CL1 Hardware Design Specification

September 29, 2008. Revision: 1.04

Contents

History

Rev. 0.1A First Version
Rev 0.9A Mar. 30, 2007 version. Prepared by C. H. Yang
Rev 0.91 Moved implementation details   into a separate document.
Rev 1.0 Added safety certification and testing.
Rev 1.01 Changed battery desc. for 2 or 4 cell LiFePO
Rev. 1.02 Changed input power specification and environmental constraints.
Rev. 1.03 Changed formatting
Rev. 1.04 Changed touchpad specification

1   <u>Introduction</u>

This document introduces the system architecture and hardware design requirements for the XO Children's Laptop version 1 (CL1).

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

While the functionality of the CL1 is similar to an ordinary notebook PC, it was designed with One Laptop per Child as a laptop for elementary school children. The foremost goal of the hardware design was low power operation. To achieve this goal, the CL1 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 CL1 provides a wireless mesh networking interface. This interface, capable of relaying mesh networking frames between other laptops and mesh access points, continues to operate when the laptop is asleep.   It is also capable of interoperation with normal 802.11b/g WiFi access points.

The CL1 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.

1.1   General Specifications

Processor & core system:
AMD LX700 CPU (433 MHz) with integrated Graphics Processing Unit
AMD CS5536 Companion chip for peripheral I/O
256 MByte DDR SDRAM system memory chip, running at 333MHz
Embedded controller for system monitoring
ISA Compatibility: Support for both the MMX and 3DNow! X86 instruction-set extensions

Storage:
1 GiB of NAND Flash memory on motherboard
1 MiB of serial Flash memory provided separately for firmware
Expandable through a single SD/MMC memory module socket.

Audio:
AC'97 audio subsystem
Internal stereo speakers and amplifier
Internal mono. microphone
Jack for external stereo headphone
Jack for external mono. microphone, sensor, or switch

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 2MB 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
Mesh networking (variant of 802.11s) supported
Capable of mesh operation when CPU is powered down

Dual antennas integrated into laptop

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 18V, internally limited to 15W draw
Integrated charger for Ni-MH/ LiFePO4 batteries
High efficiency LED Backlight control circuit
6 mm power input connector (1.65 mm center pin)

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

Battery Pack:
5 serial Ni-MH AF type batteries with integrated gas gauge IC
2 or 4 serial LiFePO4 AF type batteries with integrated gas gauge IC
Safety: UL 1642 qualified

	GoldPeak		BYD
	NiMH	**LiFePo4**	
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 requirements for all batteries			
Ambient Temperature			25°C
Number of Cycles			2000
Remaining Capacity after 2000 cycles			50%

AC adapter:

17W external AC adapter
90v(-10%) ~ 240v(+25%), 35-60Hz, AC input
12V 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")
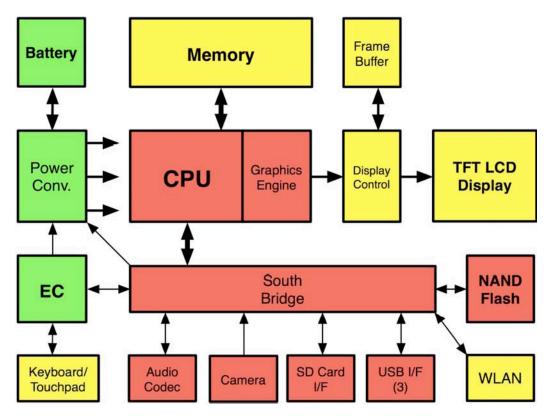
2   CL1 System Architecture

The architecture of the CL1 differs from more conventional laptop designs, in that large parts of the laptop (including the CU) may be completely powered off quickly, without affecting the operation of other parts.
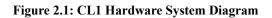
The CL1 was intended to run the Linux open source operating system, although other operating systems may be supported.

This chapter provides an overview of the architecture and the overall hardware design principles for the CL1.

2.1   System Block Diagram

Figure 2.1 is the block diagram of the CL1 system. Unlike most laptops, all components except the keyboard and touchpad are located behind the LCD panel. This 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: CL1 Hardware System Diagram

2.2   CPU & Companion Chip

The core processing system used in CL1 is an embedded x86 processor (CPU), integrating a memory management unit, x87 compatible floating point unit, a graphics processing unit. An integrated memory controller provides a unified memory model to the processor, the graphics processor, and an integrated display controller.

A companion "South Bridge" chip incorporates many peripheral and system management functions. These include an Audio Codec (AC'97) interface to the sound sytem, USB 2.0 controllers, low pin count (LPC), power management logic, and legacy PC system components such as real time clock (RTC), memory transfer engines (DMA), and programmable interrupt controllers.

The CPU core clock frequency is selectable using hardware jumpers at boot time, and may be set by software during firmware boot. The clock used for the main processor and memory is spread-spectrum modulated to reduce

the electromagnetic interference (EMI).

One example of a core processing system used in CL1 is an AMD Geode LX700 (running at 433MHz), and an AMD CS5536 Southbridge.

2.2.1 Interrupts

Dedicated system interrupts are provided for system timer, keyboard, AC'97, 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 Southbridge and used to communicate with the Embedded System 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 2D graphics processing unit (GPU) is provided in CL1 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 CL1 processor supports an integral 64 bit wide DDR1 SDRAM interface. No external buffering is used. Four 16-bit wide DDR SDRAM ICs are directly mounted on the motherboard, supporting 256 MBytes of main memory using 32M x 16 (512 Mbit) components. The speed of this memory bus is selected at boot time by firmware, and using current chips may be either DDR-266 or DDR-333.

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 CL1 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, 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 CL1 provides a DC power input jack. A DC voltage source between 11 and 18 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 15 W. 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 7.6V (for NiMH) or 6.4V (for LiFePo).

2.3.2   Battery Pack

CL1 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 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 which are typically specified as rechargable 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 which have been discharged completely. A three pin connector is used between the battery pack and CL1.

2.3.3   Backlight control

The CL1 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 which varies the brightness of the backlight.

2.3.4   Power Timing Sequence

Whenever a battery is inserted into a CL1, 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 South bridge, and communicates the power button press to it. The South bridge 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 mesh networking interface that it should isolate itself from the USB bus, places the main memory in a low power self-refresh mode, then notifies the power management logic in the South bridge. This logic will disable power from the processor and most other components of the system. Parts of the South bridge, the main memory, the display and display controller, the backlight, the keyboard, and the mesh 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 Southbridge. 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 mesh 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 CL1 firmware and operating system. This interface defines the laptop hardware that the EC must monitor and control.

Firmware and operating system running on the CL1 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 (LiFePO4 & NiMH)
        o Over voltage checking fail (LiFePO4)
        o Over temperature (58C) (LiFePO4)
        o Gauge stop or sensor break (LiFePO4 & 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 CL1 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 LiFePO4 Battery
• Enable/Disable Wireless mesh networking interface (WLAN) power

CL1 Hardware Design Specification
• 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 MByte serial Flash memory. Sixty-four KB of this memory are dedicated to EC firmware. This serial Flash is also used to store manufacturing information (up to 4 KBytes) and the firmware for the main processor (up to 832 KBytes). 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, CL1 provides a hardware 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 CL1, and produced by CHI LIN Technology, Ltd. 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. In transmissive (color) mode, it supports a display of 693 x 520 color triads, although perceptually the resolution is higher and dependent on ambient light levels, in a bright room test indicate that 1024x768 resolution is percieved. Each component of the triad has 64 brightness levels.

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 172 g.

As the CL1 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 CL1. Until suitable display controllers become available, a separate display control (DCON)

application specific integrated circuit developed for CL1 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" enables the color/monochrome LCD display to appear as a conventional 24-bit color panel
• Monochrome mode support provides for a pixel-addressable automatic color->gray scale conversion mode
• Optional anti-aliasing improves text display in color mode
• Provides a dual-edge TTL output for interfacing to the CL1 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 tranformations (color swizzling w. 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 South bridge for initialization and configuration of the DCON.

2.7   Audio
The CL1 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 Audio Codec '97 standard. An AC'97 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.

An AC'97 codec includes a number of input and output channels not supported in CL1. 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 CL1 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 CL1, 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 which 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 is 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 AC'97 codec, capable of providing 30mw continuously into a 32 ohm impedance.

2.7.4   External Microphone Input
A mono jack is provided on the laptop for connecting an external microphone, switch, or other sensor. This jack is connected to the AC'97 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 Kohm.

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 (2 V, with a 3 Kohm 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. Exceeding 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

CL1 has no spinning media storage devices, such as hard disk drives or optical drives. It relies on NAND Flash memory for non-volatile storage. 1 GByte of SLC NAND Flash is provided using a single integrated circuit. The interface between the processor and the NAND is ciritical to system performance. It is both high-speed and provides ECC calculation in hardware. Data may be accessed from the NAND device at over 30 MBytes/sec.

The endurance of the NAND device is one hundred thousand erase cycles, with a data retention of at least ten years. No wear-levelling of the device is provided in hardware, as it is provided by the operating system.

The single layer cell (SLC) type NAND Flash is used in the CL1 to extend the laptop lifetime. It provides a significantly higher number of erase cycles than the denser multiple layer cell (MLC) NAND Flash devices.
The CL1 also provides a single MMC/SD card slot for extending the laptop's storage.

2.9   Wireless Mesh Network Interface

The wireless network interface used by CL1 operates as a conventional WiFi (802.11b/g) interface, yet provides several unique features crucial to the laptop's goals. Unlike traditional wireless networking, where laptops only communicate with network access points, the CL1 supports wireless mesh networking, where laptops may relay network packets for other laptops, greatly extending the reach of any network access points. In order to encourage a mesh network, the CL1 network interface is also designed for low power operation as a mesh node, even when the laptop is powered off.

The mesh networking protocol is currently a variant of the upcoming 802.11s mesh networking standard. The CL1 will support 802.11s, when ratified, through a firmware upgrade. The current protocol and the 802.11s may be simultaneously supported at this time.

Unlike traditional laptop wireless networking interfaces, the CL1 wireless mesh networking interface includes a processor capable of forwarding packets and maintaining mesh routing tables, independent of any other laptop resources. The network interface is notified when the main processor is entering/exiting suspend mode and it is capable of notifying the embedded controller that a network event requiring attention (such as a packet destined for the laptop) has occurred. While it is possible for this interface to operate even when the laptop is completely powered off, firmware currently limits operation of the network to when the laptop is either powered on or suspended.

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.
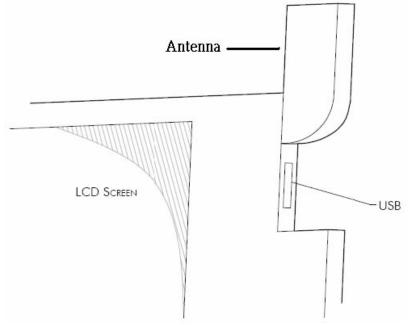
Figure 2.9: External Antenna

2.9.1   Antenna Design
The antennas for wireless networking on CL1 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 CL1 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, 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 if 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 CL1 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 CL1 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 CL1 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.
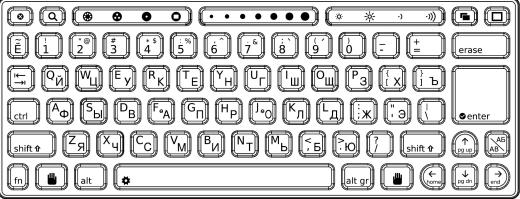

Figure 2.11: Keyboard Layout (Cyrillic version shown)

2.11.3 Core Module Buttons

The CL1 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 which 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 CL1 provides USB ports for interfacing with external devices.

2.12.1 USB

The CL1 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 Watts per USB port, the CL1 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 CL1 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 JTAG connector
• An RS-232 protocol serial connection (3.3V) to the Embedded Controller
• A JTAG connector for the WLAN module

3   Testing

The CL1 passes a wide range of environmental, mechanical, and electrical tests.

3.1   Safety

CL1 passes 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

CL1 is designed for operation over an extended range of environmental conditions:
• Ambient Temperature: 0 to 50C
• Operational Altitude: 0 to 5000 m
• Non-operational Ambient Temperature: -20 to 60C

3.3   Durability

The CL1 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 CL1 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

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 has qualified for Energy Star 4.0 Category A (the most stringent ranking); and it has received the US PC and notebook environmental ratings agency EPEAT Gold rating, one of only eight laptop computers to do so.

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 a single watt 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 LiFeP (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>

CL1 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