

# ***Technical Reference Guide***

*For the*

## **Compaq iPAQ Series of Desktop Personal Computers**

Covers iPAQ 1.0, 1.2, and 2.0 Models



***COMPAQ***

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**COMPAQ** iPAQ Series of Desktop Personal Computers

**TRG**

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*For the*  
**Compaq iPAQ Series of Desktop Personal Computers**

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# Chapter 1

## INTRODUCTION

### 1.1 ABOUT THIS GUIDE

This guide provides technical information about Compaq iPAQ Desktop Personal Computers. This document describes in detail the system's design and operation for programmers, engineers, technicians, and system administrators, as well as end-users wanting detailed information.

#### 1.1.1 USING THIS GUIDE

The chapters of this guide primarily describe the hardware and firmware elements and primarily deal with the system board and the power supply assembly. The appendices contain general data such as error codes and information about standard peripheral devices such as keyboards, graphics cards, and communications adapters.

This guide can be used either as an online document or in hardcopy form.


##### 1.1.1.1 Online Viewing

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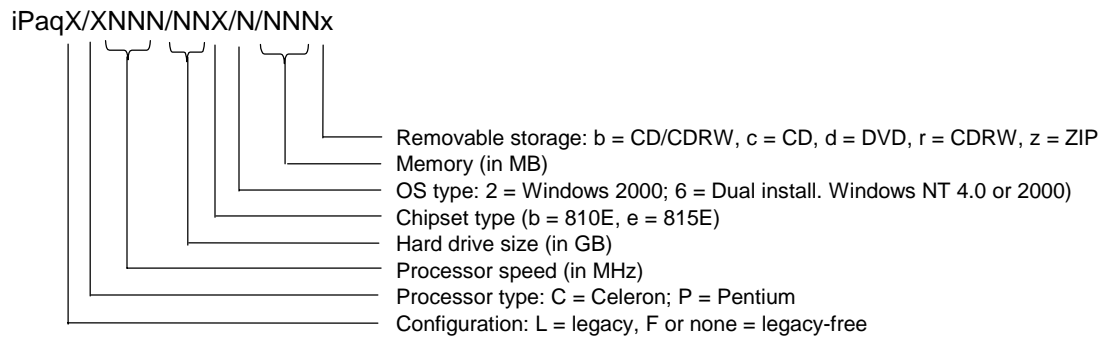
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For more information on components mentioned in this guide refer to the indicated manufacturers' documentation, which may be available at the following online sources:

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- ◆ Intel Corporation: <http://www.intel.com>
- ◆ Standard Microsystems Corporation: <http://www.smsc.com>
- ◆ Texas Instruments Inc.: <http://www.ti.com>
- ◆ USB user group: <http://www.usb.org>

## 1.3 MODEL NUMBERING CONVENTION

The model numbering convention for Compaq iPAQ units is as follows:



## 1.4 SERIAL NUMBER

The unit's serial number is located on a sticker placed on the exterior cabinet. The serial number may also be read with the Compaq Diagnostics or Compaq Insight Manager utilities.



## 1.5 NOTATIONAL CONVENTIONS

The notational guidelines used in this guide are described in the following subsections.

### 1.5.1 VALUES

Hexadecimal values are indicated by a numerical or alpha-numerical value followed by the letter “h.” Binary values are indicated by a value of ones and zeros followed by the letter “b.” Numerical values that have no succeeding letter can be assumed to be decimal unless otherwise stated.

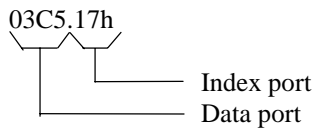
### 1.5.2 RANGES

Ranges or limits for a parameter are shown using the following methods:

Example A: Bits <7..4> = bits 7, 6, 5, and 4.  
 Example B: IRQ3-7, 9 = IRQ signals 3 through 7, and IRQ signal 9

### 1.5.3 REGISTER NOTATION AND USAGE

This guide uses standard Intel naming conventions in discussing the microprocessor’s (CPU) internal registers. Registers that are accessed through programmable I/O using an indexing scheme are indicated using the following format:



In the example above, register 03C5.17h is accessed by writing the index port value 17h to the index address (03C4h), followed by a write to or a read from port 03C5h.

### 1.5.4 BIT NOTATION AND BYTE VALUES

Bit designations are labeled between brackets (i.e., “bit <0 >”). Binary values are shown with the most significant bit (MSb) on the far left, least significant bit (LSb) at the far right. Byte values in hexadecimal are also shown with the MSB on the left, LSB on the right.

## 1.6 COMMON ACRONYMS AND ABBREVIATIONS

Table 1-1 lists the acronyms and abbreviations used in this guide.

**Table 1-1.**  
Acronyms and Abbreviations

Acronym/Abbreviation	Description
A	ampere
AC	alternating current
ACPI	Advanced Configuration and Power Interface
A/D	analog-to-digital
AGP	Accelerated graphics port
API	application programming interface
APIC	Advanced Programmable Interrupt Controller
APM	advanced power management
AOL	Alert-On-LAN™
ASIC	application-specific integrated circuit
AT	1) attention (modem commands) 2) 286-based PC architecture
ATA	AT attachment (IDE protocol)
ATAPI	AT attachment w/packet interface extensions
AVI	audio-video interleaved
AVGA	Advanced VGA
AWG	American Wire Gauge (specification)
BAT	Basic assurance test
BCD	binary-coded decimal
BIOS	basic input/output system
bis	second/new revision
BNC	Bayonet Neill-Concelman (connector type)
bps or b/s	bits per second
BSP	Bootstrap processor
BTO	Built to order
CAS	column address strobe
CD	compact disk
CD-ROM	compact disk read-only memory
CDS	compact disk system
CGA	color graphics adapter
Ch	Channel, chapter
cm	centimeter
CMC	cache/memory controller
CMOS	complimentary metal-oxide semiconductor (configuration memory)
Cntrl	controller
Cntrl	control
codec	compressor/decompressor
CPQ	Compaq
CPU	central processing unit
CRIMM	Continuity (blank) RIMM
CRT	cathode ray tube
CSM	Compaq system management / Compaq server management

*Continued*

**Table 1-1. Acronyms and Abbreviations** *Continued*

<b>Acronym/Abbreviation</b>	<b>Description</b>
DAC	digital-to-analog converter
DC	direct current
DCH	DOS compatibility hole
DDC	Display Data Channel
DIMM	dual inline memory module
DIN	Deutsche IndustriNorm (connector type)
DIP	dual inline package
DMA	direct memory access
DMI	Desktop management interface
dpi	dots per inch
DRAM	dynamic random access memory
DRQ	data request
EDID	extended display identification data
EDO	extended data out (RAM type)
EEPROM	electrically erasable PROM
EGA	enhanced graphics adapter
EIA	Electronic Industry Association
EISA	extended ISA
EPP	enhanced parallel port
EIDE	enhanced IDE
ESCD	Extended System Configuration Data (format)
EV	Environmental Variable (data)
ExCA	Exchangeable Card Architecture
FIFO	first in / first out
FL	flag (register)
FM	frequency modulation
FPM	fast page mode (RAM type)
FPU	Floating point unit (numeric or math coprocessor)
FPS	Frames per second
ft	Foot/feet
GB	gigabyte
GMCH	Graphics/memory controller hub
GND	ground
GPIO	general purpose I/O
GPOC	general purpose open-collector
GART	Graphics address re-mapping table
GUI	graphics user interface
h	hexadecimal
HW	hardware
hex	hexadecimal
Hz	Hertz (cycles-per-second)
ICH	I/O controller hub
IDE	integrated drive element
IEEE	Institute of Electrical and Electronic Engineers
IF	interrupt flag
I/F	interface

*Continued*

**Table 1-1.** Acronyms and Abbreviations *Continued*

Acronym/Abbreviation	Description
in	inch
INT	interrupt
I/O	input/output
IPL	initial program loader
IrDA	InfraRed Data Association
IRQ	interrupt request
ISA	industry standard architecture
Kb / KB	kilobits / kilobytes (x 1024 bits / x 1024 bytes)
Kb/s	kilobits per second
kg	kilogram
KHz	kilohertz
kV	kilovolt
lb	pound
LAN	local area network
LCD	liquid crystal display
LED	light-emitting diode
LPC	Low pin count
LSI	large scale integration
LSb / LSB	least significant bit / least significant byte
LUN	logical unit (SCSI)
m	Meter
MCH	Memory controller hub
MMX	multimedia extensions
MPEG	Motion Picture Experts Group
ms	millisecond
MSb / MSB	most significant bit / most significant byte
mux	multiplex
MVA	motion video acceleration
MVW	motion video window
<i>n</i>	variable parameter/value
NIC	network interface card/controller
NiMH	nickel-metal hydride
NMI	non-maskable interrupt
NRZI	Non-return-to-zero inverted
ns	nanosecond
NT	nested task flag
NTSC	National Television Standards Committee
NVRAM	non-volatile random access memory
OS	operating system
PAL	1.) programmable array logic 2.) phase altering line
PC	Personal computer
PCA	Printed circuit assembly
PCI	peripheral component interconnect
PCM	pulse code modulation
PCMCIA	Personal Computer Memory Card International Association

*Continued*

**Table 1-1. Acronyms and Abbreviations** *Continued*

Acronym/Abbreviation	Description
PFC	Power factor correction
PIN	personal identification number
PIO	Programmed I/O
POST	power-on self test
PROM	programmable read-only memory
PTR	pointer
RAM	random access memory
RAS	row address strobe
rcvr	receiver
RDRAM	(Direct) Rambus DRAM
RGB	red/green/blue (monitor input)
RH	Relative humidity
RMS	root mean square
ROM	read-only memory
RPM	revolutions per minute
RTC	real time clock
R/W	Read/Write
SCSI	small computer system interface
SDRAM	Synchronous Dynamic RAM
SEC	Single Edge-Connector
SECAM	sequential colour avec memoire (sequential color with memory)
SF	sign flag
SGRAM	Synchronous Graphics RAM
SIMD	Single instruction multiple data
SIMM	single in-line memory module
SMART	Self Monitor Analysis Report Technology
SMI	system management interrupt
SMM	system management mode
SMRAM	system management RAM
SPD	serial presence detect
SPDIF	Sony/Philips Digital Interface (IEC-958 specification)
SPN	Spare part number
SPP	standard parallel port
SRAM	static RAM
SSE	Streaming SIMD extensions
STN	super twist pneumatic
SVGA	super VGA
SW	software

*Continued*

**Table 1-1.** Acronyms and Abbreviations *Continued*

Acronym/Abbreviation	Description
TAD	telephone answering device
TAFI	Temperature-sensing And Fan control Integrated circuit
TCP	tape carrier package
TF	trap flag
TFT	thin-film transistor
TIA	Telecommunications Information Administration
TPE	twisted pair ethernet
TPI	track per inch
TTL	transistor-transistor logic
TV	television
TX	transmit
UART	universal asynchronous receiver/transmitter
UDMA	Ultra DMA
URL	Uniform resource locator
us / $\mu$ s	microsecond
USB	Universal Serial Bus
UTP	unshielded twisted pair
V	volt
VESA	Video Electronic Standards Association
VGA	video graphics adapter
VLSI	very large scale integration
VRAM	Video RAM
W	watt
WOL	Wake-On-LAN
WRAM	Windows RAM
ZF	zero flag
ZIF	zero insertion force (socket)

## Chapter 2 SYSTEM OVERVIEW

### 2.1 INTRODUCTION

The Compaq iPAQ Series of Desktop Personal Computers provides affordable business solutions with the focus on internet access and mainstream performance. Based on an Intel Celeron and Pentium III processors, these systems are designed to maximize the effectiveness of internet and intranet usage while simplifying system management.



**Figure 2–1.** Compaq iPAQ Desktop Personal Computers

This chapter includes the following topics:

- ◆ Features and options (2.2)      page 2-2
- ◆ Mechanical design (2.3)      page 2-4
- ◆ System architecture (2.4)      page 2-10
- ◆ Specifications (2.5)      page 2-20

## 2.2 FEATURES AND OPTIONS

This section describes the standard features and available options.

### 2.2.1 STANDARD FEATURES

The following standard features are available on all models:

- ◆ Celeron or Pentium III processor
- ◆ Two DIMM sockets for system memory
- ◆ AC'97 audio subsystem with front panel microphone and headphone jacks
- ◆ MultiBay w/hot-swap support
- ◆ Hard drive fault prediction
- ◆ Two USB ports on front panel
- ◆ Network interface controller
- ◆ VGA analog output (1600 x 1200 max resolution)
- ◆ APM 1.2 power management support
- ◆ Plug 'n Play compatible (with ESCD support)
- ◆ Intelligent Manageability support
- ◆ Energy Star compliant
- ◆ Security features including:
  - Setup and power-on passwords
  - DriveLock for MultiBay hard drive
  - I/O interface disabling
  - Administrator password
  - Network service boot
  - Asset tracking tag
  - UUID
  - Cable lock provision
- ◆ Compaq Easy-Access keyboard w/Windows support
- ◆ Mouse
- ◆ 90-watt power supply

Table 2-1 shows the differences in features between the iPAQ 1.0, 1.2, and 2.0 models:



**Table 2-1.**  
iPAQ Standard Feature Difference Matrix

	iPAQ 1.0		iPAQ 1.2	iPAQ 2.0	
Processor	Celeron	Pentium	Pentium	Celeron	Pentium
Processor Speed (MHz)	500	500	733	700	866
Chipset	810E	810E	810E	815E	815E
System Memory:					
DIMM type	PC100	PC100	PC100	PC133	PC133
DIMM technology (Max)	128Mb	128Mb	128 Mb	256 Mb	256 Mb
Max amount supported	256 MB	256 MB	256 MB	512 MB	512 MB
4-MB Display cache	No	Yes	Yes	Optional	Yes
Hard Drive Interface	UATA/66	UATA/66	UATA/66	UATA/100	UATA/100
Multibay eject button	At rear	At rear	At rear	At front	At front
Rear panel USB ports	3 [1]	3 [1]	3 [1]	4	4
Serial port	1 [2]	1 [2]	1 [2]	1 [2]	1 [2]
Parallel port	1 [2]	1 [2]	1 [2]	1 [2]	1 [2]

NOTES:

Legacy models ship with PS/2 keyboard and mouse. Legacy-free models ship with USB keyboard and mouse.

[1] Legacy-free models only.

[2] Legacy models only

## 2.2.2 OPTIONS

The following items are available as options for all models and may be included in the standard configuration of some models:

- ◆ Memory:
  - 32-MB DIMM (non-ECC)
  - 64-MB DIMM (non-ECC)
  - 128-MB DIMM (non-ECC)
  - 256-MB DIMM (non-ECC) (iPAQ 2.0 only)
  - 4-MB Display Cache module (iPAQ 2.0 only)
- ◆ Hard drives/accessories:
  - 4.3 or 8.4 GB UATA/66 hard drive
  - 10 GB UATA/100 hard drive (iPAQ 2.0 only)
  - Multibay hard drive adapter
  - Multibay 250 Zip drive
- ◆ I/O Expansion:
  - Legacy Module (iPAQ 2.0 only)
- ◆ Communications:
  - USB 56K V.92 Modem
  - USB 802.11b Adapter
- ◆ Security:
  - Security bar (iPAQ 2.0 only)
- ◆ MultiBay drives:
  - 24x CD-ROM drive
  - 8x DVD-ROM drive
  - 4/4/20x CD-RW drive
  - Super Disk LS-120 Power Drive

## 2.3 MECHANICAL DESIGN

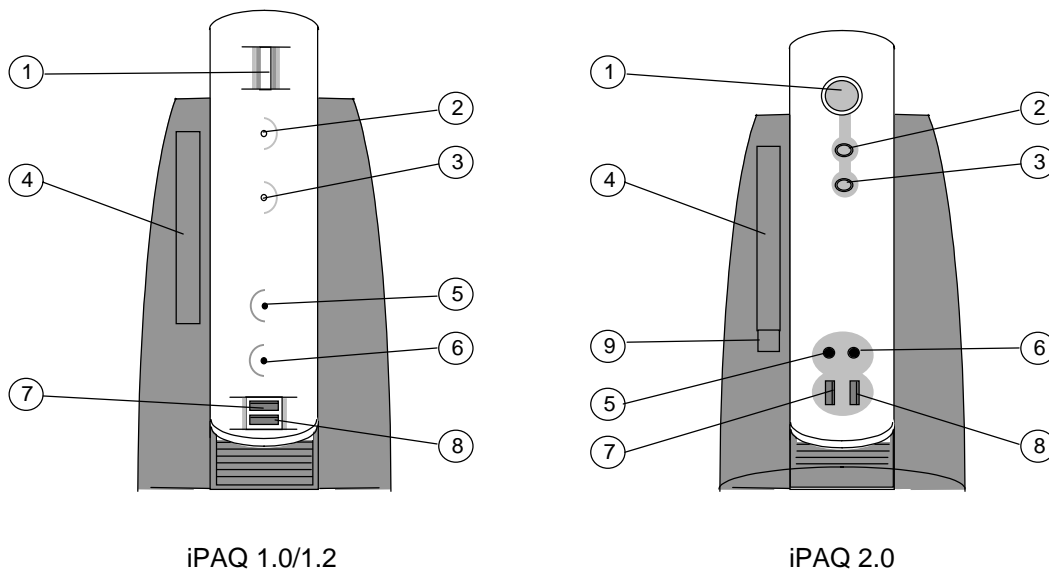
The Compaq iPAQ Internet Device uses a minitower form factor featuring a smaller footprint and reduced height than previous minitowers, allowing easy floor or desktop positioning. Commonly used audio and USB connections are accessible from the front panel.



**NOTE:** The following information is primarily for identification purposes only. For detailed information on servicing these systems refer to the applicable service guides. Most components of iPAQ 1.0/1.2 and 2.0 systems are **not** inter-changeable.

### 2.3.1 CABINET LAYOUTS

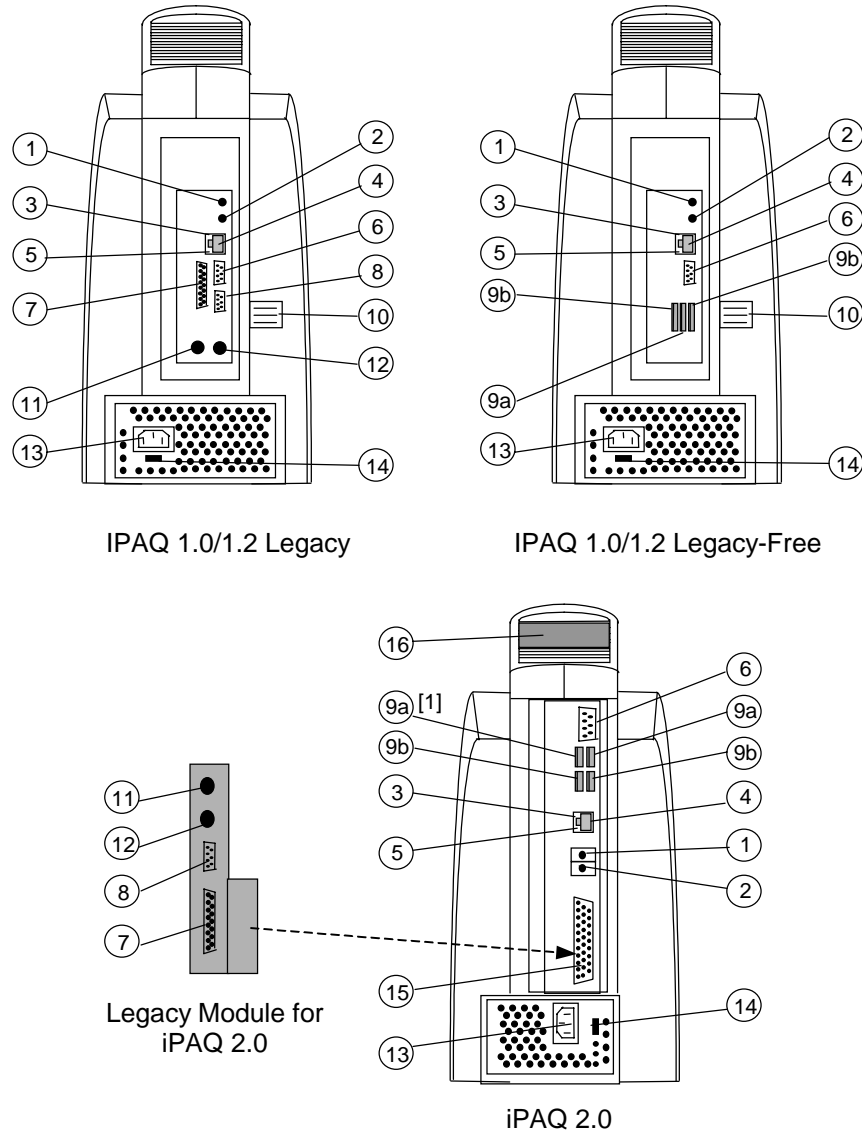
#### 2.3.1.1 Front Views



Item	Description
1	Power Button
2	Power LED
3	Hard drive activity LED
4	MultiBay device bay (accepts 5.25"/12.7 mm storage device)
5	Microphone In Jack
6	Headphone Out Jack
7	USB port (through-Hub)
8	USB port (through-Hub)
9	Multibay device eject button

Figure 2–2. Compaq iPAQ Desktops, Front Views

### 2.3.1.2 Rear Views



Item	Description	Item	Description
1	Audio line output	2	Audio line input
3	Network activity LED indicator	4	Network I/F jack
5	Network speed LED indicator	6	VGA monitor connector
7	Parallel I/F connector	8	Serial I/F connector
9	USB port: a) direct, b) through-hub	10	MultiBay device eject button
11	PS/2 mouse connector	12	PS/2 keyboard connector
13	AC line in connector	14	Line voltage select switch
15	Legacy module connector	16	Carrying depression

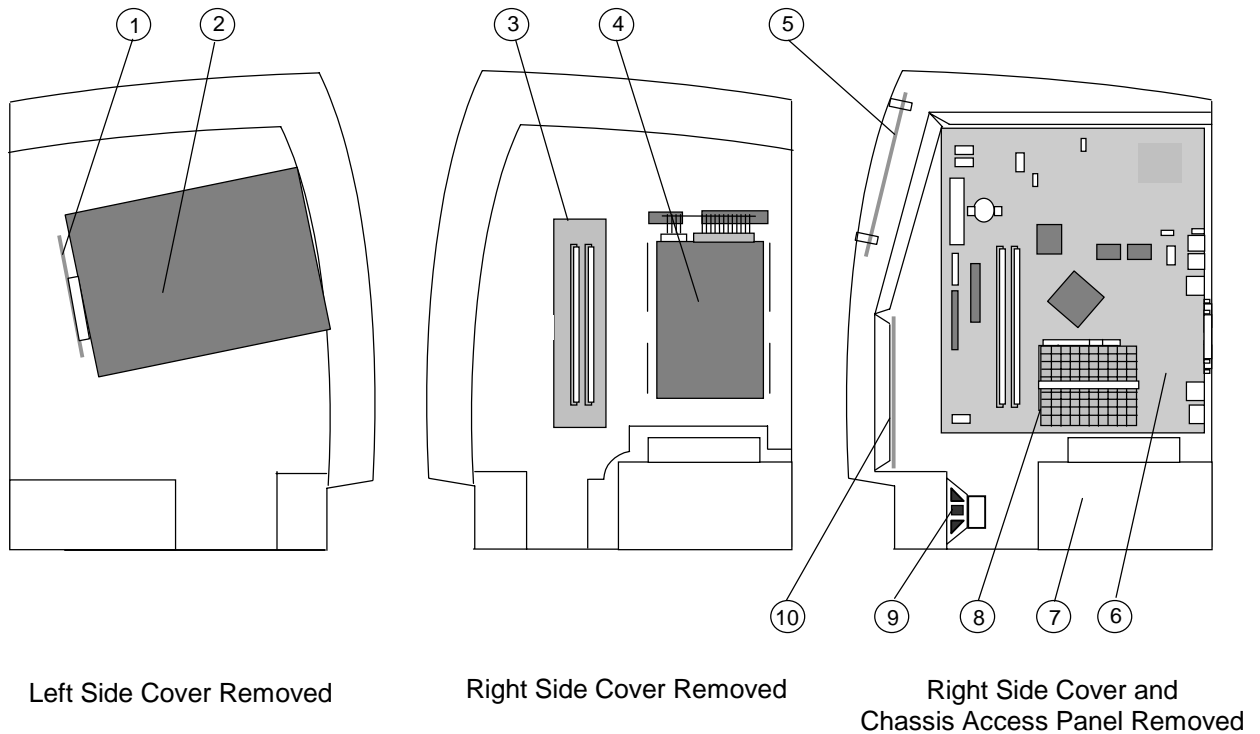
NOTE: [1] Dedicated-direct USB port.

Figure 2-3. Compaq iPAQ Desktops, Rear Views

## 2.3.2 CHASSIS LAYOUTS

### 2.3.2.1 iPAQ 1.0/1.2 CHASSIS LAYOUT

The internal assemblies of iPAQ 1.0/1.2 models are accessible from the right side of the system unit. The right side (carbon-colored) cover features tool-less removal allowing quick access to the DIMM sockets through an access opening and to the hard drive. Access to the system board and processor requires removing the right chassis access panel. The multibay device is located on the left side of the chassis and can be removed (using the eject button) without removing the left side cover. Servicing the multibay board will, however, require removal of the left side cover.

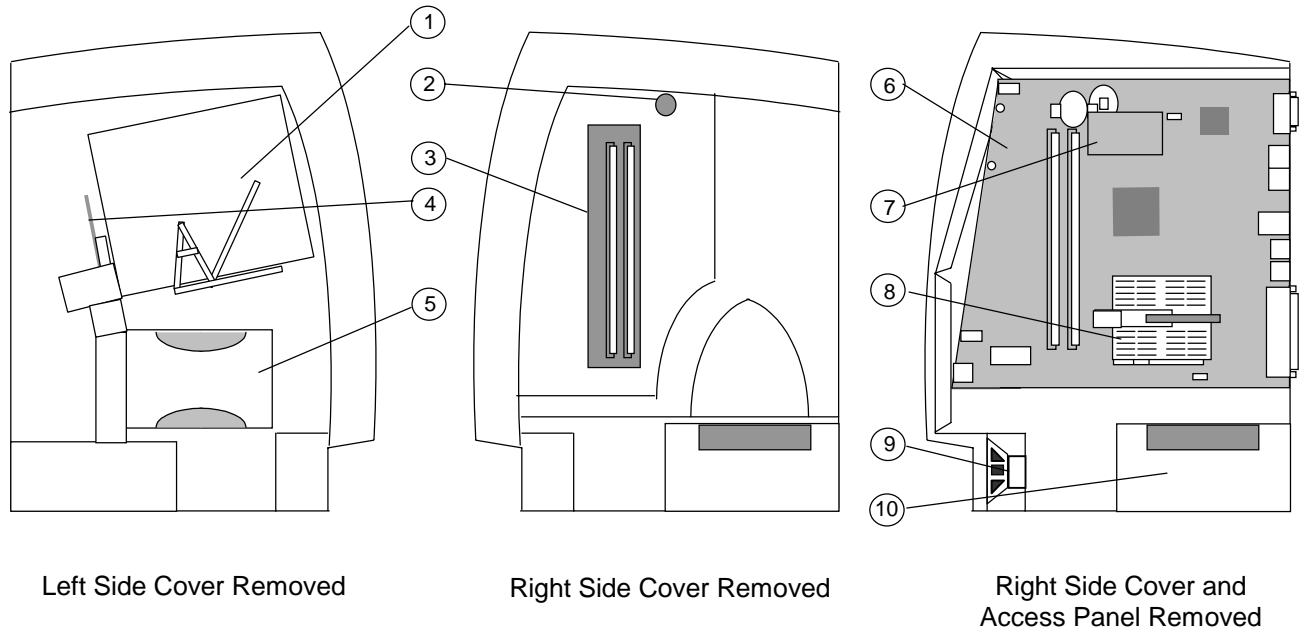


Item	Description
1	Multibay device board
2	Multibay storage device
3	Access opening to DIMM sockets
4	Hard drive in 3.5" 1/3 height bay
5	Power button/LED board (PCA# 010647)
6	System board (PCA# 161014 or 161015)
7	Power supply assembly
8	Processor
9	Speaker
10	Audio and USB I/O board (PCA# 010650)

**Figure 2-4.** Compaq iPAQ 1.0/1.2 Desktop Chassis Layout

### 2.3.2.2 iPAQ 2.0 CHASSIS LAYOUT

The internal assemblies of the iPAQ 2.0 model are accessible from both sides of the system unit. Both side covers (carbon-colored) feature tool-less removal allowing quick access to serviceable components such as DIMMs and hard drives.

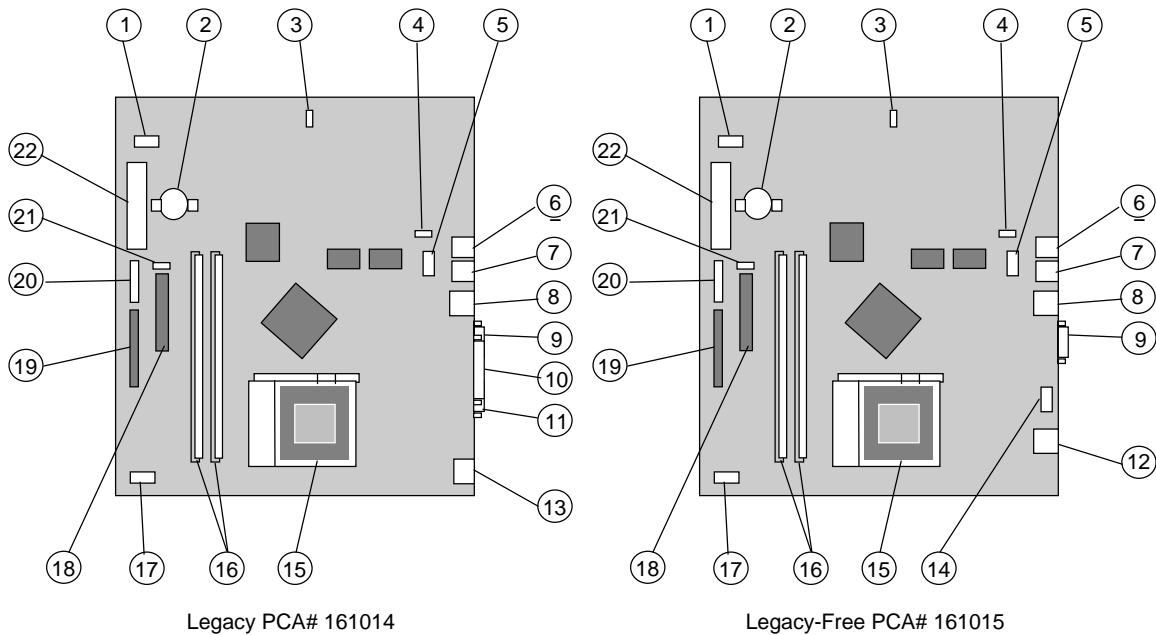


Item	Description
1	Multibay storage device
2	Access hole to CMOS clear button
3	Access opening to DIMM sockets
4	Multibay device board (PCA #011059)
5	Hard drive in 3.5" 1/3 height bay
6	System board (PCA# 011010)
7	4-MB display cache module (PCA# 011044) (if installed)
8	Processor/heat sink assembly
9	Speaker
10	Power supply assembly

Figure 2-5. Compaq iPAQ 2.0 Chassis Layout

### 2.3.3 SYSTEM BOARD LAYOUTS

Compaq iPAQ 1.0 and 1.2 systems use a FlexATX-type (9.0 x 7.5 inch) system board in one of two variations; a legacy board or a legacy-free board (Figure 2-6).



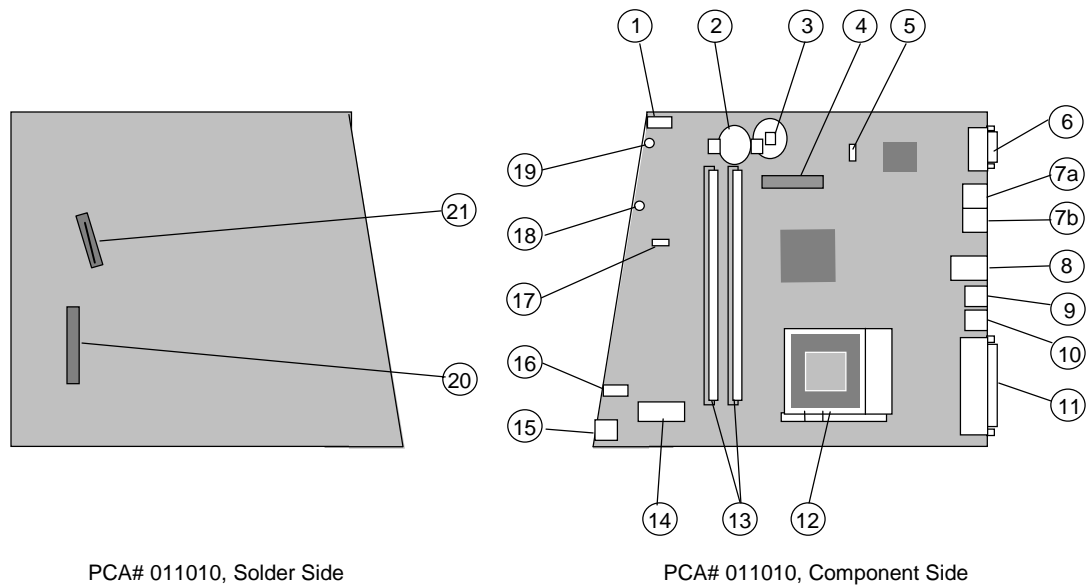
Item	Description	Item	Description
1	USB ports 3 and 4 (front panel) header	12	USB ports 0, 1, 2 connectors
2	Battery	13	Dual PS/2 conn.: (mouse, keyboard)
3	BIOS ROM configuration jumper	14	Serial I/F header
4	Speaker connector	15	PGA370 processor socket
5	Audio microphone/headphone header	16	DIMM sockets
6	Audio line out jack	17	Processor (boxed) fan header
7	Audio line in jack	18	IDE (pri.) 40-pin connector
8	Network connector	19	IDE (sec.) 50-pin (multibay) connector
9	VGA monitor connector	20	Power button/LED indicator connector
10	Parallel I/F connector	21	CD audio header
11	Serial I/F connector	22	Power supply connector

NOTE:

Refer to Chapter 7 "Power and Signal Distribution" for header pinouts.

**Figure 2-6.** Compaq iPAQ 1.0/1.2 System Board Layouts

All iPAQ 2.0 systems use a Compaq-proprietary system board (Figure 2-7).



Item	Description
1	Power button
2	Battery
3	CMOS clear switch
4	Display cache module connector
5	Password enable jumper
6	Video graphics monitor connector
7	USB connector pairs: a) J111; b) J112
8	Network connector
9	Audio line in jack
10	Audio line out jack
11	Legacy module connector
12	PGA370 processor socket
13	DIMM sockets
14	Power supply connector
15	USB triple connector (center port not used)
16	Microphone in, Headphone out jacks
17	Speaker connector
18	Hard drive activity LED
19	Power LED
20	Hard drive connector (IDE primary)
21	Multibay board connector (IDE secondary)

Figure 2-7. Compaq iPAQ 2.0 System Board Layout

## 2.4 SYSTEM ARCHITECTURE

The Compaq iPAQ Series of Desktop Personal Computers features Intel Celeron or Pentium III processors. The iPAQ 1.0/1.2 models employ an architecture based on the Intel 810e chipset while iPAQ 2.0 models are based on the Intel 815e chipset.

### 2.4.1 IPAQ 1.0/1.2 ARCHITECTURE

The architecture of iPAQ 1.0/1.2 models is based on the Intel 810e chipset with a Celeron or Pentium III processor installed as standard. iPAQ 1.0 systems feature 500-MHz processors while iPAQ 1.2 systems feature 733-MHz Pentium III processors. As indicated in the following table and shown in Figure 2-8, two basic configurations are available:

- ◆ Legacy-free with Celeron or Pentium III processor
- ◆ Legacy with Celeron or Pentium III processor

Legacy-free systems provide five Universal Serial Bus (USB) ports for connecting peripherals (including the supplied USB mouse and USB keyboard). Legacy light systems provide two USB ports along with PS/2 ports for the supplied mouse and keyboard as well as parallel and serial ports.



**NOTE:** A legacy-free iPAQ 1.0/1.2 system is upgradeable to become a legacy system **only** by changing the system board.

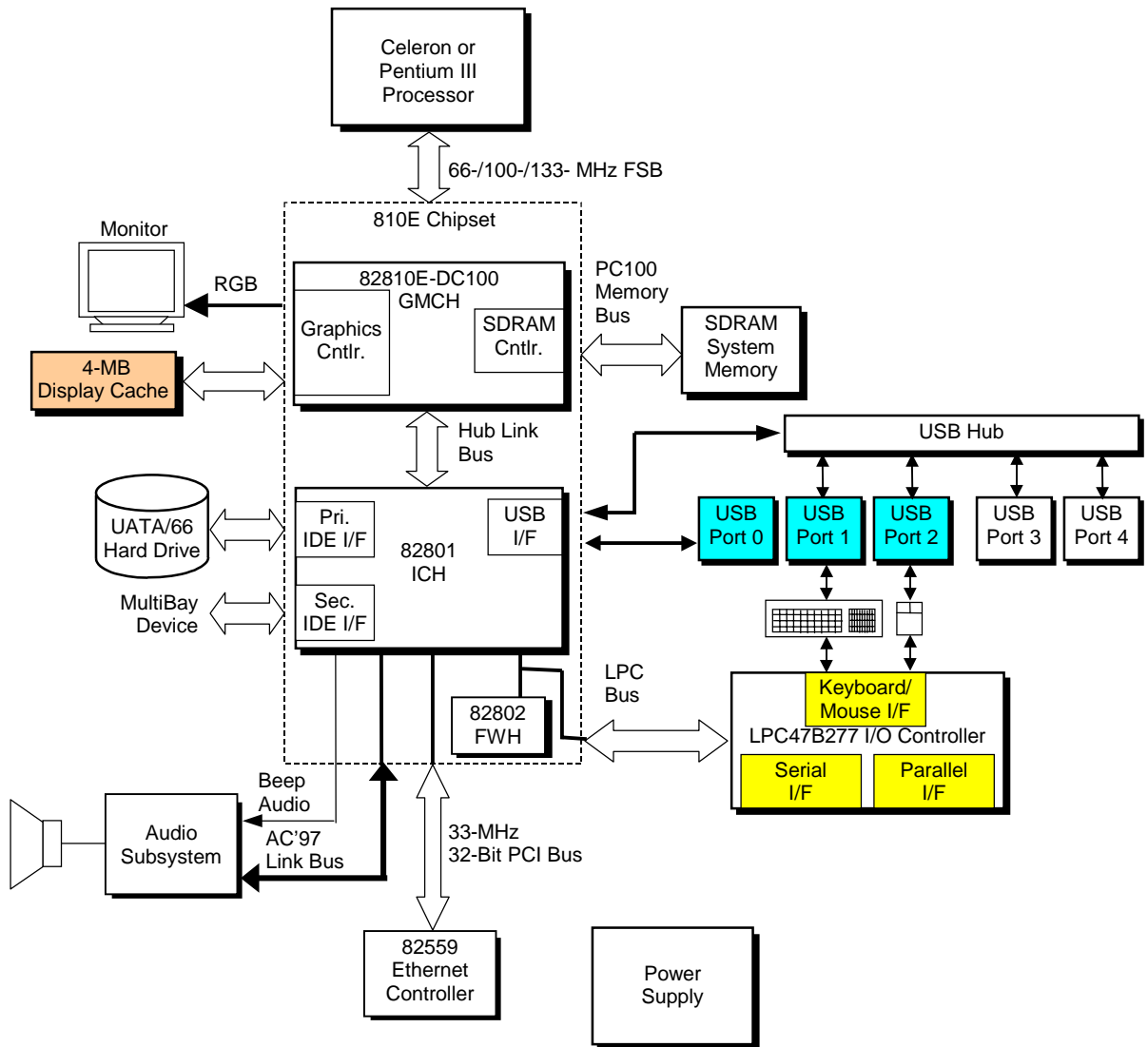
All iPAQ 1.x systems use the 810E chipset. The 810E chipset includes the 82810E-DC100 GMCH designed to support 100-MHz SDRAM and also integrates a 2D/3D Direct AGP graphics controller. Pentium III-based systems come with an additional 4-MB display cache (soldered down) to compliment the graphics controller.

The 810E chipset also includes an 82801 I/O Controller Hub (ICH) that provides two IDE interfaces, two USB interfaces, and a PCI bus controller. The 82802 Firmware Hub (FWH) component is loaded with Compaq BIOS. The iPAQ 1.0/1.2 features an AC'97 audio subsystem with 5-watt amplifier and internal speaker. All iPAQ 1.0/1.2 systems feature a 90-watt power supply. Table 2-2 lists differences between system architectures:

**Table 2-2.**  
IPAQ 1.0/1.2 Architectural Comparison

	IPAQ 1.0				IPAQ 1.2	
	Legacy-Free		Legacy		Legacy-Free	Legacy
Processor Type	Celeron	Pentium	Celeron	Pentium	Pentium	Pentium
Processor Speed (MHz)	500	500	500	500	733	733
FSB Speed (MHz)	66	100	66	100	133	133
4-MB Display Cache?	No	Yes	No	Yes	Yes	Yes
Mouse/Keyboard Type	USB	USB	PS/2	PS/2	USB	PS/2
Serial port?	No	No	Yes	Yes	No	Yes
Parallel port?	No	No	Yes	Yes	No	Yes
# of USB ports	5	5	2	2	5	2





LEGEND:

- Legacy systems only.
- Legacy-free systems only.
- Pentium III-based systems only.

Figure 2-8. Compaq iPAQ 1.0/1.2 Architecture, Block diagram

## 2.4.2 IPAQ 2.0 ARCHITECTURE

The iPAQ 2.0 models feature an architecture based on the Intel 815E chipset with a 700-MHz Celeron or 866-MHz Pentium III processor installed (Figure 2-9).

The 815E chipset includes the 82815 GMCH designed to control up to 512 megabytes of 133-MHz (PC133) SDRAM and also integrates a 2D/3D Direct AGP graphics controller. Pentium III-based systems come with a 4-MB display cache module installed to compliment the graphics controller. Celeron-based systems may be upgraded by adding the 4-MB display cache module.

The 815E chipset also includes an 82801BA I/O Controller Hub (ICH2) that provides two IDE controllers providing UATA/100 support, two USB controllers, a network interface controller, and a PCI bus controller.

All iPAQ 2.0 systems provide six USB ports. Two USB ports are configured as direct ports, with one direct port dedicated to a USB controller for maximum throughput operation. Four ports are configured as “through-hub” ports.

An LPC47B357 I/O controller is embedded on the system board of all iPAQ 2.0 systems. Functions supported by the I/O controller (serial, parallel, mouse and keyboard I/Fs) are available when the legacy module is attached to the system, making it a legacy system. A legacy-free iPAQ 2.0 system may easily be converted to a legacy system by installing the legacy module, which snaps into place at the rear of the unit.



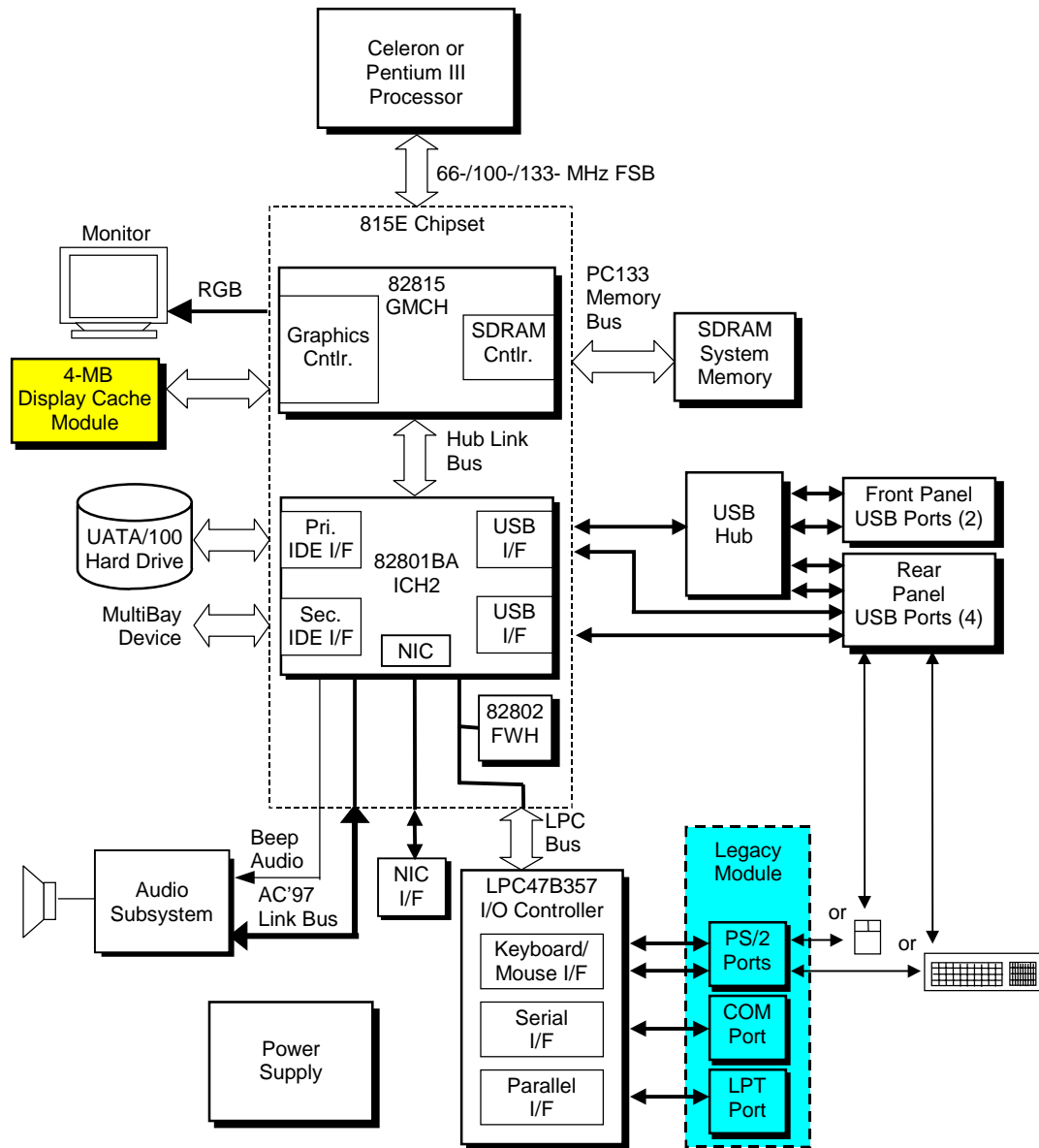
**NOTE:** Legacy-free models ship with USB keyboards and USB mouse devices. Legacy models (shipped with the legacy module installed) include PS/2 keyboards and mouse devices.

---

The Firmware Hub (FWH) component (82802 or equivalent) is loaded with Compaq BIOS.

The iPAQ 2.0 features an AC'97 audio subsystem with 8-watt amplifier and internal speaker. The audio system includes microphone and line inputs and headphone and line outputs.

All iPAQ 2.0 systems feature a 110-watt power supply.



LEGEND:

- Standard on Pentium III systems.
- Standard on legacy systems.

Figure 2-9. Compaq iPAQ 2.0 Architecture, Block diagram

## 2.4.3 PROCESSORS

The Compaq iPAQ desktop series includes models based on Celeron and Pentium III processors. These processors are backward-compatible with software written for the Pentium II, Pentium MMX, Pentium Pro, Pentium, and x86 microprocessors. Both processor architectures include a floating-point unit and first and secondary caches providing enhanced performance for multimedia applications.

### 2.4.3.1 Celeron Processor

Select Compaq iPAQ systems use the Intel Celeron processor. The Celeron processor provides economical performance and is compatible with software written for previous generation processors such as Pentium II, Pentium MMX, Pentium, and x86 processors. Featuring a Pentium-type core architecture, the Celeron processor integrates a dual-ALU CPU with a floating-point unit, 32-KB first-level cache, and 128-KB second level cache, all of which operate at full processing (CPU) speed. Celeron processors shipped with these systems provide the same level of MMX/SSE support as Pentium III-based systems.

The Celeron processor uses a Flip-Chip (FC) PGA370 package with a heat sink.

### 2.4.3.2 Pentium III Processor

The Intel Pentium III processor provides maximum performance for Compaq iPAQs. The Pentium III processor is compatible with software written for Celeron, Pentium II, Pentium MMX, Pentium, and x86 processors.

The Pentium III processor core integrates a dual-ALU CPU with a floating-point unit and 32-KB first-level cache operating at processing (CPU) speed. Featuring .18-micron technology, the Pentium III processor features 256 kilobytes of secondary cache included on the CPU die and operating at full processor speed.


The Pentium III processor includes MMX technology for enhanced multimedia performance. Also included are 70 additional streaming SIMD extensions (SSE) for enhancing 3D graphics and speech processing performance and a serial number function useful for asset tracking.

The Pentium III processor employed in these systems uses a Flip-Chip (FC) PGA370 package and heat sink (Figure 2-10).

### 2.4.3.3 Processor Upgrading

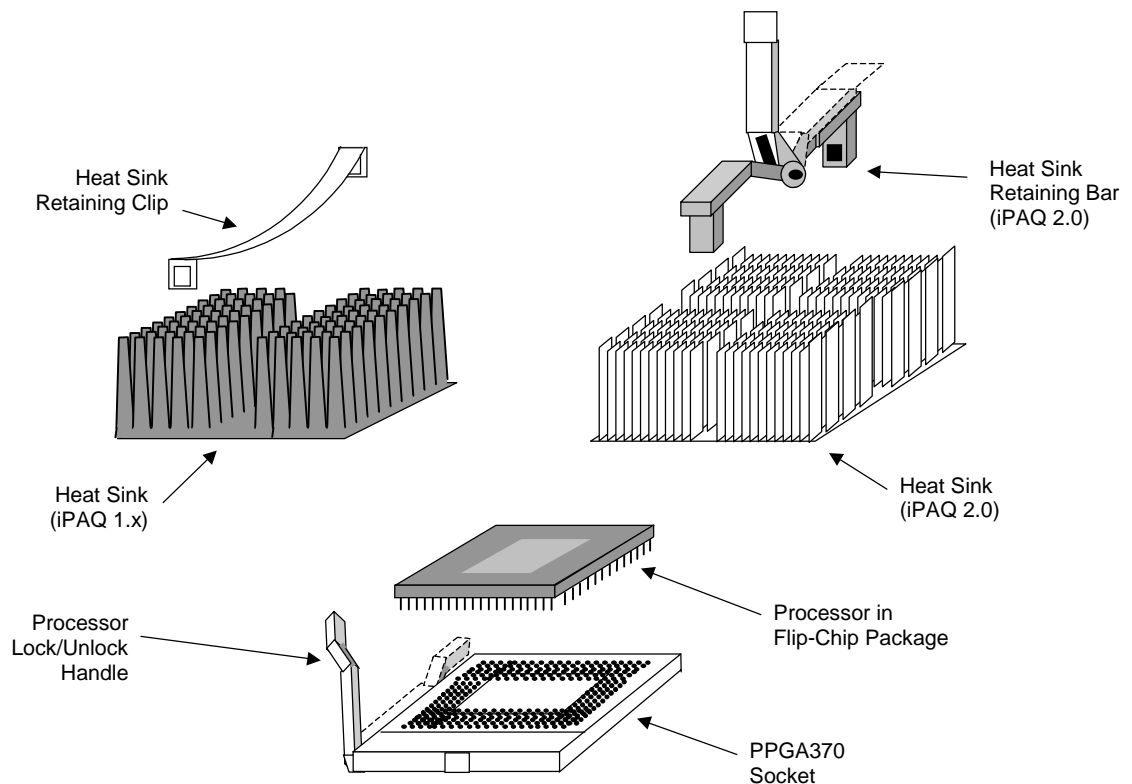
All models of the Compaq iPAQ use the PGA370 zero-insertion force (ZIF) socket for processor mounting as shown in Figure 2-10. The processor assembly includes a heat sink attached by a retaining clip or bar. Replacing the processor requires removal of the heat sink followed by removal of the processor. On iPAQ 2.0 systems, the heat sink is held in place by a retaining bar with its own locking handle.

---

 **CAUTION:** Refer to section 3.2.2 (Chapter 3) for a description of the removal and replacement of the processor assembly.


---

Factory configurations use processors fitted with passive heat sinks.



**Figure 2-10.** Processor Assembly and Mounting

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 **WARNING:** The iPAQ 1.0/1.2 system board is designed handle a maximum processor current load of 18 amps. Installing a replacement processor that draws more than 18 amps of current may damage the processor and/or the system board.

---

## 2.4.4 CHIPSET

The chipset is designed to compliment the processor and provide the central point for the system's data transactions. The Compaq iPAQ 1.0/1.2 system employs the Intel 810E while the iPAQ 2.0 system uses the Intel 815E chipset.

The chipset is composed of a graphics memory controller hub (GMCH), an I/O controller hub (ICH), and a firmware hub (FWH). Table 2-3 shows a listing of the functions provided by the two types of chipsets.

**Table 2-3.**  
Chipset Functions

Chipset	Component	Function
810E	82810E-DC100 Graphics/Memory Controller Hub (GMCH)	2D/3D graphics controller SDRAM controller supporting 2 PC100 DIMMs 66-/100-/133-MHz FSB PCI bus I/F
	82801AA I/O Controller Hub (ICH)	LPC bus I/F SMBus I/F IDE I/F with UATA/66 support AC '97 audio controller RTC/CMOS IRQ controller Power management logic USB controller (1)
	82802 Firmware Controller Hub (FWH)	Loaded with Compaq BIOS Random number generator
815E	82815 Graphics/Memory Controller Hub (GMCH)	2D/3D graphics controller SDRAM controller supporting 2 PC100 or PC133 DIMMs 66-/100-/133-MHz FSB PCI bus I/F
	82801BA I/O Controller Hub (ICH2)	LPC bus I/F SMBus I/F IDE I/F with UATA/100 support AC '97 audio controller RTC/CMOS IRQ controller Power management logic USB controller (2) Network interface controller
	82802 Firmware Controller Hub (FWH) [1]	Loaded with Compaq BIOS Random number generator

**NOTE:**

[1] Some units may use a non-Intel equivalent component.

## 2.4.5 SUPPORT COMPONENTS

Input/output functions not provided by the chipset are handled by other support components. Some of these components also provide “housekeeping” and various other functions as well. Table 2-4 shows the functions provided by the support components.

**Table 2-4.**  
Support Component Functions

Component Name	Function	Notes
LPC47B277 or LPC47B357 I/O Controller	Keyboard and pointing device I/F	[1]
	Diskette I/F	[2]
	Serial I/F	[1]
	Parallel I/F	[1]
	AGP, PCI reset generation	
	ISA serial IRQ converter	
	Power button logic	
	Slow speed detection	
	S3 regulator controller	
	GPIO ports	
AD1881 or AD1885 Audio Codec	Audio mixer	
	Digital-to-analog converter	
	Analog-to-digital converter	
	Analog I/O:	
	Mic input	
	Line input	
82559 Ethernet Controller [3]	CD input	
	Line output	
	Network interface controller PHY interface	
TUSB2046B USB Hub	4-port USB 1.1-compliant hub	

NOTE:

[1] Legacy models only.

[2] Not available for actual use but may be enabled to satisfy OS requirements.

[3] iPAQ 1.0/1.2 systems only.

## 2.4.6 SYSTEM MEMORY

These systems utilize non-ECC Synchronous DRAM (SDRAM) . Two 168-pin DIMM sockets are provided and accessible once the right side cover has been removed. iPAQ 1.2 systems use PC100-type DIMMs and iPAQ 2.0 systems use PC133 DIMMs. Up to 512 megabytes (with current DIMM technology) maybe installed in each system.

## 2.4.7 MASS STORAGE

In a standard configuration the Compaq iPAQ supports two mass storage devices; one internal IDE hard drive and a removeable-media IDE device (CD-ROM, DVD, or LS-120 Power Drive, etc.) mounted in the MultiBay. This system uses SMART drives for the internal IDE device. An adapter is available that allows a secondary IDE hard drive to be installed in the MultiBay. The MultiBay supports hot-swapping of mass storage devices **except for hard drives**. The Compaq iPAQ supports the DriveLock feature for MultiBay hard drives, providing enhanced security for removeable hard drives.

## 2.4.8 SERIAL AND PARALLEL INTERFACES

The legacy models include a serial port and a parallel port accessible at the rear of the chassis. The serial port is RS-232-C/16550-compatible and supports standard baud rates up to 115,200 as well as two high-speed baud rates of 230K and 460K , and utilize a DB-9 connector. The parallel interface is Enhanced Parallel Port (EPP1.9) and Enhanced Capability Port (ECP) compatible, and supports bi-directional data transfers through a DB-25 connector. These interfaces may be disabled through Setup for enhanced security. The iPAQ 2.0 system uses a snap-on legacy module for implementing serial and parallel interfaces.

## 2.4.9 UNIVERSAL SERIAL BUS INTERFACE

All models feature two front panel-accessible Universal Serial Bus (USB) ports that provide a 12Mb/s hot pluggable (Plug 'n Play) interface for peripherals. Legacy-free iPAQ 1.2 models include three additional USB ports on the rear panel while all iPAQ 2.0 models provide four USB ports on the rear panel. Accommodate the USB keyboard and mouse supplied with those models. Units shipped as "legacy-free" include USB keyboards and mice.

## 2.4.10 GRAPHICS SUBSYSTEM

All models use the graphics controller integrated into the 82810E/DC-100 and 82815 GMCH component of the chipset. This graphics controller is the equivalent of the Intel i740 controller and provides up to 1600 x 1200 2D resolution. Pentium III-based systems also include 4 megabytes of local display cache for increased 3D performance. Celeron-based iPAQ 2.0 systems may be upgraded with the addition of a 4-MB display cache module.



## 2.4.11 AUDIO SUBSYSTEM

The audio subsystem features an AC'97 specification-based design and uses the integrated AC97 audio controller of the chipset and an AC'97-compliant audio codec. Microphone and headphone jacks are accessible on the front panel and line input and output jacks are provided on the rear panel. A low-distortion 5-watt amplifier drives a long-excursion speaker for optimum sound.

## 2.5 SPECIFICATIONS

This section includes the environmental, electrical, and physical specifications for the Compaq iPAQ Series Internet Devices. Where provided, metric statistics are given in parenthesis. All specifications subject to change without notice.

**Table 2-5.**  
Environmental Specifications

Parameter	Operating	Nonoperating
Air Temperature	50° to 95° F (10° to 35° C)	-24° to 140° F (-30° to 60° C)
Shock	30.0 g for 2 ms half-sine pulse	60.0 g for 2 ms half-sine pulse
Vibration	0.000215g <sup>2</sup> /Hz, 10-300 Hz [1]	0.0005g <sup>2</sup> /Hz, 10-500 Hz [1]
Humidity	90% Rh @ 28° C max wet bulb [2]	95% Rh @ 38.7° C [2]
Maximum Altitude	10,000 ft (3048 m)	30,000 ft (9,144 m)

NOTE:

- [1] 0.25 grms nominal
- [2] Maximum wet bulb, non-condensing

**Table 2-6.**  
Electrical Specifications

Parameter	U.S.	International
Input Line Voltage:		
Nominal:	110 - 120 VAC	200 - 240 VAC
Maximum:	90 - 132 VAC	180 - 264 VAC
Input Line Frequency Range:		
Nominal:	50 - 60 Hz	50 - 60 Hz
Maximum:	47 - 63 Hz	47 - 63 Hz
Power Supply:		
Maximum Continuous Power	90 watts	90 watts
Maximum Line Current Draw	2.5 amps	1.25 amps

**Table 2-7.**  
Physical Specifications

	IPAQ 1.0/1.2		IPAQ 2.0	
	Standard	Metric	Standard	Metric
Height	11.80 in	29.97 cm	13.75 in	34.90 cm
Width	5.66 in	14.38 cm	5.4 in	13.80 cm
Depth	9.44 in	23.98 cm	10.4 in	26.40 cm
Weight	10.7 lb [1]	4.8 kg	10.3 lb [1]	4.68 kg

**Table 2-8.**  
MultiBay 24x CD-ROM Drive Specifications  
(SP# 161685-B21)

Parameter	Measurement
Interface Type / Protocol	IDE / ATAPI
Transfer Rate:	
Max. Sustained	3.6 MB/s
Burst	16.6 MB/s
Media Type	Mode 1,2, Mixed Mode, CD-DA, Photo CD, Cdi, CD-XA
Capacity:	
Mode 1, 12 cm	550 MB
Mode 2, 12 cm	640 MB
8 cm	180 MB
Center Hole Diameter	15 mm
Disc Diameter	8/12 cm
Disc Thickness	1.2 mm
Track Pitch	1.6 um
Laser	
Beam Divergence	53.5 +/- 1.5 °
Output Power	53.6 0.14 mW
Type	GaAs
Wave Length	790 +/- 25 nm
Average Access Time:	
Random	140 ms
Full Stroke	300 ms
Audio Output Level	0.7 Vrms
Cache Buffer	128 KB

**Table 2-9.**  
MultiBay 4x DVD-ROM Drive Specifications  
(SP# 161685-B21)

Parameter	Measurement
Interface Type / Protocol	IDE / ATAPI
Transfer Rate:	
Max. Sustained (off disk)	5.41 MB/s
Data Bus Burst	16.6 MB/s
Media Types	DVD (single/double layer), DVD-5, DVD-9, DVD-10, CD-ROM Modes 1 or 2, CD-DA, Photo CD, Cdi, CD-XA
Capacity:	
Mode 1, 12 cm	550 MB
Mode 2, 12 cm	640 MB
8 cm	180 MB
Center Hole Diameter	15 mm
Disc Diameter	8 or 12 cm
Disc Thickness	1.2 mm
Track Pitch	1.6 $\mu$ m
Average Access Time:	
DVD:	
Random	<170 ms
Full Stroke	<280 ms
CD:	
Random	<130 ms
Full stroke	<225 ms
Audio Output Level	0.7 Vrms
Cache Buffer	512 KB

**Table 2-10.**  
Hard Drive Specifications

Parameter	4.3 GB	6.0 GB [1]	8.4 GB	10 GB
P/N	158738	161684	158739	N/A
Interface / Protocol	IDE / UATA-4	IDE / UATA-4	IDE / UATA-4	IDE / UATA-5
Drive Type	65	65	65	65
Drive Size	3.5/5.25 in	2.5/5.25 in	5.25 in	5.25 in
Interface Transfer Rate (max.)	66.6 MB/s	66.6 MB/s	66.6 MB/s	100 MB/s
Max. Seek Time (w/settling)				
Single Track	2.0 ms	4.0 ms	4.75 ms	N/A
Average	9.5 ms	12.0 ms	14.9 ms	N/A
Full Stroke (max)	19.0 ms	23.0 ms	27 ms	N/A
Disk Format (logical):				
# of Cylinders	8419	13424	16383	N/A
# of Data Heads	15	15	16	N/A
# of Sectors per Track	63	63	63	N/A
Rotation Speed	5400 RPM	4200 RPM	5400 RPM	5400
Drive Fault Prediction	SMART II	SMART II	SMART III	SMART III

NOTE:

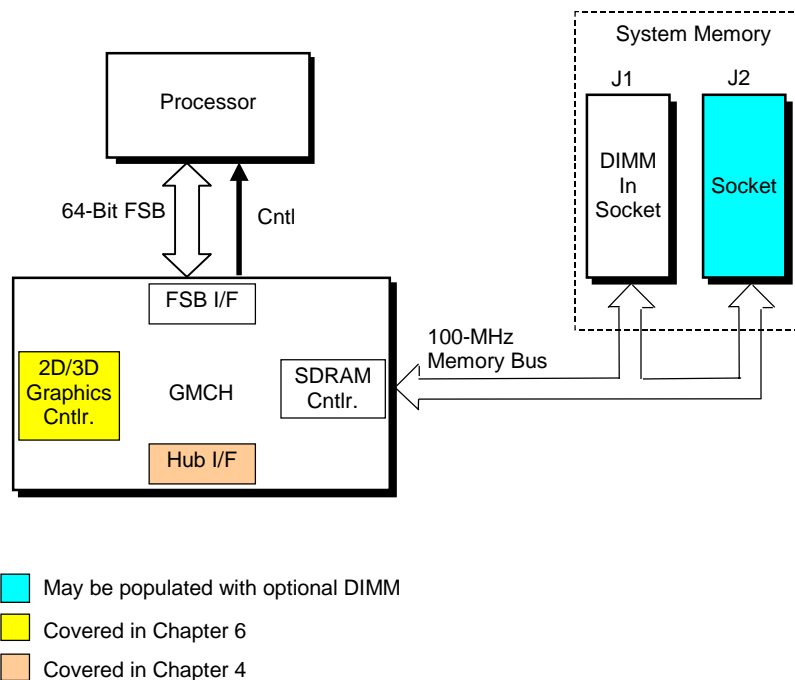
[1] For use in MultiBay.  
N/A = Not available at press time.

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# Chapter 3 PROCESSOR/ MEMORY SUBSYSTEM

## 3.1 INTRODUCTION

This chapter describes the processor/cache memory subsystem of the Compaq iPAQ Desktop Personal Computer featuring a Celeron or Pentium III processor and the 810E or 815E chipset (Figure 3-1). The chipset's GMCH supports up to two SDRAM DIMMs and integrates a 2D/3D graphics controller (covered in Chapter 6).



**Figure 3-1.** Processor/Memory Subsystem Architecture

This chapter includes the following topics:

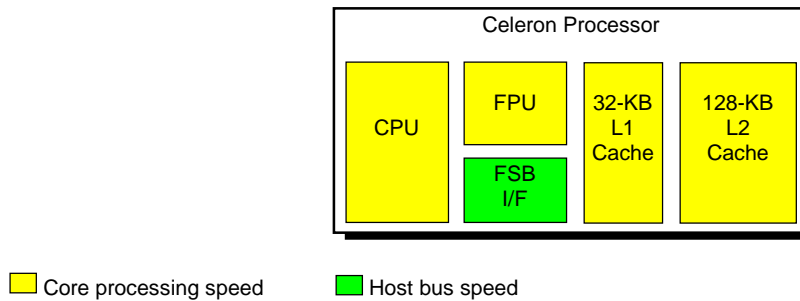
- ◆ Processor [3.2] page 3-2
- ◆ Memory subsystem [3.3] page 3-5
- ◆ Subsystem configuration [3.4] page 3-8

## 3.2 PROCESSOR

The Compaq iPAQ is configured as either a Celeron-based or Pentium III-based system.

### 3.2.1 CELERON PROCESSOR

The Celeron processor (Figure 3-2) uses a dual-ALU CPU with branch prediction and MMX support, floating point unit (FPU) for math coprocessing, a 32-KB primary (L1) cache, and a 128-KB secondary (L2) cache. All internal functions, except for the front side bus interface (FSB I/F), operate at processor speed.



**Figure 3-2.** Celeron Processor Internal Architecture

The Celeron processor is software-compatible with earlier generation Pentium II, Pentium MMX, Pentium, and x86 processors. The MMX support provided by the Celeron consists of 57 special instructions for accelerating multimedia communications applications. Such applications often involve computing-intensive loops that can take up as much as 90 percent of the CPU's execution time. Using a parallel-processing technique called single-instruction multiple-data (SIMD), MMX logic processes data 64 bits at a time. Specific applications that can benefit from MMX technology include 2D/3D graphics, audio, speech recognition, video codecs, and data compression.

The 82810-DC100 GMCH supports the processors listed in the following table:

**Table 3-1.**  
Celeron Processor Statistical Comparison

Processor	Core/L1/L2 Freq.	FSB Freq.	Core Voltage	Notes
Celeron 500	500 MHz	66 MHz	2.00 V	[1]
Celeron 533	533 MHz	66 MHz	2.00 V	
Celeron 700	700 MHz	66 MHz	1.65 V	[2]

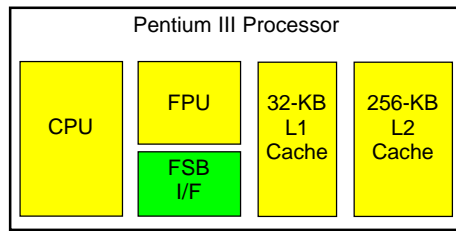
NOTES:

[1] Standard processor for iPAQ 1.0 systems.

[2] Standard processor for iPAQ 2.0 systems

### 3.2.2 PENTIUM III PROCESSOR

The Pentium III processor's architecture (Figure 3-3) includes the same core functionality as described previously for the Celeron processor but includes a larger L2 cache and higher processing speeds.



Full processing speed
  Host bus speed

**Figure 3-3.** Pentium III Processor Internal Architecture

These systems support the processor types listed in the following table.

**Table 3-2.**  
Pentium III Processor Statistical Comparison

Processor	CPU/L1 Speed	L2 Size / Speed	FSB Speed	Notes
Pentium III 500E	500 MHz	256 KB @ 500 MHz	100 MHz	[1]
Pentium III 533EB	533 MHz	256 KB @ 533 MHz	133 MHz	
Pentium III 550E	550 MHz	256 KB @ 550 MHz	100 MHz	
Pentium III 600E	600 MHz	256 KB @ 600 MHz	100 MHz	
Pentium III 600EB	600 MHz	256 KB @ 600 MHz	133 MHz	
Pentium III 667	667 MHz	256 KB @ 667 MHz	133 MHz	
Pentium III 700	700 MHz	256 KB @ 700 MHz	100 MHz	
Pentium III 733	733 MHz	256 KB @ 733 MHz	133 MHz	[2]
Pentium III 866	866 MHz	256 KB @ 866 MHz	133 MHz	[3]

NOTES:

- [1] Standard processor on iPAQ 1.0 systems.
- [2] Standard processor on iPAQ 1.2 systems.
- [3] Standard processor on iPAQ 2.0 systems.

The Pentium III processor is software-compatible with Celeron, Pentium II, Pentium MMX, Pentium, and x86 processors and also features 70 FPU-based streaming SIMD extensions (SSE) that, when implemented by appropriate software, can enhance 3D transforming and speech processing operations. Operating system requirements for SSE support are as follows:

Operating System Level of SSE Support

Windows 95	No SSE support
Windows 98, OSR0	SSE support though ISV and OpenGL 6.1 applications only
Windows 98, OSR1	SSE support though ISV, OpenGL, and DirectX applications
Windows 2000	SSE support with ISV, OpenGL, and DirectX applications
Windows NT 4.0	SSE support requires driver and Service Pack 4 (SP5 recommended)

### 3.2.3 PROCESSOR UPGRADING

All units use the PGA370 ZIF mounting socket and ship with either a Celeron or Pentium III processor installed. To replace the processor, use the following procedure:

1. Power down the system and disconnect the power cord.
2. Remove the right outer (carbon) panel.
3. On iPAQ 1.x systems, disconnect and remove the hard drive.
4. Remove the right chassis access panel.
5. After insuring that you have been properly grounded, remove the heatsink retaining clip (on the iPAQ 1.x by prying) or retaining bar (on the iPAQ 2.0 by lifting up the lock handle and then pressing the two ends together).
6. Remove the heatsink by twisting slightly before lifting off.
7. Lift the release arm of the PGA370 socket to the upright position.
8. Lift the processor package from the socket.

Replacement of the new processor is a reversal of steps 1-8.



**CAUTION:** These systems are designed for using processors with passive heat sinks. Installing a processor with an integrated fan on an iPAQ 1.x system is possible but **not** recommended (see Warning below). **Do not install a processor with an integrated fan in an iPAQ 2.0 unit.**

---

When replacing the processor it is recommended that the replacement processor be of the same family as the existing processor (i.e., Celeron for Celeron, or Pentium for Pentium).



**WARNING:** Upgrading iPAQ 1.0/1.2 models to a faster processor is possible provided that the new processor does not draw more than 18 amps of current. Using a processor that draws in excess of 18 amps may create a thermal condition and damage the system board. iPAQ 2.0 models may be upgraded to processors of up to but not exceeding 1 GHz. Installing a processor faster than 1 GHz in an iPAQ 2.0 unit may cause damage to the processor and/or the system board.

---

The processor core voltage and operating frequency are automatically set early in the power cycle process. No DIP switch settings are involved in replacing the processor.



### 3.3 MEMORY SUBSYSTEM

The iPAQ 1.0/1.2 system supports PC100 SDRAM for system memory. The iPAQ 2.0 system supports PC133 SDRAM DIMMs. These systems provide two 168-pin SDRAM DIMM sockets that accommodate single- or double-sided DIMMs. DIMMs should always be installed starting with the socket closest to the GMCH and/or processor **These systems are designed for using non-ECC DIMMs only.**

If using memory modules from third party suppliers the following DIMM type is recommended:

**For iPAQ 1.0/1.2 models: 100-MHz (PC100) unbuffered non-ECC RAM supporting CAS latency (CL) 2 or 3 with a data access time (clock-to-data out) of 9.0 ns or less @ CL=2 or CL=3.**

The 82810E GMCH supports 16-, 64-, and 128-Mb technology DIMMs for a maximum of 256 megabytes of memory space (with two 128-MB DIMMs).



**NOTE:** The 82810e GMCH performs memory accesses at 100 MHz regardless of the FSB frequency.

**For iPAQ 2.0 models: 133-MHz (PC133) unbuffered non-ECC RAM supporting CAS latency (CL) 2 or 3 with a data access time (clock-to-data out) of 9.0 ns or less @ CL=2 or CL=3.** PC100 DIMMs may be used with a slight reduction in performance.

The 82815 GMCH supports 16-, 64-, 128-, and 256-Mb technology DIMMs for a maximum of 512 megabytes of memory space (with two 256-MB DIMMs).

The RAM type and operating parameters are detected during POST by the system BIOS using the serial presence detect (SPD) method. This method employs an I<sup>2</sup>C bus to communicate with an EEPROM on each installed DIMM. The EEPROM holds the type and operating parameter data. The supported format complies with the JEDEC specification for 128-byte EEPROMs. This system also provides support for 256-byte EEPROMs to include additional Compaq-added features such as part number and serial number. The SPD format as supported in this system is shown in Table 3-3.

The key SPD bytes that BIOS checks for compatibility are 2, 9, 10, 18, 23, and 24. **If BIOS detects EDO DIMMs a “memory incompatible” message will be displayed and the system will halt.** Once BIOS determines the DIMM type the DRAM speed and CAS latency is checked based on the following criteria:

		Access from
<u>Bus Speed</u>	<u>Cycle Time</u>	<u>Clock</u>
100/133 MHz	10 ns	6 ns @ 50 pf loading

Only CAS latencies of 2 or 3 are supported. If DIMMs with unequal CAS latencies are installed then operation will occur based on the DIMM with the greatest latency.

On iPAQ 2.0 systems, if the BIOS detects an incompatible DIMM the NUM LOCK will blink for a short period of time during POST and an error message may or may not be displayed before the system hangs.

The SPD address map is shown below.

**Table 3-3.**  
SPD Address Map (SDRAM DIMM)

Byte	Description	Notes	Byte	Description	Notes
0	No. of Bytes Written Into EEPROM	[1]	27	Min. Row Prechge. Time	[7]
1	Total Bytes (#) In EEPROM	[2]	28	Min. Row Active to Delay	[7]
2	Memory Type		29	Min. RAS to CAS Delay	[7]
3	No. of Row Addresses On DIMM	[3]	30, 31	Reserved	
4	No. of Column Addresses On DIMM		32..61	Superset Data	[7]
5	No. of Module Banks On DIMM		62	SPD Revision	[7]
6, 7	Data Width of Module		63	Checksum Bytes 0-62	
8	Voltage Interface Standard of DIMM		64-71	JEP-106E ID Code	[8]
9	Cycletime @ Max CAS Latency (CL)	[4]	72	DIMM OEM Location	[8]
10	Access From Clock	[4]	73-90	OEM's Part Number	[8]
11	Config. Type (Parity, Nonparity, etc.)		91, 92	OEM's Rev. Code	[8]
12	Refresh Rate/Type	[4] [5]	93, 94	Manufacture Date	[8]
13	Width, Primary DRAM		95-98	OEM's Assembly S/N	[8]
14	Error Checking Data Width		99-125	OEM Specific Data	[8]
15	Min. Clock Delay	[6]	126, 127	Reserved	
16	Burst Lengths Supported		128-131	Compaq header "CPQ1"	[9]
17	No. of Banks For Each Mem. Device	[4]	132	Header checksum	[9]
18	CAS Latencies Supported	[4]	133-145	Unit serial number	[9] [10]
19	CS# Latency	[4]	146	DIMM ID	[9] [11]
20	Write Latency	[4]	147	Checksum	[9]
21	DIMM Attributes		148-255	Reserved	[9]
22	Memory Device Attributes				
23	Min. CLK Cycle Time at CL X-1	[7]			
24	Max. Acc. Time From CLK @ CL X-1	[7]			
25	Min. CLK Cycle Time at CL X-2	[7]			
26	Max. Acc. Time From CLK @ CL X-2	[7]			

NOTES:

- [1] Programmed as 128 bytes by the DIMM OEM
- [2] Must be programmed to 256 bytes.
- [3] High order bit defines redundant addressing: if set (1), highest order RAS# address must be re-sent as highest order CAS# address.
- [4] Refer to memory manufacturer's datasheet
- [5] MSb is Self Refresh flag. If set (1), assembly supports self refresh.
- [6] Back-to-back random column addresses.
- [7] Field format proposed to JEDEC but not defined as standard at publication time.
- [8] Field specified as optional by JEDEC but required by this system.
- [9] Compaq usage. This system requires that the DIMM EEPROM have this space available for reads/writes.
- [10] Serial # in ASCII format (MSB is 133). Intended as backup identifier in case vender data is invalid. Can also be used to indicate s/n mismatch and flag system administrator of possible system tampering.
- [11] Contains the socket # of the module (first module is "1"). Intended as backup identifier (refer to note [10]).

Figure 3-4 shows the system memory map.

Host, PCI, AGP Area	FFFF FFFFh	High BIOS Area (2 MB)	4 GB
	FFE0 0000h	PCI Memory (18 MB)	
	FFDF FFFFh	APIC Config. Space (64 KB)	
	FEC1 0000h FEC0 FFFFh	PCI Memory Expansion (2548 MB)	
Host, PCI, ISA Area	FEC0 0000h FEBF FFFFh	Host/PCI Memory Expansion (1008 MB)	1 GB
	4000 0000h 3FFF FFFFh	Extended Memory (15 MB)	16 MB
DOS Compatibility Area	0100 0000h	System BIOS Area (64 KB)	1 MB
	00FF FFFFh	Extended BIOS Area	
	0010 0000h	Option ROM (128 KB)	
	000F 0000h 000E FFFFh	Graphics/SMRAM RAM (128 KB)	
	000E 0000h 000D FFFFh	Fixed Mem. Area (128 KB)	
	000C 0000h 000B FFFFh	Base Memory (512 KB)	
	000A 0000h 0009 FFFFh		
0008 0000h 0007 FFFFh		640 KB	
			512 KB
	0000 0000h		

NOTE: All locations in memory are cacheable. Base memory is always mapped to DRAM. The next 128 KB fixed memory area can, through the north bridge, be mapped to DRAM or to PCI space. Graphics RAM area is mapped to PCI or AGP locations.

**Figure 3-4.** System Memory Map

### 3.4 SUBSYSTEM CONFIGURATION

The GMCH component provides the configuration function for the processor/memory subsystem. Table 3-4 lists the configuration registers used for setting and checking such parameters as memory control and PCI bus operation. These registers reside in the PCI Configuration Space and accessed using the methods described in Chapter 4, section 4.2.

**Table 3-4.**  
Host/PCI Bridge Configuration Registers (GMCH, Function 0)

PCI Conf. Addr.	Register	Reset Value	PCI Conf. Addr.	Register	Reset Value
00, 01h	Vendor ID	8086h	6A, 6Bh	DRAM Control Reg.	00h
02, 03h	Device ID	[1]	6C..6Fh	Memory Buffer Strength	55h
04, 05h	Command	0006h	70h	Multi-Transaction Timer	00h
06, 07h	Status	0210h	71h	CPU Latency Timer	10h
08h	Revision ID	--	72h	SMRAM Control	02h
09..0Bh	Class Code	--	90h	Error Command	00h
0Dh	Latency Timer	00h	91h	Error Status Register 0	00h
0Eh	Header Type	00h	92h	Error Status Register 1	00h
10..13h	Aperture Base Config.	8	93h	Reset Control	00h
50, 51h	PAC Config. Reg.	00h	A0..A3h	AGP Capability Identifier	N/A
53h	Data Buffer Control	83h	A4..A7h	AGP Status	N/A
55..56h	DRAM Row Type	00h	A8..ABh	AGP Command	00h
57h	DRAM Control	01h	B0..B3h	AGP Control	00h
58h	DRAM Timing	00h	B4h	Aperture Size	0000h
59..5Fh	PAM 0..6 Registers	00h	B8..BBh	Aperture Translation Table	0000h
60..67h	DRAM Row Boundary	01h	BCh	Aperture I/F Timer	00h
68h	Fixed DRAM Hole	00h	BDh	Low Priority Timer	00h

**NOTES:**

Refer to Intel Inc. documentation for detailed description of registers.

Assume unmarked locations/gaps as reserved.

[1] 2500 = iPAQ 1.x, 1130 = iPAQ 2.0

## Chapter 4 SYSTEM SUPPORT

### 4.1 INTRODUCTION

This chapter covers subjects dealing with basic system architecture and covers the following topics:

- ◆ PCI bus overview (4.2) page 4-2
- ◆ System resources (4.3) page 4-7
- ◆ System clock distribution (4.4) page 4-11
- ◆ Real-time clock and configuration memory (4.5) page 4-11
- ◆ System management (4.6) page 4-22
- ◆ Register map and miscellaneous functions (4.7) page 4-26

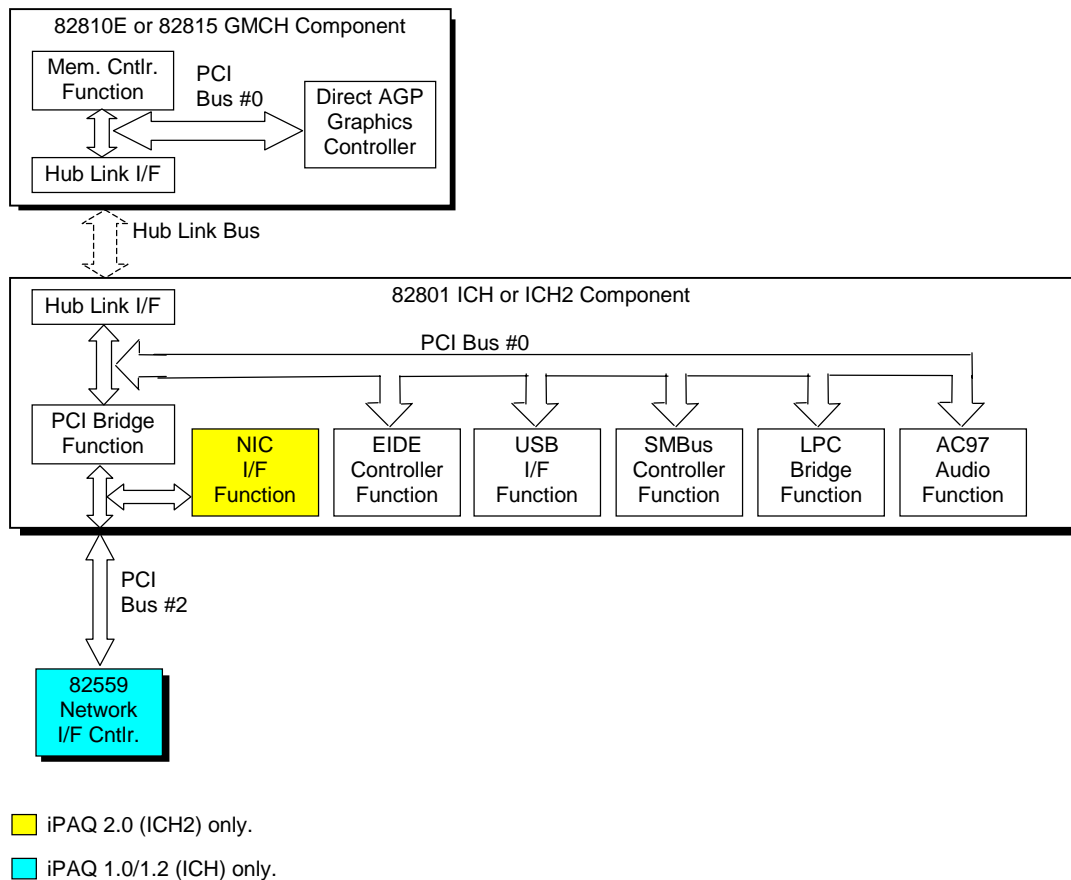
This chapter covers functions provided by off-the-shelf chipsets and therefore describes only basic aspects of these functions as well as information unique to the systems covered in this guide. For detailed information on specific components, refer to the applicable manufacturer's documentation.

## 4.2 PCI BUS OVERVIEW

**NOTE:** This section describes the PCI bus in general and highlights bus implementation in this particular system. For detailed information regarding PCI bus operation, refer to the *PCI Local Bus Specification Revision 2.2*.

These systems implement a 32-bit Peripheral Component Interconnect (PCI) bus (spec. 2.2) operating at 33 MHz. The PCI bus handles address/data transfers through the identification of devices and functions on the bus. A device is typically defined as a component or slot that resides on the PCI bus (although some components such as the GMCH and ICH are organized as multiple devices). A function is defined as the end source or target of the bus transaction. A device may contain one or more functions.

In the standard configuration these systems use a hierarchy of three PCI buses (Figure 4-1). The PCI bus #0 is internal to the GMCH/ICH chipset components and is not physically accessible. The AGP bus that services the AGP slot is designated as PCI bus #1. As this system is designed for simplicity of system management, **the PCI buses are not available for expansion purposes.**



**Figure 4-1.** PCI Bus Devices and Functions

## 4.2.1 PCI BUS TRANSACTIONS

The PCI bus consists of a 32-bit path (AD31-00 lines) that uses a multiplexed scheme for handling both address and data transfers. A bus transaction consists of an address cycle and one or more data cycles, with each cycle requiring a clock (PCICLK) cycle. High performance is realized during burst modes in which a transaction with contiguous memory locations requires that only one address cycle be conducted and subsequent data cycles are completed using auto-incremented addressing. Four types of address cycles can take place on the PCI bus; I/O, memory, configuration, and special. Address decoding is distributed (left up to each device on the PCI bus).

### 4.2.1.1 I/O and Memory Cycles

For I/O and memory cycles, a standard 32-bit address decode (AD31..0) for byte-level addressing is handled by the appropriate PCI device. For memory addressing, PCI devices decode the AD31..2 lines for dword-level addressing and check the AD1,0 lines for burst (linear-incrementing) mode. In burst mode, subsequent data phases are conducted a dword at a time with addressing assumed to increment accordingly (four bytes at a time).

### 4.2.1.2 Configuration Cycles

Devices on the PCI bus must comply with PCI protocol that allows configuration of that device by software. In this system, configuration mechanism #1 (as described in the PCI Local Bus specification Rev. 2.1) is employed. This method uses two 32-bit registers for initiating a configuration cycle for accessing the configuration space of a PCI device. The configuration address register (CONFIG\_ADDRESS) at 0CF8h holds a value that specifies the PCI bus, PCI device, and specific register to be accessed. The configuration data register (CONFIG\_DATA) at 0CFCh contains the configuration data.

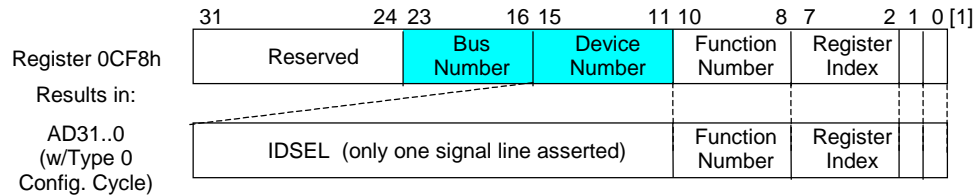
**PCI Configuration Address Register**  
I/O Port 0CF8h, R/W, (32-bit access only)

Bit	Function
31	Configuration Enable 0 = Disabled 1 = Enable
30..24	Reserved - read/write 0s
23..16	Bus Number. Selects PCI bus
15..11	PCI Device Number. Selects PCI device for access
10..8	Function Number. Selects function of selected PCI device.
7..2	Register Index. Specifies config. reg.
1,0	Configuration Cycle Type ID. 00 = Type 0 01 = Type 1

**PCI Configuration Data Register**  
I/O Port 0CFCh, R/W, (8-, 16-, 32-bit access)

Bit	Function
31..0	Configuration Data.

Two types of configuration cycles are used. A Type 0 (zero) cycle is targeted to a device on the PCI bus on which the cycle is running. A Type 1 cycle is targeted to a device on a downstream PCI bus as identified by bus number bits <23..16>. A PCI bridge may convert a Type 1 to a Type 0 if it's destined for a device being serviced by that bridge or it may forward the Type 1 cycle unmodified if it is destined for a device being serviced by a downstream bridge. Figure 4-2 shows the configuration cycle format and how the loading of 0CF8h results in a Type 0 configuration cycle on the PCI bus. The Device Number (bits <15..11> determines which one of the AD31..11 lines is to be asserted high for the IDSEL signal, which acts as a "chip select" function for the PCI device to be configured. The function number (CF8h, bits <10..8>) is used to select a particular function within a PCI component.



NOTES:

- [1] Bits <1,0> : 00 = Type 0 Cycle, 01 = Type 1 cycle
- Type 1 cycle only. Reserved on Type 0 cycle.

**Figure 4-2.** Configuration Cycle

Table 4-1 shows the standard configuration access data for components and slots residing on a PCI bus.

**Table 4-1.**  
PCI Component Configuration Access Data (iPAQ 1.x / iPAQ 2.0 [1])

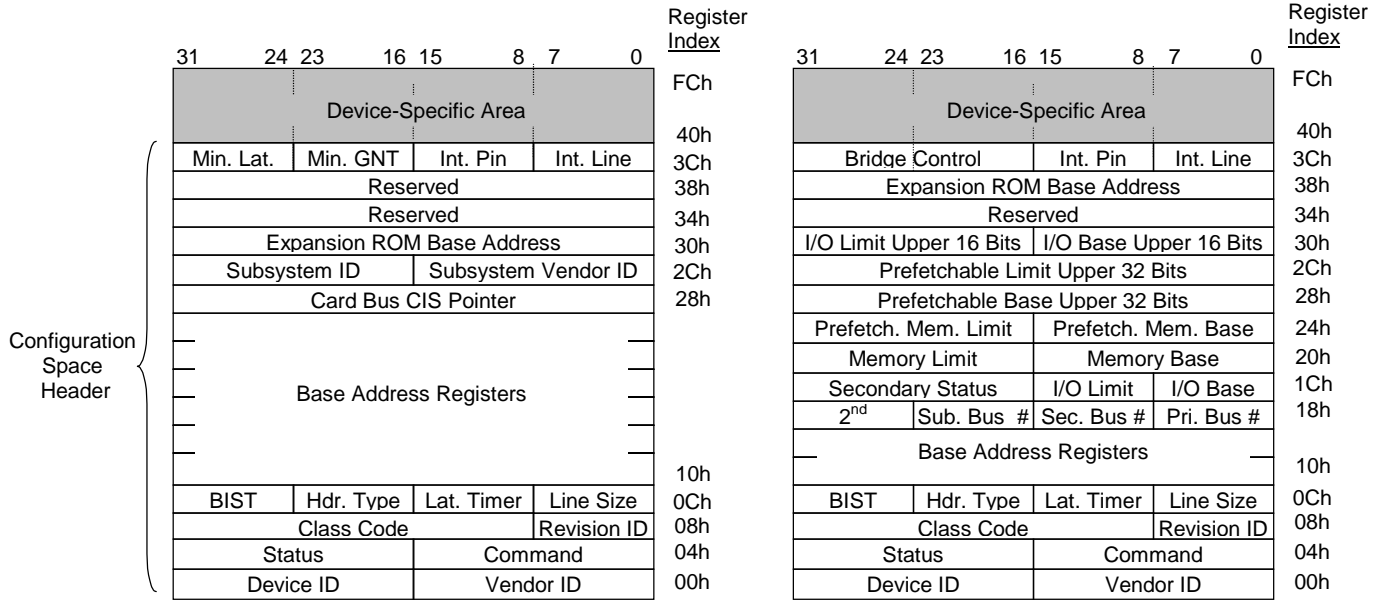
PCI Component	Device ID	PCI Bus #	Device #	Function #	IDSEL Wired to:
82810E / 82815 GMCH:					
Memory Controller	2500h / 1130h	0	0 (00h)	0	--
PCI/PCI (AGP) Bridge	2501h / 1131h	0	1 (01h)	0	
Graphics Controller	2502h / 1132h	0	2 (02h)	0	
82801AA ICH / 82801BA ICH2:					
PCI/PCI Bridge	2418h / 244Eh	0	30 (1Eh)	0	
LPC Bridge	2410h / 2440h	0	31 (1Fh)	0	
EIDE Controller	2411h / 244Bh	0	31 (1Fh)	1	
USB I/F #1	2412h / 2442h	0	31 (1Fh)	2	
SMBus Controller	2413h / 2443h	0	31 (1Fh)	3	
Reserved / USB I/F #2	na / 2444h	na / 0	na / 31 (1Fh)	na / 4	
AC97 Audio Controller	2415h / 2445h	0	31 (1Fh)	5	
AC97 Modem Controller	na	na	na	na	
Na / NIC Function	na / 2449h	na / 2	na / 8 (08h)	na / 0	
82559 Network I/F Controller [2]	1229h	2	31 (1Fh)	0	AD22

NOTES:

- Vender ID = 8086 for all components.
- 82810e and 82801AA used in iPAQ 1.0 and 1.2 systems.
- 82815 and 82801BA used fin iPAQ 2.0 systems
- na = Not applicable or implemented on these systems.
- [1] Entries and values apply to both system types unless divided by forward slash.
- [2] iPAQ 1.0 and 1.2 systems only.



The register index (CF8h, bits <7..2>) identifies the 32-bit location within the configuration space of the PCI device to be accessed. All PCI devices can contain up to 256 bytes of configuration data (Figure 4-3), of which the first 64 bytes comprise the configuration space header.



PCI Configuration Space Type 0

PCI Configuration Space Type 1

- Data required by PCI protocol
- Not required

**Figure 4-3.** PCI Configuration Space Mapping

Each PCI device is identified with a vendor ID (assigned to the vendor by the PCI Special Interest Group) and a device ID (assigned by the vendor). The device and vendor IDs for the devices on the system board are listed (previously) in Table 4-1.

## 4.2.2 PCI SUB-BUSSES

The chipset implements two data busses that are supplementary in operation to the PCI bus:

The chipset implements a Hub Link bus between the GMCH and the ICH. This bus is transparent to software and not accessible for expansion purposes.

The 82801 ICH implements a Low Pin Count (LPC) bus for handling transactions to and from the 47B357 Super I/O Controller as well as the 82802 FWH. The LPC bus transfers data a nibble (4 bits) at a time at a 33-MHz rate. Generally transparent in operation, the LPC bus becomes a factor primarily during the configuration of DMA channel modes (see section 4.4.3 “DMA”).

### 4.2.3 PCI CONFIGURATION

PCI bus operations require the configuration of certain parameters such as PCI IRQ routing, DMA channel configuration, RTC control, port decode ranges, and power management options. These parameters are handled by the LPC I/F bridge function (PCI function #0, device 31) of the ICH component and configured through the PCI configuration space registers listed in Table 4-2. Configuration is provided by BIOS at power-up but re-configurable by software.

**Table 4-2.**  
LPC Bridge Configuration Registers  
(ICH/ICH2, Function 0, Device 31)

PCI Config. Addr.	Register	Reset Value	PCI Config. Addr.	Register	Reset Value
00, 01h	Vendor ID	8086h	8Ah	Device 31 Error Status	00h
02, 03h	Device ID	[2]	90, 91h	PCI DMA Configuration	0000h
04, 05h	Command	000Fh	A0-CFh	Power Management	
06, 07h	Status	0280h	D0-D3h	General Control	0's
08h	Revision ID	00h	D4-D7h	General Status	F00h
0A-0Bh	Class Code	0106h	D8h	RTC Configuration	00h
0Eh	Header Type	80h	E0h	LPC COM Port Dec. Range	00h
40-43h	ACPI Base Address	1	E1h	LPC FDD & LPT Dec. Rge	00h
44h	ACPI Control	00h	E2h	LPC Audio Dec. Range	80h
4E, 4Fh	BIOS Control	0000h	E3h	FWH Decode Enable	FFh
54h	TCO Control	00h	E4, E5h	LPC I/F Decode Range 1	0000h
58-5Bh	GPIO Base Address	1	E6, E7h	LPC I/F Enables	0000h
5Ch	GPIO Control	00h	E8h	FWH Select	00
60-63h	INTA-D Routing Cntrl.	80h [1]	EC, EDh	LPC I/F Decode Range 2	0000h
64h	Serial IRQ Control	10h	EE, EFh	Reserved	--
65-87h	Reserved	--	F0h	Reserved	--
88h	Dev. 31 Error Config.	00h	F2h	Function Disable Register	00h

## NOTE:

- [1] Value for each byte.  
 [2] ICH = 2410h, ICH2 = 2440h  
 Assume unmarked locations/gaps as reserved.

### 4.3 SYSTEM RESOURCES

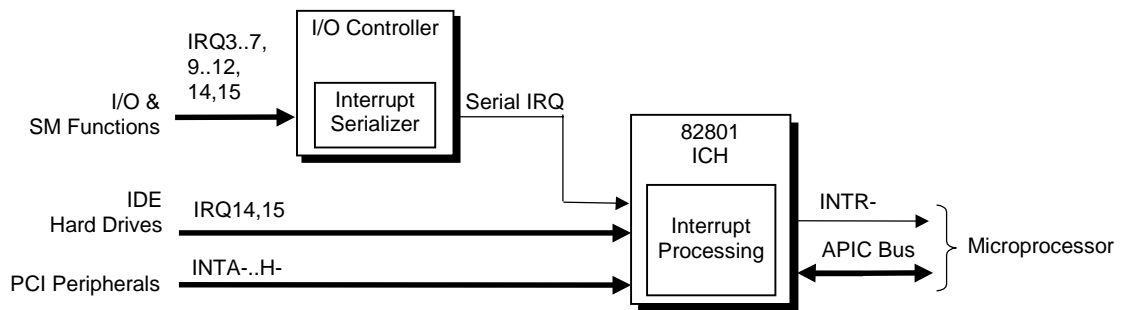
This section describes the availability and basic control of major subsystems, otherwise known as resource allocation or simply “system resources.” System resources are provided on a priority basis through hardware interrupts and DMA requests and grants.

#### 4.3.1 INTERRUPTS

The microprocessor uses two types of hardware interrupts; maskable and nonmaskable. A maskable interrupt can be enabled or disabled within the microprocessor by the use of the STI and CLI instructions. A nonmaskable interrupt cannot be masked off within the microprocessor, although it may be inhibited by hardware or software means external to the microprocessor.

##### 4.3.1.1 Maskable Interrupts

The maskable interrupt is a hardware-generated signal used by peripheral functions within the system to get the attention of the microprocessor. Peripheral functions produce a unique INTA-H (PCI) or IRQ0-15 (ISA) signal that is routed to interrupt processing logic that asserts the interrupt (INTR-) input to the microprocessor. The microprocessor halts execution to determine the source of the interrupt and then services the peripheral as appropriate. Figure 4-4 shows the routing of PCI and ISA interrupts. Most IRQs are routed through the I/O controller, which contains a serializing function. A serialized interrupt stream is applied to the 82801 ICH.



**Figure 4-4.** Maskable Interrupt Processing, Block Diagram

The 82801 ICH2 component can be configured (through the Setup utility) to handle interrupts in one of two modes of operation:

- ◆ 8259 mode
- ◆ APIC mode

## 8259 Mode

In 8259-Mode, interrupts IRQ0-IRQ15 are handled in the conventional (AT-system) method using logic that is the equivalent of two 8259 interrupt controllers. Table 4-3 lists the standard source configuration for maskable interrupts and their priorities in 8259 mode. If more than one interrupt is pending, the highest priority (lowest number) is processed first.

**Table 4-3.**  
Maskable Interrupt Priorities and Assignments

Priority	Signal Label	Source (Typical)
1	IRQ0	Interval timer 1, counter 0
2	IRQ1	Keyboard
3	IRQ8-	Real-time clock
4	IRQ9	Unused
5	IRQ10	Unused
6	IRQ11	Unused
7	IRQ12	Mouse
8	IRQ13	Coprocessor (math)
9	IRQ14	IDE primary I/F
10	IRQ15	IDE secondary I/F
11	IRQ3	Serial port (COM2)
12	IRQ4	Serial port (COM1)
13	IRQ5	Unused
14	IRQ6	Diskette drive controller
15	IRQ7	Parallel port (LPT1)
--	IRQ2	NOT AVAILABLE (Cascade from interrupt controller 2)

## APIC Mode

The Advanced Programmable Interrupt Controller (APIC) mode enhances interrupt-processing performance with the following advantages:

- ◆ Eliminating the processor's interrupt acknowledge cycle by using a separate APIC bus.
- ◆ Programmable interrupt priority.
- ◆ Additional interrupts (total of 24).



**NOTE:** The APIC mode is supported by Windows NT/2000 operating systems. Systems using the Windows 95 or 98 operating system will need to run in 8259 mode. The mode is selectable through the Setup utility (access with F10 key during boot sequence).

Maskable Interrupt processing is controlled and monitored through standard AT-type I/O-mapped registers. These registers are listed in Table 4-4.

**Table 4-4.**  
Maskable Interrupt Control Registers

I/O Port	Register
020h	Base Address, Int. Cntrl. 1
021h	Initialization Command Word 2-4, Int. Cntrl. 1
0A0h	Base Address, Int. Cntrl. 2
0A1h	Initialization Command Word 2-4, Int. Cntrl. 2

### 4.3.1.2 Non-Maskable Interrupts

Non-maskable interrupts cannot be masked (inhibited) within the microprocessor itself but may be maskable by software using logic external to the microprocessor. There are two non-maskable interrupt signals: the NMI- and the SMI-. These signals have service priority over all maskable interrupts, with the SMI- having top priority over all interrupts including the NMI-.

#### NMI- Generation

The Non-Maskable Interrupt (NMI-) signal can be generated by either a parity error detected on a PCI bus (activating SERR- or PERR-) or by an internal processor error (activating IERRA or IERRB).

The SERR- and PERR- signals are routed through the ICH component, which in turn activates the NMI to the microprocessor. The NMI Status Register at I/O port 061h contains NMI source and status data as follows:

#### NMI Status Register 61h

Bit	Function
7	NMI Status: 0 = No NMI from system board parity error. 1 = NMI requested, read only
6	IOCHK- NMI: 0 = No NMI from IOCHK- 1 = IOCHK- is active (low), NMI requested, read only
5	Interval Timer 1, Counter 2 (Speaker) Status
4	Refresh Indicator (toggles with every refresh)
3	IOCHK- NMI Enable/Disable: 0 = NMI from IOCHK- enabled 1 = NMI from IOCHK- disabled and cleared (R/W)
2	System Board Parity Error (PERR/SERR) NMI Enable: 0 = Parity error NMI enabled 1 = Parity error NMI disabled and cleared (R/W)
1	Speaker Data (R/W)
0	Interval Timer 1, Counter 2 Gate Signal (R/W) 0 = Counter 2 disabled 1 = Counter 2 enabled

Functions not related to NMI activity.

After the active NMI has been processed, status bits <7> or <6> are cleared by pulsing bits <2> or <3> respectively. The NMI Enable Register (070h, <7>) is used to enable/disable the NMI signal. Writing 80h to this register masks generation of the NMI-. Note that the lower six bits of register at I/O port 70h affect RTC operation and should be considered when changing NMI- generation status.

#### SMI- Generation

The SMI- (System Management Interrupt) is typically used for power management functions. When power management is enabled, inactivity timers are monitored. When a timer times out, SMI- is asserted and invokes the microprocessor's SMI handler. The SMI- handler works with the APM BIOS to service the SMI- according to the cause of the timeout. Although the SMI- is primarily used for power management the interrupt is also employed for the QuickLock/QuickBlank functions as well.

### 4.3.2 DIRECT MEMORY ACCESS

Direct Memory Access (DMA) is a method by which a device accesses system memory without involving the microprocessor. Although the DMA method has been traditionally used to transfer blocks of data to or from an ISA I/O device, PCI devices may also use DMA operation as well. The DMA method reduces the amount of CPU interactions with memory, freeing the CPU for other processing tasks.



**NOTE:** This section describes DMA in general. For detailed information regarding DMA operation, refer to the data manual for the Intel 82801 I/O Controller Hub.

The 82801 component includes the equivalent of two 8237 DMA controllers cascaded together to provide eight DMA channels, each (excepting channel 4) configurable to a specific device. Table 4-5 lists the default configuration of the DMA channels.

**Table 4-5**  
DMA Channel Assignments And Register Ports

DMA Channel	Function	I/O Port
Controller 1 (byte transfers)		
0	Unused	Control registers 000h-00Eh Page register 087h
1	Audio subsystem	Page register 083h
2	Diskette drive	Page register 081h
3	Parallel port (ECP or EPP mode)	Page register 082h
Controller 2 (word transfers)		
4	Cascade for controller 1	Control registers 0C0h-0DEh n/a
5	Unused	Page register 08Bh
6	Unused	Page register 089h
7	Unused	Page register 08Ah
Refresh		08Fh [see note]

**NOTE:**

The DMA memory page register for the refresh channel must be programmed with 00h for proper operation.

All channels in DMA controller 1 operate at a higher priority than those in controller 2. Note that channel 4 is not available for use other than its cascading function for controller 1. The DMA controller 2 can transfer words only on an even address boundary. The DMA controller and page register define a 24-bit address that allows data transfers within the address space of the CPU.

In addition to device configuration, each channel can be configured (through PCI Configuration Registers) for one of two modes of operation:

- ◆ LPC DMA Mode - Uses the LPC bus to communicate DMA channel control and is implemented for devices using DMA through the I/O controller such as the diskette drive controller.
- ◆ PC/PCI DMA Mode - Uses the REQ#/GNT# signals to communicate DMA channel control and is used by PCI expansion devices.

#### 4.4 SYSTEM CLOCK DISTRIBUTION

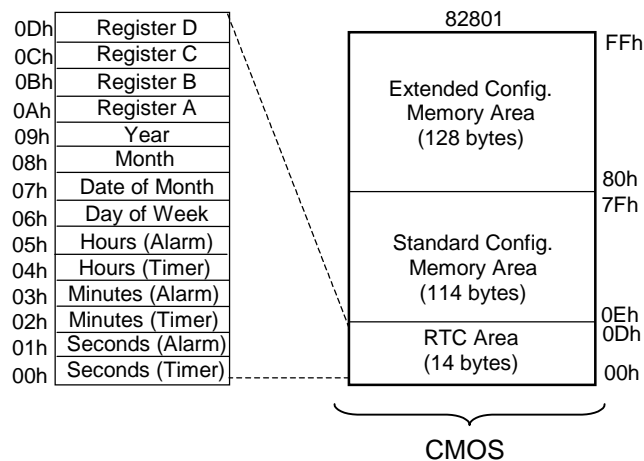
These systems use an Intel CK-type clock generator and crystal for generating the clock signals required by the system board components. Table 4-6 lists the system board clock signals and how they are distributed.

Frequency	Source	Destination
100 or 133 MHz	CK	Processor, GMCH, DIMM sockets
66 MHz	CK	GMCH, ICH2, AGP slot
48 MHz	CK	GMCH, ICH/ICH2, I/O Cntrl.
33 MHz	CK	Processor, ICH/ICH2, PCI Slots
14.31818 MHz	Crystal	CK
14.31818 MHz	CK	ICH/ICH2, I/O Cntrl., and (on iPAQ 2.0) audio codec

Certain clock outputs are turned off during reduced power modes to conserve energy. Clock output control is handled through the SMBus interface by BIOS.

#### 4.5 REAL-TIME CLOCK AND CONFIGURATION MEMORY

The Real-time clock (RTC) and configuration memory (also referred to as “CMOS”) functions are provided by the ICH component and is MC146818-compatible. As shown in the following figure, the ICH component provides 256 bytes of battery-backed RAM divided into two 128-byte configuration memory areas. The RTC uses the first 14 bytes (00-0Dh) of the standard memory area. All locations of the standard memory area (00-7Fh) can be directly accessed using conventional OUT and IN assembly language instructions through I/O ports 70h/71h, although the suggested method is to use the INT15 AX=E823h BIOS call.



**Figure 4-5.** Configuration Memory Map

A lithium 3-VDC battery is used for maintaining the RTC and configuration memory while the system is powered down. The battery is located in a battery holder on the system board is replaced with a Renata CR2032 or equivalent 3-VDC lithium battery.

### 4.5.1 CLEARING CMOS



**NOTE:** There is no provision for clearing the contents of CMOS in iPAQ 1.0/1.2 systems. Recovery from a suspected corrupted CMOS is by using the Power Button Override function as described in section 4.5.2.

---

The contents of configuration memory (including the Power-On Password) can be cleared on iPAQ 2.0 systems using the following procedure:

1. Turn off the unit.
2. Disconnect the AC power cord from the outlet and/or system unit.
3. Remove the chassis hood (cover).
4. Insert a non-metallic object (such as a pencil eraser) through the CMOS clear button access hole and press and release the CMOS clear button.
5. Replace the chassis hood (cover).
6. Reconnect the AC power cord to the outlet and/or system unit.
7. Turn the unit on.

To clear **only** the Power-On Password refer to section 4.6.1.1.

### 4.5.2 CMOS ARCHIVE AND RESTORE

On iPAQ 1.0/1.2 systems, the BIOS saves a copy of NVRAM (CMOS contents, password(s) and other system variables) in a portion of the flash ROM during the boot sequence. Should the system become un-usable, the last good copy of NVRAM data can be restored with the Power Button Override function. This function is invoked with the following procedure:

1. With the unit powered down, press and release the power button.
2. Immediately after releasing the power button in step 1, press and hold the power button until the unit powers down. This action will be recorded as a Power Button Override event.

With the next startup sequence the BIOS will detect the occurrence of the Power Button Override event and will load the backup copy of NVRAM from the ROM to the CMOS.



**NOTE:** The Power Button Override feature does **not** allow quick cycling of the system (turning on then off). If the power cord is disconnected during the POST routine, the splash screen image may become corrupted, requiring a re-flashing of the ROM (refer to chapter 8, BIOS ROM).

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### 4.5.3 STANDARD CMOS LOCATIONS

Table 4-7 and the following paragraphs describe standard configuration memory locations 0Ah-3Fh. These locations are accessible using OUT/IN assembly language instructions using port 70/71h or BIOS function INT15, AX=E823h.

**Table 4-7.**  
Configuration Memory (CMOS) Map

Location	Function	Location	Function
00-0Dh	Real-time clock	24h	System board ID
0Eh	Diagnostic status	25h	System architecture data
0Fh	System reset code	26h	Auxiliary peripheral configuration
10h	Diskette drive type	27h	Speed control external drive
11h	Reserved	28h	Expanded/base mem. size, IRQ12
12h	Hard drive type	29h	Miscellaneous configuration
13h	Security functions	2Ah	Hard drive timeout
14h	Equipment installed	2Bh	System inactivity timeout
15h	Base memory size, low byte/KB	2Ch	Monitor timeout, Num Lock Cntrl
16h	Base memory size, high byte/KB	2Dh	Additional flags
17h	Extended memory, low byte/KB	2Eh-2Fh	Checksum of locations 10h-2Dh
18h	Extended memory, high byte/KB	30h-31h	Total extended memory tested
19h	Hard drive 1, primary controller	32h	Century
1Ah	Hard drive 2, primary controller	33h	Miscellaneous flags set by BIOS
1Bh	Hard drive 1, secondary controller	34h	International language
1Ch	Hard drive 2, secondary controller	35h	APM status flags
1Dh	Enhanced hard drive support	36h	ECC POST test single bit
1Eh	Reserved	37h-3Fh	Power-on password
1Fh	Power management functions	40-FFh	Feature Control/Status

NOTES:

Assume unmarked gaps are reserved.

**RTC Control Register A, Byte 0Ah**

Bit	Function
7	Update in Progress. Read only. 0 = Time update will not occur before 2444 us 1 = Time update will occur within 2444 us
6..4	Divider Chain Control. R/W. 00x = Oscillator disabled. 010 = Normal operation (time base frequency = 32.768 KHz). 11x = Divider chain reset.
3..0	Periodic Interrupt Control. R/W. Specifies the periodic interrupt interval. 0000 = none                      1000 = 3.90625 ms 0001 = 3.90625 ms              1001 = 7.8125 ms 0010 = 7.8125 ms                1010 = 15.625 ms 0011 = 122.070 us               1011 = 31.25 ms 0100 = 244.141 us               1100 = 62.50 ms 0101 = 488.281 us               1101 = 125 ms 0110 = 976.562 us               1110 = 250 ms 0111 = 1.953125 ms              1111 = 500 ms

**RTC Control Register B, Byte 0Bh**

Bit	Function
7	Time Update Enable/disable 0 = Normal operation, 1 = Disable time updating for time set
6	Periodic Interrupt Enable/Disable. 0 = Disable, 1 = Enable interval specified by Register A
5	Alarm Interrupt Enable/disable 0 = Disabled, 1 = Enabled
4	End-of-Update Interrupt Enable/Disable 0 = Disabled, 1 = Enabled
3	Reserved (read 0)
2	Time/Date Format Select 0 = BCD format, 1 = Binary format
1	Time Mode 0 = 12-hour mode, 1 = 24-hour mode
0	Automatic Daylight Savings Time Enable/Disable 0 = Disable 1 = Enable (Advance 1 hour on 1 <sup>st</sup> Sunday in April, retreat 1 hour on last Sunday in October).

**RTC Status Register C, Byte 0Ch**

Bit	Function
7	If set, interrupt output signal active (read only)
6	If set, indicates periodic interrupt flag
5	If set, indicates alarm interrupt
4	If set, indicates end-of-update interrupt
3..0	Reserved

**RTC Status Register D, Byte 0Dh**

Bit	Function
7	RTC Power Status 0 = RTC has lost power 1 = RTC has not lost power
6..0	Reserved

**Configuration Byte 0Eh, Diagnostic Status**

Default Value = 00h

This byte contains diagnostic status data.

**Configuration Byte 0Fh, System Reset Code**

Default Value = 00h

This byte contains the system reset code.

**Configuration Byte 10h, Diskette Drive Type**

Bit	Function
7..4	Primary (Drive A) Diskette Drive Type
3..0	Secondary (Drive B) Diskette Drive Type

Valid values for bits <7..4> and bits <3..0>:

- 0000 = Not installed
- 0001 = 360-KB drive
- 0010 = 1.2-MB drive
- 0011 = 720-KB drive
- 0100 = 1.44-MB/1.25-MB drive
- 0110 = 2.88-MB drive
- (all other values reserved)

**Configuration Byte 12h, Hard Drive Type**

Bit	Function
7..4	Primary Controller 1, Hard Drive 1 Type: 0000 = none      1000 = Type 8 0001 = Type 1    1001 = Type 9 0010 = Type 2    1010 = Type 10 0011 = Type 3    1011 = Type 11 0100 = Type 4    1100 = Type 12 0101 = Type 5    1101 = Type 13 0110 = Type 6    1110 = Type 14 0111 = Type 7    1111 = other (use bytes 19h)
3..0	Primary Controller 1, Hard Drive 2 Type: 0000 = none      1000 = Type 8 0001 = Type 1    1001 = Type 9 0010 = Type 2    1010 = Type 10 0011 = Type 3    1011 = Type 11 0100 = Type 4    1100 = Type 12 0101 = Type 5    1101 = Type 13 0110 = Type 6    1110 = Type 14 0111 = Type 7    1111 = other (use bytes 1Ah)

**Configuration Byte 13h, Security Functions**

Default Value = 00h

Bit	Function
7	Reserved
6	QuickBlank Enable After Standby: 0 = Disable 1 = Enable
5	Administrator Password: 0 = Not present 1 = Present
4	Reserved
3	Diskette Boot Enable: 0 = Enable 1 = Disable
2	QuickLock Enable: 0 = Disable 1 = Enable
1	Network Server Mode/Security Lock Override: 0 = Disable 1 = Enable
0	Password State (Set by BIOS at Power-up) 0 = Not set 1 = Set

**Configuration Byte 14h, Equipment Installed**

Default Value (standard configuration) = 03h

Bit	Function
7,6	No. of Diskette Drives Installed: 00 = 1 drive      10 = 3 drives 01 = 2 drives    11 = 4 drives
5..2	Reserved
1	Coprocessor Present 0 = Coprocessor not installed 1 = Coprocessor installed
0	Diskette Drives Present 0 = No diskette drives installed 1 = Diskette drive(s) installed

**Configuration Bytes 15h and 16h, Base Memory Size**

Default Value = 280h

Bytes 15h and 16h hold a 16-bit value that specifies the base memory size in 1-KB (1024) increments. Valid base memory sizes are 512 and 640 kilobytes .

**Configuration Bytes 17h and 18h, Extended Memory Size**

Bytes 17h and 18h hold a 16-bit value that specifies the extended memory size in 1-KB increments.

### Configuration Bytes 19h-1Ch, Hard Drive Types

Byte 19h contains the hard drive type for drive 1 of the primary controller if byte 12h bits <7..4> hold 1111b. Byte 1Ah contains the hard drive type for drive 2 of the primary controller if byte 12h bits <3..0> hold 1111b. Bytes 1Bh and 1Ch contain the hard drive types for hard drives 1 and 2 of the secondary controller.

### Configuration Byte 1Dh, Enhanced IDE Hard Drive Support

Default Value = F0h

Bit	Function
7	EIDE - Drive C (83h)
6	EIDE - Drive D (82h)
5	EIDE - Drive E (81h)
4	EIDE - Drive F (80h)
3..0	Reserved

Values for bits <7..4> :

- 0 = Disable
- 1 = Enable for auto-configure

### Configuration Byte 1Fh, Power Management Functions

Default Value = 00h

Bit	Function
7..4	Reserved
3	Slow Processor Clock for Low Power Mode 0 = Processor runs at full speed 1 = Processor runs at slow speed
2	Reserved
1	Monitor Off Mode 0 = Turn monitor power off after 45 minutes in standby 1 = Leave monitor power on
0	Energy Saver Mode Indicator (Blinking LED) 0 = Disable 1 = Enable

### Configuration Byte 24h, System Board Identification

Default Value = 7Eh

Configuration memory location 24h holds the system board ID.

### Configuration Byte 25h, System Architecture Data

Default Value = 0Bh

Bit	Function
7..4	Reserved
3	Unmapping of ROM: 0 = Allowed 1 = Not allowed
2	Reserved
1,0	Diagnostic Status Byte Address 00 = Memory locations 80C0000h-80C0004h 01 = I/O ports 878h-87Ch 11 = neither place

**Configuration Byte 26h, Auxiliary Peripheral Configuration**

Default Value = 00h

Bit	Function
7,6	I/O Delay Select 00 = 420 ns (default) 01 = 300 ns 10 = 2600 ns 11 = 540 ns
5	Alternative A20 Switching 0 = Disable port 92 mode 1 = Enable port 92 mode
4	Bi-directional Print Port Mode 0 = Disabled 1 = Enabled
3	Graphics Type 0 = Color 1 = Monochrome
2	Hard Drive Primary/Secondary Address Select: 0 = Primary 1 = Secondary
1	Diskette I/O Port 0 = Primary 1 = Secondary
0	Diskette I/O Port Enable 0 = Primary 1 = Secondary

**Configuration Byte 27h, Speed Control/External Drive**

Default Value = 00h

Bit	Function
7	Boot Speed 0 = Max MHz 1 = Fast speed
6..0	Reserved

**Configuration Byte 28h, Expanded and Base Memory, IRQ12 Select**

Default Value = 00h

Bit	Function
7	IRQ12 Select 0 = Mouse 1 = Expansion bus
6,5	Base Memory Size: 00 = 640 KB 01 = 512 KB 10 = 256 KB 11 = Invalid
4..0	Internal Compaq Memory: 00000 = None 00001 = 512 KB 00010 = 1 MB 00011 = 1.5 MB . . 11111 = 15.5 MB

**Configuration Byte 29h, Miscellaneous Configuration Data**

Default Value = 00h

Bit	Function
7..5	Reserved
4	Primary Hard Drive Enable (Non-PCI IDE Controllers) 0 = Disable 1 = Enable
3..0	Reserved

**Configuration Byte 2Ah, Hard Drive Timeout**

Default Value = 02h

Bit	Function
7..5	Reserved
4..0	Hard Drive Timeout (index to SIT timeout record)

**Configuration Byte 2Bh, System Inactivity Timeout**

Default Value = 23h

Bit	Function
7	Reserved
6,5	Power Conservation Boot 00 = Reserved 01 = PC on 10 = PC off 11 = Reserved
4..0	System Inactive Timeout. (Index to SIT system timeout record) 00000 = Disabled

**Configuration Byte 2Ch, ScreenSave and NUMLOCK Control**

Default Value = 00h

Bit	Function
7	Reserved
6	Numlock Control 0 = Numlock off at power on 1 = Numlock on at power on
5	Screen Blank Control: 0 = No screen blank 1 = Screen blank w/QuickLock
4..0	ScreenSave Timeout. (Index to SIT monitor timeout record) 000000 = Disabled

### Configuration Byte 2Dh, Additional Flags

Default Value = 00h

Bit	Function
7..5	Reserved
4	Memory Test 0 = Test memory on power up only 1 = Test memory on warm boot
3	POST Error Handling (BIOS Defined) 0 = Display "Press F1 to Continue" on error 1 = Skip F1 message
2..0	Reserved

### Configuration Byte 2Eh, 2Fh, Checksum

These bytes hold the checksum of bytes 10h to 2Dh.

### Configuration Byte 30h, 31h, Total Extended Memory Tested

This location holds the amount of system memory that checked good during the POST.

### Configuration Byte 32h, Century

This location holds the Century value in a binary coded decimal (BCD) format.

### Configuration Byte 33h, Miscellaneous Flags

Default Value = 80h

Bit	Function
7	Memory Above 640 KB 0 = No, 1 = Yes
6	Reserved
5	Weitek Numeric Coprocessor Present: 0 = Not installed, 1 = Installed
4	Standard Numeric Coprocessor Present: 0 = Not installed, 1 = Installed
3..0	Reserved

### Configuration Byte 34h, International Language Support

Default Value = 00h



**Configuration Byte 35h, APM Status Flags**

Default Value = 11h

Bit	Function
7..6	Power Conservation State: 00 = Ready 01 = Standby 10 = Suspend 11 = Off
5,4	Reserved
3	32-bit Connection: 0 = Disconnected, 1 = Connected
2	16-bit Connection 0 = Disconnected, 1 = Connected
1	Real Mode Connection 0 = Disconnected, 1 = Connected
0	Power Management Enable: 0 = Disabled 1 = Enabled

**Configuration Byte 36h, ECC POST Test Single Bit Errors**

Default Value = 01h

Bit	Function
7	Row 7 Error Detect
6	Row 6 Error Detect
5	Row 5 Error Detect
4	Row 4 Error Detect
3	Row 3 Error Detect
2	Row 2 Error Detect
1	Row 1 Error Detect
0	Row 0 Error Detect

0 = No single bit error detected.

1 = Single bit error detected.

**Configuration Byte 37h-3Fh, Power-On Password**

These eight locations hold the power-on password.

## 4.6 SYSTEM MANAGEMENT

This section describes functions having to do with security, power management, temperature, and overall status. These functions are handled by hardware and firmware (BIOS) and generally configured through the Setup utility.

### 4.6.1 SECURITY FUNCTIONS

These systems include various features that provide different levels of security. Note that this subsection describes **only the hardware functionality** (including that supported by Setup) and does not describe security features that may be provided by the operating system and application software.

#### 4.6.1.1 Passwords



**CAUTION:** Both iPAQ 1.x and 2.0 systems support the use of Setup and Power-On passwords and implement them in the same way. An iPAQ 2.0 system with enabled but forgotten passwords may be restarted after clearing CMOS with the CMOS clear button (section 4.5.1). **However**, the iPAQ 1.0/1.2 **does not** include a CMOS clear button and enabling and then forgetting both the Setup and Power-On passwords on an iPAQ 1.0/1.2 system will require invoking a special utility with a service password based on the unit serial number and date. **The utility can be invoked only as a network application through Compaq Customer Support.**

---

#### Setup Password

The Setup utility may be configured to be always changeable or changeable only by entering a password. The password is held on CMOS and if enabled and forgotten, will inhibit any changes offered by the Setup utility. Refer to the previous Caution for dealing with forgotten passwords.

#### Power-On Password

These systems support the use of a power-on password, which may be enabled or disabled through the Setup utility. The password is stored in configuration memory (CMOS). If enabled and then forgotten on iPAQ 1.0/1.2 systems refer to the previous Caution statement. Forgotten Power-On passwords for iPAQ 2.0 systems can be cleared using the procedure described below or the entire CMOS be cleared (refer to section 4.5.1).

To clear **only** the Power-On password, use the following procedure:

1. Turn off the system and disconnect the AC power cord from the outlet and/or system unit.
2. Remove the cover (hood). Insure that all system board LEDs are off (not illuminated).
3. Locate the password header/jumper (labeled E49 on these systems) and remove the jumper from pins 1 and 2 and place on (just) pin 2 (for safekeeping).
4. Replace the cover.
5. Re-connect the AC power cord to the AC outlet and/or system unit.
6. Turn on the system. The POST routine will clear and disable the password.
7. To re-enable the password feature, repeat steps 1-6, replacing the jumper on pins 1 and 2 of header E49.

## DriveLock Password

These systems support the DriveLock security feature for a compatible hard drive installed in the Multibay. When enabled, DriveLock prevents unauthorized access to hard drive data by requiring either a master DriveLock or a user DriveLock password to be entered. Although this function is controlled through the Setup utility, the password information is stored in a reserved area on the hard drive so that the password(s) will stay or move with the drive.



**CAUTION:** The DriveLock feature is designed primarily for business environments where removable hard drives may be moved from system to system. Since forgetting both DriveLock passwords for a particular drive will result in the data on that drive being no longer accessible, it is **strongly advised** that this feature be invoked and managed by a system administrator. For detailed user information consult the appropriate user reference guide for this system.

### 4.6.1.2 Cable Lock Provision

These systems include a chassis cutout (on the rear panel) for the attachment of a cable lock mechanism.

### 4.6.1.3 I/O Interface Security

Serial, parallel, and (on iPAQ legacy systems) the USB interfaces may be disabled individually through the Setup utility (F10) to guard against unauthorized access to a system. On iPAQ 2.0 systems the NIC interface may also be disabled through Setup.

## 4.6.2 POWER MANAGEMENT

The iPAQ 2.0 systems provide baseline hardware support of ACPI- and APM-compliant firmware and software. Key power-consuming components (processor, chipset, I/O controller, and fan) can be placed into a reduced power mode either automatically or by user control. The system can then be brought back up (“wake-up”) by events defined by the ACPI specification. The ACPI wake-up events supported by this system are listed as follows:

ACPI Wake-Up Event	System Wakes From
Power Button	Suspend or soft-off
RTC Alarm	Suspend or soft-off
Wake On LAN (w/NIC)	Suspend or soft-off
PME	Suspend or soft-off
Serial Port Ring	Suspend or soft-off
USB	Suspend only
Keyboard	Suspend only
Mouse	Suspend only

### 4.6.3 SYSTEM STATUS

The iPAQ 2.0 systems provide a visual indication of system boot and ROM flash status through the keyboard LEDs as listed in table 4-8.



**NOTE:** The LED indications listed in Table 4-8 are valid only for PS/2-type keyboards. A USB keyboard will not provide LED status for the listed events, although audible (beep) indications will occur.

**Table 4-8.**  
iPAQ 2.0 System Boot/ROM Flash Status LED Indications

Event	NUM Lock LED	CAPs Lock LED	Scroll Lock LED
System memory failure [1]	Blinking	Off	Off
Graphics controller failure [2]	Off	Blinking	Off
System failure prior to graphics cntlr. initialization [3]	Off	Off	Blinking
ROMPAQ diskette not present, faulty, or drive prob.	On	Off	Off
Password prompt	Off	On	Off
Invalid ROM detected - flash failed	Blinking [4]	Blinking [4]	Blinking [4]
Keyboard locked in network mode	Blinking [5]	Blinking [5]	Blinking [5]
Successful boot block ROM flash	On [6]	On [6]	On [6]

**NOTES:**

- [1] Accompanied by 1 short, 2 long audio beeps
- [2] Accompanied by 1 long, 2 short audio beeps
- [3] Accompanied by 2 long, 1 short audio beeps
- [4] All LEDs will blink in sync twice, accompanied by 1 long and three short audio beeps
- [5] LEDs will blink in sequence (NUM Lock, then CAPs Lock, then Scroll Lock)
- [6] Accompanied by rising audio tone.

Table 4-9 lists the operation status codes provided by the iPAQ 2.0 power LED on the front of the chassis.

**Table 4-9.**  
iPAQ 2.0 System Status LED Indications

System Status	Power LED
S0: System on (normal operation)	Steady green
S1: Suspend	Blinks green @ 1 Hz
S3: Suspend to RAM	Blinks green @ 0.5 Hz
S4: Suspend to disk	Blinks green @ 0.25 Hz
S5: Soft off	Off - clear
Processor not seated	Steady red
CPU thermal shutdown	Blinks red @ 4 Hz
ROM error	Blinks red @ 1 Hz
Power supply crowbar activated	Blinks red @ .5 Hz
System off	Off

#### 4.6.4 TEMPERATURE SENSING AND COOLING

These systems feature a variable-speed fan integrated into the power supply assembly. Fan speed is determined by the power supply's internal sensor.

All systems are designed to use a processor with a passive heat sink. The iPAQ 1.0/1.2 system includes a system board connector for a processor fan, which, if present, operates in tandem with the power supply fan. The iPAQ 2.0 system **does not** provide a connector for a heat sink fan and therefore **should not** be upgraded with a processor using a heat sink-mounted fan (refer to processor upgrading section 3.2.3.).



**NOTE:** These systems are designed to provide optimum cooling with the cover in place. Operating a system with the cover removed may result in a thermal condition of system board components, including the processor.

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## 4.7 REGISTER MAP AND MISCELLANEOUS FUNCTIONS

This section contains the system I/O map and information on general-purpose functions of the ICH and I/O controller.

### 4.7.1 SYSTEM I/O MAP

Table 4-10 lists the fixed addresses of the input/output (I/O) ports.

**Table 4-10.**  
System I/O Map

I/O Port	Function
0000..001Fh	DMA Controller 1
0020..002Dh	Interrupt Controller 1
002E, 002Fh	Index, Data Ports to LPC47B357 I/O Controller (primary)
0030..003Dh	Interrupt Controller
0040..0042h	Timer 1
004E, 004Fh	Index, Data Ports to LPC47B357 I/O Controller (secondary)
0050..0052h	Timer / Counter
0060..0067h	Microcontroller, NMI Controller (alternating addresses)
0070..0077h	RTC Controller
0080..0091h	DMA Controller
0092h	Port A, Fast A20/Reset Generator
0093..009Fh	DMA Controller
00A0..00B1h	Interrupt Controller 2
00B2h, 00B3h	APM Control/Status Ports
00B4..00BDh	Interrupt Controller
00C0..00DFh	DMA Controller 2
00F0h	Coprocessor error register
0170..0177h	IDE Controller 2 (active only if standard I/O space is enabled for primary drive)
01F0..01F7h	IDE Controller 1 (active only if standard I/O space is enabled for secondary drive)
0278..027Fh	Parallel Port (LPT2)
02E8..02EFh	Serial Port (COM4)
02F8..02FFh	Serial Port (COM2)
0370..0377h	Diskette Drive Controller Secondary Address
0376h	IDE Controller 2 (active only if standard I/O space is enabled for primary drive)
0378..037Fh	Parallel Port (LPT1)
03B0..03DFh	Graphics Controller
03BC..03BEh	Parallel Port (LPT3)
03E8..03EFh	Serial Port (COM3)
03F0..03F5h	Diskette Drive Controller Primary Addresses
03F6h	IDE Controller 1 (active only if standard I/O space is enabled for sec. drive)
03F8..03FFh	Serial Port (COM1)
04D0, 04D1h	Interrupt Controller
0678..067Fh	Parallel Port (LPT2)
0778..077Fh	Parallel Port (LPT1)
07BC..07BEh	Parallel Port (LPT3)
0CF8h	PCI Configuration Address (dword access only)
0CF9h	Reset Control Register
0CFCh	PCI Configuration Data (byte, word, or dword access)

**NOTE:**

Assume unmarked gaps are unused, reserved, or used by functions that employ variable I/O address mapping. Some ranges may include reserved addresses.

## 4.7.2 82801 ICH GENERAL PURPOSE FUNCTIONS

The 82801 ICH2 component includes a number of single and multi-purpose pins available as general-purpose input/output (GPIO) ports. The GPIO ports are configured (enabled/disabled) during POST by BIOS through the PCI configuration registers of the ICH's LPC I/F Bridge (82801, function 0). The GPIO ports are controlled through 64 bytes of I/O space that is mapped during POST.

Table 4-11 lists the utilization of the ICH's GPIO ports.

**Table 4-11.**  
82801 ICH2 GPIO Register Utilization

GPIO Port #	Function	Direction
0	PS LED detect	I
1	NIC REQ5	I
2	IRQE-	I
3	IRQF-	I
4	IRQG-	I
5	IRQH-	I
6	HD LED detect	I
7	--	NC
8	--	NC
11	Multibay device detect	I
12	--	NC
13	SMI from I/O	I
18	--	NC
19	--	NC
20	--	NC
21	--	NC
22	--	NC
23	--	NC
24	--	NC
25	--	NC
26	--	NC
27	--	NC
28	Password (1 = Enabled, 0 = Disabled)	I

NOTE:

NC = not connected (not used).

### 4.7.3 I/O CONTROLLER FUNCTIONS

The I/O controller contains various functions such as the keyboard/mouse interfaces, diskette interface, serial interfaces, and parallel interface. While the control of these interfaces uses standard AT-type I/O addressing (as described in chapter 5) the configuration of these functions occurs through indexed ports using PnP protocol. In these systems, hardware strapping selects I/O addresses 02Eh/02Fh at reset as the Index/Data ports for accessing the logical devices within the I/O controller. Table 4-12 lists the PnP control registers for the LPC47Bxx7.

**Table 4-12.**  
I/O Controller Control Registers

Index	Function	Reset Value
02h	Configuration Control	00h
03h	Reserved	
07h	Logical Device (Interface) Select: 00h = Diskette Drive I/F 01h = Rsvd 02h = Rsvd 03h = Parallel I/F 04h = Serial I/F (UART 1) 05h = Serial I/F (UART 2) 06h = Rsvd 07h = Keyboard I/F 08h = Rsvd 09h = Rsvd 0Ah = Runtime Reg. (GPIO Config.) 0Bh = Rsvd	00h
20h	Super I/O ID Register (SID)	56H
21h	Revision	--
22h	Logical Device Power Control	00h
23h	Logical Device Power Management	00h
24h	PLL / Oscillator Control	04h
25-2Fh	Device specific [2]	--

**NOTES:**

Refer to LPC47Bxx7 data sheet for detailed register information.

The configuration registers are accessed through I/O registers 2Eh (index) and 2Fh (data) after the configuration phase has been activated by writing 55h once to I/O port 2Eh. The BIOS then initiates each logical device and then deactivates the configuration phase by writing AAh to 2Eh.



### 4.7.3.1 LPC47B357 GPIO Utilization

The LPC47B357 I/O Controller (used in iPAQ 2.0 systems) provides 62 general-purpose pins that can be individually configured for specific purposes. These pins are configured through the Runtime registers (logical device 0Ah) during the system's configuration phase of the boot sequence by the BIOS.

Table 4-13 lists the GPIO registers for the LPC47B357. Note that not all ports are listed as this table defines only the custom implementation of GPIO ports. Refer to SMC documentation for standard usage of unlisted GPIO ports.

**Table 4-13.**  
LPC47B357 GPIO Port Utilization (iPAQ 2.0 Only)

GPIO	Function	Direction	GPIO	Function	Direction
10	Board rev 1	I	42	PME- to ICH2	O
11	Board rev 0	I	43	--	NC
12	Multibay power	I	44	Hood Lock	NC
13	PME-	I	45	Hood Unlock	NC
14	WOL	NC	46	SMI- to ICH2	O
15	System ID 4 [1]	I	60	PCI Slot Reset	NC
16	Processor Fan sense	NC	61	AGP Slot Reset	NC
17	LED test	O	62	PWR Button In	I
20	Pri. IDE 80-pin Cable Detect	I	63	SLP S3	I
21	Sec. IDE 80-pin Cable Detect	I	64	SLP S5	I
22	Multibay reset	O	65	CPU Changed/Removed [2]	O
23	System ID 2 [1]	I	66	PWR Button Out	O
24	BIOS fail for AOL	O	67	PS On (1 = on, 0 = off)	O
25	System ID 3 [1]	I	70	A20 Gate control	O
26	Processor Present	I	71	System ID 0 [1]	NC
27	--	NC	72	System ID 1 [1]	NC
30	PS LED Color Grn	O	73	--	NC
31	PS LED Blink	O	74	--	NC
32	Thermal Trip	I	75	PWR GD (to clock chip)	NC
33	2 MB Media ID	NC	76	FAN OFF-	O
34	FWH Write Protect	O	85	Kybd/Mouse PWR	O
35	FWH Reset	O	86	S3 3.3 VDC On	O
36	Diskette Motor B	NC	--	--	--
37	Diskette Select B	NC	--	--	--

NOTE:

NC = Not connected (not used).

[1] System ID (ID4..0) value for these systems = 00111.

[2] If set, will force "Safe Boot" mode.

### 4.7.3.2 LPC47B357 I/O Controller Miscellaneous Functions

The iPAQ 2.0 systems utilize the following specialized functions built into the LPC 47B357 I/O Controller:

- ◆ Power/Hard drive LED control – The I/O controller provides color and blink control for the front panel LEDs used for indicating system events as listed below:

System Status	Power LED	HD LED
S0: System on (normal operation)	Steady green	Green w/HD activity
S1: Suspend	Blinks green @ 1 Hz	Off
S3: Suspend to RAM	Blinks green @ .5 Hz	Off
S4: Suspend to disk	Blinks green @ 0.25 Hz	Off
S5: Soft off	Off - clear	Off
Processor not seated	Steady red	Off
CPU thermal shutdown	Blinks red @ 4 Hz	Off
ROM error	Blinks red @ 1 Hz	Off
Power supply crowbar activated	Blinks red @ 0.5 Hz	Off
System off	Off	Off

- ◆ I/O security – The parallel, serial, and diskette interfaces may be disabled individually by software and the LPC47B357's disabling register locked. If the disabling register is locked, a system reset through a cold boot is required to gain access to the disabling (Device Disable) register.
- ◆ Processor present/speed detection – One of the battery-back general-purpose inputs (GPI26) of the LPC47B357 detects if the processor has been removed. The occurrence of this event is passed to the ICH that will, during the next boot sequence, initiate the speed selection routine for the processor. The speed selection function replaces the manual DIP switch configuration procedure required on previous systems.
- ◆ Legacy/ACPI power button mode control – The LPC47B357 receives the pulse signal from the system's power button and produces the PS On signal according to the mode (legacy or ACPI) selected. Refer to chapter 7 for more information regarding power management.

### 4.7.4 820802 FWH FUNCTIONS

The 82802 Firmware Hub (FWH) is loaded with Compaq BIOS, which is discussed in Chapter 7. The FWH component also includes general purpose ports that are utilized on the iPAQ 2.0 as indicated in the following table:

GPIO Port #	Function	Direction
0	Legacy module detect (0 = installed, 1 = not installed)	I
1, 3, 4	Not used	NC
2	Display cache module detect	I

NOTE:

NC = not connected (not used).

## Chapter 5 INPUT/OUTPUT INTERFACES

### 5.1 INTRODUCTION

This chapter describes the standard (i.e., system board) interfaces that provide input and output (I/O) porting of data and specifically discusses interfaces that are controlled through I/O-mapped registers. The following I/O interfaces are covered in this chapter:

- ◆ Enhanced IDE interface (5.2) page 5-1
- ◆ Diskette drive interface (5.3) page 5-5
- ◆ Serial interfaces (5.4) page 5-6
- ◆ Parallel interface (5.5) page 5-9
- ◆ Keyboard/pointing device interface (5.6) page 5-15
- ◆ Universal serial bus interface (5.7) page 5-22
- ◆ Audio subsystem (5.8) page 5-26
- ◆ Network support (5.9) page 5-32

### 5.2 ENHANCED IDE INTERFACE

The enhanced IDE (EIDE) interface consists of primary and secondary controllers integrated into the 82801 component of the chipset. The primary IDE controller supports the hard drive while the secondary controller supports a device installed in the Multibay. Each controller can be configured independently for the following modes of operation:

- ◆ Programmed I/O (PIO) mode – CPU controls drive transactions through standard I/O mapped registers of the IDE drive.
- ◆ 8237 DMA mode – CPU offloads drive transactions using DMA protocol with transfer rates up to 16 MB/s.
- ◆ Ultra ATA/66 and UATA/100 modes – Preferred bus mastering source-synchronous protocol providing peak transfer rates of 66 MB/s (iPAQ 1.x) and 100 MB/s (iPAQ 2.0).

#### 5.2.1 IDE PROGRAMMING

The IDE interface is configured as a PCI device during POST and controlled through I/O-mapped registers at runtime. Hard drives types not found in the ROM's parameter table are automatically configured as to (soft)type by DOS as follows:

Primary controller: drive 0, type 65; drive 1, type 66  
 Secondary controller: drive 0, type 68; drive 1, type 15

Non-DOS (non-Windows) operating systems may require using Setup (F10) for drive configuration.

### 5.2.1.1 IDE Configuration Registers

The IDE controller is configured as a PCI device with bus mastering capability. The PCI configuration registers for the IDE controller function (PCI device #31, function #1) are listed in Table 5-1.

**Table 5-1.**  
EIDE PCI Configuration Registers (82801, Device 31/Function 1)

PCI Conf. Addr.	Register	Reset Value	PCI Conf. Addr.	Register	Reset Value
00-01h	Vender ID	8086h	24-2Bh	Reserved	0's
02-03h	Device ID	[1]	2C, 2Dh	Subsystem Vender ID	8086h
04-05h	PCI Command	0000h	2E, 2Fh	Subsystem ID	2411h
06-07h	PCI Status	0280h	30-3Fh	Reserved	0's
08h	Revision ID	00h	40-43h	Primary IDE Timing	0000h
09h	Programming	80h	44h	Secondary IDE Timing	00h
0Ah	Sub-Class	01h	48h	Sync. DMA Control	00h
0Bh	Base Class Code	01h	4A-4Bh	Sync. DMA Timing	0000h
0Dh	Master Latency Timer	0000h	54h	EIDE I/O Config.Register	00h
0Eh	Header Type	80h	F8-FBh	Manufacturer's ID	
0F-1Fh	Reserved	00h	FC-FFh	Reserved	
20-23h	BMIDE Base Address	1h	--	--	--

NOTE:

Assume unmarked gaps are reserved and/or not used.  
[1] 82801AA ICH = 2411h, 82801BA ICH2 = 244Bh

### 5.2.1.2 IDE Bus Master Control Registers

The IDE interface can perform PCI bus master operations using the registers listed in Table 5-2. These registers occupy 16 bytes of variable I/O space set by software and indicated by PCI configuration register 20h in the previous table.

**Table 5-2.**  
IDE Bus Master Control Registers

I/O Addr. Offset	Size (Bytes)	Register	Default Value
00h	1	Bus Master IDE Command (Primary)	00h
02h	1	Bus Master IDE Status (Primary)	00h
04h	4	Bus Master IDE Descriptor Pointer (Pri.)	0000 0000h
08h	1	Bus Master IDE Command (Secondary)	00h
0Ah	2	Bus Master IDE Status (Secondary)	00h
0Ch	4	Bus Master IDE Descriptor Pointer (Sec.)	0000 0000h

NOTE:

Unspecified gaps are reserved, will return indeterminate data, and should not be written to.

## 5.2.2 PRIMARY IDE INTERFACE

These systems use a standard 40-pin connector for the primary IDE device that connects (via a cable) to the hard drive installed in the drive bay. Note that some signals are re-defined for UATA/33, /66, and /100 modes, which require a special 80-conductor cable (supplied) designed to reduce cross-talk. Device power is supplied through a separate connector.

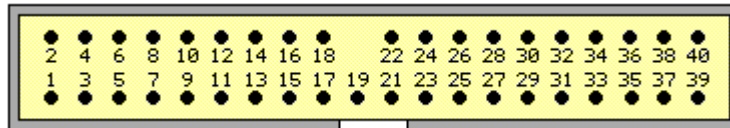


Figure 5-1. 40-Pin Primary IDE Connector (on system board).

**Table 5-3.**  
40-Pin Primary IDE Connector Pinout

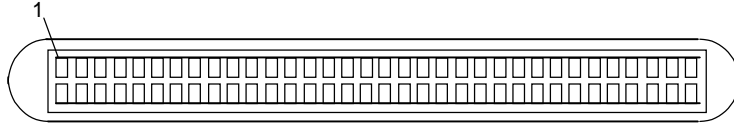
Pin	Signal	Description	Pin	Signal	Description
1	RESET-	Reset	21	DRQ	DMA Request
2	GND	Ground	22	GND	Ground
3	DD7	Data Bit <7>	23	IOW-	I/O Write [1]
4	DD8	Data Bit <8>	24	GND	Ground
5	DD6	Data Bit <6>	25	IOR-	I/O Read [2]
6	DD9	Data Bit <9>	26	GND	Ground
7	DD5	Data Bit <5>	27	IORDY	I/O Channel Ready [3]
8	DD10	Data Bit <10>	28	CSEL	Cable Select
9	DD4	Data Bit <4>	29	DAK-	DMA Acknowledge
10	DD11	Data Bit <11>	30	GND	Ground
11	DD3	Data Bit <3>	31	IRQn	Interrupt Request [4]
12	DD12	Data Bit <12>	32	IO16-	16-bit I/O
13	DD2	Data Bit <2>	33	DA1	Address 1
14	DD13	Data Bit <13>	34	DSKPDIAG	Pass Diagnostics
15	DD1	Data Bit <1>	35	DA0	Address 0
16	DD14	Data Bit <14>	36	DA2	Address 2
17	DD0	Data Bit <0>	37	CS0-	Chip Select
18	DD15	Data Bit <15>	38	CS1-	Chip Select
19	GND	Ground	39	HDACTIVE-	Drive Active (front panel LED) [5]
20	--	Key	40	GND	Ground

NOTES:

- [1] On UATA/33, /66, and /100 modes, re-defined as STOP.
- [2] On UATA/33, /66 and /100 mode reads, re-defined as DMARDY-.  
On UATA/33, /66 and /100 mode writes, re-defined as STROBE.
- [3] On UATA/33, /66 and /100 mode reads, re-defined as STROBE-.  
On UATA/33, /66 and /100 mode writes, re-defined as DMARDY-.
- [4] Primary connector wired to IRQ14, secondary connector wired to IRQ15.
- [5] Pin 39 is used for spindle sync and drive activity (becomes SPSYNC/DACT-) when synchronous drives are connected.

### 5.2.3 SECONDARY IDE INTERFACE

The secondary IDE interface supports the Multibay device, which may be an optical storage device (CD-ROM, DVD, LS-120) or a second hard drive mounted in a Multibay adapter that in turn is installed in the Multibay. Both iPAQ 1.x and 2.0 systems provide a 68-pin female connector (mounted on a Multibay board) that mates with the corresponding male connector of the Multibay device or adapter.



**Figure 5-2.** 68-Pin Multibay Connector (on Multibay board).

**Table 5-4.**  
68-Pin Multibay Connector Pinout

Pin	Signal	Description	Pin	Signal	Description
1	RST-	Reset	2	GND	Ground
3	DD7	Drive Data Bit <7>	4	DD8	Drive Data Bit <8>
5	DD6	Drive Data Bit <6>	6	DD9	Drive Data Bit <9>
7	DD5	Drive Data Bit <5>	8	DD10	Drive Data Bit <10>
9	DD4	Drive Data Bit <4>	10	DD11	Drive Data Bit <11>
11	DD3	Drive Data Bit <3>	12	DD12	Drive Data Bit <12>
13	DD2	Drive Data Bit <2>	14	DD13	Drive Data Bit <13>
15	DD1	Drive Data Bit <1>	16	DD14	Drive Data Bit <14>
17	DD0	Drive Data Bit <0>	18	DD15	Drive Data Bit <15>
19	GND	Ground	20	(key)	No connection
21	DREQ	DMA request	22	GND	Ground
23	IOW	Drive I/O Write	24	GND	Ground
25	IOR	Drive I/O Read	26	GND	Ground
27	IORDY	I/O Channel Ready	28	CSEL	Cable select
29	DACK	DMA Acknowledge	30	GND	Ground
31	IRQ	Interrupt request	32	GND	Ground
33	DA1	Drive address bit <1>	34	PDIAG	Passed diagnostics
35	DA0	Drive address bit <0>	36	DA2	Drive address bit <2>
37	CS1	Chip select 1	38	CS3	Chip select 3
39	DASP-	Drive activity/drive 1 prsnt.	40	GND	Ground
41	Vcc	+5 VDC logic power	42	MTR PWR	+5 VDC motor power
43	GND	Ground	44	AUD L	Left audio
45	GND	Left audio ground	46	GND	Right audio ground
47	AUD R	Right audio	48	INDEX-	Index
49	Vcc	+5 VDC	50	DRVSEL	Drive select
51	DSKCHG	Disk change	52	GND	Ground
53	DEN ID	Media identification	54	MTR ON-	Motor On
55	LOWDEN-	Density select	56	DIR-	Direction in
57	STEP-	Step	58	DEV PRST	System device present
59	WDATA-	Write data	60	GND	Ground
61	WGATE-	Write gate	62	TRK0-	Track 00
63	GND	Ground	64	WPROT-	Write protect
65	GND	Ground	66	RDATA-	Read data
67	GND	Ground	68	HDSSEL-	Head (side one) select

■ Diskette drive interface not connected.

### 5.3 DISKETTE DRIVE INTERFACE



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**NOTE:** The Compaq iPAQ **does not** support a diskette drive. However, the I/O controller component contains a diskette drive controller that may need to be enabled (through Setup) to satisfy the requirements of some operating systems. This may result in device manager applications indicating the presence of a diskette drive that in fact is **not** available.

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## 5.4 SERIAL INTERFACE

The legacy models include a serial interface to transmit and receive asynchronous serial data with external devices. The serial interface function is provided by the I/O controller component that includes a NS16C550-compatible UART.

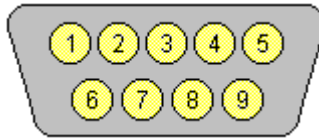


**NOTE:** Legacy-free models do not have an externally accessible serial port, but do have serial interface logic to satisfy the serial port requirements of some operating systems. The iPAQ2.0 and legacy-free iPAQ 1.x systems also includes a serial test header on the system board.

The UART supports the standard baud rates up through 115200, and also special high speed rates of 239400 and 460800 baud. The baud rate of the UART is typically set to match the capability of the connected device. While most baud rates may be set at runtime, **baud rates 230400 and 460800 must be set during the configuration phase.**

### 5.4.1 RS-232 INTERFACE

On the legacy system, the UART is associated with a DB-9 connector that complies with EIA standard RS-232-C. The DB-9 connector is shown in the following figure and the pinout of the connector is listed in Table 5-5.



**Figure 5-3.** Serial Interface Connector (Male DB-9 as viewed from rear of chassis)

**Table 5-5.**  
DB-9 Serial Connector Pinout

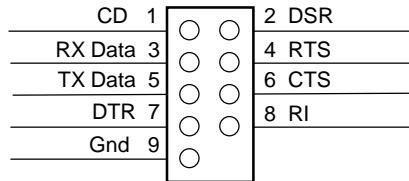
Pin	Signal	Description	Pin	Signal	Description
1	CD	Carrier Detect	6	DSR	Data Set Ready
2	RX Data	Receive Data	7	RTS	Request To Send
3	TX Data	Transmit Data	8	CTS	Clear To Send
4	DTR	Data Terminal Ready	9	RI	Ring Indicator
5	GND	Ground	--	--	--

The standard RS-232-C limitation of 50 feet (or less) of cable between the DTE (computer) and DCE (modem) should be followed to minimize transmission errors. Higher baud rates may require shorter cables.



## 5.4.2 SERIAL TEST INTERFACE

iPAQ 1.x legacy-free and iPAQ 2.0 systems include a serial header connector on the system board to satisfy the requirements of some operating systems. The test header and pinout is shown in the following figure:



**Figure 5-4.** Serial Interface Header (iPAQ 1.2 legacy-free and 2.0 system boards only)

## 5.4.3 SERIAL INTERFACE PROGRAMMING

Programming the serial interfaces consists of configuration, which occurs during POST, and control, which occurs during runtime.

### 5.4.3.1 Serial Interface Configuration

The serial interface must be configured for a specific address range (COM1, COM2, etc.) and also must be activated before it can be used. Address selection and activation of the serial interface are affected through the PnP configuration registers of the LPC47B277 I/O controller.

The serial interface configuration registers are listed in the following table:

Index Address	Function	R/W
30h	Activate	R/W
60h	Base Address MSB	R/W
61h	Base Address LSB	R/W
70h	Interrupt Select	R/W
F0h	Mode Register	R/W

NOTE:

Refer to LPC47B277 data sheet for detailed register information.

### 5.4.3.2 Serial Interface Control

The BIOS function INT 14 provides basic control of the serial interface. The serial interface can be directly controlled by software through the I/O-mapped registers listed in Table 5-7.

**Table 5-7.**  
Serial Interface Control Registers

COM1 Addr.	COM2 Addr.	Register	R/W
3F8h	2F8h	Receive Data Buffer	R
		Transmit Data Buffer	W
		Baud Rate Divisor Register 0 (when bit 7 of Line Control Reg. Is set)	W
3F9h	2F9h	Baud Rate Divisor Register 1 (when bit 7 of Line Control Reg. Is set)	W
		Interrupt Enable Register:	R/W
		<7..4> Reserved (always 0's)	
		<3> Modem status interrupt enable (active high) (CTS, DSR, RI, CD) <2> Rx line status interrupt enable (active high) (Overrun, parity, framing error) <1> Tx holding register empty interrupt enable (active high) <0> Baud rate divisor interrupt enable (active high)	
3FAh	2FAh	Interrupt ID Register:	R
		<7,6> FIFO Enable/Disable: 0 = disable, 1 = enable	
		<5,4> Reserved	
		<3..1> Interrupt Source:	
		000 = Modem status	100,101 = Reserved
		001 = TX holding reg. Empty	110 = Character time-out
		010 = RX data available	111 = Reserved
		011 = RX line status	
		<0> Interrupt pending (if cleared)	
		FIFO Control Register:	W
<7,6> RX Trigger Level: 00 = 1 byte, 01 = 4 bytes, 10 = 8 bytes, 11 = 14 bytes			
<5..3> Reserved			
<2> TX FIFO reset (active high)			
<1> RX FIFO reset (active high)			
<0> FIFO Enable/Disable: 0 = Disable TX/RX FIFO's, 1 = Enable TX/RX FIFO's			
3FBh	2FBh	Line Control Register:	R/W
		<7> Register access control:	
		0 = RX buffer, TX holding, divisor rate registers are accessible.	
		1 = Divisor rate register is accessible	
		<6> Break control (forces SOUT single low if set)	
		<5> Stick parity (if set, even parity bit is 0, odd parity bit is 1)	
		<4> Parity type: 0 = odd, 1 = even	
		<3> Parity enable: 0 = disabled, 1 = enabled	
		<2> Stop bit: 0 = 1 stop bit, 1 = 2 stop bits	
		<1,0> Word size: 00 = 5 bits, 01 = 6 bits, 10 = 7 bits, 11 = 8 bits	
3FCh	2FCh	Modem Control Register:	R/W
		<7..5> Reserved	
		<4> Internal loopback enabled (if set)	
		<3> Serial I/F interrupts enabled (if set)	
		<2> Reserved	
<1> RTS signal active (if set)			
<0> DTR signal active (if set)			
3FDh	2FDh	Line Status Register:	R
		<7> Parity error, framing error, or Break condition (if set)	
		<6> TX holding and TX shift registers are empty (if set)	
		<5> TX holding register is empty (if set)	
		<4> Break interrupt has occurred (if set)	
		<3> Framing error has occurred (if set)	
		<2> Parity error has occurred (if set)	
		<1> Overrun error has occurred (if set)	
<0> Data register ready to be read (if set)			
3FEh	2FEh	Modem Status:	R
		<7..4> DCD-, RI-, DSR, CTS (respectively) active (if set) <3..0> DCD-, RI-, DSR, CTS (respectively) changed state since last read (if set)	

## 5.5 PARALLEL INTERFACE

The legacy models include a parallel interface for connection to a peripheral device that has a compatible interface, the most common being a printer. The parallel interface function is integrated into the I/O controller component and provides bi-directional 8-bit parallel data transfers with a peripheral device. The parallel interface supports three main modes of operation:

- ◆ Standard Parallel Port (SPP) mode
- ◆ Enhanced Parallel Port (EPP) mode
- ◆ Extended Capabilities Port (ECP) mode

These three modes (and their submodes) provide complete support as specified for an IEEE 1284 parallel port.

### 5.5.1 STANDARD PARALLEL PORT MODE

The Standard Parallel Port (SPP) mode uses software-based protocol and includes two sub-modes of operation, compatible and extended, both of which can provide data transfers up to 150 KB/s. In the compatible mode, CPU write data is simply presented on the eight data lines. A CPU read of the parallel port yields the last data byte that was written. The following steps define the standard procedure for communicating with a printing device:

1. The system checks the Printer Status register. If the Busy, Paper Out, or Printer Fault signals are indicated as being active, the system either waits for a status change or generates an error message.
2. The system sends a byte of data to the Printer Data register, then pulses the printer STROBE signal (through the Printer Control register) for at least 500 ns.
3. The system then monitors the Printer Status register for acknowledgment of the data byte before sending the next byte.

In extended mode, a direction control bit (CTR 37Ah, bit <5>) controls the latching of output data while allowing a CPU read to fetch data present on the data lines, thereby providing bi-directional parallel transfers to occur. The SPP mode uses three registers for operation: the Data register (DTR), the Status register (STR) and the Control register (CTR). Address decoding in SPP mode includes address lines A0 and A1.

### 5.5.2 ENHANCED PARALLEL PORT MODE

In Enhanced Parallel Port (EPP) mode, increased data transfers are possible (up to 2 MB/s) due to a hardware protocol that provides automatic address and strobe generation. EPP revisions 1.7 and 1.9 are both supported. For the parallel interface to be initialized for EPP mode, a negotiation phase is entered to detect whether or not the connected peripheral is compatible with EPP mode. If compatible, then EPP mode can be used. In EPP mode, system timing is closely coupled to EPP timing. A watchdog timer is used to prevent system lockup. Five additional registers are available in EPP mode to handle 16- and 32-bit CPU accesses with the parallel interface. Address decoding includes address lines A0, A1, and A2.

### 5.5.3 EXTENDED CAPABILITIES PORT MODE

The Extended Capabilities Port (ECP) mode, like EPP, also uses a hardware protocol-based design that supports transfers up to 2 MB/s. Automatic generation of addresses and strobes as well as Run Length Encoding (RLE) decompression is supported by ECP mode. The ECP mode includes a bi-directional FIFO buffer that can be accessed by the CPU using DMA or programmed I/O. For the parallel interface to be initialized for ECP mode, a negotiation phase is entered to detect whether or not the connected peripheral is compatible with ECP mode. If compatible, then ECP mode can be used.

Ten control registers are available in ECP mode to handle transfer operations. In accessing the control registers, the base address is determined by address lines A2-A9, with lines A0, A1, and A10 defining the offset address of the control register. Registers used for FIFO operations are accessed at their base address + 400h (i.e., if configured for LPT1, then 378h + 400h = 778h).

The ECP mode includes several sub-modes as determined by the Extended Control register. Two submodes of ECP allow the parallel port to be controlled by software. In these modes, the FIFO is cleared and not used, and DMA and RLE are inhibited.

### 5.5.4 PARALLEL INTERFACE PROGRAMMING

Programming the parallel interface consists of configuration, which typically occurs during POST, and control, which occurs during runtime.

#### 5.5.4.1 Parallel Interface Configuration

The parallel interface must be configured for a specific address range (LPT1, LPT2, etc.) and also must be enabled before it can be used. When configured for EPP or ECP mode, additional considerations must be taken into account. Address selection, enabling, and EPP/ECP mode parameters of the parallel interface are affected through the PnP configuration registers of the LPC47B347 I/O controller. Address selection and enabling are automatically done by the BIOS during POST but can also be accomplished with the Setup utility and other software.

The parallel interface configuration registers are listed in the following table:

Index Address	Function	R/W	Reset Value
30h	Activate	R/W	00h
60h	Base Address MSB	R/W	00h
61h	Base Address LSB	R/W	00h
70h	Interrupt Select	R/W	00h
74h	DMA Channel Select	R/W	04h
F0h	Mode Register	R/W	00h
F1h	Mode Register 2	R/W	00h

### 5.5.4.2 Parallel Interface Control

The BIOS function INT 17 provides simplified control of the parallel interface. Basic functions such as initialization, character printing, and printer status are provided by subfunctions of INT 17. The parallel interface is controllable by software through a set of I/O mapped registers. The number and type of registers available depends on the mode used (SPP, EPP, or ECP). Table 5-9 lists the parallel registers and associated functions based on mode.

**Table 5-9.**  
Parallel Interface Control Registers

I/O Address	Register	SPP Mode Ports	EPP Mode Ports	ECP Mode Ports
Base	Data	LPT1,2,3	LPT1,2	LPT1,2,3
Base + 1h	Printer Status	LPT1,2,3	LPT1,2	LPT1,2,3
Base + 2h	Control	LPT1,2,3	LPT1,2	LPT1,2,3
Base + 3h	Address	--	LPT1,2	--
Base + 4h	Data Port 0	--	LPT1,2	--
Base + 5h	Data Port 1	--	LPT1,2	--
Base + 6h	Data Port 2	--	LPT1,2	--
Base + 7h	Data Port 3	--	LPT1,2	--
Base + 400h	Parallel Data FIFO	--	--	LPT1,2,3
Base + 400h	ECP Data FIFO	--	--	LPT1,2,3
Base + 400h	Test FIFO	--	--	LPT1,2,3
Base + 400h	Configuration Register A	--	--	LPT1,2,3
Base + 401h	Configuration Register B	--	--	LPT1,2,3
Base + 402h	Extended Control Register	--	--	LPT1,2,3

Base Address:  
 LPT1 = 378h  
 LPT2 = 278h  
 LPT3 = 3BCh

The following paragraphs describe the individual registers. Note that only the LPT1-based addresses are given in these descriptions.

#### Data Register, I/O Port 378h

Data written to this register is presented to the data lines D0-D7. A read of this register when in SPP-compatible mode yields the last byte written. A read while in SPP-extended or ECP mode yields the status of data lines D0-D7 (i.e., receive data).

In ECP mode in the forward (output) direction, a write to this location places a tagged command byte into the FIFO and reads have no effect.

**Status Register, I/O Port 379h, Read Only**

This register contains the current printer status. Reading this register clears the interrupt condition of the parallel port.

Bit	Function
7	Printer Busy (if 0)
6	Printer Acknowledgment Of Data Byte (if 0)
5	Printer Out Of Paper (if 1)
4	Printer Selected/Online (if 1)
3	Printer Error (if 0)
2	Reserved
1	EPP Interrupt Occurred (if set while in EPP mode)
0	EPP Timeout Occurred (if set while in EPP mode)

**Control Register, I/O Port 37Ah**

This register provides the printer control functions.

Bit	Function
7,6	Reserved
5	Direction Control for PS/2 and ECP Modes: 0 = Forward. Drivers enabled. Port writes to peripheral (default) 1 = Backward. Tristates drivers and data is read from peripheral
4	Acknowledge Interrupt Enable 0 = Disable ACK interrupt 1 = Enable interrupt on rising edge of ACK
3	Printer Select (if 0)
2	Printer Initialize (if 1)
1	Printer Auto Line Feed (if 0)
0	Printer Strobe (if 0)

**Address Register, I/O Port 37Bh (EPP Mode Only)**

This register is used for selecting the EPP register to be accessed.

**Data Port Registers 0-3, I/O Ports 37C-Fh (EPP Mode Only)**

These registers are used for reading/writing data. Port 0 is used for all transfers. Ports 1-3 are used for transferring the additional bytes of 16- or 32-bit transfers through port 0.

**FIFO Register, I/O Port 7F8h (ECP Mode Only)**

While in ECP/forward mode, this location is used for filling the 16-byte FIFO with data bytes. Reads have no effect (except when used in Test mode). While in ECP/backward mode, reads yield data bytes from the FIFO.

**Configuration Register A, I/O Port 7F8h (ECP Mode Only)**

A read of this location yields 10h, while writes have no effect.

**Configuration Register B, I/O Port 7F9h (ECP Mode, Read Only)**

A read of this location yields the status defined as follows:

Bit	Function
7	Reserved (always 0)
6	Status of Selected IRQn.
5,4	Selected IRQ Indicator: 00 = IRQ7 11 = IRQ5 All other values invalid.
3	Reserved (always 1)
2..0	Reserved (always 000)

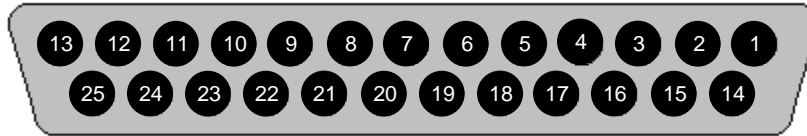
**Extended Control Register B, I/O Port 7FAh (ECP ModeOnly)**

This register defines the ECP mode functions.

Bit	Function
7..5	ECP Submode Select: 000 = Standard forward mode (37Ah <5> forced to 0). Writes are controlled by software and FIFO is reset. 001 = PS/2 mode. Reads and writes are software controlled and FIFO is reset. 010 = Parallel Port FIFO forward mode (37Ah <5> forced to 0). Writes are hardware controlled. 011 = ECP FIFO mode. Direction determined by 37Ah, <5>. Reads and writes are hardware controlled.
4	ECP Interrupt Mask: 0 = Interrupt is generated on ERR- assertion. 1 = Interrupt is inhibited.
3	ECP DMA Enable/Disable. 0 = Disabled 1 = Enabled
2	ECP Interrupt Generation with DMA 0 = Enabled 1 = Disabled
1	FIFO Full Status (Read Only) 0 = Not full (at least 1 empty byte) 1 = Full
0	FIFO Empty Status (Read Only) 0 = Not empty (contains at least 1 byte) 1 = Empty

### 5.5.5 PARALLEL INTERFACE CONNECTOR

Figure 5-5 and Table 5-10 show the connector and pinout of the parallel interface connector. Note that some signals are redefined depending on the port's operational mode.



**Figure 5-5.** Parallel Interface Connector (Female DB-25 as viewed from rear of chassis)

**Table 5-10.**  
DB-25 Parallel Connector Pinout

Pin	Signal	Function	Pin	Signal	Function
1	STB-	Strobe / Write [1]	14	LF-	Line Feed [2]
2	D0	Data 0	15	ERR-	Error [3]
3	D1	Data 1	16	INIT-	Initialize Paper [4]
4	D2	Data 2	17	SLCTIN-	Select In / Address. Strobe [1]
5	D3	Data 3	18	GND	Ground
6	D4	Data 4	19	GND	Ground
7	D5	Data 5	20	GND	Ground
8	D6	Data 6	21	GND	Ground
9	D7	Data 7	22	GND	Ground
10	ACK-	Acknowledge / Interrupt [1]	23	GND	Ground
11	BSY	Busy / Wait [1]	24	GND	Ground
12	PE	Paper End / User defined [1]	25	GND	Ground
13	SLCT	Select / User defined [1]	--	--	--

NOTES:

- [1] Standard and ECP mode function / EPP mode function
- [2] EPP mode function: Data Strobe  
ECP modes: Auto Feed or Host Acknowledge
- [3] EPP mode: user defined  
ECP modes: Fault or Peripheral Req.
- [4] EPP mode: Reset  
ECP modes: Initialize or Reverse Req.



## 5.6 KEYBOARD/POINTING DEVICE INTERFACE

The legacy models include PS/2-type keyboard/pointing device interfaces for the connection of a standard enhanced keyboard and a mouse. (Legacy-free models use USB ports for keyboard/mouse connections.) The keyboard/pointing device interface function is provided by the I/O controller component, which integrates 8042-compatible keyboard controller logic (hereafter referred to as simply the “8042”) to communicate with the keyboard and pointing device using bi-directional serial data transfers. The 8042 handles scan code translation and password lock protection for the keyboard as well as communications with the pointing device. This section describes the interface itself. The keyboard is discussed in the Appendix C.

### 5.6.1 KEYBOARD INTERFACE OPERATION

The data/clock link between the 8042 and the keyboard is uni-directional for Keyboard Mode 1 and bi-directional for Keyboard Modes 2 and 3. (These modes are discussed in detail in Appendix C). This section describes Mode 2 (the default) mode of operation.

Communication between the keyboard and the 8042 consists of commands (originated by either the keyboard or the 8042) and scan codes from the keyboard. A command can request an action or indicate status. The keyboard interface uses IRQ1 to get the attention of the CPU.

The 8042 can send a command to the keyboard at any time. When the 8042 wants to send a command, the 8042 clamps the clock signal from the keyboard for a minimum of 60 us. If the keyboard is transmitting data at that time, the transmission is allowed to finish. When the 8042 is ready to transmit to the keyboard, the 8042 pulls the data line low, causing the keyboard to respond by pulling the clock line low as well, allowing the start bit to be clocked out of the 8042. The data is then transferred serially, LSb first, to the keyboard (Figure 5-6). An odd parity bit is sent following the eighth data bit. After the parity bit is received, the keyboard pulls the data line low and clocks this condition to the 8042. When the keyboard receives the stop bit, the clock line is pulled low to inhibit the keyboard and allow it to process the data.

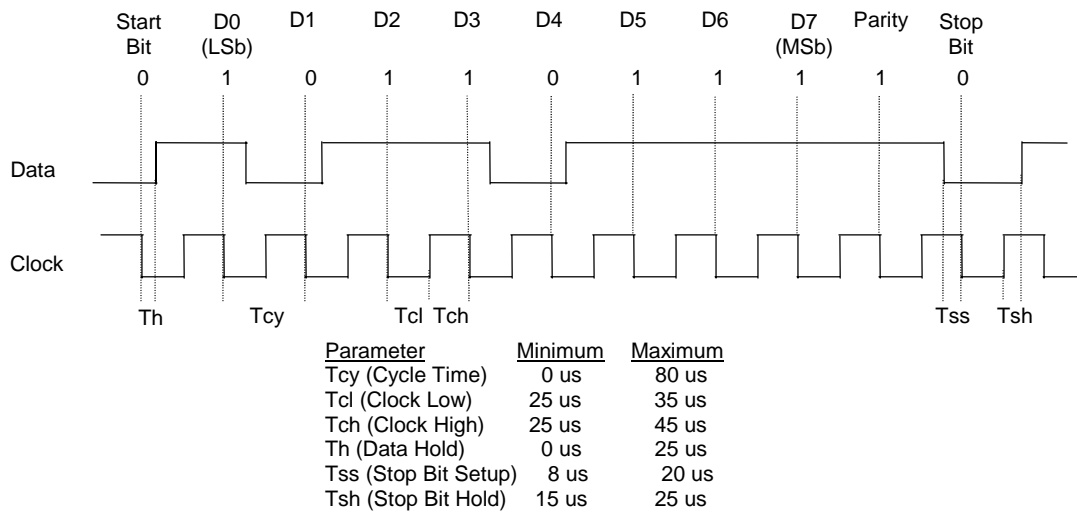


Figure 5-6. 8042-To-Keyboard Transmission of Code EDh, Timing Diagram

Control of the data and clock signals is shared by the 8042 and the keyboard depending on the originator of the transferred data. Note that the clock signal is always generated by the keyboard. After the keyboard receives a command from the 8042, the keyboard returns an ACK code. If a parity error or timeout occurs, a Resend command is sent to the 8042. Table 5-11 lists and describes commands that can be issued by the 8042 to the keyboard.

**Table 5-11.**  
8042-To-Keyboard Commands

Command	Value	Description
Set/Reset Status Indicators	EDh	Enables LED indicators. Value EDh is followed by an option byte that specifies the indicator as follows: Bits <7..3> not used Bit <2>, Caps Lock (0 = off, 1 = on) Bit <1>, NUM Lock (0 = off, 1 = on) Bit <0>, Scroll Lock (0 = off, 1 = on)
Echo	EEh	Keyboard returns EEh when previously enabled.
Invalid Command	EFh/F1h	These commands are not acknowledged.
Select Alternate Scan Codes	F0h	Instructs the keyboard to select another set of scan codes and sends an option byte after ACK is received: 01h = Mode 1 02h = Mode 2 03h = Mode 3
Read ID	F2h	Instructs the keyboard to stop scanning and return two keyboard ID bytes.
Set Typematic Rate/Display	F3h	Instructs the keyboard to change typematic rate and delay to specified values: Bit <7>, Reserved - 0 Bits <6,5>, Delay Time 00 = 250 ms 01 = 500 ms 10 = 750 ms 11 = 1000 ms Bits <4..0>, Transmission Rate: 00000 = 30.0 ms 00001 = 26.6 ms 00010 = 24.0 ms 00011 = 21.8 ms : 11111 = 2.0 ms
Enable	F4h	Instructs keyboard to clear output buffer and last typematic key and begin key scanning.
Default Disable	F5h	Resets keyboard to power-on default state and halts scanning pending next 8042 command.
Set Default	F6h	Resets keyboard to power-on default state and enable scanning.
Set Keys - Typematic	F7h	Clears keyboard buffer and sets default scan code set. [1]
Set Keys - Make/Brake	F8h	Clears keyboard buffer and sets default scan code set. [1]
Set Keys - Make	F9h	Clears keyboard buffer and sets default scan code set. [1]
Set Keys - Typematic/Make/Brake	FAh	Clears keyboard buffer and sets default scan code set. [1]
Set Type Key - Typematic	FBh	Clears keyboard buffer and prepares to receive key ID. [1]
Set Type Key - Make/Brake	FCh	Clears keyboard buffer and prepares to receive key ID. [1]
Set Type Key - Make	FDh	Clears keyboard buffer and prepares to receive key ID. [1]
Resend	FEh	8042 detected error in keyboard transmission.
Reset	FFh	Resets program, runs keyboard BAT, defaults to Mode 2.

Note:

[1] Used in Mode 3 only.

## 5.6.2 POINTING DEVICE INTERFACE OPERATION

The pointing device (typically a mouse) connects to a 6-pin DIN-type connector that is identical to the keyboard connector both physically and electrically. The operation of the interface (clock and data signal control) is the same as for the keyboard. The pointing device interface uses the IRQ12 interrupt.

## 5.6.3 KEYBOARD/POINTING DEVICE INTERFACE PROGRAMMING

Programming the keyboard interface consists of configuration, which occurs during POST, and control, which occurs during runtime.

### 5.6.3.1 8042 Configuration

The keyboard/pointing device interface must be enabled and configured for a particular speed before it can be used. Enabling and speed parameters of the 8042 logic are affected through the PnP configuration registers of the LPC47B347 I/O controller. Enabling and speed control are automatically set by the BIOS during POST but can also be accomplished with the Setup utility and other software.

The keyboard interface configuration registers are listed in the following table:

<b>Table 5-12.</b>		
<b>Keyboard Interface Configuration Registers</b>		
<b>Index</b>		
<b>Address</b>	<b>Function</b>	<b>R/W</b>
30h	Activate	R/W
70h	Primary Interrupt Select	R/W
72h	Secondary Interrupt Select	R/W
F0h	Reset and A20 Select	R/W

### 5.6.3.2 8042 Control

The BIOS function INT 16 is typically used for controlling interaction with the keyboard. Sub-functions of INT 16 conduct the basic routines of handling keyboard data (i.e., translating the keyboard's scan codes into ASCII codes). The keyboard/pointing device interface is accessed by the CPU through I/O mapped ports 60h and 64h, which provide the following functions:

- ◆ Output buffer reads
- ◆ Input buffer writes
- ◆ Status reads
- ◆ Command writes

Ports 60h and 64h can be accessed using the IN instruction for a read and the OUT instruction for a write. Prior to reading data from port 60h, the "Output Buffer Full" status bit (64h, bit <0>) should be checked to ensure data is available. Likewise, before writing a command or data, the "Input Buffer Empty" status bit (64h, bit <1>) should also be checked to ensure space is available.

#### I/O Port 60h

I/O port 60h is used for accessing the input and output buffers. This register is used to send and receive data from the keyboard and the pointing device. This register is also used to send the second byte of multi-byte commands to the 8042 and to receive responses from the 8042 for commands that require a response.

A read of 60h by the CPU yields the byte held in the output buffer. The output buffer holds data that has been received from the keyboard and is to be transferred to the system.

A CPU write to 60h places a data byte in the input byte buffer and sets the CMD/ DATA bit of the Status register to DATA. The input buffer is used for transferring data from the system to the keyboard. All data written to this port by the CPU will be transferred to the keyboard **except** bytes that follow a multibyte command that was written to 64h

#### I/O Port 64h

I/O port 64h is used for reading the status register and for writing commands. A read of 64h by the CPU will yield the status byte defined as follows:

Bit	Function
7..4	General Purpose Flags.
3	CMD/DATA Flag (reflects the state of A2 during a CPU write). 0 = Data 1 = Command
2	General Purpose Flag.
1	Input Buffer Full. Set (to 1) upon a CPU write. Cleared by IN A, DBB instruction.
0	Output Buffer Full (if set). Cleared by a CPU read of the buffer.

A CPU write to I/O port 64h places a command value into the input buffer and sets the CMD/DATA bit of the status register (bit <3>) to CMD.

Table 5-13 lists the commands that can be sent to the 8042 by the CPU. The 8042 uses IRQ1 for gaining the attention of the CPU.

**Table 5-13.**  
CPU Commands To The 8042

Value	Command Description
20h	Put current command byte in port 60h.
60h	Load new command byte. This is a two-byte operation described as follows: <ol style="list-style-type: none"> <li>1. Write 60h to port 64h.</li> <li>2. Write the command byte to port 60h as follows:               <ul style="list-style-type: none"> <li>Bit &lt;7&gt; Reserved</li> <li>&lt;6&gt; Keyboard Code Conversion                   <ul style="list-style-type: none"> <li>0 = Do not convert codes</li> <li>1 = Convert codes to 9-bit 8088/8086-compatible format</li> </ul> </li> <li>Bit &lt;5&gt; Pointing Device Enable                   <ul style="list-style-type: none"> <li>0 = Enable pointing device</li> <li>1 = Disable pointing device</li> </ul> </li> <li>Bit &lt;4&gt; Keyboard Enable                   <ul style="list-style-type: none"> <li>0 = Enable keyboard</li> <li>1 = Disable keyboard</li> </ul> </li> <li>Bit &lt;3&gt; Reserved</li> <li>Bit &lt;2&gt; System Flag                   <ul style="list-style-type: none"> <li>0 = Cold boot</li> <li>1 = CPU reset (exit from protected mode)</li> </ul> </li> <li>Bit &lt;1&gt; Pointing Device Interrupt Enable                   <ul style="list-style-type: none"> <li>0 = Disable interrupt</li> <li>1 = Enable interrupt</li> </ul> </li> <li>Bit &lt;0&gt; Keyboard Interrupt Enable                   <ul style="list-style-type: none"> <li>0 = Disable interrupt</li> <li>1 = Enable interrupt</li> </ul> </li> </ul> </li> </ol>
A4h	Test password installed. Tests whether or not a password is installed in the 8042: If FAh is returned, password is installed. If F1h is returned, no password is installed.
A5h	Load password. This multi-byte operation places a password in the 8042 using the following manner: <ol style="list-style-type: none"> <li>1. Write A5h to port 64h.</li> <li>2. Write each character of the password in 9-bit scan code (translated) format to port 60h.</li> <li>3. Write 00h to port 60h.</li> </ol>
A6h	Enable security. This command places the 8042 in password lock mode following the A5h command. The correct password must then be entered before further communication with the 8042 is allowed.
A7h	Disable pointing device. This command sets bit <5> of the 8042 command byte, pulling the clock line of the pointing device interface low.
A8h	Enable pointing device. This command clears bit <5> of the 8042 command byte, activating the clock line of the pointing device interface.
A9h	Test the clock and data lines of the pointing device interface and place test results in the output buffer. <ul style="list-style-type: none"> <li>00h = No error detected</li> <li>01h = Clock line stuck low</li> <li>02h = Clock line stuck high</li> <li>03h = Data line stuck low</li> <li>04h = Data line stuck high</li> </ul>
AAh	Initialization. This command causes the 8042 to inhibit the keyboard and pointing device and places 55h into the output buffer.

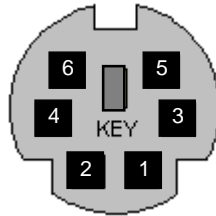
*Continued*

**Table 5-13. CPU Commands To The 8042 (Continued)**

Value	Command Description
ABh	Test the clock and data lines of the keyboard interface and place test results in the output buffer. 00h = No error detected 01h = Clock line stuck low 02h = Clock line stuck high 03h = Data line stuck low 04h = Data line stuck high
ADh	Disable keyboard command (sets bit <4> of the 8042 command byte).
A Eh	Enable keyboard command (clears bit <4> of the 8042 command byte).
C0h	Read input port of the 8042. This command directs the 8042 to transfer the contents of the input port to the output buffer so that they can be read at port 60h. The contents are as follows: Bit <7> Password Enable: 0 = Disabled, 1 = Enabled Bit <6> External Boot Enable: 0 = Enabled, 1 = Disabled Bit <5> Setup Enable: 0 = Enabled, 1 = Disabled Bit <4> VGA Enable: 0 = Enabled, 1 = Disabled Bit <3> Diskette Writes: 0 = Disabled, 1 = Enabled Bit <2> Reserved Bit <1> Pointing Device Data Input Line Bit <0> Keyboard Data Input Line
C2h	Poll Input Port High. This command directs the 8042 to place bits <7..4> of the input port into the upper half of the status byte on a continuous basis until another command is received.
C3h	Poll Input Port Low. This command directs the 8042 to place bits <3..0> of the input port into the lower half of the status byte on a continuous basis until another command is received.
D0h	Read output port. This command directs the 8042 to transfer the contents of the output port to the output buffer so that they can be read at port 60h. The contents are as follows: Bit <7> Keyboard data stream Bit <6> Keyboard clock Bit <5> IRQ12 (pointing device interrupt) Bit <4> IRQ1 (keyboard interrupt) Bit <3> Pointing device clock Bit <2> Pointing device data Bit <1> A20 Control: 0 = Hold A20 low 1 = Enable A20 Bit <0> Reset Line Status; 0 = Inactive 1 = Active
D1h	Write output port. This command directs the 8042 to place the next byte written to port 60h into the output port (only bit <1> can be changed).
D2h	Echo keyboard data. Directs the 8042 to send back to the CPU the next byte written to port 60h as if it originated from the keyboard. No 11-to-9 bit translation takes place but an interrupt (IRQ1) is generated if enabled.
D3h	Echo pointing device data. Directs the 8042 to send back to the CPU the next byte written to port 60h as if it originated from the pointing device. An interrupt (IRQ12) is generated if enabled.
D4h	Write to pointing device. Directs the 8042 to send the next byte written to 60h to the pointing device.
E0h	Read test inputs. Directs the 8042 to transfer the test bits 1 and 0 into bits <1,0> of the output buffer.
F0h-FFh	Pulse output port. Controls the pulsing of bits <3..0> of the output port (0 = pulse, 1 = don't pulse). Note that pulsing bit <0> will reset the system.

### 5.6.4 KEYBOARD/POINTING DEVICE INTERFACE CONNECTOR

The legacy model provides separate PS/2 connectors for the keyboard and pointing device. Both connectors are identical both physically and electrically. Figure 5-7 and Table 5-14 show the connector and pinout of the keyboard/pointing device interface connectors.



**Figure 5-7.** Keyboard or Pointing Device Interface Connector  
(as viewed from rear of chassis)

**Table 5-17.**  
Keyboard/Pointing Device Connector Pinout

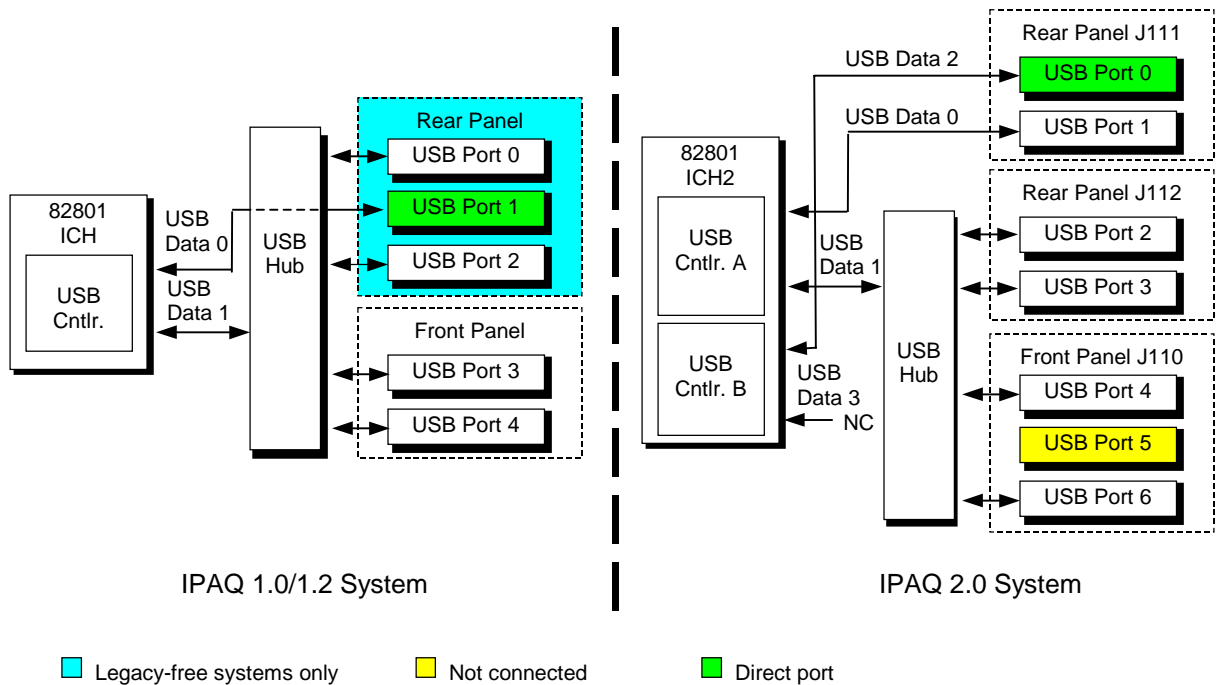
Pin	Signal	Description	Pin	Signal	Description
1	DATA	Data	4	+ 5 VDC	Power
2	NC	Not Connected	5	CLK	Clock
3	GND	Ground	6	NC	Not Connected

## 5.7 UNIVERSAL SERIAL BUS INTERFACE

The Universal Serial Bus (USB) interface provides USB 1.1-compliant asynchronous/isochronous data transfers of up to 12 Mb/s. This high-speed interface supports hot-plugging of compatible devices, making possible system configuration changes without powering down or even rebooting systems. The USB uses a tiered scheme for connecting multiple devices. A USB device may be connected directly to the computer's USB port or daisy-chained off another USB device connected to the computer. Up to 127 USB devices may be connected (tiered) to the host (computer).

**NOTE:** It is recommended to run the Windows 98 (or later) operating system when using USB peripherals, **especially a USB keyboard and USB mouse**. Problems may be encountered when using USB devices with a system running Windows 95, although some peripherals may operate satisfactorily.

As shown in Figure 5-8, USB interfacing is provided by the 82801 ICH or ICH2 component and a TPS2054 or TUS2046B hub component.



**Figure 5-8.** USB I/F, Block Diagram

Legacy-free iPAQ 1.0/1.2 and all iPAQ 2.0 systems provide both direct-controller and through-hub USB connections for USB peripherals. For maximum efficiency, direct-controller ports should be reserved for connection with a high-data throughput device such as a digital camera or CD. On iPAQ 2.0 systems, USB port 0 (upper left as viewed from rear) is a dedicated-direct port that assures full speed operation with a USB device. Through-hub ports can efficiently handle multiple (daisy-chained) devices such as a keyboard and mouse that require only intermittent or low capacity data.



### 5.7.1 USB DATA FORMATS

The USB I/F uses non-return-to-zero inverted (NRZI) encoding for data transmissions, in which a 1 is represented by no change (between bit times) in signal level and a 0 is represented by a change in signal level. Bit stuffing is employed prior to NRZI encoding so that in the event a string of 1's is transmitted (normally resulting in a steady signal level) a 0 is inserted after every six consecutive 1's to ensure adequate signal transitions in the data stream.

The USB transmissions consist of packets using one of four types of formats (Figure 5-9) that include two or more of seven field types.

- ◆ Sync Field – 8-bit field that starts every packet and is used by the receiver to align the incoming signal with the local clock.
- ◆ Packet Identifier (PID) Field – 8-bit field sent with every packet to identify the attributes (in, out, start-of-frame (SOF), setup, data, acknowledge, stall, preamble) and the degree of error correction to be applied.
- ◆ Address and Endpint Fields – 7- and 4-bit fields (respectively) that provide source/destination information required in token packets.
- ◆ Frame Field – 11-bit field sent in Start-of-Frame (SOF) packets that are incremented by the host and sent only at the start of each frame.
- ◆ Data Field – 0-1023-byte field of data.
- ◆ Cyclic Redundancy Check (CRC) Field – 5- or 16-bit field used to check transmission integrity.

Token Packet	Sync Field (8 bits)	PID Field (8 bits)	Addr. Field (7 bits)	ENDP. Field (4 bits)	CRC Field (5 bits)	
SOF Packet	Sync Field (8 bits)	PID Field (8 bits)	Frame Field (11 bits)		CRC Field (5 bits)	
Data Packet	Sync Field (8 bits)	PID Field (8 bits)	Data Field (0-1023 bytes)			CRC Field (16 bits)
Handshake Packet	Sync Field (8 bits)	PID Field (8 bits)				

**Figure 5-9.** USB Packet Formats

Data is transferred LSb first. A cyclic redundancy check (CRC) is applied to all packets (except a handshake packet). A packet causing a CRC error is generally completely ignored by the receiver.

## 5.7.2 USB PROGRAMMING

Programming the USB interface consists of configuration, which typically occurs during POST, and control, which occurs at runtime. The USB interface may be inhibited (through Setup) on legacy systems for security purposes.

### 5.7.2.1 USB Configuration

The USB interface functions as a PCI device (31) within the 82801 component (function 2) and is configured using PCI Configuration Registers as listed in Table 5-15.

**Table 5-15.**  
USB Interface Configuration Registers

PCI Config. Addr.	Register	Reset Value	PCI Config. Addr.	Register	Reset Value
00, 01h	Vender ID	8086h	0Dh	Latency Timer	00h
02, 03h	Device ID	[1]	0Eh	Header Type	00h
04, 05h	PCI Command	0000h	20-23h	I/O Space Base Address	1h
06, 07h	PCI Status	0280h	3Ch	Interrupt Line	00h
08h	Revision ID	00h	3Dh	Interrupt Pin	04h
09h	Programming I/F	00h	60h	Miscellaneous Control 1	10h
0Ah	Sub Class Code	03h	C0, C1h	Miscellaneous Control 2	2000h
0Bh	Base Class Code	0Ch	C4h	USB Resume Enable	00h

NOTE:

[1] 2412h = USB controller A, 2444h = USB controller B

### 5.7.2.2 USB Control

The USB is controlled through I/O registers as listed in table 5-16.

**Table 5-16.**  
USB Control Registers

I/O Addr.	Register	Default Value
00, 01h	Command	0000h
02, 03h	Status	0000h
04, 05h	Interupt Enable	0000h
06, 07	Frame Number	0000h
08, 0B	Frame List Base Address	0000h
0Ch	Start of Frame Modify	40h
10, 11h	Port 1 Status/Control	0080h
12, 13h	Port 2 Status/Control	0080h
18h	Test Data	00h

### 5.7.3 USB CONNECTOR

The USB ports use series-A connectors.

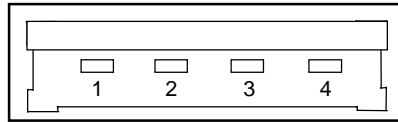


Figure 5-10. Universal Serial Bus Connector

**Table 5-17.**  
USB Connector Pinout

Pin	Signal	Description	Pin	Signal	Description
1	Vcc	+5 VDC	3	USB+	Data (plus)
2	USB-	Data (minus)	4	GND	Ground

### 5.7.4 USB CABLE DATA

The recommended cable length between the host and the USB device should be no longer than sixteen feet for full-channel (12 MB/s) operation, depending on cable specification (see following table).

**Table 5-18.**  
USB Cable Length Data

Conductor Size	Resistance	Maximum Length
20 AWG	0.036 $\Omega$	16.4 ft (5.00 m)
22 AWG	0.057 $\Omega$	9.94 ft (3.03 m)
24 AWG	0.091 $\Omega$	6.82 ft (2.08 m)
26 AWG	0.145 $\Omega$	4.30 ft (1.31 m)
28 AWG	0.232 $\Omega$	2.66 ft (0.81 m)

**NOTE:**

For sub-channel (1.5 MB/s) operation and/or when using sub-standard cable shorter lengths may be allowable and/or necessary.

The shield, chassis ground, and power ground should be tied together at the host end but left unconnected at the device end to avoid ground loops.

Color code:

Signal	Insulation color
Data +	Green
Data -	White
Vcc	Red
Ground	Black

## 5.8 AUDIO SUBSYSTEM

A PCI audio subsystem is integrated onto the system board of the Compaq iPAQ. Implementing AC'97 design guidelines, the audio subsystem is designed to provide optimum sound. Key features of the audio subsystem include:

- ◆ AC'97 ver. 2.1 compliance
- ◆ Multiple audio channel streaming
- ◆ Soft CD, DVD/AC-3 processing
- ◆ Wavetable synthesis utilizing system memory
- ◆ Acoustic echo cancellation
- ◆ 16-bit stereo PCM input and output w/ up to 48 KHz sampling

### 5.8.1 FUNCTIONAL ANALYSIS

A block diagram of the audio subsystem is shown in Figure 5-11. The architecture uses the AC'97 Audio Controller of the 82801 component to access and control an Analog Devices AD188x Audio Codec, which provides the analog-to-digital (ADC) and digital-to-analog (DAC) conversions as well as the mixing functions.

All control functions such as volume, audio source selection, and sampling rate are controlled through software over the PCI bus through the AC97 Audio Controller of the 82801 ICH. Control data and digital audio streams (record and playback) are transferred between the Audio Controller and the Audio Codec over the AC97 Link Bus. Playback audio from the Audio Codec is routed to a low-distortion mono amplifier that drives a long-excursion large-magnet speaker for optimum sound.

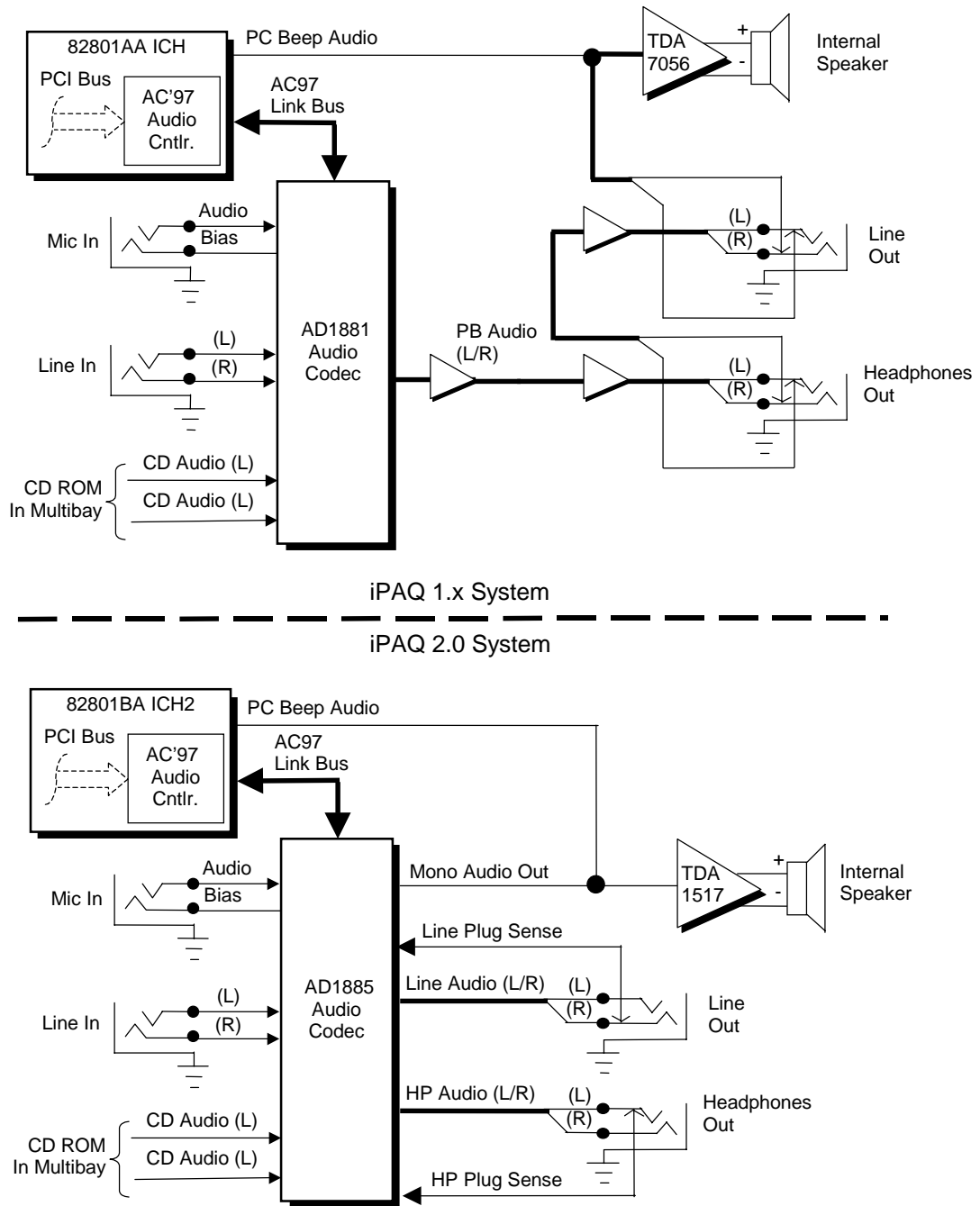
The analog interfaces allowing connection to external audio devices are discussed in the following paragraphs.

**Mic In** - This front panel-accessible input uses a three-conductor (stereo) mini-jack that is specifically designed for connection of a condenser microphone with an impedance of 10-K ohms. This is the default recording input after a system reset.

**Line In** - This input uses a three-conductor (stereo) mini-jack that is specifically designed for connection of a high-impedance (10k-ohm) audio source such as a tape deck or audio CD player.

**Headphones Out** - This front panel-accessible input uses a three-conductor (stereo) mini-jack that is specifically designed for connecting a set of 16-ohm (nom.) stereo headphones. Plugging into the Headphones jack mutes the signal to the internal speaker and the Line Out jack.

**Line Out** - This output uses a three-conductor (stereo) mini-jack for connecting left and right channel line-level signals (20-K ohm impedance). A typical connection would be to a tape recorder's Line In (Record In) jacks, an amplifier's Line In jacks, or to "powered" speakers that contain amplifiers. Plugging into the Line Out mutes the internal speaker.



**Figure 5-11.** Audio Subsystem Functional Block Diagram

The functionality of the iPAQ 1.x and iPAQ 2.0 audio systems is basically the same. The method of muting the internal speaker with insertion of a Line In or Headphone plug differs between the two codec types (mechanical (AD1881) versus logic (AD1885)) and the iPAQ 2.0 features an 8-watt speaker amplifier versus the 5-watt amplifier of the iPAQ 1.x.

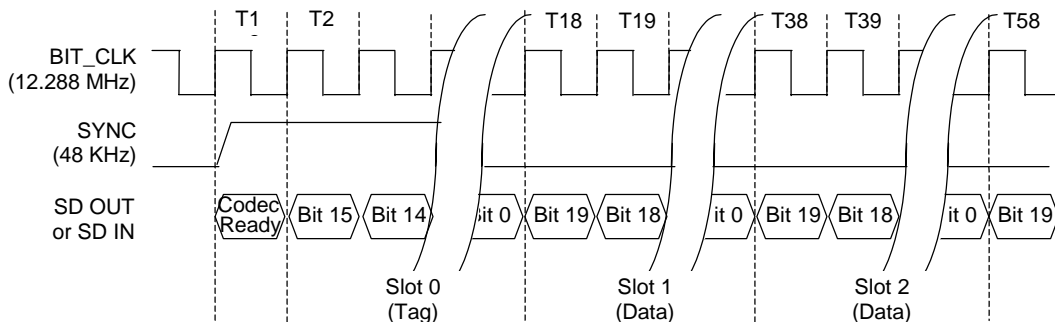
## 5.8.2 AC97 AUDIO CONTROLLER

The AC97 Audio Controller is a PCI device (device 31/function 5) that is integrated into the 82801 ICH component and supports the following functions:

- ◆ Read/write access to audio codec registers
- ◆ 16-bit stereo PCM input and output @ up to 48 KHz sampling
- ◆ Acoustic echo correction for microphone
- ◆ AC'97 Link Bus
- ◆ ACPI power management

## 5.8.3 AC97 LINK BUS

The audio controller and the audio codec communicate over a five-signal AC97 Link Bus (Figure 5-12). The AC97 Link Bus includes two serial data lines (SD OUT/SD IN) that transfer control and PCM audio data serially to and from the audio codec using a time-division multiplexed (TDM) protocol. The data lines are qualified by a 12.288 MHz BIT\_CLK signal driven by the audio codec. Data is transferred in frames synchronized by the 48-KHz SYNC signal, which is derived from the clock signal and driven by the audio controller. The SYNC signal is high during the frame's tag phase then falls during T17 and remains low during the data phase. A frame consists of one 16-bit tag slot followed by twelve 20-bit data slots. When asserted (typically during a power cycle), the RESET- signal (not shown) will reset all audio registers to their default values.



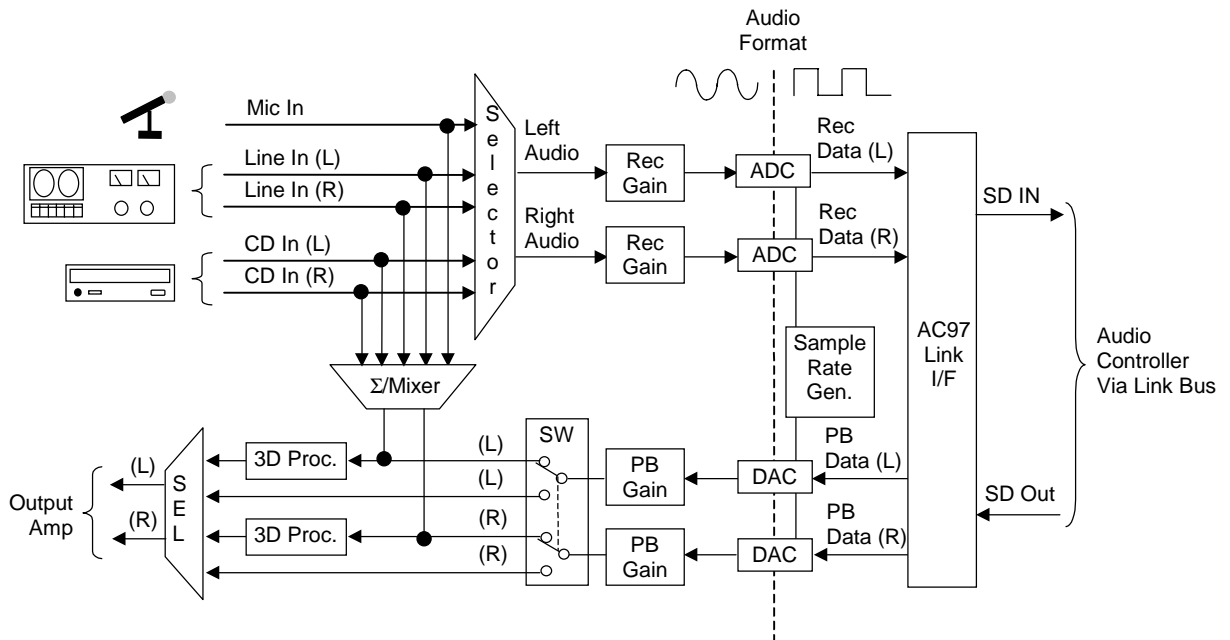
Slot	Description
0	Bit 15, Frame valid bit; Bits 14-3, Slots 1-12; valid bits; Bits 2-0, Codec ID
1	Command address: Bit 19, R/W; Bits 18..12, reg. Index; Bits 11..0, reserved.
2	Command data
3	Bits 19-4: PCM audio data, left channel (SD OUT, playback; SD IN, record) Bits 3-0 all zeros
4	Bits 19-4: PCM audio data, right channel (SD OUT, playback; SD IN, record) Bits 3-0 all zeros
5	Modem codec data (not used in this system)
6-11	Reserved
12	I/O control

Figure 5-12. AC'97 Link Bus Protocol

### 5.8.4 AUDIO CODEC

The audio codec provides pulse code modulation (PCM) coding and decoding of audio information as well as the selection and/or mixing of analog channels. As shown in Figure 5-13, analog audio from a microphone, tape, or CD can be selected and, if to be recorded (saved) onto a disk drive, routed through an analog-to-digital converter (ADC). The resulting left and right PCM record data are muxed into a time-division-multiplexed (TDM) data stream (SD IN signal) that is routed to the audio controller. Playback (PB) audio takes the reverse path from the audio controller to the audio codec as SD OUT data and is decoded and processed by the digital-to-analog converter (DAC). The codec supports simultaneous record and playback of stereo (left and right) audio. The Sample Rate Generator may be set for sampling frequencies up to 48 KHz.

Analog audio may then be routed through 3D stereo enhancement processor or bypassed to the output selector (SEL). The integrated analog mixer provides the computer control-console functionality handling multiple audio inputs.



**Figure 5-13.** AD1881 or AD1885 Audio Codec Functional Block Diagram

All inputs and outputs are two-channel stereo except for the microphone input, which is inputted as a single-channel but mixed internally onto both left and right channels. The microphone input is the default active input. All block functions are controlled through index-addressed registers of the codec.

## 5.8.5 AUDIO PROGRAMMING

Audio subsystem programming consists configuration, typically accomplished during POST, and control, which occurs during runtime. The register maps are described in the following subsections.

### 5.8.5.1 Audio Configuration

The audio subsystem is configured according to PCI protocol through the AC'97 audio controller function of the 82801 ICH. Table 5-19 lists the PCI configuration registers of the audio subsystem.

**Table 5-19.**  
AC'97 Audio Controller  
PCI Configuration Registers (82801 Device 31/Function 5)

PCI Addr.	Register	Reset Value	PCI Addr.	Register	Reset Value
00-01h	Vender ID	8086h	14-17h	Native Audio Bus Mstr. Addr.	1h
02-03h	Device ID	[1]	18-1Bh	Reserved	1h
04-05h	PCI Command	0000h	1C-2Bh	Reserved	1h
06-07h	PCI Status	0280h	2C-2Dh	Subsystem Vender ID	0000h
08h	Revision ID	xxh	2E-2Fh	Subsystem ID	0000h
09h	Programming	01h	30-3Bh	Reserved	0's
0Ah	Sub-Class	01h	3Ch	Interrupt Line	00h
0Bh	Base Class Code	04h	3Dh	Interrupt Pin	03h
0Eh	Header Type	00h	3E-FFh	Reserved	0's
10-13h	Nat. Audio Mixer Base Addr.	1h	--	--	--

NOTE:

[1] 2415h = 82801AA ICH, 2445h = 82801BA ICH2.

### 5.8.5.2 Audio Control

The audio subsystem is controlled through a set of indexed registers that physically reside in the audio codec . The register addresses are decoded by the audio controller and forwarded to the audio codec over the AC97 Link Bus previously described. The audio codec's control registers (Table 5-20) are mapped into 64 kilobytes of variable I/O space.

**Table 5-20.**  
AC'97 Audio Codec Control Registers

Offset Addr. / Register	Value On Reset	Offset Addr. / Register	Value On Reset	Offset Addr. / Register	Value On Reset
00h Reset	0100h	14h Video Vol.	8808h	28h Ext. Audio ID.	0001h
02h Master Vol.	8000h	16h Aux Vol.	8808h	2Ah Ext. Audio Ctrl/Sts	0000h
04h Reserved	X	18h PCM Out Vol.	8808h	2Ch PCM DAC SRate	BB80h
06h Mono Mstr. Vol.	8000h	1Ah Record Sel.	0000h	32h PCM ADC SRate	BB80h
08h Reserved	X	1Ch Record Gain	8000h	34h Reserved	X
0Ah PC Beep Vol.	8000h	1Eh Reserved	X	72h Reserved	X
0Ch Phone In Vol.	8008h	20h Gen. Purpose	0000h	74h Serial Config.	7x0xh
0Eh Mic Vol.	8008h	22h 3D Control	0000h	76h Misc. Control Bits	0404h
10h Line In Vol.	8808h	24h Reserved	X	7Ch Vender ID1	4144h
12h CD Vol.	8808h	26h Pwr Mgmt.	000xh	7Eh Vender ID2	5340h



## 5.8.6 AUDIO SPECIFICATIONS

The specifications of the audio subsystem are listed in Table 5-21.

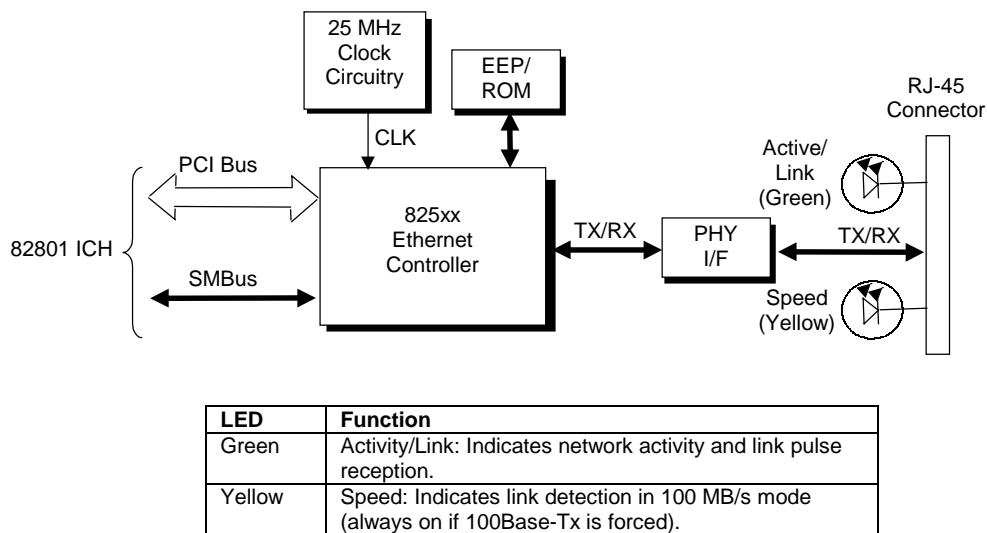
**Table 5-21.**  
Audio Subsystem Specifications

Parameter	Measurement
Sampling Rate	7.04 KHz to 48 KHz
Resolution	16-bit (1 Hz)
Nominal Input Voltage:	
Mic In (w/+20 db gain)	.283 Vp-p
Line In	2.83 Vp-p
Impedance:	
Mic In	1 K ohms (nom)
Line In	10 K ohms (min)
Line Out	800 ohms
Signal-to-Noise Ratio (Line in to Line Out)	90 dB (min)
Max. Power To Speaker (8 ohms):	
iPAQ 1.x	5.2 watts
iPAQ 2.0	8.0 watts
Total Harmonic Distortion (THD) to speaker:	
@ 0.5 watts	1 %
@ max. power output	10 %
Headphone Output Power (into 32 ohms)	60 mW
Input Gain Attenuation Range	46.5 dB
Master Volume Range	-94.5 dB
Frequency Response:	
Codec	20-20 KHz
Speaker	450 - 4000 Hz

## 5.9 NETWORK INTERFACE CONTROLLER

All Compaq iPAQ systems include a network interface controller (NIC) on the system board supported by an RJ-45 connector with two LED indicators. The iPAQ 1.x system uses an 82559 Ethernet Controller component while the iPAQ 2.0 system uses equivalent logic integrated into the ICH2 component. The following discussion applies to both systems, which are functionally the same.

The NIC supports speeds of 10 and 100 Mbps in half- or full-duplex modes, and provides IEEE 802.3u auto-negotiation. Half-duplex operation features an Intel-proprietary collision reduction mechanism while full-duplex operation follows the IEEE 802.3x flow control specification. Transmit and receive FIFOs of 3 kilobytes each reduce the chance of overrun while waiting for bus access.



**Figure 5-14.** Network Interface Controller Block Diagram

The Intel 825xx Ethernet Controller includes the following features:

- ◆ Intel 82559 Fast Ethernet controller with 32-bit architecture and 3-KB TX/RX buffers.
- ◆ Dual-mode support with auto-switching between 10BASE-T and 100BASE-TX.
- ◆ Power down and Wake up support in both APM and ACPI environments (PME- and WOL).
- ◆ Alert-on-LAN (AOL v1.0) support.
- ◆ Dual control (PCI and SM bus interfaces).
- ◆ Link and Activity LED indicator drivers

The 825xx controller features high and low priority queues and provides priority-packet (Quality of Service or “QOS”) processing for networks that can support that feature. The controller’s micro-machine processes transmit and receive frames independently and concurrently. Receive runt (under-sized) frames are not passed on as faulty data but discarded by the controller, which also directly handles such errors as collision detection or data under-run. Identification, configuration and connection parameters are held in an EEPROM.

The NIC uses 3.3 VDC auxiliary power, which allows the 825xx controller to support Wake-On-LAN (WOL) and Alert-On-LAN (AOL) functions while the main system is powered down.



**NOTE:** For the WOL and AOL features to function as described in the following paragraphs, the system unit must be plugged into a live AC outlet to allow the power supply to produce the 3.3 VDC auxiliary voltage. Controlling unit power through a switchable power strip will, with the strip turned off, disable WOL and AOL functionality.

### 5.9.1 WAKE ON LAN

The NIC supports the Wired-for-Management (WfM) standard of Wake-On-LAN (WOL) that allows the system to be booted up from a powered down condition upon the detection of special packets received over a network. Magic Packet wakeup is supported in S5 (off), S4, S3, and S1 states. Pattern Match wakeup is supported in S4, S3, and S1 states. A detected packet will result in the NIC asserting the PCI bus signal PME-, which is used by the chipset to initiate the wakeup sequence.

### 5.9.2 ALERT ON LAN

Alert-On-LAN (AOL) support allows the NIC to communicate the occurrence of certain events over a network even while the system unit is powered off. In a system-off (powered down) condition the 82801 ICH and the 825xx NIC components receive auxiliary +3.3 VDC power (derived from the +5 VDC auxiliary power from the power supply assembly). Certain events (listed in Table 5-22) detected by the 82801 ICH will result in the ICH generating an alert message over the SMBus to the NIC. Upon receiving the alert message from the ICH the NIC transmits the appropriate pre-constructed message over the network to a system management console.

Reportable AOL events are listed in the following table:

**Table 5-22.**  
AOL Events

Event	Description
BIOS Failure	System fails to boot successfully.
OS Problem	System fails to load operating system after POST.
Missing/Faulty Processor	Processor fails to fetch first instruction.
Thermal Condition	Thermal ASIC reports high temperature.
Heartbeat	Indication of system's network presence (sent approximately every 30 seconds in normal operation).

The AOL implementation requirements are as follows:

1. Intel PRO/100+ Management Adapter driver (v3.1x for iPAQ 1.x, v3.8 for iPAQ 2.0) or later (available from Compaq).
2. Client-side utility agent software and utilities (available from Compaq).
3. Management console running one of the following:
  - a. HP OpenView Network Node Manager 6.x
  - b. Intel LANDesk Client Manager
  - c. Compaq Insight Manager

## 5.9.3 POWER MANAGEMENT SUPPORT

The 825xx controller features Wired-for-Management (WfM) support providing system wake up from network events (WOL) as well as generating system status messages (AOL) and supports both APM and ACPI power management environments. The controller receives 3.3 VDC (auxiliary) power as long as the system is plugged into a live AC receptacle, allowing support of wake-up events occurring over a network while the system is powered down or in a low-power state.

### 5.9.3.1 APM Environment

The Advanced Power Management (APM) functionality of system wake up is implemented through the system's APM-compliant BIOS and the controller's Magic Packet-compliant hardware. This environment bypasses operating system (OS) intervention allowing a plugged in unit to be turned on remotely over the network (i.e., "remote wake up"). In APM mode the controller, will respond upon receiving a Magic Packet, which is a packet where the node's address is repeated 16 times. Upon Magic packet detection, the controller initiates the boot sequence.

### 5.9.3.2 ACPI Environment

The Advanced Configuration and Power Interface (ACPI) functionality of system wake up is implemented through an ACPI-compliant OS **and is the default power management mode**. The following wakeup events may be individually enabled/disabled through the supplied software driver:

- ◆ Magic Packet – Packet with node address repeated 16 times in data portion



**NOTE:** The following functions are supported in NDIS5 drivers but implemented through remote management software applications (such as LanDesk).

---

- ◆ Individual address match – Packet with matching user-defined byte mask
- ◆ Multicast address match – Packet with matching user-defined sample frame
- ◆ ARP (address resolution protocol) packet
- ◆ Flexible packet filtering – Packets that match defined CRC signature

## 5.9.4 NIC PROGRAMMING

Programming the NIC controller consists of configuration, which occurs during POST, and control, which occurs at runtime.

### 5.9.4.1 Configuration

The 825xx controller is a PCI device and configured though PCI configuration space registers using PCI protocol described in chapter 4. The PCI configuration registers are listed in the following table:

**Table 5-23.**  
NIC Controller PCI Configuration Registers

PCI Addr.	Register	Reset Value	PCI Addr.	Register	Reset Value
00-01h	Vender ID	8086h	10-13h	Cntrl. Reg. Base Addr. (Mem)	0000h
02-03h	Device ID	[1]	14-17h	Cntrl. Reg. Base Addr. (I/O)	00h
04-05h	PCI Command	0000h	18-1Bh	Flash Mem. Base Addr.	00h
06-07h	PCI Status	0280h	2C-2Dh	Subsystem Vender ID	
08h	Revision ID	xxh	2E-2Fh	Subsystem ID	
09-0Bh	Class Code	01h	30-33h	Expansion ROM Base Addr.	
0Ch	Cache Line Size	01h	34h	Capabilities Pointer	DCh
0Dh	Latency Timer	04h	3C-3D	Interrupt Line/Pin	
0Eh	Header Type	00h	3E-3Fh	Min Gnt/Max Lat	
0Fh	BIST	00h	DC-E3h	Power Mgmt. Functions	

NOTE:

Assume unmarked gaps are reserved and/or not used.

[1] iPAQ 1.x = 1229h (Function 0, Device #2); iPAQ 2.0 = 2449h (Function 0, Device # 8).

### 5.9.4.2 Control

The 82559 controller is controlled though registers that may be mapped in system memory space or variable I/O space. The registers are listed in the following table:

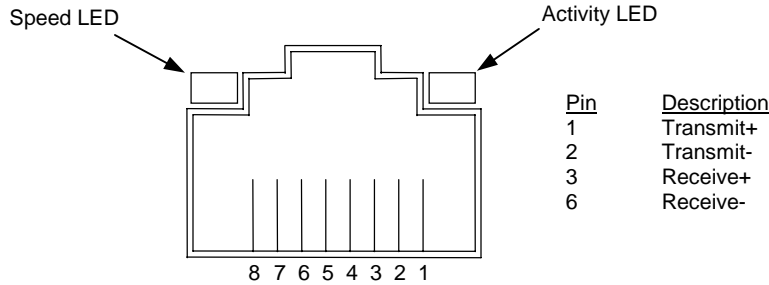
**Table 5-24.**  
NIC Control Registers

Offset Addr. / Register	No. of Bytes	Offset Addr. / Register	No. of Bytes
00h SCB Status	2	19h Flow Control Register	2
02h SCB Command	2	1Bh PMDR	1
04h SCB General Pointer	4	1Ch General Control	1
08h PORT	4	1Dh General Status	1
0Ch Flash Control Reg.	2	1E-2Fh Reserved	10
0Eh EEPROM Control Reg.	2	30h Function Event Register	4
10h Mgmt. Data I/F Cntrl. Reg.	4	34h Function Event Mask Register	4
14h Rx Direct Mem. Access Byte Cnt.	4	38h Function Present State Register	4
18h Early Receive Interrupt	1	20h Force Event Register	4

■ Not implemented in these systems (CardBus registers).

### 5.9.4.3 RJ-45 Connector

Figure 5-15 shows the RJ-45 connector used for the NIC interface. This connector includes the two status LEDs as part of the connector assembly.



**Figure 5-15.** Ethernet TPE Connector (RJ-45, viewed from card edge)

### 5.9.4.4 825xx NIC Specifications

**Table 5-25.**  
825xx NIC Specifications

Parameter	
Modes Supported	10BASE-T half duplex @ 10 MB/s 10Base-T full duplex @ 20 MB/s 100BASE-TX half duplex @ 100 MB/s 100Base-TX full duplex @ 200 MB/s
Standards Compliance	IEEE VLAN (802.1A) IEEE 802.2 IEEE 802.3 & 802.3u IEEE Intel priority packet (801.1p)
OS Driver Support	MS Windows 95,98, 2000, Me MS Windows NT 3.51 & 4.0 Novell Netware 3.11, 3.12, & 4.1x; 5 Server Sunsoft Solaris SCO UnixWare Open Desktop OpenServer
Boot ROM Support	Intel PRO/100 Boot Agent (PXE 2.0, RPL)
F12 BIOS Support	Yes
Bus Interface	PCI 2.2
Power Management Support	APM, ACPI, PCI Power Management Spec.

## Chapter 6

# GRAPHICS SUBSYSTEM

### 6.1 INTRODUCTION

All Compaq iPAQ systems feature a graphics controller that is integrated into the chipset's GMCH component. This "Direct AGP" graphics solution provides efficient, economical 2D/3D performance.

This chapter covers the following subjects:

- ◆ Functional description (6.2)                      page 6-2
- ◆ Programming (6.3)                                page 6-5
- ◆ Monitor power management (6.4)            page 6-5
- ◆ Monitor connector (6.5)                        page 6-6
- ◆ Upgrading graphics (6.6)                      page 6-6

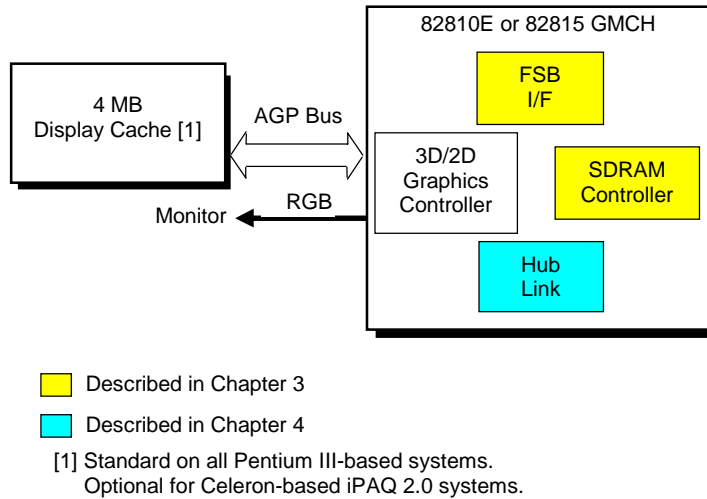
#### 6.1.1 FEATURE SUMMARY

The graphics subsystem includes the following features:

- ◆ Accelerated driver support for Windows 3.1/95/98/2000, Windows NT 4.0, OS/2
- ◆ MS ActiveMovie and Media Player support for Win95
- ◆ Direct 3D support
- ◆ MS Direct Draw 5/6 support
- ◆ DDC2B compliant
- ◆ Accelerator engine support for:
  - 3-ROP BitBLT
  - Line Draw
  - Color expansion
  - Video color conversion/scaling
  - Motion video
  - Triangle setup
- ◆ 4-MB Display Cache standard on Pentium III-based systems

## 6.2 FUNCTIONAL DESCRIPTION

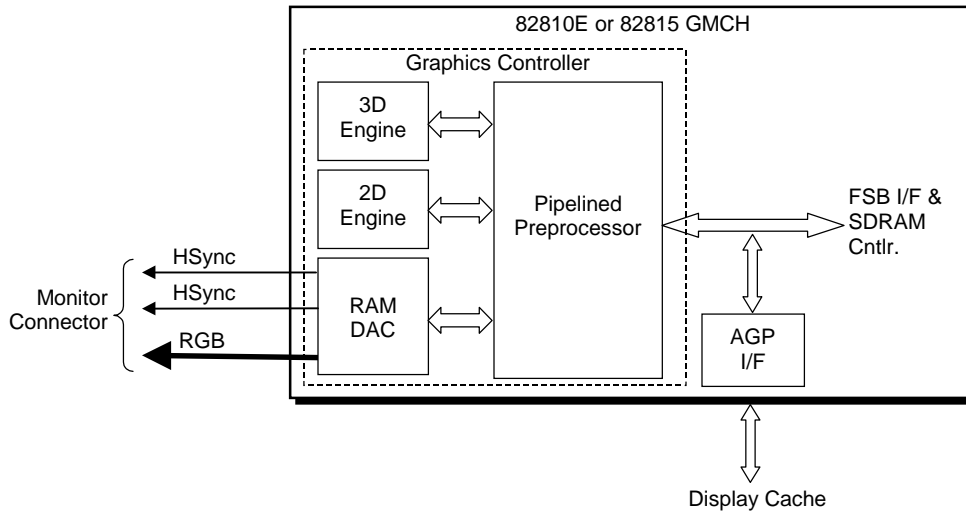
The Intel 810E and 815E chipsets integrate the graphics controller into their GMCH component (Figure 6-1). The graphics controller includes 2D and 3D accelerator engines working with a deeply pipelined pre-processor. The controller supports perspective-correct texture mapping, bilinear and anisotropic Mip-mapping, Alpha blending, Gouraud shading, and fogging.



**Figure 6-1.** Graphics Subsystem, Block diagram

The graphics controller uses a portion of system memory for instructions, textures, and frame (display) buffering. Using a process called Dynamic Video Memory Technology (DVMT), the controller dynamically allocates display and texture memory amounts according to the needs of the application. Pentium III-based systems also include four megabytes of Display Cache that can be used for Z-buffering.





**Figure 6-2.** GMCH Integrated Graphics Subsystem

The integrated graphics controller includes special enhancements for 2D operations. Motion compensation logic is included to improve performance during software decoding of MPEG2 video. Hardware cursor and overlay engines relieve software processing and provide independent gamma correction, saturation, and brightness control. The 230-MHz RAMDAC can support a variable-scan rate monitor up to a maximum resolution of 1600 x 1200 with 256 colors. Video BIOS for the controller is held in the system BIOS ROM and copied into system memory at runtime for maximum performance.

On Pentium III-based systems, four megabytes of display cache is included that enhances 2D and 3D performance up to 30%. The local display cache allows the graphics controller to simultaneously render graphics to the Z-buffer (in the display cache) while processing textures in a portion of system memory, increasing 3D performance substantially. The integrated graphics controller uses a specific amount of system memory. This memory is allocated as follows:

**Video BIOS** – 512 or 1024 kilobytes. An OS report of available system memory will be the total amount installed LESS this amount.

**Graphics Memory** – Prior to the PV 4.x driver being loaded, the graphics memory will be one megabyte for supporting standard VGA modes. After driver load, memory allocation will be set by the Dynamic Video Memory Technology (DVMT) for rendering, Z-buffering, and displaying according to need and total system memory availability. The following table indicates the amount of memory allocated depending on operating system and memory availability.

OS Type and Sys. Mem. Amount	Total Graphics Memory w/o 4-MB Display Cache	Total Graphics Memory w/ 4-MB Display Cache
Windows 98 w/32 MB	6 MB	9 MB
Windows 98 w/64 MB	10 MB	12 MB
Windows 98 w/128 MB	10 MB	12 MB
Windows NT 4.0 w/64 MB	9 MB	12 MB
Windows NT 4.0 w/128 MB	9 MB	12 MB
Windows 2000 w/64 MB	9 MB	12 MB
Windows 2000 w/128 MB	10 MB	12 MB

## 6.2.1 DISPLAY MODES

The Intel graphics controller supports the following 2D display modes:

**Table 6-1.**  
Graphics Display Modes

Resolution	Bits per pixel	Color Depth	Refresh Rate
640 x 480	8	256	60, 70, 72, 75, 85
640 x 480	16	65K	60, 70, 72, 75, 85
640 x 480	24	16.7M	60, 70, 72, 75, 85
720 x 480	8	256	75, 85
720 x 480	16	65K	75, 85
720 x 480	24	16.7M	75, 85
720 x 576	8	256	60, 75, 85
720 x 576	16	65K	60, 75, 85
720 x 576	24	16.7M	60, 75, 85
800 x 600	8	256	60, 70, 72, 75, 85
800 x 600	16	65K	60, 70, 72, 75, 85
800 x 600	24	16.7M	60, 70, 72, 75, 85
1024 x 768	8	256	60, 70, 72, 75, 85
1024 x 768	16	65K	60, 70, 72, 75, 85
1024 x 768	24	16.7M	60, 70, 72, 75, 85
1152 x 864	8	256	60, 70, 72, 75, 85
1152 x 864	16	65K	60, 70, 72, 75, 85
1152 x 864 [1]	24	16.7M	60, 70, 72, 75, 85
1280 x 720	8	256	60, 75, 85
1280 x 720	16	65K	60, 75, 85
1280 x 720 [1]	24	16.7M	60, 75, 85
1280 x 960	8	256	60, 75, 85
1280 x 960	16	65K	60, 75, 85
1280 x 960 [1]	24	16.7M	60, 75, 85
1280 x 1024	8	256	60, 70, 72, 75, 85
1280 x 1024	16	65K	60, 70, 72, 75, 85
1280 x 1024 [1]	24	16.7M	60, 70, 75, 85
1600 x 900	8	256	60, 75, 85
1600 x 900	16	65K	60, 75, 85
1600 x 1200	8	256	75

NOTE:

[1] True color (24-bpp) mode support requires the 4-MB Display Cache.

### 6.3 PROGRAMMING

The graphics controller is configured as a PCI device using PCI configuration registers listed in Table 6-2.

**Table 6-2.**  
Graphics Controller PCI Configuration Registers  
(GMCH, Device 2)

PCI Config. Addr.	Register	Reset Value	PCI Config. Addr.	Register	Reset Value
00, 01h	Vendor ID	8086h	2E, 2Fh	Subsystem ID	0000h
02, 03h	Device ID	[1]	30-33h	Vid. BIOS Base Addr.	0's
04, 05h	Command	0004h	34h	Capabilities Pointer	DCh
06, 07h	Status	02B0h	3Ch	Interrupt Line	00h
08h	Revision ID	02h	3Dh	Interrupt Pin	01h
0A, 0Bh	Class Code	0003h	3Eh	Min. Grant	00h
0Eh	Header Type	01h	3Fh	Max. Latency	00h
0Fh	BIST	00h	DC, DDh	Pwr. Mgmt. Capabilities	0001h
10-13h	Memory Range Addr.	8	DE, DFh	Pwr. Mgmt. Capabilities	0022h
14-17h	Mem. Mapped Range Addr.	0's	E0, E1h	Pwr. Mgmt. Control	0000h
2C, 2Dh	Subsys. Vendor ID	0000h	E2-FFh	Reserved	--

**NOTES:**

Assume unmarked locations/gaps as reserved. Refer to Intel documentation for detailed register descriptions.

[1] iPAQ 1.0/1.2 (82810E) = 2502h; iPAQ 2.0 (82815) = 1132h

The graphics controller is controlled through memory-mapped registers by the appropriate software driver.

### 6.4 MONITOR POWER MANAGEMENT CONTROL

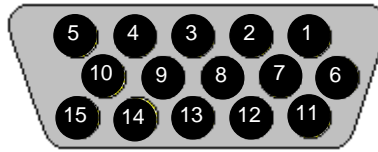
The controller provides monitor power control for monitors that conform to the VESA display power management signaling (DPMS) protocol. This protocol defines different power consumption conditions and uses the HSYNC and VSYNC signals to select a monitor's power condition. Table 6-3 lists the monitor power conditions.

**Table 6-3.**  
Monitor Power Management Conditions

HSYNC	VSYNC	Power Mode	Description
Active	Active	On	Monitor is completely powered up. If activated, the inactivity counter counts down during system inactivity and if allowed to timeout, generates an SMI to initiate the Suspend mode.
Active	Inactive	Suspend	Monitor's high voltage section is turned off and CRT heater (filament) voltage is reduced from 6.6 to 4.4 VDC. The Off mode inactivity timer counts down from the preset value and if allowed to timeout, another SMI is generated and serviced, resulting in the monitor being placed into the Off mode. Wake up from Suspend mode is typically a few seconds.
Inactive	Inactive	Off	Monitor's high voltage section and heater circuitry is turned off. Wake up from Off mode is a little longer than from Suspend.

## 6.5 MONITOR CONNECTOR

A DB-15 connector is provided on the rear chassis for connection to an analog monitor. The pinout for this connector is shown in Figure 6-3 and Table 6-5.



**Figure 6-3.** VGA Monitor Connector, (Female DB-15, as viewed from rear).

**Table 6-5.**  
DB-15 Monitor Connector Pinout

Pin	Signal	Description	Pin	Signal	Description
1	R	Red Analog	9	PWR	+5 VDC (fused) [1]
2	G	Blue Analog	10	GND	Ground
3	B	Green Analog	11	NC	Not Connected
4	NC	Not Connected	12	SDA	DDC2-B Data
5	GND	Ground	13	HSync	Horizontal Sync
6	R GND	Red Analog Ground	14	VSynC	Vertical Sync
7	G GND	Blue Analog Ground	15	SCL	DDC2-B Clock
8	B GND	Green Analog Ground	--	--	--

NOTES:

[1] Fuse automatically resets when excessive load is removed.

## 6.6 UPGRADING GRAPHICS

The graphics subsystem of the iPAQ 1.0/1.2 system is not upgradeable. The graphics subsystem of iPAQ 2.0 systems that do not include the 4-MB display cache module (as is the case with Celeron-based systems) may be upgraded by adding the 4-MB display cache module.

# Chapter 7 POWER and SIGNAL DISTRIBUTION

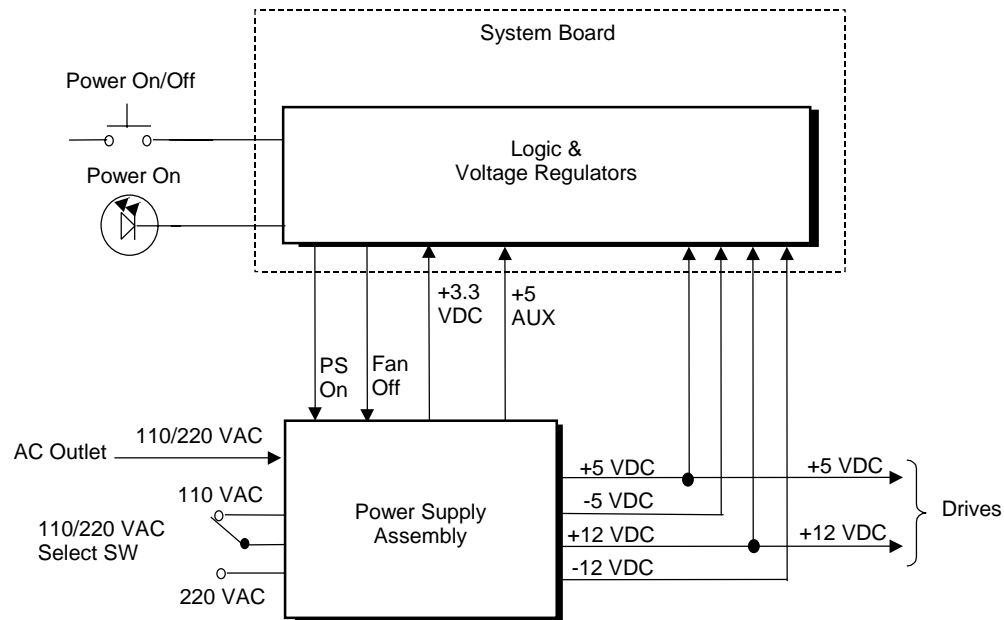
## 7.1 INTRODUCTION

This chapter describes the power supply and method of general power and signal distribution. Topics covered in this chapter include:

- ◆ Power supply assembly/control (7.2) page 7-1
- ◆ Power distribution (7.3) page 7-5
- ◆ Signal distribution (7.4) page 7-7

## 7.2 POWER SUPPLY ASSEMBLY/CONTROL

This system features a power supply assembly that is controlled through programmable logic (Figure 7-1).



**Figure 7-1.** Power Distribution and Control, Block Diagram

## 7.2.1 POWER SUPPLY ASSEMBLY

The power supply assembly is contained in a single unit that features a selectable input voltage: 90-132 VAC and 180-264 VAC. These systems use a 90-watt power supply. The specifications are listed in Tables 7-1 and 7-2.

**Table 7-1.**  
iPAQ 1.x 90-Watt Power Supply Assembly Specifications (P/N 159447)

	Range/ Tolerance	Min. Current Loading [1]	Max. Current	Surge Current [2]	Max. Ripple
Input Line Voltage:					
110 VAC Setting	90 - 132	--	--	--	--
220 VAC Setting	VAC	--	--	--	--
	180-264 VAC				
Line Frequency	47 - 63 Hz	--	--	--	--
Steady State Input (VAC) Current	--	--	3.0 A	--	--
+3.3 VDC Output	+ 5%	0.50 A	6.00 A	6.00 A	50 mV
+5 VDC Output	+ 5%	0.70 A	10.0 A	12.0 A	50 mV
+5 AUX Output	+ 4%	0.00 A	2.50 A	2.50 A	50 mV
+12 VDC Output	+ 5%	0.05 A	1.50 A	3.50 A	120 mV
-12 VDC Output	± 10%	0.00 A	0.30 A	0.30 A	200 mV

## NOTES:

- [1] Minimum loading requirements must be met at all times to ensure normal operation and specification compliance.  
 [2] Surge duration no longer than 10 seconds and +12 tolerance +/- 10%.

**Table 7-1.**  
iPAQ 2.0 90-Watt Power Supply Assembly Specifications (P/N 216922 or 218584 [3])

	Range/ Tolerance	Min. Current Loading [1]	Max. Current	Surge Current [2]	Max. Ripple
Input Line Voltage:					
110 VAC Setting	90 - 132	--	--	--	--
220 VAC Setting	VAC	--	--	--	--
	180-264 VAC				
Line Frequency	47 - 63 Hz	--	--	--	--
Steady State Input (VAC) Current	--	--	3.0 A	--	--
+3.3 VDC Output	+ 5%	0.10 A	6.00 A	6.00 A	50 mV
+5 VDC Output	+ 5%	1.30 A	14.0 A	15.0 A	50 mV
+5 AUX Output	+ 5%	0.00 A	3.00 A	3.00 A	50 mV
+12 VDC Output	+ 5%	0.05 A	1.50 A	3.00 A	120 mV
-12 VDC Output	± 10%	0.00 A	0.20 A	0.20 A	200 mV

## NOTES:

- [1] Minimum loading requirements must be met at all times to ensure normal operation and specification compliance.  
 [2] Surge duration no longer than 10 seconds and +12 VDC tolerance ± 10%.  
 [3] P/N 216922 is non-power factor correction (PFC) type. P/N 218584 is PFC type.

All power supply assemblies feature power line surge protection, withstanding brief surges of up to 2000 VAC without damage.

## 7.2.2 POWER CONTROL

The power supply assembly is controlled digitally by the PS On signal (Figure 7-1). When PS On is asserted, the Power Supply Assembly is activated and all voltage outputs are produced. When PS On is de-asserted, the Power Supply Assembly is off and no voltages (except +5 AUX) are generated. **Note that the +5 AUX voltage is always produced as long as the system is connected to a live AC source.**

The PS On signal can be controlled either by the Power Button or by the operating system (OS).

### 7.2.2.1 Power Button Control

The PS On signal is typically controlled through the Power Button which, when pressed and released, applies a negative (grounding) pulse to the power control logic. The resultant action of pressing the power button depends on the state and mode of the system at that time and is described as follows:

System State	Pressed Power Button Results In:
Off	Negative pulse, of which the falling edge results in power control logic asserting PS On signal to Power Supply Assembly, which then initializes. ACPI four-second counter is not active.
On, ACPI Disabled	Negative pulse, of which the falling edge causes power control logic to de-assert the PS On signal. ACPI four-second counter is not active.
Full On, ACPI Enabled	(Pressed and Released in Under Four Seconds): Negative pulse, of which the falling edge causes power control logic to generate SMI-, set a bit in the SMI source register, set a bit for button status, and start four-second counter. Software should clear the button status bit within four seconds and the Suspend state is entered. If the status bit is not cleared by software in four seconds PS On is de-asserted and the power supply assembly shuts down (this operation is meant as a guard if the OS is hung).  (Pressed and Held At least Four Seconds Before Release): PS On is negated, de-activating the power supply.
Suspend, ACPI Enabled	(Pressed and Released in Under Four Seconds): System wakes up to Full On. (Pressed and Held At least Four Seconds Before Release): System powers off.

### 7.2.2.2 OS Power Control

The PS On signal can be de-asserted by the ACPI-compliant operating system such as Windows 95. This system uses ACPI mode as the default power management mode, allowing the operating system to shut off the system (once the user has selected that decision) without further user intervention.

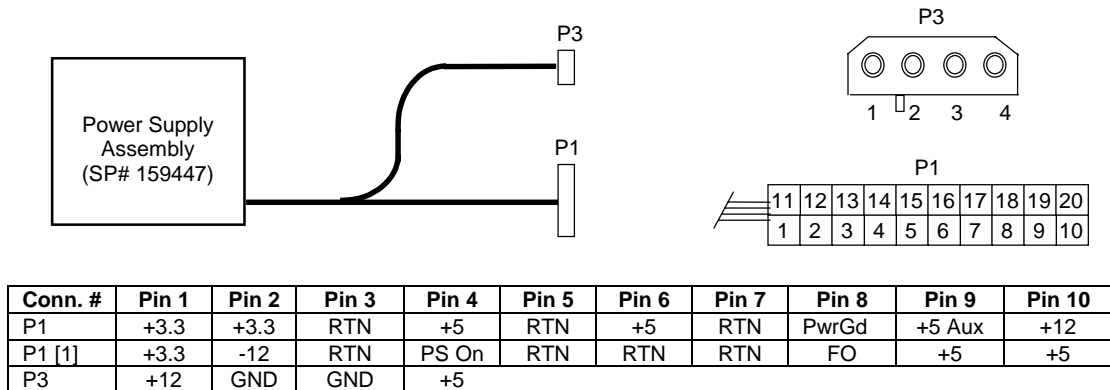
## 7.3 POWER DISTRIBUTION

### 7.3.1 3.3/5/12 VDC DISTRIBUTION

The 3.3-, 5-, and 12-volt distribution is slightly different between the iPAQ 1.x system and the iPAQ 2.0 system as described ion the following subsections.

#### 7.3.1.1 iPAQ 1.0/1.2 POWER DISTRIBUTION

The iPAQ 1.0/1.2 power supply assembly includes a multi-connector cable assembly that routes +3.3 VDC, +5 VDC, -5 VDC, +12 VC, and -12 VDC to the system board as well as to the individual drive assemblies. Figure 7-2 shows the power supply cabling.



NOTES:

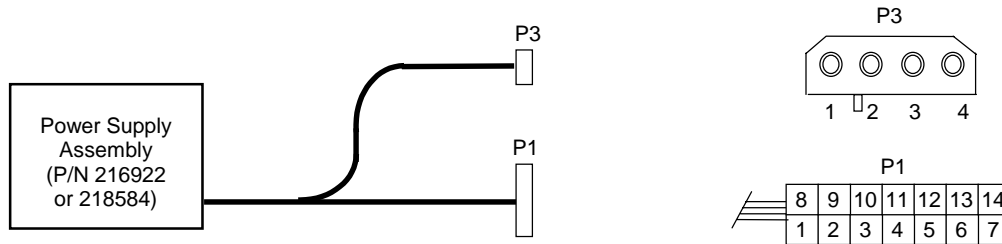
- [1] This row represents pins 11-20 of connector P1.
- All + and - values are VDC.
- RTN = Return (signal ground)
- GND = Power ground
- PwrGd = Power Good
- PS On = Power supply on
- FO = Fan off

Figure 7-2. iPAQ 1.0/1.2 Power Cable Diagram



### 7.3.1.2 iPAQ 2.0 POWER DISTRIBUTION

The iPAQ 2.0 power supply assembly includes a multi-connector cable assembly that routes +3.3 VDC, +5 VDC, -5 VDC, +12 VC, and -12 VDC to the system board as well as to the individual drive assemblies. Figure 7-3 shows the power supply cabling.



Conn. #	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7
P1	+3.3	+5	RTN	+5	RTN	+5	RTN
P1 [1]	+3.3	-12	FO	PS On	+5 Aux	RTN	+12
P3	+12	GND	GND	+5			

NOTES:

- [1] This row represents pins 8-14 of connector P1.
- All + and - values are VDC.
- RTN = Return (signal ground)
- GND = Power ground
- PS On = Power supply on
- FO = Fan off

**Figure 7-3.** iPAQ 2.0 Power Cable Diagram

### 7.3.2 LOW VOLTAGE DISTRIBUTION

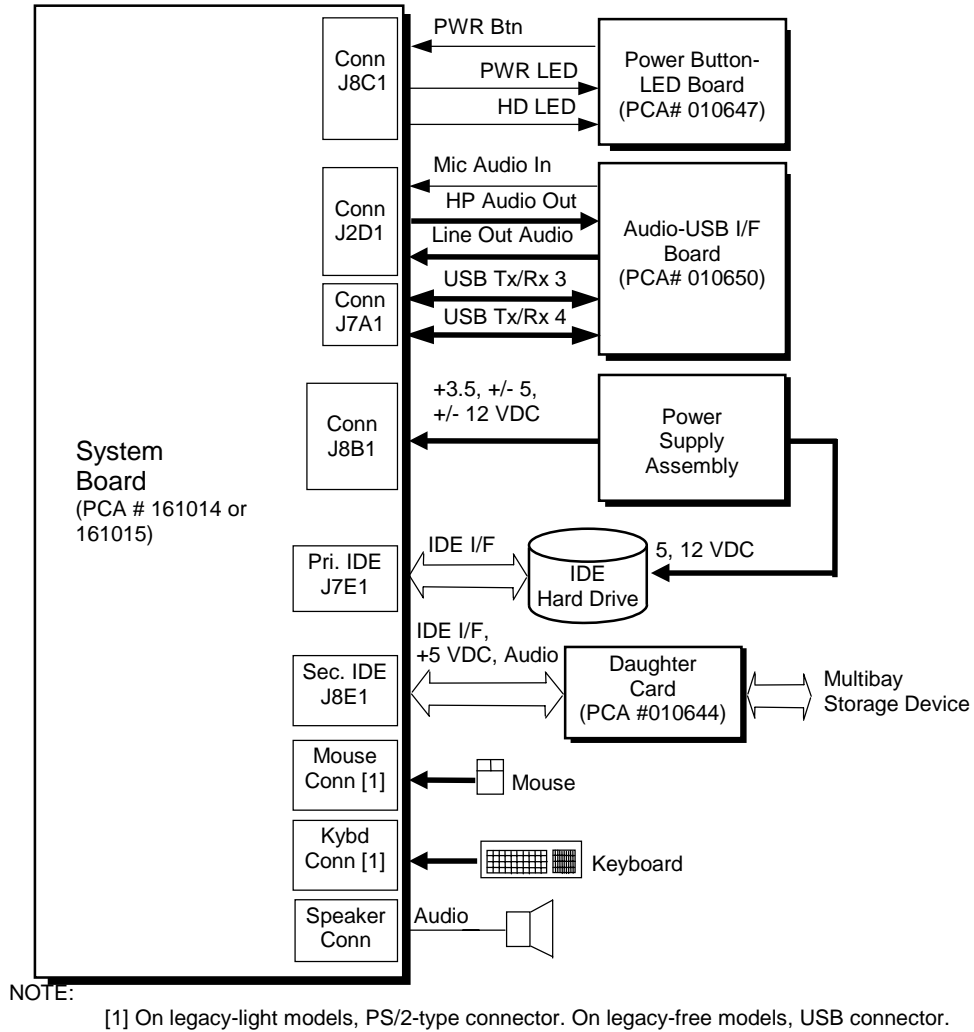
All iPAQ systems produce voltages less than 3.3 VDC (including processor core (VccP) voltage) through regulator circuitry on the system board.

An on-board regulator produces the VccP (processor core) voltage according to the strapping of signals VID3..0 by the processor. The possible voltages available are listed as follows:

<b>VID 3..0</b>	<b>VccP</b>	<b>VID 3..0</b>	<b>VccP</b>
0000	2.05 VDC	1000	1.65 VDC
0001	2.00 VDC	1001	1.60 VDC
0010	1.95 VDC	1010	1.55 VDC
0011	1.90 VDC	1011	1.50 VDC
0100	1.85 VDC	1100	1.45 VDC
0101	1.80 VDC	1101	1.40 VDC
0110	1.75 VDC	1110	1.35 VDC
0111	1.70 VDC	1111	1.30 VDC

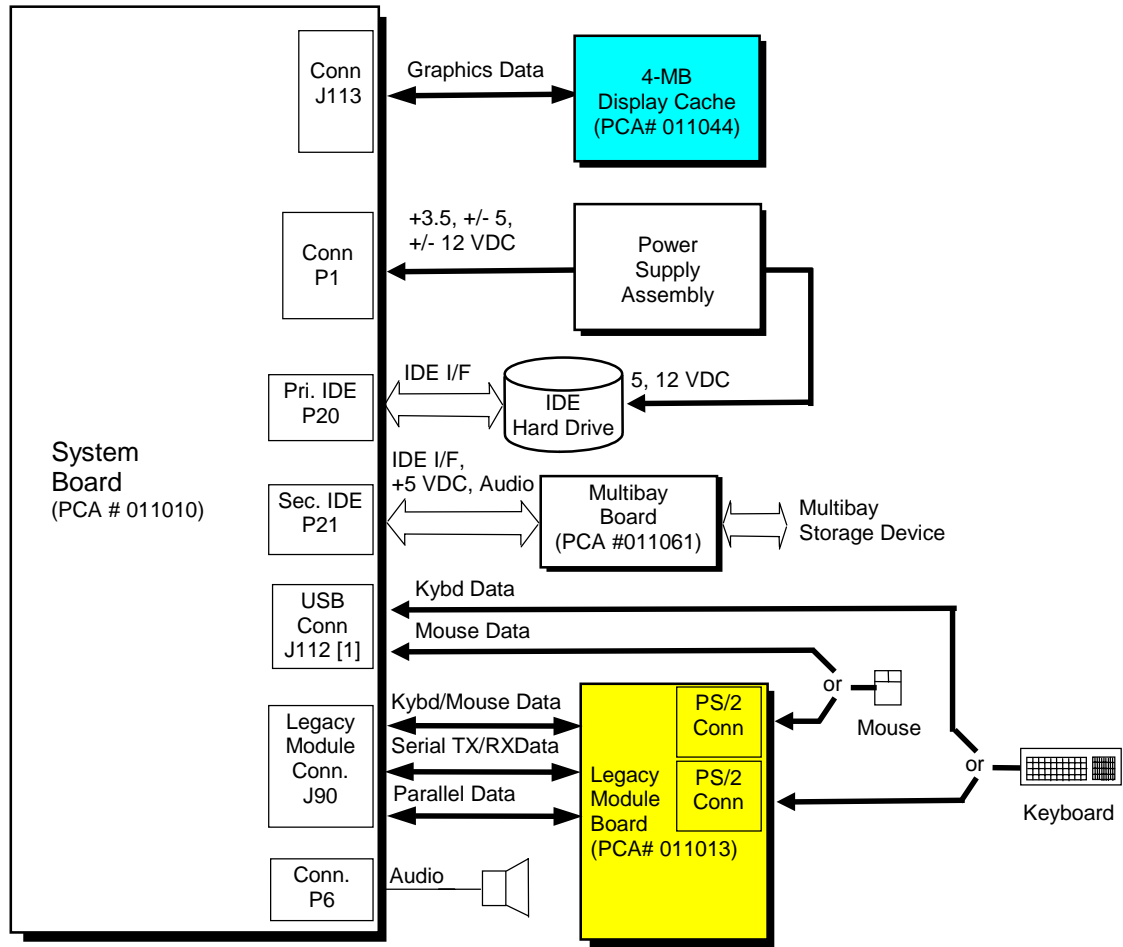
## 7.4 SIGNAL DISTRIBUTION

Figures 7-4 and 7-5 show general signal distribution for an iPAQ 1.x and 2.0 system (respectively) between the main subassemblies of the system unit in a standard configuration.



**Figure 7-4.** iPAQ 1.0/1.2 Signal Distribution Diagram

Figure 7-5 shows signal distribution for an iPAQ 2.0 system in a standard configuration.



NOTES:

Standard on legacy systems, optional on legacy-free systems.

Standard on Pentium-based systems, optional on Celeron-based systems.

[1] Suggested connection. May also use J110 or J112 .

Figure 7-5. iPAQ 2.0 Signal Distribution Diagram

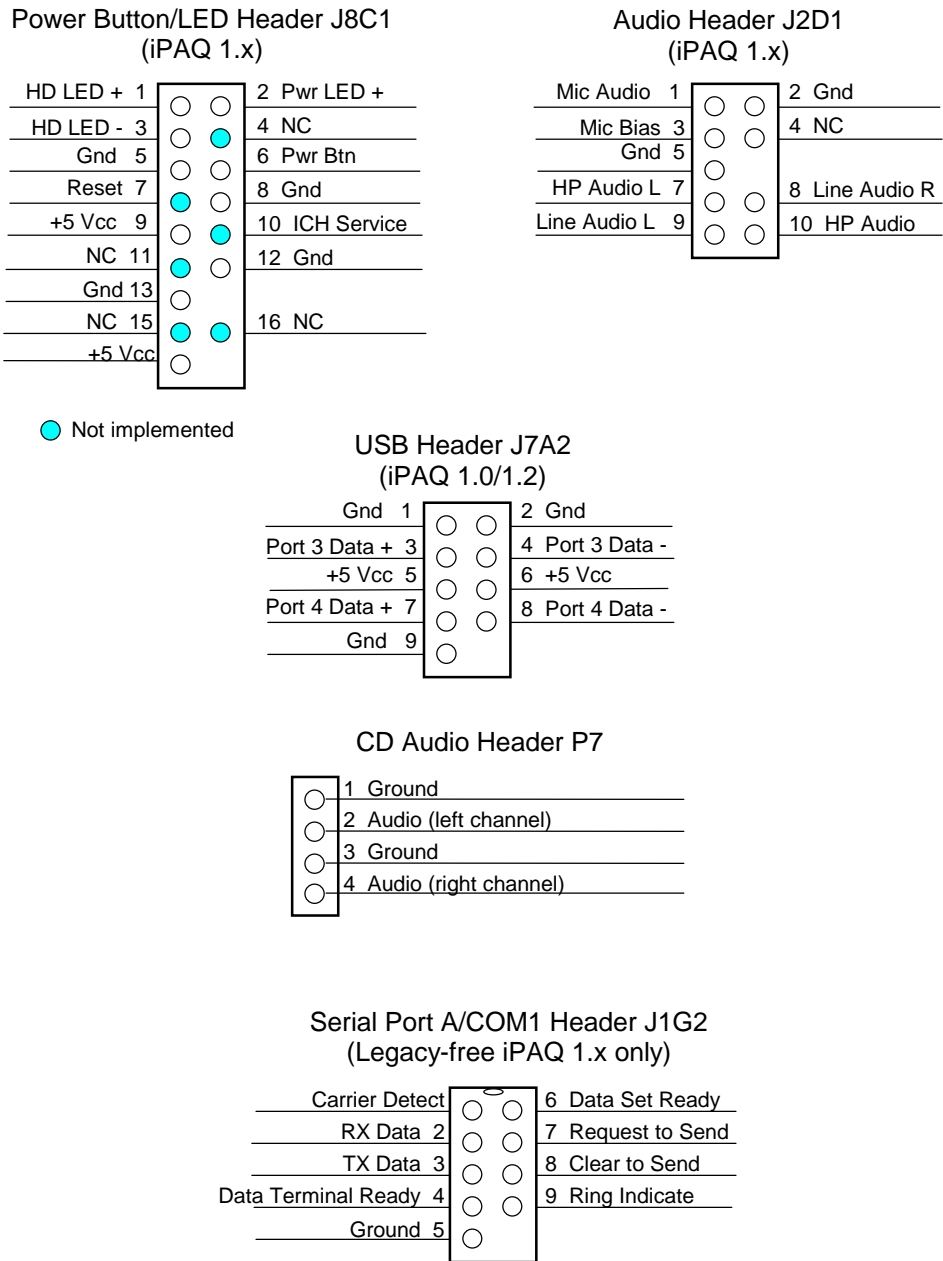


Figure 7-6. System Board Header Pinouts

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## Chapter 8 BIOS ROM

### 8.1 INTRODUCTION

The Compaq iPAQ desktops use Compaq BIOS firmware loaded into the 82802 FWH component. The BIOS ROM includes such functions as Power-On Self Test (POST), PCI device initialization, Plug 'n Play support, power management activities, and Setup. This chapter includes the following topics:

- ◆ iPAQ 2.0 features (8.2) page 8-2
- ◆ Desktop management support (8.3) page 8-3
- ◆ Memory detection and configuration (8.3) page 8-11
- ◆ PnP support (8.5) page 8-12
- ◆ Power management functions (8.6) page 8-15
- ◆ USB legacy support (8.7) page 8-17
- ◆ BIOS upgrading (8.8) page 8-18



**NOTE:** This chapter describes BIOS in general and focuses only on aspects of BIOS unique to this particular system..

---

The firmware contained in the BIOS ROM supports the following operating systems and specifications:

- ◆ DOS 6.2
- ◆ Windows for Workgroups 3.11
- ◆ Windows 95, 98, 2000, Me, and NT 3.5/4.0
- ◆ OS/2 ver 2.1 and Warp
- ◆ SCO Unix
- ◆ DMI 2.1
- ◆ Wired for Management (WfM) ver. 2.2
- ◆ SMBIOS 2.3.1
- ◆ Alert-On-LAN (AOL) and Wake-On-LAN (WOL)
- ◆ ACPI/WHIIG, APM 1.2, and OnNow
- ◆ Phoenix PMM
- ◆ PC98/99 and NetPC

During the boot sequence, the BIOS detects whether the unit is a legacy or legacy-free model.

## 8.2 IPAQ 2.0 FEATURES

The following features are unique to the BIOS of Compaq iPAQ 2.0 models:

- ◆ USB mouse support for DOS – USB mouse functionality is available outside of Windows.
- ◆ Hot-plugging of USB keyboards – USB keyboards may be added and recognized after system boot.
- ◆ Booting from a ZIP 250 drive – This feature is selectable through the Setup utility.
- ◆ QuietDrive support – This feature is selectable through the Setup utility.
- ◆ BIS remote boot security support – This feature selectable through the Setup utility.
- ◆ I/O APIC mode support (PC2001 compliance) – This feature is selectable through the Setup utility.
- ◆ ACPI S3 state support – This feature is selectable through the Setup utility.
- ◆ Secured NIC interface – The network interface controller may be disabled in the same manner that other I/O (serial, parallel) ports are disabled for security purposes. This feature selectable through the Setup utility.
- ◆ Fail-safe bootblock recovery – Recovery from a corrupted BIOS ROM is handled differently in the iPAQ 2.0 units.
- ◆ De-asserted A20 address line (legacy-free models)
- ◆ Changeable splash screen

### 8.2.1 CHANGEABLE SPLASH SCREEN

On iPAQ 2.0 systems, the splash screen (image displayed during POST) is stored in the BIOS ROM and may be replaced with another image of choice by using the Image Flash utility (Flashi.exe). The Image Flash utility allows the user to browse directories for image searching and pre-viewing. Background and foreground colors can be chosen from the selected image's palette.

The splash screen image requirements are as follows:

- ◆ Format: Windows bitmap with 4-bit RLE encoding
- ◆ Size: 424 (width) x 320 (height) pixels
- ◆ Colors: 16 (4 bits per pixel)
- ◆ File Size: ≤ 64 KB

The Image Flash utility can be invoked at a command line for quickly flashing a known image as follows:

```
>\Flashi.exe [Image_Filename] [Background_Color] [Foreground_Color]
```

The utility checks to insure that the specified image meets the splash screen requirements listed above or it will not be loaded into the ROM.



### 8.3 DESKTOP MANAGEMENT SUPPORT

Desktop Management deals with issues of security, identification, and system management functions. Desktop Management is provided by BIOS INT 15 functions listed Table 8-1.

**Table 8-1.**  
Desktop Management Functions (INT15)

AX	Function	Mode
E800h	Get system ID	Real, 16-, & 32-bit Prot.
E813h	Get monitor information	Real, 16-, & 32-bit Prot.
E814h	Get system revision	Real, 16-, & 32-bit Prot.
E816h	Get temperature status	Real, 16-, & 32-bit Prot.
E817h	Get drive attribute	Real
E818h	Get drive off-line test	Real
E819h	Get chassis serial number	Real, 16-, & 32-bit Prot.
E81Ah	Write chassis serial number	Real
E81Bh	Get drive threshold	Real
E81Eh	Get drive ID	Real
E820h	System Memory Map	Real
E822h	Flash ROM/Sys. Admin. Fnc.	Real, 16-, & 32-bit Prot.
E827h	DIMM EEPROM Access	Real, 16-, & 32-bit Prot.
E828h	Inhibit power button	Real, 16-, & 32-bit Prot.
E845h	Access CMOS Feature Bits	Real, 16-, & 32-bit Prot.
E846h	Security Functions	Real, 16-, & 32-bit Prot.

All 32-bit protected mode calls are accessed by using the industry-standard BIOS32 Service Directory. Using the service directory involves three steps:

1. Locating the service directory.
2. Using the service directory to obtain the entry point for the client management functions.
3. Calling the client management service to perform the desired function.

The BIOS32 Service Directory is a 16-byte block that begins on a 16-byte boundary between the physical address range of 0E0000h-0FFFFFFh. The format is as follows:

Offset	No. Bytes	Description
00h	4	Service identifier (four ASCII characters)
04h	4	Entry point for the BIOS32 Service Directory
08h	1	Revision level
09h	1	Length of data structure (no. of 16-byte units)
0Ah	1	Checksum (should add up to 00h)
0Bh	5	Reserved (all 0s)

To support Windows NT an additional table to the BIOS32 table has been defined to contain 32-bit pointers for the DDC and SIT locations. The Windows NT extension table is as follows:

; Extension to BIOS SERVICE directory table (next paragraph)

```

db      "32OS"      ; sig
db      2           ; number of entries in table
db      "$DDC"     ; DDC POST buffer sig
dd      ?          ; 32-bit pointer
dw      ?          ; byte size
db      "$SIT"     ; SIT sig
dd      ?          ; 32-bit pointer
dw      ?          ; byte size
db      "$ERB"     ; ESCD sig
dd      ?          ; 32-bit pointer
dw      ?          ; bytes size
    
```

The service identifier for Desktop Management functions is "\$CLM." Once the service identifier is found and the checksum verified, a FAR call is invoked using the value specified at offset 04h to retrieve the CM services entry point. The following entry conditions are used for calling the Desktop Management service directory:

INPUT:

```

EAX      = Service Identifier [$CLM]
EBX (31..8) = Reserved
EBX (7..0) = Must be set to 00h
CS       = Code selector set to encompass the physical page holding
          entry point as well as the immediately following physical page.
          It must have the same base. CS is execute/read.
DS       = Data selector set to encompass the physical page holding
          entry point as well as the immediately following physical page.
          It must have the same base. DS is read only.
SS       = Stack selector must provide at least 1K of stack space and be 32-bit.
          (I/O permissions must be provided so that the BIOS can support as necessary)
    
```

OUTPUT:

```

AL       = Return code:
          00h, requested service is present
          80h, requested service is not present
          81h, un-implemented function specified in BL
          86h and CF=1, function not supported
EBX      = Physical address to use as the selector BASE for the service
ECX      = Value to use as the selector LIMIT for the service
EDX      = Entry point for the service relative to the BASE returned in EBX
    
```

### 8.3.1 SYSTEM ID

The INT 15, AX=E800h BIOS function can be used by software to identify the type of system. This function will return the system ID in the BX register.

System	ROM Type	PnP ID	System ID
iPAQ 1.x	686J1	CPQB1A0	0630h
iPAQ 2.0	686P7	CPQ0014	06F0h

The ROM type may be checked through the Setup utility (press F10 key when prompted during the boot sequence) and by diagnostics software such as Compaq Insight Manager.

### 8.3.2 EDID RETRIEVE

The BIOS function INT 15, AX=E813h is a tri-modal call that retrieves the VESA extended display identification data (EDID). Two subfunctions are provided: AX=E813h BH=00h retrieves the EDID information while AX=E813h BX=01h determines the level of DDC support.

Input:

AX = E813h  
 BH = 00 Get EDID .  
 BH = 01 Get DDC support level

If BH = 00 then

DS:(E)SI = Pointer to a buffer (128 bytes) where ROM will return block

If 32-bit protected mode then

DS:(E)SI = Pointer to \$DDC location

Output:

(Successful)

If BH = 0:  
 DS:SI=Buffer with EDID file.  
 CX = Number of bytes written  
 CF = 0  
 AH =00h Completion of command

If BH = 1:

BH = System DDC support  
 <0>=1 DDC1 support  
 <1>=1 DDC2 support  
 BL = Monitor DDC support  
 <0>=1 DDC1 support  
 <1>=1 DDC2 support  
 <2>=1 Screen blanked during transfer

(Failure)

CF = 1  
 AH = 86h or 87h

### 8.3.3 DRIVE FAULT PREDICTION

The Compaq BIOS provides direct Drive Fault Prediction support for IDE-type hard drives. This feature is provided through two BIOS calls. Function INT 15, AX=E817h is used to retrieve a 512-byte block of drive attribute data while the INT 15, AX=E81Bh is used to retrieve the drive's warranty threshold data. If data is returned indicating possible failure then the following message is displayed:

“1720-Intellisafe Hard Drive detects imminent failure”

### 8.3.4 SYSTEM MAP RETRIEVAL

The BIOS function INT 15, AX=E820h will return base memory and ISA/PCI memory contiguous with base memory as normal memory ranges. This real mode call will indicate chipset-defined address holes that are not in use, motherboard memory-mapped devices, and all occurrences of the system BIOS as reserved. Standard PC address ranges will not be reported.

Input:

EBX = continuation value or 00000000h to start at beginning of map  
ECX = number of bytes to copy (>=20)  
EDX = 534D4150h ('SMAP')  
ES:DI = buffer for result (see below)

Offset	Size	Description
00h	QWORD	base address
08h	QWORD	length in bytes
10h	DWORD	type of address range
01h		memory, available to OS
02h		reserved, not available (e.g. system ROM, memory-mapped device)
other:		not defined

Output:

If CF=0 (success)

EAX = 534D4150h ('SMAP')  
EBX = next offset from which to copy or 00000000h if finished  
ECX = actual length returned in bytes  
ES:DI = buffer filled

If CF=1 (failure)

AH = Error Code (86h)

In order to determine the entire memory map, multiple calls must be made.  
For example, the first call would be:

Input:

EDX = 534D4150h  
EBX = 00h  
ECX = 14h  
ES:DI = some buffer to store information.

Output:

EAX = 534D4150h  
EBX = 01h  
ECX = 14h  
ES:DI = 00 00 00 00 00 00 00 00 00 FC 09 00 00 00 00 00 01 00 00 00  
(indicates 0-639k is available to the OS)

Consecutive calls would continue until EBX returns with 0, indicating that the memory map is complete.

### 8.3.5 FLASH ROM FUNCTIONS

The system BIOS may be upgraded by flashing the ROM using the INT 15, AX=E822h BIOS interface, which includes the necessary subfunctions. An upgrade utility is provided on a ROMPAQ diskette.

### 8.3.6 POWER BUTTON FUNCTIONS

The BIOS includes an interface for controlling the system unit's power button. The power button can be disabled and enabled.

The INT 15, AX=E822h, BL=08h function can be invoked to disable the power button, preventing a user from inadvertently powering down the system. This tri-modal function is typically used in the ROM flashing procedure to reduce the chance of an accidental power down while the BIOS is being upgraded.

Entry:

AX = E822h  
BL = 08h

Return:

(Successful)

CF = 0  
AH = 00

(Failure)

CF = 1  
AH = 86, not supported

**NOTE:** With the Disable function invoked the system can **still** be powered down by holding the power button in for four seconds or more.

The INT 15, AX=E822h, BL=09h function is used to restore the power button to the state it was in prior to invoking the Disable (BL=08h) function.

Entry:

AX = E822h  
BL = 09h

Return:

(Successful)

CF = 0  
AH = 00

(Failure)

CF = 1  
AH = 86, call not supported

### 8.3.7 ACCESSING CMOS

Configuration memory data can be retrieved with the BIOS call INT 15, AX=E823h. This tri-modal function retrieves a specific byte from the CMOS map described in Chapter 4. The function is described as follows:

INPUT:

EAX = E823h  
BH = 0, Read  
= 1, Write  
BL = Value to write (if a write is specified)  
CX = Bytes number (zero-based)

OUTPUT:

(Successful)

CF = 0  
AH = 00h  
AL = Byte value (on a read)

(Failure)

CF = 1  
AH = 86h, Function not supported  
= FFh, byte does not exist

### 8.3.8 ACCESSING CMOS FEATURE BITS

The BIOS function INT 15, AX=E845h is a tri-modal call for accessing areas in non-volatile memory (CMOS) used for storing variables for various features. Note that this function differs from the previously discussed call since data blocks of varying lengths are retrieved.

INPUT:

EAX = E845h  
BL = 0, Read  
= 1, Write  
BH = Value Read/to Write  
CX = Feature Bits Number (refer to Table 8-2)  
DS:SI = Pointer to buffer passing multiple byte features

OUTPUT:

(Successful)

CF = 0  
EAX = Reserved  
BH = Value read (on a read)

(Failure)

CF = 1  
AH = 86h, Function not supported

**Table 8-2.**  
CMOS Feature Bits

CX	Function	Def. Value	Def. Setting	CX	Function	Def. Value	Def. Setting
0000h	PCI 2.1 Mode Enable	01h	Yes	0025h	Asset Tag	[1]	[1]
0001h	Erase Ease Kybd	03h	Ign.	0026h	Bck-to-bck I/O Delay	00h	Norm
0002h	COM/IR Port Select	00h	COM	0027h	CMOS 10-2Fh BU	[1]	[1]
0003h	PnP Rejects SET	00h	Yes	0028h	QuickLock after Stby	00h	No
0004h	PCI VGA Snoop	00h	No	0029h	Audio Chip Enable	01h	Yes
0005h	PCI Bus Mastering	00h	Yes	002Ah	Audio IRQ	01h	IRQ5
0006h	Auto Prompt Setup	00h	Yes	002Bh	Audio DMA	02h	DMA1
0007h	Mode 2 Config. En.	01h	Yes	002Ch	Audio Addr.	00h	22xh
0008h	Sec. IDE Cntrl, En.	01h	Yes	002Dh	ECP DMA Config.	03h	DMA3
0009h	Sec. IDE Cntrl. IRQ	03h	IRQ15	002Eh	COM1 Base Addr.	3Fh	3F8h
000Ah	Custom Drive Type 1	00h	[1]	002Fh	COM1 IRQ	00h	Rsrvd
000Bh	Custom Drive Type 2	00h	[1]	0030h	COM2 Base Addr.	1Fh	2F8h
000Ch	Custom Drive Type 3	00h	[1]	0031h	COM2 IRQ	00h	Rsrvd
000Dh	Custom Drive Type 4	00h	[1]	0032h	UDMA33 Enable	0Fh	Yes
000Eh	POST Verbose/Terse	01h	Terse	0033h	Net Server Md En.	00h	No
000Fh	Translate SCSI Drive	00h	Yes	0034h	CIA BOM No. Bytes	[1]	[1]
0010h	Mfg. Process no.	[1]	[1]	0035h	Copy Std. CMOS	[1]	[1]
0011h	Admin. Password	[1]	[1]	0036h	AGP Adapter Srch.	01h	Yes
0012h	Pwr-On Password	[1]	[1]	0037h	APM Fan Throttle	00h	Auto
0013h	Ownership Tag	[1]	[1]	0038h	Mfg. Diags. Enable	00h	No
0014h	Warm Boot Pswrd En.	00h	Yes	0039h	RIPL ROM Boot En.	01h	Yes
0015h	Hood Lock Enable	00h	Yes	003Ah	Exit CleanBoot Scrn.	[1]	[1]
0016h	Hood Removal En.	00h	No	003Bh	Ethernet Speed Sel.	00h	Auto
0017h	USB Security Enable	01h	Yes	003Ch	Ethernet Mode Sel.	00h	Auto
0018h	Power Supply Mode	01h	ACPI	003Dh	Ethernet Conn. Type	01h	UTP
0019h	QuickBoot Mode	1Fh	Fast	003Eh	ACPI Enable	01h	Yes
001Ah	Onbd NIC Enable	01h	Yes	003Fh	S/W BOM S/N		
001Bh	Onbd. SCSI Enable	01h	Yes	0040h	ECP Mode Selected	01h	Yes
001Ch	Onbd. Pri. IDE Enable	01h	Yes	0041h	NT Shutdown Dvr.	00h	No
001Dh	Ultra SCSI Md. En.	00h	No	0042h	Em. SCSI Priority	00h	Lowest
001Eh	QuickLock Enable	00h	No	0043h	Factor Boot Sel.	00h	
001Fh	QuickBlank Enable	00h	No	0044h	Product Name	00h	[1]
0020h	Serial I/F 1 Security [2]	01h	No	0045h	UUID	00h	[1]
0021h	Serial I/F 2 Security	01h	No	0046h	Processor # Enable	01h	Yes
0022h	Printer I/F Security [2]	01h	No	0047h	After G3 State	00h	Off
0023h	CD/Diskette Boot	00h	Yes	0048h	UUID Enable	01h	Yes
0024h	CD/Diskette Write	00h	Yes	--	--	--	--

NOTE:

■ Not applicable to these systems.

[1] Default Value will be pointer to buffer DS:SI (16-bit mode) or DS:(E)SI (32-bit mode) where actual data is held. Default Setting will be unique for each system.

[2] Legacy-light system only.

### 8.3.9 SECURITY FUNCTIONS

The INT 15 AX=E846h BIOS function is used to control various security features of the system. This function may be issued by a remote system (over a network). The issuing driver must build a request buffer for each security feature prior to making the call. This system supports the following security features:

- ◆ QuickLock
- ◆ IDE controller disable
- ◆ Serial port disable (legacy-light only)
- ◆ Parallel port disable (legacy-light only)
- ◆ Change administrator password
- ◆ QuickLock on suspend
- ◆ Ownership tag
- ◆ USB disable (legacy-light only)

The write-protect function that determines diskette write control is extended to cover all drives that use removable read/write media (i.e., if diskette write protect is invoked, then any diskette drive, power drive (SCSI and/or ATAPI), and floptical drive installed will be inaccessible for (protected from) writes). Client management software should check the following bytes of SIT record 07h for the location and access method for this bit:

**System Information Table, Peripheral and Input Device Record (07h) (partial listing)**

Byte	Bit	Function
1Fh	7-0	Removable Read/Write Media Write Protect Enable Byte Offset (0-255)
20h	7..4	Removable Read/Write Media Write Protect Enable Bit Location: CMOS Type: 0000 = CMOS 0001 = High CMOS 0010 = NVRAM 0011 = Flat model NVRAM
	3..0	Bit Location: 0000 = Bit 0      0100 = Bit 4 0001 = Bit 1      0101 = Bit 5 0010 = Bit 2      0110 = Bit 6 0011 = Bit 3      0111 = Bit 7



## 8.4 MEMORY DETECTION AND CONFIGURATION

This system uses the Serial Presence Detect (SPD) method of determining the installed DIMM configuration. The BIOS communicates with an EEPROM on each DIMM through an I<sup>2</sup>C-type bus to obtain data on the following DIMM parameters:

- ◆ Presence
- ◆ Size
- ◆ Type
- ◆ Timing/CAS latency



**NOTE:** Refer to Chapter 3, “Processor/Memory Subsystem” for the SPD format and DIMM data specific to this system.

---

The BIOS performs memory detection and configuration with the following steps:

1. Set Memory Buffer Strength – The memory controller must be configured for correct buffer drive strength. The BIOS provides this function by reading the number of module banks, ECC enable/disable status, and SDRAM width data from the DIMMs and transferring that data to the memory controller. SPD bytes checked: 5, 11, 13
2. Determine DIMM Presence/Type – The BIOS checks each memory socket for DIMM presence. If present, the DIMM type and CAS latency is determined. SPD bytes checked: 2, 9, 10, 18, 23, 24.
 

Check Sequence:

  - a. SPD byte 2 is read for all slots first. A failed read or returned value of other than 02h (EDO) or 04h (SDRAM) results in the slot marked as empty. If mixed types are detected then only SDRAMs are used (see chapter 3 for details).
  - b. SPD byte 18 is read for maximum CAS latency, followed by reads of bytes 9 and 10 for bus speed compatibility. A DIMM detected as too-slow results in an error.
  - c. If the DIMM can handle the memory bus speed at maximum CAS latency then bytes 23 and 24 are checked to see if the DIMM can work maximum CAS latency minus 1. Once all slots are checked, the greatest CAS latency (2 or 3) is used. A DIMM detected as incompatible will result in a bit in CMOS being set and the Num Lock LED on the keyboard will blink for a short time. Depending on the progress of the BIOS routine a POST message may be displayed before the system locks up.
3. Initialize SDRAM – If SDRAM are installed then each row containing SDRAM will be initialized. This step includes pre-charging all banks, sending a CAS-before-RAS command, sending a Mode-Register-Set-Enable command, reading DIMM location/CAS latency data, and sending a Normal Op command.
4. Memory Sizing – The SPD bytes 3, 4, and 17 are checked for number of row and column addresses and (for SDRAM) the number of internal banks.
5. Memory Timing – For SDRAM, the memory controller requires the RAS pre-charge time and the RAS-to-CAS delay time. SPD bytes checked: 27 and 29.

## 8.5 PNP SUPPORT

The BIOS includes Plug 'n Play (PnP) support for PnP version 1.0A.

**NOTE:** For full PnP functionality to be realized, all peripherals used in the system must be designed as “PnP ready.” Any installed ISA peripherals that are not “PnP ready” can still be used in the system, although configuration parameters may need to be considered (and require intervention) by the user.

Table 8-2 shows the PnP functions supported (for detailed PnP information refer to the Compaq BIOS Technical Reference Guide):

---

**Table 8-2.**  
PnP BIOS Functions

Function	Register
00h	Get number of system device nodes
01h	Get system device node
02h	Set system device node
03h	Get event
04h	Send message
40h	Get ISA configuration [1]
50h	Get SMBIOS Structure Information
51h	Get Specific SMBIOS Structure

NOTE:

[1] Since no ISA slots are present, this function will return 0 for the max. CSN.

The BIOS call INT 15, AX=E841h, BH=01h can be used by an application to retrieve the default settings of PnP devices for the user. The application should use the following steps for the display function:

1. Call PnP function 01(get System Device Node) for each devnode with bit 1 of the control flag set (get static configuration) and save the results.
2. Call INT 15, AX=E841h, BH=01h.
3. Call PnP “Get Static Configuration” for each devnode and display the defaults.
4. If the user chooses to save the configuration, no further action is required. The system board devices will be configured at the next boot. If the user wants to abandon the changes, then the application must call PnP function 02 (Set System Device Node) for each devnode (with bit 1 of the control flag set for static configuration) with the results from the calls made prior to invoking this function.

### **8.5.1 SMBIOS**

This system supports System Management BIOS (SMBIOS) version 2.3.1, which is compliant with the Desktop Management Interface (DMI) specification. The PnP functions 50h and 51h are used to retrieve the SMBIOS data, which is stored using management information format (MIF) structures. Function 50h retrieves the number of structures, size of the largest structure, and SMBIOS version. Function 51h retrieves a specific structure. This system the following structure types:

<u>Type</u>	<u>Data</u>
0	BIOS Information
1	System Information
3	System Enclosure or Chassis
4	Processor Information
5	Memory Controller Information
6	Memory Module Information
7	Cache Information
8	Port Connector Information
9	System Slots
10	On Board Device Information
12	System Configuration Options
13	BIOS Language Information
16	Physical Memory Array
17	Memory Devices
18	Memory Error Information
19	Memory Array Mapped Addresses
20	Memory Device Mapped Addresses

## 8.6 POWER MANAGEMENT FUNCTIONS

The BIOS provides three types of power management support: independent PM support; ACPI support, and APM support. These power management interfaces share a common goal of reducing energy consumption during periods of system inactivity. The following table compares and describes the different system states identified by the various power management interfaces.

Global State	Sleep State	System Condition	Power Consumption	OS Restart Required
G0	--	Fully on. OS and application software is running, all devices are active, responsive, and maintaining context.	Maximum	No
G1	S1	On, with CPU executing and data held in memory, but peripheral devices (display output, some I/O) may be disabled/low	Low	No
	S2/S3	power. On, but CPU not executing and cache context lost. Memory is maintained. Display and I/O devices disabled or under low	Low	No
	S4	power. Off. CPU and most other devices powered off. No data held in RAM, but memory image from lower state has been saved to disk for recall upon wake up.	Low	Yes
G2	S5	Soft Off. OS has completed shutdown. Some devices may be powered to allow for "wake up" to occur resulting in a full boot sequence.	Minimum	Yes
G3	--	Mechanical off. Power to unit has been switched off (or unit has been unplugged). Only internal RTC battery power is being consumed. Unit may be disassembled/serviced safely.	None	Yes

### 8.6.1 INDEPENDENT PM SUPPORT

The BIOS ROM can provide power management of the system independently from any software (OS or application) that is running on the system. In this mode the BIOS uses a timer to determine when to switch the system to a different power state. State switching is not reported to the OS and occurs as follows:

**On** – The computer is running normally and is drawing full power.

**Standby** – The computer is in a low power state. In this state the processor and chipset are still running and the VSYNC signal to the monitor is turned off. Returning to the On state requires very little time and will be initiated by any of the following actions:

- a. key stroke
- b. mouse movement

**Off** – The computer is not running and drawing practically no power at all.

## **8.6.2 ACPI SUPPORT**

This system meets the hardware and firmware requirements for being ACPI compliant. The BIOS function INT 15 AX=E845h can be used to check or set the ACPI enable/disable status of the system, which defaults to the "ACPI enabled" state. The setup option for ACPI should be disabled if APM/PnP is to be used with Windows 98 or when disabling power management and PnP support for NT5.0. A hardware redetection should be made with Windows 98 and a reinstall of Windows NT5.0 should be performed when an ACPI switch is made. This system supports the following ACPI functions:

- ◆ PM timer
- ◆ Power button
- ◆ Power button override
- ◆ RTC alarm
- ◆ Sleep/Wake logic (S1, S4 (NT), S5)
- ◆ Legacy/ACPI select
- ◆ C1 state (Halt)
- ◆ C2 state (STOPGRANT)
- ◆ C3 state (no clock)
- ◆ PCI PME

## **8.6.3 APM 1.2 SUPPORT**

Advanced Power Management (APM) BIOS support provides interaction between the BIOS ROM and the operating system (OS). The BIOS advises the OS when a power state transition should occur. The OS then notifies the appropriate driver(s) and reports back to the BIOS. For maximum energy-conservation benefit, APM functionality should be implemented using the following three layers:

- ◆ BIOS layer (APM BIOS (ver. 1.2, 1.1, 1.0))
- ◆ Operating system (OS) layer (APM driver)
- ◆ Application layer (APM-aware application or device driver)

The process starts with the OS or driver making a connection with the BIOS through an APM BIOS call. In a DOS environment POWER.EXE makes a Real mode connection. In Windows 3.1 and in Windows 95, a 32-bit connection is made. Currently Windows NT does not make an APM connection. With power management enabled, inactivity timers are monitored.

When an inactivity timer times out, an SMI is sent to the microprocessor to invoke the SMI handler. The SMI handler works with the APM driver and APM BIOS to take appropriate action based on which inactivity timer timed out.

Three power states are defined under power management:

**On** - The computer is running, all subsystems are on and drawing full power. Any activity in the following subsystems will reset the activity timer, which has a default setting of 15 minutes before Standby entered:

- a. Keyboard (PS/2 only)
- b. Mouse (PS/2 only)
- c. Serial port
- d. Hard drive

**Standby** - The computer is in a low power state: video is off, some subsystems may be drawing less power, and the microprocessor is halted except for servicing interrupts. Video graphics controller is under driver control and/or VSYNC is off and the power supply fan is turned off. Any of the following activities will generate a wake-up SMI and return the system to On:

- a. Keyboard (PS/2 only)
- b. Mouse (PS/2 only)
- c. Serial port
- d. Hard drive
- e. RTC Alarm
- f. Power Button

If no APM connection is present, the BIOS will set an APM timer to 45 minutes, at which time the Suspend will be entered if no activity has occurred. This function can be defeated (so that Suspend will **not** be achieved). If an APM connection is present, the BIOS APM timer is not used and Suspend is entered only by user request either through an icon in Windows 95 or by pressing and releasing the power button under 4 seconds.

**Suspend** - The computer is in a low power state: video graphics controller is under driver control and/or HSYNC and VSYNC are off, some subsystems may be drawing less power, and the microprocessor is halted except for servicing interrupts. Any of the following activities will generate a wake-up SMI and return the system to On:

- a. Keyboard (PS/2 only)
- b. Mouse (PS/2 only)
- c. Serial port
- d. Diskette drive
- e. Hard drive
- f. RTC Alarm
- g. Network interface controller

The APM BIOS for this system supports APM 1.2 as well as previous versions 1.1 and 1.0. The APM BIOS functions are listed in Table 8-3.

**Table 8-3.**  
APM BIOS Functions (INT15)

AX	Function
5300h	APM Installation Check
5301h	APM Connect (Real Mode)
5302h	APM Connect (16-bit Protected Mode)
5303h	APM Connect (32-bit Protected Mode)
5304h	Interface Disconnect
5305h	CPU Idle
5306h	CPU Busy
5307h	Set Power State [1]
5308h	Enable/Disable Power Management
5309h	Restore Power On Defaults
530Ah	Get Power Status
530Bh	Get PM Event
530Ch	Get Power State
530Dh	Enable/Disable Device Power Management
530Eh	APM Driver Version
530Fh	Engage/Disengage Power Management
5380h	OEM (Compaq) Specific APM Function

## 8.7 USB LEGACY SUPPORT

The BIOS ROM checks the USB port, during POST, for the presence of a USB keyboard. This allows a system with only a USB keyboard to be used during ROM-based setup and also on a system with an OS that does not include a USB driver.

On such a system a keystroke will generate an SMI and the SMI handler will retrieve the data from the device and convert it to PS/2 data. The data will be passed to the keyboard controller and processed as in the PS/2 interface. Changing the delay and/or typematic rate of a USB keyboard though BIOS function INT 16 is not supported.

The system does not support hot-plugging of a USB keyboard, nor is a keyboard attached to a USB hub supported. A PS/2 keyboard and a USB keyboard can, however, be connected and used simultaneously.

## 8.8 BIOS UPGRADING

The flash ROM device can be re-written with updated BIOS code if necessary. The flashing procedure is as follows:

1. Create a system (bootable) diskette using the `FORMAT A: /S` command in DOS.
2. Download the appropriate BIOS firmware from the Compaq web site.
3. Copy the downloaded BIOS file and the flash utility file onto the boot diskette.
4. Unzip the BIOS and flash utility files, which should result in an .exe file and a .bin file.
5. Place the boot diskette into drive A: and reboot the system.
6. At the A: prompt, type in "`filename.exe filename.bin`" (there is a space between the file names) and press **Enter**.
7. At the Flash Memory Write menu, to the question "Do you want to save BIOS?" select Y. If you want to save the current BIOS then type the current BIOS name and the extension after "File name to save" (example: type in 613j900.bin). Alternately, select N if you do not want to save the current BIOS.
8. To the question "Are you sure to program?" select Y.
9. Wait until the message "Power Off or Reset the system," indicating the BIOS has been loaded successfully. Then remove the boot diskette. **Should power be lost or the system reset during this time (before the message is displayed) the BIOS code in ROM will likely be corrupted and the procedure will have to be repeated (starting at step 5).**
10. Turn off (power down) the system.
11. While holding the **End** key down, turn on (power up) the system, making sure the **End** key is held down until the Setup utility is entered.
12. Complete the Setup utility as appropriate.
13. Re-boot the system.



# Appendix A

## ERROR MESSAGES AND CODES

### A.1 INTRODUCTION

This appendix lists the error codes and a brief description of the probable cause of the error.



**NOTE:** Errors listed in this appendix are applicable **only** for systems running **Compaq BIOS**.



**NOTE:** Not all errors listed in this appendix may be applicable to a particular system model and/or configuration.

### A.2 BEEP/KEYBOARD LED CODES

**Table A-1.**  
Beep/Keyboard LED Codes

Beeps	LED [1]	Probable Cause
1 short, 2 long	NUM lock blinking	Base memory failure.
1 long, 2 short	CAP lock blinking	Video/graphics controller failure.
2 long, 1 short	Scroll lock blinking	System failure (prior to video initialization).
1 long, 3 short	(None)	Boot block executing
None	All three blink in sequence	Keyboard locked in network mode.
None	NUM lock steady on	ROMPAQ diskette not present, bad, or drive not ready.
None	CAP lock steady on	Password prompt.
None	All three blink together	ROM flash failed.
None	All three steady on	Successful ROM flash.

NOTE:

[1] PS/2 keyboard only.

### A.3 POWER-ON SELF TEST (POST) MESSAGES

**Table A-2.**  
Power-On Self Test (POST) Messages

<b>Error Message</b>	<b>Probable Cause</b>
Invalid Electronic Serial Number	Chassis serial number is corrupt. Use Setup to enter a valid number.
Network Server Mode Active (w/o kybd)	System is in network mode.
101-Option ROM Checksum Error	A device's option ROM has failed/is bad.
102-system Board Failure	Failed ESCD write, A20, timer, or DMA controller.
150-Safe POST Active	An option ROM failed to execute on a previous boot.
162-System Options Not Set	Invalid checksum, RTC lost power, or invalid configuration.
163-Time & Date Not Set	Date and time information in CMOS is not valid.
164-Memory Size Error	Memory has been added or removed.
201-Memory Error	Memory test failed.
213-Incompatible Memory Module	BIOS detected installed DIMM(s) as being not compatible.
216-Memory Size Exceeds Max	Installed memory exceeds the maximum supported by the system.
301-Keyboard Error	Keyboard interface test failed (improper connection or stuck key).
303-Keyboard Controller Error	Keyboard buffer failed empty (8042 failure or stuck key).
304-Keyboard/System Unit Error	Keyboard controller failed self-test.
404-Parallel Port Address Conflict	Current parallel port address is conflicting with another device.
510-Splash Image Corrupt	Corrupted splash screen image. Restore default image w/ROMPAQ.
601-Diskette Controller Error	Diskette drive removed since previous boot.
912-Computer Cover Removed Since Last System Start Up	Cover (hood) removal has been detected by the Smart Cover Sensor.
917-Expansion Riser Not Detected	Expansion (backplane) board not seated properly.
1720-SMART Hard Drive Detects Imminent Failure	SMART circuitry on an IDE drive has detected possible equipment failure.
1721-SMART SCSI Hard Drive Detects Imminent Failure	SMART circuitry on a SCSI drive has detected possible equipment failure.
1801-Microcode Patch Error	A processor is installed for which the BIOS ROM has no patch. Check for ROM update.
1998-Master Boot Record Backup Has Been Lost	Backup copy of the hard drive master boot record is corrupted. Use Setup to restore the backup from the hard drive.
1999-Master Boot Record Has Changed. Press Any Key To Enter Setup to Restore the MBR.	If Master Boot Record Security is enabled, this message indicates that the MBR has changed since the backup was made.
2000-Master boot Record hard drive has changed	The hard drive has been changed. Use Setup to create a backup of the new hard drive.

## A.4 SYSTEM ERROR MESSAGES (1xx-xx)

**Table A-3.**  
System Error Messages

Message	Probable Cause	Message	Probable Cause
101	Option ROM error	110-01	Programmable timer load data test failed
102	System board failure (see note)	110-02	Programmable timer dynamic test failed
103	System board failure	110-03	Program timer 2 load data test failed
104-01	Master int. cntlr. test failed	111-01	Refresh detect test failed
104-02	Slave int. cntlr. test failed	112-01	Speed test Slow mode out of range
104-03	Int. cntlr. SW RTC inoperative	112-02	Speed test Mixed mode out of range
105-01	Port 61 bit <6> not at zero	112-03	Speed test Fast mode out of range
105-02	Port 61 bit <5> not at zero	112-04	Speed test unable to enter Slow mode
105-03	Port 61 bit <3> not at zero	112-05	Speed test unable to enter Mixed mode
105-04	Port 61 bit <1> not at zero	112-06	Speed test unable to enter Fast mode
105-05	Port 61 bit <0> not at zero	112-07	Speed test system error
105-06	Port 61 bit <5> not at one	112-08	Unable to enter Auto mode in speed test
105-07	Port 61 bit <3> not at one	112-09	Unable to enter High mode in speed test
105-08	Port 61 bit <1> not at one	112-10	Speed test High mode out of range
105-09	Port 61 bit <0> not at one	112-11	Speed test Auto mode out of range
105-10	Port 61 I/O test failed	112-12	Speed test variable speed mode inop.
105-11	Port 61 bit <7> not at zero	113-01	Protected mode test failed
105-12	Port 61 bit <2> not at zero	114-01	Speaker test failed
105-13	No int. generated by failsafe timer	116-xx	Way 0 read/write test failed
105-14	NMI not triggered by failsafe timer	162-xx	Sys. options failed (mismatch in drive type)
106-01	Keyboard controller test failed	163-xx	Time and date not set
107-01	CMOS RAM test failed	164-xx	Memory size
108-02	CMOS interrupt test failed	199-00	Installed devices test failed
108-03	CMOS not properly initialized (int.test)		
109-01	CMOS clock load data test failed		
109-02	CMOS clock rollover test failed		
109-03	CMOS not properly initialized (clk test)		

**NOTE:** A 102 message code may be caused by one of a variety of processor-related problems that may be solved by replacing the processor, although system board replacement may be needed.

## A.5 MEMORY ERROR MESSAGES (2xx-xx)

**Table A-4.**  
Memory Error Messages

Message	Probable Cause
200-04	Real memory size changed
200-05	Extended memory size changed
200-06	Invalid memory configuration
200-07	Extended memory size changed
200-08	CLIM memory size changed
201-01	Memory machine ID test failed
202-01	Memory system ROM checksum failed
202-02	Failed RAM/ROM map test
202-03	Failed RAM/ROM protect test
203-01	Memory read/write test failed
203-02	Error while saving block in read/write test
203-03	Error while restoring block in read/write test
204-01	Memory address test failed
204-02	Error while saving block in address test
204-03	Error while restoring block in address test
204-04	A20 address test failed
204-05	Page hit address test failed
205-01	Walking I/O test failed
205-02	Error while saving block in walking I/O test
205-03	Error while restoring block in walking I/O test
206-xx	Increment pattern test failed
207-xx	ECC failure
210-01	Memory increment pattern test
210-02	Error while saving memory during increment pattern test
210-03	Error while restoring memory during increment pattern test
211-01	Memory random pattern test
211-02	Error while saving memory during random memory pattern test
211-03	Error while restoring memory during random memory pattern test
213-xx	Incompatible DIMM in slot x
214-xx	Noise test failed
215-xx	Random address test

## A.6 KEYBOARD ERROR MESSAGES (30x-xx)

**Table A-5.**  
Keyboard Error Messages

Message	Probable Cause	Message	Probable Cause
300-xx	Failed ID test	303-05	LED test, LED command test failed
301-01	Kybd short test, 8042 self-test failed	303-06	LED test, LED command test failed
301-02	Kybd short test, interface test failed	303-07	LED test, LED command test failed
301-03	Kybd short test, echo test failed	303-08	LED test, command byte restore test failed
301-04	Kybd short test, kybd reset failed	303-09	LED test, LEDs failed to light
301-05	Kybd short test, kybd reset failed	304-01	Keyboard repeat key test failed
302-xx	Failed individual key test	304-02	Unable to enter mode 3
302-01	Kybd long test failed	304-03	Incorrect scan code from keyboard
303-01	LED test, 8042 self-test failed	304-04	No Make code observed
303-02	LED test, reset test failed	304-05	Cannot /disable repeat key feature
303-03	LED test, reset failed	304-06	Unable to return to Normal mode
303-04	LED test, LED command test failed	--	--

## A.7 PRINTER ERROR MESSAGES (4xx-xx)

**Table A-6.**  
Printer Error Messages

Message	Probable Cause	Message	Probable Cause
401-01	Printer failed or not connected	402-11	Interrupt test, data/cntrl. reg. failed
402-01	Printer data register failed	402-12	Interrupt test and loopback test failed
402-02	Printer control register failed	402-13	Int. test, LpBk. test., and data register failed
402-03	Data and control registers failed	402-14	Int. test, LpBk. test., and cntrl. register failed
402-04	Loopback test failed	402-15	Int. test, LpBk. test., and data/cntrl. reg. failed
402-05	Loopback test and data reg. failed	402-16	Unexpected interrupt received
402-06	Loopback test and cntrl. reg. failed	402-01	Printer pattern test failed
402-07	Loopback tst, data/cntrl. reg. failed	403-xx	Printer pattern test failed
402-08	Interrupt test failed	404-xx	Parallel port address conflict
402-09	Interrupt test and data reg. failed	498-00	Printer failed or not connected
402-10	Interrupt test and control reg. failed	--	--

## A.8 VIDEO (GRAPHICS) ERROR MESSAGES (5xx-xx)

**Table A-7.**  
Video (Graphics) Error Messages

Message	Probable Cause	Message	Probable Cause
501-01	Video controller test failed	508-01	320x200 mode, color set 0 test failed
502-01	Video memory test failed	509-01	320x200 mode, color set 1 test failed
503-01	Video attribute test failed	510-01	640x200 mode test failed
504-01	Video character set test failed	511-01	Screen memory page test failed
505-01	80x25 mode, 9x14 cell test failed	512-01	Gray scale test failed
506-01	80x25 mode, 8x8 cell test failed	514-01	White screen test failed
507-01	40x25 mode test failed	516-01	Noise pattern test failed

See Table A-14 for additional graphics messages.

## A.9 DISKETTE DRIVE ERROR MESSAGES (6xx-xx)

**Table A-8.**  
Diskette Drive Error Messages

Message	Probable Cause	Message	Probable Cause
6xx-01	Exceeded maximum soft error limit	6xx-20	Failed to get drive type
6xx-02	Exceeded maximum hard error limit	6xx-21	Failed to get change line status
6xx-03	Previously exceeded max soft limit	6xx-22	Failed to clear change line status
6xx-04	Previously exceeded max hard limit	6xx-23	Failed to set drive type in ID media
6xx-05	Failed to reset controller	6xx-24	Failed to read diskette media
6xx-06	Fatal error while reading	6xx-25	Failed to verify diskette media
6xx-07	Fatal error while writing	6xx-26	Failed to read media in speed test
6xx-08	Failed compare of R/W buffers	6xx-27	Failed speed limits
6xx-09	Failed to format a tract	6xx-28	Failed write-protect test
6xx-10	Failed sector wrap test	--	--

600-xx = Diskette drive ID test  
 601-xx = Diskette drive format  
 602-xx = Diskette read test  
 603-xx = Diskette drive R/W compare test  
 604-xx = Diskette drive random seek test  
 605-xx = Diskette drive ID media  
 606-xx = Diskette drive speed test  
 607-xx = Diskette drive wrap test  
 608-xx = Diskette drive write-protect test

609-xx = Diskette drive reset controller test  
 610-xx = Diskette drive change line test  
 611-xx = Pri. diskette drive port addr. conflict  
 612-xx = Sec. diskette drive port addr. conflict  
 694-00 = Pin 34 not cut on 360-KB drive  
 697-00 = Diskette type error  
 698-00 = Drive speed not within limits  
 699-00 = Drive/media ID error (run Setup)

## A.10 SERIAL INTERFACE ERROR MESSAGES (11xx-xx)

**Table A-9.**  
Serial Interface Error Messages

Message	Probable Cause	Message	Probable Cause
1101-01	UART DLAB bit failure	1101-13	UART cntrl. signal interrupt failure
1101-02	Line input or UART fault	1101-14	DRVR/RCVR data failure
1101-03	Address line fault	1109-01	Clock register initialization failure
1101-04	Data line fault	1109-02	Clock register rollover failure
1101-05	UART cntrl. signal failure	1109-03	Clock reset failure
1101-06	UART THREE bit failure	1109-04	Input line or clock failure
1101-07	UART Data RDY bit failure	1109-05	Address line fault
1101-08	UART TX/RX buffer failure	1109-06	Data line fault
1101-09	Interrupt circuit failure	1150-xx	Comm port setup error (run Setup)
1101-10	COM1 set to invalid INT	1151-xx	COM1 address conflict
1101-11	COM2 set to invalid INT	1152-xx	COM2 address conflict
1101-12	DRVR/RCVR cntrl. signal failure	1155-xx	COM port address conflict

## A.11 MODEM COMMUNICATIONS ERROR MESSAGES (12xx-xx)

**Table A-10.**  
Serial Interface Error Messages

Message	Probable Cause	Message	Probable Cause
1201-XX	Modem internal loopback test	1204-03	Data block retry limit reached [4]
1201-01	UART DLAB bit failure	1204-04	RX exceeded carrier lost limit
1201-02	Line input or UART failure	1204-05	TX exceeded carrier lost limit
1201-03	Address line failure	1204-06	Time-out waiting for dial tone
1201-04	Data line fault	1204-07	Dial number string too long
1201-05	UART control signal failure	1204-08	Modem time-out waiting for remote response
1201-06	UART THREE bit failure	1204-09	Modem exceeded maximum redial limit
1201-07	UART DATA READY bit failure	1204-10	Line quality prevented remote response
1201-08	UART TX/RX buffer failure	1204-11	Modem time-out waiting for remote connection
1201-09	Interrupt circuit failure	1205-XX	Modem auto answer test
1201-10	COM1 set to invalid interrupt	1205-01	Time-out waiting for SYNC [5]
1201-11	COM2 set to invalid	1205-02	Time-out waiting for response [5]
1201-12	DRVVR/RCVVR control signal failure	1205-03	Data block retry limit reached [5]
1201-13	UART control signal interrupt failure	1205-04	RX exceeded carrier lost limit
1201-14	DRVVR/RCVVR data failure	1205-05	TX exceeded carrier lost limit
1201-15	Modem detection failure	1205-06	Time-out waiting for dial tone
1201-16	Modem ROM, checksum failure	1205-07	Dial number string too long
1201-17	Tone detect failure	1205-08	Modem time-out waiting for remote response
1202-XX	Modem internal test	1205-09	Modem exceeded maximum redial limit
1202-01	Time-out waiting for SYNC [1]	1205-10	Line quality prevented remote response
1202-02	Time-out waiting for response [1]	1205-11	Modem time-out waiting for remote connection
1202-03	Data block retry limit reached [1]	1206-XX	Dial multi-frequency tone test
1202-11	Time-out waiting for SYNC [2]	1206-17	Tone detection failure
1202-12	Time-out waiting for response [2]	1210-XX	Modem direct connect test
1202-13	Data block retry limit reached [2]	1210-01	Time-out waiting for SYNC [6]
1202-21	Time-out waiting for SYNC [3]	1210-02	Time-out waiting for response [6]
1202-22	Time-out waiting for response [3]	1210-03	Data block retry limit reached [6]
1202-23	Data block retry limit reached [3]	1210-04	RX exceeded carrier lost limit
1203-XX	Modem external termination test	1210-05	TX exceeded carrier lost limit
1203-01	Modem external TIP/RING failure	1210-06	Time-out waiting for dial tone
1203-02	Modem external data TIP/RING fail	1210-07	Dial number string too long
1203-03	Modem line termination failure	1210-08	Modem time-out waiting for remote response
1204-XX	Modem auto originate test	1210-09	Modem exceeded maximum redial limit
1204-01	Time-out waiting for SYNC [4]	1210-10	Line quality prevented remote response
1204-02	Time-out waiting for response [4]	1210-11	Modem time-out waiting for remote connection

NOTES:

- [1] Local loopback mode
- [2] Analog loopback originate mode
- [3] Analog loopback answer mode
- [4] Modem auto originate test
- [5] Modem auto answer test
- [6] Modem direct connect test

## A.12 SYSTEM STATUS ERROR MESSAGES (16xx-xx)

Message	Probable Cause
1601-xx	Temperature violation
1611-xx	Fan failure

## A.13 HARD DRIVE ERROR MESSAGES (17xx-xx)

Message	Probable Cause	Message	Probable Cause
17xx-01	Exceeded max. soft error limit	17xx-51	Failed I/O read test
17xx-02	Exceeded max. Hard error limit	17xx-52	Failed file I/O compare test
17xx-03	Previously exceeded max. soft error limit	17xx-53	Failed drive/head register test
17xx-04	Previously exceeded max. hard error limit	17xx-54	Failed digital input register test
17xx-05	Failed to reset controller	17xx-55	Cylinder 1 error
17xx-06	Fatal error while reading	17xx-56	Failed controller RAM diagnostics
17xx-07	Fatal error while writing	17xx-57	Failed controller-to-drive diagnostics
17xx-08	Failed compare of R/W buffers	17xx-58	Failed to write sector buffer
17xx-09	Failed to format a track	17xx-59	Failed to read sector buffer
17xx-10	Failed diskette sector wrap during read	17xx-60	Failed uncorrectable ECC error
17xx-19	Cntrl. failed to deallocate bad sectors	17xx-62	Failed correctable ECC error
17xx-40	Cylinder 0 error	17xx-63	Failed soft error rate
17xx-41	Drive not ready	17xx-65	Exceeded max. bad sectors per track
17xx-42	Failed to recalibrate drive	17xx-66	Failed to initialize drive parameter
17xx-43	Failed to format a bad track	17xx-67	Failed to write long
17xx-44	Failed controller diagnostics	17xx-68	Failed to read long
17xx-45	Failed to get drive parameters from ROM	17xx-69	Failed to read drive size
17xx-46	Invalid drive parameters from ROM	17xx-70	Failed translate mode
17xx-47	Failed to park heads	17xx-71	Failed non-translate mode
17xx-48	Failed to move hard drive table to RAM	17xx-72	Bad track limit exceeded
17xx-49	Failed to read media in file write test	17xx-73	Previously exceeded bad track limit
17xx-50	Failed I/O write test	--	--

1700-xx = Hard drive ID test	1719-xx = Hard drive power mode test
1701-xx = Hard drive format test	1720-xx = SMART drive detects imminent failure
1702-xx = Hard drive read test	1721-xx = SCSI hard drive imminent failure
1703-xx = Hard drive read/write compare test	1724-xx = Net work preparation test
1704-xx = Hard drive random seek test	1736-xx = Drive monitoring test
1705-xx = Hard drive controller test	1771-xx = Pri. IDE controller address conflict
1706-xx = Hard drive ready test	1772-xx = Sec. IDE controller address conflict
1707-xx = Hard drive recalibrate test	1780-xx = Disk 0 failure
1708-xx = Hard drive format bad track test	1781-xx = Disk 1 failure
1709-xx = Hard drive reset controller test	1782-xx = Pri. IDE controller failure
1710-xx = Hard drive park head test	1790-xx = Disk 0 failure
1714-xx = Hard drive file write test	1791-xx = Disk 1 failure
1715-xx = Hard drive head select test	1792-xx = Se. controller failure
1716-xx = Hard drive conditional format test	1793-xx = Sec. Controller or disk failure
1717-xx = Hard drive ECC test	1799-xx = Invalid hard drive type



## A.14 HARD DRIVE ERROR MESSAGES (19xx-xx)

**Table A-13.**  
Hard Drive Error Messages

Message	Probable Cause	Message	Probable Cause
19xx-01	Drive not installed	19xx-21	Got servo pulses second time but not first
19xx-02	Cartridge not installed	19xx-22	Never got to EOT after servo check
19xx-03	Tape motion error	19xx-23	Change line unset
19xx-04	Drive busy error	19xx-24	Write-protect error
19xx-05	Track seek error	19xx-25	Unable to erase cartridge
19xx-06	Tape write-protect error	19xx-26	Cannot identify drive
19xx-07	Tape already Servo Written	19xx-27	Drive not compatible with controller
19xx-08	Unable to Servo Write	19xx-28	Format gap error
19xx-09	Unable to format	19xx-30	Exception bit not set
19xx-10	Format mode error	19xx-31	Unexpected drive status
19xx-11	Drive recalibration error	19xx-32	Device fault
19xx-12	Tape not Servo Written	19xx-33	Illegal command
19xx-13	Tape not formatted	19xx-34	No data detected
19xx-14	Drive time-out error	19xx-35	Power-on reset occurred
19xx-15	Sensor error flag	19xx-36	Failed to set FLEX format mode
19xx-16	Block locate (block ID) error	19xx-37	Failed to reset FLEX format mode
19xx-17	Soft error limit exceeded	19xx-38	Data mismatch on directory track
19xx-18	Hard error limit exceeded	19xx-39	Data mismatch on track 0
19xx-19	Write (probably ID ) error	19xx-40	Failed self-test
19xx-20	NEC fatal error	19xx-91	Power lost during test

1900-xx = Tape ID test failed  
 1901-xx = Tape servo write failed  
 1902-xx = Tape format failed  
 1903-xx = Tape drive sensor test failed

1904-xx = Tape BOT/EOT test failed  
 1905-xx = Tape read test failed  
 1906-xx = Tape R/W compare test failed  
 1907-xx = Tape write-protect failed

## A.15 VIDEO (GRAPHICS) ERROR MESSAGES (24xx-xx)

**Table A-14.**  
Video (Graphics) Error Messages

Message	Probable Cause	Message	Probable Cause
2402-01	Video memory test failed	2418-02	EGA shadow RAM test failed
2403-01	Video attribute test failed	2419-01	EGA ROM checksum test failed
2404-01	Video character set test failed	2420-01	EGA attribute test failed
2405-01	80x25 mode, 9x14 cell test failed	2421-01	640x200 mode test failed
2406-01	80x25 mode, 8x8 cell test failed	2422-01	640x350 16-color set test failed
2407-01	40x25 mode test failed	2423-01	640x350 64-color set test failed
2408-01	320x200 mode color set 0 test failed	2424-01	EGA Mono. text mode test failed
2409-01	320x200 mode color set 1 test failed	2425-01	EGA Mono. graphics mode test failed
2410-01	640x200 mode test failed	2431-01	640x480 graphics mode test failed
2411-01	Screen memory page test failed	2432-01	320x200 256-color set test failed
2412-01	Gray scale test failed	2448-01	Advanced VGA controller test failed
2414-01	White screen test failed	2451-01	132-column AVGA test failed
2416-01	Noise pattern test failed	2456-01	AVGA 256-color test failed
2417-01	Lightpen text test failed, no response	2458-xx	AVGA BitBLT test failed
2417-02	Lightpen text test failed, invalid response	2468-xx	AVGA DAC test failed
2417-03	Lightpen graphics test failed, no resp.	2477-xx	AVGA data path test failed
2417-04	Lightpen graphics test failed, invalid resp.	2478-xx	AVGA BitBLT test failed
2418-01	EGA memory test failed	2480-xx	AVGA linedraw test failed

## A.16 AUDIO ERROR MESSAGES (3206-xx)

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**Table A-15.**  
Audio Error Message

Message	Probable Cause
3206-xx	Audio subsystem internal error

## A.17 DVD/CD-ROM ERROR MESSAGES (33xx-xx)

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**Table A-16.**  
DVD/CD-ROM Drive Error Messages

Message	Probable Cause
3301-xx	Drive test failed
3305-XX	Seek test failed

See Table A-18 for additional messages.

## A.18 NETWORK INTERFACE ERROR MESSAGES (60xx-xx)

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**Table A-17.**  
Network Interface Error Messages

Message	Probable Cause	Message	Probable Cause
6000-xx	Pointing device interface error	6054-xx	Token ring configuration test failed
6014-xx	Ethernet configuration test failed	6056-xx	Token ring reset test failed
6016-xx	Ethernet reset test failed	6068-xx	Token ring int. loopback test failed
6028-xx	Ethernet int. loopback test failed	6069-xx	Token ring ext. loopback test failed
6029-xx	Ethernet ext. loopback test failed	6089-xx	Token ring open

## A.19 SCSI INTERFACE ERROR MESSAGES (65xx-xx, 66xx-xx, 67xx-xx)

**Table A-18.**  
SCSI Interface Error Messages

Message	Probable Cause	Message	Probable Cause
6nyy-02	Drive not installed	6nyy-33	Illegal controller command
6nyy-03	Media not installed	6nyy-34	Invalid SCSI bus phase
6nyy-05	Seek failure	6nyy-35	Invalid SCSI bus phase
6nyy-06	Drive timed out	6nyy-36	Invalid SCSI bus phase
6nyy-07	Drive busy	6nyy-39	Error status from drive
6nyy-08	Drive already reserved	6nyy-40	Drive timed out
6nyy-09	Reserved	6nyy-41	SSI bus stayed busy
6nyy-10	Reserved	6nyy-42	ACK/REQ lines bad
6nyy-11	Media soft error	6nyy-43	ACK did not deassert
6nyy-12	Drive not ready	6nyy-44	Parity error
6nyy-13	Media error	6nyy-50	Data pins bad
6nyy-14	Drive hardware error	6nyy-51	Data line 7 bad
6nyy-15	Illegal drive command	6nyy-52	MSG, C/D, or I/O lines bad
6nyy-16	Media was changed	6nyy-53	BSY never went busy
6nyy-17	Tape write-protected	6nyy-54	BSY stayed busy
6nyy-18	No data detected	6nyy-60	Controller CONFIG-1 register fault
6nyy-21	Drive command aborted	6nyy-61	Controller CONFIG-2 register fault
6nyy-24	Media hard error	6nyy-65	Media not unloaded
6nyy-25	Reserved	6nyy-90	Fan failure
6nyy-30	Controller timed out	6nyy-91	Over temperature condition
6nyy-31	Unrecoverable error	6nyy-92	Side panel not installed
6nyy-32	Controller/drive not connected	6nyy-99	Autoloader reported tape not loaded properly

n = 5, Hard drive  
 = 6, CD-ROM drive  
 = 7, Tape drive.

yy = 00, ID  
 = 03, Power check  
 = 05, Read  
 = 06, SA/Media  
 = 08, Controller  
 = 23, Random read  
 = 28, Media load/unload

## A.20 POINTING DEVICE INTERFACE ERROR MESSAGES (8601-xx)

**Table A-19.**  
Pointing Device Interface Error Messages

Message	Probable Cause	Message	Probable Cause
8601-01	Mouse ID fails	8601-07	Right block not selected
8601-02	Left mouse button is inoperative	8601-08	Timeout occurred
8601-03	Left mouse button is stuck closed	8601-09	Mouse loopback test failed
8601-04	Right mouse button is inoperative	8601-10	Pointing device is inoperative
8601-05	Right mouse button is stuck closed	8602-xx	I/F test failed
8601-06	Left block not selected	--	--

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# Appendix B ASCII CHARACTER SET

## B.1 INTRODUCTION

This appendix lists, in Table B-1, the 256-character ASCII code set including the decimal and hexadecimal values. All ASCII symbols may be called while in DOS or using standard text-mode editors by using the combination keystroke of holding the **Alt** key and using the Numeric Keypad to enter the decimal value of the symbol. The extended ASCII characters (decimals 128-255) can only be called using the **Alt** + Numeric Keypad keys.

**NOTE:** Regarding keystrokes, refer to notes at the end of the table. Applications may interpret multiple keystroke accesses differently or ignore them completely.

**Table B-1.**  
ASCII Character Set

Dec	Hex	Symbol	Dec	Hex	Symbol	Dec	Hex	Symbol	Dec	Hex	Symbol
0	00	Blank	32	20	Space	64	40	@	96	60	`
1	01	☺	33	21	!	65	41	A	97	61	a
2	02	☹	34	22	"	66	42	B	98	62	b
3	03	♥	35	23	#	67	43	C	99	63	c
4	04	♦	36	24	\$	68	44	D	100	64	d
5	05	♣	37	25	%	69	45	E	101	65	e
6	06	♠	38	26	&	70	46	F	102	66	f
7	07	●	39	27	'	71	47	G	103	67	g
8	08	○	40	28	(	72	48	H	104	68	h
9	09	○	41	29	)	73	49	I	105	69	i
10	0A	○	42	2A	*	74	4A	J	106	6A	j
11	0B	○	43	2B	+	75	4B	K	107	6B	k
12	0C	○	44	2C	,	76	4C	L	108	6C	l
13	0D	→	45	2D	-	77	4D	M	109	6D	m
14	0E	↖	46	2E	.	78	4E	N	110	6E	n
15	0F	↗	47	2F	/	79	4F	O	111	6F	o
16	10	↘	48	30	0	80	50	P	112	70	p
17	11	↙	49	31	1	81	51	Q	113	71	q
18	12	↕	50	32	2	82	52	R	114	72	r
19	13	!!	51	33	3	83	53	S	115	73	s
20	14	¶	52	34	4	84	54	T	116	74	t
21	15	\$	53	35	5	85	55	U	117	75	u
22	16	↑	54	36	6	86	56	V	118	76	v
23	17	↑	55	37	7	87	57	W	119	77	w
24	18	↑	56	38	8	88	58	X	120	78	x
25	19	↓	57	39	9	89	59	Y	121	79	y
26	1A	→	58	3A	:	90	5A	Z	122	7A	z
27	1B	←	59	3B	;	91	5B	[	123	7B	{
28	1C	┌	60	3C	<	92	5C	\	124	7C	
29	1D	└	61	3D	=	93	5D	]	125	7D	}
30	1E	▲	62	3E	>	94	5E	^	126	7E	~
31	1F	▼	63	3F	?	95	5F	_	127	7F	△ [1]

Continued

**Table B-1.** ASCII Code Set (Continued)

Appendix B ASCII Character Set

Dec	Hex	Symbol	Dec	Hex	Symbol	Dec	Hex	Symbol	Dec	Hex	Symbol
128	80	Ç	160	A0	à	192	C0	ƒ	224	E0	α
129	81	ü	161	A1	á	193	C1	‡	225	E1	β
130	82	é	162	A2	ó	194	C2	†	226	E2	Γ
131	83	â	163	A3	ú	195	C3	‡	227	E3	π
132	84	â	164	A4	ñ	196	C4	—	228	E4	Σ
133	85	à	165	A5	Ñ	197	C5	†	229	E5	σ
134	86	â	166	A6	ª	198	C6	‡	230	E6	μ
135	87	ç	167	A7	º	199	C7	‡	231	E7	τ
136	88	ê	168	A8	¿	200	C8	‡	232	E8	φ
137	89	ë	169	A9	¬	201	C9	‡	233	E9	Θ
138	8A	è	170	AA	¬	202	CA	‡	234	EA	Ω
139	8B	ï	171	AB	½	203	CB	‡	235	EB	δ
140	8C	î	172	AC	¼	204	CC	‡	236	EC	ε
141	8D	ì	173	AD	¡	205	CD	=	237	ED	φ
142	8E	Ä	174	AE	«	206	CE	‡	238	EE	ε
143	8F	Å	175	AF	»	207	CF	‡	239	EF	∩
144	90	É	176	B0	█	208	D0	‡	240	F0	≡
145	91	æ	177	B1	█	209	D1	‡	241	F1	±
146	92	Æ	178	B2	█	210	D2	‡	242	F2	λ
147	93	ô	179	B3	‡	211	D3	‡	243	F3	≤
148	94	ö	180	B4	‡	212	D4	‡	244	F4	∫
149	95	ò	181	B5	‡	213	D5	‡	245	F5	∫
150	96	û	182	B6	‡	214	D6	‡	246	F6	+
151	97	ù	183	B7	‡	215	D7	‡	247	F7	≈
152	98	ÿ	184	B8	‡	216	D8	‡	248	F8	°
153	99	ÿ	185	B9	‡	217	D9	‡	249	F9	·
154	9A	Û	186	BA	‡	218	DA	‡	250	FA	·
155	9B	ç	187	BB	‡	219	DB	█	251	FB	√
156	9C	£	188	BC	‡	220	DC	█	252	FC	n
157	9D	¥	189	BD	‡	221	DD	█	253	FD	²
158	9E	ℳ	190	BE	‡	222	DE	█	254	FE	█
159	9F	f	191	BF	‡	223	DF	█	255	FF	Blank

NOTES:

[1] Symbol not displayed.

Keystroke Guide:

Dec #	Keystroke(s)
0	Ctrl 2
1-26	Ctrl A thru Z respectively
27	Ctrl [
28	Ctrl
29	Ctrl ]
30	Ctrl 6
31	Ctrl -
32	Space Bar
33-43	Shift and key w/corresponding symbol
44-47	Key w/corresponding symbol
48-57	Key w/corresponding symbol, numerical keypad w/Num Lock active
58	Shift and key w/corresponding symbol
59	Key w/corresponding symbol
60	Shift and key w/corresponding symbol
61	Key w/corresponding symbol
62-64	Shift and key w/corresponding symbol
65-90	Shift and key w/corresponding symbol or key w/corresponding symbol and Caps Lock active
91-93	Key w/corresponding symbol
94, 95	Shift and key w/corresponding symbol
96	Key w/corresponding symbol
97-126	Key w/corresponding symbol or Shift and key w/corresponding symbol and Caps Lock active
127	Ctrl -
128-255	Alt and decimal digit(s) of desired character

## Appendix C KEYBOARD

### C.1 INTRODUCTION

This appendix describes the Compaq keyboard that is included as standard with the system unit. The keyboard complies with the industry-standard classification of an “enhanced keyboard” and includes a separate cursor control key cluster, twelve “function” keys, and enhanced programmability for additional functions.

This appendix covers the following keyboard types:

- ◆ Standard enhanced keyboard.
- ◆ Space-Saver Windows-version keyboard featuring additional keys for specific support of the Windows operating system.
- ◆ Easy Access keyboard with additional buttons for internet accessibility functions.

Only one type of keyboard is supplied with each system. Other types may be available as an option.

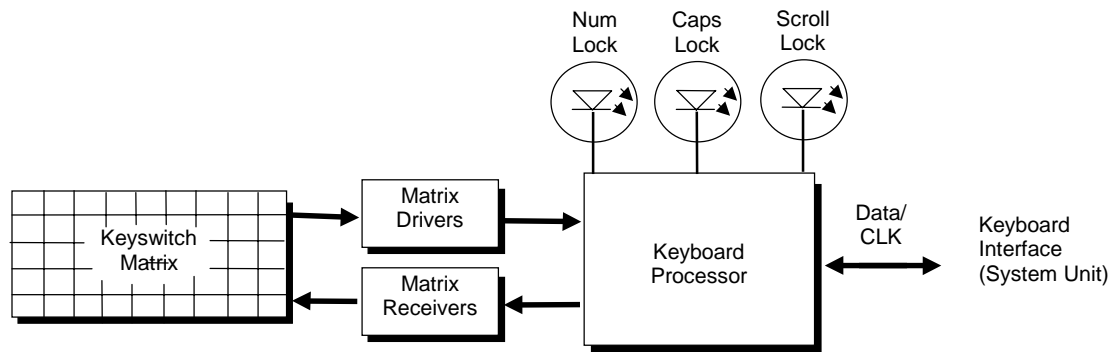
**NOTE:** This appendix discusses only the keyboard unit. The keyboard interface is a function of the system unit and is discussed in Chapter 5, Input/Output Interfaces.

Topics covered in this appendix include the following:

- ◆ Keystroke processing (C.2)                      page C-2
- ◆ Connectors (C.3)                                page C-16

## C.2 KEYSTROKE PROCESSING

A functional block diagram of the keystroke processing elements is shown in Figure C-1. Power (+5 VDC) is obtained from the system through the PS/2-type interface. The keyboard uses a Z86C14 (or equivalent) microprocessor. The Z86C14 scans the key matrix drivers every 10 ms for pressed keys while at the same time monitoring communications with the keyboard interface of the system unit. When a key is pressed, a Make code is generated. A Break code is generated when the key is released. The Make and Break codes are collectively referred to as scan codes. All keys generate Make and Break codes with the exception of the Pause key, which generates a Make code only.



**Figure C-1.** Keystroke Processing Elements, Block Diagram

When the system is turned on, the keyboard processor generates a Power-On Reset (POR) signal after a period of 150 ms to 2 seconds. The keyboard undergoes a Basic Assurance Test (BAT) that checks for shorted keys and basic operation of the keyboard processor. The BAT takes from 300 to 500 ms to complete.

If the keyboard fails the BAT, an error code is sent to the CPU and the keyboard is disabled until an input command is received. After successful completion of the POR and BAT, a completion code (AAh) is sent to the CPU and the scanning process begins.

The keyboard processor includes a 16-byte FIFO buffer for holding scan codes until the system is ready to receive them. Response and typematic codes are not buffered. If the buffer is full (16 bytes held) a 17<sup>th</sup> byte of a successive scan code results in an overrun condition and the overrun code replaces the scan code byte and any additional scan code data (and the respective key strokes) are lost. Multi-byte sequences must fit entirely into the buffer before the respective keystroke can be registered.



### C.2.1 PS/2-TYPE KEYBOARD TRANSMISSIONS

The PS/2-type keyboard sends two main types of data to the system; commands (or responses to system commands) and keystroke scan codes. Before the keyboard sends data to the system (specifically, to the 8042-type logic within the system), the keyboard verifies the clock and data lines to the system. If the clock signal is low (0), the keyboard recognizes the inhibited state and loads the data into a buffer. Once the inhibited state is removed, the data is sent to the system. Keyboard-to-system transfers (in the default mode) consist of 11 bits as shown in Figure C-2.

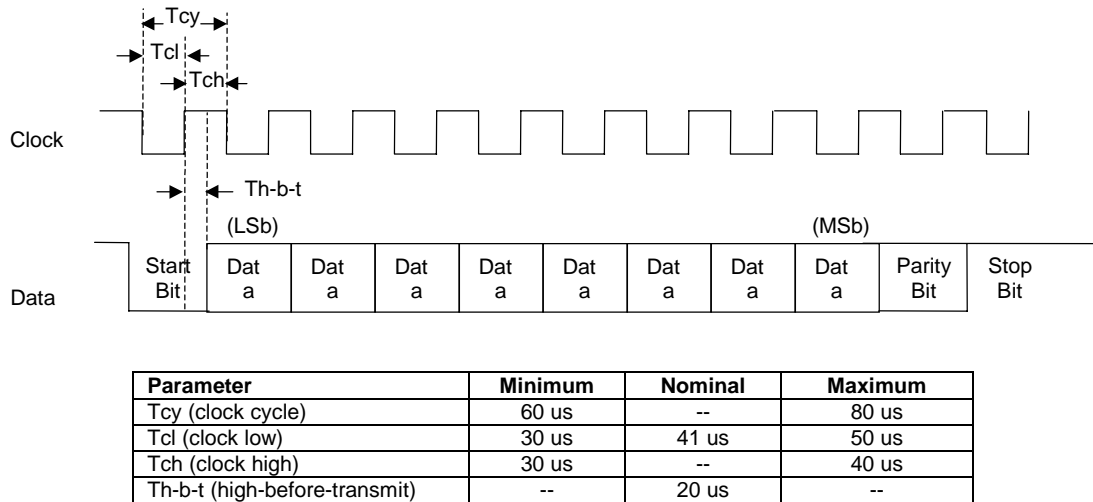


Figure C-2. PS/2 Keyboard-To-System Transmission, Timing Diagram

The system can halt keyboard transmission by setting the clock signal low. The keyboard checks the clock line every 60 us to verify the state of the signal. If a low is detected, the keyboard will finish the current transmission **if** the rising edge of the clock pulse for the parity bit has not occurred. The system uses the same timing relationships during reads (typically with slightly reduced time periods).

The enhanced keyboard has three operating modes:

- ◆ Mode 1 - PC-XT compatible
- ◆ Mode 2 - PC-AT compatible (default)
- ◆ Mode 3 - Select mode (keys are programmable as to make-only, break-only, typematic)

Modes can be selected by the user or set by the system. Mode 2 is the default mode. Each mode produces a different set of scan codes. When a key is pressed, the keyboard processor sends that key's make code to the 8042 logic of the system unit. When the key is released, a release code is transmitted as well (except for the Pause key, which produces only a make code). The 8042-type logic of the system unit responds to scan code reception by asserting IRQ1, which is processed by the interrupt logic and serviced by the CPU with an interrupt service routine. The service routine takes the appropriate action based on which key was pressed.

## **C.2.2 USB-TYPE KEYBOARD TRANSMISSIONS**

The USB-type keyboard sends essentially the same information to the system that the PS/2 keyboard does except that the data receives additional NRZI encoding and formatting (prior to leaving the keyboard) to comply with the USB I/F specification (discussed in chapter 5 of this guide).

Packets received at the system's USB I/F and decoded as originating from the keyboard result in an SMI being generated. An SMI handler routine is invoked that decodes the data and transfers the information to the 8042 keyboard controller where normal (legacy) keyboard processing takes place.

### C.2.3 KEYBOARD LAYOUTS

Figures C-3 through C-8 show the key layouts for keyboards shipped with Compaq systems. Actual styling details including location of the Compaq logo as well as the numbers lock, caps lock, and scroll lock LEDs may vary.

#### C.2.3.1 Standard Enhanced Keyboards

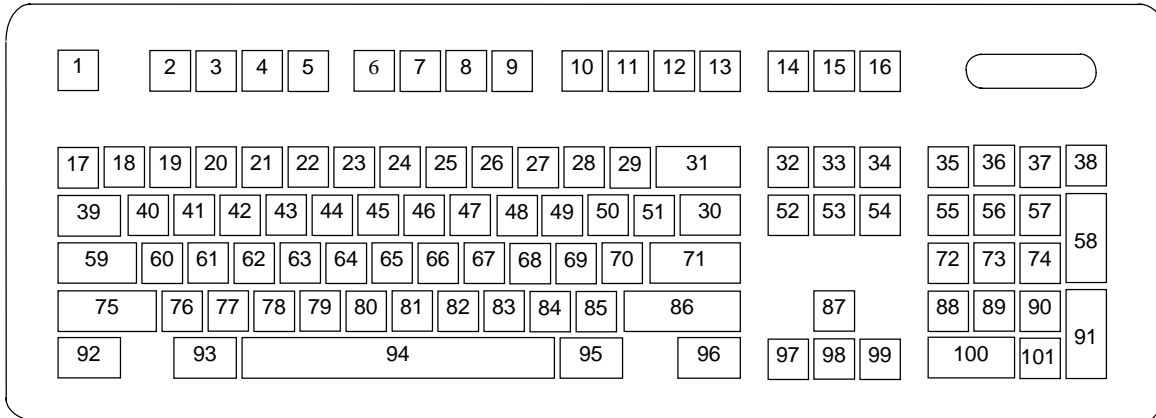


Figure C-3. U.S. English (101-Key) Keyboard Key Positions

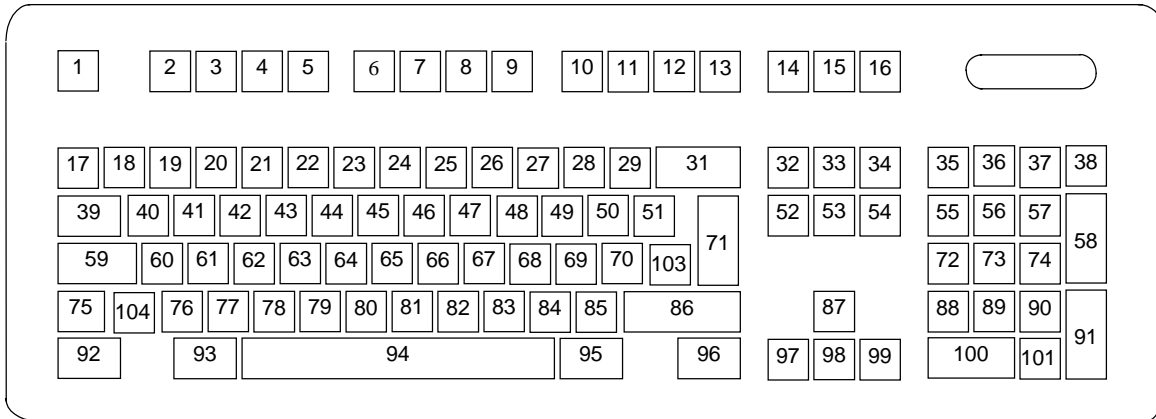
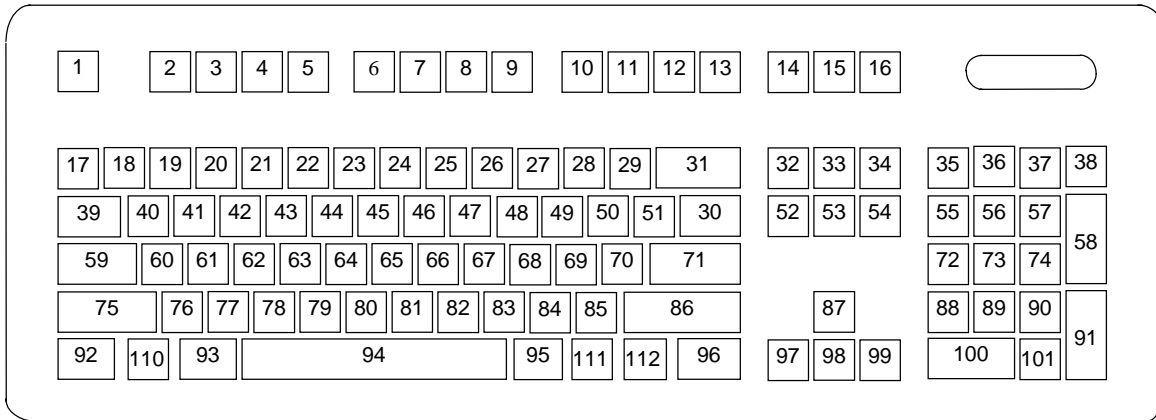
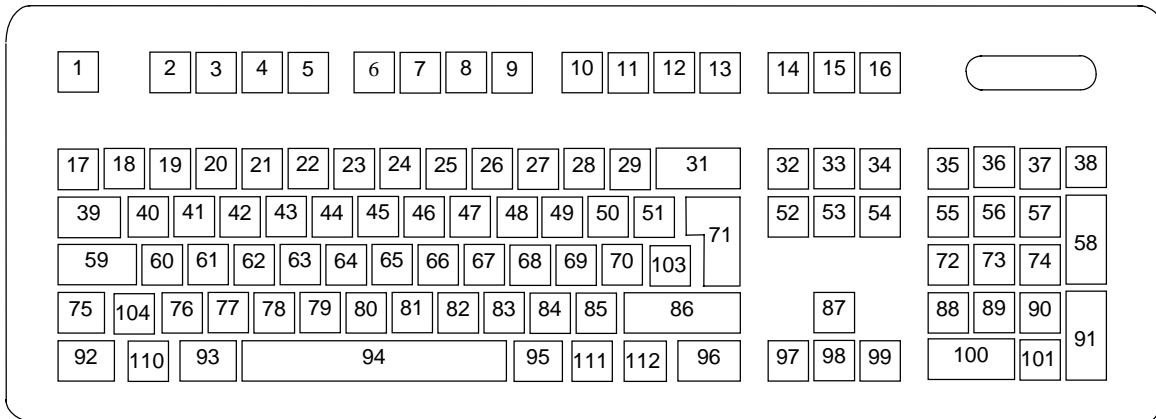


Figure C-4. National (102-Key) Keyboard Key Positions

### C.2.3.2 Windows Enhanced Keyboards



**Figure C-5.** U.S. English Windows (101W-Key) Keyboard Key Positions

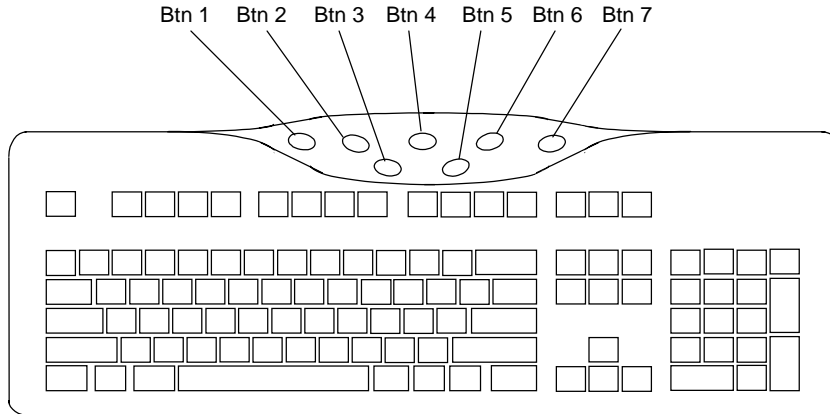


**Figure C-6.** National Windows (102W-Key) Keyboard Key Positions

### C.2.3.3 Easy Access Keyboards

The Easy Access keyboard is a Windows Enhanced-type keyboard that includes special buttons allowing quick internet navigation. Depending on system, either a 7-button or an 8-button layout may be supplied.

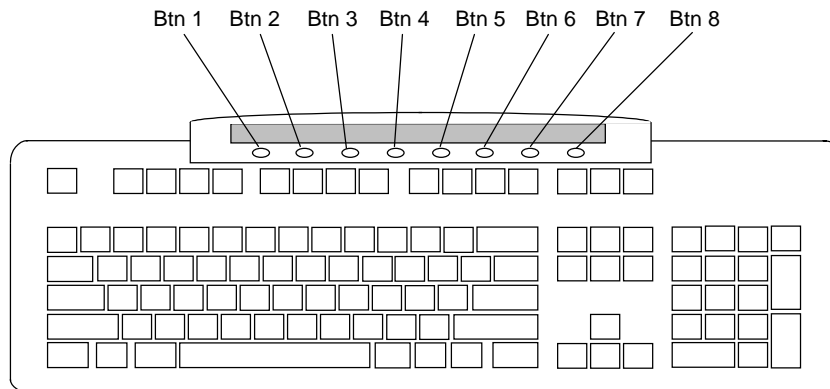
The 7-button Easy Access Keyboard uses the layout shown in Figure C-7 and is available with either a legacy PS/2-type keyboard connection or a Universal Serial Bus (USB) type connection.



NOTE:  
Main key positions same as Windows Enhanced (Figures C-5 or C-6).

**Figure C-7.** 7-Button Easy Access Keyboard Layout

The 8-button Easy Access Keyboard uses the layout shown in Figure C-8 and uses the PS/2-type connection.



NOTE:  
Main key positions same as Windows Enhanced (Figures C-5 or C-6).

**Figure C-8.** 8-Button Easy Access Keyboard Layout

## C.2.4 KEYS

All keys generate a make code (when pressed) and a break code (when released) with the exception of the **Pause** key (pos. 16), which produces a make code only. All keys with the exception of the **Pause** and Easy Access keys are also typematic, although the typematic action of the **Shift**, **Ctrl**, **Alt**, **Num Lock**, **Scroll Lock**, **Caps Lock**, and **Ins** keys is suppressed by the BIOS. Typematic keys, when held down longer than 500 ms, send the make code repetitively at a 10-12 Hz rate until the key is released. If more than one key is held down, the last key pressed will be typematic.

### C.2.4.1 Special Single-Keystroke Functions

The following keys provide the intended function in most applications and environments.

**Caps Lock** - The **Caps Lock** key (pos. 59), when pressed and released, invokes a BIOS routine that turns on the caps lock LED and shifts into upper case key positions 40-49, 60-68, and 76-82. When pressed and released again, these keys revert to the lower case state and the LED is turned off. Use of the **Shift** key will reverse which state these keys are in based on the **Caps Lock** key.

**Num Lock** - The **Num Lock** key (pos. 32), when pressed and released, invokes a BIOS routine that turns on the num lock LED and shifts into upper case key positions 55-57, 72-74, 88-90, 100, and 101. When pressed and released again, these keys revert to the lower case state and the LED is turned off.

The following keys provide special functions that require specific support by the application.

**Print Scrn** - The **Print Scrn** (pos. 14) key can, when pressed, generate an interrupt that initiates a print routine. This function may be inhibited by the application.

**Scroll Lock** - The **Scroll Lock** key (pos. 15) when pressed and released, , invokes a BIOS routine that turns on the scroll lock LED and inhibits movement of the cursor. When pressed and released again, the LED is turned off and the function is removed. This keystroke is always serviced by the BIOS (as indicated by the LED) but may be inhibited or ignored by the application.

**Pause** - The **Pause** (pos. 16) key, when pressed, can be used to cause the keyboard interrupt to loop, i.e., wait for another key to be pressed. This can be used to momentarily suspend an operation. The key that is pressed to resume operation is discarded. This function may be ignored by the application.

The **Esc**, **Fn** (function), **Insert**, **Home**, **Page Up/Down**, **Delete**, and **End** keys operate at the discretion of the application software.

### C.2.4.2 Multi-Keystroke Functions


**Shift** - The **Shift** key (pos. 75/86), when held down, produces a shift state (upper case) for keys in positions 17-29, 30, 39-51, 60-70, and 76-85 as long as the **Caps Lock** key (pos. 59) is toggled off. If the **Caps Lock** key is toggled on, then a held **Shift** key produces the lower (normal) case for the identified pressed keys. The **Shift** key also reverses the **Num Lock** state of key positions 55-57, 72, 74, 88-90, 100, and 101.

**Ctrl** - The **Ctrl** keys (pos. 92/96) can be used in conjunction with keys in positions 1-13, 16, 17-34, 39-54, 60-71, and 76-84. The application determines the actual function. Both **Ctrl** key positions provide identical functionality. The pressed combination of **Ctrl** and **Break** (pos. 16) results in the generation of BIOS function INT 1Bh. This software interrupt provides a method of exiting an application and generally halts execution of the current program.

**Alt** - The **Alt** keys (pos. 93/95) can be used in conjunction with the same keys available for use with the **Ctrl** keys with the exception that position 14 (**SysRq**) is available instead of position 16 (**Break**). The **Alt** key can also be used in conjunction with the numeric keypad keys (pos. 55-57, 72-74, and 88-90) to enter the decimal value of an ASCII character code from 1-255. The application determines the actual function of the keystrokes. Both **Alt** key positions provide identical functionality. The combination keystroke of **Alt** and **SysRq** results in software interrupt 15h, AX=8500h being executed. It is up to the application to use or not use this BIOS function.


The **Ctrl** and **Alt** keys can be used together in conjunction with keys in positions 1-13, 17-34, 39-54, 60-71, and 76-84. The **Ctrl** and **Alt** key positions used and the sequence in which they are pressed make no difference as long as they are held down at the time the third key is pressed. The **Ctrl**, **Alt**, and **Delete** keystroke combination (required twice if in the Windows environment) initiates a system reset (warm boot) that is handled by the BIOS.

### C.2.4.3 Windows Keystrokes

Windows-enhanced keyboards include three additional key positions. Key positions 110 and 111 (marked with the Windows logo ) have the same functionality and are used by themselves or in combination with other keys to perform specific “hot-key” type functions for the Windows operating system. The defined functions of the Windows logo keys are listed as follows:

Keystroke	Function
Window Logo	Open Start menu
Window Logo + F1	Display pop-up menu for the selected object
Window Logo + TAB	Activate next task bar button
Window Logo + E	Explore my computer
Window Logo + F	Find document
Window Logo + CTRL + F	Find computer
Window Logo + M	Minimize all
Shift + Window Logo + M	Undo minimize all
Window Logo + R	Display Run dialog box
Window Logo + PAUSE	Perform system function
Window Logo + 0-9	Reserved for OEM use (see following text)

The combination keystroke of the Window Logo + 1-0 keys are reserved for OEM use for auxiliary functions (speaker volume, monitor brightness, password, etc.).

Key position 112 (marked with an application window icon ) is used in combination with other keys for invoking Windows application functions.

### C.2.4.4 Easy Access Keystrokes

The Easy Access keyboards (Figures C-7 and C-8) include additional keys (also referred to as buttons) used to streamline internet access and navigation.

These buttons, which can be re-programmed to provide other functions, have the default functionality described below:

#### 7-Button Easy Access Keyboard:

Button #	Description	Default Function
1	Check email	Email
2	Go to community	Emoney
3	Extra web site	Compaq web site
4	Go to favorite web site	AltaVista web site
5	Internet search	Search
6	Instant answer	Travel expenses
7	E-commerce	Shopping

#### 8-Button Easy Access Keyboard:

Button #	Description	Default Function
1	Go to favorite web site	Customer web site of choice
2	Go to AltaVista	AltaVista web site
3	Search	AltaVista search engine
4	Check Email	Launches user Email
5	Business Community	Industry specification info
6	Market Monitor	Launches Bloomberg market monitor
7	Meeting Center	Links to user's project center
8	News/PC Lock	News retrieval service

All buttons may be re-programmed by the user through the Easy Access utility.



## C.2.5 KEYBOARD COMMANDS

Table C-1 lists the commands that the keyboard can send to the system (specifically, to the 8042-type logic).

**Table C-1.**  
Keyboard-to-System Commands

Command	Value	Description
Key Detection Error/Over/run	00h [1] FFh [2]	Indicates to the system that a switch closure couldn't be identified.
BAT Completion	AAh	Indicates to the system that the BAT has been successful.
BAT Failure	FCh	Indicates failure of the BAT by the keyboard.
Echo	EEh	Indicates that the Echo command was received by the keyboard.
Acknowledge (ACK)	FAh	Issued by the keyboard as a response to valid system inputs (except the Echo and Resend commands).
Resend	FEh	Issued by the keyboard following an invalid input.
Keyboard ID	83ABh	Upon receipt of the Read ID command from the system, the keyboard issues the ACK command followed by the two IDS bytes.

Note:

- [1] Modes 2 and 3.
- [2] Mode 1 only.

## C.2.6 SCAN CODES

The scan codes generated by the keyboard processor are determined by the mode the keyboard is operating in.

- ◆ **Mode 1:** In Mode 1 operation, the keyboard generates scan codes compatible with 8088-/8086-based systems. To enter Mode 1, the scan code translation function of the keyboard controller must be disabled. Since translation is not performed, the scan codes generated in Mode 1 are identical to the codes required by BIOS. Mode 1 is initiated by sending command F0h with the 01h option byte. Applications can obtain system codes and status information by using BIOS function INT 16h with AH=00h, 01h, and 02h.
- ◆ **Mode 2:** Mode 2 is the default mode for keyboard operation. In this mode, the 8042 logic translates the make codes from the keyboard processor into the codes required by the BIOS. This mode was made necessary with the development of the Enhanced III keyboard, which includes additional functions over earlier standard keyboards. Applications should use BIOS function INT 16h, with AH=10h, 11h, and 12h for obtaining codes and status data. In Mode 2, the keyboard generates the Break code, a two-byte sequence that consists of a Make code immediately preceded by F0h (i.e., Break code for 0Eh is "F0h 0Eh").
- ◆ **Mode 3:** Mode 3 generates a different scan code set from Modes 1 and 2. Code translation must be disabled since translation for this mode cannot be done.

**Table C-2.**  
Keyboard Scan Codes

Key Pos.	Legend	Make / Break Codes (Hex)		
		Mode 1	Mode 2	Mode 3
1	Esc	01/81	76/F0 76	08/na
2	F1	3B/BB	05/F0 05	07/na
3	F2	3C/BC	06/F0 06	0F/na
4	F3	3D/BD	04/F0 04	17/na
5	F4	3E/BE	0C/F0 0C	1F/na
6	F5	3F/BF	03/F0 03	27/na
7	F6	40/C0	0B/F0 0B	2F/na
8	F7	41/C1	83/F0 83	37/na
9	F8	42/C2	0A/F0 0A	3F/na
10	F9	43/C3	01/F0 01	47/na
11	F10	44/C4	09/F0 09	4F/na
12	F11	57/D7	78/F0 78	56/na
13	F12	58/D8	07/F0 07	5E/na
14	Print Scrn	E0 2A E0 37/E0 B7 E0 AA E0 37/E0 B7 [1] [2] 54/84 [3]	E0 2A E0 7C/E0 F0 7C E0 F0 12 E0 7C/E0 F0 7C [1] [2] 84/F0 84 [3]	57/na
15	Scroll Lock	46/C6	7E/F0 7E	5F/na
16	Pause	E1 1D 45 E1 9D C5/na E0 46 E0 C6/na [3]	E1 14 77 E1 F0 14 F0 77/na E0 7E E0 F0 7E/na [3]	62/na
17	`	29/A9	0E/F0 E0	0E/F0 0E
18	1	02/82	16/F0 16	46/F0 46
19	2	03/83	1E/F0 1E	1E/F0 1E
20	3	04/84	26/F0 26	26/F0 26
21	4	05/85	25/F0 25	25/F0 25
22	5	06/86	2E/F0 2E	2E/F0 2E
23	6	07/87	36/F0 36	36/F0 36
24	7	08/88	3D/F0 3D	3D/F0 3D
25	8	09/89	3E/F0 3E	3E/F0 3E
26	9	0A/8A	46/F0 46	46/F0 46
27	0	0B/8B	45/F0 45	45/F0 45
28	-	0C/8C	4E/F0 4E	4E/F0 4E
29	=	0D/8D	55/F0 55	55/F0 55
30	\	2B/AB	5D/F0 5D	5C/F0 5C
31	Backspace	0E/8E	66/F0 66	66/F0 66
32	Insert	E0 52/E0 D2 E0 AA E0 52/E0 D2 E0 2A [4] E0 2A E0 52/E0 D2 E0 AA [6]	E0 70/E0 F0 70 E0 F0 12 E0 70/E0 F0 70 E0 12 [5] E0 12 E0 70/E0 F0 70 E0 F0 12 [6]	67/na
33	Home	E0 47/E0 D2 E0 AA E0 52/E0 D2 E0 2A [4] E0 2A E0 47/E0 C7 E0 AA [6]	E0 6C/E0 F0 6C E0 F0 12 E0 6C/E0 F0 6C E0 12 [5] E0 12 E0 6C/E0 F0 6C E0 F0 12 [6]	6E/na
34	Page Up	E0 49/E0 C7 E0 AA E0 49/E0 C9 E0 2A [4] E0 2A E0 49/E0 C9 E0 AA [6]	E0 7D/E0 F0 7D E0 F0 12 E0 7D/E0 F0 7D E0 12 [5] E0 12 E0 7D/E0 F0 7D E0 F0 12 [6]	6F/na
35	Num Lock	45/C5	77/F0 77	76/na
36	/	E0 35/E0 B5 E0 AA E0 35/E0 B5 E0 2A [1]	E0 4A/E0 F0 4A E0 F0 12 E0 4A/E0 F0 4A E0 12 [1]	77/na
37	*	37/B7	7C/F0 7C	7E/na
38	-	4A/CA	7B/F0 7B	84/na
39	Tab	0F/8F	0D/F0 0D	0D/na
40	Q	10/90	15/F0 15	15/na

*Continued*

([x] Notes listed at end of table.)

**Table C-2. Keyboard Scan Codes (Continued)**

Key Pos	Legend	Make / Break Codes (Hex)		
		Mode 1	Mode 2	Mode 3
41	W	11/91	1D/F0 1D	1D/F0 1D
42	E	12/92	24/F0 24	24/F0 24
43	R	13/93	2D/F0 2D	2D/F0 2D
44	T	14/94	2C/F0 2C	2C/F0 2C
45	Y	15/95	35/F0 35	35/F0 35
46	U	16/96	3C/F0 3C	3C/F0 3C
47	I	17/97	43/F0 43	43/F0 43
48	O	18/98	44/F0 44	44/F0 44
49	P	19/99	4D/F0 4D	4D/F0 4D
50	[	1A/9A	54/F0 54	54/F0 54
51	]	1B/9B	5B/F0 5B	5B/F0 5B
52	Delete	E0 53/E0 D3 E0 AA E0 53/E0 D3 E0 2A [4] E0 2A E0 53/E0 D3 E0 AA [6]	E0 71/E0 F0 71 E0 F0 12 E0 71/E0 F0 71 E0 12 [5] E0 12 E0 71/E0 F0 71 E0 F0 12 [6]	64/F0 64
53	End	E0 4F/E0 CF E0 AA E0 4F/E0 CF E0 2A [4] E0 2A E0 4F/E0 CF E0 AA [6]	E0 69/E0 F0 69 E0 F0 12 E0 69/E0 F0 69 E0 12 [5] E0 12 E0 69/E0 F0 69 E0 F0 12 [6]	65/F0 65
54	Page Down	E0 51/E0 D1 E0 AA E0 51/E0 D1 E0 2A [4] E0 @a E0 51/E0 D1 E0 AA [6]	E0 7A/E0 F0 7A E0 F0 12 E0 7A/E0 F0 7A E0 12 [5] E0 12 E0 7A/E0 F0 7A E0 F0 12 [6]	6D/F0 6D
55	7	47/C7 [6]	6C/F0 6C [6]	6C/na [6]
56	8	48/C8 [6]	75/F0 75 [6]	75/na [6]
57	9	49/C9 [6]	7D/F0 7D [6]	7D/na [6]
58	+	4E/CE [6]	79/F0 79 [6]	7C/F0 7C
59	Caps Lock	3A/BA	58/F0 58	14/F0 14
60	A	1E/9E	1C/F0 1C	1C/F0 1C
61	S	1F/9F	1B/F0 1B	1B/F0 1B
62	D	20/A0	23/F0 23	23/F0 23
63	F	21/A1	2B/F0 2B	2B/F0 2B
64	G	22/A2	34/F0 34	34/F0 34
65	H	23/A3	33/F0 33	33/F0 33
66	J	24/A4	3B/F0 3B	3B/F0 3B
67	K	25/A5	42/F0 42	42/F0 42
68	L	26/A6	4B/F0 4B	4B/F0 4B
69	;	27/A7	4C/F0 4C	4C/F0 4C
70	'	28/A8	52/F0 52	52/F0 52
71	Enter	1C/9C	5A/F0 5A	5A/F0 5A
72	4	4B/CB [6]	6B/F0 6B [6]	6B/na [6]
73	5	4C/CC [6]	73/F0 73 [6]	73/na [6]
74	6	4D/CD [6]	74/F0 74 [6]	74/na [6]
75	Shift (left)	2A/AA	12/F0 12	12/F0 12
76	Z	2C/AC	1A/F0 1A	1A/F0 1A
77	X	2D/AD	22/F0 22	22/F0 22
78	C	2E/AE	21/F0 21	21/F0 21
79	V	2F/AF	2A/F0 2A	2A/F0 2A
80	B	30/B0	32/F0 32	32/F0 32

Continued

([x] Notes listed at end of table.)

**Table C-2. Keyboard Scan Codes (Continued)**

Key Pos.	Legend	Make / Break Codes (Hex)		
		Mode 1	Mode 2	Mode 3
81	N	31/B1	31/F0 31	31/F0 31
82	M	32/B2	3A/F0 3A	3A/F0 3A
83	,	33/B3	41/F0 41	41/F0 41
84	.	34/B4	49/F0 49	49/F0 49
85	/	35/B5	4A/F0 4A	4A/F0 4A
86	Shift (right)	36/B6	59/F0 59	59/F0 59
87		E0 48/E0 C8 E0 AA E0 48/E0 C8 E0 2A [4] E0 2A E0 48/E0 C8 E0 AA [6]	E0 75/E0 F0 75 E0 F0 12 E0 75/E0 F0 75 E0 12 [5] E0 12 E0 75/E0 F0 75 E0 F0 12 [6]	63/F0 63
88	1	4F/CF [6]	69/F0 69 [6]	69/na [6]
89	2	50/D0 [6]	72/F0 72 [6]	72/na [6]
90	3	51/D1 [6]	7A/F0 7A [6]	7A/na [6]
91	Enter	E0 1C/E0 9C	E0 5A/F0 E0 5A	79/F0 79[6]
92	Ctrl (left)	1D/9D	14/F0 14	11/F0 11
93	Alt (left)	38/B8	11/F0 11	19/F0 19
94	(Space)	39/B9	29/F0 29	29/F0 29
95	Alt (right)	E0 38/E0 B8	E0 11/F0 E0 11	39/na
96	Ctrl (right)	E0 1D/E0 9D	E0 14/F0 E0 14	58/na
97		E0 4B/E0 CB E0 AA E0 4B/E0 CB E0 2A [4] E0 2A E0 4B/E0 CB E0 AA [6]	E0 6B/E0 F0 6B E0 F0 12 E0 6B/E0 F0 6B E0 12[5] E0 12 E0 6B/E0 F0 6B E0 F0 12[6]	61/F0 61
98		E0 50/E0 D0 E0 AA E0 50/E0 D0 E0 2A [4] E0 2A E0 50/E0 D0 E0 AA [6]	E0 72/E0 F0 72 E0 F0 12 E0 72/E0 F0 72 E0 12[5] E0 12 E0 72/E0 F0 72 E0 F0 12[6]	60/F0 60
99		E0 4D/E0 CD E0 AA E0 4D/E0 CD E0 2A [4] E0 2A E0 4D/E0 CD E0 AA [6]	E0 74/E0 F0 74 E0 F0 12 E0 74/E0 F0 74 E0 12[5] E0 12 E0 74/E0 F0 74 E0 F0 12[6]	6A/F0 6A
100	0	52/D2 [6]	70/F0 70 [6]	70/na [6]
101	.	53/D3 [6]	71/F0 71 [6]	71/na [6]
102	na	7E/FE	6D/F0 6D	7B/F0 7B
103	na	2B/AB	5D/F0 5D	53/F0 53
104	na	36/D6	61/F0 61	13/F0 13
110	(Win95) [7]	E0 5B/E0 DB E0 AA E0 5B/E0 DB E0 2A [4] E0 2A E0 5B/E0 DB E0 AA [6]	E0 1F/E0 F0 1F E0 F0 12 E0 1F/E0 F0 1F E0 12 [5] E0 12 E0 1F/E0 F0 1F E0 F0 12 [6]	8B/F0 8B
111	(Win95) [7]	E0 5C/E0 DC E0 AA E0 5C/E0 DC E0 2A [4] E0 2A E0 5C/E0 DC E0 AA [6]	E0 2F/E0 F0 2F E0 F0 12 E0 2F/E0 F0 2F E0 12 [5] E0 12 E0 2F/E0 F0 2F E0 F0 12 [6]	8C/F0 8C
112	(Win Apps) [7]	E0 5D/E0 DD E0 AA E0 5D/E0 DD E0 2A [4] E0 2A E0 5D E0 DD E0 AA [6]	E0 2F/E0 F0 2F E0 F0 12 E0 2F/E0 F0 2F E0 12 [5] E0 12 E0 2F/E0 F0 2F E0 F0 12 [6]	8D/F0 8D

Continued

([x] Notes listed at end of table.)

**Table C-2. Keyboard Scan Codes (Continued)**

Key Pos.	Legend	Make / Break Codes (Hex)		
		Mode 1	Mode 2	Mode 3
Btn 1	[8]	E0 1E/E0 9E	E0 1C/E0 F0 1C	95/F0 95
Btn 2	[8]	E0 26/E0 A6	E0 4B/E0 F0 4B	9C/F0 9C
Btn 3	[8]	E0 25/E0 A5	E0 42/E0 F0 42	9D/F0 9D
Btn 4	[8]	E0 23/E0 A3	E0 33/E0 F0 33	9A/F0 9A
Btn 5	[8]	E0 21/E0 A1	E0 2B/E0 F0 2B	99/F0 99
Btn 6	[8]	E0 12/E0 92	E0 24/E0 F0 24	96/F0 96
Btn 7	[8]	E0 32/E0 B2	E0 3A/E0 F0 3A	97/F0 97
Btn 1	[9]	E0 23/E0 A3	E0 33/E0 F0 33	9A/F0 9A
Btn 2	[9]	E0 1F/E0 9F	E0 1B/E0 F0 1B	80/F0 80
Btn 3	[9]	E0 1A/E0 9A	E0 54/E0 F0 54	99/F0 99
Btn 4	[9]	E0 1E/E0 9E	E0 1C/E0 F0 1C	95/F0 95
Btn 5	[9]	E0 13/E0 93	E0 2D/E0 F0 2D	0C/F0 0C
Btn 6	[9]	E0 14/E0 94	E0 2C/E0 F0 2C	9D/F0 9D
Btn 7	[9]	E0 15/E0 95	E0 35/E0 F0 35	96/F0 96
Btn 8	[9]	E0 1B/E0 9B	E0 5B/E0 F0 5B	97/F0 97

**NOTES:**

All codes assume Shift, Ctrl, and Alt keys inactive unless otherwise noted.

NA = Not applicable

[1] Shift (left) key active.

[2] Ctrl key active.

[3] Alt key active.

[4] Left Shift key active. For active right Shift key, substitute AA/2A make/break codes for B6/36

codes.

[5] Left Shift key active. For active right Shift key, substitute F0 12/12 make/break codes for F0 59/59 codes.

[6] Num Lock key active.

[7] Windows keyboards only.

[8] 7-Button Easy Access keyboard.

[9] 8-Button Easy Access keyboard.

### C.3 CONNECTORS

Two types of keyboard interfaces are used in Compaq systems: PS/2-type and USB-type. System units that provide a PS/2 connector will ship with a PS/2-type keyboard but may also support simultaneous connection of a USB keyboard. Systems that do not provide a PS/2 interface will ship with a USB keyboard. For a detailed description of the PS/2 and USB interfaces refer to chapter 5 “Input/Output” of this guide. The keyboard cable connectors and their pinouts are described in the following figures:

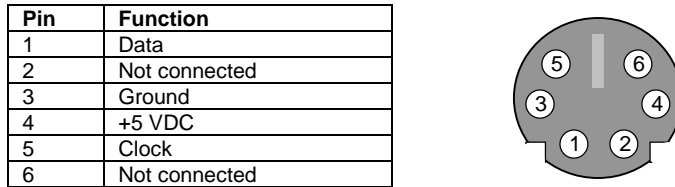


Figure C-9. PS/2 Keyboard Cable Connector (Male)

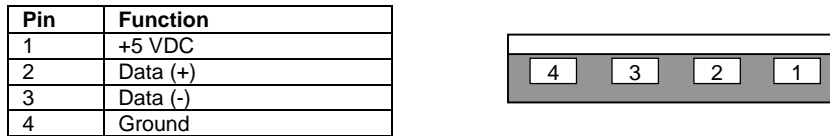


Figure C-10. USB Keyboard Cable Connector (Male)

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