Via Satellite's

Tech Focus REPORT

COTM Drives Wideband Ku **Amplifiers At Half The Size**

UAVs, Comms-On-The-Move and similar applications are driving the need for smaller, lighter, more powerful SATCOM RF amplifiers. By leveraging a combination of advances, CVG-Avtec, a Kratos company, has broken through the old barriers to produce SSPAs and BUCs that are as much as 80% smaller and lighter, consume as much as 70% less power and operate over greater bandwidths than other SSPAs.

CVG-Avtec 50w BUC
Actual Size

CVG-AVTEC
A KRATOS Company

Access Intelligence

Smaller, Lighter, More Efficient Amplifiers

When it comes to Communications-On-The-Move (COTM) and SATCOM-On-The-Move (SOTM), component devices can never be too small, too light or too efficient – as long as they are also reliable and cost-effective. Maximizing these values is an ongoing goal for SATCOM engineers.

Size, weight and power (SWAP) in SSPAs and BUCs has been improving in recent years, though incrementally. CVG-Avtec, a Kratos company, has leapfrogged these incremental gains to achieve significant advances including 40 percent to 80 percent less weight, 40 percent to 80 percent smaller size and 20 percent to 70 percent lower power consumption compared to competitive units.

CVG-Avtec achieved these results by engineering for the best balance across three critical operating factors: thermal performance, output path loss and management of impedance transformation (figure 1). Previous solutions have tended to optimize for one factor, forcing trade-offs in the others. CVG-Avtec's balanced architecture optimizes for total system size and performance, starting with heat management, a challenge that seems so fundamental that its full impact is often underestimated.

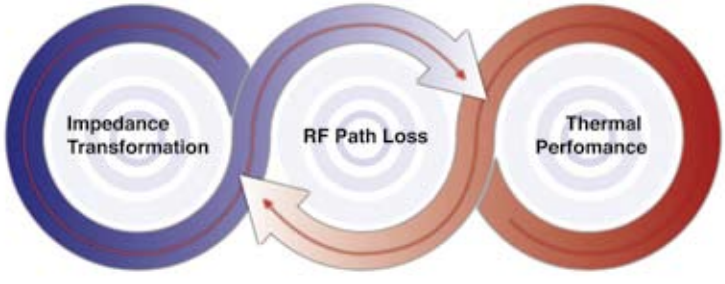

Figure 1: CVG-Avtec' architecture finds the best balance across three critical and interdependent design factors to achieve significant advantage in size, weight, power and efficiency.

Lower Heat Leads To Less Weight and Power Drain

SATCOM professionals are usually surprised to learn that typical SSPA systems run at less than 10 percent efficiency and rarely higher than 20 percent. This means, for example, that to achieve 40 Watts of RF power they must draw upwards of 400 Watts, wasting some 360 Watts as heat. Greater heat requires a heavier power supply/converter and cooling system, which adds size, weight and cost to the device. The problem is particularly debilitating in mobile applications where air temperatures can be significantly above ambient in an enclosed area such as a radome.

To manage heat better, CVG-Avtec uses a proprietary method where the transistor die are attached to a thermally conductive heat pipe structure, injecting the amplified signal into an internal waveguide. This runs the amplifier transistors as cool as possible, decreasing local thermal resistance around the area of the devices (where most of the heat rise occurs) and enabling simpler cooling systems and surer operations under higher ambient temperature conditions. This has the added advantage of allowing the units to perform more effectively in hotter environments.

An additional benefit of CVG-Avtec's thermal performance method is greater overall unit efficiency, as high as 24 percent to 30 percent. This is dramatically better than older amplifiers, as much as 70 percent better, and at least 20 percent better than newer-style amplifiers that use quasi-optical or spatial power combining construction. In contrast to CVG-Avtec's method, those types of amplifiers suspend the transistor die in the waveguide channel and rely on heat dissipation through indirect paths. Not only is this less efficient, but during operation the transistor channel in these devices quickly heats up, reducing efficiency even further, adding to the overall heat of the system and, in turn, further degrading the efficiency of the transistors. CVG-Avtec amplifiers show as much as a five-fold decrease in local thermal resistance compared to these types of systems.

Increasing Power By Reducing Output RF Path Loss

The relationship between thermal performance and RF path loss is a good example of why CVG-Avtec's balanced architecture outperforms other strategies when it comes to total SWAP and efficiency. As with all designs, CVG-Avtec's thermal management construction method has a trade-off, but in this case it means giving up barely one-tenth of a dB benefit in RF path loss versus spatial combining techniques. This is a trivial cost when totaled with a five-fold improvement in thermal performance as well as greater overall efficiency.

In fact, CVG-Avtec holds total RF insertion loss from the outputs of the semiconductors to the SSPA's waveguide output to a remarkably low 0.2dB (or less) using an innovative vertical output signal propagation method. This is accomplished through careful electromagnetic design of propagating structures and by avoiding the use of resonant impedance matching. As a result, almost every Watt produced by the semiconductor devices is faithfully delivered to the output port.

A More Practical Combining Architecture

The third leg of CVG-Avtec's enhanced architecture moderates impedance transformation, a critical factor that in other products drives heat and path loss penalties even higher.

All SSPAs and BUCs are based on transistors, which by their nature operate at voltages as low as single-digits. The only way to get large amounts of power from these transistors is to boost the current by increasing the device area – the equivalent of connecting many smaller transistors in parallel. Figure 2 provides a simplified example of this problem using standard circuit symbols that will be familiar to all electrical engineers (the actual implementation is a bit more complex at microwave frequencies, however the underlying principle is the same).

As shown in the top row of the diagram, typical amplifiers add devices in parallel, combining the AC currents of all devices. This produces a large current and very low impedance. Unfortunately, low impedances with high currents create much greater Ohmic dissipation in metal, thus generating RF loss as heat and adding to the SWAP and efficiency challenge – once again, a trade-off.

CVG-Avtec avoids this problem by

implementing ultra-low-loss power combiners, which increase voltage amplitude rather than current amplitude. Impedance increases naturally at each step moving from the devices to the SSPA port. This stands in contrast to typical architectures such as a Wilkinson where the impedance usually steps down at each power combining and then is brought back up by a quarter wave transformer. Not only is the CVG-Avtec process significantly more efficient, it entirely eliminates the need for the transformers, which are an additional cause of RF path loss.

Support for Unique and Wide Band Applications

Because its architecture eliminates lossy resonant-impedance-transformers CVG-Avtec's amplifiers maintain exceptional performance over extremely wide bandwidths, producing advantages that are particularly useful for mobile missions.

A typical transformer's bandwidth limitations are most pronounced at the edges of its resonant band, producing a double penalty in which the dissipative losses are added to the losses from the roll-off in bandwidth. Since CVG-Avtec avoids using transformers, full power is delivered over a much wider frequency band. So, where other amplifiers will experience performance degradation the closer they get to the band edges, CVG-Avtec devices have no roll-off over the range of typical SATCOM Ku-band applications.

In addition, while most Ku-band satellite amplifiers are designed to operate in only one of the Ku uplink transmission bands, either 14.0-14.5 GHz (Standard Band) or 13.75-14.5 GHz (Extended Band), CVG-Avtec amplifiers operate in the much wider range of 13.0-17.2 GHz. As a result, they support applications such as Common Data Link (CDL) and radar without needing redesign. CDL, which has been mandated by the Department of Defense for most ISR uses, typically operates in the 14.4-15.35 GHz band; and radar applications can operate up to 17 GHz or even higher. CVG-Avtec amplifiers support all these applications.

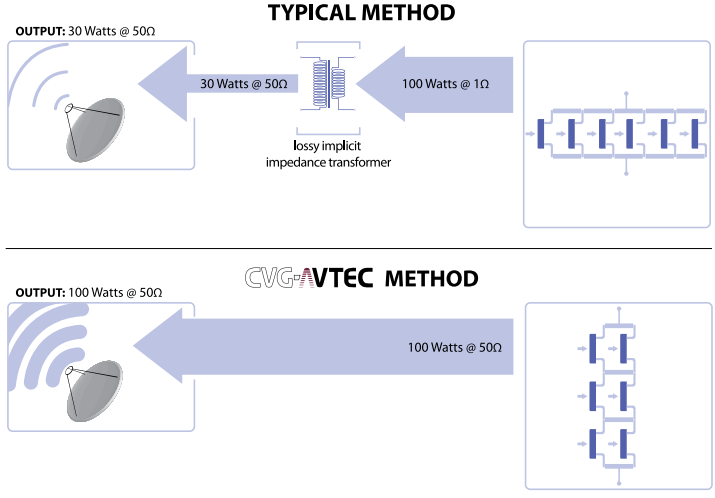

Figure 2: Typical SSPAs generate needed power by adding transistors in parallel, decreasing impedance and reducing efficiency. CVG-Avtec uses a design that is comparable to combining devices in both a serial and parallel structure that creates greater RF output power with less heat dissipation.

Pictured: CVG-Avtec's BUC-Ku100. CVG-Avtec makes Ku-band BUCs and SSPAs in five sizes, all with significant size/weight/power advantages.

Power (P1dB)	Component Configuration (LxWxH)	Total Size With Optional Fan (LxWxH)
25 Watts	5.25" x 3.15" x 3.25", 3.5 lbs	6.65" x 3.4" x 6.21", 5.0 lbs
40 Watts	5.25" x 3.15" x 3.75", 3.9 lbs	6.65" x 3.4" x 6.71", 5.4 lbs
50 Watts	5.25" x 3.15" x 3.75", 3.9 lbs	6.65" x 3.4" x 6.71", 5.4 lbs
100 Watts	11.7" x 5.3" x 3.65", 10 lbs	11.7" x 5.3" x 6.85", 15.3 lbs
200 Watts	13.1" x 12.5" x 3.65", 22.5 lbs	13.1" x12.5" x 6.85", 33.2 lbs

Advanced Technology In A Fully Realized Product

CVG-Avtec's products are designed and manufactured to be reliable, capable and ready for a broad range of mission goals and environments. In addition to their size, weight, power and efficiency advantages they deliver features which maximize their utility in SOTM and COTM applications under real world conditions, including:

- **Temperature compensation to provide stable operation over a wide temperature range.** CVG-Avtec's thermal optimization and advanced temperature compensation architecture sustains gain and linear power output over a range of operating temperatures, typically -40 degrees to +70 degrees centigrade.

- **Reduced average power in low duty cycle applications.** Fast-switching features allow CVG-Avtec amplifiers to be turned off when transmission is not required, dramatically reducing power demand in platforms such as TDMA communications and pulsed-radar systems.

- **Compact, integrated power supplies.** High efficiency power supplies in all amplifiers

accommodate input voltages from 18 VDC to 56 VDC. A MIL-STD-1275D DC power supply with surge suppression is available today and AC power supplies will be available shortly.

· **Environmental Packaging.** Units are supplied with environmentally sealed housings and optional integrated cooling fans for additional thermal performance. A robust plug-in module design reduces assembly labor and improves vibration and shock tolerance.

· **Advanced Monitoring and Control Features** include reflected power monitor, isolation/self-protection to prevent damage from high signal reflections and gain control.

The Clear Advantage For SOTM And COTM Applications

When size, weight, power and efficiency are critical to mission operations, CVG-Avtec amplifiers offer industry-leading performance in a compact size, as much as 80 percent smaller and lighter than other solutions, with as much as 70 percent lower power consumption. That means, for example, UAVs employing CVG-Avtec amplifiers can have longer, more productive operations and ground missions can have greater range and flexibility. Battery operated systems employing these amplifiers will run longer and cooler, while having the ability to support more types of missions due to their ultra wide frequency range. This contributes to lower overall life-cycle costs, especially when combined with reduced power consumption. ■

For more information about CVG-Avtec's full line of Ku SSPAs and BUCs, as well as VSATs, microsats, maritime, airborne and OTM solutions, please contact info@avtec.com or visit www.avtec.com