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MAT-103

Multiprotocol: Simplifying the Connected Home

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Agenda

01 Multiprotocol: Why

02 Multiprotocol: What

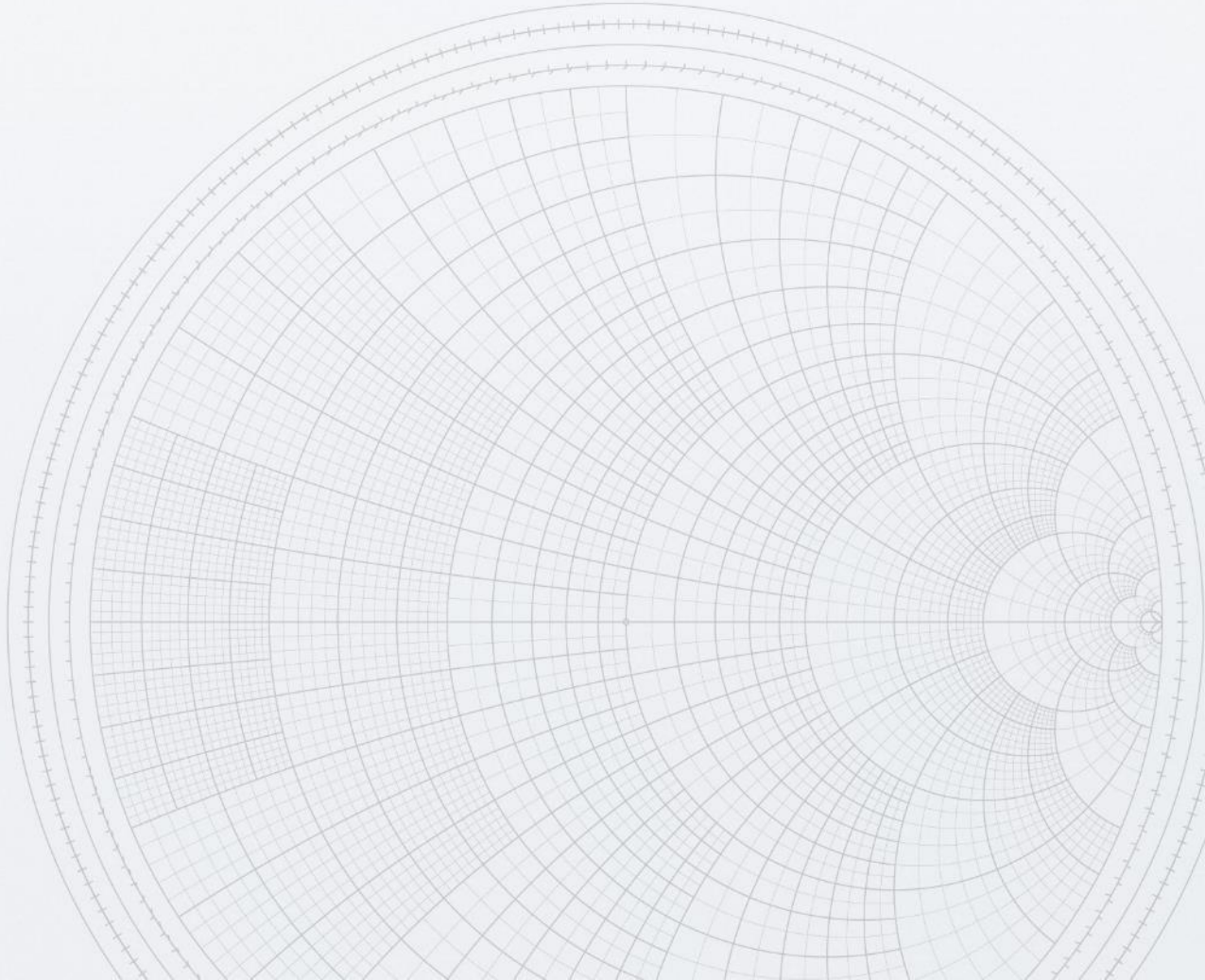
03 Multiprotocol: How

04 Multiprotocol Product Offering

05 Radio Protocol Testing (Teledyne)

06 Summary and Q&A

Multiprotocol: Why



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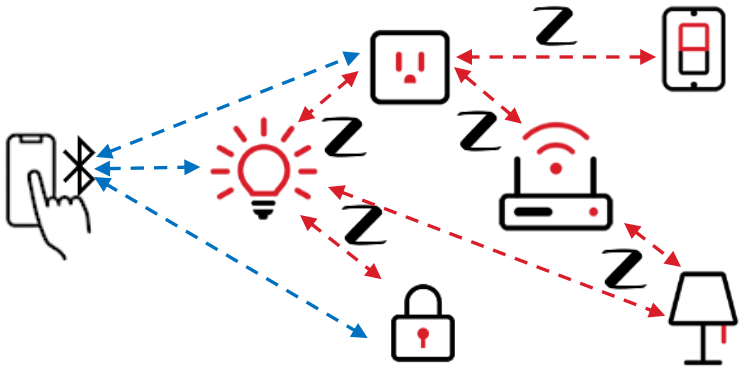
Why Multiprotocol?

- **Smart Home Challenges**
  - One size does not fit all
    - Different protocols for different applications
  - Limited Market Adoption
    - Global market penetration estimated to be ~10% of homes
      - Barriers still exist to Smart Home adoption
    - Smart Home continues to be fragmented
      - Wi-Fi, Bluetooth, Zigbee, Thread, Z-Wave, Proprietary and Matter
  - Product Complexity for Product Companies and Retailers
    - Managing multiple products based on protocol
    - Product forecast and stocking complexity
  - Poor User Experience
    - Product confusion due to number of protocols
    - Product choice may not support the protocol users want

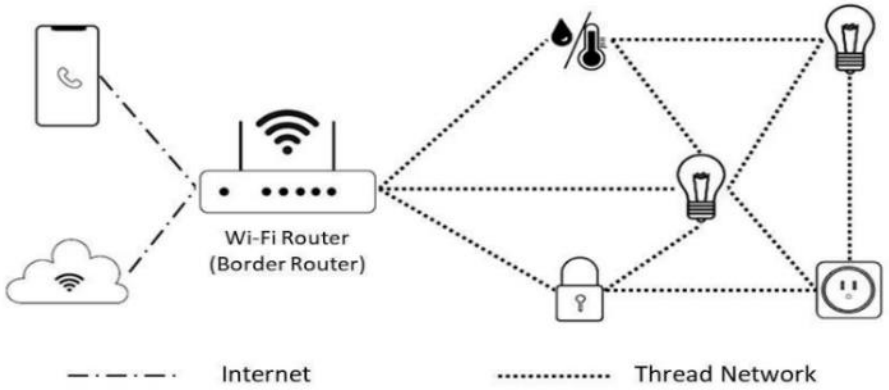
- **Multiprotocol can help overcome these challenges**
  - Cost effectively expanding the ecosystems supported by a single product

Common Multiprotocol Use Cases for the Smart Home

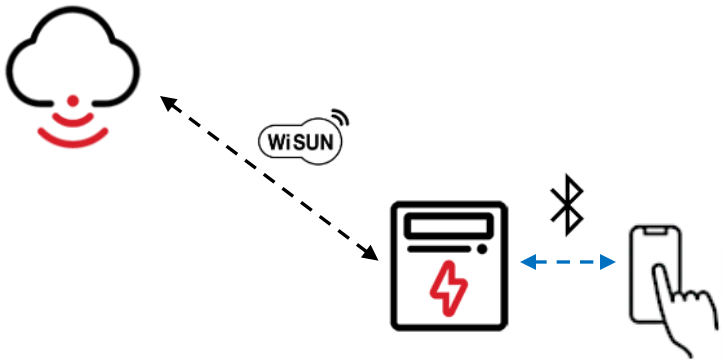
BLUETOOTH LE + ZIGBEE



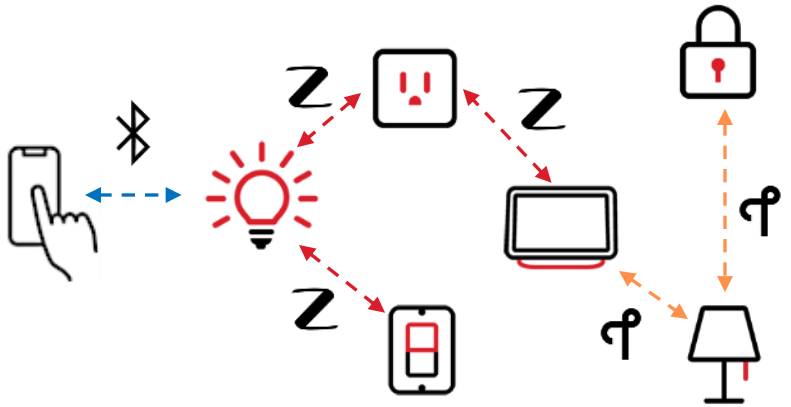
MULTIPROTOCOL FOR GATEWAYS/HUBS



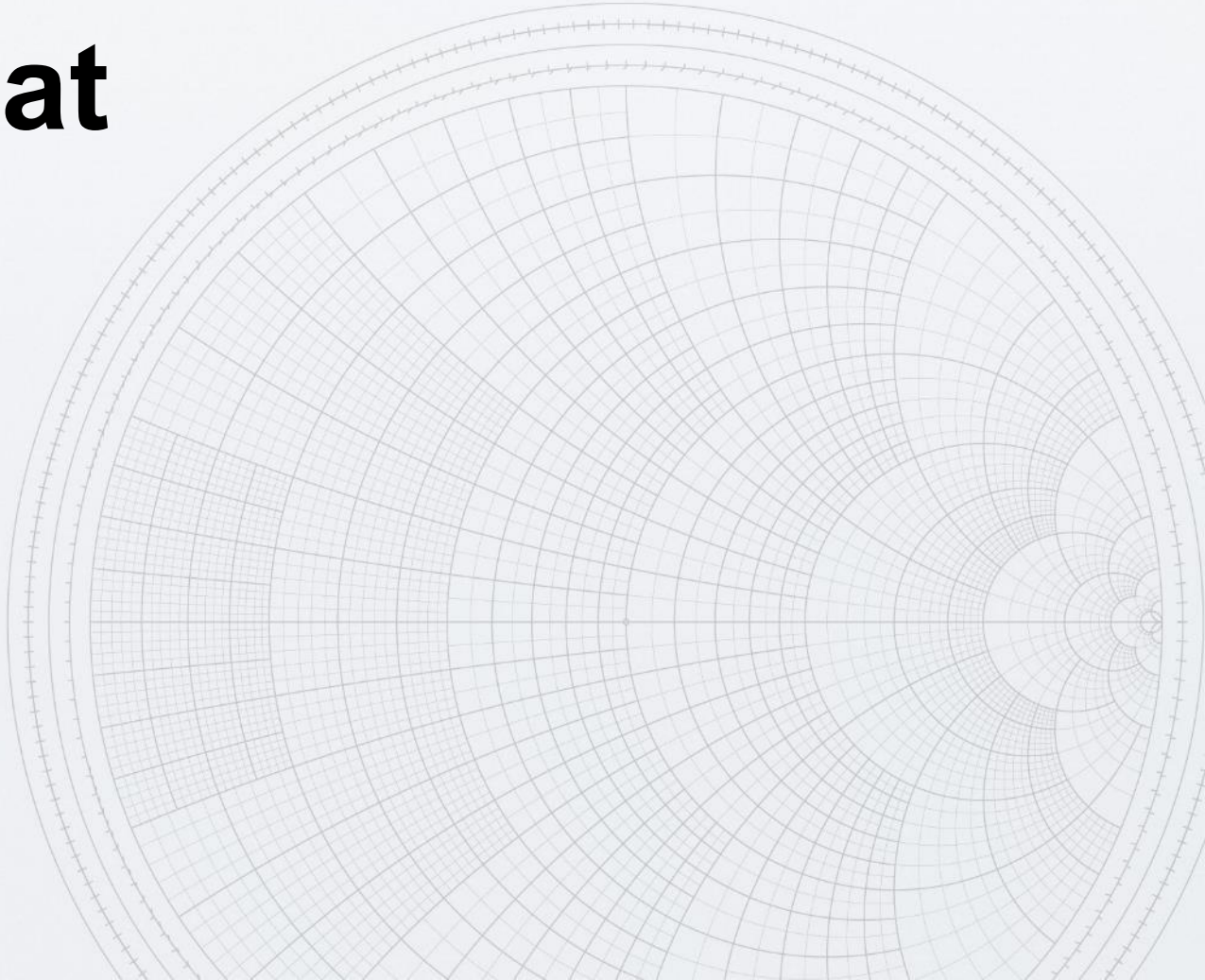
BLUETOOTH LE + SUB-GHZ



BLUETOOTH LE + ZIGBEE AND MATTER



Multiprotocol: What



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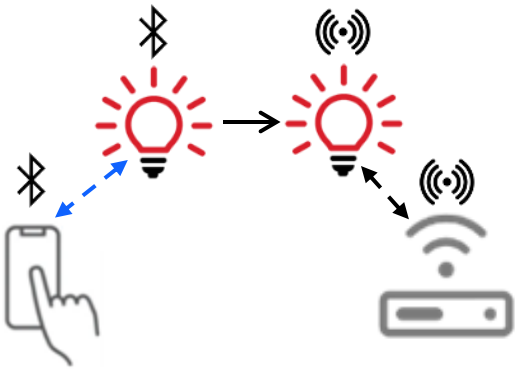
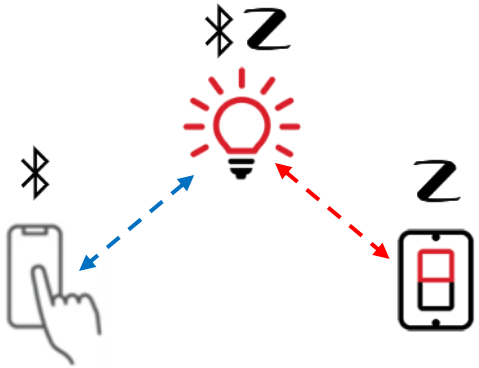
Single-Chip Multiprotocol Modes of Operation

SWITCHED MULTIPROTOCOL



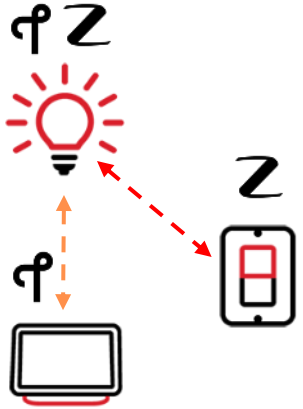
- **The device switches between protocols using a bootloader**
- Can be used when running two protocols is not an option or on more constrained devices
- Helps to update devices in the field to changing market needs
- Switching time is usually long (~hundreds of ms)
- Not ideal when switching between protocol is needed often or on demand
- Not a common use case

DYNAMIC MULTIPROTOCOL



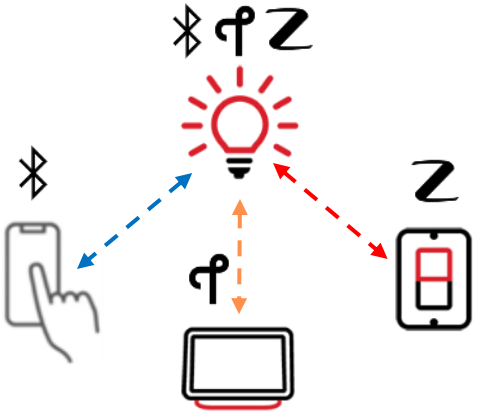
- **The device time-slices between two protocols**
- Common when one protocol is deterministic, i.e. Bluetooth LE
- The other protocol needs retry mechanisms
- Can also turn off Bluetooth until needed (i.e. commissioning)
- Time slicing is transparent to user
- Requires more resources to run both protocol stacks
- Requires careful design of scheduler for reliable operation

CONCURRENT MULTIPROTOCOL



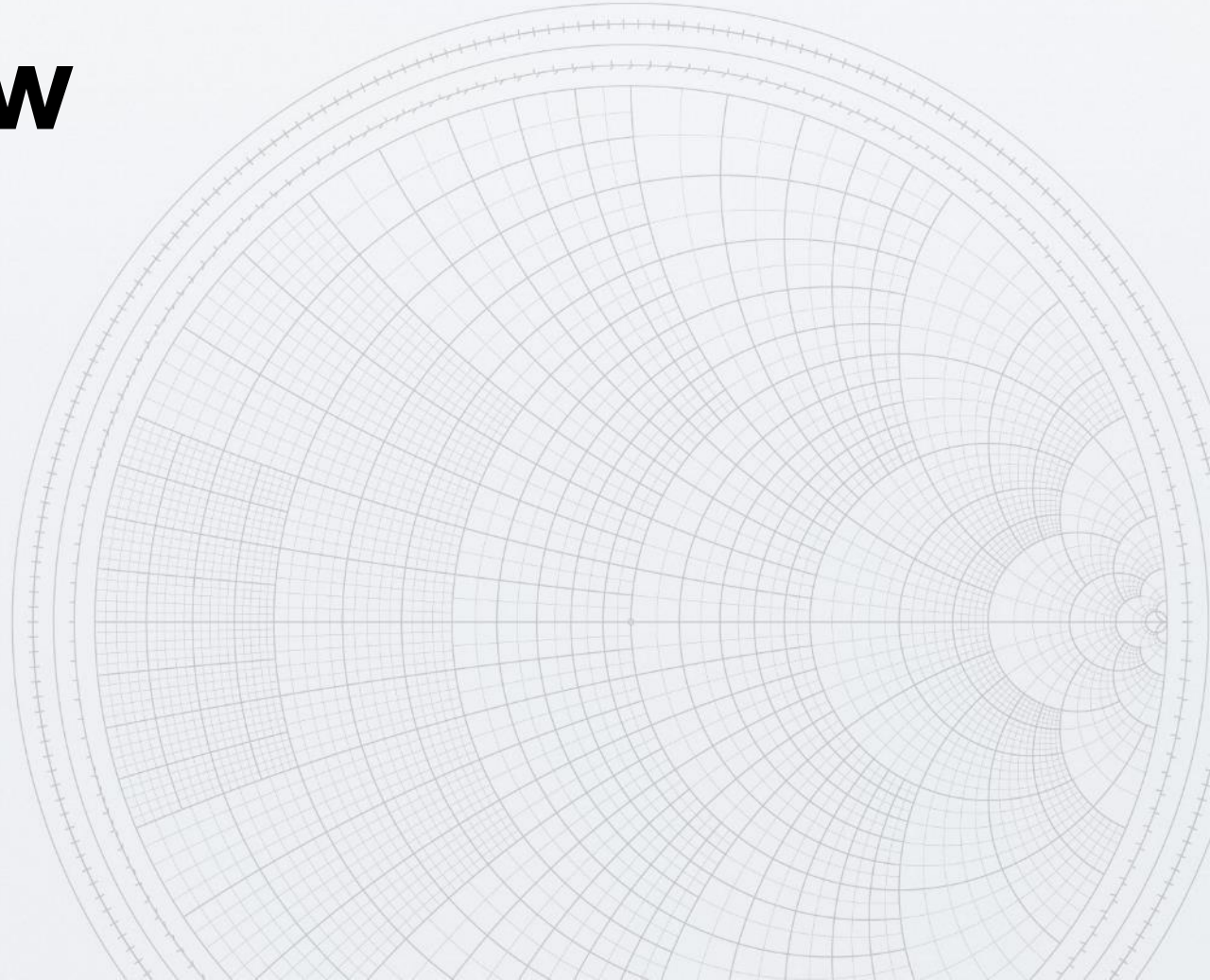
- **The device is able to receive on multiple 802.15.4 networks**
- Can be on a single channel or 2 channels without packet loss
- Typically requires fast switching and rapid preamble detection similar to Antenna Diversity
- Requires more resources to run protocol stacks
- Used for Zigbee+Matter over Thread on hubs

CONCURRENT W/ DMP



- **The device is able to time slice between BLE, Zigbee and Thread**
- Extension of DMP with CMP
- BLE continues to operate in time-sliced DMP mode
- CMP (Zigbee + Thread) operates between BLE activity
- Similar to DMP, it has little or no impact BLE performance
- Requires significant resources in Flash and RAM

Multiprotocol: How



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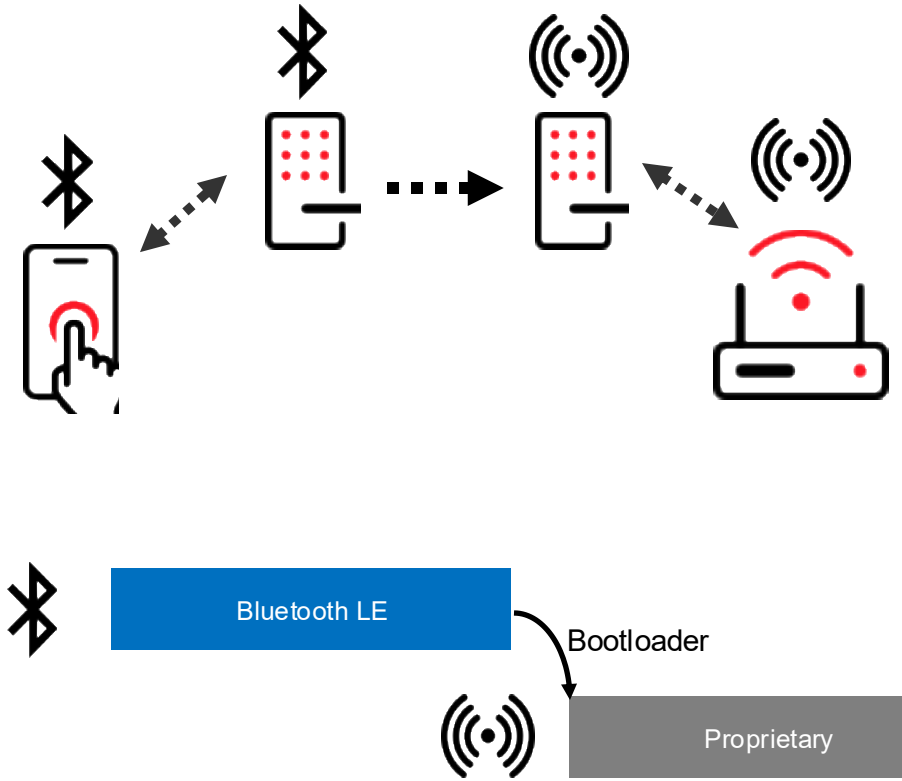
Switched Multiprotocol (SMP)

- **Operation:**
  - Device can be instructed to switch to different protocol
    - Loads a new firmware image
  - Switches between 2 protocols
  - Used when DMP won't work
    - Used when there is no dead time or retry mechanisms
  - Does not need any complex scheduler

- **Simplicity Studio Sample Applications**
  - N/A – Uses Bootloader

- **Common Use Cases:**
  - Bluetooth LE Commissioning
  - Backwards compatibility or future proofing

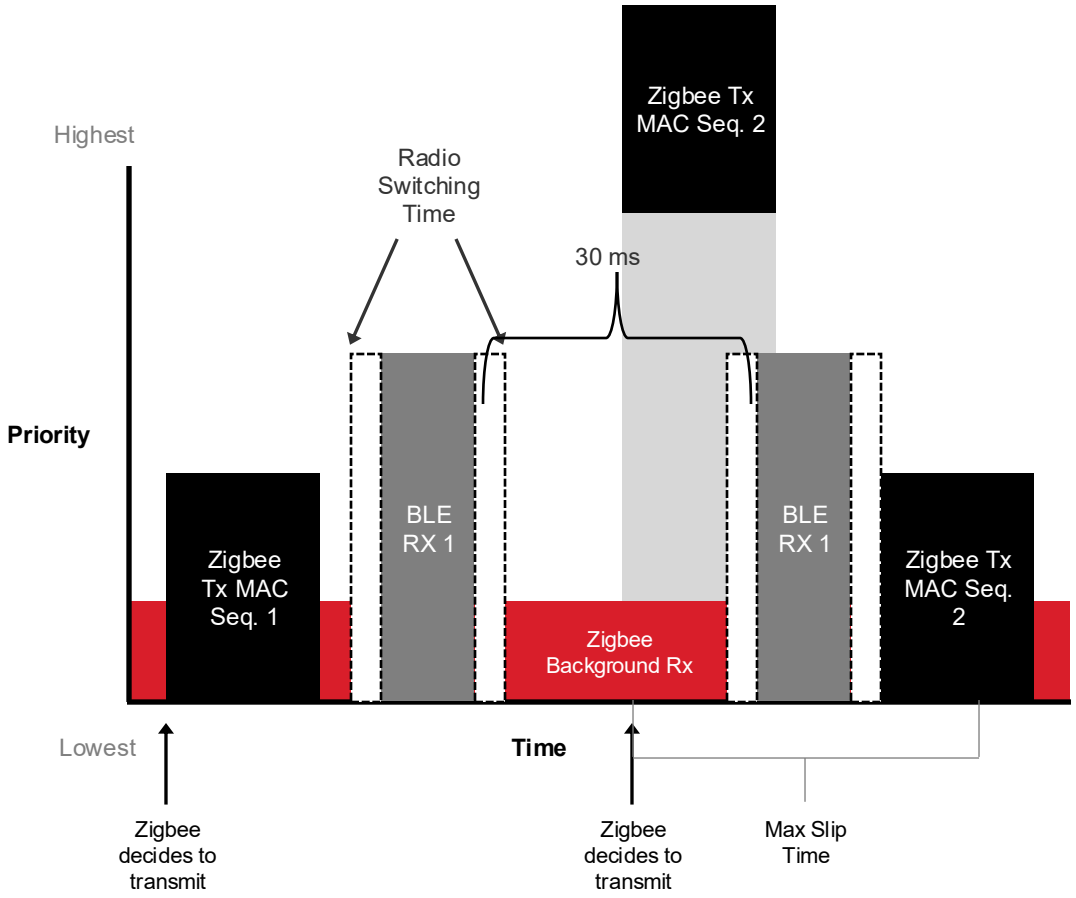


Dynamic Multiprotocol (DMP)

- **Operation:**
  - Radio time-sliced to reliably manage multiple protocols
  - Used with Bluetooth LE, in conjunction with a different protocol
  - Managed by RAIL Scheduler
    - Uses MP RAIL library and RTOS
    - Typically, Bluetooth LE operations get a higher priority but is configurable
  - Radio switching time in the order of hundreds of μs
    - Has been improved in our Series 3

- **Simplicity Studio Sample Applications**
  - Bluetooth LE+Zigbee
  - Bluetooth LE+Thread
  - Bluetooth LE+Proprietary 2.4 GHz
  - Bluetooth LE+Proprietary Sub-GHz

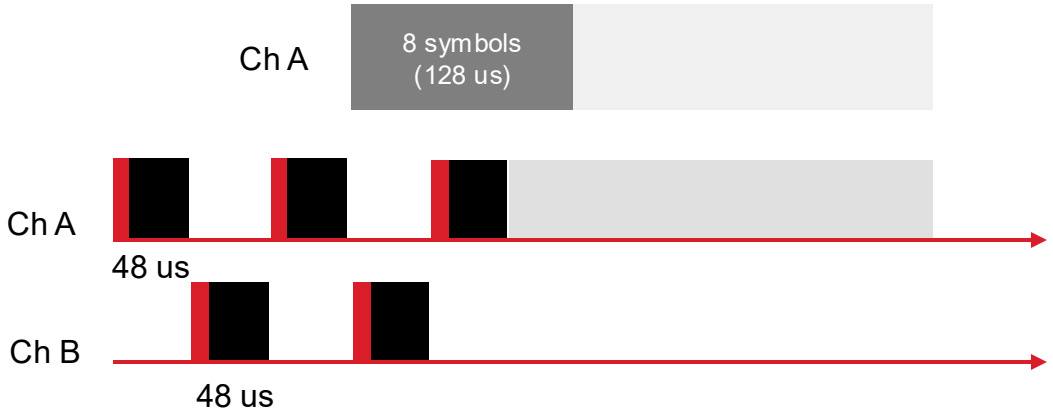
- **Common Use Cases:**
  - Multiple protocol support (Bluetooth is a fall back)
  - Commissioning / device onboarding
  - Network diagnostics or firmware updates



Example: DMP Bluetooth LE + Zigbee

Concurrent Multiprotocol (CMP)

- **Operation:**
  - Listens for two different 802.15.4 networks
  - MultiPAN: Networks are on the same channel
    - Filters packets based on PAN ID
    - Requires that a single device controls both network channels
  - Concurrent Listening: Networks are on different channels
    - Device switches between channels
    - Switches fast to listen to both channels during preamble
    - When preamble is detected, stays on the channel until completion packet
    - Sensitivity is slightly degraded
    - Antenna diversity is not available
- **Simplicity Studio Sample Applications**
  - Zigbee+Thread
- **Common Use Cases:**
  - Support for both Zigbee and Thread on a single device

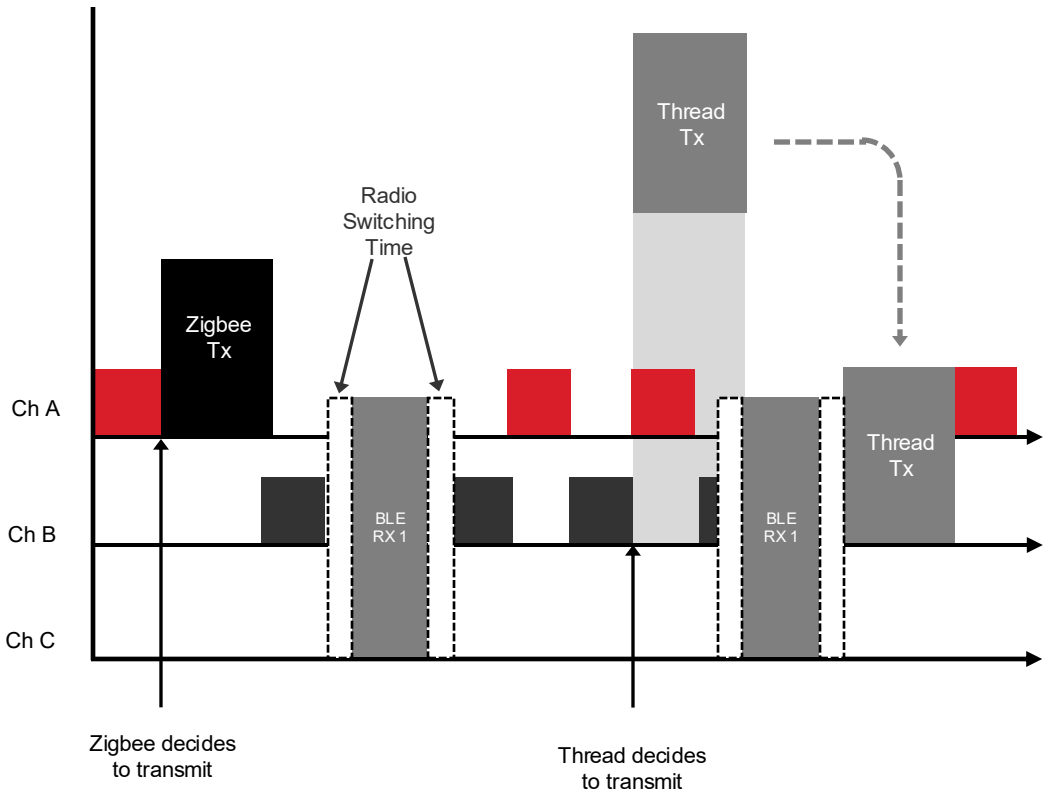


- Load RF synth for channel A & settle (~16 us)
- Listen for preamble (2 symbols, ~32us)
- Load RF synth for channel B and settle (~16 us)
- Listen for preamble (~32us)
- Repeat until preamble detected
- After packet is receive, it repeats the process again

Example: CMP Zigbee + Thread (Series 2)

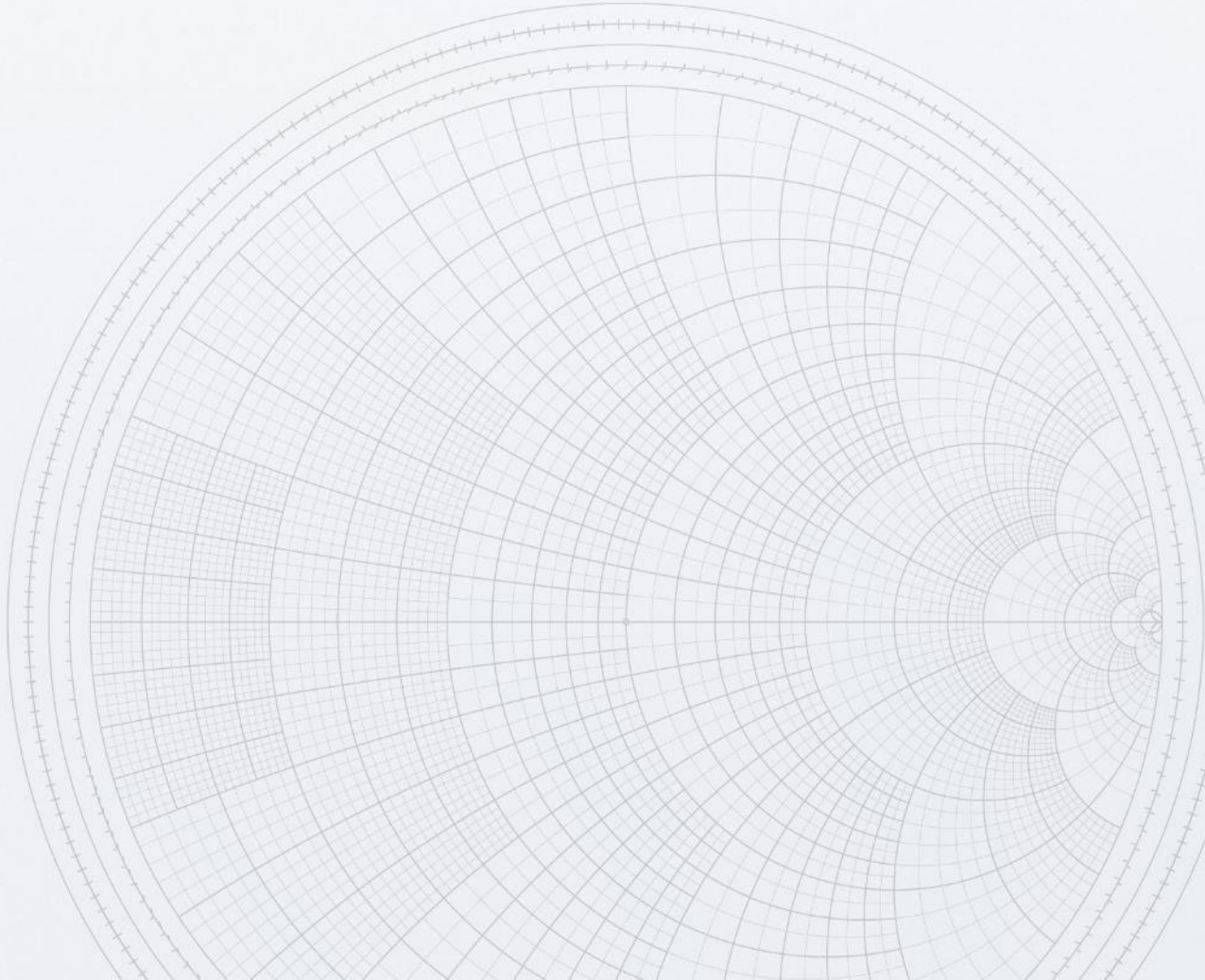
Dynamic Multiprotocol (DMP) + Concurrent Multiprotocol (CMP)

- **Operation:**
  - Extension of Bluetooth LE DMP to include CMP
  - Similar operation as DMP
    - CMP is active during between Bluetooth LE
    - Radio rapidly switches between the two 15.4 channels
  - Does not impact Bluetooth LE performance
    - Bluetooth LE operations get a higher priority but is configurable
- **Simplicity Studio Sample Applications**
  - Bluetooth LE+Zigbee+Thread
- **Common Use Cases:**
  - Support for both Zigbee and Matter over Thread



Example: DMP Bluetooth LE + CMP (Zigbee + Thread)

Silicon Labs Product Offering



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Multiprotocol Support

- **Multiprotocol Support is affected by devices protocol support and available memory**

	Flash (kB)	RAM (kB)	Bluetooth LE + Proprietary 2.4 GHz (DMP)	Bluetooth LE + Proprietary Sub-GHz (DMP)	Bluetooth LE + Wi-SUN Sub-GHz (DMP)	Bluetooth LE + Zigbee (DMP)	Bluetooth LE + Thread (DMP)	Zigbee + Thread (CMP)	Bluetooth LE + Zigbee + Thread (DMP+CMP)
BG21	1024	96	✓						
BG24	1536	256	✓						
BG26	3200	512	✓						
BG29	1024	256	✓						
MG21	1024	96	✓			✓	✓	NCP	
MG24	1536	256	✓			✓	✓	✓	
MG26	3200	512	✓			✓	✓	✓	✓
MG29	1024	256	✓			✓	✓		
MG301	4096	512	✓			✓	✓	✓	✓
FG28	1024	256		✓	✓				
ZG28	1024	256		✓	✓				

Radio Protocol Testing (Teledyne)

Priyanka Gupta

Sr. Product Manager and Marketing, Teledyne LeCroy

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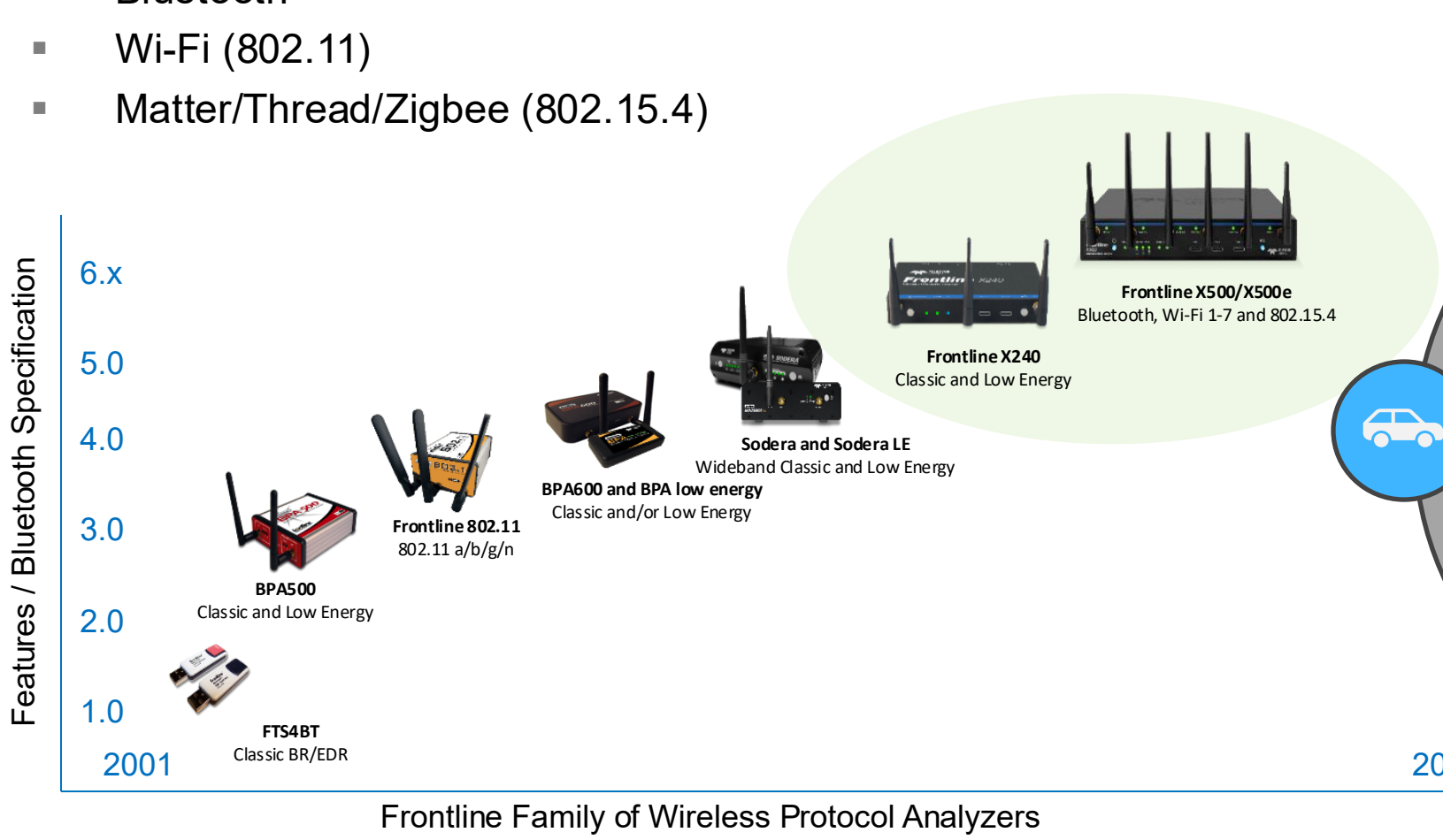
Teledyne LeCroy's Protocol Debugging Tools

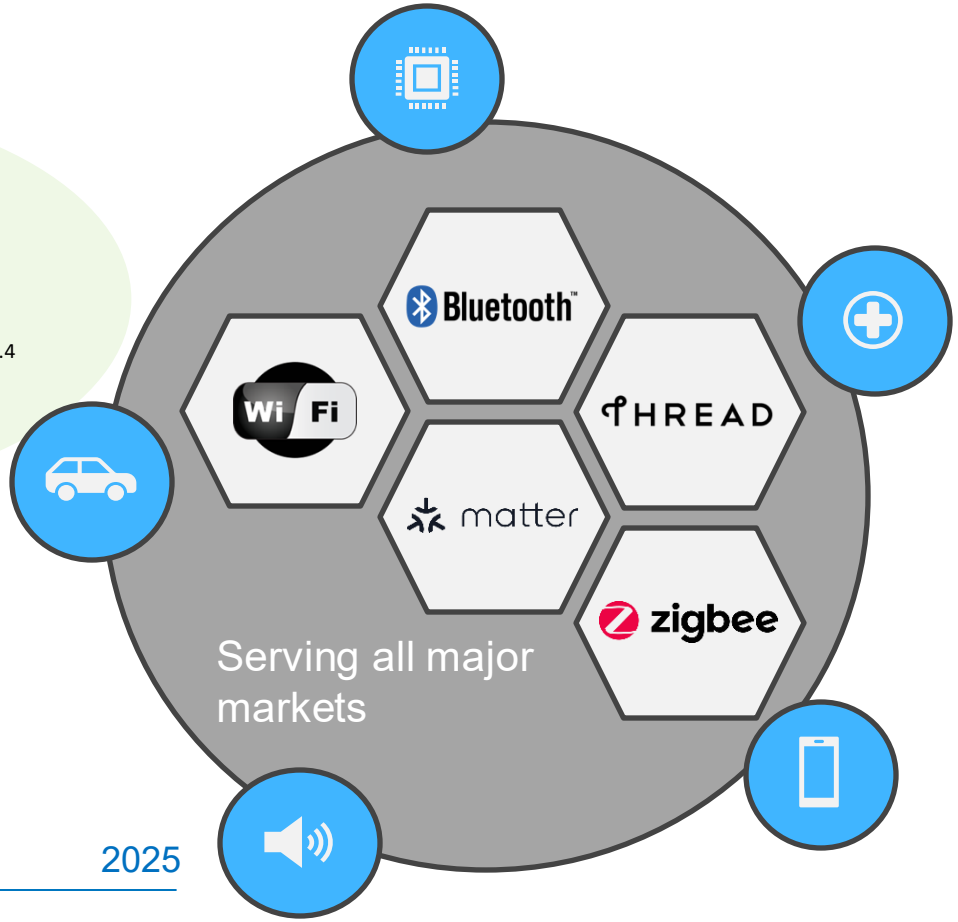
TELEDYNE LECROY
Everywhereyoulook™

About the Frontline Family of Protocol Analyzers

Teledyne LeCroy's Frontline family of wireless protocol analyzers, sniffers, and testers deliver unparalleled performance for complex multi-technology test environments including market-leading support for the latest releases of

- Bluetooth
- Wi-Fi (802.11)
- Matter/Thread/Zigbee (802.15.4)

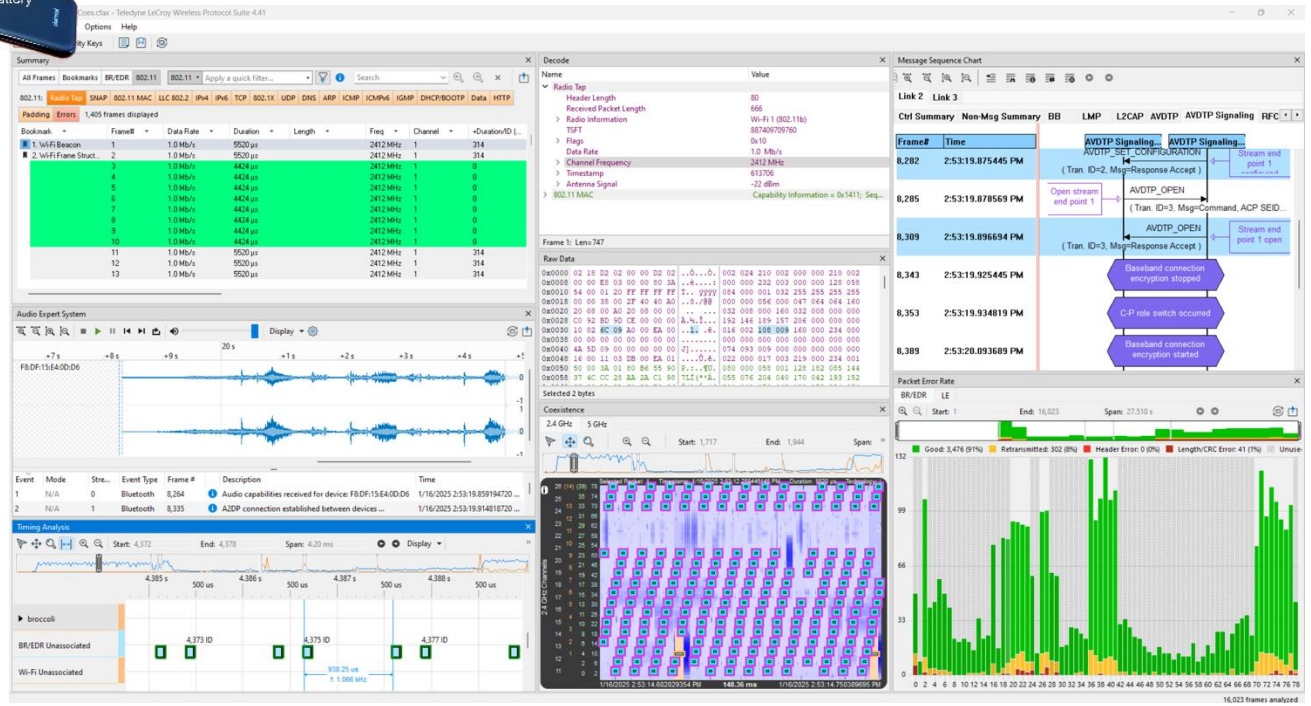




Frontline X240 Wideband Protocol Analyzer

The Frontline X240 is a highly flexible protocol analyzer

- Supported Technologies
  - Bluetooth BR/EDR
  - Bluetooth LE, LE Audio, Channel Sounding
  - Bluetooth Dual-Mode
  - 802.15.4
  - Wi-Fi 5 - 802.11 a/b/g/n & ac
- Type C USB Powered
- Wall and Car adaptor Included
- Spectrum Analysis
- Excursion mode
- Auto and Manual Gain control
- 16 channel Logic analysis via 2 x8 ch. PODs
- HCI UART, SPI, Audio I2S
- Host Communication over Ethernet



Note:

- X240 supports capture of One Technology at a time, based on selected license file
- X240 units can be connected to capture multiple technologies simultaneously

Frontline X500e Wireless Protocol Analyzer

High Performance X500e supports simultaneous capture of:

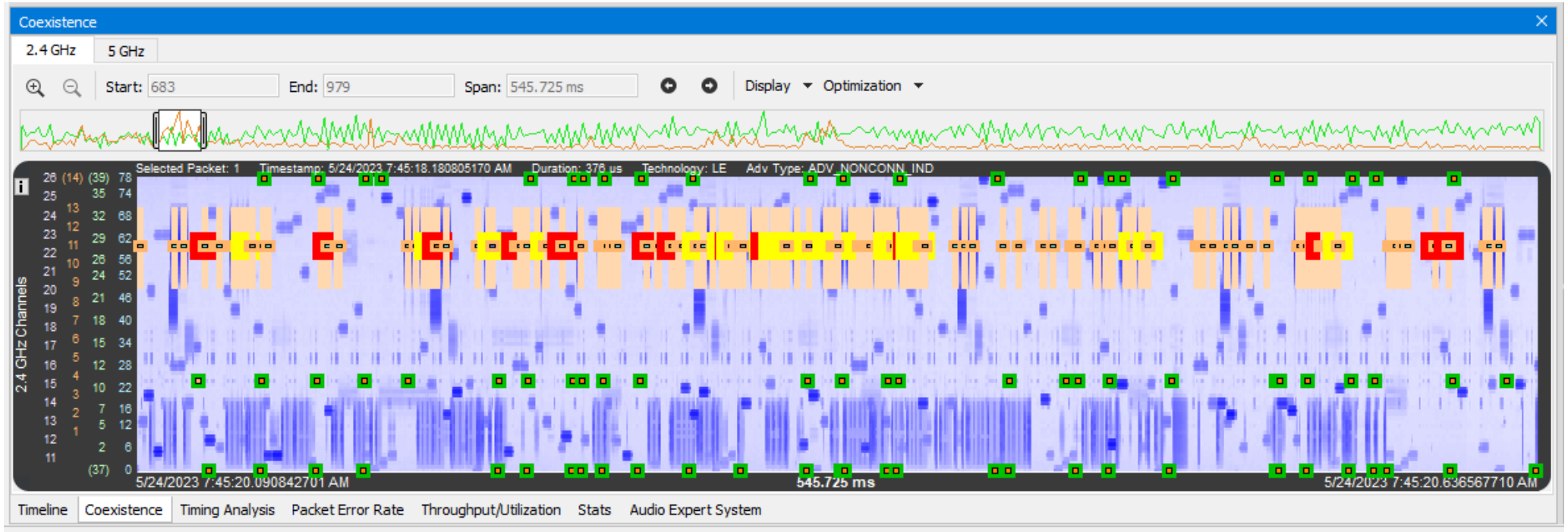
- Bluetooth Classic BR/EDR (Latest and draft specs) ……..... SDR
- Bluetooth Low Energy (Latest and draft specs) ……..... SDR
- IEEE 802.15.4 (2.4GHz) all channels…… SDR
- Wi-Fi 5 ac 2x2 MIMO (2.4GHz & 5GHz)…… Module
  - and/or
- Wi-Fi 6/6E/7 ax 2x2 MU-MIMO (2.4GHz, 5GHz & 6GHz)…….. Module
  - Supports the capture of 2 Wi-Fi channels simultaneously
  - Built in Wi-Fi scanner
- 24 channel logic analysis (via 3x8 channel PODs`
- HCI (2x UART, 2x USB, 2x SPI, 2x Audio I2S)
- Raw RF Spectrum Data
- Ethernet Host Communication

Note:

X500e has 2x Independent Bluetooth Radios for superior capture performance
X500e has 2x Independent Wi-Fi Modules for MLO feature

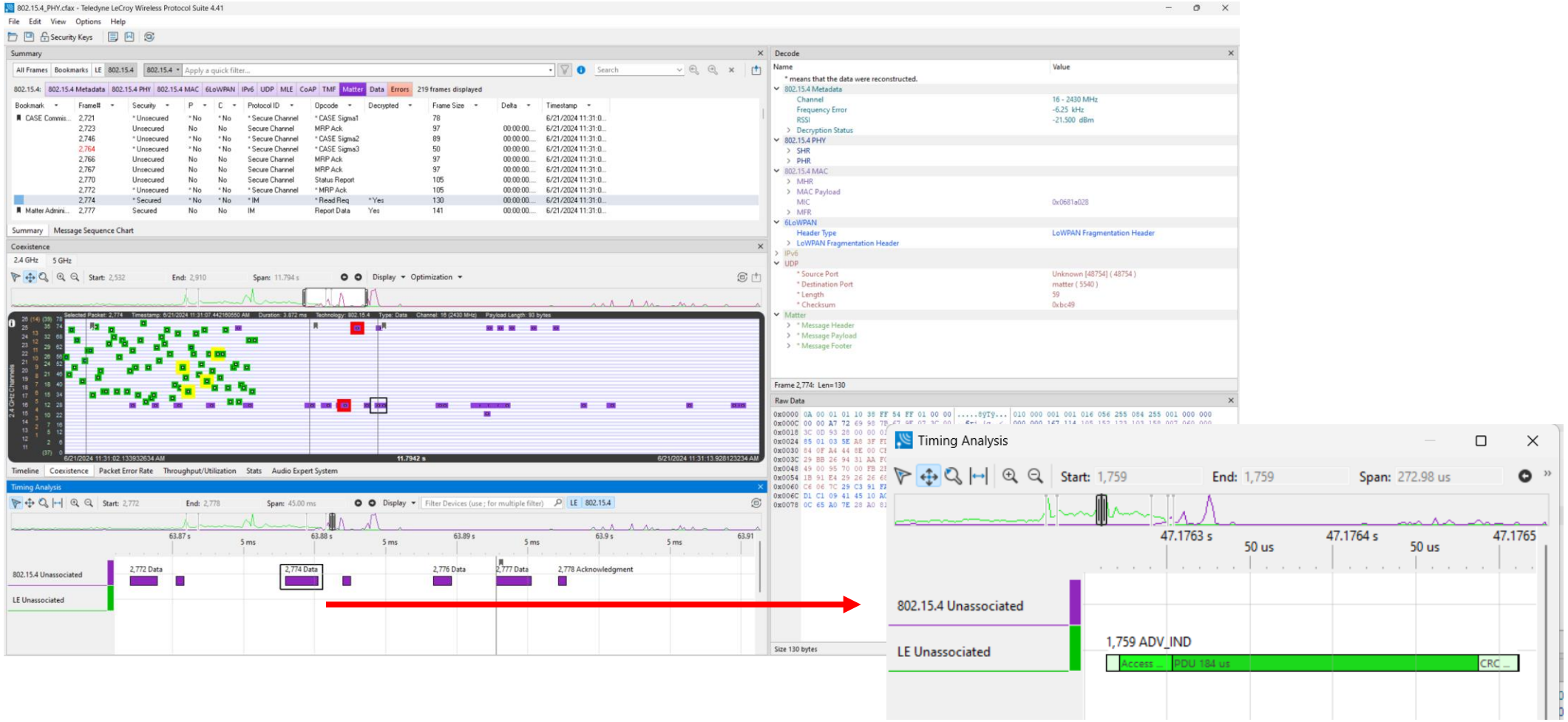
How can our Analyzers help? – Coexistence View

- Tools provide insight to speed development
  - Simultaneously capture Bluetooth with Wi-Fi and 802.15.4 technologies (Thread, Matter, Zigbee)
  - View spectrum (RF energy heat map) and debug interference issues
  - Investigate commissioning over multiple wireless technologies
  - Verify log information to narrow on problems



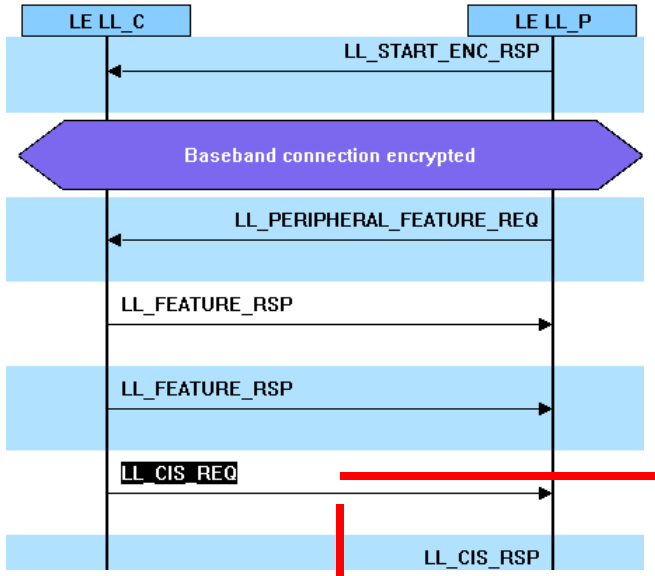
How can our Analyzers help? – Timing Analysis

- Use Timing Analysis to understand connection event timing and retries.
  - Debug interoperability and performance issues

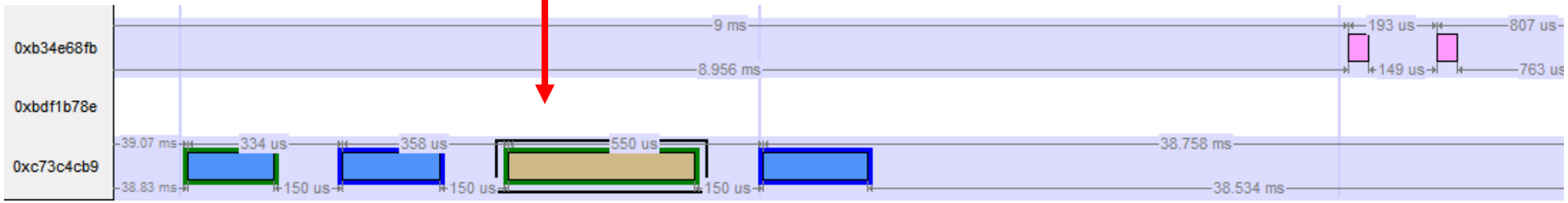


How can our Analyzers help? – Message Sequence Chart

- Aids understanding at a connection level
- Useful for coordinating analysis

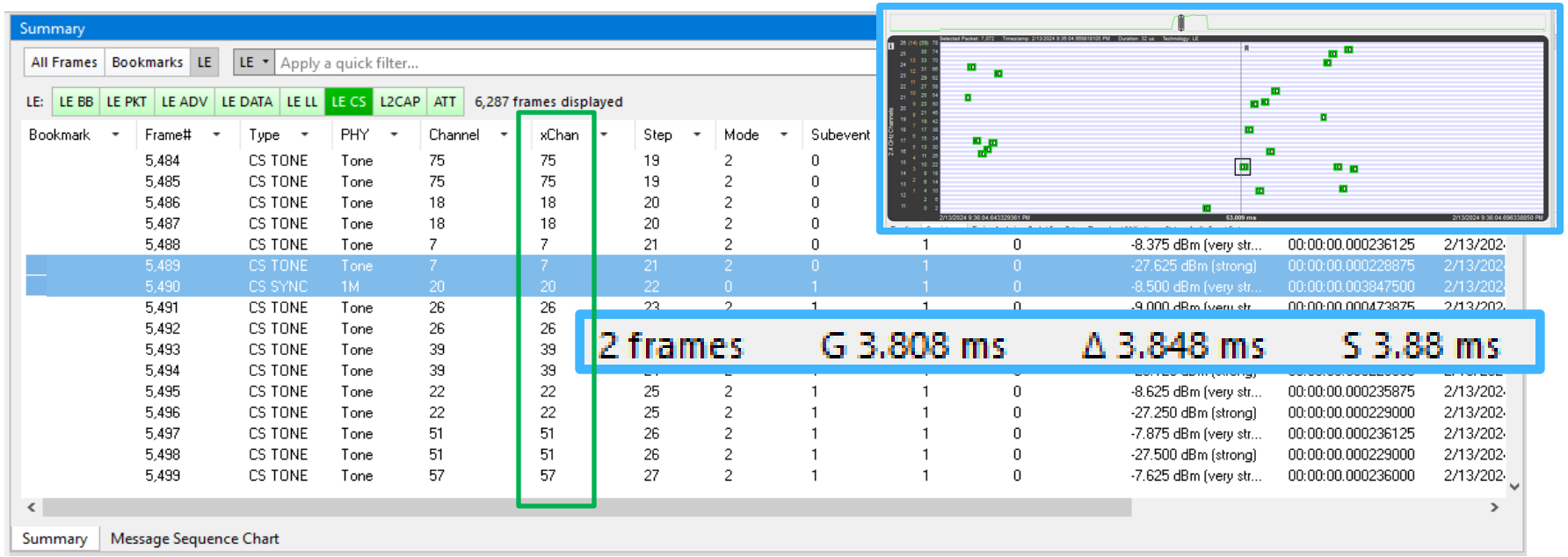


LE LL	
Control Pkt	LL_CIS_REQ
CIG ID	0x00
CIS ID	0x01
PHY_C_to_P	LE 2M PHY
PHY_P_to_C	LE 2M PHY
Max_SDU_C_TO_P	120 octets
Framing_Mode	Not applicable
Framed	Unframed
Max_SDU_P_TO_C	0 octets
SDU_Interval_C_TO_P	10000 µs
SDU_Interval_P_TO_C	10000 µs
Max_PDU_C_to_P	120
Max_PDU_P_to_C	0
Number of Subevents	3
Subevent Interval	1000 µs
BN_P_to_C	0 (No CIS Payload)
Burst Number C_to_P	1
FT_C_to_P	1
FT_P_to_C	1
ISO Interval	10.00 ms
*Calculated Flush Timeout C_to_P	10.00 ms
*Calculated Flush Timeout P_to_C	10.00 ms
CIS Offset Minimum	5500 µs
CIS Offset Maximum	5500 µs
Conn Event Counter	0x0045



How can our Analyzers help? – LE CS Support

- Robust Bluetooth 6.0 feature – LE Channel Sounding (CS) support
- Automatic verification of channel selection algorithm while capturing live data
  - Maintains channel estimation even if packets are missing



Webinars available

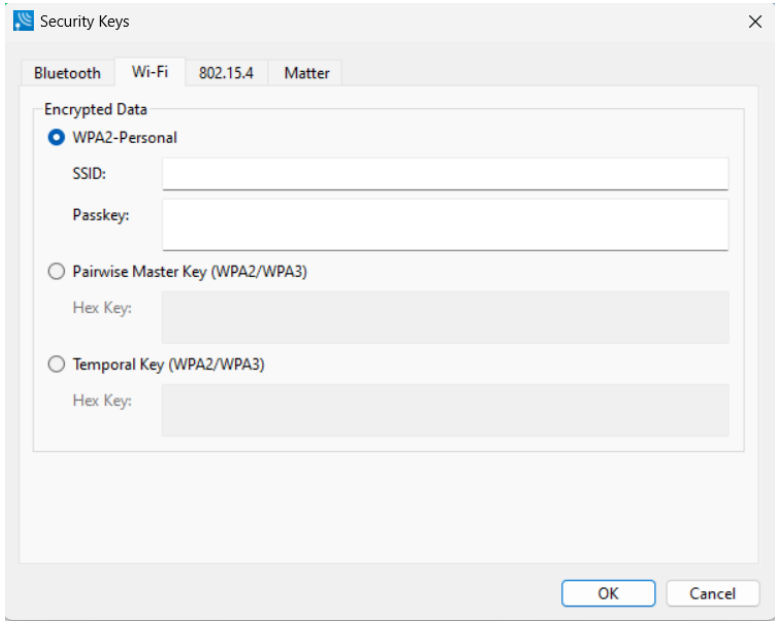
[Introduction to Channel Sounding with Wireless Protocol Suite]

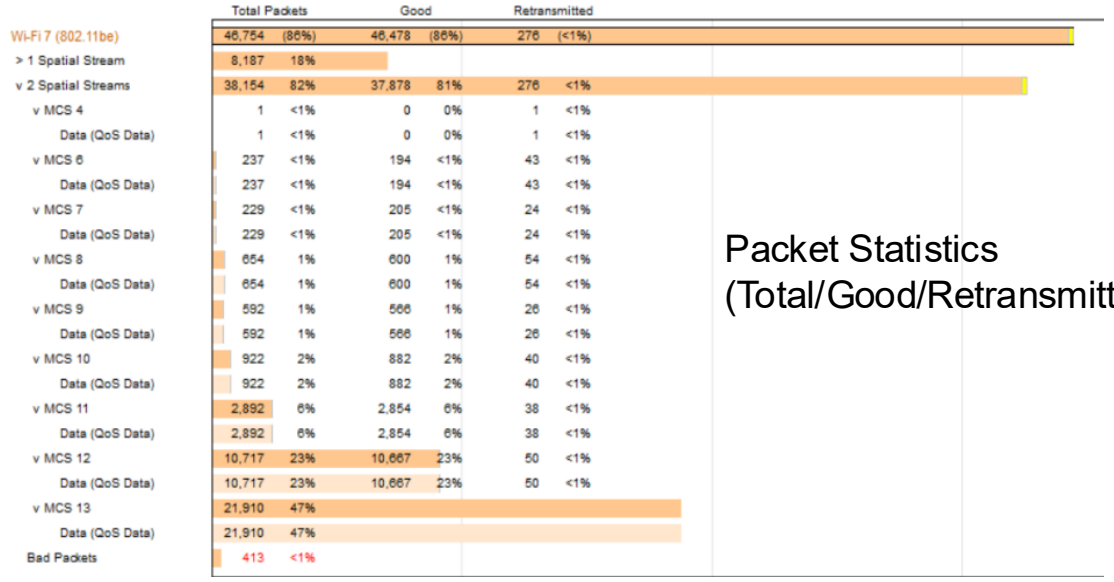
[Illustrating Channel Sounding Applications with Wireless Protocol Suite]

[Analyzing/Debugging a Channel Sounding Capture]

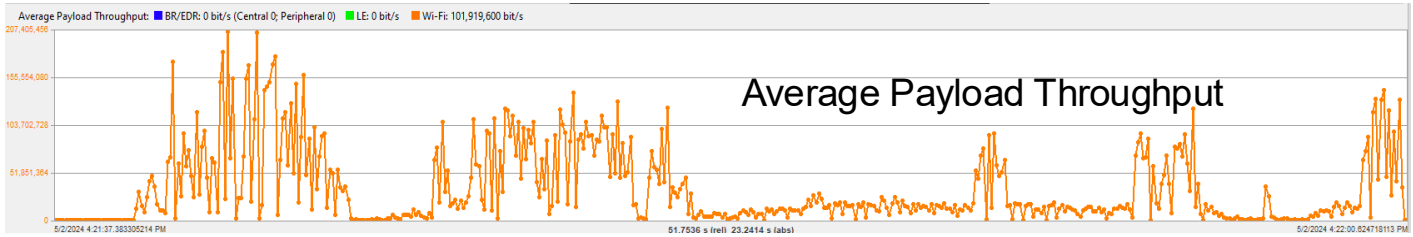
How can our Analyzers help? – Wi-Fi Support

- Ability to capture Wi-Fi 1-7 2x2 MU-MIMO in WPA3 and WPA2 environments
- Simultaneous capture of two Wi-Fi channels on two bands, including Wi-Fi 7 MLO
- Wi-Fi Scanner functionality for automatic Channel Setup
- iPerf Quality performance testing





Packet Statistics
(Total/Good/Retransmitted)



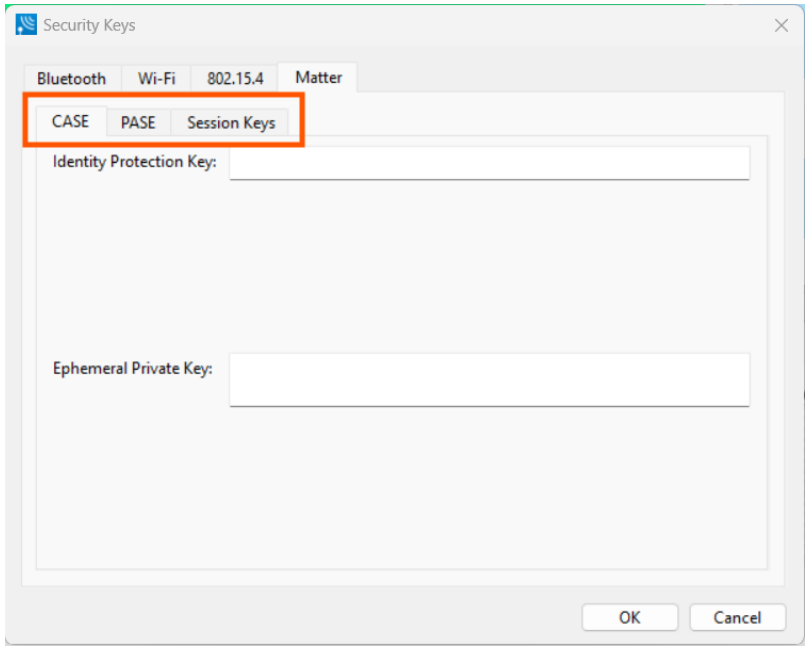
Average Payload Throughput

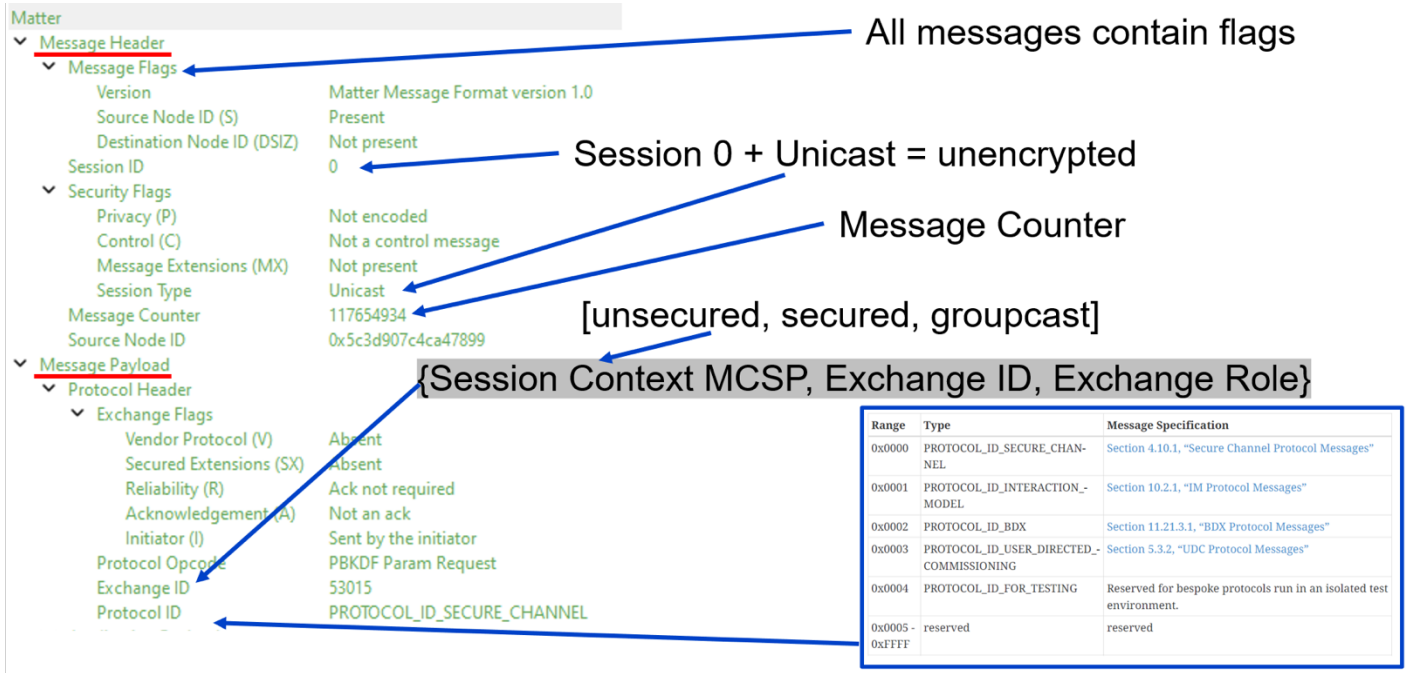
Webinars available

[Master Wi-Fi Debugging: Practical Solutions for Common Issues]
[Introducing Wi-Fi 7 Technology/Discussion Part 1]
[Part 2: In-Depth Analysis of Wi-Fi 7 and Bluetooth]
[Getting Value Out of Your Wi-Fi Capture]

How can our Analyzers help? – Matter/Thread/Zigbee Support

- Matter communication traverses over multiple RF technologies and protocols
  - Simultaneous technologies can be captured with the X500e
- Matter's flexible message-based traffic is normally encrypted and organized in a hierarchical format
  - Wireless Protocol Suite (WPS) is an important tool for debugging and analysis
  - WPS automation reduces or eliminates the data capture and analysis burden





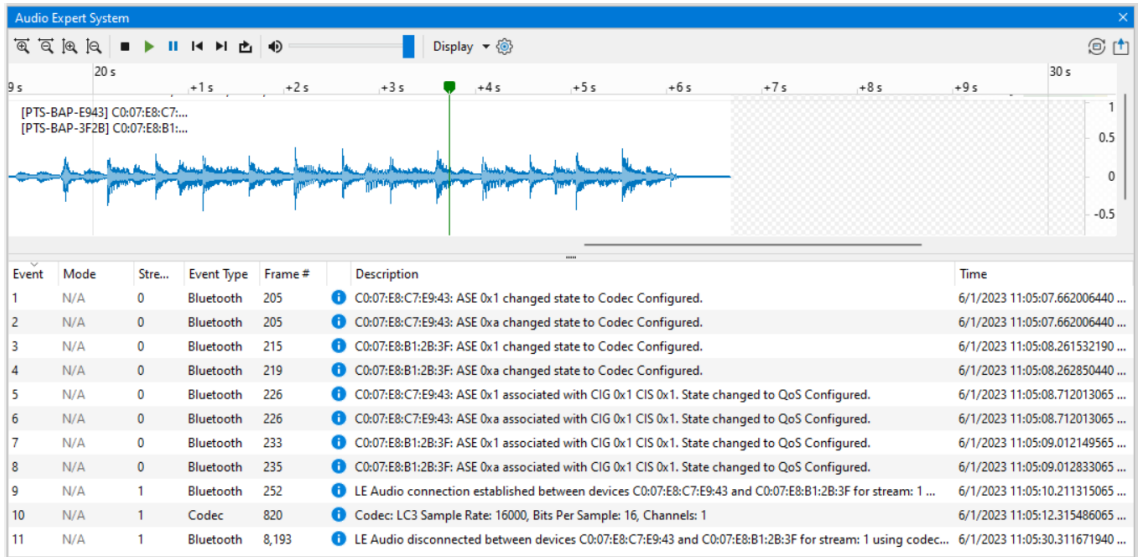
Webinars available

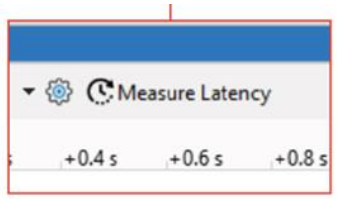
[Introduction to Matter with Wireless Protocol Suite Pt. 1]

[Introduction to Matter with Wireless Protocol Suite Pt. 2]

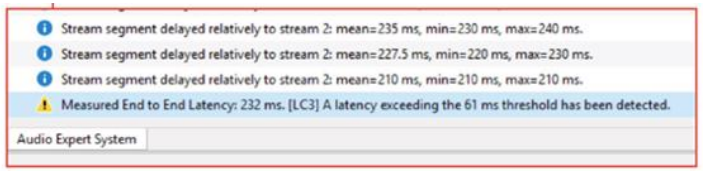
How can our Analyzers help? – Audio Expert System

- Correlates audio, codec, and Bluetooth protocol events to a single timeline as they happen
- Visualization of audio problems
- Bit rate variance analysis for coarse audio quality debugging
- In depth analysis using “Reference Mode” that allows comparing results with known baseline information
- Latency testing using “Audio Analysis Solution”
  - Transport Latency
  - End to End Latency
  - Audio Processing Latency
  - Presentation Latency
  - L/R Channel Latency

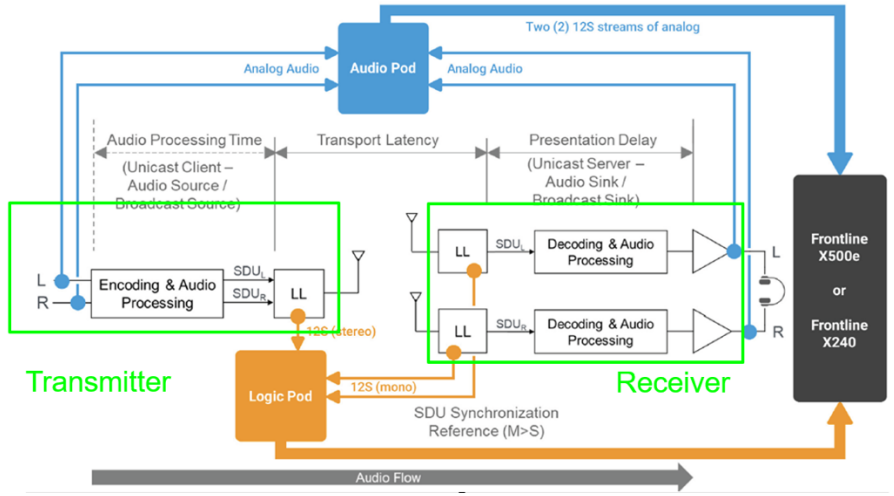




Click the "Measure Latency" button to initiate the measurement process.



Results will appear in the Audio Event Log, with each latency event tagged by its respective event type.



Webinars available

[Master Bluetooth Audio Debugging: Measuring Latencies]

[Improving Wireless Sound with WPS Reference Audio]

Summary: A Leading Choice

Tools for Professionals in Electronics Design and Testing

Comprehensive Protocol Support

Supports a wide range of wireless protocols

High Performance and Versatility

Dual Bluetooth radios for superior capture performance and support for the latest Wi-Fi technologies.

Advanced Analysis Capabilities

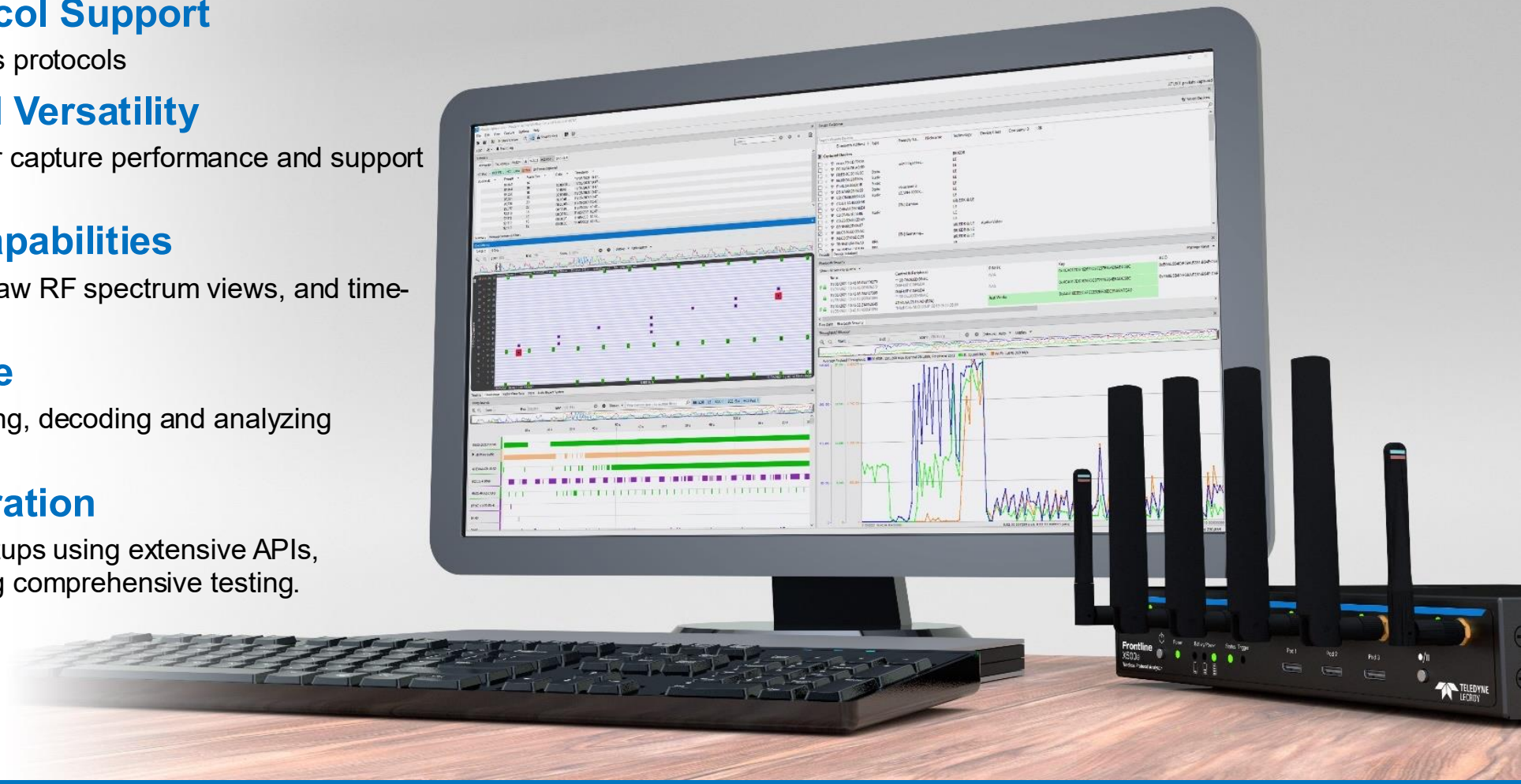
Live or post-capture decryption, raw RF spectrum views, and time-correlated captures.

User-Friendly Software

Streamlined interface for displaying, decoding and analyzing wireless data.

Automation and Integration

Integrates into automated test setups using extensive APIs, enhancing efficiency and enabling comprehensive testing.



Thank you!

Resources:

Teledyne LeCroy Website
https://www.teledynelecroy.com

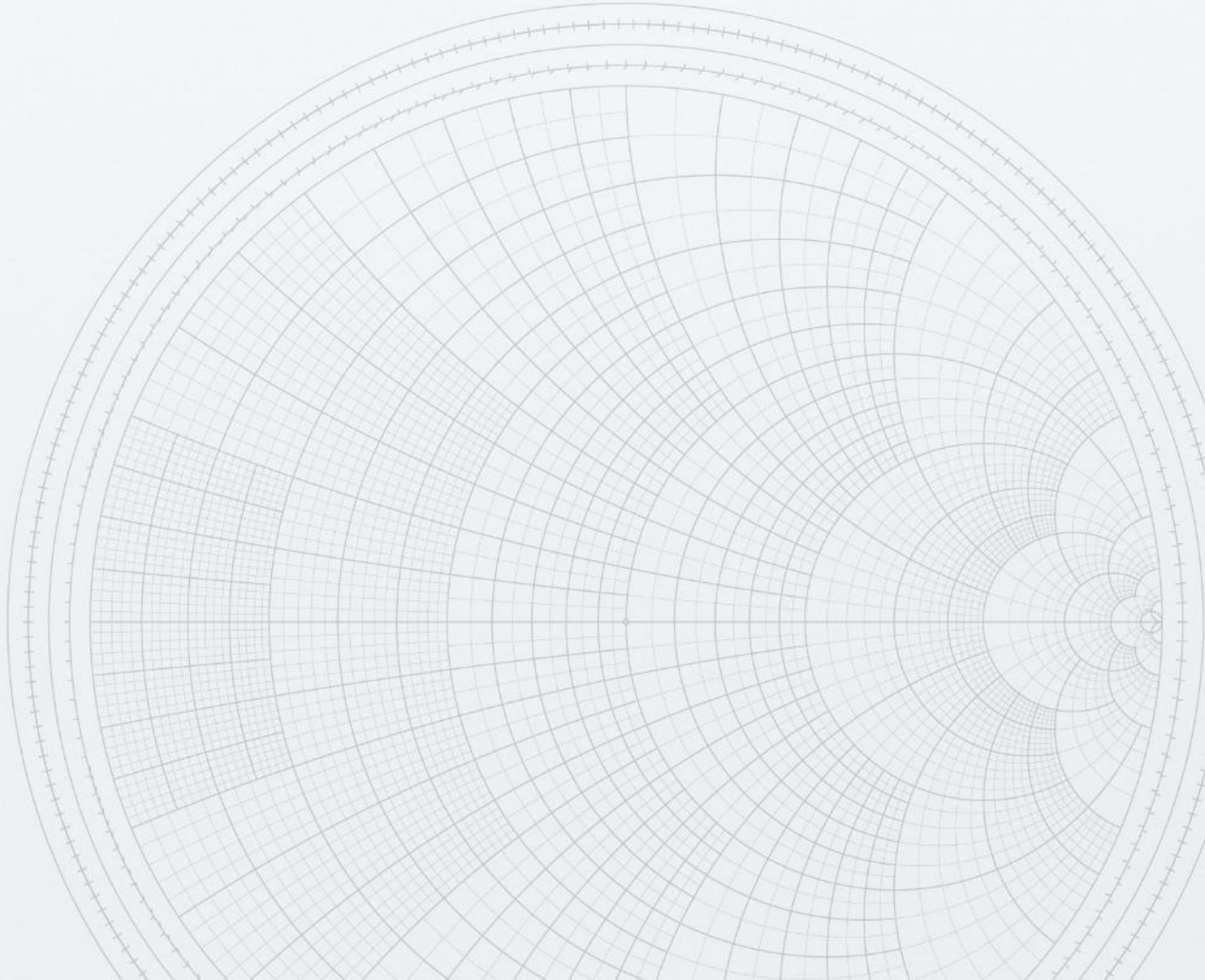
Wireless Solutions:
https://www.teledynelecroy.com/protocolanalyzer/solutions-wireless.aspx

Webinars and Videos
https://www.teledynelecroy.com/events/
https://www.teledynelecroy.com/support/techlib/videos.aspx?docgroupid=5

Contact:

Priyanka.Gupta@teledyne.com (Sr. Product Manager and Marketing)

Summary



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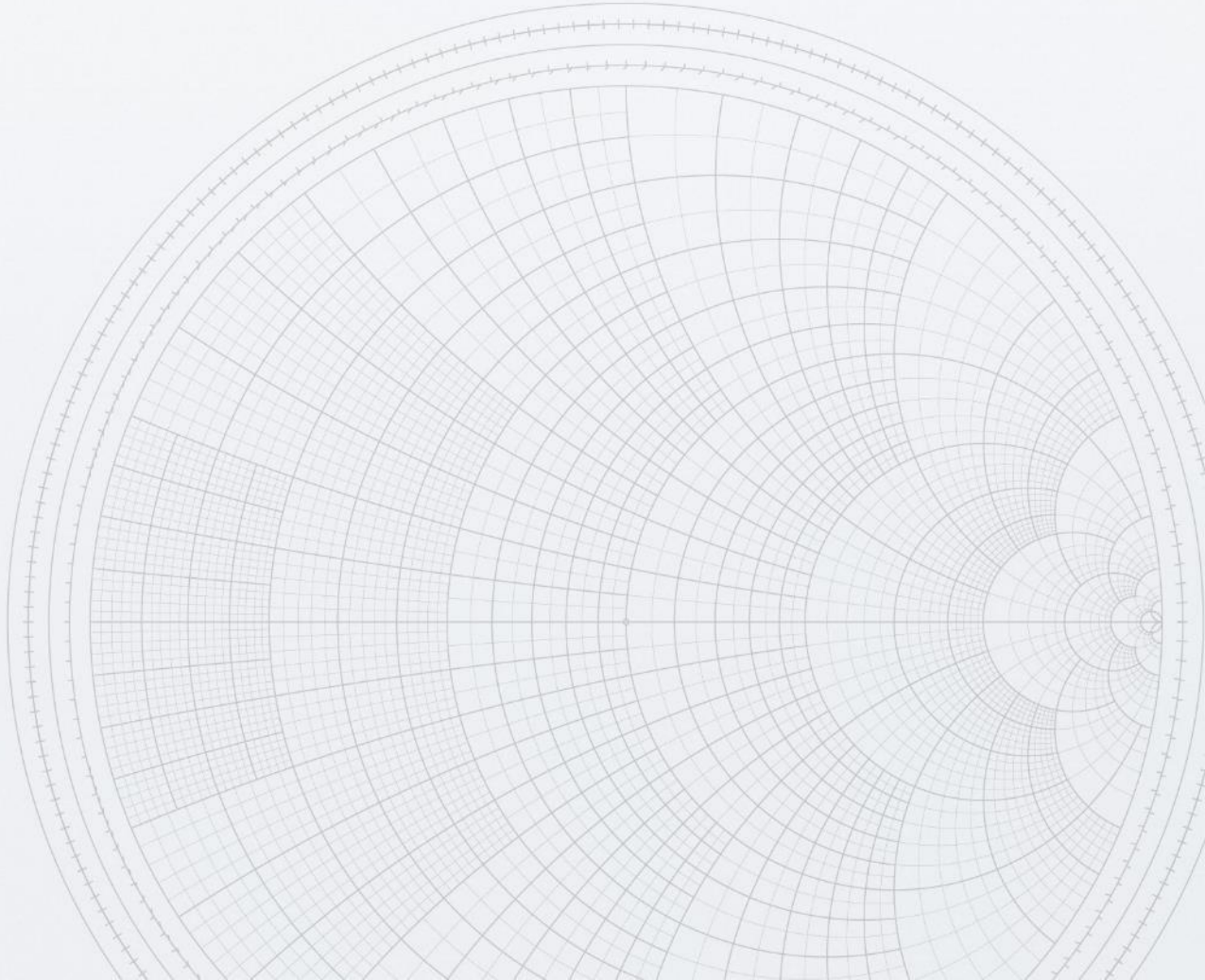
Resources

- Multiprotocol Web page
- Concurrent Multiprotocol Blog
- Docs.silab.com Multiprotocol
- UG103.16: Multiprotocol Fundamentals
- UG305 Dynamic Multiprotocol User's Guide

Multiprotocol Summary

- **Enables single RF chip to support multiple protocols**
  - Lowers product cost vs multiple RF chips
  - Simplifies hardware layout and design
  - Enables smaller form factor products
  - Helps to future proof products
  - Enables broader ecosystem support
  - Improves interoperability
  - Simplifies user choice
  - Improves user experience

Q&A



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