2020: A great year for amplifiers

Amplifiers play a fundamental but often overlooked role in satellite communications across the globe; without them, we wouldn't have access to broadcast television, essential communications, high-speed connectivity on the move or in remote and rural locations, etc. The list could go on almost indefinitely. Naturally, amplifier technology has come in fits and starts over the years, and this is no exception even in times of global pandemic.

Amy Saunders, Editor, Satellite Evolution Group

Amplifiers are just one of the necessary but often overlooked and poorly understood elements which are absolutely critical for effective and efficient satellite communications. Like consumers who largely take for granted that they have mobile phones and high-speed Internet connectivity working in their homes without ever troubling themselves over how they actually work, amplifiers retain an almost mystical air about them – they work, so we can ignore them.

Amplifier technology itself has come on in leaps and bounds since I joined the satellite sector some five years ago. From travelling wave tube amplifiers (TWTAs), vacuum tube amplifiers, magnetic amplifiers, and now, solid state power amplifiers (SSPAs), the market is bursting with new technologies to meet every application need imaginable.

Moving' on up

As the satellite sector increasingly looks to higher and higher frequency bands (Ku, Ka, and now Q and V) for a whole host of applications, amplifier technology much match that pace to ensure that the ecosystem works together to advance.

Higher frequency bands are ideal for the next generation of HTS systems, enabling the gateway traffic to go up to the satellite at higher frequencies, opening more Ka-band spectrum for users. V-band also has 4GHz of allocated spectrum, which is a considerable increase in available bandwidth. The increase in the spectrum, coupled with spot-beams on the spacecraft can reduce the cost per bit enabling a wide range of new applications and services.

The move to Q and V-bands is still very much underway, with Comtech Xicom beating others to the punch in 2019 when it shipped the world's first 250W V-band TWTAs for a commercial high throughput satellite gateway application; the XTD-250QV is a compact self-contained 250W liquid cooled TWTA featuring 80W of linear power across 47.2 to 51.4GHz. Cooling and monitor and control systems are all self-contained within the amplifier, which comes complete with multiple options including redundant configurations, preamplifiers with fixed or variable gain.

Products hot off the press

Despite the crazy heights of the COVID-19 pandemic, manufactures have continued to roll out hot new amplifier

Photo courtesy of Mission Microwave

products targeting a variety of end use applications.

Mission Microwave

In March, Mission Microwave Technologies introduced a new family of Ka-band high power products. The new wide-band Ka-band SSPAs were designed to support LEO, MEO or GEO constellations from a single gateway station. Offered in commercial models within the range of up to 27GHz to 30GHz, these GaN based SSPAs are designed to be form, fit, and function drop-in replacements for Travelling Wave Tube Amplifiers (TWTAs) commonly used on gateway ground stations.

"Customers have long been demanding high power SSPAs to replace TWT Amplifiers," said Mission Microwave's President and CEO, Francis Auricchio. "Our latest amplifier is the most advanced GaN SSPA on the market and can provide up to 166W of linear power in a multi-carrier environment and over 200 watts of linear power for a single carrier; providing an effective replacement for a 500 watt TWTA. The amplifier is designed for outdoor mounting and sustained operation at 60°C. Our team and the initial customers for this product have been very excited by the prospect of replacing their TWTA amplifier deployments with more reliable and efficient SSPAs."

MACOM

In the same month, MACOM Technology Solutions Inc. announced two new transimpedance amplifiers (TIAs) optimized for use in optical networking applications ranging from 100Gbps DR1 to 800Gbps DR8 and FR8. The new TIAs are available in flip chip and wire bonding packaging options for fast, flexible deployment in QSFP, QSFP-DD and OSFP optical modules. The rapid evolution to single lane 100G and multiple lanes 200G, 400G and 800G connectivity is increasing the demand for high-performance, power-efficient optical components needed to maximize bandwidth density in the Cloud Data Centre.

The MATA-05817 delivers low noise performance less than 2uA RMS typical and supports bandwidth up to 35GHz. The TIA supports high throughput optical data links in a very low power profile, optimal for use in high density Optical Data Centre interconnects. The device is intended for 50G, 100G,

Photo courtesy of Comtech EF Data

Photo courtesy of Comtech Xicom Technology

Identifying the trends

Communications & Power Industries LLC, Satcom & Medical Products Division (CPI SMP) is a world-leader in amplifier products for satellite communications, having now shipped more than 50,000 high power amplifiers to more than 150 countries across the globe. Pam Lugos, Vice President Business Development, CPI SMP, Satcom Products Group, identifies the current trends and projects underway in the amplifier segment.

Question: What are the most important developments in amplifier technology currently underway?
Pam Lugos: There continue to be three major areas of development in the RF amplifier universe:

- Higher power;
- Increased instantaneous bandwidth; and
- Advancement of core technology (TWT, Klystron & Solid State).

The market desire for higher power amplifiers is never satisfied. As consumers' content demand increases with advancements in compression and modulation technologies, the amplifier portion of the uplink chain must continue to keep pace with the resulting demand for higher power capabilities to handle that increased volume of signals.

The quest for higher power is faced with the ongoing challenge of keeping the package small without sacrificing reliability and functionality. Understanding how to marry the various critical parts of an RF amplifier to increase the overall output power, while also maintaining the smallest, lightest and most reliable product, is the multi-faceted puzzle that RF amplifier manufacturers like CPI face.

One advantage of these higher frequency bands, especially for broadband applications, is an increase in bandwidth. Ka-band spans 4GHz; Q- and V-band are similar and could be even wider. We know that customers want to take advantage of that increased bandwidth availability with a single amplifier that covers the entire band. This has been a challenge for HPA manufacturers: TWTAs that solve this challenge are now reliably available in Ka-band. Solid State amplifiers continue to be in development across the industry to achieve similar performance but are not there yet. CPI now offers a 650W peak power Ka-band TWTA that can cover the entire 27-31GHz spectrum and CPI is leveraging the experience in that success to advance our development of a solid state amplifier to cover that same wide band. We've also addressed the challenges related to the block up converter frequency bandwidth (typically 1GHz max.) with innovative multi-band (switchable units) and continue to innovate toward even more effective solutions.

While the commercial satcom market continues to be a major driver for innovation in CPI SMP Satcom's product offering, the overall demands for RF based technology in the medical, scientific, industrial and government segments that CPI supports also require continued innovation. The experience and development that result from CPI's participation in all of these market segments using three main technologies (klystrons, traveling wave tubes and solid state) helps to inform innovation and advancement in the development and manufacturing of all of CPI's products, including RF amplifiers.

200G and 400G receivers using multilevel modulation such as PAM4.

Meanwhile, the MATA-38134 is a quad 26/53GBaud linear PAM4 TIA with automatic gain and integrated AGC loop. The TIA consumes very low power and is primarily targeted for single-mode fibre applications. The TIA has 500um anode to anode spacing which allows customers to place two devices within the QSFP-DD form factor enabling 800Gbps applications. Both devices include RSSI for photo-alignment and power monitoring and I2C control of bandwidth, output amplitude, peaking, LOS, gain and other parameters.

Comtech Telecommunications

In March, Comtech Xicom Technology, Inc. introduced three new industry leading GaN SSPA product lines.

The Bobcat BUCs were designed for compact terminals needing high power from very small packages. Bobcats enable users to shrink their footprint while increasing the speed of their link. Bobcat's are high-performance, DC-powered, feed-mount outdoor BUCs with outsized features including extensive data logging, easy-to-use web-based GUI, ethernet SNMP (v1 or v3), and interchangeability between X, Ku and Ka-bands. Bobcat BUCs are currently available in 5lb packages at powers up to 64W in X, Ku and Ka-band.

The Puma SSPAs/BUCs were designed for fixed and transportable terminals; Pumas are flexible, high-performance AC-powered outdoor SSPAs/BUCs that offer many features and options including internal L-band BUCs, internal LO reference, extensive data logging, easy-to-use web-based GUI, ethernet SNMP (v1 or v3), and a wide range of available power combined and redundancy systems.

Puma amplifiers and BUCs are available in 15-50lb packages in X, Ku and Ka-band with power levels from 80-500W.

The Falcon Airborne SSPAs/BUCs were designed for

Question: What changes do you expect to see in the market in the next 2-4 years?

Pam Lugos: The market continues to advance in the demand for solid state technology as the primary driver for RF Amplifiers. There are limitations to current solid state technology, which means that VED (Vacuum Electron Device)-based products, which CPI also offers, still have advantages in many situations. CPI is at the centre of the development and advancement of new solid-state technologies that will continue to improve the performance these products going forward. The bigger challenge in the next few years will be to not only have robust solid-state technology operating at a reliable level, but to be able offer it in a cost-effective manner in higher power, and at higher frequency ranges.

Question: How big an impact do you feel Q and V-bands will have on the amplifier market as a whole?

Pam Lugos: Q-band and V-band are the next 'frontier' for the satcom industry. The promise of increased bandwidth is attractive for many users, both commercial and otherwise. However, there still remain the challenges of weather attenuation and other application-based challenges. Coupled with the limited number of providers for the core components used for ground segment hardware, this means that, ultimately, there is much room for innovation.

Of course, the proliferation of the need for these new bands will be dependent on the saturation of other bands. Band saturation continues to be impacted by many external factors, including, but not limited to:

- The global pandemic;
- The impact of 5G on the C-band spectrum;
- The increasing availability of the Ka-band space segment; and
- The ebb and flow of the migration between the Ku-band and Ka-band space segments.

All of those moving parts means that, while the promise of these new frequency ranges is hopeful, there are many unpredictable factors that make it unclear as to how quickly and reliably these new bands will come into full utilization.

Question: What is CPI working on right now in amplifier technology?

Pam Lugos: The Satcom Products Group of CPI's SMP Division continues to work on providing innovative and reliable amplifiers in all three of the primary technologies (klystrons, traveling wave tubes and solid state). CPI has ongoing development efforts covering all of the areas previously indicated and more. CPI recognizes the continued increase in demand for solid state technology-based products, but also the somewhat oppositional quest for increased bandwidth, which is the hallmark of VED-based amplifiers. The company continues to invest in R&D to increase power density of its amplifiers, in order for users to get more power out of compact amplifiers, without sacrificing reliability. CPI has a laser focus on technologies that can sustain the current product offering, making them even more cost effective during these challenging times.

CPI V-band TWTA for satellite uplink communications. Photo courtesy of CPI SMP, Satcom Products Group

airborne satcom systems needing high power density with high efficiency, Falcons are high-performance, in-cabin and cabin-exterior SSPAs/BUCs designed for and certified to DO-160 and MIL-STD-810 requirements. ARINC Falcon amplifiers and BUCs are available in Ku and Ka-band, including multi-band switchable BUCs built into the Ka-band units.

"Xicom is using the latest GaN technology in these products with a focus on minimizing size, weight and power consumption, while maximizing performance and reliability," said Mark Schmeichel, Senior Vice President and General Manager for Comtech Xicom Technology, Inc. "Our technical achievements are second to none and our Silicon Valley production facility offers high volume, MIL and airborne quality manufacturing with rapid deliveries. We invite customers and end users to consider Xicom for all their satcom amplifier requirements."

That's not all Comtech Xicom has been up to lately. Amongst other projects, the company is also working on Deep Space multi-amplifier systems to meet increased interest from governmental agencies and private corporations in the Moon and beyond. Comtech Xicom has in place existing and planned amplifiers to address these frequencies and power levels with high availability and redundancy.

We spoke to sister company Comtech EF Data, which has reported increased shipments of single thread and redundant Ku-band LGAN Block Upconverters/SSPAs in multiple power levels and frequency bands throughout 2020. "We see through our modem products that customers are trying to extract the most 'bits/$' from their OpEx," said Brad Thillmony, Senior Program Manager, RF Products, Comtech EF Data. "This leads to favouring very high order modulations and large carriers. Successful rollouts depend on very high linearity in the frequency conversion and amplification solutions deployed. As a 'one-stop-shop,' we are uniquely positioned to help customers identify the best solutions for these challenging requirements."

Comtech EF Data has also achieved significant advancements in mitigating drawbacks such as memory effected related multi-carrier/transponder intermodulation issues of GaN technology. Memory effect describes the fact that the transfer curve of an amplifier at time 'now' depends somewhat on what passed through it 'an instant ago.' This characteristic is much more pronounced in first generation GaN devices and can cause issues by producing intermodulation products that vary dramatically with carrier spacing. Comtech's advancement has resulted in some of the first GaN based Ku-band SSPAs on the market optimized for multi-carrier/transponder operation. Indeed, part of the Comtech solution involves working down to the bare die level to minimize stray thermal and capacitive elements which cause some of the behaviour though, like most things RF, there isn't a single 'silver bullet.'

Going forwards, Comtech EF Data plans to leverage advances in waveguide design to bring frequency conversion and amplification solutions to market for evolving Ka and higher frequency bands.

Wavestream

In October, Wavestream announced its new Matchbox 50W Wideband Ka GaN BUC as the next generation of the world's most widely deployed solid state amplifier built at this power level. Operating in both commercial and military frequency ranges, existing military applications using narrow-band Ka-band amplifiers will benefit from the wideband product that has been designed as a drop-in replacement, allowing immediate access to commercial NGSO and GEO satellite constellations. The product features a very compact light weight design and provides the same power as its previous generation, but with 52 percent less volume and a 60 percent reduction in weight.

"Wavestream is pleased to reinforce our technological superiority and leadership in the Wideband Ka-band SSPA category as we answer our customer's demands for broadband connectivity over both GEO and NGSO constellations," said Bob Huffman, General Manager at Wavestream. "As Wavestream celebrates its 20th anniversary this year, I am delighted to report that we have fielded over 40,000 products since our inception, for both commercial and military markets."

Advantech Wireless

In November, Advantech Wireless Technologies released its DeepBlu-Series 8.5kW Wideband C-Band Modular SSPA System for LEO, MEO and GEO applications that include satellite Telemetry, Tracking, and Control (TT&C) and Deep Space Communications. The newly designed DeepBlu-Systems consist of multiple high-power SSPAs packaged in ruggedized, outdoor enclosures and integrated into a single frame structure that includes combiners, loads, power distribution and M&C – perfectly suited for fixed and full motion antenna installations. Modular architecture with 1:N built-in redundancy and field replaceable amplifiers minimizes downtime, resulting in the highest service availability in the industry.

"Our DeepBlu high-power SSPA systems are designed to produce the high levels of EIRP necessary for the simultaneous control of multiple satellites, while facilitating communications with assets in Deep Space," said Cristi Damian, VP Business Development at Advantech Wireless Technologies. "Today's satellite modem technology can generate links with modulation schemes of up to 1024 APSK that, when combined with solid state power amplifier technology, can achieve extremely high levels of bandwidth efficiency. DeepBlu is an excellent enabler for critical operations. As the consumption of bandwidth from the expansion of 5G accelerates, traditional teleport operators will be able to accommodate more users in less C-band spectrum."

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New intelligence capabilities

Terrasat Communications has been manufacturing microwave and satellite RF equipment for more than 25 years, and today boasts the most innovate block upconverters (BUCs) on the market with new intelligence capabilities. Mike Gold, Regional VP of the Americas & Israel Region, outlines how Terrasat is meeting and exceeding today's amplifier and BUC demands across the board.

Question: What do you feel are the most important developments in amplifier technology ongoing right now?

Mike Gold: Over the past decade, we've seen a shift from traveling wave tube-based amplifiers (TWTAs) to solid state amplifier technology (SSPAs). This shift occurred because SSPAs allowed for higher power efficiency, better reliability, and smaller size, weight, and power. Block upconverters, BUCs, as we call them today, further shifted the market by allowing for frequency conversion and amplification in one outdoor package. The first BUCs were GaAs (Gallium Arsenide) based. But seeking further improvements in size, weight, and power, a few manufacturers, such as Terrasat, have shifted some production to GaN (Gallium Nitride) based. These newer, GaN-based BUCs, although very popular, were prone to some inherent issues. The most important being a limitation on the use in multicarrier operations such as the 'Memory Effect,' which limits their use to a very narrow spectral range. However, recent improvements in the GaN devices available to the market have allowed some manufacturers, such as Terrasat, to overcome this problem, by enabling our GaN BUCs to operate across the full band with multicarrier access. This improvement will propel the GaN-based BUCS as the leading technology in this market.

Question: What big changes do you expect to see in amplifiers in the next few years?

Mike Gold: Undoubtedly, we will see further improvements in power efficiencies in the BUC market. This will lead to more BUCs replacing TWTAs in the market. However, the biggest change may be on the cybersecurity side of technology. Almost every component in the satellite communications link is addressable via IP technology. Most of the equipment in the communications chain has hardened to prevent security intrusions by outsiders. Unfortunately, although BUCs have updated to allow access via ethernet/IP technology, almost all BUCs have relatively simple PW protection, if any, at all. One recent test by a large government contractor showed that many BUCs on the market could be successfully 'hacked' in a few minutes. Terrasat has recently introduced a 'Cyber Hardened' feature to their BUCs that incorporates SNMPv3, SSHv2, secure firmware upgrades, and encrypted web pages. The new cyber hardened IBUCs will effectively implement security management control and assure that end to end message transmission delivery will not be altered. This technology will soon be adopted as a standard in all BUCs, lest they become the 'weakest link' in the chain.

Question: How important are Q and V-bands within the future amplifier market?

Mike Gold: Certainly, the satellite market is always looking for more available bandwidth. The Q and V-bands are being researched heavily as valuable additions to the current C, Ku, and Ka-band mainstays of the market. However, the amplifier market typically is driven by the actual satellite capacity available in the sky. Currently, there are only a few real satellites with Q and V-band capacity. There are also some very interesting LEO and MEO constellations with Q and V-bands in implementation or in the planning stage. As these systems become real, naturally more amplifier manufacturers, such as Terrasat, will adopt them into their product lines.

Question: What is Terrasat working on right now in amplifier technology?

Mike Gold: Terrasat has always been a technology leader in the BUC market. We were the first company to realize that BUCs needed the same management and control access, and intelligence, like the rest of the communication chain. Therefore, the creation of the IBUC, or Intelligent BUC.

Over the next year, Terrasat will be pushing on two fronts. One, the expansion of the new IBUC3 product line. The IBUC3 is the latest generation intelligent BUC that reduces size and weight but keeps the same power efficiencies as the previous generation. The second front will be the expansion of the higher power BUCs needed to address the growing hub and gateway market. With the creation and deployment of multiple LEO and MEO systems, Terrasat sees a need to accelerate further the adoption of BUCs over current TWTA deployments. Over the next year, Terrasat will be making some significant strides in this market.

The new IBUC3. Photo courtesy of Terrasat