



TTI-P-G166/98

Accredited Bluetooth Test Facility (BQTF)

Test report no.: 4-0306-02-02/01
FCC Part15.247/CANADA RSS-210
Digital Wireless Communication System
MCW-D TABLE UNIT 1023

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1 General information

1.1 Notes

The test results of this test report relate exclusively to the test item specified in 1.5. The CETECOM ICT Services GmbH does not assume responsibility for any conclusions and generalisations drawn from the test results with regard to other specimens or samples of the type of the equipment represented by the test item. The test report may only be reproduced or published in full. Reproduction or publication of extracts from the report requires the prior written approval of the CETECOM ICT Services GmbH.

1.2 Testing laboratory

CETECOM ICT Services GmbH

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Internet : www.cetecom.de

Accredited testing laboratory

DAR-registration number : TTI-P-G 166/98-20

Equipment under test : MCW-D 1023

Ambient temperature : 25°C

Relative humidity : 47%

1.3 Details of applicant

Name : beyerdynamic GmbH & Co.

Street : Theresienstraße 8

City : 74003 Heilbronn

Country : Germany

Telephone: +49 (0) 7131 61 71 55

Telefax : +49 (0) 7131 6 04 59

Contact : Mr. Ulrich Roth

Telephone: +49 (0) 7131 61 71 55

1.4 Application details

Date of receipt of application : 05.03.2001

Date of receipt of test item : 05.03.2001

Date of test : 05.03.2001 – 15.03.2001

Re issued : 03.05.2002

1.5 Test item

Type of equipment : **Digital Wireless Communication System**

Type designation : **MCW-D Table Unit (4 similar types 1011, 1013, 1021 and 1023)**

Manufacturer : applicant

Street :

City :

Country :

Serial number :

Additional informations: :

Frequency : 2400 – 2483,5 MHz

Type of modulation : 10M0P7D (DSSS) Ch.Sep. : 5 MHz

Number of channels : 16

Antenna : internal print antenna

Power supply : 14.4 V DC by Accu

Output power rad. : 14 dBm

Type of equipment : Class B

Temperature range : -10°C - +55°C

1.6 Test standards: FCC Part 15 §15.247 / CANADA RSS-210

Equipment under test : MCW-D 1023

Ambient temperature : 25°C

Relative humidity : 47%

2 Technical test

2.1 Summary of test results

The radiated measurements were performed vertical and horizontal over the whole frequency range. We start at 1 m high with vertical receiving antenna and rotate the dish continuously. During rotation we use the antenna lift system to vary the high from 1 to 4 m. So we find maximum radiation output. At this points we do manual remeasurements. After this we do the same measurements in horizontal position of the receiving antenna. This (horizontal and vertical) is made for all the three planes of the test sample. We use the maximum received results. The detector function and selection of bandwidth are according ANSI C63.2-1996 item 8.2.1 and ANSI C63.4-1992 Item 4.2.

Antennas are conform with ANSI C63.2-1996 item 15.

150 kHz - 30 MHz: Quasi Peak measurement, 9kHz Bandwidth, passive loop antenna.

30 MHz - 200 MHz: Quasi Peak measurement, 120KHz Bandwidth, biconical antenna

200MHz - 1GHz: Quasi Peak measurement, 120KHz Bandwidth, log periodic antenna

>1GHz: Average, RBW 1MHz, VBW 10 MHz, waveguide horns and standard gain horns.

All measurement settings are according to FCC 15.35, 15.205, 15.209, 15.247 and the „Measurement guidelines for FHSS systems“, especially regarding the radiated measurements.

It was not possible to do RX-only measurements as according to this communication system the tx is transmitting in packets and listens in the Tx gaps. So we do not have a special RX-only mode.

The AF output has been covered, because at the moment special headphones can be connected only. If you need this output please contact beyerdynamic.

The samples use the same RF part and the same PCB board.

The only difference is in the number of pushbuttons(1 or 3) and with or without loudspeaker.

The product fullfills also the requirements for CANADA RSS-210

No deviations from the technical specification(s) were ascertained in the course of the tests.

Final verdict : PASS

Technical responsibility for area of testing :

10.Apr.2002

RSC 8414 Ames H.



Date

Section

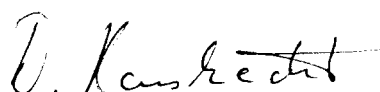
Name

Signature

Technical responsibility for area of testing :

10.Apr.2002

RSC8412 Hausknecht D.



Date

Section

Name

Signature

Equipment under test : MCW-D 1023

Ambient temperature : 25°C

Relative humidity : 47%

2.2 Testreport

TEST REPORT

Testreport no. : 4-0306-02-02/01

Equipment under test : MCW-D 1023

Ambient temperature : 25°C

Relative humidity : 47%

TEST REPORT REFERENCE

LIST OF MEASUREMENTS

Paragraph	PARAMETER TO BE MEASURED	PAGE
	Transmitter parameters	
§ 15.204	Antenna gain	7
§ 15.247 (a)(2)	Spectrum bandwidth of a DSSS System	8
§ 15.247 (b)(1)	Maximum peak output power	12
§ 15.247 (d)	Power spectral density	20
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Equipment under test : MCW-D 1023**Ambient temperature : 25°C****Relative humidity : 47%****Antenna Gain****SUBCLAUSE § 15.204**

The antenna gain of the complete system is calculated by the difference of conducted power of the module and the radiated power in EIRP.

	low channel peak	mid channel peak	high channel peak
Conducted power	19.2 dBm	19.1 dBm	18.7 dBm
Radiated power (antenna inside housing)	14.2 dBm	14.5 dBm	14.4 dBm
Gain	-5.0 dB	-4.6 dB	-4.3 dB

The calculated antenna gain is between -4.3and -5.0 dB for the internal print antenna.

Equipment under test MCW-D 1023

Ambient temperature : 25°C

Relative humidity : 47%

Spectrum Bandwidth of a DSSS System

§15.247(a)

6 dB bandwidth

TEST CONDITIONS		6 dB BANDWIDTH (kHz)		
Frequency (MHz)		2408.5 MHz	2439.5 MHz	2474.0 MHz
T _{nom} (25)°C	V _{nom} (14.4)V	3607	3607	3607
Measurement uncertainty		±1kHz		

RBW / VBW as provided in the „Measurement Guidelines“ (DA 00-705, March 30, 2000)

LIMIT

SUBCLAUSE §15.247(a) (2)

The minimum 6dB bandwidth shall be at least 500 KHz

REFERENCE NUMBER(S) OF TEST EQUIPMENT USED
(for reference numbers see test equipment listing)

Equipment under test : MCW-D 1023

Ambient temperature : 25°C

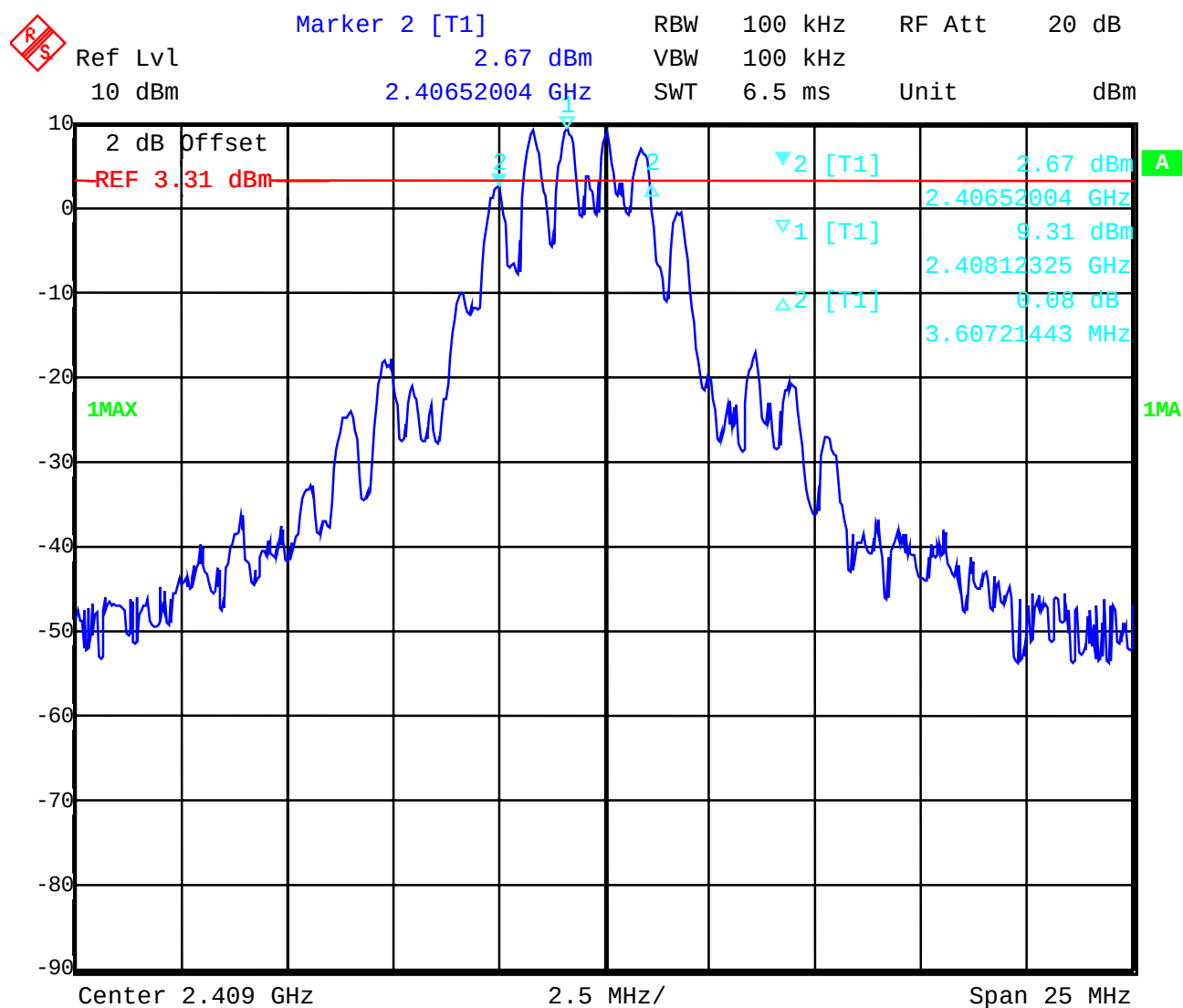
Relative humidity : 47%

Spectrum Bandwidth of a DSSS System
6 dB bandwidth

§15.247(a)

Channel 1

The measurement was performed with the same RF-module tested with 4-0306-02-01/01.



Equipment under test : MCW-D 1023

Ambient temperature : 25°C

Relative humidity : 47%

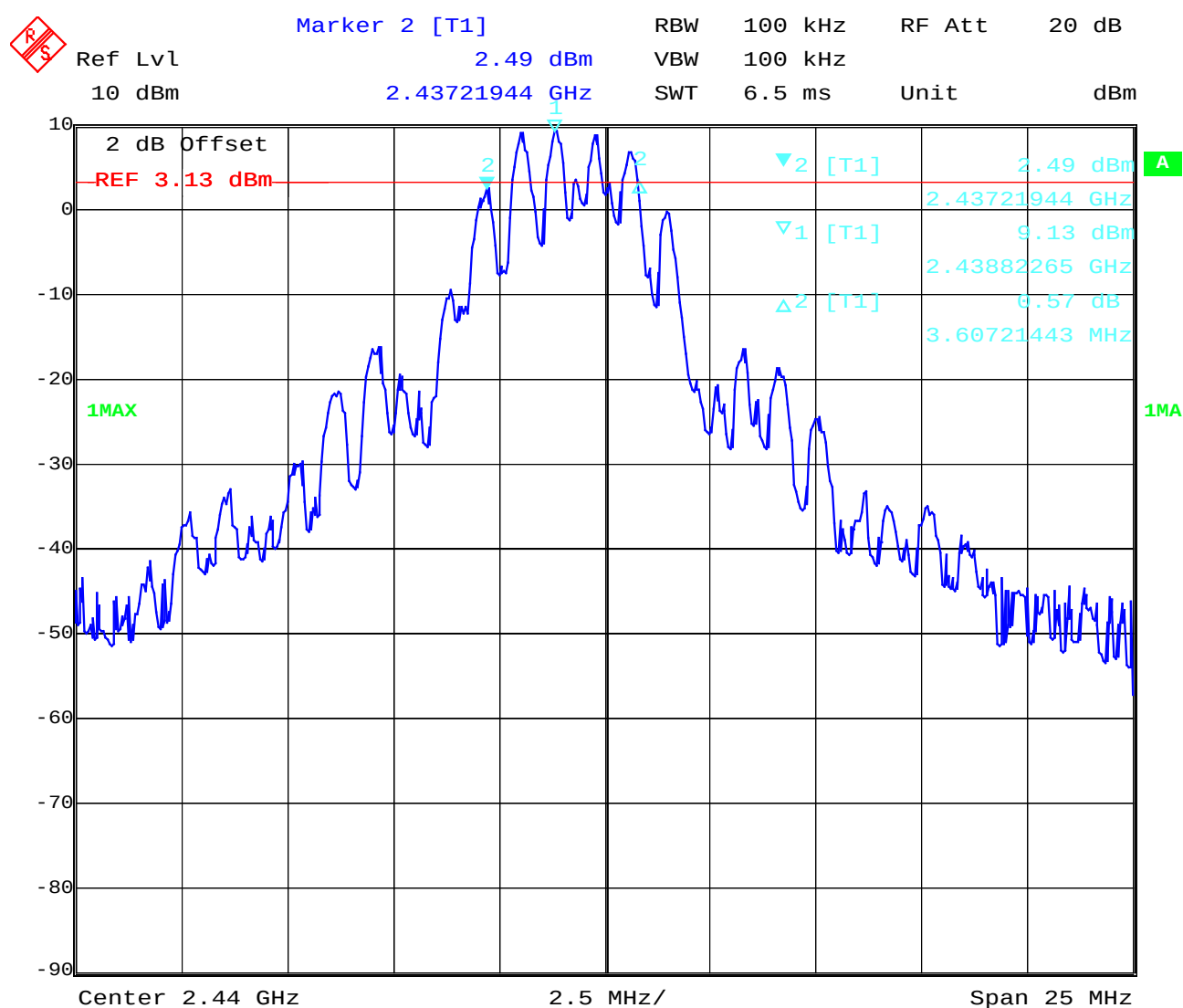
Spectrum Bandwidth of a DSSS System

§15.247(a)

6 dB bandwidth

Channel 2

The measurement was performed with the same RF-module tested with 4-0306-02-01/01.



Date: 15.MAR.2002 15:03:44

Equipment under test : MCW-D 1023

Ambient temperature : 25°C

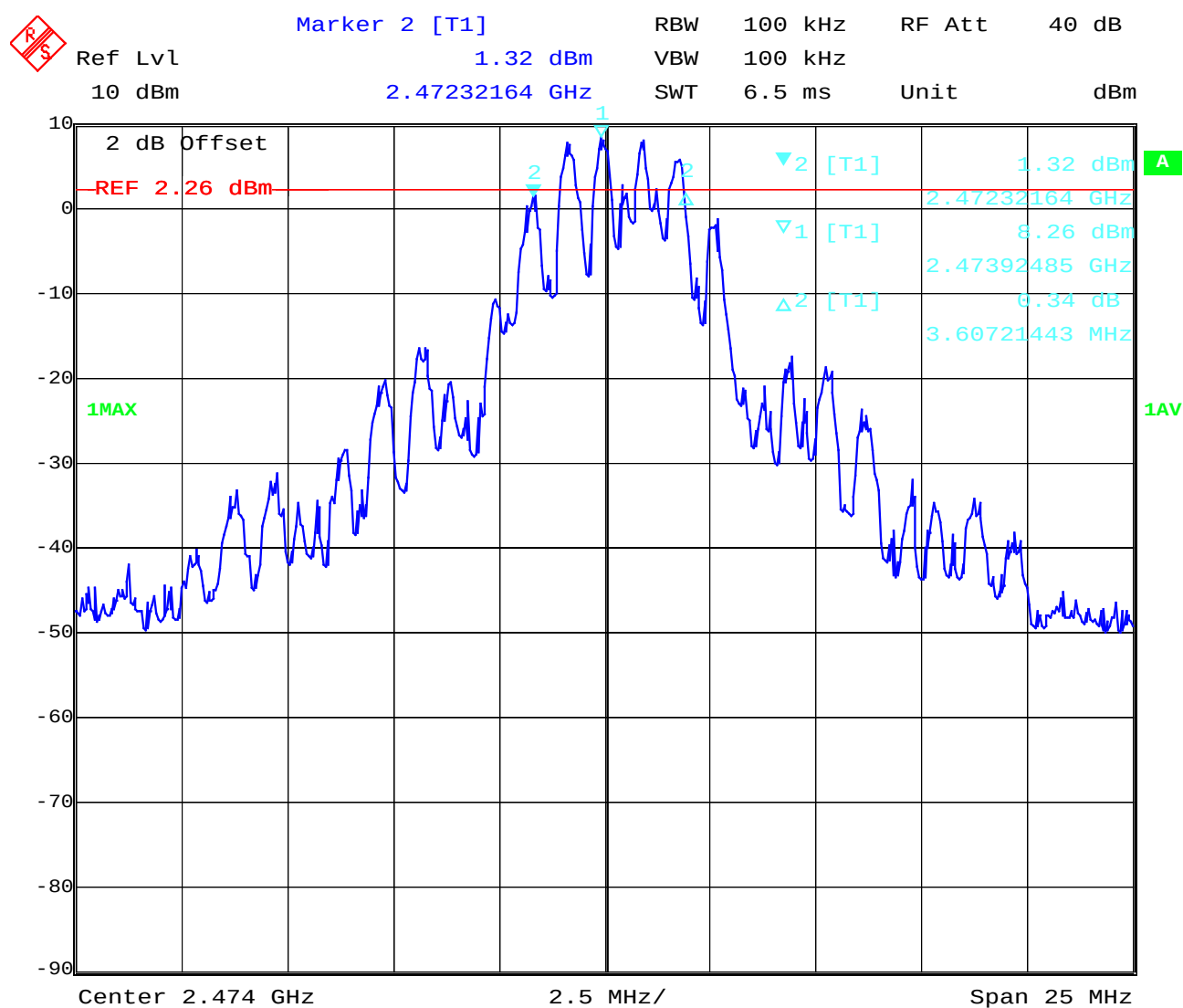
Relative humidity : 47%

Spectrum Bandwidth of a DSSS System
6 dB bandwidth

§15.247(a)

Channel 3:

The measurement was performed with the same RF-module tested with 4-0306-02-01/01.



Date: 15.MAR.2002 15:11:10

Equipment under test : MCW-D 1023

Ambient temperature : 25°C

Relative humidity : 47%

MAXIMUM PEAK OUTPUT POWER (CONDUCTED)

SUBCLAUSE § 15.247 (b) (1)

TEST CONDITIONS		MAXIMUM PEAK OUTPUT POWER (mW)		
Frequency (MHz)		2408.5 MHz	2439.5 MHz	2474.0 MHz
T _{nom} (25)°C	V _{nom} (115)V	Peak :19.21 dB AV : 12.61 dB	Peak :19.16 dB AV : 12.56 dB	Peak :18.71 dB AV : 12.11 dB
Maximum deviation from output power under extreme test conditions (dBc)		0.5	0.5	0.5
Measurement uncertainty		±3dB		

RBW/VBW : 10 MHz

LIMIT

SUBCLAUSE § 15.247 (b) (1)

Frequency range	RF power output
2400-2483.5 MHz	1.0 Watt/ 30dBm

Equipment under test : MCW-D 1023

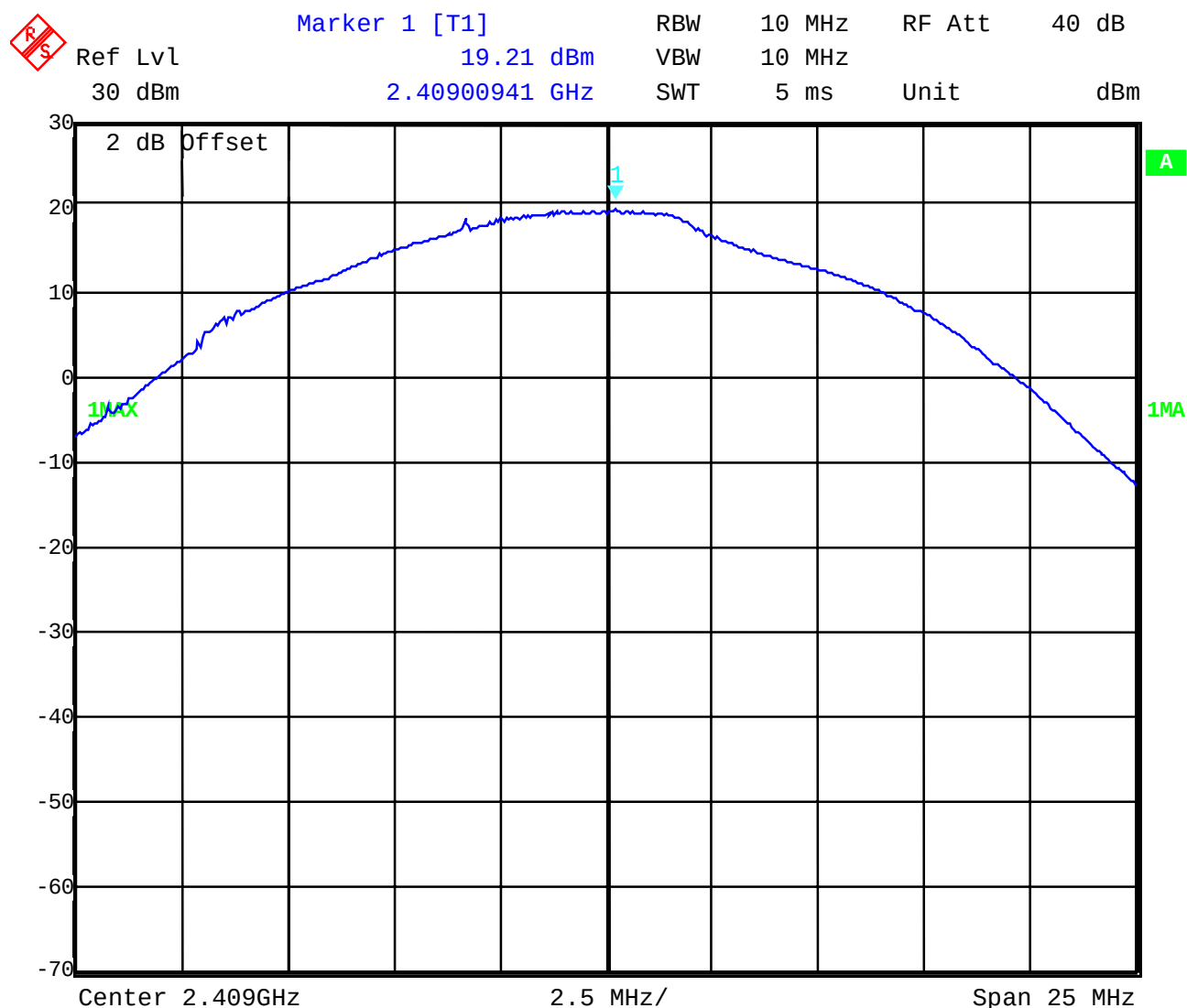
Ambient temperature : 25°C

Relative humidity : 47%

MAXIMUM PEAK OUTPUT POWER (CONDUCTED)

SUBCLAUSE § 15.247 (b) (1)

low channel peak



Equipment under test : MCW-D 1023

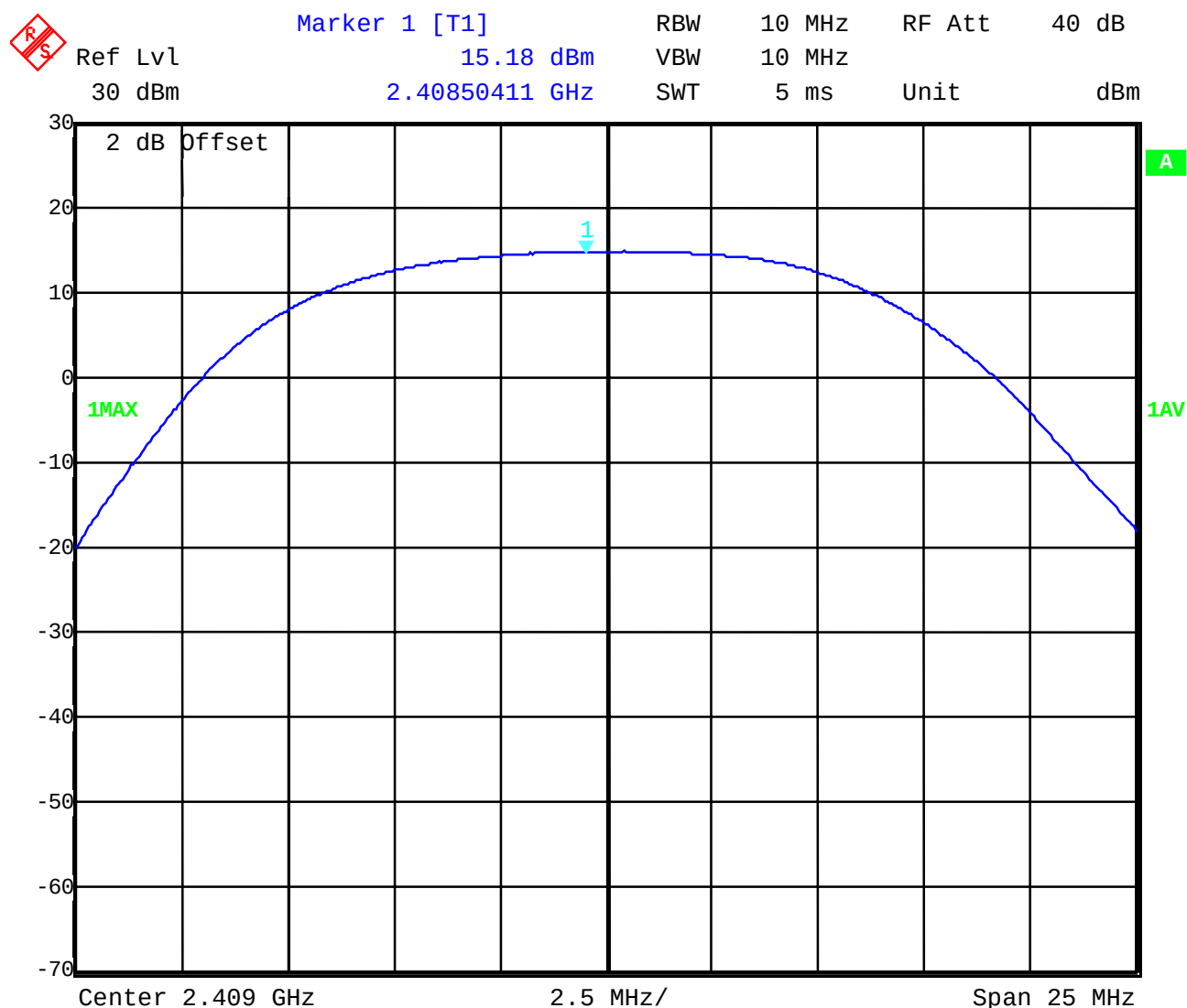
Ambient temperature : 25°C

Relative humidity : 47%

MAXIMUM PEAK OUTPUT POWER (CONDUCTED)

SUBCLAUSE § 15.247 (b) (1)

low channel average



Equipment under test : MCW-D 1023

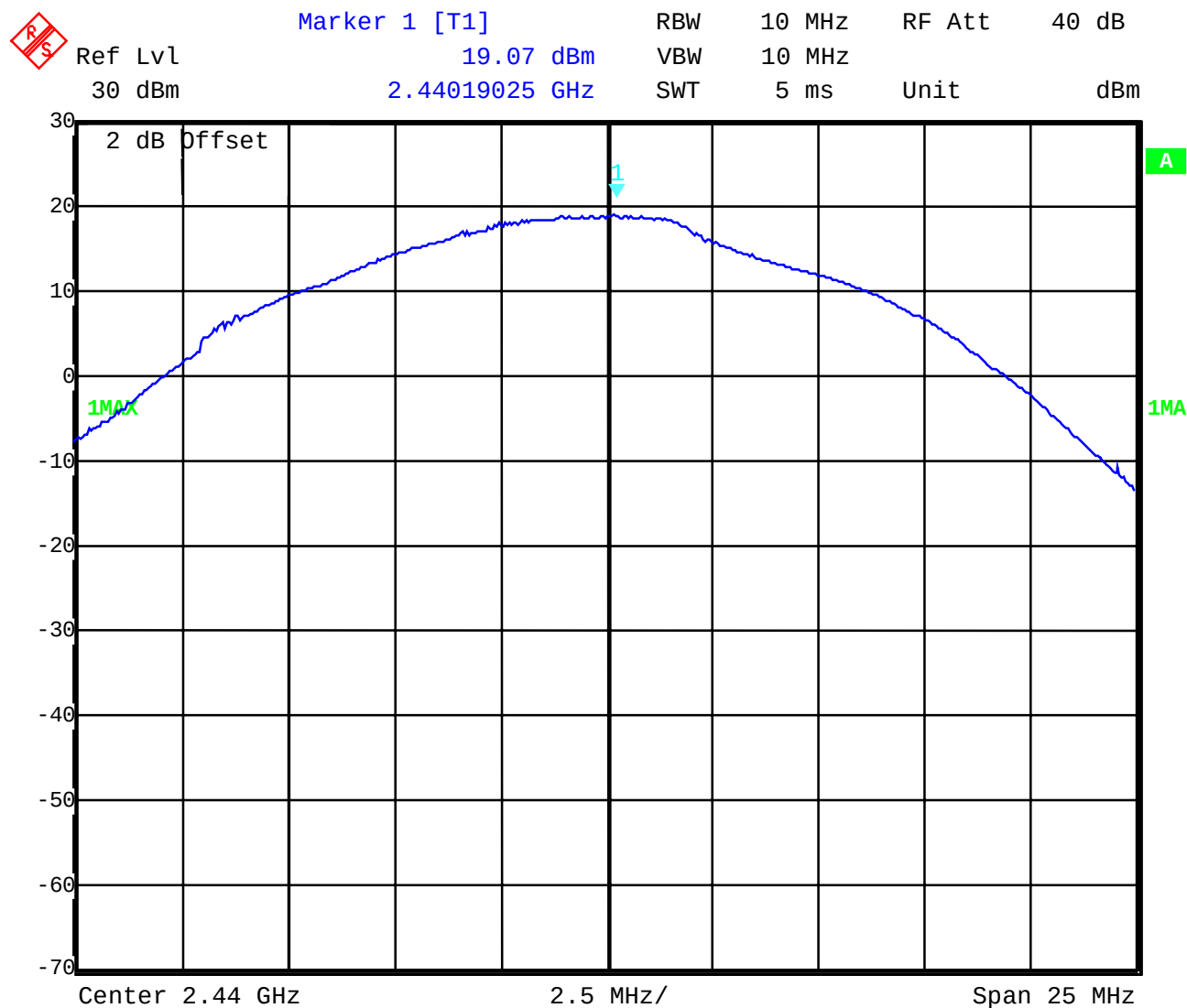
Ambient temperature : 25°C

Relative humidity : 47%

**MAXIMUM PEAK OUTPUT POWER
(CONDUCTED)**

SUBCLAUSE § 15.247 (b) (1)

mid channel peak



Equipment under test : MCW-D 1023

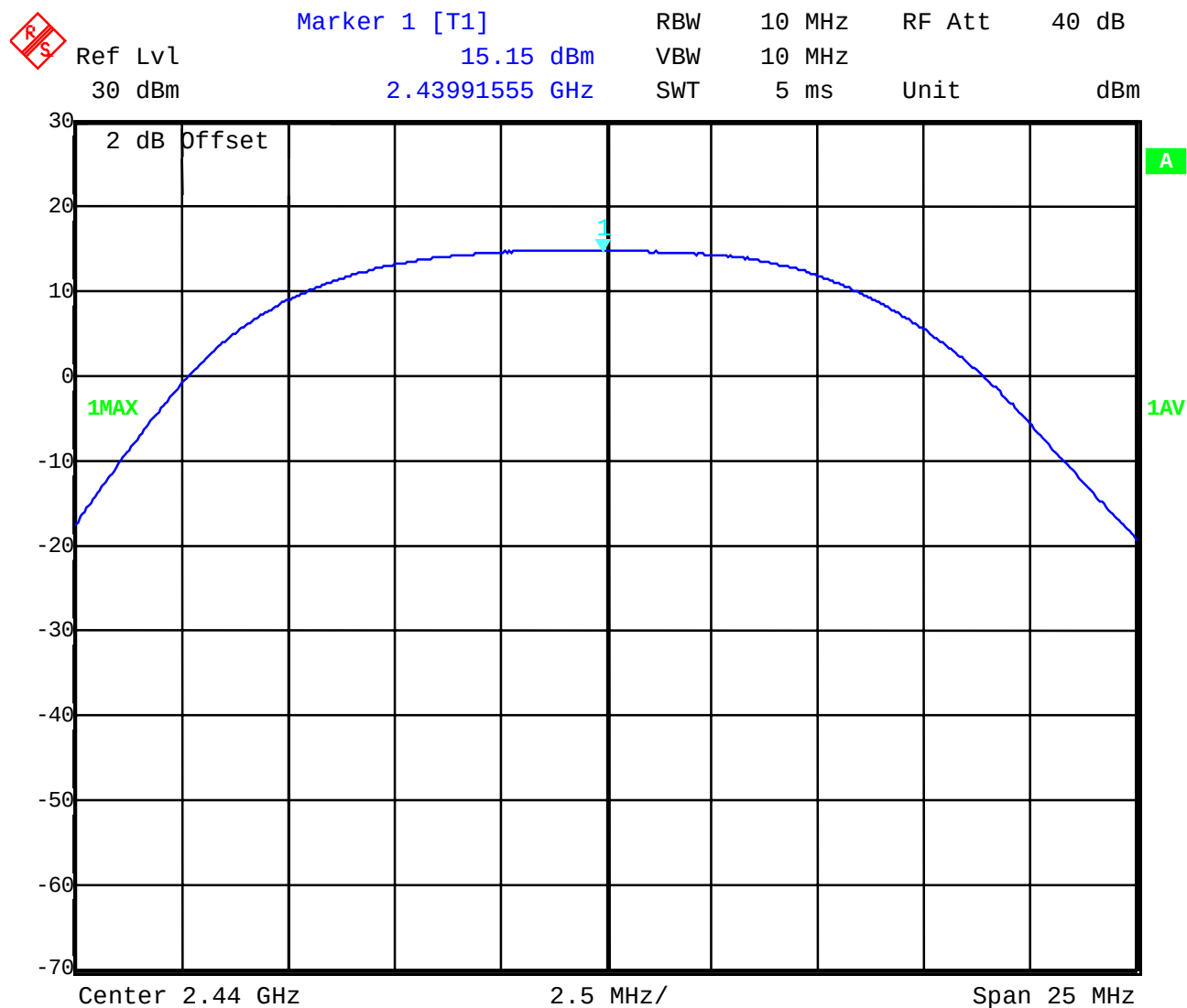
Ambient temperature : 25°C

Relative humidity : 47%

**MAXIMUM PEAK OUTPUT POWER
(CONDUCTED)**

SUBCLAUSE § 15.247 (b) (1)

mid channel average



Equipment under test : MCW-D 1023

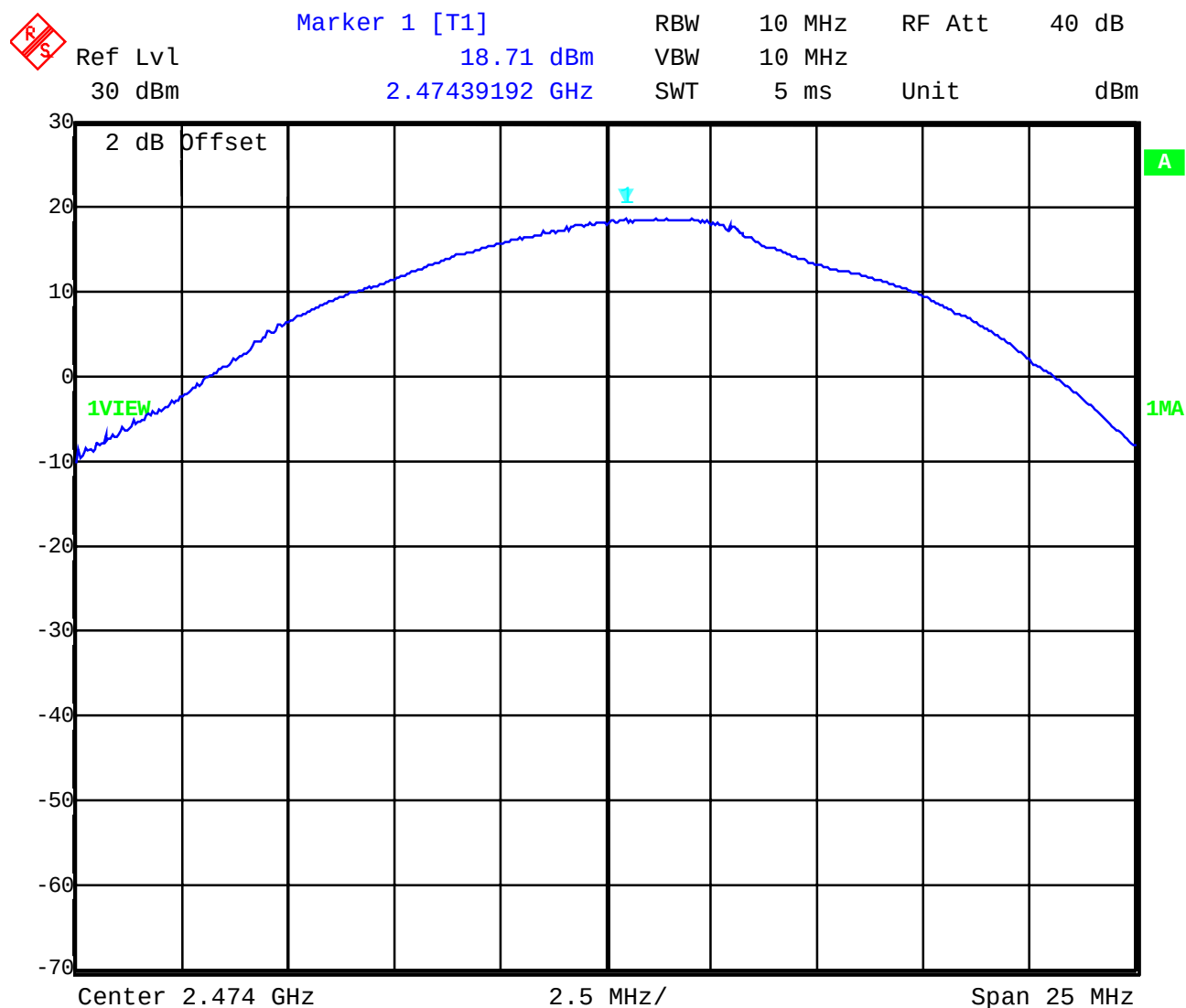
Ambient temperature : 25°C

Relative humidity : 47%

**MAXIMUM PEAK OUTPUT POWER
(CONDUCTED)**

SUBCLAUSE § 15.247 (b) (1)

high channel peak



Equipment under test : MCW-D 1023

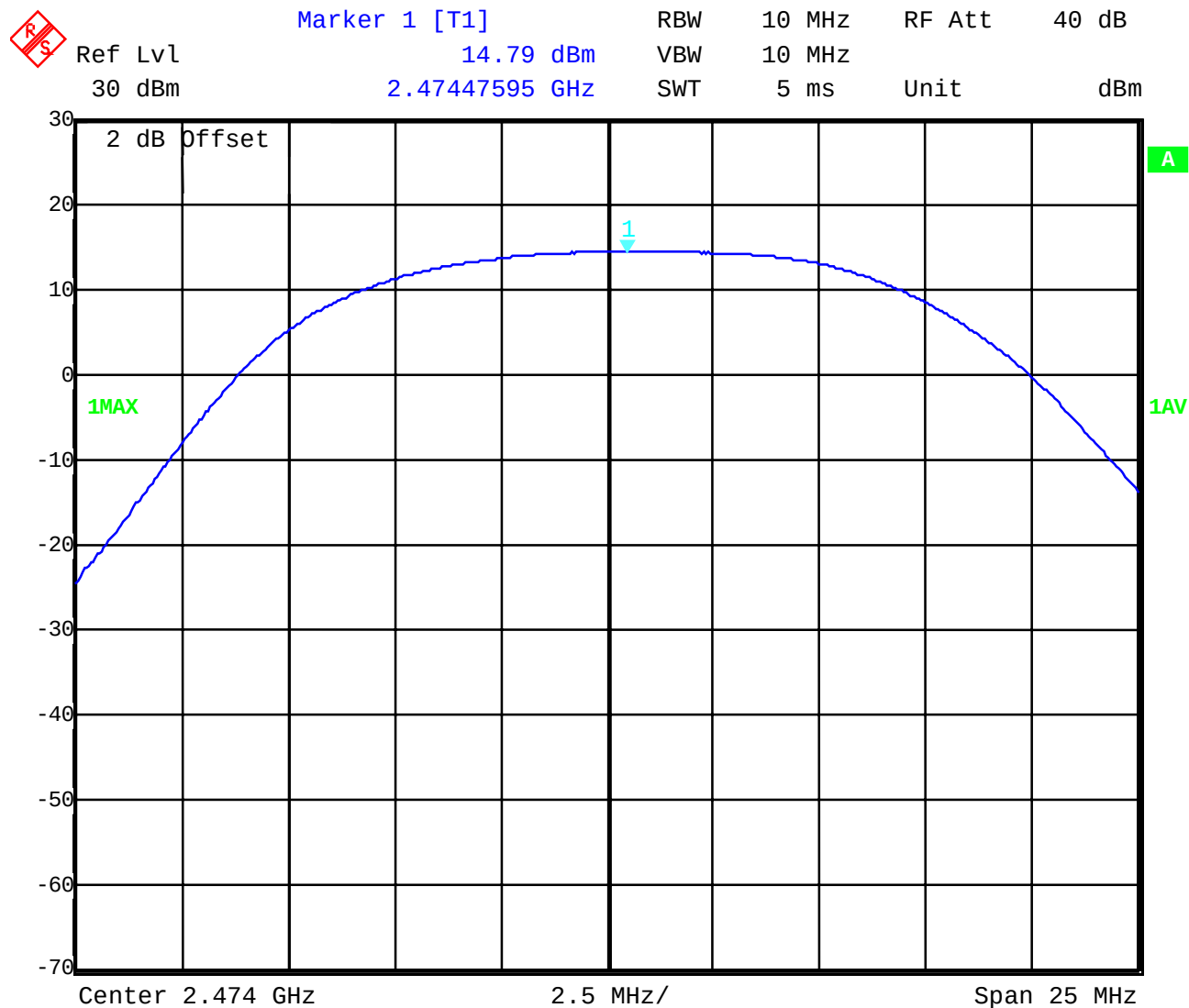
Ambient temperature : 25°C

Relative humidity : 47%

**MAXIMUM PEAK OUTPUT POWER
(CONDUCTED)**

SUBCLAUSE § 15.247 (b) (1)

high channel average



Equipment under test : MCW-D 1023

Ambient temperature : 25°C

Relative humidity : 47%

MAXIMUM PEAK OUTPUT POWER (RADIATED)

SUBCLAUSE § 15.247 (b) (1)

TEST CONDITIONS		MAXIMUM PEAK OUTPUT POWER (mW)		
Frequency (MHz)		2408.5 MHz	2439.5 MHz	2474.0 MHz
T _{nom} (25)°C	V _{nom} (14.4)V	14.2 dBm 26.3 mW	14.5 dBm 28.2 mW	14.4 dBm 27.5 mW
Maximum deviation from output power under extreme test conditions (dBc)		n.a.	n.a.	n.a.
Measurement uncertainty		±3dB		

RBW/VBW : 10 MHz

Measured at a distance of 3m

LIMIT

SUBCLAUSE § 15.247 (b) (1)

Frequency range	RF power output
2400-2483.5 MHz	1.0 Watt

REFERENCE NUMBER(S) OF TEST EQUIPMENT USED
(for reference numbers see test equipment listing)

Equipment under test : MCW-D 1023

Ambient temperature : 25°C

Relative humidity : 47%

Power spectral density §15.247 (d)

The measurement was performed with the same RF-module tested with 4-0306-02-01/01.

TEST CONDITIONS		RF POWER LEVEL IN 3 kHz BW		
Frequency (MHz)		2408.5	2439.5	2474.0
T _{nom} (25)°C	V _{nom} (14.4)V	-4.45 dBm	-4.36 dBm	-3.86 dBm
Maximum deviation from output power under extreme test conditions (dBc)				
Measurement uncertainty		±3dB		

The measurement was performed with the power density funktion of the analyzer.
The readout is related to 1 Hz BW. For 3 kHz BW we have to add 34.8 dB.

LIMIT

SUBCLAUSE §15.247(d)

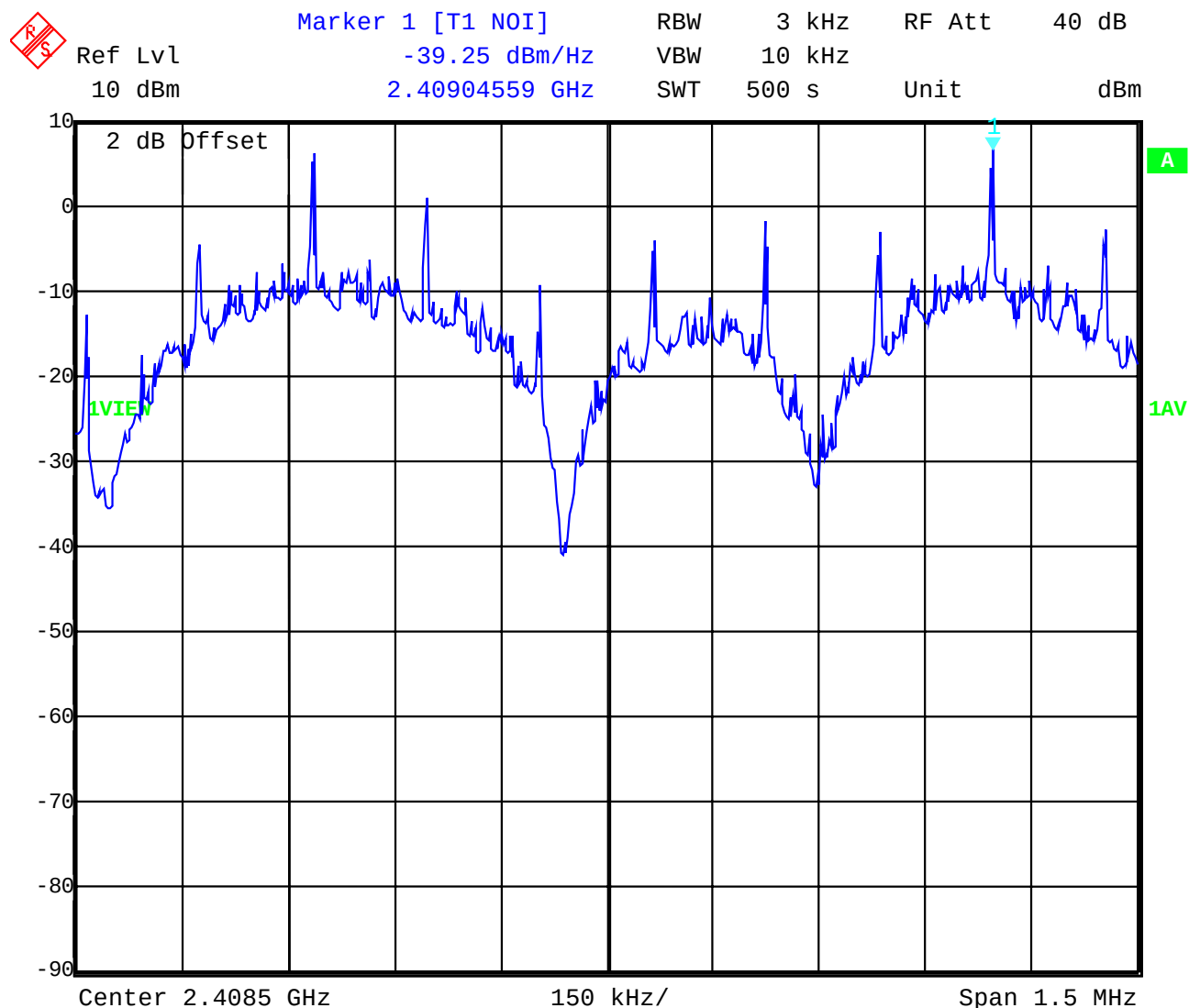
The peak power spectral density shall not be greater than 8 dBm in any 3 kHz band

REFERENCE NUMBER(S) OF TEST EQUIPMENT USED
(for reference numbers see test equipment listing)

Equipment under test : MCW-D 1023

Ambient temperature : 25°C

Relative humidity : 47%

POWER SPECTRAL DENSITY
2408.5 MHz**SUBCLAUSE § 15.247 (d)****LIMIT****SUBCLAUSE §15.247(d)**

The peak power spectral density shall not be greater than 8 dBm in any 3 kHz band

Equipment under test : MCW-D 1023

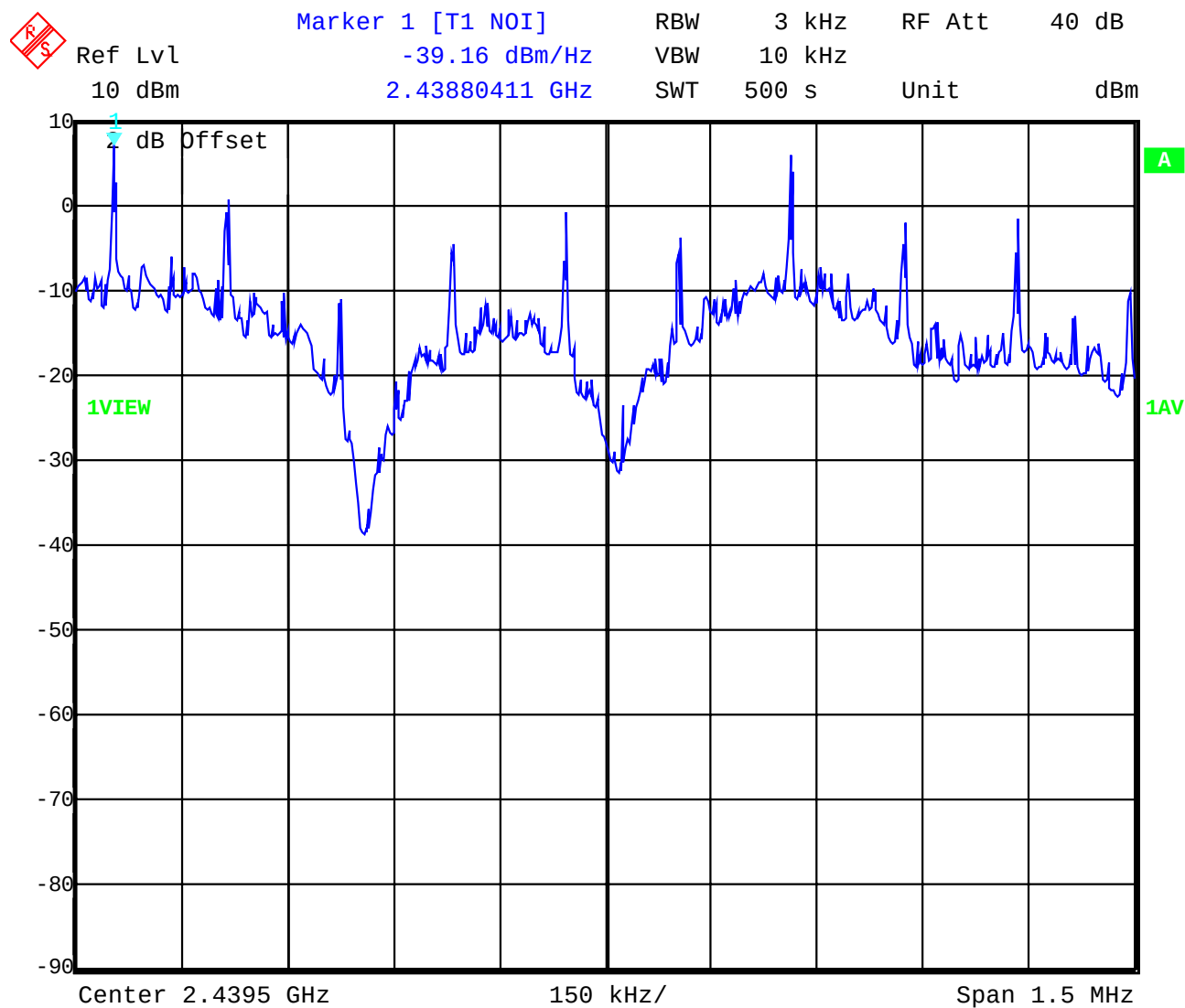
Ambient temperature : 25°C

Relative humidity : 47%

POWER SPECTRAL DENSITY

SUBCLAUSE § 15.247 (d)

2439.5 MHz



LIMIT

SUBCLAUSE §15.247(d)

The peak power spectral density shall not be greater than 8 dBm in any 3 kHz band

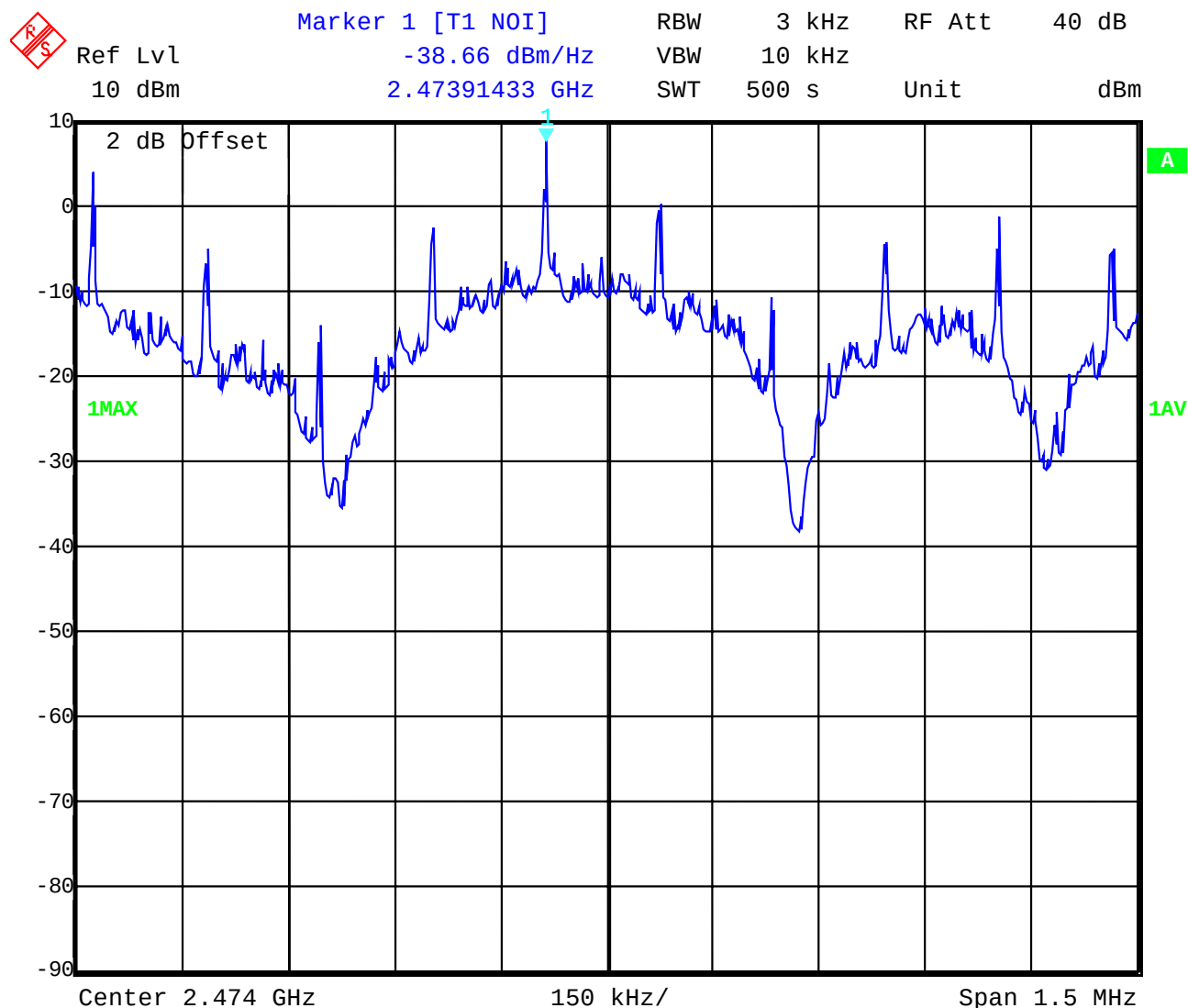
Equipment under test : MCW-D 1023

Ambient temperature : 25°C

Relative humidity : 47%

POWER SPECTRAL DENSITY 2474 MHz

SUBCLAUSE § 15.247 (d)



LIMIT

SUBCLAUSE §15.247(d)

The peak power spectral density shall not be greater than 8 dBm in any 3 kHz band

Equipment under test : MCW-D 1023

Ambient temperature : 25°C

Relative humidity : 47%

Band-edge compliance of conducted emissions

§15.247 (c)

high channel

The measurement was performed with the same RF-module tested with 4-0306-02-01/01.



Equipment under test : MCW-D 1023

Ambient temperature : 25°C

Relative humidity : 47%

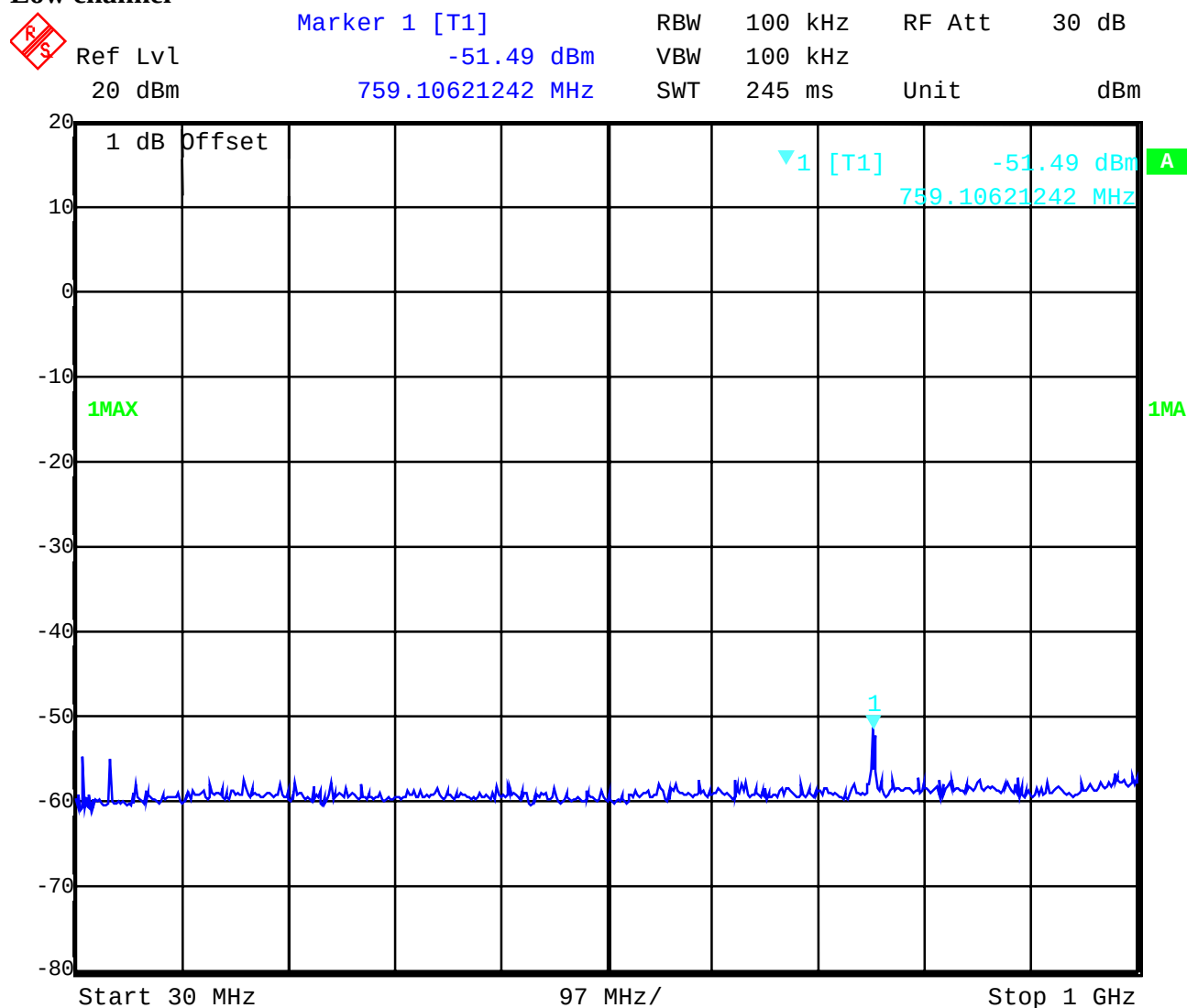
SPURIOUS EMISSION LIMITATION CONDUCTED

§ 15.247 (c) (1)

The measurement was performed with the same RF-module tested with 4-0306-02-01/01.

All unwanted conducted emissions are << 20 dBc.

Low channel



Equipment under test : MCW-D 1023

Ambient temperature : 25°C

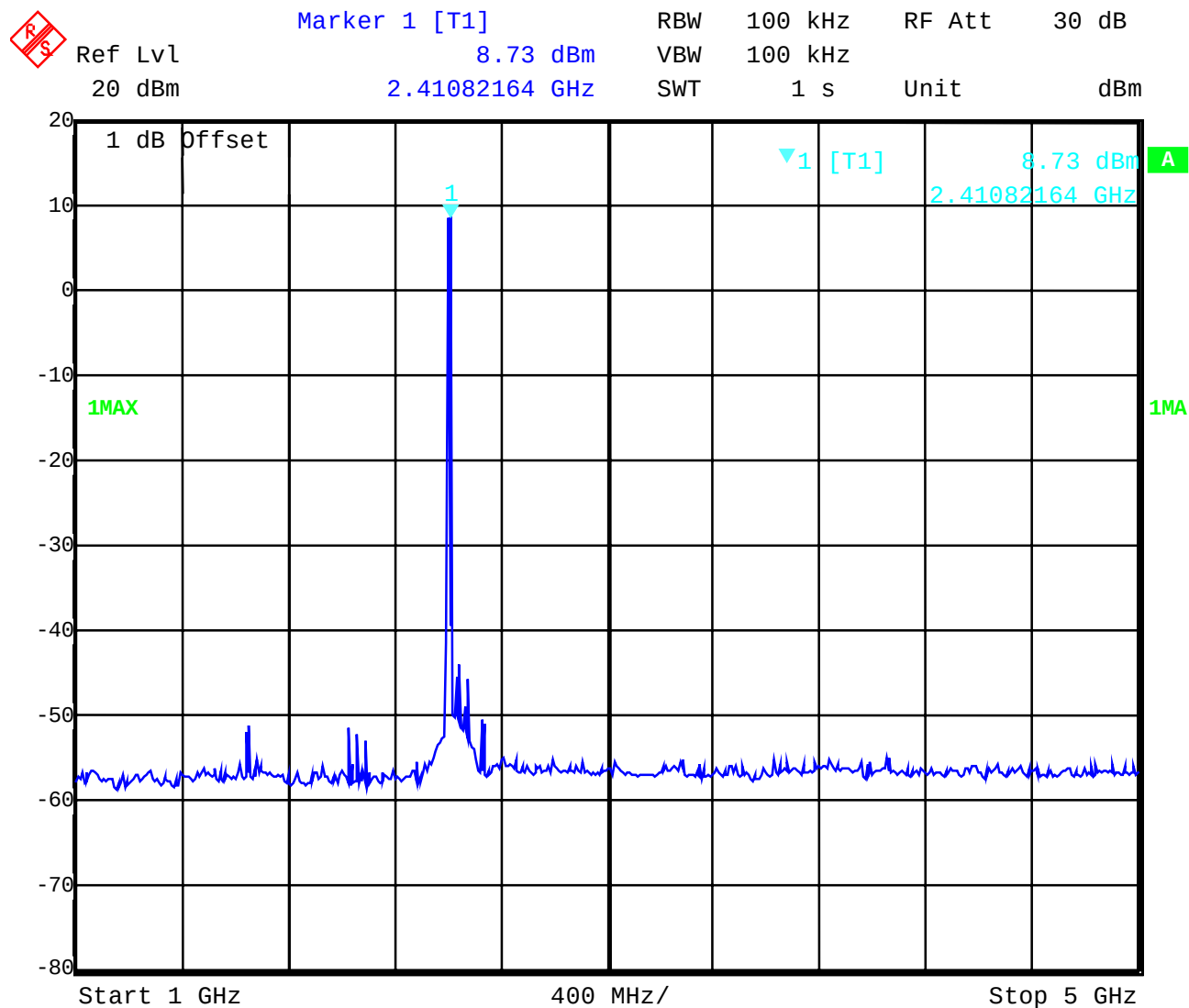
Relative humidity : 47%

SPURIOUS EMISSION

§ 15.247 (c) (1)

CONDUCTED

Low channel (peak)



Equipment under test : MCW-D 1023

Ambient temperature : 25°C

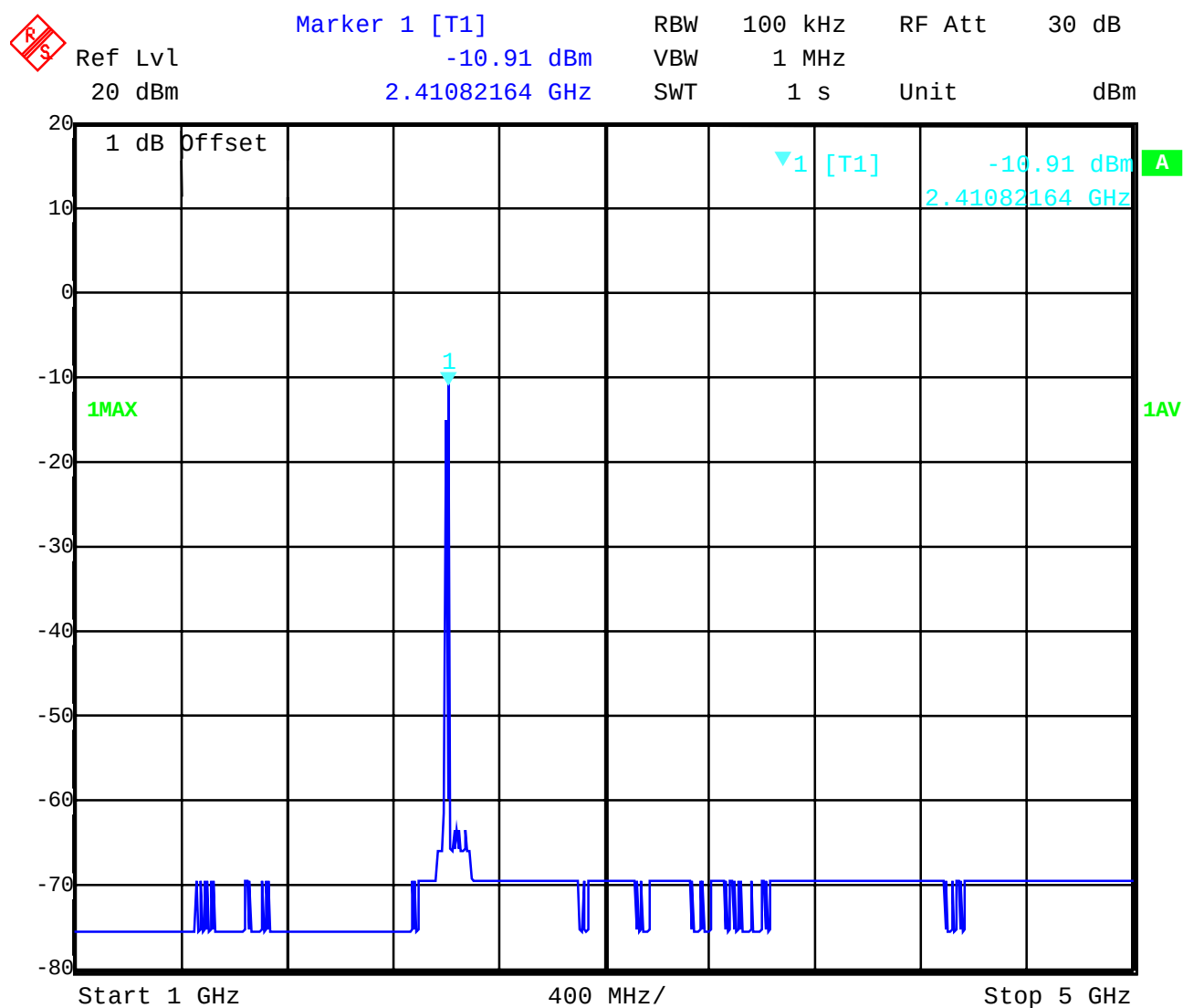
Relative humidity : 47%

SPURIOUS EMISSION

§ 15.247 (c) (1)

CONDUCTED

Low channel (average)



Equipment under test : MCW-D 1023

Ambient temperature : 25°C

Relative humidity : 47%

SPURIOUS EMISSION

CONDUCTED

§ 15.247 (c) (1)

Low channel (peak)



Ref Lvl
11 dBm

Marker 1 [T1]

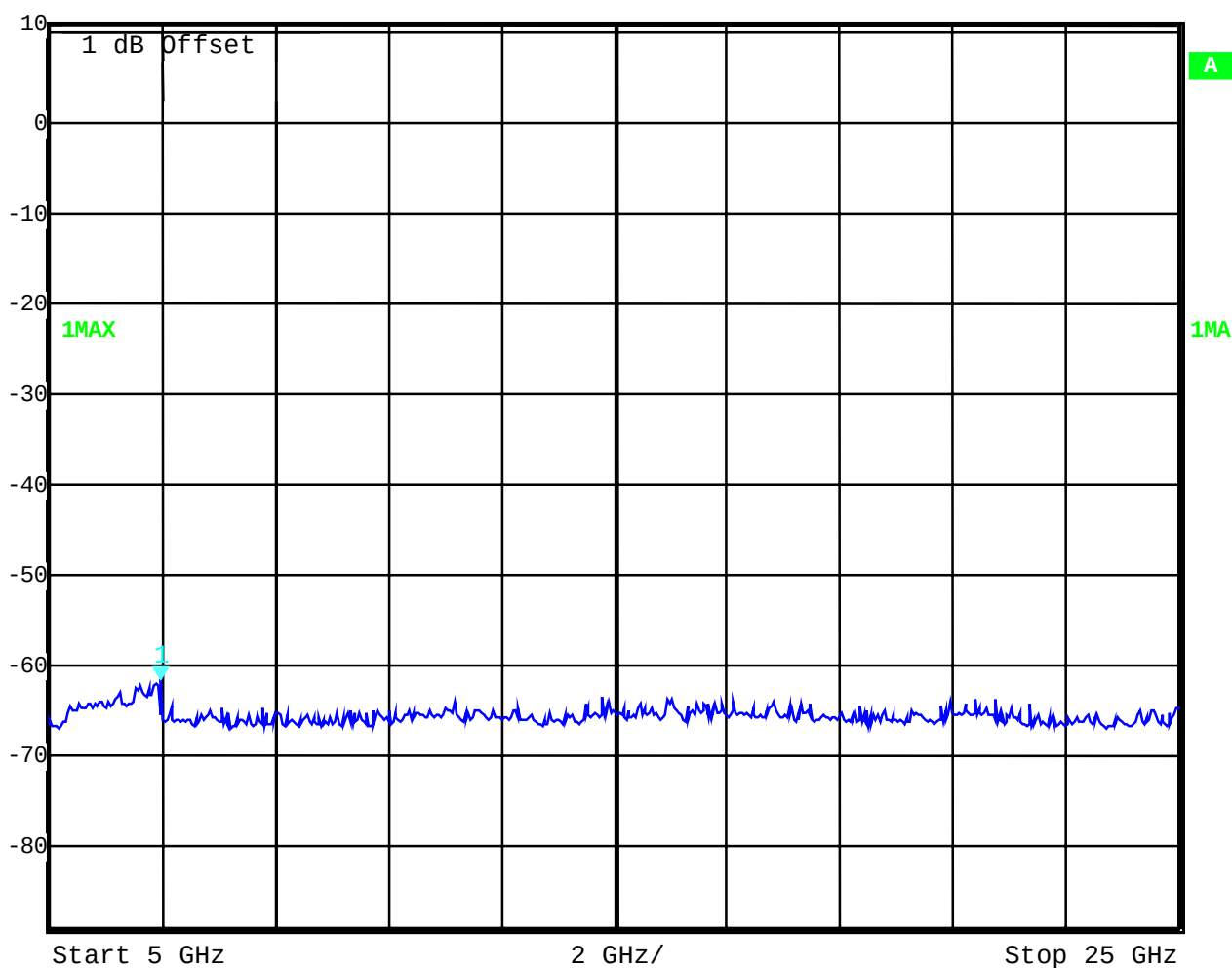
-61.72 dBm

6.96392786 GHz

RBW 100 kHz RF Att 20 dB

VBW 100 kHz

SWT 5 s Unit dBm



Equipment under test : MCW-D 1023

Ambient temperature : 25°C

Relative humidity : 47%

SPURIOUS EMISSION

CONDUCTED

§ 15.247 (c) (1)

Low channel (average)



Ref Lvl
11 dBm

Marker 1 [T1]

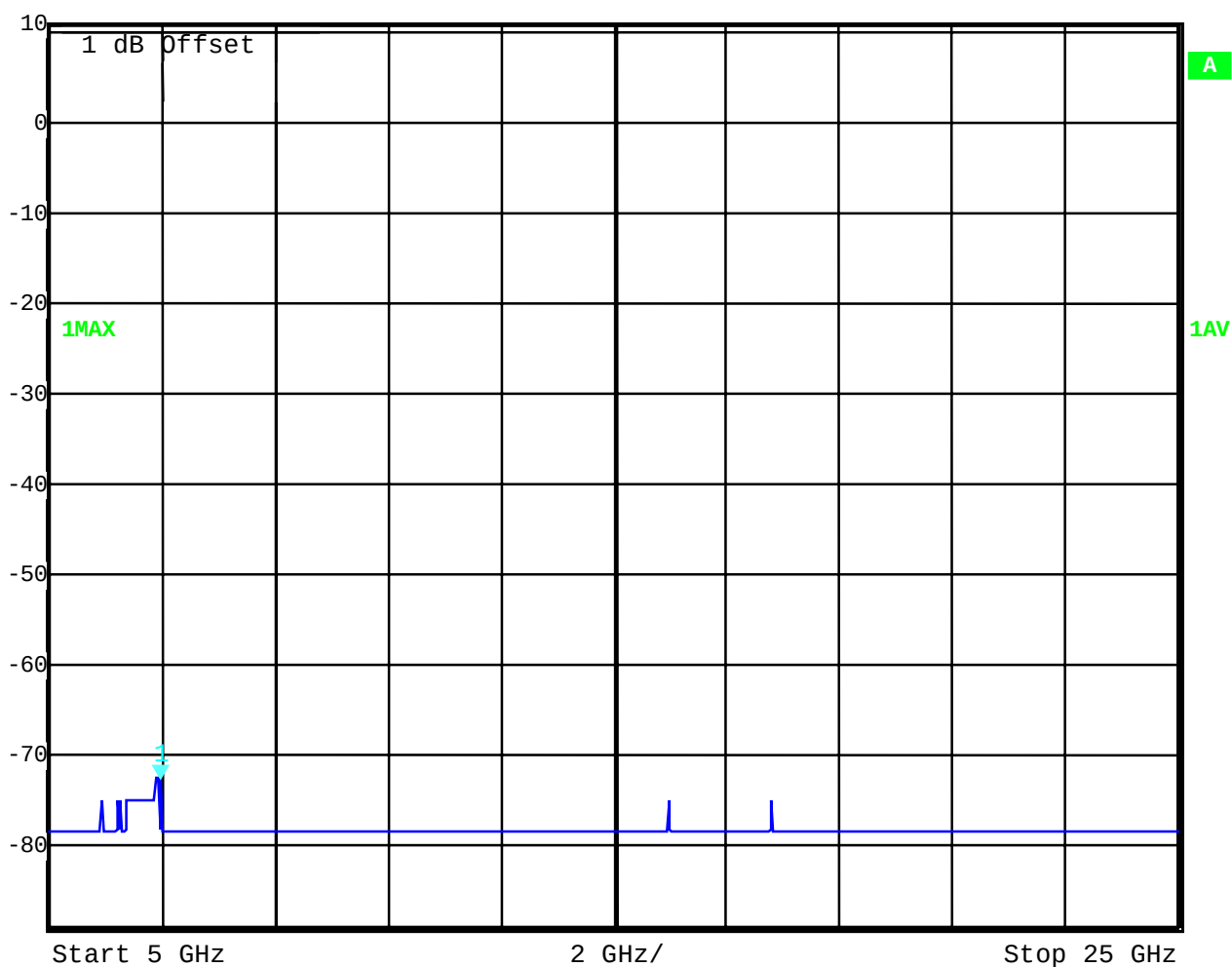
-72.52 dBm

6.96392786 GHz

RBW 100 kHz RF Att 20 dB

VBW 1 MHz

SWT 5 s Unit dBm



Equipment under test : MCW-D 1023

Ambient temperature : 25°C

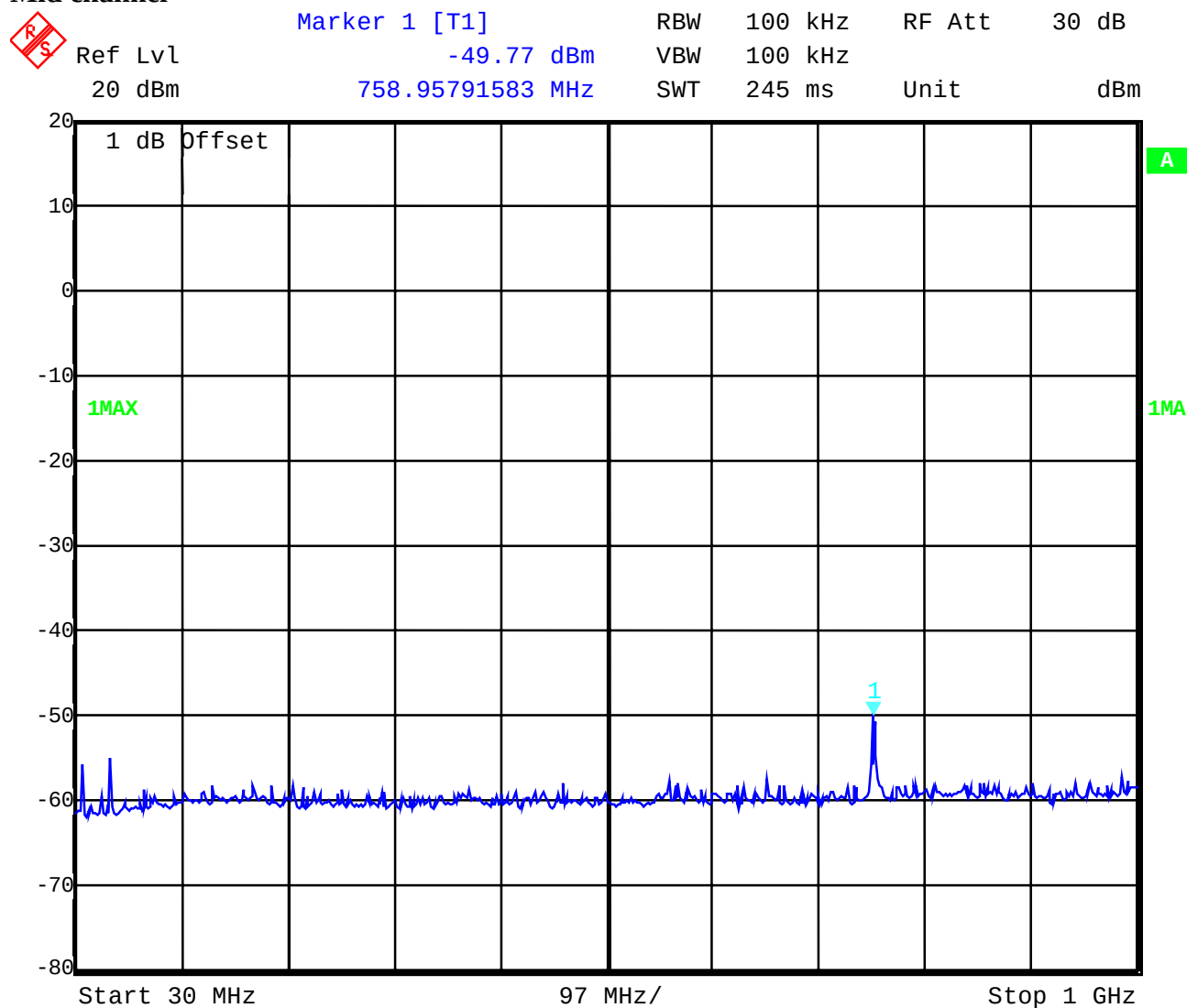
Relative humidity : 47%

SPURIOUS EMISSION

§ 15.247 (c) (1)

CONDUCTED

Mid channel



The ref level is set to 20 dBm, that is the output of the card at nominal frequency.

Equipment under test : MCW-D 1023

Ambient temperature : 25°C

Relative humidity : 47%

SPURIOUS EMISSION

CONDUCTED

§ 15.247 (c) (1)

Mid channel (peak)



Ref Lvl

20 dBm

Marker 2 [T1]

-41.99 dBm

1.67334669 GHz

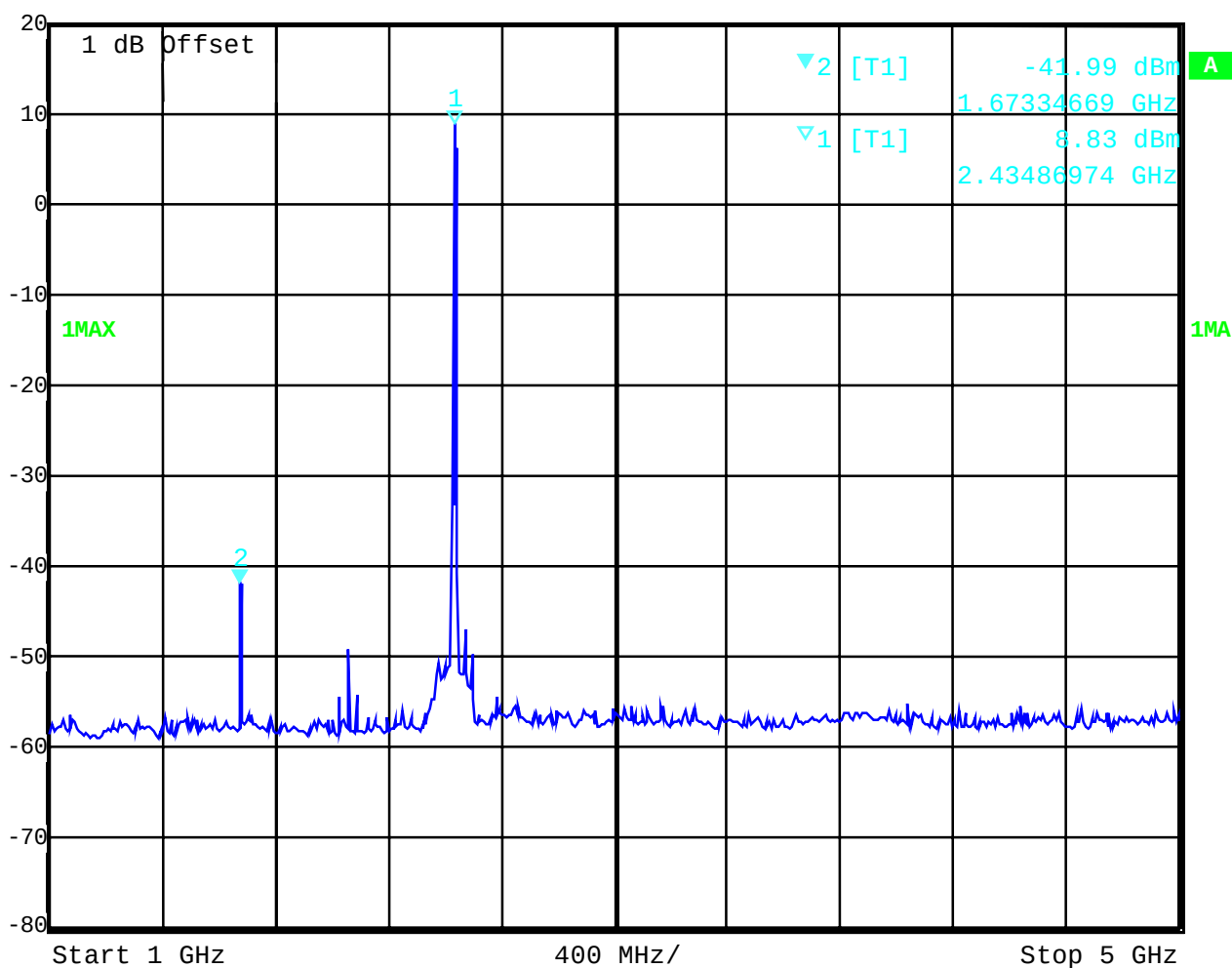
RBW 100 kHz

VBW 100 kHz

SWT 1 s

RF Att 30 dB

Unit dBm



Equipment under test : MCW-D 1023

Ambient temperature : 25°C

Relative humidity : 47%

SPURIOUS EMISSION

CONDUCTED

§ 15.247 (c) (1)

Mid channel (average)



Ref Lvl

20 dBm

Marker 2 [T1]

-60.00 dBm

1.67334669 GHz

RBW

100 kHz

RF Att

30 dB

VBW

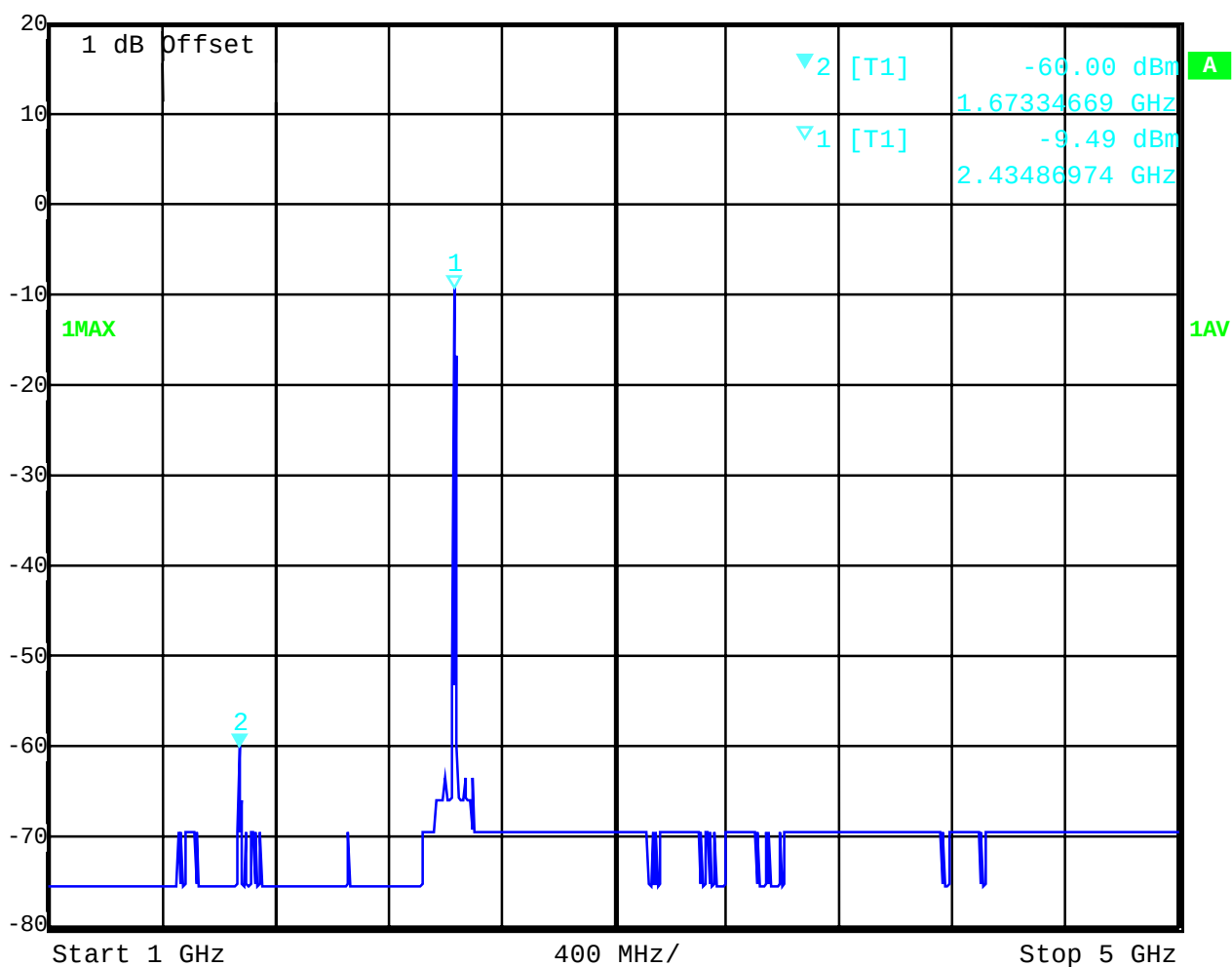
1 MHz

SWT

1 s

Unit

dBm



Equipment under test : MCW-D 1023

Ambient temperature : 25°C

Relative humidity : 47%

SPURIOUS EMISSION

§ 15.247 (c) (1)

CONDUCTED

Mid channel (peak)



Ref Lvl

20 dBm

Marker 1 [T1]

-51.75 dBm

6.88376754 GHz

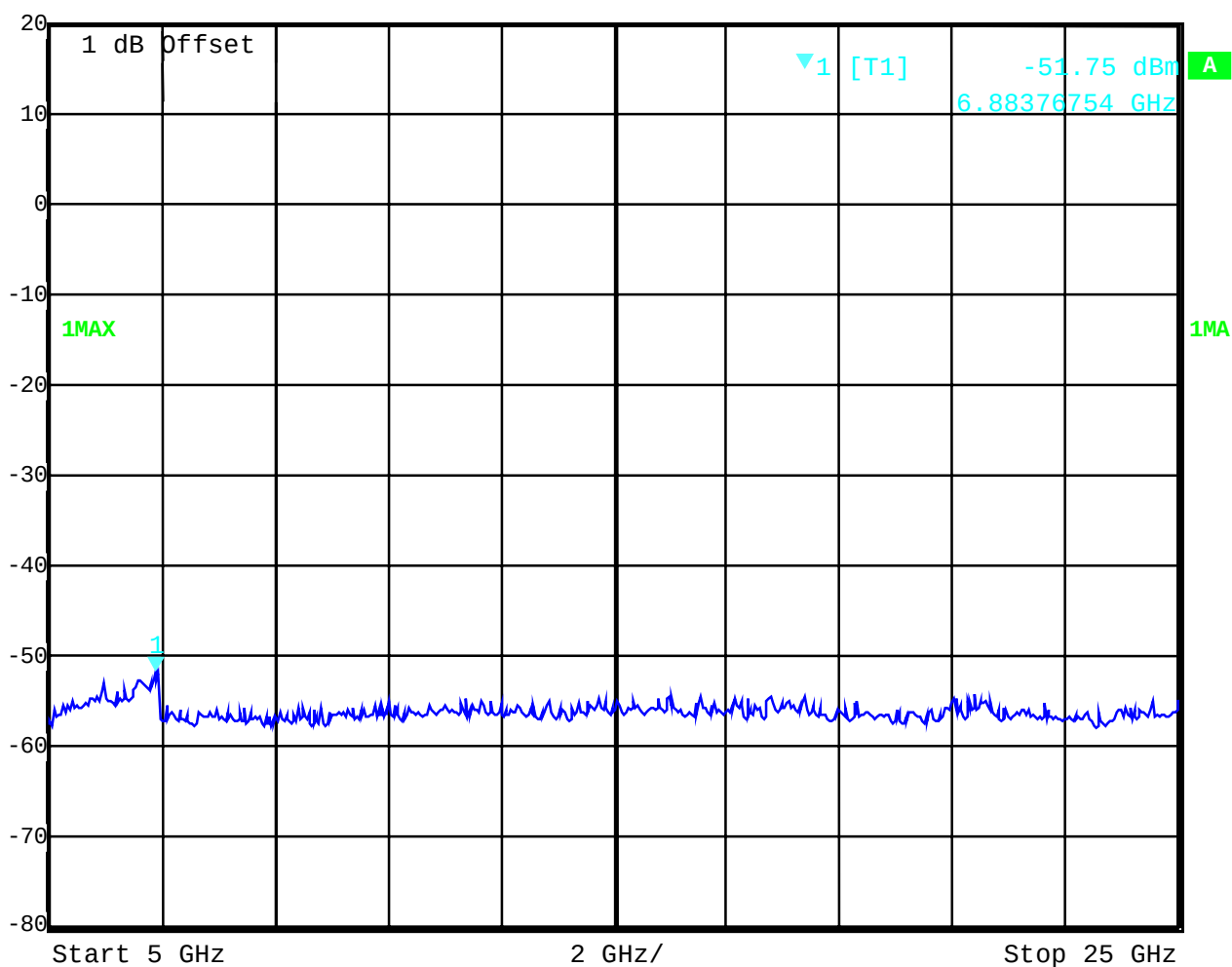
RBW 100 kHz

VBW 100 kHz

SWT 5 s

RF Att 30 dB

Unit dBm



Equipment under test : MCW-D 1023
Ambient temperature : 25°C
Relative humidity : 47%
SPURIOUS EMISSION
CONDUCTED

§ 15.247 (c) (1)

Mid channel (average)

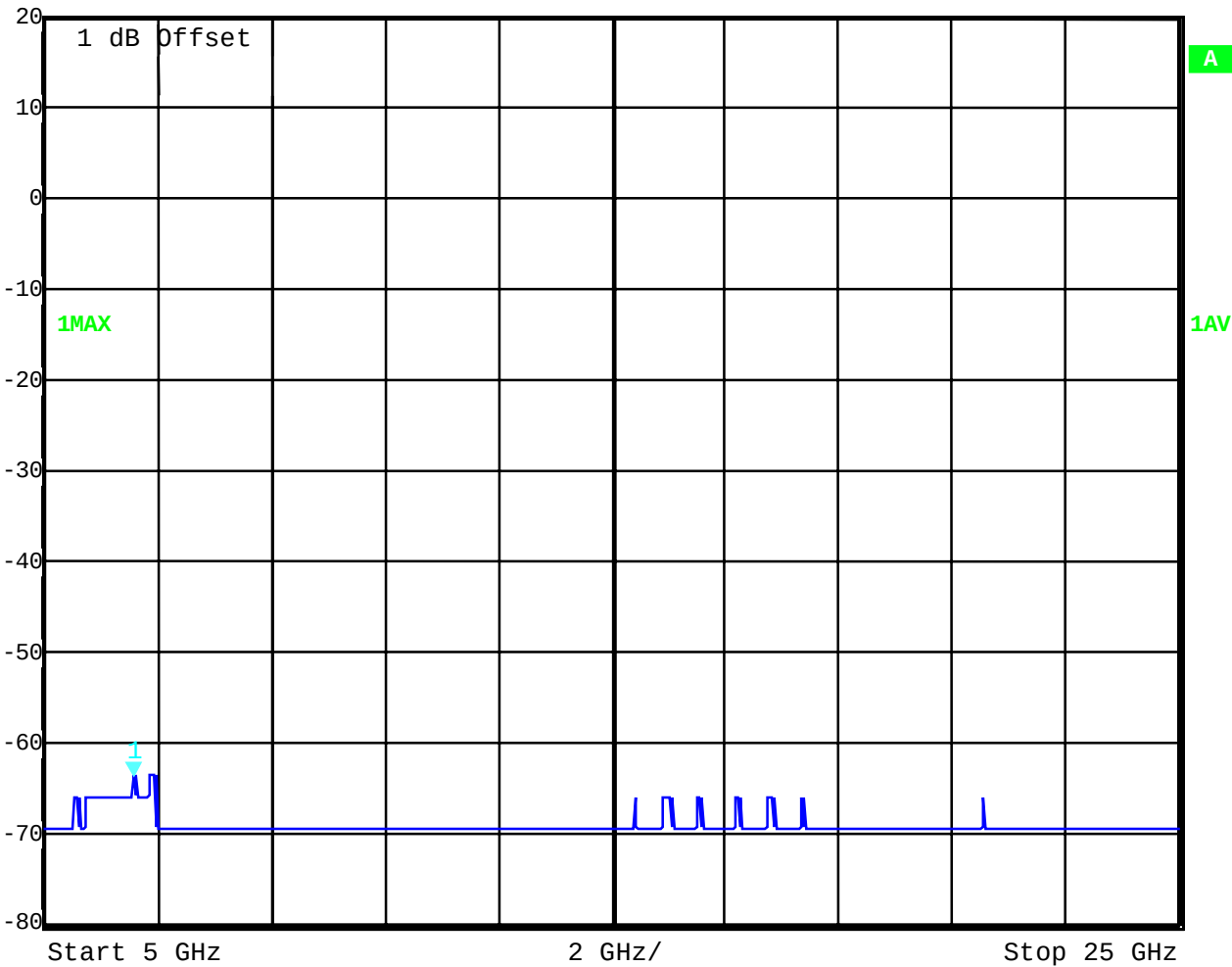


Ref Lvl
20 dBm

Marker 1 [T1]

-63.52 dBm
6.56312625 GHz

RBW 100 kHz RF Att 30 dB
VBW 1 MHz
SWT 5 s Unit dBm



Equipment under test : MCW-D 1023

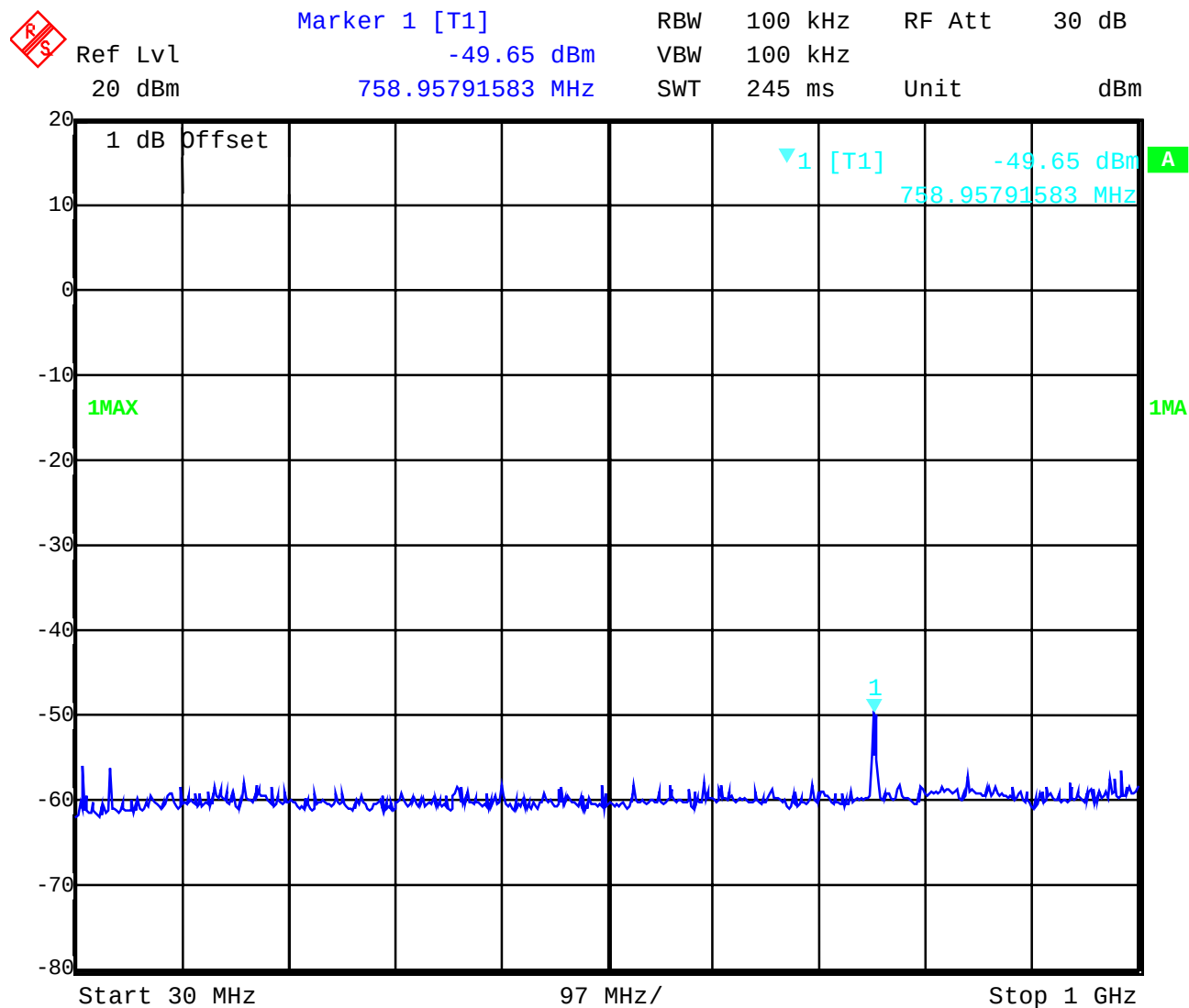
Ambient temperature : 25°C

Relative humidity : 47%

SPURIOUS EMISSION CONDUCTED

§ 15.247 (c) (1)

High channel



Equipment under test : MCW-D 1023

Ambient temperature : 25°C

Relative humidity : 47%

SPURIOUS EMISSION

CONDUCTED

§ 15.247 (c) (1)

High channel (peak)



Ref Lvl

20 dBm

Marker 3 [T1]

-45.76 dBm

2.09018036 GHz

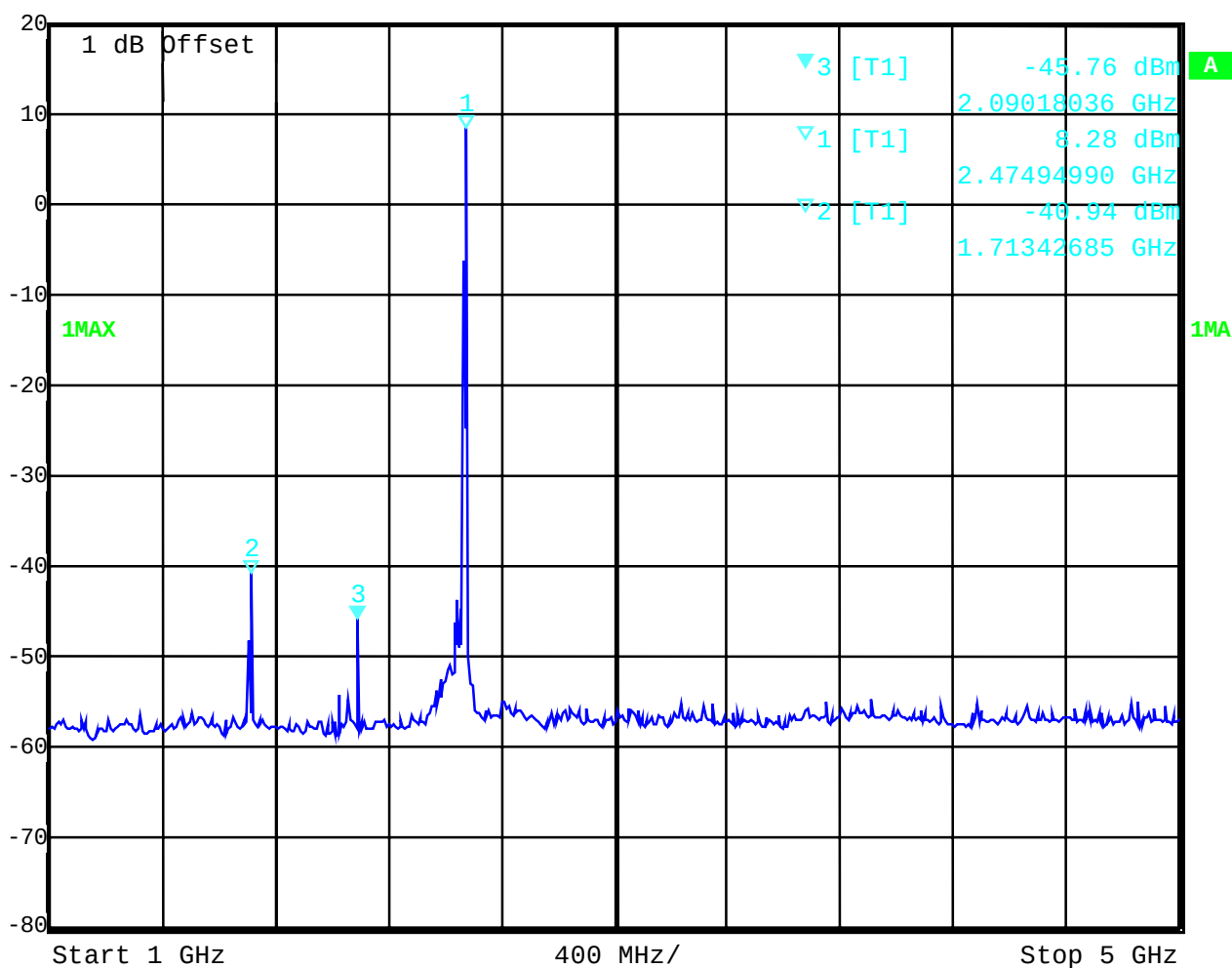
RBW 100 kHz

VBW 100 kHz

SWT 1 s

RF Att 30 dB

Unit dBm



Equipment under test : MCW-D 1023

Ambient temperature : 25°C

Relative humidity : 47%

SPURIOUS EMISSION

CONDUCTED

§ 15.247 (c) (1)

High channel (average)



Ref Lvl

20 dBm

Marker 3 [T1]

-69.54 dBm

2.09018036 GHz

RBW

100 kHz

RF Att

30 dB

VBW

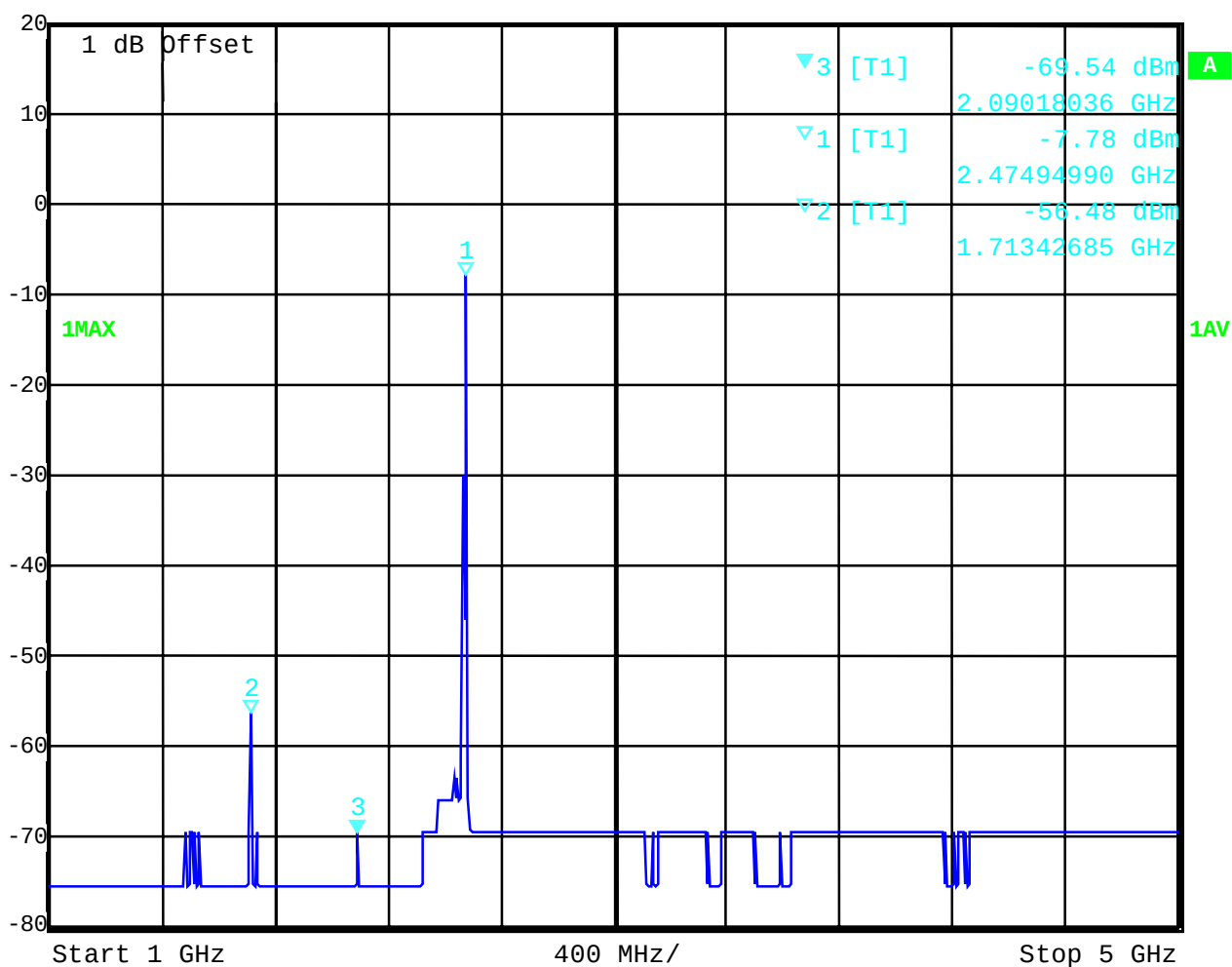
1 MHz

SWT

1 s

Unit

dBm



Equipment under test : MCW-D 1023

Ambient temperature : 25°C

Relative humidity : 47%

SPURIOUS EMISSION

CONDUCTED

§ 15.247 (c) (1)

High channel (peak)



Marker 1 [T1]

RBW 100 kHz RF Att 30 dB

Ref Lvl -51.51 dBm

VBW 100 kHz

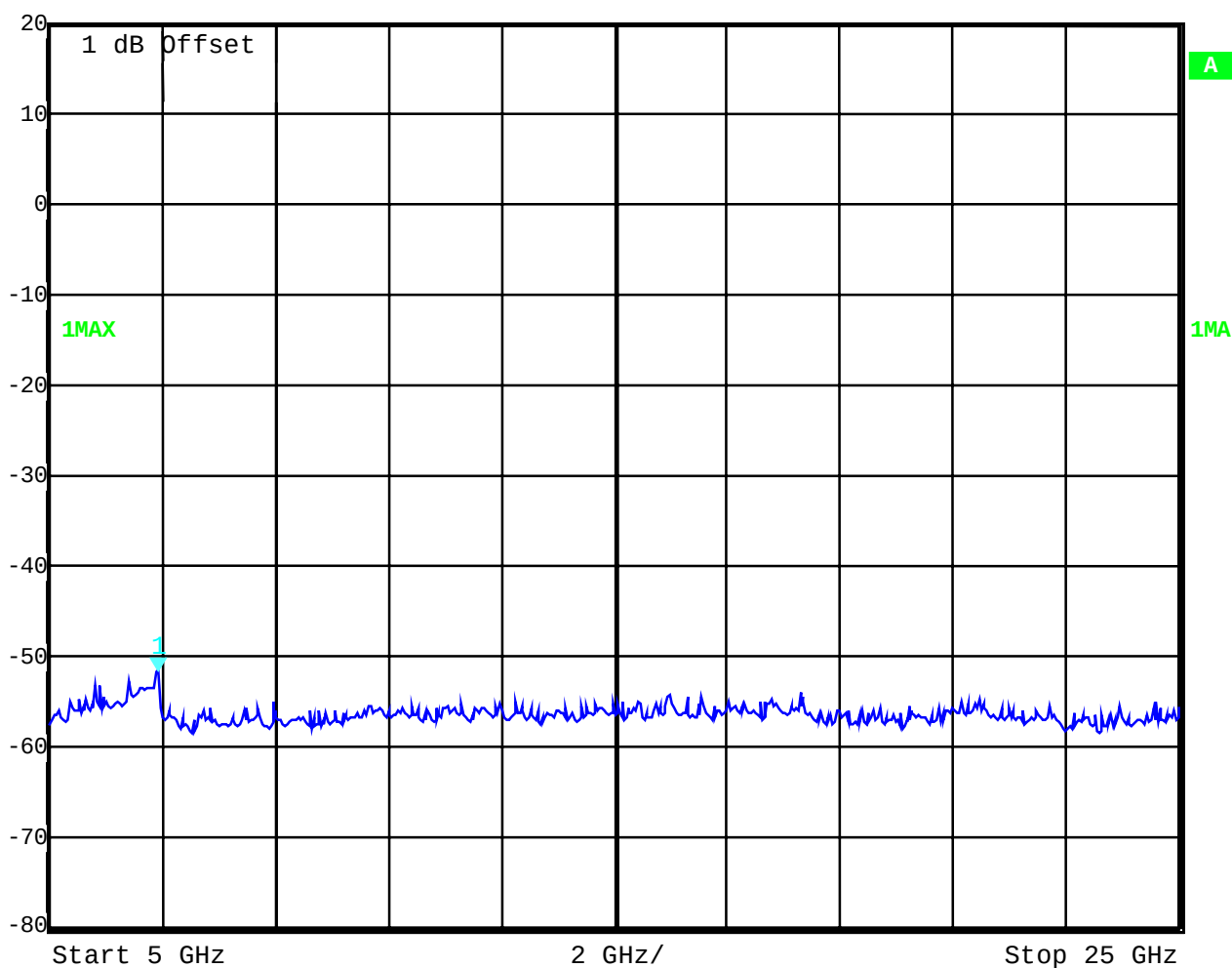
20 dBm

6.92384770 GHz

SWT 5 s

Unit

dBm



Equipment under test : MCW-D 1023

Ambient temperature : 25°C

Relative humidity : 47%

SPURIOUS EMISSION

§ 15.247 (c) (1)

CONDUCTED

High channel (average)



Ref Lvl

20 dBm

Marker 1 [T1]

-63.52 dBm

6.56312625 GHz

RBW

100 kHz

RF Att

30 dB

VBW

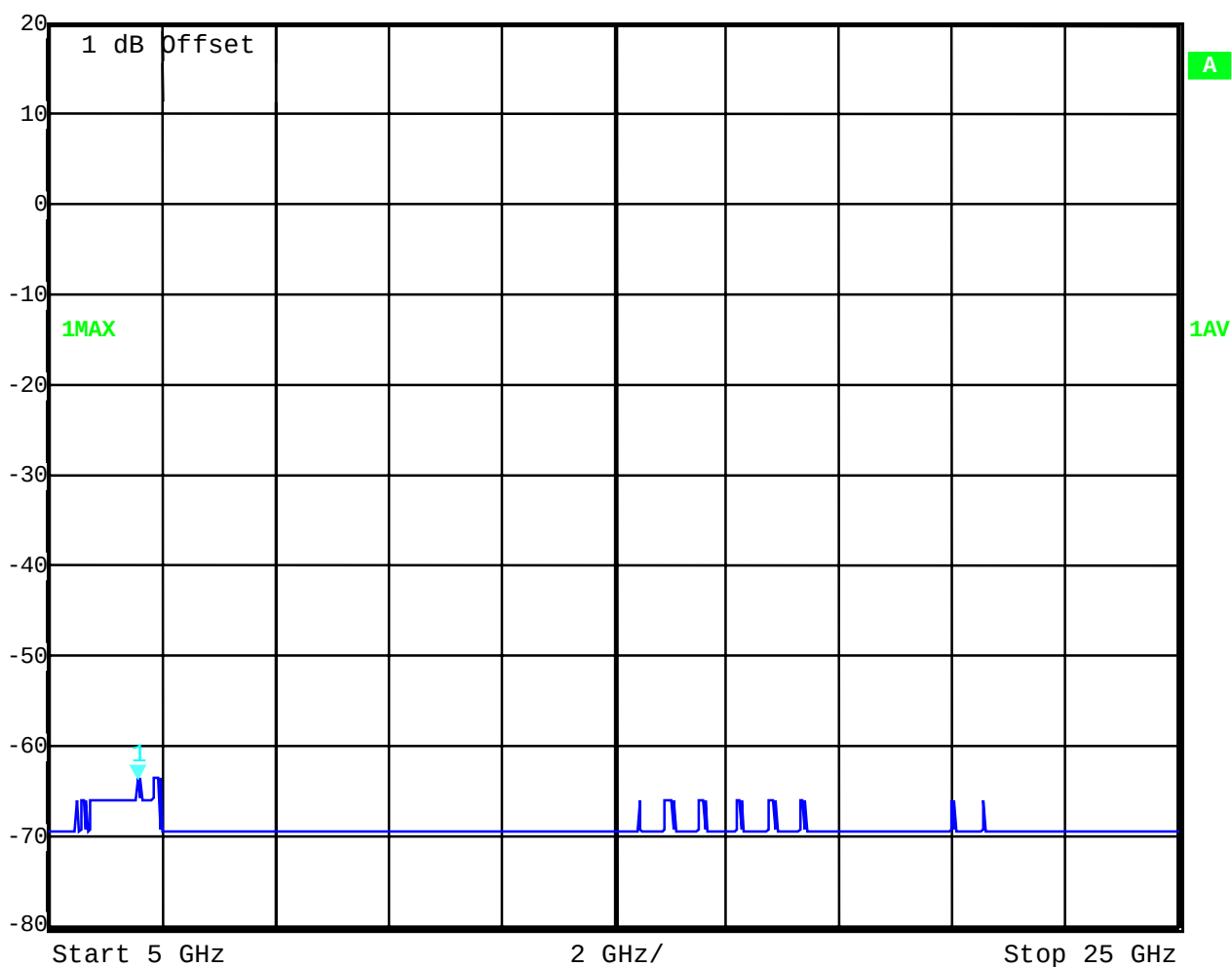
1 MHz

SWT

5 s

Unit

dBm



Equipment under test : MCW-D 1023
Ambient temperature : 25°C
Relative humidity : 47%
**SPURIOUS EMISSION (radiated)
up to 4 GHz (three stations simultan activated)**
§ 15.247 (c) (1)

EMISSION LIMITATIONS					
f (MHz)	polarization	amplitude of emission (dBμV/m) AVERAGE	amplitude of emission (dBμV/m) QUASI PEAK	limit max. allowed emmission power (dBμV/m)	results
low channel					
75.9	vertical		46.3	-20 dBc	no restr. band
85.8	vertical		46.6	-20 dBc	no restr. band
91.2	vertical		38.9	43.5	complies
1197.3	vertical	31.7		54.0	complies
1716.2	vertical	39.2		54.0	complies
1864.9	vertical	32.1		54.0	complies
mid channel					
75.9	vertical		46.3	-20 dBc	no restr. band
85.8	vertical		46.6	-20 dBc	no restr. band
91.2	vertical		38.9	43.5	complies
1197.3	vertical	31.7		54.0	complies
1716.2	vertical	39.2		54.0	complies
1864.9	vertical	32.1		54.0	complies
high channel					
75.9	vertical		46.3	-20 dBc	no restr. band
85.8	vertical		46.6	-20 dBc	no restr. band
91.2	vertical		38.9	43.5	complies
1197.3	vertical	31.7		54.0	complies
1716.2	vertical	39.2		54.0	complies
1864.9	vertical	32.1		54.0	complies
Measurement uncertainty		± 3dB			

LIMITS
SUBCLAUSE § 15.247 (c)

In any 100 kHz bandwidth outside the frequency band at least 20dB below the highest level of the desired power. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

Equipment under test : MCW-D 1023

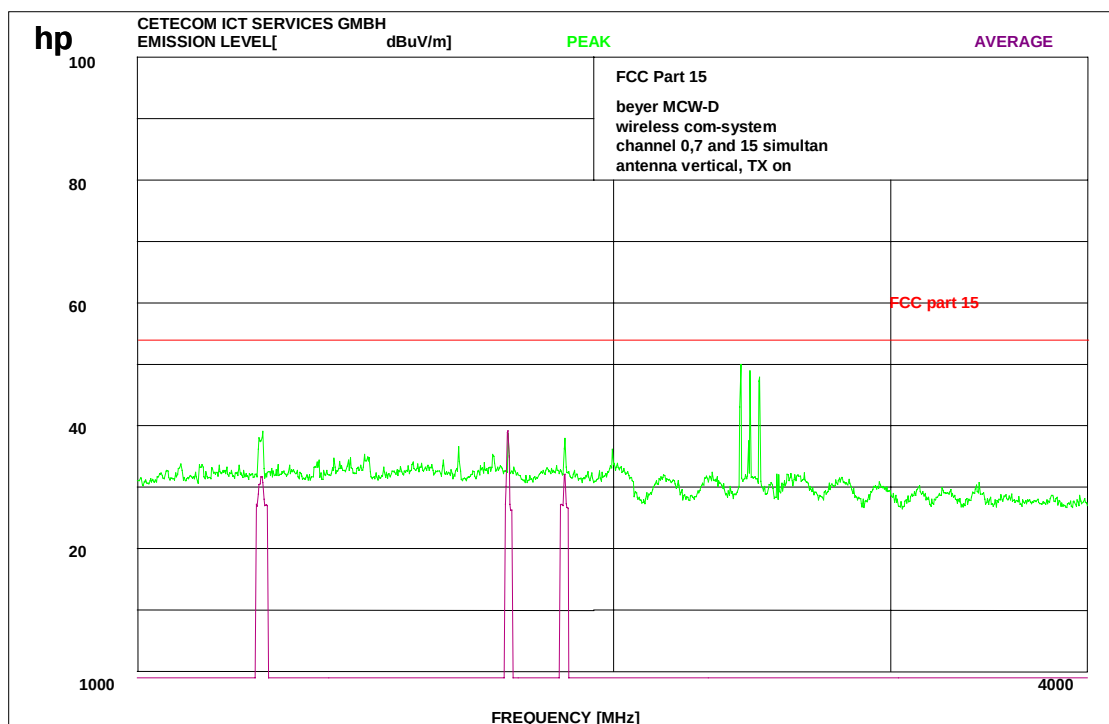
Ambient temperature : 25°C

Relative humidity : 47%

EMISSION LIMITATIONS- Radiated

§ 15.247 (c) (1)

3 channels simultan up to 4 GHz, carrier suppressed by a stub tuner to avoid oversteering.



This is only a scan.

Measurements were performed by main with 100/120 kHz BW for CISPR Quasipeak below 1 GHz, above 1 GHz with 1MHz RBW/VBW at average and peak.

REFERENCE NUMBER(S) OF TEST EQUIPMENT USED

(for reference numbers see test equipment listing)

Equipment under test : MCW-D 1023

Ambient temperature : 25°C

Relative humidity : 47%

SPURIOUS EMISSION (radiated)

§ 15.247 (c) (1)

up to 12 GHz

EMISSION LIMITATIONS					
f (MHz)	polarization	amplitude of emission (dBµV/m) AVERAGE	amplitude of emission (dBµV/m) QUASI PEAK	limit max. allowed emission power (dBµV/m)	results
valid for all 3 channels					
4815.8	vertical	40.5		54.0	complies
4879.8	vertical	40.2		54.0	complies
4950.9	vertical	41.2		54.0	complies
7218.9	vertical	24.2		54.0	complies
7314.8	vertical	23.6		54.0	complies
7420.2	vertical	24.4		54.0	complies
Measurement uncertainty		± 3dB			

Horizontal measurements were more than 6 dB lower

LIMITS

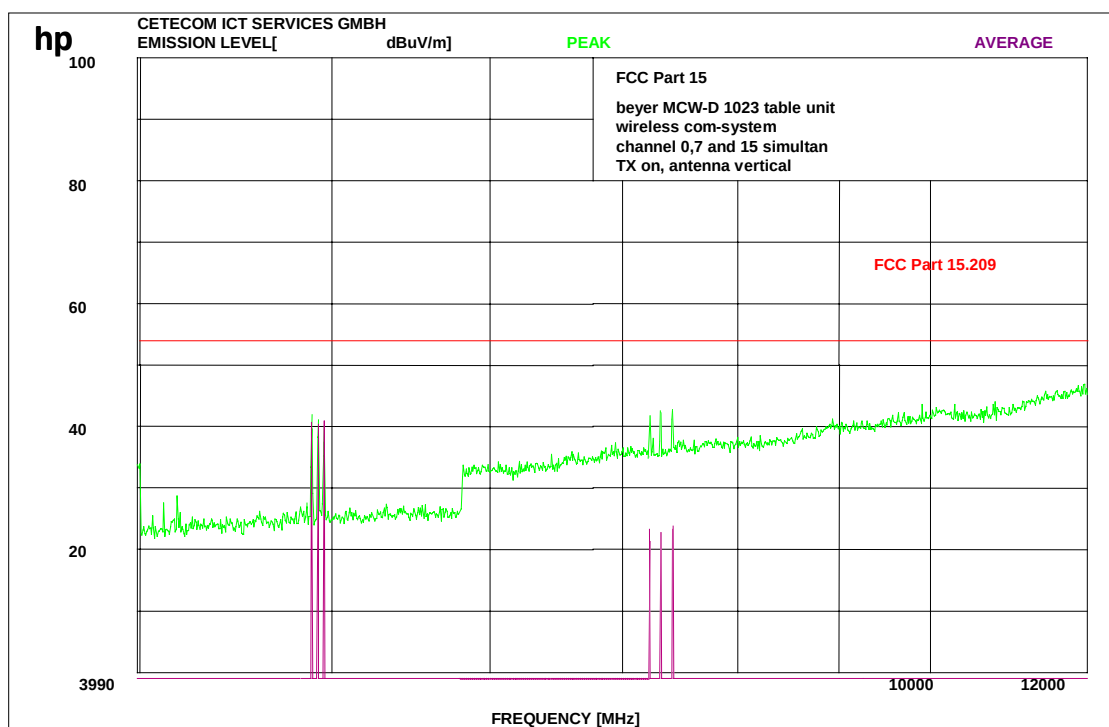
SUBCLAUSE § 15.247 (c)

In any 100 kHz bandwidth outside the frequency band at least 20dB below the highest level of the desired power. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

EMISSION LIMITATIONS- Radiated

§ 15.247 (c) (1)

3 channels simultan up to 12 GHz, carrier suppressed by a high pass filter to avoid oversteering.



This is only a scan.

Measurements were performed by main with 100/120 kHz BW for CISPR Quasipeak below 1 GHz, with 1MHz RBW/VBW at average and peak over 1 GHz.

Equipment under test : MCW-D 1023

Ambient temperature : 25°C

Relative humidity : 47%

EMISSION LIMITATIONS

(Transmitter)

CLAUSE § 15.247 (c) (1)

Channel 1-3 (this is valid for all 3 channels)

Peak



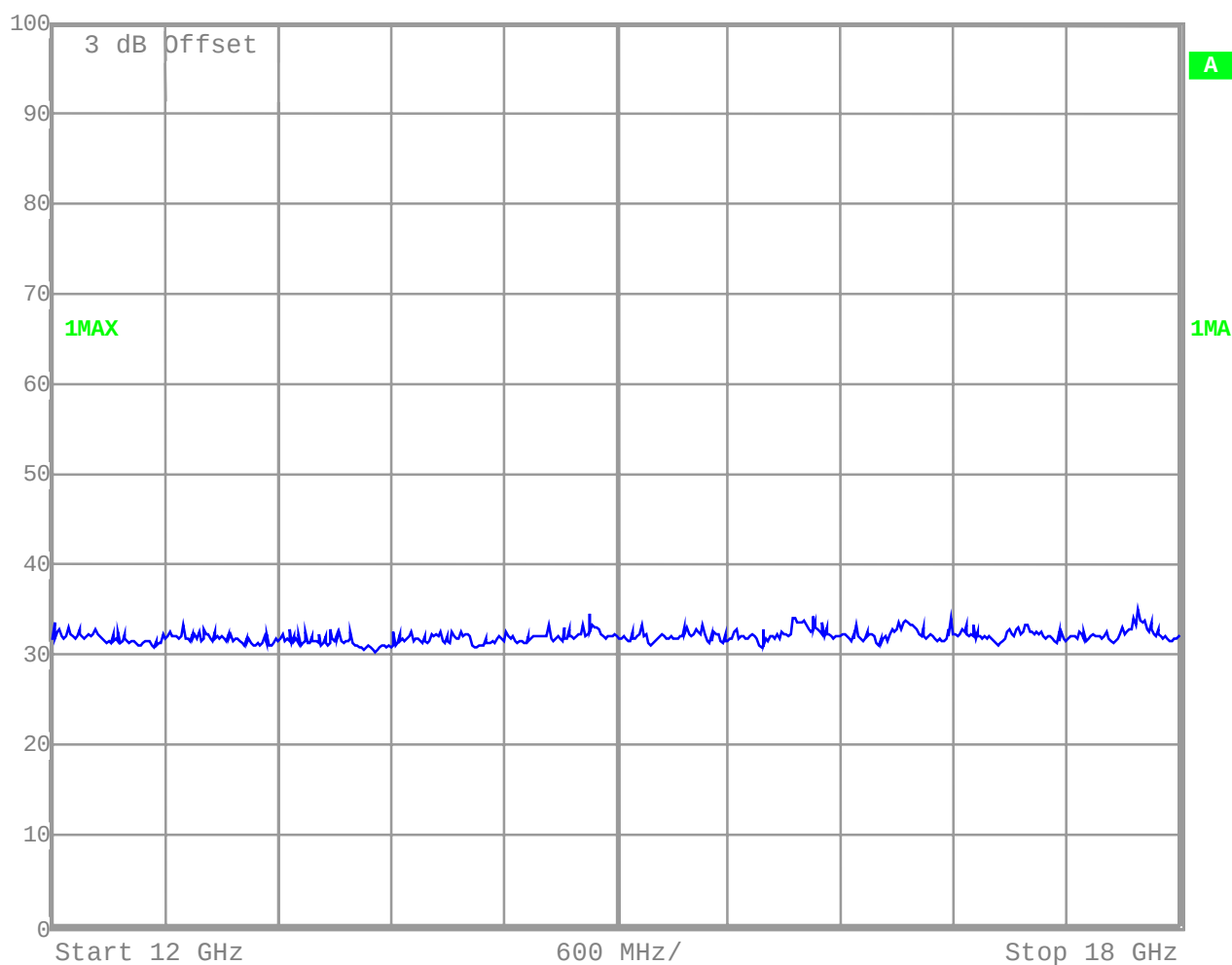
Ref Lvl

100 dBμV

RBW 1 MHz RF Att 0 dB

VBW 1 MHz

SWT 34 ms Unit dBμV



LIMITS

SUBCLAUSE § 15.247 (c)

In any 100 kHz bandwidth outside the frequency band at least 20dB below the highest level of the desired power. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

Equipment under test : MCW-D 1023

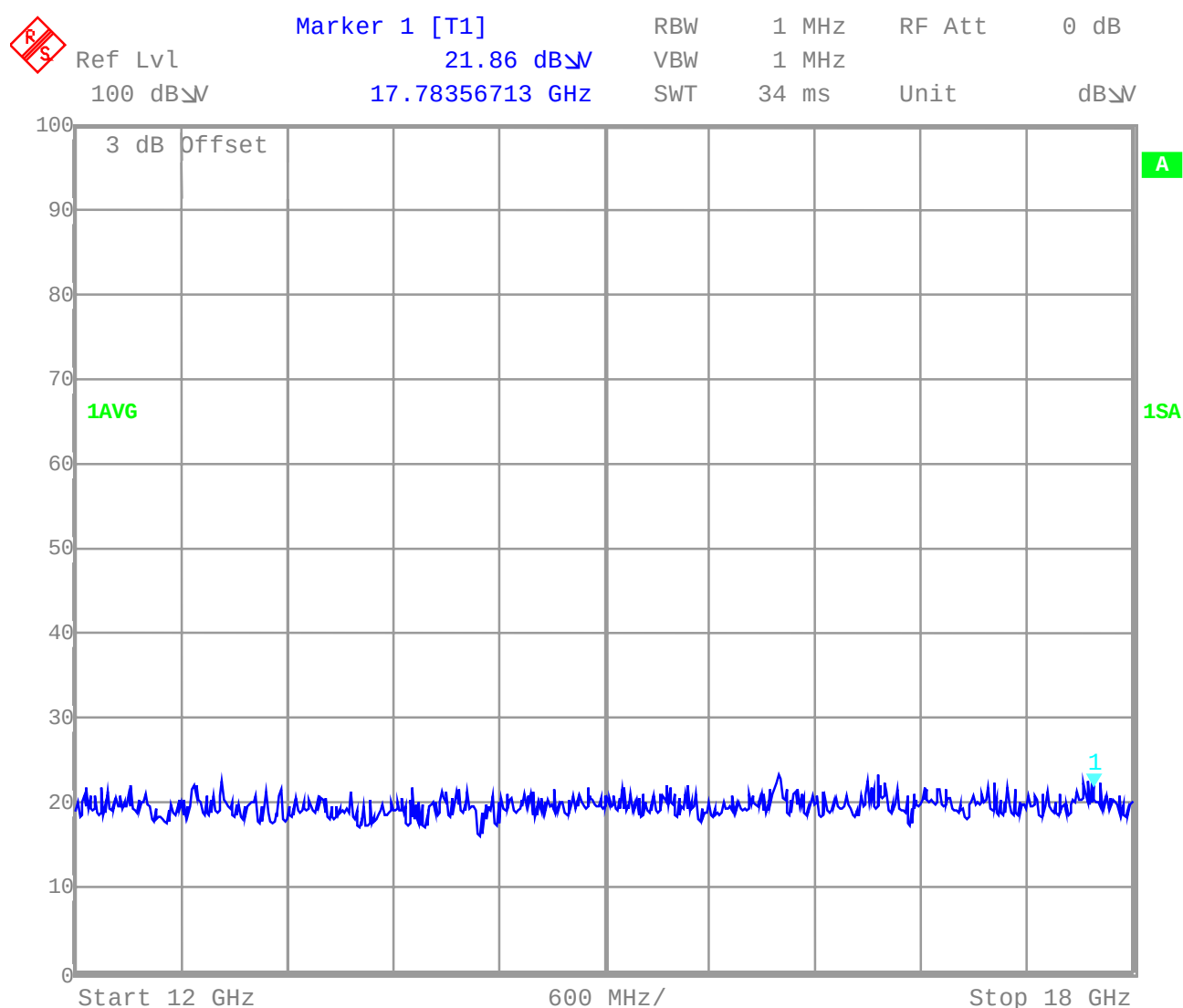
Ambient temperature : 25°C

Relative humidity : 47%

EMISSION LIMITATIONS (Transmitter) CLAUSE § 15.247 (c) (1)

Channel 1-3 (this is valid for all 3 channels)

Average



LIMITS

SUBCLAUSE § 15.247 (c)

In any 100 kHz bandwidth outside the frequency band at least 20dB below the highest level of the desired power. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

Equipment under test : MCW-D 1023

Ambient temperature : 25°C

Relative humidity : 47%

EMISSION LIMITATIONS (Transmitter) **CLAUSE § 15.247 (c) (1)**

Channel 1-3 (this is valid for all 3 channels)

Peak



Marker 1 [T1]

RBW 1 MHz RF Att 0 dB

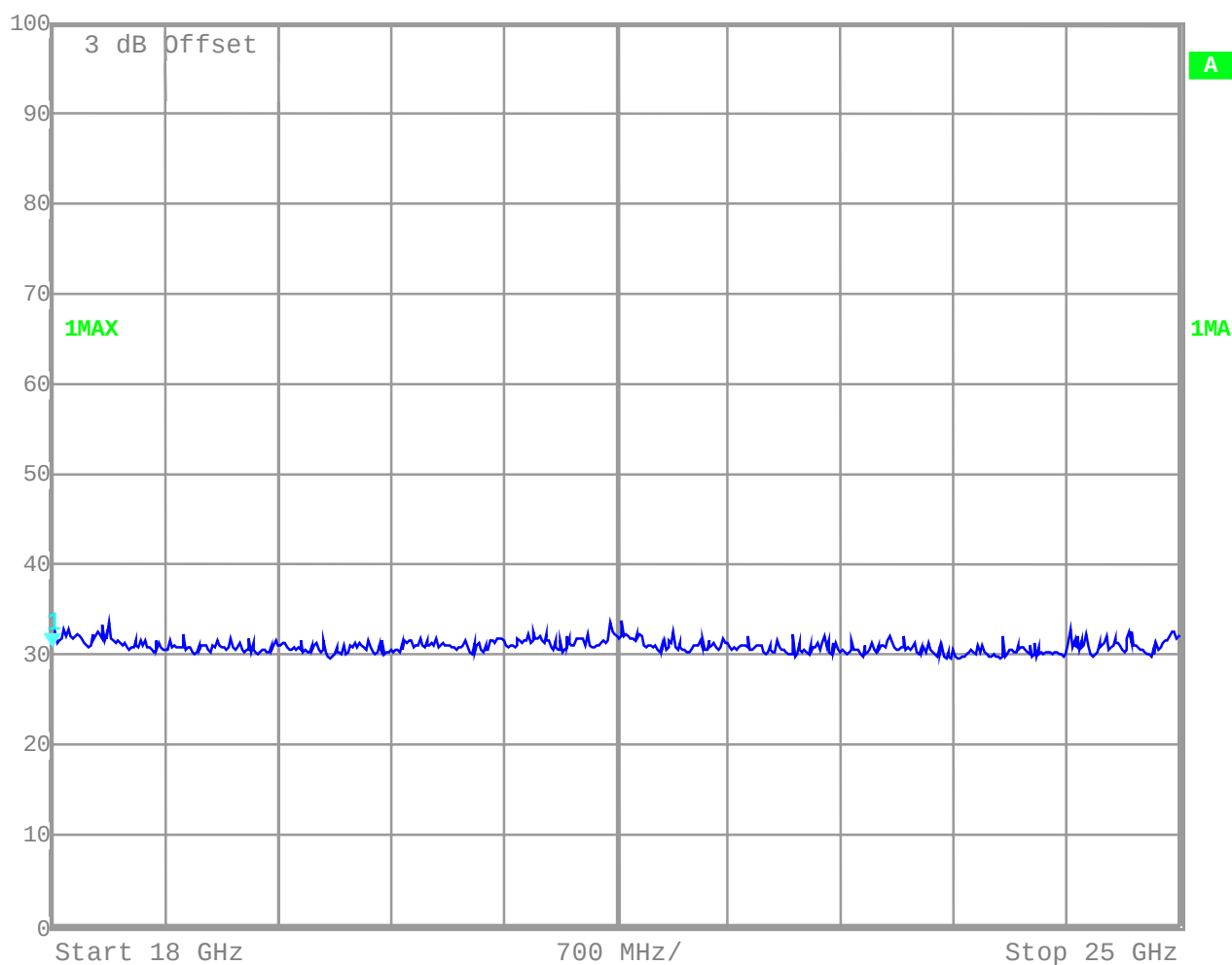
Ref Lvl 30.97 dB μ V

VBW 1 MHz

100 dB μ V 18.00000000 GHz

SWT 40 ms

Unit dB μ V



LIMITS

SUBCLAUSE § 15.247 (c)

In any 100 kHz bandwidth outside the frequency band at least 20dB below the highest level of the desired power. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

Equipment under test : MCW-D 1023

Ambient temperature : 25°C

Relative humidity : 47%

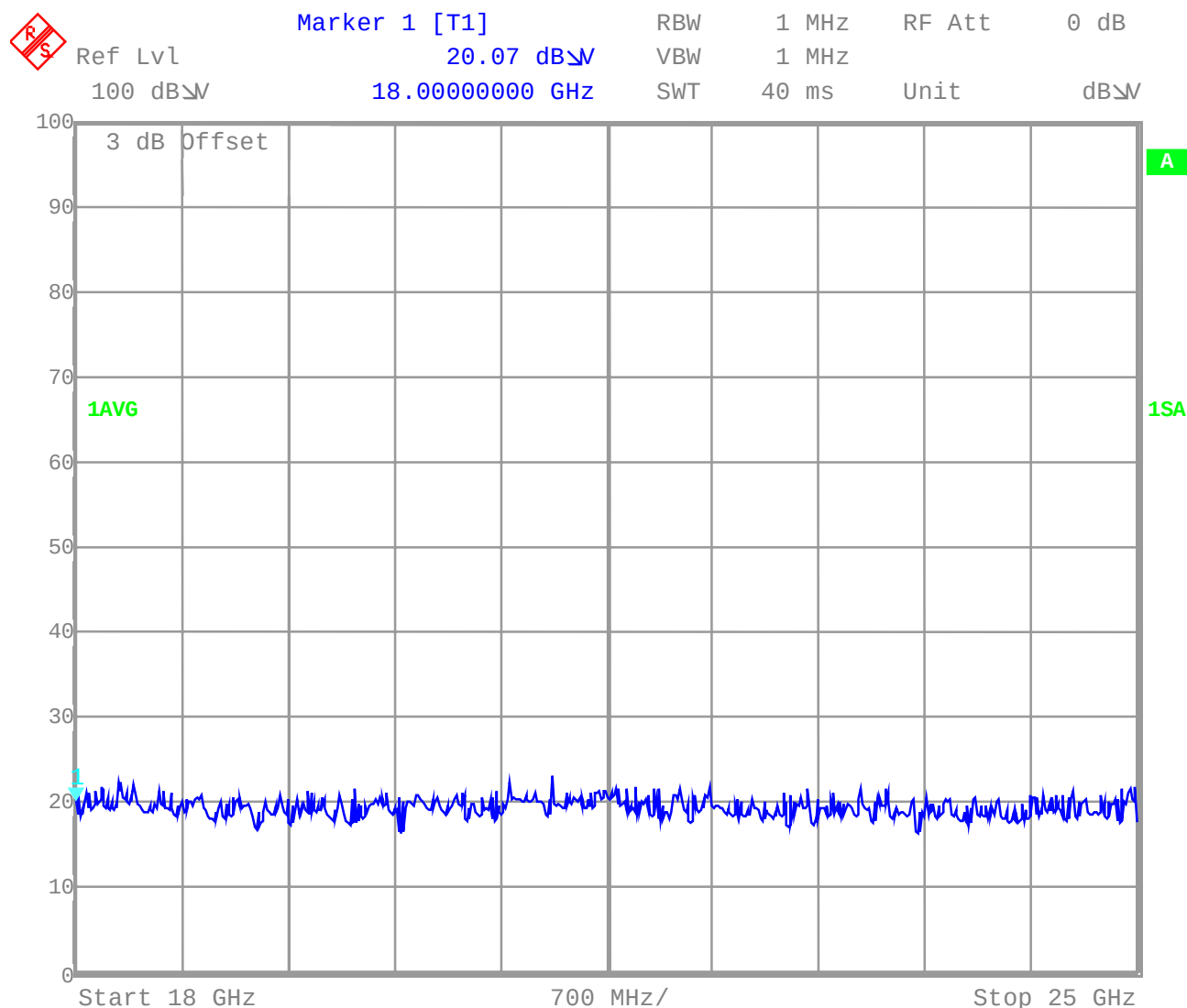
EMISSION LIMITATIONS

(Transmitter)

CLAUSE § 15.247 (c) (1)

Channel 1-3 (this is valid for all 3 channels)

Average



LIMITS

SUBCLAUSE § 15.247 (c)

In any 100 kHz bandwidth outside the frequency band at least 20dB below the highest level of the desired power. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

Equipment under test : MCW-D 1023

Ambient temperature : 25°C

Relative humidity : 47%

PROCESSING GAIN OF DSSS SYSTEMS

SUBCLAUSE §15.247 (e)

The processing gain of this product was measured by ADCON

It will be provided in an external paper.

It is in all cases over 10 dB.

Equipment under test : MCW-D 1023

Ambient temperature : 25°C

Relative humidity : 47%

TEST EQUIPMENT AND ANCILLARIES USED FOR TESTS

To simplify the identification on each page of the test equipment used, on each page of the test report, each item of test equipment and ancillaries such as cables are identified (numbered) by the Test Laboratory, below.

No	Instrument/Ancillary	Type	Manufacturer	Serial No.
01	Spectrum Analyzer	8566 A	Hewlett-Packard	1925A00257
02	Analyzer Display	8566 A	Hewlett-Packard	1925A00860
03	Oscilloscope	7633	Tektronix	230054
04	Radio Analyzer	CMTA 54	Rohde & Schwarz	894 043/010
05	System Power Supply	6038 A	Hewlett-Packard	2848A07027
06	Signal Generator	8111 A	Hewlett-Packard	2215G00867
07	Signal Generator	8662 A	Hewlett-Packard	2224A01012
08	Funktionsgenerator	AFGU	Rohde & Schwarz	862 480/032
09	Regeltrenntrafo	MPL	Erfi	91350
10	Netznachbildung	NNLA 8120	Schwarzbeck	8120331
11	Relais-Matrix	PSU	Rohde & Schwarz	893 285/020
12	Power-Meter	436 A	Hewlett-Packard	2101A12378
13	Power-Sensor	8484 A	Hewlett-Packard	2237A10156
14	Power-Sensor	8482 A	Hewlett-Packard	2237A00616
15	Modulationsmeter	9008	Racal-Dana	2647
16	Frequenzzähler	5340 A	Hewlett-Packard	1532A03899
17	Absorber Schirmkabine	---	MWB	87400/002
18	Spectrum Analyzer	85660 B	Hewlett-Packard	2747A05306
19	Analyzer Display	85662 A	Hewlett-Packard	2816A16541
20	Quasi Peak Adapter	85650 A	Hewlett-Packard	2811A01131
21	RF-Preselector	85685 A	Hewlett-Packard	2833A00768
22	Biconical Antenne	3104	Emco	3758
23	Log. Per. Antenne	3146	Emco	2130
24	Double Ridge Horn	3115	Emco	3088
25	EMI-Testreceiver	ESAI	Rohde & Schwarz	863 180/013
26	EMI-Analyzer-Display	ESAI-D	Rohde & Schwarz	862 771/008
27	Biconical Antenne	HK 116	Rohde & Schwarz	888 945/013
28	Log. Per. Antenne	HL 223	Rohde & Schwarz	825 584/002
29	Relais-Switch-Unit	RSU	Rohde & Schwarz	375 339/002
30	Highpass	HM985955	FSY Microwave	001
31	Amplifier	P42-GA29	Tron-Tech	B 23602
32	Absorber Schirmkabine		Frankonia	
33	Steuerrechner	PSM 7	Rohde & Schwarz	834 621/004
34	EMI Test Reciever	ESMI	Rohde & Schwarz	827 063/010
35	EMI Test Receiver	Display	Rohde & Schwarz	829 808/010

Equipment under test : MCW-D 1023

Ambient temperature : 25°C

Relative humidity : 47%

TEST EQUIPMENT AND ANCILLARIES USED FOR TESTS

To simplify the identification on each page of the test equipment used, on each page of the test report, each item of test equipment and ancillaries such as cables are identified (numbered) by the Test Laboratory, below.

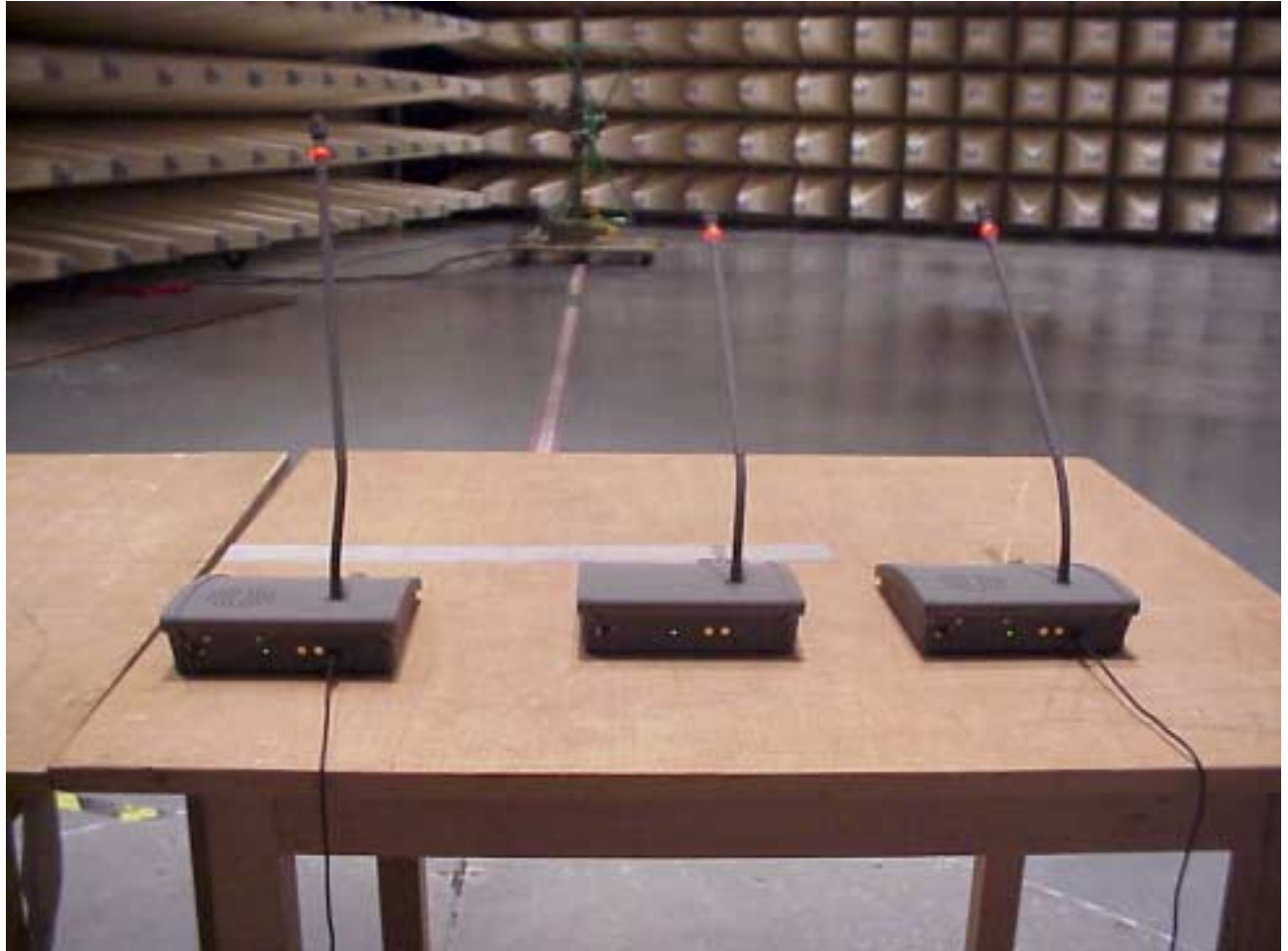
No	Instrument/Ancillary	Type	Manufacturer	Serial No.
36	Controler	HD 100	Deisel	100/322/93
37	Relais Matrix	PSN	Rohde & Schwarz	829 065/003
38	Control Unit	GB 016 A2	Rohde & Schwarz	344 122/008
39	Relais Switch Unit	RSU	Rohde & Schwarz	316 790/001
40	Power Supply	6032A	Hewlett Packard	2846A04063
41	Spektrum Monitor	EZM	Rohde & Schwarz	883 720/006
42	Meßempfänger	ESH 3	Rohde & Schwarz	890 174/002
43	Meßempfänger	ESVP	Rohde & Schwarz	891 752/005
44	Biconi Ant. 20-300MHz	HK 116	Rohde & Schwarz	833 162/011
45	Logper Ant. 0.3-1 GHz	HL 223	Rohde & Schwarz	832 914/010
46	Amplifier 0.1-4 GHz	AFS4	Miteq Inc.	206461
47	Logper Ant. 1-18 GHz	HL 024 A2	Rohde & Schwarz	342 662/002
48	Polarisationsnetzwerk	HL 024 Z1	Rohde & Schwarz	341 570/002
49	Double Ridge G Horn Antenne 1-26.5 GHz	3115	EMCO	9107-3696
50	Microw. Sys. Amplifier 0.5- 26.5 GHz	8317A	Hewlett Packard	3123A00105
51	Spectrum Analyzer	8562A	Hewlett Packard	2809AO2682
52				
53				
54				
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60				
61				
62				
63				
64				
65				
66				
67				

Equipment under test : MCW-D 1023

Ambient temperature : 25°C

Relative humidity : 47%

Test Site



Equipment under test : MCW-D 1023

Ambient temperature : 25°C

Relative humidity : 47%

Photographs of the equipment



Equipment under test : MCW-D 1023

Ambient temperature : 25°C

Relative humidity : 47%

Photographs of the equipment

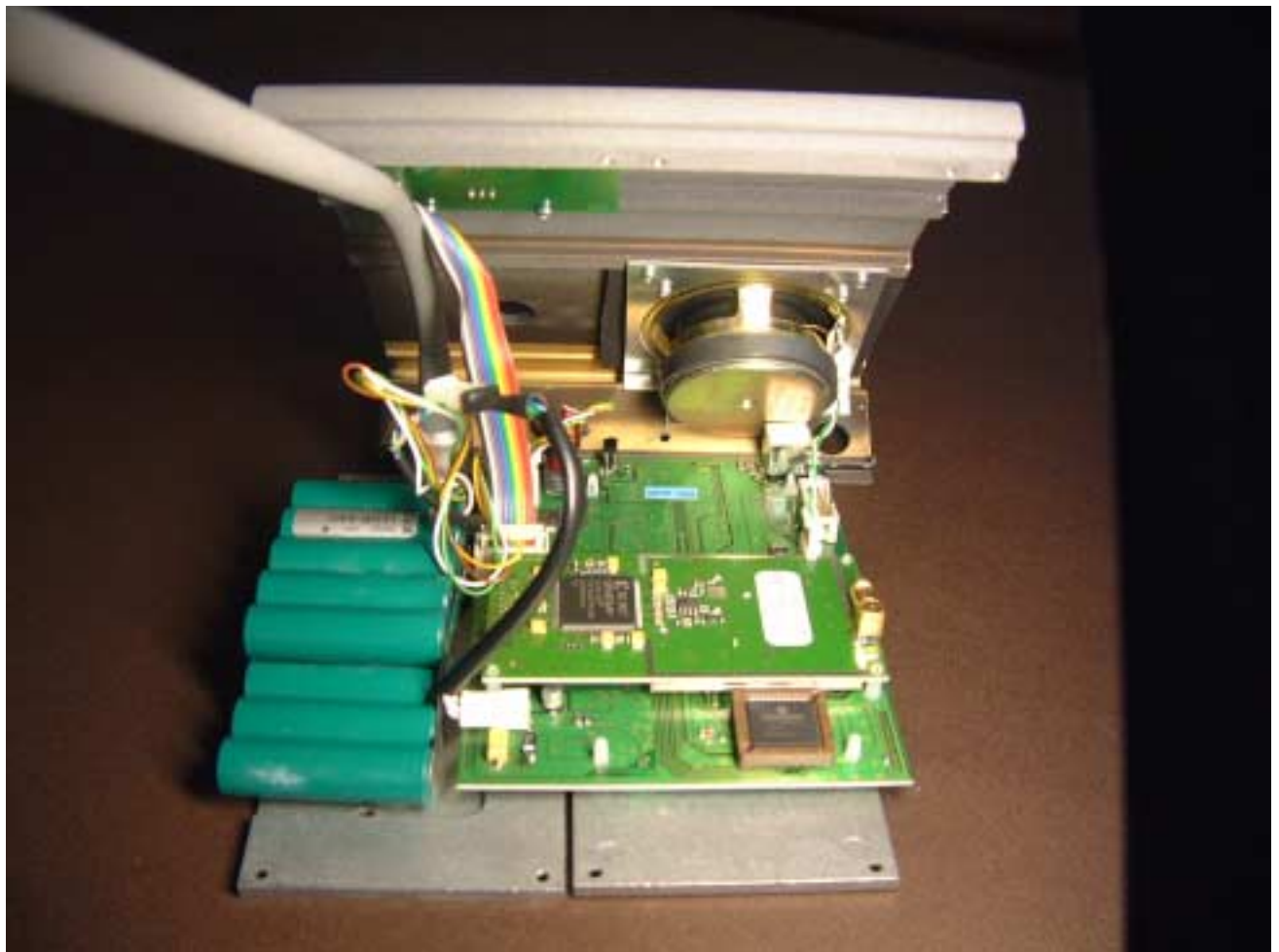


Equipment under test : MCW-D 1023

Ambient temperature : 25°C

Relative humidity : 47%

Photographs of the equipment

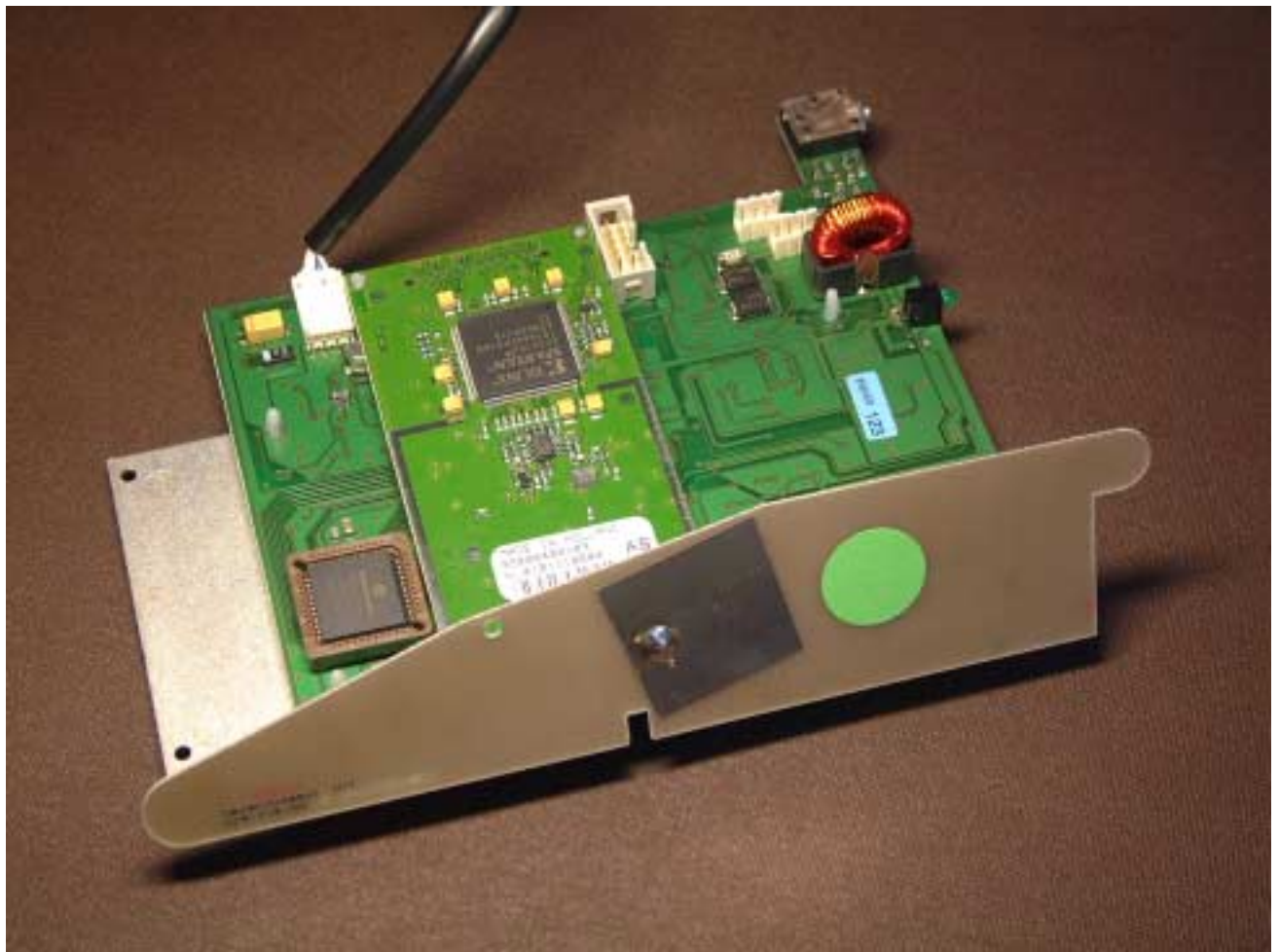


Equipment under test : MCW-D 1023

Ambient temperature : 25°C

Relative humidity : 47%

Photographs of the equipment

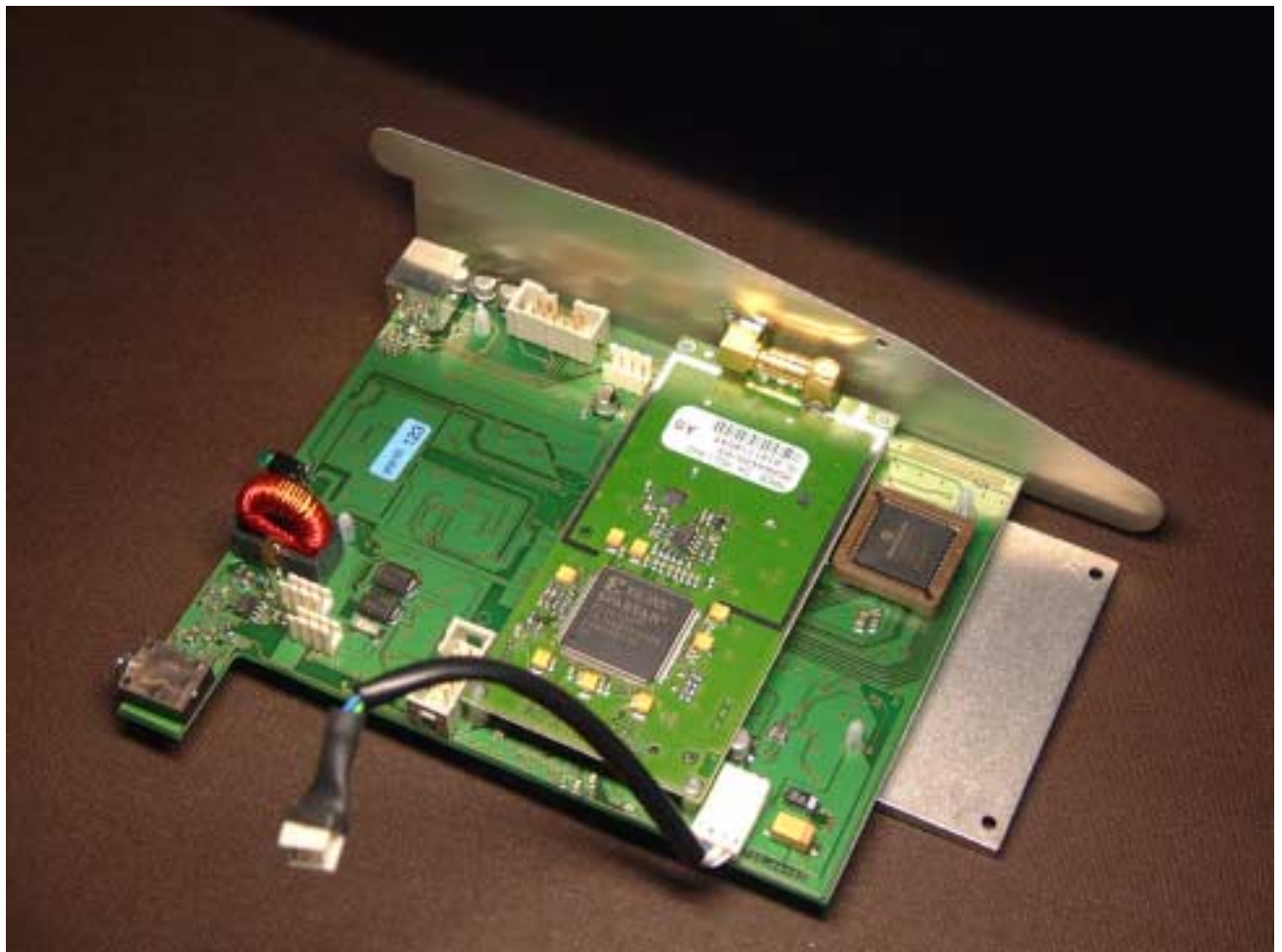


Equipment under test : MCW-D 1023

Ambient temperature : 25°C

Relative humidity : 47%

Photographs of the equipment

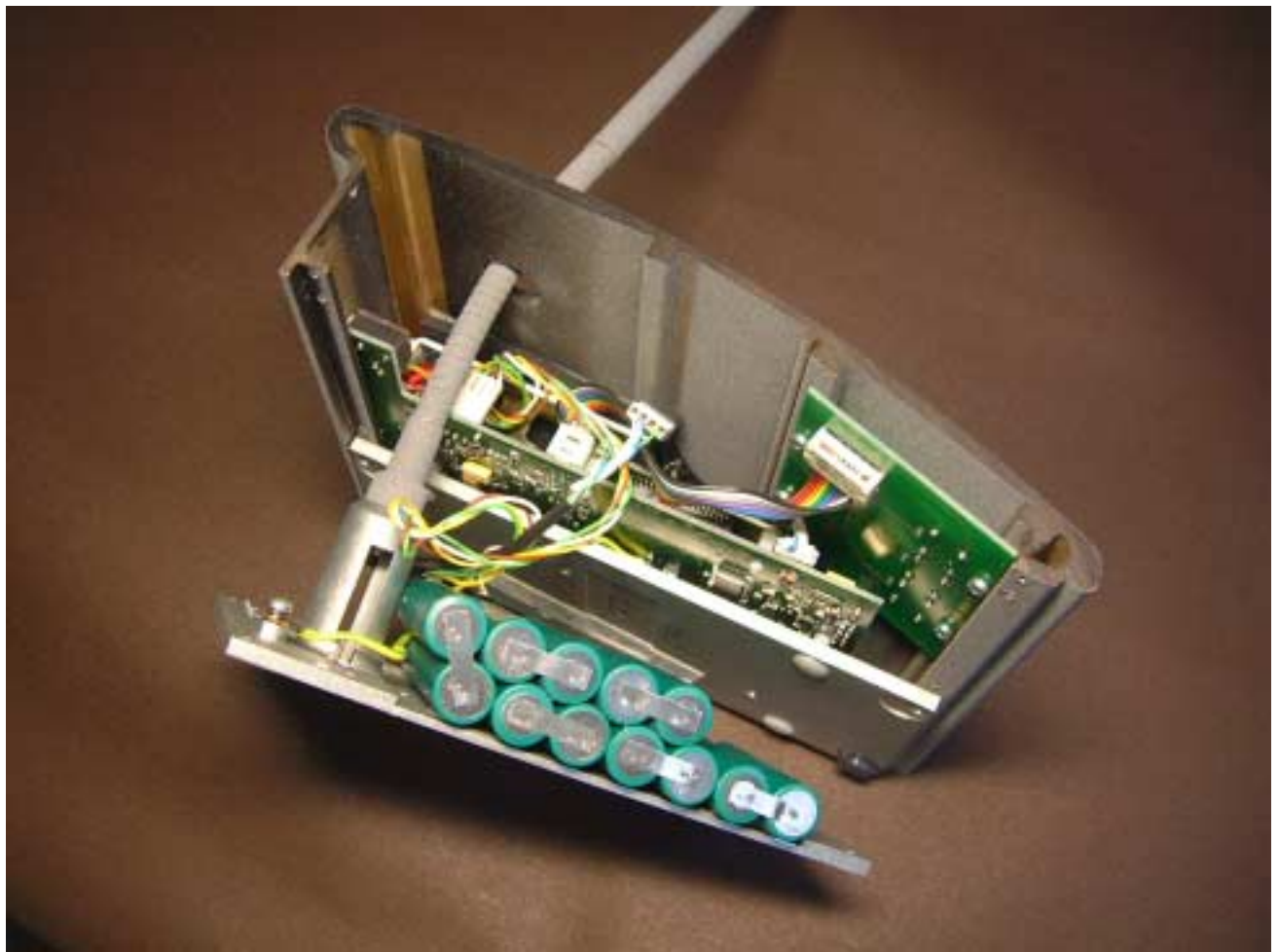


Equipment under test : MCW-D 1023

Ambient temperature : 25°C

Relative humidity : 47%

Photographs of the equipment



Equipment under test : MCW-D 1023

Ambient temperature : 25°C

Relative humidity : 47%

Photographs of the equipment

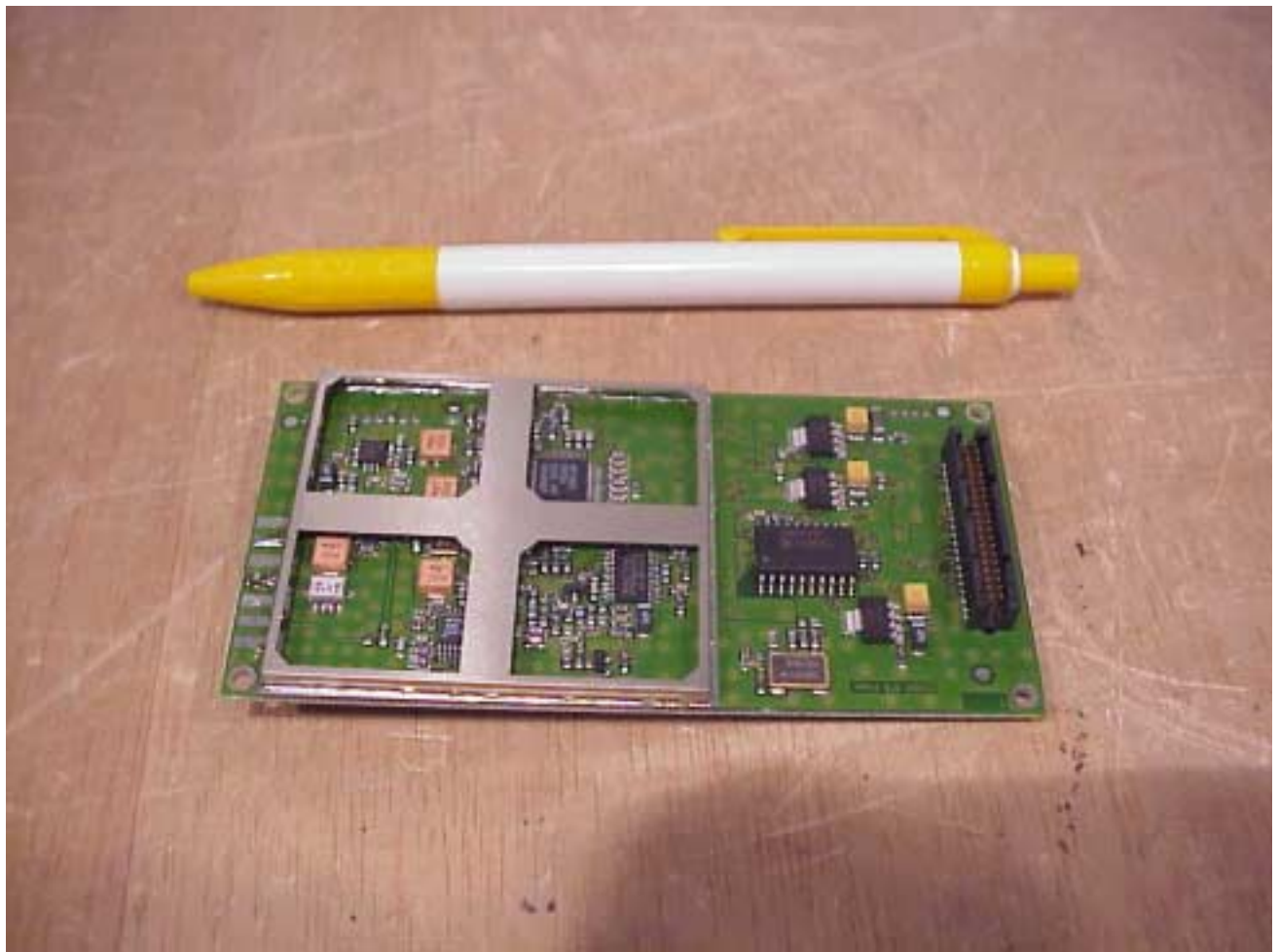


Equipment under test : MCW-D 1023

Ambient temperature : 25°C

Relative humidity : 47%

Photographs of the equipment

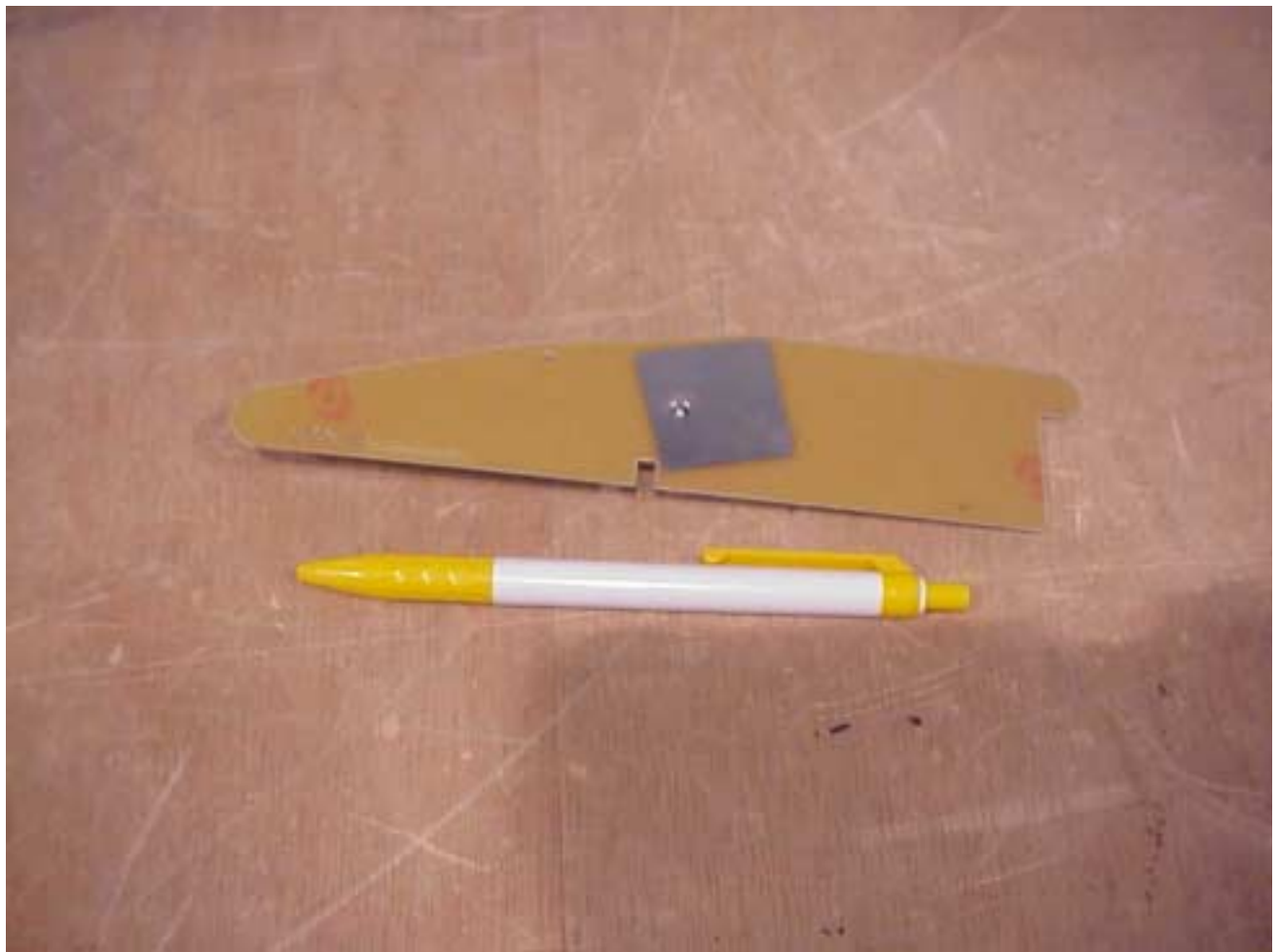


Equipment under test : MCW-D 1023

Ambient temperature : 25°C

Relative humidity : 47%

Photographs of the equipment



Equipment under test : MCW-D 1023

Ambient temperature : 25°C

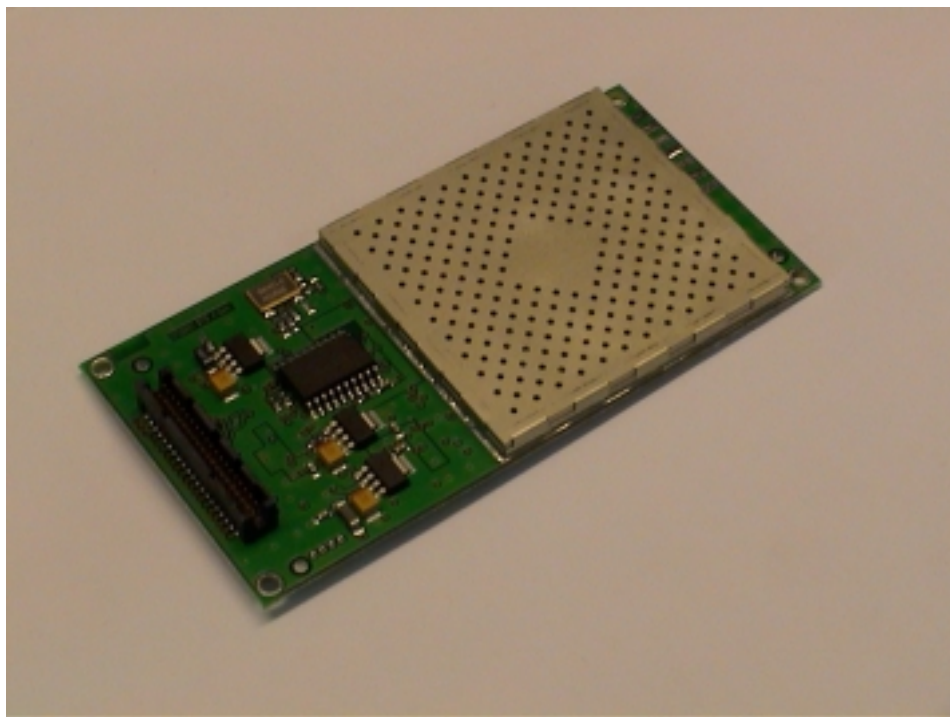
Relative humidity : 47%

Photographs of the equipment





MAX RF Module



Technical Construction File

V0.7

ADCON RF Technology B.V.

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1 Introduction

The MAX module is a plug-in module for real-time data transception at 2.4GHz. It comprises 16 RF channels. The air aggregate data rate is 611 kpbs. It utilises a dBPSK DSSS modulation scheme. Air framing, CRC checking and configuration of the RF components is handled by the module itself which leaves the communication to the board to which it interfaces limited to transception of messages.

This interface physically consists of a 40 pin connector to which the supply voltage is also connected. The module is without housing, because it is intended for integration in a customer defined final product. The PCB size is 100 x 50 mm. There is no antenna connector. There is a land pattern on the PCB instead to which a coaxial cable can be soldered to connect an external antenna.

This document describes the technical details of the MAX module. The following information is included:

- Technical specifications of the MAX module
- Description of hardware, including schematics and layout
- Short description of the software embedded in the MAX module

In the following text “customer” references to the manufacturer of the final product who incorporates the MAX modules into a final product.

This document is intended for radio approval authorities and laboratories.

2 Hardware

2.1 Specifications of MAX module

Parameter	Min.	Typ.	Max.	Unit	Condition
Overall					
Operating Frequency Range		2400 to 2483		MHz	
Channel Bandwidth			7	MHz	
RF channels		8			
Transmit mode		TDD/FDMA			Time domain duplex/Frequency domain multiple access
Modulation Method		QPSK			
Spread Spectrum Technique		DS			
Spreading		11bit barker			
Process gain		10.4		dB	
Aggregate data rate		611		kbps	
Operating Ambient Temp.		+10 to +50		°C	
RF Connection Type		Pigtail solder pads			
RF Impedance		50		Ω	
Interface Connector		40 pin, 1.27mm			40 pin BERG 87409-120 (male)
PCB Material		FR4			
PCB Size		100x50		mm	
Transmitter					
Tx Output Power	7.2	11.5	15.9	dBm	
Tx Spurious Outputs		ETSI compliant			
Carrier suppression		- 20		dBc	
Carrier Frequency Accuracy		+/- 25		ppm	Overall
Receiver					
RF Frequency Range		2400 to 2483		MHz	
IF Frequency		380		MHz	
Receive Sensitivity		-93		dBm	
Power Supply					
Supply Voltage Range	3.5	3.6	4	V	
Average power consumption		310	330	mA	Full operation
Average power consumption		140	170	mA	Receive only
Startup power consumption			800	mA	During max. 300ms
Air format					
Transmit/receive cycle		12,45833		ms	
Or cycles per second		80,26755853		s ⁻¹	
Address range		16		Bits	
Datagram size		16		Bytes	
Error detection		16bit CRC			
Audio samples per subframe		25			
Error detection per subframe		16bit CRC			
Audio subframes per frame		12			

Audio quality					
Input signal					
Quantisation		16		bits	
Sample rate		24.000		ksp/s	
Interface		Serial			Conform PCM3500 specs, time slotted, master mode. Clock is provided by radio module
Compression		1:2			STS proprietary compression algorithm
Error suppression					Windowed repeat of last correct frame or mute
Sample rate bridging					Elegant sample skipping/inserting algorithm
Control interface					
Interface type		Async serial			
Baudrate		113.8		kbps	Can be used with 111.86kbps
Supporting signals		MIF BSY SRES			Message in FIFO Busy Serial Reset
Digital levels					
Vih	2.0			V	
Vil			0.8	V	
Voh	2.4			V	@Ioh=-24 mA
Vol			0.4	V	@Iol=24 mA

Settable channels:

0	2408.4MHz
1	2412.8MHz
2	2417.2MHz
3	2421.6MHz
4	2426.0MHz
5	2430.3MHz
6	2434.7MHz
7	2439.1MHz
10	2452.3MHz
11	2456.7MHz
12	2461.1MHz
13	2465.4MHz
14	2469.8MHz
15	2474.2MHz

Though the module permits the setting of 16 individual RF channels it is advisable to only select either the even or uneven channels to minimize the risk of modules interfering with each other. This reduces the number of useable RF channels to 8. The choice between the use of either the even or uneven channels should depend on the frequency location of possible interfering signals.

2.2 Technical Description of the Hardware

The following description refers to the schematics of the RF-PCB (see Appendix xxx) and to the included block diagram (see figure 1).

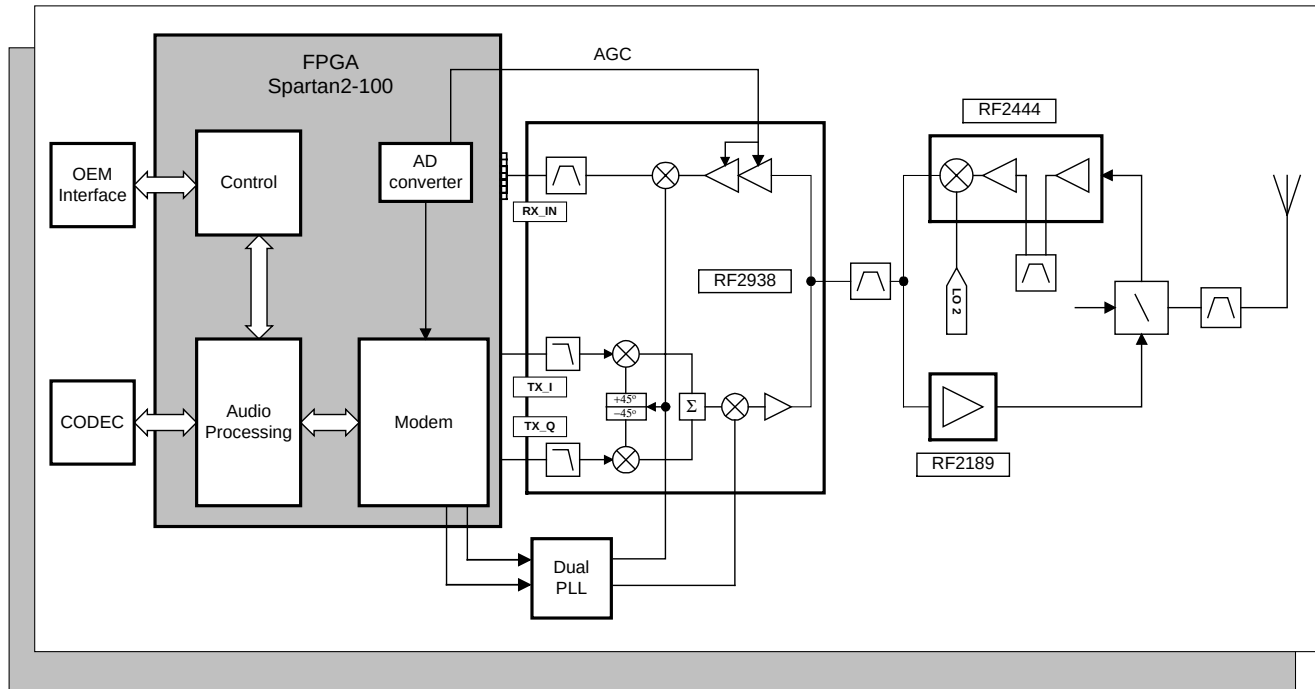


Figure 1. Block diagram of MAX module

Baseband Spread Spectrum

All baseband functionality is integrated in the Spartan2-100 FPGA. This device also provides the necessary signals to configure the RF chip set as well as the interface to the externally connected device (i.e. the device utilizing the MAX module as it's wireless interface).

Radio

The RF2938 (U1) is a 2.4GHz transceiver IC. It includes the modulator, demodulator, programmable low pass filters, the variable gain amplifier for reception and a driver stage for the PA, the RF2189. The IF frequency for receiving and transmitting is 380MHz. The SAW-filter SAW855771 from Sawtek (U4) is used to limit the bandwidth and to increase channel selectivity.

Low pass filter LFK30-05E2442LO84 (U13) and Bandpass filter DFC_22_LIGHT (U21) are used to reduce the bandwidth during transmission and receiving. An extra filter for receiving is band pass filter DFC_22_LIGHT (U22). During transmission the following two extra filters are used: DFC_22_LIGHT (U11,12). The AS169_73 (U3) is an RF-switch that is controlled by the FPGA to switch the RF signal path between reception and transmission.

Synthesizers

The Si4136 (U7) is a dual PLL that includes two VCOs for generation of the 2GHz RF LO-signal and the $2 \times \text{IF} = 760\text{MHz}$ IF LO-signal. The buffer amplifier around the BFR520 (Q2) provides isolation and some gain to get a proper power level at the RF2938 input. The reference signal for the PLL is supplied by the Rakon SXO110A TCXO (U6) operating at a frequency of 12.228MHz. The PLL is configured by the FPGA.

2.3 PCB information in appendices

The following PCB information can be found into the appendices:

Appendix A: Photographs of the MAX module

Appendix B: The schematic of the MAX module

Appendix C: Layout of the MAX module with the following information included:

- Layer 1
- Layer 2
- Layer 3
- Layer 4
- Drill

Appendix D: Silkscreen data of the MAX module

Appendix E: Bill Of Materials of the MAX module

2.4 Changing the antenna port configuration

To facilitate mounting of the MAX module in Base Station units, it is possible to change the antenna port configuration from a shared TX/RX port to separate TX and RX ports. To accomplish this, one resistor and one capacitor have to be rotated. See figure 2 for details.

Resistor R60 has to be rotated 90° so that it becomes resistor R69. Capacitor C67 has to be removed and on the position of R68 a 22pF 0603 capacitor must be placed.

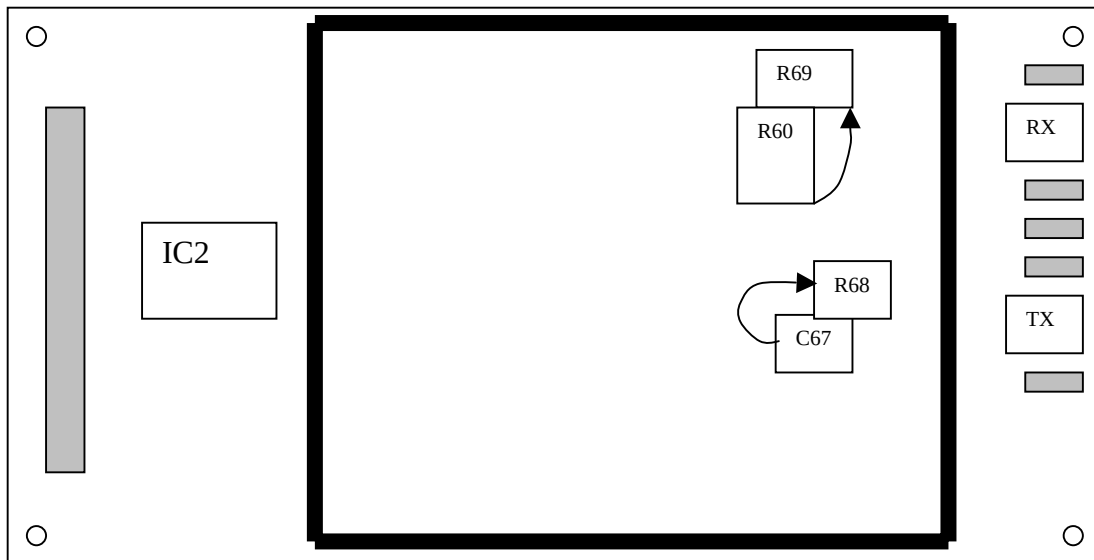


Figure 2. Changing antenna port configuration

3 Software

3.1 *Short software description*

The MAX module is intended to be used for real time audio transception (full duplex audio and data communication). Therefore it is able to interface to a Burr-Brown PCM3500 Codec. The audio sample rate is 24kHz. The system clock is therefore 12.288MHz (512 x 24kHz).

The radio modules support time domain duplex communication, meaning that there is a possibility for simultaneous flow of communication in both directions for audio and data at the same time.

3.1.1 Voice transmission

The audio that is transmitted is of "conference quality" (16 bit 24kHz sampling). This means that it is of a better quality than a voice connection as in telecommunications (300..3300 Hz) but typically less suited for hi-fi audio.

The audio signal is compressed by a factor of two to reduce the radio bandwidth. Great care has been taken to ensure that no disturbances are put out at the receiver side when the signal is perturbed by interference. The likelihood of such a disturbance under normal operating conditions is assumed to be less than once in the lifetime of a unit. On event of a perturbed audio sub frame, an effort is made to mask this or in case of longer interruptions, to mute the audio output.

Mismatch in clock frequencies of the base station and the table units is eliminated by an elegant remove/insert sample algorithm.

All of these algorithms have been demonstrated to and approved by the customer. For this purpose two CD's have been compiled with sound samples with the actual algorithms applied.

3.1.2 Control communication

Next to the audio transmission a control link is established. This control data is sent in the same frame as the audio data. The control link is addressable and broadcasts can be applied. Each airframe can convey 16 bytes of payload. The capacity of this link is approximately 10kbps. The address space is 16 bits, so a total of 65000 table units can be addressed.

3.2 Interface Description

In addition to real time audio transception, the MAX module offers addressable data communication facilities. All processing, audio compression and error detection, masking and muting is performed in the module.

The 40 pin BERG 87409-120, 1.27 mm pitch, connector supplies all other signals. A mating connector could be the BERG 87023-620 for a surface mount solution.

Pin	Name	Function	Remark
1.	VDD_RF	Power supply	Should be a clean and stable 3.6 v signal and should be able to deliver 800mA at startup.
2.	VDD_RF		
3.	VDD_RF		
4.	MCU_IN	Control output ¹	
5.	MCU_OUT	Control input ²	
6.	BSY	Busy input	Holds of new messages on control output
7.	MIF	Message in FIFO	Signifies that a message is in the FIFO. This line gets asserted after the entire message is written into the module.
8.	SRES	Serial Reset	Resets the serial interface to a defined state
9.	FLASH_TDO	No user pin	Leave not connected
10.	DI	CODEC data out	
11.	DO	CODEC data in	
12.	FS	CODEC frame sync	CODEC output
13.	BCK	CODEC bit clock	CODEC output
14.	PD_CDC	CODEC power down	
15.	SCKIO	CODEC serial clock	CODEC input
16.	OSC_IN	TCXO input	12.288MHz +/-25ppm overall accuracy
17.	SOF(IN/OUT)	Frame synchronization	Base station only, input for slave, output for master.
18.	TXMUTE	Audio transmit disable	Only valid in table unit mode
19.	GPD	Global power down	Puts radio module in low power state
20.	FPGA_TMS	No user pin	Leave not connected
21.	FPGA_TCK	No user pin	Leave not connected
22.	FSO	CODEC frame sync	CODEC output
23.	HST_OUT	High speed output	Not implemented
24.	GND	Ground	
25.	HST_IN	High speed input	Not implemented
26.	GND	Ground	
27.	NC	Not connected	
28.	PD_REG_DIG	FPGA supply power down	Tie high normally. Ground pin to put module in zero power mode.
29.	/RESET	Reset FPGA	
30.	PD_FPGA	FPGA power down pin	Not supported yet. Tie high.
31.	FPGA_TDO	No user pin	Leave not connected
32.	FPGA_TDI	No user pin	Leave not connected
33.	FLASH_TCK	No user pin	Leave not connected
34.	FLASH_TMS	No user pin	Leave not connected

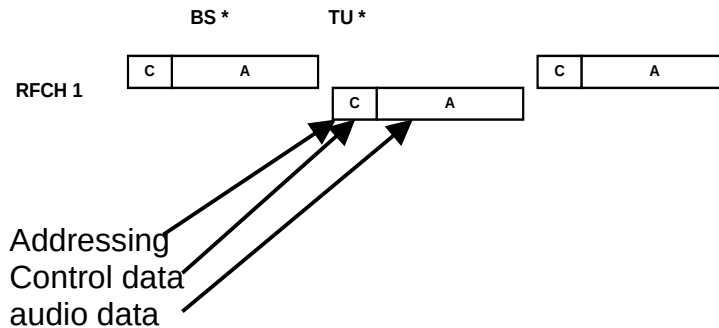
¹ To user micro controller

² From user micro controller

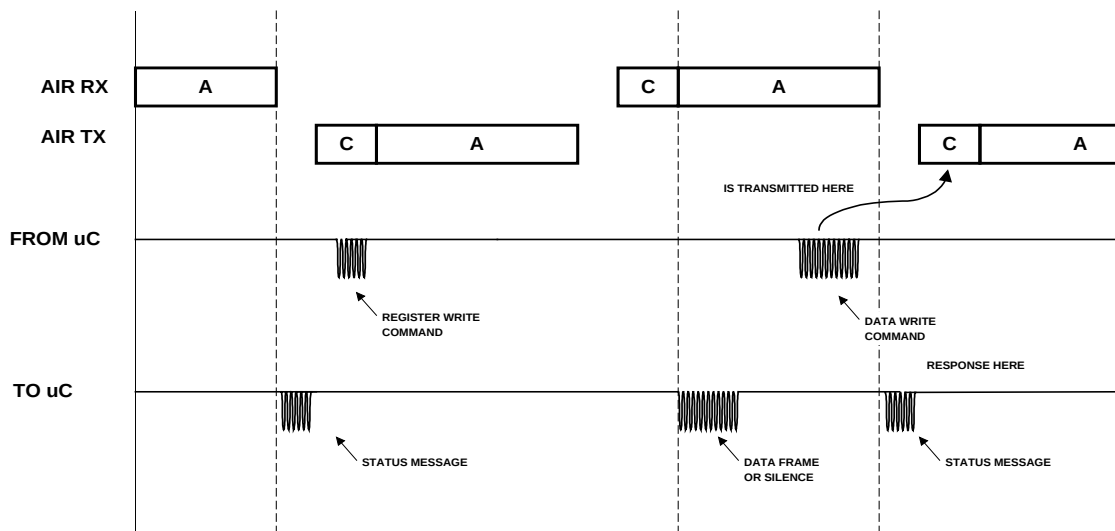
35.	FLASH_TDI	No user pin	Leave not connected
36.	GAIN_LNA	LNA gain select	Enables reduction of sensitivity
37.	HI_LOW_POWER	PA power select	Enables reduction of transmit power
38.	GND	Ground	A good clean ground signal should be supplied
39.	GND		
40.	GND		

3.3 Air timing

The radio modules use a Time Domain Duplex system to attain bi-directional communication. This processing is transparent to the user and it is of limited value to have knowledge about this. In some cases however to get the maximum performance of the system it is good to have some idea of system operation.



The airframes contain Addressing Control data and Audio data. These data packets are transmitted alternately by the base station and the table units. This is done in an interval of a little more than 12ms. In these 12ms a number of things happen on the control interface. This activity is depicted in the image below:



This section will discuss the different kinds of activity on the control interface in- and outputs. A detailed description of the messages will be given in the programming model chapter.

At the reception of each frame a message is sent to the user micro controller informing the latter about the quality of reception. In the base station this can be used as a criterion to switch to a different reception antenna. Besides the quality indicator room has been left to implement register reads. Right now there is no information inside the FPGA that can or is worth to be read.

A second message that is put out by the radio module is the Control Data message. This message is put out if the message validates for reception at that module. Validation will be done on whether a message received correctly, if the message is filled, if the address is correct or if a broadcast message is received.

At any time the user can take the initiative to send a control message to the radio module. This can be either a control data message or a command. Though the control data message can be fed to the radio module at any time, it is only transmitted at the airframe starting after message completion. This means that though a user can take a second to feed the message into the module, it will only be sent after it has been completed. A message can be cancelled by asserting the SRES line on the radio module.

To respond to a message received from the radio module the user has limited time to make sure that the reply is transmitted at the next message slot. A spreadsheet has been provided to calculate this available processing time with regard to the baud rate.

3.4 User interface

The MAX module interfaces to a customer specific control unit. The interface to the user is through the customer's hardware. Therefore every reference to the user interface is left to the manufacturer that incorporates the MAX module into a final product.

Appendix A: Photographs of MAX module

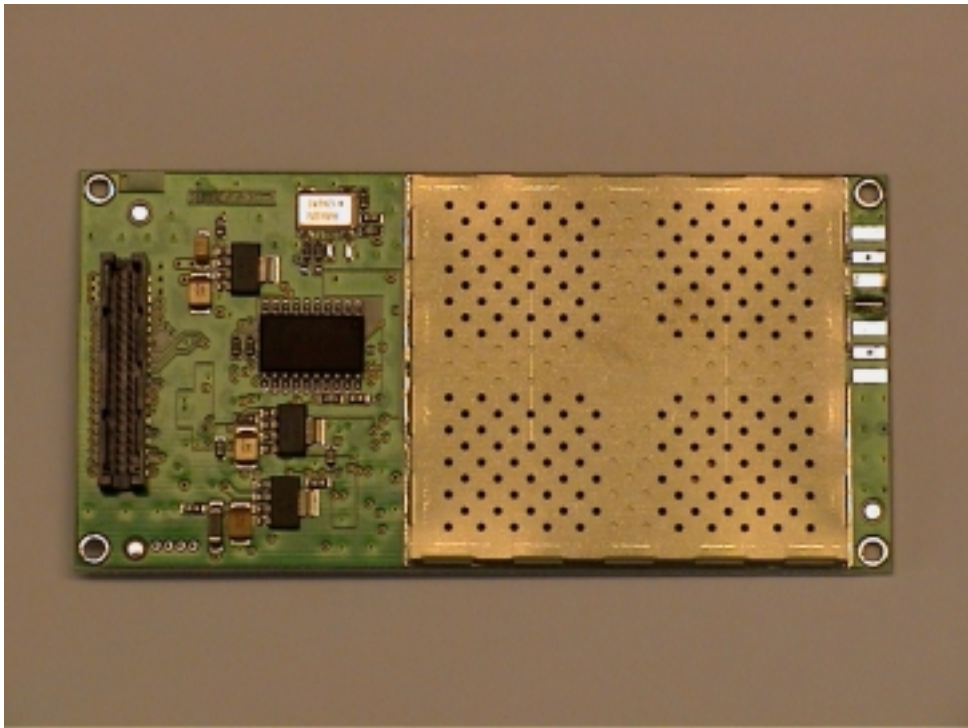


Figure 3. MAX module as supplied

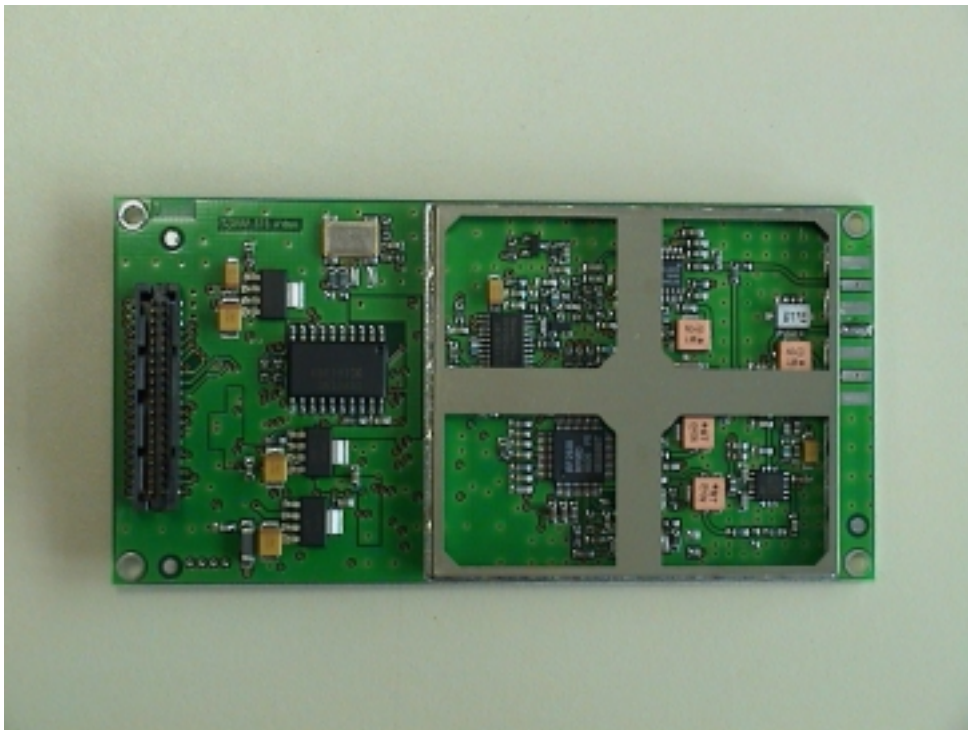


Figure 4. MAX module with lid removed

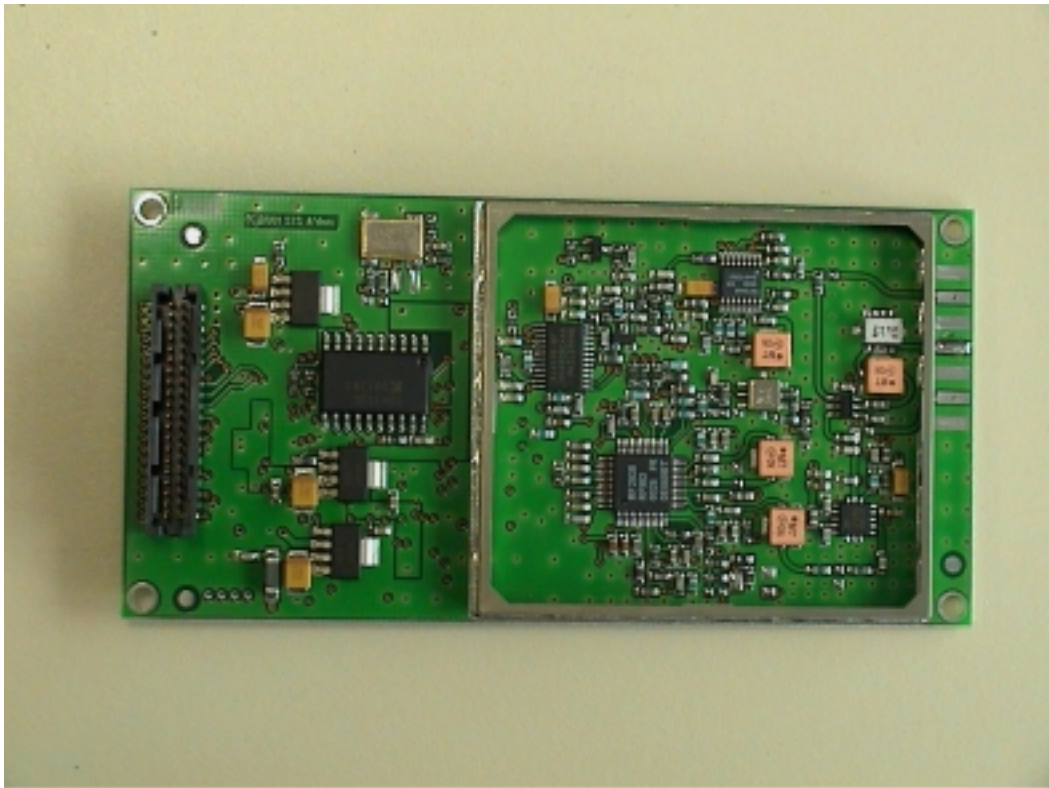


Figure 5. MAX module with cross removed

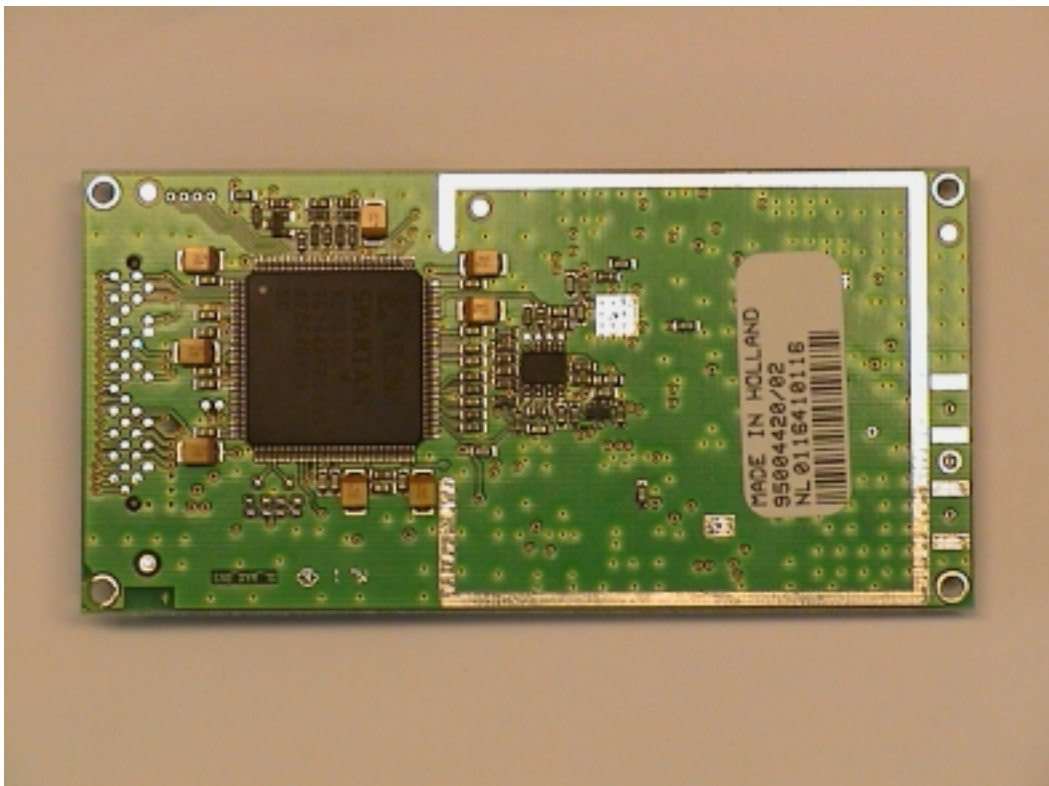
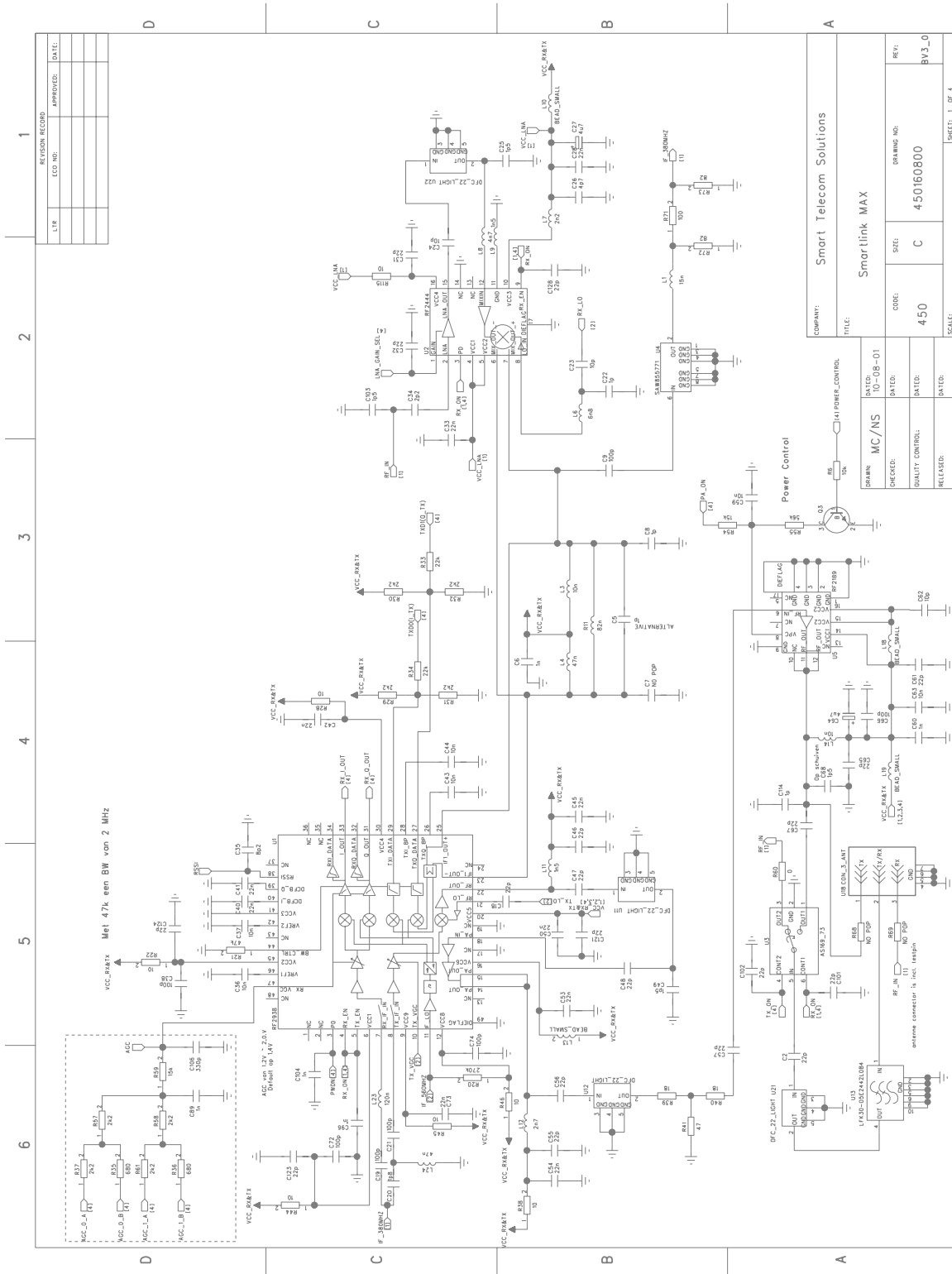
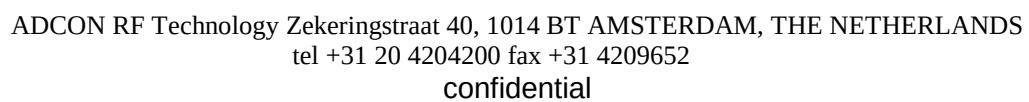
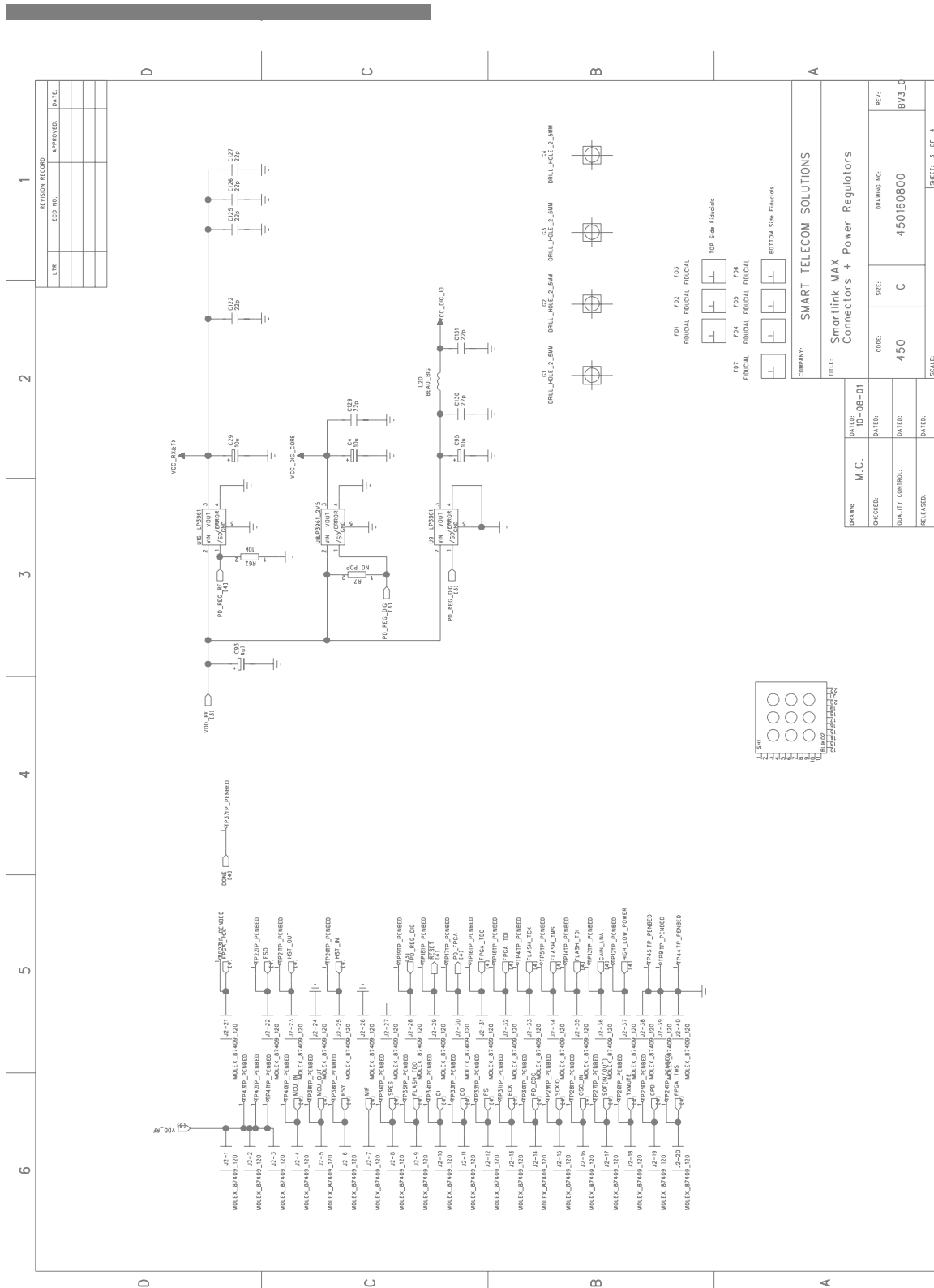


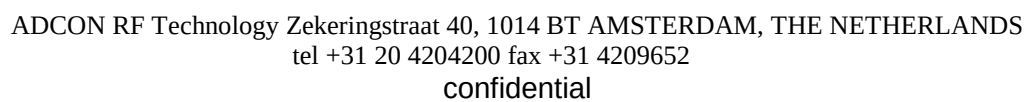
Figure 6. MAX module bottom side

Appendix B: Schematics of MAX module

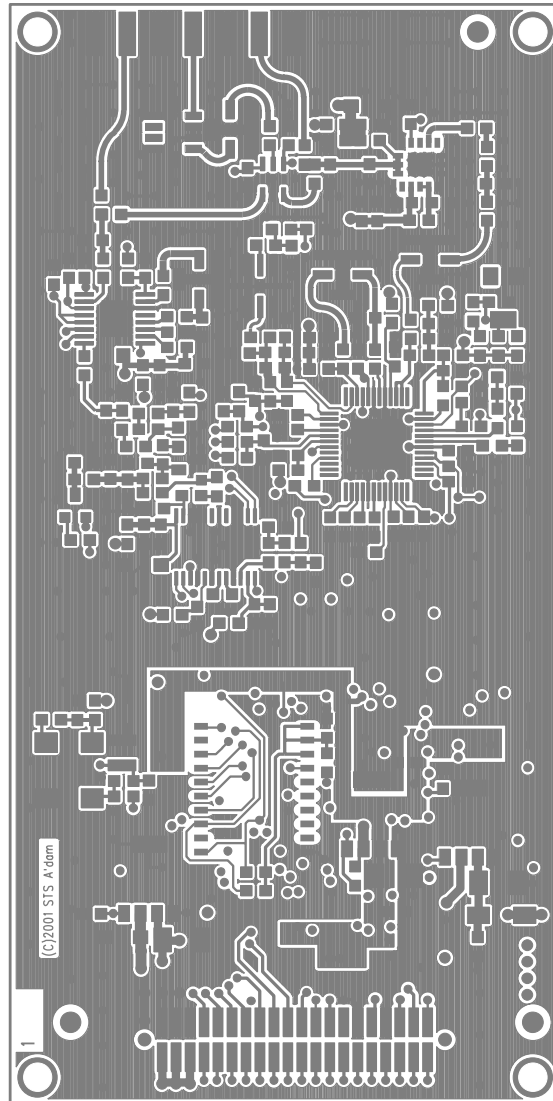






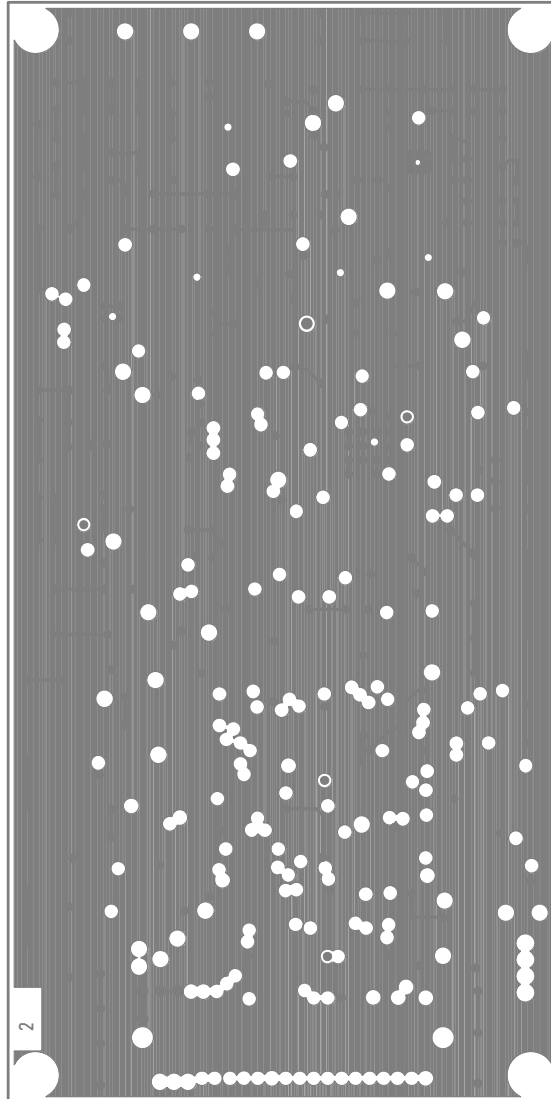


Appendix C: Gerber files of MAX module



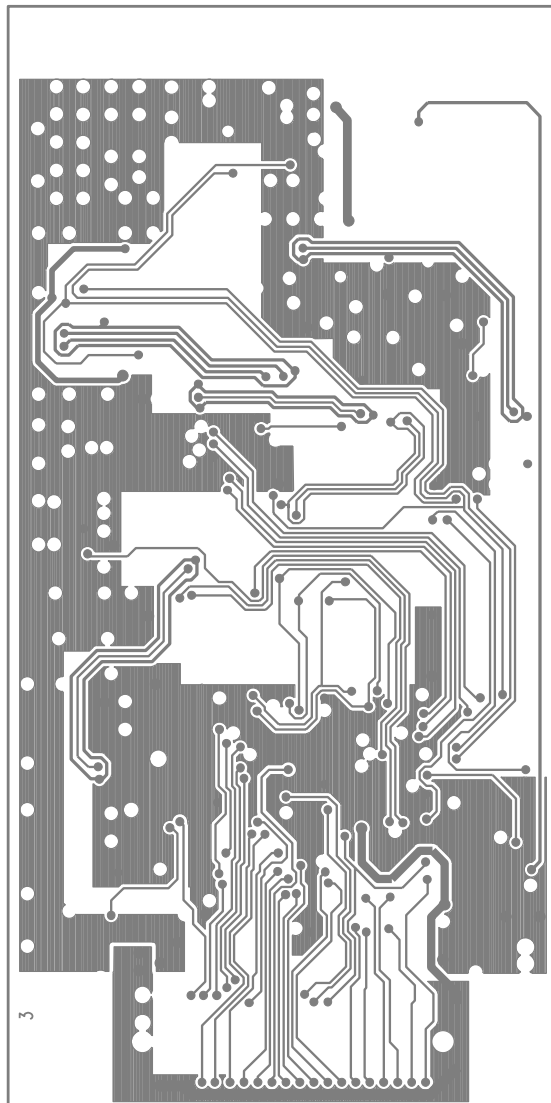
SL_MAX_BV2_16.pcb - Fri Sep 21 14:56:14 2001

Figure 7. Top layer



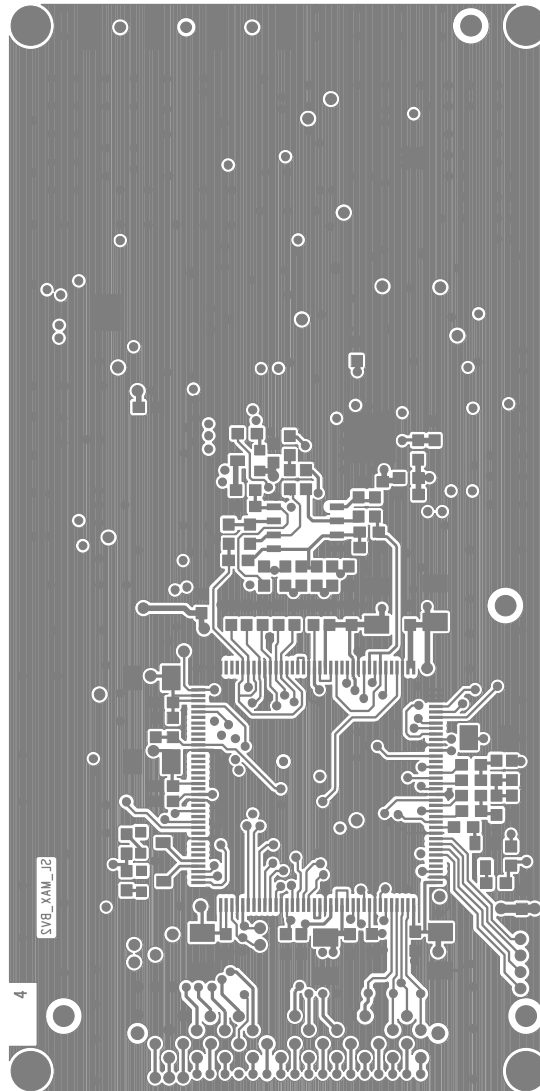
SL_MAX_BV2_16.pcb – Fri Sep 21 14:54:42 2001

Figure 8. Layer 2



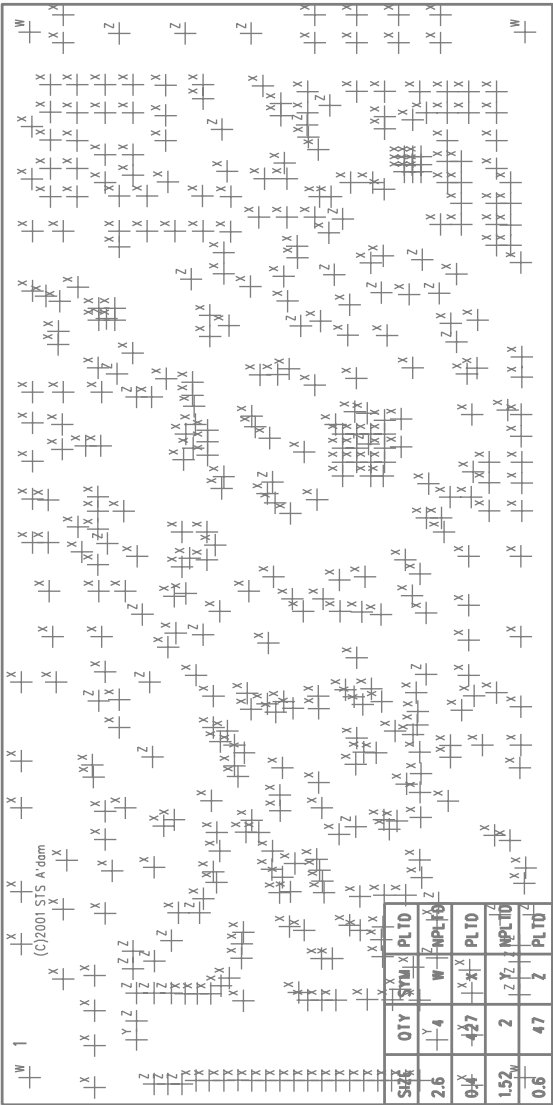
SL_MAX_BV2_16.pcb – Fri Sep 21 14:55:27 2001

Figure 9. Layer 3



SL_MAX_BV2_16.pcb – Fri Sep 21 14:47:54 2001

Figure 10. Bottom layer



SL_MAX_BV2_16.pcb – Fri Sep 21 14:57:07 2001

Figure 11. Drill data

Appendix D: Silk screen data of MAX module

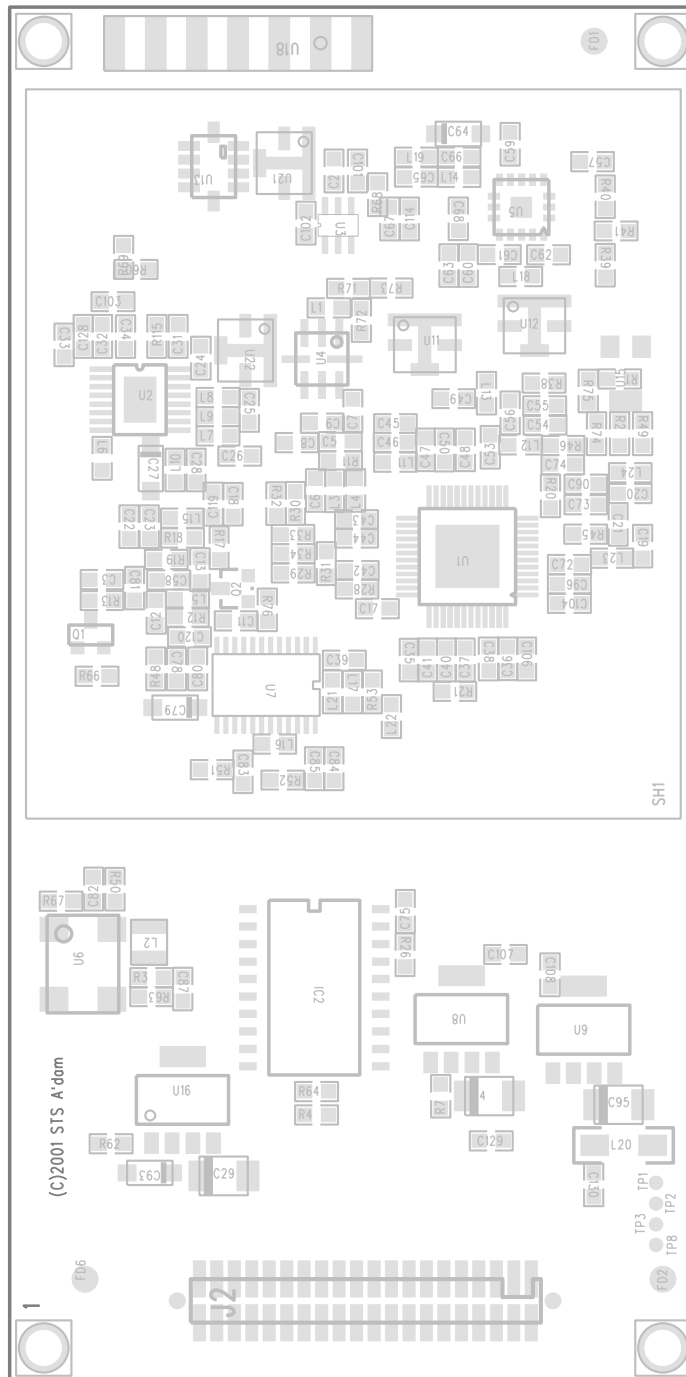


Figure 12. Silk screen top layer

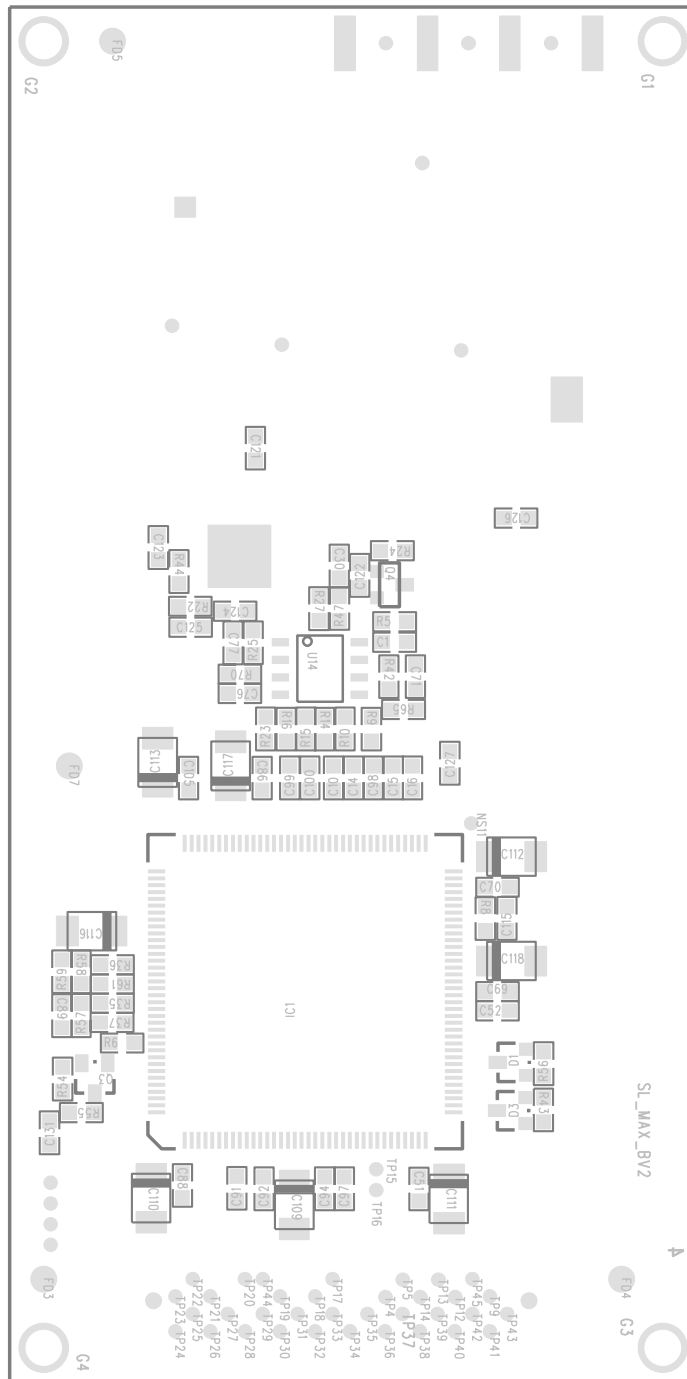


Figure 13. Silk screen bottom layer

[illegible]

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confidential

129	L7	SLF 2.2m 0603 +/-0.3mH	6L12N2	ALTERNATIVE	TKO	LL1608-FH2N2S	2h2	+/-0.3mH	8567/0262	NOT	TRIE COMPONENTEN
130	L12	SLF 2.7m 0603 +/-0.3mH	6L12N7	ALTERNATIVE	TKO	LL1608-FH2N7S	2h7	+/-0.3mH	8567/0263	NOT	TRIE COMPONENTEN
131	L4	SLF 4.7m 0603 5%	6L147N	ALTERNATIVE	TKO	LL1608-FH147N	47n	5%	8567/0278	NOT	TRIE COMPONENTEN
132	L24	SLF 4.7m 0603 5%	6L147N	ALTERNATIVE	TKO	LL1608-FH147N	47n	5%	8567/0278	NOT	TRIE COMPONENTEN
133	L8	SLF 4.7m 0603 +/-0.3mH	6L14N7	ALTERNATIVE	TKO	LL1608-FH14N7S	4n7	+/-0.3mH	8567/0265	NOT	TRIE COMPONENTEN
134	L15	SLF 4.7m 0603 +/-0.3mH	6L14N7	ALTERNATIVE	TKO	LL1608-FH14N7S	4n7	+/-0.3mH	8567/0265	NOT	TRIE COMPONENTEN
135	L16	SLF 4.7m 0603 +/-0.3mH	6L14N7	ALTERNATIVE	TKO	LL1608-FH14N7S	4n7	+/-0.3mH	8567/0265	NOT	TRIE COMPONENTEN
136	L6	SLF 6.8m 0603 5%	6L16N8	ALTERNATIVE	TKO	LL1608-FH16N8	6n8	5%	8567/0266	NOT	TRIE COMPONENTEN
137	R11	SLF 8.2m 0603 5%	6L18N2	ALTERNATIVE	TKO	LL1608-FH18N2	82n	5%	8567/0279	NOT	TRIE COMPONENTEN
138	R75	RES NTC 47K 0603	6N1C47K	PREFERRED	MURATA	NTH5618P40B47C507H	47K @ 25 C	TEMP: 4050 3% RES: 1%	80300020	732.163	±0.5% ±0.5% ±0.5%
139	R3	RES 0 0603 1%	6R0	ALTERNATIVE	ROHM	MCRO3 EZH F 000	0	1%	80260019	772.227	±0.5% ±0.5% ±0.5%
140	R60	RES 0 0603 1%	6R0	ALTERNATIVE	ROHM	MCRO3 EZH F 000	0	1%	80260019	772.227	±0.5% ±0.5% ±0.5%
141	R63	RES 0 0603 1%	6R0	ALTERNATIVE	ROHM	MCRO3 EZH F 000	0	1%	80260019	772.227	±0.5% ±0.5% ±0.5%
144	R76	RES 0 0603 1%	6R0	ALTERNATIVE	ROHM	MCRO3 EZH F 000	0	1%	80260019	772.227	±0.5% ±0.5% ±0.5%
145	R5	RES 10 0603 1%	6R10	ALTERNATIVE	ROHM	MCRO3 EZH F 100	10	1%	80261009	910.995	±0.5% ±0.5% ±0.5%
146	R22	RES 10 0603 1%	6R10	ALTERNATIVE	ROHM	MCRO3 EZH F 100	10	1%	80261009	910.995	±0.5% ±0.5% ±0.5%
147	R26	RES 10 0603 1%	6R10	ALTERNATIVE	ROHM	MCRO3 EZH F 100	10	1%	80261009	910.995	±0.5% ±0.5% ±0.5%
148	R28	RES 10 0603 1%	6R10	ALTERNATIVE	ROHM	MCRO3 EZH F 100	10	1%	80261009	910.995	±0.5% ±0.5% ±0.5%
149	R38	RES 10 0603 1%	6R10	ALTERNATIVE	ROHM	MCRO3 EZH F 100	10	1%	80261009	910.995	±0.5% ±0.5% ±0.5%
150	R44	RES 10 0603 1%	6R10	ALTERNATIVE	ROHM	MCRO3 EZH F 100	10	1%	80261009	910.995	±0.5% ±0.5% ±0.5%
151	R45	RES 10 0603 1%	6R10	ALTERNATIVE	ROHM	MCRO3 EZH F 100	10	1%	80261009	910.995	±0.5% ±0.5% ±0.5%
152	R46	RES 10 0603 1%	6R10	ALTERNATIVE	ROHM	MCRO3 EZH F 100	10	1%	80261009	910.995	±0.5% ±0.5% ±0.5%
153	R48	RES 10 0603 1%	6R10	ALTERNATIVE	ROHM	MCRO3 EZH F 100	10	1%	80261009	910.995	±0.5% ±0.5% ±0.5%
154	R50	RES 10 0603 1%	6R10	ALTERNATIVE	ROHM	MCRO3 EZH F 100	10	1%	80261009	910.995	±0.5% ±0.5% ±0.5%
155	R51	RES 10 0603 1%	6R10	ALTERNATIVE	ROHM	MCRO3 EZH F 100	10	1%	80261009	910.995	±0.5% ±0.5% ±0.5%
156	R115	RES 10 0603 1%	6R10	ALTERNATIVE	ROHM	MCRO3 EZH F 100	10	1%	80261009	910.995	±0.5% ±0.5% ±0.5%
157	R17	RES 18 0603 1%	6R18	ALTERNATIVE	ROHM	MCRO3 EZH F 180	18	1%	80261809	911.021	±0.5% ±0.5% ±0.5%
158	R18	RES 18 0603 1%	6R18	ALTERNATIVE	ROHM	MCRO3 EZH F 180	18	1%	80261809	911.021	±0.5% ±0.5% ±0.5%
159	R19	RES 18 0603 1%	6R18	ALTERNATIVE	ROHM	MCRO3 EZH F 180	18	1%	80261809	911.021	±0.5% ±0.5% ±0.5%
160	R39	RES 18 0603 1%	6R18	ALTERNATIVE	ROHM	MCRO3 EZH F 180	18	1%	80261809	911.021	±0.5% ±0.5% ±0.5%
161	R40	RES 18 0603 1%	6R18	ALTERNATIVE	ROHM	MCRO3 EZH F 180	18	1%	80261809	911.021	±0.5% ±0.5% ±0.5%
162	R52	RES 27 0603 1%	6R27	ALTERNATIVE	ROHM	MCRO3 EZH F 270	27	1%	80262709	911.045	±0.5% ±0.5% ±0.5%
163	R13	RES 33 0603 1%	6R33	ALTERNATIVE	ROHM	MCRO3 EZH F 330	33	1%	80263309	911.057	±0.5% ±0.5% ±0.5%
164	R14	RES 47 0603 1%	6R47	ALTERNATIVE	ROHM	MCRO3 EZH F 470	47	1%	80264709	911.070	±0.5% ±0.5% ±0.5%
165	R15	RES 47 0603 1%	6R47	ALTERNATIVE	ROHM	MCRO3 EZH F 470	47	1%	80264709	911.070	±0.5% ±0.5% ±0.5%
166	R41	RES 47 0603 1%	6R47	ALTERNATIVE	ROHM	MCRO3 EZH F 470	47	1%	80264709	911.070	±0.5% ±0.5% ±0.5%
167	R72	RES 82 0603 1%	6R82	ALTERNATIVE	ROHM	MCRO3 EZH F 820	82	1%	80268209	911.100	±0.5% ±0.5% ±0.5%
168	R73	RES 82 0603 1%	6R82	ALTERNATIVE	ROHM	MCRO3 EZH F 820	82	1%	80268209	911.100	±0.5% ±0.5% ±0.5%
169	R10	RES 100 0603 1%	6R100	ALTERNATIVE	ROHM	MCRO3 EZH F 101	100	1%	80261001	911.112	±0.5% ±0.5% ±0.5%
170	R16	RES 100 0603 1%	6R100	ALTERNATIVE	ROHM	MCRO3 EZH F 101	100	1%	80261001	911.112	±0.5% ±0.5% ±0.5%
171	R71	RES 100 0603 1%	6R100	ALTERNATIVE	ROHM	MCRO3 EZH F 101	100	1%	80261001	911.112	±0.5% ±0.5% ±0.5%
172	R35	RES 680 0603 1%	6R680	ALTERNATIVE	ROHM	MCRO3 EZH F 681	680	1%	80266801	911.215	±0.5% ±0.5% ±0.5%
173	R36	RES 680 0603 1%	6R680	ALTERNATIVE	ROHM	MCRO3 EZH F 681	680	1%	80266801	911.215	±0.5% ±0.5% ±0.5%
174	R23	RES 820 0603 1%	6R820	ALTERNATIVE	ROHM	MCRO3 EZH F 821	820	1%	80268201	911.227	±0.5% ±0.5% ±0.5%
175	R6	RES 10K 0603 1%	6R10K	ALTERNATIVE	ROHM	MCRO3 EZH F 103	10K	1%	80261003	911.355	±0.5% ±0.5% ±0.5%
177	R8	RES 10K 0603 1%	6R10K	ALTERNATIVE	ROHM	MCRO3 EZH F 103	10K	1%	80261003	911.355	±0.5% ±0.5% ±0.5%
178	R24	RES 10K 0603 1%	6R10K	ALTERNATIVE	ROHM	MCRO3 EZH F 103	10K	1%	80261003	911.355	±0.5% ±0.5% ±0.5%
179	R27	RES 10K 0603 1%	6R10K	ALTERNATIVE	ROHM	MCRO3 EZH F 103	10K	1%	80261003	911.355	±0.5% ±0.5% ±0.5%
180	R47	RES 10K 0603 1%	6R10K	ALTERNATIVE	ROHM	MCRO3 EZH F 103	10K	1%	80261003	911.355	±0.5% ±0.5% ±0.5%
182	R62	RES 10K 0603 1%	6R10K	ALTERNATIVE	ROHM	MCRO3 EZH F 103	10K	1%	80261003	911.355	±0.5% ±0.5% ±0.5%
183	R65	RES 10K 0603 1%	6R10K	ALTERNATIVE	ROHM	MCRO3 EZH F 103	10K	1%	80261003	911.355	±0.5% ±0.5% ±0.5%
184	R66	RES 10K 0603 1%	6R10K	ALTERNATIVE	ROHM	MCRO3 EZH F 103	10K	1%	80261003	911.355	±0.5% ±0.5% ±0.5%
185	R67	RES 10K 0603 1%	6R10K	ALTERNATIVE	ROHM	MCRO3 EZH F 103	10K	1%	80261003	911.355	±0.5% ±0.5% ±0.5%
186	R70	RES 12K 0603 1%	6R12K	ALTERNATIVE	ROHM	MCRO3 EZH F 123	12K	1%	80261203	911.357	±0.5% ±0.5% ±0.5%
187	R74	RES 12K 0603 1%	6R12K	ALTERNATIVE	ROHM	MCRO3 EZH F 123	12K	1%	80261203	911.357	±0.5% ±0.5% ±0.5%
188	R1	RES 15K 0603 1%	6R15K	ALTERNATIVE	ROHM	MCRO3 EZH F 153	15K	1%	80261503	911.379	±0.5% ±0.5% ±0.5%
189	R54	RES 15K 0603 1%	6R15K	ALTERNATIVE	ROHM	MCRO3 EZH F 153	15K	1%	80261503	911.379	±0.5% ±0.5% ±0.5%
190	R59	RES 15K 0603 1%	6R15K	ALTERNATIVE	ROHM	MCRO3 EZH F 153	15K	1%	80261503	911.379	±0.5% ±0.5% ±0.5%
193	R2	RES 22K 0603 1%	6R22K	ALTERNATIVE	ROHM	MCRO3 EZH F 223	22K	1%	80262203	911.392	±0.5% ±0.5% ±0.5%
194	R33	RES 22K 0603 1%	6R22K	ALTERNATIVE	ROHM	MCRO3 EZH F 223	22K	1%	80262203	911.392	±0.5% ±0.5% ±0.5%
195	R34	RES 22K 0603 1%	6R22K	ALTERNATIVE	ROHM	MCRO3 EZH F 223	22K	1%	80262203	911.392	±0.5% ±0.5% ±0.5%
196	R20	RES 270K 0603 1%	6R270K	ALTERNATIVE	ROHM	MCRO3 EZH F 274	270K	1%	80262704	911.525	±0.5% ±0.5% ±0.5%
197	R9	RES 2.2K 0603 1%	6R2K2	ALTERNATIVE	ROHM	MCRO3 EZH F 222	2K2	1%	80262202	911.276	±0.5% ±0.5% ±0.5%
198	R29	RES 2.2K 0603 1%	6R2K2	ALTERNATIVE	ROHM	MCRO3 EZH F 222	2K2	1%	80262202	911.276	±0.5% ±0.5% ±0.5%

199	R30	RES 2.2K 0603 1%	682K2	ALTERNATIVE	ROHM	MCRO3 EZH F 222	2K2	1%	80262202	911-276 N ELECTRONICS BV	
200	R31	RES 2.2K 0603 1%	682K2	ALTERNATIVE	ROHM	MCRO3 EZH F 222	2K2	1%	80262202	911-276 N ELECTRONICS BV	
201	R32	RES 2.2K 0603 1%	682K2	ALTERNATIVE	ROHM	MCRO3 EZH F 222	2K2	1%	80262202	911-276 N ELECTRONICS BV	
202	R37	RES 2.2K 0603 1%	682K2	ALTERNATIVE	ROHM	MCRO3 EZH F 222	2K2	1%	80262202	911-276 N ELECTRONICS BV	
203	R57	RES 2.2K 0603 1%	682K2	ALTERNATIVE	ROHM	MCRO3 EZH F 222	2K2	1%	80262202	911-276 N ELECTRONICS BV	
204	R58	RES 2.2K 0603 1%	682K2	ALTERNATIVE	ROHM	MCRO3 EZH F 222	2K2	1%	80262202	911-276 N ELECTRONICS BV	
205	R61	RES 2.2K 0603 1%	682K2	ALTERNATIVE	ROHM	MCRO3 EZH F 222	2K2	1%	80262202	911-276 N ELECTRONICS BV	
206	R25	RES 33K 0603 1%	683K3	ALTERNATIVE	ROHM	MCRO3 EZH F 333	33K	1%	80263303	911-410 N ELECTRONICS BV	
207	R42	RES 33K 0603 1%	683K3	ALTERNATIVE	ROHM	MCRO3 EZH F 333	33K	1%	80263303	911-410 N ELECTRONICS BV	
208	R21	RES 47K 0603 1%	684K7	ALTERNATIVE	ROHM	MCRO3 EZH F 472	47K	1%	80264703	911-434 N ELECTRONICS BV	
209	R4	RES 47K 0603 1%	684K7	ALTERNATIVE	ROHM	MCRO3 EZH F 472	47K	1%	80264702	911-318 N ELECTRONICS BV	
210	R64	RES 47K 0603 1%	684K7	ALTERNATIVE	ROHM	MCRO3 EZH F 472	47K	1%	80264702	911-318 N ELECTRONICS BV	
211	R35	RES 58K 0603 1%	685K6	ALTERNATIVE	ROHM	MCRO3 EZH F 583	58K	1%	80265803	911-468 N ELECTRONICS BV	
212	R12	RES 58K 0603 1%	685K6	ALTERNATIVE	ROHM	MCRO3 EZH F 583	58K	1%	80265803	911-468 N ELECTRONICS BV	
213	U3	SWI SPDT 2.4GHz	AS169_73	PREFERRED	ALPHA	AS169-73	AS169-73	-	837400148	SEMI DICE INTERNATIONAL	
214	Q3	TRA BC847A NPN	BC847	ALTERNATIVE	PHILIPS	BC847A	BC847A	A	82330002	Matchus	
215	L20	SLF BLM41P8005 EMILF 1806	BEAD BIG	ALTERNATIVE	MURATA	BLM41P8005PT	00 MHz 80 Ohm	-	85670258	DECATEL	
216	L10	SLF NCB0603R600 0603	BEAD SMALL	ALTERNATIVE	NIC	NCB0603R600	100 MHz 60 Ohm	25% DC Resistance\$ 0.2 Ohm	85670273	Furus	
217	L13	SLF NCB0603R600 0603	BEAD SMALL	ALTERNATIVE	NIC	NCB0603R600	100 MHz 60 Ohm	25% DC Resistance\$ 0.2 Ohm	85670273	Furus	
218	L18	SLF NCB0603R600 0603	BEAD SMALL	ALTERNATIVE	NIC	NCB0603R600	100 MHz 60 Ohm	25% DC Resistance\$ 0.2 Ohm	85670273	Furus	
219	L19	SLF NCB0603R600 0603	BEAD SMALL	ALTERNATIVE	NIC	NCB0603R600	100 MHz 60 Ohm	25% DC Resistance\$ 0.2 Ohm	85670273	Furus	
220	Q2	TRA BFR520 NPN	BFR520	PREFERRED	PHILIPS	BFR520	BFR520	-	82330002	TPC	
221	SH1	REEN SMARTTELECOM 02 & LID SMARTTELE	BLK02	PREFERRED	MICROMETALLIC	RTTELECOM 02 & SMARTTELECO	-	-	84660316 & 8468	CROMETALLIC	
222	C4	CND 100F 16V Tant B	CT100	ALTERNATIVE	AVX KYOCERA	TAJB106K06X	10u	+/- 10% 16V dc	81840051	498-737 NEDERLAND BV	
223	C29	CND 100F 16V Tant B	CT100	ALTERNATIVE	AVX KYOCERA	TAJB106K06X	10u	+/- 10% 16V dc	81840051	498-737 NEDERLAND BV	
224	C29	CND 100F 16V Tant B	CT100	ALTERNATIVE	AVX KYOCERA	TAJB106K06X	10u	+/- 10% 16V dc	81840051	498-737 NEDERLAND BV	
225	C95	CND 100F 16V Tant B	CT100	ALTERNATIVE	AVX KYOCERA	TAJB106K06X	10u	+/- 10% 16V dc	81840051	498-737 NEDERLAND BV	
226	C109	CND 100F 16V Tant B	CT100	ALTERNATIVE	AVX KYOCERA	TAJB106K06X	10u	+/- 10% 16V dc	81840051	498-737 NEDERLAND BV	
227	C110	CND 100F 16V Tant B	CT100	ALTERNATIVE	AVX KYOCERA	TAJB106K06X	10u	+/- 10% 16V dc	81840051	498-737 NEDERLAND BV	
228	C111	CND 100F 16V Tant B	CT100	ALTERNATIVE	AVX KYOCERA	TAJB106K06X	10u	+/- 10% 16V dc	81840051	498-737 NEDERLAND BV	
229	C112	CND 100F 16V Tant B	CT100	ALTERNATIVE	AVX KYOCERA	TAJB106K06X	10u	+/- 10% 16V dc	81840051	498-737 NEDERLAND BV	
230	C113	CND 100F 16V Tant B	CT100	ALTERNATIVE	AVX KYOCERA	TAJB106K06X	10u	+/- 10% 16V dc	81840051	498-737 NEDERLAND BV	
231	C116	CND 100F 16V Tant B	CT100	ALTERNATIVE	AVX KYOCERA	TAJB106K06X	10u	+/- 10% 16V dc	81840051	498-737 NEDERLAND BV	
232	C117	CND 100F 16V Tant B	CT100	ALTERNATIVE	AVX KYOCERA	TAJB106K06X	10u	+/- 10% 16V dc	81840051	498-737 NEDERLAND BV	
233	C118	CND 100F 16V Tant B	CT100	ALTERNATIVE	AVX KYOCERA	TAJB106K06X	10u	+/- 10% 16V dc	81840051	498-737 NEDERLAND BV	
234	C27	CND 4.7uF 16V Tant A	CT407	ALTERNATIVE	AVX KYOCERA	TJAJ475K06X	407	+/- 10% 16V dc	81840052	197-269 NEDERLAND BV	
235	C64	CND 4.7uF 16V Tant A	CT407	ALTERNATIVE	AVX KYOCERA	TJAJ475K06X	407	+/- 10% 16V dc	81840052	197-269 NEDERLAND BV	
236	C79	CND 4.7uF 16V Tant A	CT407	ALTERNATIVE	AVX KYOCERA	TJAJ475K06X	407	+/- 10% 16V dc	81840052	197-269 NEDERLAND BV	
237	C93	CND 4.7uF 16V Tant A	CT407	ALTERNATIVE	AVX KYOCERA	TJAJ475K06X	407	+/- 10% 16V dc	81840052	197-269 NEDERLAND BV	
238	U11	FLT DFC22R44P084LHA BPF	DFC 22 LIGHT	PREFERRED	MURATA	DFC22R44P084LHA	FC-2 4GHz	-	85670259	498-737 NEDERLAND BV	
239	U12	FLT DFC22R44P084LHA BPF	DFC 22 LIGHT	PREFERRED	MURATA	DFC22R44P084LHA	FC-2 4GHz	-	85670259	498-737 NEDERLAND BV	
240	U21	FLT DFC22R44P084LHA BPF	DFC 22 LIGHT	PREFERRED	MURATA	DFC22R44P084LHA	FC-2 4GHz	-	85670259	498-737 NEDERLAND BV	
241	U22	FLT DFC22R44P084LHA BPF	DFC 22 LIGHT	PREFERRED	MURATA	DFC22R44P084LHA	FC-2 4GHz	-	85670259	498-737 NEDERLAND BV	
242	Q1	TRA IRLML6302 PBT PMOS	IRLML6302	ALTERNATIVE	International Rectifier	IRLML6302	IRLML6302	-	82330093	?	
243	Q4	TRA IRLML6302 PBT PMOS	IRLML6302	ALTERNATIVE	International Rectifier	IRLML6302	IRLML6302	-	82330093	?	
244	U13	FLT LFK30-05E2442L084 LPF	LFK30-05E2442L084	PREFERRED	Murata	LFK30-05E2442L084	F=C-2 4GHz	-	85670271	NIJERK/DECATEL	
245	U9	CIN LP3961EMP-3.3	LP3961	PREFERRED	National Semiconductor	LP3961EMP-3.3	3V 800mA SOT223-5	-	83520086	EBV	
246	U6	CIN LP3961EMP-3.3	LP3961	PREFERRED	National Semiconductor	LP3961EMP-3.3	3V 800mA SOT223-5	-	83520086	EBV	
247	U16	CIN LP3961EMP-3.3	LP3961	PREFERRED	National Semiconductor	LP3961EMP-3.3	3V 800mA SOT223-5	-	83520085	EBV	
248	U8	CIN LP3961EMP-2.5	LP3961 2V5	PREFERRED	National Semiconductor	LP3961EMP-2.5	3V 800mA SOT223-5	-	83520085	EBV	
249	U14	CIN MAX4016ESA	MAX4016	PREFERRED	MAXIM	MAX4016ESA	DUAL OPAMP SQ	-	83500075	NG EN HARTMAN	
250	U2	CON BFRG 40P5 87409-1201R	MOLEX 87409 120	PREFERRED	BERG	7409-1201R Taps & ISI whip-up	12.288 MHz	-	94350244	RAKON	
251	U6	QT Z 12.288MHz 25ppm	RAKON SXO110A 12 288	PREFERRED	RAKON	SXO110A 12.288MHz	12.288 MHz	-	94350244	RAKON	
252	U5	CIN RF2189	RF2189	PREFERRED	RFMD	RF2189	PA 2.4GHz 3V	-	25 ppm	RFMD	
253	U2	CIN RF2444	RF2444	PREFERRED	RFMD	RF2444	DOWNCONVERT	-	89000064	RFMD	
254	U1	CIN RF2938	RF2938	PREFERRED	RFMD	RF2938	8 Spectrum Trans	-	89000065	RFMD	
255	U4	FLT 855954 (old name: 855771)	SAWTEK	PREFERRED	SAWTEK	855954 (old name: 855771)	FC-38MHz BW	-	89000066	SAWTEK	
256	U7	CIN SI4336-BT	SI4336	PREFERRED	Silicon Labs	SI4336-BT	YNTHESE/HZ WR	-	89000067	SILICON LABS	
312	IC2	CIN XC17S100A-SO20C	XC17S100XL	PREFERRED	XILINX	XC17S100A-SO20C	OTF CONFIG FR-	-	832700703	ANMET	
313	IC1	CIN XC2S100-5TQ44C	XC2S100	PREFERRED	XILINX	XC2S100-5TQ44C	SPARTAN-II FRG-	-	837401493	ANMET	