CL1B Hardware Design Specification

April 5, 2010, Revision: 1.43

Contents

History

Rev 1.0 First draft. Closely derived from CL1 Hardware Design Specification v1.04
Rev 1.1 Changed input voltage, corrected input wattage, indicated ambiguous processor choice
Rev 1.2 Changed to stereo external microphone, firmware protection now in software
Rev 1.3 Change to reflect 8 GB version, update to current network interface
Rev 1.4 Changed to reflect internal micro SD storage, added display specs

1   Introduction

This document introduces the system architecture and hardware design requirements for the XO Children's Laptop version 1.5 (CL1B).

The features of the laptop are described in section 2. Testing and certification is described in section 3.

While the functionality of the CL1B is similar to an ordinary notebook PC, it was designed by One Laptop per Child as a laptop for elementary school children.   The foremost goal of the hardware design is low-power operation. To achieve this goal, the CL1B incorporates novel technologies such as a color/monochrome dual mode TFT LCD display, and networking and display controllers capable of independent operation.

In order to support networking connectivity in areas lacking wired networking infrastructure, the CL1B provides a wireless networking interface. It is designed to remain functional while the laptop is in a very low power mode, allowing the low power mode to be entered frequently without interrupting network connections. This interface interoperates with normal 802.11b/g WiFi access points, but may also be used for direct laptop/laptop communication without access points (ad-hoc mode).

The CL1B is designed with a 19 cm (diagonal) color/monochrome dual mode TFT LCD panel and using NAND Flash as storage device in the system. It supports a 20 WH battery, allowing many hours of operation.

The CL1B is a system/motherboard upgrade to the existing CL1A design.   No changes to the overall industrial design or tooling will be made. The addition of three rasied dots to the hinge cover allows easy differentiation of CL1 and CL1B machines in the field.

1.1   General Specifications

Processor & core system:
Via C7-M (1 GHz) ULV CPU
Via VX855 northbridge / southbridge companion chip for peripheral I/O
1 GiByte DDR2 SDRAM system memory, running at 400MHz
Embedded controller for system monitoring
ISA Compatibility: Support for both the MMX and SSE, SSE2, and SSE3 x86 instruction-set extensions

Storage:
4 GBytes of NAND Flash memory on motherboard
1 MByte of serial Flash memory provided separately for firmware
Expandable through a single externally accessible SD/MMC memory card socket.

Audio:
HD Audio subsystem
Internal stereo speakers and amplifier
Internal monoaural microphone
Jack for external stereo headphone
Jack for external stereo microphone, dual sensors, or switches

Display:
7.5in (19 cm) color/monochrome dual mode TFT LCD, 1200x900 (200dpi)
Viewing area: 152.4 mm x 114.3 mm; 6 in x 4.5 in
Sunlight readable
Dedicated display controller (with separate 2-MByte SGRAM frame buffer) supports use of display when CPU is powered down
Solid state (LED) backlight

Camera module:
Integrated color video camera
640 x 480 resolution
Full frame rate (30fps)

Wireless Networking:
Integrated IEEE 802.11/b/g (2.4 GHz) wireless networking interface
Ad-hoc and AP mode networking supported
Capable of network operation when CPU is powered down

Expansion Ports:
Three external USB 2.0 ports provided

Input Devices:
Water and dust proof 80+ key rubber keyboard, with 1mm stroke
Capacitive touchpad used for pointing device

Buttons:
Power button on the side of the display
Screen rotate button on the side of the display
Two sets of 4-direction cursor control buttons
Magnetic sensor detects laptop closure
Magnetic sensor detects use in eBook mode

Indicators:
Power on/off LED
Battery status LED (Dual color)
Two Wi-Fi status LEDs
Hardware controlled internal Microphone In Use LED
Hardware controlled Camera In Use LED

Power Conversion:
DC power input, from 11V to 25V
Integrated charger for Ni-MH/ LiFePO$_4$ batteries
High efficiency LED Backlight control circuit
6 mm power input connector (1.65 mm center pin)

Overall Safety:
IEC 60950-1 qualified
EN 60950-1 qualified
CSA/UL 60950-1 qualified
ASTM F 963 – Standard Consumer Spec on Toy Safety qualified

Battery Pack:
5 serial NiMH AF type batteries with integrated gas gauge IC
2 or 4 serial LiFePO$_4$ AF type batteries with integrated gas gauge IC
Safety: UL 1642 and UL 2054 qualified

	GoldPeak		**BYD**
	NiMH	**LiFePo$_4$**	
Typical capacity (mAh)	3050	2900	3150
Minimum capacity (mAh)	3000 *Only 80% usable*	2800	3100
Operating Voltage Range @ 0.2C discharge current	7.5—5V	7.3—4V	7.5—5V
Operating Temp Charge	0 ~ +45°C	0 ~ +60°C	-10 ~ +50°C
Operating Temp Discharge	-20 ~ +50°C	-20 ~ +70°C	-20 ~ +55°C
Standard charge rate	note CC-CV .1C	CC-CV .8C up to 7.3V	
Max charge rate		1.5C (4200 mA)	1C (3150 mA)
Lifetime characteristics of all batteries			

Ambient Temperature	25°C
Number of Cycles	2000
Remaining Capacity after 2000 cycles	50%

AC adapter:
25W external AC adapter
90v(-10%) ~ 240v(+25%), 35-60Hz, AC input
14V DC output
Safety: IEC 60950-1, EN 60950-1 & CSA/UL 60950-1 qualified
Extra Transient and Burst Immunity: IEC 61000-4-4 passed
Extra Surge Immunity: IEC 61000-4-5 passed

Weight: <1.5Kg **Size:** 245mm (9.65") × 230mm (9") × 30.5mm (1.2")

2   CL1B System Architecture

This chapter provides an overview of the architecture and the overall hardware design principles for the CL1B. The architecture of the CL1B differs from more conventional laptop designs in that large parts of the laptop (including the CPU) may be completely powered off quickly, without affecting the operation of other parts. The CL1B is designed to run the Linux open source operating system or Microsoft Windows XP, both of which are available as factory-installed options. Standard Fedora and Ubuntu distributions and other operating systems may be available from the OLPC developer community.

2.1   System Block Diagram

Figure 2.1 is the block diagram of the CL1B system. Unlike most laptops, all components except the keyboard and touchpad are located behind the LCD panel. This assembly is called the **Core Module**. The keyboard matrix, keyboard encoder, touch pad module, and battery are combined together in a separate **Input Module**, connected to the core module through two small cables in the laptop hinge.
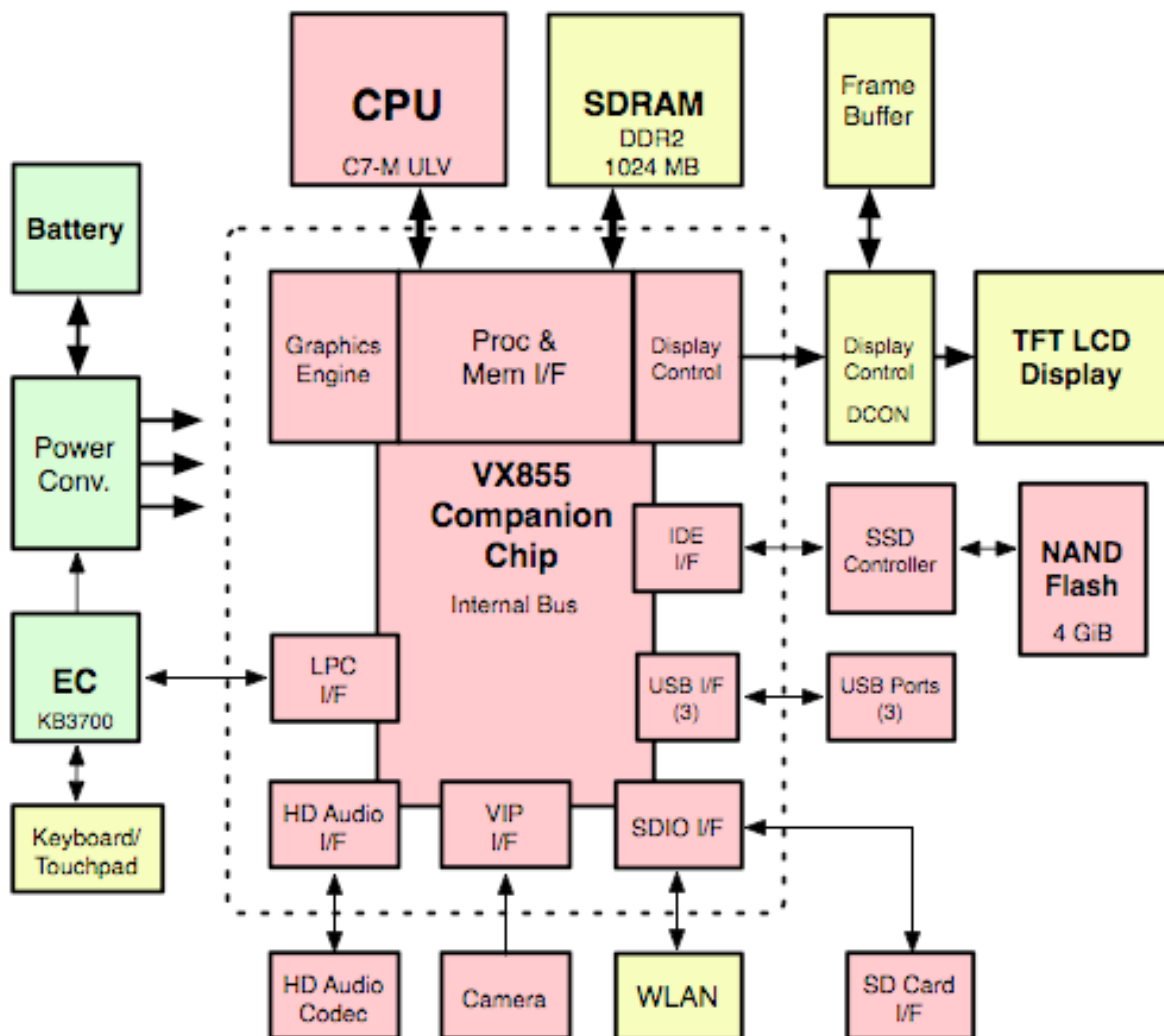
Figure 2.1: CL1B Hardware System Diagram

2.2   CPU & Companion Chip

 The core processing system used in CL1B is the VIA C7-M ULV, an embedded x86 processor (CPU), integrating a

memory management unit, and an x87 compatible floating point unit.

A companion chip, the VIA VX855, incorporates most of the remainder of the system components. This includes a graphics processing unit, an integrated memory controller providing a unified memory, and an integrated display controller. Also included are an HD Audio interface to the sound sytem, USB 2.0 controllers, power management logic, and legacy PC system components such as real time clock (RTC), memory transfer engines (DMA), and programmable interrupt controllers. .

2.2.1   Interrupts
Dedicated system interrupts are provided for system timer, keyboard, HD Audio, SD Card, Camera, RTC, system control, USB (also used for networking), display control, touchpad, math co-processor, and DMA.

2.2.2   Firmware
The Low Pin Count (LPC) interface, provided by the companion chip and used to communicate with the Embedded Controller (EC), is also used by the main processor to load the laptop's firmware. The EC's LPC interface in turn reads the firmware from a serial interface Flash memory.

2.2.3   Graphics Processing Unit
A 3D graphics-processing unit (GPU) is provided in CL1B to accelerate common graphics and video operations. This GPU shares the main memory with the main processor, using a unified memory architecture. It provides separate processing pipelines for video and graphics, with a hardware blend before display. Separate color-space converters and rescaling is provided for each pipeline.

2.2.4   Memory
The CL1B processor supports an integral 64 bit wide DDR2 SDRAM interface. No external buffering is used. Eight 8-bit wide DDR2 SDRAM ICs are directly mounted on the motherboard, supporting 1 GByte of main memory using 128M x 8 (1024 MBit) components. The speed of this memory bus is selected at boot time by firmware, and using current chips may be either DDR2-333 or DDR2-400.

As the memory is mounted on the motherboard, and not expandable, there is no SPD interface supported for detecting the speed or size of memory.

2.3   Power Conversion
The power subsystem design in the CL1B is complex relative to a normal laptop. In order to minimize the power consumption, the power supplied to a number of subsystems may be sequenced on or off as needed. Referring to Figure 2.1, the subsystems in green are always powered (drawing microamps if the laptop is not in use). The subsystems in yellow (the display, the wireless networking, keyboard/touchpad, and the main memory) may optionally be left powered. The remainder of the laptop, colored in red, is powered only when needed to perform computation or react to user events.

The subsystems marked in yellow in Figure 2.1 are powered independently of one another. It is possible to operate the display without powering the wireless networking, or operate the wireless networking without powering any other parts of the laptop.

Many of the peripherals marked in red, such as the camera, the audio subsystem, and the USB interfaces, may be individually powered down to conserve power when not in use.

2.3.1   Battery Charger
The CL1B provides a DC power input jack. A DC voltage source between 11 and 25 volts is suitable for powering the laptop. The DC input jack will safely withstand an input voltage between –32V and 40V. Exceeding these input parameters should not cause permanent harm to the laptop, but will destroy an internal fuse, requiring repair.

An integrated battery charger is provided, which converts power input to the laptop into voltages suitable for charging and controls the charge current.

The battery charger supports both constant voltage and constant current charging algorithms, under control of firmware running on the Embedded Controller.

The battery charger is designed to limit in hardware the power drained from an external input. The total input

wattage is limited to 35W. If the laptop components are drawing less than this amount, any remaining power is used to charge the battery.

The maximum charge current may be set by software to be either 0.3 A or 2 A. Supported charge voltages are 8.4V (for NiMH) or 7.5V (for LiFePO$_4$).

2.3.2 Battery Pack

CL1B is designed to support a variety of battery technologies. Currently, the laptops are available with battery packs comprised of either five NiMH cells in series or two/four LiFePO$_4$ cells in series. Each battery pack contains an integral gas gauge IC.

The battery packs can be recharged 2000 times (to 50% capacity – as repeated charge and discharge slowly decreases how much power can be stored in the battery). Nonetheless, these batteries last approximately four times longer than the standard laptop batteries that are typically specified as rechargeable 500 times (to 50% capacity).

Communications between the laptop and the gas gauge chip are carried over a single wire, using the Dallas Semiconductor One-Wire protocol and specifications. This single wire interface allows the laptop's Embedded Controller to read information about a battery pack's technology, status, and history. It even allows the laptop to power the gas gauge chip in batteries that have been discharged completely. A three-pin connector is used between the battery pack and CL1B.

2.3.3 Backlight control

The CL1B LCD backlight is provided by white LEDs. Multiple LEDs are connected in series into three chains in order to equalize their brightness. These chains are powered in parallel. LEDs from all three chains should be interleaved, to minimize the impact of a single chain burning out. Up to 60 mA of current (at 17.6V) is provided to drive the backlight.

Two signals are used to control the backlight operation. One enables/disables the backlight, and a second one is pulse-width modulated at 200Hz to generate a voltage that varies the brightness of the backlight.

2.3.4 Power Timing Sequence

Whenever a battery is inserted into a CL1B, or power is supplied to the DC power input, the system Embedded Controller (EC) is powered and operating.

2.3.4.1 Power Off to On

If the laptop power button is pressed, the EC supplies power to the power management logic in the companion chip, and communicates the power button press to it. The companion chip will enable power to the main memory, processor, and most other components of the system. The EC notices this action, and powers up the display controller in response. The display controller then powers up the LCD display and backlight.

2.3.4.2 On to Suspend

If the operating system determines that the CPU should be suspended in order to conserve power, it takes the needed steps to disable the operation of any co-processors which might access main memory, notifies the networking interface, places the main memory in a low power self-refresh mode, then notifies the power management logic in the companion chip. This logic will disable power from the processor and most other components of the system. Parts of the companion chip, the main memory, the display and display controller, the backlight, the keyboard, and the networking interface remain powered and operational.

2.3.4.3 Suspend to On

When any button press is detected, either from the keyboard or the buttons around the display (power, rotate, and game keys/pad), the EC notifies both the display controller and the power management logic in the VX855. The display controller immediately unblanks the display (if blanked due to inactivity). The power management logic enables power to the processor and most other components.

2.3.4.4 On to Off

When the operating system determines that the laptop should be turned off (usually in response to the power button being pressed), it sends a command to the EC. The EC disables power to all subsystems, including the keyboard, display controller and networking interface. If powered by the DC Power input, the EC remains awake to handle battery charging. If operating from a battery, the EC enters a deep sleep state and awaits a press of the power

button (or the arrival of DC Power input).

2.4 Embedded Controller

The Embedded Controller (EC) is a microprocessor providing a number of critical system monitoring and management functions. These include large parts of the system power management, the gamepad keys/rotate/power button interface, a PS/2 interface for the touch pad and keyboard, and battery management. It is powered whenever there is a battery with sufficient charge or the laptop has DC power input, although it enters a sleep mode when possible.

The EC communicates with the main processor through the LPC interface. This is also used to provide system firmware to the main processor from the EC's external serial Flash memory.

2.4.1 Programming Interface

The functions supported by the EC are best described by the programming interface provided for use by the CL1B firmware and operating system. This interface defines the laptop hardware that the EC must monitor and control.

Firmware and operating system running on the CL1B laptop may read the following hardware status through the Embedded Controller, using I/O ports (in the x86 input/output address space) 0x6C and 0x68:

• Battery Voltage
• Battery Current
• Battery Accumulated Current Register (ACR)
• Battery Temperature
• Ambient Temperature
• Battery Status (Exists, Fully Charged, Low, Destroyed, DC Power input present)
• Battery State of Charge
• Battery Gas Gauge Serial Number
• Laptop motherboard ID
• System Control Interrupt (SCI) Source
    o Game Button
    o Battery Status Change
        ☒ DC Power input provided or removed
        ☒ Battery inserted or removed
        ☒ Battery low
        ☒ Battery full
        ☒ Battery destroyed
    o Battery SOC change
    o Battery subsystem error
    o eBook mode change
    o Lid status change
• System Control Interrupt Mask
• Display Panel Button Status (eight directional game keys and display rotate)
• Battery subsystem error
    o Pack info fail (LiFePO$_4$ & NiMH)
    o Over voltage checking fail (LiFePO$_4$)
    o Over temperature (58C) (LiFePO$_4$)
    o Gauge stop or sensor break (LiFePO$_4$& NiMH)
    o Sensor out of control (NiMH)
    o Battery ID fail & temperature > 52C
    o Accumulated Charge Register fail (NiMH)
• Laptop power status (Display Controller, Wireless mesh networking interface)

Firmware and operating system running on the CL1B laptop may control the following hardware functions through the Embedded Controller, using ports 0x6C and 0x68:

• Set System Control Interrupt (SCI) Mask
• Initialize NiMH and LiFePO$_4$Battery
• Enable/Disable Wireless mesh networking interface (WLAN) power
• Wake up WLAN

• Reset WLAN
• Enable/Disable Display Controller power

Additional system status and control are available through the standard ACPI protocol (using I/O ports 0x66 and 0x62). The EC supports the following commands:
• Query System Control Interrupt Event Queue
• Power Off
• Keyboard Stop
• Keyboard Pause
• Keyboard Resume

The keyboard and touchpad control/status and data are available through the standard PS/2 protocol (using I/O ports 0x64 and 0x60).

2.4.2   Embedded Controller Firmware
The firmware for the Embedded Controller is stored in a separate 1 MiByte serial Flash memory. Sixty-four KiBytes of this memory are dedicated to EC firmware. This serial Flash is also used to store manufacturing information (up to 4 KiBytes) and the firmware for the main processor (up to 832 KiBytes). The LPC interface on the Embedded Controller transparently multiplexes access to the serial Flash between the EC and the main processor.

2.4.2.1   Write Protect Function
In order to prevent malicious software from rewriting crucial firmware and manufacturing information stored in the Embedded Controller's serial Flash, CL1B provides a firmware write protect mechanism. This mechanism is only disabled by a full system reset. It is enabled by the EC. Once enabled, the write protect may not be disabled except by another system reset.

After a system reset, firmware from the serial Flash will be loaded and executed by the main processor. If the firmware determines that a trusted update to the firmware is available, it may perform the update at that time (followed by a reboot of both the EC and the main processor). If no update is available, the main processor tells the EC to write protect the serial Flash, before execution of the operating system begins. This prevents malicious applications or modifications of the OS from modifying the basic firmware and boot process.

2.5 Display
The TFT LCD display used is a unique design, developed specifically for the CL1B, and produced by Chi Mei Innolux. It is a dual mode 19cm display, providing a color display when used in transparent mode, and a very low power monochrome display when used in reflective mode. It can be used in bright sunlight.

In reflective (monochrome) mode, it supports a display of 1200 x 900 pixels (200 dots per inch), each capable of 64 gray levels. The frame buffer stores a full 24 bits for each pixel. In transmissive (color) mode, the perceived resolution is 1024x768 or higher, depending on the ambient illumination.

As a transflective display, the luminance depends on the ambient lighting. In a dimly lit room (140 cd/m^2), the display luminance is 100 cd/m^2, minimum, and typically 120 cd/m^2. In office lighting (350 cd/m^2), the luminance is typically 170 cd/m^2, and in daylight, the luminance is roughly 25% of the ambient illumination.   The contrast ratio of the display is 85:1 in low ambient illumination.

The LCD backlight for transmissive mode is provided by white LEDs.   Multiple LEDs are connected in series into three chains in order to equalize their brightness.   These chains are then powered in parallel. LEDs from all three chains are interleaved, to minimize the impact of a single chain burning out. The exact spectrum (white point) of the LEDs used in the backlight is not specified, but the LEDs used in any single backlight are closely matched to provide a uniform backlight spectrum.

The dimensions of the LCD are 17.0cm x 14.0cm x 0.62cm (thick). The active display area is 15.2cm by 11.4cm, and the bezel area is 15.5cm by 11.7cm. Its weight is only 172g.

As the CL1B design minimizes the length of the cabling between the display controller and the display, a dual-edge TTL signaling protocol is used for interfacing.   One 55-pin flexible cable provides data connections, with a separate 4-pin flex cable connecting the integral LED backlight to the laptop motherboard.

2.6   Display Controller

Display controllers in conventional integrated processors and laptops do not meet the low power design requirements of the CL1B. Until suitable display controllers become available, a separate display control (DCON) application-specific integrated circuit developed for CL1B will be used.   The DCON provides the following features:

• Autonomous display refresh, independent of the CPU or GPU's power state
• Support for "color swizzling", allowing a conventional graphics engine to drive the dual-mode color/monochrome LCD display
• Monochrome mode support provides for a pixel-addressable automatic color-to-gray-scale conversion mode
• Optional anti-aliasing improves text display in color mode
• A dual-edge TTL output for interfacing to the CL1B LCD display.

The DCON is designed to work with a conventional display controller. It provides an input interface emulating a TTL-compatible LCD display, allowing direct connection to a conventional display controller.   In normal operation, when the conventional display controller is powered and operating, the DCON simply passes the video directly through, performing any required transformations (color swizzling with anti-aliasing or monochrome mode) but not buffering any of the video.

Before the operating system places the laptop into suspend power mode, it notifies the DCON and the DCON buffers the frame of video being displayed in its own memory. The DCON will then continue to display this frame until notified by the operating system that it has exited suspend mode and is generating valid video again.

An SMBus connection is provided through the VX855's southbridge for initialization and configuration of the DCON.

2.7   Audio

The CL1B provides both internal and external audio input and output. Internally, stereo speakers are provided on each side of the display, along with a single channel microphone mounted on one side of the display. Jacks are provided for use of headphones, external speakers, or an external microphone.

The audio subsystem is built around the HD Audio standard. An HD Audio compatible codec provides conversion between digital and analog audio signals, as well as mixing capabilities.   This codec supports input or output sampling at rates up to 96 KHz, using analog/digital converters with a dynamic range of 80 dB and digital/analog converters with a dynamic range of over 90 dB. The audio codecs support operation with either 16 or 24 bit audio data.

An HD Audio codec includes a number of input and output channels not supported in CL1B. These are disabled by firmware to conserve power. The entire codec will be powered down when no audio is being input or output.

2.7.1   Internal Speakers
There are two internal speakers in the CL1B laptop, each driven by a separate audio channel. These are driven by a dedicated audio amplifier capable of providing 1.4 W continuously into each speaker, with a total harmonic distortion of 1%. The frequency response of the internal speakers is roughly from 480 Hz to 40 KHz.

2.7.2   Internal Microphone
An internal microphone is included with CL1B, located on the left side of the display.   This provides a single channel of audio input. The microphone is an electret condenser microphone, with a minimum S/N of 56 dB, and a minimum sensitivity of –46 dB (0 dB at 1Pa, freq. of 1 KHz).

An indicator light is provided near the microphone on the left side of the display that indicates if the microphone is currently being used (turned on).   This light is directly controlled by hardware whenever it is possible for the internal microphone to be in use. It may not be disabled by software.

2.7.3   External Headphones or Speakers
A stereo jack is provided on the laptop for connecting headphones or an external amplifier and speakers. When a plug is inserted into this jack, the internal speakers are automatically disconnected and their amplifier is powered

down. The state of this jack may be determined by software.

The headphone is driven by the internal amplifier of the HD Audio codec, capable of providing 30mW continuously into a 32Ω impedance.

2.7.4   External Microphone Input

A stereo jack is provided on the laptop for connecting an external microphone, switch, or other sensor. This jack is connected to the audio codec's microphone input, with provides a programmable gain preamplifier, with a gain of 0, 10, 20, or 30 dB. The input impedance is 10 KΩ.

A DC blocking capacitor may be inserted into the input signal path, under software control. This is used when the input is an audio signal. When used, the frequency response of the input is flat down to 10 Hz.

A bias voltage (1.5 or 2.5V, with a 3 KΩ source impedance) may also be driven onto this external microphone input, under software control. This may be used to power external electret condenser microphones, or used to sense whether an external switch is open or closed. Due to the high impedance of the bias source, this input may safely be shorted to ground.

An external voltage applied to this input is limited to between 0 and 3.5 V. Inputs exceeding this range may cause excessive current to flow through a protective diode.

When the external microphone jack is in use, the internal microphone is disconnected, and the indicator light indicating microphone use is disabled. The state of this jack may be queried by software.

2.8   Storage System

CL1B has no spinning media storage devices, such as hard disk drives or optical drives. It relies on NAND Flash memory for non-volatile storage.   4 GBytes of MLC NAND Flash are provided using a single internal micro MMC/SD card. Alternative SKUs which provide other size internal Flash storage may be provided. The interface between the processor and the NAND is critical to system performance. It is high-speed (guaranteed to be at least 2MBytes/s with regular performance above 10 MBytes/s) and provides error-correction and wear-leveling functions in hardware.

The endurance of the NAND device is five thousand erase cycles, with a data retention lifetime of at least ten years.   Wear-leveling of the device to avoid premature failure is provided in hardware.   The internal micro MMC/SD card may be replaced by dismantling the laptop.

The CL1B also provides a single MMC/SD card slot for extending the laptop's storage.

2.9   Wireless Networking Interface

The wireless network interface used by CL1B operates as a conventional WiFi (802.11b/g) interface. The wireless system also supports the draft 802.11s mesh networking protocol through the use of the Open 802.11s software stack.

For operation in 802.11b mode, the RF output power is 17 dBm (+/- 1.5 dBm), with a receiver sensitivity of –87 dBm. In 802.11g mode, the RF output power is 13 dBm (+/- 1.5 dBm), with a receiver sensitivity of –72 dBm.
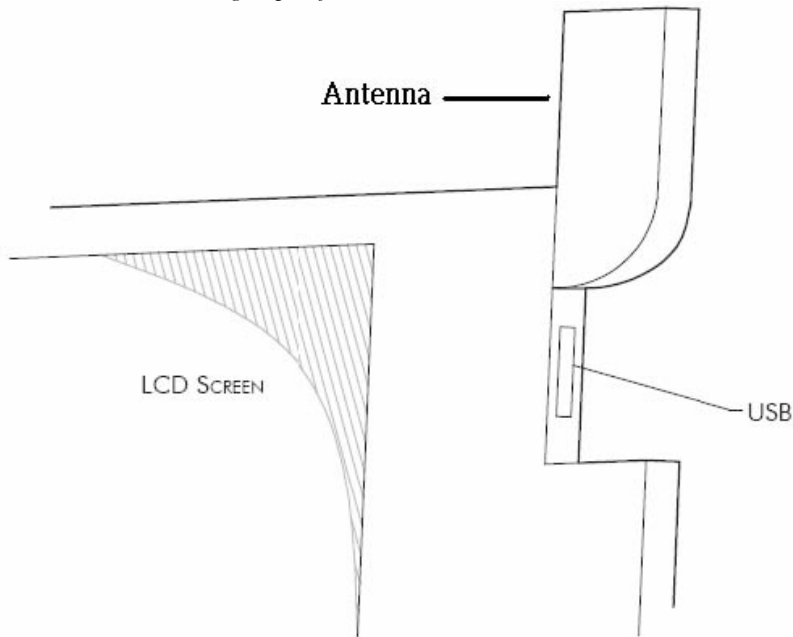
Figure 2.9: External Antenna

2.9.1   Antenna Design

The antennas for wireless networking on CL1B are designed to provide the best performance possible. Two rotatable external antennas are provided, located at the top right and left corners of the display, frequently referred to as *rabbit ears*. The ability to rotate the antennas up, away from the body of the laptop, provides optimum antenna performance. When the rabbit ears are down, they cover the laptop's I/O ports (USB and audio), and provide a latching mechanism.

2.10 Camera Module

The CL1B provides a video camera with a fixed lens, located on the right side of the display. This camera has a resolution of 640 x 480 pixels, and may operate at up to thirty frames per second. It provides a signal/noise ratio of at least 46 dB, and has a sensor array size of 2.36mm x 1.76mm. The F-number of the optical system is 2.8 (+/- 5%), effective focal length is 2.45mm, and the field of view is 60 degrees.

Parameters of the video camera (such as automatic gain control, automatic exposure control, automatic white balance, lens correction, manual color balance, or black level control) are adjustable under software control.
An indicator light is provided near the camera on the right side of the laptop display which indicates whether the camera is currently being used (turned on). This light is directly controlled by hardware whenever it is possible that the camera might be in use. It may not be disabled by software.

2.11 User Input Devices

In addition to the microphone, and camera described separately, the user input devices provided on CL1B are a keyboard, a touchpad, a directional gamepad and *display rotation* button on the left side of the display, and four game keys and a power button on the right side.

2.11.1   Keyboard

The CL1B keyboard is a 72-key rubber-membrane keyboard, with a 1mm stroke. It is sealed against water and dust ingress.

The keyboard and the touchpad share a single cable connection to the Core Module, using a standard PS/2 signaling protocol.

2.11.2   Touch Pad

The CL1B is equipped with a touchpad for use as a pointing device, requiring just a bare finger. This touchpad has

a resolution of 1000dpi, and an active area of 6.0 cm by 4.4 cm. It is located underneath the plastic in front of the keyboard, maximizing the resistance to moisture, dirt, and electrostatic discharge.
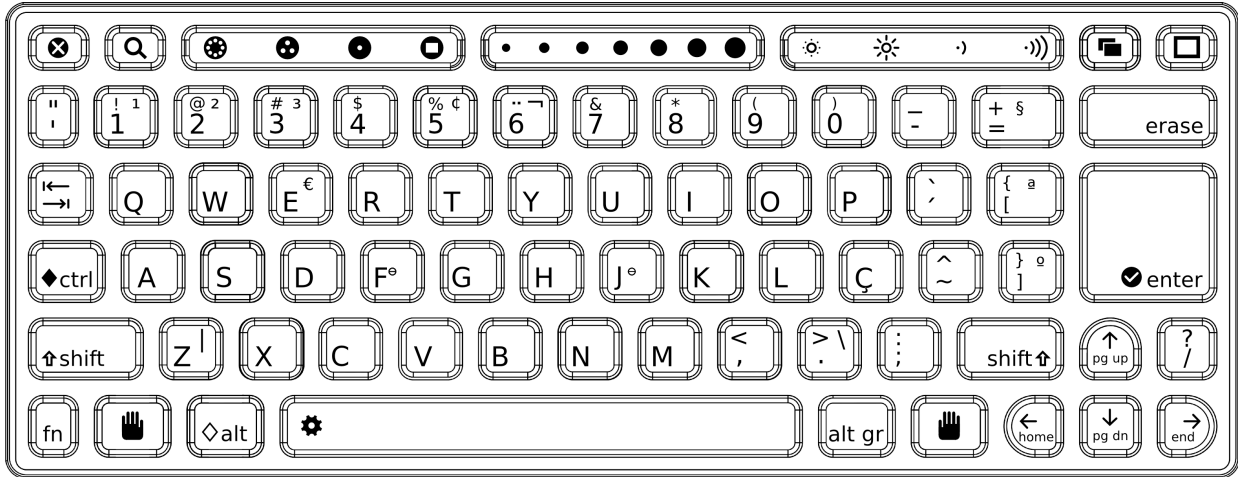

Figure 2.11: Keyboard Layout (Portuguese version shown)

2.11.3 Core Module Buttons

The CL1B includes two sets of directional input buttons, one on each side of the display. On the left side, these are combined into a single large directional button. On the right side of the display, these are marked with distinctive icons (square, circle, check and X) as well as having a directional grouping. Both sets are oriented to provide up, down, left, and right input relative to the display.

In addition, a single user input button is provided on the left side of the display (mirroring the power button). This button is dedicated to rotating the display orientation (to better support eBook mode).

The Embedded Controller provides the interface for these buttons, inserting them into the character stream received from the keyboard.

2.11.4 Lid and eBook Switches

There are two magnetic sensors in the Core Module that determine its proximity and orientation relative to the Input Module. One of these is used to detect if the laptop is closed, with the display unviewable and keyboard unreachable. The operating system will use it to either suspend or power off the laptop. The other is used to detect if the laptop is being used in eBook mode, where the display is rotated before the laptop is "closed". In this mode, the keyboard is unusable but the display and Core Module buttons are still usable.

These sensors are connected to the Embedded Controller, and changes in their state are communicated to the operating system via System Control Interrupts.

2.12 I/O Ports

In addition to the headphone (audio out) and microphone (audio/sensor in) jacks described above, the CL1B provides USB ports for connecting to external devices.

2.12.1 USB

The CL1B supports three USB 2.0 ports, two on one side of the display and one on the other. These are all USB type A connectors, for connecting to peripheral and storage devices.

Unlike a regular laptop, which provides up to 2.5 W of power per USB port, the CL1B provides a total power consumption of 5 W for all three USB ports. This may be shared equally among all the ports or drawn through a single one, but cannot be exceeded.

2.12.2 Debugging Support

The CL1B motherboard in the Core Module includes a number of connectors to aid in firmware and operating system debugging. These are not populated in production machines, but may be easily added to aid in software development. They are not accessible unless the laptop is partially disassembled. These connectors include:

• An RS-232 protocol serial connection (3.3V) to the main processor
• A main processor LPC bus connector
• An RS-232 protocol serial connection (3.3V) to the Embedded Controller
• An SPI interface for reprogramming the SPI boot ROM.

3 <u>Testing</u>

The CL1B meets a wide range of environmental, mechanical, and electrical tests.

3.1 Safety

CL1B meets UL and EC safety certification. The laptop meets IEC 60950-1, EN 60950-1, and CSA/UL 60950-1 (Safety of Information Technology Equipment) specifications. It also complies with UL 1310 and UL 498. In order to guarantee the safety of children using the laptop, it also passes ASTM F 963 (Standard Consumer Safety Specification on Toy Safety, 2003 edition).

The external power adapter complies with IEC, EN, and CSA/UL 60950-1. The removable battery pack complies with IEC, EN, and CSA/UL 60950-1 and UL 2054 (Household and Commercial Batteries).

3.2 Environmental Conditions

CL1B is designed for operation over an extended range of environmental conditions:
• Ambient Temperature: 0C to 50C
• Operational Altitude: 0m to 5000 m
• Non-operational Ambient Temperature: -20C to 60C

3.3 Durability

The CL1B was designed for durability.

3.3.1 Input Devices

The core module buttons (Power, display rotate, gamepads) are tested to 500,000 cycles.
The keyboard is tested to 5,000,000 cycles.
All I/O connectors (Power, USB, Headphone, and Microphone) are tested to 5,000 cycles.

3.3.2 Drop Tests

The CL1B passes a 10 point free-drop test from a height of 150 cm onto a carpet covered steel plate, and a 10 point free-drop test from a height of 80 cm onto a steel plate.

3.4 Environmental

The XO is the most energy-efficient and environmentally friendly laptop ever made, based on independent evaluations and data. XO consumes the least power, minimizes toxic materials, is extraordinarily rugged, has a long lifetime, works with renewable power sources, and is itself recyclable. XO has earned the highest environmental certifications: it is in full compliance with the European Union's rigorous Reduction of Harmful Substances (RoHS) standards; it is designed for Energy Star Version 4.0 Category A Tier 2 performance, the most stringent level..

According to ENERGY STAR®, an average idle desktop computer uses 70 watts of power and an average idling laptop computer consumes 20 watts of power. When idle, the XO laptop uses twowatts of electricity.

Among the XO's other environmentally friendly attributes and innovations:

XO is more rugged — it will last longer, thus staying out of landfills longer. The XO has been designed for a **five-year lifetime** even in extreme environments like the outdoors, the jungle, and the desert. The average laptop has a two-year lifetime when used in an office and far less when brought outside or to the desert. Doubling the lifetime of the laptop halves its environmental impact.

XO is about **half the size and weight** of typical laptops. Less material halves the environmental impact.

XO is designed for use with **renewable energy sources**. It's the first laptop made with renewable energy accessories: a hand crank, a small solar panel, a foot pedal, or a lawnmower style rope pull will recharge the laptop.

XO uses a new battery using $LiFePO_4$ (Lithium Ferro Phosphate) chemistry that lasts **four times longer** than

standard laptop batteries, and is vastly safer than the current dominant technology of Lithium Ion.

4 <u>Reference</u>

CL1B Software Functional Specification, Available at: `http://wiki.laptop.org/go/Power_Management`

Intel Low Pin Count Interface Specification, Revision 1.1, August 2002. Available at: http://www.intel.com/design/chipsets/industry/lpc.htm