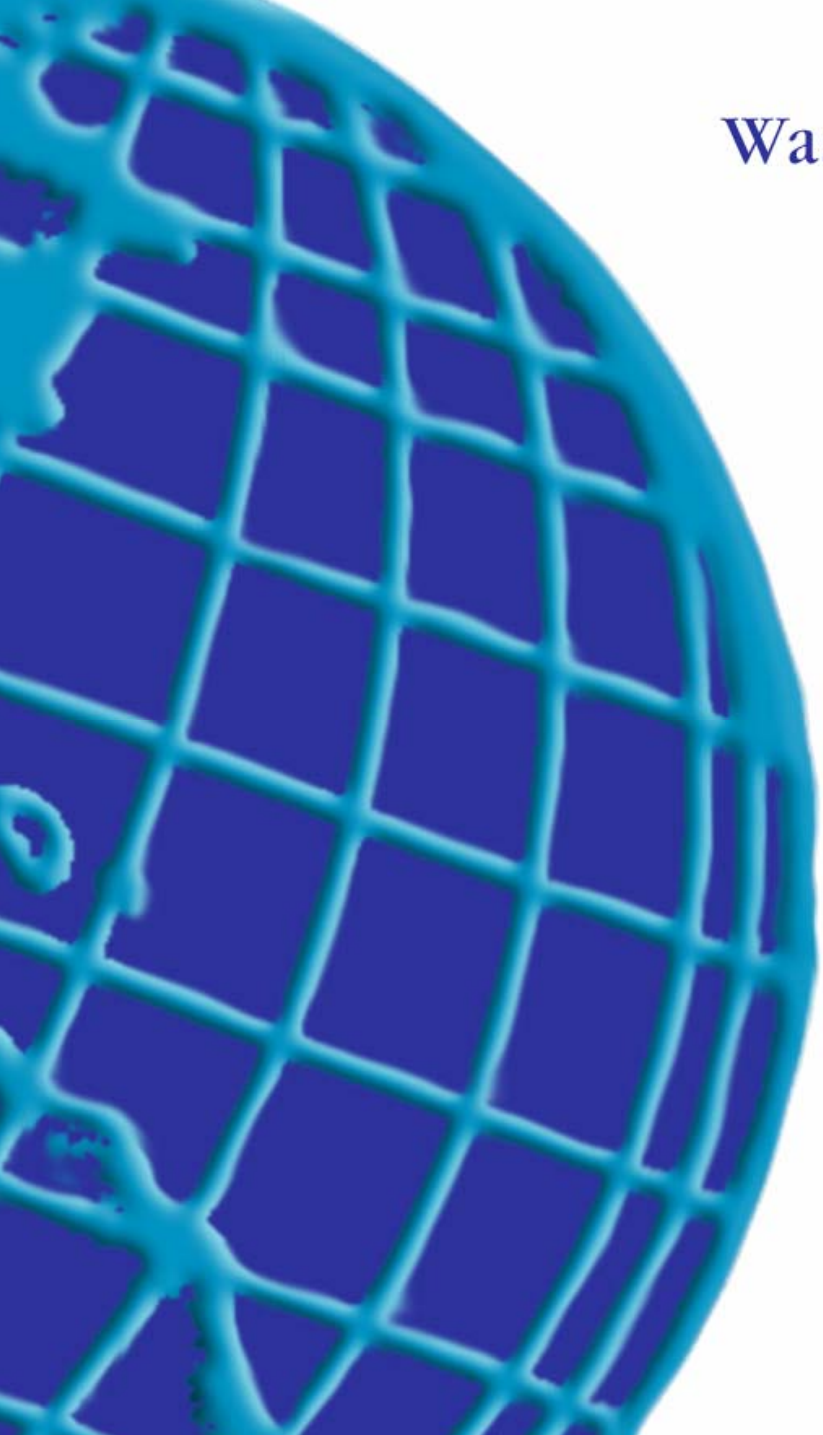


Washington Laboratories, Ltd.

Regulations for Global Compliance Workshop

Wireless Compliance

Washington Laboratories, Ltd.
Laboratory Workshop
September 24, 2004
Gaithersburg, MD

Regulatory Requirements for Wireless Systems

Greg Snyder

Chief EMC Engineer

Routes to Compliance

US: Federal Communications Commission

- Title 47 CFR
- Telecommunications Certification Bodies
  - FCC Identifier & Certification

EU: R&TTE (+EMC+Safety)

- Self-Declaration
  - CE Marking
- Notified Body/Conformity Assessment Body (CAB)
  - Technical Construction File
    - CE Marking

FCC CFR 47 Regulations

- Part 2 General Requirements
- Part 5 Experimental Radio Service
- Part 15 Subpart C, D, and E Unlicensed Low Power Transmitters
- Part 20 Common Carrier
- Part 21 Domestic Public Service
- Part 22 Public Mobile Service
- Part 24 Licensed PCS

FCC CFR 47 Regulations

- Part 25 Satellite Communication Services
- Part 26 General Wireless services
- Part 27 Miscellaneous Wireless Services
- Part 68 Telecom Services
- Part 73 Education Services
- Part 74 Television Broadcast
- Part 80 Maritime Service

FCC CFR 47 Regulations

- Part 87 Aviation
- Part 90 Private Land Mobile
- Part 95 Personal Radio Service
- Part 97 Amateur Radio
- Part 100 Digital Satellite Broadcast (Eliminated and now requirements are in Part 25)
- Part 101 Fixed Microwave

Certification

- "Equipment Authorizations"
- Requires a detailed list of "Exhibits"
  - See 2.1033 for complete details
- Essentially, two classes
  - Licensed (e.g. Part 90, VHF/UHF Radios)
  - Unlicensed: (e.g. Part 15, Much of the wireless development is unlicensed (802.11, WLAN, UWB, Low Power Devices)

FCC Part 2 Requirements

Test Report Requirements

- Designed to show transmitter is “well-behaved”
- 2.1046 – Output Power
- 2.1047 – Modulation Requirements
- 2.1049 – Occupied Bandwidth
- 2.1051 – Antenna Conducted Spurs
- 2.1053 – Transmitter Radiated Spurs
- 2.1055 – Frequency Stability

Licensed Radio Services Test Parameters

- Reference Standards
- TIA/EIA 603 Land Mobile FM or PM Communications Equipment Measurement and Performance Standards
- TIA/EIA Telecommunications System BulletinTSB102 (Digital C4FM/CQPSK Transceivers Measurement Method)

Licensed Radio Services Test Parameters

- Power Output: 2.1046
- Carrier Power
  - Used to derive harmonic limits
  - Specified as conducted power or radiated power (ERP or EIRP)

Pager Transmitter Alphanumeric Pager

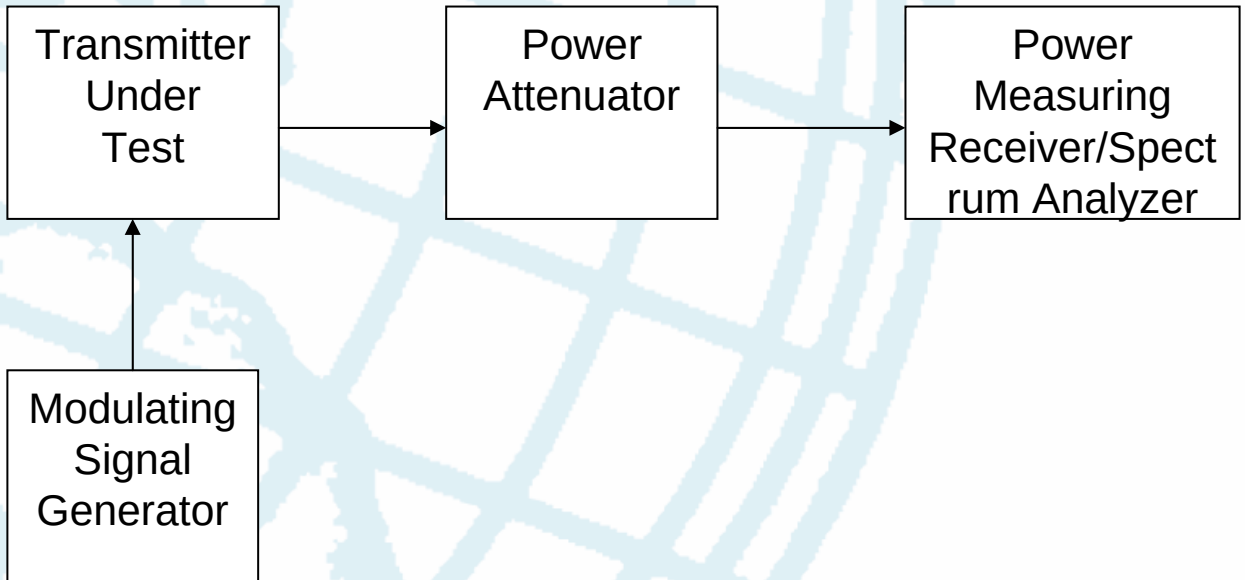
Licensed Radio Services Test Parameters

Modulation Characteristics: 2.1047

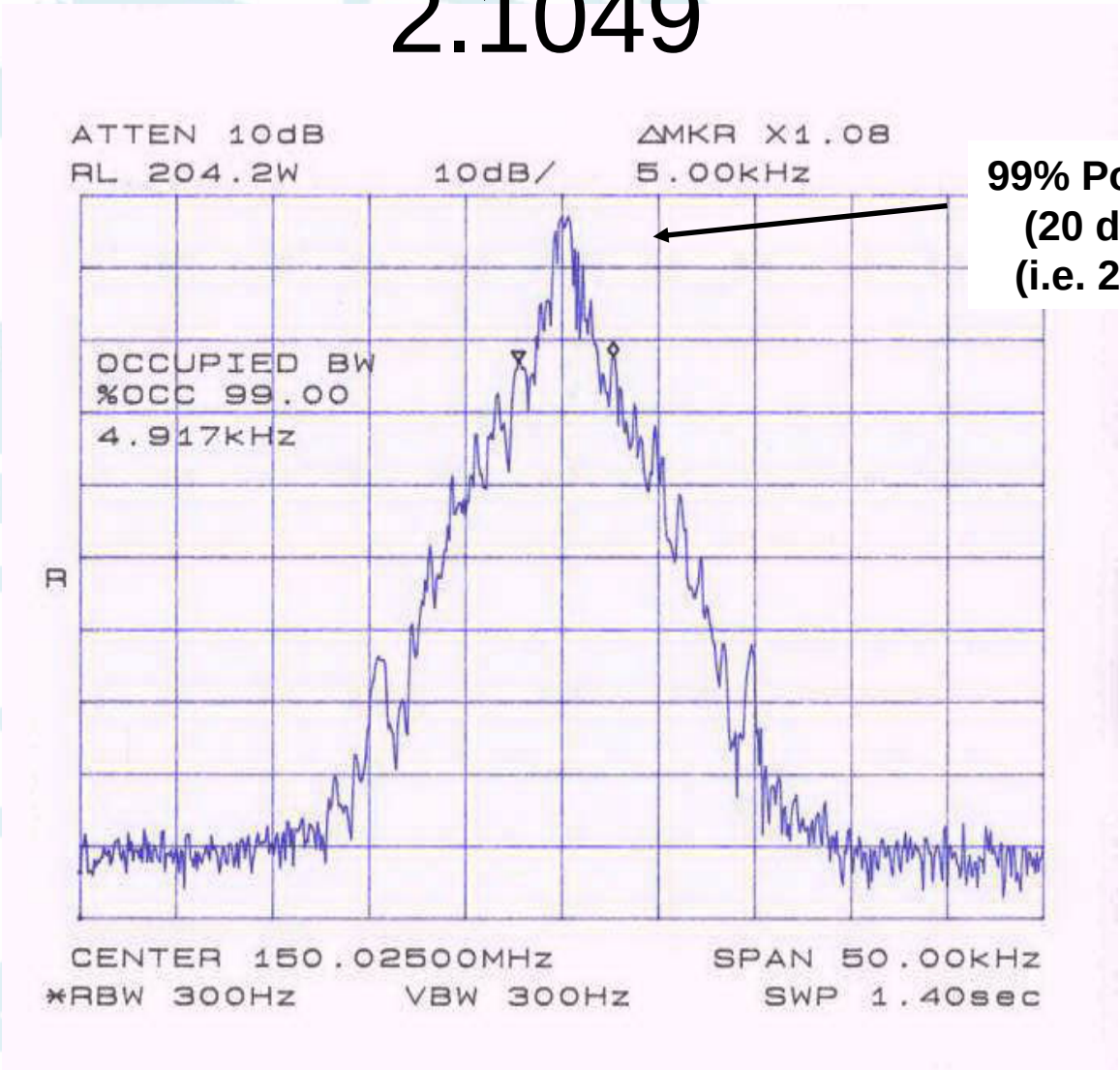
- Audio frequency response
  - 100Hz to 5000Hz
- Modulation limiting
  - Modulation % vs. Modulation Input Voltage

Licensed Radio Services Test Parameters

- Occupied Bandwidth 2.1049
- 99% Power Bandwidth
- OBW @ 10 Log (0.01) = -20dBc

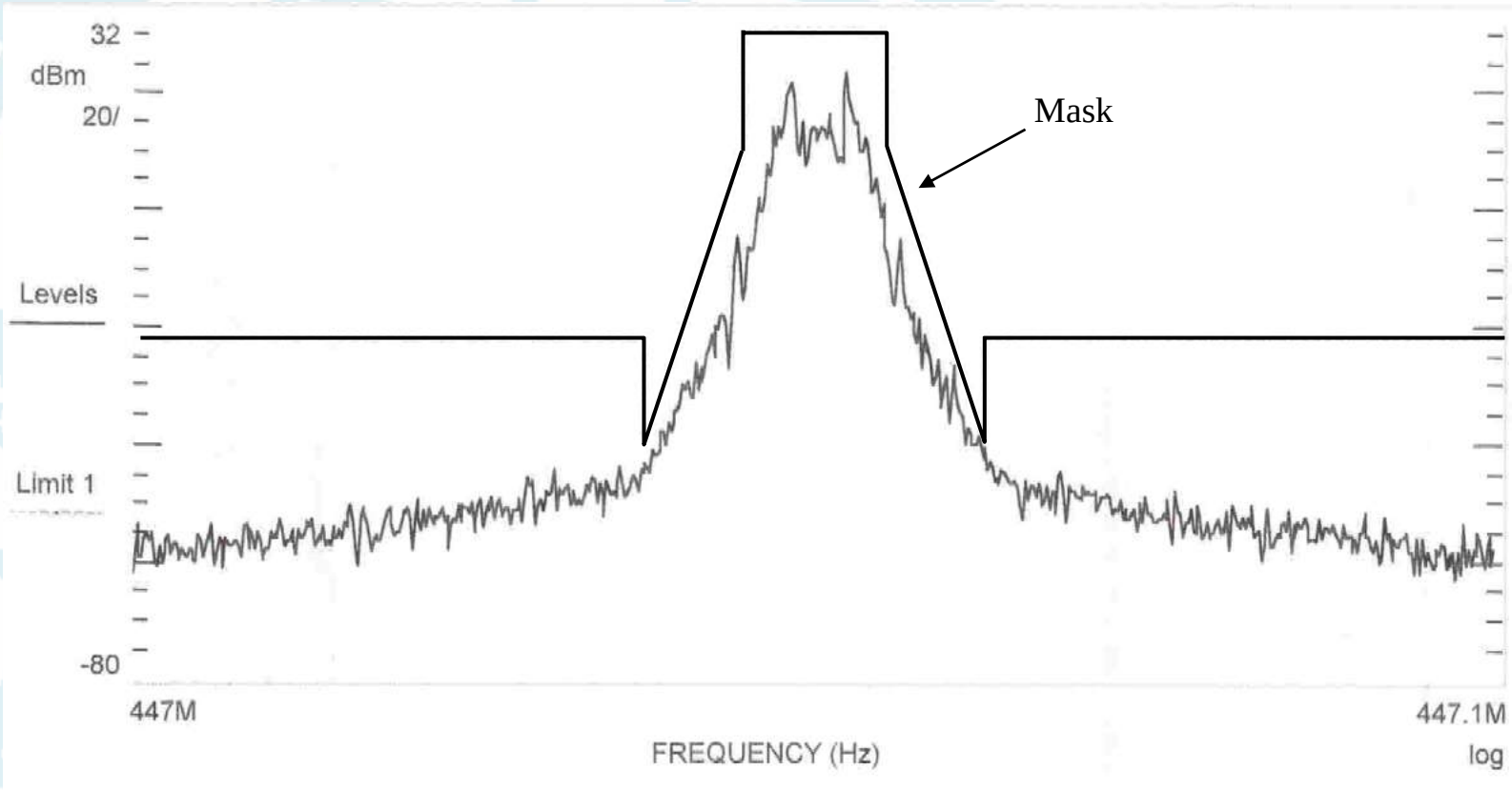


Occupied Bandwidth 2.1049



99% Power Point (20 dB down) (i.e. 20dB BW)

Emissions Mask Example
Frequency Modulation



Emissions Mask Example

Analog Modulation

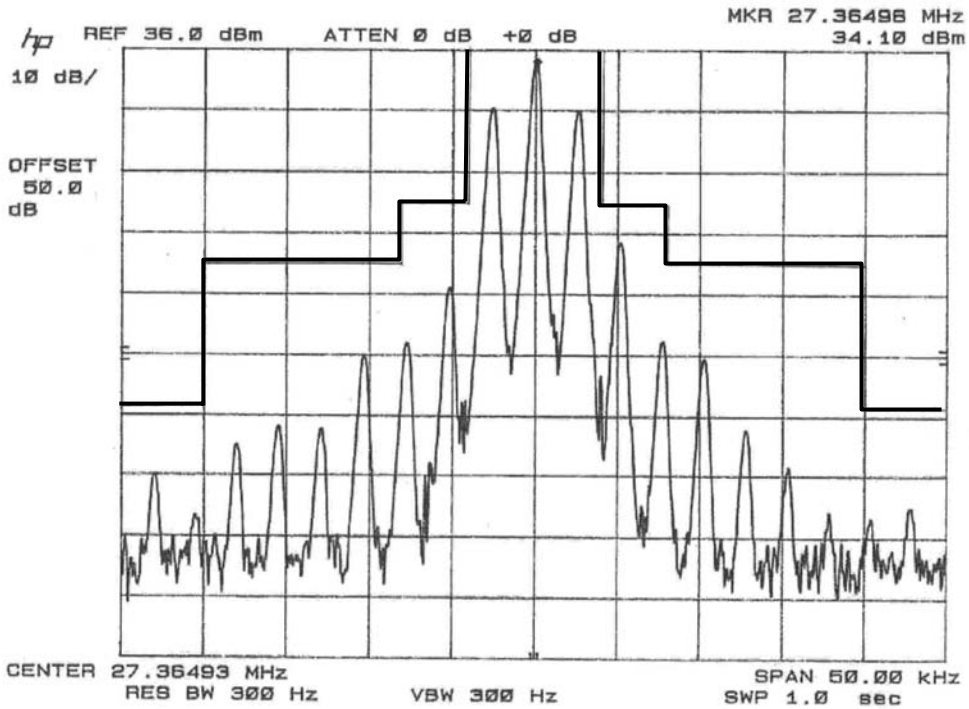
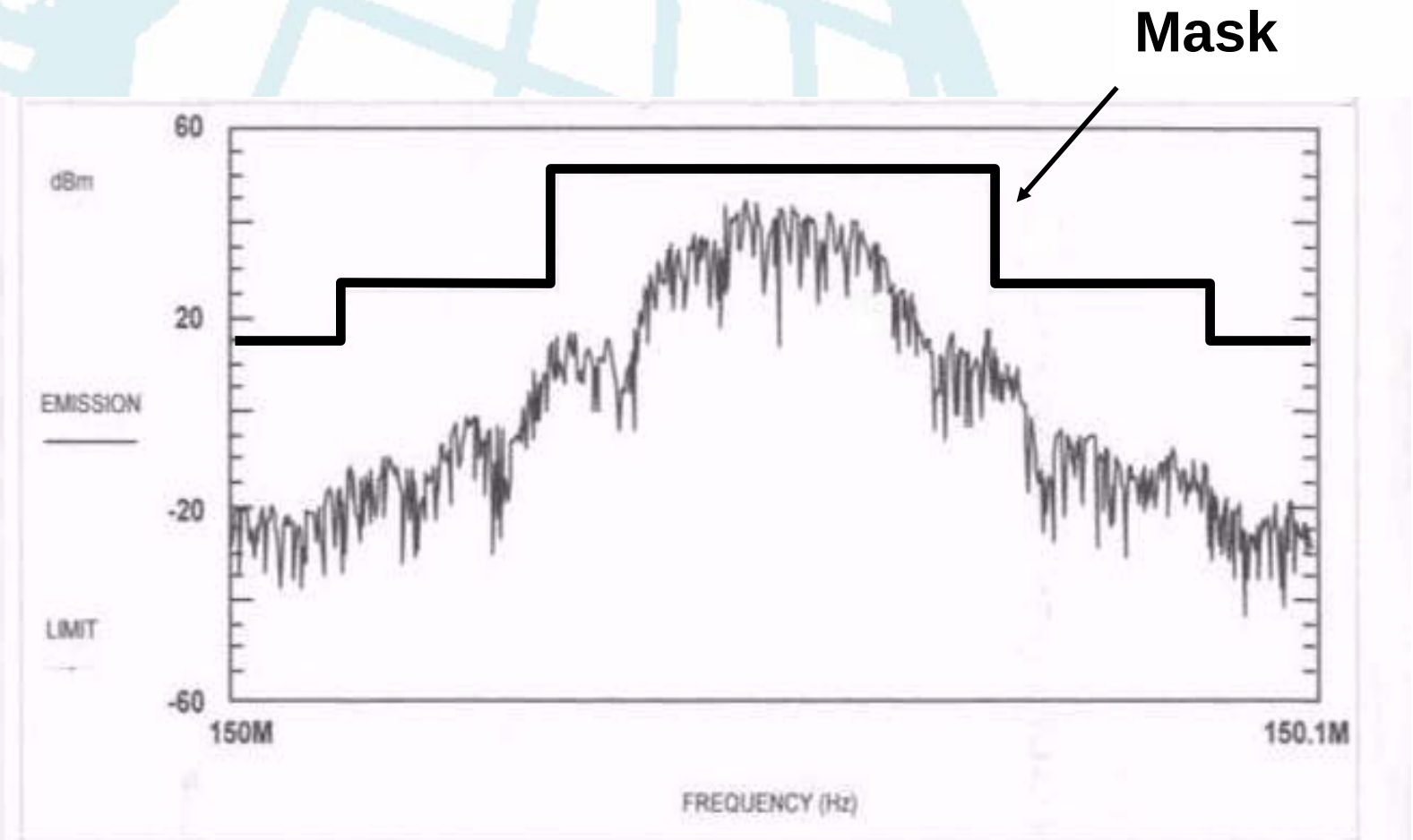


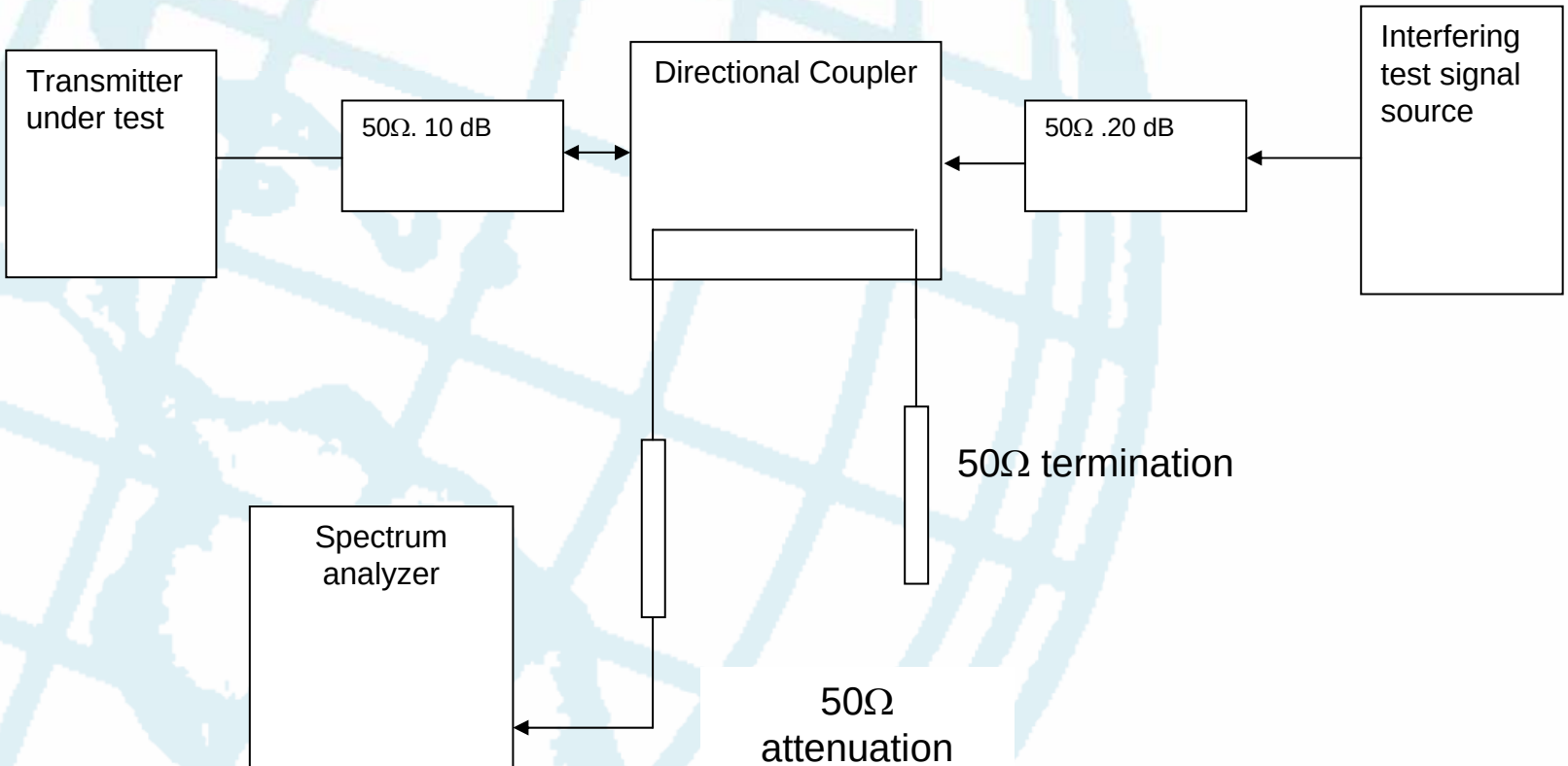
Figure 3. Occupied Bandwidth, Channel 36 (27.36 MHz)

Emissions Mask Example
Digital Modulation

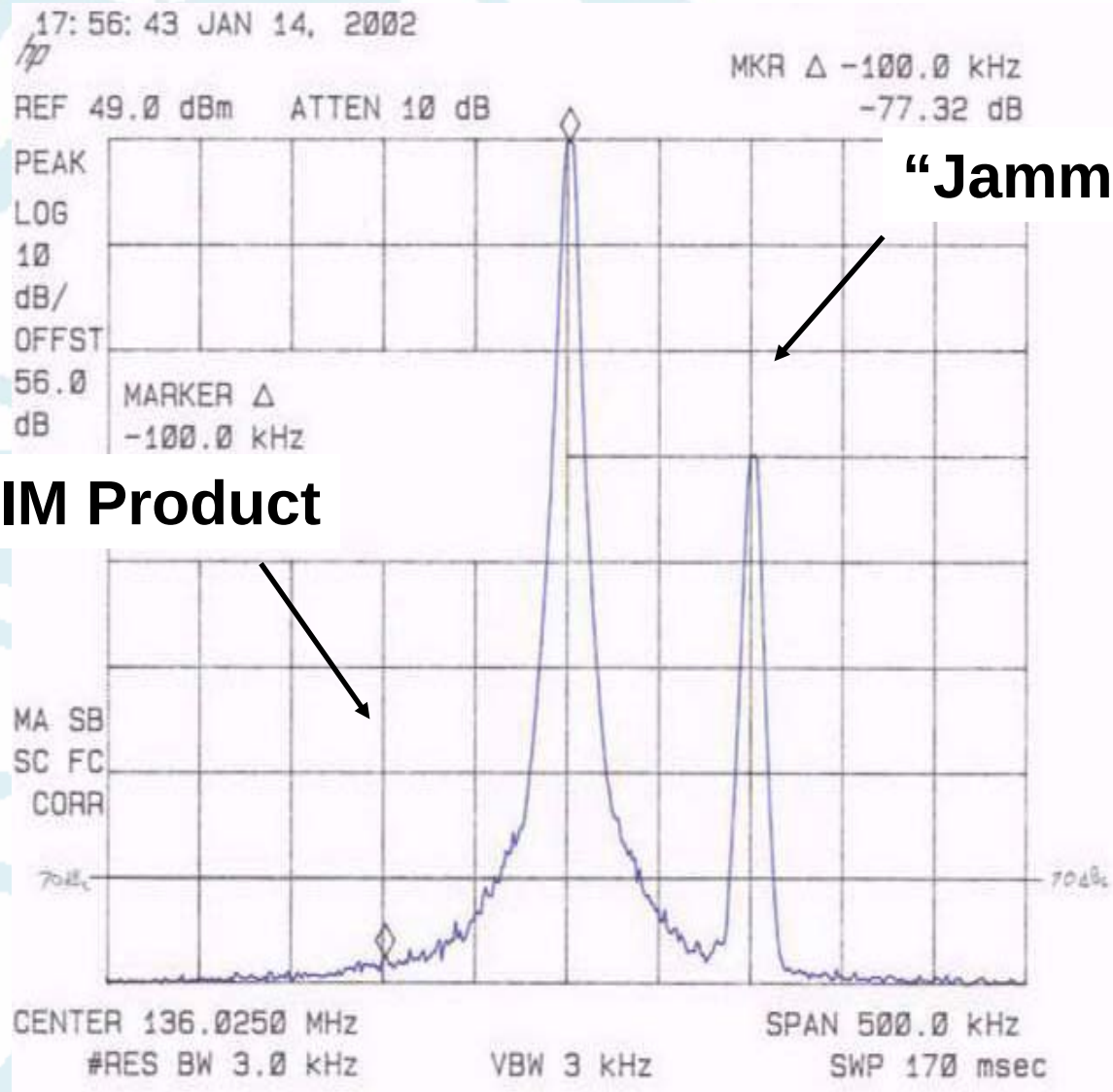


Intermodulation

IM Test Setup



Example: IM Plot



"Jamming Signal"

IM Product

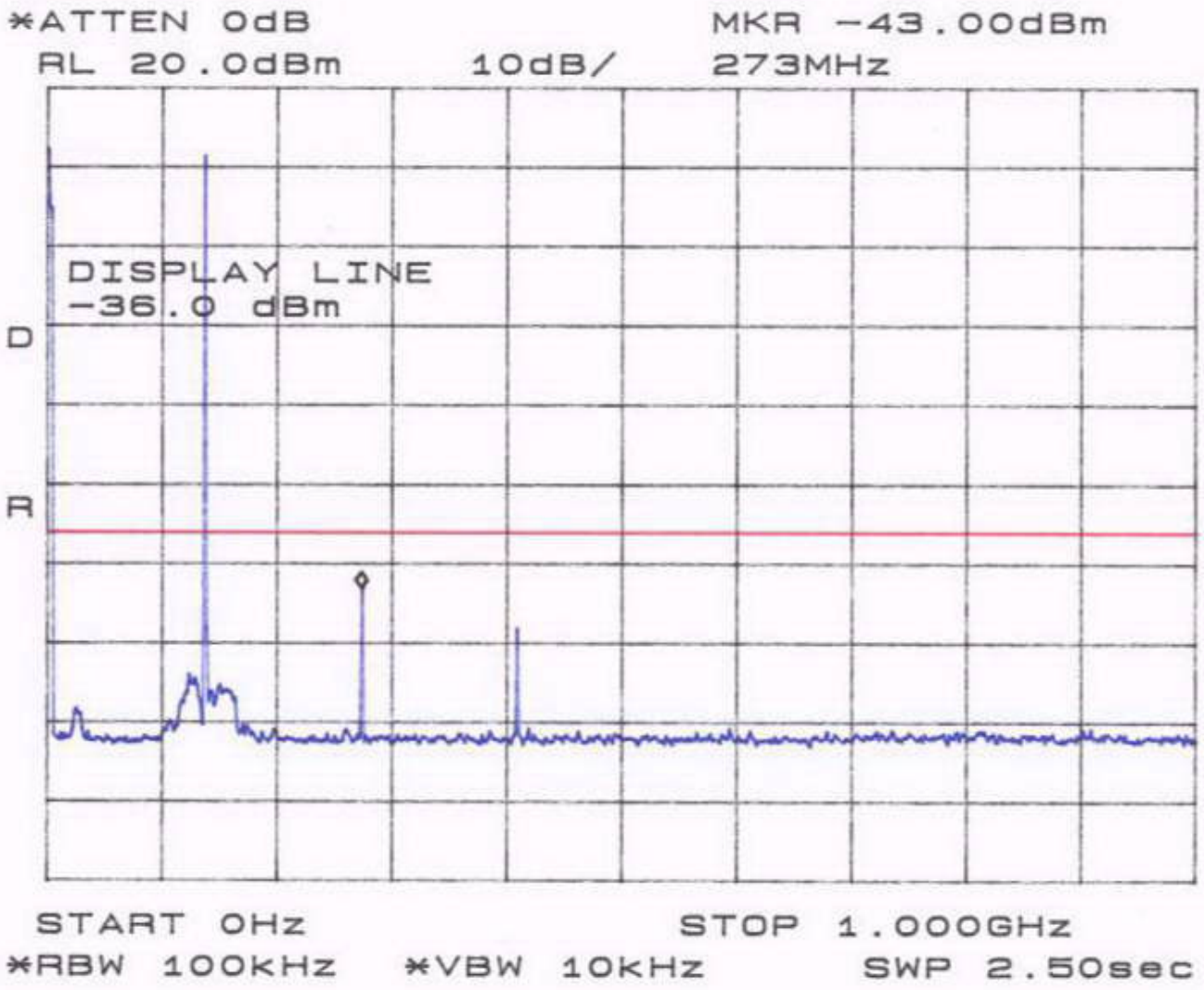
Licensed Radio Services Test Parameters

Antenna Terminal Spurious Emissions (Conducted Emissions)

- FCC 2.1057

An extension of the emission mask test showing the emission up to the highest frequency as specified in Section 2.1057 (typically 10th Harmonic)

Example:
Spurious Emission Plot

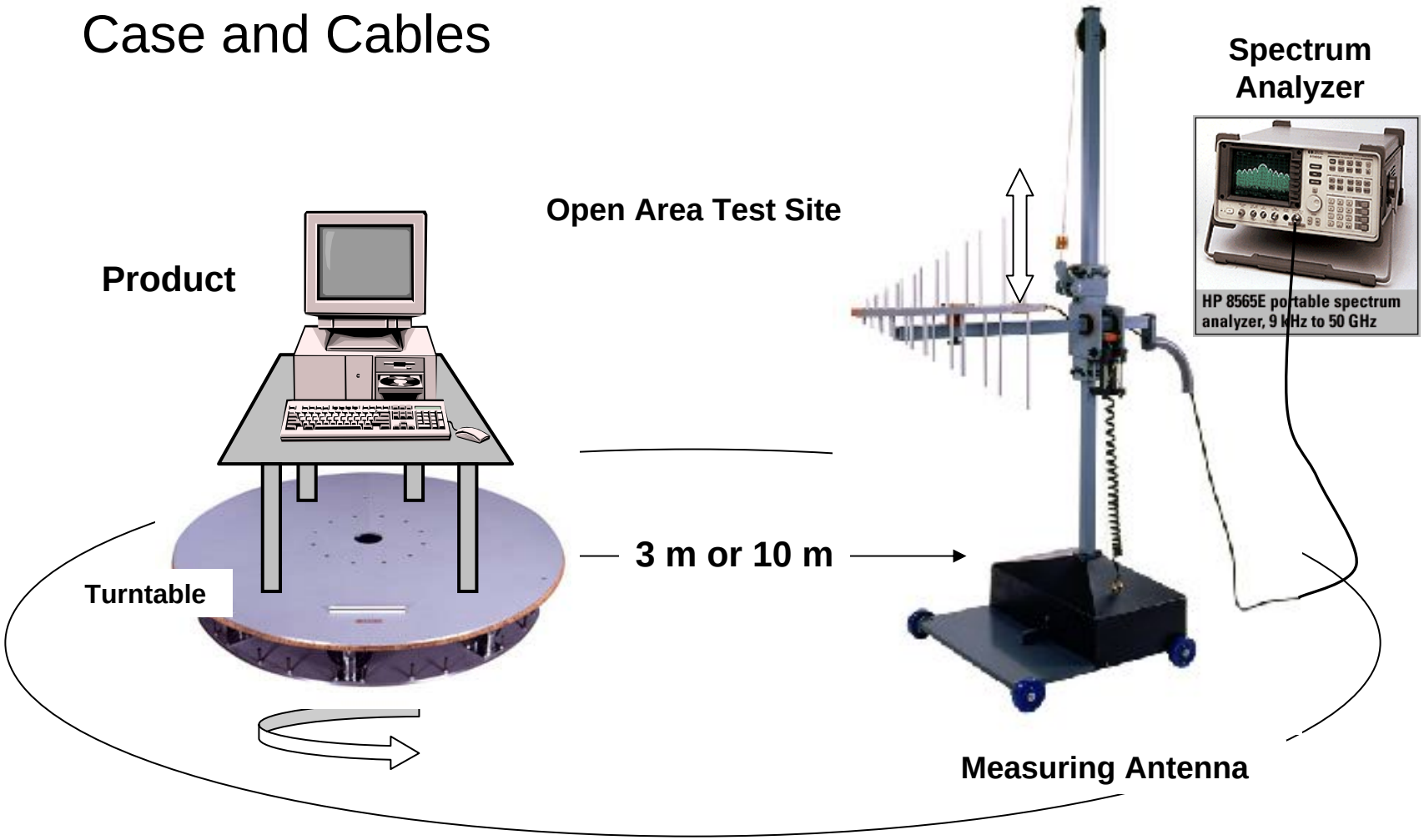


Licensed Radio Services Test Parameters

- Field Strength of Spurious Emissions 2.1057 (radiated)
  - ERP/EIRP Measurement
  - Limits = Emission Mask
- Emissions radiated from the
  - cabinet, chassis, and associated wiring
- Signal substitution measurement method (Described in TIA/EIA 603)

Field Strength of Spurious Emissions

- Test Site: Measure Radiated Noise from Equipment Case and Cables



Licensed Radio Services Test Parameters

- Frequency Stability 2.1055
- Done over temperature (-30°C to +50°C) and operating voltage (+/-15%) specifications.
- Usually defined in ppm. Other units such as Hz and % are acceptable depending on rule section.

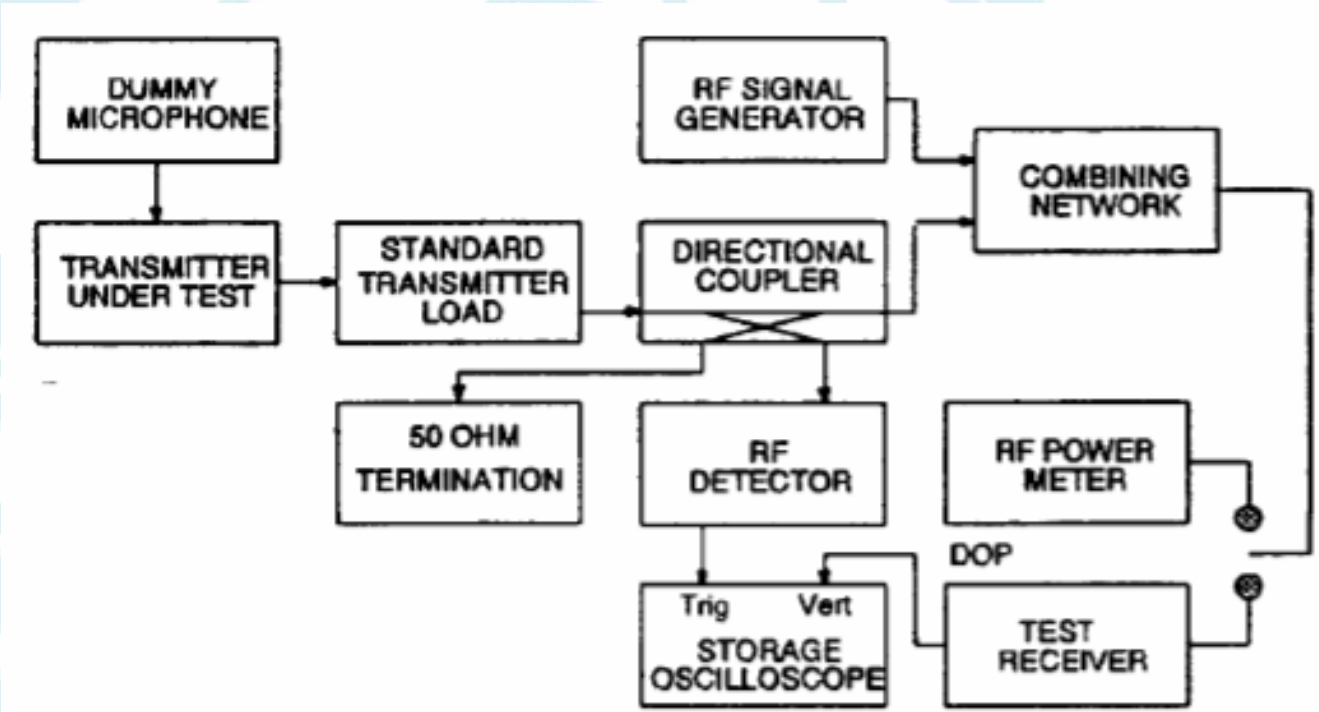
Additional Tests

Licensed Radios operating in the 150-174MHz and 421-512MHz bands under Part 90 require Transient Frequency Behavior test. TIA/EIA 603

- Tests to verify Tx is at frequency stability limits within specified time after Tx on/keying. (turn on time)
- Verifies stability after Tx off (turn off time)

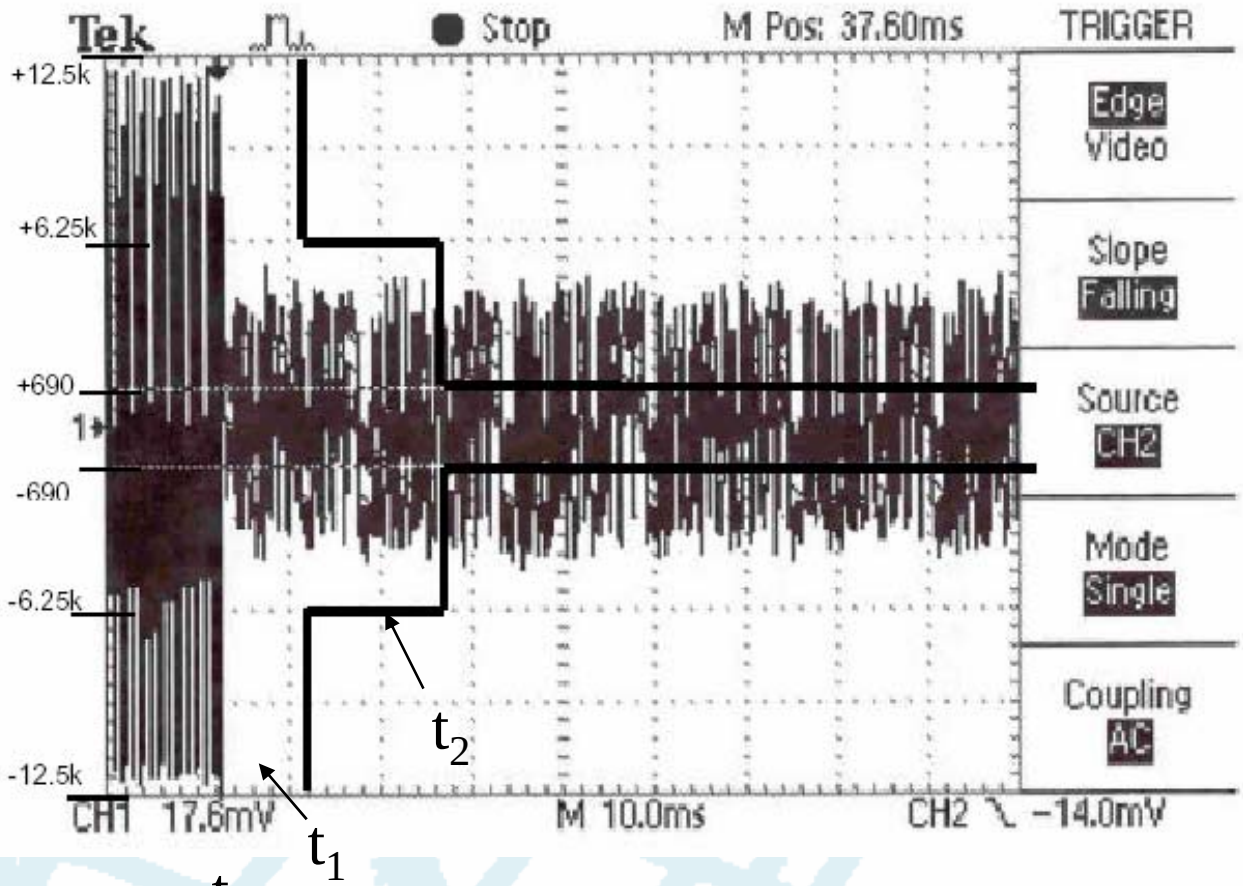
Additional Tests

Transient Frequency Behavior Test Setup TIA/EIA-603



Additional Tests

Example Transient Frequency Behavior Test Results



Licensed Radio Services Test Parameters

- Emission Designator: Determined from the Occupied bandwidth and the modulation scheme used

- Required as part of submittal

  Example Deignator: 8M00F1D (8MHz necessary bandwidth, Frequency Modulation, Single Channel Digital Data, Data Transmission /Telemetry)

FCC Part 15C
Low Power Transmitters
“Unlicensed Operation”

15 C Intentional Radiators

- General Requirements:
- FCC 15.207
- FCC 15.209
  - Class B Limits Only

15.203 Antenna Requirements

15.203 Antenna requirement. - An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device.

- Unique connector
- Permanently affixed
- Professional Installation

15.205 Restricted Bands

- Bands are generally US Government, military bands, Biomedical Telemetry
- The field strength of emissions appearing within these frequency bands shall not exceed the limits shown in §15.209.
- Basis for all radiated “band edge” requirements (i.e. 2483.5MHz).
- Caution: Restricted Bands change over time

AC Conducted Limits 15.207

- Unless specified elsewhere, all Intentional Radiators must meet 15.207 limits anywhere outside of their allotted frequency band
  - CISPR 22 Limits (150 kHz – 30MHz, peak and average) (July 10, 2004)
  - Limit = 250uV 450kHz to 30 MHz (peak only)
- Required if it connects directly or indirectly to AC mains
- Conducted emissions not required for battery powered devices

Radiated Emission Limits 15.209
General Emissions Limits

- Unless specified elsewhere, all Intentional Radiators must meet 15.209 limits anywhere outside of their allotted frequency band
- Test set-up per ANSI C63.4-2001
- Limits identical to FCC Class B. Tighter limits apply at all band edges
- Specific rules may apply for the device.
- Intentional radiators must generally be measured to the 10th Harmonic

Measurement Standards

- ANSI C63.4-2001- per Part 15.31 (a) (3)
- CISPR 22 (Must use ANSI setup)
- FCC Part 15
- Other Resources:
  - Public Notices, FCC Dockets, Interpretations www.fcc.gov

15.225: 13.110 – 14.010MHz

- RFID devices (new rules in 2003)
- Allow the tag to be certified with the interrogator device
- Increased frequency range
- Limits increased

15.231 Periodic Operation

- 40.66MHz – 40.70MHz
- Above 70MHz
- Now allows data transmission to be sent with control signal (Late 2003)
- Limited to 5 second Tx duration
- Periodic transmissions not allowed
  - Polling/supervision transmissions allowed for security and safety applications (e.g. alarm system)
  - Limited in duration (2 sec./hour)

15.231 Periodic Operation

Field strength limits:

- QP below 1GHz
- Average above 1GHz
  - Duty cycle correction for pulsed operations
- Peak limit above 1GHz also applies

20dB Bandwidth limited to 0.25% of operating frequency

15.231 Periodic Operation

Common devices:

- Garage door remotes
- Car entry systems/keyfobs
- Alarm systems

Voice, video and radio controlled toys only permitted under 15.231(e)

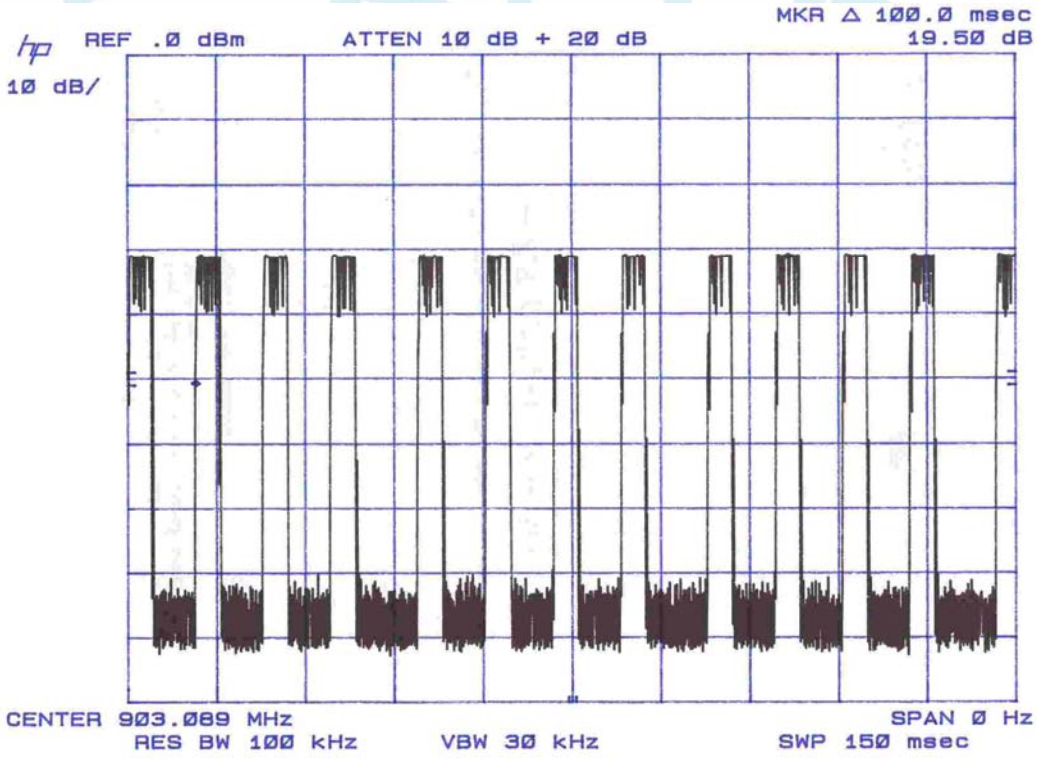
- Tighter limits
- Limited transmission duration

Duty Cycle Correction

- Used with pulsed operation to obtain average value of emission
- Based on pulse train or worst case 100ms.
- 20dB Max duty cycle correction allowed

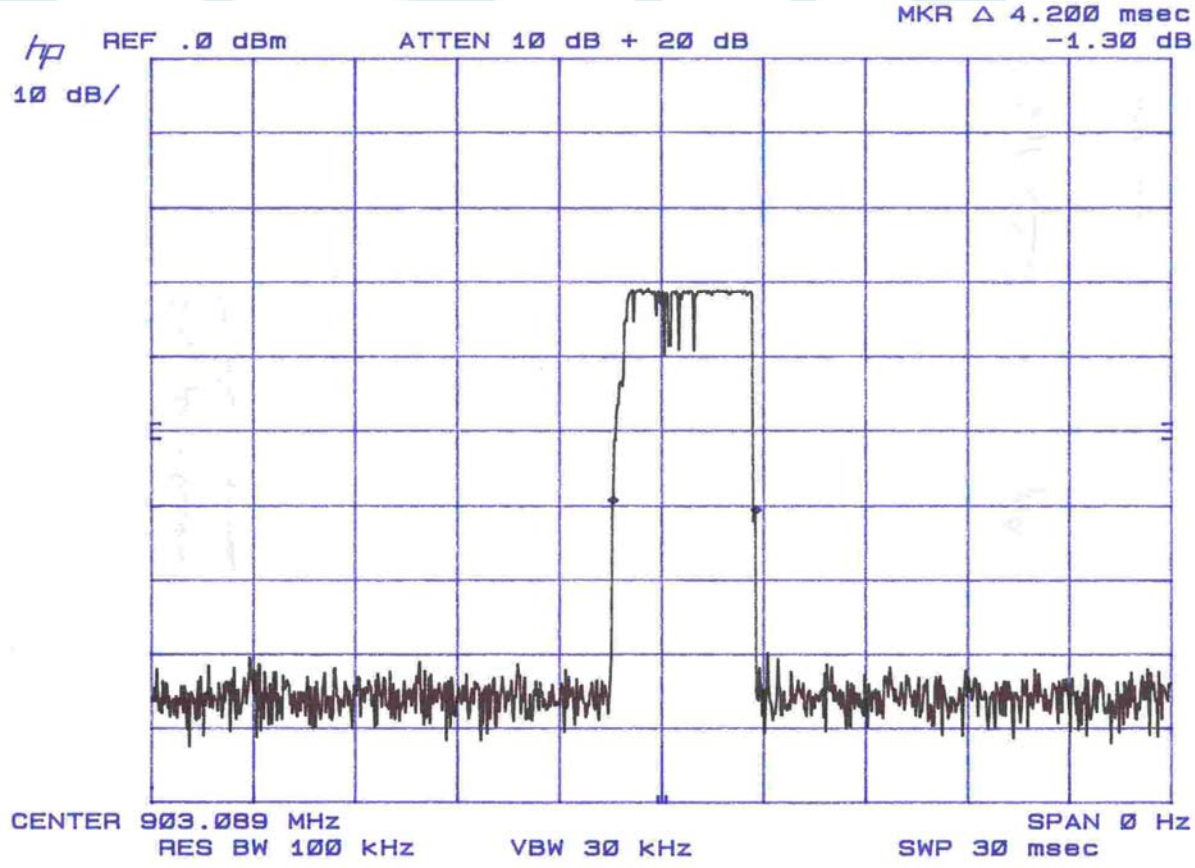
Duty Cycle Correction

- Example: Worst case 100ms



Duty Cycle Correction

- Pulse Width:



Duty Cycle Correction

Calculation:

- On Time Per 100ms (worst case):
  - 8.5 x 4.2ms = 35.7ms
- Duty cycle calculation:
  - 35.7ms/100ms = 35.77% on time
  - 20 * LOG(0.3577) = -8.9dB duty cycle correction.

15.247 Spread Spectrum

- ISM Band
  - 902 – 928 MHz
  - 2400 – 2483.5MHz
  - 5725 – 5850MHz
- Direct Sequence and Digital Transmission Systems
- Frequency Hopping Systems
- 802.11 a/b/g systems

15.247 Spread Spectrum FCC Requirements

- Tx Output Power 1 Watt
- Effective Isotropic Radiated Power 4 Watts (36dBm)
- Antenna Gain: Limited to 6dBi (Output power must be reduced 1dB for every dB gain over 6dBi)
  - Fixed Pt. to Pt. Systems in 2.4GHz band: Reduce power 1dB for every 3dB exceeding 6dBi.
  - Fixed Pt. to Pt. Systems in 5.8GHz band: No reduction in output power required.
  - Antenna requirements

15.247 Spread Spectrum FCC Requirements DSSS

- Out of band emissions: 20dBc in any 100kHz band
- Band edge requirements
- Bandwidth: DSSS (6dB minimum 500kHz)
- Spectral Power Density averaged over 1 second not to exceed +8dBm in any 3kHz bandwidth
- Processing Gain: No longer a requirement

15.247 Spread Spectrum FCC Requirements FHSS

Minimum number of hopping frequencies

- 50 hopping frequencies for 902-928 MHz
- 15 hopping frequencies for 2400-2483.5 MHz
- 75 hopping frequencies for 5725-5850 MHz

Average occupancy less then 0.4 seconds in a 30 second period. [0.4 seconds in 0.4 second period x number of channels 2.4GHz band]

20dB bandwidth: 1 MHz 5.8 GHz/ 500kHz 902-928 MHz. Not specified at 2.4GHz

Random non-sequential hop pattern

15.249
General Unlicensed/ISM Band

- 902-928 MHz
- 2400-2483.5 MHz
- 5725-5875 MHz
- 24.0-24.25 GHz
- Any type of data
- Continuous transmission
- E-Field emission limits

Unlicensed Transmitters Millimeter Wave Devices

- FCC Part 15.253
- Frequencies of operation
  - 46.7-46.9 GHz, 76-77 GHz
- Limited to vehicle mounted field-disturbance systems

Unlicensed Transmitters Millimeter Wave Devices

- FCC Part 15.255

- Frequencies of operation
  - 57 - 64 GHz
  - Can not be used on aircraft or satellites

Part 15 Subpart D - Unlicensed PCS Bands

- 1910 -1930 MHz
- 2390-2400 MHz
- Unique Antenna Connector Required
- 3dBi Max (1 to 1 Power Reductions vs. antenna gain)

Unlicensed National Information Infrastructure
UNII - Part 15.401

- 5.15 -5.25 GHz
- 5.25 -5.35 GHz
- 5.725 -5.825 GHz

Specific power and usage limitations for each band

- Indoor use only with integral antennas in the 5.25-5.35 GHz band.
  - **Unique antenna connectors DO NOT qualify**

UNII Devices Continued

- New Rules: Docket No. 03-122, Feb. 19, 2004
- New 255 MHz of spectrum
  - 5.47 – 5.725GHz
  - Dynamic Frequency Range Selection (DFS) for devices in the 5.25 – 5.35GHz and 5.47 – 5.725GHz bands
  - DFS Interim Test Procedures in rules.
  - Transmit Power Control (TPC) 5.47 – 5.725GHz band. No testing, statement will suffice.
  - Requires submission of application to FCC

Part 15 Subpart F: UWB

- Technology referred to as Ultra-Wide Band.
- This is a new rule part adopted in April of 2002
- Does not yet qualify for TCB Approval
- No standardized test procedures yet adopted
- Devices range from see-through-wall devices, ground radar for construction and safety, to low power communication.
- Coordination with NTIA is required.
- Operates over wide area of band (1 to 6 GHz wide signals)

Comparison of Spectrum

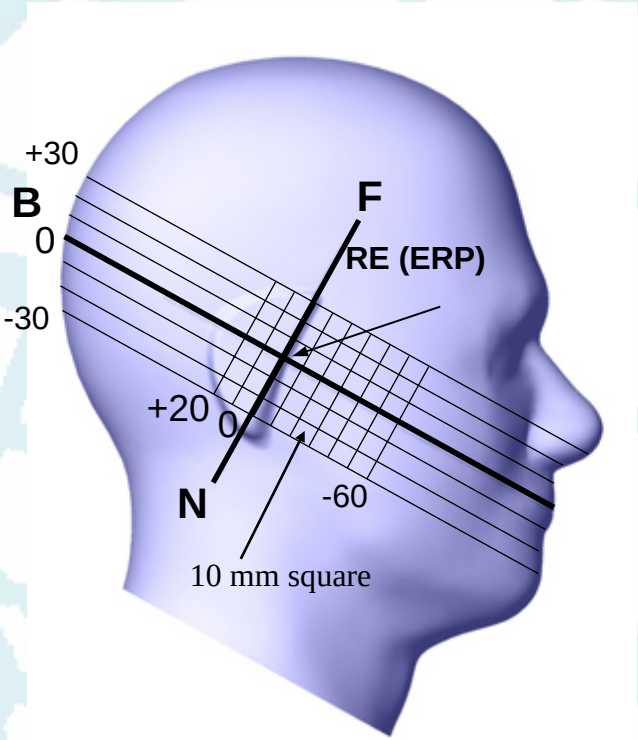
30 kHz
Analog Cellular Voice Channel

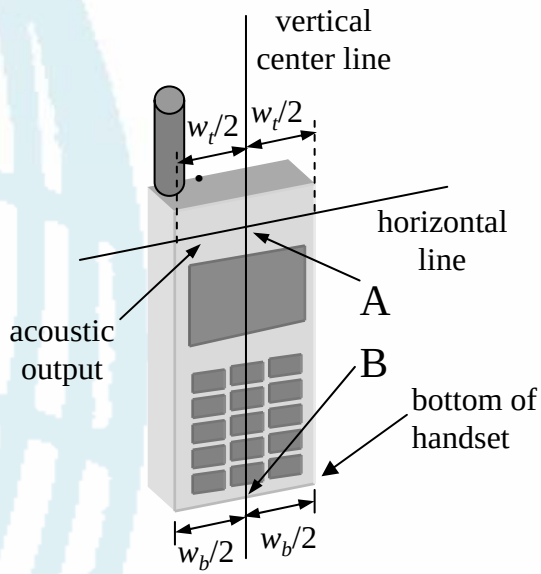
6 MHz
TV Channel

28 - 100 MHz
Unlicensed Spread Spectrum Devices

1000 - 3000 MHz Ultra-Wideband Devices

RF Exposure


+30
B
0
-30
F
RE (ERP)
+20
0
N
-60
10 mm square


vertical
center line
$w_t/2$
$w_t/2$
horizontal
line
A
B
acoustic
output
bottom of
handset
$w_b/2$
$w_b/2$

RF Safety Issues OET 65 (FCC)

- **MPE**: Maximum Permissible Exposure (calculation to determine separation distances)
- **SAR**: Specific Absorption Rate (test for body-worn devices)
- MPE or SAR Test Required?
- This can be determined by referencing OET Bulletin 65 Supplement C.

RF Safety Issues Human Exposure

Rules and Regulations

- ANSI C95.1
- OET 65
- OET 65-C
- FCC Part 1.1037
- FCC Part 2.1091 Mobile Devices
- FCC Part 2.1093 Portable Devices
- FCC Part 15.247 (b) (4)

Part 15 and RF Exposure

Though categorically excluded from Routine Examination under the FCC Rules, the FCC frequently requires a SAR test or SAR modeling done for **portable** devices if the power exceeds 100mW EIRP

Part 15 and RF Exposure

- The FCC will require a MPE study for both Mobile and Fixed devices that use high gain antennas.

- For evaluation purposes for SAR and MPE, the default limits are for **Uncontrolled Environments** which use the tighter limits.

Controlled Environment

People are aware of potential hazards (posted warnings/training)

- Radio Facilities
- Test Environments
- Manufacturing Environments

Limits:

- 5mW/cm^2 over a 5 minute period

Uncontrolled Environment

- People are unaware of potential hazards
  - General Public
- Limits
  - 1mW/cm^2 over a 30 minute period

Categories of Devices

- Fixed
- Mobile
- Portable

Fixed Device

- Permanent mounted device
- Antenna 2 meters away from all users and bystanders
- Antenna usually roof mounted or pole mounted

Mobile devices

- Designed to operate at 20cm or more from any bystander
- Subject to MPE study
  - MPE Example Calculation:
- Desktop devices

Portable devices

- Operate less then 20cm from any user or bystander
- Usually involves body worn devices
- SAR Testing may be required

European Requirements Overview

European R&TTE Market

Before R&TTE Directive: highly fragmented

- > 1000 national regulations, around 30 harmonised EU regulations
- fragmentation of spectrum

After R&TTE Directive: less fragmented

R&TTE

Covers the following aspects:

- Efficient use of spectrum (Article 3.2)
- EMC (Article 3.1b)
- Safety (Article 3.1a)

R&TTE Approval Process

- CE Marking by manufacturer
- Self-Declaration for many products
- Reduced approval procedures and processes
- Harmonized standards developed (Official Journal)

Annexes

- Annex I: Things NOT covered
  - Cables, Receive-only broadcast, Kits, Aviation and Air Traffic, marine
- Annex II: Internal Production Control
  - Basis for all Annexes (good documentation!)
- Annex III: Annex II + Testing
  - Type testing
- Annex IV: TCF
  - Notified Body (for new technologies)
- Annex V: Full QA
  - Accredited Quality Assurance System

R&TTE Testing

- No longer requires involvement of accredited test house
- Test to harmonized standards
  - DoC
  - CE Marking
  - Ship
- Non-harmonized frequencies:
  - Notification to Spectrum Authority
  - Alert Signal (Equipment Class Identifier)
  - Restricted Geographical Area

Harmonized Frequencies (Short Range Devices)

- Document CEPT 70-03
  - Lists frequencies and usage in different European countries
  - Latest: Feb 2004
- Published by: European Conference of Postal and Telecommunications Administrators
- Available at http://www.ero.dk/

Examples from CEPT 70-03

Annex 1 Band E

Non Specific Short Range Devices

433.050-434.790 MHz

Estonia	Audio and video not allowed	Video only above 2.4 GHz
Finland	Audio and voice not allowed	Voice, Audio and video only on frequencies above 2.4 GHz
France	None	No dutycycle limit
Germany	None	Duty cycle limit suspended until April 2002
Hungary	Two way speech not allowed	
Italy	Limited to 433.05-433.575 MHz for audio signals with 12.5 or 25 kHz channel spacing. Audio and voice signals not allowed	Military applications
Latvia	Voice, audio, video not allowed	
Luxembourg	Audio and voice not allowed	
Sweden	None	25 mW is allowed. No duty cycle limitation
The Netherlands	None	No duty cycle limit
Turkey	Not implemented	
United Kingdom	Voice not allowed	

Edition of 1 February 2002

Example from CEPT 70-03

Annex 3 Wideband Data Transmission systems and HIPERLANs

Scope of Annex

This annex covers frequency bands and regulatory as well as informative parameters recommended for Wideband data transmission systems formerly known as (Radio Local Area Networks (RLANs)) within the band 2400-2483.5 MHz and for High Performance Radio Local Area Networks (HIPERLANs) within the bands 5150-5350 MHz, 5470-5725 MHz and 17.1-17.3 GHz.

Regulatory parameters related to Annex 3

	Frequency Band	Power		Duty cycle	Channel spacing	ERC Decision	Notes
a	2400 - 2483.5 MHz	100 mW	e.i.r.p.	No Restriction	No spacing	ERC DEC (01)07	For direct sequence spread spectrum, the maximum spectrum power density is limited to -20 dBW/1 MHz. For FHSS the maximum spectrum power density is limited to -10 dBW/100 kHz.
b	5150 - 5350 MHz	200 mW	Max mean		No spacing	ERC DEC (99)23	Indoor use only
c	5470 - 5725 MHz	1 W	Max mean	No Restriction	No spacing	ERC DEC (99)23	
d	17.1 - 17.3 GHz	100 mW	e.i.r.p.	No Restriction	No spacing		

Notification

- Applies to radio equipment using a non-harmonized frequency
- If non-harmonized frequency band, the manufacturer must determine if the frequency is available for use in a particular member state
- Notify each member state where the equipment is to be sold

Notification

Notify the Spectrum Authorities in each member state

- Available on-line

Must be made 4 weeks prior to the equipment being offered for sale.

ETSI/EN Standards

Available from www.etsi.org (free!)

EMC & Radio Matters

ETS 300 328:

- Radio Equipment and Systems (RES); Wideband transmission systems; Technical characteristics and test conditions for data transmission equipment operating in the 2,4 GHz ISM band and using spread spectrum modulation techniques

EN 301 428:

- Satellite Earth Stations and Systems (SES); Harmonized EN for Very Small Aperture Terminal (VSAT); Transmit-only, transmit/receive or receive-only satellite earth stations operating in the 11/12/14 GHz frequency bands covering essential requirements under article 3.2 of the R&TTE directive

Example: Short Range Device

Equipment Parameters:

- 433.92MHz
- Low power <2.5mW
- Modulation: FSK
- Duty Cycle: <1%
- Integral Antenna
- Battery Powered

Example: Short Range Device

- Markets of interest:
  - UK
  - France
  - Italy
- Refer to CEPT 70-03 for restrictions

Example:

Short Range Device at 433MHz

CEPT 70-03 Restrictions

Annex 1 Band E

Non Specific Short Range Devices

433.050-434.790 MHz

Estonia	Audio and video not allowed	Video only above 2.4 GHz
Finland	Audio and voice not allowed	Voice, Audio and video only on frequencies above 2.4 GHz
France	None	No dutycycle limit
Germany	None	Duty cycle limit suspended until April 2002
Hungary	Two way speech not allowed	
Italy	Limited to 433.05-433.575 MHz for audio signals with 12.5 or 25 kHz channel spacing. Audio and voice signals not allowed	Military applications
Latvia	Voice, audio, video not allowed	
Luxembourg	Audio and voice not allowed	
Sweden	None	25 mW is allowed. No duty cycle limitation
The Netherlands	None	No duty cycle limit
Turkey	Not implemented	
United Kingdom	Voice not allowed	

Edition of 1 February 2002

Example: Short Range Device

- Compliance test requirements
  - LVD: EN 60065
  - EMC EN 301 489-3 (SRD)
    - Emissions
    - Immunity
  - Radio: EN 300 220-1
    - Spurious emissions
    - Power (ERP)
    - Bandwidth
    - Frequency Stability

Example: Short Range Device

Documentation

- Equipment complies: Test report/TCF
- Generates and signs DOC
- Labels equipment
- Notifies countries before marketing (Only of frequencies are not harmonized)

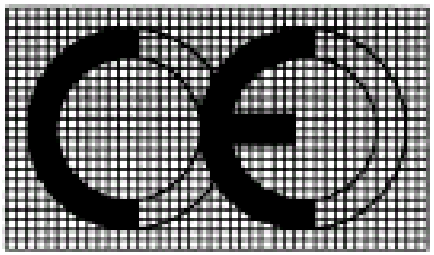
R&TTE Labeling Example

NAME OF A COMPANY

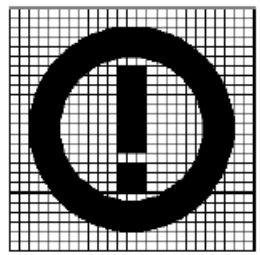
MODEL NUMBER

SERIAL NUMBER

FREQUENCY BAND



nnnn



The Notified Body Number: used when either annex III, IV or V have been used

WLL Contact Information

www.wll.com; info@wll.com
Phone: 800-839-1649; Fax: 301-417-9069
7560 Lindbergh Dr., Gaithersburg, MD 20879

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