



Insertion Loss: Double Ridge Waveguide

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Insertion Loss of Double Ridge Waveguide (WRD)

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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: $F_{\text{low}} / F_{\text{high}} = 2.4:1$ to $3.0:1$.
 - A. For example, standard WRD-750 operates across the frequency range: 7.5 to 18 GHz, so its bandwidth ratio = $18/7.5 = 2.4 \rightarrow$ WRD-750D24.
 - B. Standard WRD-250 operates across the frequency range: 2.6 to 7.8 GHz, so its frequency bandwidth ratio = $7.8/2.6 = 3.0 \rightarrow$ 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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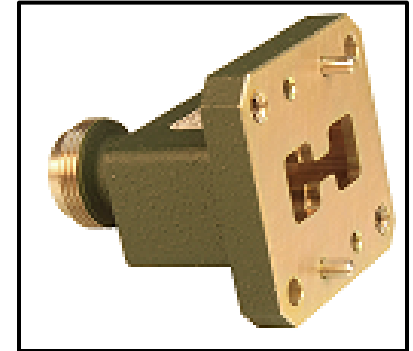
Some RF Components in Double Ridge Waveguide (and many others too)



WRD Ferrite Circulator



Extruded Copper
Double Ridge Waveguide



End Launched Adaptor



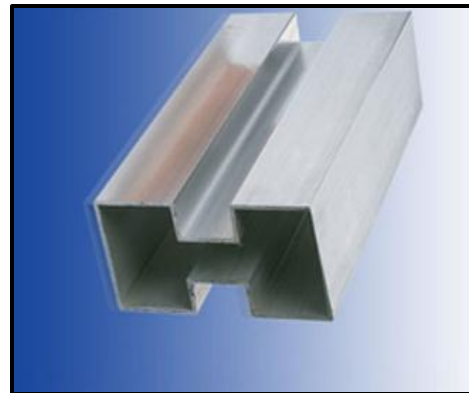
Cross-Guide Coupler



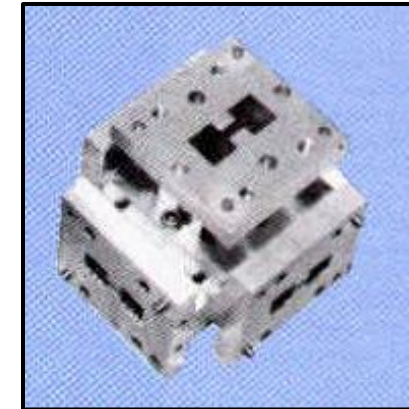
WRD Termination



Dual Loop Coupler



Extruded Aluminum
Double Ridge Waveguide



4-port Magic Tee

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Insertion Loss Calculation: Ridge Waveguide

The insertion loss of ridge waveguide is calculated as:

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

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

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

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

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

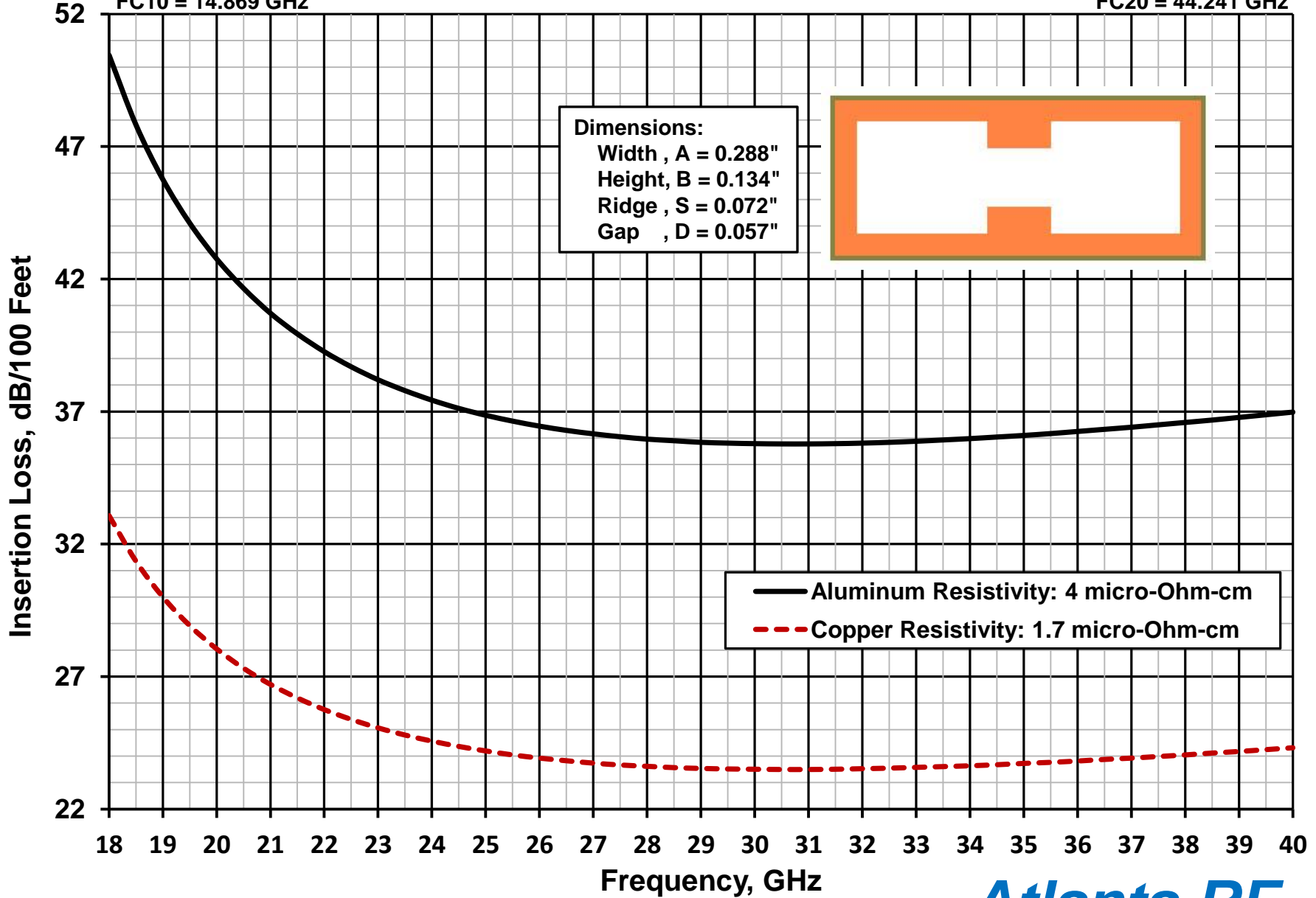
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Insertion Loss: WRD-180D24 Double Ridge W/G (18 to 40 GHz)

FC10 = 14.869 GHz

FC20 = 44.241 GHz



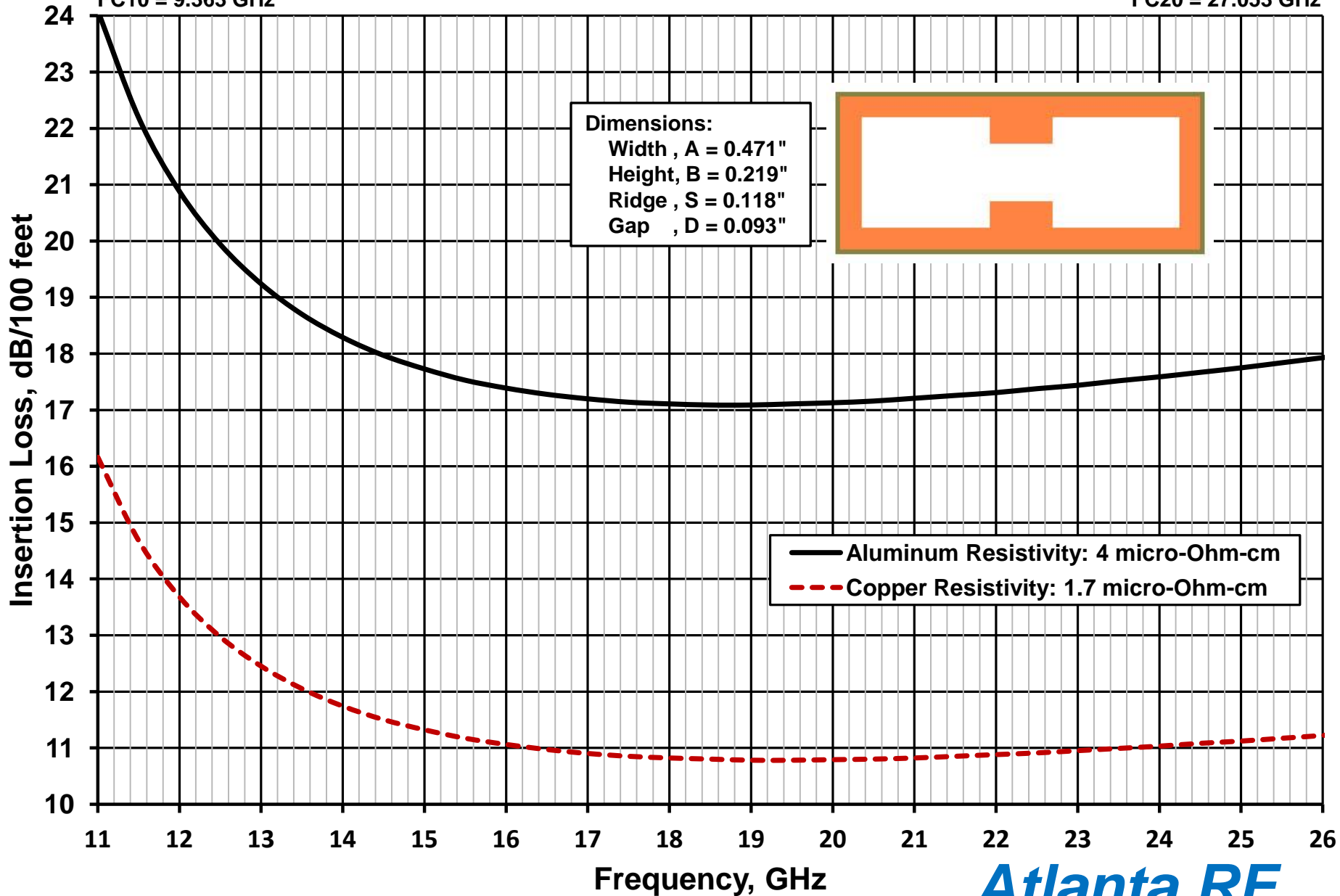
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Insertion Loss: WRD-110D24 Double Ridge W/G (11 to 26.5GHz)

FC10 = 9.363 GHz

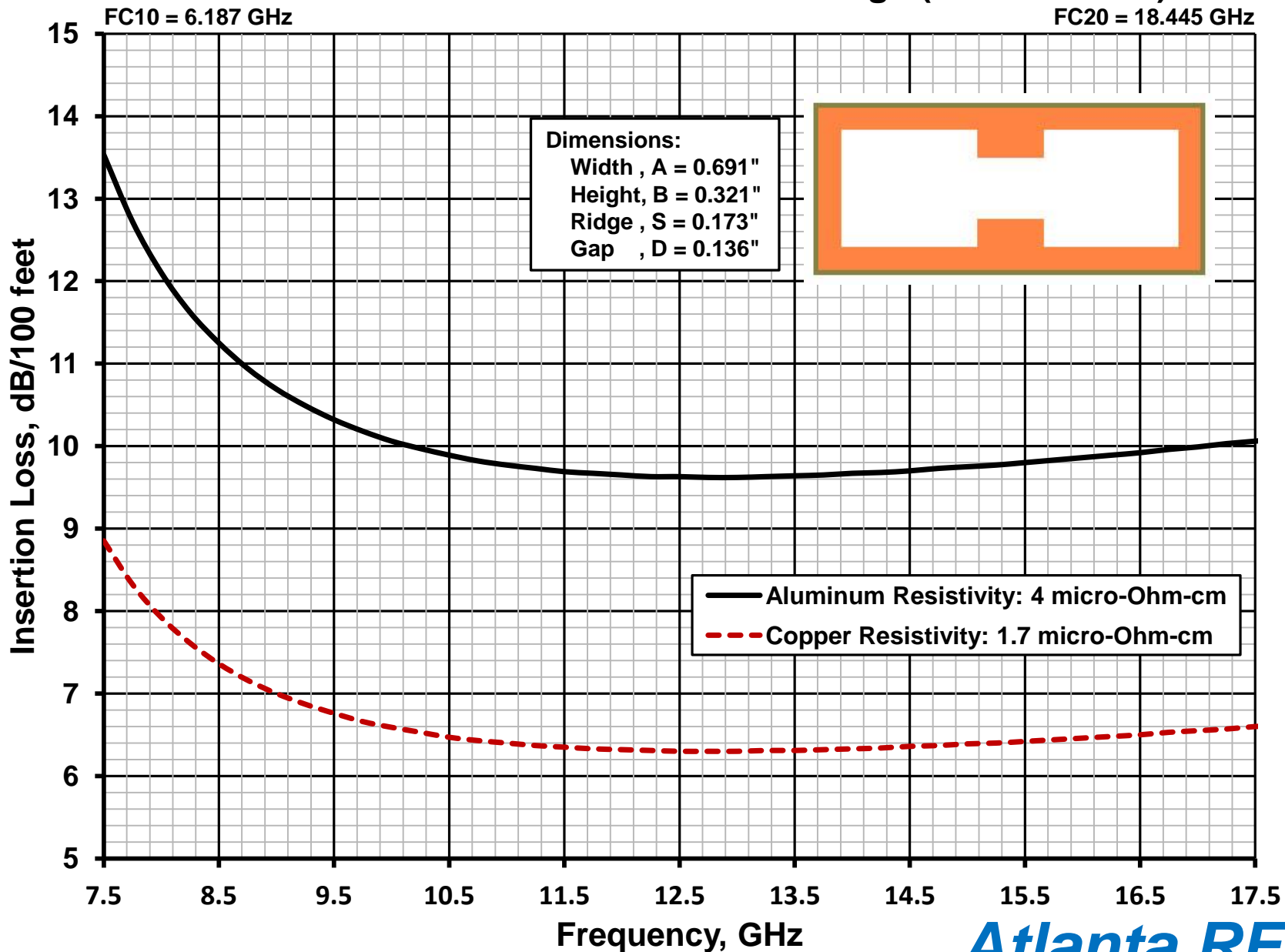
FC20 = 27.053 GHz



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



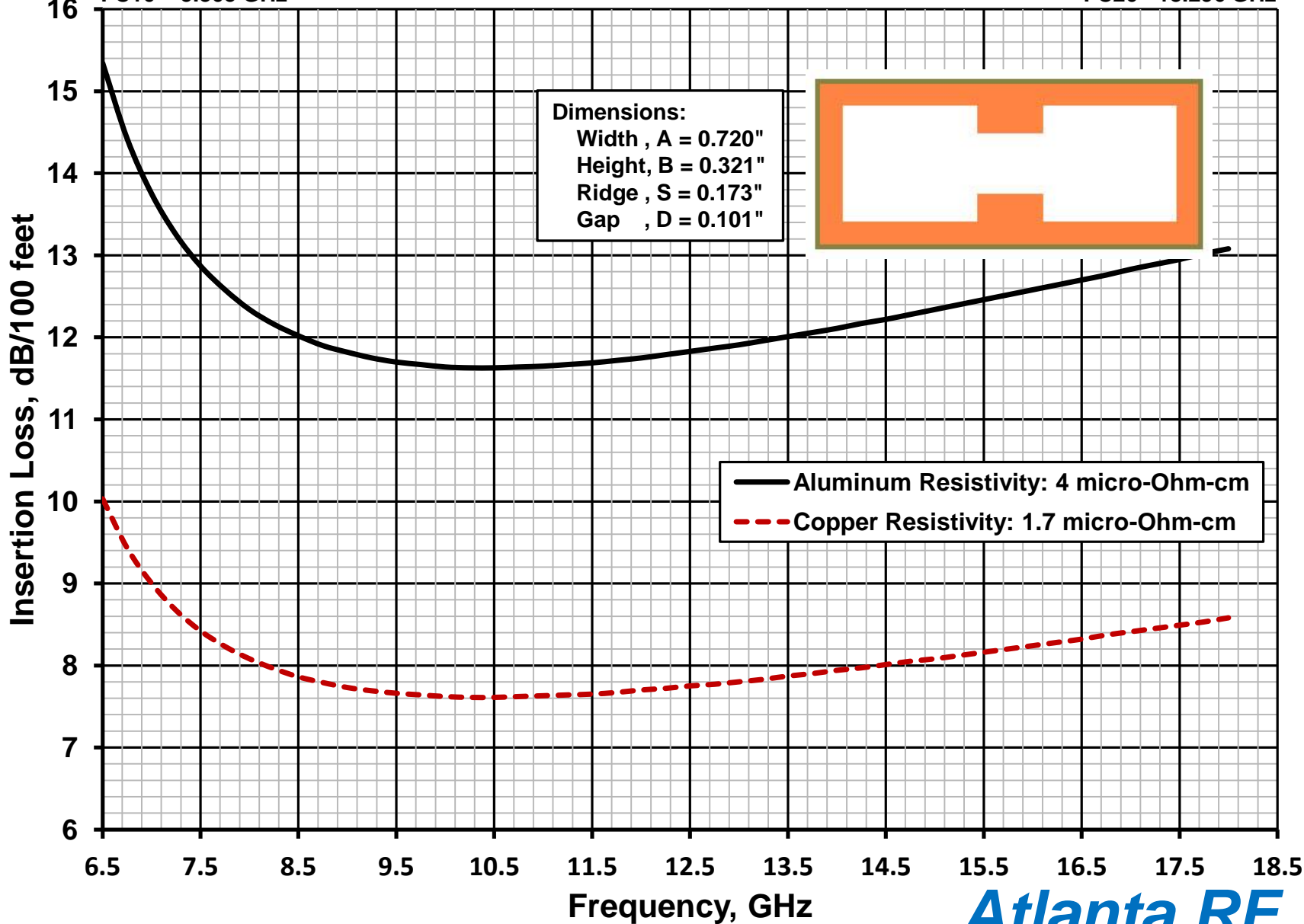
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Insertion Loss: WRD-650D28 Double Ridge (6.5 to 18 GHz)

FC10 = 5.305 GHz

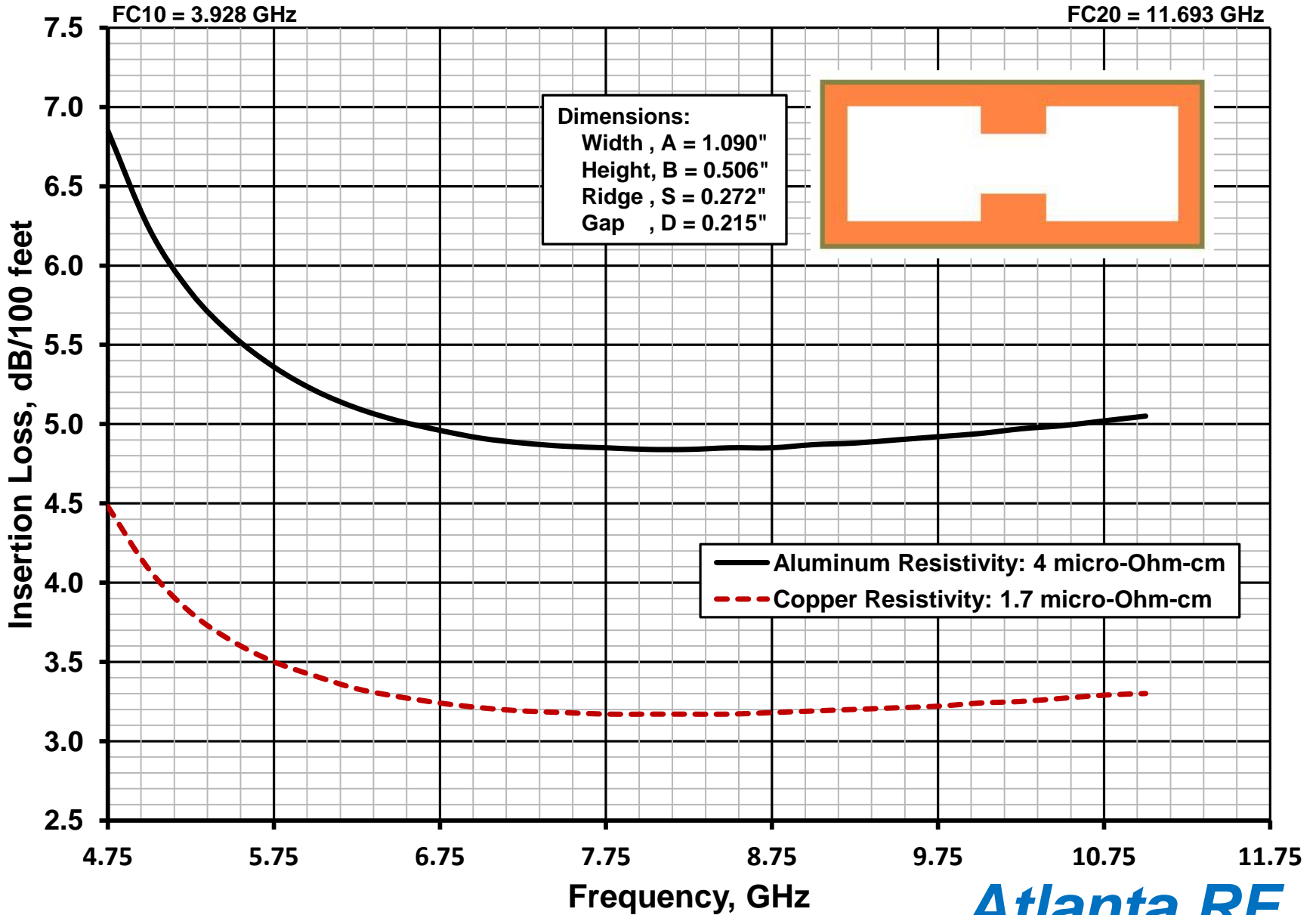
FC20 = 18.296 GHz



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



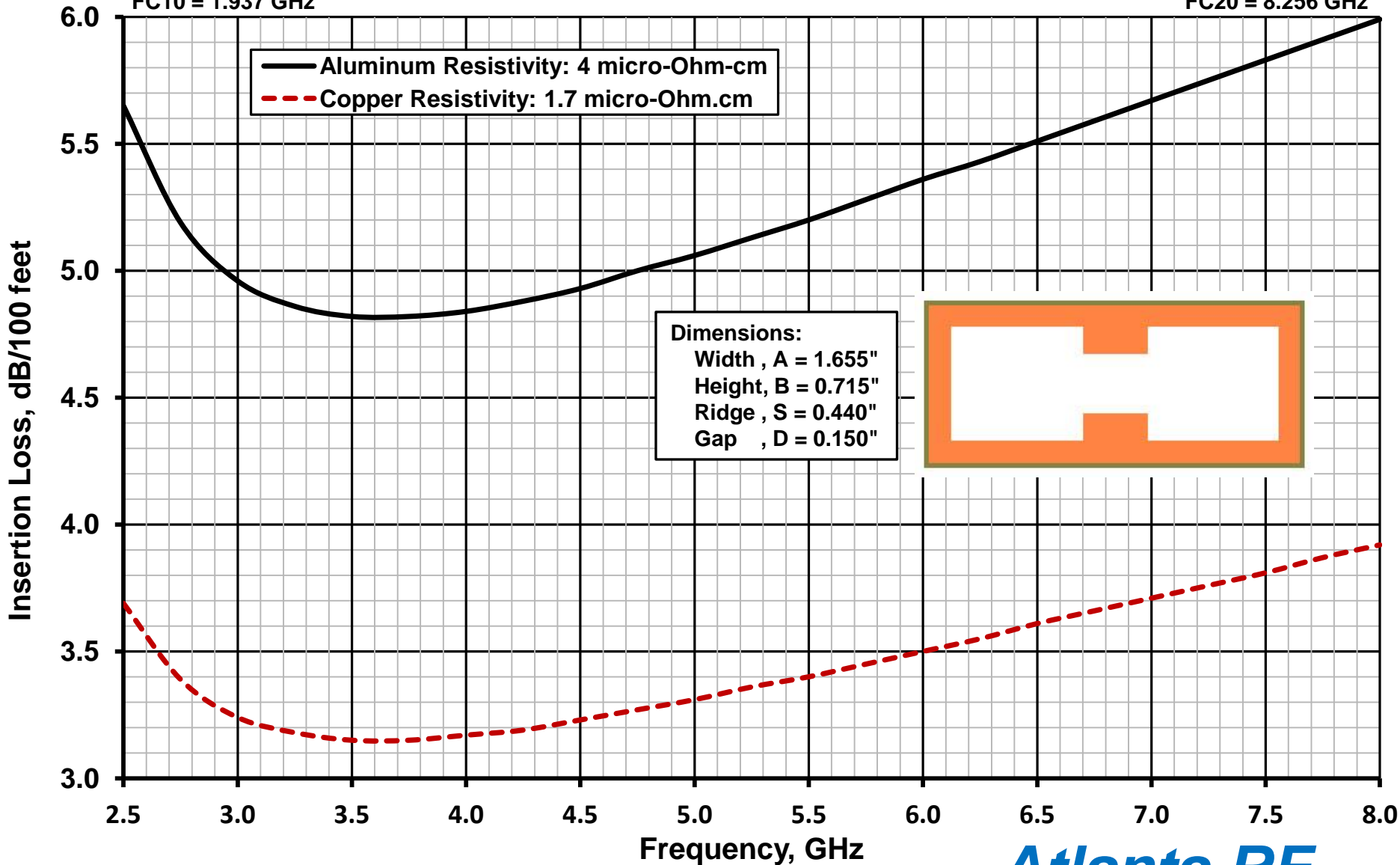
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Insertion Loss: WRD-250D30 Double Ridge W/G (2.6 to 7.8 GHz)

FC10 = 1.937 GHz

FC20 = 8.256 GHz



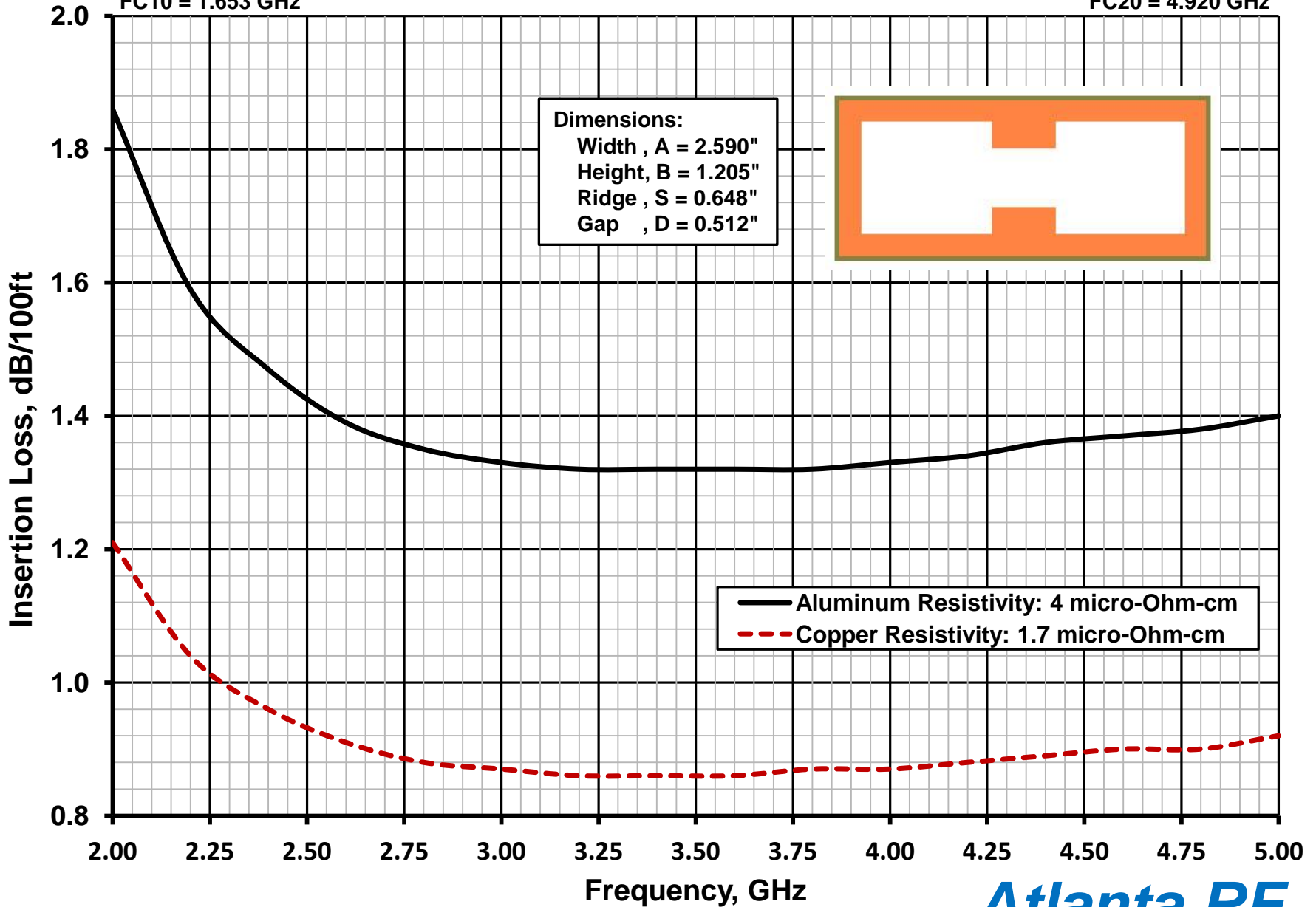
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Insertion Loss: WRD-200D24 Double Ridge W/G (2 to 4.8 GHz)

FC10 = 1.653 GHz

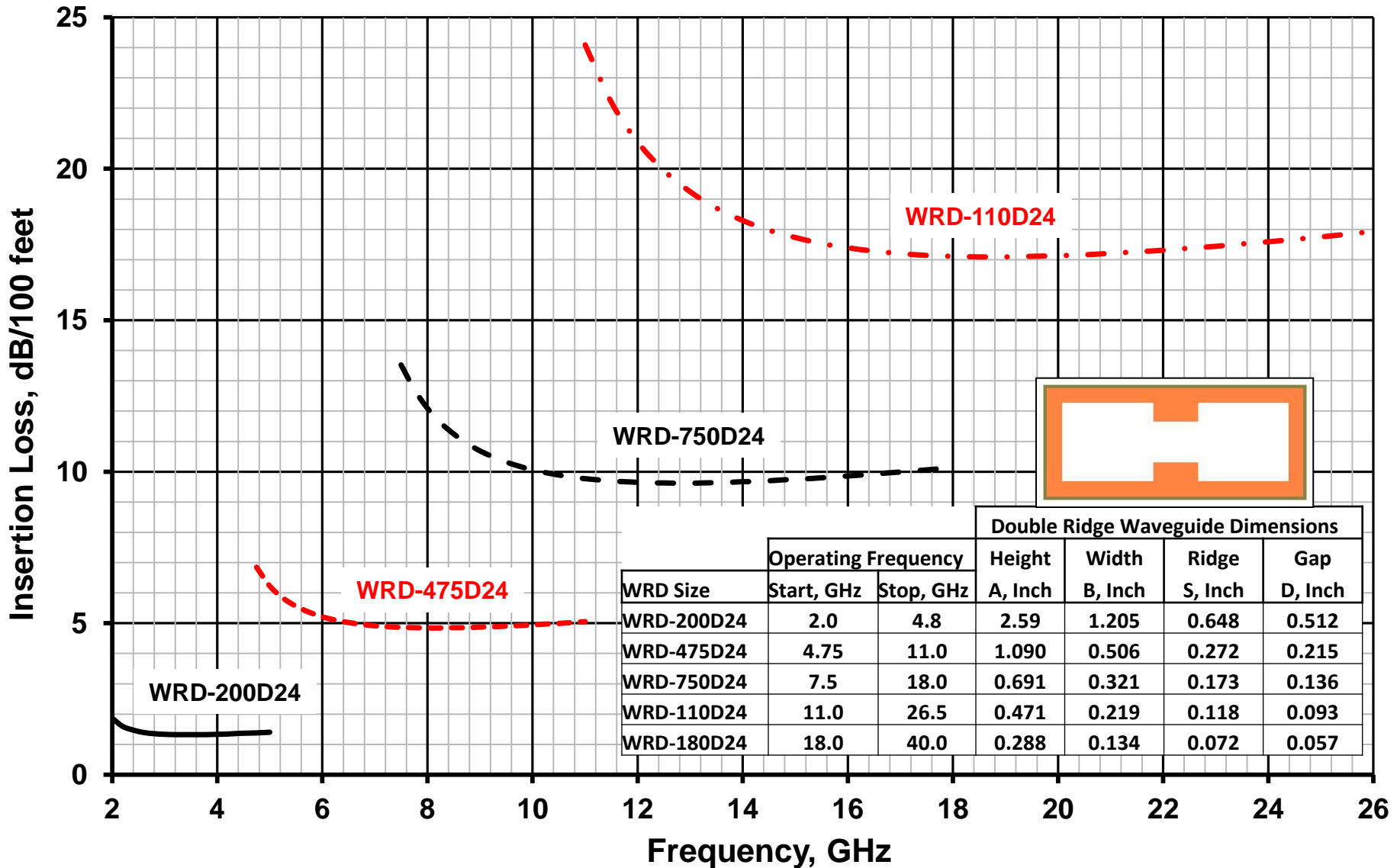
FC20 = 4.920 GHz



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Insertion Loss of several Double Ridge Waveguides



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.



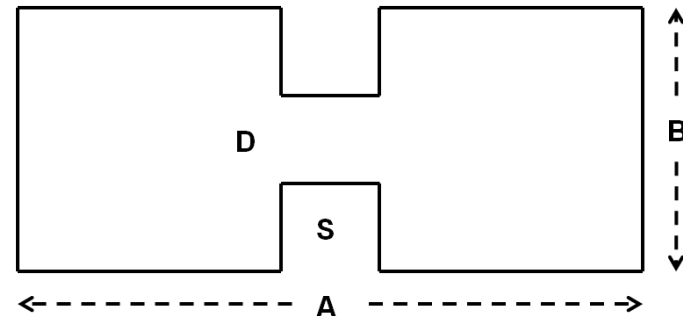
Atlanta RF *Software*: Double Ridge Waveguide

*Where Synthesis enables Analysis*TM

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 (Q_u) 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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Thank You!

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