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(54) **AUDIO OVER A STANDARD VIDEO CABLE**

(75) Inventors: **John W. Frederick**, Spring, TX (US); **Christopher D. Voltz**, Spring, TX (US)

(73) Assignee: **Hewlett-Packard Development Company, L.P.**, Houston, TX (US)

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(51) **Int. Cl.**
H04N 5/50 (2006.01)

(52) **U.S. Cl.** **348/552**

(58) **Field of Classification Search** 348/552, 348/553, 725, 723, 21–24; 345/204, 213; 710/63, 69, 70

See application file for complete search history.

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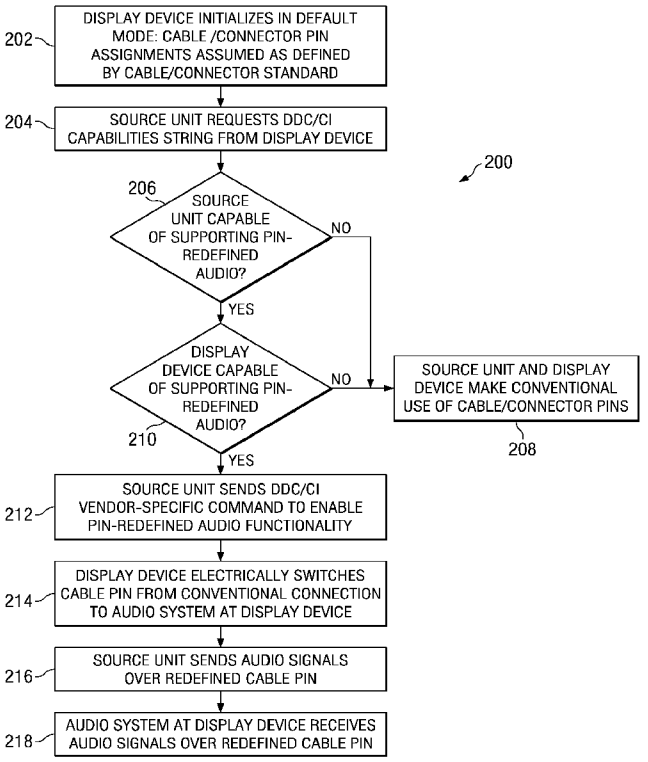
(57) **ABSTRACT**

A source unit has a video source, a digital audio source, a DDC/CI communications capability and a switch for coupling a pin of a standard video cable either to the digital audio source or to a non-audio conventional connection. A display device has a video consumer, a digital audio consumer, a DDC/CI communications capability and a switch for coupling the pin of the standard video cable either to the digital audio consumer or to a non-audio conventional connection. The switch in the display device is responsive to a DDC/CI command.

20 Claims, 2 Drawing Sheets



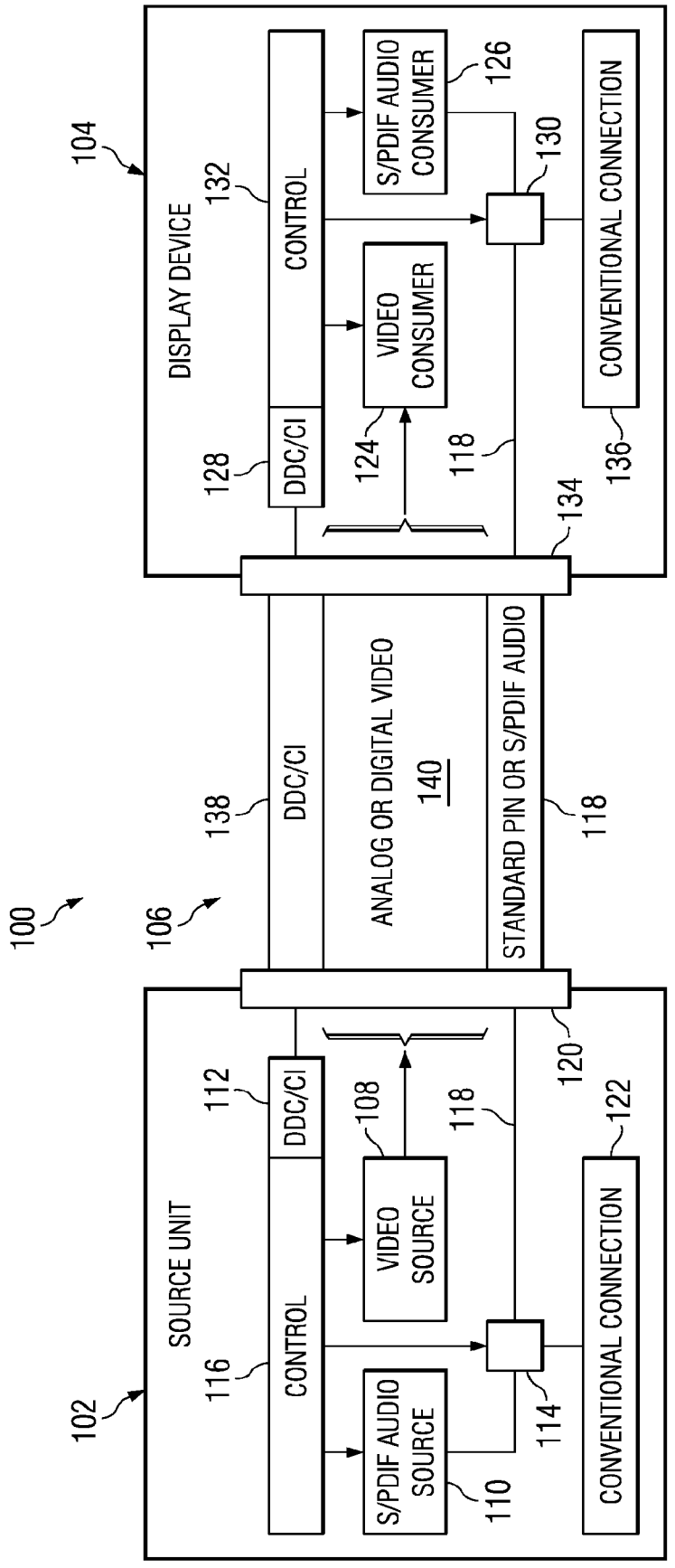
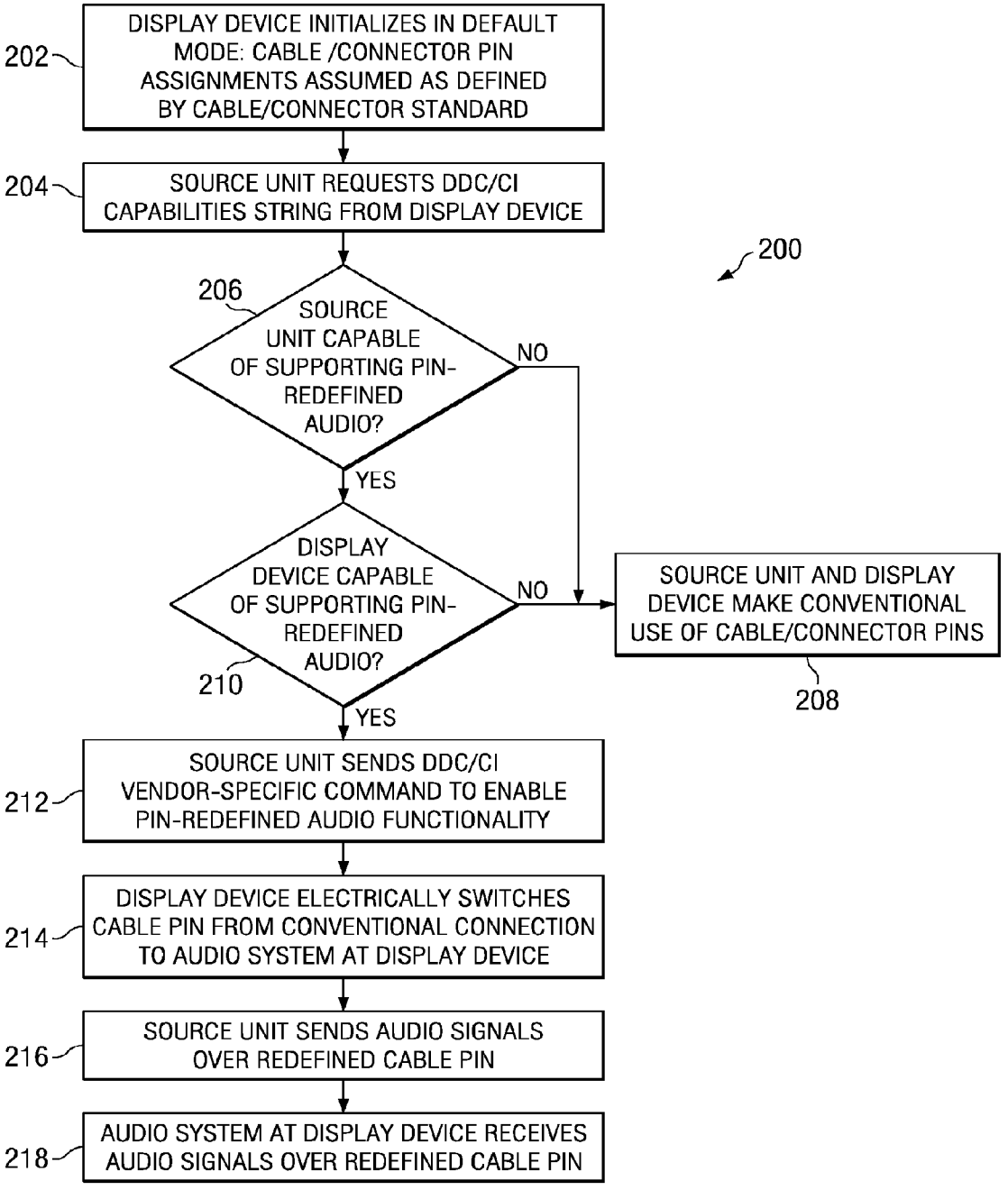

100
102
SOURCE UNIT
104
DISPLAY DEVICE
106
112
DDC/CI
116
CONTROL
108
VIDEO SOURCE
110
S/PDIF AUDIO SOURCE
114
118
120
122
CONVENTIONAL CONNECTION
132
CONTROL
126
S/PDIF AUDIO CONSUMER
130
VIDEO CONSUMER
124
128
DDC/CI
134
136
CONVENTIONAL CONNECTION
138
DDC/CI
ANALOG OR DIGITAL VIDEO
140
STANDARD PIN OR S/PDIF AUDIO
118

FIG. 1

FIG. 2


200
202
DISPLAY DEVICE INITIALIZES IN DEFAULT MODE: CABLE /CONNECTOR PIN ASSIGNMENTS ASSUMED AS DEFINED BY CABLE/CONNECTOR STANDARD
204
SOURCE UNIT REQUESTS DDC/CI CAPABILITIES STRING FROM DISPLAY DEVICE
206
SOURCE UNIT CAPABLE OF SUPPORTING PIN-REDEFINED AUDIO?
NO
YES
210
DISPLAY DEVICE CAPABLE OF SUPPORTING PIN-REDEFINED AUDIO?
NO
YES
208
SOURCE UNIT AND DISPLAY DEVICE MAKE CONVENTIONAL USE OF CABLE/CONNECTOR PINS
212
SOURCE UNIT SENDS DDC/CI VENDOR-SPECIFIC COMMAND TO ENABLE PIN-REDEFINED AUDIO FUNCTIONALITY
214
DISPLAY DEVICE ELECTRICALLY SWITCHES CABLE PIN FROM CONVENTIONAL CONNECTION TO AUDIO SYSTEM AT DISPLAY DEVICE
216
SOURCE UNIT SENDS AUDIO SIGNALS OVER REDEFINED CABLE PIN
218
AUDIO SYSTEM AT DISPLAY DEVICE RECEIVES AUDIO SIGNALS OVER REDEFINED CABLE PIN

AUDIO OVER A STANDARD VIDEO CABLE

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation of U.S. patent application Ser. No. 11/192,614, filed Jul. 29, 2005, now U.S. Pat. No. 7,893,998 the entire contents of which are hereby incorporated by reference as though fully set forth herein.

FIELD

This invention relates generally to computer or media systems having a source unit coupled to a display device by a cable. More specifically, the invention relates to techniques for providing audio output at the location of the display device in such systems.

BACKGROUND

In computer or media systems having a source unit coupled to a display device by a cable, it has become desirable to provide audio output at the location of the display device. When this is achieved, the audio output may be presented to the user via one or more sound transducers that are typically integrated into the display device or otherwise placed in close proximity to the display device.

One known technique for providing audio output at the location of the display device is to use two separate cables between the source unit and display device—one cable for video signals and one cable for audio signals. For example, it is known to use one VGA ("Video Graphics Array") cable and pair of connectors to couple analog video signals and associated video timing signals from the source unit to the display device, and to use a separate non-VGA cable with its own pair or pairs of connectors to couple analog audio signals from the source unit to the display device. It is also known to use a DVI ("Digital Visual Interface") cable and pair of connectors to couple analog or digital video signals and associated video timing signals from the source unit to the display device, and to use a separate non-DVI cable with its own pair or pairs of connectors to couple analog audio signals from the source unit to the display device. Typically, two channels of audio are provided using the separate-cables technique, the left channel and the right channel. Although the separate-cables technique represents a straightforward solution, it is expensive because it requires two cables and at least two pairs of connectors, and it degrades the quality of the audio somewhat because the audio signals are transmitted in analog form.

Another known technique for providing audio output at the location of the display device is to follow the HDMI ("High-Definition Multimedia Interface") standard. The HDMI standard specifies a way of coupling digital audio and digital video signals between the source unit and display device in time-multiplexed fashion over a single cable and pair of connectors. An HDMI cable includes enough wires to support three different types of communication channels: TMDS ("Transition Minimized Differential Sampling"), DDC ("Display Data Channel") and CEC ("Consumer Electronics Control"). More Specifically, an HDMI cable includes four shielded TMDS wire pairs. These four TMDS wire pairs are used to transmit digital video and timing signals from the source unit to the display device. These same four TMDS wire pairs are also used to transmit digital audio signals from the source unit to the display device during the horizontal and vertical blanking intervals of the video. To accomplish this, the HDMI standard specifies a new transport protocol that is superimposed on top of the older IEC 60958 and IEC 61937 digital audio transmission protocols (hereinafter the "IEC protocols").

According to the HDMI transport protocol, audio data being carried across the TMDS links does not retain the original audio sample clock that the IEC protocols provided. Instead, typically between one and four packets of audio data are transmitted over the TMDS links during every horizontal blanking interval, each of the packets carrying a payload of up to four subpackets, each of the subpackets carrying at most one IEC protocol frame or block of audio samples. The sound system associated with the display device must then continually recreate the audio sample clock and synchronize it with the video clock using HDMI-specified audio clock regeneration packets that are also transmitted across the TMDS links.

Because numerous audio encodings, sample rates and sample sizes are supported by the IEC protocols, it is necessary to set corresponding parameters for use between a given source unit and display device/audio system. According to the HDMI standard, the source unit uses the DDC channel in the HDMI cable to determine which audio encodings are supported by the display device's audio system. It does so by reading an HDMI-specified "vendor specific data block" from the E-EDID ("Enhanced Extended Display Identification Data") data stored in the display device. The source unit then dictates which parameters will be used for audio by setting appropriate bits in the IEC protocol packets and by sending HDMI-specified "audio infoframe packets" at frequent, HDMI-specified times.

One of the benefits of the HDMI standard is that it addresses the problem of audio quality degradation by transmitting digital audio signals instead of analog audio signals. The HDMI standard also eliminates the need for separate audio and video cables and pairs of connectors by time-multiplexing digital audio and digital video on a common set of TMDS wires. Unfortunately, HDMI implementations introduce significant manufacturing expense: The relatively elaborate HDMI cable and connectors are costly, and the encoding/decoding logic that is necessary to implement the HDMI protocol in the source unit and in the display device are complex. Moreover, because HDMI sends audio packets during video blanking intervals, the bandwidth available for audio in an HDMI implementation is limited by, and various in accordance with, the video timing of the display device and the source unit's graphics system. In addition, many display devices and source units that support the HDMI standard also support the VGA and/or the DVI standards for backward compatibility. Consequently, the expense of including VGA and DVI connectors is not avoided in such HDMI-equipped systems.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic diagram illustrating a source unit and display device configured to provide audio output at the location of the display device according to a preferred embodiment of the invention.

FIG. **2** is a flow diagram illustrating a preferred method for providing audio output at the location of a display device in a suitably-configured system such as the system of FIG. **1**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **1** illustrates a system **100** according to a preferred embodiment of the invention. In system **100**, a source unit **102** and display device **104** are coupled to one another by means

of a standard video cable **106** and a single pair of connectors **120**, **134**. Cable **106** may be any standard video cable such as, for example, a VGA cable, a DVI cable or an HDMI cable. Connectors **120**, **134** may be standard connectors corresponding to the standard of cable **106**. Source unit **102** includes a video source **108**, a digital audio source **110**, a DDC/CI communications capability **112** and a switch **114**. Switch **114** may be controlled by a control unit such as control unit **116**, and is configured to couple a pin or wire **118** of standard video cable connector **120** either to digital audio source **110** or to a non-audio conventional connection **122**. Conventional connection **122** may be whichever connection is specified for pin or wire **118** by the standard that defines video cable **106**.

Display device **104** includes a video consumer **124**, a digital audio consumer **126**, a DDC/CI communications capability **128**, and a switch **130**. Switch **130** may be controlled by a control unit such as control unit **132**, and is configured to couple pin or wire **118** of video cable **106** from connector **134** either to digital audio consumer **126** or to a non-audio conventional connection **136**. As was the case in source unit **102**, convention connection **136** may be whichever connection is specified for pin or wire **118** by the standard that defines video cable **106**. Control unit **132** is preferably configured to switch pin or wire **118** from conventional connection **136** to digital audio consumer **126** responsive to a DDC/CI command received from source unit **102** over DDC/CI channel **138** of video cable **106**.

After source unit **102** has switched pin or wire **118** from conventional connection **122** to digital audio source **110**, and display device **104** has switched pin or wire **118** from conventional connection **136** to digital audio consumer **126**, then digital audio may be transmitted continuously over pin or wire **118** from source unit **102** to display device **104** while analog or digital video is simultaneously transmitted from source unit **102** to display device **104** over a different set of pins or wires comprising channel **140** of video cable **106**. Alternatively, source unit **102** may switch pin or wire **118** to conventional connection **122** to be operational with a standard display device that does not have the inventive features of display device **104**. Similarly, display device **104** may switch pin or wire **118** to conventional connection **136** to be operational with a standard source unit that does not have the inventive features of source unit **102**.

FIG. **2** illustrates a method **200** for providing audio over a standard video cable in a manner consistent with the just-described system **100**. In step **202**, display device **104** may initialize itself in a default mode. In the default mode, switch **130** connects pin or wire **118** from connector **134** to conventional connection **136** so that the display device would be compatible with a standard source unit. In step **204**, source unit **102** may then request a DDC/CI capabilities string from display device **104** using DDC/CI channel **138** of video cable **106**. Steps **206**-**210** illustrate that, if either one of the display device or source unit is not able to support redefinition of pin or wire **118** for audio use, then the source unit and display device may make conventional use of video cable **106**. For example, in step **210**, source unit **102** may use information provided by display device **104** in the capabilities string to determine whether display device **104** includes the features necessary to redefine non-audio pin or wire **118** for audio use. (A standard display device without the inventive features of display device **104** would respond to the capabilities string request of step **204** with a capabilities string that does not include a command for operating switch **130**.) If source unit **102** determines that the display device does not support redefinition of pin or wire **118**, then it may leave pin or wire **118** connected to conventional connection **122** as shown in step **208**.

If source unit **102** determines from the capabilities string that display device **104** does support redefinition of pin or wire **118** for audio use, then it may send a DDC/CI command to the display device in step **212** to enable pin-redefined audio. In step **214**, display device **104** responds to the DDC/CI command of step **212** by controlling switch **130** so that it connects pin or wire **118** to audio consumer **126**. In step **216**, source unit **102** controls switch **114** so that it connects pin or wire **118** to digital audio source **110**. At that point, in step **218**, source unit **102** may send, and display device **104** may receive, digital audio signals over redefined pin or wire **118**. Simultaneously, analog or digital video signals may be transmitted from source unit **102** to display device **104** over separate wires in cable **106** comprising video channel **140**.

Source unit **102** may take a wide variety of forms. For example, source unit **102** may be a personal computer or a media box in an entertainment system. And video cable **106** may also take a variety of standard forms. For example, video cable **106** and connectors **120**, **134** may be compliant with a VGA standard, a DVI standard or an HDMI standard. The inventors hereof have determined that, if a VGA cable is used, pin or wire **118** may correspond to conventionally non-audio pins 4 or 11 of the VGA cable. If a DVI cable is used, pin or wire **118** may correspond to conventionally non-audio pin 8 of the DVI cable. If an HDMI cable is used, pin or wire **118** may correspond to conventionally non-audio pin 14 of the HDMI cable. In addition or in the alternative, pin or wire **118** may correspond to a CEC line of a standard video cable. Digital audio source **110** and consumer **126** may also take a variety of forms. In one preferred embodiment, source **110** and consumer **126** may use the well-known S/PDIF digital audio format.

While the invention has been described in detail with reference to preferred embodiments thereof, the described embodiments have been presented by way of example and not by way of limitation. It will be understood by those skilled in the art that various changes may be made in the form and details of the described embodiments without deviating from the spirit and scope of the invention as defined by the appended claims.

What is claimed is:

1. A source unit configured to provide audio over a standard video cable, comprising:
- a video source;
- a digital audio source;
- a DDC/CI communications capability; and
- a switch for coupling a pin of a standard video cable connector in the source unit either to the digital audio source or to a non-audio conventional connection.

2. The source unit of claim **1**, wherein:
the standard video cable connector is a VGA connector a standard video cable connector.

3. The source unit of claim **2**, wherein:
the pin coupled to the switch corresponds to pin 4 of the VGA connector.

4. The source unit of claim **2**, wherein:
the pin coupled to the switch corresponds to pin 11 of the VGA connector.

5. The source unit of claim **1**, wherein:
the standard video cable connector is a DVI connector.

6. The source unit of claim **5**, wherein:
the pin coupled to the switch corresponds to pin 8 of the DVI connector.

7. The source unit of claim 1, wherein:
the standard video cable connector is an HDMI connector.
8. The source unit of claim 7, wherein:
the pin coupled to the switch corresponds to pin 14 of the HDMI connector.
9. The system of claim 1, wherein:
the pin coupled to the switch corresponds to a CEC line in the standard video cable.
10. The source unit of claim 1, wherein:
the digital audio source uses the S/PDIF format.
11. A display device configured to receive audio over a standard video cable, comprising:
a video consumer;
a digital audio consumer;
a DDC/CI communications capability; and
a switch for coupling a pin of a standard video cable connector in the display device either to the digital audio consumer or to a non-audio conventional connection, wherein the switch is responsive to a DDC/CI command.
12. The source unit of claim 11, wherein:
the standard video cable connector is a VGA connector.
13. The source unit of claim 12, wherein:
the pin coupled to the switch corresponds to pin 4 of the VGA connector.
14. The source unit of claim 12, wherein:
the pin coupled to the switch corresponds to pin 11 of the VGA connector.
15. The source unit of claim 11, wherein:
the standard video cable connector is a DVI connector.
16. The source unit of claim 15, wherein:
the pin coupled to the switch corresponds to pin 8 of the DVI connector.
17. The source unit of claim 11, wherein:
the standard video cable connector is an HDMI connector.
18. The source unit of claim 17, wherein:
the pin coupled to the switch corresponds to pin 14 of the HDMI connector.
19. The system of claim 11, wherein:
the pin coupled to the switch corresponds to a CEC line in the standard video cable.
20. The source unit of claim 11, wherein:
the digital audio consumer uses the S/PDIF format.

* * * * *