GENERAL DESCRIPTION

The NWPA4060-50 is a highly linear solid-state power amplifier (SSPA) for continuous wave (CW) operation based on GaN device technology. The minimum output power at 1 dB compression at output is 50.0 dBm (100 W) minimum.

The amplifier offers very low gain and phase ripple over the frequency band of 3.9 to 6.1 GHz. The group delay time variations are less than ± 200.0 ps within the whole band.

This amplifier is designed for applications which demand very high linearity. The amplifier can be arranged in arrays of e.g. 16 or 32 units (or more if required), and therefore offers very low gain and phase variances across the ensemble of amplifiers. Typical applications are e.g. Stochastic Cooling Systems of Particle Accelerators, or highly linear communication systems. Other frequency ranges (e.g. 1.0 to 2.0 GHz, 2.0 to 4.0GHz or 6.0 to 8.0 GHz) as well as higher output power levels are available on request.
The SSPA unit and Power Supply can be within the same enclosure, or in separate rack-mountable units connected by a control and supply harness of up to 15m length.

FEATURES

- Ultra-linear CW SSPA
- 2 GHz Bandwidth with low Group Delay Time Variation
- Operating Frequency: 4000–6000 MHz
- Water or FAN (optional) Cooling of SSPA, PSU with FAN Cooling
- Ethernet and RS-232 Control Interfaces

APPLICATIONS

- Particle Accelerator Technology
- In a set of N x 8 Amplifiers for Stochastic Cooling of high-energy particles
- Ultra-Linear Communication Systems

ELECTRICAL PARAMETERS

Parameter	Unit	Min	Typ	Max	Remarks
Frequency range	GHz	4.0		6.0	
Gain	dB		45.0		
Gain variation amplifier-to-amplifier	dB			± 0.5	
Gain variation vs frequency @ 10dB below OP-1dB 2)	dB			± 1.0	

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Parameter	Unit	Min	Typ	Max	Remarks
Gain variation vs frequency @ OP-1dB	dB			± 1.5	
Maximum gain with phase error $\|\Delta\varphi\| > 60\ deg$relative to mean gain	dB			-5.0	For any in-band frequency
Electrical length	m	1.5		3.0	3)
Variation of phase relative to electrical length @ 10dB below OP-1dB	deg			± 12.0	
Variation of phase relative to electrical length @ OP-1dB	deg			± 18.0	
Input reflection factor	dB			-10.0	In range 3.9 – 6.1 GHz 1)
	dB			-8.0	In range 3.8 to 6.2 GHz 1)
Output reflection factor	dB			-10.0	In range 3.8 to 6.2 GHz 1)
Noise Figure	dB			6.0	In range 3.9 – 6.1 GHz
	dB			7.0	In range 3.8 to 6.2 GHz
1 dB compression point at output 2)	dBm	50.0			
3rd order intercept point at output	dBm	57.0			
Group delay time ripple	ps			±200.0	
Tolerable load impedance	ohm	0		∞	Unconditionally stable
Maximum tolerable input power	dBm	13.8			Is10dB above the input power which drives amplifier into 1dB compression

Notes:
1) S11, S21, S12, S22 are the scattering parameters of the amplifier, The input port 1 and the output port 2 have the reference impedance ZL. The reference planes are at the case of the amplifier. $|S_{ij}|$ are the magnitudes of Sij . $\overline{|S_{ij}|}$ are the arithmetic mean values of $|S_{ij}|$ over the given frequency range.
2) OP_{-1dB} is the lowest value of the 1 dB compression point over the frequency range 4.0 to 6.0 GHz.
3) The phase φ of the complex transmission $S_{21} = |S_{21}|e^{i\varphi}$ is a superposition $\varphi = \varphi_{lin} + \Delta\varphi$ of a frequency-linear part φ_{lin} and a frequency dependant part $\Delta\varphi$. The frequency-linear part φ_{lin} is defined as $\varphi_{lin} = \frac{L_{el}}{c} \cdot f$, where L_{el} is the electrical length of the amplifier and c is the vacuum speed of light. $\frac{L_{el}}{c}$ has to be calculated from a affine linear least square fit of φ over the frequency range from 4 to 6 GHz

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Mechanical and Environmental Parameters

Parameter	Unit	Min	Typ	Max	Remarks
Operating Temperature Range	ºC				
Input / Output Connectors			SMA		Female
Size (L, W, H)	inch		8.0 16.73 1.72		The SSPA comes in a very compact housing. 1)
Weight	kg		tbd		Depends on type of cooling system 1)
AC Power Supply Input Voltage (nominally 230 V single line)	V	95		240	fulfils the EMC requirements according to EN 61000-3-2 (class A)
Water Cooling	W			600	(tbd) see below note 2)
Has to withstand Ionizing Radiation!					

Notes: Specifications subject to change without notice.

1) SSPA housing size and weight depends on type of cooling system
2) Water cooling system has additional requirements e.g. for water pressure and flow. Please contact NANOWAVE fr details.

Water Cooling System

The SSPA can optionally be equipped with FAN cooling.

Measurement	Value	Remarks
Medium	Deionized water	1)
Conductivity	< 1 µS/cm	
pH-value	7 to 9	
Oxygen content	< 0.1 mg/l	
Inlet temperature	25 ºC ± 2 ºC	
Maximum allowed outlet temperature	45 ºC	
Maximum regular pressure	13 bar	2)
Peak pressure	15 bar	2)
Difference pressure	≤ 1 bar	
Medium	Deionized water	1)

Notes:

1) All materials of the cooling circuits must be suited for deionized water. If other materials than stainless steel, copper, zinc-free cast-bronze, or plumb-free tin solder are to be used, the ordering party must be asked for permission.
2) These are the specifications of a typical water cooling system. If these high pressures are technically or economically not justifiable, a pressure-reducing valve can be used to reduce the maximum regular pressure to 6 bar and the peak pressure to 8 bar. The ordering party must be asked for permission for this option.
As connects for the water, Swagelok® quick connects are recommended. The details must be arranged with the ordering party.

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Digital Control Interface

The SSPA can be monitored and controlled via RS232 connection. An **Ethernet TCP/IP** based interface is available as option. The standard Communication Protocol via RS232 is SCPI (Standard Commands for Programmable Instruments). Optionally, higher-level communication protocols (e.g. MODBUS, CAN-Bus) can be implemented. A web-browser based GUI (Graphical User Interface) is optionally available.
Monitored parameters are:

- Temperatures
- Voltages
- Current Failures
- RF Power OK
- General Status

The following functions can be remote controlled:

- RF Power ON / OFF
- SSPA Standby / Operate (optional)
- (further options on request)

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Outline Drawing

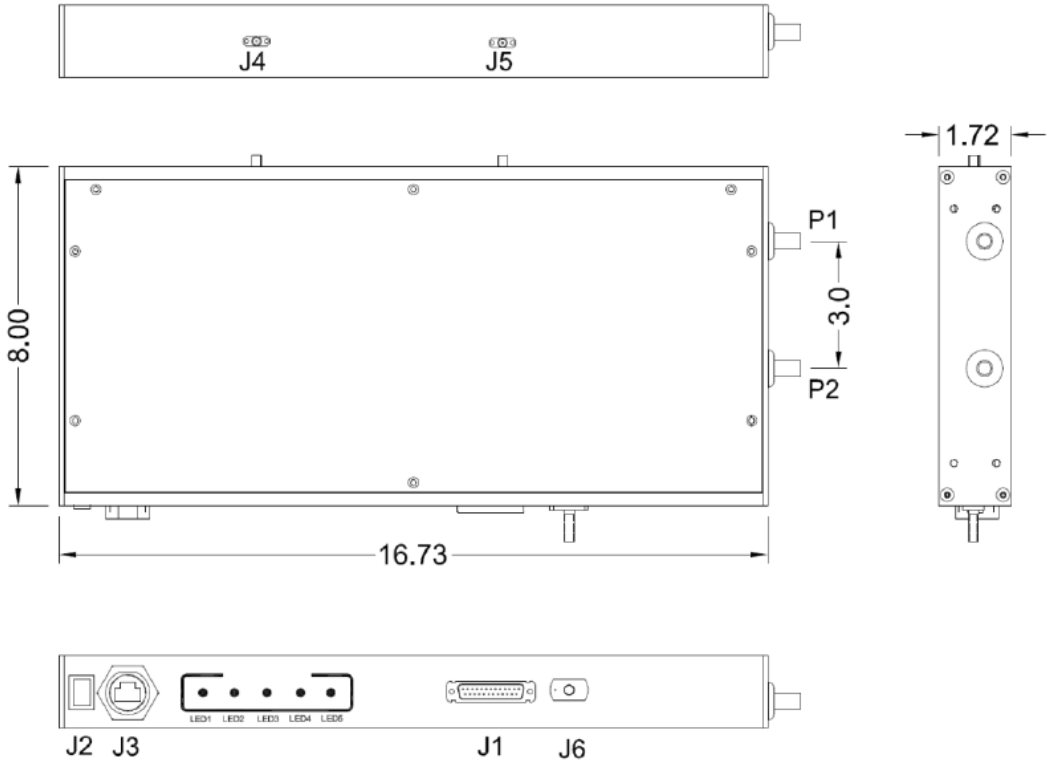

Fig 1: Outline Drawing of SSPA Unit with Water Cooling

Table 1: List of Connectors

J1	DC Power Supply DB25
J2	RF On/Off Switch
J3	LAN
J4	RF input
J5	RF output
J6	Safety GND Terminal

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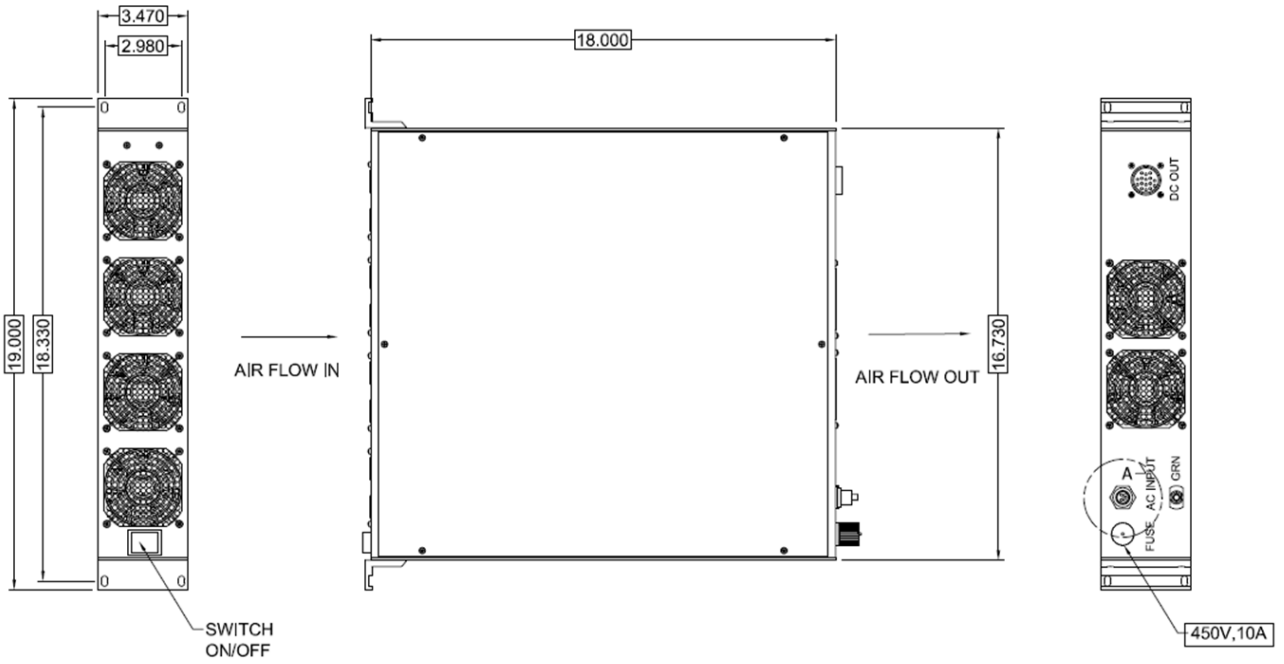

Fig 2: Outline Drawing of Power Supply Unit (FAN cooling)

Additional features:

- Marking: the unit is marked with manufacturer part no., date code, and Serial Number.
- All plating and painting is RoHS compliant

For further information please contact NANOWAVE Technologies Inc. at sales@nanowavetech.com, or call at (+1) 416-252-5602.

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