

Radio test report

99475930

based on:
IEC 61993-2 First edition 2001

Class A Shipborne AIS equipment
McMurdo
M2

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This report comprises of four modules. The total number of pages is: 63.

Main module

1 Introduction

This report contains the result of tests performed by:

Telefication bv
Edisonstraat 12a
6902 PK Zevenaar
The Netherlands

Telefication complies with the accreditation criteria for test laboratories as laid down in ISO/IEC 17025:1999. The accreditation covers the quality system of the laboratory as well as the specific activities as described in the authorized annex bearing the accreditation number L021 and is granted on 30 November 1990 by the Dutch Council For Accreditation (RvA: Raad voor Accreditatie). The contents of this test report, if reproduced, shall be copied in full, unless special consent in writing for reproduction in part is granted by Telefication. Copyright of this test report is reserved to Telefication.

Ordering party:

Company name : McMurdo Ltd
Address : Silver Point, Airpoint Service Road
Zipcode : P03 5PB
City/town : Portsmouth
Country : United Kingdom
Date of order : 12 August 2003

2 Product

A sample of the following product was submitted for testing:

Product category	:	Universal Automatic Identification System
Manufacturer	:	McMurdo
Trade mark	:	McMurdo
Type designation	:	M2 (complete system)
Transponder		Hardware version : see hardware list
		Software version : see software list
		Serial number : Sample 03
MKD		Hardware version : see hardware list
		Software version : see software list
		Serial number : Sample 01

3 Test schedule

The tests were carried out at the following locations:

- Telefication, Zevenaar

The tests were carried out between:

- 12 May 2004 and 30 August 2004

4 Product documentation

For production of this report the following product documentation was used:

Description	Identification	Date
Installation manual	35-060N, iss.0	27 September 2004
User manual	35-061N	27 September 2004
Block diagram transponder, RF electronics	LM040407176, rev 1.5, sheet No. 1	29 July 2004
Schematics transponder RF electronics	LM040407176, rev 1.5, sheet No. 2 to 10	29 July 2004
Schematics Baseband electronics	LN040407174, rev. 517, sheet 1 to 6	23 April 2004

The above-mentioned documentation will be filed at Telefication by for a period of 10 years following the issue of this report.

5 Hardware list

The table below shows the release version of hardware used by various processes at date of testing:

Transponder	Module	Hardware Nr.
	RF pcb	35-421, rev 3.0
	Screw Terminal pcb	35-401, rev 1.0
	Baseband pcb	35-411, rev 3.0
	GPS module	Manf.: U-BLOX, mod.: TIM-LC
MKD	Display PCB	35-201, rev 1.0
	Interconnect pcb	35-211, rev 1.0

6 Software list

The table below shows the software release version of the various processes.

Transponder	Software module	Software file
	System software	Kontiki-032.hex
	FPGA software	Kontiki-fpga014.mcs
MKD	System software	29lv160b, V 0.5.0

7 Observations and comments

This test report covers the IEC 61993-2 chapter 15 testing of the M2 transponder and is complementary to Telefication test report 99475920, which covers the EN60945 testing.

8 Summary

The product is intended for use in the following application area:

Universal Automatic Identification System

The sample was tested according to the following specification:

IEC 61993-2: (2001-12),	Clause 4.4	Marking & Identification
	Clause 14.8	Transmitter Protection
	Clause 15	Physical Tests.

9 Conclusions

The sample of the product showed **NO NON-COMPLIANCES** to the specification stated in chapter 8 of this report.

The results of the test as stated in this report are exclusively applicable to the product item as identified in this report. Telefication does not accept any responsibility for the results stated in this report, with respect to the properties of product items not involved in these tests.

All tests are performed by:

name : H.H. Lodewijk

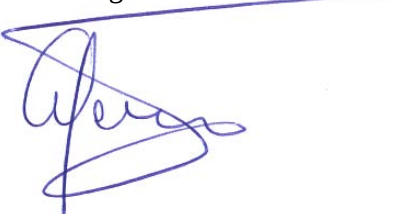
function : Test Engineer Radio/EMC

signature : 

Review of test methods and report by:

name : M.W. Jansen

function : Senior Engineer Maritime

signature : 

The above conclusions have been verified by the following signatory:

date : 21 October 2004

name : J.P. van de Poll

function : Co-ordinator Test Group

signature : 

Test results module

1 Summary

LIST OF VERIFICATION

The list of measured or checked parameters called for in IEC 61993-2 Clause 15 is given below.

IEC 61993-2 Clause	GENERAL REQUIREMENTS	Performed verification (yes/no/n.a)
15 Physical Tests		
15.1 TDMA Transmitter		
15.1.1	Frequency Error	yes
15.1.2	Carrier Power	yes
15.1.3	Modulation Spectrum 25 kHz channel mode	yes
15.1.4	Modulation Spectrum 12.5 kHz channel mode	yes
15.1.5	Transmitter Attack Time	yes
15.1.6	Transmitter Release Time	yes
15.2 DSC Transmissions		
15.2.1	Frequency error of the DSC Signal	yes
15.2.2	Modulation Rate	yes
15.3 TDMA Receivers		
15.3.1	Sensitivity - 25 kHz Operation	yes
15.3.2	Sensitivity - 12.5 kHz Operation	yes
15.3.3	Error Behaviour at High Input Levels	yes
15.3.4	Co-Channel Rejection - 25 kHz Operation	yes
15.3.5	Co-Channel Rejection - 12.5 kHz Operation	yes
15.3.6	Adjacent Channel selectivity - 25 kHz Operation	yes
15.3.7	Adjacent Channel selectivity - 12.5 kHz Operation	yes
15.3.8	Spurious Response Rejection	yes
15.3.9	Intermodulation response rejection and blocking	yes
15.3.10	Transmit to receive switching time	yes
15.4 DSC Receiver		
15.4.1	Maximum sensitivity	yes
15.4.2	Error Behaviour at High Input Levels	yes
15.4.3	Co-Channel Rejection	yes
15.4.4	Adjacent Channel selectivity	yes
15.4.5	Spurious Response Rejection	yes
15.4.6	Intermodulation response Rejection	yes
15.4.7	Blocking or Desensitisation	yes
15.5 Conducted Spurious Emissions conveyed to the antenna		
15.5.1	Spurious Emissions from the Receiver	yes
15.5.2	Spurious Emissions from the Transmitter	yes

2 Test results

2.1 4.1.4 Transmitter shutdown

Date of test: *31August 2004*

Transmitter shutdown	Result
Shutdown within 1 second of end transmission slot	Pass

2.2 4.4 Marking & identification

Date of test: *31August 2004*

Marking and identification	Result
Information power supply	Pass

Remark: Marking can be found on photographs.

2.3 14.8 Transceiver protection

Date of test: *31August 2004*

Transceiver protection	Result
Open and short circuit VHF-antenna terminal 60 seconds	Pass

Remark: EUT operative within 2 minutes after refitting antenna.

2.4 15.1 TDMA Transmitter

2.4.1 15.1.1 Frequency Error

Date of test:	25 August 2004	Ambient temp.: 24 °C	R.H.: 42 %
Date of test:	26 August 2004	Ambient temp.: 25 °C	R.H.: 45 %
Date of test:	27 August 2004	Ambient temp.: 25 °C	R.H.: 46 %

TEST CONDITIONS		FREQUENCY ERROR (Hz)			
Temperature	Voltage	156.025 kHz	157.4125 kHz	160.6375 kHz	162.025 kHz
T_{nom} (+15 – 35 °C)	V_{nom} (24.0 V)	+ 238	+ 258	+ 253	+ 261
T_{min} (-15 °C)	V_{min} (21.6 V)	- 244	- 243	- 243	- 243
T_{max} (+55 °C)	V_{max} (31.2 V)	+ 516	+ 515	+ 512	+ 510
Measurement uncertainty		± 4 Hz			
Limits		$\leq \pm 0.5$ kHz under normal conditions, $\leq \pm 1$ kHz under extreme conditions.			

Test equipment used: (Item numbers)	2, 4, 5, 13, 18, 20, 29,33, 37, 38, 40
-------------------------------------	--

2.4.2 15.1.2 Carrier Power

Date of test: 25 August 2004 Ambient temp.: 24 °C R.H.: 42 %
 Date of test: 26 August 2004 Ambient temp.: 25 °C R.H.: 45 %
 Date of test: 27 August 2004 Ambient temp.: 25 °C R.H.: 46 %

Rated output carrier power: H.P. : 12.5 W
 L.P. : 2.0 W

TEST CONDITIONS		CARRIER POWER (dBm)							
		156.025 kHz		157.4125 kHz		160.6375 kHz		162.025 kHz	
Temperature	Voltage	H.P.	L.P.	H.P.	L.P.	H.P.	L.P.	H.P.	L.P.
T_{nom} (+15 – 35 °C)	V_{nom} (24.0 V)	41.2	33.3	41.3	33.2	40.9	32.7	40.8	32.6
T_{min} (-15 °C)	V_{min} (21.6 V)	41.5	32.9	41.6	33.0	41.6	33.0	41.6	33.0
T_{max} (+55 °C)	V_{max} (31.2 V)	41.0	33.4	41.0	33.4	41.0	33.4	40.9	33.3
Measurement uncertainty		0.5 dB							
Limits		<u>Normal test conditions:</u> => H.P.: - between 8.8 and 17.7 W => L.P.: - between 1.4 and 2.8 W - within ± 1.5 dB of the rated carrier power <u>Extreme test conditions:</u> => H.P.: - between 6.3 and 19.8 W => L.P.: - between 1.0 and 3.2 W - within +2.0 & -3.0 dB of the rated carrier power							

H.P. = Output carrier power set at its nominal High: 12.5 W(41dBm)
 L.P. = Output carrier power set at its nominal Low: 2 W(33dBm)

Test equipment used: (Item numbers)	2, 4, 5, 13, 18, 20, 29, 38, 40
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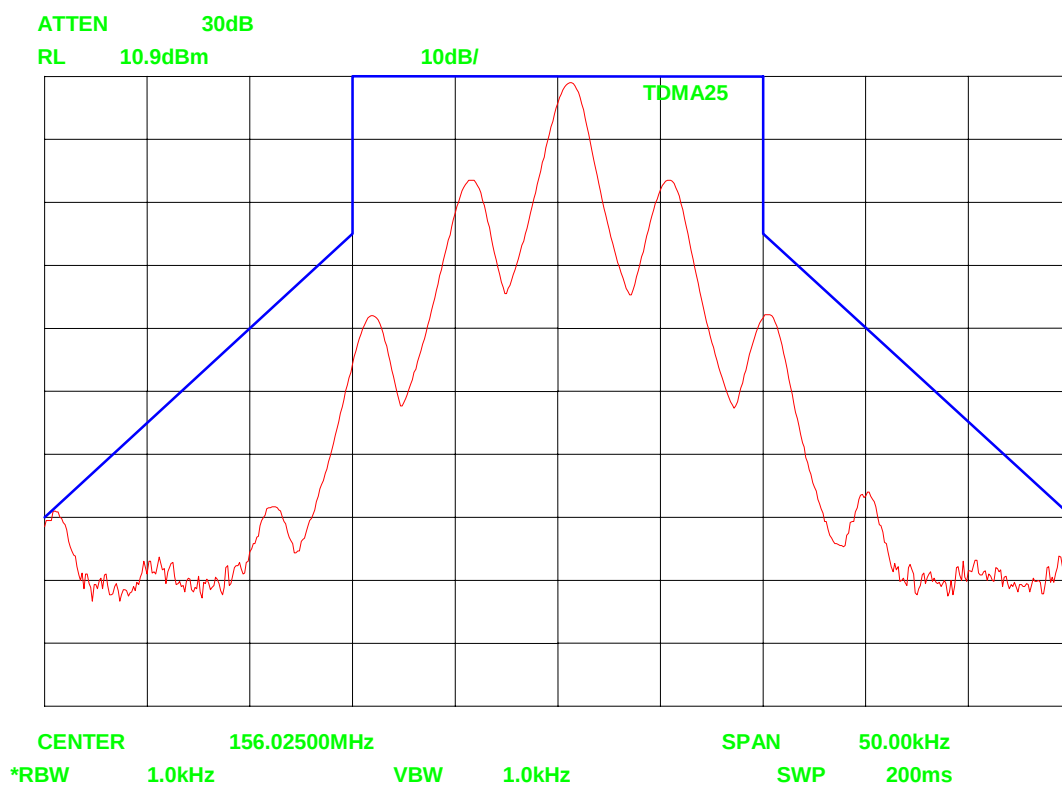
2.4.3 15.1.3 Modulation Spectrum 25 kHz channel mode

2.4.3.1 GMSK Spectrum TDMA at 156.025 MHz

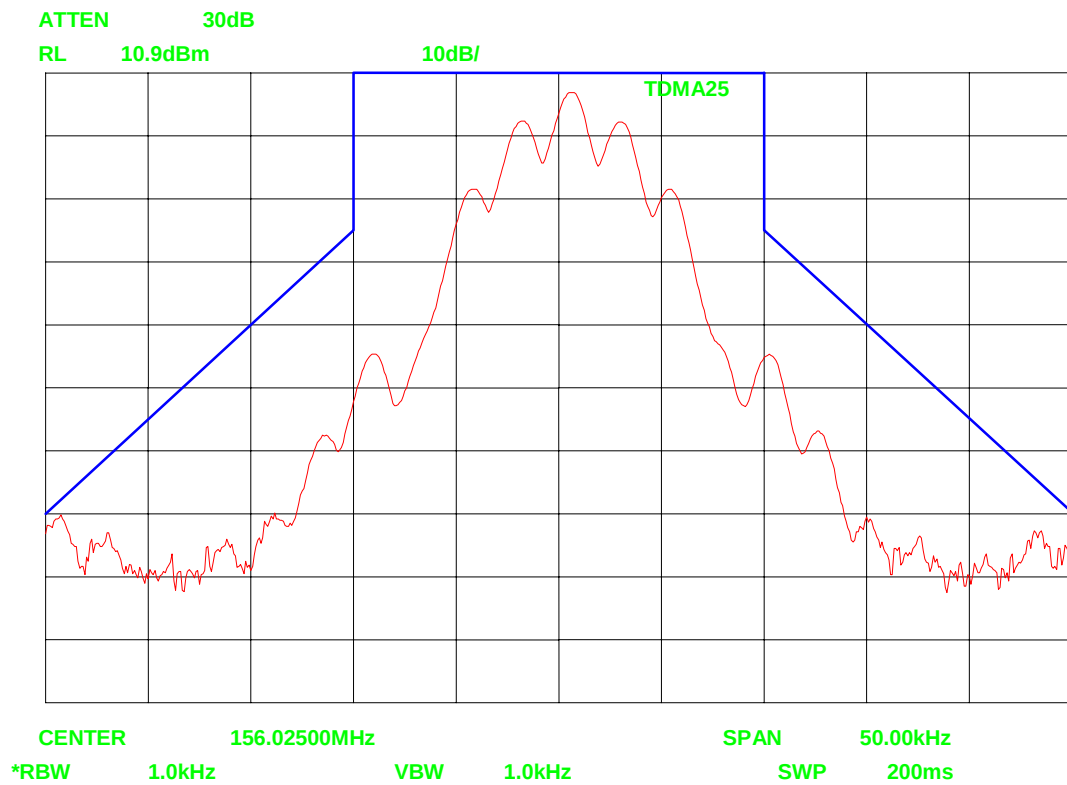
Date of test: 13 May 2004 Ambient temp.: 25 °C R.H.: 42 %

TX freq.: 156.025 MHz Carrier power: H. P.

(1) TDMA Type 1 mode (Standard Test Signal Number 2):



(2) TDMA Type 2 ((Standard Test Signal Number 3):



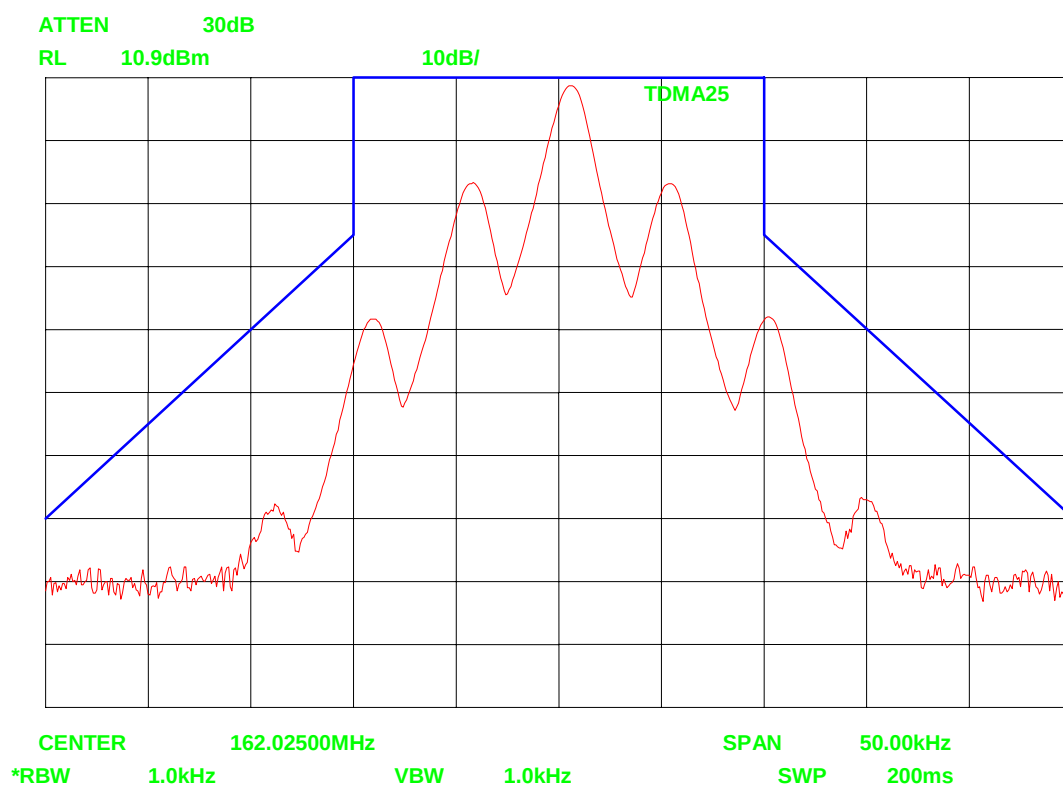
Test equipment used: (Item numbers)	1, 2, 6, 7, 11, 18, 20, 38, 40
-------------------------------------	--------------------------------

2.4.3.2 GMSK Spectrum TDMA at 162.025 MHz

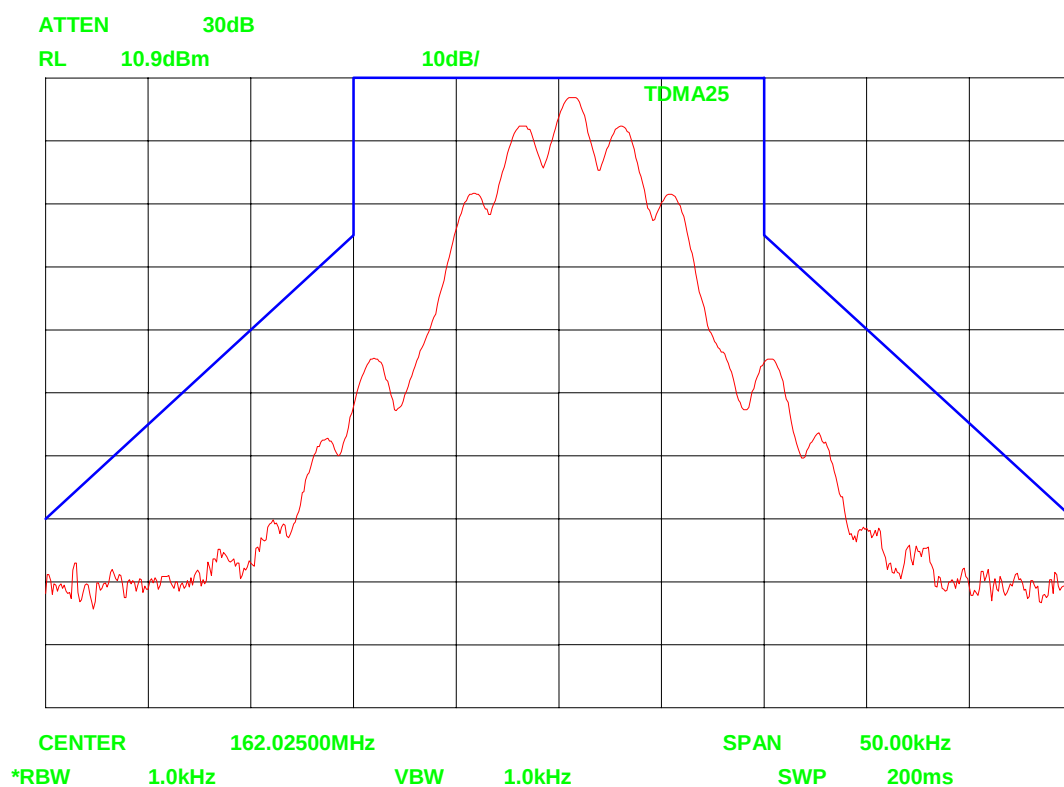
Date of test: 13 May 2004 Ambient temp.: 25 °C R.H.: 42 %

TX freq.: 162.025 MHz Carrier power: H. P.

(1) TDMA Type 1 mode (Standard Test Signal Number 2):



(2) TDMA Type 2 (Standard Test Signal Number 3):

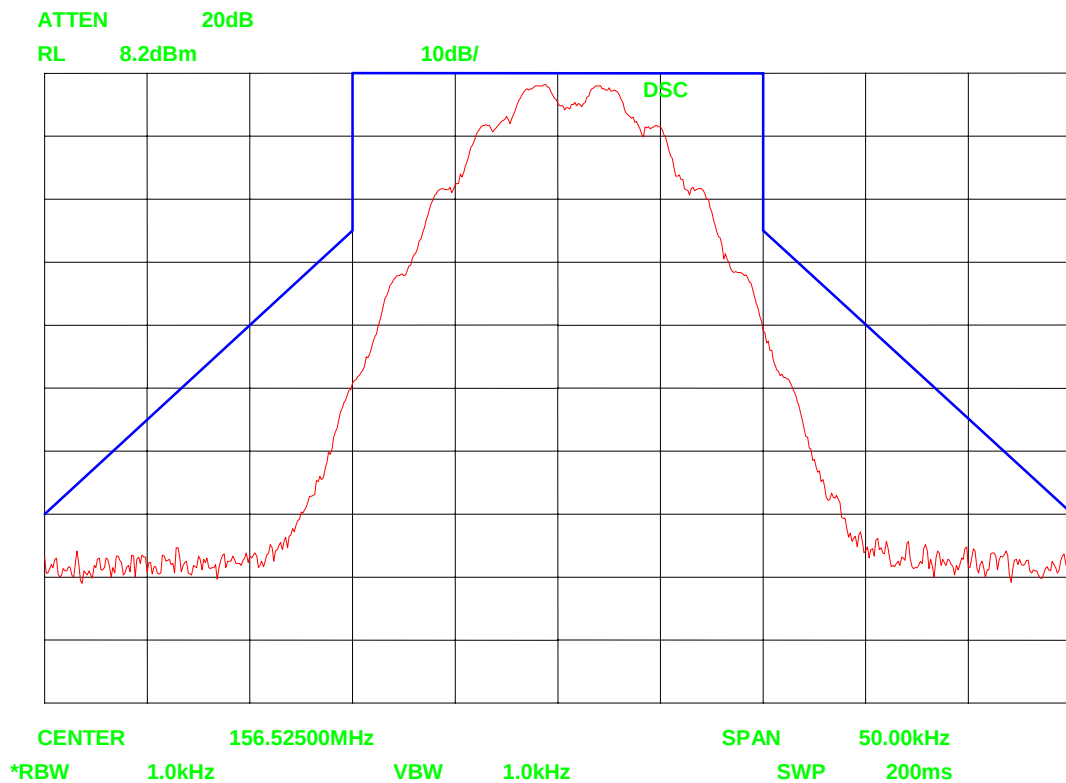


Test equipment used: (Item numbers)	1, 2, 6, 7, 11, 18, 20, 38, 40
-------------------------------------	--------------------------------

2.4.3.3 AFSK Spectrum DSC at 156.525 MHz

Date of test: 13 May 2004 Ambient temp.: 25 °C R.H.: 42 %

- (3) DSC mode (standard Test Signal Number 1):
TX freq.: 156.525 MHz Carrier power: H.P



Limit : within the mask specified in figure 4, Clause 15.1.3, IEC 61993-2.

(Emission mask):

- At ± 10 kHz removed from the carrier, the modulation sidebands is below -25 dBc.
- At ± 25 kHz removed from the carrier, the modulation sidebands is below -70 dBc, without any need to be below 0.25 μ W.

In the region between ± 10 kHz and ± 25 kHz removed from the carrier, the modulation sidebands is below a line specified between these two points.

Test equipment used: (Item numbers)	1, 2, 6, 7, 11, 18, 20, 38, 40
-------------------------------------	--------------------------------

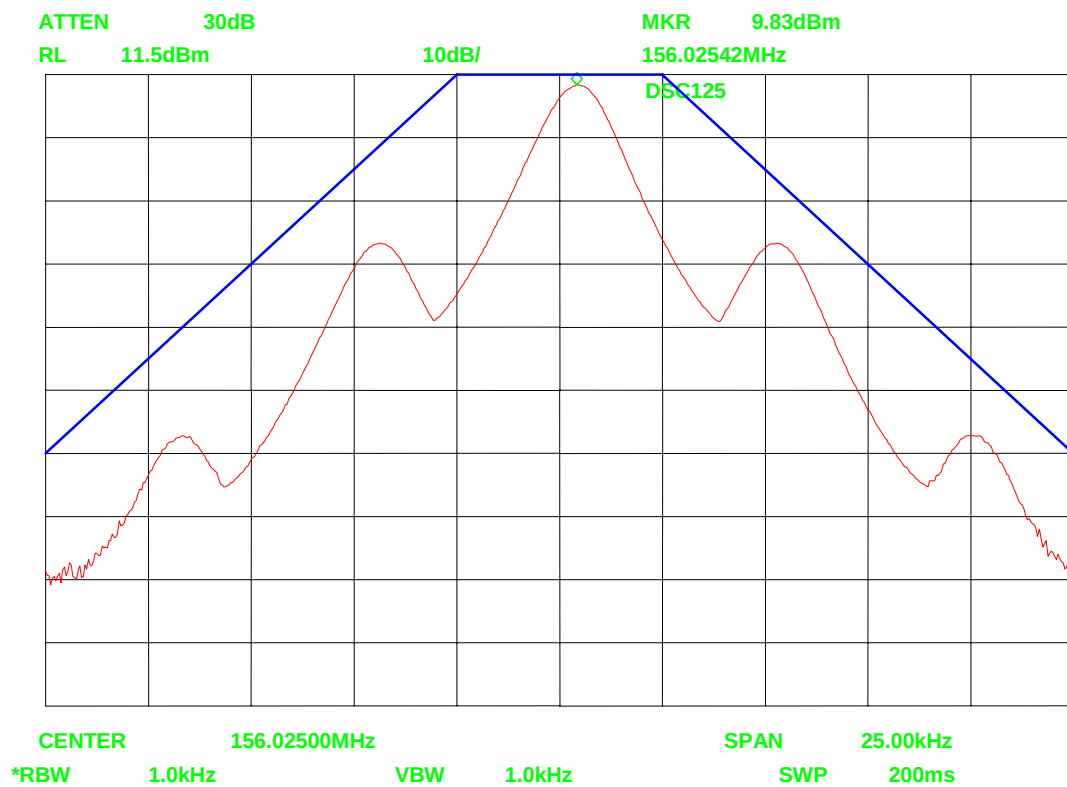
2.4.4 15.1.4 Modulation Spectrum 12.5 kHz channel mode

2.4.4.1 GMSK Spectrum TDMA at 156.025 MHz

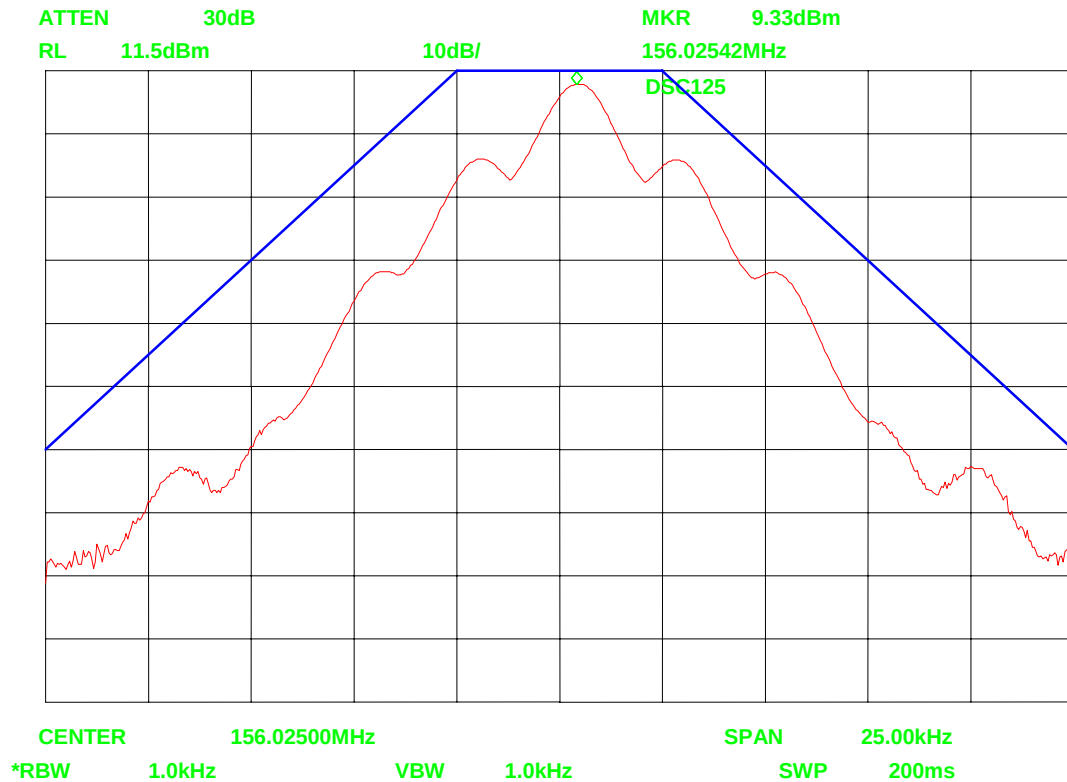
Date of test: 13 May 2004 Ambient temp.: 25 °C R.H.: 42 %

TX freq.: 156.025 MHz Carrier power: H. P.

(1) TDMA Type 1 mode (Standard Test Signal Number 2):



(2) TDMA Type 2 (Standard Test Signal Number 3):



Limit: within the mask specified in figure 5, Clause 15.1.4, IEC 61993-2.

(Emission mask):

At ± 12.5 kHz removed from the carrier, the modulation sidebands is below -60 dBc.

In the region between ± 2.5 kHz and ± 12.5 kHz removed from the carrier, the modulation sidebands is below a line starting at 0 dBc / ± 2.5 kHz and ending at -60 dBc / ± 12.5 kHz without any need to be below 0.25 μ W.

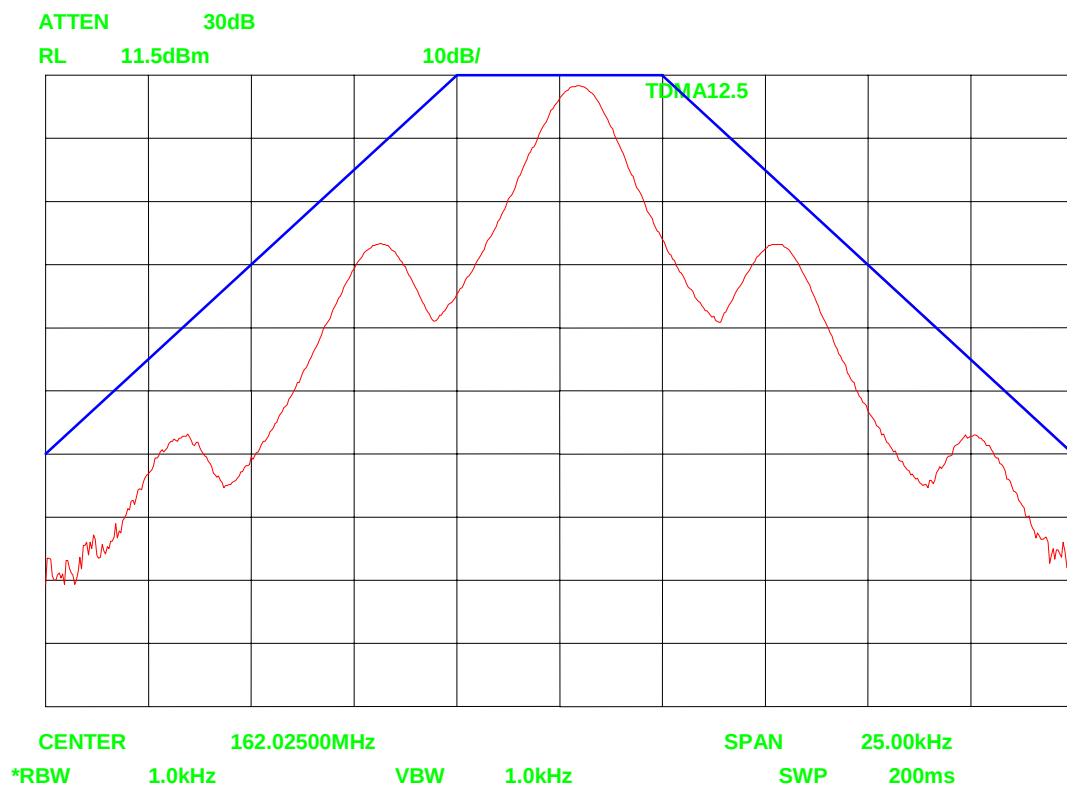
Test equipment used: (Item numbers)	1, 2, 6, 7, 11, 18, 20, 38, 40
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2.4.4.2 GMSK Spectrum TDMA at 162.025 MHz

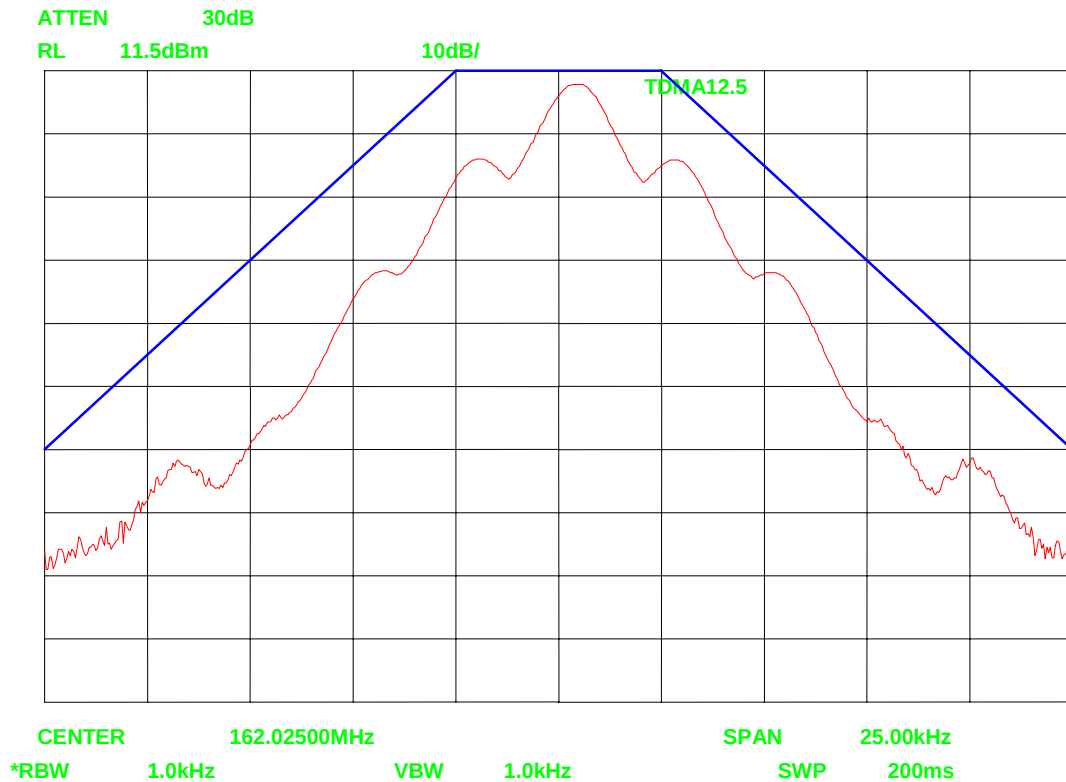
Date of test: 13 May 2004 Ambient temp.: 25 °C R.H.: 42 %

TX freq.: 162.025 MHz Carrier power: H. P.

(1) TDMA Type 1 mode (Standard Test Signal Number 2):



(2) TDMA Type 2 (Standard Test Signal Number 3):



Limit: within the mask specified in figure 5, Clause 15.1.4, IEC 61993-2.

(Emission mask):

At ± 12.5 kHz removed from the carrier, the modulation sidebands are below -60 dBc.

In the region between ± 2.5 kHz and ± 12.5 kHz removed from the carrier, the modulation sidebands are below a line starting at 0 dBc / ± 2.5 kHz and ending at -60 dBc / ± 12.5 kHz without any need to be below 0.25 μ W.

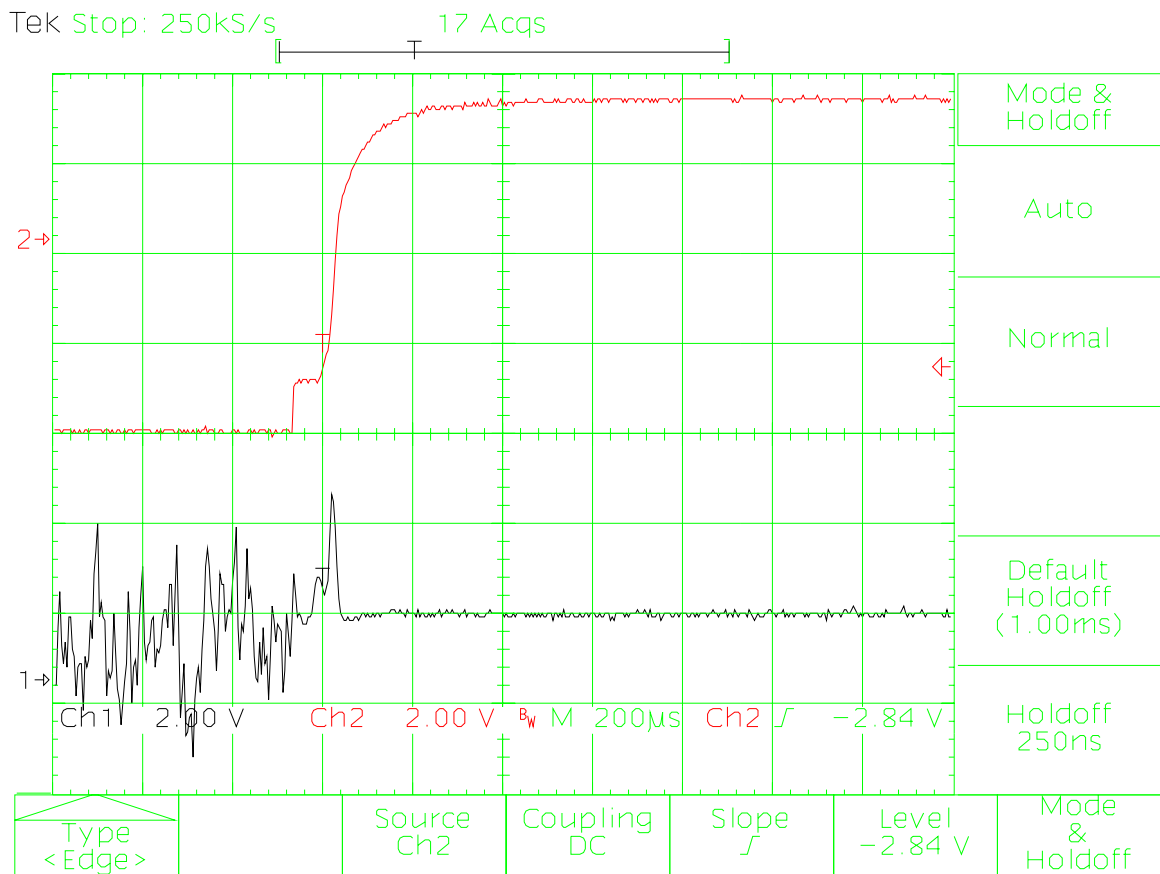
Test equipment used: (Item numbers)	1, 2, 6, 7, 11, 18, 20, 38, 40
-------------------------------------	--------------------------------

2.4.5 15.1.5 Transmitter Attack Time

Date of test: 14 May 2004 Ambient temp.: 24 °C R.H.: 40 %

TX freq.: 159.025 MHz
Carrier power: H. P.

PLOT OF FREQUENCY AND POWER BEHAVIOUR


Measurement Uncertainty: $\pm 2\%$

Limit:

- Transmitter attack time T_0 : within 1 ms,
- Transient power level: within ± 1.5 dB of its final value at any time,
- Carrier frequency F_c : within ± 1 kHz of its required value after 1 ms.

High trace : RF Power transient behaviour

Lower trace: output from test discriminator (5 kHz / div)

Time base = 200µs/div.

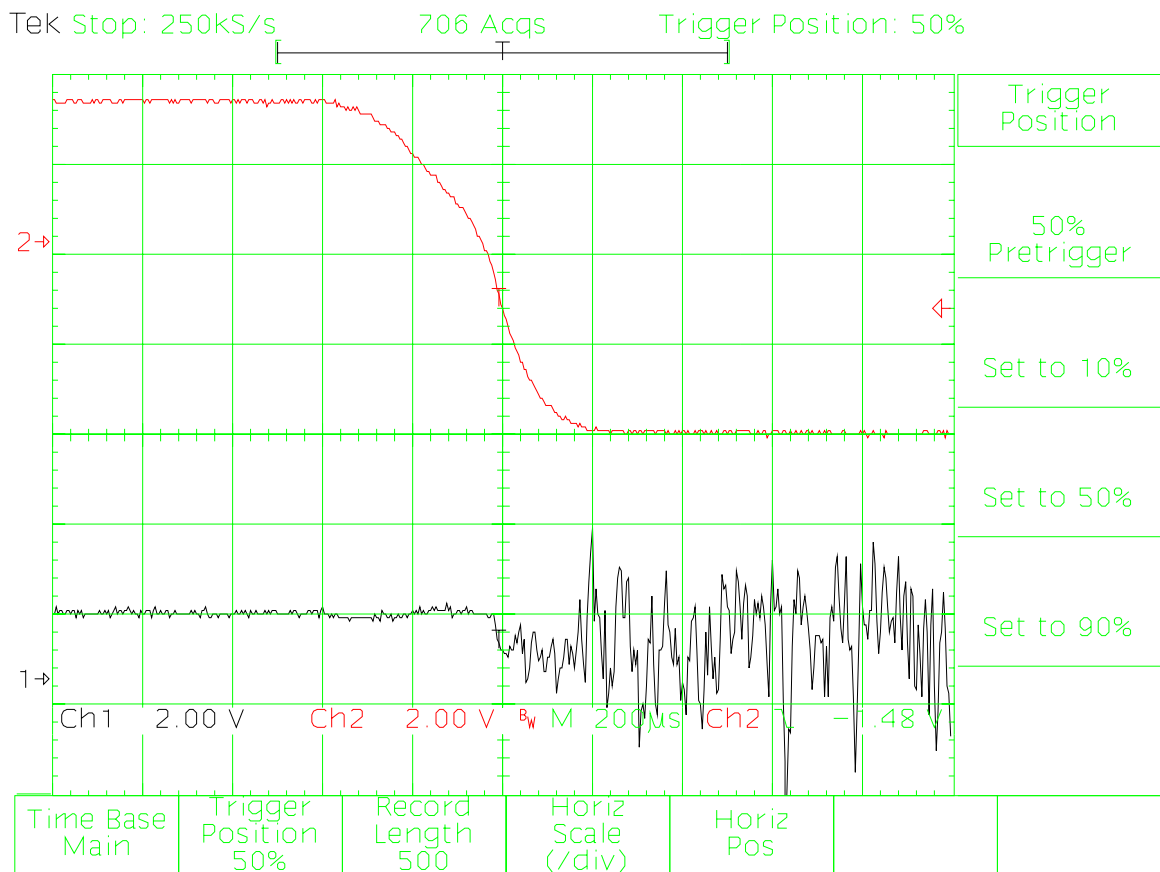
Test equipment used: (Item numbers) 2, 8, 9, 12, 13, 17, 18, 20, 21, 24, 30, 38, 40

2.4.6 15.1.6 Transmitter Release Time

Date of test: 14 May 2004 Ambient temp.: 24 °C R.H.: 40 %

TX freq.: 159.025 MHz
Carrier power: H. P.

PLOT OF FREQUENCY AND POWER BEHAVIOUR


Measurement Uncertainty: $\pm 2\%$

Limit:

Transmitter release time T_r : within 1 ms,

High trace : RF Power transient behaviour

Lower trace: output from test discriminator (2.5 kHz / div)

Time base = 200µS/div.

Test equipment used: (Item numbers)	2, 8, 9, 12, 13, 17, 18, 20, 21, 24, 30, 38, 40
-------------------------------------	---

2.5 15.2 DSC Transmissions

2.5.1 15.2.1 Frequency error of the DSC Signal

Date of test:	14 May 2004	Ambient temp.: 24 °C	R.H.: 40 %
Date of test:	26 August 2004	Ambient temp.: 23 °C	R.H.: 45 %
Date of test:	27 August 2004	Ambient temp.: 23 °C	R.H.: 46 %

CHANNEL 70

Fn = 156.525 MHz

TEST CONDITIONS		FREQUENCY ERROR (Hz)	
Temperature	Voltage	B-STATE (2100 Hz)	Y-STATE (1300Hz)
<i>T_{nom}</i> (+15 – 35 °C)	<i>V_{nom}</i> (24.0 V)	- 0.2	+ 0.1
<i>T_{min}</i> (-15 °C)	<i>V_{min}</i> (21.6 V)	- 0.3	+ 0.0
<i>T_{max}</i> (+55 °C)	<i>V_{max}</i> (31.2 V)	- 0.3	+ 0.0
Limits		≤ ±1%	
Measurement uncertainty		± 0.5 Hz	

Test equipment used: (Item numbers)	2, 5, 13, 18, 20, 21, 29, 38, 40
-------------------------------------	----------------------------------

2.5.2 15.2.2 Modulation Rate

Date of test: 14 May 2004 Ambient temp.: 24 °C R.H.: 40 %

CHANNEL 70 Fn = 156.525 MHz

TEST CONDITIONS		Modulation Rate error (ppm)
Temperature	Voltage	
<i>T_{nom}</i> (+15 – 35 °C)	<i>V_{nom}</i> (24.0 V)	-17
Limit		1200 bit/s ± 30 ppm (± 0.036 bits/s).
Measurement uncertainty		2 ppm

Test equipment used: (Item numbers)	2, 13, 18, 20, 21, 23, 24, 29, 38, 40
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2.6 15.3 TDMA Receivers

2.6.1 15.3.1 Sensitivity - 25 kHz Operation

Date of test:	25 August 2004	Ambient temp.: 24 °C	R.H.: 46 %
Date of test:	26 August 2004	Ambient temp.: 23 °C	R.H.: 45 %
Date of test:	27 August 2004	Ambient temp.: 23 °C	R.H.: 46 %

TEST CONDITIONS		SENSITIVITY LEVEL	
		Fn: 156.025 MHz	Fn: 162.025 MHz
Temperature	Voltage	RF level (dBm)	RF level (dBm)
<i>T_{nom}</i> (+15 – 35 °C)	<i>V_{nom}</i> (24.0 V)	-110 dBm at 19% PER	-110 dBm at 18% PER
<i>T_{min}</i> (-15 °C)	<i>V_{min}</i> (21.6 V)	- 111 dBm at 19% PER	- 111 dBm at 17% PER
<i>T_{max}</i> (+55 °C)	<i>V_{max}</i> (31.2 V)	- 109 dBm at 16% PER	- 107 dBm at 13% PER
Measurement uncertainty		±1.2 dB	
Limits		≤ - 107 dBm with a PER of 20% under normal test conditions, ≤ - 101 dBm with a PER of 20% under extreme test conditions,	

Test equipment used: (Item numbers)	2, 4, 5, 18, 19, 29, 33, 37, 38, 40
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2.6.2 15.3.2 Sensitivity - 12.5 kHz Operation

Date of test:	17 May 2004	Ambient temp.: 21 °C	R.H.: 46 %
Date of test:	26 August 2004	Ambient temp.: 23 °C	R.H.: 45 %
Date of test:	27 August 2004	Ambient temp.: 23 °C	R.H.: 46 %

TEST CONDITIONS		SENSITIVITY LEVEL	
		Fn: 157.4125 MHz	Fn: 160.6375 MHz
Temperature	Voltage	RF level (dBm)	RF level (dBm)
T_{nom} (+15 – 35 °C)	V_{nom} (24.0 V)	- 104 dBm at 14% PER	- 103 dBm at 15% PER
T_{min} (-15 °C)	V_{min} (21.6 V)	- 106 dBm at 14% PER	- 105 dBm at 19% PER
T_{max} (+55 °C)	V_{max} (31.2 V)	-103 dBm at 17% PER	- 103 dBm at 6% PER
Measurement uncertainty		±1.2 dB	
Limits		$\leq$ - 98 dBm with a PER of 20% under normal test conditions, $\leq$ - 92 dBm with a PER of 20% under extreme test conditions,	

Test equipment used: (Item numbers)	2, 4, 5, 18, 19, 29, 33, 37, 38, 40
-------------------------------------	-------------------------------------

2.6.3 15.3.3 Error Behaviour at High Input Levels

Date of test: 17 May 2004 Ambient temp.: 21 °C R.H.: 46 %

TEST CONDITIONS		Packet Error Rate (%)	
		Fn = 156.025 MHz	
Standard Test Signal		as described in clause 15.3.1	
Input signal (dBm)		-77	-7
Temperature	Voltage	0%	0%
T_{nom} (+15 – 35 °C)	V_{nom} (24.0 V)		
Measurement uncertainty		±1.2 dB (signal level)	
Limits		Difference < 1%	

Test equipment used: (Item numbers)	2, 18, 19, 29, 33, 37, 38, 40
-------------------------------------	-------------------------------

2.6.4 15.3.4 Co-channel Rejection - 25 kHz Operation

Date of test: 17 May 2004 Ambient temp.: 21 °C R.H.: 46 %

TEST CONDITIONS		CO-CHANNEL REJECTION RATIO (dB)	
Temperature	Voltage	Fn = 159.025 MHz	
<i>Tnom</i> (+15 – 35 °C)	<i>Vnom</i> (24.0 V)	Fn +3 kHz	-10 dB at 5% PER
		Fn	-9 dB at 18% PER
		Fn –3 kHz	-10 dB at 8% PER
Measurement uncertainty		±1.1 dB	
Limits		Between -10.0 dB and 0 dB. Any positive value is also acceptable.	

Remark: Unwanted signal modulated with GMSK test signal #2, 2.4 kHz deviation, BT 0.4

TEST CONDITIONS		CO-CHANNEL REJECTION RATIO (dB)	
Temperature	Voltage	Fn = 159.025 MHz	
<i>Tnom</i> (+15 – 35 °C)	<i>Vnom</i> (24.0 V)	Fn +3 kHz	-10 dB at 4% PER
		Fn	-9 dB at 9% PER
		Fn –3 kHz	-10dB at 6% PER
Measurement uncertainty		±1.1 dB	
Limits		Between -10.0 dB and 0 dB.	

Remark: Unwanted signal modulated with 400Hz / 3kHz deviation

Test equipment used: (Item numbers)	2, 12, 17, 18, 19, 29, 33, 36, 37, 38, 40
-------------------------------------	---

2.6.5 15.3.5 Co-channel Rejection - 12.5 kHz Operation

Date of test: 17 May 2004 Ambient temp.: 21 °C R.H.: 46 %

TEST CONDITIONS		CO-CHANNEL REJECTION RATIO (dB)	
Temperature	Voltage	Fn = 159.025 MHz	
<i>Tnom</i> (+15 – 35 °C)	<i>Vnom</i> (24.0 V)	Fn +1.5 kHz	-17 dB at 16% PER
		Fn	-15 dB at 15% PER
		Fn –1.5 kHz	-16 dB at 6% PER
Measurement uncertainty		±1.1 dB	
Limits		Between -18.0 dB and 0 dB.	

Remark: Unwanted signal modulated with GFSK, test signal #2, 1.2 kHz deviation, BT 0.3

TEST CONDITIONS		CO-CHANNEL REJECTION RATIO (dB)	
Temperature	Voltage	Fn = 159.025 MHz	
<i>Tnom</i> (+15 – 35 °C)	<i>Vnom</i> (24.0 V)	Fn +1.5 kHz	-16dB at 12% PER
		Fn	-16 dB at 8% PER
		Fn –1.5 kHz	-16 dB at 19% PER
Measurement uncertainty		±1.1 dB	
Limits		Between -18.0 dB and 0 dB. Any positive value is also acceptable.	

Remark: Unwanted signal modulated with 400Hz / 1.5 kHz deviation

Test equipment used: (Item numbers)	2, 12, 17, 18, 19, 29, 33, 36, 37, 38, 40
-------------------------------------	---

2.6.6 15.3.6 Adjacent Channel selectivity - 25 kHz Operation

Date of test:	17 May 2004	Ambient temp.: 21 °C	R.H.: 46 %
Date of test:	26 August 2004	Ambient temp.: 23 °C	R.H.: 45 %
Date of test:	27 August 2004	Ambient temp.: 23 °C	R.H.: 46 %

TEST CONDITIONS		ADJACENT CHANNEL SELECTIVITY (dB)	
		Fn: 159.025 MHz	
Temp.	Voltage	Unwanted signal – 25 kHz	Unwanted signal + 25 kHz
<i>T_{nom}</i> (+15 – 35 °C)	<i>V_{nom}</i> (24.0V)	76 dB at 7% PER	76dB at 5% PER
<i>T_{min}</i> (-15 °C)	<i>V_{min}</i> (21.6 V)	77 dB at 16% PER	76 dB at 8% PER
<i>T_{max}</i> (+55 °C)	<i>V_{max}</i> (31.2 V)	79 dB at 3% PER	80 dB at 8% PER
Measurement uncertainty		+2.3 / -2.8 dB	
Limits		> 70.0 dB @ ≤20% PER under normal test conditions, > 60.0 dB @ ≤20% PER under extreme test conditions.	

Test equipment used: (Item numbers)	2, 5, 12, 17, 18, 19, 29, 33, 37, 38, 40
-------------------------------------	--

2.6.7 15.3.7 Adjacent Channel selectivity - 12.5 kHz Operation

Date of test:	17 May 2004	Ambient temp.: 21 °C	R.H.: 46 %
Date of test:	26 August 2004	Ambient temp.: 23 °C	R.H.: 45 %
Date of test:	27 August 2004	Ambient temp.: 23 °C	R.H.: 46 %

TEST CONDITIONS		ADJACENT CHANNEL SELECTIVITY (dB)	
		Fn = 159.025 MHz	
Temp.	Voltage	Unwanted signal – 12.5 kHz	Unwanted signal + 12.5 kHz
T_{nom} (+15 – 35 °C)	V_{nom} (24.0V)	63 dB at 8% PER	63 dB at 10% PER
T_{min} (-15 °C)	V_{min} (21.6 V)	62 dB at 17% PER	62 dB at 19% PER
T_{max} (+55 °C)	V_{max} (31.2 V)	62 dB at 5% PER	62 dB at 10% PER
Measurement uncertainty		+2.3 / -2.8 dB	
Limits		> 50.0 dB @ $\leq 20\%$ PER under normal test conditions, > 50.0 dB @ $\leq 20\%$ PER under extreme test conditions.	

Test equipment used: (Item numbers)	2, 5, 12, 17, 18, 19, 29, 33, 37, 38, 40
-------------------------------------	--

2.6.8 15.3.8 Spurious Response Rejection at 156.025 MHz

Date of test: 19 May 2004 Ambient temp.: 22 °C R.H.: 46%

Tested frequency : 156.025 MHz

Funw (MHz)	SPURIOUS RESPONSE REJECTION RATIO (dB)
*	--
*	--
*	--
Measurement uncertainty: +2.4 / -2.9 dB	
Limit: 70 dB	

Funw = unwanted frequency

* : Rejection on all spurious responses was >80 dB.

- (1) Frequency of the Receiver (f_R): 156.025 MHz
- (2) Frequency of the local oscillator signal applied to the 1st mixer of the Receiver (f_{LO}): 201.025
- (3) The frequency of the second LO = 44.645 MHz.
- (4) Intermediate frequencies (f_{I1} , f_{I2} , f_{I3}): f_{I1} = 45MHz, f_{I2} = 455 kHz
- (5) Switching range of the Receiver (sr): 156.025 to 162.025 MHz

2.6.9 15.3.8 Spurious Response Rejection at 162.025 MHz

Date of test: 19 May 2004 Ambient temp.: 22 °C R.H.: 46 %

Tested frequency : 162.025 MHz

Funw (MHz)	SPURIOUS RESPONSE REJECTION RATIO (dB)
*	--
*	--
*	--
Measurement uncertainty: +2.4 / -2.9 dB	
Limit: 70 dB	

Funw = unwanted frequency

* : Rejection on all spurious responses was >80 dB.

- (1) Frequency of the Receiver (f_R): 162.025 MHz
- (2) Frequency of the local oscillator signal applied to the 1st mixer of the Receiver (f_{LO}): 207.025 MHz
- (3) The frequency of the second LO = 44.645 MHz.
- (4) Intermediate frequencies (f_{I1} , f_{I2} , f_{I3}): f_{I1} = 45 MHz, f_{I2} = 455 kHz
- (5) Switching range of the Receiver (sr): 156.025 to 162.025 MHz

Test equipment used: (Item numbers)	2, 12, 17, 18, 19, 29, 33, 37, 38, 40
-------------------------------------	---------------------------------------

2.6.10 15.3.9 Intermodulation response rejection and blocking

Date of test: 19 May 2004 Ambient temp.: 22 °C R.H.: 46 %

TEST CONDITIONS		PACKET ERROR RATE (%)	
		Fn = 156.025 MHz	Fn = 162.025 MHz
Temperature	Voltage	Test #1	Test #2
T_{nom} (+15 – 35 °C)	V_{nom} (24.0 V)	11%	3%
Measurement uncertainty		+2.4 / -2.8 dB (signal levels)	
Limits		≤20% PER	

Remark: test configuration

	Generator A wanted –101 dbm	Generator B unwanted –27 dbm unmodulated	Generator C unwanted –27 dbm Mod. 400Hz / 3 kHz	Generator D unwanted –15 dbm unmodulated
Test #1	156.025MHz	Fn + 500 kHz (156.525 MHz)	Fn + 1000 kHz (157.025 MHz)	Fn + 5.725 (161.750 MHz)
Test #2	162.025MHz	Fn - 500 kHz (161.525 MHz)	Fn - 1000 kHz (161.025 MHz)	Fn - 5.725 (156.300 MHz)

Test equipment used: (Item numbers)	2, 7, 9, 12, 14, 15, 16, 17, 18, 19, 29, 33, 37, 38, 40
-------------------------------------	---

2.6.11 15.3.10 Transmit to receive switching time

Date of test: 22 August 2004

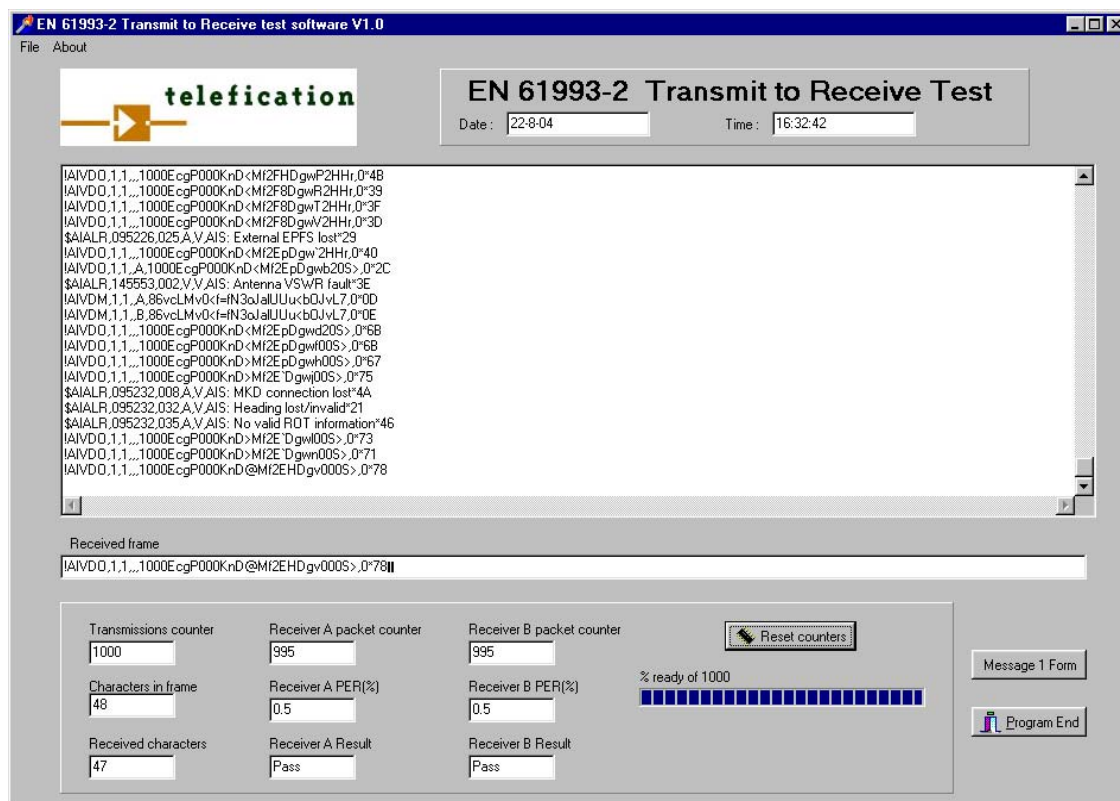
Ambient temp.: 25 °C

R.H.: 45 %

TEST CONDITIONS	TEST RESULTS	
Receive frequency	RX 159.025 MHz	
Packet Error Rate	As shown on screen dump of test software	
Result	RX-1	0.5 PER
	RX-2	0.5 PER
Measurement uncertainty	±1.2 dB (applied RF levels)	
Limits	PER 20% or better @ -107 dBm	

Test set-up:

The test was carried out by connecting two signal generators via attenuators and combiner to the VHF antenna connector. The signal generators were modulated by the GMSK packet generator box which was triggered at the TX slot start signal from the transponder under test. In the next slot after the trigger signal the packet contents were sent to the radio. The test software was counting the number of packets received and a calculation was performed upon the correct received packets compared to the number of send packets.



The screenshot shows the 'EN 61993-2 Transmit to Receive Test' software interface. It includes a date field (22-8-04) and a time field (16:32:42). A large text area displays a log of test results, including packet counts and error rates. Below the log, there are fields for 'Received frame' and 'Received characters'. At the bottom, there are three columns of counters: 'Transmissions counter' (1000), 'Receiver A packet counter' (995), and 'Receiver B packet counter' (995). There are also fields for 'Characters in frame' (48), 'Receiver A PER(%)' (0.5), and 'Receiver B PER(%)' (0.5). A '% ready of 1000' progress bar is shown. Buttons for 'Reset counters', 'Message 1 Form', and 'Program End' are visible.

Test equipment used: (Item numbers)

2, 12, 17, 18, 29, 33, 36, 37, 38, 39, 40

2.7 15.4 DSC Receiver

2.7.1 15.4.1 Maximum sensitivity

Date of test:	16 August 2004	Ambient temp.:	24 °C	R.H.:	46 %
Date of test:	26 August 2004	Ambient temp.:	23 °C	R.H.:	45 %
Date of test:	27 August 2004	Ambient temp.:	236 °C	R.H.:	46 %

TEST CONDITIONS		SENSITIVITY LEVEL (dBm)		
		Fn: 156.525 MHz (CH 70)		
Temperature	Voltage	Fn	Fn - 1.5 kHz	Fn + 1.5 kHz
<i>T_{nom}</i> (+15 – 35 °C)	<i>V_{nom}</i> (24.0 V)	- 112 dBm at 0.4 % BER	- 110 dBm at 0.5 % BER	- 110 dBm at 0.7 % BER
<i>T_{min}</i> (-15 °C)	<i>V_{min}</i> (21.6 V)	- 112 dBm at 0.2 % BER	- 110 dBm at 0.2 % BER	- 110 dBm at 0.5 % BER
<i>T_{max}</i> (+55 °C)	<i>V_{max}</i> (31.2 V)	- 112 dBm at 0.9 % BER	- 110 dBm at 0.8 % BER	- 110 dBm at 0.3 % BER
Measurement uncertainty		±1.2 dB		
Limits		≤ - 107 dBm with a BER of 1% under normal test conditions, ≤ - 101 dBm with a BER of 1% under extreme test conditions,		

Test equipment used: (Item numbers)	4, 5, 13, 19, 20, 21, 29, 33, 37, 38, 40
-------------------------------------	--

2.7.2 15.4.2 Error Behaviour at High Input Levels

Date of test: 16 August 2004 Ambient temp.: 24 °C R.H.: 46 %

CHANNEL 70: Fn: 156.525 MHz

TEST CONDITIONS		BIT ERROR RATE (%)
Temperature	Voltage	RF input -7 dBm / Standard Test Signal #1
<i>T_{nom}</i> (+15 – 35 °C)	<i>V_{nom}</i> (24.0 V)	0.0
Measurement uncertainty		±1.2 dB (signal level)
Limits		BER <1%

Test equipment used: (Item numbers)	2, 13, 19, 20, 29, 33, 37, 38, 40
-------------------------------------	-----------------------------------

2.7.3 15.4.3 Co-Channel Rejection

Date of test: 16 August 2004 Ambient temp.: 24 °C R.H.: 46 %

CHANNEL 70: Fn: 156.525 MHz

TEST CONDITIONS		CO-CHANNEL REJECTION RATIO (dB)	
		Standard Test Signal #1/ -104 dBm	
		Fn = 156.525 MHz (CH70)	
Temperature	Voltage	Unwanted signal	
<i>Tnom</i> (+15 – 35 °C)	<i>Vnom</i> (24.0 V)	Fn + 3 kHz	- 6 dB at 0.3% BER
		Fn	- 6 dB at 0.1 % BER
		Fn - 3 kHz	- 6 dB at 0.3 % BER
Measurement uncertainty		±1.1 dB	
Limits		Between -10.0 dB and 0 dB @ BER < 1%	

Test equipment used: (Item numbers)	2, 12, 17, 18, 19, 29, 33, 36, 37, 38, 40
-------------------------------------	---

2.7.4 15.4.4 Adjacent Channel selectivity

Date of test:	16 August 2004	Ambient temp.:	24 °C	R.H.:	46 %
Date of test:	26 August 2004	Ambient temp.:	23 °C	R.H.:	45 %
Date of test:	27 August 2004	Ambient temp.:	23 °C	R.H.:	46 %

CHANNEL 70: Fn: 156.525 MHz

TEST CONDITIONS		ADJACENT CHANNEL SELECTIVITY (dB)	
		Fn = 156.525 MHz(CH70)	
Temp.	Voltage	Funw =Fn - 25 kHz	Funw =Fn + 25 kHz
<i>Tnom</i> (+15 – 35 °C)	<i>Vnom</i> (24.0V)	80 dB at 0.9% BER	80 dB at 0.1% BER
<i>Tmin</i> (-15 °C)	<i>Vmin</i> (21.6 V)	78 dB at 0.8% BER	78 dB at 0.3% BER
<i>Tmax</i> (+55 °C)	<i>Vmax</i> (31.2 V)	78 dB at 0.6% BER	78 dB at 0.6% BER
Measurement uncertainty		+2.3 / -2.8 dB	
Limits		≥ 70.0 dB @ BER <1% under normal test conditions, ≥ 60.0 dB @ BER <1% under extreme test conditions.	

Funw = unwanted frequency modulated with 400Hz / 3 kHz deviation

Test equipment used: (Item numbers)	2, 5, 12, 17, 18, 19, 29, 33, 37, 38, 40
-------------------------------------	--

2.7.5 15.4.5 Spurious Response Rejection

Date of test: 16 August 2004 Ambient temp.: 24 °C R.H.: 46 %

CHANNEL 70: Fn: 156.525 MHz

Funw (MHz)	SPURIOUS RESPONSE REJECTION RATIO (dB)
--	--
*	--
--	--
Measurement uncertainty	+2.4 / -2.9 dB
Limit	≥ 70 dB @ BER < 1%

Funw = unwanted frequency

* : Rejection on all spurious responses was > 80 dB.

- (1) Frequency of the Receiver (f_R): 156.525 MHz
- (2) Frequency of the local oscillator signal applied to the 1st mixer of the Receiver (f_{LO}): 211.525 MHz
- (3) The frequency of the second LO = 54.545 MHz.
- (4) Intermediate frequencies (f_{I1} , f_{I2} , f_{I3}): f_{I1} = 55.0 MHz, f_{I2} = 455 kHz
- (5) Switching range of the Receiver (sr): 156.025 to 162.025 MHz

Test equipment used: (Item numbers)	2, 12, 17, 18, 19, 29, 33, 37, 38, 40
-------------------------------------	---------------------------------------

2.7.6 15.4.6 Intermodulation response Rejection

Date of test: 16 August 2004 Ambient temp.: 24 °C R.H.: 46 %

CHANNEL 70: Fn: 156.525 MHz

TEST CONDITIONS		Intermodulation response rejection ratio (dB)	
Temperature	Voltage	Test #1	Test #2
T_{nom} (+20 °C)	V_{nom} (24.0 V)	73 dB at 0.2% BER	73 dB at 0.1% BER
Measurement uncertainty		+2.4 / 2.8 dB	
Limits		65.0 dB at BER < 1%	

Remark: test configuration

	Generator A wanted –104 dbm	Generator B unwanted –39 dbm unmodulated	Generator C unwanted –39 dbm Mod. 400Hz / 3 kHz
Test #1	156.525MHz (Fn)	Fn + 50 kHz	Fn + 100 kHz
Test #2	156.525MHz (Fn)	Fn - 50 kHz	Fn - 100 kHz

Test equipment used: (Item numbers)	2, 7, 9, 12, 14, 16, 18, 19, 29, 33, 37, 38, 40
-------------------------------------	---

2.7.7 15.4.7 Blocking or Desensitisation

Date of test: 16 August 2004 Ambient temp.: 24 °C R.H.: 46 %

CHANNEL 70: Fn: 156.525 MHz

Unwanted frequency (MHz)	BER (%)
Fn -10	0.3 @ 90 dB
Fn - 9	0.0 @ 90 dB
Fn - 8	0.0 @ 90 dB
Fn - 7	0.0 @ 90 dB
Fn - 6	0.0 @ 90 dB
Fn - 5	0.0 @ 90 dB
Fn - 4	0.0 @ 90 dB
Fn - 3	0.0 @ 90 dB
Fn - 2	0.0 @ 90 dB
Fn - 1	0.1 @ 90 dB
Fn + 1	0.3 @ 90 dB
Fn + 2	0.0 @ 90 dB
Fn + 3	0.0 @ 90 dB
Fn + 4	0.0 @ 90 dB
Fn + 5	0.0 @ 90 dB
Fn + 6	0.0 @ 90 dB
Fn + 7	0.0 @ 90 dB
Fn + 8	0.0 @ 90 dB
Fn + 9	0.0 @ 90 dB
Fn + 10	0.3 @ 90 dB
Measurement uncertainty	+2.3 / -2.8 dB
Limit	≥ 84 dB @ BER < 1% except at spurious response frequencies

Test equipment used: (Item numbers)	2, 12, 17, 18, 19, 29, 33, 37, 38, 40
-------------------------------------	---------------------------------------

2.8 15.5 Conducted Spurious Emissions conveyed to the antenna

2.8.1 15.5.1 Spurious Emissions from the Receiver

Date of test: 13 May 2004 Ambient temp.: 25 °C R.H.: 42 %

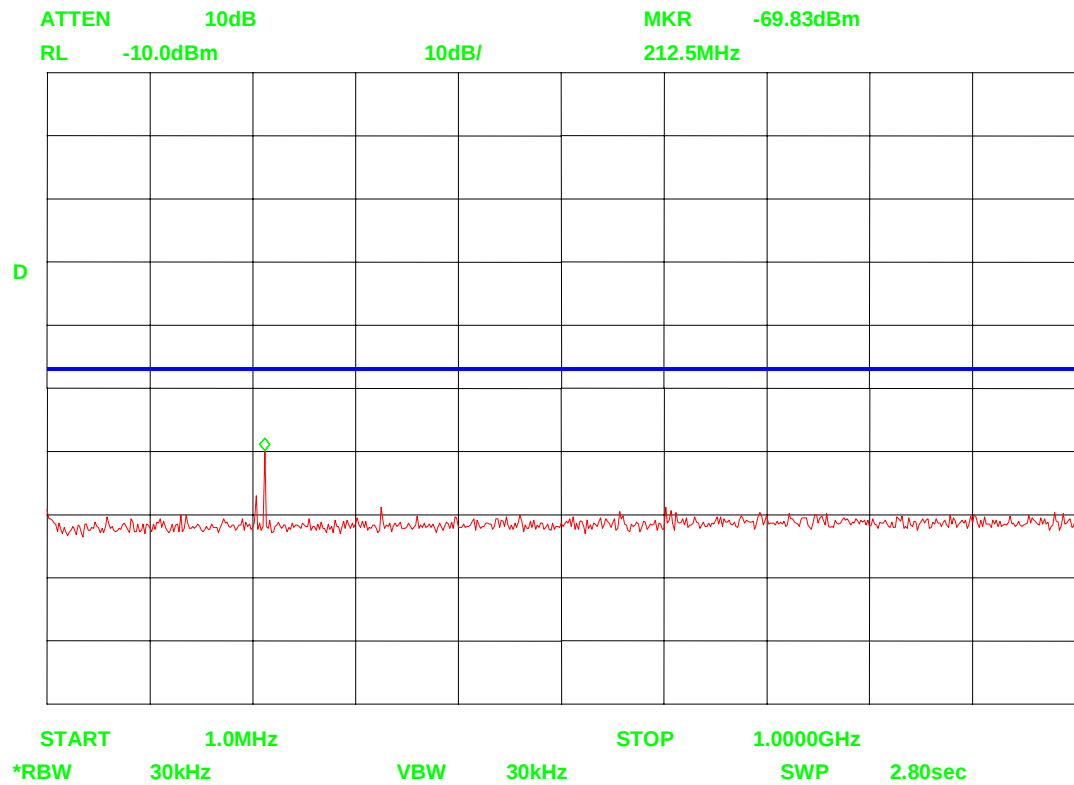
TDMA Receivers and DSC Receiver

Fn = 156.025, 162.025 MHz and 156.525 MHz

SPURIOUS EMISSIONS POWER LEVEL	
Spurious frequency (MHz)	Power level (dBm)
212.6	-68.5
*	All other emissions more than 20 dB below the limit
*	--
Measurement uncertainty	+1.7 / -1.9 dB
Limit (150 kHz - 2 GHz)	≤ -57 dBm (2 nW) for 150 kHz - 1 GHz, ≤ -47 dBm (20 nW) for 1 GHz - 2 GHz.

Test equipment used: (Item numbers)	1, 2, 20
-------------------------------------	----------

2.8.1.1 15.5.2 Spurious Emissions plot transponder in receive mode



2.8.2 15.5.2 Spurious Emissions from the Transmitter at 156.025 MHz

Date of test: 13 May 2004 Ambient temp.: 25 °C R.H.: 42 %

Fn = 156.025 at High and Low power

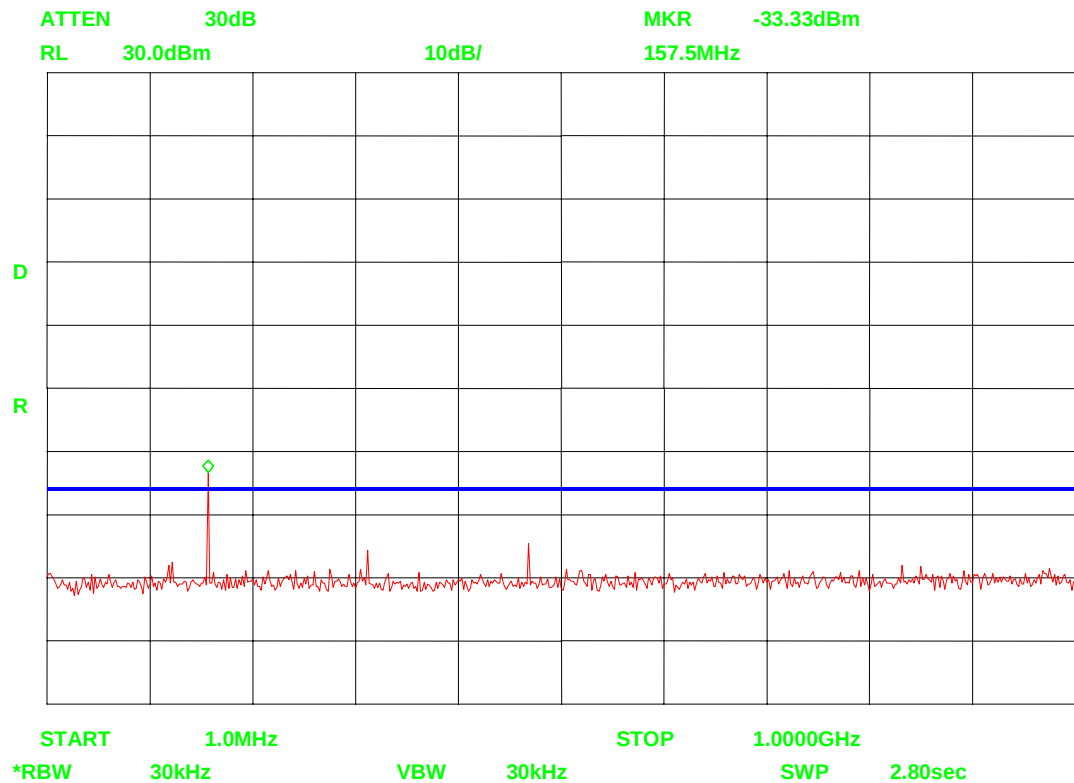
SPURIOUS EMISSIONS POWER LEVEL	
Spurious frequency (MHz)	Power level (dBm)
312.050 (1st. harmonic)	-44.0
468.075 (2nd. harmonic)	-44.3
*	All frequencies more than 10 dB below the limit
Measurement uncertainty	+1.7 / -1.9 dB
Limit (150 kHz - 2 GHz)	≤ -36 dBm (0.25 μ W) for 150 kHz - 1 GHz, ≤ -30 dBm (1 μ W) for 1 GHz - 2 GHz.

Remark: Test was carried out on high and low power.

Highest emission levels were measured when the transmitter was on high power

Test equipment used: (Item numbers)	1, 2, 6, 10, 20, 26, 28
-------------------------------------	-------------------------

2.8.2.1 15.5.2 Spurious Emissions plot (TX freq = 156.025 MHz at high power)



Remark: Marker at suppressed carrier

2.8.3 15.5.2 Spurious Emissions from the Transmitter at 162.025 MHz

Date of test: 13 May 2004 Ambient temp.: 25 °C R.H.: 42 %

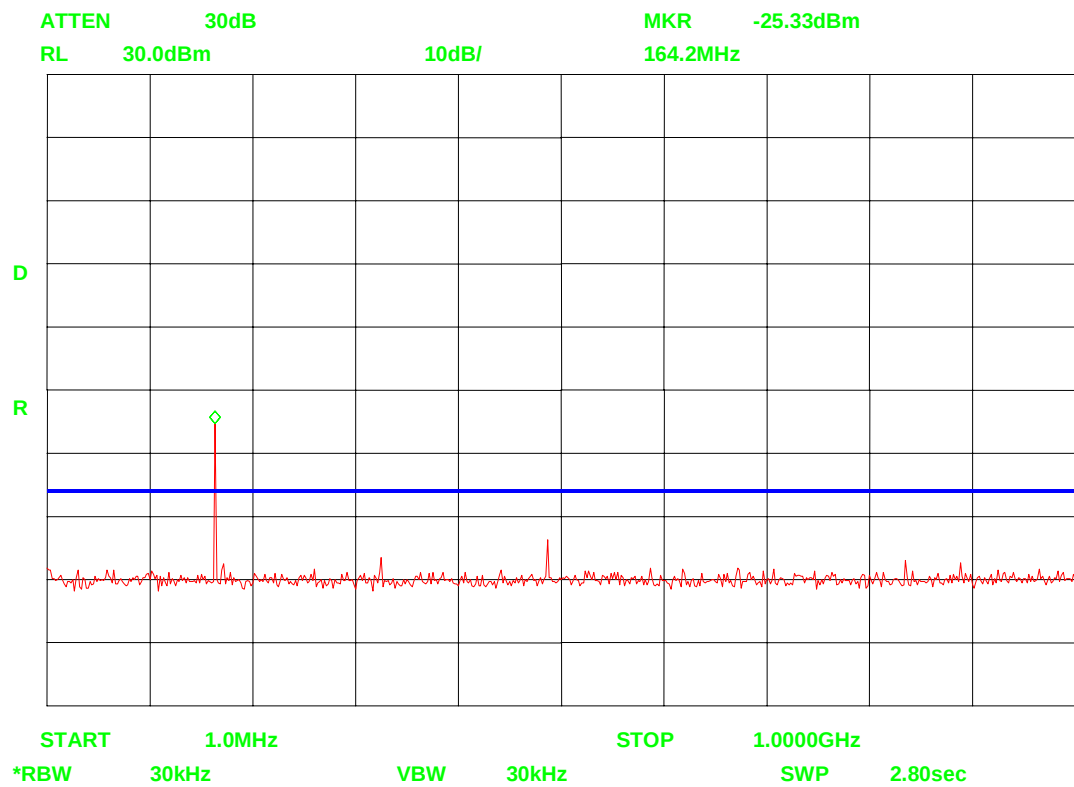
Fn = 162.025 at High and Low power

SPURIOUS EMISSIONS POWER LEVEL	
Spurious frequency (MHz)	Power level (dBm)
324.050 (1st. harmonic)	-45.5
486.075 (2nd harmonic)	-42.0
*	all other frequencies more then 10 dB below the limit
Measurement uncertainty	+1.7 / -1.9 dB
Limit (150 kHz - 2 GHz)	≤ -36 dBm (0.25 μ W) for 150 kHz - 1 GHz, ≤ -30 dBm (1 μ W) for 1 GHz - 2 GHz.

*Remark: Test was carried out on high and low power.
Highest emission levels were measured when the transmitter was on high power*

Test equipment used: (Item numbers)	1, 2, 6, 10, 20, 26, 28
-------------------------------------	-------------------------

2.8.3.1 15.5.2 Spurious Emissions plot (TX freq = 162.025 MHz at high power)



Remark: Marker at suppressed carrier

Used test equipment module

This module contains the total list of test equipment used.

Item	Description	Manufacturer	Model	Reference	Serial number
1	Spectrum analyser 20Hz – 26.5 GHz	HP	8563E	TE 00359	--
2	Power supply	Delta	SM6020	TE 00849	--
3	Power supply	Delta	E030-3	TE 00706	--
4	Power supply	Delta	E030-3	TE 00549	--
5	Environmental chamber	CTS	C-40/350	TE 00741	--
6	RF Attenuator 20 dB 100 Watt	Tenuline	8343-200	TE 00072	--
7	RF Attenuator 10 dB 1 Watt	HP	8491A	TE 00784	--
8	RF Attenuator 20 dB 1 Watt	HP	8491A	TE 00788	--
9	RF Attenuator 20 dB 100 Watt	Tenuline	8343-200	TE 00127	--
10	RF Attenuator 10 dB 25 Watt	Tenuline	8340-100	TE 00239	--
11	RF Attenuator 10 dB 25 Watt	Tenuline	8340-100	TE 00068	--
12	Signal generator	Marconi	2042	TE 00427	--
13	Radiocommunication Analyser	Marconi	2945A		--
14	Radiocommunication Analyser	Rohde & Schwartz	CMTA	TE 00221	--
15	Radiocommunication Analyser	Rohde & Schwartz	CMTA	TE 00035	--
16	RF Splitter	Minicircuits	ZSC-3-1	--	8931-03
17	RF Splitter	Minicircuits	ZSC-2-1W	--	9601-03
18	RS232-USB hub	Edgeport	50001231-01	--	--
19	Programmable modulation generator	Sine Qua Non	PMG1	--	010101-0016
20	Multimeter	HP	3478A	TE 00358	--
21	Oscilloscope	Tektronics	TDS860B	TE 00204	--
22	Thermometer	Keithley	870	TE 00853	
23	Frequency counter	Philips	PM6615	TE 00037	--
24	Transient detector 10 Mhz	JOZ	JOZ-1	TE 00800	--
25	FSK demodulator 1200 baud	Telefication	JOZ-2	TE 00800	--
26	Tuneable Notch filter	K&L	3TNF-100/200-N/N	TE 00588	--
27	Crystal detector	HP	8470A	TE 00422	--
28	RF diplexer	Procom	Pipx 225/330	--	220798242
29	GPS Time base receiver	HP	58503A	TE 00222	--
30	RF Mixer	HP	10514A	TE 00417	--

[illegible]

Photographs module

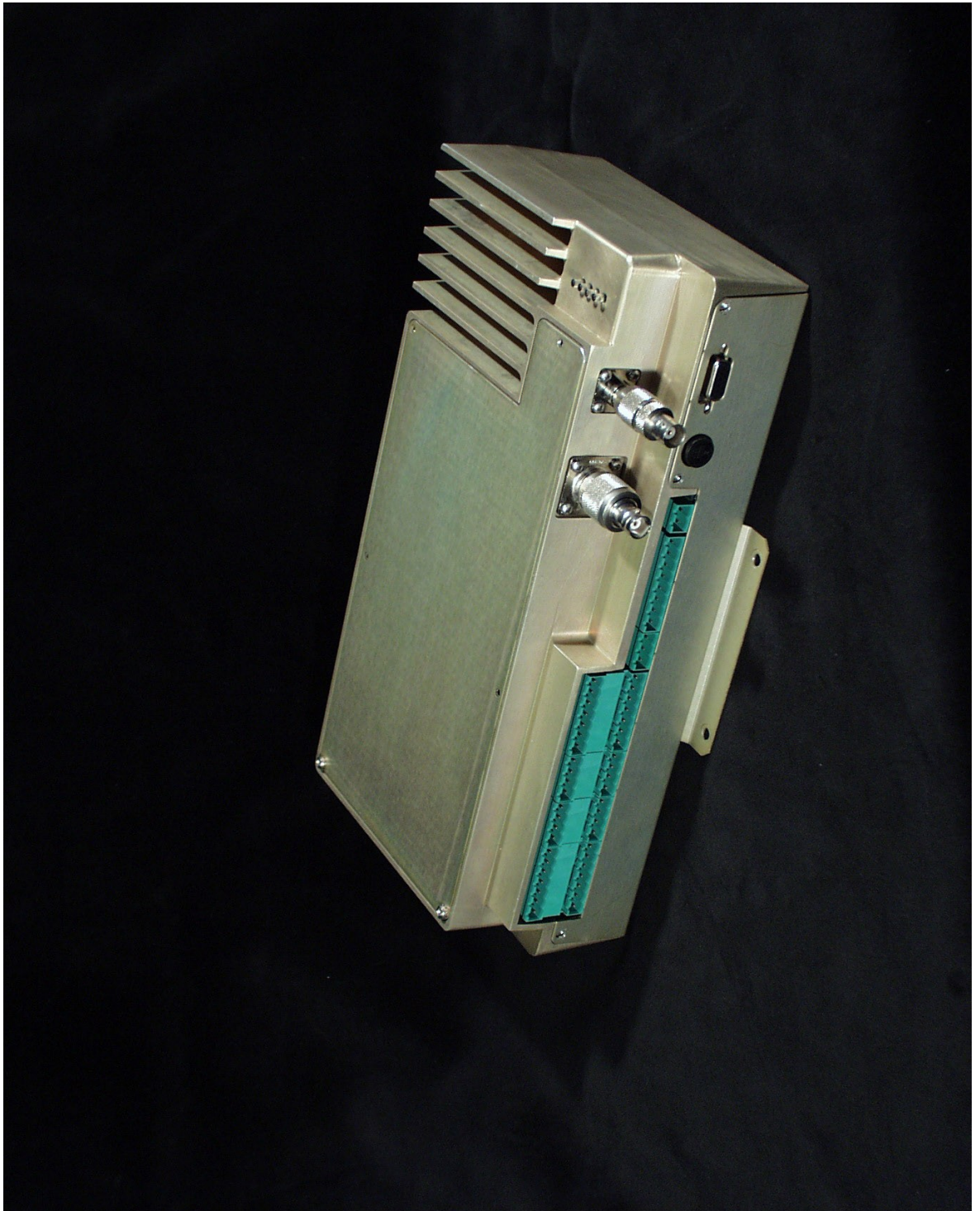
List of Photographs

Photograph 1: <i>Assembled view M2 transponder</i>	54
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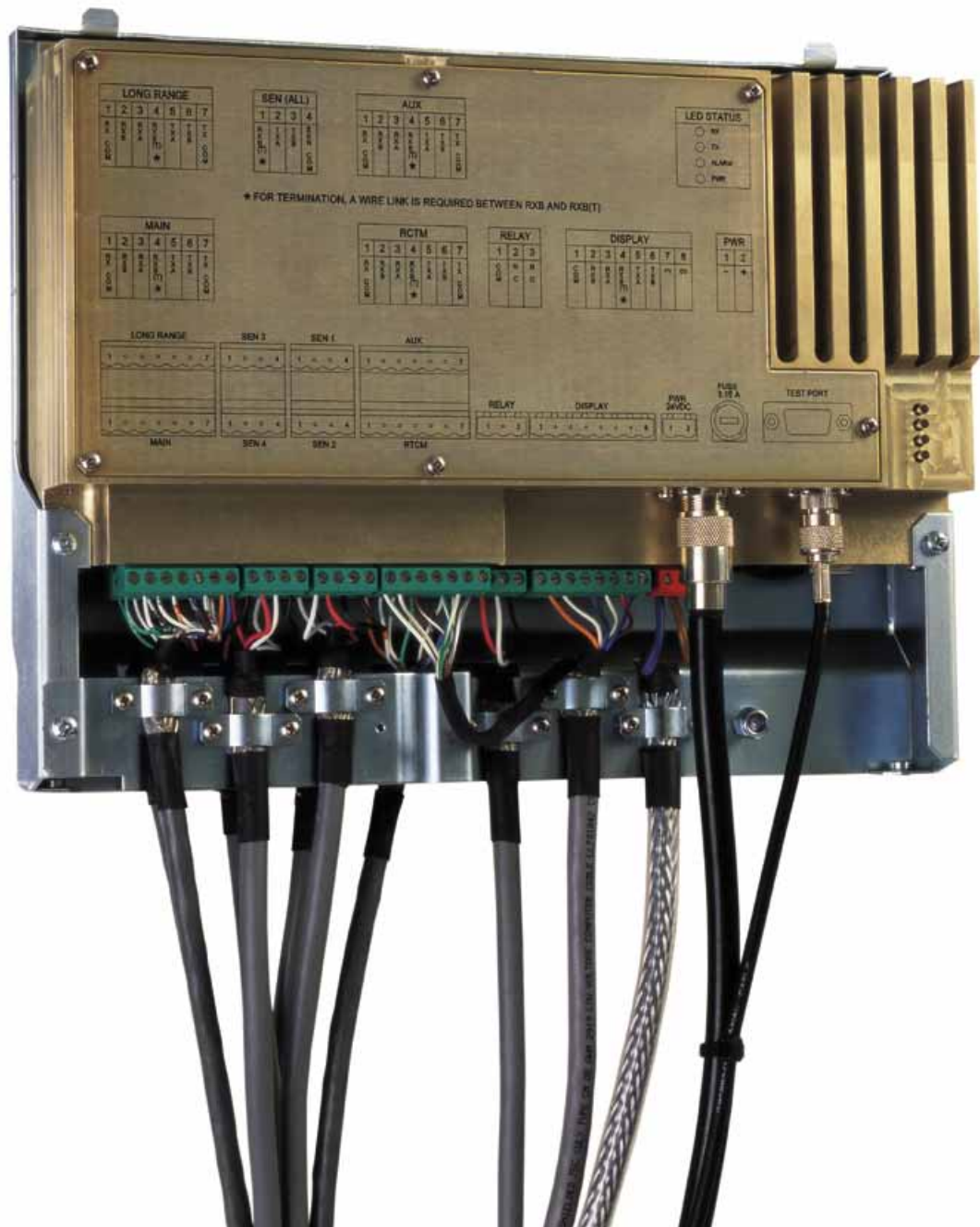
Photograph 1: *Assembled view M2 transponder*



Photograph 2: *M2 transponder without plastic enclosure*



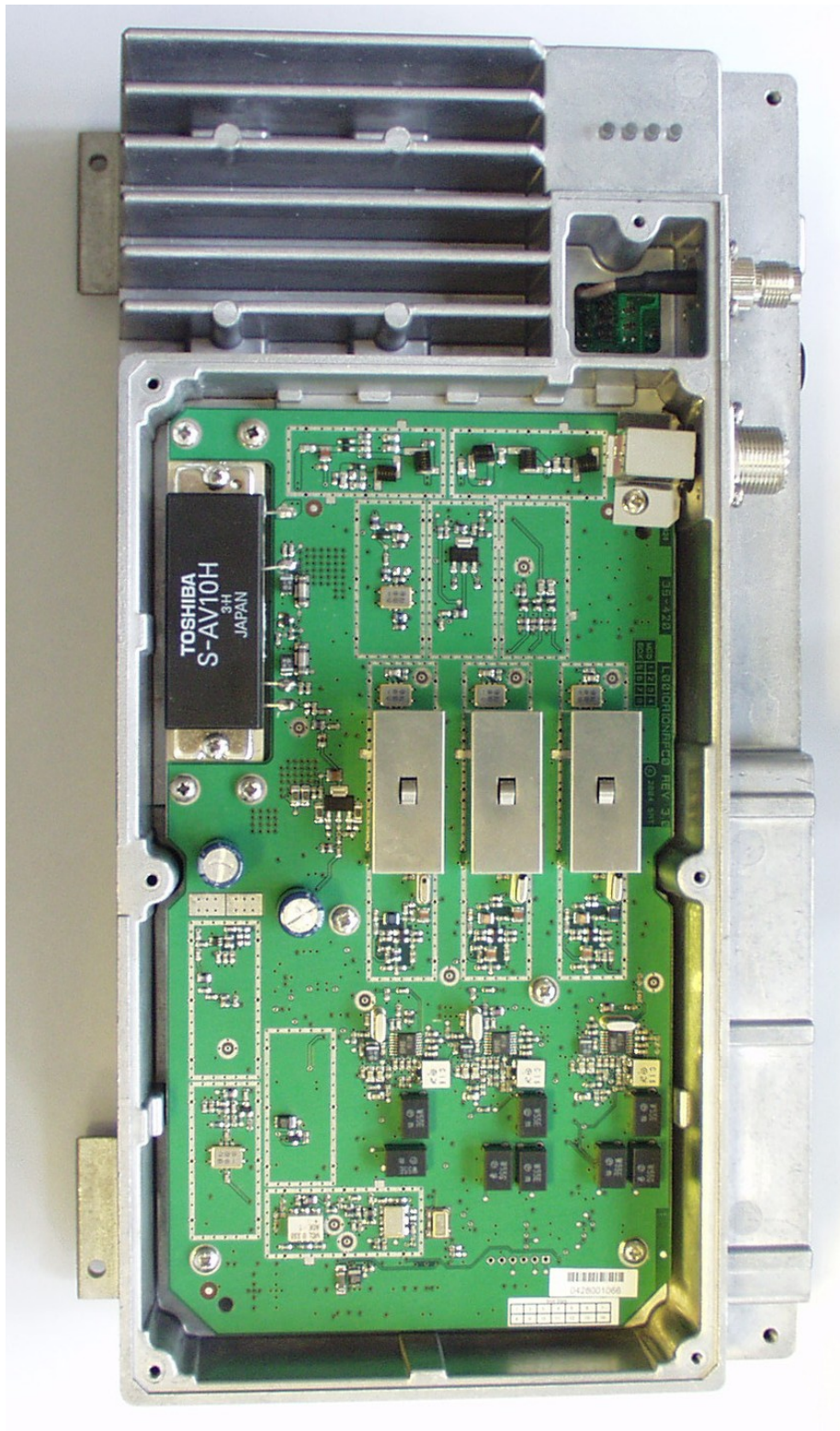
Photograph 3: *Cabling assembly overview*



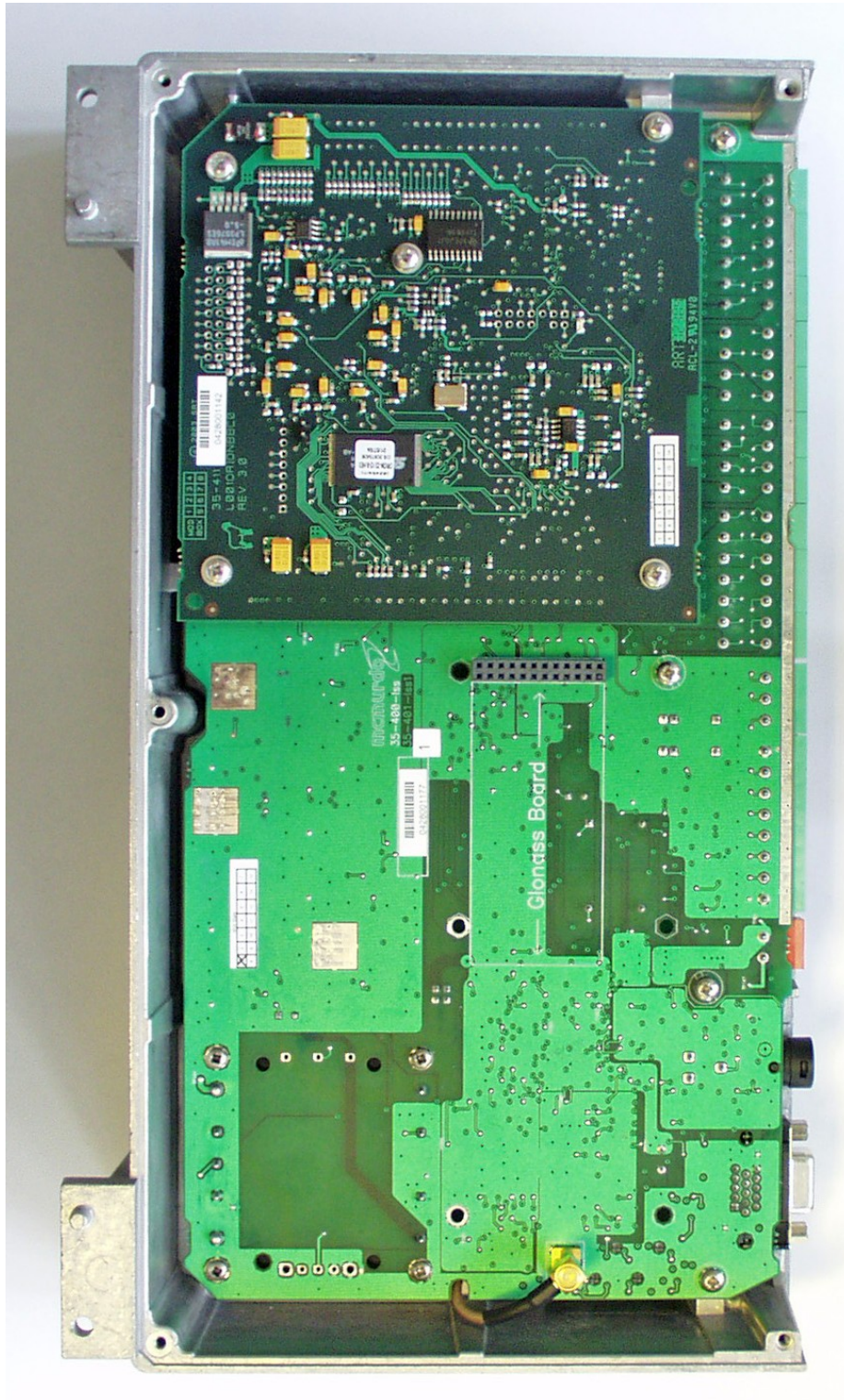
Photograph 4: *Label*



Photograph 5: *Opened enclosure RF side*



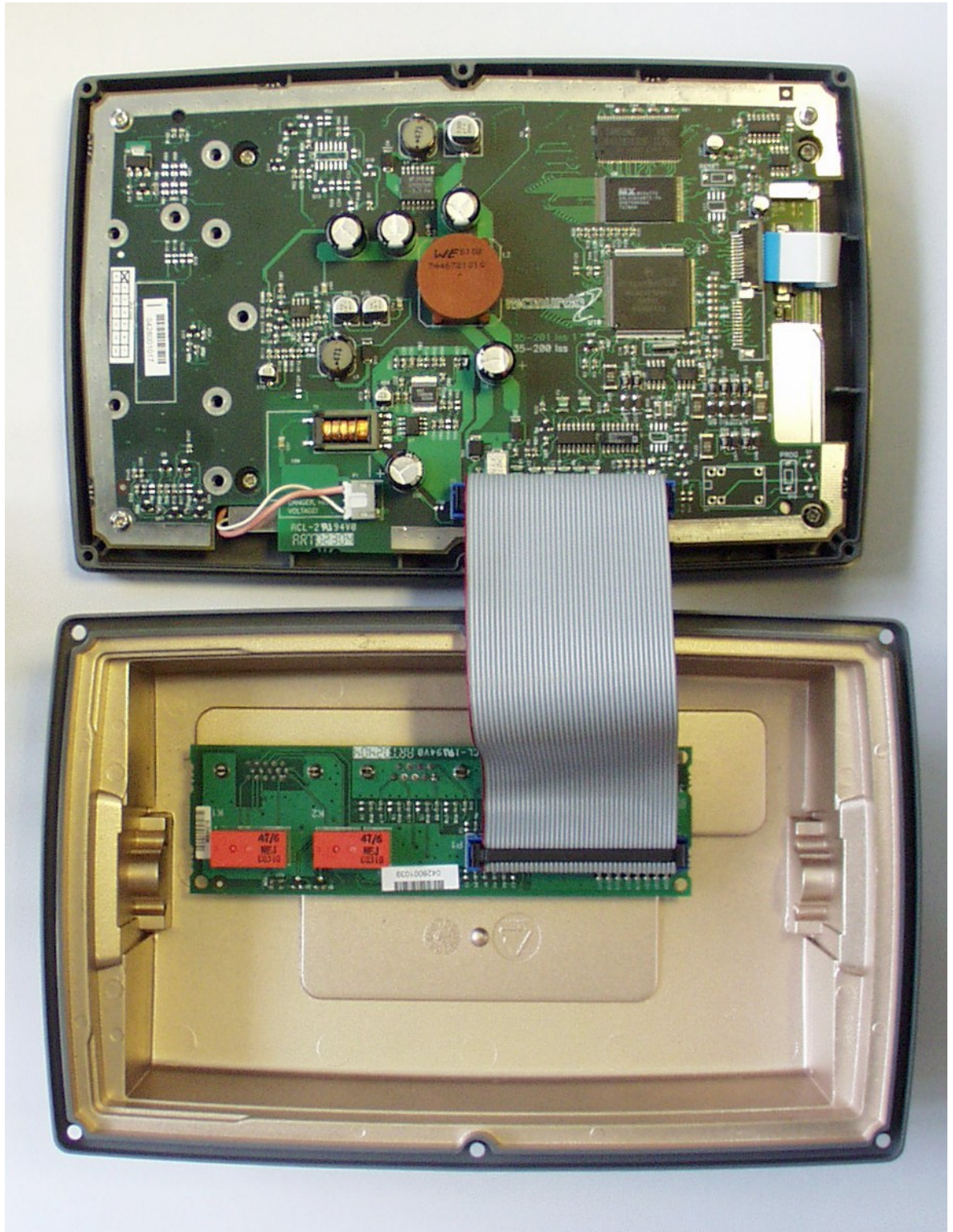
Photograph 6: *Opened enclosure, logic and connection side*



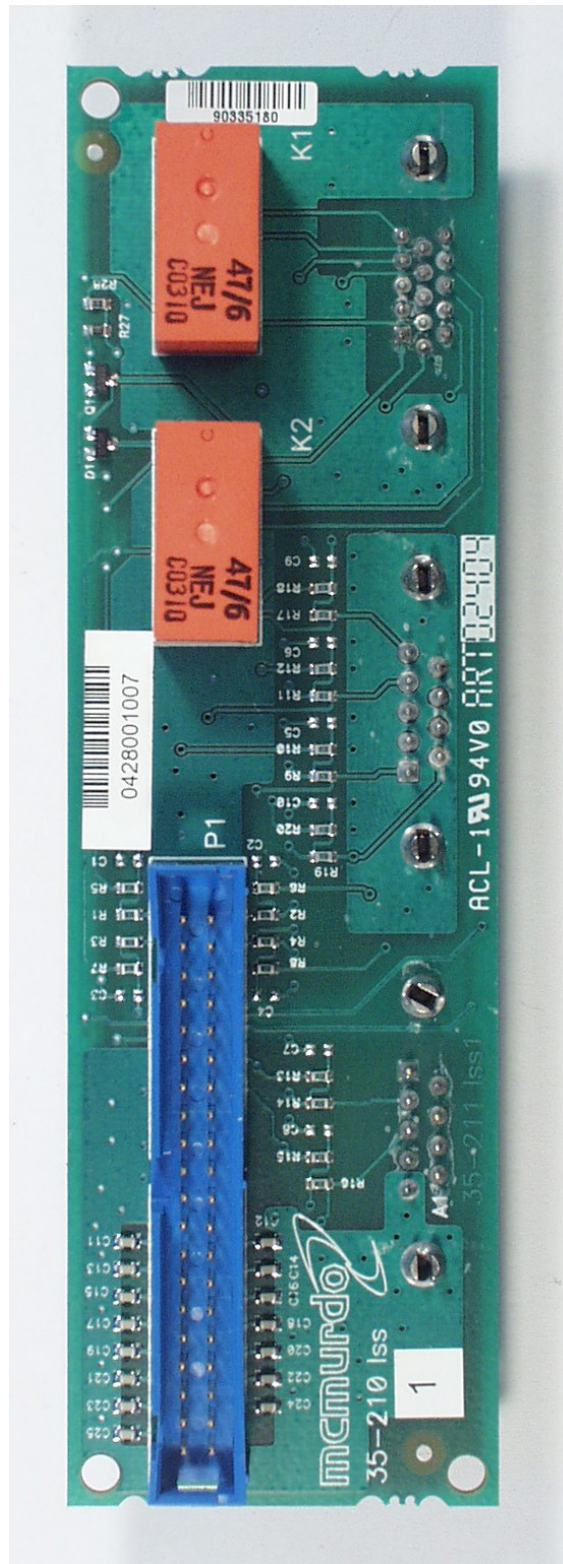
Photograph 7: General view MKD



Photograph 8: MKD, opened enclosure



Photograph 9: MKD, Connection board



Photograph 10: MKD, opened enclosure

