# *Module contents*

★ **Avaya Wireless versus** Avaya Wireless

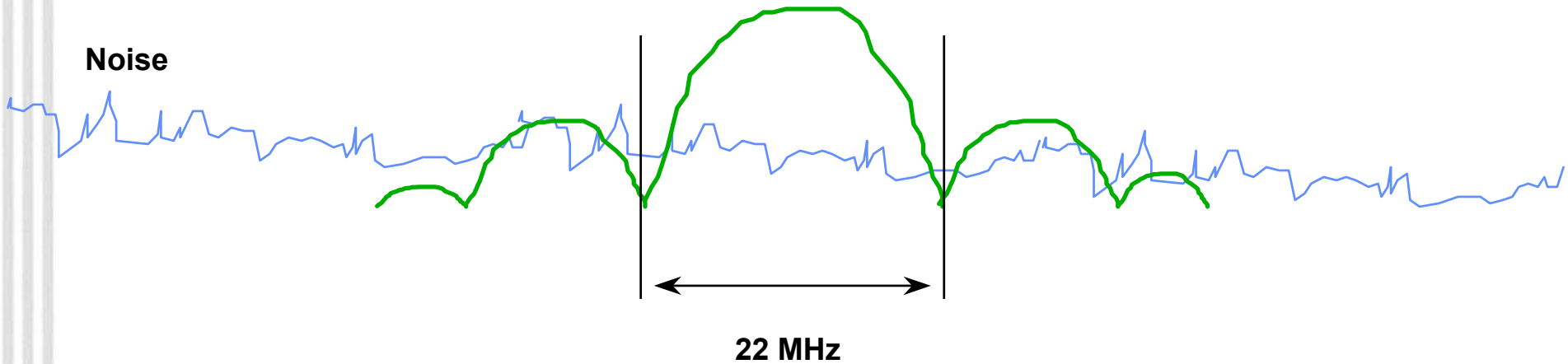
★ The ISM Band

★ Sources of interference

★ Methods to coexist

# *Avaya Wireless versus Avaya Wireless*

*Terminology - Channel*




- ★ 22 MHz wide band used for data communication of up 11 Mbit/s
- ★ forward looking error correction through 11x spreading code
- ★ Avaya Wireless Signal level at least 10 dB stronger than Noise level,

  e.g. when noise is -80 dBm than required Avaya Wireless signal is -70 dBm

# *Avaya Wireless versus Avaya Wireless*

*Terminology - Deferring*

- ★ Multiple stations can share the same channel through CSMA/CA
- ★ Avaya Wireless PC Card radio recognizes other Avaya Wireless transmissions in the same band as being a RF modem and will defer (I.e. wait for other stations transmission to be completed)
- ★ Avaya Wireless PC Card only defers for signals that are recognized as “RF modem signal”, not for all detected RF energy
- ★ Deferring manifests implies sharing bandwidth

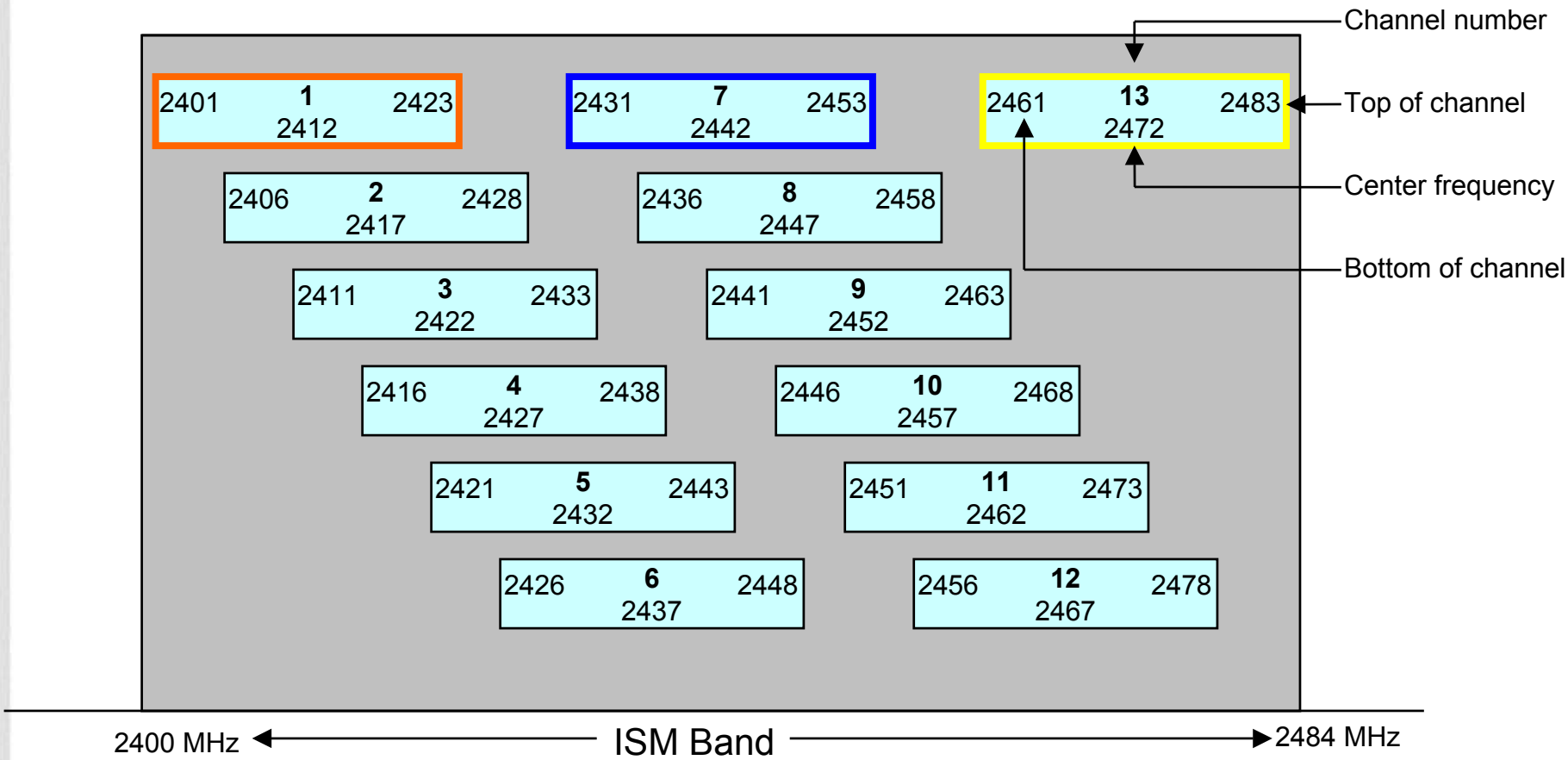
# *Avaya Wireless versus Avaya Wireless*

*Terminology - Interference*

- ★ Any form of RF energy sensed by the radio, and that is not recognized as a RF modem signal, is considered “interference”
- ★ Avaya Wireless PC Card radios will not defer for interference
- ★ Interference may lead to loss of packets, and re-transmissions and to a fallback to lower speed
- ★ Interference depends on position of the source of disturbance relative to the receiver
- ★ Interference manifests itself to a user as a reduction in coverage distance and performance

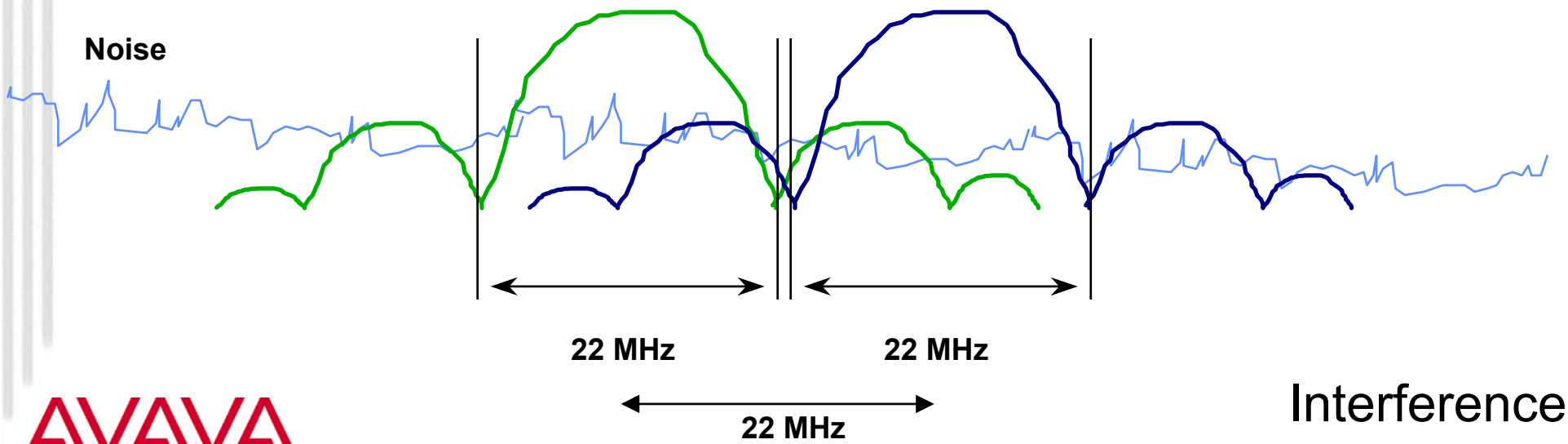
# Avaya Wireless versus Avaya Wireless

*Multiple channels in the available band*



# *Avaya Wireless versus Avaya Wireless* *Terminology - Channel separation*

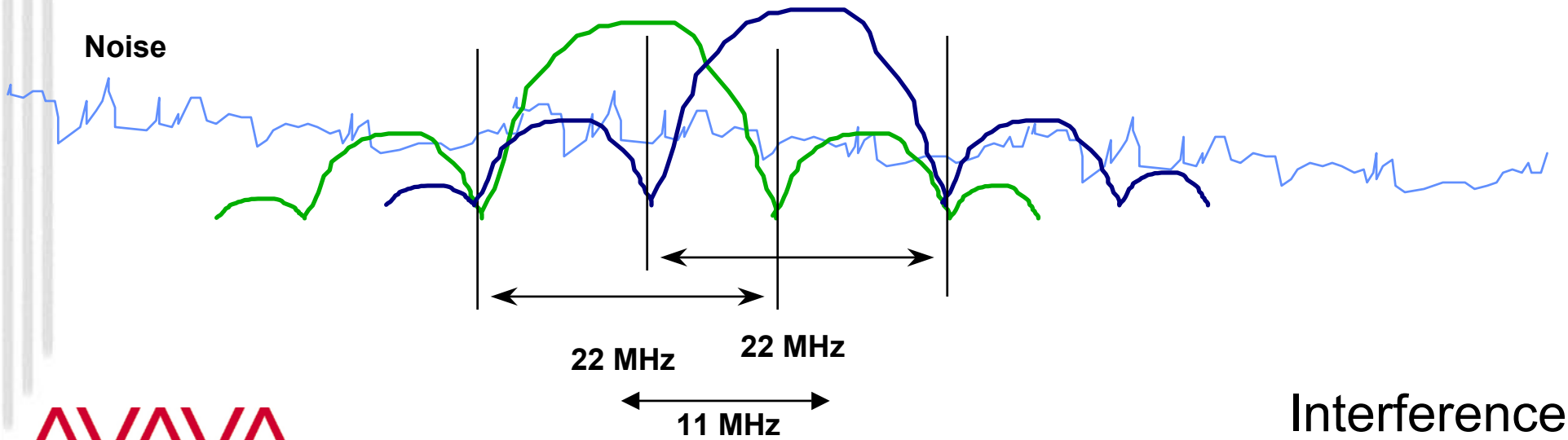
- ★ Distance between the center frequency of channel when multiple channels are used
- ★ Side lobes may overlap:
  - ★ Signal level at 11 MHz from center low enough to be non - interfering with channel at 22 MHz distance (center to center)



# *Avaya Wireless versus Avaya Wireless*

*Terminology - Channel separation*

- ★ Insufficient channel separation
- ★ Main lobes also overlap:
  - ★ Signal level at 11 MHz from center will not be strong enough to be sensed due to the signal strength of the other channel
  - ★ One channel senses the other channel's transmission as interference




AVAYA communication

# *Avaya Wireless versus Avaya Wireless*

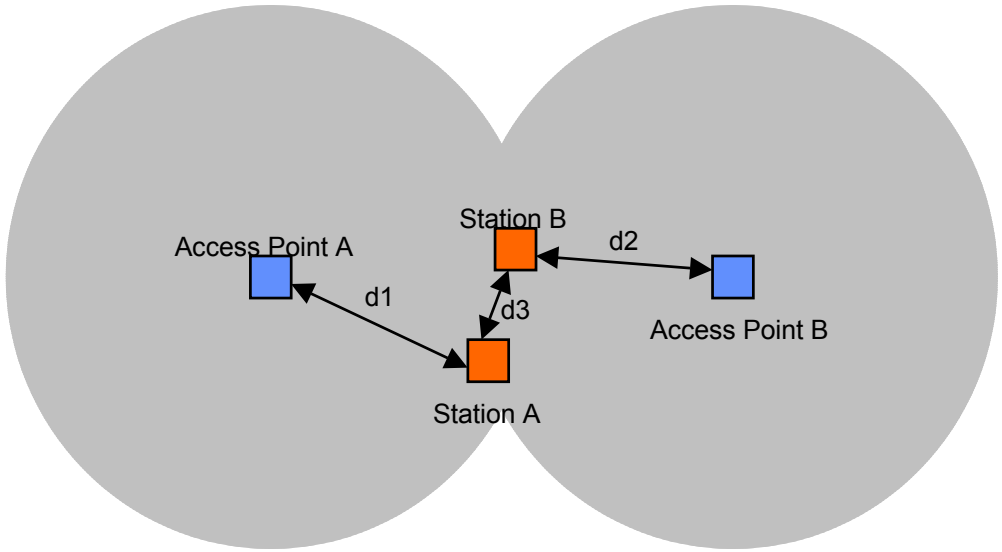
*Terminology - Adjacent Channel Rejection*

- ★ Capability of the Avaya Wireless PC Card receiver to recognize the transmission of an adjacent channel as a RF modem signal and filter it as such making the receiving station defer for the signal
- ★ Expressed as delta of strength of the “in-band” signal and the signal received from the adjacent channel (in dB)
  - ★ ACR measured to be 35 dB, meaning: if signal from adjacent channel is 35 dB stronger that the in-band channel, it can be recognized and rejected
- ★ Depends on the channel separation and the physical distance between the receiving station and the transmitting station in the other band (Near-Far Behavior)

# Avaya Wireless versus Avaya Wireless

*Terminology - Near-Far Behavior*

- ★ Impact of physically nearby station that operates in different channel
- ★ Seen as interference - no defer
- ★ Minimum distances need to be observed to allow good operation




| Station-A's channel | Station-B's channel | | | | |
|---|---|---|---|---|---|
| Channel 1 | Channel 3 | Channel 4 | Channel 5 | Channel 6 | Channel 7 |
| Distance d3 | 5-10 meter | 1-4 meter | 1-2.5 meter | 1-2 meter | 1-1.5 meter |

d1 = d2 = 20 meter

# *Module contents*

★ Avaya Wireless versus Avaya Wireless

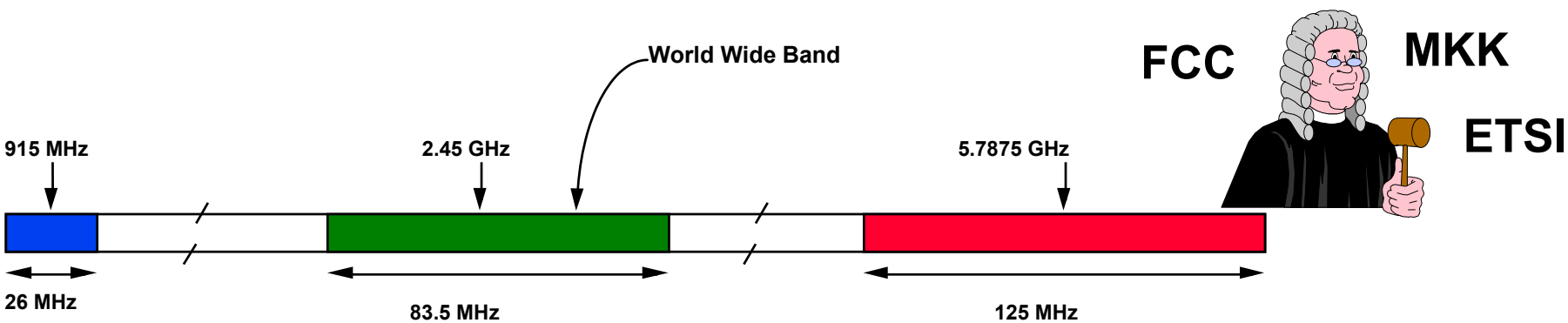
★ **The ISM Band**

★ Sources of interference

★ Methods to coexist

# The ISM Band

★ Dedicated band made available for radio LANs
★ Industrial, Scientific and Medical band : 2400 - 2483.5 MHz
★ Set aside under ETSI (EMEA), FCC (USA), MKK (Japan)
★ Each country endorses band (local type approval)
★ Regulatory body can help out in case of “Illegal users”

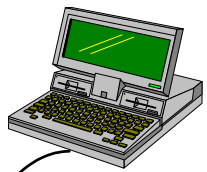


# The ISM Band

*2400 - 2483.5 MHz ISM  Band Mix*

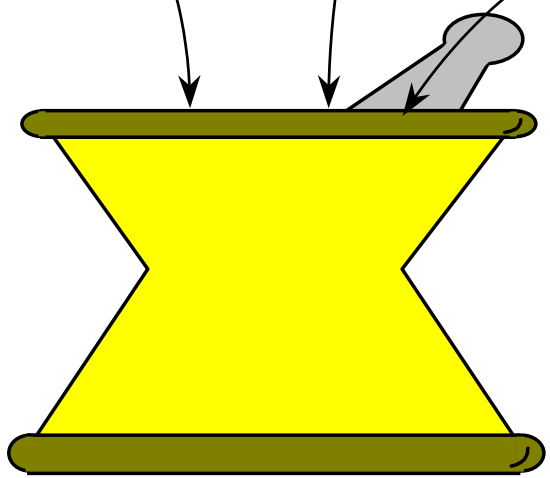
Microwave Ovens & other
Industrial, Scientific equipment

1 Watt leakage



Wireless LANs, WANs
all ISM bands @ 100 mWatt

Government & Military
radio links



# *Module contents*

★ Avaya Wireless versus Avaya Wireless

★ The ISM Band

★ **Sources of interference**

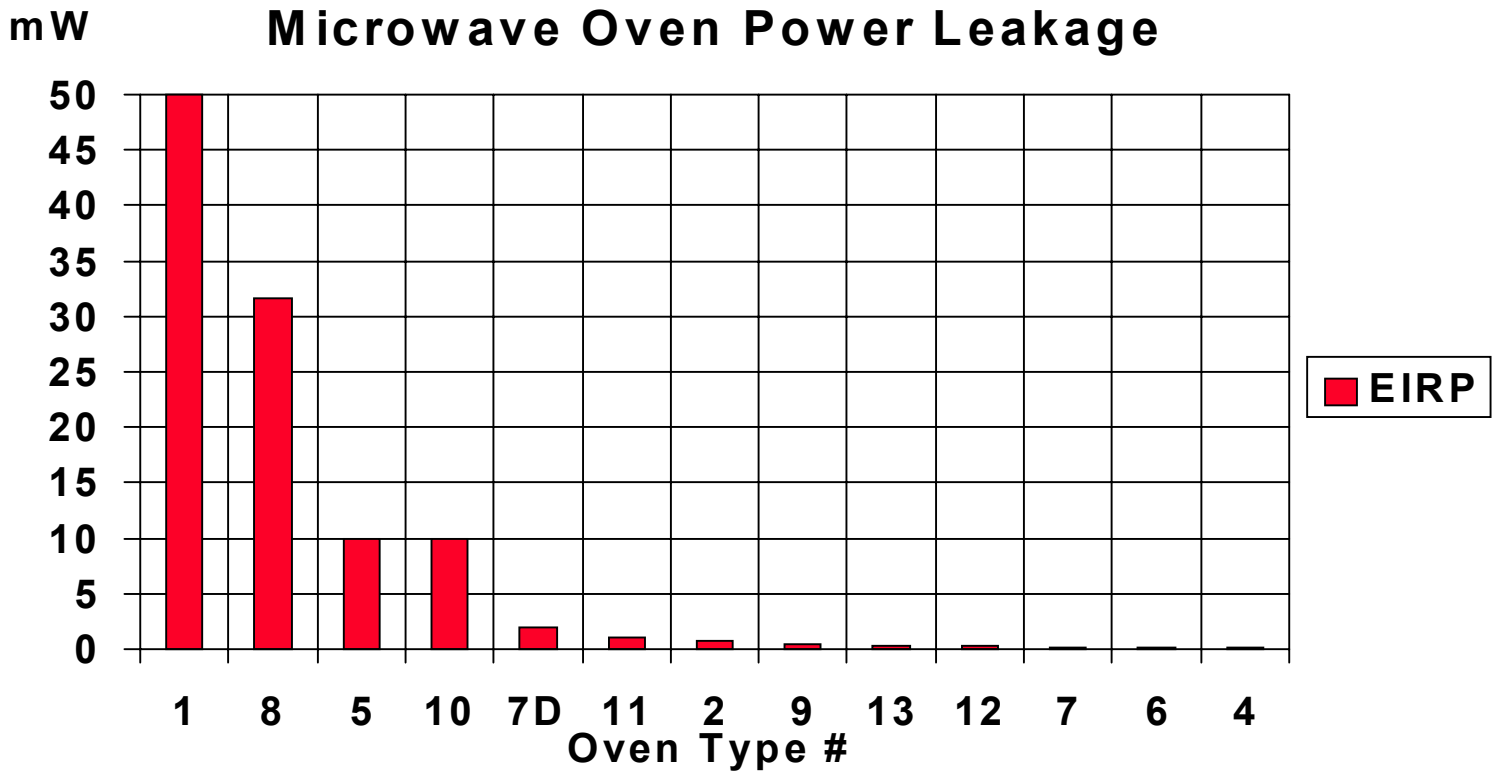
★ Methods to coexist

# *Sources of interference*

- ★ Microwave ovens
- ★ Other wireless systems
- ★ Electrical devices
- ★ Passive systems

# Sources of interference

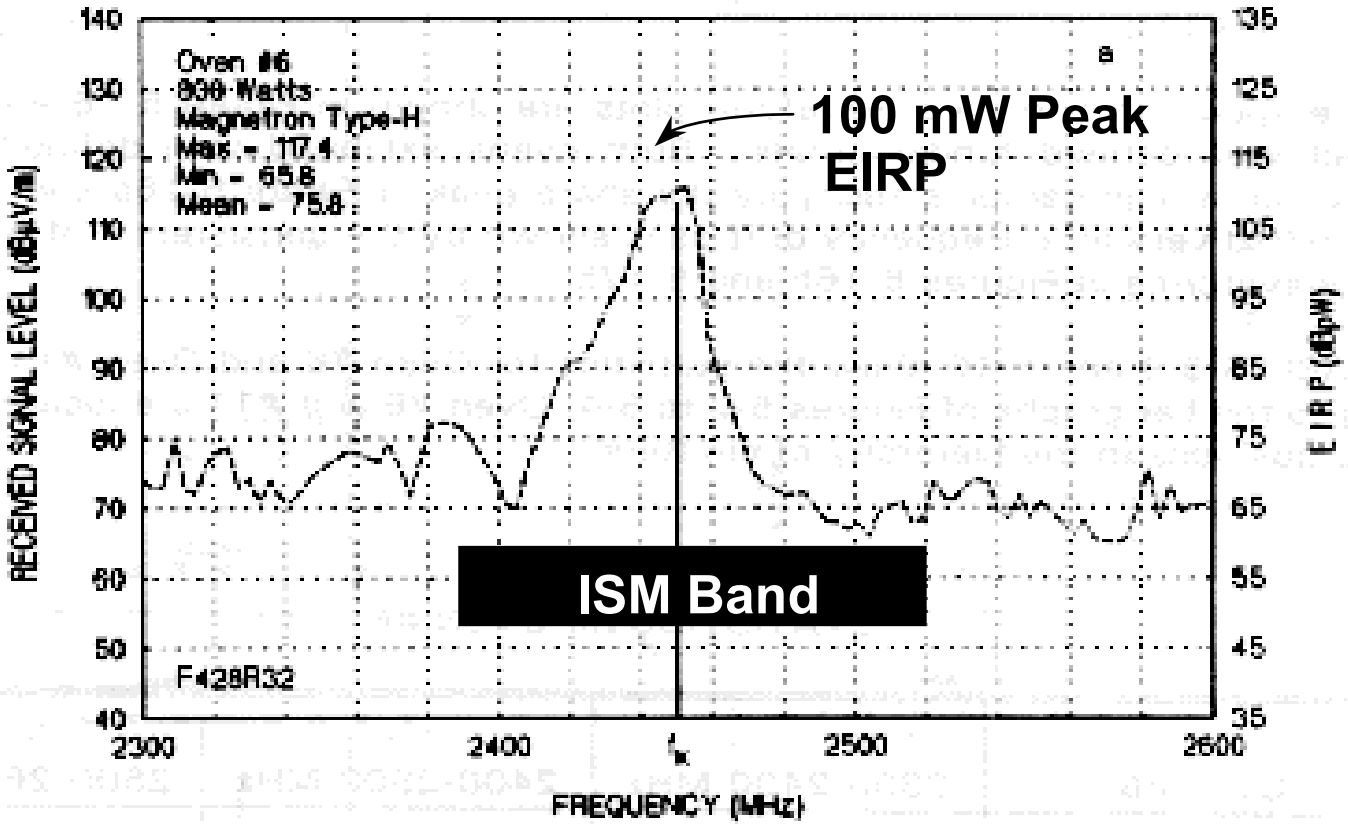
*Microwave oven*




**Data from NTIA Report 94-303-1 US department of Commerce**

# Sources of interference

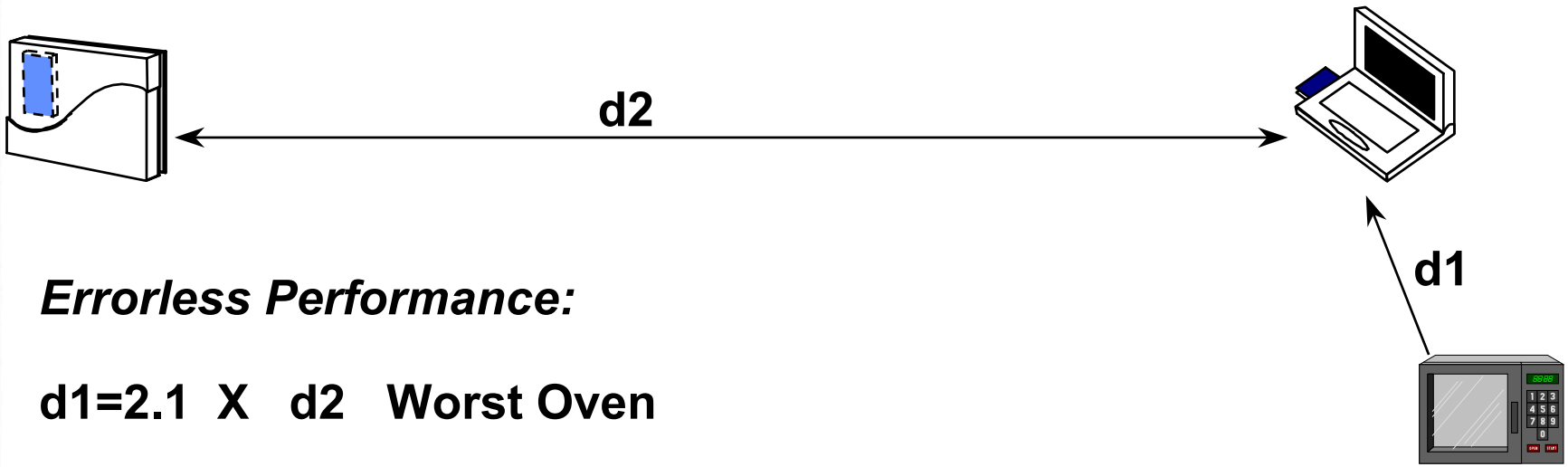
*Microwave oven - example of spectrum used*




**Data from NTIA Report 94-303-1 US department of Commerce**

# Sources of interference

*Microwave oven - operational distances*




***Errorless Performance:***

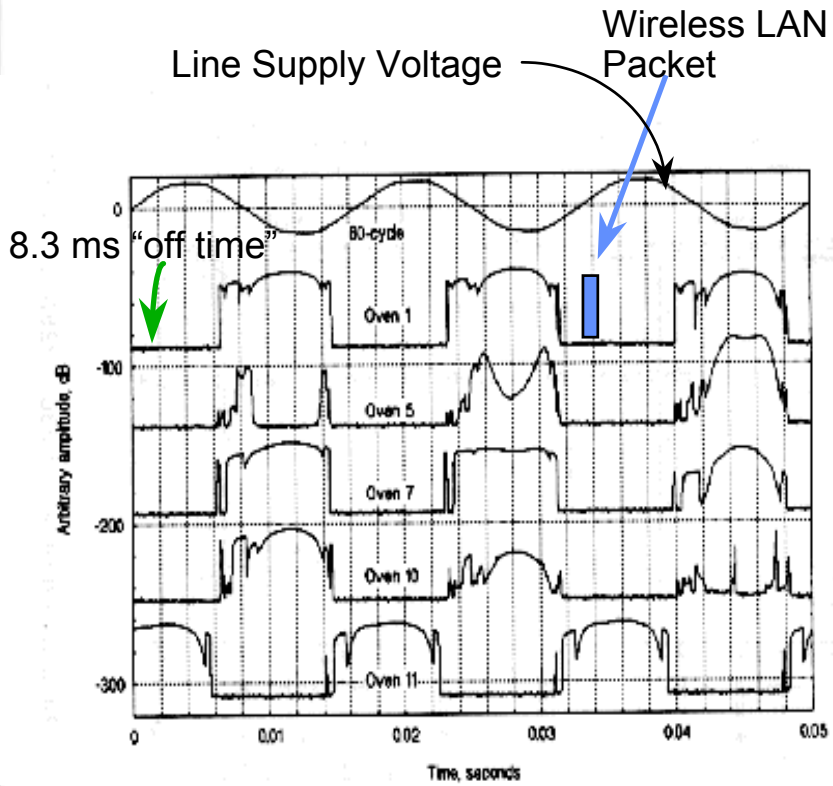
**d1=2.1 X d2 Worst Oven**

**d1= .6 X d2 Average Oven**

**d1= .35 X d2 Best Case Oven**

# Sources of interference

*Time Domain Emission of Microwave Oven*




- ★ Microwave oven uses on/off cycle
- ★ Off cycle could be used to get wireless transmissions through
- ★ Depending on the power cycle (50 or 60 Hz), the "off time" equals to 10 or 8.3 msec
- ★ Transmitting a max size packet (1500 bytes) takes app.:

| | |
|---|---|
| 12.5 msec | @1 Mbps |
| 6.2 msec | @2 Mbps |
| 2.3 msec | @5.5 Mbps |
| 1.1 msec | @11 Mbps |

Data from NTIA Report 94-303-1 US department of Commerce

# Sources of interference

*Microwave Oven robustness*


- ★ Under normal operational settings, the Avaya Wireless PC Card will fall back in speed after two successive lost ACKs (which can happen as result of interference)
- ★ If the Microwave Oven is the source of the interference, it would mean that the situation gets worse (lower speed means less chance to hit the off-cycle)
- ★ Selecting “Microwave Oven Robustness” avoids falling back in speed too quickly and never drops to 1 Mbps

# *Sources of interference*

*Other wireless systems*

- ★ Other ISM systems
  - ★ Wireless LANs (FH and DS) typically use low power if adhere to regulations
- ★ Other (unknown Avaya Wireless users)
  - ★ Office buildings with more than company
  - ★ May need coordination between IT staff of Avaya Wireless using companies
- ★ Non-ISM systems
  - ★ High powered devices
  - ★ May need arbitration from regulatory authorities

# *Sources of interference*

*Electrical devices*

- ★ Indoor:
  - ★ Elevator motors
  - ★ Overhead cranes with heavy spiking electric motors
  - ★ Welding equipment
- ★ Outdoor elements
  - ★ Power lines
  - ★ Electrical railroad track
  - ★ Power stations

# *Sources of interference*

*Passive systems*

## Passive systems

- ★ Indoor
  - ★ walls that contain metal
  - ★ cabinets
  - ★ metal desks
- ★ Outdoor
  - ★ Structures, buildings etc
  - ★ Moving objects: aircraft, cranes, vehicles

# *Module contents*

★ Avaya Wireless versus Avaya Wireless

★ The ISM Band

★ Sources of interference

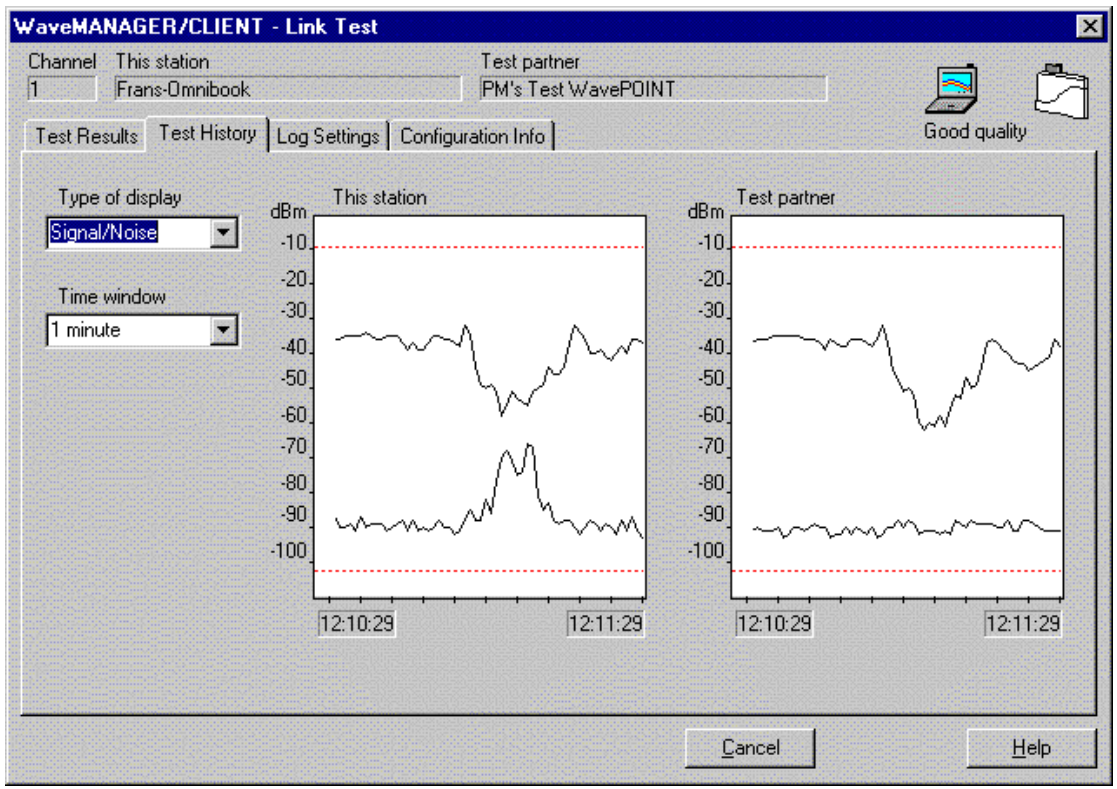
★ **Methods to coexist**

# *Methods to coexist*

*Locate source of interference*

★ Avaya Wireless Client Manager provides noise level reading

★ Select channel and roam looking for noise spikes:



# *Methods to coexist*

*Access Point and Station deployment*

★ Proper site survey to identify potential sources of interference

★ Proper positions of the AP-1000 / AP-500 systems as far away from potential sources of interference

★ Deploy additional (redundant AP-1000 / AP-500 systems)

★ Advice to mobile users to stay clear from sources of interference, when roaming

# *Methods to coexist*

*Channel choice*

★ Based on site analysis choose channels away from frequency used by source of interference

★ “Tune around source of interference”

# *Methods to coexist*

*Environmental control*

★ Shield the source of interference

★ Change the source of interference (re-tuning to be out of the band)

★ Shield the AP-1000 / AP-500 systems to be less effected by source of interference

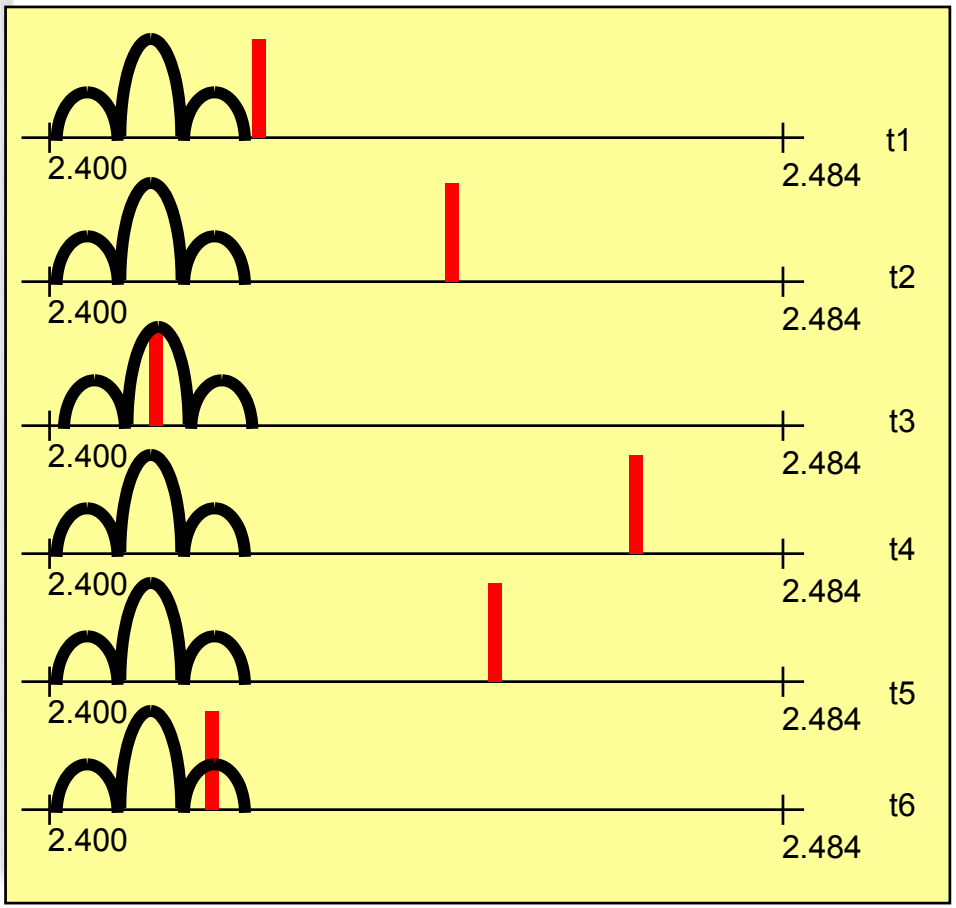
# *Methods to coexist*

*Coexistence of FH and DS*

- ★ FH and DS systems experience each other's traffic as noise
- ★ Generally DS systems suffer more from FH systems than vice versa
  - ★ FH systems "hop" around DS systems
  - ★ DS systems establish on a given channel (can only tune around a static source of interference; FH system represent a moving source of interference)
- ★ Interference can be significant depending on
  - ★ respective locations (near/far situations)
  - ★ respective output power levels
  - ★ amount of traffic generated on the FH system
  - ★ the dwell time of the hopper (fast hoppers create less impact that slow ones)
  - ★ Number of co-located FH "channels"

# Methods to coexist

*Coexistence of FH and DS*




**Co-existence of Avaya Wireless LAN and WaveACCESS BR132**

- ★ Per 1.6 second, 11 noise spikes can be expected, that may interfere with the channel, based on following parameters:
  - dwell time is 20 msec
  - hop sequence uses 80 frequencies
  - width of the Avaya Wireless frequency channel is 11 MHz
  - there is data traffic between the WaveACCESS LINK BR132 stations
- ★ Spike is narrow (1 MHz)
- ★ Spike lasts for 20 msec



AVAYA communication

# *Methods to coexist*

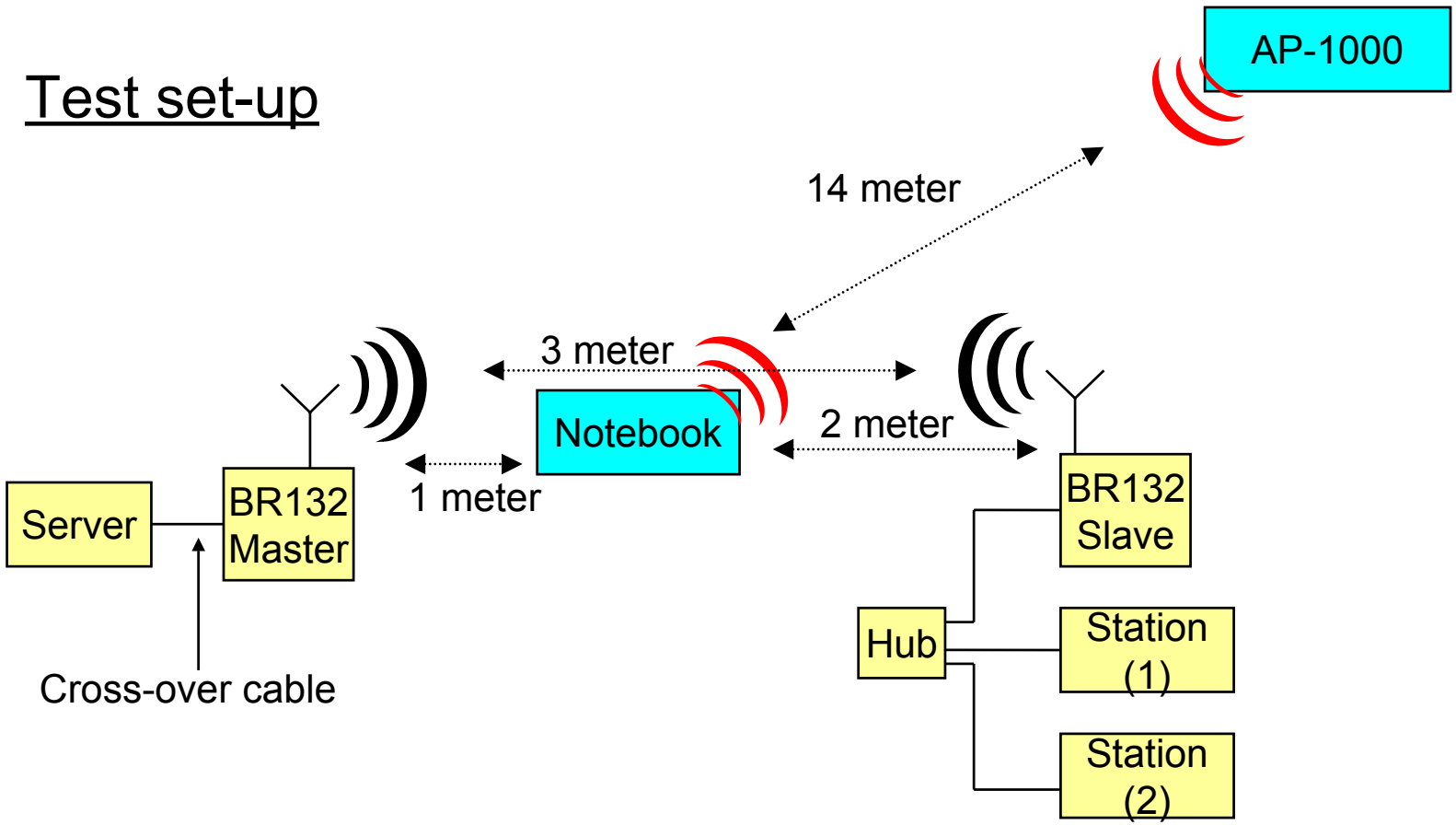
*Coexistence of FH and DS*

Tests have been conducted to assess the impact

- ★ Created WaveACCESS LINK BR132 cell:
- ★ Connect Ethernet station (server) to the BR132 Master
- ★ Connect 2 Ethernet stations (server) to the BR132 Slave
- ★ Establish continued traffic between the stations:
  - ★ Use highest power setting and medium-gain, outdoor Omni-directional antenna
  - ★ Download large files (24 Mbytes) from server to stations (simultaneously)
- ★ Execute Avaya Wireless Client Manager tests from notebook and capture results

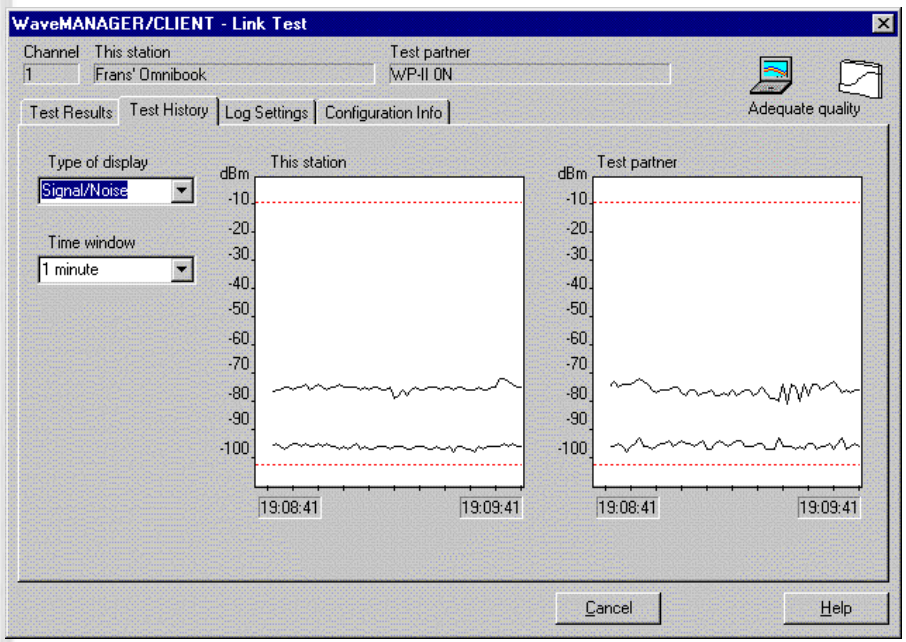
# Methods to coexist

*Coexistence of FH and DS - test set-up*



# Methods to coexist

*Coexistence of FH and DS - test results*

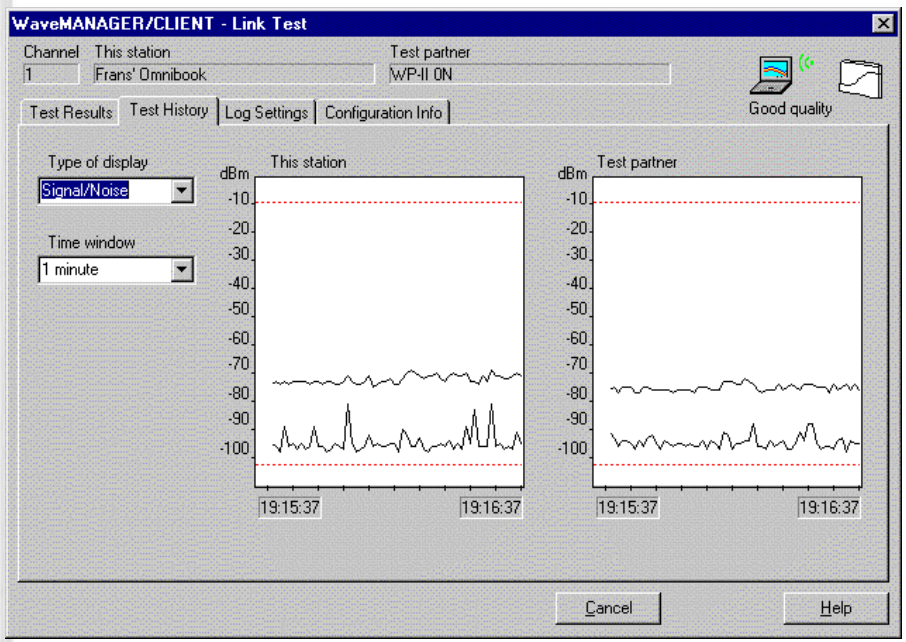



**Screen capture taken prior to activating the BR132 link**

- ★ No spikes are noticed by the notebook station

# Methods to coexist

*Coexistence of FH and DS - test results*

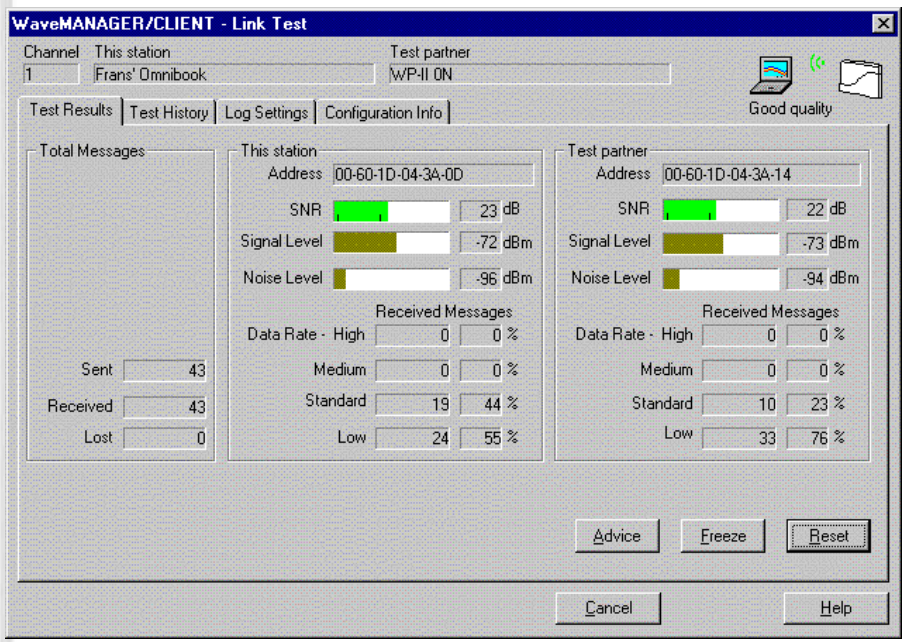



**Screen capture taken after activating the BR132 link**

- ★ Notebook station notices spikes, as result of the file transmission between the stations and the server
- ★ Spikes are not hurting the SNR as there is still enough signal left to communicate, so the Avaya Wireless wireless LAN continues to be operational

# Methods to coexist

*Coexistence of FH and DS - test results*




**Screen capture taken after activating the BR132 link**

- ★ No packets are lost as result of the “interfering” transmission.
- ★ The Avaya Wireless PC Card has dropped in speed and is no longer able to run at Turbo speed, but stays operational

# *Methods to coexist*

*Coexistence of FH and DS - conclusion*

- ★ WaveACCESS Link BR132 systems will coexist with Avaya Wireless wireless LAN systems, without significant negative impact
- ★ Similar test with WaveACCESS NET have resulted in similar results: co-existence does not seem to present major issues
- ★ In WaveACCESS net systems, interference for Avaya Wireless wireless LAN systems could be compounded when co-located CUs are applied:
  - ★ With each added CU, the number of spike occurrences will be increased with 11
  - ★ Does apply only when CU uses Omni-directional antennae (does not apply when sectored antennae are used)

# *Module summary*

★ Avaya Wireless versus Avaya Wireless

★ The ISM Band

★ Sources of interference

★ Methods to coexist