



NANOWAVE Technologies Inc.

Continuous Wave SSPAs

Version 1.6



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CONTENT

Product Overview 3

FACTS ON THE TECHNOLOGY..... 4

SOLID-STATE POWER AMPLIFIERS 5

ABOUT NANOWAVE 8

RF Components and Subsystems

NANOWAVE Technologies Inc. is a privately owned Canadian manufacturer of advanced high reliability RF and microwave components, modules and subsystems for the Aerospace, Avionics, Defense, Industrial and Medical markets.

At NANOWAVE all critical processes are conducted in-house to provide a controlled supply chain to the end customer over product life spans up to and beyond 20 years. In house processes include:

- Packaging and Housing Technology
- Thin-Film Technology
- Semiconductor Device and MMIC Design
- RF Circuit Engineering
- RF Filter Design
- Circuit Card Design and Manufacturing
- Assembly and Integration
- Electrical and Environmental testing
- Quality Assurance

The foundation of the NANOWAVE product is a proprietary, high reliability, hybrid monolithic integrated circuit (HMIC) process. The HMIC process integrates bare die with in-house thin film circuits which are then hermetically sealed within a modular assembly. The resultant circuits can be sustained

over product lifetimes of up to and beyond 20 years without change in module function or physical form fit making NANOWAVE product ideally suited to the high reliability long duration product requirements of aerospace and defense applications.

The RF subassemblies comprise Solid-State Power amplifiers, Up-/Down-Converters, Filters, Synthesizers, Low-Noise Receivers, and Limiters. All RF blocks can be complemented by sophisticated Digital Control Interfaces, which allow interrogation from supervision systems, enabling remote status reporting on all major subsystem parameters, such as voltages, currents, or RF power levels.

NANOWAVE uses the following integrated circuit processes in its HMIC modules and is continuously reviewing and assessing the potential of new technologies to address customer requirements:

- Gallium Nitrid (GaN)
- Gallium Arsenid (GaAs)
- Silicon Germanium (SiGe)
- Bi-polar CMOS (BiCMOS)
- High Power Silicon (LDMOS)
- Indium Phosphide (InP)

Product Overview

NANOWAVE's product portfolio covers a wide range of RF modules, components, subsystems, systems and sophisticated assemblies for the following Markets

- Commercial Aerospace
- Defense
- Communications
- Industrial
- Medical

NANOWAVE RF products can be found in applications such as

- Airborne and Ground-based RADAR
- SatCom
- Terrestrial Communication

NANOWAVE's Aerospace products can be found on the following platforms



A380 B787 A320 B737



F-18



P-3





| Category Market | GaAs / GaN Die | Thin Film | Transmitter < 400 W | Transmitter > 400 W | Signal Sources | Frequency Converter | High-Power Transceiver | Broadband SSPA | Active Array |
|---------------------------|--|---|--|--|---|---|---|---|--|
| Commercial Aerospace (CA) |  GaAs/GaN FET & MMIC |  nF Capacitor |  100/200 W Gann | | |  Miniature Tx / Rx |  | | |
| Defense | |  Thick Copper substrate |  400 W X-Band Tx |  4 kW L-Band (Pulsed) |  L- to X-Band Synthesizer |  Data Link Tx/Rx | |  6 to 18 GHz 1.5 W CW | |
| SatCom & Fiber Optics | |  LASER Mount |  200 W INMARSAT Tx | | | | | |  Ka-Band Array |
| Industrial | |  5-pole SIW Filter | |  600 W X-Band (Pulsed) |  C-Band STALO |  X-Band RADAR Test Set | |  2-4 GHz 100W CW SSPA | |
| Medical | |  Quartz Capacitor | | | | | | | |

Fig. 1: Overview on NANOWAVE's Product Portfolio and Markets

FACTS ON THE TECHNOLOGY

ACTIVE DEVICE TECHNOLOGY

NANOWAVE uses GaN, GaAs, SiGe, BiCMOS, LDMOS, and InP bare die active devices in its RF subassemblies in order to obtain

- Best possible thermal management
- High efficiency
- Lowest parasitics
- Smallest size
- Multi-octave matching
- Multi-decade obsolescence mitigation

All RF subassemblies are packaged into hermetically sealed housings to achieve high reliability and high MTBF performance.

KEY TECHNOLOGIES

NANOWAVE has all manufacturing technologies in-house to produce high volumes of complex assemblies. This comprises

- Engineering
- Chip Design
- Thin Film Technology
- Packaging Technologies (Machining, Reflow)
- Surface Mount Technology (PCB and Ceramic)

QUALITY ASSURANCE

NANOWAVE Technologies Inc. is certified to the following standards

- ISO 9001:2008
- AS 9100

The products are qualified and tested according to the following standards:

- DO-160
- MIL-STD-883
- MIL-C-9858A
- MIL-PRF-38534C

- Hybrid Module Assembly (Pick & Place, Eutectic Pick & Place, Automated Wire Bonding)
- Integration
- Test & Tune
- Quality Assurance (Electrical and Environmental testing)

FREQUENCY BAND DEFINITION

| Band | Frequency Range |
|------|---------------------------|
| L | 1.0 - 2.0 |
| S | 2.0 - 4.0 |
| C | 4.0 - 8.0 |
| X | 8.0 - 12.0 |
| Ku | 12.0 - 18.0 |
| Ka | 28.0 - 32.0 |
| BB | Broad band (multi octave) |



SOLID-STATE POWER AMPLIFIERS

The SSPAs comprise a building block architecture based on bare die power devices from various technologies including:

- Gallium Nitride (GaN)
- Gallium Arsenide (GaAs)
- Silicon Germanium (SiGe)
- High Power Silicon (LDMOS)
- Indium Phosphide (InP)

Utilizing bare-die devices in all RF sections, NANOWAVE has full control on thermal and RF characteristics for pulsed and CW operated small-band or broad band circuits. Power amplifier designs range from fast, pulsed to CW operated with very high linearity in both, amplitude and phase behaviour.

CW LINEAR AMPLIFIER MODULES

This series of NANOWAVE amplifiers are designed for CW operation, but can also handle pulsed RF input signals. The series is complemented by

amplifiers for applications where high linearity with respect to output power and phase are required.

Application:

- Communication systems with high linearity requirement
- SATCOM
- Industrial

Special Features:

- GaN or GaAs device technology
- High efficiency
- High amplitude and phase linearity
- Arbitrary load capability
- High MTTF of > 180,000 h
- AC supply voltage 110 to 240 V (internal, or separate unit)
- Water Cooling (Forced FAN Cooling optional)
- Digital Control via Ethernet (optional) or RS232
- Web Browser based GUI (optional)
- 19 " rack mountable or custom designed compact housing



Fig 2: NW6418-28 6 to 18 GHz TWTA Exciter Amplifier

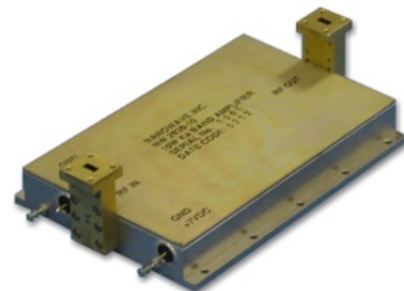


Fig 3: NW2930-36 Ka-Band SSPA Module

COMMERCIAL PRODUCTS

Selection Guide for CW and Linear Amplifiers

| Model Number | Band | Frequency GHz | Pout dBm | Gain dB | Ripple dB | Noise Figure dB | Operating Temperature °C | Vd / Id V / A | Size inch |
|--------------|------|---------------|----------|---------|-----------|-----------------|--------------------------|---------------|---------------------|
| NW6418-28 | BB | 6.4 - 18.0 | 29.0 1) | 40.0 | ±1.0 | 4.5 | -25 - +75 | +9 / 4.1 4) | 9.23 x 2.5 x 0.9 |
| NW6770-43 | O | 0 | .0 | .0 | | .0 | 0 | / | 0 |
| NW2930-36 | Ka | 29.0 - 30.0 | 36.0 | 51.0 | ±0.5 3) | .0 | -30 - +60 | +7 / 12.9 | 0 |
| NW1213-40 | Ku | 12.7 - 13.2 | 40.0 1) | 50.0 | ±1.0 | 5.5 | -40 - +70 | +12 / 13.5 | 7.80 x 3.94 x 1.125 |
| NW0520-20 | L | 0.5 - 2.0 | 20.0 1) | 52.0 | ±1.0 | 5.0 | -55 - +85 | +15 / 0.8 | 3.83 x 1.73 x 0.62 |
| NW0102-10 | L | 1.0 - 2.0 | 10.0 1) | 40.0 | ±1.0 | 3.0 | -55 - +85 | +15 / 0.16 | 3.83 x 1.73 x 0.62 |
| NW2553-20 | S | 2.5 - 5.3 | 20.0 1) | 21.0 | ±1.0 | 4.5 | -55 - +85 | +15 / 0.275 | 3.83 x 1.73 x 0.62 |
| NW2065-27 | BB | 2.0 - 6.5 | 27.0 1) | 22.5 | ±1.0 | 8.0 | -55 - +85 | +15 / 1.5 | 3.83 x 1.73 x 0.62 |
| NW1732-24 | BB | 17.0 - 32.0 | 24.0 2) | 15.0 | ±3.0 | .0 | -55 - +85 | +15 / 0.8 | 3.83 x 1.73 x 0.62 |
| NW0014-18 | BB | 0.03 - 15.0 | 17.0 1) | 20.0 | ±4.0 | 11.0 | -55 - +85 | +15 / 0.6 | 3.83 x 1.73 x 0.62 |
| NW2640-06 | Ka | 26.0 - 40.0 | 6.0 1) | 18.0 | ±2.0 | 7.0 | -55 - +85 | +15 / 0.2 | 3.83 x 1.73 x 0.62 |
| NW2816-29 | BB | 2.8 - 15.5 | 29.0 1) | 15.0 | ±2.0 | 8.0 | -55 - +85 | +15 / 2.1 | 3.83 x 1.73 x 0.62 |

Notes:

- 1) P1dB
- 2) Saturated output power @ 3 dB saturation
- 3) Over any 40 MHz band
- 4) Multi supply voltages required (see Data Sheet for details)

All specifications are subject to change without notice.
 Full Data Sheets of NANOWAVE products are available on request at sales@nanowavetech.com.

SSPA UNITS FOR CONTINUES WAVE (CW) OPERATION

NANOWAVE has developed highly efficient, narrow- and broadband Solid-State Power Amplifiers (SSPA) for continuous wave (CW) operation offering very high amplitude and phase linearity over the respective frequency band. The amplifiers can be

used for pulsed RF operation, offering high pulse-to-pulse stability. The SSPAs comprise GaN transistor technology. The entire RF section based on NANOWAVE's HMIC technology is hermetically sealed.

Application:

- Communication systems with high linearity requirement
- Particle Accelerator Electronics (e.g. Klystron Driver, Stochastic Cooling Systems)
- Industrial

Special Features:

- Gallium Nitride (GaN) Device Technology
- High efficiency
- High amplitude and phase linearity
- Low group delay time variations
- High pulse-to-pulse stability
- Arbitrary load capability
- High MTTF of > 180,000 h
- AC supply voltage 110 to 240 V (internal, or separate unit)
- Water Cooling (Forced FAN Cooling optional)
- Digital Control via Ethernet (optional) or RS232
- Web Browser based GUI (optional)
- 19 " rack mountable or custom designed compact housing

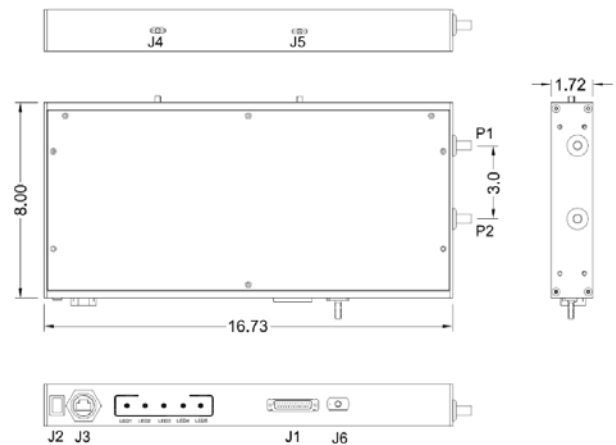


Fig 4: 19" rack mountable 100 W 2 - 4 GHz SSPA Unit with separate Power Supply unit (Individual systems may vary in size, weight, front and back panel configuration)

Selection Guide for CW SSPA Units

| Model Number | Band | Frequency GHz | P1dB dBm | Gain dB | Ripple dB | Noise Figure dB | Operating Temperature °C | Vac V | Size inch |
|--------------|------|---------------|----------|---------|-----------|-----------------|--------------------------|------------|---------------------|
| NWPA1020-54 | L | 1.0 - 2.0 | 54 | 52 | ±1.0 | 6 | +25 ±4 1) | 110/230 | 19.0 x 2HU x 20.0 |
| NWPA2040-48 | S | 2.0 - 4.0 | 48 | 45 | ±1.0 | 6 | +25 ±4 1) | 110/230 2) | 16.73 x 12.0 x 1.72 |
| NWPA4060-50 | C | 4.0 - 6.0 | 50 | 50 | ±1.0 | 6 | +25 ±4 1) | 110/230 2) | 16.73 x 12.0 x 1.72 |
| NWPA1200-56 | Ku | 12.00 | 56 | 56 | ±1.0 | - | +15 - +30 3) | 110/230 | 19.0 x 4HU x 20.0 |

Notes:

- 1) Water cooling system with controlled water temperature required
- 2) Power Supply in separate 19 " unit, connected via 10 m DC supply cable
- 3) Requires water cooling or controlled environment for operation

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ABOUT NANOWAVE

NANOWAVE Technologies Inc. was founded in 1992 and is a leading Canadian Designer and Manufacturer of Advanced Microwave and Millimeter Wave Components and Sub-Systems for the Radar, Communications, Industrial and Medical markets.

The company's products can be found on the most advanced commercial and defense aircrafts, as well as ground based Radar and Communication Systems.

NANOWAVE's commitment to annual investments in R&D combined with in-house control of critical design, manufacturing and test processes results in rapid response to our customers' demands for:

- Customization
- Obsolescence Mitigation
- Demanding Technical Specifications
- On-time Delivery
- High Reliability
- Traceability



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