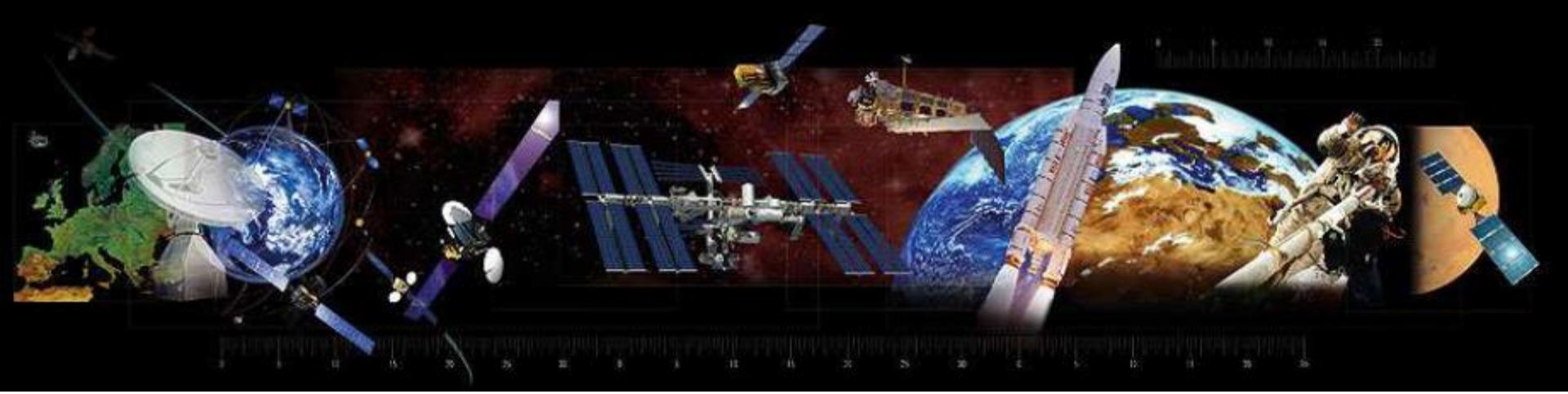

Insertion Loss: Double Ridge Waveguide

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Presentation Content

Insertion Loss of Double Ridge Waveguide (WRD)

1. Introduction: Insertion Loss of Double Ridge Waveguide
2. Electrical & Physical Data for standard Double Ridge Waveguide.
3. Some RF Components in Double Ridge Waveguide.
4. Insertion Loss Calculation: Ridge Waveguide.
5. Insertion Loss versus Frequency: OFHC Copper & Aluminum alloy
    a. WRD-180D24: 18 to 40 GHz.
    b. WRD-110D24: 11 to 26.5 GHz.
    c. WRD-750D24: 7.5 to 18 GHz.
    d. WRD-650D28: 6.5 to 18 GHz.
    e. WRD-475D24: 4.75 to 11 GHz.
    f. WRD-250D30: 2.6 to 7.8 GHz.
    g. WRD-200D24: 2 to 4.8 GHz.
6. Summary: WRD Insertion Loss.
7. Software Product Data Sheet: WRDguide.

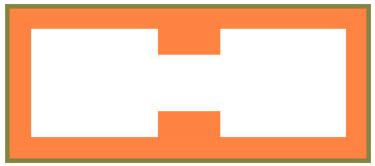
Introduction

Insertion Loss of Double Ridge Waveguide

1. Double Ridge Waveguide is available in various physical sizes, based on the operating frequency range needed for the RF system.
2. The double ridge waveguide's ridge width: S and ridge gap: D strongly determine its operating bandwidth and insertion loss level.
3. The operating frequency bandwidth ratio of double ridge waveguide is often in the range: F_{low} / F_{high} = 2.4:1 to 3.0:1.
   A. For example, standard WRD-750 operates across the frequency range: 7.5 to 18 GHz, so its bandwidth ratio = 18/7.5 = 2.4 → WRD-750D24.
   B. Standard WRD-250 operates across the frequency range: 2.6 to 7.8 GHz, so its frequency bandwidth ratio = 7.8/2.6 = 3.0 → WRD-250D30.
4. Most double ridge waveguide is fabricated (machined or extruded) from 6061 aluminum alloy or Oxygen Free High Conductivity (OFHC) copper whose electrical resistivity = 4×10^{-8} Ohm-meter or 1.7×10^{-8} Ohm-meter, respectively. These electrical resistivities are used in the Insertion Loss graphs which follow.

Note: 1×10^{-8} Ohm-meter = 1×10^{-6} Ohm-cm = 1 micro-Ohm-cm.

Electrical & Physical Data for Standard Double Ridge Waveguide



WRD Size	MIL-DTL-23351 Dash No.	Frequency Range (GHz)	TE10 Mode Cut-off Freq , GHz	TE20 Mode Cut-off Freq, GHz	RF Power Rating (One Atmosphere)		WRD Width A, Inch	WRD Height B, Inch	Ridge Width S, Inch	Ridge Gap D, Inch	Wall Thick, Inch
					CW (kW)	Peak (kW)					
WRD-200D24	4-025	2.0-4.8	1.666	4.920	50	450	2.590	1.205	0.648	0.512	0.080
WRD-250D30	-	2.6-7.8	2.093	8.256	24	120	1.655	0.715	0.440	0.150	0.173
WRD-350D24	4-029 4-031	3.5-8.2	2.915	8.611	18	150	1.480	0.688	0.370	0.292	0.064
WRD-475D24	4-033 4-035	4.75-11.0	3.961	11.613	8	85	1.090	0.506	0.272	0.215	0.050
WRD-500D36	2-025 2-027	5.0-18.0	4.222	18.386	4	15	0.752	0.323	0.188	0.063	0.050
WRD-580D28	-	5.8-16.0	4.892	16.687	5.2	32	0.780	0.370	0.200	0.120	0.050
WRD-650D28	-	6.5-18.0	5.348	18.296	4	25	0.720	0.321	0.173	0.101	0.050
WRD-700D26	-	7.0-18.5	5.679	18.992	4.3	28	0.686	0.310	0.173	0.105	0.050
WRD-750D24	4-037 4-039	7.5-18.0	6.239	18.45	4.8	35	0.691	0.321	0.173	0.136	0.050
WRD-110D24	4-041 4-043	11.0-26.5	9.363	27.053	1.4	15	0.471	0.219	0.118	0.093	0.040
WRD-180D24	4-045 4-047	18 - 40	14.995	44.24	0.8	5	0.288	0.134	0.072	0.057	0.040

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Some RF Components in Double Ridge Waveguide

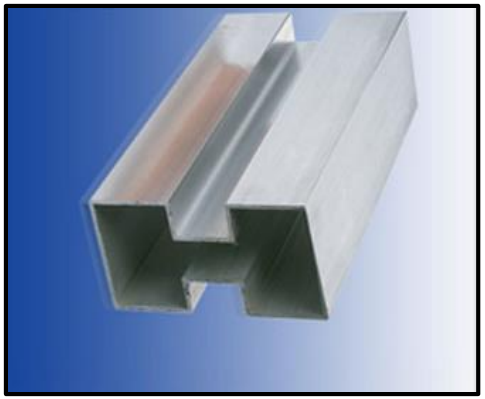
(and many others too)

WRD Ferrite Circulator

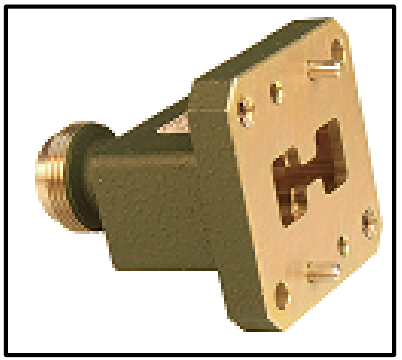
Cross-Guide Coupler

Dual Loop Coupler

Extruded Copper
Double Ridge Waveguide



Extruded Aluminum
Double Ridge Waveguide



End Launched Adaptor

WRD Termination

4-port Magic Tee

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Insertion Loss Calculation: Ridge Waveguide

The insertion loss of ridge waveguide is calculated as:

$$\sigma = 8.686 \frac{\pi\lambda_c/b\lambda^2 + Q}{\sqrt{(\lambda_c/\lambda)^2 - 1}} \rho \; db/m$$

where:

$$Q = \frac{\left\{2\pi \frac{\alpha-\beta}{\beta^2}\rho^2\left[\tan\frac{\pi\gamma}{k} + \frac{\pi\gamma}{k}\sec^2\frac{\pi\gamma}{k}\right] + \frac{4\pi^2}{k}B'^2\frac{\alpha-\beta}{\alpha}\right\}\tan^2\frac{2\pi\delta}{k} + \frac{4\pi^2}{k}\sec^2\frac{2\pi\delta}{k}}{ka^2\left\{\frac{2\alpha}{\beta}\left[\tan\frac{\pi\gamma}{k} + \frac{\pi\gamma}{k}\sec^2\frac{\pi\gamma}{k}\right]\tan^2\frac{2\pi\delta}{k} - 2\tan\frac{2\pi\delta}{k} + \frac{4\pi\delta}{k}\sec^2\frac{2\pi\delta}{k}\right\}}$$

and:

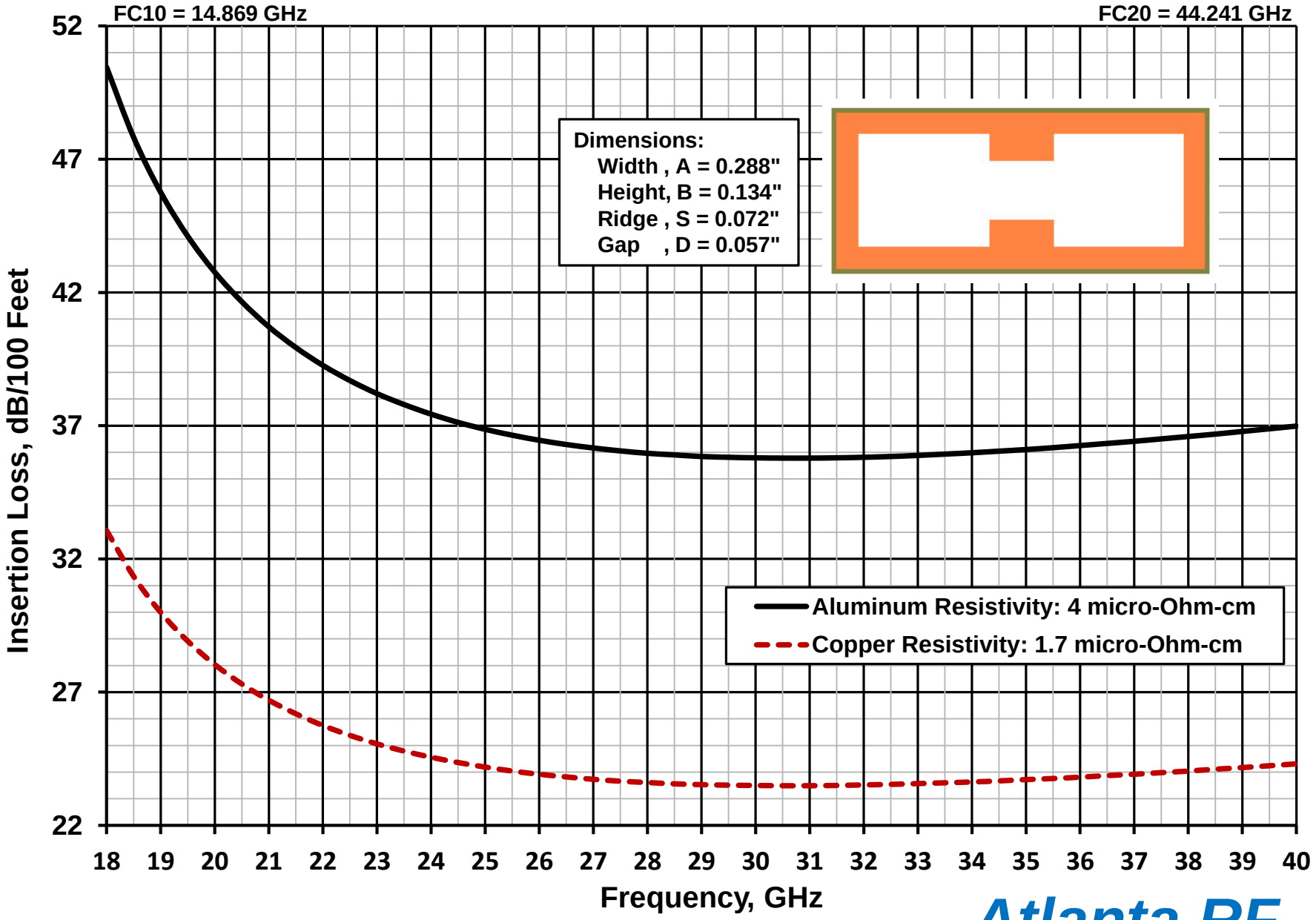
ρ = skin depth in meters

$\alpha = b/a \qquad \gamma = s/a \qquad k = \lambda_c/a$

$\beta = d/a \qquad \delta = \frac{1 - s/a}{2} \qquad p = \lambda_c/\lambda.$

Source: "The Design of Ridge Waveguide", S. Hopfer, IRE-MTT, Vol. 3, No. 10, Oct-1955.

Insertion Loss: WRD-180D24 Double Ridge W/G (18 to 40 GHz)



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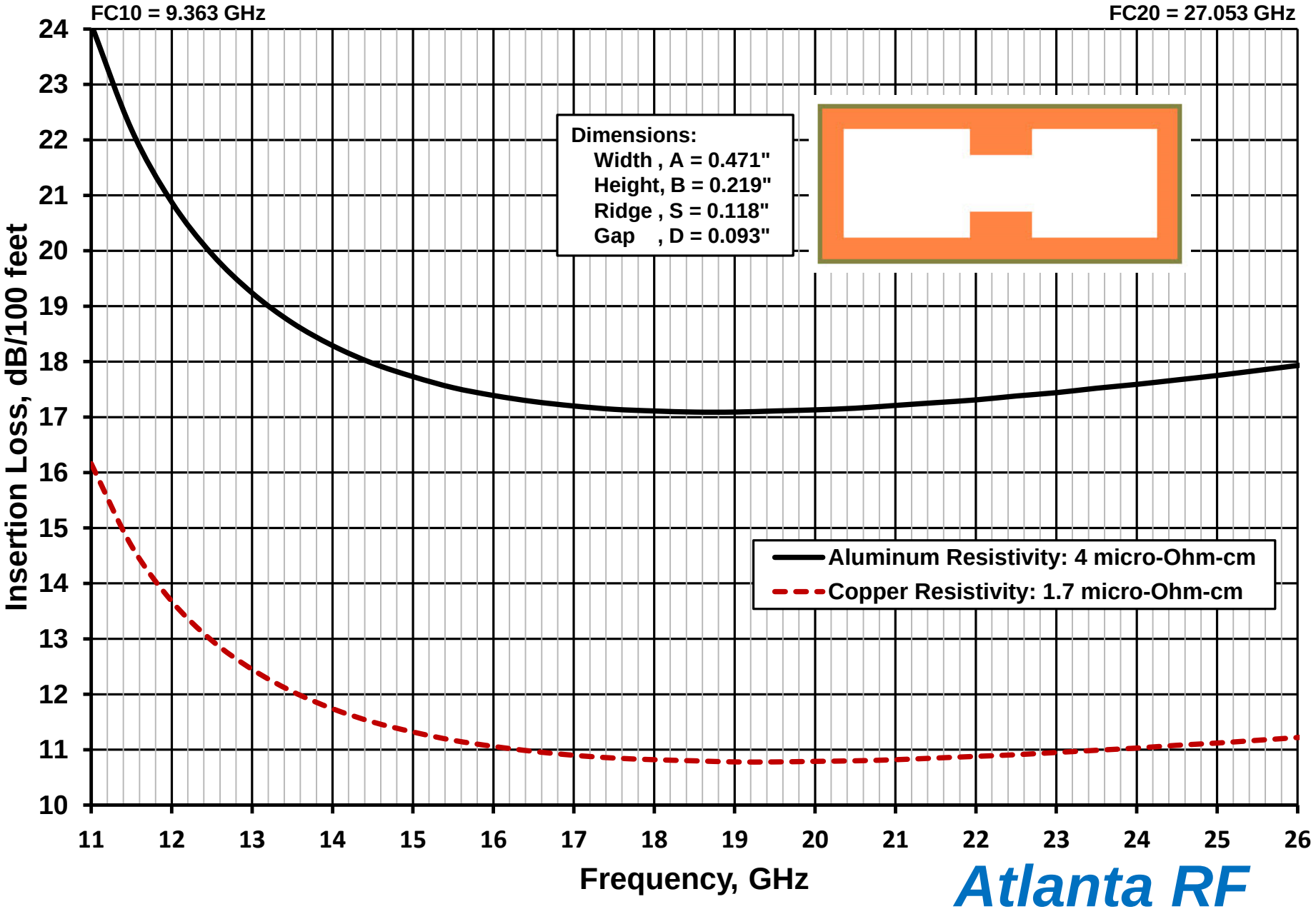
Insertion Loss: WRD-110D24 Double Ridge W/G (11 to 26.5GHz)



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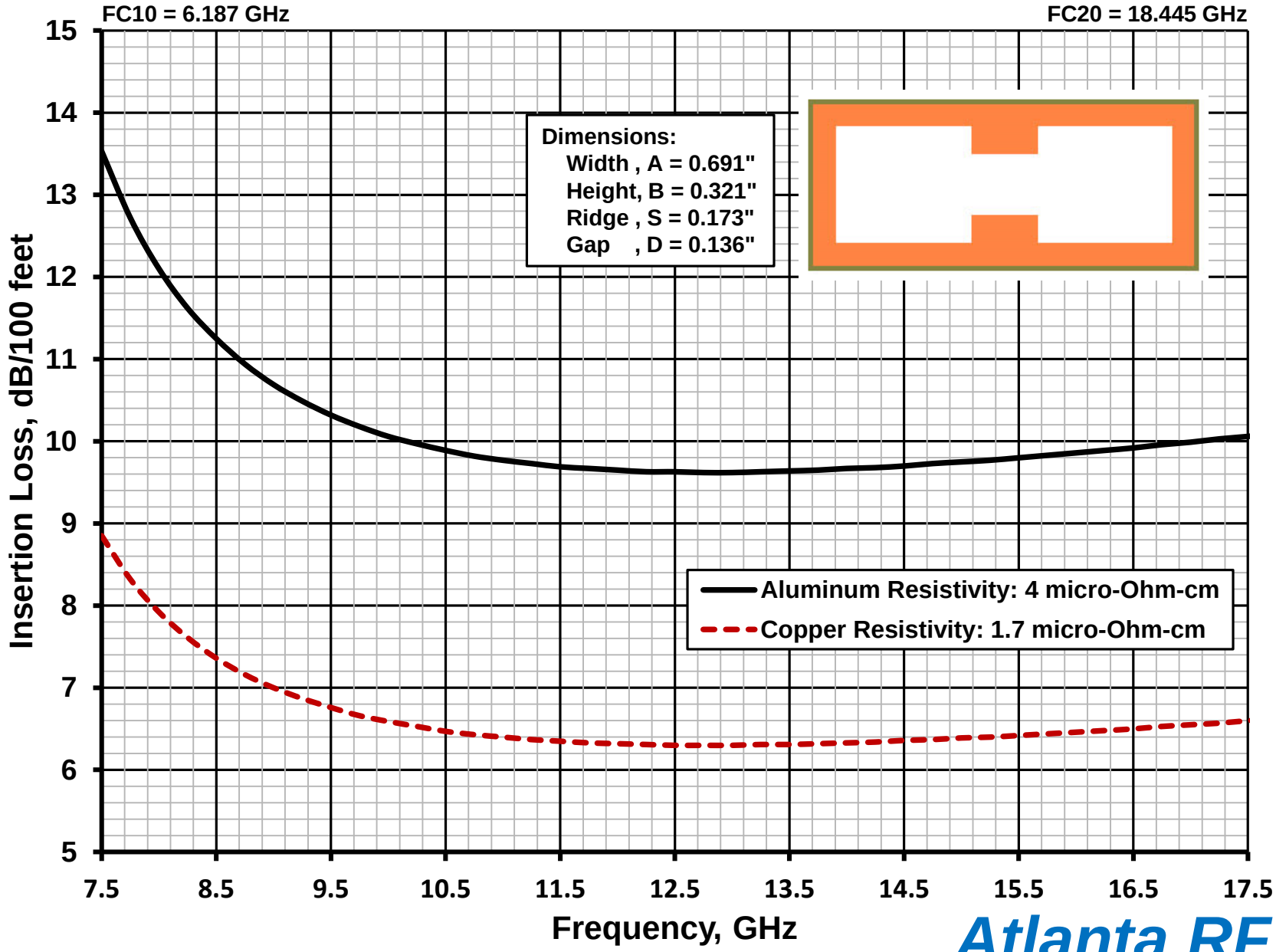
Insertion Loss: WRD-750D24 Double Ridge (7.5 to 18 GHz)



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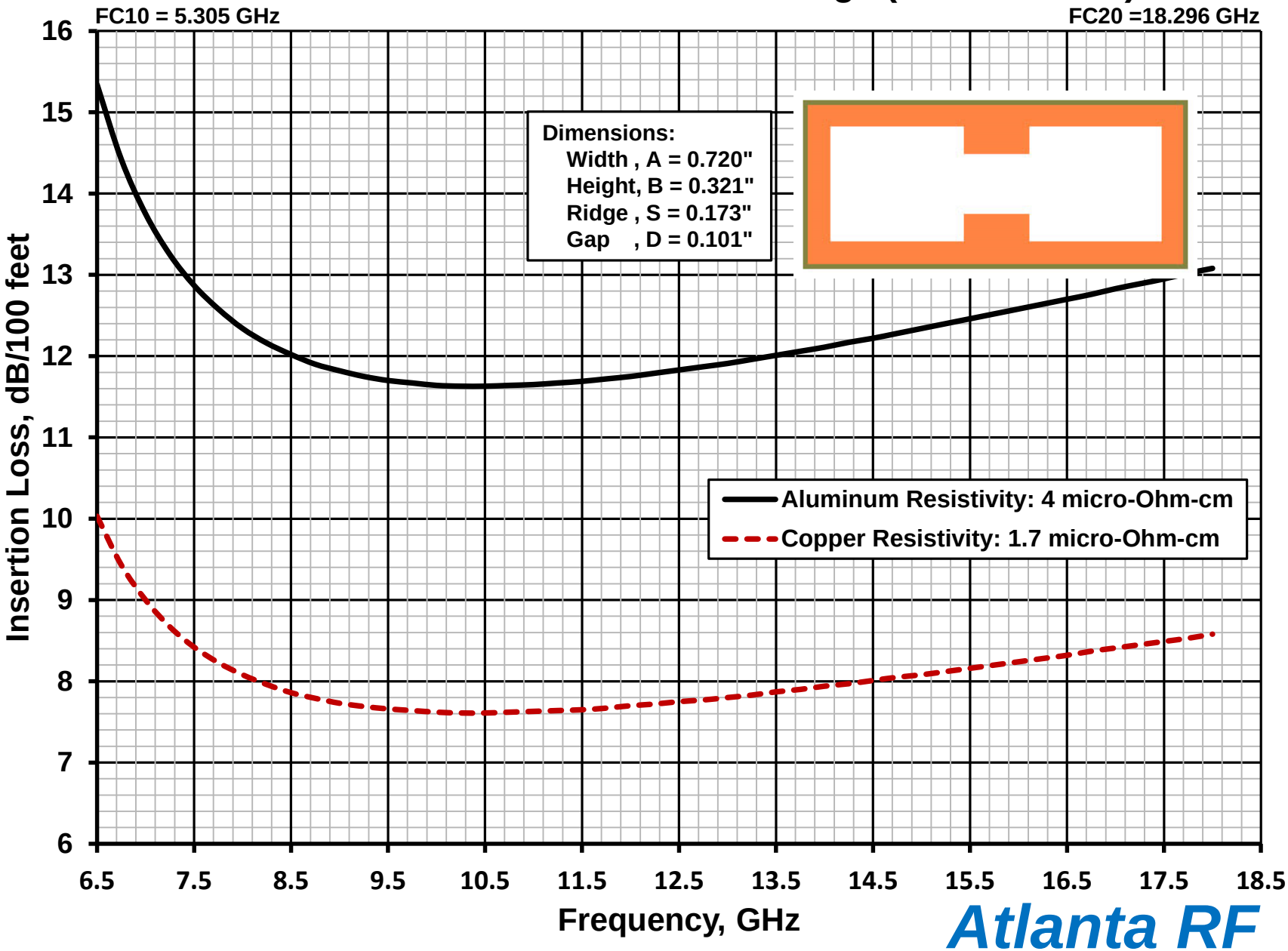
Insertion Loss: WRD-650D28 Double Ridge (6.5 to 18 GHz)



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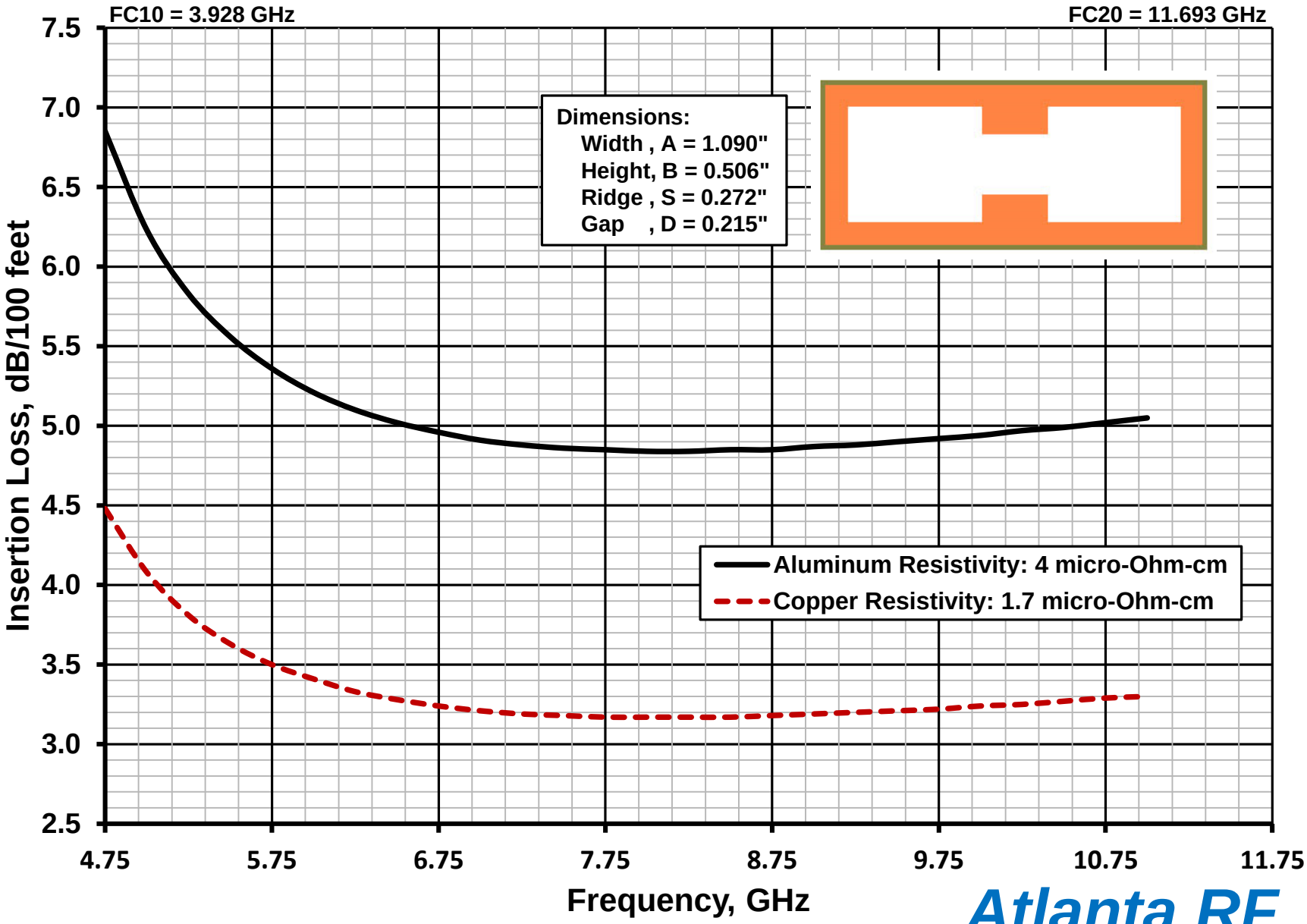
Insertion Loss: WRD-475D24 Double Ridge (4.75 to 11 GHz)



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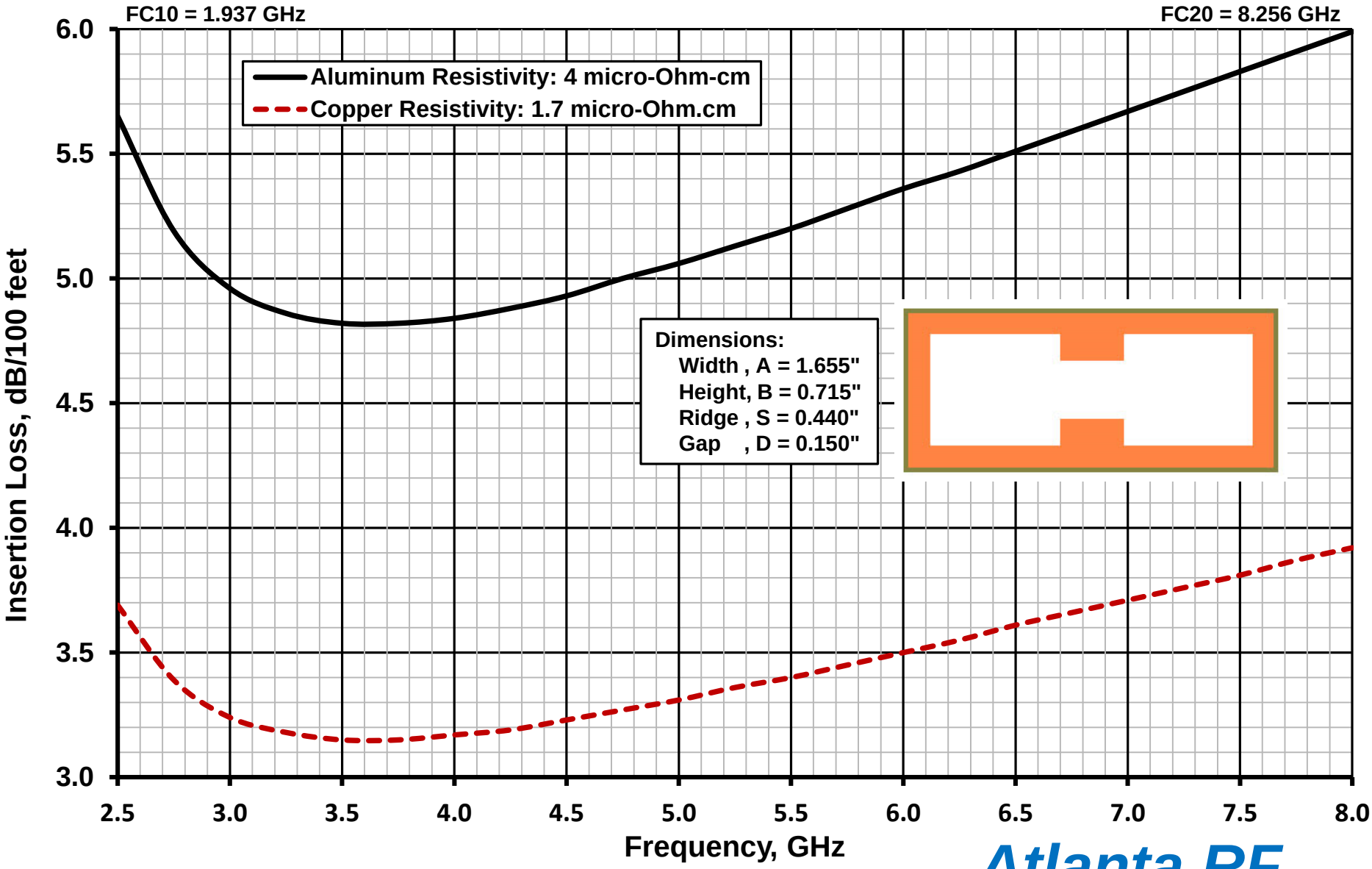
Insertion Loss: WRD-250D30 Double Ridge W/G (2.6 to 7.8 GHz)



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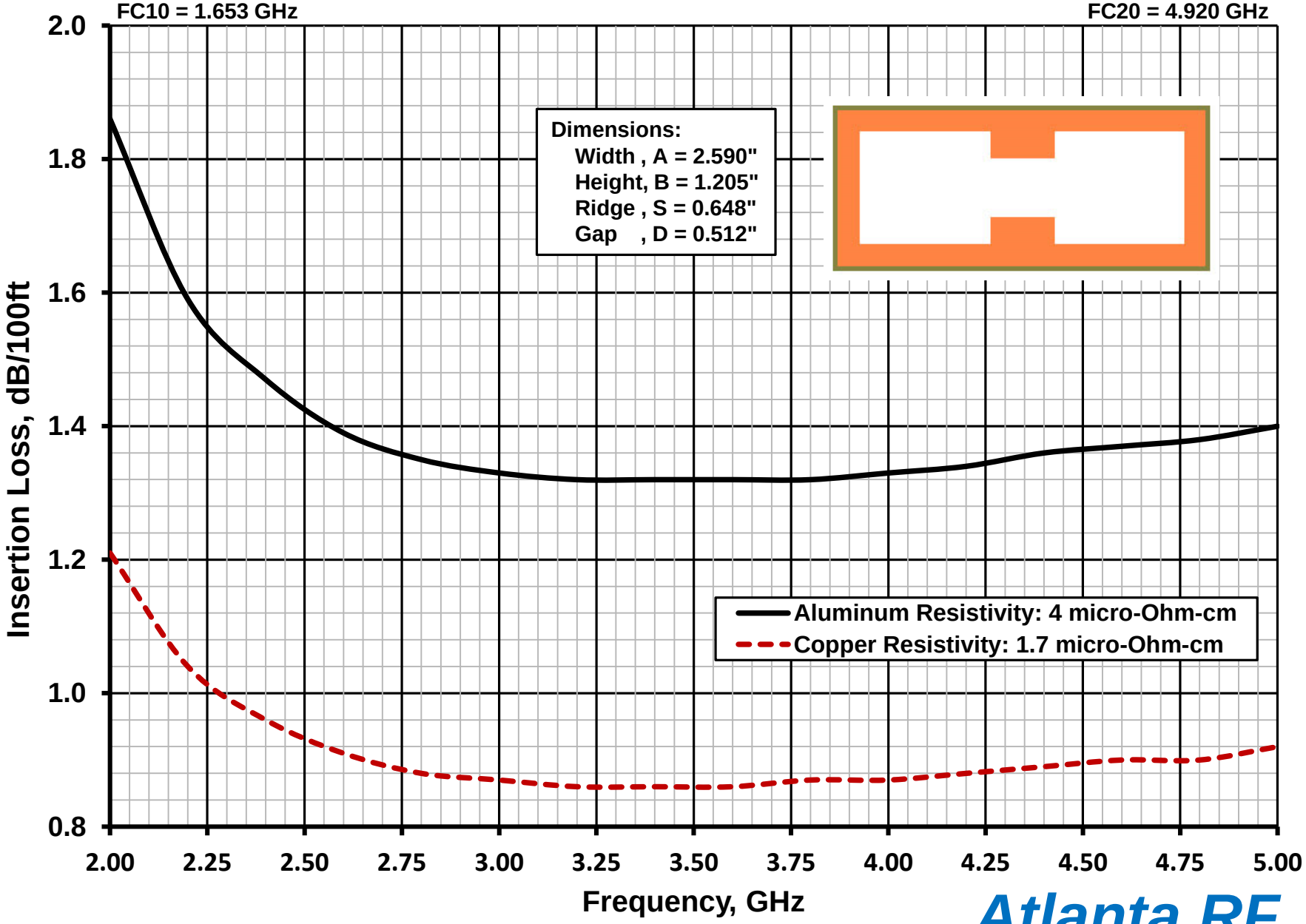
Insertion Loss: WRD-200D24 Double Ridge W/G (2 to 4.8 GHz)



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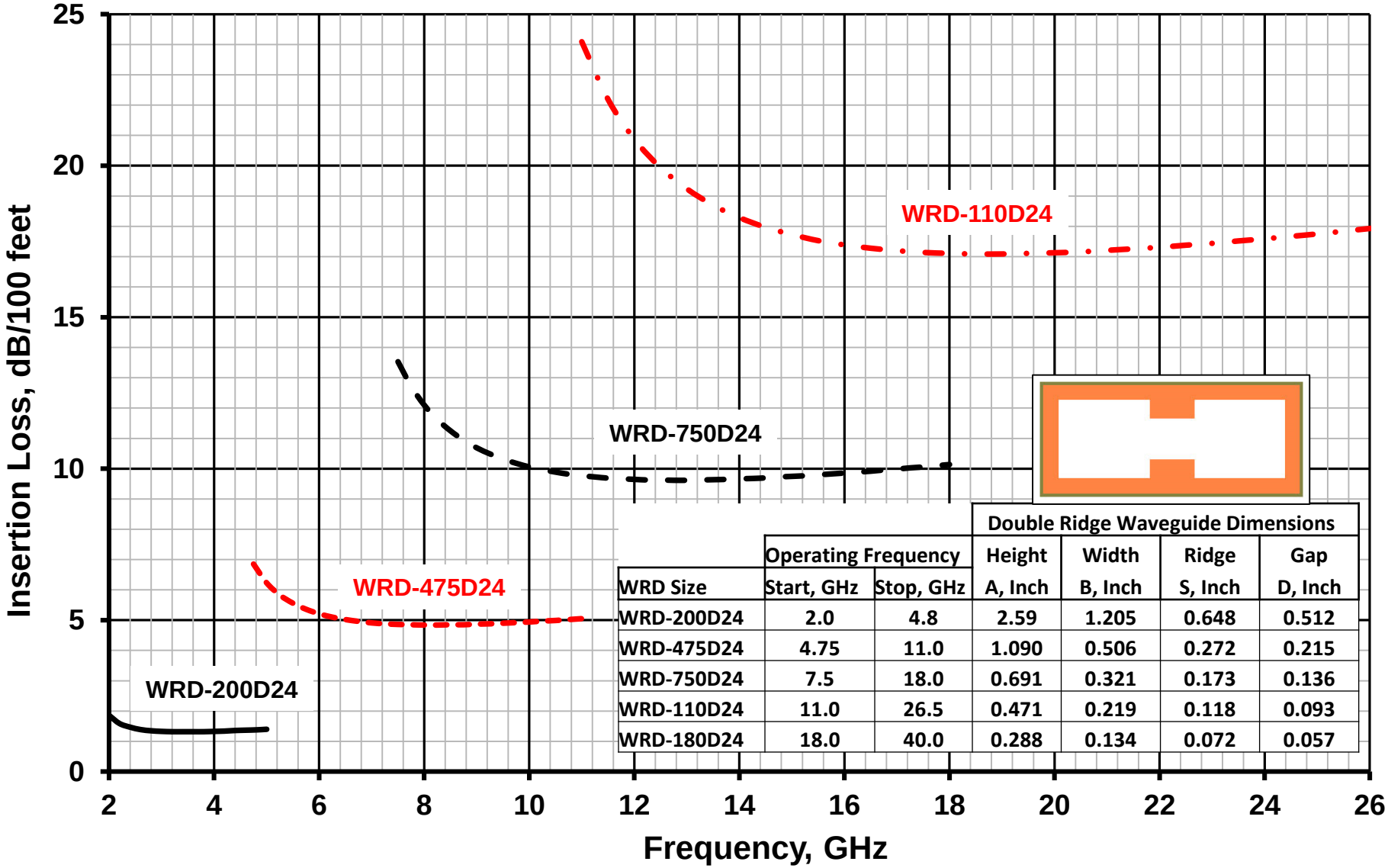
Insertion Loss of several Double Ridge Waveguides



WRD Size	Operating Frequency Start, GHz	Operating Frequency Stop, GHz	Double Ridge Waveguide Dimensions Height A, Inch	Width B, Inch	Ridge S, Inch	Gap D, Inch
WRD-200D24	2.0	4.8	2.59	1.205	0.648	0.512
WRD-475D24	4.75	11.0	1.090	0.506	0.272	0.215
WRD-750D24	7.5	18.0	0.691	0.321	0.173	0.136
WRD-110D24	11.0	26.5	0.471	0.219	0.118	0.093
WRD-180D24	18.0	40.0	0.288	0.134	0.072	0.057

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Summary

Insertion Loss of Double Ridge Waveguide

1. The insertion loss of popular double ridge waveguide, which operates across the frequency range: 2 GHz thru 40 GHz, is graphed based on its fabrication from 2 popular base metals: 6061 aluminum alloy and OFHC copper.
2. The insertion loss profile of double ridge waveguide is not monotonic versus frequency, which contrasts the monotonic insertion loss profile produced by standard rectangular waveguide versus frequency.
3. The electrical performance, including insertion loss, thru standard and custom-designed double ridge and single ridge waveguide, can be calculated using Atlanta RF's software product: WRDguide.

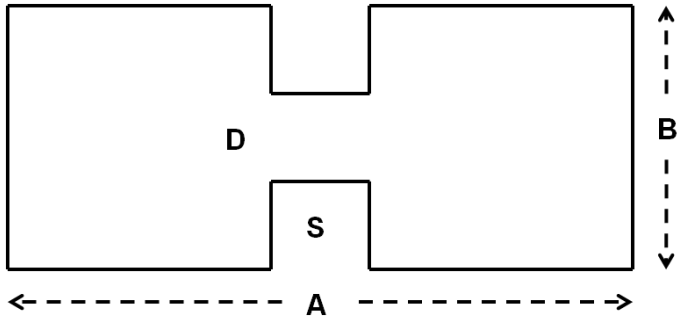
Atlanta RF Software: Double Ridge Waveguide

Where Synthesis enables Analysis ™

Software Product: WRDguide

Atlanta RF Software offers RF/microwave CAE software product: **WRDguide,** which performs dimensional synthesis and analysis of Double Ridge and Single Ridge Waveguide, and includes the following product features:

1. Synthesis of physical dimensions from User-selected WRD Impedance:
    a) Power-Voltage Impedance: Z(P,V).
    b) Voltage-Current Impedance: Z(V,I).
    c) Power-Current Impedance: Z(P,I). . . . . perhaps the best choice!
2. Analysis of Impedances from known ridge waveguide dimensions.
3. Sensitivity Analysis of Impedance to:
    a) Waveguide width: A.
    b) Waveguide Height: B.
    c) Ridge Gap: D.
    d) Ridge Width: S.
4. Response profile versus Frequency of:
    a) WRD Impedance: Z(P,V), Z(V,I) and Z(P,I) versus Frequency.
    b) Guide wavelength versus Frequency.
    c) Conductor losses versus Frequency (Resistivity & Surface Roughness).
    d) Unloaded Q (Qu) versus Frequency.
5. Percent of RF power between the Ridge Gap: D.
6. Default values for each User-entered input data.
7. Output Data stored on your hard drive for graphical plots.



Software product: **WRDguide** can readily synthesize & analyze all standard Ridge Waveguide cross-sections, plus allow the User to develop new and custom WRD cross-sections that operate across broader operating Frequency ranges. **WRDguide** is useful when developing Double Ridge Waveguide products, like: Magic Tees; transitions to coax/microstrip/stripline; impedance-matching circuits, and many other WRD applications.

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Sample Output: Frequency Analysis of WRD-750

RF Software Product: WRDguide

WRDguide (v. 1.2) Date:10/18/2014 at 15:40:33 Hours

RF/Microwave Computer-Aided Engineering Design Data For
DOUBLE Ridge Waveguide Transmission Lines:

Width,A = 0.6910" Frequency Analysis RES = 4.000

Height,B = 0.3210" ========== Roughness = 1.000 micro"

Gap,D = 0.1360" (OPTION 2) Ridge,S = 0.1730"

FC10 = 6.187 GHz FC20 = 18.445 GHz

	Wavelength		Guide Impedances					
Fre-Queny (GHz)	Free-Sp (In.)	Guide (In.)	Z(P,I) (Ohms)	Z(V,I) (Ohms)	Z(P,V) (Ohms)	Total Loss (dB/Ft)	Peak Power (kW)	Point of CP (In.)
7.50	1.5737	2.7841	241.44	276.56	316.78	0.1353	39.60	
8.00	1.4754	2.3272	215.27	246.58	282.45	0.1210	44.41	
9.00	1.3114	1.8058	187.92	215.25	246.55	0.1069	50.88	
10.00	1.1803	1.5023	173.71	198.98	227.92	0.1006	55.04	
11.00	1.0730	1.2977	165.06	189.06	216.56	0.0977	57.93	
12.00	0.9836	1.1479	159.28	182.44	208.97	0.0965	60.03	0.1845
13.00	0.9079	1.0323	155.18	177.74	203.59	0.0962	61.62	0.1631
14.00	0.8431	0.9398	152.14	174.26	199.61	0.0967	62.85	0.1481
15.00	0.7869	0.8638	149.81	171.60	196.56	0.0975	63.82	0.1364
16.00	0.7377	0.7999	147.99	169.51	194.16	0.0986	64.61	0.1265
17.00	0.6943	0.7454	146.52	167.83	192.24	0.0999	65.25	0.1182
18.00	0.6557	0.6983	145.33	166.47	190.68	0.1014	65.79	0.1109

Output Data stored in User filename: WRD750Alum1.xls

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Atlanta RF LLC was founded to provide engineering solutions, design software solutions, and product development solutions to the high-frequency RF/microwave industry in the areas of: Telecommunications (ground segment), Satellite (space segment) and military/defense (RF front-ends).

Through teamwork, Atlanta RF applies our diverse technical experience to your project's challenges with creative and innovative solutions while holding ourselves accountable fo the results. With professionalism and commitment to our clients, Atlanta RF will be there for you, both today and tomorrow.

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- Atlanta RF ***Software*** : **Sales@AtlantaRF.com**
- Atlanta RF ***Designs*** : **Designs@AtlantaRF.com**

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4. Link Budget: Digital Modulation Part 1 (Overview & M-ASK).
5. Link Budget: Digital Modulation Part 2 (M-FSK).
6. Link Budget: Digital Modulation Part 3 (M-PSK & QAM).
7. Link Budget: Error Control & Detection.
8. Multiple Access Techniques: FDMA, TDMA and CDMA.
9. Insertion Loss: Double Ridge Waveguide.
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12. Parallel Coupled Bandpass Filters.

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