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Model 3164 Series

Open-Boundary Quad-Ridged Horns

User Manual



 **ETS-LINDGREN**[™]
An ESCO Technologies Company

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| Revision | Description | Date |
|----------|---|----------------|
| A | Initial Release | March, 2007 |
| B | Added 3164-08; updated 3164-05 mounting bracket; converted to half-size | February, 2008 |

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| Internet Address http://www.ets-lindgren.com | |
|---|---|
| USA 1301 Arrow Point Drive Cedar Park, TX 78613 USA Tel: +1.512.531.6400 Fax: +1.512.531.6500 Email: support@ets-lindgren.com | Finland Mekaanikontie 1, 27510 Eura, Finland Tel: +358.2.838.330 Fax: +358.2.865.1233 Email: info@ets-lindgren.eu.com |
| Japan 4-2-6, Kohinata Bunkyo-ku, Tokyo 112-0006 Japan Tel: +81.3.3813.7100 Fax: +81.3.3813.8068 Email: info@ets-lindgren.co.jp | China B506 Technology Fortune Center No. 8 Xue Qing Road Haidian District Beijing 100085 China Tel: +86.010.827.30877 Fax: +86.010.827.55307 Email: info@ets-lindgren.net |

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Safety and Regulatory Information

Safety Symbol Definitions


This product and related documentation must be reviewed for familiarization with safety markings and instructions prior to operation.

| Safety Symbol | Definition |
|--|--|
|  | <p>Refer to Manual: When product is marked with this symbol, refer to the instruction manual for additional information.</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> |

General Safety Considerations


| Safety Symbol | Definition |
|---|---|
|  | <p>CONTACT ETS-LINDGREN PRIOR TO SERVICING. Servicing (or modifying) the unit by yourself may void your warranty. If you attempt to service the unit by yourself, disconnect all electrical power before starting. There are voltages at many points in the instrument that could, if contacted, cause personal injury. Only trained service personnel should perform adjustments and/or service procedures upon this instrument. Capacitors inside this instrument may still be CHARGED even when instrument is disconnected from its power source.</p> |

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| Safety Symbol | Definition |
|---|---|
|  | ONLY QUALIFIED PERSONNEL should operate or service this equipment. |

Waste Electrical and Electronic Equipment (WEEE)

Directive

| | |
|---|--|
|  | (European Union) At end of useful life, this product should be deposited at an appropriate waste disposal facility for recycling and disposal. Do not dispose of with household waste. |
|---|--|

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1.0 Introduction

The ETS-Lindgren Model 3164 Open-Boundary Quad-Ridge Horns include the 3164-05, 3164-06, 3164-07, and 3164-08 antennas. The Model 3164 Series was designed for antenna pattern measurement ranging from the ultra high frequency (UHF) to the Ku band. Each antenna is a dual linear polarized open boundary horn that allows the user to measure the principal polarizations of the field radiated by the antenna under test.



The Model 3164 Series antennas are precision machined from aluminum and PVC. Two orthogonally-placed input connectors permit simultaneous measurements for horizontal and vertical polarizations for linearly polarized electromagnetic waves. By using an additional 90-degree hybrid phase shifter, the antennas may be used to transmit or receive circularly polarized electromagnetic waves.

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Testing of the Model 3164 Series shows that the isolation level between the two orthogonal test ports is better than 24 dB in the specified operating frequency range. The port isolation is the limiting factor in the cross-polarization levels of the antenna.

The Model 3164 Series antennas are designed to operate from 300 MHz to 18 GHz in a free-space environment. When the antenna is installed in a rectangular shielded anechoic chamber, the equipment under test must be at a test distance meeting the far field requirements to operate either antenna within the full frequency range.

In a quasi-free space test environment such as a tapered anechoic chamber, the Model 3164 Series antennas are ideal plane-wave transmit and receive antennas. They are ideal for use in a taper chamber over the entire range, provided it is repositioned inside the taper to obtain the optimum illumination.

Model 3164-05

The **3164-05** is the smallest of the Model 3164 Series, with an operating range of 2 GHz to 18 GHz.

The 3164-05 is designed for the antenna measurement in the MW range, and covers the S, C, X, and Ku bands. It was designed as a receive antenna, but can be used as a low power radiator with a maximum continuous power handling capability of 10 W.



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Model 3164-06

The **3164-06** is the largest of the Model 3164 Series, with an operating range of 300 MHz to 6 GHz.

The 3164-06 is designed as a receive antenna, but can also be used to transmit with a power handling capability of 20 W. The 3164-06 is ideal for taper chambers.



Model 3164-07

The **3164-07** is smaller of the medium-sized antennas of the Model 3164 Series, with an operating range of 700 MHz to 6 GHz.

The range of the 3164-07 overlaps with the upper range of the 3164-06, enabling the user to operate within most wireless frequency bands with the smaller antenna. The 3164-07 is ideal for rectangular chambers.



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Model 3164-08

The **3164-08** is the larger of the medium-sized antennas of the Model 3164 Series, with an operating range of 700 MHz to 10 GHz.

With the highest gain in the 5.8 GHz range, the 3164-08 is ideal for WiMAX™ testing. Additional applications include UWB wireless testing (3 GHz to 10 GHz) and lower frequency testing (700 MHz to 3 GHz) for applications such as GSM, PCS, and WiFi.



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2.0 Receiving Your Order

Unpacking and Acceptance

1. Upon delivery of your order, inspect the shipping container(s) for evidence of damage. Record any damage on the delivery receipt before signing it. In case of concealed damage or loss, retain the packing materials for inspection by the carrier.
2. Remove the product from its shipping container(s). Save the container(s) and any protective packing materials for future use.
3. Check all materials against the packing list to verify that the equipment you received matches what was ordered. If you find any discrepancies, note them and call ETS-Lindgren Customer Service for further instructions.

Make sure you are satisfied with the contents and condition of your order prior to placing the product into service.

Service Procedures

To return a system or system component for service:

1. Contact ETS-Lindgren Customer Service to obtain a Service Request Order (SRO).
2. Briefly describe the problem in writing. Give details regarding the observed symptom(s) or error codes, and whether the problem is constant or intermittent in nature. Please include the date(s), the service representative you spoke with, and the nature of the conversation. Include the serial number of the item being returned.

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3. Package the system or component carefully. If possible, use the original packing materials to return a system or system component to ETS-Lindgren at the following address:

ETS-Lindgren
Attn: Service Department
1301 Arrow Point Drive
Cedar Park, TX, USA 78613
Phone: +1.512.531.6400
Customer Service: +1.512.531.6498
www.ets-lindgren.com

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3.0 Maintenance

Annual Calibration

To ensure reliable and repeatable long-term performance, annual recalibration of your antenna by an ETS-Lindgren experienced technician is recommended. Our staff can recalibrate almost any type or brand of antenna. Please call to receive a Service Request Order (SRO) prior to sending an antenna for calibration.

For more information about our calibration services, visit our website at www.ets-lindgren.com/calibration.

Replacement and Optional Parts

Use the following table to order replacement or optional parts for the Model 3164 Series.

| | Part Description | Part Number |
|----------------|---------------------------------------|-------------|
| 3164-05 | Tripod | 7-TR |
| | Bracket mount | 108071 |
| | Knob for bracket mount, 1/4–20 thread | H-34JCL-34 |
| | Center rotation boom assembly | 108197 |
| | Stinger for center rotation mount | 108070 |
| | 1/4–20 set screw for Stinger | 910467 |
| | SMA connector (2) | 512082 |
| 3164-06 | Bracket mount | 106974 |
| | Knob for boom mount | 104136 |
| | SMA connector (2) | 512082 |

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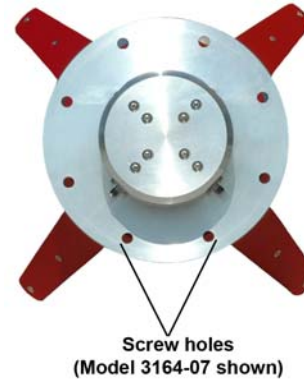
| | Part Description | Part Number |
|----------------|----------------------------------|-------------|
| 3164-07 | Tripod | 7-TR |
| | Bracket mount | 106974 |
| | Threaded insert for tripod mount | 105861B |
| | Knob for boom mount | 104136 |
| | SMA connector (2) | 512082 |
| 3164-08 | Tripod | 7-TR |
| | Bracket mount | 112859 |
| | Threaded insert for tripod mount | 105861B |
| | Knob for boom mount | 104136 |
| | SMA connector (2) | 512082 |

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4.0 Mounting the Model 3164 Series

The Model 3164 Series Open-Boundary Quad-Ridge Horns are designed to mount directly on the shield line of a shielded anechoic chamber. Mounting features include:

- **Chamber wall mounting holes—** Equidistant holes around the circumference of the adapter plate accept 1/4–20 thread screws and nuts for mounting to a chamber wall. The Model 3164-06 provides twelve holes, and the Model 3164-07 provides eight.



- **Easy access to SMA connectors—**The circular mounting plate provides the primary interface to the shielded enclosure mount panel. By fastening the mounting plate to the shielded enclosure, the two SMA connectors are on the outside of the enclosure, providing easy access. This also puts the cables outside of the enclosure, which reduces the effect of the cables on the measurement.
- **Security of shielding integrity—**The back end of the antenna is machined of a single aluminum block, so the shielding effectiveness of the enclosure is not compromised by installation. This unique feature eliminates the need for a transmit antenna positioning device or a walk path inside the shielded anechoic chamber, both of which could present unwanted reflections of shielded anechoic chambers when installed improperly.
- **Maximize test range distance—**The integrated mount fixture allows maximizing of the test range distance for a shielded anechoic chamber of defined dimensions.

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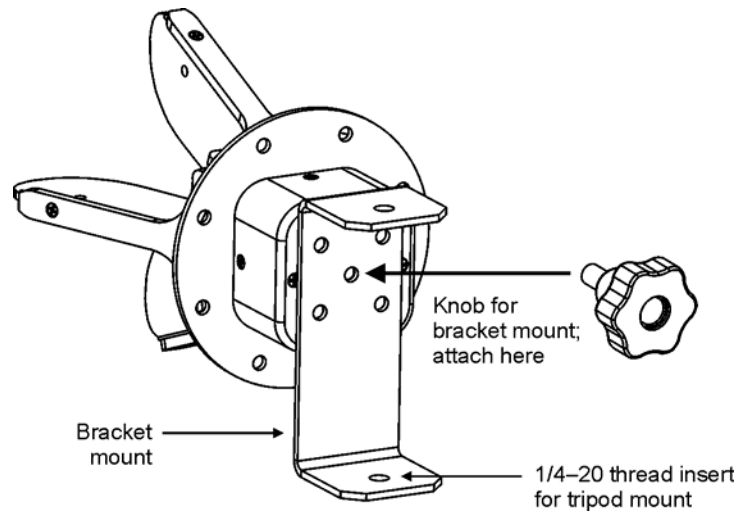
CAUTION

The Model 3164 Series antennas are precision measurement devices. Handle your antenna with care.

Mounting Illustrations for Model 3164-05

MODEL 3164-05 BRACKET MOUNT

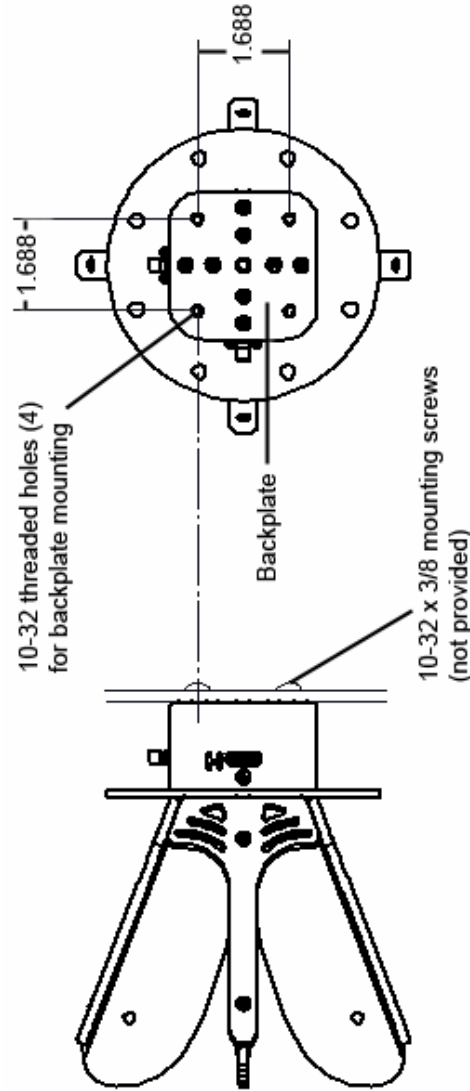
A mounting bracket attaches the Model 3164-05 onto a tripod or mast. The bracket attaches to the antenna backplate with a 1/4–20 thread knob, and includes an insert that fastens to a 1/4–20 thread screw on the tripod or mast.



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MODEL 3164-05 BACKPLATE MOUNT

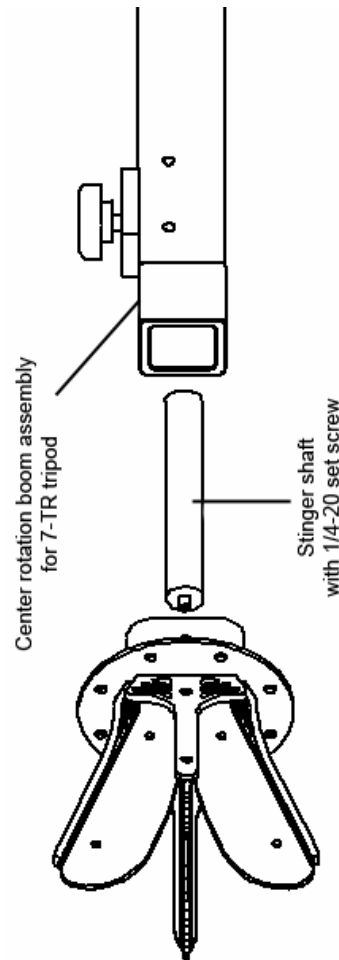
As found with traditional antennas that cover the same frequency range, the backplate of the Model 3164-05 provides four 10-32 threaded holes for mounting.



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MODEL 3164-05 CENTER ROTATION MOUNT

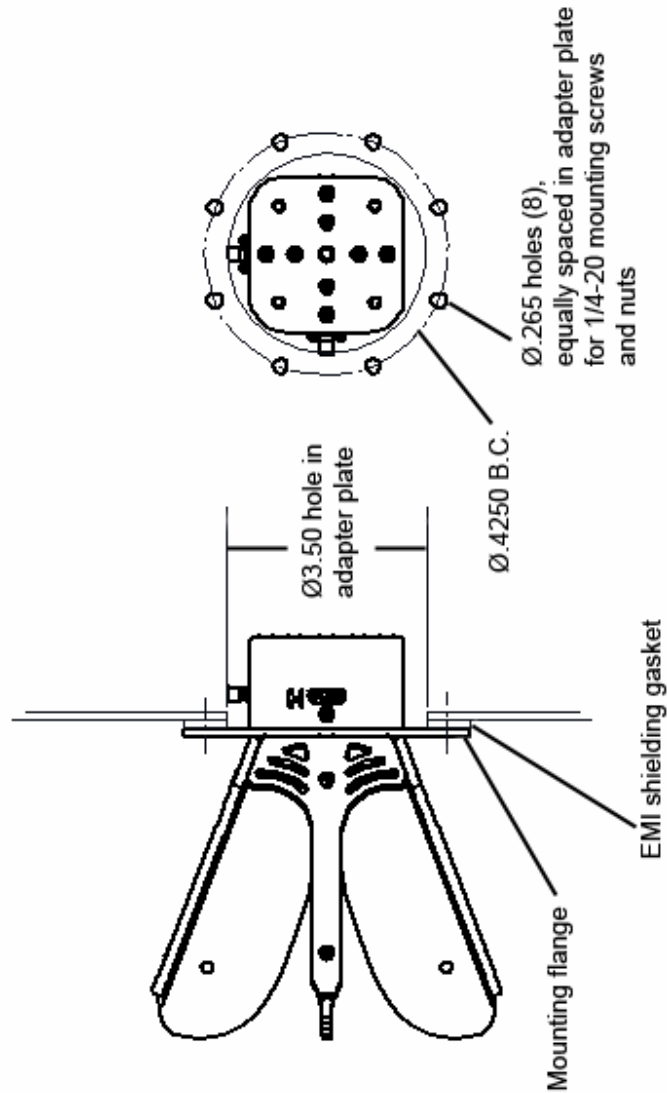
A stinger shaft can be attached to the Model 3164-05 for mounting to stinger compatible tripods, such as the 7-TR. The stinger screws into the antenna backplate with a 1/4-20 set screw.



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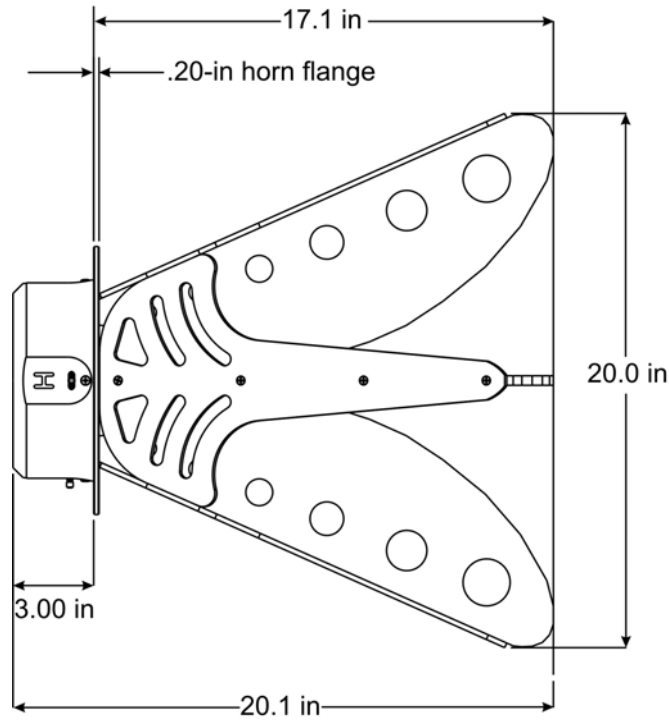
MODEL 3164-05 CHAMBER WALL MOUNT

The Model 3164-05 provides eight equidistant holes around the circumference of the adapter plate of the antenna. These holes accept 1/4-20 thread screws and nuts for mounting to a chamber wall.

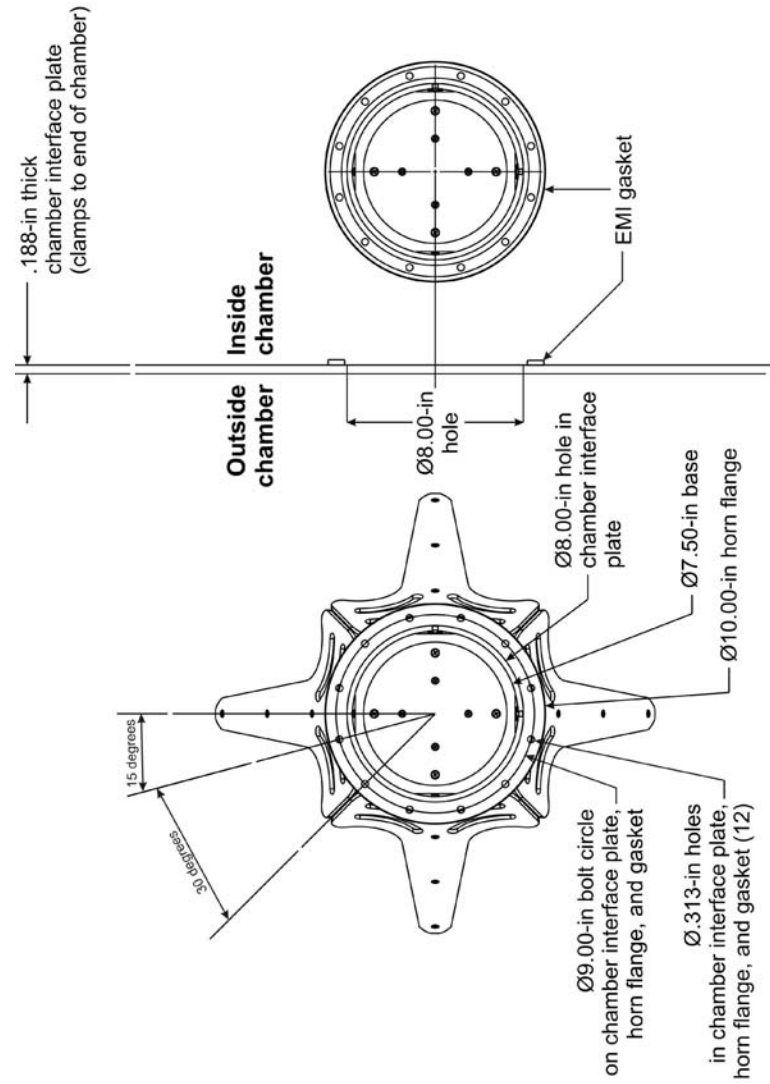


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Chamber Wall Mount Illustrations for Model 3164-06

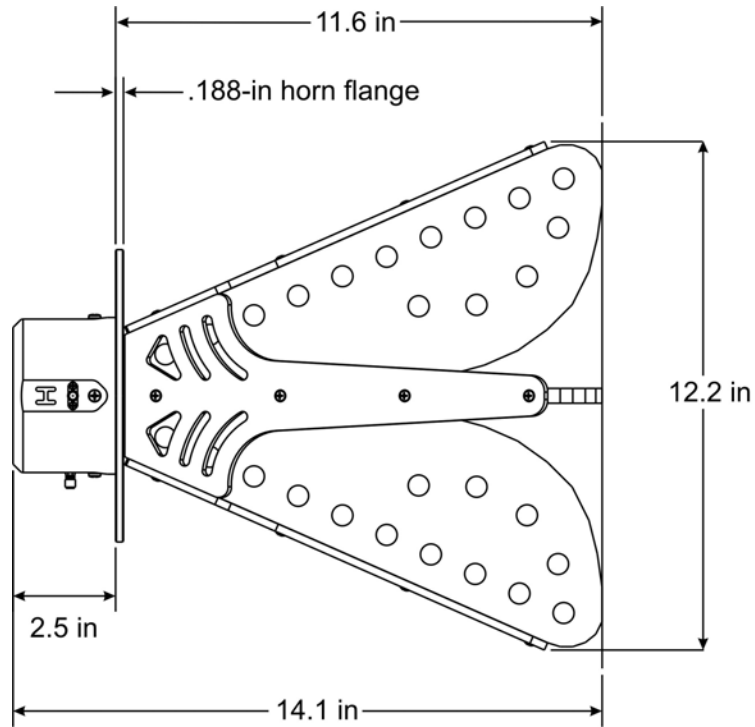


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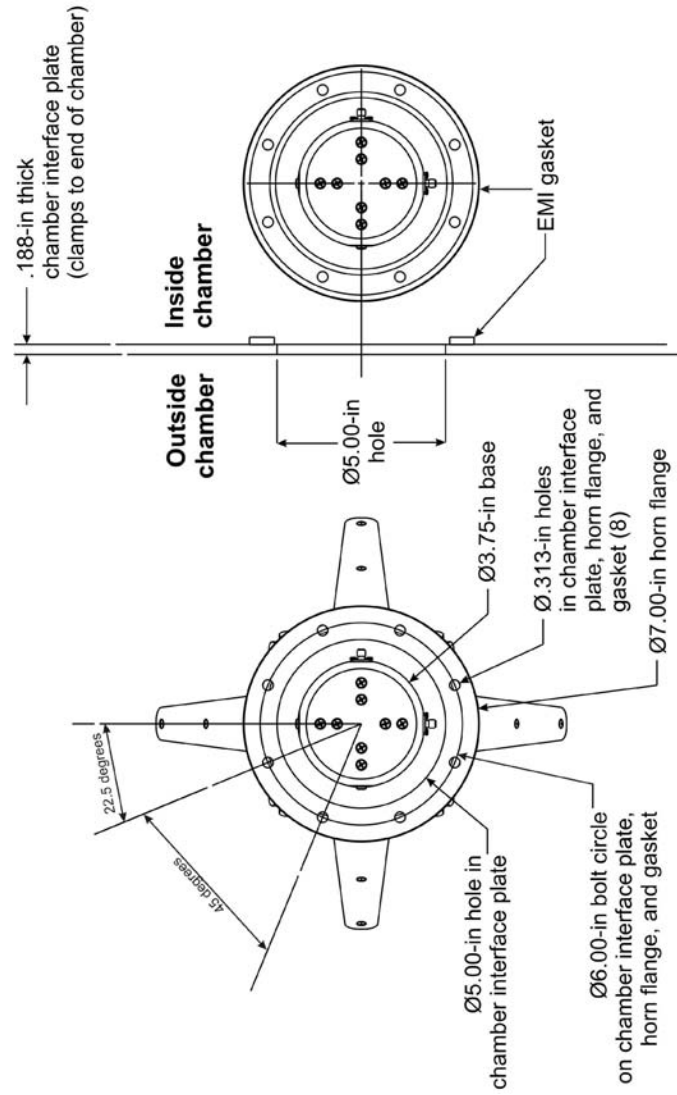


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Chamber Wall Mount Illustrations for Model 3164-07

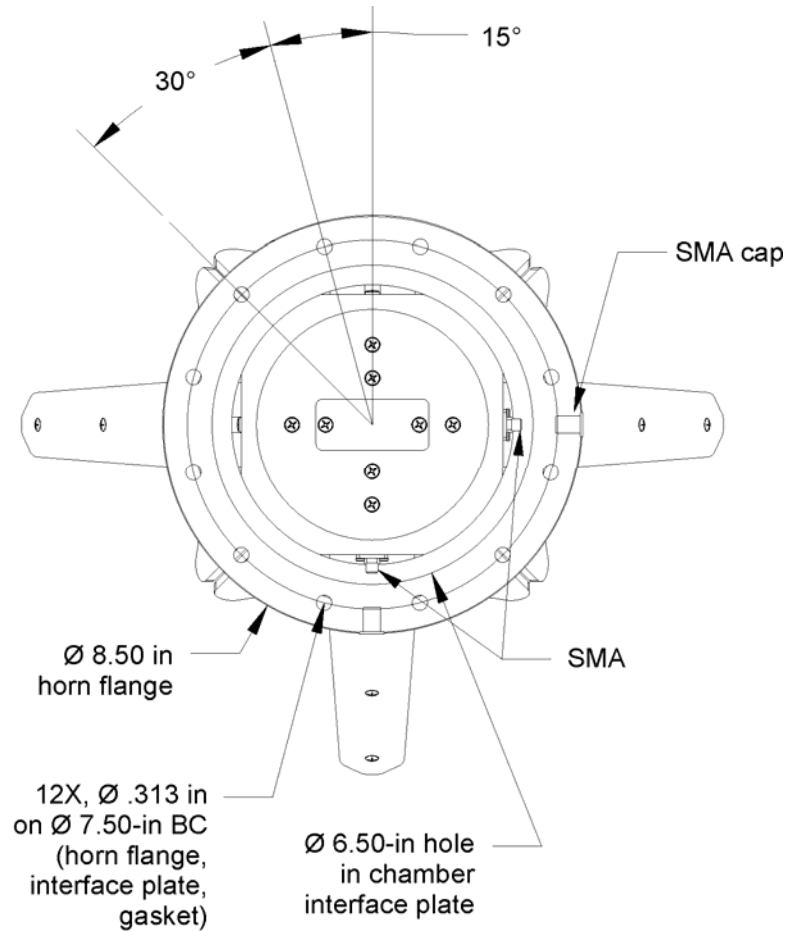


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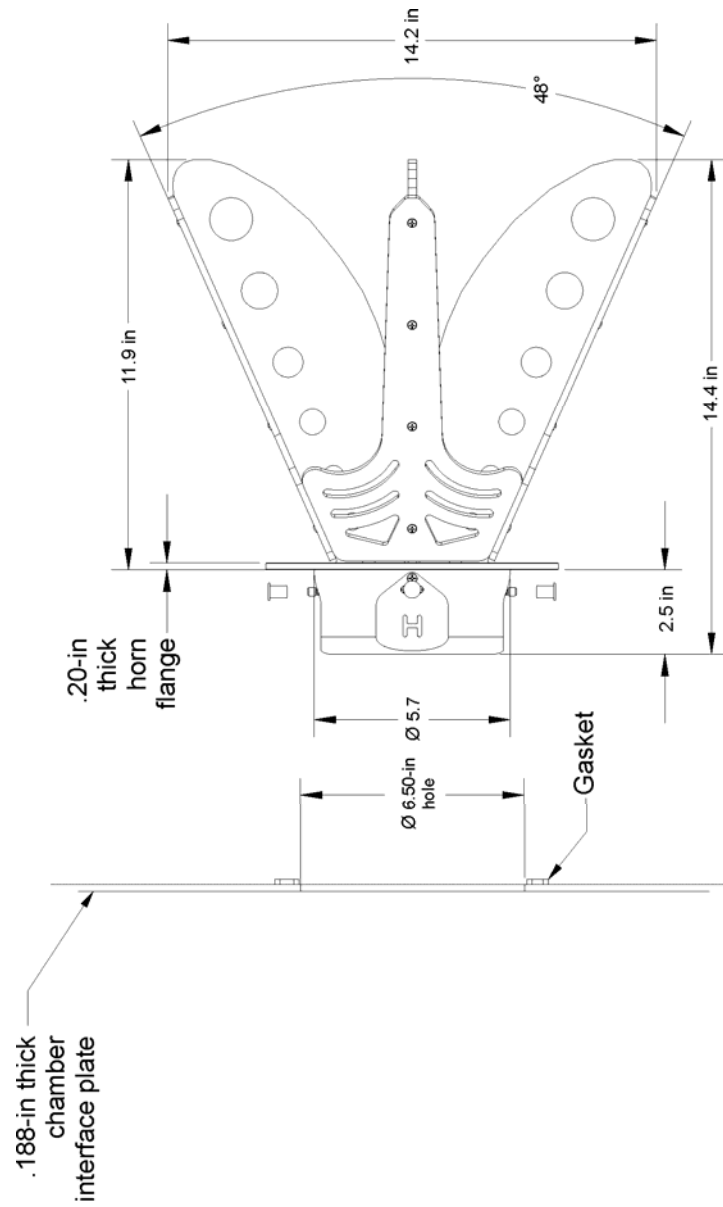


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Chamber Wall Mount Illustrations for Model 3164-08



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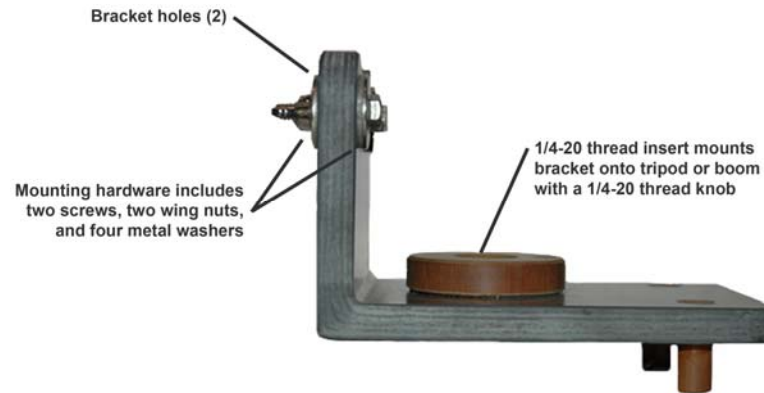
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Bracket Mount Instructions for Model 3164-06, Model 3164-07, and Model 3164-08

CAUTION

Due to the size and weight of the Model 3164-06, do not mount it onto a tripod. When using the bracket, only mount the Model 3164-06 onto a boom.

An L-shaped mounting bracket is included with the antenna. The bracket mounts the Model 3164-06 onto a boom, and the Model 3164-07 and 3164-08 onto a tripod or boom. Bracket hardware includes two screws, two wing nuts, and four metal washers.

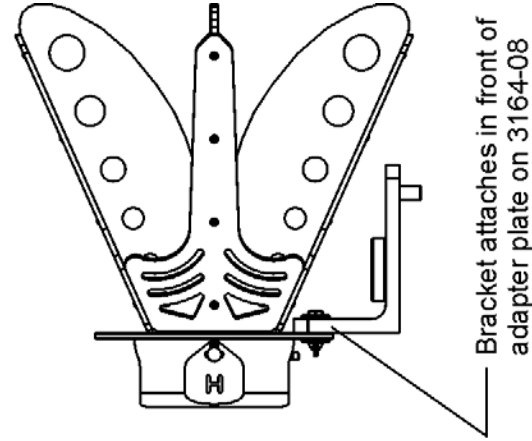


Included with the bracket are two mounting adapters:

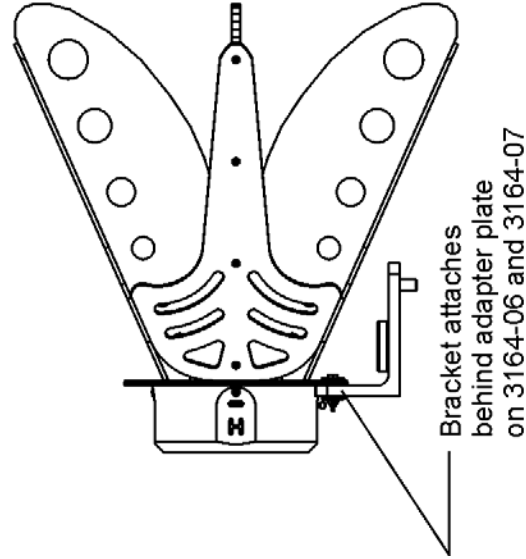
- 1/4–20 thread insert that fastens to a 1/4–20 screw on the tripod or boom
- 1/4–20 thread knob that attaches the bracket to the tripod or boom

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3164-08 shown with mounting bracket attached



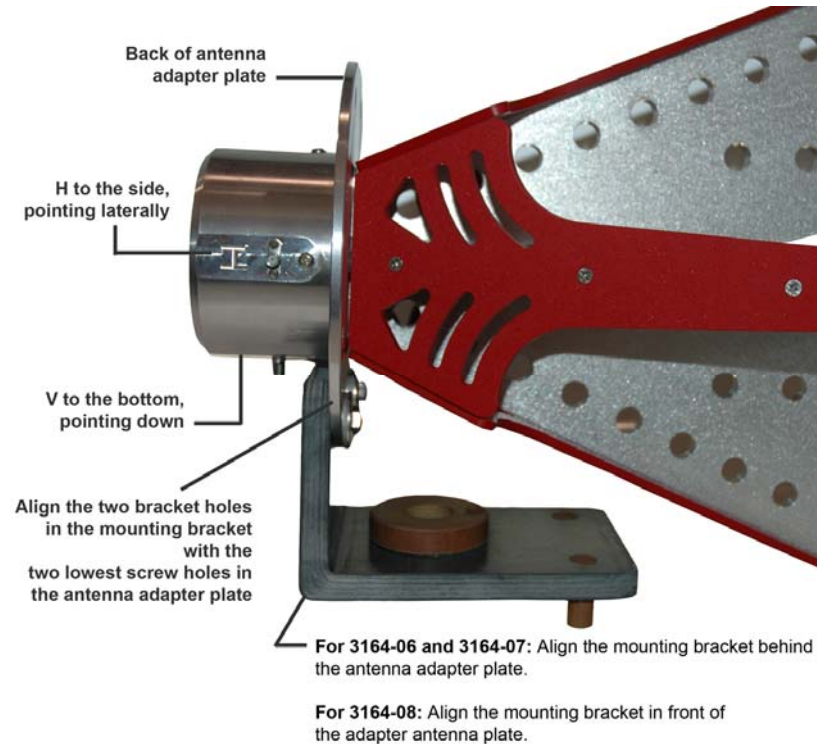
3164-06 shown with mounting bracket attached



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To attach the mounting bracket:

1. Place the antenna in a stable position and location to prevent it from falling or rolling while attaching the bracket.
2. Orient the antenna so the **H** (horizontal) mark is at the side pointing laterally, and the **V** (vertical) mark is at the bottom, pointing down.



3. With the antenna oriented, align the two bracket holes in the mounting bracket with the two lowest screw holes in the antenna adapter plate.
 - **For Model 3164-06 and 3164-07**, align the mounting bracket on the back of the adapter plate.
 - **For Model 3164-08**, align the mounting bracket on the front of the adapter plate.

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4. Thread a washer onto a screw. From the front of the antenna adapter plate, insert the screw and washer through one of the bracket holes.
5. On the back of the mounting bracket, thread a washer onto the screw, and then tighten a wing nut onto the screw.
6. Repeat for the remaining bracket hole.

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5.0 Application

The Model 3164 Series can be used as transmit or receive antennas for measuring all wireless telecommunications devices, such as cell phones and Internet devices. Additionally, the antennas cover most of the common radar and MW bands used in military applications.

When an antenna is configured for receive mode, it can be used to measure far field antenna patterns for the two orthogonal polarizations simultaneously. When an antenna is configured for transmit mode, it can be used to transmit signals from a base station simulator. Many intrinsic RF properties of wireless handsets can be measured at these two configurations. The user may also configure the same system to measure the RF interaction between a wireless handset and the operator.

The Model 3164 Series can also be configured to transmit or receive circularly polarized signals for testing antennas or receiving devices for Global Positioning Systems.

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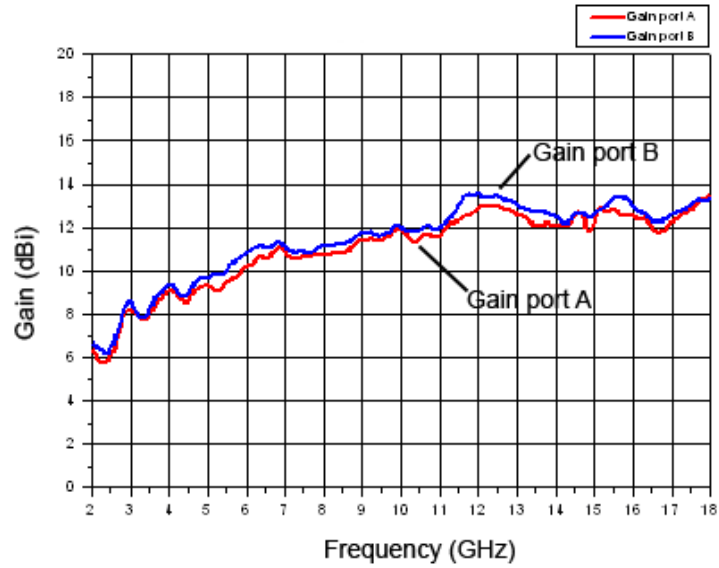
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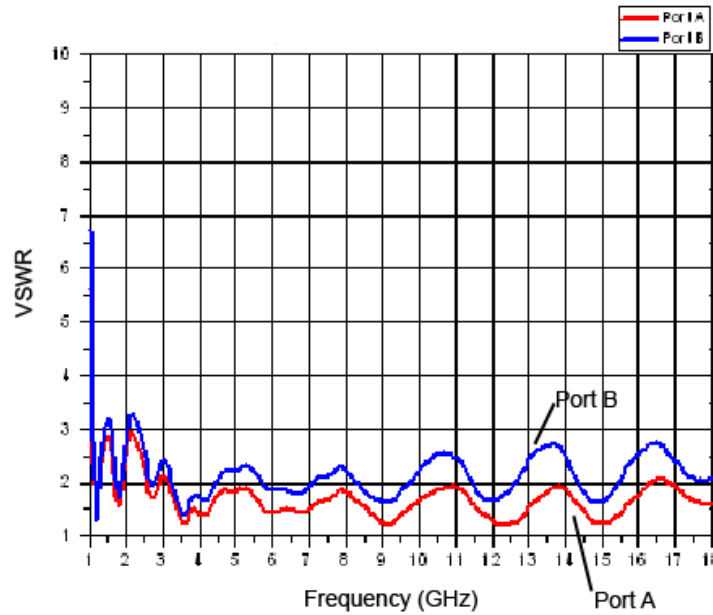
6.0 Model 3164-05 Typical Data

Model 3164-05 Gain Measured Per SAE 958 Method

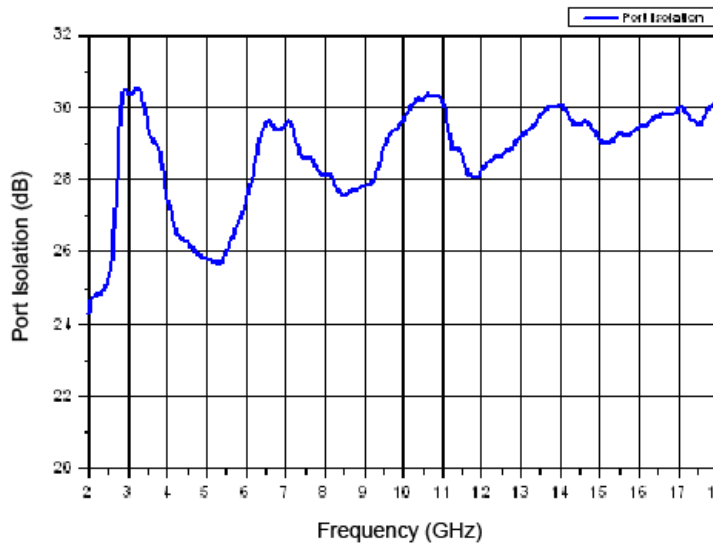


Use only the content for 3164-07 in this manual. Disregard content for all other 3164 models; see ETS-Lindgren website for other 3164 content.

Model 3164-05 VSWR – Both Ports

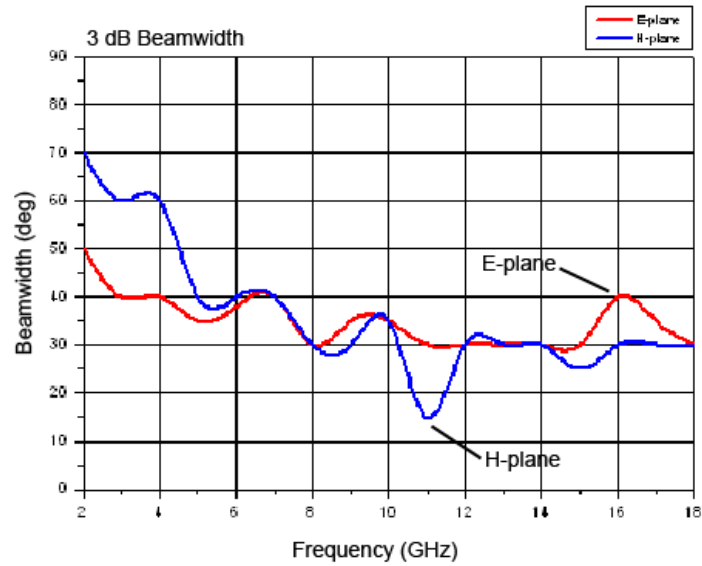


Model 3164-05 Cross-Port Isolation

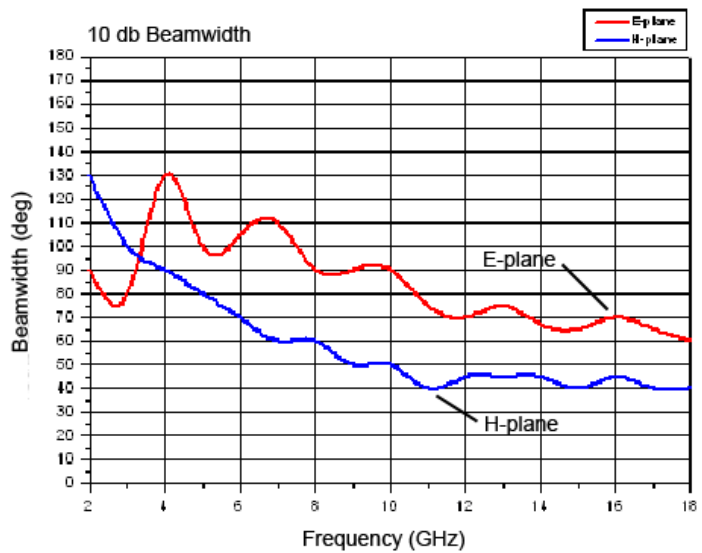


Use only the content for 3164-07 in this manual. Disregard content for all other 3164 models; see ETS-Lindgren website for other 3164 content.

Model 3164-05 Half-Power Beamwidth



Model 3164-05 10 dB Beamwidth



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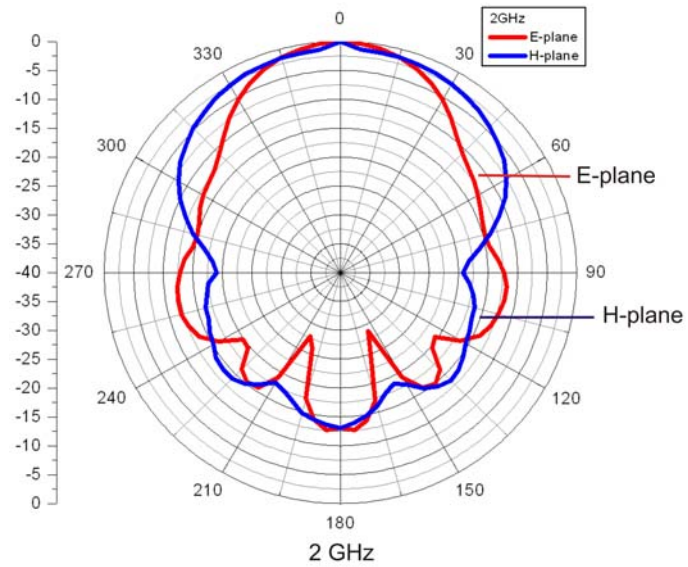
Use only the content for 3164-07 in this manual. Disregard content for all other 3164 models; see ETS-Lindgren website for other 3164 content.

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Use only the content for 3164-07 in this manual. Disregard content for all other 3164 models; see ETS-Lindgren website for other 3164 content.

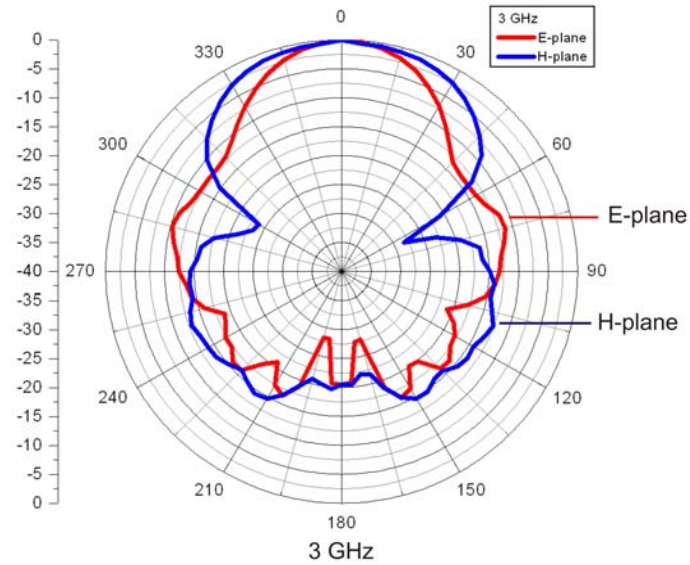
7.0 Model 3164-05 Typical Radiation Patterns

Model 3164-05 at 2 GHz

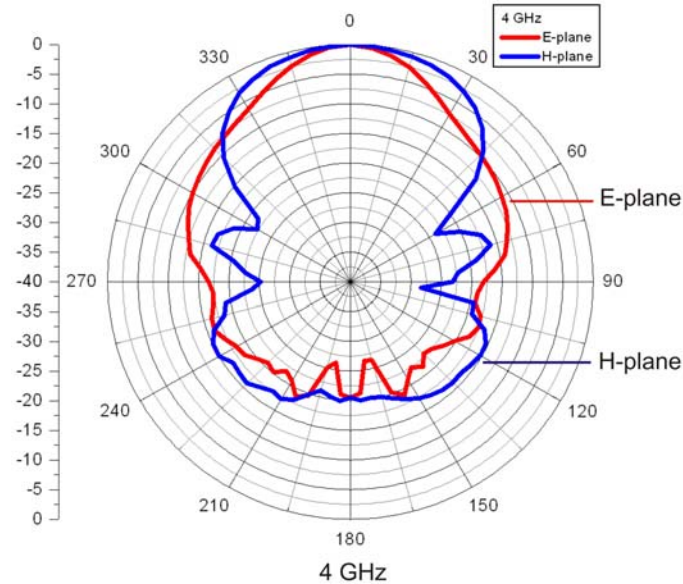


Use only the content for 3164-07 in this manual. Disregard content for all other 3164 models; see ETS-Lindgren website for other 3164 content.

Model 3164-05 at 3 GHz

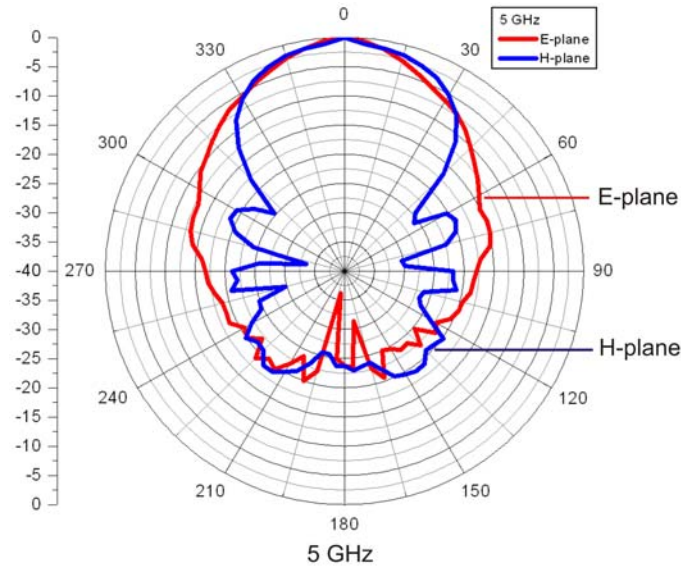


Model 3164-05 at 4 GHz

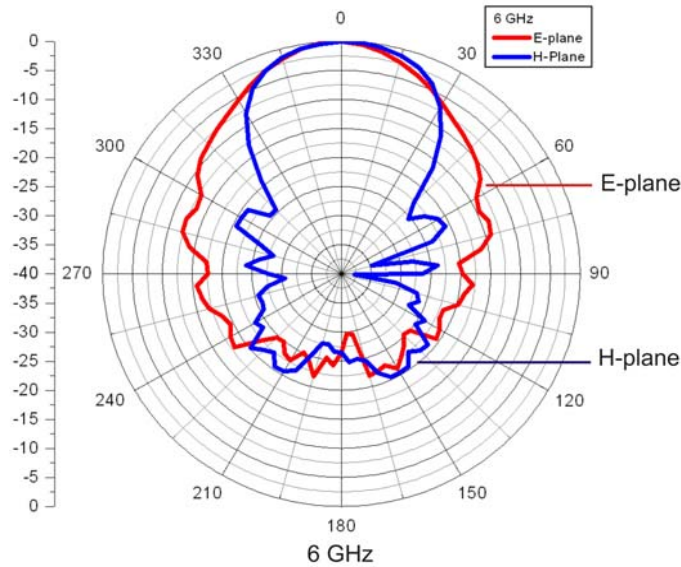


Use only the content for 3164-07 in this manual. Disregard content for all other 3164 models; see ETS-Lindgren website for other 3164 content.

Model 3164-05 at 5 GHz

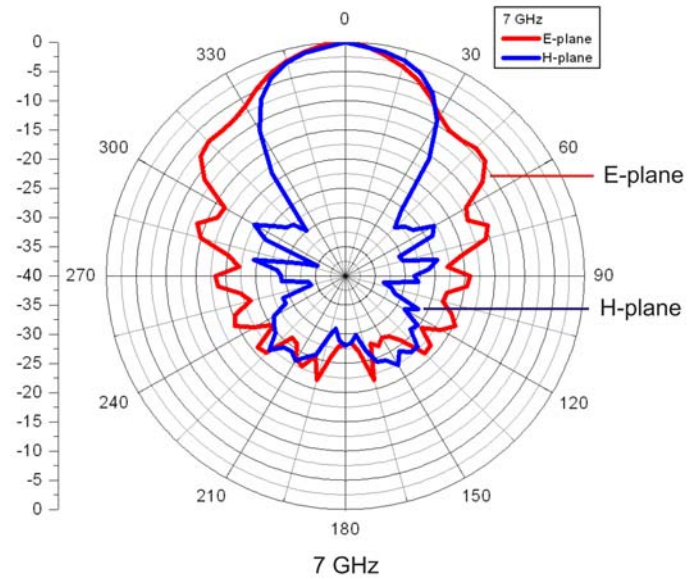


Model 3164-05 at 6 GHz

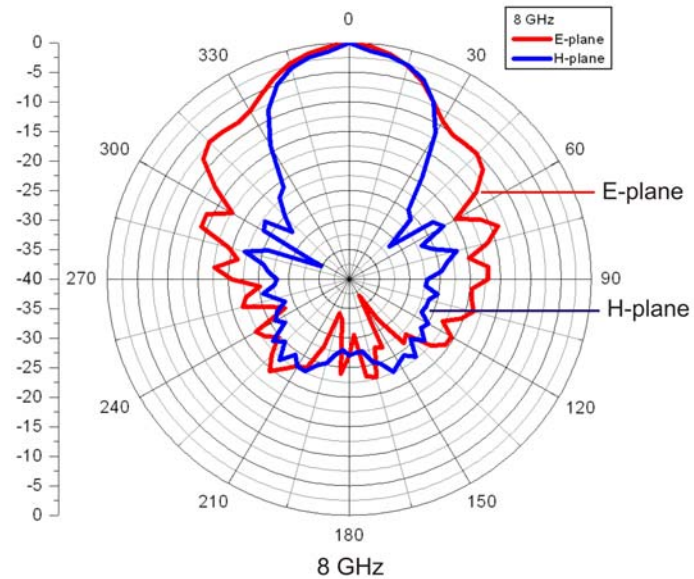


Use only the content for 3164-07 in this manual. Disregard content for all other 3164 models; see ETS-Lindgren website for other 3164 content.

Model 3164-05 at 7 GHz

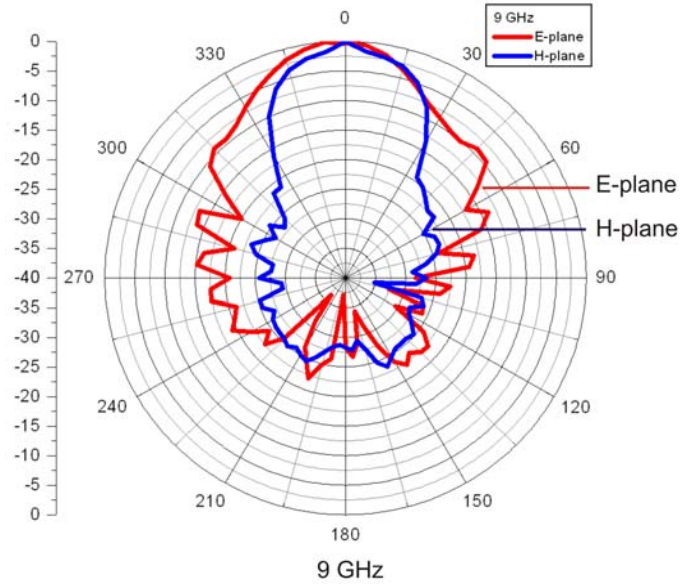


Model 3164-05 at 8 GHz

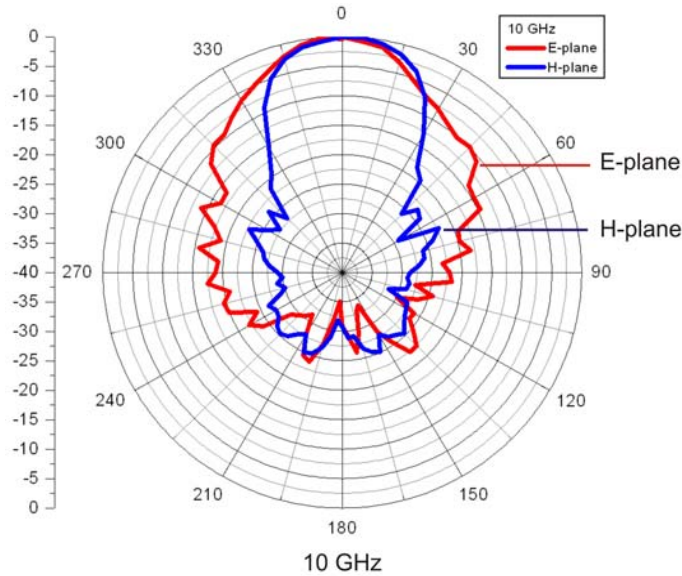


Use only the content for 3164-07 in this manual. Disregard content for all other 3164 models; see ETS-Lindgren website for other 3164 content.

Model 3164-05 at 9 GHz

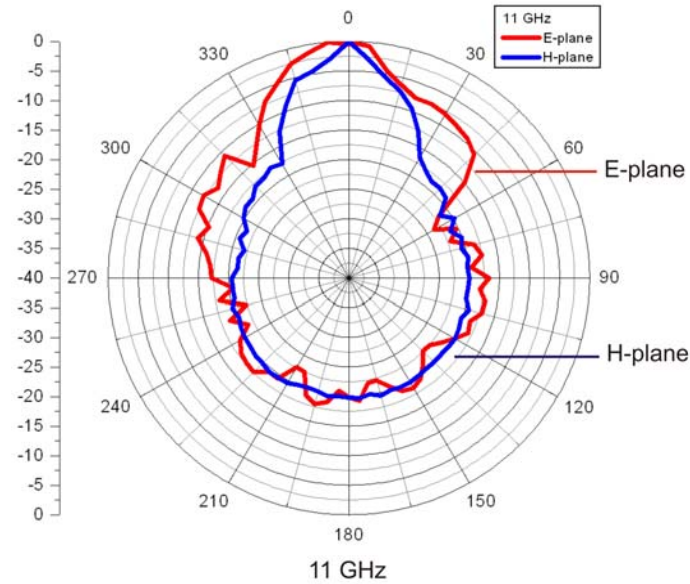


Model 3164-05 at 10 GHz

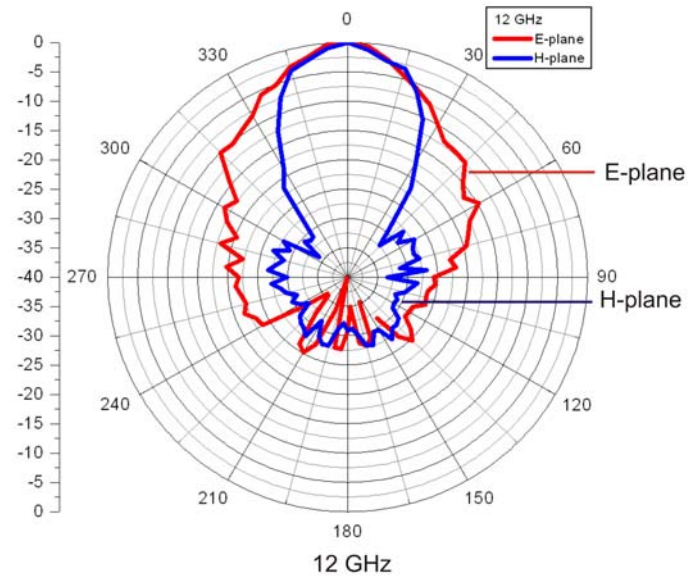


Use only the content for 3164-07 in this manual. Disregard content for all other 3164 models; see ETS-Lindgren website for other 3164 content.

Model 3164-05 at 11 GHz

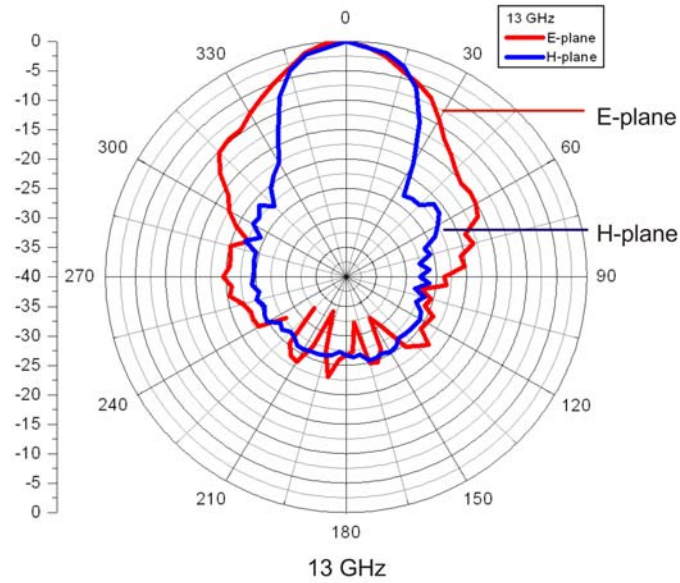


Model 3164-05 at 12 GHz

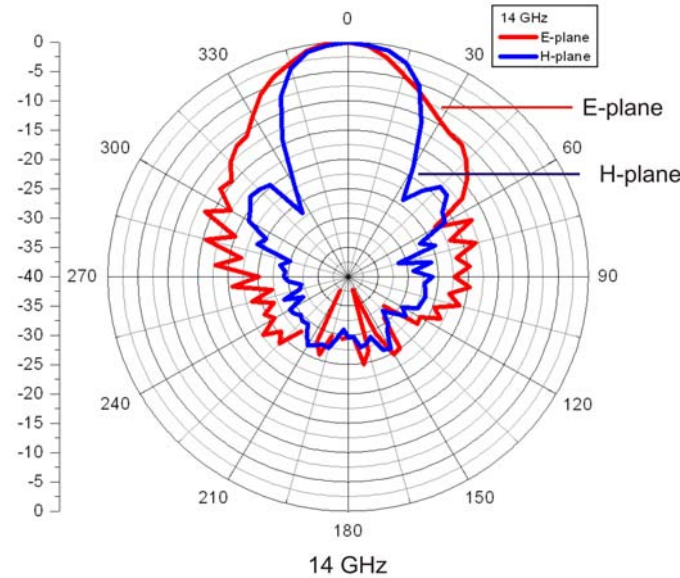


Use only the content for 3164-07 in this manual. Disregard content for all other 3164 models; see ETS-Lindgren website for other 3164 content.

Model 3164-05 at 13 GHz

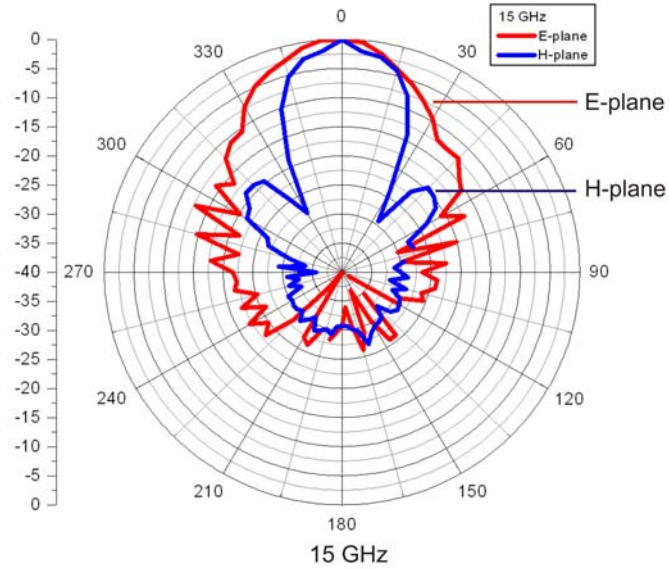


Model 3164-05 at 14 GHz

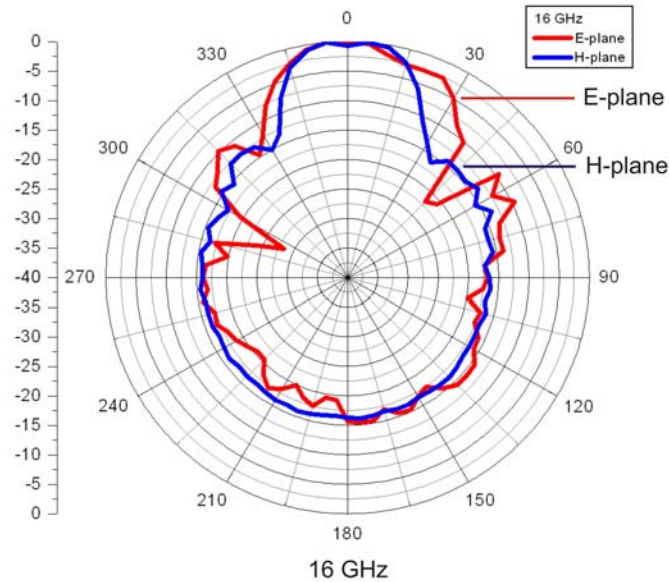


Use only the content for 3164-07 in this manual. Disregard content for all other 3164 models; see ETS-Lindgren website for other 3164 content.

Model 3164-05 at 15 GHz

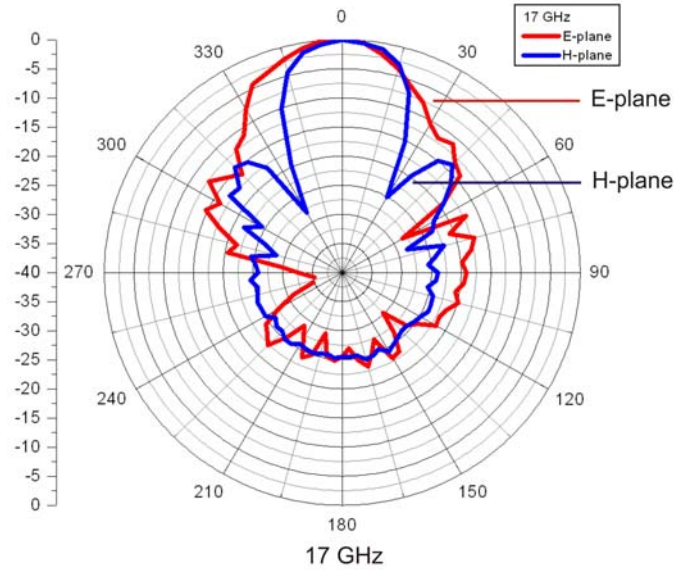


Model 3164-05 at 16 GHz

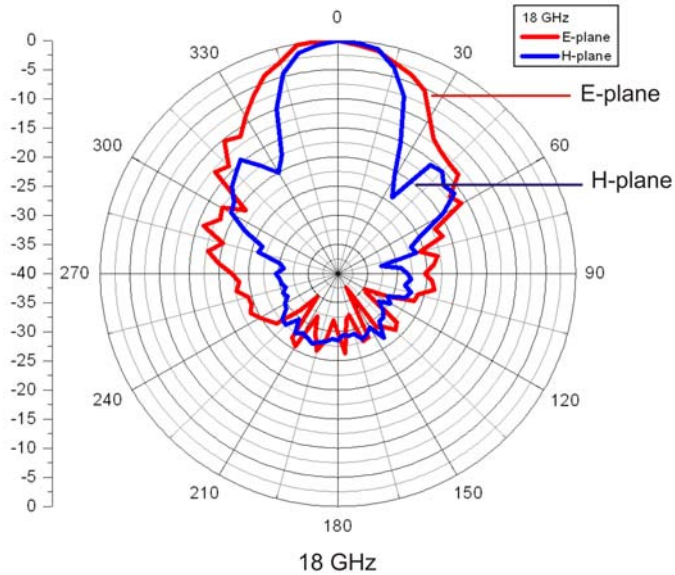


Use only the content for 3164-07 in this manual. Disregard content for all other 3164 models; see ETS-Lindgren website for other 3164 content.

Model 3164-05 at 17 GHz



Model 3164-05 at 18 GHz



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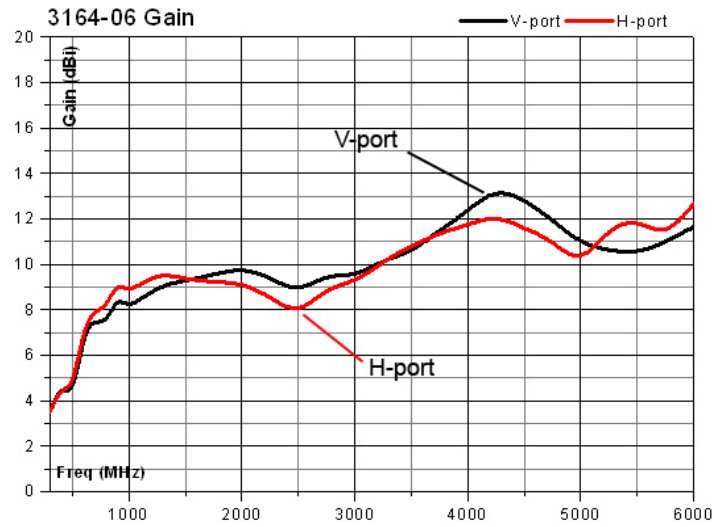
Use only the content for 3164-07 in this manual. Disregard content for all other 3164 models; see ETS-Lindgren website for other 3164 content.

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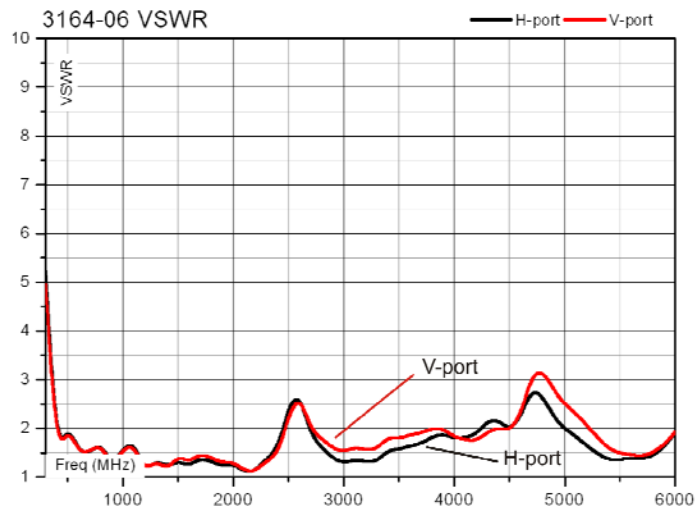
Use only the content for 3164-07 in this manual. Disregard content for all other 3164 models; see ETS-Lindgren website for other 3164 content.

8.0 Model 3164-06 Typical Data

Model 3164-06 Gain

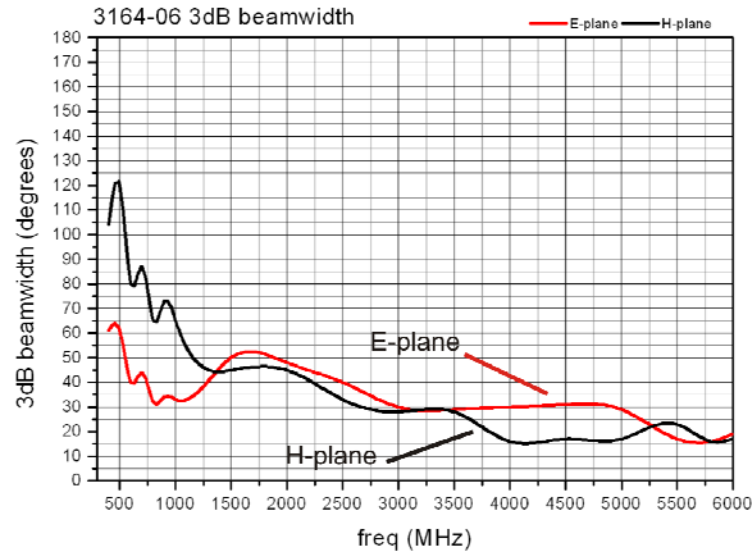


Model 3164-06 VSWR

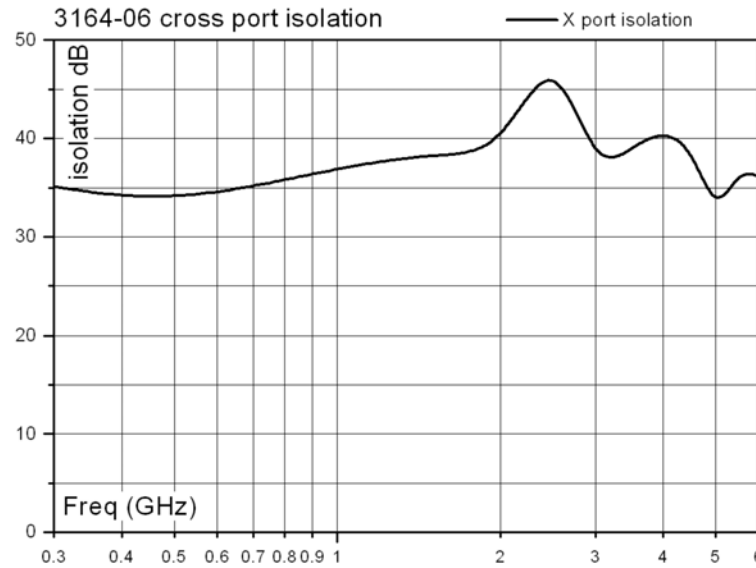


Use only the content for 3164-07 in this manual. Disregard content for all other 3164 models; see ETS-Lindgren website for other 3164 content.

Model 3164-06 3 dB Half-Power Beamwidth



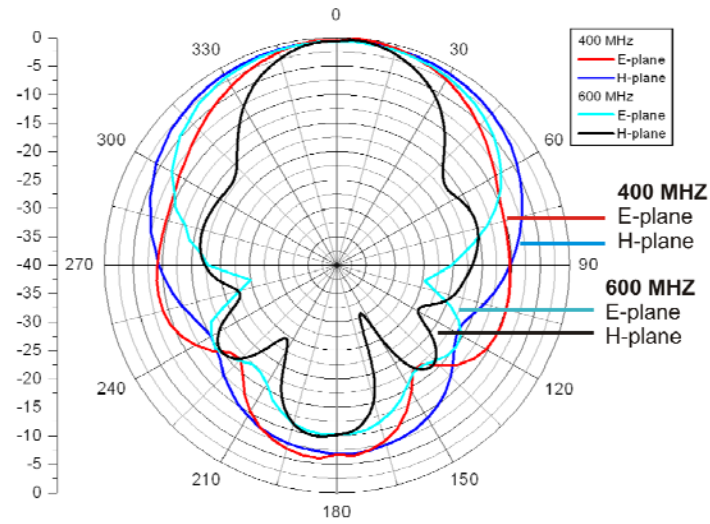
Model 3164-06 Cross-Port Isolation



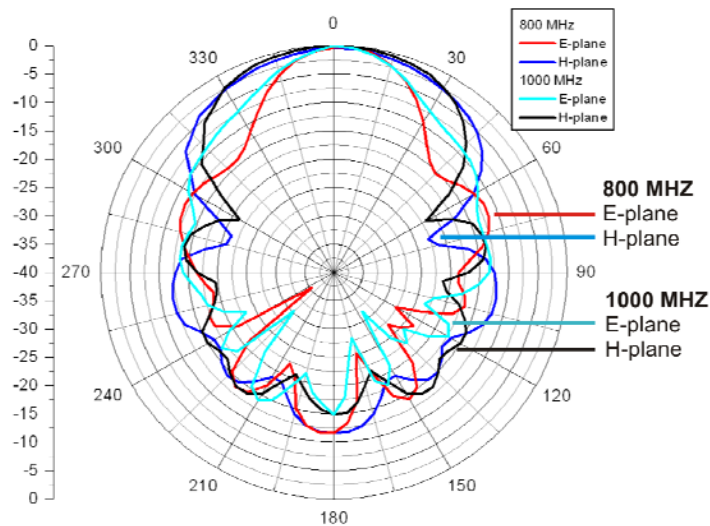
Use only the content for 3164-07 in this manual. Disregard content for all other 3164 models; see ETS-Lindgren website for other 3164 content.

9.0 Model 3164-06 Typical Radiation Patterns

Model 3164-06 at 400 MHz – 600 MHz

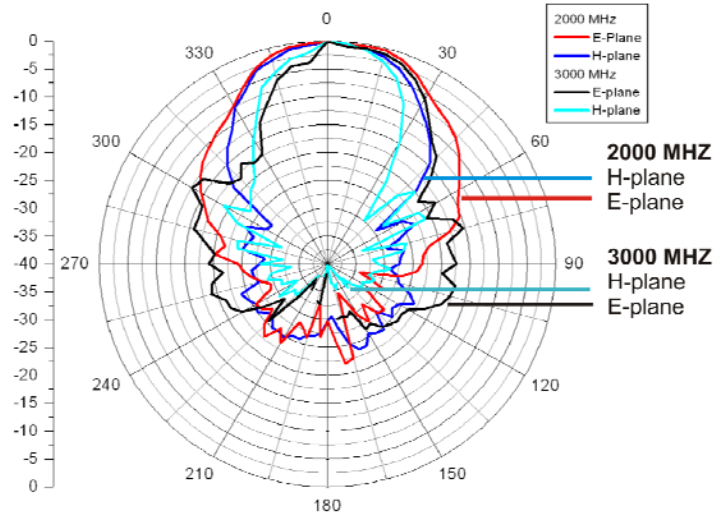


Model 3164-06 at 800 MHz – 1000 MHz

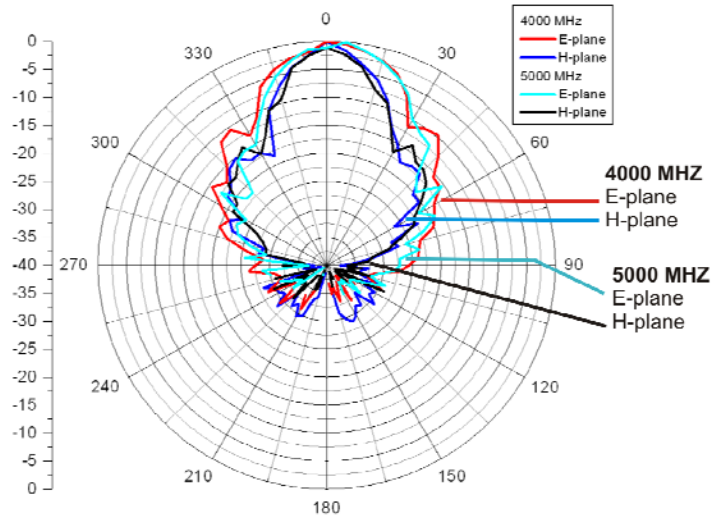


Use only the content for 3164-07 in this manual. Disregard content for all other 3164 models; see ETS-Lindgren website for other 3164 content.

Model 3164-06 at 2000 MHz – 3000 MHz

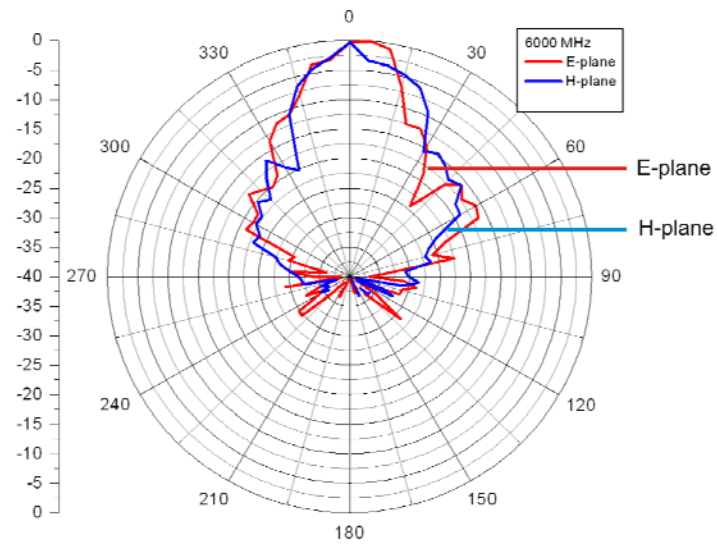


Model 3164-06 at 4000 MHz – 5000 MHz



Use only the content for 3164-07 in this manual. Disregard content for all other 3164 models; see ETS-Lindgren website for other 3164 content.

Model 3164-06 at 6000 MHz



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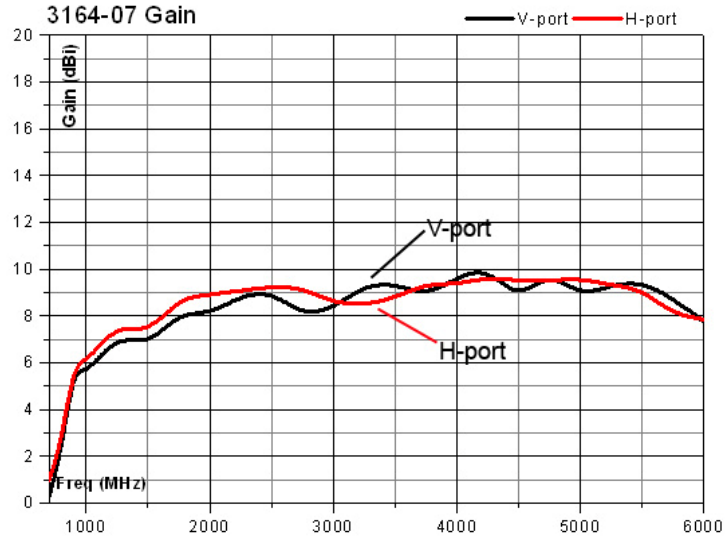
Use only the content for 3164-07 in this manual. Disregard content for all other 3164 models; see ETS-Lindgren website for other 3164 content.

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Use only the content for 3164-07 in this manual. Disregard content for all other 3164 models; see ETS-Lindgren website for other 3164 content.

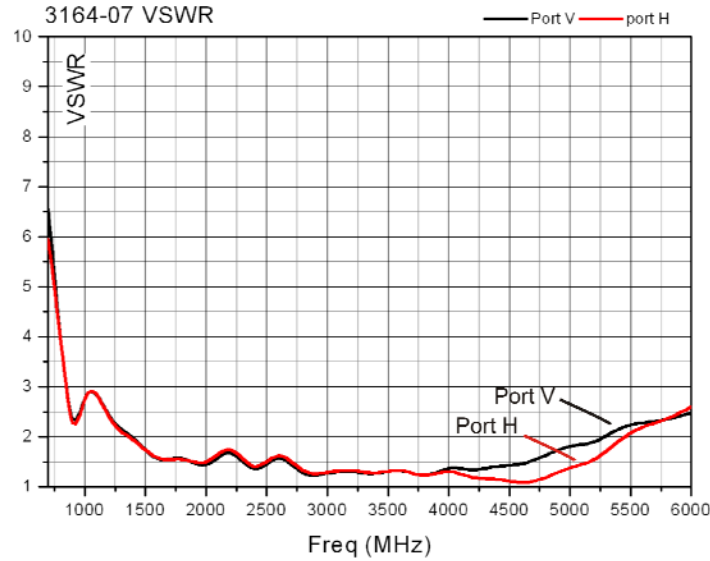
10.0 Model 3164-07 Typical Data

Model 3164-07 Gain

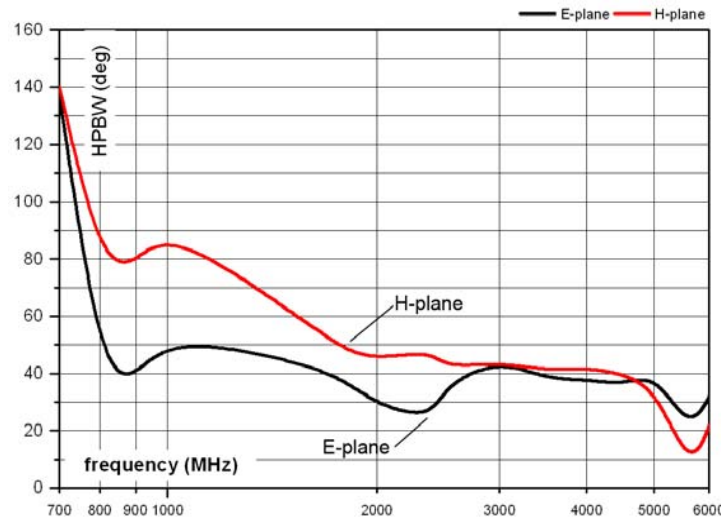


Use only the content for 3164-07 in this manual. Disregard content for all other 3164 models; see ETS-Lindgren website for other 3164 content.

Model 3164-07 VSWR



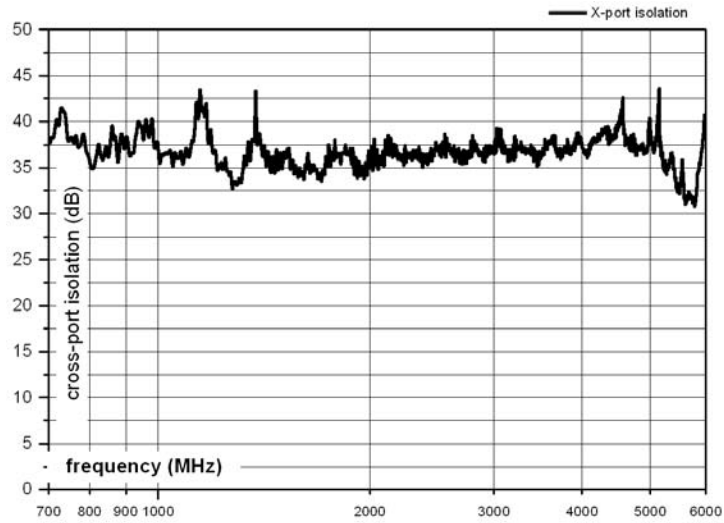
Model 3164-07 Half-Power Beamwidth



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Use only the content for 3164-07 in this manual. Disregard content for all other 3164 models; see ETS-Lindgren website for other 3164 content.

Model 3164-07 Cross-Port Isolation



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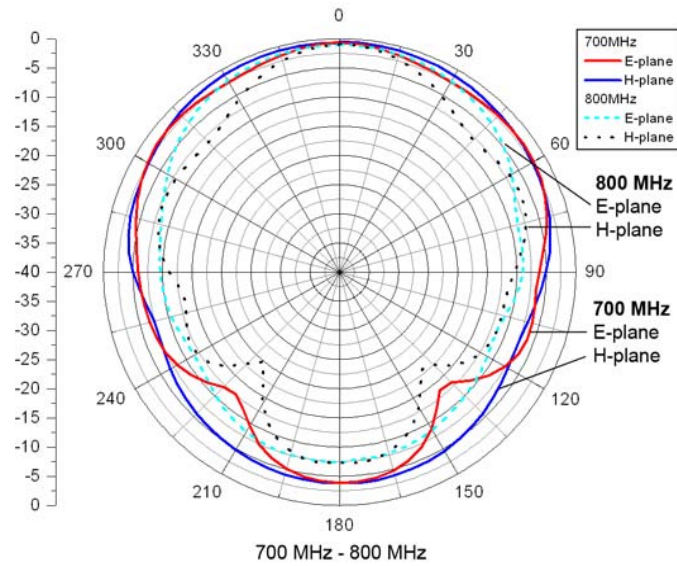
Use only the content for 3164-07 in this manual. Disregard content for all other 3164 models; see ETS-Lindgren website for other 3164 content.

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Use only the content for 3164-07 in this manual. Disregard content for all other 3164 models; see ETS-Lindgren website for other 3164 content.

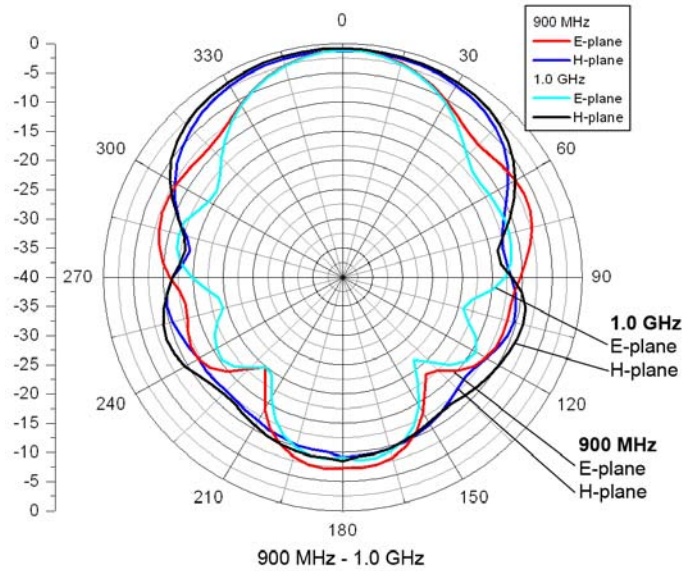
11.0 Model 3164-07 Typical Radiation Patterns

Model 3164-07 at 700 MHz – 800 MHz

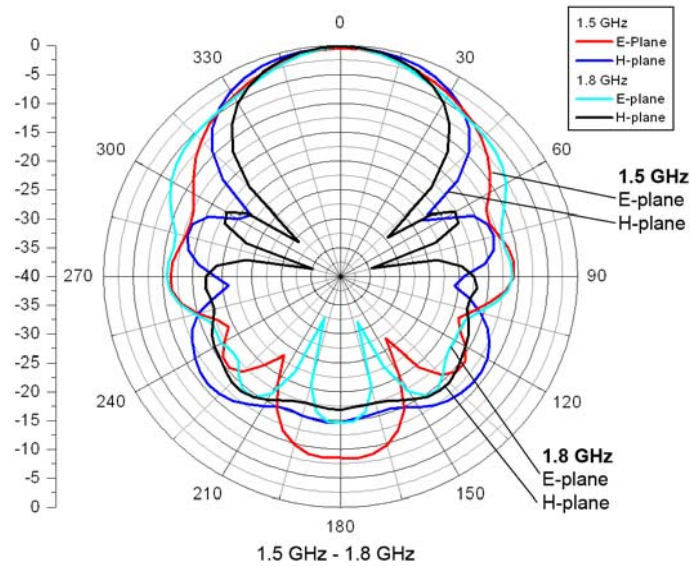


Use only the content for 3164-07 in this manual. Disregard content for all other 3164 models; see ETS-Lindgren website for other 3164 content.

Model 3164-07 at 900 MHz – 1.0 GHz

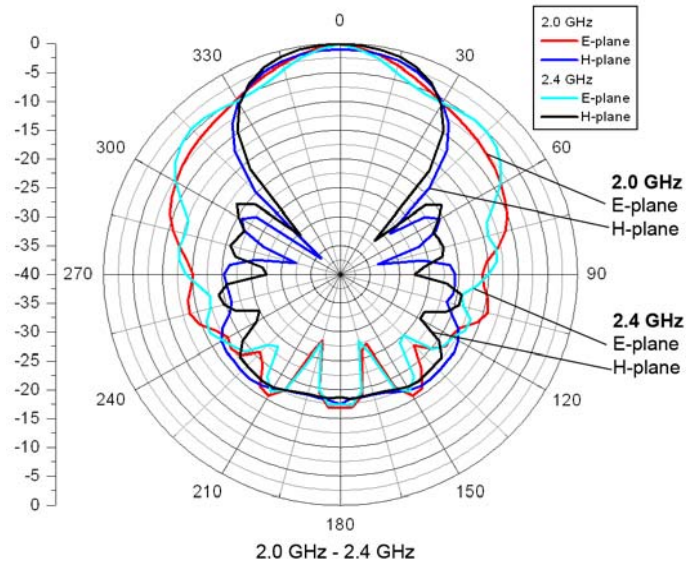


Model 3164-07 at 1.5 GHz – 1.8 GHz

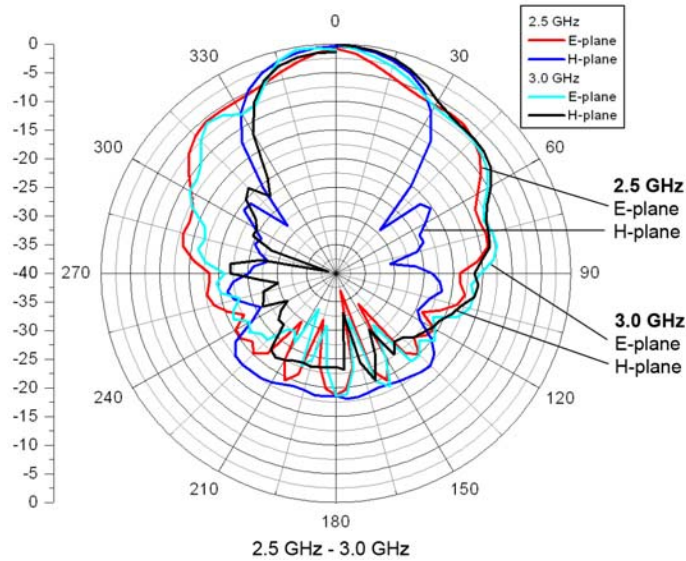


Use only the content for 3164-07 in this manual. Disregard content for all other 3164 models; see ETS-Lindgren website for other 3164 content.

Model 3164-07 at 2.0 GHz – 2.4 GHz

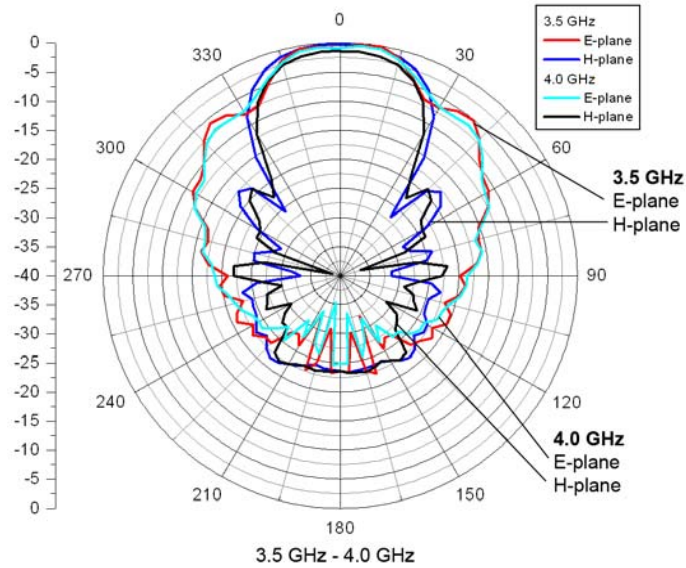


Model 3164-07 at 2.5 GHz – 3.0 GHz

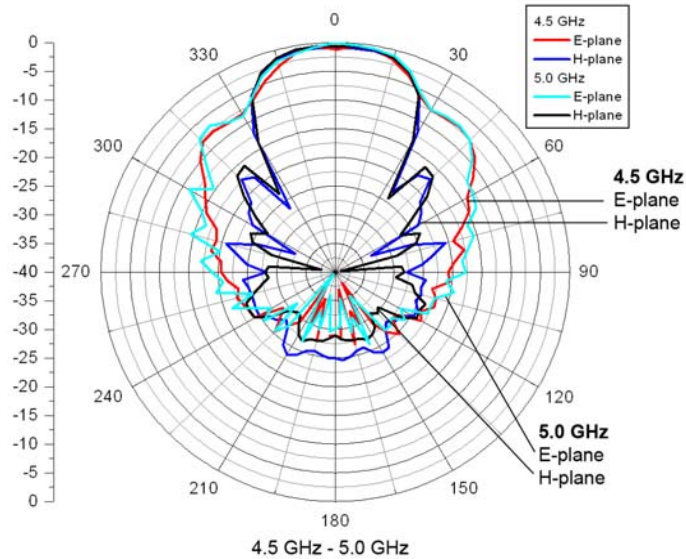


Use only the content for 3164-07 in this manual. Disregard content for all other 3164 models; see ETS-Lindgren website for other 3164 content.

Model 3164-07 at 3.5 GHz – 4.0 GHz



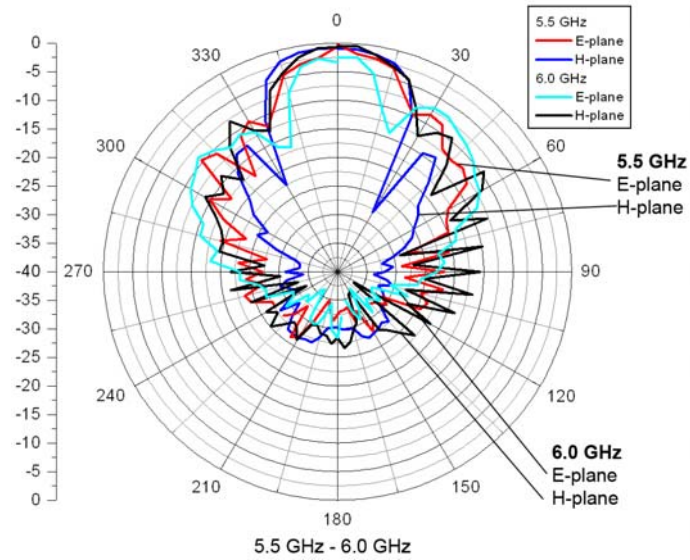
Model 3164-07 at 4.5 GHz – 5.0 GHz



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Model 3164-07 at 5.5 GHz – 6.0 GHz



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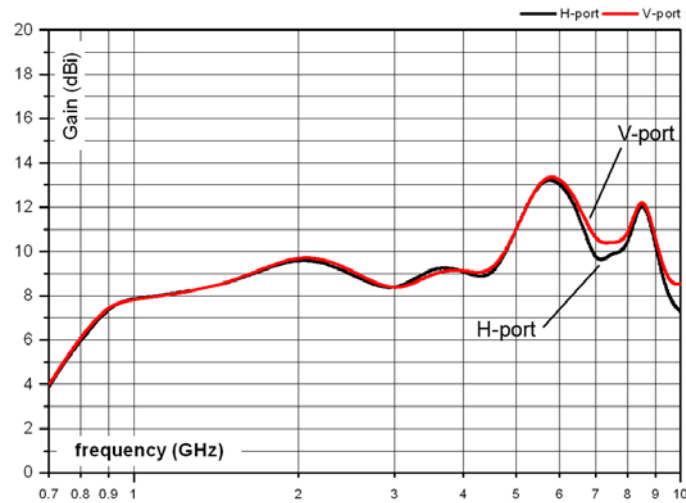
Use only the content for 3164-07 in this manual. Disregard content for all other 3164 models; see ETS-Lindgren website for other 3164 content.

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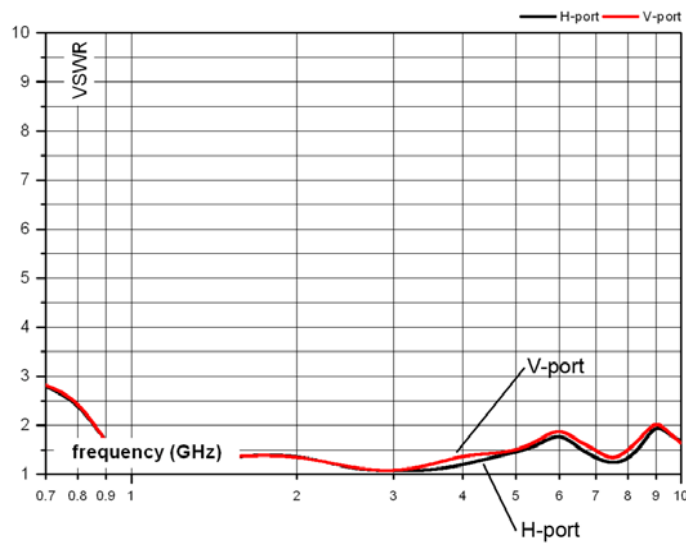
Use only the content for 3164-07 in this manual. Disregard content for all other 3164 models; see ETS-Lindgren website for other 3164 content.

12.0 Model 3164-08 Typical Data

Model 3164-08 Gain



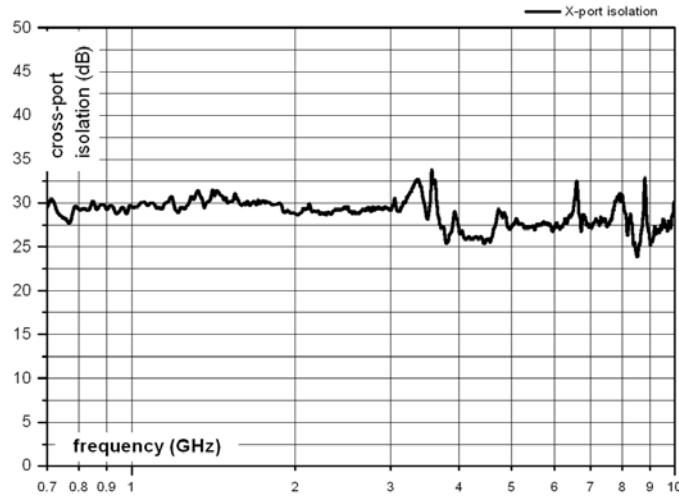
Model 3164-08 VSWR



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Use only the content for 3164-07 in this manual. Disregard content for all other 3164 models; see ETS-Lindgren website for other 3164 content.

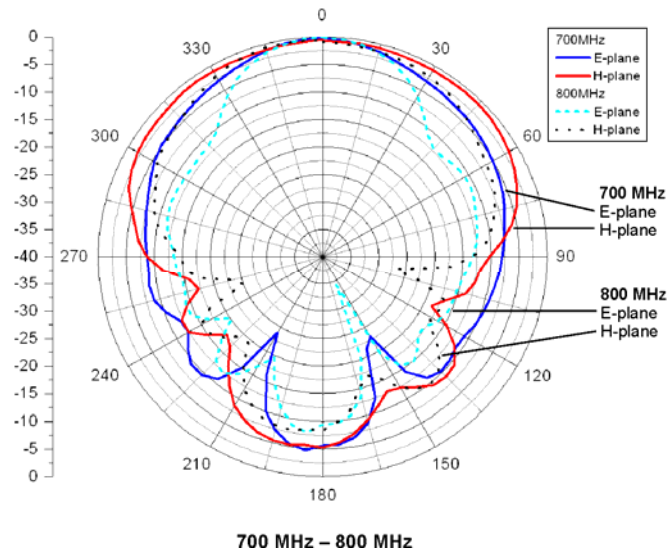
Model 3164-08 Cross-Port Isolation



Use only the content for 3164-07 in this manual. Disregard content for all other 3164 models; see ETS-Lindgren website for other 3164 content.

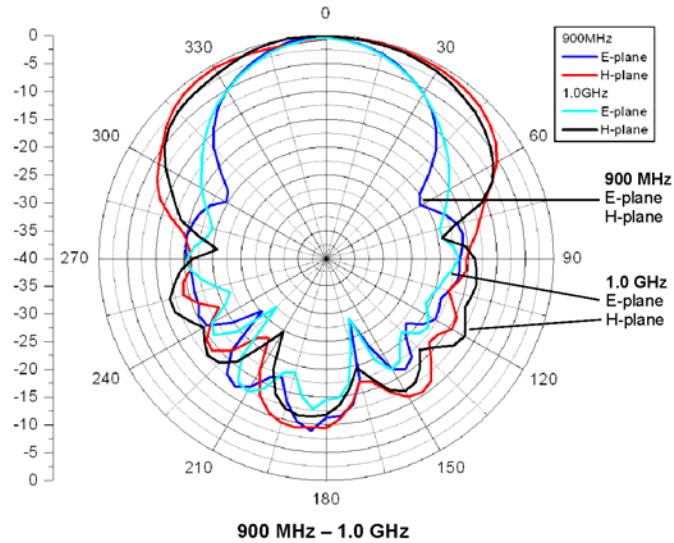
13.0 Model 3164-08 Typical Radiation Patterns

Model 3164-08 at 700 MHz – 800 MHz

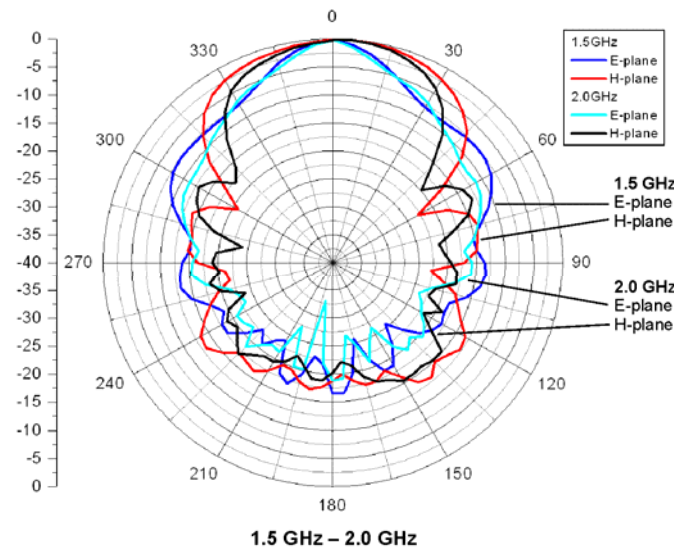


Use only the content for 3164-07 in this manual. Disregard content for all other 3164 models; see ETS-Lindgren website for other 3164 content.

Model 3164-08 at 900 MHz – 1000 MHz

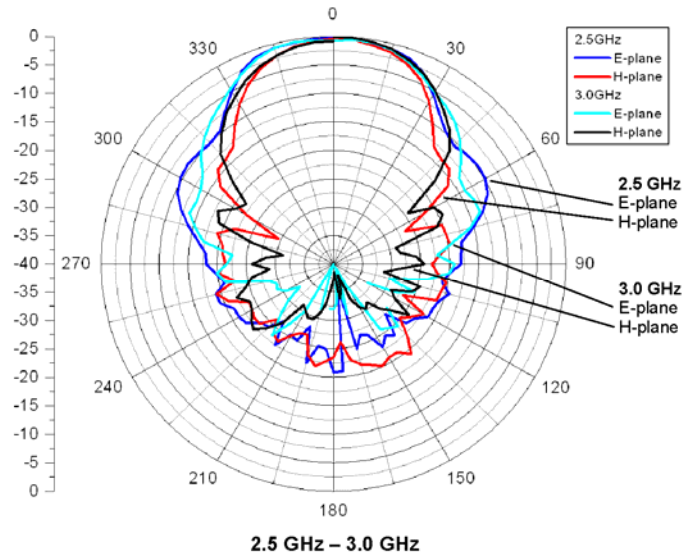


Model 3164-08 at 1.5 GHz – 2.0 GHz

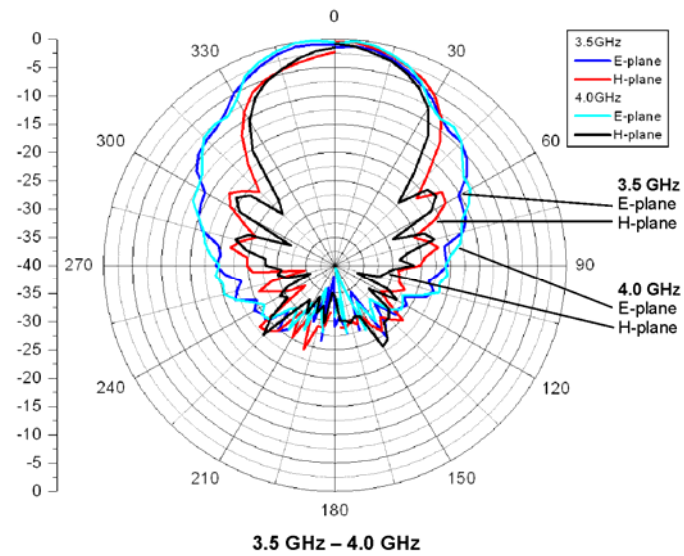


Use only the content for 3164-07 in this manual. Disregard content for all other 3164 models; see ETS-Lindgren website for other 3164 content.

Model 3164-08 at 2.5 GHz – 3.0 GHz

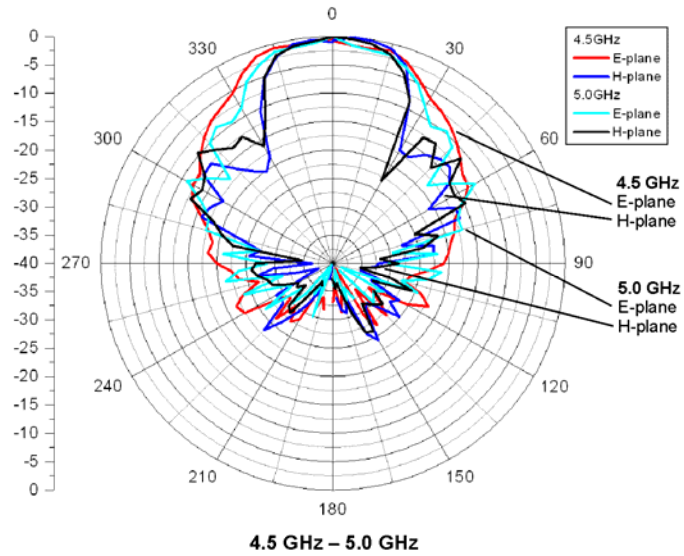


Model 3164-08 at 3.5 GHz – 4.0 GHz

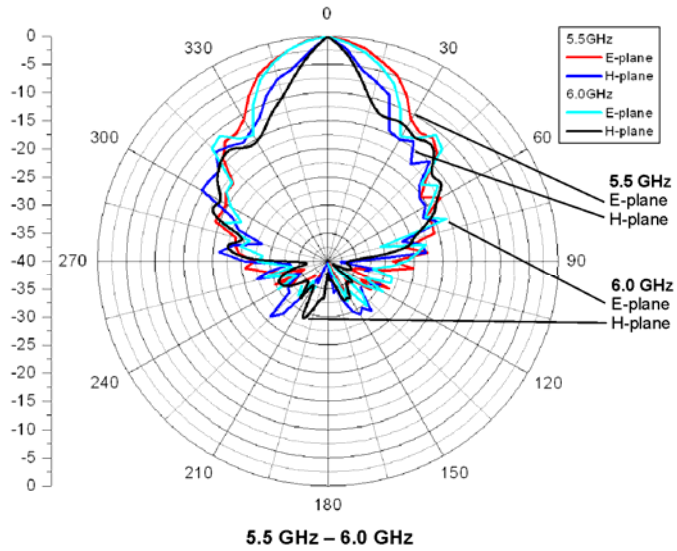


Use only the content for 3164-07 in this manual. Disregard content for all other 3164 models; see ETS-Lindgren website for other 3164 content.

Model 3164-08 at 4.5 GHz – 5.0 GHz

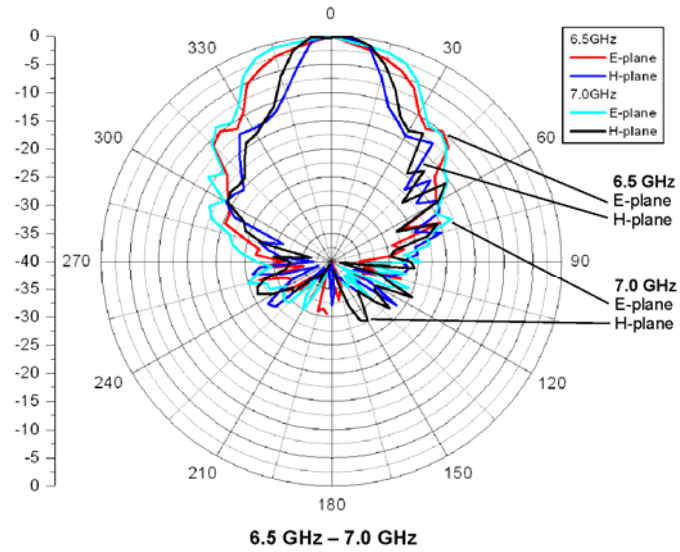


Model 3164-08 at 5.5 GHz – 6.0 GHz

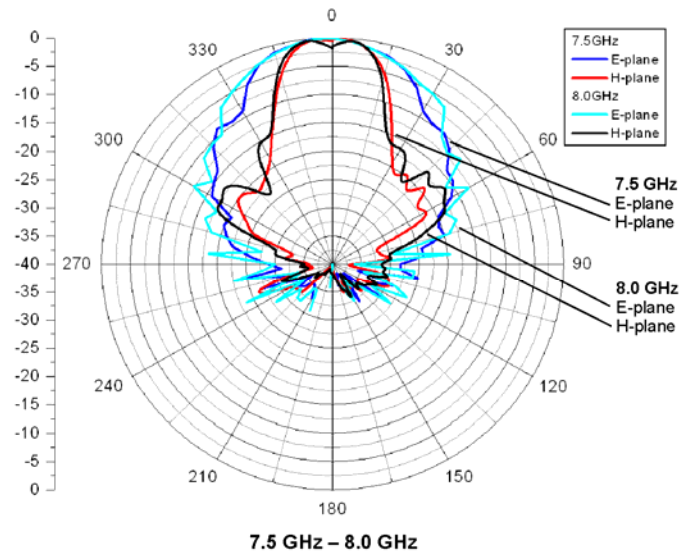


Use only the content for 3164-07 in this manual. Disregard content for all other 3164 models; see ETS-Lindgren website for other 3164 content.

Model 3164-08 at 6.5 GHz – 7.0 GHz

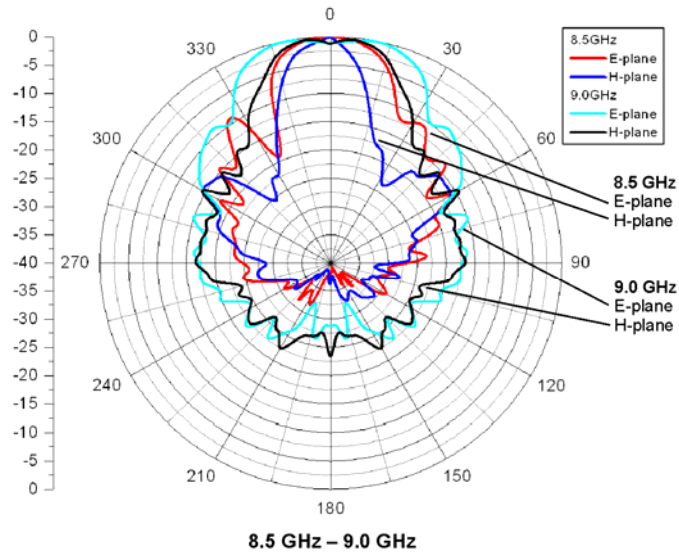


Model 3164-08 at 7.5 GHz – 8.0 GHz

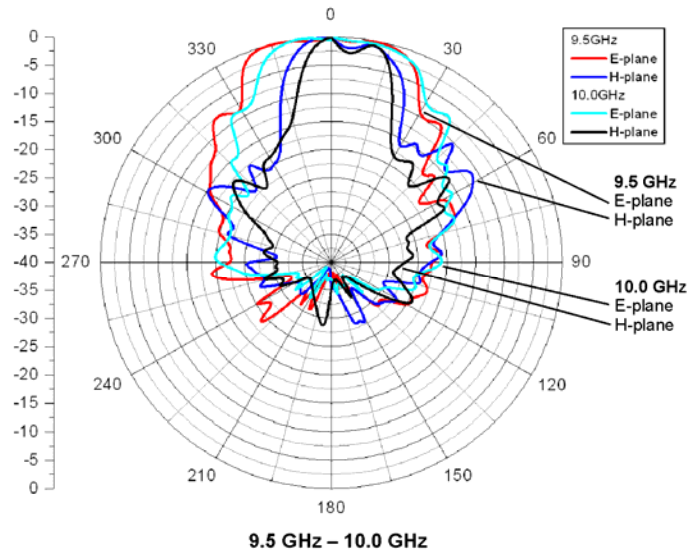


Use only the content for 3164-07 in this manual. Disregard content for all other 3164 models; see ETS-Lindgren website for other 3164 content.

Model 3164-08 at 8.5 GHz – 9.0 GHz



Model 3164-08 at 9.5 GHz – 10.0 GHz



Use only the content for 3164-07 in this manual. Disregard content for all other 3164 models; see ETS-Lindgren website for other 3164 content.

14.0 Specifications

Electrical Specifications

| | Model 3164-05 | Model 3164-06 | Model 3164-07 | Model 3164-08 |
|---------------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| Frequency Range: | 2 GHz – 18 GHz | 300 MHz – 6 GHz | 700 MHz – 6 GHz | 700 MHz – 10 GHz |
| Max VSWR: | < 3.25:1 | < 6.5:1 | < 6.5:1 | < 3:1 |
| Gain over Operating Frequency: | See <i>Gain</i> data on page 37 | See <i>Gain</i> data on page 51 | See <i>Gain</i> data on page 57 | See <i>Gain</i> data on page 67 |
| Maximum Continuous Power: | 10 W | 20 W | 20 W | 20 W |
| Impedance (Nominal): | 50 Ω | 50 Ω | 50 Ω | 50 Ω |
| Connector: | SMA (2) | SMA (2) | SMA (2) | SMA (2) |
| Cross Polarization Isolation: | > 24 dB | > 25 dB | > 25 dB | > 20 dB |
| Dual Polarization Symmetry: | See <i>Gain</i> data on page 37 | See <i>Gain</i> data on page 51 | See <i>Gain</i> data on page 57 | See <i>Gain</i> data on page 67 |

Use only the content for 3164-07 in this manual. Disregard content for all other 3164 models; see ETS-Lindgren website for other 3164 content.

Physical Specifications

| | Model 3164-05 | Model 3164-06 | Model 3164-07 | Model 3164-08 |
|----------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Height: | 17.1 cm 6.7 in | 50.80 cm 20 in | 30.99 cm 12.2 in | 36.07cm 14.2 in |
| Width: | 17.1 cm 6.7 in | 50.80 cm 20 in | 30.99 cm 12.2 in | 36.07 cm 14.2 in |
| Depth: | 18.6 cm 7.3 in | 50.80 cm 20 in | 35.81 cm 14.1 in | 36.58 cm 14.4 in |
| Weight: | 0.7 kg 1.5 lb | 9.5 kg 21 lb | 4 kg 9 lb | 5.1 kg 11.4 lb |

Use only the content for 3164-07 in this manual. Disregard content for all other 3164 models; see ETS-Lindgren website for other 3164 content.

Appendix A: Warranty

SCOPE AND DURATION OF WARRANTIES

Seller warrants to Buyer that the Standard EMCO Brand Products Excluding 5211 & 5220 be (1) free from defects in material, manufacturing workmanship, and title, and (2) conform to the Seller's applicable product descriptions and specifications, if any, contained in or attached to Seller's quotation. If no product descriptions or specifications are contained in or attached to the quotation, Seller's applicable product descriptions and specifications in effect on the date of shipment shall apply. The criteria for all testing shall be Seller's applicable product specifications utilizing factory-specified calibration and test procedures and instruments.

All product warranties, except the warranty of title, and all remedies for warranty failures are limited in time as shown in the following table.

| Product Warranted | Duration of Warranty Period |
|--|-----------------------------|
| Standard EMCO Brand Products Excluding 5211 & 5220 | 2 Years |

Any product or part furnished to Buyer during the warranty period to correct a warranty failure shall be warranted to the extent of the unexpired term of the warranty applicable to the repaired or replaced product.

The warranty period shall commence on the date the product is delivered to Buyer; however, if Seller assembles the product, or provides technical direction of such assembly, the warranty period for such product shall commence on the date the assembly of the product is complete. Notwithstanding the foregoing, in the event that the assembly is delayed for a total of thirty (30) days or more from the date of delivery for any reason or reasons for which Seller is not responsible, the warranty period for such product may, at Seller's options, commence on the thirtieth (30th) day from the date such product is delivered to Buyer. Buyer shall promptly inspect all products upon delivery. No claims for shortages will be allowed unless shortages are reported to Seller in writing within ten (10) days after delivery. No other claims against Seller will be allowed unless asserted in writing within thirty (30) days after delivery (or assembly if the products are to be assembled by Seller) or, in the case of alleged breach of warranty, within the applicable warranty period.

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WARRANTY EXCLUSIONS

Except as set forth in any applicable patent indemnity, the foregoing warranties are exclusive and in lieu of all other warranties, whether written, oral, express, implied, or statutory. EXCEPT AS EXPRESSLY STATED ABOVE, SELLER MAKES NO WARRANTY, EXPRESS OR IMPLIED, BY STATUTE OR OTHERWISE, WHETHER OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE OR USE OR OTHERWISE ON THE PRODUCTS, OR ON ANY PARTS OR LABOR FURNISHED DURING THE SALE, DELIVERY OR SERVICING OF THE PRODUCTS. THERE ARE NO WARRANTIES WHICH EXTEND BEYOND THE DESCRIPTION ON THE FACE HEREOF.

Warranty coverage does not include any defect or performance deficiency (including failure to conform to product descriptions or specifications) which results, in whole or in part, from (1) negligent storage or handling of the product by Buyer, its employees, agents, or contractors, (2) failure of Buyer to prepare the site or provide an operating environmental condition in compliance with any applicable instructions or recommendations of Seller, (3) absence of any product, component, or accessory recommended by Seller but omitted at Buyer's direction, (4) any design, specification, or instruction furnished by Buyer, its employees, agents or contractors, (5) any alteration of the product by persons other than Seller, (6) combining Seller's product with any product furnished by others, (7) combining incompatible products of Seller, (8) interference with the radio frequency fields due to conditions or causes outside the product as furnished by Seller, (9) improper or extraordinary use of the product, or failure to comply with any applicable instructions or recommendations of Seller, or (10) acts of God, acts of civil or military authority, fires, floods, strikes or other labor disturbances, war, riot, or any other causes beyond the reasonable control of Seller. This warranty does not cover (1) contact fingers or replacements unless loss is caused by a defect in material or manufacturing workmanship within the scope of this warranty (2) items designed to be consumable and (3) removal and reconstruction of walls, partitions, ceilings and other facility costs arising from repair or replacement of the product or parts thereof by Seller under the warranty. Seller does not warranty products of others which are not included in Seller's published price lists for shielding products and systems supplies and accessories.

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BUYER'S REMEDIES

If Seller determines that any product fails to meet any warranty during the applicable warranty period, Seller shall correct any such failure by either, at its option, repairing, adjusting, or replacing without charge to Buyer any defective or nonconforming product, or part or parts of the product. Seller shall have the option to furnish either new or exchange replacement parts or assemblies.

Warranty service during the applicable warranty period will be performed without charge to Buyer within the contiguous 48 United States during Seller's normal business hours. After the warranty period, service will be performed at Seller's prevailing service rates. Subject to the availability of personnel, after-hours service is available upon request at an additional charge. For service outside the contiguous 48 United States, travel and per diem expenses, when required, shall be the responsibility of the Buyer, or End User, whichever is applicable.

The remedies set forth herein are conditioned upon Buyer promptly notifying Seller within the applicable warranty period of any defect or non-conformance and making the product available for correction.

The preceding paragraphs set forth Buyer's exclusive remedies and Seller's sole liability for claims based on failure of the products to meet any warranty, whether the claim is in contract, warranty, tort (including negligence and strict liability) or otherwise, and however instituted, and, upon the expiration of the applicable warranty period, all such liability shall terminate. IN NO EVENT SHALL SELLER BE LIABLE TO BUYER FOR ANY SPECIAL INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES OF ANY KIND ARISING OUT OF, OR AS A RESULT OF, THE SALE, DELIVERY, NON-DELIVERY, SERVICING, ASSEMBLING, USE OR LOSS OF USE OF THE PRODUCTS OR ANY PART THEREOF, OR FOR ANY CHARGES OR EXPENSES OF ANY NATURE INCURRED WITHOUT SELLER'S WRITTEN CONSENT DESPITE ANY NEGLIGENCE ON BEHALF OF THE SELLER. IN NO EVENT SHALL SELLER'S LIABILITIES UNDER ANY CLAIM MADE BY BUYER EXCEED THE PURCHASE PRICE OF THE PRODUCT IN RESPECT OF WHICH DAMAGES ARE CLAIMED. This agreement shall be construed in accordance with laws of the State of Illinois. In the event that any provision hereof shall violate any applicable statute, ordinance, or rule of law, such provision shall be ineffective to the extent of such violation without invalidating any other provision hereof.

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Any controversy or claim arising out of or relating to the sale, delivery, nondelivery, servicing, assembling, use or loss of use of the products or any part thereof or for any charges or expenses in connection therewith shall be settled in Austin, Texas by arbitration in accordance with the Rules of the American Arbitration Association, and judgment upon the award rendered by the Arbitrator may be entered in either the Federal District Court for the Western District of Texas or the State District Court in Austin, Texas, all of the parties hereto consenting to personal jurisdiction of the venue of such court and hereby waive the right to demand a jury trial under any of these actions.