GTM_TOM_3_Phase_Inverter_PWM_1 for KIT_AURIX_TC275_LK
GTM TOM 3 Phase Inverter using PWM
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_PwmHi_Config` is created and initialized with its default values by the function `IfxGtm_Tom_PwmHi_initConfig()`

- The elements of the `IfxGtm_Tom_PwmHi_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:

<table>
<thead>
<tr>
<th>PWM Type</th>
<th>Center Aligned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>20 kHz</td>
</tr>
<tr>
<td>Polarity</td>
<td>Duty-On High</td>
</tr>
<tr>
<td>Complementary Output</td>
<td>Enabled (opposite polarity)</td>
</tr>
<tr>
<td>Dead times</td>
<td>0,5 µS</td>
</tr>
<tr>
<td>Minimum pulse time</td>
<td>1 µS</td>
</tr>
</tbody>
</table>

- Initial values of PWM duty cycles:

<table>
<thead>
<tr>
<th>PHASE_U</th>
<th>PHASE_V</th>
<th>PHASE_W</th>
</tr>
</thead>
<tbody>
<tr>
<td>25%</td>
<td>50%</td>
<td>75%</td>
</tr>
</tbody>
</table>
Implementation

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

<table>
<thead>
<tr>
<th>PWM Signal</th>
<th>Pin Mapping</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHASE_U_HS</td>
<td>P00.11</td>
</tr>
<tr>
<td>PHASE_U_LS</td>
<td>P00.10</td>
</tr>
<tr>
<td>PHASE_V_HS</td>
<td>P33.0</td>
</tr>
<tr>
<td>PHASE_V_LS</td>
<td>P00.12</td>
</tr>
<tr>
<td>PHASE_W_HS</td>
<td>P33.2</td>
</tr>
<tr>
<td>PHASE_W_LS</td>
<td>P23.0</td>
</tr>
</tbody>
</table>
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`. 
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:

- PHASE_U_HS
- PHASE_U_LS
- PHASE_V_HS
- PHASE_V_LS
- PHASE_W_HS
- PHASE_W_LS
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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