

Frequency stability

§ 90.213
§ 7

Frequency error vs. Supply voltage

DC-Voltage	Frequency Error Hz			Frequency Error ppm		
	450 MHz	460 MHz	470 MHz	450 MHz	460 MHz	470 MHz
6,2 V	-50	-50	-70	-0,11	-0,11	-0,15
5,27 V	-60	-60	-70	-0,13	-0,13	-0,15
7,13 V	-70	-40	-60	-0,16	-0,09	-0,13
10 V	-60	-80	-70	-0,13	-0,17	-0,15

Frequency error vs. Temperature

Temperature °C	Frequency Error Hz			Frequency Error ppm		
	450 MHz	460 MHz	470 MHz	450 MHz	460 MHz	470 MHz
-30	+560	+580	+370	+1,24	+1,26	+0,79
-20	+80	+110	+80	+0,18	+0,24	+0,17
-10	+110	+150	+190	+0,24	+0,33	+0,40
±0	-30	+20	+180	-0,07	+0,04	+0,38
+10	-20	+20	+190	-0,04	+0,04	+0,40
+20	-50	-50	-70	-0,11	-0,11	-0,15
+30	-40	-20	+190	-0,09	-0,04	+0,40
+40	-190	-140	+190	-0,42	-0,30	+0,40
+50	-230	-190	+220	-0,51	-0,41	+0,47

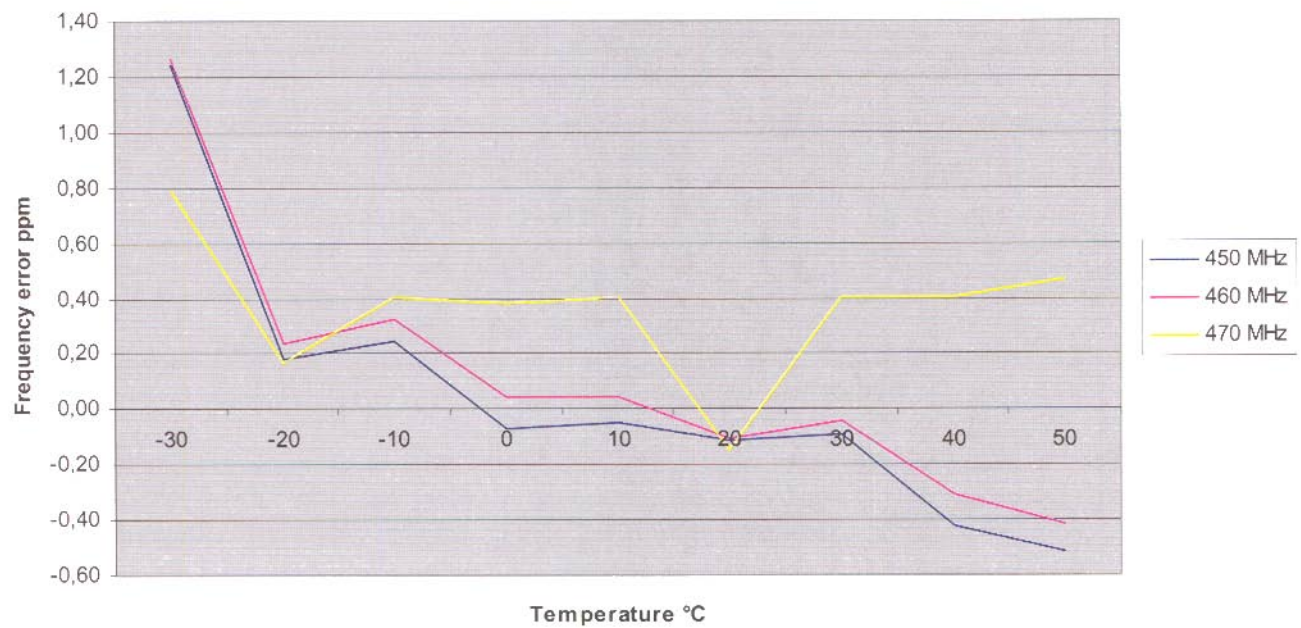
LIMIT 90.213(a) (7 Table 5)

In the 421-512 (450-470) MHz band, fixed and base stations with a 12,5 kHz channel bandwidth must have a frequency stability of 1,5 ppm. In the 421-512 (450-470) MHz band, mobile stations with a 12,5 kHz channel bandwidth must have a frequency stability of 2,5 ppm.

Frequency stability

§ 90.213
§ 7

Frequency error vs. Temperature



Test Equipment used: NT-207, M-512

Transient frequency behaviour

§ 90.214

§ 6.5

LIMIT

90.214 and 6.5:

Transmitters designed to operate in the 150-174 MHz and 421-512 MHz frequency bands must maintain transient frequencies within the maximum frequency difference limits during the time intervals indicated:

Time intervals ^{1,2}	Maximum frequency Difference ³	All Equipment	
		150 to 174 MHz	421 to 512 MHz
Transient Frequency Behaviour for Equipment designed to Operate on 25 kHz Channels			
t_1 ⁴	± 25,0 kHz	5,0 ms	10,0 ms
t_2	± 12,5 kHz	20,0 ms	25,0 ms
t_3 ⁴	± 25,0 kHz	5,0 ms	10,0 ms
Transient Frequency Behaviour for Equipment designed to Operate on 12,5 kHz Channels			
t_1 ⁴	± 12,5 kHz	5,0 ms	10,0 ms
t_2	± 6,25 kHz	20,0 ms	25,0 ms
t_3 ⁴	± 12,5 kHz	5,0 ms	10,0 ms
Transient Frequency Behaviour for Equipment designed to Operate on 6,25 kHz Channels			
t_1 ⁴	± 6,25 kHz	5,0 ms	10,0 ms
t_2	± 3,125 kHz	20,0 ms	25,0 ms
t_3 ⁴	± 6,25 kHz	5,0 ms	10,0 ms

¹ t_{on} is the instant when a 1 kHz test signal is completely suppressed, including any capture time due to phasing.

t_1 is the time period immediately following t_{on}

t_2 is the time period immediately following t_1

t_3 is the time period from the instant when the transmitter is turned off until t_{off}

² During the time from the end of t_2 to the beginning of t_3 , the frequency difference must not exceed the limits specified in § 90.213.

³ Difference between the actual frequency and the assigned transmitter frequency.

⁴ If the transmitter carrier output power rating is 6 watts or less, the frequency difference during this time period may exceed the maximum frequency difference for this time period.

Transient frequency behaviour

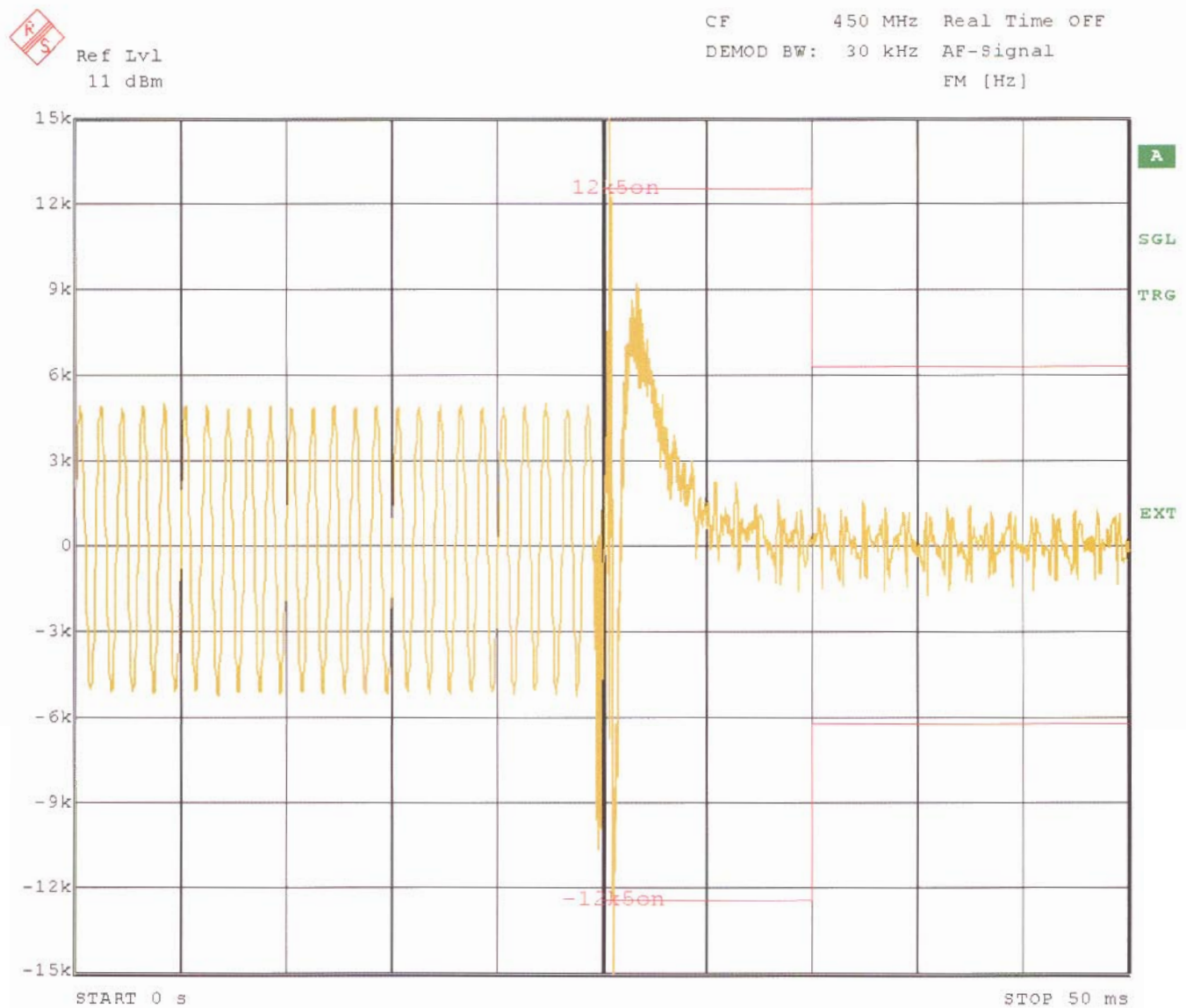
§ 90.214

§ 6.5

Operating mode: t_{on} is in the middle of the screen (25ms pre-trigger)

Frequency: 450 MHz

Transmitter switching on



Date: 21.FEB.2005 10:55:30

Test Equipment used: NT-207, NT-310

Transient frequency behaviour

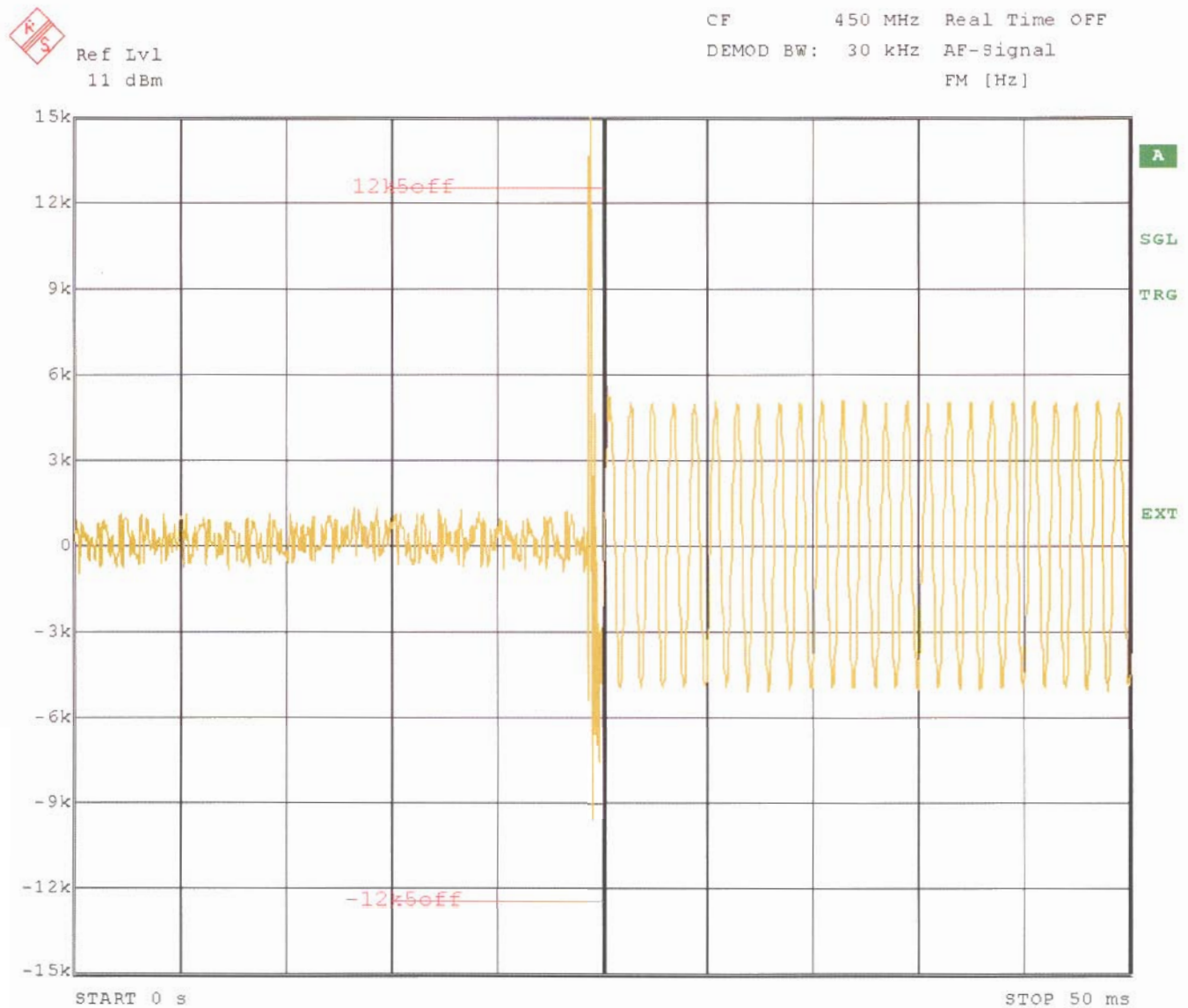
§ 90.214

§ 6.5

Operating mode: t_{off} is in the middle of the screen (25ms pre-trigger)

Frequency: 450 MHz

Transmitter switching off



Date: 21.FEB.2005 10:56:39

Test Equipment used: NT-207, NT-310

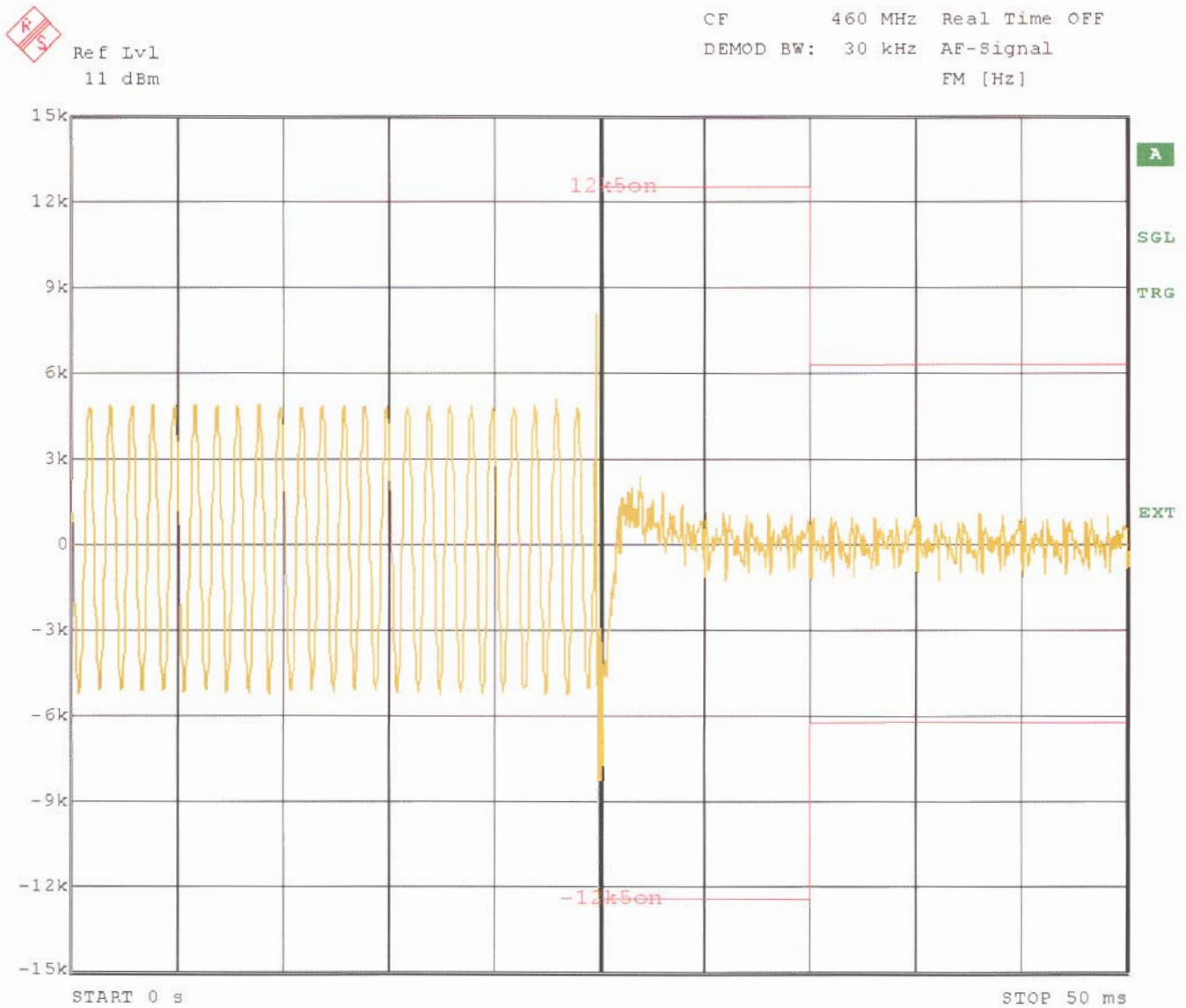
Transient frequency behaviour

§ 90.214
§ 6.5

Operating mode: t_{on} is in the middle of the screen (25ms pre-trigger)

Frequency: 460 MHz

Transmitter switching on



Date: 21.FEB.2005 10:49:08

Test Equipment used: NT-207, NT-310

Transient frequency behaviour

§ 90.214

§ 6.5

Operating mode: t_{off} is in the middle of the screen (25ms pre-trigger)

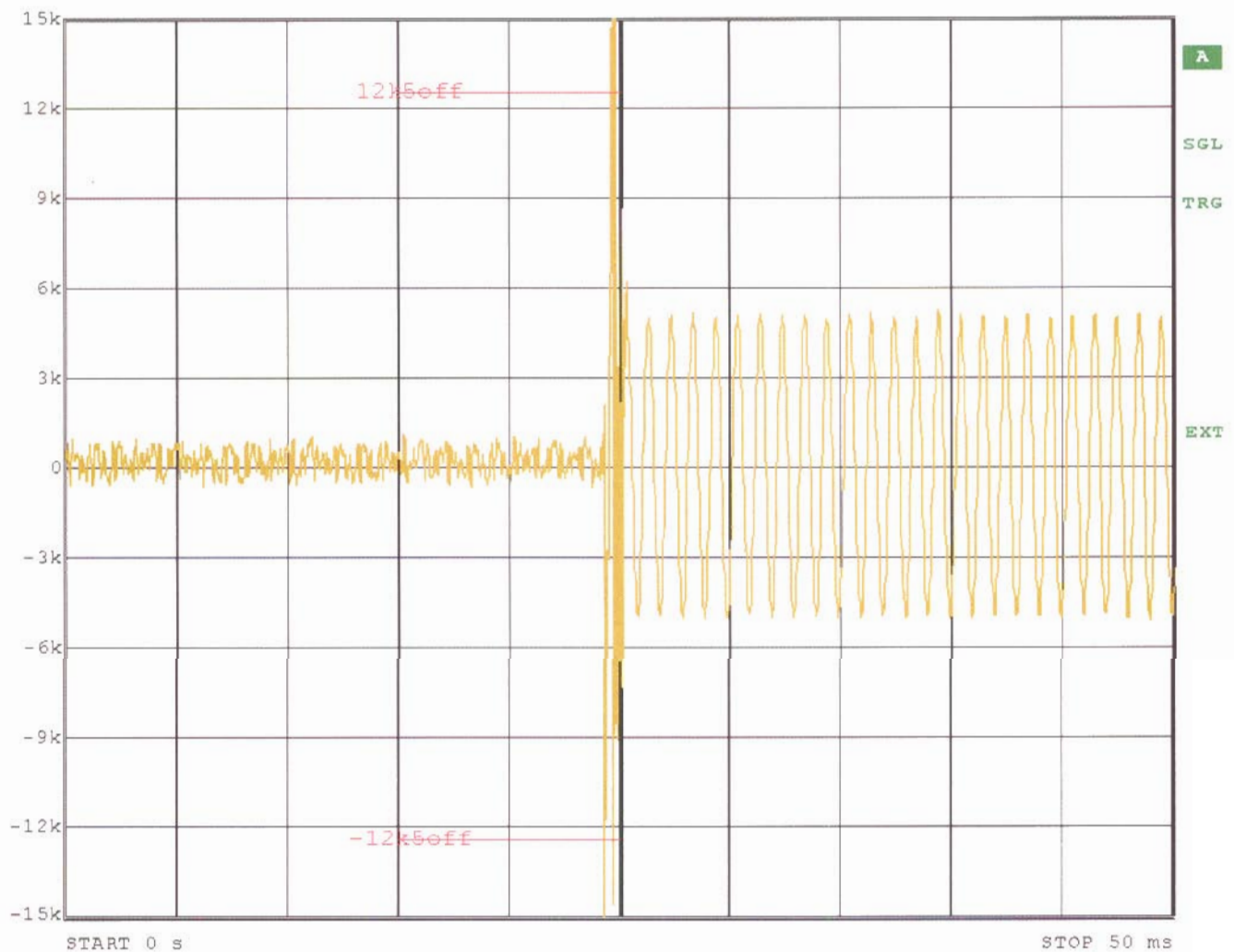
Frequency: 460 MHz

Transmitter switching off



Ref Lvl
11 dBm

CF 460 MHz Real Time OFF
DEMOD BW: 30 kHz AF-Signal
FM [Hz]



Date: 21.FEB.2005 10:48:04

Test Equipment used: NT-207, NT-310

Transient frequency behaviour

§ 90.214
§ 6.5

Operating mode: t_{on} is in the middle of the screen (25ms pre-trigger)

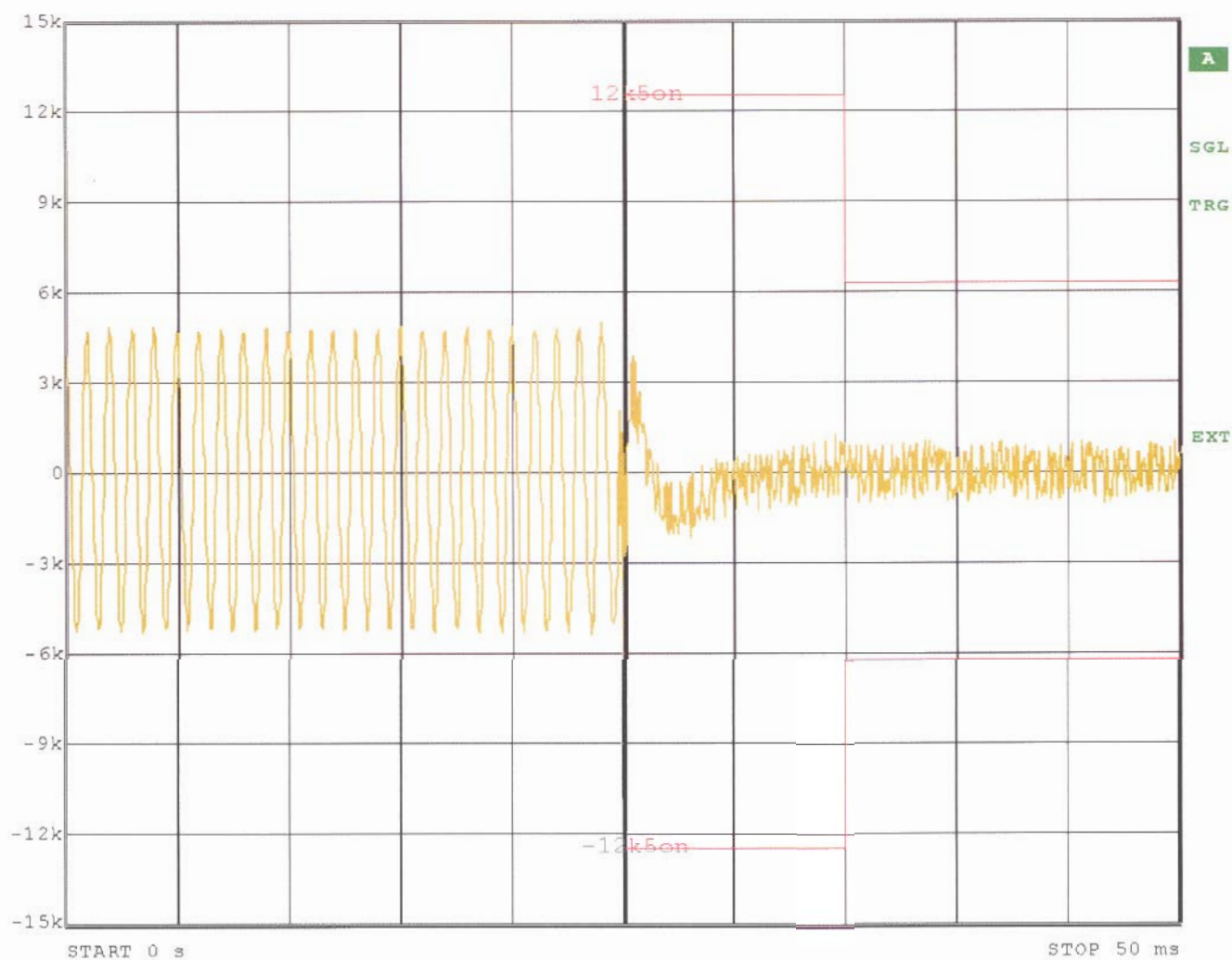
Frequency: 470 MHz

Transmitter switching on



Ref Lvl
11 dBm

CF 470 MHz Real Time OFF
DEMOD BW: 30 kHz AF-Signal
FM [Hz]



Date: 21.FEB.2005 10:45:52

Test Equipment used: NT-207, NT-310

Ambient temperature: 23°C

Relative humidity: 51%

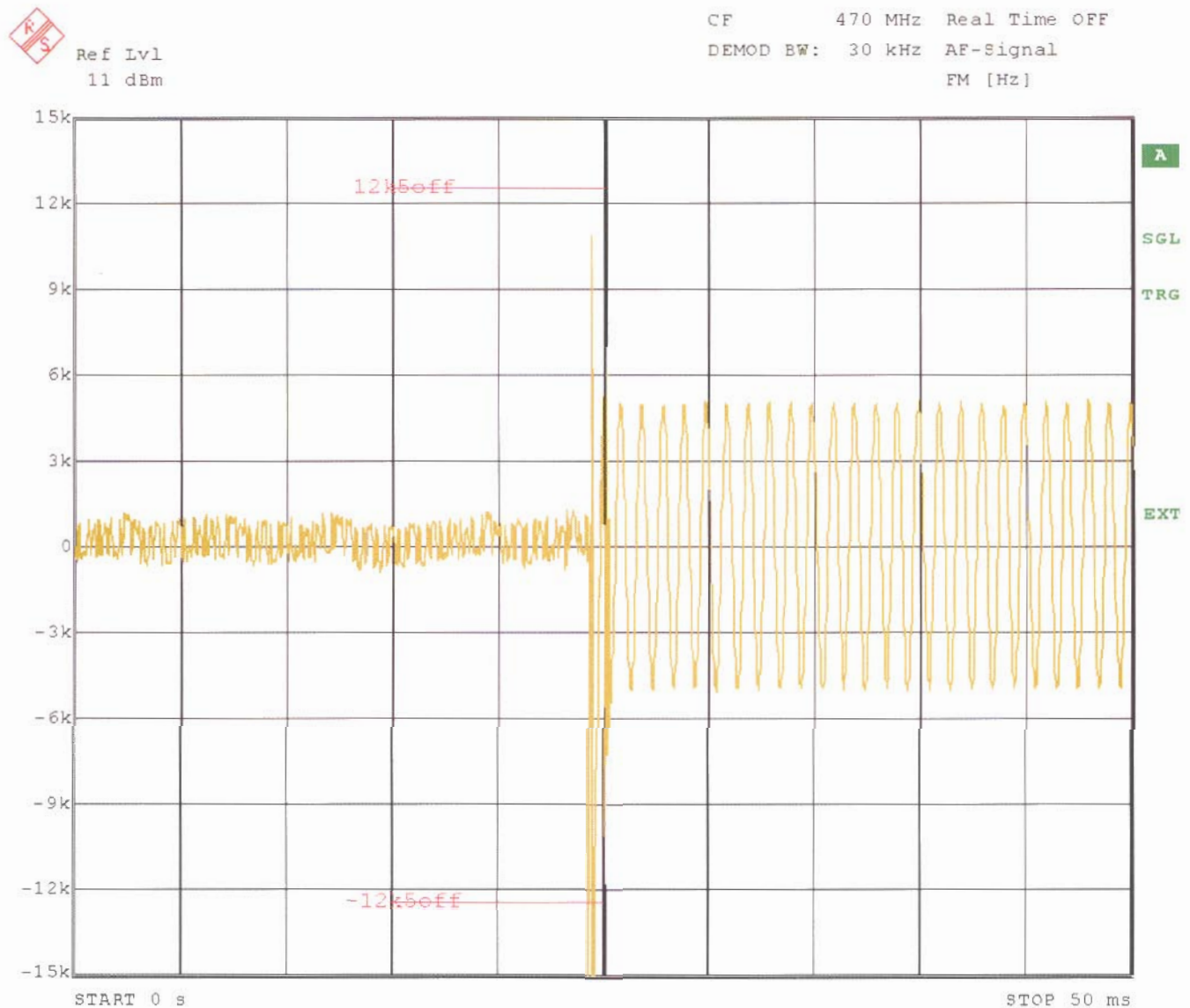
Transient frequency behaviour

§ 90.214
§ 6.5

Operating mode: t_{off} is in the middle of the screen (25ms pre-trigger)

Frequency: 470 MHz

Transmitter switching off



Date: 21.FEB.2005 10:47:08

Test Equipment used: NT-207, NT-310

Receiver spurious emissions

§ 8

LIMIT

8 (i):

The field strength of any spurious frequency generated by the receiver in each polarization (vertical and horizontal), measured at a distance of 3 metres, shall not exceed the limits of Table 6. The resolution bandwidth of the spectrum analyser shall be 100 kHz for measuring spurious emissions below 1,0 GHz and 1,0 MHz for above 1,0 GHz.

Table 6: Spurious Emission Limits for Receivers

Spurious frequency (MHz)	Field strength ($\mu\text{V/m}$) at 3 metres
30-88	100
88-216	150
216-960	200
960-1610	500
above 1610	1000

Test Equipment used: NT-100; NT-110; NT-111; NT-112; NT-125; NT-207

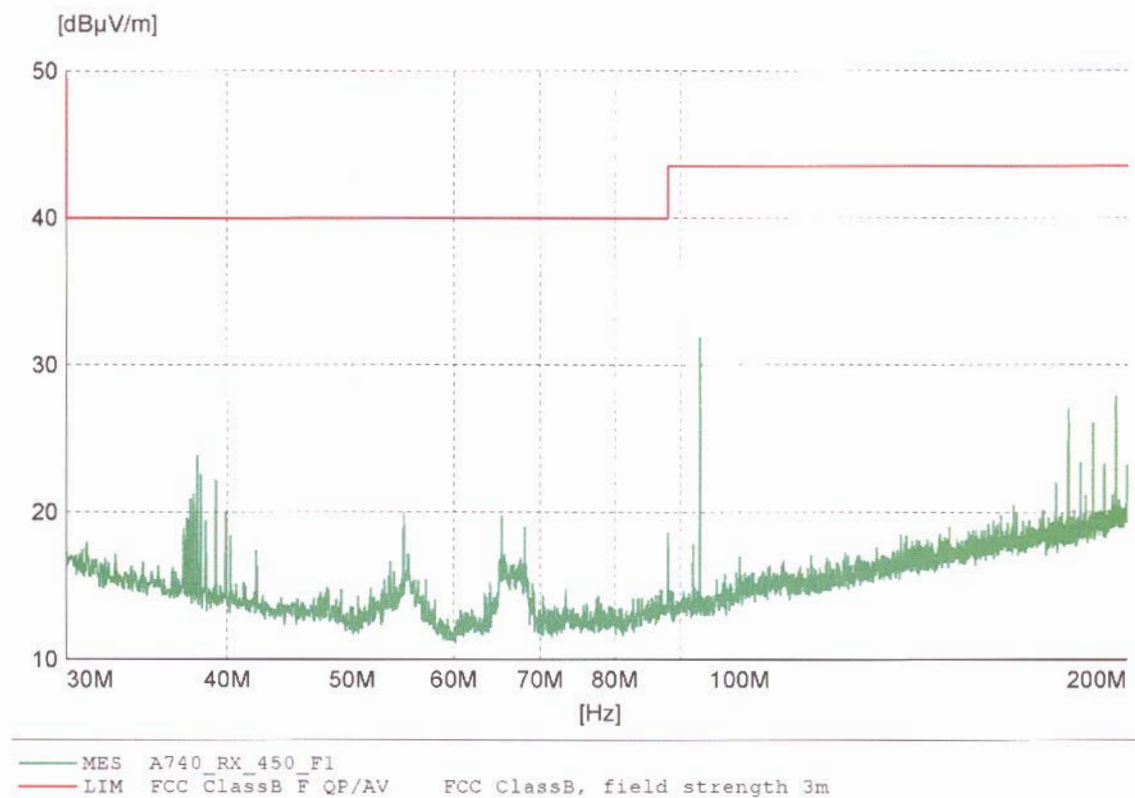
Receiver spurious emissions

§ 8

Operating mode:

Frequency: 450 MHz

Receiving, antenna connected



Seite 1 21.02.2005 15:00

Test Equipment used: NT-100; NT-110; NT-111; NT-112; NT-125; NT-207

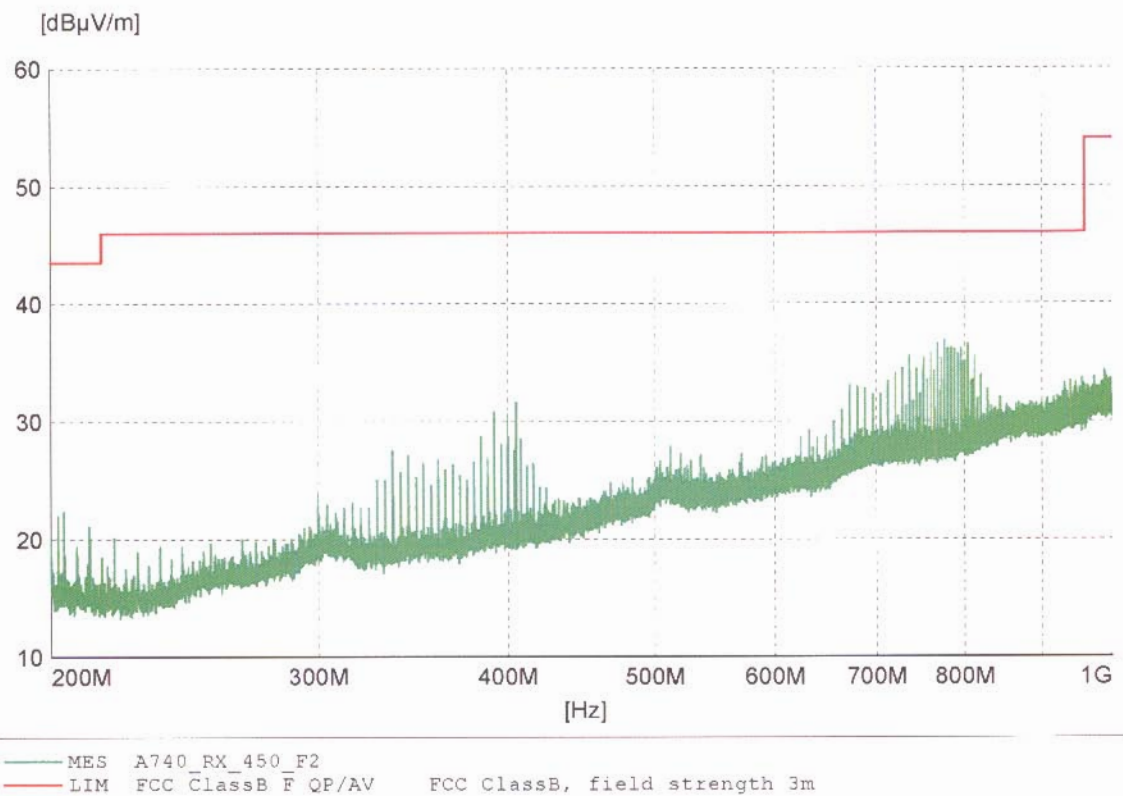
Receiver spurious emissions

§ 8

Operating mode:

Frequency: 450 MHz

Receiving, antenna connected



Seite 1 21.01.2005 15:06

Test Equipment used: NT-100; NT-110; NT-111; NT-112; NT-125; NT-207

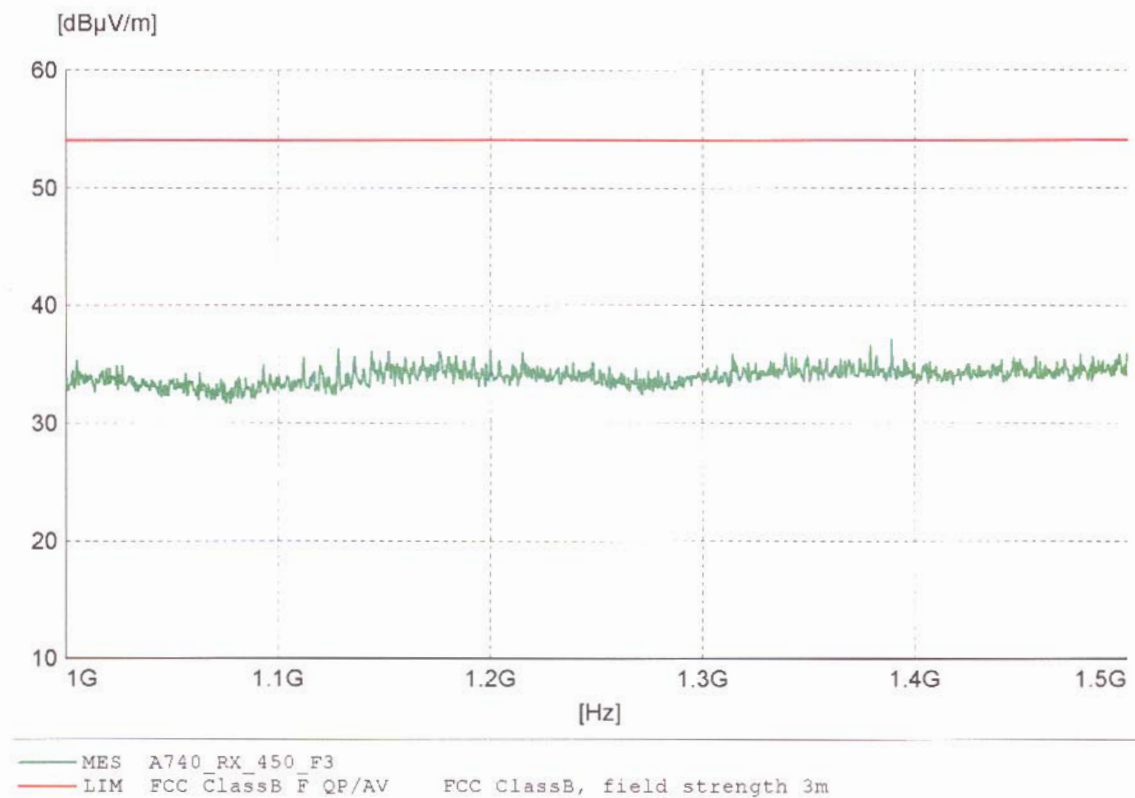
Receiver spurious emissions

§ 8

Operating mode:

Frequency: 450 MHz

Receiving, antenna connected



Seite 1 21.02.2005 15:11

Test Equipment used: NT-100; NT-110; NT-111; NT-112; NT-125; NT-207

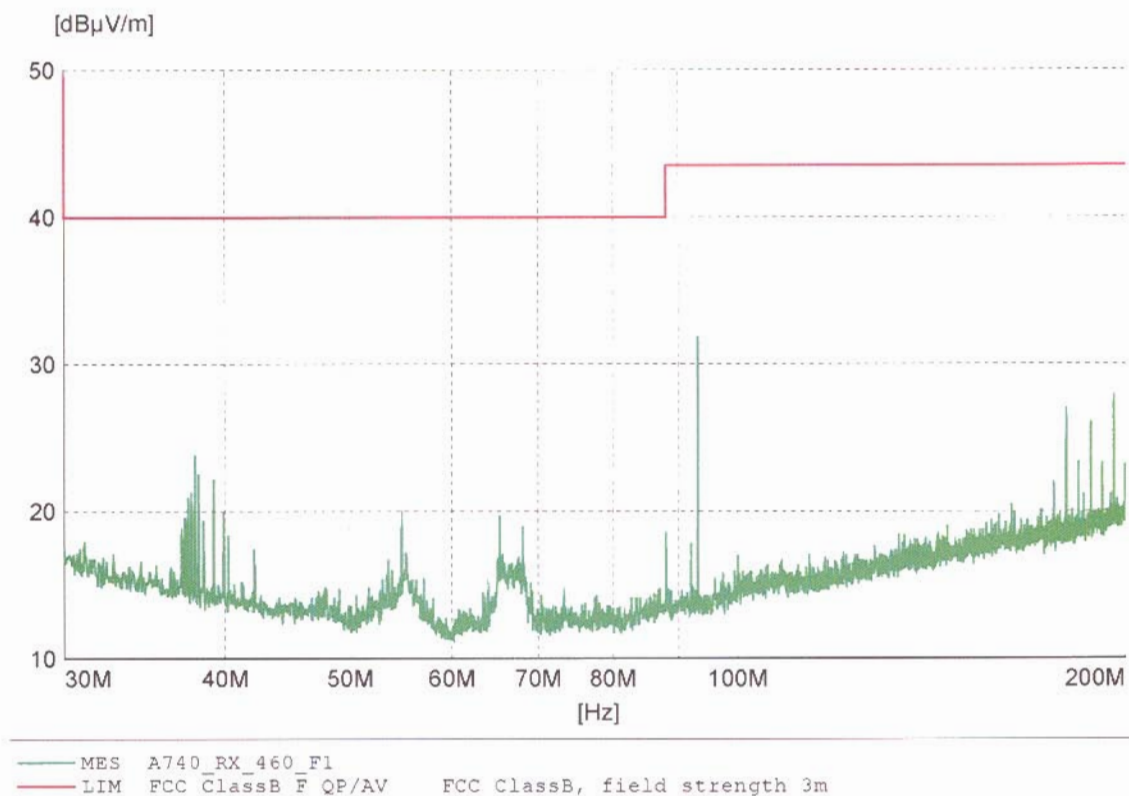
Receiver spurious emissions

§ 8

Operating mode:

Frequency: 460 MHz

Receiving, antenna connected



Seite 1 21.02.2005 15:01

Test Equipment used: NT-100; NT-110; NT-111; NT-112; NT-125; NT-207

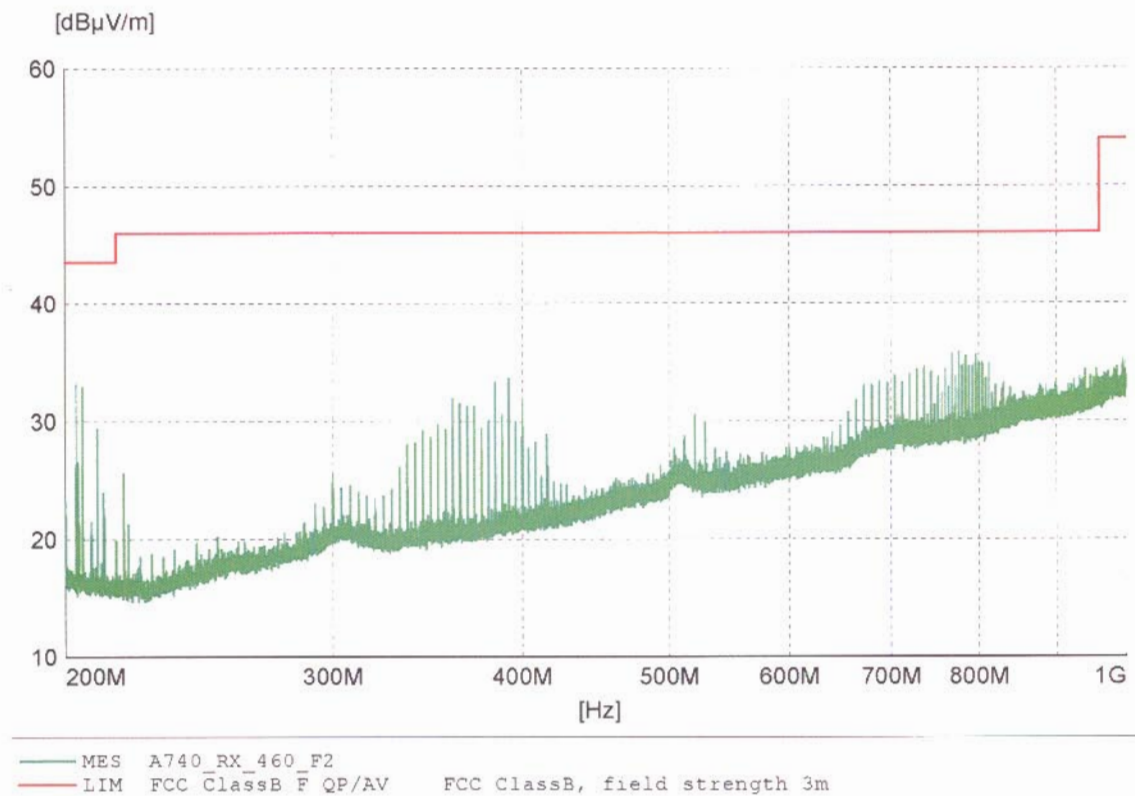
Receiver spurious emissions

§ 8

Operating mode:

Frequency: 460 MHz

Receiving, antenna connected



Seite 1 21.01.2005 15:06

Test Equipment used: NT-100; NT-110; NT-111; NT-112; NT-125; NT-207

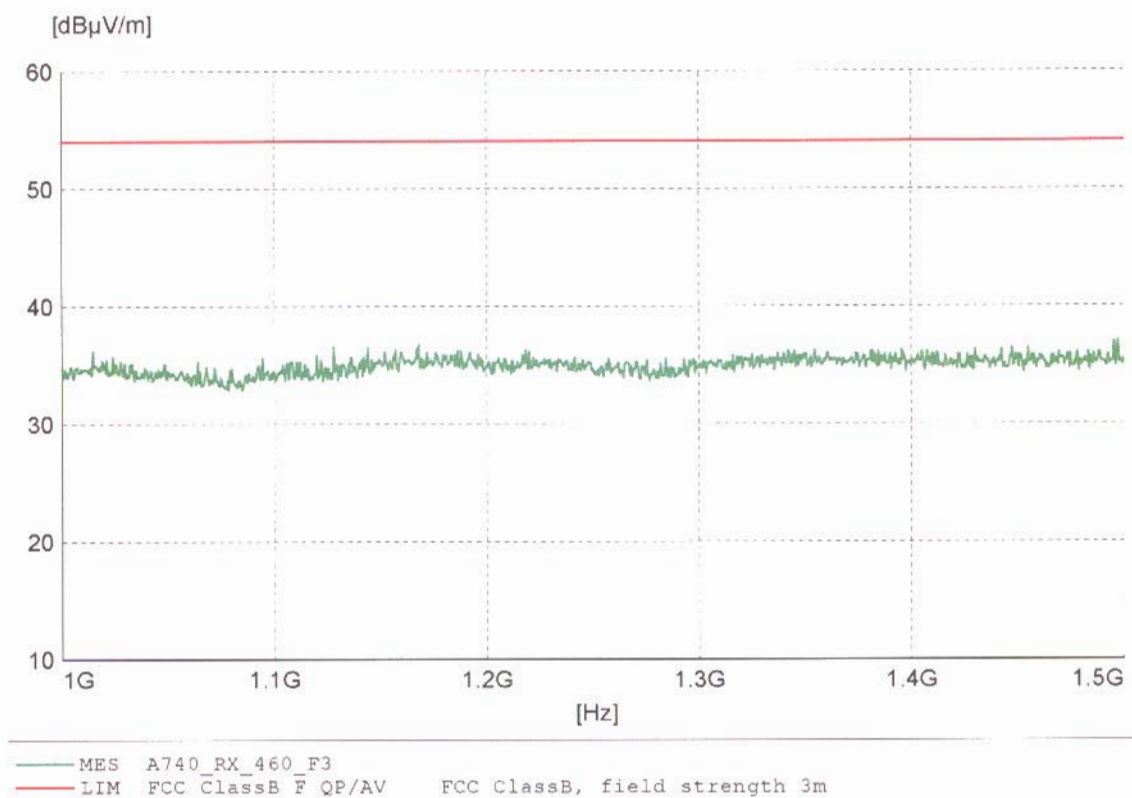
Receiver spurious emissions

§ 8

Operating mode:

Frequency: 460 MHz

Receiving, antenna connected



Seite 1 01.02.2005 15:12

Test Equipment used: NT-100; NT-110; NT-111; NT-112; NT-125; NT-207

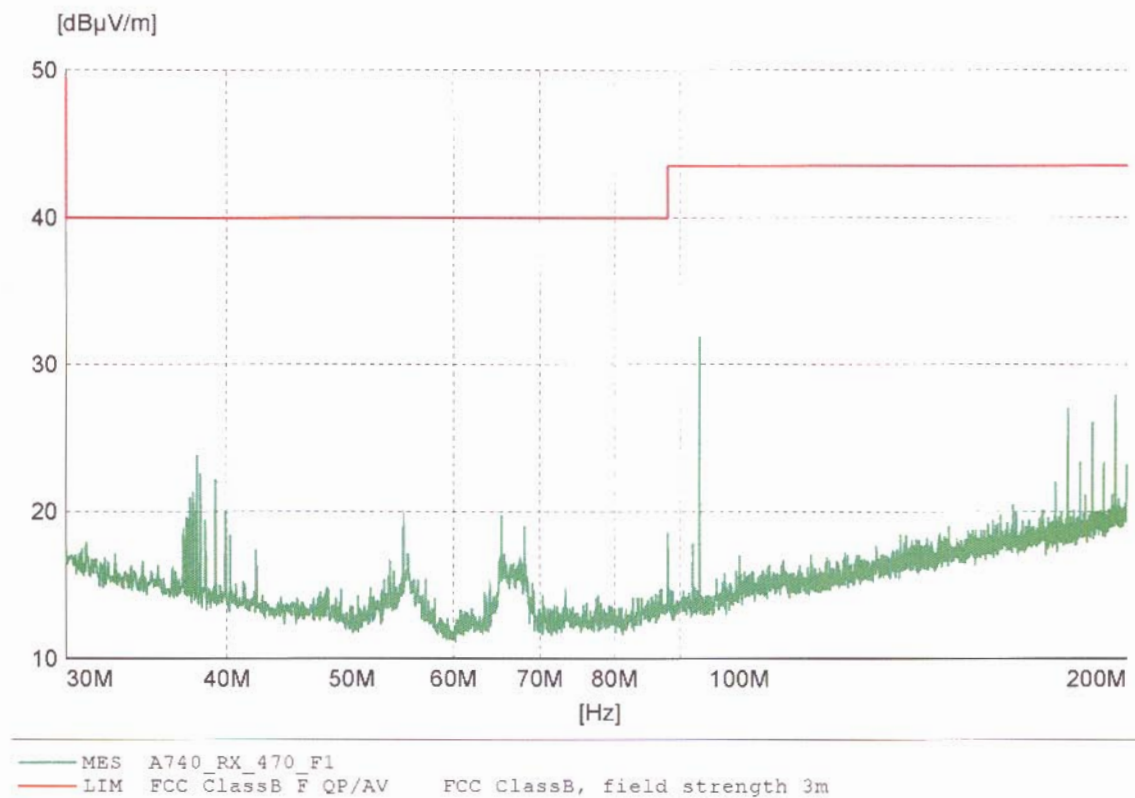
Receiver spurious emissions

§ 8

Operating mode:

Frequency: 470 MHz

Receiving, antenna connected



Seite 1 21.02.2005 15:01

Test Equipment used: NT-100; NT-110; NT-111; NT-112; NT-125; NT-207

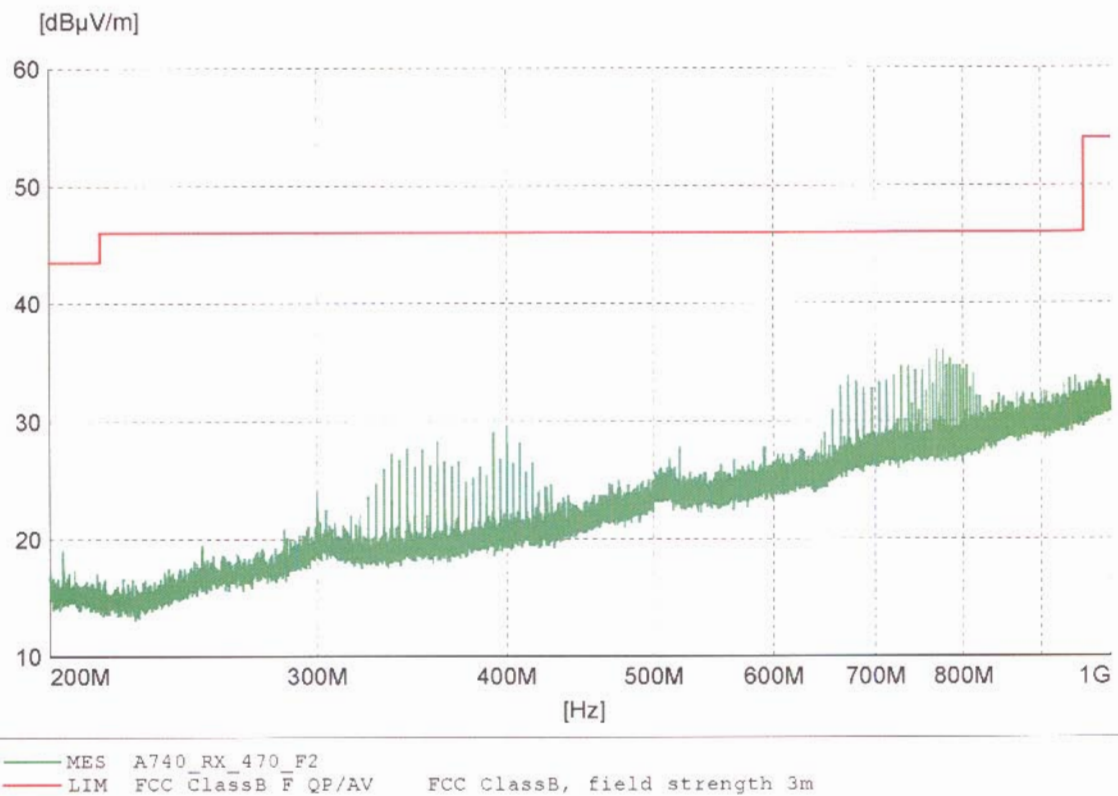
Receiver spurious emissions

§ 8

Operating mode:

Frequency: 470 MHz

Receiving, antenna connected



Seite 1 21.01.2005 15:37

Test Equipment used: NT-100; NT-110; NT-111; NT-112; NT-125; NT-207

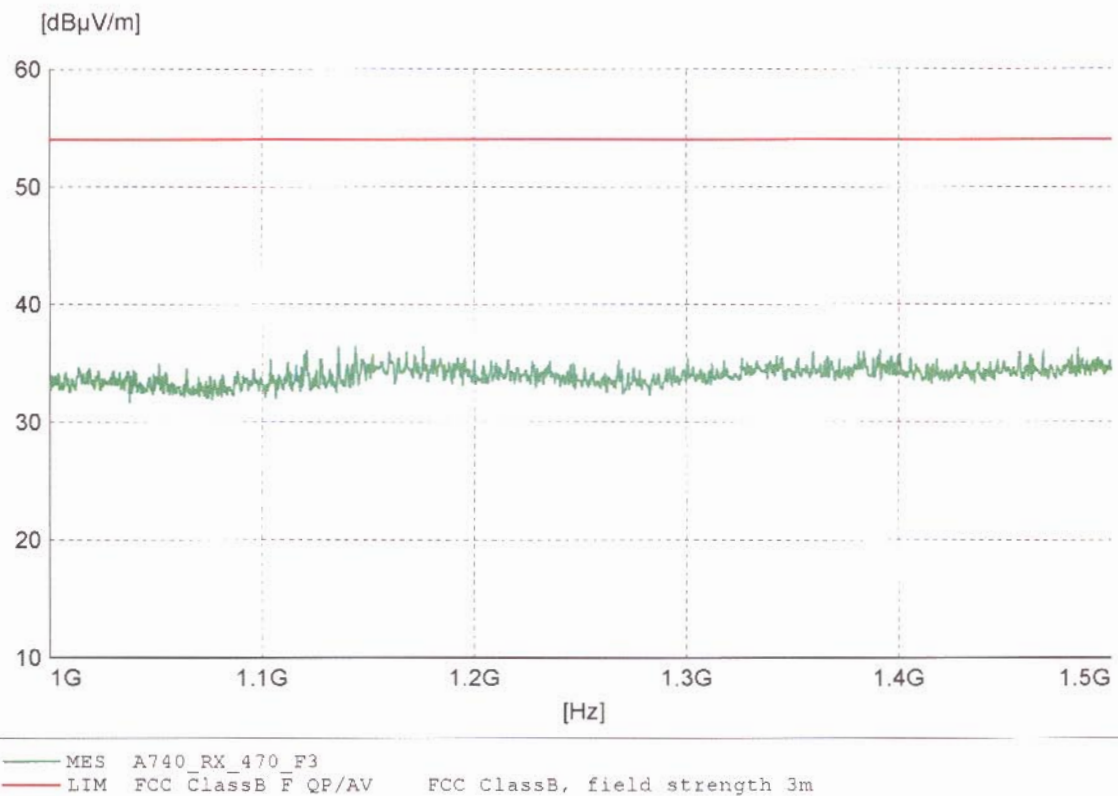
Receiver spurious emissions

§ 8

Operating mode:

Frequency: 470 MHz

Receiving, antenna connected



Seite 1 21.02.2005 15:12

Test Equipment used: NT-100; NT-110; NT-111; NT-112; NT-125; NT-207

Appendix 1

Test equipment used

☐	Anechoic Chamber with 3m measurement distance	NT-100	☐	ESVP - Test receiver 20 - 1000 MHz	NT-201
☐	MA 240 - Antenna mast 1 - 4 m height	NT-110	☐	ESPC - Test receiver 9 kHz - 2,5 GHz	NT-203
☐	DS 412 - Turntable 0 - 400 ° Azimuth	NT-111	☐	ESI26 - Test receiver 20 Hz - 26,5 GHz	NT-207
☐	HD 100 Controller Mast+Turntable	NT-112	☐	Digital Radio Tester CTS55	NT-208
☐	HUF-Z2 - Bicon. Antenna 20 - 300 MHz	NT-120	☐	Noise-gen., ITU-R 559-2 20 Hz - 20 kHz	NT-209
☐	HUF-Z3 - Log. Per. Antenna 200 - 1000 MHz	NT-121	☐	CMTA - Radiocommunication analyzer ; 0,1 - 1000 MHz	NT-210
☐	HFH-Z2 - Loop Antenna. 9 kHz - 30 MHz	NT-122	☐	3271 - Spectrum analyzer 100 Hz - 26,5 GHz	NT-211
☐	HFH-Z6 - Rod Antenna 9 kHz - 30 MHz	NT-123	☐	Radiocommunication analyzer Marconi 2945A	NT-212
☐	3121C - Dipole Antenna 28 - 1000 MHz	NT-124	☐	2855S - Communication analyzer	NT-213
☐	3115 - Horn Antenna 1 - 18 GHz	NT-125	☐	Mixer M28HW 26,5 GHz - 40 GHz	NT-214
☐	3116 - Horn Antenna 18 - 40 GHz	NT-126	☐	Diode Detector 0,01 GHz - 26,5 GHz	NT-215
☐	SAS-200/543 - Bicon. Ant. 20 MHz - 300 MHz	NT-127	☐	RubiSource T&M Timing reference	NT-216
☐	AT-1080 - Log. Per. Ant. 80 - 1000 MHz	NT-128	☐	Radiocommunication analyzer SWR 1180 MD	NT-217
☐	HK-116 - bicon. Ant. 20 MHz - 300 MHz	NT-129	☐	Mixer M19HWD 40 GHz - 60 GHz	NT-218
☐	HK-116 - bicon. Ant. 20 MHz - 300 MHz	NT-130	☐	Mixer M12HWD 60 GHz - 90 GHz	NT-219
☐	3146 - Log. Per. Ant. 200 - 1000MHz	NT-131	☐	TDS - 540 DSO Digital scope	NT-220
☐	Loop Antenna H-Field	NT-132	☐	PM97 Scopemeter	NT-221
☐	Horn Antenna 500 MHz - 2900 MHz	NT-133	☐	TPS 2014 Digital scope	NT-222
☐	Log. per. Antenna 800 MHz - 2500 MHz	NT-134	☐	B10 - Harmonics and flicker analyzer	NT-232
☐	Log. per. Antenna 800 MHz - 2500 MHz	NT-135	☐	EFA-3 H-field- / E-field probe	NT-243
☐	BiConiLog Antenna 26 MHz - 2000 MHz	NT-137	☐	E-field measuring instrument EMR-200; 100 kHz - 3 GHz	NT-244
☐	Conical Dipol Antenna PCD8250	NT-138	☐	E-field probe 100 kHz - 3 GHz	NT-245
☐	HZ-1 Antenna tripod	NT-150	☐	Magnetic field-Sensor 300 kHz - 30 MHz	NT-246
☐	BN 1500 Antenna tripod	NT-151	☐	E-field probe 10 MHz - 18 GHz	NT-247
☐	Ant. tripod for EN61000-4-3 Model TP1000A	NT-156	☐	H-field probe 10 MHz - 1 GHz	NT-248
☐	Spectrum analyzer - FSP7 9 kHz - 7 GHz	NT-200	☐	ELT-400 1 Hz - 400 kHz	NT-249

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Appendix 1 (continued)

Test equipment used

☐ MDS 21 - Absorbing clamp 30 - 1000 MHz	NT-250	☐ T82-50 RF-Amplifier 2 GHz – 8 GHz	NT-331
☐ FCC-203I EM Injection clamp	NT-251	☐ 500W1000M7 - RF-Amplifier 80 - 1000 MHz / 500 W	NT-332
☐ FCC-203I-DCN Ferrite decoupling network	NT-252	☐ AS0102-65R - RF-Amplifier 1 GHz - 2 GHz	NT-333
☐ PR50 Current Probe	NT-253	☐ APA01 – RF-Amplifier 0,5 GHz – 2,5 GHz	NT-334
☐ PR630 Current Probe	NT-254	☐ Preamplifier 1 GHz - 4 GHz	NT-335
☐ Fluke 87 V True RMS Multimeter	NT-260	☐ Preamplifier for GPS MKU 152 A	NT-336
☐ Model 2000 Digital Multimeter	NT-261	☐ Preamplifier 100 MHz – 23 GHz	NT-337
☐ Fluke 79 Digital Multimeter	NT-262	☐ DC Block 10 MHz – 18 GHz Model 8048	NT-338
☐ Fluke 79 Digital Multimeter	NT-263	☐ 2-97201 Electronic load	NT-341
☐ ESH2-Z5 Artificial mains network 4x25A	NT-300	☐ TSX3510P - Power supply 0-30 V / 0 - 10 A	NT-344
☐ ESH3-Z5 Artificial mains network 2x10A	NT-301	☐ TSX3510P - Power supply 0-30 V / 0 - 10 A	NT-345
☐ ESH3-Z6 Artificial mains network 1x100A	NT-302	☐ VDS 200 Mobil-impuls-generator	NT-350
☐ ESH3-Z4 T-Artificial network	NT-303	☐ LD 200 Mobil-impuls-generator	NT-351
☐ PHE 4500/B Power amplifier	NT-304	☐ MPG 200 Mobil-Impuls-Generators	NT-352
☐ EZ10 T-Artificial network	NT-305	☐ EFT 200 Mobil-impuls-generator	NT-353
☐ SMG - Signal generator 0,1 - 1000 MHz	NT-310	☐ FP 16/3-1 3 ph. Coupling filter (Burst)	NT-400
☐ PM 5518 TXVPS Video generator	NT-311	☐ PHE 4500 - Mains impedance network	NT-401
☐ RefRad Reference generator	NT-312	☐ IP 6.2 Coupling filter for data lines (Surge)	NT-403
☐ SMP 02 Signal generator 10 MHz - 20 GHz	NT-313	☐ ESH2-Z3 - Probe 9 kHz - 30 MHz	NT-410
☐ 40 MHz Arbitrary Generator T1241	NT-315	☐ IP 4 - Capacitive clamp (Burst)	NT-411
☐ PEFT - Burst generator up to 4 kV	NT-320	☐ Highpass-Filter 100 MHz – 4 GHz	NT-412
☐ ESD 30 System up to 25 kV	NT-321	☐ Highpass-Filter 600 MHz – 4 GHz	NT-413
☐ PSURGE 4.1 Surge generator	NT-324	☐ Highpass-Filter 1250 MHz – 4 GHz	NT-414
☐ TRANSIENT 1000 Immunity test system	NT-325	☐ Highpass-Filter 1800 MHz – 18 GHz	NT-415
☐ VCS 500-M6 Surge-Generator	NT-326	☐ Highpass-Filter 3500 MHz – 18 GHz	NT-416
☐ BTA-250 - RF-Amplifier 9 kHz - 220 MHz / 250 W	NT-330	☐ HV-Attenuator 54,5 dB (Burst)	NT-420

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Appendix 1 (continued)

Test equipment used

☐ RF-Attenuator 20 dB 0,1 - 1000 MHz / 25 W	NT-421	☐ FCC-801-S25 Coupling decoupling network	NT-462
☐ RF-Attenuator 10 dB 0,1 - 1000 MHz / 20 W	NT-422	☐ FCC-801-T4 Coupling decoupling network	NT-463
☐ RF-Attenuator 30 dB 0,1 - 1000 MHz / 1 W	NT-423	☐ FCC-801-C1 Coupling decoupling network	NT-464
☐ RF-Attenuator 30 dB	NT-424	☐ F-16A - Current probe 1kHz - 70MHz	NT-465
☐ RF-Attenuator 6 dB 0,1 - 1000 MHz / 1 W	NT-425	☐ PC P4 3 GHz Test computer	NT-500
☐ RF-Attenuator 6 dB 0,1 - 1000 MHz / 1 W	NT-426	☐ PC P4 1700 MHz Notebook	NT-505
☐ Voltage-divider 1:100	NT-427	☐ PC Intel Centrino 1600 MHz Notebook	NT-506
☐ RF-Attenuator 6 dB	NT-428	☐ Monitoring camera with Monitor	NT-511
☐ RF-Attenuator 0 dB - 81 dB	NT-429	☐ ES-K1 Version 1.71 Test software	NT-520
☐ WRU 27 - Band blocking 27 MHz	NT-430	☐ SPS-PHE Test software V2.32 voltage fluctuations/harmonics	NT-525
☐ WHJ450C9 AA - High pass 450 MHz	NT-431	☐ SPS-EM Test software V2.32 for PHE 4500/B	NT-527
☐ WHJ250C9 AA - High pass 250 MHz	NT-432	☐ Noise power test apparatus according to EN 55014	NT-530
☐ RF-Load 150 W	NT-433	☐ Vertical coupling plane (ESD)	NT-531
☐ Impedance transducer 1:4 ; 1:9 ; 1:16	NT-435	☐ TEM-Zelle	NT-533
☐ RF-Attenuator DC – 18 GHz 6 dB	NT-436	☐ Test cable #4 for EN 61000-4-6	NT-553
☐ RF-Attenuator DC – 18 GHz 6 dB	NT-437	☐ Test cable #3 for conducted emission	NT-554
☐ RF-Attenuator DC – 18 GHz 10 dB	NT-438	☐ Test cable #5 ESD-cable (2x470k)	NT-555
☐ RF-Attenuator DC – 18 GHz 20 dB	NT-439	☐ Test cable #6 ESD-cable (2x470k)	NT-556
☐ I+P 7780 Directional coupler 100 - 2000 MHz	NT-440	☐ Test cable #8 Sucoflex 104EA	NT-559
☐ ESH3-Z2 - Pulse limiter 9 kHz - 30 MHz	NT-441	☐ Test cable #9 (for outdoor measurements)	NT-580
☐ Power Divider 6 dB/1 W/50 Ohm	NT-443	☐ Test cable #10 (for outdoor measurements)	NT-581
☐ Directional coupler 0,1 MHz – 70 MHz	NT-444	☐ Test cable #13 Sucoflex 104PE	NT-584
☐ Directional coupler 0,1 MHz – 70 MHz	NT-445	☐ Shield chamber	NT-600
☐ Tube imitations according to EN 55015	NT-450	☐ Climatic chamber -55°C to +180°C	M-512
☐ FCC-801-M2-50A Coupling decoupling network	NT-459	☐ Control and simulation equipment for EUT	---
☐ FCC-801-M5-25 Coupling decoupling network	NT-460		
☐ FCC-801-AF10 Coupling decoupling network	NT-461		

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