chapter 10

POWER SUPPLY

The power supply is designed to operate from multiple power sources and has advanced power management features. This power subsystem consists of an external 44 peak watt AC adapter, DC/DC converter, and a rechargeable 6 cell lithium-ion (Li-Ion) battery pack or an extended life, 9 cell Li-Ion battery pack, a nickel cadmium (NiCd) auxilliary battery and a lithium Real-Time clock (RTC) battery.

Functional Description

The external AC adapter assembly converts 110/220 volts AC into low voltage DC to drive the DC-DC converter and to recharge either battery pack. The output of this auto-configuring AC/DC supply is the battery voltage, approximately 10 V to 19 V.

The internal DC/DC power supply accepts this voltage and generates the required system voltages. A firmware controlled fan is used in the system for cooling the supply and the rest of the system components.

The internal DC-DC converter also takes the input DC voltage from the battery pack and converts it to the voltages required by the computer and display circuitry. The power supply provides +3.3, and +5 VDC.

The computer is powered from a 10.8 V (nominal) rechargeable lithium-ion (Li-Ion) battery pack or extended life, Li-Ion battery pack. Either Li-Ion battery pack is composed of battery cells and control circuitry that reports battery fuel gauge information and protects the battery from overheating or overcharging.

A NiCd auxiliary battery provides a maximum of five minutes of power to allow hot swapping of the Li-Ion battery pack. A lithium battery is provided to maintain power to the RTC when all other power is removed from the system.

Figure 10-1 shows a block diagram of the power supply subsystem.

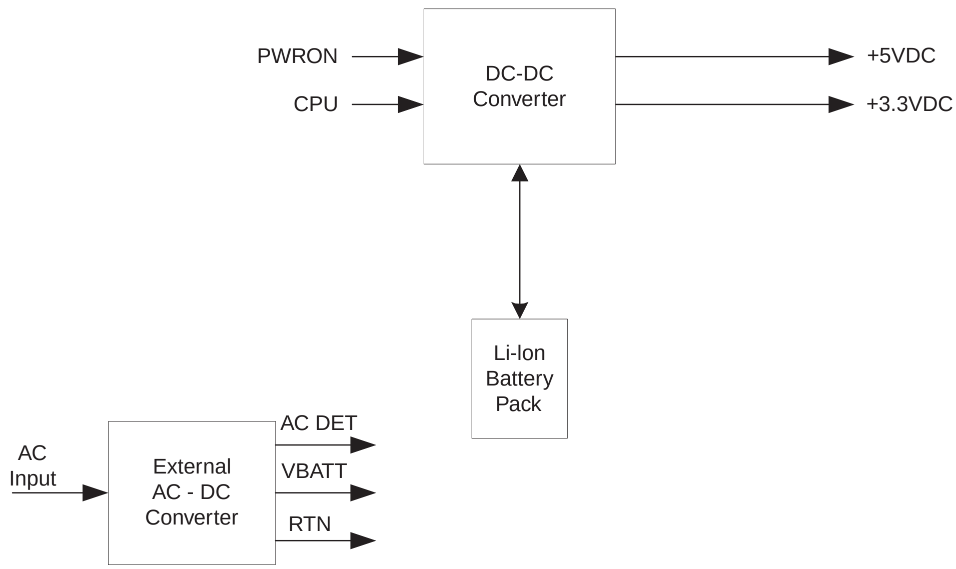

Figure 10-1. *Power Supply, Block Diagram*

AC/DC Converter

The AC input to the power supply is through a three-wire (hot, neutral, ground) power cord that uses small gauge, high flexibility wire. This power cord connects to the external AC/DC converter through an IEC 320 type C6 three-pin power connector on the rear panel of the computer.

The external AC adapter converts high voltage AC into low voltage DC that is used to drive the DC/DC converter and to recharge either battery pack. The AC adapter provides two output signals, VBATT+ and AC DETECT.

When charging a battery, the DC output voltage is limited to the same voltage as the battery pack, but never below 8.0 VDC. In the absence of a battery pack, or if the battery is not charging, the adapter output can rise to a maximum of 12.0 VDC.

Table 10-1 shows operating specifications for the AC/DC converter.

Table 10-1
AC/DC Converter Specifications

AC Input:	
Voltage	90 - 240 Volts AC
Frequency	47 - 63 Hz
Current	1.2 amps (90 VAC)
DC Output:	
Voltage	12.0 nominal
Current	2.4 A maximum
Power	36 W typical

The AC/DC power supply returns an AC DETECT signal to indicate to the system that AC is present and can run the system. This line is used to drive an input to the 8051 and is connected to the MASTERBAT line as part of the power arbitration scheme. When converted AC voltage is applied, the AC DETECT signal will be low.

DC-DC Converter

The internal DC-DC converter is built on the system board. Total output power is rated at 38W continuous and 48W peak. Power supply input current is limited by a fuse. DC input from the AC adapter or battery is converted to two DC outputs:

- +3.3 VDC @ 4.0A
- +5.0 VDC @ 5.0A

Specifications for the DC-DC converter are shown in Table 10-2.

Table 10-2
DC-DC Converter Specifications

Parameter	Value
Input DC Voltage Range	8.0 to 20.0 VDC
Input Current (max)	6 A maximum at minimum input voltage
Power Output:	
Steady State	24 W
Peak	30 W
Output Voltage/Wattage	
Voltage	Watts
3.3 VDC	13.2 maximum
5.0 VDC	22.5 maximum
Voltage Regulation:	
Output Voltage	Variance
3.3 VDC	±3%
5.0 VDC	±3%

Fan Control

The fan control circuitry is located in the DC/DC power supply section of the system board. Fan speed is controlled by MSIO-driven I^2C interfaced potentiometers to control the two fans in the system. This allows the fan speed to be changed based on the CPU temperature, battery status, and other parameters.

Fault-Detection Circuits

The fault-detection circuits shut down the power supply until all faults are removed and the power switch is turned off, then on. Power supply faults[1] that trigger the protection circuitry include:

- Thermal overload: The protection circuit triggers if the power supply becomes too hot as a result of fan failure or a restriction of the air flow.
- Overvoltage: All supplies activate the overvoltage crowbar circuit that triggers the protection circuit when the output exceeds the maximum voltage level.
- Short circuit: The protection circuit triggers if any power supply output is shorted to ground or to another output. This function prevents any shock or fire hazard.

Battery Pack

The lithium-ion (Li-Ion) battery pack provides for long battery run time in a light-weight package. The 6 cell battery pack delivers a total capacity of 32.4 Wh and the 9 cell battery pack 48.6 Wh. The computer battery pack is connected in such a way as to provide from 10 to 16 volts (10.8 volts nominal) output and the monitoring circuitry for the battery fuel gauge. In addition, a temperature sensor and other circuit protection devices are housed in the battery pack.

The specifications of the Li-Ion battery pack are shown in Table 10-3.

Table 10-3
Lithium-Ion (Li-Ion) Battery Pack Electrical Specifications

	Value		Notes
Parameter	**6 Cell**	**9 Cell**	
Open circuit voltage:	10.8 V	10.8 V	Nominal
Capacity:	38.4 Wh	48.6 Wh	
Temperature:			
Charge		10°C to 40°C (50°F to 104°F)	
Storage		0°C to 50°C (32°F to 122°F)	

[1]Minimum load conditions must be met at all times to ensure normal operation and meet specifications.

The battery pack has an onboard microcontroller that monitors the battery history and charge state of the battery cells. This microcontroller communicates with the 8051 in the system by I^2C internal bus. The 8051 is the master, and the battery pack is the slave on the bus. The battery can signal the system that attention is required through a Compaq implemented technique that does not violate the I^2C protocols. The Li-Ion battery pack has six contacts as described in Table 10-4.

Table 10-4
Lithium-ion (Li-Ion) Battery Pack Contacts

Contact	Function
BAT+	Battery (+) connection (high current)
LOCRES	Analog position indicator
SCL	Serial clock line referenced to BAT–
SDA	Serial data line referenced to BAT–
MASTERBAT	Master battery line, bi-directional
BAT–	Battery (–) connection

Charge Status Monitoring

The battery pack has internal circuitry that monitors the charge state and charge history. This internal battery controller monitors the charge state and communicates battery status and charge level to the system for use by the system fuel gauge. This information is available to the user on request.

The battery pack has intelligence that communicates with the system via the system I^2C bus. The battery pack behaves like a pseudo-master on the I^2C bus. The battery pack microcontroller is not able to initiate a complete transaction on the I^2C bus. It is only able to generate a start condition followed by a stop condition on the bus. This short bus transaction generates an interrupt to the system 8051 in the MSIO ASIC. In response to this interrupt, the 8051 queries each of the possible pack locations to find out which pack is in need of service.

The battery pack contains two FETs—one to control charging of the pack and one to allow discharge of the pack. The microcontroller inside the pack controls each of these FETs according to commands from the 8051.

Master Battery Arbitration

The MASTERBAT line is pulled down when the battery pack is installed in the system to allow the battery to provide power to the system and cause an interrupt to the battery microcontroller. The battery microcontroller then decides if the battery is powering the system and relays the information to the 8051 through the I^2C bus. The 8051 checks the MASTERBAT line for status changes and determines if the battery is to power the system. If the battery is determined to be the highest priority for discharge in the system, the MASTERBAT line is driven high by the battery supplying power to the system.

The MASTERBAT signal is also generated from the AC DETECT signal output by the AC adapter to indicate AC line power is available. If AC is present, the power supply drives the MASTERBAT line high. This keeps the Li-Ion battery pack turned off, letting the AC power supply provide all of the current to run the system. If AC power is removed while the system is running, the MASTERBAT line goes low, causing the battery pack in the computer battery bay to start supplying power to the system.

Fuel Gauges

System Fuel Gauges

Through a hotkey sequence(**Fn**+**F8**), the Li-Ion battery pack charge state can be displayed on a popup window on the screen. The popup is capable of displaying the fuel gauge information for each of the batteries installed in the system. A total system fuel gauge is also displayed when the system is running off of one of these batteries. If the system is powered by AC power, the battery that is currently being charged is indicated by highlighting.

The battery pack provides LEDs to indicate the amount of battery life remaining.

Real Time Clock Power Supply

The RTC in the 37C95xFR has its own power pins (VCC0). The 8051 and associated interface circuitry in the 37C951FR also has a separate power pin (VCC1). These two sources are provided power whenever any power source is available in the system. The available power sources include: the AC supply or the Li-Ion battery pack. All of these sources drive the VBAT+ line in the system. A coin cell provides power to the RTC when all other power sources are removed.