White Paper

WP_003

Android Peripheral Options

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Android devices have several options for peripherals. This white paper describes the different types and identifies offerings from FTDI for each type.

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1 Introduction

We need to connect things to our computers. We've always done it but it hasn't always been easy. Keyboards, mice, storage drives, test equipment, printers and displays – they all need a connection point. In the early days of personal computers, each device had its own connection scheme: DIN plug for the keyboard, serial port for the mouse, SCSI for drives, GPIB for test equipment, and so on.

Toward the end of the '90s, a new connection scheme aimed to create one standard for everything. So far, this standard has done a rather good job of accomplishing its goal. This standard is the Universal Serial Bus, or USB. Just as its name implies, USB has become the *de facto* standard among computing devices. The standard has been in place for well over a decade with a strong foot-hold occurring around the time Microsoft Windows XP was released. This was the first generally available operating system to offer native support of the USB host port that was starting to appear toward the end of the Microsoft Windows 98 era. The USB Implementers Forum (USB-IF)[1] ensured that companies strictly adhered to the standard to make the use of USB a true "plug-and-play" experience.

The USB specification defines a strict Host-Peripheral arrangement. It also allows multiple peripherals to connect to a given USB host through one or more hubs. In all cases, though, the host PC ultimately controls all the peripherals. Another USB host cannot be connected to this tree. Peripherals take on numerous forms: digital camera, biometric devices, sensors of all types, printers, etc. With all of these peripherals, the control of the USB is left to the host PC.

More recently, peripherals have been getting smarter. The underlying operating system could be an "embedded" version of a desktop counterpart. These modern embedded OSs have the capability of providing a USB host port. In some cases, the USB host may be a "stripped down" host, what the USB-IF calls an "Embedded Host". These Embedded Hosts, or EH, allow connection of a limited number of peripherals, for example a thumb drive for data logging but not a keyboard or sound device. This allows a common hardware connection to be used for specific purposes.

In addition to the EH, one more type of USB host is present on some products. It's a USB port that can negotiate between being a host or a peripheral on-the-fly. The USB-IF calls this "On-The-Go", or OTG. While the full specification allows for a port to be a full USB host or USB peripheral through this negotiation, in practice most OTG ports lock down the functionality to being a host or client. When acting as a host, the functionality is usually further limited to the EH realm by limiting the number and types of peripherals it supports, a so-called Target Peripheral List or TPL.

1.1 Open Handset Alliance & Android

In 2007, Google, along with the Open Handset Alliance, publicly introduced the Android operating system and about a year later the first commercially available handset with an ARM CPU running the OS[2]. The kernel is based on Linux while the user interface bypassed the traditional desktop interfaces (i.e. Gnome or KDE) and used their own inspired by the Java programming language. With the kernel based on Linux, it can have support for both USB Host and Peripheral functions. This platform has evolved through the past few years and now is part of what some say is a majority of mobile phones and tablet computers. Android is used in numerous embedded applications as well, from medical devices to automotive "infotainment" systems to more common products.

[1] http://www.usb.org/home
[2] http://en.wikipedia.org/wiki/Android_operating_system

2 Peripherals for Android

Although the underlying Linux kernel on Android provides USB host support, it is important to note that most Android devices are portable or mobile requiring battery power to operate. In these cases, it is advantageous to bypass the host and only include the peripheral function. Doing so eliminates the requirement for the Android USB port to provide power (500mA, minimal) to a downstream peripheral. It also eliminates the need for the Android device to provide the complex USB host connection and software stack. Both of these result in saving battery size and cost. As outlined in the USB specifications the USB host will provide the power. This takes care of the power arrangement, but now the device we're calling the peripheral (usually a smart phone or tablet) is as "smart" as the host (the PC).

2.1 Android Open Accessory Peripherals

What may be desired is to control a much simpler peripheral from the Android device… which is also a peripheral. There's a problem here; USB has this strict host-peripheral arrangement and there is *no host*.

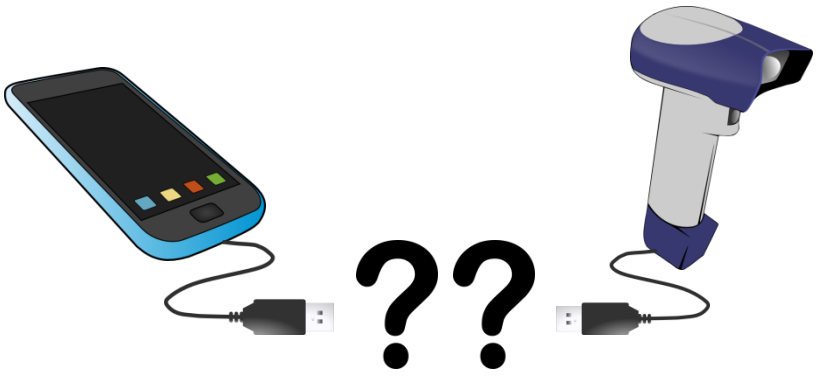

Figure 2.1 Peripheral on Android without USB Host

Enter "Android Open Accessory". Google introduced Android Open Accessory, or AOA, in May 2011 to address this dilemma[3]. It allowed the introduction of a new family of devices, or accessories, which have a USB Embedded Host as their interface to the Android platform/USB device[4]. At the physical layer and through the establishment of the USB connection (aka Enumeration), a traditional host-peripheral connection is made. The power arrangement is also maintained. The AOA EH could provide the full 500mA to the Android device. As such, the AOA could have larger batteries or be mains powered.

It is above this layer that one can think of the two entities – Android host and AOA peripheral – as swapping logical functions. The Android platform / USB device *is now controlling* the accessory through an installed application (APK).

[3] http://developer.android.com/tools/adk/index.html

[4] Most new Android devices offered today ship with AOA as part of the OS image. Devices prior to phone version 2.3.4 and tablet versions 3.1 do not contain AOA support.

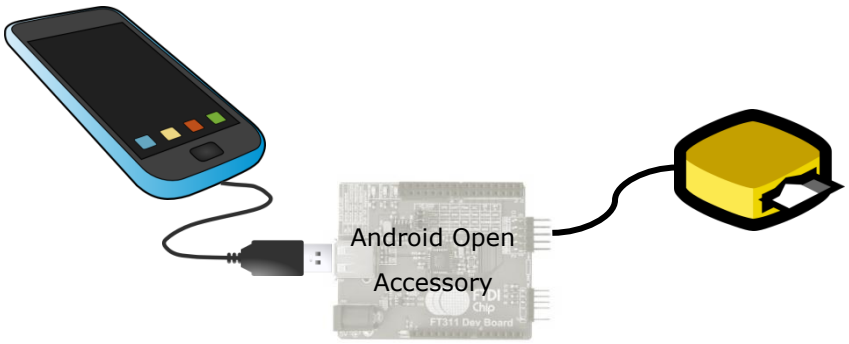

Figure 2.2 Peripheral with Android Open Accessory Interface

The application running on the Android device initiates control of the accessory. In other words, the USB peripheral (Android device) is now controlling the USB host (Accessory). This opens up a world of opportunities:

- An Android phone controls and logs activity on an exercise treadmill
- An Android tablet connects to a medical infusion pump to set up flow rates based on a particular patient record
- A USB connected thermostat can use the Android touch screen interface to configure the settings
- A barcode scanner with larger batteries can utilize the GPS and touch screen and sound capabilities of the Android device to provide a complete inventory system capable of lasting several days
- A robotic arm can be controlled through the gyroscopic and tilt sensors contained in many Android devices. The Accessory would take this input and translate it to PWM signals to move the arm

The system connected to the Android platform can now utilize the resources of the tablet/phone in conjunction with a downloaded application to enhance the end product.

Adding the USB host functionality has traditionally been a complex undertaking. There are several new devices, though, that aim to reduce this complexity. There are two devices from FTDI that directly support AOA:

- FT311D[5] – This is a single-chip EH device with inbuilt AOA support. This IC requires no programming and provides one the following interfaces based on power-on pin states: UART, SPI master, SPI slave, I2C slave, GPIO or PWM. Sample programs for each interface including source code for the Android applications are available.
- VNC2[6] – This is a single-chip EH device which can be programmed to include AOA support. In addition to the interfaces contained on the FT311D, the VNC2 also includes a second USB port that can be configured as Host or Peripheral. With the second USB port of the VNC2 configured for host, it is possible to add USB support for traditional USB peripherals such as a barcode scanner that already uses a FTDI peripheral IC or connects as a HID peripheral.

[5] http://www.ftdichip.com/Products/ICs/FT311D.html
[6] http://www.ftdichip.com/Products/ICs/VNC2.htm

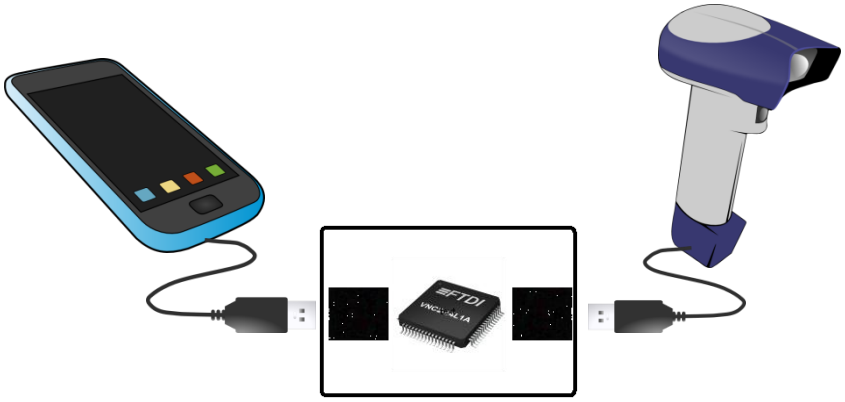

Figure 2.3 USB Peripheral through Android Open Accessory

2.2 Directly Supported USB Peripherals on Android

Some Android devices, such as a tablet, may have a USB host port. When present, the Android USB host often does not have full capabilities as with a PC-based USB host. The supported devices are limited, typically to HID (mouse & keyboard), BOMS (thumb drive) or maybe CDC (serial device or modem) – devices on the TPL.

With its two configurable USB ports, the VNC2 can have one enabled as a host for AOA and the other as a traditional peripheral for a targeted, supported class such as HID. This provides the "best of both worlds" for the end product as it even allows use beyond Android devices. The built-in peripherals of the VNC2 (UART, SPI, PWM, etc.) could then be used through either approach.

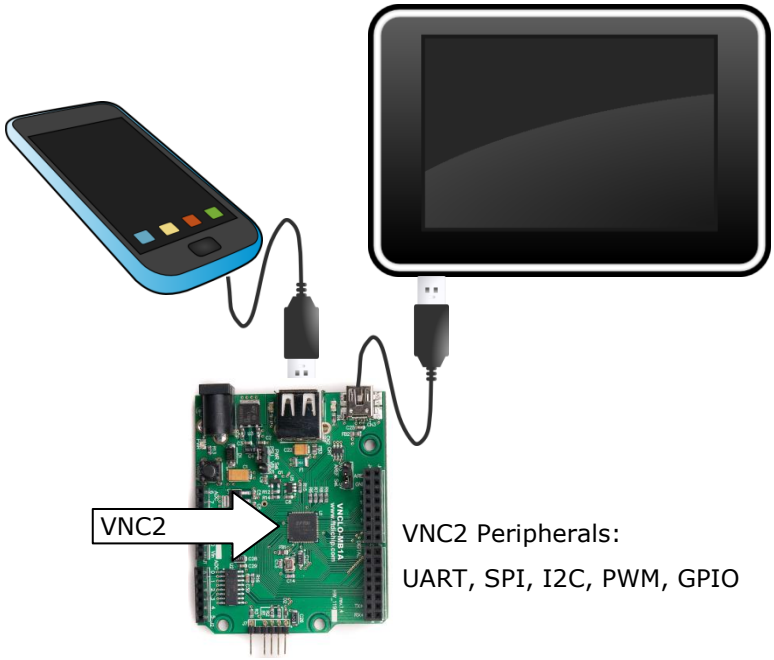

Figure 2.4 VNC2 Host (AOA) and Peripheral (HID, BOMS or CDC)

The VNC2 is also useful for non-AOA where USB host functionality may be needed for a simple device. Numerous samples, including AOA, are provided with the VNC2 Toolchain IDE.

2.3 Android USB Host Mode

One other possibility for Android devices with a USB host port is to use Android USB Host Mode. This is different than the traditional operating system approach of loading a device driver and writing an application to communicate with the device driver. With USB Host Mode, an Android application accesses the USB bus and directly communicates with a USB device. There is no device driver loaded at the protected operating system level.

FTDI has converted the D2XX API traditionally associated with its D2XX device driver into a JAVA "driver" API to support this mode. While it's known as the "Java D2XX driver", in reality, this is a Java library that is linked to an Android application. The resulting user mode application runs directly on any Android device with a USB host port and Android version 3.2 or higher.

Figure 2.5 USB Host Mode & FTDI J2XX

The Android device may provide power to the USB device. Specifications of the available USB host power and peripheral power requirements need to be considered.

2.4 Other USB devices on Android

An Android device with a USB host port that might be running an older version of the Android operating system can also support peripherals beyond what is on the TPL. Doing so requires that the Android system is "rooted" so that an independently developed version of Android can be loaded. As with the USB Host Mode, the peripheral power requirements must be considered.

With Android being based on the Linux kernel, nearly any device that Linux supports can be included in the operating system image that is loaded on an Android device. This is a complex process and beyond the scope of this article.

FTDI does, however, offer support for adding the "FT-series" peripheral devices to an older Android image for those willing to take this approach. Although USB hosts exist on Android, using an Android Open Accessory device such as the FT311D or VNC2 would be the simplest approach.

3 Conclusion

The Universal Serial Bus has indeed become "universal". By using the Android Open Accessory protocol and Android USB Host Mode, USB is extended to easily support most Android products. Incorporating FTDI products in end-user peripherals provides the "USB Made Easy" path to supporting traditional PCs as well as Android devices.

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Appendix A – References

Document References

USB-IF Website: http://www.usb.org/home

Wikipedia page on Android: http://en.wikipedia.org/wiki/Android_operating_system

Android Developer Website: http://developer.android.com/tools/adk/index.html

FTDI FT311D Product Page: http://www.ftdichip.com/Products/ICs/FT311D.html

FTDI VNC2 Product Page: http://www.ftdichip.com/Products/ICs/VNC2.htm

Acronyms and Abbreviations

Terms	Description
AOA	Android Open Accessory
BOMS	Bulk Only Mass Storage
BSP	Board Support Package
CDC	Communications Device Class
DIN	Deutsches Institut für Normung (German Institute for Standardization)
EH	Embedded Host
GPIB	General Purpose Instrument Bus
GPIO	General Purpose Input / Output
GPS	Global Positioning System
HID	Human Interface Device
I2C	Inter-Integrated Circuit (bus)
IDE	Integrated Development Environment
OS	Operating System
OTG	On-The-Go
PC	Personal Computer
PWM	Pulse Width Modulation
SCSI	Small Computer System Interface
SPI	Serial Peripheral Interface (bus)
TPL	Targeted Product List
UART	Universal Asynchronous Receiver / Transmitter
USB	Universal Serial Bus
USB-IF	USB Implementers Forum

Appendix B – FTDI Android Selection Chart

Feature \ Device	FT311D	FT313H[2]	VNC2[2]	FT12 family[2]	FT2xxx family[1]
USB Host – AOA	X	X[4]	X		
USB Host – Other		X	X		
USB Peripheral			X	X	X
USB Host Mode (Java D2XX peripheral)			X[6]	X[3]	X
UART	X		X		X
SPI – Master	X		X		X
SPI – Slave	X		X	X	
I2C – Master	X		X		X
I2C – Slave	X		X		X
PWM	X		X		
GPIO	X		X		X
USB HID Peripheral			X	X	
USB CDC Peripheral			X	X	
Requires Android ROOT Access			X[3,7]	X[3,7]	X[7]
Android system design level (BSP)		X[5]			
Android APK	X		X		
One-chip	X		X		X
Two-chip (Second chip is MCU)		X		X	
Firmware Development Required		X	X	X	

Table B.1 FTDI Android Selection Chart

[1] Devices include FT232B/R/H, FT245B/R, FT2232D/H, FT4232H, X-chips. Not all FT2xxx family devices support all modes noted here. See individual datasheets for specific features.

[2] Depends on firmware

[3] Only if configured for a USB class that is not directly supported by the Android device.

[4] If FT313H is configured as the AOA host

[5] If FT313H is configured as the USB host for Android device itself

[6] If VNC2 is configured to emulate a FT232 device

[7] Prior to Android version 3.2

Appendix C – List of Tables & Figures

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Appendix D – Revision History

Document Title: WP_003 Android Peripheral Options
Document Reference No.: FT_000782
Clearance No.: FTDI# 325
Product Page: http://www.ftdichip.com/Android.htm
Document Feedback: Send Feedback

Revision	Changes	Date
1.0	Initial Release	2013-01-21
1.1	Added Java D2XX information	2013-02-08