

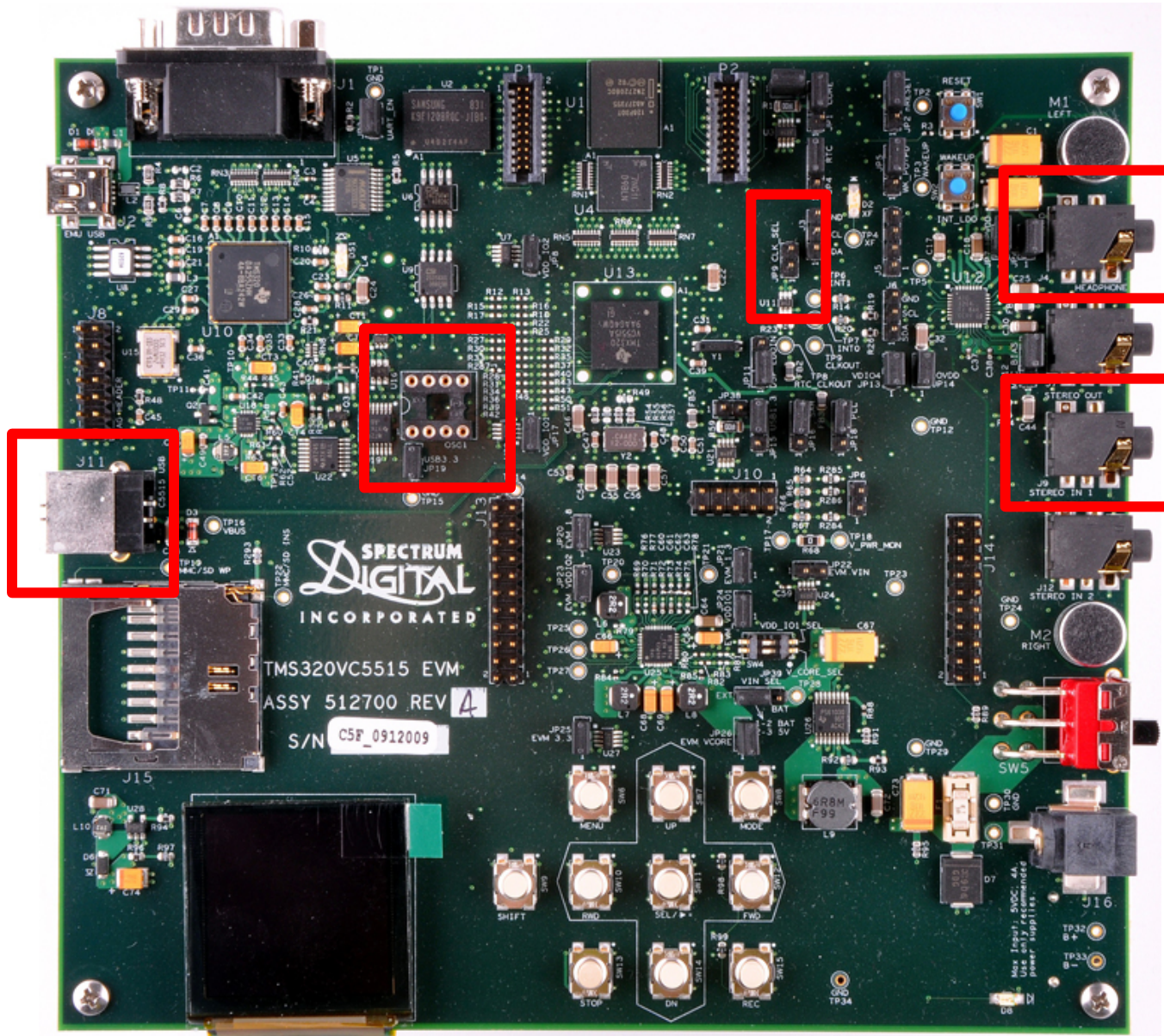
USB Audio Class 2.0 Demo on C5515 EVM

Demo Details – C5515 EVM

- Hardware
 - C5515 EVM
 - Remove jumper from JP9 (CLK_SEL=0)
 - 12 MHz external OSC inserted into OSC1
 - Connect USB cable between Host and USB-B connector (J11)
 - Connect headphones/speakers to HEADPHONE connector (J4)
 - Connect powered audio source (mic, cell phone, C/D player, etc.) to STEREO IN connector (J9)
 - Connect PC with CCS to EVM via JTAG. Load/execute code using emulator.
- Build
 - Tested with CCSv3.3. CCSv3.3 project located in c55_usbac2\build\CSL_USB_IsoHighSpeedExample_Out
 - Tested with codegen 4.3.9
 - Tested with BIOS 5.41.10.36
 - Debug and Release build profiles tested for correct functionality

Demo Details – C5515 EVM (cont.)

- Execute
 - Ensure PLL setup in GEL file uses RTC clock source for DSP (e.g. OnTargetConnect() function in c5505evm_pg20.gel contains call to ProgramPLL_120MHz_clkse0())
 - Load executable to EVM
 - Execute code. EVM should enumerate as “TI C55x USB Audio” (e.g. see Windows Volume Control or Sounds and Audio Device Properties).
 - If problem with execution
 - Scripts→C5505EVM_Configuration→CPU_Reset
 - Scripts→C5505EVM_Configuration→Peripheral_Reset
- Install USB Audio Class 2.0 Driver
 - Unzip timwei_USBAudio_Driver.zip (under host_driver folder)
 - Make sure the C5515 EVM is connected to the PC and the code is executing
 - Execute timwei_USBAudio_Driver\release\setup.exe
 - Restart the PC
- Functionality
 - Initiate playback of audio on Host (e.g. Windows Media Player). Audio will play back on EVM.
 - Initiate record of audio on Host (e.g. Windows Sound Recorder). Audio will record to Host.
- Playback and record tested on Windows XP SP3.



USB Audio Class 2.0 Demo on C5535 eZdsp

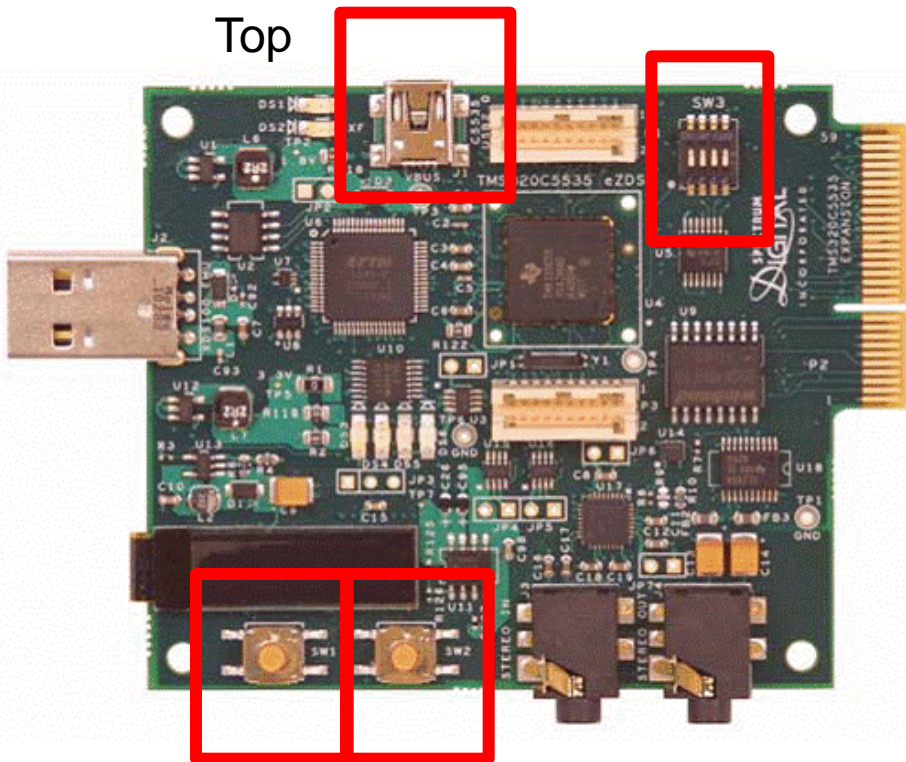
Demo Details – C5535 eZdsp

- Hardware
 - C55x eZdsp
 - DSP switch SW3 1:OFF, 3:OFF
 - Connect USB cable between Host and USB connector (J1)
 - Connect headphones/speakers to STEREO OUT connector (J4)
 - Connect audio source (mic), to STEREO IN connector (J3)
 - (Option 1) Insert micro-SD card into micro-SD connector (J6). Power eZdsp to bootload code.
 - (Option 2) Connect PC with CCS to XDS100 emulator USB connector (J2). Load/execute code via emulator.
- Build
 - Tested with CCSv3.3. CCSv3.3 project located in c55_usbac2\build\CSL_USB_IsoHighSpeedExample_Out with “C5535_EZDSP” defined in the project
 - Tested with BIOS 5.41.10.36 and code generation tools 4.3.9
 - Debug and Release build profiles tested for correct functionality

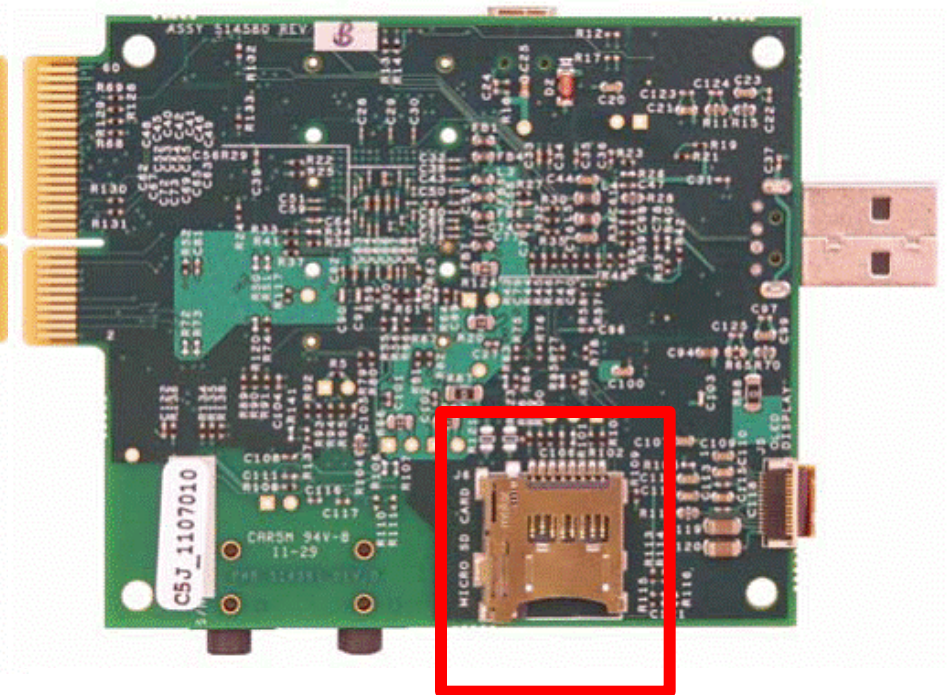
Demo Details – C5535 eZdsp (cont.)

- Execute from CCS
 - Ensure PLL setup in GEL file uses internal clock source (CLK_SEL=0)
 - Load executable to eZdsp
 - Execute code. eZdsp should enumerate and USB Audio Device (see Windows Volume Control or Sounds and Audio Device Properties).
 - If problem with execution
 - Scripts→CPU_Reset
 - Scripts→Peripheral_Reset
- Install USB Audio Class 2.0 Driver
 - Unzip timwei_USBAudio_Driver.zip (under host_driver folder)
 - Make sure the C5535 eZdsp is connected to the PC and the code is executing
 - Execute timwei_USBAudio_Driver\release\setup.exe
 - Restart the PC
- Functionality
 - Initiate playback of audio in Windows (e.g. Media Player). Audio will play back on eZdsp.
 - Initiate record of audio in Windows (e.g. Sound Recorder). Audio will record to Host.
- Playback tested on Windows XP SP3.

Top



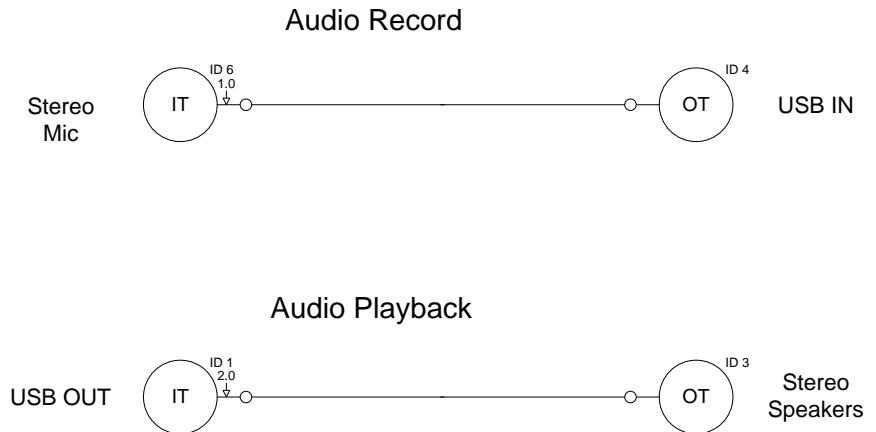
Bottom



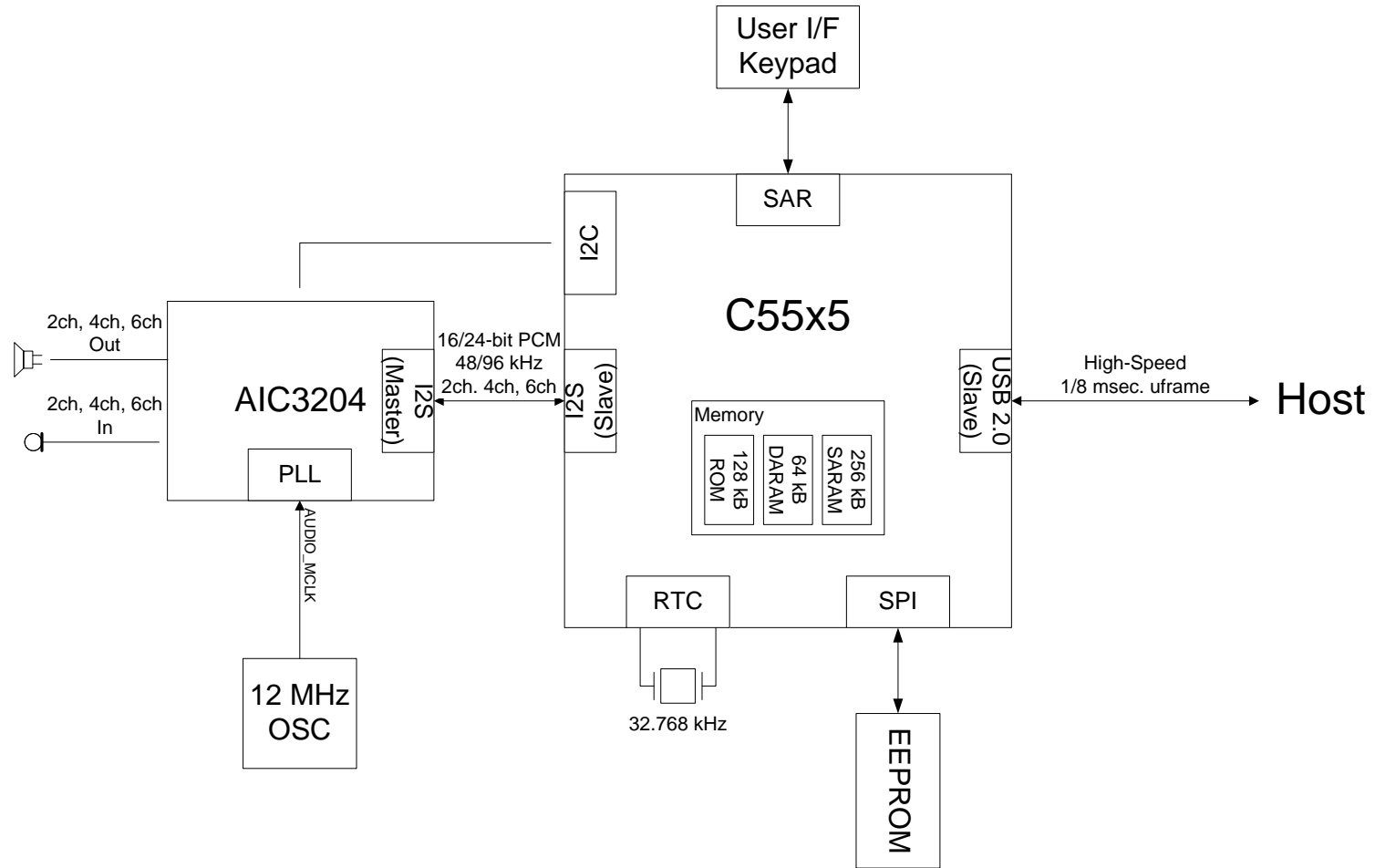
C55xx USB Audio Class Overview

Supported Features

- USB high-speed operation
- Audio Device Class 2.0 compliant
- Audio Record
 - 16/24-bit PCM
 - 48/96 kHz sampling rate
 - 2ch, 4ch and 6ch
 - Asynchronous synchronization
- Audio Playback
 - 16/24-bit PCM
 - 48/96 kHz sampling rate
 - 2ch, 4ch and 6ch
 - Asynchronous synchronization

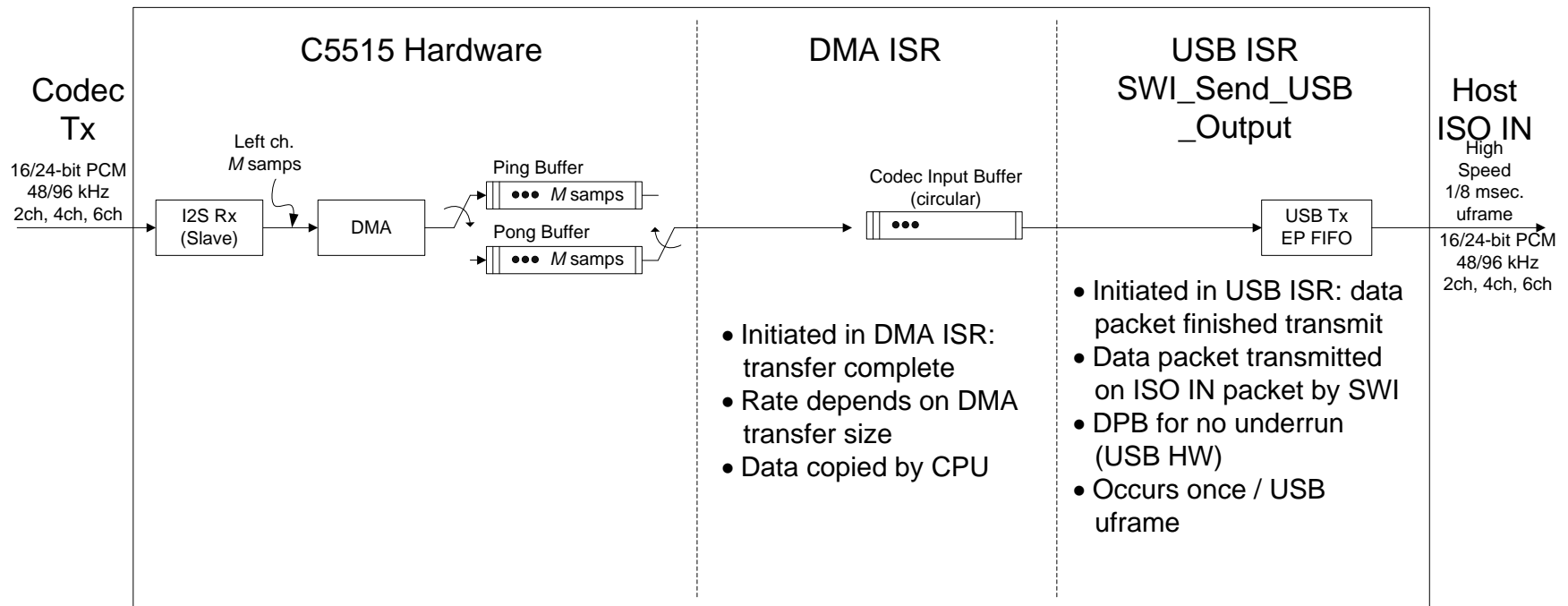


Hardware Block Diagram



Record Data Flow

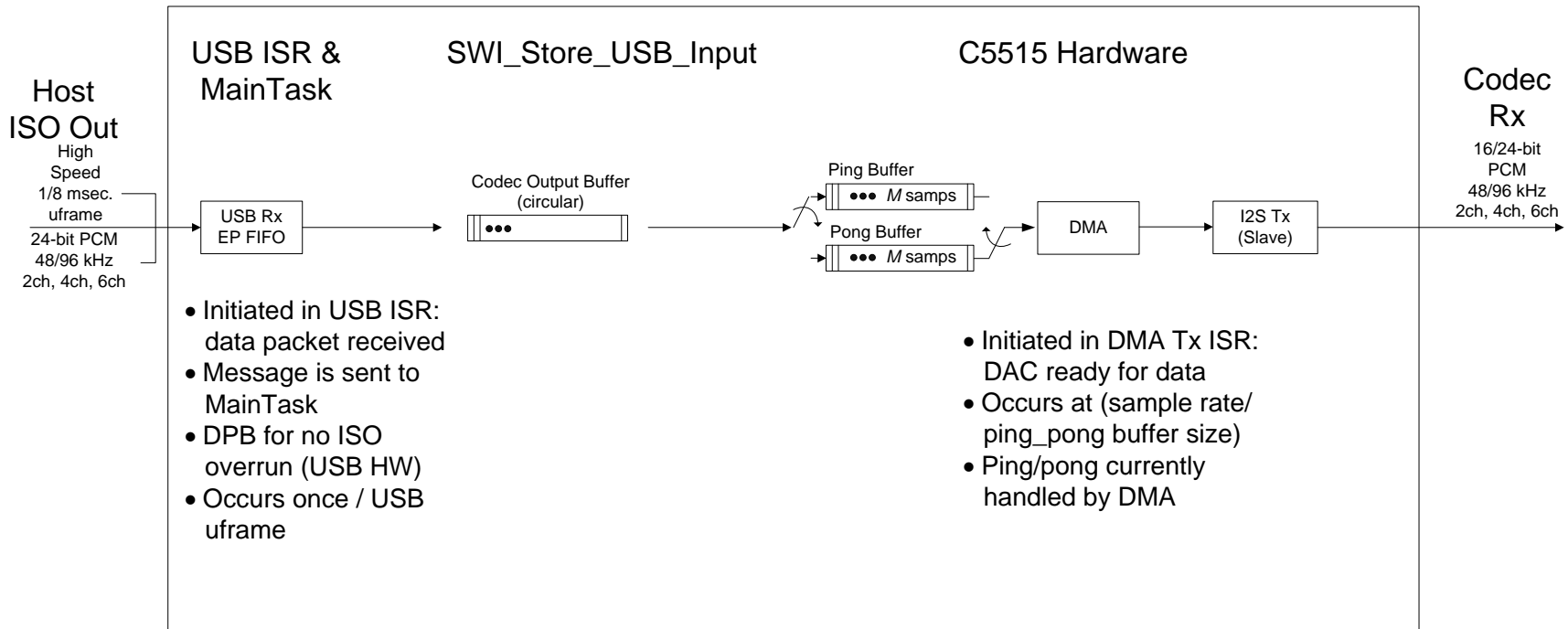
Asynchronous Isochronous



- M : number of samples in DMA transfer can be changed (default 1 msec.)
- N : number of output samples in USB frame varies
- Data rate to USB matches ADC data rate

Playback Data Flow

Asynchronous Isochronous



- N : number of input samples in USB uframe varies
- M : number of samples in ping/pong buffers can be changed (default 1 msec.)
- Data rate to DAC matches USB data rate

HID Description

- Four binary HID Controls exposed to Host in HID descriptors
 - Playback Mute on Master Channel
 - Playback Volume Up on Left / Right Front channels
 - Playback Volume Down on Left / Right Front channels
 - Record Mute on Master Channel
- Physical controls are buttons in push-button network on C55xx board (EVM or eZdsp)
 - SAR samples network every 64 msec. (configurable) checking for change in control state
 - Report generated if change in state. Reports contain all control states.
- Device sends reports when requested by Host
 - Host polls device on interrupt IN endpoint every 32 msec. (configurable)
 - If no report available, request is NAK'ed
- Host driver interprets report data, changes controls on Host
 - Length of Short, Long, and Double presses determined by Host. Device simply sends state (binary) of HID control when change in control state.
- Host driver interprets report data, translates into control IN messages
 - Messages are setup requests to Audio Controls (e.g Playback Volume Control). Minimum, maximum, and resolution for Audio Controls specified in Audio Control Interface.
 - Message contents interpreted and codec configured as requested

Resource Requirements

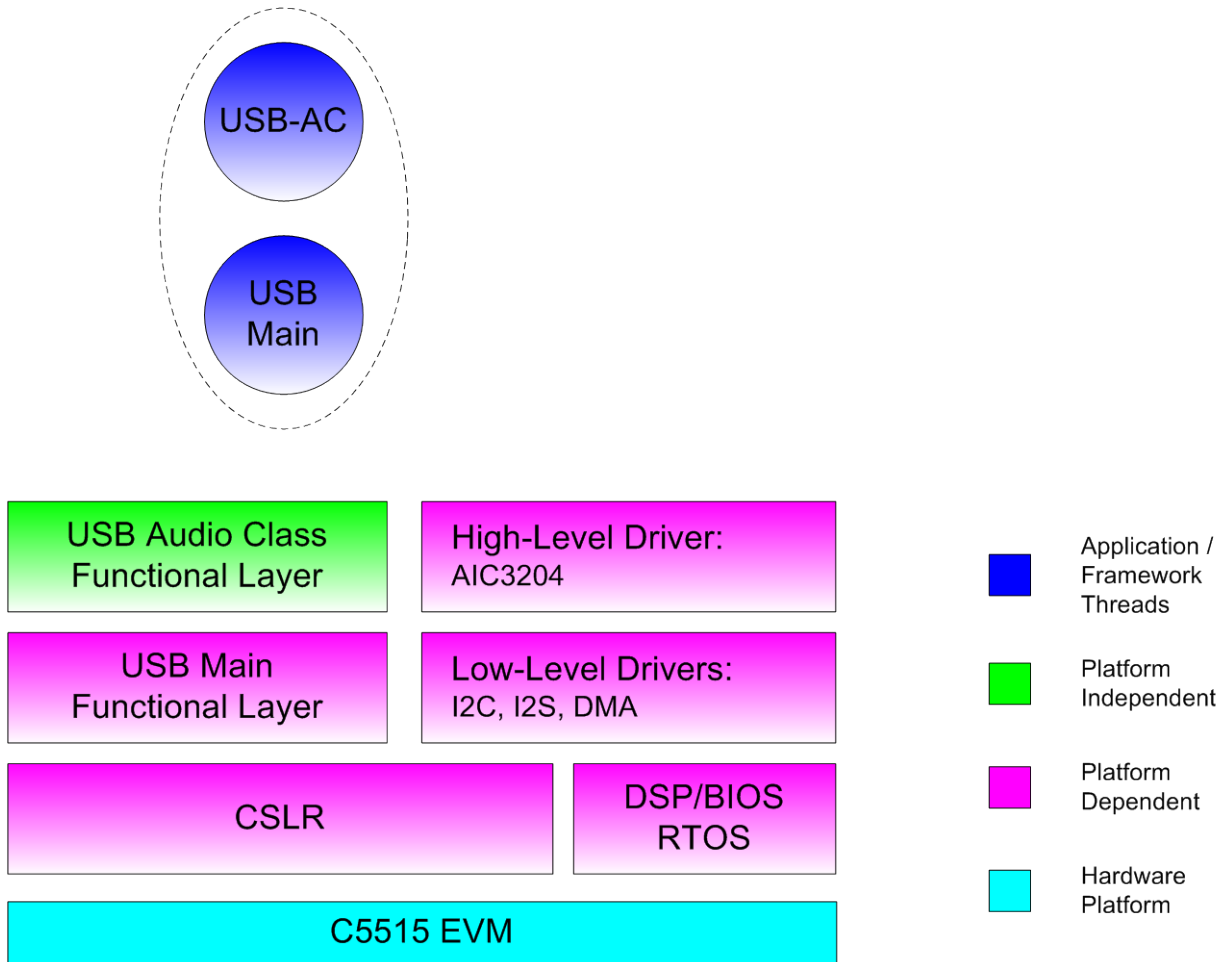
C5515 EVM, Release Version

Function	CPU in Mhz	Memory Footprint in KB
48Khz 2Ch In 2Ch Out 24 bit	33.20	147.32
48Khz 4Ch In 4Ch Out 24 bit	45.97	167.23
48Khz 6Ch In 6Ch Out 24 bit	58.34	187.83
96Khz 2Ch In 2Ch Out 24 bit	45.12	165.34
96Khz 4Ch In 4Ch Out 24 bit	70.04	203.23
96Khz 6Ch In 6Ch Out 24 bit	92.53	241.83

- Optimization for MHz and memory not yet performed. Expect reduction in resource requirements with optimization.

Software Architecture Overview

Software Architecture



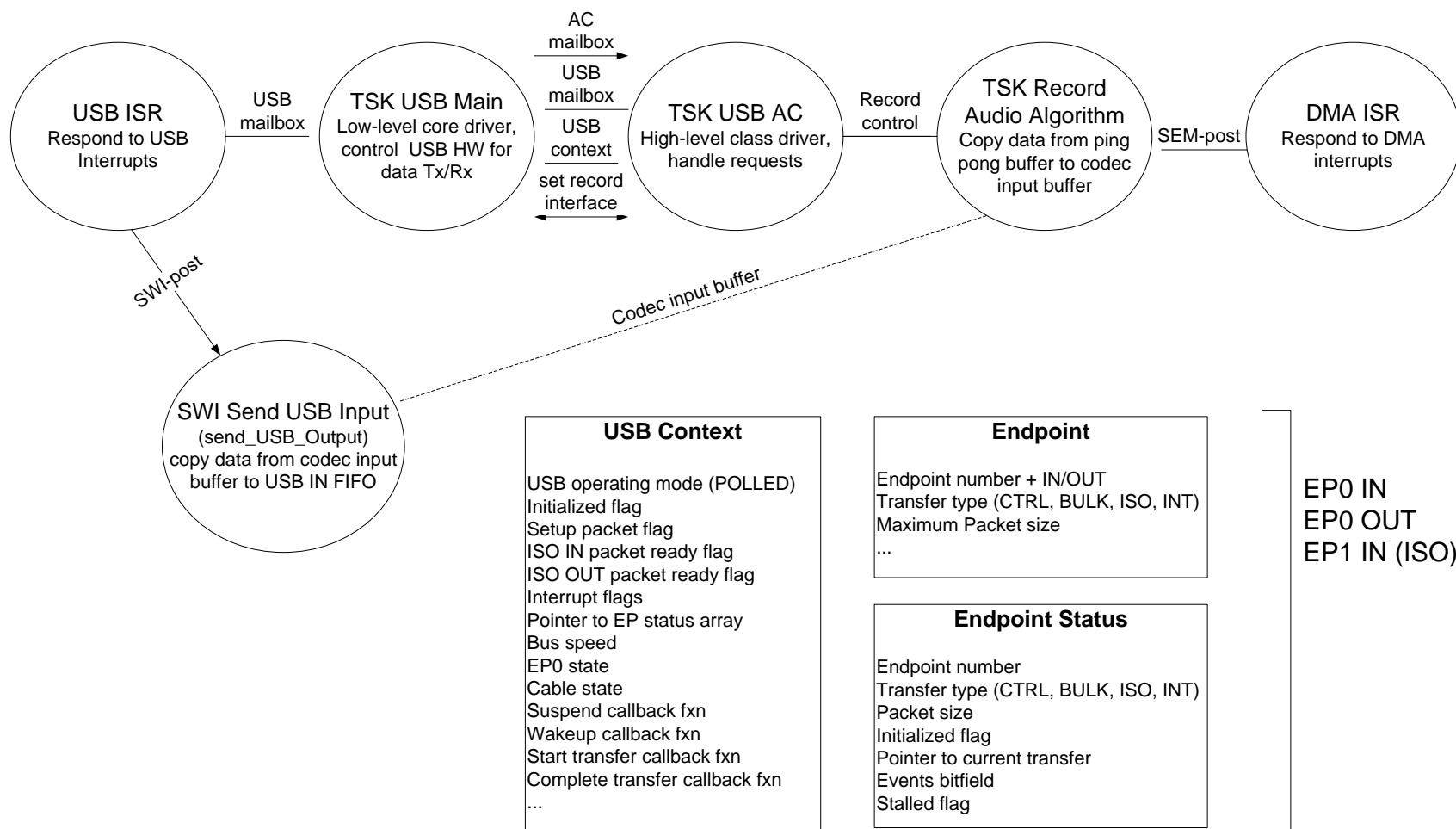
Software Description

- Chip Support Library
 - Set of macros providing simple hardware abstraction
 - Enables developers to configure registers symbolically, eliminating need to calculate bit-maps for each register
- DSP/BIOS Real-Time Operating System
 - Scheduling with different thread types: Hardware Interrupt, Software Interrupt, Task
 - Inter-task synchronization and communication: semaphores and mailboxes
 - Small-footprint instrumentation with logging and statistics objects
- Low-level drivers for I2C, I2S and DMA
 - Support basic resource management, preventing simultaneous assignment of resource to more than one use
- USB driver
 - USB Main functional layer specific to C5515 USB hardware. Controls USB hardware for data Tx/Rx.
 - USB Audio Class functional layer independent of C5515 USB hardware. Interprets/handles USB Standard and Audio Class requests.
- Framework
 - Threading model allowing data throughput and real-time deadline requirements to be achieved

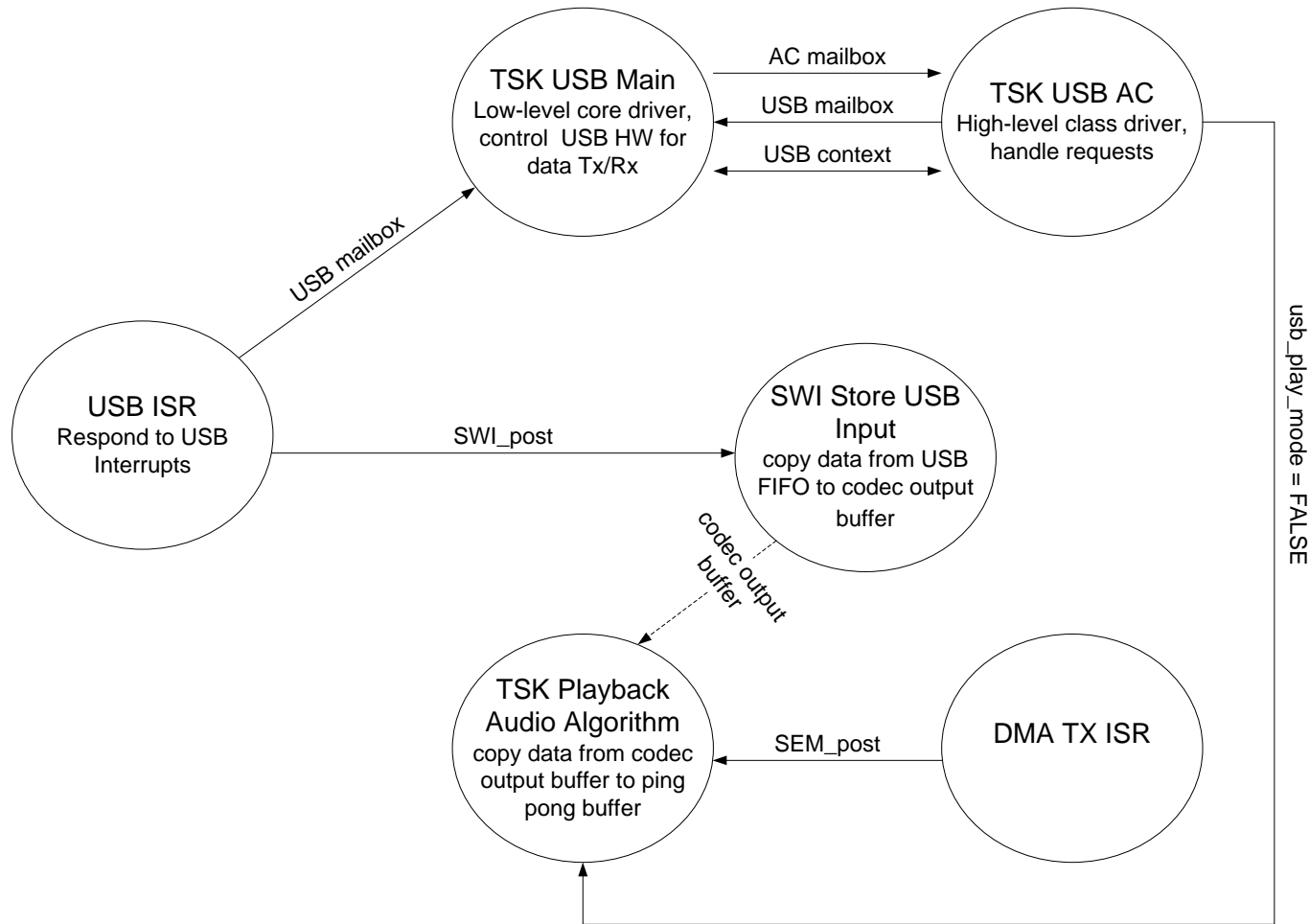
Thread Summary

Name	Purpose	Executes	Priority	Frequency
Hardware Interrupts				
HWI_INT4 (gpt1Isr())	Initiate processing of user interface (SAR sampling, etc.).	Timer Int	0	64 msec.
HWI_INT8 (DMA_Isr())	Execute callback functions for active DMA channels.	DMA1 Ch0 Int	1	2 per msec
HWI_INT14 (i2s_txIsr())	Not in use	I2S2 TX Int	2 - highest	
HWI_INT20 (USBIsr())	Respond to USB interrupts. Send message to TSK_MUSBMainTask indicating interrupt occurrence. Post SWI_Store_USB_Input for storing USB input for playback.	USB Int	1	1/uframe ISO IN 1/uframe ISO OUT 1/uframe SOF
Software Interrupts				
SWI_Store_USB_Input (store_USB_input())	Copy frame data from EP2 OUT FIFO to codec_input_buffer. Prepare EP2 OUT FIFO to receive next frame data.	Post from MainTask() HandleUSBInterrupt()	5 - highest	uframe rate (125 usec)
SWI_Send_USB_Output (send_USB_input())	Copy frame data from EP1 IN FIFO to codec_output_buffer. Prepare EP2 OUT FIFO to receive next frame data.	Post from MainTask() HandleUSBInterrupt()	5	uframe rate (125 usec)
SWI_UserInterface	Check change in state in push-button network. If change, format report and indicate report ready to USB Interrupt In EP handler.	Post from gpt1Isr()	4	64 msec
Tasks				
mainTsk (CSL_acTest())	System initialization.	Application startup	15 – highest	Run once
TSK_MUSBMainTask	USB Main driver. Control USB HW for Tx/Rx. Adjust EP sample rates and interface mute & volume controls.	USB Main mbx msg (e.g. USB interrupt, USB transaction post from USB AC)	9	
TSK_MUSBACTask	USB AC driver. Handle Standard and AC-specific requests on EP0. Handle IN/OUT requests on ISO EPs.	USB AC mbx msg (e.g. ISO EP IN/OUT req., EP0 req., USB reset)	8	N/A
TSK_PbAudioAlg	Process playback audio command.	Copy data from codec output buffer to ping pong buffer	7	1 per msec
TSK_RecAudioAlg	Process record audio command.	Copy data from ping pong buffer to codec input buffer	7	1 per msec
TSK_CodecConfig	Configure codec via I2C in response to USB commands on EP0.	Codec cfg mbx msg	6	N/A

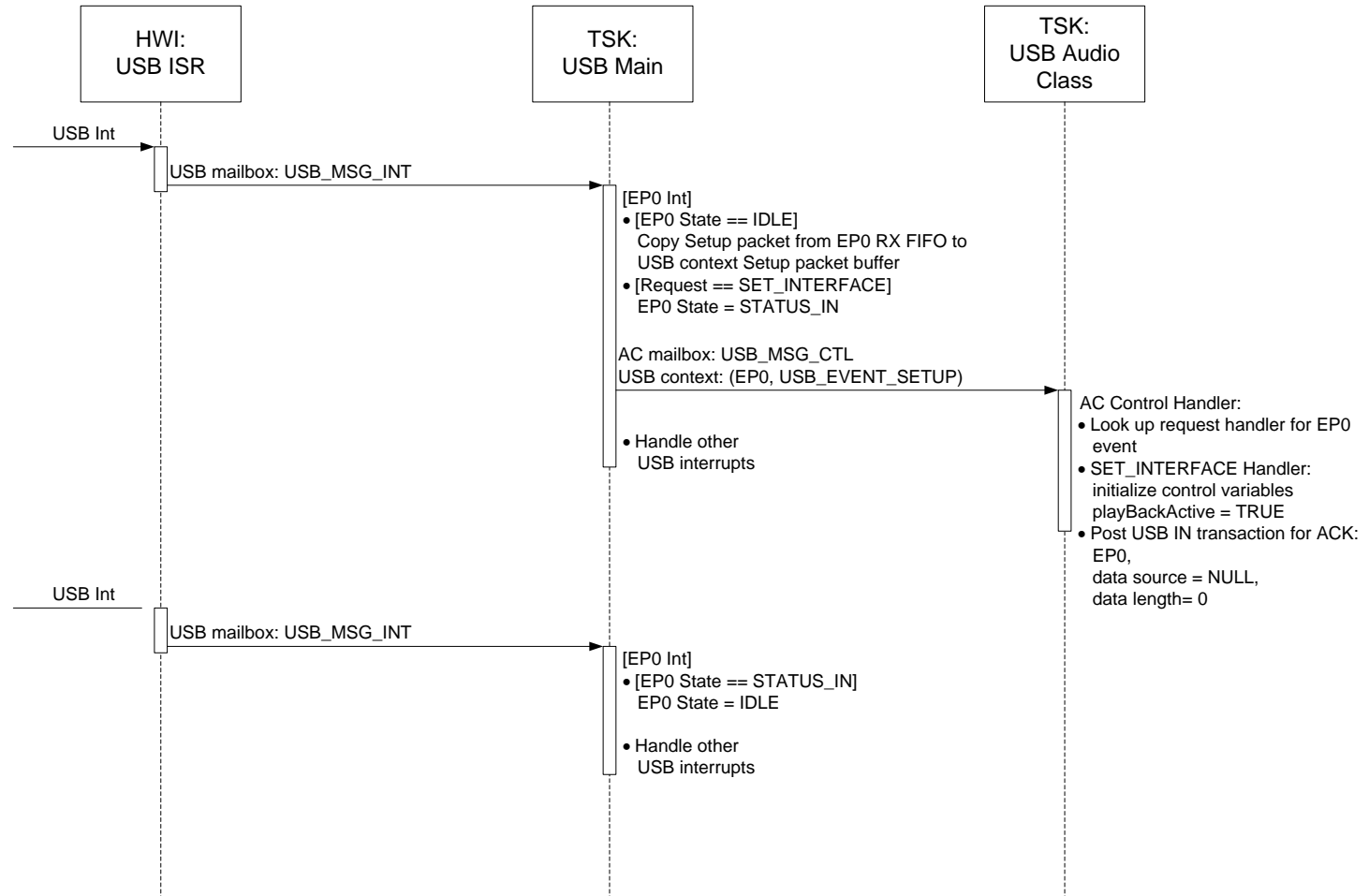
Record Thread Collaboration



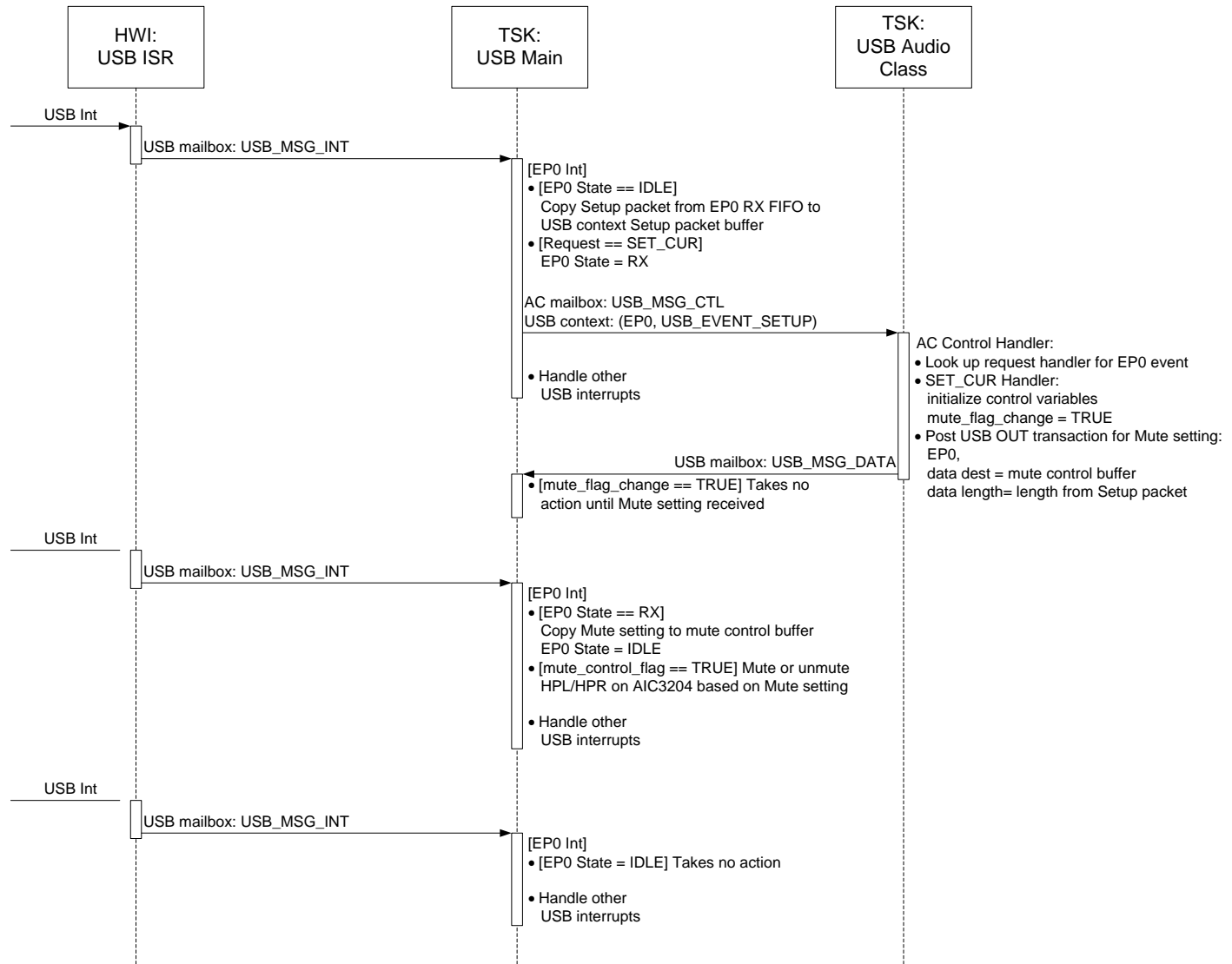
Playback Thread Collaboration



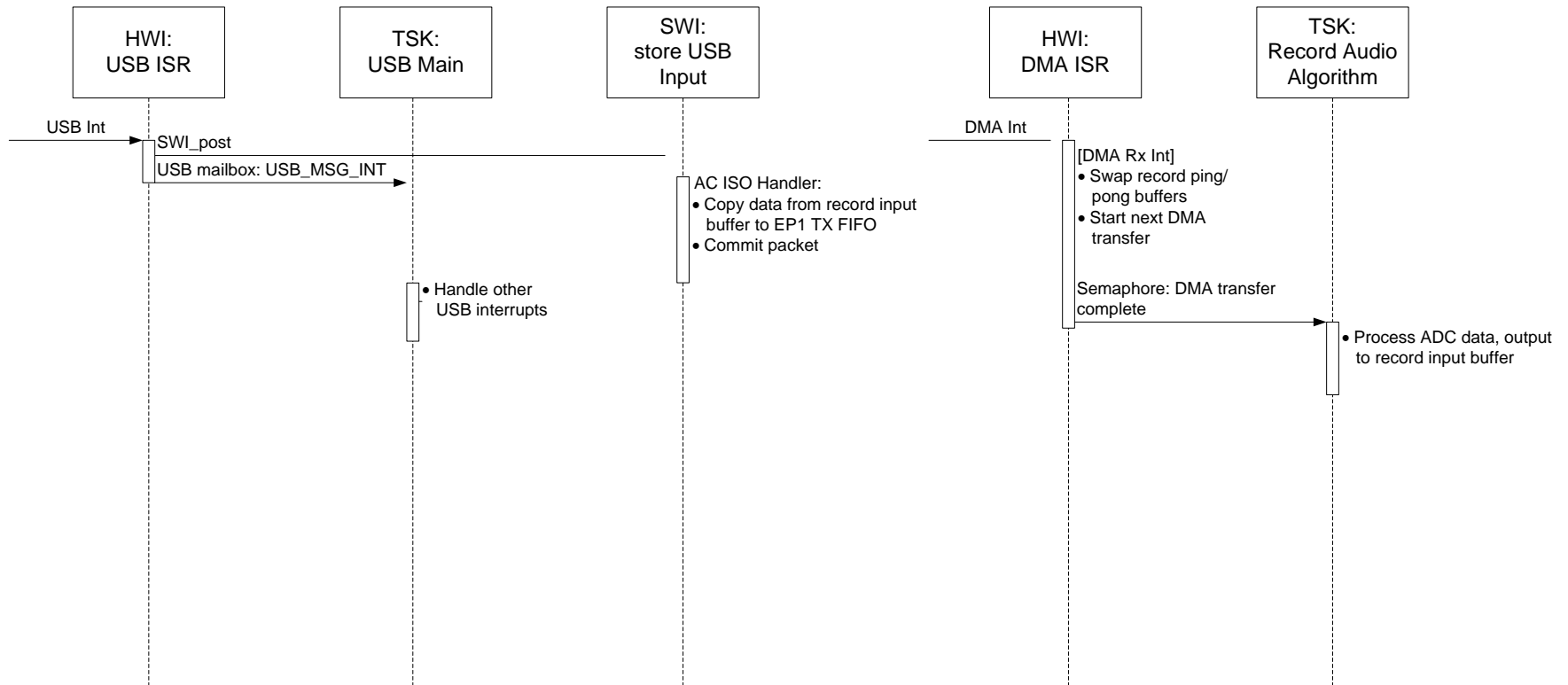
Set Interface Sequence Diagram



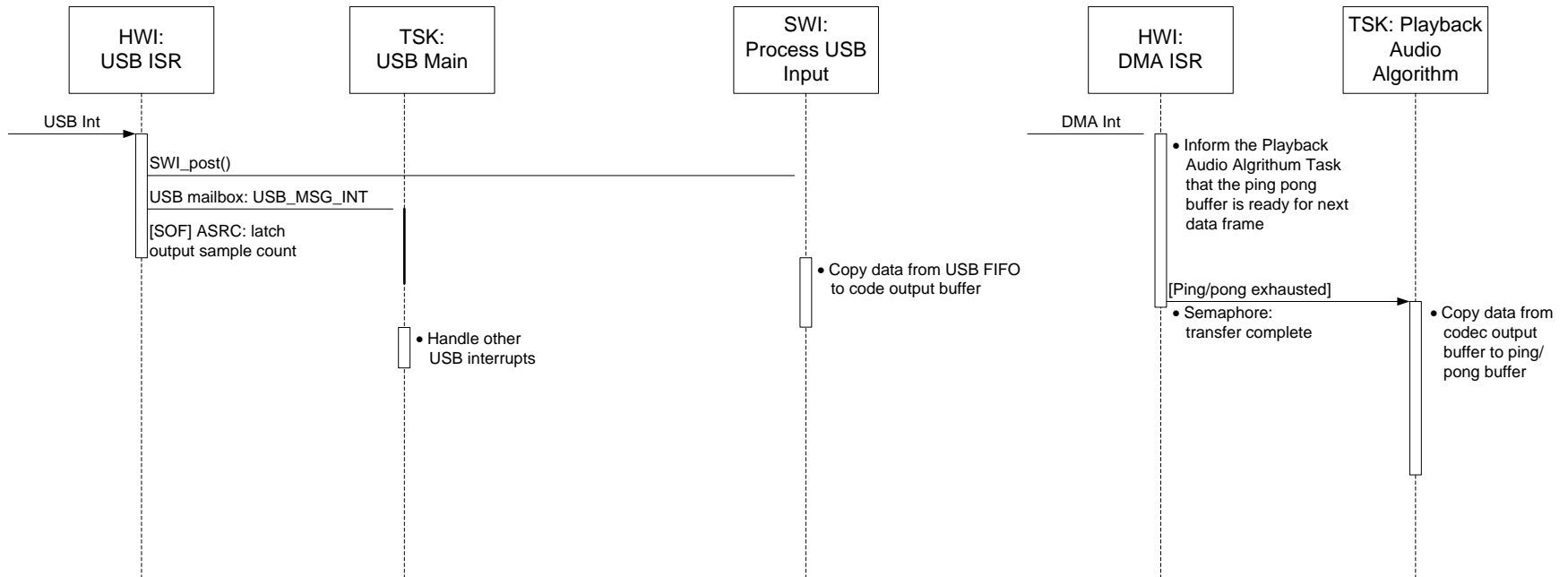
Set Mute Control Sequence Diagram



Record Sequence Diagram

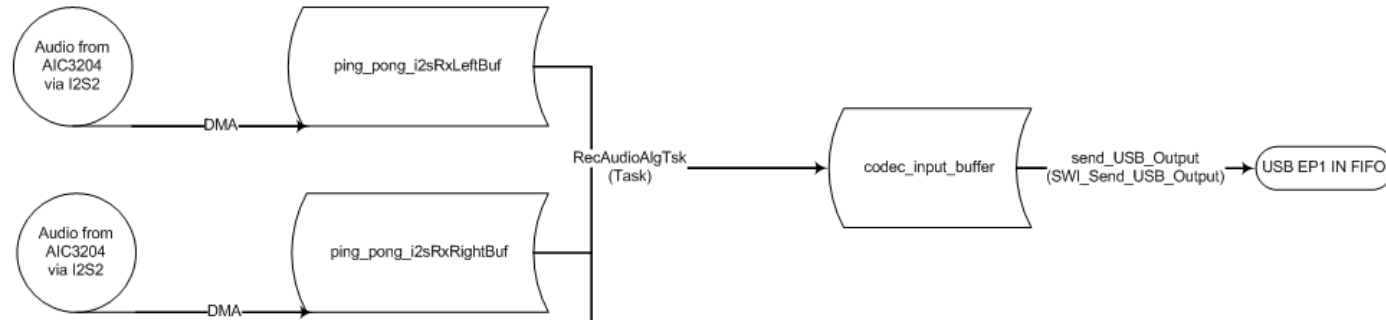


Playback Sequence Diagram

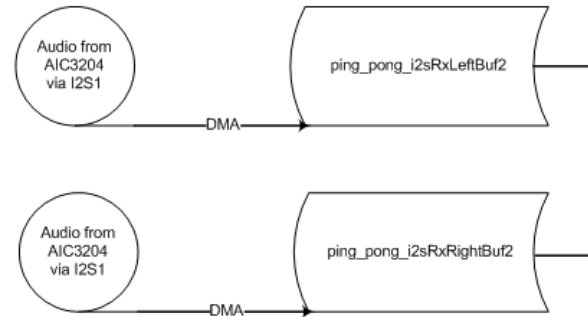


Record Data Flow

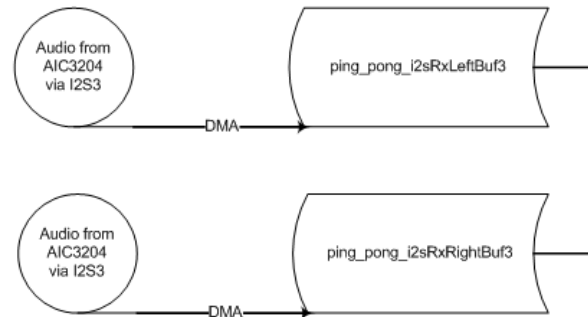
2Ch Record Data Flow



4Ch Record Data Flow (USE_TWO_CODEC is defined)

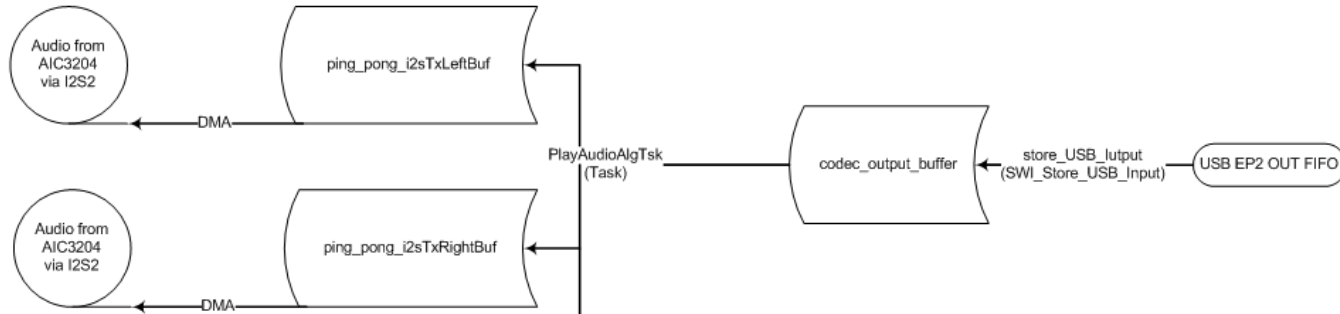


6Ch Record Data Flow (USE_THREE_CODEC is defined)

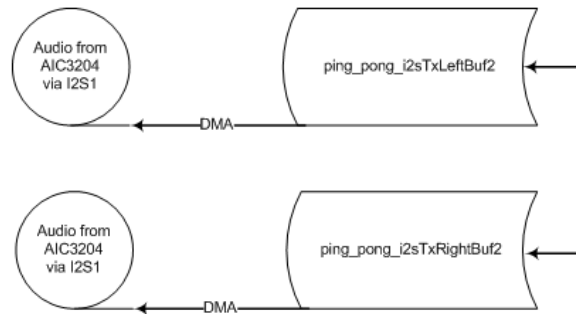


Playback Data Flow

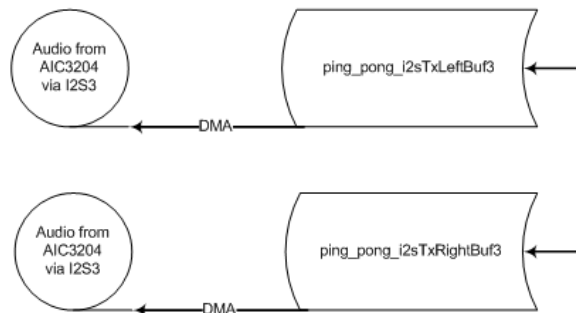
2Ch Playback Data Flow



4Ch Playback Data Flow (USE_TWO_CODEC is defined)

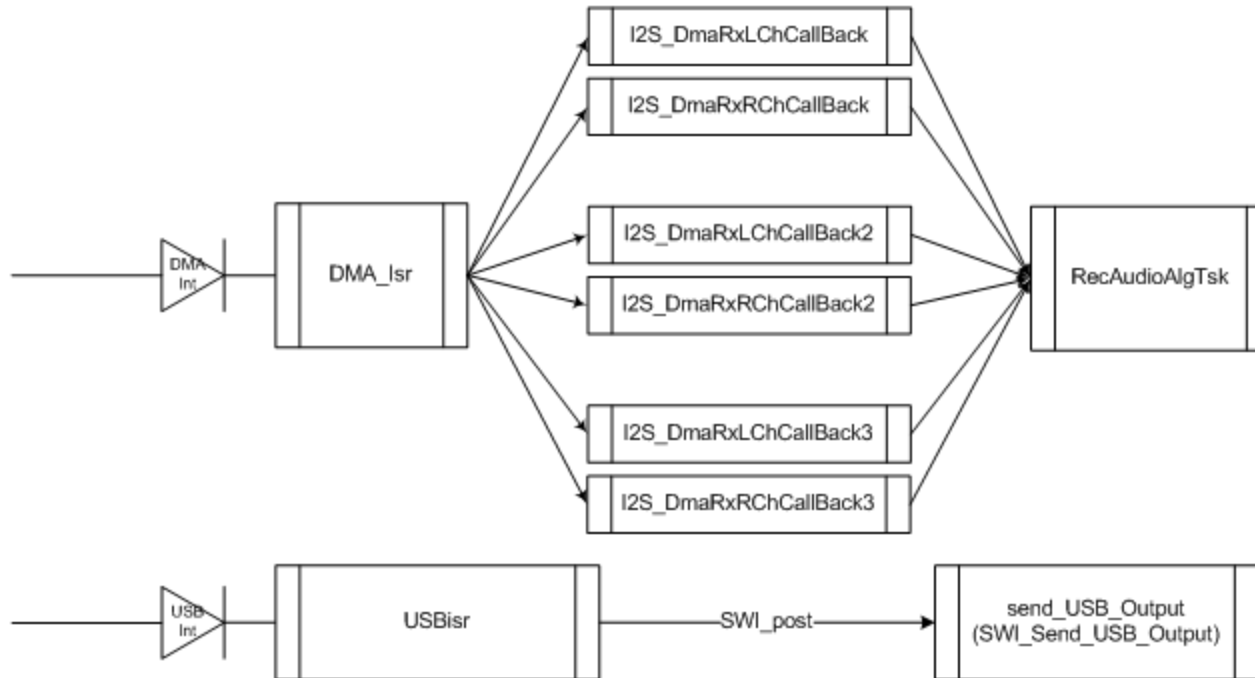


6Ch Playback Data Flow (USE_THREE_CODEC is defined)



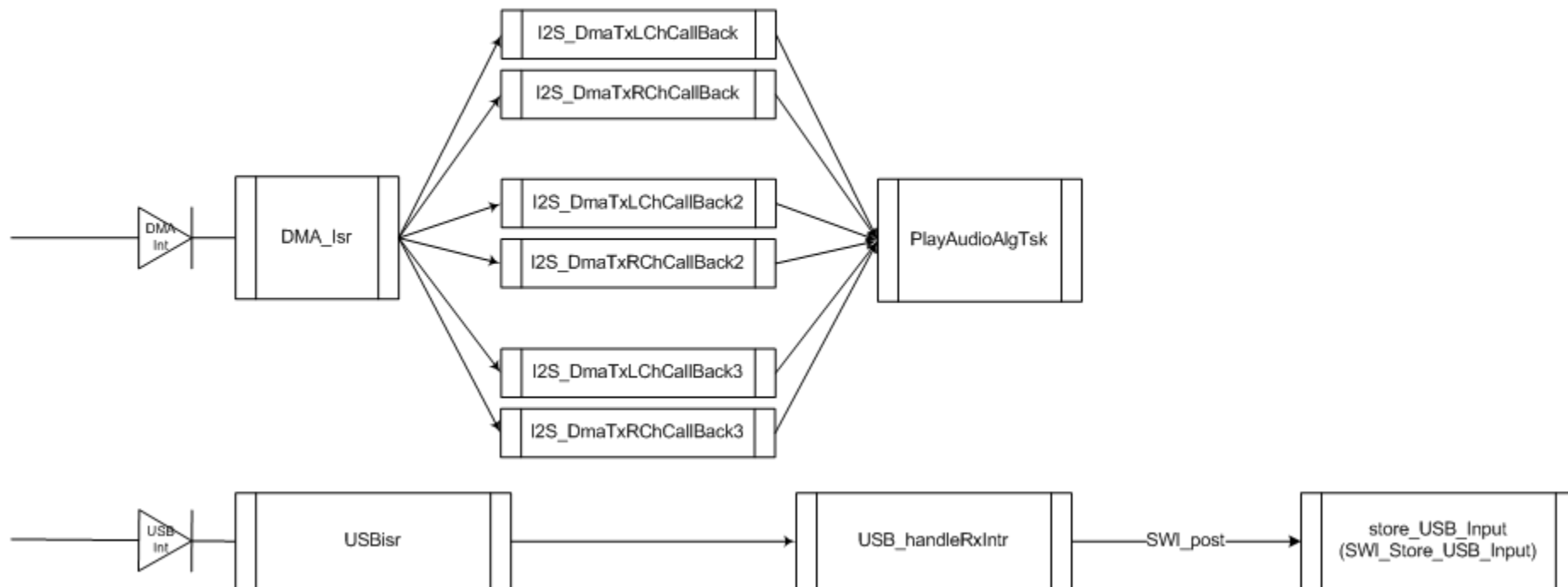
Record Control Flow

Record Control Flow (2Ch,4Ch and 6Ch)



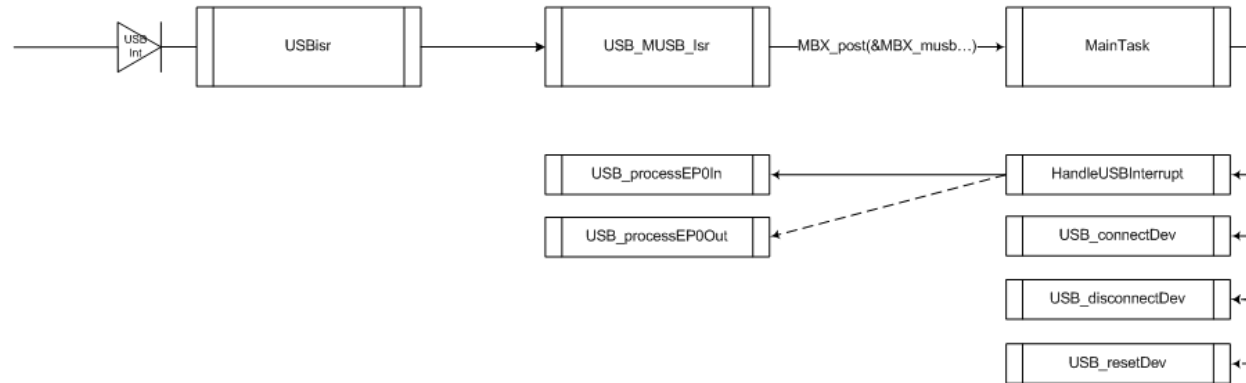
Playback Control Flow

Playback Control Flow (2Ch,4Ch and 6Ch)



USB Enumeration and EP0 Control Flow

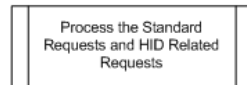
USB Enumeration and EP0 Control Flow



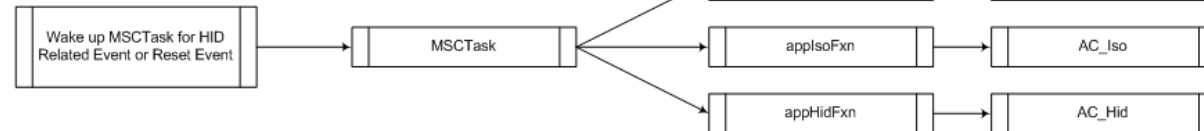
HandleUSBInterrupt



MUSB_Handle_EP0_Intr



MUSB_Handle_EP0_Intr



USB Enumeration and EP0 Control Flow

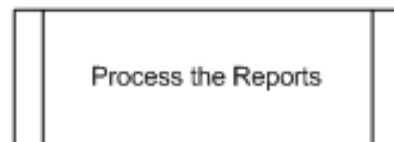
AC_Ctrl



AC_Iso



AC_Hid



USB Audio 2.0 (4Ch In, 4Ch Out) Demo

- Since we only have one audio codec on C5515 EVM and C5535 eZdsp, therefore, the 4ch in test has to be done by feeding the same 2ch input (Stereo In 1, J9 on C5515 EVM) from audio codec (AIC3204) to both I2S2 (default) input and I2S1 input.
- It requires three blue wires (I2S_CLK, I2S_FS and I2S_RX) on both C5515 EVM and C5535 eZdsp (on the Expansion Connector).
- On output side, we can only test 2ch out, because only I2S2 output is connected to the audio codec, so only ch1 and ch2 are played back to the audio codec. ch3 and ch4 (I2S1 output) are not connected to the audio codec, therefore you cannot hear them.

USB Audio 2.0 (4Ch In, 4Ch Out) Demo

- On PC side, you will need install the Audacity 2.0.0 (freeware) which can record and playback multiple channels. Of course, the recorded 4 channels are actually two channels and their duplication (ch1 and ch3 are the same, ch2 and ch4 are the same).
- When recording, please use USBIN and 4 channels
- When playback, please use USBOUT
- Use boot5505.bin for C5515 EVM
- Use bootimg.bin for C5535 eZdsp

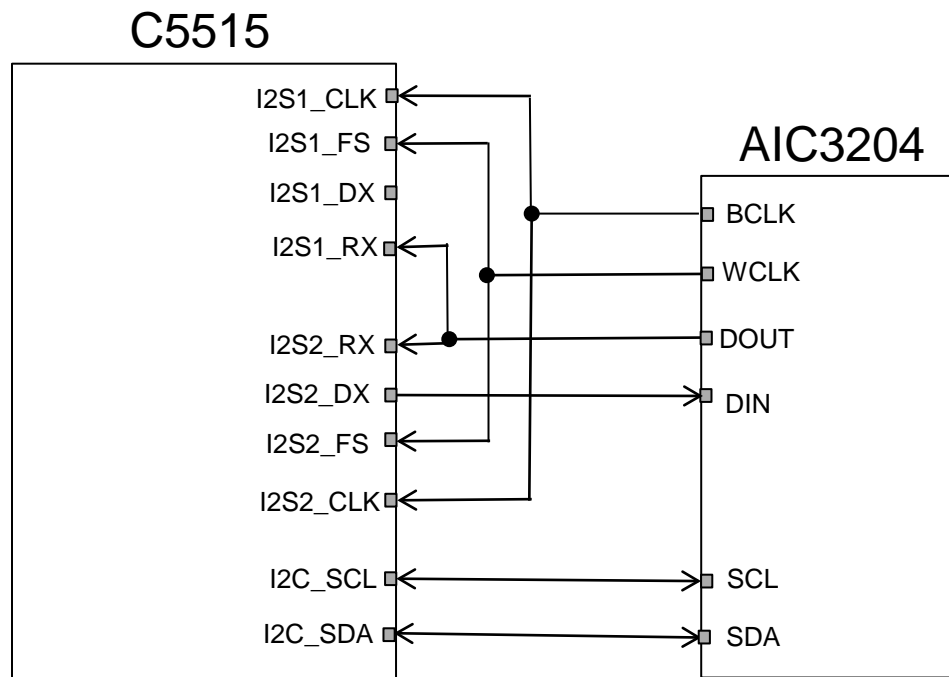
USB Audio 2.0 (4Ch In, 4Ch Out) Demo

C5515 EVM Modification : External Clock

- The AIC3204 on the C5515 EVM is used to provide the I2S input.
- AIC3204 is working in master mode. It needs 12Mhz clock input.
- The 12Mhz oscillator is required on OSC1.

USB Audio 2.0 (4Ch In, 4Ch Out) Demo

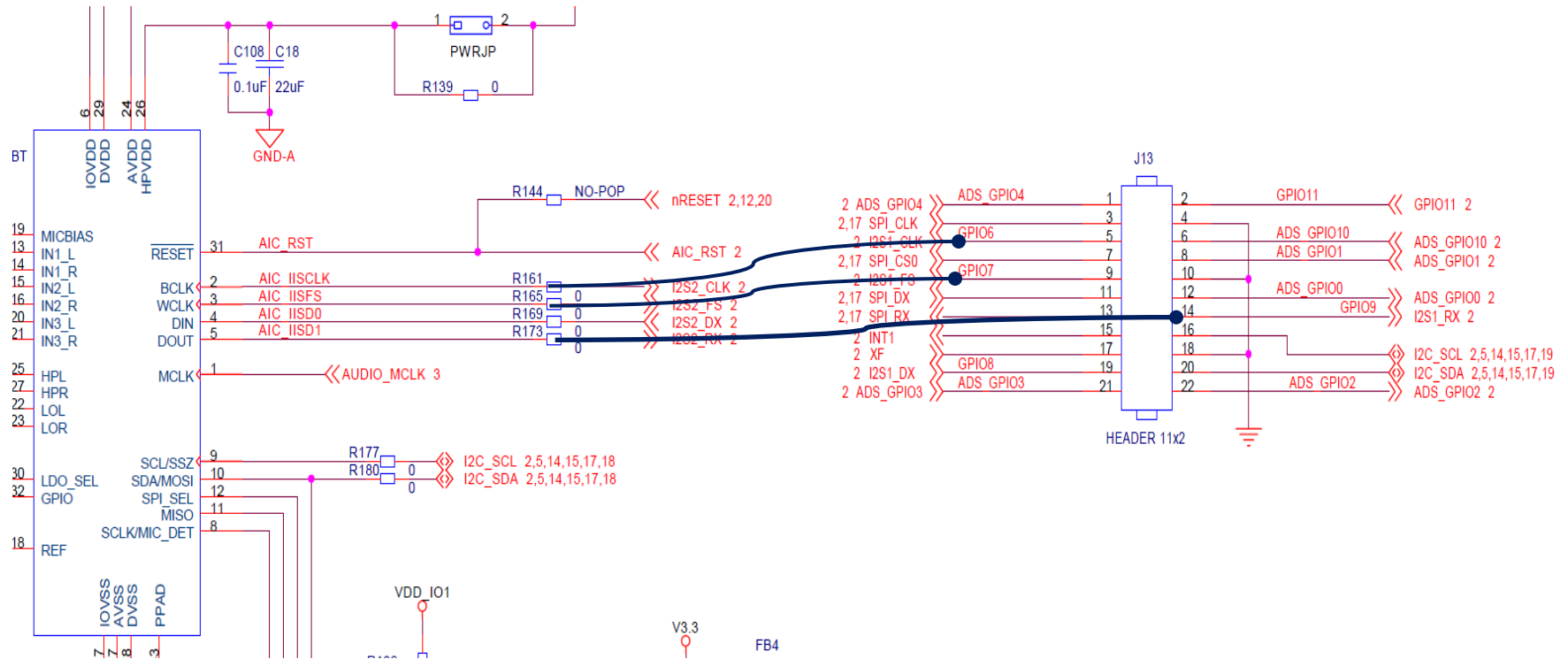
C5515 EVM Modification : Block Diagram



- Two Channel Stereo inputs from one Codec (duplicated stereo data)
- Two Channel Stereo outputs (actual one stereo output to Codec)

USB Audio 2.0 (4Ch In, 4Ch Out) Demo

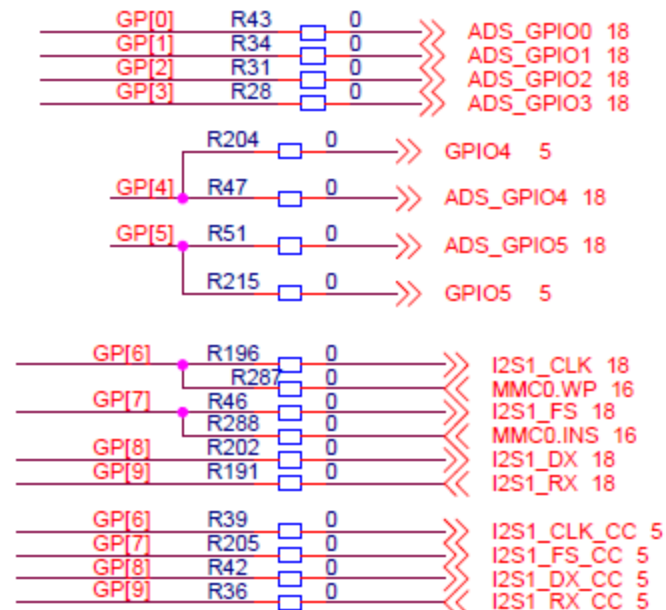
C5515 EVM Modification: Blue wires



USB Audio 2.0 (4Ch In, 4Ch Out) Demo

C5515 EVM Modification : Boot from SD

- The write protection pin (MMC0.WP) and the card detection pin (MMC0.INS) for SD0 are merged with I2S1_CLK and I2S1_FS respectively.
- If you want boot from SD card, R287 and R288 need to be removed.



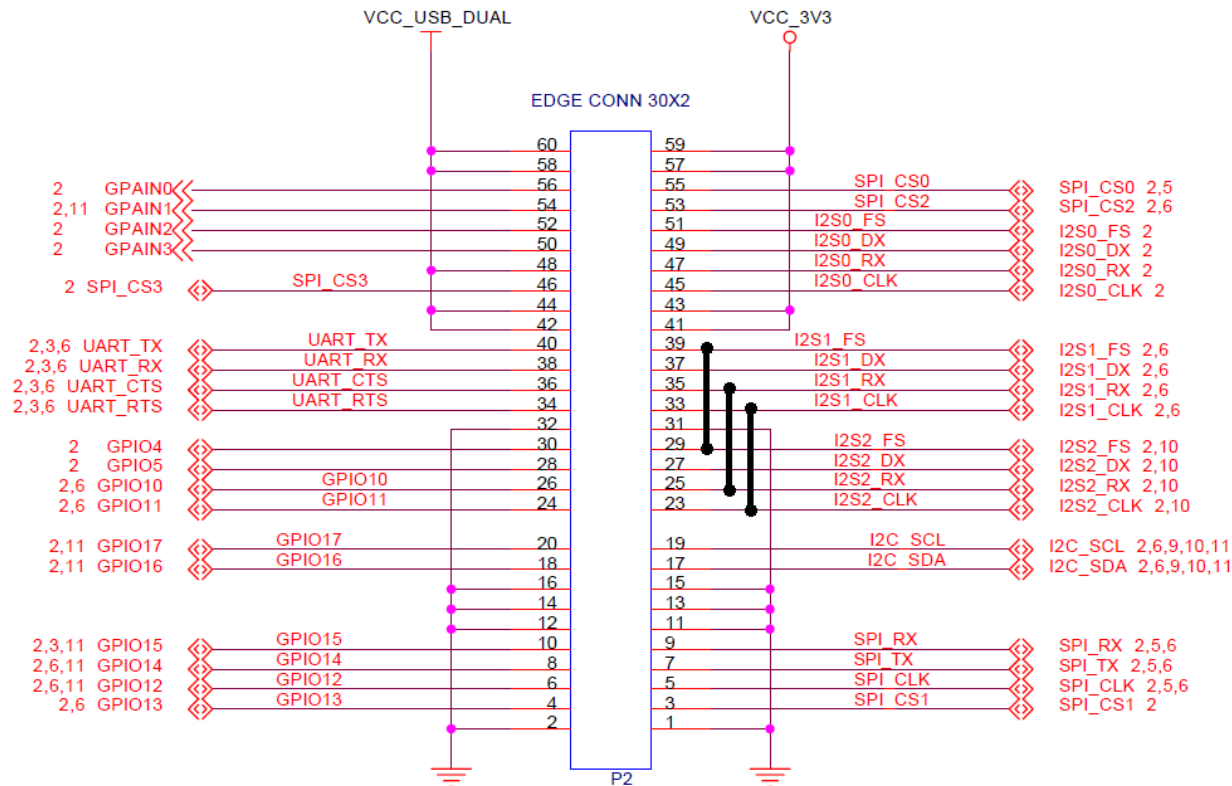
USB Audio 2.0 (4Ch In, 4Ch Out) Demo

C5535 eZdsp : External Clock

- The AIC3204 on the C5535 eZdsp is used to provide the I2S input.
- AIC3204 is working in master mode. It needs 12Mhz clock input.
- The USB 12Mhz oscillator is used as external clock for AIC3204.

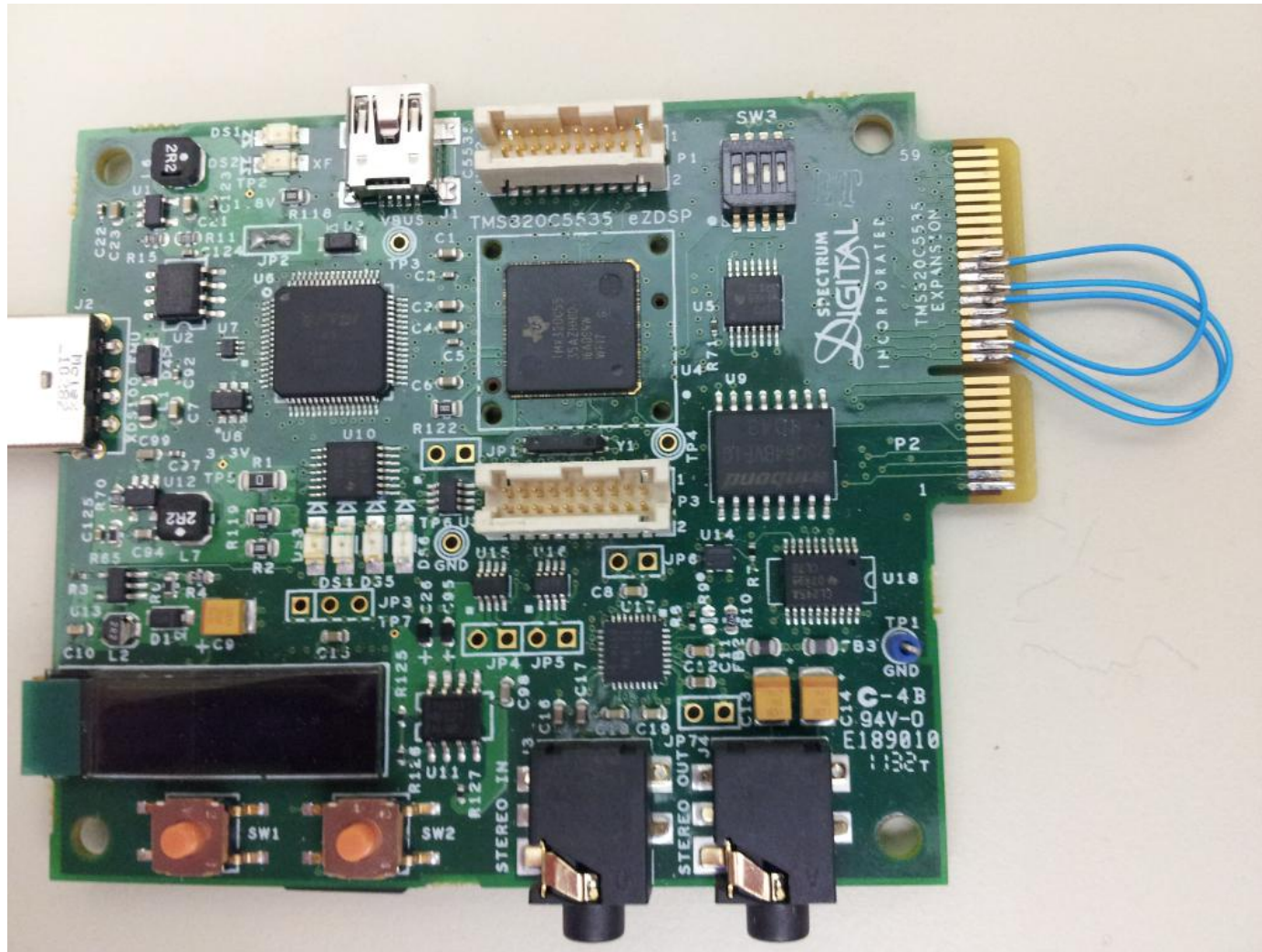
USB Audio 2.0 (4Ch In, 4Ch Out) Demo

C5535 eZdsp Modification : Blue wires



- Two Channel Stereo inputs from one Codec (duplicated stereo data)
- Two Channel Stereo outputs (actual one stereo output to Codec)

USB Audio 2.0 (4Ch In, 4Ch Out) Demo C5535 eZdsp Modification : Blue wires



USB Audio 2.0 (6Ch In, 6Ch Out) Demo

- Since we only have one audio codec on C5515 EVM and C5535 eZdsp, therefore, the 6ch in test has to be done by feeding the same 2ch input (Stereo In 1, J9 on C5515 EVM) from audio codec (AIC3204) to I2S2 (default) input, I2S1 input and I2S3 input.
- It requires six blue wires (I2S_CLK, I2S_FS and I2S_RX) on both C5515 EVM and C5535 eZdsp (on the Expansion Connector).
- On output side, we can only test 2ch out, because only I2S2 output is connected to the audio codec, so only ch1 and ch2 are played back to the audio codec. Ch3 and ch4 (I2S1 output), ch5 and ch6 (I2S3 output) are not connected to the audio codec, therefore you cannot hear them.

USB Audio 2.0 (6Ch In, 6Ch Out) Demo

- On PC side, you will need install the Audacity 2.0.0 (freeware) which can record and playback multiple channels. Of course, the recorded 6 channels are actually two channels and their duplication (ch1, ch3 and ch5 are the same, ch2, ch4 and ch6 are the same).
- When recording, please use USBIN and 6 channels
- When playback, please use USBOUT
- Use boot5505.bin for C5515 EVM
- Use bootimg.bin for C5535 eZdsp

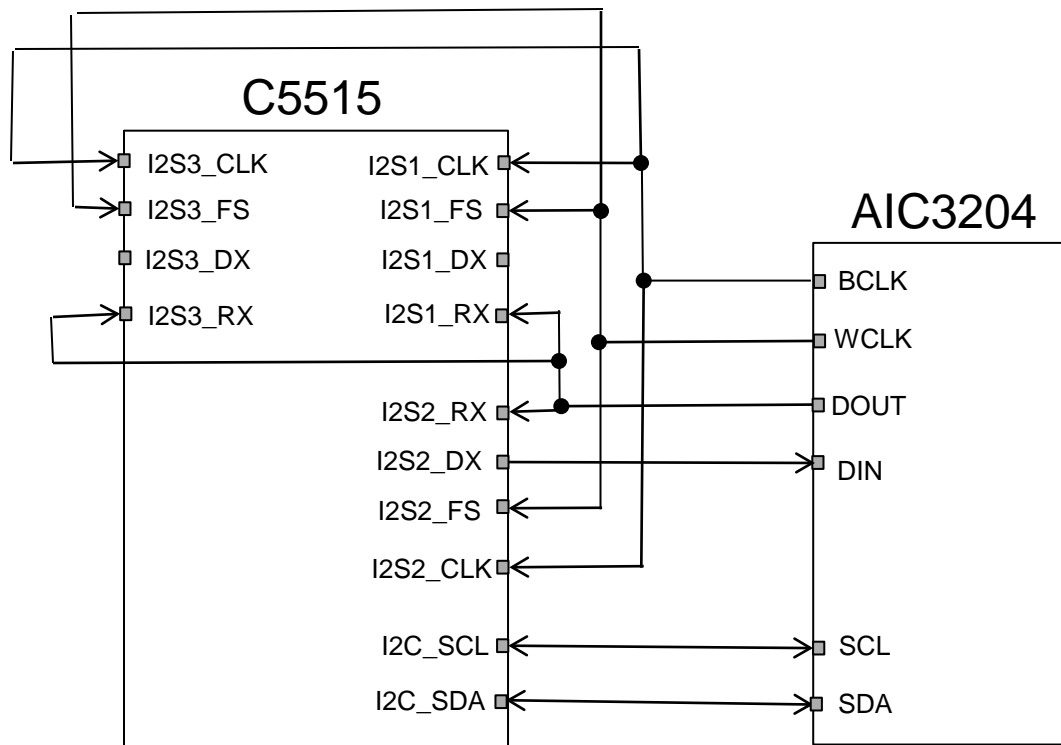
USB Audio 2.0 (6Ch In, 6Ch Out) Demo

C5515 EVM Modification : External Clock

- The AIC3204 on the C5515 EVM is used to provide the I2S input.
- AIC3204 is working in master mode. It needs 12Mhz clock input.
- The 12Mhz oscillator is required on OSC1.

USB Audio 2.0 (6Ch In, 6Ch Out) Demo

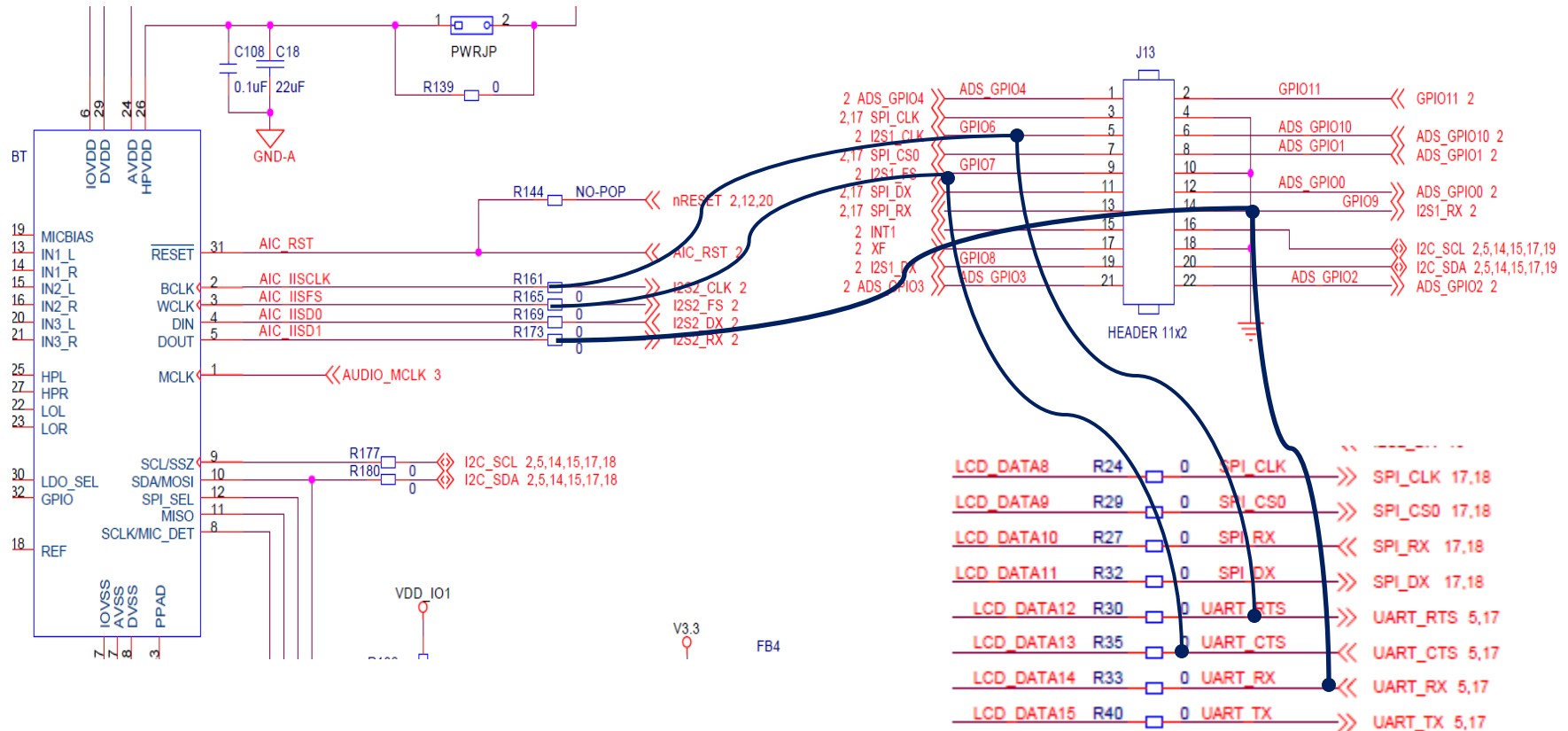
C5515 EVM Modification : Block Diagram



- Three Channel Stereo inputs from one Codec (duplicated stereo data)
- Three Channel Stereo outputs (actual one stereo output to Codec)

USB Audio 2.0 (6Ch In, 6Ch Out) Demo

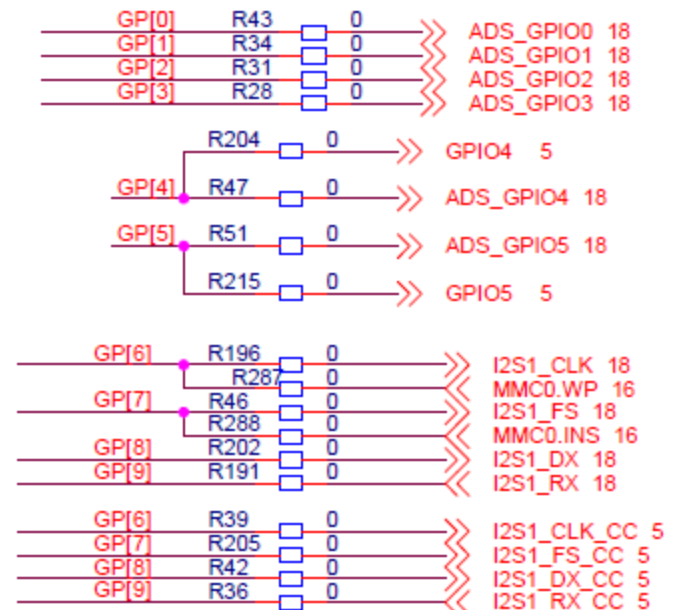
C5515 EVM Modification: Blue wires



USB Audio 2.0 (6Ch In, 6Ch Out) Demo

C5515 EVM Modification : Boot from SD

- The write protection pin (MMC0.WP) and the card detection pin (MMC0.INS) for SD0 are merged with I2S1_CLK and I2S1_FS respectively.
- If you want boot from SD card, R287 and R288 need to be removed.
- UART CTS, RTS and RX are pin muxed with I2S3 CLK, FS and RX, so remove UART_EN (JP3)



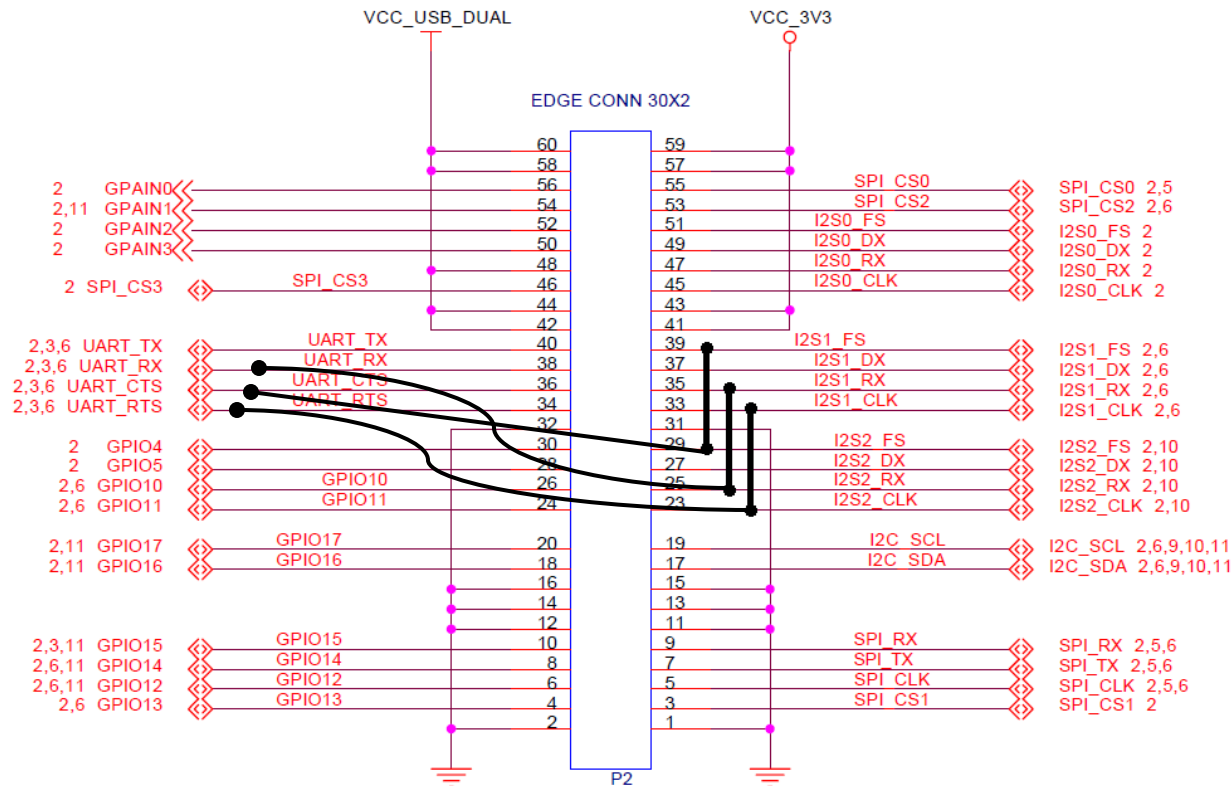
USB Audio 2.0 (6Ch In, 6Ch Out) Demo

C5535 eZdsp : External Clock

- The AIC3204 on the C5535 eZdsp is used to provide the I2S input.
- AIC3204 is working in master mode. It needs 12Mhz clock input.
- The USB 12Mhz oscillator is used as external clock for AIC3204.
- Since UART CTS, RTS and RX are pin-muxed with I2S3 CLK, FS and RX, need to turn switch-2 of SW3 to off position in order to disable UART

USB Audio 2.0 (6Ch In, 6Ch Out) Demo

C5535 eZdsp Modification : Blue wires



- Three Channel Stereo inputs from one Codec (duplicated stereo data)
- Three Channel Stereo outputs (actual one stereo output to Codec)