SEIBERSDORF LABORATORIES

Kalibrierstelle für Antennen und Feldsonden
Calibration Body for Antennas and Field Probes

Akkreditiert durch / *accredited by*
AKKREDITIERUNG AUSTRIA

Kalibrierschein nach ISO/IEC 17025
Calibration Certificate according to ISO/IEC 17025

Kalibrierzeichen
Calibration mark

EH-A1040/20
0612
07.08.2020

Gegenstand *Object*	Biconical Antenna
Hersteller & Typ *Manufacturer & Type*	Tekbox TBMA2
Herstellernummer *Serial number*	TBMA2200003
Auftraggeber *Customer*	TekBox Digital Solutions Vietnam Co. Ltd. Saigon Hi-Tech Park, Factory 4, 5F, Lot I-3B-1, N6 Str., Tan Phu Ward, D 9 70000 Ho Chí Minh Vietnam
Auftragsnummer *Order Nr.*	L.L7.00059.0.0-A-7888_1 Ext. Ord. No.: PO-20200710002
Anzahl der Seiten des Kalibrierscheines *Number of pages of the certificate*	1 - 9
Datum der Kalibrierung *Date of calibration*	07.08.2020

Akkreditierung Austria ist Vollmitglied bei der International Laboratory Accreditation Cooperation ILAC und Unterzeichner der MRAs für die Bereiche „Testing, Calibration and Inspection".

Die Kalibrierung erfolgt auf der gesetzlichen Grundlage des Akkreditierungsgesetzes in gültiger Fassung entsprechend den Anforderungen der ÖVE/ÖNORM EN ISO/IEC 17025.

Dieser Kalibrierschein dokumentiert die Rückführbarkeit auf nationale Normale zur Darstellung der physikalischen Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI).

Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.

Akkreditierung Austria is a full member of the International Laboratory Accreditation Cooperation ILAC and a signatory of the MRA for "Testing, Calibration and Inspection".

The calibration is performed in accordance with the Akkreditierungsgesetz in the amended version and the requirements of ÖVE/ÖNORM EN ISO/IEC 17025.

This calibration certificate documents the traceability to national standards, which realize the physical units or measurements according to the International System of Units (SI).

The user is obliged to have the object recalibrated at appropriate intervals.

Dieser Kalibrierschein darf nur vollständig und unverändert weiterverarbeitet werden. Auszüge oder Änderungen sind unzulässig. Kalibrierscheine ohne Unterschrift haben keine Gültigkeit.

This calibration certificate may not be reproduced other than in full. Calibration certificates without signature are not valid.

Datum *Date*	Zeichnungsberechtigter *Authorized person*	Bearbeiter *Person responsible*
10.08.2020	Patrick Preiner	Markus Vaclav

Calibration Procedure

ARP 958 Calibration, Three-Antenna Method

The ARP 958 standard [1] is extended to a 3-antenna method [2] so that non-identical antennas can be used for the calibration procedure. Calibrations are carried out in vertical and horizontal polarisation of the antennas mounted 3 m above the ground. At the terminal of each antenna an attenuator is inserted in order to minimise mismatch.

The voltage reflection coefficient (VRC) is measured using a network analyser. Results are shown as voltage standing wave ration (VSWR) calculated from the voltage reflection coefficient as following:

$$\mathrm{VSWR} = \frac{1+\mathrm{VRC}}{1-\mathrm{VRC}}$$

Calibrations are carried out as described in working procedure EH-AA/L-6. All relevant additional ports of the device under test are terminated.

Test Equipment

Type	**Identification**
Network Analyzer R&S ZVA8	E0156
Biconical Antenna Schwarzbeck VHBB 9124 + BBA 9106	E1680
Biconical Antenna Schwarzbeck VHBB 9124 + BBA 9106	E1681
Attenuator 10 dB	E1273
Attenuator 10 dB	E1274
CalStan 10.0	E0920

Environmental Conditions

Test Site Temperature	23°C	± 3 °C
Test Site Humidity	83 %	± 10 %
Control Room Temperature	21°C	± 3 °C
Control Room Humidity	75 %	± 10 %

Results

Type	Distance	Polarisation	Height	Fig./Table
AF_VER	1 m	Vertical	3 m	1
Gain_VER	1 m	Vertical	3 m	2
AF_HOR	1 m	Horizontal	3 m	3
Gain_HOR	1 m	Horizontal	3 m	4
VSWR			2 m	5

Accuracy of Calibration

The reported expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor *k = 2*, which for a normal distribution corresponds to a coverage probability of approximately 95%. The standard uncertainty of measurement has been determined in accordance with EAL Publication EA 4/02 M.

References

[1] SAE ARP 958, Revision D, 2003, Electromagnetic Interference Measurement Antennas; Standard Calibration Method.

[2] The Handbook of Antenna Design, Volume 1, A.W.Rudge, K.Milne, A.D.Olver, P.Knight, IEE Electromagnetic Waves Series 15, 1982 Peter Peregrinus Ltd.,London, UK.

[3] EA-4/02 M: “Expression of the Uncertainty of Measurement in Calibration”, European co-operation for Accreditation, September 2013, rev02.

Figure 1: AF_VER; distance = 1 m; polarization = Vertical; height = 3 m

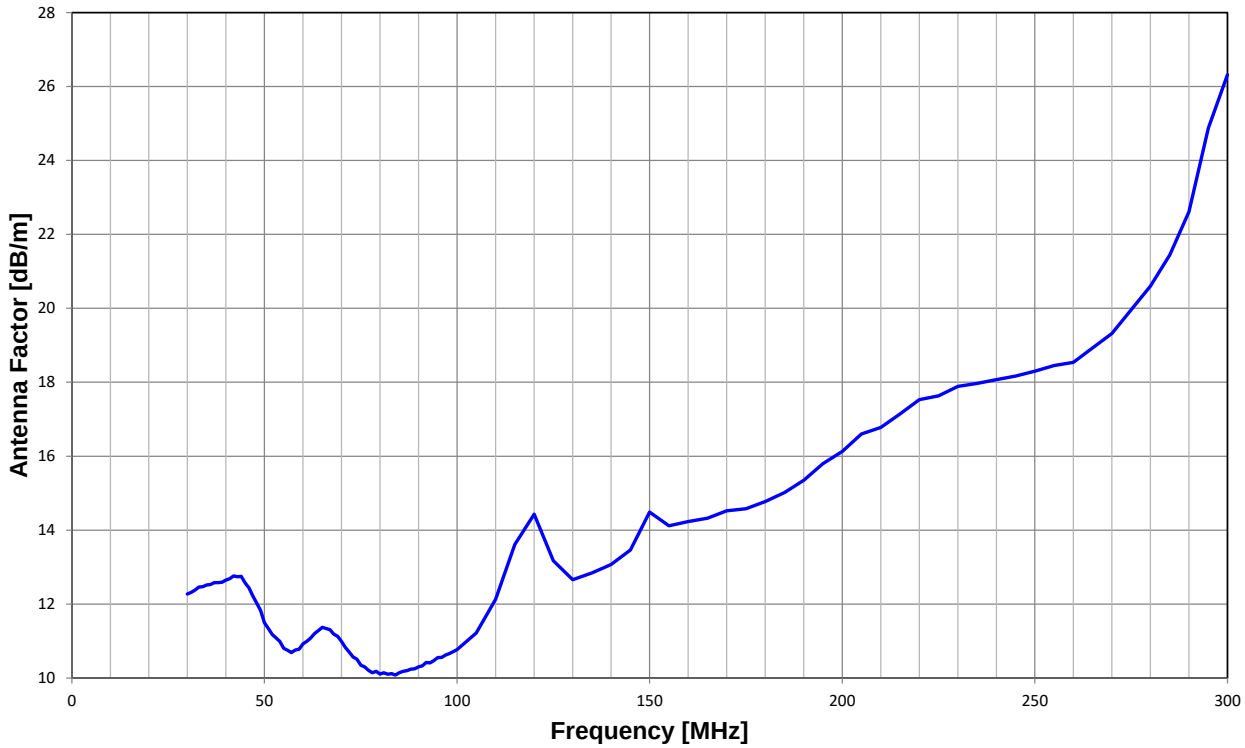

Table 1: AF_VER; distance = 1 m; polarization = Vertical; height = 3 m

f [MHz]	AF [dB/m]	U [dB]	f [MHz]	AF [dB/m]	U [dB]	f [MHz]	AF [dB/m]	U [dB]
30	12.27	1.00	63	11.20	1.00	96	10.56	1.00
31	12.32	1.00	64	11.28	1.00	97	10.62	1.00
32	12.38	1.00	65	11.37	1.00	98	10.66	1.00
33	12.46	1.00	66	11.34	1.00	99	10.71	1.00
34	12.47	1.00	67	11.31	1.00	100	10.77	1.00
35	12.52	1.00	68	11.19	1.00	105	11.22	1.00
36	12.53	1.00	69	11.13	1.00	110	12.13	1.00
37	12.58	1.00	70	10.99	1.00	115	13.61	1.00
38	12.58	1.00	71	10.83	1.00	120	14.43	1.00
39	12.59	1.00	72	10.70	1.00	125	13.17	1.00
40	12.65	1.00	73	10.57	1.00	130	12.66	1.00
41	12.69	1.00	74	10.51	1.00	135	12.84	1.00
42	12.76	1.00	75	10.35	1.00	140	13.07	1.00
43	12.74	1.00	76	10.30	1.00	145	13.46	1.00
44	12.75	1.00	77	10.21	1.00	150	14.49	1.00
45	12.57	1.00	78	10.14	1.00	155	14.12	1.00
46	12.44	1.00	79	10.18	1.00	160	14.23	1.00
47	12.22	1.00	80	10.11	1.00	165	14.32	1.00
48	12.02	1.00	81	10.14	1.00	170	14.52	1.00
49	11.83	1.00	82	10.10	1.00	175	14.58	1.00
50	11.50	1.00	83	10.12	1.00	180	14.77	1.00
51	11.34	1.00	84	10.08	1.00	185	15.02	1.00
52	11.18	1.00	85	10.14	1.00	190	15.35	1.00
53	11.09	1.00	86	10.18	1.00	195	15.80	1.00
54	10.99	1.00	87	10.20	1.00	200	16.13	1.00
55	10.80	1.00	88	10.24	1.00	205	16.60	1.00
56	10.75	1.00	89	10.25	1.00	210	16.78	1.00
57	10.69	1.00	90	10.30	1.00	215	17.14	1.00
58	10.76	1.00	91	10.33	1.00	220	17.53	1.00
59	10.78	1.00	92	10.42	1.00	225	17.63	1.00
60	10.92	1.00	93	10.41	1.00	230	17.89	1.00
61	10.99	1.00	94	10.47	1.00	235	17.97	1.00
62	11.08	1.00	95	10.55	1.00	240	18.07	1.00

f [MHz]	AF [dB/m]	U [dB]	f [MHz]	AF [dB/m]	U [dB]	f [MHz]	AF [dB/m]	U [dB]
245	18.17	1.00	265	18.93	1.00	285	21.44	1.00
250	18.30	1.00	270	19.32	1.00	290	22.61	1.00
255	18.45	1.00	275	19.96	1.00	295	24.87	1.00
260	18.54	1.00	280	20.60	1.00	300	26.32	1.00

Figure 2: Gain_VER; distance = 1 m; polarization = Vertical; height = 3 m

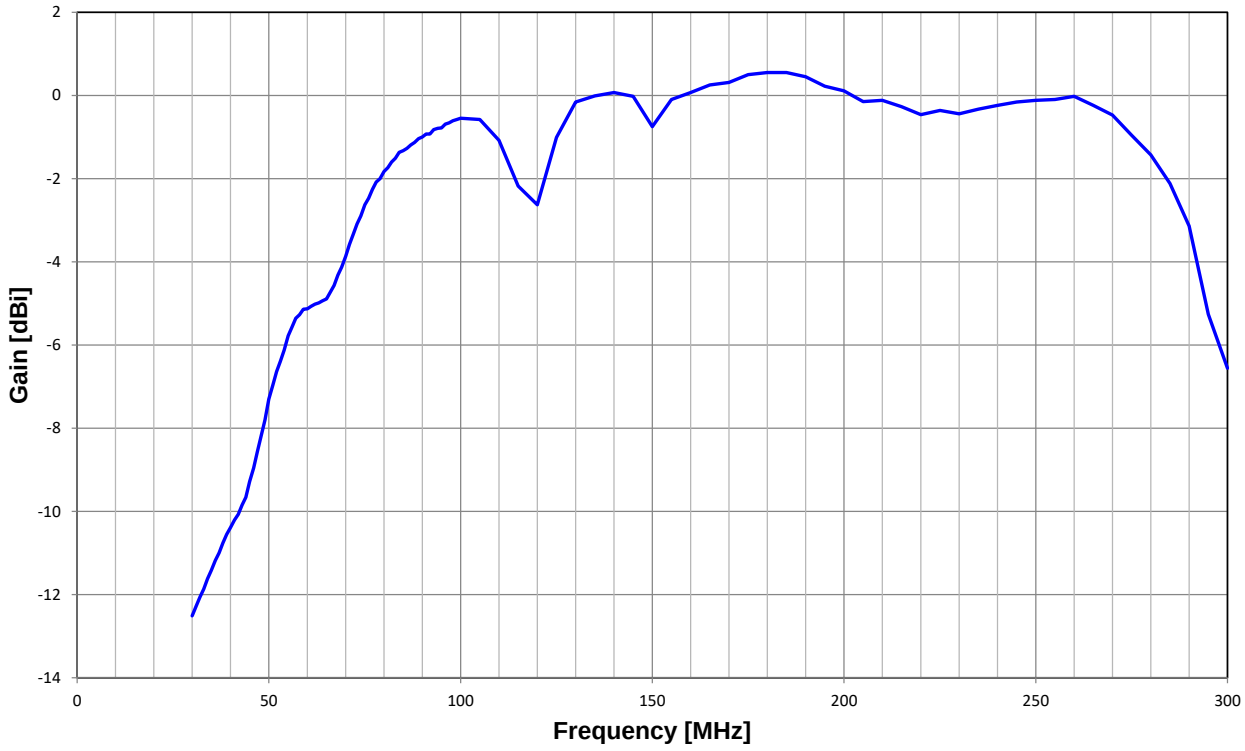

Table 2: Gain_VER; distance = 1 m; polarization = Vertical; height = 3 m

f [MHz]	G [dBi]	U [dB]	f [MHz]	G [dBi]	U [dB]	f [MHz]	G [dBi]	U [dB]
30	-12.51	1.00	55	-5.78	1.00	80	-1.83	1.00
31	-12.28	1.00	56	-5.57	1.00	81	-1.74	1.00
32	-12.06	1.00	57	-5.36	1.00	82	-1.60	1.00
33	-11.87	1.00	58	-5.27	1.00	83	-1.51	1.00
34	-11.62	1.00	59	-5.14	1.00	84	-1.37	1.00
35	-11.42	1.00	60	-5.13	1.00	85	-1.33	1.00
36	-11.18	1.00	61	-5.07	1.00	86	-1.27	1.00
37	-11.00	1.00	62	-5.02	1.00	87	-1.19	1.00
38	-10.76	1.00	63	-4.99	1.00	88	-1.13	1.00
39	-10.55	1.00	64	-4.94	1.00	89	-1.04	1.00
40	-10.39	1.00	65	-4.89	1.00	90	-1.00	1.00
41	-10.21	1.00	66	-4.73	1.00	91	-0.93	1.00
42	-10.07	1.00	67	-4.57	1.00	92	-0.93	1.00
43	-9.85	1.00	68	-4.32	1.00	93	-0.82	1.00
44	-9.66	1.00	69	-4.13	1.00	94	-0.79	1.00
45	-9.28	1.00	70	-3.87	1.00	95	-0.78	1.00
46	-8.96	1.00	71	-3.58	1.00	96	-0.69	1.00
47	-8.56	1.00	72	-3.34	1.00	97	-0.66	1.00
48	-8.18	1.00	73	-3.09	1.00	98	-0.61	1.00
49	-7.80	1.00	74	-2.90	1.00	99	-0.58	1.00
50	-7.30	1.00	75	-2.63	1.00	100	-0.55	1.00
51	-6.97	1.00	76	-2.47	1.00	105	-0.58	1.00
52	-6.64	1.00	77	-2.26	1.00	110	-1.08	1.00
53	-6.39	1.00	78	-2.08	1.00	115	-2.18	1.00
54	-6.12	1.00	79	-2.00	1.00	120	-2.63	1.00

f [MHz]	G [dBi]	U [dB]	f [MHz]	G [dBi]	U [dB]	f [MHz]	G [dBi]	U [dB]
125	-1.01	1.00	185	0.55	1.00	245	-0.16	1.00
130	-0.16	1.00	190	0.45	1.00	250	-0.12	1.00
135	-0.01	1.00	195	0.22	1.00	255	-0.10	1.00
140	0.07	1.00	200	0.11	1.00	260	-0.02	1.00
145	-0.02	1.00	205	-0.15	1.00	265	-0.24	1.00
150	-0.75	1.00	210	-0.12	1.00	270	-0.47	1.00
155	-0.10	1.00	215	-0.27	1.00	275	-0.96	1.00
160	0.07	1.00	220	-0.46	1.00	280	-1.43	1.00
165	0.25	1.00	225	-0.36	1.00	285	-2.12	1.00
170	0.31	1.00	230	-0.44	1.00	290	-3.14	1.00
175	0.50	1.00	235	-0.33	1.00	295	-5.26	1.00
180	0.55	1.00	240	-0.24	1.00	300	-6.56	1.00

Figure 3: AF_HOR; distance = 1 m; polarization = Horizontal; height = 3 m

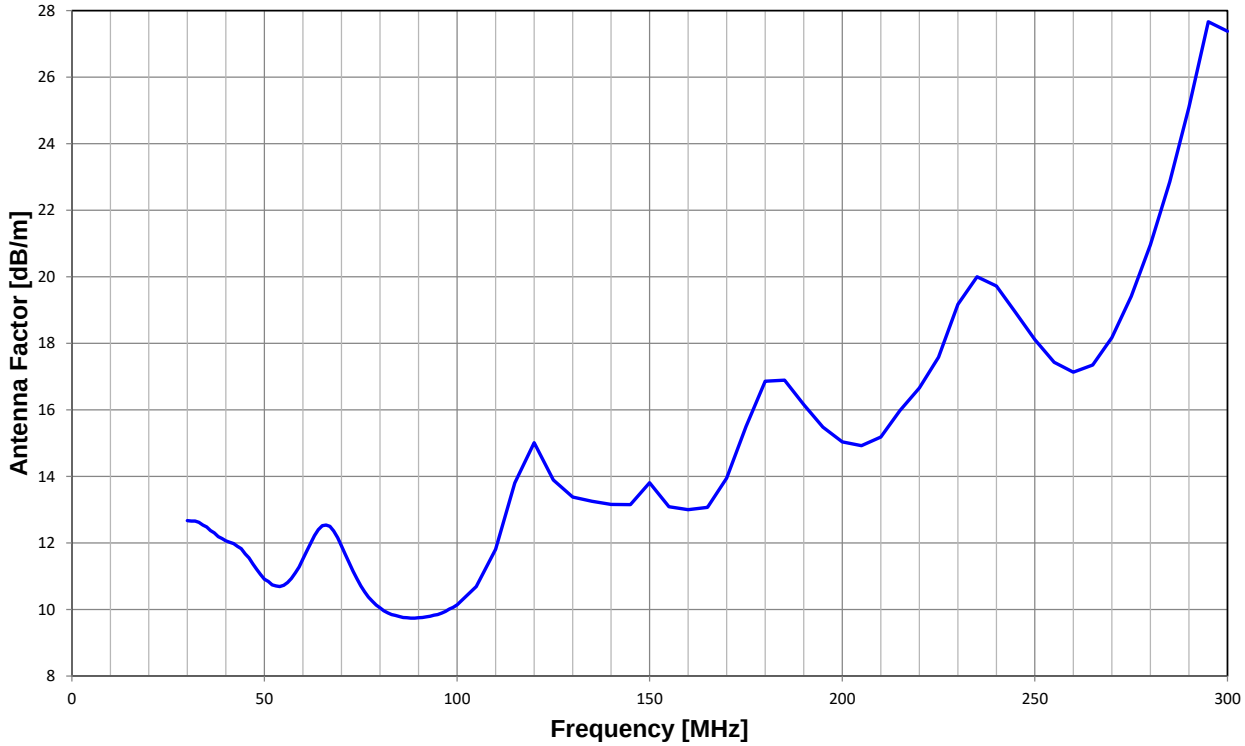

Table 3: AF_HOR; distance = 1 m; polarization = Horizontal; height = 3 m

f [MHz]	AF [dB/m]	U [dB]	f [MHz]	AF [dB/m]	U [dB]	f [MHz]	AF [dB/m]	U [dB]
30	12.67	1.00	47	11.37	1.00	64	12.40	1.00
31	12.66	1.00	48	11.20	1.00	65	12.52	1.00
32	12.66	1.00	49	11.05	1.00	66	12.54	1.00
33	12.62	1.00	50	10.91	1.00	67	12.50	1.00
34	12.54	1.00	51	10.84	1.00	68	12.36	1.00
35	12.48	1.00	52	10.74	1.00	69	12.16	1.00
36	12.37	1.00	53	10.71	1.00	70	11.91	1.00
37	12.30	1.00	54	10.69	1.00	71	11.66	1.00
38	12.19	1.00	55	10.73	1.00	72	11.40	1.00
39	12.13	1.00	56	10.81	1.00	73	11.15	1.00
40	12.06	1.00	57	10.93	1.00	74	10.93	1.00
41	12.02	1.00	58	11.10	1.00	75	10.71	1.00
42	11.98	1.00	59	11.28	1.00	76	10.53	1.00
43	11.90	1.00	60	11.52	1.00	77	10.37	1.00
44	11.83	1.00	61	11.75	1.00	78	10.25	1.00
45	11.67	1.00	62	11.99	1.00	79	10.13	1.00
46	11.55	1.00	63	12.22	1.00	80	10.05	1.00

f [MHz]	AF [dB/m]	U [dB]	f [MHz]	AF [dB/m]	U [dB]	f [MHz]	AF [dB/m]	U [dB]
81	9.96	1.00	105	10.69	1.00	205	14.92	1.00
82	9.90	1.00	110	11.81	1.00	210	15.18	1.00
83	9.85	1.00	115	13.80	1.00	215	15.98	1.00
84	9.82	1.00	120	15.01	1.00	220	16.66	1.00
85	9.79	1.00	125	13.89	1.00	225	17.58	1.00
86	9.76	1.00	130	13.38	1.00	230	19.17	1.00
87	9.75	1.00	135	13.25	1.00	235	20.00	1.00
88	9.74	1.00	140	13.16	1.00	240	19.72	1.00
89	9.74	1.00	145	13.15	1.00	245	18.92	1.00
90	9.75	1.00	150	13.81	1.00	250	18.11	1.00
91	9.76	1.00	155	13.09	1.00	255	17.43	1.00
92	9.78	1.00	160	13.00	1.00	260	17.13	1.00
93	9.80	1.00	165	13.07	1.00	265	17.35	1.00
94	9.83	1.00	170	13.95	1.00	270	18.17	1.00
95	9.85	1.00	175	15.50	1.00	275	19.41	1.00
96	9.89	1.00	180	16.86	1.00	280	20.96	1.00
97	9.94	1.00	185	16.89	1.00	285	22.85	1.00
98	10.01	1.00	190	16.16	1.00	290	25.09	1.00
99	10.06	1.00	195	15.48	1.00	295	27.66	1.00
100	10.14	1.00	200	15.04	1.00	300	27.38	1.00

Figure 4: Gain_HOR; distance = 1 m; polarization = Horizontal; height = 3 m

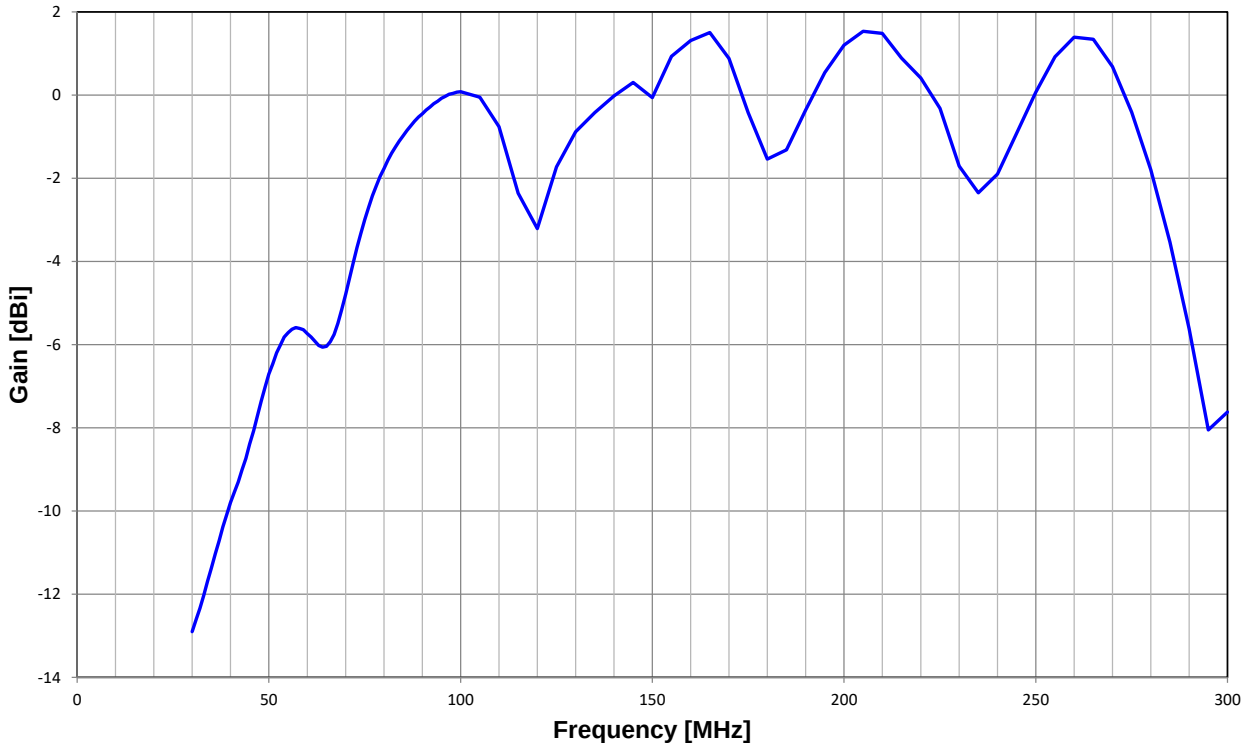

Table 4: Gain_HOR; distance = 1 m; polarization = Horizontal; height = 3 m

f [MHz]	G [dBi]	U [dB]	f [MHz]	G [dBi]	U [dB]	f [MHz]	G [dBi]	U [dB]
30	-12.90	1.00	39	-10.09	1.00	48	-7.36	1.00
31	-12.61	1.00	40	-9.80	1.00	49	-7.03	1.00
32	-12.34	1.00	41	-9.54	1.00	50	-6.71	1.00
33	-12.03	1.00	42	-9.30	1.00	51	-6.46	1.00
34	-11.69	1.00	43	-9.01	1.00	52	-6.20	1.00
35	-11.38	1.00	44	-8.74	1.00	53	-6.01	1.00
36	-11.03	1.00	45	-8.39	1.00	54	-5.82	1.00
37	-10.72	1.00	46	-8.07	1.00	55	-5.71	1.00
38	-10.38	1.00	47	-7.71	1.00	56	-5.63	1.00

f [MHz]	G [dBi]	U [dB]	f [MHz]	G [dBi]	U [dB]	f [MHz]	G [dBi]	U [dB]
57	-5.59	1.00	86	-0.85	1.00	175	-0.42	1.00
58	-5.61	1.00	87	-0.74	1.00	180	-1.54	1.00
59	-5.64	1.00	88	-0.63	1.00	185	-1.32	1.00
60	-5.74	1.00	89	-0.53	1.00	190	-0.36	1.00
61	-5.82	1.00	90	-0.45	1.00	195	0.54	1.00
62	-5.92	1.00	91	-0.36	1.00	200	1.20	1.00
63	-6.02	1.00	92	-0.29	1.00	205	1.53	1.00
64	-6.06	1.00	93	-0.21	1.00	210	1.48	1.00
65	-6.04	1.00	94	-0.15	1.00	215	0.89	1.00
66	-5.93	1.00	95	-0.08	1.00	220	0.41	1.00
67	-5.76	1.00	96	-0.03	1.00	225	-0.32	1.00
68	-5.49	1.00	97	0.02	1.00	230	-1.71	1.00
69	-5.16	1.00	98	0.04	1.00	235	-2.35	1.00
70	-4.79	1.00	99	0.07	1.00	240	-1.90	1.00
71	-4.41	1.00	100	0.08	1.00	245	-0.92	1.00
72	-4.03	1.00	105	-0.05	1.00	250	0.07	1.00
73	-3.66	1.00	110	-0.76	1.00	255	0.92	1.00
74	-3.33	1.00	115	-2.36	1.00	260	1.39	1.00
75	-2.99	1.00	120	-3.21	1.00	265	1.34	1.00
76	-2.70	1.00	125	-1.73	1.00	270	0.68	1.00
77	-2.42	1.00	130	-0.88	1.00	275	-0.41	1.00
78	-2.19	1.00	135	-0.42	1.00	280	-1.80	1.00
79	-1.96	1.00	140	-0.02	1.00	285	-3.54	1.00
80	-1.77	1.00	145	0.30	1.00	290	-5.62	1.00
81	-1.57	1.00	150	-0.06	1.00	295	-8.05	1.00
82	-1.40	1.00	155	0.93	1.00	300	-7.62	1.00
83	-1.25	1.00	160	1.31	1.00			
84	-1.11	1.00	165	1.50	1.00			
85	-0.98	1.00	170	0.88	1.00			

Figure 5: VSWR; height = 2 m

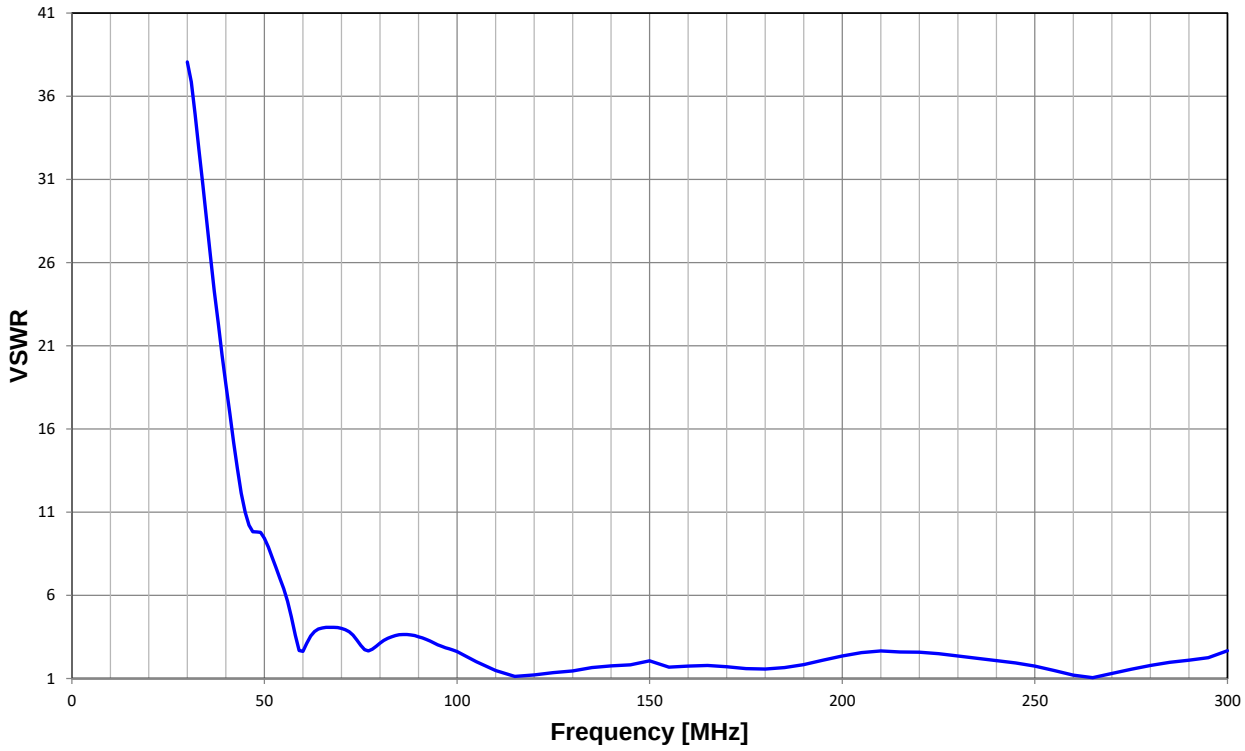

Table 5: VSWR; height = 2 m

f [MHz]	VSWR [1]	U [1]	f [MHz]	VSWR [1]	U [1]	f [MHz]	VSWR [1]	U [1]
30	38.06	-6.38/9.48	67	4.08	-0.13/0.13	120	1.22	-0.12/0.13
31	36.86	-6.02/8.84	68	4.08	-0.13/0.13	125	1.36	-0.13/0.15
32	34.92	-5.47/7.86	69	4.06	-0.12/0.13	130	1.46	-0.14/0.16
33	32.81	-4.89/6.88	70	4.01	-0.12/0.13	135	1.66	-0.17/0.19
34	30.65	-4.32/5.95	71	3.94	-0.12/0.12	140	1.76	-0.18/0.21
35	28.51	-3.79/5.11	72	3.81	-0.11/0.12	145	1.82	-0.19/0.21
36	26.38	-3.30/4.34	73	3.61	-0.10/0.11	150	2.06	-0.22/0.25
37	24.29	-2.84/3.66	74	3.32	-0.09/0.10	155	1.68	-0.17/0.19
38	22.36	-2.44/3.09	75	2.99	-0.08/0.08	160	1.74	-0.18/0.20
39	20.44	-2.08/2.57	76	2.73	-0.07/0.07	165	1.79	-0.18/0.21
40	18.69	-1.76/2.15	77	2.66	-0.07/0.07	170	1.71	-0.17/0.20
41	16.93	-1.47/1.77	78	2.76	-0.07/0.07	175	1.60	-0.16/0.18
42	15.19	-1.21/1.43	79	2.94	-0.08/0.08	180	1.57	-0.16/0.18
43	13.60	-0.99/1.15	80	3.13	-0.08/0.09	185	1.66	-0.17/0.19
44	12.14	-0.81/0.92	81	3.29	-0.09/0.09	190	1.84	-0.19/0.22
45	10.98	-0.68/0.76	82	3.42	-0.10/0.10	195	2.10	-0.22/0.26
46	10.22	-0.60/0.67	83	3.51	-0.10/0.10	200	2.36	-0.26/0.31
47	9.82	-0.56/0.62	84	3.58	-0.10/0.11	205	2.56	-0.29/0.35
48	9.81	-0.55/0.62	85	3.63	-0.10/0.11	210	2.66	-0.31/0.37
49	9.78	-0.55/0.61	86	3.64	-0.11/0.11	215	2.60	-0.30/0.36
50	9.43	-0.52/0.57	87	3.64	-0.11/0.11	220	2.58	-0.29/0.35
51	8.90	-0.47/0.52	88	3.62	-0.10/0.11	225	2.49	-0.28/0.33
52	8.28	-0.41/0.45	89	3.58	-0.10/0.11	230	2.35	-0.26/0.31
53	7.67	-0.36/0.39	90	3.51	-0.10/0.10	235	2.21	-0.24/0.28
54	7.04	-0.31/0.34	91	3.44	-0.10/0.10	240	2.08	-0.22/0.26
55	6.39	-0.26/0.28	92	3.35	-0.09/0.10	245	1.94	-0.20/0.23
56	5.64	-0.21/0.23	93	3.25	-0.09/0.09	250	1.74	-0.18/0.20
57	4.71	-0.16/0.17	94	3.14	-0.08/0.09	255	1.48	-0.15/0.16
58	3.60	-0.10/0.11	95	3.03	-0.08/0.08	260	1.20	-0.11/0.13
59	2.68	-0.07/0.07	96	2.93	-0.08/0.08	265	1.05	-0.05/0.11
60	2.63	-0.06/0.07	97	2.85	-0.07/0.08	270	1.30	-0.12/0.14
61	3.11	-0.08/0.09	98	2.79	-0.07/0.07	275	1.56	-0.15/0.17
62	3.55	-0.10/0.11	99	2.71	-0.07/0.07	280	1.78	-0.18/0.21
63	3.82	-0.11/0.12	100	2.62	-0.30/0.36	285	1.97	-0.21/0.24
64	3.97	-0.12/0.13	105	2.01	-0.21/0.25	290	2.10	-0.22/0.26
65	4.04	-0.12/0.13	110	1.48	-0.14/0.16	295	2.25	-0.24/0.29
66	4.08	-0.13/0.13	115	1.12	-0.11/0.12	300	2.67	-0.31/0.37