LOW POWER DIGITAL AUDIO DECODING/PLAYING SYSTEM FOR COMPUTING DEVICES

[0001] This application claims the benefit of provisional application serial No. 60/250,899, filed on Dec. 1, 2000, entitled "Low Power Digital Audio Decoding System for Computing Devices" and provisional application serial No. 60/265,466, filed on Jan. 30, 2001, entitled "Low Power Digital Audio Decoding/Play System for Computing Devices".

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates generally to portable devices (e.g., notebook computers) for reproducing audio recordings, and more particularly, to low-power hardware and software for decoding and reproducing compressed audio recordings in a variety of compression formats from a variety of sources. While particular utility for the present application is in the reproduction of MP3 digital audio files, especially for use with portable computers, other utilities are contemplated herein.

[0004] 2. Description of Related Art

[0005] Presently there exist various portable devices for replaying digital audio recordings that have been compressed in accordance with one or more compressed audio digital recording formats, e.g., MPEG (Moving Picture Experts Group) Audio Layer-3 (MP3), Windows® Media Audio (WMA), and Advanced Audio Coding (AAC). To date, the most popular format has been MP3, a compression scheme that results in about a 10:1 compression of the size of digital music files. These devices can be divided into two classes, those which store the compressed digital audio recordings in an electronic solid-state memory, and those which record the compressed digital audio for subsequent reproduction using an electromechanical device such as a compact disk ("CD") player or on a hard disk drive of a digital computer.

[0006] For example, portable devices for playing MP3 compressed digital audio recordings that use electronic solid-state memory, e.g., flash-memory, are capable of storing about ten (10) music selections. With an add-in memory card, such devices can carry a total of about twenty (20) music selections. These MP3 players that store the MP3 compressed digital audio recordings in an electronic solid-state memory consume comparatively little electrical power. Thus, such MP3 players provide an extended playing interval without having to power the computer's CD-ROM or hard disk drive.

[0007] U.S. Pat. No. 6,226,237, entitled "Low Power CD-ROM Player for Portable Computers", issued May 1, 2001 (the "'237" patent), which is hereby incorporated by reference in its entirety, describes how a conventional notebook computer, when simply playing a conventional music CD, consumes an unnecessarily large amount of electrical energy. That is largely due to the large number of background functions that are unrelated to the playing of music that the Operating System (e.g., Windows®) is performing whenever the computer is turned on. That excessive electrical energy consumption for functions unrelated to the function the user is performing at the moment, i.e., playing music, quickly drains the battery of a notebook computer of power that could more prudently be applied at another time in performance of microprocessor intensive tasks such as word processing and spreadsheet analysis. The solution presented in the '237 patent is a state machine that operates when main power to the portable device is OFF. The invention of the '237 patent couples a CD-ROM to the audio subsystem (when main power is OFF) so that CDs can be played, without excessive battery drain, or without having to boot up the portable computer.

[0008] The prior art also includes silicon solutions that are dedicated function integrated circuits (ICs) or incorporated into application-specific integrated circuits, or ASICs. These are usually expensive solutions as the digital signal processor (DSP) required in a dedicated chip results in a large, costly integrated circuit. One of the results is the use of a larger amount of PCB (printed circuit board) space.

[0009] Further, the 15 to 20 MIPS (million instructions per second) decode engine known in the art must be continuously running to generate the audio stream for the Codec. Additionally, the dedicated decode engine needs to have the high-power-consuming hard disk drive (HDD) continuously operating. These approaches are limited to functioning only with MP3 compression, thereby eliminating the opportunity to adapt the system to newly emerging music compression algorithms, such as Microsoft's WMA or the music industry's proposed Secure Digital Music Initiative (SDMI) for secure audio.

[0010] Dedicated silicon solutions known in the art employ a DSP that must constantly be decoding the compressed audio files from a hard disk drive, which must therefore be constantly reading the audio files. Such known methods require much power, resulting in a fast battery discharge, (e.g., much faster than the possible 4 to 10 hours of desired use on a transoceanic flight).

[0011] Thus, known hardware MP3 decoder and players requiring an IC implementation and a hard disk drive being accessed non-stop are high in power consumption, difficult to upgrade, and expensive.

[0012] The present invention provides a solution that is low in power consumption, can be upgraded in the field for various music compression formats, is expected to cost no more than half the cost of the currently available hardware implementation, and may be made capable of playing up to hundreds of musical selections, while only having to access the HDD or CD-ROM less than 0.5% of the time.

SUMMARY OF THE INVENTION

[0013] It is becoming more and more desirable for mobile platform companies to add MP3 and other compressed audio player capability to their products, with low cost, while providing very long music playing time, and perhaps even a player that can be later upgraded to other compression formats by the owner. These mobile platform companies may also want to market differentiate their products within a very short development time frame.

[0014] The music playing solution of the present invention utilizes a special purpose circuit in combination with the mini-OS (operating system) software of the present invention. The present invention uses the embedded computing power of the standard CPU to perform the file decompres-