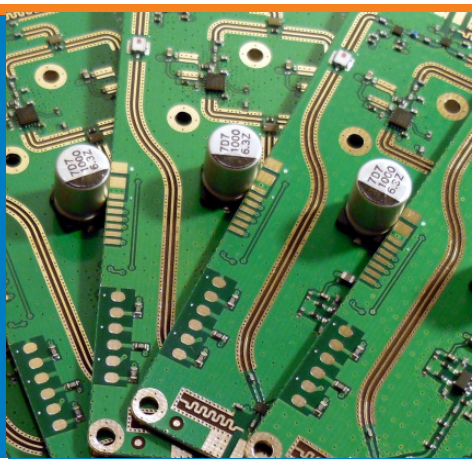
GEM MICROWAVE

Data Sheet

PCBA-24G1W-V5

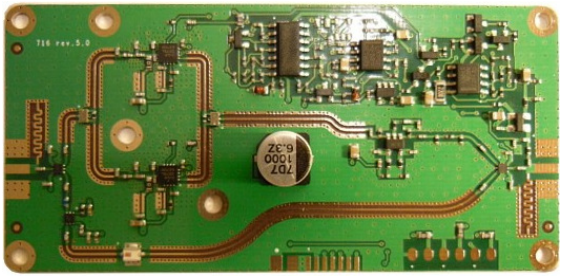
Bi-directional RF Amplifier module



Taking performance to a new peak

PCBA-24G1W-V5 Bi-directional RF Amplifier module

GEM Microwave introduces the latest development of a 2.4 GHz bi-directional amplifier module. The main difference compared to our previously developed 1Watt bi-directional amplifiers is the possibility of microcontroller connection and more stable and trouble-free operation. The amplifier module is offered in the form of a printed circuit assembly.



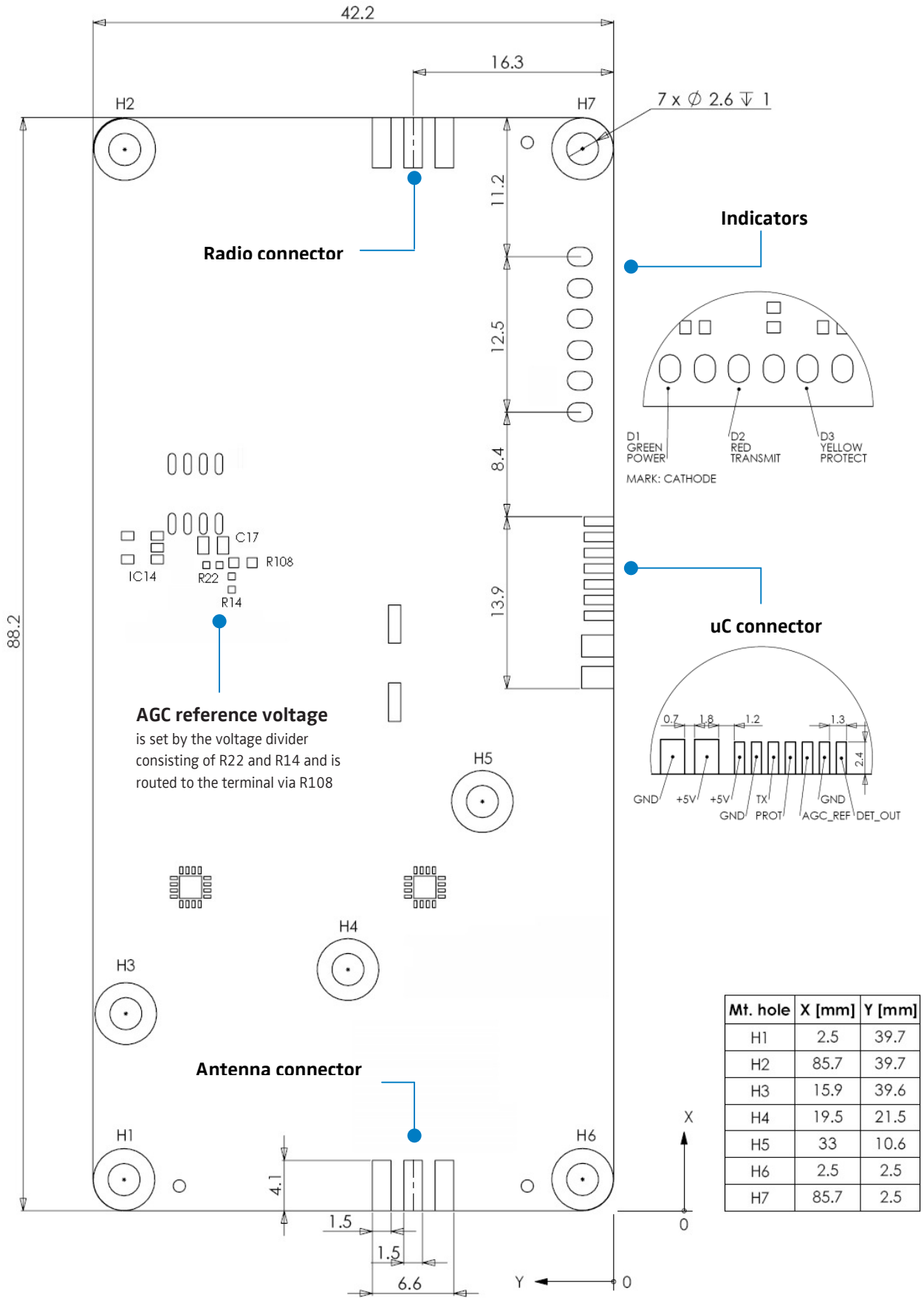
The scope of use of the module is still diverse, it can be used optimally from RC through leaky feeder systems to 64-QAM WiFi signal amplification. As with previous types, the well-proven RF input power protection, thermal protection and transmit AGC have been retained. The AGC reference voltage, which can be changed, the filtered output voltage of the RF detector and some other necessary signals for the microcontroller have been routed through a separate connector. The AGC reference voltage setting allows optimization the average RF output power for input signals with different peak-to-average power ratio, from BPSK to 64-QAM.

Key Specifications

Frequency range	2.3 GHz to 2.6 GHz
Tx input power range	0 dBm to 20 dBm
Tx amp 1dB compression point	34.5 to 35.5 dBm
Switching time	< 300 ns
AGC dynamic range	17.5 dB
Power control accuracy	0.5 dB
Rx amp gain	15.5 dB
Rx amp noise figure	1.3 dB

Key Features

- **Connector for microcontroller**
- **Works with and without a microcontroller**
- **802.11 compatibility**
- **Automatic gain control**
- **Calibration, full characterization (optional)**
- **Control module with SNMP Ethernet monitoring including PoE power supply (optional)**
- **Thermal, RF input power and lightning protection**



Mt. hole	X [mm]	Y [mm]
H1	2.5	39.7
H2	85.7	39.7
H3	15.9	39.6
H4	19.5	21.5
H5	33	10.6
H6	2.5	2.5
H7	85.7	2.5

Operation

The 24G1W-V5 bi-directional amplifier can operate in either stand-alone or microcontroller managed configuration. The radio port of the amplifier is monitored by a fast RF detector switching the amplifier from receive to transmit mode above 0 dBm RF input power. In receive mode the LNA provides 15.5 dB gain with excellent linearity, signals outside the frequency band are filtered out. Return loss and gain of the receive path is shown in Figure 1.

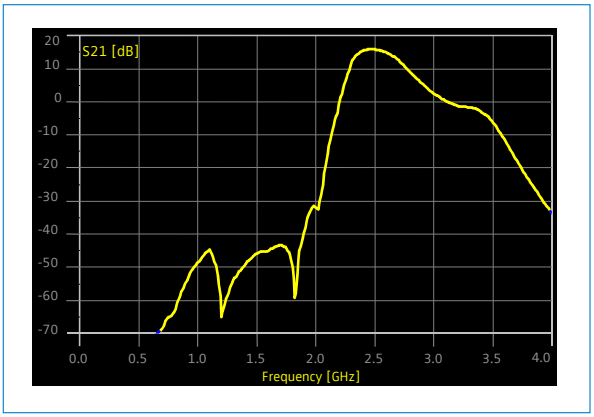


Figure 1a. Broadband S21 of the receive path.

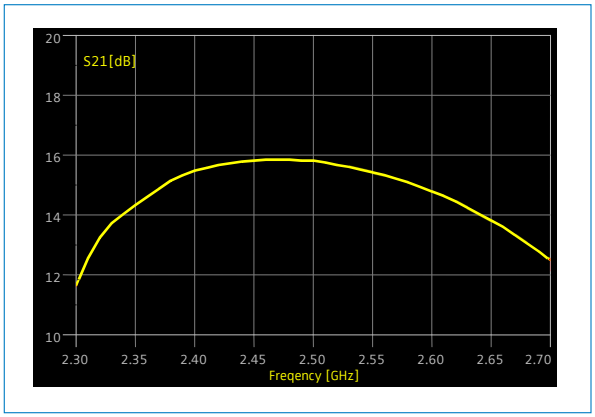


Figure 1b. Narrowband S21 of the receive path.

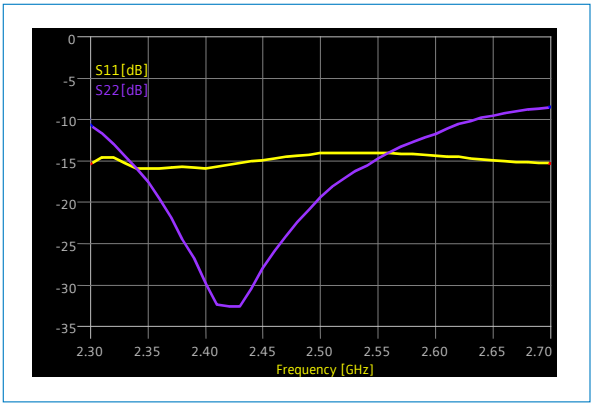


Figure 1c. S11 and S22 of the receive path.

The transmit path comprises a fixed and a controllable attenuator, PA and RF detector. The AGC circuit compares the output voltage of the RF detector and the reference voltage, the output signal controls the attenuator. The dynamic range of the AGC is 17.5 dB. The video bandwidth of the RF detector is 40 kHz and optionally 390 kHz in managed mode. Figure 2. shows the output voltage of the RF detector. AGC reference voltage is set by a voltage divider comprising R22 (20 kOhm) and R14 (3.3 kOhm), therefore AGC_ref is 708 mV at +5 V supply voltage and 779 mV at +5.5 V. The maximum transmit gain is 20 dB, thus at least 10 dBm input power is required for 30 dBm output power at 2.4 GHz.

AGC_ref can also be set externally via the uC connector. The maximum supply voltage of the amplifier is +5.5V, in this case the 1 dB compression point of the transmit path is 35.5 dBm. The module must be installed on a heatsink during operation.

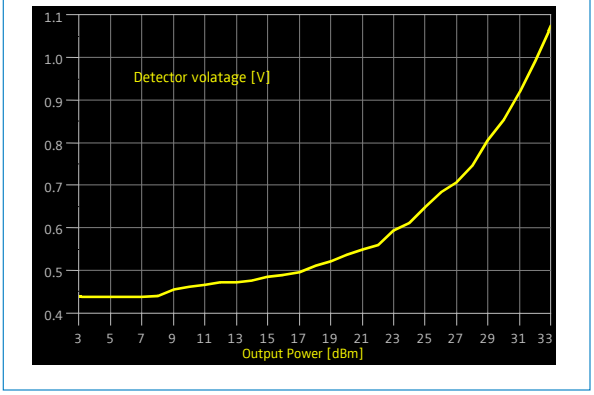


Figure 2. RF Detector output voltage.

The built in thermal protection and input overload protection operate the same way in stand-alone and microcontroller managed configuration. As the temperature of 70°C or average input power of 26 dBm is reached, the PA is switched off. The protected state switches back to active state with a 10 seconds delay after the effect that activates the protection ceases. Even if the protection is active, the receive mode is unaffected, but the cathode of D3 LED (yellow) has low level and D3 lights up. It is also allowed to switch to protected state by driving the "PROT" pin to zero volts, drive current is 20 mA.

Why a microcontroller?

The presented analog AGC circuit works appropriately with 64-QAM input signal. However, a different approach is required for 256-QAM and 1024-QAM, only a sophisticated AGC algorithm provides a suitable and distortion free result. Furthermore, in the case of 802.11ax, an amplitude error may occur due to the temperature dependence of the gain of the PA transistors, which must be compensated during the maximum length of 8ms of the RF burst.

On the other hand, demand came from industrial users who prefer to monitor the operation of the network with SNMP and use leaky feeder type Distributed Antenna System. The 24G1W-V5 amplifier module, along with its associated control module, meets exactly this requirement. We provide more information, data sheets and manuals about the controller upon request.

We produce bi-directional amplifiers with different designs, frequency range, output power capability and with the possibility of fully digital control, in which the RF attenuator can be directly controlled via the uC connector.

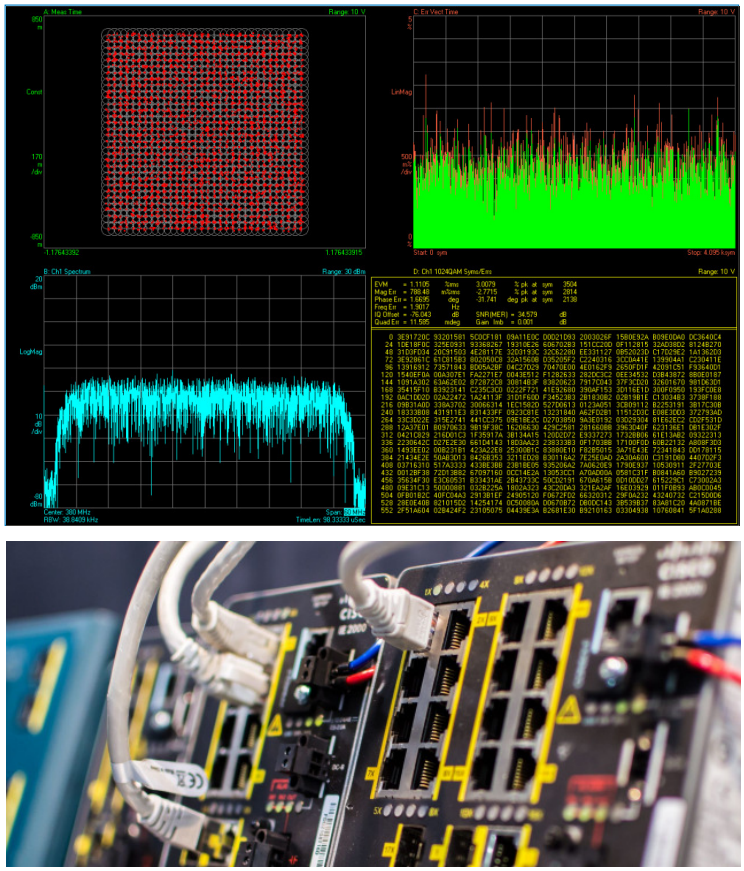


Figure 3. 1024-QAM example (a) Industrial ethernet switch (b)

Device characterization

GEM Microwave utilizes a special automatic measurement setup to calibrate bi-directional amplifiers. The measurement system, which contains ATS-802 type switch matrix (Figure 4.) automatically runs tasks such as RF and DC measurements, programming the controller's calibration constants and formatting the measurement data files. Comprehensive calibration enables users to precisely adjust the output power of the amplifier module, as well as better than 0.5 dB overall power accuracy can be achieved.

For a narrow band, between 2.4 and 2.5 GHz, single frequency point calibration is sufficient. In contrast, wideband amplifier modules (i.e. 58G1W-V5) need multiple frequency-point calibration. The accuracy achieved by calibration also applies to models with analog AGC, including the microcontroller managed 5 GHz version.

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Figure 4. ATS-802 RF switch matrix

How to calculate amplifier backoff?

Spectral mask and EVM requirements should be considered to optimally adjust the output power. The dependence of the spectrum on the amplifier backoff is shown in Figure 5. Average RF output power relative to 1 dB compression point is set by taking into account amplifier backoff values in Table 1. as well as maximum allowed EVM values for a given modulation.

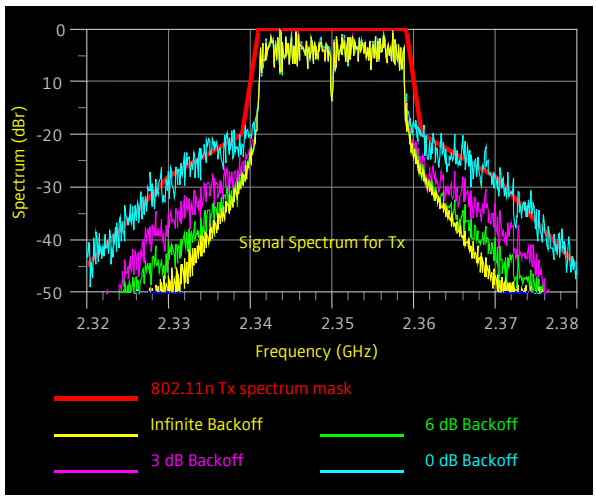

Figure 5. 802.11n transmit spectrum vs. power amplifier backoff.

Modulation	Coding Rate	MCS Index	Max. allowed EVM [dB]	Amplifier Backoff [dB]	EVM (Preamble and Data) [dB]	EVM (Data) [dB]	EVM (Pilot) [dB]
BPSK	1/2	0	-5	0	-13.4	-13.4	-13.6
				3	-20.8	-20.8	-20.9
				6	-28.2	-28.2	-28.4
QPSK	1/2	1	-10	0	-13.0	-12.9	-14.5
				3	-20.5	-20.4	-21.8
				6	-28.0	-27.7	-29.1
QPSK	3/4	2	-13	0	-13.0	-12.9	-14.4
				3	-20.4	-20.4	-21.7
				6	-28.0	-27.7	-29.1
16-QAM	1/2	3	-16	0	-13.6	-13.6	-14.5
				3	-20.5	-20.4	-21.8
				6	-28.0	-27.7	-29.1
16-QAM	3/4	4	-19	0	-13.6	-13.5	-14.4
				3	-20.4	-20.3	-21.6
				6	-27.7	-27.7	-28.9
64-QAM	2/3	5	-22	0	-17.4	-17.8	-14.4
				3	-20.9	-20.9	-21.8
				6	-28.0	-28.0	-29.1
64-QAM	3/4	6	-25	0	-17.4	-17.8	-14.5
				3	-21.0	-20.9	-21.8
				6	-28.0	-27.7	-29.1
64-QAM	5/6	7	-27	0	-17.5	-17.8	-14.5
				3	-20.9	-20.8	-21.8
				6	-28.0	-28.0	-29.4
256-QAM	3/4	8	-30	N/A			
256-QAM	5/6	9	-32	N/A			
1024-QAM	3/4	10	-35	N/A			
1024-QAM	5/6	11	-35	N/A			
4096-QAM	3/4	12	-38	N/A			
4096-QAM	5/6	13	-38	N/A			

Table 1. Maximum allowed Error Vector Magnitude, EVM vs. amplifier backoff.

Specifications

Receive Amplifier

RF Frequency Range	2300 MHz to 2600 MHz
Gain	15.5 dB @ 2.45 GHz
Noise Figure	1.3 dB
Gain Flatness	0.5 dB (2.4 – 2.5 GHz)
Out of the Band Supression	
40 dB	880 – 915 MHz
42 dB	1.71 – 1.99 GHz
30 dB	2.1 GHz
30 dB	4.8 – 5.0GHz
35 dB	7.2 – 7.5GHz
Input Return Loss	15 dB
Output Return Loss	
20 dB	2.4 – 2.5 GHz
10 dB	2.3 – 2.62 GHz
Output 1dB Compression Power	13 dBm

Transmit Amplifier

Frequency Range	2300 MHz to 2600 MHz
Operating Modes	
TDD	max. 31 dBm avg.
Pulsed CW	50 % duty cycle
Gain (Automatic)	
20 dB	maximum
2.5 dB	minimum
Average Output Power	Adjustable, 30 dBm, EVM =4 %, MCS7
Optimal Input Power	
10 – 20 dBm	30 dBm MCS7 output
Output 1dB Compression Point	
34.5 dBm	5 V power supply voltage
35.5 dBm	5.5 V power supply voltage
Harmonics	
-50 dBm/MHz	2f, 3f, Pout= 32 dBm, MCS0
ACPR	
-36 dBc	CH1, 31 dBm, 802.11b
-57 dBc	CH2, 31 dBm, 802.11b
Input Return Loss	
25 dB	2.4 – 2.5 GHz
17 dB	2.3 – 2.6 GHz
EVM	
measured at 5.5V supply voltage	
-28 dB	30 dBm
-30.5 dB	28 dBm
-34 dB	27.5 dBm
-36 dB	26.5 dBm

AGC

Dynamic Range	17.5 dB
Reference Voltage Preset	
708 mV	5 V power supply
779 mV	5.5 V power supply

Power Detector

Dynamic Range	>20 dB
Accuracy vs VSWR	
1.2 dB	3:1
Video Bandwidth	
40 kHz	preset
390 kHz	optional
Output Voltage	0.3 – 1.35 V, low Z

Transmit/Receive Switch

Input Power Threshold	-0.7 dBm
Switching Time	<300 ns

Circuit Protection

RF Ports	λ/4
RF Input Power	26 dBm
Thermal	70 °C

Controller (optional)

Functions	
RF power monitor, RF power setting (20 – 31 dBm), Amplitude slope compensation (only for MCS10 and 11), Temperature monitor, IP and SNMP parameters settings, Status (TX/ RX/ Protected), Factory preset	
Protocol	SNMP v2c/v3
Interface	
RJ45, 10/100Base-T (TCP/IP Ethernet)	
Internal Power Supply	+48 V (PoE)
PoE Operation	
Fully IEEE 802.3af compliant, Mode A, Mode B	
Supply Voltage	36 – 57 V
Transient Voltage Protection	TVS
Calibration	full

Characterization for stand-alone module (optional)

S-Parameters	receive and transmit mode
Detector Voltage vs RF Power	15 – 35.5 dBm
Detector Voltage vs Frequency	2.3 –2.7 GHz
Detector Voltage vs Supply Voltage	+5 V, +5.5 V
Noise Figure	receive
DC Current vs RF Output Power	

Absolute Maximum Ratings

Supply Voltage	5.7 V
Supply Current	1500 mA
RF Input Power	27 dBm
Operating Temperature	70 °C

Other Characteristics

RF Connectors	SMA (optional)
Supply Voltage	5 V – 5.5 V
Supply Current	
50 mA	receive
1400 mA	transmit, 31 dBm
Regulatory	
CE Mark	
2011/65/EU	EN 60950-1:2006
1999/519/EC	EN 55022:2010
2006/95/EC	EN 55024:2010
2004/108/EC	EN 61000-3-2:2001
EN 62311:2008	EN 61010-1:2010

Transmit Power Preset	
30 dBm	can be changed externally
Environmental	
Operating Temperature	-40 °C to 55 °C
Storage Temperature	-55 °C to 100 °C
Operating Humidity	0 to 90% RH, non-condensing
Operating Altitude	10,000 ft max (3048 m)
Dimensions (HxWxD)	88.2 mm x 42.2 mm x 12 mm
PCBA Thickness	1 mm
Weight	0.011 kg
Packaging	antistatic bag

Ordering Information

PCBA-24G1W-V5 **BI-DIRECTIONAL AMPLIFIER MODULE**
2300 – 2600 MHz, 35.5 dBm P1dB

Options

001	SMA Connectors
002	390 kHz Detector Video Bandwidth
003	RF Attenuator External Input
004	Full Device Characterization (2300 – 2700 MHz)

Optional Accessories

CNT-1W	Amplifier Controller (SNMP v2c/v3, PoE)

Available Manageable Amplifiers

PCBA-24G1W-V5	2300 – 2600 MHz, 35.5 dBm P1dB
PCBA-58G1W-V5	5150 – 5850 MHz, 36 dBm P1dB
PCBA-24G2W-V5	2300 – 2700 MHz, 40 dBm P1dB
COS-AMP1	Custom Bi-directional Amplifier, 100 – 26500 MHz, 27 – 50 dBm P1dB
COS-AMP2	Ka-Band Front-End, 26.5 – 50 GHz, 27 – 43 dBm P1dB, SISO, MIMO

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