

The logo for MIPI DevCon Virtual Event. It features the word "mipi" in black lowercase letters with a registered trademark symbol, followed by "DEVCON" in large, bold, black uppercase letters. The "DEV" part of "DEVCON" is in red. Below this, the words "VIRTUAL EVENT" are written in a smaller, grey, uppercase font. Above the "mipi" text is a decorative arc of colored dots in purple, blue, green, and orange.

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Lalan Mishra
Qualcomm Inc.

**A Snapshot on MIPI RFFE
v3.0 from A Systems Architecture
Perspective**

MOBILE & BEYOND

**MIPI ALLIANCE
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**22-23
SEPTEMBER
2020**

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Contents Contributed By (Alphabetically by 1st Name)

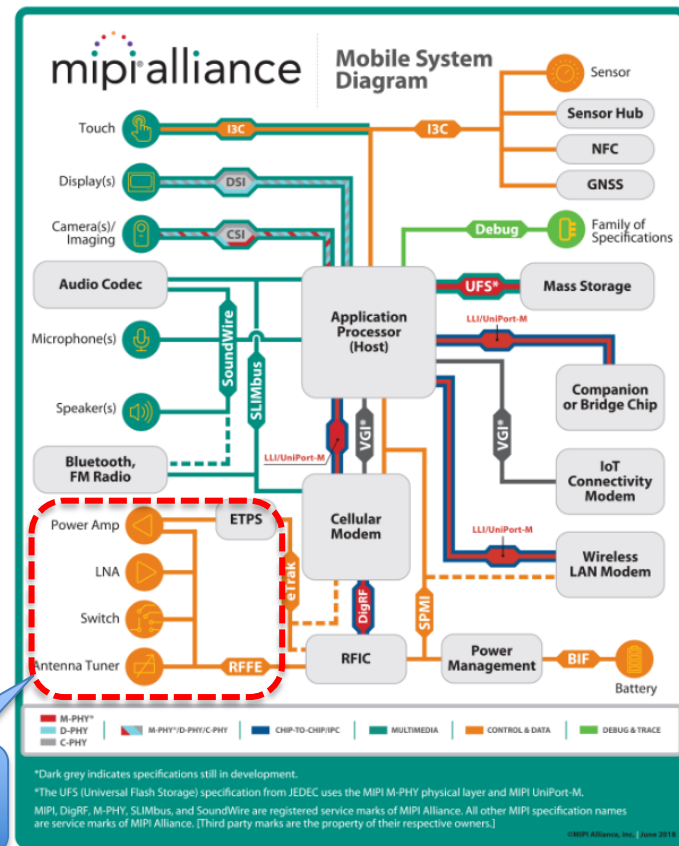
- Jim Ross – Skyworks Inc.
- Lalan Mishra – Qualcomm Inc.
- Vic Wilkerson – Qorvo Inc.
- Werner Hein – (while at Intel Inc.)

Session Agenda

- Introduction to MIPI RFFE
- RFFE Evolution : A Quick Glance
- 5G Systems and New RF-FE Control Requirements
- RFFE v3.0 : New Features
 - Additional Extended Triggers
 - Timed Trigger
 - Mappable Triggers
- Summary
- Q&A

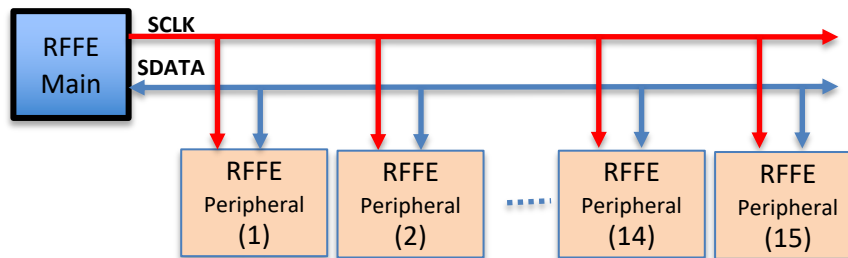
Introduction To MIPI RFFE

- Pre-MIPI-RFFE Era:
 - Complex solution for RF-Front-End Control
 - Discrete GPIOs >> Excessive I/O pins, Higher System-cost
 - Custom Buses >> Incompatible RF-FE products, Complex System Design
 - Complex Software and Control-Timing Challenges
- MIPI Introduces RFFE Bus in 2010:
 - 2-Wire Multi-drop Bus (1 Main and up to 15 RF-Peripheral devices)
 - Easy to implement logic
 - I/O reduction, Interface compatible RF-products, less complex system S/W, Easier to meet Real-Time Control-Timing budget
- For the past 10 years, MIPI RFFE Specification has enabled billions of RF-FE components in:
 - Cellular
 - IoT
 - Automotive
 - And other Wireless products



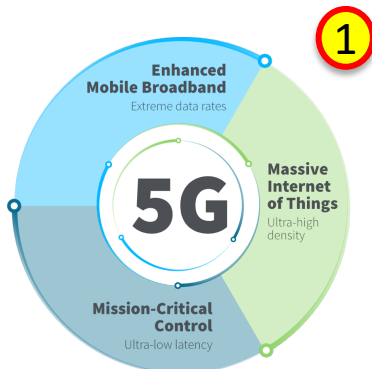
The MIPI RFFE Domain

Evolution of MIPI RFFE

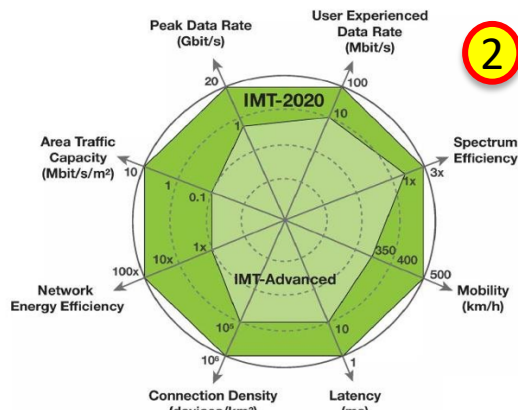


V1.0 Adopted July-2010	V1.1 Adopted Nov-2011	V2.0 Adopted Dec-2014	V2.1 Adopted April-2018	V3.0 Adopted April-2020
• 1st release • 26-MHz • 3-Triggers	• Bug Fixes • No major enhancements	• Synchronous Read • Extended Speed (52 MHz) • Multi-Master Support • Reserved Register Space Expansion	• Masked-Write • Master Context Transfer • Longer Reach • Extended Triggers • Register Space Expansion	• Additional Extended Triggers • Timed Triggers • Mappable Triggers

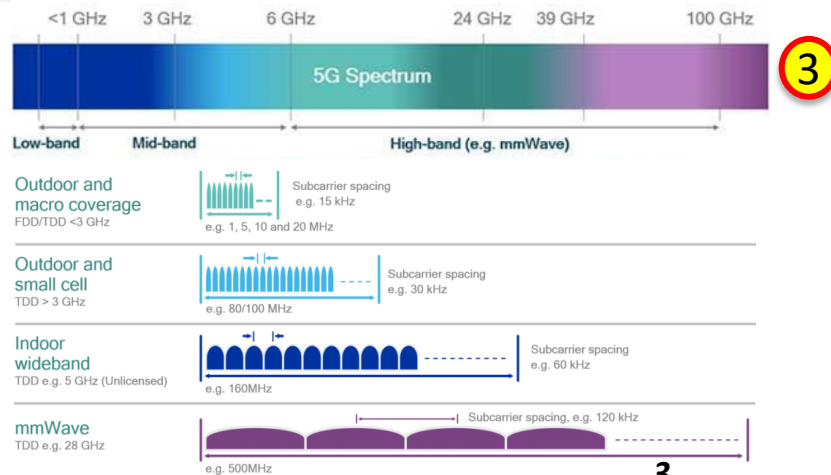
5G Systems : A High-Level Perspective



The Core Vision of 5G ¹



5G KPI-Envelope Expansion ²



5G Spectrum and Subcarrier Spacing ³

μ	SCS (kHz)	T_U (μ s)	Type CP	T_{CP} (μ s)	Slot (μ s)	Slots
0	15	66.66	Normal	5.21/4.69	1000	1
1	30	33.33	Normal	2.60/2.34	500	2
2	60	16.66	Normal	1.30/1.17	250	4
			Extended	4.16	250	4
3	120	8.33	Normal	0.65/0.59	125	8
4	240	4.17	Normal	0.33/0.29	62.5	16

5G Numerology and Critical Timings ⁴

- Mobile-Wireless KPI expanding with 5G
- Higher-order MIMO and resource bring new challenges
- RF-Front-End control Timing-Budget is shortening
- Shorter Firing-Timing and configuration flexibility of “Triggers” are key requirements

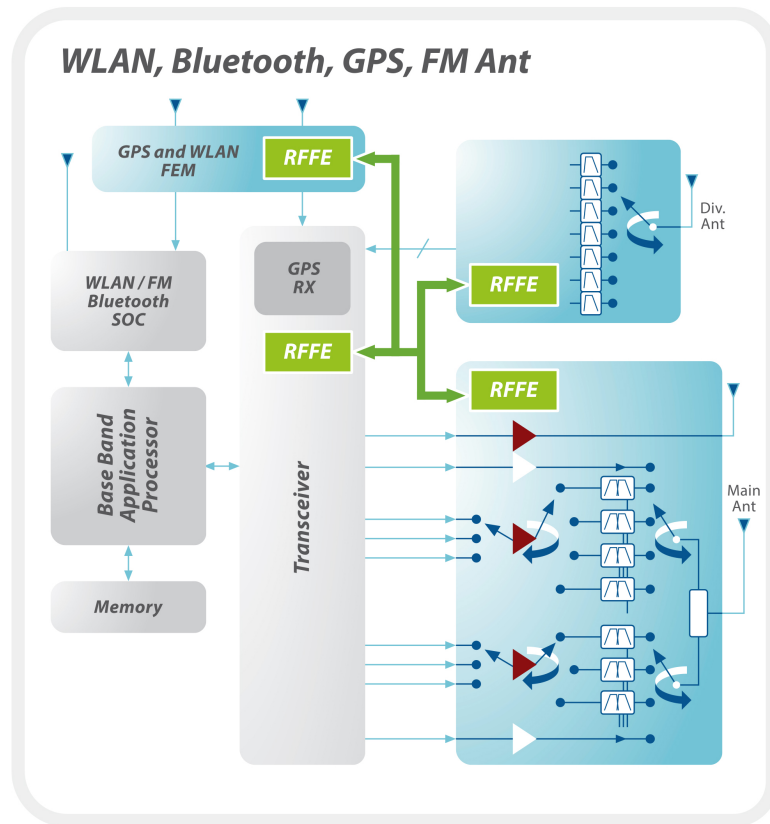
References: [1](#), [2](#), [3](#), [4](#)

5G Systems And New RF-FE Control Requirements

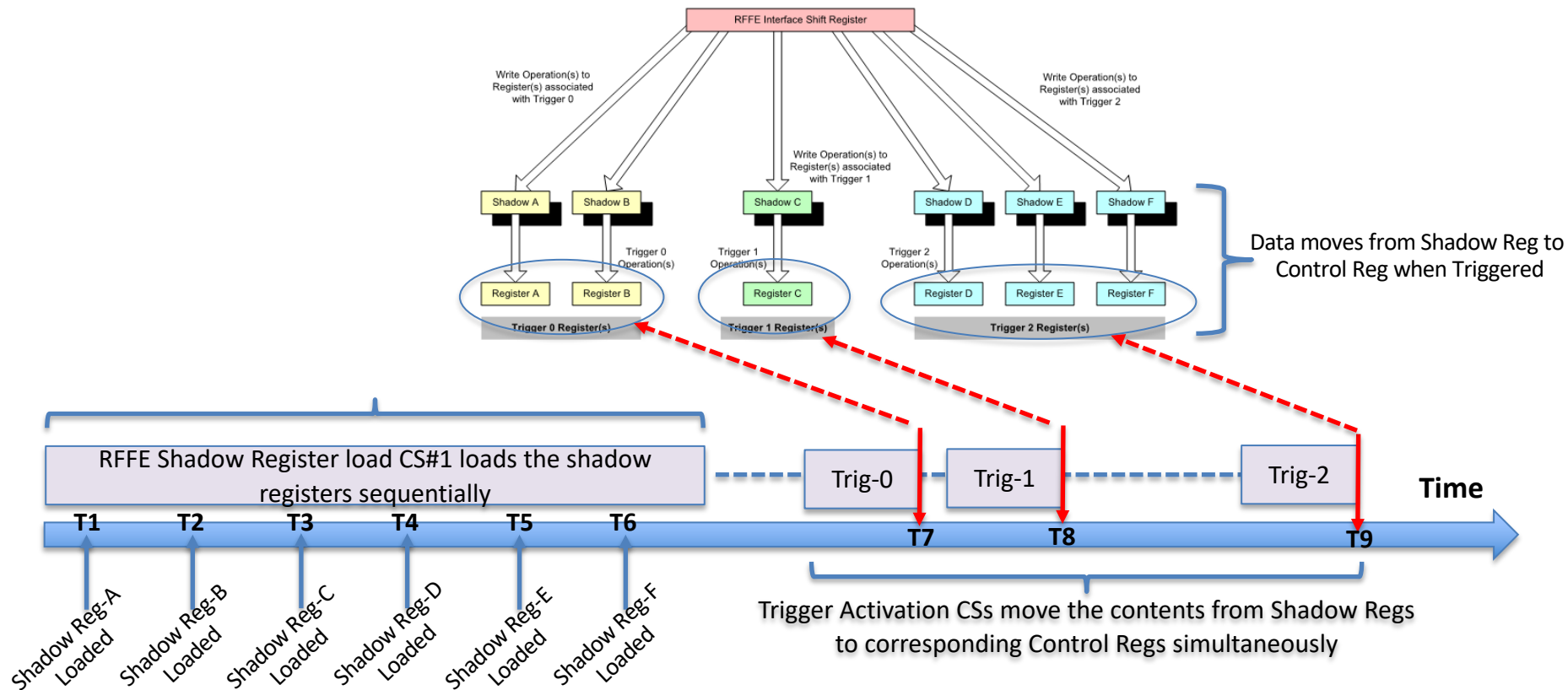
Evolving complexity in 5G Wireless System design requires:

1. *Additional Triggers*
✓ *Solution:* Additional Extended-Triggers
2. *Narrow Timing Budget*
✓ *Solution:* Timed Triggers
3. *Dynamic Mapping of Triggers*
✓ *Solution:* Mappable Triggers

RF-FE v3.0 enables the above required features to meet 5G systems' RF-FE control needs.



Fundamentals of RFFE Trigger Operation



RFFE Trigger Evolution

RFFE v1.0

(Total: 3 Triggers)

RFFE v2.1 (Total: 11 Triggers)

RFFE v3.0 (Total: 18 Triggers)

Trig 0	Trig 1	Trig 2
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Trig 3	Trig 4	Trig 5	Trig 6	Trig 7	Trig 8	Trig 9	Trig 10
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Trig 11	Trig 12	Trig 13	Trig 14	Trig 15	Trig 16	Trig 17
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Nomenclature

RFFE 2.1 → *Extended-Triggers*

RFFE 3.0 → *Extended-Triggers "Block-A"*

RFFE 3.0 → *Extended-Triggers "Block-B"*

Implementation Options

Timed Trigger Feature Supported

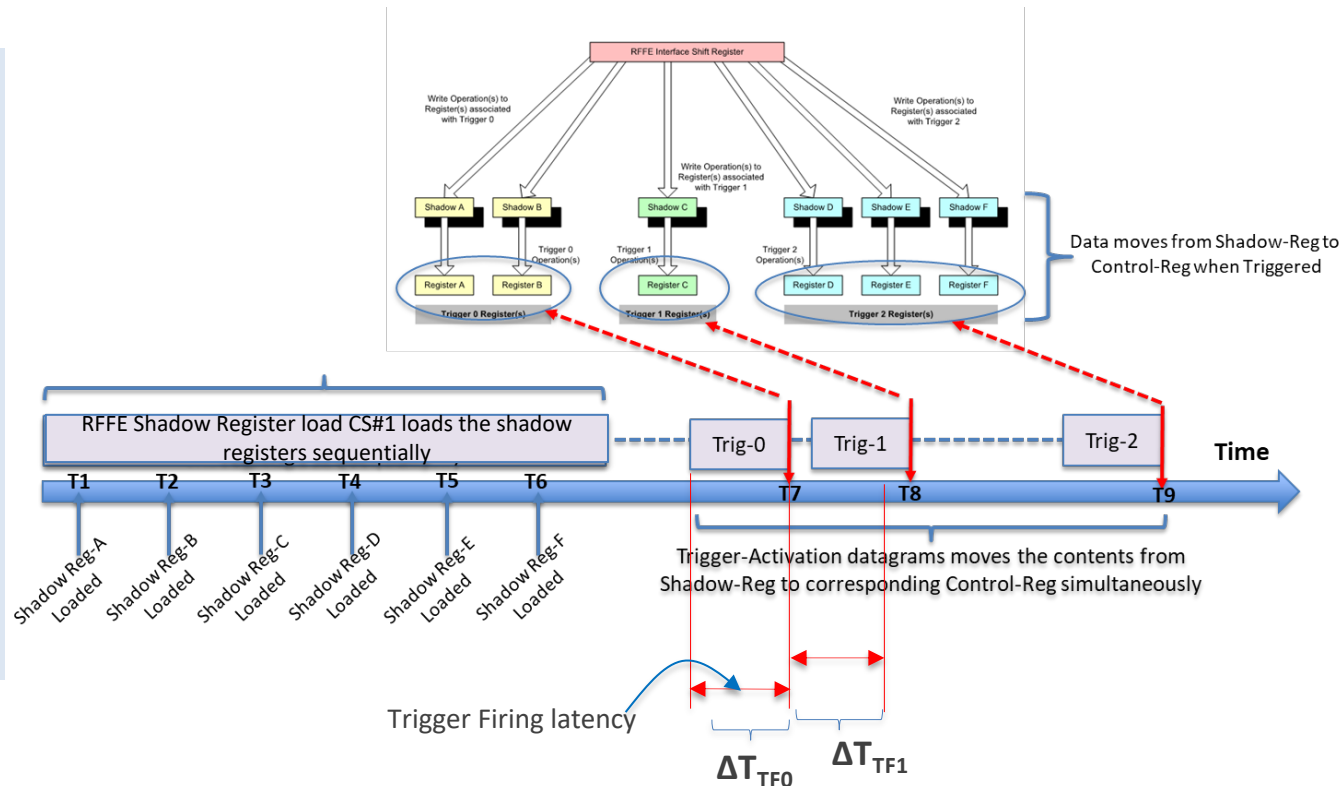
Timed Trigger Feature Supported

Mappable Trigger Feature Supported

Mappable Trigger Feature Supported

What Problem Does Timed Trigger Attempt To Solve?

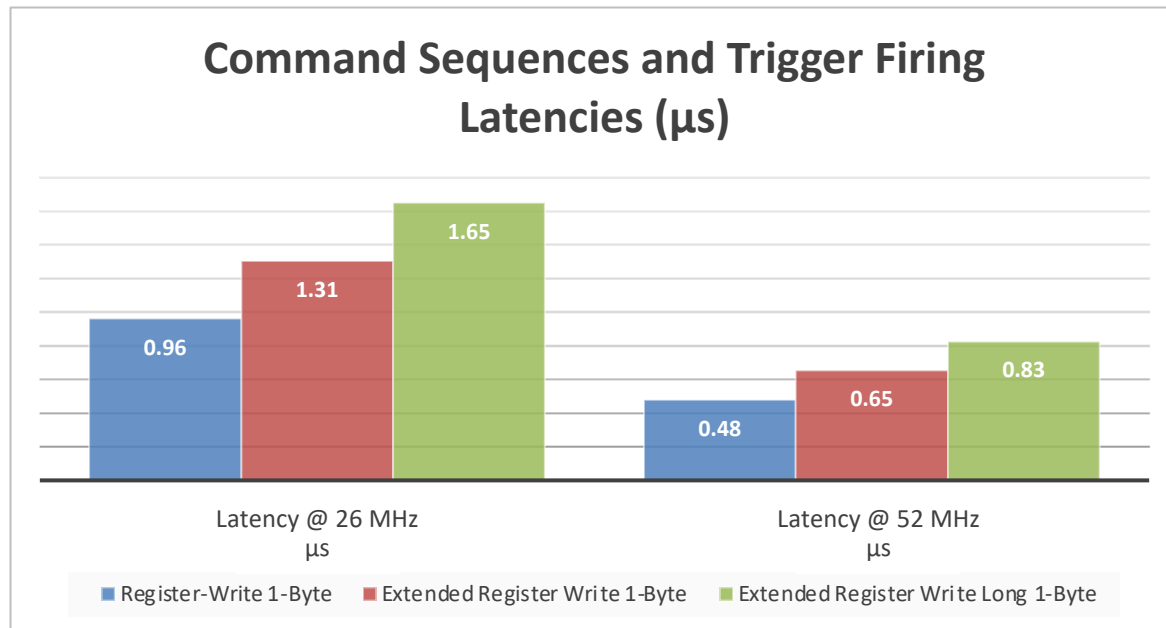
- Datagram based Trigger-Firing has a minimum delay involved
- Minimum 25 SCLK cycles required for Register Write datagram
- This translates to:
 - 0.96 μs @ 26-MHz SCLK
 - 0.48 μs @ 52-MHz SCLK
- Other datagrams add additional latency
- Latency < 0.5 μs desired for 5G
- Timed-Trigger helps meet this latency goal



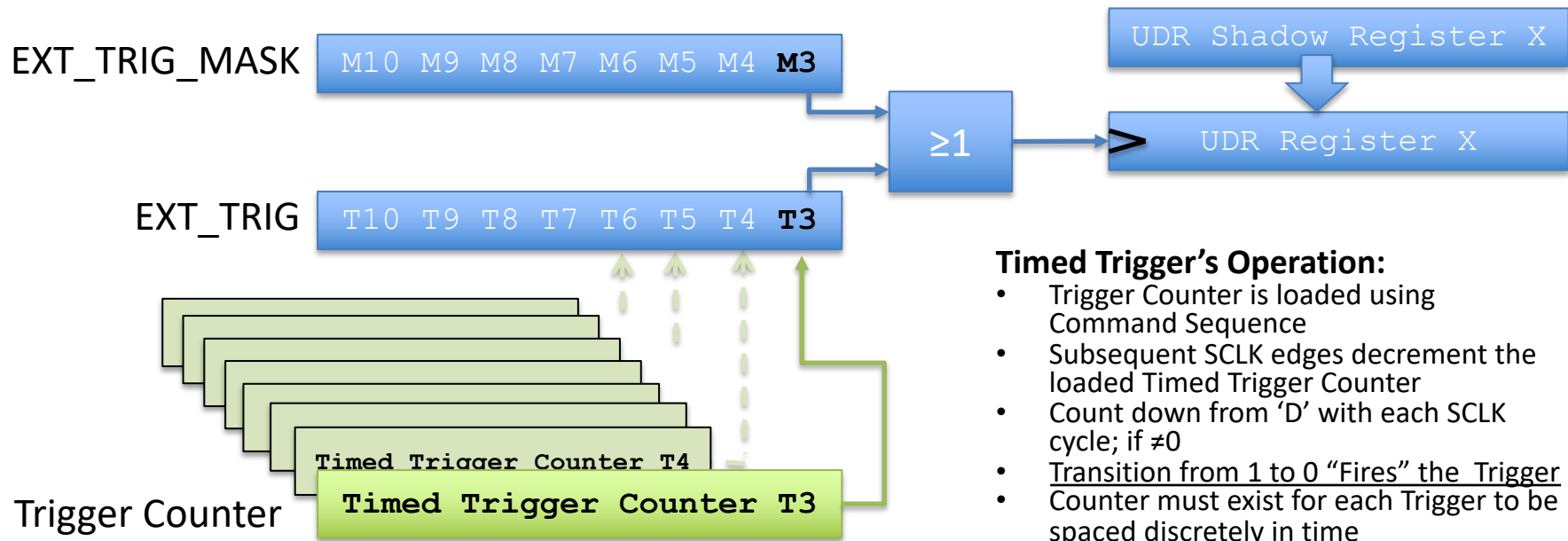
Command Sequences And Trigger Firing Latencies

Command Sequence Type	Payload	Required SCLK Cycles	Lat @ 26 MHz (μs)	Lat @ 52 MHz (μs)
Register-Write	1-Byte	25	0.96	0.48
Extended Register Write	1-Byte	34	1.31	0.65
Extended Register Write Long	1-Byte	43	1.65	0.83

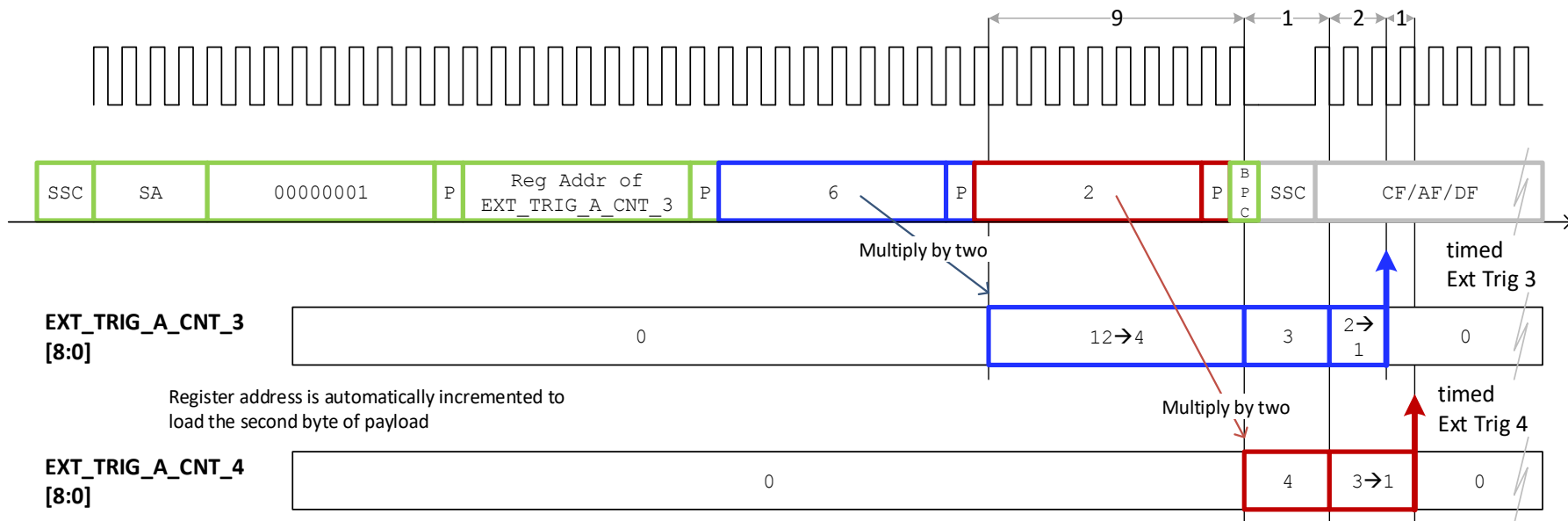
- Sub Micro-Sec (ideally < 0.5μs) Trigger Firing latency leaves limited choice for system designers
- This is where Timed Triggers help



Operational Principle Of Timed Trigger

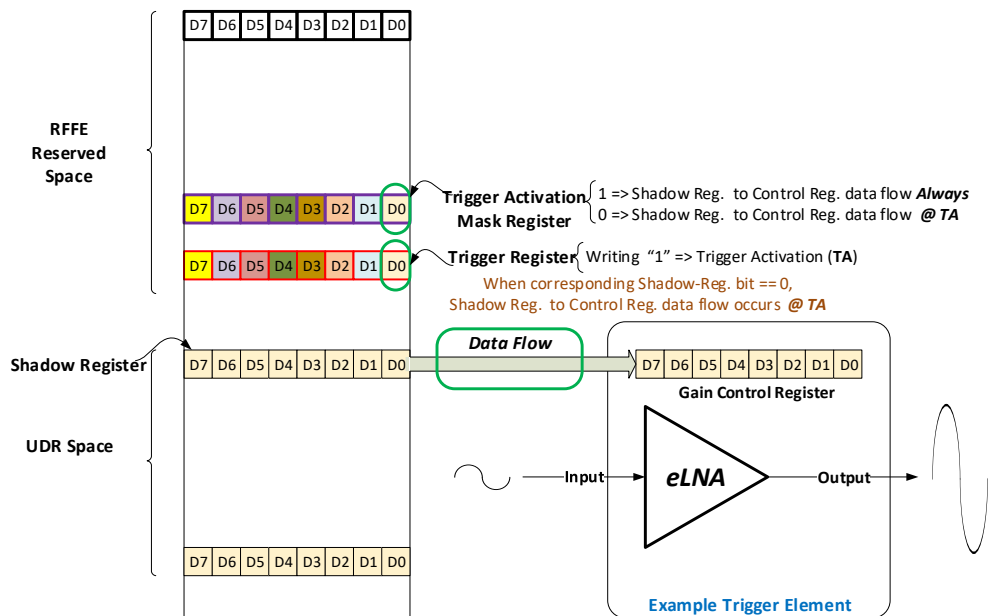


How Do Timed Triggers Reduce Trigger Firing Latency?

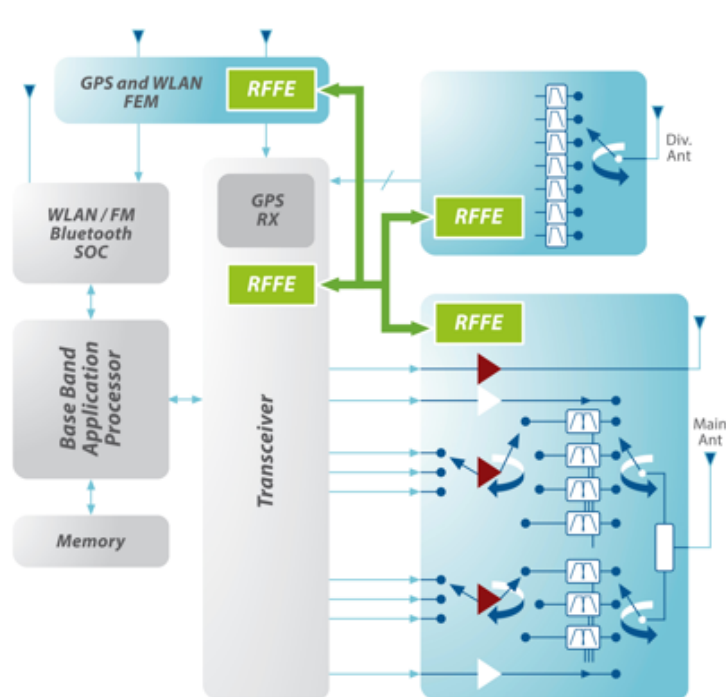


- ✓ Timed Triggers give the ability to fire adjacent Triggers within the resolution of SCLK cycles vs Command Sequence distances;
- ✓ Useful for LTE/NR inter-band UL CA control

What Are Mappable Triggers? How Do They Help?

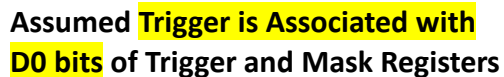


RFFE v2.1 Trigger Association is "Hardened"

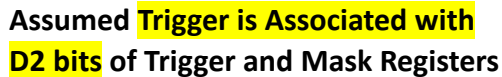


Complex 5G RF-Front-End demands dynamic Trigger-Association Configurability

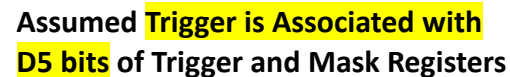
Examples Configuration-1



Examples Configuration-2



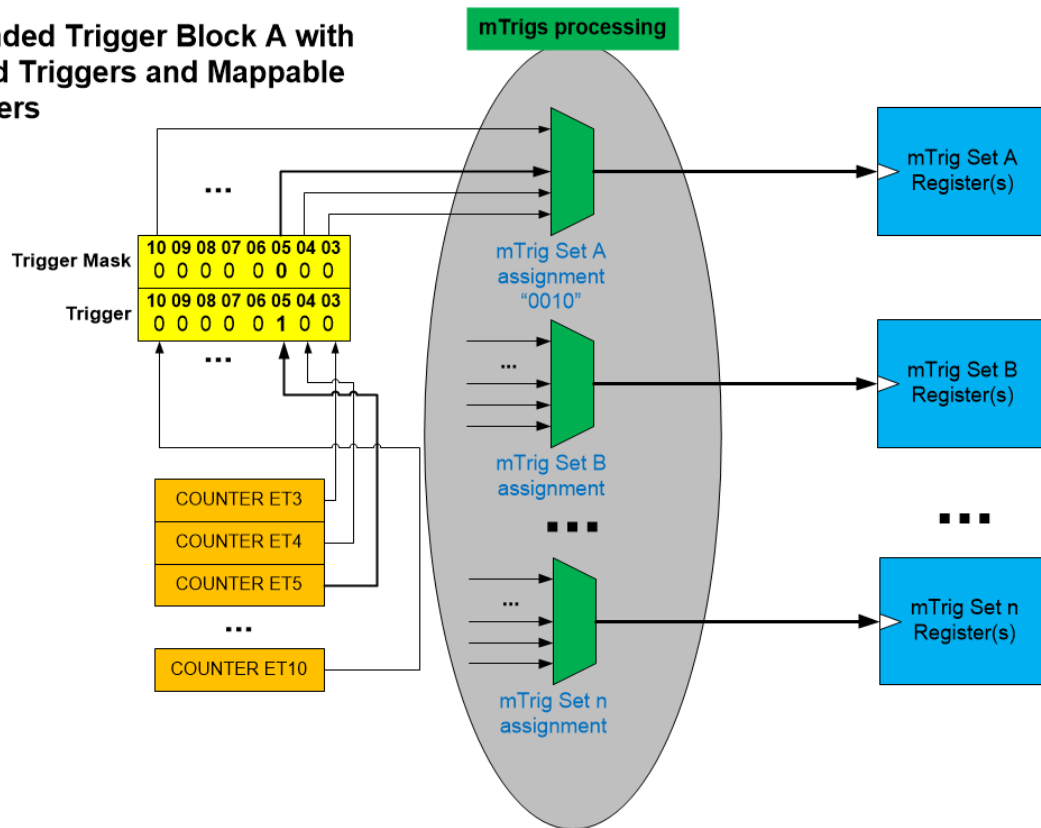
Examples Configuration-3



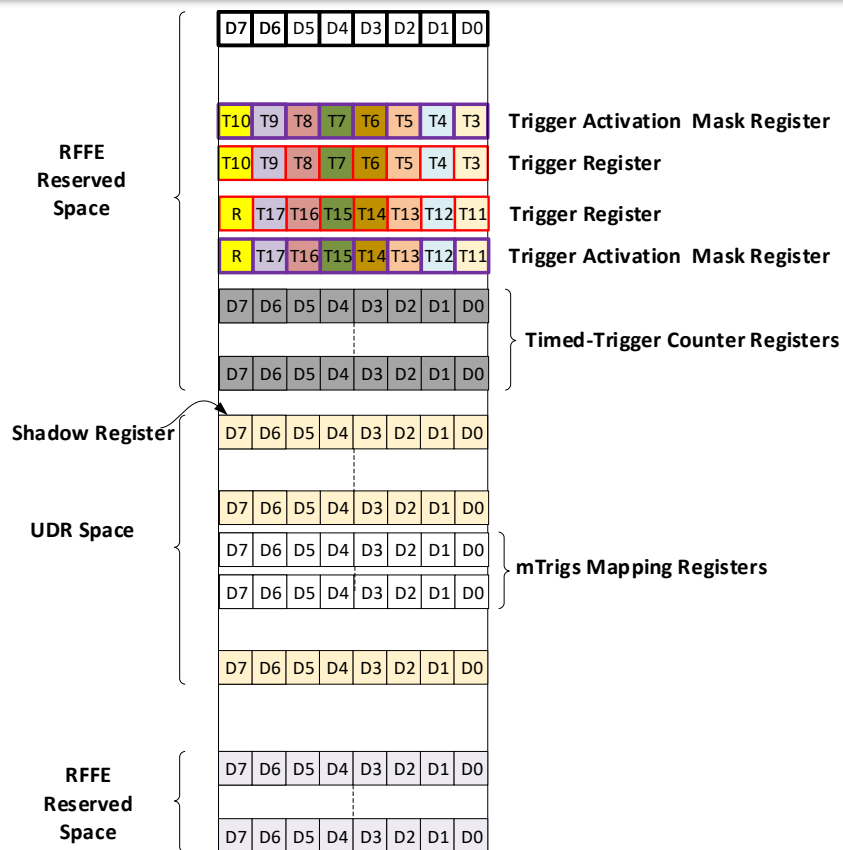
Notice that the association of Shadow Register to Trigger Element's Control Register does not change

Timed Triggers and Mappable Triggers Convergence

Extended Trigger Block A with
Timed Triggers and Mappable
Triggers



Trigger Register Utilization : An Overview



Summary

- The latest version of RFFE v3.0 was adopted in April 2020
- It introduces three key architectural enhancements:
 - Adds 7 more Extended-Triggers over RFFE v2.1 (An optional feature)
 - Up to 15 Extended-Triggers could be supported now (for 18 Triggers total)
 - Adds Timed Trigger Architecture (An optional feature)
 - Timed Trigger feature could be enabled to all or selected Extended Triggers (See Spec for details)
 - Adds Mappable Trigger Architecture (An optional feature)
 - Mappable Triggers could be supported on all or selected Extended Triggers (see Spec for details)
- RFFE v3.0 follows the same electrical spec as applicable to RFFE v2.1
- The WG is currently discussing proposals for the next version of RFFE.



THANK YOU

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