the front enclosure assembly, rear enclosure assembly, and main chassis assembly as described in *Section 7.2.8*.
2. Remove the mechanism assembly as described in *Section 7.2.13.5*.
3. Using the flat blade screwdriver, remove the 4-40 hex screw securing the door pivot cap to the mechanism assembly.
4. Disengage the cassette door from the opener handle assembly, and remove the door.
5. Disengage the clips on the back side of the fluid shield that retain the upper portion of the shield to the mechanism assembly.
6. Disconnect the fluid shield/driver flex connector from J12 on the driver PWA.

   Note: Lift the locking pins of J12 to release the flex connector.

7. Pull the shield away from the top of the mechanism assembly at an approximate 15-degree angle. Pull the shield up and away, clearing the mechanism assembly pins and plunger.
8. Install the replacement fluid shield in the exact reverse order of removal.

   Note: Prior to fluid shield replacement, align the mechanism assembly pins.

9. Install the replacement cassette door in the exact reverse order of removal.
10. Replace the mechanism assembly in the exact reverse order of removal.

To verify successful cassette door and fluid shield replacement, perform the PVT in *Section 5.2*.

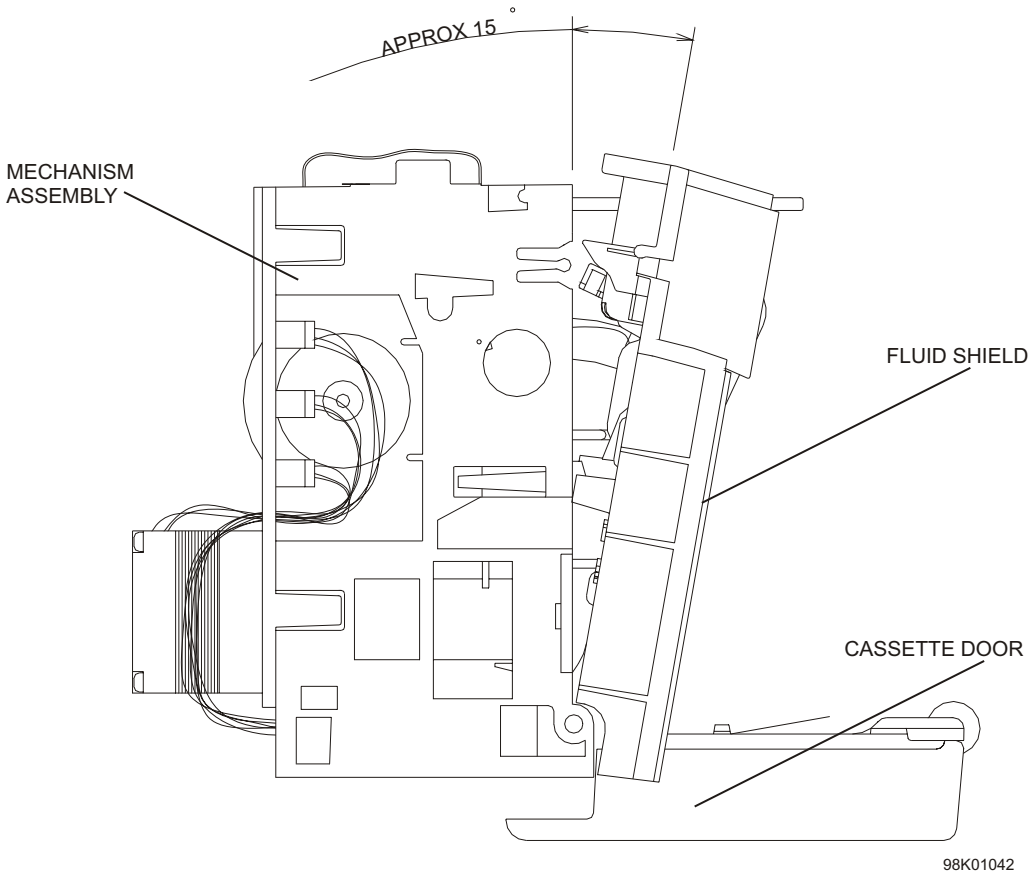


Figure 7-14. Fluid Shield Replacement

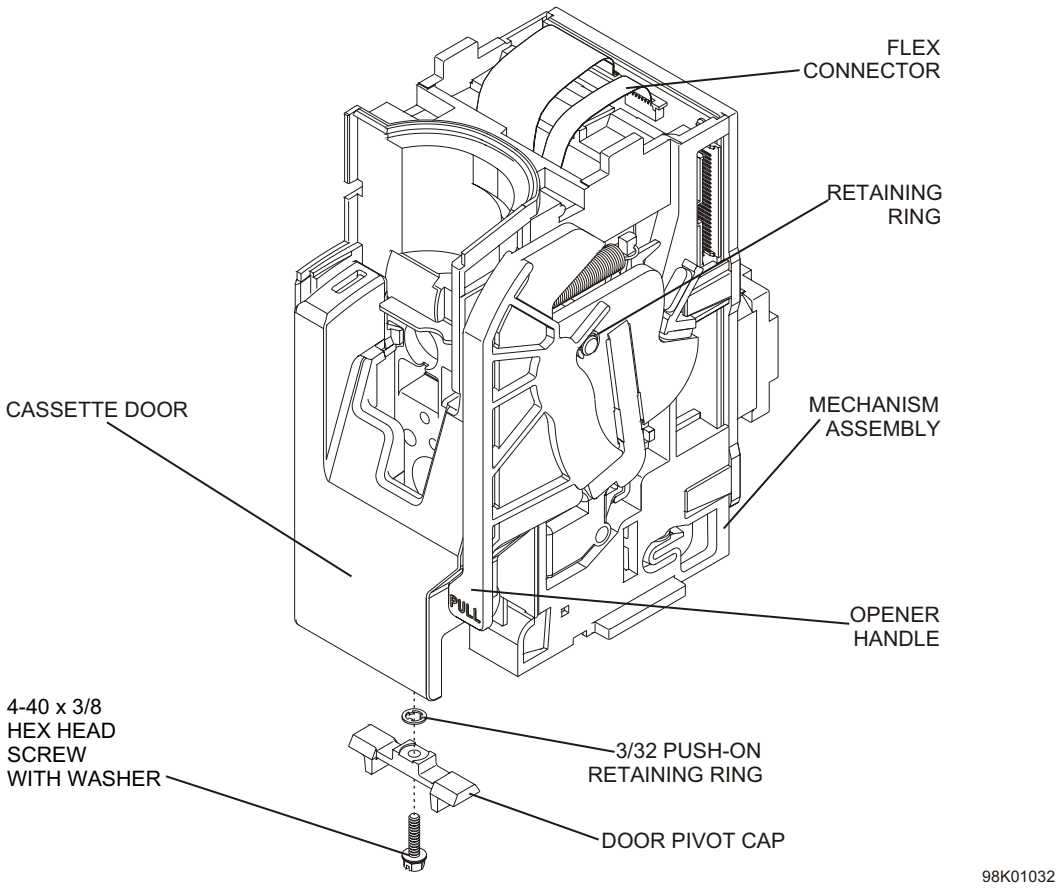


Figure 7-15. Cassette Door and Opener Handle Replacement

7.2.13.7

OPENER HANDLE ASSEMBLY REPLACEMENT

The recommended tool for this procedure is a medium size flat blade screwdriver.

The replacement parts for this procedure are:

Assembly, Opener Handle
Ring, Retaining, Push-On, 3/32

To replace the opener handle assembly, refer to *Figure 7-15*, then proceed as follows:

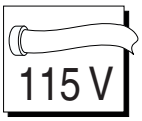
1. Separate the front enclosure assembly, rear enclosure assembly, and main chassis assembly as described in *Section 7.2.8*.
2. Remove the mechanism assembly as described in *Section 7.2.13.5*.
3. Open the cassette door. Disengage and fully open the cassette door from the opener handle assembly *(see Figure 7-14)*.
4. Close the opener handle assembly.
5. Remove and inspect the retaining ring, and replace, if necessary.
6. Insert the flat blade screwdriver between the opener handle assembly and the mechanism assembly, and carefully pry the assemblies apart.
7. Install the replacement opener handle assembly in the exact reverse order of removal. Confirm the opener handle is aligned properly.
8. Replace the mechanism assembly in the exact reverse order of removal.

To verify successful opener handle assembly replacement, perform the PVT in *Section 5.2*.

Section 8

SPECIFICATIONS

8.1
PLUM A+ DOMESTIC (110 V_{AC})



The following specifications apply to the Plum A+ domestic infusion system.

PHYSICAL

Dimensions: Approximately 8.0 H x 8.0 W x 6.0 D inches (excluding pole clamp and power cord storage)

Weight: Approximately 9.5 lbs (with battery)

Casing: High-impact plastic

ELECTRICAL

Power Requirements: 120 V_{AC}, 50-60 Hz, 35 W

Power Cord: Hospital-grade AC cord. 10 feet, with transparent plug and retainer plate

Fuses: 0.5 A, 250 V_{AC}

Battery: Sealed lead acid, rechargeable 6 V battery, internal

Battery Operation: A fully charged new battery provides six hours of operation at 125 mL/hr, or delivers 500 mL on one line, whichever occurs first. Operation time is measured from initial pumping to the Depleted Battery alarm. The infusion pump should be operated on battery power for six continuous hours every six months for optimum performance and battery life.

Recharge: The battery charges whenever the infusion pump is connected to AC power. If the infusion pump is operating at 125 mL/hr or less, a full recharge takes less than six hours.

Self-Discharge: 50% of charge is retained for a minimum of one month when the infusion pump is not connected to AC power or is not operating.

Nurse Call System: Circuitry Ratings: Voltage - 30 V_{DC} Max
Current - 0.25 A max
Contact Rating - 3 W max

Default: Normally-open (NO)

Contact Hospira Technical Support Operations to make an internal adjustment to change the device from normally-open to normally-closed (NC).

ENVIRONMENT

Operating: 41° to 104° F (5° to 40° C) 10% to 90% relative humidity

Transporting and Storage: -4° to 140° F (-20° to 60° C) 10% to 90% relative humidity

Atmospheric Pressure: 0 - 10,000 feet (0 - 3000 meters) or equivalent atmospheric pressure

Relative Humidity: 10 - 90% (104° F max)

DELIVERY RATE RANGE

Lines A and B: 0.1 to 99.9 mL/hr (in 0.1 mL/hr increments)
100 to 999 mL/hr (in 1 mL/hr increments)

Concurrent Delivery: 0.5 mL/hr minimum for each line

PlumSet: 500 mL/hr cumulative (A+B) maximum

KVO: 1.0 mL/hr or the last primary delivery rate, whichever is less

VTBI Range: 0.1 to 99.9 mL (in 0.1 mL/hr increments)
100 to 9999 mL (in 1 mL/hr increments)

OCCLUSION ALARM AND LIMITS

Distal: The distal occlusion alarm sounds after the distal tubing or set outlet fitting becomes occluded.

Proximal: The proximal occlusion alarm sounds within two pumping cycles when the tubing proximal to the cassette becomes occluded.

Distal Pressure Limit (without alarm): 1 to 15 psi. The maximum pressure limit is user-selectable. Factory setting is 6 psi.

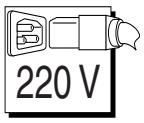
Maximum Infusion Pressure: 20 psi

AIR-IN-LINE ALARM

PlumSet (Distal): Bolus: 0.5 mL of air or larger
Cumulative: 0.5 mL of air out of 5.3 mL of fluid

PlumSet (Proximal): Bolus at 0.5 mL, total 1.0 mL (0.5 ml concurrent)

8.2
PLUM A+ INTERNATIONAL (220 V_{AC})



The following specifications apply to the Plum A+ International.

PHYSICAL

Dimensions: Approximately 20.3 H x 20.3 W x 15.2 D centimeters (excluding pole clamp and power cord storage)

Weight: Approximately 4.3 kg (with battery)

Casing: High-impact plastic

ELECTRICAL

Power Requirements: 210 - 260 V_{AC}, 47 - 63 Hz, 35 VA

Mains Fusing: Two 0.5 A slow-blow fuses

Mains Cord: IEC-601-1 approved, removable cord, 3 meters in length

Battery: One sealed, rechargeable 6 V battery, internal

Battery Operation: A fully charged new battery provides six hours of operation at 125 mL/hr, or delivers 500 mL on one line, whichever occurs first. Operation time is measured from initial pumping to the Depleted Battery alarm. The infusion pump should be operated on battery power for six continuous hours every six months for optimum performance and battery life.

Recharge: The battery recharges whenever the infusion pump is connected to AC power. If the infusion pump is operating at 125 mL/hr or less on one line, a full recharge takes less than six hours.

ENVIRONMENT

Operating: 5° to 40° C (41° to 104° F) 10% to 90% relative humidity

Transporting and Storage: -20° to 60° C (-4° to 140° F) 10% to 90% relative humidity

Atmospheric Pressure: 0 - 10,000 feet (0 - 3000 meters) or equivalent atmospheric pressure

Relative Humidity: 10 - 90% (40° C max)

DELIVERY RATE RANGE

Lines A and B: 0.1 to 99.9 mL/hr (in 0.1 mL/hr increments)
100 to 999 mL/hr (in 1 mL/hr increments),

Concurrent Delivery: 0.5 mL/hr minimum for each line

PlumSet: 500 mL/hr cumulative (A+B) maximum

KVO: 1.0 mL/hr or the last primary delivery rate, whichever is less

VTBI Range: 0.1 to 99.9 mL (in 0.1 mL/hr increments)
100 to 9999 mL (in 1 mL/hr increments)

OCCLUSION ALARM AND LIMITS

Distal: The distal occlusion alarm sounds after the distal tubing or set outlet fitting becomes occluded.

Proximal: The proximal occlusion alarm sounds within two pumping cycles when the tubing proximal to the cassette becomes occluded.

Distal Pressure Limit (without alarm): 51.7 mmHg to 776 mmHg. The maximum pressure limit is user-selectable. Factory setting is 310 mmHg.

Maximum Infusion Pressure: 1034 mmHg

AIR-IN-LINE ALARM

PlumSet (Distal): Bolus: 0.5 mL of air or larger
Cumulative: 0.5 mL of air out of 5.3 mL of fluid

PlumSet (Proximal): Bolus at 0.5 mL, total 1.0 mL (0.5 mL concurrent)

Section 9
DRAWINGS

Figure 9-1 through *Figure 9-17* show the illustrated parts breakdown (IPB), infusion pump assembly diagrams, and PWA schematic diagrams. *Table 9-1, Drawings*, lists drawings by figure number, title, and part number. *Table 9-2, IPB for the Infusion Pump*, identifies parts by index numbers which correlate to *Figure 9-1*.

Note: Drawings and schematics in *Section 9* are provided as information only. Drawings and schematics may not exactly reflect current product configuration.

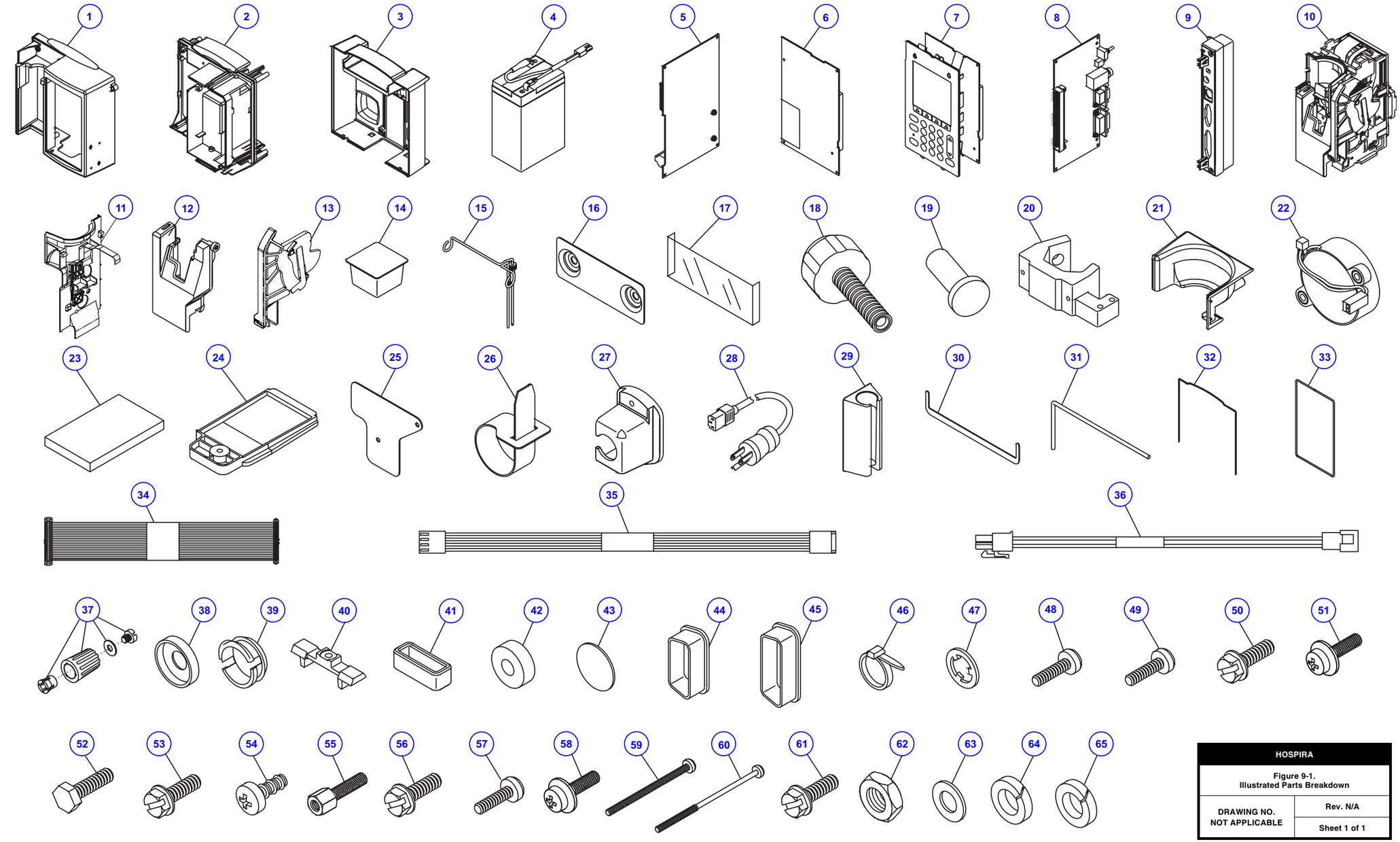
Table 9-1. Drawings

Figure Number	Title	Drawing Number
9-1	Illustrated Parts Breakdown	Not Applicable
9-2	Front Enclosure, Rear Enclosure, and Main Chassis Assemblies	
9-3	Front Enclosure Assembly	
9-4	Rear Enclosure Assembly	
9-5	Peripheral Assembly	
9-6	Main Chassis Assembly (3 Sheets)	
9-7	AC (Mains) Power Cord, Power Cord Retainer, and Battery	
9-8	Minipole Assembly	
9-9	CPU PWA and Main Chassis	
9-10	Mechanism Assembly	
9-11	Power Supply PWA Schematic (110 V) (15 Sheets)	249-95005
9-12	Peripheral PWA Schematic (4 Sheets)	249-95006
9-13	CPU PWA Schematic (10 Sheets)	249-95007
9-14	Driver PWA Schematic (6 Sheets)	249-95018
9-15	Switch PWA Schematic	249-95022
9-16	APP PWA Schematic (3 Sheets)	249-95034
9-17	Power Supply PWA Schematic (220 V) (5 Sheets)	249-95242

Table 9-2. IPB for the Infusion Pump		
Index Number	**Nomenclature**	**Replacement Procedure**
1	Enclosure, Front	*Section 7.2.9*
2	Chassis, Main	*Section 7.2.9*
3	Enclosure, Rear	*Section 7.2.9*
4	Assembly, Battery, with Wire Harness	*Section 7.2.4*
5	PWA, Power Supply	*Section 7.2.13.1*
6	PWA, CPU	*Section 7.2.13.3*
7	Assembly, Display/CPU	*Section 7.2.13.2*
8	PWA, Peripheral	*Section 7.2.6*
9	Cover, Peripheral Assembly	*Section 7.2.7.2*
10	Assembly, Mechanism	*Section 7.2.13.5*
11	Assembly, Fluid Shield	*Section 7.2.13.6*
12	Assembly, Cassette Door	*Section 7.2.13.6*
13	Assembly, Opener Handle	*Section 7.2.13.7*
14	Foot, Rubber	*Section 7.2.3*
15	Assembly, Minipole	*Section 7.2.12*
15A	Housing, Clutch, Minipole	*Section 7.2.12.3*
15B	Spring, Clutch, Minipole	*Section 7.2.12.4*
15C	Hanger, Bag, Minipole	*Section 7.2.12.2*
15D	Ring, Cotter, Minipole	*Section 7.2.12.1*
16	Plate, Backing, Pole Clamp	*Section 7.2.11.1*
17	Tape, Insulation, Backing Plate	*Section 7.2.11.1*
18	Assembly, Shaft/Knob, Pole Clamp	*Section 7.2.11.2*
19	Tip, Shaft, Pole Clamp	*Section 7.2.11.2*
20	Extrusion, Pole Clamp	*Section 7.2.11.1*
21	Shoe, Front Enclosure	*Section 7.2.9*
22	Assembly, Piezo Alarm	*Section 7.2.13.4*
23	Pad, Battery Door	*Section 7.2.4*
24	Door, Battery	*Section 7.2.4*
25	Splashguard	*Section 7.2.13.4*
26	Strap, Velcro, AC Power Cord	*Section 7.2.5*
27	Retainer, AC Power Cord	*Section 7.2.5*

Table 9-2. IPB for the Infusion Pump		
Index Number	**Nomenclature**	**Replacement Procedure**
28	Cordset, AC Power, Detachable	*Section 7.2.5*
29	Holder, Barcode Reader Wand	*Section 7.2.10.1*
30	Gasket, Handle	*Section 7.2.11.3*
31	Gasket, Shoe	*Section 7.2.10.2*
32	Gasket, Rear Enclosure	*Section 7.2.11.3*
33	Gasket, Front/Rear Enclosure	*Section 7.2.10.3*
34	Cable, CPU PWA/Driver PWA	*Section 7.2.13.2*
35	Cable, Power Supply PWA/Driver PWA	*Section 7.2.13.1*
36	Cable, Power Supply PWA/Battery	*Section 7.2.13.1*
37	Assembly, Volume Control Knob	*Section 7.2.7.1*
38	Cover, Nut	*Section 7.2.7.1*
39	Cap, Knob	*Section 7.2.7.1*
40	Cap, Door Pivot	*Section 7.2.13.6*
41	Bumper, Mechanism	*Section 7.2.13.5*
42	Spacer, Nylon	*Section 7.2.7.1*
43	Seal, Nylon	*Section 7.2.7.2*
44	Cover, 9 pin	*Section 7.2.7.2*
45	Cover, 15 pin	*Section 7.2.7.2*
46	Tie, Cable	*Section 7.2.13.5*
47	Ring, Retaining, Push-On, 3/32	*Section 7.2.13.7*
48	Screw, 4-24 x 1/4, Pan Head, Phillips	As applicable
49	Screw, 4-40 x 1/4, Pan Head, Phillips	As applicable
50	Screw, 4-40 x 1/4, Hex Head, Slotted, with Washer	As applicable
51	Screw, 4-40 x 3/8, Pan Head, Phillips, with Washer	As applicable
52	Screw, 4-40 x 3/8, Hex Head, Nylon	As applicable
53	Screw, 4-40 x 3/8, Hex Head, Slotted, with Washer	As applicable
54	Screw, 4-40 x 1/2, Pan Head, Square Cone, Phillips	As applicable
55	Screw, Jack, 4-40 x 7/16	As applicable
56	Screw, 6-32 x 3/8, Hex Head, Slotted, with Washer	As applicable
57	Screw, 6-32 x 1/2, Pan Head, Phillips	As applicable
58	Screw, 6-32 x 5/8, Pan Head, Phillips, with Washer	As applicable

Table 9-2. IPB for the Infusion Pump		
Index Number	**Nomenclature**	**Replacement Procedure**
59	Screw, 6-32 x 2 1/2, Pan Head, Phillips	As applicable
60	Screw, 6-32 x 3 1/4, Pan Head, Phillips	As applicable
61	Screw, 10-32 x 1/2, Hex Head, Slotted, with Washer	As applicable
62	Nut, 4-40, Hex	As applicable
63	Washer, Flat, .128 Dia., Nylon	As applicable
64	Washer, Lock, Split, #4	As applicable
65	Washer, Lock, Helical, #6	As applicable



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HOSPIRA	
Figure 9-1. Illustrated Parts Breakdown	
DRAWING NO. NOT APPLICABLE	Rev. N/A
	Sheet 1 of 1

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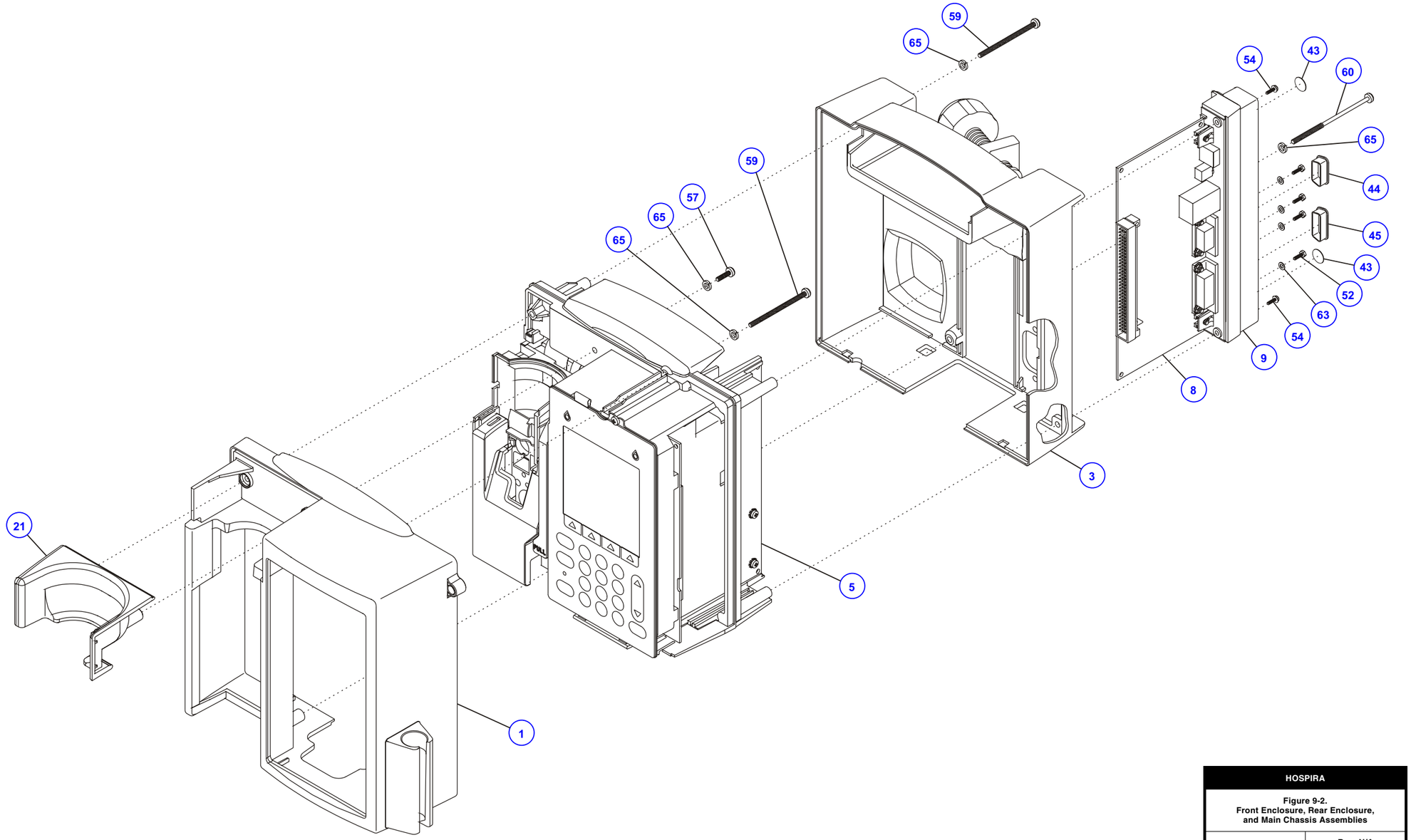

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Figure 9-2. Front Enclosure, Rear Enclosure, and Main Chassis Assemblies	
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	Sheet 1 of 1

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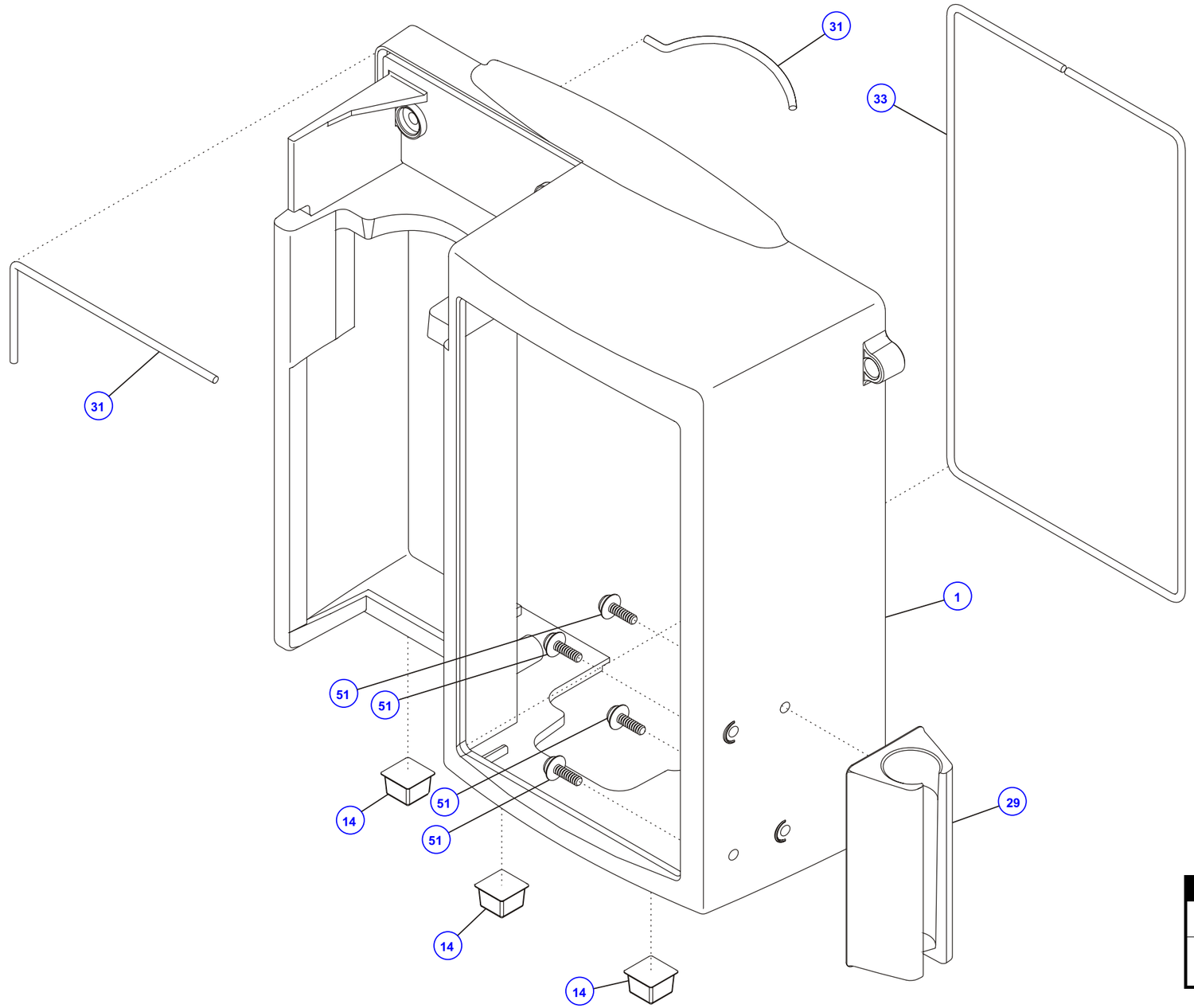

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Figure 9-3. Front Enclosure Assembly	
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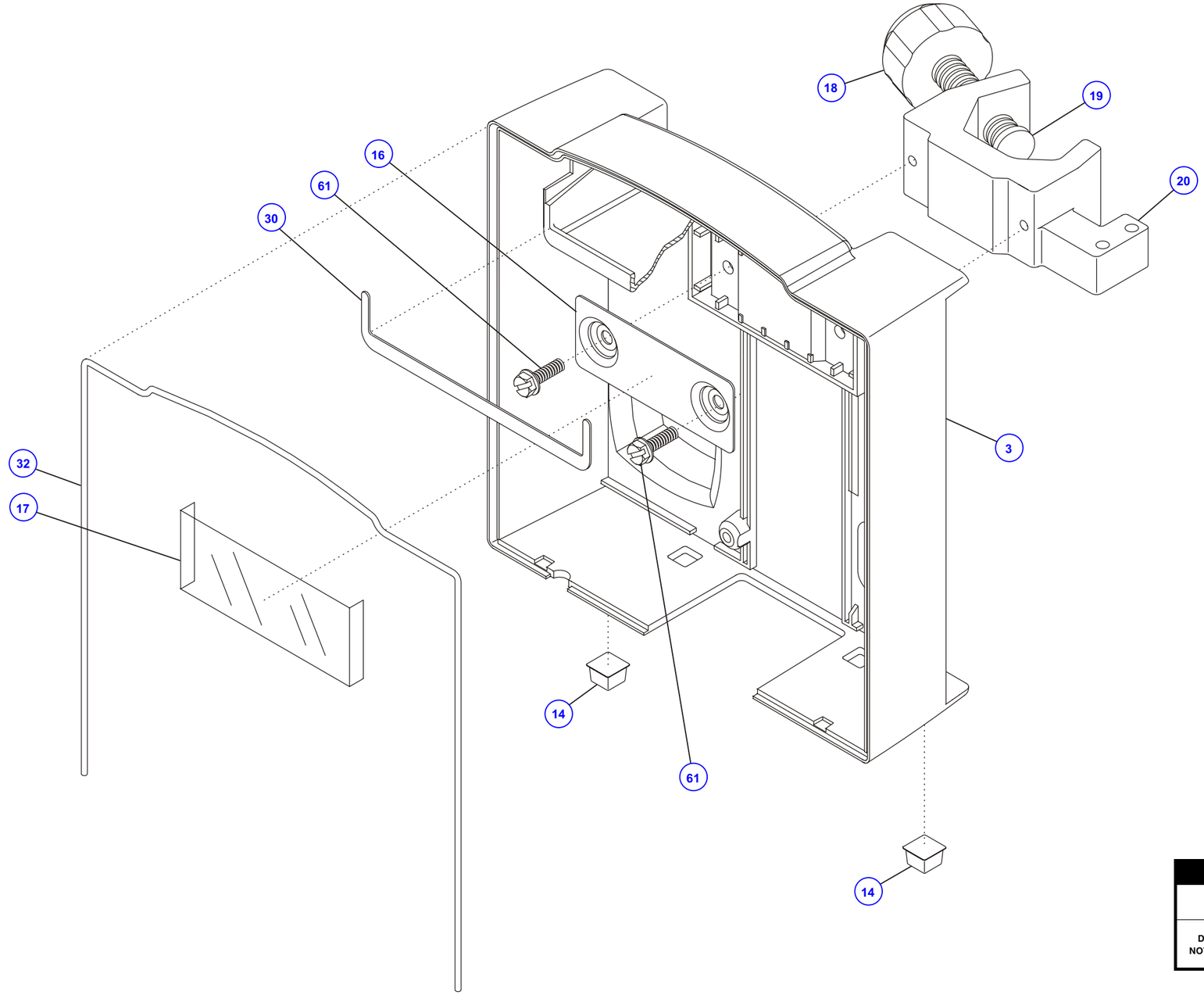

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HOSPIRA	
Figure 9-4. Rear Enclosure Assembly	
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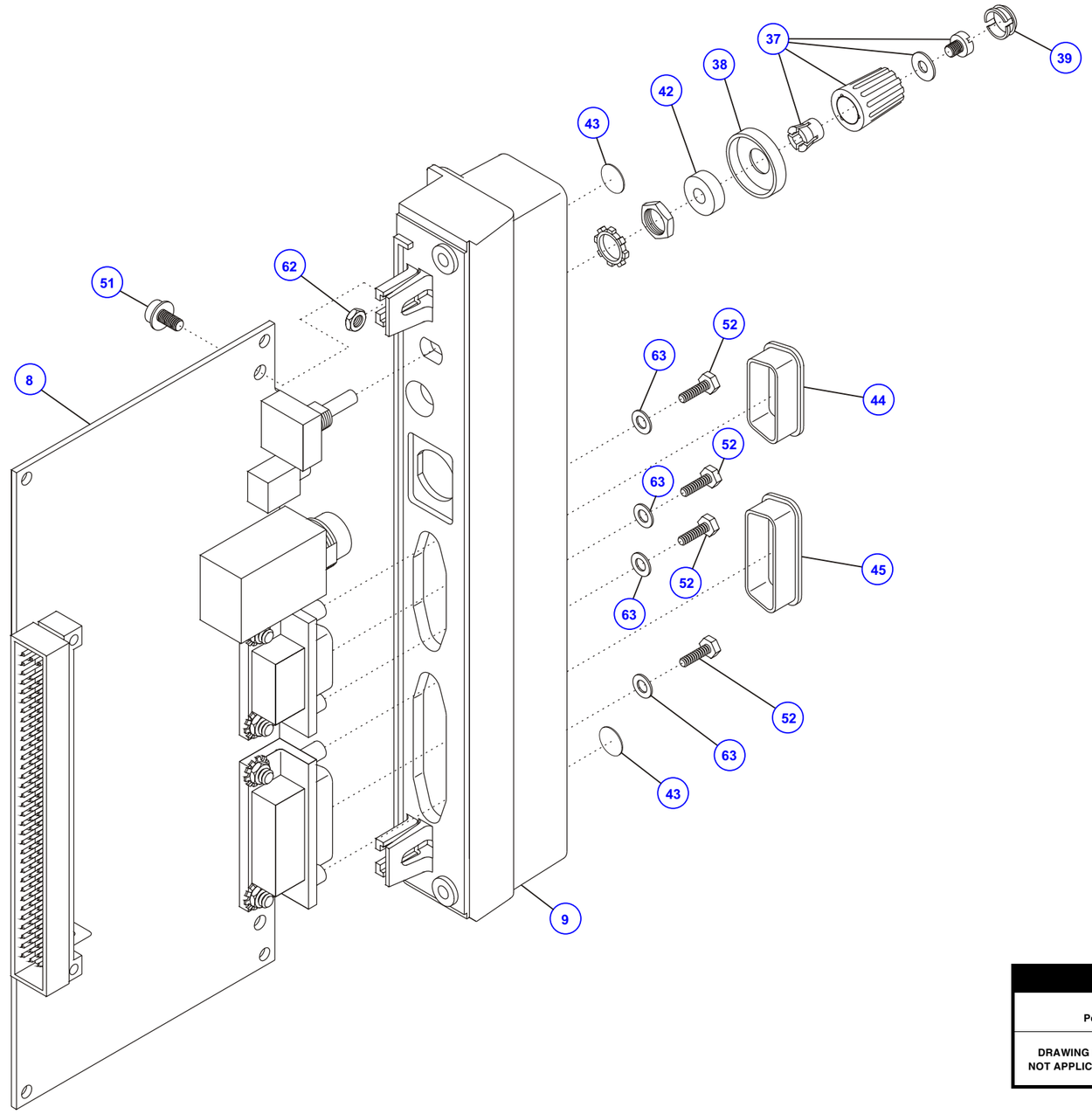

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Figure 9-5. Peripheral Assembly	
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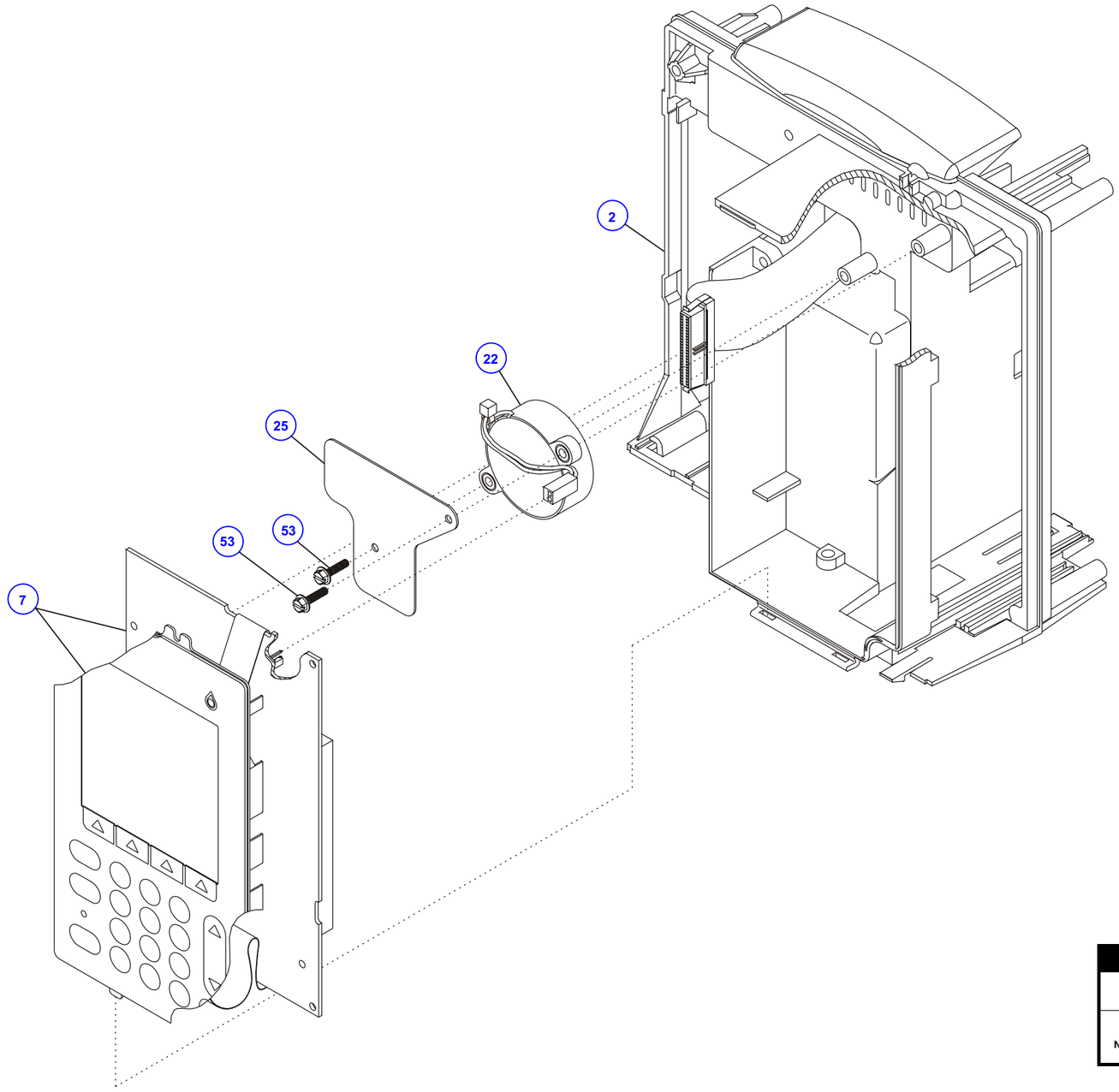

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HOSPIRA	
Figure 9-6. Main Chassis Assembly	
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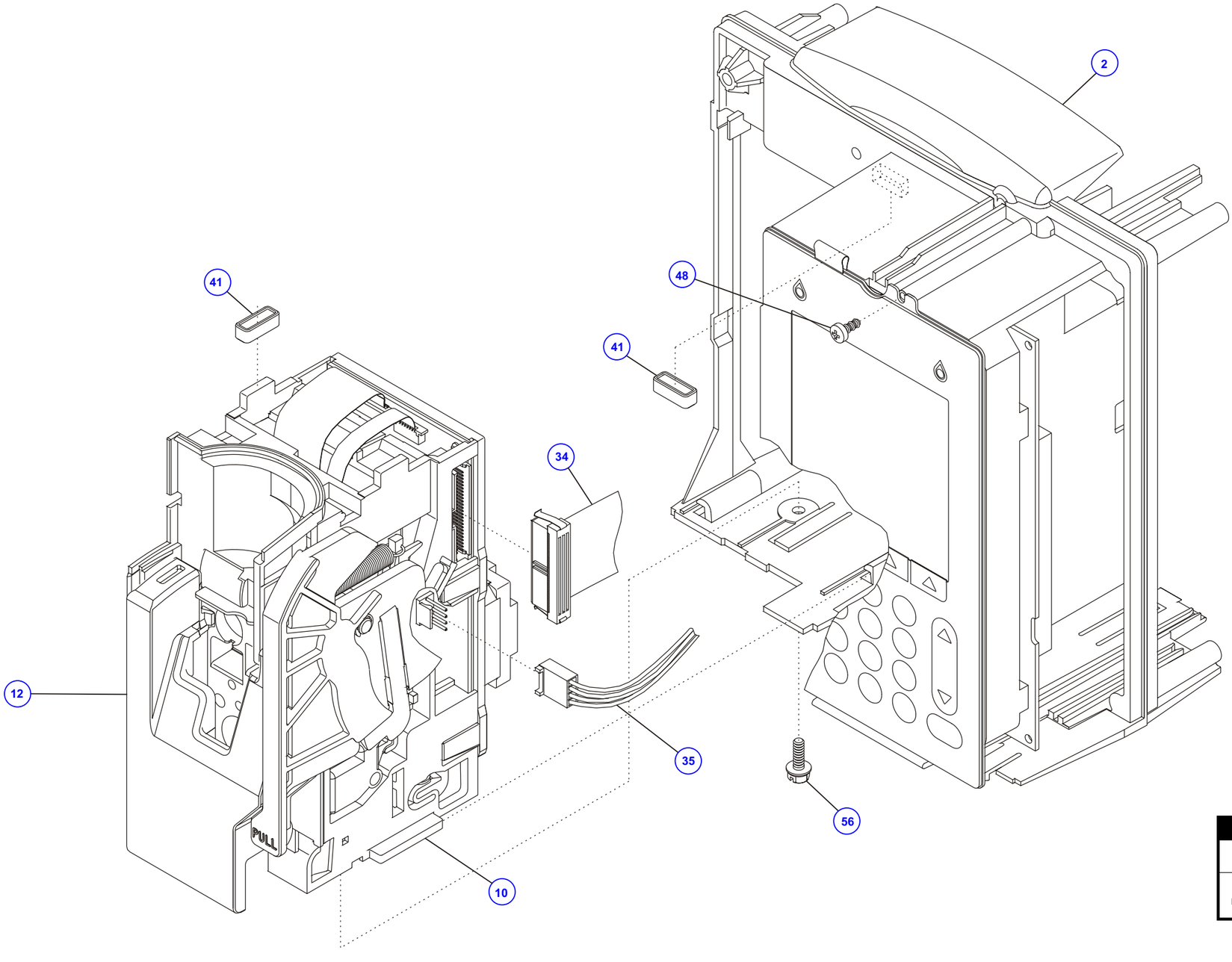

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HOSPIRA	
Figure 9-6. Main Chassis Assembly	
DRAWING NO. NOT APPLICABLE	Rev. N/A
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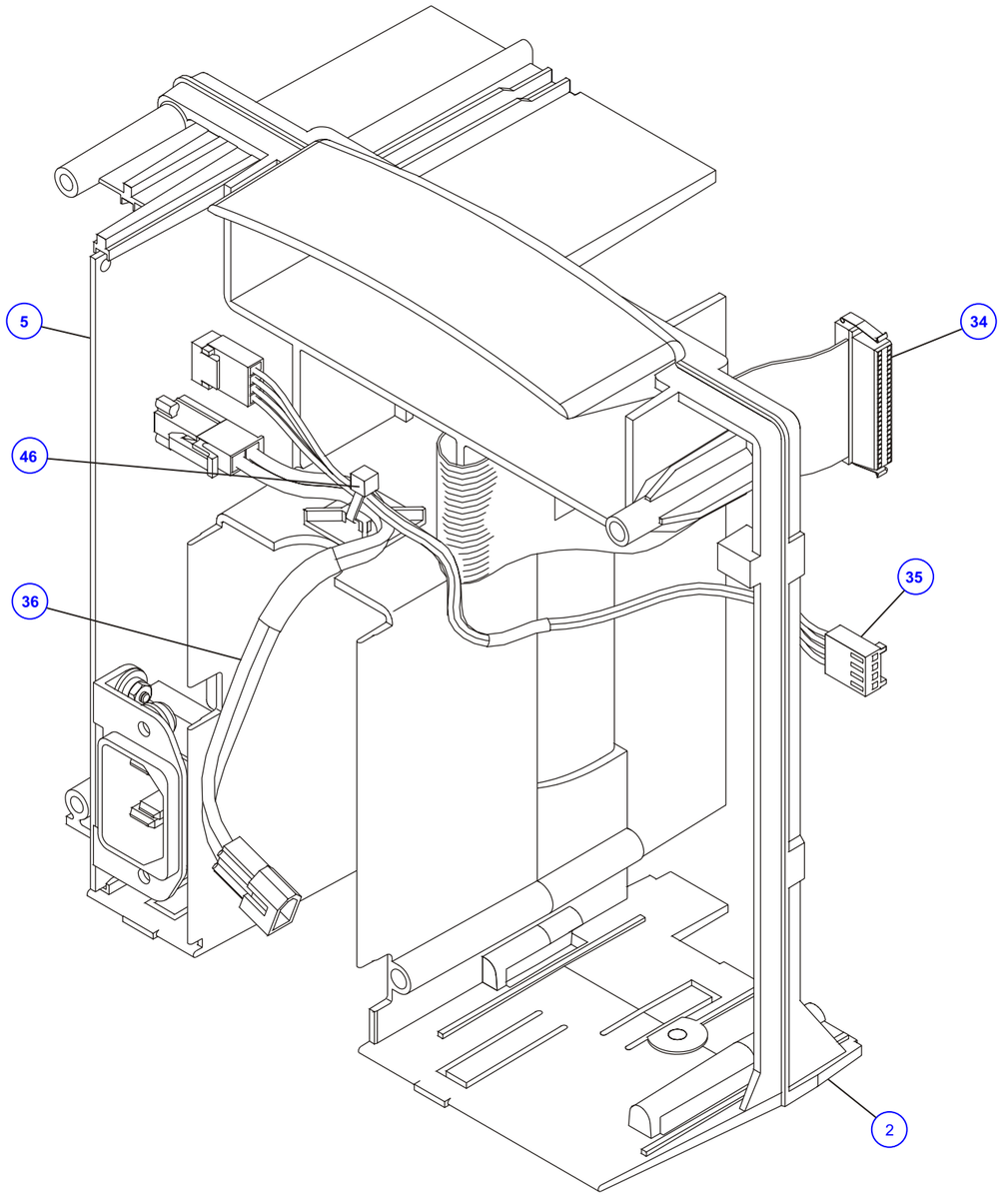

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HOSPIRA	
Figure 9-6. Main Chassis Assembly	
DRAWING NO. NOT APPLICABLE	Rev. N/A
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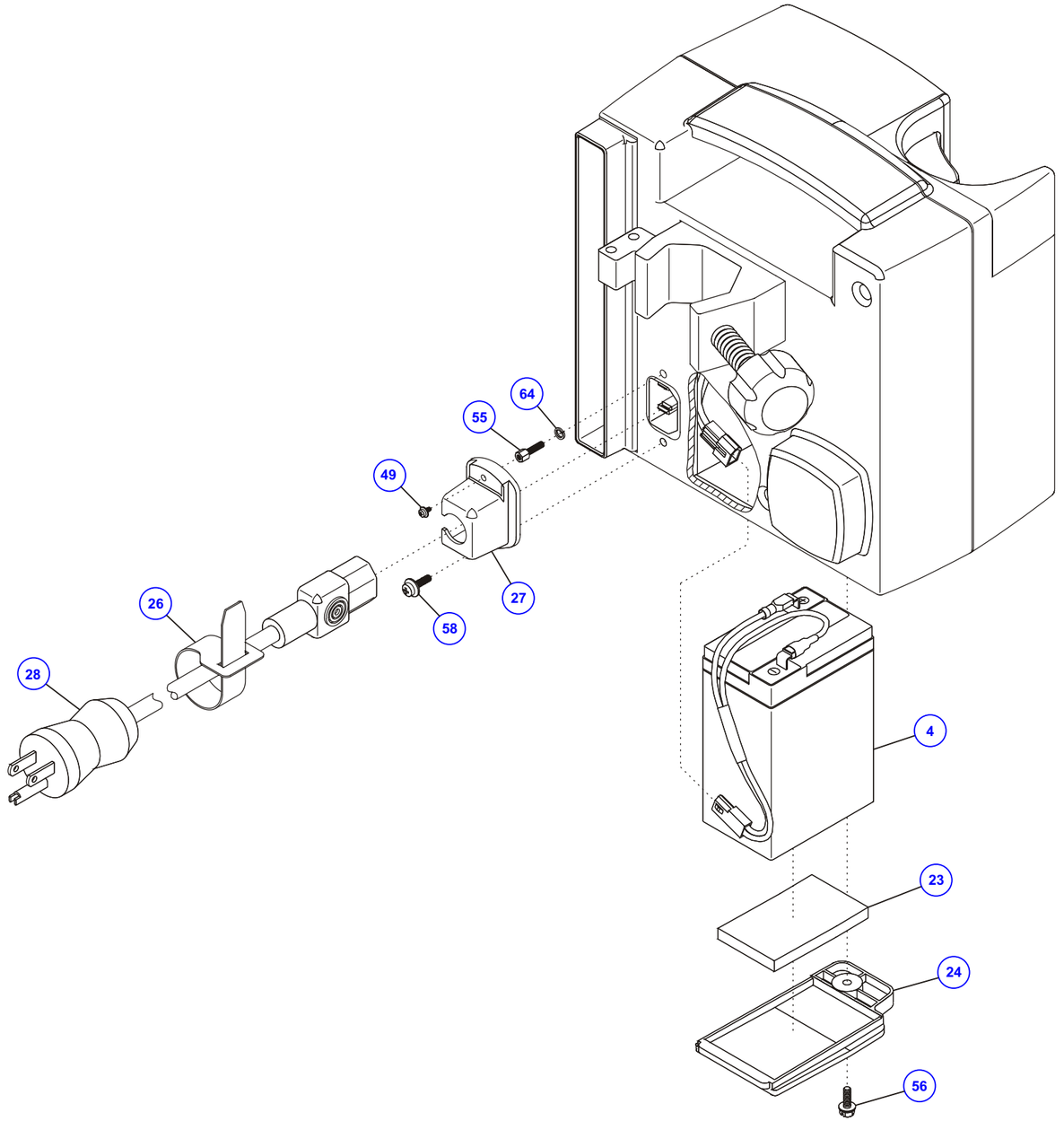

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HOSPIRA	
Figure 9-7. AC (Mains) Power Cord, Power Cord Retainer, and Battery	
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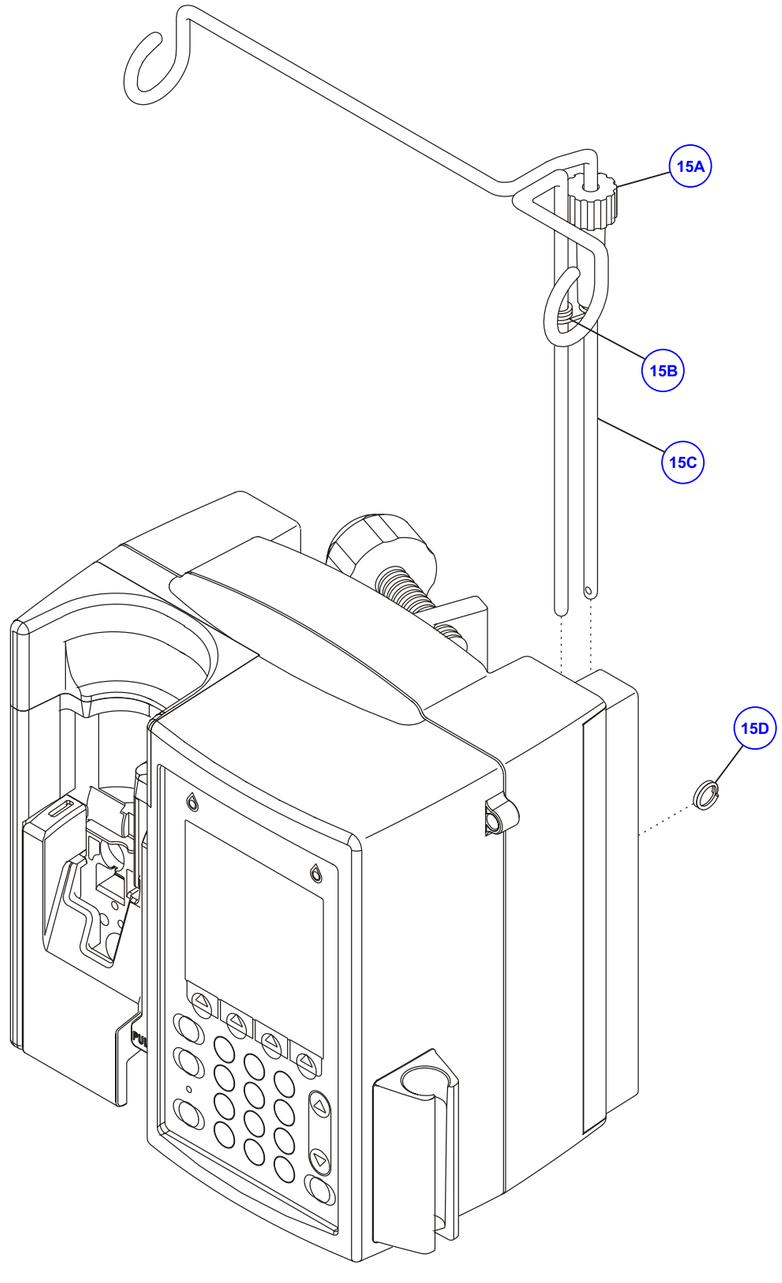

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Figure 9-8. Minipole Assembly	
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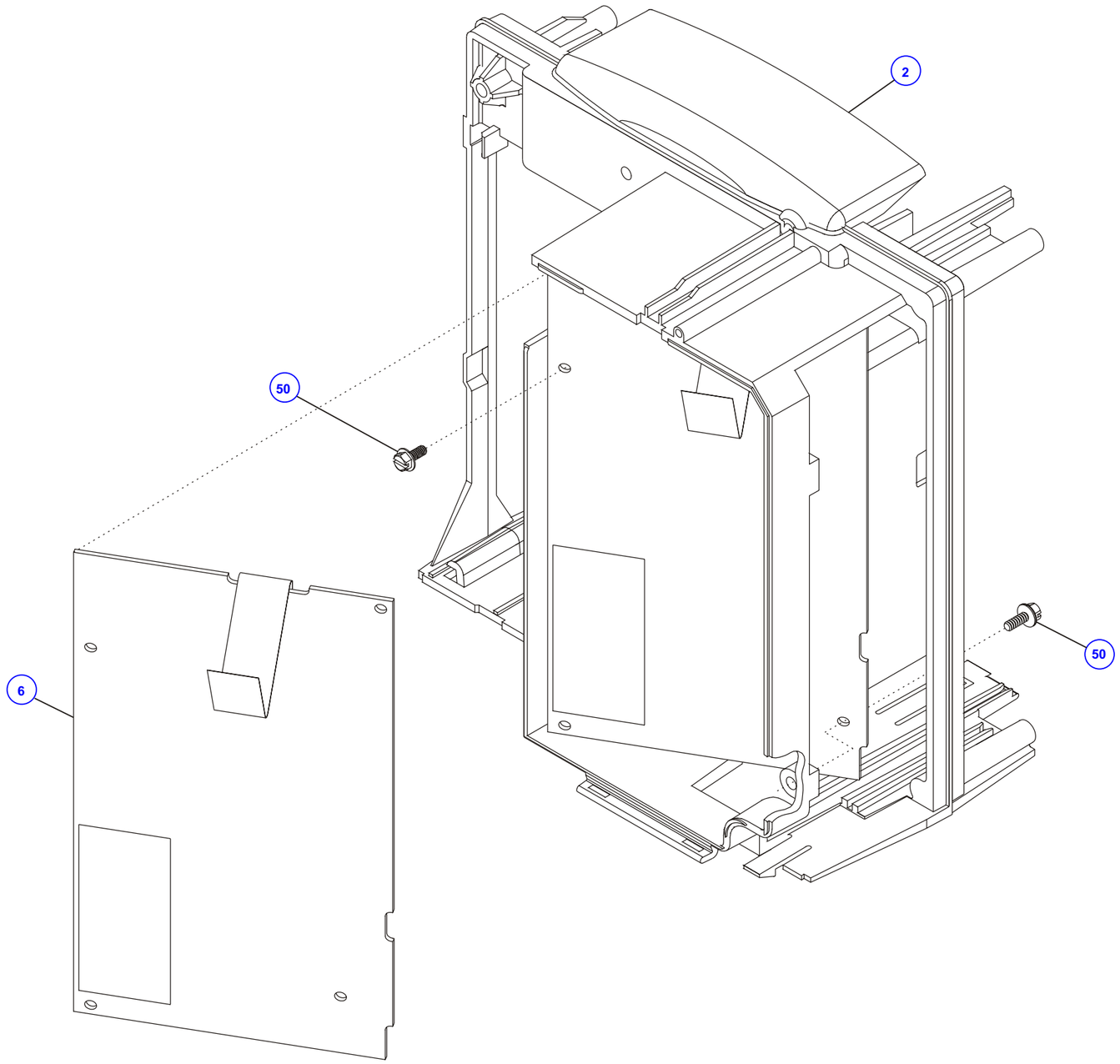

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HOSPIRA	
Figure 9-9. CPU PWA and Main Chassis	
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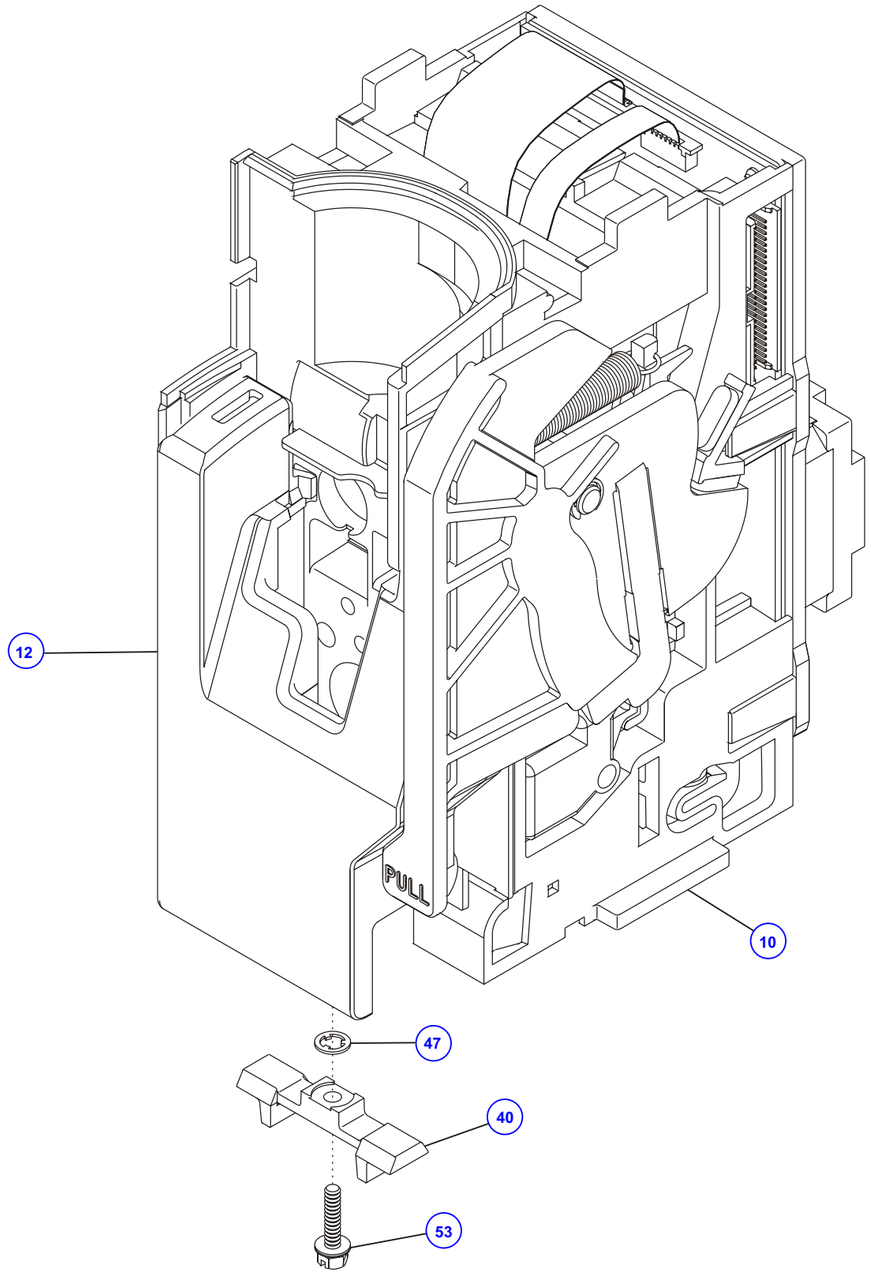

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Figure 9-10. Mechanism Assembly	
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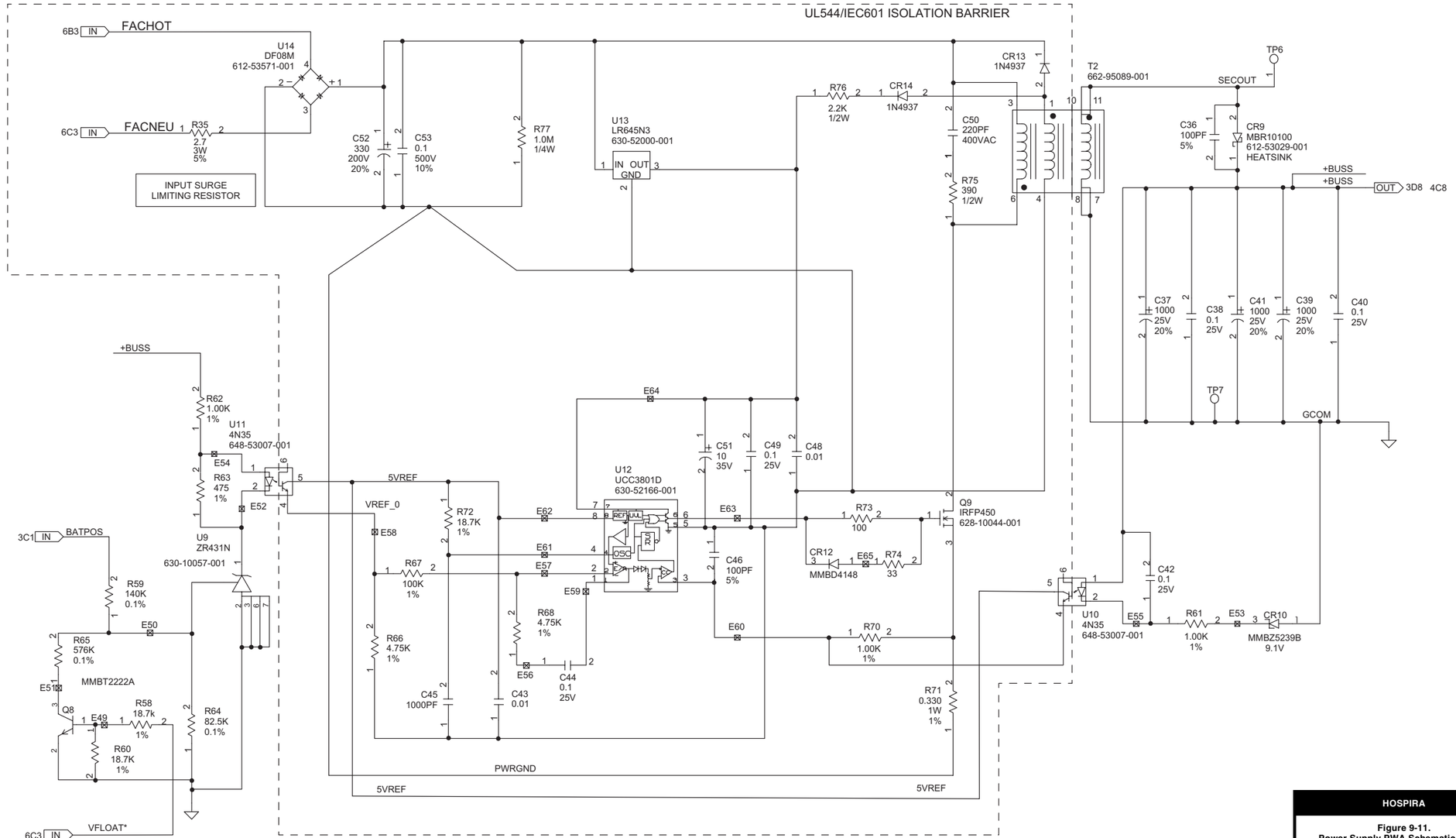

HOSPIRA	
Figure 9-11. Power Supply PWA Schematic (110 V)	
DRAWING NO. 249-95005-012	**Rev. M**
	Sheet 1 of 15

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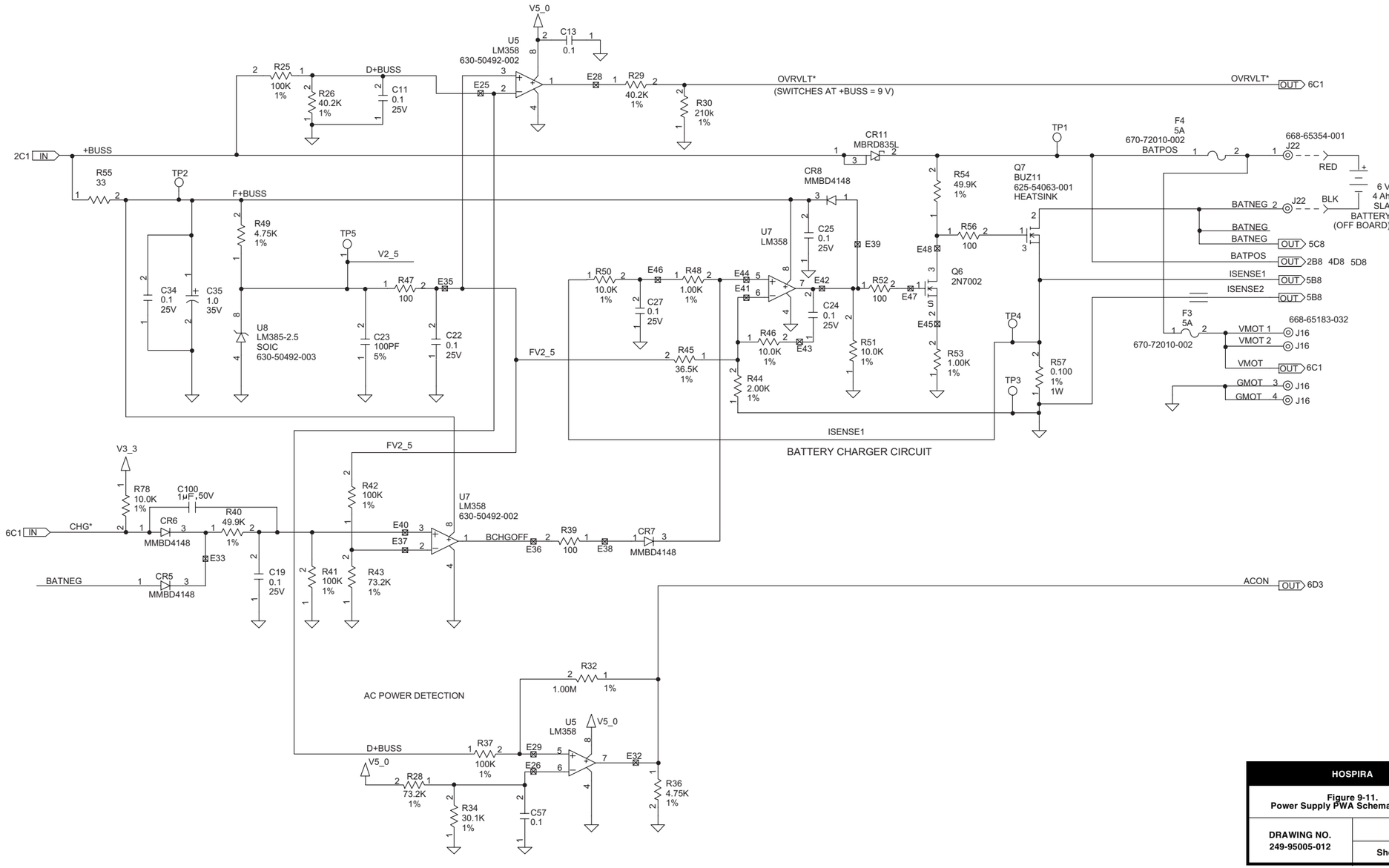

HOSPIRA	
Figure 9-11. Power Supply PWA Schematic (110 V)	
DRAWING NO. 249-95005-012	Rev. M
	Sheet 2 of 15

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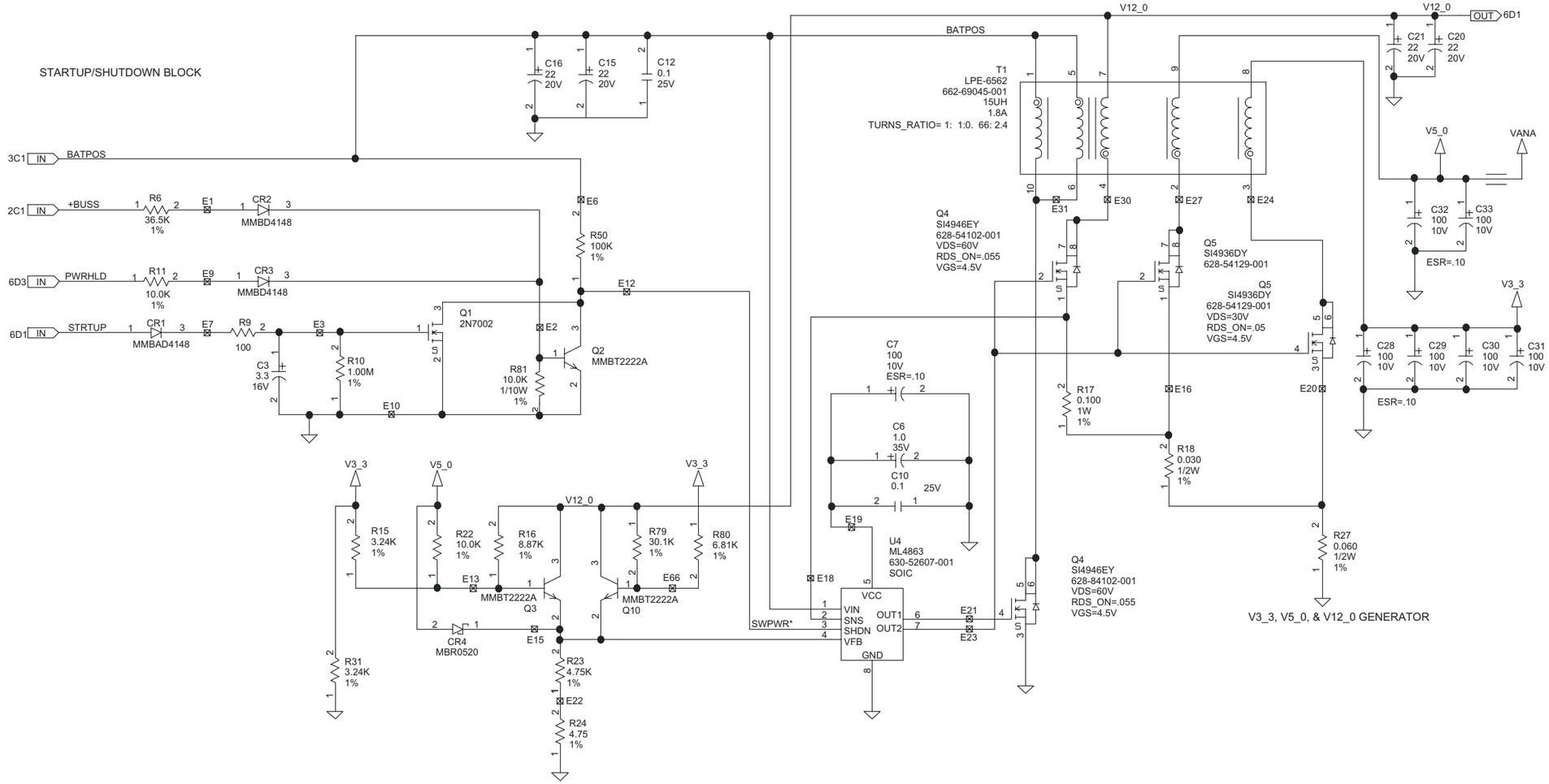

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Figure 9-11. Power Supply PWA Schematic (110 V)	
DRAWING NO. 249-95005-012	Rev. M
	Sheet 3 of 15

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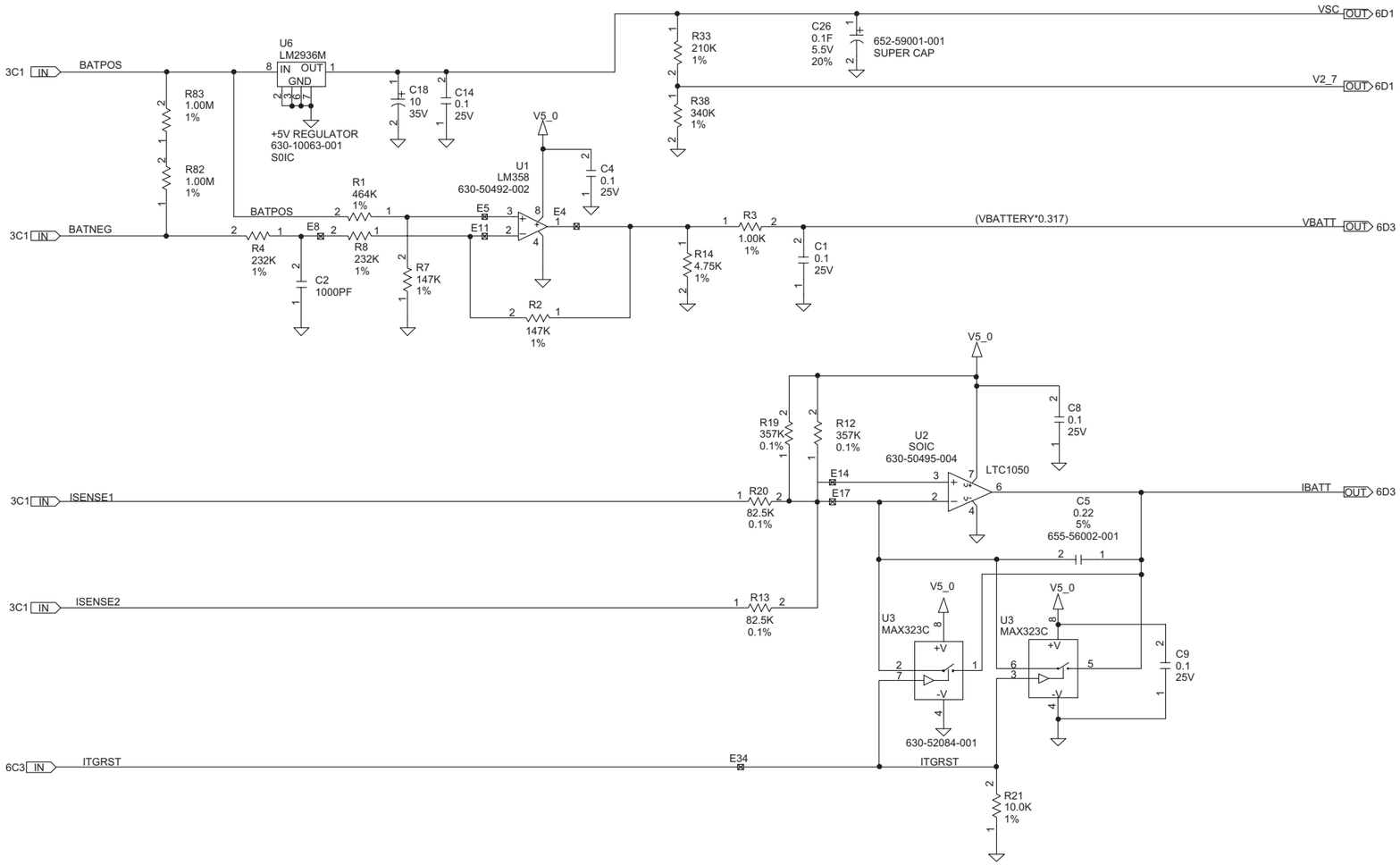

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Figure 9-11. Power Supply PWA Schematic (110 V)	
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	Sheet 4 of 15

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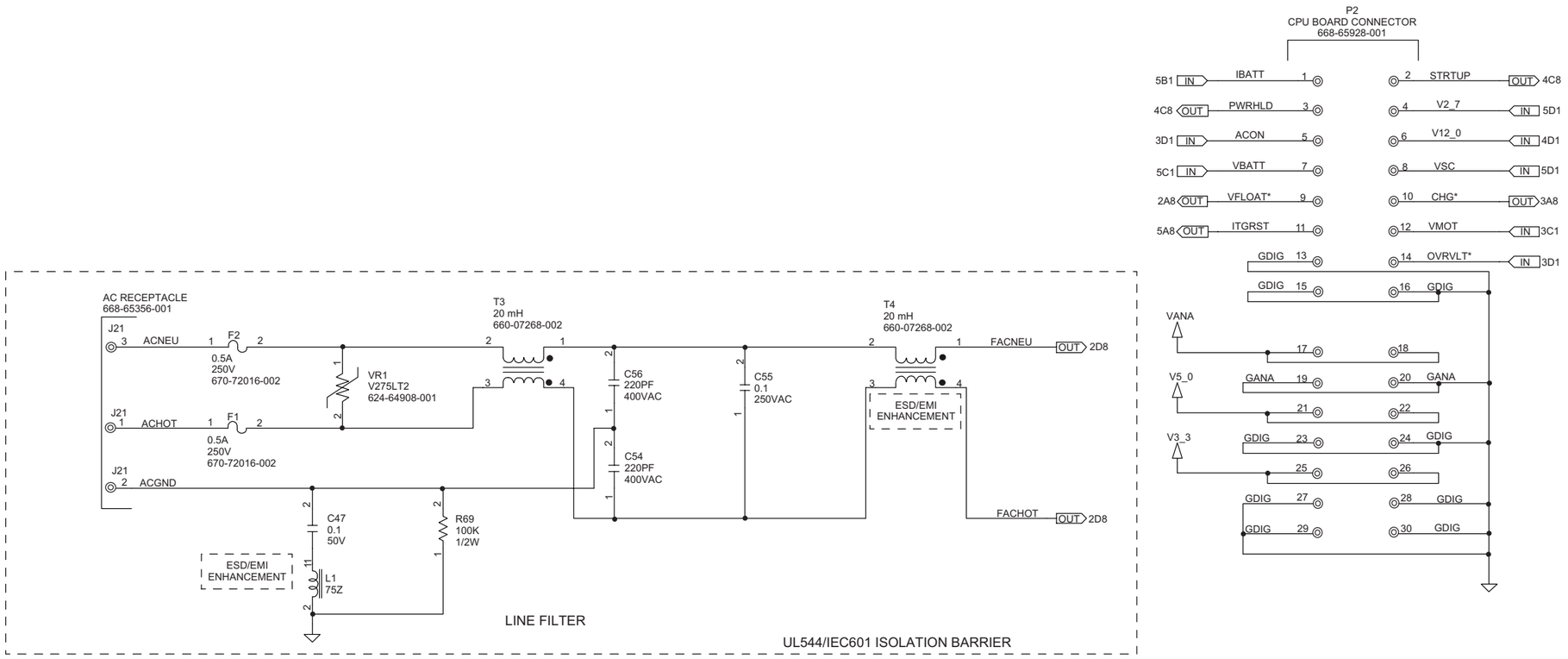

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Figure 9-11. Power Supply PWA Schematic (110 V)	
DRAWING NO. 249-95005-012	Rev. M
	Sheet 5 of 15

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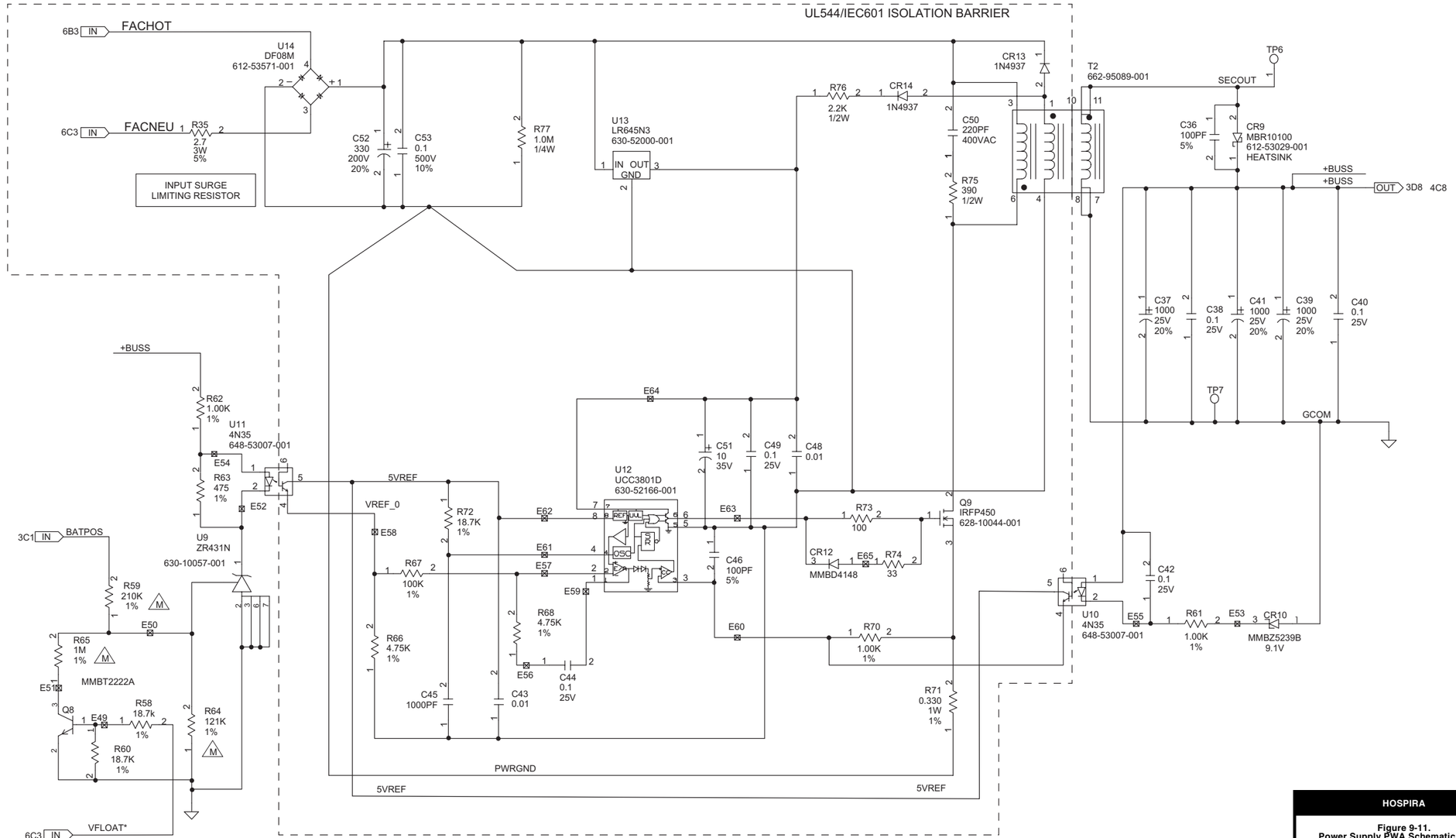

HOSPIRA	
Figure 9-11. Power Supply PWA Schematic (110 V)	
DRAWING NO. 249-95005-013	**Rev. M**
	Sheet 6 of 15

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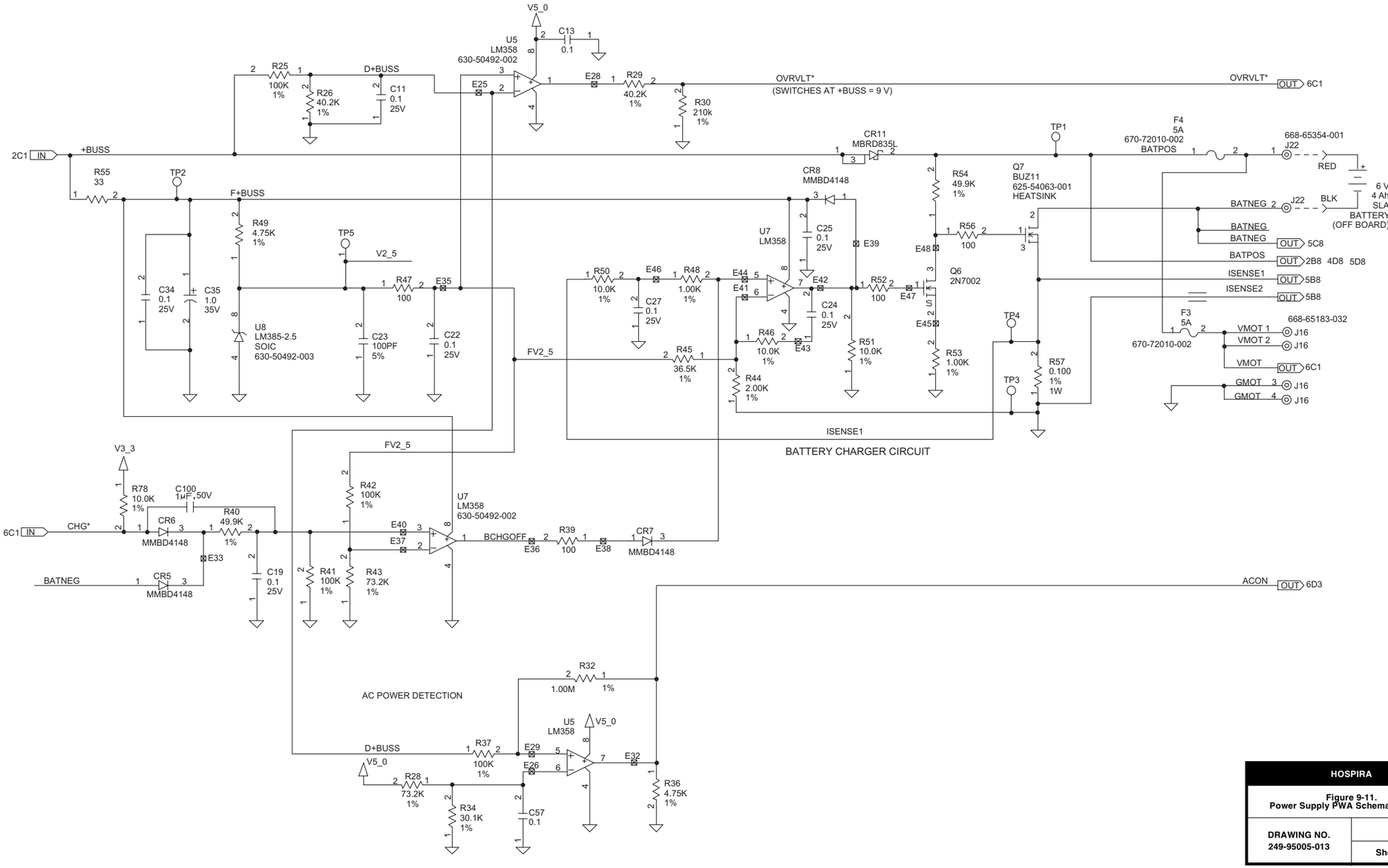

HOSPIRA	
Figure 9-11. Power Supply PWA Schematic (110 V)	
DRAWING NO. 249-95005-013	Rev. M
	Sheet 7 of 15

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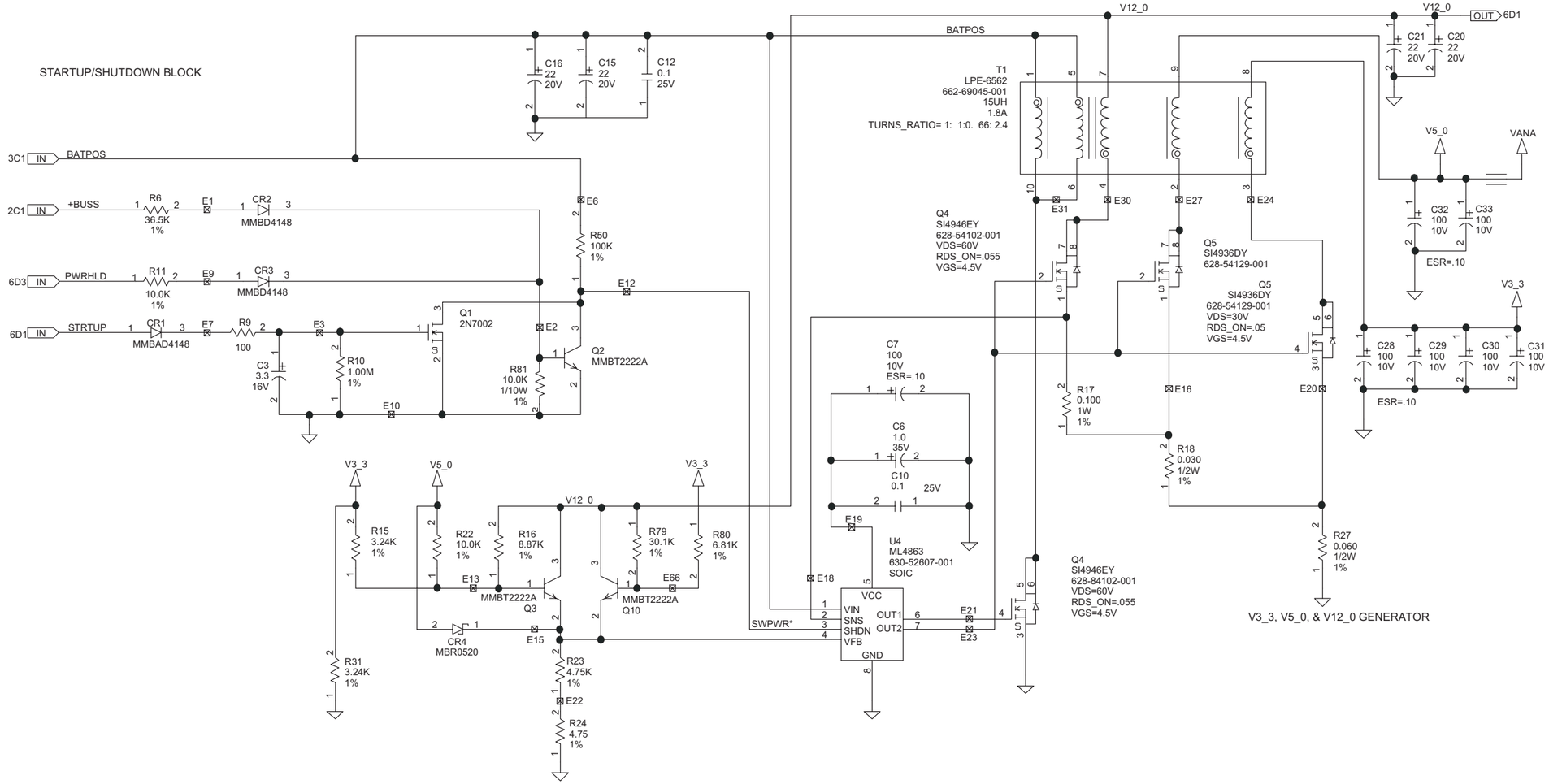

HOSPIRA	
Figure 9-11. Power Supply PWA Schematic (110 V)	
DRAWING NO. 249-95005-013	Rev. M
	Sheet 8 of 15

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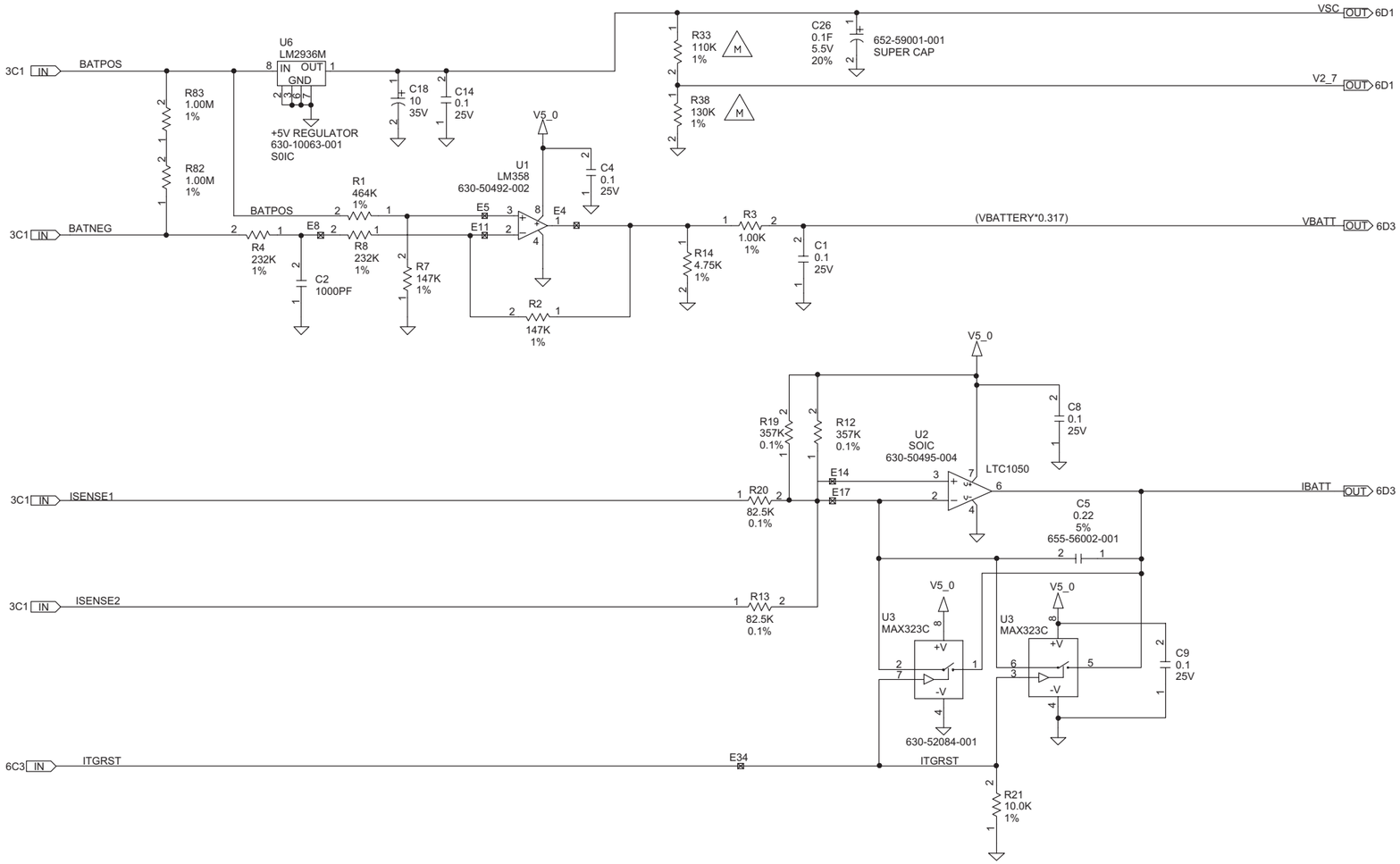

HOSPIRA	
Figure 9-11. **Power Supply PWA Schematic (110 V)**	
DRAWING NO. **249-95005-013**	**Rev. M**
	Sheet 9 of 15

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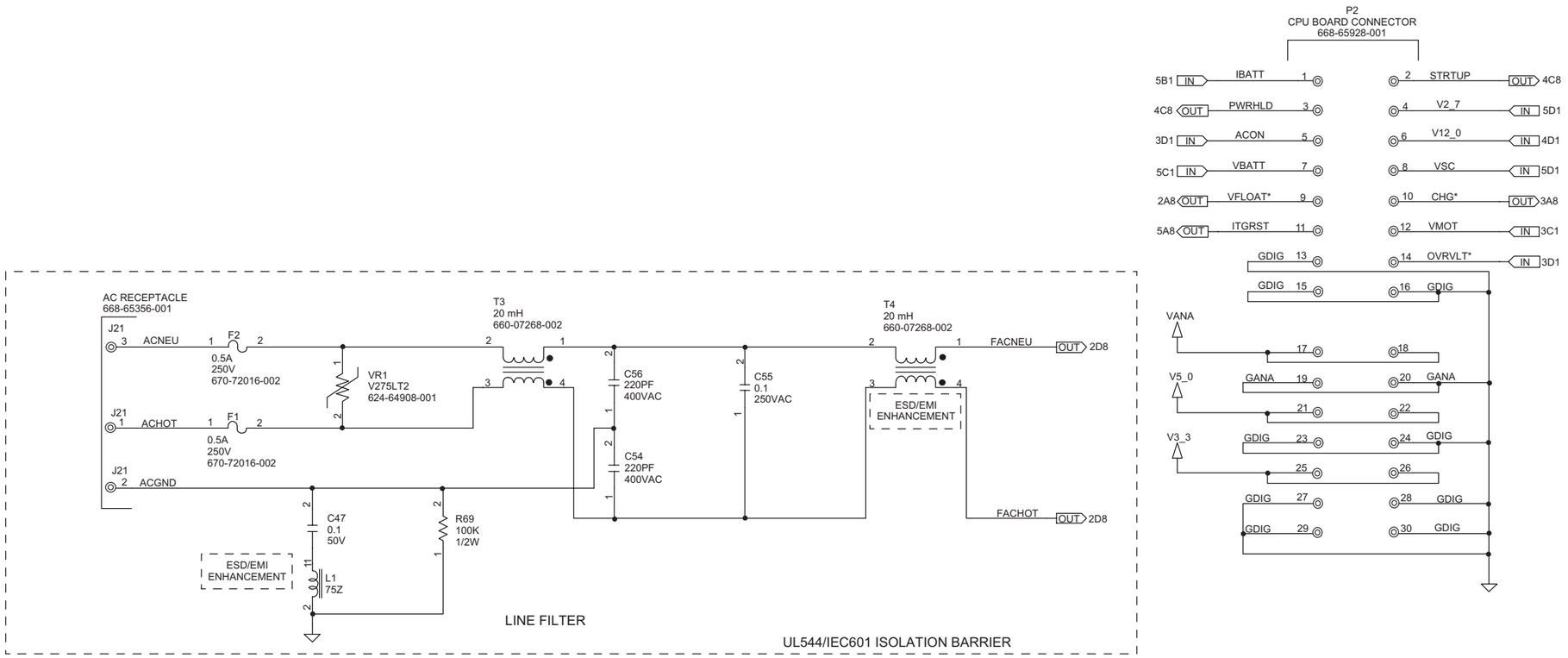

HOSPIRA	
Figure 9-11. Power Supply PWA Schematic (110 V)	
DRAWING NO. 249-95005-013	Rev. M
	Sheet 10 of 15

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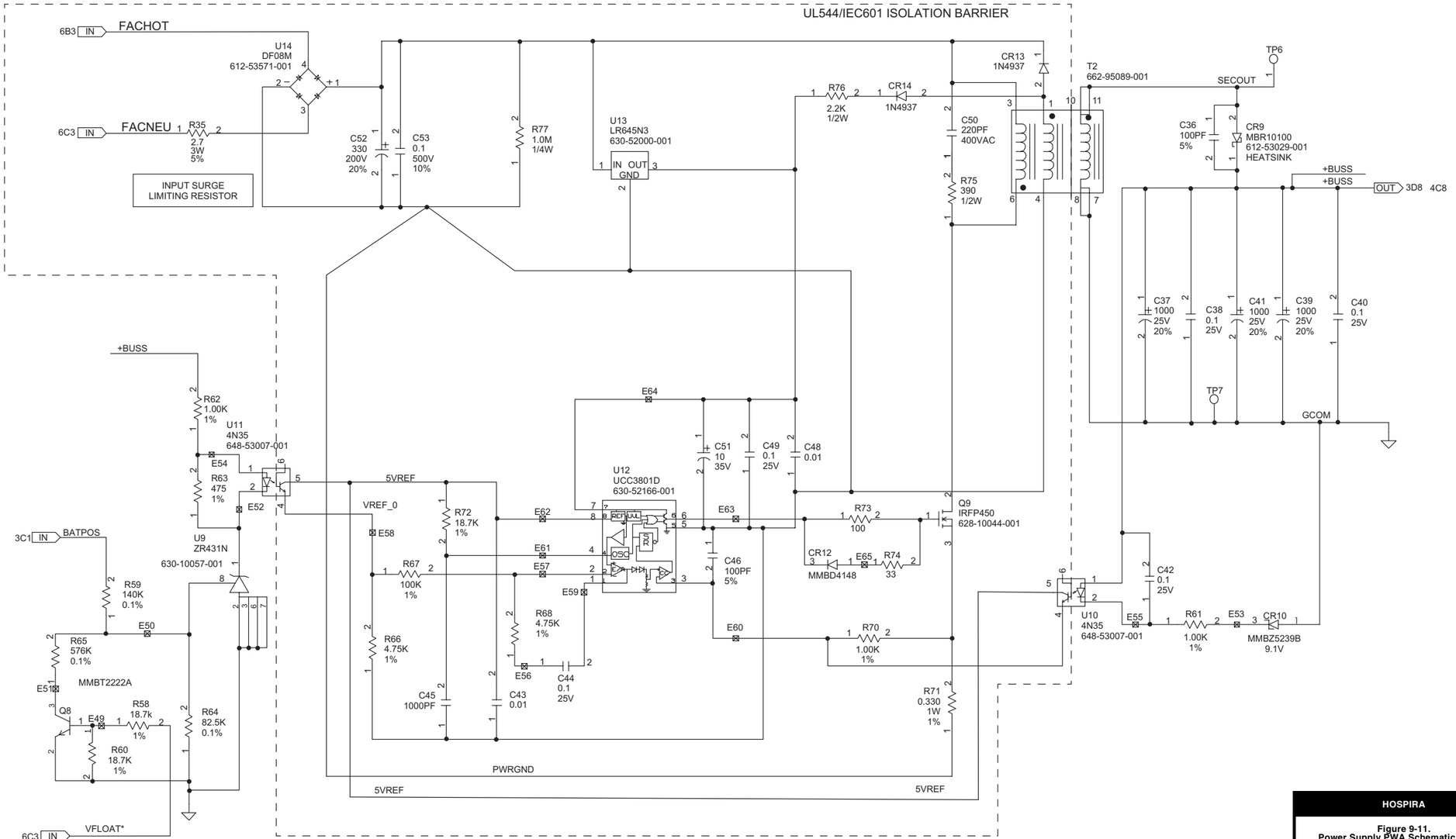

HOSPIRA	
Figure 9-11. Power Supply PWA Schematic (110 V)	
DRAWING NO. 249-95005-014	**Rev. M**
	Sheet 11 of 15

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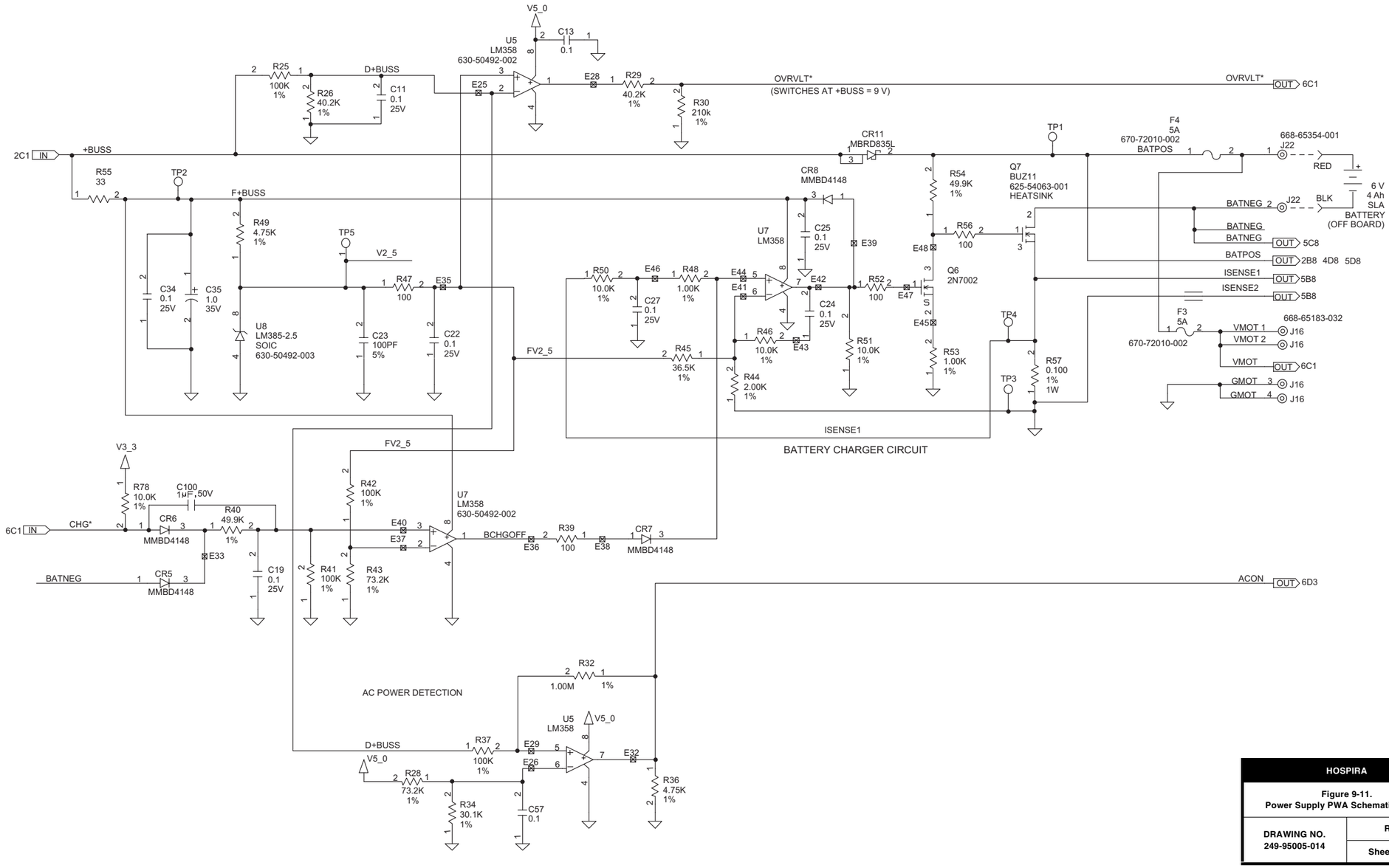

HOSPIRA	
Figure 9-11. Power Supply PWA Schematic (110 V)	
DRAWING NO. 249-95005-014	Rev. M
	Sheet 12 of 15

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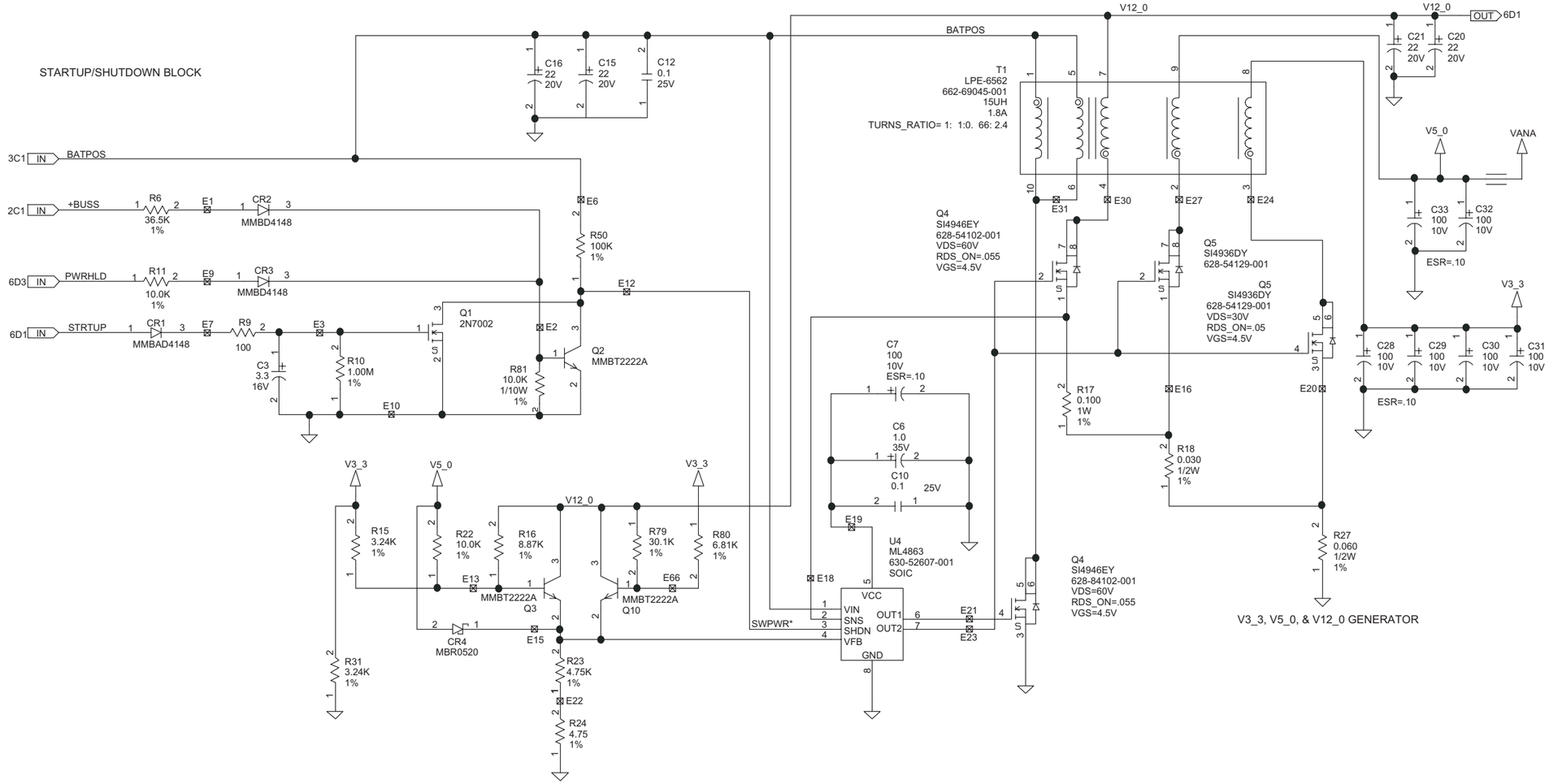

HOSPIRA	
Figure 9-11. Power Supply PWA Schematic (110 V)	
DRAWING NO. 249-95005-014	Rev. M
	Sheet 13 of 15

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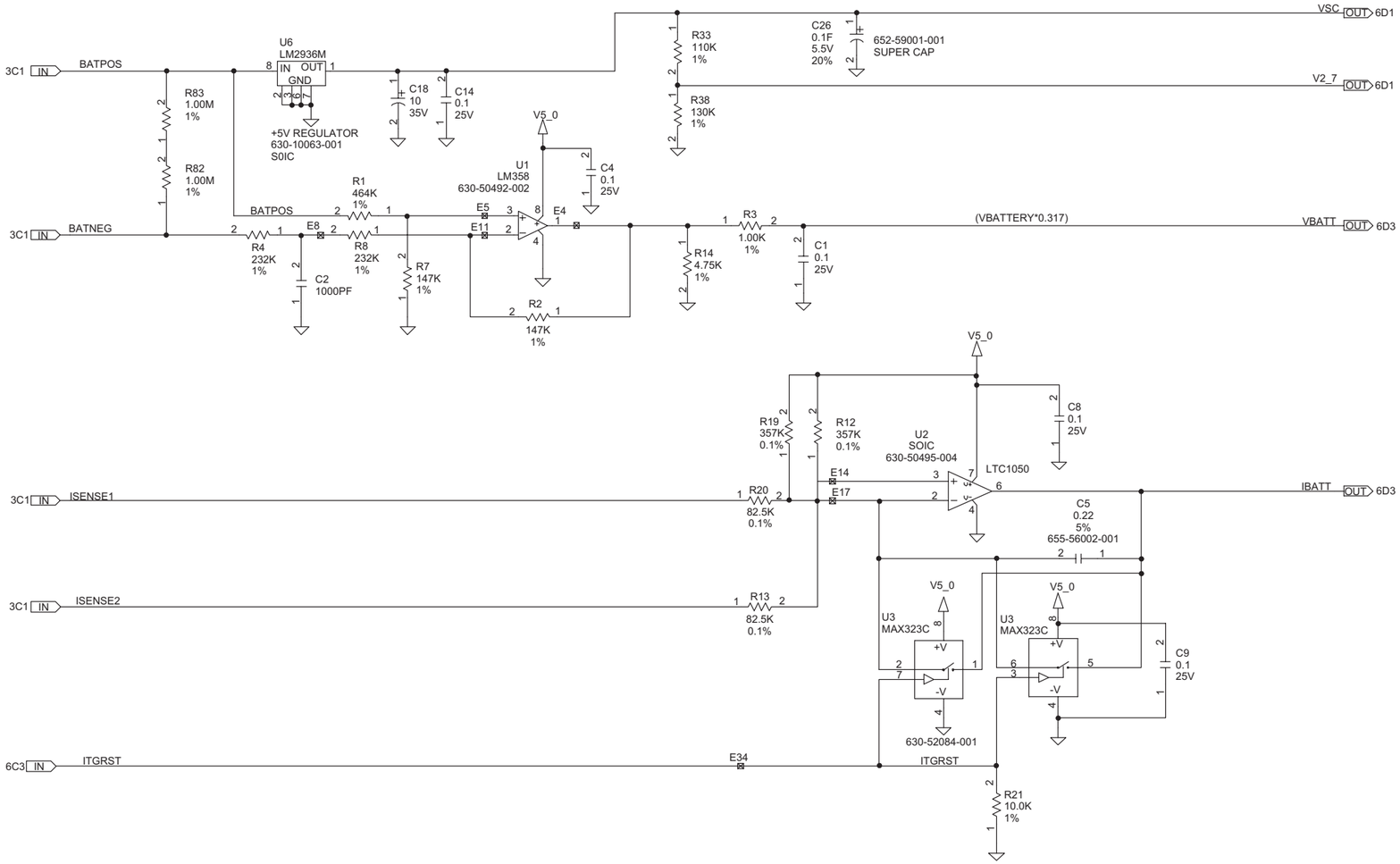

HOSPIRA	
Figure 9-11. Power Supply PWA Schematic (110 V)	
DRAWING NO. 249-95005-014	**Rev. M**
	Sheet 14 of 15

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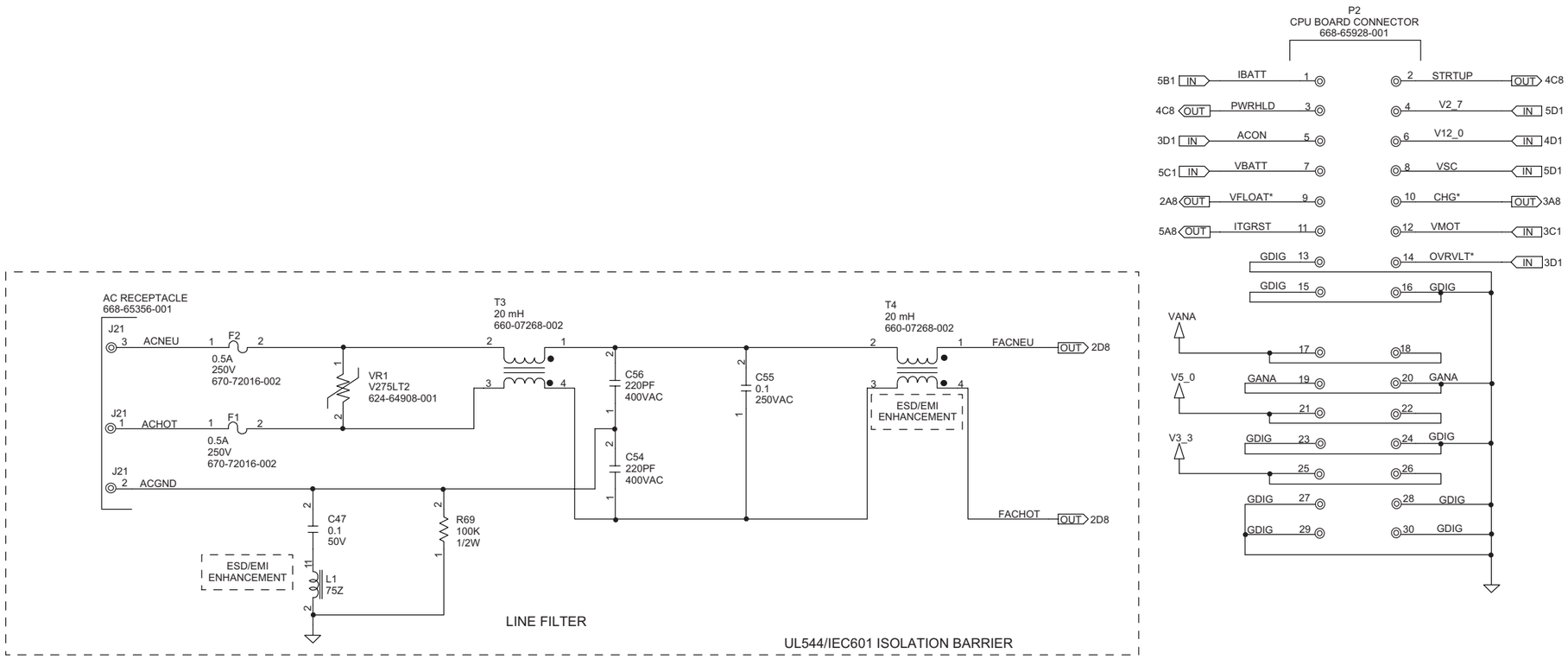

HOSPIRA	
Figure 9-11. Power Supply PWA Schematic (110 V)	
DRAWING NO. 249-95005-014	Rev. M
	Sheet 15 of 15

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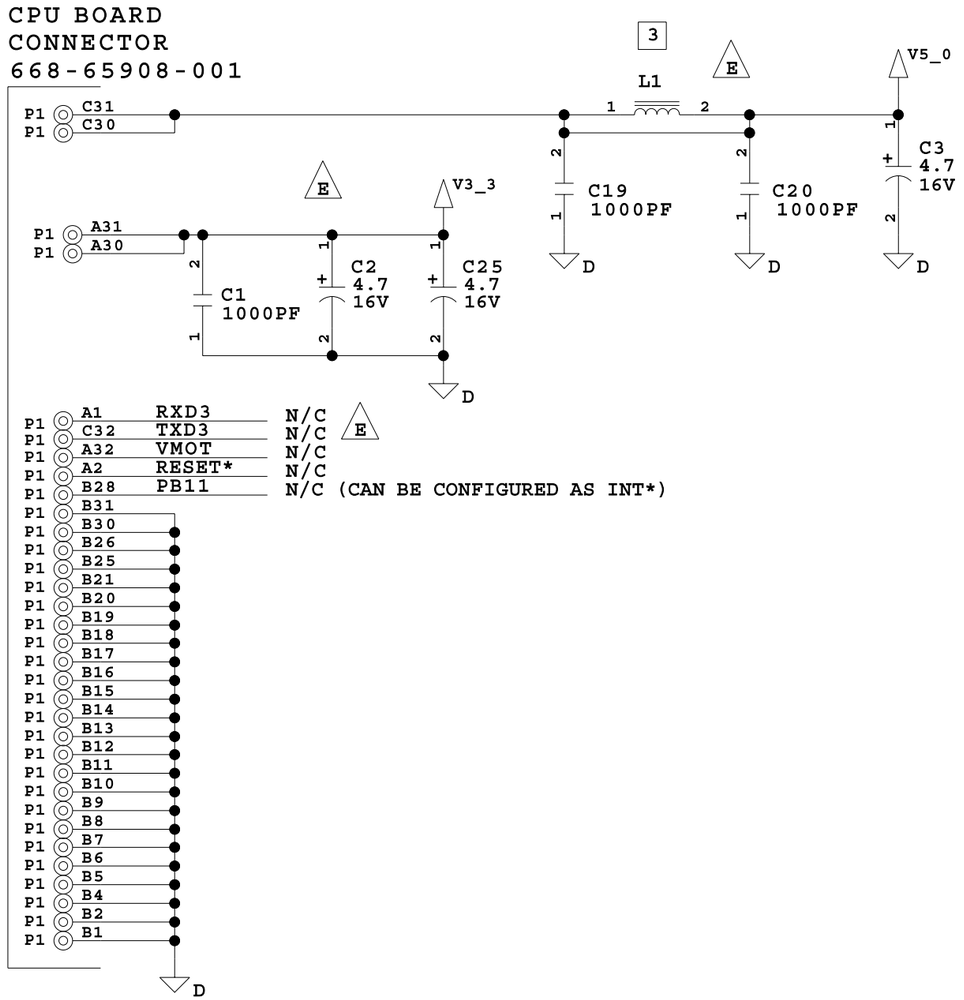

HOSPIRA	
Figure 9-12. Peripheral PWA Schematic	
DRAWING NO. 249-95006-007	Rev. F
	Sheet 1 of 4

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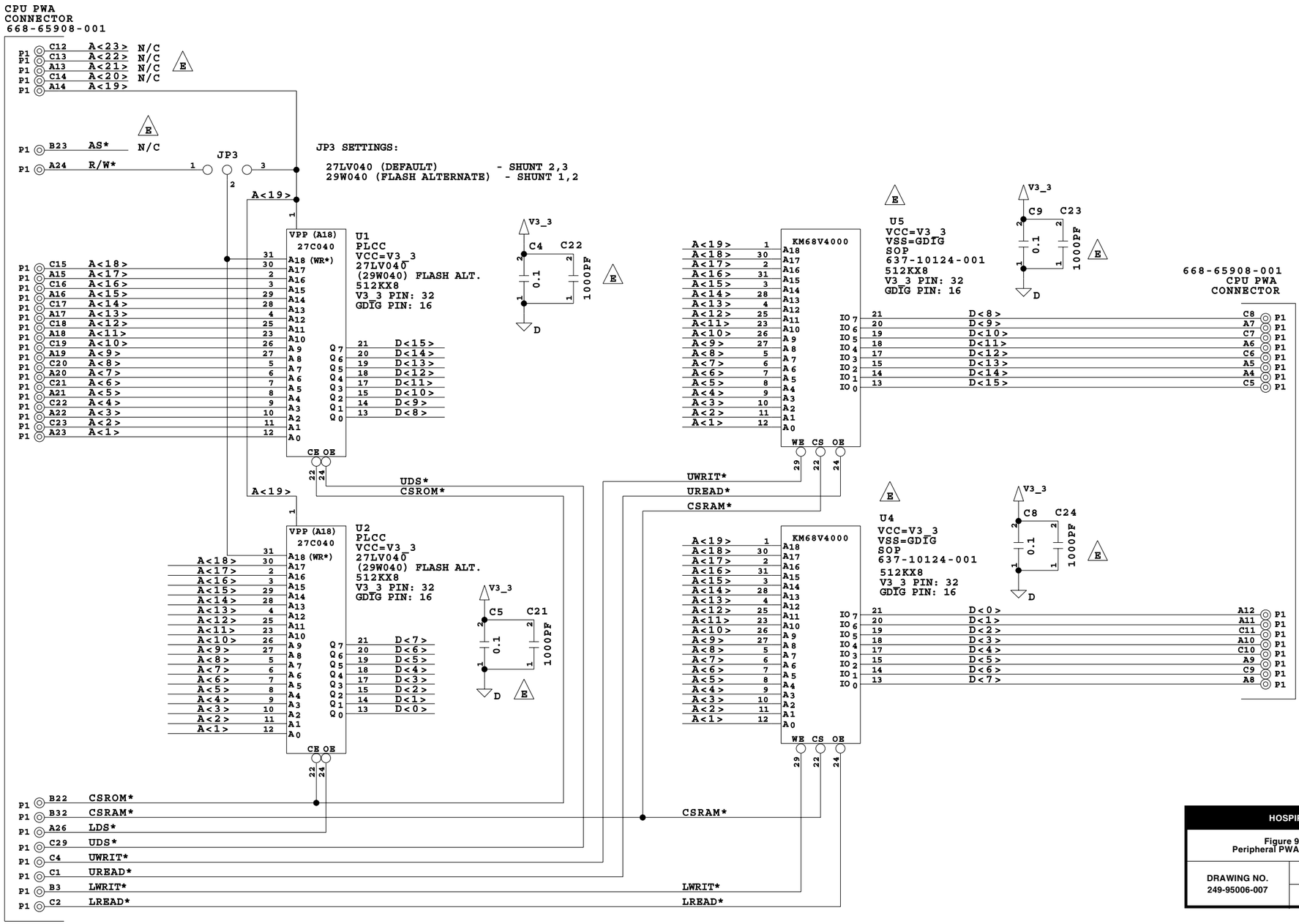

HOSPIRA	
Figure 9-12. Peripheral PWA Schematic	
DRAWING NO. 249-95006-007	Rev. F
	Sheet 2 of 4

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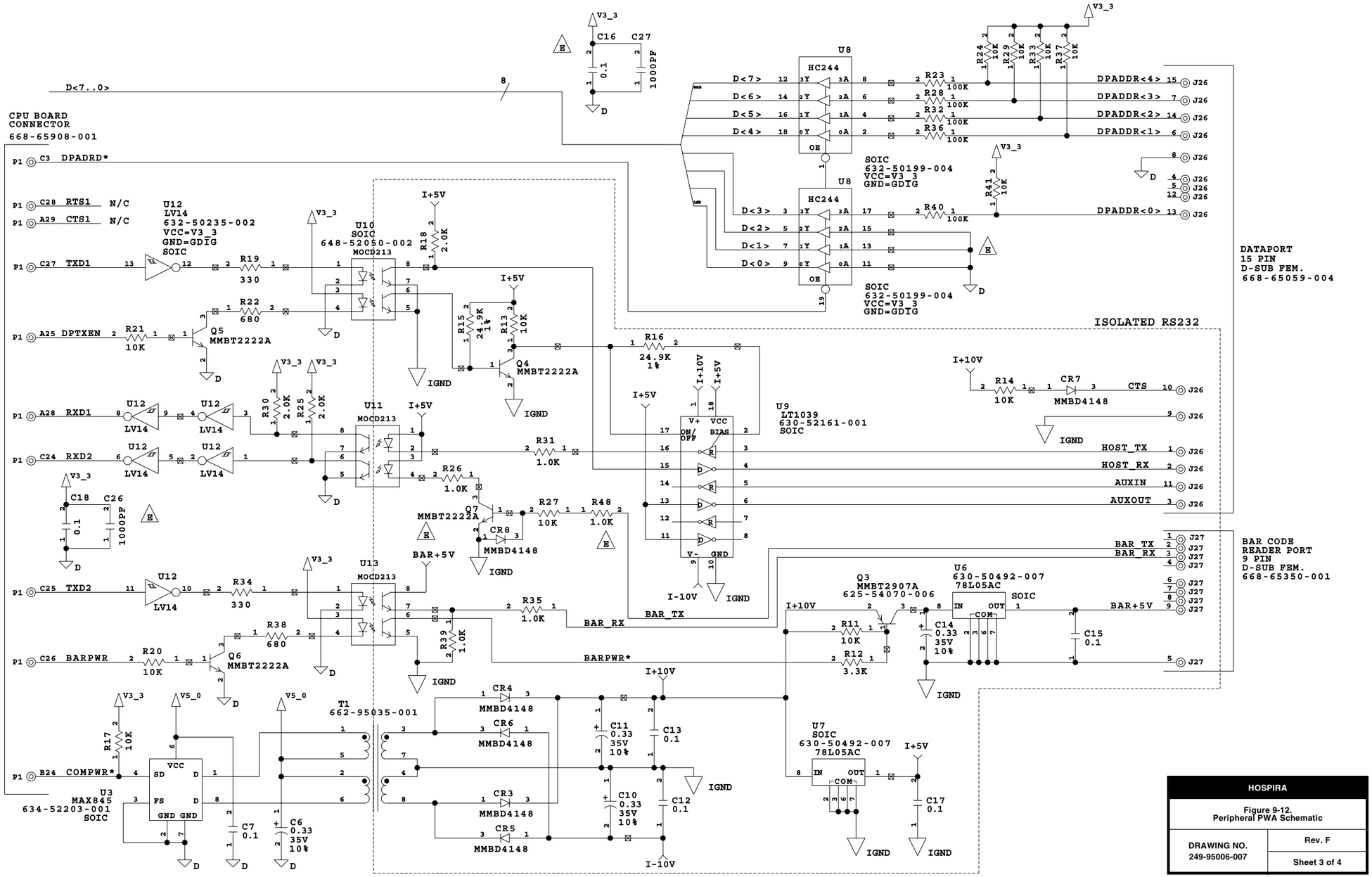

HOSPIRA	
Figure 9-12. Peripheral PWA Schematic	
DRAWING NO. 249-95006-007	Rev. F
	Sheet 3 of 4

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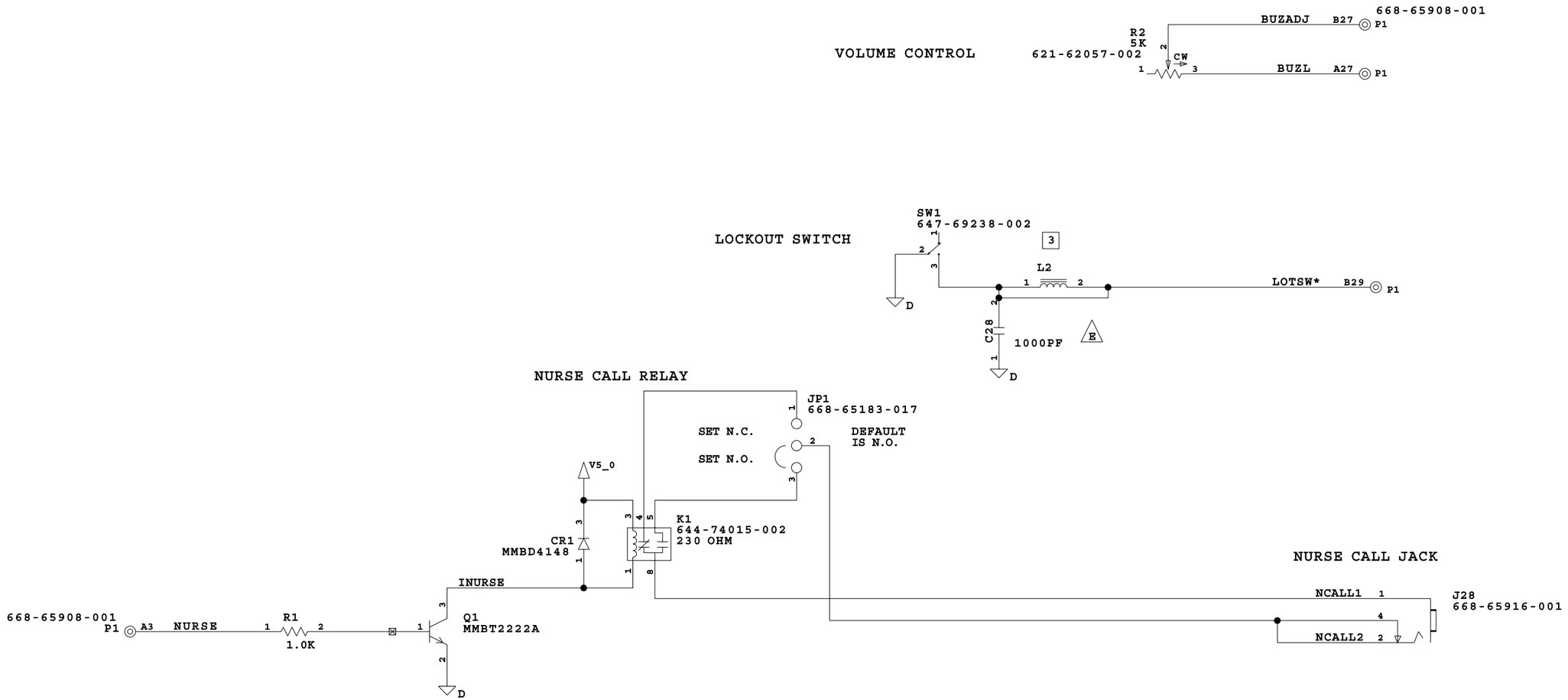

HOSPIRA	
Figure 9-12. Peripheral PWA Schematic	
DRAWING NO. 249-95006-007	Rev. F
	Sheet 4 of 4

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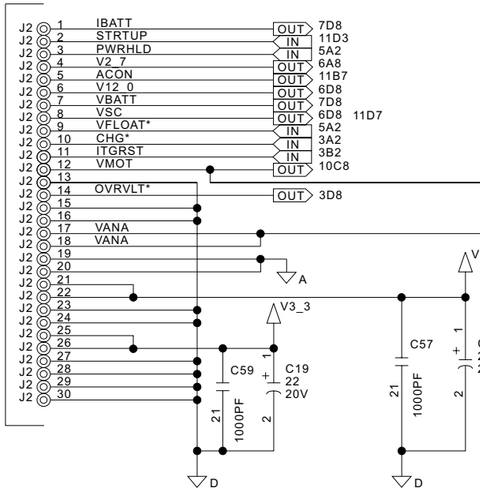
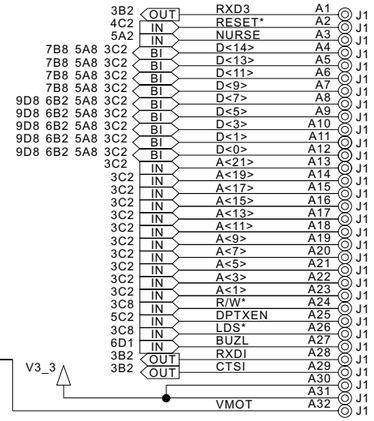
POWER SUPPLY CONNECTOR
668-65183-035

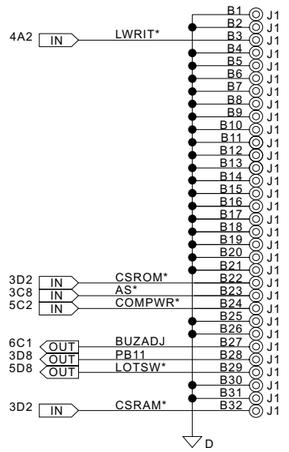


PERIPHERAL CONNECTOR

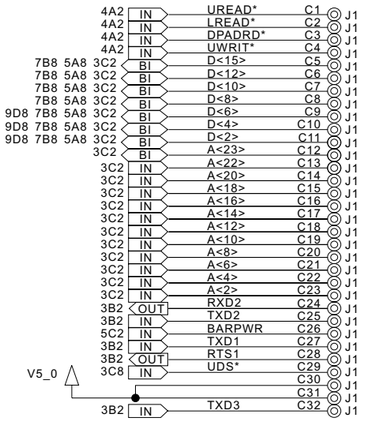
668-65907-002



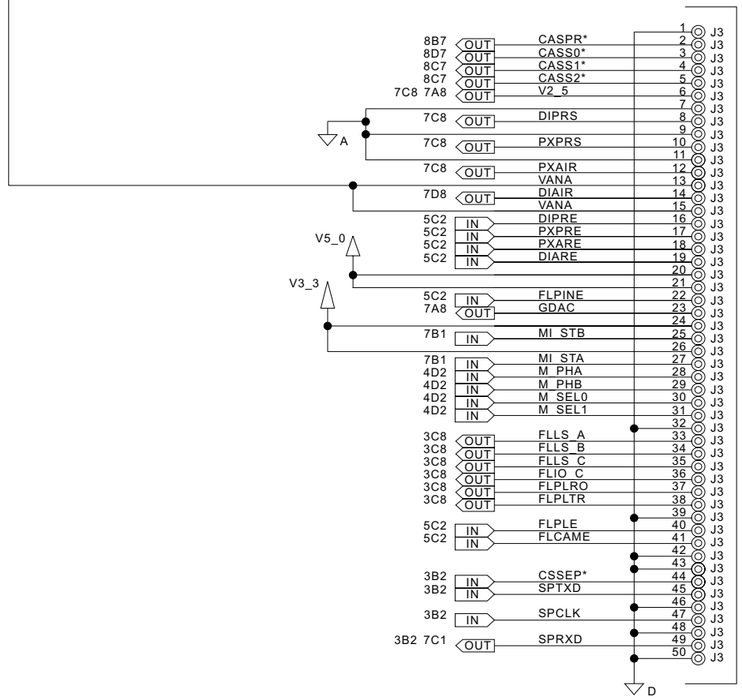
668-65907-002



668-65907-002



DRIVER PWA CONNECTOR
668-65923-002



HOSPIRA	
Figure 9-13. CPU PWA Schematic	
DRAWING NO 249-95007-008	Rev. J
	Sheet 1 of 10

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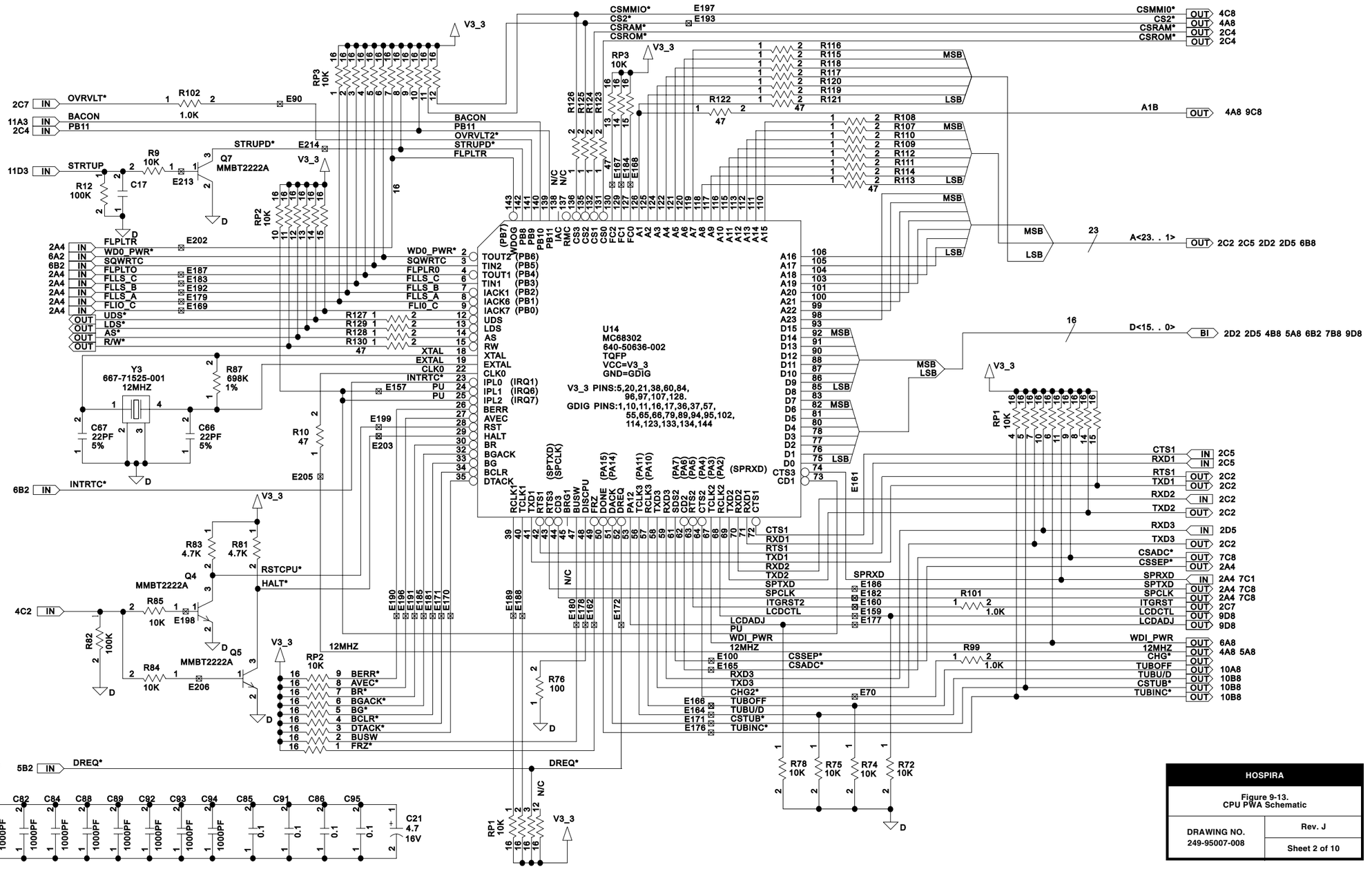
U14
MC68302
640-50636-002
TQFP
VCC=V3_3
GND=GDIG
V3_3 PINS:5,20,21,38,60,84, 96,97,107,128.
GDIG PINS:1,10,11,16,17,36,37,57, 55,65,66,79,89,94,95,102, 114,123,133,134,144
Y3
667-71525-001
12MHZ
OVRVLT*
BACON
PB11
STRTUP
STRUPD*
FLPLTR
WD0_PWR*
SQWRTC
FLPLTO
FLLS_C
FLLS_B
FLLS_A
FLIO_C
UDS*
LDS*
AS*
R/W*
INTRTC*
DREQ*
RSTCPU*
HALT*
12MHZ
CSMMIO*
CS2*
CSRAM*
CSROM*
A1B
A<23. . 1>
D<15. . 0>
CTS1
RXD1
RTS1
TXD1
RXD2
TXD2
RXD3
TXD3
CSADC*
CSSEP*
SPRXD
SPTXD
SPCLK
ITGRST2
LCDCTL
LCDADJ
WDI_PWR
CHG*
TUBOFF
TUBU/D
CSTUB*
TUBINC*
SPTXD
SPCLK
SPRXD
CSSEP*
CSADC*
CHG2*
TOUT2 (PB6)
TIN2 (PB5)
TOUT1 (PB4)
TIN1 (PB3)
IACK1 (PB2)
IACK6 (PB1)
IACK7 (PB0)
IPL0 (IRQ1)
IPL1 (IRQ6)
IPL2 (IRQ7)
HOSPIRA
Figure 9-13.
CPU PWA Schematic
DRAWING NO.
249-95007-008
Rev. J
Sheet 2 of 10

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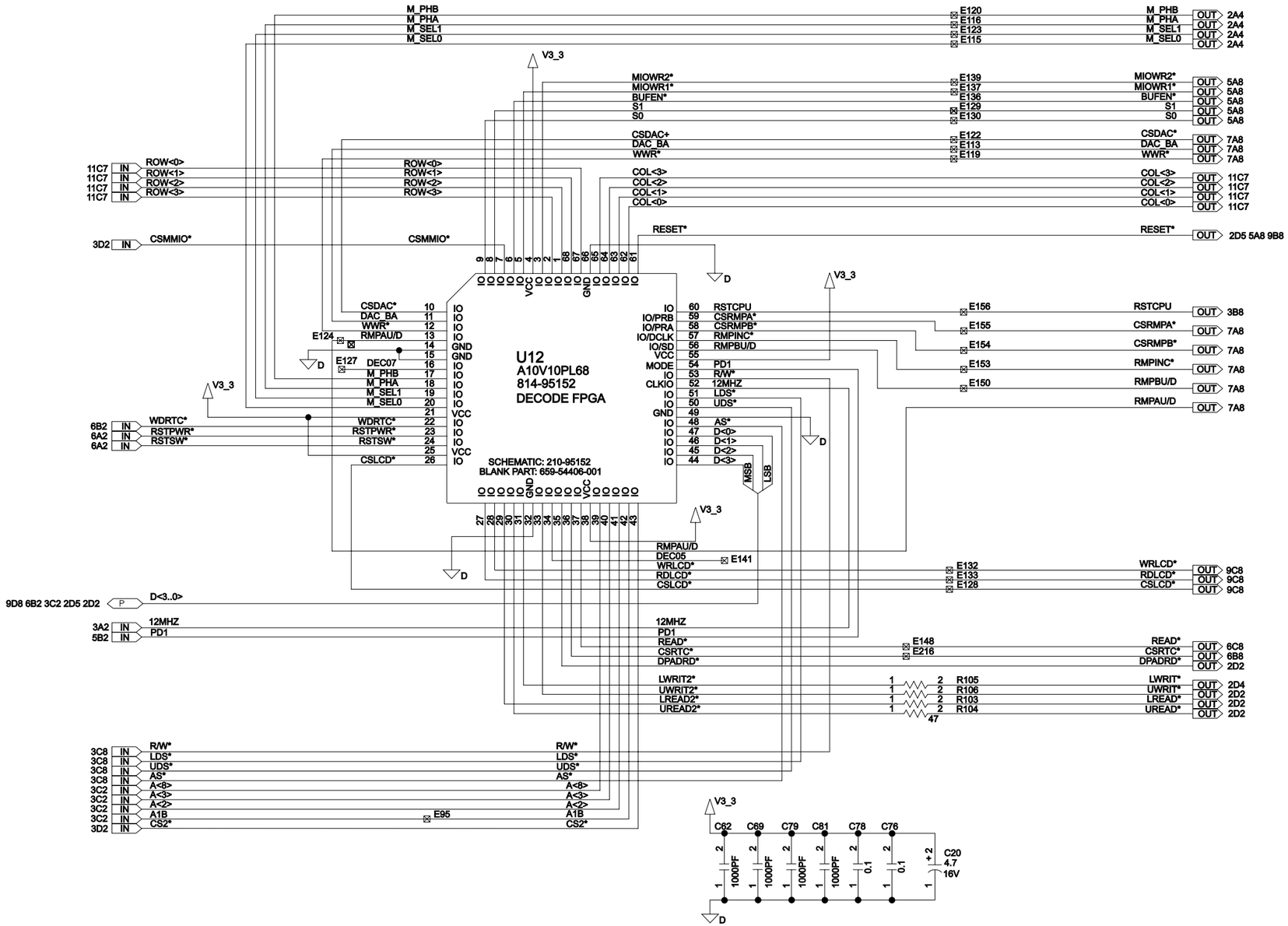

HOSPIRA	
Figure 9-13. CPU PWA Schematic	
DRAWING NO. 249-95007-008	Rev. J
	Sheet 3 of 10

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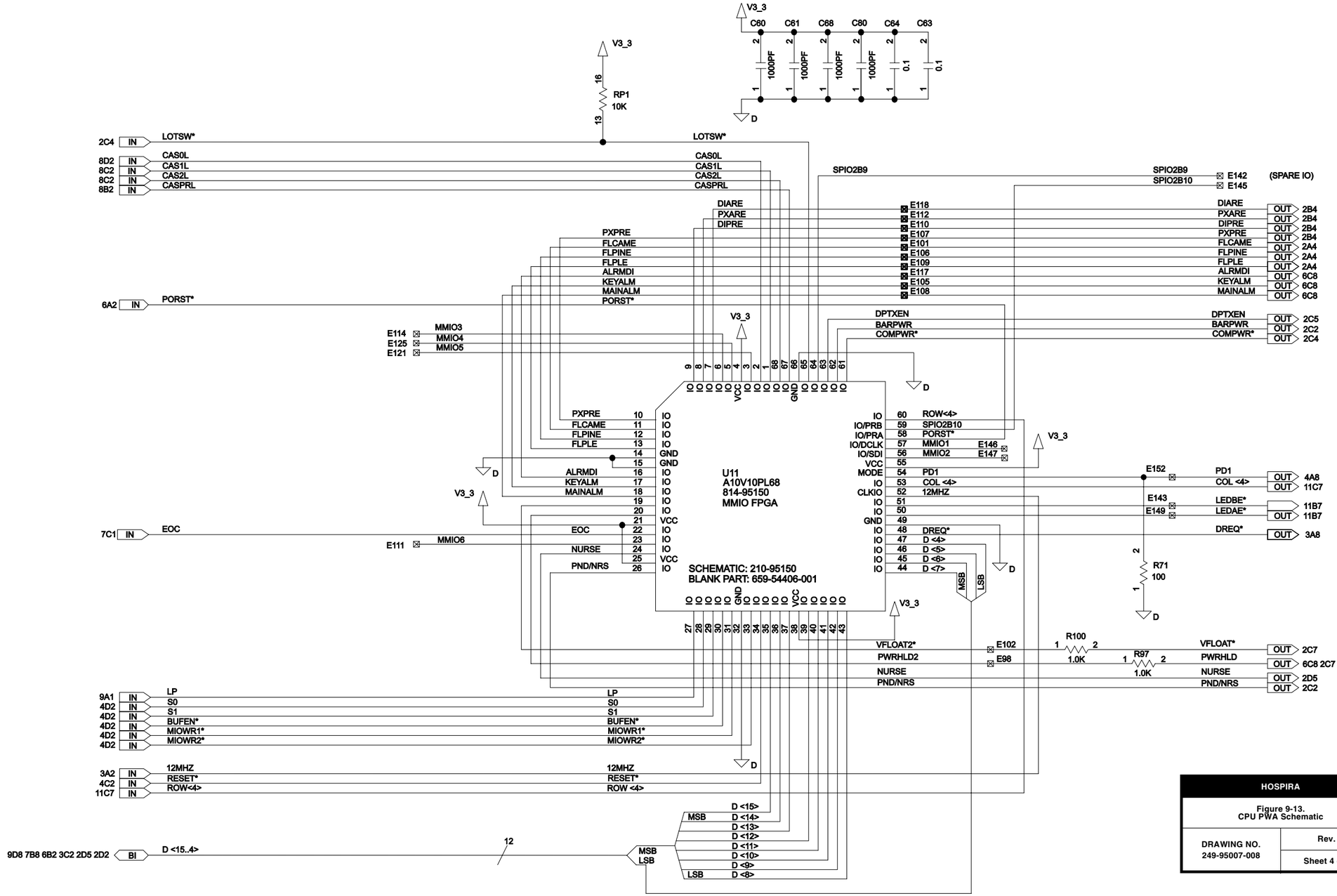

HOSPIRA	
Figure 9-13. CPU PWA Schematic	
DRAWING NO. 249-95007-008	Rev. J
	Sheet 4 of 10

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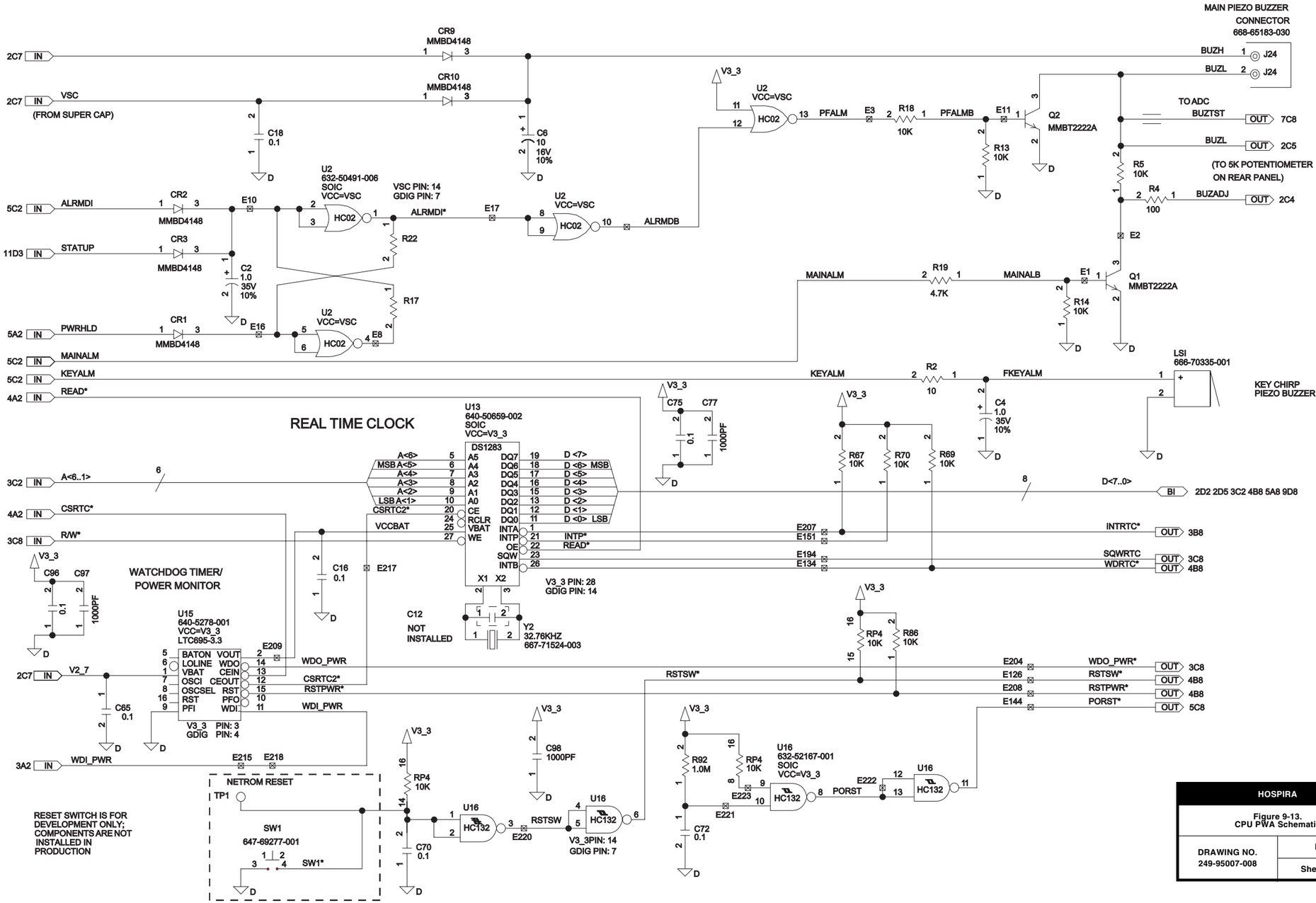

HOSPIRA	
Figure 9-13. CPU PWA Schematic	
DRAWING NO. 249-95007-008	Rev. J
	Sheet 5 of 10

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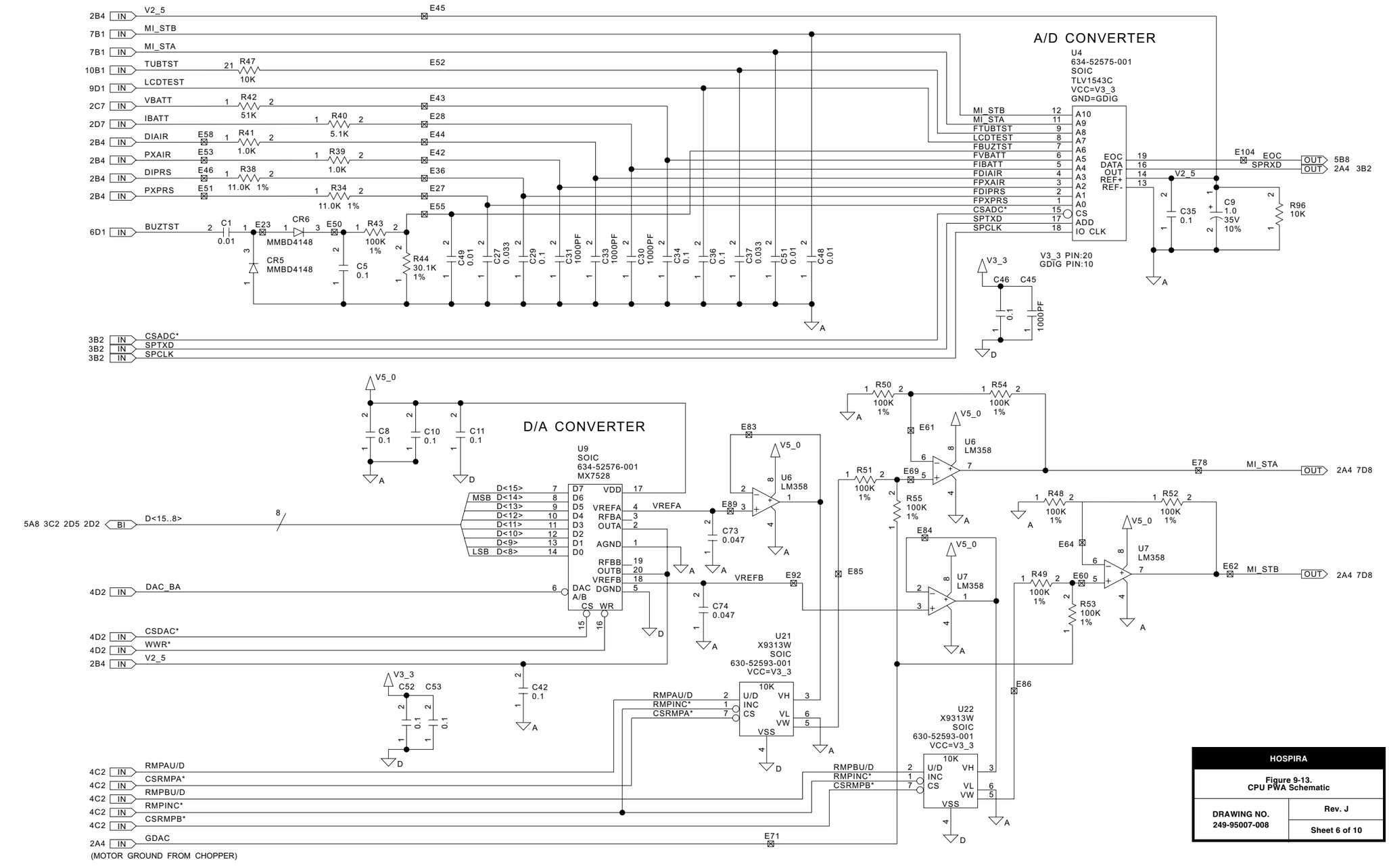
A/D CONVERTER
U4
634-52575-001
SOIC
TLV1543C
VCC=V3_3
GND=GDIG
V3_3 PIN:20
GDIG PIN:10
D/A CONVERTER
U9
SOIC
634-52576-001
MX7528
U21
X9313W
SOIC
630-52593-001
VCC=V3_3
U22
X9313W
SOIC
630-52593-001
VCC=V3_3
U6
LM358
U7
LM358
V2_5
V3_3
V5_0
MI_STB
MI_STA
TUBTST
LCDTEST
VBATT
IBATT
DIAIR
PXAIR
DIPRS
PXPRS
BUZTST
CSADC*
SPTXD
SPCLK
DAC_BA
CSDAC*
WWR*
RMPAU/D
CSRMPA*
RMPBU/D
RMPINC*
CSRMPB*
GDAC
(MOTOR GROUND FROM CHOPPER)
HOSPIRA
Figure 9-13.
CPU PWA Schematic
DRAWING NO.
249-95007-008
Rev. J
Sheet 6 of 10

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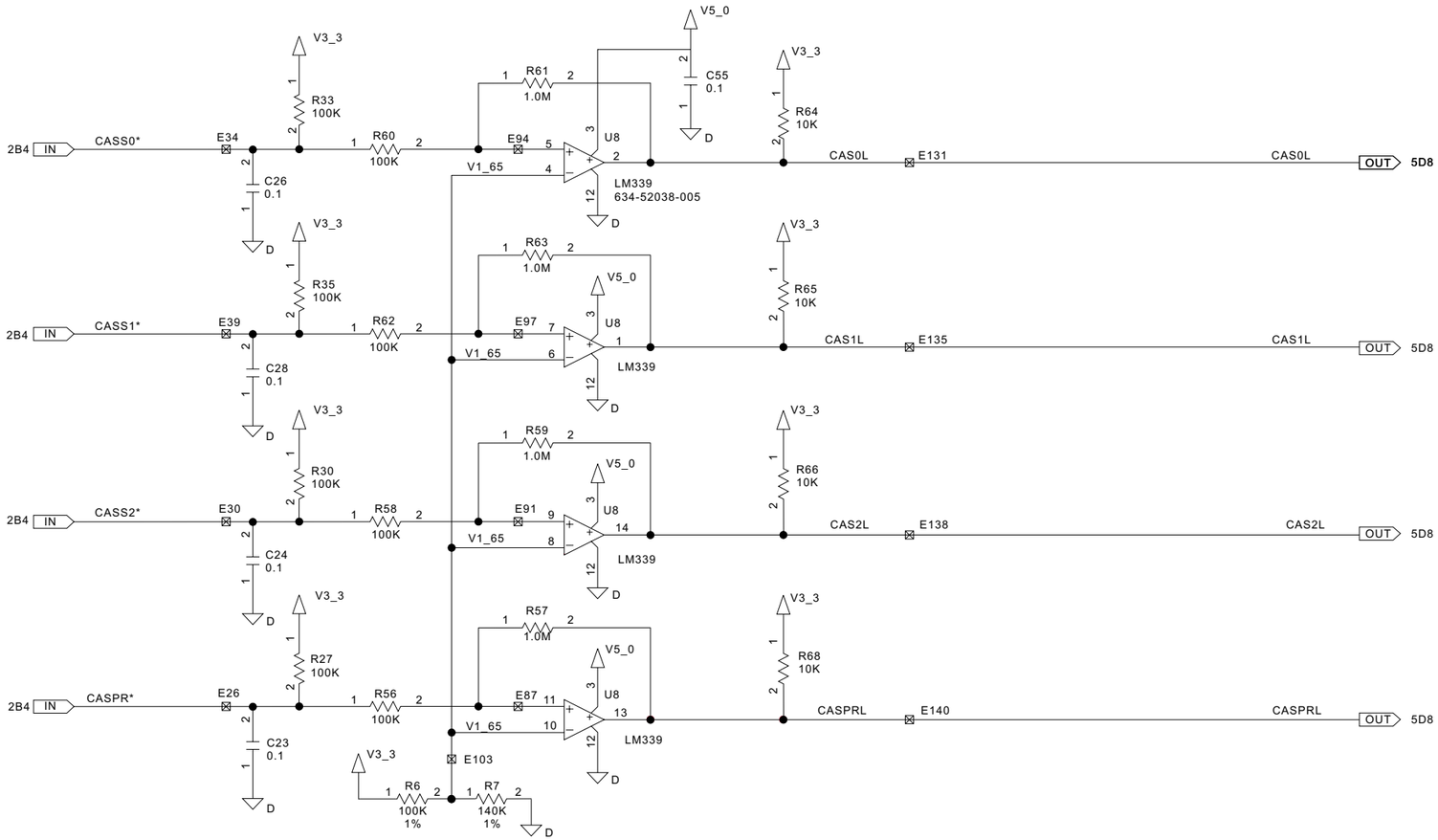
CASSETTE ID FSR
COMPARATORS



HOSPIRA	
Figure 9-13. CPU PWA Schematic	
DRAWING NO. 249-95007-008	Rev. J
	Sheet 7 of 10

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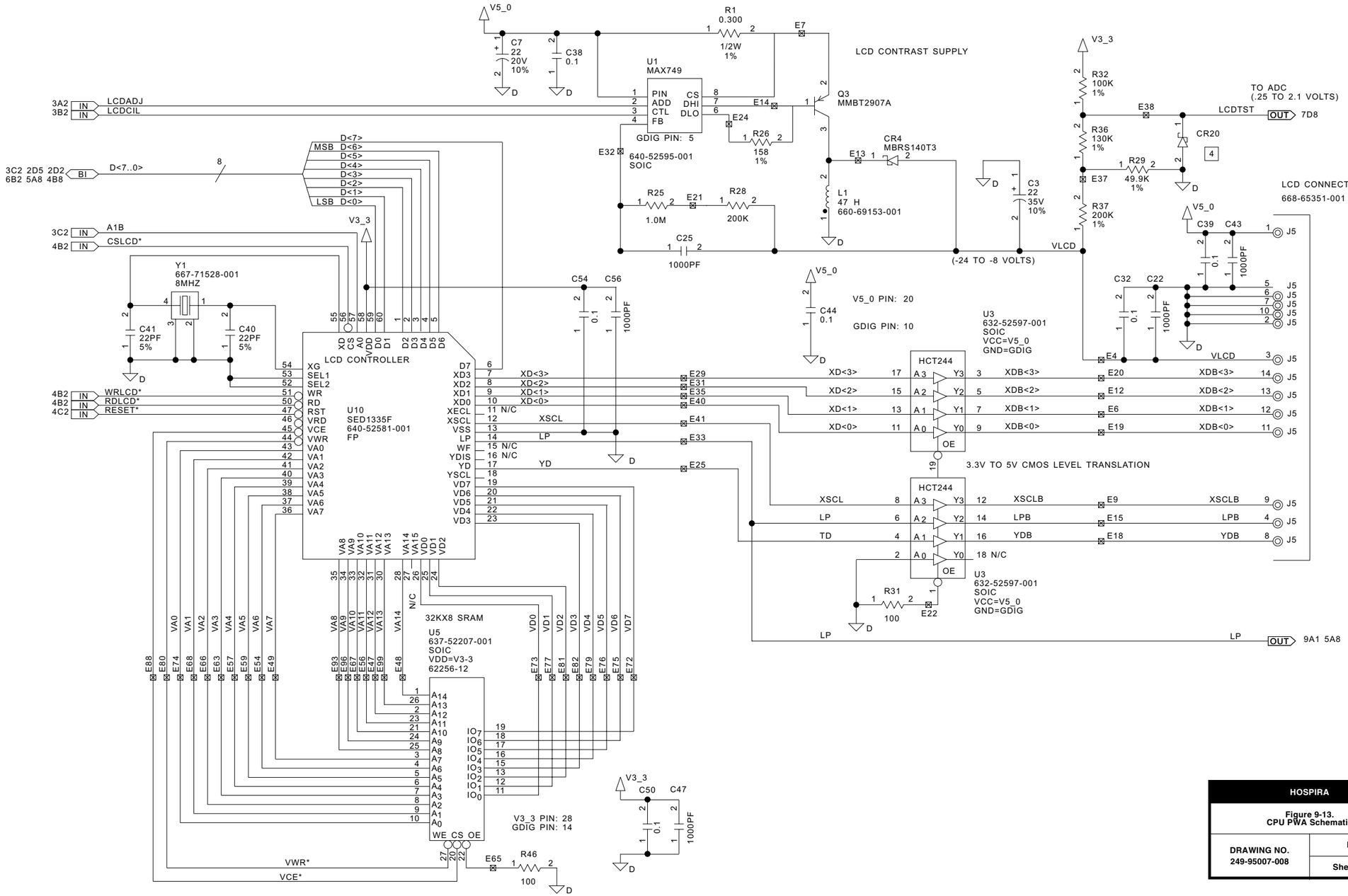

HOSPIRA	
Figure 9-13. CPU PWA Schematic	
DRAWING NO. 249-95007-008	Rev. J
	Sheet 8 of 10

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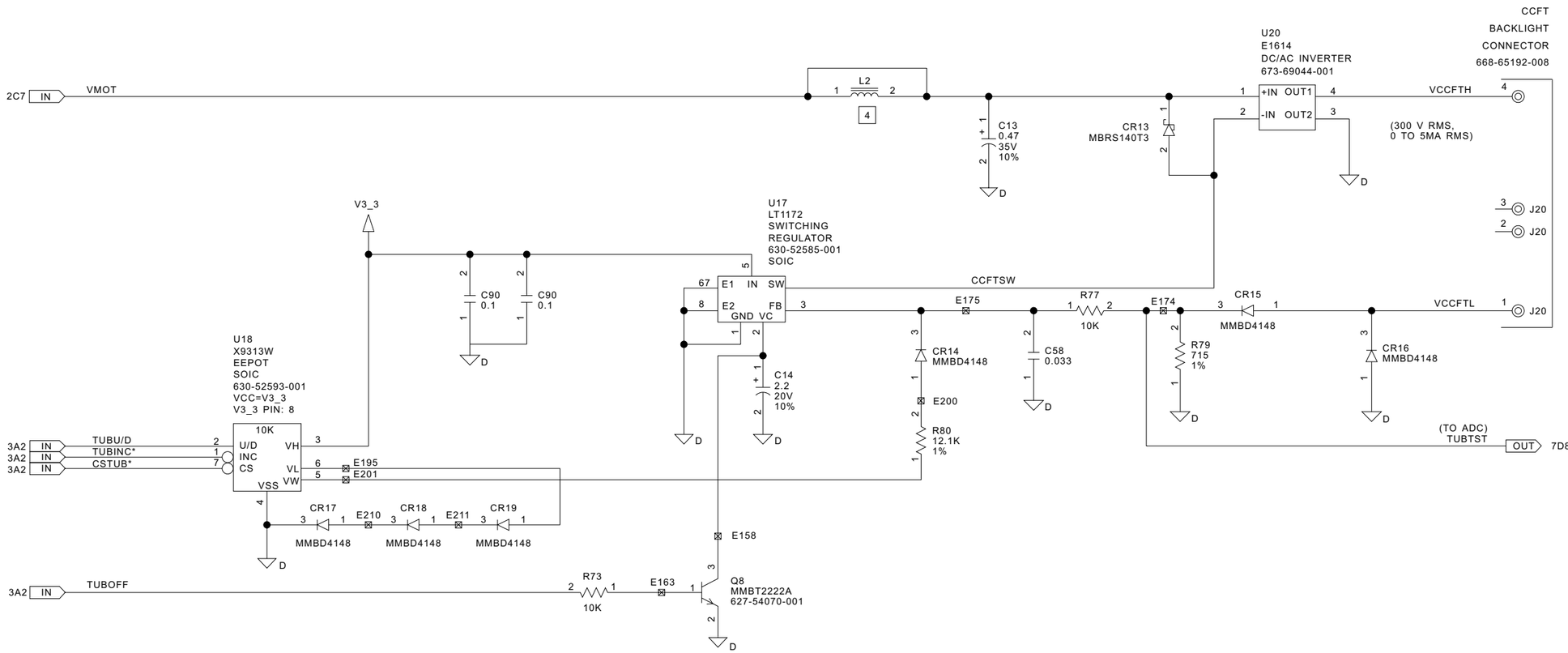

HOSPIRA	
Figure 9-13. CPU PWA Schematic	
DRAWING NO. 249-95007-008	Rev. J
	Sheet 9 of 10

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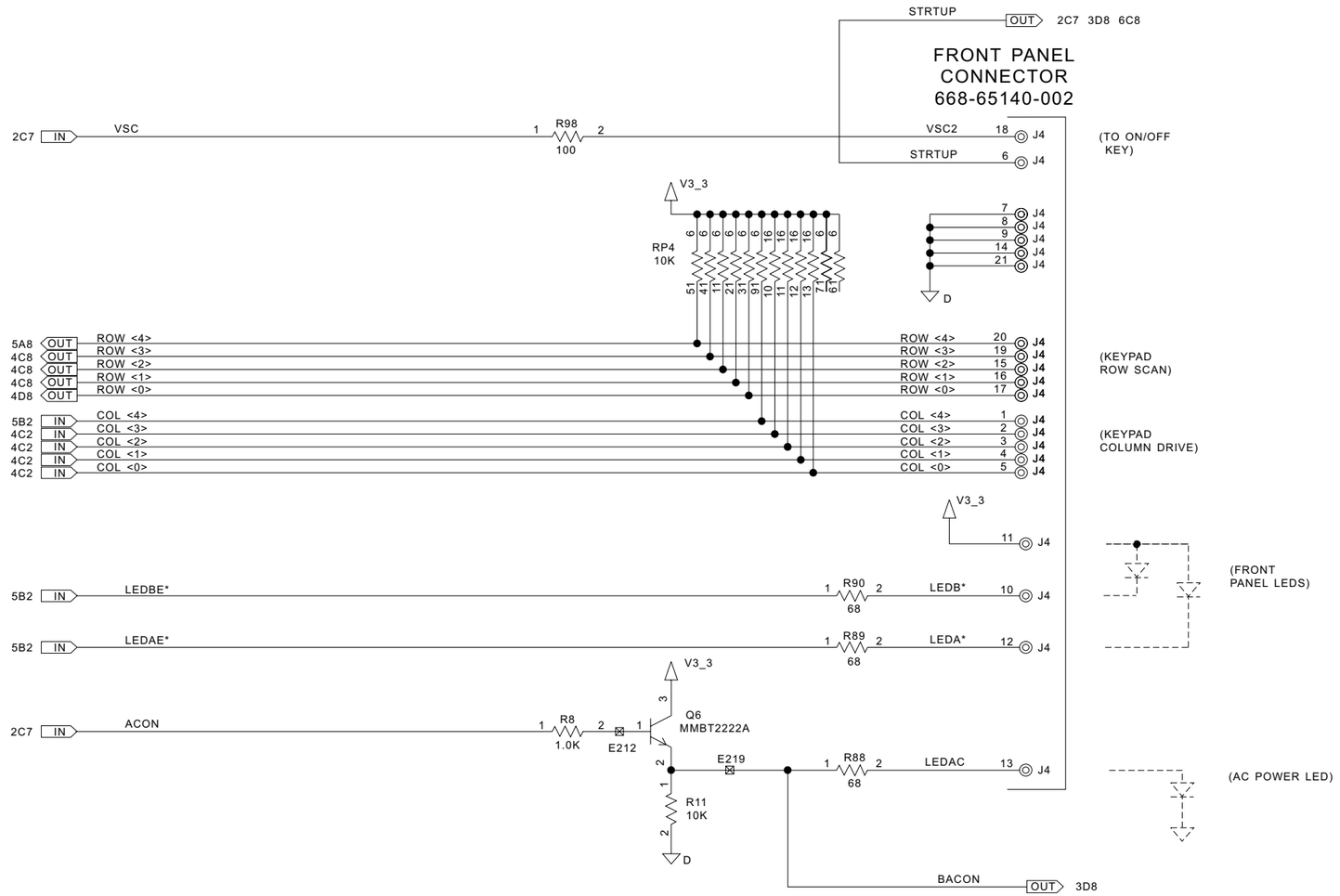

HOSPIRA	
Figure 9-13. CPU PWA Schematic	
DRAWING NO. 249-95007-008	Rev. J
	Sheet 10 of 10

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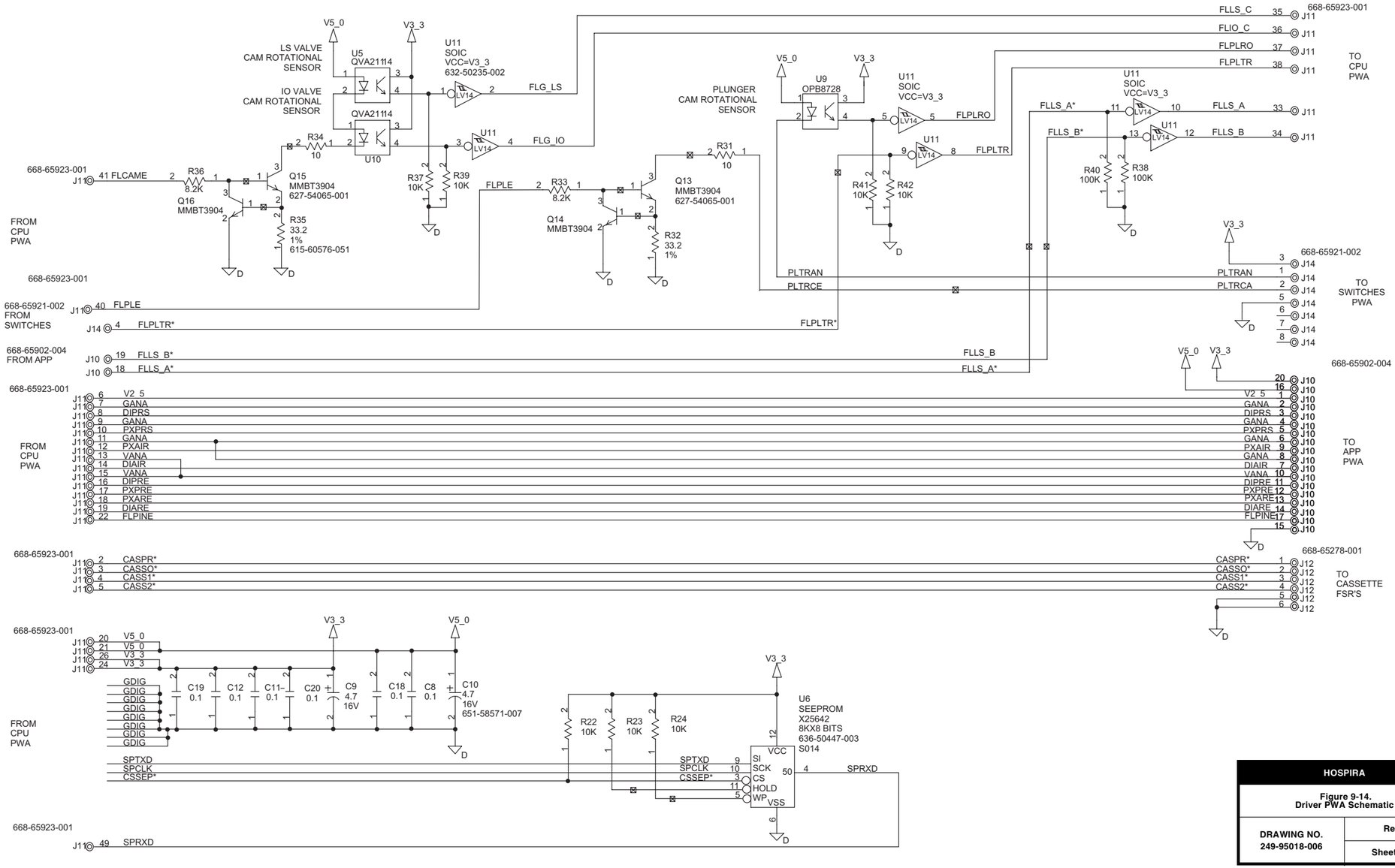

HOSPIRA	
Figure 9-14. Driver PWA Schematic	
DRAWING NO. 249-95018-006	**Rev. E**
	Sheet 1 of 6

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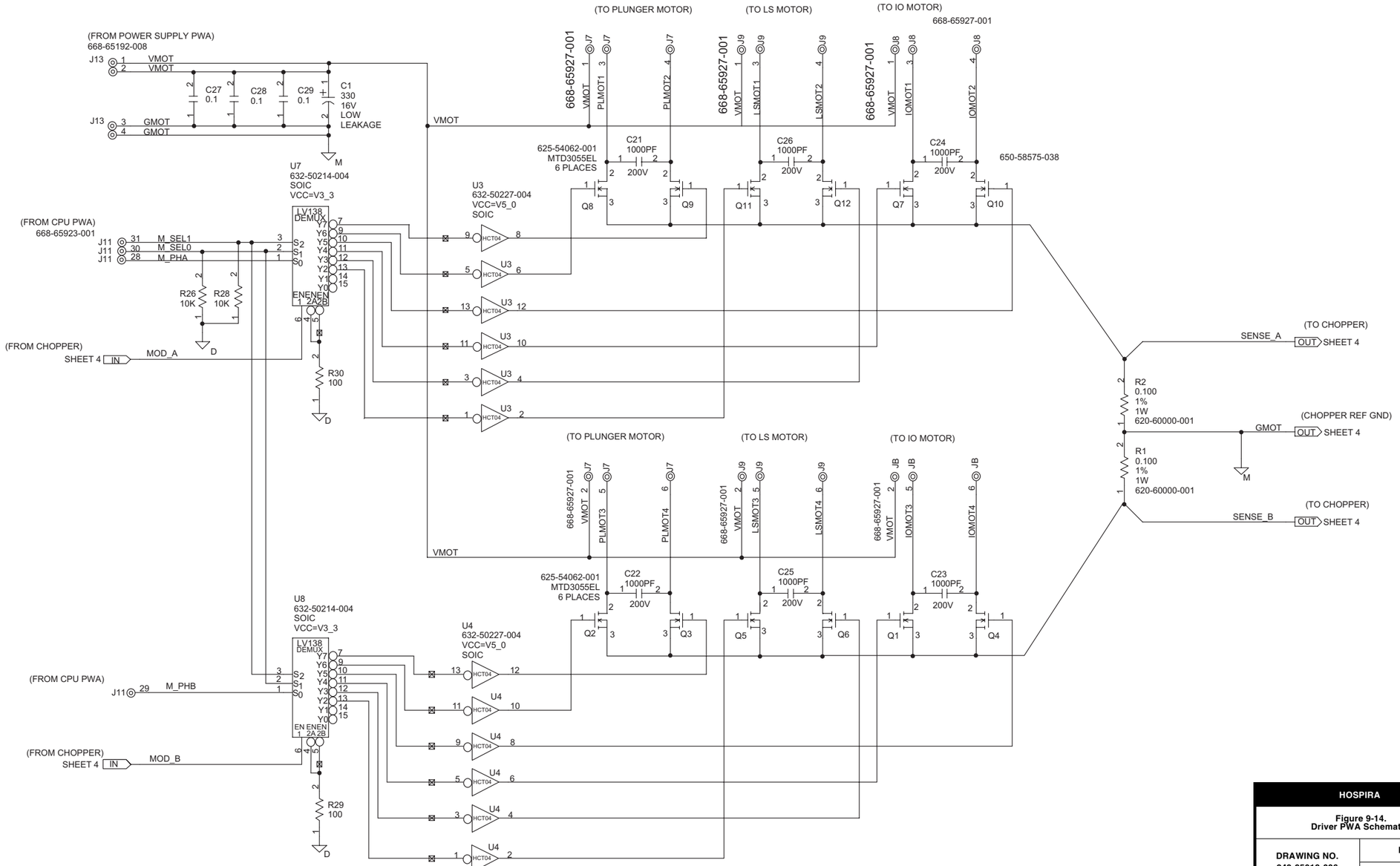

HOSPIRA	
Figure 9-14. Driver PWA Schematic	
DRAWING NO. 249-95018-006	Rev. E
	Sheet 2 of 6

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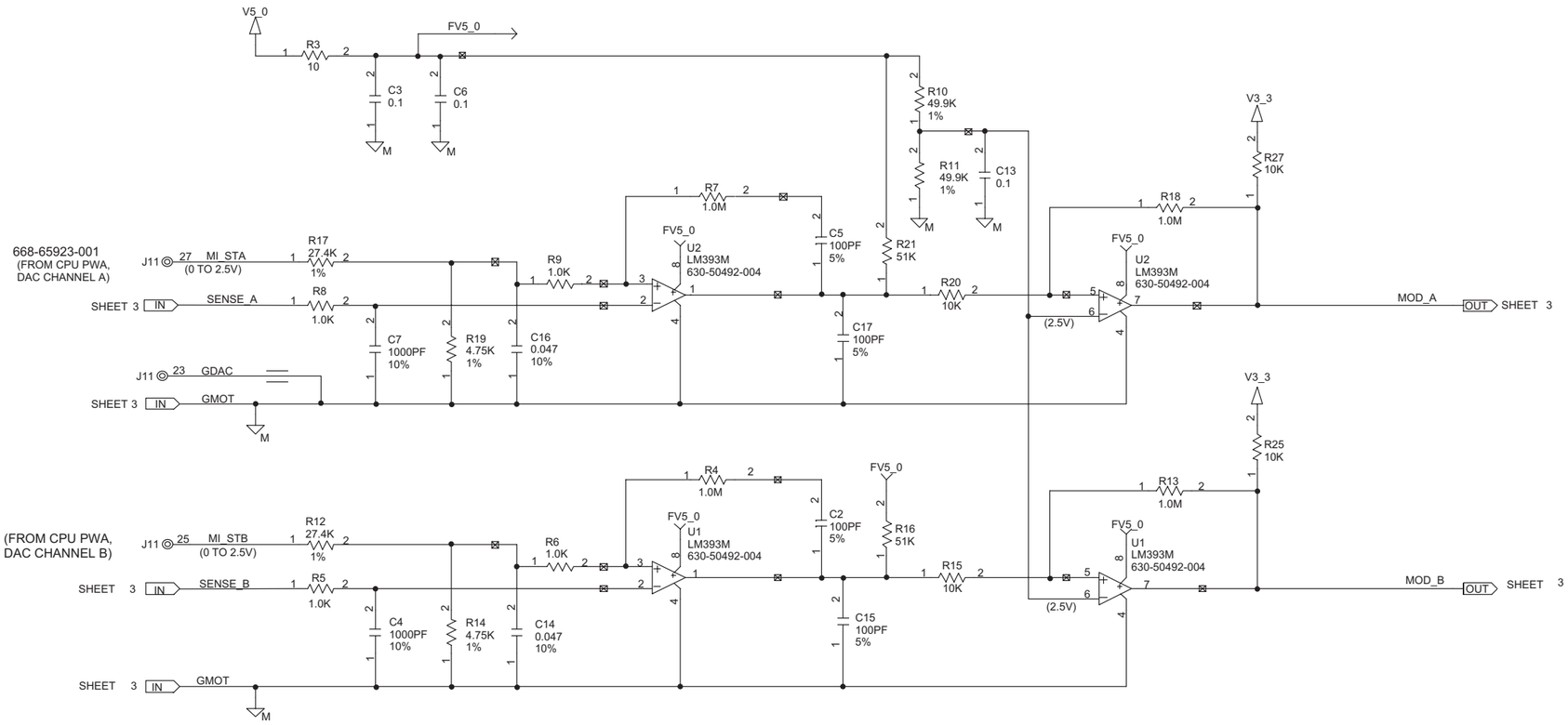

HOSPIRA	
Figure 9-14. **Driver PWA Schematic**	
DRAWING NO. **249-95018-006**	**Rev. E**
	Sheet 3 of 6

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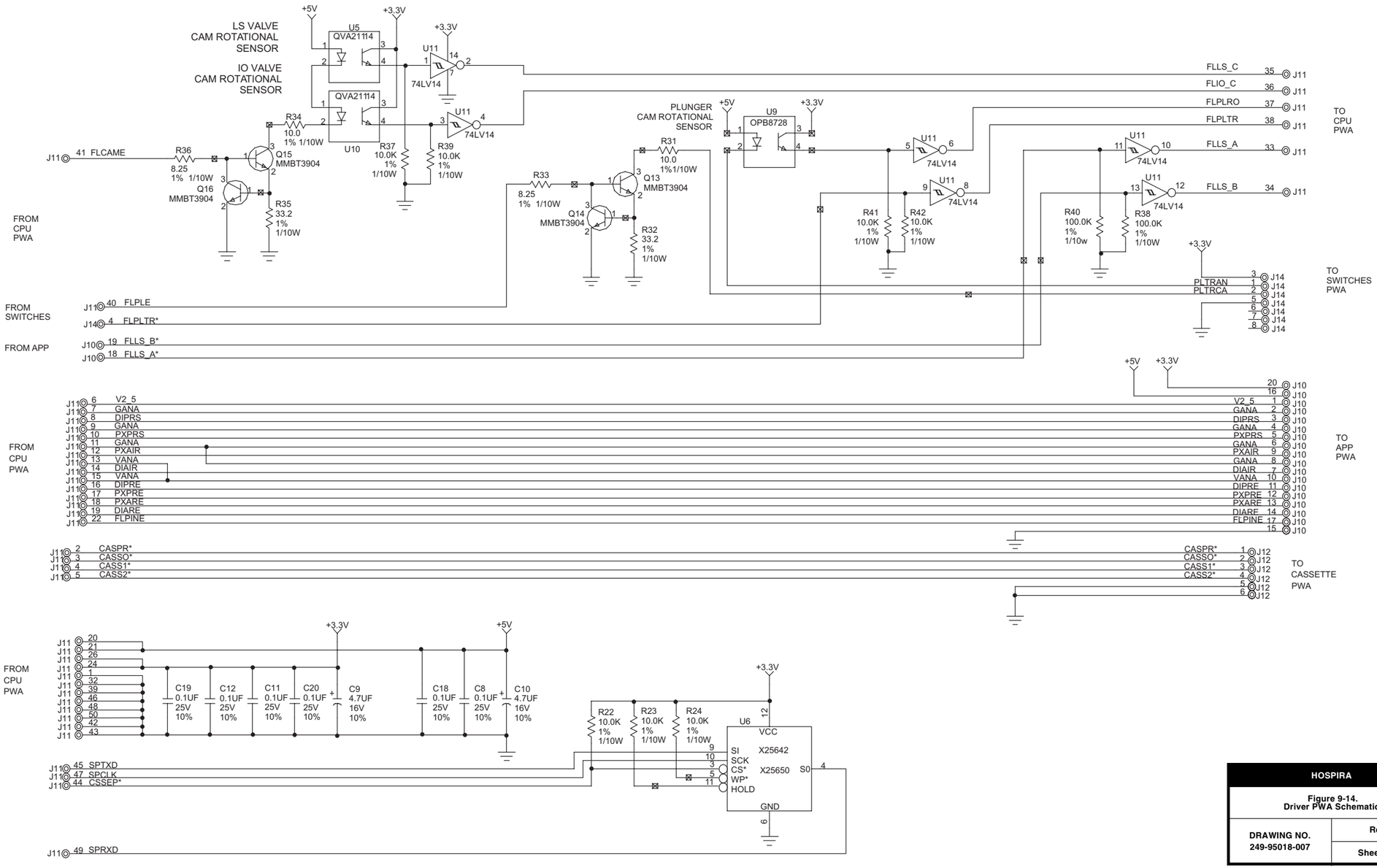

HOSPIRA	
Figure 9-14. Driver PWA Schematic	
DRAWING NO. 249-95018-007	**Rev. E**
	Sheet 4 of 6

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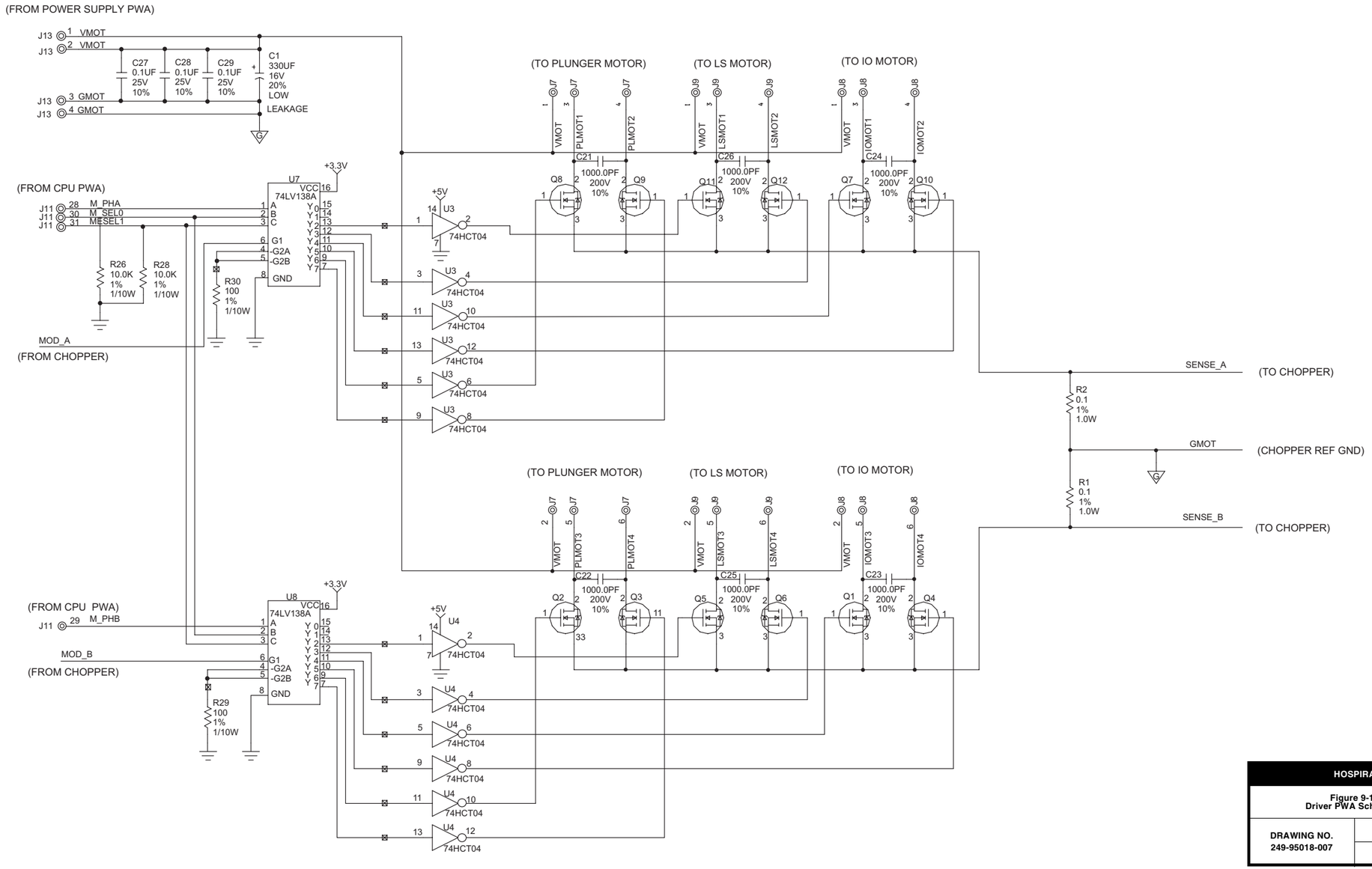

HOSPIRA	
Figure 9-14. Driver PWA Schematic	
DRAWING NO. 249-95018-007	Rev. E
	Sheet 5 of 6

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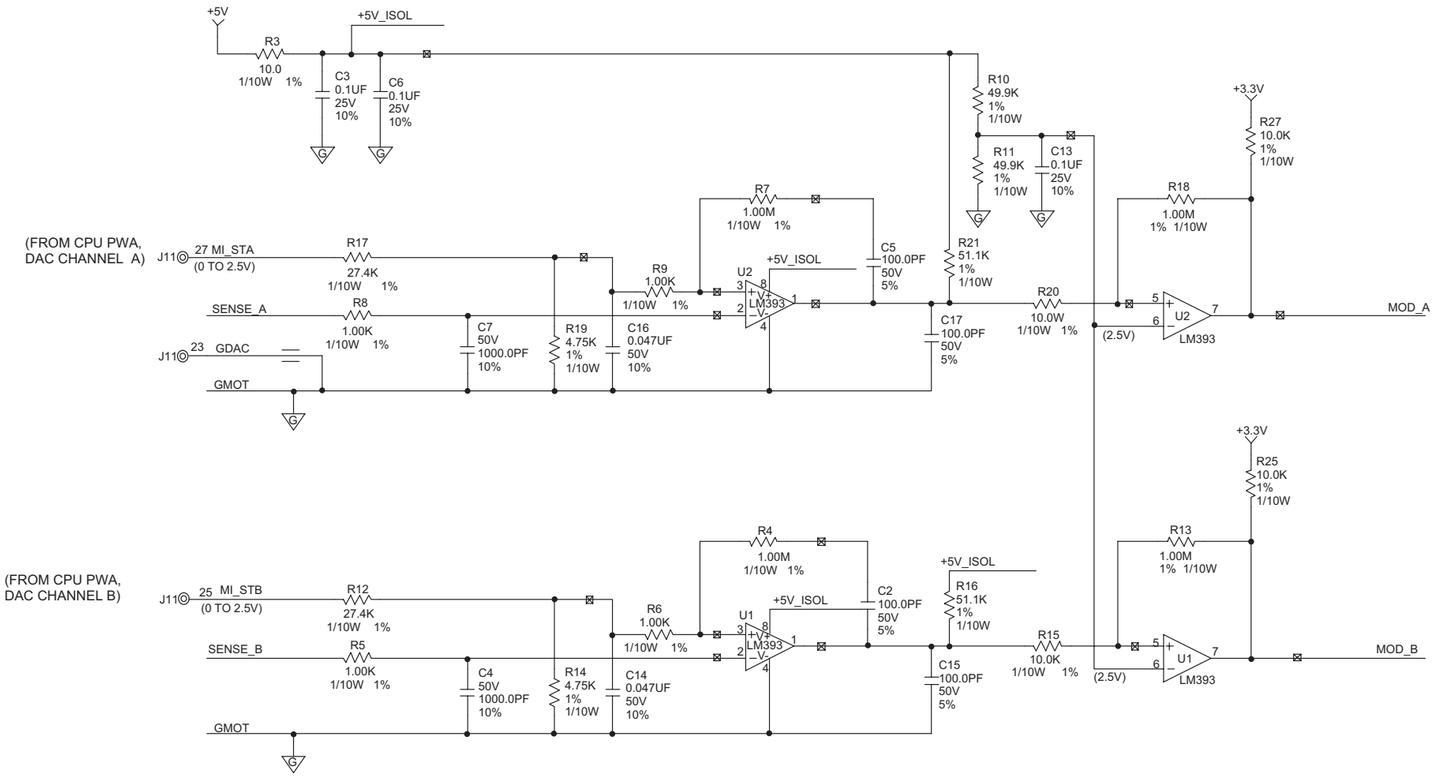

HOSPIRA	
Figure 9-14. Driver PWA Schematic	
DRAWING NO. 249-95018-007	Rev. E
	Sheet 6 of 6

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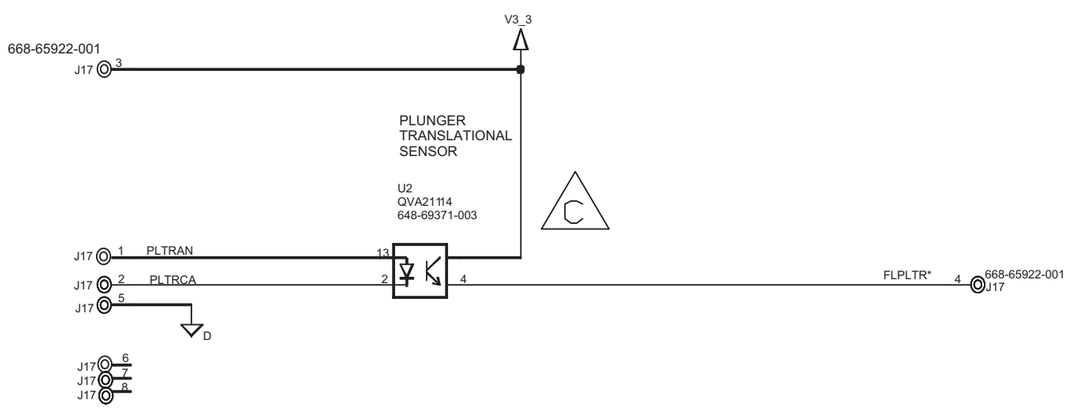

HOSPIRA	
Figure 9-15. Switch PWA Schematic	
DRAWING NO. 249-95022-004	Rev. C
	Sheet 1 of 1

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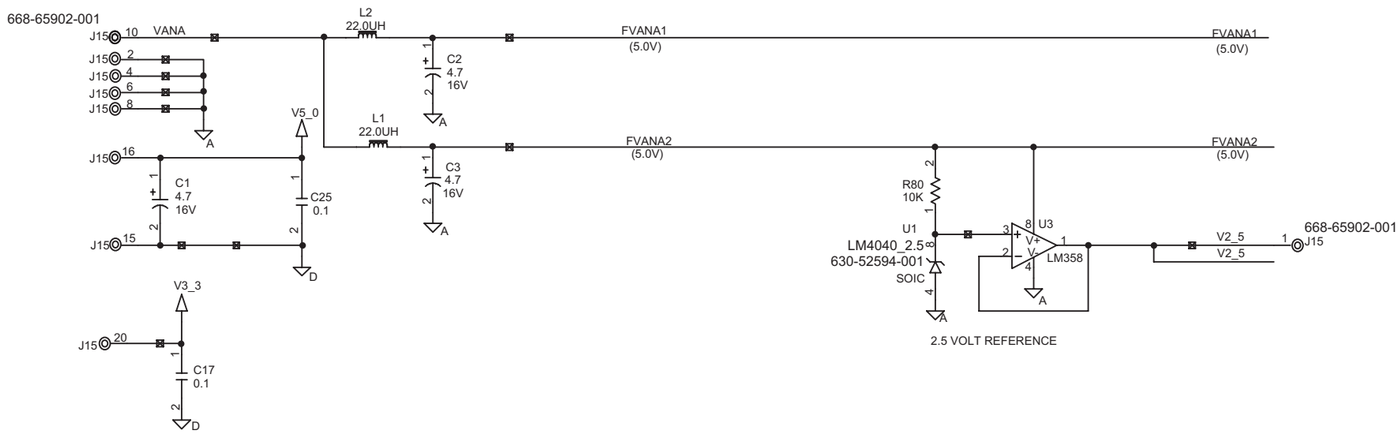

HOSPIRA	
Figure 9-16. APP PWA Schematic	
DRAWING NO. 249-95034-009	Rev. F
	Sheet 1 of 3

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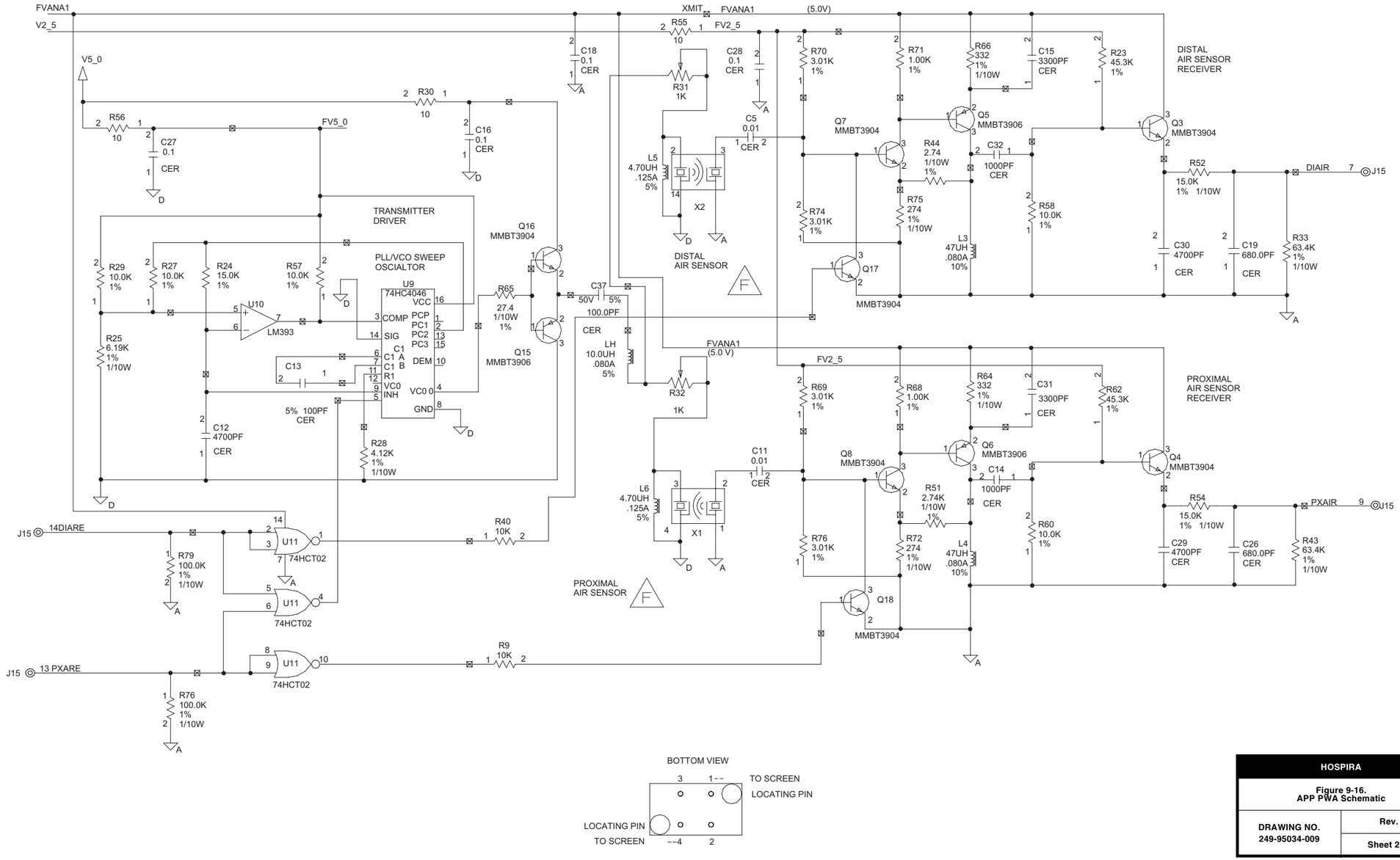

HOSPIRA	
Figure 9-16. **APP PWA Schematic**	
DRAWING NO. **249-95034-009**	**Rev. F**
	Sheet 2 of 3

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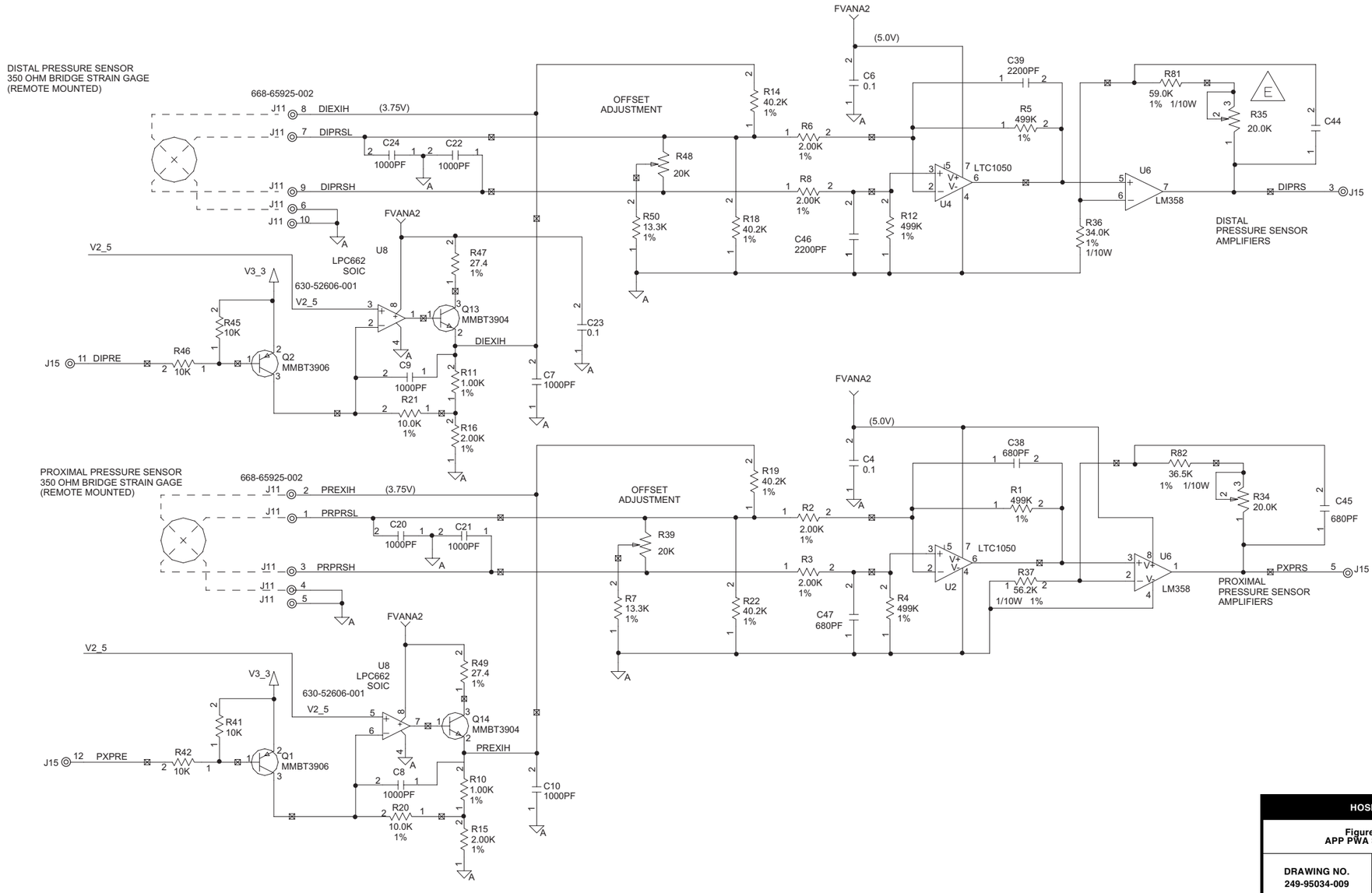

HOSPIRA	
Figure 9-16. APP PWA Schematic	
DRAWING NO. 249-95034-009	Rev. F
	Sheet 3 of 3

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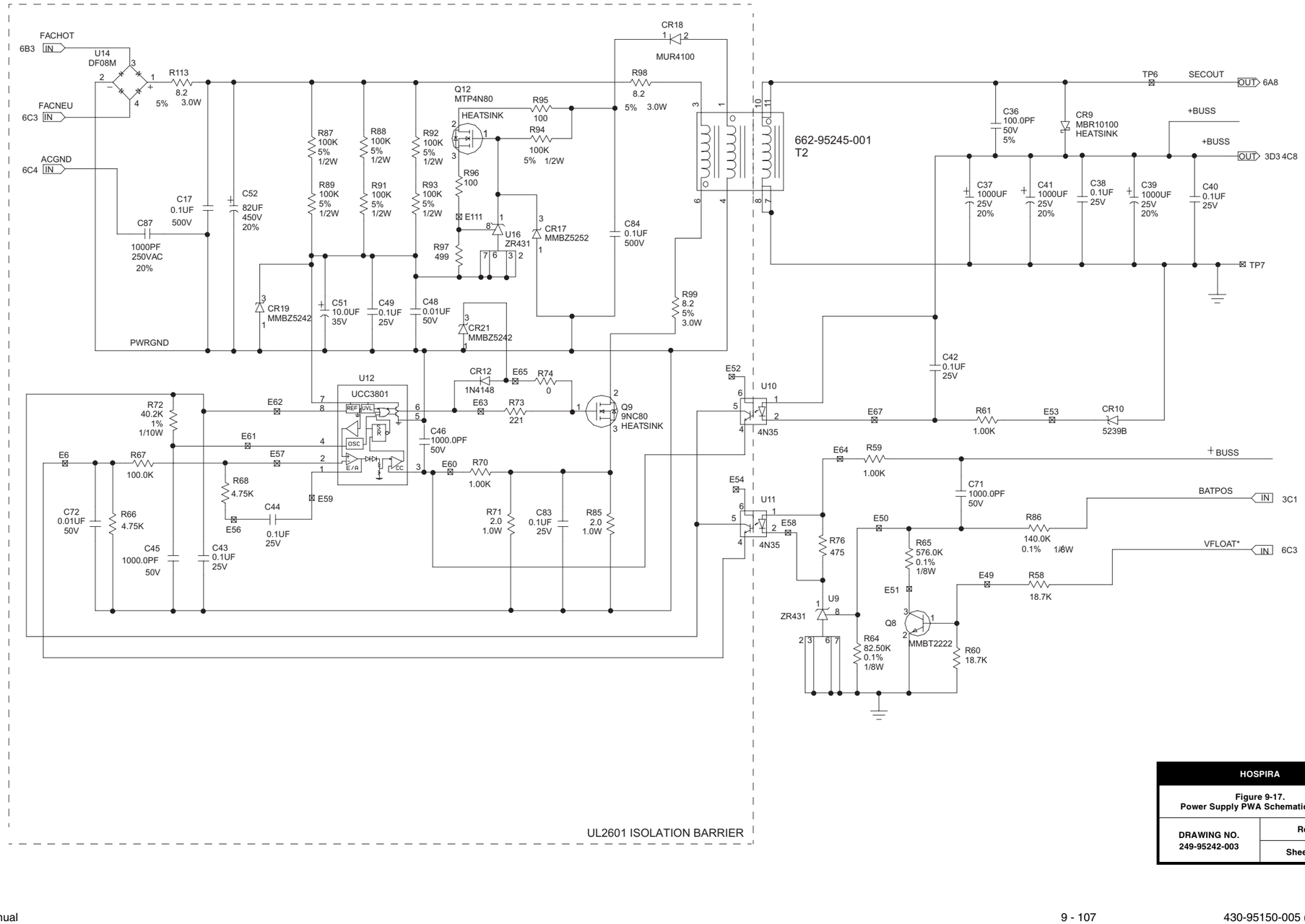

HOSPIRA	
Figure 9-17. **Power Supply PWA Schematic (220 V)**	
DRAWING NO. **249-95242-003**	**Rev. A**
	Sheet 1 of 5

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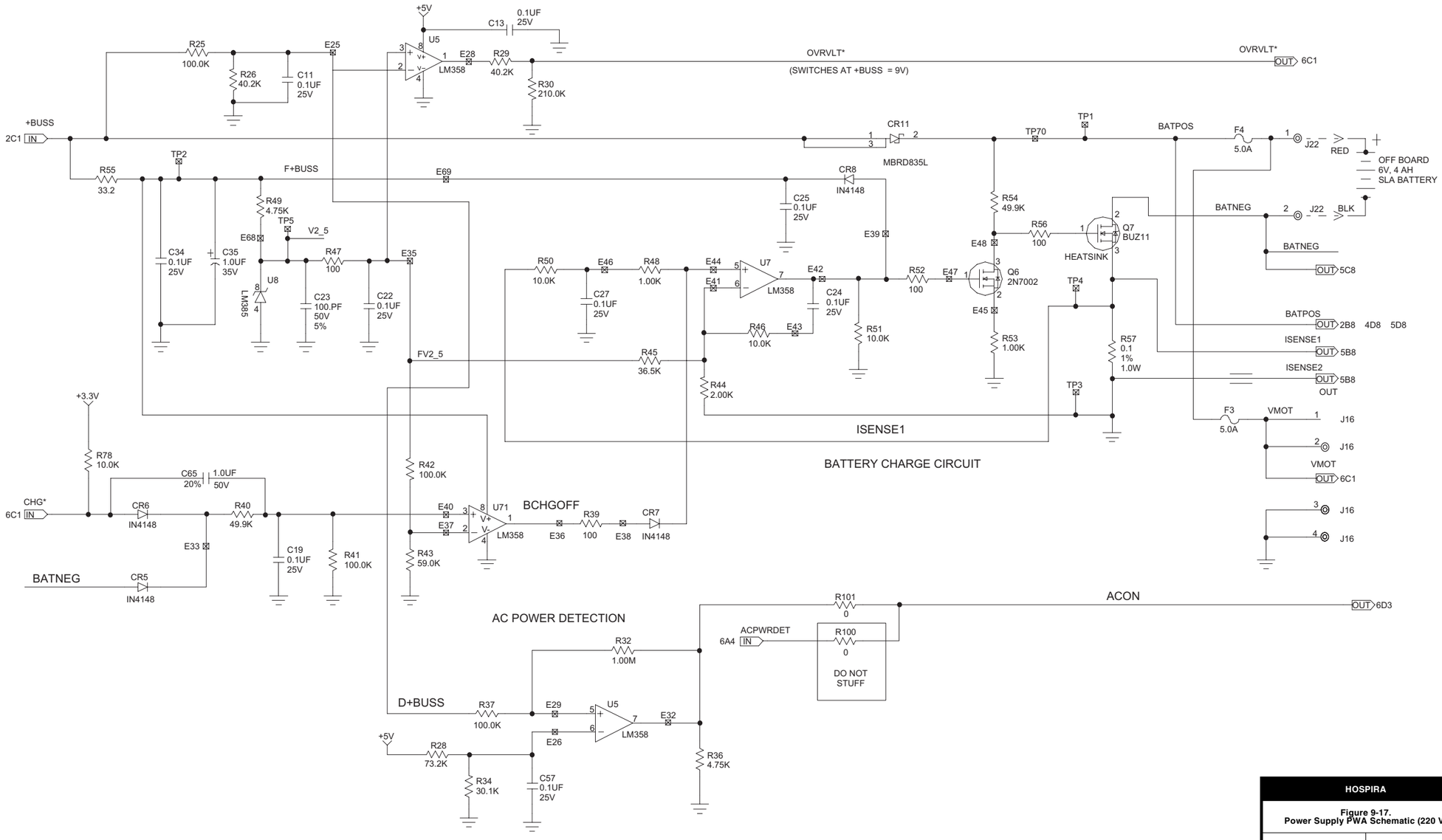

HOSPIRA	
Figure 9-17. Power Supply PWA Schematic (220 V)	
DRAWING NO. 249-95242-003	**Rev. A**
	Sheet 2 of 5

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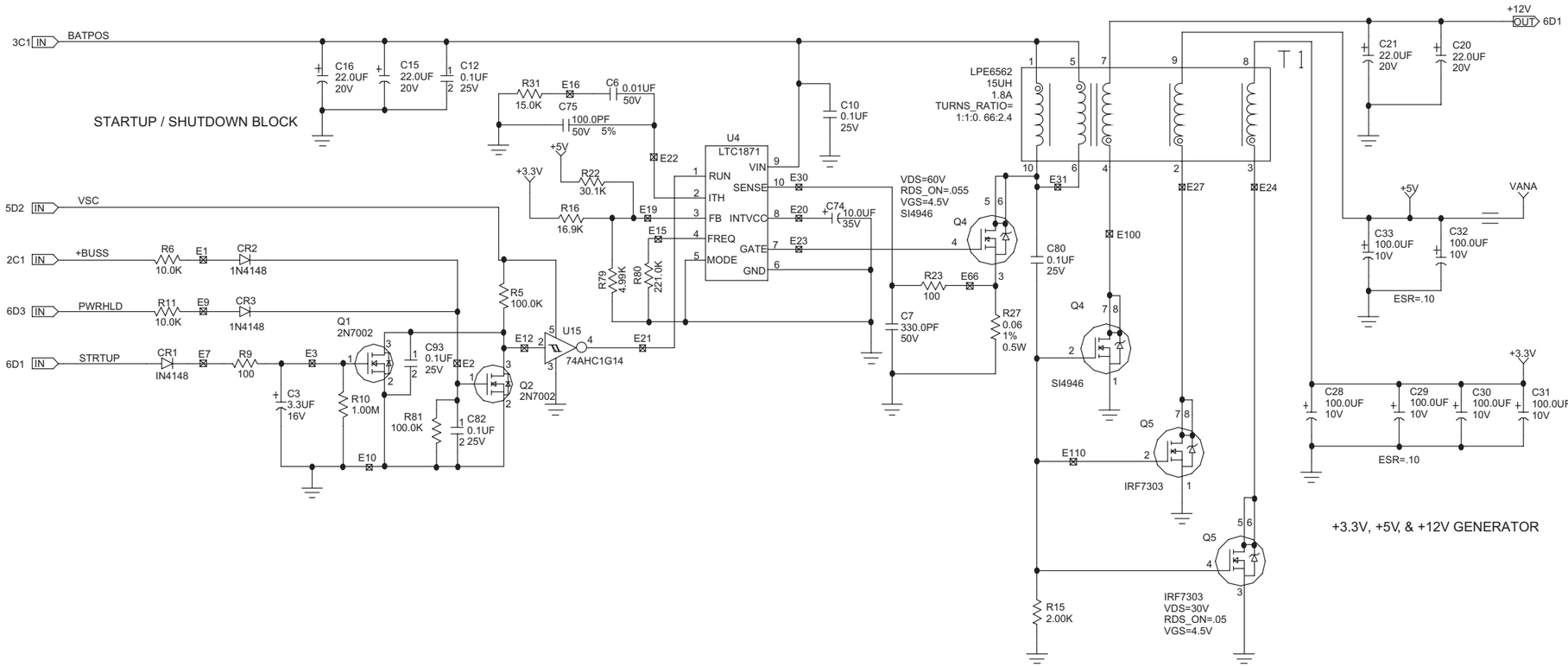

+3.3V, +5V, & +12V GENERATOR

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Figure 9-17. Power Supply PWA Schematic (220 V)	
DRAWING NO. 249-95242-003	Rev. A
	Sheet 3 of 5

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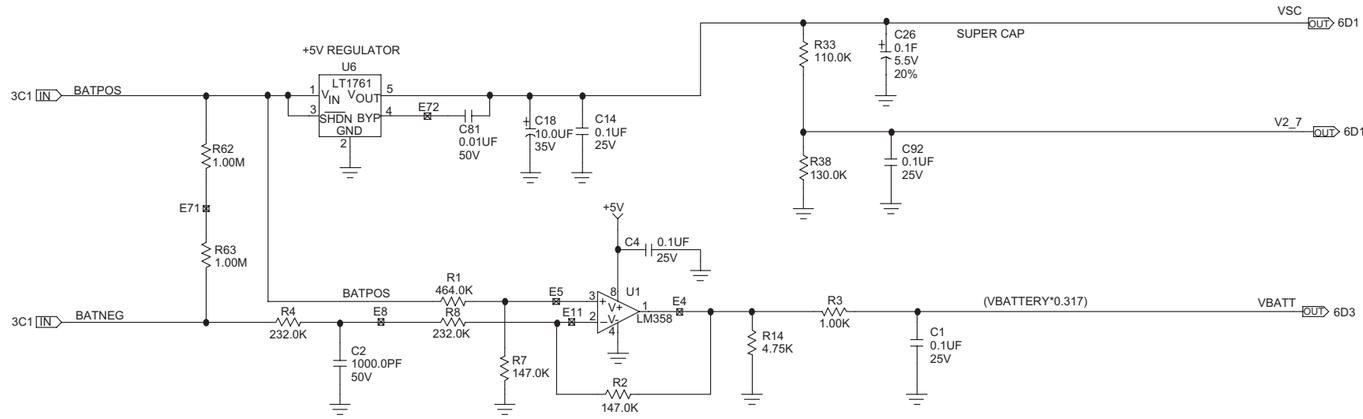

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Figure 9-17. Power Supply PWA Schematic (220 V)	
DRAWING NO. 249-95242-003	Rev. A
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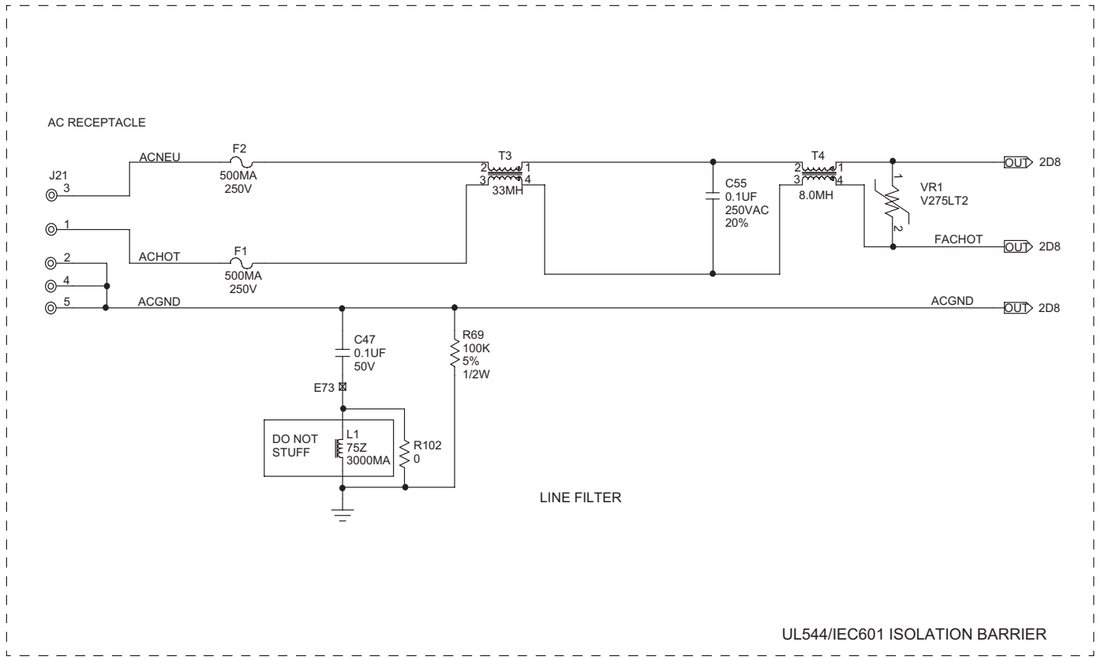

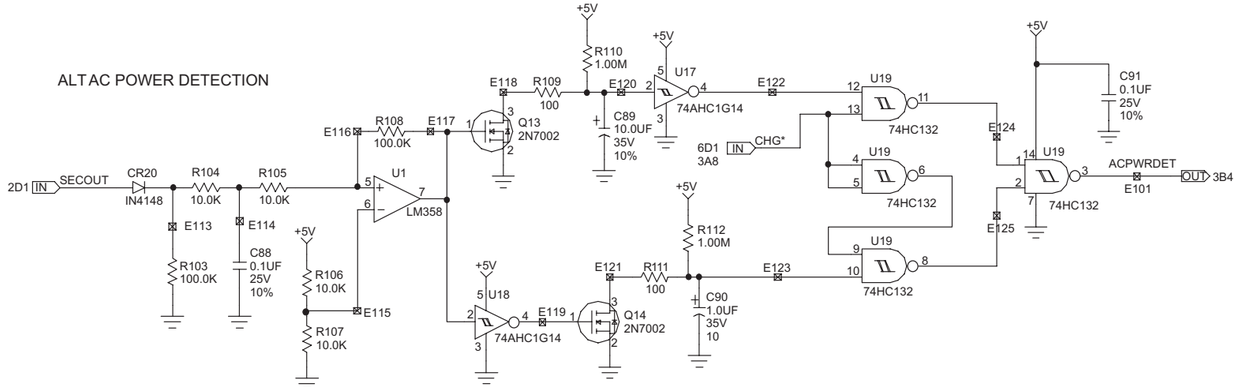

P2
CPU PWA CONNECTOR

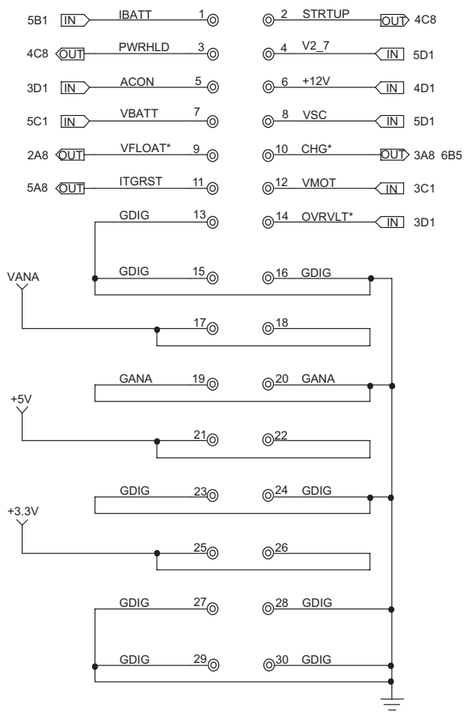

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Figure 9-17. **Power Supply PWA Schematic (220 V)**	
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