Customer Training Workshop
Traveo™ II Mixer

Q4 2020
# Target Products

- Target product list for this training material

<table>
<thead>
<tr>
<th>Family Category</th>
<th>Series</th>
<th>Code Flash Memory Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traveo™ II Automotive Cluster</td>
<td>CYT3DL</td>
<td>Up to 4160KB</td>
</tr>
<tr>
<td>Traveo™ II Automotive Cluster</td>
<td>CYT4DN</td>
<td>Up to 6336KB</td>
</tr>
</tbody>
</table>
Introduction for Traveo II Cluster

The Mixer is part of the Peripheral blocks

System Interconnect (Multi Layer AXI/AHB, IPC, MPU/SMPU)

CPU Subsystem

System Resources

Power
Sleep Control
DOP
LVD
PowerSVS-HT
LDO

Clock
Clock Control
PLL
PLL
DPLL

Reset
Reset Control
WRES

Test
TestMode Entry
Vector off
Analog off

I/O Subsystem
Peripheral Interconnect (MMIO, PPU)

Peripheral Interconnect (MMIO, PPU)

GFX Subsystem

GFX Interconnect (AXI)

GFX Subsystem

CPU Subsystem

System Interconnect (Multi Layer AXI/AHB, IPC, MPU/SMPU)

GFX Subsystem

2D Engine

2x SMIF
2x RGB/HD Out
1x RGB/HD In

ROM 64 KB
ARM Cortex-M0+
100 MHz

Flash 6336 KB Code
Flash + 128 KB Work Flash

SAR ADC
(12-bit)

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SAR ADC
(12-bit)
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

Hint Bar
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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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

Hint Bar

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 an 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 upscaled or downscaled using the scale function: \( y_{pcm}[22:0] = x_{pcm}[35:13] + x_{pcm}[12] \)

③ The upscaled or downscaled PCM data is clipped to a 16-bit value

Hint Bar

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

Hint Bar
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_STRUCTy_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: \( y_{\text{pcm}}[17:0] = (\text{MultiplierTable}[ ] \times \text{fir}_{\text{pcm}}[15:0]) >> \text{ShiftTable}[ ] \)
3. The PCM data is clipped to a 16-bit value

1 For destination, the PCM data is summed data (sum_pcm)
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 complete\(^1\)
  - 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

\(^1\) 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

![Fade control diagram](image)

Gain-controlled PCM data goes through multiplication based on the MultiplierTable, followed by right-shift and clipping to a 16-bit value.
Mixing

Sums the PCM samples from all enabled sources

Operation

1. The PCM samples from all enabled sources are combined
2. The summed PCM samples are clipped to a 16-bit value

The clip function is the same as the FIR clip function

Hint Bar

Review TRM section 33.5.3.5 for additional details

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

<table>
<thead>
<tr>
<th>Mixer Destination Stream</th>
<th>DST_CTL.ENABLE D bit</th>
<th>TX_CTL.ENABLE D bit</th>
<th>Operation</th>
</tr>
</thead>
</table>
| Memory path               | 1                     | 0                   | - 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  |
| I²S transmitter           | 1                     | 1                   | - No interrupt is generated  
- Mixer streams out on the I²S interface autonomously  |
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## Revision History

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