White Paper

Advantech Wireless

High Power GaN based Ku-Band SSPA Systems

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1. Scope

Taking in account the latest achievements in the digital signals processing, encoding techniques, IP based communications systems, new modulation and FEC techniques – the Satellite communications systems today are moving from Multi-carrier Transponder usage to a Single high Data rate carrier per Transponder. All services sharing the common carrier (TV channels, Radio channels, VoIP services, Data channels and so on, are multiplexed into a common high data rate stream which is transferred trough the communications channel and separated at receive site based on their packet identifiers in real time. The main advantage of this approach is the Single carrier Transponder usage which allows using of the Satellite Transponders close to their saturation point (instead of 4-5dB output Back-off in Multicarrier mode) – this way of using them allows much smaller Receive Antenna dishes (40 – 80cm in Ku band systems), improved system margins and Link availability figures, better Quality of all services.

Even by significantly improved Satellite Transponder parameters – the requirements to Ground station HPAs were increased rapidly in the last years, so even highest power SSPA units (up to 500W Ku-band SSPA single unit) appear to be not enough to meet the big Teleport Requirements.

2. Advantech Wireless High Power Phase Combined Systems – description, advantages, applications.

2.1 Outdoor versus Indoor solutions

One the most important factors by Earth Station design considerations is the required EIRP of the Earth Station, which is calculated by a simple formula:

EIRP = A + Pout – FL [dBW],

where A is Antenna Gain [dB],

Pout – HPA output Power [dBW],

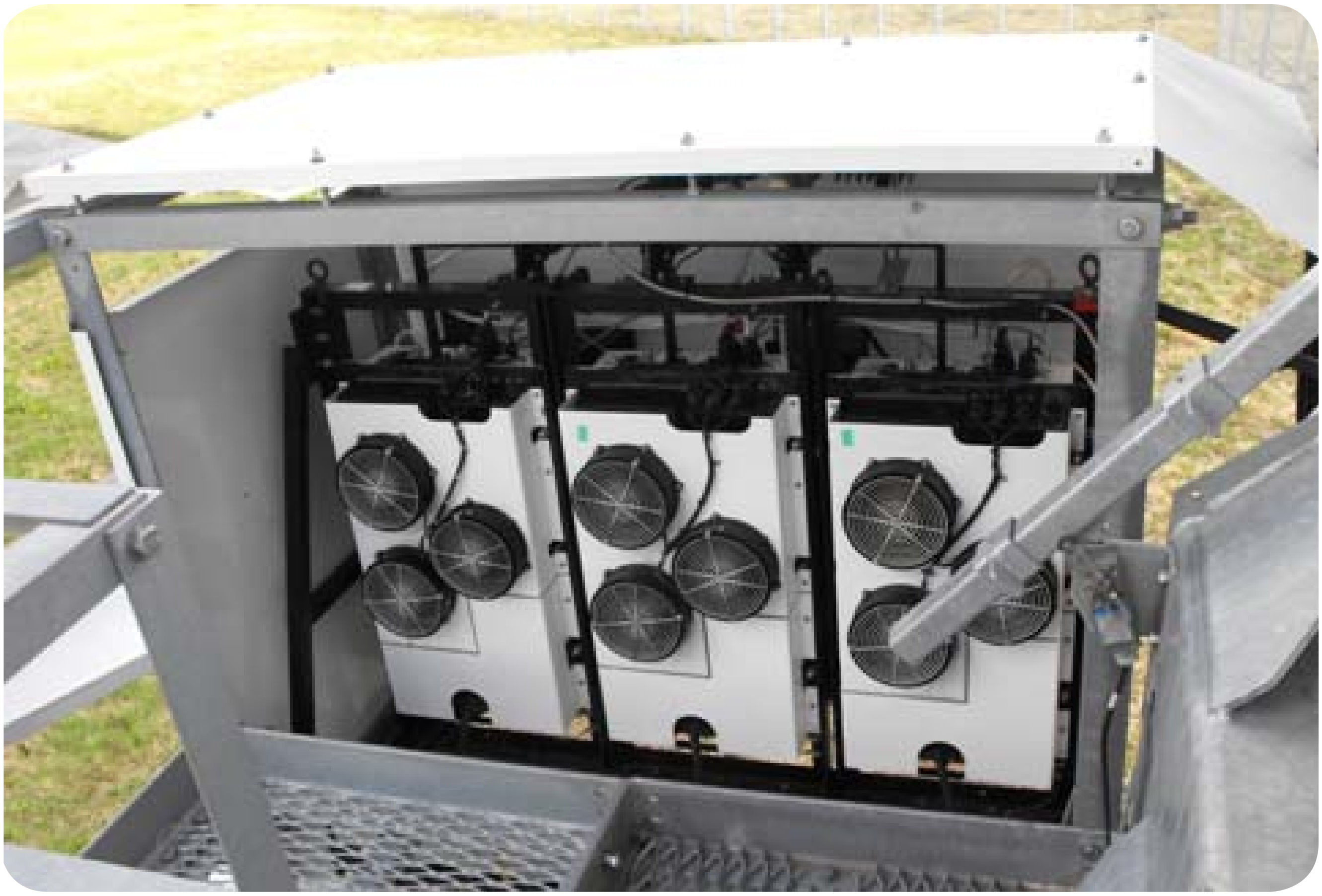
FL – Feed Loss [dB] -the loss in the waveguide system between HPA output and Antenna input.

In order to increase the Earth Station EIRP the system designer should try to minimize the FL as much as possible. Especially in Ku-band where the Losses in the Waveguide are about 0.16dB/m – 10m of wave-guide path between HPA and Antenna is already 1.6dB less EIRP.

In case of high power systems 1.6dB is a significant loss which cost a lot in terms of output power of the HPA. For example 2KW HPA (63dBm) will drop to (63-1.6=61.4dBm (1380W)– 620W of very expensive RF power in KU band will be lost in the W/G system (10m long).

In case of a 20m W/G system – more than half of the HPA power will be just wasted in the feed.

Picture 1



Picture 2

The example above shows how important (especially in Ku-band systems) is to minimize the feed loss, so it is strongly recommended to install the HPA as close as possible to the Antenna input. That is why – the outdoor systems, which allow to minimize the feed loss are much more suitable for the High Power Ku-band Applications.

Few practical examples:

1. 900W Phase Combined Redundant system (3 x 500W SSPAs GaN operating in configuration 1: 1+1) was installed at less than 3m away from the Antenna input and measured feed loss was below 0.4dB – installation is shown on Picture 1 and 2.

The considerable reduction in size, weight, and energy consumption achieved when using GaN technology as opposed to any previous Solid State Technology , makes this new architecture now the only viable solution

In case of Indoor equipment (installed in a shelter) – a 1300W min HPA would be required to achieve the same EIRP, so in this case 900W Outdoor system is equivalent to a 1300W Indoor system (both systems deliver same Earth Station EIRP).

2. 1600W Phase combined system (8 x 250W Ku band GaN SSPAs) was installed in the same way on a special mobile platform just behind the 13m Antenna input – Feed losses reported were below 0.5dB. Similar Indoor system installed in a

weatherized container under 13m Antenna will have at least 1dB more Feed loss.

3. 2400W Phase combined systems (8 x 400W Ku-band GaN based SSPAs) were installed on the same mobile platform behind the main reflector of a 13m Ku-band antenna. When operating 2 x 2400W Ku-band, one unit per each polarization, all transponders of an existing satellite were saturated, taking maximum advantage of bandwidth and power. Prior to the GaN technology introduction, never was his possible with any of the existing SSPA or HPA technologies.

Another serious disadvantage of the Indoor systems is the need of powerful and sophisticated Air-conditioner system to extract the generated heat out of the shelter.

This affects the whole system reliability and power consumption/efficiency.

2.2. Phase Combined systems versus standard 1:1 and 1:2 Redundant systems

In all Redundant systems (1:1, 1:2) one of the HPAs is always operating on a Dummy Load – that means half of the installed RF power is not really used – it is there just to provide redundancy in case of unit Failure. This leads to twice lower efficiency of the system and real waste of produced RF power. By very high power systems the losses in equipment and maintenance cost will be significant. Another serious disadvantage of these systems is the Switching time of the W/G switches (about 0.2s) which will cause significant amount of information to be lost in the payload Data streams and very probable loss of synchronization at the Receive site of the system by each redundancy switching event.

By newly developed by Advantech Wireless GaN based SUMMIT technology – the High Power SSPA consists of up to 16 SSPA modules operating in a

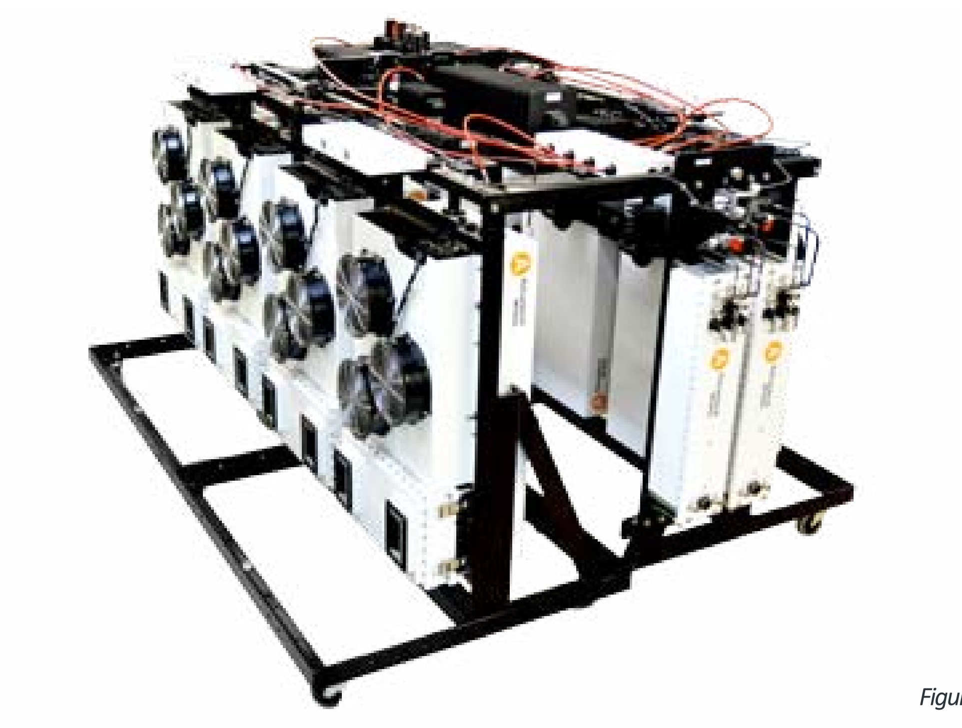


Figure 1

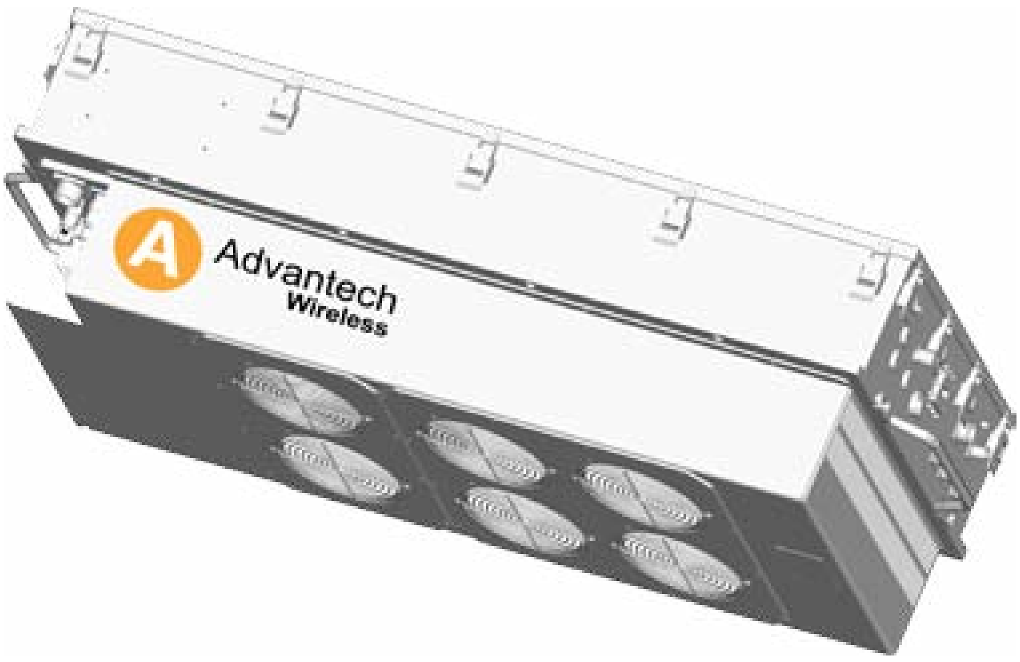
Phase combined system where all units in the system are all the time delivering their output power to the Antenna – no waste of installed RF power in the system, much higher system Efficiency. The system does not contain any W/G switch, so no any service interruption by unit failure event.

An example of High Power Phase combined system is shown on Fig. 1

The system consists of 8 x 400W SSPAs delivering 2400W on the output. The system is equipped with 1:1 redundant Up Converters in order to have a convenient L-band input. Some of the main system characteristics are:

- All Modules are Factory pre-set to equal Gain and Phase characteristics and the system allows hot-swappable unit replacement without any tuning and adjustments procedures.

- By unit Failure – the maximum output level degradation is 1.2dB, which can be automatically compensated by increasing the input level of the system by system controller (adjusting the Up converter output level). The 1.2dB short term drop is actually within the system margin and should not affect the whole communication system performance.



1250W Ku-Band
GaN Based - SapphireBlu™ Series

- Minimized maintenance cost – the spare unit (recommended) is only 1/8 of the total power of the system. By 1:1 redundant system – the spare unit (recommended) needs to be same as the unit in operation – able to maintain full output RF Power – much higher spares cost in this case.

2.3. GaN based SSPAs and Phase Combined Systems

The latest achievements in SSPA technology implemented by Advantech Wireless are using the Highest Efficiency GaN FETs like output stage of the SSPAs – this leads to the most compact SSPA units and allows Advantech Phase combined systems to deliver highest possible output power level on the market today.

For example, we can analyze a similar system like the one shown on Fig. 1 using 8 x 400W GaN based SSPAs. Some of the major system characteristics are:

- Minimum output Power in Saturation - +64dBm (2500W)
- Linear Output Power - +61dBm (1250W) – IMD level -25dBc measured by two tone method.
- Usable Output power in Multicarrier mode - +60dBm (1000W)
- Frequency Band – 13.75 – 14.5GHz

A similar system in X-band and C-band will achieve 6.6 KW total RF power

The specifications above can not be achieved by any other HPA technology on the market today – SSPA, TWTA or Klystron HPA. The power levels specified above are close to the practical and theoretical limits for the Antenna Feeds capabilities, the system offers the maximum usable HPA power in Ku-band Satellite communications systems.

If higher Linear Power is needed – a multiple Antenna solution would be recommended and splitting the payload to two or more Antennas depends of the system requirements.

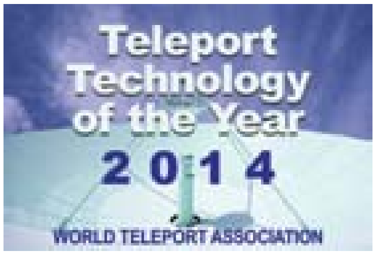
Just to compare – the maximum Available TWTA (1250W) on the market can not deliver more then half of the above specified above linear power –the limit for this tube is 470W max at -25dbc IMD level by using a Linearizer.

Note: The output power of this Amplifier is limited up to 500W maximum - even if it is designated 1250W (which is actually the power of the Tube itself, not the power on the output Flange of the Amplifier).

Klystron HPAs are usable in very narrow frequency bands (72MHz), so in order to cover the full band 13.75 – 14.5Ghz – multiple Klystrons have to be combined by very complicated Frequency dependant combining circuits, which makes this solution without practical usage. The Linearity performance of these Amplifiers is also very poor, so special Linearizers should be used for each particular tube. Phase Linearity and Group delay Ripples are another problem by Klystron tubes, so the performance under higher level Modulation schemes (higher than QPSK) will be very also very limited – special Group delay equalizers should be used.

3. Conclusion

GaN and GaAs based SSPAs and Phase combined systems developed by Advantech Wireless are able to deliver highest possible EIRP in Satellite communications systems today and these EIRP values touch the theoretical and practical limitations set by waveguide components and Antenna feeds power handling capabilities. The large variety of system architectures provided by Advantech SSPAs portfolio can satisfy all possible system requirements in the most suitable way in terms of Efficiency, Reliability, Maintenance and Installation cost.



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