ELECTRONIC WARFARE STIMULUS ARCHITECTURAL OVERVIEW

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Make ideas real

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ELECTRONIC WARFARE RF STIMULUS DIGITAL BACKEND

CONSIDERATIONS

- Pulse descriptor word (PDW) interface
- Pulse density per digital PDW interface
- Pulse dropping and prioritization
- Multiple basebands and pulse-on-pulse

WHAT IS A PULSE DESCRIPTOR WORD?

- Fully characterizes an RF Pulse.

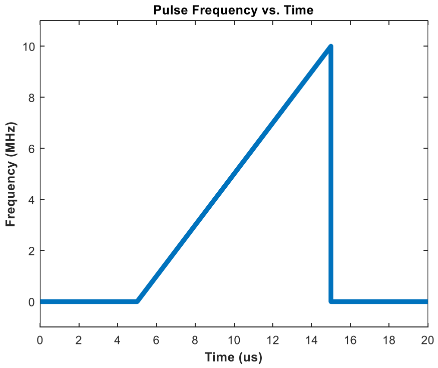
TOA

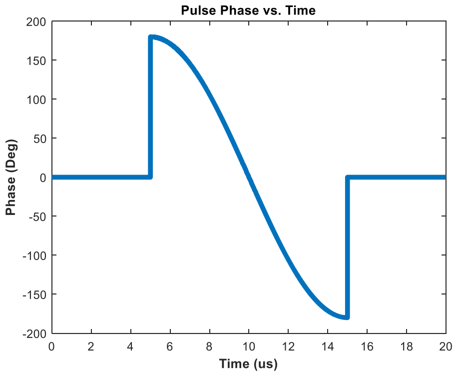
Frequency

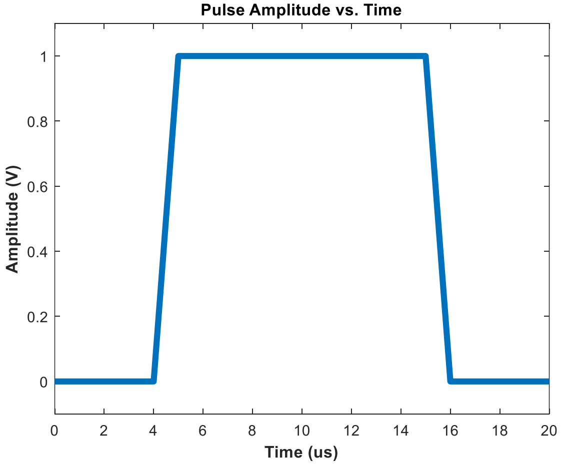
Level

Phase

Modulation

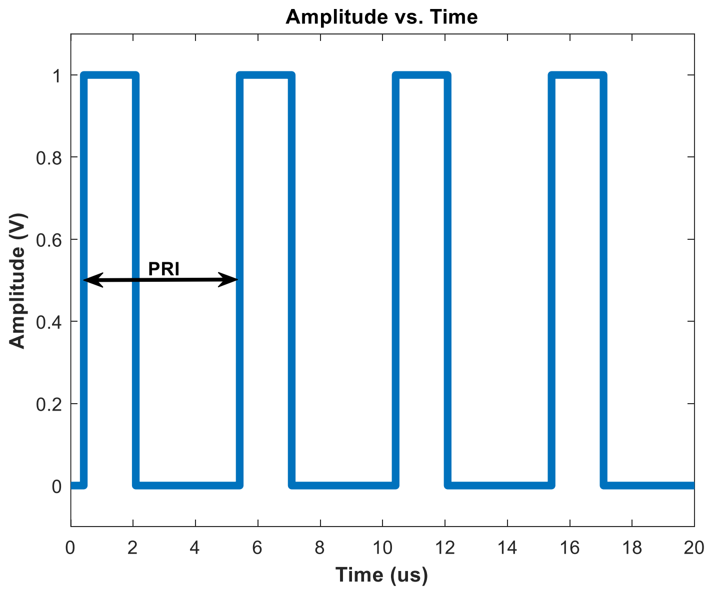






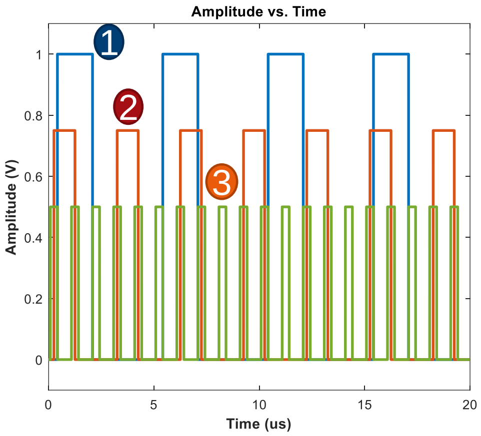
PULSE DENSITY PER PDW INTERFACE

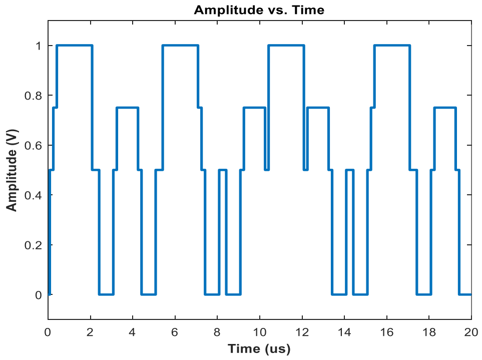
- What is the highest PDW rate?
- Higher PDW rate → higher density scenarios, higher PRFs
- Congested RF environments



PULSE DROPPING AND PRIORITIZATION

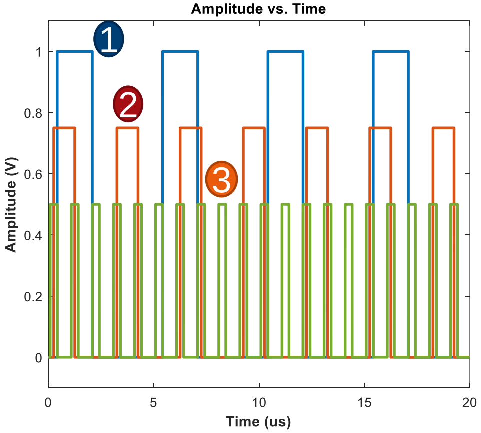
- One PDW per digital processor
- Simultaneous pulses can create problems
- Prioritization schemes provide a partial solution

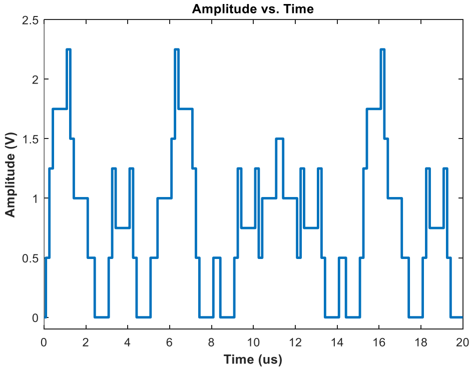




MULTIPLE PDW INTERFACES AND PULSE-ON-PULSE

- Summing multiple PDW interfaces → solves simultaneous pulse problem
- Pulse-on-pulse generation capabilities increase density
- Requires more hardware

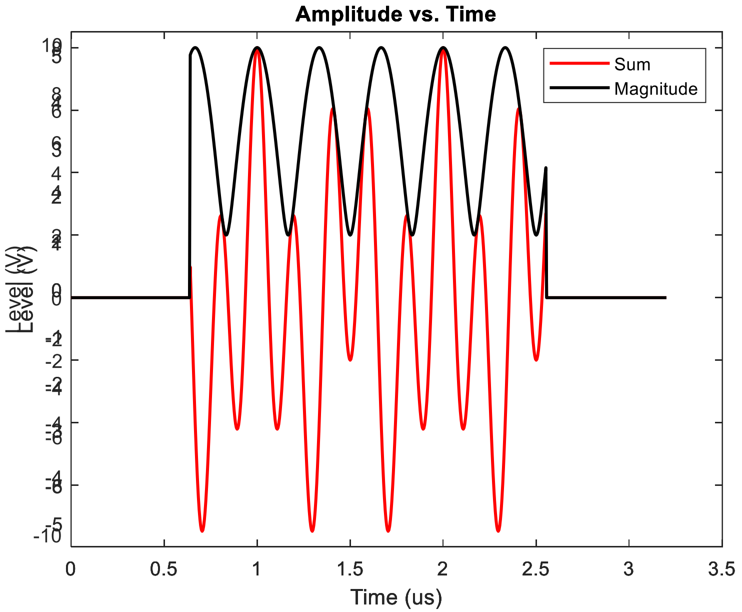




SIMULTANEOUS PULSES AS SEEN BY A RECEIVER

- ► Summing frequency and phase-aligned RF pulses → clean amplitude over time

- ► What if we have simultaneous pulses spread in frequency and phase?



SUMMARY

- ► PDWs fully describe an RF pulse
- ► Higher PDW rates → higher density congested environments
- ► Pulse dropping required on a single digital generator
- ► Pulse-on-pulse capabilities available with multiple digital generation interfaces
- ► Pulse on pulse with frequency/phase spreading leads to ringing on the magnitude capture

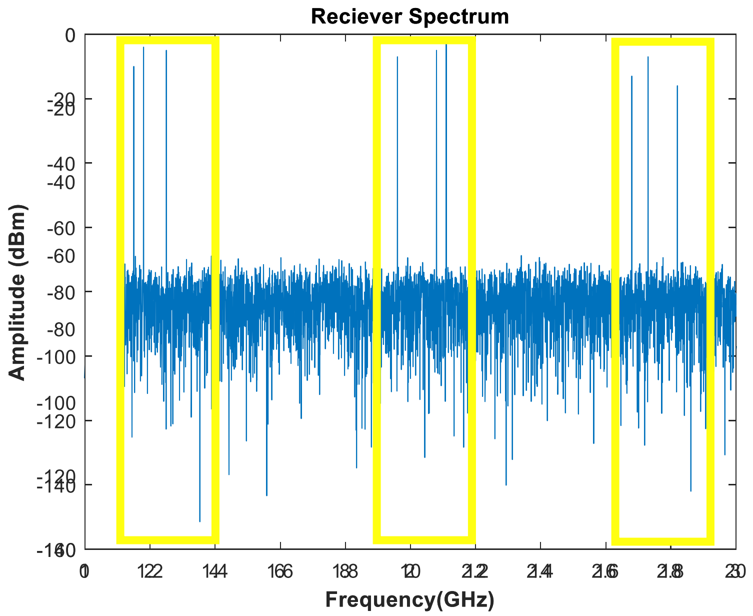
ELECTRONIC WARFARE RF STIMULUS FREQUENCY AND LEVEL AGILITY

CONSIDERATIONS

- Instantaneous bandwidth
- Hopping bandwidth
- Agile frequency hopping vs instantaneous modulation bandwidth
- Digital vs Analog Pulse-on-Pulse

INSTANTANEOUS BANDWIDTH

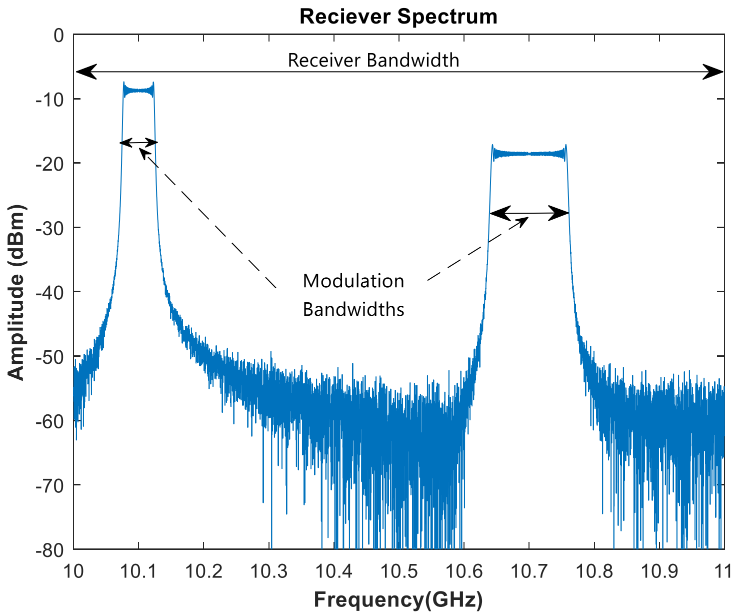
- What bandwidth is the EW receiver covering?
- Many receivers operate at multiple bands



MODULATION BANDWIDTH

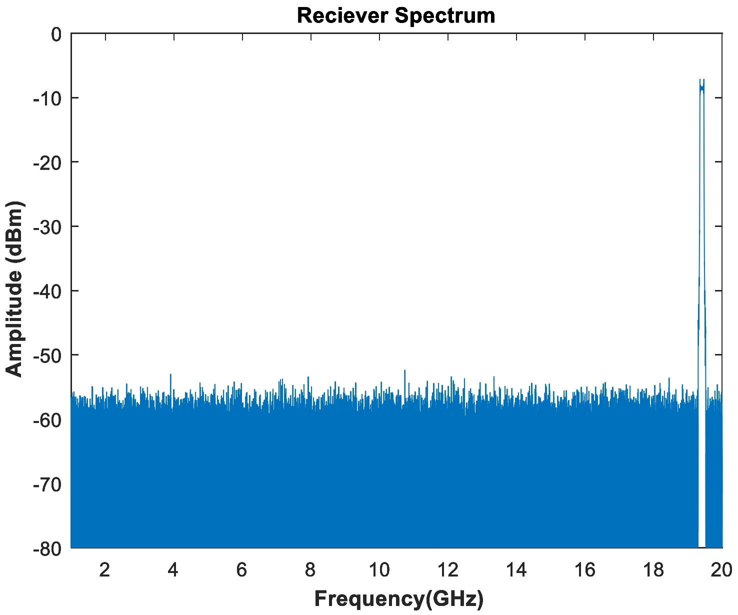
- The maximum bandwidth of a single signal within the RF spectrum.

- For example, a 30MHz linear FM chirp utilizes 30MHz of instantaneous bandwidth over the duration of the pulse.



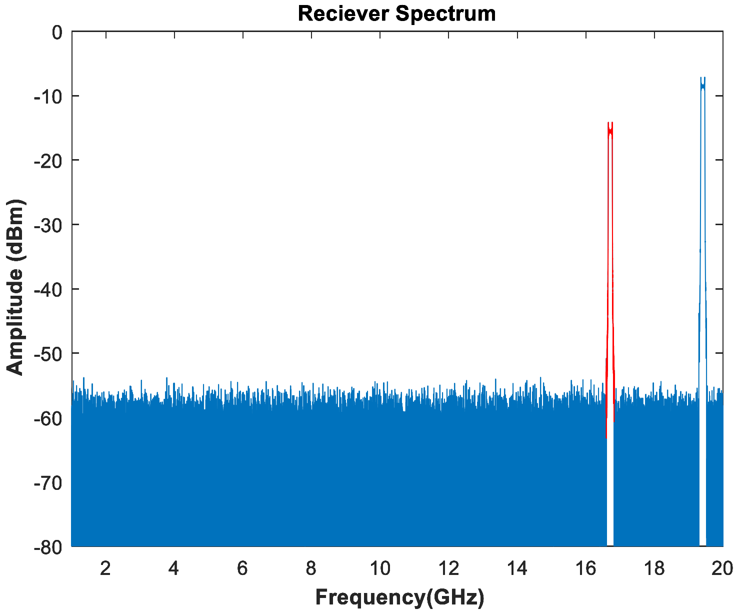
HOPPING BANDWIDTH

- What bandwidth can the signal generator change the pulse center frequency?
- How fast can the generator hop the frequency?
- Benefit of reduced hardware for interleaving on one RF port



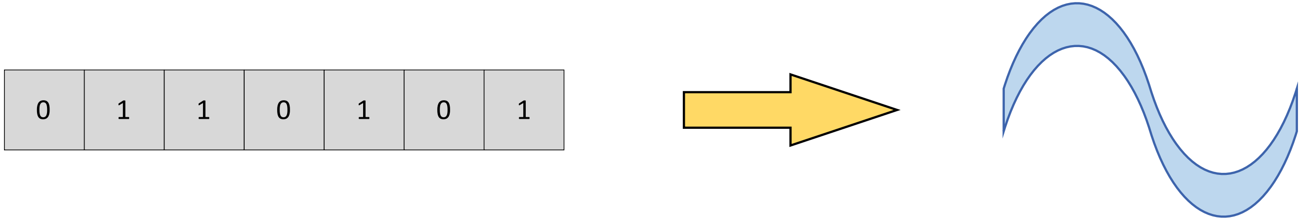
HOPPING AND PULSE DROPPING

- Simultaneous emitters and pulse dropping when interleaving.
- Multiple pulse sources are required to solve the problem.



ARCHITECTURAL CONSIDERATIONS

- ► Pulse-on-Pulse in the ANALOG domain
- ► Pulse-on-Pulse in the DIGITAL domain

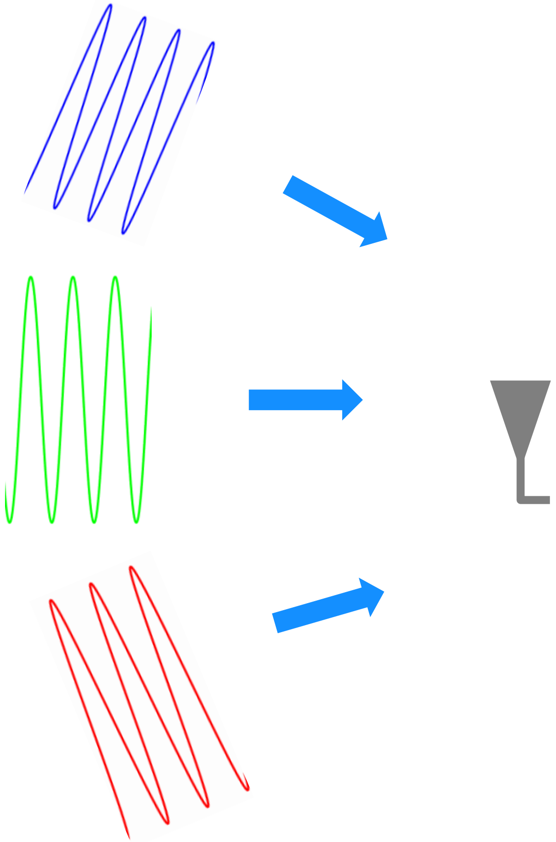


PULSE-ON-PULSE IN THE ANALOG DOMAIN

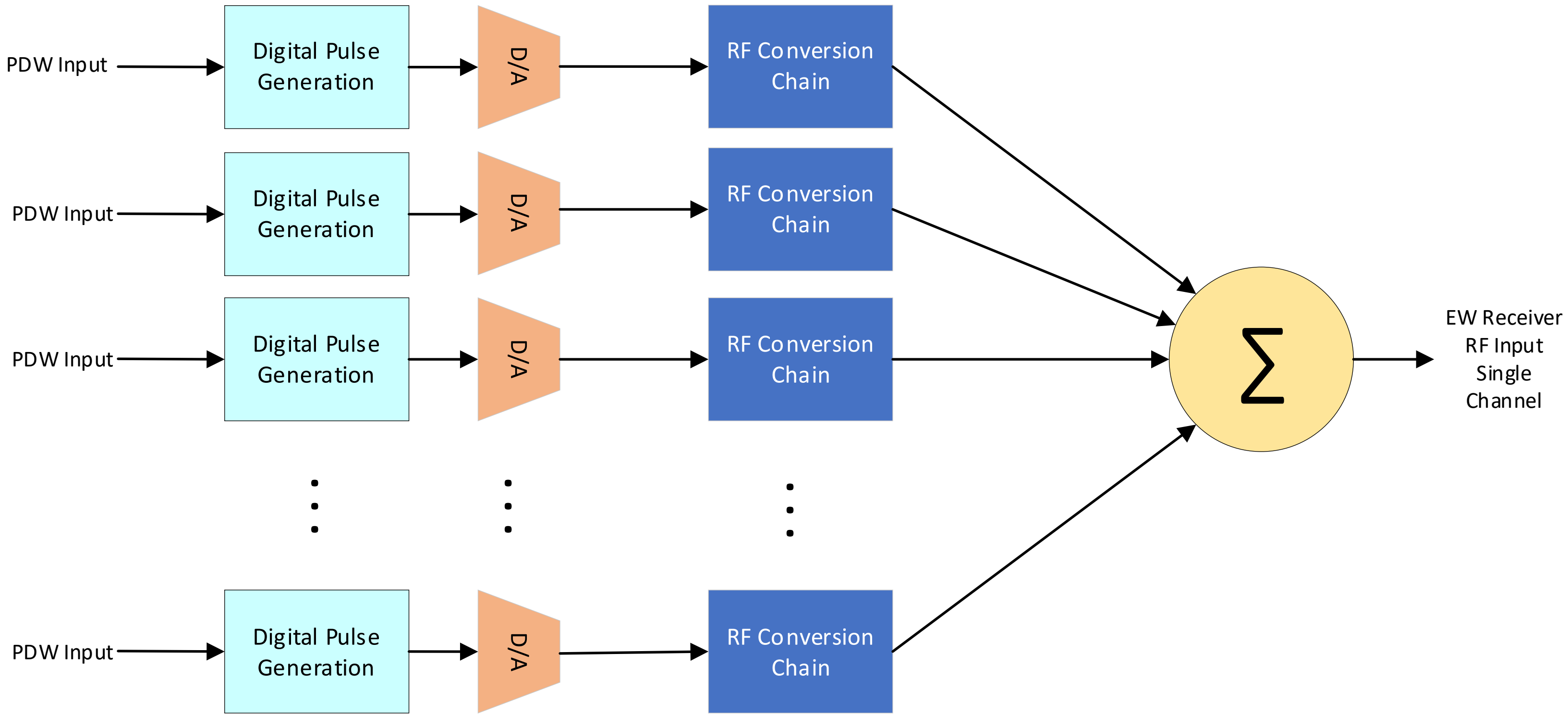
- External combination of multiple RF signal sources

- Benefits:
  - Higher dynamic range
  - Wider bandwidth coverage

- Drawbacks:
  - SWAPC
  - Time alignment of pulses at the RF combiner output

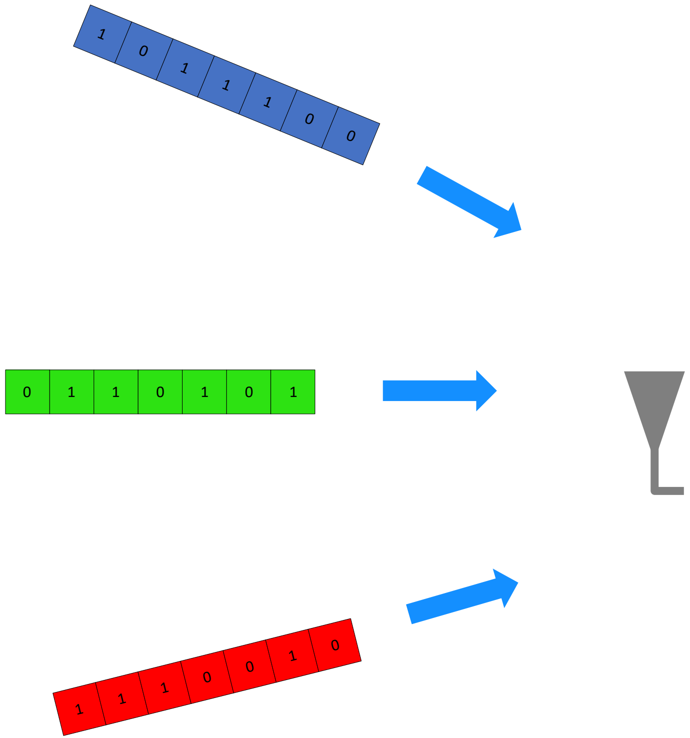


ANALOG PULSE ON PULSE COMBINATION

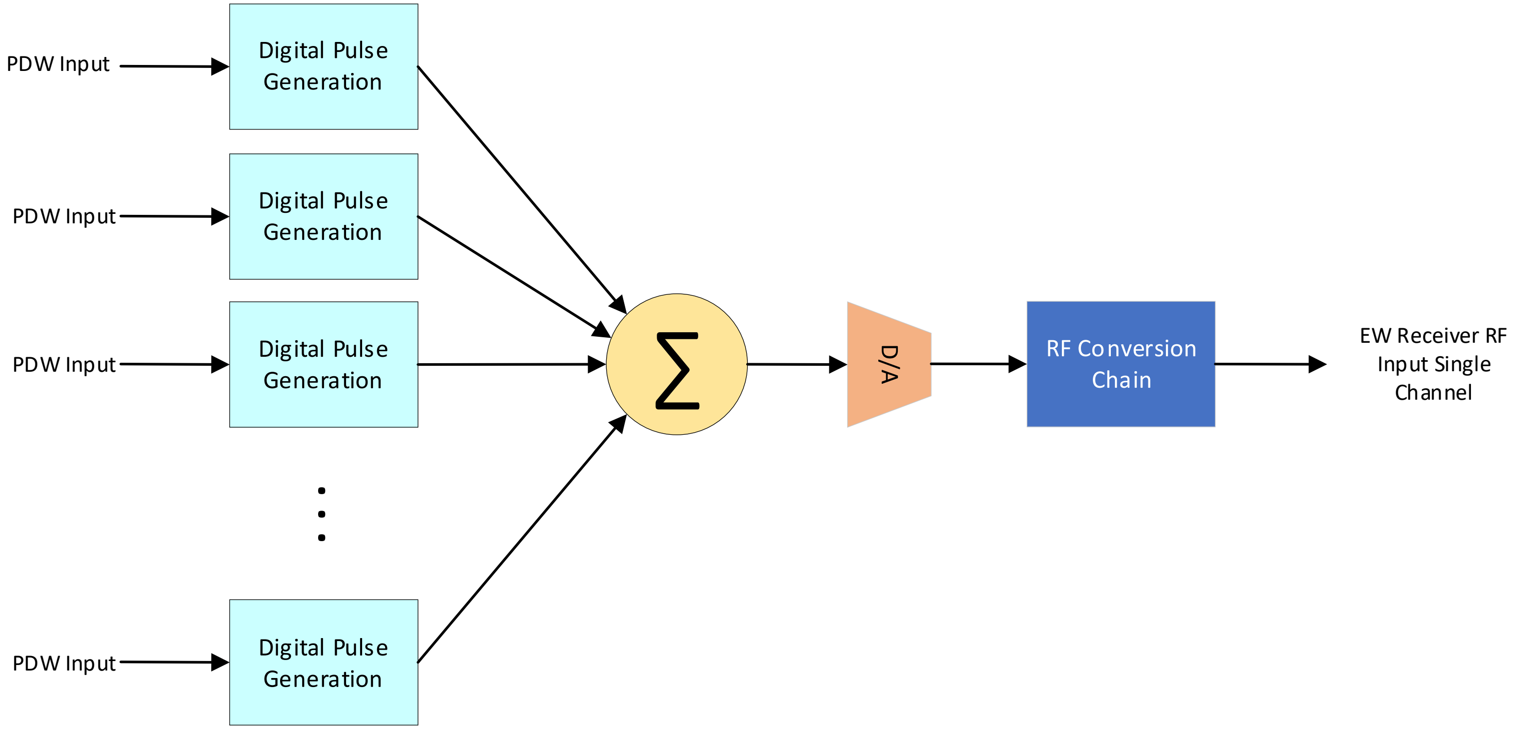


PULSE-ON-PULSE IN THE DIGITAL DOMAIN

- Digital combination of multiple baseband signals behind a single RF channel
- Benefits:
  - SWAPC
  - Time alignment of pulses at the RF output
- Drawbacks:
  - Limited dynamic range
  - Narrower bandwidth coverage



DIGITAL PULSE-ON-PULSE COMBINATION



SUMMARY

- Instantaneous, modulation, and hopping bandwidth are all *different*

- Architectural tradeoffs between analog and digital pulse combination
  - Analog → Dynamic range and bandwidth coverage
  - Digital → SWAPC, level control speed, time alignment

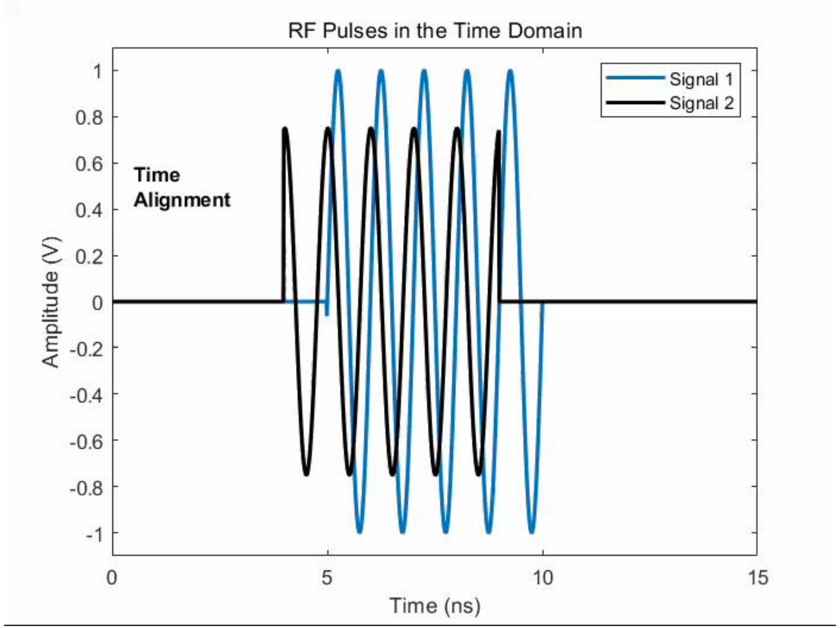
ALIGNMENT OF MULTIPLE RF CHANNELS IN AMPLITUDE, PHASE, AND TIME

CONSIDERATIONS

- Alignment of multiple RF channels in level, phase, and time at a specific reference plane
- Alignment techniques
- RF network system architecture considerations

ALIGNING MULTIPLE RF CHANNELS IN TIME, AMPLITUDE, AND PHASE

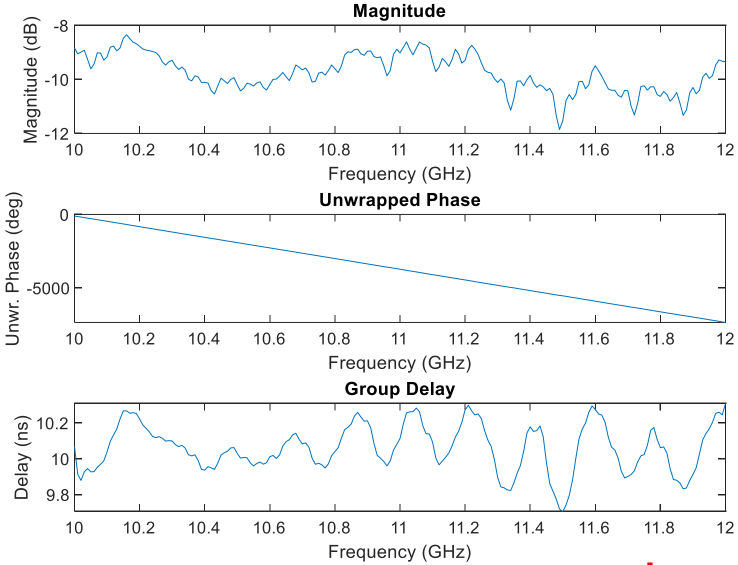
- Interferometers → phase and amplitude alignment
- TDOA systems → time alignment
- Mixed systems → time, amplitude, and phase alignment

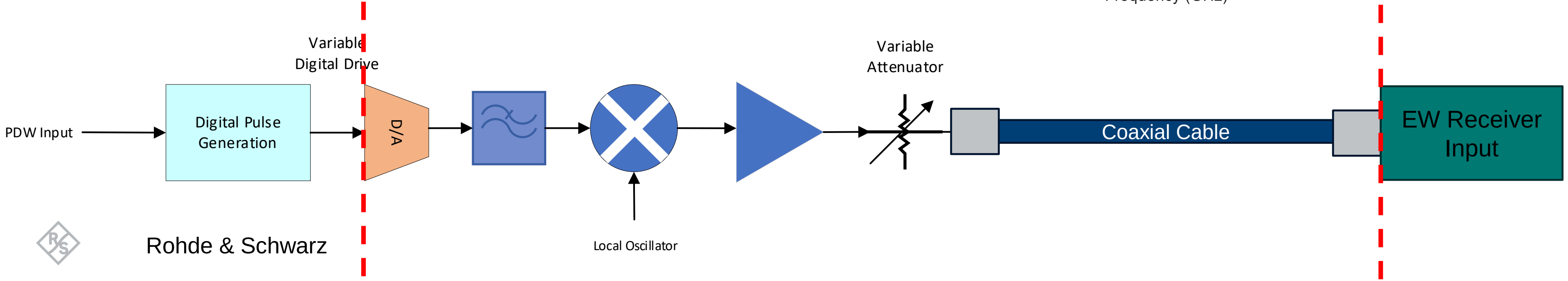


CONSIDER THE FREQUENCY RESPONSE OF ANY RF SYSTEM

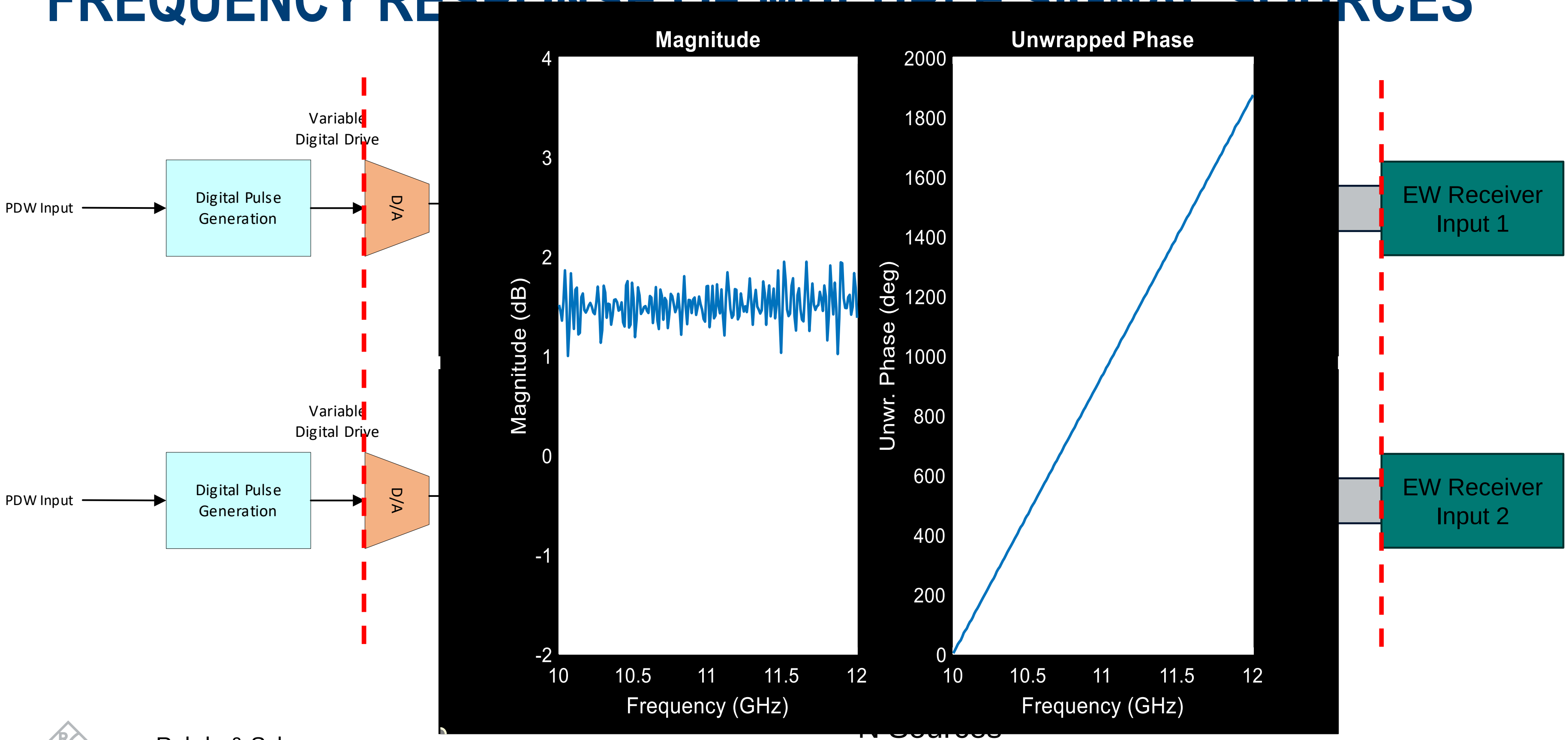
- RF system frequency response inherent in all generator-to-receiver setups

- Impacts alignment of multiple RF ports

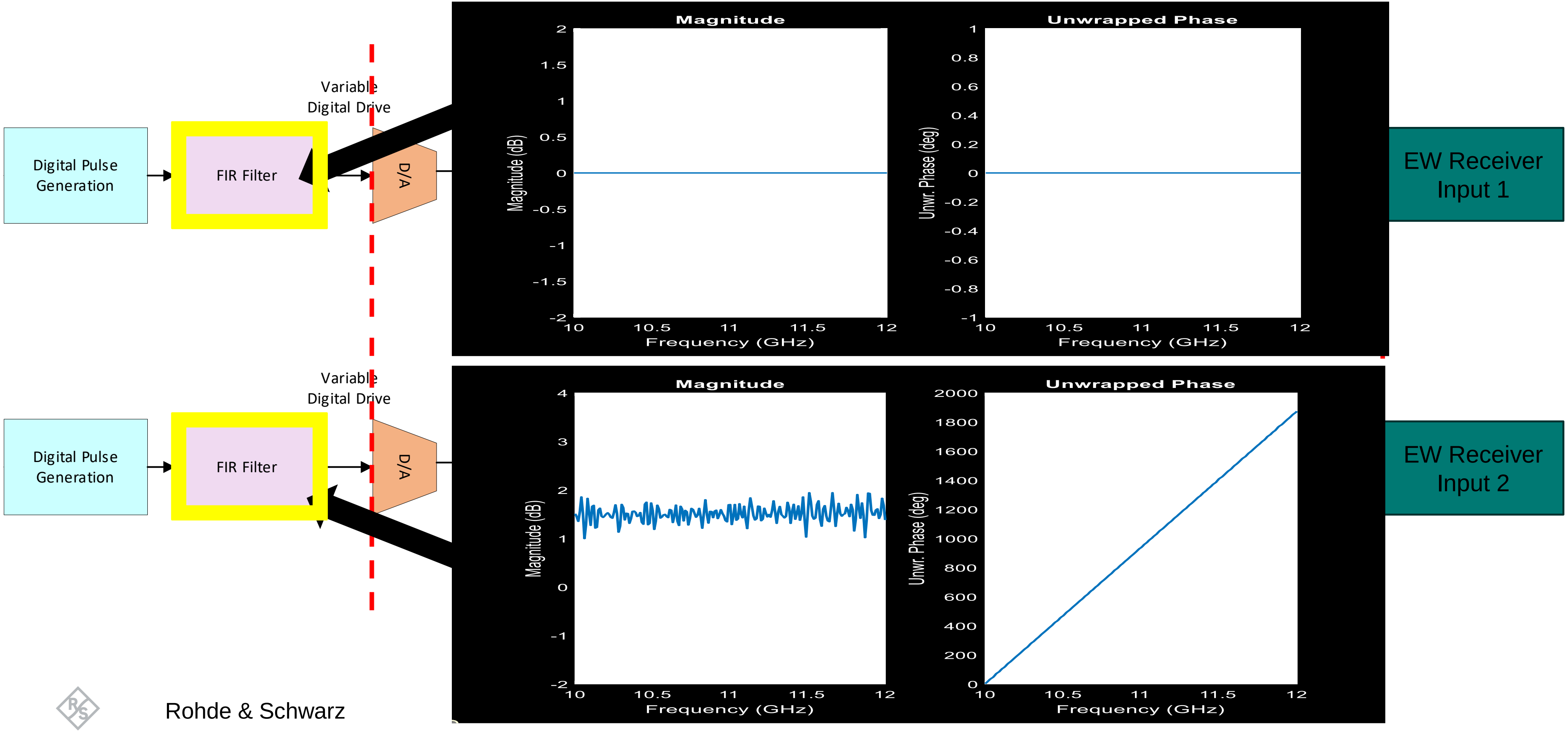




FREQUENCY RESPONSE OF MULTIPLE SIGNAL SOURCES

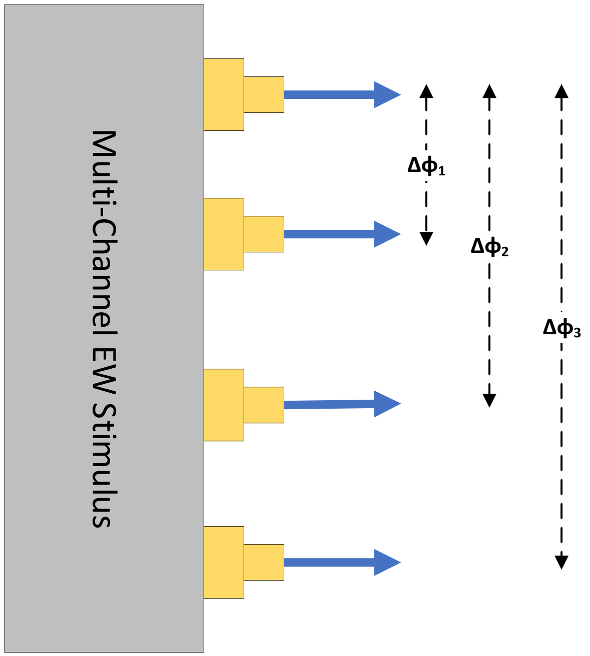


FREQUENCY RESPONSE OF MULTIPLE SIGNAL SOURCES



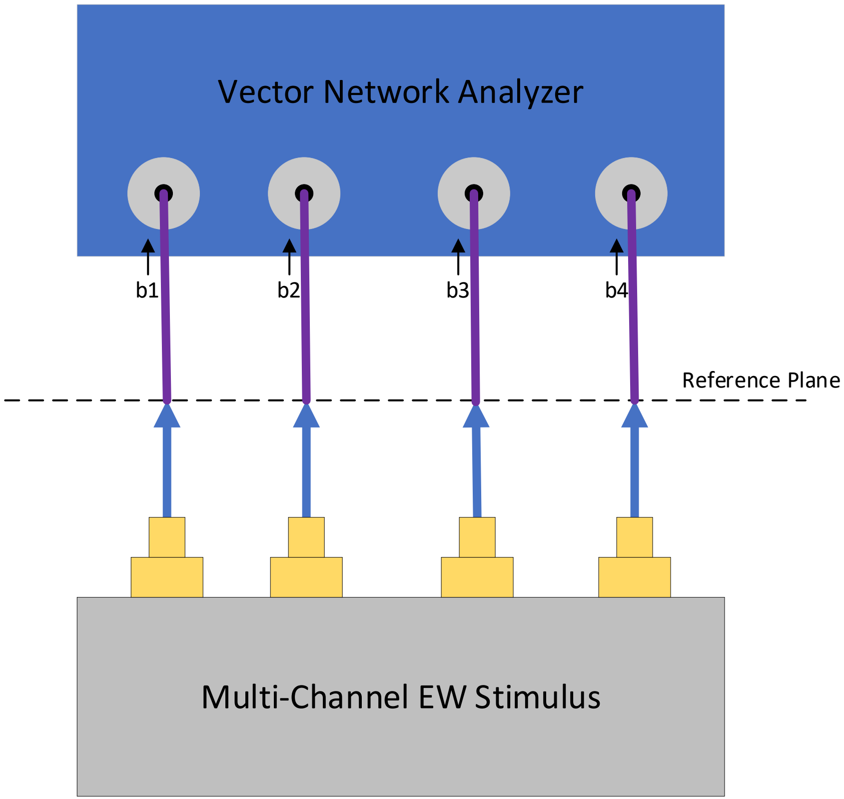
HOW DO WE MEASURE THE FREQUENCY RESPONSE?

- Direct S-parameter measurement is not practical, or even possible
- Vector network analyzers can measure relative amplitude, phase, and time delay



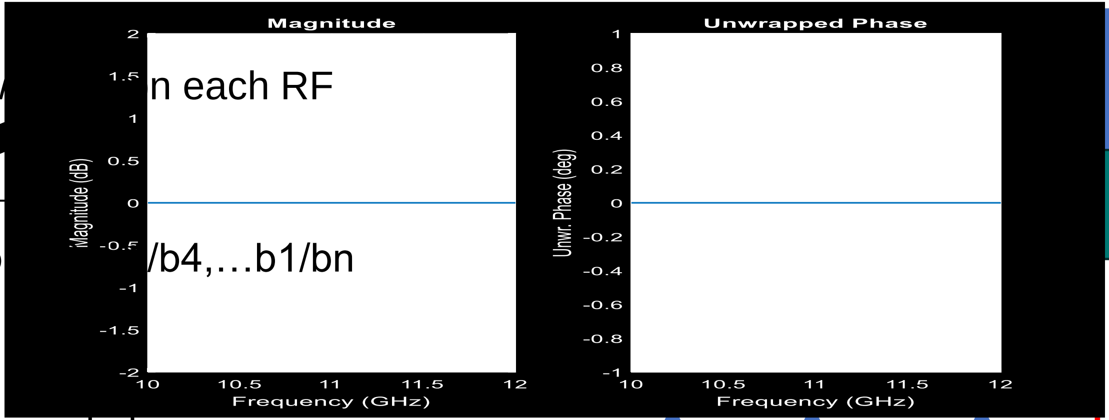
VECTOR CORRECTED WAVE RATIOS FOR MULTI-PORT STIMULUS

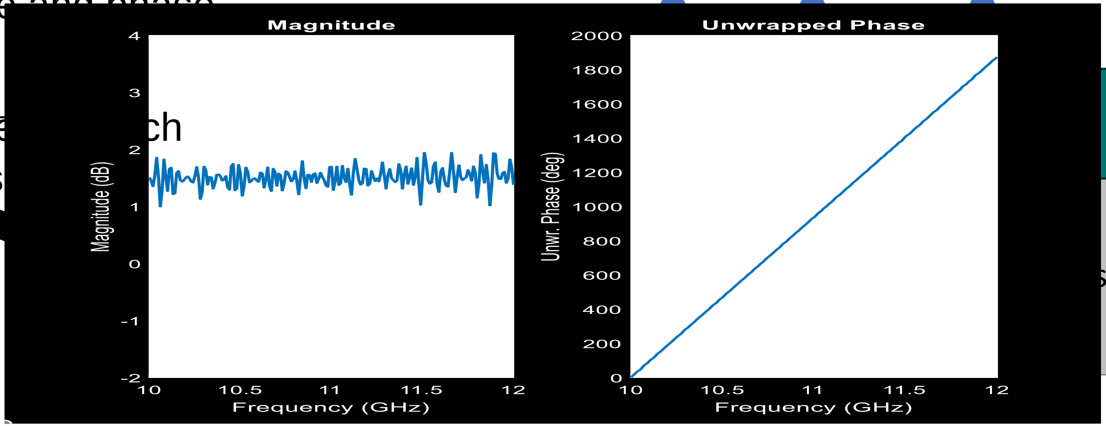
- The VNA is no longer used for traditional S Parameters
- The source on the VNA is de-activated
- The multi-port stimulus simultaneously drives all VNA ports
- Ratio measurements are conducted on the b receivers of the VNA

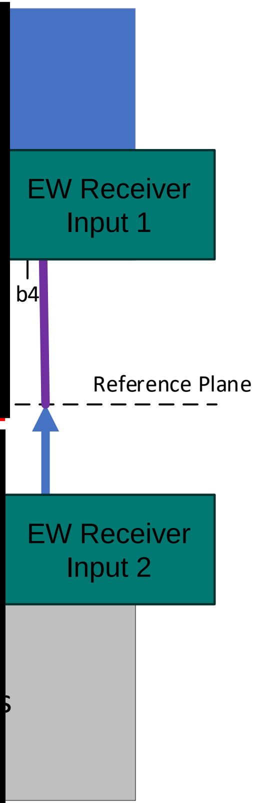


B WAVE RATIOS FOR RF PORT ALIGNMENT

- Produce the same CV… n each RF port
- Measure the b1/b2, b… /b4,…b1/bn wave ratios
- Compare in amplitude and phase
- Apply to each FIR filte… ch independent stimulus





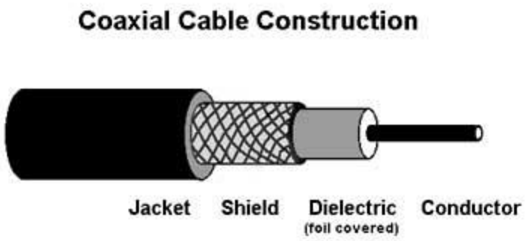


Digital Pulse Generation
FIR Filter
Variable Digital Drive
D/A

LOCAL OSCILLATOR DISTRIBUTION

DISTRIBUTING THE LOCAL OSCILLATOR TO MULTIPLE RF STIMULUS PORTS

- Temperature deviation → RF system phase deviation

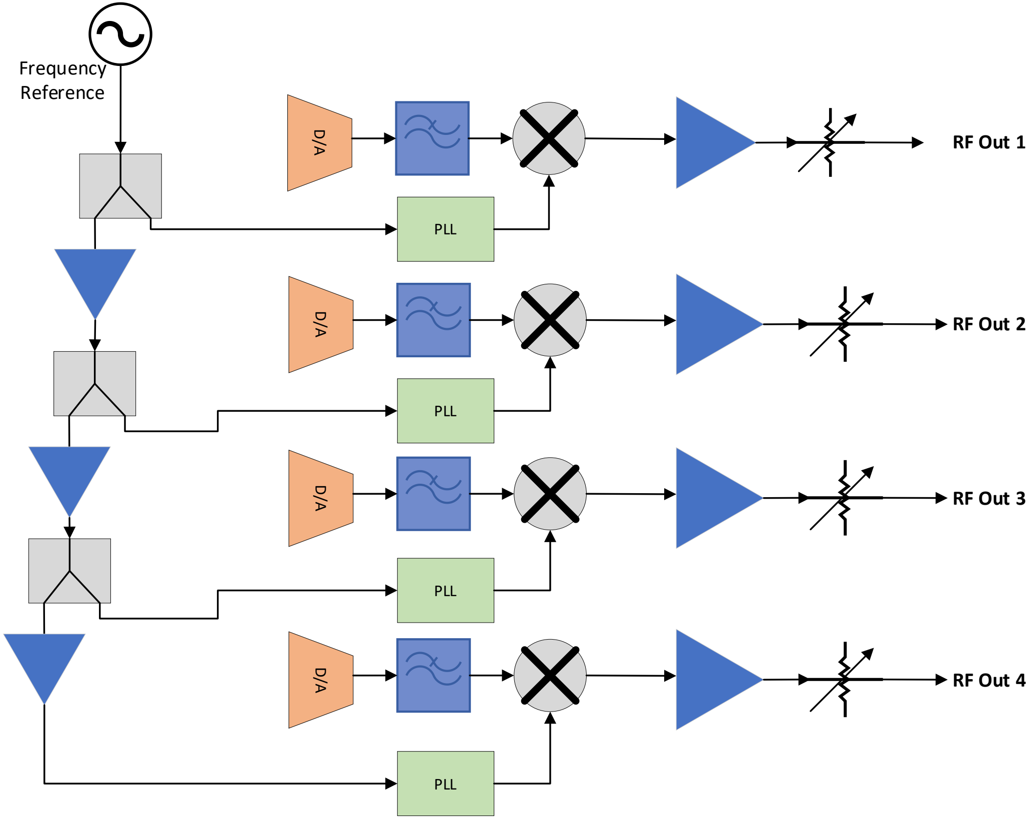


- Variations in temperature create minor mechanical variations in RF cable/component lengths.

- Local oscillator distribution improves phase stability over time

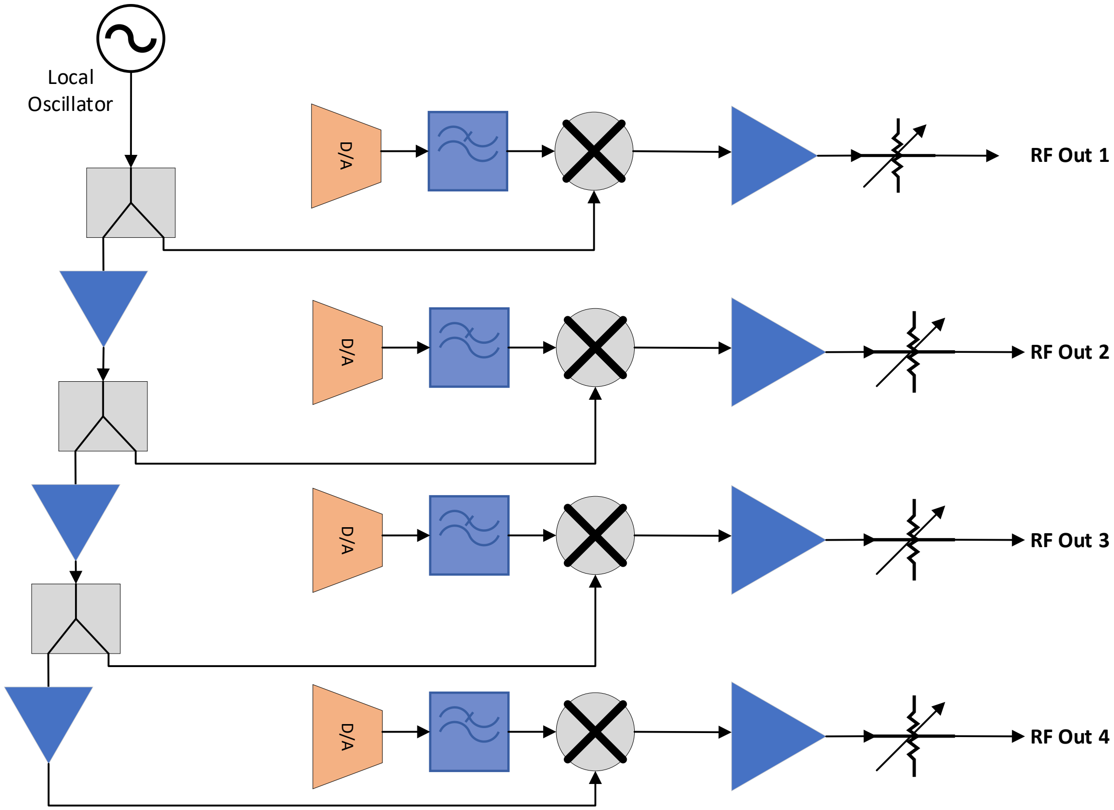
PLL REFERENCE FREQUENCY DISTRIBUTION

- Pros:
  - Frequency locked between ports
  - Common amongst the majority of RF Signal generators
- Cons:
  - Minor perturbations in the low frequency reference cables results in large phase fluctuations at the RF outputs



DAISY CHAINED LO DISTRIBUTION

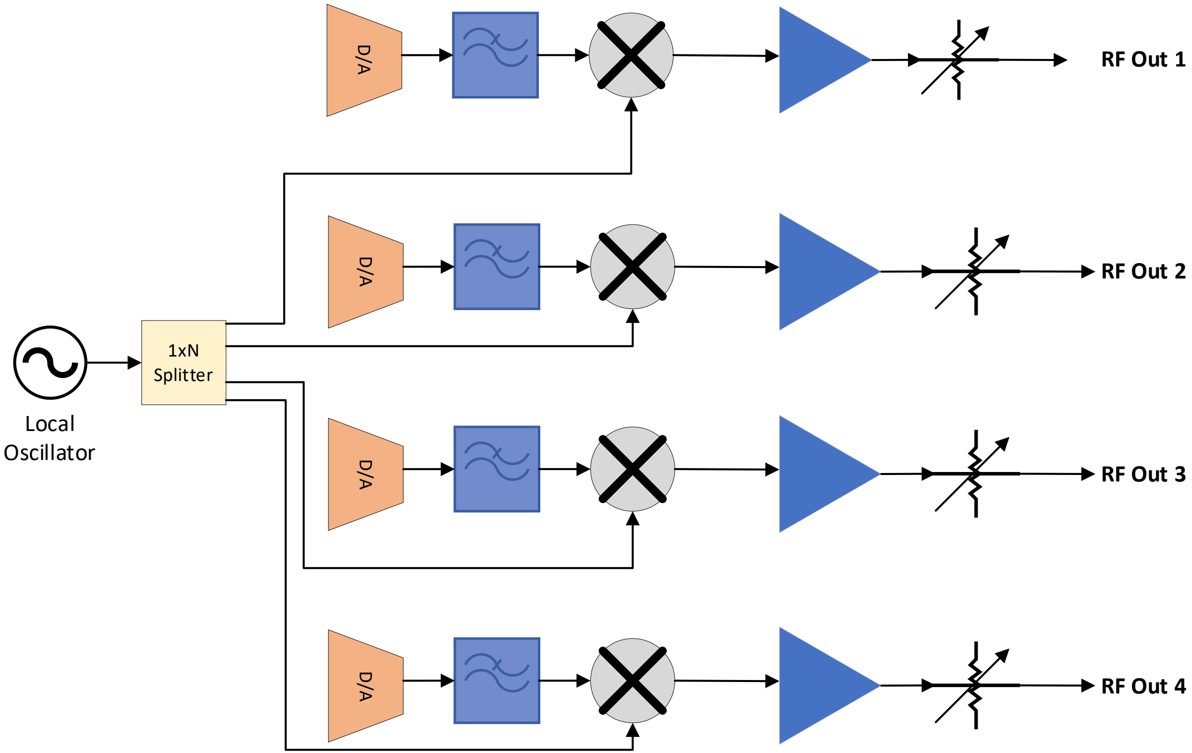
- Pros:
  - Truly phase locked on the RF front end.
  - Could utilize the internal LO of the master signal generator (depending on the architecture)
- Cons:
  - Each “hop” adds electrical length from the source LO → phase variations over temperature.



LO DISTRIBUTION WITH MATCHED CABLE LENGTHS

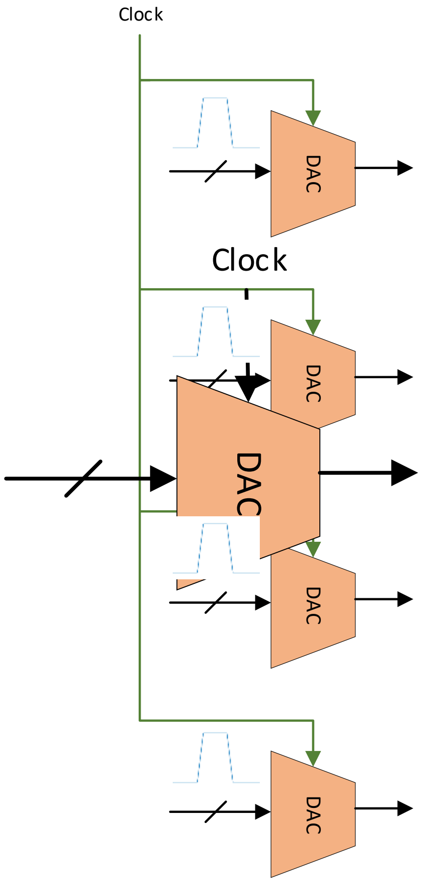
- Pros:
  - Matched cable lengths provide common phase drift

- Cons:
  - Could be a more costly solution



DIGITAL BACK END CLOCK DISTRIBUTION

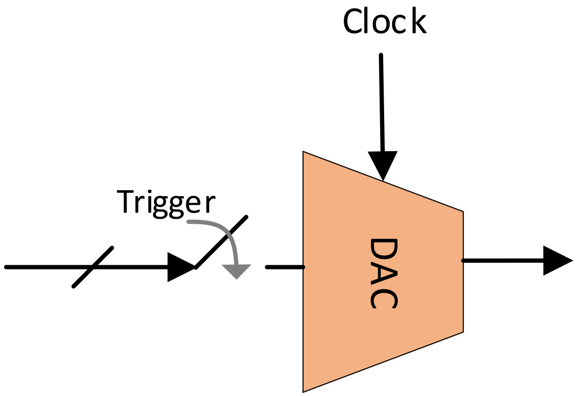
- Basic digital-to-analog converter consists of a clock and data bus input
- Data bus of each DAC input needs synchronization on a sample-to-sample basis



DIGITAL BACK END CLOCK DISTRIBUTION

- Multiple DACs across multiple hardware chassis requires a clock and data synchronization technique.

- Possible solution:
  - Distribute the DAC clock and align input data samples on a synchronized release trigger



SUMMARY

- Temperature deviations → phase deviations
- Low frequency reference coupling only → larger phase drift
- True LO distribution → common phase drift
- Digital backend synchronization → Time aligned pulses at RF
- Digital backend reference → could lead to phase drift

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