Design of Optical HDMI Extender

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Abstract

HDMI is a digital interface. It provides the best quality of the video since there is no loss due to analog to digital conversions as is required for all analog connections. Fiber-optic communication is a method of transmitting information from one place to another by sending pulses of light through an optical fiber. The light forms an electromagnetic carrier wave that is modulated to carry information. In this paper, we design the optical HDMI extender for long distance multimedia data transmission.

Keywords: HDMI, Optical interface, Extender, HDMI extender, Optical extender

1. Introduction

Nowadays most consumer electronics are introduced HDMI (High-Definition Multimedia Interface) [1] for multimedia data transmission. Digital televisions, Blu-ray player, PC, laptop and smart phone with a variety of devices to the HDMI adopted. HDMI is utilized in various devices as space is also used in non-living room. If transmission distance is equal to more than 10 meters, data is corrupted. However, use of fiber-optic communication, data transfer a few kilometers or more is possible.

Fiber-optic communication is used for the high-speed Internet, IPTV and Digital Audio Interface. Fiber-optic communication is lossless data communication system. Fiber-optic communication of the long-distance transmission is possible without any loss of data.

This paper, we design of optical HDMI extender for long distance multimedia data transmission. That support the transmission distance more than 1km.

2. HDMI Interface

The HDMI is provided for transmitting digital television audio/video signals from blu-ray players, set-top boxes and other audio/video sources to television sets, projectors and other video displays. HDMI can carry high quality multi-channel audio data and can carry all standard and high-definition consumer electronics video formats. Content protection technology is available. HDMI can also carry control and status information in both directions. As shown in Figure 1, the HDMI cable and connectors carry four differential pairs that make up the TMDS data and clock channels.
In HDMI, when transmitting the data, the audio clock is not transmitted separately. Therefore the audio clock should be recovered in the receiver side from TMDS clock (video data timing clock) coming from the transmitter. HDMI recommended seven different audio sampling clocks, which are 32 KHz, 44.4 KHz, 88.2 KHz, 176.4 KHz, 48 KHz, 96 KHz, and 192 KHz. Frequency range between 25.2MHz to 148.5MHz is used for TMDS clocks. With various combinations with TMDS clock frequency, N, and CTS, the recommended sampling audio clocks are generated. Since the output is 128*fs, the final output frequency varies from 4.096MHz to 24.576MHz [2]. As shown in Figure 2 and 3, Block diagram of HDMI Tx and Rx Controller interface.

Figure 1. Database contexts

Figure 2. Block diagram of HDMI Tx Controller interface
From the HDMI connector's pins, signals transmit through twisted pairs of copper cable. Three audio and video channels transmit through two pins each, for a total of six pins. The TMDS clock, which allows devices to synchronize the incoming data, transmits through one pair of pins. Each of four pairs has a shield. As shown in Figure 1 is HDMI connector.

HDMI supports CEC(Consumer Electronics Channel). If devices support it, this channel allows them to send instructions to one another. For example, a Blu-ray player could automatically turn on an HDTV when it started playing a disk.

The High-bandwidth Digital Content Protection System was developed by the Intel Cooperation in 1999. It was designed especially for protecting audiovisual content transmitted over high-bandwidth interfaces like HDMI, DVI, or DisplayPort [3].

HDMI devices are manufactured to adhere to various versions of the specification. Table 2 shows version comparison.
### Table 2. Version comparison[4]

<table>
<thead>
<tr>
<th>HDMI version</th>
<th>1.0</th>
<th>1.1</th>
<th>1.2</th>
<th>1.3</th>
<th>1.4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date initially released</td>
<td>December 9, 2002</td>
<td>May 20, 2004</td>
<td>August 8, 2005</td>
<td>June 22, 2006</td>
<td>May 28, 2009</td>
</tr>
<tr>
<td>Maximum clock rate (MHz)</td>
<td>165</td>
<td>165</td>
<td>165</td>
<td>340</td>
<td>340</td>
</tr>
<tr>
<td>Maximum TMDS throughput per channel (Gbit/s) including 8b/10b overhead</td>
<td>1.65</td>
<td>1.65</td>
<td>1.65</td>
<td>3.40</td>
<td>3.40</td>
</tr>
<tr>
<td>Maximum total TMDS throughput (Gbit/s) including 8b/10b overhead</td>
<td>4.95</td>
<td>4.95</td>
<td>4.95</td>
<td>10.2</td>
<td>10.2</td>
</tr>
<tr>
<td>Maximum throughput (Gbit/s) with 8b/10b overhead removed</td>
<td>3.96</td>
<td>3.96</td>
<td>3.96</td>
<td>8.16</td>
<td>8.16</td>
</tr>
<tr>
<td>Maximum audio throughput (Mbit/s)</td>
<td>36.86</td>
<td>36.86</td>
<td>36.86</td>
<td>36.86</td>
<td>36.86</td>
</tr>
<tr>
<td>Maximum color depth (bit/px)</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>48</td>
<td>48</td>
</tr>
<tr>
<td>Maximum resolution over single link at 24-bit/px</td>
<td>1920x1200p 60</td>
<td>1920x1200p 60</td>
<td>1920x1200p 60</td>
<td>2560x1600p 75</td>
<td>4096x2160p 24</td>
</tr>
<tr>
<td>Maximum resolution over single link at 30-bit/px</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>2560x1600p 60</td>
<td>4096x2160p 24</td>
</tr>
<tr>
<td>Maximum resolution over single link at 36-bit/px</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>1920x1200p 75</td>
<td>4096x2160p 24</td>
</tr>
<tr>
<td>Maximum resolution over single link at 48-bit/px</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>1920x1200p 60</td>
<td>1920x1200p 60</td>
</tr>
<tr>
<td>Maximum 3D resolution over single link at 24-bit/px</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>1920x1200p 60</td>
<td>1920x1200p 60</td>
</tr>
</tbody>
</table>

EDID (Extended Display Identification Data) is a VESA standard data format that contains basic information about a monitor and its capabilities, including vendor information, maximum image size, color characteristics, factory pre-set timings, frequency range limits, and character strings for the monitor name and serial number.

### 3. Fiber-optic Communication

Most important demands on optical fibers are a proper waveguiding, low loss of optical power and low distortion of the transmitted optical signals. The principle of operation of guiding a light wave can be explained by “total internal reflection” [5]. The process of communicating using fiber-optics involves the following basic steps. Creating the optical signal involving the use of a transmitter, relaying the signal along the fiber, ensuring that the signal does not become too distorted or weak, receiving the optical signal, and converting it into an electrical signal.

Modern fiber-optic communication systems generally include an optical transmitter to convert an electrical signal into an optical signal to send into the optical fiber, a cable containing bundles of multiple optical fibers that is routed through underground conduits and buildings, multiple kinds of amplifiers, and an optical receiver to recover the signal as an
electrical signal. The information transmitted is typically digital information generated by computers, telephone systems, and cable television companies.

The light in a fiber-optic cable travels through the core (hallway) by constantly bouncing from the cladding (mirror-lined walls), a principle called total internal reflection. Because the cladding does not absorb any light from the core, the light wave can travel great distances. Figure 3 shows diagram of total internal reflection in an optical fiber.

![Figure 3. Diagram of total internal reflection in an optical fiber](image)

Fiber optic adapters are used to link fiber patch cables or fiber optic connectors. Figure 4 shows fiber optic adapters.

![Figure 4. Fiber optic adapters](image)

4. **Optical HDMI extender**

Optical HDMI is used to long-distance transmission images of lossless high-definition multimedia data. Optical HDMI extender is to serialize the HDMI electrical signal. To serialize the signal using the SerDes(Serializer/Deserializer). A SerDes or Serializer/Deserializer converts a parallel data source to one or more serial data lanes and vice-versa. The serial data channels use differential signaling and a point to point configuration with a separate Transmit (TX) and a separate Receive (RX) function.
comprising a lane. [6] Convert the serialized electrical signal to optical signal using the OEC(Optical-Electronic Converter) in Tx. Rx is progression in reverse. Figure 4 shows diagram of optical HDMI extender.

\[
\text{Figure 4. Diagram of optical HDMI extender}
\]

1-core system is required only one optical fiber. This system is simple to produce. The price is cheaper than the 2 or 3 core system. It may correspond to 3.4Gb/s to HDMI Ver1.3 is required in the 1-core system.

5. Verification

The Pattern Generator and HDTV are used to verify the performance of the optical HDMI extender. The video and audio signals are generated using the Mik K-8278 Multi Video Pattern Generator. The resolution of video source is 1080i 60fps. Target device is LG Full HDTV. Transmit distance is 1km. Tx and Rx device’s HDMI version is 1.3. Table 2 shows verification environment.

\[
\text{Table 2. Verification environment}
\]

<p>| | |</p>
<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Tx</td>
<td>mik K-8278 Multi Video Pattern Generator</td>
</tr>
<tr>
<td>Rx</td>
<td>LG Full HDTV</td>
</tr>
<tr>
<td>Distance</td>
<td>1km</td>
</tr>
<tr>
<td>Resolution</td>
<td>1920x1080i 60fps</td>
</tr>
<tr>
<td>HDMI version</td>
<td>1.3</td>
</tr>
</tbody>
</table>

The HDMI cable is used to connect the pattern generator and Tx. Both Tx and Rx are connected by 1km length fiber-optic cable. The HDMI cable is also used to connect the Full HDTV and Rx. Figure 5 shows verification environment.
Figure 5. Verification environment

As a result, the device under test was operating normally. Figure 6, 7, 8 shows the results of resolution, EDID and HDCP tests. Table 3 summarizes test results.

Figure 6. Resolution test

Figure 7. EDID test
Figure 8. HDCP test

Table 3. Test results

<table>
<thead>
<tr>
<th>Item</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resolution</td>
<td>1920x1080i</td>
</tr>
<tr>
<td>EDID</td>
<td>OK</td>
</tr>
<tr>
<td>HDCP</td>
<td>OK</td>
</tr>
<tr>
<td>Distance</td>
<td>1km</td>
</tr>
</tbody>
</table>

5. Conclusion

With the copper HDMI cable, long-distance transmission is difficult. Optical fiber is advantageous for long-distance transmission than copper wire. Using Optical fiber for HDMI data transmission, long-distance transmission can be possible. The optical HDMI extender presented is working properly. The hardware design was verified using multi video pattern generator and full HDTV. The optical HDMI extender can send/receive the 1080i HDMI data within 1km.

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References


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