GTM_TOM_3_Phase_Inverter_PWM_1 for KIT_AURIX_TC275_LK

GTM TOM 3 Phase Inverter using PWM

AURIX™ TC2xx Microcontroller Training
V1.0.0

Scope of work

The GTM TOM is configured to generate PWM signals for two-level three phase inverter.

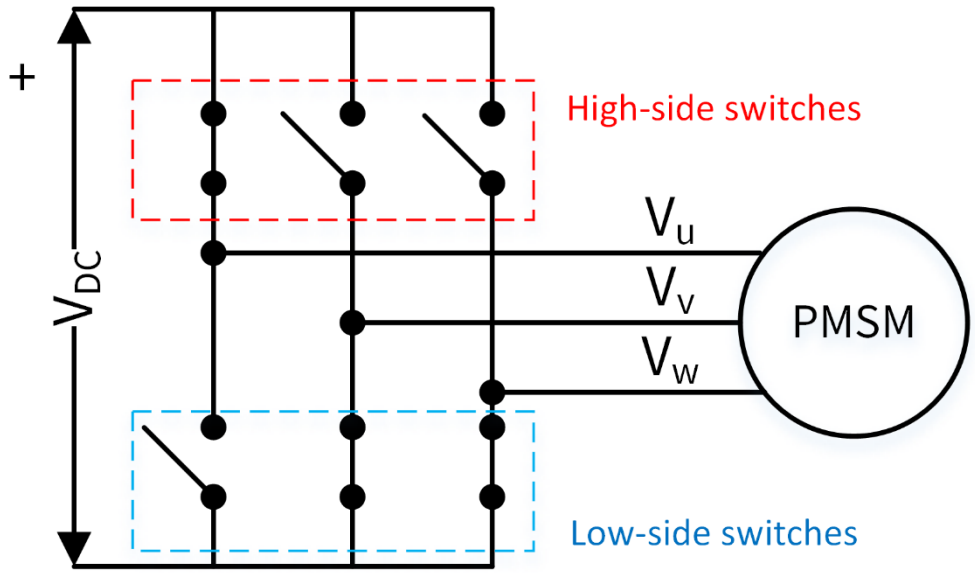
The states of 6 pins are controlled by the PWM signals generated by the Generic Timer Module (GTM) in-built Timer Output Module (TOM). All signals are synchronous to each other, center-aligned and with dead-times (positive/negative) for the complementary pairs.

Introduction

- The Generic Timer Module (GTM) is a modular timer unit designed to accommodate many timer applications
- It has an in-built Timer Output Module (TOM) that can offer up to 16 independent channels to generate output signals
- The Clock Management Unit (CMU) is responsible for clock generation of the GTM. The Fixed Clock Generation (FXU) is one of its subunits and it provides five predefined non-configurable clocks for GTM modules, including the TOM

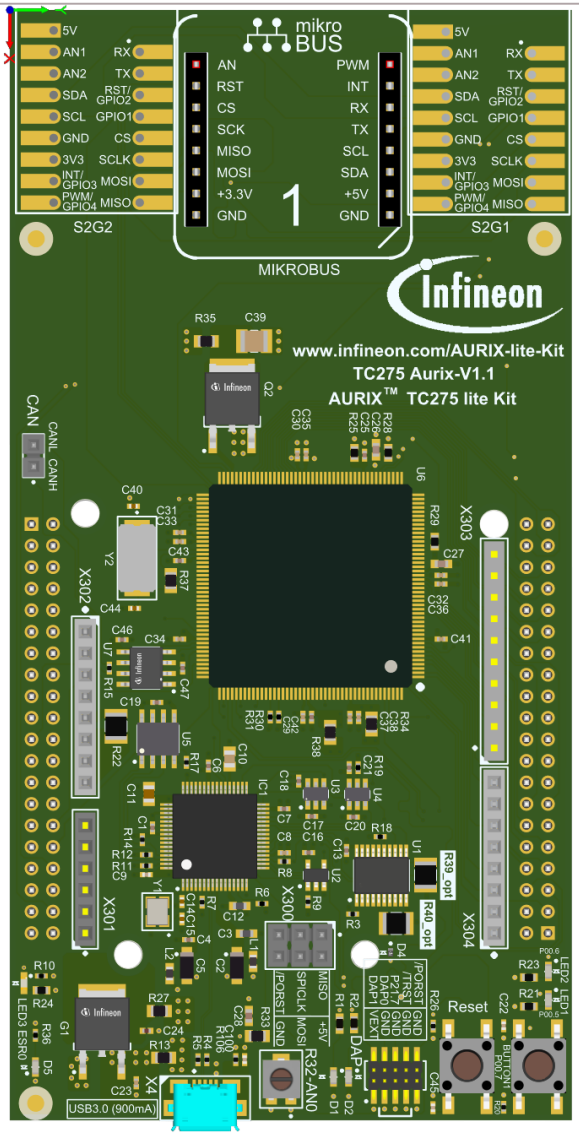
Introduction

- This example shows how to generate PWM signals to control a two-level three-phase inverter
- A simplified schema of the two-level three-phase inverter is shown in the image below



Hardware setup

This code example has been developed for the board KIT_AURIX_TC275_LITE.



Implementation

GTM configuration

- The ***IfxGtm_Tom_PwmHl.h*** iLLDs provide the GTM PWM driver to configure the required peripheral resources and drive them to produce the PWM waveform. PWM drivers are initialized and driven by the TriCore™ core

- The configuration of the TOM is done once in the setup phase by calling the initialization function ***initGtmTomPwm()***, which contains the following steps:

  - Configuration of the GTM frequencies
  - Configuration of the PWM master channel
  - Configuration of the PWM channels used to produce 3 complementary pair signals
  - Initialization and run of the PWM signals

Implementation

Configuration of the GTM frequencies

- First of all, the GTM module is enabled with the function ***IfxGtm_enable()***
- The GTM global clock frequency is then set with the function ***IfxGtm_Cmu_setGclkFrequency()***
- The GTM configurable clock frequency is set with the function ***IfxGtm_Cmu_setClkFrequency()***
- Finally, the FXU clocks are enabled by calling the function ***IfxGtm_Cmu_enableClocks()***

Implementation

Configuration of the PWM master channel

- To configure the PWM master channel the function ***IfxGtm_Tom_Timer_initConfig()*** initializes an instance of the structure ***IfxGtm_Tom_Timer_Config*** with its default values

- The elements of the ***IfxGtm_Tom_Timer_Config*** structure allows to set specific parameters:
  - ***base.frequency*** – Set the timer frequency
  - ***clock*** – Select the CMU-FXCLK0
  - ***tom*** – Select the timer to be used
  - ***timerChannel*** – Select the channel to be used

- Finally, the function ***IfxGtm_Tom_Timer_init()*** initializes the TOM with the user configuration

Implementation

Configuration of the PWM channels

- To configure the PWM channels to produce three complementary pair signals, an instance of the structure ***IfxGtm_Tom_PwmHl_Config*** is created and initialized with its default values by the function ***IfxGtm_Tom_PwmHl_initConfig()***

- The elements of the ***IfxGtm_Tom_PwmHl_Config*** structure allows to set specific parameters:
  - ***base.channelCount*** – Set the number of PWM channels
  - ***base.deadtime*** – Set the dead time between the top and bottom channels
  - ***base.minPulse*** – Set the minimum pulse time allowed as active state
  - ***base.outputMode*** – Set the port pin mode of the channels
  - ***base.outputDriver*** – Set the port pin strength and slew rate of the channels
  - ***base.ccxActiveState*** – Set the High-side PWM signals active state
  - ***base.coutxActiveState*** – Set the Low-side PWM signals active state
  - ***ccx*** – Select the channels used for the High-side PWM signals
  - ***coutx*** – Select the channels used for the Low-side PWM signals
  - ***timer*** – Select the timer to be used
  - ***tom*** – Select the module to be used

- The function ***IfxGtm_Tom_Timer_init()*** initializes the TOM with the user configuration

Implementation

Configuration of the PWM channels (cont.)

- The PWM mode is then configured to be center aligned with the function ***IfxGtm_Tom_PwmHl_setMode()***
- Finally, the input frequency of the TOM is updated by calling ***IfxGtm_Tom_Timer_updateInputFrequency()***

Initialization and run of the PWM signals

- The timer starts running after calling the function ***IfxGtm_Tom_Timer_run()***
- The initial values of the PWM signals are calculated and set calling:
  - ***IfxGtm_Tom_Timer_disableUpdate()*** – to stop the update of the TOM (In order to update all signals at the same time)
  - ***IfxGtm_Tom_PwmHl_setOnTime()*** – to set the calculated duty cycle
  - ***IfxGtm_Tom_Timer_applyUpdate()*** – to apply the changes by re-starting the update of the TOM channels

Implementation

The following PWM parameters are enabled/configured with this example:

PWM Type	Center Aligned
Frequency	20 kHz
Polarity	Duty-On High
Complementary Output	Enabled (opposite polarity)
Dead times	0,5 µS
Minimum pulse time	1 µS

› Initial values of PWM duty cycles:

PHASE_U	PHASE_V	PHASE_w
25%	50%	75%

Implementation

The below table provides the mapping between the PWM signal and the Port Pins:

PWM Signal	Pin Mapping
PHASE_U_HS	P00.11
PHASE_U_LS	P00.10
PHASE_V_HS	P33.0
PHASE_V_LS	P00.12
PHASE_W_HS	P33.2
PHASE_W_LS	P23.0

Implementation

GTM update

- Once the GTM is configured and started, a duty cycle update is performed every 10ms in the ***updateGtmTomPwmDutyCycles()*** function:
  - Each channel x is cyclically modified incrementing its duty cycle by 10%, from 10% to 90% using the variable ***g_pwm3PhaseOutput[x]***
  - The duty cycle of all channels is then updated using the iLLD functions:
    - ***IfxGtm_Tom_Timer_disableUpdate()***
    - ***IfxGtm_Tom_PwmHl_setOnTime()***
    - ***IfxGtm_Tom_Timer_applyUpdate()***

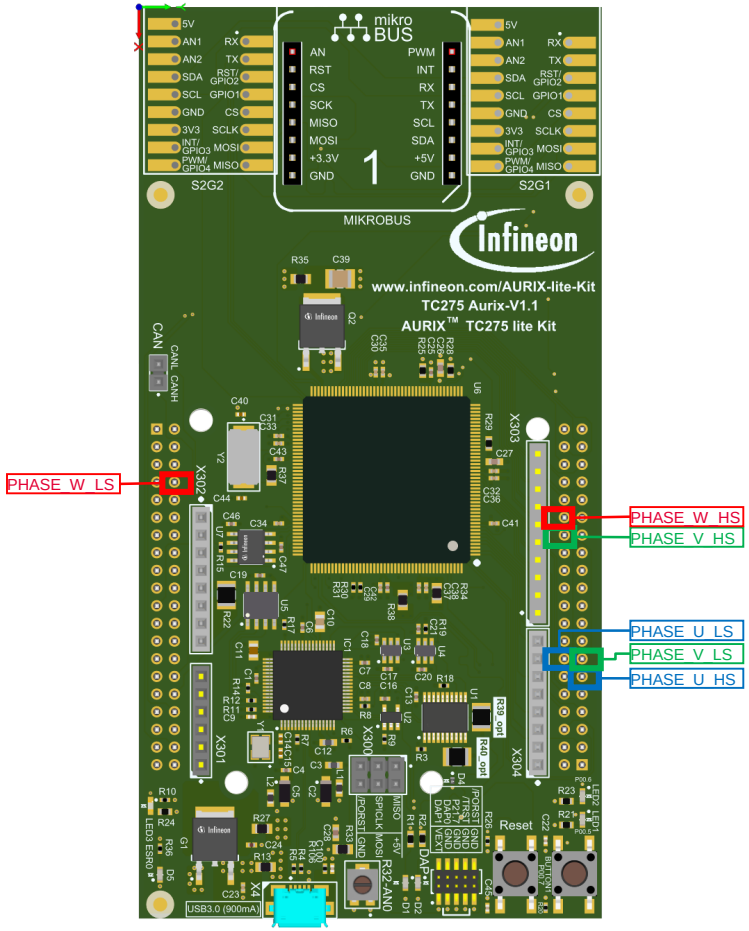
All the functions used for the configuration of the TOM are provided by the iLLD header ***IfxGtm_Tom_PwmHl.h***.

Run and Test

After code compilation and flashing the device, the PWM signals can be observed using a logic analyser or an oscilloscope connected to the following pins:

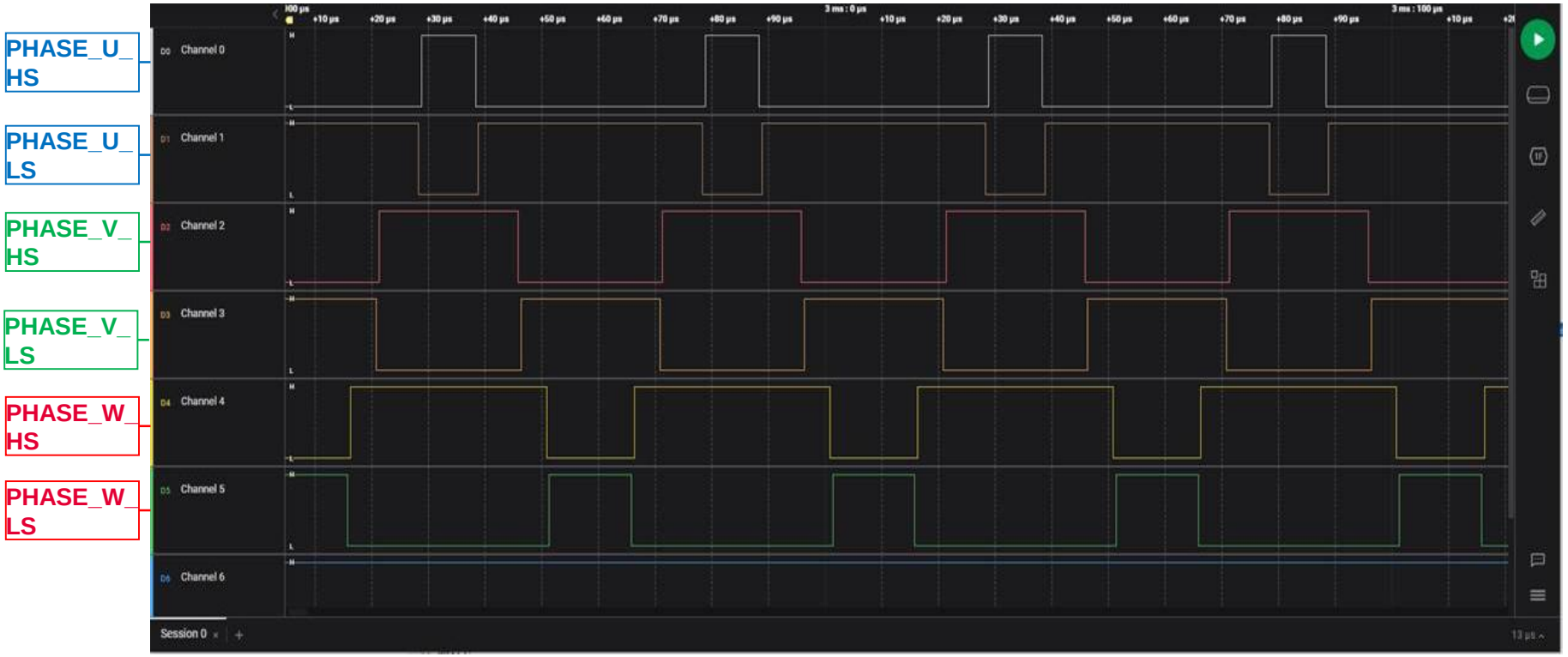
	X1			
	GND	1	2	VEXT	
	P33.11	3	4	P33.12	
	P33.13	5	6	P32.0	
	P23.1	7	8	P23.0	PHASE_W_LS
	P23.3	9	10	P23.2	
	P23.5	11	12	P23.4	
MRST -	P22.1	13	14	P22.0 - MTSR	
	P21.0	15	16	P22.2 - SS	
MDC -	P21.2	17	18	P22.3 - SCLK	
	P21.4	19	20	P21.3 - MDIO	
	P20.10	21	22	P21.5	
TXD2_S2G2 -	P20.0	23	24	P20.1	
RXD2_S2G2 -	P20.3	25	26	ESR1	
	ESR0	27	28	P20.14	
SDA0 -	P15.5	29	30	/PORST - Reset	
SCL0 -	P15.4	31	32	P11.12	
CRSDV -	P11.11	33	34	P11.10 - CS_S2G2	
RXD1 -	P11.9	35	36	P11.6	
TXD0 -	P11.3	37	38	P11.2 - CS_S2G1	
	VDD_USB	39	40	GND	

	X2			
	GND	40	39	VEXT	
	P33.10	38	37	P33.9 - TXD1_S2G1	
RXD1_S2G1 -	P33.8	36	35	P33.7	
	P33.6	34	33	P33.5	
	P33.4	32	31	P33.3	
PHASE_W_HS	P33.2	30	29	P33.1	
PHASE_V_HS	P33.0	28	27	AN0 - Potentiometer	
	AN1	26	25	AN2	
	AN3	24	23	AN4	
	AN5	22	21	AN6	
	AN7	20	19	AN44	
	AN45	18	17	AN46	
	AN47	16	15	VAREF1	
PHASE_U_HS	P00.11	14	13	P00.12	PHASE_V_LS
	P00.9	12	11	P00.10	PHASE_U_LS
Button1 -	P00.7	10	9	P00.8	
LED1 -	P00.5	8	7	P00.6 - LED2	
	P00.3	6	5	P00.2	
	P00.1	4	3	P00.0 - TXDCAN	
	VDD_USB	2	1	GND	



Run and Test

The following image shows the generated PWM signals:



References

- AURIX™ Development Studio is available online:
- https://www.infineon.com/aurixdevelopmentstudio
- Use the *„Import...“* function to get access to more code examples.

- More code examples can be found on the GIT repository:
- https://github.com/Infineon/AURIX_code_examples

- For additional trainings, visit our webpage:
- https://www.infineon.com/aurix-expert-training

- For questions and support, use the AURIX™ Forum:
- https://www.infineonforums.com/forums/13-Aurix-Forum

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