HOSPIRA

TECHNICAL SUPPORT OPERATIONS
ELECTRONIC TECHNICAL SERVICE MANUAL

APM and APM II
Infusion Pumps

EPS-85656-005 (Rev. 03/05)

Hospira

APM®

and

APM™ II

For use with the following list numbers:

13960-04 All Codes

13965-04 All Codes

Technical Service Manual

Hospira

430-85656-005 (Rev. 03/05)

Change History

Part Number	Description of Change
430-85656-001 (Rev. 02/94)	**Original issue**
430-85656-002 (Rev. 06/94)	**Second issue** Added PVT Data Form and winged bottom case in appropriate figures; added international screens for global use
430-85656-003 (Rev. 08/96)	**Third issue** Reformatted text and added APM II pump information
430-85656-004 (Rev. 01/00)	**Fourth issue** Section 5: 1. Updated cleaning materials. 2. Added password protected entry to PVT mode for APM II software version 7.005 and greater. 3. Deleted description of screen messages not relevant to performance of delivery test. 4. Added configuration mode information for software 7.005 and greater. Section 6: 1. Added Year 2000 effect on Error Code Event Log description 2. Revised APM II Malfunction Code 18 to specify not applicable to software versions 7.005 and greater 3. Added section to troubleshooting table for failure to power-on with AC power supply Section 7: Defined motor repair/replacement procedure using Portescap 22N motor (motor installation differences also noted in Section 4) Section 9: Added overvoltage protection to APM PCA (see Figure 9-4 and Figure 9-5) General: Added Seiko DPU414 as compatible printer

430-85656-005 (Rev. 03/05)	**Fifth issue** Complete redesign and revision to Hospira style Removed unecessary equipment from PVT in Section 5 Reorganized and simplified repair procedures in Section 7

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Section 1

INTRODUCTION

The APM® and APM™II infusion pumps are single-channel devices designed for epidural, patient-controlled analgesia and other therapies requiring delivery rates at or below 25 mL/hr. The versatility, flexibility, and adaptability of the APM and APM II devices make them ideal for all pain management protocols.

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
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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 APM and APM II System Operating Manuals. Provision is made for the inclusion of the system operating manuals in *Section 3* of this manual.

Note: Unless otherwise specified, the terms “device” and “pump” refer to all configurations of both the APM and APM II.

Note: Non-English language keypad names and display text are not indicated in this manual.

Note: Figures are rendered as graphic representations to approximate actual product; therefore, figures may not exactly reflect the product. Display screens and key labels may vary slightly, depending on the configuration of the pump in use.

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 are described in all caps and enclosed in brackets	[1], [0], [YES/ENTER]
ALL CAPS	Screen displays	INITIALIZE NVRAM OR USE ARROWS
Bold	Emphasis	**CAUTION: Do not use the infusion pump if it appears to be damaged. Should damage be found, contact Hospira.**

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 equipment damage or loss of data.

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

1.3 ACRONYMS AND ABBREVIATIONS

Acronyms and abbreviations used in this manual are as follows:

A	Ampere
AC	Alternating current
A/D	Analog-to-digital
CMOS	Complementary metal-oxide semiconductor
CPU	Central processing unit
DC	Direct current
ECG	Electrocardiograph
EEG	Electroencephalogram
EMG	Electromyogram
EMI	Electromagnetic interference
EPROM	Electrically programmable read-only memory
ESD	Electrostatic discharge
ETO	Ethylene oxide
FDA	Food and Drug Administration
hr	Hour
IC	Integrated circuit
I/O	Input/output
IPB	Illustrated parts breakdown
KB	Kilobytes
kHz	Kilohertz
kPa	Kilopascal
LCD	Liquid crystal display
LED	Light emitting diode
mA	Milliampere
mg	Milligram
MHz	Megahertz
mL	Milliliter
mL/hr	Milliliter per hour
ms	Millisecond
mV	Millivolt
N/A	Not applicable
NVRAM	Nonvolatile random access memory
PCB	Printed circuit board
PVT	Performance verification test
RAM	Random-access memory

ROM	Read-only memory
V	Volt
$\mathbf{V_{AC}}$	Volts AC
$\mathbf{V_{BE}}$	Base to emitter voltage
$\mathbf{V_{CC}}$	Collector supply voltage
$\mathbf{V_{DC}}$	Volts DC
$\mathbf{V_{DD}}$	Drain supply voltage
$\mathbf{V_{IN}}$	Voltage in
$\mathbf{V_{OS}}$	Offset voltage
$\mathbf{V_{PP}}$	Volts peak-to-peak
$\mathbf{V_{SET}}$	Voltage set point
µA	Microampere
µg	Microgram
µV	Microvolt

1.4
APM AND APM II OVERVIEW

The APM and APM II infusion pumps share the same design and functionality, other than the hardware and software differences described in *Section 1.4.3, APM and APM II Hardware Differences*.

1.4.1
PUMP DESCRIPTION

The APM and APM II infusion pumps are single-channel devices designed to deliver analgesic drugs to patients in the hospital, in outpatient treatment centers, and at home. Primarily designed for pain management protocols, the pumps may also be used for other therapies that require infusion delivery schedules of continuous rates at or below 25 mL per hour. The pumps provide accurate, pulsatile administration of single-fluid regimens delivered via the following routes: epidural, intravenous, subcutaneous, or arterial. A remote bolus switch allows for patient controlled analgesia (PCA).

Special safety features are integrated into the pump design, which include an occlusion alarm, an air in line alarm, a motor watchdog circuit, motor parameter monitoring, and numerous backup failure detection modes to prevent single-point failures from endangering the patient.

The pump is microprocessor-based and is programmed through a 24-key keypad on the front of the pump. The state of the pump is displayed using a 16-character-by-2-line alphanumeric LCD module. Dedicated cartridges are required to deliver fluids through rotary peristaltic pumping action. Power is supplied by two, 9 V alkaline batteries, an optional nickel-cadmium rechargeable battery pack, or an external AC power supply.

APM and APM II system kits contain a pump, a remote bolus switch, a wall plug-in AC power supply (110 V or 220 V), two 9 V alkaline batteries, and a System Operating Manual. Some international configurations contain a tabletop 220 V AC power supply with a separate power cord.

1.4.2
PUMP OPERATION

The pump has several programming modes: Continuous, Bolus (PCA) only, or Continuous and Bolus (PCA). The continuous mode delivers fluid in small doses spaced evenly over time. Delivery rates and bolus dosage amounts are programmed in one of three units of measure: milliliters (mL), milligrams (mg), or micrograms (µg). A loading dose is programmable for immediate delivery or delayed delivery. Bolus doses can be programmed to begin delivery on demand.

The operator programs the pump by selecting the mode (epidural or PCA), volume delivery (mL) or mass delivery (mg or µg), concentration (only if mass delivery is selected), rate, loading dose (if desired), and total amount to be delivered. If mass delivery is selected, the pump automatically converts milligrams or micrograms to the closest number of tenths-of-mL. The amount of fluid delivered is shown on the display. When a bolus is programmed, a minimum lockout time between boluses must also be programmed. In addition to the lockout time, the operator can also program the maximum total volume that can be delivered in a selected period.

The pump contains a time-of-day clock and event history storage capability. The program settings and significant events that take place while a protocol is running can be reviewed on the liquid crystal display (LCD), along with time and date of occurrence. A printer jack allows printout of this history information when a pump is connected to a compatible printer. With proper communication software, a pump's history can also be downloaded to a personal computer as an ASCII file.

For specific instructions regarding pump operation, refer to the APM System Operating Manual or the APM II System Operating Manual.

1.4.3
APM AND APM II HARDWARE DIFFERENCES

Table 1-2, APM and APM II Hardware Differences details the significant hardware differences between the APM and the APM II infusion pumps.

Table 1-2. APM and APM II Hardware Differences

Item	APM	APM II
Winged bottom case design that stabilizes the motor if the pump is dropped	This change has been implemented for APM pumps, but some earlier models may not have this feature. All replacement bottom case assemblies have this feature	All APM II pumps are manufactured with the winged bottom case design
Add-on PCBs (not interchangeable)	Surge suppressor board	Add-on board

Table 1-2. APM and APM II Hardware Differences		
Item	**APM**	**APM II**
External unit interface	None	External unit interface uses two previously unused pins in the printer port; a circuit was added to interface pins with the microprocessor. This interface is not currently used
Circuit protection against incorrect AC power supply usage	None	A transient voltage suppressor was added to prevent damage to the U35 comparator should an incorrect AC adapter be used

1.4.4
APM AND APM II SOFTWARE DIFFERENCES

Table 1-3, APM and APM II Software Differences details the significant software differences between the APM and the APM II.

Table 1-3. APM and APM II Software Differences		
Item	**APM**	**APM II**
Scrolling	HISTORY key provides forward-only scrolling	Arrow keys provide back and forth scrolling; HISTORY key provides forward scrolling
Volume History	User can review entire history event log only	User can review entire history event log or shift and container volume information
Bolus Counts	Delivered and demand counts logged to two places (max. 99)	Delivered and demand counts logged to four places (max. 9999)
Program Totals Text	GRAND TO GO	VOLUME INFUSED VTBI
Numeric Entries	If entered value is too large or too small, pump defaults to maximum or minimum value	If entered value is too large or too small, pump defaults to zero
Micrograms Range	0.1 to 9999.9 µg	1 to 999,999 µg
Bolus Lockout Time	5 to 99 minutes	5 to 999 minutes
Volume Limits	Four-hour limit available	One-hour and four-hour limits available; epidural mode defaults to one-hour, 25 mL limit
Container Size	Pump requests TOTAL AMOUNT for container size entry	Pump requests CONTAINER SIZE

Table 1-3. APM and APM II Software Differences

Item	APM	APM II
Air Sensitivity	Defaults to HIGH setting unless keypad is locked at different setting	Sensitivity setting selected during programming
Purging	Two minute maximum; purging available only after programming complete	Four minute maximum; purging available during programming before delivery of loading dose
Loading Dose	If stopped, cannot be completed	Loading dose may be completed after an interruption
Keypad Lock	Full lock only	Full lock or container lock, which allows user to reset program and clear shift amount
Air in Line Alarm	Cleared by unlocking pump and pressing PURGE key	Cleared by pressing SILENCE then STOP, whether the pump is locked or not
RESET Key Display	`1. RESET SHIFT` `2. RESET PROGRAM`	`1. NEW SHIFT TOTL` `2. NEW CONTAINER`
CHANGE Key Functionality	Units of delivery can be changed through the CHANGE key function	Units of delivery cannot be changed without programming

1.5
USER QUALIFICATION

The APM and APM II infusion pumps are 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. Training should emphasize preventing related IV complications, including appropriate precautions to prevent accidental infusion of air.

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, pagers, 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.

1.7.1 UNPACKING

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

1.7.2 INSPECTION

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

CAUTION: Do not use the infusion pump if it appears to be damaged. Should damage be found, contact Hospira.

Inspect the infusion pump 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 *(see Section 5.1.1, Inspection)*.

1.7.3 SELF TEST

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

To perform the self test, proceed as follows:

1. Press [ON/OFF] to power on the pump.
2. Confirm the following display appears:

```
UNIT SELF-TEST
IN PROGRESS
```

3. Verify that the self test completes and that the backlight illuminates.
   - A series of short beeps sounds.
4. The current program displays if it was not cleared before the pump was powered off:

```
PCA MODE
CONTINUOUS ONLY
```

5. The unit displays the current time for several seconds:

```
TIME IS 4:19 PM
MON, SEPT 29, 03
```

   - If the time and date are incorrect, refer to *Section 1.7.4* to change the settings.
6. If the history and the previous program have not been cleared, the following display appears:

```
CLEAR HISTORY & Rx?
YES OR NO
```

7. Press [YES], and confirm the following display appears:

```
CLEARING HISTORY
AND Rx
```

   - No response is required.

8. Confirm the following display appears:

```
HISTORY AND Rx
   CLEARED
```

- The previous program and history are cleared. The pump automatically advances to the next screen:

```
EPIDURAL MODE
  YES OR NO
```

1.7.4 SETTING THE TIME AND DATE

The set the time and date, proceed as follows:

1. Confirm that the pump is in stop mode, and the following screen displays:

```
PRESS RUN/STOP
  TO INFUSE
```

2. Press [ENTER], then [2], and confirm the following display appears:

```
12-HOUR CLOCK?
  YES OR NO
```

- Press [YES] for the 12-hour clock or [NO] to choose the 24-hour clock.
- After selecting the appropriate clock, confirm the following display appears:

```
SET MONTH (arws)
 AUG 6,04 9:05A
```

3. Use the [△] or [▽] keys to select the month. Press [ENTER].
4. Use the number or arrow keys as indicated to change the day, year, hour, minute, AM/PM, and the day of the week. Press [ENTER] to accept each change.
5. When all changes are made, the changed time and date briefly display, then the pump returns to the stop mode.

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, 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, revenue, or profits. Warranty product returned to Hospira must be properly packaged.

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, defaced, 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.

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 an Hospira representative performing repair or service is not an authorized agent of Hospira.

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Section 3

SYSTEM OPERATING MANUAL

A System Operating Manual is included with every APM and APM II infusion pump. 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 APM and APM II theory of operation. Related drawings are provided in *Section 9, Drawings*. The theory of operation details the general description, circuit block diagram, and circuit description.

4.1 GENERAL DESCRIPTION

The pump has a modular construction that consists of top and bottom case assemblies; a motor frame mounted with the latch, motor, and optics assemblies; and a printed circuit board (PCB) with mounted display module assembly *(see Figure 4-1, Assemblies)*.

The top case is constructed of durable, shock-resistant plastic that contains or is coated with a conductive material to provide enhanced ESD and EMI protection for the pump electronics. A clear plastic window protects the liquid crystal display (LCD) mounted on the PCB. The keypad provides user interface with 24 membrane switches connected to the PCB by a ribbon cable threaded through a slot in the top case. Refer to the pump's System Operating Manual for descriptions of key functionality.

The bottom case is constructed of the same durable, shock-resistant, ESD/EMI-protected plastic as the top case. The battery door is removable to allow access to the battery compartment. Battery terminals are constructed of spring clips that are insulated from the conductive case. Positive and negative contacts are identified. Batteries are installed in a diode-isolated parallel configuration. Wires housed in a crimp terminal connect the four battery contacts to the PCB.

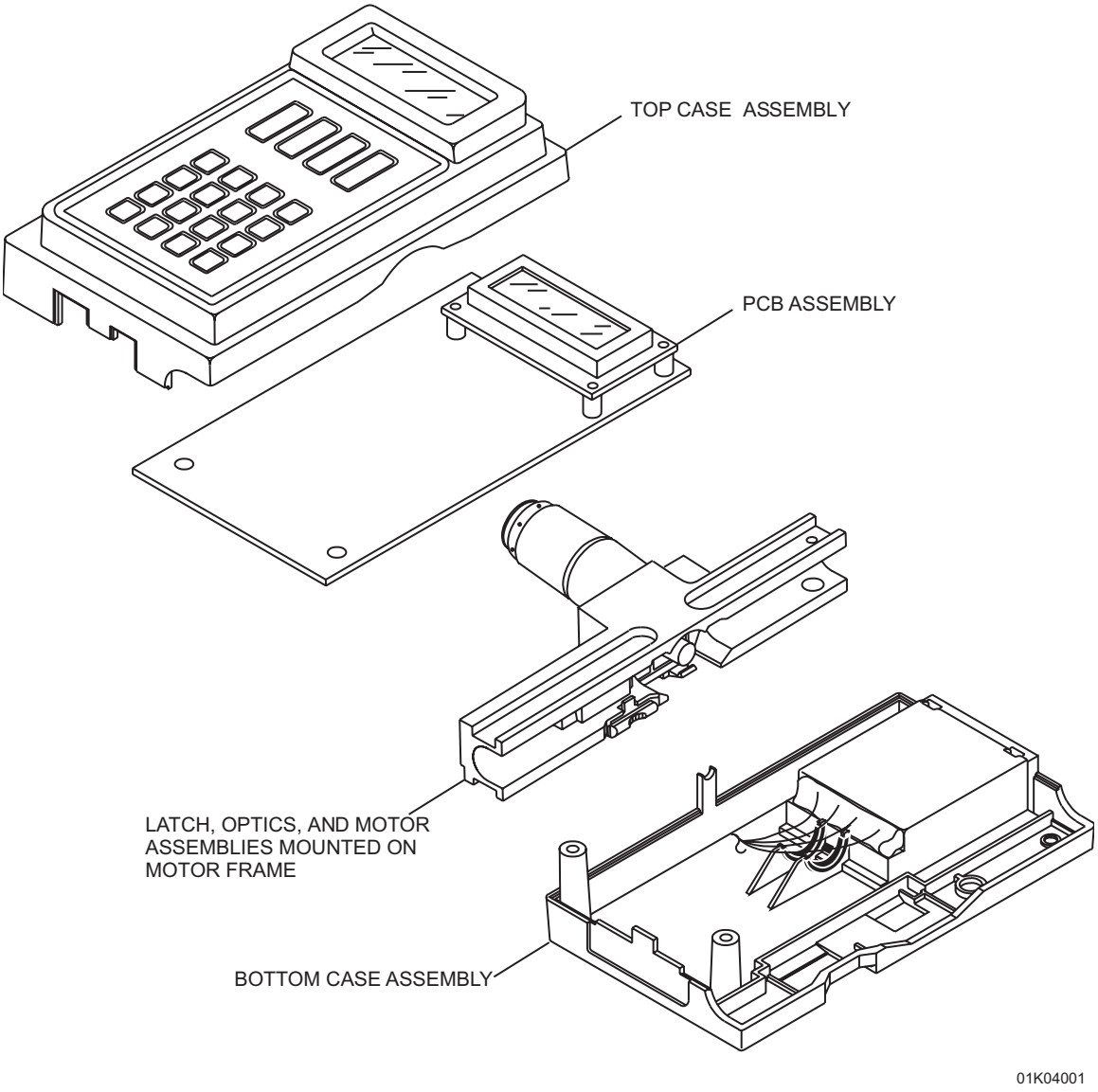

Figure 4-1. Assemblies

4.1.1 MOTOR FRAME

The motor frame aligns the cartridge to the drive motor and optical sensors, and completes the outer part of the pumping mechanism *(see Figure 4-2, Motor Frame)*. The alignment of the cartridge is critical to the performance of the pump. Air in line and occlusion detection systems require correct cartridge alignment to function properly.

The location, height, and perpendicularity of the dowel pins determine the location of the cartridge within the motor frame. Dowel pin insertion into the motor frame is accomplished by using specially designed equipment. Therefore, replacement of the motor frame must be performed by Hospira.

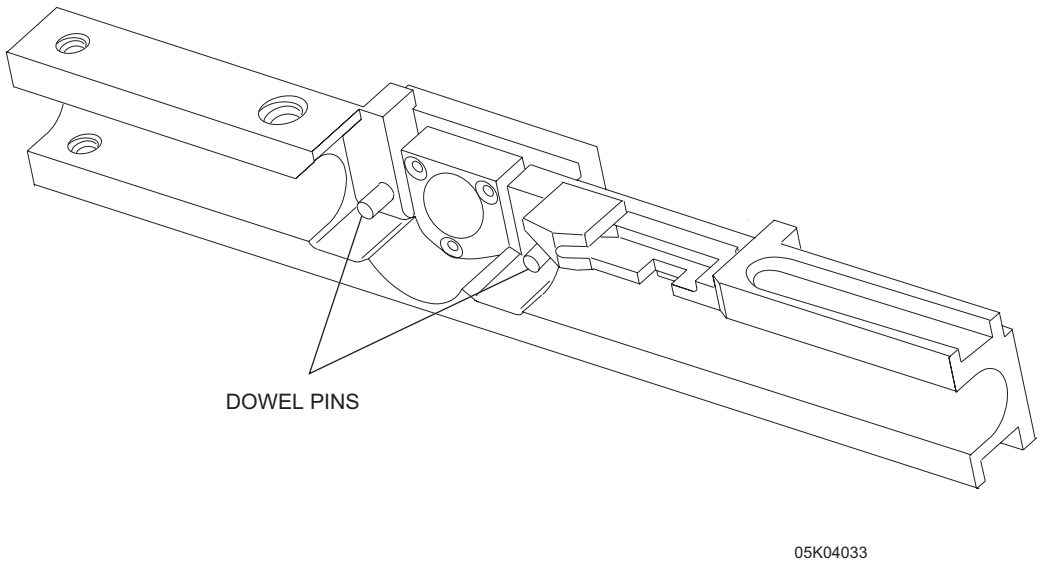

Figure 4-2. Motor Frame

4.1.2
LATCH ASSEMBLY

The latch holds the cartridge in the motor frame with tabs at two points to keep it properly aligned to the motor and the optics assembly. One capture point on the cartridge is the indentation on the side of the cartridge near the rotor; the second point is a protruding tab on the cartridge next to the blue foil.

Two pivot pins hold the latch assembly onto the motor frame. Once the pump is assembled, tabs hold the pivot pins in place *(see Figure 4-3, Latch Assembly)*.

The latch is opened by moving the thumb tab down and rotating it back. This action rotates the lever arms outward from the motor frame and ejects a cartridge if one is installed. The latch is closed and the cartridge locked into place by moving the thumb tab down, inward and then upward.

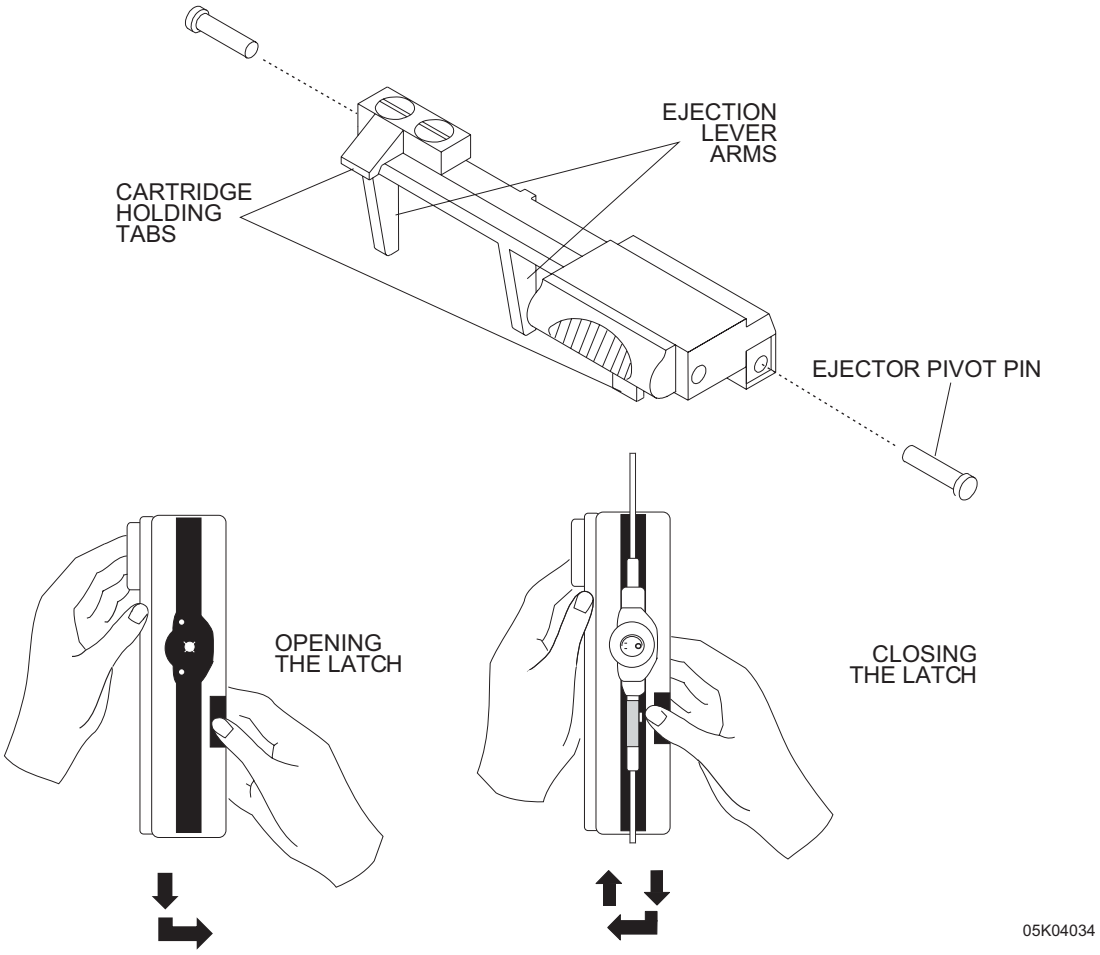

Figure 4-3. Latch Assembly

4.1.3
MOTOR ASSEMBLY

The motor assembly is attached to the motor frame with three locking screws. The motor consists of a DC brush-type, iron-less core motor with attached gearbox and integral tachometer built into the motor. An extension is attached to the motor shaft to mesh with the cartridge rotor *(see Figure 4-4, Motor Assembly)*.

All motors are tested at the factory and a resistor may or may not be added to make all motors electrically interchangeable. If a resistor is installed, the white/red wire is attached to the resistor lead and the yellow wire is not present.

Note: The Portescap 22N motor has replaced the 22C motor for use in the APM and APM II. **These motors are not interchangeable**. Motor assemblies using 22N must have an encoder PCB attached. To upgrade to a 22N motor, *see Section 7.2.4.1, PCB Modification for the 22N Motor*.

4.1.3.1
MOTOR GEARBOX

The motor gearbox contains a 128:1 gear reduction to transform the relatively high speed, low torque output of the motor to the slower speed, higher torque requirements necessary to drive the rotary peristaltic cartridge pumping mechanism. The pump drive motor is driven at various speeds, depending on the rate programmed.

4.1.3.2
MOTOR TACHOMETER

The tachometer consists of a disk mounted on the motor shaft on the end of the motor opposite the gearbox. The flat surface of the disk is dark colored (not light-reflective) over approximately 180 degrees of rotation and is light colored (light-reflective) over the remaining 180 degrees of rotation. A side-by-side, light emitting diode (LED) and phototransistor pair is mounted over the surface of the disk, such that the light beam from the LED shines on the disk, and the phototransistor receives the reflected light from the disk.

As the disk rotates, the phototransistor receives high and low levels of light reflected, depending on whether the light or dark area of the disk is closest to the phototransistor. The output of the phototransistor is connected to an electronic circuit that transforms the light-to-dark-to-light transitions into pulses that correspond to motor turns. For each 128 pulses, or motor turns, the gearbox output shaft going to the cartridge completes one full turn, resulting in a fluid delivery of approximately 0.0876 milliliters (mL). The pump's software keeps track of volume of fluid delivered by counting pulses.

4.1.3.3
MOTOR SHAFT EXTENSION

The motor shaft extension is cast with splines that mesh with the rotor in the cartridge set. The motor shaft extension is attached to the motor with a set screw.

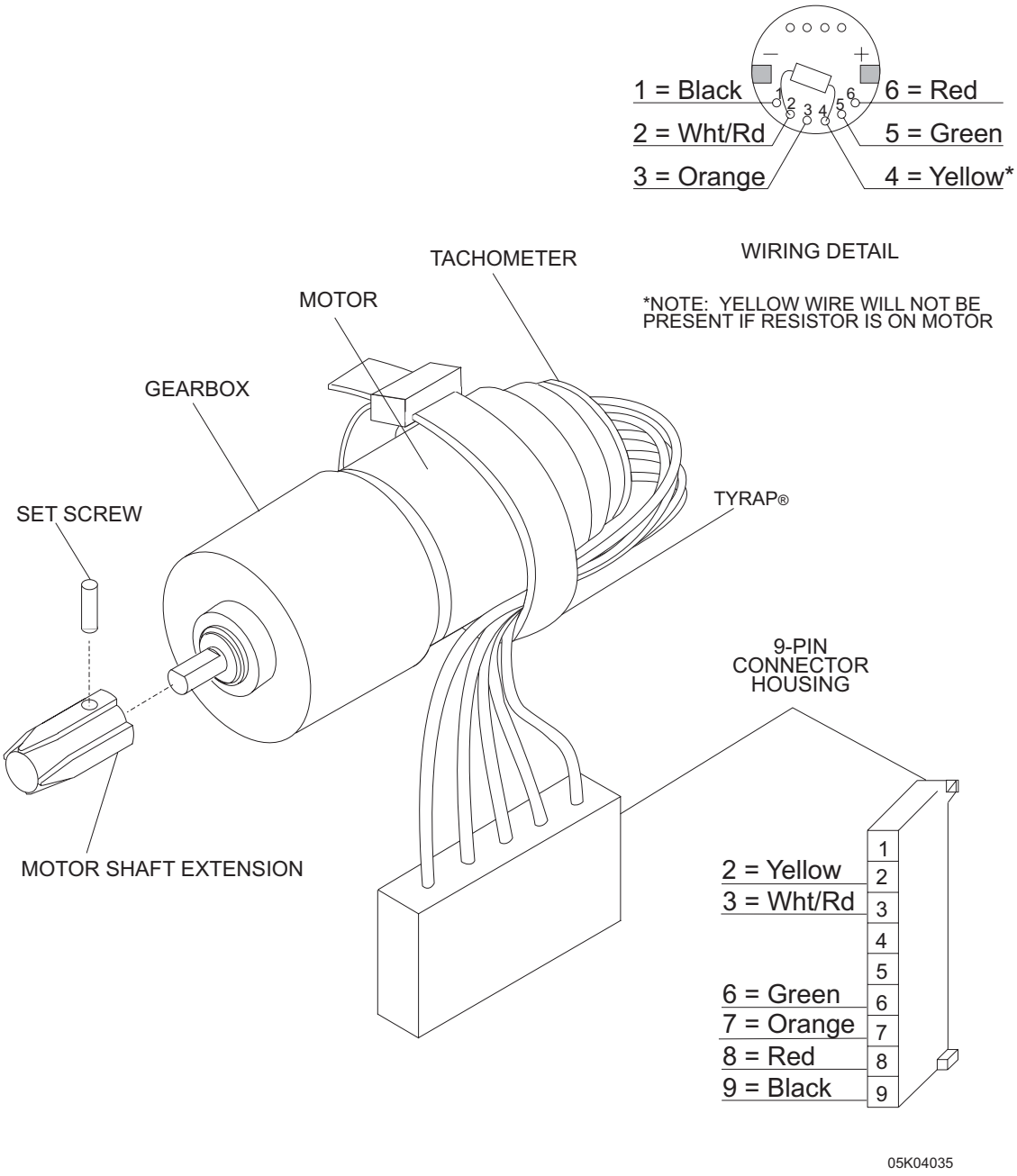

Figure 4-4. Motor Assembly

4.1.4
OPTICS ASSEMBLY

The optics assembly is attached to the motor frame with two screws. The optics assembly consists of a carrier that holds two mounted LED/phototransistor pairs and four optics surfaces *(see Figure 4-5, Optics Assembly)*. The LED/phototransistor pairs detect air in line and occlusion conditions by reflecting infrared light beams off a sensing chamber within the cartridge. In order to function correctly, the optics surfaces must be kept clean and free of scratches, which could impede light transmission, and the cartridge must be inserted correctly so that the sensing chamber of the cartridge aligns properly with the optics detectors.

The LED/phototransistor pairs, functioning properly with the cartridge sensing chamber, perform the following functions.

4.1.4.1
AIR IN LINE DETECTION

When fluid is present in the cartridge it diffuses light from the LED, thus the air-detection phototransistor receives relatively low levels of light and remains in the OFF state. When air is present in the sensing chamber of the cartridge, however, the air behind the surface of the sensing chamber makes the sensing chamber behave as a mirror, reflecting much of the light from the LED to the phototransistor. Presence of air thus causes the air-detection phototransistor to go further into conduction. In summary, air-detection phototransistor ON = air in line condition.

4.1.4.2
OCCLUSION DETECTION

When no occlusion condition is present, light from the LED reaches the occlusion phototransistor, driving it further into conduction. When a distal occlusion condition is present, cartridge rotation causes fluid pressure to expand a small balloon segment within the cartridge-sensing chamber. When the balloon expands sufficiently such that a significant amount of the balloon surface touches the plastic on the inside of the sensing chamber, the mirror surface becomes less reflective. An occlusion condition therefore results in a decrease in occlusion phototransistor drive and causes the transistor to go further out of conduction. In summary, occlusion phototransistor OFF = occlusion condition.

4.1.4.3
CARTRIDGE INSTALLATION

When no cartridge is installed in the pump, or the cartridge is incorrectly installed or defective, and the pump has been placed in the run mode, the occlusion-detection LED/ phototransistor pair activates a check cartridge alarm. Once the pump is running, the occlusion alarm is displayed for any interruption of the light beam.

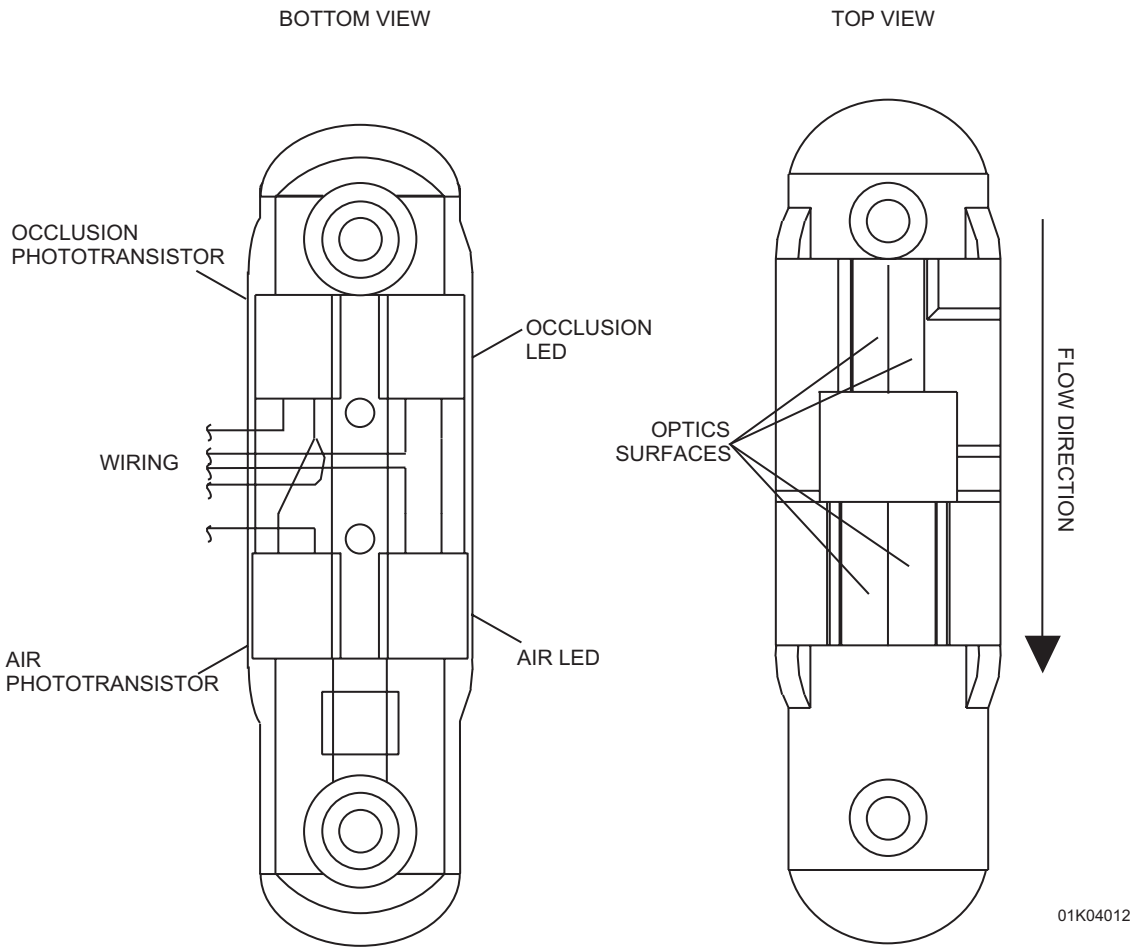

Figure 4-5. Optics Assembly

4.2 ELECTRONIC SYSTEM OVERVIEW

The basic electronic system consists of the following components *(see Figure 4-6, Circuit Block Diagram)*.

- ❏ Microprocessor
- ❏ External EPROM
- ❏ Port Expander
- ❏ External Timer
- ❏ Alphanumeric Display Module
- ❏ Power Supply
- ❏ Tachometer
- ❏ Motor Drive
- ❏ D/A Converter
- ❏ Optics Interface
- ❏ Serial EEPROM
- ❏ Isolated Printer Interface

A particular pin of a component is identified by appending the pin number to the component designator with a dash. For example, integrated circuit 10, pin 8 is written as U10-8.

4.2.1 PRINTED CIRCUIT BOARD

Table 4-1, PCB Reference Designators, lists reference designators on the printed circuit board (PCB) assembly.

Table 4-1. PCB Reference Designators

BT	battery	**MOT**	motor
C	capacitor	**PCB**	printed circuit board
D	diode	**Q**	transistor
E	enable test point	**R**	resistor
F	fuse	**SP**	speaker or beeper
J	jack	**T**	transformer or transducer
JP	jumper	**TP**	test point
L	inductor	**U**	integrated circuit
LED	light emitting diode	**X**	crystal

4.2.1.1
MICROPROCESSOR AND EXTERNAL EPROM

The CMOS microprocessor, with internal EEPROM, counter/timers, RAM, and A/D converter, is configured in the expanded multiplexed mode, which utilizes an external EPROM for program memory (64 KB x 8 bit). The address latch demultiplexes the multiplexed lower eight bits of the address/data buss into address bits A0 through A7. The microprocessor has a number of general-purpose I/O ports used to interface to the motor control and monitoring circuits.

The major digital modules of the circuit are interfaced to the main address and data busses of the microprocessor, and are thus considered to be memory mapped. Each digital peripheral device has its unique address and is addressed just like external memory. The microprocessor can be placed in two different low-power modes to extend battery life.

4.2.1.2
PORT EXPANDER

Because the number of port lines available on the microprocessor is not sufficient to interface to the entire system, the port expander was added to increase the total number of available ports. The port expander essentially replaces port lines that are lost to address and data lines because the microprocessor is configured in the expanded multiplexed mode. The 24-key keypad is interfaced to the system via the port expander ports. The remote bolus switch jack is also interfaced to these ports.

4.2.1.3
EXTERNAL TIMER

An external timer is utilized (in addition to the timers internal to the microprocessor) to maintain the current time and date and to generate timing interrupts to the microprocessor. Because the timer operates on only a 32 kilohertz (kHz) crystal, and the microprocessor on a 2 megahertz (MHz) crystal, the timer can operate at much lower standby currents than the microprocessor to greatly extend battery life. The microprocessor can be put in the stop mode without interrupting the external timer. The timer automatically switches over to an internal backup battery when the 5.0 V supply provided by the power circuit is no longer present.

4.2.1.4
ALPHANUMERIC DISPLAY MODULE

The alphanumeric display is a 16-character-by-2-line LCD module that interfaces to the address and data busses and provides programming and operating status information to the user. The module contains all I/O interface and LCD driver circuitry built in on its own printed circuit board.

4.2.1.5
POWER SUPPLY

The power circuit provides regulated 5.0 V to most of the devices in the system and also generates power-fail interrupts and reset signals to the microprocessor under certain low-voltage operating conditions. Because some of the circuitry is utilized only part of the time, the power-switching circuit was added to allow the microprocessor to cause power to be applied to these low-duty cycle use circuits only when needed.

4.2.1.6
TACHOMETER

Motor speed is indicated to the microprocessor via a tachometer and a tachometer interface circuit. The circuit interfaces to either optical or magnetic Hall-effect type tachometers and allows power to be pulsed on and off to minimize power consumption.

4.2.1.7
MOTOR DRIVE

The motor drive circuit allows the motor to be driven at various input speeds as determined by the D/A outputs under microprocessor control. The motor driver provides analog (not pulsed) DC drive to the permanent magnet DC motor. Because the drive signal is not pulsed, the motor is driven with a relatively smooth, slowly varying level to maximize brush and gearbox life. Switching regulator DC-to-DC step-down converter techniques are utilized to convert the battery voltage to a lower voltage to the motor.

Motor speed is maintained relatively constant by a servo system that utilizes motor voltage and current information to indicate the motor speed. The motor drive circuit contains safety circuits to cause shutdown of the motor to prevent runaway in the event of any single component failure.

4.2.1.8
D/A CONVERTER

To allow the motor to operate at various output speeds, a two-channel, D/A converter is used to set the speed references for the motor drive circuit. The converter provides two independent analog outputs to provide a high and low range of motor speed control, for high (bolus or loading dose) or low rates, respectively.

4.2.1.9
OPTICS INTERFACE

The optics air-detection and occlusion-detection circuits interface to the separate air-detection and occlusion-detection optics. Both air and occlusion circuits have been modified to allow microprocessor control over the trip points. The optics interface allows the optics to be pulsed on and off to minimize power consumption.

4.2.1.10
SERIAL EEPROM

A serial EEPROM interfaces to the microprocessor via port lines and is utilized for nonvolatile storage of history data that can be reviewed on the display or printed out.

4.2.1.11
ISOLATED PRINTER INTERFACE

An optically isolated RS-232 circuit interfaces the microprocessor port lines to a connector. The circuit has provision for one serial data line in, one serial data line out, and an input control line and an output control line.

4.2.2
CIRCUIT DESCRIPTION

This section describes the electronic circuitry, CPU system, and analog circuits. See *Section 9, Drawings*, for schematics and PCB assembly drawings.

4.2.2.1
MICROPROCESSOR (CPU)

The heart of the CPU system is the Motorola 68HC11E1FN CMOS microprocessor (U2). The microprocessor is configured in the expanded multiplexed mode through the pull-up connections at MODA and MODB inputs. When the microprocessor is reset, both of these inputs are read as “1’s,” which instructs the microprocessor to go into the expanded multiplexed mode. Other modes can be initiated at reset by pulling one or both of these lines low with a clip lead to digital ground. For troubleshooting the address decoder circuit, initiate mode B testing by grounding TP2.

The oscillator circuit is formed via X1, R13, R11, and C1. The oscillator is a single inverter parallel resonant type operating at a crystal frequency of 2.00 MHz. The resulting microprocessor bus speed is 1/4 of the crystal frequency, or 500 kHz. Resistor R13 serves to bias the single inverter in the 68HC11E1FN somewhere in the linear region of operation. Resistor R11 acts to limit the drive energy to the relatively low power capacity X1. C1 helps to establish the correct phase shift for stable oscillation to occur. Since this circuit is especially vulnerable to even very small amounts of stray capacitance from other components or runs, the layout of this circuit is extremely critical.

4.2.2.2
ADDRESS LATCH

The multiplexed address/data lines (A/D0 through A/D7) are available on PC0 through PC7, and the upper address lines (A8 through A15) are available from PB0 through PB7. Address latch U3 demultiplexes the lower address lines (A0 through A7) from the multiplexed lines A/D0 through A/D7. The address latch U3 is clocked by the U2 address strobe (AS) output connected to the G input of U3.

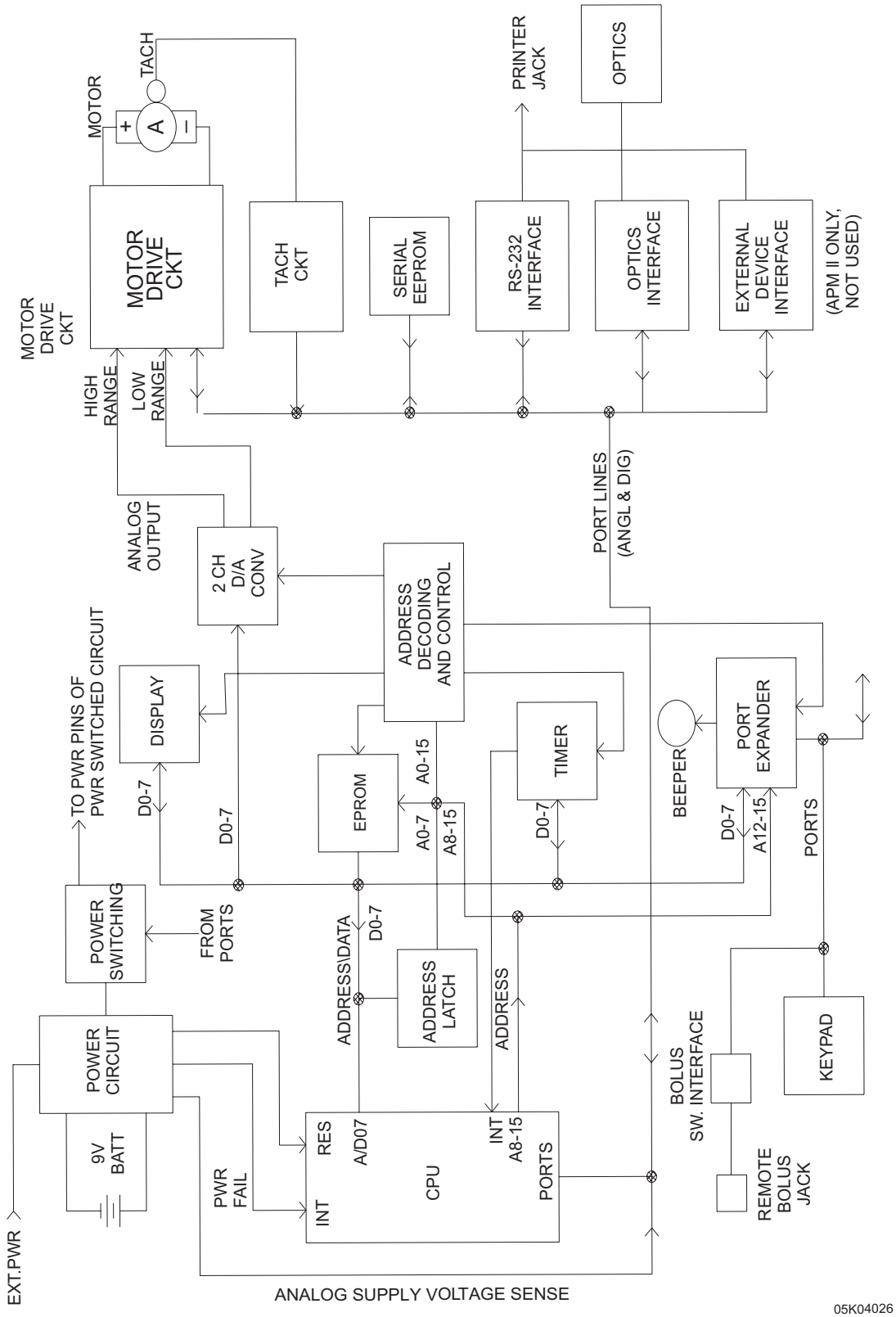

Figure 4-6. Circuit Block Diagram

4.2.2.3
PROGRAM MEMORY

Program memory is stored in a 64 KB x 8 bit CMOS EPROM (27C512), U4. The address decoding for U4 is accomplished by U17A and U14F. Any address of 1000 H or greater enables gate U7B to cause the U4 chip enable input to pulse low when E clock and Read are simultaneously high. Thus U4 is chip selected for any read operation whose address is 1000 H through FFFF H.

4.2.2.4
PORT EXPANDER

The address decode for the port expander U1 consists of U14C and internal decoding from A12 through A15. Following reset, U1 is addressed as 12XX, 13XX, 16XX, 17XX H, etc., but the software reprograms U1 to an address of 02XX, 03XX, etc. The port expander adds two extra 8-bit ports to the system as PC0 through PC7 and PB0 through PB7. Note that reset on U1 is connected to the same reset as U2, so that both ICs are reset simultaneously.

4.2.2.5
EXTERNAL TIMER

U9, U7C, U8B, and associated inverters decode the address for the timer. U9 decodes the address 08XX H, where U7 defines the lower two nibbles to be in the range of 00 H to 1 FH. U8 decodes the total address to thus be in the range of 0800 H to 081 FH. The $\overline{RD}$ and $\overline{WR}$ control lines with proper timing are generated by summing the E clock from U2 with read or write, respectively, via U8C and U8D. 1M pull-up resistors such as R17, R15, and R16 pull up control lines to maintain the U5 power consumption low when the 5.0 V supply is not present. When the 5.0 V supply drops below a preset threshold, U5 contains internal circuits that automatically switch the U5 ground circuit to the negative side of the three volt lithium backup battery BT1. Address lines A0 to A4 are connected directly to the multiplexed address/data bus, because U5 contains its own address latch clocked by the U2 address strobe (AS) connected to the U5 ALE input.

The oscillator circuit for U5 consists of components X2, C7, and C8. C7 is an adjustable trimmer capacitor to allow trimming the time base for minimal timing error. The oscillator circuit is similar to the microprocessor oscillator (U2), except that the frequency and resultant power consumption is much lower. The U5 oscillator circuit is also susceptible to coupling from other components or traces. The effective ground for the U5 oscillator is 5.0 V. Interrupts to the microprocessor can be generated through pin 6 of U5 via an open drain output pulled up by R12.

4.2.2.6
LCD ALPHANUMERIC DISPLAY MODULE

U6 and U7A perform address decoding for the LCD module. U6 combines the decode of 08XX from U9 with the decode of XX20 to XX23 to result in a decode of 0820 to 0823. When this is ANDed with $\overline{A1}$ via U7A and E clock, the final resultant decode is 0820 to 0821 to the display from U8A. The ANDing of E clock with the address decode assures that only stable address decode, glitch-free enable pulses are presented to the enable display input. The display is configured to operate in a 4-bit mode with only the upper four data bits being connected to the display — DB4 to DB7. U12 serves as a switch for the bidirectional-directional AD4 to AD7 lines to allow these lines to be effectively disconnected from the display when the display power is shut off.

Display power is shut off by the microprocessor when the display is not needed in order to minimize 5.0 V drain current. Power to the display can be turned on and off via PB5 (DISPLAY PWRON) from the microprocessor. When power to the display is shut off, gates U13A to U13C cause the control lines to the display to go to zero volts. Transistor Q7 functions as the power switch to the display to turn the display's V_{DD} power on and off. The RC and diode networks (C29, R49, D7; and C30, R50, and D6) function as time-delay circuits to assure that all signal lines to the display are either at 0 V or floating before V_{DD} to the display is shut off. When V_{DD} is turned back on, the delay circuits allow V_{DD} to be applied to the display before signal lines become active. These delays are necessary to prevent latchup in the display when switching display power on and off.

4.2.2.7
D/A CONVERTER

Address decoding for the D/A converter is the same as address decoding for the display as described above, except that A1 is used in place of $\overline{A1}$ to give the resultant address of 0822-23 for the DAC. Address bit A0 determines whether the A or B section of the two-channel D/A converter is addressed, thus 0822 addresses section A and 0823 addresses section B of the DAC. The $\overline{WR}$ input clocks the DAC when WRITE and Eclock are both high, with the same signal that clocks the $\overline{WR}$ of the timer.

4.2.2.8
KEYPAD

The keypad interfaces to the microprocessor via port expander ports PC0 to PC5 and PB0 to PB4. The four columns of the keypad are driven by output ports PB03, and the six rows are read by input ports PC05. Diodes D20 through D23 are in series between the column drive and the actual column of the keypad for isolation that prevents conflicts should two or more keys in the same row be pressed simultaneously. PB4 is an extra output used currently only to drive the bolus switch interface, but also serves as a spare column drive for a fifth column to allow for potential keypad expansion.

Pull-down resistors R31 to R34, R40, and R57 keep the input ports at a 0 level until a key is pressed and the column drive is pulsed. U15A allows generation of an interrupt to the microprocessor on $\overline{IRQ}$ when the interrupt is enabled via PB7 and the on/off key is pressed in row 1, provided that the appropriate column drive for the on/off key is high. The keyboard interrupt is used to allow the microprocessor to be removed from stop mode to turn the system from off to on. U13D ORs the keyboard-generated interrupt with the interrupt from the timer to cause an interrupt to the microprocessor on $\overline{IRQ}$ for either a keyboard or a timer interrupt.

U15B and U15C are added as interface buffers to either the bolus switch or the remote bolus jack. R121, R56, R55, and C34 serve as a low-pass filter to attenuate potential noise or ESD pickup from the remote bolus switch. U15B and U15C further isolate any ESD or noise from the microprocessor port inputs. U15C will pulse high whenever the bolus switch is pressed and Column 4 drive is pulsed simultaneously. Diode D4 prevents U15C from holding row 4 drive in the low state when U15C is in its normally low-output state.

4.2.2.9
BATTERY POWER CIRCUIT

Input power from the two 9 V alkaline batteries or rechargeable battery pack is routed through diodes D1 and D2. These diodes prevent circuit damage in the event of an incorrect battery polarity and also prevent one battery from loading down or shorting out the other in case the two batteries are at different states of depletion and voltages (e.g., a new battery being paired with a depleted battery). These are Schottky diodes for minimal voltage drop. C20 provides low ESR filtering against fluctuations on the V_PWR line caused by such loads as pulses from the motor drive circuits, tachometer or optics circuits, or display LCD. R53, R54, and C65 form an attenuator and low-pass filter to allow the microprocessor's A/D port PE6 to sample the supply voltage. The attenuator attenuates by a factor of 0.3651 so that a 13.7 V supply voltage results in a 5.0 V input to the A/D (maximum input range). The low-pass filter serves to average out voltage fluctuations so that the microprocessor reads a sample of the average battery voltage.

Power can also reach the V_PWR line from an external power supply coupled to D5. D1, D2, and D5 provide isolation between the battery voltage and the external power supply. Normally, the power supply voltage (typically 12 V) is higher than the battery voltage, thus the power supply will override the batteries when it is plugged in and functioning. By sampling the voltage at PE6, the microprocessor can determine when the pump is operating on external (AC) power.

The supply voltage is regulated down to 5.0 V by the micropower voltage regulator U11. C21 provides additional higher frequency regulation and noise suppression on the 5.0 V bus. C22 provides energy storage and a 5.0 V bus loss-delay in the event of power failure to allow the microprocessor to store certain information in its internal EEPROM prior to being reset by the reset circuitry. C32 limits the rate of change of 5.0 V supply voltage when power is removed and then reapplied to prevent false resets from being issued by U16.

4.2.2.10
LOW-VOLTAGE DETECTION AND RESET

The dual low-voltage detect IC U16 functions as both a microprocessor reset and a power fail interrupt to the microprocessor. The reset is generated when the 5.0 V supply is less than approximately 3.3 V. R25, R26, and R27 form a voltage divider that attenuates the 5.0 V supply voltage down to a voltage to be compared with the approximately 1.3 V internal reference of U16. C24 provides filtering to prevent any noise pulses on the 5.0 V supply line from resetting the microprocessor. R58 adds hysteresis to the sensed input VS1 to prevent ringing of the output at O1 during transitions. When the 5.0 V supply line is below approximately 3.3 V, O1 will be high, causing transistor Q3 to be driven on, which drives $\overline{\text{RESET}}$ low. C37 provides additional filtering against noise pulses causing inadvertent resets. It is important that $\overline{\text{RESET}}$ be held low to the microprocessor down to a supply voltage of approximately 1.0 V, or the point where the microprocessor crystal oscillator stops running to assure that the microprocessor does not attempt to run at very low supply voltages and cause corruption of its internal CONFIG register. At very low supply voltages, the U16 output O1 floats high, resulting in Q3 remaining on down to approximately the V_{BE} cut-in voltage of Q3, or approximately 0.6 V.

Signal $\overline{\text{V BAT LOW}}$ goes low when the VBATT voltage drops below approximately 6 V. R59, R23, and R24 function as voltage dividers, and C23 functions as a filter, while R120 provides hysteresis. $\overline{\text{V BAT LOW}}$ is connected to the microprocessor's $\overline{\text{XIRQ}}$ input to indicate to the microprocessor that the supply power is failing, for example when the user removes the 9 V batteries and no power supply is connected to the pump.

4.2.2.11
TACHOMETER

The tachometer (encoder) circuit consists of U18 and associated components. This circuit provides a continuous square wave output to be read by the microprocessor even though the power supplied to the encoder is not continuous. This circuit allows use of either an optical or a Hall-effect type encoder. When the LED tachometer is to be used, the LED anode is connected to pin 6 and cathode to ground. When the Hall-effect sensor is used, the Hall-effect sensor ground is connected to pin 4 and the Hall-effect supply to pin 5 (+5.0 V). R46 and C28 together determine the operating frequency of U18. R45, R47, and R48 form a voltage divider to establish a set-point reference for operation of U18 at its SET input (pin 3). R48 sets a hysteresis level (Δ) above and below this selected set point of operation. The collector output from the phototransistor in the encoder is pulled up by R44 and connected to the V_{IN} (pin 2) of U18. The V_{PP} output of U18 pulses high approximately every 4 ms, turns on transistor Q8, and drives the tachometer LED ON. Shortly after V_{PP} pulses high, U18 samples V_{IN}. If V_{IN} is higher than the SET input plus Δ, then the OUT pin will be low for the next cycle. If V_{IN} is lower than the SET input minus Δ, then OUT will be high for the next cycle.

4.2.2.12
MOTOR DRIVE AND SPEED CONTROL

The following sections describe the functioning of the motor:

- ❏ D/A Converter Output
- ❏ Motor Speed
- ❏ Current Sensing
- ❏ Servo Error Amplifiers
- ❏ DC-to-DC Switching Regulator
- ❏ Runaway Prevention Circuits

4.2.2.12.1
D/A Converter Output

The current outputs of the D/A converter U20 are converted to voltages by U21A and U21C, which work in conjunction with internal resistors in U20. The output voltages at U21A and U21C are directly proportional to the value written to the D/A converter. Full scale (FF) at the converter produces an output voltage of 5.0 V.

4.2.2.12.2
Motor Speed

The voltage applied to the motor at any given time is equal to the sum of the back EMF generated by the motor plus the IR drop across the motor winding resistance. In other words, the speed of the motor can be determined from the motor applied voltage and the current through the motor, since the motor constant and motor resistance are known fixed quantities. In this circuit, the set-point speed is established by the DA voltage outputs from U21A or U21C. U21A is utilized to determine the high-speed range of the motor, while U21B sets the low-speed range. This set-point speed is constantly compared to the measured speed. The servo system raises or lowers the applied motor voltage to attempt to maintain the speed at the set point. For example, if the motor current increases due to increased torque loading, then voltage increases by the same amount as the resulting increase in the IR drop.

4.2.2.12.3

Current Sensing

Current sensing for the motor is accomplished by U34B and associated components. R71 serves as a current sensing resistor to convert motor current to a voltage (1 mA results in 1 mV of sensed voltage). Noninverting operational amplifier U34B amplifies this voltage with a gain of 40, as determined by the ratio of R61/R60. Capacitor C40 and resistor R61 together act as a low-pass filter to smooth out fast fluctuations in motor current, which results in a voltage proportional to an average motor current at U34 to U37. This output, in addition to being used by the motor speed controller is also fed back to an A/D input on the microprocessor for checks of motor current under software control.

4.2.2.12.4

Servo Error Amplifiers

Summing and inverting amplifier U34A sums the DA set-point voltage V_{SET} and motor current I, such that the output at U34A is as follows:

(high range) - (K1)(V_{set})(K2)(I) = -.411 V_{set} - 7.27 I

(low range) - (K1)(V_{set})(K2)(I) = -.182 V_{set} - 7.27 I

Assuming the total resistance in the motor circuit consisting of winding resistance plus the Rds ON resistance of Q12 equals 24.2 Ω, then (24.2)(I) represents the IR drop across the motor and drive transistor Q12. Note from the equation above that V-IR can be written in terms of motor speed.

For the Portescap 12 V winding motor, and 128:1 gearbox, the relationship is as follows:

S= 4.88 (V-IR)

S= output speed (in RPM) at the output shaft of the gearbox

V= motor voltage

I= motor current

R= motor resistance

U21B inverts the normally negative voltage output signal from U34A to provide a positive voltage to the negative input of U35A, or:

(high range) U35A = .411 V_{SET} + 7.27 I

(low range) U35A = .182 V_{SET} + 7.27 I

When the servo system is in regulation, the voltage at U35(2) will match the voltage at U35(3). Considering just the high range:

.411 V_{SET} + 7.27 I = .333 V + V_{OS} where V_{OS} is an offset voltage = .0699 V (from R98)

or, after rearranging:

.333 V - 7.27 I = .411 V_{SET} - .07

14.65 (.333 V - 7.27 I) = 14.65 (.411 V_{SET} - .07)

4.88 (V-21.8 I) = 6.02 V_{SET} -1

Substitute S = (4.88)(V-IR) in the above equation set and assume R = 21.8 Ω, then:

(high) S = 6.02 V_{SET} - 1 where S = motor shaft speed in RPM and V_{SET} = U21A D/A output voltage in volts,

or

(low) S = 1.95 V_{SET} -1

The output of the D/A amplifier V_{SET} = 5 (D/255) V, where D is the decimal value written to the D/A converter, from 0 to 255 DEC. Therefore:

(high range) S = (.118)D - 1

(low range) S = (.0382)D - 1

4.2.2.12.5

DC-to-DC Switching Regulator

The voltage to the motor is generated by a DC-to-DC switching regulator converter consisting of U35, Q11, L1, D10, and associated components. The switching regulator technique minimizes power losses in the drive to the motor.

Q11 is driven into saturation or completely off by the output from U35A. The U35A output pulses low whenever the negative input is greater than the positive input. When Q11 is on, current flows from the power source (either battery or power supply), through L1 and charges C43 to a higher voltage. When Q1 is on, L1 causes the current to ramp up approximately linearly to its peak value. When the voltage at the motor reaches the desired servo voltage, the positive (+) input to U35A will go higher than the negative (-) input, and the U35A output will go to a high level near V_PWR, thus shutting off Q11. When Q11 shuts off, the current flow continues through the free-wheeling diode D10, and the current begins to linearly ramp down to some minimum value.

The peak and minimum current values reached vary considerably, depending on the difference between the supply voltage and the motor voltage, and the motor load torque. L1 and D10 together act to smooth the current flow and minimize current spikes and resultant power losses due to high currents. C43 smooths the output ripple voltage to the motor to present a relatively slowly varying DC level to the motor. Because pulses are not applied to the motor, the power loss in the motor winding resistance is minimized, and brush life is extended because peak currents to the motor are maintained as low as possible. In addition, mechanical vibration to the motor and gearbox due to torque pulsations are minimized with the described drive technique.

Transistor Q26 functions to prevent Q11 from being allowed to turn on whenever the motor drive circuit is shut off (i.e., the switched 5.0 V from Q23 and Q27 goes to 0). Whenever Q26 is off, the gate of Q11 cannot be pulled low, even if the U35A output goes low.

Capacitor C44 in the voltage feedback loop serves to provide feed-forward phase compensation to help stabilize the servo loop and minimize ripple to the motor due to "hunting." C44 also helps minimize peak currents in cases where the motor voltage is very low and currents through L1 would otherwise be able to ratchet up without limit. C44 tends to accentuate any rapid ramp in voltage across C43 due to a current increase and causes U35A to cease driving Q11 before the L1 current can build up to sufficiently high values to cause L1 to saturate. The overall effect of C44 is to improve the power efficiency of the motor drive circuit.

U26 is a converter that converts +5.0 V to 5.0 V for power of the operational amplifiers plus serves as the negative reference to the D/A converter. Transistors Q23 and Q27 enable power to the operational amplifiers and U26 only when needed. Transistors Q23 and Q27 are controlled by the NAND gate U25A, which causes Q23 and Q27 to be driven on whenever MTR_ON is selected from PA6.

4.2.2.12.6
Runaway Prevention Circuits

In order for the motor drive circuits to be enabled, re-triggerable one shot U27A must be continuously pulsed by the microprocessor from PA7. When the one shot is triggered, U27-6 (Q output) is high, enabling gates U25A. If the microprocessor should fail, then the trigger pulses to the one-shot watchdog timer U27A will cease, causing the U27A Q output to go low, disabling the gate U25A. In addition, if U27A times out due to absence of trigger pulses, then the Q output goes high, causing Q19 to be driven on, which turns off Q12, blocking any possibility of current flow to the motor. Other safety features include the ability to monitor motor voltage via voltage divider R69 and R70 and filter C45. If the microprocessor should detect voltage at the motor after the drive command to the motor has been removed, then the microprocessor stops pulsing the watchdog timer and causes the motor drive to be disabled. Additionally, the tachometer circuit can be monitored for presence of tachometer pulses when the motor should be disabled. If tachometer pulses are still present after the MTR_ON drive signal is brought low, then the watchdog timer trigger is terminated.

The runaway protection circuitry is designed to prevent runaway in the event of any single component failure. For instance, if Q11 becomes shorted from drain to source, then the tachometer pulse rate is, in most cases, higher than expected and the motor voltage less motor current multiplied by motor resistance (V-IR) is higher than expected. In addition, tachometer pulses and motor voltage remain present after MTR_ON is brought low. In this case, the microprocessor software terminates drive pulses to U27A and transistor Q12 is turned off, blocking any current flow to the motor. The effect is the same for a failure in U35A, which causes Q11 to be driven on at improper times. Certain failures of two or more components simultaneously could result in a runaway condition. For instance, if Q11 and Q12 both develop a short from drain to source, then the motor turns continuously. Under this condition, however, the microprocessor causes the beeper to sound continuously to alert the user of a failure condition.

Other failures in the motor speed control circuitry such as in the D/A converter, in the error operational amplifiers, or in the switching regulator can cause the motor to run at too high a speed, which is detected by either a tachometer pulse rate or by a V-IR value at the motor above an expected worst-case threshold.

4.2.2.13
AIR AND OCCLUSION DETECTION OPTICS

Air and occlusion LEDs are connected in series and pulsed by Q17. Q17 with its emitter-resistor R87 functions as a constant current source to maintain a relatively constant current to the LEDs in spite of battery voltage fluctuations or LED forward-drop variations. A positive-going pulse is generated at the microprocessor port PA4, which causes Q18 and Q24 to turn on simultaneously. D11 and D12 drop the approximately 5.0 V level at the drain of Q18 by approximately 1.2 V to place a reference voltage at the base of Q17 of approximately 3.8 V. The emitter voltage at Q17 is maintained at approximately 2.9 V, which maintains a constant current through R87 of 35 mA.

The occlusion phototransistor collector is pulled up through resistor R81 to 5.0 V and is connected to the A/D input PE1. An occlusion or check-cartridge condition is displayed whenever the collector-pulsed voltage is above a limit established by software (typically 2.5 V). An occlusion condition is represented by a reduction in light returned from the occlusion-sensing surfaces in the sensing chamber, and thus a reduction in phototransistor collector current (resulting in an increase in collector voltage).

The air detection phototransistor collector is connected to A/D input port PE0 and pulled up by R84 and R85, when in the low gain setting (Q20 off). When PD5 is low, the air-high gain is selected and Q20 is off, disconnecting R85 from the collector pull-up network, which increases the overall collector resistance. An increase in collector resistance causes an increase in detector sensitivity to light. Air is detected whenever the collector voltage is below a reference threshold as established under software control (typically 2.5 V). An air detection is caused by an increase in the amount of light returned from the air-sensing surfaces, and thus an increase in air-phototransistor collector current (resulting in a decrease in collector voltage).

4.2.2.14
NONVOLATILE MEMORY

History information is stored in a serial EPROM, U19. The serial EPROM input and output data is handled by PD2 and PD3, and PD4 generates the clock signal required by the X24C16S EPROM.

4.2.2.15
RS-232 SERIAL DATA INTERFACE FOR PRINTER

A printer can be connected to the jack J11 for printout of history data. One of two special accessory cables can be used to interface the pump to a compatible printer. U32 and U33 work together as a chip set to provide optical isolation between the printer jack J11 and the ports PD0, PD1, PA2, and PA3. U32 contains an internal circuit that drives transformer T1 in push-pull fashion. U33 takes the secondary output of T1 and converts the AC waveform to approximately +10 and -10 V supplies at V+ and V-, respectively. Capacitors C53 and C54 filter out the ripple at the switching frequency. U32 and U33 act together as both opto-isolator drivers and receivers to interface to opto-isolators U28 and U31, respectively.

The following is an example to illustrate how the interface functions. Suppose that the SERIAL_OUT line from PD1 goes high. U32-4, T1IN, then goes high and U32-3, T1LDR, goes high, driving the LED in U28 ON. The phototransistor collector in U28 then goes low, causing U33-12, T1OUT, to swing close to the negative RS-232 rail, as referenced to SIGNAL_GND (U33-14). The path in the reverse direction (e.g., from U33-10 to U32-9) works similarly. Both path directions invert the logic (i.e., a high level in causes a low level out).

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 infusion pump.

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, and 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. The pump case exterior and cartridge channel should be kept clean and free of contamination.

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 infusion pump.

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: Do not use sharp objects to clean the pump.

CAUTION: Do not use solvents that are harmful to plastic, such as isopropyl alcohol or acetone. Do not use abrasive cleaners.

CAUTION: To avoid infusion pump damage, cleaning solutions should be used only as directed in *Table 5-1, Cleaning Solutions*. 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 (5.25% sodium hypochlorite)	Various	Per hospital procedures; do not exceed one part bleach to ten parts water

To clean the pump, proceed as follows:

1. Clean the exposed surfaces of the pump with a soft, lint-free cloth dampened with the appropriate cleaning solution listed in *Table 5-1, Cleaning Solutions*. The pump is not affected by the appropriate cleaning solutions.
2. If the pump has been in an isolation area, disinfect the external surfaces of the pump.

   Note: Not all cleaning solutions are disinfectants. Check the product labeling.

3. Clean the cartridge channel on a regular basis. Use a moistened cotton swab to clean the optics surfaces *(see Figure 5-1, Cartridge Channel Detail)*.
4. Wipe the solution from the pump surface with a moistened cloth. Do not immerse the pump in fluid. Assure the optics surfaces are free of detergent film.

5. Dry the pump after cleaning.

Note: Wiping the pump free of cleaning solutions helps prevent detergent buildup, which could affect the performance of the pump.

Note: Perform the air in line test in *Section 5.2.4.6* after each cleaning.

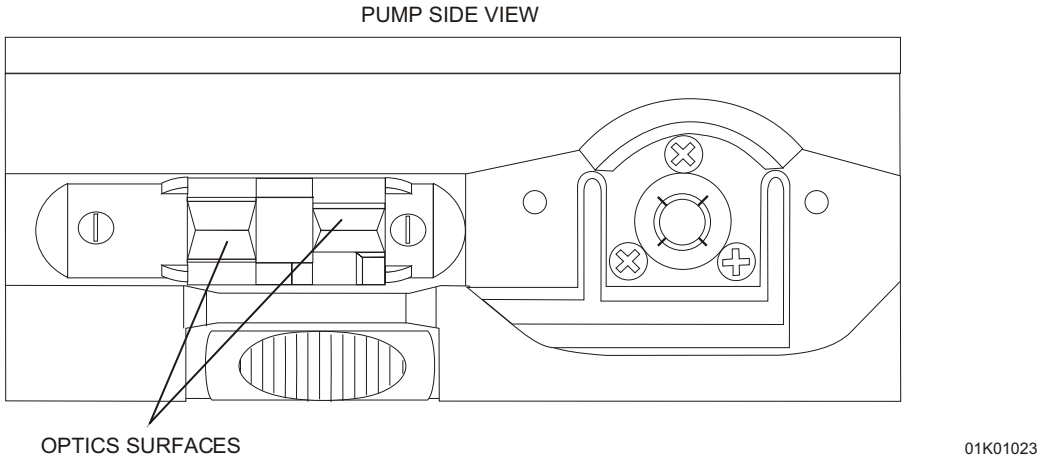

Figure 5-1. Cartridge Channel Detail

5.1.3
SANITIZING THE INFUSION PUMP

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.

The PVT must be performed exactly as described in this manual to assure effective and reliable product evaluation information. For more information regarding any alarms that occur or other abnormal performance detected during the PVT, see *Section 6, Troubleshooting*.

5.2.1
EQUIPMENT REQUIRED

The PVT requires the following equipment (or equivalents):

- ❑ Quick-Load™ cartridge set
- ❑ Kodak Diconix®150 Plus or 180si printer, or Seiko® DPU411 or DPU414 printer, with cable (if a printout of the electrical test is desired). Refer to the System Operating Manual for printer setup.
- ❑ Two 9-volt alkaline batteries
- ❑ AC power adapter
- ❑ Rechargeable battery pack
- ❑ Remote bolus switch
- ❑ Graduated cylinder, 20 mL, with 0.2 mL graduations
- ❑ Fluid reservoir

5.2.2
INSPECTION

Periodically inspect the infusion pump and accessories for damaged parts and cosmetic defects. In addition, inspect the pump after repair or during cleaning, and replace any damaged or defective assemblies, components, or accessories as required.

5.2.2.1
PUMP INSPECTION

Inspect the following components:

- ❑ Top Case
  - Inspect the case for cracks or breakage
  - Inspect the keypad and the LCD for any physical damage
- ❑ Bottom Case
  - Inspect the case for cracks or breakage
  - Verify the presence of closure hardware
  - Verify the presence and legibility of all labels
  - Verify the VOID Label is intact
- ❑ Motor Frame Assembly (includes optics and latch assemblies)
  - Verify the motor frame is free from scratches, discoloration, or contamination
  - Confirm the motor shaft extension is present and firmly attached to the motor shaft
  - Rotate the motor shaft clockwise to assure smooth rotation
  - Verify the presence of motor mount screws
- ❑ Latch Assembly
  - Verify dowel pin presence and condition
  - Verify latch engagement operates smoothly without binding. When closed, the latch should be flush with the bottom case
  - Verify the presence and condition of the cartridge hold-down tab.
  - Install a test cartridge and confirm the cartridge fits smoothly into the motor frame and is properly locked into place. Confirm the latch closes completely

- ❑ Optics Assembly
  - Verify the optics surfaces are free of any dirt or residue
  - Verify the presence of optics retention screws
- ❑ External Jacks
  - Test the printer and bolus jacks by inserting the appropriate connectors into the jacks and confirming full connection.
  - Inspect for bent pins and cracked or loose jacks.
  - Remove the batteries. Connect the AC power adapter to the power jack on the bottom of the pump. Confirm the unit powers on.
  - Confirm the LED next to the international plug symbol on the keypad is lit.

    ✎ **Note:** For AC power adapters with a battery backup module attached to the cord, the power LED remains lit if the plug is pulled from the outlet because the backup battery module continues to provide power. The power LED will go off when the AC adapter plug is removed from the pump jack.

- ❑ Battery Compartment
  - Verify easy installation and removal of the batteries and battery door.
  - Verify the battery contacts are free of any residue and are not bent or broken.
  - Verify the pump turns on with one battery in either battery position. Try each battery position one at a time.

5.2.2.2
ACCESSORIES INSPECTION

Inspect the following accessories:

- ❑ Rechargeable Battery Pack
  - Confirm the pack slides fully into place and locks firmly to the pump
  - Press the on/off key and verify the pump powers on. Power off the pump
- ❑ AC Power Adapter
  - Inspect the cord for damage or fraying, and confirm its connection
  - Remove the batteries and confirm the pump powers on with AC power
- ❑ Remote Bolus Cord and Switch
  - Check the cord and bolus switch for damage, and confirm the cord connection
  - Verify the connector fits firmly into the bolus jack
- ❑ Printer and Printer Cable
  - Inspect the printer cable for damage
  - Inspect the connections to the pump and printer, and check the pins for damage
  - Inspect the printer in accordance with the manufacturer's recommendations
- ❑ Lockbox and Pole Clamp:
  - Confirm the locking mechanism and hinges on the lockbox door are secure.
  - Confirm the pole clamp attaches firmly to the pole and the pump and that all hardware is in place.

5.2.3
DIAGNOSTIC TESTS

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

The diagnostic tests use the pump's diagnostic mode to detect electrical and software-related problems. *Table 5-2, Diagnostic Tests* lists tests that can be used by trained technicians and field service personnel to isolate problems with the APM and APM II infusion pumps. This table is provided for quick reference. Some tests are to be performed by Hospira only.

Table 5-2. Diagnostic Tests

Test Name	Test Description
VERSION NUMBER	Software version verification
INITIALIZE NVRAM	Restores RAM to factory settings
CLEAR ERROR LOGS	Clears all stored error messages
SET CLOCK	Set time and date
HIGH SPEED MOTOR	Tests the motor for calibration and proper operation at high speeds
LOW SPEED MOTOR	Tests the motor for calibration and proper operation at low speeds
OPTICS CHECK	Confirms the optics are functioning properly **Note:** Perform the air in line test in *Section 5.2.4.6* in place of the optics check.
KEYPAD CHECK	Confirms all keys are functioning properly
DISPLAY CHECK	Confirms the display is functioning properly
TIMER CHIP CHECK	Test not required
AUTO EXT NVRAM	Test not required
AUTO SERIAL DATA	**Note:** This is a factory level service to be performed by Hospira internal personnel only.
PRINTER TEST	Confirms the printer is functioning properly with the pump
POWER ON/OFF	Confirms the pump turns on and off properly **Note:** Performing this test during routine pump testing is not necessary.

Table 5-2. Diagnostic Tests	
Test Name	**Test Description**
PRINT LOGS/NVRAM	**Note:** Printing these logs is a factory level service to be performed by Hospira internal personnel only.

5.2.3.1
ENTERING THE DIAGNOSTIC TEST MODE

To enter the diagnostic test mode, proceed as follows:

1. With the pump powered off, press and firmly hold both the [ENTER] and [ON/OFF] keys simultaneously for approximately eight seconds. An alarm sounds and the following display temporarily appears:

```
KEYPAD CHECK
RELEASE KEY
```

Note: If this display does not appear within eight seconds, power off the pump and repeat step one, being sure to firmly press on both keys simultaneously.

2. Continue to hold the keys until the following display appears:

```
ENTER PASSWORD
```

- Release the [ENTER] and [ON/OFF] keys and enter the following password:

[ON/OFF] [YES] [▽] [0] [4]

Note: If testing the **APM** or **APM II** with software version earlier than **7.005** no password is required.

3. Confirm the following display appears:

```
VERSION NUMBER
OR USE ARROWS
```

5.2.3.2
SETTING THE CLOCK

To set the clock, proceed as follows:

1. Press the [▽] key until the following display appears:

```
SET CLOCK
OR USE ARROWS
```

2. Press [ENTER] and confirm the following display appears:

```
12-HOUR CLOCK?
YES OR NO
```

3. Follow the instructions on the display to set the clock to match the current time. Press [ENTER] to accept each entry.

5.2.3.3
HIGH-SPEED MOTOR TEST

To perform the high-speed motor test, refer to *Figure 5-2, Motor Test Display* and *Figure 5-3, High-Speed Motor Test Display*, then proceed as follows:

1. Install a Quick-Load cartridge in the pump.

   Note: The motor tests can be done with either a primed cartridge or a dry cartridge.

2. Press the [▽] key until the following display appears:

```
HIGH SPEED MOTOR
OR USE ARROWS
```

3. Press [ENTER] and confirm the display is similar to *Figure 5-2*.

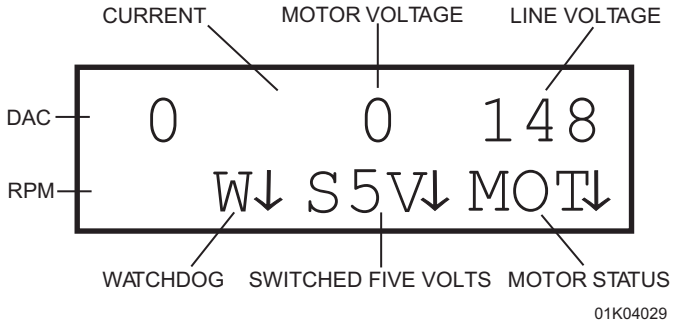

Figure 5-2. Motor Test Display

The UP arrow indicates the function is on. The DOWN arrow indicates the function is off. The RPM value does not appear on the display until DAC speed is ramped up.

Note: Values shown are examples only.

4. Press the [7] key to enable the watchdog, and the [8] key to turn on the motor.
5. Press the [1] key to enable switched five volts (S5V).
6. Press and hold the [△] key to ramp up the DAC value. Verify the speed increases smoothly and that the motor is turning.

   Note: The pump beeps several times during ramp up.

7. With the DAC value at a maximum **255**, verify the values displayed are similar to those shown in *Figure 5-3*, and within the ranges listed below.

- Motor RPM: 250-350
- Motor current: 82 or less

Note: The far-right digit for RPM is tenths, although the decimal point is not shown. Therefore, the actual RPM value is **25.0** to **35.0**.

8. Press the [4] key to disable the watchdog. Verify the motor is not turning.
9. Press the [7] key to enable the watchdog. Verify the motor is turning.
10. Press the [5] key to disable the motor. Verify the motor turns off.
11. Press the [RESET] key to set the DAC value to zero.
12. Press [NO] to exit.

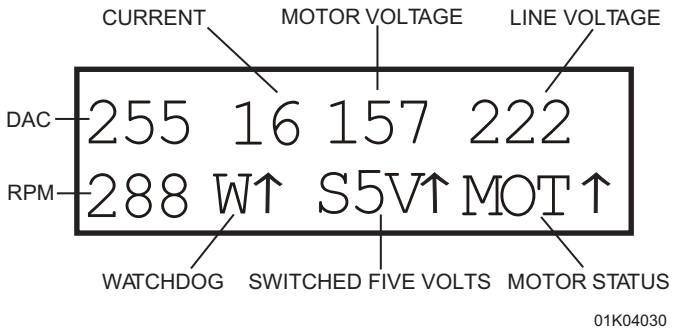

Figure 5-3. High-Speed Motor Test Display

5.2.3.4
LOW-SPEED MOTOR TEST

To perform the low-speed motor test, refer to *Figure 5-2* and *Figure 5-4, Low-Speed Motor Test Display*, and proceed as follows:

1. Press the [▽] key until the following display appears:

```
LOW SPEED MOTOR
OR USE ARROWS
```

2. Press [ENTER] and confirm the display is similar to *Figure 5-2*.
3. Use the [△] or [▽] keys to set the DAC value to **90**.
4. Press the [7] key to enable the watchdog and press the [8] key to turn on the motor.
5. If necessary, press [1] to turn on the S5V.
6. After the reading stabilizes, verify the readings are similar to those shown in *Figure 5-4*, and are within the ranges listed below:
   - Motor RPM: 19 to 35
   - Motor current: 35 or less

Note: The far right digit for RPM is tenths, although the decimal point is not shown. Therefore, the actual RPM value is **1.9** to **3.5** RPM.

7. Press the [5] key to disable the motor. Verify the motor turns off.

8. Remove the cartridge and press [NO] to exit.

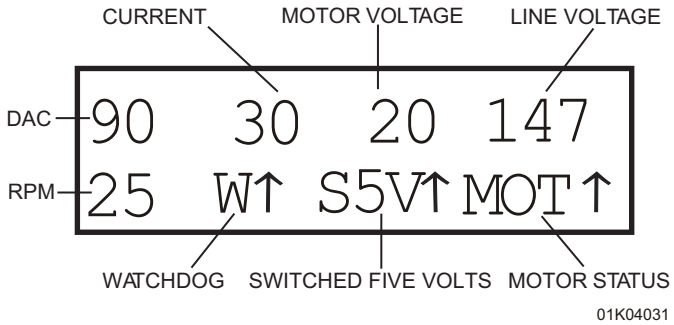

Figure 5-4. Low-Speed Motor Test Display

5.2.3.5
KEYPAD AND REMOTE BOLUS CHECK

To perform the keypad and remote bolus check, proceed as follows:

1. Press the [▽] key until the following display appears:

```
KEYPAD CHECK
OR USE ARROWS
```

2. Press [ENTER], and confirm the following display appears:

```
00 00 00 00 00
```

3. Press each key on the keypad and verify that the displayed value matches the key pressed.
4. Plug in the remote bolus switch. Press the remote bolus switch and verify that BOLUS reads on the display. No beep will occur.
5. Press and hold the [NO] key for approximately five seconds to exit the keypad check.

5.2.3.6
DISPLAY CHECK

To perform the display check, proceed as follows:

1. Press the [▽] key until the following display appears:

```
DISPLAY CHECK
OR USE ARROWS
```

2. Press [ENTER] and confirm the following display appears:

```
0123456789ABCDEF
GHIJKLMNOPQRSTUV
```

3. Press [NO] to exit.

5.2.3.7
PRINTER TEST

Note: This test can be bypassed if no printer is available.

To perform the printer test, proceed as follows:

1. Press the [▽] key until the following display appears:

```
PRINTER TEST
OR USE ARROWS
```

2. Connect the printer to the printer port.

   Note: For detailed instructions on setting up the printer, see the System Operating Manual.

3. Press [ENTER] and confirm **PRINTING** appears on the display.
4. Verify the printer completes the following test pattern:

```
************** PRINT TEST **************
,!"#$%&'()*+,-./0123456789:;<=>?@ABCDEFG
HIJKLMNOPQRSTUVWXZY[\]^_'abcdefghijklmno
pqrstuvwxyz{|}~ !"#$%&'()*+,-./012345678
9:;<=>?@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]^_'
abcdefghijklmnopqrstuvwxyz{|}~ !"#$%&'()
************  PRINT  TEST  COMPLETE
***********
```

5. Disconnect the printer.

5.2.4
OPERATION TEST

The operation test confirms the accuracy of the pump in medication delivery and in air and occlusion detection.

5.2.4.1
EQUIPMENT REQUIRED

The operation test requires the following equipment (or equivalents):

- ❏ Quick-Load cartridge set
- ❏ Beaker or other fluid reservoir
- ❏ 25 mL graduated cylinder (0.2 graduations)
- ❏ 20+ mL of fluid water
- ❏ Two 9 V batteries

5.2.4.2
TEST SETUP

1. Install the 9 V batteries in the pump.
2. Install a primed cartridge set with a fluid reservoir into the pump. Refer to the System Operating Manual for detailed instructions regarding cartridge installation.
3. Position a graduated cylinder to measure the liquid delivered.
4. Plug the bolus cable into the bolus jack.

5.2.4.3
SELF TEST

To perform the self test, proceed as follows:

1. Press [ON/OFF] to power on the pump.
2. Confirm the following display appears:

```
UNIT SELF-TEST
  IN PROGRESS
```

3. Verify that the self test completes and that the backlight illuminates.
   - A series of short beeps sounds.
4. The current program displays if it was not cleared before the pump was powered off:

```
    PCA MODE
CONTINUOUS ONLY
```

5. The unit displays the current time for several seconds:

```
TIME IS 4:19 PM
MON, SEPT 29, 03
```

- If the time and date are incorrect, refer to *Section 1.7.4* or *Section 5.2.3.2* to change the settings.

6. If the history and the previous program have not been cleared, the following display appears:

```
CLEAR HISTORY &
      Rx?
   YES OR NO
```

7. Press [YES], and confirm the following display appears:

```
CLEARING HISTORY
    AND Rx
```

- No response is required.

8. Confirm the following display appears:

```
HISTORY AND Rx
   CLEARED
```

- The previous program and history are cleared. The pump automatically advances to the next screen:

```
EPIDURAL MODE
  YES OR NO
```

5.2.4.4

PROGRAM ENTRY TEST

To perform the program entry test, proceed as follows:

1. After performing the self test, confirm the following display appears:

```
EPIDURAL MODE
  YES OR NO
```

- Press [YES] to choose epidural mode.

2. Confirm the following display appears:

```
1 CONT    3 BOTH
2 BOLUS ONLY
```

- Press [3] to choose continuous with bolus.

3. Confirm the following display appears:

```
SELECT ML ONLY
  YES OR NO
```

- Press [YES] to select mL only.

4. Confirm the following display appears:

```
SET RATE
0.0 ML/HR
```

   - Press [2] [5] [ENTER] to select 25 mL/hr.

5. Confirm the following display appears:

```
LOADING DOSE?
  YES OR NO
```

   - Press [NO].

6. Confirm the following display appears:

```
SET BOLUS DOSE
0.0 ML
```

   - Press [△] [2] [ENTER] to select 0.2 mL.

7. Confirm the following display appears:

```
BOLUS LOCKOUT
 XXX MINUTES
```

   - Press [5] [ENTER] to select 5 minutes.

8. Confirm the following display appears:

```
4 OR 1 HR LIMIT?
   YES OR NO
```

   - Press [YES].

9. Confirm the following display appears:

```
1=1 HOUR LIMIT
4=4 HOUR LIMIT
```

   - Press [1].

10. Confirm the following display appears:

```
SET 1 HOUR LIMIT
     0.0 ML
```

   - Press [2] [5] [ENTER] to select 25.0 mL.

11. Confirm the following display appears:

```
CONTAINER SIZE
     0.0 ML
```

   - Press [1] [0] [ENTER] to select 100.0 mL

12. Confirm the following display appears:

```
AIR SENSITIVITY
1=HI 2=LOW 3=OFF
```

- Press [1] to choose high air sensitivity. The following messages flash briefly:

```
HIGH SENSITIVITY
  AIR ALARM ON
```

```
SAVING PROGRAM
```

13. Confirm the following display appears:

```
PRESS RUN/STOP
  TO INFUSE
```

- The pump enters the stop mode. The first time the pump enters the stop mode while using batteries after power on, the pump beeps three times and flashes ON BATTERIES on the second line.

14. Press [HISTORY], and confirm the following display appears:

```
1 REVIEW HISTORY
2 VOLUME INFO
```

15. Press [1], then [△] to scroll through the program and verify that it is correct. To end review, press [ENTER]. The pump returns to stop mode.

5.2.4.5
OCCLUSION TEST

To perform the occlusion test, proceed as follows:

1. Assure that a primed Quick-Load set is installed.

   Note: Refer to the System Operating Manual for detailed instructions regarding installing and priming a set.

2. Verify that the bolus cord is plugged into the bolus jack.
3. Occlude the distal end of the set by clamping the tubing.
4. Press [RUN/STOP], then press the button on the bolus cord to begin a bolus delivery.
5. Confirm the following display appears:

```
TOTAL x.x ML /
BOLUS DELIVERY
```

6. Wait for the occlusion alarm to occur, and confirm the following display appears:

```
TOTAL x.x ML /
  OCCLUSION
```

7. Press [SILENCE] to silence the alarm.
8. Remove the clamp from the tubing to clear the alarm and resume pumping.
9. Press [RUN/STOP] to return to stop mode.

5.2.4.6
AIR IN LINE TEST

To perform the air in line test, proceed as follows:

1. Press [RUN/STOP] to resume bolus delivery.
2. Disconnect the proximal end of the tubing from the reservoir, and allow air to fill the tubing.
3. Verify that the audible alarm sounds and AIR IN LINE flashes on the display.
4. Press [RUN/STOP] to silence the alarm and return to stop mode.

Note: Perform this test once every three months or when the pump is inadvertently mishandled.

5.2.4.7
PURGING FUNCTION TEST

Note: The purging function test must be completed before performing the delivery test to avoid inaccurate results.

To perform the purging function test, proceed as follows:

1. Reconnect the proximal end of the tubing to the reservoir.
2. Confirm the following display appears:

```
PRESS RUN/STOP
  TO INFUSE
```

- Press [PURGE].

3. Confirm the following display appears:

```
  PURGE NOW?
 YES OR NO
```

- Press [YES].

4. The following message displays for five seconds, no response is required:

```
DISCONNECT FROM
  PATIENT NOW
```

5. Confirm the following display appears:

TO PURGE, PRESS AND HOLD 'PURGE'

- Press and hold [PURGE] until the air is cleared from the line.

6. Confirm the following display appears when [PURGE] is released:

PURGE COMPLETE? YES OR NO

7. Press [YES]. The pump returns to stop mode.
8. Press [RUN/STOP] and allow any remaining bolus delivery to complete. When continuous delivery begins, press [RUN/STOP] to return to stop mode.

5.2.4.8

DELIVERY TEST

The delivery test requires a 25 mL graduated cylinder.

To perform the delivery test, proceed as follows:

1. Assure that a primed Quick-Load set is installed.
2. Press [LOADING DOSE], and confirm the following display appears:

LOADING DOSE? YES OR NO

- Press [YES].

3. Confirm the following display appears:

SET LOAD DOSE 0.0 ML

- Press [1] [0] [ENTER].

4. Confirm the following display appears:

DEL. LOAD DOSE? YES OR NO

- Press [YES].

5. Confirm the following display appears:

TO INFUSE, PRESS 'LOADING DOSE'

- Press [LOADING DOSE].

6. Confirm the following display appears, and pump begins to deliver the loading dose:

```
DEL. LOADING
    DOSE
  x.x ML
```

   - When delivery is complete, the pump enters the stop mode.
7. Verify total amount of fluid delivered is between 9.5 and 10.5 mL.

5.2.4.9

CLEARING PROGRAM AND TEST HISTORY

To clear the program and the test history, proceed as follows:

1. Confirm the pump is in stop mode, and the following display appears:

```
PRESS RUN/STOP
  TO INFUSE
```

   - Press [REVIEW/CHANGE].
2. Confirm the following display appears:

```
1 REVIEW
2 CHANGE
```

   - Press [2].
3. Confirm the following display appears:

```
1 CHANGE PROGRAM
2 NEW PROGRAM
```

   - Press [2].
4. Confirm the following display appears:

```
CLEAR HISTORY?
  YES OR NO
```

   - Press [YES] to clear the history and the current program.
5. Confirm the following display appears:

```
EPIDURAL MODE
  YES OR NO
```

   - Power off the pump.

5.2.5
PREPARATION FOR USE

To prepare the pump for use after all testing is complete, enter the diagnostic test mode *(see Section 5.2.3.1)* to initialize the NVRAM and clear the error logs.

5.2.5.1
INITIALIZE NVRAM

To reset the NVRAM, proceed as follows:

1. Enter the diagnostic test mode *(see Section 5.2.3.1)*.
2. Press the [△] or [▽] keys until the following display appears:

```
INITIALIZE NVRAM
  OR USE ARROWS
```

3. Press [ENTER] to begin the NVRAM initialization, and confirm the following display appears:

```
RESETTING NVRAM
- - - - - - - - -
```

   - Wait for the initialization to complete.
4. After a few seconds, confirm two beeps sound and the following display appears:

```
INITIALIZE NVRAM
  OR USE ARROWS
```

5. Press [NO] to exit.

5.2.5.2
CLEAR ERROR LOGS

To clear the error logs, proceed as follows:

1. Press the [▽] key until the following display appears:

```
CLEAR ERROR LOGS
  OR USE ARROWS
```

2. Press [ENTER] to begin clearing the logs. Confirm the following display appears:

```
  CLEARING LOGS
- - - - - - - - -
```

3. Wait for clearance of the logs to complete. Two beeps will sound.
4. Press [NO] to exit, and press [ON/OFF] to power off the pump.

5.3 CONFIGURATION GUIDE FOR APM II

The APM II configuration mode allows the pump to be tailored to particular specifications. If the requirements change, new custom settings may be entered *(see Table 5-3, APM II Configurable Settings)*.

This mode is available only in software versions **7.005 and higher**. To display the software version, press [ENTER], then press and hold [5].

Table 5-3. APM II Configurable Settings

Setting	Factory Default	Configurable Limits
Mode of Delivery	Epidural and PCA	Epidural and/or PCA
Units of Delivery	mL, mg, and µg	Any combination of the three units
Continuous Rate	Max. 25 mL	Max. 0.1 - 25 mL
Loading Dose	Max. 25 mL	Max. 0.1 - 25 mL
Alarm after Loading Dose	No	No or Yes
Bolus Dose	Max. 25 mL	Max. 0.1 - 25 mL
One or Four Hour Limit	Soft (bolus completes when limit is reached)	Soft or Hard (bolus stops when limit is reached

5.3.1 ENTERING THE CONFIGURATION MODE

Note: The pump must be turned off to enter the configuration mode.

1. Press the [ON/OFF] and [ENTER] keys simultaneously while the pump completes a self test. An alarm sounds and KEYPAD CHECK displays until the following display appears:

```
ENTER PASSWORD
*****
```

2. Enter the password [6] [0] [4] [5] [7]. Asterisks will appear on the screen as the numbers are entered. When the correct password is entered, the following screen displays for approximately three seconds:

```
SYSTEM CONFIG
SET  JAN 15, 02
```

The last date the configuration was changed appears on the display. The pump automatically enters the configuration mode.

5.3.2
CONFIGURATION PROGRAMMING

As each configuration screen displays, the current setting will be shown. For non-numeric settings, the current setting will be flashing, and, as applicable, more than one item may be flashing.

Configuration programming includes the following key functions:

- ❏ To accept the desired setting(s), press [ENTER].
- ❏ To set a numeric value to zero or de-select the current selection, press [RESET].
- ❏ To return to the previous screen, press [▽].
- ❏ To exit the configuration mode and enter the stop mode, press [RUN/STOP].
- ❏ To turn the pump off, press [ON/OFF] at any time.

5.3.2.1
MODES OF DELIVERY

Both Epidural and PCA modes of delivery are displayed as default programming choices. In the configuration mode either or both modes can be selected. If only one mode is chosen, the mode selection screen will not display during programming.

Confirm the following display appears:

```
SET MODES
1-EPI 2-PCA
```

- Press [1] and/or [2] to select either or both of the modes, then press [ENTER] to accept the flashing selection(s).

5.3.2.2
UNITS OF DELIVERY

Units of delivery in mL, mg, and µg are displayed as default programming choices. In the configuration mode any combination of the three can be selected. If only one unit is chosen, the unit selection screen will not display during programming.

Confirm the following display appears:

```
SET UNITS
1-mL  2-mg  3-µg
```

- Press [1], [2], and/or [3] to select any combination of the units, then press [ENTER] to accept the flashing selection(s).

5.3.2.3
MAXIMUM CONTINUOUS RATE

The default maximum value of the continuous rate is 25.0 mL/hr. In the configuration mode a maximum value can be set from 0.1 mL/hr to 25.0 mL/hr. If the pump is programmed in mg or µg, the maximum rate will be concentration multiplied by the value selected.

Confirm the following display appears:

```
SET RATE MAX
     25.0 mL
```

- Use the numeric keys to change the setting, then press [ENTER] to accept the desired value.

5.3.2.4
MAXIMUM VOLUME OF LOADING DOSE

The default maximum value of the loading dose is 25.0 mL. In the configuration mode a maximum value can be set from 0.1 mL to 25.0 mL. If the pump is programmed in mg or µg, the maximum loading dose will be concentration multiplied by the value selected.

Confirm the following display appears:

```
LOADING DOSE MAX
     25.0 mL
```

- Use the numeric keys to change the setting, then press [ENTER] to accept the desired value.

5.3.2.5
ALARM AFTER LOADING DOSE COMPLETES

The default value is for no alarm to activate upon completion of a loading dose. In the configuration mode the pump can be set to always alarm after any loading dose delivery.

Pressing any key except [ON/OFF] clears the alarm. When the alarm is cleared, the pump returns to the mode it was in prior to delivery of the loading dose.

Confirm the following display appears:

```
ALARM AFTER LOAD
DOSE?   YES OR NO
```

- Press [YES] or [NO] to change the selection, then press [ENTER] to accept the flashing selection.

5.3.2.6
MAXIMUM VOLUME OF PCA/BOLUS DOSE

The default maximum value of a PCA or bolus dose is 25.0 mL. In the configuration mode a maximum value can be set from 0.1 mL to 25.0 mL. If the pump is programmed in mg or µg, the maximum bolus will be concentration multiplied by the value selected.

Confirm the following display appears:

```
SET BOLUS MAX
     0.0 mL
```

- Use the numeric keys to change the setting, then press [ENTER] to accept the desired value.

5.3.2.7
SOFT OR HARD BOLUS/PCA LIMITS

The default is a soft limit. When the 1 or 4 hour limit is reached, continuous delivery stops but a PCA or bolus dose in progress completes.

In the configuration mode a hard limit can be set. When the 1 or 4 hour limit is reached, all delivery stops, including a PCA or bolus dose in progress. The PCA or bolus dose will not be completed.

Confirm the following display appears:

```
1 and 4 HR LIMIT
 1 HARD  2 SOFT
```

- Press [1] or [2] to change the selection, then press [ENTER] to accept the flashing selection.

5.3.2.8
SAVING CHANGES

Confirm the following display appears:

```
SAVE CHANGES?
   YES OR NO
```

- Press [YES] to replace the previous settings with the new settings. Entering a new configuration clears the current program, shift history, and event history. The time and date will display briefly, followed by the Rx CLEARED message and the first programming screen.
- Press [NO] to exit the configuration mode without changing the settings. If there is a current program, the pump enters the stop mode. If no program is entered, the first programming screen displays.

5.4
APM AND APM II PVT RECORD

The record in *Table 5-4, APM/APM II PVT and Inspection Record* may be copied and used for recording inspection and performance verification test results.

Table 5-4. APM/APM II PVT and Inspection Record

	Pass	Fail
Inspection		
Top Case	❒	❒
Bottom Case	❒	❒
Motor Frame Assembly	❒	❒
Latch Assembly	❒	❒
Optics	❒	❒
External Jacks	❒	❒
Battery Compartment	❒	❒
Accessories	❒	❒
Performance Verification Test: Diagnostic Tests		
Setting the Clock	❒	❒
High-Speed Motor Test	❒	❒
Low-Speed Motor Test	❒	❒
Keypad and Remote Bolus Check	❒	❒
Display Check	❒	❒
Timer Chip Check	❒	❒
RAM Chip Self Test	❒	❒
Printer Test	❒	❒
Power On/Off Test	❒	❒
Performance Verification Test: Operation Test		
Self Test	❒	❒
Program Entry Test	❒	❒
Occlusion Test	❒	❒

Table 5-4. APM/APM II PVT and Inspection Record		
	Pass	**Fail**
Air in Line Test	❒	❒
Purging Function Test	❒	❒
Delivery Test	❒	❒
Clearing Program and Test History	❒	❒
Initializing NVRAM	❒	❒
Clearing Error Logs	❒	❒
Additional Testing (write in as required		
	❒	❒
	❒	❒
	❒	❒
	❒	❒

5.5
PERIODIC MAINTENANCE INSPECTION

Periodic maintenance inspections should be performed per hospital procedures for compliance to accreditation requirements. It is recommendation 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*.

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Section 6

TROUBLESHOOTING

This section contains information on technical assistance, alarm messages and error codes, and troubleshooting procedures for the APM and APM II infusion systems.

6.1 TECHNICAL ASSISTANCE

For technical service 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, including Technical Service Bulletins, 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

The following tables are provided to assist in troubleshooting problems with the pump. If problems require component or assembly replacement, refer to *Section 7, Replaceable Parts and Repairs*. Also refer to the PVT in *Section 5.2* to aid in troubleshooting the pump.

6.2.1
ALERTS AND ALARMS

Table 6-1, Alerts and Alarms, lists the pump's alert and alarm conditions and suggests causes and corrective actions.

Table 6-1. Alerts and Alarms

Message	Description	Possible Causes	Corrective Action
START	Message alternates with stop mode screen and alarm beeps.	Pump is programmed but has not been placed in run mode.	1. Press [SILENCE] to mute audible alarm. 2. Press [RUN/STOP] to start pump.
AIR IN LINE	Message flashes and alarm beeps.	Air LED/ phototransistor pair has detected air in cartridge.	1. Press [SILENCE] to mute audible alarm for one minute. 2. Press [RUN/STOP] to place pump in stop mode. This clears the alarm for the APM II. 3. Disconnect patient from set. 4. For the APM, press the [PURGE] key to clear the alarm. 5. Follow the appropriate procedure to eliminate air.
CHECK CARTRIDGE	Message flashes and alarm beeps.	Improperly installed cartridge. Alarm occurs while pump is in stop mode.	1. Press [SILENCE] to mute audible alarm for one minute. 2. Check that latch is fully closed. 3. Check for proper cartridge installation by removing cartridge and tubing, realigning dot in red circle of cartridge, and reinserting cartridge in pump.

Table 6-1. Alerts and Alarms

Message	Description	Possible Causes	Corrective Action
OCCLUSION	Message flashes and alarm beeps.	Blockage in line or improperly installed cartridge. Alarm occurs while pump is in run mode.	1. Press [SILENCE] to mute audible alarm for one minute. 2. Press [RUN/STOP] to place pump in stop mode. 3. Check that latch is fully closed. 4. Check for source of occlusion and correct problem. 5. Check for proper cartridge installation by removing cartridge and tubing, realigning dot in red circle of cartridge, and reinserting cartridge in pump.
PURGE OVERUSE	Message and alarm constant.	[PURGE] key has been pressed for more than two minutes on the APM or four minutes on the APM II.	Audible alarm cannot be muted. Press [ENTER] once and [UP ARROW] twice.
ON BATTERIES	Message flashes and alarm beeps.	Pump has lost AC power and is now running on batteries.	1. Press [SILENCE] to clear audible alarm. 2. Check for secure AC connection. Restore AC power if disconnected.
LOW BATTERY	Message flashes and alarm beeps.	System has detected that battery voltage is dropping.	1. Press [SILENCE] to mute audible alarm for two minutes. 2. Press [RUN/STOP] to place pump in stop mode. 3. Replace batteries or connect pump to AC power. 4. Press [RUN/STOP] to place pump in run mode.
CHANGE BATTERIES	Message constant. Alarm beeps, then is constant as voltage drops.	System cannot meet delivery cycle. System has detected battery voltage below allowed minimum.	Audible alarm cannot be muted. 1. Press [RUN/STOP] to place pump in stop mode. 2. Replace batteries or connect pump to AC power. 3. Press [RUN/STOP] to place pump in run mode.

Table 6-1. Alerts and Alarms

Message	Description	Possible Causes	Corrective Action
x HOUR LIMIT	Message flashes on lower display line.	APM: Four-hour limit has been exceeded. APM II: One or four-hour limit has been exceeded.	No action required. Note: After alarm condition has been reached, reprogramming is required to change or extend limit.
ALMOST EMPTY	Message flashes and alarm beeps.	Above 1 mL/hr, delivery will complete in 30 minutes or less. Below 1 mL/hr, less than 1 mL remains to be delivered.	1. Press [SILENCE] to mute audible alarm for two minutes. 2. Press [RUN/STOP] to place pump in stop mode.
EMPTY	Message flashes and alarm beeps.	Pump has completed delivery.	1. Press [SILENCE] to mute audible alarm for two minutes. 2. Press [RUN/STOP] to place pump in stop mode.
CHECK PRINTER	Message flashes and alarm beeps.	Pump to printer connection has been disrupted or printer button was pressed when printer was not connected.	1. Press [SILENCE] to mute audible alarm for two minutes. 2. Check printer connection.

6.3
SYSTEM ERROR CODES

When system error codes occur, the device displays a SYSTEM ALARM message. The SYSTEM ALARM message indicates that the system has detected a problem with the PCB, motor circuit, batteries, or cartridge.

Many system error codes can be cleared by proceeding as follows:

1. Press [SILENCE] to mute the alarm and [RUN/STOP] to stop the pump and clear the alarm message.
2. Remove the cartridge and turn the rotor, confirming that the cartridge rotor turns freely. Place the cartridge rotor in the closed position by positioning the hole in the rotor inside the red circle. Reinsert the cartridge in the pump.
3. Press and release [ENTER], then press and hold the [5] key. The display shows the software version on the top line and the last four system errors on the bottom line (ERR-xxxx). If the first number to the right of ERR- is 0 (ERR-0xxx), the alarm is recovered and no further troubleshooting is necessary.

   - If the alarm is not cleared, replace the cartridge.

- If this doesn't clear the alarm, turn off the pump and replace both batteries with fresh 9V batteries. Power off the pump, then power on again. Answer [NO] to the CLEAR HIST & Rx? YES OR NO screen, then check to see if the alarm has been cleared.
- If the alarm is not cleared, refer to *Table 6-2* for error codes, possible causes, and corrective actions.

4. If the alarm is cleared, press [RUN/STOP] to place the pump in the run mode.

Table 6-2. System Error Codes

Error Code	Description	Possible Cause	Corrective Action
01	Motor speed off by more than 50%.	Defective motor, motor current or voltage monitoring circuit, motor tachometer, or tachometer interface circuit.	Replace motor *(see Section 7.2.4)*
02	No encoder counts (tach tics) when running.	Defective motor, motor drive circuit, motor tachometer, or tachometer circuit.	Replace motor *(see Section 7.2.4)*
03	Motor still on at next TO_FAST cycle and motor current above 100 mA.	Defective (high torque) cartridge. Defective motor or motor drive circuit.	Replace cartridge Replace motor *(see Section 7.2.4)*
04	Motor still on at next GO_SLO cycle.	Defective (high torque) cartridge. Defective motor or motor drive circuit.	Replace cartridge Replace motor *(see Section 7.2.4)*
05	Excessive motor current (MOTI) while running (>100 mA).	Defective (high torque) cartridge. Defective motor, motor current amplifier U34B, or associated components.	Replace cartridge Replace motor *(see Section 7.2.4)*
06	No encoder counts (tach tics) while purging.	Defective motor, motor drive circuit, motor tachometer, or tachometer circuit.	Replace motor *(see Section 7.2.4)*
07	Excessive motor current (MOTI) while purging (>100 mA).	Defective (high torque) cartridge. Defective motor, motor current amplifier U34B, or associated components.	Replace cartridge Replace motor *(see Section 7.2.4)*
08	Motor speed voltage or current error.	Defective motor, encoder, or tachometer circuit. Incorrect motor current or voltage readings.	Replace motor *(see Section 7.2.4)*

Table 6-2. System Error Codes			
Error Code	**Description**	**Possible Cause**	**Corrective Action**
09	Motor speed calculations not done in 10 seconds.	Defective microprocessor (U2).	Replace PCB *(see Section 7.2.7)*
10	APM II Only: Overuse of purge.	Purge was exceeded by four minutes or keypad is defective.	Follow steps in *Section 6.3* Replace keypad *(see Section 7.2.8)*

6.4
MALFUNCTION CODES

When internal malfunctions occur, the system has detected a mechanical or software problem. The message INTERNAL MALFUNCTION with the time of occurrence and the code number replaces the typical display. An alarm sounds constantly and cannot be muted.

Many malfunction codes can be cleared by proceeding as follows:

1. Press [ON/OFF] to power off the pump. Disconnect AC power and remove the batteries.
2. Wait at least five seconds, then power on the pump.
3. If the pump completes the self test sequence, the alarm is cleared. Reset the program before using the pump on a patient.

If an alarm is not cleared (i.e., the self test does not complete and the malfunction code display returns), refer to *Table 6-3, Malfunction Codes* for malfunction codes, descriptions, possible causes and corrective actions.

Table 6-3. Malfunction Codes			
Code	**Description**	**Possible Causes**	**Corrective Action**
01	ROM checksum error.	Defective EPROM U4.	Non-recoverable error: Replace PCB *(see Section 7.2.7)*
02	RAM integrity error.	Defective microprocessor U2.	Replace PCB *(see Section 7.2.7)*
03	Stack overflow.	Defective microprocessor U2.	Replace PCB *(see Section 7.2.7)*
04	Keypad active when batteries installed.	Defective keypad or keypad interface.	Replace keypad *(see Section 7.2.8)*
05	Motor runaway at power-up test.	Defective motor drive circuit or microprocessor port line PA6.	Replace motor *(see Section 7.2.4)* Replace PCB *(see Section 7.2.7)*

Table 6-3. Malfunction Codes

Code	Description	Possible Causes	Corrective Action
06	ROM check did not complete.	Defective microprocessor U2 or EPROM U4.	Replace PCB *(see Section 7.2.7)*
07	RAM check did not complete.	Defective microprocessor U2.	Replace PCB *(see Section 7.2.7)*
08	NVRAM checksum error in program.	Defective microprocessor U2.	Initialize NVRAM *(see Section 5.2.5.1)*
09	NVRAM checksum error run-time parameters.	Defective microprocessor U2.	Initialize NVRAM *(see Section 5.2.5.1)*
10	NVRAM checksum error - p_flg.	Defective microprocessor U2.	Initialize NVRAM *(see Section 5.2.5.1)*
11	APM: Overuse of purge.	Purge was exceeded by two minutes or keypad is defective.	Power off, then on. If alarm recurs, replace keypad *(see Section 7.2.8)*
	APM II: NVRAM checksum error - history.	Defective U19.	Initialize NVRAM *(see Section 5.2.5.1)*
12	Motor runaway.	Defective motor drive circuit or tachometer circuit.	Replace motor *(see Section 7.2.4)*
13	Voltage present on motor when it should be off.	Defective motor drive circuit or A/D input on input monitoring motor voltage.	Replace motor *(see Section 7.2.4)*
14	External NVRAM does not acknowledge message.	Defective U19.	Replace PCB *(see Section 7.2.7)*
15	APM: NVRAM checksum error - history.	Defective U19.	Initialize NVRAM *(see Section 5.2.5.1)*
	APM II: Error writing to internal NVRAM.	Defective microprocessor U2.	Power off, then on. Clear program and reprogram the pump before using on a patient.
16	APM: Error writing to internal NVRAM.	Defective microprocessor U2.	Power off, then on. Clear program and reprogram the pump before using on a patient.
	APM II: Clock chip error - getting ahead of rti.	Defective clock chip U5 or U2.	Replace PCB *(see Section 7.2.7)*
17	APM II Only: Clock chip error - falling behind rti.	Defective clock chip U5 or U2.	Replace PCB *(see Section 7.2.7)*

Table 6-3. Malfunction Codes			
Code	**Description**	**Possible Causes**	**Corrective Action**
18	APM II Only: External interface voltage (<Ver. 7.005) level error.	Defective A/D port lines PE5 or PE5 to J11, pin 6 circuitry. (N/A to ver. 7.005 or greater.)	Replace PCB *(see Section 7.2.7)*
19	APM II Only: Power supply voltage is too high.	Incorrect power supply used or defective power circuitry or microprocessor A/D port PE6.	Verify that a Hospira approved power supply is in use Allow up to 30 minutes to elapse before reconnecting power supply to allow the fuse to reset

6.5
TROUBLESHOOTING PROBLEMS AND SOLUTIONS

Table 6-4, Troubleshooting, lists a selection of possible functional problems that may occur with the pump. The solutions are offered in order of magnitude of the repair required. Attempt all noninvasive solutions before repairing the pump.

Table 6-4. Troubleshooting		
Symptoms	**Possible Causes**	**Corrective Actions**
No pump display upon installing batteries.	Batteries may be dead or not fully charged.	Check batteries with voltmeter to assure 9V charge in both batteries Replace batteries (refer to System Operating Manual)
Display scrambled and beeper pattern is not normal.	PCB assembly may be defective.	Replace PCB assembly *(see Section 7.2.7)*
No display or scrambled display on power-up, but beeper pattern appears normal.	LCD may be defective.	Replace PCB assembly *(see Section 7.2.7)*
	LCD connector on PCB may be defective.	Replace PCB assembly *(see Section 7.2.7)*
One or more keys on keypad inoperative. Typical keypad failure causes one entire row or column to be inoperative.	Keypad locked	Unlock keypad
	Defective keypad	Replace keypad *(see Section 7.2.8)*
Beeper inoperative, but display appears normal.	Beeper may be defective.	Replace PCB assembly *(see Section 7.2.7)*.

Table 6-4. Troubleshooting

Symptoms	Possible Causes	Corrective Actions
Motor won't turn or turns at incorrect speed.	Motor may be defective.	Replace motor assembly *(see Section 7.2.4)*
	PCB assembly may be defective.	Replace PCB assembly *(see Section 7.2.7)*
Timer does not keep time.	If time is lost when batteries are removed, check BT1.	Replace PCB assembly *(see Section 7.2.7)*
Tachometer produces incorrect RPM or no pulses.	Connections from board to motor may be defective.	Repair connections if necessary.
	Tachometer in motor may be defective or output level may have shifted.	Check tach output from motor, verify that amplitude swings less than 2.5 V to greater than 4.2 V. Replace motor if necessary *(see Section 7.2.4)*
Pump will not power-on with AC power supply.	Incorrect power supply.	Verify list number 13036 or 13868 power supply is in use
	Defective power supply.	Verify power supply output is 12 VDC at .4 amperes
	AC over voltage fuse blown or reset.	For APM with fast acting fuse protection: Perform continuity across fuse F001, norminal resistance is approximately 3 Ω Replace PCB assembly, if necessary *(see Section 7.2.7)*
		For APM II with resetable fuse protection: ❏ Allow 30 minutes for reset ❏ Attempt power-up ❏ If pump does not power-up after 30 minutes, verify continuity across fuse F1 Post trip resistance is .3 to .8 Ω ❏ Verify U11 voltage regulator. Should be LP2951 OR LP2951CM ❏ If MIC 2951 is found, replace with LP2951 ❏ Replace PCB assembly, if necessary *(see Section 7.2.7)*

Table 6-4. Troubleshooting

Symptoms	Possible Causes	Corrective Actions
Short battery life.	Verify battery voltage is 9 V using a voltmeter.	Replace batteries (refer to the System Operating Manual)
	Motor drive circuit may be defective, or motor may be defective.	Test motor as directed in *Section 5.2.3.3* and *Section 5.2.3.4* Measure supply current and motor current drains to isolate problem. Replace motor *(see Section 7.2.4)*
	PCB assembly may be defective.	Measure ON current drain (motor off) and OFF current drain. *(see Section 5.2.3.3* and *Section 5.2.3.4)* If not within range, replace PCB assembly *(see Section 7.2.7)*
OCCLUSION or CHECK CARTRIDGE display does not appear when occlusion is present.	Occlusion phototransistor or wiring may be defective.	Replace optics assembly *(see Section 7.2.5)* Replace PCB assembly *(see Section 7.2.7)*
OCCLUSION alarm or CHECK CARTRIDGE alarm stays on.	Cartridge may not be fully installed.	Check to assure cartridge is firmly seated in motor frame and that latch is fully closed and flush with bottom case.
	b) No cartridge installed or cartridge may be faulty.	Install new cartridge
	Optics may be dirty.	Clean optics surfaces as directed in *Section 5.1.2* Replace optics assembly *(see Section 7.2.5)*
	Latch may be loose.	Check for loose screws on latch assembly Replace latch assembly *(see Section 7.2.6)*
	Optics LED or phototransistor may be faulty.	Replace optics assembly *(see Section 7.2.5)* Replace PCB assembly *(see Section 7.2.7)*

Table 6-4. Troubleshooting

Symptoms	Possible Causes	Corrective Actions
AIR IN LINE alarm does not come on when air is present in sensing chamber of tubing.	Air sensitivity alarm may be disarmed (applies to domestic pump configuration only).	Place pump in stop mode and check air sensitivity setting. Revise if necessary. (Refer to System Operating Manual for instructions.)
	Optics surfaces may be dirty.	Clean optics surfaces as directed in *Section 5.1.2*
	Cartridge may not fit properly into motor frame assembly or may not be completely latched.	Assure cartridge is seated properly Replace cartridge Replace latch assembly *(see Section 7.2.6)*
	Optics wiring may be defective.	Check and repair wiring if necessary.
	Air LED or phototransistor may be defective.	Replace optics assembly *(see Section 7.2.5)* Replace PCB assembly *(see Section 7.2.7)*
AIR IN LINE alarm stays on even when air is not present in sensing chamber of cartridge.	[PURGE] key may not have been pressed to clear alarm.	Press [PURGE]. (Refer to the System Operating Manual for instructions.)
	Optics wiring may be defective.	Replace optics assembly *(see Section 7.2.5)*
	Air LED or phototransistor may be defective.	Replace optics assembly *(see Section 7.2.5)* Replace PCB assembly if necessary *(see Section 7.2.7)*

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Section 7

REPLACEABLE PARTS AND REPAIRS

This section itemizes all parts and subassemblies of the APM and APM II infusion devices 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 infusion system 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* through *Figure 9-3*. To request a copy of the current spare parts price list, contact Hospira *(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 system. Unless otherwise stated, always perform the PVT after a replacement procedure.

7.2.1
SAFETY AND EQUIPMENT PRECAUTIONS

Before opening the top case of the infusion system, take all necessary precautions for working on high-voltage equipment.

WARNING: UNLESS OTHERWISE INDICATED, DISCONNECT THE INFUSION SYSTEM FROM AC POWER BEFORE PERFORMING ANY REPLACEMENT PROCEDURE.

WARNING: POSSIBLE EXPLOSION HAZARD EXISTS IF PRODUCT IS SERVICED OR REPAIRED IN THE PRESENCE OF FLAMMABLE ANESTHETICS.

CAUTION: Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store the PCB assemblies in an antistatic bag 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 required for that specific procedure.

- ❑ 5/64-inch Allen wrench
- ❑ Phillips screwdriver
- ❑ Flat blade screwdriver
- ❑ Soldering iron
- ❑ Solder
- ❑ Loctite® Threadlocker adhesive
- ❑ Isopropyl alcohol

7.2.3
SEPARATING THE TOP AND BOTTOM CASES

The required tool for this procedure is a Phillips screwdriver.

The replacement parts for this procedure are:

Assembly, Bottom Case
Door, Battery
Screw, 4-40 x 1 1/2, Phillips Flat Head
Screw, 2-56 x 7/8, Phillips Flat Head
Screw, 10-24 x 5/16, Phillips Flat Head

To separate the top and bottom cases, refer to *Figure 7-2, Separating the Top and Bottom Cases*, and proceed as follows:

1. Lay the pump face down on a soft surface with the base facing you.
2. Remove the battery door and replace if necessary. Remove the battery.
3. Peel the void label off of the screw on the upper-left corner of the bottom case. Using the Phillips screwdriver, remove all four bottom case screws.
4. Open the latch and lift the bottom case. Remove the battery pin P1 from PCB connector J1 *(see Figure 7-1, PCB Connections)*.
5. Remove the bottom case from the pump, inspect for damage, and replace if necessary.

Note: Regarding domestic configurations: Infusion pumps are significant devices and are therefore serialized for customer safety per FDA Good Manufacturing Practices and Hospira Guidelines. The serial number is crucial for tracking the manufacture, sale, and maintenance of each device and must not be altered for any reason at any time.

When replacing the bottom case, contact Hospira to obtain a Product Indentification Form. When receiving a replacement bottom case assembly, assure that the serial number is matched to the correct pump being serviced. If the serial number does not match, contact Hospira.

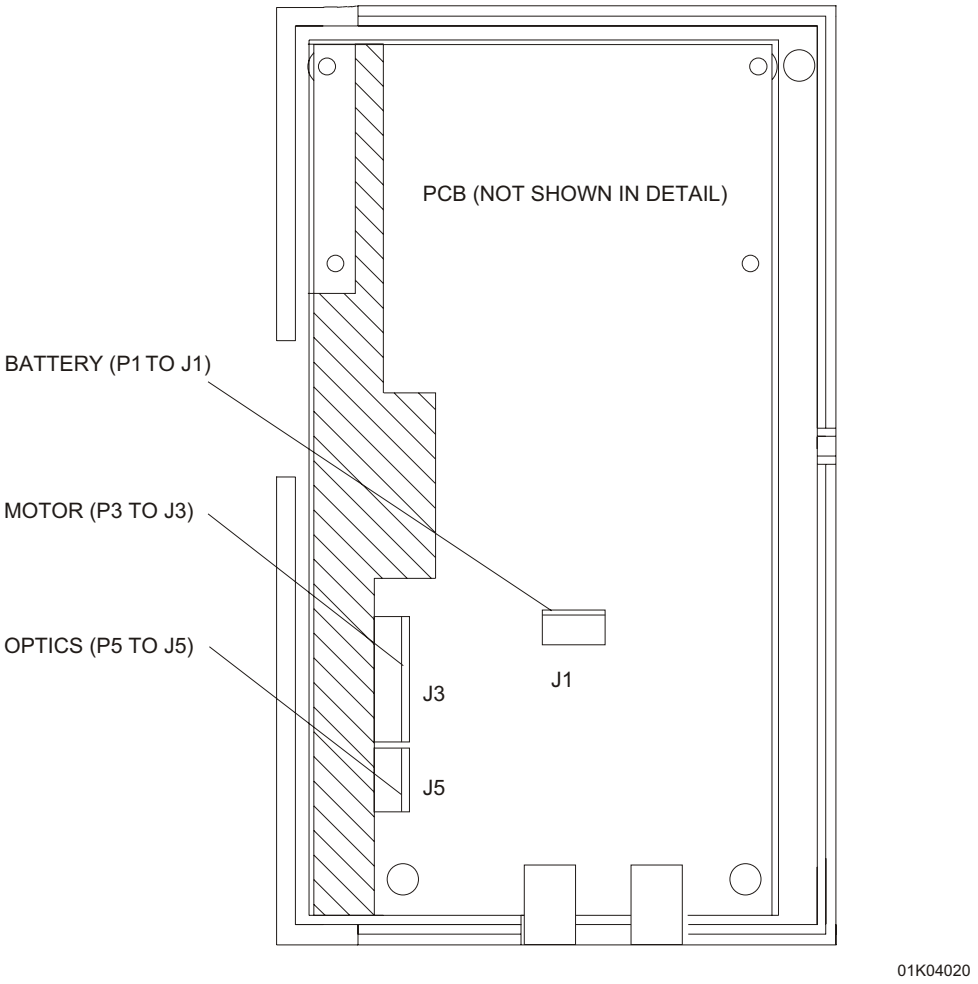

Figure 7-1. PCB Connections

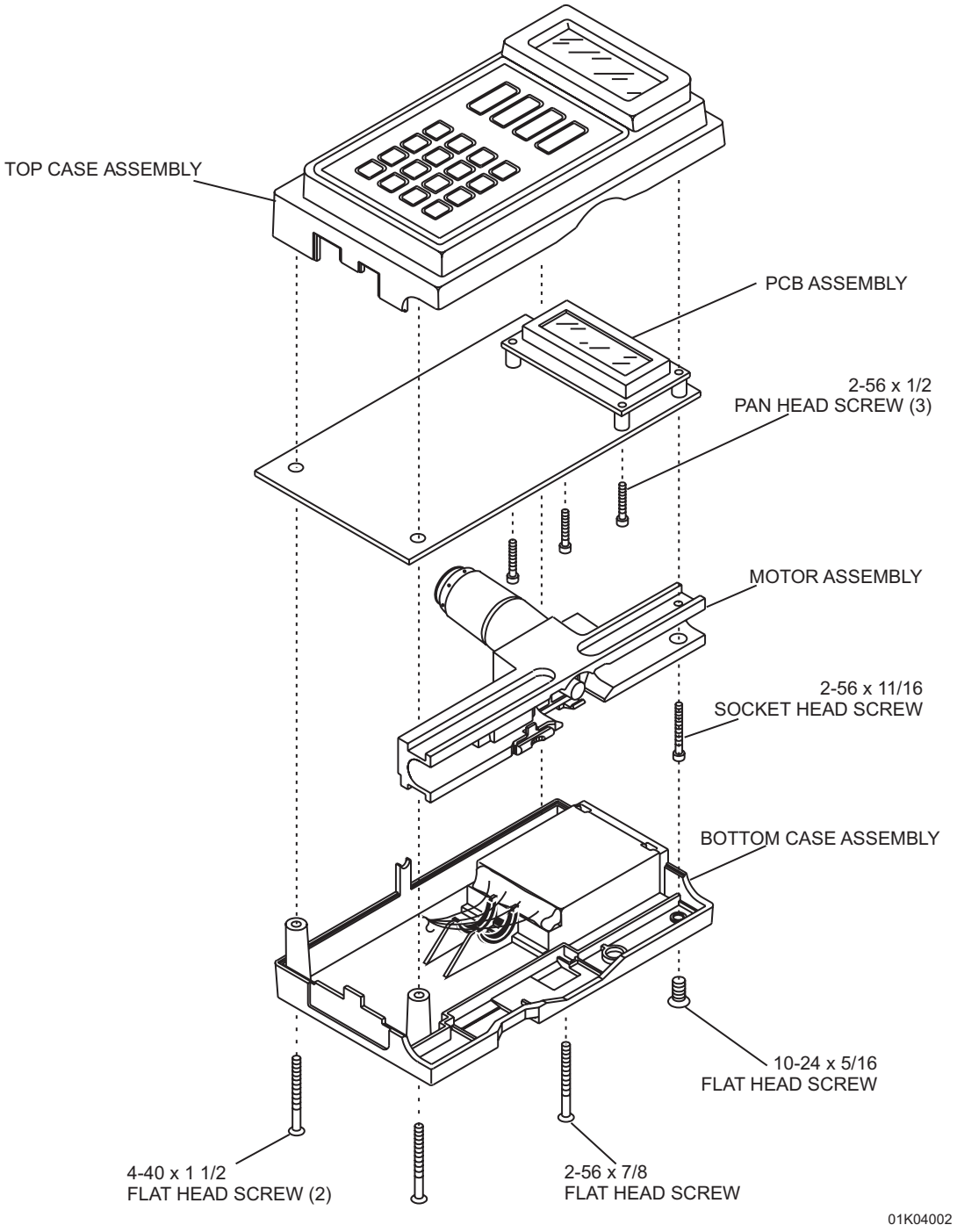

Figure 7-2. Separating the Top and Bottom Cases

7.2.4
MOTOR AND MOTOR ASSEMBLY REPLACEMENT

The motor assembly consists of the motor frame, gear motor, motor shaft extension, motor connector wires and housing fully assembled.

Note: The Portescap 22N motor has replaced the 22C motor for use in the APM and APM II. These motors are not interchangeable. Motor replacement requires modification of the PCB. For modification procedures, refer to *Section 7.2.4.1, PCB Modification for the 22N Motor*.

Recommended tools and materials for this procedure are: 5/64 Allen wrench, small flat blade screwdriver, Phillips screwdriver, and Loctite® Threadlocker 222 adhesive.

The replacement parts for this procedure are:

Assembly, Motor
or
Motor, Gear, 22N
Screw, 2-56 x 0.687, Socket Head, Hex

To remove the motor assembly, refer to *Figure 7-1*, *Figure 7-2*, and *Figure 7-3, Separating the Motor from the Motor Frame*, then proceed as follows:

1. Separate the top and bottom cases as described in *Section 7.2.3*.
2. Using the allen wrench, remove the socket head screw holding the proximal end of the motor frame to the top case *(see Figure 7-2)*.
3. Remove the motor pin P3 and the optics pin P5 from the PCB connections J3 and J5 *(see Figure 7-1)*.
4. Lift the motor and motor frame up and out of the top case. If replacing the motor assembly, proceed to step 5. If replacing the motor only, proceed as follows:
   - Remove the three M2 x 16 mm slotted screws holding the motor to the motor frame and lift the motor from the frame *(see Figure 7-3)*.
   - Place the replacement motor through the back of the motor frame. Align the motor mounting holes to the screw holes in the motor frame with the motor wires toward the optics carrier end of the motor frame.
   - Apply the Threadlocker 222 adhesive to the three M2 x 16 mm screws and thread into place. Tighten the screws.
5. Position the motor assembly in the top case.
6. Reassemble the device in the exact reverse order of its disassembly.

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

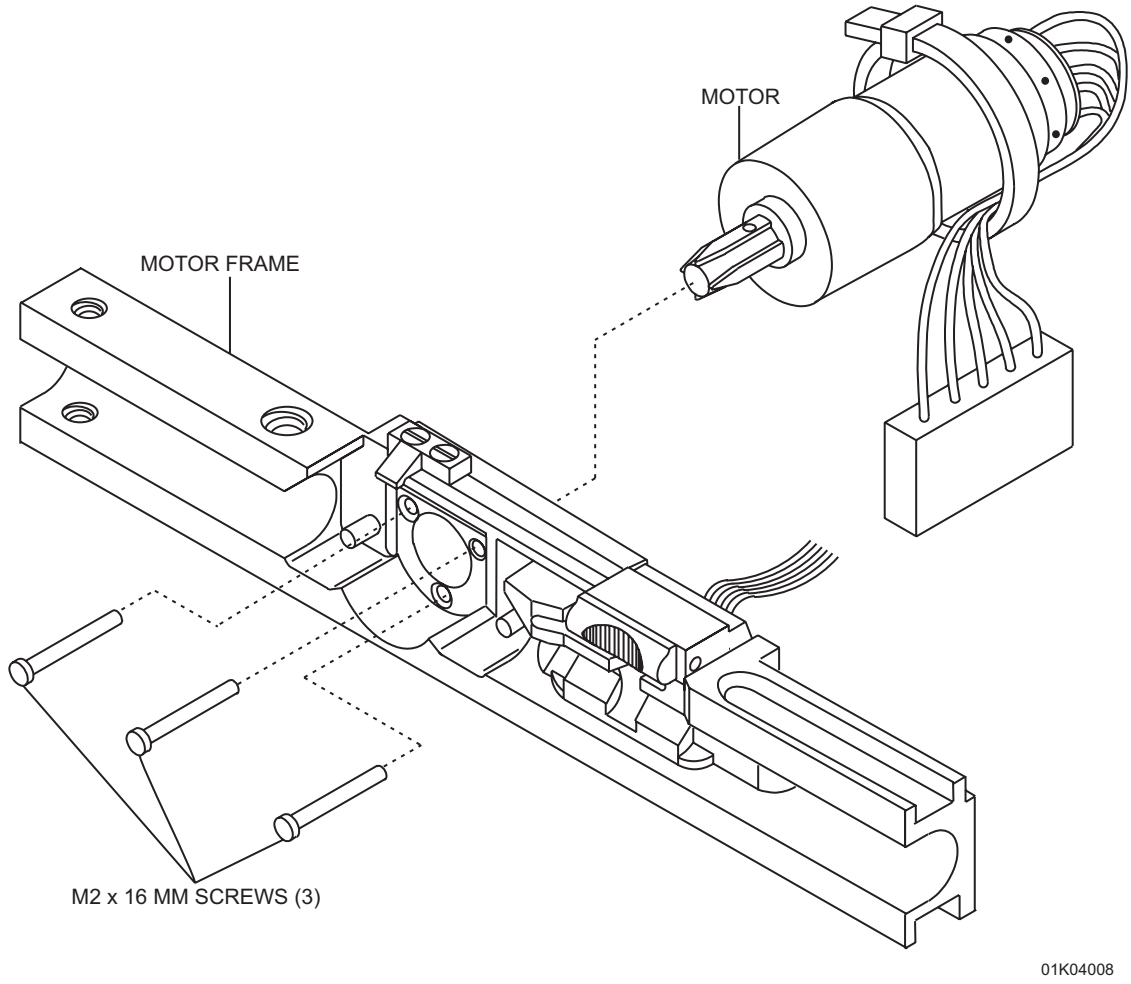

Figure 7-3. Separating the Motor from the Motor Frame

7.2.4.1

PCB MODIFICATION FOR THE 22N MOTOR

Motor assemblies using 22N must have an encoder PCB attached. An upgrade to the 22N motor assembly with encoder requires the addition of an insulator to capacitor C22 and a jumper wire between U18, pin 8 and J3, pin 1 on the main PCB. The 22N motor cannot be installed without the encoder PCB *(see Figure 7-5, Circuit Board Modification for the 22N Motor)*.

Recommended tools and materials for this procedure are a soldering iron and solder.

The replacement parts for this procedure are:

Motor, Gear, 22N
PCB Assembly, Motor Encoder
Insulation Material

To install a 22N motor and modify the PCB, refer to *Figure 7-4, Portescap 22N Motor Assembly with Encoder PCB/Insulator*, and *Figure 7-5, Circuit Board Modification for the 22N Motor*, then proceed as follows:

1. Separate the top and bottom assembly as described in *Section 7.2.3*.
2. Remove the defective motor as described in *Section 7.2.4, Motor and Motor Assembly Replacement*.
3. Using the soldering iron, install a jumper wire from U18, pin 8 to J3, pin 1 on the main PCB and add an insulator to the top of capacitor C22.
4. Connect the 9-pin connector on the motor encoder PCB to J3 on the main PCB.
5. Install a 22N motor through the back of the motor frame. Align the motor mounting holes to the screw holes in the motor frame with the motor wires toward the optics carrier end of the motor frame.
6. Apply the Threadlocker to the three M2 x 16 mm screws and thread into place. Tighten the screws.
7. Reassemble the device in the exact reverse order of its disassembly.

To verify successful PCB modification and motor assembly replacement, perform the PVT in *Section 5.2*.

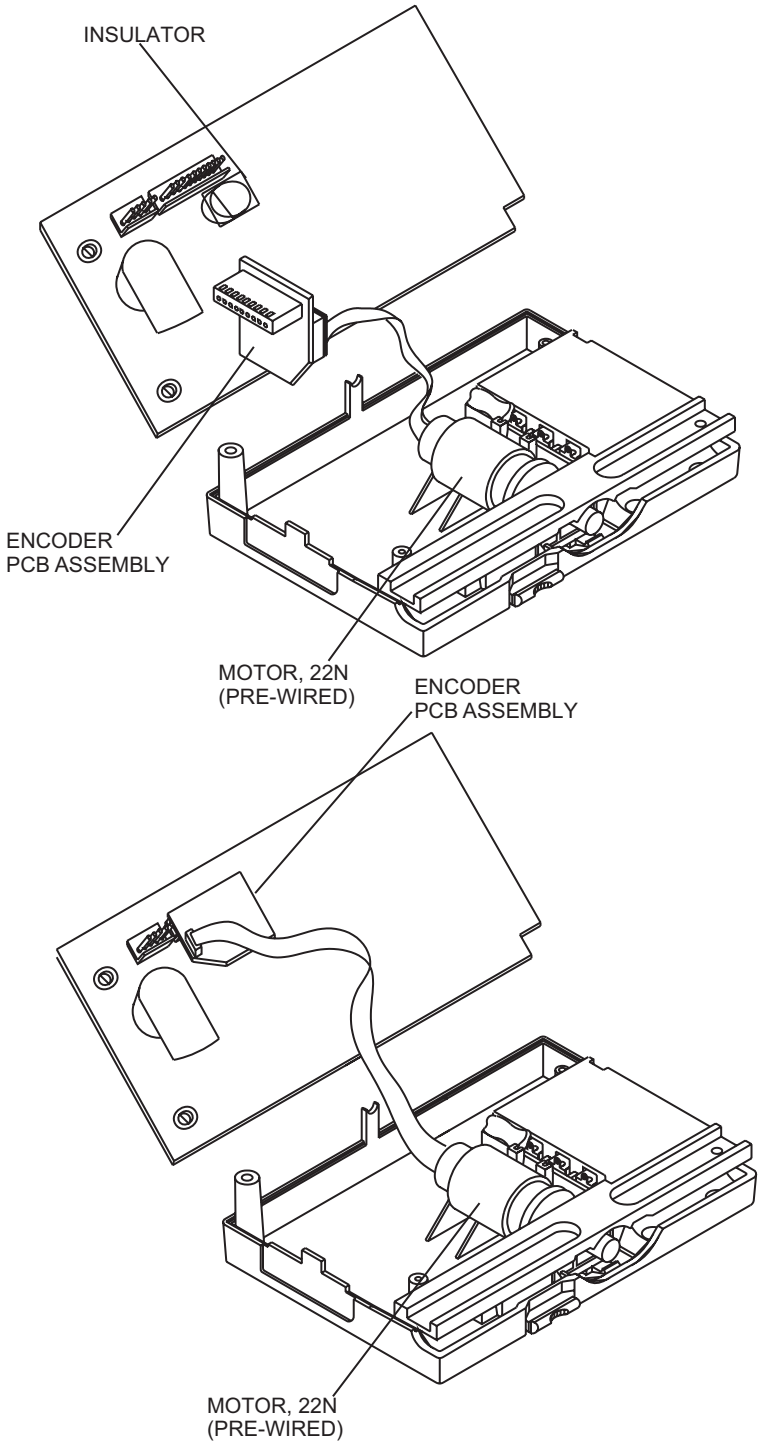

Figure 7-4. Portescap 22N Motor Assembly with Encoder PCB/Insulator

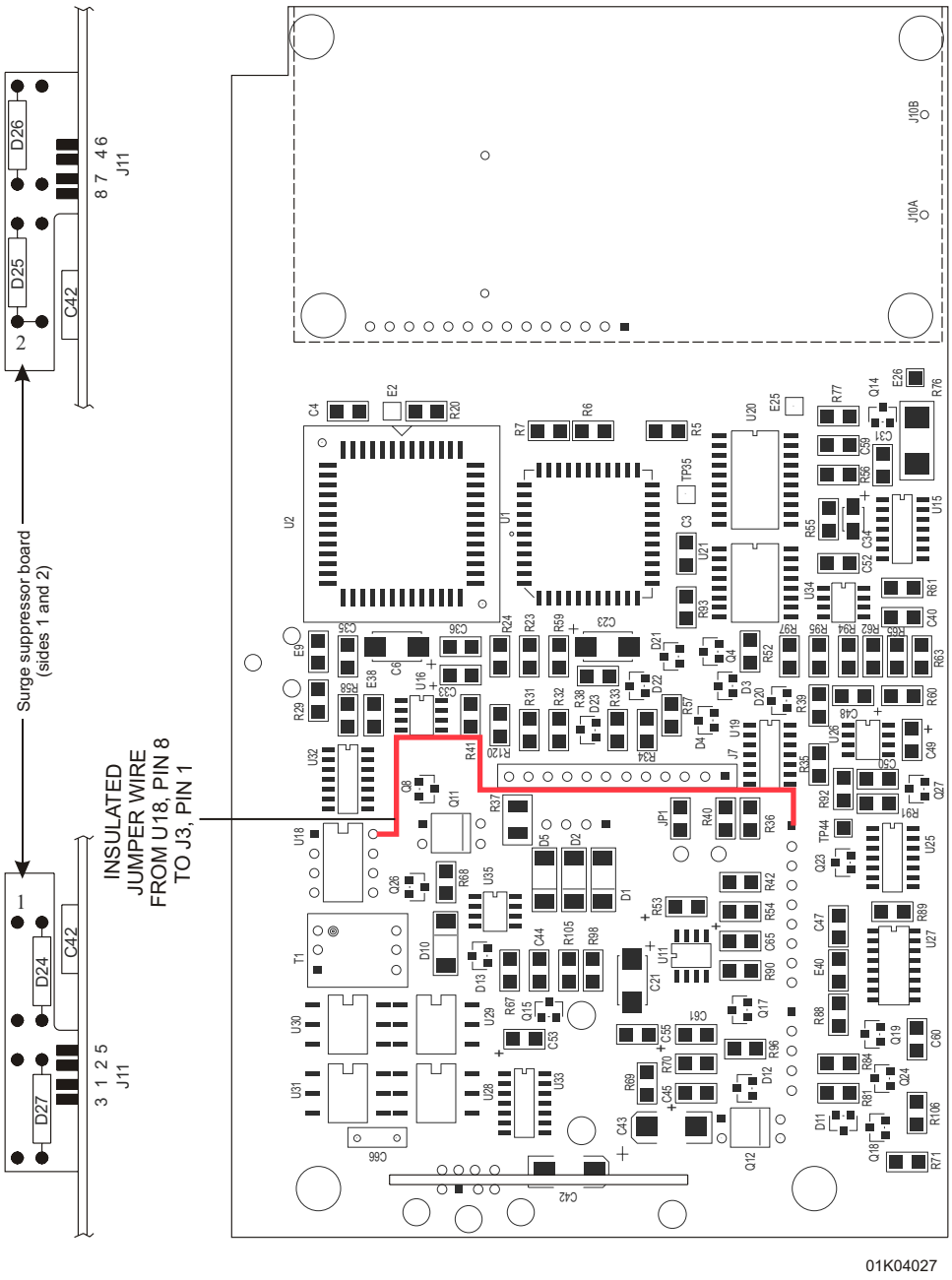

Figure 7-5. Circuit Board Modification for the 22N Motor

7.2.5
OPTICS ASSEMBLY REPLACEMENT

The optics assembly comes with the two LED/phototransistor pairs, the four optics surfaces, and the five connector wires with crimp pins mounted on the optics carrier *(see Figure 7-7, Optics Carrier Detail)*. The connector housing is attached after threading the wires through the motor frame.

Recommended tool for this procedure is a small, flat head screwdriver.

The replacement parts for this procedure are:

Assembly, Optics

To replace the optics assembly, refer to *Figure 7-6, Optics Assembly Replacement* and *Figure 7-8, Optics Wiring Details*, then proceed as follows:

1. Separate the top and bottom cases as described in *Section 7.2.3*.
2. Remove the motor assembly as described in *Section 7.2.4*.
3. Pull the crimp pins from the connector housing.
4. Using the flat head screwdriver, remove the two 2-56 x 1/4 inch fillister-head screws holding the optics assembly to the motor frame and detach the optics assembly from the motor frame *(see Figure 7-6)*.
5. Install the replacement optics assembly on the motor frame by guiding the wires through the large hole in the motor frame and seating the optics carrier on the frame *(see Figure 7-6)*.
6. Secure the optics assembly to the motor frame with the two screws and tighten.
7. Insert the pins into the 5-pin connector housing *(see Figure 7-8)*. Assure that the pins are locked securely into the housing by gently pulling on the wires.
8. Reassemble the pump in the exact reverse order of disassembly.

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

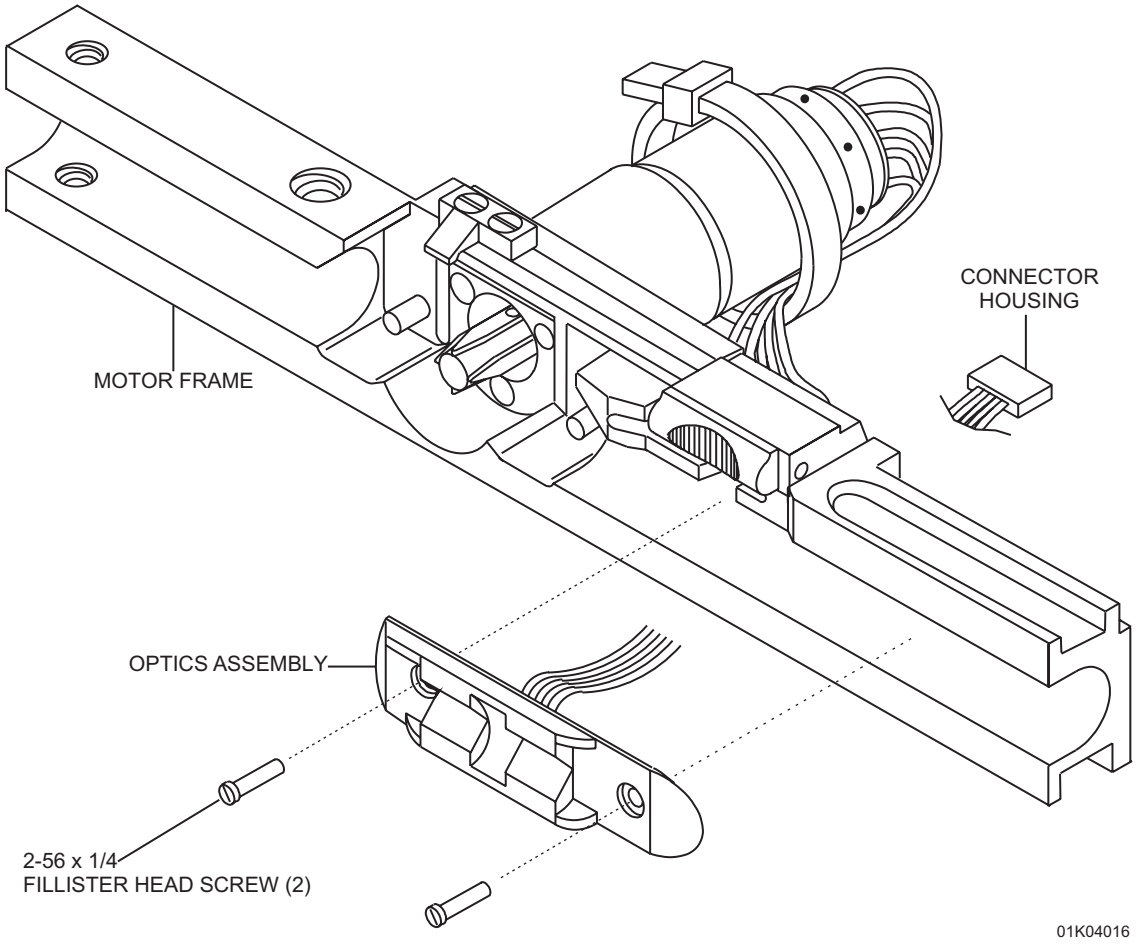

Figure 7-6. Optics Assembly Replacement

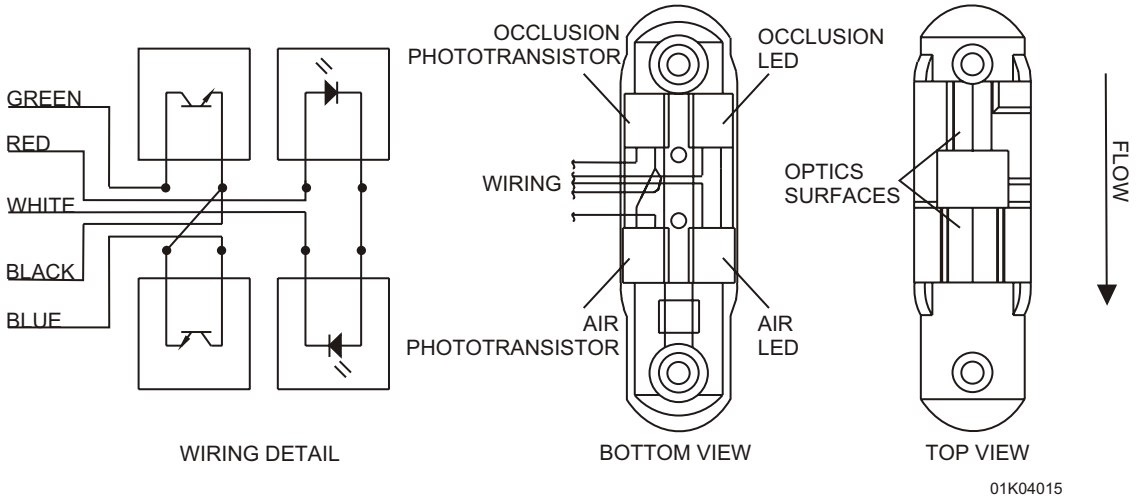

Figure 7-7. Optics Carrier Detail

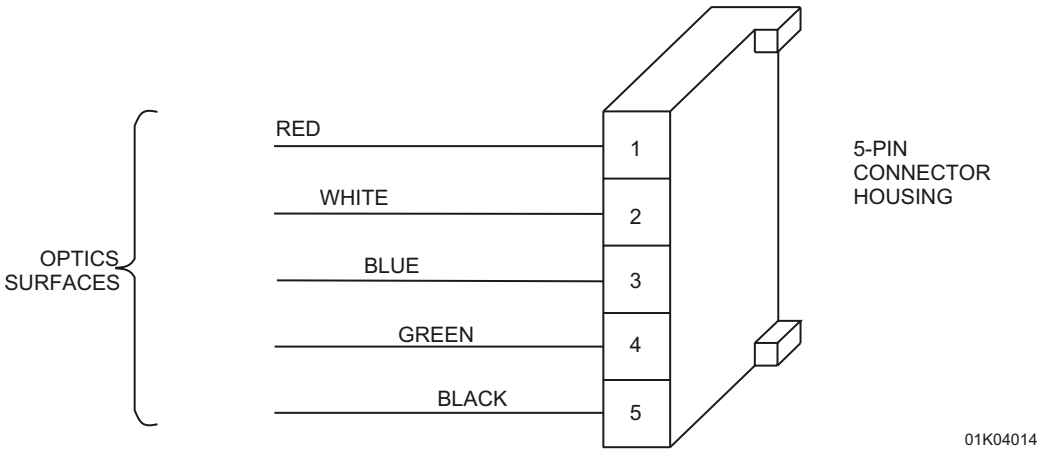

Figure 7-8. Optics Wiring Details

7.2.6
LATCH ASSEMBLY REPLACEMENT

No tools are required for this procedure.

The replacement parts for this procedure are:

Assembly, Latch
Pivot Pins, Ejector

To replace the latch assembly, refer to *Figure 7-9, Latch Assembly to Motor Frame* and proceed as follows:

1. Separate the top and bottom cases as described in *Section 7.2.3*.
2. Remove the ejector pivot pins and lift the latch assembly from the motor frame *(see Figure 7-9)*.
3. Position the replacement latch assembly into the motor frame and insert the ejector pivot pins.
4. Reassemble the device in the exact reverse order of disassembly.

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

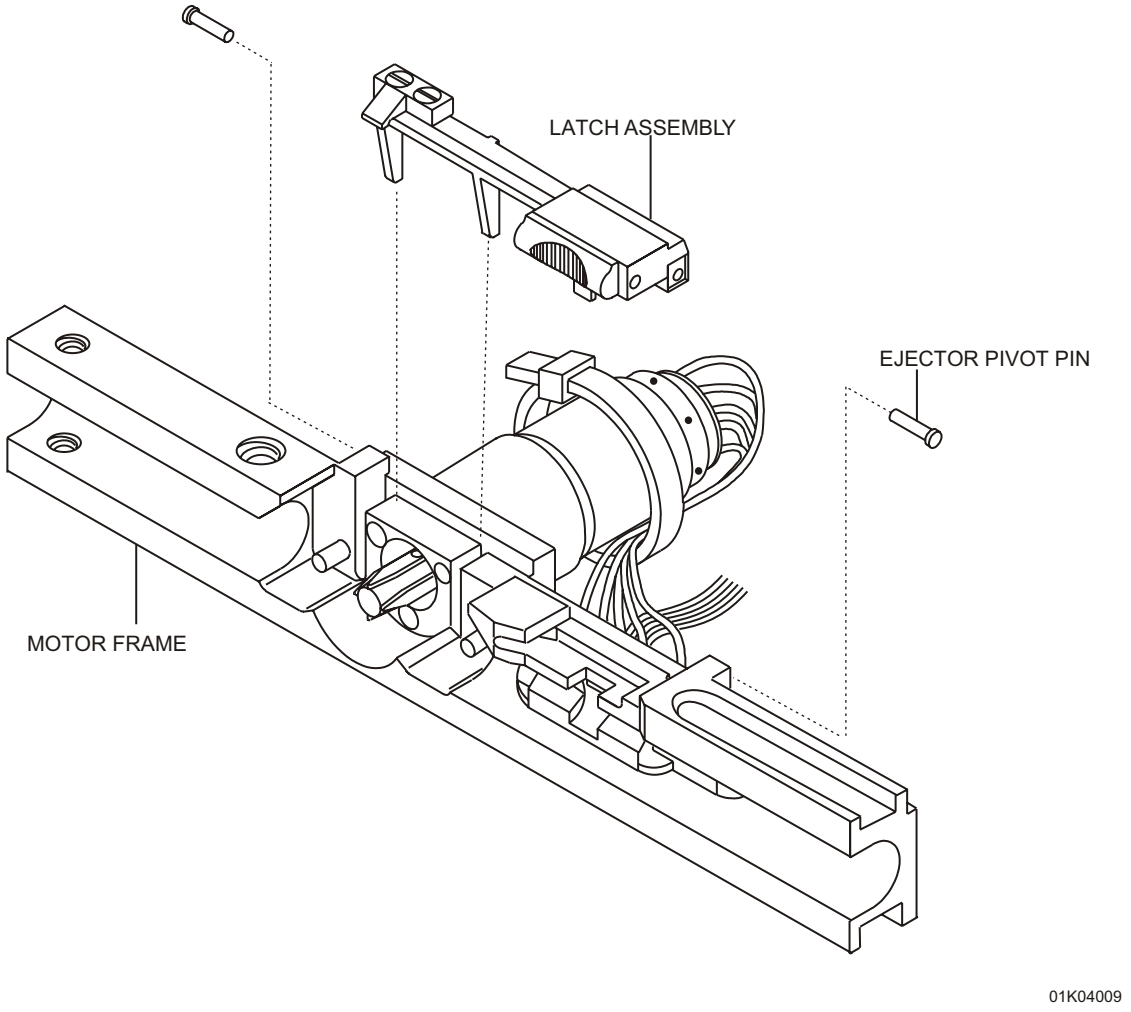

Figure 7-9. Latch Assembly to Motor Frame

7.2.7
PCB ASSEMBLY REPLACEMENT

Recommended tool for this procedure is a Phillips screwdriver.

The replacement parts for this procedure are:

Assembly, PCB
Screw, 2-56 x 1/2, Pan Head, Phillips

To remove the PCB Assembly, refer to *Figure 7-2, Separating the Top and Bottom Cases*, and *Figure 7-10, PCB Back Detail*, then proceed as follows:

1. Separate the top and bottom cases as described in *Section 7.2.3*.
2. Remove the motor assembly as described in *Section 7.2.4*.
3. Using the Phillips screwdriver, remove the three screws holding the board to the top case *(see Figure 7-2)*.
4. Disconnect the optics (J5), motor (J3), and battery (J1) connections *(see Figure 7-10)*.
5. Gently lift the PCB from the top case.
6. Disconnect the keypad ribbon cable from the front side of the PCB. Remove the defective PCB, and install the replacement.
7. Reassemble the device in the exact reverse order of disassembly.

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

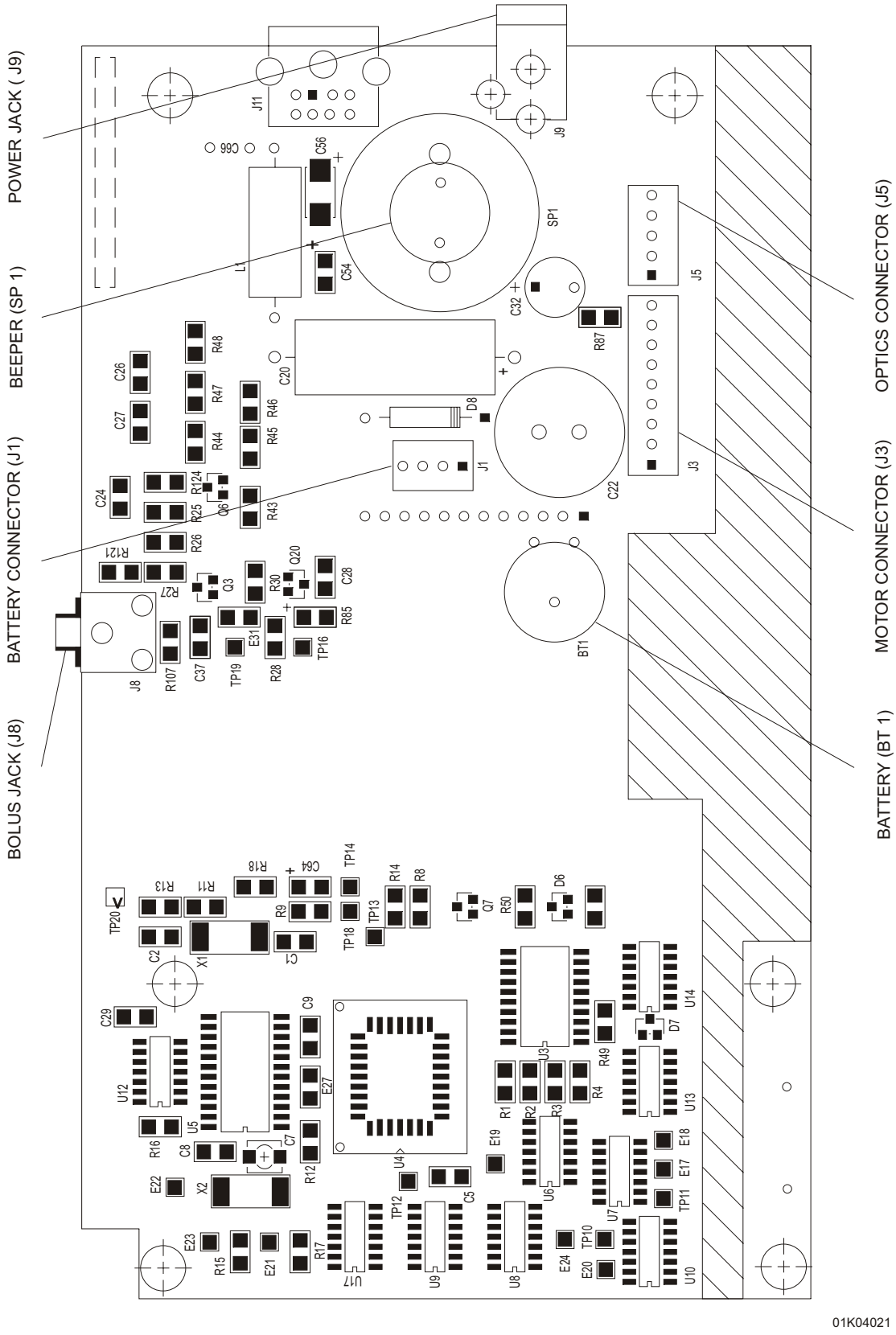

Figure 7-10. PCB Back Detail

7.2.8
TOP CASE ASSEMBLY REPLACEMENT

No tools are required for this procedure.

The replacement parts for this procedure are:

Assembly, Top Case

To replace the top case assembly, refer to *Figure 7-2, Separating the Top and Bottom Cases*, and *Figure 7-11, Top Case Assembly*, then proceed as follows:

1. Separate the top and bottom cases as described in *Section 7.2.3*.
2. Remove the motor assembly as described in *Section 7.2.4*.
3. Remove the PCB assembly as described in *Section 7.2.7*.
4. Remove the defective top case assembly, and replace.
5. Reassemble the device in the exact reverse order of disassembly.

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

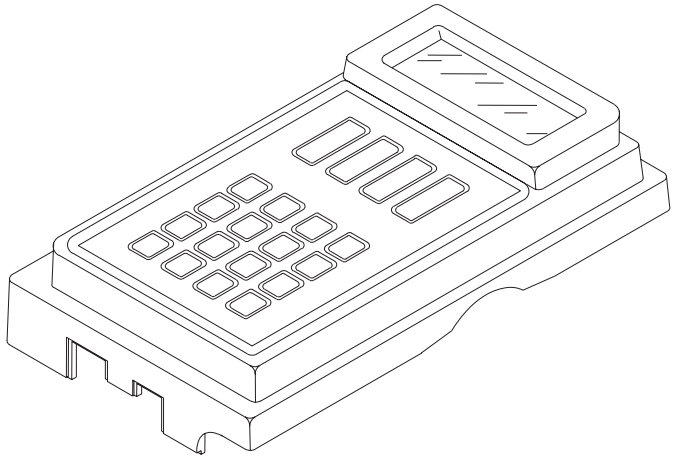

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Figure 7-11. Top Case Assembly

7.2.8.1

LCD WINDOW REPLACEMENT

Material required for this procedure is isopropyl alcohol.

The replacement parts for this procedure are:

Window, LCD, with Adhesive

To replace the LCD window, refer to *Figure 7-12, LCD Window to Top Case*, then proceed as follows:

1. Remove the top case as described in *Section 7.2.8*.
2. Detach the LCD window from the top case, being careful not to damage the case or the keypad.
3. If necessary, clean the inner top case surface with isopropyl alcohol and allow to dry completely.
4. Remove the paper adhesive protector from the matte surface of the LCD window and place inside the case facing the front.
5. Rub the back of the window to assure a complete sealing of the window adhesive to the top case.
6. Remove the clear protective cover from the smooth surface of the window.
7. Reassemble the device in the exact reverse order of disassembly.

To verify successful LCD window replacement, perform the PVT in *Section 5.2*.

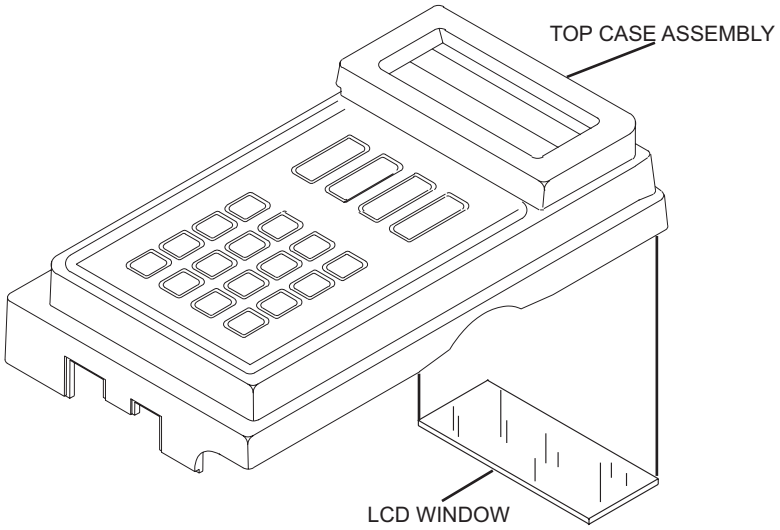

Figure 7-12. LCD Window to Top Case

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Section 8

SPECIFICATIONS

PHYSICAL

Dimensions: 17.1 (H) x 10 (W) x 5.8 (D) cm (6.75 x 4.0 x 2.3 inches)

Weight: Approximately 1.0 kg (2 pounds)

FUNCTIONAL

Pump Mechanism: One microcomputer-controlled eccentric-rotor peristaltic motor

Display: Two-line, liquid crystal display (LCD) with backlight
On AC power: continuously backlit
On battery power: continuously backlit during programming, program review, and history display. At other times, the backlight is activated by keystrokes and remains on for three seconds after the keystroke. Pressing the remote bolus switch does not activate the backlight

Time of Day Clock: 12-hour clock with AM/PM displayed adjustable to 24-hour clock without AM/PM displayed
Accuracy: ±3 minutes/month or better

Operating Controls: Keypad: 24 membrane-type switches
ON/OFF: One electromechanical switch
Remote Bolus: Jack for remote switch connection

Printer Interface: Jack and isolated interface circuit
Printers: Kodak Diconix 150 Plus or 180si, or Seiko DPU411 or DPU414
Printer Port: RS232C serial interface port

Memory Protection: Nonvolatile memory of up to 256 events for up to one year when batteries are removed from pump

Electrical Safety: Meets CSA (NRTL) guidelines and IEC 601-1-1 and 601-1-2 standards

ENVIRONMENTAL

Temperature Ranges: Operating: +10 to +40 degrees Celsius
Shipping and Storage: -20 to +60 degrees Celsius

Relative Humidity: 10 to 90 percent

Atmospheric Pressure: 0 to 10,000 feet (0 to 3,000 m) equivalent pressure

POWER SOURCES

AC Power: AC power indicator: Amber colored LED next to the international plug icon on the keypad; illuminated LED does not indicate if the voltage is correct
Use Hospira List 13036 AC Power Adapter with 3.6 m (12 ft) cord and molded plug

Power Supply	Input	Output
13036-04 (domestic)	115 VAC 60 Hz 0.18 A	12 VDC 0.4 A
13036-24 (int'l table top)	220-240 VAC 50 Hz 12 VA	12 VDC 0.3 A
13036-36 or -54 (int'l or UK wall plug-in)	230 VAC 50 Hz 12 VA or 0.10 A	12 VDC 0.4 or 0.5 A

Disposable Batteries: Two 9 V alkaline batteries
Capacity: Approximately four days at 6.0 mL/hr

Rechargeable Pack: Attachable separate battery pack
Recharge time: Full recharge requires up to six hours
Capacity: Approximately five days at 6.0 mL/hr

OCCLUSION PRESSURE

Occlusion Alarm Pressure: 45 psi (310 kPa)

Maximum Delivery Pressure: 45 psi (310 kPa)

ALARMS (AUDIBLE AND VISUAL)

Low batteries	On batteries	Change batteries
Limit exceeded	Callback alert	Purge overuse
End of infusion	Empty container	Check printer
Check cartridge	Air In Line	Occlusion
Amount too small	Amount too large	
System error	Internal malfunction	

PROGRAMMABLE RANGES

Entry	APM	APM II
Concentration	0.1 - 50.0 mg/mL 0.1 - 1000 µg/mL	0.1 - 50.0 mg/mL 1 - 1000 µg/mL
Delivery Rate	0.1 - 25 mL/hr 0.1 - 9999.9 mg/hr 0.1 - 9999.9 µg/hr	0.1 - 25 mL/hr 0.1 - 9999.9 mg/hr 1 - 999999 µg/hr
	mg and µg entries cannot exceed 25 mL/hr equivalent	
Bolus and Loading Doses	0.1 -25 mL 0.1 - 9999.9 mg 0.1 - 9999.9 µg	0.1 -25 mL 0.1 - 9999.9 mg 1 - 999999 µg
Flow rate: 125 mL/hr	mg and µg entries cannot exceed 25 mL equivalent	
Bolus Lockout Time	5 - 99 min. (dom) 5 - 999 min. (int'l)	5 - 999 min.
Delivery Limit	4 hour limit 0.1 - 1000 mL 0.1 - 9999.9 mg 0.1 - 9999.9 µg	1 or 4 hour limit 0.1 - 1000 mL 0.1 - 9999.9 mg 1 - 999999 µg
	Cont/Cont+Bolus: must be greater than continuous delivery over limit period Bolus Only: must be at least one bolus dose	
Container Size (Volume)	0.1 - 1000 mL 0.1 - 9999.9 mg 0.1 - 9999.9 µg	0.1 - 1000 mL 0.1 - 9999.9 mg 1 - 999999 µg
	mg and µg entries cannot exceed 1000 mL equivalent	
Air Sensitivity	High (pump alarms at approx. 100 µL) Low (pump alarms at approx. 300 µL) Off (air alarm off)	

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Section 9
DRAWINGS

Figure 9-1 through *Figure 9-13* show the illustrated parts breakdown (IPB), infusion pump assembly diagrams, PCB assembly configurations, and schematic diagrams for the AIM and AIM Plus.

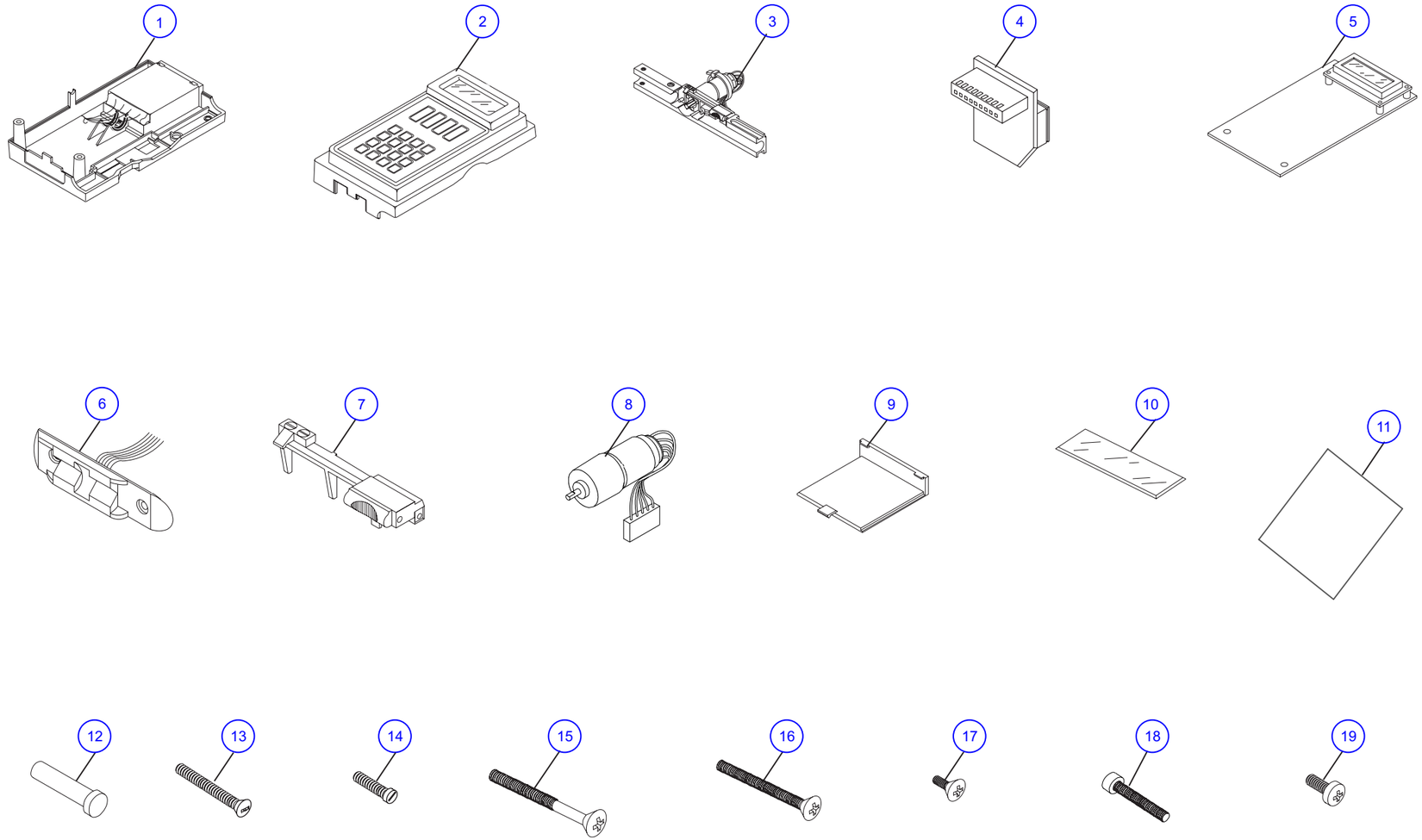
Table 9-1, Drawings, lists drawings by figure number, title, and part number. *Table 9-2, IPB for the Infusion Pump*, identifies parts by index numbers which correlate to *Figure 9-1*.

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 No.	Title	Part Number
9-1	Illustrated Parts Breakdown	Not Applicable
9-2	APM Exploded View	Not Applicable
9-3	APM Motor Assembly	Not Applicable
9-4	APM Schematic - Analog	100987
9-5	APM Microprocessor (CPU) Schematic	100987
9-6	APM Power and Miscellaneous Circuitry Schematic	100987
9-7	APM PC Board, Front Side	101199
9-8	APM PC Board, Back Side	101199
9-9	APM II Schematic - Analog	101871
9-10	APM II Microprocessor (CPU) Schematic	101871
9-11	APM II Power and Miscellaneous Circuitry Schematic	101871
9-12	APM II PC Board Front Side	101870
9-13	APM II PC Board Back Side	101870

Table 9-2. IPB for the Infusion Pump		
Index No.	**Nomenclature**	**Replacement Procedure**
1	Assembly, Bottom Case	*Section 7.2.3*
2	Assembly, Top Case	*Section 7.2.8*
3	Assembly, Motor	*Section 7.2.4*
4	PCB Assembly, Motor Encoder	*Section 7.2.4.1*
5	Assembly, PCB	*Section 7.2.7*
6	Assembly, Optics	*Section 7.2.5*
7	Assembly, Latch	*Section 7.2.6*
8	Motor, Gear, 22N	*Section 7.2.4.1*
9	Door, Battery	*Section 7.2.3*
10	Window, LCD, with Adhesive	*Section 7.2.8.1*
11	Insulator, Right	*Section 7.2.4.1*
12	Pin, Ejector, Pivot	*Section 7.2.6*
13	Screw, M2 x 16mm, Flat Head, Slotted	*Section 7.2.4*
14	Screw, 2-56 x 1/4, Fillister Head, Slotted	*Section 7.2.5*
15	Screw, 4-40 x 1 1/2, Phillips Flat Head	*Section 7.2.3*
16	Screw, 2-56 x 7/8, Phillips Flat Head	*Section 7.2.3*
17	Screw, 10-24 x 5/16, Phillips Flat Head	*Section 7.2.3*
18	Screw, 2-56 x 0.687, Socket Head, Hex	*Section 7.2.4*
19	Screw, 2-56 x 1/2, Pan Head, Phillips	*Section 7.2.7*



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

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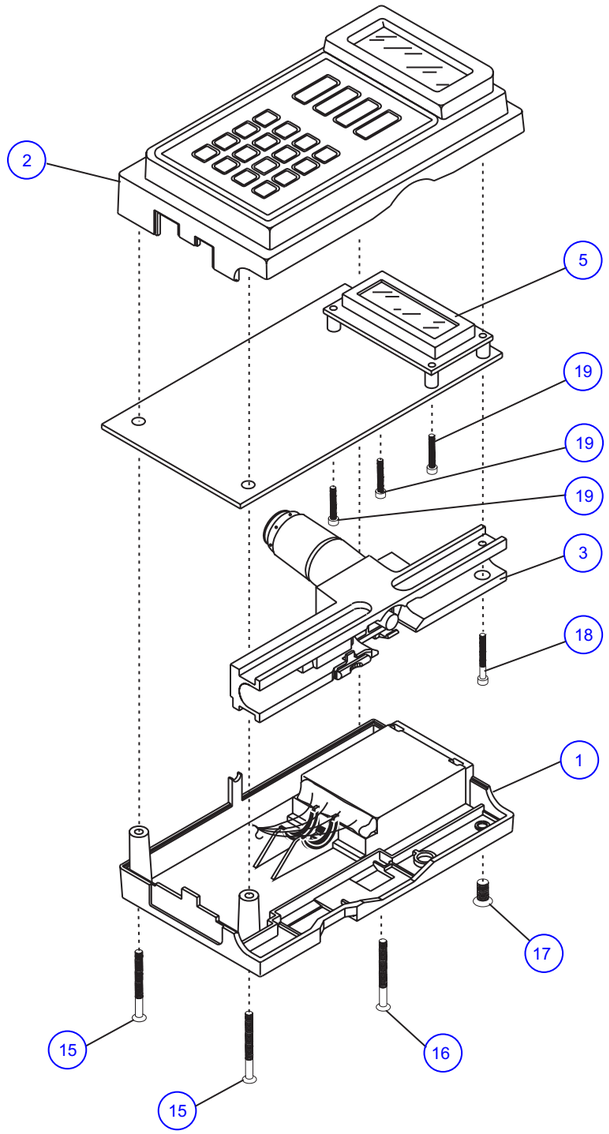

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HOSPIRA, INC.	
Figure 9-2. APM Exploded View	
DRAWING NO. NOT APPLICABLE	Rev. N/A
	Sheet 1 of 1

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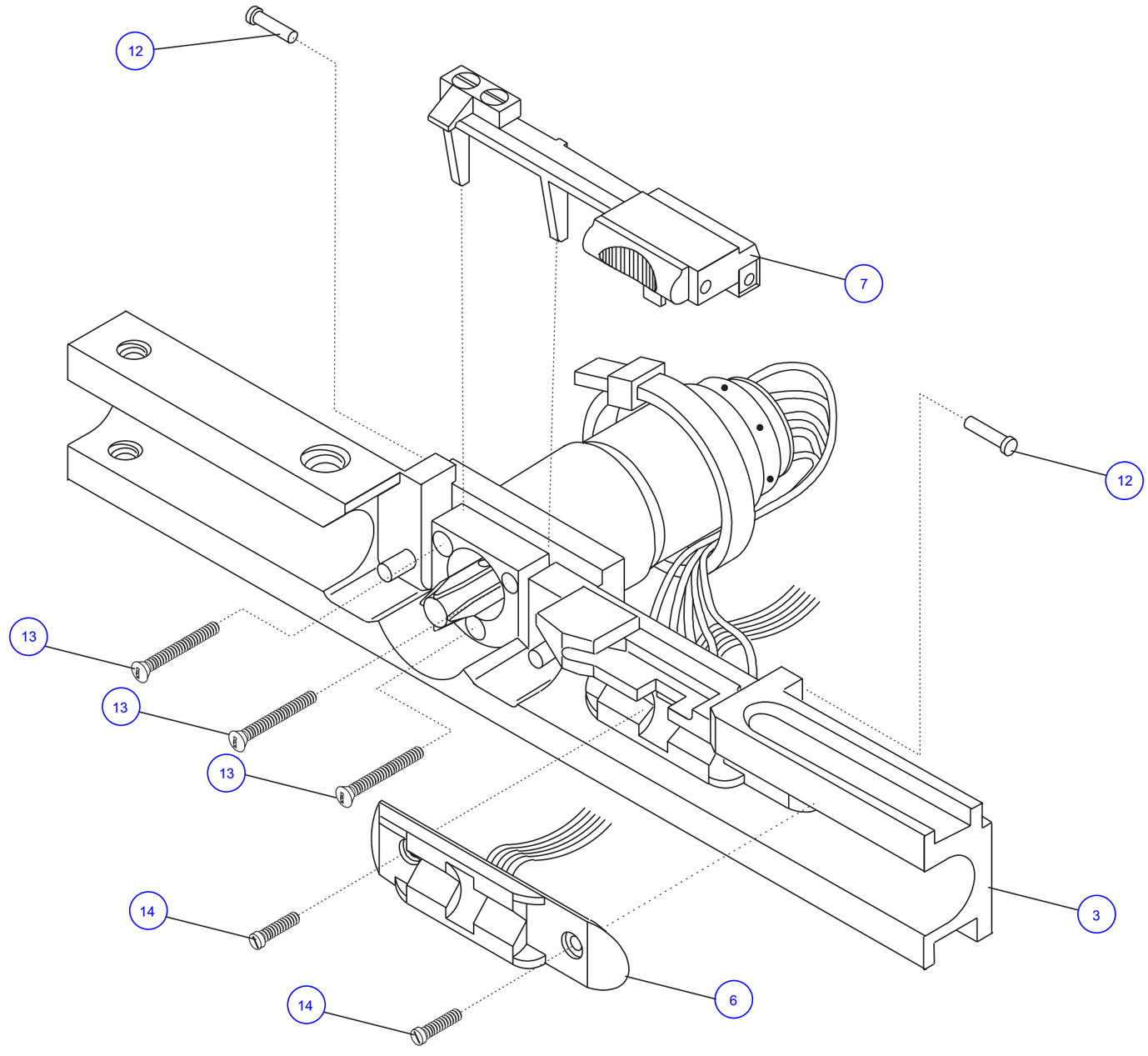

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HOSPIRA, INC.	
Figure 9-3. APM Motor Assembly	
DRAWING NO. NOT APPLICABLE	Rev. N/A
	Sheet 1 of 1

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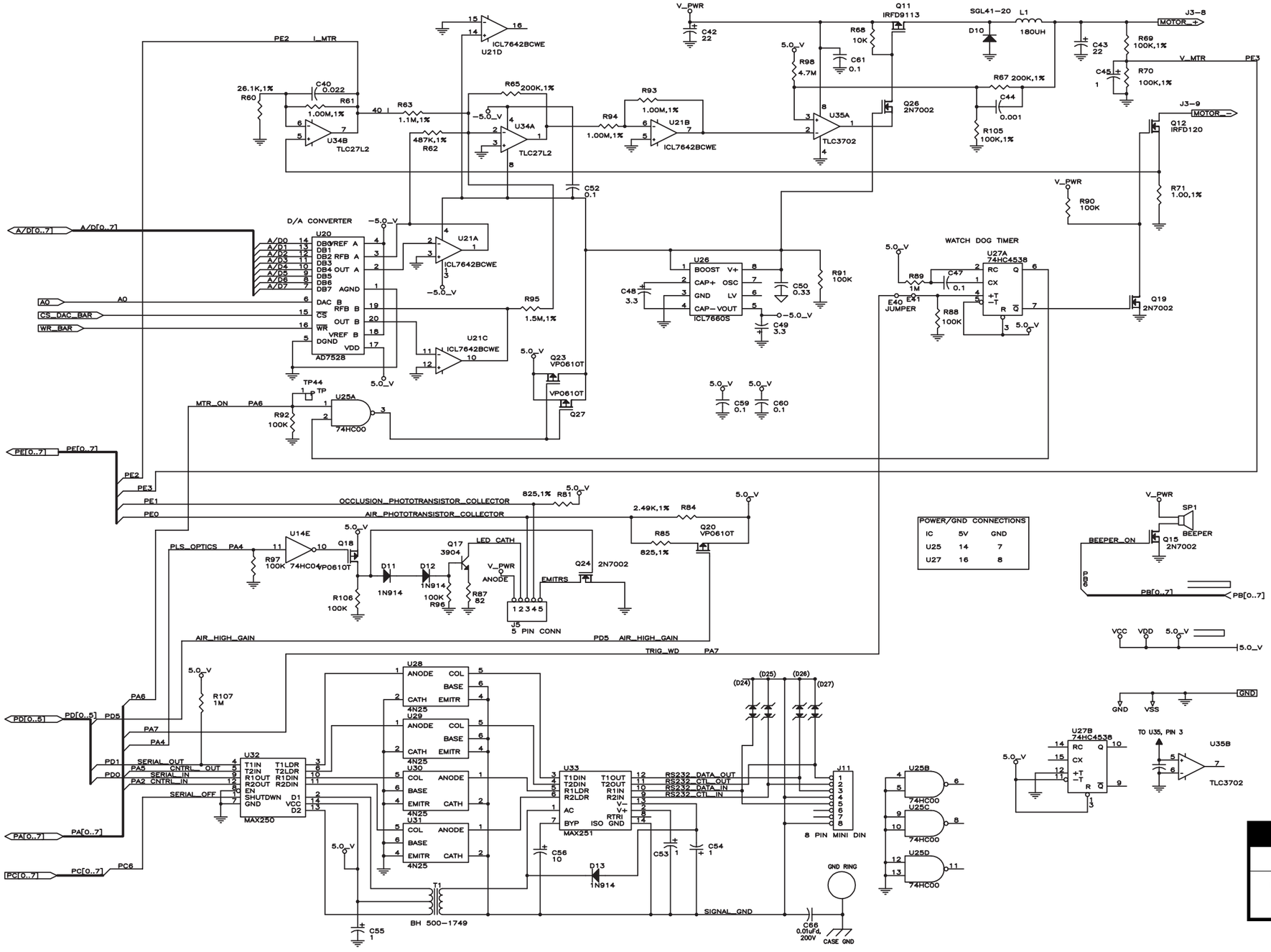

HOSPIRA, INC.	
Figure 9-4. APM Analog Schematic	
DRAWING NO. 100987	Rev. L
	Sheet 1 of 1

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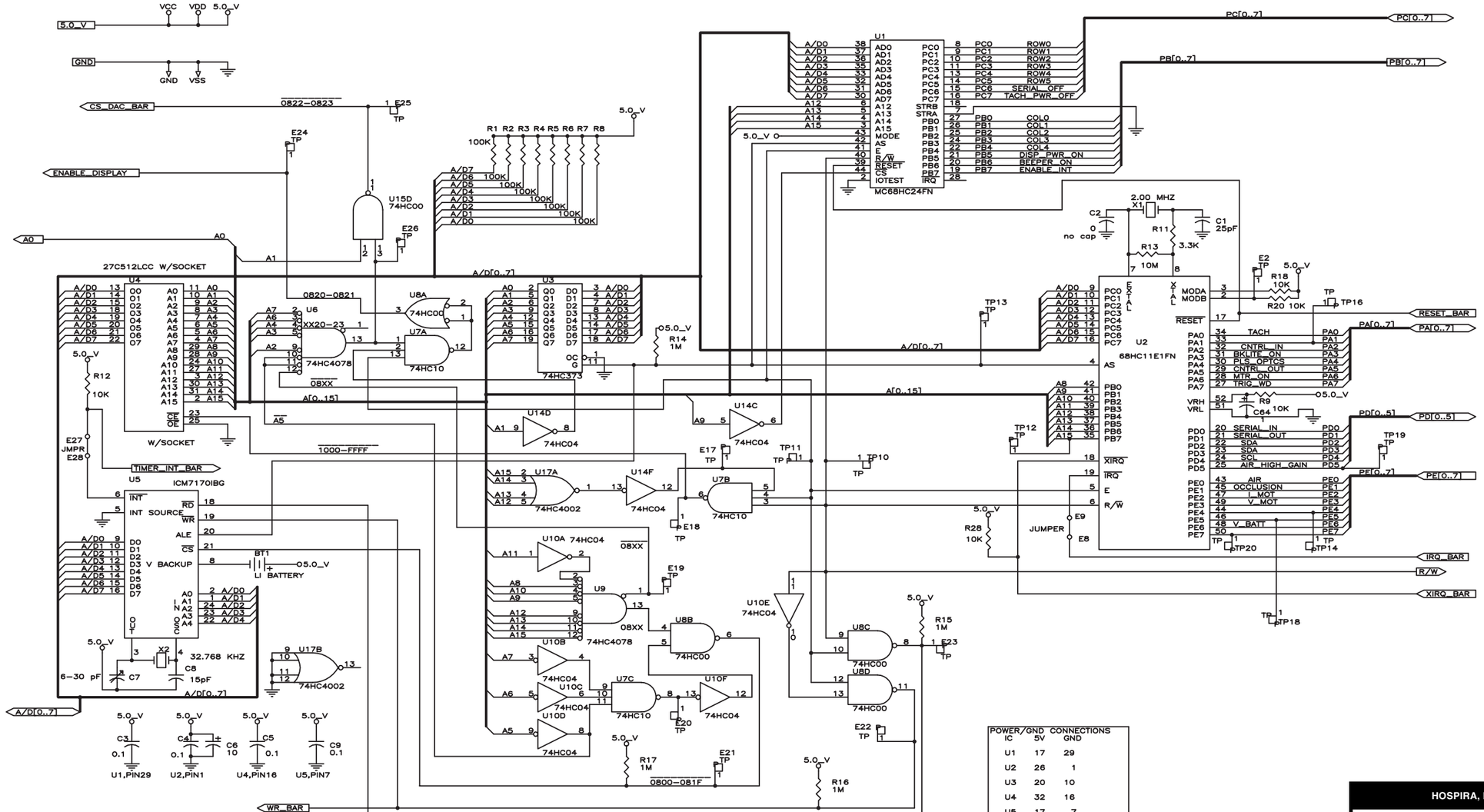

POWER/GND CONNECTIONS		
IC	5V	GND
U1	17	29
U2	26	1
U3	20	10
U4	32	16
U5	17	7
U6	14	7
U7	14	7
U8	14	7
U9	14	7
U10	14	7

HOSPIRA, INC.	
Figure 9-5. APM Microprocessor (CPU) Schematic	
DRAWING NO. 100987	Rev. L
	Sheet 1 of 1

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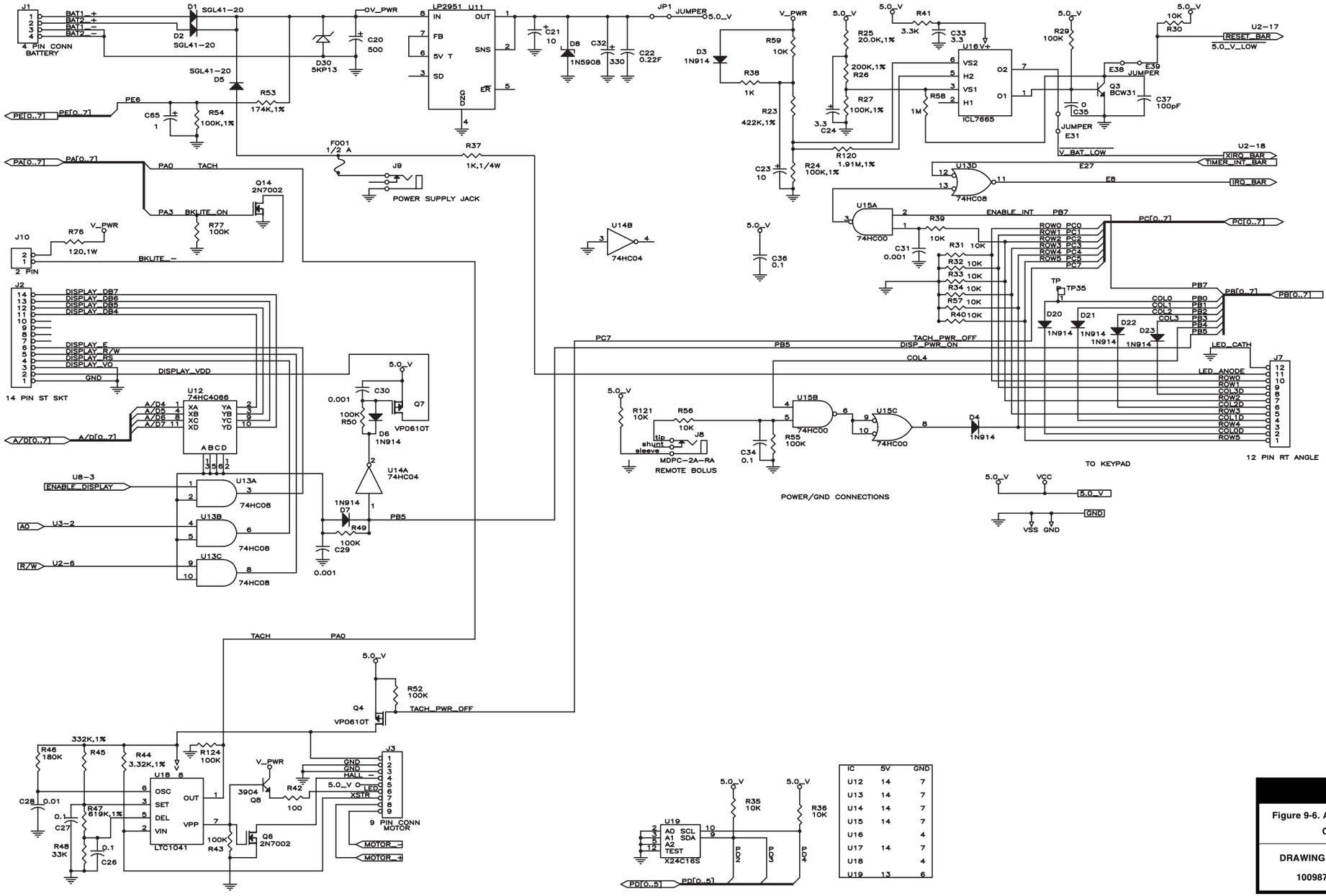

IC	5V	GND
U12	14	7
U13	14	7
U14	14	7
U15	14	7
U16		4
U17	14	7
U18		4
U19	13	6

HOSPIRA, INC.	
Figure 9-6. APM Power and Miscellaneous Circuitry Schematic	
DRAWING NO. 100987	Rev. L
	Sheet 1 of 1

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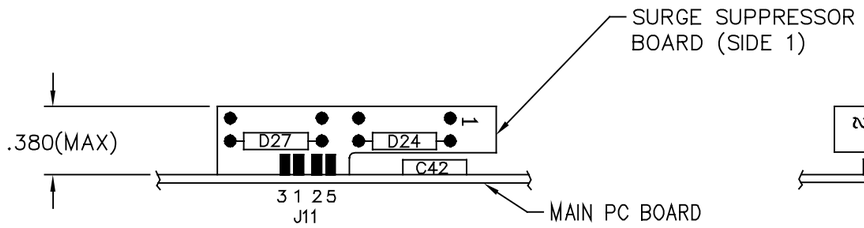
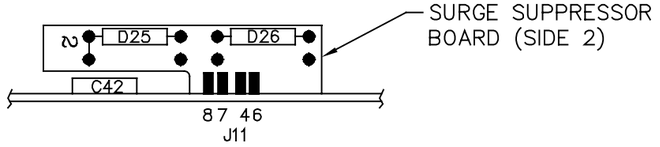
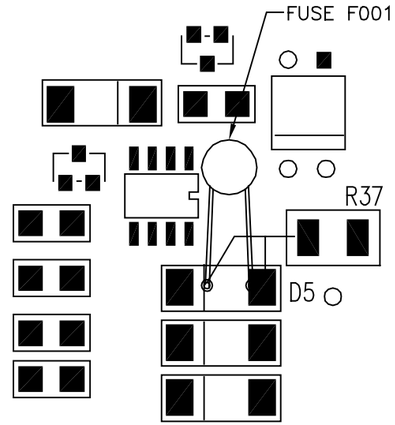


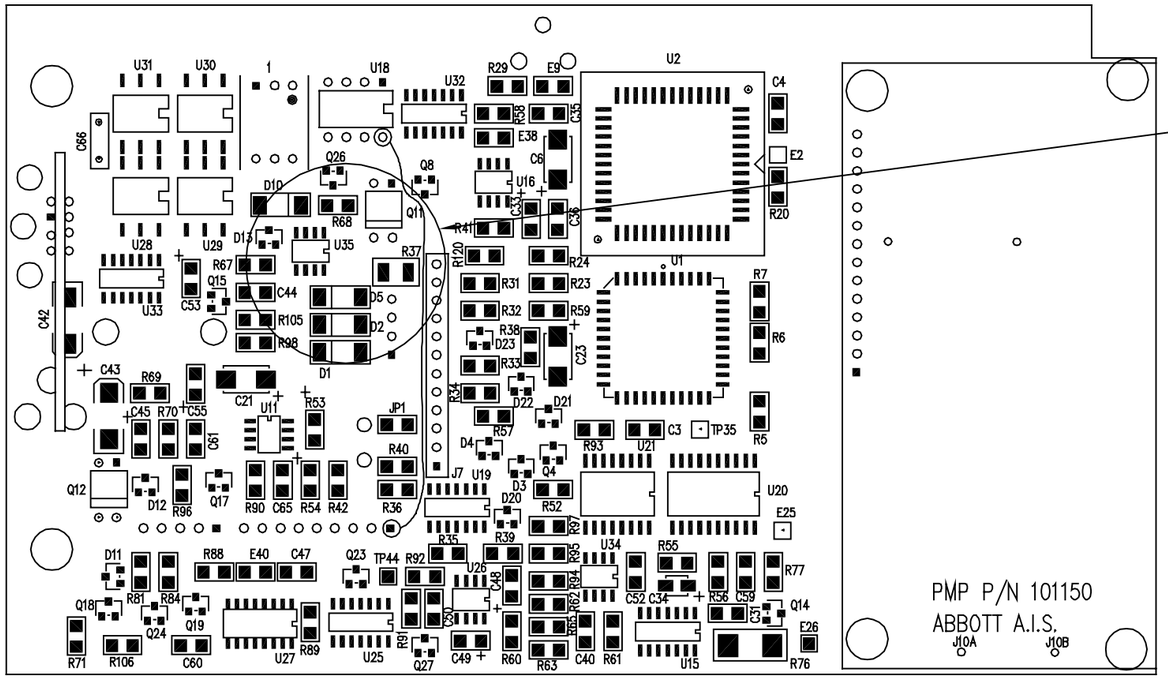
DETAIL B



DETAIL C



DETAIL D



HOSPIRA, INC.	
Figure 9-7. APM PC Board, Front Side	
DRAWING NO. 101199	Rev. N
	Sheet 1 of 1

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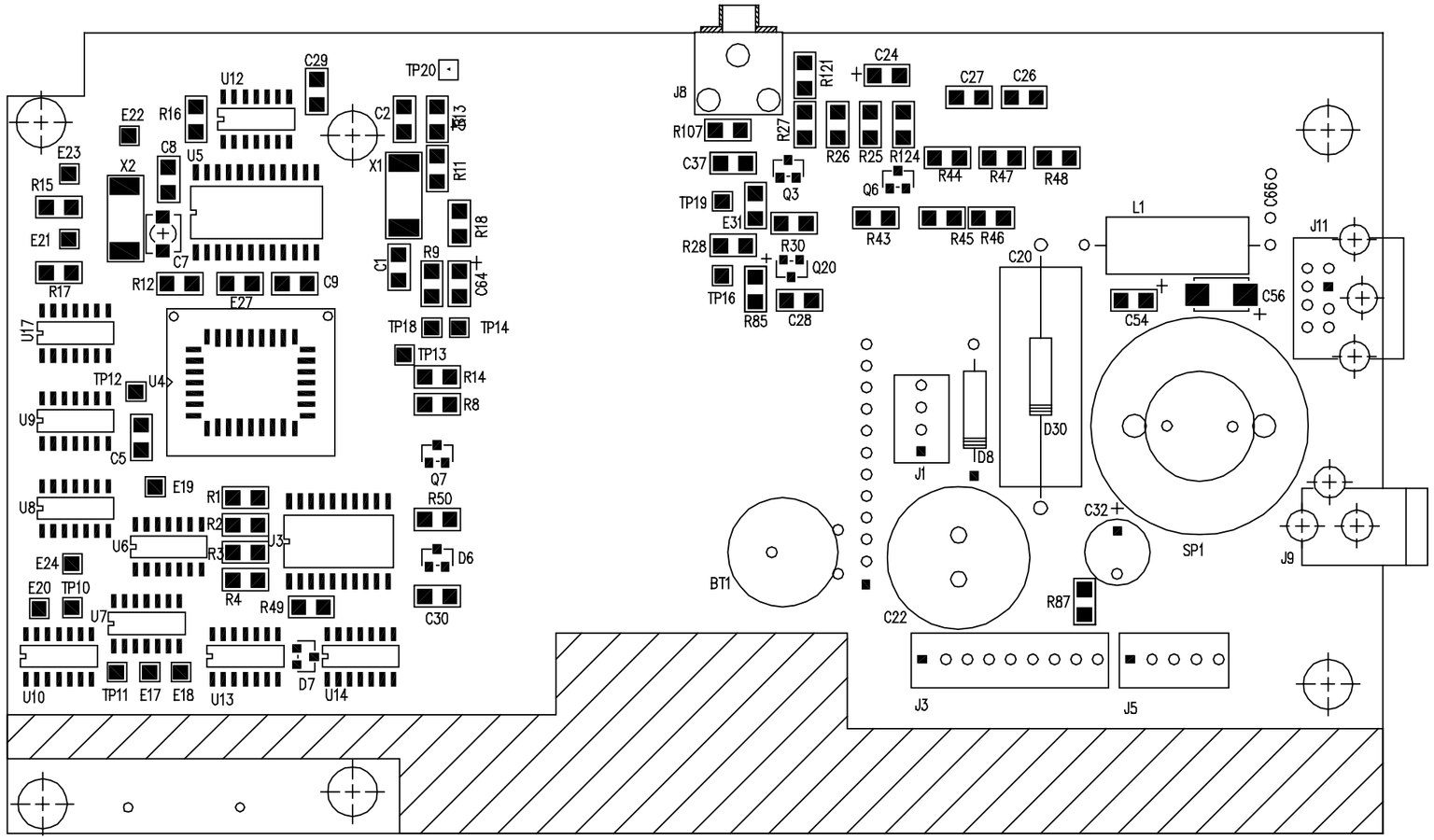

HOSPIRA, INC.	
Figure 9-8. APM PC Board, Back Side	
DRAWING NO. 101199	Rev. N
	Sheet 1 of 1

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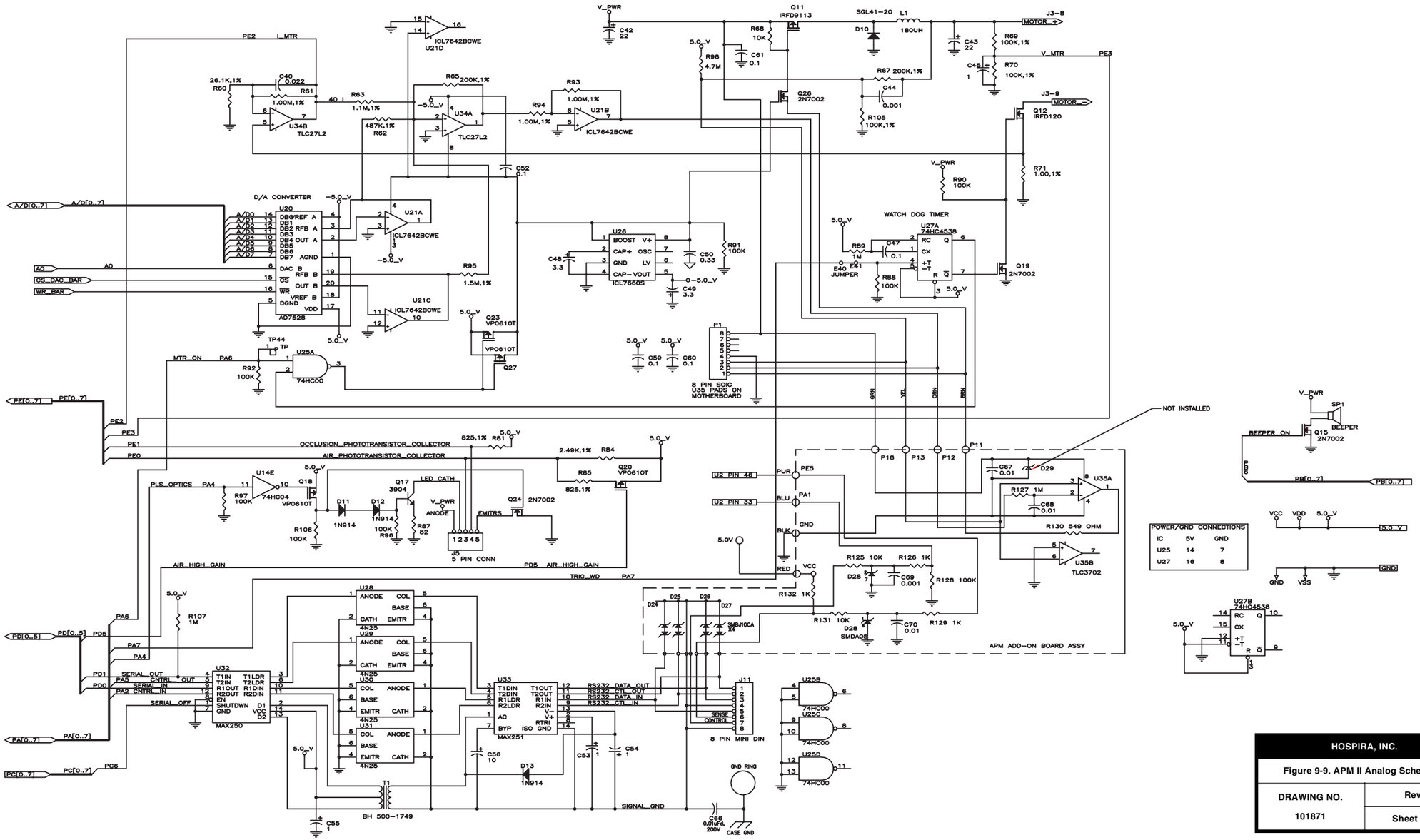

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Figure 9-9. APM II Analog Schematic	
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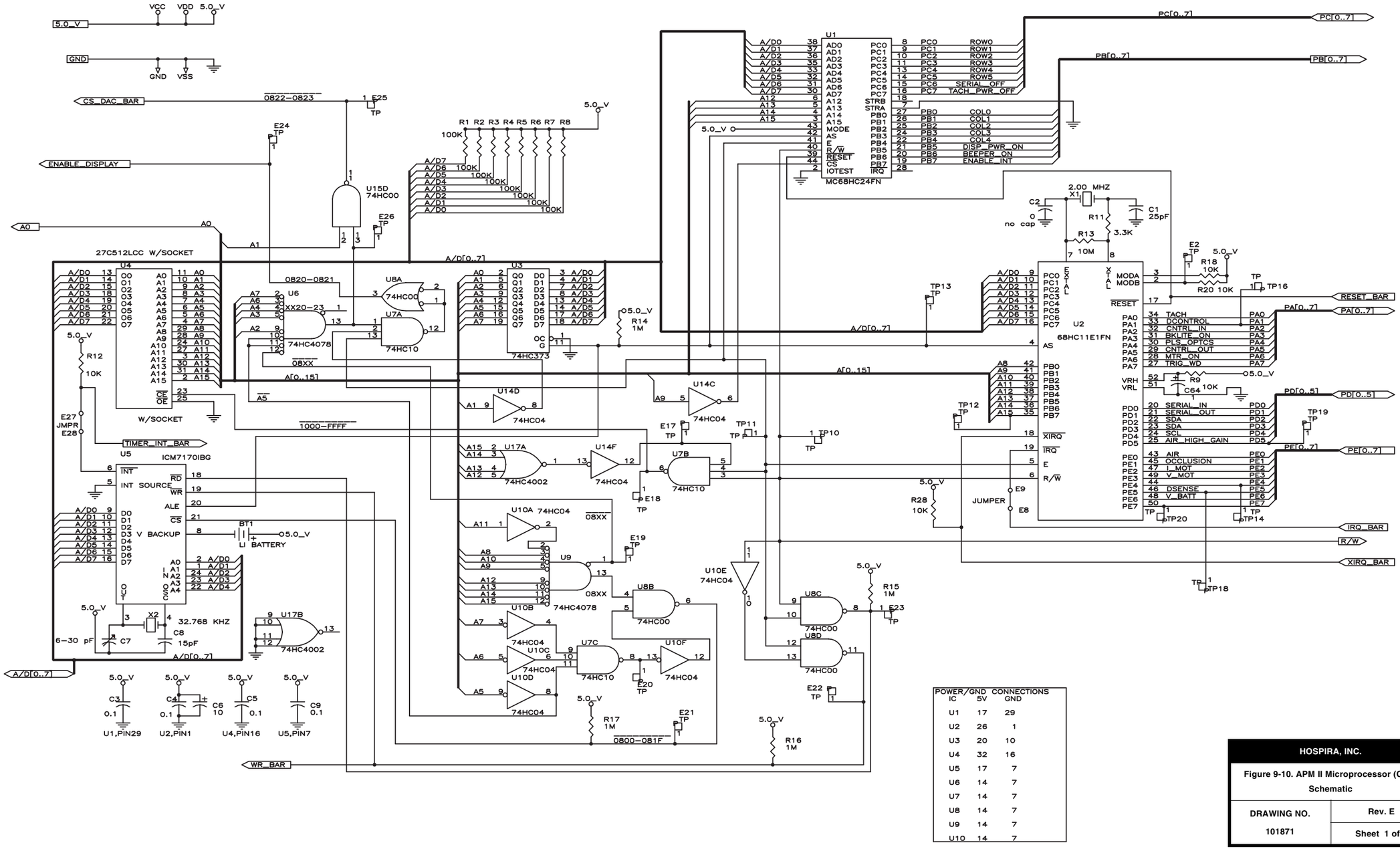

POWER/GND CONNECTIONS		
IC	5V	GND
U1	17	29
U2	26	1
U3	20	10
U4	32	16
U5	17	7
U6	14	7
U7	14	7
U8	14	7
U9	14	7
U10	14	7

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Figure 9-10. APM II Microprocessor (CPU) Schematic	
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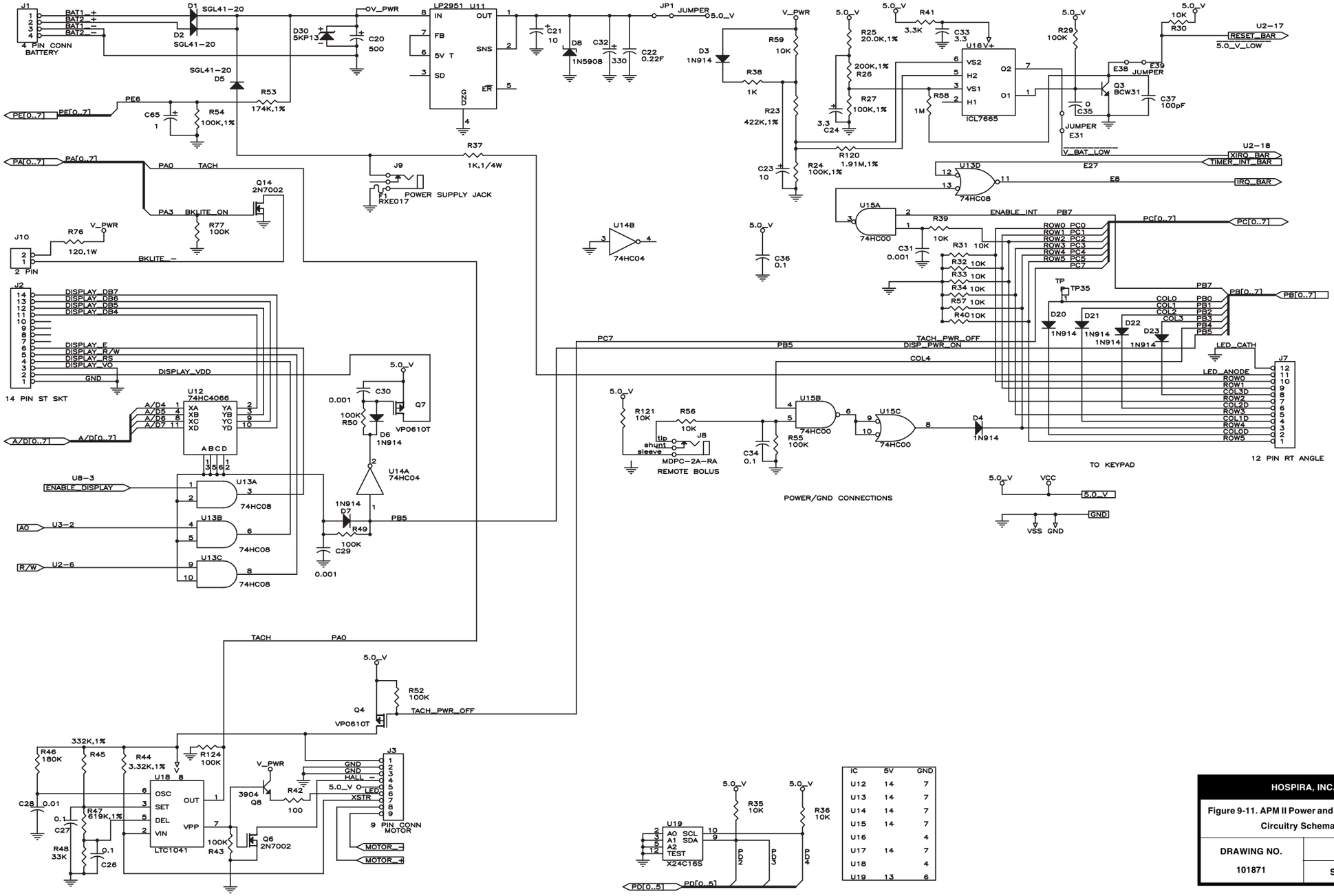

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Figure 9-11. APM II Power and Miscellaneous Circuitry Schematic	
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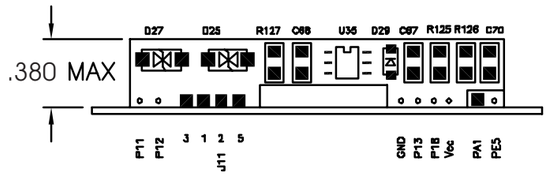
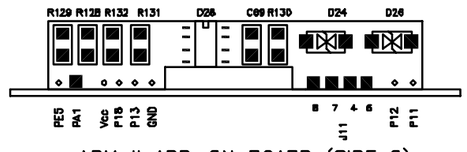


APM II ADD-ON BOARD (SIDE 1)



APM II ADD-ON BOARD (SIDE 2)

MAIN PC BOARD

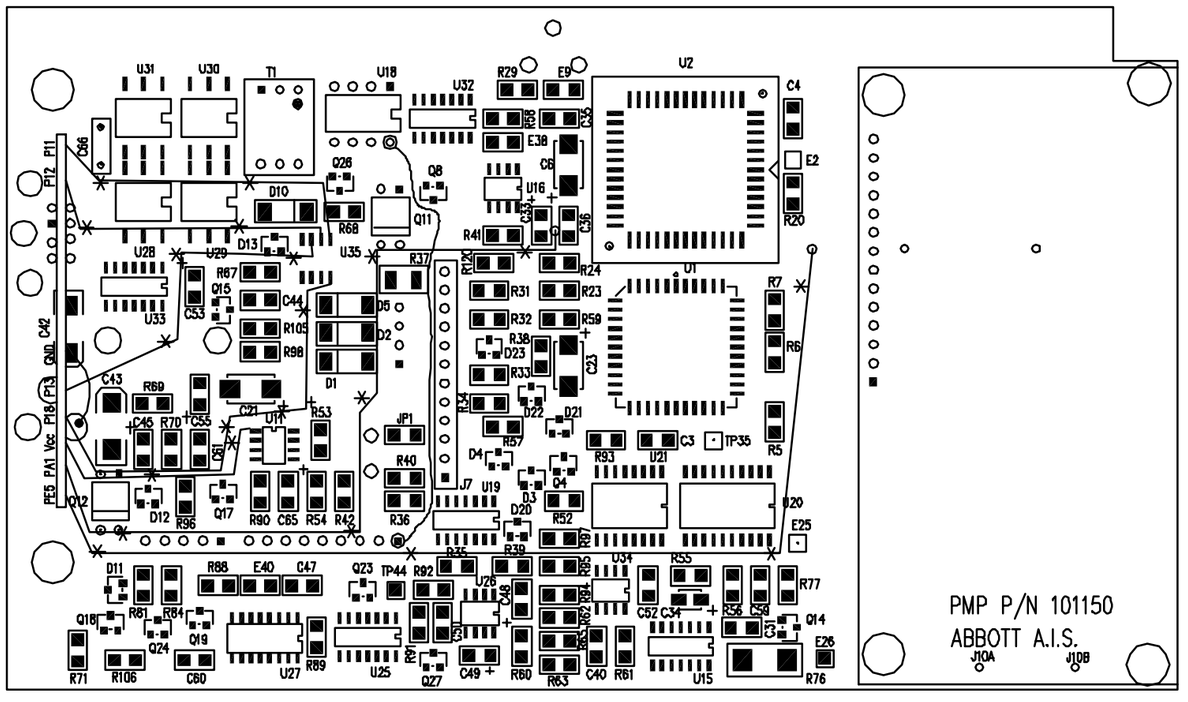


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Figure 9-12. APM II PC Board Front Side	
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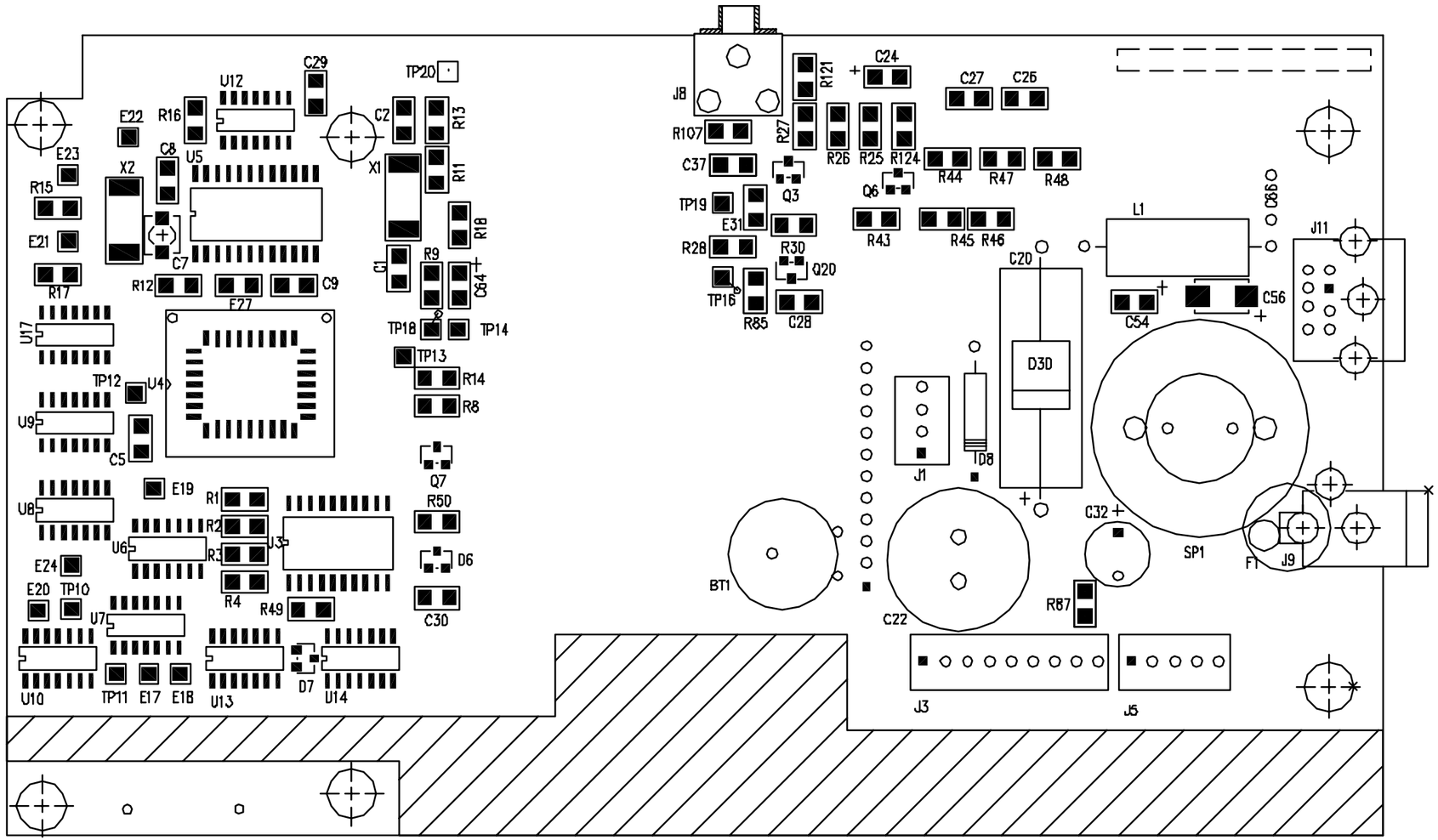

HOSPIRA, INC.	
Figure 9-13. APM II PC Board Back Side	
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WARNING: POSSIBLE EXPLOSION HAZARD EXISTS IF THE COMPUTER IS USED IN THE PRESENCE OF FLAMMABLE ANESTHETICS.

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IPX1 — Drip Proof Medical Equipment

Class 1 — Mains supply equipment using protective earth

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