# PAM-0118P
# Preamplifier
# Operation Manual



REV D

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# INTRODUCTION


The PAM-0118P broadband preamplifier is an excellent choice for improving system dynamic range. The performance of this preamplifier will increase your system sensitivity by at least 35 dB and is ideal for low-amplitude test measurements. When measuring in the EMC lab or out in the field for general RFI testing, this preamplifier has a rugged compact design.

## BEFORE APPLYING POWER

Review this manual and become familiar with this preamplifier and testing instructions. Verify that the equipment line voltage is compatible with the main power source.

## INTENDED PURPOSES

This equipment is intended for general laboratory use in a wide variety of industrial and scientific applications and designed to be used in the process of generating, controlling and measuring high levels of electromagnetic Radio Frequency (RF) energy. It is the responsibility of the user to assure that the device is operated in a location which will control the radiated energy such that it will not cause injury and will not violate regulatory levels of electromagnetic interference.

## HAZARDOUS RF VOLTAGES

The PAM-0118P preamplifier is reliable when operated under specified conditions; however the use of sensitive, high-performance semiconductors causes the preamplifier to be susceptible to ESD and EOS. The risk of damage due to ESD is small, but possible, because the charged object would have to come in contact with one of the center conductors. It is more likely that EOS damage will cause the failure of the preamplifier.

ESD – (Electrostatic Discharge)
A discharge of static electricity can degrade or even worse, seriously damage the preamplifier. There are two kinds of ESD damage that can occur. The worst being severe resulting in complete failure of the preamplifier. This damage is relatively easy to create although often expensive and time consuming to fix. The second kind of damage is less severe and can result in degradation or weakening of components which will not result in evident failure. This kind of damage is difficult to detect and often results in faulty or degraded performance.

EOS – (Electrical Overstress)
Precautions against EOS should always be maintained while operating the preamplifier. It must be emphasized that excessive power applied to the RF input of the preamplifier will damage the input stage. EOS damage can even occur when storing the preamplifier in areas of strong EMI or RFI fields. Improper connection sequence is another possible source of EOS damage such as application of RF signals to the preamplifier before powering up. When connecting alternate sources of DC power caution should be made that excessive Input DC voltage is not applied as this is another source of EOS damage. Loose connections causing intermittent events can also damage the preamplifier.

## PROBABLE CAUSES OF FAILURE

**Excessive input power** is the number one failure analysis with the preamplifiers. This type of damage is without fault of A.H. Systems and will void the warranty. Caution should always be maintained when operating the preamplifier and conveyed to all personnel handling the preamplifier.

**Storage near strong EMI or RF fields** is typically not an issue with common labs, however in the EMC community it is common practice to produce high fields for some standards. These preamplifiers are not intended to withstand a high field environment.

**Handling the antenna** is another possible cause of failure and one that most engineers don't realize is an issue. Most antennas (such as log periodic and drg horn antennas) are an electrical DC short at the RF connection. When performing a test where switching antennas or changing polarities is a requirement, please realize that touching the antenna is like touching the input center conductor of the preamplifier.

## CONSIDERATIONS AND SOLUTIONS

**Adding a one-watt limiter** shunts the ESD narrow pulse to ground before it can reach the preamplifier input. We have introduced a preamplifier with a built-in one-watt input limiter (PAM-0118P). So far, we have not had any of these units fail or returned for repair.

**Understanding the maximum field** that the preamplifier can handle is extremely important. Preamplifiers are very delicate amplifiers used to amplify very low signals and not to be used in a high field environment. Customers who do general lab testing (NOT EMI testing), know that exceeding the input CW power of approximately +10 dBm will burn out the first stage of the preamplifier. They also know that an input signal above (+10 dBm minus gain) will saturate the output.

**Proper grounding techniques** will prevent ESD and is recommended at all times.

**Antenna handling** is very important and caution should be exercised at all times. The use of a RF switch at the input of the preamplifier will

reduce the threading and unthreading of the connector and ensure that the preamplifier is not connected when changing antennas.

An over voltage at the preamplifier RF input will damage the preamplifier. This type of damage is without fault of A.H. Systems and will void the warranty.

To connect:

1. Apply DC Voltage
2. Connect output load
3. Apply RF input

To disconnect:

1. Remove RF input
2. Remove load
3. Remove DC voltage

## RANGE OF ENVIRONMENTAL CONDITIONS

This equipment is designed to be safe under the following environmental conditions:

Indoor use

Altitude: up to 2 km

Temperature: 5° C to 40° C

Maximum relative humidity: 80% for temperatures up to 31° C. Decreasing linearly to 50% at 40° C

Pollution degree 2: Normally non-conductive with occasional condensation.

DC supply voltage fluctuations not to exceed +/- 10% of the nominal voltage.

While the equipment will not cause hazardous conditions over this environmental range, performance may vary.

# OPERATING INSTRUCTIONS

## ASSEMBLY INSTRUCTIONS

The Model PAM-0118P preamplifier is shipped completely assembled. Simply supply the required 15 Vdc to the preamplifier.

## MOUNTING INSTRUCTIONS

The Model PAM-0118P is a bench top preamplifier. Ordinarily, the preamplifier should be used near the test equipment, rather than at the antenna. There are a few exceptions, however, including:

- Magnetic Loop antennas in quiet locations. These antennas have relatively low sensitivity or gain. When used in quiet locations, they do not provide much background noise to the system.
- Long cable runs. If the cable loss is high, performance will improve with the preamplifier mounted near the antenna.

## OPERATING INSTRUCTIONS

Operation of the Model PAM-0118P preamplifier is quite simple. The unit is turned on by first plugging the phone-type plug from an external power supply into the power input connector. The power supply is then plugged into the appropriate line voltage supply. Ensure that the preamplifier has sufficient time (15 minutes) to warm up and stabilize. Pushing the switch to the on position turns on the preamplifier and the power indicator LED will light. The output signal is taken from the jack marked “OUTPUT” and fed to the desired amplifier or test equipment. The input signal is connected to the jack marked “INPUT”.

**CAUTION:**

**The Model PAM-0118P preamplifier is not critical in regards to source and load VSWR and will remain unconditionally stable with any magnitude and phase of source and load VSWR. However, input signals greater than -30 dBm are not recommended, as they will saturate the preamplifier and amplitudes higher than +10 dBm will damage the preamplifier.**

# GENERAL INFORMATION

SPECIFICATIONS

The PAM-0118P Pre-amplifier specifications:

| | |
|---|---|
| Power output | +10 dBm at 1 dB compression |
| Frequency Range | 20 MHz – 18 GHz |
| Gain (typical) | 38 dB |
| Gain (minimum) | 35 dB |
| Gain Flatness | +/- 2.75 dB |
| Noise Figure | 2.5 dB Max |
| Modulation Capability | will reproduce AM, FM or pulse modulation on the input signal |
| Primary Power | +15 Vdc, 110 mA |
| RF Connectors | Type N (f) |
| Impedance | 50 Ω, < 2.5 VSWR |
| Weight | 1.1 lbs. |
| Size (W x H x D) | 3.75" x 2.5" x 6.25” |

## INCLUDED EQUIPMENT

The Model PAM-0118P preamplifier is supplied with an external regulated power supply, that can be used on 110 – 120 Vac, 60 Hz or 220 – 240 Vac, 50 Hz, and supplies +15 Vdc up to 1 A. The power supply has a standard AC input connector and uses a 5.5 x 2.1mm plug. The preamplifier has a low voltage indicator that allows you to power the preamplifier with an external battery supply.

## OPTIONAL EQUIPMENT

The following is a recommend accessory list for the Model PAM-0118P preamplifier:

**SAC-18G-0.5**

0.5 meter high-frequency, low-loss cable to interconnect the preamplifier to the receiver or analyzer. This high-performance cable is made with the best materials and precision N-type male connectors. Other connectors are available and these cables can be made to your specified length.

**SAC-18G-3**

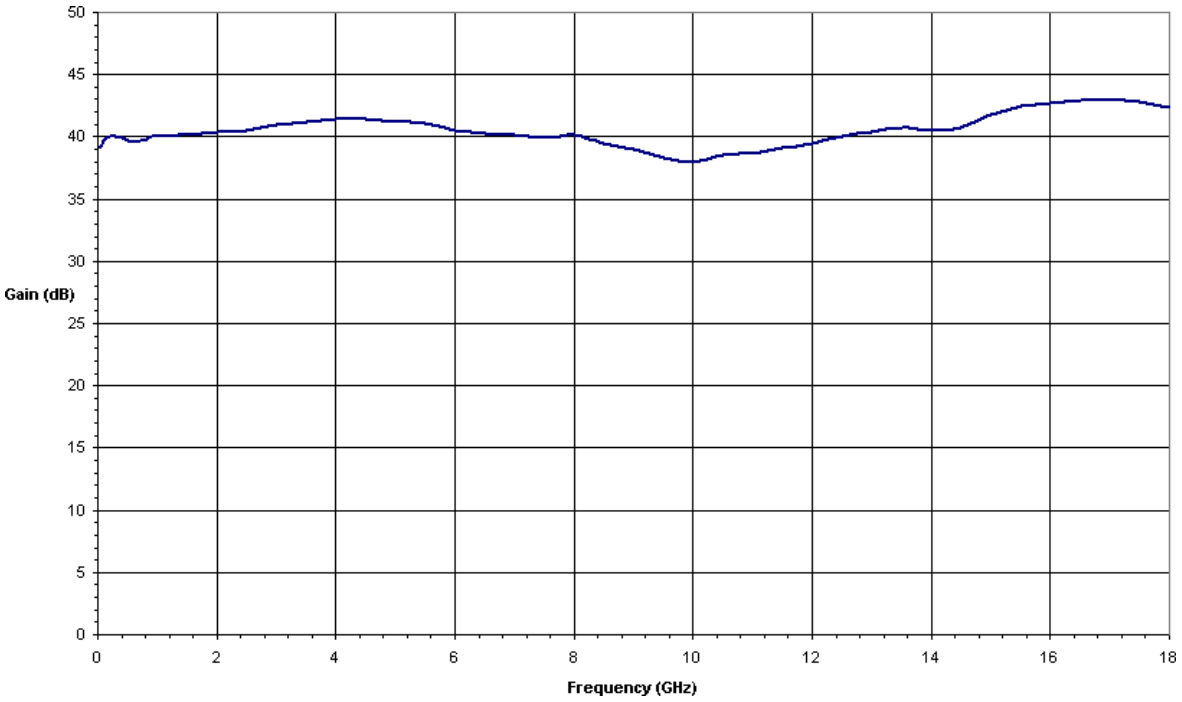
3 meter high-frequency, low-loss cable to interconnect the preamplifier to the antenna or chamber wall. This high-performance cable is made with the best materials and precision N-type male connectors. Other connectors are available and these cables can be made to your specified length.

Adapters

Need an adapter? We stock those as well.

## TYPICAL DATA

The following is typical data of the Model PAM-0118P preamplifier:



# CALCULATIONS

## EMISSIONS TESTING

Individual calibration data for the log periodic antenna is supplied at appropriate distances (3, and 10 meter) to comply with various emissions test requirements. For emissions measurements, add antenna factor plus cable loss to receiver reading in dBμV to convert to field strength in dBμV/m.

**Field Strength(dBuV/m) = SA(dBuV) + AF(dB/m) + cable loss (dB)**

SA = Spectrum Analyzer or Receiver voltage reading

AF = Antenna Correction Factor

CL = Cable Loss in dB

## IMMUNITY TESTING

For Immunity measurements, the generated electric field strength can be calculated by:

FS = Approximate Field Strength in (V/m)

$$FS\ (V/m) = \frac{\sqrt{30Pg}}{d}$$

P = Power in watts
g = Numeric Gain
d = Distance in meters

# TYPICAL CONVERSION FORMULAS

**$dBmW = dB\mu V - 107$**

The constant in the above equation is derived as follows. Power is related to voltage according to Ohm's law. The $Log_{10}$ function is used for relative (dB) scales, so applying the logarithmic function to Ohm's law, simplifying, and scaling by ten (for significant figures) yields:

$$P = V^2 / R$$

$$10Log_{10}[P] = 20Log_{10}[V] - 10Log_{10}[50^{\Omega}]$$

Note, the resistance of 50 used above reflects that RF systems are matched to $50^{\Omega}$. Since RF systems use decibels referenced from 1 mW, the corresponding voltage increase for every 1 mW power increase can be calculated with another form of Ohm's law:

$$V = (PR)^{0.5} = 0.223\ V = 223000\ \mu V$$

Given a resistance of $50\Omega$ and a power of 1 mW

$$20Log_{10}[223000\ \mu V] = \underline{107\ dB}$$

The logarithmic form of Ohm's law shown above is provided to describe why the log of the corresponding voltage is multiplied by 20.

**$dBmW/m^2 = dB\mu V/m - 115.8$**

The constant in this equation is derived following similar logic. First, consider the pointing vector which relates the power density ($W/m^2$) to the electric field strength (V/m) by the following equation.

$$P=|E|^2/\eta$$

Where $\eta$ is the free space characteristic impedance equal to $120\pi^{\Omega}$. Transforming this equation to decibels and using the appropriate conversion factor to convert $dBW/m^2$ to $dBmW/m^2$ for power density and dBV/m to $dB\mu V/m$ for the electric field, the constant becomes 115.8.

**$dB\mu V/m = dB\mu V + AF$**

Where AF is the antenna factor of the antenna being used, provided by the antenna manufacturer or a calibration that was performed within the last year.

**$V/m = 10^{\{[(dBuV/m)-120]/20\}}$**

Not much to this one; just plug away!

**$dB\mu A/m = dB\mu V/m - 51.5$**

To derive the constant for the above equation, simply convert the characteristic impedance of free space to decibels, as shown below.

$$20Log_{10}[120\pi] = 51.5$$

**$A/m = 10^{\{[(dBuA/m)-120]/20\}}$**

As above, simply plug away.

**$dBW/m^2 = 10Log_{10}[V/m - A/m]$**

A simple relation to calculate decibel-Watts per square meter.

**$dBmW/m^2 = dBW/m^2 + 30$**

The derivation for the constant in the above equation comes from the decibel equivalent of the factor of 1000 used to convert W to mW and vice versa, as shown below.

$10Log_{10}[1000] = 30$

**dBpT = dBμA/m + 2.0**

In this equation, the constant 2.0 is derived as follows. The magnetic flux density, B in Teslas (T), is related to the magnetic field strength, H in A/m, by the permeability of the medium in Henrys per meter (H/m). For free space, the permeability is given as...

$\mu_o = 4\pi \times 10^{-7}$ H/m

Converting from T to pT and from A/m to μA/m, and deriving the Log, the constant becomes:

$240 - 120 + 20Log_{10}[4\pi \times 10^{-7}] = 2.0$

dBpT = dBμV + dBpT/μV + Cable Loss

dBμV/m = dBpT + 49.5 dB

# MAINTENANCE

The Model PAM-0118P preamplifier requires virtually no maintenance as long as the unit is not exposed to moisture, or extreme temperatures. But as with any electrical device ESD and EOS is always a concern.

To ensure reliable and repeatable long-term performance, annual re-calibration of your Model PAM-0118P preamplifier by A.H. Systems' experienced technicians is recommended. Our staff can recalibrate almost any type or brand of antenna.

For more information about our calibration services or to place an order for antenna calibration, visit our website www.AHSystems.com or call (818) 998-0223.

# WARRANTY INFORMATION

A.H. Systems Inc. warrants that our Antennas, Sensors and Probes will be free from defects in materials and workmanship for a period of three (3) years. All other products delivered under contract will be warranted for a period of two (2) years. Damage caused by excessive signals at the product's input is not covered under the warranty. A.H. Systems' obligation under this warranty shall be limited to repairing or replacing, F.O.B. Chatsworth, California, each part of the product which is defective, provided that the buyer gives A.H. Systems notice of such defect within the warranty period commencing with the delivery of the product by A.H. Systems.

The remedy set forth herein shall be the only remedy available to the buyer, and in no event shall A.H. Systems be liable for direct, indirect, incidental or consequential damages.

This warranty shall not apply to any part of the product which, without fault of A.H. Systems has been subject to alteration, failure caused by a part not supplied by A.H. Systems, accident, fire or other casualty, negligence, misuse or normal wear of materials.

Except for the warranty set forth above, there are no other warranties, expressed or implied, with respect to the condition of the product or it's suitability for the use intended for them by the buyer.

For prompt service, please contact our service department for a Return Material Authorization Number before shipping equipment back to us.