White Paper

# Integrated EHCI and USB 2.0 Hub Solution to meet Embedded Host solutions


## EXECUTIVE SUMMARY

The evolving complexity of the newer Universal Serial Bus (USB) devices has necessitated the need for low cost USB 2.0 Host solution. This paper addresses the key reasons to have integrated hub and Enhanced Host controller interface (EHCI) in the newer generation of embedded hosts. Also, this paper will provide design guidelines for such integrated solutions, and the factors to be considered for such designs.

## Introduction

USB has been the most popular peripheral interface adopted by the industry. In 2008 3 billion USB devices were produced. This is projected to double to 6 billion in 2015. This demonstrates a growing demand for USB from peripheral vendors.

The complexity of embedded systems has grown such that a single port host controller solution is not sufficient to meet the requirements of multiple attached devices. For instance, a single USB system can have a USB flash controller, a camera, and an option to support external device.

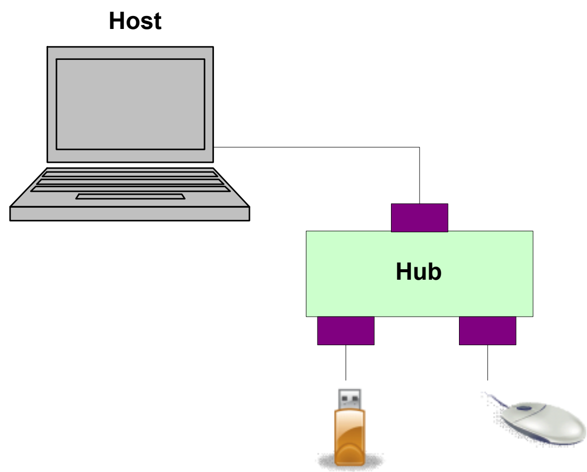


**Figure 1: USB Eco System**

In USB systems, there are three basic entities that constitute the system: a Host controller, a Hub, and a Device. The USB system is a host-centric system, in which the entire topology of the USB system is governed by the token packets generated from the Host controller. The Hub is an entity which provides the mechanism to expand the number of USB ports in the system, and the Device is the end peripheral in the system. Typically, a Device has one or more endpoints which source or sync the data in the USB system. Figure 1 depicts a sample USB system. The Hub in this system provides multiple port connectivity to the host controller.

## COMPANION HOST CONTROLLER (VS) INTEGRATED HUB

Figure 2 Depicts a host controller architecture with a companion host controller. In this architecture, the Enhanced Host Controller Interface (EHCI) is responsible for supporting high speed (480 MHz) devices, and the companion host controller is responsible to support full speed (12 MHz) and low speed (1.5 MHz) devices. The typical interfaces used for a companion host controller are Open Host Controller Interface (OHCI) or Universal Host Controller Interface (UHCI).

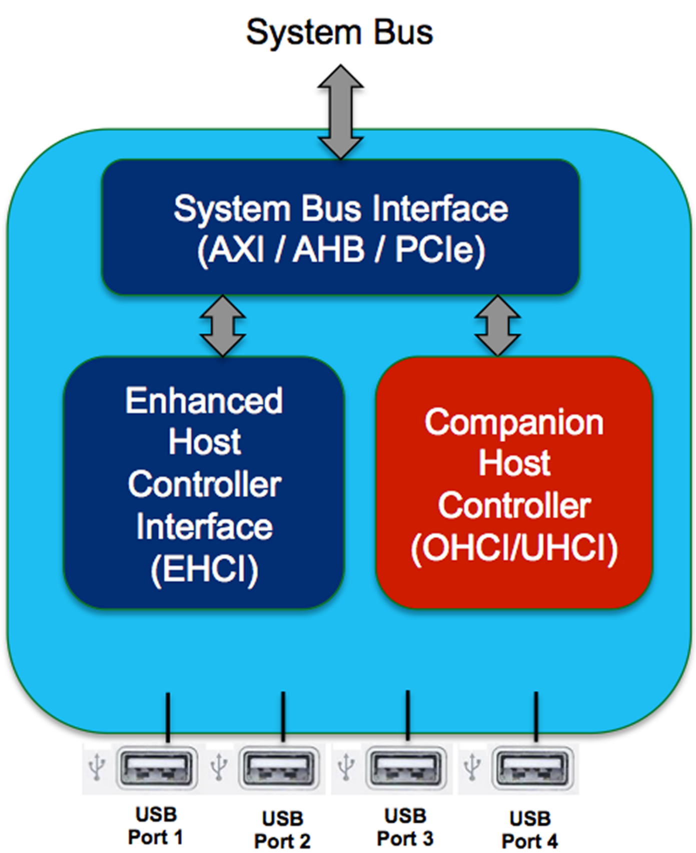


**Figure 2: USB 2.0 Host controller with companion host controller**

Figure 3 depicts the host controller solution from Arasan, which integrates Arasan's Enhanced Host Controller Interface and USB 2.0 Hub IPs. The Enhanced Host Controller Interface module is responsible for the high speed traffic, while the USB 2.0 Hub is responsible for the high speed, full speed, and low speed traffic, thus eliminating the necessity to have a companion host controller. This is an attractive feature for embedded systems, since this eliminates the software driver requirement for the companion host controller, which saves memory space required for the driver. This architecture also paves way for compound devices to be implemented within the system.

Refer to paper ***Integrated USB Hub Solution*** white paper from Arasan for more details on compound device solution.

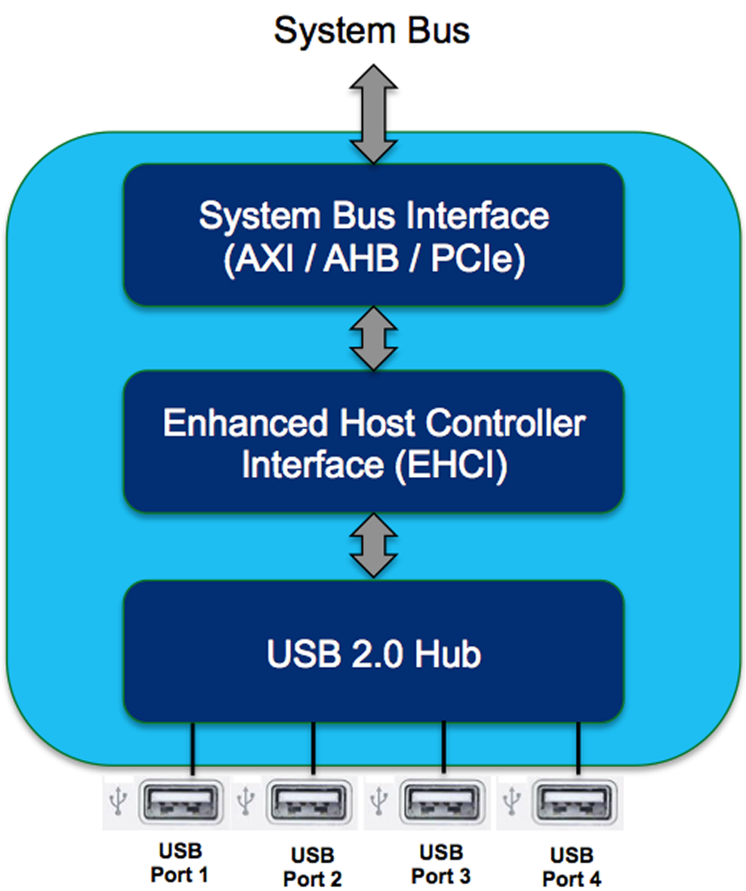


**Figure 3: Arasan USB 2.0 Host Controller Solution**

The compound device is a system in which the hub has one or more downstream ports permanently connected to a device. The hub could be a physical component connected to the device, or it could be integrated with the device functionality. Device vendors with multiple functionalities find this solution very attractive, since this reduces silicon real estate and power. Also, this provides an easier way to club multiple device functionality into a single chip in a shorter time frame.

Another device category for consideration could be a composite device. A composite device has multiple interfaces in the design which can be switched during operation. The functionality is desirable, but the complexity needed in the software and hardware makes this option less popular with system designers.

## FACTORS TO BE CONSIDERED FOR AN EMBEDDED USB HOST CONTROLLER

### *Speed*

USB 2.0 has defined support for the following speeds:

- Low speed – 1.5 MHz
- Full speed – 12 MHz
- High speed – 480 MHz

The support for the device speed on each of the downstream port (attachable & permanent) dictates the speeds to be supported for the solution. For instance, if the system demands usage of a single high speed device, then the USB 2.0 Hub could be completely eliminated.

### *Downstream Port*

The total number of downstream ports to be supported by the host controller is a major factor in the design. The downstream ports can be broadly classified into two categories: permanently attached device port, and attachable device port. The physical layer to the USB port on the permanently attached device port can be bypassed and can be replaced with wrappers communicating to the Hub's controller, which saves area consumed by the physical layer on both the upstream and downstream port of the device.

For attachable device port, the Hub should implement the physical layer of the USB connectivity, providing the ability to support an external device. Another key factor to be considered on the downstream port is the port power. If the compound device is bus powered, then the USB power specification limits the number of downstream ports that can be supported.

### *Power*

Power is a key factor in this design. The integrated Hub in the Host controller solution has to meet the self-powered requirements of the specification. For each external downstream port, the system should provide a maximum of 500 mA in order to support a bus powered hub beneath it. The only exception would be if the system restricts the attached device to be self-powered devices. In this scenario, it would be sufficient to provide a maximum current of 100 mA.

### *Transaction Translator*

Transaction Translator (TT) is a key module in the Hub, which is necessary to bridge between a high speed host controller and full/low speed device attached. The TT provides a buffering mechanism between the high speed traffic and other USB 1.1 speed devices.

There are two specific implementations of the TT: per-port TT, and single-port TT. As the name specifies, the per-port TT architecture has a dedicated TT for each downstream port. In single-port TT architecture, a single TT is shared between all the downstream ports. Obviously, the per-port TT architecture has more bandwidth allocation than the single-port TT architecture.

Optionally, the TT can be omitted in the case where the devices attached are high speed devices. This option is of significant consideration where the system is going to interact with high speed devices alone. This would save buffer space and chip area in the design.

### *Repeater Buffer*

In addition, the repeater buffer shall be included in order to support attachable downstream ports. In case of permanently attached super speed devices this repeater buffer can be omitted, provided they are synchronous to the same clock source, and the buffering in the functional devices are sufficient to handle the latency requirements.

## BENEFITS OF USING INTEGRATED HUB WITH EHCI

1. Eliminate the driver support for companion host controller.
2. Save area and space by eliminating the physical layer between the Host and the Hub.
3. Easy to implement compound devices as part of the system.

## Conclusion

With the increasing needs for the embedded USB host controller, integrated hub with EHCI is an attractive architecture for embedded systems. The reduced amount of complexity in the driver and architecture makes Arasan USB 2.0 Host controller solution attractive. This architecture provides the necessary features of a PC based host controller system on an embedded platform.

## Arasan's USB IP Portfolio

Arasan Chip Systems Inc. has been a leading developer of USB IP dating back to it's first release of USB 1.0 in 1996. Arasan's USB cores have been used in diverse applications ranging from the world's first PDA to mission critical defense applications. Arasan offers a complete portfolio of USB IP including host, device, hub, USB 2.0 analog PHY, embedded controllers and hardware validation (HVP) platforms. Arasan's USB 2.0 device has been certified by the USB Implementors Forum. Arasan also supports the latest USB 3.0 standard. With a sizeable group of engineers dedicated to USB IP development, Arasan is committed to being the highest quality provider of USB IP in the market.