Interfering thresholds of radio services and spectrum emission masks from PLT, CATV and ADSL

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Purpose / Motivation

- Provide trigger levels & RF Emission Masks
- Simplify regulation and calculations
- Topic of RF community interest; essential to broadcasting & land mobile services
- Used at RRC 06 (GE 06) planning, PLT ITU-R Recommendations and reports
- Advances penetration of new technologies

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Outline

- Triggers define compatibility between radio systems
- Thresholds calculated as power and field-strength
- Thresholds to protect radio services from interfering incidental radiators: PLT, cable installations and ISM
- Assuming minimum distance from interferer to victim, the spectrum emission mask can be calculated
- The study offers practical values
- Measurements of noise levels & interference support calculations & provide evidence to the methodology

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Criterion to Protect Radio Services

$$\text{Degradation (dB)} = 10 \log\left(\frac{Interference + Thermal\_Noise}{Thermal\_Noise}\right)$$

Interference level relative to receiver thermal noise (dB)	Resultant degradation in sensitivity (dB)
0	3
–6	1
–10	0.5
–20	0.05

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Assumptions to Calculate Thresholds

- Receiver noise floor dominated by thermal noise: no man-made or other noises
- The tolerated desensitisation of the terrestrial receivers is 0.05 dB, the allowed interfering signal is 20 dB below the thermal noise: therefore, the trigger power level is KTBF-20 dB
- Cellular Terminals' and broadcasting receivers' isotropic antenna gains: Gr (dBi) = 0 and no feeder loss (LF)
- Macrocellular BTS antenna gain: Gi (dBi) =15 and LF (dB) =3
- Fixed stations ant gain: Gi (dBi) = 15 and LF (dB) =3
- Radiolocation stations Gi (dBi) =23 and LF (dB) =3
- Noise Figure (F) of 5 dB; typical to victim Rx
- RF reference 460 MHz

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Distance from Incidental Radiators 2 Victims

- **1 m** between incidental radiator (PLT, CATV, ADSL, ISM) and cellular or broadcasting terminals, indoor
- **10 m** to macrocellular base-stations or fixed stations or TV ant. outdoor
- **100** m to Radiolocation stations, outdoor

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Power Threshold levels (PER 1 MHz)

KTBF/1MHz= -114 +5 = -109 dBm/MHz (1)

KTBF(1MHz)-20dB =-109dBm -20dB = -129dBm/MHz (2)

As 0 dB ant gain @ cellular handsets & broadcasting receivers, this is also the PSD to protect terminals from radiators (MHz)

$$\mathbf{P_{terminals}\ (1\ MHz) = -129\ dBm/MHz} \quad (3)$$

To calculate power @ BTS Rx, Gi(dBi)=15 & LF(dB)=3 are included, to get power trigger @ ant input:

$$\mathbf{P_{BS}\ (1MHz)}\text{=-129dBm/MHz- 12 dB=-}\mathbf{141\ dBm/MHz} \quad (4)$$

power level @ the radiolocation (RL) Rx, Gi(dBi)=23 & LF(dB)=3:

$$\mathbf{P_{RL}(1MHz)}\text{=-129 dBm/MHz- 20dB=-}\mathbf{149\ dBm/MHz} \quad (5)$$

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Field Strength Threshold levels (per 1 MHz)

Conversion of ant input power (dBm) to the FS(dBμV/m) :

$$Poynting Vector : (\vec{E} x \vec{H}) = \frac{1}{\mu_0}(\vec{E} \times \vec{B}) = \frac{E_O^2}{Zo} \equiv pfd \; E_O^2 = P_r \times \frac{480\pi^2}{g\lambda^2}$$

$$P_r = pfd \times A_e = \frac{E_O^2}{Zo} \times \frac{g\lambda^2}{4\pi} = \frac{E_O^2}{120\pi} \times \frac{g\lambda^2}{4\pi} \; E_O = \sqrt{30 \frac{P_r}{g}} \times \frac{4\pi}{\lambda}$$

P(dBm)=E(dBμV/m)-77.21-20Log f(MHz)+ Gi- LF (6)

-129 (dBm)= E(dBμV/m) - 77.21 – 53.25 (7)

power noise level @ Rx input (same noise figure) is identical, so different FS due to ant gains @ BTS, fixed & radiolocation

$E_{terminal}$ (1MHz) = 1.5 (dBμV/m) (8)

E_{BS}/MHz=E_{fixed}/MHz=1.5(dBμV/m)-12dB=-10.5(dBμV/m) (9)

E_{RL}/MHz=1.5 (dBμV/m)- 20 dB= -18.5(dBμV/m) (10)

Allowed incidental radiators' Spectrum Emission Masks

Power and field-strength per 1 MHz	Indoor Cellular terminal, radio or TV	Outdoor Macrocellular base-station and fixed station	Outdoor Radiolocation station
Power Trigger Level (dBm)	**-129**	**-141**	**-149**
Field-strength Trigger Level (dBµV/m)	**1.5**	**-10.5**	**-18.5**
Max incidental radiator peak-power (dBm)	**-103** (1meter)	**-95** (10meter)	**-83** (100 meter)

incidental radiators' mask depends on RF, as propagation varies with RF; table refers to 460 MHz, using free-space propagation model

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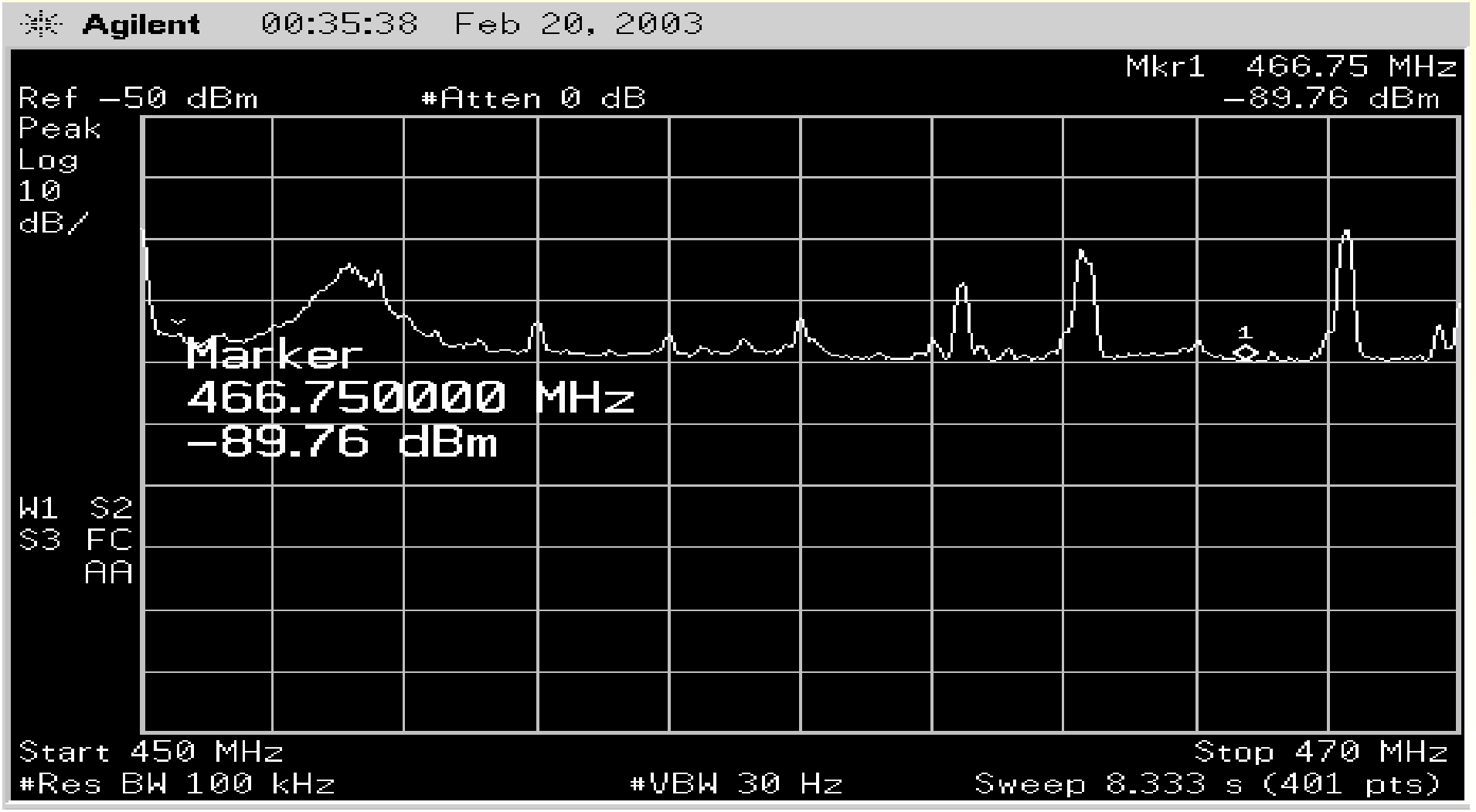
Measuring Thermal and Man-Made Noise



UHF results in rural area (Beit Yizhak)

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Measuring Sensitivity Degradation for GE-06

Interference Level dBm	Equal noise level calculated dBm	Sensitivity measured dBm	Sensitivity degrade measured dB	Sensitivity degrade calculated dB
No interference	-111	-127	**0**	**0**
-114	-109	-125	**-2**	**-1.8**
-111	-108	-123	**-4**	**-3**
-108	-106	-122	**-5**	**-4.8**
-105	-104	-120	**-7**	**-7**

CDMA 1X interfered by DVB-T OFDM

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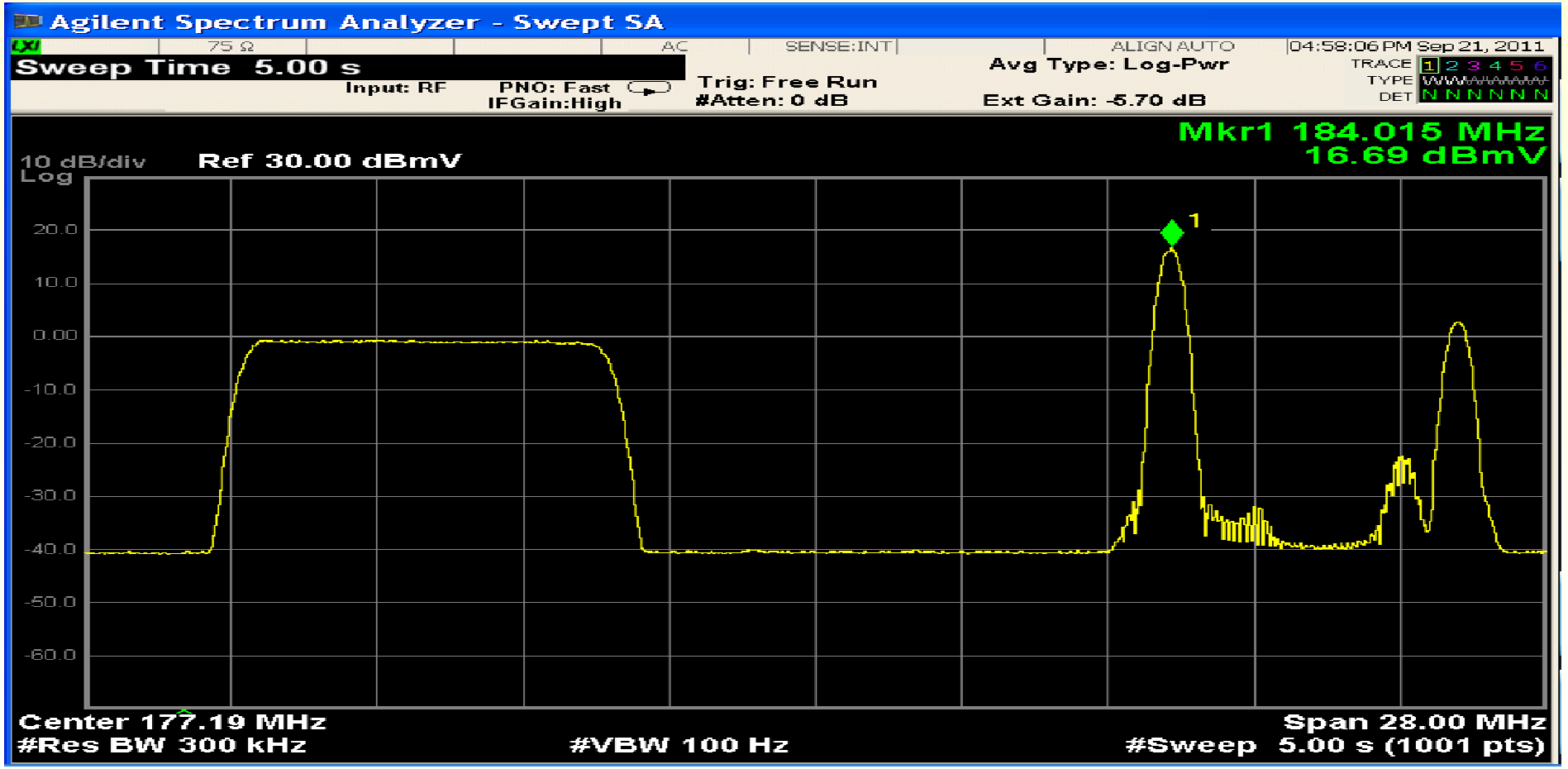
Interference from CATV

QAM 256 CATV is similar to the white noise



CATV QAM 256, white noise (below and above the QAM) & analog TV

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Conclusion

- A simple and productive methodology to evaluate RFI
- Thresholds & emission masks may define signal leakage tasks, to deny degraded performance to radiocommunications
- Methodology can be generalised to avoid interference from UWB & mutual interference between radio services; the only change is the protection criterion; instead of I/N = -20 dB; it should be I/N = -6 dB

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Thank you

Hyperlink to the COMCAS 11 **full-text**

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