POWER SENSORS INTRODUCTION

Stone Lin

ROHDE&SCHWARZ

Make ideas real

WHY ARE ACCURATE POWER MEASUREMENTS IMPORTANT?

- Sending signals at the wrong power levels will cause problems
- The problems will vary based on application
- Too much power can…
  - Interfere with other systems
  - Damage the receiver's input
  - Drain the battery of a mobile device
- Too little power can…
  - Impact Quality of Service
  - Lost communication

- Power Sensors make..
  - The most accurate RF power measurements
  - The Fastest Power Measurements

RANGE OF SENSORS OFFER DIFFERENT CAPABILITIES

Multi Path Sensors

- Wide Measurement Range
- Many different measurement capabilities
- Fastest results

→ Most widely used

Wideband Sensors

- Envelope analysis for pulsed RF signals
- Pulse Analysis
- Time Analysis

→ Used on Pulsed Signals

Thermoelectric Sensors

- Most accurate sensors
- Highest frequency range

→ Used in Cal labs and for High Precision

Average Power Sensors

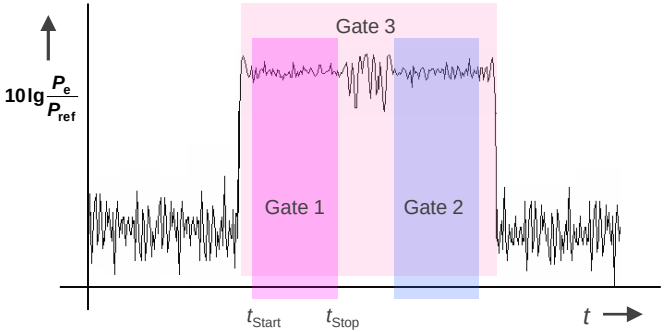
- Only Measures Average Power
- Similar Performance to Multi Path Sensors

→ Typically only used in EMC

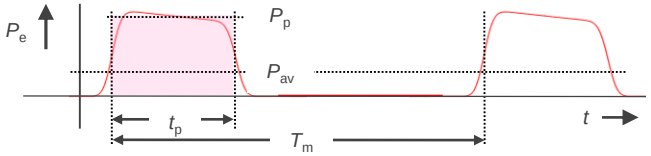
UNDERSTAND WHAT YOU WANT TO MEASURE

- The type of signal and the types of measurements required greatly influence the sensor choice

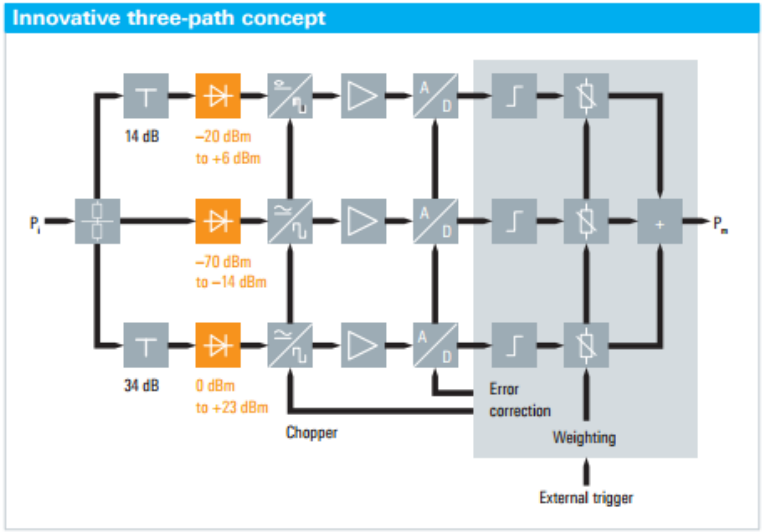
- What type of signal?
  - CW
  - Analog or Digital
  - Pulses, etc



- What type of measurements
  - Average power (CW &/or modulated signals)
  - Time Slotted measurements
  - Envelope power versus time



MULTIPATH SENSORS



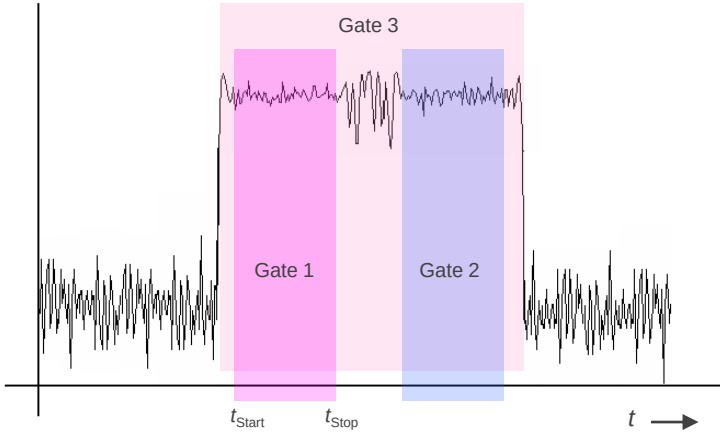
Key Takeaway
Ensure the different paths are overlapping & measuring simultaneously

- Technology
  - Use separate diode paths measure power over a wide range
  - Overlapping paths, simultaneous measurements & signal weighting deliver accurate results
- Performance
  - Widest Measurement Range
  - Fastest Speed
  - Good accuracy
- Best all-round type of sensor

MULTIPATH SENSORS

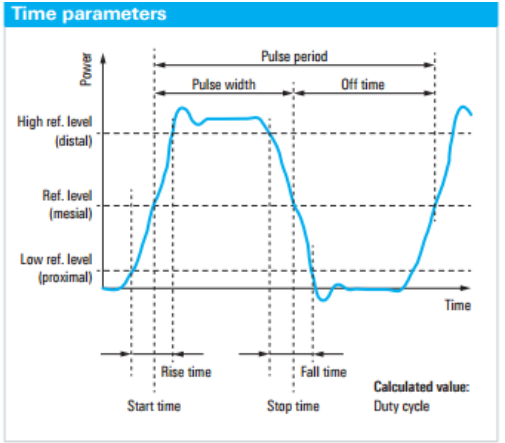
- Measurements
  - Continuous Average
  - Burst Average
  - Time Slot Average
  - Gate Average
  - Trace Measurements

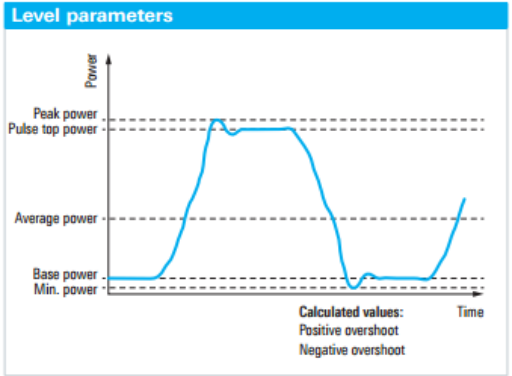
- Disadvantages
  - Video bandwidths can be too narrow for some pulse measurements



WIDEBAND SENSORS AS COMPARED TO MULTI PATH SENSOR

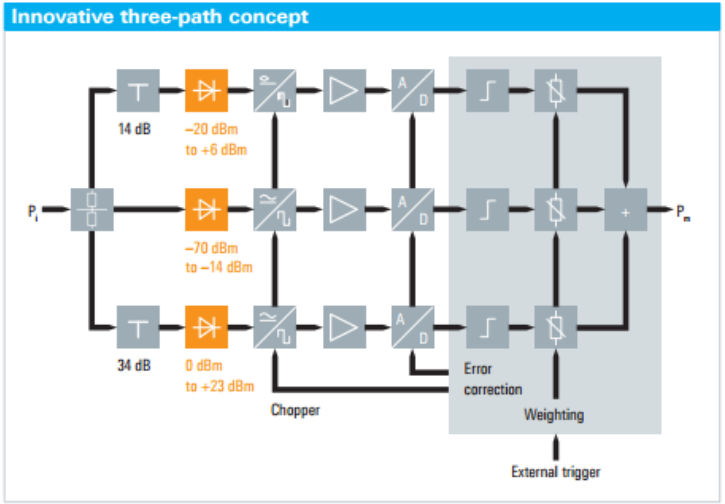
- Advantages
  - Wider Video Bandwidth
  - More types of measurements
- Additional Measurement Capabilities
  - Envelope Statistics
  - Pulse Analysis
  - Time Analysis
- Disadvantage
  - Less measurement range than multipath sensors
  - Slightly higher measurement uncertainty





AVERAGE POWER SENSOR AS COMPARED TO MULTI PATH SENSORS

- Advantages
  - Measures down to 8 kHz
  - Similar performance
- Measurement Capabilities
  - Average Power Only
    - CW & modulated signal
- Disadvantage
  - Limited measurement functionality
- Ideal for EMC applications



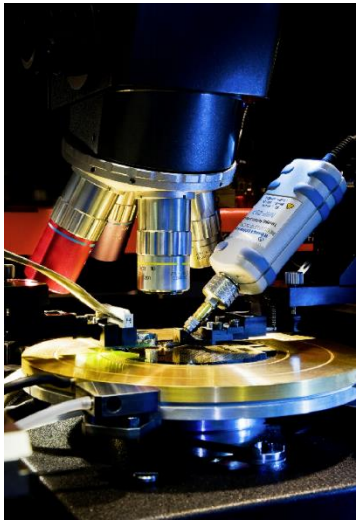
THERMOELECTRIC SENSORS AS COMPARED TO MULTI PATH SENSORS

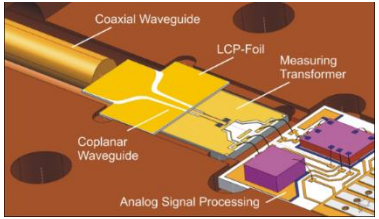
- Advantages
  - Most accurate type of sensor
  - Highest frequency coverage
  - Measures down to DC

- Measurement Capabilities
  - Average Power Only
    - CW & modulated signal

- Disadvantage
  - Small Measurement range
  - Limited measurement functionality

- Ideal for Calibration Labs & demanding reference applications





POWER MEASUREMENTS BY SENSOR TYPE

	Multi Path	Wideband	Average	Thermoelectric
Average Power (CW)	Y	Y	Y	Y
Average Power (modulated signals)	Y	Y	Y	Y
Average Power (modulated signals, gated)	Y	Y		
Pulse Power	Y	Y		
Envelope Power	Y	Y		
Envelope Statistics		Y		
Pulse Analysis		Y		
Time Analysis		Y		

POWER SENSORS

- Leading performance delivers measurements you can trust

- Connect & Control from anywhere
  - Full range of USB and LAN sensors

Power Sensors

Universal	**Get Accurate Results Faster**
Thermal	**Most Accurate Results, from DC to 110 GHz**
Wideband	**Ideal for characterizing Pulses**
Average	**Designed for EMC testing**
OTA	**Accurate, affordable measurement solution for 802.11ad**
Receiver based	**Accurate as power sensor, Sensitive as spectrum analyzer**

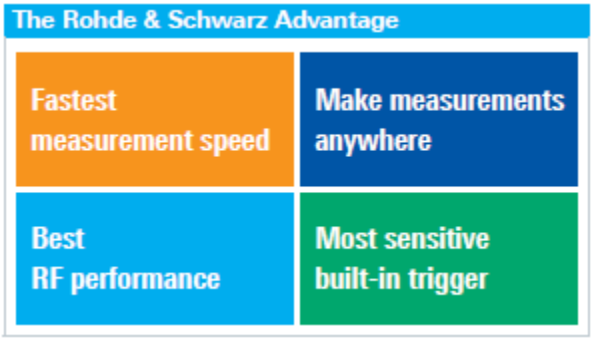
MULTIPATH SENSORS
DELIVER MORE ACCURATE RESULTS, FASTER

Frequency	USB	LAN
8 GHz	NRP8S	NRP8SN
18 GHz	NRP18S	NRP18SN
33 GHz	NRP33S	NRP33SN
40 GHz	NRP40S	NRP40SN
50 GHz	NRP50S	NRP50SN

Key Facts:

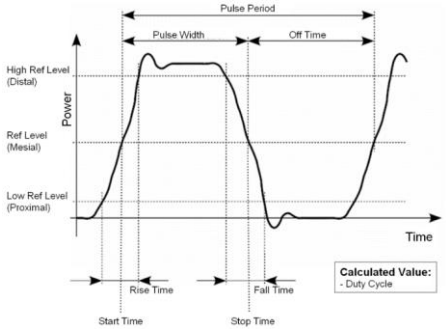
- Range: Measure down to -70 dBm
- Speed: 50,000 measurements / sec

- ► Only LAN Sensors at frequency points
- ► Best Performance, faster speed ensure accurate results are achieved quicker
- ► Outstanding Usability simplify operation and improve results



WIDEBAND SENSORS
IDEAL FOR CHARACTERIZING PULSES

- ► Outstanding dynamic range and accuracy
- ► Time Domain Analysis of envelope power
- ► Automatic Pulse Measurements



Key Facts:

- Measurement Range: -60 dBm to + 20 dBm
- 30 MHz Video Bandwidth
- Rise/Fall Time < 13 ns
- > 9500 measurements / second

Frequency	USB	LAN	RF Connector
18 GHz	NRP-Z81	N/A	N
40 GHz	NRP-Z85	N/A	2.92 mm
40 GHz	NRP-Z86 .v40	N/A	2.4 mm
44 GHz	NRP-Z86 .v40	N/A	2.4 mm

THERMAL POWER SENSORS
MOST ACCURATE RESULTS, FROM DC TO 110 GHZ

Frequency	USB	LAN
18 GHz	NRP18T	NRP18TN
33 GHz	NRP33T	NRP33TN
40 GHz	NRP40T	NRP40TN
50 GHz	NRP50T	NRP50TN
67 GHz	NRP67T	NRP67TN
110 GHz	NRP110T	N/A

Key Facts:

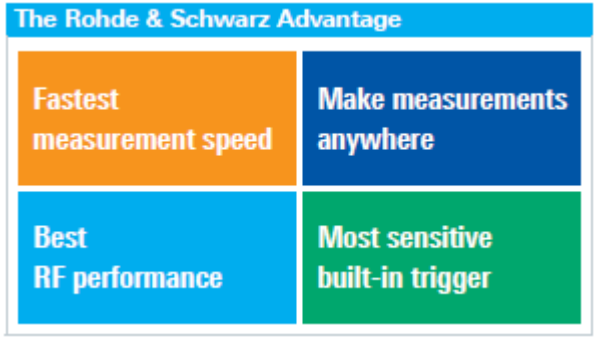
- Measurement Range: -35 dBm to + 20 dBm
- Measures all the way down to DC
- Measurement Speed: 45 ms

- Only Thermal Sensors with LAN support
- Only 110 GHz Coaxial sensor
- Unparalleled performance
  - Most accurate absolute measurements
  - Most accurate relative measurements
- Measures 3 times faster than comparable products
- Only Thermal sensor with 2 Year Calibration cycle

AVERAGE SENSORS IDEAL FOR EMC APPLICATIONS

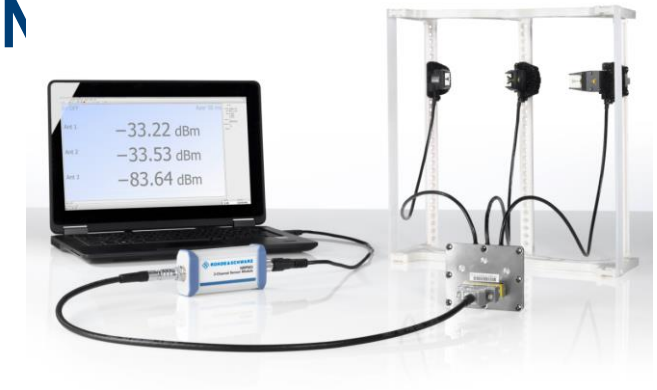
- Measure down to 8kHz
- Lower noise and uncertainty than competition
- More Measurement Range than competition
- Faster Measurement speed than competition
- Deliver results faster than the competition
- Only Average Sensors with LAN interface

Frequency	USB	LAN
8 kHz - 6 GHz	NRP6A	NRP6AN
8 kHz -18 GHz	NRP18A	NRP18AN



NRPM – OTA POWER MEASUREMEN

- Accurate, affordable measurement solution
- Measurements made at high performance antenna to ensure best accuracy
- Scalable to fit to testing requirements
- Can be easily integrated into a Shield Box
- PC Software provides control and displays results in real-time



NRPM Key Specifications	
Frequency Range	27.5 GHz to 75 GHz
Measurement Range	
Continuous Average	-75 dBm to -25 dBm
Trace	-62 dBm to -25 dBm

NRQ6 – FREQUENCY SELECTIVE POWER MEASUREMENTS

- Received based technology enables accurate, fast power measurements down -130 dBm
- Perform all the traditional Power measurements, plus ACLR measuremetns
- Export IQ Data for offline analysis of vector modulation
- Easy operation via built in web browser
- Operate anywhere via LAN + PoE inteferace

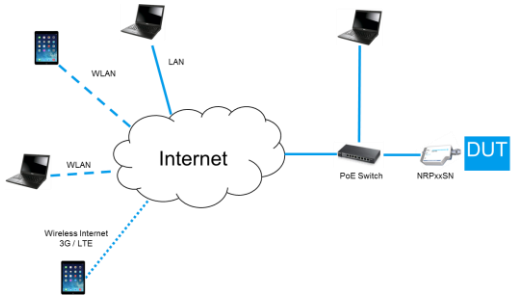
NRQ6	
Frequency Range	50 MHz to 6 GHz
Measurement Range	-130 dBm to + 20 dBm
Analysis Bandwidth	100 MHz
Measurement Uncertainty	0.06 dB
Linearity	0.02 dB

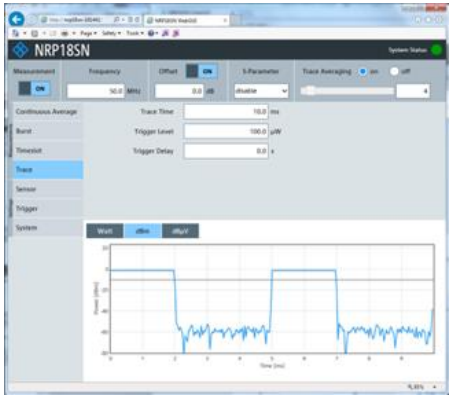
FROM A PC OVER THE USB INTERFACE

- Connect through USB and use windows based PC software
- Removes the need for Base Unit without giving up functionality
- When enabled with USBTMC sensors can be easily integrated into ATE systems
- For field use, control through a mobile device

CONTROL DIRECTLY OVER ETHERNET

- LAN sensors have the same performance and capabilities as the USB based equivalent
- Ideal for ATE systems or remote monitoring site
- Built in Web Server allows for real-time monitoring from multiple locations





OPERATING WITH A TRADITIONAL BASE UNIT

- Manually control and make measurements from the front panel
- Control multiple sensors from a single instrument
- Single Trigger point for multiple sensors
- Remote control via GP-IB, LAN and USB
- Emulation Mode that enables drop in replacement of Legacy power meters
- Built in Reference source checking sensor

SUMMARY

- Signal type and measurement requirements will decide the type of sensor
- Comparing sensor performance requires more than just comparing the banner specs
- Many different ways to operate sensors

- Power Sensors from Rohde & Schwarz offer
- Leading Performance
  - Lowest Noise Floor
  - Lowest Uncertainty Factors
  - Fastest Measurement Speed
- Outstanding Usability
  - LAN interface
  - Built in Triggering
  - Gamma correction
  - Compensation for S Parameters

Div.8 Military Measurement

R&S®ZPH

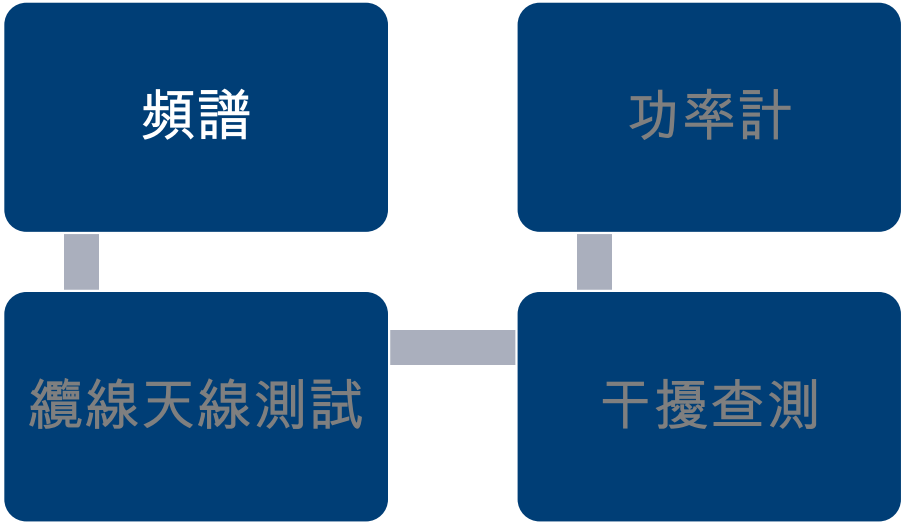
Robert Chen
2024/06/14

ROHDE&SCHWARZ
Make ideas real

R&S®CABLE RIDER ZPH
手持式頻譜分析儀

- 頻譜
- 功率計
- 纜線天線測試
- 干擾查測

R&S®CABLE RIDER ZPH
手持式頻譜分析儀



R&S®CABLE RIDER ZPH: 頻譜模式

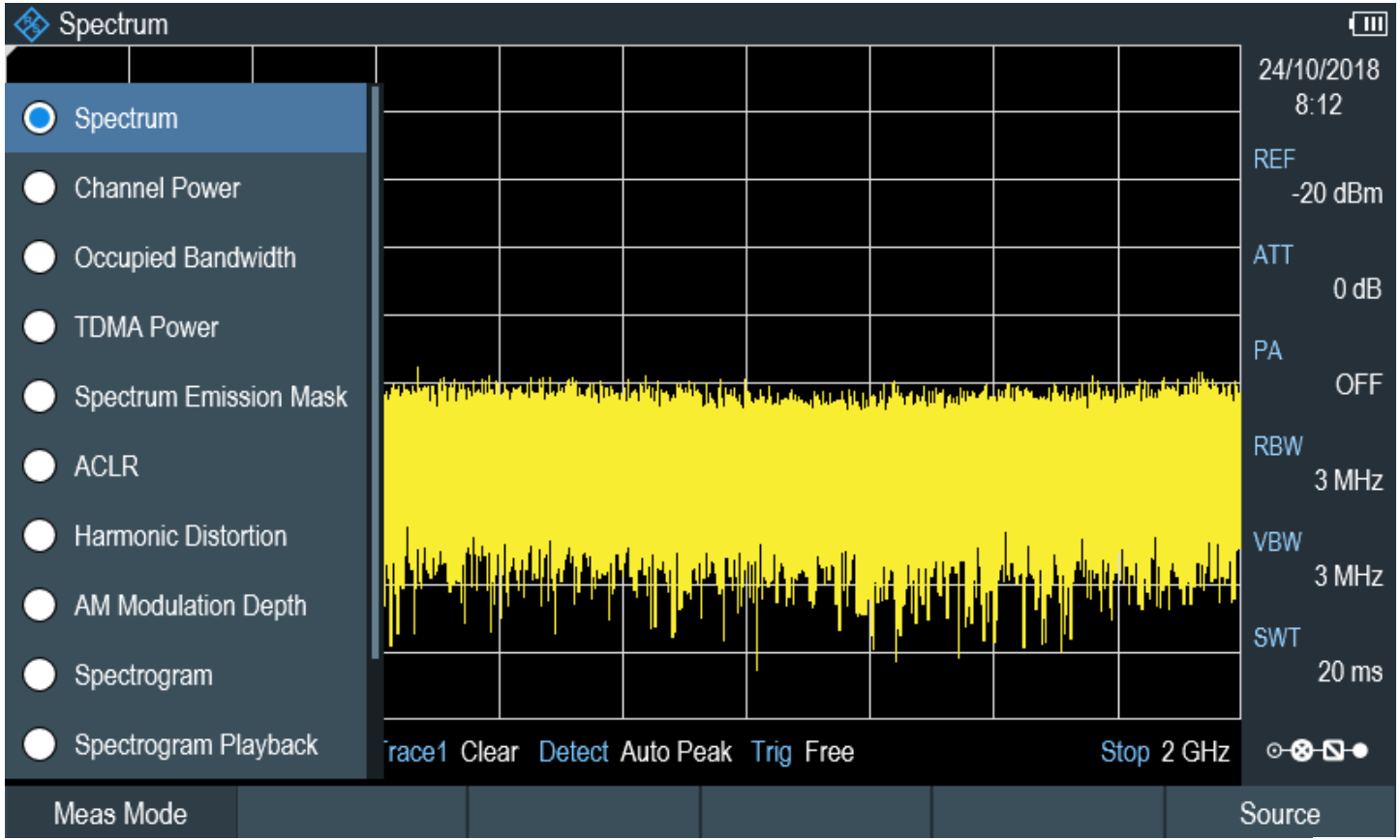
► 頻譜模式可以幹嘛?

利用頻譜觀察空氣中看不見的訊號的狀態。

觀察有興趣的訊號特徵，例如頻點、頻寬，
更進一步可以進行訊號解析，看看是什麼樣的調變。

各式訊號分析功能等等....

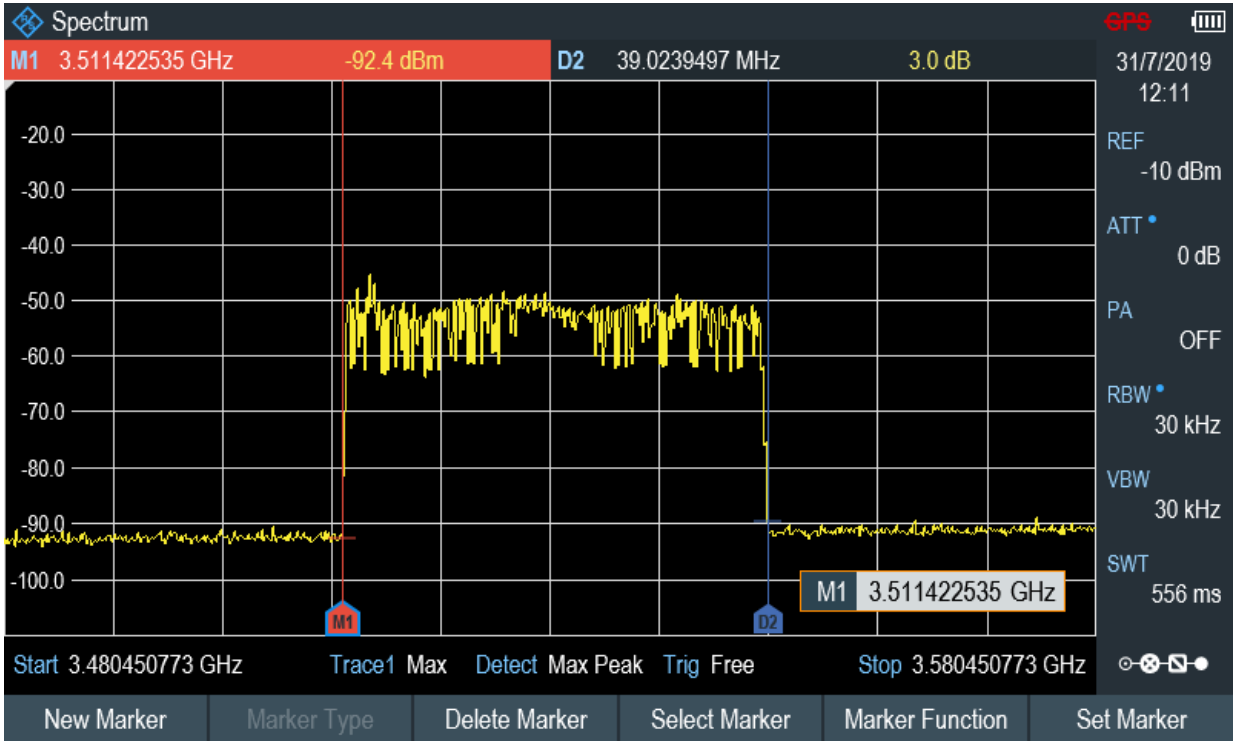
R&S®CABLE RIDER ZPH: 頻譜模式



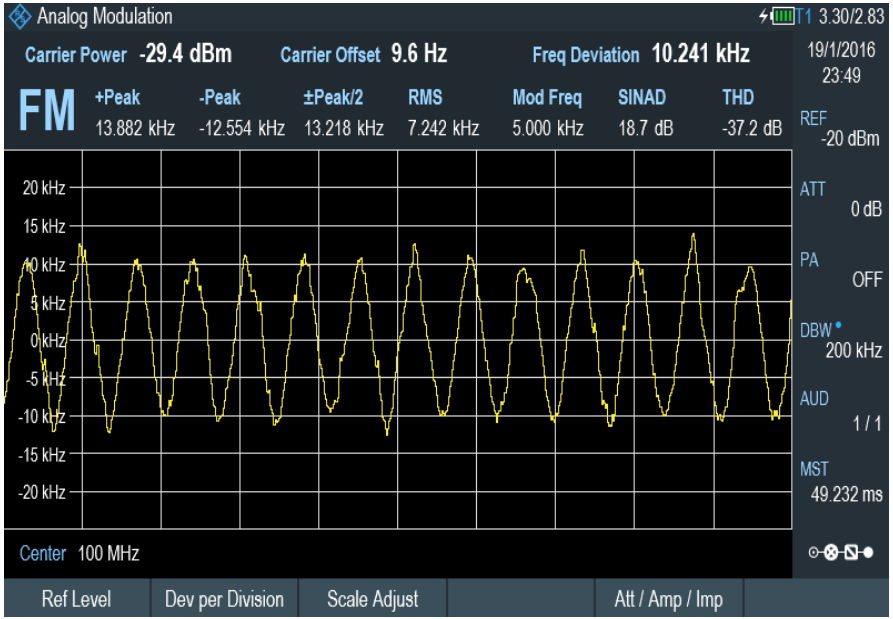
R&S®CABLE RIDER ZPH: 頻譜模式
頻譜分析– 占用頻寬 OCCUPIED BAND WIDTH (OBW)

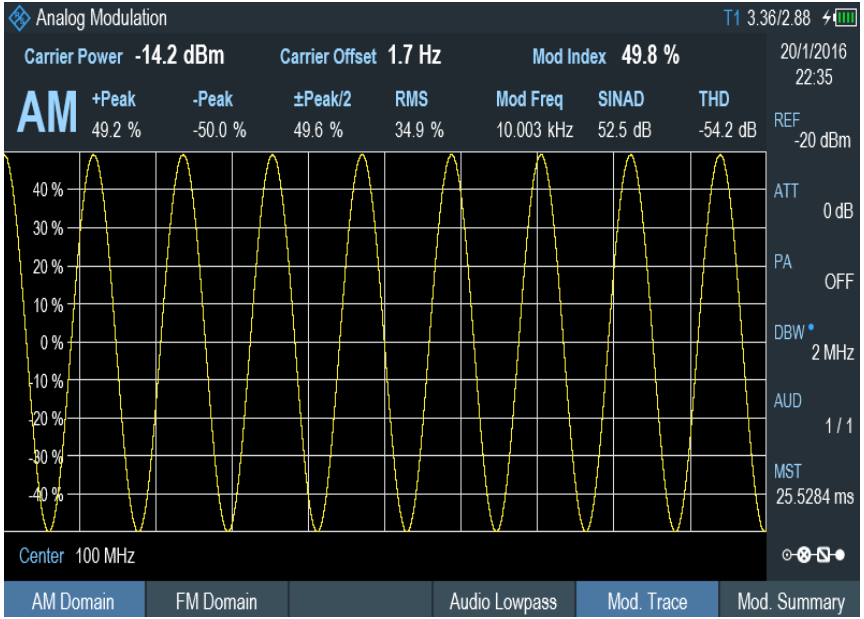
使用Max Hold 功能來分析該訊號的頻寬大小

Yellow Trace = Max Hold

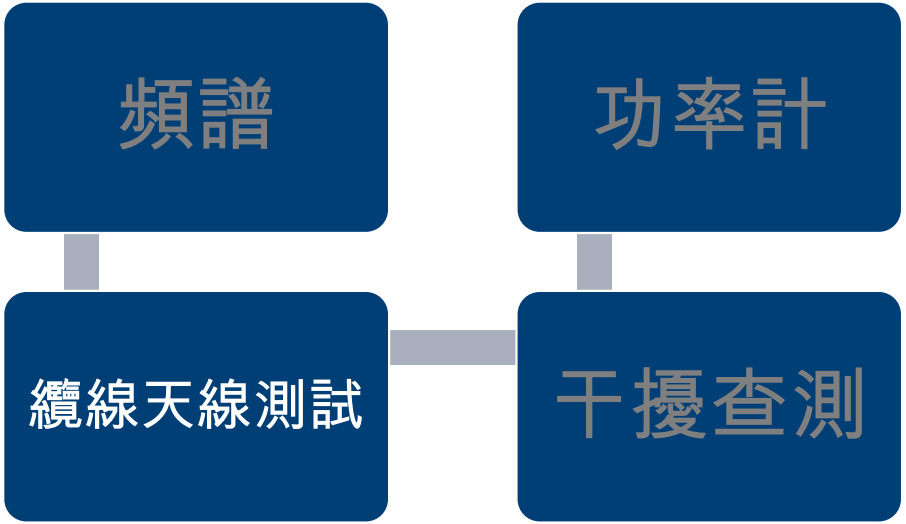


R&S®CABLE RIDER ZPH: 頻譜模式
AM/FM & ASK/FSK 分析





R&S®CABLE RIDER ZPH
手持式頻譜分析儀



R&S®CABLE RIDER ZPH: 網路分析儀 纜線天線測試器

► 網分模式可以幹嘛?

利用追蹤訊號功能，來觀察設備在不同頻率點的反應，稱之為頻率響應。

可以測試天線是否符合規定，
也可以測試纜線的loss，
以及DTF斷點測試。

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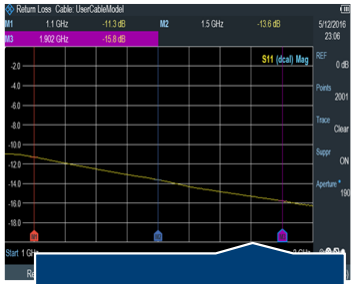
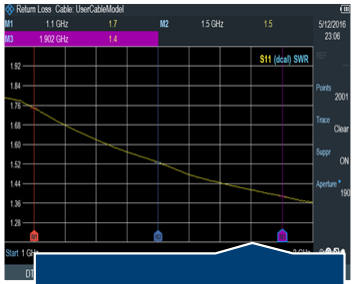
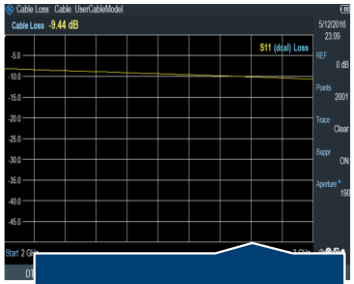
Distance to fault (DTF)



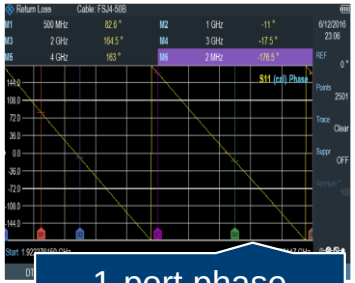
Return Loss



VSWR



1-port Cable Loss



1-port phase measurement

Smith chart

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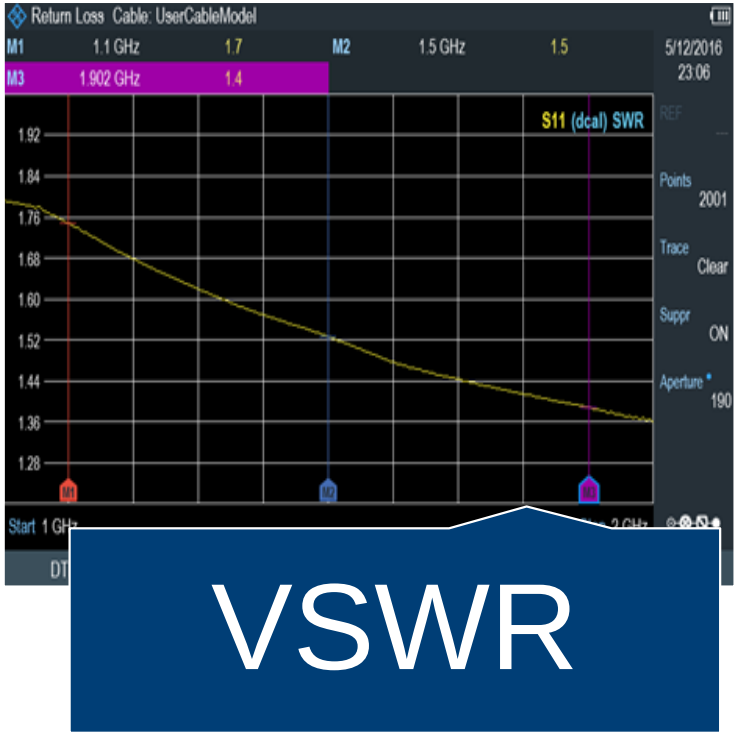


- 反射駐波比

量測順向功率以及反射功率
理想值1:1.0
阻抗匹配，可獲得最大功率轉移。

一般天線的VSWR條件在 < 1.5 , < 2

$$VSWR = \frac{(1+(10^{(RL/20)}))}{((10^{(RL/20)})-1)}$$

$$RL = 20LOG10\left(\frac{(VSWR+1)}{(VSWR-1)}\right)$$

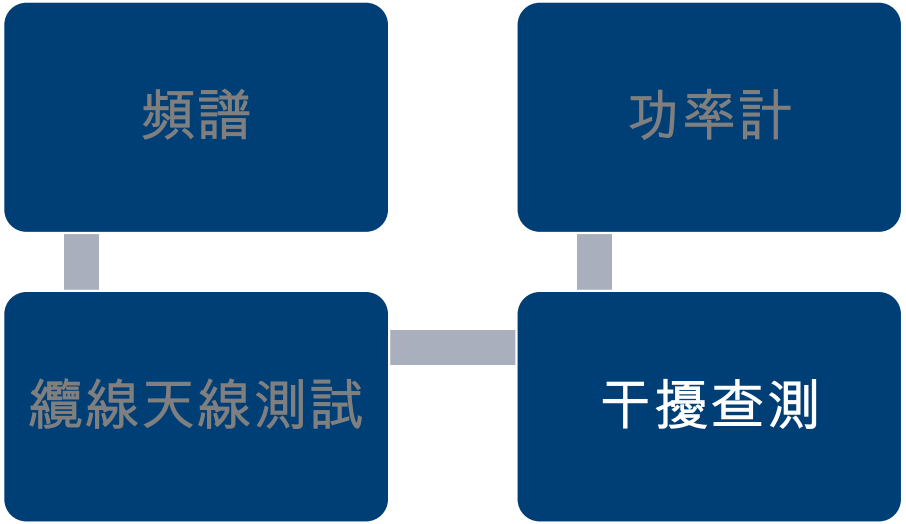
INTRODUCING THE R&S®CABLE RIDER ZPH 2 PORT MODEL

Expect **Fast & Efficient**

MORE

- ✓ 內建式 VSWR 橋接器
- ✓ 支援 S11 and S21 量測

R&S®CABLE RIDER ZPH
手持式頻譜分析儀



R&S®CABLE RIDER ZPH: 干擾查測

► 發生訊號遭到干擾怎麼辦?如何查測干擾訊號?

利用ZPH頻譜功能搭配指向型天線，來量測干擾訊號的來源方向(DF-AOA)
利用多個點位的AOA結果，可以採用三角定位法來找出干擾訊號源。

RF INTERFERENCE
ROHDE & SCHWARZ SOLUTIONS

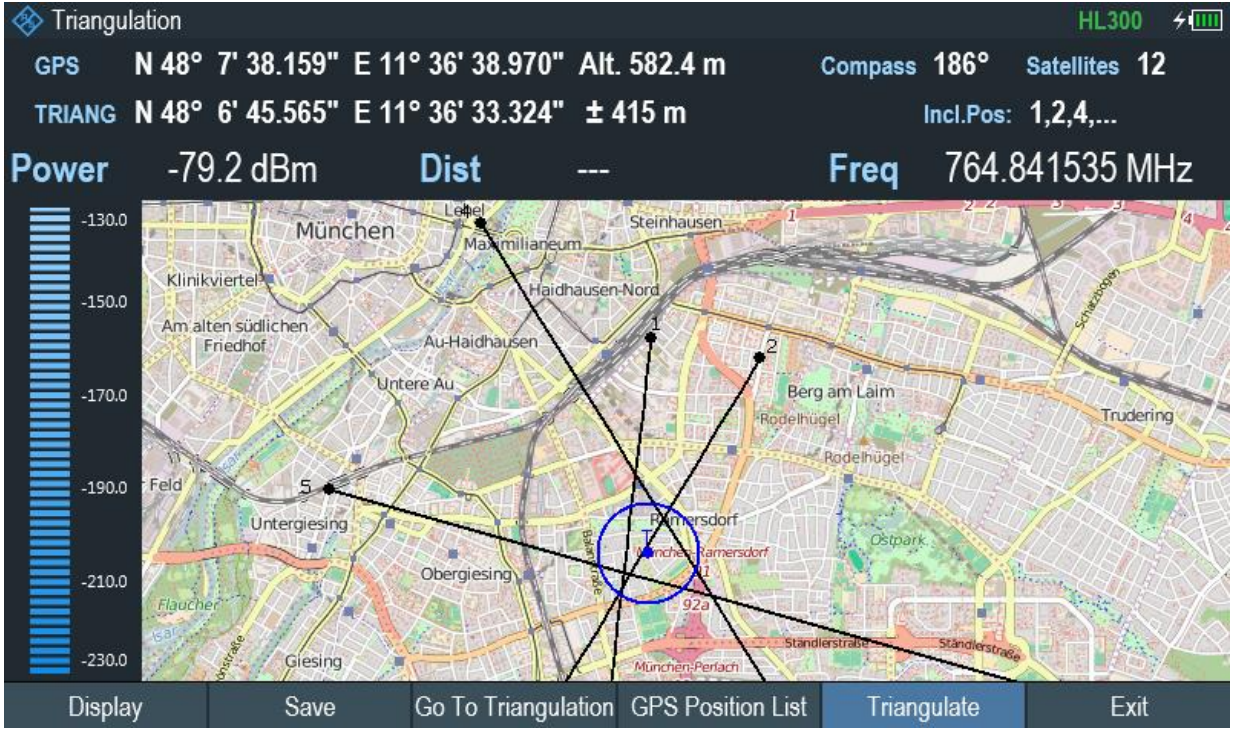
► 手持式頻譜分析儀+指向性天線

R&S®Spectrum Rider FPH + R&S®HA-Z900 Yagi 天線

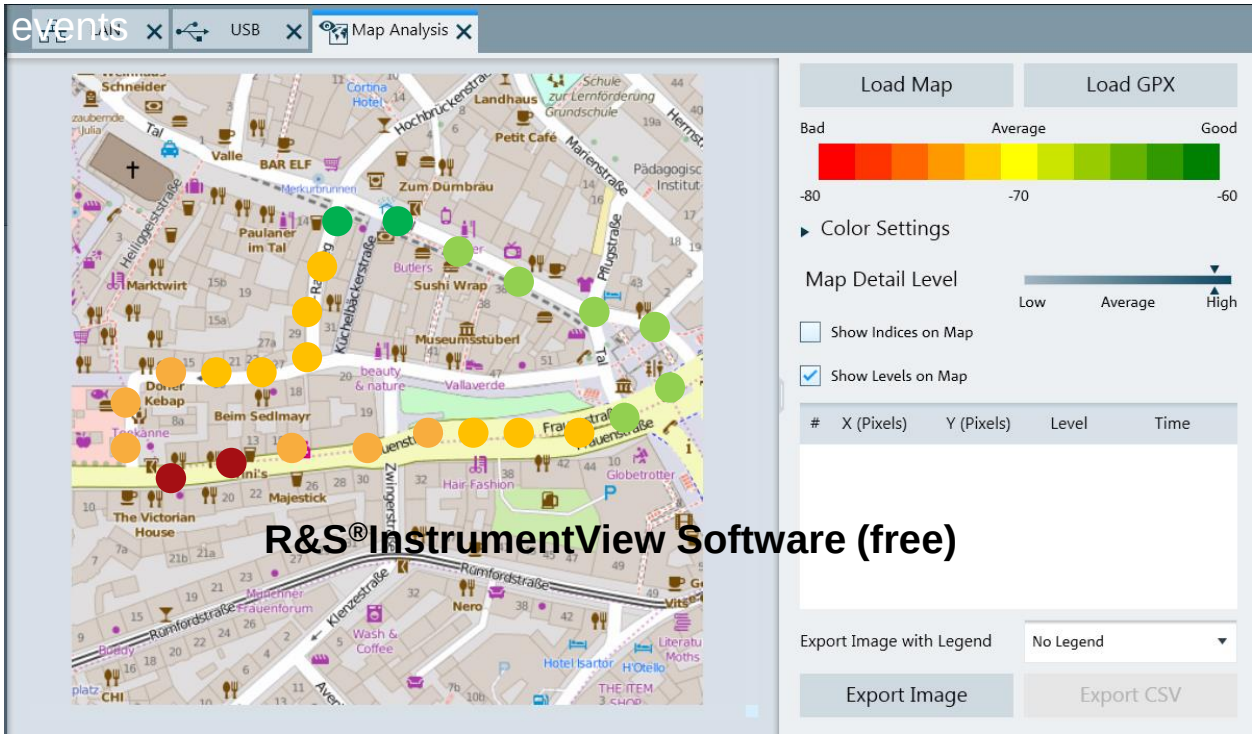
R&S®HE400 指向型天線

RF 干擾查測

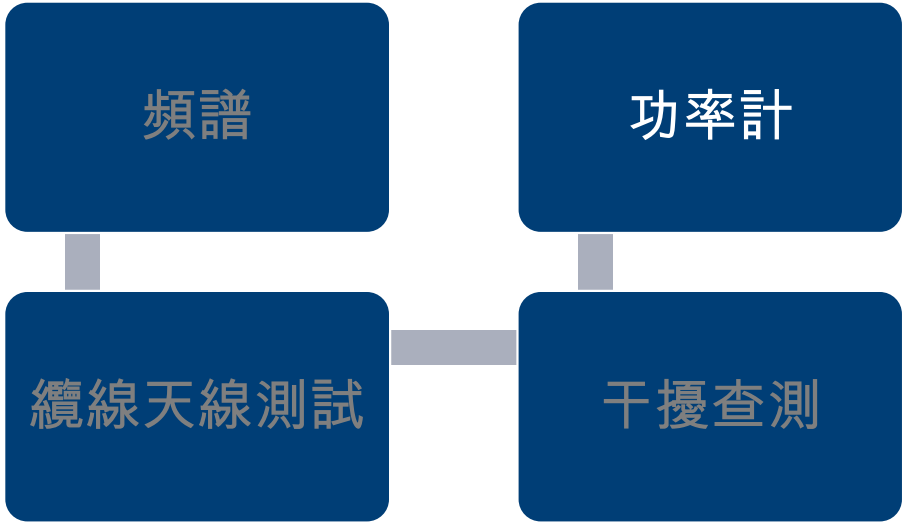
R&S®CABLE RIDER ZPH:
干擾查測 – 三角定位法



R&S®CABLE RIDER ZPH: SPECTRUM MODE
訊號強度分佈圖



R&S®CABLE RIDER ZPH
手持式頻譜分析儀



R&S®CABLE RIDER ZPH: 功率計

► 量測功率，可搭配Power Senser。

須注意不可直接將無線電或其他RF訊號直接接入儀表，
以免造成設備損壞。(RF in port燒毀，人為操作損壞)

R&S®ZPH-K9 功率計 SENSOR
精準的功率量測

Average Power Sensor

NRP-Zx
Measurements up to 110 GHz

Wideband Power Sensor

NRP-Z8x
Measurements up to 44 GHz
Pulse analysis down to 50 ns pulses

Directional Power Sensor

FSH-Z14/44
Measurements up to 4 GHz

R&S®ZPH-K9 功率計 SENSOR SUPPORT

Use power sensor for

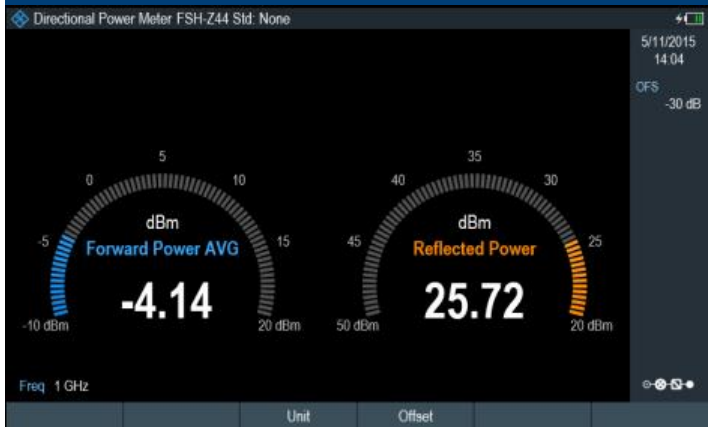
- very precise power measurement
- Power measurement beyond analyser frequency
- Forward and reflected power measurement

For installation and maintenance of

- Radar system
- Satellite system
- Mobile radios
- Broadcast transmitter

R&S®ZPH-K9 功率計 SENSOR SUPPORT

Example



R&S FSH-Z44/-Z14

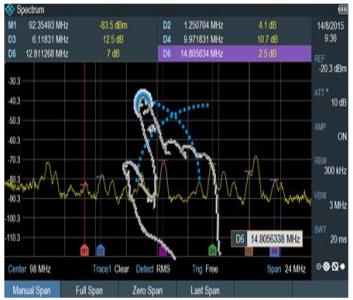
Antenna

Transmitter

USB port

R&S®CABLE RIDER ZPH
特點

觸控螢幕



- 可調整頻譜
- 可調整頻寬
- 可以設定參數
- 輕易調整Marker

抗強光反射面板

- 在強光大太陽下，可清楚閱讀與操作儀表。
- 減少眼睛疲勞

背光鍵盤

- 可在光線不佳時，輕易操作
- 內部光源顯示

無風扇設計

- 無噪音
- 可防塵
- 抗濕氣保護

R&S®ZPH 實機展示

- 情境題1 :

  承上午的題目，使用者說 無線電沒聲音?怎麼排查?

- 情境題2 :

  無線電定期維護檢查? 測哪些?

無線電實機測試展示

無線電機

RF電纜線

天線

CMA180
無線電綜合測
試儀

ZPH
掌上型頻譜分
析儀

無線電實機測試展示

- 可能的情況有哪些?

- 另一端無線電訊號是否有正確送出?(頻譜模式)
- 天線壞掉? (網分VSWR)
- 轉接頭防水失效導致，接頭進水? (網分VSWR，cable loss)
- 纜線中間有劇烈凹折處，
  甚至纜線斷掉? (DTF斷點測試)

簡報結束

- 簡報結束，謝謝聆聽