MACOM®

Partners from RF to Light

Linear Products

Linearizer Group

Robert Gray 6/15/2023

Linear Power at V-band with Advanced Linearizer Technology

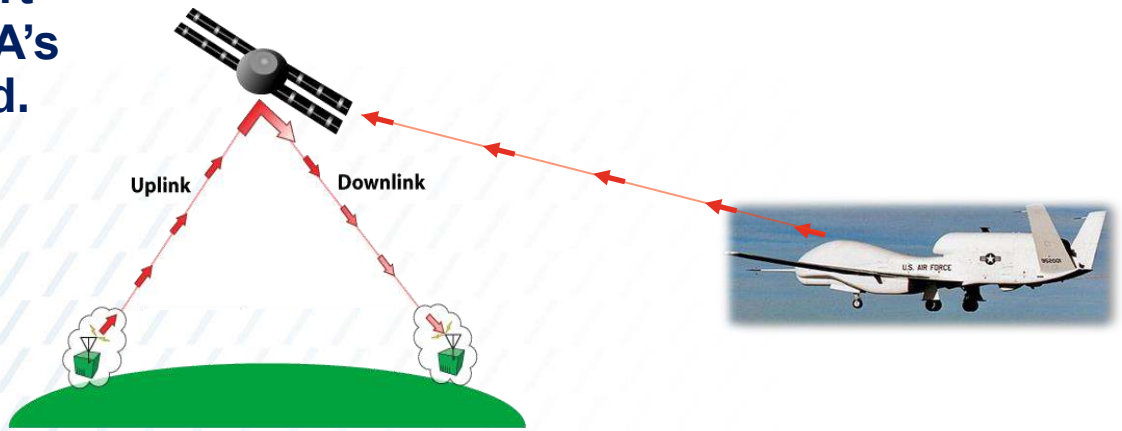
IMS2022 Microapp Session THMA12

V-Band Uplink Linearizered Amplifiers

- Greater data transmission rates is moving satellite technology to the higher millimeter wave bands, beyond Ka-Band to V-Band.
- The higher millimeter frequencies provide more bandwidth needed by these high throughput satellite architectures, >5 GHz
- Ground stations will need linear high-power amplifiers to allow efficient transmission of this information.
- All amplifiers will utilize a **linearizer** to produce this **linear** power.

Progress in advancing the art of linearization of uplink HPA's at V-band has been achieved.

(47.2 - 52.4 GHz)

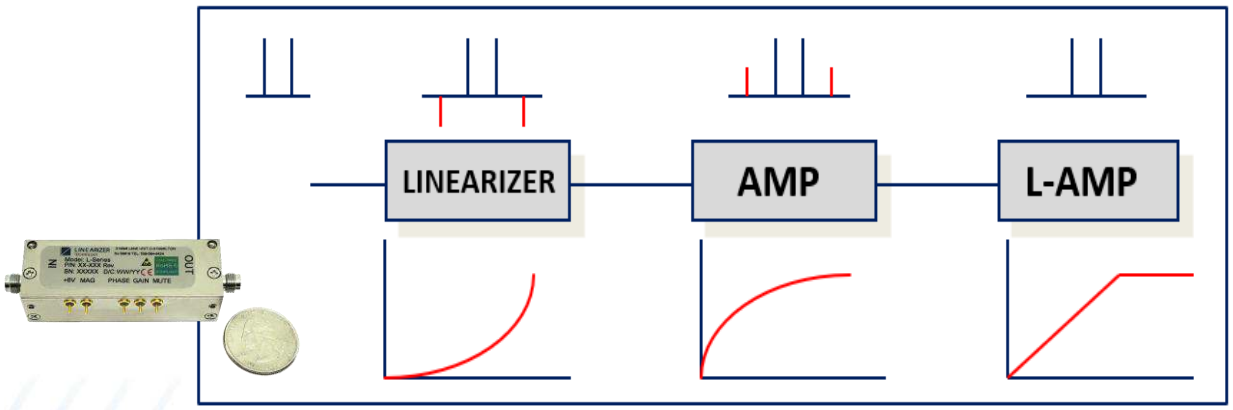


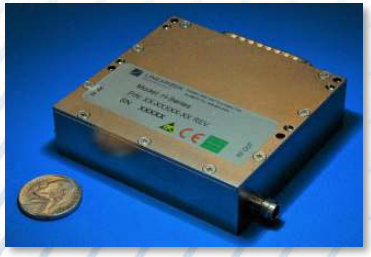
Linearizered Amplifiers - Predistortion

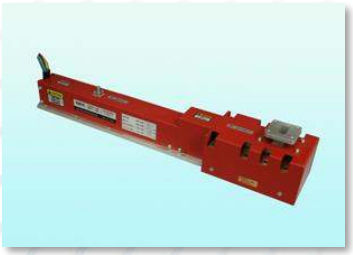
Predistorter linearization must produce the opposite of the HPA transfer characteristics in both MAGNITUDE and PHASE.

The desired result is the ideal limiter transfer characteristic.

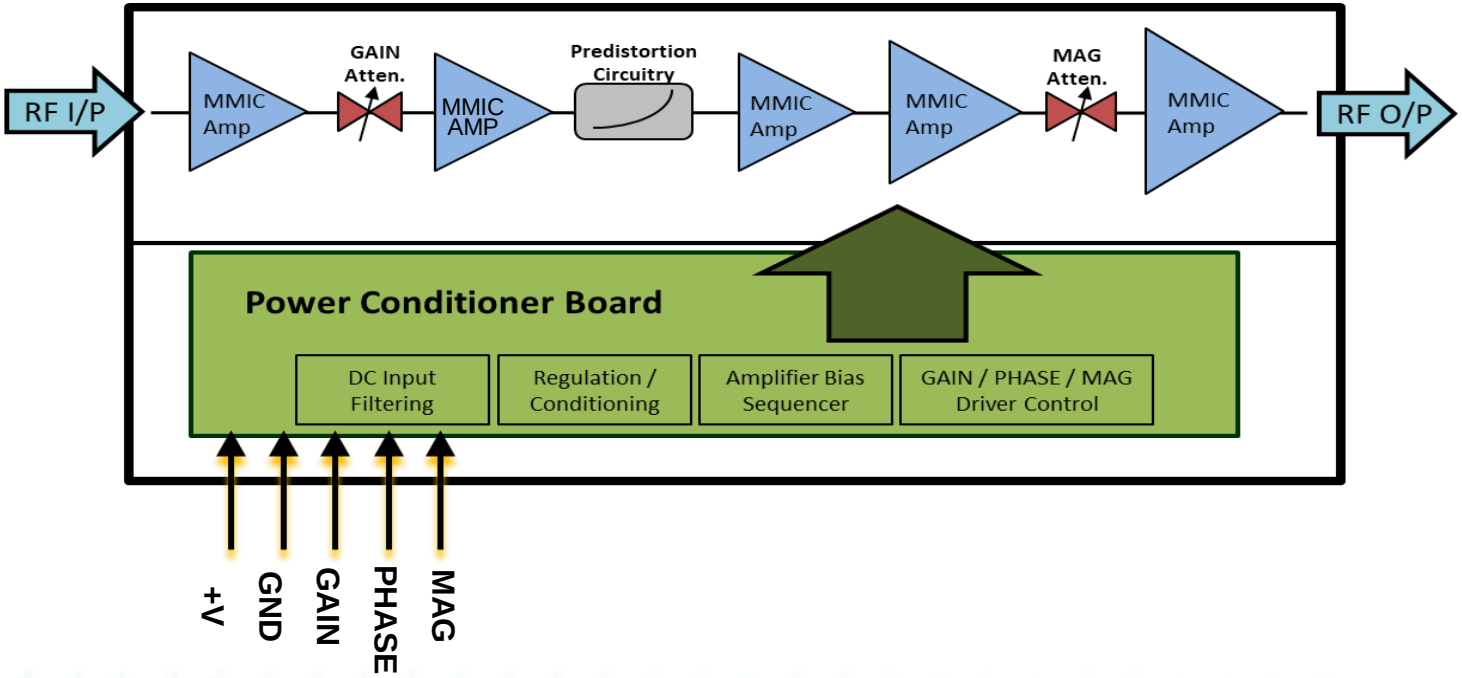
The challenge is to produce these transfer curves at these higher MMW frequencies!







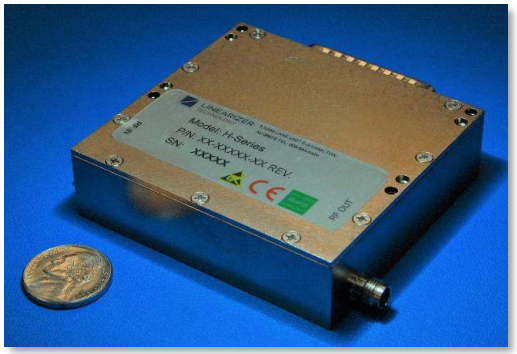
Linearizer Simplified Block Diagram

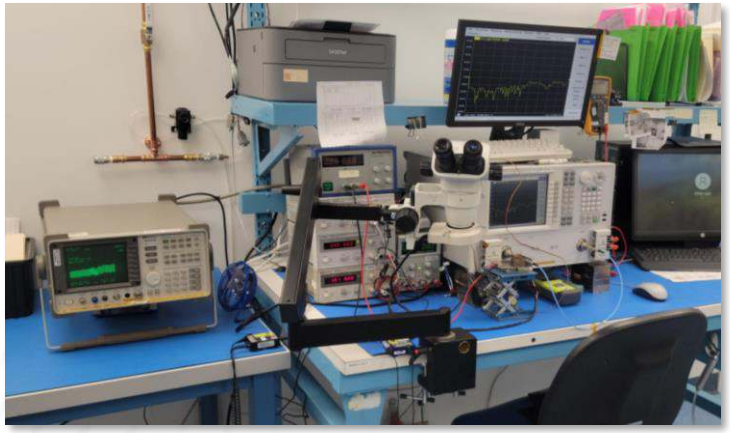


A linearizer is a frontend mini-system used in conjunction with a TWTA, MPM, or SSPA amplifier to provide superior HPA linearity performance. The linearizer provides RF gain, predistortion, input and output level control, and RF output power to drive an amplifier to saturation.

Linearizer Functions

- Provides RF signal gain up to ~45 dB.
- Analog predistortion linearizer. (TWT or SSPA)
- Provides instantaneous bandwidths of greater than 5 GHz.
- Dual AM/AM, AM/PM correction modes.
- Input attenuator to set predistortion RF drive power.
- Predistortion phase control to shape linearizer response.
- Output attenuator to adjust PA drive over temperature.
- Internal temperature compensation.
- RMS Power detector and RF Inhibit Mode.
- Output power range is typically +15 to +25 dBm.
- Various communications I/O protocols.

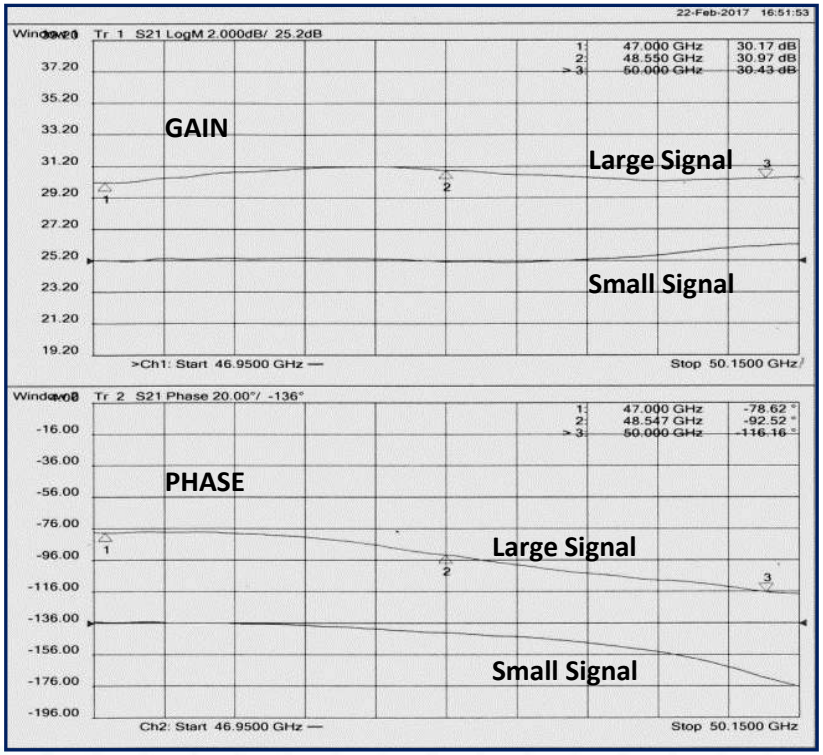




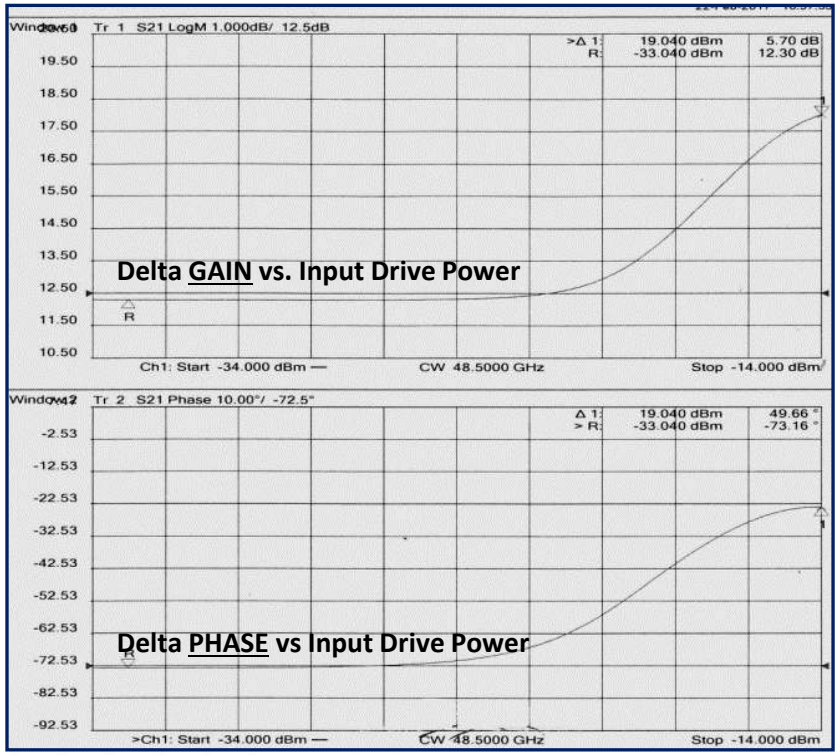
Performance Network Analyzers (PNA) are used to tune and align the predistorter module before temperature testing.

Linearizers are mini-systems that minimize the interconnections between components that become performance degraders at these frequencies.

Linearizer Performance



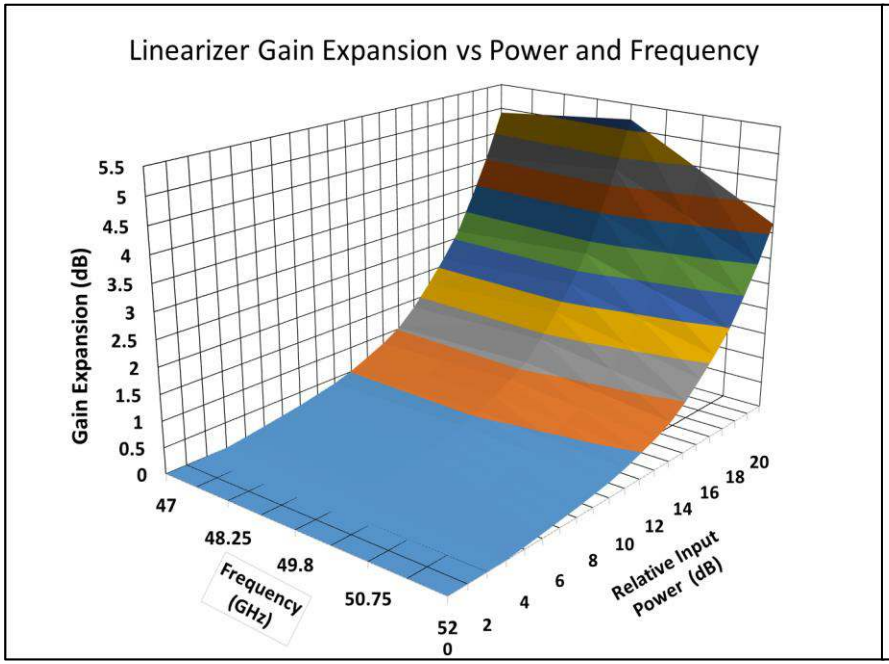
Small and Large Gain and Phase Response vs. Frequency and RF drive power.



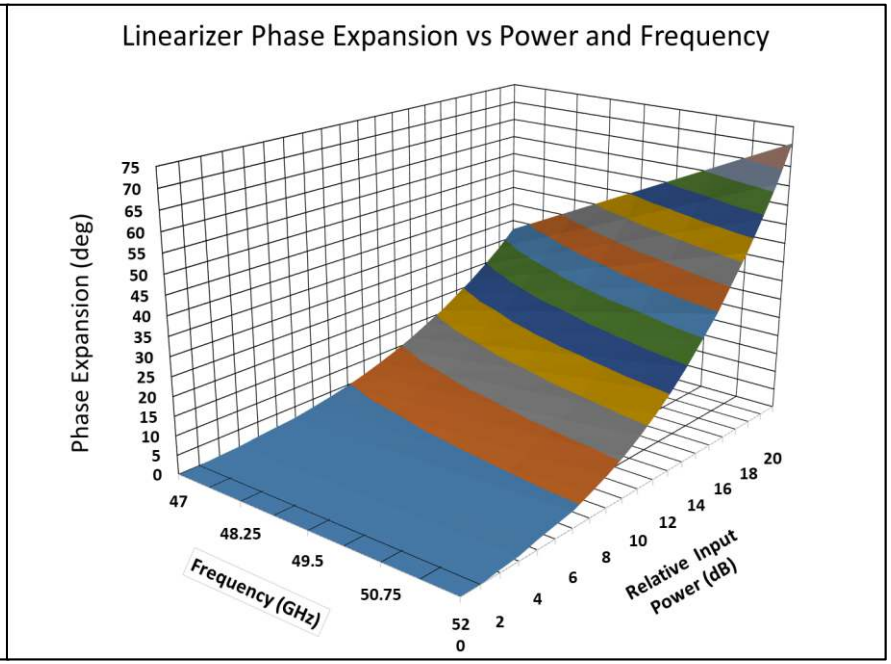
Gain delta (5.5 dB) and Phase delta (50°) vs. RF input drive power @ 48.5GHz

Analog predistortion linearization (APDL) provides the only method that offers the bandwidth required for SATCOM.

Challenges for Optimum Performance



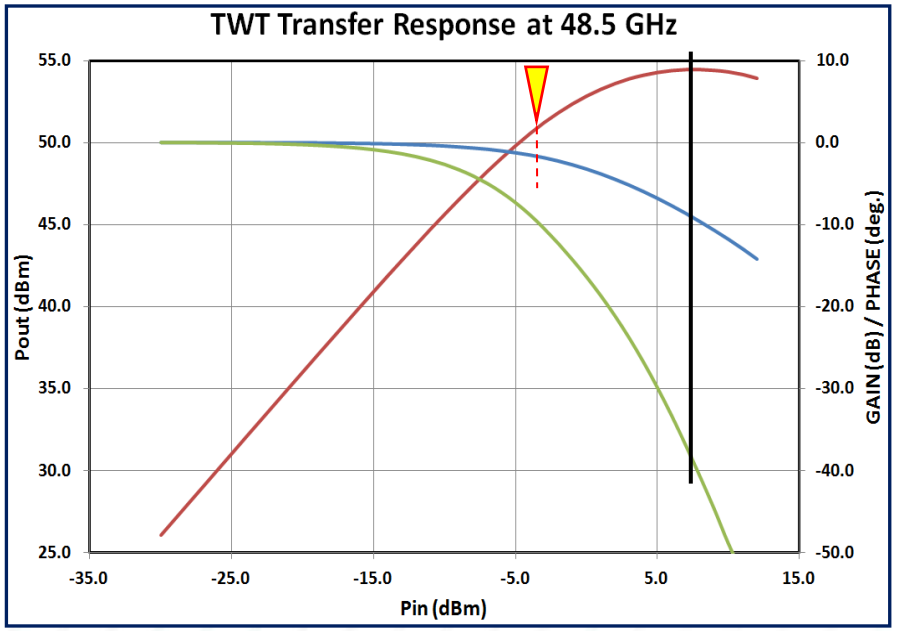
The amplifier gain varies > 2 dB across the operating band.



The amplifier phase varies > 30 degrees across the operating band.

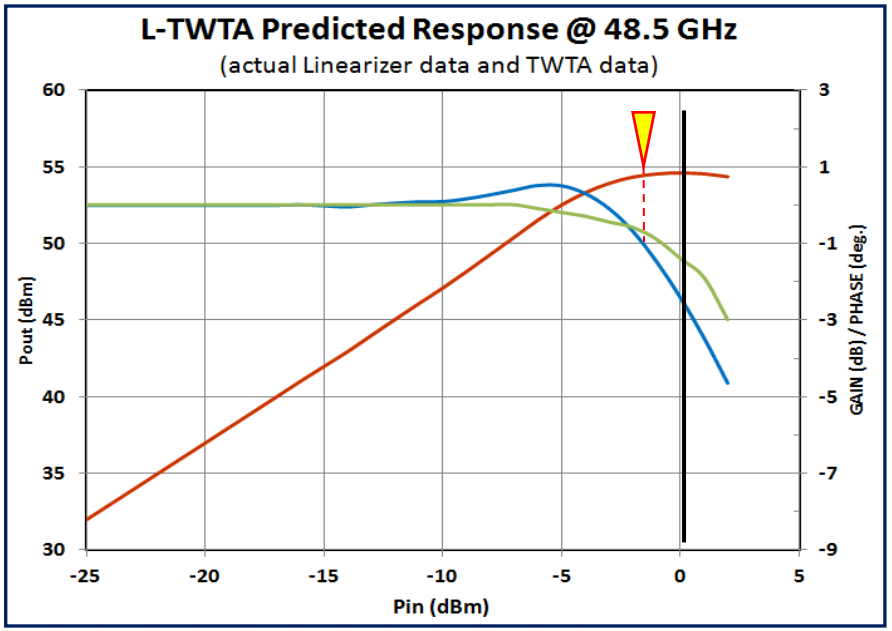
The linearizer must be aligned to compensate a variable surface for both amplitude and phase versus frequency for optimum performance.

TWTA and Linearized TWTA Transfer Curves



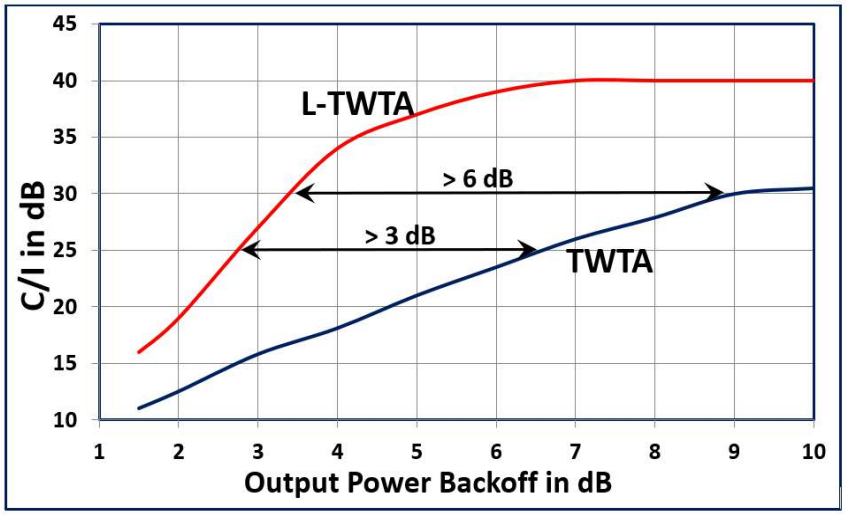
@ Psat
Gain Compression = 8 dB
Phase Compression = 40 deg.

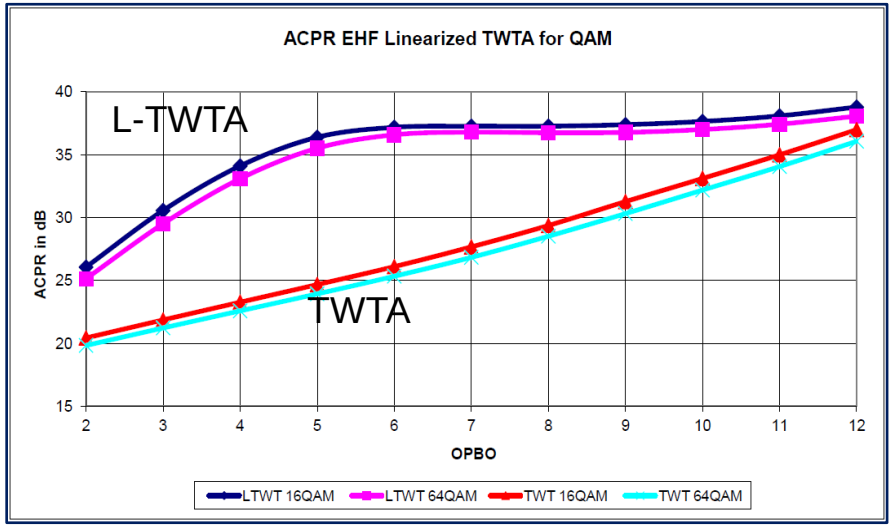
w/ addition of the LINEARIZER



@ Psat
Gain Compression = 2 dB
Phase Compression = 1 deg.

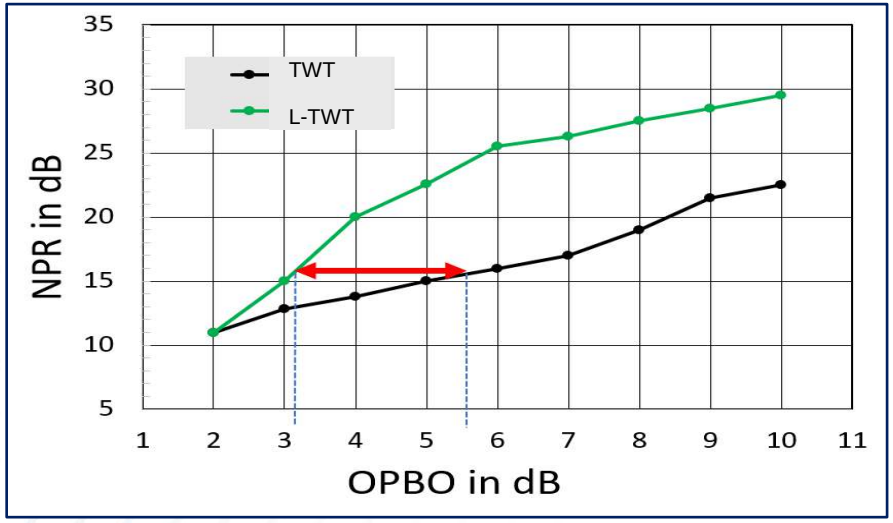
Linearized TWTA Performance - Linearity





2X increase (3 dB) in O/P for a 2-Tone **C/I of 25 dB**
4X increase (3 dB) in O/P for a 2-Tone **C/I of 30 dB**

MEASURE	OPBO=3dB	OPBO=4dB
2- Tone C/I	>25 dB	>30dB
NPR	>16 dB	>19 dB
ACPR (1 symbol spacing)	>30 dB	>35 dB



Conclusion

- Linearizers are NOW available at all SATCOM uplink bands including V-Band.
- Linearized Front-ends reduce the number of components and interconnects needed providing cost savings and improved RF performance.
- Analog predistortion is the preferred method of linearization at and beyond millimeter-wave frequencies.
- Analog Predistortion can provide instantaneous bandwidths of 5 GHz or more.
- High performance Linearizered HPAs can meet and exceed today's transmission requirements.
- This technology has value for space-borne, ground-based, airborne, portable, and mobile communication systems.

Thank you.