TronAIS_TR-8000
AIS Transponder

TEST REPORT

IEC 61993-2 ed.2 Class A

Nemko Project no: 150521
Date: January 14th, 2011

Title: Type approval test of TronAIS_TR8000

Test object: TronAIS_TR8000 consisting of AIS Transceiver and Display Unit

Project no: Nemko 150521

Manufacturer: Jotron AS

Specifications: IEC 61993-2 ed.2, Class A, Operational and performance requirements

Result: TronAIS_TR-8000 is compliant with IEC 61993-2 ed.2, Class A

Date: January 11th, 2011

Approved: _____

Otto Holm, CTO JOTRON AS

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1 Test report summary

1.1 General

The tests were conducted on production equipment for the purpose of demonstrating compliance with IEC 61993-2 ed.2, Class A

The test methods have been in accordance with IEC 61993-2 ed.2, Class A where applicable.

The samples tested were prototype production samples, randomly selected.

1.2 Summary

1.2.1 Transmitter requirements

Clause	Result
15.1.1 Frequency Error	Pass
15.1.2 Carrier Power	Pass
15.1.3 Slotted Transmission Spectrum	Pass
15.1.4 Modulation accuracy	Pass
15.1.5 Transmitter output power characteristics	Pass
15.3.1 Spurious emissions from the transmitter	Pass

Table 1: Summary of transmitter requirements

1.2.2 Receiver requirements

Clause	Result
15.2.1 Sensitivity	Pass
15.2.2 Error behavior at high input levels	Pass
15.2.3 Co-channel rejection	Pass
15.2.4 Adjacent channel selectivity	Pass
15.2.5 Spurious response rejection	Pass
15.2.6 Intermodulation response rejection and blocking	Pass
15.2.7 Transmit to receive switching time	Pass
15.2.8 Immunity to out of band energy	Pass
15.3.2 Spurious emissions from the receiver	Pass

Table 2: Summary of receiver requirements

1.2.3 DSC receiver requirements

Clause	Result
D.2.1 Maximum sensitivity	Pass
D.2.2 Error behavior at high input levels	Pass
D.2.3 Co-channel rejection	Pass
D.2.4 Adjacent channel selectivity	Pass
D.2.5 Spurious response rejection	Pass
D.2.6 Intermodulation response rejection	Pass
D.2.7 Blocking or desensitisation	Pass

Table 3: Summary of DSC receiver requirements

2 Test information

2.1 Tested item

UUT	Serial Number	Software version
TR-8000	S-0003	

2.2 Test environment

2.2.1 Temperature and humidity

- Room temperature: + 15° C to +35° C
- Humidity in accordance with IEC 61993-2 ED.2, CLASS A
  (20% – 75%)

2.2.2 Power sources

- On normal conditions the transceiver is powered using 24V DC Mascot power on normal conditions
- On extreme conditions, the transceiver is powered by GW power supply (JE-121) at 10.8V DC and 31.2V DC

2.2.3 Extreme conditions

- Minimum temperature: -25°C
- Maximum temperature: +55°C

2.3 Test period

August 2010 - January 2011

2.4 Test engineers

Per Jørgensen, Arne Fredriksen, Martin Carlsen (Jotron AS)

2.5 Test equipment and calibration status

Manufacturer	Type	Serial number	Jotron AS number	Next calibration date:
National Instruments[1]	NI PXI 5152	0xECE9C1	JE-517	08/11
National Instruments[1]	NI PXI 5441	0xED4DBC	JE-511	08/11
National Instruments[1]	NI PXI 5610	0xEDBCEB	JE-510	08/11
National Instruments[1]	NI PXI 5600	0xED970F	JE-507	08/11
National Instruments[1]	NI PXI 5620	0xED86D9	JE-509	08/11
Rohde & Schwarz	SMA 100 A	102012	JE-458	09/11
Rohde & Schwarz	FSEM 1079.8500	846821/004	JE-253	09/11
Mascot	9522 24VDC			Note[2]
Marconi Instruments	Low noise signal generator 2040	119860/059	Jot201	09/11
Heraeus Vötsch	VMT04/140	30336	JE-249	12/10
GW	GPR3010H	2120507	JE-121	Note[2]
Jotron	Directional Coupler			Note[4]
Jotron	Notch Filter			Note[4]
N/A	Attenuator 10dB			Note[4]
BIRD	Attenuator 20dB 0751			Note[4]
BIRD	Attenuator 40dB 0708			Note[4]
Mini-Circuits	ZPSC-4-175W	155420		Note[3]
Fluke	189 Multimeter		JE-383	04/11
Agilent Technologies	Network Analyzer N5230A	MY45001044	JE-394	06/11

Table 4: Test equipment and calibration status

[1] The PXI is a modular test set, and all the PXI components listed are part of a test system referred to only as PXI in the test report.
[2] The power supply is verified with multimeter JE-383.
[3] The signal generator desired output is verified on Spectrum analyzer JE-253
[4] The function and losses of the test equipment are verified by network analyzer JE-394

3 Test Results

3.1 TDMA Transmitter

3.1.1 Frequency Error, clause 15.1.1

Measurement set up: Figure 1: Measurement arrangement for frequency error.
Conditions: Normal temperature and humidity
extreme temperature conditions
Test equipment used: PXI
Computer with test software
Attenuator 40dB
Method of measurement: 15.1.1
Limits: Frequency error < ±0.5kHz for normal test conditions.
Frequency error < ±1kHz for extreme test conditions.
Result: Pass

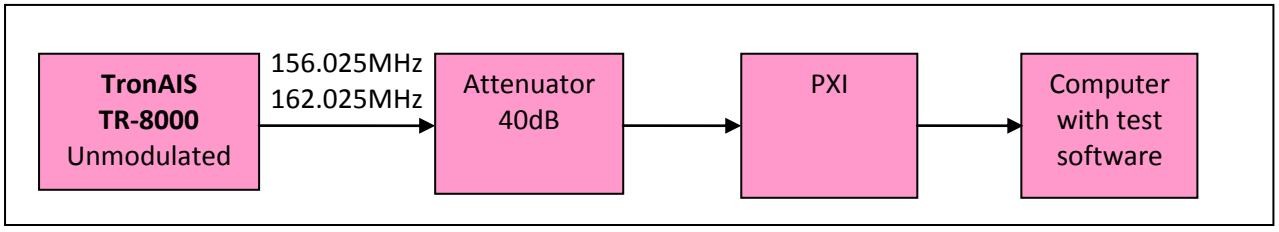

Figure 1: Measurement arrangement for frequency error.

Condition	Frequency (F_0)	Measured error (Hz)	Limit	Result
Normal Conditions	156.025MHz	375Hz	±0.5kHz	Pass
Normal Conditions	162.025MHz	314Hz	±0.5kHz	Pass

Table 5: Frequency error measurement results for normal conditions.

Condition	Frequency (F_0)	Measured error		Limit	Result
		Supply = 10.8V	Supply = 31.2V		
Extreme, T_{Low}	156.025MHz	358Hz	481Hz	±1kHz	Pass
Extreme, T_{Low}	162.025MHz	468Hz	451Hz	±1kHz	Pass
Extreme, T_{High}	156.025MHz	230Hz	293Hz	±1kHz	Pass
Extreme, T_{High}	162.025MHz	319Hz	220Hz	±1kHz	Pass

Table 6: Frequency error measurement results for extreme conditions.

3.1.2 Carrier Power, clause 15.1.2

Measurement set up: Figure 2: Carrier power test setup.
Conditions: Normal temperature and humidity
Extreme temperature conditions
High power mode (41dBm)
Low power mode (30dBm)
Test equipment used: PXI
Computer with test software
Attenuator 40dB

Method of measurement: 15.1.2
Limits: Power error < ±1.5dB for normal conditions
Power error < ±3dB for extreme conditions
Result: Pass

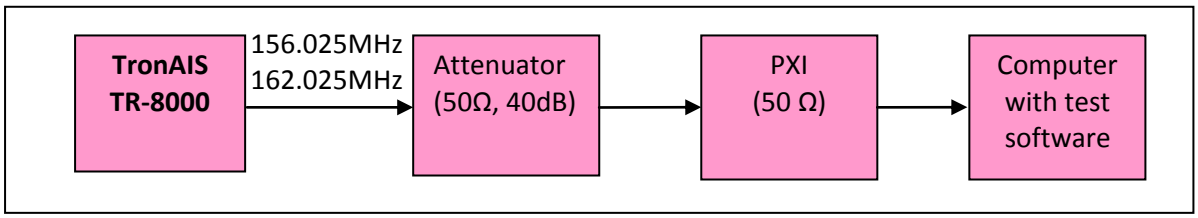

Figure 2: Carrier power test setup.

Condition	Frequency (F_0)	Nominal power	Supply = 24V		Limit	Result Pass/Fail
			Measured (dBm)	Error (dB)		
Normal	156.025MHz	30dBm	30.5	0.5	±1.5dB	Pass
Normal	162.025MHz	30dBm	29.2	-0.8	±1.5dB	Pass

Table 7: Carrier power measurement results for low power, normal conditions.

Condition	Frequency (F_0)	Nominal power	Supply = 24V		Limit	Result Pass/Fail
			Measured (dBm)	Error (dB)		
Normal	156.025MHz	41dBm	41.2	0.2	±1.5dB	Pass
Normal	162.025MHz	41dBm	41.1	0.1	±1.5dB	Pass

Table 8: Carrier power measurement results for high power, normal conditions.

Condition	Frequency (F_0)	Nominal power	Supply = 10.8V		Supply = 31.2V		Limit	Result
			Measured (dBm)	Error (dB)	Measured (dBm)	Error (dB)		
Extreme, T_{Low}	156.025MHz	30dBm	32.5	2.5	32.5	2.5	±3dB	Pass
Extreme, T_{Low}	162.025MHz	30dBm	32.2	2.2	32.1	2.1	±3dB	Pass
Extreme, T_{High}	156.025MHz	30dBm	31.4	1.4	31.2	1.2	±3dB	Pass
Extreme, T_{High}	162.025MHz	30dBm	30.3	0.3	30.3	0.3	±3dB	Pass

Table 9: Carrier power measurement results for low power, extreme conditions.

Condition	Frequency (F_0)	Nominal power	Supply = 10.8V		Supply = 31.8V		Limit	Result
			Measured (dBm)	Error (dB)	Measured (dBm)	Error (dB)		
Extreme, T_{Low}	156.025MHz	41dBm	41.8	0.8	41.5	0.5	±3dB	Pass
Extreme, T_{Low}	162.025MHz	41dBm	41.7	0.7	41.8	0.8	±3dB	Pass
Extreme, T_{High}	156.025MHz	41dBm	40.3	-0.7	39.4	-1.6	±3dB	Pass
Extreme, T_{High}	162.025MHz	41dBm	40.5	-0.5	39.7	-1.3	±3dB	Pass

Table 10: Carrier power measurement results for high power, extreme conditions.

3.1.3 Slotted Transmission Spectrum, clause 15.1.3

Measurement set up:	Figure 3: Slotted transmission spectrum measurement setup.
Conditions:	Normal temperature and humidity
Test equipment used:	PXI Attenuator 40dB
Method of measurement:	15.1.3
Limits:	Figure 4: Emission mask for slotted transmission.
Notes:	The measurement uses the measured output power from test 3.1.2 as reference (0dBc).
Result:	Pass See 4.1 Annex 1, spectral plots

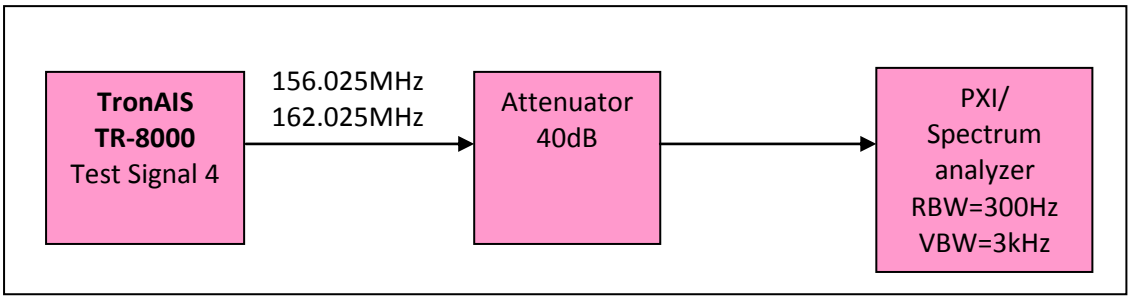

Figure 3: Slotted transmission spectrum measurement setup.

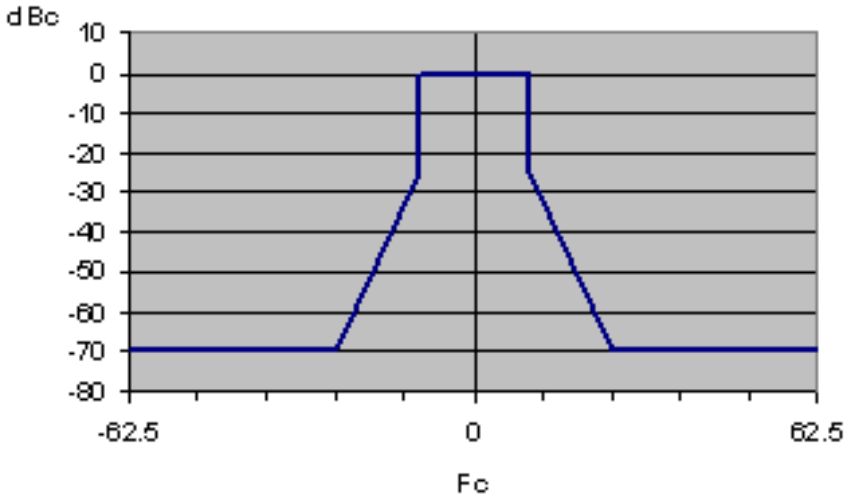

Figure 4: Emission mask for slotted transmission.

3.1.4 Modulation Accuracy, clause 15.1.4

Measurement set up: Figure 5: Measurement arrangement for modulation accuracy.
Conditions: Normal temperature and humidity
Extreme temperature conditions
Test equipment used: PXI
Computer with test software
Attenuator 40dB
Method of measurement: 15.1.4
Limits: 15.1.4
Result: Pass

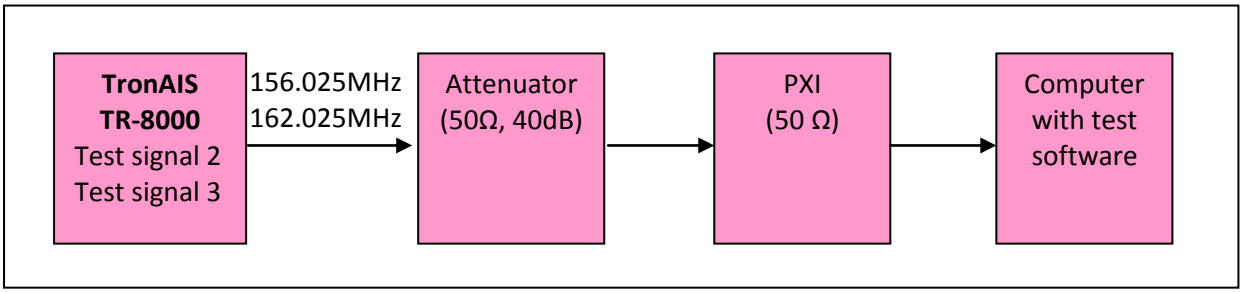

Figure 5: Measurement arrangement for modulation accuracy.

Conditions	Frequency (MHz)	Expected value (Hz)	Measured Min/Max (Hz)	Limit Min/Max (Hz)	Result Pass/Fail
Normal	156.025	1740	1596 / 1773	1565 / 1915	Pass
Normal	162.025	1740	1650 / 1830	1565 / 1915	Pass

Table 11: Modulation accuracy measurement results for test signal 2.

Conditions	Frequency (MHz)	Expected value (Hz)	Measured Min/Max (Hz)	Limit Min/Max (Hz)	Result Pass/Fail
Normal	156.025	2400	2238 / 2539	2160 / 2640	Pass
Normal	162.025	2400	2225 / 2516	2160 / 2640	Pass

Table 12: Modulation accuracy measurement results for test signal 3.

Conditions	Frequency (MHz)	Expected value (Hz)	Supply = 10.8V	Supply = 31.8V	Limit Min/Max (Hz)	Result Pass/Fail
			Measured Min/Max (Hz)	Measured Min/Max (Hz)		
Extreme, T_{Low}	156.025	1740	1624/1773	1613/1791	1390 / 2090	Pass
Extreme, T_{Low}	162.025	1740	1682/1787	1689/1751	1390 / 2090	Pass
Extreme, T_{High}	156.025	1740	1615 / 1777	1618 / 1755	1390 / 2090	Pass
Extreme, T_{High}	162.025	1740	1614 / 1796	1603 / 1797	1390 / 2090	Pass

Table 13: Modulation accuracy measurement results for test signal 2 under extreme conditions.

Conditions	Frequency (MHz)	Expected value (Hz)	Supply = 10.8V	Supply = 31.8V	Limit Min/Max (Hz)	Result Pass/Fail
			Measured Min/Max (Hz)	Measured Min/Max (Hz)		
Extreme, T_{Low}	156.025	2400	2312/2508	2303/2486	1920 / 2880	Pass
Extreme, T_{Low}	162.025	2400	2249/2461	2253/2476	1920 / 2880	Pass
Extreme, T_{High}	156.025	2400	2252 / 2540	2249 / 2542	1920 / 2880	Pass
Extreme, T_{High}	162.025	2400	2203 / 2596	2215 / 2540	1920 / 2880	Pass

Table 14: Modulation accuracy measurement results for test signal 3 under extreme conditions.

3.1.5 Transmitter output power characteristics, clause 15.1.5

Measurement set up: Figure 6: Measurement arrangement for transmitter output power characteristics.

Conditions: Normal temperature and humidity

Test equipment used: PXI
Attenuator 40dB
Computer with test software

Method of measurement: 15.1.5

Limits: 15.1.5

Result: Pass
See Annex 2
Figure 26-Figure 31

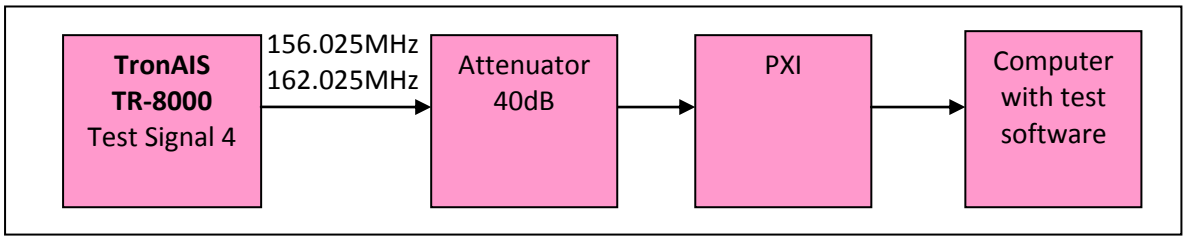

Figure 6: Measurement arrangement for transmitter output power characteristics.

3.2 TDMA receivers

3.2.1 Sensitivity, clause 15.2.1

Measurement set up: Figure 7: Receiver sensitivity measurement setup.
Conditions: Normal temperature and humidity
extreme temperature conditions
Test equipment used: PXI
Computer with test software
Attenuator 40dB
Method of measurement: 15.2.1
Limits: The Packet Error Rate (PER) shall not exceed 20%
Result: Pass

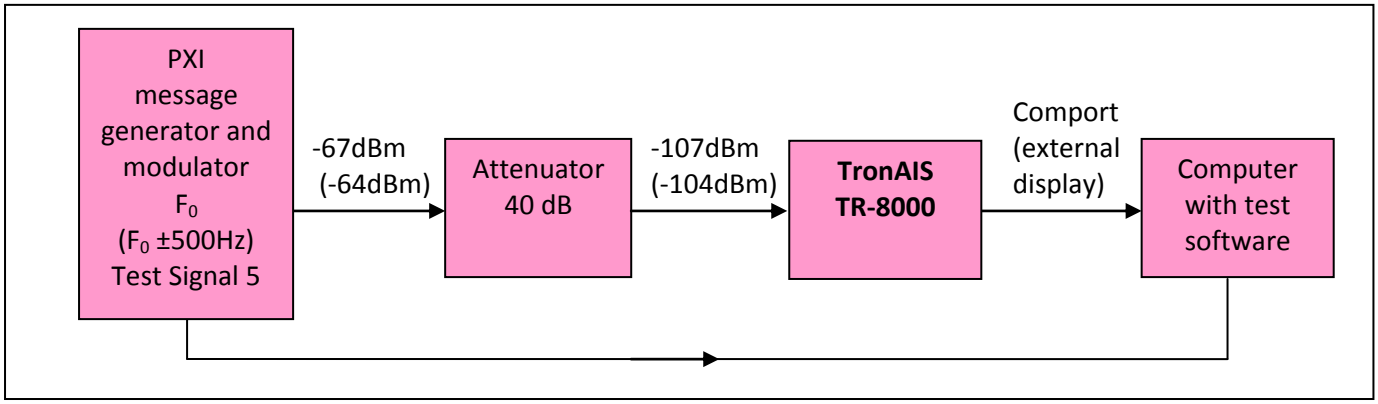

Figure 7: Receiver sensitivity measurement setup.

Condition	Frequency (F_0)	Frequency displacement	Received power level	Measured PER	Limit	Result Pass/Fail
Normal	156.025MHz	0Hz	-107dBm	2.5%	20%	Pass
Normal	156.025MHz	+500Hz	-104dBm	0.5%	20%	Pass
Normal	156.025MHz	-500Hz	-104dBm	0.0%	20%	Pass
Normal	162.025MHz	0Hz	-107dBm	2.0%	20%	Pass
Normal	162.025MHz	+500Hz	-104dBm	0.5%	20%	Pass
Normal	162.025MHz	-500Hz	-104dBm	0.0%	20%	Pass

Table 15: Receiver sensitivity measurement results for normal conditions.

Condition	Frequency (F_0)	Received power level	Measured PER		Limit	Result Pass/Fail
			Supply=10.8V	Supply=31.2V		
Extreme, T_{Low}	156.025MHz	-101dBm	0.0%	0.0%	20%	Pass
Extreme, T_{Low}	162.025MHz	-101dBm	0.0%	0.0%	20%	Pass
Extreme, T_{high}	156.025MHz	-101dBm	0.0%	0.5%	20%	Pass
Extreme, T_{high}	162.025MHz	-101dBm	1.0%	1.5%	20%	Pass

Table 16: Receiver sensitivity measurement results for extreme conditions.

3.2.2 Error behavior at high input levels, clause 15.2.2

Measurement set up: Figure 8: Measurement arrangement for error behavior at high input levels.
Conditions: Normal temperature and humidity
Test equipment used: PXI
Computer with test software
Attenuator 10dB
Method of measurement: 15.2.2
Limits: The PER shall not exceed 1%
Result: Pass

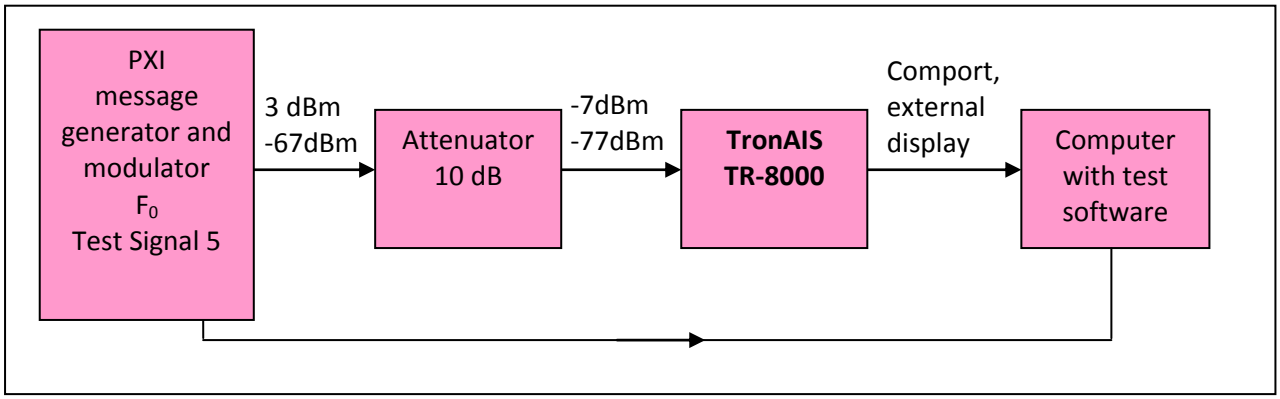

Figure 8: Measurement arrangement for error behavior at high input levels.

Condition	Frequency (F_0)	Received power level	Measured PER	Limit	Result
Normal	156.025MHz	-7dBm	0.0%	1%	Pass
Normal	162.025MHz	-7dBm	0.0%	1%	Pass
Normal	156.025MHz	-77dBm	0.0%	1%	Pass
Normal	162.025MHz	-77dBm	0.0%	1%	Pass

Table 17: Measured results for error behavior at high input levels.

3.2.3 Co-channel rejection, clause 15.2.3

Measurement set up: Figure 9: Measurement arrangement for co-channel rejection.
Conditions: Normal temperature and humidity.
Test equipment used: PXI
Computer with test software
Attenuator 40dB
Method of measurement: 15.2.3
Limits: The PER shall not exceed 20%
Result: Pass

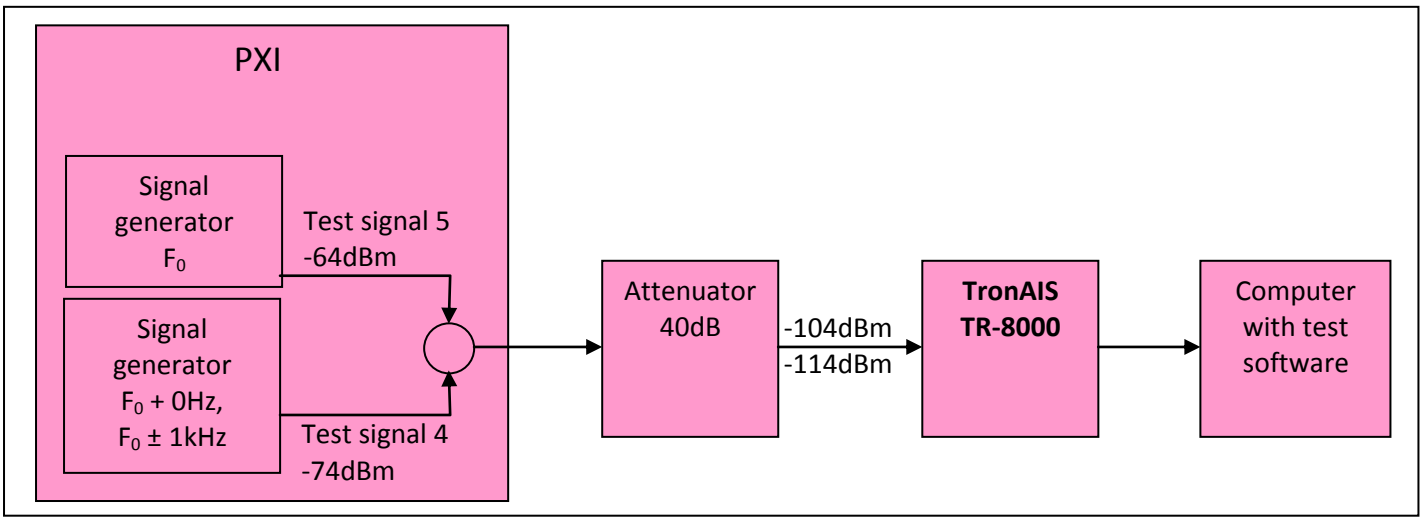

Figure 9: Measurement arrangement for co-channel rejection.

Frequency (F_0)	Unwanted frequency displacement	Measured PER	Limit	Result Pass/Fail
156.025MHz	0Hz	9.0%	20%	Pass
156.025MHz	+1kHz	15.5%	20%	Pass
156.025MHz	-1kHz	7.0%	20%	Pass
162.025MHz	0Hz	9.5%	20%	Pass
162.025MHz	+1kHz	16.5%	20%	Pass
162.025MHz	-1kHz	7.5%	20%	Pass

Table 18: Measured results for co-channel rejection.

3.2.4 Adjacent channel selectivity, clause 15.2.4

Measurement set up: Figure 10: Measurement arrangement for adjacent channel selectivity.

Conditions: Normal temperature and humidity, extreme temperature conditions.

Test equipment used: Signal Generator A (PXI)
Signal Generator B (JE-458)
Computer with test software
Attenuator 40dB
Signal mixer (mini circuits)

Method of measurement: 15.2.4

Limits: The PER shall not exceed 20%

Result: Pass

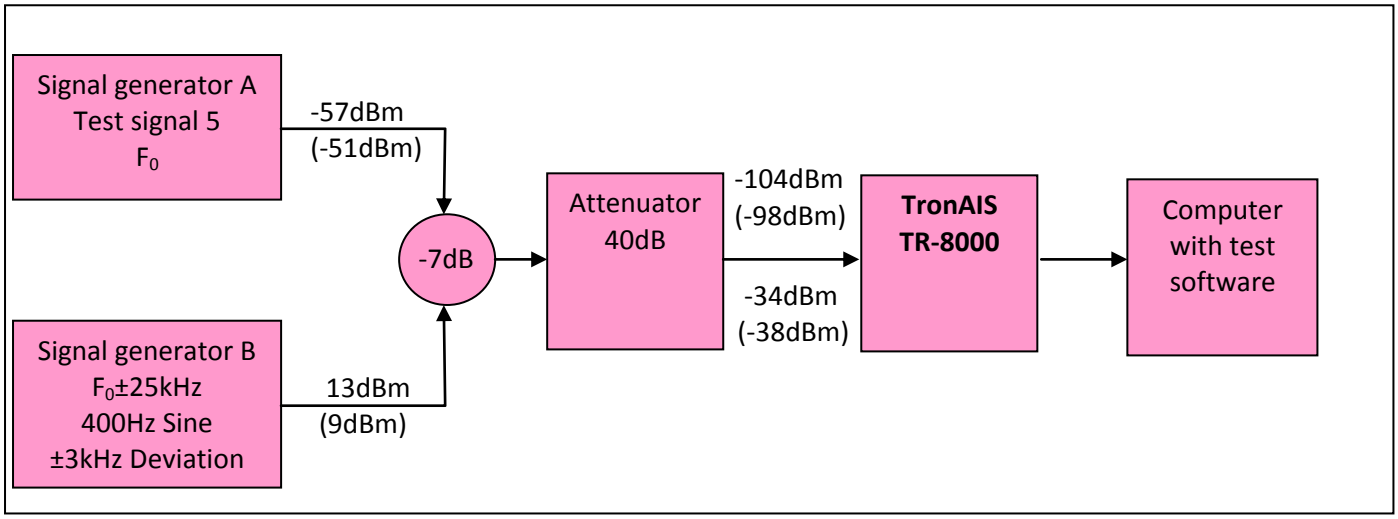

Figure 10: Measurement arrangement for adjacent channel selectivity.

Frequency (F_0)	Unwanted frequency	Measured PER	Limit	Result Pass/Fail
156.025MHz	156.050MHz	0.5%	20%	Pass
162.025MHz	162.050MHz	0.5%	20%	Pass
156.025MHz	156.000MHz	0.0%	20%	Pass
162.025MHz	162.000MHz	1.5%	20%	Pass

Table 19: Measured results for adjacent channel selectivity. Wanted signal level is -104dBm, unwanted signal level is -34dBm.

Conditions	Frequency (F_0)	Unwanted frequency	Measured PER		Limit	Result Pass/Fail
			Supply=10.8V	Supply=31.2V		
Extreme, T_{Low}	156.025MHz	156.050MHz	0.0%	0.0%	20%	Pass
Extreme, T_{Low}	156.025MHz	156.000MHz	0.0%	0.5%	20%	Pass
Extreme, T_{Low}	162.025MHz	162.050MHz	0.0%	0.0%	20%	Pass
Extreme, T_{Low}	162.025MHz	162.000MHz	0.0%	0.0%	20%	Pass
Extreme, T_{high}	156.025MHz	156.050MHz	0.0%	0.0%	20%	Pass
Extreme, T_{high}	156.025MHz	156.000MHz	0.5%	0.5%	20%	Pass
Extreme, T_{high}	162.025MHz	162.050MHz	0.5%	0.0%	20%	Pass
Extreme, T_{high}	162.025MHz	162.000MHz	0.0%	0.0%	20%	Pass

Table 20: Measured results for adjacent channel selectivity at extreme conditions. Wanted signal level is -98dBm, unwanted signal level is -38dBm at the receiver.

3.2.5 Spurious response rejection, clause 15.2.5

Measurement set up: Figure 11: Measurement arrangement for spurious response rejection.

Conditions: Normal temperature and humidity.

Test equipment used: Signal Generator A (PXI)
Signal generator B (JE-458)
Computer with test software
Attenuator 40dB
Signal mixer (mini-circuits)

Method of measurement: 15.2.5

Limits: At any frequency separated from the nominal frequency of the receiver by two channels or more, the spurious responses shall not result in a PER of greater than 20%.

Notes: Limited Frequency Range (LFR) = $f_{LO} \pm (IF_1 + IF_2 + ... + IF_N)$
Specific Frequencies of Interest (SFI)= SFI = $(K * f_{LO}) \pm IF_1$
where K is an integer from 2 to 4.
The frequencies used for calculating the Limited Frequency Range and the Specific Frequencies of Interest is:
If_1=45MHz
If_2=455kHz
f_Lo_L=201.025MHz
f_Lo_H=207.025MHz

Result: Pass

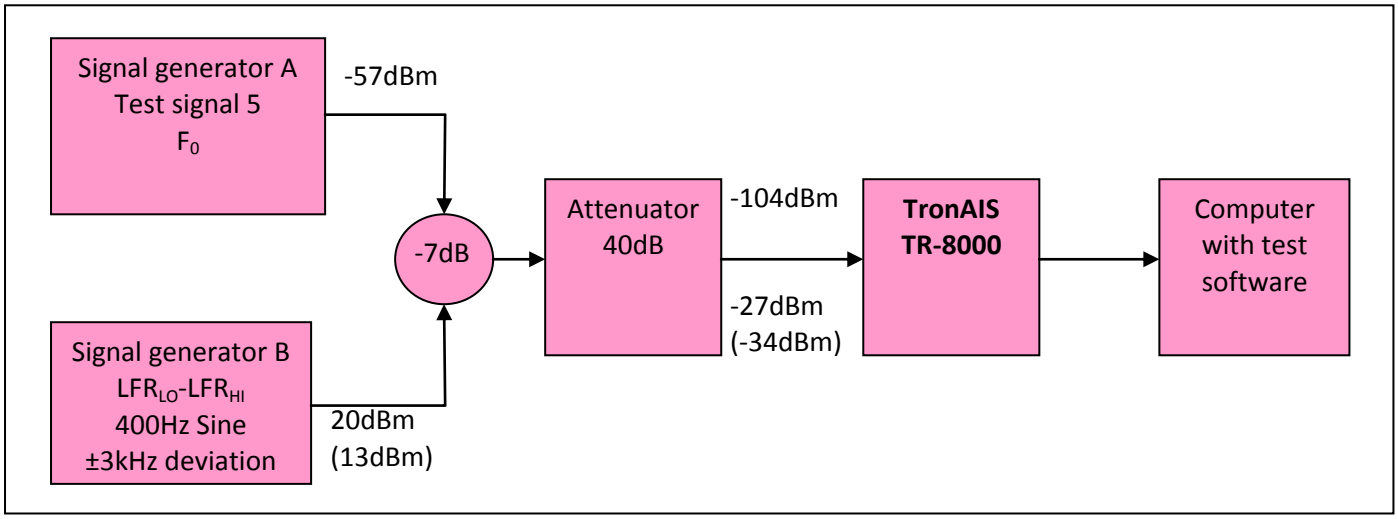

Figure 11: Measurement arrangement for spurious response rejection.

F_0 = 156.025MHz			F_0 = 162.025MHz		
Detected spurious frequency (MHz)	**PER**	**Result Pass/Fail**	**Detected spurious Frequency (MHz)**	**PER**	**Result Pass/Fail**
Generator B switched off	1%	Pass	Generator B switched off	0.5%	Pass
156.930	10%	Pass	162.930	10%	Pass
156.935	6.5%	Pass	162.935	7%	Pass
156.940	15.5%	Pass	162.940	10%	Pass
178.520	0%	Pass	-	-	-
178.525	1.5%	Pass	-	-	-
178.530	1%	Pass	-	-	-

Table 21: Spurious response frequencies found in the Limited frequency Range. The corresponding PER is measured with wanted signal level adjusted to -104dBm and wanted signal level adjusted to -34dBm at the receiver.

F_0 = 156.025MHz			F_0 = 162.025MHz		
Frequency (MHz)	**PER**	**Result Pass/Fail**	**Frequency (MHz)**	**PER**	**Result Pass/Fail**
447.050	0.5%	Pass	459.050.	1.0%	Pass
648.075	0.5%	Pass	666.075	0.0%	Pass
849.100	0.5%	Pass	873.075	0.0%	Pass
357.075	0.0%	Pass	369.050	0.5%	Pass
558.075	1.0%	Pass	576.075	0.5%	Pass
759.100	0.5%	Pass	783.100	0.0%	Pass

Table 22: Measured results for the specific frequencies of interest.

3.2.6 Intermodulation response rejection and blocking, clause 15.2.6

Measurement set up: Figure 12: Measurement setup for intermodulation response rejection and blocking.

Conditions: Normal temperature and humidity.

Test equipment used: Signal generator A (PXI)
Signal Generator B (Jot201)
Signal Generator C (JE-253)
Signal Generator D (JE-458)
Computer with test software
Attenuator 10dB
Signal mixer (mini-circuits)

Method of measurement: 15.2.6

Limits: The PER shall not exceed 20%

Notes: The test is performed with cavity PB-filters on the interfering generators in order to get the unwanted frequency components as narrow as possible.

Result: Pass

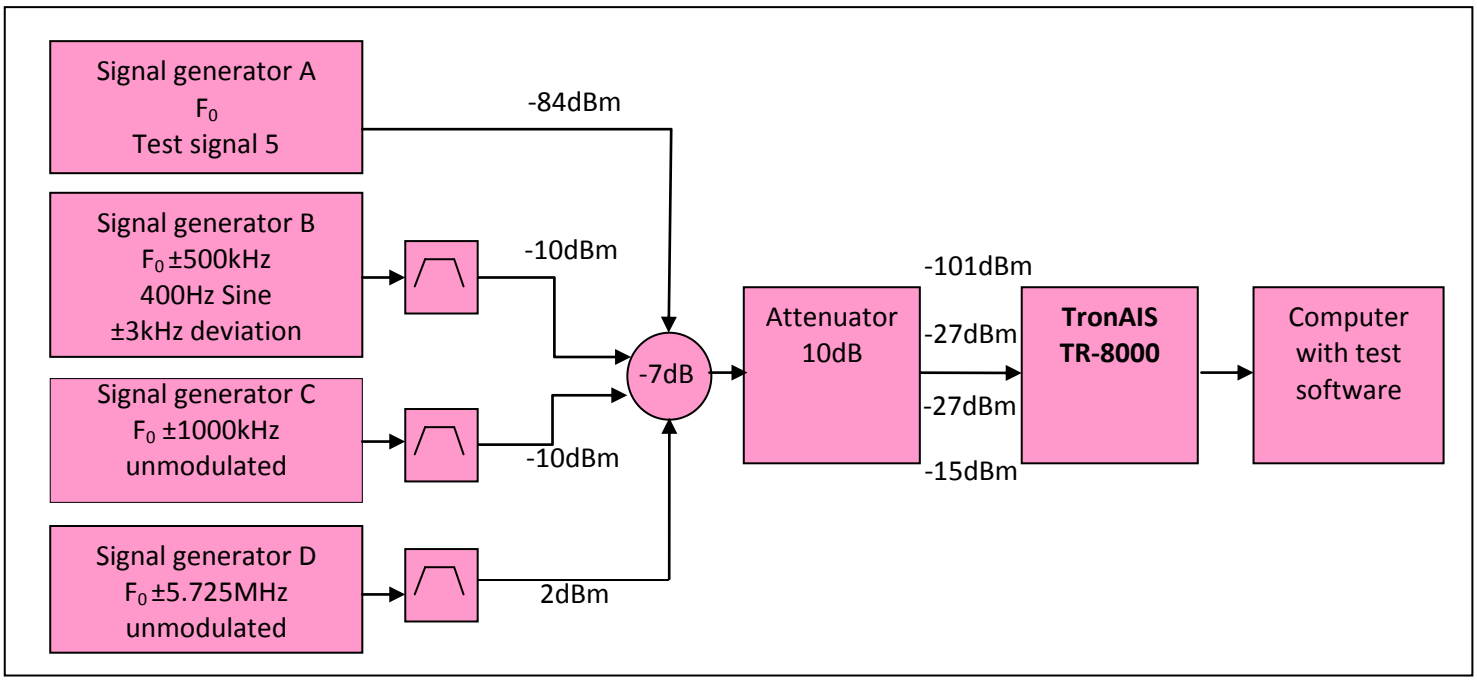

Figure 12: Measurement setup for intermodulation response rejection and blocking.

Test type	Generator A	Generator B	Generator C	Generator D
Test #1	156.025MHz	156.525MHz	157.025MHz	161.750MHz
Test #2	162.025MHz	161.525MHz	161.025MHz	156.300MHz

Table 23: Generator frequency plan for intermodulation response rejection and blocking.

Test type	PER	Limit	Result Pass/Fail
Test #1	15.5%	20%	Pass
Test #2	1.5%	20%	Pass

Table 24: Measured test results for intermodulation response rejection and blocking.

3.2.7 Transmit to receive switching time, clause 15.2.7

Measurement set up: Figure 13: Transmit to receive switching time measurement setup.
Conditions: Normal temperature and humidity.
Test equipment used: PXI
Computer with test software
Directional coupler (Jotron)
Attenuator 40dB
Method of measurement: 15.2.7
Limits: The PER shall not exceed 20%
Result: Pass

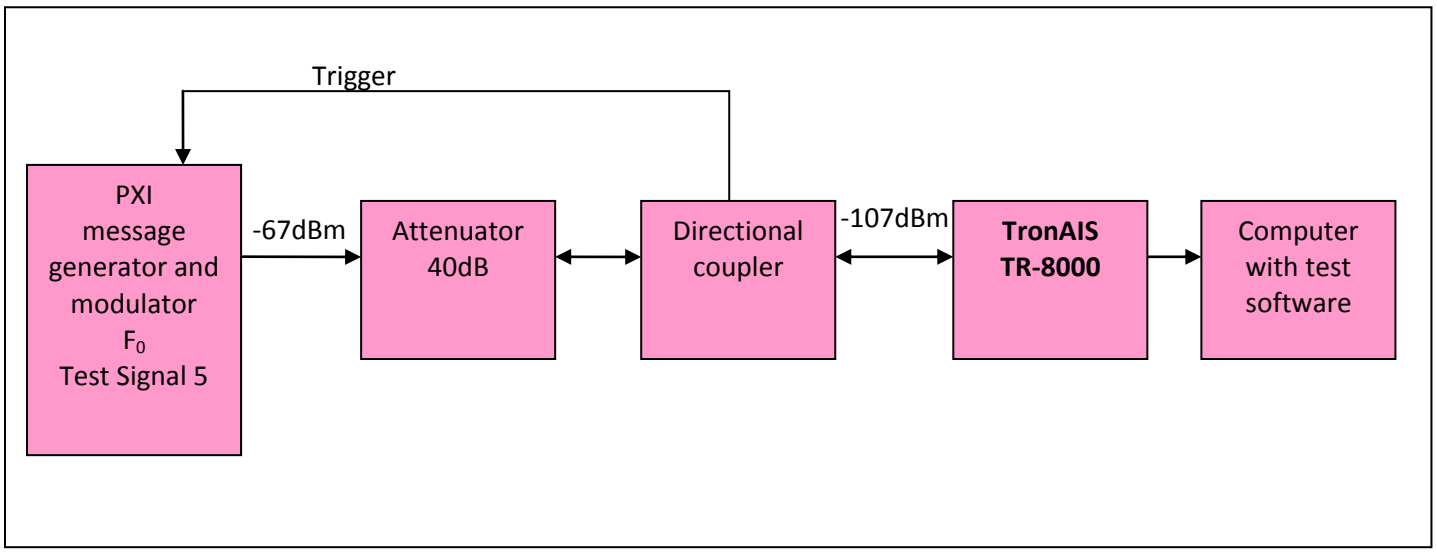

Figure 13: Transmit to receive switching time measurement setup. A 40dB attenuator is used in order to protect the output of the message generator.

Frequency (F_0)	PER	Limit	Result Pass/Fail
156.025MHz	0.5%	20%	Pass
162.025MHz	1.0%	20%	Pass

Table 25: Transmit to receive switching time test results.

3.2.8 Immunity to out of band energy, clause 15.2.8

Measurement set up: Figure 14: Immunity to out of band energy measurement setup.
Conditions: Normal temperature and humidity.
Test equipment used: PXI
Computer with test software
Attenuator 10dB
Signal mixer (mini-circuits)
Signal generator (JE-458)
Method of measurement: 15.2.8
Limits: The PER shall not exceed 20%
Result: Pass

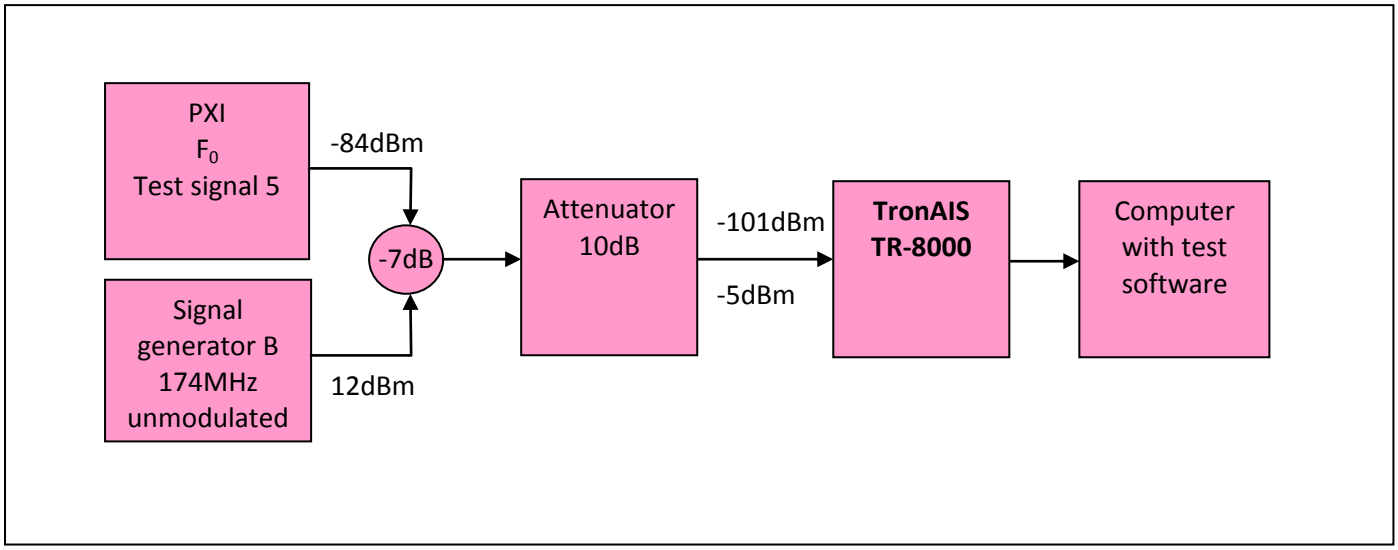

Figure 14: Immunity to out of band energy measurement setup.

Frequency (F_0)	PER	Limit	Result Pass/Fail
156.025MHz	0.0%	20%	Pass
162.025MHz	0.5%	20%	Pass

Table 26: Immunity to out of band energy test results.

3.3 DSC Receiver tests

3.3.1 Maximum Sensitivity, clause D.2.1

Measurement set up: Figure 15: DSC maximum sensitivity measurement setup.
Conditions: Normal temperature and humidity
Extreme temperature conditions
Test equipment used: PXI
Computer with test software
Attenuator 40dB
Method of measurement: D.2.1
Limits: The BER shall not exceed 10^{-2} (equivalent to PER < 20%)
Result: Pass

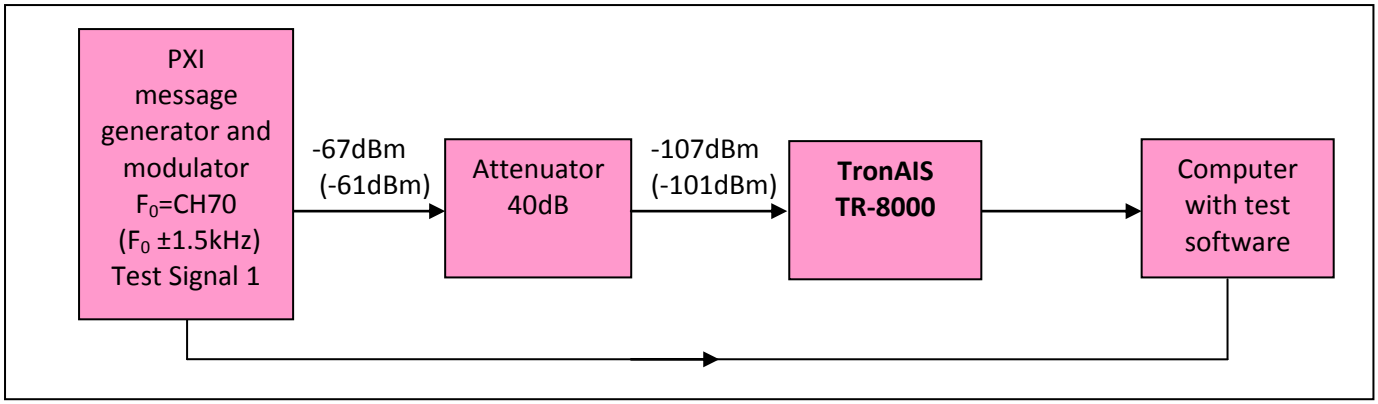

Figure 15: DSC maximum sensitivity measurement setup.

Condition	Frequency displacement	Received power level	Measured PER	Limit	Result Pass/Fail
Normal	0Hz	-107dBm	0.0%	20%	Pass
Normal	+1.5kHz	-107dBm	0.0%	20%	Pass
Normal	-1.5kHz	-107dBm	0.0%	20%	Pass

Table 27: DSC maximum sensitivity test results, normal test conditions.

Condition	Frequency displacement	Received power level	Measured PER		Limit	Result Pass/Fail
			Supply=10.8V	Supply=31.2V		
Extreme, T_{Low}	0Hz	-101dBm	0.0%	0.5%	20%	Pass
Extreme, T_{High}	0Hz	-101dBm	0.5%	0.0%	20%	Pass

Table 28: DSC maximum sensitivity test results in extreme test conditions.

3.3.2 Error Behavior at High Input Levels, clause D.2.2

Measurement set up: Figure 16: DSC error behavior at high input levels measurement setup.
Conditions: Normal temperature and humidity.
Test equipment used: PXI
Computer with test software
Attenuator 10dB
Method of measurement: D.2.2
Limits: The BER shall not exceed 10^{-2} (PER < 20%)
Result: Pass

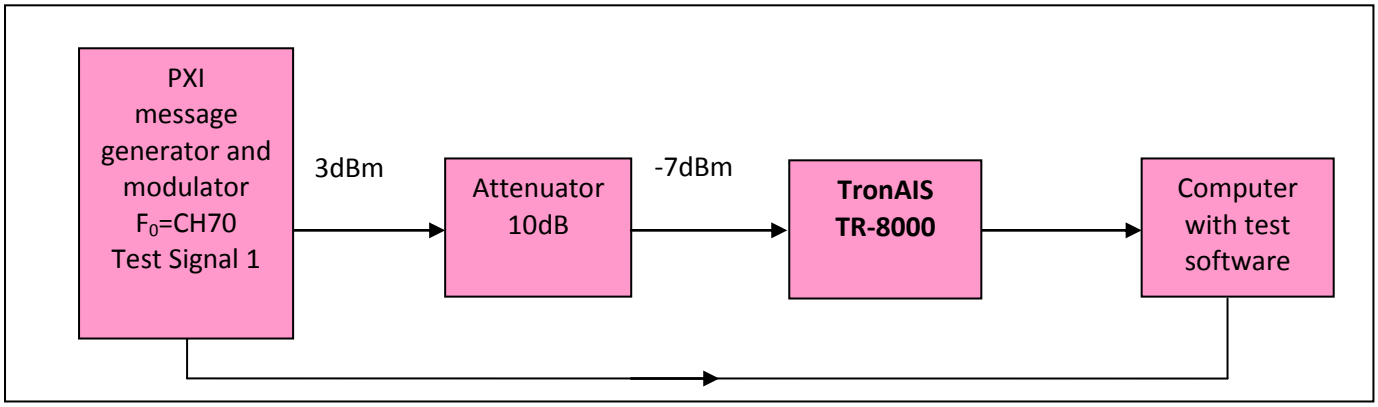

Figure 16: DSC error behavior at high input levels measurement setup.

Condition	Frequency displacement	Received power level	Measured PER	Limit	Result Pass/Fail
Normal	0Hz	-7dBm	0.5%	20%	Pass

Table 29: DSC maximum sensitivity test results in extreme test conditions.

3.3.3 Co-Channel Rejection, clause D.2.3

Measurement set up: Figure 17: Measurement arrangement for DSC co-channel rejection.
Conditions: Normal temperature and humidity.
Test equipment used: Signal Generator A (PXI)
Signal Generator B (JE-458)
Computer with test software
Attenuator 40dB
Signal mixer (mini-circuits)
Method of measurement: D.2.3
Limits: The BER shall not exceed 10^{-2} (PER < 20%)
Result: Pass

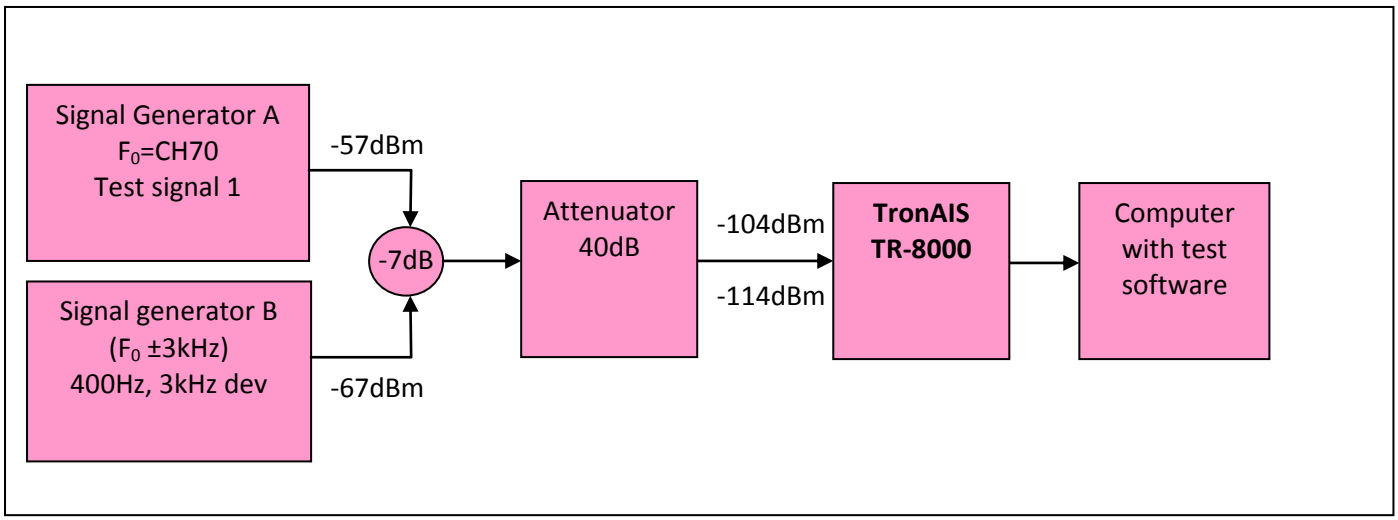

Figure 17: Measurement arrangement for DSC co-channel rejection.

Frequency (F_0)	Unwanted frequency	Measured PER	Limit	Result Pass/Fail
156.525MHz	156.525MHz	0.0%	20%	Pass
156.525MHz	156.528MHz	0.5%	20%	Pass
156.525MHz	156.522MHz	0.0%	20%	Pass

Table 30: Measured results for DSC co-channel rejection.

3.3.4 Adjacent Channel selectivity, clause D.2.4

Measurement set up: Figure 18: Measurement arrangement for DSC channel selectivity.
Conditions: Normal temperature and humidity.
Extreme temperature conditions
Test equipment used: Signal Generator A (PXI)
Signal Generator B (JE-458)
Computer with test software
Attenuator 20dB
Signal mixer (mini-circuits)
Method of measurement: D.2.4
Limits: The BER shall not exceed 10^{-2} (PER < 20%)
Result: Pass

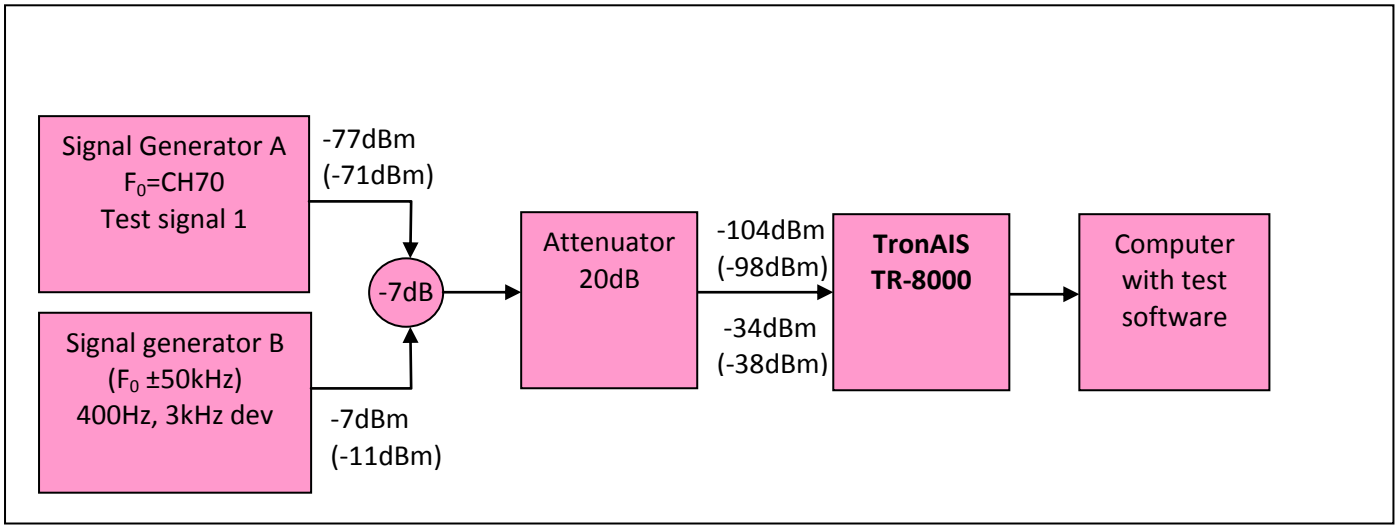

Figure 18: Measurement arrangement for DSC channel selectivity.

Conditions	Unwanted Frequency	Measured PER	Limit	Result Pass/Fail
Normal	156.575MHz	0.0%	20%	Pass
Normal	156.475MHz	0.0%	20%	Pass

Table 31: Measured results for DSC adjacent channel selectivity, normal conditions.

Conditions	Unwanted Frequency	Measured PER		Limit	Result Pass/Fail
		Supply=10.8V	Supply=31.2V		
Extreme, T_{Low}	156.575MHz	0.5%	0.5%	20%	Pass
Extreme, T_{Low}	156.475MHz	0.0%	0.0%	20%	Pass
Extreme, T_{High}	156.575MHz	0.0%	0.0%	20%	Pass
Extreme, T_{High}	156.475MHz	0.0%	0.5%	20%	Pass

Table 32: Measured results for DSC adjacent channel selectivity, extreme conditions.

3.3.5 Spurious Response Rejection , clause D.2.5

Measurement set up: Figure 19: Measurement arrangement for DSC spurious response rejection.

Conditions: Normal temperature and humidity.

Test equipment used: Signal Generator A (PXI)
Signal Generator B (JE-458)
Computer with test software
Attenuator 20dB
Signal mixer (mini-circuits)

Method of measurement: D.2.5 and 15.2.5

Limits: The BER shall not exceed 10^{-2} (PER < 20%)

Notes: The test were initiated by a search over the Limited Frequency range, with a wanted signal level of -104dBm and an unwanted signal level of -27dBm. Frequencies identified by an increase in PER is noted and further investigated at an unwanted signal level of -34dBm .
Limited Frequency Range (LFR) = $f_{LO} \pm (IF_1 + IF_2 + ... + IF_N)$ Specific Frequencies of Interest (SFI)= SFI = $(K * f_{LO}) \pm IF_1$
where K is an integer from 2 to 4.
If_1=45MHz
If_2=455kHz
f_Lo=201.525MHz

Result: Pass
See Annex 3, Table 38 and Table 39

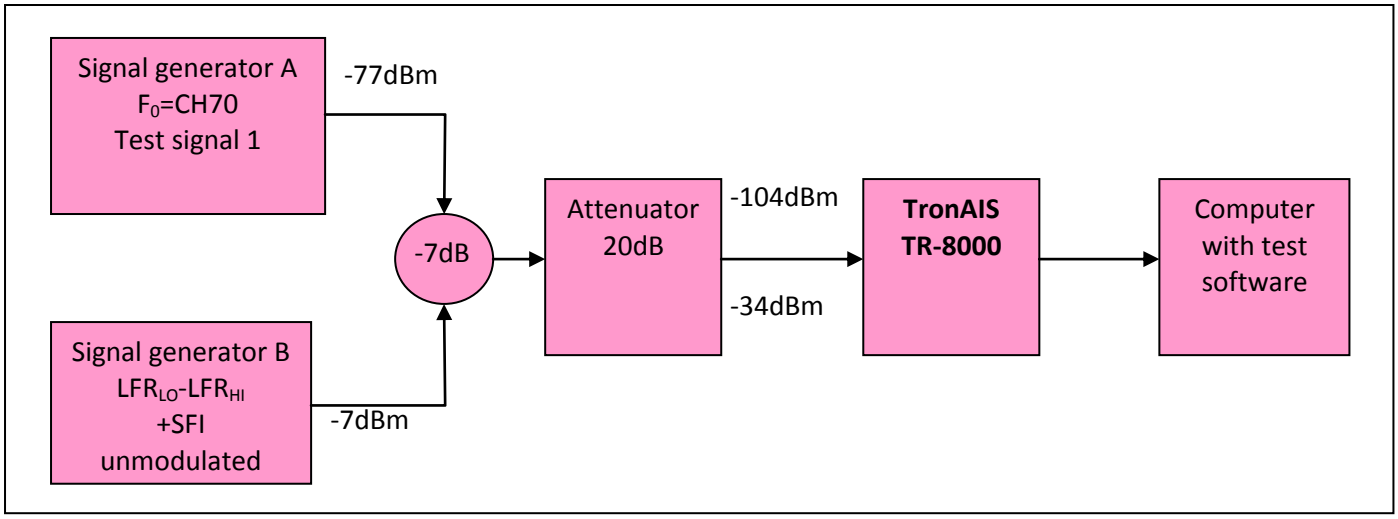

Figure 19: Measurement arrangement for DSC spurious response rejection.

3.3.6 Intermodulation Response Rejection , clause D.2.6

Measurement set up: Figure 20: Measurement setup for DSC intermodulation response rejection.

Conditions: Normal temperature and humidity.

Test equipment used: Signal Generator A (PXI)
Signal Generator B (JE-311)
Signal Generator C (JE-458)
Computer with test software
Attenuator 20dB
Signal mixer (mini-circuits)

Method of measurement: D.2.6

Limits: The BER shall not exceed 10^{-2} (PER < 20%)

Result: Pass

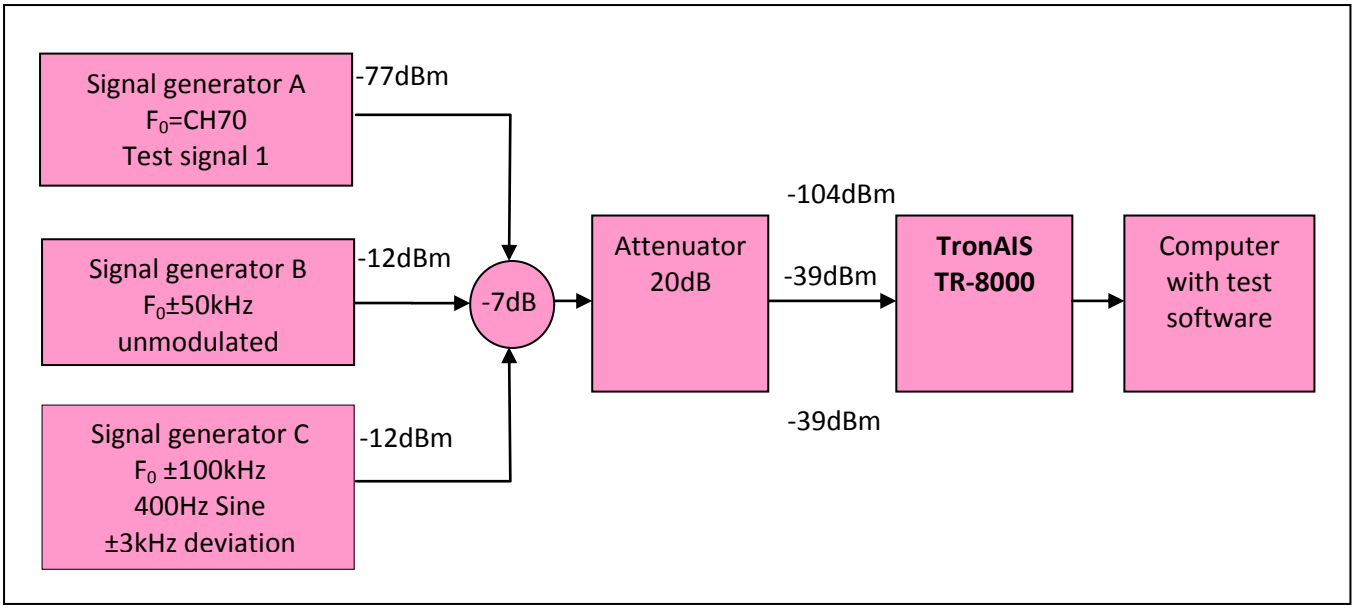

Figure 20: Measurement setup for DSC intermodulation response rejection.

Frequency B	Frequency C	Measured PER	Limit	Result Pass/Fail
156.575MHz	156.625MHz	0.0%	20%	Pass
156.475MHz	156.425MHz	0.0%	20%	Pass

Table 33: Measured results for DSC intermodulation response rejection.

3.3.7 Blocking or Desensitisation, clause D.2.7

Measurement set up: Figure 21: Measurement arrangement for DSC Blocking or desensitisation.

Conditions: Normal temperature and humidity.

Test equipment used: Signal Generator A (PXI)
Signal Generator B (JE-458)
Computer with test software
Attenuator 20dB
Signal mixer (mini-circuits)

Method of measurement: D.2.7

Limits: The BER shall not exceed 10^{-2} (PER < 20%)

Result: Pass

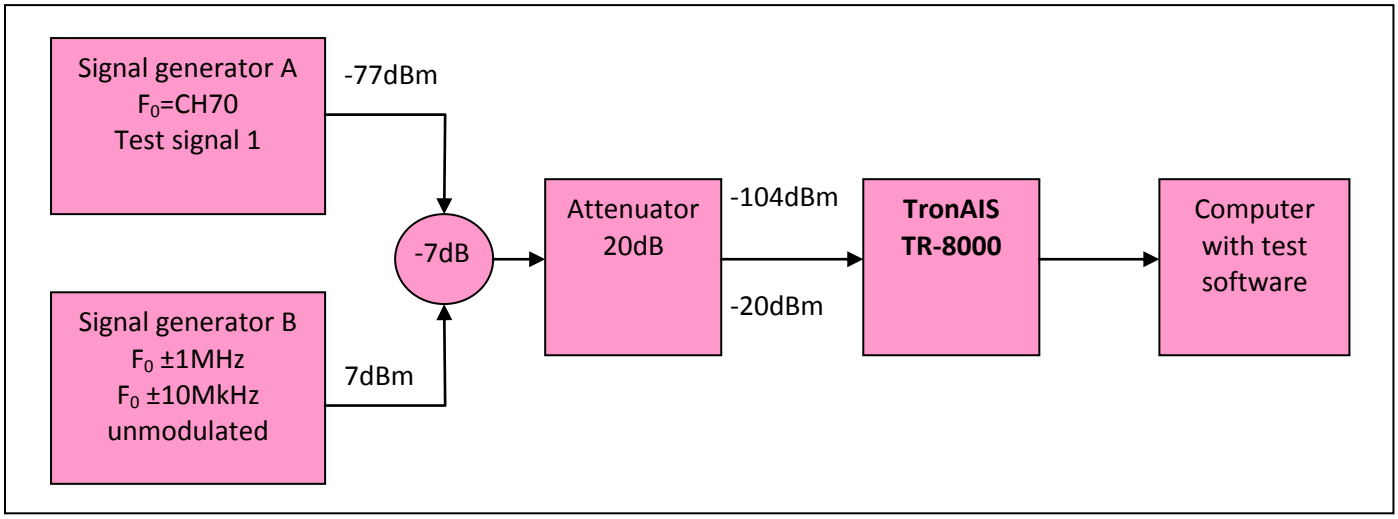

Figure 21: Measurement arrangement for DSC Blocking or desensitisation.

Unwanted signal Frequency (MHz)	Measured PER	Limit	Result Pass/Fail
146.525	0.0%	20%	Pass
155.525	2.0%	20%	Pass
166.525	0.0%	20%	Pass
157.525	0.0%	20%	Pass

Table 34: Measured results for DSC Blocking or desensitisation.

3.4 Conducted spurious emissions

3.4.1 Spurious emissions from the transmitter, clause 15.3.1

Measurement set up: Figure 22: Spurious emission from the transmitter measurement setup

Conditions: Normal temperature and humidity.

Test equipment used: Spectrum Analyzer (JE-253)
Attenuator 20dB
Notch filter (Jotron)

Method of measurement: 15.3.1

Limits: The power of any spurious emission on any discrete frequency shall not exceed 0,25 µW (-36 dBm) in the frequency range 9 kHz to 1 GHz and 1 µW (-30 dBm) in the frequency range 1 GHz to 4 GHz.

Notes: In order to measure the lowest noise components on the spectrum analyzer, a low resolution bandwidth is used in the band close to the transmission band and in the lowest frequency range. For all other frequencies a notch filter is applied to reduce the carrier power, and thereby increase the ability for the spectrum to measure low power components at higher resolution bandwidths (10kHz).

Result: Pass
See 4.4 Annex 4, Plots for the Conducted spurious emissions from the transmitter.

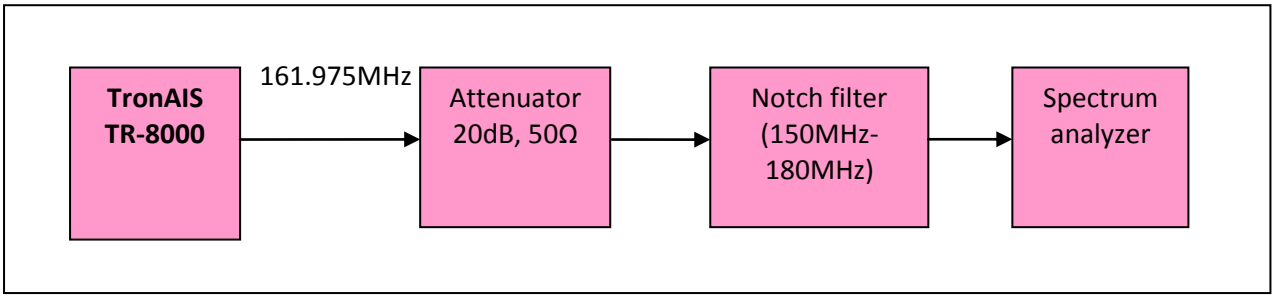

Figure 22: Spurious emission from the transmitter measurement setup.

Fstart	Fstop	RBW	Limit	Notch filter applied	Result Pass/Fail
9kHz	1MHz	3kHz	-36 dBm	Yes	Pass
1MHz	140MHz	10kHz	-36 dBm	Yes	Pass
140MHz	161.5MHz	3kHz	-36 dBm	No	Pass
161.5MHz	161.9125MHz	300Hz	-36 dBm	No	Pass
162.0375MHz	162.5MHz	300Hz	-36 dBm	No	Pass
162.5MHz	180MHz	3kHz	-36 dBm	No	Pass
180MHz	1GHz	10kHz	-36 dBm	Yes	Pass
1GHz	4GHz	10kHz	-30 dBm	Yes	Pass

Table 35: Test results and setup for the spectrum analyzer on the frequency bands analyzed. On some of the frequency bands, a notch filter is applied on the carrier frequency.

Frequency	RBW	Level	Limit	Notch filter applied	Result Pass/Fail
149.175MHz	3kHz	-39.6dBm	-36dBm	No	Pass
174.775MHz	3kHz	-36.7dBm	-36dBm	No	Pass
323.980MHz	10kHz	-39.6dBm	-36dBm	Yes	Pass
485.925MHz	10kHz	-50dBm	-36dBm	Yes	Pass
647.900MHz	10kHz	-50.4dBm	-36dBm	Yes	Pass

Table 36: Noted spurious emissions from the transmitter.

3.4.2 Spurious emissions from the receiver, clause 15.3.2

Measurement set up: Figure 23: Spurious emission from the receiver measurement setup.

Conditions: Normal temperature and humidity.

Test equipment used: Spectrum Analyzer (JE-253)
Attenuator 20dB

Method of measurement: 15.3.2

Limits: The power of any spurious emission in the specified range at the antenna terminal shall not exceed –57dBm (2nW) in the frequency range 9kHz to 1 GHz and –47dBm (20nW) in the frequency range 1GHz to 4GHz.

Result: Pass,
See 4.5 Annex 5, Plots for the Conducted spurious emissions from the receiver.

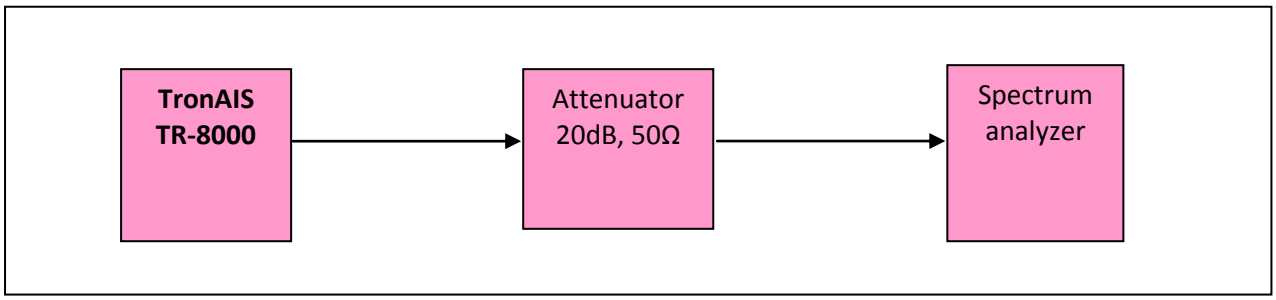

Figure 23: Spurious emission from the receiver measurement setup.

Fstart	Fstop	RBW	Limit	Result Pass/Fail
9kHz	1MHz	3kHz	-57dBm	Pass
1MHz	1GHz	10kHz	-57dBm	Pass
1GHz	4GHz	10kHz	-47dBm	Pass

Table 37: Test results and setup for the spectrum analyzer on the frequency bands analyzed.

4 Annex

4.1 Annex 1, spectral plots

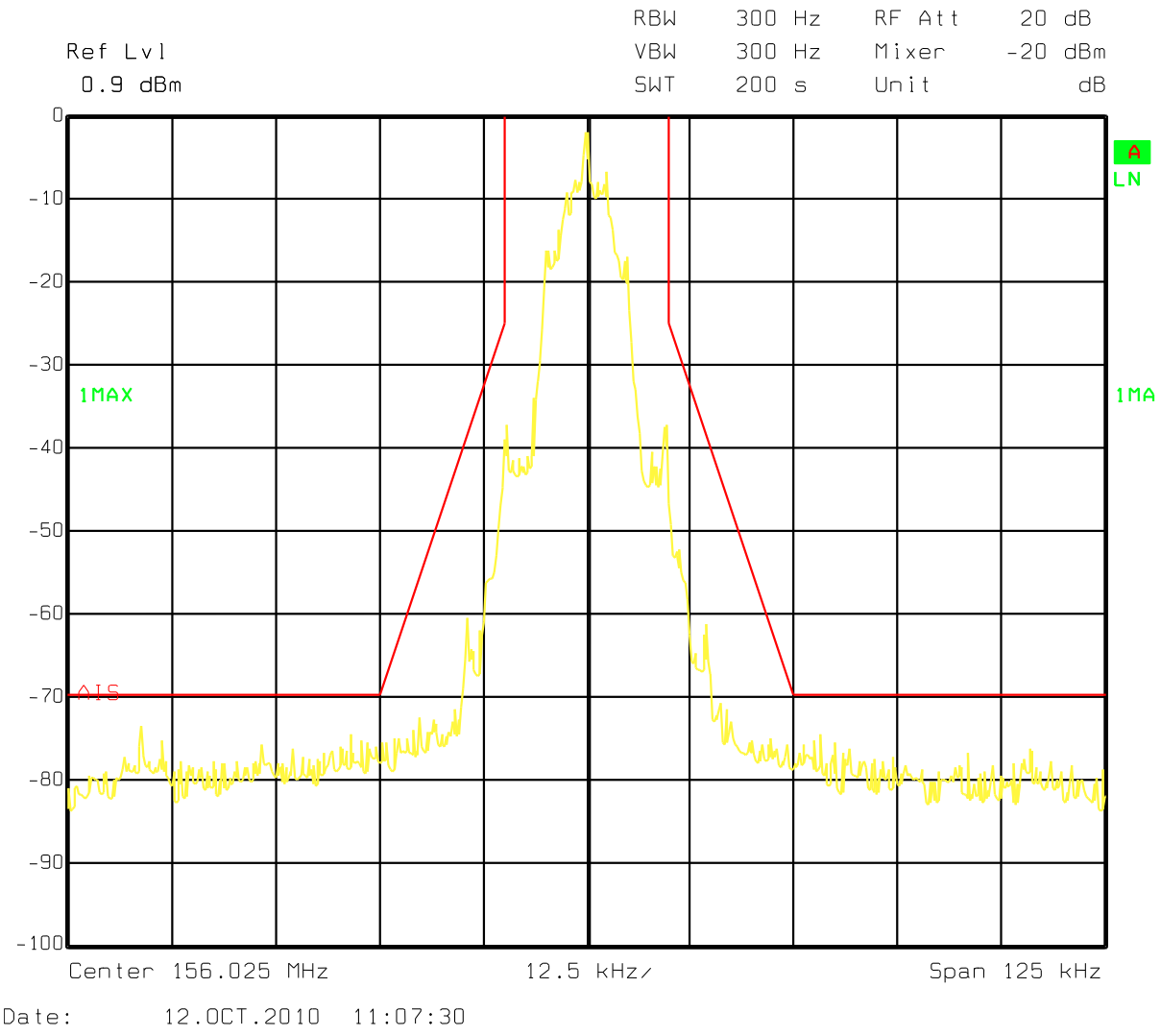

Figure 24: Modulation spectrum at 156.025MHz with test signal 4. The scale is in dBc, relative to the measured transmitted power in 3.1.2. A 40dB external attenuator is used.

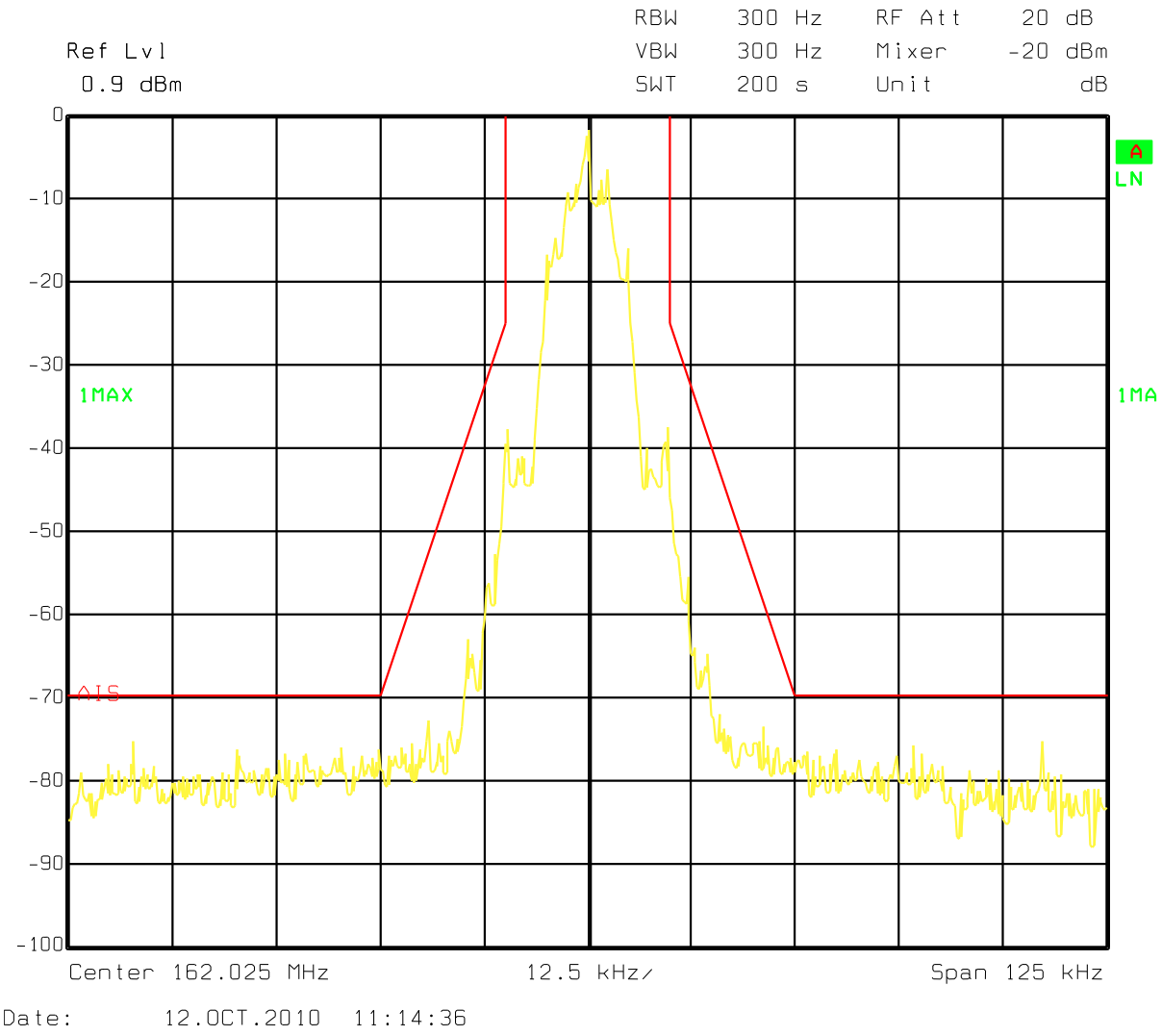

Figure 25: Modulation spectrum at 162.025MHz with test signal 4. The scale is in dBc, relative to the measured transmitted power in 3.1.2. A 40dB external attenuator is used.

4.2 Annex 2, Transmitter output power characteristics measurement plots

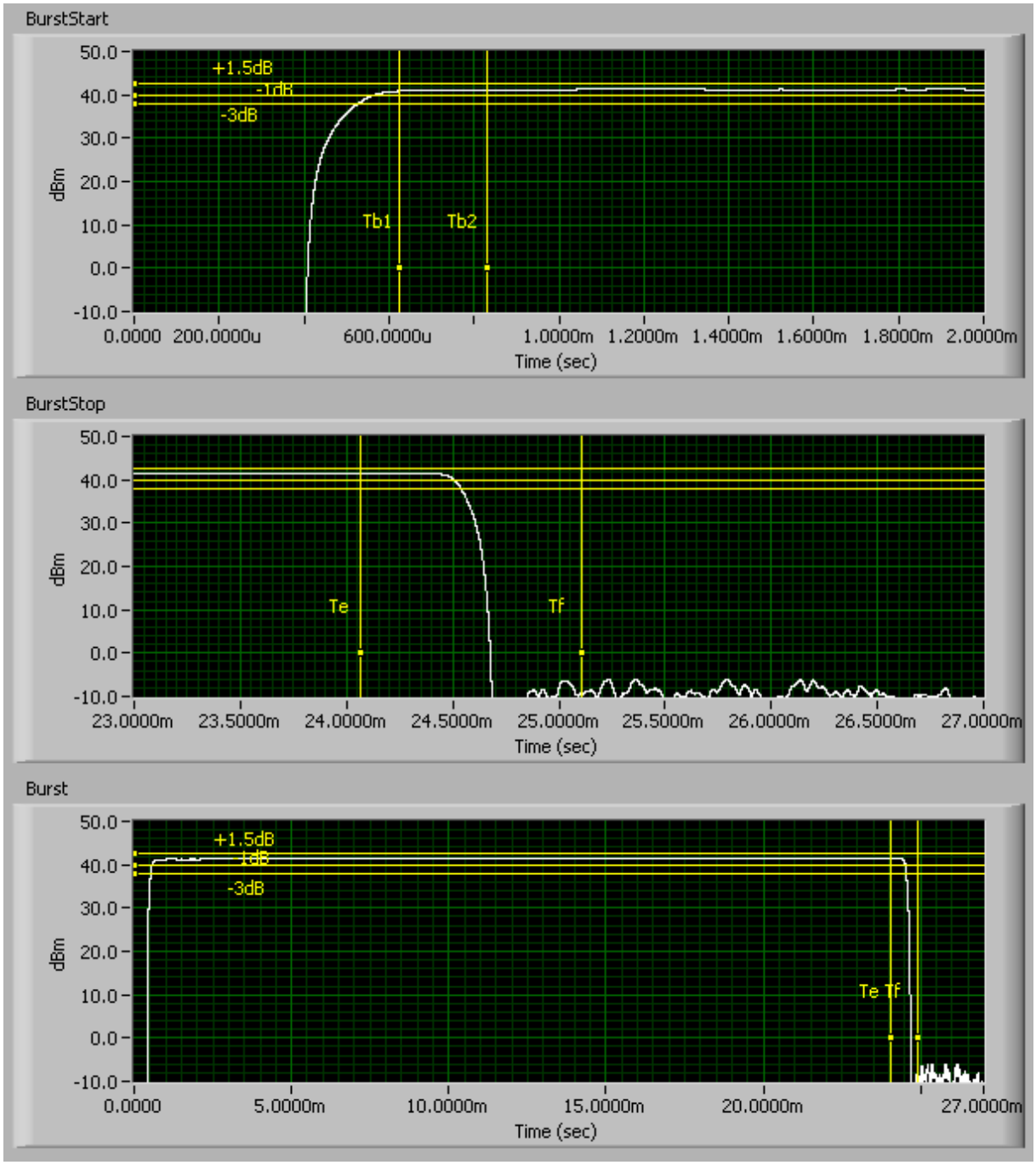

Figure 26: Power versus time characteristics with emphasis on time, f_0=156.025MHz.

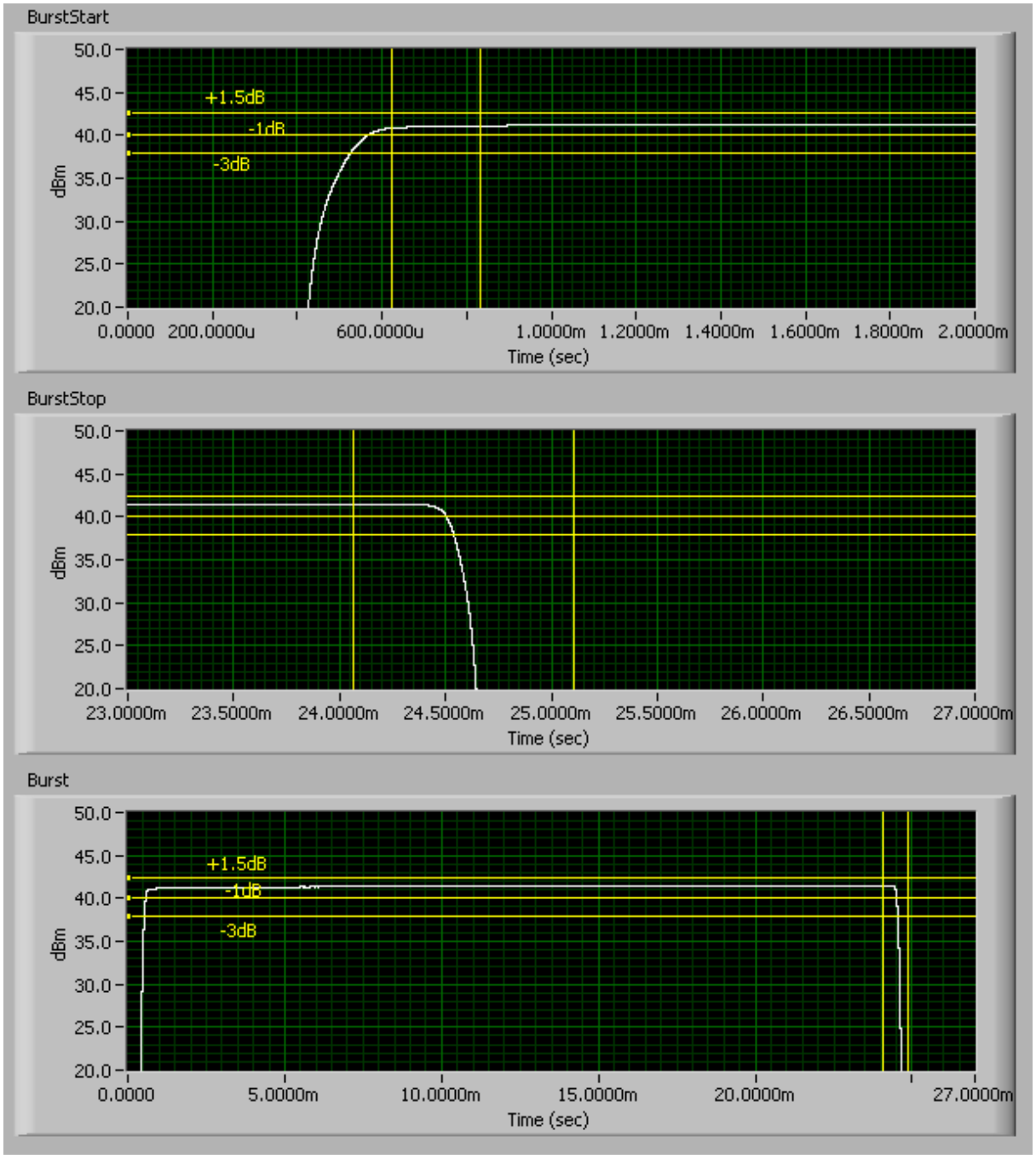

Figure 27: Power versus time characteristics with emphasis on power, f_0=156.025MHz.

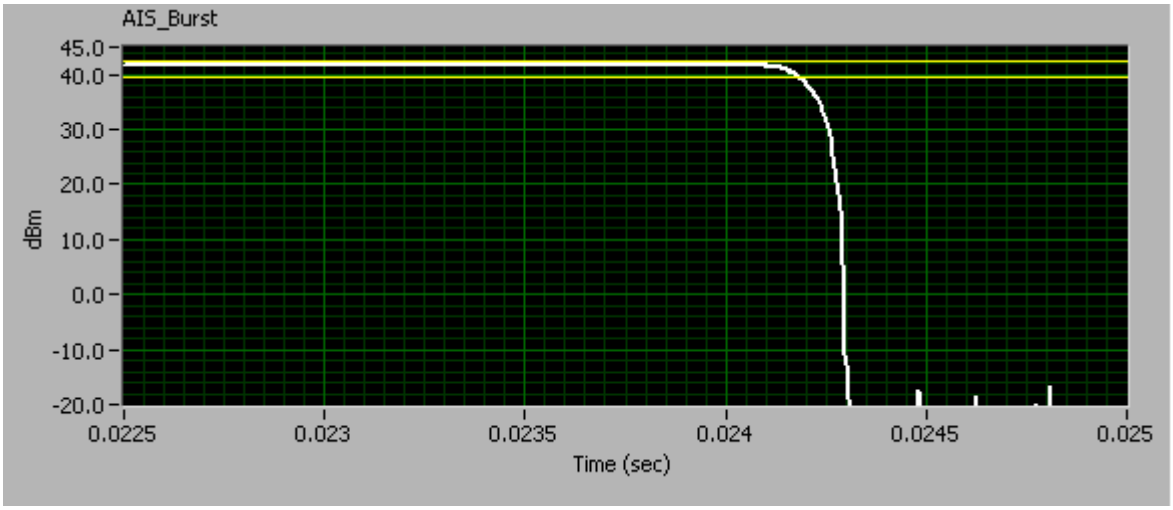

Figure 28: Power versus Time characteristics with emphasis on the low power area f_0=156.025MHz. (Timing is not exact in this plot.)

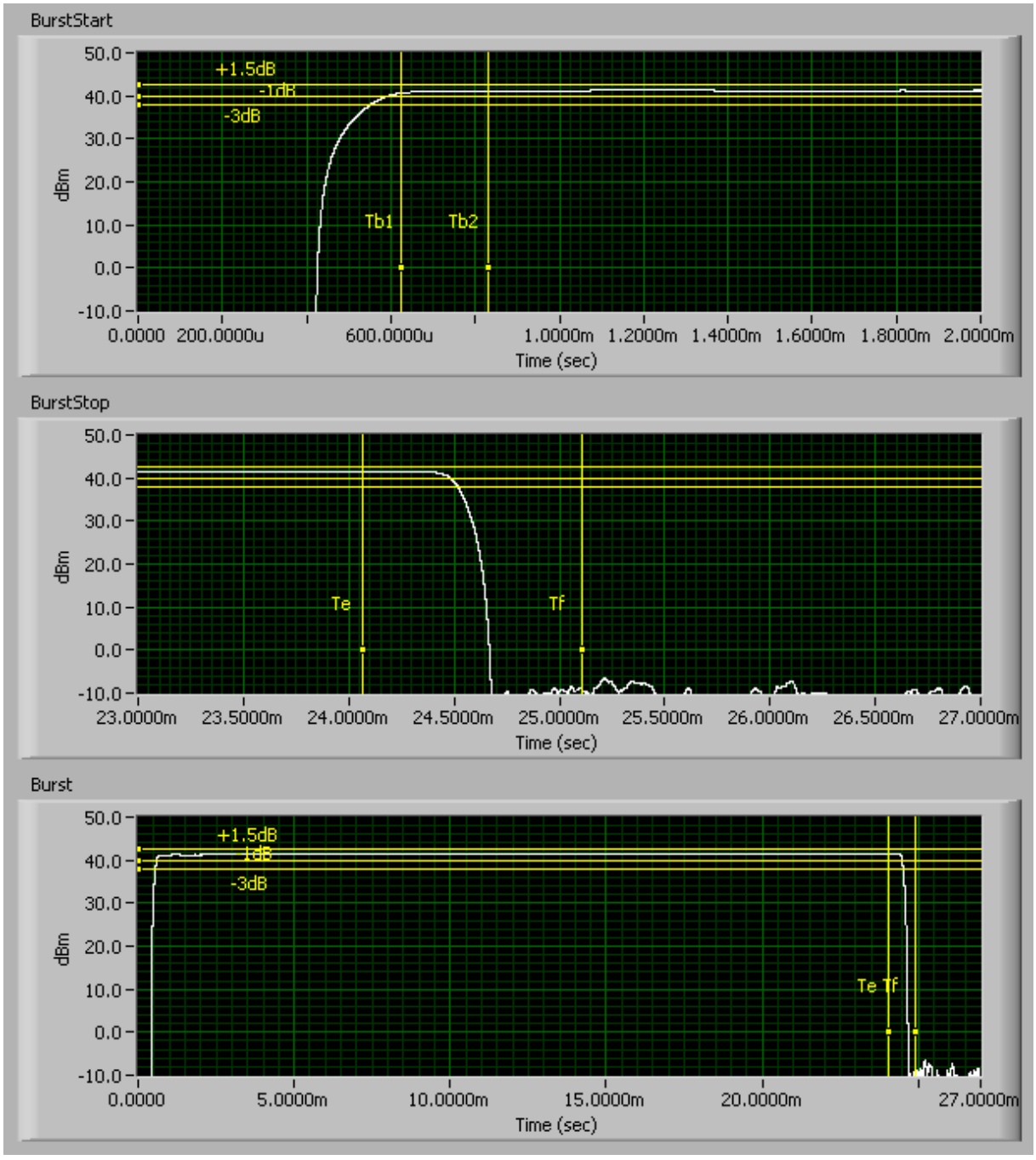

Figure 29: Power versus time characteristics with emphasis on time, f_0=162.025MHz.

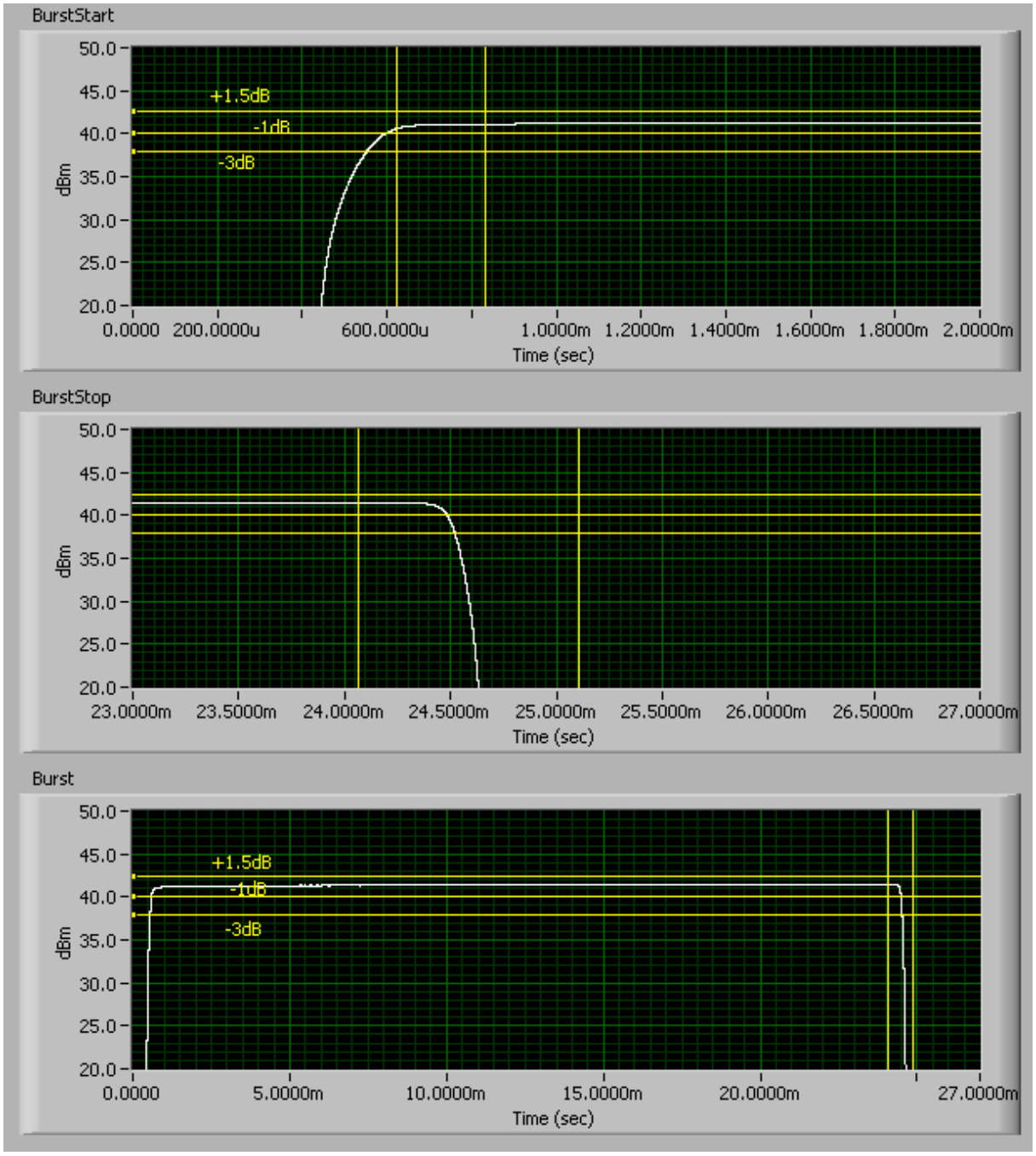

Figure 30: Power versus time characteristics with emphasis on power, f_0=162.025MHz.

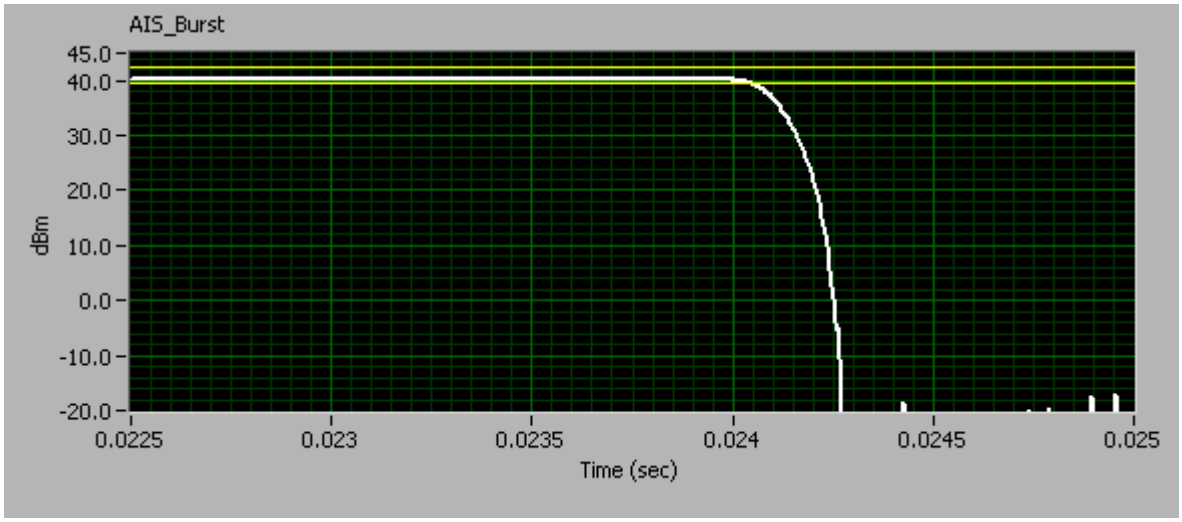

Figure 31: Power versus Time characteristics with emphasis on the low power area f_0=162.025MHz. (Timing is not exact in this plot.)

4.3 Annex 3, DSC Spurious Response Rejection results.

F_0 = 156.525MHz (DSC)			
Detected spurious frequency (MHz)	**PER**	**Limit**	**Result Pass/Fail**
156.495	5 %	20%	Pass
157.435	3 %	20%	Pass
163.995	3 %	20%	Pass
167.965	1.50 %	20%	Pass
168.475	4 %	20%	Pass
171.330	6 %	20%	Pass
173.095	3 %	20%	Pass
178.615	2.50 %	20%	Pass
178.880	4 %	20%	Pass
179.020	1.50 %	20%	Pass
179.025	0 %	20%	Pass
179.030	2.50 %	20%	Pass
179.055	2.50 %	20%	Pass
181.955	1 %	20%	Pass
185.835	4 %	20%	Pass
192.925	3.50 %	20%	Pass
194.090	6 %	20%	Pass
195.235	2.50 %	20%	Pass
195.485	1.50 %	20%	Pass
204.880	4.50 %	20%	Pass
209.575	0.50 %	20%	Pass
209.680	1.50 %	20%	Pass
219.810	3 %	20%	Pass
224.835	3.50 %	20%	Pass
225.090	1.50 %	20%	Pass
226.940	2.50 %	20%	Pass
230.300	1.50 %	20%	Pass
246.465	2.50 %	20%	Pass

Table 38: Search results for spurious response and corresponding PER over the Limited Frequency Range for the DSC receiver. Wanted signal level is adjusted to -104dBm and unwanted signal level is adjusted to -34dBm at the receiver.

F_0 = 156.525MHz (DSC)			
Detected spurious frequency (MHz)	**PER**	**Limit**	**Result Pass/Fail**
358.050	3%	20%	Pass
448.050	2%	20%	Pass
559.575	5.5%	20%	Pass
649.575	2.5%	20%	Pass
761.100	2%	20%	Pass
851.100	5%	20%	Pass

Table 39: PER for the Specific Frequencies of interest for the DSC receiver. Wanted signal level is adjusted to -104dBm and unwanted signal level is adjusted to -34dBm at the receiver.

4.4 Annex 4, Plots for the Conducted spurious emissions from the transmitter.

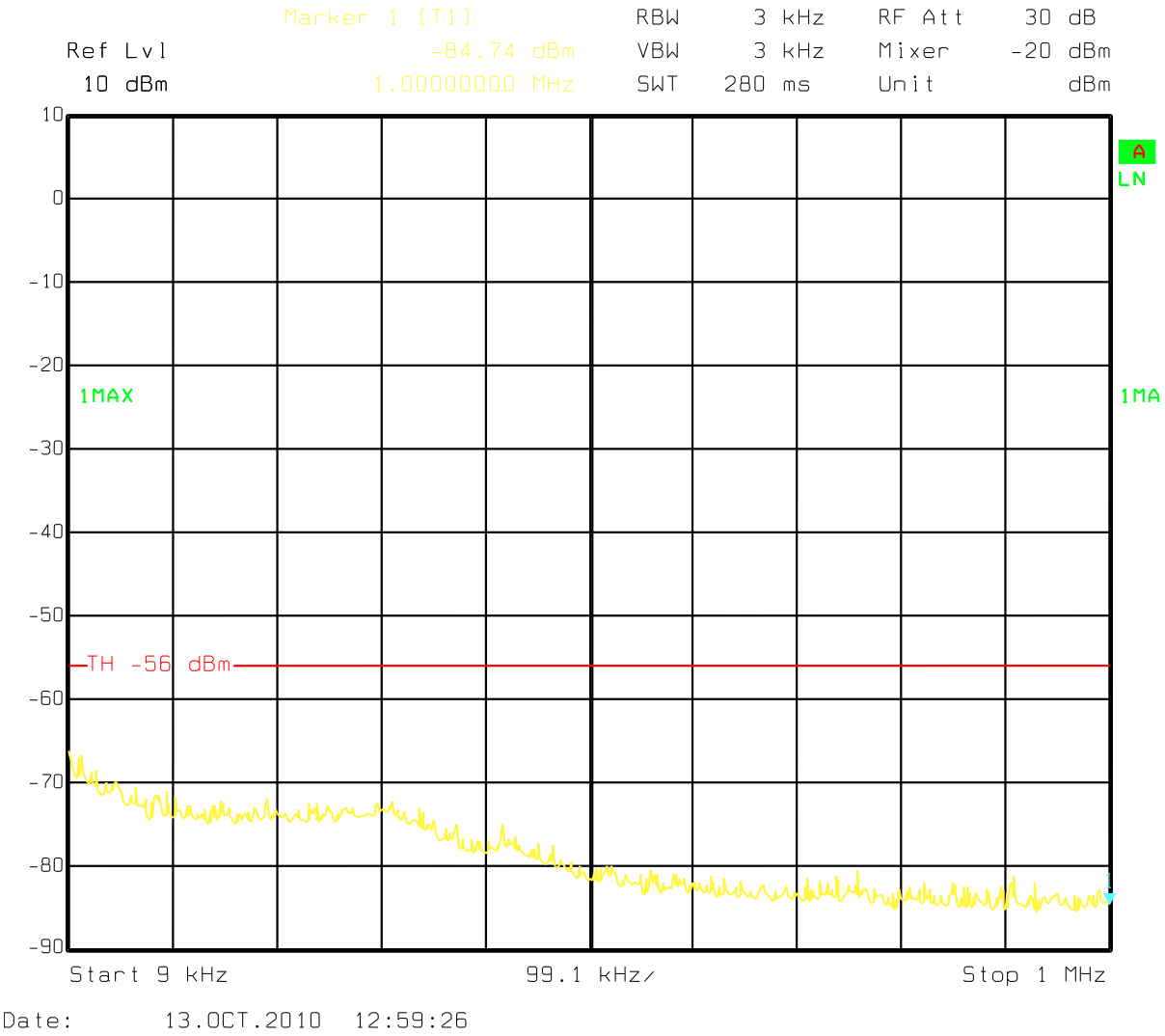

Figure 32: Conducted spurious emissions from the transmitter in the frequency region from 9kHz to 1MHz. A notch filter is applied at the transmitter frequency in order to increase the resolution of the measuring device at low power (see Figure 45). A 20dB external attenuator is used.

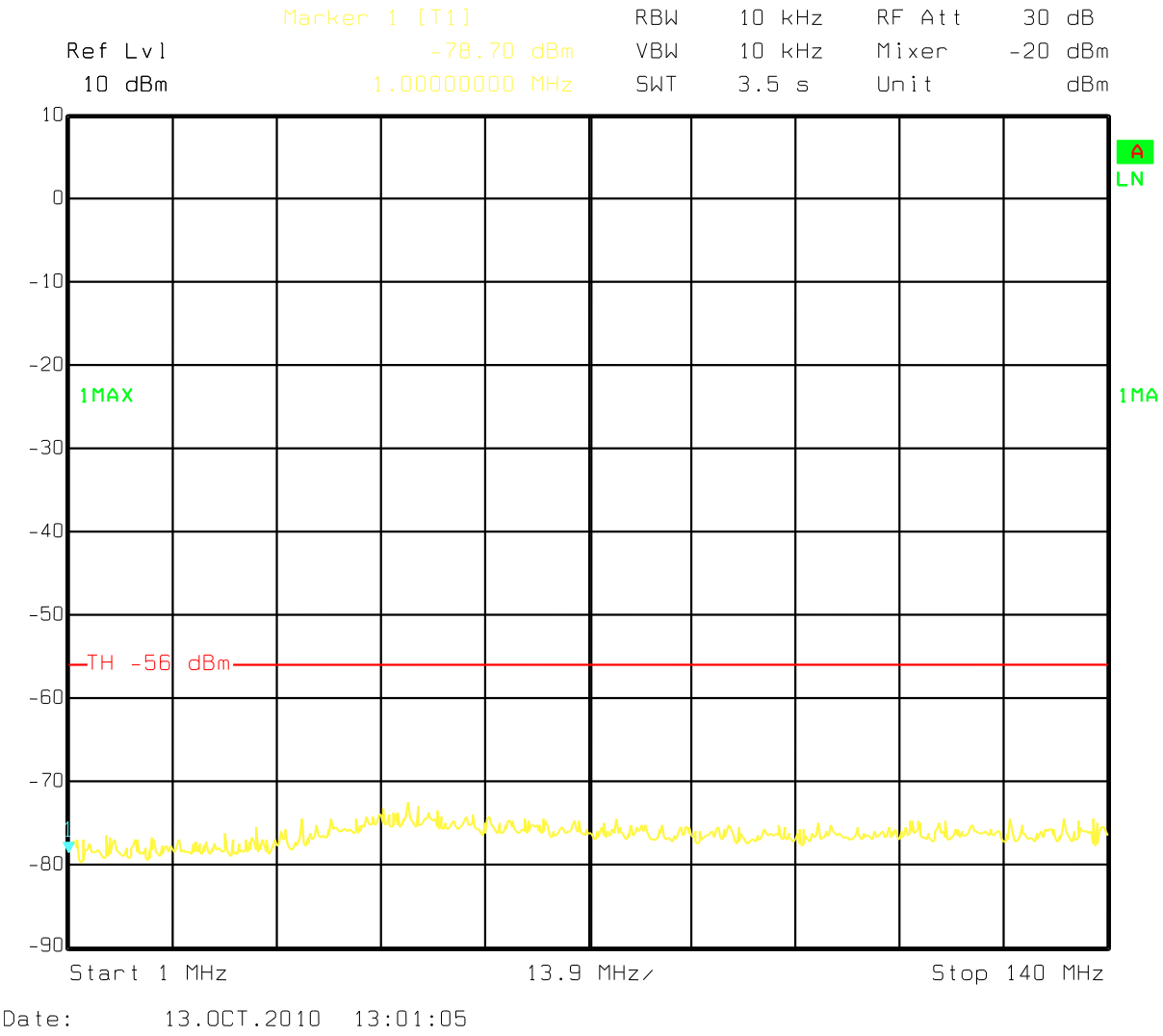

Figure 33: Conducted spurious emissions from the transmitter in the frequency region from 1MHz to 140MHz. A notch filter is applied at the transmitter frequency in order to increase the resolution of the measuring device at low power (see Figure 45). A 20dB external attenuator is used.

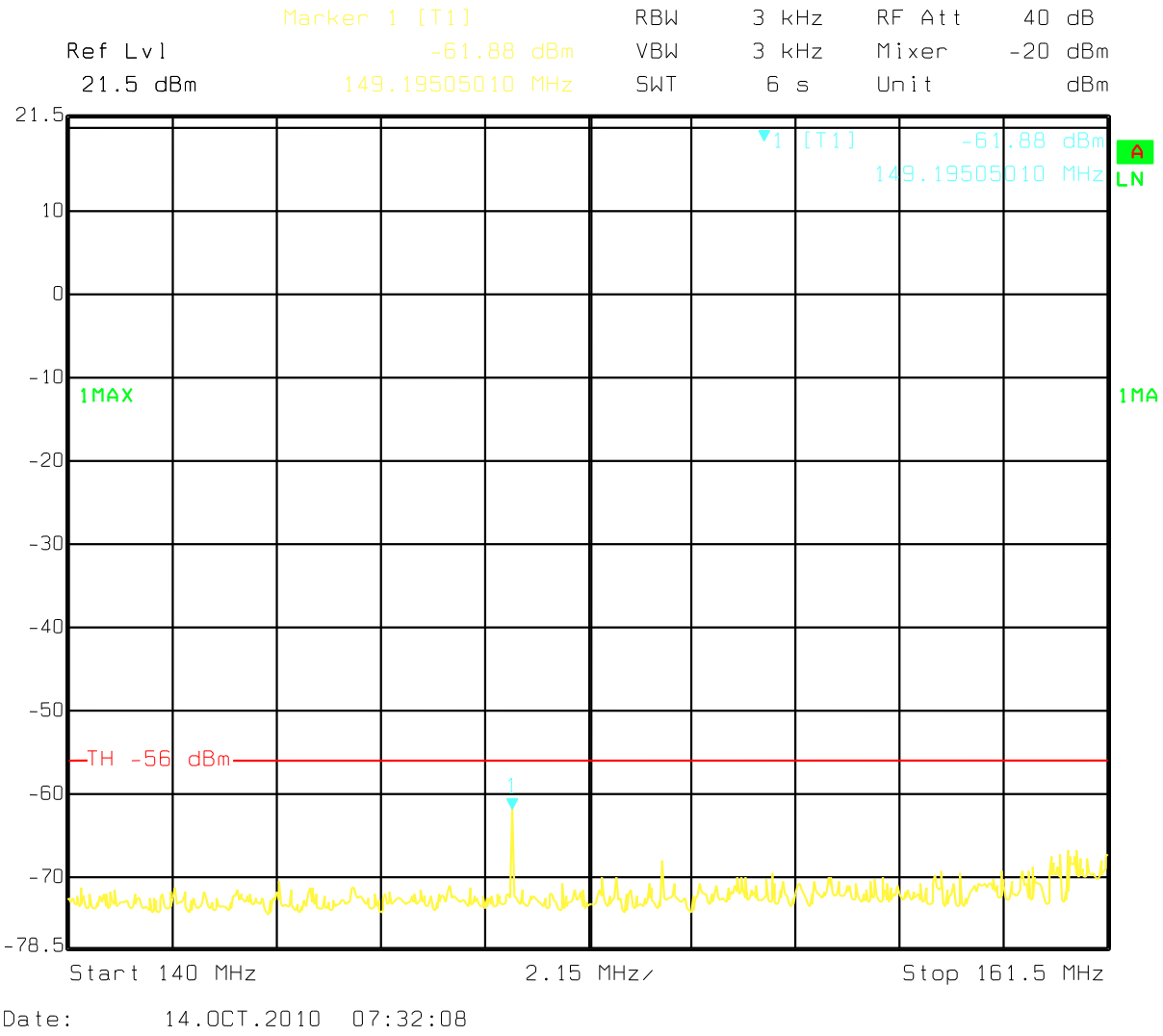

Figure 34: Conducted spurious emissions from the transmitter in the frequency region from 140MHz to 161.5MHz. A low RBW is used in order to measure the low power components without applying a notch filter, which would affect measurements this close to the transmitter frequency at 161.975MHz. The spurious emission marked is further evaluated in Figure 40. A 20dB external attenuator is used.

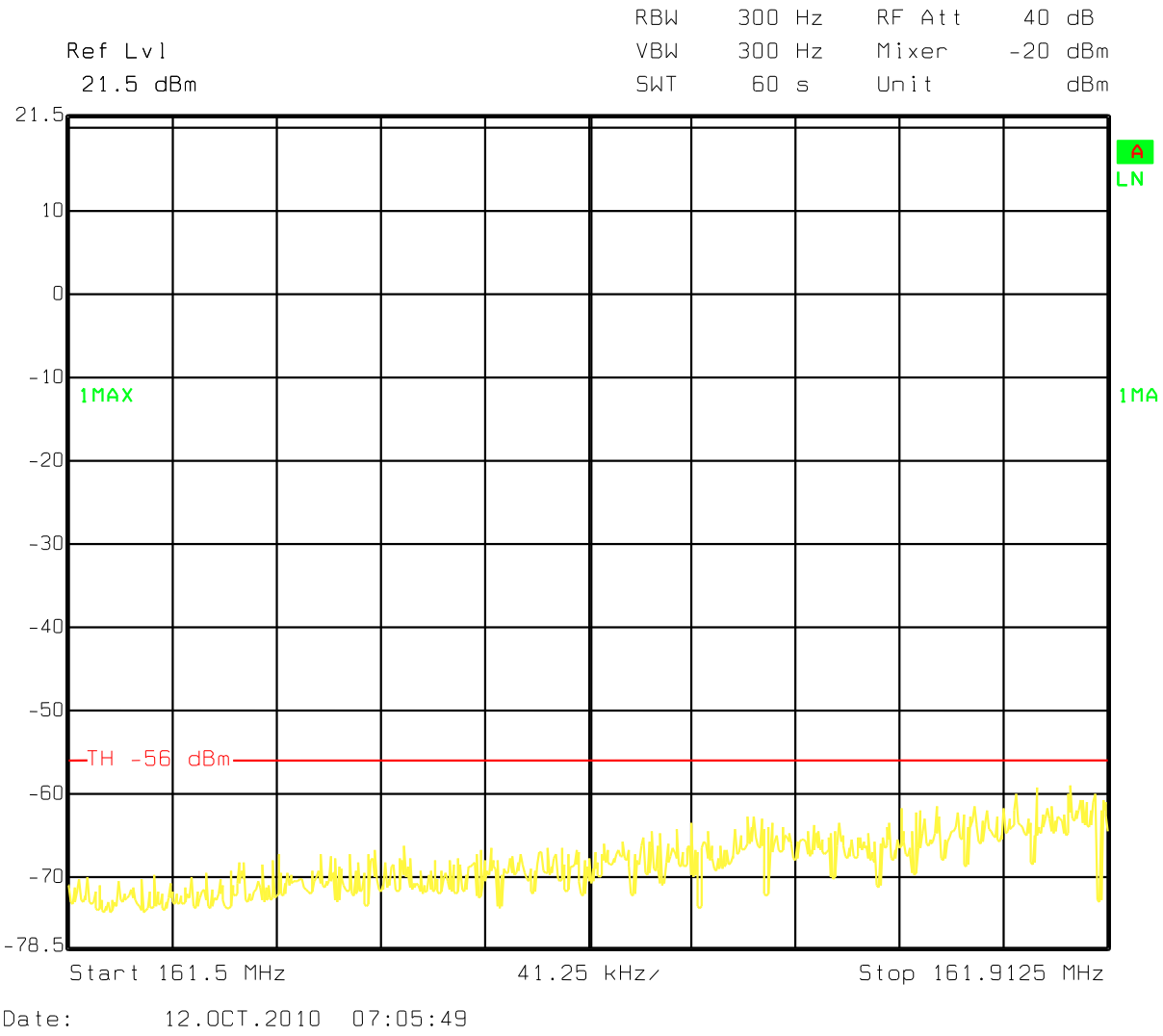

Figure 35: Conducted spurious emissions from the transmitter in the frequency region from 161.5MHz to 161.9125MHz. A low RBW is used in order to measure accurately close to the transmitter frequency at 161.975MHz. A 20dB external attenuator is used.

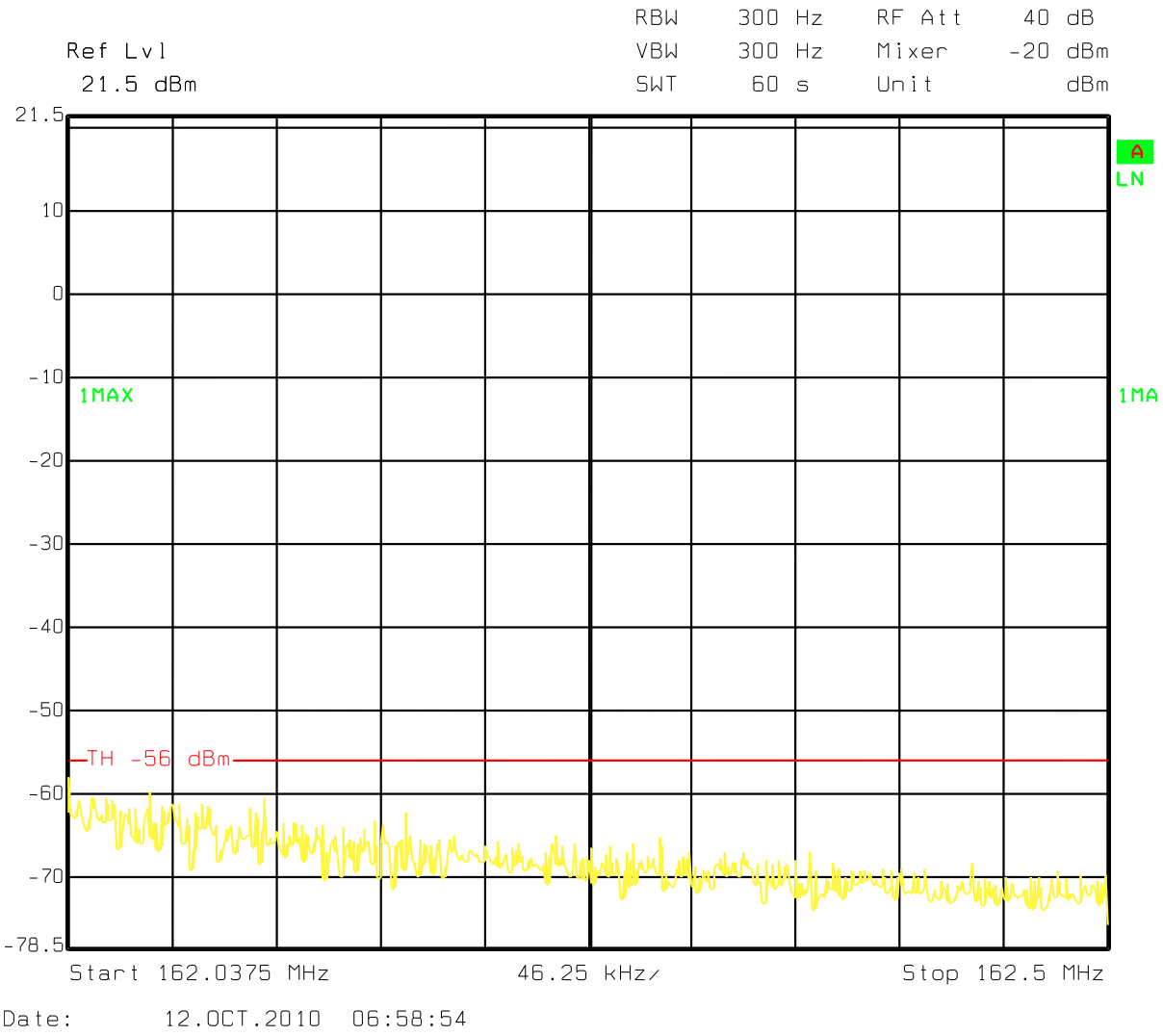

Figure 36: Conducted spurious emissions from the transmitter in the frequency region from 162.0375MHz to 162.5MHz. A low RBW is used in order to measure accurately close to the transmitter frequency at 161.975MHz. A 20dB external attenuator is used.

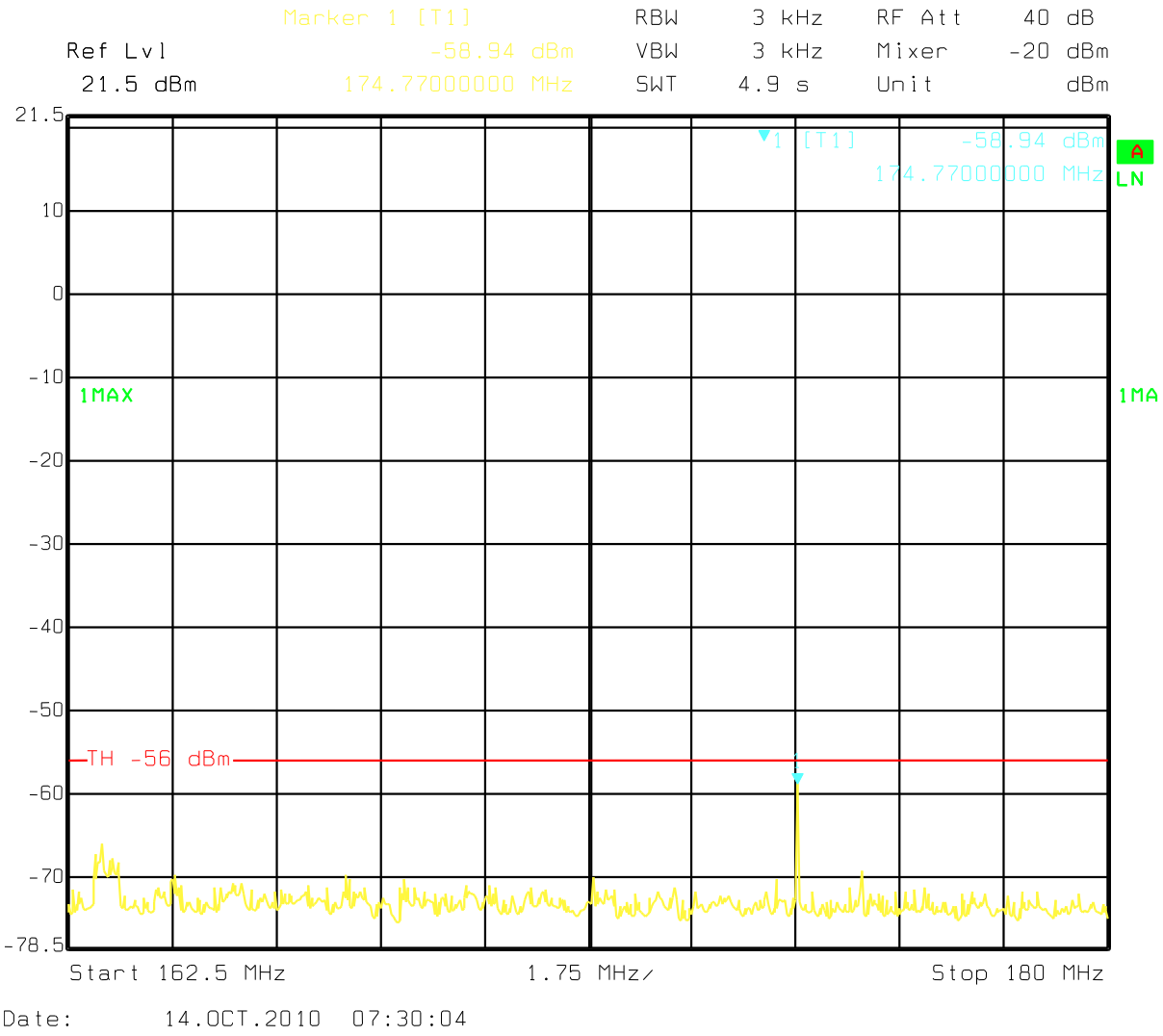

Figure 37: Conducted spurious emissions from the transmitter in the frequency region from 162.5MHz to 180MHz. A low RBW is used in order to measure the low power components without applying a notch filter, which would affect measurements this close to the transmitter frequency at 161.975MHz. The spurious emission marked is further evaluated in Figure 41. A 20dB external attenuator is used.

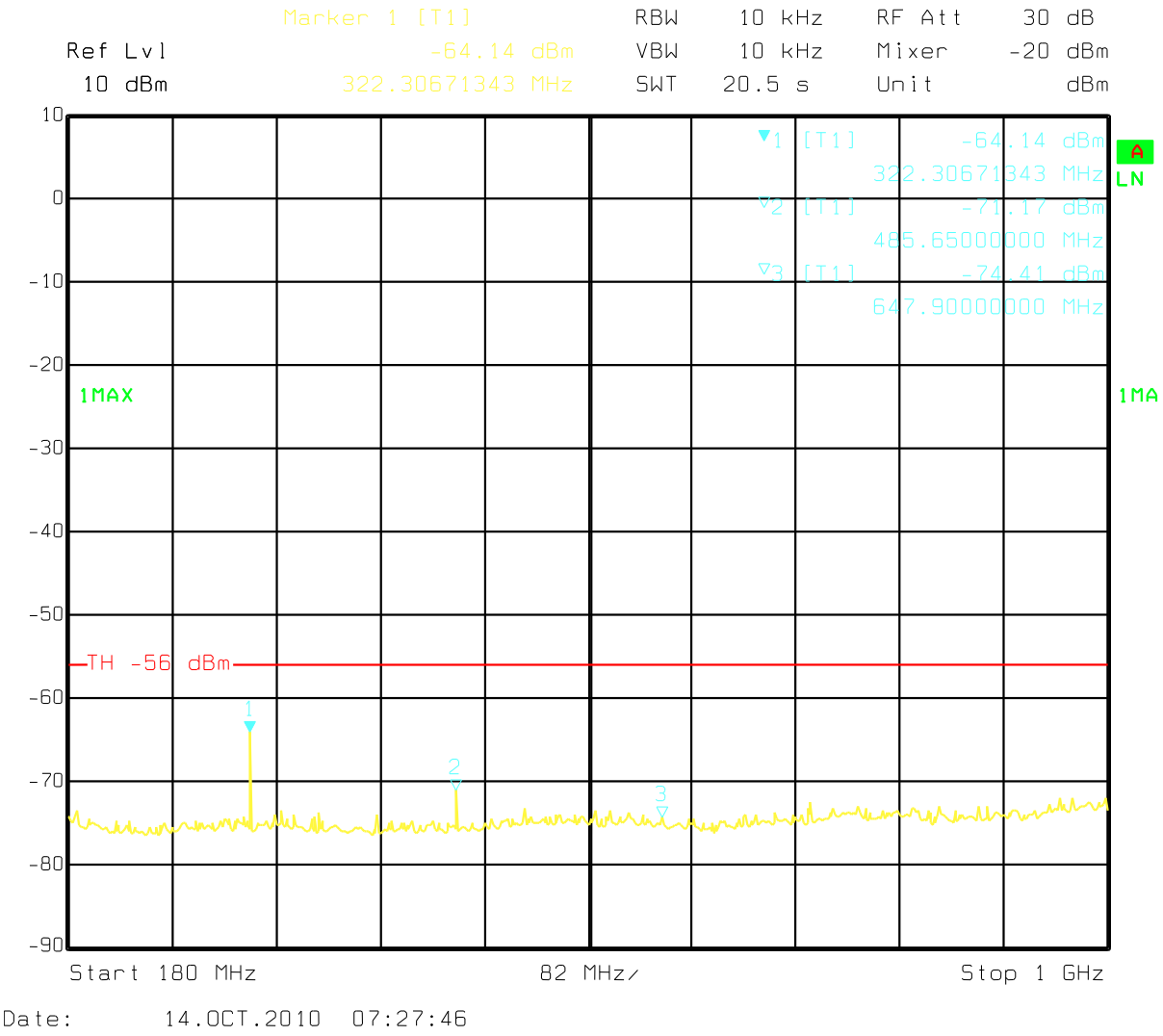

Figure 38: Conducted spurious emissions from the transmitter in the frequency region from 180MHz to 1GHz. A notch filter is applied at the transmitter frequency in order to increase the resolution of the measuring device at low power (see Figure 45). Some spurious components are marked and further evaluated in Figure 42 to Figure 44. A 20dB external attenuator is used.

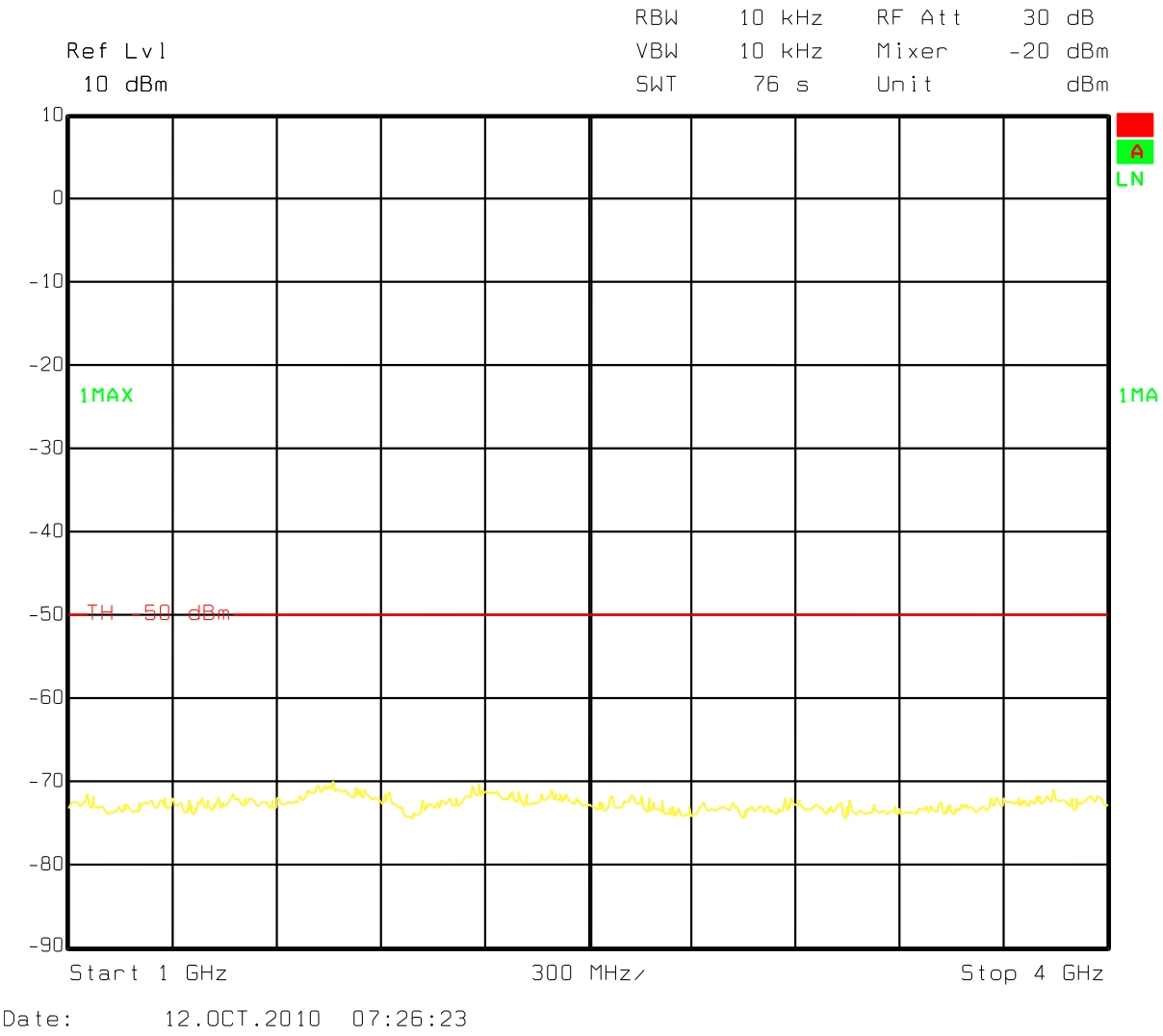

Figure 39: Conducted spurious emissions from the transmitter in the frequency region from 180MHz to 1GHz. A notch filter is applied at the transmitter frequency in order to increase the resolution of the measuring device at low power (see Figure 45). A 20dB external attenuator is used.

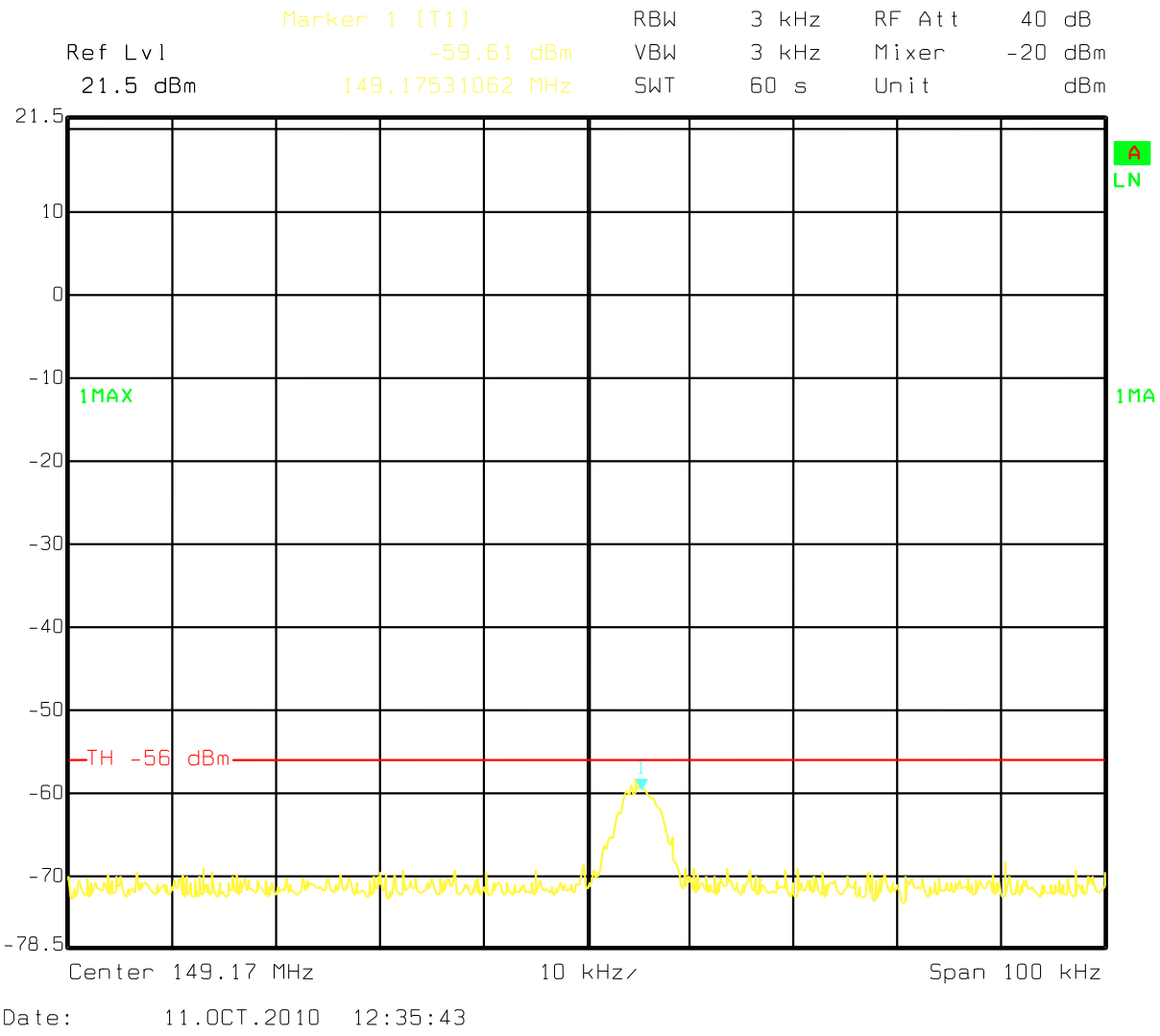

Figure 40: Noted spurious emission at 149.175MHz (transmitting frequency – 12.8MHz), the level measured is -39.6dBm. A 20dB external attenuator is used.

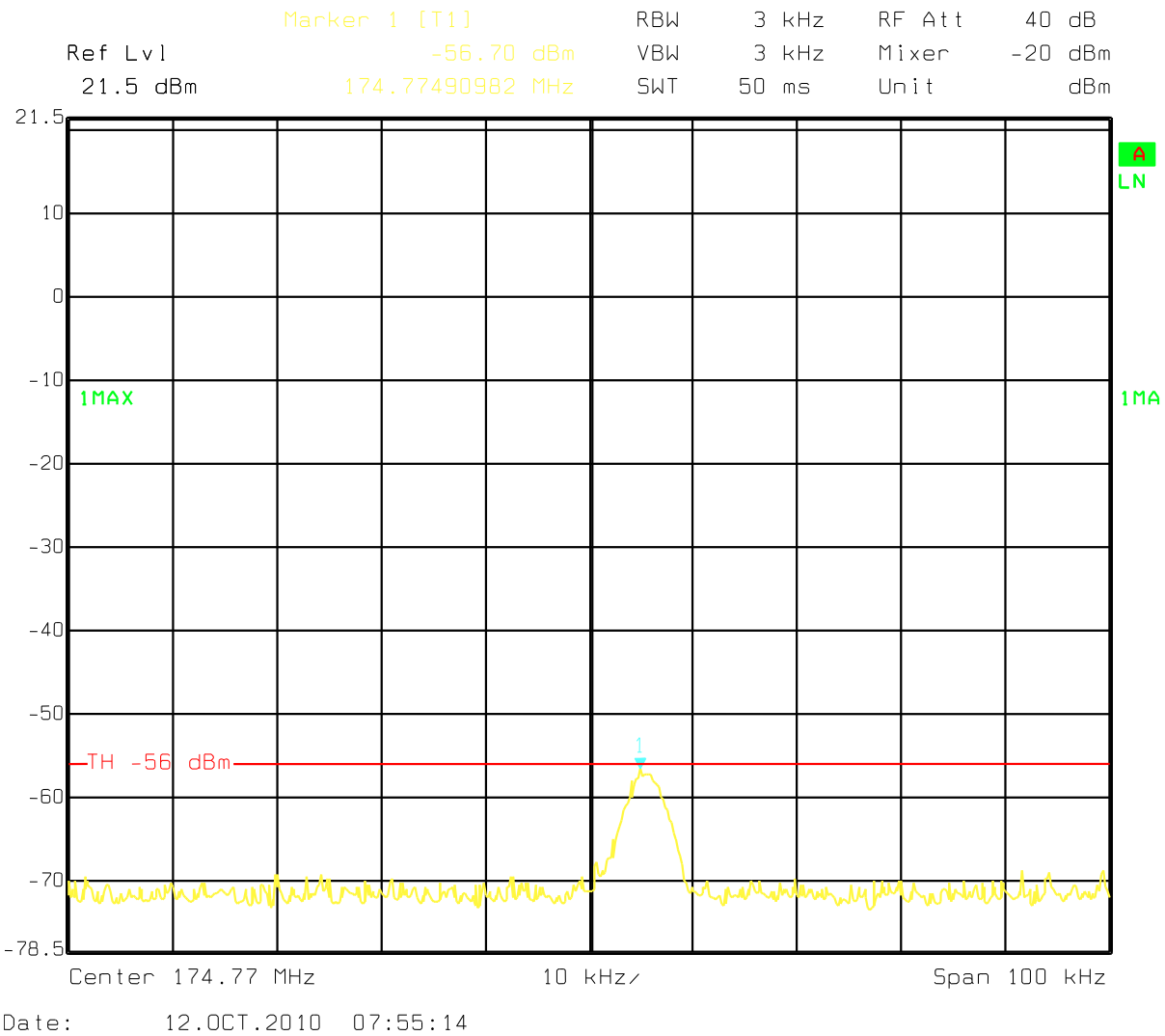

Figure 41: Noted spurious emission at 174.775MHz (transmitting frequency + 12.8MHz), the level measured is -36.7dBm. A 20dB external attenuator is used.

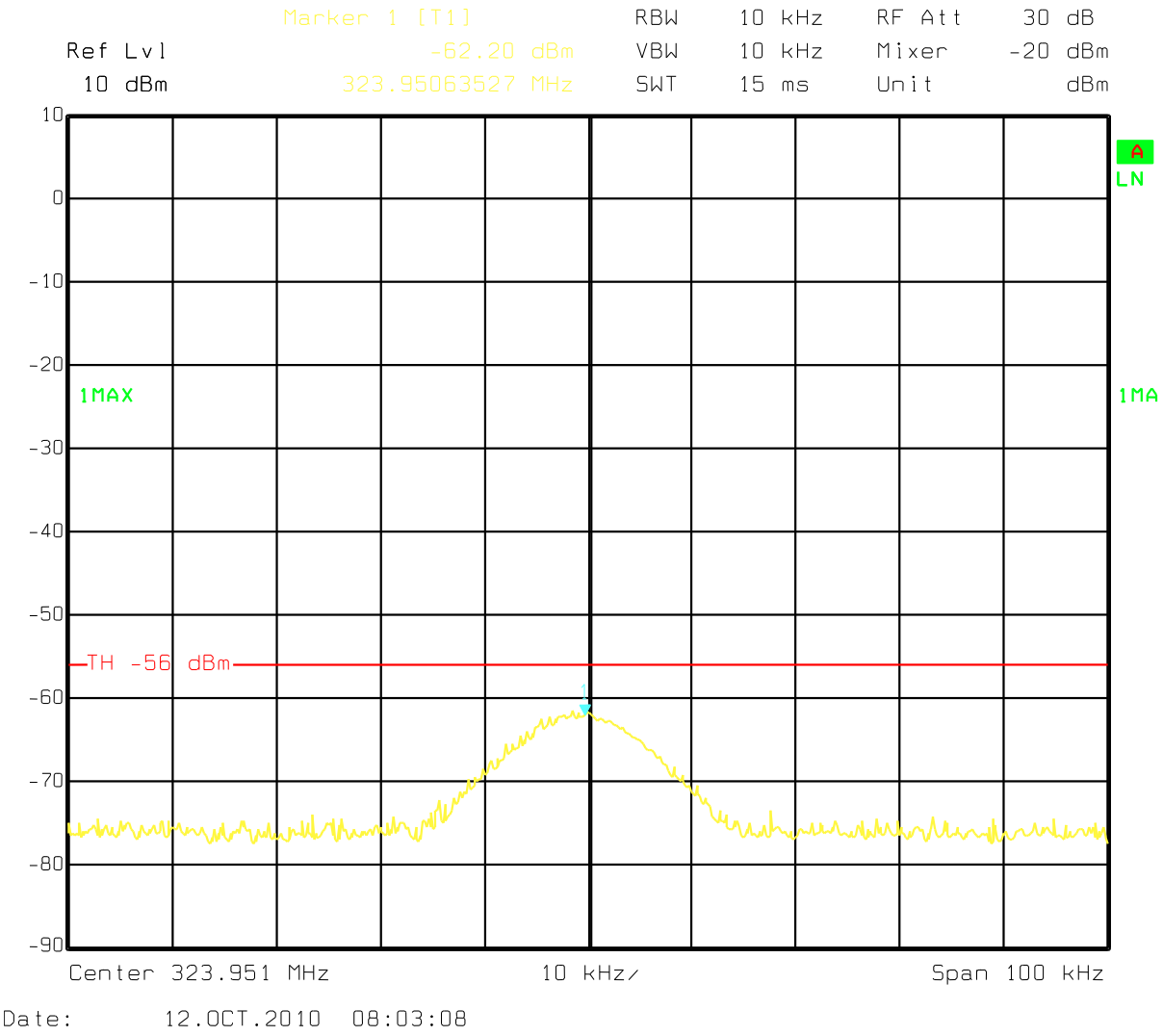

Figure 42: Noted spurious emission at 323.95MHz (transmitting frequency * 2), the level measured is -42.2dBm. A notch filter is applied at the transmitter frequency in order to increase the resolution of the measuring device at low power. A 20dB external attenuator is used.

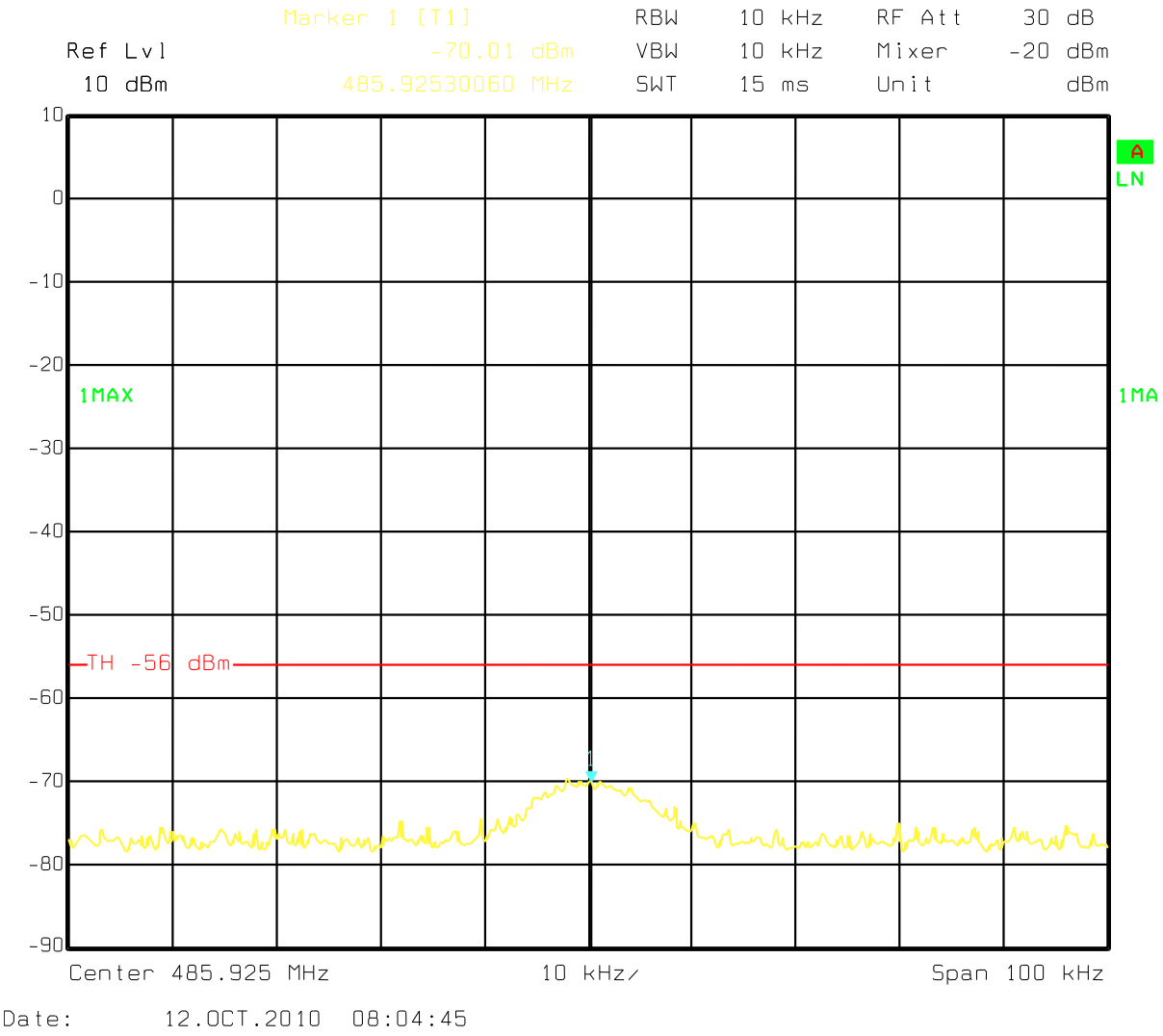

Figure 43: Noted spurious emission at 485.925MHz (transmitting frequency * 3), the level measured is -50dBm. A notch filter is applied at the transmitter frequency in order to increase the resolution of the measuring device at low power. A 20dB external attenuator is used.

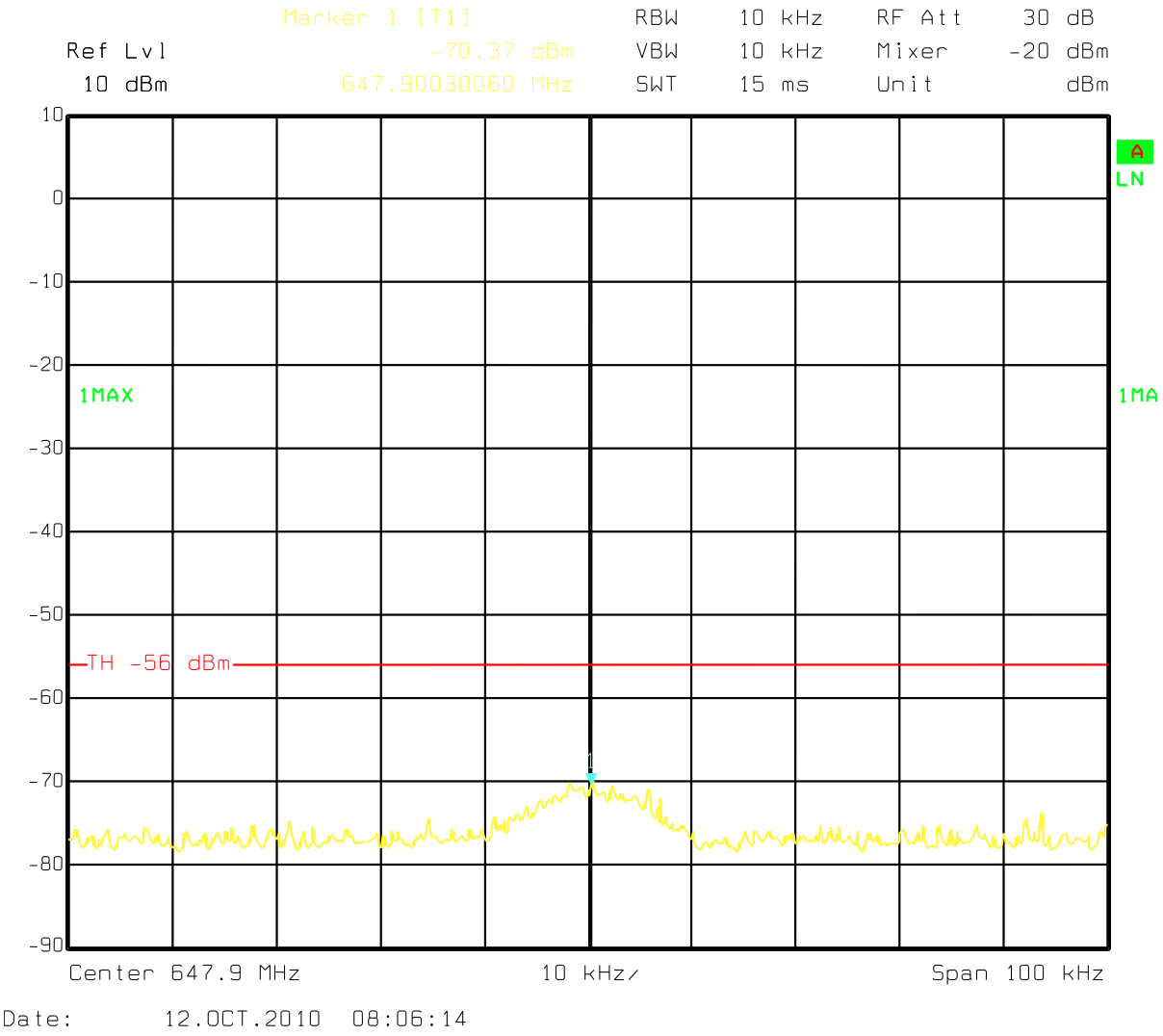

Figure 44: Noted spurious emission at 647.9MHz (transmitting frequency * 4), the level measured is -50.37dBm. A notch filter is applied at the transmitter frequency in order to increase the resolution of the measuring device at low power. A 20dB external attenuator is used.

Figure 45: Filter response for the Notch filter applied in some of the measurements of the conducted spurious emissions from the transmitter.

4.5 Annex 5, Plots for the Conducted spurious emissions from the receiver.

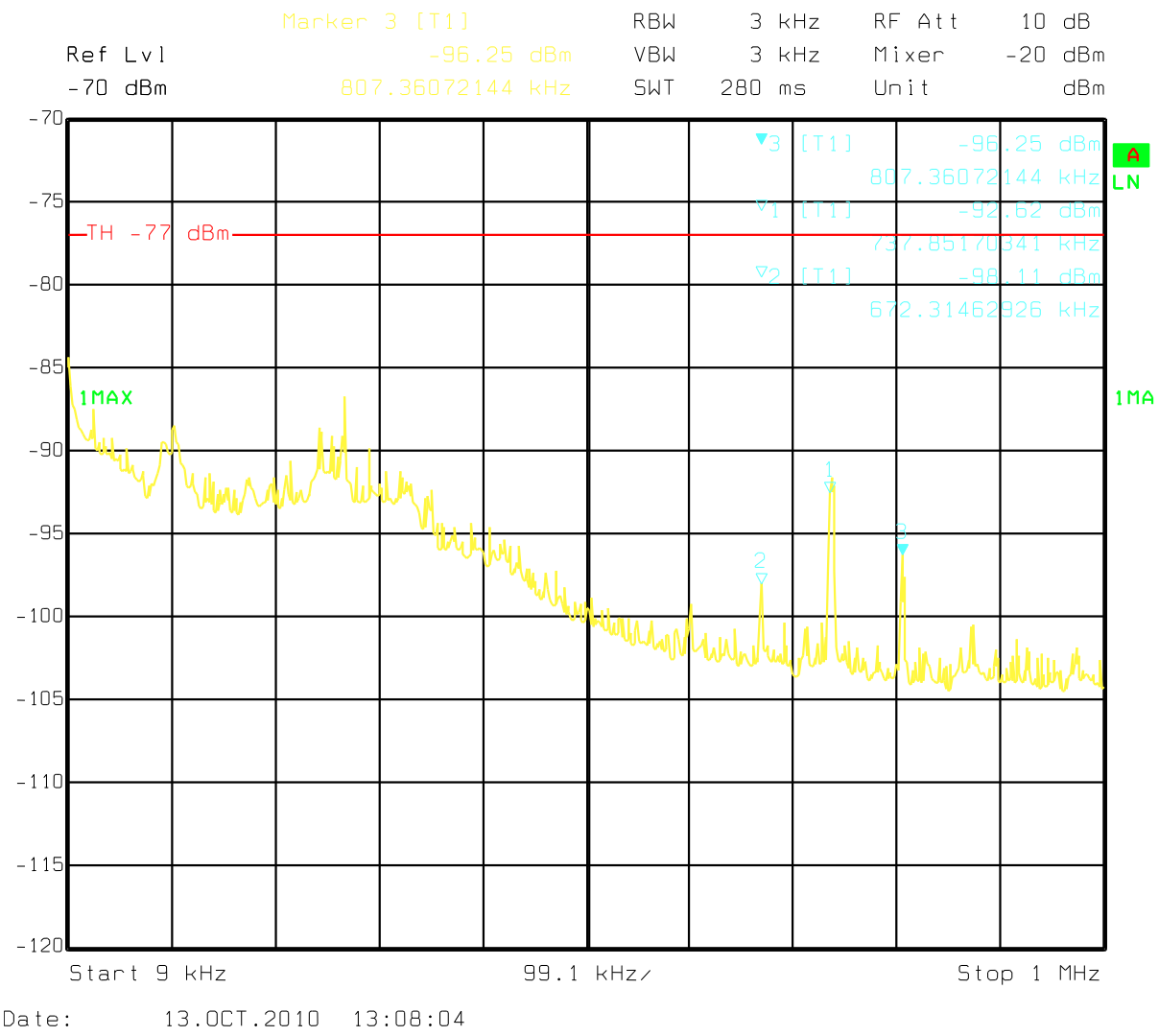

Figure 46: Conducted spurious emissions from the receiver in the frequency region from 9kHz to 1MHz. The spurious components noted with markers are also present when there is no power applied to the DUT and is concluded to be generated elsewhere. A 20dB external attenuator is used.

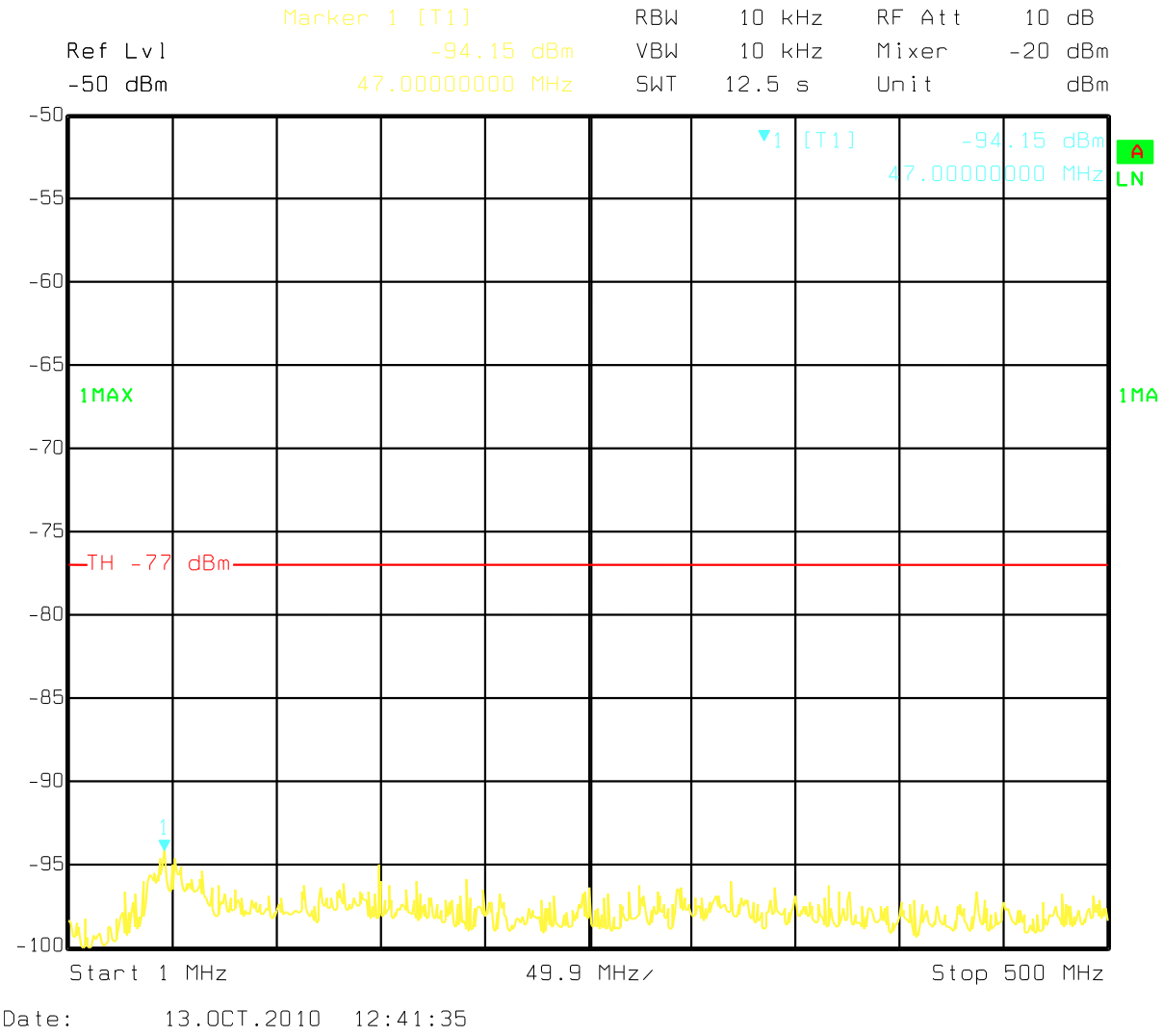

Figure 47: Conducted spurious emissions from the receiver in the frequency region from 1MHz to 500MHz. A 20dB external attenuator is used.

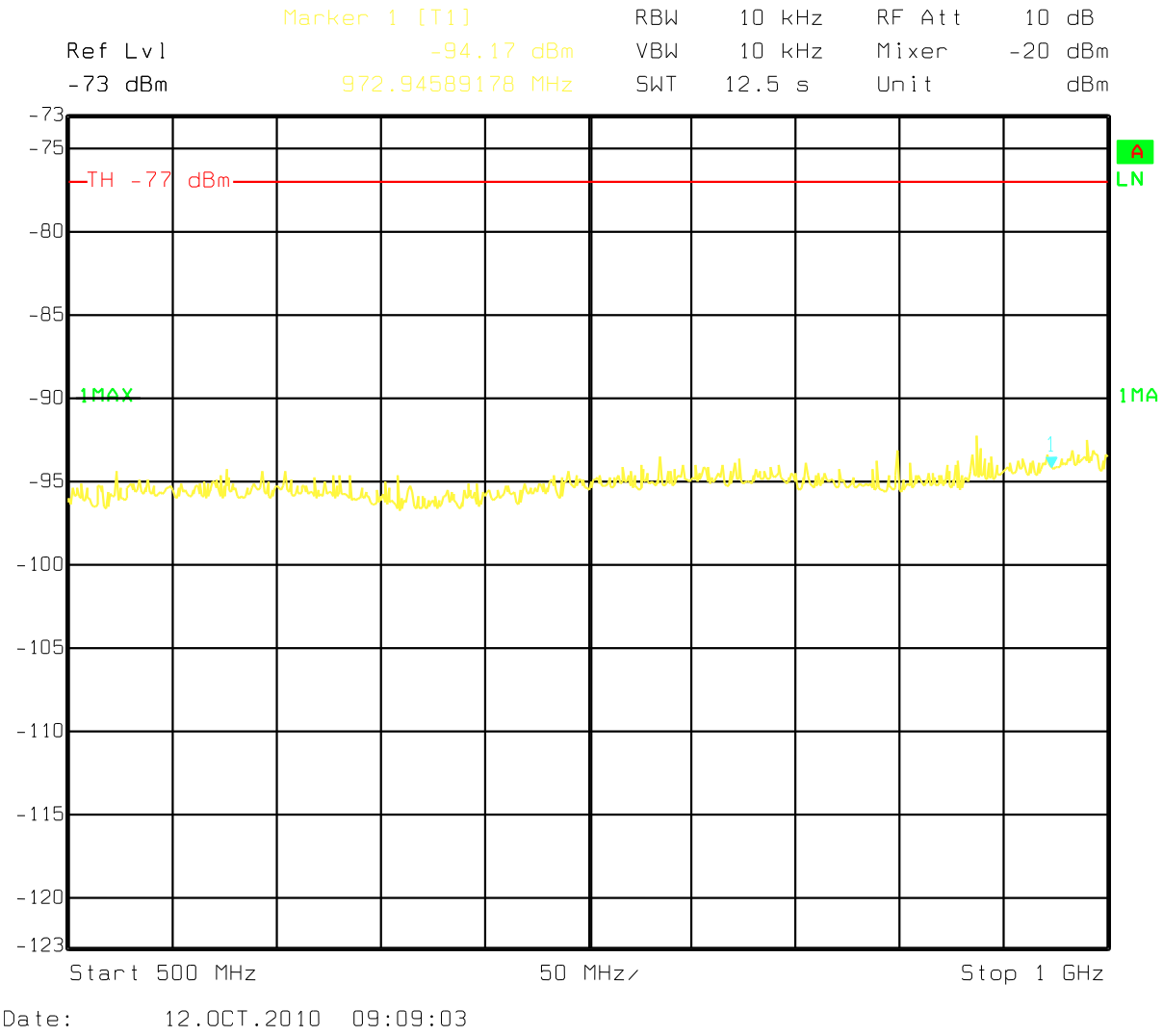

Figure 48: Conducted spurious emissions from the receiver in the frequency region from 500MHz to 1GHz. A 20dB external attenuator is used.

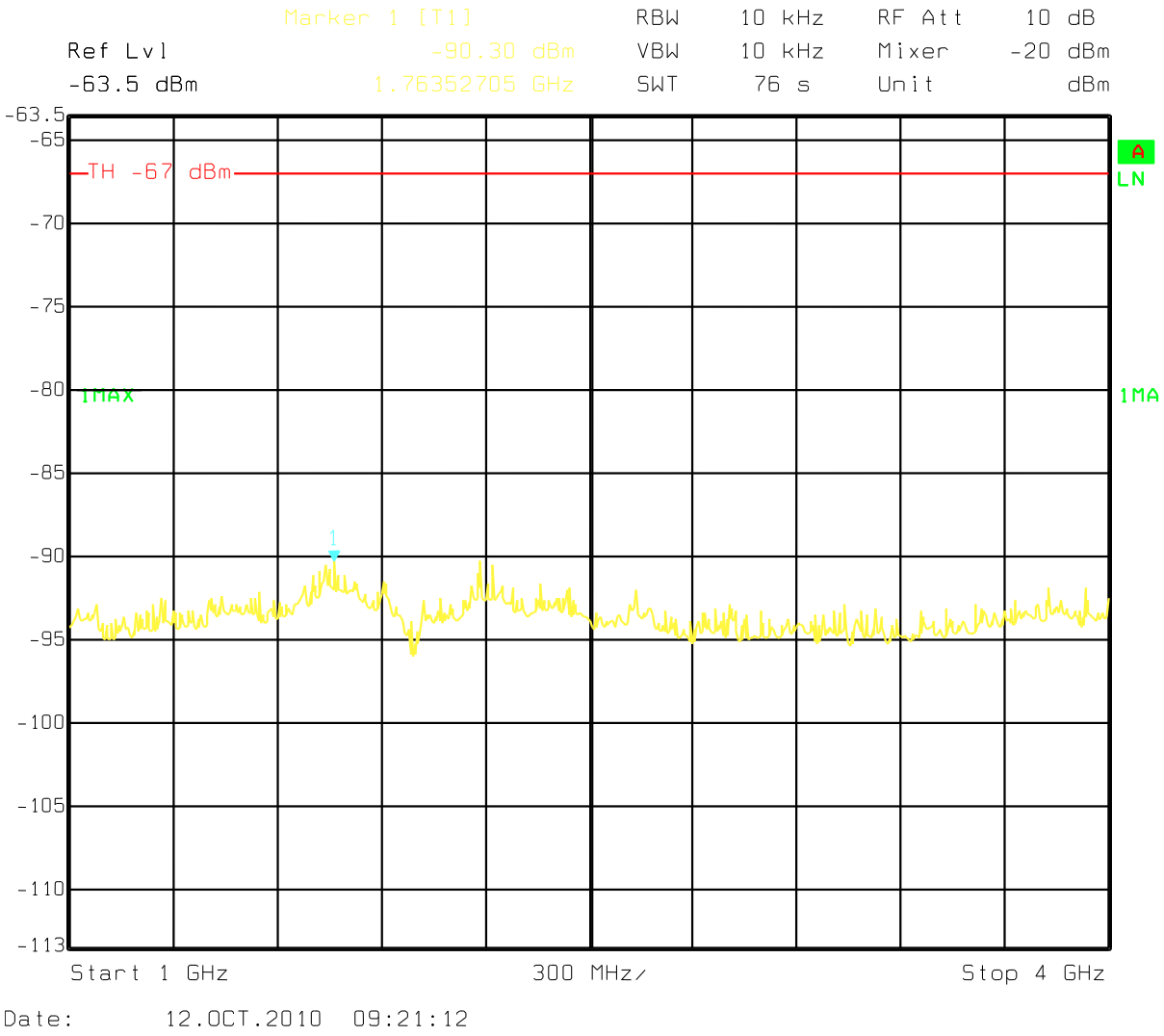

Figure 49: Conducted spurious emissions from the receiver in the frequency region from 1GHz to 4GHz. A 20dB external attenuator is used.