Application Note

AN_426

FT90x USB Examples using MCCI Data Pump USB Stack

Version 1.0

Issue Date: 2017-09-13

This application note demonstrates the usage of MCCI USBD examples ported to FT90x.

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Table of Contents

1 Introduction ................................................................. 2
  1.1 Overview ................................................................. 2
  1.2 Scope ........................................................................... 2

2 Prerequisites ........................................................................ 3
  2.1 Required Hardware ....................................................... 3
  2.2 Required Tools and software ........................................ 3
  2.3 Build process and source code structure ...................... 3
    2.3.1 Global Environment Variables .................................. 3
    2.3.2 Build Process .......................................................... 5
    2.3.3 Debug and Release Builds ........................................ 5
    2.3.4 Folder Structure ....................................................... 6
  2.4 Importing examples to Eclipse ....................................... 6
  2.5 MCCI USB Device Examples ........................................... 8
    2.5.1 MCCI USBD Audio Loopback Example ...................... 8
    2.5.2 MCCI USBD BOMS Example ..................................... 9
    2.5.3 MCCI USBD CDC ACM Example ............................... 10
    2.5.4 MCCI USBD HID Example ........................................ 11
    2.5.5 MCCI USBD RNDIS Example ..................................... 12
    2.5.6 MCCI USBD Video Example ....................................... 13

3 Contact Information ........................................................... 15

Appendix A ............................................................................ 16
  Document References .......................................................... 16
  Acronyms and Abbreviations ............................................... 16

Appendix B – List of Tables & Figures .................................... 17
  List of Figures ..................................................................... 17
  List of Tables ...................................................................... 17

Appendix C – Revision History ................................................. 18
1 Introduction

MCCI’s Data Pump USB stack has been ported onto the FT90x and the demo examples corresponding to this application note illustrate the common USB class devices using the Stack. This provides an alternative to the default Bridgetek USB stack that is shipped with the FT90x Toolchain. Users those who wish to use the MCCI USB stack, can base their products on the examples in this section. The data pump is available as a static library within the examples. Please contact Bridgetek if access to the source code of the Data Pump library is required.

1.1 Overview

The MCCI Data Pump is a comprehensive USB framework that attempts to encapsulate USB hardware, protocol and class level details, allowing the application developer to concentrate more on application programming than having to understand USB details. The framework supports both USB devices and hosts and a large variety of USB classes. The examples in this document cover the common USB device applications.

1.2 Scope

This application note demonstrates the USB device examples utilizing the MCCI Data Pump stack. It explains the project configurations and settings required to build the source code and how to get the demo applications up and running quickly. For more details on the MCCI Data Pump framework and individual USB class specific APIs, please refer to other relevant application notes.

The following application notes from Bridgetek can provide further information:

<table>
<thead>
<tr>
<th>Related Application Notes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AN_400_MCCI_USB_Resource_Compiler_UserGuide</td>
<td>Describes the syntax of the USB Resource Compiler utility that is responsible for generating the USB Descriptors from a text .urc file</td>
</tr>
<tr>
<td>AN_402_MCCI_USB_DataPump_UserGuide</td>
<td>Detailed explanations of the Data Pump API and architecture</td>
</tr>
<tr>
<td>AN_403_MCCI_USB_DataPump_Mass_Storage_Protocol_UserGuide</td>
<td>Data Pump API specific to the USB Mass Storage Class</td>
</tr>
<tr>
<td>AN_406_MCCI-USB-DataPump-Virtual-Ethernet-Protocol-UserGuide</td>
<td>Data Pump API specific to the USB RNDIS</td>
</tr>
</tbody>
</table>

Table 1 MCCI Data Pump Application Notes
2 Prerequisites

2.1 Required Hardware

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. MM900EVxA</td>
<td>FT900 MCU Evaluation Module, x=1,2, or 3</td>
</tr>
<tr>
<td>2. UMFTPD2A</td>
<td>MM900EV MCU Programmer / Debugger Module</td>
</tr>
<tr>
<td>3. Micro USB Cables</td>
<td>1 x micro USB cable to interface the MM900EV board to the host PC</td>
</tr>
<tr>
<td></td>
<td>1 x micro USB cable to interface the UMFTPD2A to the host PC</td>
</tr>
</tbody>
</table>

Table 2 Hardware Required

2.2 Required Tools and software

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. FT90x Toolchain</td>
<td>Utilities required for the MCCI build are available only with FT90x Toolchain v2.2.0 or above.</td>
</tr>
<tr>
<td>2. MCCI Example Projects</td>
<td>The source code corresponding to this application note is available for download on the Bridgetek website.</td>
</tr>
<tr>
<td>3. Terminal Application</td>
<td>Serial Port (COM) terminal emulation program. For example, Br@y's Terminal, HyperTerminal, PuTTY, Tera Term.</td>
</tr>
</tbody>
</table>

Table 3 Tools Required

2.3 Build process and source code structure

The MCCI examples have a different build process and code structure compared to other Bridgetek examples shipped along with the FT90x Toolchain. This section will provide a brief overview of these differences, for further details please refer to the application notes listed in Table 1.

The MCCI build depends on a few external utilities like the USB resource compiler, bsdmake and some standard UNIX coreutils. It also requires a shell environment to execute the build. These utilities and shell are provided as part of the FT90xToolchain installation and are available in the installation directory in the FT90x Toolchain\MCCI\ directory, if selected as part of the installation options. Note that these tools are only available with the FT90x Toolchain v2.2.0 and above.

2.3.1 Global Environment Variables

The MCCI build depends on a few environment variables that have been pre-configured in the example projects. The configuration can be viewed in the project settings in Eclipse (Project | Properties | C/C++ Build | Environment). When creating a new MCCI project, these variables must be imported. The simplest way is to copy the environment settings from an existing example.

While modifying or adding new paths, avoid spaces and other special characters as much as possible. They are described in Table 4 and shown in Figure 1.
<table>
<thead>
<tr>
<th>Shell Variable</th>
<th>Description</th>
<th>Default Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>BUILD_TYPE</td>
<td>Variable to help the automated build to choose between Release and Debug configurations</td>
<td>RELEASE or DEBUG depending on the project configuration selected</td>
</tr>
<tr>
<td>LD_LIBC_DIR</td>
<td>Path to the standard C library</td>
<td>${FT90X_TOOLCHAIN}/tools/ft32-elf/lib</td>
</tr>
<tr>
<td>LD_LIBFT900_DIR</td>
<td>Path to the FT90x peripheral driver library</td>
<td>${FT90X_TOOLCHAIN}/hardware/lib</td>
</tr>
<tr>
<td>LD_LIBGCC_DIR</td>
<td>Path to the GCC library</td>
<td>${FT90X_TOOLCHAIN}/tools/lib/gcc/ft32-elf/</td>
</tr>
<tr>
<td>MAKE</td>
<td>Path to BSDMAKE executable (available at ${MCCI_TOOLS}/bin)</td>
<td>bsdmake.exe</td>
</tr>
<tr>
<td>MAKESHELL</td>
<td>Path to the SHELL to be used for the build (available at ${FT90X_TOOLCHAIN}/../MCCI/msys32/usr/bin)</td>
<td>bash.exe</td>
</tr>
<tr>
<td>MCCIUSBRC_INC</td>
<td>Path to USBRC Includes</td>
<td>${MCCI_TOOLS}/i/usbrc</td>
</tr>
<tr>
<td>MCCI_TOOLS</td>
<td>Path to MCCI proprietary tools</td>
<td>${FT90X_TOOLCHAIN}/../MCCI/tools/</td>
</tr>
<tr>
<td>PATH</td>
<td>System PATH to be used for the build</td>
<td>${FT90X_TOOLCHAIN}/tools/bin; ${FT90X_TOOLCHAIN}/../MCCI/msys32/usr/bin; ${MCCI_TOOLS}/bin;</td>
</tr>
<tr>
<td>TARGET_BIN_NAME</td>
<td>Name for the output binary file</td>
<td>Same as the project name - ${ProjName}</td>
</tr>
<tr>
<td>TMP</td>
<td>Path to a temporary working directory for the SHELL</td>
<td>Same as system %TMP% directory - ${TMP}</td>
</tr>
<tr>
<td>XARGS</td>
<td>Path to XARGS executable</td>
<td>&quot;${MCCI_TOOLS}/bin/xargs.exe&quot;</td>
</tr>
</tbody>
</table>

Table 4 MCCI Projects - Environment Variables

**Note:** The environment variables are configured to **replace the native environment variables**; this is to ensure that the build is not affected by any pre-existing configurations in the user’s PC for variables such as PATH.
2.3.2 Build Process

The MCCI examples are all custom makefile projects within Eclipse. Any changes to the build process (adding new .c files) or changing compiler options must be done by editing the appropriate makefiles in the project and the convenient Eclipse Bridgetek plugin features are also not available. However, Eclipse can still be used to edit, build, and debug the projects and all the CDT extensions for source code navigation and analysis can be used.

The build is controlled by a series of shell scripts and makefiles. The top most makefile is located in the project root directory. This invokes a script mcci-gen-make.sh which runs the script /usbkern/makebuildtree (generated from /usbkern/makebuildtree.sh). This generates a /usbkern/build folder with all the dependencies, sources and makefiles necessary for the release or debug build. In order to force a rebuild of the entire source tree (necessary if moving a previously built project to another directory), the user can manually delete the /usbkern/build directory along with the /usbkern/makebuildtree file. In most situations, issuing a build and/or clean followed by build from the Eclipse GUI should suffice.

2.3.3 Debug and Release Builds

Each MCCI example project can be built with either of two configuration options - Debug or Release. The default setting is a Debug build. The difference between them is that the Debug build has UART logs enabled while the Release build has logs disabled. The UART output is over UART0 with the baud rate configured to be 115200bps.

To switch the configuration right click the project in Eclipse and go to Build Configurations | Set Active | Debug / Release. Output binary for the Debug and Release builds are located in the path usbkern/build/ft32/mm900beta/none-gcc-checked and usbkern/build/ft32/mm900beta/none-gcc-free respectively.
### 2.3.4 Folder Structure

The top level folder is `/usbkern`, inside of which there are various folders organized functionally. The important folders and files are summarized in Table 5.

<table>
<thead>
<tr>
<th>Path</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>usbkern\arch\ft32\os\none\soc\ft900\app\ft900dci_xxx</code></td>
<td>A large part of the application specific source code is available here. Including initialization sequence customizations and any callbacks registered with the Data Pump layer.</td>
</tr>
<tr>
<td><code>usbkern\arch\ft32\os\none\soc\ft900\app\ft900dci_xxx\*.urc</code></td>
<td>The *.urc file contains the <strong>configurations for USB descriptors</strong> including VID/PID etc. Refer AN_400_MCCI_USB_Resource_Compiler_UserGuide for information on the syntax for defining USB descriptors. To change these configurations, edit this file and rebuild the project.</td>
</tr>
<tr>
<td><code>\usbkern\libport\arch\ft32\mk\gcc\sys.mk</code></td>
<td>Configurations for compiler/linker options, global settings for the whole project</td>
</tr>
<tr>
<td><code>usbkern\mk\libdesc.mk</code></td>
<td>Libraries used are specified here</td>
</tr>
<tr>
<td><code>UsbMakefile.inc</code></td>
<td>This makefile defines the source code files that are to be compiled in each directory. To add a new source file, the UsbMakefile.inc in the appropriate path should be modified.</td>
</tr>
</tbody>
</table>

**Table 5 MCCI Projects - paths of important files**

### 2.4 Importing examples to Eclipse

1. Install the FT90x Toolchain v2.2.0 or above.

2. Extract or copy the source code related to this application note to a convenient location. Please make sure the destination directory depth is not very deep, as the MCCI tools are unable to work with long path names (200 characters or more).

3. Launch Eclipse and import the MCCI projects into the current workspace by going to File | Import | General | Existing Projects into Workspace as shown in Figure 2

4. Browse and select the root folder of the examples as shown in Figure 3. This will import all the MCCI projects into the workspace.

5. Now the examples can be built and programmed into the FT900 IC. See AN_325_FT900 Toolchain Installation Guide for more information.
Figure 2 Import Existing Projects to Workspace

Figure 3 Import all MCCI projects
2.5 MCCI USB Device Examples

2.5.1 MCCI USBD Audio Loopback Example
This example creates a USB Audio device with a virtual USB Speaker and Microphone.

2.5.1.1 Purpose
The example code will enumerate as a USB Audio Class device on the PC with a speaker and microphone. Data is internally looped back from the speaker interface to the microphone interface for illustration.

2.5.1.2 Setup
Compile the example source code and program the “checked” binary (with UART logs enabled) from the usbkern/build/ft32/mm900beta/none-gcc-checked/ folder onto the FT90x EVM. Connect the EVM to a PC via USB and monitor the UART0 output on a serial port monitor. The “free” binary can be used if UART logs are not desired.

To test the loopback device, an audio playback application can be used to play audio over the USB Speaker device while a recording program such as Windows Sound Recorder can be used to record audio received over the USB Microphone.

2.5.1.3 Execution
1. A welcome message should appear like so (followed by other Data Pump related messages):

```
(C) Copyright Bridgetek Pte Ltd
---------------------------------------------------------------------
Welcome to MCCI USBD Audio Loopback Example...
FT900 will enumerate as an Audio Class Device with both Microphone and Speaker
Any data sent over the USB Speaker interface will be looped back over the USB
Microphone interface.
---------------------------------------------------------------------
```

2. Navigate to Control Panel | Hardware and Sound | Manage Audio Devices. MCCI(r) Audio Demo Loopback device should be visible in both the Playback and Recording tabs as shown in Figure 4 and Figure 5.

![Figure 4 Audio Demo – Speaker](image-url)
3. In the Audio Devices panel, set the loopback device as the default speaker and default microphone (right click and select Set as Default Device).

4. Play some audio in a multimedia application such as Windows Media Player. While audio is being played run the Sound Recorder application (All Programs | Accessories | Sound Recorder) and click on the Start Recording button.

5. Stop recording after a while. Disconnect the USB device or change the default speaker setting to the system speaker. Playback the recorded sound clip. The recorded clip should contain the audio that was played in step 4.

2.5.2 MCCI USBD BOMS Example

This example creates a USB Mass Storage Class Device using Bulk Only transport.

2.5.2.1 Purpose

The example code will enumerate as an USB Mass Storage Class Device on a PC and the user can perform various file operations on an SD card mounted on the FT90x EVM.

2.5.2.2 Setup

Compile the example source code and program the “checked” binary (with UART logs enabled) from the usbkern/build/ft32/mm900beta/none-gcc-checked/ folder onto the FT90x EVM. Connect the EVM to a PC via USB and monitor the UART0 output on a serial port monitor. The “free” binary can be used if UART logs are not desired.

An SD card should be mounted on the FT90x EVM.
2.5.2.3 Execution

1. A welcome message should appear like so (followed by other Data Pump related messages):

   (C) Copyright Bridgetek Pte Ltd
   --------------------------------------------------------------
   Welcome to MCCI USBD BOMS Example...
   FT900 will enumerate as BOMS Mass Storage Device.
   On-board SD Card (on FT90x EVM) can be accessed from a PC.
   --------------------------------------------------------------

2. Open a Windows Explorer window and navigate to “My Computer”. A removable disk corresponding to the SD Card connected to FT90x EVM should be visible as shown in Figure 7.

   Figure 7 Mass Storage Device Demo - Removable Disk

3. The drive can be accessed and normal file operations (create file, read, write etc.) can be done on it.

2.5.3 MCCI USBD CDC ACM Example

This example emulates a Communications Device Class (CDC) Abstract Control Model (ACM) device.

2.5.3.1 Purpose

When connected to a host, the operating system on the host can open a Virtual COM Port (VCP) to the CDC ACM device. Data sent from the Host over this VCP is echoed back to the Host via the same VCP.

2.5.3.2 Setup

Compile the example source code and program the “checked” binary (with UART logs enabled) from the usbkern/build/ft32/mm900beta/none-gcc-checked/ folder onto the FT90x EVM. Connect the EVM to a PC via USB and monitor the UART0 output on a serial port monitor. The “free” binary can be used if UART logs are not desired.

2.5.3.3 Execution

1. A welcome message should appear like so (followed by other Data Pump related messages):

   (C) Copyright Bridgetek Pte Ltd
   --------------------------------------------------------------
   Welcome to MCCI USBD CDC ACM Example...
   Connect a terminal application to the Virtual COM Port enumerated.
   Data typed into the terminal will be echoed back.
   --------------------------------------------------------------
2. A new VCP corresponding to the CDC-ACM device should be enumerated in Windows. In case Windows is unable to install the driver for this device the user must install the .INF file included with this example.

3. Open a new terminal to this VCP and type a message (e.g. “Hello World”). The entered string will be echoed back to the terminal.

### 2.5.4 MCCI USBD HID Example

This example creates a USB Human Interface device.

#### 2.5.4.1 Purpose

The example code will enumerate as a USB Human Interface Device (HID) on a Host PC.

#### 2.5.4.2 Setup

Compile the example source code and program the “checked” binary (with UART logs enabled) from the `usbkern/build/ft32/mm900beta/none-gcc-checked/` folder onto the FT90x EVM. Connect the EVM to a PC via USB and monitor the UART0 output on a serial port monitor. The “free” binary can be used if UART messages are not desired.

#### 2.5.4.3 Execution

1. A welcome message should appear like so (followed by other Data Pump related messages):

   ```
   (C) Copyright Bridgetek Pte Ltd
   --------------------------------------------------------------------------------------------------------
   Welcome to MCCI USBD HID Example...
   Device will enumerate as an USB HID Class
   --------------------------------------------------------------------------------------------------------
   ```

2. A new USB Input Device shall be visible in Windows device manager.

3. Alternatively software such as Microsoft USBView can be used to view the descriptors of the attached device. This is shown in Figure 8 and Figure 9.

   ![USBView Screenshot](image)

   **Figure 8 HID Demo – USB View - Left Pane**
2.5.5 MCCI USBD RNDIS Example

This example creates a Remote Network Driver Interface Specification (RNDIS) compliant device when connected to a USB host. The FT900 device is the network device that provides network connectivity to the host PC over USB.

A USB RNDIS device is implemented as a USB Communication Device Class (CDC) device with two interfaces. A Communication Class interface, of type Abstract Control, and a Data Class interface combined to form a single functional unit representing the USB Remote NDIS device. The Communication Class interface includes a single endpoint for event notification and uses the shared bidirectional Control endpoint for control messages. The Data Class interface includes two bulk endpoints for data traffic.
2.5.5.1 Purpose
The example illustrates the RNDIS function by enabling the FT900 to appear as a USB-to-Ethernet bridge.

2.5.5.2 Setup
Compile the example source code and program the “checked” binary (with UART logs enabled) from the usbkern/build/ft32/mm900beta/none-gcc-checked/ folder onto the FT90x EVM. Connect the EVM to a PC via USB and monitor the UART0 output on a serial port monitor. The “free” binary can be used if UART logs are not desired.

An Ethernet cable should be connected to the FT90x EVM. The cable should be connected to a LAN or Internet via a router (for testing internet access).

2.5.5.3 Execution
1. A welcome message should appear like so (followed by other Data Pump related messages):

```
(C) Copyright Bridgetek Pte Ltd
---------------------------------------------------------------------
Welcome to MCCI USBD RNDIS Example...
Device will behave as a USB-to-Ethernet bridge.
---------------------------------------------------------------------
```

2. After enumeration on the Host PC, the RNDIS device should appear as a new Network Adapter in Windows device manager.

![Network adapters](image)

Figure 10 RNDIS Demo - Device Manager

3. The host PC should be able to browse the internet if the Ethernet cable on the FT90x EVM is connected to the internet. To test, open a browser and navigate to [http://www.brtchip.com/](http://www.brtchip.com/).

2.5.6 MCCI USBD Video Example
This example creates a simple USB Video Class (UVC) device.

2.5.6.1 Purpose
The FT900 will enumerate as a UVC device and a dummy image/video can be viewed from the Host PC. The image is sent in MJPEG format.

2.5.6.2 Setup
Compile the example source code and program the “checked” binary (with UART logs enabled) from the usbkern/build/ft32/mm900beta/none-gcc-checked/ folder onto the FT90x EVM. Connect the EVM to a PC via USB and monitor the UART0 output on a serial port monitor. The “free” binary can be used if UART logs are not desired.
2.5.6.3 Execution

1. A welcome message should appear like so (followed by other Data Pump related messages):

```
(C) Copyright Bridgetek Pte Ltd
---------------------------------------------------------------------
Welcome to MCCI USBD Video Example...
FT90x enumerates as an USB Video Class (UVC) Device.
---------------------------------------------------------------------
```

2. After enumeration on the Host PC, the UVC device will appear as a USB Composite device on the Host PC.

3. Any PC application that accepts video input like a MyCam application, VLC player or Skype can be used to view the default video data. The video capture shows the Bridgetek CleO board logo (Figure 11) and a still image capture will show the FT900 logo (Figure 12). Both images are 160x120 resolution JPG files stored in the file usbkern\app\videodemo\videodemo_mjpegimage.c

![Figure 11 Default video image - CleO Logo](image)

![Figure 12 Default still image - FT900 logo](image)
3 Contact Information

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Appendix A

Document References

FT900 Product Page: http://brtchip.com/mcu/
MCCI Data Pump
AN_324 FT900 User Manual
USB Virtual COM Port Tutorial
USB Class Specifications
AN_400 MCCI USB Resource Compiler UserGuide
AN_402 MCCI USB DataPump UserGuide
AN_403 MCCI USB DataPump Mass Storage Protocol UserGuide
AN_406 MCCI USB DataPump Virtual Ethernet Protocol UserGuide
FT90x Development Modules: MM900EVxA and UMFTPD2A
FT90x Toolchain
AN_325 FT900 Toolchain Installation Guide
Microsoft USBView
MCCI Example Projects: http://brtchip.com/ft90x/

Acronyms and Abbreviations

<table>
<thead>
<tr>
<th>Terms</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACM</td>
<td>Abstract Control Model</td>
</tr>
<tr>
<td>BOMS</td>
<td>Bulk Only Mass Storage</td>
</tr>
<tr>
<td>CDC</td>
<td>Communications Device Class</td>
</tr>
<tr>
<td>EVM</td>
<td>Evaluation Module</td>
</tr>
<tr>
<td>HID</td>
<td>Human Interface Device</td>
</tr>
<tr>
<td>RNDIS</td>
<td>Remote Network Driver Interface Specification</td>
</tr>
<tr>
<td>USB</td>
<td>Universal Serial Bus</td>
</tr>
<tr>
<td>USB-IF</td>
<td>USB Implementers Forum</td>
</tr>
<tr>
<td>UVC</td>
<td>USB Video Class</td>
</tr>
<tr>
<td>VCP</td>
<td>Virtual COM Port</td>
</tr>
</tbody>
</table>
Appendix B – List of Tables & Figures

List of Figures
Figure 1 MCCI Projects - Environment Variables ................................................................. 5
Figure 2 Import Existing Projects to Workspace ..................................................................... 7
Figure 3 Import all MCCI projects .......................................................................................... 7
Figure 4 Audio Demo – Speaker ............................................................................................... 8
Figure 5 Audio Demo - Microphone ........................................................................................ 9
Figure 6 Audio demo - Recording from the loopback device ..................................................... 9
Figure 7 Mass Storage Device Demo - Removable Disk .......................................................... 10
Figure 8 HID Demo – USB View - Left Pane .......................................................................... 11
Figure 9 HID Demo – USB View - Right Pane ....................................................................... 12
Figure 10 RNDIS Demo - Device Manager ............................................................................ 13
Figure 11 Default video image - CleO Logo .......................................................................... 14
Figure 12 Default still image - FT900 log ............................................................................. 14

List of Tables
Table 1 MCCI Data Pump Application Notes ......................................................................... 2
Table 2 Hardware Required ..................................................................................................... 3
Table 3 Tools Required ........................................................................................................... 3
Table 4 MCCI Projects - Environment Variables ................................................................. 4
Table 5 MCCI Projects - paths of important files .................................................................. 6
# Appendix C – Revision History

<table>
<thead>
<tr>
<th>Revision</th>
<th>Changes</th>
<th>Date</th>
</tr>
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<tbody>
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<td>1.0</td>
<td>Initial Release</td>
<td>2017-09-13</td>
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