MICROWAVE TRANSMITTERS FOR SMALLSAT PLATFORMS FOR EARTH OBSERVATION (EO) AND REMOTE SENSING

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Objectives of Earth Observation (EO) and Active Remote Sensing using SmallSat

- Observe Critical Geophysical Phenomena
- Measure Critical Environmental Factors
- Monitor and Measure Changes in Earth's Surface, Vegetation and Frozen Regions
- Monitor Weather-related Physical Parameters
- Research and Development of New Climate and Geophysical Models
- Track and Predict Severe Weather Events

Sea Ice thickness, size and speed, cloud profiling, Soil Moisture, precipitation, changes or deformation of earth, surface water and ocean topography

Instruments and Equipment Used for Active Remote Sensing/EO

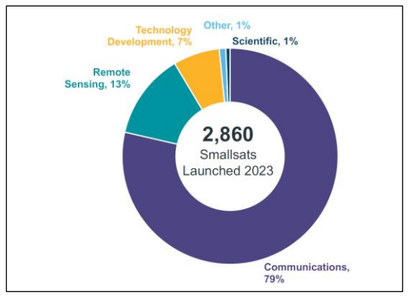
- Pulsed Radars, Cloud Profiling Radars
- Backscatter Radar, Doppler Scatterometer
- Interferometers
- Synthetic Aperture Radars (SAR)
- Interferometric Synthetic Aperture Radars (InSAR)
- FMCW Radars
- Altimeters

Also, High-Capacity Data Links for Downloading Acquired Data

Why SmallSat* for EO and Remote Sensing?

*SmallSat (by Mass Class) < 500 kg

- Low Size, Weight, Power Consumption and Cost (SWaP-C) achieved with functionality and performance comparable to larger satellites!
-Outstanding improvement in instruments and data links during the last decade
-Constellations of SmallSat achieve global coverage with very short re-visit times.
- Reduced risk, incorporate new technologies with low finances
- Short development cycle and launch times



Some Space-based Radars for Earth Observation and Remote Sensing

- SAR- ICEYE; Capella's Whitney and Acadia; Umbra Space
- RainCube, CloudCube, tomorrow.io, RadarSat
- SWOT, EarthCARE, CloudSat, NISAR

Critical Requirements for Transmitters for Active Remote Sensing

- Very Low SWAP-C, especially for Smaller Satellites (e.g., CubeSats)
- Form Factors compatible with the Platform and Antennas
- High Efficiency (Conversion from Prime Power to RF Output Power)

Examples of Applications, Mission and Frequency Band	Frequency	Transmitter Power, Watts
Weather Imaging Radar/Ka-band Interferometric SAR	35-36	50 to 200
Dual-frequency Ku-band SAR to measure terrestrial snow mass	13.5, 17.5	500
Cloud Profiling Radar- W-band	94.05	75-150
Precipitation and Cloud Profiling Radars, Ka-band	35-36	200-300
Sea Surface Pressure Mapping using Differential Absorption Radar in V-band	50-75	100-200

Innovations and Advances in GaN Technology

-GaN on Diamond

-Qualification for Space Use

-Derating Guidelines

-Approved Fabrication Processes

-Sub 50 nm Processes

Gallium Nitride(GaN)-based Devices for Solid-State Power Amplifiers in Transmitters

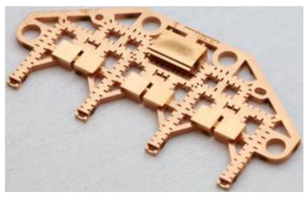
GaN Advantages

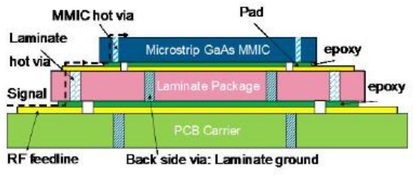
(a) High RF Power Output Capability 50 W at X-band (8 GHz) to 5 W at 75 GHz
(b) Superior Power Added Efficiency, from 50% at 5 GHz to 15% at 75 GHz
(c) High Operating Channel Temperature with Excellent Reliability 145 deg. C
(d) Highly Suitable for Space Environment, High radiation tolerance
(e) High Operating Voltage, Low Current (improved power supply efficiency)
(f) Linearizers can Significantly Improve Performance/Efficiency

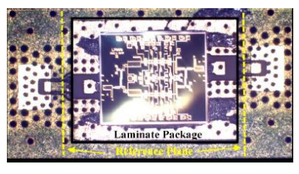
A Strong Challenger to Tube-based Power Amplifiers (TWTA)

Architecture, Packaging and Integration

-Use of Surface-Mounted Devices and Components (SMD)
-Additive Manufacturing (3D Printing)
-Modular Construction and Standardized Assemblies
-Microwave and Millimeter-wave Transmitter Functions on Printed-Circuit Boards

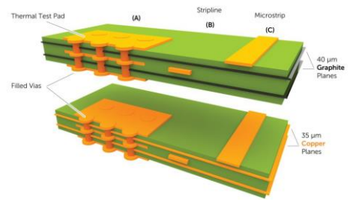


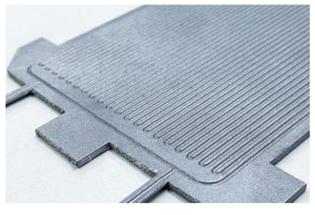


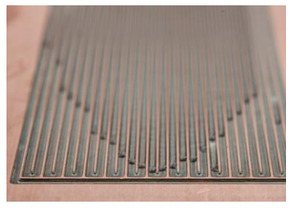


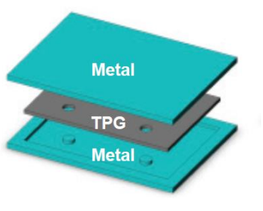
Thermal Management and Reliability

- Novel Materials for Device Mounting/Carrier and Heat-Spreaders using Composite Material Substrates (Mo, Cu-Mo, AlSiC, Aerospace-grade Copper-Diamond, Aluminum Diamond, Silver-Diamond, Strain-balanced structures, Tungstun-Copper, ...)
- Thermally Conductive Synthetic Graphite in High Frequency Printed Circuit Boards
- Thermal Interface Materials, Gap-fillers (Carbon nanofiber/nanotube layers
- Highly Effective Heat Pipes (Oscillating Heat Pipes, Additive manufacturing, ...)

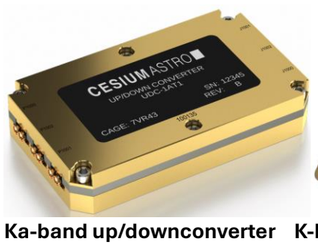






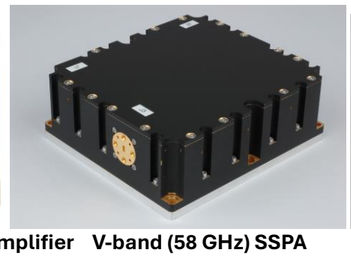


Some Examples of Solid-State Power Amplifiers and Upconverters used within Transmitter for EO and Remote Sensing



Ka-band up/downconverter

K-band Solid-State Power Amplifier

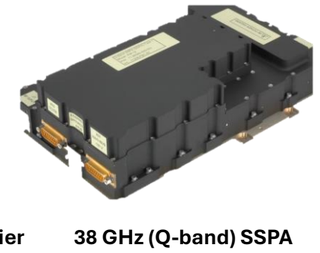


V-band (58 GHz) SSPA

25-27 GHz SSPA

35 GHz 100 Watt Pulsed SSPA

K/Ka band Solid-State Power Amplifier



38 GHz (Q-band) SSPA