
AT13722: USB Dual Role Implementation on SAM V7x E7x S7x

APPLICATION NOTE

Introduction

The USB OTG (On-The-Go) is an interface to communicate with portable USB devices. In the Atmel® | SMART SAM V7x / E7x / S7x series, the USB host and device share the same transceiver. The shared USB transceiver can be controlled either by the USB Host Port Controller or by the USB Device Controller. This configuration allows to emulate a "USB OTG like" connector.

The purpose of this document is to help the developers to implement this kind of USB.

References

1. Universal Serial Bus Specification, Rev 2.0, April 27, 2000.
2. On-The-Go and Embedded Host Supplement to the USB Revision 2.0 version 1.1a.

Table of Contents

Introduction..... 1

References 1

1. USB in SAM V7x / E7x / S7x Products..... 3

 1.1. Features of USBHS..... 3

 1.2. USB Dual Role Implementation on SAM V71 Xplained Ultra..... 3

2. Difference from USB OTG..... 11

3. Revision History..... 12

1. USB in SAM V7x / E7x / S7x Products

The USB High-Speed Interface (USBHS) complies with the Universal Serial Bus (USB) 2.0 specification in all speeds. This interface is composed with a USB Device and a USB Mini Host.

1.1. Features of USBHS

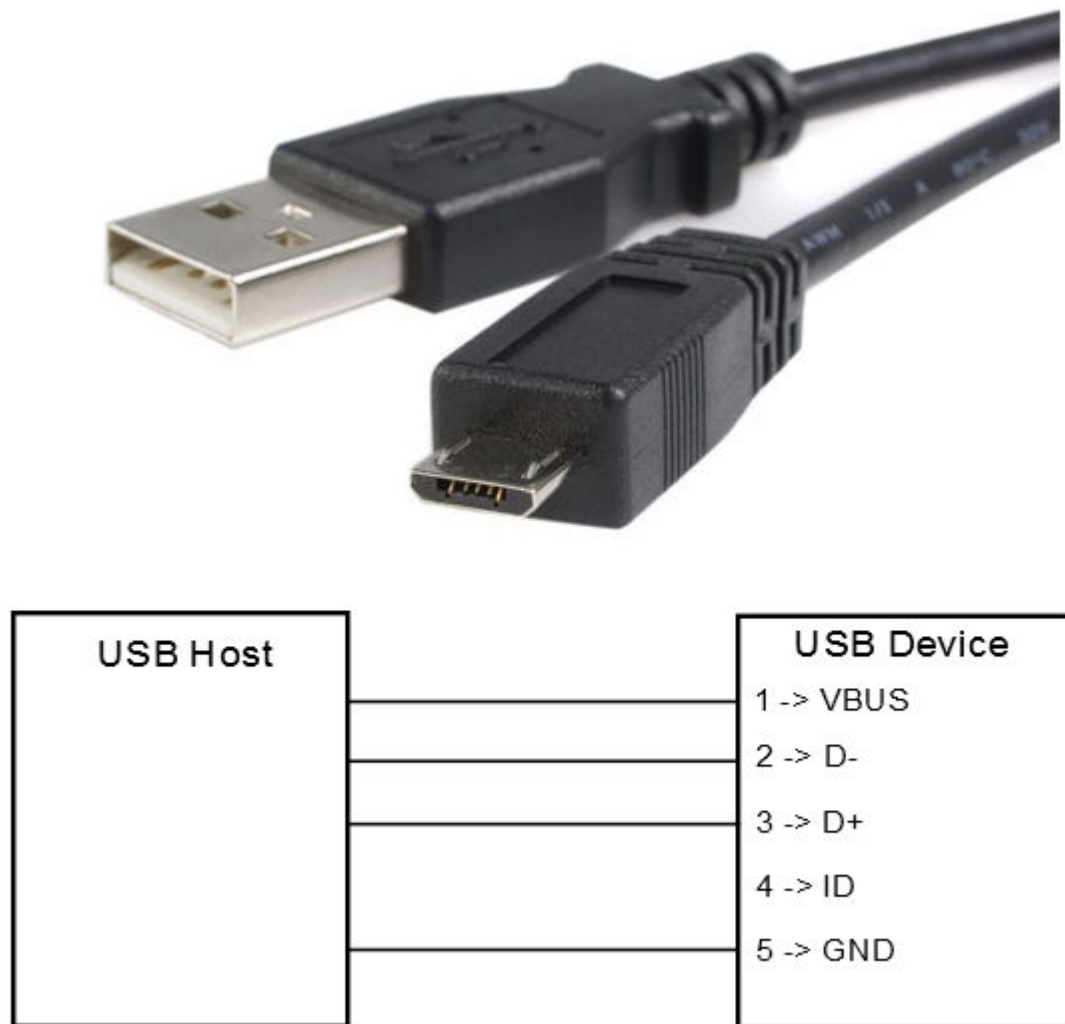
- Compatible with the USB 2.0 Specification
- Supports High-Speed (480Mbps), Full-Speed (12Mbps), and Low-Speed (1.5Mbps) Communication
- 10 Pipes/Endpoints
- 4096 bytes of Embedded Dual-Port RAM (DPRAM) for Pipes/Endpoints
- Up to three Memory Banks per Pipe/Endpoint (not applicable for Control Pipe/Endpoint)
- Flexible Pipe/Endpoint Configuration and Management with Dedicated DMA Channels
- On-Chip UTMI Transceiver including Pull-ups/Pull-downs

1.2. USB Dual Role Implementation on SAM V71 Xplained Ultra

1.2.1. Auto Detection of ID Pin and Switching of VBUS

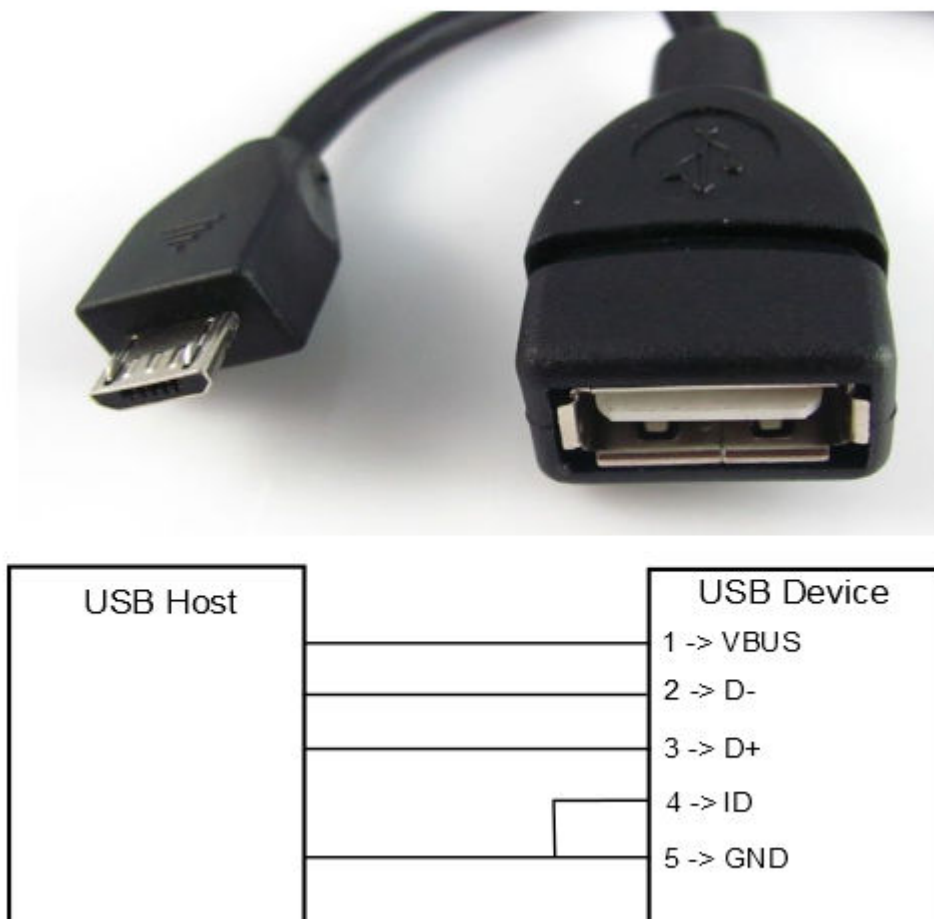
A USB cable with standard-A plug on one end and Micro-B on the other end of the cable can be connected from a Host USB port (e.g. PC) to the TARGET USB connector on the SAMV71 Xplained Ultra. In this case, VBUS pin is powered by the external host and the SAMV71 device should act as a USB device.

Figure 1-1 Connection in Device Mode



When a USB cable with standard-A receptacle on one end and Micro-A plug on the other end of the cable is plugged to the 'TARGET USB' connector, the ID pin will be pulled LOW. The application should detect this change and re-initialize the USB module as host. To achieve this, an interrupt needs to be configured for PC16. Inside the corresponding interrupt service routine, the application can initialize host. When PC16 goes LOW, output of an onboard voltage regulator is enabled to power the VBUS line.

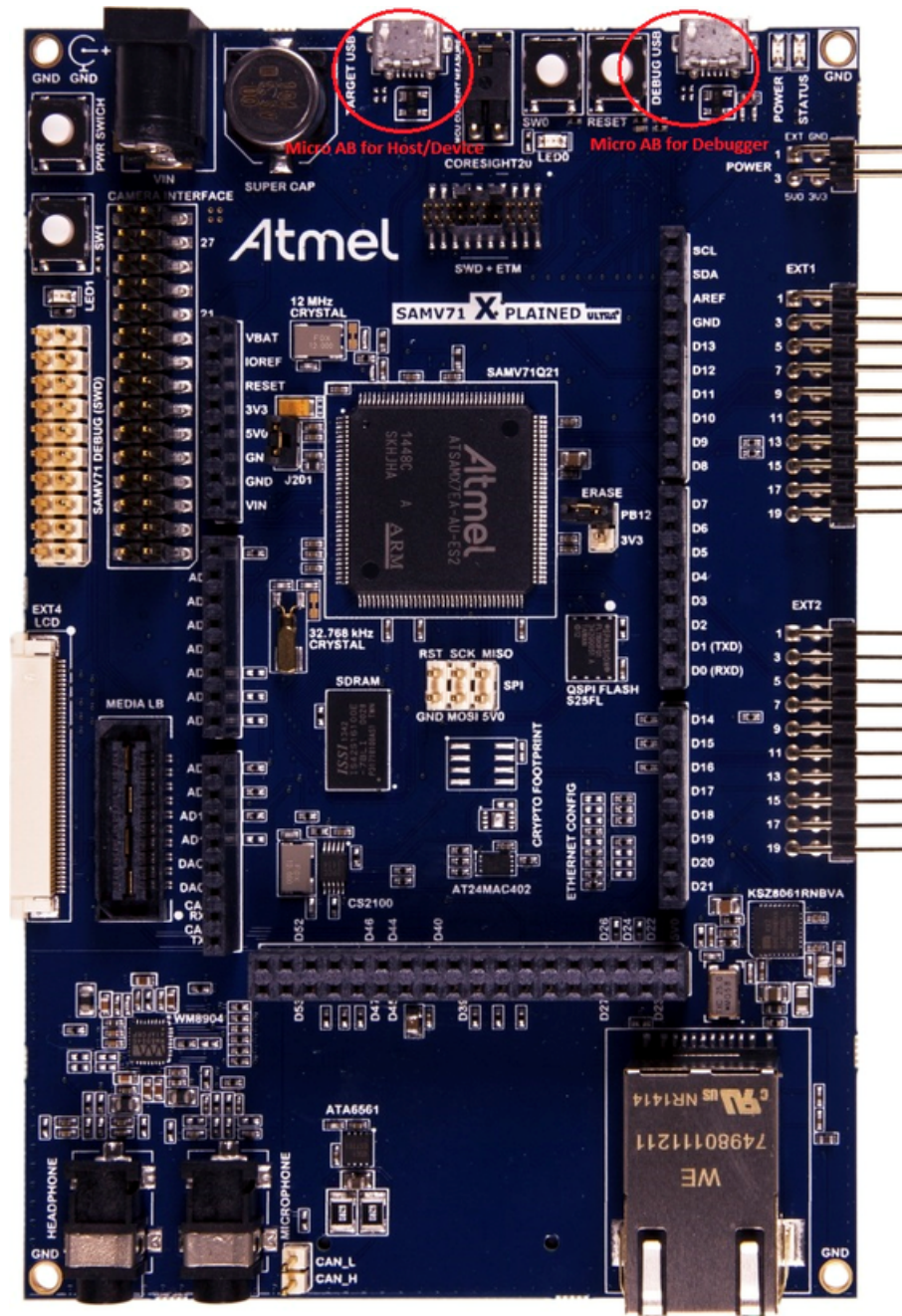
Figure 1-2 Connection in Host Mode



1.2.2. Hardware Connections

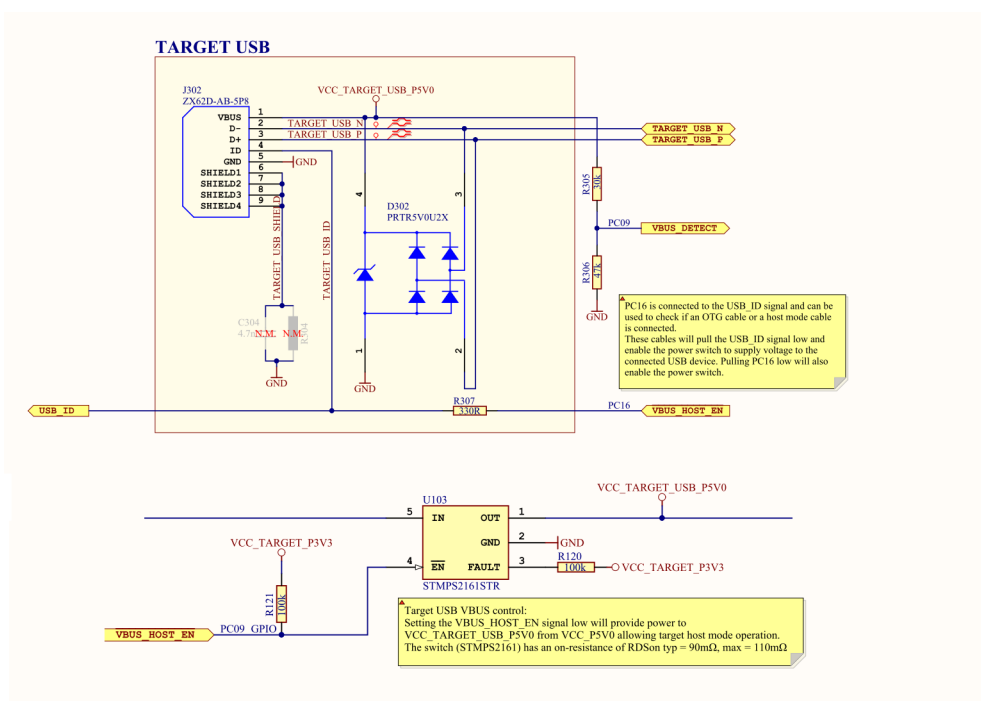
The following illustration shows Micro-AB receptacles available on the SAM V71 Xplained Ultra.

Figure 1-3 Micro-AB Connectors on SAM V71 Xplained Ultra



On the SAM V71 Xplained Ultra (hardware revision 8), the USB ID pin of the Micro-USB receptacle is connected to PC16 of the ATSAMV71Q21 device. This pin is also routed to the enable pin for the voltage regulator which powers VBUS in host mode. PC16 can be configured to generate an interrupt, which can be used for switching roles (Host/Device).

Figure 1-4 USB ID Pin Connection and VBUS Enable



1.2.3. Software Implementation

The application is developed with the help of example applications available in the Software Package for SAM V7x / E7x / S7x. Modified source files are available in the zip file associated with this application note. Steps to develop the application are provided in the upcoming sections.

Both the host and device stack are included in the project. The USB module will be initialized as CDC device or a MSC host based on the cable connected to the Micro-USB connector on the SAM V71 Xplained Ultra. When a USB flash drive connected to a USB OTG cable is plugged into the Micro-AB receptacle, the USB ID pin will be pulled LOW, which in turn will generate an interrupt. Inside the corresponding interrupt handler a specific flag will be cleared to indicate that the USB module needs to be configured as MSC host. This flag is checked inside the infinite loop in the main function, the USB module will be configured as MSC host and a text file will be created on the disk connected. When the OTG cable is removed, the USB module will be re-configured as CDC device. When the bit UIMOD in USBHS_CTRL register is set, the USBHS will be in device mode. When this bit is cleared, the USBHS will be in Host mode.

1.2.4. Developing a Dual Role Application with SAMV71-XULT Atmel Studio Software Package

Software package for SAM V7 devices is available at <http://www.atmel.com/tools/samv71-samv70-same70-sams70-software-package.aspx>.

The Dual Role application is tested using software package version 1.4 and it may need slight changes when working with any updated version of the software package. Download and extract the software package to the PC. The paths used in the following description refers to the files inside the folder created using the software package installer. Start developing an application using an available example project in the software package. There are examples for Host Mass Storage and Device CDC. These steps assume that we start with the Host Mass Storage example available at the location \Atmel\samv71_Xplained_Ultra\examples_usb\host_examples\usb_host_msc in the software package.

Download and extract the software package to the PC. The paths used in the following description refers to the files inside the folder created using the software package installer. Start developing an application using an available example project in the software package. There are examples for Host Mass Storage and Device CDC. These steps assume that we start with the Host Mass Storage example present at the location `\Atmel\samv71_Xplained_Ultra\examples_usb\host_examples\usb_host_msc` in the software package.

1. Create folders in the `samv71_Xplained_Ultra\examples_usb` folder to develop the dual role application.

For example, create a folder named 'dual_role_examples'. Within this folder create another sub-folder and copy all folders/files from `samv71_Xplained_Ultra\examples_usb\host_examples\usb_host_msc`. The folder structure is important since the project uses relative paths for all driver files. After copying the files, open the project available in 'build\studio' and change the optimization level to -O1. Build the project and make sure that copying the files didn't break the relative paths.

2. To add files for CDC support, refer to the CDC example in software package and copy all the required files.

The paths specified in the following path are created by the software package installer.

1. `samv71_Xplained_Ultra\libraries\libusb\device\cdc-serial\CDCDSerial.c`
2. `samv71_Xplained_Ultra\libraries\libusb\device\cdc-serial\CDCDSerial_Callbacks.c`
3. `samv71_Xplained_Ultra\libraries\libusb\device\cdc-serial\CDCDSerialDriver.c`
4. `samv71_Xplained_Ultra\libraries\libusb\device\cdc-serial\CDCDSerialDriver_Callbacks.c`
5. `samv71_Xplained_Ultra\libraries\libusb\device\cdc-serial\CDCDSerialPort.c`
6. `samv71_Xplained_Ultra\libraries\libusb\device\core\USBD.c`
7. `samv71_Xplained_Ultra\libraries\libusb\device\core\USBDCallbacks.c`
8. `samv71_Xplained_Ultra\libraries\libusb\device\core\USBDDriver.c`
9. `samv71_Xplained_Ultra\libraries\libusb\device\core\USBDDriverCallbacks.c`
10. `samv71_Xplained_Ultra\libraries\libusb\common\cdc\CDCLineCoding.c`
11. `samv71_Xplained_Ultra\libraries\libusb\common\cdc\CDCSetControlLineStateRequest.c`
12. `samv71_Xplained_Ultra\libraries\libusb\common\core\USBD_HAL.c`
13. `samv71_Xplained_Ultra\libraries\libusb\common\core\USBDescriptors.c`
14. `samv71_Xplained_Ultra\libraries\libusb\common\core\USBRequests.c`
15. `samv71_Xplained_Ultra\libraries\libchip_samv7\source\usart.c`
16. `samv71_Xplained_Ultra\libraries\libchip_samv7\source\usart_dma.c`

3. Rename `USBHS_Handler` in `USBD_HAL.c` to `USBHS_Device_Handler` since it is required to use a single entry point for both Host and Device interrupt handlers.
4. After these files are added, copy the files `USBH.c`, `USBH_HAL.c`, and `usbhs.h` from the zip file available with this application note and replace the corresponding files available in the software package.
5. Copy the file named `USBDDriverDescriptors.c` from the CDC example and add it to the project.

6. Use the `main.c` file available with this application note as main application file.
7. Build the project and check it on the SAM V71 Xplained Ultra.
Details required to test the application is provided in the `main.c` file available in the zip file available with this application note.



Pressing the letter 't' sends a series of characters to the COM port of the CDC device

[illegible]

2. Difference from USB OTG

From the hardware perspective, the same Micro-AB receptacle can be used for host and device, similar to USB OTG. A single GPIO is used to detect ID pin status and switch between host and device role.

In host mode, a voltage regulator on the SAM V71 Xplained Ultra drives VBUS. The regulator, which powers VBUS is enabled when the USB ID pin is LOW. However, the solution is not the same with the real USB OTG that does not need external detection circuit. Another major difference is that the USB cable has to be manually changed to switch between Host and Device modes.

Other differences between them are :

VBUS output voltage range:

- USB 2.0: 4.75V to 5.25V ⁽¹⁾
- USB OTG: 4.4V to 5.25V

VBUS output current range:

- USB 2.0: 100mA to 500mA ⁽¹⁾
- USB OTG: from 8mA

HNP and SRP are not supported on the USB module in SAM V7x / E7x / S7x series.

Note:

1. This is the value for the USB Dual Role implementations.

3. Revision History

Doc Rev.	Date	Comments
42565A	11/2015	Initial document release.



Atmel Corporation 1600 Technology Drive, San Jose, CA 95110 USA T: (+1)(408) 441.0311 F: (+1)(408) 436.4200 | www.atmel.com

© 2015 Atmel Corporation. / Rev.: Atmel-42565A-USB-Dual-Role-Implementation-on-SAM-V7x-E7x-S7x_AT13722_Application Note-11/2015

Atmel®, Atmel logo and combinations thereof, Enabling Unlimited Possibilities®, and others are registered trademarks or trademarks of Atmel Corporation in U.S. and other countries. ARM®, ARM Connected® logo, and others are the registered trademarks or trademarks of ARM Ltd. Windows® is a the registered trademark of Microsoft Corporation in U.S. and or other countries Other terms and product names may be trademarks of others.

DISCLAIMER: The information in this document is provided in connection with Atmel products. No license, express or implied, by estoppel or otherwise, to any intellectual property right is granted by this document or in connection with the sale of Atmel products. EXCEPT AS SET FORTH IN THE ATMEL TERMS AND CONDITIONS OF SALES LOCATED ON THE ATMEL WEBSITE, ATMEL ASSUMES NO LIABILITY WHATSOEVER AND DISCLAIMS ANY EXPRESS, IMPLIED OR STATUTORY WARRANTY RELATING TO ITS PRODUCTS INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTY OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, OR NON-INFRINGEMENT. IN NO EVENT SHALL ATMEL BE LIABLE FOR ANY DIRECT, INDIRECT, CONSEQUENTIAL, PUNITIVE, SPECIAL OR INCIDENTAL DAMAGES (INCLUDING, WITHOUT LIMITATION, DAMAGES FOR LOSS AND PROFITS, BUSINESS INTERRUPTION, OR LOSS OF INFORMATION) ARISING OUT OF THE USE OR INABILITY TO USE THIS DOCUMENT, EVEN IF ATMEL HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. Atmel makes no representations or warranties with respect to the accuracy or completeness of the contents of this document and reserves the right to make changes to specifications and products descriptions at any time without notice. Atmel does not make any commitment to update the information contained herein. Unless specifically provided otherwise, Atmel products are not suitable for, and shall not be used in, automotive applications. Atmel products are not intended, authorized, or warranted for use as components in applications intended to support or sustain life.

SAFETY-CRITICAL, MILITARY, AND AUTOMOTIVE APPLICATIONS DISCLAIMER: Atmel products are not designed for and will not be used in connection with any applications where the failure of such products would reasonably be expected to result in significant personal injury or death ("Safety-Critical Applications") without an Atmel officer's specific written consent. Safety-Critical Applications include, without limitation, life support devices and systems, equipment or systems for the operation of nuclear facilities and weapons systems. Atmel products are not designed nor intended for use in military or aerospace applications or environments unless specifically designated by Atmel as military-grade. Atmel products are not designed nor intended for use in automotive applications unless specifically designated by Atmel as automotive-grade.