R&S®IRAPS®: INTEGRATED RECORD, ANALYSIS, PLAYBACK SYSTEM

Application Brief

Products:
- ► R&S®FSW
- ► R&S®SMW200A
- ► ERISYS SigPro-2000
- ► ERISYS SigPro-4000
- ► ERISYS ZoomOut®

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CONTENTS

1 OVERVIEW

Platform verification with signals that reflect the real-world is challenging but is always the best approach to the determine true system performance. There are many challenges in different applications: range & chamber platform testing, EW technique development, EW system verification, and satellite development. To overcome these challenges, bringing the real-world into the lab is the best method to ensure system effectiveness.

To capture the outside world and find the signals that are of interest is a challenging, time-consuming task. When needed, performing in line signal processing & synchronizing to the system under test is a critical need for applications like EW technique development. Without prior knowledge of when the signals will appear, long data captures of the RF environment must be taken. There is often great uncertainty knowing whether a recording was successful or not as a number of problems can prevent a clean, usable recording from being acquired. It may require extensive analysis to determine if a recording was successful or if another test run is required. Once the data is captured it is time to find the needle in the haystack.

R&S®IRAPS® enables the real-world RF spectrum to be captured, analyzed and played back in an efficient manner enabling quick and insightful analysis. The Erisys ZoomOut® software reduces the time it takes to identify the critical signals of interest. With high dynamic range, and long capture time you can be sure of capturing the signals of interest. Scalable devices allow multiple channels of recording and playback / emitter / environmental simulation. Unique and powerful analysis tools ensure quick and insightful analysis tools that will identify these critical signals. Then testing can begin, with the playback of high quality, complex scenarios that reflects the true environment that the system under test will face when deployed.

The R&S®FSW Signal and Spectrum Analyzer serves as RF front end for capturing the digital IQ data stream from the RF environment. The R&S®SMW Vector Signal Generator enables playback of the captured signal, by taking the digital IQ data stream and upconverting it to RF. These are both calibrated laboratory grade instruments with high dynamic range, excellent RF performance and wide bandwidth as well as full applications support for measurements of radar, electronic warfare, communications signals, and satellite measurements. The FSW and SMW can meet the challenges from the most advanced systems.

2 R&S®IRAPS® SYSTEM

The R&S®IRAPS® system is the Integrated Record, Analyze, and Playback System based on commercial off-the-shelf (COTS) test and measurement equipment. With 1 GHz of BW, signals can be quickly captured, identified and played back. System capabilities include:

► Capture and record signals at 1 GHz of bandwidth for over 6 hours.
► Capture the details using the industry leading R&S®FSW signal and spectrum analyzer, giving a COTS solution with high dynamic range and wide input range.
► Generate calibrated, high dynamic range signals with a 1 or 2 channel with the industry leading R&S®SMW200A for signal playback, environmental simulation, multi emitter scenario generation, and more.
► Scalable configuration: capture using up to 2 RF channels with 1 or more R&S®FSW spectrum analyzers, and playback with up to 4 RF channels with 1 or 2 R&S®SMW200A signal generators.
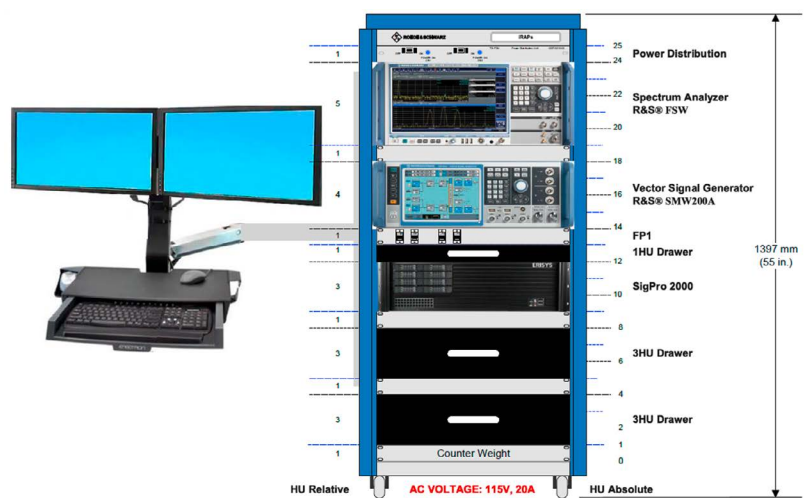
- ▶ Fast results: near real time analysis with in line signal processing to display analysis as the recording is visualized.
- ▶ Unique view to quickly determine if a recording is successful: view hours of data in a single display with no loss of data.
- ▶ Intuitive GUI allows easy navigation and zoom in on signals of interest
- ▶ Extract signals of interest from a recording, convert to a PDW format or use IQ segmented records for playback later.
- ▶ Create complex scenarios by combining captured signals with existing scenarios.
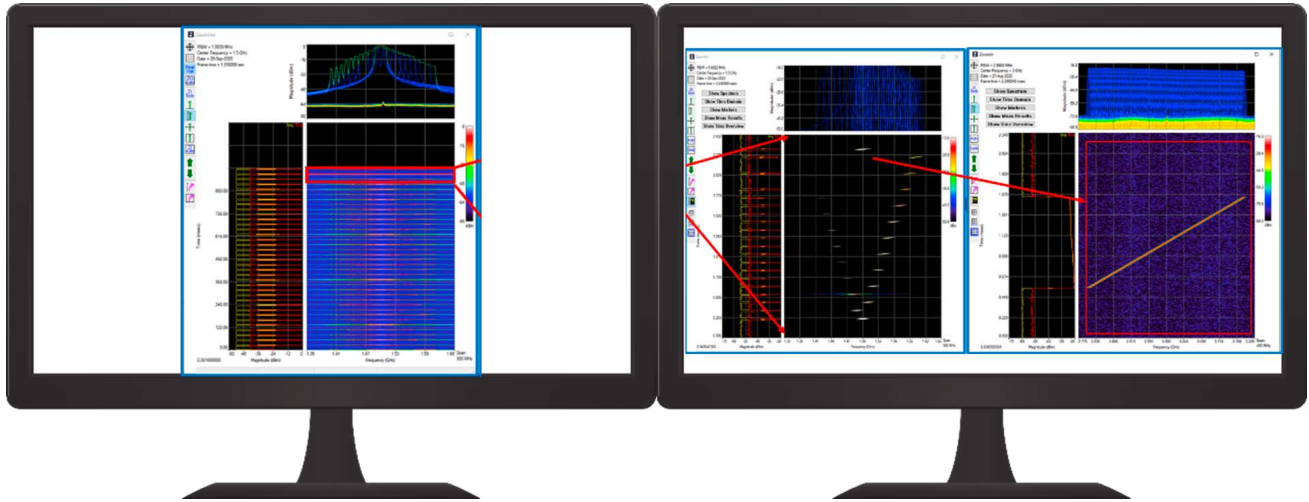
ZoomOut® Software: (1) first display shows entire recording without loss of any durations down to 1 sample long, (2) ZoomIn to specific portion of the recording for deeper analysis (3) ZoomIn further to individual pulse

Hardware Configurations

- ▶ Rack System
  - – A fully integrated 19" rack-based system is available for laboratory use.

Figure 1: IRAPS configured in a rack system—includes 2 monitors with mouse and keyboard tray, and storage drawers for accessories. The main components for the IRAPs system are the R&S® FSW Spectrum Analyzer, the R&S® SMW Signal Generator, and the Erisys SigPro.

- ► Mobile System
  - – Transportable mini racks are available as a configuration. Each system component is contained within its own portable rack (wheels optional) for ease of system setup and break down.
- ► 17.3" dual monitor, able to be folded into rack for transport

- ► Keyboard with touchpad, able to be folded into rack for transport
- ► SigPro 2000/4000
- ► FSW Signal Analyzer
  - – 2 HU drawer for cables/accessories
- ► SMW200A Vector Signal Generator
  - – 2 HU drawer for cables/accessories

3 SYSTEM WORKFLOW CONCEPT

R&S®FSW: RF to digital
IQ data down conversion

T&M based COTS
equipment

Erisys SigPro:

High speed processor
Recording & data storage
Custom DSP possible

R&S®SMW200A:
Upconvert IQ signals
and PDWs to RF
T&M based COTS
equipment

Figure 2: IRAPS functional description for each major component

Erisys ZoomOut® Analysis Software

See the big picture: Analysis Software for long captures of electronic warfare, communications, and other signals.

► System Control
   – ZoomOut R&S Control software: Enables IQ data streaming via a R&S FSW Spectrum Analyzer for IQ data capture and a R&S SMW200A Vector Signal Generator for RF Playback and provides setup/remote control via virtual front-panel displays for all R&S equipment
   – Possible to start recordings with a pre trigger recording buffer. This buffer can run continuously so that once a recording is started, pre-trigger or pre-start signal information is available.
   – Timing synchronization: IRIG-B & GPS timing for recorded data, also live streaming data can generate triggers to mark data or provide a TTL output.
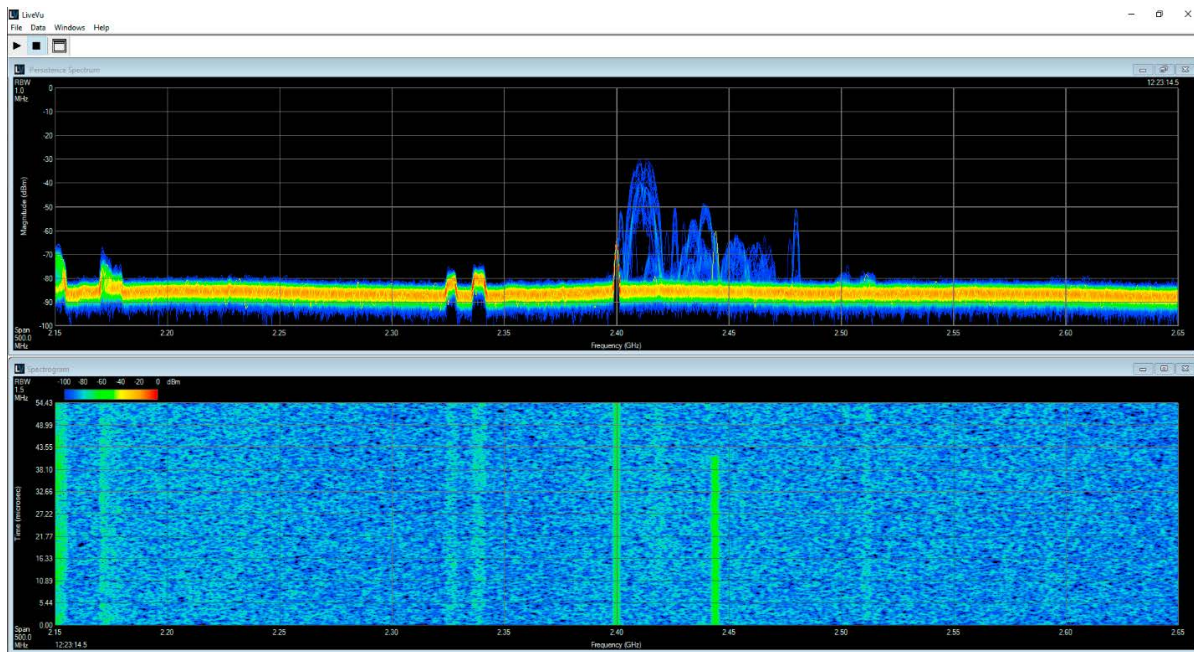► During recording/playback signal visualization

Figure 3: LiveVu contains 1 GHz displays of Persistence and Spectrogram. These are both real time spectrum analyzer displays to provide a spectrum monitor while the recording is taking place.

- LiveVu enables a real time spectrum display to visualize signals as they enter the FPGA of the SigPro over 1 GHz bandwidth. This capability allows users to view signals before & during recording to ensure proper capture setup, and eliminating downtime setting up the recording. LiveVu also allows visualization if signals being played back from the onboard SSDs to a R&S SMW Vector Signal Generator for RF Playback. This is useful in verifying that the output waveform is correct when stimulating a SUT from the SMW.
  - Segmented memory options allow users to capture just the pertinent data of a long duration recording, and ignore the off time, greatly reducing the memory needed for a given recording, or to extend the maximum recording time by more efficiently using the SSDs.
► Big Data Analysis
  - ZoomOut SW is a deep capture analysis software package which allows users to view/analyze large data files in the ZoomOut Summary Window while simultaneously using the ZoomIn Window to analyze the IQ Data of a smaller selected ZoomOut time slot.
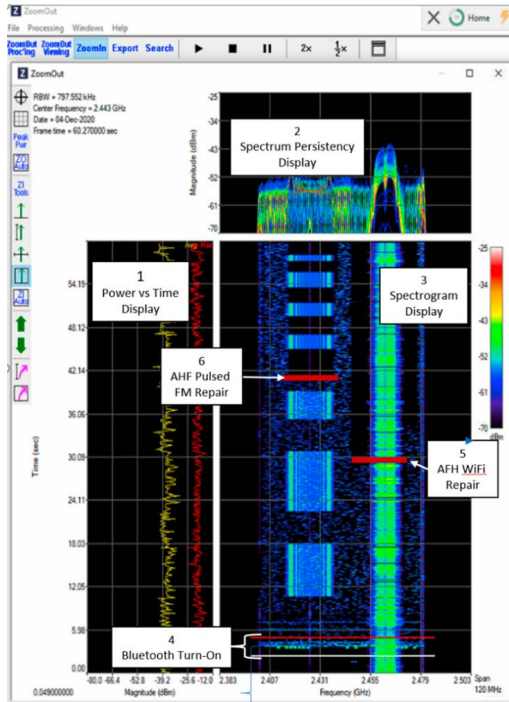

Figure 4: Deep memory recording of one minute shown in the ZoomOut display - in this case a 2.4 GHz ISM band with WLAN, Bluetooth, and an AHF Pulsed FM Repair signal.

Figure 4 shows a ZoomOut display of the analysis of a deep memory recording of approximately one minute over a bandwidth of 120 MHz. The power vs. time display, label 1, shows the record of the peak power and average power vertically over the one-minute recording, while label 2 shows the spectrum persistency of the entire recording, frequency vs power intensity (temperature bar on far right).
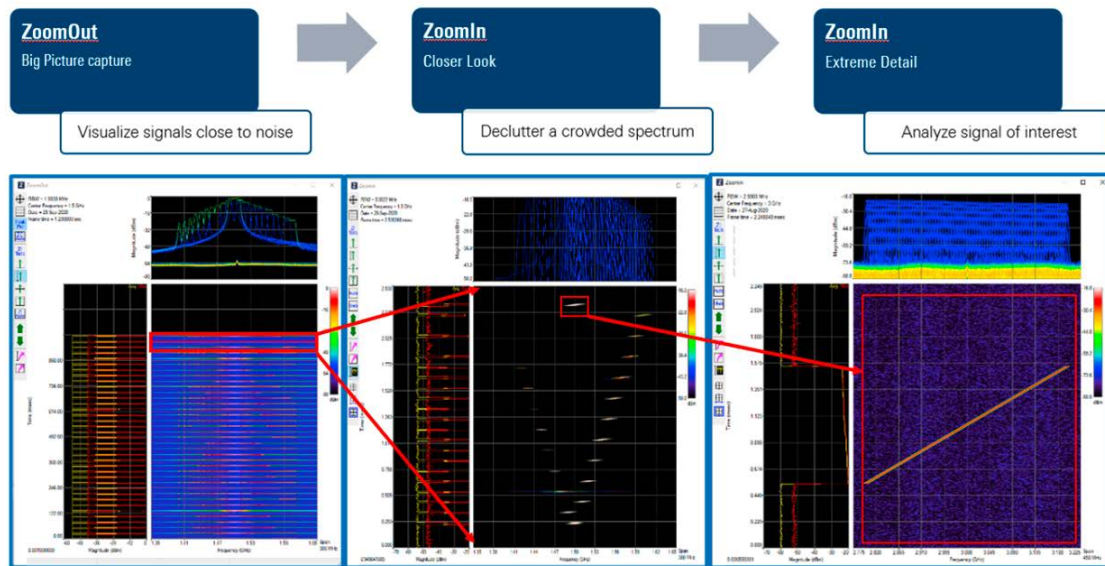
Figure 5: The 3 panes show different levels of zoom. The first pane is the ZoomOut display with the complete capture, with the other 2 being increasingly zoomed in. The left most display is the final ZoomIn display showing the 200 nsecond pulse.

Figure 5 shows 3 panes with different levels of Zoom. In each of the panes, each display uses the same format: the top indicates the persistence display, the left side strip shows a power vs time display, and the center shows a spectrogram. The left most panel is the ZoomOut display, able to show the entire recording in single display with these 3 different views of the same signal.

► Noteworthy is that the underlying IQ data is always preserved through a Zoom In process. If desired, once a smaller duration and frequency range signal of interest is found, it can be filtered and save for repetitive playback to further stimulate the SUT.

► Through multiple zooms, Figure 5 shows a 200 nsecond pulse in extreme detail. This capability gives the user to zoom into any portion of the IQ capture and quickly reprocess signals of interest without any loss of data.

► ZoomIn contains power features such as:
  – OneFrm (one frame) can immediately show the entire capture in one trace window
  – OneSgmt (one segment) can instantly page through memory segments
  – Spectrum with markers & measurements
  – Time domain traces
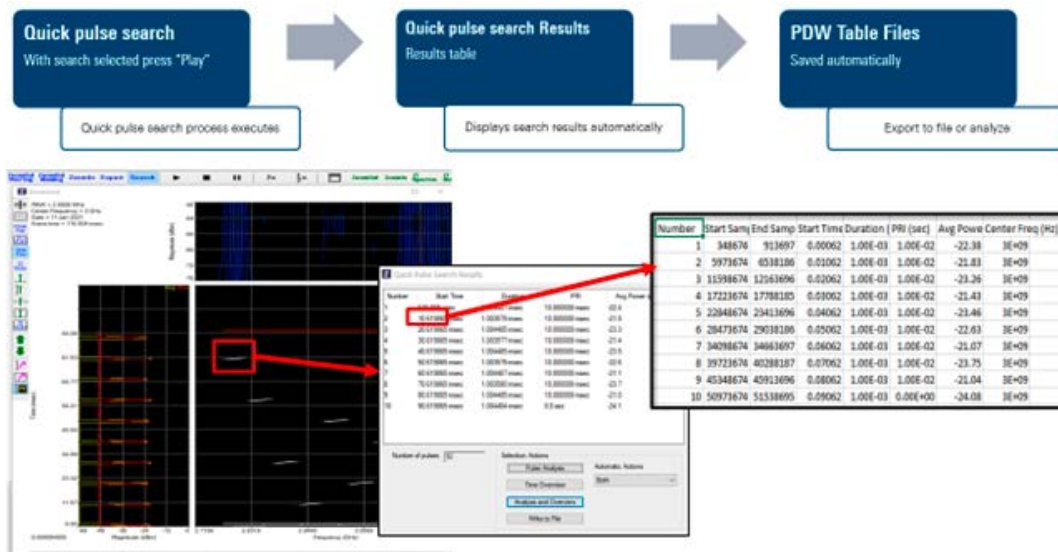
► Searching for Signals of Interest

Figure 6: Quick Pulse Search and PDW Table File export shown - extracting a PDW file from a recorded signal

Figure 6 shows the work flow to quickly search the recorded IQ file for pulses/bursts and analyze results in detailed pulse analysis table and Frequency / Power/ Phase verse time displays.

► Data Export

Figure 7: IQ segments with PDW parameters shown as processed from a recorded signal.

– Export selected portions of IQ Data of signals of interest (IQ) to a file for further analysis or RF playback
– Figure 7 shows a Pulse Descriptor Word files created for analysis and stream PDW commands to R&S SMW200A for RF Playback of selected signal bursts/pulses.

► Powerful Post Recording Tools using QuadVu and Spectrum Stitch to time align adjacent captures.
– To achieve up to 4 GHz capture bandwidth, captures from 4 FSW's and 4 SigPro4000's can be set up. The recordings can be easily time aligned and processed as a single wide band recording. Note that each 1 GHz segment is only time aligned and a phase discontinuity will exist across each 1 Ghz band.
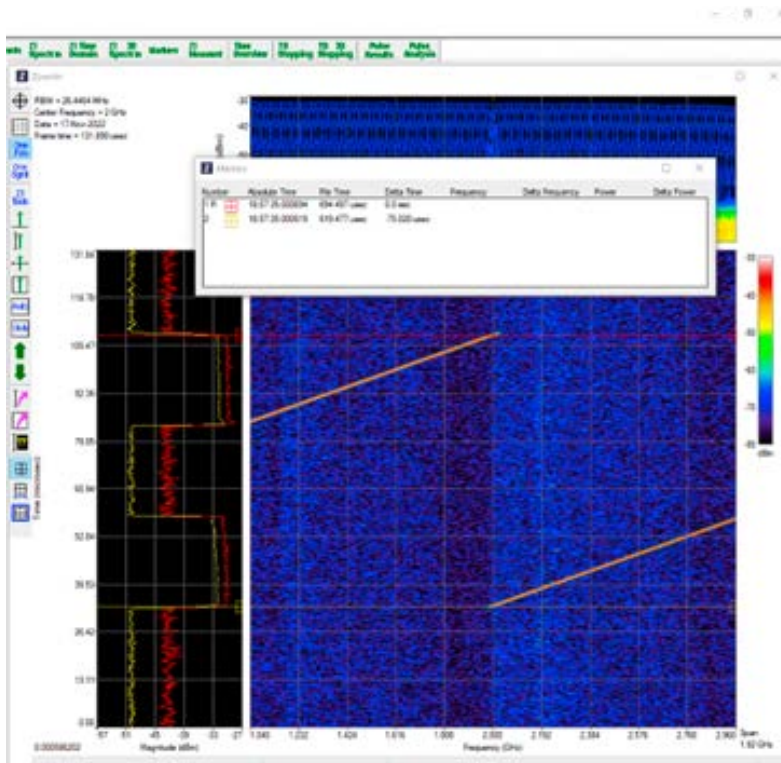

Figure 8: 1 GHz recordings from 2 different sources (Recording A and Recording B) are shown - the markers measure the time differences between the un-aligned recordings.
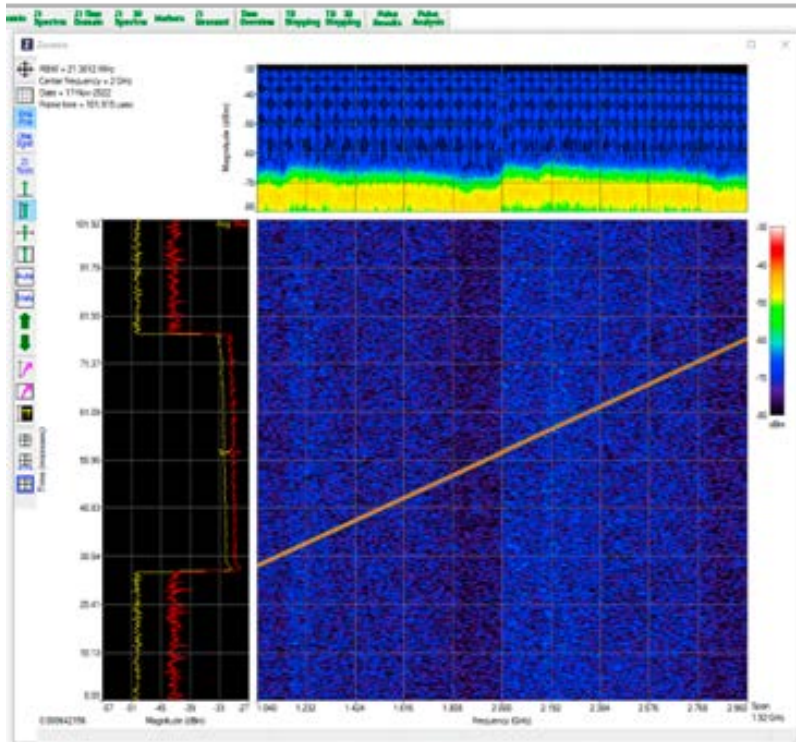
Figure 9: Final 2 GHz bandwidth display shown after the timing adjustment is applied to the 2nd display.

- QuadVu with Spectrum Stitch allows for a user to "stich" up to 4 recording files to make a new single recording. Powerful tools to time align the files enables users to create a wider bandwidth recording showing more of the spectrum of interest.
- To achieve 4 GHz BW recording, 4 FSW's and 4 SigPro's signal processors are utilized. An additional FPGA Enhanced Development System, or FEDS described later, is also required.

► Channelization is available to improve analysis of low Signal to Noise Ratio signals. By using Digital Down Conversion and Signal Smoothing, data analysis can be improved for low level signals. As much as 30 dB improvement can be achieved using this method.
- Figure 10 shows the signal that is first captured normally. Low level signals of interest captured with 1 GHz bandwidth may appear to be mainly noise, as shown in this example. This is displayed using the Time Overview, selecting the frequency band and time duration from the ZoomOut spectrogram.

Figure 10: The Time Overview display of a low level signal captured within a recording.

– Using DDC and Smoothing for Channelization, the signal of interest can be clearly visualized with the Time Overview. This is simply filtering & this snip of the IQ signal can be saved for further processing as shown in Figure 11.
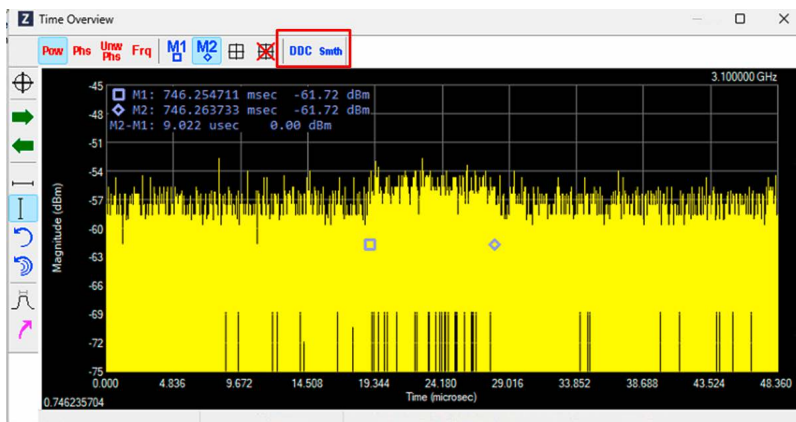

Figure 11: Same signal now with DDC processing applied - powerful processing shows as much as 30 dB improvement in showing the signal of interest

4 ERISYS FEDS

The Erisys SigPro series can have the optional FPGA Enhanced Development System, or FEDS. This is a separate signal processing chassis with customer programmable FPGA for in line live signal processing. With the addition of FEDS, the IRAPS™ system can be serve as a Hardware in the Loop (HIL) or System in the Loop (SIL) test bed for EW, Radar, Satellite, or Communications system test.

A FEDS equipped IRAPS system is suitable for system test because it provides a stable testing environment with deterministic latency. FEDS is an add on to IRAPS, so it reuses the FSW and SMW as a high-performance RF front end. FEDS has 1 GHz instantaneous bandwidth and provides a test bed where users can provide any DSP in the form of FPGA code. Sophisticated fixed latency triggers are available to maintain timing and respond to specific pulse width signals, making the IRAPS® and FEDS system capable to become a complete solution test bed.

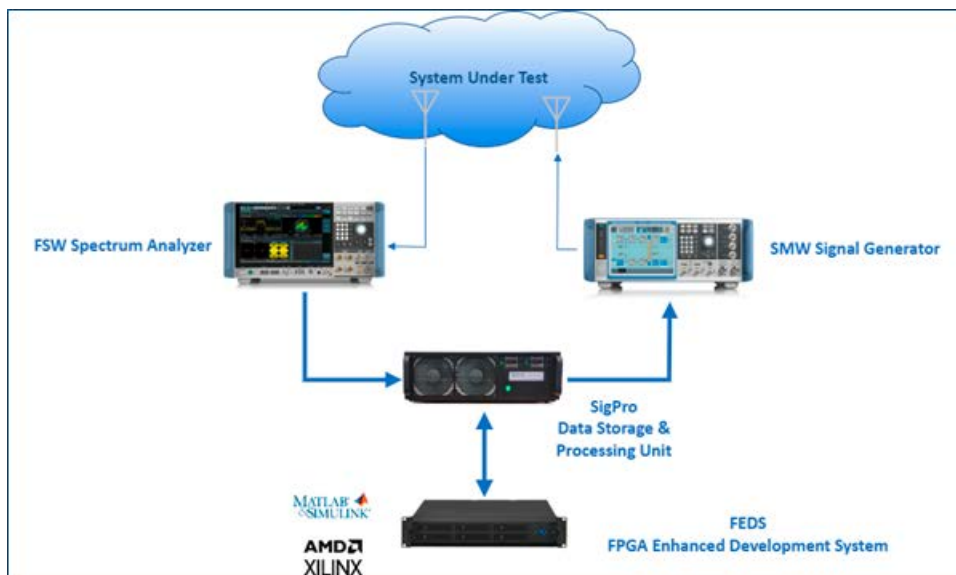Figure 12 shows a simplified diagram of how FEDS would be configured to test a system.

Figure 12: Block diagram showing how the IRAPS can be extended with FEDS to perform HIL / SIL testing.

5 R&S®FSW SIGNAL ANALYZER FREQUENCY RANGE AND BANDWIDTHS

RF Front End for recording system to receive signals. Also useful as a general-purpose high-performance spectrum and signal analyzer.

Model & Frequency Range	Recording Bandwidth Supported	Internal Analysis Bandwidth
FSW8	512 MHz	512 MHz
FSW13	512 MHz	512 MHz
FSW26	1 GHz	2 GHz
FSW43	1 GHz	8.3 GHz
FSW50	1 GHz	8.3 GHz
FSW67	1 GHz	8.3 GHz
FSW85	1 GHz	8.3 GHz

R&S®FSW key specifications, typical

▶ TOI: +30 dBm (1 GHz)
▶ DANL: -169 dBm (150 MHz to 8 GHz)
▶ Phase Noise: -140 dBc/Hz (10 kHz offset, 1 GHz carrier)

R&S®FSW analysis capabilities

▶ Real Time Spectrum Analysis: up to 800 MHz, 0.46 μs minimum signal duration for 100% probability of intercept
▶ Pulse Measurements: up to 200,000 pulses with IQ segmented memory and over 40 measurements: single pulse, trend and statistical analysis, uses up to 8.3 GHz integrated instrument bandwidth
▶ Vector Signal Analysis
▶ OFDM analysis
▶ Wireless standards analysis: 5G, WLAN, Bluetooth, and more

6 R&S®SMW200A SIGNAL GENERATOR FREQUENCY RANGE AND BANDWIDTHS

RF Front End for recording system to transmit & generate signals. Also useful as a general-purpose high-performance vector signal generator.

Frequency Range	RF Channels	IQ Streaming bandwidth	RF Signal bandwidth
Up to 67 GHz	1 Channel up to 67 GHz 2 Channels up to 44 GHz	1 GHz	2 GHz

SMW Key Specifications

▶ Phase Noise< –150 dBc (typ.) (20 kHz offset, 1 GHz carrier)
▶ Output Power: +18 dBm
▶ Frequency Response: < 0.4 dB (meas.)
▶ PDW Rate: Up to 12 M PDW/Sec
▶ Number of PDW Streams: Up to 6

SMW Signal Generation Capabilities

- ► Stream up to 12M PDW/second to create emitter dense RF environments
- ► Create Pulse-on-Pulse scenarios by streaming up to 6 parallel PDW streams
- ► Two independent RF Outputs enable multi-band testing
- ► Easily add in commercial wireless signals to create real world RF Environments
- ► Two Baseband Generators enable two waveforms to be combined in to a single RF signal
- ► Excellent RF Performance will ensure accurate test results
- ► Multi-channel box is ideal for Phase Coherent generation

7 ERISYS SIGPRO SERIES ANALYSIS SYSTEMS

The Erisys SigPro series system is a Vector Signal Processor with High Speed Fiber Connectivity. The systems provide standard integrated functionality with the Erisys ZoomOut® software. The SigPro systems can also be customized with tailored DSP processing for real-time signal development.

Erisys SigPro Series Vector Signal Processors with ZoomOut® Software Key Highlights

- ► Powerful ZoomOut software running on the SigPro series signal processor – nearly instantaneous analysis of recording with the latest CPU and FPGA for acceleration
  - ZoomOut Basic is the core software allowing for operators to process the IQ data to view the entire recording as well as "Zoom In" to make more detailed spectrum measurements using markers. Zoom In also include the capability to view the time domain traces of selected waveforms.
  - ZoomOut Radar enables powerful time domain measurement and pulse analysis tools to view complex bursted and pulsed waveforms
  - Also included are various waveform searching tools to find, view, and sort signal of interest
  - ZoomOut Power Tools further extends the visualization and data tools of ZoomOut to store just the on time of signals, export to R&S VSE software for more detailed signal analysis as well as 3D visualization of spectrum & spectrogram traces
  - ZoomOut RS Control Basic helps coordinate the connected and control of the R&S FSW and the R&S SMW to ensure smooth operation. Easy playback of IQ signals is managed as advanced triggering. Finally pre-recording, during recording, and during playback signal visualization is possible with the LiveVu module.
- ► QuadVu module makes possible the visualization of 2-4 already recorded signals to provide deeper analysis insights.
  - Spectrum Stitch module extends the QuadVu capability and enables time alignment of all the files and the power to "stitch" them into 1 recording with all of the data.
- ► Key Hardware Specifications
  - High speed data link, dedicated high speed FPGA and CPUs for large amounts of signal processing
  - Up to 120TB of waveform recording & storage for hours of recording time
  - Secure with removable SSD's an no sensitive information left on device
  - IRIG-B and GPS timing synchronizing
  - DSP available for real-time signal development

8 ORDERING INFORMATION

Option	Part Number	Description
SigPro Hardware		
SigPro-2000B	3689.2402.02	SigPro-2000B: ▶ Instrument controller, recorder, and data router ▶ Capture and stream IQ Data capabilities ▶ Control of up to two Rohde & Schwarz instruments simultaneously with up to 1 GHz Real Time Bandwidth.
SigPro-4000B	3719.9215.02	SigPro-4000B: ▶ Instrument controller, recorder, and data router ▶ Capture and stream IQ Data capabilities ▶ Control of up to four Rohde & Schwarz instruments simultaneously with up to 1 GHz Real Time Bandwidth
SP-SSD15	3688.4299.02	SigPro Option: 15 TB SSD
SP-SSD30	3688.4682.02	SigPro Option: 30 TB SSD
SP-SSD60	3693.7163.02	SigPro Option: 60 TB SSD
SP-SSD120	3718.5916.02	SigPro Option: 120 TB SSD
SP-GPS/IR-	3719.9280.02	SigPro Option: GPS/IRIG-B Module
SP-FEDS	3689.2660.02	SigPro 4000B Option: ▶ FPGA Real-time I/Q processing Development Environment
SP-10GBLINK	3715.6005.02	SigPro-4000B Option: ▶ Fiber Optic 10 GB Link hardware to connect two SigPro Controllers
SP-FO-KIT	3715.6470.02	SigPro-4000B Option: ▶ 10 GB Single Mode Fiber Optic Cable Kit
SP4-Upgrade	3705.6731.02	SigPro2000(B) Upgrade of Hardware and Software to SigPro-4000B
SP2K-EXTW	3713.5947.02	Extended Warranty of SigPro-2000B from 3 years to 5 years
SP4K-EXTW	3713.5953.02	Extended Warranty of SigPro-4000B from 3 years to 5 years
Instrument Control		
RSCTRL	3693.3068.02	ZoomOut R&S Control: ▶ Instrument control software for recording and playback with Rohde & Schwarz FSW and SMW
RSCTRL-LV	3688.3828.02	ZoomOut R&S Control Option: LiveView ▶ Real-Time Spectrum and Spectrogram Display
RSCTRL-PDW	3723.1750.02	ZoomOut R&S Control Option: PDW Streaming ▶ PDW Command Streaming to SMW
RSCTRL-ATG	3723.1767.02	SigPro-4000B only. ZoomOut R&S Control Option: FSW Advanced Triggering ▶ Advanced triggering mode for FSW

Option	Part Number	Description
Signal Analysis Software		
ZO-Basic	3693.7240.02	ZoomOut-Basic, including: ▶ ZoomOut Processing and OneFrame Analysis ▶ ZoomIn Spectrum includes occupied bandwidth ▶ ZoomIn Time Domain ▶ ZoomIn Spectrum ▶ ZoomIn Markers & Measurement ▶ Export with time, frequency, and span adjustments
ZO-RADAR	3715.4548.02	ZoomOut Option: Radar ▶ Time Overview Radar ▶ Time Domain Stepping Radar ▶ Pulse Analysis Tools ▶ Waveform search resuts, sorting, and PDWs ▶ Waveform ID and Recognition using correlation
ZO-PWRTOOL	3715.4554.02	ZoomOut Option: Power Tools ▶ ZoomOut 3D Spectrum ▶ ZoomIn 3D Spectrum ▶ Data Reduction using Segmented Memory Contention ▶ Segmented Memory Data Read, Write and OneFrame Analysis ▶ Digital down conversion and Export to VSE or MATLAB
ZO-QV-SPST	3715.4560.02	ZoomOut Option: Quad View and Spectrum Stitch ▶ QuadView: Simultaneous display of up to four I/Q files ▶ Spectrum Stitch: Combining of multiple I/Q recordings into a single wide-bandwidth file.
ZO-CELLVU	3715.4577.02	ZoomOut Option: CellVu ▶ LTE & 5G Physical Resource Blocks Analysis

Contact your local Rohde & Schwarz Account Manager for configuration and pricing.

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Rohde & Schwarz
The Rohde & Schwarz electronics group offers innovative solutions in the following business fields: test and measurement, broadcast and media, secure communications, cybersecurity, monitoring and network testing. Founded more than 80 years ago, the independent company which is headquartered in Munich, Germany, has an extensive sales and service network with locations in more than 70 countries.

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