Integration Manual

for S32K3 DIO Driver

Document Number: IM34DIOASRR21-11 Rev0000R3.0.0 Rev. 1.0

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

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

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
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 Signifigant Bit
MCU	Micro Controller Unit
MIDE	Multi Integrated Development Environment
MSB	Most Significant Bit
N/A	Not Applicable
RAM	Random Access Memory
SIU	Systems Integration Unit
SWS	Software Specification
VLE	Variable Length Encoding
XML	Extensible Markup Language

2.5 Reference List

#	Title	Version
1	Specification of Dio Driver	AUTOSAR Release R21-11
2	Reference Manual	S32K3xx Reference Manual, Rev.6, Draft B, 01/2023
		S32K39 and S32K37 Reference Manual, Rev. 2 Draft A, 11/2022
		S32M27x Reference Manual, Rev.2, Draft A, — 02/2023
3	Datasheet	S32K3xx Data Sheet, Rev. 6, 11/2022
		S32K396 Data Sheet, Rev. 1.1 — 08/2022
		S32M2xx Data Sheet, Rev. 2 RC — 12/2022
4	Errata	S32K358_0P14E Mask Set Errata – Rev. 28, 9/2022
		S32K396_0P40E Mask Set Errata, Rev. DEC2022, 12/2022
		S32K311_0P98C Mask Set Errata, Rev. 6/March/2023, 3/2023
		S32K312: Mask Set Errata for Mask 0P09C, Rev. 25/April/2022
		S32K342: Mask Set Errata for Mask 0P97C, Rev. 10, 11/2022
		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
-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
-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 aforementioend -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 initalization 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 initalization in source file system.c under the Platform driver
-DENABLE_FPU	Predefine ENABLE_FPU as a macro, with definition 1. Enables FPU initalization in source file system.c under the Platform driver
-DMCAL_ENABLE_USER_MODE_SUPPORT	Predefine MCAL_ENABLE_USER_MODE_SUPPO↩ 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
-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
-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 #if 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 -std 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 initalization 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 initalization in source file system.c under the Platform driver
-DENABLE_FPU	Predefine ENABLE_FPU as a macro, with definition 1. Enables FPU initalization in source file system.c under the Platform driver
-DMCAL_ENABLE_USER_MODE_SUPPORT	Predefine MCAL_ENABLE_USER_MODE_SUPPO↩ RT 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	Bitfelds 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 andgenerate 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 initalization 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 initalization in source file system.c under the Platform driver
-DENABLE_FPU	Predefine ENABLE_FPU as a macro, with definition 1. Enables FPU initalization in source file system.c under the Platform driver
-DMCAL_ENABLE_USER_MODE_SUPPORT	Predefine MCAL_ENABLE_USER_MODE_SUPPO↩ RT 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. DWA↩ RF 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 themodules 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
-Ohz	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 initalization 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 initalization in source file system.c under the Platform driver
-DENABLE_FPU	Predefine ENABLE_FPU as a macro, with definition 1. Enables FPU initalization in source file system.c under the Platform driver
-DMCAL_ENABLE_USER_MODE_SUPPORT	Predefine MCAL_ENABLE_USER_MODE_SUPPO↩ RT 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 DIO 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.

Dio Files

- ..\Dio_TS_T40D34M30I0R0\include\Dio.h
- ..\Dio_TS_T40D34M30I0R0\include\Dio_Ipw.h
- ..\Dio_TS_T40D34M30I0R0\include\Siul2_Dio_Ip.h
- ..\Dio_TS_T40D34M30I0R0\include\Dio.c
- ..\Dio_TS_T40D34M30I0R0\include\Dio_Ipw.c
- ..\Dio_TS_T40D34M30I0R0\include\Siul2_Dio_Ip.c

Dio Generated Files

- Dio_Cfg.c - This file should be generated by the user using a configuration tool for compilation.
- Dio_Cfg.h - This file should be generated by the user using a configuration tool for compilation.
- Siul2_Dio_Ip_Cfg.h - This file should be generated by the user using a configuration tool for compilation.

As a deviation from standard:

- Dio_Cfg.c - This file will contain the definition for all configuration structures containing only variables that are not variant aware, configured and generated only once. This file alone does not contain the whole structure needed by Port_Init function to configure the driver. Based on the number of variants configured in the EcuC, there can be more than one configuration structure for one module even for PreCompile variant.

Files from Base common folder

- ..\BaseNXP_TS_T40D34M30I0R0\include\
- ..\BaseNXP_TS_T40D34M30I0R0\header\
- ..\BaseNXP_TS_T40D34M30I0R0\src\OsIf_Timer.c
- ..\BaseNXP_TS_T40D34M30I0R0\src\OsIf_Timer_System.c

Files from Det folder:

- ..\Det_ TS_T40D34M30I0R0\include\Det.h
- ..\Det_ TS_T40D34M30I0R0\src\Det.c

Files from Rte folder:

- ..\Rte_TS_T40D34M30I0R0\include\SchM_Dio.h
- ..\Rte_TS_T40D34M30I0R0\src\SchM_Dio.c

Files from Os folder:

- ..\Os_TS_T40D34M30I0R0\include\Os.h

3.3 Setting up the plugins

The DIO driver was designed to be configured by using the EB Tresos Studio (version EB tresos Studio 29.0.0 or later.)

Location of various files inside the DIO module folder:

- VSMD (Vendor Specific Module Definition) file in EB tresos Studio XDM format:
  - ..\Dio_TS_T40D34M30I0R0\config\Dio.xdm
- VSMD (Vendor Specific Module Definition) file(s) in AUTOSAR compliant EPD format:
  - Dio_TS_T40D34M30I0R0\autosar\Dio_s32k310_lqfp48.epd
  - Dio_TS_T40D34M30I0R0\autosar\Dio_s32k310_mqfp100.epd
  - Dio_TS_T40D34M30I0R0\autosar\Dio_s32k311_lqfp48.epd
  - Dio_TS_T40D34M30I0R0\autosar\Dio_s32k311_mqfp100.epd
  - Dio_TS_T40D34M30I0R0\autosar\Dio_s32k312_mqfp100.epd
  - Dio_TS_T40D34M30I0R0\autosar\Dio_s32k312_mqfp172.epd
  - Dio_TS_T40D34M30I0R0\autosar\Dio_s32k314_mapbga257.epd
  - Dio_TS_T40D34M30I0R0\autosar\Dio_s32k314_mqfp172.epd

  - Dio_TS_T40D34M30I0R0\autosar\Dio_s32k322_mqfp100.epd
  - Dio_TS_T40D34M30I0R0\autosar\Dio_s32k322_mqfp172.epd
  - Dio_TS_T40D34M30I0R0\autosar\Dio_s32k324_mapbga257.epd
  - Dio_TS_T40D34M30I0R0\autosar\Dio_s32k324_mqfp172.epd
  - Dio_TS_T40D34M30I0R0\autosar\Dio_s32k328_mapbga289.epd
  - Dio_TS_T40D34M30I0R0\autosar\Dio_s32k328_mqfp172.epd
  - Dio_TS_T40D34M30I0R0\autosar\Dio_s32k338_mapbga289.epd
  - Dio_TS_T40D34M30I0R0\autosar\Dio_s32k338_mqfp172.epd
  - Dio_TS_T40D34M30I0R0\autosar\Dio_s32k341_mqfp100.epd
  - Dio_TS_T40D34M30I0R0\autosar\Dio_s32k341_mqfp172.epd
  - Dio_TS_T40D34M30I0R0\autosar\Dio_s32k342_mqfp100.epd
  - Dio_TS_T40D34M30I0R0\autosar\Dio_s32k342_mqfp172.epd
  - Dio_TS_T40D34M30I0R0\autosar\Dio_s32k344_mapbga257.epd
  - Dio_TS_T40D34M30I0R0\autosar\Dio_s32k344_mqfp172.epd
  - Dio_TS_T40D34M30I0R0\autosar\Dio_s32k348_mapbga289.epd
  - Dio_TS_T40D34M30I0R0\autosar\Dio_s32k348_mqfp172.epd
  - Dio_TS_T40D34M30I0R0\autosar\Dio_s32k358_mapbga289.epd
  - Dio_TS_T40D34M30I0R0\autosar\Dio_s32k358_mqfp172.epd
  - Dio_TS_T40D34M30I0R0\autosar\Dio_s32k394_mapbga289.epd
  - Dio_TS_T40D34M30I0R0\autosar\Dio_s32k396_mapbga289.epd
  - Dio_TS_T40D34M30I0R0\autosar\Dio_s32m274_lqfp64.epd
  - Dio_TS_T40D34M30I0R0\autosar\Dio_s32m276_lqfp64.epd

- Code Generation Templates for parameters without variation points:
  - ..\Dio_TS_T40D34M30I0R0\generate_PC\include\Dio_Cfg.h
  - ..\Dio_TS_T40D34M30I0R0\generate_PC\include\Siul2_Dio_Ip_Cfg.h
  - ..\Dio_TS_T40D34M30I0R0\generate_PC\src\Dio_Cfg.c

Steps to generate the configuration:

1. Copy the module folders Dio_TS_T40D34M30I0R0, BaseNXP_TS_T40D34M30I0R0, Resource_TS_T40↩ D34M30I0R0, Det_TS_T40D34M30I0R0, Rte_TS_T40D34M30I0R0, Ecuc_TS_T40D34M30I0R0, Os_T↩ S_T40D34M30I0R0, Rm_TS_T40D34M30I0R0 into the Tresos plugins folder.
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

4.1 Function Calls during Start-up

None.

4.2 Function Calls during Shutdown

None.

4.3 Function Calls during Wake-up

None.

Chapter 5

Module requirements

5.1 Exclusive areas to be defined in BSW scheduler

In the current implementation, DIO is using the services of Run-Time Environment (RTE) for entering and exiting the critical regions. RTE implementation is done by the integrators of the RTD using OS or non-OS services. For testing the Dio driver, stubs are used for RTE. The following critical regions are used in the DIO driver:

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

DIO_EXCLUSIVE_AREA_00 is used in function Dio_FlipChannel to protect the SIUL2_GPDO_ADDR32 register from read/modify/write operation;

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

DIO_EXCLUSIVE_AREA_01 is used in function Siul2_Dio_Ip_WritePin to protect the PGPDO register from read/modify/write operation;

Critical Region Exclusive Matrix
Below is the table depicting the exclusivity between different critical region IDs from the DIO driver. If there is an "X" in the table, it means that those 2 critical regions cannot interrupt each other.

#	DIO_EA_00	DIO_EA_01
DIO_EA_00	x	
DIO_EA_01		x

Note
DIO_EA_xx means DIO_EXCLUSIVE_AREA_xx

5.2 Exclusive areas not available on this platform

None.

5.3 Peripheral Hardware Requirements

The Dio driver uses SIUL2 peripheral.
Port pins that are available on a particular package are descibed in the S32K3XX Reference Manual.
The formula for calculating port and channel number for PINx is:
PORT = PINx / 16
CHANNEL = PINx % 16

5.4 ISR to configure within AutosarOS - dependencies

None.

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 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

- **PORT**: The PORT module is used to configure the port pins with the needed modes, before they are used by the DIO - module.
- **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 Dio↩ DevErrorDetect configuration parameter.
- **BASE**: The BASE module contains the common files/definitions needed by all RTD modules.
- **RESOURCE**: The RESOURCE module is used to select microcontroller derivatives.
- **RTE**: The RTE module is used to manage the exclusive area inside DIO driver.
- **ECUC**: The ECUC module is used for ECU configuration. RTD modules need ECUC to retrieve the variant information.
- **Os**: The OS module is used for OS configuration. RTD modules need OS to retrieve the application information.
- **MCU**: The MCU driver provides services for basic microcontroller initialization, power down functionality, reset and microcontroller specific functions required by other RTD software modules. The clocks need to be initialized prior to using the DIO driver
- **RM**: The RM module is used to manage the Virtual Wrapper using in DIO driver.

5.7 Data Cache Restrictions

None.

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

The Dio driver can be run from user mode. Dio driver depends on Port when it comes to configuration of its capability to run in user mode. The user mode (Port Enable User Mode Support) should be enabled in Port plugin in order for Dio to be able to run its code in user mode.

Please note that according with Dio external assumption SWS_Dio_00102, "The Dio module's user shall only use the Dio functions after the Port driver has been initialized. Otherwise the Dio module will exhibit undefined behavior."

5.8.2 User Mode configuration in AutosarOS

When User mode is enabled, the driver may has 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 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 unmarshalling 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.

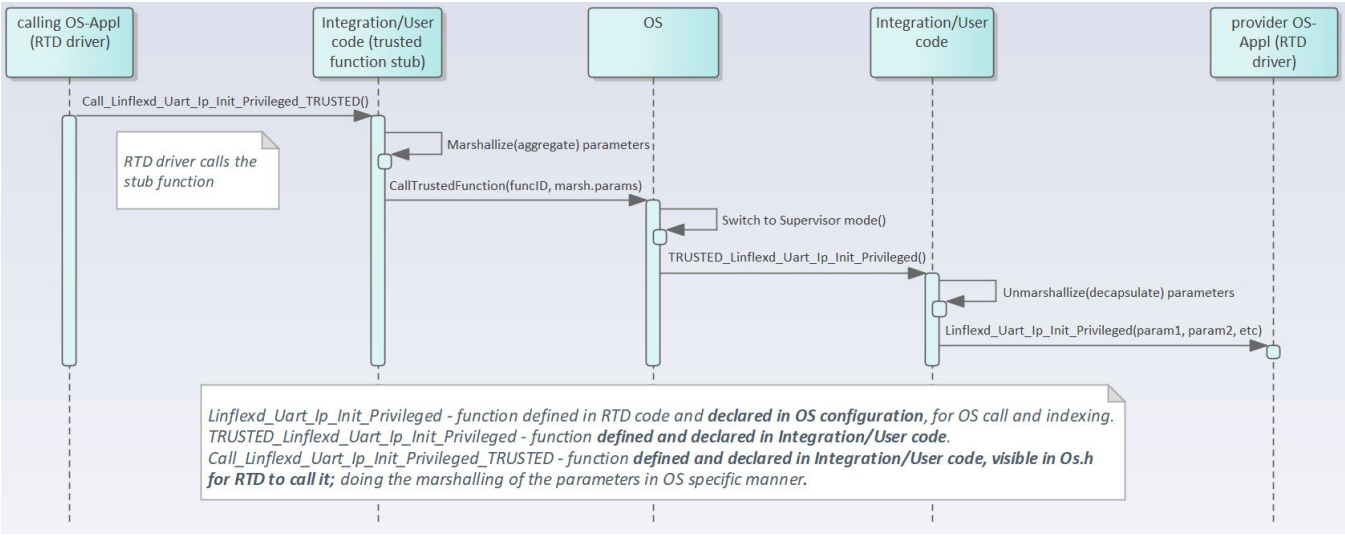

Figure 5.1 Example sequence chart for calling `Linflexd_Uart_Ip_Init_Privileged` as trusted function

5.9 Multicore support

The **Dio** implements the **"Autosar R21-11 RTD Multicore Distribution"** according to type III, in which the mappable element is set to Channels. For additional details, please refer to **AUTOSAR_EXP_BSW↩ DistributionGuide**.

The **Dio** and the mappable elements can be allocated to zero, one or several ECUC partitions, by means of **"↩ DioEcucPartionRef"**. If the Dio is mapped to zero ECUC partitions, the **Dio** behavior reverts to single-core implementation, similar to previous Autosar versions. If the **Dio** is mapped to one or more ECUC partitions, the Dio enforces the following multi-core assumptions:

1. The Dio 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 Dio 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 Dio internal variables and the EcucCoreIDs are used for indexing those variables. (AR-86601 Zero based and dense IDs for OS-Cores and OS-Applications)
3. The Dio assumes that initialization is performed on a single, designated core. It is called only once, with a single configuration structure(Type III).
4. The Dio 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; It will be called with configuration structure init, on Core 1.
5. The Dio 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 Dio requires that all variables in NonCacheable MemMap sections be allocated accordingly, to avoid data corruption in multicore context.

7. The Dio 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 Dio usecase, to be detailed/removed if some modules require such kind of functionality for critical features which cannot be atomically shared among cores)

Chapter 6

Main API Requirements

6.1 Main function calls within BSW scheduler

None.

6.2 API Requirements

None.

6.3 Calls to Notification Functions, Callbacks, Callouts

None.

Chapter 7

Memory allocation

7.1 Sections to be defined in Dio_MemMap.h

Section name	Section type	Description
DIO_START_SEC_CODE	Code	Start of Memory Section for Code
DIO_STOP_SEC_CODE	Code	End of Memory Section for Code
DIO_START_SEC_CONFIG_DATA_↩ UNSPECIFIED	Configuration Data	Start of Memory Section for Config Data
DIO_STOP_SEC_CONFIG_DATA_U↩ NSPECIFIED	Configuration Data	End of Memory Section for Config Data
DIO_START_SEC_VAR_INIT_32	Variables	Used for initialized variables which have to be aligned to 32 bit
DIO_STOP_SEC_VAR_INIT_32	Variables	End of above section
DIO_START_SEC_CONST_8	Variables	Used for variables and constants which have to be aligned to 8 bit
DIO_STOP_SEC_CONST_8	Variables	End of above section
DIO_START_SEC_CONST_16	Variables	Used for variables and constants which have to be aligned to 16 bit
DIO_STOP_SEC_CONST_16	Variables	End of above section
DIO_START_SEC_CONST_32	Variables	Used for variables and constants which have to be aligned to 32 bit
DIO_STOP_SEC_CONST_32	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 DIO driver into the application.

External Assumption Req ID	External Assumption Text
SWS_Dio_00061	The Dio module shall not provide APIs for overall configuration and initialization of the port structure which is used in the Dio module. These actions are done by the PORT Driver Module. Note: DIO module implementation shall be made independent of PORT configuration. (DIO_SW001)
SWS_Dio_00102	The Dio module's user shall only use the Dio functions after the Port Driver has been initialized. Otherwise the Dio module will exhibit undefined behavior. Note: Dio module works on pins and ports which are configured by the Port driver
SWS_Dio_00127	The Port module shall configure a DIO channel as input or output [SWS↩ _Dio_00001 and SWS_Dio_00002].
SWS_Dio_00001	The Dio module shall not provide an interface for initialization of the hardware. The Port Driver performs this. Note: DIO module implementation shall be made independent of PORT configuration. (DIO_SW001)
SWS_Dio_00002	The PORT driver shall provide the reconfiguration of the port pin direction during runtime. Note: DIO module implementation shall be made independent of PORT configuration. (DIO_SW001)
SWS_Dio_00017	For parameter values of type Dio_ChannelType, the Dio's user shall use the symbolic names provided by the configuration description. Furthermore, S↩ WS_Dio_00103 applies to the type Dio_ChannelType. Note: If supported by the external application, parameter validation at production time is no more needed.
SWS_Dio_00020	For parameter values of type Dio_PortType, the user shall use the symbolic names provided by the configuration description. Furthermore, SWS_↩ Dio_00103 applies to the type Dio_PortType. Note: If supported by the external application, parameter validation at production time is no more needed.
SWS_Dio_00022	For parameter values of type Dio_ChannelGroupType, the user shall use the symbolic names provided by the configuration description. Furthermore, SWS_Dio_00056 applies to the type Dio_ChannelGroupType. Note: If supported by the external application, parameter validation at production time is no more needed.
EA_RTD_00071	If interrupts are locked, a centralized function pair to lock and unlock interrupts shall be used.

External assumptions for driver

External Assumption Req ID	External Assumption Text
EA_RTD_00078	If the platform supports configuring the port pins as Input-Output then the pins for which the application intends to use Dio_FlipChannel() function at run-time should be configured as Input-Output as in this case FlipChannel() function writes the output buffer and returns the value from the input buffer. If the platform supports configuring the port pins as either Input or Output then the pins for which the application intends to use Dio_FlipChannel() function at run-time should be configured as Output and in this case Flip↩ Channel() function writes the output buffer and returns the value from the output buffer.
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 Dio is allocated shall be exclusively mapped to a core. Note↩ : Internally, the Dio 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_00095	The application shall call Dio_Init() on a single, designated core, using a single configuration pointer.
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 a 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>TRUSTE↩ D(parameter1,parameter2,...) in Integration/User code. They need to 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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