Webinar

SATELLITE SYSTEMS
TESTING YOUR DIGITAL DESIGN

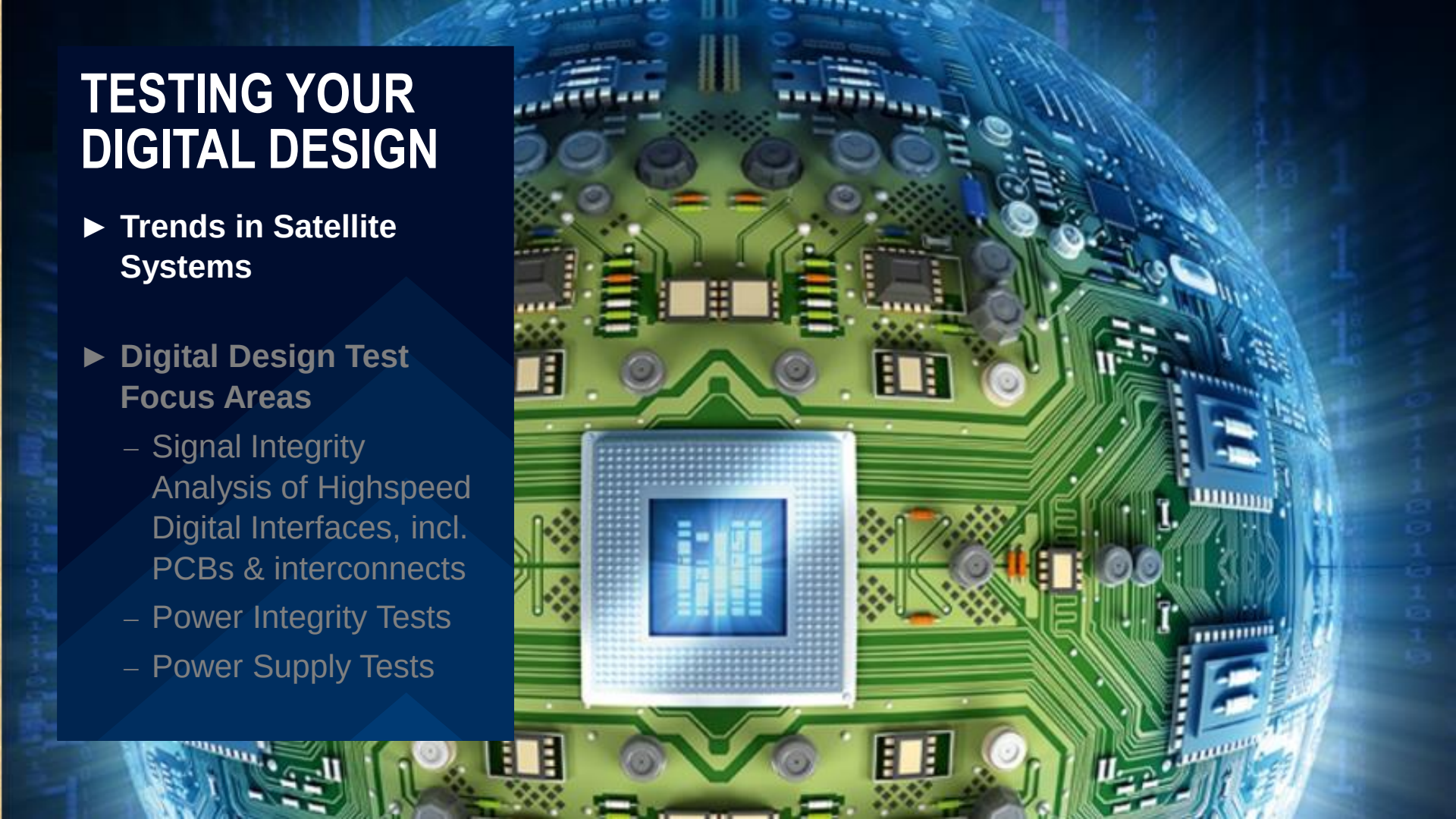
Albert Ramirez Perez, Market Segment Manager Aerospace & Defense
Guido Schulze, Product Manager Oscilloscopes

ROHDE&SCHWARZ

Make ideas real

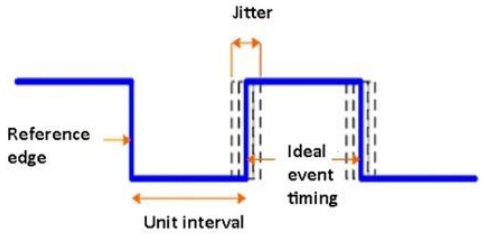
TESTING YOUR DIGITAL DESIGN

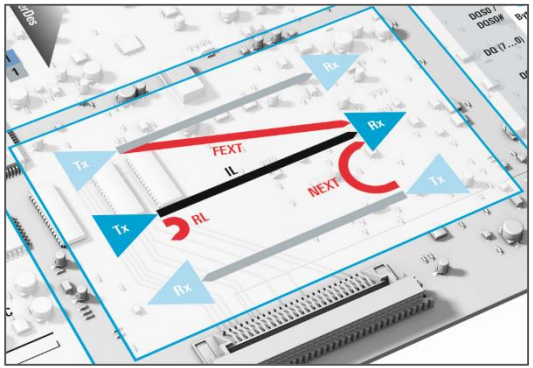
- **Trends in Satellite Systems**
- **Digital Design Test Focus Areas**
  - Signal Integrity Analysis of Highspeed Digital Interfaces, incl. PCBs & interconnects
  - Power Integrity Tests
  - Power Supply Tests

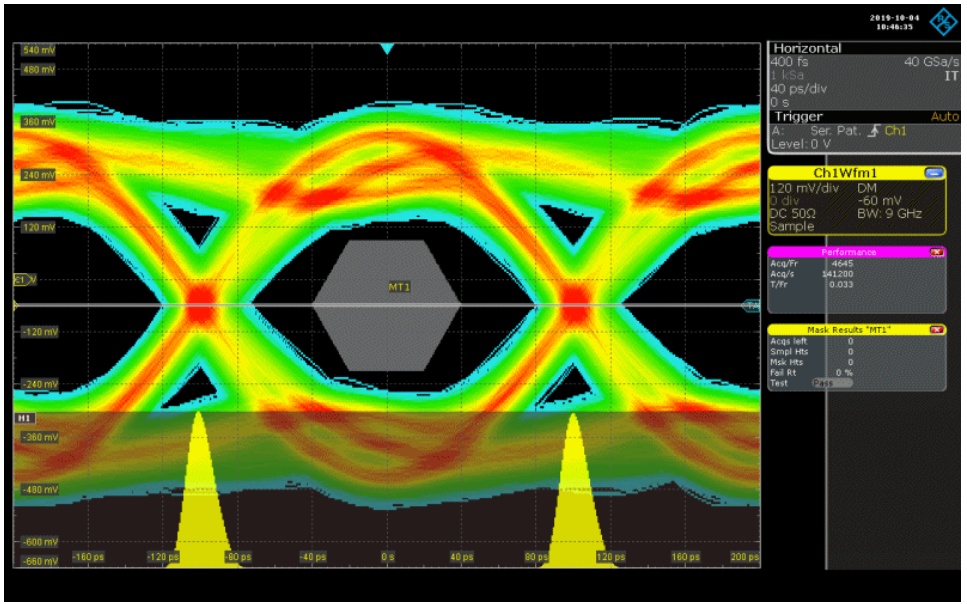


DIGITAL DESIGN?

SATELLITE SEGMENT







TRENDS IN SATELLITE TEST

HIGH THROUGHPUT SATELLITES

- Geostationary Satellites – GEO orbit
  - Higher frequencies (Q, V ≤ 52 GHz) and E-band (86 - 93 GHz) → BW: 3 GHz (6-8 GHz)
  - Precise beamforming with AESA Antennas

- Benefits
  - Current capacity over 100Gbits/s, 1.34 TB/s expected
  - Price Gigabit per second $100 vs $3 million

- Challenges
  - Long and expensive programs
  - Robustness and integrity is a must by Design

TRENDS IN SATELLITE TEST

SMALLSATS AND CUBESATS

Characteristics and challenges

- Volume is often calculated in cm^3
- Weight ranges from few grams to several Kg
- Mainly scientific, but not only
- Communications transmit power around 2W

Minisatellite (100–500 kg)
Microsatellite (10–100 kg)
Nanosatellite (1–10 kg)
Picosatellite (0.1–1 kg)
Femtosatellite (0.01–0.1 kg)

Benefits:

- Design and Testing workflows evolution
- Lower cost access to space - around $50K
- Flexible and scalable solutions

- Challenges
  - Equipped with accessible low-cost COTS
  - Power Sources and Power management optimization

TRENDS IN SATELLITE TEST

MEGA CONSTELLATIONS

Middle Earth Orbits - MEO

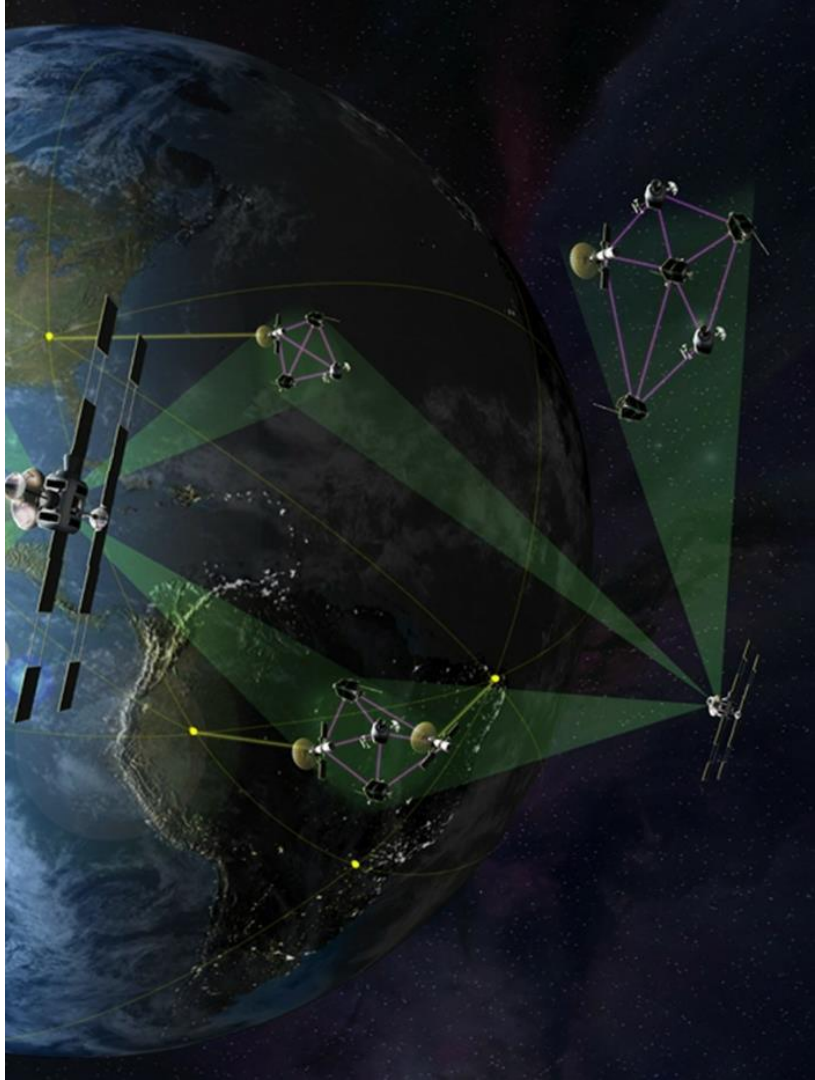
- Mainly Navigation but can provide high-speed phone and high-Bandwidth internet up to 1.6Gbits/s
- Low latency - 0.1 sec

Low Earth Orbit - LEO

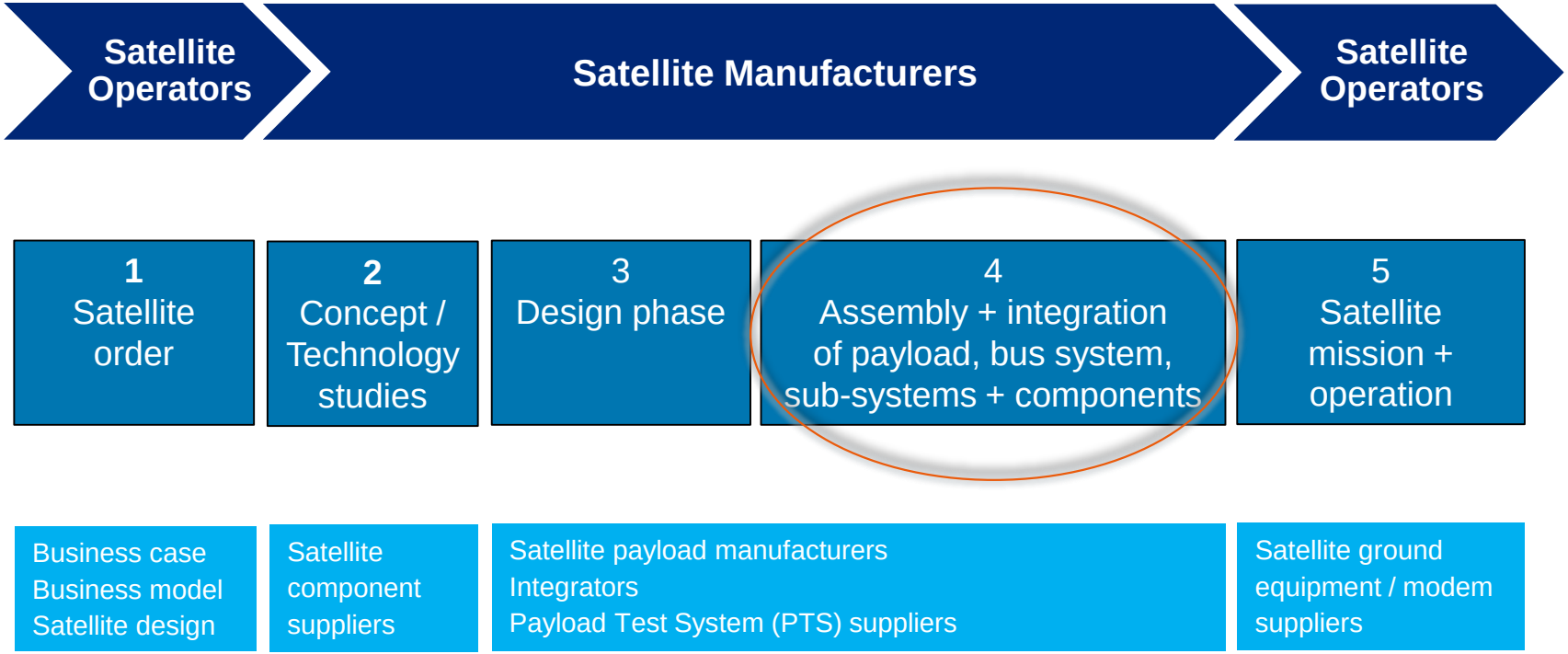
- Mainly for very high speed communications, 10GBit/s
- Very low latency – 50 msec

Benefits and Challenges

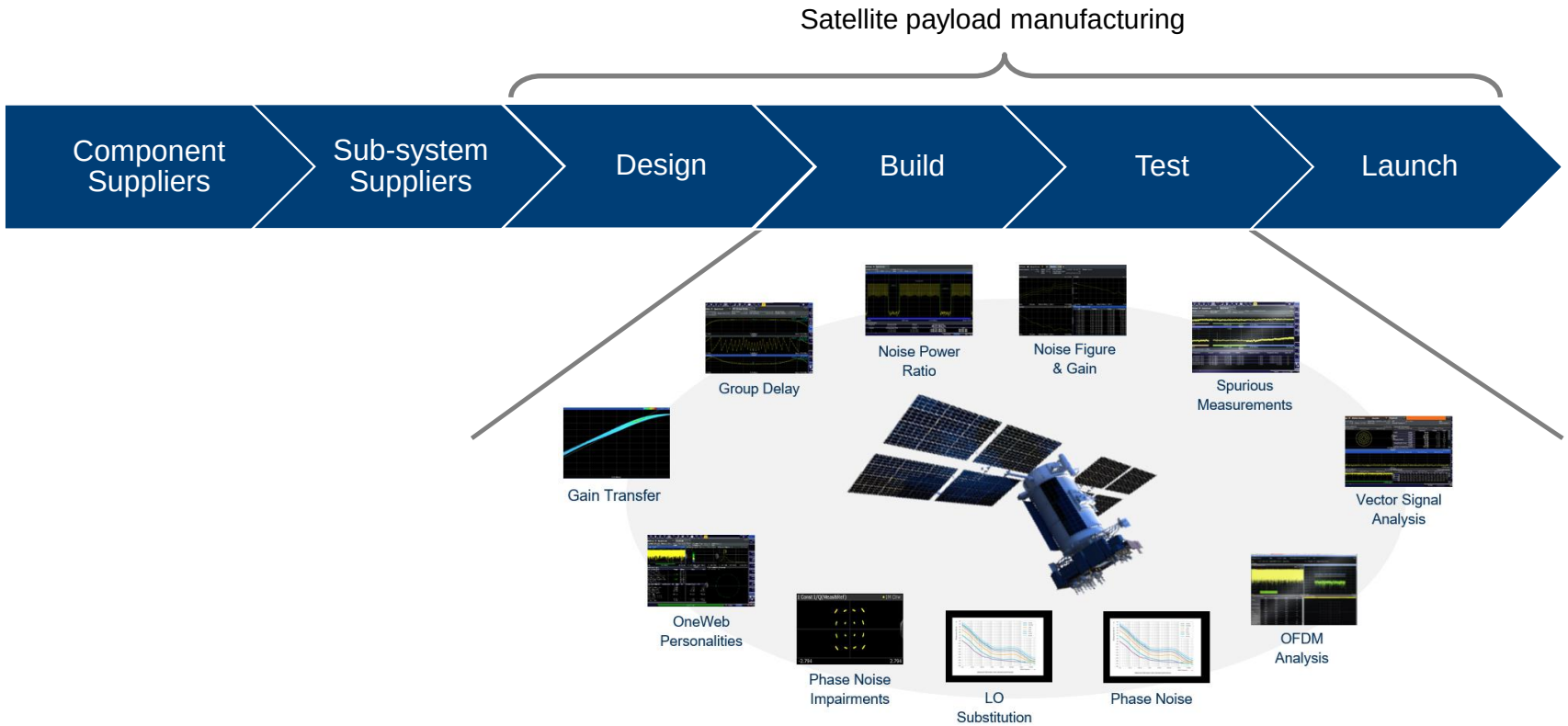
- Large coverage with flexible, reconfigurable payloads,
- Faster time-to-market, maximize the use of COTS
- Digital Design verification before deployment



TRADITIONAL GEO SATELLITE ECO VALUE CHAIN



SATELLITE MANUFACTURING – RF

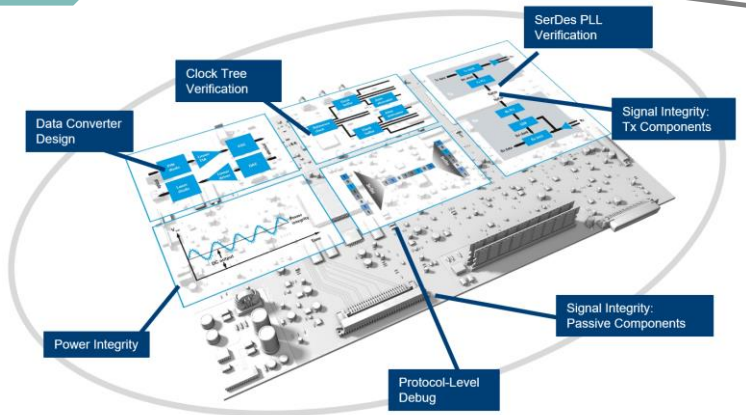


SATELLITE MANUFACTURING – RF

Satellite component manufacturing

Component Suppliers | Sub-system Suppliers | Design | Build | Test | Launch

Design | Implement | Test | Supply



R&S SATELLITE TESTING SOLUTIONS PORTFOLIO

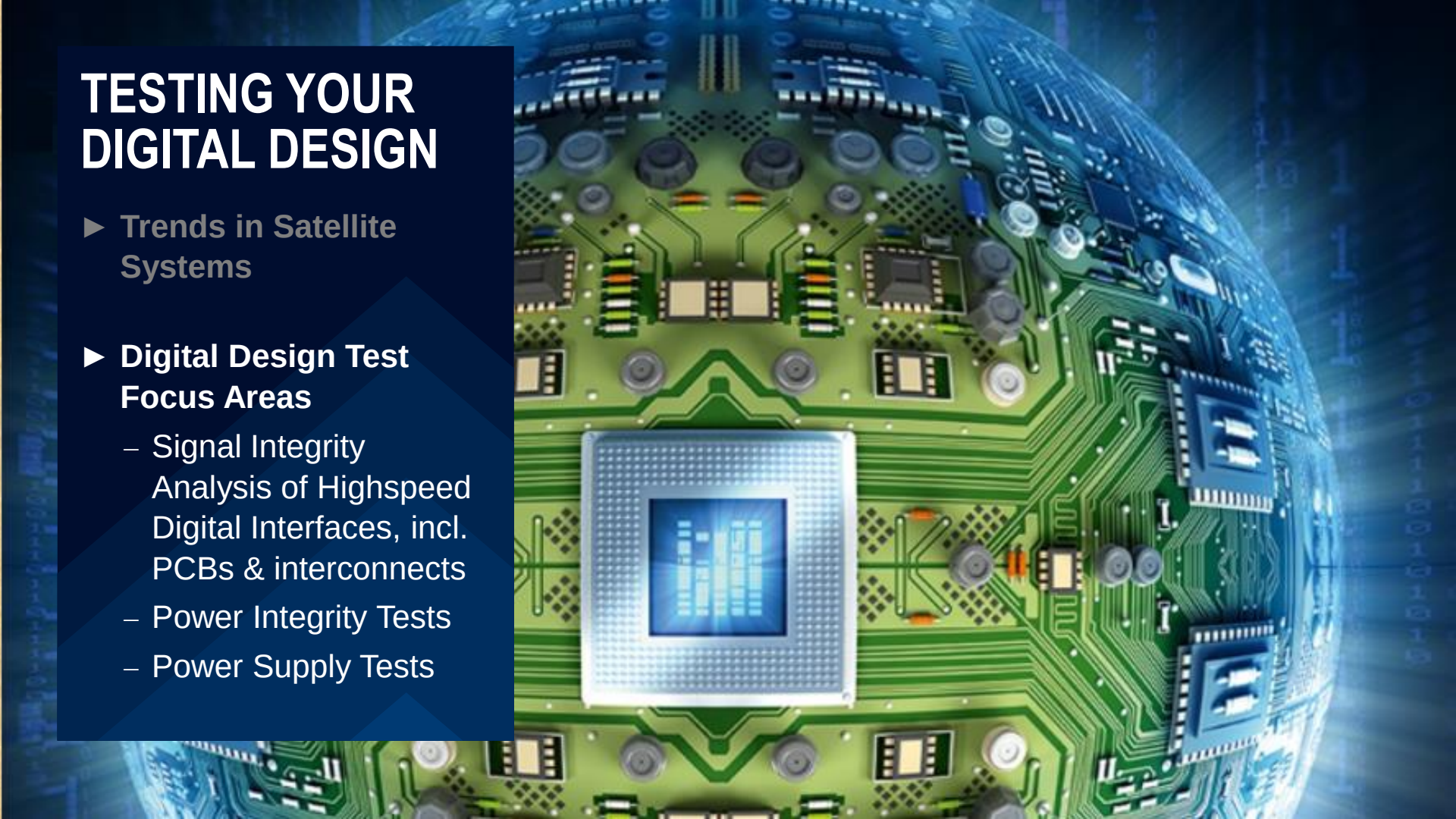
	Signal Generators
	Signal and Spectrum Analysis
	IQ Acquisition and Replay
	Network Analysis
	OTA Chambers
	Oscilloscopes

	Power Sensors
	TVAC
	Switch Matrix
	Satellite Load Generators
	Ground Station Power Amplifiers
	Monitoring and Planning Software

TESTING YOUR DIGITAL DESIGN

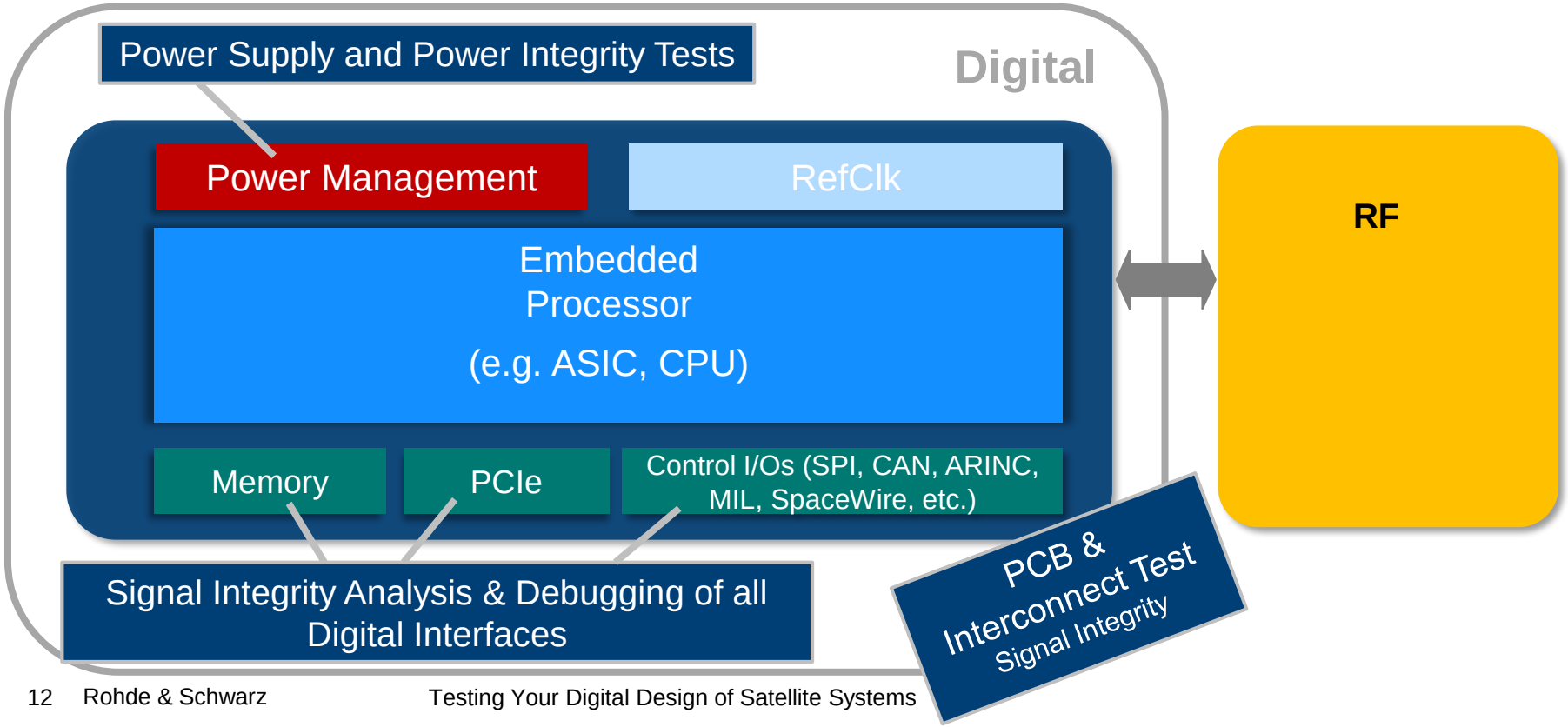
- Trends in Satellite Systems

- **Digital Design Test Focus Areas**
  - Signal Integrity Analysis of Highspeed Digital Interfaces, incl. PCBs & interconnects
  - Power Integrity Tests
  - Power Supply Tests

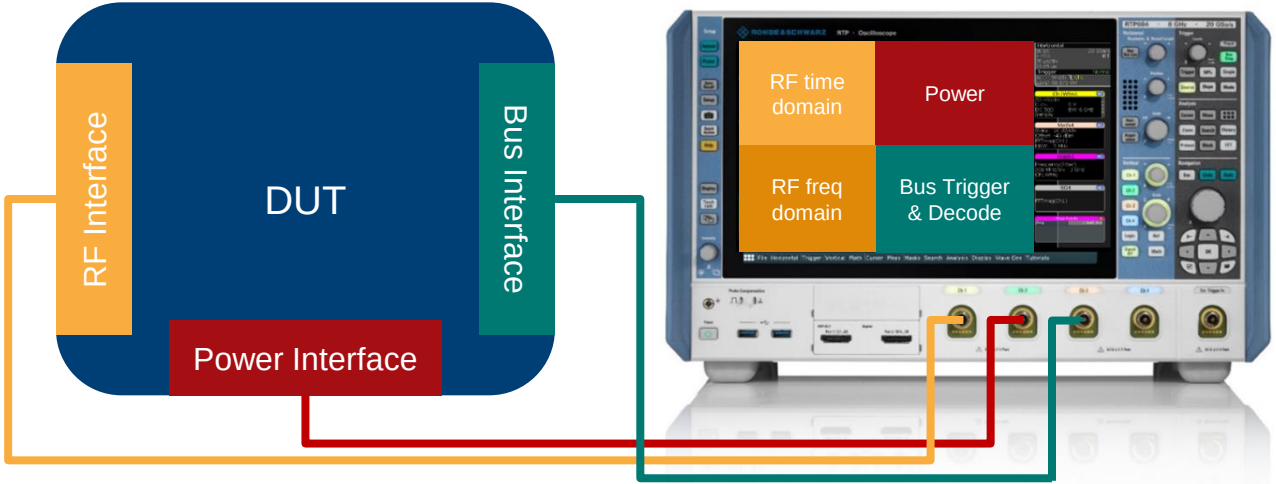


SATELLITE DESIGNS

THE DIGITAL PART: TYPICAL TEST AREAS FOR EVERY NEW DESIGNS



MULTIDOMAIN ANALYSIS FOR SYSTEM-LEVEL DEBUGGING



CAN/CAN FD
MIL-STD-1553
ARINC 429
SpaceWire
…
LVDS, PCIe, DDR, etc.

System-level Debugging

- Combine multiple measurements from different DUT interfaces on the same screen
- Look for possible correlations to determine causes of signal anomalies

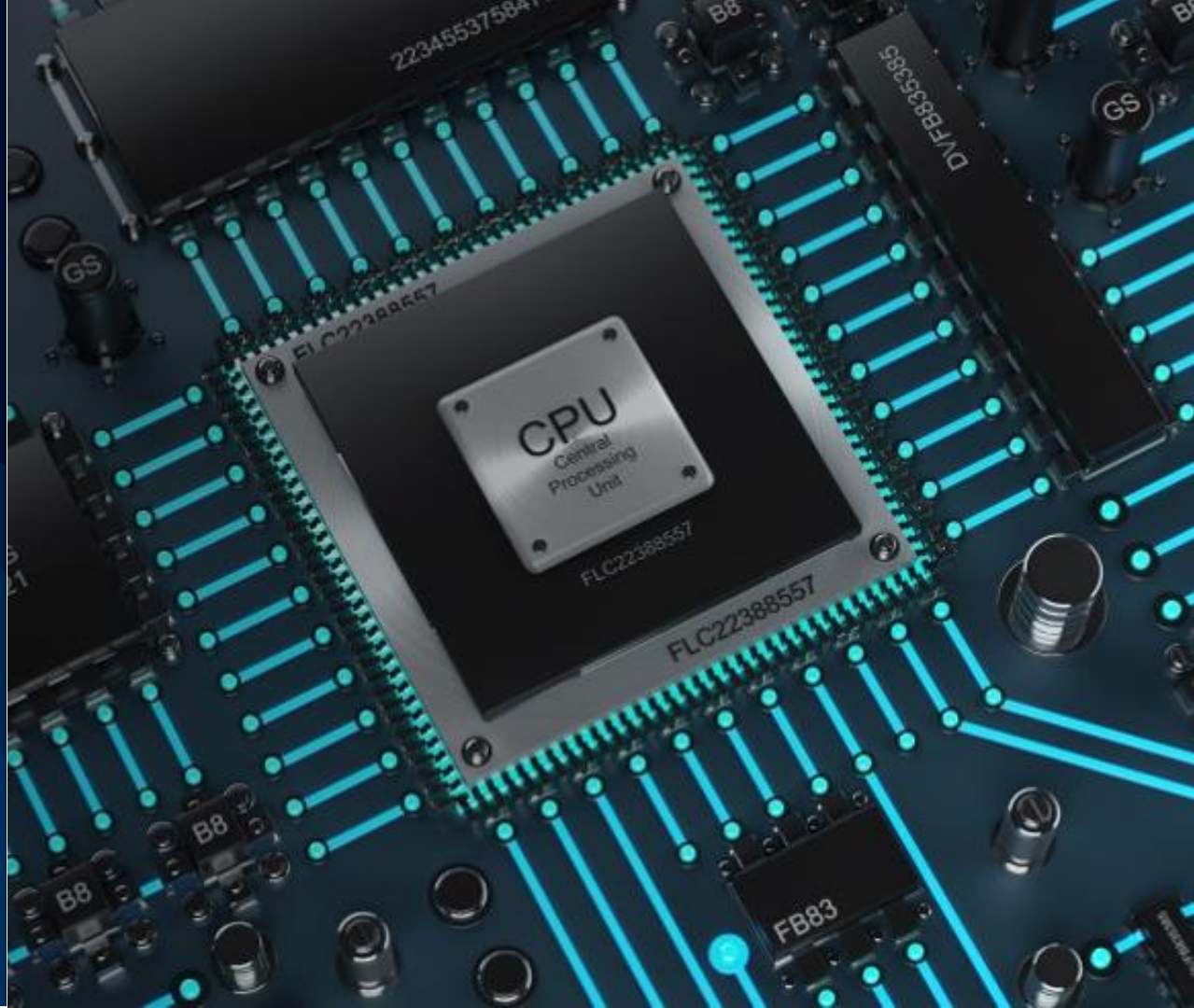
1. HIGH SPEED DIGITAL INTERFACES

Why fast and reliable signal integrity solutions including PCB and interconnect tests are so important for integration of Highspeed Digital Interfaces?

HIGHSPEED DIGITAL INTERFACES CHALLENGES

- Signal integrity challenges due to increasing data rates
- Interference issues due to increasing level of integration

For optimal Signal Integrity analysis – T&M equipment needs to collect statistical data fast.

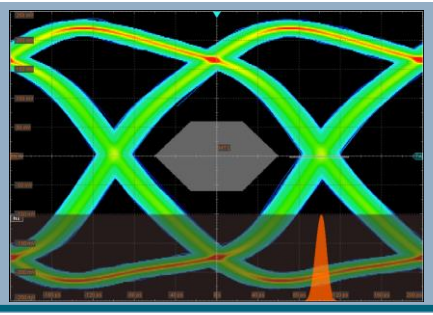


HIGH SPEED DIGITAL INTERFACES

REQUIRE DEDICATED TESTS FOR VERIFICATION & DEBUGGING

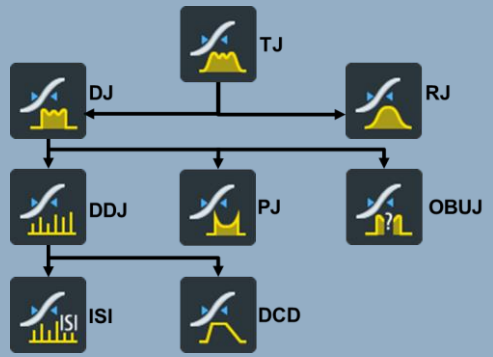
Eye Diagram

- Fast update rate for statistical confidence
- Continously operating Clock-Data-Recovery (CDR)
- Mask tests
- Deembedding function to compensate transmission loss



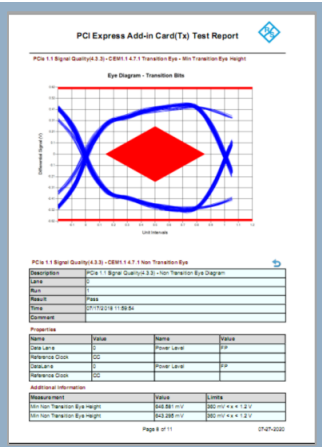
Jitter Analysis

- Break-down of jitter and noise into individual components for characterization & debugging



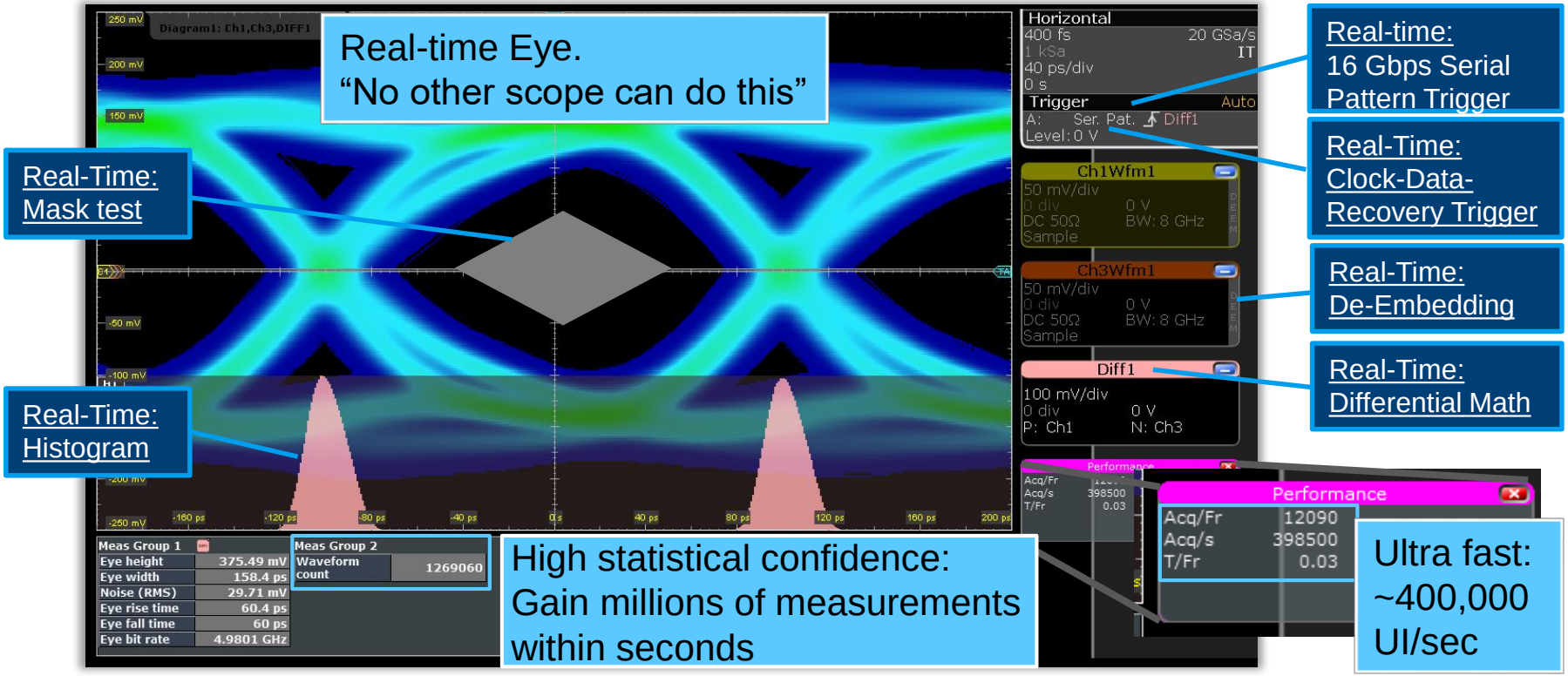
Automated Compliance Tests

- Verify compliance of the physical layer to interface standards and report results



R&S RTP HIGH PERFORMANCE OSCILLOSCOPES

MAKING IT FAST – REAL-TIME ANALYSIS



R&S RTP HIGH-PERFORMANCE OSCILLOSCOPE

- 4-16 GHz bandwidth
- Dedicated hardware for real-time Signal-Integrity
- Most compact & silent for everyday use in the lab

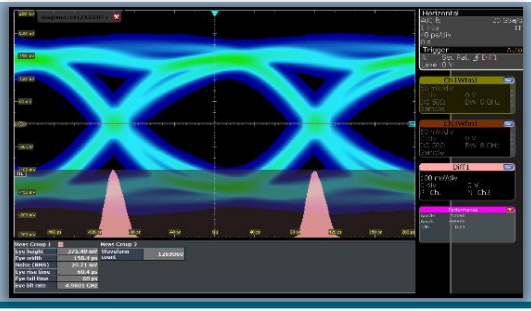
Providing Unique Signal Integrity Analysis Functions

R&S RTP HIGH-PERFORMANCE OSCILLOSCOPE

PROVIDING UNIQUE SIGNAL INTEGRITY ANALYSIS FUNCTIONS

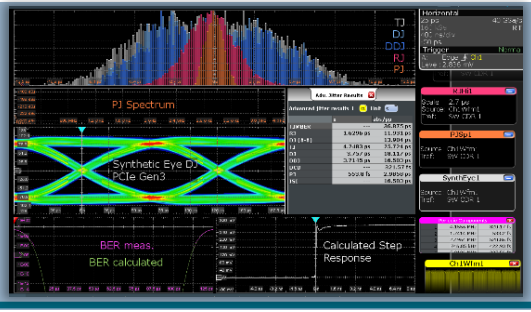
Fastest Eye Diagram Analysis

- CDR based triggering
- Real-time deembedding
- Real-time differential math
- Real-time analysis (histogram, mask)



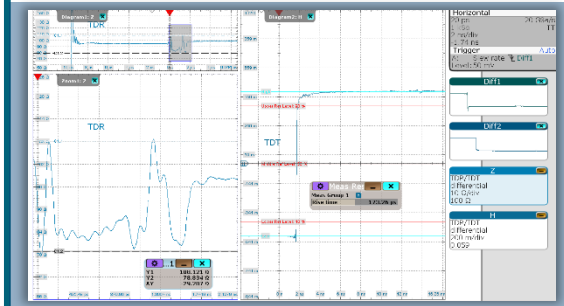
Most detailed Jitter Decomposition

- Histograms for all components
- Track and Spectrum views
- Eye diagram, BER bathtub
- Step/Frequency response



Most versatile TDR/TDT Analysis

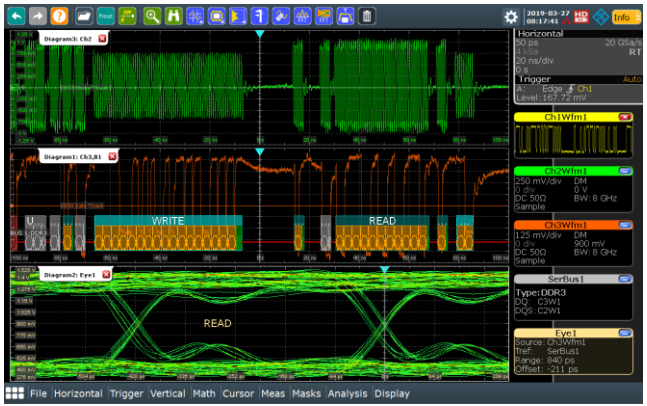
- 16 GHz differential Pulse Source
- TDR / TDT Analysis SW
- Guided calibration & measurement
- PacketMicro Probe



R&S RTP HIGH-PERFORMANCE OSCILLOSCOPE

DDR DEBUGGING AND COMPLIANCE

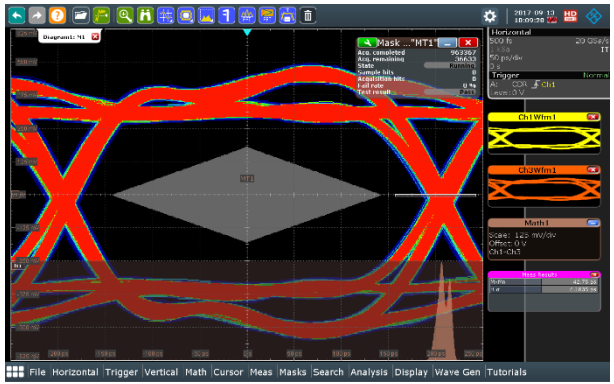
- Solutions for DDR3 and DDR4
- Powerful debugging capabilities
  - Read/Write Decoding
  - Data Eye – mask test, eye measurements
  - Combine with Realtime Deembedding
- Compliance test according JEDEC standards
  - DDR3/4, LPDDR3/4
- Interposer from partners such as Nexus Technologies or EyeKnowHow



R&S RTP HIGH-PERFORMANCE OSCILLOSCOPE

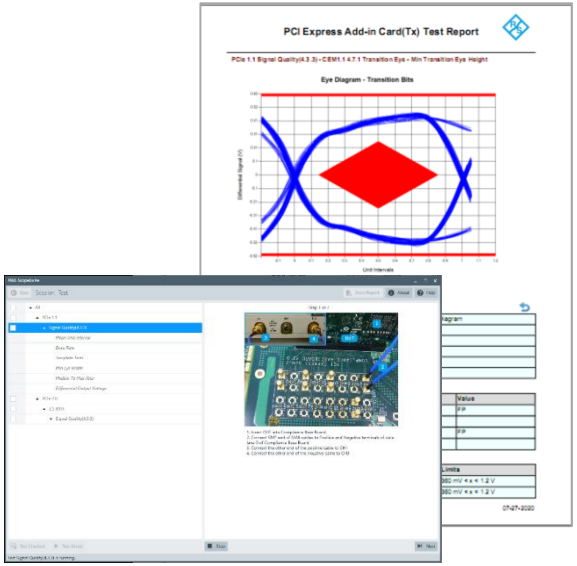
PCI EXPRESS DEBUGGING AND COMPLIANCE

- Solution for PCIe 1.1/2.0/3.0
  - Signal Integrity debugging (Serial pattern trigger / CDR)
  - Protocol triggering and decoding
  - Compliance testing with R&S ScopeSuite



Data eye and mask testing

Decoding of 5 Gbps PCIe 2.0



Automated Compliance testing

2. LOW SPEED DIGITAL INTERFACES

Why trigger and decoding solutions are so important for integration of Low-speed Digital Interfaces?

LOWSPEED DIGITAL INTERFACES CHALLENGES

- Protocol coding data complicate debugging
- Interference issues due to increasing level of integration

For optimal data debugging – T&M equipment needs protocol-specific triggering and data analysis.

LOW SPEED DIGITAL INTERFACES

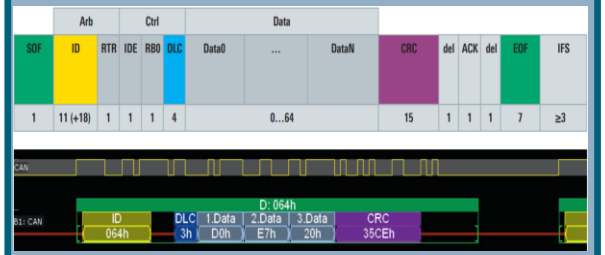
REQUIRE DEDICATED TOOLS FOR PROTOCOL-SPECIFIC DEBUGGING

Protocol Decoding

- Decoding of various control and programming protocol standards
- User definable decoding based on NRZ, 8B/10B or Manchester coding

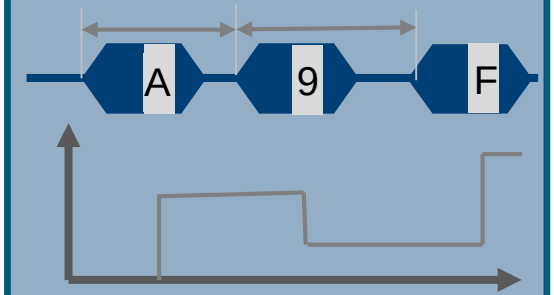
Protocol Triggering

- For debugging – trigger on Protocol events and errors



Bus Measurements

- Measurement of protocol timing
- Measurement and analysis of protocol data



R&S PROTOCOL TRIGGERING AND DECODING SOLUTIONS

- Dedicated protocol options
- Flexible decode option for certain coding schemes
- HW processing support for fast results

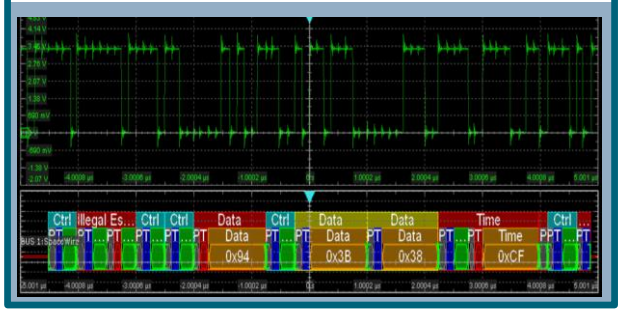
Providing Unique Protocol-Specific Analysis Functions

R&S OSCILLOSCOPE

PROVIDING UNIQUE PROTOCOL-SPECIFIC ANALYSIS FUNCTIONS

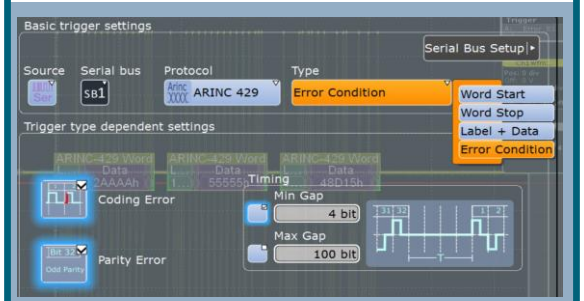
Gain protocol inside with decoding options

- Comprehensive portfolio of decoding options
- Time-correlation of waveform and protocol data
- View data in waveform or table
- Powerful search and navigation



Powerful protocol-based trigger functions

- Reliable isolate protocol events (e.g. address or data) and errors with protocol specific trigger
- HW support



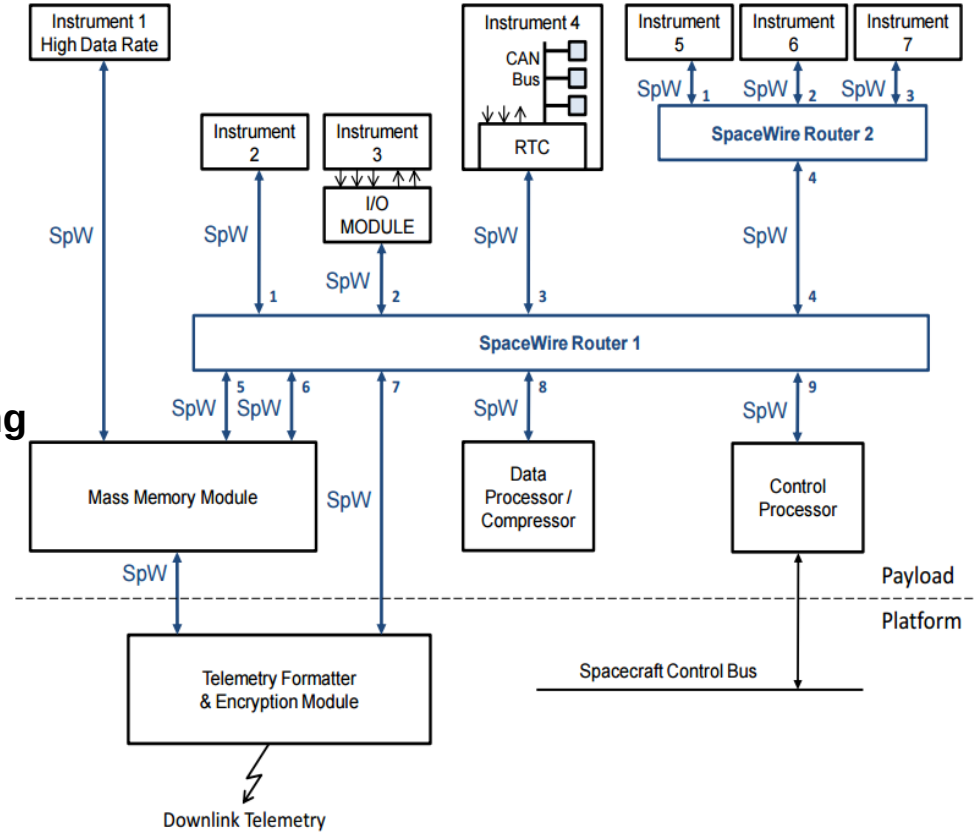
Analyze protocol data with bus measurement option

- supports I2C, SPI, UART, RS232, CAN, CAN-FD, LIN, Ethernet
- Display protocol data as waveform
- Measure frame spacing, frame error rate, or bus idle time, etc.

SPACEWIRE

- **High-speed link & network**
  - 2 Mbits/sec up to 200 Mbits/sec
  - LVDS drivers & receivers with 100 Ω differential impedance

- **Support of different payload processing architectures:**
  - Point-to-Point links
  - SpaceWire routing switches

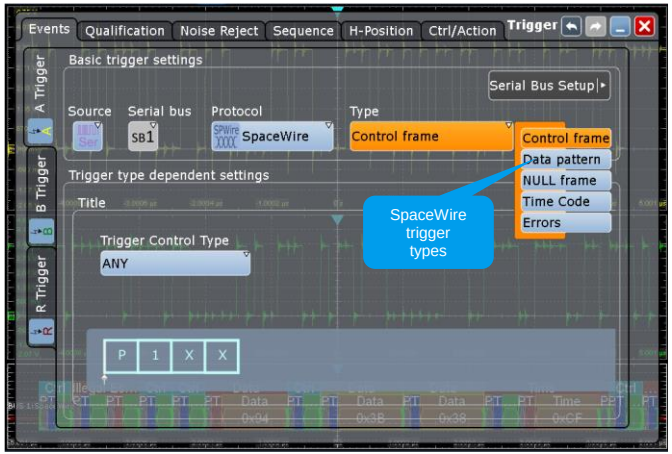


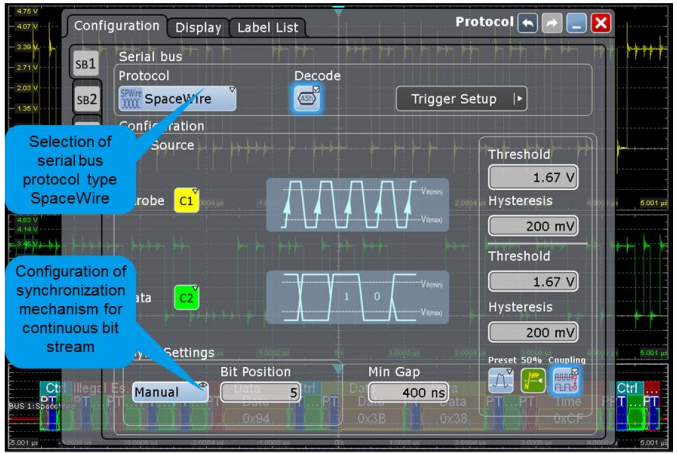
SPACEWIRE

Challenge: Spacewire has no well-defined packet identifier

- Rohde & Schwarz was the 1st on the market with
  - SpaceWire trigger & decode option
  - Synchronization algorithm for continuous bit streams.

- Learn more:
  - Joined Paper, CTI Brasil
  - User Video “Debugging and Verification”





ROHDE&SCHWARZ

Centro de Tecnologia da Informação Renato Archer

Debug and Verification of SpaceWire Links

Test and Verification session – May 15, 2018
8th International SpaceWire Conference - Los Angeles (USA)

CTI / CITAR Project (BRA)	Rohde&Schwarz (USA, GER)
Daniel B. De Lazari	Armin Horn
Alexsander Deucher	Matthias Beer
Angela Santos / Saulo Finco	Volker Ohlen

3. POWER INTEGRITY

What are the right tools and analyzing functions for appropriate characterizing & debugging?

POWER INTEGRITY CHALLENGES

- Increasing number of power rails
- Lower margins due to lower supply voltages
- Interferences due to dense designs of mixed technologies

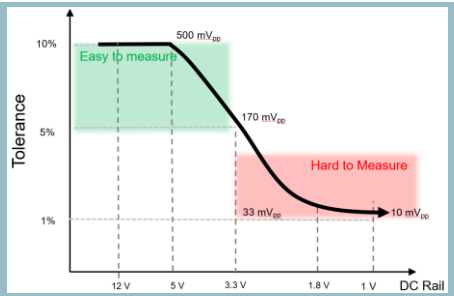
An optimal solution for characterizing and debugging DC power rails demands suitable probes & oscilloscopes.

POWER INTEGRITY

REQUIRES DEDICATED TOOLS FOR VERIFICATION & DEBUGGING

The Right Scope

- Fast update rate
- Min. vertical scale: 1..2 mV/div in HW at full bandwidth
- Low noise
- Support of specialized probes also on high-performance class instruments

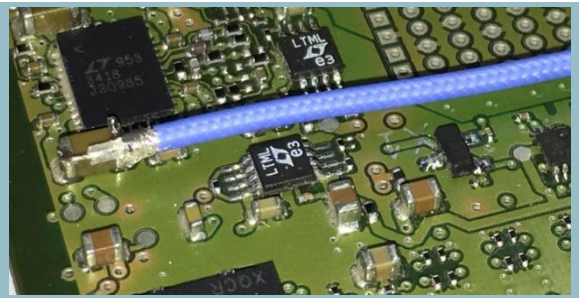


Specialized Probes

Power Integrity Probe

- Bandwidth >2 GHz
- Low noise with 1:1 attenuation
- Extended offset range
- Connectivity

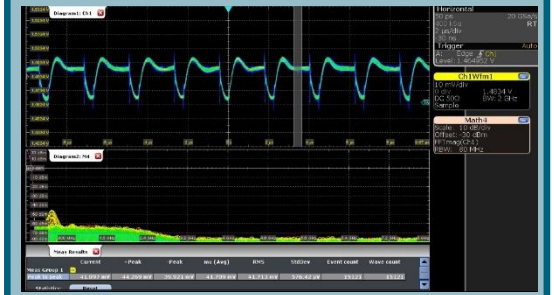
Current probes, etc.



Dedicated Analysis Functions

Typical measurements

- Ripple, Load step response
- Power-up/down, Sequencing
- Drift over temperature and input voltage
- EMI debugging / harmonic analysis

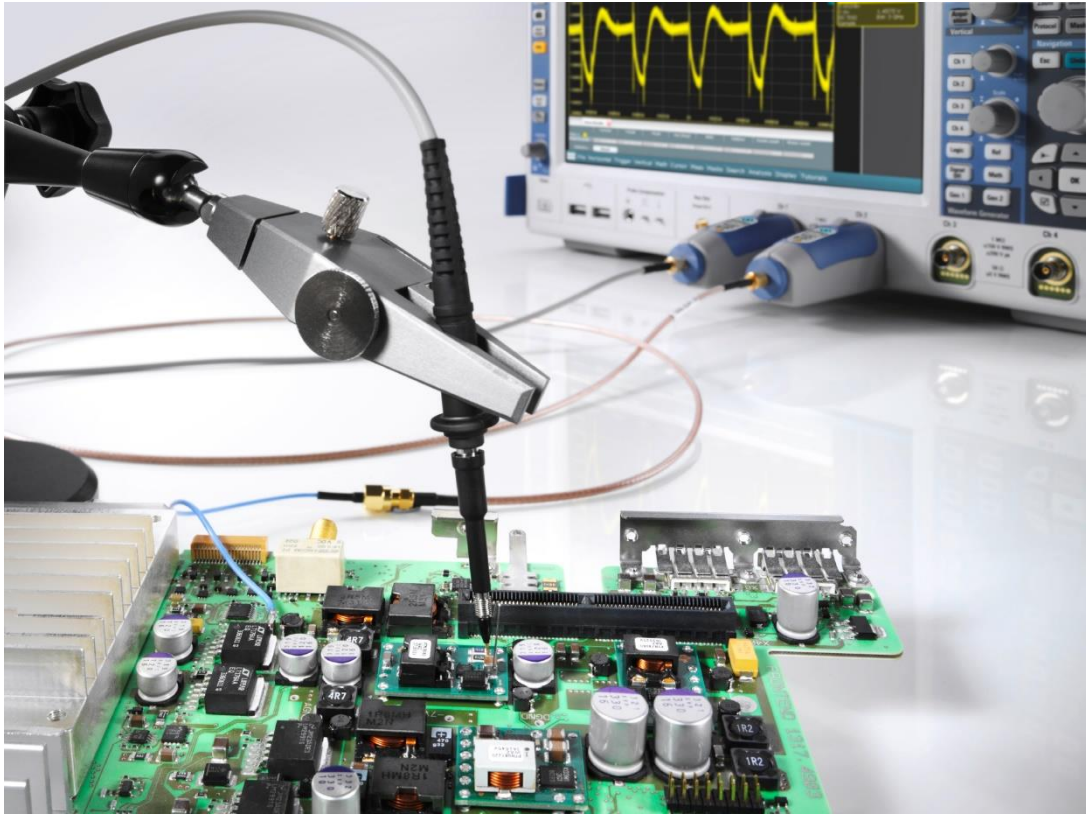


R&S POWER INTEGRITY SOLUTION

- Low Noise
- Fast FFT
- Fast Update Rate

- Low-Price Alternatives
  -RTM / RTA Oscilloscopes

- **Superior Power Rail Probes**



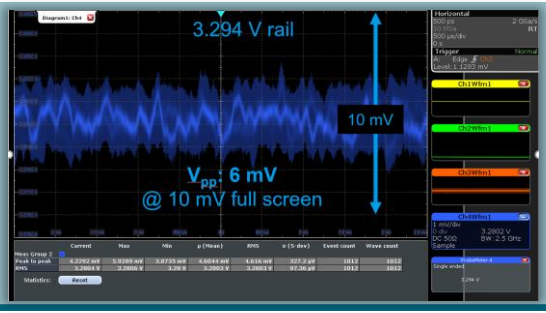
Providing Unique Power Integrity Analysis Functions

R&S RTO & RTP HIGH-PERFORMANCE OSCILLOSCOPE

PROVIDING UNIQUE POWER INTEGRITY ANALYSIS FUNCTIONS

Fast Scopes: RTE, RTO, RTP

- Up to 1,000,000 wfms/s to find worst case tolerances quickly
- 1mV/div in HW, full bandwidth
- Lowest noise w/ 16 bit HD mode
- Most sensitive trigger to capture very small amplitude droops



Best Power Rail Probes

- RT-ZPR20/40 Power Rail Probes
  - 1:1, 2/4 GHz bandwidth
  - Highest offset: +/-60 V
  - Browser and solder-in tips
  - Unique R&S Probe Meter (high accuraccy DC voltmeter)
- Portfolio of current probes
- Multi-channel 18 bit power probes

Unique Analysis Functions in one instrument

- Fast and responsive FFT to detect interferer
- R&S ProbeMeter for precise DC measurements (0.05%)
- Fast measurements for statistics analysis

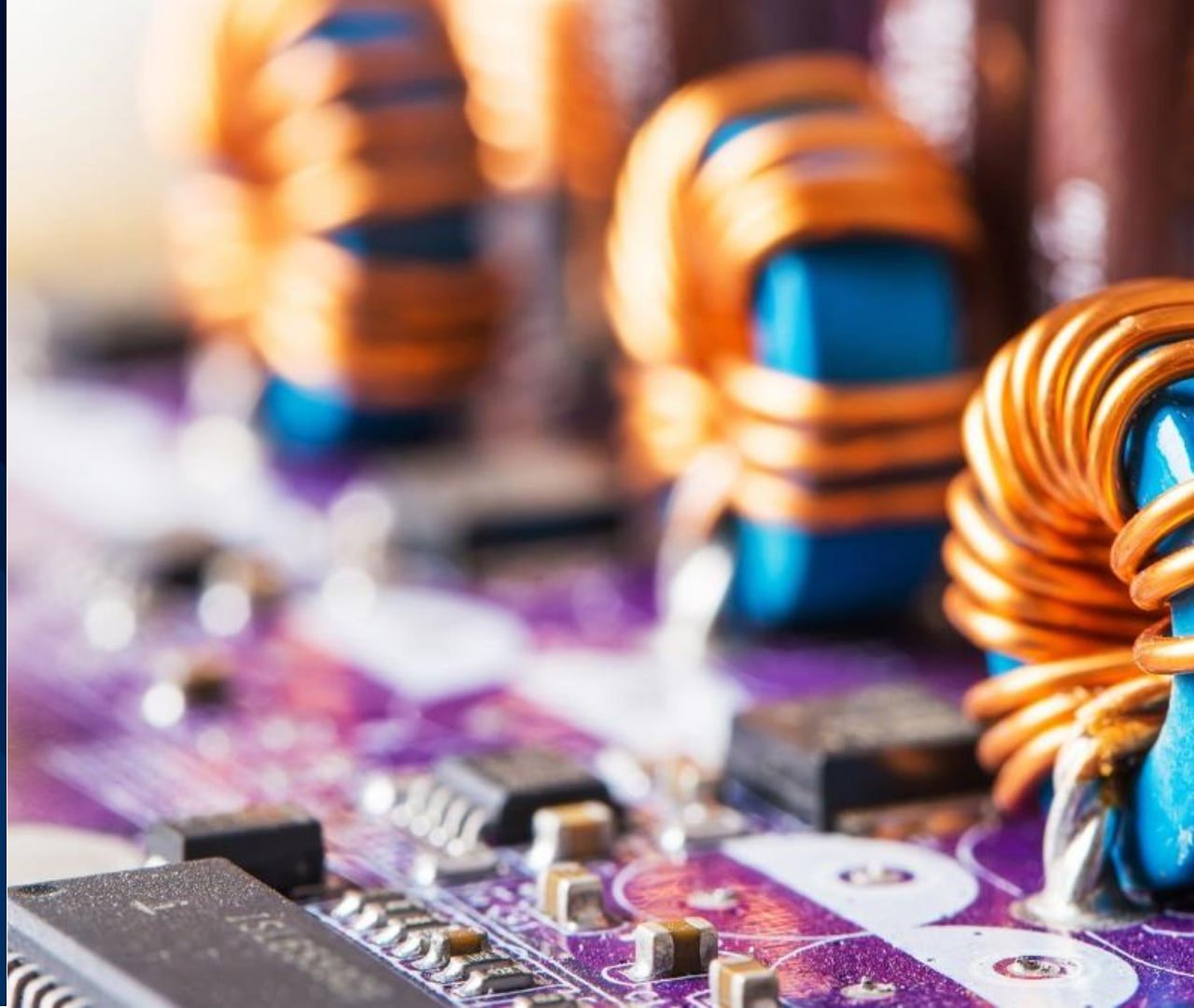
4. POWER SUPPLIES

What are the right tools and analyzing functions for appropriate characterizing & debugging?

POWER SUPPLY CHALLENGES

- Increasing number of converters and PMICs
- Tight timing requirements for power up and power down sequences
- Efficiency
- Higher frequency conversion
- Power saving modes

An optimal solution for characterizing and debugging power supplies requires suitable probes and oscilloscope performance.

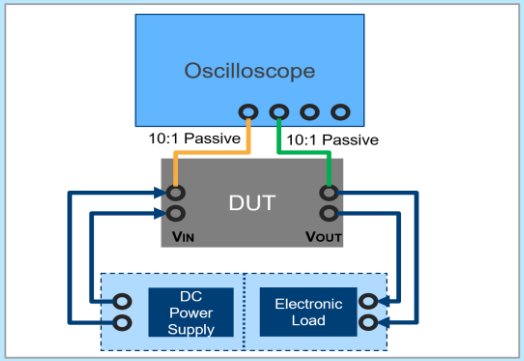


POWER SUPPLIES

REQUIRES DEDICATED TOOLS FOR VERIFICATION & DEBUGGING

The Right Scope

- Low noise
- High resolution
- High measurement dynamic
- Deep memory
- Typical bandwidth 350 MHz to 1 GHz



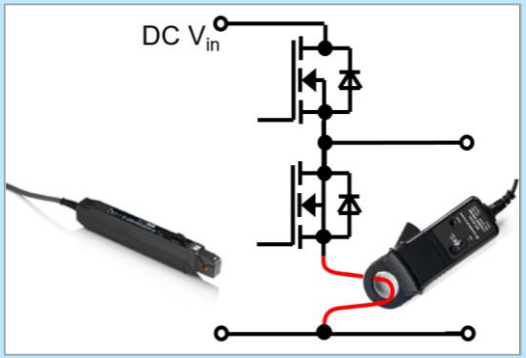
Specialized Probes

Current Probes:

- Bandwidth / sensitivity

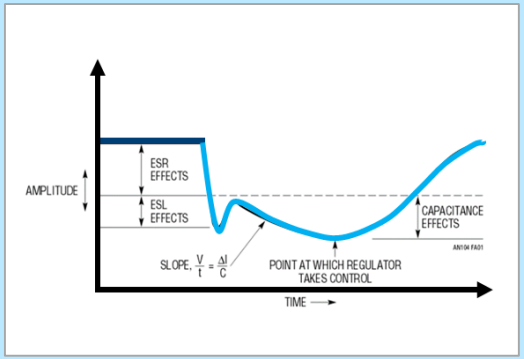
High voltage probes:

- High CMRR and linearity
- Build-in offset compensation
- Low noise, low zero error



Dedicated Analysis Functions

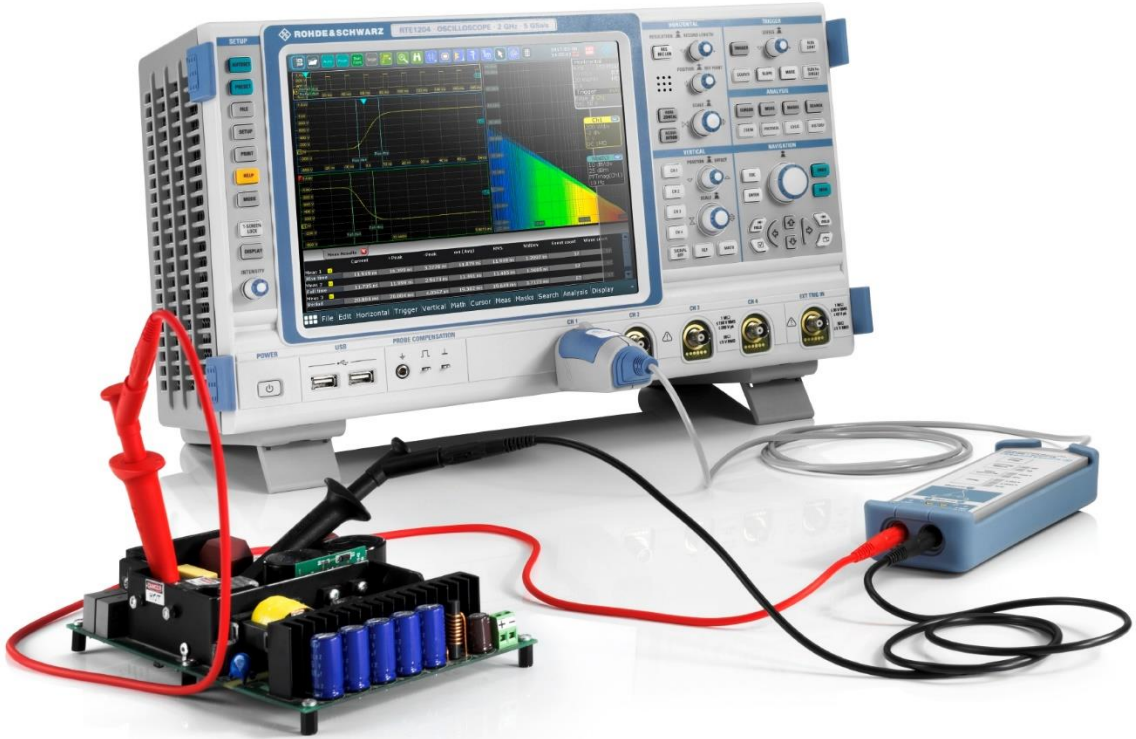
- Measurement and track, complex math functions
- User definable filters
- Frequency response analysis (Bode-Plot)
- FFT and harmonics analysis



R&S POWER SUPPLY SOLUTION

- Low Noise
- Up to 16 bit vertical resolution
- Large and segmented memory

- **Rich Probes Portfolio to address your needs**



Providing Unique Power Supply Analysis Functions

R&S OSCILLOSCOPE AND PROBES

PROVIDING UNIQUE POWER SUPPLY TEST FUNCTIONS

“The Power of 10”

- RTB/ RTM/ RTA with:
  - 10 bit ADC (16 bit in HiRes)
  - up to 1 GSa segmented memory
  - 10” display
- RTE/ RTO with 16 bit HD mode
- RTH with isolated channels

Rich Probe Portfolio

- RT-ZHD diff. high voltage probes
  - Up to 200 MHz; up to 6000 V
  - Lowest noise
  - High linearity and small zero error
  - Unique up to 2000 V offset
- Portfolio of current probes
- Multi-channel 18 bit power probes

Unique Analysis Functions

- Bipolar PWM analysis
- Complex math
- User definable filters
- Frequency response analysis option
- Spectrum analyzer option

R&S T&M SOLUTIONS FOR POWER CONVERTER DESIGN

ADDRESSING THE WHOLE PRODUCT CHAIN

Power Devices → Power Modules → Products → Systems

Component Test / Validation

Power MOSFET Dynamic Characterization

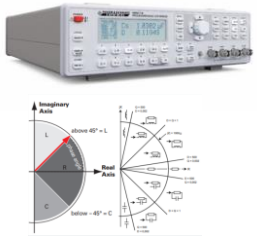
Converter / Inverter Design

Product / System Test

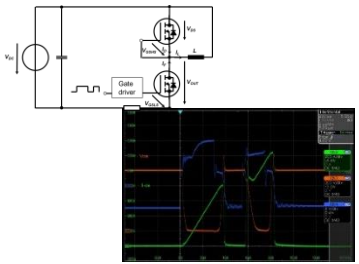
EMI / Safety / General Compliance

Standard lab equipment: Power Supplies, Multimeter

Characterizing passives: R&S HM8118 LCR Bridge



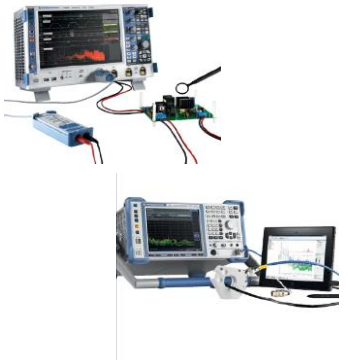
Double-pulse testing with R&S Oscilloscopes



Switching Analysis with R&S RT-ZHD HV-Diff Probes

Stability Analysis with Bode Plots

EMI Debug, Pre-compliance and Compliance

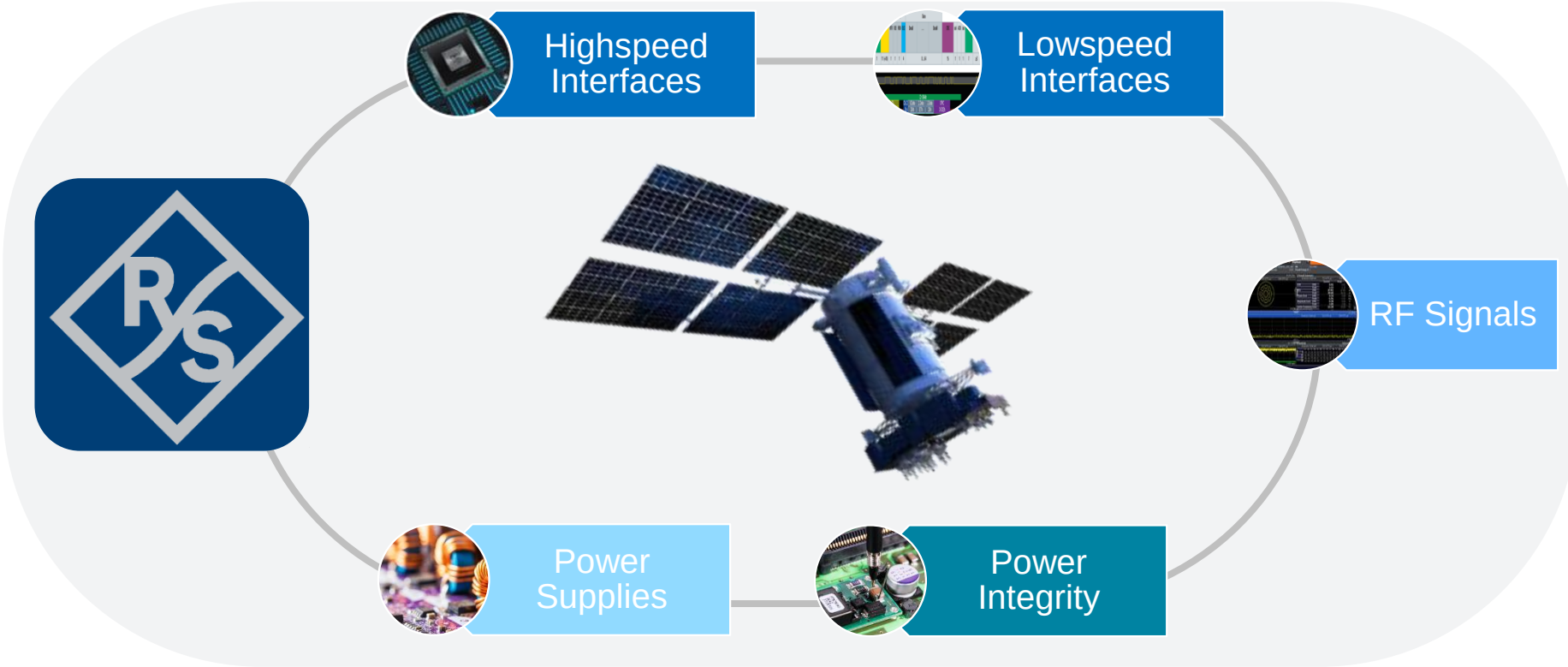


SUMMARY

R&S addresses T&M needs for RF, highspeed digital and power design.

VERIFY YOUR SATELLITE DESIGNS AND COMPONENTS

R&S A RELIABLE PARTNER – PROVIDING OVERALL T&M SOLUTIONS



CONNECT WITH US AND STAY UP-TO-DATE

With Rohde & Schwarz aerospace & defense testing

- Visit our website here
- Register for our newsletter here
- Follow us on Linkedin here