AMP-12
OPERATOR'S MANUAL

Version 1.0

Vatell Corporation
P.O. Box 66
Christiansburg, VA 24068

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Fax: (540) 953-3010

WARNING: **Read instructions carefully and completely before operating the AMP-12. Improper usage could damage the unit. Save this manual for safety and operating instructions, as well as**

FORWARD

Thank you for purchasing the AMP-12 signal-conditioning amplifier. The AMP-12 was designed for use with Vatell Corporation's line of Heat Flux Microsensors with Thermocouple (HFM-8). It is portable, has selectable gains, and is simple to operate.

To fully appreciate the capabilities of your AMP-12, please read this Operator's Manual thoroughly. If you have any questions or need any assistance please contact:

Vatell Corporation
Attn.: Amplifier Assistance
P.O. Box 66
Christiansburg, VA 24068

Phone: (540) 961-3576
Fax: (540) 951-3010

Please indicate model and serial number in all correspondence. The model and serial number is printed on the bottom of the amplifier.

CONVENTIONS

As you go through this manual, certain conventions are consistently used:

- All front and rear panel control label references are italicized capitals - for example, reference to the power switch would be shown as *POWER*.
- All safety alerts will be preceded by **"WARNING:"**
- Necessary, but not safety related information will be preceded by **"NOTE:"**
- Referenced information will be in *italics*.

AMP-12 Operators Manual

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UNPACKING AND INSPECTION

Included with each AMP-12 are the following items:

1) Operator's manual
2) Battery charger
3) Heat Flux Microsensor connection cable
4) Small screwdriver for potentiometer adjustments
5) Gain Calibration Sheet

If any of these items are missing or damaged, contact Vatell Corporation at the address listed in the Foreword section of this manual.

AMP-12 EQUIPMENT OVERVIEW

FRONT AND REAR PANEL DESCRIPTIONS

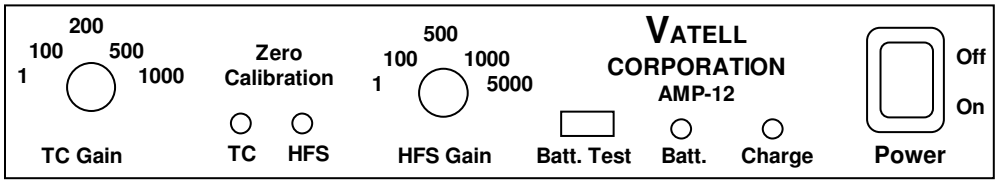

Figure 1- Front Panel

TC Gain: Sets the gain for the Thermocouple (TC) channel. Values are 1, 100, 200, 500, and 1000.

Zero Calibration (TC): Precision multi-turn potentiometer used to adjust the amplifier TC output to zero.

Zero Calibration (HFS): Precision multi-turn potentiometer used to adjust the amplifier Heat Flux Output to zero.

HFS Gain: Sets the gain for the HFS channel. Values are 1, 100, 500, 1000, and 5000.

Batt. Test: Used to determine if the batteries are charged. The rear panel charge switch must be in the *BATTERY* position and the *POWER* switch must be *ON*.

Batt.: When the battery test switch is pushed, this green light indicates if the batteries are charged.

Charge: Indicates charging with a red light. It will light when the rear panel switch is in the *CHARGE* position and the charger is plugged into an AC wall outlet.

Power: Turns the amplifier on when the rear panel switch is in the *BATTERY* position.

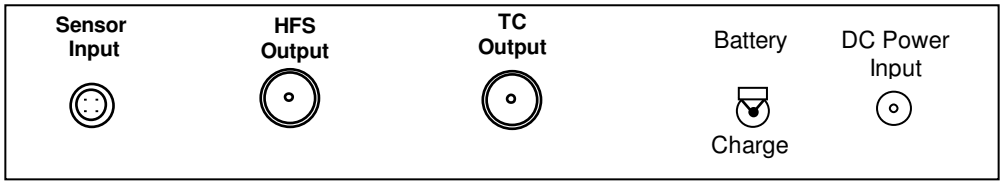

Figure 2- Rear Panel

Sensor Input: Lemo connector for the HFM cable.

HFS Output: Output of the Heat Flux amplifier channel. It is a BNC type connector.

TC Output: Output of the Thermocouple amplifier channel. It is a BNC type connector.

Charge/Battery Switch: When the switch is in the *BATTERY* position, the amplifier operates off of the batteries. In the *CHARGE* position, the amplifier batteries can be charged through the DC Power Input connector.

NOTE: In the *CHARGE* position, the amplifier will not operate.

DC Power Input: The connecting point between the battery charger and the amplifier.

CABLING AND CONNECTIONS

The standard cable supplied with the AMP-12 is 2 meters in length. Cables of longer lengths can be supplied by Vatell Corporation as an option.

The standard connector supplied with each Vatell Corporation AMP-12 and HFM is a 4 pin Lemo connector. Some customers may need to make custom cables or need to replace damaged connectors. To obtain Lemo parts, you can either order them from Vatell Corporation or Lemo, USA.

Lemo, USA
P.O. Box 11488
Santa Rosa, CA 95406

Phone: (800) 444-5366
Fax: (707) 578-1545

Lemo part numbers:

Male Lemo connector (used on cable)- FGG.0B.304.CLAD56
Female Lemo connector (used on sensor)- PHG.0B.304.CLLD21

Figure 3 illustrates the connections on each of the 4 pins of the sensor's Lemo connector and their respective orientations.

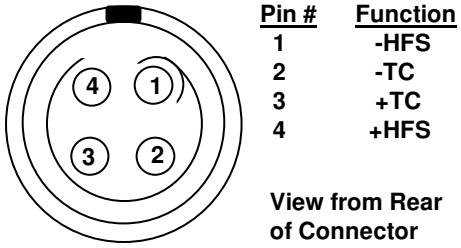

Figure 3 - Female Lemo Connector Pin Out

OPERATION

PRINCIPLES OF OPERATION

The AMP-12 is a 2-channel, signal-conditioning instrumentation amplifier designed for use with a Vatell Corporation Heat Flux Microsensor with Thermocouple (HFM-8). The HFM-8 is a state-of-the-art sensor that requires low-noise, precision amplification. The AMP-12 is designed specifically with these requirements in mind to give the user quality data.

The HFM-8 consists of two sensors on the same surface. The Heat Flux Sensor (HFS) measures heat flux flowing through the sensor surface. The Thermocouple (TC) measures the temperature at the face of the sensor. One channel of the AMP-12 amplifies signals from the HFS portion of the HFM-8. The other channel amplifies the signals from the TC.

Both the HFS and TC channels have independently selectable gain and offset controls. The HFS has gains of 1, 100, 500, 1000, and 5000. The TC has gains of 1, 100, 200, 500, and 1000. The offset controls allow zeroing of the amplifier outputs. Prior to measurement, the gains are selected and the sensor offset is adjusted. *See Taking Measurements section for more information.*

The AMP-12 is powered by four 9-Volt Nickel-Cadmium batteries. These are rechargeable batteries. *See Battery Charging for more information.*

TAKING MEASUREMENTS

In order to collect data from the HFM-8, proceed with the following steps. *See Front & Rear Panel Descriptions in the OPERATIONS section for illustration of control locations*.

1. The amplifier should be placed in a position that avoids strong electromagnetic fields and large temperature excursions. *See Theory of Operations section for detailed discussion.*

2. Turn the amplifier on. The *POWER* switch is located on the front panel.

3. Test the battery condition by depressing the *BATT. TEST* switch on the front panel. Check to see if the green *BATT.* light is illuminated. The light will be very dim or not lit when batteries require charging.

4. Attach one end of the 2 m cable to the HFM-8 and the other end to the input connection (*SENSOR INPUT)* on the back panel of the amplifier. The cable and HFM-8 connectors are keyed to assure proper pin alignment.

5. Connect output BNC connections *HFS OUTPUT* and *TC OUTPUT* to a measuring device (chart recorder, oscilloscope, voltmeter, etc.).

6. Allow amplifier to warm-up (become temperature stable). This takes approximately eight minutes from the time the amplifier is turned on. *See step 2.*

7. Zero Calibration: This should be done after the amplifier has warmed up. It may be necessary to zero again if the testing environment changes (i.e. temperature, humidity, or atmosphere change; connection of a different sensor; etc.).

    a. Set *TC GAIN* to desired value (1, 100, 200, 500, or 1000).

    b. Set *HFS GAIN* to desired value (1, 100, 500, 1000, or 5000).

    c. Zero both the heat flux and thermocouple channels using the *ZERO CALIBRATION* potentiometers (*HFS* and *TC*) located on the front panel. The channels are zeroed when their measured outputs read zero volts. *See Zeroing the HFS and Zeroing the TC sections for more information.*

NOTE: The temperature (T_0) at which the amplifier is zeroed and the selected gains (G) are used in the calibration equations. ***See "Use of Vatell Heat Flux Microsensor Calibration Equations" supplied with each sensor.***

8. System is now ready for measurement of heat flux and temperature.

HEAT FLUX MEASUREMENTS USING THE HFS

The heat flux predicted by the HFS is a function of the face temperature of the sensor (measured by the TC), the gain of the HFS channel, and the voltage at the HFS output. This relationship is described in "Use of Vatell Heat Flux Microsensor Calibration Equations" included with each Heat Flux Microsensor.

Zeroing the HFS

Before zeroing, let the amplifier warm up for at least eight minutes. Zeroing is then accomplished by exposing the Heat Flux Microsensor to zero heat flux and adjusting the *HFS ZERO CALIBRATION* potentiometer until the *HEAT FLUX OUTPUT* measures zero volts. The Heat Flux Microsensor will see zero heat flux if it is in still air and in thermal equilibrium with the environment.

TEMPERATURE MEASUREMENTS USING THE THERMOCOUPLE

The temperature predicted by the Thermocouple (TC) is a function of the initial temperature of the TC, the gain of the TC channel, and the voltage at the TC output. This relationship is described in "Use of Vatell Heat Flux Microsensor Calibration Equations" included with each HFM-8.

Zeroing the Thermocouple

Before Zeroing, let the amplifier warm up for at least eight minutes. The TC is a device that accurately measures changes in temperature. It is necessary to establish a reference temperature in order to know the absolute temperature at any given time. The reference temperature (T_o) is the temperature at which the TC is zeroed and must be measured by an independent source such as a thermometer.

It is important to zero the TC at a temperature between 0°C and 250°C. Zeroing is accomplished by turning the *TC ZERO CALIBRATION* potentiometer located at the face of the amplifier until the *TC OUTPUT* measures as close to zero volts as possible. Because the thermocouple on the HFM-8 is a thin film thermocouple, it does not necessarily match with tabulated thermocouple values. Refer to the "Use of Vatell Heat Flux Microsensor Calibration Equations" instruction manual for information on the thermocouple calibration. Once the sensor is zeroed, changes in temperature will produce a change in the TC output voltage, yielding a known absolute temperature at the sensor.

BATTERY CHARGING

WARNING: If the red light does not illuminate within 30 minutes of attempting to charge the batteries, disconnect the system from the wall outlet.

The AMP-12 is powered by four 9V Nickel Cadmium batteries. They last approximately 12 hours before needing to be recharged. It is recommended that the user recharge the batteries overnight after a full day of use. This is accomplished by plugging the battery charger into a 110 VAC outlet and switching the charge select switch on the back panel to the *CHARGE* position. The LED (Light Emitting Diode) on the front panel labeled *CHARGE* indicates that the amplifier is charging. The AMP-12 is fully charged prior to shipping, so it should not require charging before its first use. If the amplifier is not used for six months, the batteries should be charged (Nickel-Cadmium batteries lose their charge after prolonged periods of inactivity).

Battery life should be approximately 800 to 1000 charge-discharge cycles. They can be easily replaced with standard 9V Nickel-Cadmium rechargeable batteries. S*ee Battery Replacement/Substitution section for more details*.

Checking Battery Charge

To test the charge on the batteries, depress the *BATT. TEST* button located on the front panel. The green *BATT.* light will be illuminated when the batteries are charged, and dim or not illuminated when batteries require charging.

Charging Procedure

To charge the AMP-12 batteries, use the following steps:

(There is no need to remove any of the cables connected to the AMP-12 during recharging.)

1. Turn the *POWER* switch off.

2. Connect the battery charger to the AMP-12 *DC POWER INPUT* connector on the back panel, then plug it into any standard 110VAC outlet.

3. Switch the charge select switch on the back panel to the *CHARGE* position.

4. A red LED labeled *CHARGE* on the front panel will light to indicate charging. If the batteries have been totally discharged, i.e. power left on for an extended period of time, it is possible that the red *CHARGE* light will not illuminate when first charging the batteries. In this case, it will take 20 to 30 minutes of charging before the red light illuminates. If after this period of time the *CHARGE* light is still extinguished, disconnect the battery charger from the wall outlet and *refer to the Battery Replacement/Substitution section of this manual*.

5. After 12 to 14 hours the AMP-12 should be fully charged. The batteries can be charged for longer than this time, however there will be no significant performance enhancement. A "trickle charge" method is employed to avoid overcharging the batteries.

6. Switch the charge select switch on the back panel to the *BATTERY* position.

7. Switch the *POWER* switch on the front panel to the *ON* position and depress the *BATT. TEST* button. The green *BATT.* light should illuminate indicating that the batteries are charged. If this LED does not light, *refer to the Battery Replacement/Substitution section of this manual for help.*

NOTE: The front panel controls are not functional when the charge select switch is in the *CHARGE* position. The AMP-12 is specifically designed to operate only with batteries.

THEORY OF OPERATION

The AMP-12 is a 2-channel amplifier based on 2 Analog Devices' AD624 instrumentation amplifier chips. These instrumentation amplifiers have dual supplies, differential inputs, and pre-selectable gains. The AMP-12 was designed for use with a Vatell Corporation Heat Flux Microsensor with Thermocouple (HFM-8). One channel is used to amplify the Heat Flux Sensor (HFS) portion of the HFM-8 and the other channel is used to amplify the Thermocouple (TC) portion. The HFS channel and TC channel inputs are connected to a single 4 pin Lemo connector located on the back panel. The outputs (single ended) are connected to two male BNC coax connectors located on the back panel. The value at which the amplifiers rail is dependent on the charged state of the batteries. Most amplifiers will rail at approximately ±6 V or greater.

The heat flux channel has switch selectable gains of 1, 100, 500, 1000, and 5000. The heat flux amp has both its inputs tied directly to the Lemo connector. There are two bias resistors (200 kΩ) placed from the inputs of the amplifier to ground. Figure 4 shows a simplified circuit diagram. The heat flux channel is zeroed with the *HFS ZERO CALIBRATION* potentiometer. It should be zeroed with the sensor connected and seeing no heat flux. The sensor will produce zero output when there is no source or sink of heat flux. This zeroing process controls the input offset to the heat flux channel's instrumentation amplifier. This offset adjusts for amplifier drift, which is mostly influenced by temperature. The amplifier should be turned on at least 8 minutes prior to adjustment, and should be at the same temperature as its environment. *See specifications for operating limits.*

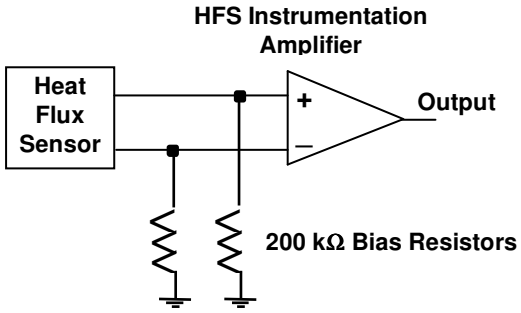

Figure 4 - Simplified Heat Flux Signal Circuit Diagram

The TC channel has switch selectable gains of 1, 100, 200, 500, and 1000. The circuit configuration is otherwise just like the HFS channel, i.e. with two bias resistors (200 kΩ) placed from the inputs of the amplifier to ground, etc. The TC signal may be set to zero at any desired temperature between 0°C and 250°C. S*ee Temperature Measurements Using the Thermocouple*.

NOISE REDUCTION

All precision amplifiers working with small signals are susceptible to Electromagnetic Interference (EMI). Special care should be taken in the placement of the sensor and amplifier relative to any source of EMI noise. The following actions will tend to reduce EMI noise problems:

- Avoid creating ground loops.
- Do not subject the amplifier, sensor, or cables to large electrical fields.
- High frequency PWM (Pulse Width Modulated) motors tend to be very noisy.

If possible, avoid data collection when motors are on.

- Use shielded, twisted pair for any connections beyond the cable supplied with the sensor and amplifier.
- Do not ground the cable supplied with the amplifier at the end nearest the sensor.

CARE AND MAINTENANCE

The AMP-12 is a durable instrument. If handled carefully, it should last for years. The batteries are the only parts that may require replacement.

CLEANING

The AMP-12 can be cleaned with a soft dry cloth. Avoid the use of strong chemicals and solvents, especially when cleaning the front and rear panel surfaces.

BATTERY REPLACEMENT/SUBSTITUTION

After approximately 800 to 1000 recharging cycles, the original Ni-Cd batteries may need to be replaced. They can be easily replaced with standard 9-V Ni-Cd rechargeable batteries.

Non-rechargeable (i.e. carbon, alkaline, or lithium) batteries can be used in an emergency.

WARNING: **If any batteries other than standard 9 V Nickel-Cadmium batteries are used, do not attempt to recharge them with the charging circuit built into the amplifier.**

Follow these steps to replace the batteries. *See Front & Rear Panel Descriptions in previous section for illustration of control panels.*

1. Remove the 4 screws that hold the front and rear panels in place.

2. Remove the *TC GAIN* and *HFS GAIN* control knobs. To do this, remove the brown caps from the control knobs. Insert a small flat head screwdriver into one of the slots on the gold collet screw and turn it counter-clockwise. The knobs should now be removed.

3. Remove the *TC GAIN* and *HFS GAIN* switch nuts.

4. Remove the *TC OUTPUT* and *HFS OUTPUT* BNC nuts located on the back panel.

5. Remove the rear control panel and bezel.

6. Loosen and pull forward the front control panel and bezel being careful not to disconnect the *POWER* switch that is connected to the amplifier circuit board.

7. Slide the amplifier circuit board forward and out of the instrument case.

8. Snap out the old batteries and replace them.

9. Put the amplifier back together following the reverse order of disassembly.

10. Test for proper operation.

In case of any difficulty with operation or maintenance of this amplifier, contact Vatell Corporation for further assistance.

WARRANTY

Vatell Corporation warrants that this product will be free from defects in materials and workmanship for a period of 90 days from the date of shipment. If the product proves defective during this warranty period, Vatell Corporation, at its option, either will repair the defective product without charge for parts and labor, or will provide a replacement in exchange for the defective product.

In order to obtain service under this warranty, the customer must notify Vatell Corporation in writing of the defect before the expiration of the warranty period and make arrangements for service. The customer shall be responsible for packaging and shipping of the defective product to Vatell Corporation with shipping charges prepaid. Vatell Corporation will pay for the return of the product to the customer, if the shipment is to a location within the United States of America. The customer is responsible for paying all shipping charges, duties, taxes, and any other charges for products returned to locations outside of the USA.

This warranty shall not apply to any defect, failure or damage caused by improper use or improper or inadequate maintenance and care.

THIS WARRANTY IS GIVEN IN LIEU OF ANY OTHER WARRANTIES, EXPRESS OR IMPLIED. VATELL CORPORATION DISCLAIMS ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. VATELL CORPORATION'S REPAIR OR REPLACEMENT OF A DEFECTIVE PRODUCT IS THE SOLE AND EXCLUSIVE REMEDY PROVIDED TO THE CUSTOMER FOR WARRANTED DEFECTS. VATELL CORPORATION WILL NOT BE LIABLE FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.

AMP-12 SPECIFICATIONS

	Heat Flux Channel	Temperature Channel
Gain Settings	1, 100, 500, 1000, 5000	1, 100, 200, 500, 1000
Gain Accuracy %		
Gain = 1	±0.6	±0.6
Gain = 100	±1.5	±1.5
Gain = 200, 500	±1.5	±1.5
Gain = 1000	±2.1	±2.1
Gain = 5000	±3.6	
Bandwidth		
Gain = 1	1 MHz	1 MHz
Gain = 100	150 kHz	150 kHz
Gain = 200		100 kHz
Gain = 500	50 kHz	50 kHz
Gain = 1000	25 kHz	25 kHz
Gain = 5000	5 kHz	
Input Impedance	10^9 Ω	10^9 Ω
Input Noise	0.2 µV	0.2 µV
Maximum RTS Resistance	factory adjustable	factory adjustable
Full Scale Output	6 V	6 V

Dimensions:

Height = 4.3 cm (1.7") Width = 19 cm (7.5")

Depth = 28 cm (11") Weight = 1.3 kg (46 oz.)