

Integration Manual

for S32K3XX I2S Driver

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Chapter 1

Revision History

Revision	Date	Author	Description
1.0	31.03.2023	NXP RTD Team	S32K3 Real-Time Drivers AUTOSAR 4.4 & R21-11 Version 3.0.0

Chapter 2

Introduction

- [Supported Derivatives](#)
- [Overview](#)
- [About This Manual](#)
- [Acronyms and Definitions](#)
- [Reference List](#)

This integration manual describes the integration requirements for the I2s Driver for S32K3XX microcontrollers.

Note: The Sai driver has been renamed to I2s starting with release RTD S32K3 Version 2.0.0. The API of the driver maintains the same functionality as previous releases. However, API names have been changed, beginning with the prefix "I2s_" instead of "Sai_". Existing application code should be updated to be in accordance with the new API naming.

2.1 Supported Derivatives

The software described in this document is intended to be used with the following microcontroller devices of NXP Semiconductors:

- s32k310_mqfp100
- s32k310_lqfp48
- s32k311_mqfp100 / MWCT2015S_mqfp100
- s32k311_lqfp48
- s32k312_mqfp100 / MWCT2016S_mqfp100
- s32k312_mqfp172 / MWCT2016S_mqfp172
- s32k314_mqfp172
- s32k314_mapbga257
- s32k322_mqfp100 / MWCT2D16S_mqfp100

- s32k322_mqfp172 / MWCT2D16S_mqfp172
- s32k324_mqfp172 / MWCT2D17S_mqfp172
- s32k324_mapbga257
- s32k341_mqfp100
- s32k341_mqfp172
- s32k342_mqfp100
- s32k342_mqfp172
- s32k344_mqfp172
- s32k344_mapbga257
- s32k394_mapbga289
- s32k396_mapbga289
- s32k358_mqfp172
- s32k358_mapbga289
- s32k328_mqfp172
- s32k328_mapbga289
- s32k338_mqfp172
- s32k338_mapbga289
- s32k348_mqfp172
- s32k348_mapbga289
- s32m274_lqfp64
- s32m276_lqfp64

All of the above microcontroller devices are collectively named as S32K3.

Note: MWCT part numbers contain NXP confidential IP for Qi Wireless Power.

2.2 Overview

AUTOSAR (AUTomotive Open System ARchitecture) is an industry partnership working to establish standards for software interfaces and software modules for automobile electronic control systems.

AUTOSAR:

- paves the way for innovative electronic systems that further improve performance, safety and environmental friendliness.
- is a strong global partnership that creates one common standard: "Cooperate on standards, compete on implementation".
- is a key enabling technology to manage the growing electrics/electronics complexity. It aims to be prepared for the upcoming technologies and to improve cost-efficiency without making any compromise with respect to quality.
- facilitates the exchange and update of software and hardware over the service life of the vehicle.

2.3 About This Manual

This Technical Reference employs the following typographical conventions:

- **Boldface** style: Used for important terms, notes and warnings.
- *Italic* style: Used for code snippets in the text. Note that C language modifiers such "const" or "volatile" are sometimes omitted to improve readability of the presented code.

Notes and warnings are shown as below:

Note

This is a note.

Warning

This is a warning

2.4 Acronyms and Definitions

Term	Definition
API	Application Programming Interface
ASM	Assembler
BSMI	Basic Software Make file Interface
CAN	Controller Area Network
C/CPP	C and C++ Source Code
CDD	Complex Device Driver
CS	Chip Select
CTU	Cross Trigger Unit
DEM	Diagnostic Event Manager
DET	Development Error Tracer
DMA	Direct Memory Access
ECU	Electronic Control Unit
FIFO	First In First Out
LSB	Least Significant Bit
MCU	Micro Controller Unit
MSB	Most Significant Bit
N/A	Not Applicable
RAM	Random Access Memory
I2S	Inter-IC Sound
SIU	Systems Integration Unit
SWS	Software Specification
XML	Extensible Markup Language

2.5 Reference List

#	Title	Version
1	S32K3XX Reference Manual	S32K3xx Reference Manual, Rev.6 Draft B, 01/2023
2	S32K396 Reference Manual	S32K39 and S32K37 Reference Manual, Rev. 2 Draft A, 11/2022
3	S32M27x Reference Manual	S32M27x Reference Manual, Rev.2, Draft A - 02/2023
4	S32K3XX Datasheet	S32K3xx Data Sheet, Rev. 6, Draft B. 01/2023
5	S32K396 Datasheet	S32K396 Data Sheet, Rev. 1.1, 08/2022
6	S32M2xx Datasheet	S32M2xx Data Sheet, Rev. 2 RC — 12/2022
7	S32K358 Errata	S32K358 Mask Set Errata for Mask 0P14E, Rev. 28, 9/2022
8	S32K311 Errata	S32K311 Mask Set Errata S32K311_0P98C, Rev. 6/March/2023, 3/2023
9	S32K396 Errata	SS32K396 Mask Set Errata for Mask 0P40E, Rev. DEC2022, 12/2022
10	S32K312 Errata	S32K312 Mask Set Errata for Mask 0P09C, Rev. 25/April/2022
11	S32K342 Errata	S32K342 Mask Set Errata for Mask 0P97C, Rev. 10 11/2022
12	S32K3x4 Errata	S32K3x4 Mask Set Errata for Mask 0P55A/1P55A, Rev. 14/Oct/2022

Chapter 3

Building the driver

- [Build Options](#)
- [Files required for compilation](#)
- [Setting up the plugins](#)

This section describes the source files and various compilers, linker options used for building the driver. It also explains the EB Tresos Studio plugin setup procedure.

3.1 Build Options

- [GCC Compiler/Assembler/Linker Options](#)
- [DIAB Compiler/Assembler/Linker Options](#)
- [GHS Compiler/Assembler/Linker Options](#)
- [IAR Compiler/Assembler/Linker Options](#)

The RTD driver files are compiled using:

- NXP GCC 10.2.0 20200723 (Build 1728 Revision g5963bc8)
- Wind River Diab Compiler 7.0.4
- Compiler Versions: Green Hills Multi 7.1.6d / Compiler 2021.1.4
- Compiler Versions: IAR ANSI C/C++ Compiler V8.50.10 (safety version)

The compiler, assembler, and linker flags used for building the driver are explained below.

The TS_T40D34M30I0R0 part of the plugin name is composed as follows:

- T = Target_Id (e.g. T40 identifies Cortex-M architecture)
- D = Derivative_Id (e.g. D34 identifies S32K3 platform)
- M = SW_Version_Major and SW_Version_Minor
- I = SW_Version_Patch
- R = Reserved

3.1.1 GCC Compiler/Assembler/Linker Options

3.1.1.1 GCC Compiler Options

Compiler Option	Description
-mcpu=cortex-m7	Targeted ARM processor for which GCC should tune the performance of the code
-mthumb	Generates code that executes in Thumb state
-mlittle-endian	Generate code for a processor running in little-endian mode
-mfpv=fpv5-sp-d16	Specifies the floating-point hardware available on the target
-mfloat-abi=hard	Specifies the floating-point ABI to use. "hard" allows generation of floating-point instructions and uses FPU-specific calling conventions
-std=c99	Specifies the ISO C99 base standard
-Os	Optimize for size. Enables all -O2 optimizations except those that often increase code size
-ggdb3	Produce debugging information for use by GDB using the most expressive format available, including GDB extensions if at all possible. Level 3 includes extra information, such as all the macro definitions present in the program
-Wall	Enables all the warnings about constructions that some users consider questionable, and that are easy to avoid (or modify to prevent the warning), even in conjunction with macros
-Wextra	This enables some extra warning flags that are not enabled by -Wall
-pedantic	Issue all the warnings demanded by strict ISO C. Reject all programs that use forbidden extensions. Follows the version of the ISO C standard specified by the aforementioned -std option
-Wstrict-prototypes	Warn if a function is declared or defined without specifying the argument types
-Wundef	Warn if an undefined identifier is evaluated in an #if directive. Such identifiers are replaced with zero
-Wunused	Warn whenever a function, variable, label, value, macro is unused
-Werror=implicit-function-declaration	Make the specified warning into an error. This option throws an error when a function is used before being declared
-Wsign-compare	Warn when a comparison between signed and unsigned values could produce an incorrect result when the signed value is converted to unsigned.
-Wdouble-promotion	Give a warning when a value of type float is implicitly promoted to double
-fno-short-enums	Specifies that the size of an enumeration type is at least 32 bits regardless of the size of the enumerator values.
-funsigned-char	Let the type char be unsigned by default, when the declaration does not use either signed or unsigned
-funsigned-bitfields	Let a bit-field be unsigned by default, when the declaration does not use either signed or unsigned

Compiler Option	Description
-fno-common	Makes the compiler place uninitialized global variables in the BSS section of the object file. This inhibits the merging of tentative definitions by the linker so you get a multiple-definition error if the same variable is accidentally defined in more than one compilation unit
-fstack-usage	This option is only used to build test for generation Ram/↔ Stack size report. Makes the compiler output stack usage information for the program, on a per-function basis
-fdump-ipa-all	This option is only used to build test for generation Ram/↔ Stack size report. Enables all inter-procedural analysis dumps
-c	Stop after assembly and produce an object file for each source file
-DS32K3XX	Predefine S32K3XX as a macro, with definition 1
-D \$ (DERIVATIVE)	Predefine S32K3's derivative as a macro, with definition 1. For example: Predefine for S32K344 will be -DS32K344.
-DGCC	Predefine GCC as a macro, with definition 1
-DUSE_SW_VECTOR_MODE	Predefine USE_SW_VECTOR_MODE as a macro, with definition 1. By default, the drivers are compiled to handle interrupts in Software Vector Mode
-DD_CACHE_ENABLE	Predefine D_CACHE_ENABLE as a macro, with definition 1. Enables data cache initialization in source file system.↔ c under the Platform driver
-DI_CACHE_ENABLE	Predefine I_CACHE_ENABLE as a macro, with definition 1. Enables instruction cache initialization in source file system.c under the Platform driver
-DENABLE_FPU	Predefine ENABLE_FPU as a macro, with definition 1. Enables FPU initialization in source file system.c under the Platform driver
-DMCAL_ENABLE_USER_MODE_SUPPORT	Predefine MCAL_ENABLE_USER_MODE_SUPPORT↔ RT as a macro, with definition 1. Allows drivers to be configured in user mode.
-sysroot=	Specifies the path to the sysroot, for Cortex-M7 it is /arm-none-eabi/newlib
-specs=nano.specs	Use Newlib nano specs
-specs=nosys.specs	Do not use printf/scanf

3.1.1.2 GCC Assembler Options

Assembler Option	Description
-Xassembler-with-cpp	Specifies the language for the following input files (rather than letting the compiler choose a default based on the file name suffix)
-mcpu=cortexm7	Targeted ARM processor for which GCC should tune the performance of the code
-mfpu=fpv5-sp-d16	Specifies the floating-point hardware available on the target
-mfloat-abi=hard	Specifies the floating-point ABI to use. "hard" allows generation of floating-point instructions and uses FPU-specific calling conventions
-mthumb	Generates code that executes in Thumb state

Assembler Option	Description
-c	Stop after assembly and produce an object file for each source file

3.1.1.3 GCC Linker Options

Linker Option	Description
-Wl,-Map,filename	Produces a map file
-T linkerfile	Use linkerfile as the linker script. This script replaces the default linker script (rather than adding to it)
-entry=Reset_Handler	Specifies that the program entry point is Reset_Handler
-nostartfiles	Do not use the standard system startup files when linking
-mcpu=cortexm7	Targeted ARM processor for which GCC should tune the performance of the code
-mthumb	Generates code that executes in Thumb state
-mfpv=fpv5-sp-d16	Specifies the floating-point hardware available on the target
-mfloat-abi=hard	Specifies the floating-point ABI to use. "hard" allows generation of floating-point instructions and uses FPU-specific calling conventions
-mlittle-endian	Generate code for a processor running in little-endian mode
-ggdb3	Produce debugging information for use by GDB using the most expressive format available, including GDB extensions if at all possible. Level 3 includes extra information, such as all the macro definitions present in the program
-lc	Link with the C library
-lm	Link with the Math library
-lgcc	Link with the GCC library
-specs=nano.specs	Use Newlib nano specs
-specs=nosys.specs	Do not use printf/scanf

3.1.2 DIAB Compiler/Assembler/Linker Options

3.1.2.1 DIAB Compiler Options

Compiler Option	Description
-tARMCORTEXM7MG:simple	Selects target processor (hardware single-precision, software double-precision floating-point)
-mthumb	Selects generating code that executes in Thumb state
-std=c99	Follows the C99 standard for C
-Oz	Like -O2 with further optimizations to reduce code size
-g	Generates DWARF 4.0 debug information
-fstandalone-debug	Emits full debug info for all types used by the program
-Wstrict-prototypes	Warn if a function is declared or defined without specifying the argument types
-Wsign-compare	Produce warnings when comparing signed type with unsigned type
-Wdouble-promotion	Give a warning when a value of type float is implicitly promoted to double

Compiler Option	Description
-Wunknown-pragmas	Issues a warning for unknown pragmas
-Wundef	Warns if an undefined identifier is evaluated in an <code>#if</code> directive. Such identifiers are replaced with zero
-Wextra	Enables some extra warning flags that are not enabled by '-Wall'
-Wall	Enables all of the most useful warnings (for historical reasons this option does not literally enable all warnings)
-pedantic	Emits a warning whenever the standard specified by the <code>-std</code> option requires a diagnostic
-Werror=implicit-function-declaration	Generates an error whenever a function is used before being declared
-fno-common	Compile common globals like normal definitions
-fno-signed-char	Char is unsigned
-fno-trigraphs	Do not process trigraph sequences
-V	Displays the current version number of the tool suite
-c	Stop after assembly and produce an object file for each source file
-DS32K3XX	Predefine S32K3XX as a macro, with definition 1
-D \$ (DERIVATIVE)	Predefine S32K3's derivative as a macro, with definition 1
-DDIAB	Predefine DIAB as a macro, with definition 1
-DUSE_SW_VECTOR_MODE	Predefine USE_SW_VECTOR_MODE as a macro, with definition 1. By default, the drivers are compiled to handle interrupts in Software Vector Mode
-DD_CACHE_ENABLE	Predefine D_CACHE_ENABLE as a macro, with definition 1. Enables data cache initialization in source file system.c under the Platform driver
-DI_CACHE_ENABLE	Predefine I_CACHE_ENABLE as a macro, with definition 1. Enables instruction cache initialization in source file system.c under the Platform driver
-DENABLE_FPU	Predefine ENABLE_FPU as a macro, with definition 1. Enables FPU initialization in source file system.c under the Platform driver
-DMCAL_ENABLE_USER_MODE_SUPPORT	Predefine MCAL_ENABLE_USER_MODE_SUPPORT as a macro, with definition 1. Allows drivers to be configured in user mode

3.1.2.2 DIAB Assembler Options

Assembler Option	Description
-mthumb	Selects generating code that executes in Thumb state
-Xpreprocess-assembly	Invokes C preprocessor on assembly files before running the assembler
-Xassembly-listing	Produces an .lst assembly listing file
-c	Stop after assembly and produce an object file for each source file
-tARMCORTEXM7MG:simple	Selects target processor (hardware single-precision, software double-precision floating-point)

3.1.2.3 DIAB Linker Options

Linker Option	Description
-e Reset_Handler	Make the symbol Reset_Handler be treated as a root symbol and the start label of the application
linker_script_file.dld	Use linker_script_file.dld as the linker script. This script replaces the default linker script (rather than adding to it)
-m30	m2 + m4 + m8 + m16
-Xstack-usage	Gathers and display stack usage at link time
-Xpreprocess-lecl	Perform pre-processing on linker scripts
-Llibrary_path	Points to the libraries location for ARMV7EMMG to be used for linking
-lc	Links with the standard C library
-lm	Links with the math library
-tARMCORTEXM7MG:simple	Selects target processor (hardware single-precision, software double-precision floating-point)

3.1.3 GHS Compiler/Assembler/Linker Options

3.1.3.1 GHS Compiler Options

Compiler Option	Description
-cpu=cortexm7	Selects target processor: Arm Cortex M7
-thumb	Selects generating code that executes in Thumb state
-fpu=vfpv5_d16	Specifies hardware floating-point using the v5 version of the VFP instruction set, with 16 double-precision floating-point registers
-fsingle	Use hardware single-precision, software double-precision FP instructions
-C99	Use (strict ISO) C99 standard (without extensions)
-ghstd=last	Use the most recent version of Green Hills Standard mode (which enables warnings and errors that enforce a stricter coding standard than regular C and C++)
-Osize	Optimize for size
-gnu_asm	Enables GNU extended asm syntax support
-dual_debug	Generate DWARF 2.0 debug information
-G	Generate debug information
-keeptempfiles	Prevents the deletion of temporary files after they are used. If an assembly language file is created by the compiler, this option will place it in the current directory instead of the temporary directory
-Wimplicit-int	Produce warnings if functions are assumed to return int
-Wshadow	Produce warnings if variables are shadowed
-Wtrigraphs	Produce warnings if trigraphs are detected
-Wundef	Produce a warning if undefined identifiers are used in #if preprocessor statements

Compiler Option	Description
-unsigned_chars	Let the type char be unsigned, like unsigned char
-unsigned_fields	Bitfields declared with an integer type are unsigned
-no_commons	Allocates uninitialized global variables to a section and initializes them to zero at program startup
-no_exceptions	Disables C++ support for exception handling
-no_slash_comment	C++ style // comments are not accepted and generate errors
-prototype_errors	Controls the treatment of functions referenced or called when no prototype has been provided
-incorrect_pragma_warnings	Controls the treatment of valid #pragma directives that use the wrong syntax
-c	Stop after assembly and produce an object file for each source file
-DS32K3XX	Predefine S32K3XX as a macro, with definition 1
-D \$ (DERIVATIVE)	Predefine S32K3's derivative as a macro, with definition 1. For example: Predefine for S32K344 will be -DS32K344.
-DGHS	Predefine GHS as a macro, with definition 1
-DUSE_SW_VECTOR_MODE	Predefine USE_SW_VECTOR_MODE as a macro, with definition 1. By default, the drivers are compiled to handle interrupts in Software Vector Mode
-DD_CACHE_ENABLE	Predefine D_CACHE_ENABLE as a macro, with definition 1. Enables data cache initialization in source file system.c under the Platform driver
-DI_CACHE_ENABLE	Predefine I_CACHE_ENABLE as a macro, with definition 1. Enables instruction cache initialization in source file system.c under the Platform driver
-DENABLE_FPU	Predefine ENABLE_FPU as a macro, with definition 1. Enables FPU initialization in source file system.c under the Platform driver
-DMCAL_ENABLE_USER_MODE_SUPPORT	Predefine MCAL_ENABLE_USER_MODE_SUPPORT as a macro, with definition 1. Allows drivers to be configured in user mode

3.1.3.2 GHS Assembler Options

Assembler Option	Description
-cpu=cortexm7	Selects target processor: Arm Cortex M7
-fpu=vfpv5_d16	Specifies hardware floating-point using the v5 version of the VFP instruction set, with 16 double-precision floating-point registers
-fsingle	Use hardware single-precision, software double-precision FP instructions
-preprocess_assembly_files	Controls whether assembly files with standard extensions such as .s and .asm are preprocessed
-list	Creates a listing by using the name and directory of the object file with the .lst extension
-c	Stop after assembly and produce an object file for each source file

3.1.3.3 GHS Linker Options

Linker Option	Description
-e Reset_Handler	Make the symbol Reset_Handler be treated as a root symbol and the start label of the application
-T linker_script_file.ld	Use linker_script_file.ld as the linker script. This script replaces the default linker script (rather than adding to it)
-map	Produce a map file
-keepmap	Controls the retention of the map file in the event of a link error
-Mn	Generates a listing of symbols sorted alphabetically/numerically by address
-delete	Instructs the linker to remove functions that are not referenced in the final executable. The linker iterates to find functions that do not have relocations pointing to them and eliminates them
-ignore_debug_references	Ignores relocations from DWARF debug sections when using -delete. DWARF debug information will contain references to deleted functions that may break some third-party debuggers
-Llibrary_path	Points to library_path (the libraries location) for thumb2 to be used for linking
-larch	Link architecture specific library
-lstartup	Link run-time environment startup routines. The source code for the modules in this library is provided in the src/libstartup directory
-lind_sd	Link language-independent library, containing support routines for features such as software floating point, run-time error checking, C99 complex numbers, and some general purpose routines of the ANSI C library
-v	Prints verbose information about the activities of the linker, including the libraries it searches to resolve undefined symbols
-keep=C40_Ip_AccessCode	Avoid linker remove function C40_Ip_AccessCode from Fls module because it is not referenced explicitly
-nostartfiles	Controls the start files to be linked into the executable

3.1.4 IAR Compiler/Assembler/Linker Options

3.1.4.1 IAR Compiler Options

Compiler Option	Description
-cpu Cortex-M7	Targeted ARM processor for which IAR should tune the performance of the code
-cpu_mode thumb	Generates code that executes in Thumb state
-endian little	Generate code for a processor running in little-endian mode
-fpu VFPv5-SP	Use this option to generate code that performs floating-point operations using a Floating Point Unit (FPU). Single-precision variant.
-e	Enables all IAR C language extensions
-Osz	Optimize for size. the compiler will emit AEABI attributes indicating the requested optimization goal. This information can be used by the linker to select smaller or faster variants of DLIB library functions
-debug	Makes the compiler include debugging information in the object modules. Including debug information will make the object files larger

Compiler Option	Description
-no_clustering	Disables static clustering optimizations. Static and global variables defined within the same module will not be arranged so that variables that are accessed in the same function are close to each other
-no_mem_idioms	Makes the compiler not optimize certain memory access patterns
-do_explicit_zero_opt_in_named_sections	Disable the exception for variables in user-named sections, and thus treat explicit initializations to zero as zero initializations, not copy initializations
-require_prototypes	Force the compiler to verify that all functions have proper prototypes. Generates an error otherwise
-no_wrap_diagnostics	Does not wrap long lines in diagnostic messages
-diag_suppress Pa050	Suppresses diagnostic message Pa050
-DS32K3XX	Predefine S32K3XX as a macro, with definition 1
-D \$ (DERIVATIVE)	Predefine S32K3's derivative as a macro, with definition 1. For example: Predefine for S32K344 will be -DS32K344.
-DIAR	Predefine IAR as a macro, with definition 1
-DUSE_SW_VECTOR_MODE	Predefine USE_SW_VECTOR_MODE as a macro, with definition 1. By default, the drivers are compiled to handle interrupts in Software Vector Mode.
-DD_CACHE_ENABLE	Predefine D_CACHE_ENABLE as a macro, with definition 1. Enables data cache initialization in source file system.c under the Platform driver
-DI_CACHE_ENABLE	Predefine I_CACHE_ENABLE as a macro, with definition 1. Enables instruction cache initialization in source file system.c under the Platform driver
-DENABLE_FPU	Predefine ENABLE_FPU as a macro, with definition 1. Enables FPU initialization in source file system.c under the Platform driver
-DMCAL_ENABLE_USER_MODE_SUPPORT	Predefine MCAL_ENABLE_USER_MODE_SUPPORT as a macro, with definition 1. Allows drivers to be configured in user mode.

3.1.4.2 IAR Assembler Options

Assembler Option	Description
-cpu Cortex-M7	Targeted ARM processor for which IAR should generate the instruction set
-fpu VFPv5-SP	Use this option to generate code that performs floating-point operations using a Floating Point Unit (FPU). Single-precision variant.
-cpu_mode thumb	Selects the thumb mode for the assembler directive CODE
-g	Disables the automatic search for system include files
-r	Generates debug information

3.1.4.3 IAR Linker Options

Linker Option	Description
-map filename	Produces a map file
-config linkerfile	Use linkerfile as the linker script. This script replaces the default linker script (rather than adding to it)
-cpu=Cortex-M7	Selects the ARM processor variant to link the application for
-fpu VFPv5-SP	Use this option to generate code that performs floating-point operations using a Floating Point Unit (FPU). Single-precision variant.
-entry _start	Treats _start as a root symbol and start label
-enable_stack_usage	Enables stack usage analysis. If a linker map file is produced, a stack usage chapter is included in the map file
-skip_dynamic_initialization	Dynamic initialization (typically initialization of C++ objects with static storage duration) will not be performed automatically during application startup
-no_wrap_diagnostics	Does not wrap long lines in diagnostic messages

3.2 Files required for compilation

This section describes the include files required to compile, assemble (if assembler code) and link the I2s driver for S32K3XX microcontrollers. To avoid integration of incompatible files, all the include files from other modules shall have the same AR_MAJOR_VERSION and AR_MINOR_VERSION, i.e. only files with the same AUTOSAR major and minor versions can be compiled.

3.2.0.0.1 I2s Driver Files:

- I2s_TS_T40D34M20I0R0\src\CDD_I2s.c
- I2s_TS_T40D34M20I0R0\src\Sai_Ip_Isr.c
- I2s_TS_T40D34M20I0R0\src\Sai_Ip.c
- I2s_TS_T40D34M20I0R0\src\Flexio_I2s_Ip.c
- I2s_TS_T40D34M20I0R0\src\I2s_Ipw.c
- I2s_TS_T40D34M20I0R0\include\CDD_I2s_Types.h
- I2s_TS_T40D34M20I0R0\include\CDD_I2s.h
- I2s_TS_T40D34M20I0R0\include\Sai_Ip_DeviceRegisters.h
- I2s_TS_T40D34M20I0R0\include\Flexio_I2s_Ip_DeviceRegisters.h
- I2s_TS_T40D34M20I0R0\include\Sai_Ip_FeatureDefines.h
- I2s_TS_T40D34M20I0R0\include\Flexio_I2s_Ip_FeatureDefines.h
- I2s_TS_T40D34M20I0R0\include\Sai_Ip_HwAccess.h
- I2s_TS_T40D34M20I0R0\include\Flexio_I2s_Ip_HwAccess.h
- I2s_TS_T40D34M20I0R0\include\Sai_Ip_Types.h
- I2s_TS_T40D34M20I0R0\include\Flexio_I2s_Ip_Types.h

- I2s_TS_T40D34M20I0R0\include\Sai_Ip.h
- I2s_TS_T40D34M20I0R0\include\Flexio_I2s_Ip.h
- I2s_TS_T40D34M20I0R0\include\Flexio_I2s_Ip_Irq.h
- I2s_TS_T40D34M20I0R0\include\I2s_Ipw_Types.h
- I2s_TS_T40D34M20I0R0\include\I2s_Ipw.h

3.2.0.0.2 I2s Driver Generated Files (must be generated by the user using a configuration tool):

- CDD_I2s_PBcfg.c
- I2s_Ipw_PBcfg.c
- Sai_Ip_PBcfg.c
- Flexio_I2s_Ip_PBcfg.c
- CDD_I2s_Cfg.h
- CDD_I2s_CfgDefines.h
- CDD_I2s_PBcfg.h
- Sai_Ip_Cfg.h
- Flexio_I2s_Ip_Cfg.h
- Sai_Ip_CfgDefines.h
- Flexio_I2s_CfgDefines.h
- Sai_Ip_PBcfg.h
- Flexio_I2s_Ip_PBcfg.h
- I2s_Ipw_Cfg.h
- I2s_Ipw_CfgDefines.h
- I2s_Ipw_PBcfg.h

3.2.0.0.3 Base Files:

- Base_TS_T40D34M20I0R0\include\Mcal.h
- Base_TS_T40D34M20I0R0\include\I2s_MemMap.h
- Base_TS_T40D34M20I0R0\include\Platform_Types.h
- Base_TS_T40D34M20I0R0\include\Soc_Ips.h
- Base_TS_T40D34M20I0R0\include\Std_Types.h
- Base_TS_T40D34M20I0R0\include\OsIf.h
- Base_TS_T40D34M20I0R0\generate_PC\include\modules.h

3.2.0.0.4 DET Files:

- Det_TS_T40D34M20I0R0\include\Det.h
- Det_TS_T40D34M20I0R0\src\Det.c

3.2.0.0.5 RTE Files:

- Rte_TS_T40D34M20I0R0\include\SchM_I2s.h
- Rte_TS_T40D34M20I0R0\src\SchM_I2s.c

3.2.0.0.6 OS Files:

- Os_TS_T40D34M20I0R0\src\Os_counter_api.c
- Os_TS_T40D34M20I0R0\include\Os.h
- Os_TS_T40D34M20I0R0\include\Os_counter_api.h
- Os_TS_T40D34M20I0R0\include\Os_counter_types.ah
- Os_TS_T40D34M20I0R0\include\Os_types_basic.h
- Os_TS_T40D34M20I0R0\include\Os_types_common_public.h
- Os_TS_T40D34M20I0R0\include\Os_types_public.h
- Os_TS_T40D34M20I0R0\include\Os_version.h
- Os_TS_T40D34M20I0R0\generate_PC\include\Os_cfg.h

3.2.0.0.7 Mcl Files:

- Mcl_TS_T40D34M20I0R0\include\CDD_Mcl.h
- Mcl_TS_T40D34M20I0R0\include\Mcl.h
- Mcl_TS_T40D34M20I0R0\include\Dma_Ip.h
- Mcl_TS_T40D34M20I0R0\include\Flexio_Mcl_Ip_HwAccess.h
- Mcl_TS_T40D34M20I0R0\include\Dma_Ip_Types.h
- Mcl_TS_T40D34M20I0R0\include\Mcl_EnvCfg.h

- Mcl_TS_T40D34M20I0R0\include\Mcl_Types.h
- Mcl_TS_T40D34M20I0R0\src\CDD_Mcl.c
- Mcl_TS_T40D34M20I0R0\src\Dma_Ip.c
- Mcl_TS_T40D34M20I0R0\src\Flexio_Mcl_Ip_HwAccess.c
- Mcl_TS_T40D34M20I0R0\src\Dma_Ip_Irq.c
- Mcl_TS_T40D34M20I0R0\generate_PC\src\CDD_Mcl_Cfg.c
- Mcl_TS_T40D34M20I0R0\generate_PB\src\CDD_Mcl_PBcfg.c

3.3 Setting up the plugins

The I2s driver was designed to be configured by using the EB Tresos Studio (version EB tresos Studio 27.1.0 or later.)

3.3.0.0.1 Location of various files inside the I2s module folder:

- VSMD (Vendor Specific Module Definition) file in EB Tresos Studio XDM format:
 - I2s_TS_T40D34M20I0R0\config\I2s.xdm
- VSMD (Vendor Specific Module Definition) file(s) in AUTOSAR compliant EPD format:
 - I2s_TS_T40D34M20I0R0\autosar\I2s_<subderivative_name>.epd
- Code Generation Templates for variant aware parameters:
 - I2s_TS_T40D34M20I0R0\generate_PB\src\CDD_I2s_<VariantName>_PBcfg.c
 - I2s_TS_T40D34M20I0R0\generate_PB\src\I2s_Ipw_<VariantName>_PBcfg.c
 - I2s_TS_T40D34M20I0R0\generate_PB\src\Sai_Ip_<VariantName>_PBcfg.c
 - I2s_TS_T40D34M20I0R0\generate_PB\src\Flexio_I2s_Ip_<VariantName>_PBcfg.c
 - I2s_TS_T40D34M20I0R0\generate_PB<VariantName>_PBcfg.h
 - I2s_TS_T40D34M20I0R0\generate_PB<VariantName>_PBcfg.h
 - I2s_TS_T40D34M20I0R0\generate_PB<VariantName>_PBcfg.h
 - I2s_TS_T40D34M20I0R0\generate_PB<VariantName>_PBcfg.h
- Code Generation Templates for parameters without variation points:
 - I2s_TS_T40D34M20I0R0\generate_PC\include\CDD_I2s_Cfg.h
 - I2s_TS_T40D34M20I0R0\generate_PC\include\CDD_I2s_CfgDefines.h
 - I2s_TS_T40D34M20I0R0\generate_PC\include\I2s_Ipw_Cfg.h
 - I2s_TS_T40D34M20I0R0\generate_PC\include\I2s_Ipw_CfgDefines.h
 - I2s_TS_T40D34M20I0R0\generate_PC\include\Sai_Ip_Cfg.h
 - I2s_TS_T40D34M20I0R0\generate_PC\include\Flexio_I2s_Ip_Cfg.h
 - I2s_TS_T40D34M20I0R0\generate_PC\include\Sai_Ip_CfgDefines.h
 - I2s_TS_T40D34M20I0R0\generate_PC\include\Flexio_I2s_Ip_CfgDefines.h

3.3.0.0.2 Steps to generate the configuration:

1. Copy the following module folders into the Tresos plugins folder:
 - Base_TS_T40D34M20I0R0
 - Det_TS_T40D34M20I0R0
 - EcuC_TS_T40D34M20I0R0
 - Rte_TS_T40D34M20I0R0
 - Resource_TS_T40D34M20I0R0
 - Mcu_TS_T40D34M20I0R0
 - Mcl_TS_T40D34M20I0R0
 - Os_TS_T40D34M20I0R0
 - Platform_TS_T40D34M20I0R0
 - I2s_TS_T40D34M20I0R0
2. Set the desired Tresos Output location folder for the generated sources and header files.
3. Use the EB Tresos Studio GUI to modify ECU configuration parameters values.
4. Generate the configuration files

Chapter 4

Function calls to module

- [Function Calls during Start-up](#)
- [Function Calls during Shutdown](#)
- [Function Calls during Wake-up](#)

4.1 Function Calls during Start-up

I2s shall be initialized during STARTUP phase of EcuM initialization. The API to be called for this is `I2s_Init()`. The MCU module should be initialized before the I2s is initialized.

4.2 Function Calls during Shutdown

None.

4.3 Function Calls during Wake-up

None.

Chapter 5

Module requirements

- Exclusive areas to be defined in BSW scheduler
- Exclusive areas are not available on this platform
- Peripheral Hardware Requirements
- ISR to configure within AutosarOS - dependencies
- ISR Macro
- Other AUTOSAR modules - dependencies
- Data Cache Restrictions
- User Mode support
- Multicore support

5.1 Exclusive areas to be defined in BSW scheduler

In the current implementation, I2S is using the services of Schedule Manager (SchM) for entering and exiting the exclusive areas. The following critical regions are used in the I2S driver:

Exclusive Areas are used in High level driver layer (HLD)

I2S_EXCLUSIVE_AREA_00 is used in function `I2s_SyncTransmit` to protect the registers from read/modify/write operation in `Sai_Ip_SetMaster`

I2S_EXCLUSIVE_AREA_00 is used in function `I2s_AsyncTransmit` to protect the registers from read/modify/write operation in `Sai_Ip_SetMaster`

I2S_EXCLUSIVE_AREA_01 is used in function `I2s_SyncTransmit` to protect the `Sai_Ip_apxTxState` variable from read/modify/write operation in `Sai_Ip_Send`

I2S_EXCLUSIVE_AREA_01 is used in function `I2s_AsyncTransmit` to protect the `Sai_Ip_apxTxState` variable from read/modify/write operation in `Sai_Ip_Send`

I2S_EXCLUSIVE_AREA_02 is used in function `I2s_SyncTransmit` to protect the TCSR register from read/modify/write operation in `Sai_Ip_Send`

I2S_EXCLUSIVE_AREA_02 is used in function `I2s_AsyncTransmit` to protect the TCSR register from read/modify/write operation in `Sai_Ip_Send`

I2S_EXCLUSIVE_AREA_03 is used in function `I2s_SyncTransmit` to protect the `Sai_Ip_apxTxState` variable from read/modify/write operation in `Sai_Ip_Send`

I2S_EXCLUSIVE_AREA_03 is used in function `I2s_AsyncTransmit` to protect the `Sai_Ip_apxTxState` variable from read/modify/write operation in `Sai_Ip_Send`

I2S_EXCLUSIVE_AREA_04 is used in function `I2s_SyncTransmit` to protect the RCSR register from read/modify/write operation in `Sai_Ip_Receive`

I2S_EXCLUSIVE_AREA_04 is used in function `I2s_AsyncTransmit` to protect the RCSR register from read/modify/write operation in `Sai_Ip_Receive`

I2S_EXCLUSIVE_AREA_06 is used in function `I2s_SyncTransmit` to protect the TCSR register from read/modify/write operation in `Sai_Ip_SendBlocking`

I2S_EXCLUSIVE_AREA_06 is used in function `I2s_AsyncTransmit` to protect the TCSR register from read/modify/write operation in `Sai_Ip_SendBlocking`

I2S_EXCLUSIVE_AREA_06 is used in function `I2s_AbortTransmit` to protect the TCSR register from read/modify/write operation in `Sai_Ip_AbortTransfer`

I2S_EXCLUSIVE_AREA_07 is used in function `I2s_SyncTransmit` to protect the RCSR register from read/modify/write operation in `Sai_Ip_Receive`

I2S_EXCLUSIVE_AREA_07 is used in function `I2s_AsyncTransmit` to protect the RCSR register from read/modify/write operation in `Sai_Ip_Receive`

I2S_EXCLUSIVE_AREA_08 is used in function `I2s_SyncTransmit` to protect the RCSR register from read/modify/write operation in `Sai_Ip_Receive`

I2S_EXCLUSIVE_AREA_08 is used in function `I2s_AsyncTransmit` to protect the RCSR register from read/modify/write operation in `Sai_Ip_Receive`

I2S_EXCLUSIVE_AREA_09 is used in function `I2s_SyncTransmit` to protect the RCSR register from read/modify/write operation in `Sai_Ip_Receive`

I2S_EXCLUSIVE_AREA_09 is used in function `I2s_AsyncTransmit` to protect the RCSR register from read/modify/write operation in `Sai_Ip_Receive`

I2S_EXCLUSIVE_AREA_12 is used in function `I2s_SyncTransmit` to protect the TCSR register from read/modify/write operation in `Sai_Ip_Send`

I2S_EXCLUSIVE_AREA_12 is used in function `I2s_AsyncTransmit` to protect the TCSR register from read/modify/write operation in `Sai_Ip_Send`

I2S_EXCLUSIVE_AREA_13 is used in function `I2s_SyncTransmit` to protect the TCSR register from read/modify/write operation in `Sai_Ip_Send`

Module requirements

I2S_EXCLUSIVE_AREA_13 is used in function `I2s_AsyncTransmit` to protect the TCSR register from read/modify/write operation in `Sai_Ip_Send`

I2S_EXCLUSIVE_AREA_15 is used in function `I2s_SyncTransmit` to protect the TCSR register from read/modify/write operation in `Sai_Ip_SendBlocking`

I2S_EXCLUSIVE_AREA_15 is used in function `I2s_AsyncTransmit` to protect the TCSR register from read/modify/write operation in `Sai_Ip_SendBlocking`

I2S_EXCLUSIVE_AREA_15 is used in function `I2s_AbortTransmit` to protect the TCSR register from read/modify/write operation in `Sai_Ip_AbortTransfer`

I2S_EXCLUSIVE_AREA_16 is used in function `I2s_SyncTransmit` to protect the RCSR register from read/modify/write operation in `Sai_Ip_SendBlocking`

I2S_EXCLUSIVE_AREA_16 is used in function `I2s_AsyncTransmit` to protect the RCSR register from read/modify/write operation in `Sai_Ip_SendBlocking`

I2S_EXCLUSIVE_AREA_16 is used in function `I2s_AbortTransmit` to protect the RCSR register from read/modify/write operation in `Sai_Ip_AbortTransfer`

I2S_EXCLUSIVE_AREA_17 is used in function `I2s_SyncTransmit` to protect the TCSR register from read/modify/write operation in `Sai_Ip_TxAutoDisableClock`

I2S_EXCLUSIVE_AREA_17 is used in function `I2s_AsyncTransmit` to protect the TCSR register from read/modify/write operation in `Sai_Ip_TxAutoDisableClock`

Exclusive Areas are used in Interrupt service request (ISR)

I2S_EXCLUSIVE_AREA_05 is used in function `Sai_0_Ip_DmaTxCompleteCallback` to protect the RCSR register from read/modify/write operation in `Sai_Ip_CompleteSendDataUsingDma`

I2S_EXCLUSIVE_AREA_05 is used in function `Sai_0_Ip_DmaTxErrorCallback` to protect the RCSR register from read/modify/write operation in `Sai_Ip_CompleteSendDataUsingDma`

I2S_EXCLUSIVE_AREA_05 is used in function `Sai_1_Ip_DmaTxCompleteCallback` to protect the RCSR register from read/modify/write operation in `Sai_Ip_CompleteSendDataUsingDma`

I2S_EXCLUSIVE_AREA_05 is used in function `Sai_1_Ip_DmaTxErrorCallback` to protect the RCSR register from read/modify/write operation in `Sai_Ip_CompleteSendDataUsingDma`

I2S_EXCLUSIVE_AREA_10 is used in function `Sai_0_Ip_DmaRxCompleteCallback` to protect the RCSR register from read/modify/write operation in `Sai_Ip_CompleteReceiveDataUsingDma`

I2S_EXCLUSIVE_AREA_10 is used in function `Sai_0_Ip_DmaRxErrorCallback` to protect the RCSR register from read/modify/write operation in `Sai_Ip_CompleteReceiveDataUsingDma`

I2S_EXCLUSIVE_AREA_10 is used in function `Sai_1_Ip_DmaRxCompleteCallback` to protect the RCSR register from read/modify/write operation in `Sai_Ip_CompleteReceiveDataUsingDma`

I2S_EXCLUSIVE_AREA_10 is used in function `Sai_1_Ip_DmaRxErrorCallback` to protect the RCSR register from read/modify/write operation in `Sai_Ip_CompleteReceiveDataUsingDma`

I2S_EXCLUSIVE_AREA_11 is used in function SAI0_IRQHandler to protect the RCSR register from read/modify/write operation in Sai_Ip_IRQHandler

I2S_EXCLUSIVE_AREA_11 is used in function SAI1_IRQHandler to protect the RCSR register from read/modify/write operation in Sai_Ip_IRQHandler

I2S_EXCLUSIVE_AREA_14 is used in function SAI0_IRQHandler to protect the TCSR register from read/modify/write operation in Sai_Ip_IRQHandler

I2S_EXCLUSIVE_AREA_14 is used in function SAI1_IRQHandler to protect the TCSR register from read/modify/write operation in Sai_Ip_IRQHandler

I2S_EXCLUSIVE_AREA_18 is used in function SAI0_IRQHandler to protect the updates for TCSR register from read/modify/write operation in Sai_Ip_IRQHandler

I2S_EXCLUSIVE_AREA_18 is used in function SAI1_IRQHandler to protect the updates for TCSR register from read/modify/write operation in Sai_Ip_IRQHandler

Exclusive Areas are implemented in Low level driver layer (IPL)

I2S_EXCLUSIVE_AREA_00 is used in function Sai_Ip_SetMaster to protect the updates for:

- TCSR register
- TCR2 register
- TCR4 register
- RCSR register
- RCR2 register
- RCR4 register

I2S_EXCLUSIVE_AREA_01 is used in function Sai_Ip_SendBlocking to protect the Sai_Ip_apxTxState variable from read/modify/write operation in Sai_Ip_SetMaster

I2S_EXCLUSIVE_AREA_01 is used in function Sai_Ip_Send to protect the updates for Sai_Ip_apxTxState variable

I2S_EXCLUSIVE_AREA_02 is used in function Sai_Ip_SendBlocking to protect the TCSR register from read/modify/write operation in Sai_Ip_Send

I2S_EXCLUSIVE_AREA_02 is used in function Sai_Ip_Send to protect the updates for TCSR register

I2S_EXCLUSIVE_AREA_03 is used in function Sai_Ip_SendBlocking to protect the Sai_Ip_apxTxState variable from read/modify/write operation in Sai_Ip_Send

I2S_EXCLUSIVE_AREA_03 is used in function Sai_Ip_Send to protect the updates for Sai_Ip_apxTxState variable

I2S_EXCLUSIVE_AREA_04 is used in function Sai_Ip_SendBlocking to protect the RCSR register from read/modify/write operation in Sai_Ip_Receive

Module requirements

I2S_EXCLUSIVE_AREA_04 is used in function Sai_Ip_Receive to protect the updates for RCSR register

I2S_EXCLUSIVE_AREA_05 is used in function Sai_Ip_CompleteSendDataUsingDma to protect the updates for TCSR register

I2S_EXCLUSIVE_AREA_06 is used in function Sai_Ip_SendBlocking to protect the updates for TCSR register

I2S_EXCLUSIVE_AREA_06 is used in function Sai_Ip_AbortTransfer to protect the updates for TCSR register

I2S_EXCLUSIVE_AREA_07 is used in function Sai_Ip_ReceiveBlocking to protect the RCSR register from read/modify/write operation in Sai_Ip_Receive

I2S_EXCLUSIVE_AREA_07 is used in function Sai_Ip_Receive to protect the updates for RCSR register

I2S_EXCLUSIVE_AREA_08 is used in function Sai_Ip_ReceiveBlocking to protect the RCSR register from read/modify/write operation in Sai_Ip_Receive

I2S_EXCLUSIVE_AREA_08 is used in function Sai_Ip_Receive to protect the updates for RCSR register

I2S_EXCLUSIVE_AREA_09 is used in function Sai_Ip_ReceiveBlocking to protect the RCSR register from read/modify/write operation in Sai_Ip_Receive

I2S_EXCLUSIVE_AREA_09 is used in function Sai_Ip_Receive to protect the updates for RCSR register

I2S_EXCLUSIVE_AREA_10 is used in function Sai_Ip_CompleteReceiveDataUsingDma to protect the updates for RCSR register

I2S_EXCLUSIVE_AREA_11 is used in function Sai_Ip_IRQHandler to protect the updates for RCSR register

I2S_EXCLUSIVE_AREA_12 is used in function Sai_Ip_SendBlocking to protect the TCSR register from read/modify/write operation in Sai_Ip_Send

I2S_EXCLUSIVE_AREA_12 is used in function Sai_Ip_Send to protect the updates for TCSR register

I2S_EXCLUSIVE_AREA_13 is used in function Sai_Ip_SendBlocking to protect the TCSR register from read/modify/write operation in Sai_Ip_Send

I2S_EXCLUSIVE_AREA_13 is used in function Sai_Ip_Send to protect the updates for TCSR register

I2S_EXCLUSIVE_AREA_14 is used in function Sai_Ip_IRQHandler to protect the updates for TCSR register

I2S_EXCLUSIVE_AREA_15 is used in function Sai_Ip_SendBlocking to protect the updates for TCSR register

I2S_EXCLUSIVE_AREA_15 is used in function Sai_Ip_AbortTransfer to protect the updates for TCSR register

I2S_EXCLUSIVE_AREA_16 is used in function Sai_Ip_ReceiveBlocking to protect the updates for RCSR register

I2S_EXCLUSIVE_AREA_16 is used in function Sai_Ip_AbortTransfer to protect the updates for RCSR register

I2S_EXCLUSIVE_AREA_17 is used in function Sai_Ip_TxAutoDisableClock to protect the updates for TCSR register

I2S_EXCLUSIVE_AREA_18 is used in function Sai_Ip_IRQHandler to protect the updates for TCSR register

Critical Region Exclusive Matrix

Below is the table depicting the exclusivity between different critical region IDs from the I2S driver. If there is an **✕** in the table, it means that those 2 critical regions cannot interrupt each other.

Exclusive Area Matrix																			
Exclusive Area ID	I2S_EXCLUSIVE_AREA_00	I2S_EXCLUSIVE_AREA_01	I2S_EXCLUSIVE_AREA_02	I2S_EXCLUSIVE_AREA_03	I2S_EXCLUSIVE_AREA_04	I2S_EXCLUSIVE_AREA_05	I2S_EXCLUSIVE_AREA_06	I2S_EXCLUSIVE_AREA_07	I2S_EXCLUSIVE_AREA_08	I2S_EXCLUSIVE_AREA_09	I2S_EXCLUSIVE_AREA_10	I2S_EXCLUSIVE_AREA_11	I2S_EXCLUSIVE_AREA_12	I2S_EXCLUSIVE_AREA_13	I2S_EXCLUSIVE_AREA_14	I2S_EXCLUSIVE_AREA_15	I2S_EXCLUSIVE_AREA_16	I2S_EXCLUSIVE_AREA_17	I2S_EXCLUSIVE_AREA_18
	x		x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
		x																	
	x		x			x	x						x	x				x	
				x															
	x				x			x	x	x	x	x					x		
	x		x				x	x						x	x			x	x
	x						x	x	x	x	x	x							
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5.2 Exclusive areas are not available on this platform

None.

5.3 Peripheral Hardware Requirements

None.

5.4 ISR to configure within AutosarOS - dependencies

The following ISR's are used by the I2s driver: Table with Interrupt Service Routines used:

ISR Name	HW INT Vector	Observations
ISR(SAI0_IRQHandler)	174	Tx/Rx interrupt handler, SAI HW unit 0, not support S32↔K312
ISR(SAI1_IRQHandler)	175	TX/Rx interrupt handler, SAI HW unit 1, not support S32↔K312
ISR(MCL_FLEXIO_ISR)	139	Flexio interrupt handler

If DMA transfer mode is used, MCL DMA channel ISR routines should be used for each DMA channel. It depends on the MCL configuration. In this case, I2s_x_Ip_DmaTxCompleteCallback/I2s_x_Ip_DmaRxCompleteCallback

Module requirements

function should be configured for DMA notification parameter. This is required to update I2s driver internal statuses. The following functions should be configured for DMA notification parameter:

Function Name	Observations
Sai_0_Ip_DmaTxCompleteCallback	DMA notification parameter for send data complete, SAI HW unit 0, not support S32K312
Sai_0_Ip_DmaRxCompleteCallback	DMA notification parameter for receive data complete, SAI HW unit 0, not support S32K312
Sai_0_Ip_DmaTxErrorCallback	DMA notification parameter for send data error, SAI HW unit 0, not support S32K312
Sai_0_Ip_DmaRxErrorCallback	DMA notification parameter for receive data error, SAI HW unit 0, not support S32K312
Sai_1_Ip_DmaTxCompleteCallback	DMA notification parameter for send data complete, SAI HW unit 1, not support S32K312
Sai_1_Ip_DmaRxCompleteCallback	DMA notification parameter for receive data complete, SAI HW unit 1, not support S32K312
Sai_1_Ip_DmaTxErrorCallback	DMA notification parameter for send data error, SAI HW unit 1, not support S32K312
Sai_1_Ip_DmaRxErrorCallback	DMA notification parameter for receive data error, SAI HW unit 1, not support S32K312
FlexIO_I2s_Ip_DmaTxTransferCompleteShifter0	DMA notification parameter for send data complete
FlexIO_I2s_Ip_DmaTxTransferCompleteShifter1	DMA notification parameter for send data complete
FlexIO_I2s_Ip_DmaTxTransferCompleteShifter2	DMA notification parameter for send data complete
FlexIO_I2s_Ip_DmaTxTransferCompleteShifter3	DMA notification parameter for send data complete
FlexIO_I2s_Ip_DmaTxTransferCompleteShifter4	DMA notification parameter for send data complete
FlexIO_I2s_Ip_DmaTxTransferCompleteShifter5	DMA notification parameter for send data complete
FlexIO_I2s_Ip_DmaTxTransferCompleteShifter6	DMA notification parameter for send data complete
FlexIO_I2s_Ip_DmaRxTransferCompleteShifter1	DMA notification parameter for receive data complete
FlexIO_I2s_Ip_DmaRxTransferCompleteShifter2	DMA notification parameter for receive data complete
FlexIO_I2s_Ip_DmaRxTransferCompleteShifter3	DMA notification parameter for receive data complete
FlexIO_I2s_Ip_DmaRxTransferCompleteShifter4	DMA notification parameter for receive data complete
FlexIO_I2s_Ip_DmaRxTransferCompleteShifter5	DMA notification parameter for receive data complete
FlexIO_I2s_Ip_DmaRxTransferCompleteShifter6	DMA notification parameter for receive data complete
FlexIO_I2s_Ip_DmaRxTransferCompleteShifter7	DMA notification parameter for receive data complete

5.5 ISR Macro

RTD drivers use the ISR macro to define the functions that will process hardware interrupts. Depending on whether the OS is used or not, this macro can have different definitions.

5.5.1 Without an Operating System

The macro `USING_OS_AUTOSAROS` must not be defined.

5.5.1.1 Using Software Vector Mode

The macro `USE_SW_VECTOR_MODE` must be defined and the ISR macro is defined as:

```
#define ISR(IsrName) void IsrName(void)
```

In this case, the drivers' interrupt handlers are normal C functions and their prologue/epilogue will handle the context save and restore.

5.5.1.2 Using Hardware Vector Mode

The macro `USE_SW_VECTOR_MODE` must not be defined and the ISR macro is defined as:

```
#define ISR(IsrName) INTERRUPT_FUNC void IsrName(void)
```

In this case, the drivers' interrupt handlers must also handle the context save and restore.

5.5.2 With an Operating System Please refer to your OS documentation for description of the ISR macro.

5.6 Other AUTOSAR modules - dependencies

- **BASE:** The BASE module contains the common files/definitions needed by all MCAL modules.
- **DET:** The DET module is used for enabling Development error detection. The API function used is `Det_ReportError()`. The activation / deactivation of Development error detection is configurable using the 'I2sDevErrorDetect' configuration parameter.
- **ECUC:** The ECUC module is used for ECU configuration. MCAL modules need ECUC to retrieve the variant information.
- **MCU:** The MCU driver provides services for basic microcontroller initialization, power down functionality, reset and microcontroller specific functions required by other MCAL software modules. The clocks need to be initialized prior to using the I2s driver.
- **MCL Module** is needed by DMA transfer functions and provide resources for `Flexio_I2s`.
- **DEM:** The DEM module is needed by MCU and MCL modules which are dependencies for I2s.
- **RESOURCE** Resource module is used to select microcontroller's derivatives.

Current driver has support for the following derivatives, everyone having attached a Resource file: `S32K311_mqfp100`, `S32K311_lqfp48`, `S32K358_172mqfp`, `S32K358_289bga`, `S32K396_mapbga289`.

- **RTE** The RTE module is needed for implementing data consistency of exclusive areas that are used by I2s module.

5.7 Data Cache Restrictions

In the DMA transfer mode, DMA transfers may issue cache coherency problems. To avoid possible coherency issues when D-CACHE is enabled, the user shall ensure that the buffers used as TCD source and destination are allocated in the NON-CACHEABLE area (by means of `I2s_Memmap`).

5.8 User Mode support

- [User Mode configuration in the module](#)
- [User Mode configuration in AutosarOS](#)

5.8.1 User Mode configuration in the module

No special measures need to be taken to run I2S module from user mode. The I2S driver code can be executed at any time from both supervisor and user mode.

5.8.2 User Mode configuration in AutosarOS

When User mode is enabled, the driver may have the functions that need to be called as trusted functions in AutosarOS context. Those functions are already defined in driver and declared in the header `<IpName>_Ip↔_TrustedFunctions.h`. This header also included all headers files that contains all types definition used by parameters or return types of those functions. Refer the chapter [User Mode configuration in the module](#) for more detail about those functions and the name of header files they are declared inside. Those functions will be called indirectly with the naming convention below in order to AutosarOS can call them as trusted functions.

```
Call_<Function_Name>_TRUSTED(parameter1,parameter2,...)
```

That is the result of macro expansion `OsIf_Trusted_Call` in driver code:

```
#define OsIf_Trusted_Call[1-6params](name,param1,...,param6) Call_##name##_TRUSTED(param1,...,param6)
```

So, the following steps need to be done in AutosarOS:

- Ensure `MCAL_ENABLE_USER_MODE_SUPPORT` macro is defined in the build system or somewhere global.
- Define and declare all functions that need to call as trusted functions follow the naming convention above in Integration/User code. They need to be visible in `Os.h` for the driver to call them. They will do the marshalling of the parameters and call `CallTrustedFunction()` in OS specific manner.
- `CallTrustedFunction()` will switch to privileged mode and call `TRUSTED_<Function_Name>()`.
- `TRUSTED_<Function_Name>()` function is also defined and declared in Integration/User code. It will un-marshalling of the parameters to call `<Function_Name>()` of driver. The `<Function_Name>()` functions are already defined in driver and declared in `<IpName>_Ip_TrustedFunctions.h`. This header should be included in OS for OS call and indexing these functions.

See the sequence chart below for an example calling `Linflexd_Uart_Ip_Init_Privileged()` as a trusted function.

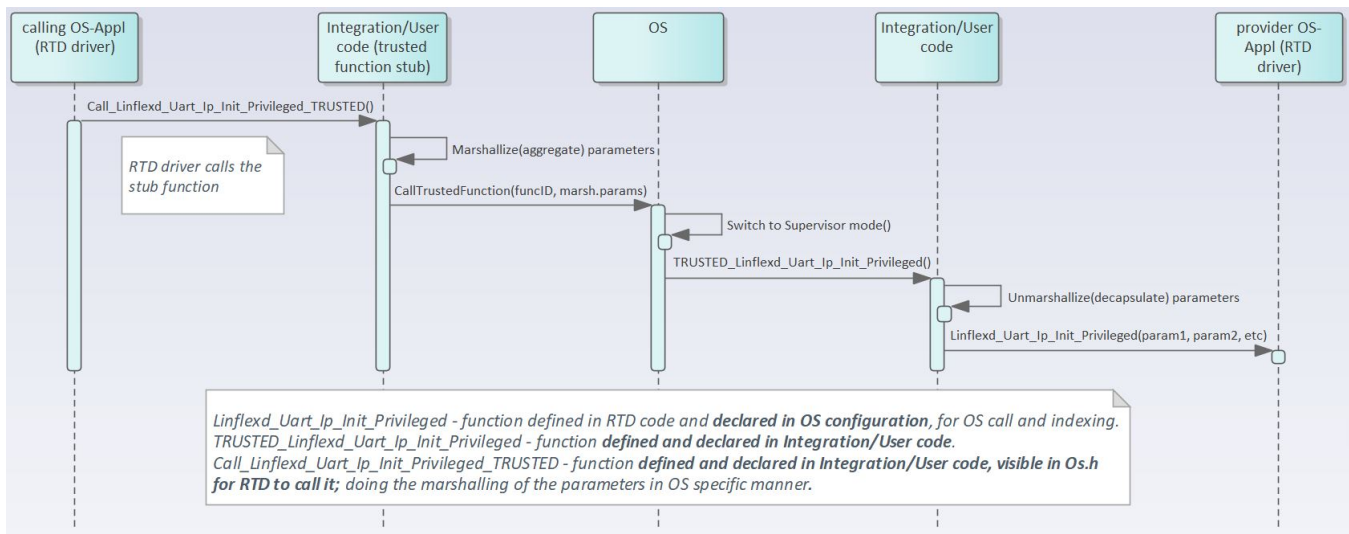


Figure 5.1 Example sequence chart for calling `Linflexd_Uart_Ip_Init_Privileged` as trusted function

5.9 Multicore support

The **I2s** implements the "Autosar 4.4 MCAL Multicore Distribution" according to type II, in which the mappable element is set to channel. For additional details, please refer to **AUTOSAR_EXP_BSWDistributionGuide**. The **I2s** and the mappable elements can only be allocated one ECUC partitions, by means of "I2sEcucPartitionRef". If there is only one instance of **I2s** is used, the **I2s** behavior reverts to single-core implementation, similar to previous Autosar versions. If the number of **I2s** is more than one, the **I2s** enforces the following multicore assumptions:

1. The **I2s** assumes there is a single EcucPartition allocated per core. Internally, the module will use the Core ID returned by GetCoreID API to reference the appropriate global data and configuration elements.
2. The **I2s** assumes the EcucCoreIDs are defined in a compact/consecutive order, starting from zero. The rationale is that the number of EcucPartitions is used for dimensioning the **I2s** internal variables and the EcucCoreIDs are used for indexing those variables.
3. The **I2s** assumes that initialization is performed on each core, `I2s_Init()` is called separately for each core, using a different configuration structure. (Type II).
4. The **I2s** initialization expects the upper layer will pass the correct initialization pointer, specific to the partition in which the driver is to be used. For example: `EcucPartition_1` is assigned to CoreID 1; `I2s_Init` function will be called with configuration structure `init`, on Core 1.
5. The **I2s** will check upon each API call if the requested resource is configured to be available on the current core, if DET error reporting is enabled.
6. The **I2s** assumes that RTE module implements the EXCLUSIVE AREAS to be coreaware only. The rationale is that the module implementation ensures data integrity by separating the mappable elements for different cores already, thus implementing the EXCLUSIVE AREAS in a blocking manner (ex: spin-lock) on a multicore scope, might affect the performance of the drivers on the two cores, although they might access separate HW elements. For single-core scope, the EXCLUSIVE AREAS keep the same purpose as on previous AUTOSAR implementations. (to be updated per **I2s** usecase, to be detailed/removed if some modules require such kind of functionality for critical features which cannot be atomically shared among cores).
7. The **I2s** assumes that each interrupt is routed by the system only to the core on which is supposed to be serviced.

Chapter 6

Main API Requirements

- [Main function calls within BSW scheduler](#)
- [API Requirements](#)
- [Calls to Notification Functions, Callbacks, Callouts](#)

6.1 Main function calls within BSW scheduler

None.

6.2 API Requirements

None.

6.3 Calls to Notification Functions, Callbacks, Callouts

Call-back Notifications: The I2S Driver provides a notification that is called when transfer complete or selected events occurred. The notifications can be configured as pointers to user defined functions. If notification is not desired, NULL_PTR shall be configured.

The examples of the syntax of this function are as follows:

For I2s over SAI: void I2s_TransmitterNotification(Sai_Ip_ReportType event)

For I2s over Flexio: void I2s_MasterNotification(Flexio_I2s_Ip_EventType Event, void *UserData);

The function has to be implemented by the user.

Chapter 7

Memory allocation

- [Sections to be defined in I2s_MemMap.h](#)
- [Linker command file](#)

7.1 Sections to be defined in I2s_MemMap.h

Section name	Type of section	Description
I2S_START_SEC_CONST_8	Configuration Data	Start of Memory Section for Config Data
I2S_STOP_SEC_CONST_8	Configuration Data	End of Memory Section for Config Data.
I2S_START_SEC_CONST_32	Configuration Data	Start of Memory Section for Config Data.
I2S_STOP_SEC_CONST_32	Configuration Data	End of Memory Section for Config Data.
I2S_START_SEC_CONST_UNSPECIFIED	Configuration Data	Start of Memory Section for Config Data.
I2S_STOP_SEC_CONST_UNSPECIFIED	Configuration Data	End of Memory Section for Config Data.
I2S_START_SEC_CONFIG_DATA_UNSPECIFIED	Configuration Data	Start of Memory Section for Config Data.
I2S_STOP_SEC_CONFIG_DATA_UNSPECIFIED	Configuration Data	End of Memory Section for Config Data.
I2S_START_SEC_CODE	Code	Start of memory Section for Code in flash.
I2S_STOP_SEC_CODE	Code	Stop of memory Section for Code in flash.
I2S_START_SEC_RAMCODE	Code	Start of memory Section for Code in ram.
I2S_STOP_SEC_RAMCODE	Code	Stop of memory Section for Code in ram.
I2S_START_SEC_VAR_INIT_UNSPECIFIED	Variables	Used for variables, structures, arrays, when the SIZE (alignment) does not fit the criteria of 8,16 or 32 bit. These variables are initialized with values after every reset
I2S_STOP_SEC_VAR_INIT_UNSPECIFIED	Variables	End of above section.
I2S_START_SEC_VAR_INIT_16	Variables	Used for variables which have to be aligned to 16 bit. For instance used for variables of size 16 bit or used for composite data types: arrays, structs containing elements of maximum 16 bits. These variables are initialized with values after every reset

Memory allocation

Section name	Type of section	Description
I2S_STOP_SEC_VAR_INIT_16	Variables	End of above section.
I2S_START_SEC_VAR_INIT_32	Variables	Used for variables which have to be aligned to 32 bit. For instance used for variables of size 32 bit or used for composite data types: arrays, structs containing elements of maximum 32 bits. These variables are initialized with values after every reset
I2S_STOP_SEC_VAR_INIT_32	Variables	End of above section.
I2S_START_SEC_VAR_CLEARED_↔ UNSPECIFIED	Variables	Used for variables, structures, arrays when the SIZE (alignment) does not fit the criteria of 8,16 or 32 bit. These variables are cleared to zero by start-up code (BBS).
I2S_STOP_SEC_VAR_CLEARED_↔ UNSPECIFIED	Variables	End of above section.

7.2 Linker command file

Memory shall be allocated for every section defined in the driver's "<Module>_MemMap.h.

Chapter 8

Integration Steps

This section gives a brief overview of the steps needed for integrating this module:

1. Generate the required module configuration(s). For more details refer to section [Files Required for Compilation](#)
2. Allocate the proper memory sections in the driver's memory map header file ("`<Module>_MemMap.h`") and linker command file. For more details refer to section [Sections to be defined in `<Module>_MemMap.h`](#)
3. Compile & build the module with all the dependent modules. For more details refer to section [Building the Driver](#)

Chapter 9

External assumptions for driver

The section presents requirements that must be complied with when integrating the I2S driver into the application.

External Assumption Req ID	External Assumption Text
EA_RTD_00071	If interrupts are locked, a centralized function pair to lock and unlock interrupts shall be used.
EA_RTD_00081	The integrator shall assure that <MSN>_Init() and <MSN>_DeInit() functions do not interrupt each other.
EA_RTD_00082	When caches are enabled and data buffers are allocated in cacheable memory regions the buffers involved in DMA transfer shall be aligned with both start and end to cache line size. Note: Rationale: This ensures that no other buffers/variables compete for the same cache lines.
EA_RTD_00092	The integrator shall allocate a single EcucPartition per core or the partition in which the I2s is allocated shall be exclusively mapped to a core. Note: Internally, the I2s will use the Core ID returned by GetCoreID API to reference the appropriate global data and configuration elements, that is why a core should reference only one configured partition.
EA_RTD_00093	The application shall define EcucCoreIDs in a compact/consecutive order, starting from zero.
EA_RTD_00094	When multicore support is enabled, the application shall call I2s_Init() for each core, using the dedicated configuration pointer for that core.
EA_RTD_00096	The application shall pass the correct initialization pointer, specific to the partition in which the driver is to be used.
EA_RTD_00106	Standalone IP configuration and HL configuration of the same driver shall be done in the same project
EA_RTD_00107	The integrator shall use the IP interface only for hardware resources that were configured for standalone IP usage. Note: The integrator shall not directly use the IP interface for hardware resources that were allocated to be used in HL context.
EA_RTD_00108	The integrator shall use the IP interface to build a CDD, therefore the BSWMD will not contain reference to the IP interface
EA_RTD_00113	When RTD drivers are integrated with AutosarOS and User mode support is enabled, the integrator shall assure that the definition and declaration of all RTD functions needed to be called as trusted functions follow the naming convention Call<Function_Name>TRUSTED(parameter1,parameter2,...) in Integration/User code. They need to be visible in Os.h for the driver to call them. They will call RTD <Function_Name>() as trusted functions in OS specific manner.

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