8W Ku-Band "Shoebox" Antenna-Mount SSPA Block Upconverter. Photo courtesy of Xicom Technology.

The rise of the SSPA

Solid State Power Amplifiers have been replacing the older vacuum technology for quite some time now. The satellite industry has embraced their advanced technology especially with the advent of satellite broadband. Satellite Evolution looks at the technology and what is available on the market.

A new generation of amplifiers is being embraced by the satellite industry. They are smaller, offer superior intermodulation characteristics, lower power consumption, lower operating costs and longer life than their ancestors, the Travelling Wave Tube Amplifier (TWTA). They are Solid State Power Amplifiers (SSPA), and their popularity continues to grow.

The newer SSPA technology has been replacing the older TWTA vacuum technology for some decades now but one of the few applications that has resisted this change until fairly recently has been satellite earth station applications. However, the tide is definitely on the turn.

High Power Amplifiers (HPA) amplify the signal to be transmitted from an satellite earth station before it is sent to the satellite and there are various types of amplifier used to achieve this depending on linearity, reliability and cost:

- Klystron amplifiers have a high power output and are easy to repair and have a long life of up to eight years. They tend to be larger and heavier and are often used in the military, for example.
- TWTAs. These were invented during the Second World War by Rudolf Kompfner in a British radar lab. The device uses foot-long vacuum tubes to amplify signals. They amplify signals from a wide range of frequencies and can handle an entire satellite from just one dish. TWTAs are small but can be difficult to repair, are more expensive and have a shorter life-span of 4-6 years.

TWTAs and SSPAs have always been rivals but the efficiency of SSPAs is winning over the satellite industry although different amplifiers are more appropriate in different situations. Overall, the TWTA basically has more to go wrong. They contain a tube and filament and therefore the mean-between-time-failure (MBTF) is higher than

that of an SSPA due to its construction.

SSPAs use solid state electronics rather than a tube. They use a combination of quartz-based oscillator clocks and signal mixers to increase power. Should a component fail within the amplifier then the signal would weaken but the amplifier would not lose power completely. Power consumption can be higher but developments in the technology have seen companies producing SSPAs that use a great deal less power than they originally did. SSPAs were initially believed to be too expensive, too large and heavy and also less reliable than TWTAs. They also suffered with heatsink issues which means that they were prone to overheating.

In Paradise Datacom's whitepaper entitled "Thermal Design Techniques Improve Solid State Power Amplifier Performance", three issues were identified that needed to be addressed before SSPAs would be able to compete with and take over TWTA's reign as most widely used amplifier in the satellite industry. These were size and weight, comparable cost and also superior overall reliability. Paradise Datacom designed a 1.1kw C-band SSPA that was designed with a modular architecture and semiconductor device reliability. The modular architecture can be modelled as a parallel system and therefore, failure of a single part does not make the entire system fail. The use of semiconductors helps the SSPA to meet temperature requirements.

Power

SSPAs and TWTAs are competing types of amplifiers, particularly in the 6-14 GHz satellite uplink frequency bands. The TWTAs have always been regarded as having an advantage over SSPAs as they are able to produce large amounts of microwave energy in a single electron tube. TWTAs also have the ability to operate at high temperatures and power densities. SSPAs, on the other hand, are not able to disseminate the heat produced as efficiently and therefore, they are normally accepted as being the amplifier of choice for low-power applications.

However, the use of thermal design and 'heatsink' technology has given rise to a new type of SSPA. This has resulted in great reductions in size and weight and it means that SSPAs can be used for applications usually dominated by TWTAs plus there is the added attraction of lower cost of manufacture.

Reliability

It is widely accepted that TWTAs are slightly more reliable that SSPAs. However, recently, there have been vast improvements made regarding the reliability of both types of amplifier and reliability alone is not reason enough to choose an SSPA over a TWTA. Both have their pros and cons when the question of reliability is posed. SSPAs tend to perform better at lower powers but TWTAs perform best at higher powers. When looking for a cost-effective amplifier this should be taken into account.

The new generation of satellite requirements is seeing SSPAs offering features such as power, temperature and voltage sensors with communication ports and power monitoring and gain settings.

Ruggedness

TWTAs are rugged amplifiers that now use 'multi-collector' technology. This enables them to function using lower amounts of energy. They are widely used for applications such as RF testing, radar simulation and calibration and are renowned for their performance and reliability. The tube amplifiers are very suitable for use in hostile environments and are capable of dealing with shock and vibration very well. On the other hand, SSPA products now can meet the demand for on-the-move platforms, even airborne systems as they have become much smaller and lighter. Higher power and broader bandwidth applications are also being developed for SSPAs where TWTAs were used before. Both TWTAs and SSPAs are used for army and naval applications due to their stamina in difficult conditions.

What is on offer?

Toshiba is just one of the companies that is upgrading its SSPAs to cope with the new demands placed upon amplifiers due to new satellite applications such as broadband.

Toshiba America Electronic Components, Inc (TAEC) introduced two internally-matched Extended Ku-Band power gallium arsenide field effect transistors (GaAs FETs) that provide wider frequency ranges to meet various regional spectrum requirements around the world for applications in satellite communications.

The 9-watt Toshiba TIM1314-9L features high power output of 39.5 decibels relative to 1 milliwatt (dBm) at a frequency range of 13.75 to 14.5GHz, compared to the 14.0 to 14.5GHz range of typical

A 100W Antenna-Mount SSPA. Photo courtesy of Xicom Technology.

Ku-Band FETs. The TIM1314-9L is ideal for use in Block Upconverter modules in Ku-Band transceivers for Very Small Aperture Terminals (VSAT). The device is offered in the 9.7mm x 17.0mm package used for Toshiba's 2W, 4W, 7W and 14.0 to 14.5GHz 9W Ku-Band GaAs FETs, enabling the TIM1314-9L to be used as a drop-in replacement for these devices to increase power output or frequency range in existing designs.

Toshiba's 30W TIM1314-30L is the highest power device of its class currently offered for the solid-state power amplifier (SSPA) market with a power output of 45.0dBm (typ.), and now supports a broader frequency range than Toshiba's previous 30W Ku-Band FET. The device is designed for high power SSPAs used in earth or base stations for satellite communication applications such as those used as replacement for Travelling Wave Tube Amplifiers (TWTA).

"Toshiba has been a recognised leader in advanced technology for internally matched, high power GaAs FETs for C-Band and Ku-Band since the late 1970s. We have been working closely with our OEM customers to continue to advance the technology for this market, and these extended Ku-Band devices have been developed in response to customer demand to meet varying bandwidth requirements worldwide," said Christine Lee, Business Development Manager, Microwave Devices, for TAEC.

US-based company Xicom offer a wide range of amplifiers to the satellite industry and manufacture some of the world's leading HPA products. Their SSPA line includes several recently-introduced products at 50 and 60 watts, 14.0-14.5 GHz and 50, 100 and 200 watts, 5.85-6.425GHz for use in Ku and C-band satellite communications. They are compact in size and employ the same thermal management techniques as existing Xicom amplifiers.

The Xicom SSPA incorporates a modular approach both in the RF subsystem and the removable power supply, allowing easy component upgrading and maintenance. In addition, redundancy and power combining control are into the Xicom SSPA.

Paradise Datacom offers a wide range of Solid State Power Amplifiers in both indoor and outdoor configurations.

Paradise Datacom's Compact Outdoor (C) series SSPAs bring high power solid state transmit amplifiers right to the antenna's feed. Designed for antenna-mount applications, the Compact Outdoor series SSPAs deliver the highest uplink powers available per unit volume and weight offered anywhere in solid state technology. Packaged for outdoor use, these amplifiers are entirely self-contained with on board power supply, cooling and monitor and control systems.

Paradise Datacom's High Power Outdoor (W) series SSPAs represent the latest in High Power Microwave Amplifier Technology. The SSPA package achieves the highest power density in the industry along with enhanced maintainability.

Paradise Datacom's Indoor Rack Mount (R) series SSPAs achieve the highest power density in the industry along with enhanced maintainability. Local, front panel, control is available with a user-friendly interface.

Five-fault condition LEDs on left side of the front panel reflect some of the SSPA major faults states, plus a summary fault indicator. The SSPA online LED turns green when the amplifier is in Online mode (1:1 Mode) or serves as an AC power indicator in standalone mode. Local/Remote and Mute/Unmute LEDs show the current control mode and mute state of the amplifier.

The new generation of satellite requirements is seeing SSPAs offering features such as power, temperature and voltage sensors with communication ports and power monitoring and gain settings. The advancements made in SSPA technology could see them taking the lead in amplifiers for satellite communications. This is acknowledged in Paradise Datacom and R-Theta's paper 'Thermal Design Techniques Improve Solid State Power Amplifier Performance': "SSPAs can now be manufactured with tremendous size and weight reductions. This allows SSPAs to be used in installations that were previously the domain of TWTAs…..Now considering the inherent reliability and distortion advantage of solid state devices the SSPA is poised to be the preferred amplifier in satellite communication earth stations."