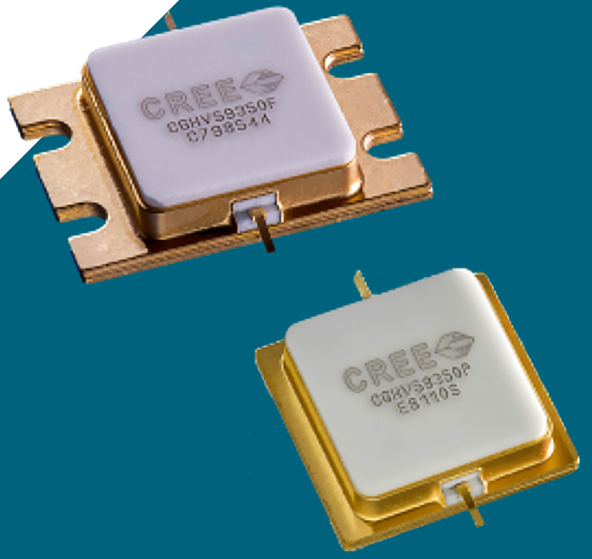
Powerful weather radar performance with SSPA

VAISALA

Radar is critical for short-term weather forecasting, helping people prepare for storms, hurricanes and other dangerous weather conditions. The technology is used in all corners of the world — from meteorological organizations to airports. Vacuum tube-based power amplifiers have been used for decades in their design, but solid state power amplifiers (SSPA) are changing the game for good.

SSPA based on gallium nitride (GaN) transistors is the future of radiofrequency power generation, and is now available for weather radars.

Why is SSPA better than tube-based power amplifiers? The answers are in this eBook, which highlights the advantages and explains why SSPA will soon become the standard in weather radar design.



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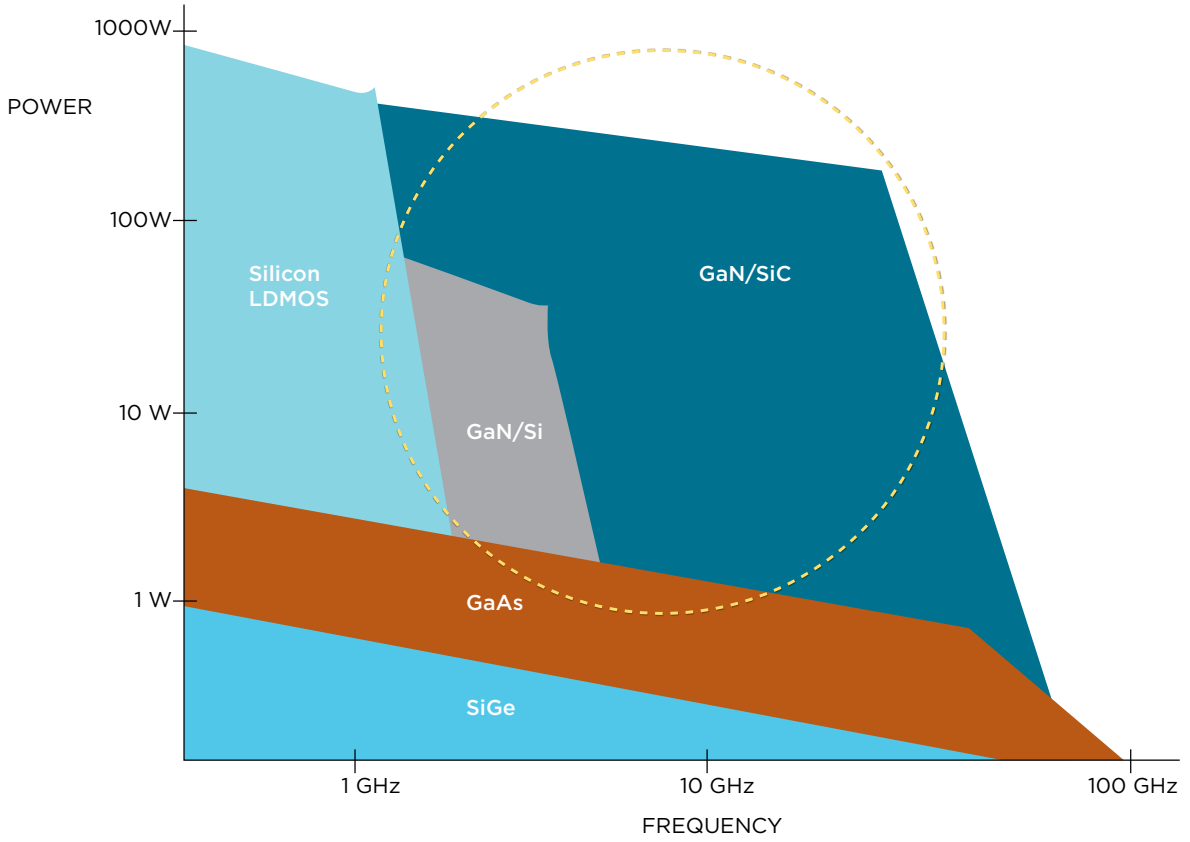
Trusted weather observations for a sustainable future

Technology advancements

Tube technology has been the go-to for transmitters in weather radar systems such as magnetron, klystron and traveling wave tubes. All of them require high voltages and peak power, resulting in large and complex transmitter systems.

Solid state technology as a power amplifier is not new: Telecommunication, microwave links, military radar and others have used it for years. However, high-power components at high frequencies simply have not been available at reasonable prices, keeping them out of reach for weather radar.

Fortunately, advancements in GaN transistor technology have expanded the power and frequency range of semiconductors, and cost-effective GaN components are now available. In addition, GaN transistors on silicon carbide (SiC) substrate can now achieve high power densities.



Semiconductors for microwave frequencies
Traditional semiconductor technologies such as silicon or gallium arsenide technologies cannot produce the high peak powers required to provide proper sensitivity from the weather radar system. GaN/SiC components are now available for weather radar frequencies, including X-band and C-band.

Reliability

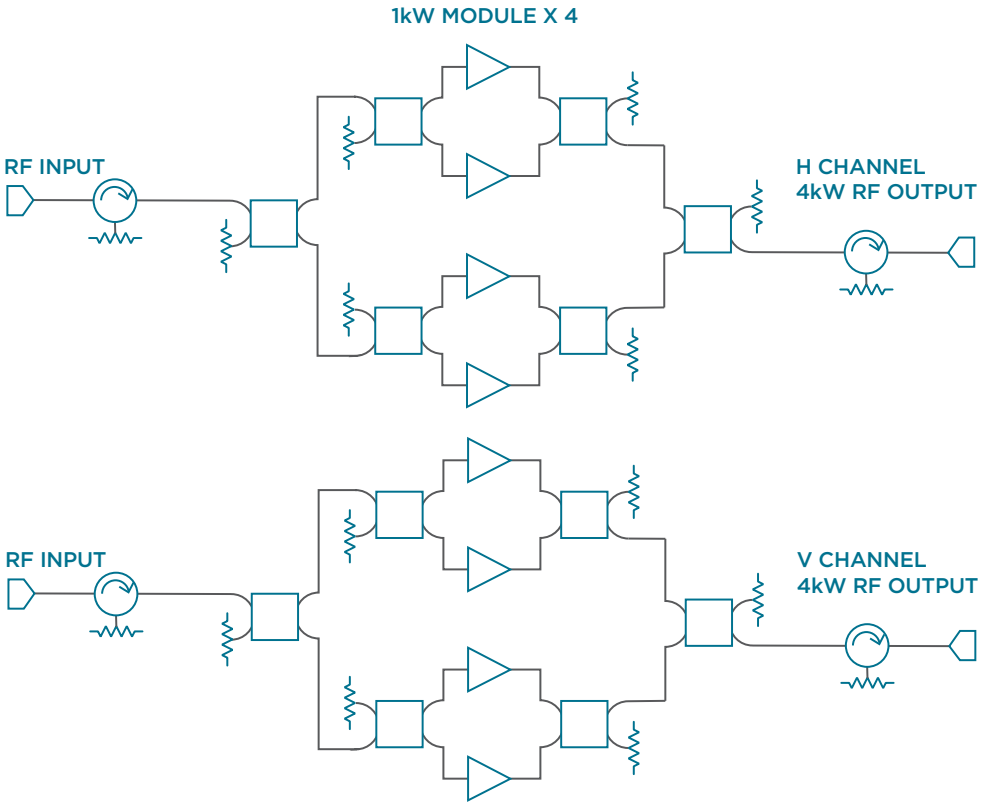
SSPA has key advantages over tube technology that increase reliability.

Solid state power amplifiers

- Uses GaN transistors with MTBF of more than 1,000,000 hour lifespan
- No consumable components
- Built-in redundancies
- Continuous calibration for high data quality
- Lower maintenance and lifetime costs

Magnetron or klystron tubes

- Up to 50,000 hour lifespan
- Consumable components replaced every few years
- Component failure can stop data collection
- Higher lifetime costs and maintenance requirements



Transmitter redundancy
A single component failure will not stop weather radar operation. There are separate transmitters for horizontal and vertical channels in a dual-polarization weather radar, producing horizontal and vertical transmitted pulses for system redundancy. Each transmitter contains several amplifier modules parallel to each other, producing pulse power. Each module contains several parallel GaN transistors in the final amplification phase of the signal, for yet another level of redundancy in case one of the transistors fails.

Maintenance

Maintenance is an important factor in weather radar, and solid state power amplifiers are designed to last for the lifetime of the system. Tube-based designs including consumable parts with limited lifespans, oil tanks, X-ray radiation and others raise maintenance costs and make safety precautions necessary.

Low maintenance with SSPA

- No consumables, oil tank or X-ray radiation
- Better environmental sustainability
- Fewer site visits and expenses
- Automatic calibration for continuous data availability

Peak power

SSPA uses a much lower peak power than tube technology, which improves the reliability of a weather radar system. To maximize measurement sensitivity, Vaisala uses long pulses with pulse compression.

Lower peak power enables simpler, cost-effective weather radar design with several benefits:

- Less stress to the sensitive receiver front end during the transmit pulse
- Enables the use of semiconductor limiters without radioactive discharge tube technology
- Easier and more reliable design of waveguide parts without a risk of arcing
- Less interference for other radiofrequency devices

Cost efficiency

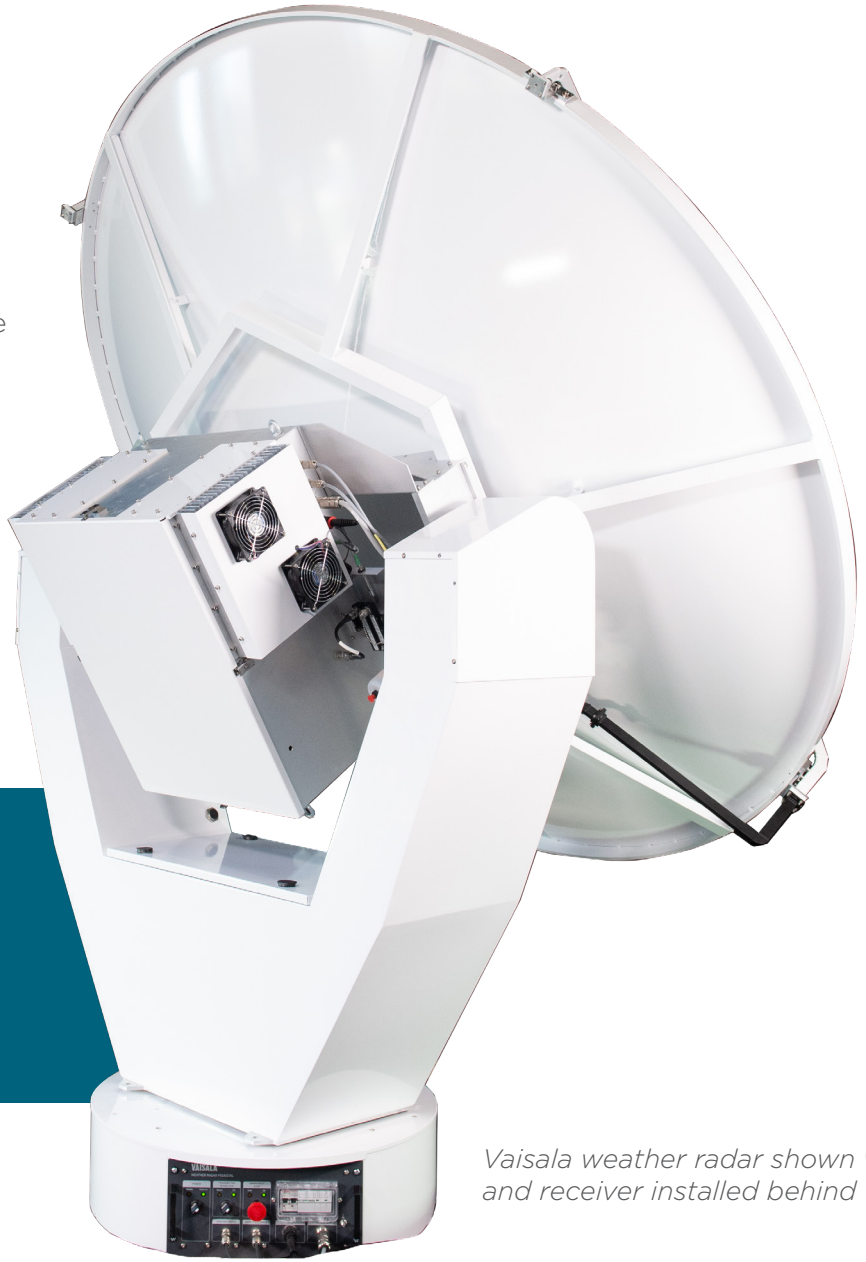
SSPA enables more efficient weather radar design with better performance. For example, it is possible to install the transmitter and receiver behind the antenna.

Some components are not needed such as expensive waveguide rotary joints and site-specific long waveguides. TR limiters are easier to design, have better reliability, and no radioactive or consumable parts.

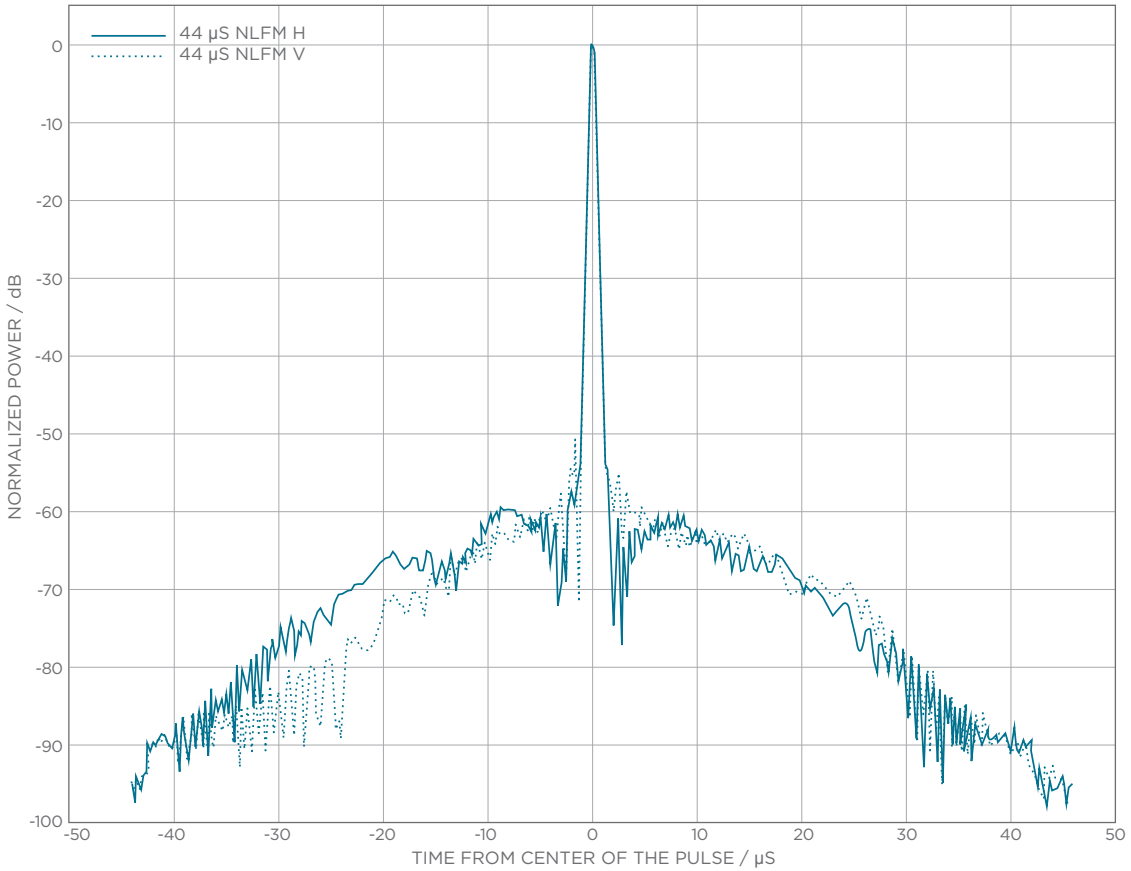
Solid state transmitters are widely available in X-band weather radar, and increasingly for C-band. Because of its obvious advantages, SSPA will eventually become the standard for weather radar.

Cost efficiency across the board

- Weather radar design
- Delivery, installation and site preparation
- Maintenance
- Lifecycle costs



Vaisala weather radar shown with transmitter and receiver installed behind the antenna.



Range ambiguity plot
This diagram shows the ambiguity plot of a compressed pulse after the compression. This 44 microsecond pulse from a Vaisala X-band weather radar has been compressed to a half-microsecond. The 75-meter range resolution is equal to a half-microsecond pulse in a traditional tube transmitter. Note the low side slopes: From the actual measured bin to the next bin, the attenuation is more than 60 DB.

Pulse compression and modulation

Proper signal processing algorithms are important for SSPA to maximize the weather radar design benefits. Peak power is lower, and in order to get the same average power and sensitivity, the radar must transmit longer pulses. A long pulse on its own results in poor range solution, but using well-known pulse compression methods maintains resolution.

The pulse compression technique achieves the same resolution from the weather area as traditional tube transmitters, while retaining the sensitivity from the long pulse.

Hybrid pulsing is also utilized, which combines sending long and short pulses to provide a full range of measurements without data gaps.

Run-time calibration allows you to take full advantage of the power amplifier with solid state redundant modules.

Get more with the webinar

See the in-depth discussion plus Q&A with the experts.

Watch the webinar

We believe in the relentless pursuit of quality and performance, anywhere and everywhere. Our expertise is built on 85+ years of highly accurate observations. Vaisala has delivered more than 220 weather radar systems to customers across the globe. 60 meteorological institutes and other organizations trust Vaisala to provide their weather radar. From the North Pole to the South Pole, from the ground to NASA on Mars — weather-critical organizations trust Vaisala to deliver a full service offering for measuring the weather.

With decades of experience providing the best technologies and expert know-how, Vaisala's support, training and philosophy of partnership are unmatched in the industry.

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