CoolHD™ - Recovers & Recycles Energy

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The world today is bursting with ideas for new gadgets using the latest and greatest technologies. Since the introduction of digital TVs, HDMI has taken the deep roots in serving the needs of large-screen HD display. Blu-ray technology, Plasma, LCD and LED televisions, and now the introduction of a 3D viewing experience, have taken the consumption of multimedia content to a new level.

With few exceptions, the portable segment has lacked the ability to process and drive HD content to a large display. The introduction of several new 'palm-held' devices like super smartphones, tablets with state of the art application processors, and various HD multimedia applications provides a new paradigm for multimedia consumption. Consumers are already accustomed to enjoying HD content on a large display. Portable devices with HD processing capabilities makes enjoying HD content on a large display a 'must-have' instead of a 'nice-to-have' feature.

In order to achieve this though, three things are needed: a HD capable handheld, an application to drive HD contents, and a connectivity option to the larger HD display for a superior user experience. However, the process of adding more features to the portable devices has been complex and expensive. Notwithstanding the complexities, any such new feature becomes a larger power draw on the handheld. The weight and the form factor of such portable devices limit the battery size and the thin palm-held battery needs to be sacrificed to achieve a greater viewing effect.

The Need for Green Energy, Renewable to Recyclable

With the proliferation of new gadgets for consumers around the world -- increasing the need for more energy -- the world's governments are imposing energy consumption restrictions on the various appliances. "Energy Recycling" is also a real and distinct solution that is often forgotten in this complex world of energy consuming appliances.

CoolHD™ Technology – Recovers and Recycles Energy

Analogix Semiconductor invented and introduced CoolHD technology, which not only recovers the energy that would otherwise have been wasted but also *recycles* that energy to power up the *Integrated Circuit* device for full functional operation. Essentially, CoolHD technology facilitates HD multimedia rendering on HDTVs with

ZERO power consumption from the battery of the portable device. In the process, this technology extends the battery charge life of any handheld or Smartphone device. Thus it decreases the demand for frequent battery recharging while enhancing user productivity and providing better user experience for an extended period.

What is CoolHD™ Technology? Going Back to Basics

In order to understand CoolHD technology and its benefits, we have to explore and understand the basic principle of electrical connectivity between two audio-video electronic appliances. With the exception of wireless technology, two audio-video appliances are connected through a cable to transfer the multimedia information from one appliance to the other. This cable connectivity can be termed as "*DC Coupled*" (Directly Connected) or "*AC Coupled*" (Indirectly Connected) electrically. In multimedia connectivity terms, the audio-video appliance responsible for delivering the contents is called the "*Source"* or "*Transmitter,"* while the appliance receiving the contents and connected through cable is called the "*Sink*" or "*Receiver.*"

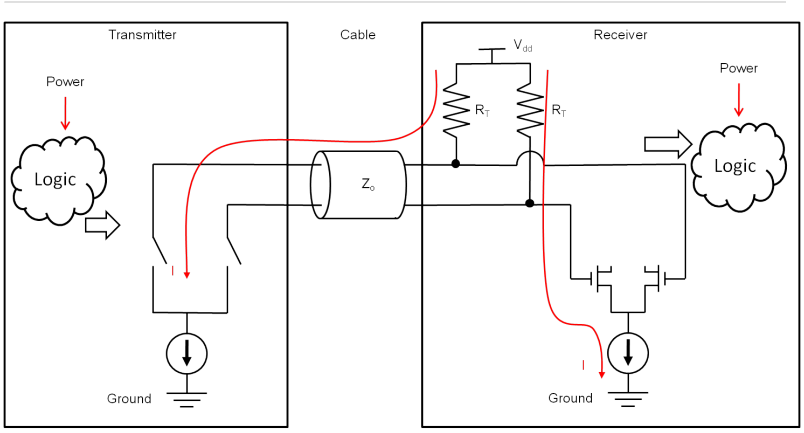

Figure 1 - DC Coupled Connectivity between a Source and Sink Device

In "DC Coupled" connectivity, as shown in Figure 1, two audio-video appliances i.e. a Source and a Sink are connected through a cable without any passive component blocking the path of DC current flow. For simplicity, the connectivity shown demonstrates the "*DC Coupled*" connectivity of transistors without the additional transistors that are driven on both sides of the respective *Integrated Circuit* devices. The termination resistors on the Sink side provide the desired pull-up supply voltages to both sides. The Source device needs to be powered up by its own power supply in order to transact with the Sink device over the cable. Similarly, the Sink device needs to be powered up by its own power supply to receive the transactions from the Source device. In this case, current flows directly through the cable between two Audio-Video appliances to achieve the desired transactions. The key point here is that the Transistors on either side of the "*DC Coupled*" connectivity have to tolerate and switch to the same voltage supply.

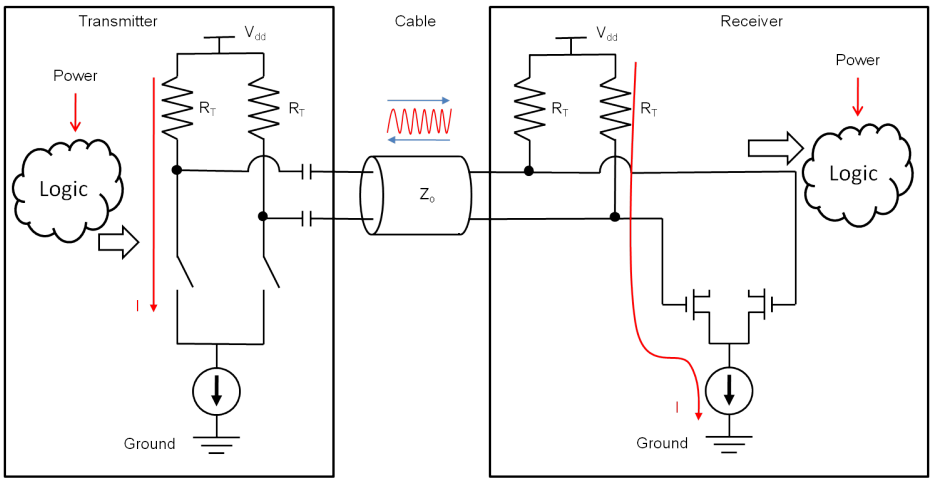

Figure 2 - AC Coupled Connected Source and Sink Devices

In the case of "*AC Coupled*" devices, as shown in Figure 2, "*Capacitive Coupling*" is used between the two Audio-Video appliances. Capacitors block the flow of DC current through the devices, allowing only AC current to pass through. Hence, the rate of change on one side of the appliance is passed to the other side while blocking the direct current flow between them. Unlike "*DC Coupled*" connectivity, the transistors on the either side of the "*AC Coupled*" devices do not need to be on the same voltage supply.

Why one type of connectivity is prescribed over the other is beyond the scope of this article. A simple explanation is that the "*AC Coupled*" solution allows the *Integrated Circuit* devices to operate at different voltage rails. Hence, it helps in migration of the IC devices to deep sub-micron technology with higher integration. Also, in deep sub-micron process technologies, the voltage supplies available for the IC devices are lowered to reduce the power consumption. Typically, the electronics industry drives higher functional integration in order to lower the system cost to build a "System-On-A-Chip." Hence, the deep sub-micron process technology helps in higher integration and lower power consumption. At the same time, all IC devices on the same or different platforms do not migrate to similar process technology. As a result, a voltage rails disparity exists between IC devices inter-connected to each other. "*AC Coupled*" connectivity helps to drive the signals between two IC devices which are operating at different voltage levels. The rate of change in voltage levels above or below logical thresholds defined on either side is communicated to the other side.

Regardless of the "*DC Coupled*" and "*AC Coupled*" connectivity between two IC devices, power is consumed on both sides to achieve the desired transactions between the two Audio-Video appliances.

Growing Demand for HD Connectivity

HDMI was primarily specified for consumer electronics appliances which operate largely by being plugged into a wall outlet. Though the higher functional integration for System-on-a-Chip was always planned for the chip

makers, reducing the power consumption was a very low priority for this same group of people. The introduction of portable multimedia devices and the advent of the Super-Smart-Phones in the last few years, and with the processing power of these appliances approaching that of the general computing world, the small form factor display on these smart portable devices limit the user experience. The consumer is already used to experiencing HD contents on large display since the inception of the HD televisions. The HD capability of these portable devices is driving an increasing demand to connect them to a large HD display.

With a very rich legacy in analog and mixed signal designs and a long history of association with HDMI Technology, Analogix has invented a novel architectural implementation to "*Recover and Recycle Energy.*" HDMI Technology works on the principle of "*DC Coupled*" connectivity between two Audio-Video appliances. In HDMI terms, a '*Source*' or '*Transmitter*' device is always responsible for providing the HD content to a '*Sink*' or '*Receiver*'. Analogix has developed an innovative implementation for "DC Coupled" connectivity between a '*Source*' and a '*Sink*' that "*Recovers*" the energy inside of the Source. Through this unique implementation, the recovered energy is further "*Recycled"* inside of the '*Source*' to power itself without needing any further power for its functional operation. This innovation is called Analogix' CoolHD **t**echnology.

How Does CoolHD Technology Help Recover and Recycle Energy?

With the knowledge of connectivity fundamentals and the understanding of the benefits of CoolHD technology, it is worthwhile to take a closer look at the CoolHD implementation. Sometimes a complex implementation can be explained in simple words, and these simple things can alter the design paradigm on how we think about implementing our next Integrated Circuit devices. Without resorting to the full protocol of HDMI technology, for simplicity, we can safely discuss a system with "DC Coupled" connectivity between two IC devices through a cable.

The CoolHD technology implementation (A Patent Pending Technology) is presented in Figure 3. As we already have learned from the "*DC Coupled*" connectivity, when a cable is connected between the Source (Transmitter) and Sink (Receiver) devices, the energy received from the Sink (Receiver) would have largely dissipated as heat through the cable and the Source driver devices. Finally, this energy would have been lost to ground.

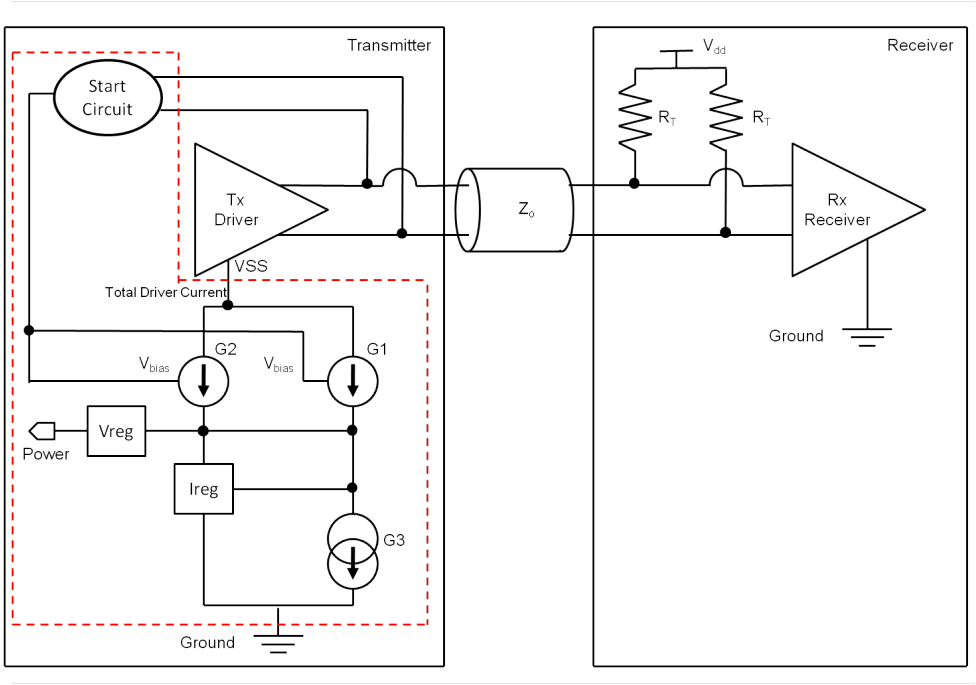

Figure 3 – Illustration of CoolHD Architectural Implementation

In Figure 3, a CoolHD transmitter is shown connected through a cable to a standard receiver in "*DC Coupled*" way. In CoolHD technology implementation, the ground connectivity of the Source (Transmitter) driver is supplemented with a CoolHD circuit implementation as shown within the red dotted lines. These CoolHD circuit implementations are responsible for energy recovery and recycle inside of the Transmitter. The startup circuit taps a miniscule amount of current to generate the bias voltage for the G1 and G2 as shown in Figure 3. The Low Drop-Out Voltage Regulator (Vreg) is responsible to generate various voltage supplies internal to the source or transmitter IC device. Thus this 'recovery and recycle' continues as long as the cable is connected to the Sink (Receiver) device.

The novelty in this implementation lies in the fact that the Source device does not need upstream power to function. The Source device powers itself when a cable connects it with the Sink Device. Then the transactions between them are carried out as long as the Source is receiving upstream contents and passes them to the Sink device on the downstream. When the power is terminated on the Sink side i.e. Sink does not require the payload from upstream the source goes back to its original state.

What Does CoolHD Technology Bring to Portable Devices?

It is important to put the benefit of CoolHD technology implementation into perspective. At Analogix, we have measured the power consumptions of a real Tier-1 HD capable portable device currently selling in the market. The portable device carries an Application Processor which is capable of processing and outputting resolutions starting from VGA right up to Full-HD (1080p). The Application Processor was coupled with two types of discrete HDMI Transmitters on two test vehicles i.e. a standard discrete HDMI Transmitter on one test vehicle and a CoolHD HDMI transmitter on the other vehicle to output HD contents through a HDMI Port. The measured data was plotted to understand the benefit of the CoolHD technology.

The display capability of a screen is usually defined in terms of number vertical lines and number of horizontal lines at a certain refresh rate per second. This can be understood with the help of a simple example. Let us assume that a transmitter is sending VGA resolution at 60Hz. A VGA frame corresponds to 640 vertical lines and 480 horizontal lines. In order to achieve transition at 60Hz refresh rate, the frame has to be redrawn 60 times per second to achieve the desired VGA resolution at 60Hz. Now, if we layout the 640 vertical lines and 480 horizontal lines in a matrix, it will be a matrix of 640 x 480. Each element on the matrix is known as pixel on the screen. Each pixel is represented by its basic color depths i.e. Red, Green and Blue. Again, each basic color of the pixel is driven by number of digital bits to show the pixel on the screen. A pixel clock is responsible for clocking a group of transistor circuits to turn-on or turn-off the pixel to render the pixel on the screen. So, the higher the resolution results in higher pixel counts. This means more pixels need to be clocked at the same time to render an image on a higher resolution and so on.

In Figure 4, we have plotted the pixel clock frequency, on horizontal axis, corresponding to various resolutions starting from VGA to all the way Full-HD (1080p). The power measurements were taken in three stages - Application Processor ONLY power consumption, Application Processor with a standard discrete HDMI Transmitter power consumption, and Application Processor with CoolHD HDMI transmitter power consumption. The power consumption of the Application Processor ONLY was taken at the lowest resolution, i.e. VGA, and it served as the baseline number. All other power consumption measurements were divided by the baseline power consumption number to derive the "*Power Consumption Index.*" The "Power Consumption Index" is plotted on the vertical axis of Figure 4.

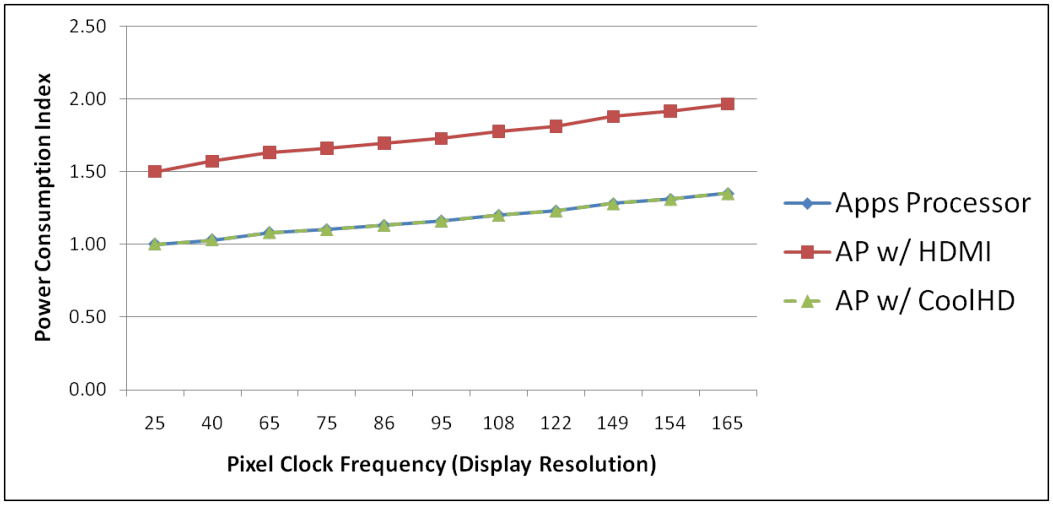

Figure 4 - Consumptions of Application Processor, with Typical and CoolHD

It is evident from the Figure 4 that the power consumption is directly proportional to the raw video pixel clock frequency. We have already established that as the display resolution goes up a higher number of pixels per unit area need to be processed. Subsequently, to render the image on a continuum basis, the pixel clock frequency has to go up to process more pixels at the same unit time interval. Thus it raises the power consumption of the Application Processor alone to provide display at a higher resolution. Since the HD multimedia contents have to be carried through the HDMI Port, a typical HDMI Transmitter adds power consumption to the existing Application Processor power consumption. Usually, the frequency of the HDMI clock is about 10 times the frequency of the raw video pixel clock. It is evident from Figure 4 that the power consumption of the Application Processor with the typical HDMI transmitter is about 1.45 times the power consumption of the Application Processor alone. However, the system with the Application Processor and CoolHD HDMI Transmitter did not add additional power consumption to the power already consumed by the application processor alone.

In essence, CoolHD HDMI Transmitter did not consume any functional power to render the HD display.

In Summary

Analogix Semiconductor continues its rich tradition of innovations in the field of analog and mixed signal design implementations, now evident in its CoolHD technology. Analogix is not only committed to building better products in the High Definition Multimedia Interface technology segments, but also to raising the bar to a new level so that consumers get the most from their hard earned money. Analogix continues working to lower power consumption on all of its product offerings. This innovation has seen adoptions in various form factor portable devices such as personal media players, digital still cameras, digital camcorders, personal video recorders, Smart-Phones and many more. Consumer demand is driving the need to deliver HD content from a portable device to a large-screen HD display, and the ability to do that with green technology serves them better.

Analogix is deeply committed to applying CoolHD technology to introduce improved IC devices to serve the need of tomorrow's portable devices. Analogix is committed to enhancing user productivity and to providing a better user experience to consumers, from a portable device to a large HD display.

About the Author

Soumendra Mohanty is a Senior Director of Marketing at Analogix Semiconductor. At Analogix, he has been involved in the successful launch of the World's first discrete DisplayPort™ Transmitter and first ever CoolHD HDMI transmitter products. In his current position, he manages the Portable-HD Product Line and the Intellectual Property Business Line. Soumendra has a Master's Degree in Electrical Engineering from University of Louisville, Kentucky, USA and Business Degree from Ashridge Business School, Berkhamsted, Hertfordshire, United Kingdom. His personal interests include but not limited to watching and playing cricket, reading, travelling and above all design wins for his favorite Product Line. He can be reached at smohanty@analogixsemi.com.