APPLICATIONS WITH NEW FEATURES OF GTM 4.1

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Applications with new features of GTM 4.1

Who should know about these improvements?

System architects

Hardware developer

Software developer

To take the right decision for their system/ application towards

Circuit topology selection

Compute power estimation

Cost / resource estimation

Selection of external components

Hardware/ software partitioning

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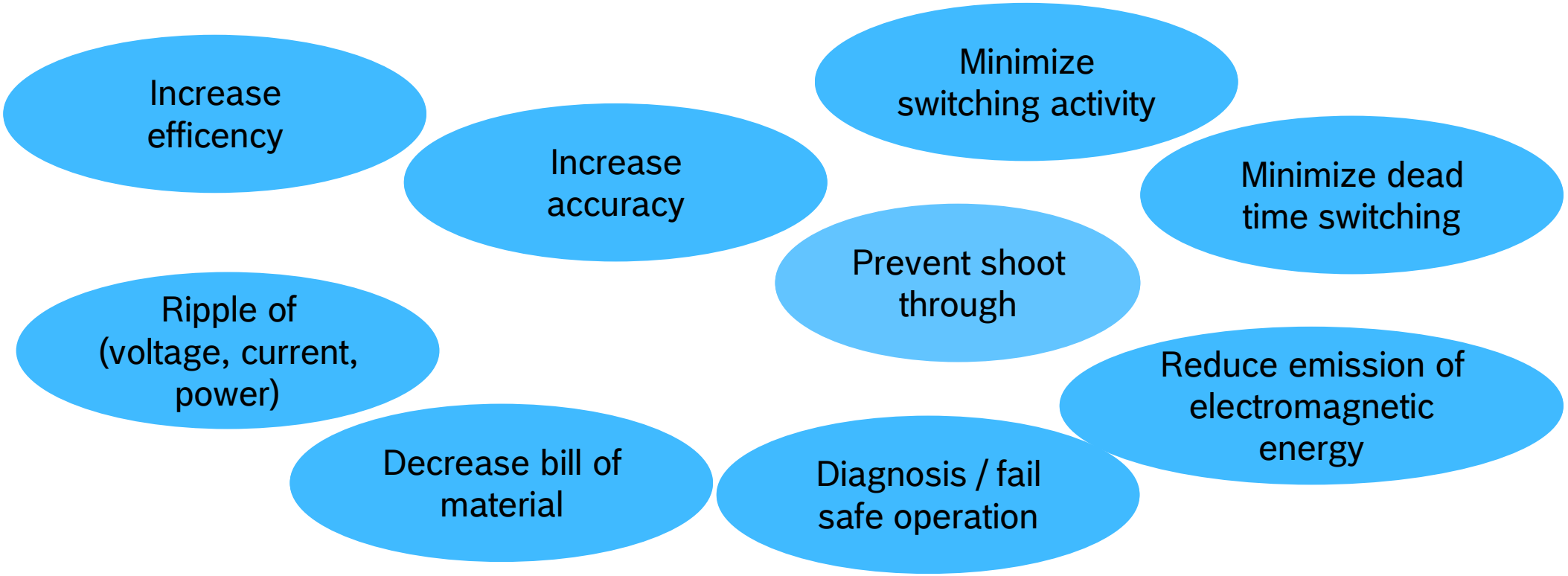
Applications with new features of GTM 4.1

GTM can address diverse system requirements



Each application will have its own optimization criterias

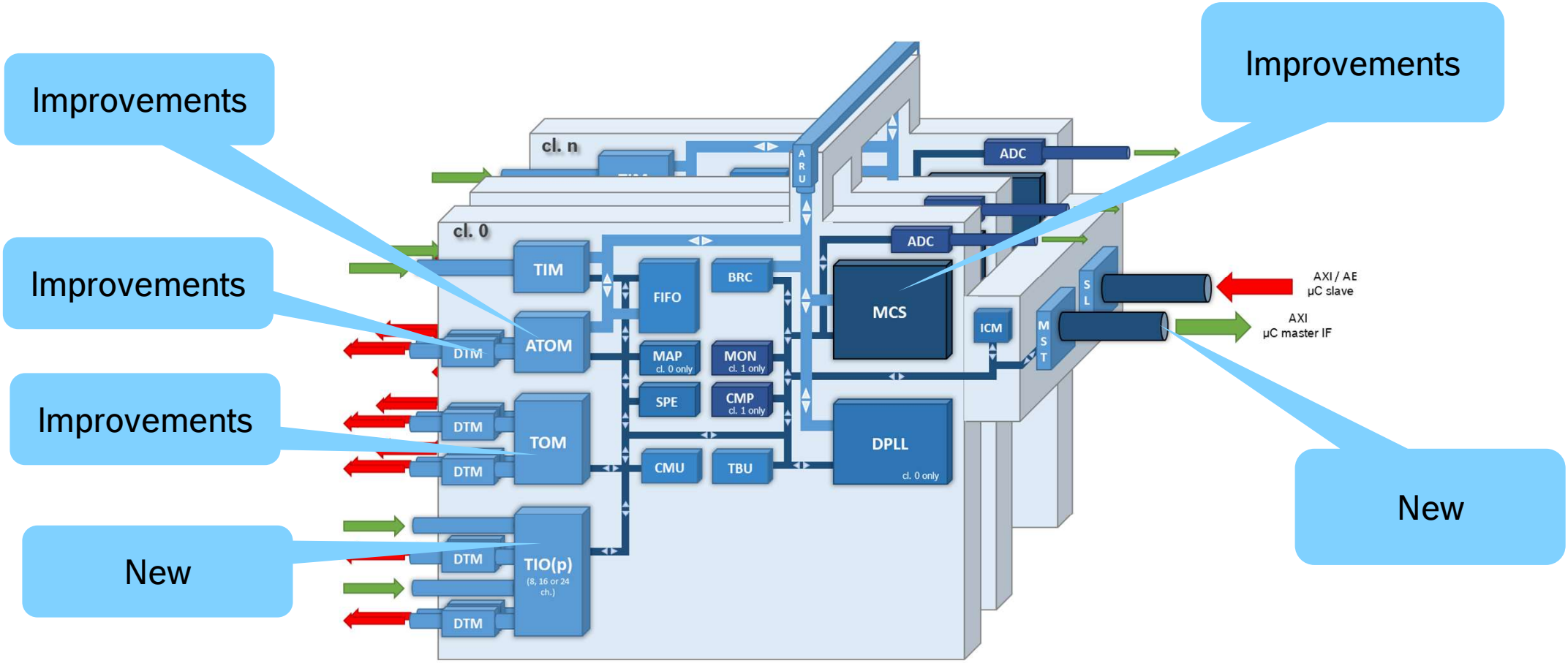
Many are contradictionary

*Following new **GTM** functionalities can be applied to achieve your system requirements*

- Easier

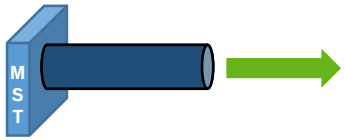
Applications with new features of GTM 4.1

Improvements with GTM 4.1



Applications with new features of GTM 4.1
Flexibility for MCS program execution

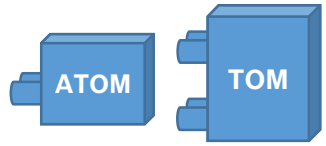
- introduced modified harvard architecture
  - MCS program execution speedup
- MCS builtin hardware breakpoint unit
  - Enhanced debugging/ breakpoint capabilites
- AXI master interface
  - GTM bus master interfaces; enables MCS to access/control µC resources outside GTM



- MCS shared interrupts
  - MCS can be triggered by GTM external interrupts/ events

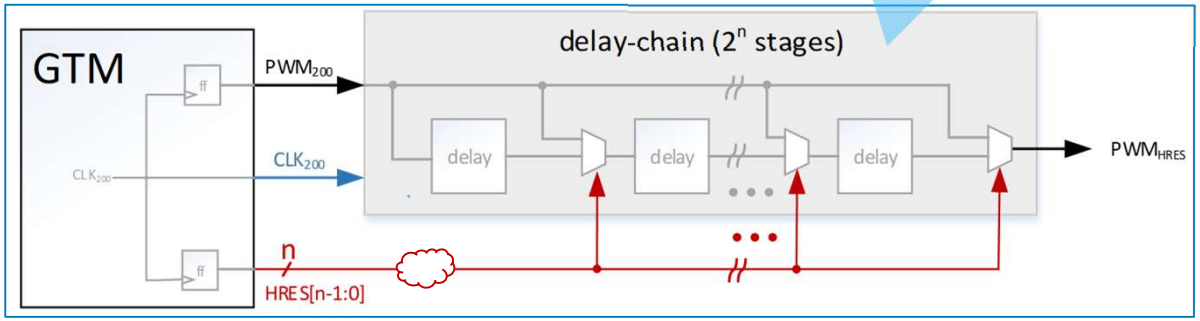
MCS is able to act similar as a task on a main uC core, can even take over DMA capabilities

Applications with new features of GTM 4.1
PWM high resolution support



- Supported in TOM / ATOM
- ATOM / TOM still operate on GTM clock frequency (e.g.: 200 MHz)
- Increase resolution by factor of 32 (n=5 bit)
  - Resolution = 156.2 ps (GTM @ 200 MHz)

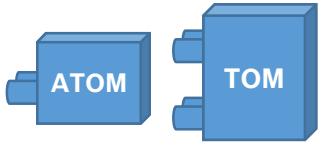
Alternatively, a PLL based implementation is possible



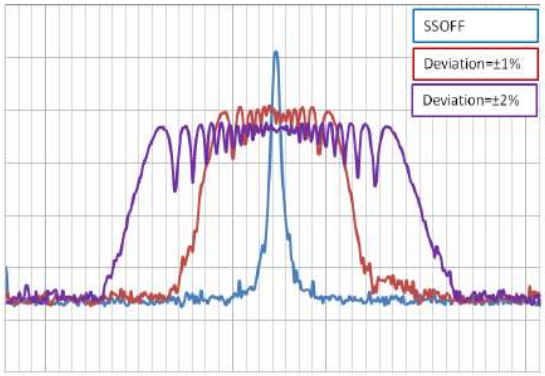
Fully register compatible with GTM GEN 1-3

Existing application only needs to scale the duty/ period parameters by 32 to make use of high resolution PWM resolution generation

Applications with GTM 4.1
Spread spectrum clocks / Dithered PWM



How to implement ?



Source: https://www.microcontrollertips.com/spread-spectrum-clocks

Shadow register support in ATOM /TOM / DTM allows period/duty cycle parameter update on a period rate

- Solution A: Variation of period/duty by a defined percentage can be possible with:
  - CPU, MCS
  - FIFO (pseudo random sequence)
- Solution B: Generate a spread sprectrum clock resolution which can be used as source of PWM generation
  - Idea: use (50 + deviation) % duty PCM mode

    adapt duty value on a period rate; random or pseudo random sequence can be used (constraint: E.g: -1<deviation< 1)
  - Multiple PWMs can operate without shadow register update fully synchronous on spread spectrum clock resolution

Applications with new features of GTM 4.1
DTM: Dead time high resolution support

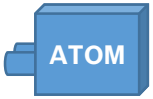
Similar as in ATOM / TOM based on factor 32 increased resolution

- Allows signal manipulation on high resolution
  - Delay edges:
    - Lengthen/ shorthen/ mask pulse
  - Dead time generation
- Can be enabler to higher efficency of systems

Other DTM improvements

- Shadow register for deadtime parameter update synchronous to PWM
- Individual shut off

Applications with GTM 4.1
PCM as alternative for PWM



PWM:

- single high pulse with length of duty
- after period elapses, pulse will be repeated

PCM: Pulse count modulation

- High pulses will be evenly spread in period time frame
- Duty = Integration of high pulses

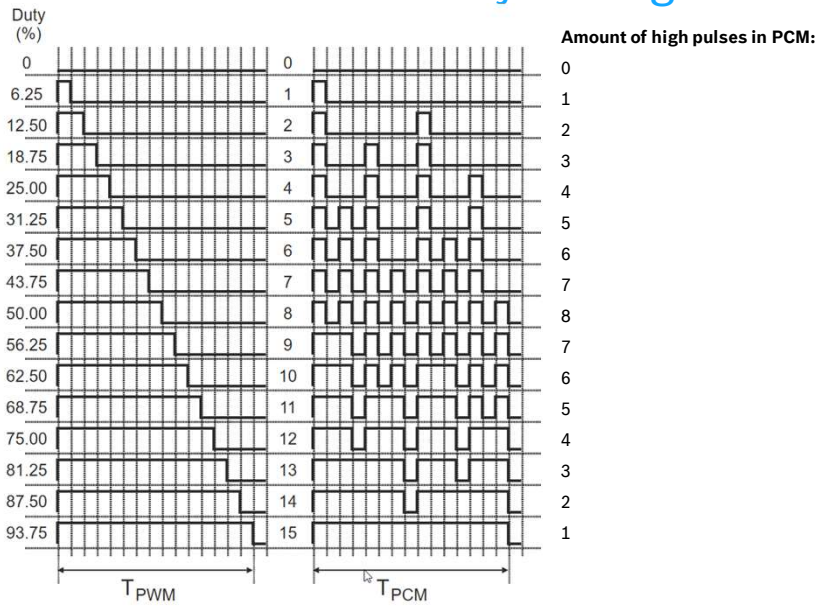
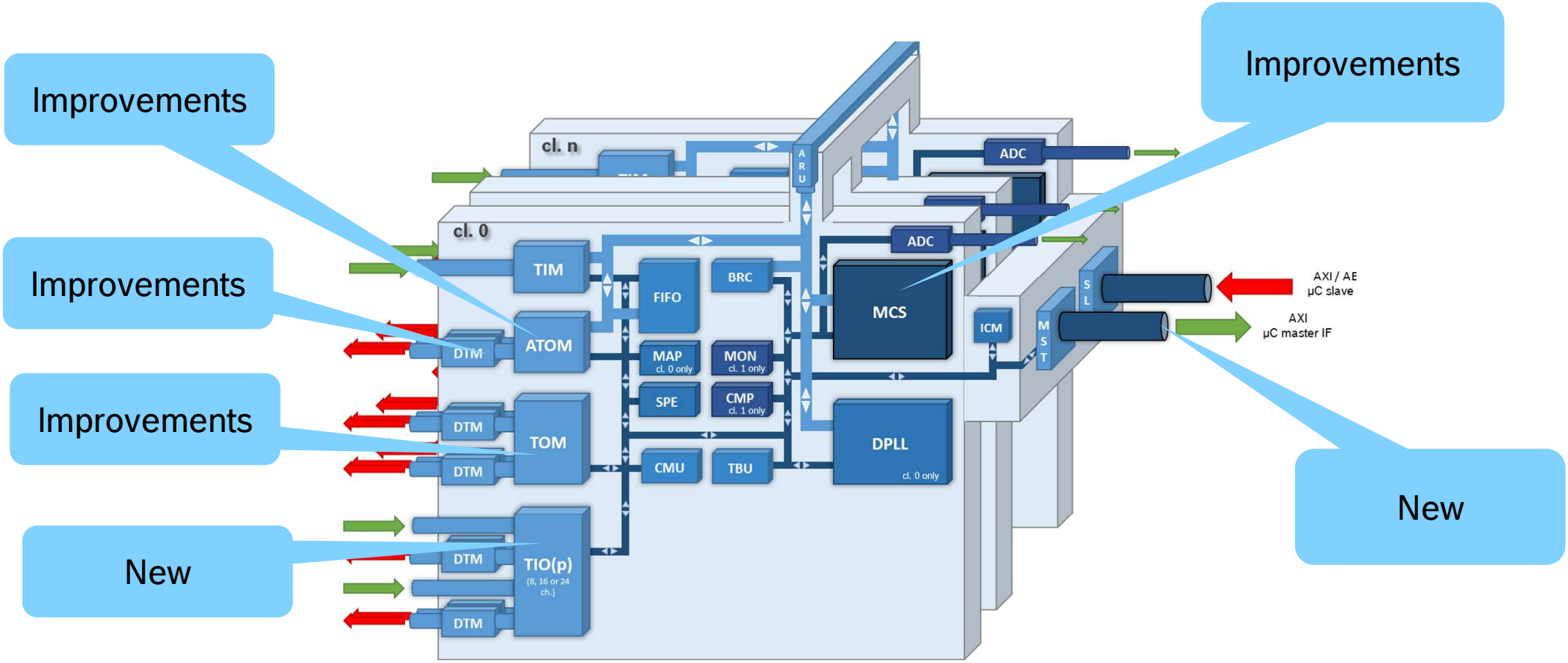


Figure 6. Duty cycle switching scheme of PWM and PCM modulators
Source: https://dergipark.org.tr/tr/download/article-file/234115

Applications with new features of GTM 4.1

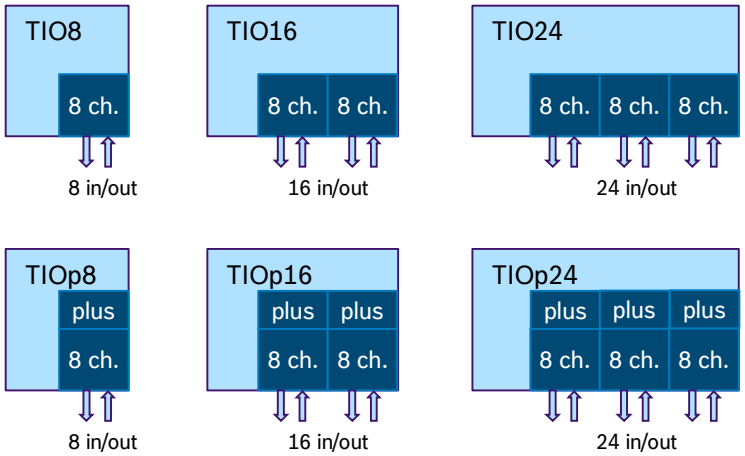
Improvements with GTM 4.1

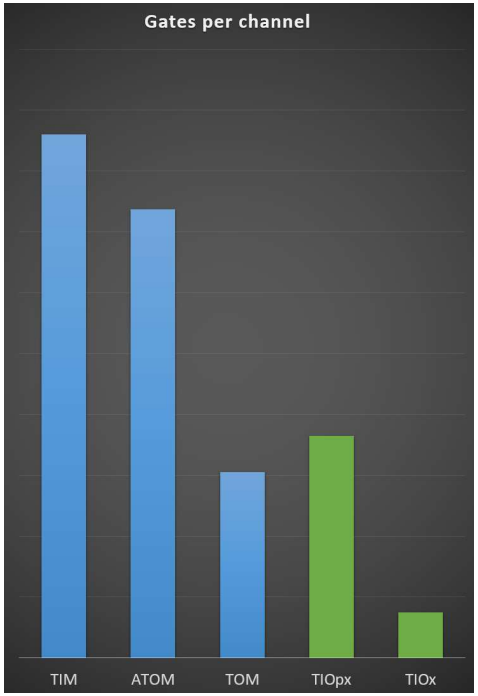


Applications with new features of GTM 4.1
New TIOx / TIOpx modules

- Support for low-end applications with reduced design complexity and function requirements
- Flexible usage as input or output on a per channel granularity (configurable at runtime)
- Reduced gate count for optimized support of low-range devices

- Up to double capture/compare per channel
- PWMs up to 25 ns resolution (using 1 MCS channel)
- Serial shift of flexible pattern length
- Basic filter functionality
- IN and OUT functionality in same channel (dynamic re-config.)
- 6 TIO module configurations





Applications with new features of GTM 4.1

TIO: Functional equivalence to TIM, TOM, ATOM modes

TIO was designed to provide alternative solutions of existing functions

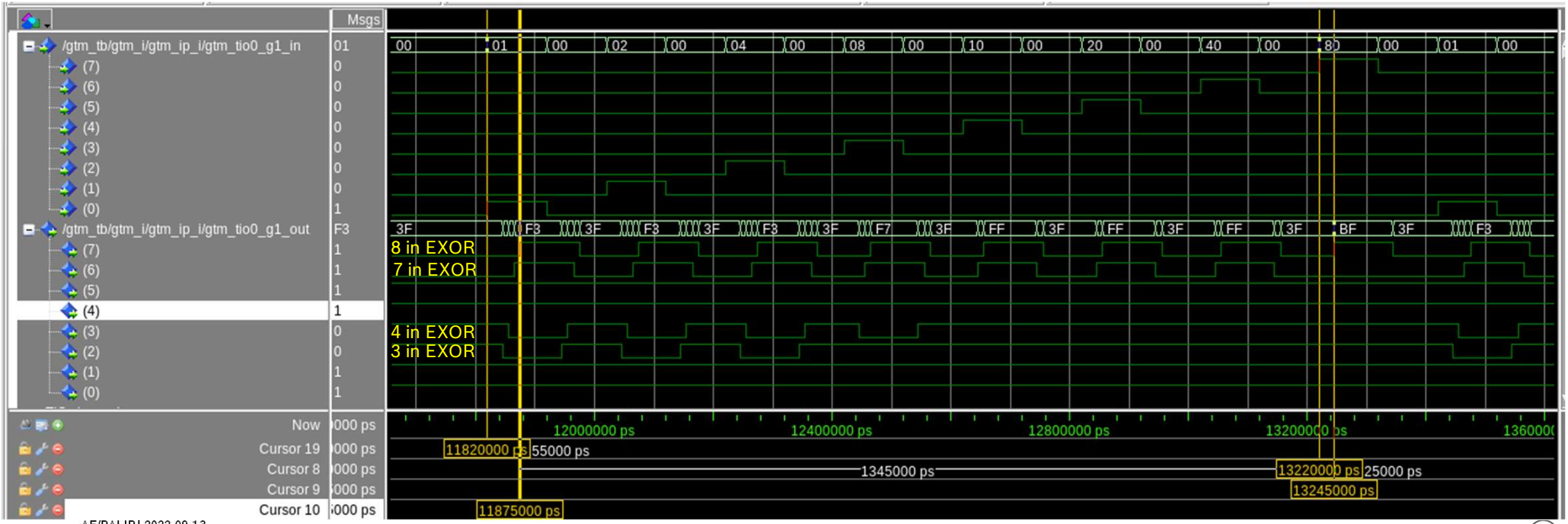
- TIM:
  - Filter functions
  - Timeout functions
  - Measurement functions
    - TIEM, TPWM, TPIM, TIPM, TGPS, TSSM
    - TBCM mode not available with TIO
- TOM, ATOM:
  - SOMP mode
    - PWM, PCM not available with TIO
    - HRES not available with TIO
  - Synchronous start
  - Trigger chain
- ATOM:
  - SOMI, SOMS, SOMC
- TIO has no ARU connection

Applications with new features of GTM 4.1

TIO: Boolean functions, simple: low latency

8 inputs -> 1 output: Function EXOR output signal resolution 5ns

- 3 input function: min latency 5 cluster clocks :~ 25ns
- 4-8 input function: max latency 11 cluster clocks: ~ 55ns



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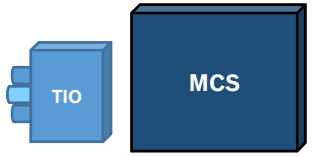
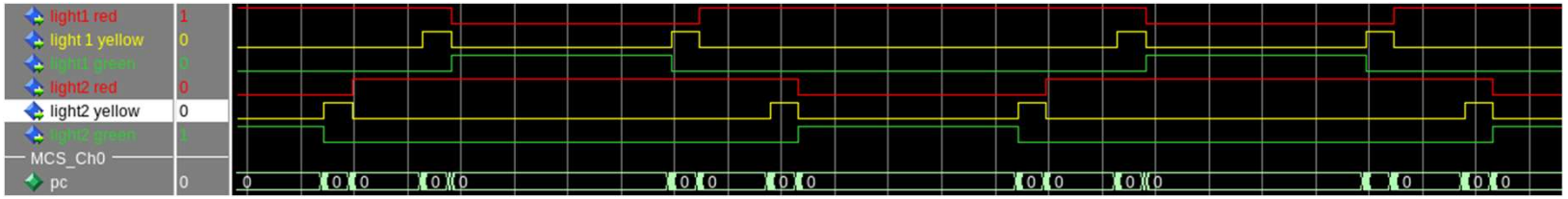
Applications with new features of GTM 4.1

TIO: Boolean functions, advanced



Implement in MCS a FSM (similar to a simple PLD)

- TIO with 8 channels can host
  - 8-j inputs controlling 8+j outputs
  - State length can be controlled by timebase compare




```
39 states:
40 R_G:   .var red * traffic11 | green * traffic12
41 R_Y:   .var red * traffic11 | yellow * traffic12
42 R_R:   .var red * traffic11 | red * traffic12
43 RY_R:  .var redyellow * traffic11 | red * traffic12
44 G_R:   .var green * traffic11 | red * traffic12
45 Y_R:   .var yellow * traffic11 | red * traffic12
46 R_R_2: .var red * traffic11 | red * traffic12
47 R_RY:  .var red * traffic11 | redyellow * traffic12
48
49 nstates:
50 N_R_G:    .var  wait10 | (R_Y  - states)  * mhbpos
51 N_R_Y:    .var  wait1  | (R_R  - states)  * mhbpos
52 N_R_R:    .var  wait3  | (RY_R - states)  * mhbpos
53 N_RY_R:   .var  wait1  | (G_R  - states)  * mhbpos
54 N_G_R:    .var  wait10 | (Y_R  - states)  * mhbpos
55 N_Y_R:    .var  wait1  | (R_R_2 - states) * mhbpos
56 N_R_R_2:  .var  wait3  | (R_RY - states)  * mhbpos
57 N_R_RY:   .var  wait1  | (R_G  - states)  * mhbpos
58
59 ;*************************************************************
60 ;*   task 0:
61 ;*          R0 output data
62 ;*          R5 state_offset
63 ;*          R1 TBU_WAIT offset / value
64 ;*************************************************************
65
66 ch0_init:
67     movl   R5, 0x0                ; initial state offset
68
69 l_loop:
70     mrdi R0, R5, states
71     bwr  R0, TIO_0                ; write output
72     mrdi R1, R5, nstates          ; read next state
73     mov R5, MHB                   ; set nextstate
74
75     ## wait for a defined time to change state
76     add    R1, TBU_TS0
77     wuce  R1, TBU_TS0
78
79     jmp    l_loop
```

TIO/ MCS solution has lesser latency compared to TIM/ ATOM/ MCS approach simpler control of atomic output signal changes

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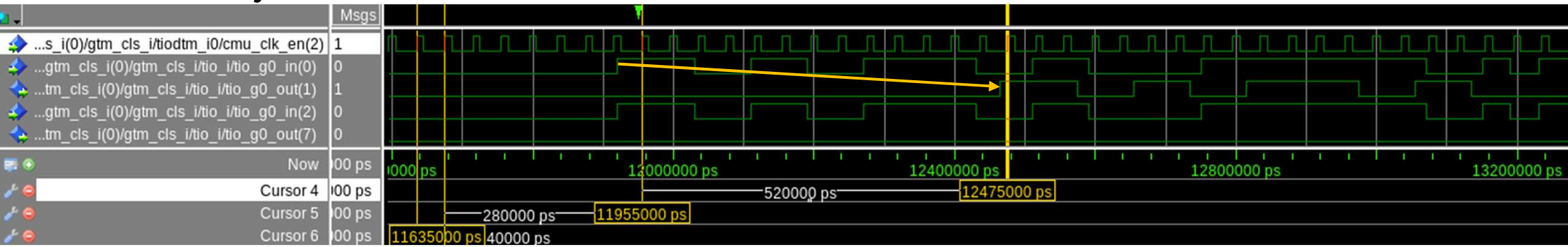
Applications with new features of GTM 4.1

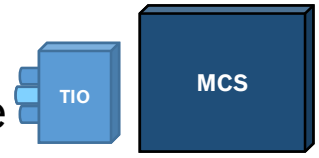
TIO: Signal Delay chain (serial data stream)

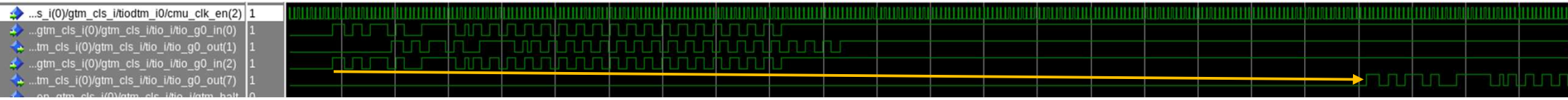
Delay input stream by x=13 clock resolutions

amount of delay > 24 clock resolution needs additional buffer resources inside TIO



Using MCS assitance (memory): Delay is just limited by available memory for data storage





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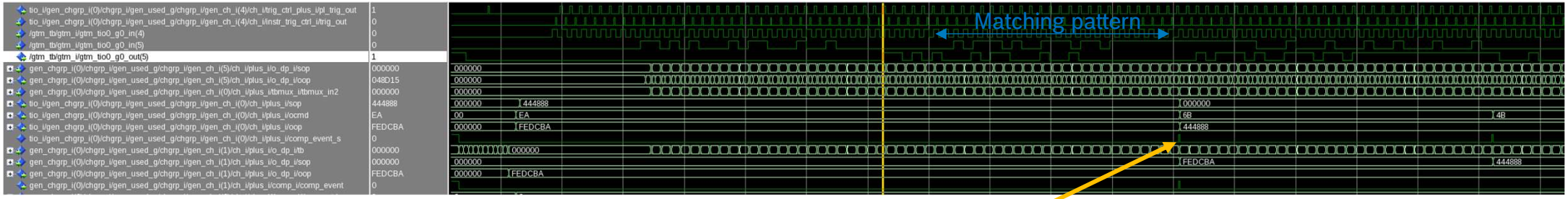
Applications with new features of GTM 4.1

TIO: Match a pattern in a serial data stream



Raise IRQ in case a predefined pattern occurs in a serial data stream

Allows to react based on MCS or uC core

E.g: Selective sending of data based on matching address in serial input data stream

Applications with new features of GTM 4.1

TIO: "simple DPLL„ fractional multiply

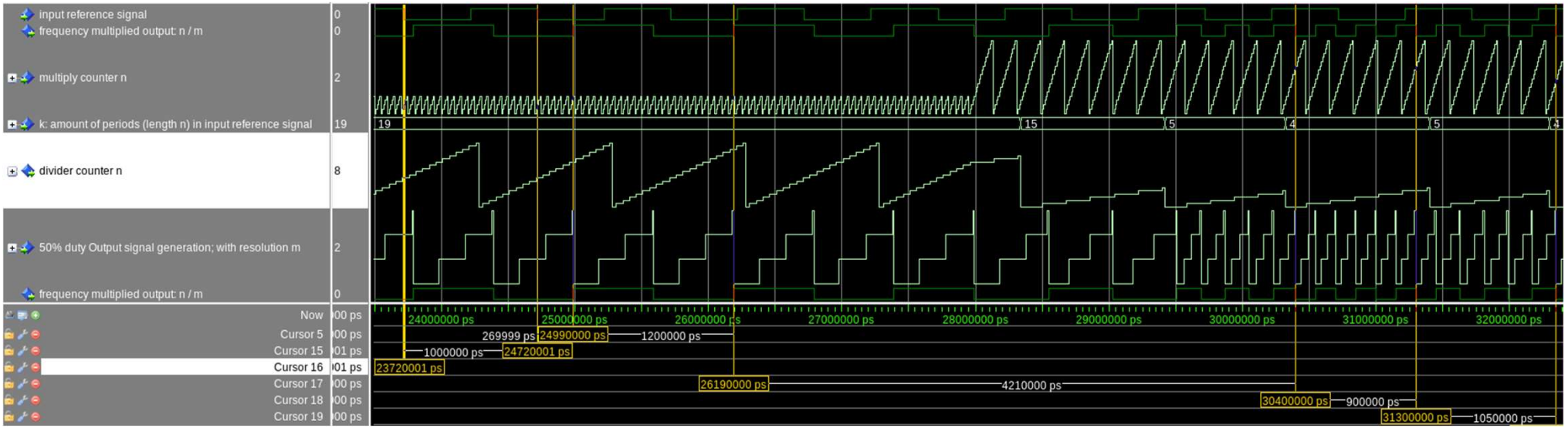
Signal input period can be scaled by factor n/m: n, m configurable by application

Lower frequency:

Multiply by 5/6

Higher frequency:

Multiply by 18/6



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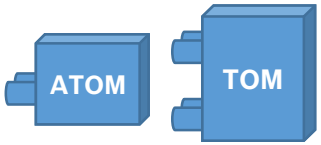
Thank You

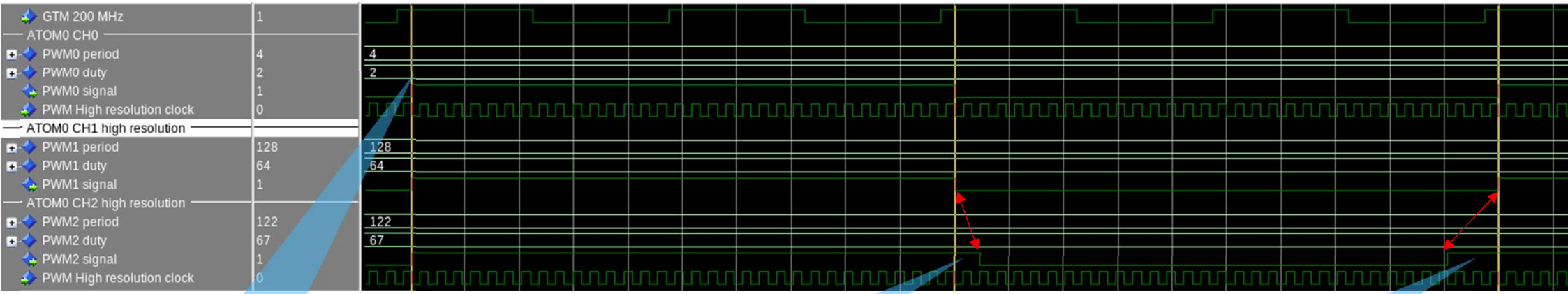
*Further **GTM** improvements*

and more details

Applications with new features of GTM 4.1
PWM high resolution support



- ATOM CH1 / CH2 high resolution example (PLL delay chain support of n=5)



Standard PWM generation

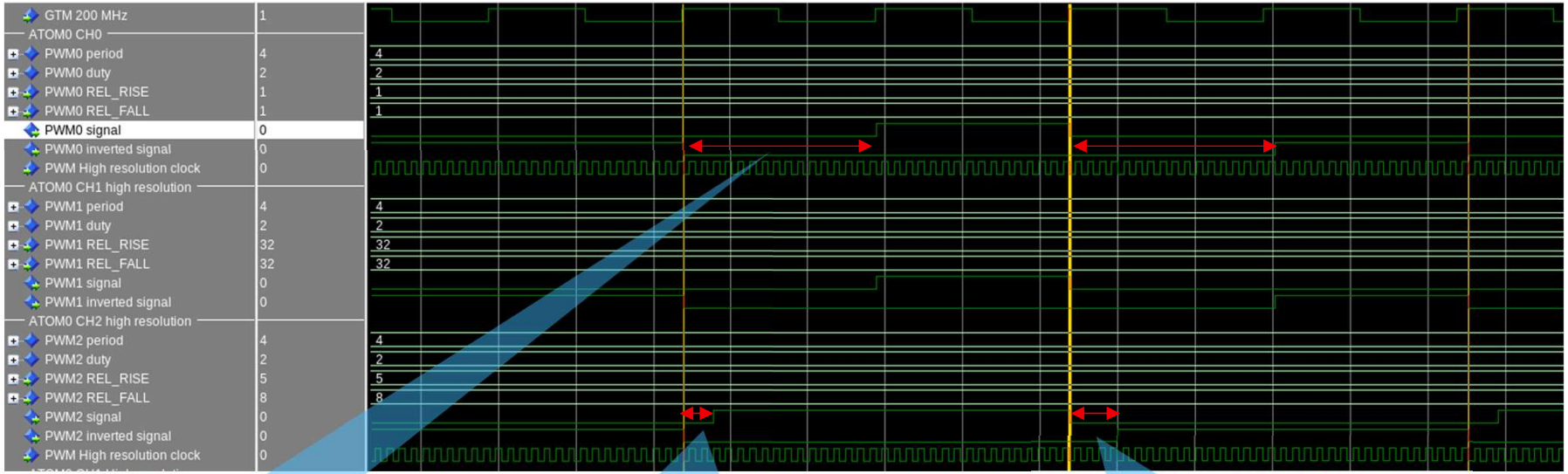
Duty cycle increase by 3 high resolution tics

Period decrease by 6 high resolution tics

Applications with new features of GTM 4.1

DTM: Dead time high resolution support

Example



Standard DTM dead time insertion

Dead time rise insertion by 5 high resolution tics

Dead time fall insertion by 8 high resolution tics

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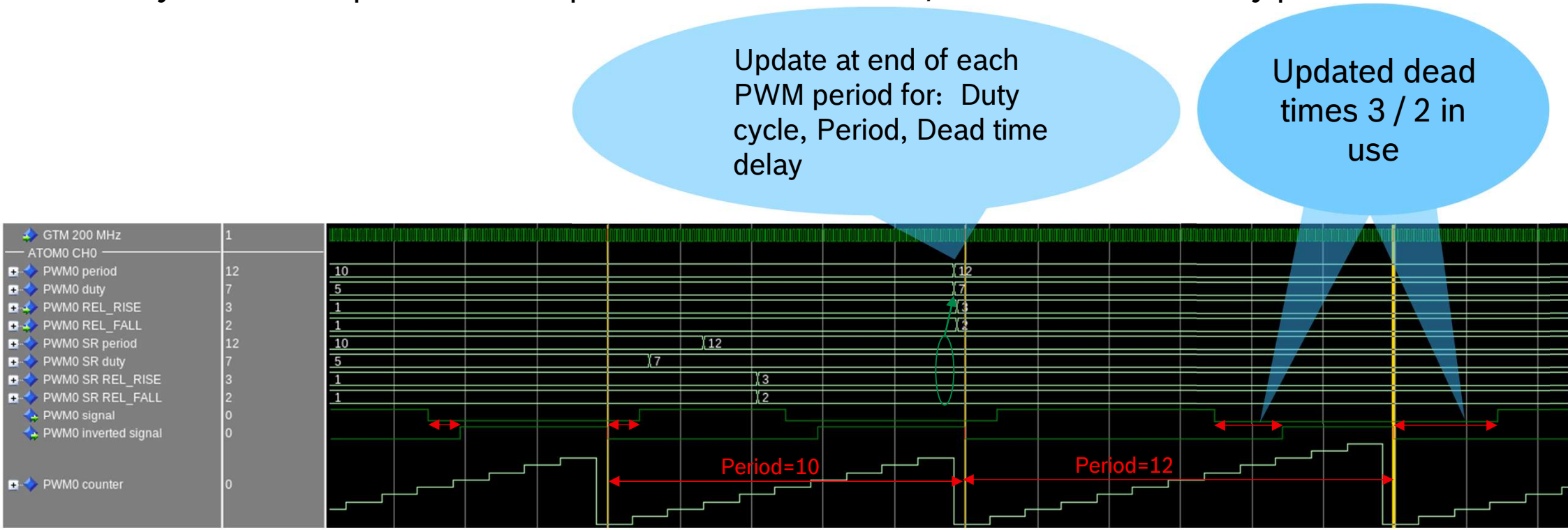
Applications with new features of GTM 4.1
DTM: Shadow register

Introduced shadow register for signal delay parameter REL_RISE / REL_FALL

Allows synchronous update of PWM parameters used in TOM/ ATOM and DTM delay parameters



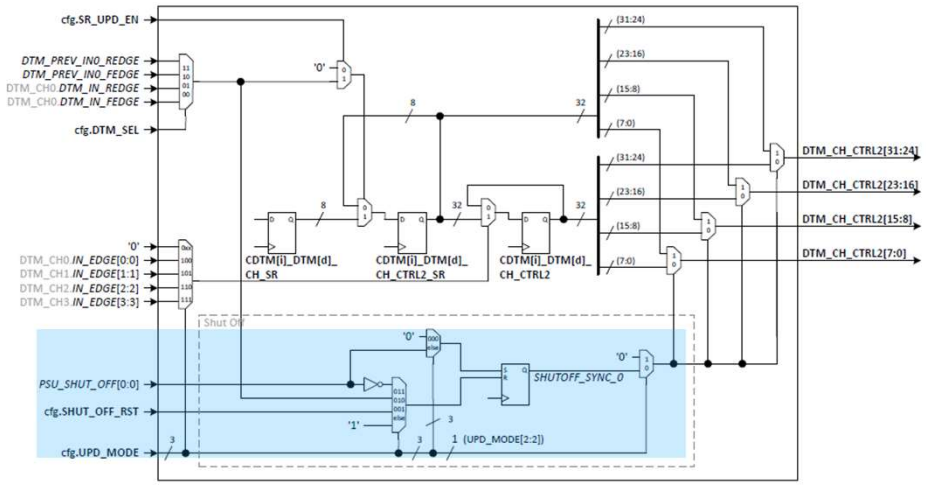
Applications with new features of GTM 4.1

DTM: Individual shut off

GTM 2, 3:

1 shut off signal could activate the „emergency states“ for all 4 x 2 outputs of a DTM module

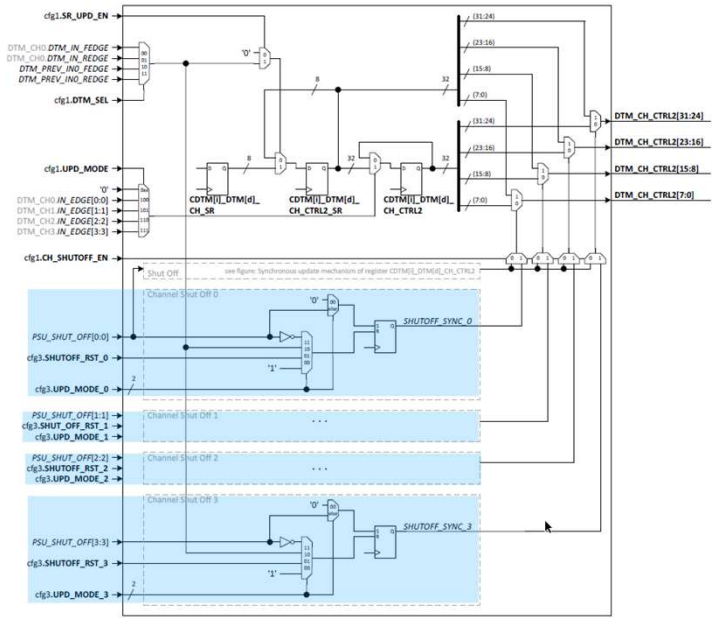
- Allows consistent control: E.g. 3 phase output stage



GTM 4:

4 shut off signals available, each will activate 2 outputs

- Allows individual shutoff control for each high side/ low side dead time pair

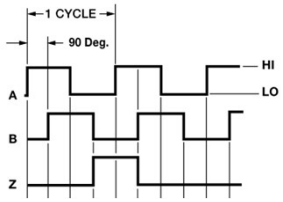


Applications with new features of GTM 4.1

TIO AB decoder: Higher resolution position counter

Use low resolution AB decoder:

e.g: 32 cycles per turn



TIO supports internal position counter:

- Position increment/ decrement based on edges of A / B
- Position reset based on Z
- Direction change support
- TIO output signal generation based on compare to TIO internal position counter

Generate an „factor k higher resolution AB signal“ with TIO DPLL functionality

- Use XOR of A/ B signal as input reference signal for frequency multiplication by k
- Operate TIO position counter on „factor k higher resolution AB signal“
- TIO output signal generation, will operate on factor k higher resolution too

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