LW- MW- diplexer
135.6 kHz, 100 kW - 540 kHz, 150 kW

Lakihegy/ Budapest
(Hungary)

Technical Documentation

for acceptance tests

Sept. /Oct. 2006

Waniewski

LW- MW- diplexer Lakihegy (Hungary) 135.6 kHz, 100 kW - 540 kHz, 150 kW

Technical Documentation for acceptance tests Sept./Oct. 2006

Contents

LW- MW- diplexer Lakihegy (Hungary) 135.6 kHz, 100 kW - 540 kHz, 150 kW

Technical Documentation for acceptance tests Sept./Oct. 2006

1.0 Introduction

The Lakihegy Tower was constructed in 1933. It's height is 314 metres. At the time of it's erection it was the tallest building of Europe and it still the tallest building and a landmark of Hungary.
This mast design is known as Blaw-Knox radiator developed by the **Blaw-Knox** company which was a manufacturer of steel structures and construction equipment based in Pittsburgh, Pennsylvania (USA). The company designed radio towers, most of which were constructed during the 1930s in the United States and Europe. [1]

Recently the tower in Lakihegy was completely restored because a new applicant was found: the provider EFR (Eurpäische Funk-Rundsteuerung) from Munich.
This company uses the frequency 135.6 kHz for controlling power systems of power producers. This means for example the remote switching on and off of wind mill power producers or the controlling of street lamps.
Simultanously the antenna shall be used as a redundancy for the national radio supplier Antenna Hungaria on 540 kHz, 2000 W radiating from Solt, 75 km South of Budapest in the center of the country.

Therefore a LW- MW- diplexer for 135.6 kHz, 100 kW and 540 kHz, 150 kW was designed and installed.

The frequencies 810 kHz und 873 kHz are also radiated from the site in Lakihegy. Filters for these frequencies are part of the diplexer.

---

[1] Although Blaw-Knox built many kinds of towers, the term **Blaw-Knox tower** (or radiator) usually refers to the company's unusual "diamond cantilever" design, which is held upright by guy wires attached only at the vertical center of the mast, where its cross-section is widest.
Many Blaw-Knox towers, of both conventional (uniform cross-section) and diamond design, remain in use in the United States. Few of the diamond towers were built, and several remain; all transmit AM radio signals:

Nashville, Tennessee: 246 m; originally 267 m; tower located in Brentwood, Tennessee.
Cincinnati, Ohio: 227 m; originally 253 m; tower located in Mason, Ohio.
Charlotte, North Carolina: three towers, 130 m each (one original, two reproductions from the original plans after the originals were destroyed in a hurricane)
Manchester, New Hampshire: 121 m
Columbus, Ohio: 116 m

Several additional such towers are in use at stations in California but are less well-known.

The following Blaw-Knox diamond-cantilever towers remain standing in Europe:

Lisnargarvey Mast (constructed: 1936) at Lisnargarvey, Northern Ireland Its height was originally 144.8 metres, but it was shortened when the station's broadcast frequency was changed.

Vakarel Transmitter (constructed: 1937, height: 352.9 metres**, tallest Blaw-Knox Tower in the world**) at Vakarel, Bulgaria

Stara Zagora Transmitter at Stara Zagora, Bulgaria

LW- MW- diplexer Lakihegy (Hungary) 135.6 kHz, 100 kW - 540 kHz, 150 kW

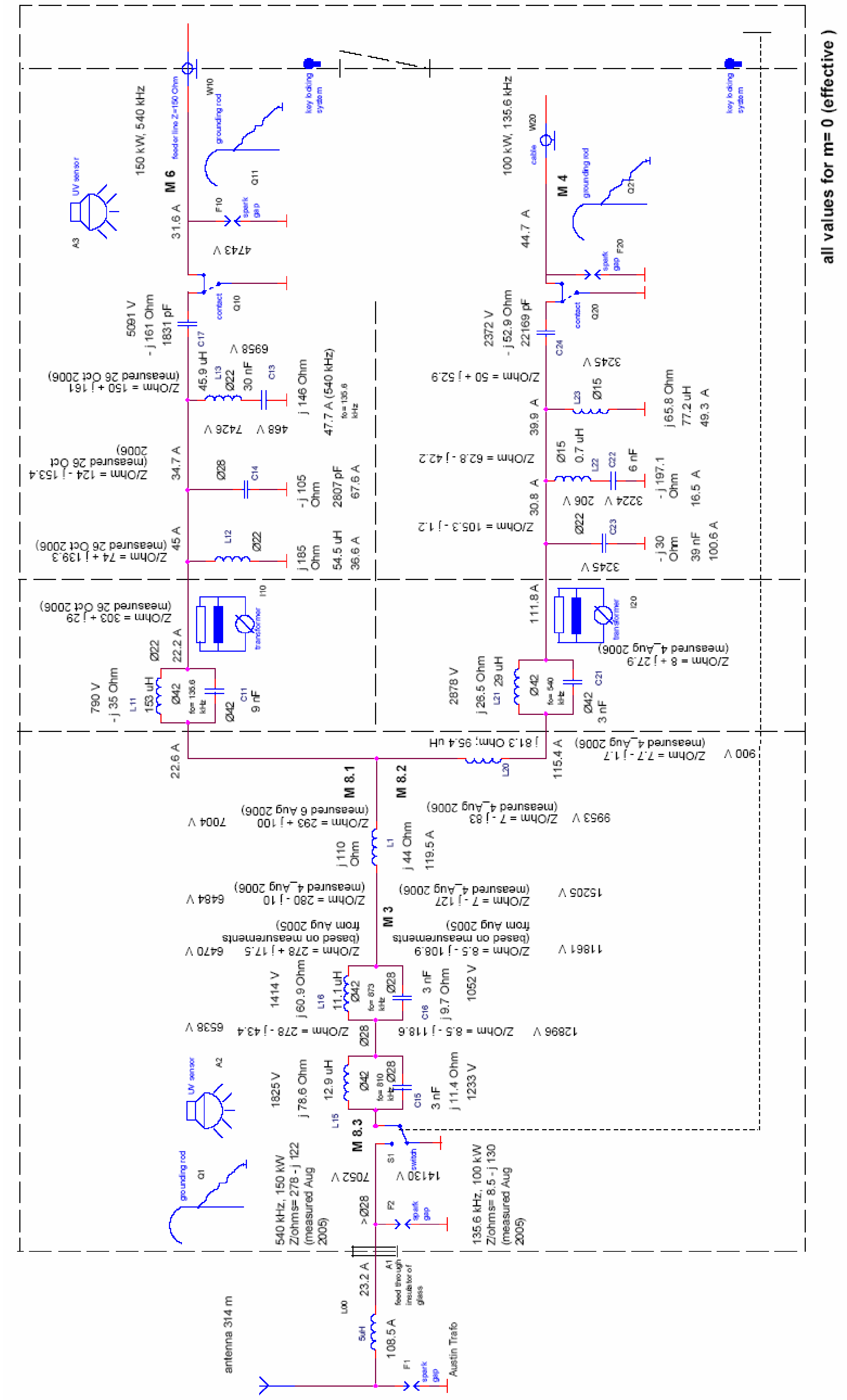
Technical Documentation for acceptance tests Sept./Oct. 2006

2.0 Design of antenna tuning unit as diplexer and operational values

The design of the antenna tuning unit as diplexer is shown below. The same document is given as file 51-8920-810-00 WSP_LAKIHEGY_ATU_AE05.pdf (A3 format) in the appendix (1).

LW- MW- diplexer Lakihegy (Hungary) 135.6 kHz, 100 kW - 540 kHz, 150 kW

Technical Documentation for acceptance tests Sept./Oct. 2006



wski

LW- MW- diplexer Lakihegy (Hungary) 135.6 kHz, 100 kW - 540 kHz, 150 kW

Technical Documentation for acceptance tests Sept./Oct. 2006

At the base of the antenna the coil L00 for protection against lightning is installed. Lightning current flowing from the mast into this coil increases the voltages at the spark gaps F1 and F2 (u = L • di/dt) avoiding damages of antenna tuning components by lightning.

The drawing contains also operational values as currents and voltages.

3.0 Measured value of antenna impedances for 135.6 kHz

In order to protect the measuring instruments against high voltages occurring at the base of the antenna - caused by the frequencies 810 kHz and 873 kHz which also radiated from the site in Lakihegy - the antenna impedance was measured behind the filters for 810 and 873 kHz. (Measuring point M3)

antenna impedances for 135.6 kHz:

f/ kHz	Z/ Ohm
135.6	7.0 – j 127.0

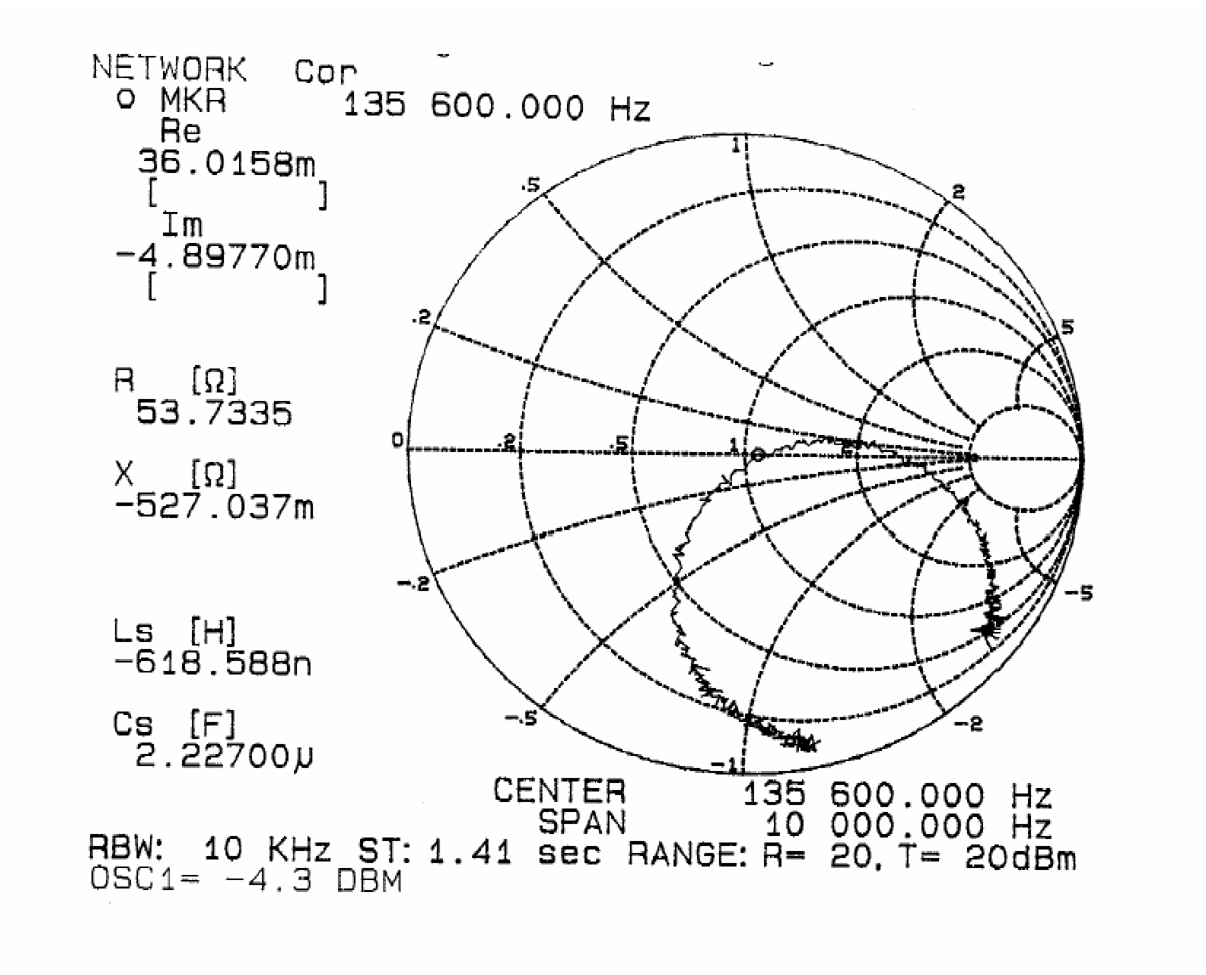
4.0 Measured values of impedances for 135.6 kHz +- 5 kHz at cable output

The measured values of impedances for 135.6 kHz +- 5 kHz at the cable output are given in the following table and the plot below. (Measuring point M4)

f/ kHz	Z/ Ohm
135.6	53.7 – j 0.5
135.8	62.4 + j 3.1
136.0	72.9 + j 5.0
137.7	183.5 – 114.2
140.15	36.3 – j 155.7
135.4	45.4 – j 6.1
135.2	40.3 – j 10
134.6	27.6 – j 21.6
130.6	6.0 – j 61.1

LW- MW- diplexer Lakihegy (Hungary) 135.6 kHz, 100 kW - 540 kHz, 150 kW

Technical Documentation for acceptance tests Sept./Oct. 2006



5.0 Measured values of antenna impedances for 540 kHz +- 20 kHz

In order to protect the measuring instruments against high voltages occurring at the base of the antenna - caused by the frequencies 810 kHz and 873 kHz which also radiated from the site in Lakihegy - the antenna impedance was measured behind the filters for 810 and 873 kHz. (Measuring point M3)

antenna impedances for 540 kHz:

f/ kHz	Z/ Ohm	f/ kHz	Z/ Ohm	f/ kHz	Z/ Ohm
540.0	280 – j 10	520.0	285 – j 47.0	560.0	203.5 + j 32.5
		525.0	270 – j 20.0	555.0	212 + j 25.0

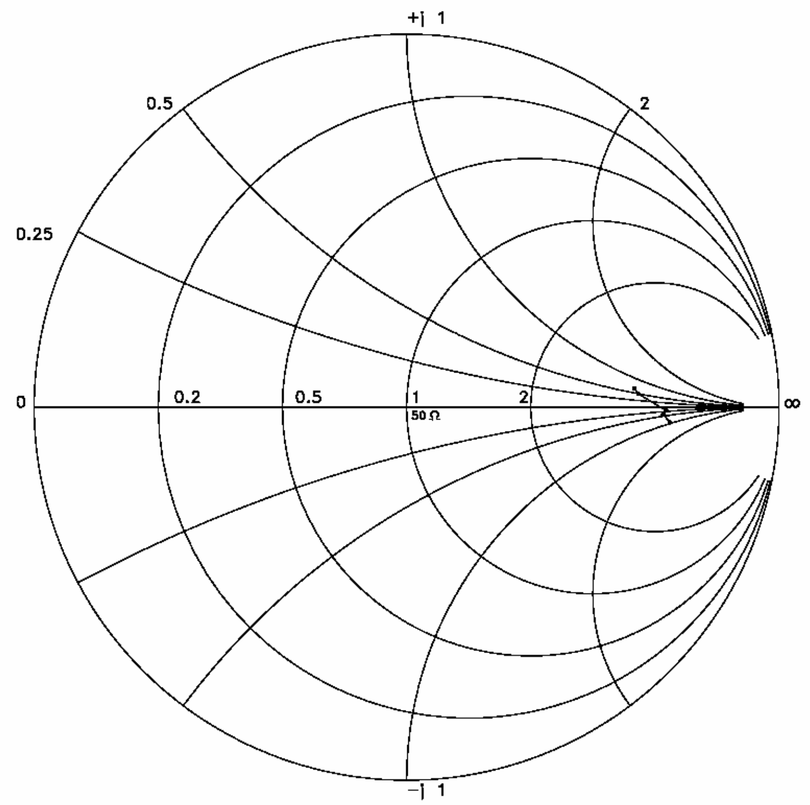
LW- MW- diplexer Lakihegy (Hungary) 135.6 kHz, 100 kW - 540 kHz, 150 kW

Technical Documentation for acceptance tests Sept./Oct. 2006

Please see Smith- Chart below:

17.11.2006 16:41:09 SMITH-CHART 0 DB F540.IMP 17.11.2006 16:39:21

U:\ENTWIC~1\ANT_E\LW\UNGARN~2\AUFTRA~1\F540.imp



IMPEDANCE d'ENTREE/Ohm:

f /kHz	Re(Z)	Im(Z)	Re(Z)/ZL	Im(Z)/ZL	Re(r)	Im(r)	SWR	r/dB
520.0	285.00	−46.99	0.570E+01	−0.940E+00	0.707	− 0.041	5.86	−2.99
525.0	270.00	−19.99	0.540E+01	−0.400E+00	0.689	− 0.019	5.43	−3.24
540.0	280.00	−9.99	0.560E+01	−0.200E+00	0.697	− 0.009	5.61	−3.13
555.0	212.00	25.00	0.424E+01	0.500E+00	0.622	0.036	4.30	−4.11
560.0	203.50	32.50	0.407E+01	0.650E+00	0.612	0.050	4.18	−4.24

IMPEDANCE D"ENTREE A LA POS.:(3)
IMPEDANCE DE REFERENCE: ZL=(50.000; 0.000) OHM

2006	date	nom
expert	17.11.	Waniewski
approu.		
ville		
départ.		E1

MW/LW Ungarn
simultaneously with 135.6 kHz
150 kW, 540 kHz
measured values close to antenna base

T-Nr.
feuil
Bl.

TRANSRADIO
SenderSysteme Berlin

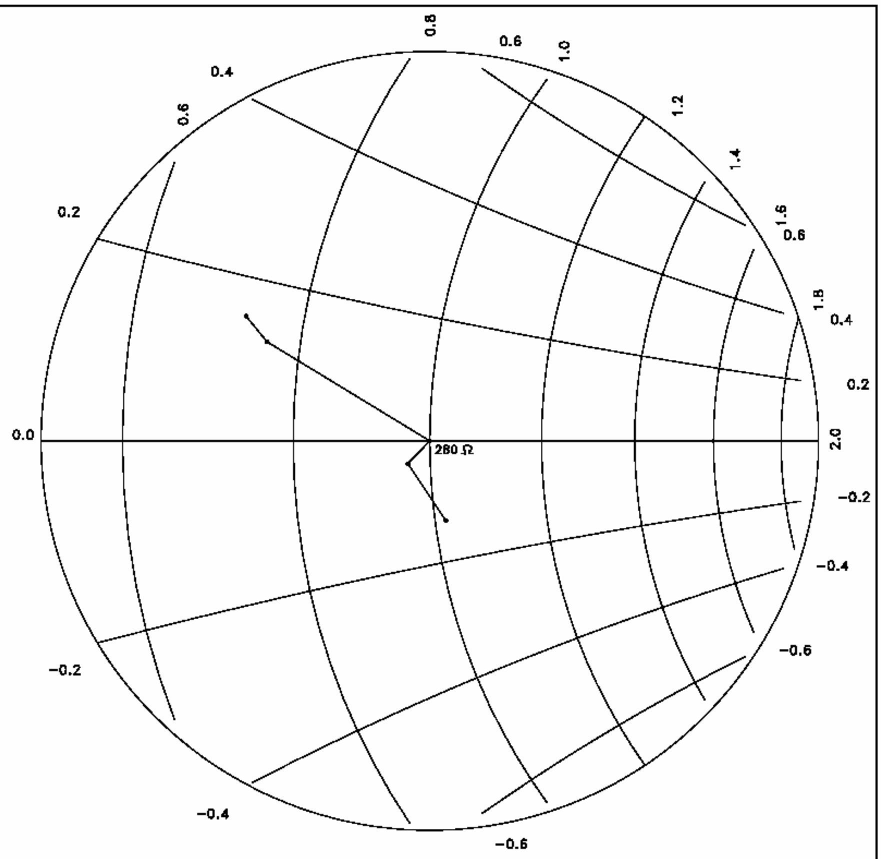
51 A 7626_SA1_F540

Index | modification | date | nom | Ursprung: | Ers. fuer: | Ers. durch:

LW- MW- diplexer Lakihegy (Hungary) 135.6 kHz, 100 kW - 540 kHz, 150 kW

Technical Documentation for acceptance tests Sept./Oct. 2006

The standing wave ratio can be obtained by relating all impedance values to the antenna impedance of 540 kHz:



Tenez compte Copyright apres DIN 34

17.11.2006 16:48:43 SMITH−CHART 10 DB F540.IMP 17.11.2006 16:39:21

U:\ENTWIC~1\ANT_E\LW\UNGARN~2\AUFTRA~1\F540.imp

IMPEDANCE d'ENTREE/Ohm:

f /kHz	Re(Z)	Im(Z)	Re(Z)/ZL	Im(Z)/ZL	Re(r)	Im(r)	SWR	r/dB
520.0	285.00	−36.99	0.102E+01	−0.132E+00	0.013	− 0.065	1.14	− 23.62
525.0	270.00	−9.99	0.964E+00	−0.357E−01	−0.018	− 0.018	1.05	− 31.80
540.0	280.00	0.01	0.100E+01	0.280E−04	0.000	0.000	1.00	− 97.07
555.0	212.00	35.00	0.757E+00	0.125E+00	− 0.132	0.081	1.37	− 16.19
560.0	203.50	42.50	0.727E+00	0.152E+00	− 0.149	0.101	1.44	− 14.88

IMPEDANCE D"ENTREE A LA POS.:(3)
IMPEDANCE DE REFERENCE: ZL=(280.000; 0.000) OHM ZI= −10.000 Ohm

				2006	date	nom	MW/LW Ungarn simultaneously with 135.6 kHz 150 kW, 540 kHz measured values close to antenna base	
				expert	17.11	Waniewski		
				approu.				
				ville				
				départ.		E1		T−Nr.
				TRANSRADIO SenderSysteme Berlin			51 A 7626_SA2_F540	feuil
								Bl.
Index	modification	date	nom	Ursprung:			Ers. fuer:	Ers. durch:

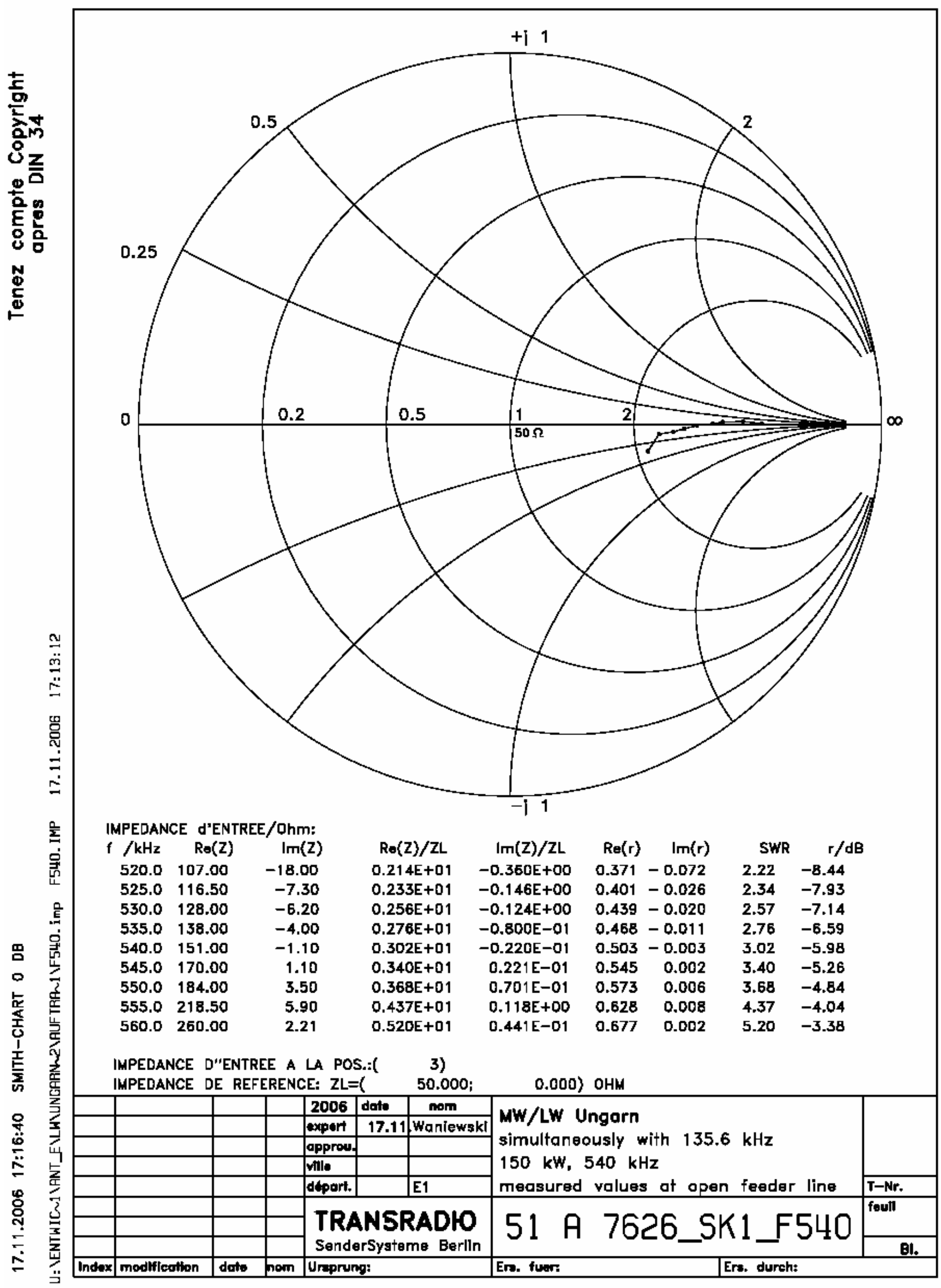
LW- MW- diplexer Lakihegy (Hungary) 135.6 kHz, 100 kW - 540 kHz, 150 kW

Technical Documentation for acceptance tests Sept./Oct. 2006

6.0 Measured values of impedances for 540 kHz +- 20 kHz at open wire line

The measured values of impedances for 540 kHz +- 20 kHz at the open wire line are given in the following table and the plot below. (Measuring point M6)

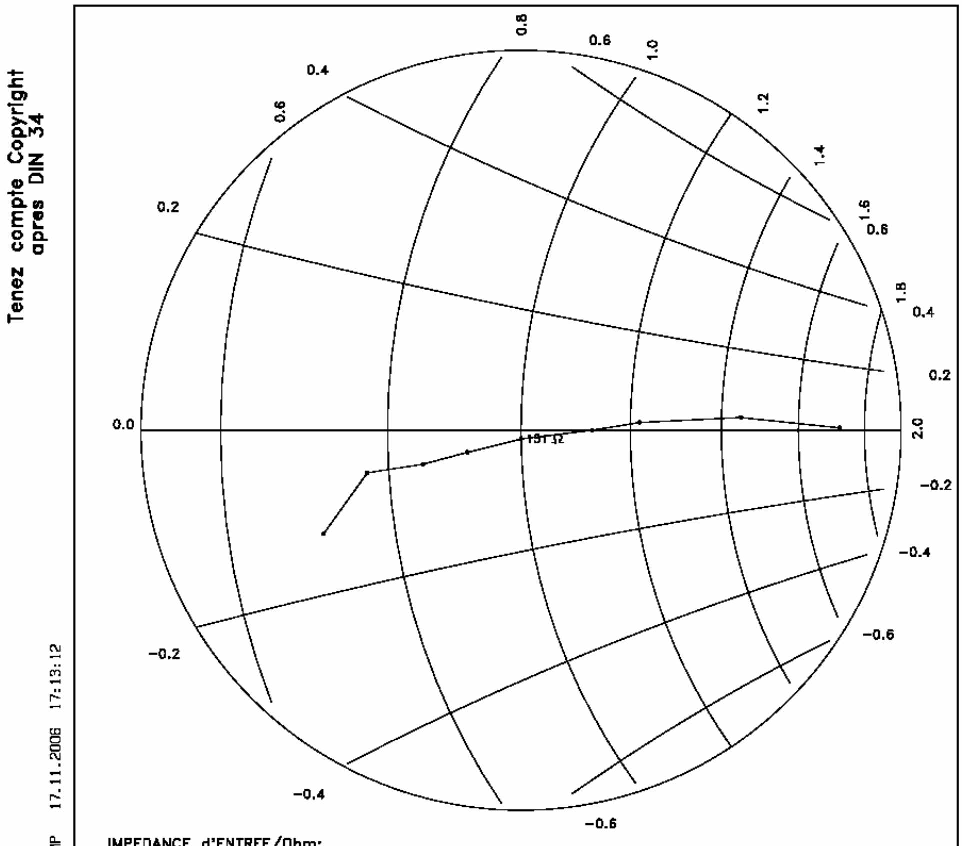
f/ kHz	Z/ Ohm	f/ kHz	Z/ Ohm	f/ kHz	Z/ Ohm
540.0	151 – j 1.1	520	107 – j 18.0	560	260 + j 2.2
		525	116.5 – j 7.3	555	218.5 + j 5.9
		530	128 – j 6.2	550	184 + j3.5
		535	138 – j 4.0	545	170 + j 1.1



LW- MW- diplexer Lakihegy (Hungary) 135.6 kHz, 100 kW - 540 kHz, 150 kW

Technical Documentation for acceptance tests Sept./Oct. 2006

The standing wave ratio can be obtained by relating all impedance values to the antenna impedance of 540 kHz:



IMPEDANCE d'ENTREE/Ohm:

f /kHz	Re(Z)	Im(Z)	Re(Z)/ZL	Im(Z)/ZL	Re(r)	Im(r)	SWR	r/dB
520.0	107.00	-19.10	0.709E+00	-0.126E+00	-0.164	- 0.086	1.46	- 14.64
525.0	116.50	-8.40	0.772E+00	-0.556E-01	-0.128	- 0.035	1.31	- 17.54
530.0	128.00	-7.30	0.848E+00	-0.483E-01	-0.082	- 0.028	1.19	- 21.26
535.0	138.00	-5.10	0.914E+00	-0.338E-01	-0.045	- 0.018	1.10	- 26.32
540.0	151.00	-2.20	0.100E+01	-0.146E-01	0.000	- 0.007	1.01	- 42.76
545.0	170.00	0.00	0.113E+01	0.191E-04	0.059	0.000	1.13	- 24.56
550.0	184.00	2.40	0.122E+01	0.159E-01	0.099	0.006	1.22	- 20.11
555.0	218.50	4.80	0.145E+01	0.318E-01	0.183	0.011	1.45	- 14.75
560.0	260.00	1.11	0.172E+01	0.733E-02	0.265	0.002	1.72	- 11.53

IMPEDANCE D"ENTREE A LA POS.:(3)
IMPEDANCE DE REFERENCE: ZL=(151.000; 0.000) OHM Zl= 1.100 Ohm

2006	date	nom	MW/LW Ungarn	
expert	17.11.	Waniewski	simultaneously with 135.6 kHz	
approu.			150 kW, 540 kHz	
ville				
départ.		E1	measured values at open feeder line	T-Nr.
TRANSRADIO SenderSysteme Berlin			51 A 7626_SK2_F540	feuil Bl.
Ursprung:			Ers. fuer:	Ers. durch:

Index | modification | date | nom

7.0 Coils and condensors, operational settings

Coils in alphabetic order:

coil	D/mm	d/mm	windings total	windings active
L1	450	42	23	23 (all)
L11	450	22	40	40 (all)
L12	450	28	20	20 (all)

LW- MW- diplexer Lakihegy (Hungary) 135.6 kHz, 100 kW - 540 kHz, 150 kW

Technical Documentation for acceptance tests Sept./Oct. 2006

Coils (continued):

L13	300	22	30	27
L15	450	42	10	8
L16	450	42	10	8,05
L20	450	22	30	26,25
L21	700	28	2 x 11	11 (all) top 10,4 bottom
L22	300	15	8	0, short circuited
L23	300	15	30	30 (all)

Condensors in alphabetic order:

C11	pF	pF	pF		pF	pF	pF
	front				**rear**		
	In series : 1000 1000	In series : 1000 1000	In series : 1000 1000		In series : 1000 1000	In series : 1000 1000	In series : 1000 1000
	In series : 1000 1000	In series : 1000 1000	In series : 1000 1000		In series : 1000 1000	In series : 1000 1000	In series : 1000 1000
	In series : 1000 1000	In series : 1000 1000	In series : 1000 1000		In series : 1000 1000	In series : 1000 1000	In series : 1000 1000
	Front and rear are in parallel						
	Total :	**9000 pF**					

C13	pF	pF		pF	pF
	front			**rear**	
	In parallel : 3000 3000	In parallel : 3000 3000		In parallel : 3000 3000 3000	In parallel : 3000 3000 3000
	front and rear all in parallel				
	Total :	**30000 pF**			

C14	pF	pF		pF	pF	Σ
	rear			**front**		
	In series : 3000 3000 3000	In series : 1000 1000 200		In series : 3000 3000 3000	In series : 3000 3000 400 in parallel with 200 and 400 in series = 533	 10000 10000 6733
	all four rows in parallel of front and rear are in parallel					
	Total :	**2869 pF**				

LW- MW- diplexer Lakihegy (Hungary) 135.6 kHz, 100 kW - 540 kHz, 150 kW

Technical Documentation for acceptance tests Sept./Oct. 2006

Condensors (continued):

C15	pF	pF	pF
	1000	1000	1000
	all three in parallel		
	Total :	**3000 pF**	

C16	pF	pF	pF
	1000	1000	1000
	all three in parallel		
	Total :	**3000 pF**	

C17	pF	pF		pF	pF
	rear			**front**	
	In series : 1000 3000 1000	In series : 1000 200		In series : 3000 400	In series : 3000 1000
Σ	428.6	166.7		352.9	750
	all four rows in parallel of front and rear are in parallel				
	Total :	**1698 pF**			

C21	pF	pF	pF	pF	pF		pF	pF	pF	pF
	front						**rear**			
	1000 1000 1000	1000 1000 1000	1000 1000 1000	1000 1000 1000	1000 1000 1000		1000 1000 1000	1000 1000 1000	1000 1000 1000	1000 1000 1000
	all columns of front and rear are in series									
	Total :	**3000 pF**								

C22	pF	pF	pF		pF	pF	pF
	front				**rear**		
	1000 1000	1000	1000 1000		1000 1000	1000 1000	1000 1000
	all are in parallel						
	Total :	**11000 pF**					

C23	pF	pF	pF		pF	pF	pF
	front				**rear**		
	3000 3000	3000 3000	3000 3000		3000 3000	3000 3000 3000	3000 3000
	all are in parallel						
	Total :	**39000 pF**					

LW- MW- diplexer Lakihegy (Hungary) 135.6 kHz, 100 kW - 540 kHz, 150 kW

Technical Documentation for acceptance tests Sept./Oct. 2006

C24	pF	pF	pF		pF	pF	pF
	front				**rear**		
	3000 3000	3000 3000	2000		2000 1000	3000 3000	3000 3000
	all are in parallel						
	Total :	**29000 pF**					

"Front" must be understood as "looking towards the nearest wall".

8.0 Decoupling by filters

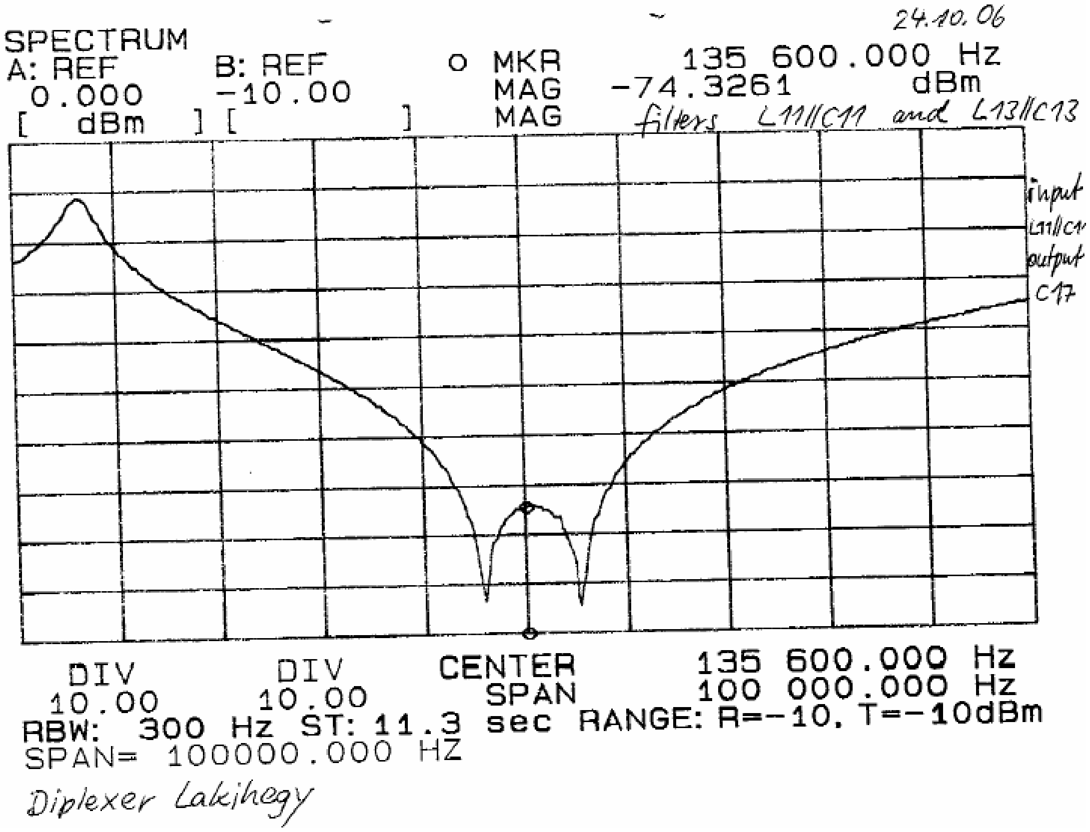
In addition to the necessary decoupling of the two frequencies of the diplexer 135.6 kHz and 540 kHz filters are needed for the frequencies 810 kHz an d 873 kHz which are induced in the antenna from masts nearby on the same site of Lakihegy.

The measurement of the following filters has been carried out:

- **Filters for 135.6 kHz**

  Tuning elements L11/ C11 in parallel (rejection) and L13 / C13 in series (drain)

Transmission measurement was carried out between M8.1 and M6. M8.1 is open and disconnected from the other tuning elements. M6 is disconnected from the open feeder line.



The same document is given as file "filters_135_6_kHz.pdf" in the appendix (2).

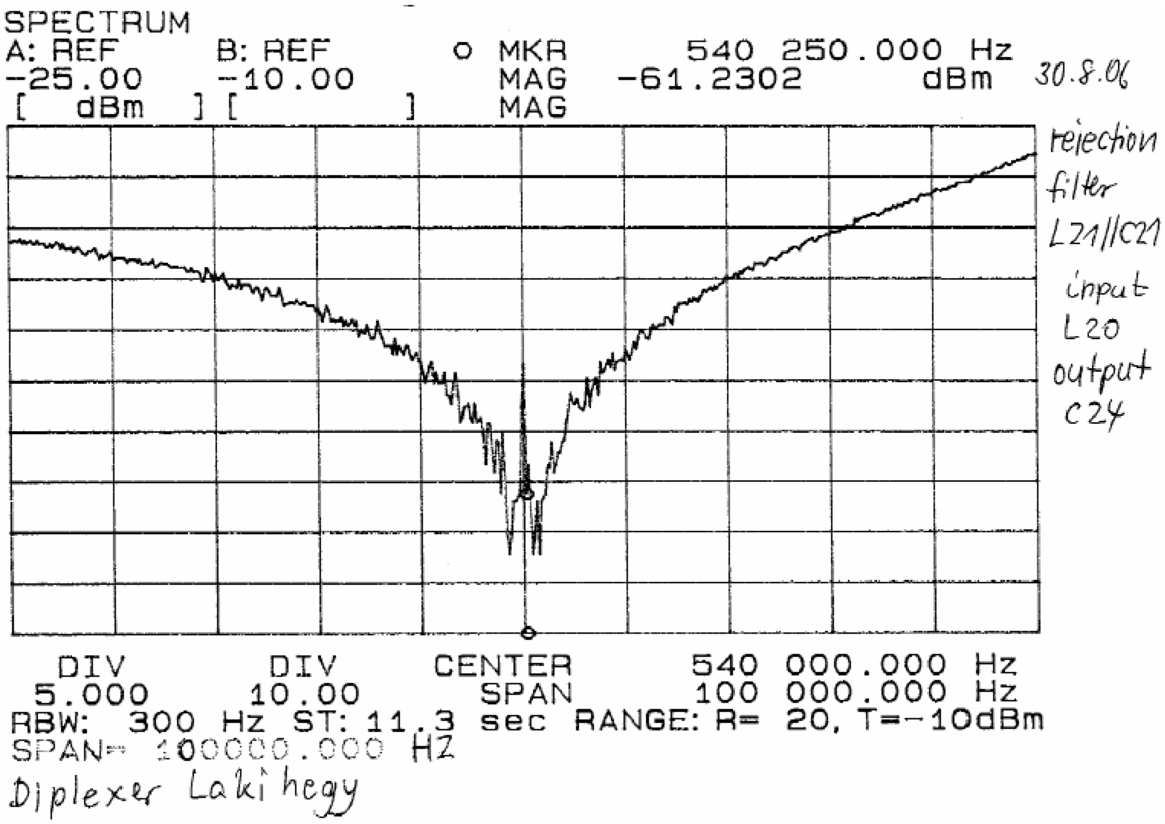
LW- MW- diplexer Lakihegy (Hungary) 135.6 kHz, 100 kW - 540 kHz, 150 kW

Technical Documentation for acceptance tests Sept./Oct. 2006

- **Rejection Filter for 540 kHz**

Tuning elements L21/ C21 in parallel (rejection)

Transmission measurement was carried out between M8.2 and M4.
M8.2 is open, disconnected from the other tuning elements. M4 is disconnected from cable.



The same document is given as file “filter_540.pdf” in the appendix (2).

Rejection Filters for 810 kHz and 873 kHz

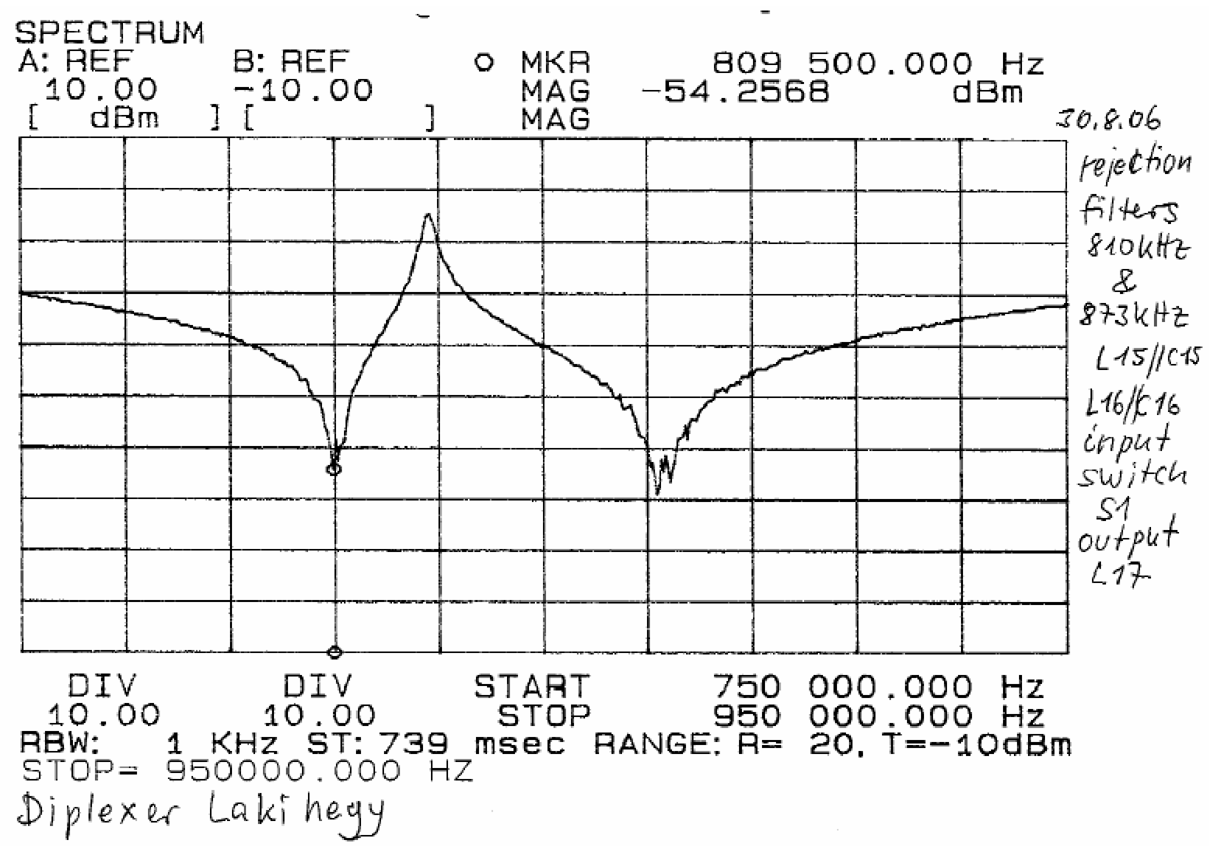
Tuning elements L15/ C15 in parallel (rejection) for 810 kHz

Tuning elements L16/ C16 in parallel (rejection) for 873 kHz

Transmission measurement was carried out between M8.3 and M6. M8.3 is open and disconnected from the other tuning elements. M6 is disconnected from the open feeder line.

LW- MW- diplexer Lakihegy (Hungary) 135.6 kHz, 100 kW - 540 kHz, 150 kW

Technical Documentation for acceptance tests Sept./Oct. 2006



The same document is given as file “filters_810_873_kHz.pdf” in the appendix (4).

9.0 Spark gaps

The setting of the spark gaps can be seen below:

Spark gap	sphere diameter mm	Spacing mm
F1 base of mast	80	70
F1A Austin transformer	60	50
F2 feed through insulator	50	30
F10 open feeder line 540 kHz	50	15
F20 cable 135.6 kHz	50	15

10.0 Measuring instruments

Measurements were carried out using equipment of Antenna Hungaria (Mr. Kovacs) or TRANSRADIO.

The equipment of Antenna Hungaria consists of:

Delta Electronics OIB-3 Operating Impedance Bridge
Delta Electronics RG-4 Receiver Generator

LW- MW- diplexer Lakihegy (Hungary) 135.6 kHz, 100 kW - 540 kHz, 150 kW

Technical Documentation for acceptance tests Sept./Oct. 2006

The equipment of TRANSRADIO consists of:

Network- Analyzer:	HP 4195A
Directional coupler :	TELEFUNKEN/TRANSRADIO
Amplifier:	EIN Model A150
Plotter:	HP Color Pro

11.0 Appendixes

Anlage	Document	Pdf- file	Contents
1	Dwg. 51-8920-810-00 WSP	51-8920-810-00 WSP_LAKIHEGY_ATU_AE05.pdf	Design of diplexer Operational values
2	Plot	filters_135_6_kHz.pdf	Attenuation by filter
3	Plot	filter_540.pdf	Attenuation by filter
4	Plot	filters_810_873_kHz.pdf	Attenuation by filter