Calibration certificates RISE equipment used for test report P111266-F30

	Serial number on equipment	RISE number	File name/ Page number
R&S FSW 43 test after 2021-07	100 560	902 073	902 073 - FSW43 2021.pdf
R&S FSW 43 test before 2021-07	100 560	902 073	902 073 - FSW43 2020.pdf
R&S ESU 40	100 321	901 385	901 385 - ESU40.pdf
R&S ZNB 40	101 544	BX50051	BX50051 - ZNB40.pdf
Mixer FS-Z60	100 996	BX90566	BX90566 R&S Mixer FS-Z60.pdf
Mixer FS-Z90	101 871	BX90567	BX90567 R&S Mixer FS-Z90.pdf
Mixer FS-Z110	101 467	BX81425	BX81425 R&S Mixer FS-Z110.pdf
Mixer FS-Z170	100974	BX81426	BX81426 R&S Mixer FS-Z170.pdf
Mixer FS-Z220	100967	BX81427	BX81427 R&S Mixer FS-Z220.pdf
Bilog antenna Schaffner 6143A	23 169	504 079	2 – 9
EMCO Horn Antenna 3115	9509-4562	502 175	10 – 16
EMCO Horn Antenna 3115	00143 161	902 212	17 – 21
EMCO Horn Antenna 3116	9904-2426	503 279	22 – 26
Flann STD Gain Horn Antenna 20240-20	Manufacturer provided gain 275170	KWP02600	27
Flann STD Gain Horn Antenna 22240-20	Manufacturer provided gain 274184	KWP02601	28
Flann STD Gain Horn Antenna 24240-20	Manufacturer provided gain 141	BX92414	29
Flann STD Gain Horn Antenna 26240-20	Manufacturer provided gain 124 440	BX92416	30
Flann STD Gain Horn Antenna 27240-20	Manufacturer provided gain 281	BX92417	31
Flann STD Gain Horn Antenna 29240-20	Manufacturer provided gain 46	BX92419	32
Flann STD Gain Horn Antenna 30240-20	Manufacturer provided gain 29	BX92420	33

NATIONAL PHYSICAL LABORATORY
Teddington Middlesex UK TW11 0LW Telephone +44 20 8977 3222

Certificate of Calibration

UKAS CALIBRATION
0478

BICONICAL-LOG HYBRID ANTENNA
Model: Teseq CBL 6143A
Serial number: 23169

FOR: RISE
Brinellgatan 4
SE-504 62 BORÅS
Sweden

Order no. IX84237

DESCRIPTION: Teseq CBL 6143A biconical-log hybrid antenna with an operating frequency range of 30 MHz to 3000 MHz. The low frequency elements were of a modified triangular type (L-shaped).

IDENTIFICATION: The antenna is marked with the manufacturer's serial number 23169. The antenna was calibrated with the customer supplied 6 dB attenuator attached, with the customer number BX61531.

MEASUREMENTS COMPLETED ON: 4 July 2018

The reported uncertainty is based on a coverage factor k=2, providing a level of confidence of approximately 95%

Reference : 2018050459-1
Date of Issue : 4 July 2018
Checked by :

Signed :
Name : D A Knight

(Authorised Signatory)
on behalf of NPLML

MEASUREMENT PROCEDURE

Antenna Factor

The measurement method is traceable to field standards which have been validated on the national standard open field site (OFS) at NPL. The OFS comprises a 60 m by 30 m metal ground plane, flat to within ± 6 mm. The receiver linearity has been calibrated, traceable to national standards, and its frequency accuracy has been shown to be better than 10 ppm. On request a complete set of antenna factors, and the complex components of the reflection coefficient can be supplied in ASCII format by email.

The antenna was positioned in the configuration required for each measurement, and where necessary the RF cables were supported in order to minimise parasitic reflections. A summary of the applicable parameters for each measurement is given below. Each summary refers to a later table which contains a subset of results, and the accompanying graphs present the full data set.

The antenna was calibrated according to ANSI C63.5 (see Annex) as one of three antennas, which were calibrated by the height scanning method described in the procedure. The customer's antenna is defined as the Antenna Under Test (AUT). The other antenna in any pair is defined as ANT2. HP and VP are horizontal and vertical polarisation respectively.

Summary of applicable parameters in Table 1

Measurement range	From 30 MHz to 1000 MHz
Measurement parameter	ANSI C63.5:2017 10.0 m separation, AUT Scanned (1.0 m - 4.0 m), ANT2 at HP 2.0 m Near Free Space Antenna Factors
Measurement uncertainty *	±1.0 dB

* The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k = 2, providing a coverage probability of approximately 95 %. The uncertainty evaluation has been carried out in accordance with UKAS requirements. The uncertainty applies only to the measured values and gives no indication of the long term stability of the antenna. See annex concerning exemptions to the stated uncertainty.

Balance Test (applies to frequencies below 300 MHz - see Annex)

This test indicated no significant balun imbalance.

The balun balance was measured according to ANSI C63.5:2017, with an estimated expanded uncertainty of ±0.25 dB.

Return Loss and VSWR

The antenna was positioned in a near free-space environment and the complex reflection coefficient, S_{11}, was measured. The result is presented as return loss and VSWR. The estimated uncertainty in the measured reflection coefficient is ± 0.05 units.

NOTES

The antenna was assembled following the markings on the elements and the balun.

The 10 m separation was measured from the marked reference = 0.523 m from the antenna tip.

During calibration NPL uses good quality matching attenuators on the transmit and receive cables, which ensure a return loss better than 10dB. In order to meet the CISPR 16-1-4 requirement for emission measurements a calibrated attenuator should be used on the receive cable to ensure a minimum match of 10dB. When requested NPL will calibrate the antenna with a supplied attenuator attached and the attenuation will be included in the antenna factor and the measured return loss. Alternatively, if no attenuator is supplied, the calibrated value of the attenuator may be included in the loss of the receive cable. ANSI C63.4:2014 requires a match of 2.5:1 VSWR, which equates to a return loss of 7.4dB; it is possible to meet this requirement with a 4dB attenuator. It is recommended to use a 6dB attenuator for hybrid or biconical antennas which have a poor match at 30MHz.

ENVIRONMENT

The measuring equipment was in a temperature controlled room at 22°C ± 2°C. In our experience there is no significant variation in the performance of passive antennas in the temperature range -5°C to +35°C.

ANNEX TO NPL CERTIFICATE

The annex describes some sources of possible measurement uncertainty when biconical-log hybrid antennas are used for emission testing. The antenna factor uncertainty and any additional measurement uncertainty can be combined by following the guidance given by UKAS[1].

[1] The expression of uncertainty in EMC testing, LAB 34, UKAS, August 2002.

[2] The annex for the biconical-log hybrid antenna can be found on the NPL website, www.npl.co.uk, search on "Antennas and Field Probes support documentation" with the address http://www.npl.co.uk/emc-certificates

Table 1 ANSI C63.5:2017 10.0 m separation, AUT Scanned (1.0 m - 4.0 m), ANT2 at HP 2.0 m Teseq CBL 6143A, s/n 23169			
Frequency (MHz)	Antenna Factor (dB/m)	Frequency (MHz)	Antenna factor (dB/m)
30	28.4	520	23.1
40	23.4	540	24.1
60	16.1	560	24.5
80	13.3	580	24.4
100	16.0	600	24.4
120	18.7	620	24.6
140	18.4	640	24.9
160	16.6	660	24.6
180	16.2	680	24.7
200	17.5	700	24.7
220	18.5	720	25.0
240	17.8	740	25.3
260	18.5	760	25.5
280	18.7	780	25.9
300	19.2	800	25.7
320	19.6	820	25.8
340	19.7	840	26.1
360	20.3	860	26.2
380	20.8	880	26.6
400	22.0	900	26.3
420	21.6	920	26.4
440	21.9	940	26.6
460	22.5	960	26.9
480	22.9	980	26.9
500	22.9	1000	27.4

Figure 1
ANSI C63.5:2017 10.0 m separation,
AUT Scanned (1.0 m - 4.0 m), ANT2 at HP 2.0 m
Teseq CBL 6143A, s/n 23169.

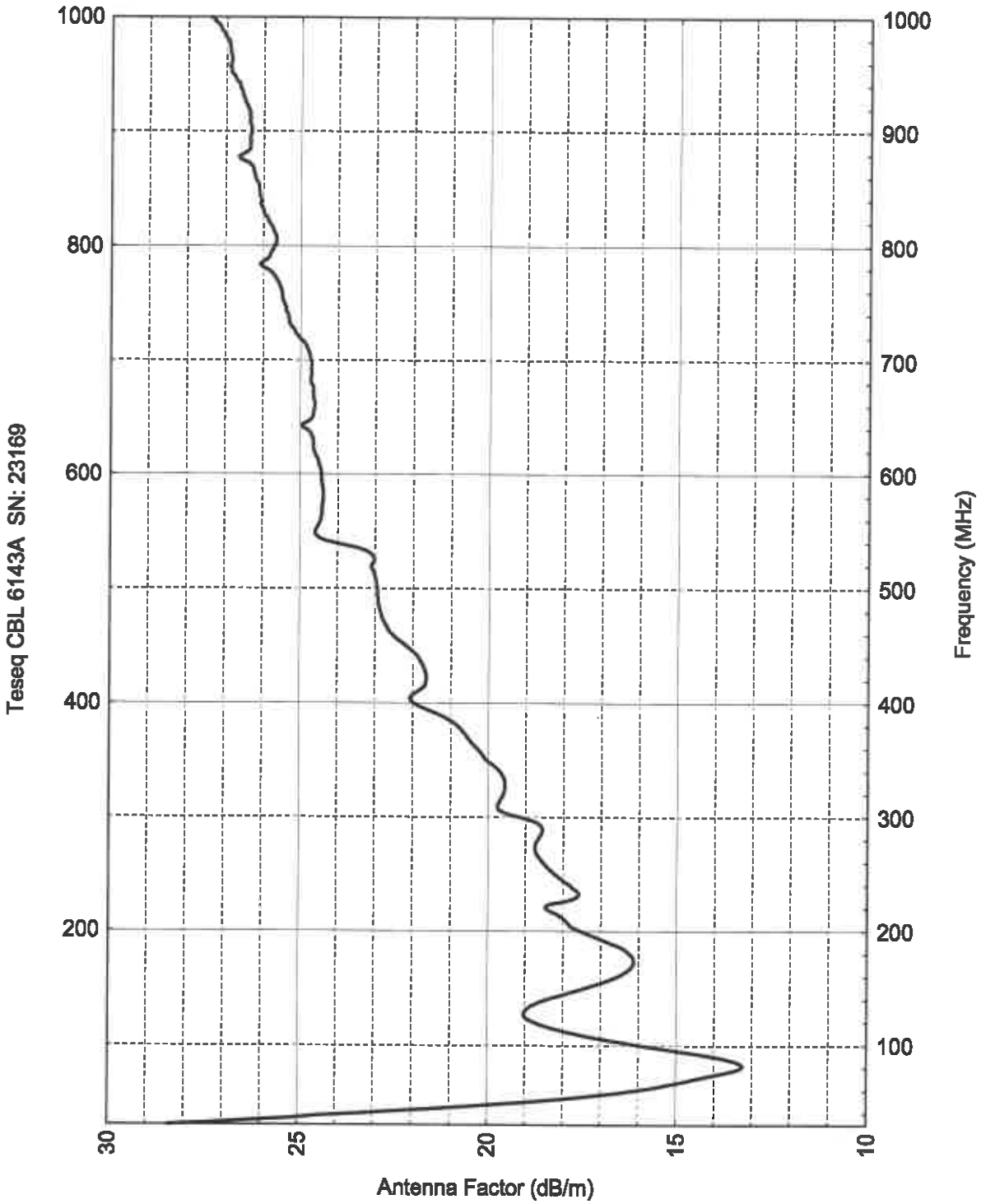


Figure 2
VSWR
Teseq CBL 6143A, s/n 23169.

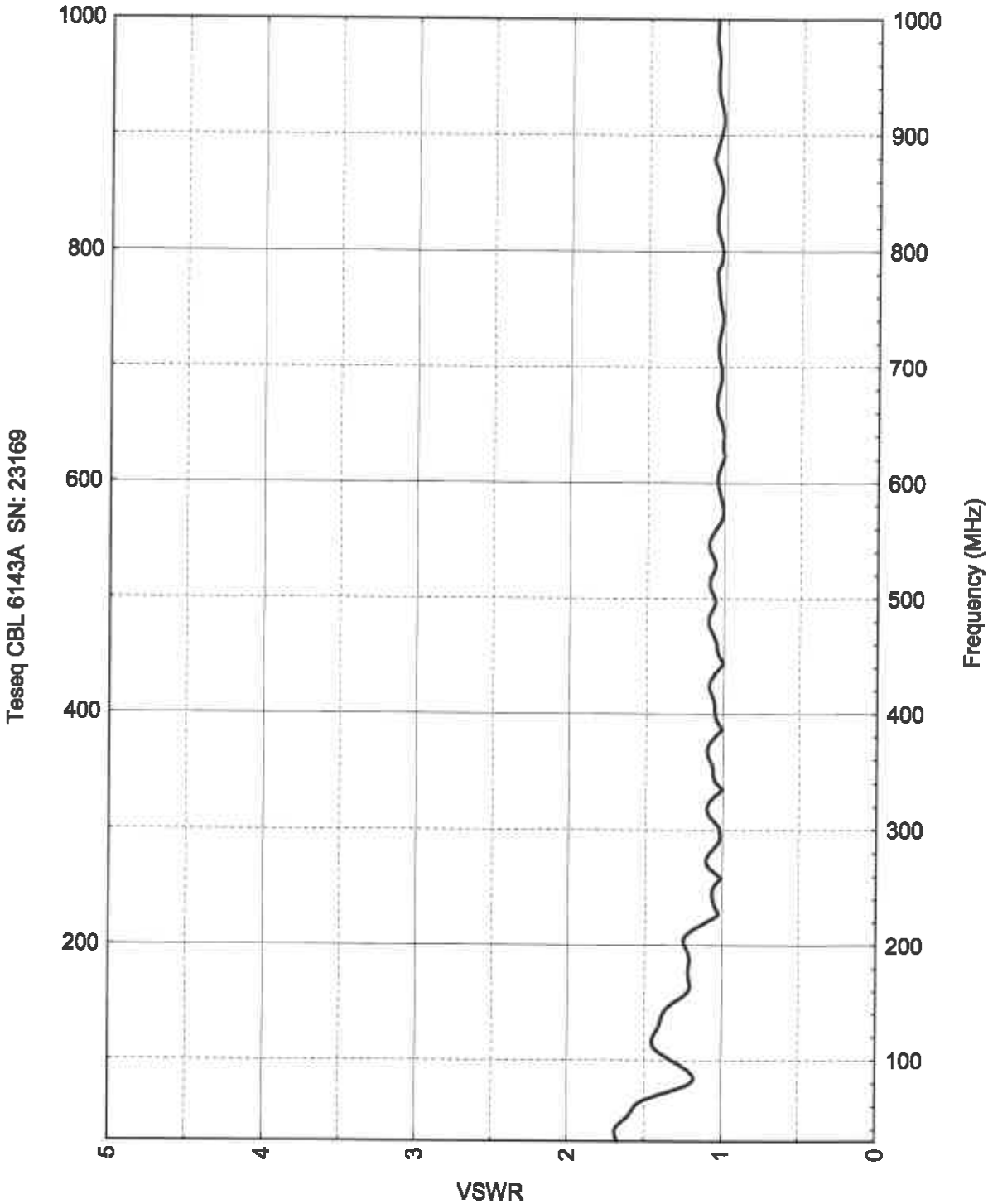


Figure 3
Return Loss for antenna model: Teseq CBL 6143A, s/n 23169.

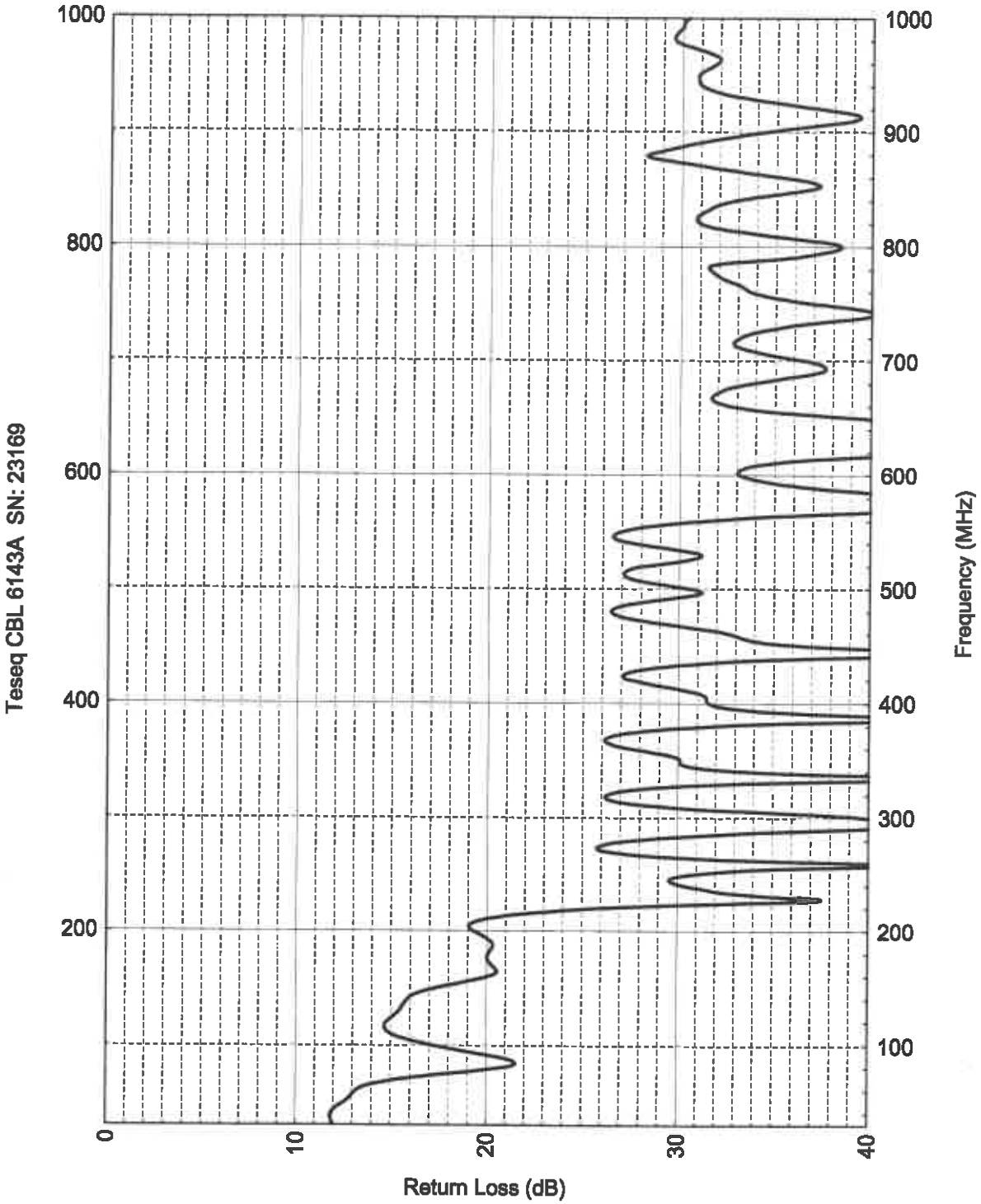
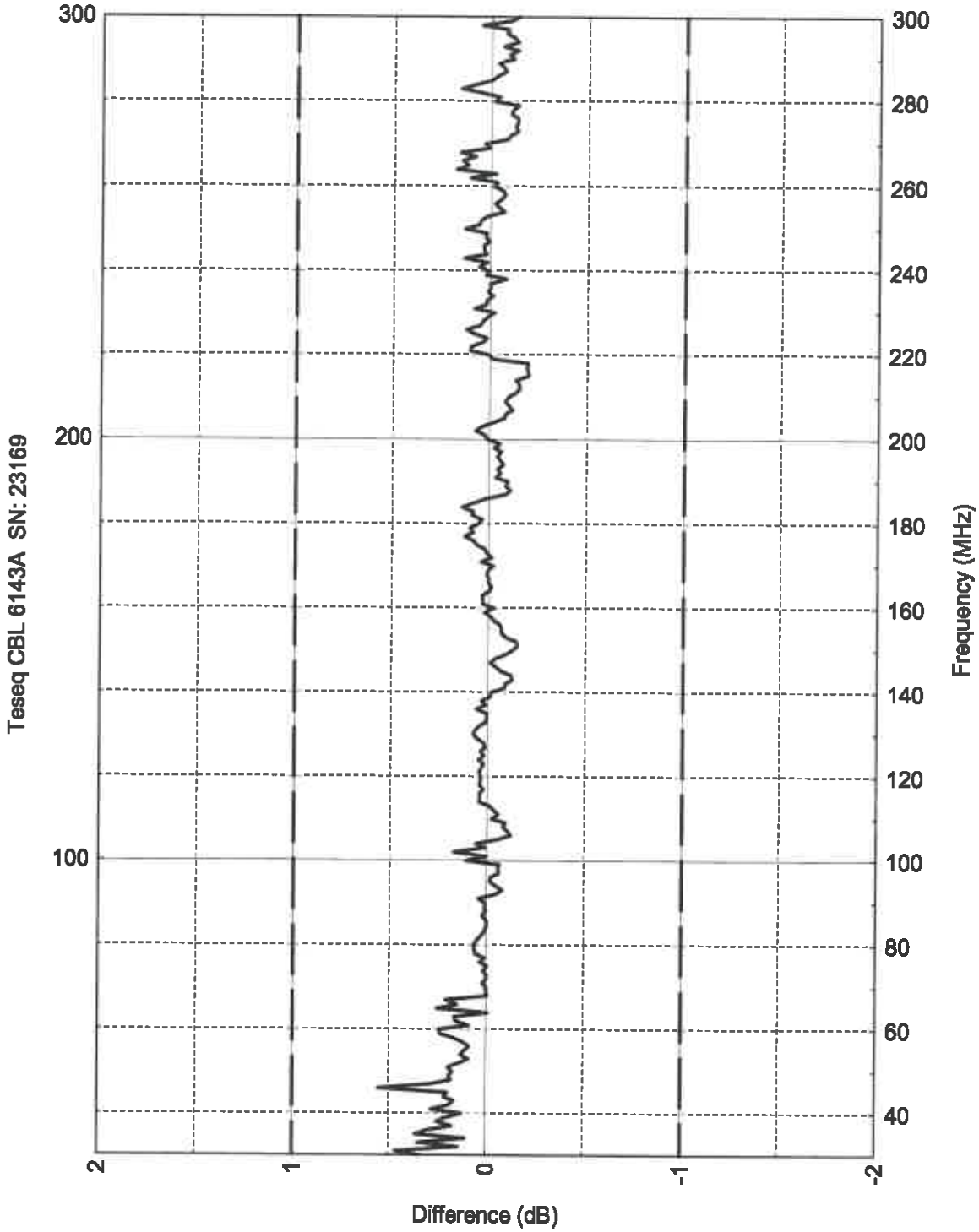


Figure 4
Balance test for antenna model: Teseq CBL 6143A, s/n 23169.



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Certificate of Calibration

UKAS CALIBRATION
0478

EMCO 3115
Double Ridged Guide Horn Antenna s/n 9509-4562

REPLACEMENT FOR CERTIFICATE 2018050459-2

FOR:	RISE Brinellgatan 4 SE-504 62 BORÅS Sweden
DESCRIPTION:	EMCO 3115 Double Ridged Guide Horn Antenna
IDENTIFICATION:	s/n 9509-4562
CALIBRATION FREQUENCIES:	0.7 GHz to 18.0 GHz in 0.1 GHz steps
DATE(S) OF CALIBRATION:	28 June to 5 July 2018

Reference: 2018050459-2R

Date of Issue: 15 July 2020

Signed:

(Authorised Signatory)

Checked by:

Name: D A Knight

on behalf of NPLML

CIPM MRA

This certificate is consistent with the capabilities that are included in Appendix C of the MRA drawn up by the CIPM. Under the MRA, all participating institutes recognise the validity of each other's calibration and measurement certificates for the quantities, ranges and measurement uncertainties specified in Appendix C (for details see http://www.bipm.org).

MEASUREMENTS

The measurements in the frequency range 1.0 GHz to 18.0 GHz were made in accordance with the ANSI 63.5:2017 standard. The results of this calibration comply with the basic requirement set out in section 5.1.3.1 a) 1) ii) of the standard: "AFs measured at distances with $0.62\sqrt{D^3/\lambda} \leq R < 2D^2/\lambda$ shall be deemed acceptable at the calibrated distance" for radiated emission measurements.

In the following, the IEEE definition of gain is used: the gain of an antenna in a given direction is defined as "the ratio of the radiation intensity, in a given direction, to the radiation intensity that would be obtained if the power accepted by the antenna were isotropically radiated". The apparent gain is obtained by multiplying the gain by the factor $(1 - |\Gamma|^2)$, where Γ is the reflection coefficient of the antenna.

The apparent gain of the antenna was measured by the three antenna technique. The antenna separation was 3 m, measured from the aperture of the antenna. A vector network analyser was used to measure the complex reflection coefficients of the antennas and components used in the measurement circuit. Mismatch corrections were calculated from these measurements and applied to the measured gains to give the apparent gains. The antenna factors were calculated from the apparent gains using the following formula:

$$AF = 30.23 + 20\log_{10}(F_{\mathrm{GHz}}) - G_{\mathrm{dBi}} \quad [\mathrm{dB}\ (1/\mathrm{m})]$$

where F_{GHz} is the frequency in GHz and G_{dBi} is the apparent gain in dBi.

All measurements were made in a temperature controlled electromagnetic anechoic chamber in a screened laboratory at a temperature of 23 ± 2° C.

CALIBRATION DATA

This certificate contains a subset of the full calibration data. A complete set of results will be provided via email in Excel format.

MEASUREMENT UNCERTAINTIES

The estimated uncertainty in the apparent gain is ± 1.0 dB for frequencies below 1.0 GHz and ± 0.8 dB for frequencies 1.0 GHz and above. The uncertainties in the real or imaginary parts of the reflection coefficients are given in the table below. The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor $k = 2$, providing a coverage probability of approximately 95 %. The uncertainty evaluation has been carried out in accordance with UKAS requirements. These uncertainties apply only to the measured values and give no indication of the long term stability of the antenna.

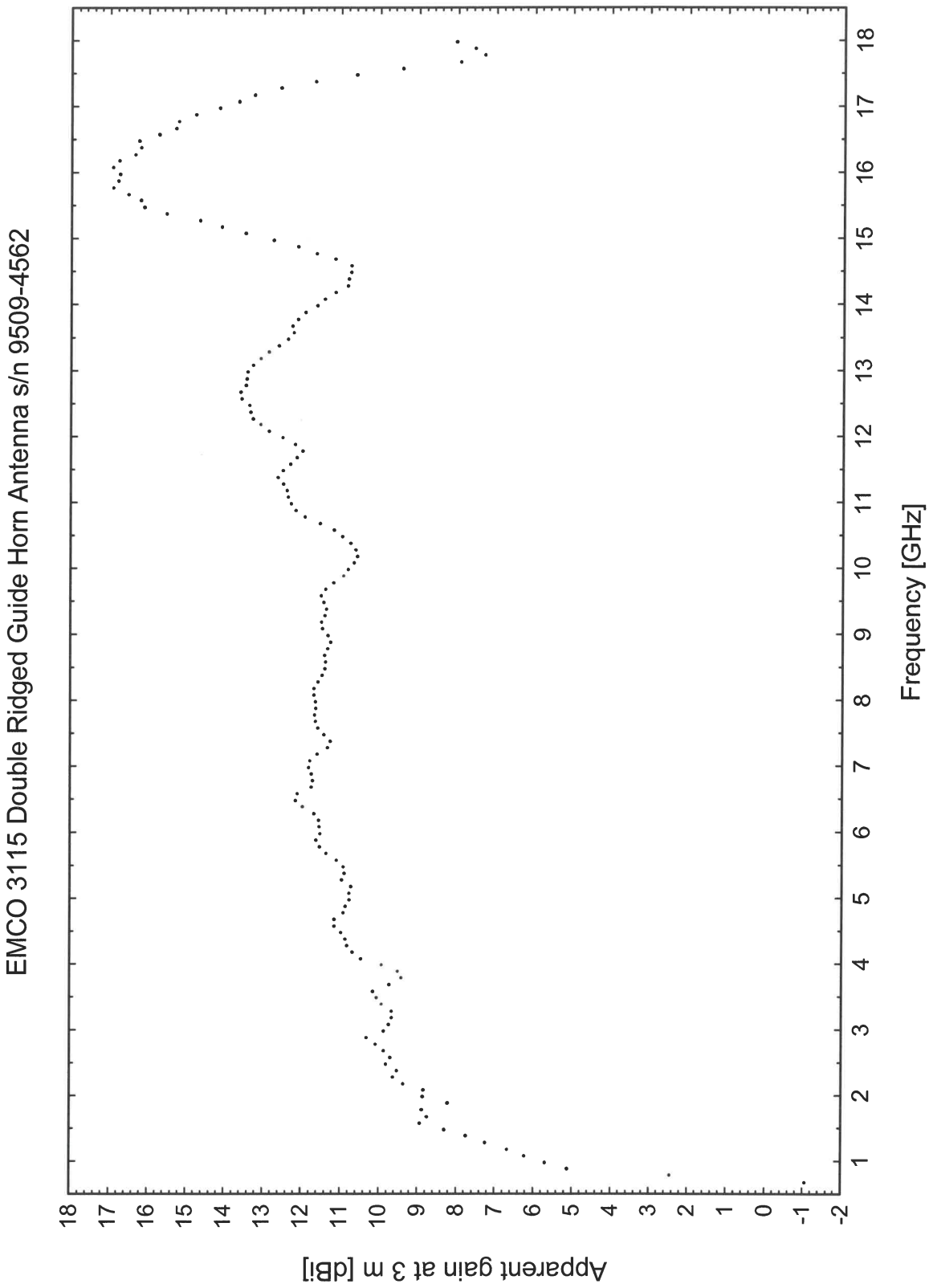
Uncertainties in the components of the reflection coefficients.

Frequency range [GHz]	Uncertainty in real or imaginary parts
0.7 to 0.9	± 0.050 units
1.0 to 1.5	± 0.015 units
1.6 to 18.0	± 0.011 units

RESULTS

Apparent Gain and Antenna Factor at 3 m from the antenna aperture.		
Frequency [GHz]	Gain 3 m [dBi]	Antenna Factor [dB (1/m)]
0.70	-1.1	28.2
0.80	2.4	25.9
0.90	5.1	24.2
1.00	5.7	24.6
1.50	8.3	25.5
2.00	8.8	27.4
2.50	9.8	28.4
3.00	9.8	29.9
3.50	10.0	31.1
4.00	9.9	32.4
4.50	11.0	32.3
5.00	10.7	33.5
5.50	10.9	34.1
6.00	11.5	34.3
6.50	12.1	34.4
7.00	11.8	35.4
7.50	11.4	36.3
8.00	11.6	36.7
8.50	11.4	37.4
9.00	11.3	38.0
9.50	11.4	38.4
10.00	10.8	39.4
10.50	10.9	39.7
11.00	12.2	38.8
11.50	12.5	39.0
12.00	12.5	39.4
12.50	13.3	38.8
13.00	13.4	39.1
13.50	12.3	40.5
14.00	11.6	41.6
14.50	10.7	42.7
15.00	12.7	41.0
15.50	16.1	37.9
16.00	16.7	37.6
16.50	16.2	38.4
17.00	14.1	40.7
17.50	10.6	44.5
18.00	8.0	47.3

Reflection Coefficients and VSWR			
Freq [GHz]	Real Part	Imaginary Part	VSWR
0.70	0.801	0.241	11.26
0.80	0.641	-0.143	4.82
0.90	0.373	-0.201	2.47
1.00	0.370	-0.177	2.39
1.50	-0.162	-0.219	1.75
2.00	-0.337	-0.006	2.02
2.50	-0.238	0.066	1.65
3.00	-0.134	0.087	1.38
3.50	0.091	0.085	1.29
4.00	0.139	-0.112	1.44
4.50	-0.092	-0.094	1.30
5.00	-0.183	0.171	1.67
5.50	-0.003	0.306	1.88
6.00	0.160	0.172	1.62
6.50	0.166	-0.070	1.44
7.00	-0.023	-0.171	1.42
7.50	-0.114	-0.021	1.26
8.00	0.019	0.088	1.20
8.50	0.134	0.019	1.31
9.00	0.132	-0.118	1.43
9.50	-0.010	-0.239	1.63
10.00	-0.238	-0.176	1.84
10.50	-0.149	0.060	1.38
11.00	-0.095	-0.053	1.24
11.50	-0.121	0.016	1.28
12.00	-0.009	0.050	1.11
12.50	0.043	-0.053	1.15
13.00	-0.051	-0.129	1.32
13.50	-0.152	-0.044	1.38
14.00	-0.093	0.091	1.30
14.50	0.100	0.083	1.30
15.00	0.193	-0.125	1.60
15.50	0.042	-0.303	1.88
16.00	-0.183	-0.268	1.96
16.50	-0.292	-0.037	1.84
17.00	-0.122	0.215	1.66
17.50	0.216	0.129	1.67
18.00	0.218	-0.235	1.95



Reference: 2018050459-2R

Checked by:

CHANGES TO CERTIFICATE

This re-issued certificate contains the requested ANSI 63.5:2017 statement.

NATIONAL PHYSICAL LABORATORY
Teddington Middlesex UK TW11 0LW Telephone +44 20 8977 3222

Certificate of Calibration

UKAS CALIBRATION
0478

ETS-Lindgren 3115
Double Ridged Guide Horn Antenna S/N: 00143161

FOR:	**RISE** **Box 857** **Se 501 15** **Boras** **Sweden**
DESCRIPTION:	**ETS-Lindgren 3115 Double Ridged Guide Horn Antenna**
IDENTIFICATION:	**S/N:00143161**
CALIBRATION FREQUENCIES:	**1.0 GHz to 18.0 GHz in 0.1 GHz steps**
DATE(S) OF CALIBRATION:	**11 December 2018**

Reference: 2018100184-1 **Page 1 of 5**

Date of Issue: 11 December 2018 **Signed:** D G Gentle **(Authorised Signatory)**

Checked by: A Beardmore **Name:** D G Gentle **on behalf of NPLML**

CIPM MRA

This certificate is consistent with the capabilities that are included in Appendix C of the MRA drawn up by the CIPM. Under the MRA, all participating institutes recognise the validity of each other's calibration and measurement certificates for the quantities, ranges and measurement uncertainties specified in Appendix C (for details see http://www.bipm.org).

NPLC03-08M3

MEASUREMENTS

The measurements were made in accordance with the ANSI 63.5:2017 standard. The results of this calibration comply with the basic requirement set out in section 5.1.3.1 a) 1) ii) of the standard: "AFs measured at distances with $0.62\sqrt{D^3/\lambda} \leq R < 2D^2/\lambda$ shall be deemed acceptable at the calibrated distance" for radiated emission measurements.

In the following, the IEEE definition of gain is used: the gain of an antenna in a given direction is defined as "the ratio of the radiation intensity, in a given direction, to the radiation intensity that would be obtained if the power accepted by the antenna were isotropically radiated". The apparent gain is obtained by multiplying the gain by the factor $(1 - |\Gamma|^2)$, where Γ is the reflection coefficient of the antenna.

The apparent gain of the antenna was measured by the three antenna technique. The antenna separation was 3 m, measured from the aperture of the antenna. A vector network analyser was used to measure the complex reflection coefficients of the antennas and components used in the measurement circuit. Mismatch corrections were calculated from these measurements and applied to the measured gains to give the apparent gains. The antenna factors were calculated from the apparent gains using the following formula:

$$AF = 30.23 + 20\log_{10}(F_{GHz}) - G_{dBi} \quad [\text{dB } (1/\text{m})]$$

where F_{GHz} is the frequency in GHz and G_{dBi} is the apparent gain in dBi.

All measurements were made in a temperature controlled electromagnetic anechoic chamber in a screened laboratory at a temperature of 23 ± 2° C.

CALIBRATION DATA

This certificate contains a subset of the full calibration data. A complete set of results will be provided via email in Excel format.

MEASUREMENT UNCERTAINTIES

The estimated uncertainty in the apparent gain is ± 0.8 dB and the uncertainties in the real or imaginary parts of the reflection coefficients are given in the table below. The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor $k = 2$, providing a coverage probability of approximately 95%. The uncertainty evaluation has been carried out in accordance with UKAS requirements. These uncertainties apply only to the measured values and give no indication of the long term stability of the antenna.

Uncertainties in the components of the reflection coefficients.

Frequency range [GHz]	Uncertainty in real or imaginary parts
1.0 to 1.5	± 0.015 units
1.6 to 18.0	± 0.011 units

Checked by: 

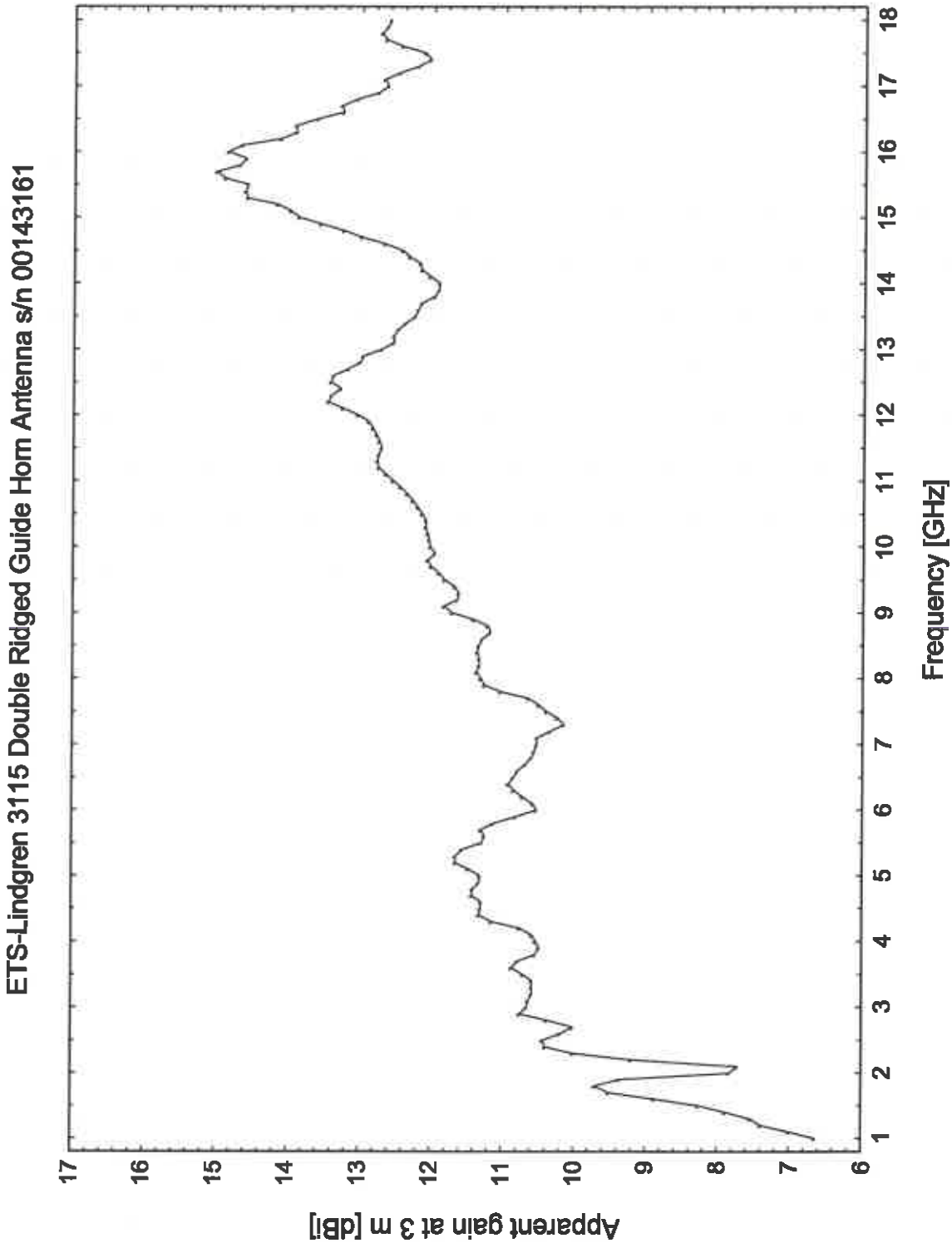
RESULTS

Apparent Gain and Antenna Factor at 3 m from the antenna aperture.		
Frequency [GHz]	Gain 3 m [dBi]	Antenna Factor [dB (1/m)]
1.00	6.6	23.6
1.50	8.3	25.5
2.00	7.8	28.4
2.50	10.4	27.8
3.00	10.7	29.1
3.50	10.7	30.4
4.00	10.5	31.7
4.50	11.3	32.0
5.00	11.3	32.9
5.50	11.3	33.8
6.00	10.5	35.3
6.50	10.9	35.6
7.00	10.5	36.6
7.50	10.4	37.3
8.00	11.3	37.0
8.50	11.3	37.5
9.00	11.7	37.6
9.50	11.8	38.0
10.00	12.0	38.2
10.50	12.1	38.5
11.00	12.6	38.5
11.50	12.7	38.7
12.00	13.0	38.8
12.50	13.4	38.8
13.00	12.7	39.8
13.50	12.3	40.6
14.00	11.9	41.2
14.50	12.4	41.0
15.00	13.9	39.9
15.50	14.6	39.5
16.00	14.9	39.5
16.50	13.6	41.0
17.00	12.6	42.2
17.50	12.1	43.0
18.00	12.6	42.7

Checked by: A Beauchaue

Reflection Coefficients and VSWR			
Freq [GHz]	Real Part	Imaginary Part	VSWR
1.00	0.119	-0.161	1.50
1.50	-0.331	-0.011	1.99
2.00	-0.400	0.172	2.54
2.50	-0.158	0.225	1.76
3.00	0.000	0.175	1.43
3.50	0.172	0.208	1.74
4.00	0.283	0.107	1.87
4.50	0.102	0.010	1.23
5.00	-0.060	0.150	1.38
5.50	0.058	0.278	1.80
6.00	0.255	0.164	1.87
6.50	0.348	-0.053	2.08
7.00	0.234	-0.254	2.05
7.50	-0.008	-0.222	1.57
8.00	-0.065	-0.003	1.14
8.50	0.069	0.055	1.19
9.00	0.133	-0.067	1.35
9.50	0.080	-0.205	1.57
10.00	-0.052	-0.245	1.67
10.50	-0.135	-0.162	1.53
11.00	-0.129	-0.069	1.34
11.50	-0.109	-0.030	1.25
12.00	-0.094	0.002	1.21
12.50	-0.050	0.000	1.10
13.00	-0.030	-0.059	1.14
13.50	-0.091	-0.109	1.33
14.00	-0.188	-0.061	1.49
14.50	-0.219	0.090	1.62
15.00	-0.104	0.254	1.76
15.50	0.114	0.268	1.82
16.00	0.262	0.133	1.83
16.50	0.280	-0.043	1.79
17.00	0.179	-0.162	1.63
17.50	0.037	-0.116	1.28
18.00	0.092	0.074	1.27

Checked by: A Beardmore



Reference: 2018100184-1

Checked by: ABeanhow

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Teddington Middlesex UK TW11 0LW Telephone +44 20 8977 3222

Certificate of Calibration

UKAS CALIBRATION
0478

EMCO 3116
Double Ridged Guide Horn Antenna S/N: 9904-2426

FOR:	**RISE** **Brinellgatan 4** **SE-504 62 BORÅS** **Sweden**
DESCRIPTION:	**EMCO 3116 Double Ridged Guide Horn Antenna**
IDENTIFICATION:	**S/N 9904-2426**
CALIBRATION FREQUENCIES:	**18.00 GHz to 40.00 GHz in 0.25 GHz steps**
DATE(S) OF CALIBRATION:	**19 July 2018**

Reference: 2018050459-3

Date of Issue: 20 July 2018

Checked by: Elm

Signed: DGGentle

Name: D G Gentle

(Authorised Signatory)

on behalf of NPLML

CIPM MRA

MEASUREMENTS

In the following, the IEEE definition of gain is used: the gain of an antenna in a given direction is defined as "the ratio of the radiation intensity, in a given direction, to the radiation intensity that would be obtained if the power accepted by the antenna were isotropically radiated". The apparent gain is obtained by multiplying the gain by the factor $(1 - |\Gamma|^2)$, where Γ is the reflection coefficient of the antenna.

The apparent gain of the antenna was measured by the three antenna technique. The antenna separation was 3 m measured from the aperture of the antenna. A vector network analyser was used to measure the complex reflection coefficients of the antennas and components used in the measurement circuit. Mismatch corrections were calculated from these measurements and applied to the measured gains to give the apparent gains. The antenna factors were calculated from the apparent gains using the following formula:

$$AF = 30.23 + 20\log_{10}(F_{\mathrm{GHz}}) - G_{\mathrm{dBi}} \quad [\mathrm{dB}\ (1/\mathrm{m})]$$

where F_{GHz} is the frequency in GHz and G_{dBi} is the apparent gain in dBi.

All measurements were made in a temperature controlled electromagnetic anechoic chamber in a screened laboratory at a temperature of 23 ± 2° C.

CALIBRATION DATA

This certificate contains a subset of the full calibration data. A complete set of results will be provided via email in Excel format.

MEASUREMENT UNCERTAINTIES

The estimated uncertainty in the apparent gain is ± 0.8 dB and the uncertainty in the real or imaginary parts of the reflection coefficients are given in the table below. The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor $k = 2$, providing a coverage probability of approximately 95 %. The uncertainty evaluation has been carried out in accordance with UKAS requirements. These uncertainties apply only to the measured values and give no indication of the long term stability of the antenna.

Uncertainties in the components of the reflection coefficients.

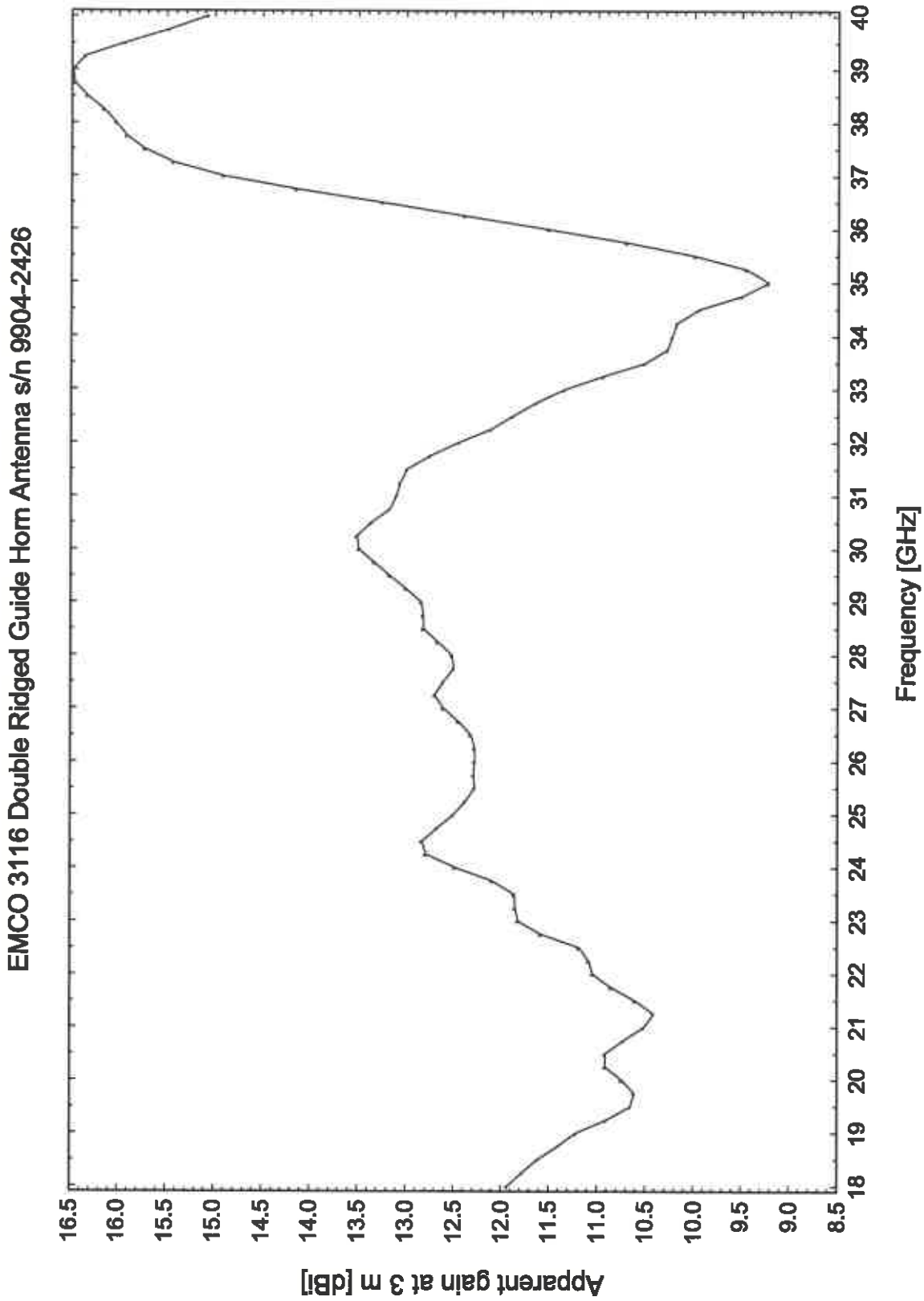
Frequency range [GHz]	Uncertainty in real or imaginary parts
18.00 to 26.50	± 0.028 units
26.75 to 40.00	± 0.043 units

RESULTS

Apparent Gain and Antenna Factor at 3 m from the antenna aperture.		
Frequency [GHz]	Gain 3 m [dBi]	Antenna Factor [dB (1/m)]
18.00	11.9	43.4
18.50	11.6	44.0
19.00	11.2	44.6
19.50	10.7	45.4
20.00	10.7	45.5
20.50	10.9	45.6
21.00	10.5	46.2
21.50	10.6	46.3
22.00	11.0	46.0
22.50	11.2	46.1
23.00	11.8	45.6
23.50	11.9	45.8
24.00	12.5	45.4
24.50	12.8	45.2
25.00	12.5	45.7
25.50	12.3	46.1
26.00	12.3	46.2
26.50	12.3	46.4
27.00	12.6	46.2
27.50	12.6	46.4
28.00	12.5	46.7
28.50	12.8	46.5
29.00	12.8	46.6
29.50	13.2	46.4
30.00	13.5	46.3
30.50	13.4	46.6
31.00	13.1	47.0
31.50	13.0	47.2
32.00	12.5	47.9
32.50	11.9	48.6
33.00	11.3	49.3
33.50	10.5	50.2
34.00	10.2	50.6
34.50	10.0	51.0
35.00	9.2	51.9
35.50	10.0	51.2
36.00	11.5	49.8
36.50	13.3	48.2
37.00	14.9	46.7
37.50	15.7	46.0
38.00	16.0	45.8
38.50	16.3	45.6
39.00	16.5	45.6
39.50	15.9	46.2
40.00	15.1	47.2

Reflection Coefficients and VSWR			
Freq [GHz]	Real Part	Imaginary Part	VSWR
18.00	0.123	0.000	1.28
18.50	0.095	-0.151	1.43
19.00	-0.059	-0.200	1.53
19.50	-0.163	-0.145	1.56
20.00	-0.238	-0.067	1.66
20.50	-0.253	0.070	1.71
21.00	-0.167	0.159	1.60
21.50	-0.102	0.182	1.53
22.00	-0.017	0.207	1.52
22.50	0.063	0.152	1.39
23.00	0.085	0.116	1.34
23.50	0.142	0.066	1.37
24.00	0.133	-0.034	1.32
24.50	0.072	-0.083	1.25
25.00	0.015	-0.101	1.23
25.50	-0.055	-0.078	1.21
26.00	-0.068	-0.007	1.15
26.50	-0.037	0.023	1.09
27.00	-0.008	0.044	1.09
27.50	0.045	0.031	1.12
28.00	0.062	-0.012	1.13
28.50	0.068	-0.047	1.18
29.00	0.055	-0.105	1.27
29.50	-0.005	-0.138	1.32
30.00	-0.062	-0.138	1.36
30.50	-0.122	-0.124	1.42
31.00	-0.179	-0.066	1.47
31.50	-0.194	0.008	1.48
32.00	-0.177	0.081	1.48
32.50	-0.114	0.145	1.45
33.00	-0.025	0.142	1.34
33.50	0.032	0.090	1.21
34.00	0.039	0.017	1.09
34.50	-0.013	-0.027	1.06
35.00	-0.062	-0.015	1.14
35.50	-0.084	0.009	1.18
36.00	-0.103	0.041	1.25
36.50	-0.100	0.085	1.30
37.00	-0.075	0.120	1.33
37.50	-0.031	0.150	1.36
38.00	0.031	0.145	1.35
38.50	0.064	0.103	1.28
39.00	0.073	0.073	1.23
39.50	0.072	0.042	1.18
40.00	0.060	0.020	1.13

Checked by:



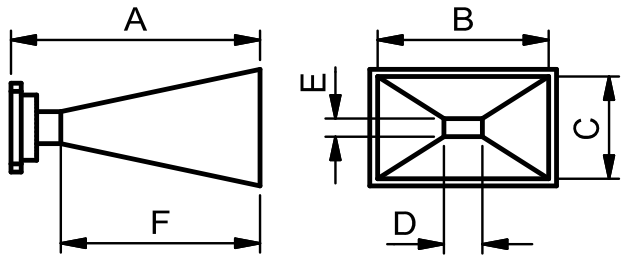
Reference: 2018050459-3

Checked by:

Standard Gain Horn

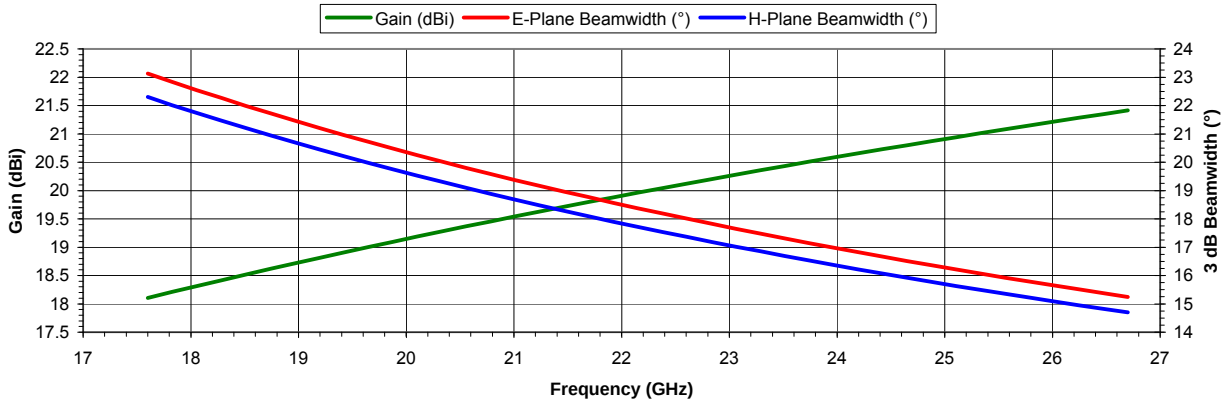
Model 20240-20

Waveguide Size:	WG20 (WR42, R220)
Nominal Gain:	20 dBi
Operating Frequencies:	17.6 - 26.7 GHz
Overall Length (A):	120.3 mm (4.736 inch)
Aperture Width (B):	52.00 mm (2.047 inch)
Aperture Height (C):	37.40 mm (1.472 inch)
Waveguide Width (D):	10.668 mm (0.420 inch)
Waveguide Height (E):	4.318 mm (0.170 inch)
Flare Length (F):	115.20 mm (4.535 inch)



Typical Performance Data

Frequency (GHz)	Gain (dBi)	Beamwidth E-Plane	Beamwidth H-Plane	Frequency (GHz)	Gain (dBi)	Beamwidth E-Plane	Beamwidth H-Plane	Frequency (GHz)	Gain (dBi)	Beamwidth E-Plane	Beamwidth H-Plane
17.6	18.11	23.1°	22.3°	20.7	19.42	19.7°	19.0°	23.85	20.54	17.1°	16.5°
17.7	18.15	23.0°	22.2°	20.85	19.48	19.5°	18.8°	24	20.59	17.0°	16.4°
17.85	18.22	22.8°	22.0°	21	19.54	19.4°	18.7°	24.15	20.64	16.9°	16.3°
18	18.29	22.6°	21.8°	21.15	19.59	19.2°	18.6°	24.3	20.69	16.8°	16.2°
18.15	18.36	22.4°	21.6°	21.3	19.65	19.1°	18.4°	24.45	20.74	16.6°	16.1°
18.3	18.42	22.2°	21.4°	21.45	19.71	19.0°	18.3°	24.6	20.79	16.5°	16.0°
18.45	18.49	22.1°	21.3°	21.6	19.76	18.8°	18.2°	24.75	20.83	16.4°	15.9°
18.6	18.56	21.9°	21.1°	21.75	19.82	18.7°	18.0°	24.9	20.88	16.3°	15.8°
18.75	18.62	21.7°	20.9°	21.9	19.87	18.6°	17.9°	25.05	20.93	16.3°	15.7°
18.9	18.69	21.5°	20.8°	22.05	19.93	18.5°	17.8°	25.2	20.97	16.2°	15.6°
19.05	18.75	21.4°	20.6°	22.2	19.98	18.3°	17.7°	25.35	21.02	16.1°	15.5°
19.2	18.82	21.2°	20.4°	22.35	20.03	18.2°	17.6°	25.5	21.06	16.0°	15.4°
19.35	18.88	21.0°	20.3°	22.5	20.09	18.1°	17.4°	25.65	21.11	15.9°	15.3°
19.5	18.94	20.9°	20.1°	22.65	20.14	18.0°	17.3°	25.8	21.15	15.8°	15.2°
19.65	19.00	20.7°	20.0°	22.8	20.19	17.9°	17.2°	25.95	21.20	15.7°	15.1°
19.8	19.06	20.6°	19.8°	22.95	20.24	17.7°	17.1°	26.1	21.24	15.6°	15.0°
19.95	19.13	20.4°	19.7°	23.1	20.29	17.6°	17.0°	26.25	21.28	15.5°	15.0°
20.1	19.19	20.3°	19.5°	23.25	20.35	17.5°	16.9°	26.4	21.33	15.4°	14.9°
20.25	19.25	20.1°	19.4°	23.4	20.40	17.4°	16.8°	26.55	21.37	15.3°	14.8°
20.4	19.31	20.0°	19.2°	23.55	20.45	17.3°	16.7°	26.7	21.41	15.2°	14.7°
20.55	19.36	19.8°	19.1°	23.7	20.50	17.2°	16.6°				



Notes:
Gain calculations based on NRL Report 4433 - accuracy to approx ± 0.3dBi
Half-power (3dB) beamwidth estimates calculated using 50.8 λ / C (E-Plane) and 68.1 λ / B (H-Plane). This is a 'large aperture' approximation that breaks down at gain values smaller than around 12 dBi. For 10dBi Standard Gain Horns, beamwidths are approximately 63º at the lowest frequency and 48º at the highest frequency.

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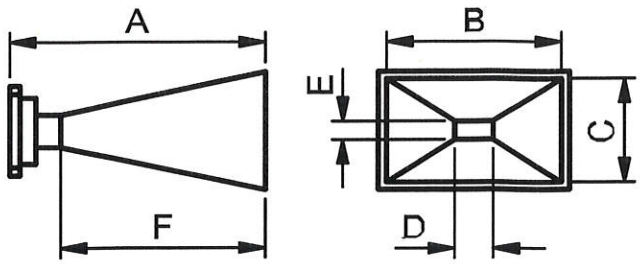
STANDARD GAIN HORN

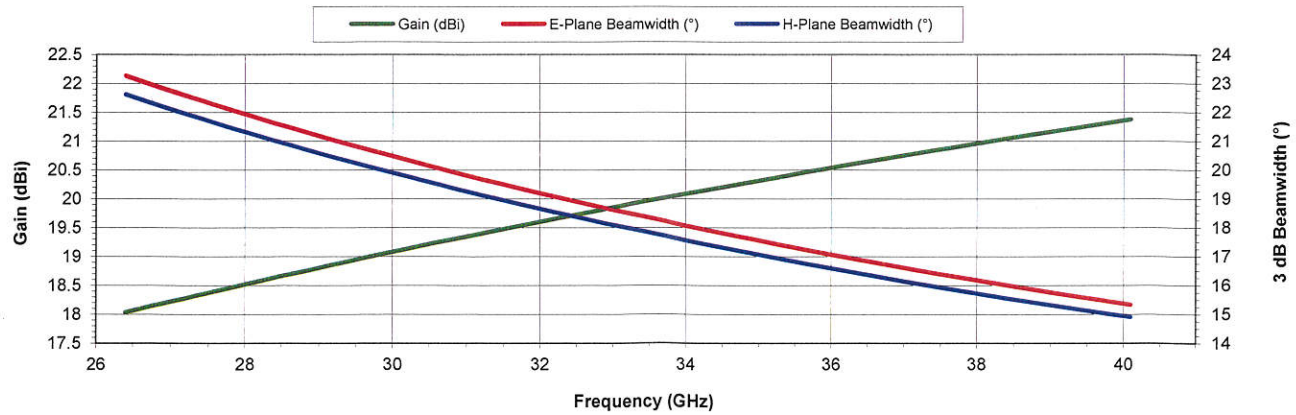
Model 22240-20

Waveguide Size:	WG22 (WR28, R320)
Nominal Gain:	20 dBi
Operating Frequencies:	26.4 - 40.1 GHz
Overall Length (A):	86.0 mm (3.386 inch)
Aperture Width (B):	34.20 mm (1.346 inch)
Aperture Height (C):	24.80 mm (0.976 inch)
Waveguide Width (D):	7.112 mm (0.280 inch)
Waveguide Height (E):	3.556 mm (0.140 inch)
Flare Length (F):	75.00 mm (2.953 inch)



Typical Performance Data

Frequency	Gain	Beamwidth		Frequency	Gain	Beamwidth		Frequency	Gain	Beamwidth	
(GHz)	(dBi)	E-Plane	H-Plane	(GHz)	(dBi)	E-Plane	H-Plane	(GHz)	(dBi)	E-Plane	H-Plane
26.4	18.03	23.3°	22.6°	31.5	19.47	19.5°	18.9°	36.75	20.69	16.7°	16.2°
26.5	18.06	23.2°	22.5°	31.75	19.53	19.3°	18.8°	37	20.74	16.6°	16.1°
26.75	18.14	22.9°	22.3°	32	19.60	19.2°	18.6°	37.25	20.80	16.5°	16.0°
27	18.22	22.7°	22.1°	32.25	19.66	19.0°	18.5°	37.5	20.85	16.4°	15.9°
27.25	18.29	22.5°	21.9°	32.5	19.72	18.9°	18.4°	37.75	20.90	16.3°	15.8°
27.5	18.37	22.3°	21.7°	32.75	19.78	18.7°	18.2°	38	20.95	16.2°	15.7°
27.75	18.44	22.1°	21.5°	33	19.84	18.6°	18.1°	38.25	21.00	16.0°	15.6°
28	18.52	21.9°	21.3°	33.25	19.90	18.5°	17.9°	38.5	21.05	15.9°	15.5°
28.25	18.59	21.7°	21.1°	33.5	19.96	18.3°	17.8°	38.75	21.10	15.8°	15.4°
28.5	18.66	21.5°	20.9°	33.75	20.02	18.2°	17.7°	39	21.15	15.7°	15.3°
28.75	18.73	21.4°	20.8°	34	20.08	18.1°	17.6°	39.25	21.20	15.6°	15.2°
29	18.80	21.2°	20.6°	34.25	20.14	17.9°	17.4°	39.5	21.25	15.5°	15.1°
29.25	18.87	21.0°	20.4°	34.5	20.19	17.8°	17.3°	39.75	21.30	15.4°	15.0°
29.5	18.94	20.8°	20.2°	34.75	20.25	17.7°	17.2°	40	21.34	15.3°	14.9°
29.75	19.01	20.6°	20.1°	35	20.31	17.5°	17.1°	40.1	21.36	15.3°	14.9°
30	19.08	20.5°	19.9°	35.25	20.36	17.4°	16.9°				
30.25	19.14	20.3°	19.7°	35.5	20.42	17.3°	16.8°				
30.5	19.21	20.1°	19.6°	35.75	20.48	17.2°	16.7°				
30.75	19.28	20.0°	19.4°	36	20.53	17.1°	16.6°				
31	19.34	19.8°	19.3°	36.25	20.58	16.9°	16.5°				
31.25	19.41	19.6°	19.1°	36.5	20.64	16.8°	16.3°				



Notes:

Gain calculations based on NRL Report 4433 - accuracy to approx ± 0.3dBi. Antenna Gain is only valid within the 'far-field' of the antenna. For more details, please see Ch 16, 'Antenna Theory, Analysis & Design' Balanis, Wiley or Ch 18 'Antenna', Kraus, McGraw-Hill.

Half-power (3dB) beamwidth estimates calculated using 50.8 λ / C (E-Plane) and 68.1 λ / B (H-Plane). This is a 'large aperture' approximation that breaks down at gain values smaller than around 12 dBi. For 10dBi Standard Gain Horns, beamwidths are approximately 63º at the lowest frequency and 48º at the highest frequency.

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STANDARD GAIN HORN

Model No: 24240-20 **Nominal Gain: 20dB**

Typical Performance Data

Frequency (GHz)	Gain dBi (acc. ± .25dB)	3dB Beamwidth (deg.) E-PLANE	H-PLANE
39.3	18.0	24	23
40.0	18.2	23	22
41.0	18.4	23	22
42.0	18.6	22	21
43.0	18.8	22	21
44.0	19.0	21	20
45.0	19.2	21	20
46.0	19.3	20	20
47.0	19.5	20	19
48.0	19.7	19	19
49.0	19.9	19	18
50.0	20.0	19	18
51.0	20.2	18	18
52.0	20.3	18	17
53.0	20.5	18	17
54.0	20.6	17	17
55.0	20.8	17	16
56.0	20.9	17	16
57.0	21.1	16	16
58.0	21.2	16	16
59.0	21.4	16	15
59.7	21.4	16	15

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STANDARD GAIN HORN

Model No: 26240-20dB **Nominal Gain: 20dB**

Typical Performance Data

Frequency (GHz)	Gain dBi (acc. ± .25dB)	3dB Beamwidth (deg.) E-PLANE	H-PLANE
60.5	18.1	23	23
62.0	18.3	23	22
64.0	18.6	22	22
66.0	18.9	21	21
68.0	19.1	21	20
70.0	19.4	20	20
72.0	19.6	19	19
74.0	19.8	19	19
76.0	20.0	18	18
78.0	20.2	18	18
80.0	20.4	17	17
82.0	20.5	17	17
84.0	20.8	17	17
86.0	21.0	16	16
88.0	21.2	16	16
90.0	21.4	16	16
92.0	21.6	15	15

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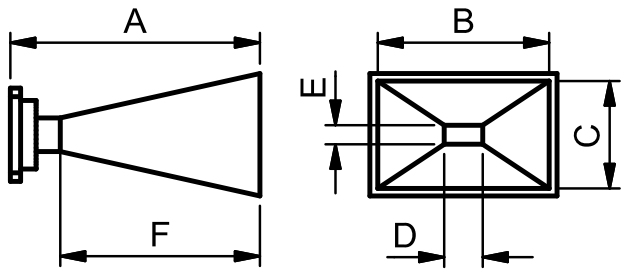
Standard Gain Horn

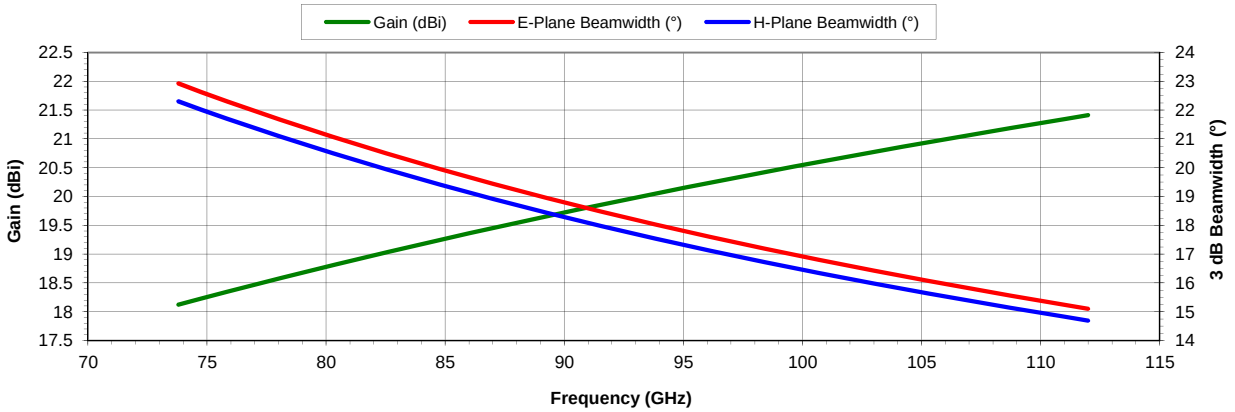
Model 27240-20

Waveguide Size:	WG27 (WR10, R900)
Nominal Gain:	20 dBi
Operating Frequencies:	73.8 - 112 GHz
Overall Length (A):	32.5 mm (1.280 inch)
Aperture Width (B):	12.40 mm (0.488 inch)
Aperture Height (C):	9.00 mm (0.354 inch)
Waveguide Width (D):	2.540 mm (0.100 inch)
Waveguide Height (E):	1.270 mm (0.050 inch)
Flare Length (F):	26.00 mm (1.024 inch)



Typical Performance Data

Frequency (GHz)	Gain (dBi)	Beamwidth E-Plane	Beamwidth H-Plane	Frequency (GHz)	Gain (dBi)	Beamwidth E-Plane	Beamwidth H-Plane	Frequency (GHz)	Gain (dBi)	Beamwidth E-Plane	Beamwidth H-Plane
73.8	18.12	22.9°	22.3°	89.25	19.66	19.0°	18.4°	105	20.92	16.1°	15.7°
74.25	18.17	22.8°	22.2°	90	19.72	18.8°	18.3°	105.75	20.98	16.0°	15.6°
75	18.26	22.6°	21.9°	90.75	19.79	18.6°	18.1°	106.5	21.03	15.9°	15.5°
75.75	18.34	22.3°	21.7°	91.5	19.85	18.5°	18.0°	107.25	21.08	15.8°	15.3°
76.5	18.42	22.1°	21.5°	92.25	19.92	18.3°	17.8°	108	21.14	15.7°	15.2°
77.25	18.50	21.9°	21.3°	93	19.98	18.2°	17.7°	108.75	21.19	15.6°	15.1°
78	18.57	21.7°	21.1°	93.75	20.04	18.0°	17.6°	109.5	21.24	15.4°	15.0°
78.75	18.65	21.5°	20.9°	94.5	20.11	17.9°	17.4°	110.25	21.29	15.3°	14.9°
79.5	18.73	21.3°	20.7°	95.25	20.17	17.8°	17.3°	111	21.34	15.2°	14.8°
80.25	18.80	21.1°	20.5°	96	20.23	17.6°	17.1°	111.75	21.39	15.1°	14.7°
81	18.88	20.9°	20.3°	96.75	20.29	17.5°	17.0°	112	21.41	15.1°	14.7°
81.75	18.95	20.7°	20.1°	97.5	20.35	17.3°	16.9°				
82.5	19.03	20.5°	20.0°	98.25	20.41	17.2°	16.8°				
83.25	19.10	20.3°	19.8°	99	20.47	17.1°	16.6°				
84	19.17	20.1°	19.6°	99.75	20.53	17.0°	16.5°				
84.75	19.24	20.0°	19.4°	100.5	20.58	16.8°	16.4°				
85.5	19.31	19.8°	19.3°	101.25	20.64	16.7°	16.3°				
86.25	19.38	19.6°	19.1°	102	20.70	16.6°	16.1°				
87	19.45	19.4°	18.9°	102.75	20.76	16.5°	16.0°				
87.75	19.52	19.3°	18.8°	103.5	20.81	16.3°	15.9°				
88.5	19.59	19.1°	18.6°	104.25	20.87	16.2°	15.8°				



Notes:
Gain calculations based on NRL Report 4433 - accuracy to approx ± 0.3dBi
Half-power (3dB) beamwidth estimates calculated using 50.8 λ / C (E-Plane) and 68.1 λ / B (H-Plane). This is a 'large aperture' approximation that breaks down at gain values smaller than around 12 dBi. For 10dBi Standard Gain Horns, beamwidths are approximately 63º at the lowest frequency and 48º at the highest frequency.

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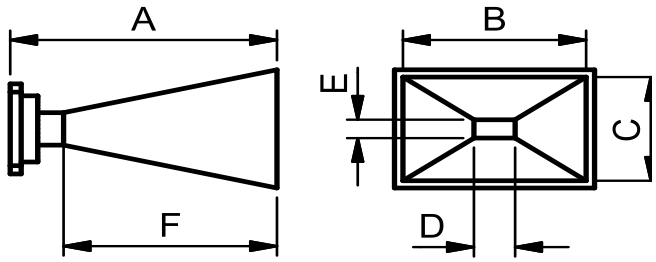
STANDARD GAIN HORN

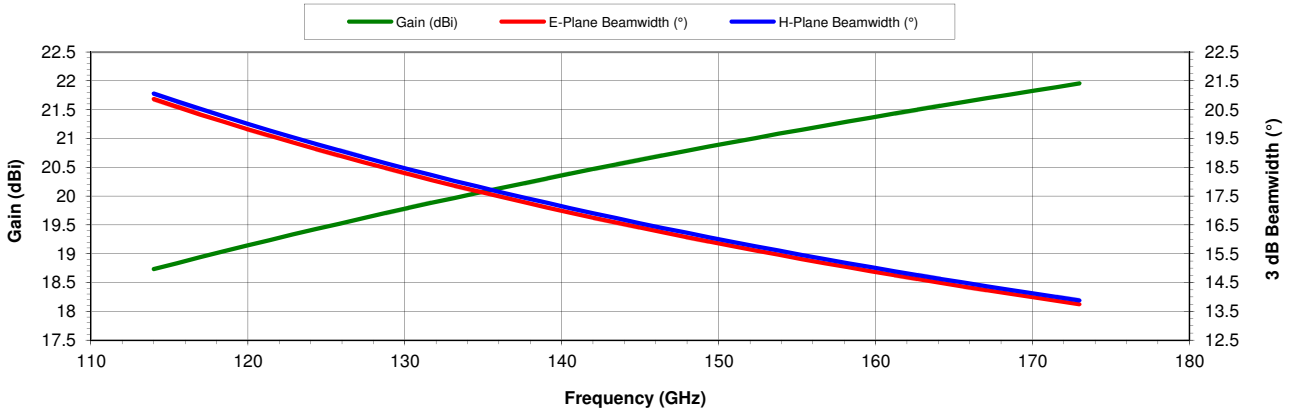
Model 29240-20

Waveguide Size:	WG29 (WR6, R1400)
Nominal Gain:	20 dBi
Operating Frequencies:	114 - 173 GHz
Overall Length (A):	24.4 mm (0.961 inch)
Aperture Width (B):	8.50 mm (0.335 inch)
Aperture Height (C):	6.40 mm (0.252 inch)
Waveguide Width (D):	1.651 mm (0.065 inch)
Waveguide Height (E):	0.826 mm (0.033 inch)
Flare Length (F):	18.00 mm (0.709 inch)



Typical Performance Data

Frequency (GHz)	Gain (dBi)	Beamwidth E-Plane	Beamwidth H-Plane	Frequency (GHz)	Gain (dBi)	Beamwidth E-Plane	Beamwidth H-Plane	Frequency (GHz)	Gain (dBi)	Beamwidth E-Plane	Beamwidth H-Plane
114	18.73	20.9°	21.1°	135	20.08	17.6°	17.8°	156	21.19	15.2°	15.4°
115	18.80	20.7°	20.9°	136	20.13	17.5°	17.7°	157	21.24	15.2°	15.3°
116	18.87	20.5°	20.7°	137	20.19	17.4°	17.5°	158	21.28	15.1°	15.2°
117	18.94	20.3°	20.5°	138	20.25	17.2°	17.4°	159	21.33	15.0°	15.1°
118	19.01	20.2°	20.3°	139	20.30	17.1°	17.3°	160	21.38	14.9°	15.0°
119	19.08	20.0°	20.2°	140	20.36	17.0°	17.2°	161	21.42	14.8°	14.9°
120	19.14	19.8°	20.0°	141	20.42	16.9°	17.0°	162	21.47	14.7°	14.8°
121	19.21	19.7°	19.8°	142	20.47	16.8°	16.9°	163	21.52	14.6°	14.7°
122	19.28	19.5°	19.7°	143	20.52	16.6°	16.8°	164	21.56	14.5°	14.6°
123	19.34	19.3°	19.5°	144	20.58	16.5°	16.7°	165	21.61	14.4°	14.6°
124	19.41	19.2°	19.4°	145	20.63	16.4°	16.6°	166	21.65	14.3°	14.5°
125	19.47	19.0°	19.2°	146	20.68	16.3°	16.4°	167	21.70	14.2°	14.4°
126	19.53	18.9°	19.1°	147	20.74	16.2°	16.3°	168	21.74	14.2°	14.3°
127	19.60	18.7°	18.9°	148	20.79	16.1°	16.2°	169	21.78	14.1°	14.2°
128	19.66	18.6°	18.8°	149	20.84	16.0°	16.1°	170	21.83	14.0°	14.1°
129	19.72	18.4°	18.6°	150	20.89	15.9°	16.0°	171	21.87	13.9°	14.0°
130	19.78	18.3°	18.5°	151	20.94	15.8°	15.9°	172	21.91	13.8°	14.0°
131	19.84	18.2°	18.3°	152	20.99	15.7°	15.8°	173	21.95	13.8°	13.9°
132	19.90	18.0°	18.2°	153	21.04	15.5°	15.7°				
133	19.96	17.9°	18.1°	154	21.09	15.4°	15.6°				
134	20.02	17.8°	17.9°	155	21.14	15.3°	15.5°				



Notes:
Gain calculations based on NRL Report 4433 - accuracy to approx ± 0.3dBi. Antenna Gain is only valid within the 'far-field' of the antenna. For more details, please see Ch 16, 'Antenna Theory, Analysis & Design' Balanis, Wiley or Ch 18 'Antenna', Kraus, McGraw-Hill.
Half-power (3dB) beamwidth estimates calculated using 50.8 λ / C (E-Plane) and 68.1 λ / B (H-Plane). This is a 'large aperture' approximation that breaks down at gain values smaller than around 12 dBi. For 10dBi Standard Gain Horns, beamwidths are approximately 63º at the lowest frequency and 48º at the highest frequency.

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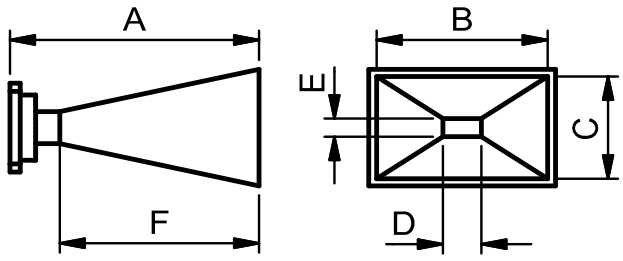
Standard Gain Horn

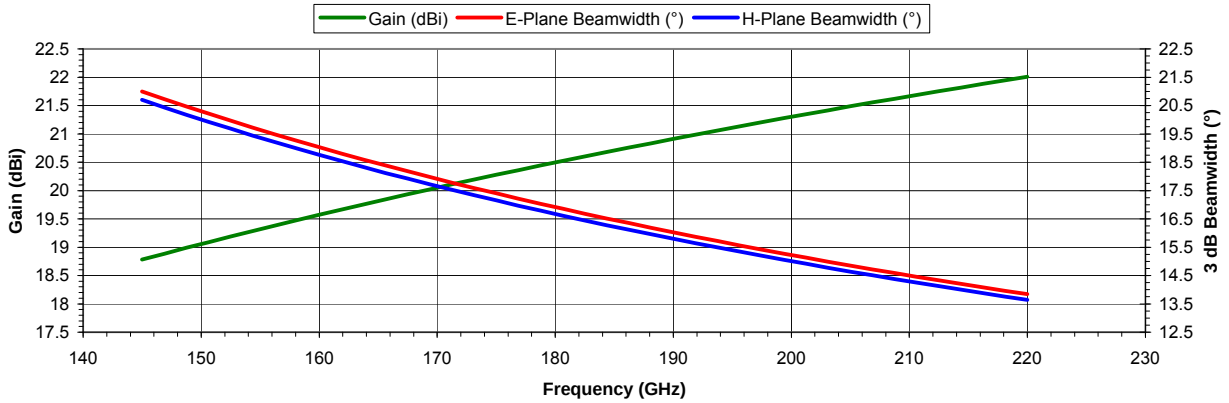
Model 30240-20

Waveguide Size:	WG30 (WR5, R1800)
Nominal Gain:	20 dBi
Operating Frequencies:	145 - 220 GHz
Overall Length (A):	17.5 mm (0.689 inch)
Aperture Width (B):	6.80 mm (0.268 inch)
Aperture Height (C):	5.00 mm (0.197 inch)
Waveguide Width (D):	1.295 mm (0.051 inch)
Waveguide Height (E):	0.648 mm (0.026 inch)
Flare Length (F):	14.50 mm (0.571 inch)



Typical Performance Data

Frequency	Gain	Beamwidth		Frequency	Gain	Beamwidth		Frequency	Gain	Beamwidth	
(GHz)	(dBi)	E-Plane	H-Plane	(GHz)	(dBi)	E-Plane	H-Plane	(GHz)	(dBi)	E-Plane	H-Plane
145	18.78	21.0°	20.7°	175.5	20.30	17.3°	17.1°	207	21.56	14.7°	14.5°
145.5	18.81	20.9°	20.6°	177	20.37	17.2°	17.0°	208.5	21.61	14.6°	14.4°
147	18.89	20.7°	20.4°	178.5	20.43	17.1°	16.8°	210	21.67	14.5°	14.3°
148.5	18.98	20.5°	20.2°	180	20.50	16.9°	16.7°	211.5	21.72	14.4°	14.2°
150	19.06	20.3°	20.0°	181.5	20.56	16.8°	16.5°	213	21.77	14.3°	14.1°
151.5	19.14	20.1°	19.8°	183	20.62	16.6°	16.4°	214.5	21.82	14.2°	14.0°
153	19.21	19.9°	19.6°	184.5	20.69	16.5°	16.3°	216	21.87	14.1°	13.9°
154.5	19.29	19.7°	19.4°	186	20.75	16.4°	16.1°	217.5	21.92	14.0°	13.8°
156	19.37	19.5°	19.2°	187.5	20.81	16.2°	16.0°	219	21.97	13.9°	13.7°
157.5	19.45	19.3°	19.1°	189	20.87	16.1°	15.9°	220	22.01	13.8°	13.6°
159	19.52	19.2°	18.9°	190.5	20.93	16.0°	15.8°				
160.5	19.60	19.0°	18.7°	192	20.99	15.9°	15.6°				
162	19.67	18.8°	18.5°	193.5	21.05	15.7°	15.5°				
163.5	19.74	18.6°	18.4°	195	21.11	15.6°	15.4°				
165	19.82	18.5°	18.2°	196.5	21.17	15.5°	15.3°				
166.5	19.89	18.3°	18.0°	198	21.23	15.4°	15.2°				
168	19.96	18.1°	17.9°	199.5	21.28	15.3°	15.0°				
169.5	20.03	18.0°	17.7°	201	21.34	15.1°	14.9°				
171	20.10	17.8°	17.6°	202.5	21.39	15.0°	14.8°				
172.5	20.16	17.7°	17.4°	204	21.45	14.9°	14.7°				
174	20.23	17.5°	17.2°	205.5	21.50	14.8°	14.6°				



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