

Customer Training Workshop

Traveo™ II Mixer

Q4 2020



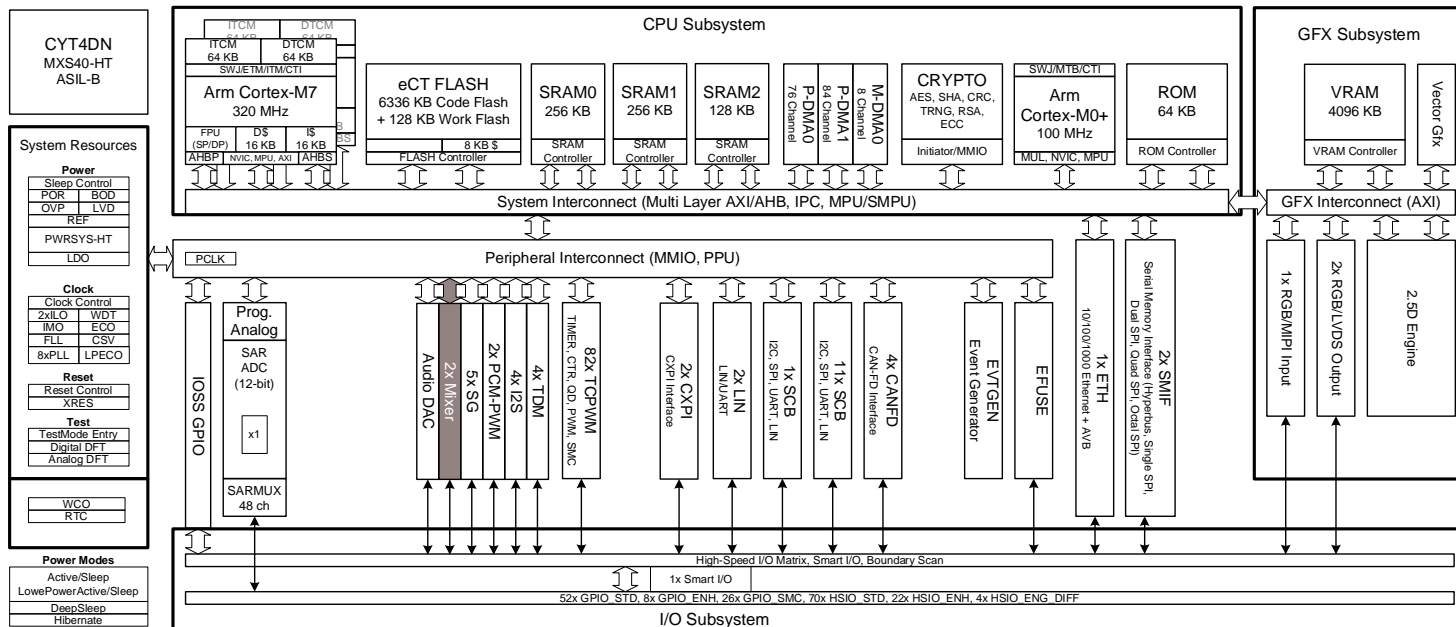
Target Products

> Target product list for this training material

Family Category	Series	Code Flash Memory Size
Traveo™ II Automotive Cluster	CYT3DL	Up to 4160KB
Traveo™ II Automotive Cluster	CYT4DN	Up to 6336KB

Introduction for Traveo II Cluster

> The Mixer is part of the Peripheral blocks



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Review TRM chapter 33 for additional details

Mixer Overview

- › Mixer combines multiple PCM source streams in memory into a single PCM destination stream, which is either written to memory or transmitted over an I2S interface
- › Features
 - PCM source stream
 - Can be gain/volume-controlled
 - Can be faded in (at the stream start) and faded out (just before the stream end)
 - Sample frequency with a specific ratio to the PCM destination sample frequency (0.5x, 1x, 2x, 3x, 4x, 6x, 8x, 12x)
 - PCM destination stream
 - Can be gain/volume-controlled
 - Can be faded in and faded out
 - Fixed PCM sample formatting: 16-bit pairs
 - I2S transmitter with master and slave functionality

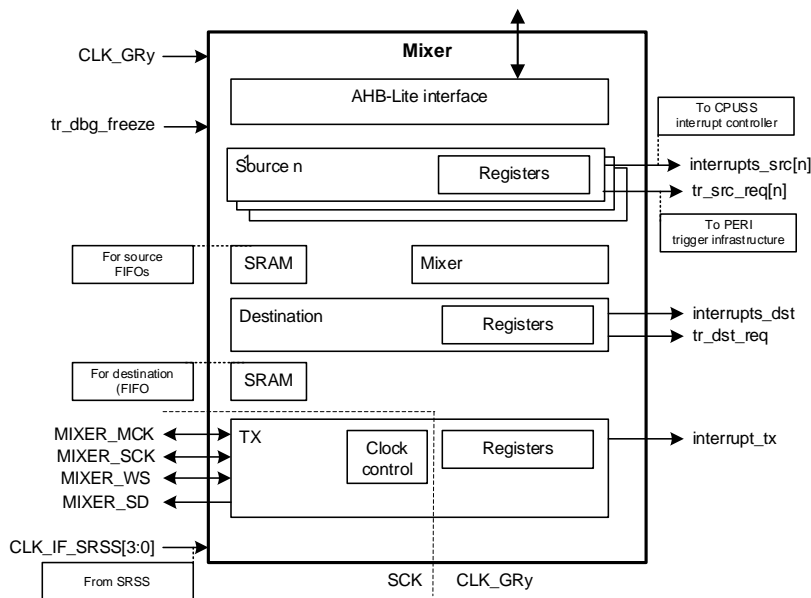
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Review TRM section 33.5 for additional details

Mixer Block Diagram

> Mixer components

- Handling PCM Stream
- Operation
 - Mixer Signal Processing
 - FIR Filter
 - Down and Up Conversion
 - Source Gain Control
 - Fade In Fade Out
 - Source Fade Control
 - Mixing
 - Destination Stream Options



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Review TRM section 33.5.2 for additional details

High-Frequency clock (CLK_HF) is dependent on the device

CLK_GR: Clock input to peripheral functions, which is grouped by the clock gater

¹ Number of source (n) varies by device

Handling PCM Stream

- › To handle a PCM stream, the source must be both enabled (MIXER_MIXER_TX_STRUCT_TX_CTL.ENABLED) and activated (MIXERx_MIXER_SRC_STRUCTy_SRC_FIFO_CTL.ACTIVE)
- › PCM stream start event
 - SW identifies the enabled and deactivated source and programs its registers
 - SW enables the P-DMA/M-DMA controller to provide PCM samples to the source FIFO
 - SW may activate the source before or after the P-DMA/M-DMA controller provides PCM samples
- › PCM stream end event
 - Source is deactivated immediately, or it is faded out
 - On completion of a fade out, a MIXERx_MIXER_SRC_STRUCTy_INTR_SRC.FADED_OUT interrupt cause is activated, and the channel may be deactivated
- › Mixer progress is throttled by the source and destination FIFO states
 - The enabled and activated source FIFOs should be non-empty
 - PCM samples can be provided to the FIFO without activating the channel
 - The enabled destination FIFO should be non-full

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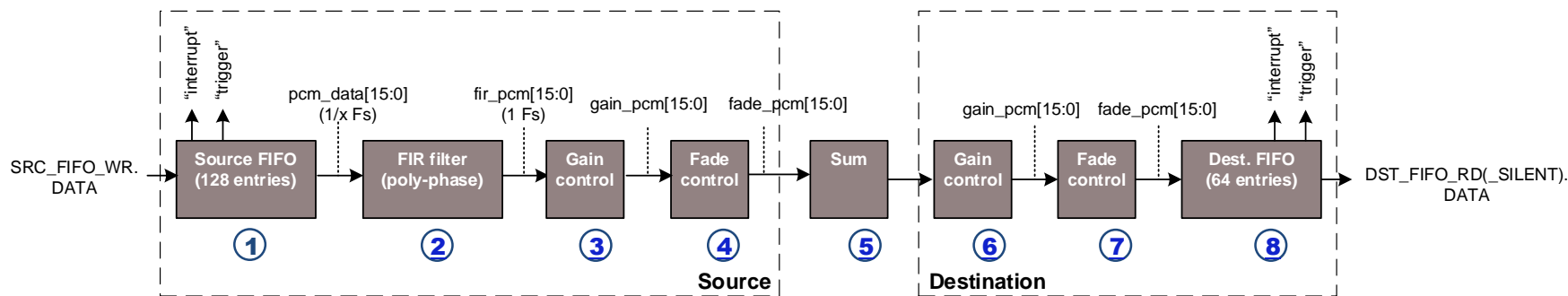
Review TRM section 33.5.3 for additional details

Each source can handle one PCM source stream at a time

Mixer Signal Processing

> Mixer's signal processing path

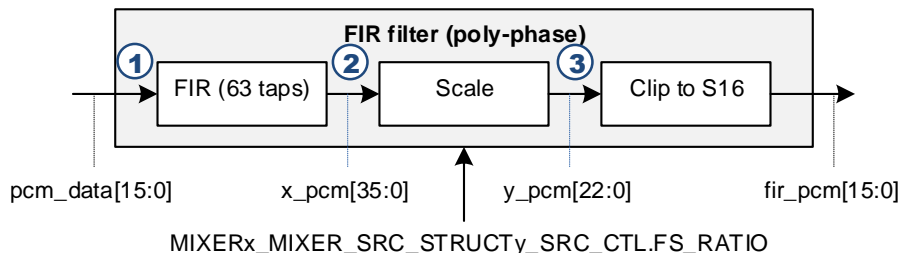
- ① A source consumes PCM samples through its source FIFO from memory
- ② The PCM data goes through a 63-tap polyphase FIR filter
- ③ Source gain control provides volume control
- ④ Source fade control provides the HW-based volume control to create fade in fade out effects
- ⑤ Mixing sums the PCM samples from all enabled sources
- ⑥ Destination gain control mimics source gain control
- ⑦ Destination fade control mimics source fade control
- ⑧ A destination produces PCM samples through its destination FIFO to either memory or directly to a I2S interface



Note: The mixer has multiple sources and a single destination

FIR Filter

- > Calculates PCM source stream at the desired PCM destination stream sample frequency
- > Operation
 - ① PCM source stream goes through a 63-tap FIR with 14-bit signed filter coefficients
 - ② PCM source stream is upsampled or downsampled using the scale function: $y_pcm[22:0] = x_pcm[35:13] + x_pcm[12]$
 - ③ The upsampled or downsampled PCM data is clipped to a 16-bit value



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Review TRM section 33.5.3.2 for additional details

Finite Impulse Response (FIR)

Review the Down and Up Conversion section for additional details about sample frequency upscale ratio

Down and Up Conversion

- › Mixer upscales or downscales a PCM source stream to the desired PCM destination stream sample frequency
 - Upscaling factor: 2x, 3x, 4x, 6x, 8x, 12x
 - Downscaling factor: 2x
- › Can be configured using SRC_CTL.FS_RATIO
- › Each conversion factor and phase uses its own set of 63 FIR coefficients

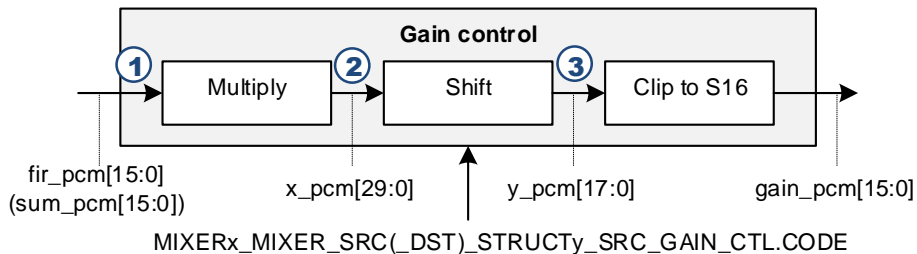
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Review TRM section 33.5.4 for additional details

1x means no scaling. The source PCM samples are used as is

Gain Control

- > Provides volume control independent of fade control
- > The scaling on a logarithmic scale in 1-dB steps is specified by the MIXERx_MIXER_SRC_STRUCTUREy_SRC_GAIN_CTL.CODE in the range [0, 127]
- > Operation
 - ① FIR filtered PCM data1 goes through multiplication based on MultiplierTable[]
 - ② The PCM data is right shifted based on ShiftTable[]
 - Gain function: $y_pcm[17:0] = (\text{MultiplierTable}[] \times \text{fir_pcm}[15:0]) \gg \text{ShiftTable}[]$
 - ③ The PCM data is clipped to a 16-bit value



¹ For destination, the PCM data is summed data (sum_pcm)

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Review TRM section 33.5.3.3 for additional details

The clip function is the same as the FIR clip function

Fade In Fade Out

- › Fade in is used at PCM stream start and should be programmed before the stream start
- › Fade out is used at PCM stream end and should be programmed on a stream end event
- › To ensure proper fade out, the source should only be deactivated after fade out is complete¹
 - Advantage: HW deactivation prevents throttling of mixer progress due to a faded out source
- › Fade in and fade out “in the middle” of a continuous PCM stream is possible
 - If the number of possible PCM streams is less than or equal to number of sources, all sources can be continuously enabled and deactivated with the same continuous PCM stream

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Review TRM section 33.5.3.1 for additional details

Review the [Fade Control](#) section for additional details about Fade In Fade Out

¹ Either SW or HW can deactivate the source

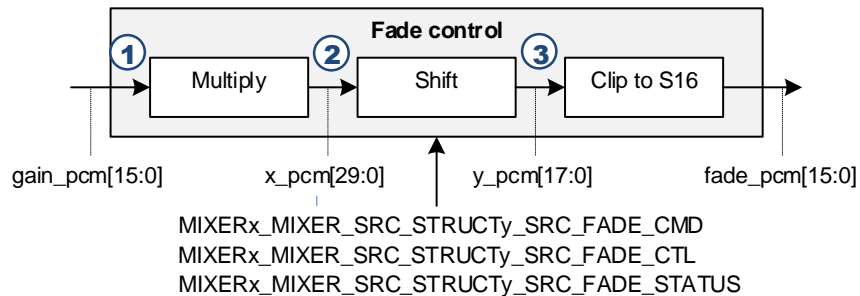
Fade Control

- > Provides the hardware-based volume control to create fade in and fade out effects
 - Fade in increments the fade control code to “115” (a gain of 0 dB)
 - Fade out decrements the fade control code to “0” (a gain of -infinity dB)
- > The scaling is specified by the fade control code `FADE_CTL.CODE` in the range [0, 115]
- > Operation
 - ① Gain-controlled PCM data goes through multiplication based on the `MultiplierTable[]`
 - ② The PCM data is right-shifted based on `ShiftTable[]`
 - ③ The PCM data is clipped to a 16-bit value

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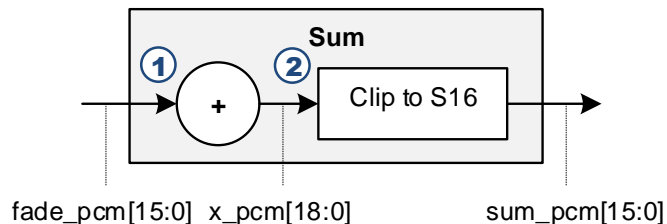
Review TRM section 33.5.3.4 for additional details

The fade function and the clip function are the same as the gain control functions



Mixing

- > Sums the PCM samples from all enabled sources¹
- > Operation
 - ① The PCM samples from all enabled sources are combined
 - ② The summed PCM samples are clipped to a 16-bit value



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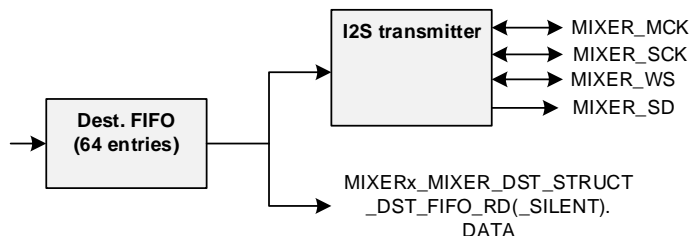
Review TRM section 33.5.3.5 for additional details

The clip function is the same as the FIR clip function

¹ Any enabled, deactivated source contributes PCM sample values of "0"

Destination Stream Options

- › Destination FIFO PCM samples are either written to memory or transmitted over an I2S interface



Mixer Destination Stream	DST_CTL.ENABLE D bit	TX_CTL.ENABLE D bit	Operation
Memory path	1	0	<ul style="list-style-type: none"> - Interrupt and/or trigger is activated when data is ready to be transferred out from the destination FIFO - Data transfer is handled by P-DMA or by CPU
I ² S transmitter	1	1	<ul style="list-style-type: none"> - No interrupt is generated - Mixer streams out on the I²S interface autonomously

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Review TRM section 33.5.3.6 for additional details



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Revision History

Revision	ECN	Submission Date	Description of Change
**	6630904	07/19/2019	Initial release
*A	6796198	02/04/2020	Added note descriptions in each slide
*B	7053115	12/21/2020	Updated page 2, 3, 5, 12