

# **CPI**

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# **SUPERLINEAR® HPA**

### ***What is a SuperLinear® HPA?***

"SuperLinear" is a trade name for a product line of special Traveling Wave Tube Amplifiers created by CPI Satcom Division. This family of amplifiers exhibits superior operating characteristics (including better prime power efficiency) compared to both solid state amplifiers and traditional TWTAs when the amplifiers are running at linear output power levels.

### ***What superior characteristics do SuperLinear® HPAs possess?***

The main one is efficiency. SuperLinear TWTAs range in efficiency (prime to output power) from 13% for lower power models to over 22% for 2500 W HPAs. For instance, a Ka-band SuperLinear TWTA designed to produce 40 W of linear power at the flange (i.e. the operating point where third order intermodulation = -25 dBc with two equal carriers) requires only 300 W of prime power to do so. Similar high power Solid State Power Amplifiers, which can only provide 25 W of linear power, require over 550 W of prime power, an efficiency of just 4.5%! The high efficiency of SuperLinear amplifiers bears itself out in many ways: SuperLinear HPAs are far lighter per watt of output; they consume less energy; and since they generate far less heat than SSPAs or traditional TWTAs, they are better suited to operate in a hotter environment.

### ***A Comparison: Conversion Efficiency in High Power Amplifiers at the Linear RF Operating Point***

In a typical uplink application, it is important to meet RF operating linearity requirements (IM3, NPR, ACPR). To achieve this, traditional TWTAs and SSPAs must operate at output power levels well below  $P_{sat}$  and P1dB. CPI SuperLinear TWTAs are optimized to operate at linear power - the power level you really use! In most applications the ability to operate between linear power and P1dB or  $P_{sat}$  is a wasted asset. Table 1 (next page) shows how much more efficient CPI SuperLinear amplifiers are during operation compared to both SSPAs and traditional TWTAs. The comparison provided is among outdoor (ODU) amplifiers in the X, Ku and Ka-bands, ranging in RF peak power levels from 50 to 500 watts.



	Frequency	SuperLinear TWTAs	Traditional TWTAs	Solid State PAs
<b>P1dB or Peak Power</b>	<i>Ka-band</i>	150 W	150 W	50 W
	<i>Ku-band</i>	250 W	200 W	80 W
	<i>X-band</i>	500 W	400 W	200 W
<b>Linear Output Power</b>	<i>Ka-band</i>	40 W	50 W	25 W
	<i>Ku-band</i>	100 W	68 W	40 W
	<i>X-band</i>	200 W	140 W	125 W
<b>Power Consumption (typ) at Linear Output Power</b>	<i>Ka-band</i>	300 W	570 W	550 W
	<i>Ku-band</i>	400 W	620 W	600 W
	<i>X-band</i>	650 W	1350 W	1050 W
<b>Prime Power to Linear Output Power Efficiency</b>	<i>Ka-band</i>	<b>13.3%</b>	8.8%	4.5%
	<i>Ku-band</i>	<b>25.0%</b>	11.0%	6.7%
	<i>X-band</i>	<b>30.1%</b>	10.3%	11.9%

Table 1. Conversion Efficiency Comparison

Efficiency is calculated by dividing linear output power by prime power consumption. The analysis shows that SuperLinear TWTAs are by far the most efficient uplink amplifiers on the market. This efficiency manifests itself in several ways. When an amplifier is more efficient, it can weigh less and be smaller, due to less power dissipation allowing for a reduced cooling circuit. Table 2 below shows those comparisons.

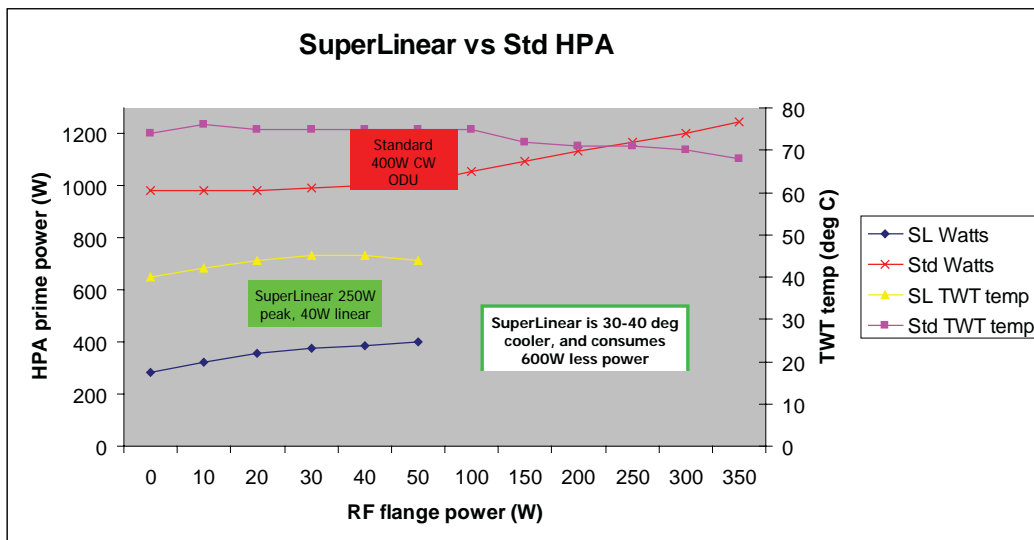
	Frequency	SuperLinear TWTAs	Traditional TWTAs	Solid State PAs
<b>Linear Output Power</b>	<i>Ka-band</i>	40 W	50 W	25 W
	<i>Ku-band</i>	100 W	68 W	40 W
	<i>X-band</i>	200 W	140 W	125 W
<b>Linear Output Power per Pound (kg)</b>	<i>Ka-band</i>	<b>1.38 W (3.03 W)</b>	1.12 W (2.46 W)	0.78 W (1.72 W)
	<i>Ku-band</i>	<b>4.00 W (8.77 W)</b>	2.72 W (5.96 W)	1.67 W (3.67 W)
	<i>X-band</i>	<b>6.25 W (13.79 W)</b>	2.55 W (5.60 W)	3.68 W (8.06 W)
<b>Linear Output Power per Cubic Inch (cm)</b>	<i>Ka-band</i>	<b>.028 W (.0108 W)</b>	.026 W (.0101 W)	.022 W (.0086 W)
	<i>Ku-band</i>	<b>.092 W (.0363 W)</b>	.062 W (.0238 W)	.066 W (.0262 W)
	<i>X-band</i>	<b>.132 W (.0519 W)</b>	.063 W (.0250 W)	.124 W (.0488 W)

Table 2. Weight and Size Comparison Per Linear Watt Generated

## Amplifier Reliability, Lifetime Cost

There are claims in the market that solid state amplifiers are more reliable than traditional traveling wave tube amplifiers, resulting in lower lifetime costs for solid state. In fact, the only study ever done comparing the two technologies shows that there is almost no difference in MTBF or lifetime reliability between the two. Further, SuperLinear HPAs are more advanced than traditional TWTAs and SSPAs, offering even higher MTBF.

Consider the question of heat. Heat is often the primary cause of failures in TWTAs and SSPAs. SuperLinear TWTAs experience a temperature reduction of at least 30 degrees C over comparable TWTAs, and even more over comparable SSPAs. It is estimated (MIL 217F) that this will result in an MTBF increase of 2-4 times over traditional TWTAs. See the graph below showing relative operating temperatures for SuperLinear TWTAs versus traditional TWTAs.



## Contact Us

Interested in learning further how SuperLinear TWTAs could work for you? Please **contact us**.