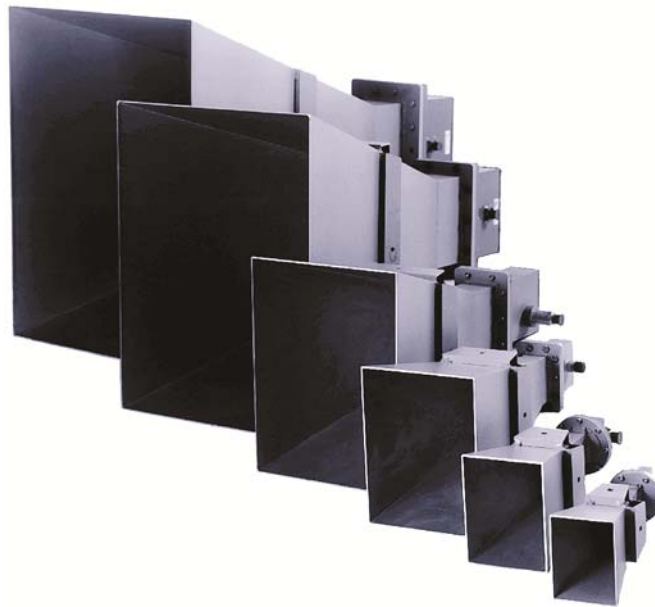


Model 3161 Series

Octave Bandwidth Pyramidal Horn Antenna

User Manual



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An ESCO Technologies Company

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Notes, Cautions, and Warnings

	<p>Note: Denotes helpful information intended to provide tips for better use of the product.</p>
<p>CAUTION</p>	<p>Caution: Denotes a hazard. Failure to follow instructions could result in minor personal injury and/or property damage. Included text gives proper procedures.</p>
<p>WARNING</p>	<p>Warning: Denotes a hazard. Failure to follow instructions could result in SEVERE personal injury and/or property damage. Included text gives proper procedures.</p>



See the ETS-Lindgren *Product Information Bulletin* for safety, regulatory, and other product marking information.

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1.0 Introduction

The **ETS-Lindgren Model 3161 Series Octave Bandwidth Pyramidal Horn Antenna** is designed specifically for emissions and immunity testing over the 1 GHz to 8 GHz frequency range. Characteristics of the Model 3161 Series include linear polarization, medium gain, medium half-power beamwidth in both the horizontal and vertical planes, low VSWR over the recommended operating frequency range, and antenna factors constant within 2 dB. The wide bandwidth was selected to allow use with octave bandwidth traveling-wave tube (TWT) amplifiers without the need to change antennas over the band.

Each Model 3161 is furnished with a high performance, low VSWR, Type N coax-to-waveguide adapter. This adapter limits antenna power-handling capacity, and may be removed if a power source with waveguide output is available. In such a configuration, fields in excess of 10,000 V/m at 10 meters are obtainable.

The Model 3161 Series is constructed of aluminum, and then is conversion coated and painted for protection against corrosion and changes in the weather.

The Model 3161 Series can be used as transmit or receive antennas. The 50 Ω input impedance is matched to most standard coax cables. In receiving applications, the antennas are matched to the free space impedance (377 Ω). Typical performance data is provided beginning on page 23. Methodology for radiated emissions measurement is described on page 27.

ETS-Lindgren Product Information Bulletin

See the ETS-Lindgren *Product Information Bulletin* included with your shipment for the following:

- Warranty information
- Safety, regulatory, and other product marking information
- Steps to receive your shipment
- Steps to return a component for service
- ETS-Lindgren calibration service
- ETS-Lindgren contact information

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2.0 Maintenance

CAUTION

Before performing any maintenance, follow the safety information in the ETS-Lindgren *Product Information Bulletin* included with your shipment.



Maintenance of the Model 3161 Series is limited to external components such as cables or connectors.

If you have any questions concerning maintenance, contact ETS-Lindgren Customer Service.

- When not in use, the Model 3161 Series Octave Bandwidth Pyramidal Horn Antenna should be stored on a shelf face down to keep dust out of the feed areas.
- If the Model 3161 Series is used outdoors, the antennas should be checked for water accumulations. Water has a high dielectric constant and can alter performance.
- If an antenna is dropped, the feed/horn joint should be checked for misalignment.

Annual Calibration

See the *Product Information Bulletin* included with your shipment for information on ETS-Lindgren calibration services.

Service Procedures

For the steps to return a system or system component to ETS-Lindgren for service, see the *Product Information Bulletin* included with your shipment.

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3.0 Specifications

Electrical Specifications

- The VSWR indicated in the following table is that of the pyramidal horn antenna and coax-to-waveguide adapter. The VSWR of the antenna by itself is of the order of 1.1:1.
- The maximum continuous power indicated in the following table is mainly limited by the coax-to-waveguide adapter. The antenna itself is capable of handling continuous power on the order of 10^4 Watts to 10^7 Watts.

	3161-01	3161-02	3161-03
Frequency Range:	1.0 GHz to 2.0 GHz	2.0 GHz to 4.0 GHz	4.0 GHz to 8.0 GHz
Antenna Factor:	15.40 dB(1/m)	16.85 dB(1/m)	20.60 dB(1/m)
VSWR With Feed:	1.6	1.5	1.3
Maximum Continuous Power:	550 W	500 W	250 W
Connector Type:	Type N female	Type N female	Type N female

Physical Specifications

	3161-01	3161-02	3161-03
Height:	39.8 cm 15.6 in	23.1 cm 9.1 in	11.7 cm 4.6 in
Width:	53.1 cm 20.9 in	34.6 cm 13.6 in	17.4 cm 6.8 in
Depth:	88.0 cm 34.6 in	59.3 cm 23.3 in	31.8 cm 12.5 in
Weight:	8.0 kg 17.6 lb	5.0 kg 11.0 lb	2.0 kg 4.4 lb
Waveguide Number:	WR-650	WR-320	WR-159

Power Requirements

The Model 3161 Series Octave Bandwidth Pyramidal Horn Antenna is an efficient transmitting antenna, capable of generating high electric field strengths using little power. For a given electric field strength, the required power can be computed using the transmission equation:

$$\text{Power Transmitted} = \frac{(\text{Field Strength})^2 (\text{Distance in meters})^2}{(30 \times \text{Numeric Gain})}$$

$$P_t = \frac{|E|^2 R^2}{30 g}$$

The typical power requirements in Watts for a given field strength computed from the transmission equation for the Model 3161 Series are shown in Table 1 through Table 6. Distance is measured from the aperture of the antenna.

TABLE 1: MODEL 3161-01 POWER REQUIREMENTS AT 1 METER

Freq GHz	Gain dB	Gain Num.	AF dB(1/m)	Field Strength		
				100 V/m	200 V/m	500 V/m
1.0	13.02	20.04	17.20	16.6	66.5	415.7
1.1	13.69	23.38	17.36	14.3	57.0	356.3
1.2	14.28	26.79	17.52	12.4	49.8	311.0
1.3	14.80	30.20	17.70	11.0	44.2	275.9
1.4	15.25	33.50	17.89	10.0	39.8	248.8
1.5	15.64	36.64	18.10	9.1	36.4	227.4
1.6	15.98	39.62	18.32	8.4	33.6	210.3
1.7	16.27	42.36	18.55	7.9	31.5	196.7
1.8	16.52	44.87	18.80	7.4	29.7	185.7
1.9	16.73	47.10	19.06	7.0	28.3	176.9
2.0	16.90	48.98	19.34	6.8	27.2	170.1

TABLE 2: MODEL 3161-01 POWER REQUIREMENTS AT 3 AND 10 METERS

Freq GHz	Field Strength at 3 Meters			Field Strength at 10 Meters		
	50 V/m	100 V/m	150 V/m	10 V/m	20 V/m	50 V/m
1.0	37.4	150.0	336.7	16.6	66.5	415.7
1.1	32.1	128.3	288.6	14.3	57.0	356.3
1.2	28.0	112.0	251.9	12.4	49.8	311.0
1.3	24.8	99.3	223.5	11.0	44.2	275.9
1.4	22.4	89.6	201.5	10.0	39.8	248.8
1.5	20.5	81.9	184.2	9.1	36.4	227.4
1.6	18.9	75.7	170.3	8.4	33.6	210.3
1.7	17.7	70.8	159.3	7.9	31.5	196.7
1.8	16.7	66.9	150.4	7.4	29.7	185.7
1.9	15.9	63.7	143.3	7.1	28.3	176.9
2.0	15.3	61.3	137.8	6.8	27.2	170.1

TABLE 3: MODEL 3161-02 POWER REQUIREMENTS AT 1 METER

Freq GHz	Gain dB	Gain Num.	AF dB(1/m)	Field Strength		
				100 V/m	200 V/m	500 V/m
2.0	15.15	32.73	21.09	10.18	40.73	254.58
2.2	15.91	38.99	21.16	8.55	34.19	213.71
2.4	16.59	45.60	21.23	7.31	29.24	182.73
2.6	17.20	52.48	21.32	6.35	25.41	158.79
2.8	17.75	59.57	21.41	5.60	22.38	139.90
3.0	18.25	66.83	21.51	4.99	19.95	124.69
3.2	18.70	74.13	21.62	4.50	17.99	112.41
3.4	19.12	81.66	21.73	4.08	16.33	102.05
3.6	19.49	88.92	21.86	3.75	14.99	93.72
3.8	19.84	96.38	21.98	3.46	13.83	86.46
4.0	20.15	103.51	22.11	3.22	12.88	80.50

TABLE 4: MODEL 3161-02 POWER REQUIREMENTS AT 3 AND 10 METERS

Freq GHz	Field Strength at 3 Meters			Field Strength at 10 Meters		
	50 V/m	100 V/m	150 V/m	10 V/m	20 V/m	50 V/m
2.0	22.91	91.65	206.21	10.18	40.73	254.58
2.2	19.23	76.93	173.10	8.55	34.19	213.71
2.4	16.45	65.78	148.01	7.31	29.24	182.73
2.6	14.29	57.16	128.62	6.35	25.41	158.79
2.8	12.59	50.36	113.32	5.60	22.38	139.90
3.0	11.22	44.89	101.00	4.99	19.95	124.69
3.2	10.12	40.47	91.05	4.50	17.99	112.41
3.4	9.18	36.74	82.66	4.08	16.33	102.05
3.6	8.43	33.74	75.91	3.75	14.99	93.72
3.8	7.78	31.13	70.03	3.46	13.83	86.46
4.0	7.25	28.98	65.21	3.22	12.88	80.50

TABLE 5: MODEL 3161-03 POWER REQUIREMENTS AT 1 METER

Freq GHz	Gain dB	Gain Num.	AF dB(1/m)	Field Strength		
				100 V/m	200 V/m	500 V/m
4.0	14.96	31.33	27.30	10.64	42.55	265.96
4.5	15.84	38.37	27.44	8.69	34.75	217.18
5.0	16.59	45.60	27.61	7.31	29.24	182.73
5.5	17.24	52.97	27.79	6.29	25.17	157.33
6.0	17.81	60.39	27.97	5.52	22.08	137.98
6.5	18.29	67.45	28.19	4.94	19.77	123.54
7.0	18.71	74.30	28.41	4.49	17.94	112.16
7.5	19.07	80.72	28.65	4.13	16.52	103.23
8.0	19.38	86.70	28.90	3.84	15.38	96.12

TABLE 6: MODEL 3161-03 POWER REQUIREMENTS AT 3 AND 10 METERS

Freq GHz	Field Strength at 3 Meters			Field Strength at 10 Meters		
	50 V/m	100 V/m	150 V/m	10 V/m	20 V/m	50 V/m
4.0	23.94	95.75	215.43	10.64	42.55	265.96
4.5	19.55	78.18	175.92	8.69	34.75	217.18
5.0	16.45	65.78	148.01	7.31	29.24	182.73
5.5	14.16	56.64	127.44	6.29	25.17	157.33
6.0	12.42	49.67	111.76	5.52	22.08	137.98
6.5	11.12	44.48	100.07	4.94	19.77	123.54
7.0	10.09	40.38	90.85	4.49	17.94	112.16
7.5	9.29	37.16	83.62	4.13	16.52	103.23
8.0	8.65	34.60	77.86	3.84	15.38	96.12

4.0 Mounting Instructions

CAUTION

Before connecting any components, follow the safety information in the ETS-Lindgren Product Information Bulletin included with your shipment.

CAUTION

The Model 3161 Series antennas are precision measurement devices. Handle your antenna with care.



Horizontal and vertical polarizations can be achieved by rotating the antenna from one mount to the other.

The Model 3161 Series Octave Bandwidth Pyramidal Horn Antenna is equipped with a standard 1/4–20 mount. The mount is placed so as not to interfere with incoming electromagnetic energy.

Once mounted, remove the red cover from the Type N connector and attach a cable between the antenna and a transmitting/receiving RF device.

Mount to 4-TR

Model 3161 Series antennas mount directly to an ETS-Lindgren 4-TR Tripod; no additional hardware is required. Secure the mount onto the 4-TR by tightening the 1/4–20 UNC mount knob.

Mount to 7-TR and Mast

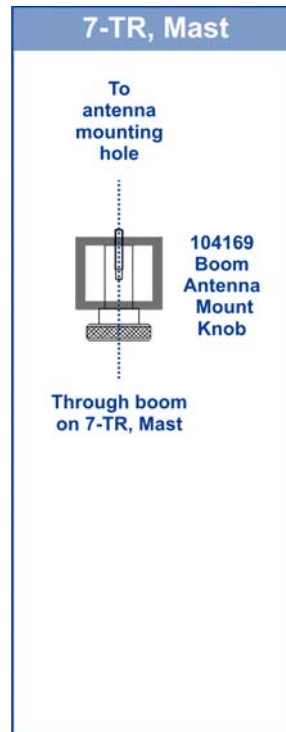
Following is an option for mounting the Model 3161 Series onto an ETS-Lindgren 7-TR Tripod or mast. Contact the ETS-Lindgren Sales Department for information on ordering optional mounting hardware.



Mast refers to 2070 Series, 2075, and 2175 Antenna Towers.

7-TR refers to 109042, 106328, and 108197 booms:

- *109042 boom*—Straight boom; for general antenna mounting on a 7-TR
- *106328 boom*—Offset boom; for general antenna mounting on a 7-TR with pneumatic or manual polarization
- *108197 boom*—Center rotate boom; for rear-mount stinger-type antennas only

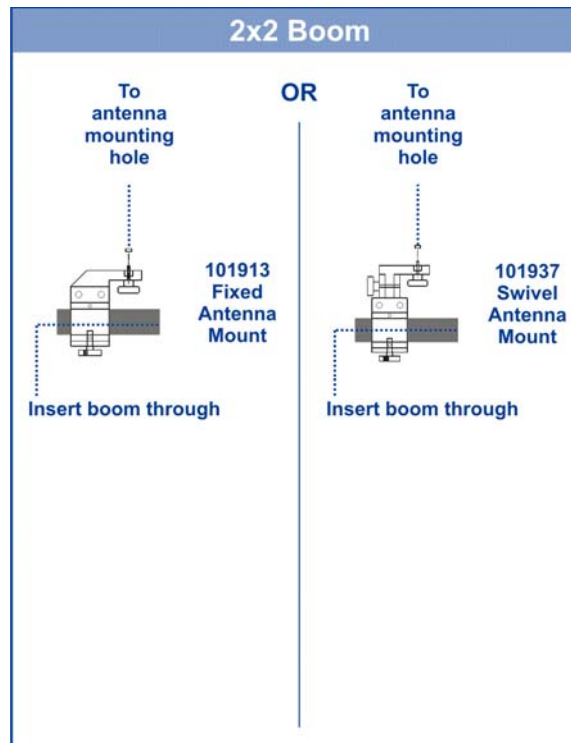


Mount to 2x2 Boom

Following are options for mounting the Model 3161 Series onto a 2x2 boom. Contact the ETS-Lindgren Sales Department for information on ordering optional mounting hardware.



2x2 boom refers to a typical 2-inch by 2-inch boom.



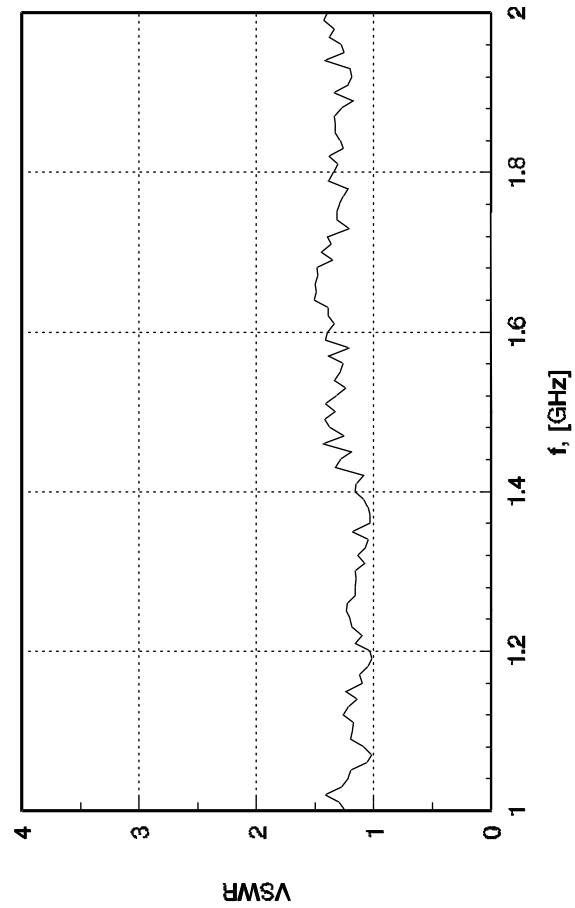
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5.0 Typical Data

Following is typical electromagnetic performance data for the Model 3161 Series Octave Bandwidth Pyramidal Horn Antenna, using Model 3161-01 data as representative of the series.

Typical VSWR

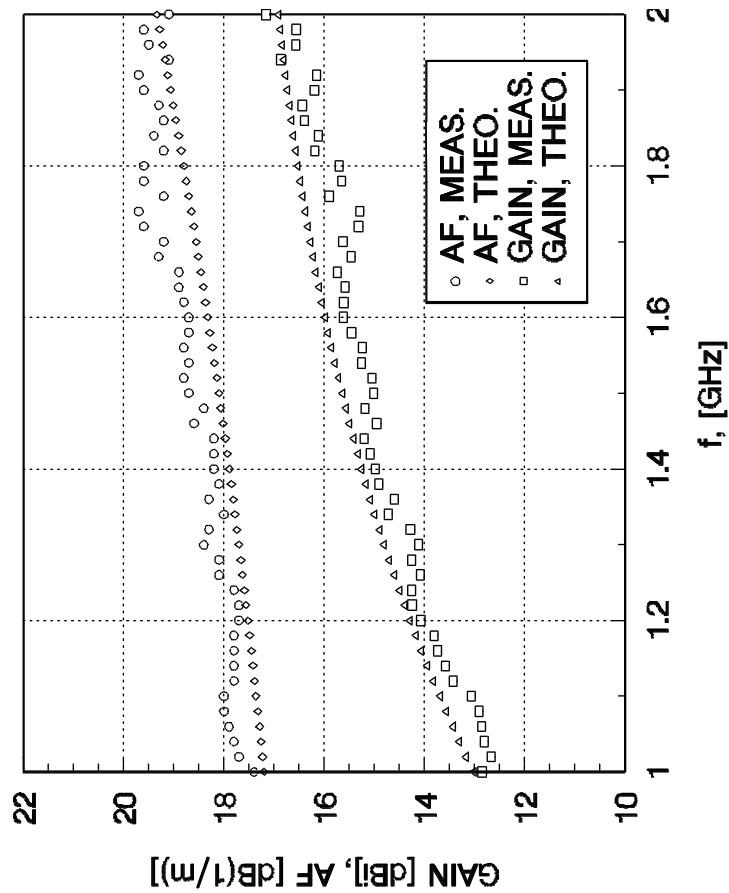
The following plot of VSWR shows the antenna/coax-to-waveguide adapter assembly.



Typical Measured and Theoretical Gain and Antenna Factor

Following is a plot of computed and measured gain and antenna factor versus frequency. The measured and computed results agree within 3 dB, which is typical of pyramidal horns. Differences are attributed to inevitable systematic measurement error. The left vertical scale is for the gain measured in dBi, and the right vertical scale is for the antenna factor in dB(m⁻¹). Gain is computed from antenna factor using:

$$G(\text{dB}) = 20 \log (f_{\text{GHz}}) - AF_{\text{dB(m}^{-1}\text{)}} + 30.22$$

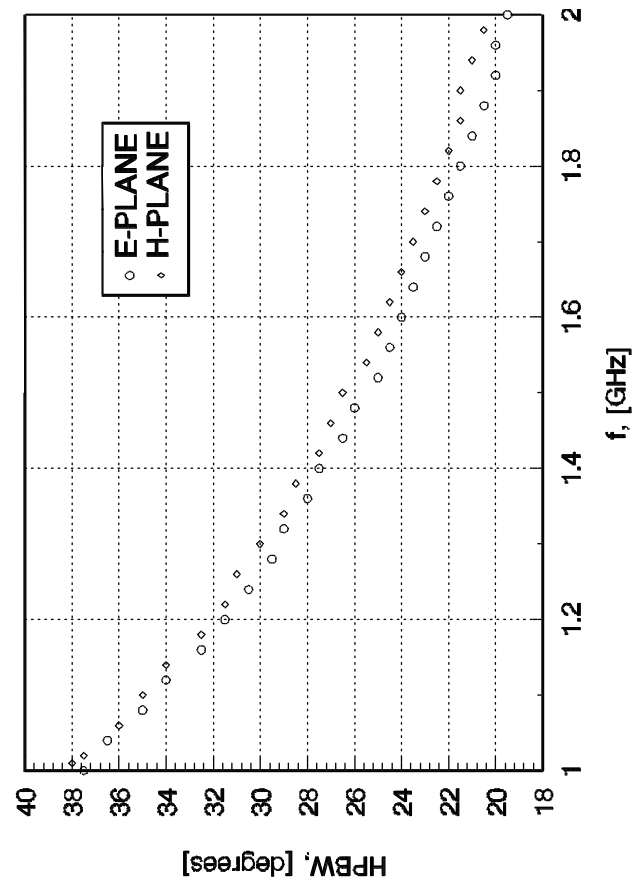


Typical Half-Power Beamwidth

Following is a plot of the half-power beamwidth (HPBW) versus frequency. The information provides the size of the Equipment Under Test (EUT) that can be illuminated without scanning. The size of the EUT can be obtained as:

$$\text{EUT} = 2 \left[\text{Distance} \cdot \tan \left(\frac{\text{HPBW}}{2} \right) \right]$$

Distance is the distance between the EUT and the aperture of the antenna



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6.0 Radiated Emissions Measurements

Measure Ambient Field Strength Values

1. Install the antenna where measured field strength values are desired.
2. Adjust the desired orientation of the antenna, both bore site direction and polarization.
3. Connect the output connector of the antenna to the input of the receiving system using a low VSWR, low loss 50 Ω coaxial cable.
4. Set desired measurement frequency. Make sure that the selected frequency is one that can be used with the antenna that is connected to the system.
5. Measure the RF voltage, V_a , referenced to the input port of the receiving system. The units of the measurement should be in decibels referenced to 1 microvolt, dB(μ V). If the units of measurements are millivolts, they should be converted to dB(μ V) by:

$$V_a = 20 \log_{10} (\text{RF voltage in microvolts})$$

$$V_a = 20 \log_{10} V_d$$

6. Determine the field strength at the frequency of observation by adding the voltage reading on the receiving system in dB(μ V) to the antenna factor in dB(m^{-1}):

$$\text{RF Voltage, dB}(\mu\text{V}) + \text{Antenna Factor, dB}(m^{-1}) = \\ \text{Field Strength, dB}(\mu\text{V}/m)$$

$$E_a = V_a + AF$$

The losses of the coaxial cable, A_c , should be included in the computations. In this case, the previous equation becomes:

$$\text{RF Voltage, dB}(\mu\text{V}) + \text{Cable Loss, dB} + \\ \text{Antenna Factor, DB}(m^{-1}) = \text{Field Strength, dB}(\mu\text{V}/m)$$

$$E_a = V_a + A_c + AF$$

Conversion Formulas

Following are some useful conversion formulas, including how the constants are obtained:

EQUATION 1

$$\text{dBm} = \text{dB}(\mu\text{V}) - 107$$

The power is related to the voltage and the system impedance as:

$$P = \frac{V^2}{R}$$

In a 50 Ω system, the previous equation becomes:

$$10 \log_{10} P = 20 \log_{10} V - 10 \log_{10}(50)$$

Converting from dB to dBm for power and from dB(V) to dB(μ V) for voltage, the overall constant becomes:

$$30 - 120 - 10 \log_{10}(50) = -107$$

EQUATION 2

$$\text{dB}(\text{mW}/\text{m}^2) = \text{dB}(\mu\text{V}/\text{m}) - 115.8$$

The constant in this equation is obtained by considering the Poynting vector which relates the power density in (W/m^2) to the electric field strength in (V/m) by:

$$P = \frac{|E|^2}{\eta}$$

Where η is the free space characteristic impedance equal to $120\pi \Omega$. Transforming the previous questions to decibels and using the appropriate conversion factors to convert $\text{dB}(\text{W}/\text{m}^2)$ to $\text{dB}(\text{mW}/\text{m}^2)$ for power density and $\text{dB}(\text{V}/\text{m})$ to $\text{dB}(\mu\text{V}/\text{m})$ for the electric field, the constant becomes:

$$30 - 120 - 10 \log_{10}(120\pi) = -115.8$$

EQUATION 3

$$\text{dB}(\mu\text{V}/\text{m}) = \text{dB}(\mu\text{V}) + \text{AF}$$

EQUATION 4

$$\text{V}/\text{m} = 10^{\frac{\text{dB}(\mu\text{V}/\text{m}) - 120}{20}}$$

EQUATION 5

$$\text{dB}(\mu\text{A}/\text{m}) = \text{dB}(\mu\text{V}/\text{m}) - 51.5$$

The magnetic field strength is related to the electric field strength via the characteristic impedance of free space. When the transformation is made to decibels, the constant becomes:

$$20 \log_{10}(120\pi) = 51.5$$

EQUATION 6

$$A/m = 10^{\frac{dB(\mu A/m) - 120}{20}}$$

EQUATION 7

$$dB(W/m^2) = 10 \log (V/m \cdot A/m)$$

EQUATION 8

$$dB(mW/m^2) = dB(W/m^2) + 30.0$$

EQUATION 9

$$dB(pT) = dB(\mu A/m) + 2.0$$

The magnetic flux density **B** in (T) is related to the magnetic field strength **H** in (A/m) by the permeability of the medium in (H/m). For free space, the permeability is $\mu_0 = 4\pi \cdot 10^{-7}$ H/m. Converting from (T) to (pT) and from (A/m) to ($\mu A/m$) and taking the log, the constant becomes:

$$240 - 120 + 20 \log_{10} (4\pi \times 10^{-7}) = 2.0$$

Appendix A: Warranty



See the *Product Information Bulletin* included with your shipment for the complete ETS-Lindgren warranty for your Model 3161 Series.

DURATION OF WARRANTIES FOR MODEL 3161 SERIES

All product warranties, except the warranty of title, and all remedies for warranty failures are limited to two years.

Product Warranted	Duration of Warranty Period
Model 3161 Series Octave Bandwidth Pyramidal Horn Antenna	2 Years