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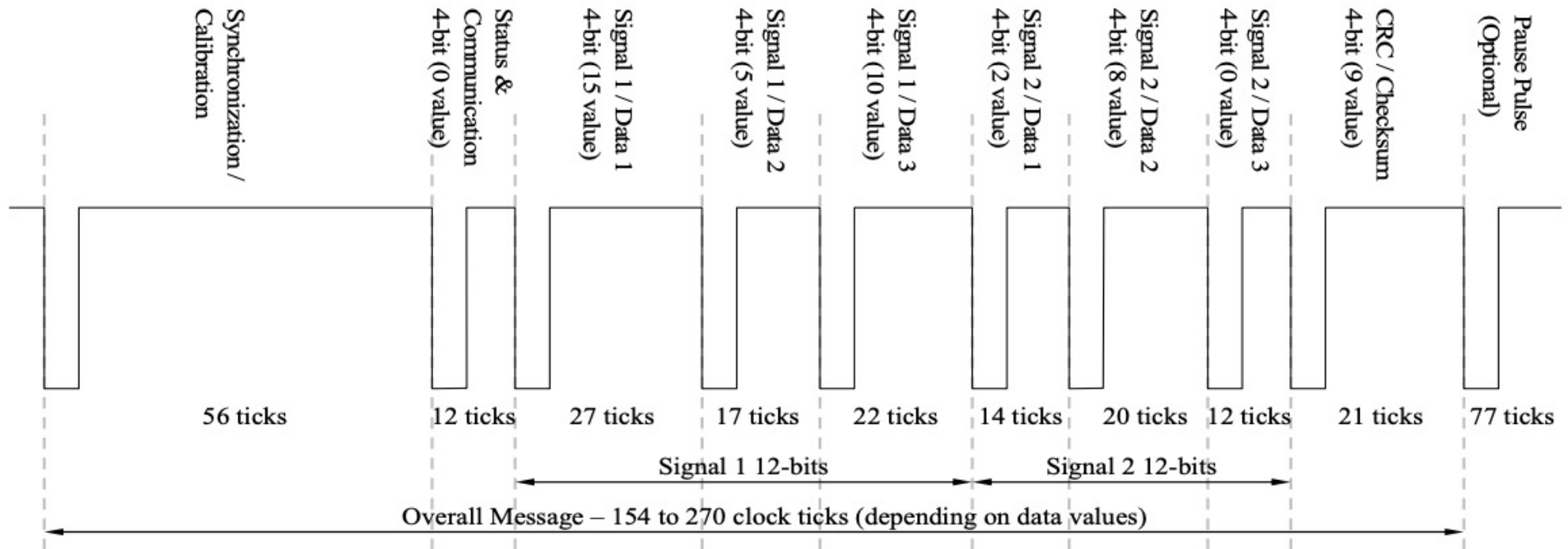
# Resource-efficient MCS programming

22/09/22 – Christian Lederer

# Introduction

- Emulation of communication interfaces using GTM
  - ❖ Additional communication interfaces on general purpose I/Os
  - ❖ MCS for protocol handling to keep the workload of the main CPU low
  - ❖ Multiple communication channels handled by single MCS channel

# Single Edge Nibble Transmission



[1]

## Features

- 6 data nibbles
- 4-bit CRC calculated over the data nibbles
- Nominal clock period (tick) / unit times (UT) from 3 to 90  $\mu\text{s}$
- Maximum clock variation  $\pm 20\%$
- Successive calibration pulse deviation  $< 1.5625\%$  (1/64)
  - ❖ 2 different options to handle deviation errors
- Additional serial message channel (slow channel)
  - ❖ 1 or bits encoded in 16 consecutive messages
    - Short serial message: 16 bit payload
    - Enhanced serial message: 21 bit payload
      - 6-bit CRC

## Signal reception

- TIM channel in PWM measurement mode
  - Timing constraints:
    - ❖ Min UT: 3  $\mu$ s
      - 20 % clock variaton
      - > Min UT 2.4  $\mu$ s
    - ❖ Calibration pulse is 56 UT long and may vary by 1/64
      - $\frac{56}{64} * 2.4 \text{ us} = 2.1 \text{ us}$
- > TIM clock higher than 1 MHz should be sufficient
- > But there is another timing constraint

# Data Nibble

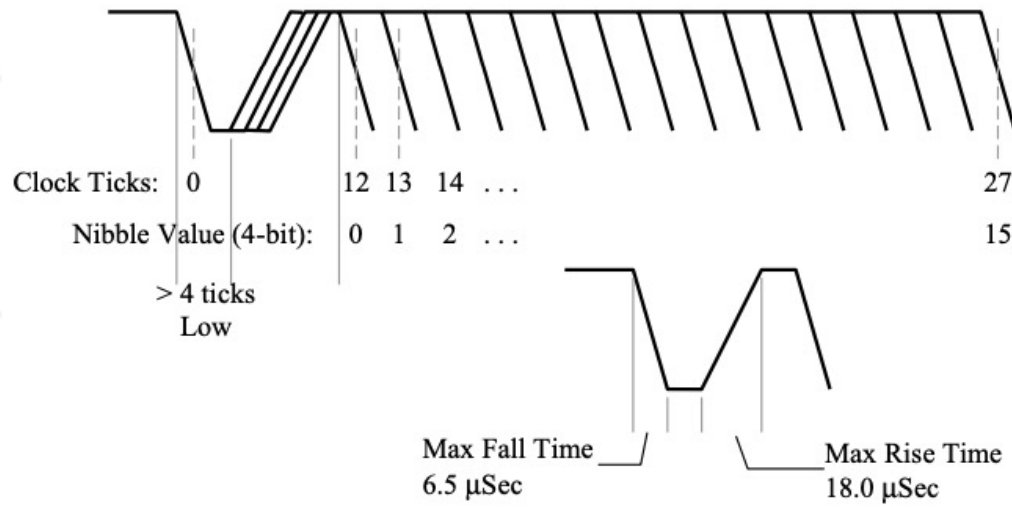
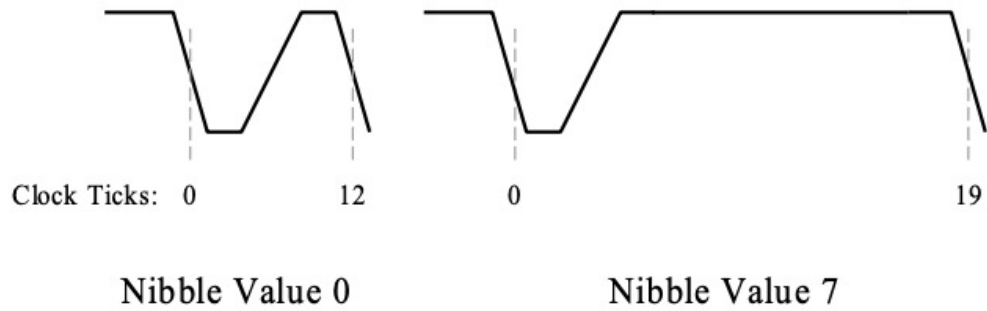


FIGURE 5.2.3-1 – EXAMPLE NOMINAL NIBBLE TIMES



[1]

## Accuracy

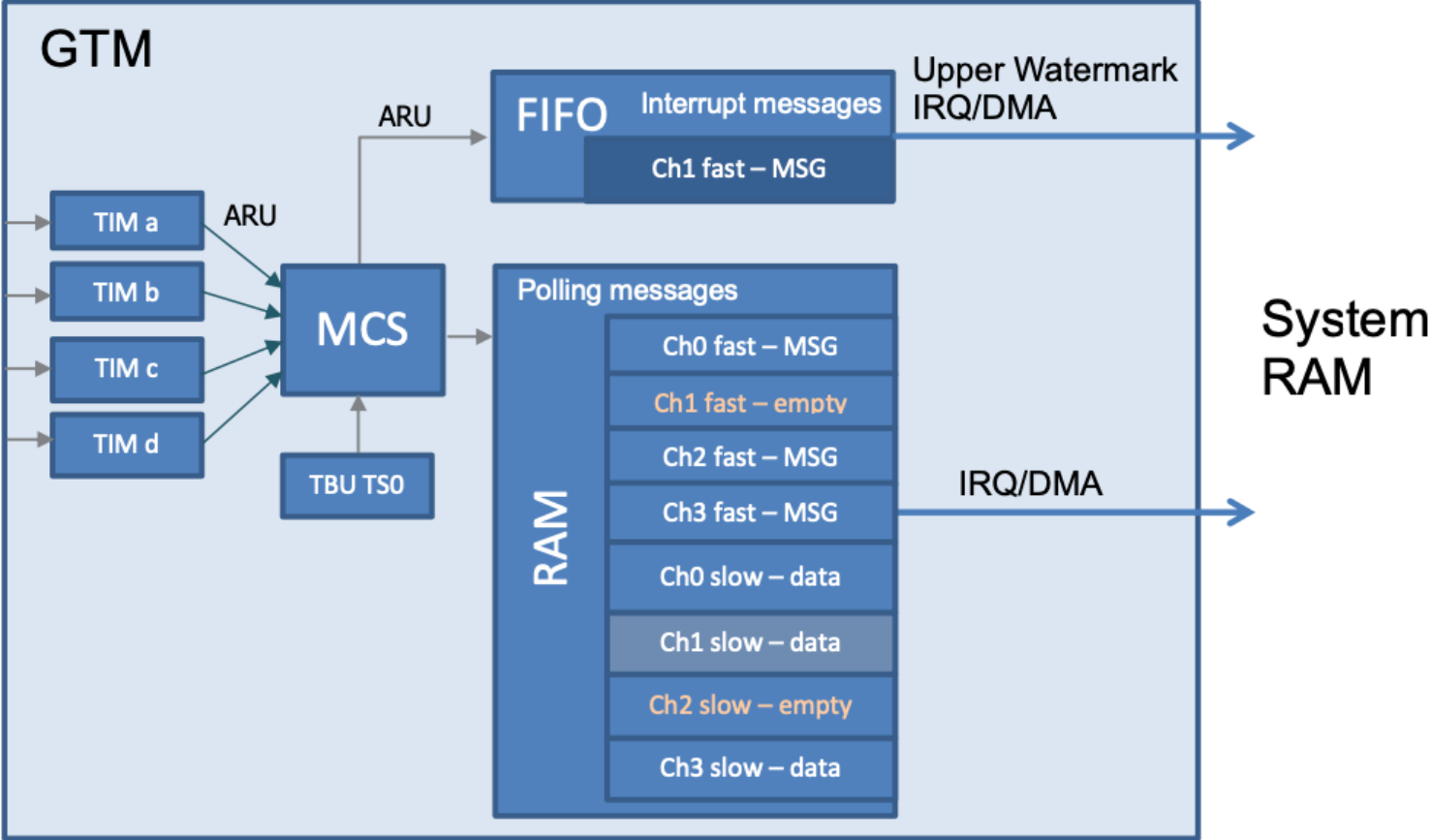
- UT = 3  $\mu$ s, TIM Clk = 25 MHz
  - ❖ Synchronization pulse:  $56 \cdot 3 \mu\text{s} \cdot 25 \text{ MHz} = 4200 \text{ ticks (TIM)}$ 
    - with -20% tolerance = 3360 ticks (TIM)
    - 1UT in TIM ticks:  $\frac{3360}{56} = 60$ 
      - Worst case:  $\frac{3415}{56} = 60.98$  (will be floored to 60)
  - > calc error  $\frac{1}{61} = 1.64 \%$
  - Multiplies with bits
    - max 15-bit -> last bit will be detected 24.59 % in advance

# Unit Time Calculation

- Calculation of  $\frac{1}{56}$  using shift and add (backward compatibility to GTM 1.5)
  - ❖ Required precision
  - ❖ Stay within the registers' word range
- $\frac{1}{56} = \frac{1}{2^6} + \frac{1}{2^9} + \frac{1}{2^{12}} + \frac{1}{2^{15}} + \frac{1}{2^{18}} + \dots$
- UT = 90  $\mu$ s, TIM Clk = 25 MHz
  - ❖ Synchronization pulse:  $56 \cdot 90 \mu\text{s} \cdot 25 \text{ MHz} = 126000$  ticks (TIM)
    - with +20% tolerance = 151200 ticks (TIM)
    - Max. left shift of 6 to stay within 24-bit range of register
- $\frac{1}{56} = \frac{1}{2^6} + \frac{1}{2^9} + \frac{1}{2^{12}} + \frac{1}{2^{15}} + \frac{1}{2^{18}} + \dots = [2^6 + 2^3 + 1 + \frac{1}{2^3} + \frac{1}{2^6} + \dots] \frac{1}{2^{12}}$



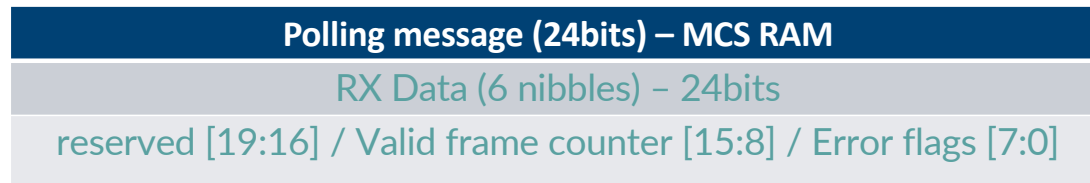
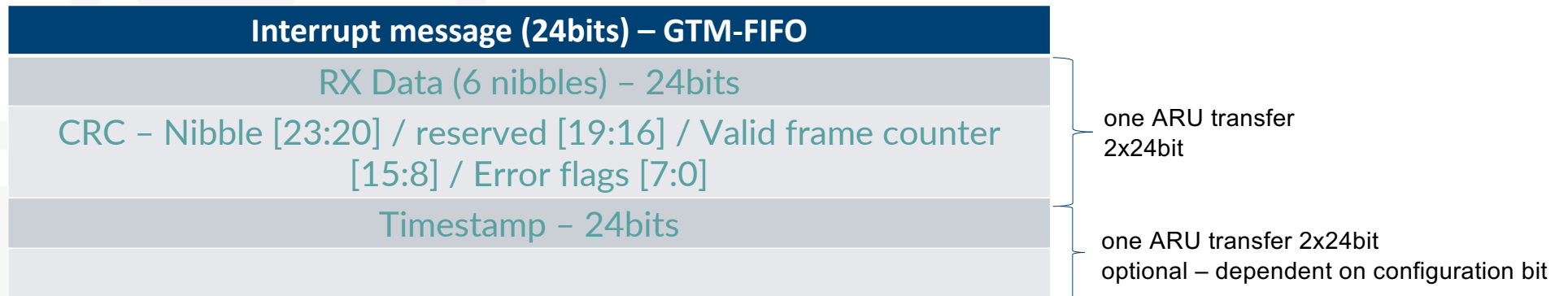
# System Architecture



## Features

- Each SENT channel has [2]:
  - ❖ Polling message (periodic messages – OS tasks)
  - ❖ Interrupt message (sensor synchronous – immediately needed by application after reception)
- Polling messages will be stored in MCS RAM and transferred by DMA
  - ❖ DMA is triggered by MCS in configurable time period (e.g. 1ms)
- GTM-FIFO will be used for interrupt message
  - ❖ FIFO interrupt after reaching configured watermark

# Message Handling



## Conclusion

- 1 MCS channel can handle up to 4 SENT receivers in parallel (80 MHz sysclk)
- ARU polling is the limiting factor (GTM 1.5 compatible)
  - ❖ Bus Master Interface of newer GTM versions allows even more SENT channels per MCS channel
- But since 4 TIM channels can be used by 1 MCS channel
  - ❖ Available TIM channels and available I/Os are the limiting factor

## References

- [1] SAE International: SENT—Single Edge Nibble Transmission for Automotive Applications; J2716; Jan 2010
- [2] Eugen Becker: 590\_360\_SW-SENT\_Interface; v15; March 3<sup>rd</sup>, 2016

An overhead photograph of four people (three men and one woman) sitting on the floor in a circle, leaning in towards each other with their hands stacked in the center. They appear to be in a collaborative meeting or huddle. The background is a plain, light-colored floor.

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