

GTM: Example Code for GTM IP functions

ME-IC/PRM-IP | March 15th, 2024

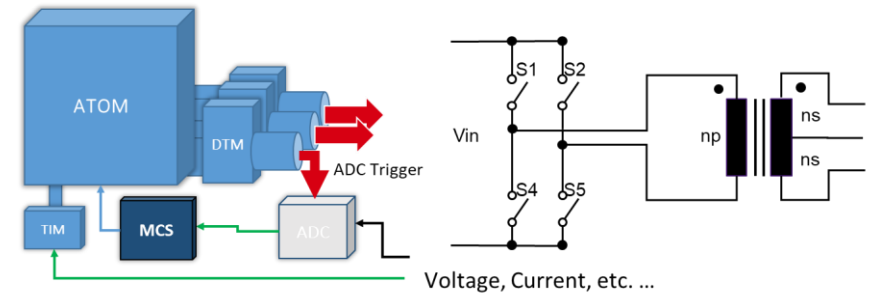
Example Code for GTM IP functions

Agenda

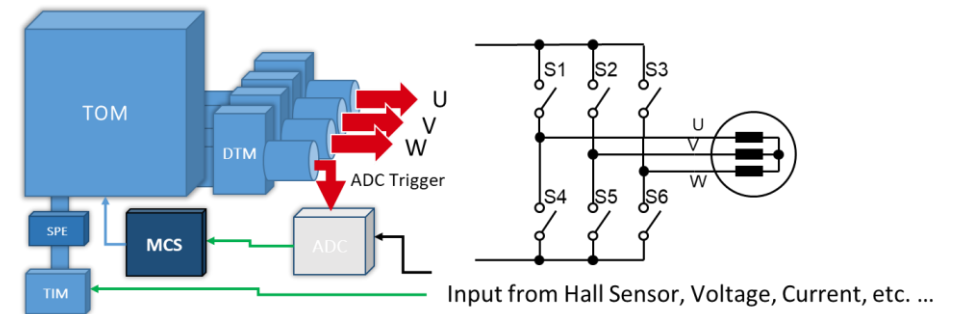
1. AD Converter integration
2. Two point regulation
3. Access to GTM external resources
4. TIO BLDC control
5. Multi level / Multi rate support
6. Summary



Example: Full Bridge PFC (Power Factor Correction)



Example: BLDC (Brushless DC) Motor



01

AD Converter Integration

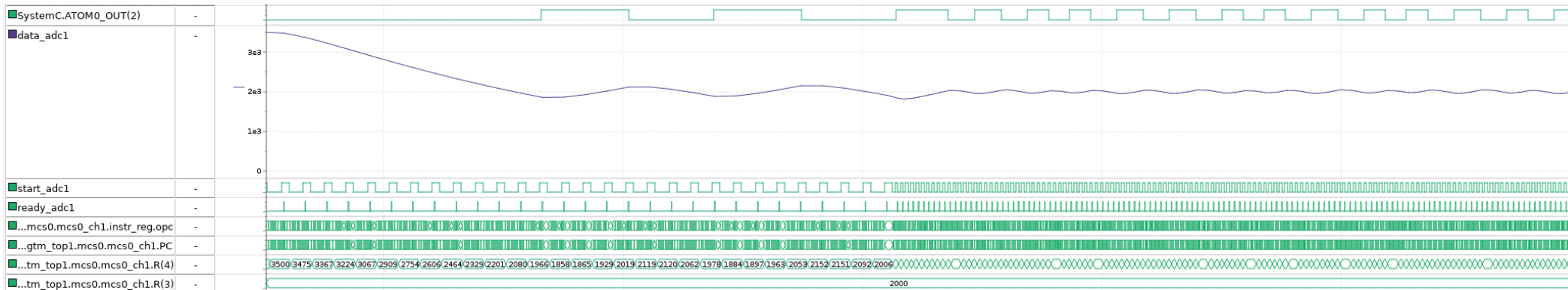
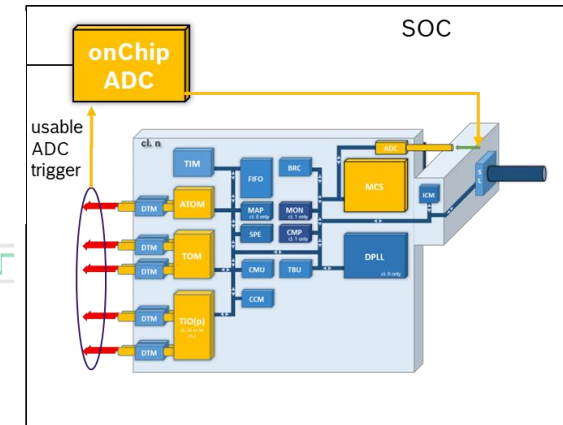
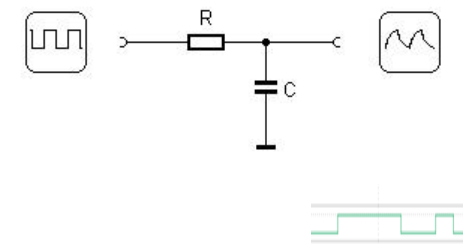
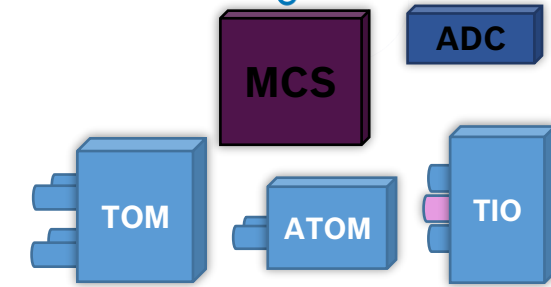
02

Two point regulation

Example Code for GTM IP functions

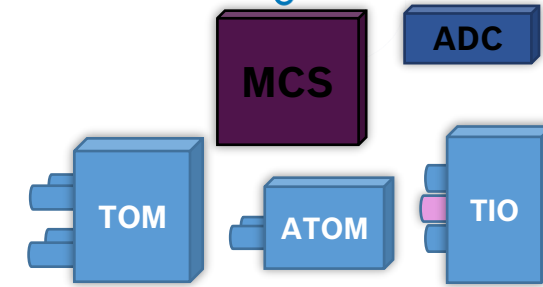
Two point regulation

- Description
 - Use AD converted values for GTM regulation/ calculation
 - Generate ADC trigger for data sampling
- Applicable modules
 - MCS; ADCIF
- Implementation example
 - Control an external voltage at a desired target value
 - Read ADC value will be used to increase/decrease the external voltage



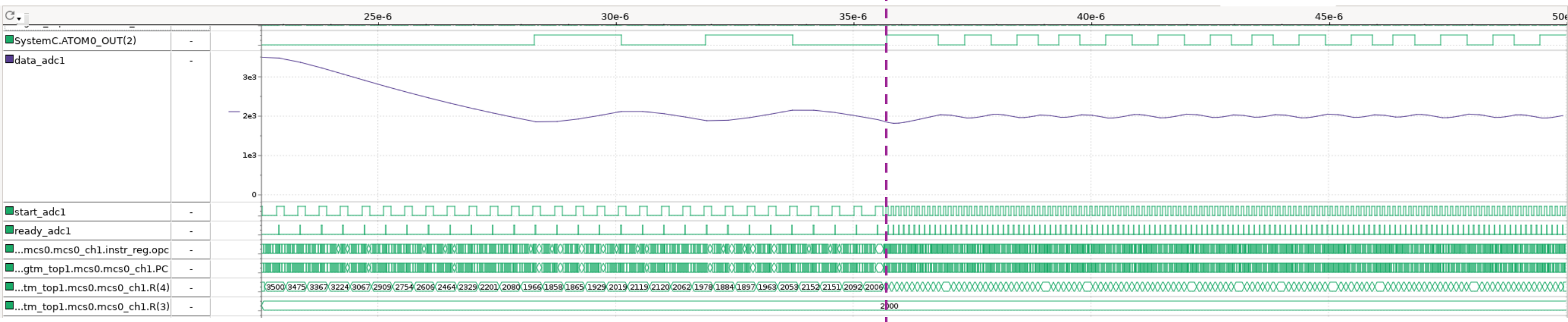
Example Code for GTM IP functions

Two point regulation



- Performance of MCS control loop:
 - Round robin: max. 2 MHz ADC sample rate
 - Single prio: max. 9 MHz ADC sample rate

← MCS Round robin scheduling | MCS single prio scheduling →

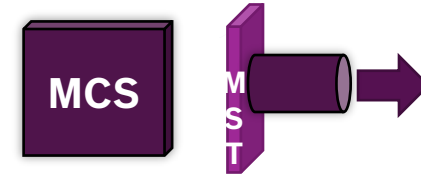


03

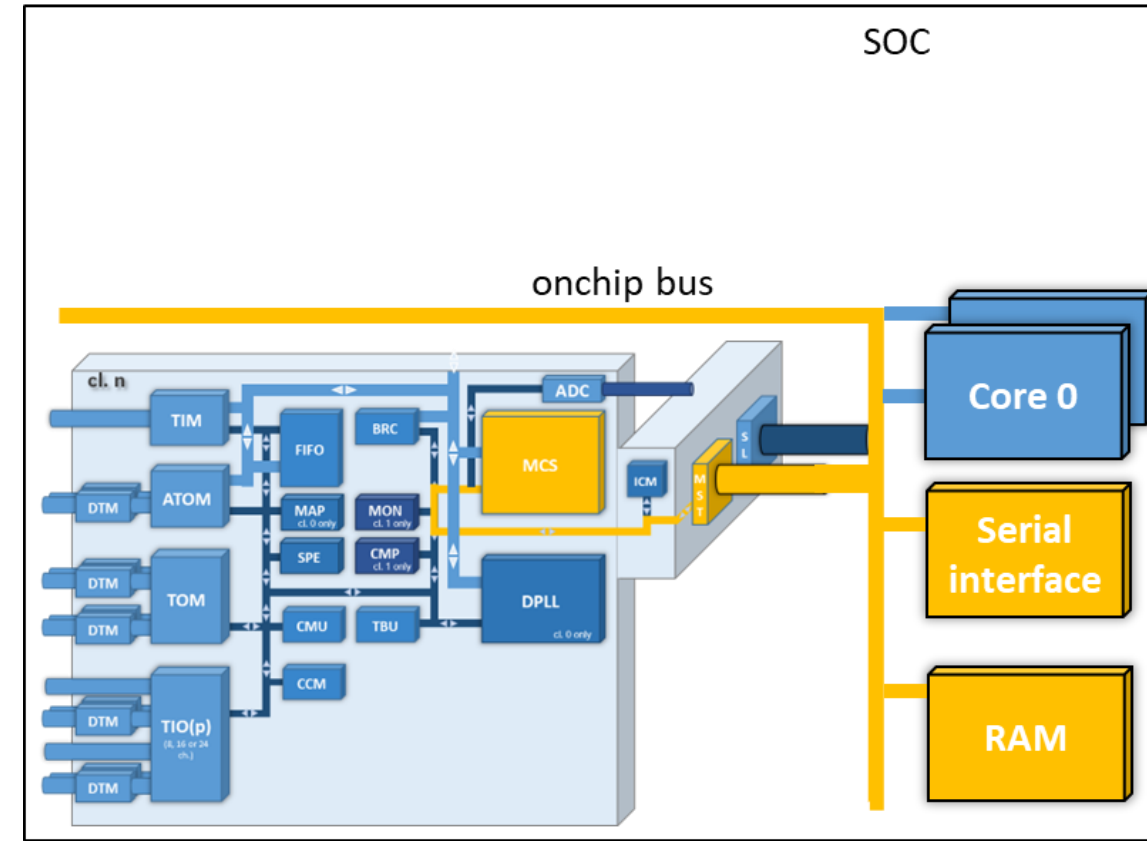
Access to GTM external resources

Example Code for GTM IP functions

Access to GTM external resources

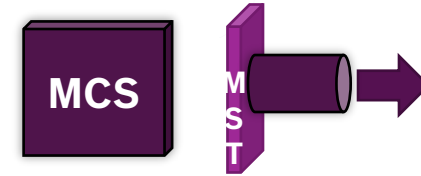


- **Functionality**
 - Master access of MCS core to GTM external resources
 - Multiple MCS can use master interface
 - Arbitration by configurable priority scheme
- **Applicable modules**
 - MCS; AXIM
- **Benefits**
 - MCS can read/write arbitrary data
 - No external resource needed (e.g. DMA)
 - Access can be serviced in the background, MCS can continue other operations



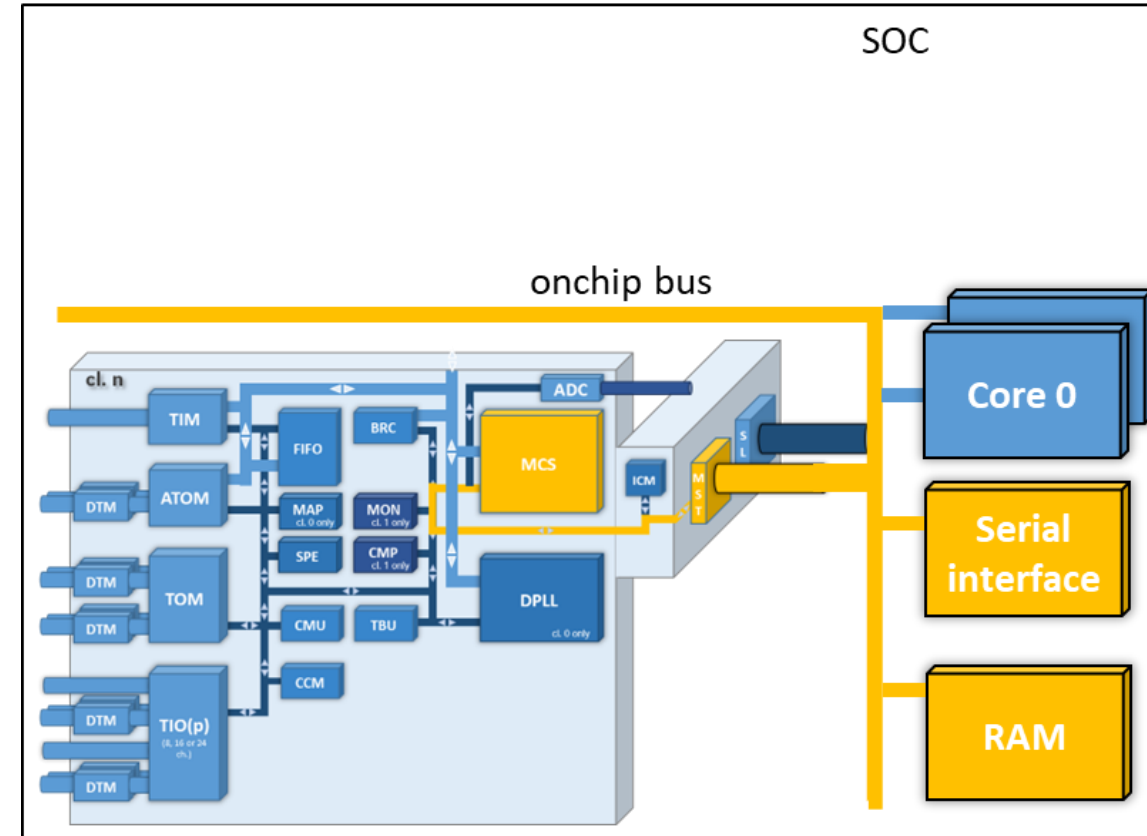
Example Code for GTM IP functions

Access to GTM external resources



- AXIM interface performance
 - Dependent on external bus load

- Max. bandwidth (GTM operating on 200 MHz)
 - Assume no external bus load
 - Single prio scheduling
 - 1 MCS 1 channel RD 13,19 Mtransfers/s
 - Round robin scheduling
 - 1 MCS 1 channel RD 2,77 Mtransfers/s
 - 1 MCS 2 channels RD/WR 5,54 Mtransfers/s
 - 4 MCS 2 channels RD/WR 22,14 Mtransfers/s
 - 8 MCS 2 channels RD/WR 44,33 Mtransfers/s



Example Code for GTM IP functions

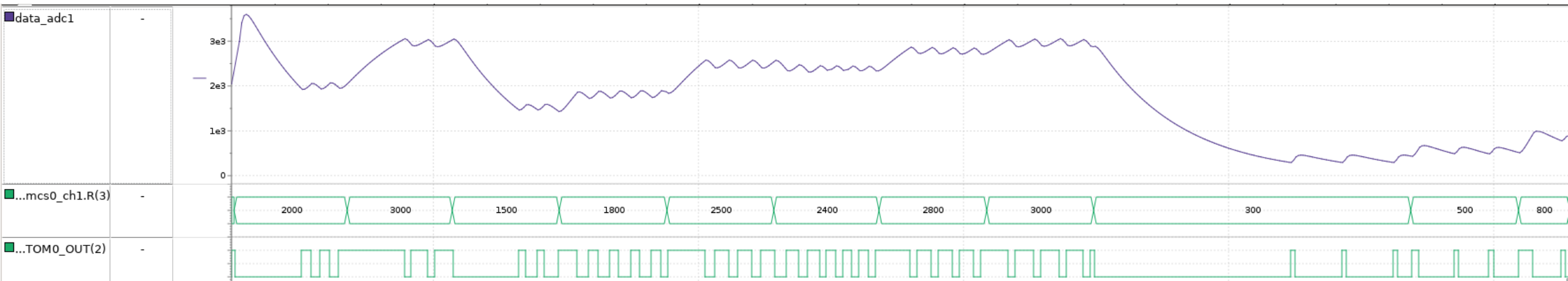
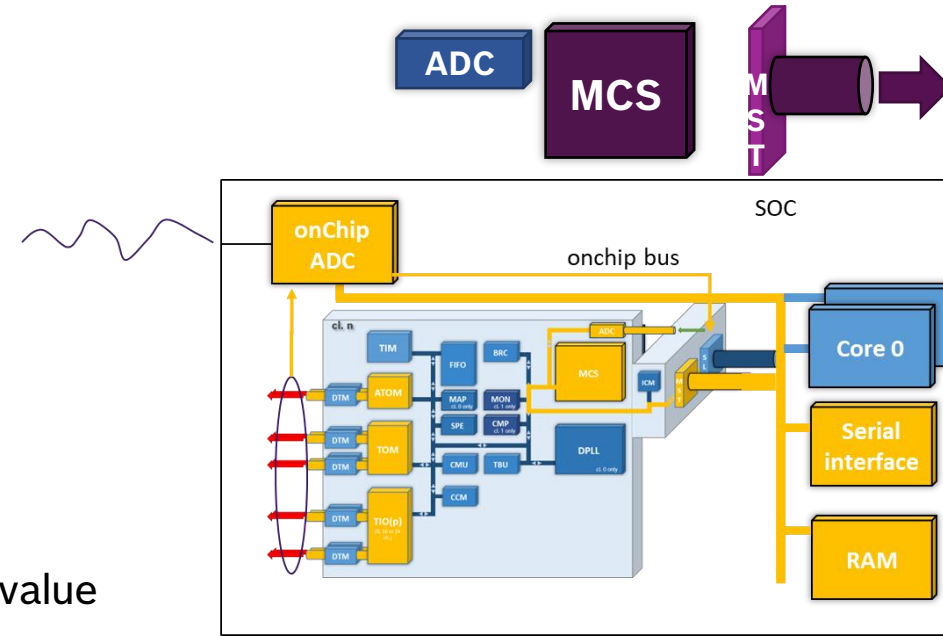
Access to GTM external resources

■ Description

- MCS could setup/ control external ADC
- Target value can be stored/ received in the SOC, accessed via AXI Master
- Target voltage can be dynamically changed

■ Implementation example

- Read target values via MCS from resource external to the GTM
- Dynamic control of output dependent on parameters in external RAM and ADC value



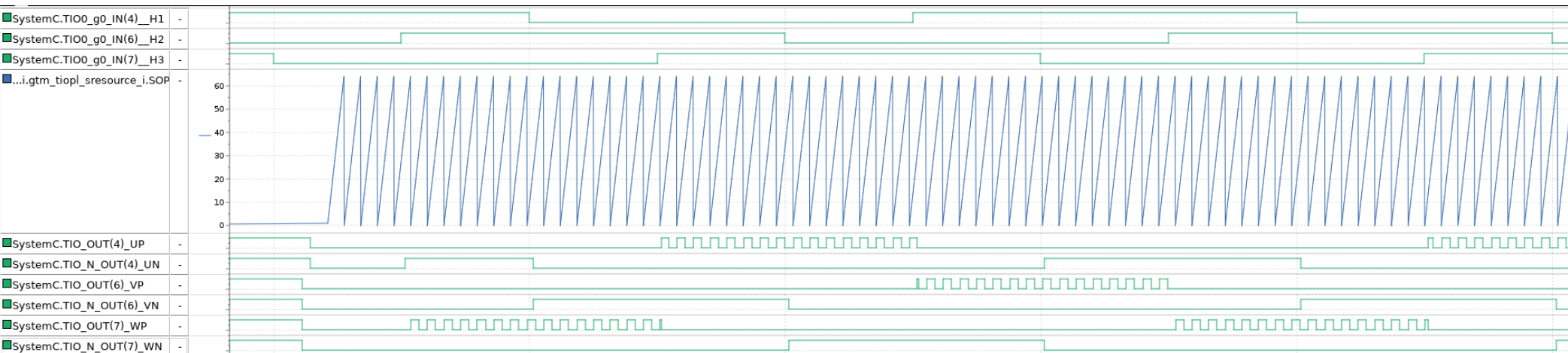
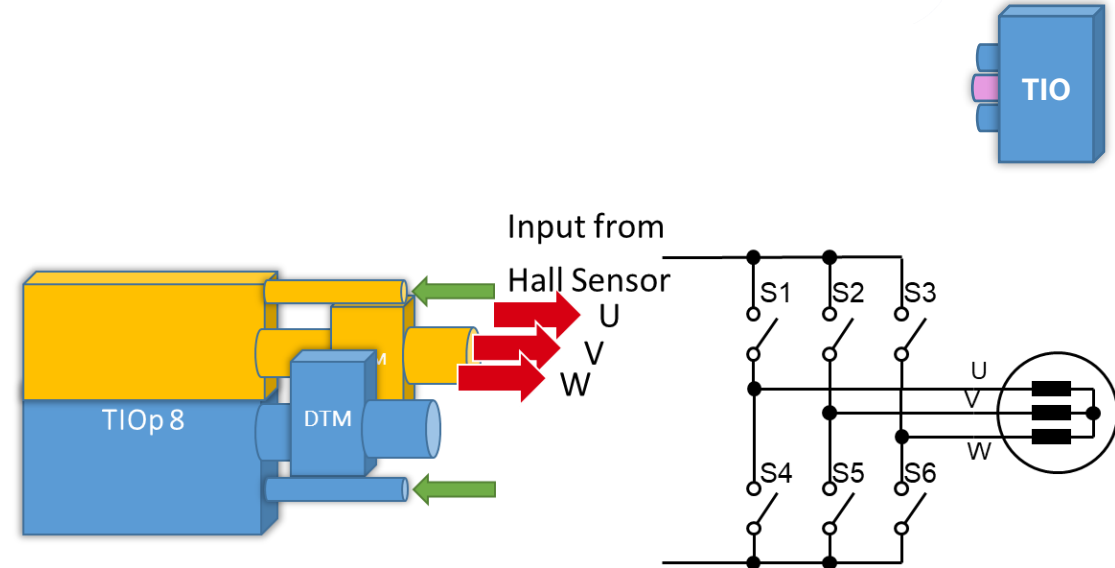
04

TIO BLDC control

Example Code for GTM IP functions

TIO BLDC control

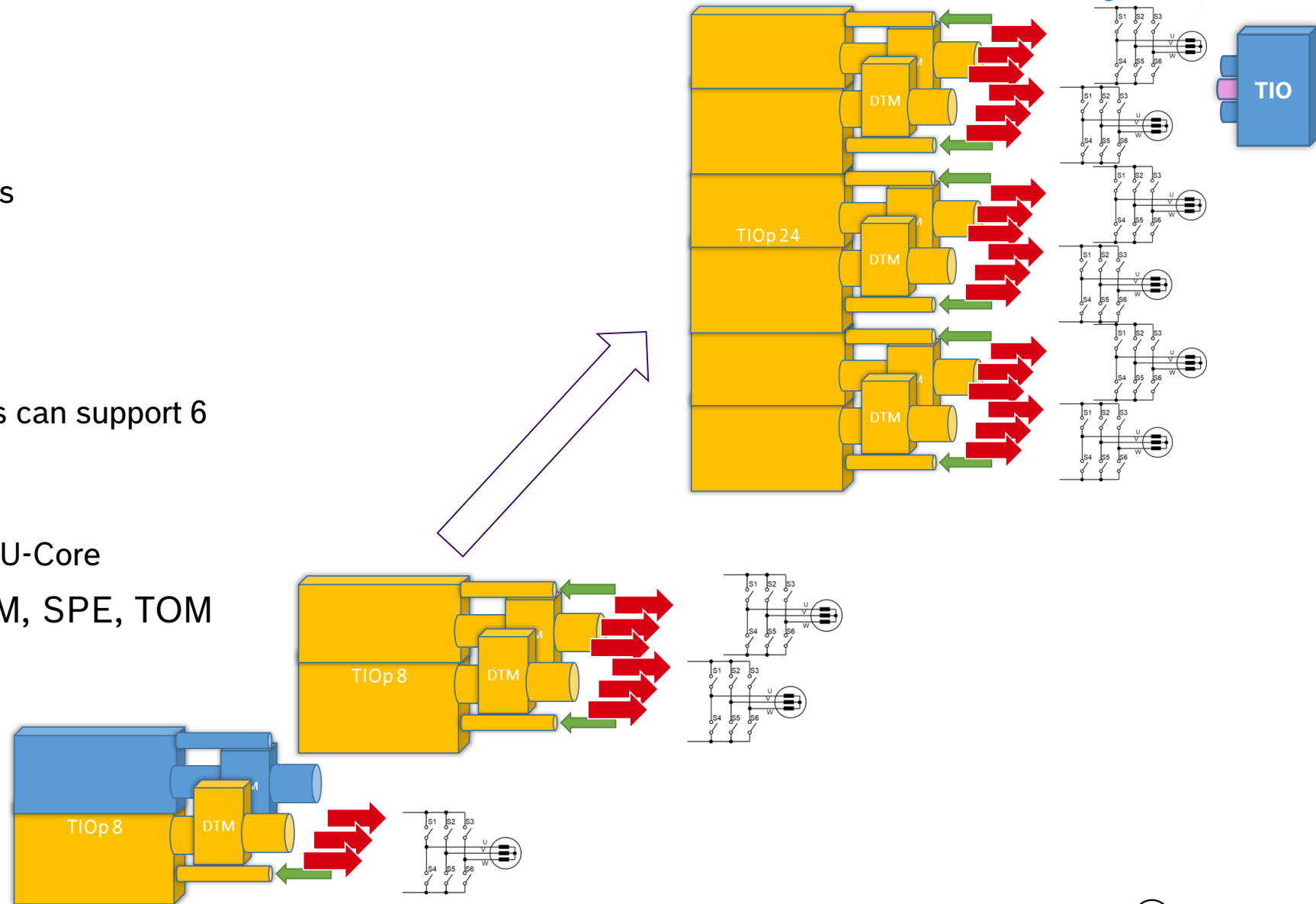
- Description
 - TIO controlling a Brushless DC motor
- Applicable modules
 - TIOp8, DTM
- Implementation example
 - 4 TIO channels with DTM shutoff capability in use
 - Hall decoding with speed determination supported



Example Code for GTM IP functions

TIO BLDC control

- Description
 - Functional scalability 4 - 24 channels
- Applicable modules
 - TIOp 24 channels, DTM
- Implementation example
 - One TIOp instance with 24 channels can support 6 brushless DC motors
 - All operating fully independent
 - Control can be done by MCS or MCU-Core
- Lesser resources needed than TIM, SPE, TOM approach (needs 6 clusters)

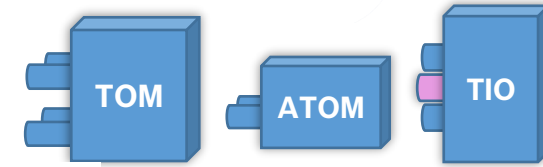


05

Multi level / Multi rate support

Example Code for GTM IP functions

Multi level / Multi rate support



■ Description

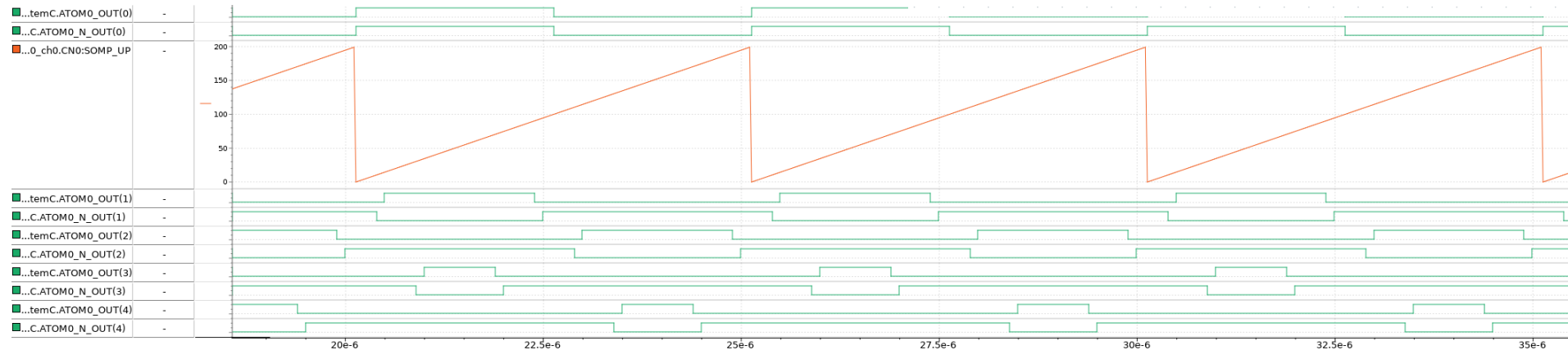
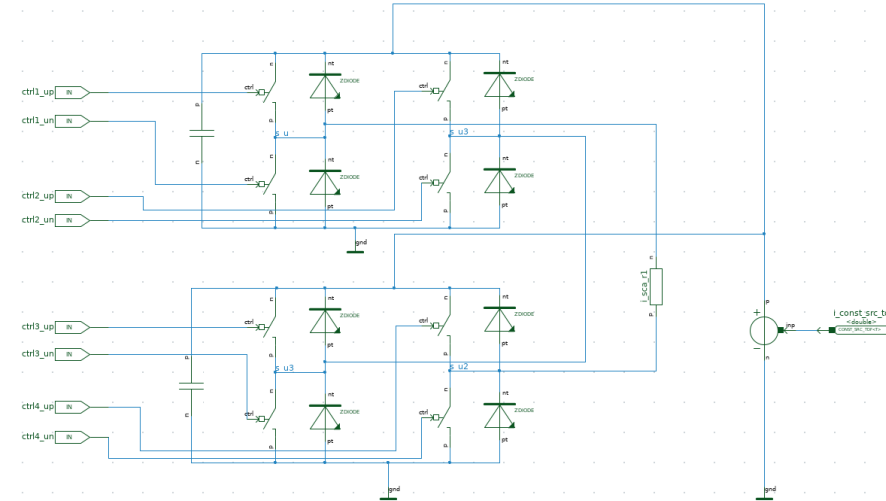
- Multiphase synchronous operation
- Deadtime insertion

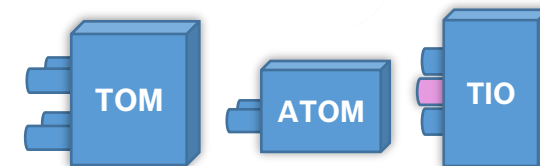
■ Applicable modules

- TOM; ATOM; TIO

■ Implementation example

- Drive a 5 level cascaded H-Bridge



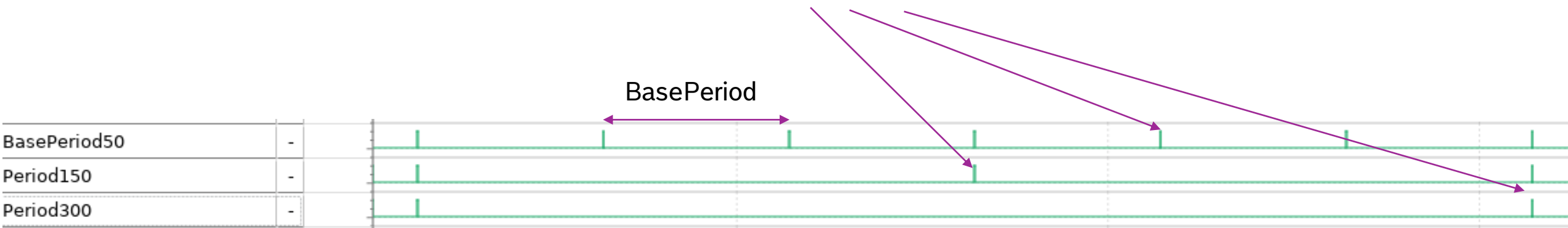


Example Code for GTM IP functions

Multi rate support

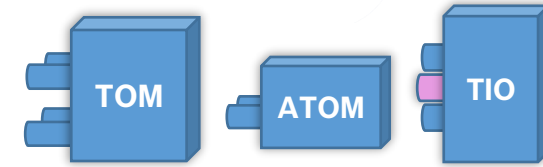
- Use-Case/Benefits

- Synchronous operation of multiple PWM operating on a base period e.g. BasePeriod = 50
 - Slave PWM can use any $\text{Period}_x = N * \text{BasePeriod}$
- Synchronous update/ start of duty cycles on any slave period_x possible



- Applicable modules

- TOM; ATOM; TIO

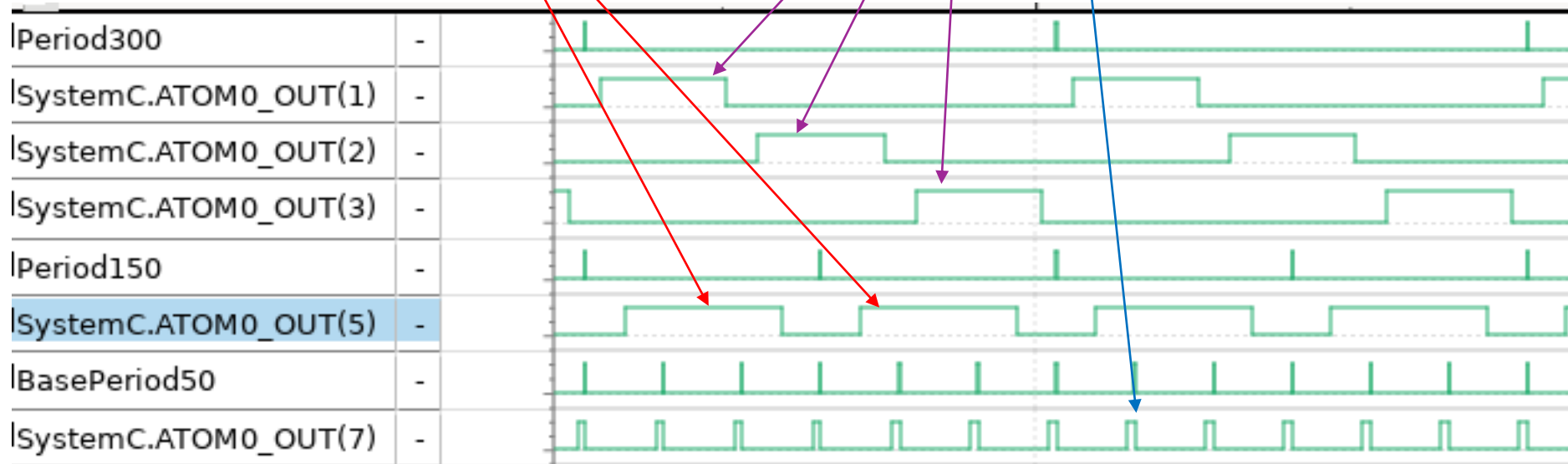


Example Code for GTM IP functions

Multi rate support

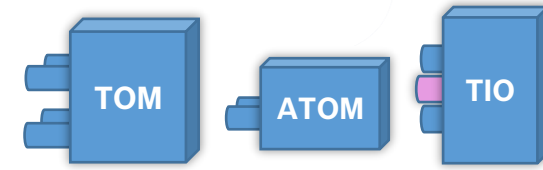
Example

- Operation on Period300: 3 Phases operating with 100 phase shift
- Operation on Period150: Center aligned pulse
- Operation on BasePeriod50: Could serve as ADC triggers (e.g. for current/ voltage measurements)



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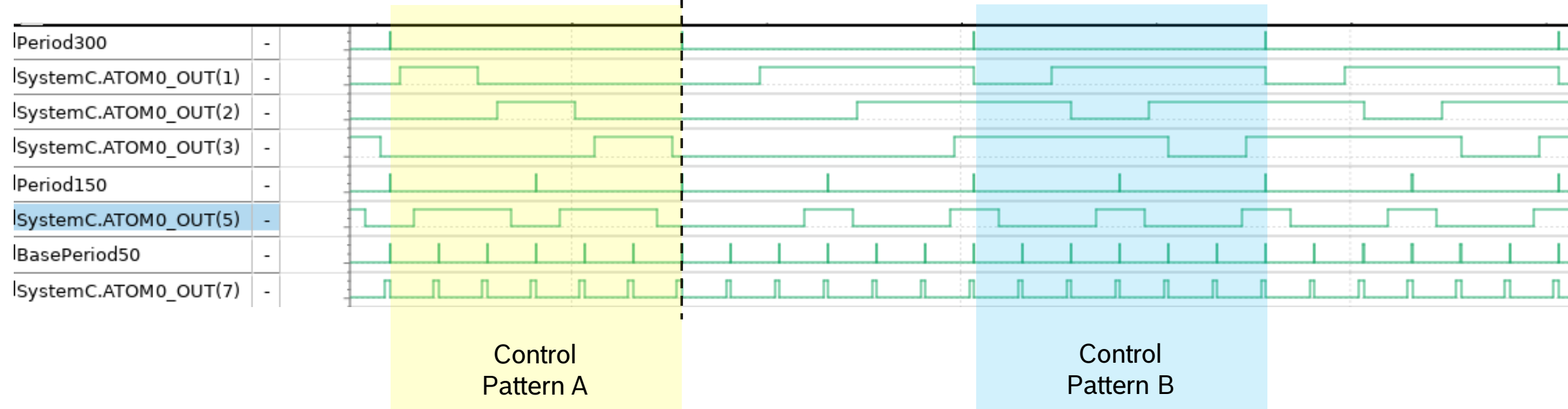
Multi rate support



Example

- Synchronous update of all outputs on Period300
- Allows synchronous switching of multiple phases operating on different period values

Synchronous update
on Period300



06

Summary

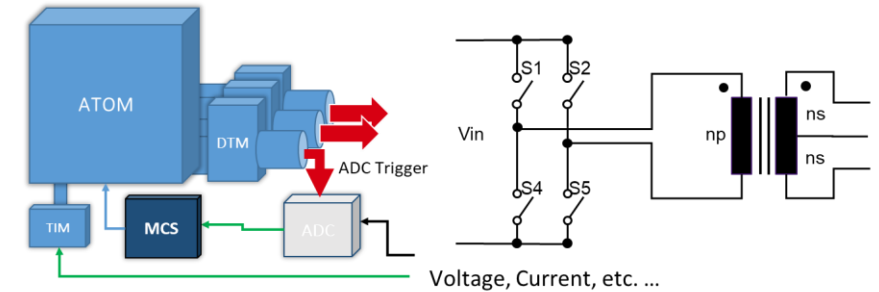
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Summary

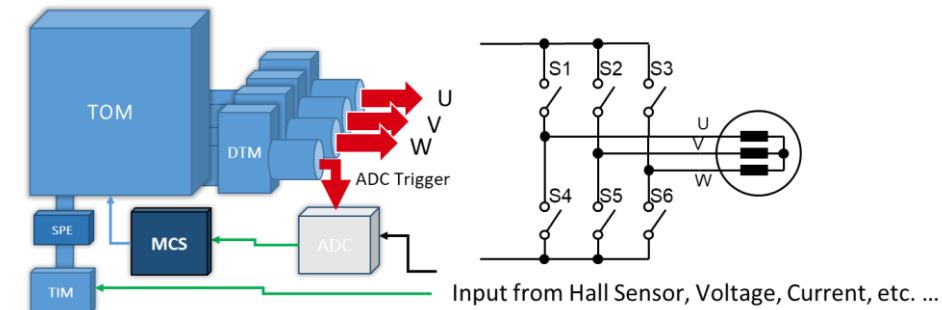
Benefits of GTM IP functions

- Speedup of SW development, due to predefined functions
- Applicable with any GTM resource
 - ATOM, TOM, TIO
- Functions can be used on
 - Any CPU core in the microcontroller
 - Any channel of a MCS in GTM (using MCS C-Code compilation)
- MCS code execution enables support of fast control loops
 - Deterministic execution
 - Including ADC converted values in control loops
 - Using GTM external stored data
 - Sensor data received on serial interfaces of the microcontroller
 - Parameter sets in use for algorithms located in CPU main memory
- Usable in virtualGTM Coside simulation environment

Example: Full Bridge PFC (Power Factor Correction)



Example: BLDC (Brushless DC) Motor



A decorative header consisting of a series of overlapping, semi-transparent geometric shapes (triangles and polygons) in a color gradient from red on the left to green on the right.

Thank you for your attention!