

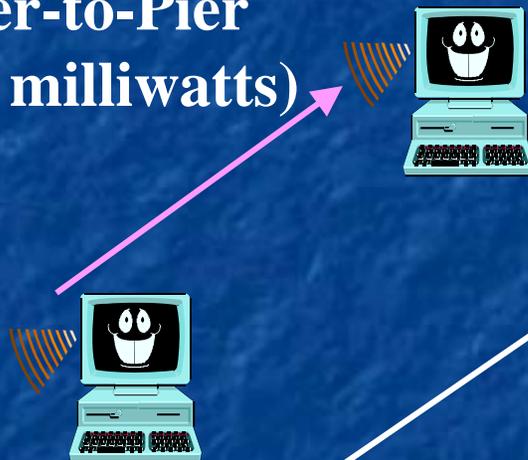


Unlicensed Devices in the Television Bands

*OET Lab Meeting
September 19, 2006*

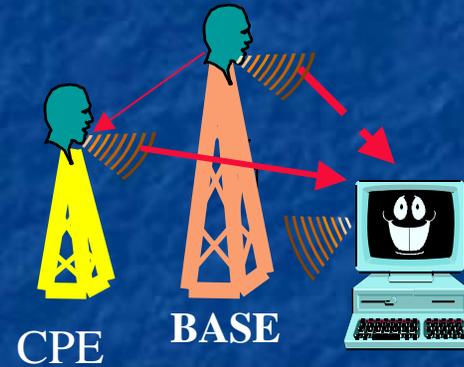
NPRM on Unlicensed Devices

Pier-to-Pier
(400 milliwatts)



Portable devices

Positive Control



CPE

BASE

Point-to-multipoint
(4 Watts)

NPRM on Unlicensed Devices

- Unlicensed devices cannot operate within a co-channel contour of NTSC and DTV full power station, Class A station, LPTV, translator and booster. Operation outside a station contour is allowed provided that they meet the following criteria:
 - D/U ratio of 34 dB for *analog stations*
 - D/U ratio of 23 dB for *digital stations*

NPRM on Unlicensed Devices

- **Adjacent channel operation**
 - Fixed access devices *must not cause harmful interference* to first adjacent TV channels.
Operation based on D/U ratios below:
 - *Upper adjacent*
 - -17 dB for analog
 - -26 dB for digital
 - *Lower adjacent*
 - -14 dB for analog
 - -28 dB for digital
 - Allow adjacent channel operation for portable or pier-to-pier operation

Concerns

- Interference is caused to consumers' **TV receivers**
- Can't control locations of unlicensed devices or TV receivers
- Can't prevent an unlicensed device from being too close to **TV receiver**

Potential Interference

- **Out-of-band interference**
 - §15.209 limits not sufficient to protect TV operations
 - CRC measurements show **interference at 78 feet**
- **Adjacent channel interference**
 - §73.623 adjacent channel protection limits also required for portable devices
 - 100 mW portable device could cause **interference at distances of 780 meters**
- **Co-channel interference/Spectrum Sensing**
 - If unlicensed device inadvertently transmits on a channel being used for TV service – **interference range of 3 km (indoor TV antenna) to 16 km (outdoor TV antenna)**

Out-of-Band Emission

CRC LABORATORY REPORTS

Phase 1 & 2

Laboratory Tests (CRC)

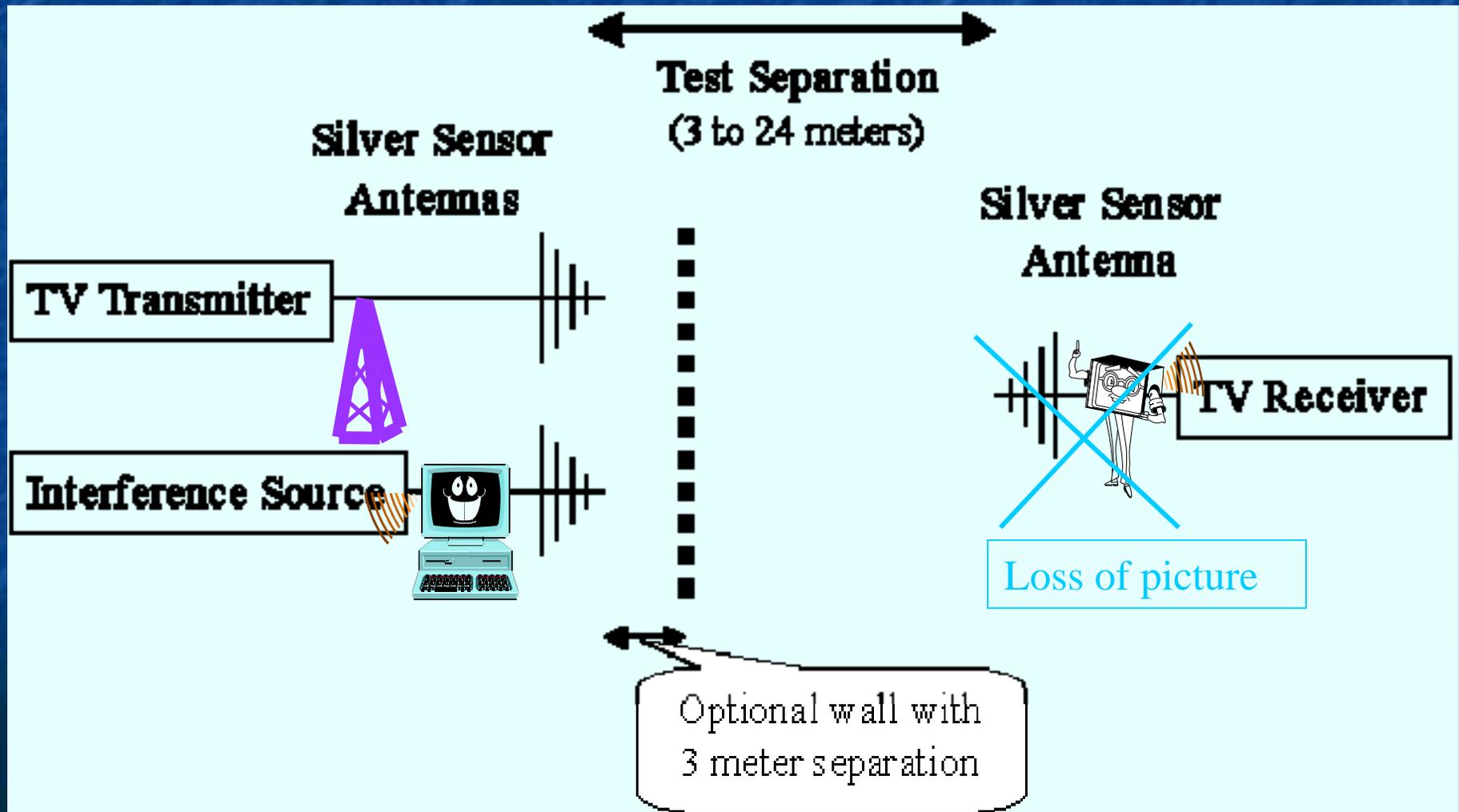
- Determine the interference distance from an unlicensed device (portable) complying with out-of-band emission required for FCC Part 15 devices
 - FCC requires an out-of-band signal to be no greater than 200 $\mu\text{V}/\text{m}$ (46 $\text{dB}\mu\text{V}/\text{m}$) within a 120 kHz bandwidth at 3 meters
 - Convert to dBm:
 - $$P \text{ (dBm)} = -75.5 + 46 \text{ dB}\mu\text{V}/\text{m} - 20 \log(\text{Frequency in MHz})$$
$$= -29.5 - 20 \log(\text{Frequency in MHz})$$
 - For TV Ch. 48 (677 MHz), the interference level is $-29.5 - 20 \log(677) = -86.1 \text{ dBm within 120 kHz}$

CRC Laboratory Report

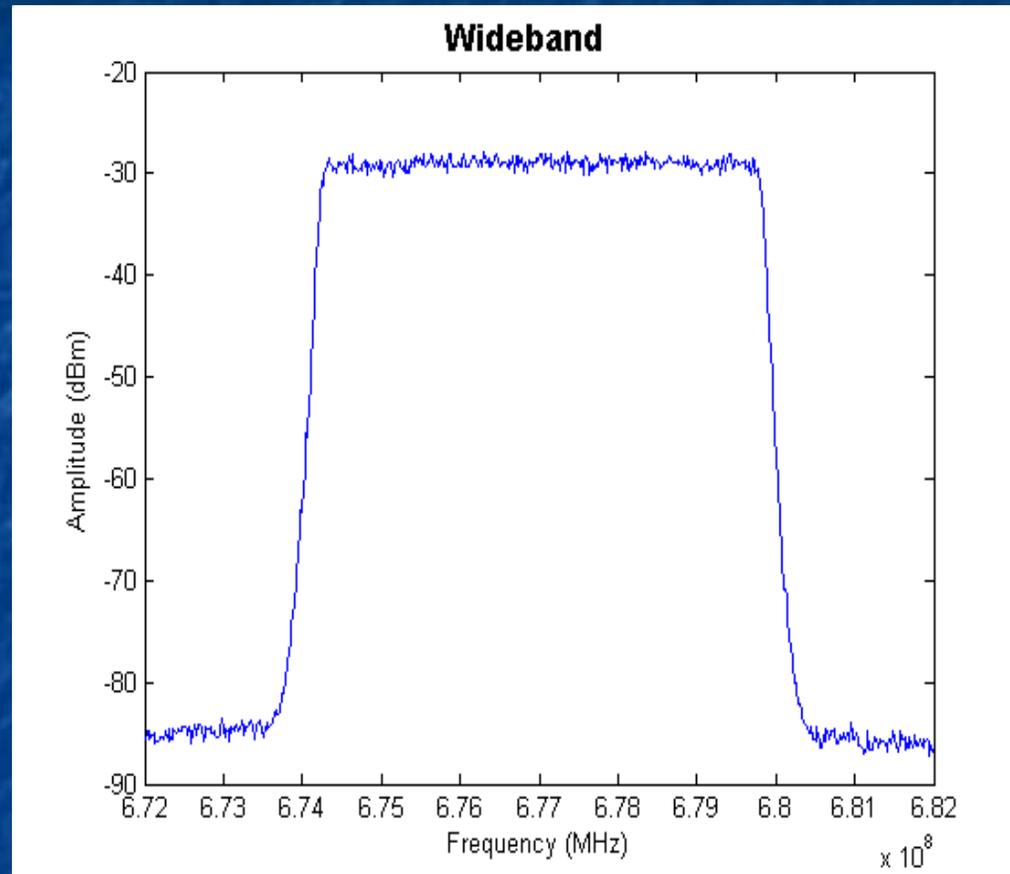
Phase 1 (Nov. 2004)

- Measurements were conducted on channel 48 at a signal level that is 3 dB below § 15.209 value. *(-89.1 dBm for 120 kHz)*
- Tested 5 DTV & 3 NTSC receivers
 - De-sensitization of NTSC & DTV receivers indoor
 - De-sensitization through a wall
- The DTV signal and the UD sideband signals were transmitted and received in the same room. Calibration was done at a distance of 3 m from the DTV receiver

Laboratory Tests (CRC)



Phase 1 Laboratory Signals

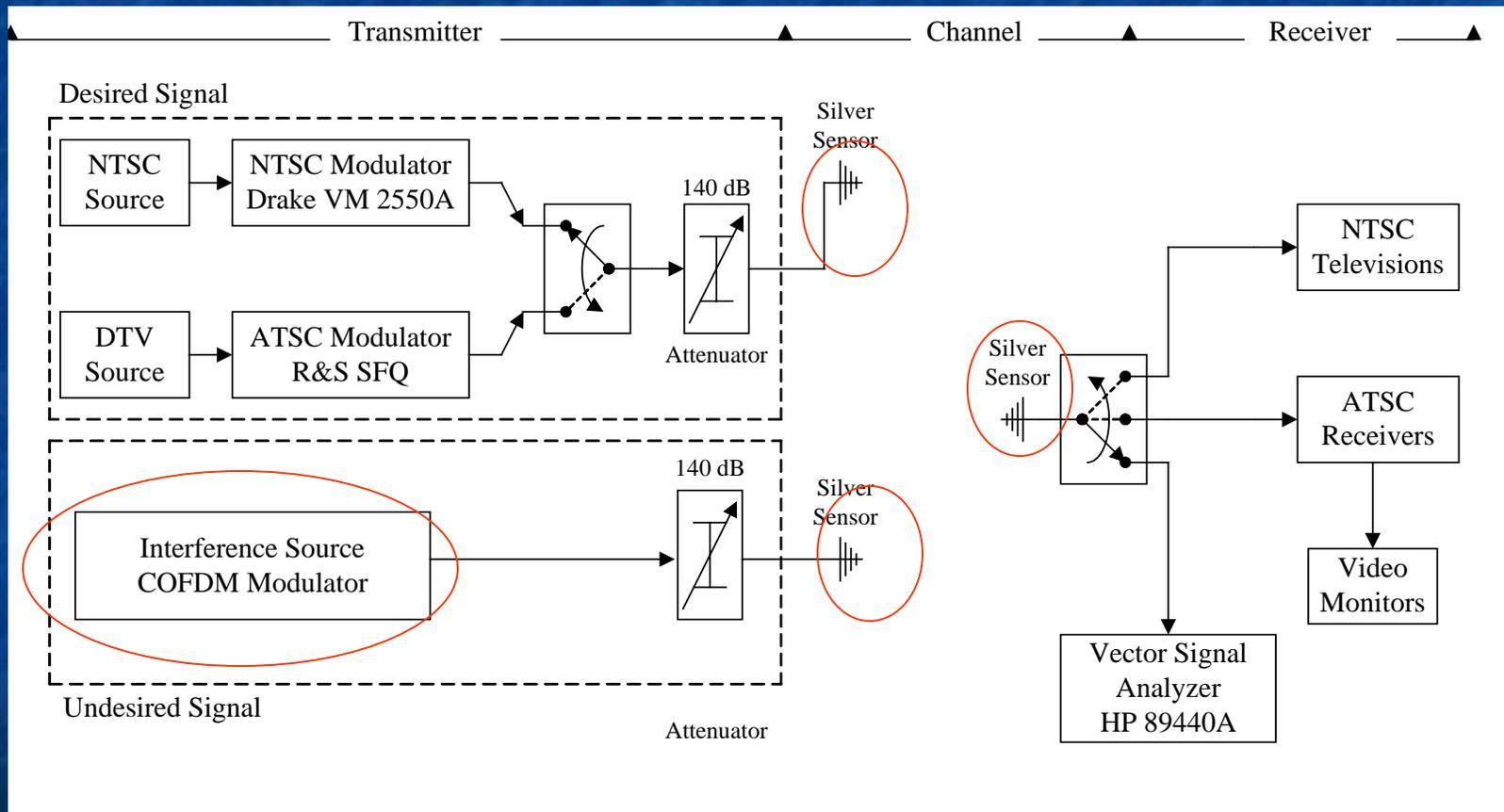


5.6 MHz wide COFDM Signal

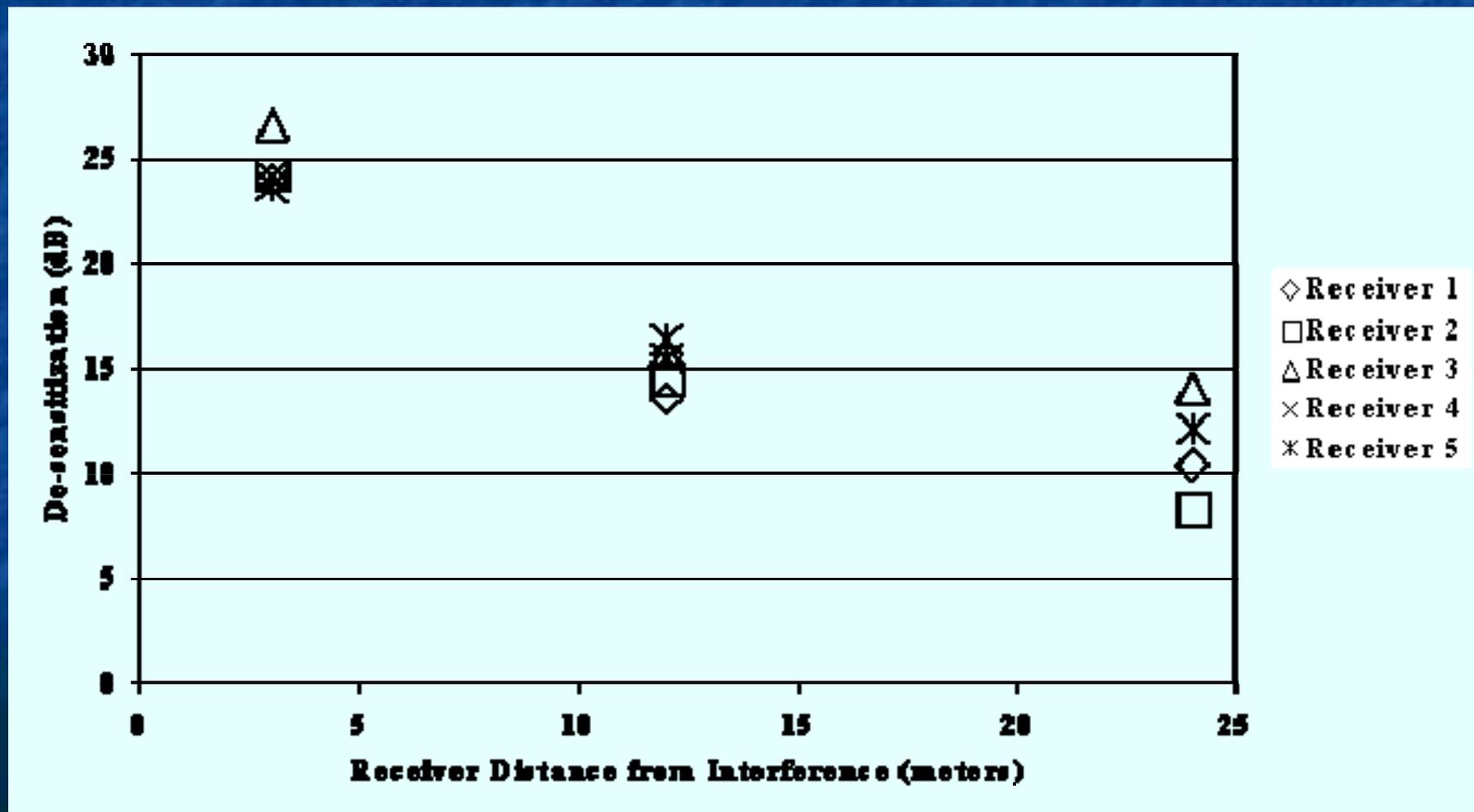
Total interference power for this signal

$$-89.1 + 10 \log (5.6/0.12) = -72.4 \text{ dBm}$$

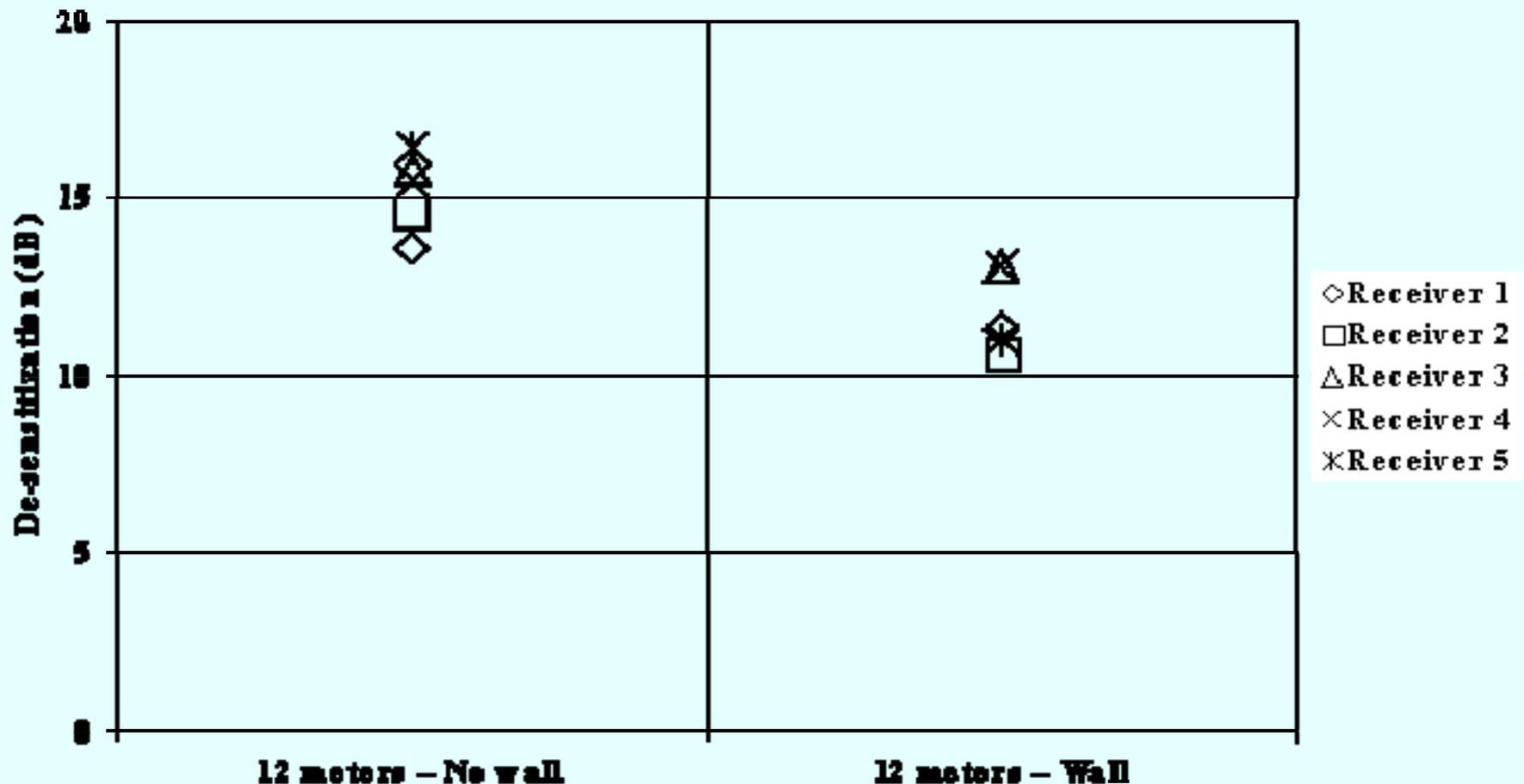
Phase 1 Lab Test Configuration



De-sensitization of DTV receivers by out-of-band interference from a single unlicensed device with a wideband (5.6 MHz) emission



De-sensitization of DTV receivers by out-of-band interference through a wall from a single unlicensed device with a wideband (5.6 MHz) emission

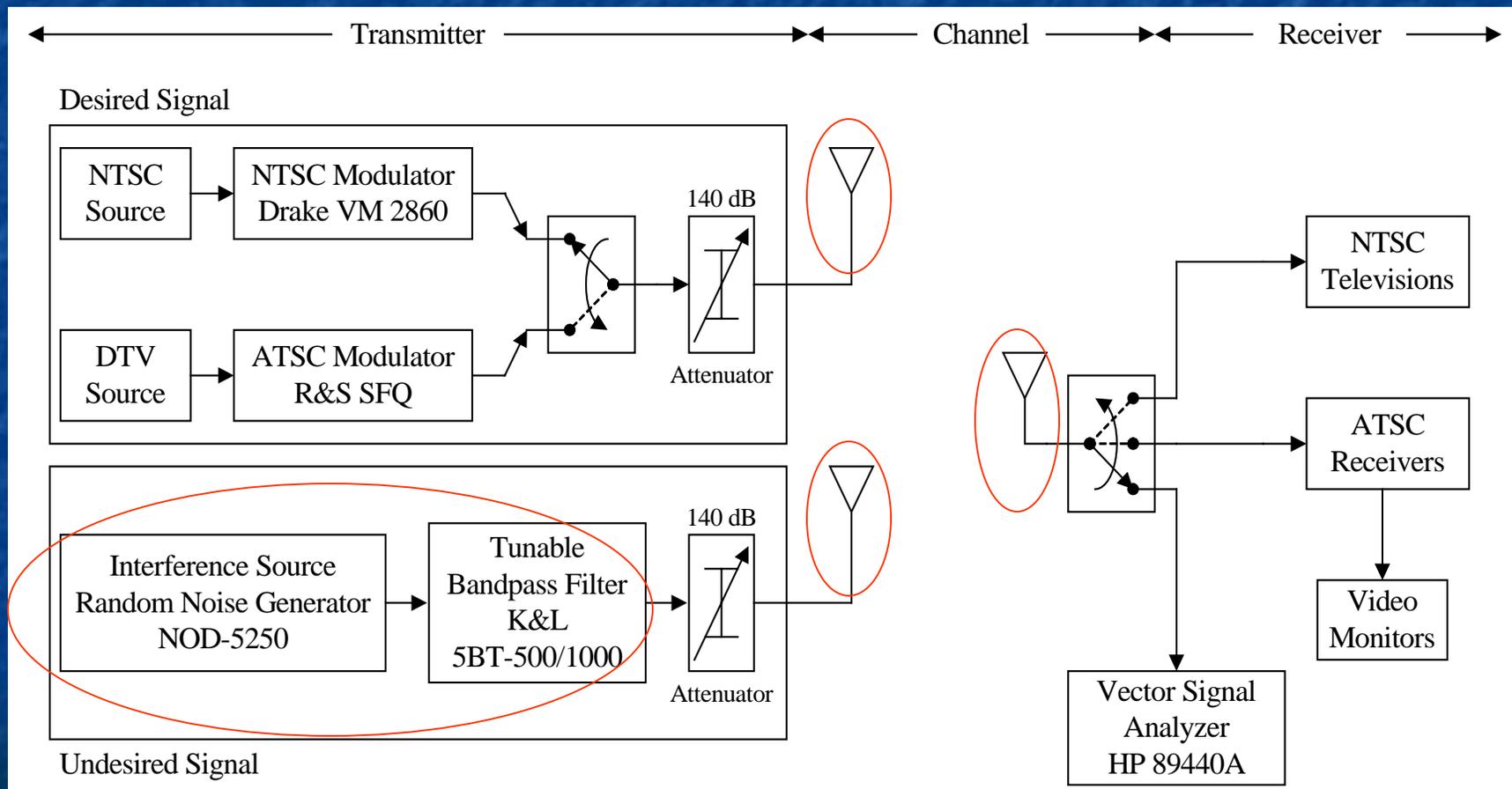


CRC Laboratory Report

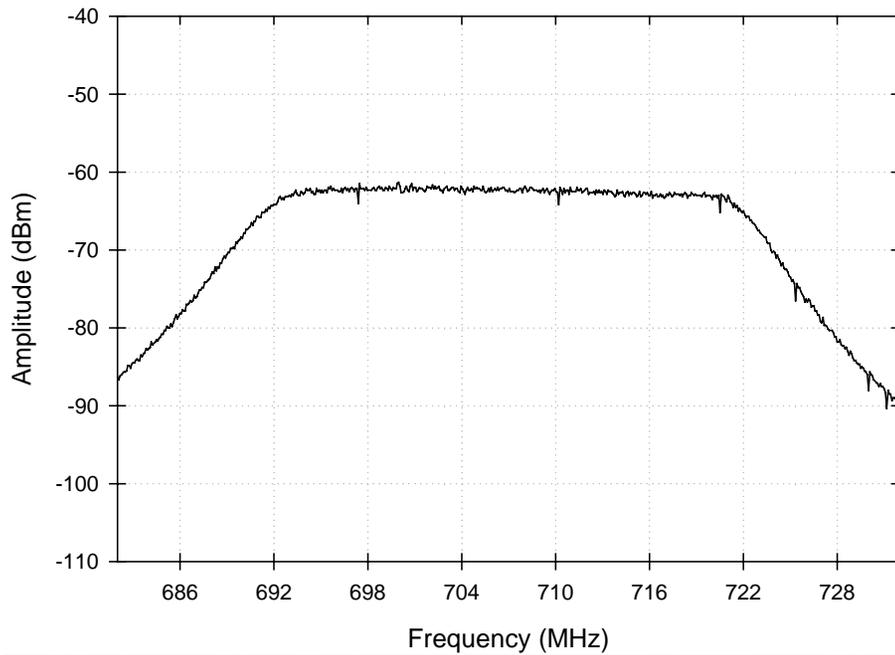
Phase 2 (February 2005)

- Measurements were conducted on channels 52, 53, 54 at a signal level that is 3 dB below § 15.209 value. *(-89.1 dBm for 120 kHz)*
- Tested 1 DTV & 1 NTSC receivers to validate previous tests
 - De-sensitization of NTSC & DTV receivers indoor
- The DTV signal and the UD sideband signals were transmitted and received in the same room. Calibration was done at a distance of 3 m from the DTV receiver

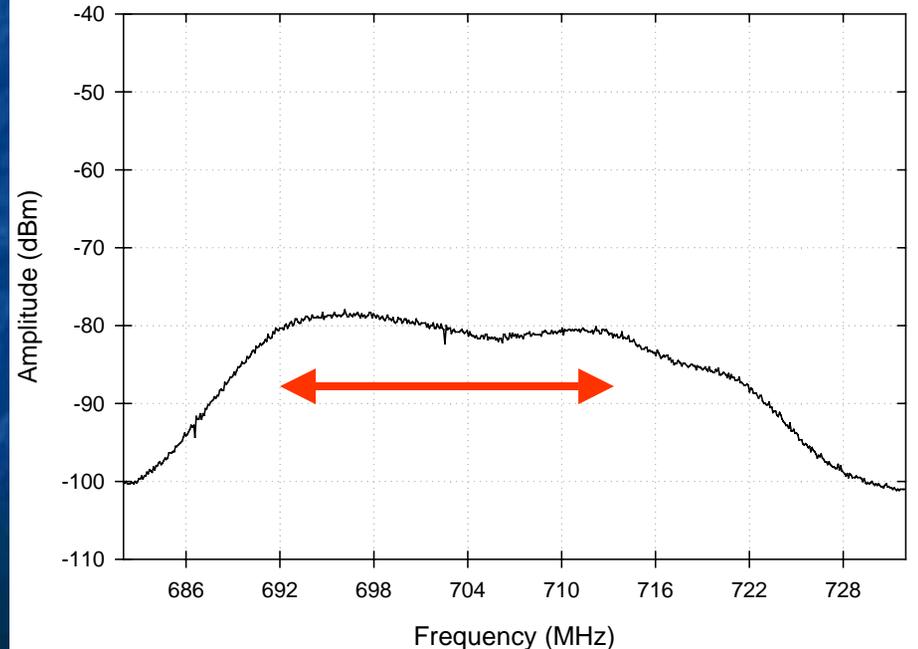
Phase 2 Lab Test Configuration



Phase 2 Laboratory Signals



**Spectrum of the Filtered
Random Noise Signal Source**



**Spectrum of the Filtered Random
Noise Signal Received at 3 Meters**

De-sensitization of DTV receivers by out-of-band interference from a single unlicensed device with a wideband (30 MHz) emission

Channel	52	53	54
Rx Sensitivity	-76.7 dBm	-78.5 dBm	-78.8 dBm
De-Sensitisation	20.5 dB	21.0 dB	21.0 dB

IEEE 802.22 Exparte Filing (Sep. 2005)

Fundamental requirements for WRAN systems to protect TV broadcasting

- Systems should not be allowed to operate on N or $N\pm 1$ within the protected contour of a DTV station
- Need to consider DTV D/U's and DTV receiver saturation for $N\pm 2$ channels and beyond and resulting possible need for an "EIRP profile" for WRAN devices
- Our studies indicate that Part 15.209(a) out-of-band emission levels are insufficient to protect DTV receivers for $N\pm 2$ and beyond (by some 33 dB for 1 dB desensitization of DTV receivers)
- IEEE 802.22 anticipates recommending an out-of-band emission mask to the Commission, based on an agreed deployment scenario once D/U's are agreed for $N\pm 2$ channels and beyond and an EIRP profile is specified

Adjacent Channel Interference

Why Can't Adjacent Channels Be Used

- Let's look at a simple model
 - Required adjacent channel protection is D/U of -26 dB (§73.623)
 - DTV service contour is 41 dBu (§73.625)
 - Assume unlicensed device at 100 mW (much less than FCC proposed)
 - Free space propagation model

1st Adjacent Channels Can't be Used Without Causing Interference

Unlicensed Device Power	DTV Signal Strength	Interference to DTV Reception
100 mW	41 dBu	780 meters
	59 dBu	100 meters
	69 dBu	30 meters
400 mW (portable device limit with antenna gain)	41 dBu	1560 meters
	59 dBu	200 meters
	69 dBu	60 meters

Note: Grade B signal is 41 dBu and signal required for community of license is 48 dBu.

WHD Ch. 34 Field Data

Adjacent Channel Interference

Field Strength	Percent of sites measured	Interference distance
> 79 dBu	5.2%	Less than 10 m
78.8 dBu – 68.8 dBu	17.8 %	11 m to 30 m
68.7dBu – 58.8 dBu	25.1%	31 m to 100 m
58.7 dBu – 52.8 dBu	13.9%	101 m to 200 m
52.7 dBu – 46.8 dBu	10.3%	201 m to 400 m
46.7 dBu – 41 dBu	8 %	401 m to 780 m

WETA Ch. 26 Field Data

Adjacent Channel Interference

Field Strength	Percent of sites measured	Interference distance
> 79 dBu	4.3 %	Less than 10 m
78.8 dBu – 68.8 dBu	7.6%	11 m to 30 m
68.7dBu – 58.8 dBu	17.0%	31 m to 100 m
58.7 dBu – 52.8 dBu	14.3%	101 m to 200 m
52.7 dBu – 46.8 dBu	14.3%	201 m to 400 m
46.7 dBu – 41 dBu	17.0%	401 m to 780 m

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Spectrum Sensing

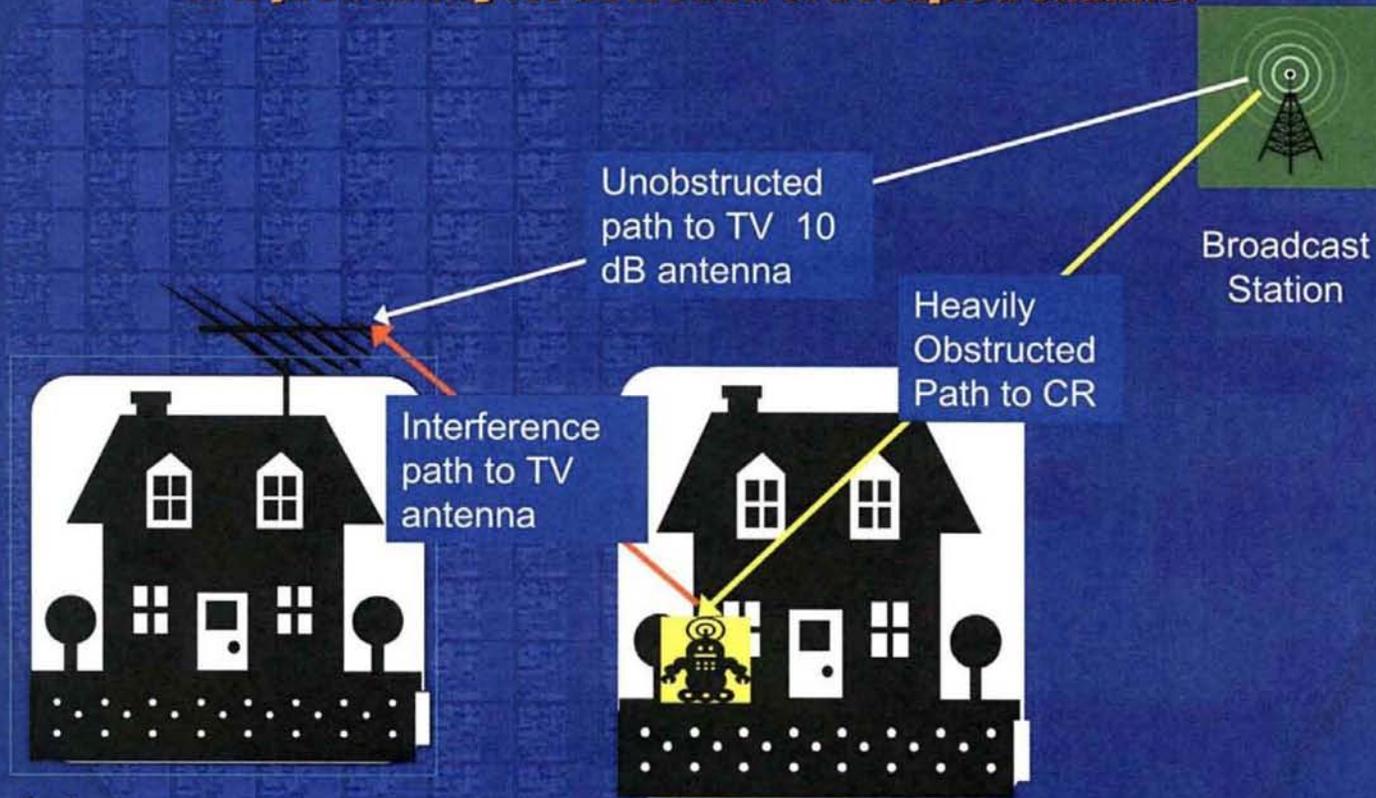
TV Band Spectrum Sensing

Protecting TV reception is fundamentally different technical problem than 5 GHz

- Need to protect consumers TV receivers
- Need to detect at very low levels
 - Receiver performance differences of TV and unlicensed device
 - Hidden Node problem
 - Sensing antenna efficiency
- Need to detect correctly all the time
 - Every failure potentially can cause 75 square miles or more of interference!

Worst Case Hidden Transmitter Scenario

Low probability for detection of occupied channel



intel.

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Co channel avoidance

- DTV D/U ratio -23dB gives moderate interference range therefore detect and avoid
- Detect some feature of Broadcast TV signal
 - Pilot tone, frame sync (DTV)
 - Video carrier, line sync (NTSC)
- Indoor CR scenario (*Hidden Transmitter Problem*)
 - Low antenna gain (0 versus 10 dB)
 - Low antenna height (2 versus 10 m)
 - Building losses (Average 5.7, SD 8.6dB)
 - Multipath (4 to 19 dB)

Low detection threshold

intel.

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Let's Use Intel's Example

Minimum Useable DTV Signal Strength	-83 dBm	
Required Protection Ratio (dB)	-23 dB	
Difference in Antenna Gain (dB)	-10 dB	
	Intel's "very conservative" proposal	Numbers from Intel's slide example
Difference in Antenna Height (dB)	-23 dB	-7 dB
Building Losses (dB)		-5.7dB (8.6 dB SD)
Multipath Losses (dB)		-19 dB
Detection Signal Level	-118 dBm*	-126.7 to -135.3 dBm

* Include a **2 dB** to account for the excess path loss at 8 km outside the service contour

IEEE 802.22 Activities

- Group chartered to develop standards for Cognitive Regional Area Network (WRAN) for P-MP between 54 to 862 MHz that protect incumbent licensed services from harmful interference
- Group formed in Nov. 2004
- Issued a Requirement Document in Sep. 2006
- 16 proposals were submitted in Oct. 2006
- Merging of proposal into a single proposal Mar. 2006
 - Motorola, Thomson, Samsung, Philips, Nextwave, Runcom, STmicro, France Telecom, Huawei, Paragon & ETRI
- Evaluation of proposal including testing Dec. 2006
- WG draft standard to sponsor ballot Jan. 2007 – Dec. 2007
- Publication of Standard Spring 2008