Precision Timing Measurements in 5G TDD Networks

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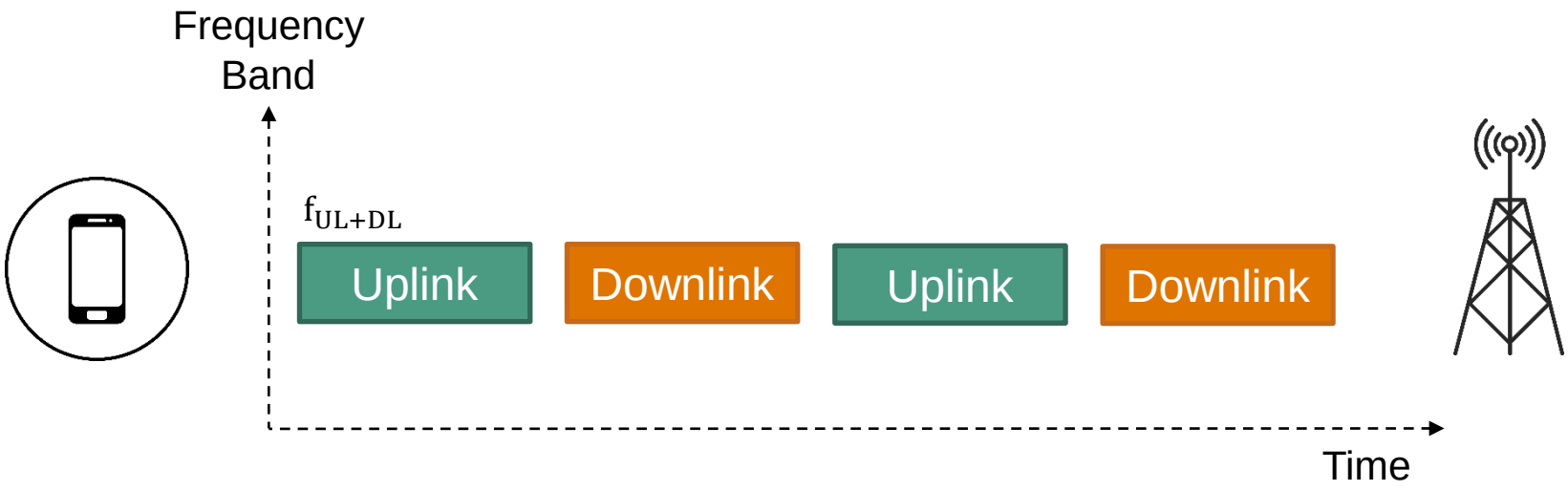
Agenda

- 5G TDD Networks Overview
  - TDD vs FDD
  - Importance of timing
- Essential RF Testing Metrics
  - Rise time, fall time, settling time
  - Propagation delay
  - Waveform anomalies
  - Crest factor
- Test Instrument Considerations
- Wrap Up

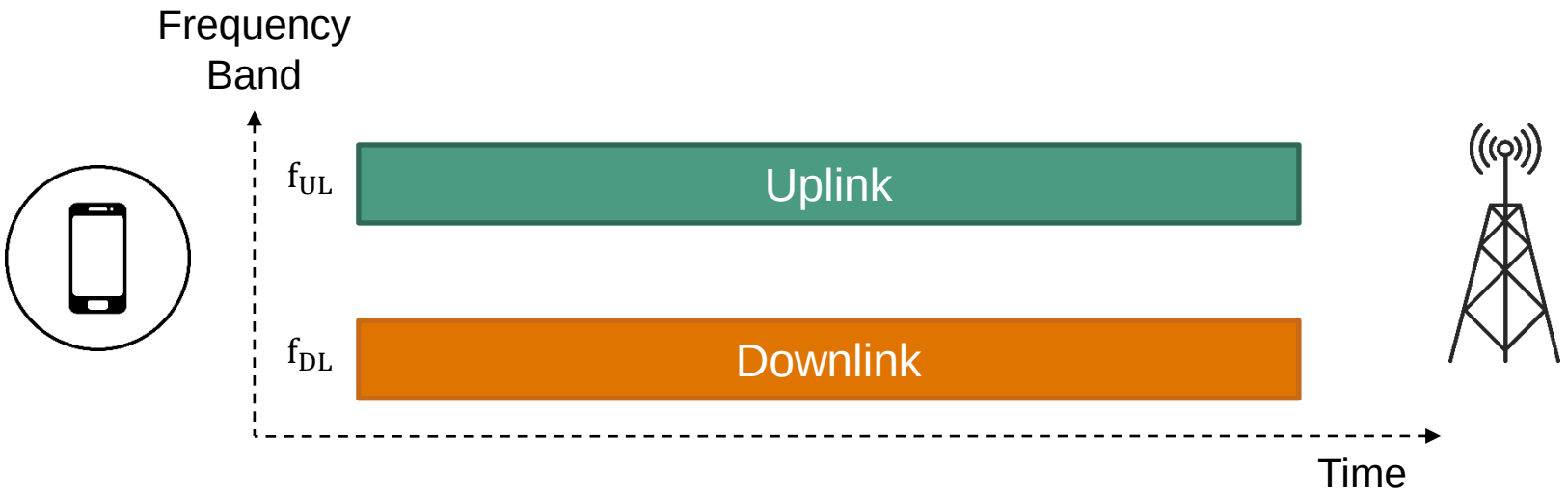
5G TDD: Overview

- Time Division Duplex (TDD)
  - Uplink/downlink transmissions share a frequency band
  - Time slots change rapidly
  - Guard band between uplink/downlink



5G TDD vs FDD

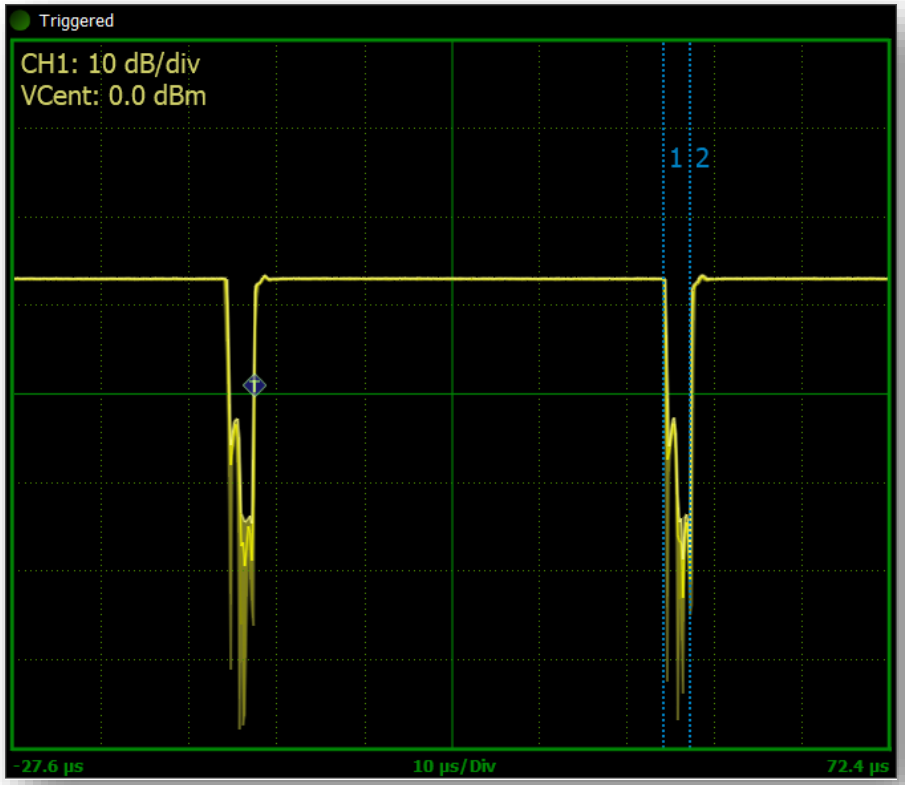
- Frequency Division Duplex (FDD)
  - Uplink/downlink on different channels
  - Needs frequency gap to avoid interference
  - Pre-determined uplink/downlink allocation



5G TDD: Pros & Cons

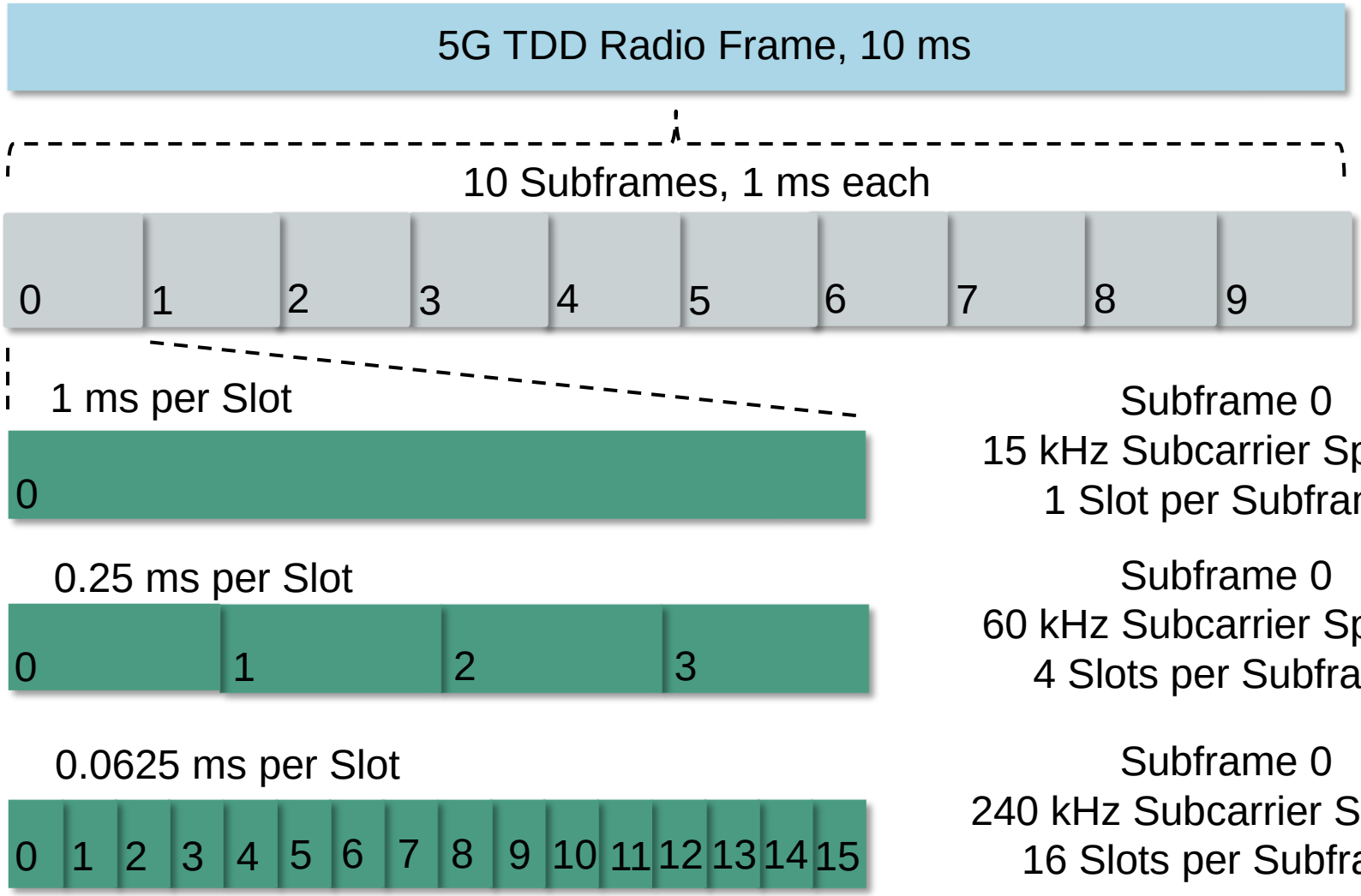
- TDD Benefits:
  - Efficient use of spectrum
  - Dynamic allocation of bandwidth for asymmetric traffic
- TDD Challenges:
  - Precision timing to avoid interference & delay
  - Timing compresses at higher frequencies

5G TDD Pulse
(without modulation)



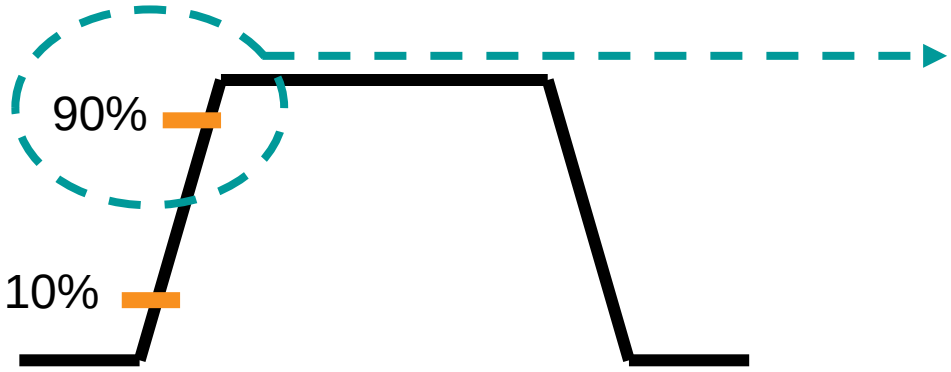
Pulse Width = 47 µs
Gap = 3 µs

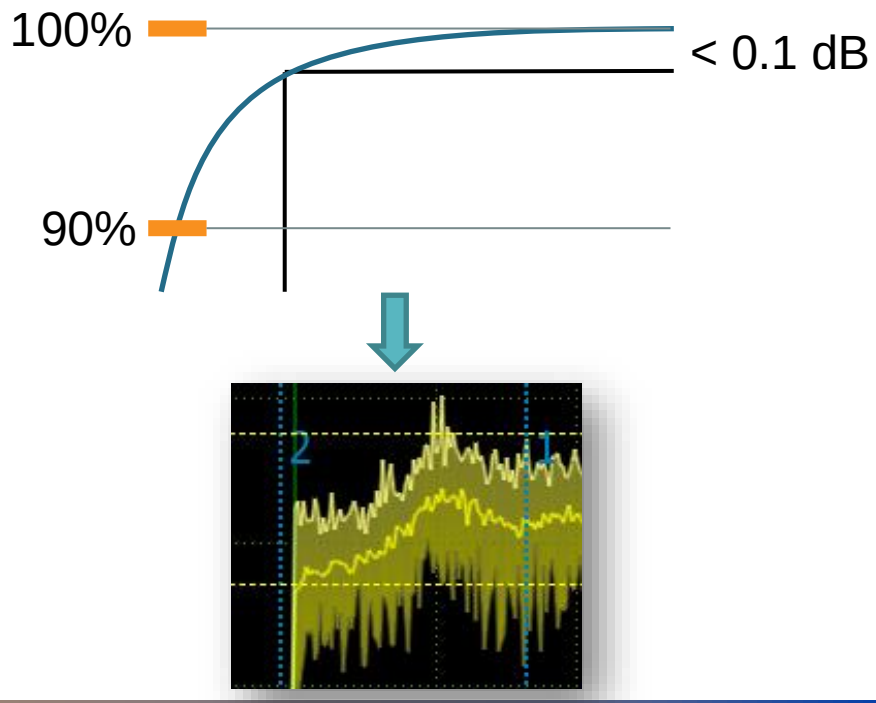
5G TDD Timing



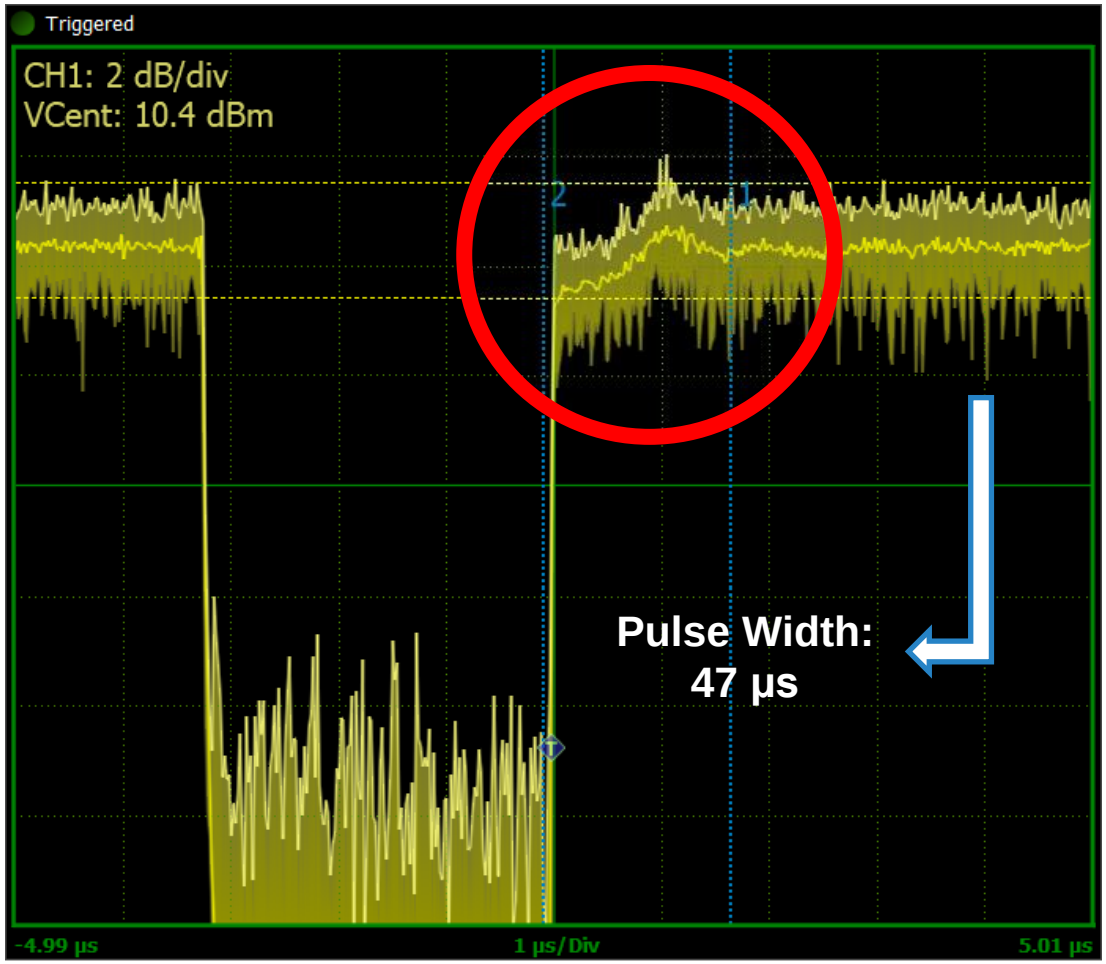
Rise Time & Fall Time

- **Rise Time:** Signal change from 10% to 90% of Its Magnitude
- **Fall Time:** Signal Changes from 90% to 10% of Its Magnitude
- **Settling Time:** Interval from 90% to Signal's Steady State Maximum Level
- All Key in Determining Switching Speed



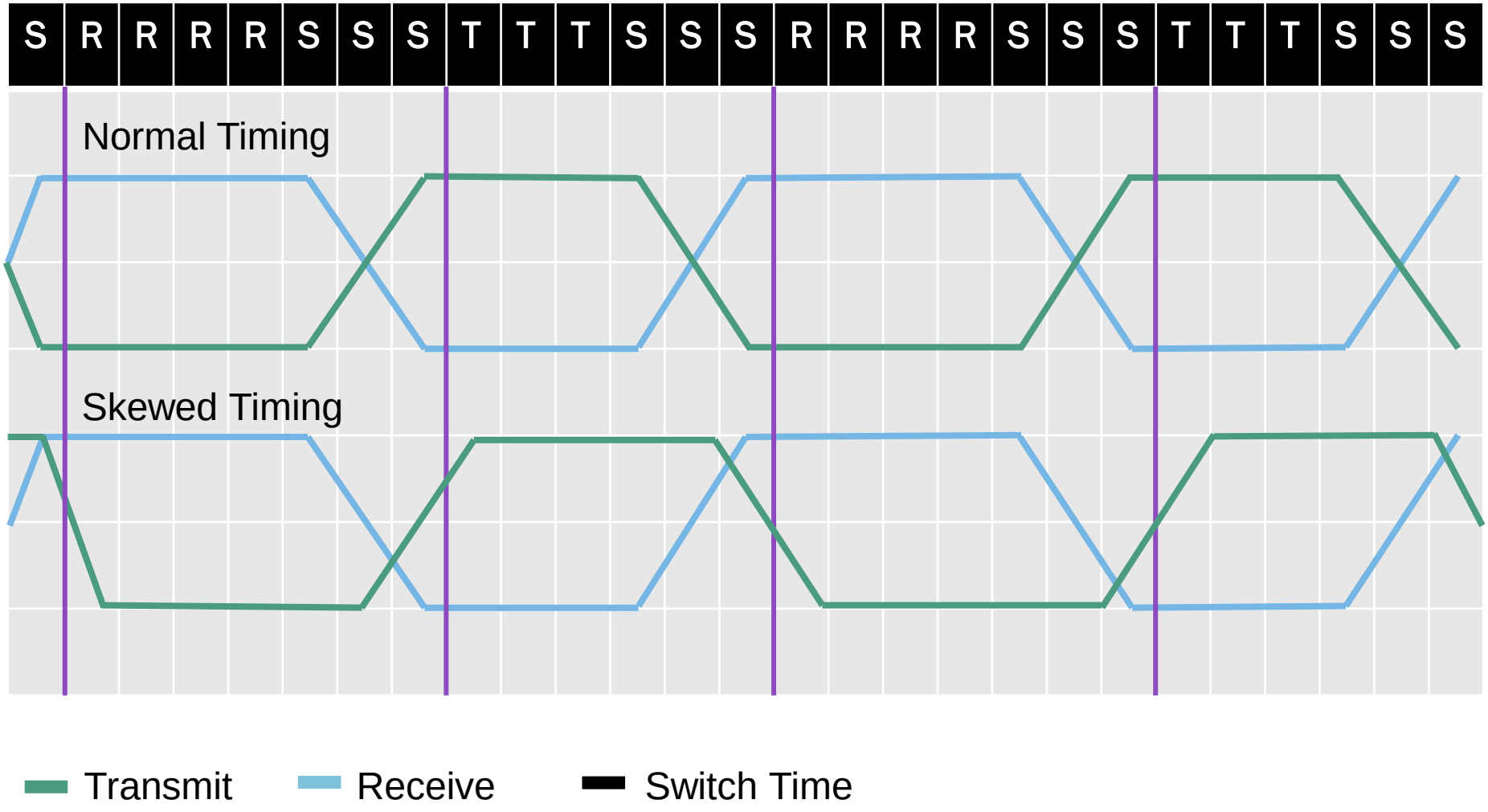


Settling Time



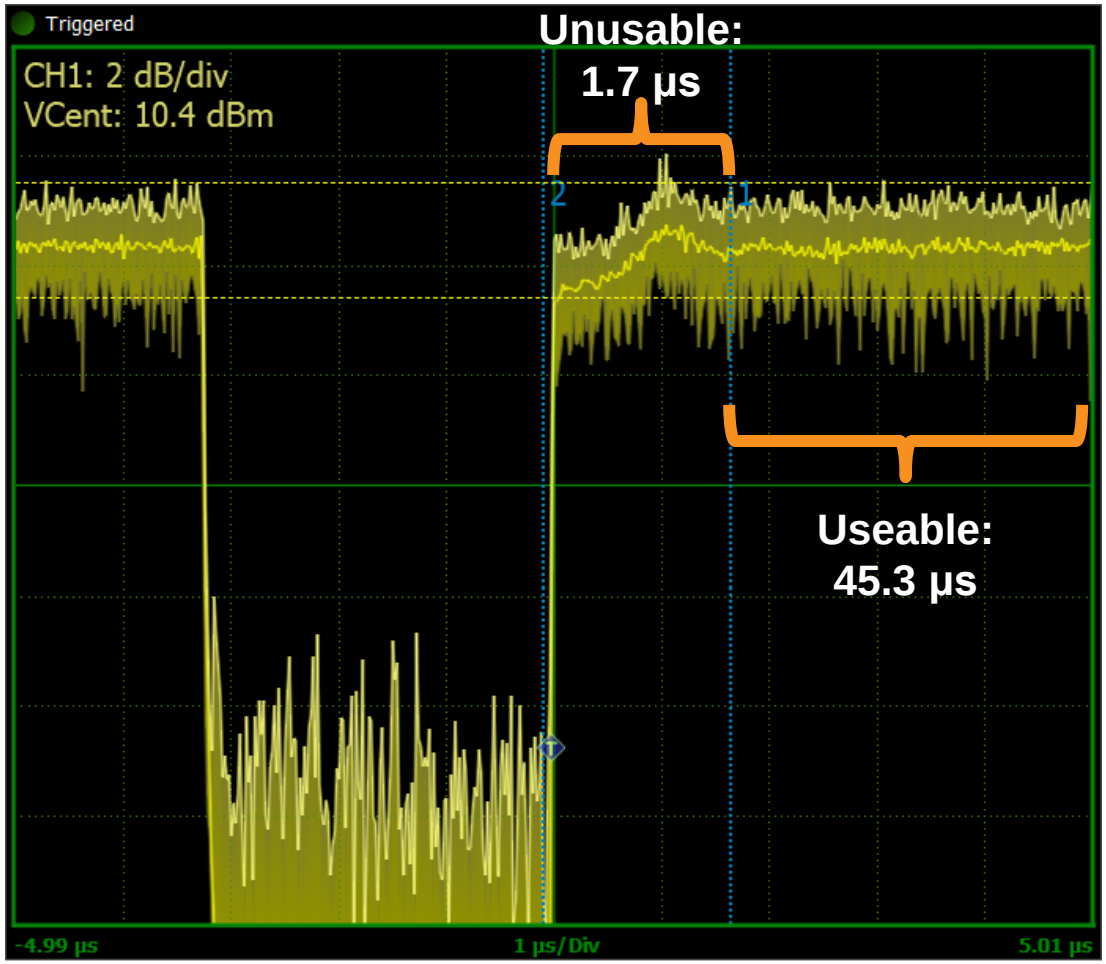
- **Settling Time:** 90% to Signal's Steady State Max Level
  - Dead time, region of unusable data
- Response Time = Rise Time + Settling Time

Propagation Delay



Propagation Delay

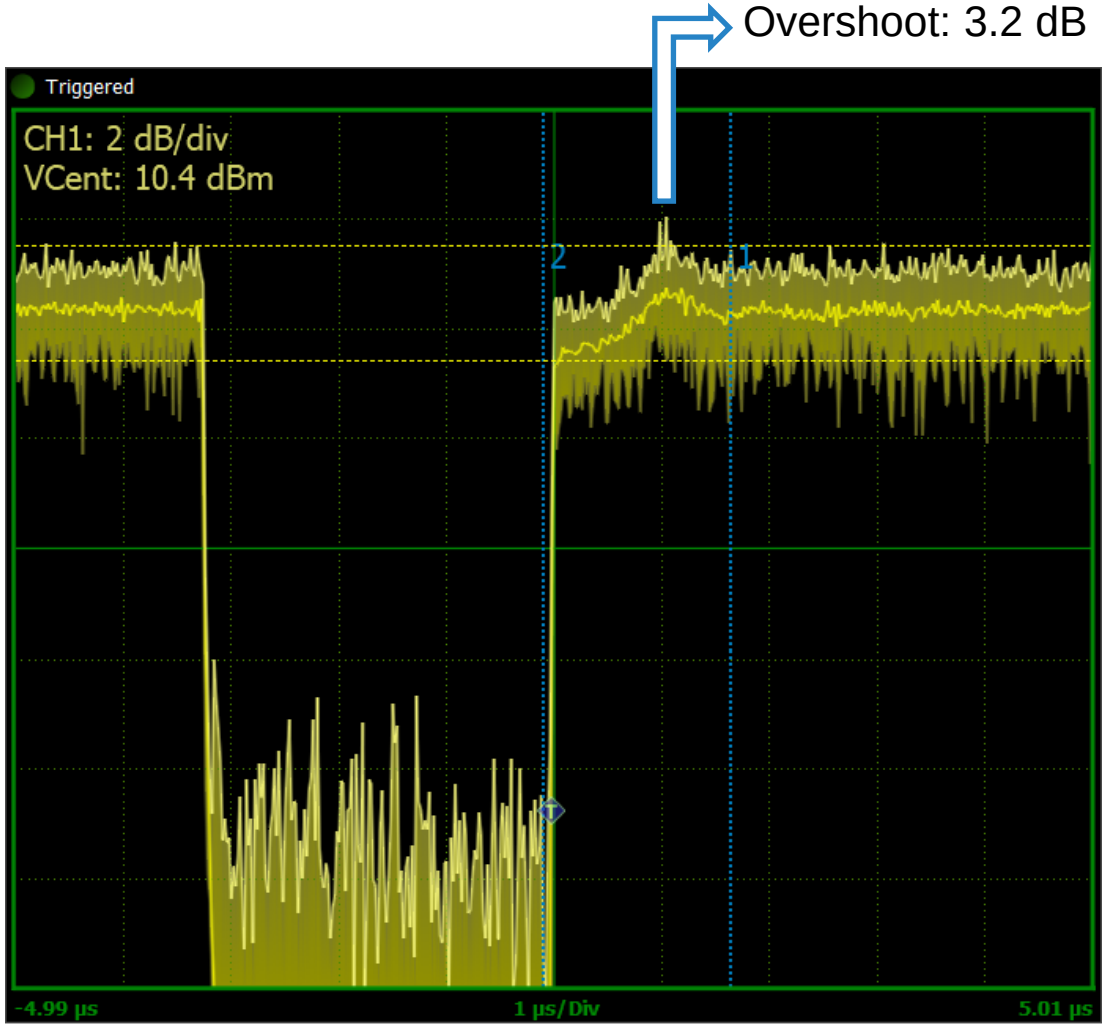
Pulse width is 47 µs, but only 45.3 µs useable



- **Propagation Delay:**
  Round-trip Time Interval from the Sender to the Receiving Device

- Leads to:
  - Uplink/downlink overlap
  - Interference
  - Performance degradation

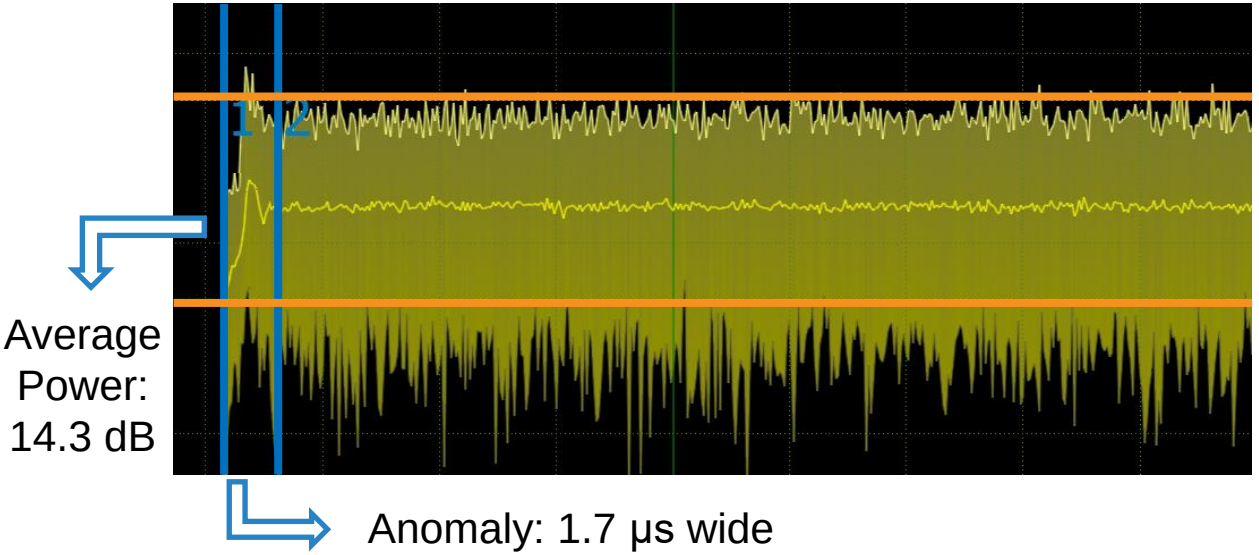
Waveform Anomalies



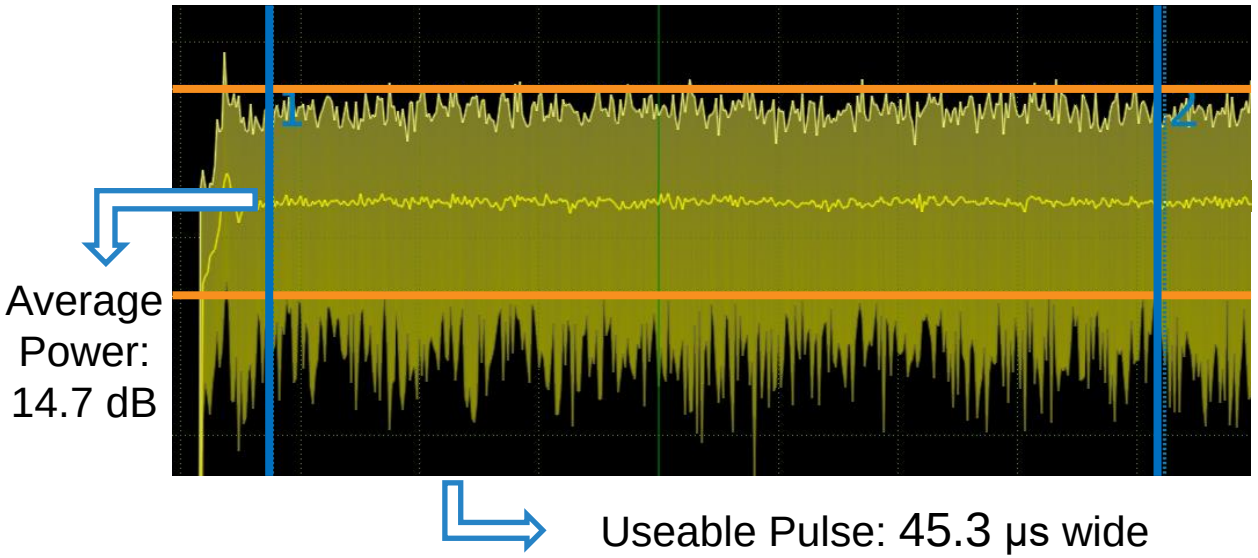
- **Overshoot:** Signal Exceeds Its Top Amplitude
  - Often followed by ringing
- Degrades Communications Integrity

Crest Factor

- Crest Factor of Anomaly: 2.4 dB



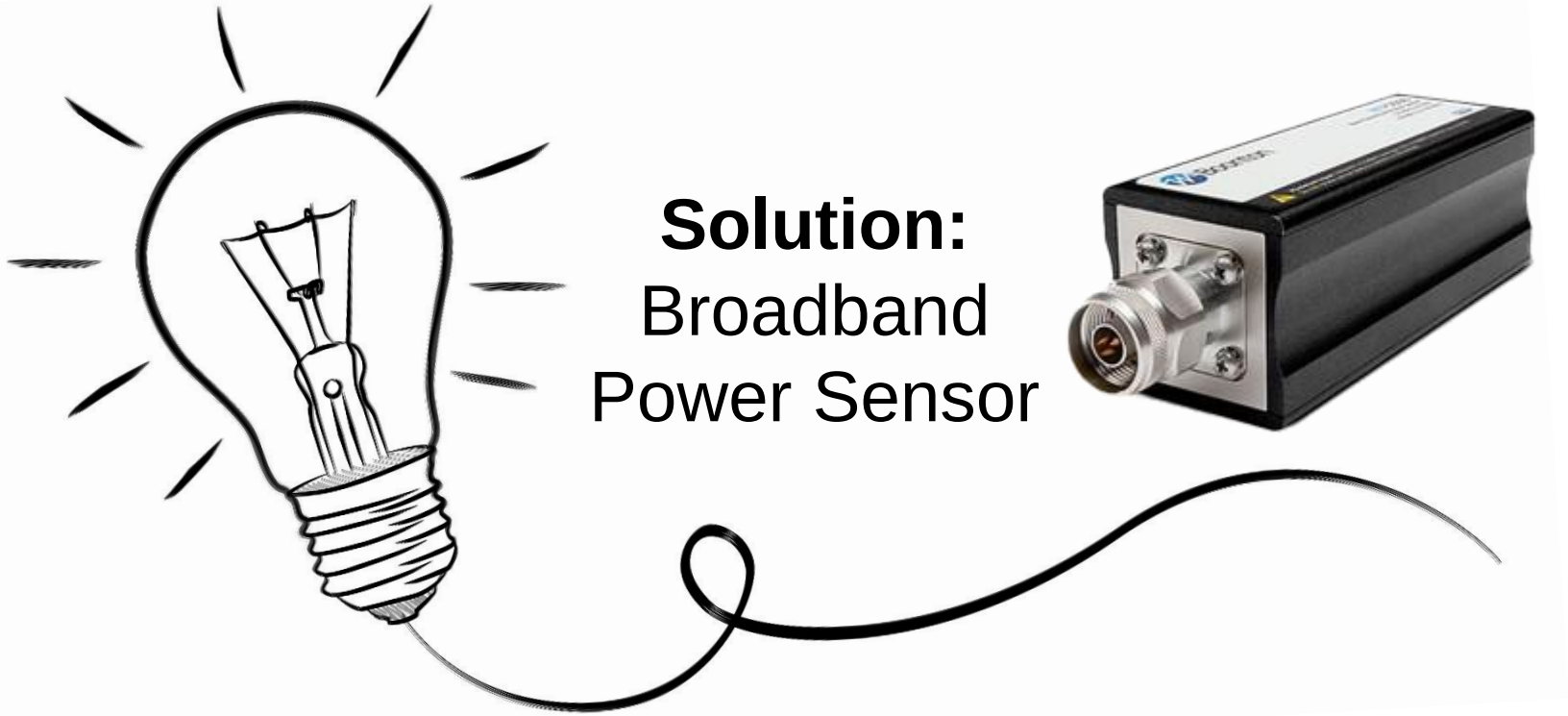
- Crest Factor of Remaining Pulse: 1.45 dB



Vertical Markers Horizontal Markers

Test Instrument Capabilities

What Test Instrument Can Capture the Critical Metrics for 5G TDD Networks?



Solution:
Broadband
Power Sensor

Test Instrument Capabilities

- Low-Cost Device
  - More economical compared to a VNA
- Fast Rise Times
  - Capture TDD signal's rising edge
  - Ideal: 3 ns
- Fast Measurement Speed
  - Validate switching performance and catch anomalies
  - Unique DSP enables gap-free acquisition
  - Ideal: 100,000 measurements per second

Test Instrument Capabilities

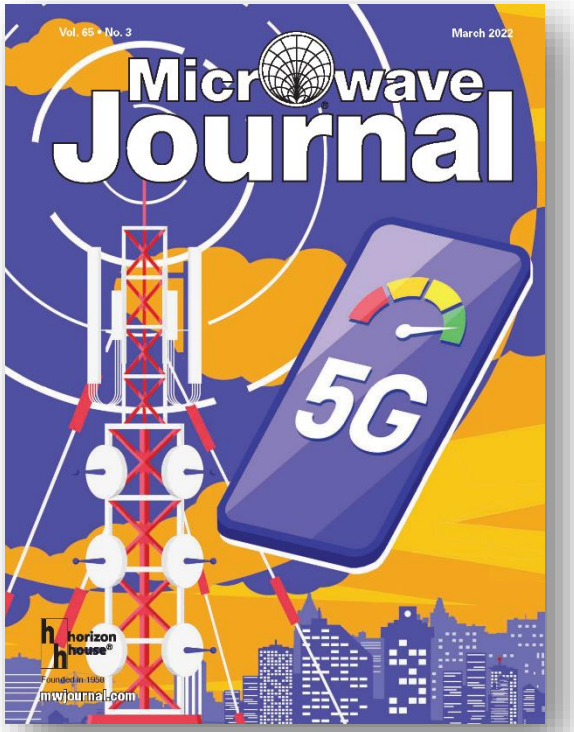
- Video Bandwidth
  - Accommodate 100-MHz 5G channel
  - Ideal: 195 MHz
- Cursor Resolution
  - Resolve timing difference between TDD switches
  - Ideal: 100 ps
- Test Setup Synchronization
  - Economical alternative to a VNA
  - Use client's actual signals

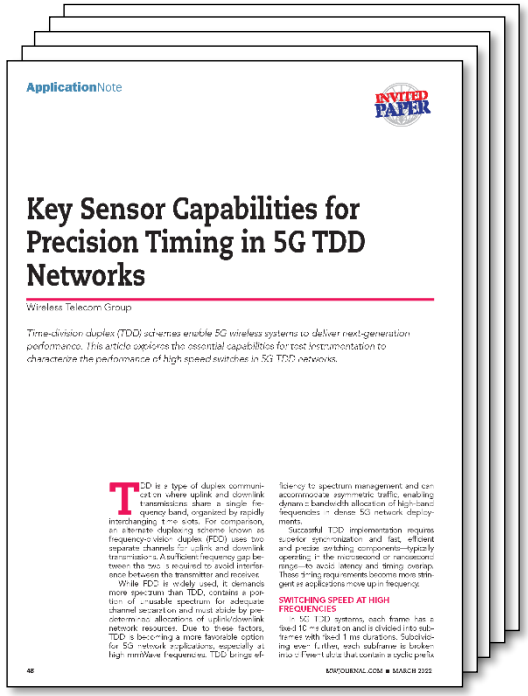
Wrap-up

- 5G TDD Networks & Timing Requirements
- Critical Test Parameters
  - Rise time, fall time, settling time
  - Propagation delay & waveform anomalies
  - Crest factor
- Test Instrument Considerations
  - Cost & ease of use
  - Fast rise times & measurement speed
  - Video bandwidth & time resolution
  - Test setup synchronization

Learn More

- MWJ March 2022 Issue: Test & Measurement
  - **Article:** “Key Sensor Capabilities for Precision Timing in 5G TDD Networks”





Questions

Any

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