PWM 3.0 driver user guide

TRAVEO™ T2G family

About this document

Scope and purpose

This guide describes the architecture, configuration, and use of the pulse width modulation (PWM) driver. It will help you to understand the functionality of the driver and will provide a reference to the driver's API.

The installation, build process and general information about the use of EB tresos are not within the scope of this document.

Intended audience

This document is intended for anyone who uses the PWM driver of the TRAVEO™ T2G family.

Document structure

Chapter 1 General overview gives a brief introduction to the PWM driver, explains the embedding in the AUTOSAR environment and describes the supported hardware and development environment.

Chapter 2 Using the PWM driver details the steps required to use the PWM driver in your application.

Chapter 3 Structure and dependencies describes the file structure and the dependencies for the PWM driver.

Chapter 4 EB tresos Studio configuration interface describes the driver's configuration.

Chapter 5 Functional description gives a functional description of all services offered by the PWM driver.

Chapter 6 Hardware resources gives a description of all hardware resources used.

The Appendix A and Appendix B provides a complete API reference and access register table.

Abbreviations and definitions

Abbreviation	Description
ADC	Analog Digital Converter
API	Application Programming Interface
ASCII	American Standard Code for Information Interchange
ASIL	Automotive Safety Integrity Level
AUTOSAR	Automotive Open System Architecture
BSW	Basic Software. Standardized part of software which does not fulfill a vehicle functional job.
CDD	Complex Device Driver
DEM	Diagnostic Event Manager
DET	Default Error Tracer
EcuM	ECU State Manager
GCE	Generic Configuration Editor

Abbreviation	Description
IoHwAbs	Input/Output Hardware Abstraction
ISR	Interrupt Service Routine
µC	Microcontroller
MCU	Microcontroller Unit
MCAL	Microcontroller Abstraction Layer
OS	Operating System
PWM	Pulse Width Modulation
TCPWM	Timer Counter Pulse Width Modulation
EB tresos Studio	Elektrobit Automotive configuration framework
UART	Universal Asynchronous Receiver-Transmitter
UTF-8	8-Bit Universal Character Set Transformation Format
Tick	Defines the timer resolution, the duration of a timer increment

Related documents

AUTOSAR requirements and specifications

Bibliography

[1] General specification of basic software modules, AUTOSAR release 4.2.2.

[2] Specification of PWM driver, AUTOSAR release 4.2.2.

[3] Specification of standard types, AUTOSAR release 4.2.2.

[4] Specification of ECU configuration parameters, AUTOSAR release 4.2.2.

[5] Specification of default error tracer, AUTOSAR release 4.2.2.

[6] Specification of memory mapping, AUTOSAR release 4.2.2.

Elektrobit automotive documentation

Bibliography

[7] EB tresos Studio for ACG8 user's guide.

Hardware documentation

Bibliography

[8] The hardware documents are listed in the delivery notes.

Related standards and norms

Bibliography

[9] Layered software architecture, AUTOSAR release 4.2.2.

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1 General overview

1.1 Introduction to the PWM driver

The PWM driver is a set of software routines, which enables you to create PWM signals on dedicated output pins of the CPU.

For this purpose, the PWM driver provides services for modifying the period and the duty cycle of a PWM signal. In addition, the PWM driver provides services for initializing and de-initializing the PWM module, setting of the output to idle level, and enabling or disabling of a notification callback function on a specified edge.

The PWM driver is not responsible for initializing or configuring hardware ports. This task is performed by the PORT driver.

The driver conforms to the AUTOSAR standard and is implemented according to the *specification of PWM driver* [2].

The PWM driver is delivered with a plugin for the EB tresos Studio, which allows you to statically configure the driver. The driver provides an interface to enable PWM channels and to configure period, duty cycle, and other parameters.

1.2 User profile

This guide is intended for users with a least basic knowledge of the following:

- Automotive embedded systems
- C programming language
- AUTOSAR standard
- Target hardware architecture

1.3 Embedding in the AUTOSAR environment

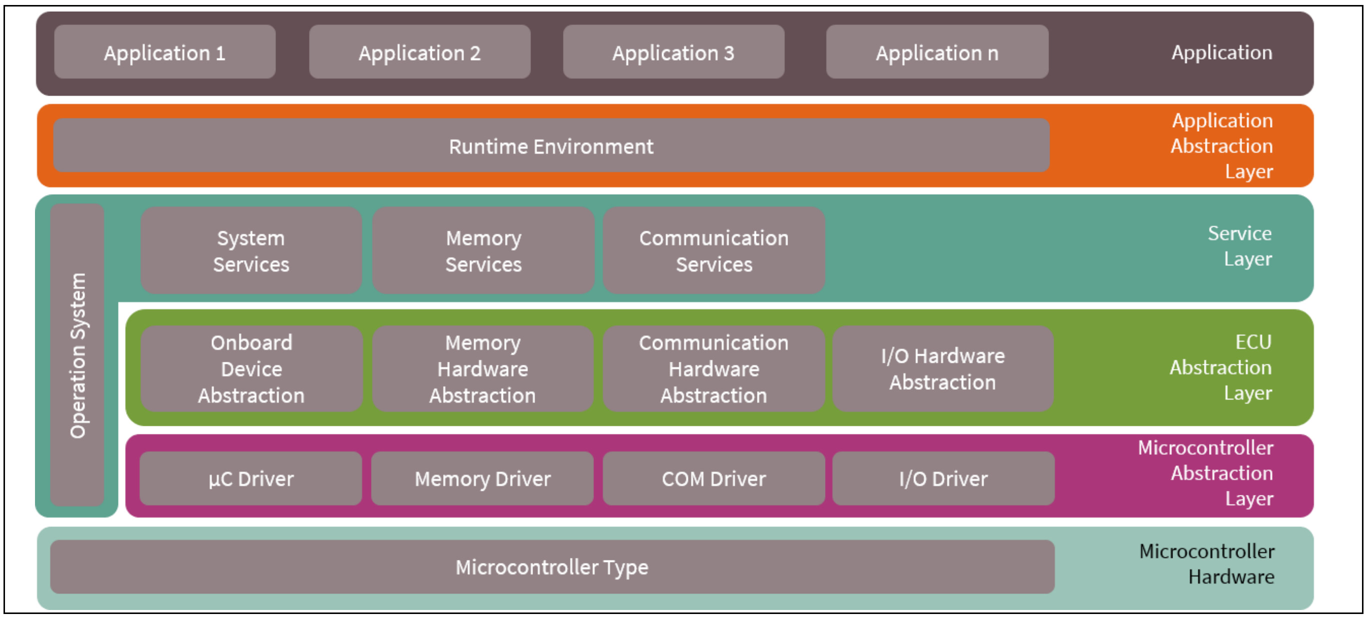


Figure 1 Overview of AUTOSAR software layers

Figure 1 depicts the layered AUTOSAR software architecture. The PWM driver (Figure 2) is part of group of I/O drivers within the microcontroller abstraction layer (MCAL), the lowest layer of basic software in the AUTOSAR environment.

For an exact overview of the AUTOSAR layered software architecture, see the *layered software architecture* [9].

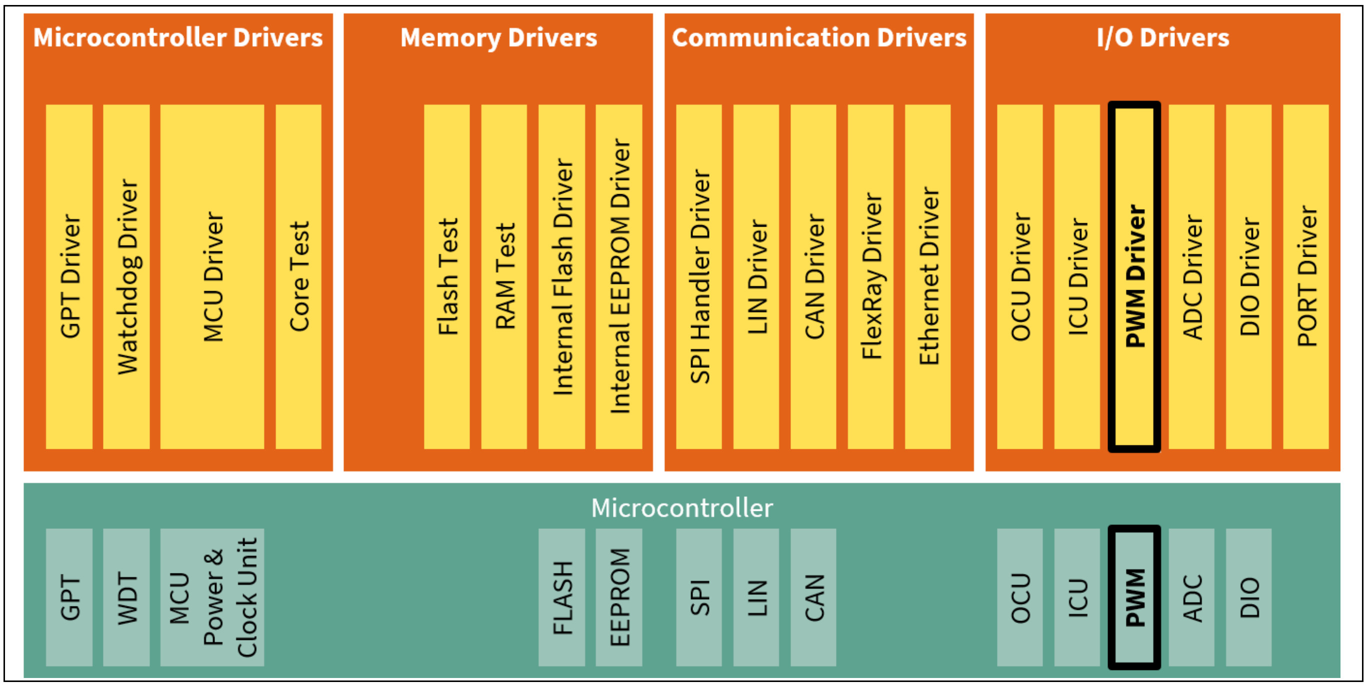


Figure 2 **PWM driver in MCAL layer**

1.4 Supported hardware

This version of the PWM driver supports the TRAVEO™ T2G family. No special external hardware devices are required.

The supported derivatives are listed in the release notes.

1.5 Development environment

The development environment corresponds to AUTOSAR release 4.2.2. The modules BASE, MAKE, MCU, PORT, and RESOURCE are needed for proper functionality of the PWM driver.

1.6 Character set and encoding

All source code files of the PWM driver are restricted to the ASCII character set. The files are encoded in UTF-8 format, with only the 7-bit subset (values 0x00 … 0x7F) being used.

1.7 Multicore support

The PWM driver supports multicore type II. The multicore type III can also be supported for some APIs (for example, read-only API or atomic-write API). For each multicore type, see the following sections:

Note: *If multicore type III is required, the section including the data related to the read-only API or atomic write API must be allocated to the memory, and can be read from any cores.*

1.7.1 Multicore type

In this section, type I, type II, and type III are defined as multicore characteristics.

1.7.1.1 Single core only (multicore type I)

For this multicore type, the driver is available only on a single core. This type is referred as “Multicore Type I”.

Multicore type I has the following characteristics:

- The peripheral channels are accessed by only one core.

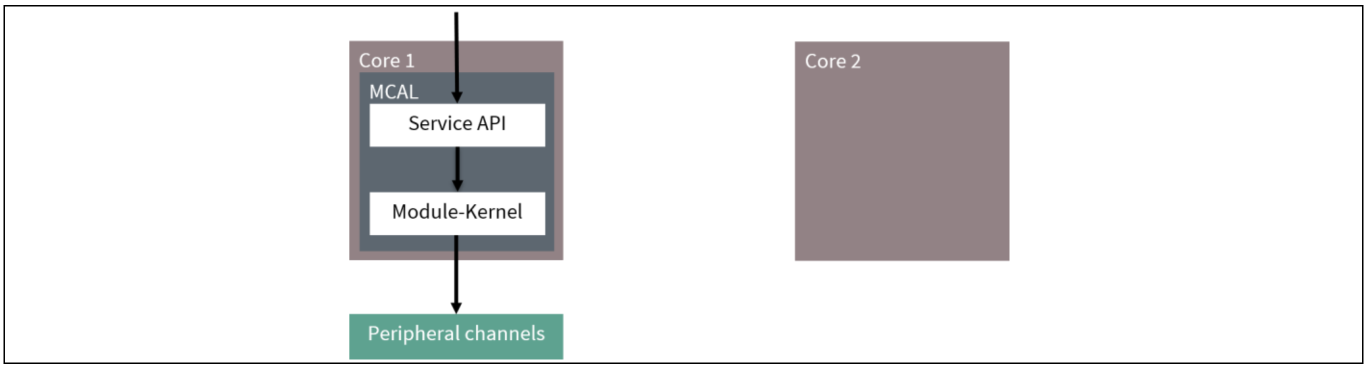


Figure 3 Overview of the multicore type I

1.7.1.2 Core-dependent instances (multicore type II)

For this multicore type, the driver has core-dependent instances with individually allocable hardware. This type is referred as multicore type II.

Multicore type II has the following characteristics:

- The driver code is shared among all cores:
  - A common binary is used for all cores.
  - A configuration is common for all cores.
- Each core runs an instance of the driver.
- Peripheral channels and their data can be individually allocated to cores, but cannot be shared among cores.
- One core will be the master; and the master core must be initialized first:
  - Cores other than the master core are called satellite cores.

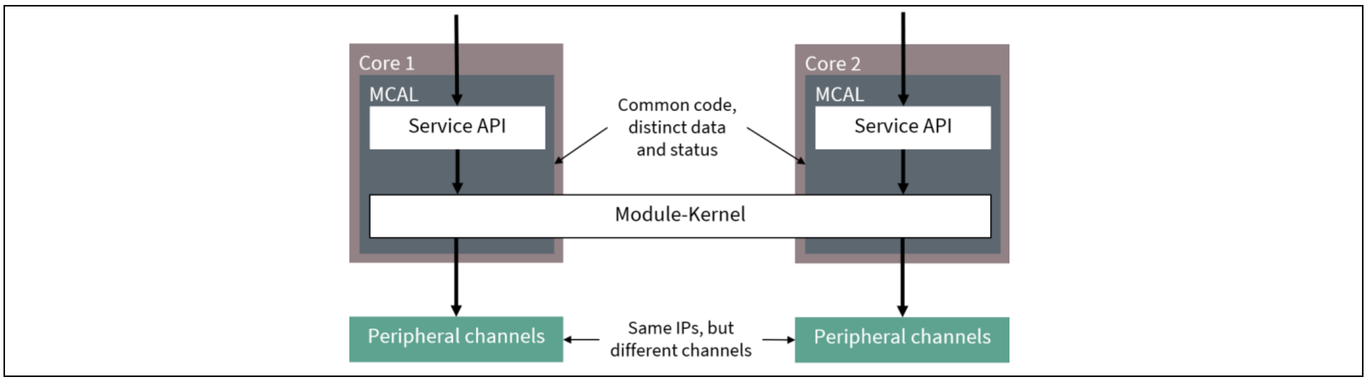


Figure 4 **Overview of the multicore type II**

1.7.1.3 Core-independent instances (multicore type III)

For this multicore type, the driver has core-independent instances with globally available hardware. This type is referred as multicore type III.

Multicore type III has the following characteristics:

- The code of the driver is shared among all cores:
  - A common binary is used for all cores.
  - A configuration is common for all cores.
- Each core runs an instance of the driver.
- Peripheral channels are globally available for all cores.

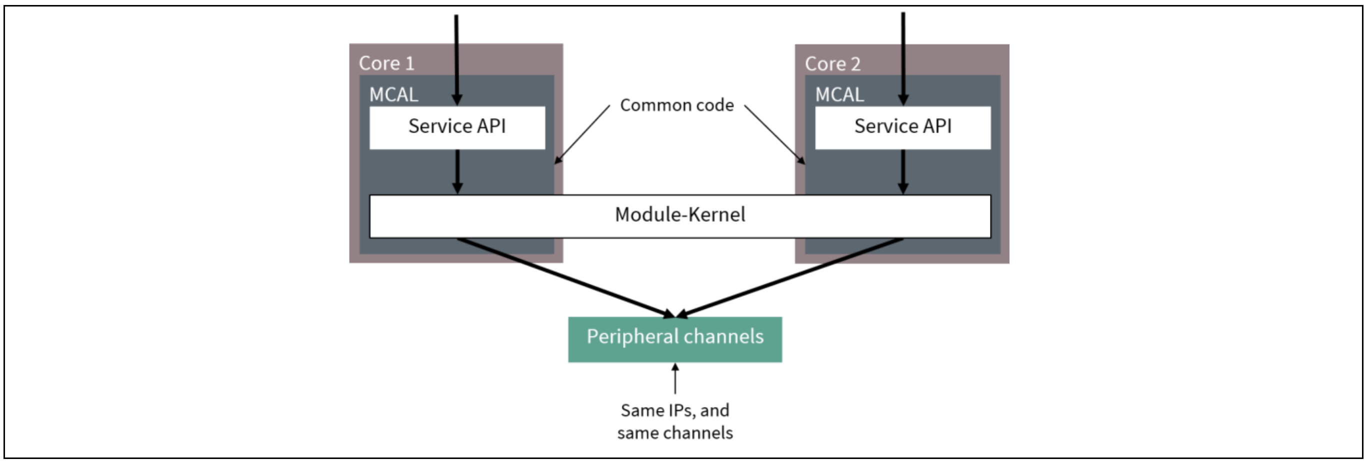


Figure 5 **Overview of the multicore type III**

1.7.2 Virtual core support

The PWM driver supports a number of cores. The configured cores need not be equal to the physical cores.

The PWM driver calls a configurable callout function (`PwmGetCoreIdFunction`) to identify the core that is currently executing the code. This function can be implemented in the integration scope. The function can be written such that it does not return the physical core, but instead returns. the SW partition ID, OS application ID, or any attribute/parameter. By interpreting these as the core, the PWM driver can support multiple SW partitions on a single physical core.

2 Using the PWM driver

This chapter describes all necessary steps to incorporate the PWM driver into your application.

2.1 Installation and prerequisites

Note: *Before you start, see the EB tresos Studio for ACG8 user's guide [7] for the following information.*

1. *The installation procedure of EB tresos ECU AUTOSAR components*
2. *The usage of the EB tresos Studio*
3. *The usage of the EB tresos ECU AUTOSAR build environment (It includes the steps to setup and integrate the own application within the EB tresos ECU AUTOSAR build environment)*

The installation of the PWM driver corresponds with the general installation procedure for EB tresos AUTOSAR components given in the documents mentioned above. If the driver has been successfully installed, the driver will appear in the module list of the EB tresos Studio (see the *EB tresos Studio for ACG8 user's guide* [7]).

This document assumes that the project is properly set up and is using the application template as described in the *EB tresos Studio for ACG8 user's guide* [7]. This template provides the necessary folder structure, project and makefiles needed to configure and compile your application within the build environment. You also must be familiar with the use of the command shell.

2.2 Configuring the PWM driver

The PWM driver can be configured with any AUTOSAR compliant GCE tool. Save the configuration in a separate file named e.g. *Pwm.epc*. More information about the PWM driver configuration can be found in 4 EB tresos Studio configuration interface.

2.2.1 Architecture specifics

See 4.3 Vendor and driver specific parameters, where all vendor- and driver-specific configuration parameters are described.

2.3 Adapting your application

To use the PWM driver in your application, you have to include the header files of PWM, MCU, and PORT driver by adding the following lines of code to your source file:

```
#include "Mcu.h"
#include "Port.h"
#include "Pwm.h"
```

This publishes all needed function and data prototypes and symbolic names of the configuration into the application. In addition, you must implement the error callout function for ASIL safety extension.

To use the PWM driver, the appropriate port pins and PWM interrupts must be configured in MCU driver, PORT driver, and OS. For detailed information see 6 Hardware resources.

Initialization of MCU, PORT, and PWM driver needs to be done in the following order:

For the master core:

```
Mcu_Init(&Mcu_Config[0]);
Port_Init(&Port_Config[0]);
```

```
Pwm_Init(&Pwm_Config[0]);
```

For the satellite core:

```
Mcu_Init(&Mcu_Config[0]);
Pwm_Init(&Pwm_Config[0]);
```

The function `Mcu_Init()` is called with a pointer to a structure of type `Mcu_ConfigType`, which is published by the MCU Driver itself.

The function `Port_Init()` is called with a pointer to a structure of type `Port_ConfigType`, which is published by the PORT Driver itself. This function must be called on the master core only.

The function `Pwm_Init()` is called with a pointer to a structure of type `Pwm_ConfigType`, which is published by the PWM Driver itself.

The master core must be initialized prior to the satellite core. All cores must be initialized with the same configuration.

After initialization of the PWM driver, its API functions can be used. Each configured PWM channel operates, but no callback functions are called until you enable the functions.

`PwmStartTriggerSelect0` specifies the input trigger of TCPWM instance 0 to start all PWM channels synchronously except `PwmStartAtInit` is set to *FALSE*. When this parameter is configured, a trigger signal is required to start those channels. It is necessary to call `Port_ActTrigger()` to issue a trigger signal after calling `Pwm_Init()`. In this case, the group trigger configuration is also required in the PORT module. When this parameter is not configured, channels are started sequentially by `Pwm_Init()`.

`PwmStartTriggerSelect1` specifies the input trigger of TCPWM instance 1 to start all PWM channels synchronously except `PwmStartAtInit` is set to *FALSE*. When this parameter is configured, a trigger signal is required to start those channels. It is necessary to call `Port_ActTrigger()` to issue a trigger signal after calling `Pwm_Init()`. In this case, the group trigger configuration is also required in the PORT module. When this parameter is not configured, channels are started sequentially by `Pwm_Init()`.

Note: *If `PwmStartTriggerSelect0` or `PwmStartTriggerSelect1` is configured, `Port_ActTrigger()` should be called after `Pwm_Init()` is called on all cores.*

`PwmChannelGroupStartTrigger` specifies the input trigger to start the PWM channel group synchronously. When this parameter is configured, a trigger signal is required to start all channels in the group. It is necessary to call `Port_ActTrigger()` to issue a trigger signal after calling `Pwm_StartGroupTrigger()`. In this case, the group trigger configuration is also required in the PORT module. When this parameter is not configured, the channels in the group are started sequentially by `Pwm_StartGroupTrigger()`.

`PwmChannelGroupStopTrigger` specifies the input trigger to stop the PWM channel group synchronously. When this parameter is configured, a trigger signal is required to stop all channels in the group. It is necessary to call `Port_ActTrigger()` to issue a trigger signal after calling `Pwm_StopGroupTrigger()`. In this case, the group trigger configuration is also required in PORT module. When this parameter is not configured, the channels in the group are stopped sequentially by `Pwm_StopGroupTrigger()`.

For a configured channel with the name `MY_PWM_CHANNEL` (`PwmChannelClass` = `PWM_VARIABLE_PERIOD`, `PwmPolarity` = `PWM_HIGH`, `PwmIdleState` = `PWM_LOW`), following functions can be called:

```
/* set 50% duty */
Pwm_SetDutyCycle(MY_PWM_CHANNEL, 0x4000);
/* period = 0x6000 ticks with 25% duty */
```

```
Pwm_SetPeriodAndDuty(MY_PWM_CHANNEL, 0x6000, 0x2000);
/* force polarity level = constant output = HIGH = 100% duty */
Pwm_SetDutyCycle(MY_PWM_CHANNEL, 0x8000);
/* set output into idle state = LOW */
Pwm_SetOutputToIdle(MY_PWM_CHANNEL);
/* start PWM channel again after it was idle */
Pwm_SetDutyCycle(MY_PWM_CHANNEL, 0x0815);
```

2.4 Starting the build process

Do the following to build your application:

Note: For a clean build, use the build command with target `clean_all` *before (make* `clean_all`*).*

1. On the command shell, type the following command to generate the necessary configuration dependent files. See 3.3 Generated files
```
> make generate
```
2. Type the following command to resolve the required file dependencies:
```
> make depend
```
3. Type the following command to compile and link the application:
```
> make (optional target: all)
```

The application is now built. All files are compiled and linked to a binary file, which can be downloaded to the target CPU cores.

2.5 Measuring stack consumption

Do the following to measure stack consumption. It requires the Base module for proper measurement.

Note: All files (including library files) should be rebuilt with the dedicated compiler option. The executable file built in this step must be used only to measure stack consumption.

To measure stack consumption:

1. Add the following compiler option to the Makefile to enable stack consumption measurement.
```
-DSTACK_ANALYSIS_ENABLE
```
2. Type the following command to clean library files:
```
> make clean_lib
```
3. Follow the build process described in 2.4 Starting the build process.
4. Measure the stack consumption by following the instructions given in the release notes.

2.6 Memory mapping

The *Pwm_MemMap.h* file in the *$(TRESOS_BASE)/plugins/MemMap_TS_T40D13M0I0R0/include* directory is a sample. This file is replaced by the file generated by MEMMAP module. Input to MEMMAP module is generated as *Pwm_Bswmd.arxml* in the *$(PROJECT_ROOT)/output/generated/swcd* directory of your project folder.

2.6.1 Memory allocation keyword

- `PWM_START_SEC_CODE_ASIL_B` / `PWM_STOP_SEC_CODE_ASIL_B`

  The memory section type is CODE. All executable code is allocated in this section.

- `PWM_START_SEC_CONST_ASIL_B_UNSPECIFIED` / `PWM_STOP_SEC_CONST_ASIL_B_UNSPECIFIED`

  The memory section type is CONST. The following constants are allocated in this section:

  - PWM channel configuration setting
  - PWM group configuration setting
  - PWM whole configuration setting
  - Lookup table to search a specific PWM channel by logical channel index
  - Pointer to the driver status

- `PWM_CORE[PwmCoreConfigurationId]_START_SEC_VAR_INIT_ASIL_B_GLOBAL_UNSPECIFIED` / `PWM_CORE[PwmCoreConfigurationId]_STOP_SEC_VAR_INIT_ASIL_B_GLOBAL_UNSPECIFIED`

  The memory section type is VAR. The following variables are allocated in this section:

  - Pointer to whole configuration setting
  - Information for PWM driver state

- `PWM_CORE[PwmCoreConfigurationId]_START_SEC_VAR_CLEARED_ASIL_B_GLOBAL_UNSPECIFIED` / `PWM_CORE[PwmCoreConfigurationId]_STOP_SEC_VAR_CLEARED_ASIL_B_GLOBAL_UNSPECIFIED`

  The memory section type is VAR. The following variables are allocated in this section:

  - Information for target PWM channel state

2.6.2 Memory allocation and constraints

All memory sections that store init or uninit status must be zero-initialized before any driver function is executed on any core. If core consistency checks are disabled, inconsistent parameters would be detected and reported by PPU and SMPU.

`PWM_CORE[PwmCoreConfigurationId]_START_VAR_[INIT_POLICY]_ASIL_B_GLOBAL_[ALIGNMENT]` / `PWM_CORE[PwmCoreConfigurationId]_STOP_VAR_[INIT_POLICY]_ASIL_B_GLOBAL_[ALIGNMENT]`

This section is read/write accessed from the core represented by `PwmCoreConfigurationId` and read accessed from the other cores. Therefore, this section must not be allocated to TCRAM. For the core represented by `PwmCoreConfigurationId`, this section must be allocated to either non-cache-able or write-through cache-able SRAM area. For performance, it is recommended to allocate the section to write-through cache-able SRAM. For other cores, this section must be allocated to non-cache-able SRAM area.

For multicore type III, this section is read accessed from other cores. So, this section must not be allocated to TCRAM. For the core represented by `PwmCoreConfigurationId`, this section must be allocated to either non-cache-able or write-through cache-able SRAM area. For performance, it is recommended to allocate the section to non-cache-able SRAM. For the other cores, this section must be allocated to non-cache-able SRAM area.

- STACK section:

  TCRAM has dedicated memory for each core at the same address, and because of its performance it is recommended to allocate STACK to TCRAM.

Note: *This restriction is applied only to Arm® Cortex®-M7 devices because they include TCMs and inner cache. There is no restriction when using Cortex®-M4 devices.*

For the details of `INIT_POLICY` and `ALIGNMENT`, see the *Specification of memory mapping* [6].

3 Structure and dependencies

The PWM driver consists of static, configuration, and generated files.

3.1 Static files

- $(PLUGIN_PATH)=$(TRESOS_BASE)/plugins/Pwm_TS_* is the path to the PWM driver plugin.
- *$(PLUGIN_PATH)/lib_src* contains all static source files of the PWM driver. These files contain the functionality of the driver, which does not depend on the current configuration. The files are grouped into a static library.
- *$(PLUGIN_PATH)/src* comprises configuration dependent source files or special derivative files. Each file will be rebuilt when the configuration is changed.

All necessary source files will automatically be compiled and linked during the build process and all include paths will be set if the PWM driver is enabled.

- *$(PLUGIN_PATH)/include* is the basic public include directory needed by the user and should be included in *Pwm.h*.
- *$(PLUGIN_PATH)/autosar* directory contains the AUTOSAR ECU parameter definition with vendor, architecture, and derivative specific adaptations to create a correct matching parameter configuration for the PWM driver.

3.2 Configuration files

The configuration of the PWM driver is done via EB tresos Studio. The file containing the PWM driver's configuration is named *Pwm.xdm* and is in the directory *$(PROJECT_ROOT)/config*. This file serves as input for the generation of the configuration dependent source and header files during the build process.

3.3 Generated files

During the build process the following files are generated based on the current configuration description. They are in the *output/generated* sub folder of your project folder:

- include/Pwm_Cfg.h
- include/Pwm_Cfg_Include.h
- include/Pwm_PBcfg.h
- src/Pwm_Irq.c
- src/Pwm_PBcfg.c

Note: *Generated source files need not to be added to your application make file. These files will be compiled and linked automatically during the build process.*

- swcd/Pwm_Bswmd.arxml

Note: *Additional steps are required for the generation of BSW module description. In EB tresos Studio, follow the menu path **Project** > **Build Project** and click **generate_swcd**.*

3.4 Dependencies

3.4.1 PORT driver

Although the PWM driver can successfully be compiled and linked without an AUTOSAR compliant PORT driver, the latter is required to configure and initialize all ports. Also, the configuration of triggers is required and it is necessary to call `Port_ActTrigger()` to issue a trigger signal after either of the following case:

1. Calling `Pwm_Init()` if the `PwmStartTriggerSelect0` or `PwmStartTriggerSelect1` parameter is configured.
2. Calling `Pwm_StartGroupTrigger()` if the `PwmChannelGroupStartTrigger` parameter is configured.
3. Calling `Pwm_StopGroupTrigger()` if the `PwmChannelGroupStopTrigger` parameter is configured.

If `Port_ActTrigger()` is not called, channels or channels in the group are not started/stopped. The PORT driver needs to be initialized before the PWM driver is initialized. See the *PORT driver's user guide* for details.

The configuration of triggers is required in the next case:

4. Calling `Pwm_Init()` if the `PwmStartDelayTrigger` parameter is configured.

If `Port_ActTrigger()` is called with the `PwmStartDelayTrigger`, the PWM driver will show undefined behavior.

3.4.2 MCU driver

The MCU driver needs to be initialized and all MCU clock reference points referenced by the MCU driver channels via configuration parameter `PwmMcuClockReferencePoint` must have been activated (via calls of MCU API functions) before initializing the MCU driver. `Mcu_GetCoreID` can optionally be set to configuration parameter `PwmGetCoreIdFunction`. See the *MCU driver's user guide* for details.

3.4.3 AUTOSAR OS

The OS must be used to configure and create the ISR vector table entries for the PWM used channels. See the hardware and derivatives specified in 6.3 Interrupts. `GetCoreID` can optionally be set to the configuration parameter `PwmGetCoreIdFunction`.

3.4.4 DET

If the development error detection is enabled in the PWM driver configuration, the DET module needs to be installed, configured, and integrated into the application also.

3.4.5 Error callout handler

The error callout handler is called on every error that is detected, regardless of whether development error detection is enabled or disabled. The error callout handler is an ASIL safety extension that is not specified by AUTOSAR. It is configured via the configuration parameter `PwmErrorCalloutFunction`.

3.4.6 BSW scheduler

The PWM driver uses the following services of the BSW scheduler to enter and leave critical sections:

- `SchM_Enter_Pwm_PWM_EXCLUSIVE_AREA_[PwmCoreConfigurationId](void)`
- `SchM_Exit_Pwm_PWM_EXCLUSIVE_AREA_[PwmCoreConfigurationId](void)`

You must ensure that the BSW scheduler is properly configured and initialized before using the PWM driver.

You must ensure that all interrupts does not occur during enter critical section.

4 EB tresos Studio configuration interface

Use an AUTOSAR compliant GCE to adapt the configuration files as desired.

Note: *The ECU parameter description of the PWM driver basically corresponds to the one defined by AUTOSAR. However, as there are some vendor-specific extensions, you must use the ECU parameter description file that is delivered with the PWM driver. There are two types of the file:*

- The EB tresos Studio configuration description *($(TRESOS_BASE)/plugins/Pwm_TS_<VARIANT>/config/Pwm.xdm)*: This file is automatically loaded when the module is selected in EB tresos. The file contains specific support for calculated values and error checks.
- The AUTOSAR compatible configuration description *($(TRESOS_BASE)/plugins/Pwm_TS_<VARIANT>/autosar/Pwm.arxml)*: This file can be used as a basis for GCEs other than Tresos. The file does not contain specific support for calculated values and error checks, but only general ranges that cover all possible values for all derivatives.

4.1 General configuration

The module comes preconfigured with default settings. These settings must be adapted if necessary.

4.2 Standard parameters

This section lists all configuration parameters required by AUTOSAR. Deviations or hardware-specific restrictions from the specification are mentioned where applicable.

4.2.1 Container PwmGeneral

4.2.1.1 PwmDevErrorDetect

Description

Enables or disables development error notification for the PWM driver.

Remarks

Setting this parameter to FALSE will disable the notification of development errors via DET. However, in contrast to AUTOSAR specification, detection of development errors is still enabled and errors will be reported via `PwmErrorCalloutFunction`.

4.2.1.2 PwmDutycycleUpdatedEndperiod

Description

Switch for enabling the update of the duty cycle parameter at the end of the current period.

Remarks

- `TRUE`: Duty cycle is updated at the end of the period of the currently generated waveform (current waveform is finished).
- `FALSE`: Duty cycle is updated immediately (just after service call, current waveform is cut).

4.2.1.3 PwmIndex

Description

Specifies the `InstanceId` of this module instance. If only one instance is present, the Id will be 0.

Remarks

This parameter is not used by the PWM driver and therefore not being evaluated.

4.2.1.4 PwmNotificationSupported

Description

Adds or removes the services `Pwm_EnableNotification()` and `Pwm_DisableNotification()` from the code.

Remarks

None

4.2.1.5 PwmPeriodUpdatedEndperiod

Description

Switch for enabling the update of the period parameter at the end of the current period.

Remarks

- `TRUE`: Period or duty cycle is updated at the end of the period of the currently generated waveform (current waveform is finished).
- `FALSE`: Period or duty cycle is updated immediately (just after service call, current waveform is cut).

4.2.1.6 PwmLowPowerStatesSupport

Description

Adds or removes all power state management related APIs (`Pwm_SetPowerState`, `Pwm_GetCurrentPowerState`, `Pwm_GetTargetPowerState`, `Pwm_PreparePowerState`, `Pwm_Main_PowerTransitionManager`), indicating whether the HW offers low power state management.

Remarks

The HW does not offer low power state management, so `PwmLowPowerStatesSupport` is always set to `FALSE`.

4.2.1.7 PwmPowerStateAsynchTransitionMode

Description

Enables or disables PWM driver's support to the asynchronous power state transition.

Remarks

The parameter `PwmLowPowerStatesSupport` is always set to `FALSE`, so this parameter will not be configured.

4.2.2 Container PwmChannel

4.2.2.1 PwmChannelClass

Description

Class of PWM channel: `PWM_FIXED_PERIOD`, `PWM_FIXED_PERIOD_SHIFTED` or `PWM_VARIABLE_PERIOD`.

Remarks

- `PWM_FIXED_PERIOD`: `PwmChannelStartDelay` is disabled. Calling `Pwm_SetPeriodAndDuty()` becomes an error of `PWM_E_PERIOD_UNCHANGEABLE`.
- `PWM_FIXED_PERIOD_SHIFTED`: `PwmChannelStartDelay` is enabled. Calling `Pwm_SetPeriodAndDuty()` becomes an error of `PWM_E_PERIOD_UNCHANGEABLE`.
- `PWM_VARIABLE_PERIOD`: `PwmChannelStartDelay` is enabled. Calling `Pwm_SetPeriodAndDuty()` is effective.

4.2.2.2 PwmChannelId

Description

Channel Id of the PWM channel.

Range

0..[65535 or number of configured channels - 1, whichever is lower]

Value must be unique among all channels.

Remarks

This value is assigned to a symbolic name. Use only the symbolic channel names defined in *Pwm_Cfg.h* for API calls.

4.2.2.3 PwmDutycycleDefault

Description

Value of duty cycle used at initialization.

Remarks

Valid range: 0 (0% duty). 0x8000 (100% duty).

4.2.2.4 PwmIdleState

Description

Specifies the output state of the PWM after the signal is stopped (e.g. by call of `Pwm_SetOutputToIdle`): `PWM_HIGH or PWM_LOW`.

Remarks

None

4.2.2.5 PwmMcuClockReferencePoint

Description

This parameter contains reference to `McuClockReferencePoint`.

Remarks

`PwmMcuClockReferencePoint` must have the target's `McuClockReferencePoint` setting.

4.2.2.6 PwmNotification

Description

Definition of the notification callback function.

Remarks

This parameter can be configured as empty string, or NULL can be entered. Both will result in no notification being called. Otherwise, the function name must be unique.

4.2.2.7 PwmPeriodDefault

Description

Period value used at initialization in seconds.

Range

Depends on `PwmMcuClockReferencePoint`.

Remarks

A symbolic name for the tick value of `PwmPeriodDefault` is generated. This symbolic name is defined in *Pwm_PBcfg.h*. The tick value helps to calculate a new period tick value in relation with the existing `PwmPeriodDefault` for usage in `Pwm_SetPeriodAndDuty()`.

`PwmPeriodDefault` must be equal to or more than 1 / (`McuClockReferencePointFrequency` of `PwmMcuClockReferencePoint`) and less than 1 / (`McuClockReferencePointFrequency` of `PwmMcuClockReferencePoint`) * 128 * 65535.

Note: The prescale value (1, 2, 4, 8, 16, 32, 64 or 128) is calculated by the McuClockReferencePointFrequency and PwmPeriodDefault values.
The configurable prescale value is derived from the result of the formula below:
*(McuClockReferencePointFrequency * PwmPeriodDefault)/32767*
e.g. When the calculated value is greater than 64, the actual prescale value is set to 128.
The prescale value can get with Pwm_GetChannelStatus API after PWM initialization.

4.2.2.8 PwmPolarity

Description

Specifies the polarity of each PWM channel: `PWM_HIGH` or `PWM_LOW`.

Remarks

None

4.2.3 Container PwmConfigurationOfOptApiServices

4.2.3.1 PwmDeInitApi

Description

Adds or removes the service `Pwm_DeInit()` from the code.

Remarks

None

4.2.3.2 PwmGetOutputState

Description

Adds or removes the service `Pwm_GetOutputState()` from the code.

Remarks

None

4.2.3.3 PwmSetDutyCycle

Description

Adds or removes the service `Pwm_SetDutyCycle()` from the code.

Remarks

None

4.2.3.4 PwmSetOutputToIdle

Description

Adds or removes the service `Pwm_SetOutputToIdle()` from the code.

Remarks

None

4.2.3.5 PwmSetPeriodAndDuty

Description

Adds or removes the service `Pwm_SetPeriodAndDuty()` from the code.

Remarks

None

4.2.3.6 PwmVersionInfoApi

Description

Adds or removes the service `Pwm_GetVersionInfo()` from the code.

Remarks

None

4.2.4 Container PwmPowerStateConfig

4.2.4.1 PwmPowerState

Description

Each instance of this parameter describes a different power state supported by the PWM HW. It should be defined by the HW supplier and used by PWM driver to reference specific HW configurations, which sets the PWM HW module in the referenced power state. At least the power mode corresponding to full power state will be always configured.

Remarks

The parameter `PwmLowPowerStatesSupport` is always set to FALSE, so this parameter will not be configured.

4.2.4.2 PwmPowerStateReadyCbkRef

Description

Each instance of this parameter contains a reference to a power mode callback defined in a CDD or IoHwAbs component.

Remarks

The parameter `PwmLowPowerStatesSupport` is always set to `FALSE`, so this parameter will not be configured.

4.3 Vendor and driver specific parameters

4.3.1 Container PwmGeneral

4.3.1.1 PwmHwTriggerOutputUnitType

Description

Switches a unit type to second or tick.

Type

`EcucEnumerationParamDef`

Range

`PWM_TRIGGER_TICK`: `PwmHwTriggerOutputDefaultTick` is available.

`PWM_TRIGGER_SECOND`: `PwmHwTriggerOutputDefaultTime` is available.

4.3.1.2 PwmMultipleUpdateInPeriod

Description

Switch for enabling multiple updates within a period. `PwmMultipleUpdateInPeriod` specifies the behavior when the following functions are called while the channel is waiting for an update by the next period (`PWM_CH_COND_WAIT_UPDATE`).

`Pwm_SetPeriodAndDuty`, `Pwm_SetDutyCycle`, `Pwm_SetTriggerDelay`, `Pwm_SetOutputOffset`

Type

`EcucBooleanParamDef`

Range

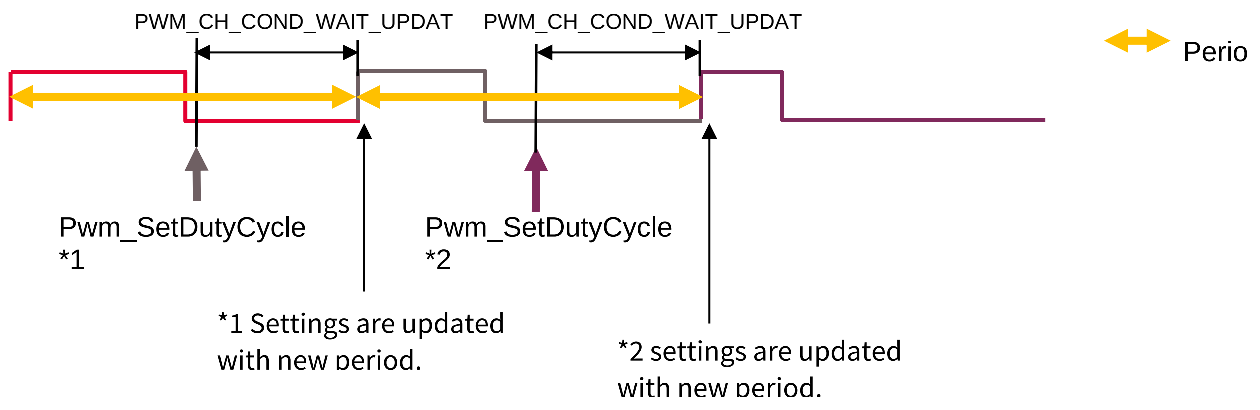
- `TRUE`: The function overwrites the register with the new value. PWM channel continues the output waveform. There is a risk of abnormal waveform output if API is continuously called at intervals shorter than one period.
- `FALSE`: The PWM channel stops and restarts with the new value.

Remarks

In the following cases, the channel transitions to the wait for update state (`PWM_CH_COND_WAIT_UPDATE`) until the next period:

- Calling `Pwm_SetTriggerDelay`, `Pwm_SetOutputOffset`, and `Pwm_SetChannelOutput`.
- Calling `Pwm_Init` or `Pwm_StartGroupTrigger` with any start delay configured channel.
- Calling `Pwm_SetPeriodAndDuty` or `Pwm_SetDutyCycle` when `PwmPeriodUpdatedEndperiod` is TRUE.

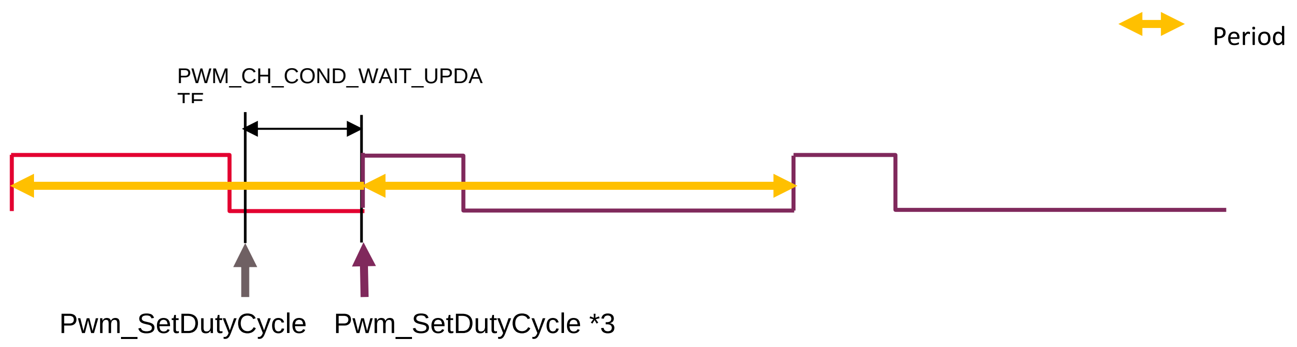
Note 1: If update only once within a certain period (Call it single update), the settings will be updated at the next period after the Pwm_SetDutyCycle is called even if PwmMultipleUpdateInPeriod is FALSE or TRUE.



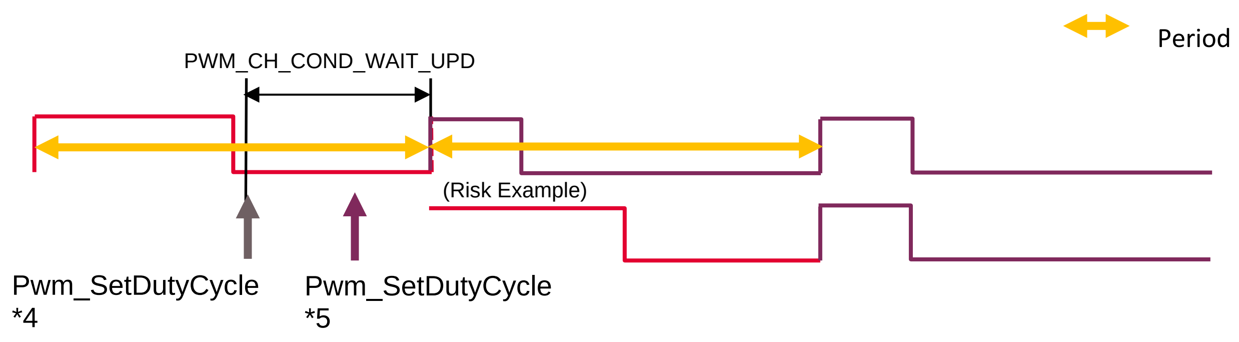
Note 2: If update twice or more in a same period (Depend on PwmMultipleUpdateInPeriod setting), it may lead 2 cases. One is PwmMultipleUpdateInPeriod FALSE, the other is PwmMultipleUpdateInPeriod TRUE.

Below are images showing both situations.

PwmMultipleUpdateInPeriod FALSE: Stop period and restart with *3 setting.



PwmMultipleUpdateInPeriod TRUE: *5 settings are updated with new period. If the *5 calling time is just end of the period, the *4 setting is canceled and the *5 updating is delayed one period.
The following example shows the risk for abnormal waveform output if the API is continuously called at intervals shorter than one period.



4.3.1.3 PwmErrorCalloutFunction

Description

Error callout function. Syntax:

```
void ErrorCalloutHandler
(
  uint16 ModuleId,
  uint8 InstanceId,
  uint8 ApiId,
  uint8 ErrorId
);
```

The error callout function is called on every error. The ASIL level of this function limits the ASIL level of the PWM driver.

Type

`EcucFunctionNameDef`

Remarks

`PwmErrorCalloutFunction` must be a valid C function name.

4.3.1.4 PwmIncludeFile

Description

Lists the filenames that will be included within the driver. Any application specific symbol that is used by the PWM configuration (e.g. error callout function) should be included by configuring this parameter.

Type

`EcucStringParamDef`

Remarks

`PwmIncludeFile` must be a unique filename with an extension *.h*.

4.3.1.5 PwmStartTriggerSelect0

Description

Specifies the input trigger of TCPWM instance 0 to start all PWM channels synchronously except `PwmStartAtInit,` which is set to `FALSE`. When this parameter is configured, a trigger signal is required to start those channels. It is necessary to call `Port_ActTrigger()` to issue a trigger signal after calling `Pwm_Init()`. In this case, the group trigger configuration is also required in the PORT module. When this parameter is not configured, channels are started sequentially by `Pwm_Init()`.

Type

`EcucEnumerationParamDef`

Range

- `TCPWM_0_TR_ALL_CNT_IN_0`: Input trigger 0 of TCPWM instance 0
- `TCPWM_0_TR_ALL_CNT_IN_1`: Input trigger 1 of TCPWM instance 1
- …
- `TCPWM_0_TR_ALL_CNT_IN_n`: Input trigger n of TCPWM instance 0

Note: The number of available input triggers depends on the hardware resources.

Remarks

PWM, ICU, GPT, and OCU drivers use input triggers of TCPWM.

An error occurs, if the value of the `PwmStartTriggerSelect0` parameter is configured to be the same as that of the following parameters:

- `PwmGroupStartDelayTrigger`
- `PwmStartDelayTrigger`
- `PwmChannelGroupStartTrigger`
- `PwmChannelGroupStopTrigger`
- `PwmChannelGroupSwitchEventTrigger`
- `IcuInputTriggerSelection`
- `IcuChannelGroupStartTrigger`
- `IcuChannelGroupStopTrigger`
- `GptPredefTimerStartTriggerSelect`

- `GptInputTriggerSelection`

A warning occurs if the following trigger is used:

- `OcuStartTriggerSelect0`

4.3.1.6 PwmStartTriggerSelect1

Description

Specifies the input trigger of TCPWM instance 1 to start all PWM channels synchronously except `PwmStartAtInit,` which is set to `FALSE`. When this parameter is configured, a trigger signal is required to start those channels. It is necessary to call `Port_ActTrigger()` to issue a trigger signal after calling `Pwm_Init()`. In this case, the group trigger configuration is also required in the PORT module. When this parameter is not configured, channels are started sequentially by `Pwm_Init()`.

Type

`EcucEnumerationParamDef`

Range

- `TCPWM_1_TR_ALL_CNT_IN_0`: Input trigger 0 of TCPWM instance 1
- `TCPWM_1_TR_ALL_CNT_IN_1`: Input trigger 1 of TCPWM instance 1
- ...
- `TCPWM_1_TR_ALL_CNT_IN_n`: Input trigger n of TCPWM instance 1

Note: *The number of available input triggers depends on the hardware resources.*

Remarks

PWM, ICU, GPT, and OCU drivers use input triggers of TCPWM.

An error occurs, if the value of the `PwmStartTriggerSelect1` parameter is configured to be the same as that of the following parameters:

- `PwmGroupStartDelayTrigger`
- `PwmStartDelayTrigger`
- `PwmChannelGroupStartTrigger`
- `PwmChannelGroupStopTrigger`
- `PwmChannelGroupSwitchEventTrigger`
- `IcuInputTriggerSelection`
- `IcuChannelGroupStartTrigger`
- `IcuChannelGroupStopTrigger`
- `GptPredefTimerStartTriggerSelect`
- `GptInputTriggerSelection`

A warning occurs, if the value of the `PwmStartTriggerSelect1` parameter is configured to be the same as that of the following parameter:

- `OcuStartTriggerSelect1`

4.3.2 Container PwmChannel

4.3.2.1 PwmTimer

Description

Specifies the physical hardware timer that is assigned to this logical channel.

Type

`EcucEnumerationParamDef`

Range

- `TCPWM_0_0`: Timer Counter Pulse Width Modulation Instance 0 Channel 0
- `TCPWM_0_1`: Timer Counter Pulse Width Modulation Instance 0 Channel 1
- ...
- `TCPWM_1_0`: Timer Counter Pulse Width Modulation Instance 1 Channel 0
- `TCPWM_1_1`: Timer Counter Pulse Width Modulation Instance 1 Channel 1
- ...
- `TCPWM_m_n`: Timer Counter Pulse Width Modulation Instance m Channel n

Note: The number of available physical hardware timer channels depends on the configured target derivative.

Remarks

Only one configuration per `PwmTimer` is allowed in the same configuration set.

`PwmTimer` must not use TCPWM channel that is used by `PwmStartDelayTimer` and `PwmGroupStartDelayTimer`.

`PwmTimer` shows all TCPWM resources on the device. See the hardware documentation [8] for the TCPWM connected to the pin for `PwmTimer`.

GPT, ICU, OCU drivers, and OS use TCPWM channels. PWM driver must not use TCPWM channel that is used by other modules.

4.3.2.2 PwmAlignment

Description

Defines aligned type of timer channel.

Type

`EcucEnumerationParamDef`

Range

- `PWM_LEFT_ALIGNED`: The PWM channel output is left aligned.
- `PWM_CENTER_ALIGNED`: The PWM channel output is center aligned.
- `PWM_RIGHT_ALIGNED`: The PWM channel output is right aligned.

4.3.2.3 PwmHwTriggerOutputLine

Description

This parameter is used to allow the PWM channel to output trigger. TCPWM has two output triggers; `TR_OUT0` and `TR_OUT1`. The available output trigger depends on the hardware. The PORT module and connecting target module should be configured. Group trigger or One-to-One trigger is available.

Type

`EcucEnumerationParamDef`

Range

- `TR_OUT0`: The PWM driver will generate the output triggers to `TR_OUT0` after delay time or delay ticks is specified by `PwmHwTriggerOutputDefaultTime` or `PwmHwTriggerOutputDefaultTick` from the beginning of period.
- `TR_OUT1`: The PWM driver will generate the output triggers to `TR_OUT1` after delay time or delay ticks is specified by `PwmHwTriggerOutputDefaultTime` or `PwmHwTriggerOutputDefaultTick` from the beginning of period.
- `BOTH`: The PWM driver will generate the output triggers to `TR_OUT0` and `TR_OUT1` after delay time or delay ticks is specified by `PwmHwTriggerOutputDefaultTime` or `PwmHwTriggerOutputDefaultTick` from the beginning of period.

Remarks

The connection target of `PwmHwTriggerOutputLine` depends on the hardware resource.

4.3.2.4 PwmHwTriggerOutputFactor

Description

Defines the output trigger factor of timer channel.

Type

`EcucEnumerationParamDef`

Range

- `PWM_TRIGGER_SYNC_PERIOD`: The PWM driver will generate the output triggers after delay time or delay ticks is specified by `PwmHwTriggerOutputDefaultTime` or `PwmHwTriggerOutputDefaultTick` from the beginning of period.
- `PWM_TRIGGER_SYNC_DUTY`: The PWM driver will generate the output triggers after delay time or delay ticks specified by `PwmHwTriggerOutputDefaultTime` or `PwmHwTriggerOutputDefaultTick` from the beginning of duty.

Remarks

When `PwmHwTriggeOutputLine` is enabled, `PwmHwTriggerOutputFactor` is enabled.

When duty is 0% with `PWM_TRIGGER_SYNC_DUTY`, output trigger is not output.

When duty is 100% with `PWM_TRIGGER_SYNC_DUTY`, output trigger is output with match period.

4.3.2.5 PwmChannelStartDelay

Description

Channel start delay value defines the time in ticks that the period start is delayed from the moment of initialization.

Type

`EcucIntegerParamDef`

Range

0..65535

Remarks

When `PwmStartDelayTimer` or `PwmGroupStartDelay` is enabled and `PwmChannelClass` is `PWM_FIXED_PERIOD_SHIFTED` or `PWM_VARIABLE_PERIOD`, `PwmChannelStartDelay` is enabled.

4.3.2.6 PwmChannelPrescale

Description

Shows a calculated prescaler value of the `PwmTimer` based on `PwmPeriodDefault` and `McuClockReferencePointFrequency`.

Type

`EcucIntegerParamDef`

Range

0..7

Remarks

This parameter is enabled when `PwmGroupStartDelay` is enabled in the group that references this channel. `PwmChannelPrescale` is used to check if all channels in the PWM channel group have the same prescaler value.

When `PwmPeriodDefault` is changed, the value of `PwmChannelPrescale` is updated by pressing the **Calculate Value** button.

4.3.2.7 PwmStartDelayTimer

Description

Specifies the physical hardware timer for `PwmChannelStartDelay`.

Type

`EcucEnumerationParamDef`

Range

- `TCPWM_0_0`: Timer Counter Pulse Width Modulation Instance 0 Channel 0
- `TCPWM_0_1`: Timer Counter Pulse Width Modulation Instance 0 Channel 1
- ...
- `TCPWM_1_0`: Timer Counter Pulse Width Modulation Instance 1 Channel 0
- `TCPWM_1_1`: Timer Counter Pulse Width Modulation Instance 1 Channel 1
- ...
- `TCPWM_m_n`: Timer Counter Pulse Width Modulation Instance m Channel n

Note: The number of available physical hardware timer channels depends on the configured target derivative.

Remarks

When `PwmChannelClass` is `PWM_FIXED_PERIOD_SHIFTED` or `PWM_VARIABLE_PERIOD`, `PwmStartDelayTimer` is enabled.

Only one configuration per `PwmStartDelayTimer` is allowed in the same configuration set.

`PwmStartDelayTimer` must not use TCPWM channel that is used by `PwmTimer` and `PwmGroupStartDelayTimer`.

GPT, ICU, OCU drivers and OS use TCPWM channels. PWM driver must not use TCPWM channel that is used by other modules.

4.3.2.8 PwmStartDelayMcuClockReferencePoint

Description

This parameter contains reference to the `McuClockReferencePoint` for `PwmStartDelayTimer`

Type

`EcucReferenceDef`

Remarks

When `PwmStartDelayTimer` is enabled (`PwmChannelClass` is `PWM_FIXED_PERIOD_SHIFTED` or `PWM_VARIABLE_PERIOD`), `PwmStartDelayMcuClockReferencePoint` is enabled.

The clock frequency of `PwmStartDelayTimer` must be the same as `PwmTimer`.

4.3.2.9 PwmStartDelayTrigger

Description

Specifies the input trigger for `PwmChannelStartDelay`.

Type

`EcucEnumerationParamDef`

Range

- `TCPWM_0_TR_ALL_CNT_IN_0`: Input trigger 0 of TCPWM instance 0
- `TCPWM_0_TR_ALL_CNT_IN_1`: Input trigger 1 of TCPWM instance 0
- ...
- `TCPWM_1_TR_ALL_CNT_IN_0`: Input trigger 0 of TCPWM instance 1
- `TCPWM_1_TR_ALL_CNT_IN_1`: Input trigger 1 of TCPWM instance 1
- ...
- `TCPWM_m_TR_ALL_CNT_IN_n`: Input trigger n of TCPWM instance m

Note: The number of available input triggers depends on the hardware resources.

Remarks

When `PwmStartDelayTimer` is enabled (`PwmChannelClass` is `PWM_FIXED_PERIOD_SHIFTED` or `PWM_VARIABLE_PERIOD`), `PwmStartDelayTrigger` is enabled.

PWM, ICU, GPT, and OCU drivers use input triggers of TCPWM.

An error occurs, if the value of the `PwmStartDelayTrigger` parameter is configured to be the same as that of the following parameters in the same configuration set:

- PwmGroupStartDelayTrigger
- PwmStartDelayTrigger
- PwmChannelGroupStartTrigger
- PwmChannelGroupStopTrigger
- PwmChannelGroupSwitchEventTrigger

An error occurs, if the value of the `PwmStartDelayTrigger` parameter is configured to be the same as that of the following parameters:

- PwmStartTriggerSelect0
- PwmStartTriggerSelect1
- IcuInputTriggerSelection
- IcuChannelGroupStartTrigger
- IcuChannelGroupStopTrigger
- OcuStartTriggerSelect0
- OcuStartTriggerSelect1
- GptPredefTimerStartTriggerSelect
- GptInputTriggerSelection

4.3.2.10 PwmHwTriggerOutputDefaultTime

Description

Specifies the value of output trigger default delay time in seconds.

This value describes a fixed time from the beginning of the period when the output trigger is set off. The respective register value depending on the current period is calculated and set. If the period is modified by `Pwm_SetPeriodAndDuty()`, the register value is recalculated accordingly.

If `PwmHwTriggerOutputDefaultTime` is greater than `PwmPeriodDefault`, an error will be reported at configuration time.

Type

`EcucFloatParamDef`

Range

0..PwmPeriodDefault

Remarks

When `PwmHwTriggerOutputLine` is enabled and the value of `PwmHwTriggerOutputUnitType` is `PWM_TRIGGER_SECOND` and `PwmOutputOffset` is disabled, `PwmHwTriggerOutputDefaultTime` is enabled.

4.3.2.11 PwmHwTriggerOutputDefaultTick

Description

Specifies the value of output trigger default delay in ticks.

This value describes the fixed ticks from the beginning of the period when the output trigger is set off. The respective register value depending on the current period is calculated and set. If the period is modified by `Pwm_SetPeriodAndDuty()`, the register value is recalculated accordingly.

If `PwmHwTriggerDefaultOutputTick` is greater than `PwmPeriodDefault` (converted to ticks), an error will be reported at configuration time.

Type

`EcucIntegerParamDef`

Range

0..65534

Remarks

When `PwmHwTriggerOutputLine` is enabled and the value of `PwmHwTriggerOutputUnitType` is `PWM_TRIGGER_TICK` and `PwmOutputOffset` is disabled, `PwmHwTriggerOutputDefaultTick` is enabled.

4.3.2.12 PwmHwTriggerOutputScaled

Description

Switch for enabling the scaling of the output trigger delay with the period by specified by `Pwm_SetPeriodAndDuty`.

Type

`EcucBooleanParamDef`

Range

- `TRUE`: Scaling with the period change.
- `FALSE`: Not scaling with the period change.

Remarks

`PwmHwTriggerOutputScaled` can be editable only when `PwmHwTriggerOutputLine` is enabled and `PwmOutputOffset` is disabled.

4.3.2.13 PwmSetOutputEnable

Description

Supports set channel output state.

Type

`EcucBooleanParamDef`

Range

- `TRUE`: Supports the set channel output state.
- `FALSE`: Does not support the set channel output state.

Remarks

When `PwmSetOutputState` is `TRUE` and the channel has a function to set the output state, `PwmSetOutputEnable` is enabled.

4.3.2.14 PwmOutputOffset

Description

The offset value for the rising edge in ticks.

Type

`EcucIntegerParamDef`

Range

0..65533

Remarks

`PwmOutputOffset` cannot exceed the end of a period.

`PwmOutputOffset` cannot use when `PwmAlignment` is `PWM_RIGHT_ALIGNED`.

`PwmOutputOffset` can set the value from 0 to (period ticks - duty ticks - 1) when `DutyCycle` is not 0% nor100%.

`PwmOutputOffset` can set the value from 0 to (period ticks - 1) when `DutyCycle` is 0% or 100%.

4.3.2.15 PwmOutputOffsetScaled

Description

Switch for enabling the scaling of the rising edge offset together with the period by `Pwm_SetPeriodAndDuty`.

Type

`EcucBooleanParamDef`

Range

- `TRUE`: Scaling with the period change.

5. `FALSE`: Not scaling with the period change.

Remarks

`When PwmOutputOffset` is enabled and `PwmChannelClass` is `PWM_VARIABLE_PERIOD`, `PwmOutputOffsetScaled` is enabled.

4.3.2.16 PwmStartAtInit

Description

PWM channel is started when `Pwm_Init()` is called. If disabled, PWM channel will be started when `Pwm_SetDutyCycle()`, `Pwm_SetPeriodAndDuty()`, or `Pwm_StartGroupTrigger()` is called.

Type

`EcucBooleanParamDef`

Range

- `TRUE`: PWM channel is started by `Pwm_Init()`
- `FALSE`: PWM channel will be started by `Pwm_SetDutyCycle()`, `Pwm_SetPeriodAndDuty()`, or `Pwm_StartGroupTrigger()`

Remarks

If `PwmStartAtInit` is set to `FALSE`, the output level depends on `PwmIdleState`.

In case of PWM start delay function:

If `PwmStartAtInit` is set to `TRUE` and the channel is waiting for `Port_ActTrigger()`, the output level will be one of the following:

- `PwmChannelStartDelay` is not 0 with enabled: If `PwmOutputOffset` is disabled and `PwmAlignment` is `PWM_LEFT_ALIGNED`, the output level is the active level (`PwmPolarity`), else it is the inactive level.
- `PwmChannelStartDelay` is 0 or disabled and current `DutyCycle` is 100%: The output level is the active level (`PwmPolarity`).
- `PwmChannelStartDelay` is 0 or disabled and current `DutyCycle` is 0%: The output level is the inactive level (`PwmPolarity`).

- `PwmChannelStartDelay` is 0 or disabled and current `DutyCycle` is not 0% or 100%: If `PwmAlignment` is `PWM_LEFT_ALIGNED` and `PwmOutputOffset` is 0 and enabled, the output level is the active level (`PwmPolarity`), else it is the inactive level.

In case of PWM group start delay function:

If `PwmStartAtInit` is set to `TRUE` and the channel is waiting for `Port_ActTrigger()`, the output level will be `PwmIdelState.`

If `PwmGroupStartDelay` is enabled, the `PwmStartAtInit` of all channels in a group should be of the same value.

4.3.2.17 PwmDebugMode

Description

Specifies the behavior of PWM channel when processor is in debug mode.

Type

`EcucEnumerationParamDef`

Range

- `PWM_DEBUG_MODE_CONTINUE`: The counter operation continues in debug mode.
- `PWM_DEBUG_MODE_HALT`: The counter operation freezes in debug mode.

4.3.2.18 PwmCoreAssignment

Description

Reference to `PwmCoreConfiguration` for channel core assignment.

Type

`EcucReferenceDef`

Remarks

`PwmCoreAssignment` must have the target's `PwmCoreConfiguration` setting.

The same resource cannot be allocated to multiple cores.

4.3.2.19 PwmUpdateOutputAtInitEnable

Description

Enables configuration settings for the line state and complementary line state for the configured channel when the `Pwm_Init` API is called.

`PwmUpdateOutputAtInitEnable` can be set if the channel resource has the stepping motor control feature and `PwmChannelClass` is disabled or `PwmChannelClass` is `PWM_FIXED_PERIOD`.

`PwmOutputAtInitSelect` and `PwmCompOutputAtInitSelect` can be set if `PwmUpdataOutputAtInitEnable` is TRUE.

Type

`EcucBooleanParamDef`

Range

- `TRUE`: The PWM line state is set to `PwmOutputAtInitSelect`. The PWM complementary line state is set to `PwmCompOutputAtInitSelect`.
- `FALSE`: The PWM line state is fixed to `PWM`. The PWM complementary line state is fixed to `PWM_INV` state.

4.3.2.20 PwmOutputAtInitSelect

Description

Specifies the line state of the channel when the `Pwm_Init()` is called.

`PwmOutputAtInitSelect` can be set if `PwmUpdataOutputAtInitEnable` is TRUE.

Type

`EcucEnumerationParamDef`

Range

- `LOW`: Line state is set to LOW.
- `HIGH`: Line state is set to HIGH.
- `PWM`: Line state is set to PWM.
- `PWM_INV`: Line state is set to PWM_INV.
- `HIGHZ`: Line state is set to HIGHZ.

Remarks

The edge of the `Pwm_EnableNotification` API is set to the timing of the notification as if `PwmOutputAtInitSelect` is always `PWM`. Therefore, it may be different from the edge of the output waveform.

4.3.2.21 PwmCompOutputAtInitSelect

Description

Specifies the complementary line state of the channel when the `Pwm_Init()` is called.

`PwmCompOutputAtInitSelect` can be set if `PwmUpdataOutputAtInitEnable` is TRUE.

Type

`EcucEnumerationParamDef`

Range

- `LOW`: Complementary line state is set to LOW.
- `HIGH`: Complementary line state is set to HIGH.
- `PWM`: Complementary line state is set to PWM.
- `PWM_INV`: Complementary line state is set to PWM_INV.
- `HIGHZ`: Complementary line state is set to HIGHZ.

4.3.3 Container PwmChannelGroup

4.3.3.1 PwmChannelGroupId

Description

Group Id of the PWM channel group. This value will be assigned to the symbolic names.

Type

`EcucIntegerParamDef`

Range

0..[ChannelId]

Remarks

Value must be unique among all groups.

4.3.3.2 PwmChannelGroupStartTrigger

Description

Specifies the input trigger to start the PWM channel group synchronously. When this parameter is configured, a trigger signal is required to start all channels in the group. It is necessary to call `Port_ActTrigger()` to issue a trigger signal after calling `Pwm_StartGroupTrigger()`. In this case, the group trigger configuration is also required in the PORT module. When this parameter is not configured, the channels in the group are started sequentially by `Pwm_StartGroupTrigger()`.

Type

`EcucEnumerationParamDef`

Range

- `TCPWM_0_TR_ALL_CNT_IN_0`: Input trigger 0 of TCPWM instance 0
- `TCPWM_0_TR_ALL_CNT_IN_1`: Input trigger 1 of TCPWM instance 0
- ...
- `TCPWM_1_TR_ALL_CNT_IN_0`: Input trigger 0 of TCPWM instance 1
- `TCPWM_1_TR_ALL_CNT_IN_1`: Input trigger 1 of TCPWM instance 1
- ...
- `TCPWM_m_TR_ALL_CNT_IN_n`: Input trigger n of TCPWM instance m

Note: The number of available input triggers depends on the hardware resources.

Remarks

PWM, ICU, GPT, and OCU drivers use input triggers of TCPWM.

An error occurs, if the value of the `PwmChannelGroupStartTrigger` parameter is configured to be the same as that of the following parameters in the same configuration set:

- `PwmGroupStartDelayTrigger`
- `PwmStartDelayTrigger`
- `PwmChannelGroupStopTrigger`

- `PwmChannelGroupSwitchEventTrigger`

An error occurs, if the value of the `PwmChannelGroupStartTrigger` parameter is configured to be the same as that of the following parameters:

- `PwmStartTriggerSelect0`
- `PwmStartTriggerSelect1`
- `IcuInputTriggerSelection`
- `IcuChannelGroupStopTrigger`
- `OcuStartTriggerSelect0`
- `OcuStartTriggerSelect1`
- `GptPredefTimerStartTriggerSelect`
- `GptInputTriggerSelection`

A warning occurs, if the value of the `PwmChannelGroupStartTrigger` parameter is configured to be the same as that of the following parameter in the same configuration set:

- `PwmChannelGroupStartTrigger`

A warning occurs, if the value of the `PwmChannelGroupStartTrigger` parameter is configured to be the same as that of the following parameter:

- `IcuChannelGroupStartTrigger`

If `PwmChannelRef` has `PwmTimer` of different instance, an error occurs.

4.3.3.3 PwmChannelGroupStopTrigger

Description

Specifies the input trigger to stop the PWM channel group synchronously. When this parameter is configured, a trigger signal is required to stop all channels in the group. It is necessary to call `Port_ActTrigger()` to issue a trigger signal after calling `Pwm_StopGroupTrigger()`. In this case, the group trigger configuration is also required in PORT module. When this parameter is not configured, the channels in the group stop sequentially by `Pwm_StopGroupTrigger()`.

Type

`EcucEnumerationParamDef`

Range

- `TCPWM_0_TR_ALL_CNT_IN_0`: Input trigger 0 of TCPWM instance 0
- `TCPWM_0_TR_ALL_CNT_IN_1`: Input trigger 1 of TCPWM instance 0
- ...
- `TCPWM_1_TR_ALL_CNT_IN_0`: Input trigger 0 of TCPWM instance 1
- `TCPWM_1_TR_ALL_CNT_IN_1`: Input trigger 1 of TCPWM instance 1
- ...

- `TCPWM_m_TR_ALL_CNT_IN_n`: Input trigger n of TCPWM instance m

Note: The number of available input triggers depends on hardware resources.

Remarks

PWM, ICU, GPT, and OCU drivers use input triggers of TCPWM.

An error occurs, if the value of the `PwmChannelGroupStopTrigger` parameter is configured to be the same as that of the following parameters in the same configuration set:

- `PwmGroupStartDelayTrigger`
- `PwmStartDelayTrigger`
- `PwmChannelGroupStartTrigger`
- `PwmChannelGroupSwitchEventTrigger`

An error occurs, if the value of the `PwmChannelGroupStopTrigger` parameter is configured to be the same as that of the following parameters:

- `PwmStartTriggerSelect0`
- `PwmStartTriggerSelect1`
- `IcuInputTriggerSelection`
- `IcuChannelGroupStopTrigger`
- `OcuStartTriggerSelect0`
- `OcuStartTriggerSelect1`
- `GptPredefTimerStartTriggerSelect`
- `GptInputTriggerSelection`

A warning occurs, if the value of the `PwmChannelGroupStopTrigger` parameter is configured to be the same as that of the following parameter in the same configuration set:

- `PwmChannelGroupStopTrigger`

A warning occurs, if the value of the `PwmChannelGroupStopTrigger` parameter is configured to be the same as that of the following parameter:

- `IcuChannelGroupStopTrigger`

If `PwmChannelRef` has `PwmTimer` of different instance, an error occurs.

4.3.3.4 PwmChannelRef

Description

Assignment of channels to a channel group.

Type

`EcucReferenceDef`

Remarks

Referenced channel must be unique in a group. Referenced channel must be unique among all groups when `PwmChannelGroupStopTrigger` is effective.

When `PwmChannelGroupSwitchEventTrigger` is enabled and `PwmChannelClass` is not configured as disabled or `PwmChannelClass` is `PWM_FIXED_PERIOD` for channels in the group, an error occurs.

When `PwmGroupStartDelay` is configured, the following checks are conducted:

- If `PwmChannelClass` is disabled or `PWM_FIXED_PERIOD`, an error occurs.
- If `PwmStartDelayTimer` of the referenced channel is enabled, an error occurs.
- If `PwmMcuClockReferencePoint` of the referenced channel and `PwmGroupStartDelayMcuClockReferencePoint` are different from `McuClockReferencePointFrequency`, an error occurs.
- If `PwmStartAtInit` of all referenced channels is not same, an error occurs.
- If `PwmChannelPrescale` of all referenced channels is not same, an error occurs.
- If referenced channel is referred from other group, an error occurs.
- If `PwmCoreAssignment` of all channels in group is not same, an error occurs.

4.3.3.5 PwmChannelGroupSwitchEventTrigger

Description

Specifies the input trigger for `Pwm_SetDutyAndChannelOutputBuffer`, `Pwm_SetDutyCycleBuffer`, `Pwm_SetChannelOutputBuffer` function with `Port_ActTrigger`. The input trigger is used to reserve switching of the output waveform after the end of the period for the channels in the group.

Type

`EcucEnumerationParamDef`

Range

- `TCPWM_0_TR_ALL_CNT_IN_0`: Input trigger 0 of TCPWM instance 0
- `TCPWM_0_TR_ALL_CNT_IN_1`: Input trigger 1 of TCPWM instance 0
- ...
- `TCPWM_1_TR_ALL_CNT_IN_0`: Input trigger 0 of TCPWM instance 1
- `TCPWM_1_TR_ALL_CNT_IN_1`: Input trigger 1 of TCPWM instance 1
- ...
- `TCPWM_m_TR_ALL_CNT_IN_n`: Input trigger n of TCPWM instance m

Note: *The number of available input triggers depends on hardware resources.*

Remarks

PWM, ICU, GPT, and OCU drivers use input triggers of TCPWM.

An error occurs, if the value of the `PwmChannelGroupSwitchEventTrigger` parameter is configured to be the same as that of the following parameters in the same configuration set:

- `PwmGroupStartDelayTrigger`
- `PwmStartDelayTrigger`
- `PwmChannelGroupStartTrigger`
- `PwmChannelGroupStopTrigger`
- `PwmChannelGroupSwitchEventTrigger`

An error occurs, if the value of the `PwmChannelGroupSwitchEventTrigger` parameter is configured to be the same as that of the following parameters:

- `PwmStartTriggerSelect0`
- `PwmStartTriggerSelect1`
- `IcuInputTriggerSelection`
- `IcuChannelGroupStartTrigger`
- `IcuChannelGroupStopTrigger`
- `OcuStartTriggerSelect0`
- `OcuStartTriggerSelect1`
- `GptPredefTimerStartTriggerSelect`
- `GptInputTriggerSelection`

4.3.4 Container PwmGroupStartDelay

4.3.4.1 PwmGroupStartDelayTimer

Description

Specifies the physical hardware timer for PWM group start delay function.

Type

`EcucEnumerationParamDef`

Range

- `TCPWM_0_0`: Timer Counter Pulse Width Modulation Instance 0 Channel 0
- `TCPWM_0_1`: Timer Counter Pulse Width Modulation Instance 0 Channel 1
- …
- `TCPWM_1_0`: Timer Counter Pulse Width Modulation Instance 1 Channel 0
- `TCPWM_1_1`: Timer Counter Pulse Width Modulation Instance 1 Channel 1
- …
- `TCPWM_m_n`: Timer Counter Pulse Width Modulation Instance m Channel n

Note: The number of available physical hardware timer channels depend on the configured target derivative.

Remarks

`PwmGroupStartDelayTimer` must not use TCPWM channel that is used by `PwmTimer` and `PwmStartDelayTimer`.

GPT, ICU, OCU drivers, and OS use TCPWM channels. PWM driver must not use TCPWM channel that is used by other modules.

4.3.4.2 PwmGroupStartDelayMcuClockReferencePoint

Description

This parameter contains reference to `McuClockReferencePoint` for `PwmGroupStartDelayTimer`

Type

`EcucReferenceDef`

Remarks

The clock frequency of `PwmGroupStartDelayMcuClockReferencePoint` must be the same as `PwmMcuClockReferencePoint` of each channel in the group. The prescaler value `PwmChannelPrescale` of grouped channels must be same.

4.3.4.3 PwmGroupStartDelayTrigger

Description

Specifies the input trigger for PWM group start delay function. The input trigger is used to reserve switching of the output waveform after the delay time.

Type

`EcucEnumerationParamDef`

Range

- `TCPWM_0_TR_ALL_CNT_IN_0`: Input trigger 0 of TCPWM instance 0
- `TCPWM_0_TR_ALL_CNT_IN_1`: Input trigger 1 of TCPWM instance 0
- ...
- `TCPWM_1_TR_ALL_CNT_IN_0`: Input trigger 0 of TCPWM instance 1
- `TCPWM_1_TR_ALL_CNT_IN_1`: Input trigger 1 of TCPWM instance 1
- ...
- `TCPWM_m_TR_ALL_CNT_IN_n`: Input trigger n of TCPWM instance m

Note: *The number of available input triggers depends on the hardware resources.*

Remarks

PWM, ICU, GPT, and OCU drivers use input triggers of TCPWM.

An error occurs, if the value of the `P PwmGroupStartDelayTrigger` parameter is configured to be the same as that of the following parameters in the same configuration set:

- `PwmGroupStartDelayTrigger`
- `PwmStartDelayTrigger`

- `PwmChannelGroupStartTrigger`
- `PwmChannelGroupStopTrigger`
- `PwmChannelGroupSwitchEventTrigger`

An error occurs, if the value of the `PwmGroupStartDelayTrigger` parameter is configured to be the same as that of the following parameters:

- `PwmStartTriggerSelect0`
- `PwmStartTriggerSelect1`
- `IcuInputTriggerSelection`
- `IcuChannelGroupStartTrigger`
- `IcuChannelGroupStopTrigger`
- `OcuStartTriggerSelect0`
- `OcuStartTriggerSelect1`
- `GptPredefTimerStartTriggerSelect`
- `GptInputTriggerSelection`

4.3.5 Container PwmConfigurationOfOptApiServices

4.3.5.1 PwmSetOutputState

Description

Adds or removes the service `Pwm_SetChannelOutput()` from the code.

Type

`EcucBooleanParamDef`

4.3.5.2 PwmSetPrescaler

Description

Adds or removes the service `Pwm_SetPrescaler()` from the code.

Type

`EcucBooleanParamDef`

4.3.5.3 PwmSetTriggerDelay

Description

Adds or removes the service `Pwm_SetTriggerDelay()` from the code.

Type

`EcucBooleanParamDef`

4.3.5.4 PwmStopGroup

Description

Adds or removes the service `Pwm_StopGroupTrigger()` from the code.

Type

`EcucBooleanParamDef`

4.3.5.5 PwmSetOutputOffset

Description

Adds or removes the service `Pwm_SetOutputOffset()` from the code.

Type

`EcucBooleanParamDef`

4.3.5.6 PwmEnableDisableTriggerApi

Description

Adds or removes `Pwm_EnableTrigger()` and `Pwm_DisableTrigger()` from the code.

A configurable option called `PwmEnableDisableTriggerApi` which specifies whether the output trigger is enabled by `Pwm_Init()` is available

If the option `PwmEnableDisableTriggerApi` is set to `TRUE`, `Pwm_Init()` will not enable the output trigger.

If the option `PwmEnableDisableTriggerApi` is set to `FALSE`, `Pwm_Init()` will enable the output trigger.

Type

`EcucBooleanParamDef`

4.3.5.7 PwmSetDutyCycleBufferApi

Description

Adds or removes the `Pwm_SetDutyCycleBuffer()` service from the code. Default value is FALSE.

Type

`EcucBooleanParamDef`

4.3.5.8 PwmSetDutyAndChannelOutputBufferApi

Description

Adds or removes the `Pwm_SetDutyAndChannelOutputBuffer()` service from the code. Default value is FALSE.

Type

`EcucBooleanParamDef`

4.3.5.9 PwmSetChannelOutputBufferApi

Description

Adds or removes the `Pwm_SetChannelOutputBuffer()` service from the code. Default value is FALSE.

Type

`EcucBooleanParamDef`

4.3.6 Container PwmMulticore

4.3.6.1 PwmCoreConsistencyCheckEnable

Description

This parameter enables core consistency check during run-time. If enabled, Pwm function checks if provided parameter (channel, group) is allowed on the current core.

Type

`EcucBooleanParamDef`

Remarks

Development error detect shall be enabled in Pwm driver to enable this parameter.

4.3.6.2 PwmGetCoreIdFunction

Description

Specify the API to be called to get the core ID. E.g. `GetCoreID`.

Type

`EcucFunctionNameDef`

Remarks

`PwmGetCoreIdFunction` must be a valid C function name.

4.3.6.3 PwmMasterCoreReference

Description

Reference to the master core configuration.

Type

`EcucReferenceDef`

Remarks

`PwmMasterCoreReference` must have the target's `PwmCoreConfiguration` setting.

4.3.7 Container PwmCoreConfiguration

4.3.7.1 PwmCoreConfigurationId

Description

This is a zero-based, consecutive integer value. This is used as a logical core ID.

Type

`EcucIntegerParamDef`

Range

0..254

Remarks

`PwmCoreConfigurationId` must be unique across `PwmCoreConfiguration`.

4.3.7.2 PwmCoreId

Description

This is core ID assigned to PWM channels and groups. This ID is returned from the configured `PwmGetCoreIdFunction` execution to identify the executing core.

Type

`EcucIntegerParamDef`

Range

0..254

Remarks

`PwmCoreId` must be unique across `PwmCoreConfiguration`.

The combination of `PwmCoreConfigurationId` and `PwmCoreId` must be unique across `PwmCoreConfiguration`.

Note: *PwmCoreConfiguration can also be configured without PWM channel assignment.*

5 Functional description

5.1 Initialization

The PWM driver needs to be initialized once on each core before use. Initialization of the PWM driver is made by calling `Pwm_Init()`.

Note: *This PWM driver supports post-build-time configuration, thus different configuration set pointer can be passed to the function `Pwm_Init()`. `Pwm_Init()` must be called on the master core before any other cores are initialized. If `Pwm_Init()` is called on the satellite core, the master core must be already initialized. The same configuration set must be specified on all cores during initialization. If no channel is assigned to the satellite core, `Pwm_Init()` is not required on that core.*

No other function must be called before `Pwm_Init()` has been executed except `Pwm_GetChannelStatus()` and `Pwm_GetVersionInfo()`.

Not all necessary initializations are performed by the PWM driver. The PORT module needs to be called before the PWM driver is used. See 2.3 Adapting your application.

After initialization, all configured channels run with disabled notification.

If the configured default value for `PwmDutycycleDefault` results in a HW tick limit, the channel is appropriately forced into 0% or 100% duty. The HW constraints restrictions are forced into a constant output level. See 6 Hardware resources.

5.2 De-initialization

The PWM driver can be de-initialized once on each core after use. De-initialization of the PWM driver is made by calling `Pwm_DeInit()`.

Note: *`Pwm_DeInit()` must be called on the master core after all satellite cores are de-initialized. If `Pwm_DeInit()` is called on the satellite core, the master core must be already initialized. The integrated system must prevent other cores from calling the PWM API while `Pwm_DeInit()` is being called.*

5.3 Runtime reconfiguration

The PWM driver is not reconfigurable at runtime. The only way to change the driver's configuration is to stop all channels, de-initialize the driver, and reinitialize with a different configuration set.

5.4 PWM channel

The `PwmChannelId` defines the channel number to use. It specifies the PWM channel for which the service is done. A user-given symbolic name is available or generated for each configured channel. Use this symbolic name for API calls. APIs related to the resource must be executed on the core to which that resource is allocated.

5.5 PWM channel group

PWM channels can be organized in channel groups. The parameter `PwmChannelGroupId` defines the group which references the selected channels. Only configured channels can be assigned to a group and all referenced channels have the same `PwmCoreAssignment` setting. The channel groups can be triggered by using `Pwm_StartGroupTrigger()` and `Pwm_StopGroupTrigger()`.

A user-given symbolic name is available or generated for each configured channel group. Use this symbolic name for API calls.

5.6 Notification

Notification can be enabled or disabled by calling `Pwm_EnableNotification()` and `Pwm_DisableNotification()`.

Notifications are disabled by default after calling of `Pwm_Init()`.

Notification is disabled when a channel duty is 0% or 100%.

If the configured notification function name (`PwmNotification`) is blank or NULL, no notification function prototype is declared. Enabling and disabling is still possible, but no notification call is done by the PWM driver.

Note: *The notification can be disabled by calling `Pwm_DisableNotification` as mentioned in this chapter. However, it would not work with notifications that have already been handled, if `Pwm_DisableNotification` is called from a higher interruption during a few cycles before the user-defined notification function is called. The notification reason can be changed by the second argument of `Pwm_EnableNotification`. However, it would not work with notifications that have already been handled, if `Pwm_EnableNotification` is called from a higher interruption during a few cycles before the user-defined notification function is called.*

5.7 Stopping a channel

A channel can be stopped by calling `Pwm_SetOutputToIdle()`.

5.8 Starting a channel

After a channel is stopped it can be restarted by calling `Pwm_SetDutyCycle()` or `Pwm_SetPeriodAndDuty()` with new duty/period values.

Notification depends on the new duty value.

5.9 Updating a channel duty and period

A channel duty can be updated by calling `Pwm_SetDutyCycle()` or `Pwm_SetPeriodAndDuty()`.

A channel period can be updated by calling `Pwm_SetPeriodAndDuty()`.

Note: *A channel duty is updated immediately by calling `Pwm_SetDutyCycle()` when `PwmDutycycleUpdatedEndperiod` is `FALSE`. If not, the update is in sync with the end of period. A channel period and duty are updated immediate by calling `Pwm_SetPeriodAndDuty()` when `PwmPeriodUpdatedEndperiod` is `FALSE`. If not, the update is in sync with the end of period.*

5.10 Delaying PWM output

Start delay function is used to delay the output of a PWM with the configuration parameter `PwmChannelStartDelay`. There are two types of start delay functions.

- PWM channel start delay

  The PWM channel start delay function is configured by `PwmChannelStartDelay`, `PwmStartDelayTimer`, `PwmStartDelayMcuClockReferencePoint`, and `PwmStartDelayTrigger` in the `PwmChannel` container. It requires an additional TCPWM resource per PWM channel for the PWM start delay function.

  When the PWM start delay function is configured, the function `Pwm_Init()`, `Pwm_StartGroupTrigger()`, `Pwm_SetDutyCycle()`, or `Pwm_SetPeriodAndDuty()` starts the channel with a start delay value. When `PwmAlignment` is `PWM_LEFT_ALIGNED` and `PwmOutputOffset` is enabled, the output level during the start delay is at the `PwmPolarity` level. Other than that, the output level is inverse of the `PwmPolarity` level.

- PWM group start delay

  The PWM group start delay function is configured by `PwmChannelStartDelay` in the `PwmChannel` container, `PwmGroupStartDelayTimer`, `PwmGroupStartDelayMcuClockReferencePoint`, and `PwmGroupStartDelayTrigger` in the `PwmChannelGroup` container. It requires a TCPWM resource per PWM channel group for the PWM start delay function. The delay time can be configured by `PwmChannelStartDelay` for each PWM channel.

  When the PWM group start delay function is configured, the function `Pwm_Init()` or `Pwm_StartGroupTrigger()` start the grouped channels with a start delay value. The output level during the start delay is an inverse of the `PwmPolarity` level.

Note: *All PWM channels in a group need the same time base for the PWM group start delay function. If the frequency of `PwmGroupStartDelayMcuClockReferencePoint` and `PwmMcuClockReferencePoint` of each channel in the group do not match, an error occurs on EB tresos. If `PwmChannelPrescale` of the grouped channels is not the same, an error occurs on EB tresos. If the grouped channels have different prescaler values, `Pwm_StartGroupTrigger` reports the error code `PWM_E_DIFFERENT_PRESCALER`.*
All PWM channels in a group must have the same value for `PwmStartAtInit`.
`Pwm_SetDutyCycle` and `Pwm_SetPeriodAndDuty` start a stopped channel without the group start delay function.

Note: *PWM channels with the PWM channel start delay can belong to a PWM channel group, but if `PwmGroupStartDelay` is enabled in the PWM channel group, `PwmStartDelayTimer`, `PwmStartDelayMcuClockReferencePoint`, and `PwmStartDelayTrigger` in the `PwmChannel` container cannot be configured in the grouped channels. The start delay function works as the PWM group start delay.*

5.11 Triggering input to a channel group

A channel group can be triggered by calling `Pwm_StartGroupTrigger()`. The trigger will start all channels in the group simultaneously. The settings of the channels are not modified.

A channel group can be triggered by calling `Pwm_StopGroupTrigger()`. The trigger will stop all channels in the group simultaneously. The settings of the channels are not modified.

If `PwmStartAtInit` is set to `FALSE` or the channels is set to idle (e.g. using `Pwm_SetOutputToIdle()`), the channels are started by `Pwm_StartGroupTrigger()`. If the channels were already started, then the channels in the group will be re-triggered.

The group's channels specify their delay time via `PwmChannelStartDelay`.

5.12 Output trigger to peripherals

The PWM driver generates the output triggers to peripherals such as ADC channel at the timing configured by `PwmHwTriggerOutputDefaultTime` or `PwmHwTriggerOutputDefaultTick`.

The parameter `PwmHwTriggerOutputLine` allows the PWM channel to output trigger. The trigger signal should be configured by the PORT driver and target peripherals. Multiplexer-based trigger or One-to-One trigger is available for this function.

The value of this parameter specifies the output trigger of TCPWM as below:

- TR_OUT0: Output trigger 0
- TR_OUT1: Output trigger 1
- BOTH: Both output trigger 0 and 1

The available output trigger depends on the hardware.

5.13 Prescaler setting function

The PWM driver provides the prescaler setting function for PWM channel during runtime. This function is to maintain the same tick frequency of a channel by changing the prescaler setting without initialization when the input clock frequency for a channel is changed.

`Pwm_SetPrescaler()` changes the TCPWM prescaler setting of the selected channel according to the specified input clock frequency.

The PWM channel is stopped by calling `Pwm_SetPrescaler()`. If the PWM channel is in the running state before calling `Pwm_SetPrescaler()`, the PWM channel is restarted.

Input clock frequency of `PwmConf_PwmChannel_MY_CHANNEL` is changed by the MCU driver.

```
Pwm_SetPrescaler(PwmConf_PwmChannel_MY_CHANNEL, MY_CLOCK_FREQUENCY);
```

Note: *`Pwm_SetPrescaler()` calculates the prescaler value based on the value of the input clock frequency and tick frequency.*
Calculating formula: `MY_CLOCK_FREQUENCY` divided by tick frequency (Round down decimals).
The input frequency of the argument of `Pwm_SetPrescaler()` may cause a poor accuracy of tick duration. In that case, the frequency of input clock should be adjusted by the MCU driver to meet the prescaler value (1, 2, 4, 8, 16, 32, 64, 128).
1. The calculation result of input clock frequency divided by tick frequency does not meet the prescaler value (1, 2, 4, 8, 16, 32, 64, 128).
2. If the input clock frequency is close to the tick frequency, the appropriate prescaler value may not be set.

5.14 Retrieving status of a channel

The status of a channel can be assessed by calling `Pwm_GetChannelStatus()`. The internal register values are read out and correspondence between the software and hardware status is determined.

5.15 Sleep mode

The PWM module does not have a Sleep mode: therefore, the PWM channel should be stopped before MCU enters the Sleep mode.

Note: *All TCPWM counters must be stopped before entering DeepSleep mode with the following APIs.*

Pwm_DeInit(), Pwm_SetOutputToIdle(), or Pwm_StopGroupTrigger() if the channel group is configured.

5.16 API parameter checking

The driver's services perform regular error checks.

When an error occurs, the error hook routine (configured via `PwmErrorCalloutFunction`) is called and the error code, service ID, module ID, and instance ID are passed as parameters.

If development error detection is enabled, all errors are also reported to DET, a central error hook function within the AUTOSAR environment. The checking itself cannot be deactivated for safety reasons.

The following development error checks are performed by the services of the PWM driver:

- If one of the functions `Pwm_DeInit`, `Pwm_SetDutyCycle`, `Pwm_SetPeriodAndDuty`, `Pwm_SetOutputToIdle`, `Pwm_GetOutputState`, `Pwm_DisableNotification`, `Pwm_EnableNotification`, `Pwm_SetChannelOutput`, `Pwm_StartGroupTrigger`, `Pwm_StopGroupTrigger`, `Pwm_SetPrescaler`, `Pwm_SetOutputOffset`, `Pwm_SetTriggerDelay`, `Pwm_EnableTrigger`, `Pwm_DisableTrigger`, `Pwm_GetChannelStatus`, `Pwm_SetDutyCycleBuffer`, `Pwm_SetDutyAndChannelOutputBuffer`, or `Pwm_SetChannelOutputBuffer` is called before `Pwm_Init` is called, the error code `PWM_E_UNINIT` is reported.
- If the function `Pwm_GetChannelStatus` is called with abnormal configured data, the error code `PWM_E_UNINIT` is reported.
- If one of the functions `Pwm_SetDutyCycle`, `Pwm_SetPeriodAndDuty`, `Pwm_SetOutputToIdle`, `Pwm_GetOutputState`, `Pwm_DisableNotification`, `Pwm_EnableNotification`, `Pwm_DisableTrigger`, `Pwm_EnableTrigger`, `Pwm_SetChannelOutput`, `Pwm_SetOutputOffset`, `Pwm_SetTriggerDelay`, `Pwm_SetPrescaler`, `Pwm_GetChannelStatus`, `Pwm_SetDutyCycleBuffer`, `Pwm_SetDutyAndChannelOutputBuffer`, or `Pwm_SetChannelOutputBuffer` is called with an invalid parameter `ChannelNumber`, the error code `PWM_E_PARAM_CHANNEL` is reported.
- If the function `Pwm_SetPeriodAndDuty` is called and the period was configured as fixed, the error code `PWM_E_PERIOD_UNCHANGEABLE` is reported.
- If the function `Pwm_Init` is called on the master core when any cores are already initialized, the error code `PWM_E_ALREADY_INITIALIZED` is reported.
- If the function `Pwm_Init` is called on the satellite core when the satellite core is already initialized, the error code `PWM_E_ALREADY_INITIALIZED` is reported.
- If one of the functions `Pwm_GetVersionInfo` or `Pwm_GetChannelStatus` is called with NULL pointer, the error code `PWM_E_PARAM_POINTER` is reported.
- If one of the functions `Pwm_SetDutyCycle`, `Pwm_SetPeriodAndDuty`, `Pwm_SetDutyCycleBuffer`, or `Pwm_SetDutyAndChannelOutputBuffer` is called with an invalid duty parameter (Duty > 0x8000), the error code `PWM_E_DUTY_OUT_OF_RANGE` is reported.
- If the function `Pwm_SetPeriodAndDuty` is called with an invalid parameter `Period`, the error code `PWM_E_PERIOD_OUT_OF_RANGE` is reported.

- If the function `Pwm_EnableNotification` is called with an invalid parameter `Notification`, the error code `PWM_E_PARAM_NOTIFICATION` is reported.
- If the function `Pwm_Init` is called on the master core with an invalid parameter `ConfigPtr`, the error code `PWM_E_INIT_FAILED` is reported.
- If the function `Pwm_Init` is called on the satellite core when the master core is not initialized yet, the error code `PWM_E_INIT_FAILED` is reported.
- If the function `Pwm_Init` is called on the satellite core with a parameter `ConfigPtr` which is different from the initialized configuration of the master core, the error code `PWM_E_DEFFERENT_CONFIG` is reported.
- If the function `Pwm_StartGroupTrigger` or `Pwm_StopGroupTrigger` is called with an invalid group identifier, the error code `PWM_E_PARAM_GROUP` is reported.
- If the function `Pwm_StartGroupTrigger` is called with a group identifier which includes channels that do not have the same prescaler value, the error code `PWM_E_DIFFERENT_PRESCALER` is reported.
- If the function `Pwm_SetChannelOutput` is called with an invalid parameter `State`, the error code `PWM_E_PARAM_STATE` is reported.
- If the function `Pwm_SetDutyAndChannelOutputBuffer` or `Pwm_SetChannelOutputBuffer` is called with an invalid parameter LineState or LineCompState, the error code `PWM_E_PARAM_STATE` is reported.
- If the function `Pwm_SetOutputOffset` is called with an invalid parameter `OffsetTick`, the error code `PWM_E_PARAM_TICK` is reported.
- If the function `Pwm_SetTriggerDelay` is called with an invalid parameter `TriggerTicks`, the error code `PWM_E_PARAM_TICK` is reported.
- If the function `Pwm_SetPrescaler` is called with an invalid parameter `ClockFrequency`, the error code `PWM_E_PARAM_CLOCK` is reported.
- If one of the functions `Pwm_SetDutyCycle`, `Pwm_SetPeriodAndDuty`, `Pwm_SetOutputToIdle`, `Pwm_SetChannelOutput`, `Pwm_StartGroupTrigger`, `Pwm_StopGroupTrigger`, `Pwm_DisableTrigger`, `Pwm_EnableTrigger`, `Pwm_SetOutputOffset`, `Pwm_SetTriggerDelay`, `Pwm_SetPrescaler`, `Pwm_SetDutyCycleBuffer`, `Pwm_SetDutyAndChannelOutputBuffer`, or `Pwm_SetChannelOutputBuffer` is called with waiting trigger state, the error code `PWM_E_WAITING_TRIGGER` is reported.
- If the function `Pwm_SetChannelOutput` is called while channel is in idle state, the error code `PWM_E_IDLE` is reported.
- If the function `Pwm_Init` or `Pwm_DeInit` is called and the core ID is invalid, the error code `PWM_E_INVALID_CORE` is reported.
- If one of the functions `Pwm_DisableNotification`, `Pwm_EnableNotification`, `Pwm_DisableTrigger`, `Pwm_EnableTrigger`, `Pwm_SetDutyCycle`, `Pwm_SetOutputToIdle`, `Pwm_SetChannelOutput`, `Pwm_SetOutputOffset`, `Pwm_SetTriggerDelay`, `Pwm_SetPrescaler`, `Pwm_SetPeriodAndDuty`, `Pwm_InterruptHandler`, `Pwm_StartGroupTrigger`, `Pwm_StopGroupTrigger`, `Pwm_SetDutyCycleBuffer`, `Pwm_SetDutyAndChannelOutputBuffer`, or `Pwm_SetChannelOutputBuffer` is called from unexpected core, the function is executed on unexpected core, the error code `PWM_E_INVALID_CORE` is reported.
- If the function `Pwm_DeInit` is called from master core when not all cores are uninitialized, the error code `PWM_E_BUSY` is reported.

5.17 Configuration checking

The `PwmChannelId` defines the assignment of the channel to the physical PWM hardware channel. `PwmChannelId` and `PwmChannelGroupId` must be unique in the same configuration set.

5.18 Reentrancy

The following functions are reentrant if called on different channel numbers:

- `Pwm_SetDutyCycle()`
- `Pwm_SetPeriodAndDuty()`
- `Pwm_SetOutputToIdle()`
- `Pwm_GetOutputState()`
- `Pwm_DisableNotification()`
- `Pwm_EnableNotification()`
- `Pwm_GetChannelStatus()`
- `Pwm_SetChannelOutput()`
- `Pwm_SetPrescaler()`
- `Pwm_SetOutputOffset()`
- `Pwm_SetTriggerDelay()`
- `Pwm_EnableTrigger()`
- `Pwm_DisableTrigger()`
- `Pwm_SetDutyCycleBuffer()`
- `Pwm_SetDutyAndChannelOutputBuffer()`
- `Pwm_SetChannelOutputBuffer()`

Note: *The PWM module's user shall establish a mutual exclusion mechanism in case several function calls are made during run time in different tasks or ISRs targeting the same PWM channel.*

They are non-reentrant if called on the same channel number. The functions may be accessed by different tasks/interrupts simultaneously if the tasks/interrupts access disjunctive sets of channels. All parameters of `Pwm_GetChannelStatus()` have to be called by different values. `Pwm_GetVersionInfo()` is reentrant. `Pwm_Init()` and `Pwm_DeInit()` are not reentrant.

The following functions are reentrant if called on different channel numbers within different channel group numbers. They are non-reentrant if not.

- `Pwm_StartGroupTrigger()`
- `Pwm_StopGroupTrigger()`

5.19 Debugging support

The PWM driver does not support debugging.

5.20 Execution time dependencies

The execution time of certain API functions is dependent on certain factors. See Table 1 for details.

Table 1 Execution time dependencies

Affected function	Dependency

`Pwm_Init()`
`Pwm_DeInit()`
`Pwm_StartGroupTrigger()`
`Pwm_StopGroupTrigger()`
	Runtime depends on the number of configured channels and groups because all configured channels and groups are processed in these functions.

5.21 Functions available without core dependency

The following function is available on any core without any restriction:

- `Pwm_GetVersionInfo()`

The following functions are available on any cores with a specific section allocation described in the Note:

- `Pwm_GetOutputState()`
- `Pwm_GetChannelStatus()`

Note: *The section `VAR_[INIT_POLICY]_ASIL_B_GLOBAL_[ALIGNMENT]` must be allocated to the memory. This can be read from any cores to call the APIs on any cores.*
For the details of `INIT_POLICY` and `ALIGNMENT`, see the Specification of memory mapping [6].

6 Hardware resources

6.1 Ports and pins

To use the PWM driver, you should configure the following pins within the PORT driver first.

The following physical hardware needs to be configured for PWM channel: (m is instance number. n is channel number)

- `PwmTimer` = TCPWM_m_n

The PORT driver must be configured with the appropriate port pin:

- `PortPinName` = Pxxx_y for PWM pin
- `PortPinDirection` = PORT_PIN_OUT
- `PortPinInitialMode` = TCPWM_m_LINE_n
- `PortPinMode` = TCPWM_m_LINE_n (same as PortPinInitialMode)

The associated port pin for each PWM channel is subderivative dependent and see the hardware manual.

6.2 Timer

For each configured PWM channel, one hardware timer of the TRAVEO™ T2G family is reserved exclusively. This is done via configuration parameter `PwmTimer`.

6.3 Interrupts

The PWM driver uses the interrupts associated with the configured hardware resource. The ISR should be allocated to the same core as allocated resource. The ISR must be declared in the AUTOSAR OS as Category 1 Interrupt or Category 2 Interrupt.

Note: *IRQ numbers depend on the subderivative. See the hardware manual.*

You can define the ISR. The ISR is specified as:

The IRQ-Name of each PWM channel must be `Pwm_Isr_Vector_<IRQ No>_Cat1` for Category-1 ISR or `Pwm_Isr_Vector_<IRQ No>_Cat2` for Category-2 ISR.

Note: *`Pwm_Isr_Vector_<IRQ No>_Cat2` must be called from the (OS) interrupt service routine.*
In the case of Category-1 usage, the address of `Pwm_Isr_Vector_<IRQ No>_Cat1` must be the entry in the (OS) interrupt vector table.

Example: Category-1 ISR for the configured PWM Channel 0 located in the generated file *src/Pwm_Irq.c*:

```
ISR_NATIVE(Pwm_Isr_Vector_273_Cat1)
{
...
}
```

Example: Category-2 ISR for the configured PWM Channel 0 located in the generated file *src/Pwm_Irq.c*:

```
ISR(Pwm_Isr_Vector_273_Cat2)
{
  ...
  }
```

Note: *On the Arm® Cortex®-M4 CPU, priority inversion of interrupts may occur under specific timing conditions in the integrated system with TRAVEO™ T2G MCAL. For more details, see the following errata notice.*

Arm® Cortex®-M4 Software Developers Errata Notice - 838869:
"Store immediate overlapping exception return operation might vector to incorrect interrupt"

If the user application cannot tolerate the priority inversion, a DSB instruction should be added at the end of the interrupt function to avoid the priority inversion.

TRAVEO™ T2G MCAL interrupts are handled by an ISR wrapper (handler) in the integrated system. Thus, if necessary, the DSB instruction should be added just before the end of the handler by the integrator.

6.4 Triggers

In general, a trigger input signal indicates the completion of a peripheral action or a peripheral event. A trigger output signal initiates a peripheral action. There are two kinds of trigger groups: Trigger (Multiplexer-based trigger) group and trigger One-to-One group. Trigger group is a multiplexer-based connectivity group. This type connects a peripheral input trigger to multiple peripheral output triggers. Trigger One-to-One group is a One-to-One-based connectivity group. This type connects a peripheral input trigger to one specific peripheral output trigger.

For more detail about triggers, see hardware documentation [8].

PWM driver uses input/output trigger signal in the following cases:

- Triggering peripheral action

  PWM channel generates output trigger signal to peripherals. See 5.12 Output trigger to peripherals.

- Triggering input for timer synchronous start/stop or switching line state and complementary line state for `Pwm_SetDutyCycleBuffer`, `Pwm_SetDutyAndChannelOutputBuffer`, and `Pwm_SetChannelOutputBuffer` APIs

  A trigger multiplexer from CPUSS_ZERO to TCPWM channels should be configured in PORT driver.

  `PortOutputTrigger` configuration setting:

  - `PortTrOutputName`: Select trigger signal to all TCPWM (e.g. `TCPWM_0_TR_ALL_CNT_IN_8`).
  - `PortTrInputName`: Select trigger signal (e.g. `CPUSS_ZERO`)
  - `PortTrInvertEnable`: Disable
  - `PortTrSensitiveType`: `PORT_TR_SENSITIVE_EDGE`

- Debug capability to stop a timer channel

  A trigger multiplexer from CTI (Cross triggering interface) to TCPWM for each TCPWM instance should be configured in PORT driver.

  `PortOutputTrigger` configuration setting 1:

- `PortTrOutputName`: Select debug input trigger (e.g. `TR_GROUP_9_INPUT_1`)
- `PortTrInputName`: Select CTI signal (e.g. `CPUSS_CTI_TR_OUT_0`)
- `PortTrInvertEnable`: Disable
- `PortTrSensitiveType`: `PORT_TR_SENSITIVE_LEVEL`

`PortOutputTrigger` configuration setting 2:

- `PortTrOutputName`: `TCPWM_n_TR_DEBUG_FREEZE (n: TCPWM instance number)`
- `PortTrInputName`: Select debug output trigger (e.g. `TR_GROUP_9_OUTPUT_1`)
- `PortTrInvertEnable`: Disable
- `PortTrSensitiveType`: PORT_TR_SENSITIVE_LEVEL

• `PwmStartDelayTrigger settings`

A trigger multiplexer from TCPWM to TCPWM channel should be configured in PORT driver.

`PortOutputTrigger` configuration setting:

- `PortTrOutputName`: Select trigger signal (e.g. `TCPWM_0_TR_ALL_CNT_IN_1`).
- `PortTrInputName`: Select same instance number and channel number of `PwmStartDelayTimer` (e.g. `TCPWM_0_TR_OUT0_0`). If there are `OUT0` and `OUT1`, `OUT0` should be selected.
- `PortTrInvertEnable`: Disable
- `PortTrSensitiveType`: `PORT_TR_SENSITIVE_EDGE`

• `PwmGroupStartDelayTrigger` settings

A trigger multiplexer from TCPWM to TCPWM channel should be configured in PORT driver.

`PortOutputTrigger` configuration setting:

- `PortTrOutputName`: Select trigger signal (e.g. `TCPWM_0_TR_ALL_CNT_IN_1`).
- `PortTrInputName`: Select same instance number and channel number of `PwmGroupStartDelayTimer` (e.g. `TCPWM_0_TR_OUT0_0`). If `OUT0` and `OUT1 are available`, `OUT0` should be selected.
- `PortTrInvertEnable`: Disable
- `PortTrSensitiveType`: `PORT_TR_SENSITIVE_EDGE`

7 Appendix A – API reference

7.1 Include files

The Pwm.h file includes the necessary external identifiers. Thus, the application only needs to include Pwm.h to make all API functions and data types available.

7.2 Data types

7.2.1 Pwm_ChannelType

Type

```
uint16
```

Description

Defines the Channel Id of the PWM channel.

7.2.2 Pwm_PeriodType

Type

```
uint32
```

Description

Defines the period length in ticks. The period length can be up to 2^16 ticks. To use this type for calculation, it is extended to 32 bits.

7.2.3 Pwm_OutputStateType

Type

```
typedef enum
{
    PWM_LOW = 0,
    PWM_HIGH
}  Pwm_OutputStateType;
```

Description

Defines the output states of a PWM channel

7.2.4 Pwm_EdgeNotificationType

Type

```
typedef enum
{
    PWM_RISING_EDGE = 0,
    PWM_FALLING_EDGE,
    PWM_BOTH_EDGES
}  Pwm_EdgeNotificationType;
```

Description

Defines the edge notification states of a PWM channel

7.2.5 Pwm_ClkFrequencyType

Type

```
uint32
```

Description

Defines the clock frequency

The unit of this type is Hz

7.2.6 Pwm_ConfigType

Type

```
typedef struct
```

Description

Defines the type of data structure containing the initialization data for the PWM driver

7.2.7 Pwm_ChannelGroupType

Type

```
uint16
```

Description

Defines the ChannelGroup Id of the PWM channel group

7.2.8 Pwm_DriverStatusType

Type

```
typedef enum
{
    PWM_S_UNINITIALIZED = 0,
    PWM_S_INITIALIZED
}  Pwm_DriverStatusType;
```

Description

Defines the type of driver states

7.2.9 Pwm_ChannelStatusType

Type

```
typedef struct
{
    Pwm_PeriodType    PeriodTicks;
    Pwm_PeriodType      DelayTicks;
    Pwm_PeriodType      OutputOffsetTicks;
    Pwm_PeriodType      TriggerTicks;
    uint16              DutyCycle;
    Pwm_ChannelType     ChannelId;
    uint8               Prescaler;
    uint8               Status;
    boolean             NotificationEnabled;
    boolean             TriggerEnabled;
}  Pwm_ChannelStatusType;
```

Description

Holds the status parameters of a channel.

Note: For the value of status member, see Table 7. Status has multiple values.

7.2.10 Pwm_OutputLineStateType

Type

```
typedef enum
{
    PWM_LINESTATE_LOW = 0,
    PWM_LINESTATE_HIGH,
    PWM_LINESTATE_PWM,
    PWM_LINESTATE_PWM_INV,
    PWM_LINESTATE_HIGHZ
}  Pwm_OutputLineStateType;
```

Description

Defines the output line states of a PWM channel.

7.3 Constants

7.3.1 Error codes

A service may return one of the error codes, listed in Table 2, if development error detection is enabled.

Table 2 Error codes

Name	Value	Description
`PWM_E_INIT_FAILED`	0x10	API `Pwm_Init` service called with wrong parameter.
`PWM_E_UNINIT`	0x11	API service used without module initialization.
`PWM_E_PARAM_CHANNEL`	0x12	API service used with an invalid channel identifier.

Name	Value	Description
`PWM_E_PERIOD_UNCHANGEABLE`	0x13	Usage of unauthorized PWM service on PWM channel configured a fixed period.
`PWM_E_ALREADY_INITIALIZED`	0x14	API `Pwm_Init` service called, but module is already initialized.
`PWM_E_PARAM_POINTER`	0x15	API service is called with a NULL parameter.
`PWM_E_NOT_DISENGAGED`	0x16	API `Pwm_SetPowerState` is called while the PWM module is still in use.
`PWM_E_POWER_STATE_NOT_SUPPORTED`	0x17	The requested power state is not supported by the PWM module.
`PWM_E_TRANSITION_NOT_POSSIBLE`	0x18	The requested power state is not reachable from the current one.
`PWM_E_PERIPHERAL_NOT_PREPARED`	0x19	API `Pwm_SetPowerState` has been called without having called the API `Pwm_PreparePowerState` before.
`PWM_E_WAITING_TRIGGER`	0x52	API service is called when waiting trigger.
`PWM_E_IDLE`	0x53	API service is called while channel is in idle state.
`PWM_E_PARAM_STATE`	0x54	Invalid channel state.
`PWM_E_DUTY_OUT_OF_RANGE`	0x55	Duty value argument greater than 0x8000.
`PWM_E_PERIOD_OUT_OF_RANGE`	0x56	Period value argument out of range.
`PWM_E_PARAM_GROUP`	0x57	API service used with an invalid group identifier.
`PWM_E_PARAM_NOTIFICATION`	0x58	API service used with an invalid notification type.
`PWM_E_PARAM_TICK`	0x59	Timer tick value is out of range.
`PWM_E_PARAM_CLOCK`	0x60	Clock frequency is out of range.
`PWM_E_DIFFERENT_PRESCALER`	0x61	Specified grouped channels have different prescaler values when `PwmGroupStartDelay` is enabled.
`PWM_E_INVALID_CORE`	0x62	API called with parameter which does not belong to this core.
`PWM_E_DIFFERENT_CONFIG`	0x63	Intended configuration initialization of this core does not match to the initialized configuration of other cores.
`PWM_E_BUSY`	0x64	API service is called when any satellite cores are working.

7.3.2 Version information

The version information listed in Table 3 is published in the driver's header file:

Table 3 Version information

Name	Value	Description
`PWM_AR_RELEASE_MAJOR_VERSION`	4	Major version number (AUTOSAR)
`PWM_AR_RELEASE_MINOR_VERSION`	2	Minor version number (AUTOSAR)
`PWM_AR_RELEASE_REVISION_VERSION`	2	Patch version number (AUTOSAR)

Name	Value	Description
`PWM_SW_MAJOR_VERSION`	See release notes	Vendor specific major version number
`PWM_SW_MINOR_VERSION`	See release notes	Vendor specific minor version number
`PWM_SW_PATCH_VERSION`	See release notes	Vendor specific patch version number

7.3.3 Module information

Table 4 Module information

Name	Value	Description
`PWM_MODULE_ID`	121	Module ID (`Pwm`)
`PWM_VENDOR_ID`	66	Vendor ID

7.3.4 API service IDs

Table 5 API service IDs

Name	Value	API name
`PWM_API_INIT`	0x0	`Pwm_Init`
`PWM_API_DEINIT`	0x1	`Pwm_DeInit`
`PWM_API_SETDUTYCYCLE`	0x2	`Pwm_SetDutyCycle`
`PWM_API_SETPERIODANDDUTY`	0x3	`Pwm_SetPeriodAndDuty`
`PWM_API_SETOUTPUTTOIDLE`	0x4	`Pwm_SetOutputToIdle`
`PWM_API_GETOUTPUTSTATE`	0x5	`Pwm_GetOutputState`
`PWM_API_DISABLENOTIFICATION`	0x6	`Pwm_DisableNotification`
`PWM_API_ENABLENOTIFICATION`	0x7	`Pwm_EnableNotification`
`PWM_API_GETVERSIONINFO`	0x8	`Pwm_GetVersionInfo`
`PWM_API_SETPOWERSTATE`	0x9	`Pwm_SetPowerState`
`PWM_API_GETCURRENTPOWERSTATE`	0xA	`Pwm_GetCurrentPowerState`
`PWM_API_GETTARGETPOWERSTATE`	0xB	`Pwm_GetTargetPowerState`
`PWM_API_PREPAREPOWERSTATE`	0xC	`Pwm_PreparePowerState`
`PWM_API_MAIN_POWERTRANSITIONMANAGER`	0xD	`Pwm_Main_PowerTransitionManager`
`PWM_API_GETCHANNELSTATUS`	0x20	`Pwm_GetChannelStatus`
`PWM_API_INTERRUPTHANDLER`	0x40	`Pwm_InterruptHandler`
`PWM_API_STARTGROUPTRIGGER`	0x41	`Pwm_StartGroupTrigger`
`PWM_API_STOPGROUPTRIGGER`	0x42	`Pwm_StopGroupTrigger`
`PWM_API_SETCHANNELOUTPUT`	0x43	`Pwm_SetChannelOutput`
`PWM_API_SETPRESCALER`	0x44	`Pwm_SetPrescaler`
`PWM_API_SETOUTPUTOFFSET`	0x45	`Pwm_SetOutputOffset`
`PWM_API_SETTRIGGERDELAY`	0x46	`Pwm_SetTriggerDelay`
`PWM_API_ENABLETRIGGER`	0x47	`Pwm_EnableTrigger`
`PWM_API_DISABLETRIGGER`	0x48	`Pwm_DisableTrigger`
`PWM_API_SETDUTYCYCLEBUFFER`	0x49	`Pwm_SetDutyCycleBuffer`

Name	Value	API name
PWM_API_SETCHANNELOUTPUTBUFFER	0x4A	Pwm_SetChannelOutputBuffer
PWM_API_SETDUTYCHANNELOUTPUTBUFFER	0x4B	Pwm_SetDutyAndChannelOutputBuffer

7.3.5 Symbolic names

Table 6 Symbolic names

Name	Description
PwmConf_PwmChannel_<n>	Symbolic name for PWM channel *n* (n is channel's short name).
PwmConf_PwmChannelGroup_<n>	Symbolic name for PWM group *n* (n is channel group's short name).
PwmConf_[Config Set]_PwmPeriodDefault_<n>	Symbolic name for the ticks value of the default period of PWM channel *n* (n is channel's short name) in *Config Set* (Config Set is configuration set's short name).
PwmConf_PwmChannelConfigSet_[Config Set]	Symbolic names for PWM *Config Set* (Config Set is configuration set's short name).

7.3.6 Channel status values

Table 7 Channel status values

Name	Value	API name
PWM_CH_COND_TIMER_DISABLED	0x1	The PWM channel timer is OFF.
PWM_CH_COND_TIMER_ENABLED	0x2	The PWM channel timer is ON.
PWM_CH_COND_IDLE_LOW	0x4	The PWM channel timer is in idle state LOW.
PWM_CH_COND_IDLE_HIGH	0x8	The PWM channel timer is in idle state HIGH.
PWM_CH_COND_WAIT_HWTRIGGER	0x10	The PWM channel timer has been started and is waiting for HW trigger.
PWM_CH_COND_WAIT_UPDATE	0x20	The PWM channel timer has been started and is waiting for an update.

7.3.7 Invalid core ID value

Table 8 Invalid core ID

Name	Value	Description
PWM_INVALID_CORE	255	Invalid core ID.

7.4 Functions

7.4.1 Pwm_Init

Syntax

```
void Pwm_Init
(
   const Pwm_ConfigType* ConfigPtr
)
```

Service ID

0x0

Parameters (in)

`ConfigPtr` - Pointer to the configuration set.

Parameters (out)

None

Return value

None

DET errors

- `PWM_E_ALREADY_INITIALIZED` - The routine `Pwm_Init()` is called on the master core while any cores are already initialized or the routine `Pwm_Init()` is called on the satellite core while the satellite core is already initialized.
- `PWM_E_INIT_FAILED` - The routine `Pwm_Init()` is called on the master core with an invalid parameter `ConfigPtr` or the routine `Pwm_Init()` is called on the satellite core while the master core is not initialized yet.
- `PWM_E_INVALID_CORE` - The core ID is invalid.
- `PWM_E_DIFFERENT_CONFIG` - The routine `Pwm_Init()` is called on the satellite core with a parameter ConfigPtr which is different from the initialized configuration of the master core.

DEM errors

None

Description

`Pwm_Init()` is a service for PWM initialization.

Note: *This service only affects PWM channels assigned to the current core.*

7.4.2 Pwm_DeInit

Syntax

```
void Pwm_DeInit
(
   void
)
```

Service ID

0x1

Parameters (in)

None

Parameters (out)

None

Return value

None

DET errors

- `PWM_E_UNINIT` - Driver is not yet initialized.
- `PWM_E_BUSY` - All satellite core is not uninitialized when the service is called on the master core.
- `PWM_E_INVALID_CORE` - The core ID is invalid.

DEM errors

None

Description

`Pwm_DeInit()` is a service for PWM deinitialization. It disables all PWM interrupts and notifications and sets the PWM output signals to idle level as specified in configuration data.

Note: *This service only affects PWM channels assigned to the current core.*

7.4.3 Pwm_SetDutyCycle

Syntax

```
void Pwm_SetDutyCycle
(
   Pwm_ChannelType ChannelNumber,
   uint16 DutyCycle
)
```

Service ID

0x2

Parameters (in)

- `ChannelNumber` - Numeric identifier of the PWM channel.
- `DutyCycle` - Duty cycle time.

Parameters (out)

None

Return value

None

DET errors

- `PWM_E_UNINIT` - Driver is not yet initialized.
- `PWM_E_DUTY_OUT_OF_RANGE` - The passed duty cycle is out of range.
- `PWM_E_PARAM_CHANNEL` - ChannelNumber is invalid.
- `PWM_E_WAITING_TRIGGER` - The channel is waiting trigger.
- `PWM_E_INVALID_CORE` - The current core and channel assignment core are different. The core ID is invalid.

DEM errors

None

Description

`Pwm_SetDutyCycle()` sets the duty cycle of the PWM channel.

If the parameter `DutyCycle` of `Pwm_SetDutyCycle()` is 0x0000 == 0%, the PWM output state is negated `PwmPolarity`. If the parameter `DutyCycle` of `Pwm_SetDutyCycle()` is 0x8000 == 100%, the PWM output state is active level (`PwmPolarity`).

If the parameter `DutyCycle` of `Pwm_SetDutyCycle()` is > 0% and < 100%, the PWM output is in active state according to duty cycle and period parameters.

Note: *If this function is called while the value of `Status` of `Pwm_ChannelStatusType` has `PWM_CH_COND_WAIT_UPDATE`, the channel behavior depends on the configuration parameter `PwmMultipleUpdateInPeriod`.*

7.4.4 Pwm_SetPeriodAndDuty

Syntax

```
void Pwm_SetPeriodAndDuty
(
    Pwm_ChannelType ChannelNumber,
    Pwm_PeriodType Period,
    uint16 DutyCycle
)
```

Service ID

0x3

Parameters (in)

- `ChannelNumber` - Numeric identifier of the PWM channel.
- `Period` - Period time in ticks. The minimum value depends on `PwmHwTriggerOutputDefaultTime` (if configured). The maximum value is 65534.
- `DutyCycle` - Duty cycle time. The value is interpreted in the same way as by `Pwm_SetDutyCycle()`.

Parameters (out)

None

Return value

None

DET errors

- `PWM_E_UNINIT` - Driver is not yet initialized.
- `PWM_E_PERIOD_UNCHANGEABLE` - PWM channel is not declared as a variable period type.
- `PWM_E_PARAM_CHANNEL` - `ChannelNumber` is invalid.
- `PWM_E_DUTY_OUT_OF_RANGE` - The passed duty cycle is out of range.
- `PWM_E_PERIOD_OUT_OF_RANGE` - The passed period is out of range.
- `PWM_E_WAITING_TRIGGER` - The channel is waiting trigger.
- `PWM_E_INVALID_CORE` - The current core and channel assignment core are different. The core ID is invalid.

DEM errors

None

Description

`Pwm_SetPeriodAndDuty()` sets the period and the duty cycle of a PWM channel.

If the parameter `DutyCycle` of `Pwm_SetPeriodAndDuty()` is 0x0000 == 0%, the PWM output state is negated `PwmPolarity`. If the parameter `DutyCycle` of `Pwm_SetDutyCycle()` is 0x8000 == 100%, the PWM output state is active level (`PwmPolarity`).

If the parameter `DutyCycle` of `Pwm_SetPeriodAndDuty()` is > 0% and < 100%, the PWM output is in active state according to duty cycle and period parameters.

The period can only be updated, if the channel is configured to variable period and if the parameter period of `Pwm_SetPeriodAndDuty()` is >= 0 and <= 65534. If the parameter period is zero, the hardware is set to its minimum period of one tick. The setting of the duty-cycle is not relevant in this case; the output is set to zero percent duty-cycle.

Since the hardware's minimum period is one tick, the parameter period's value of '0' or '1' set the same frequency.

If the parameter `PwmHwTriggerOutputScaled` is enabled, the delay of output trigger is scaled with the period by `Pwm_SetPeriodAndDuty()`.

If the parameter `PwmOutputOffsetScaled` is enabled, the rising edge offset is scaled with the period by `Pwm_SetPeriodAndDuty()`.

Note: *If this function is called while the value of `Status` of `Pwm_ChannelStatusType` has `PWM_CH_COND_WAIT_UPDATE`, the channel behavior depends on the configuration parameter `PwmMultipleUpdateInPeriod`.*

7.4.5 Pwm_SetOutputToIdle

Syntax

```
void Pwm_SetOutputToIdle
(
   Pwm_ChannelType ChannelNumber
)
```

Service ID

0x4

Parameters (in)

`ChannelNumber` - Numeric identifier of the PWM channel.

Parameters (out)

None

Return value

None

DET errors

- `PWM_E_UNINIT` - Driver is not yet initialized.
- `PWM_E_PARAM_CHANNEL` - `ChannelNumber` is invalid.
- `PWM_E_WAITING_TRIGGER` - The channel is waiting trigger.
- `PWM_E_INVALID_CORE` - The current core and channel assignment core are different. The core ID is invalid.

DEM errors

None

Description

`Pwm_SetOutputToIdle()` sets the PWM output state to the `PwmIdleState` level.

7.4.6 Pwm_GetOutputState

Syntax

```
Pwm_OutputStateType Pwm_GetOutputState
(
   Pwm_ChannelType ChannelNumber
)
```

Service ID

0x5

Parameters (in)

`ChannelNumber` - Numeric identifier of the PWM channel.

Parameters (out)

None

Return value

- `PWM_LOW` - Either PWM output level is low or a development error has occurred.
- `PWM_HIGH` - PWM output level is high.

DET errors

- `PWM_E_UNINIT` - Driver is not yet initialized.
- `PWM_E_PARAM_CHANNEL` - `ChannelNumber` is invalid.

DEM errors

None

Description

`Pwm_GetOutputState()` shall read the PWM output signal level and return it.

Note: *There is a possibility of returning to the previous state when `PwmDutycycleUpdatedEndperiod` is `TRUE` and this API is called immediately after executing `Pwm_SetDutyCycle()`.*
There is a possibility of returning to the previous state when `PwmPeriodUpdatedEndperiod` is `TRUE` and this API is called immediately after executing `Pwm_SetPeriodAndDuty()`.
If the value of those executed APIs is necessary, wait for the next period.

7.4.7 Pwm_DisableNotification

Syntax

```
void Pwm_DisableNotification
(
   Pwm_ChannelType ChannelNumber
)
```

Service ID

0x6

Parameters (in)

`ChannelNumber` - Numeric identifier of the PWM channel.

Parameters (out)

None

Return value

None

DET errors

- `PWM_E_UNINIT` - Driver is not yet initialized.
- `PWM_E_PARAM_CHANNEL` - `ChannelNumber` is invalid.
- `PWM_E_INVALID_CORE` - The current core and channel assignment core are different. The core ID is invalid.

DEM errors

None

Description

This service disables the PWM signal edge notification.

7.4.8 Pwm_EnableNotification

Syntax

```
void Pwm_EnableNotification
(
   Pwm_ChannelType ChannelNumber,
   Pwm_EdgeNotificationType Notification
)
```

Service ID

0x7

Parameters (in)

- `ChannelNumber` - Numeric identifier of the PWM channel.
- `Notification` - Type of notification edge can be `PWM_RISING_EDGE`, `PWM_FALLING_EDGE`, or `PWM_BOTH_EDGE`.

Parameters (out)

None

Return value

None

DET errors

- `PWM_E_UNINIT` - Driver is not yet initialized.
- `PWM_E_PARAM_CHANNEL` - `ChannelNumber` is invalid.
- `PWM_E_PARAM_NOTIFICATION` - `Notification` is invalid.
- `PWM_E_INVALID_CORE` - The current core and channel assignment core are different. The core ID is invalid.

DEM errors

None

Description

This service enables the PWM signal edge notification according to parameter `Notification`.

7.4.9 Pwm_GetVersionInfo

Syntax

```
void Pwm_GetVersionInfo
(
  Std_VersionInfoType* versioninfo
)
```

Service ID

0x8

Parameters (in)

None

Parameters (out)

`versioninfo` - Pointer to the location where the version information of this module is stored.

Return value

None

DET errors

- `PWM_E_PARAM_POINTER` - `versioninfo` is NULL pointer.

DEM errors

None

Description

This service returns the version information of this module.

7.4.10 Pwm_GetChannelStatus

Syntax

```
Std_ReturnType Pwm_GetChannelStatus
(
  Pwm_DriverStatusType* DriverStatusPtr,
  Pwm_ChannelStatusType* ChannelStatusPtr,
  Pwm_ChannelType ChannelNumber
)
```

Service ID

0x20

Parameters (in)

`ChannelNumber` - Numeric identifier of the PWM channel.

Parameters (out)

`DriverStatusPtr` - Pointer of driver status data.

`ChannelStatusPtr` - Pointer to where to store the channel status parameters.

Return value

- `E_OK` - Software and hardware states are in sync.
- `E_NOT_OK` - Software and hardware states are inconsistent.

DET errors

- `PWM_E_PARAM_CHANNEL` - `ChannelNumber` is invalid.
- `PWM_E_PARAM_POINTER` - API service is called with a NULL parameter.
- `PWM_E_UNINIT` - Configured data is abnormal.

DEM errors

None

Description

`Pwm_GetChannelStatus()` reads out internal registers and checks consistency of the software and hardware status.

This is a vendor-specific function.

Note: *`Pwm_GetChannelStatus()` may return `E_NOT_OK` if the hardware status has not yet changed to the running after `Pwm_Init()`, `Pwm_SetDutyCycle()`, `Pwm_SetPeriodAndDuty()`, and `Pwm_StartGroupTrigger()` for the stopped channel.*
`Pwm_GetChannelStatus()` also may return `E_NOT_OK` if the hardware status has not yet changed to the running after `Pwm_DisableTrigger()`, `Pwm_EnableTrigger()`, `Pwm_SetDutyCycle()`, `Pwm_SetPeriodAndDuty()`, `Pwm_SetOutputOffset()`, `Pwm_SetTriggerDelay()`, `Pwm_SetPrescaler()` for the running channel.
It may occur when the tick frequency of the PWM channel is very slow.
If this API returned `E_NOT_OK`, retry after waiting for one tick time of the PWM timer.

7.4.11 Pwm_StartGroupTrigger

Syntax

```
void Pwm_StartGroupTrigger
(
  Pwm_ChannelGroupType ChannelGroupNumber
)
```

Service ID

0x41

Parameters (in)

`ChannelGroupNumber` - Numeric identifier of the PWM channel group.

Parameters (out)

None

Return value

None

DET errors

- `PWM_E_UNINIT` - Driver is not yet initialized.
- `PWM_E_PARAM_GROUP` - `ChannelGroupNumber` is invalid.
- `PWM_E_WAITING_TRIGGER` - The channel is waiting trigger.
- `PWM_E_DIFFERENT_PRESCALER` – Specified grouped channels have different prescaler values when `PwmGroupStartDelay` is enabled.
- `PWM_E_INVALID_CORE` - The current core and channel assignment core are different. The core ID is invalid.

DEM errors

None

Description

`Pwm_StartGroupTrigger()` starts the output by the channel group.

This is a vendor-specific function!

7.4.12 Pwm_StopGroupTrigger

Syntax

```
void Pwm_StopGroupTrigger
(
  Pwm_ChannelGroupType ChannelGroupNumber
)
```

Service ID

0x42

Parameters (in)

`ChannelGroupNumber` - Numeric identifier of the PWM channel group.

Parameters (out)

None

Return value

None

DET errors

- `PWM_E_UNINIT` - Driver is not yet initialized.
- `PWM_E_PARAM_GROUP` - ChannelGroupNumber is invalid.
- `PWM_E_WAITING_TRIGGER` - The channel is waiting trigger.

- `PWM_E_INVALID_CORE` - The current core and channel assignment core are different. The core ID is invalid.

DEM errors

None

Description

`Pwm_StopGroupTrigger()` stops the output by the channel group. `Pwm_StopGroupTrigger()` sets the PWM output state to the `PwmIdleState` level for each channel.

This is a vendor-specific function.

7.4.13 Pwm_SetChannelOutput

Syntax

```
void Pwm_SetChannelOutput
(
  Pwm_ChannelType ChannelNumber,
  Pwm_OutputStateType State
)
```

Service ID

0x43

Parameters (in)

- `ChannelNumber` - Numeric identifier of the PWM channel.
- `State` - PWM output state.

Parameters (out)

None

Return value

None

DET errors

- `PWM_E_UNINIT` - Driver is not yet initialized.
- `PWM_E_PARAM_CHANNEL` - `ChannelNumber` is invalid.
- `PWM_E_PARAM_STATE` - State is invalid.
- `PWM_E_WAITING_TRIGGER` - The channel is waiting trigger.
- `PWM_E_IDLE` - The channel is idle state.
- `PWM_E_INVALID_CORE` - The current core and channel assignment core are different. The core ID is invalid.

DEM errors

None

Description

`Pwm_SetChannelOutput()` sets the PWM output to the specified state.

This is a vendor-specific function.

Note: *If the specified channel is called by the `Pwm_SetChannelOutput` API at the end of the period in the waiting update state, the output waveform might be disturbed.*

In the following cases, the channel is set to the waiting update state (`PWM_CH_COND_WAIT_UPDATE`) until the next period.

- Calling `Pwm_SetTriggerDelay`, `Pwm_SetOutputOffset` or `Pwm_SetChannelOutput`
- Calling `Pwm_Init` or `Pwm_StartGroupTrigger` with any start delay configured channel
- Calling `Pwm_SetPeriodAndDuty` (`PwmPeriodUpdatedEndperiod` is TRUE)
- Calling `Pwm_SetDutyCycle` (`PwmDutycycleUpdatedEndperiod` is TRUE)

Workaround:
Call the `Pwm_SetChannelOutput` API after the next period.

7.4.14 Pwm_SetPrescaler

Syntax

```
void Pwm_SetPrescaler
(
  Pwm_ChannelType ChannelNumber,
  Pwm_ClkFrequencyType ClockFrequency
)
```

Service ID

0x44

Parameters (in)

- `ChannelNumber` - Numeric identifier of the PWM channel.
- `ClockFrequency` - Input clock frequency.

Parameters (out)

None

Return value

None

DET errors

- `PWM_E_UNINIT` - Driver is not yet initialized.
- `PWM_E_PARAM_CHANNEL` - `ChannelNumber` is invalid.
- `PWM_E_PARAM_CLOCK` - `ClockFrequency` is invalid.
- `PWM_E_WAITING_TRIGGER` - The channel is waiting trigger.
- `PWM_E_INVALID_CORE` - The current core and channel assignment core are different. The core ID is invalid.

DEM errors

None

Description

`Pwm_SetPrescaler()` sets prescaler for the specified channel.

This is a vendor-specific function.

Note: *If this function is called while the value of `Status` of `Pwm_ChannelStatusType` has `PWM_CH_COND_TIMER_ENABLED`, the channel is restarted and `PwmChannelStartDelay` is canceled.*

7.4.15 Pwm_SetOutputOffset

Syntax

```
void Pwm_SetOutputOffset
(
  Pwm_ChannelType ChannelNumber,
  Pwm_PeriodType OffsetTick
)
```

Service ID

0x45

Parameters (in)

- `ChannelNumber` - Numeric identifier of the PWM channel.
- `OffsetTick` - Offset time for PWM output. The maximum value is 65533 at the period maximum value (65534).

Parameters (out)

None

Return value

None

DET errors

- `PWM_E_UNINIT` - Driver is not yet initialized.
- `PWM_E_PARAM_CHANNEL` - `ChannelNumber` is invalid or `PwmOutputOffset` is disabled.
- `PWM_E_PARAM_TICK` - `OffsetTick` is invalid.
- `PWM_E_WAITING_TRIGGER` - The channel is waiting trigger.
- `PWM_E_INVALID_CORE` - The current core and channel assignment core are different. The core ID is invalid.

DEM errors

None

Description

`Pwm_SetOutputOffset()` sets offset the PWM duty output.

This is a vendor-specific function.

Note: *If this function is called while the value of `Status` of `Pwm_ChannelStatusType` has `PWM_CH_COND_WAIT_UPDATE`, the channel behavior depends on the configuration parameter `PwmMultipleUpdateInPeriod`.*
`OffsetTick` can set the value from 0 to (period ticks - duty ticks - 1) when duty is not 0% nor 100%.
`OffsetTick` can set the value from 0 to (period ticks - 1) when duty is 0% or 100%.

7.4.16 Pwm_SetTriggerDelay

Syntax

```
void Pwm_SetTriggerDelay
(
  Pwm_ChannelType ChannelNumber,
  Pwm_PeriodType TriggerTicks
)
```

Service ID

0x46

Parameters (in)

- `ChannelNumber` - Numeric identifier of the PWM channel.
- `TriggerTicks` - Delay ticks for the output trigger. The maximum value is 65534 at the period maximum value (65534).

Parameters (out)

None

Return value

None

DET errors

- `PWM_E_UNINIT` - Driver is not yet initialized.
- `PWM_E_PARAM_CHANNEL` - `ChannelNumber` is invalid or `PwmOutputOffset` is enabled.
- `PWM_E_PARAM_TICK` - `TriggerTicks` is invalid.
- `PWM_E_WAITING_TRIGGER` - The channel is waiting trigger.
- `PWM_E_INVALID_CORE` - The current core and channel assignment core are different. The core ID is invalid.

DEM errors

None

Description

`Pwm_SetTriggerDelay()` sets delay ticks for the output trigger.

This is a vendor-specific function.

Note: *If this function is called while the value of `Status` of `Pwm_ChannelStatusType` has `PWM_CH_COND_WAIT_UPDATE`, the channel behavior depends on the configuration parameter `PwmMultipleUpdateInPeriod`.*

7.4.17 Pwm_EnableTrigger

Syntax

```
void Pwm_EnableTrigger
(
  Pwm_ChannelType ChannelNumber
)
```

Service ID

0x47

Parameters (in)

`ChannelNumber` - Numeric identifier of the PWM channel.

Parameters (out)

None

Return value

None

DET errors

- `PWM_E_UNINIT` - Driver is not yet initialized.
- `PWM_E_PARAM_CHANNEL` - `ChannelNumber` is invalid.
- `PWM_E_WAITING_TRIGGER` - The channel is waiting trigger.
- `PWM_E_INVALID_CORE` - The current core and channel assignment core are different. The core ID is invalid.

DEM errors

None

Description

`Pwm_EnableTrigger()` enables the output trigger on the specified channel.

This is a vendor-specific function.

Note: *If this function is called while the value of `Status of Pwm_ChannelStatusType` has `PWM_CH_COND_TIMER_ENABLED`, the channel is restarted and `PwmChannelStartDelay` is canceled.*

7.4.18 Pwm_DisableTrigger

Syntax

```
void Pwm_DisableTrigger
(
  Pwm_ChannelType ChannelNumber
)
```

Service ID

0x48

Parameters (in)

`ChannelNumber` - Numeric identifier of the PWM channel.

Parameters (out)

None

Return value

None

DET errors

- `PWM_E_UNINIT` - Driver is not yet initialized.
- `PWM_E_PARAM_CHANNEL` - `ChannelNumber` is invalid.
- `PWM_E_WAITING_TRIGGER` - The channel is waiting trigger.
- `PWM_E_INVALID_CORE` - The current core and channel assignment core are different. The core ID is invalid.

DEM errors

None

Description

`Pwm_DisableTrigger()` disables the output trigger on the specified channel.

This is a vendor-specific function.

Note: *If this function is called while the value of `Status of Pwm_ChannelStatusType` has `PWM_CH_COND_TIMER_ENABLED`, the channel is restarted and `PwmChannelStartDelay` is canceled.*

7.4.19 Pwm_SetDutyCycleBuffer

Syntax

```
void Pwm_SetDutyCycleBuffer
(
  Pwm_ChannelType ChannelNumber,
  uint16 DutyCycle
)
```

Service ID

- 0x49

Parameters (in)

- `ChannelNumber` - Numeric identifier of the PWM channel.
- `DutyCycle` - Duty cycle time.

Parameters (out)

None

Return value

None

DET errors

- `PWM_E_UNINIT` - Driver is not yet initialized.
- `PWM_E_PARAM_CHANNEL` - `ChannelNumber` is invalid.
- `PWM_E_DUTY_OUT_OF_RANGE` - The passed duty cycle is out of range.
- `PWM_E_WAITING_TRIGGER` - The channel is waiting for the trigger.
- `PWM_E_INVALID_CORE` - The current core and channel assignment core are different. The core ID is invalid.

DEM errors

None

Description

`Pwm_SetDutyCycleBuffer()` prepares to change the duty cycle of the PWM channel. The line state and complementary line state are retained. To change to this setting, call the `Port_ActTrigger` API after this API.

This is a vendor-specific function.

Note: *Do not call `Pwm_SetDutyCycleBuffer()` and following APIs in the same period: `Pwm_SetPeriodAndDuty`, `Pwm_SetDutyCycle`, `Pwm_SetChannelOutput`, `Pwm_SetOutputOffset`, `Pwm_SetTriggerDelay`.*

Note: *If this function is called again after the `Port_ActTrigger API` has been called and before the end of the period, the result is not guaranteed.*

Note: *Call the `Port_ActTrigger` API when the channel is running.*

7.4.20 Pwm_SetChannelOutputBuffer

Syntax

```
void Pwm_SetChannelOutputBuffer
(
  Pwm_ChannelType ChannelNumber,
  Pwm_OutputLineStateType LineState
  Pwm_OutputLineStateType LineCompState
)
```

Service ID

- 0x4a

Parameters (in)

- `ChannelNumber` - Numeric identifier of the PWM channel.
- `LineState` - PWM line output state.
- `LineCompState` - PWM line complementary output state.

Parameters (out)

None

Return value

None

DET errors

- `PWM_E_UNINIT` - Driver is not yet initialized.
- `PWM_E_PARAM_CHANNEL` - `ChannelNumber` is invalid.
- `PWM_E_PARAM_STATE` - LineState or LineCompState is invalid.
- `PWM_E_WAITING_TRIGGER` - The channel is waiting for the trigger.
- `PWM_E_INVALID_CORE` - The current core and channel assignment core are different. The core ID is invalid.

DEM errors

None

Description

`Pwm_SetChannelOutputBuffer()` prepares to change the line state and complementary line state of the PWM channel. The duty cycle is retained. To change to this setting, call the `Port_ActTrigger` API after this API.

This is a vendor-specific function.

Note: *Do not call `Pwm_SetChannelOutputBuffer()` and following APIs in the same period: `Pwm_SetPeriodAndDuty`, `Pwm_SetDutyCycle`, `Pwm_SetChannelOutput`, `Pwm_SetOutputOffset`, `Pwm_SetTriggerDelay`.*

Note: *If this function is called again after the `Port_ActTrigger` API has been called and before the end of the period, the result is not guaranteed.*

Note: *Call the `Port_ActTrigger` API when the channel is running.*

Note: *The channel sets the configuration parameter `PwmSetOutputEnable` as ON.*

Note: *The edge of the `Pwm_EnableNotification` API is set as if LineState is always PWM. Therefore, it may be different from the edge of the output waveform.*

7.4.21 Pwm_SetDutyAndChannelOutputBuffer

Syntax

```
void Pwm_SetDutyAndChannelOutputBuffer
(
  Pwm_ChannelType ChannelNumber,
  uint16 DutyCycle,
  Pwm_OutputLineStateType LineState
  Pwm_OutputLineStateType LineCompState
)
```

Service ID

- 0x4b

Parameters (in)

- `ChannelNumber` - Numeric identifier of the PWM channel.
- `DutyCycle` - Duty cycle time.
- `LineState` - PWM line output state.
- `LineCompState` - PWM line complementary output state.

Parameters (out)

None

Return value

None

DET errors

- `PWM_E_UNINIT` - Driver is not yet initialized.
- `PWM_E_PARAM_CHANNEL` - `ChannelNumber` is invalid.
- `PWM_E_DUTY_OUT_OF_RANGE` - The passed duty cycle is out of range.
- `PWM_E_PARAM_STATE` - LineState or LineCompState is invalid.
- `PWM_E_WAITING_TRIGGER` - The channel is waiting for the trigger.
- `PWM_E_INVALID_CORE` - The current core and channel assignment core are different. The core ID is invalid.

DEM errors

None

Description

`Pwm_SetDutyAndChannelOutputBuffer()` prepares to change the duty cycle, line state, and complementary line state of the PWM channel. To change to this setting, call the `Port_ActTrigger` API after this API.

This is a vendor-specific function.

Note: *Do not call `Pwm_SetDutyAndChannelOutputBuffer()` and following APIs in the same period: `Pwm_SetPeriodAndDuty`, `Pwm_SetDutyCycle`, `Pwm_SetChannelOutput`, `Pwm_SetOutputOffset`, `Pwm_SetTriggerDelay`.*

Note: *If this function is called again after the `Port_ActTrigger` API has been called and before the end of the period, the result is not guaranteed.*

Note: *Call `Port_ActTrigger` API when the channel is running.*

Note: *The channel sets the configuration parameter `PwmSetOutputEnable` as ON.*

Note: *The edge of the `Pwm_EnableNotification` API is set as if LineState is always PWM. Therefore, it may be different from the edge of the output waveform.*

7.5 Required callback functions

7.5.1 DET

If development error detection is enabled, the PWM driver uses the following callback function provided by DET. If you do not use DET, you must implement this function within your application.

Det_ReportError

Syntax

```
Std_ReturnType Det_ReportError
(
    uint16 ModuleId,
    uint8 InstanceId,
    uint8 ApiId,
    uint8 ErrorId
)
```

Reentrancy

Reentrant

Parameters (in)

`ModuleId` - Module ID of calling module.

`InstanceId` - `PwmCoreConfigurationId` of the core that calls this function or `PWM_INVALID_CORE`.

`ApiId` - ID of the API service that calls this function.

`ErrorId` - ID of the detected development error.

Return value

Returns always `E_OK`.

Description

Service for reporting development errors.

7.5.2 DEM

The PWM driver does not report to DEM.

7.5.3 PWM notifications

The following notification functions are used by the PWM driver to inform other software modules about the change of the PWM output signal.

The callback notification names are statically configurable by the PWM driver configuration via the `PwmNotification` parameter.

The notifications are enabled by calling `Pwm_EnableNotification()`.

The notifications are stopped by calling `Pwm_DisableNotification()`.

Pwm_Notification_<#Channel>

Syntax

```
void Pwm_Notification_<#Channel>
(
   void
)
```

Parameters (in)

None

Parameters (out)

None

Return value

None

Description

`Pwm_Notification_<#Channel>()` is called within the appropriate interrupt context after the requested edge type occurs on the corresponding PWM output signal.

7.5.4 Callout functions

7.5.4.1 Error callout API

The AUTOSAR PWM module requires an error callout handler. Each error is reported to this handler, error checking cannot be switched off. The name of the function to be called can be configured by the `PwmErrorCalloutFunction` parameter.

Syntax

```
void Error_Handler_Name
(
    uint16 ModuleId,
    uint8 InstanceId,
    uint8 ApiId,
    uint8 ErrorId
)
```

Reentrancy

Reentrant

Parameters (in)

- `ModuleId` - Module ID of calling module.
- `InstanceId` - `PwmCoreConfigurationId` of the core that calls this function or `PWM_INVALID_CORE`.
- `ApiId` - ID of the API service that calls this function.
- `ErrorId` - ID of the detected error.

Return value

None

Description

Service for reporting errors.

7.5.5 Get core ID API

The AUTOSAR PWM module requires a function to get valid core ID. This function is being used to determine from which core the code is getting executed. The name of the function to be called can be configured by the `PwmGetCoreIdFunction` parameter.

Syntax

```
uint8 GetCoreID_Function_Name (void)
```

Reentrancy

Reentrant

Parameters (in)

None

Return value

- `CoreId` - ID of the current core.

Description

Service for getting valid core ID.

Note: *This function shall return the core ID configured in the `PwmMulticore/PwmCoreConfiguration/PwmCoreId`.*

For example: Two cores are configured in the `PwmCoreConfiguration`.

Executing core	PwmCoreConfigurationId	PwmCoreId
CM7_0	0	15
CM7_1	1	16

Upon calling this function from core CM7_0, it shall return 15.

Upon calling this function from core CM7_1, it shall return 16.

8 Appendix B – Access register table

8.1 TCPWM

Table 9 **TCPWM access register table**

Register	Bit No.	Access size	Value	Description	Timing	Mask value	Monitoring value
CTRL	31:0	Word (32 bits)	Depends on configuration value or API.	Counter control register	Pwm_DeInit Pwm_Init Pwm_EnableTrigger Pwm_DisableTrigger Pwm_StartGroupTrigger Pwm_StopGroupTrigger Pwm_SetPrescaler Pwm_SetOutputToIdle Pwm_SetPeriodAndDuty Pwm_SetDutyCycle Pwm_SetChannelOutput Pwm_SetOutputOffset Pwm_SetTriggerDelay Pwm_SetDutyCycleBuffer Pwm_SetChannelOutputBuffer Pwm_SetDutyAndChannelOutputBuffer	0xC40336FF (PwmTimer) 0x00000000 (Monitoring is not needed for PwmStartDelayTimer.)	0x*400*6** (PwmTimer: After Pwm_Init, digit * depends on configuration value and API.) 0x0000*0F0 (PwmTimer: After Pwm_DeInit, digit * depends on configuration value and API.) 0x00000000 (Monitoring is not needed for PwmStartDelayTimer.)
STATUS	31:0	Word (32 bits)	-	Counter status register	Read only.	0x00000000 (Monitoring is not needed.)	0x00000000 (Monitoring is not needed.)

Register	Bit No.	Access size	Value	Description	Timing	Mask value	Monitoring value
COUNTER	31:0	Word (32 bits)	Counter value.	Counter count register	Pwm_DeInit Pwm_Init Pwm_EnableTrigger Pwm_DisableTrigger Pwm_SetPeriodAndDuty Pwm_SetDutyCycle Pwm_StartGroupTrigger Pwm_SetOutputOffset Pwm_SetTriggerDelay Pwm_SetPrescaler	0x00000000 (Monitoring is not needed.)	0x00000000 (Monitoring is not needed.)
CC0	31:0	Word (32 bits)	Duty tick value.	Counter compare/capture 0 register	Pwm_DeInit Pwm_Init Pwm_EnableTrigger Pwm_DisableTrigger Pwm_SetPeriodAndDuty Pwm_SetDutyCycle Pwm_StartGroupTrigger Pwm_SetOutputOffset Pwm_SetTriggerDelay Pwm_SetPrescaler	0x00000000 (Monitoring is not needed.)	0x00000000 (Monitoring is not needed.)
CC0_BUFF	31:0	Word (32 bits)	Duty tick value.	Counter buffered compare/capture 0 register	Pwm_DeInit Pwm_Init Pwm_EnableTrigger Pwm_DisableTrigger Pwm_SetPeriodAndDuty Pwm_SetDutyCycle Pwm_StartGroupTrigger Pwm_SetOutputOffset Pwm_SetTriggerDelay Pwm_SetPrescaler Pwm_SetChannelOutput Pwm_SetDutyCycleBuffer Pwm_SetDutyAndChannelOutputBuffer	0x00000000 (Monitoring is not needed.)	0x00000000 (Monitoring is not needed.)

Register	Bit No.	Access size	Value	Description	Timing	Mask value	Monitoring value
`CC1`	31:0	Word (32 bits)	Trigger tick value.	Counter compare/capture 1 register	`Pwm_DeInit` `Pwm_Init` `Pwm_EnableTrigger` `Pwm_DisableTrigger` `Pwm_SetPeriodAndDuty` `Pwm_SetDutyCycle` `Pwm_StartGroupTrigger` `Pwm_SetOutputOffset` `Pwm_SetTriggerDelay` `Pwm_SetPrescaler`	0x00000000 (Monitoring is not needed.)	0x00000000 (Monitoring is not needed.)
`CC1_BUFF`	31:0	Word (32 bits)	Trigger tick value.	Counter buffered compare/capture 1 register	`Pwm_DeInit` `Pwm_Init` `Pwm_EnableTrigger` `Pwm_DisableTrigger` `Pwm_SetPeriodAndDuty` `Pwm_SetDutyCycle` `Pwm_StartGroupTrigger` `Pwm_SetOutputOffset` `Pwm_SetTriggerDelay` `Pwm_SetPrescaler` `Pwm_SetChannelOutput` `Pwm_SetDutyCycleBuffer` `Pwm_SetDutyAndChannelOutputBuffer`	0x00000000 (Monitoring is not needed.)	0x00000000 (Monitoring is not needed.)
`PERIOD`	31:0	Word (32 bits)	Period tick value.	Counter period register	`Pwm_DeInit` `Pwm_Init` `Pwm_EnableTrigger` `Pwm_DisableTrigger` `Pwm_SetPeriodAndDuty` `Pwm_SetDutyCycle` `Pwm_StartGroupTrigger` `Pwm_SetOutputOffset` `Pwm_SetTriggerDelay` `Pwm_SetPrescaler`	0x00000000 (Monitoring is not needed.)	0x00000000 (Monitoring is not needed.)

Register	Bit No.	Access size	Value	Description	Timing	Mask value	Monitoring value
PERIOD_BUFF	31:0	Word (32 bits)	Period tick value.	Counter buffered period register	Pwm_DeInit Pwm_Init Pwm_EnableTrigger Pwm_DisableTrigger Pwm_SetPeriodAndDuty Pwm_SetDutyCycle Pwm_StartGroupTrigger Pwm_SetOutputOffset Pwm_SetTriggerDelay Pwm_SetPrescaler Pwm_SetChannelOutput	0x00000000 (Monitoring is not needed.)	0x00000000 (Monitoring is not needed.)
LINE_SEL	31:0	Word (32 bits)	0x00000032, 0x00000010, 0x00000001.	Counter line selection register	Pwm_DeInit Pwm_Init Pwm_EnableTrigger Pwm_DisableTrigger Pwm_SetPeriodAndDuty Pwm_SetDutyCycle Pwm_StartGroupTrigger Pwm_SetOutputOffset Pwm_SetTriggerDelay Pwm_SetPrescaler Pwm_SetChannelOutput	0x00000000 (Monitoring is not needed.)	0x00000000 (Monitoring is not needed.)

Register	Bit No.	Access size	Value	Description	Timing	Mask value	Monitoring value

`LINE_SEL_BUFF`	31:0	Word (32 bits)	0x00000032,
			0x00000001,
			0x00000010.
				Counter buffered line selection register	`Pwm_DeInit`
					`Pwm_Init`
					`Pwm_EnableTrigger`
					`Pwm_DisableTrigger`
					`Pwm_SetPeriodAndDuty`
					`Pwm_SetDutyCycle`
					`Pwm_StartGroupTrigger`
					`Pwm_SetOutputOffset`
					`Pwm_SetTriggerDelay`
					`Pwm_SetPrescaler`
					`Pwm_SetChannelOutput`
					`Pwm_SetChannelOutputBuffer`
					`Pwm_SetDutyAndChannelOutputBuffer`
						0x00000000
						(Monitoring is not needed.)
							0x00000000
							(Monitoring is not needed.)

`DT`	31:0	Word (32 bits)	0x00000000 |
			Divider value.
				Counter PWM dead time register	`Pwm_DeInit`
					`Pwm_Init`
					`Pwm_SetPrescaler`
						0x00000000
						(Monitoring is not needed.)
							0x00000000
							(Monitoring is not needed.)

`TR_CMD`	31:0	Word (32 bits)	Depends on configuration value or API.	Counter trigger command register	`Pwm_Init`
					`Pwm_SetPeriodAndDuty`
					`Pwm_SetDutyCycle`
					`Pwm_StartGroupTrigger`
					`Pwm_DisableTrigger`
					`Pwm_EnableTrigger`
					`Pwm_SetPrescaler`
					`Pwm_SetOutputOffset`
					`Pwm_SetChannelOutput`
					`Pwm_SetTriggerDelay`
						0x00000000
						(Monitoring is not needed.)
							0x00000000
							(Monitoring is not needed.)

Register	Bit No.	Access size	Value	Description	Timing	Mask value	Monitoring value
`TR_IN_SEL0`	31:0	Word (32 bits)	0x00000100 | Stop trigger select value << 24 | Reload trigger select value << 16 | Capture0 trigger select value.	Counter input trigger selection register 0	`Pwm_DeInit` `Pwm_Init` `Pwm_StartGroupTrigger`	0xFFFFFFFF	0x00000100
`TR_IN_SEL1`	31:0	Word (32 bits)	0x00000000.	Counter input trigger selection register 1	`Pwm_DeInit` `Pwm_Init`	0x00000000 (Monitoring is not needed.)	0x00000000 (Monitoring is not needed.)
`TR_IN_EDGE_SEL`	31:0	Word (32 bits)	Depends on configuration value.	Counter input trigger edge selection register	`Pwm_DeInit` `Pwm_Init` `Pwm_StartGroupTrigger`	0x00000FFF	0x00000F0C
`TR_PWM_CTRL`	31:0	Word (32 bits)	Depends on configuration value.	Counter trigger PWM control register	`Pwm_DeInit` `Pwm_Init`	0x000000FF	0x00000000 (Monitoring is not needed.)
`TR_OUT_SEL`	31:0	Word (32 bits)	Depends on configuration value.	Counter output trigger selection register	`Pwm_DeInit` `Pwm_Init` `Pwm_DisableTrigger` `Pwm_EnableTrigger`	0x00000077	0x00000000 (Monitoring is not needed.)
`INTR`	31:0	Word (32 bits)	Depends on configuration value or API.	Interrupt request register	`Pwm_DeInit` `Pwm_Init` `Pwm_Isr_Vector_[VectorNumber]_Cat1` `Pwm_Isr_Vector_[VectorNumber]_Cat2`	0x00000000 (Monitoring is not needed.)	0x00000000 (Monitoring is not needed.)
`INTR_SET`	31:0	Word (32 bits)	-	Interrupt set request register	Do not use.	0x00000000 (Monitoring is not needed.)	0x00000000 (Monitoring is not needed.)

Register	Bit No.	Access size	Value	Description	Timing	Mask value	Monitoring value
`INTR_MASK`	31:0	Word (32 bits)	0x00000000, 0x00000001, 0x00000002, 0x00000003.	Interrupt mask register	`Pwm_DeInit` `Pwm_Init` `Pwm_EnableNotification` `Pwm_DisableNotification` `Pwm_SetPeriodAndDuty` `Pwm_SetDutyCycle`	0x00000000 (Monitoring is not needed.)	0x00000000 (Monitoring is not needed.)
`INTR_MASKED`	31:0	Word (32 bits)	-	Interrupt masked request register	Read only.	0x00000000 (Monitoring is not needed.)	0x00000000 (Monitoring is not needed.)

Revision history

Document revision	Date	Description of change
**	2020-08-13	Initial release
*A	2020-11-19	Changed a memmap file include folder in chapter 2.6. Changed Remarks of PwmTimer in chapter 4.3.2. MOVED TO INFINEON TEMPLATE.
*B	2021-04-29	Corrected numbering in chapter 7. Added a note in section 5.6 Notification. Added a note in section 7.4.13 Pwm_SetChannelOutput. Added the following sections to support stepping motor control: • 4.3.2.19 PwmUpdateOutputAtInitEnable • 4.3.2.20 PwmOutputAtInitSelect • 4.3.2.21 PwmCompOutputAtInitSelect • 4.3.3.5 PwmChannelGroupSwitchEventTrigger • 4.3.5.7 PwmSetDutyCycleBufferApi • 4.3.5.8 PwmSetDutyAndChannelOutputBufferApi • 4.3.5.9 PwmSetChannelOutputBufferApi • 7.2.10 Pwm_OutputLineStateType • 7.4.19 Pwm_SetDutyCycleBuffer • 7.4.20 Pwm_SetChannelOutputBuffer • 7.4.21 Pwm_SetDutyAndChannelOutputBuffer Updated the following sections to support stepping motor control: • Added PwmChannelGroupSwitchEventTrigger condition and improved readability in error conditions and warning conditions: – 4.3.1.5 PwmStartTriggerSelect0 – 4.3.1.6 PwmStartTriggerSelect1 – 4.3.2.9 PwmStartDelayTrigger – 4.3.3.2 PwmChannelGroupStartTrigger – 4.3.3.3 PwmChannelGroupStopTrigger – 4.3.3.4 PwmChannelRef – 4.3.4.3 PwmGroupStartDelayTrigger • Added Pwm_SetDutyCycleBuffer, Pwm_SetChannelOutputBuffer and Pwm_SetDutyAndChannelOutputBuffer API descrption: – 5.16 API Parameter Checking – 5.18 Reentrancy – 6.4 Triggers 8.1 TCPWM

Revision history

Document revision	Date	Description of change
*C	2021-08-18	Added a note on DeepSleep mode in 5.15 Sleep mode Added a note on ARM® errata in 6.3 Interrupts
*D	2021-12-21	Updated to the latest branding guidelines.
*E	2023-10-06	Added a note on chapter 4.3.1.2 PwmMultipleUpdateInPeriod. Corrected core identification keyword on chapter 2.6 and 5.21.
*F	2023-12-08	Web release. No content updates.
*G	2024-03-18	Deleted the description in chapter 6.1. Added note in chapter 4.2.2.7.

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