A-M Systems

AC/DC Differential Amplifier

3000

INSTRUCTION MANUAL

FOR

AC/DC DIFFERENTIAL AMPLIFIER

MODEL 3000

Serial #__________

Date____________

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Version 3.0
April, 2010

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Each AC/DC Differential Amplifier
is delivered complete with:

One 3 Foot Cable
Remote Power Supply
Rack Mount Hardware
Instructions & Maintenance Manual

NOTE

This instrument is not intended for clinical measurements using human subjects. A-M Systems does not assume responsibility for injury or damage due to the misuse of this instrument.

General Description

Instrument Features

The *AC/DC Differential Amplifier, Model 3000* is a single-channel, differential amplifier that can be used with or without a head stage probe. The instrument is designed for low-noise recordings from excitable tissue. It is intended for extracellular recording and/or stimulating in conjunction with microelectrodes. It can be used in a number of research or teaching applications requiring extracellular neurophysiological recording from excitable tissue, such as nerve, muscle (EMG), EEG, EKG, and ERG recordings. **The instrument is not intended for clinical measurements using humans.**

The *Model 3000* contains a high-gain, low-noise differential amplifier stage followed by low frequency, high-frequency, and notch filters. Three operating modes are available to accommodate recording, stimulating, and verification of electrode impedance. Record Mode offers six levels of signal gain (x50, x100, x500, x1000, x5000, and x10,000). Stimulus Mode allows the current passing through the electrode to be measured during stimulation at six levels of gain (5V/mA, 10V/mA, 0.05V/µA, 0.1V/µA, 0.5V/µA, 1V/µA). Impedance Mode utilizes an internally calibrated current source to allow in situ verification of electrode impedance and adjustment of capacitance compensation. Units that are sold with a head stage are pre-configured to work with the head stage.

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Controls and Connectors

Input Controls

PROBE: This 15-pin connector receives a signal either directly from the electrodes (non head stage version) or from the Head Stage probe for further processing.

INPUT SELECT (DIFF-MONO-GND) (non head stage version only)**:** This switch sets the input for differential operation, monopolar operation, or grounds the inputs to the amplifier.

INPUT LEADS (standard)**:** Supplied with the Model 3000 is a DB-15 connector with three leads. The black wire is the "+" electrode lead. The white wire is the "-" reference lead. The silver wire is a driven shield, and ***should not be grounded!*** This wire serves to minimize signal loss due to capacitance.

HEAD STAGE PROBE (optional)**:** The Head stage Probe has three sockets for connection to electrodes. **PROBE+** is used to connect to the electrode (usually an high impedance recording microelectrode; see figure pg. 7). **PROBE-** is used to connect to the indifferent lead. Either the **PROBE GND** connector, or the front panel **GND** must be connected for proper operation. Usually the **PROBE GND** connector is tied to the indifferent lead. If you desire to have the current constrained to a known path you may want to place the **GND** elsewhere. Actual **GND** placement depends on the application.

Mode Controls

ELECTRODE TEST: This toggle switch activates (**Ω TEST**) a 2 nA p-p, 100 Hz square-wave current source used to test electrode resistance and to adjust the capacitance compensation. The **ELECT TEST** switch must be set to **Ω TEST** and the **STIM-GATE-REC** switch must be set to **REC** for the test signal to be monitored. (Note*: Recording and reference electrodes should be in a saline solution for resistance testing*.) To accurately measure the impedance verify at the OUTPUT connector that the signal is a square wave of 100 Hz, adjust the **CAPACITY COMPENSATION** knob to square the corners of the waveform. The amplitude of the square wave is a direct measure of impedance in each of the six ranges (0.1Vp-p/MΩ, 0.2Vp-p/MΩ, 1Vp-p/MΩ, 2Vp-p/MΩ, 10Vp-p/MΩ, 20Vp-p/MΩ).

STIMULUS: This isolated BNC connector enables a stimulus source to be utilized to pass current through the electrode while the unit is in stimulate mode (**STIM**). The center pin of the BNC is the + input and the outer conductor is the - stimulus input. When the unit is in the (**STIM**) mode the output will be a measure of the current passing through the electrode in six ranges (5V/mA, 10V/mA, 50mV/µA, 0.1V/µA, 0.2V/µA, or 1V/µA).

GATE: This BNC connector enables the amplifier to have an external input that switches the amplifier between record mode and stimulate mode. When the input the **MODE** switch is set to **GATE** and there is a high TTL level signal (5V) in the **GATE** BNC then the amplifier is in stimulus mode. When the TTL level is low (0V) then the unit is in record mode.

STIM-GATE-REC: This toggle switch controls the operating mode for the Model 3000. The switches allows the user to select Record Mode (**REC**) Stimulate Mode (**STIM**), or Gate Mode (**GATE**).

Output

Output: This BNC connector provides the output signal from the amplifier.

GND: This connector on the front panel provides access to the circuit ground. Either the **PROBE GND** connector or the front panel **GND** must be connected for proper operation. Usually the **PROBE GND** connector is tied to the indifferent lead. If you desire to have the current constrained to a known path you may want to place the **GND** elsewhere. Actual **GND** placement depends on the application. For low-noise recordings a ground connection should be made in the recording medium (i.e. bath ground, animal ground, etc.).

GAIN: This rotary switch controls the level of signal gain for its channel while the channel is in Record, Stimulate, and Impedance Mode. In Record mode (**REC**) the switch allows the user to select from **X50, X100, X500, X1000, X5000,** or **X10,000** gain. In Stimulate mode (**STIM**) the gain switch selects one six ranges (5V/mA, 10V/mA, 50mV/µA, 0.1V/µA, 0.2V/µA, or 1V/µA). In Impedance test mode (**REC**, **Ω TEST**) the gain switch selects one of six ranges (0.1Vp-p/MW, 0.2Vp-p/MΩ, 1Vp-p/MΩ, 2Vp-p/MΩ, 10Vp-p/MΩ, or 20Vp-p/MΩ).

Capacity Compensation

Capacity Comp: This knob is used to adjust an active feedback circuit to compensate for up to 30 pF of electrode capacitance. The capacitance compensation can be adjusted with the electrode in the experimental preparation using the internal square-wave generator and an oscilloscope connected to the **output** BNC. This control should be adjusted to obtain the sharpest corners possible on the square-wave with very little overshoot. Clockwise rotation of this control increases the capacity compensation. *Warning: Turning the Capacity Compensation too high will cause the circuit to oscillate wildly and change frequency, and may also cause the electrode to behave in a similar manner. The extreme swings in voltage may be harmful to neural tissue, and care should be exercised in using this control. It is a good practice to turn the knob half way off once the impedance is measured, to minimize the chance of overcompensation when recording.*

DC Offset

DC OFFSET KNOBS: These two knobs sets the variable DC offset voltage, which is summed with the input voltage. This feature may be used to compensate for electrode potentials and to position the signal trace on an oscilloscope recording device. An input offset range of 0.0 V to ±250 mV is available. The **COARSE** knob will cover 250 mV and the **FINE** knob will add up to 25 mV to the **COARSE** knob's position.

DC OFFSET SWITCH (+ OFF -): This switch sets the DC offset polarity or alternately turns the feature **OFF**.

OVER RANGE INDICATORS: These LED's will illuminate when the output of the device is beyond its limit of +10 V (top LED) or -10 V (bottom LED).

Filter

HIGH PASS: This rotary switch enables the user to select the lower boundary frequency at which point the channel's input signal begins to be cutoff. Signals below the cutoff frequency will be attenuated by a factor of 100 (-40 dB) per decade decrease in the input signal frequency. For example, if the **HIGH PASS** switch is set at **100 HZ**, then a 10 Hz signal will be attenuated by a factor of 100 while a 1 Hz signal will be attenuated by a factor of 10,000. The high pass frequency should be selected based on the frequency content of the signal to be recorded. One of the uses of this filter is to reduce slow variations or DC levels in the input signal. When the switch is in the DC position the high pass filter is off.

NOTCH: This switch allows the Notch Filter (-50dB at 60Hz) to be included in the signal processing path (**ON**) or bypassed (**OFF**). *Warning: Although the Notch Filter provided can significantly reduce unwanted interference from the power source, it will cause some distortion of the signal, especially in frequencies below 100 Hz. Therefore, the Notch Filter should only be used if other noise reduction techniques such as proper grounding and shielding are inadequate.*

LOW PASS: This rotary switch enables the user to select the upper boundary frequency that the input signal begins to be cutoff. Signals above the cutoff frequency will be attenuated by a factor of 100 (-40 dB) per decade increase in the input signal frequency. For example, if the **LOW PASS** switch is set at **1 kHz**, then a 10 kHz signal will be attenuated by a factor of 100 while a 100 kHz signal will be attenuated by a factor of 10,000. One of the uses of this filter is to reduce high-frequency noise that is above the frequency content of the signal being recorded.

Head stage indicator

HEAD STAGE: This LED indicates whether the unit is configured for use with (**HEAD STAGE** lit) or without (**HEAD STAGE** off) a head stage (See configuring the Model 3000 for use with a head stage pg. 5).

Power Supply

POWER: This toggle switch is the main power switch, controlling the DC power input to the main circuit of the instrument. The LED next to the toggle switch is lit when the instrument is **ON**. This button does not control the power input to the remote AC Power Supply. Once the remote AC Power Supply is plugged in there is 30 Volts DC to the unit. If this situation is undesirable please unplug the remote AC Power Supply when the instrument is not in use.

Configuring the Model 3000 for use with a head stage

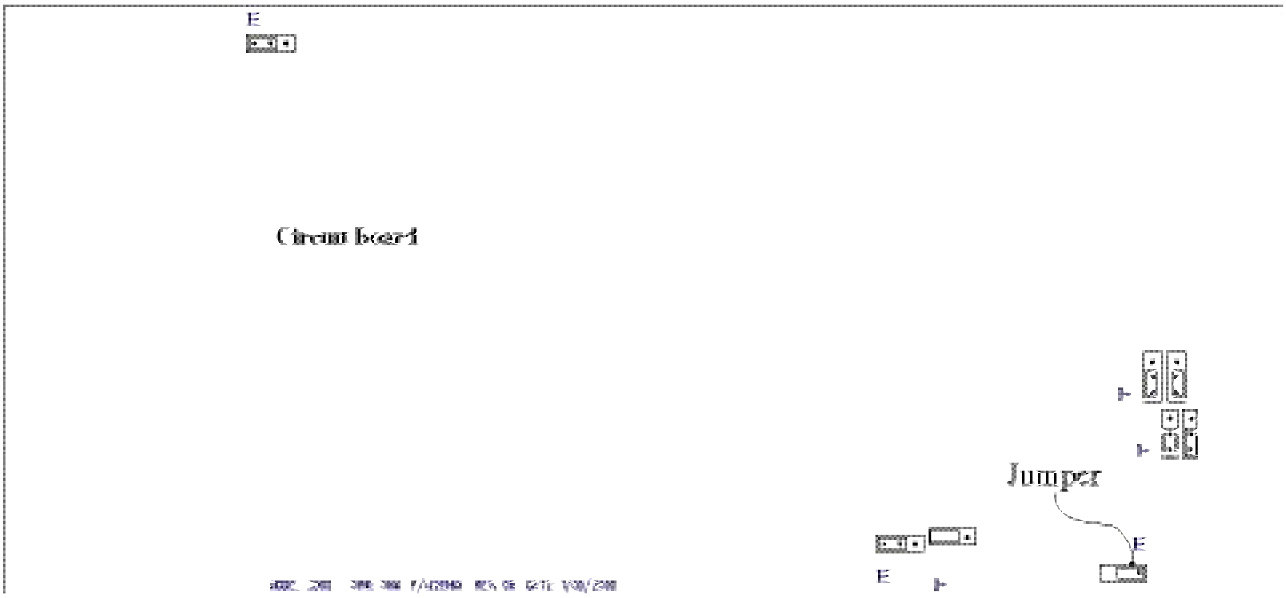
If your unit was sold with a head stage then the jumpers are allready set to the head stage position, however if you purchased the head stages at a different time than the model 3000 you will need to complete the following procedure.

To set the model 3000 for use with a head stage, all jumpers must be set to the **H** position (see figure 2 below). Once the jumpers are in the H position the unit can only be used with a head stage. To return the unit for use without a head stage simple move the jumpers to their previous position.

Calibrate the unit for headstage. Set the unit in the following positions:

HIGH PASS: DC	NOTCH: OFF	CAPACITY COMP: Counter Clock-wise
DC OFFSET: OFF	Ω TEST: OFF	MODE: REC

Ground the head stage inputs and adjust R41 for zero volts at the OUTPUT.



Operating Instructions

Typical Set-Up Procedure

The Model 3000 comes with an input cable that connects to the DB15 input. One end of this cable is left open to allow for maximum flexibility in connecting to extracellular electrodes. The Model 3000 will function properly in this configuration if the head stage (**HEAD STAGE**) LED is off.

The Head Stage Probe (optional) connects to the DB15 input and will function properly if the head stage (**HEAD STAGE**) LED is on. The probe is used to connect the extracellular electrodes to the amplifier. The **GND** connector on the front panel of the amplifier should be used as the system ground in the particular recording medium (e.g. bath or animal ground). *Note: Either the Head Stage* **PROBE GND** *or the* **GND** *on the front panel must be connected to provide a return current path. If neither ground is connected the Head Stage Amplifier will saturate and no signal will be measured.*

Care should be taken to keep the power cables from all instruments as far away as possible from the recording setup. One exception is the DC power cable that supplies power to the model 3000. This side of the cable is DC and therefore does not carry disrupting power line frequencies. **Proper grounding and shielding techniques should be used to insure a minimum of interference.**

Recording

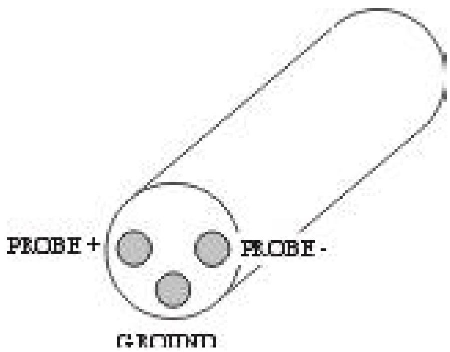
This is a generalized procedure for setting up the *AC/DC Differential Amplifier* for recording. Portions of this procedure may need to be modified for your specific application.

1. If you are planning on using the Model 3000 with a head stage connect the Head stage Probe cable to the **PROBE** connector.
2. Set the instrument controls as follows:

HIGH PASS	**DC**
NOTCH FILTER	**OFF**
LOW PASS	**20 kHz**
CAPACITY COMP.	counterclockwise
DC OFFSET FINE AND COARSE knob	counterclockwise
DC OFFSET (+ OFF -)	**OFF**
GAIN knob	**50**
INPUT (DIFF MONO GND)	**GND**
MODE (STIM-GATE-REC)	**REC**
Ω TEST	**OFF**

3. Turn on power to the *Model 3000* and allow it to warm up for 5 minutes.
4. Non Head stage option: connect measuring electrode to the black wire and a reference electrode to the white wire of the probe cable.

   Head stage option: connect measuring electrode to the + input of the head stage and a reference electrode to the - input of the head stage (see diagram to the right). Note: the reference electrode can be tied to the gnd input on the head stage. Clamp the Head stage in a micromanipulator.



5. Dip the measuring and reference electrode into a beaker of physiological saline solution (or the solution in which the tissue will be bathed). The solution should have the same temperature and ionic strength as that in which measurements will be made. *Note: immerse the measuring electrode to approximately the same depth as will be used during the measurement.*
6. Connect an oscilloscope to the **OUTPUT** BNC, with the horizontal sweep rate set to 2ms/division. Zero the scope. Flip the input switch to **DIFF.**
7. Observe the offset potential between the two electrodes on the oscilloscope. Set the **DC OFFSET (+ OFF -)** switch to the appropriate polarity and adjust the **DC OFFSET** knob to zero the amplifier output. Note: make sure your oscilloscope is in DC mode.
8. Turn on the **Ω TEST** button to inject a 100 Hz square-wave current through the electrode.
9. Adjust the oscilloscope for a good display of the square-wave. The Oscilloscope will display a square wave at 0.1 V peak to peak for every 1 MΩ of electrode resistance.
10. Increase the **CAPACITY COMPENSATION** to “square-up” the corners of the waveform. Avoid overcompensation, which will cause ringing, excessive noise, and high frequency oscillation.
11. Turn the **CAPACITY COMPENSATION** knob to approximately half way between its present position and the off position. This will minimize the chance of overcompensation during recording.
12. Turn off the **Ω TEST** switch to stop the test signal.
13. Apply the electrodes to the experimental preparations.
14. Apply the **HIGH PASS, LOW PASS**, and **NOTCH FILTERS** if necessary.
15. Increase the **gain** switch until the output voltage is in the range necessary for saving data. Note: The **GAIN** Switch should be set so that the signal at the **OUTPUT** connector is less than ±10 V, otherwise higher and/or lower portions of the signal may appear cutoff or flattened.

Stimulating

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The **MODE** switch should be placed in the **STIM** position. Stimulation current (I) is monitored by measuring the voltage (V) across an internal, fixed resistor (R = 100 Ω) in series with the electrodes. Since I=V/R and R is known, the voltage is a measure of the stimulus current. The internal resistor is in series with the indifferent lead (**PROBE-**) so that excessive voltages do not appear at the Probe Amplifier inputs. Therefore, to insure that the current in the indifferent lead is equal to and opposite of that in the active lead, only isolated stimulus sources should be used. An added benefit of isolated stimulus sources is that they produce less stimulus artifact than ground referenced sources. The Positive Conductor of the Stimulus connector (center pin) is connected through the Probe to the active electrode lead, while the Negative Conductor (outside ring of the BNC) is connected to the indifferent electrode lead. When an isolated stimulator is used the **PROBE-** connector must be grounded to function properly.

Mounting Micropipettes

The easiest way to mount a micropipette is to place the micropipette in a micropositioner with a electrode clamp. The micropipette should we filled with a salt solution (usually 3M KCl). A coarse micropositioner can be used to hold the head stage a short distance away from the electrode. A short thin Ag/AgCl wire can be used to electrically connect the head stage + input with the micropipette. Place the end of the wire into the stem of the filled micropipette. Crimp the other end with a standard gold pin connector (Catalog number 521200). Coil the wire between the pipette and pin connector into spring. Insert the clean and dry pin connector in the Head stage.

Mounting the Head stage in a Micromanipulator

The Head stage should be clamped in the manipulator by means of the mounting rod supplied. The mounting rod can be screwed into the cable end of the head stage for in-line mounting.

Problem Solving

If you are experiencing problems with the *Model 3000*, the following procedure will assist in diagnosing the source of the problem. It is important to follow these steps in the order presented and change only those controls listed. For the following procedures, a variable frequency function generator capable of producing sine wave outputs and an oscilloscope will be needed. A simple resistor voltage divider may be needed to obtain the small signals in the mV range which should be applied to the probe amplifier inputs in order to test the system. Make sure that all input cables are shielded. The following procedures assume that the *Model 3000* has been properly adjusted, and calibrated.

Initial Settings

Controls	Inputs / Observations	Adjust / Check
HIGH PASS: 10 HZ **LOW PASS: 10 KHZ**		

Record Mode

Controls	Inputs / Observations	Adjust / Check
MODE: REC **GAIN: X50**	Apply a 1 mV p-p, 500 Hz sine wave signal to the **PROBE INPUTS** Observe voltage at **OUTPUT** with an oscilloscope	Check for 50 mV p-p, 500 Hz undistorted signal
GAIN: X100		Check for 100 mV p-p, 500 Hz undistorted signal
GAIN: X500		Check for 500 mV p-p, 500 Hz undistorted signal
GAIN: X1000		Check for 1 V p-p, 500 Hz undistorted signal
GAIN: X5000		Check for 5 V p-p, 500 Hz undistorted signal
GAIN: X10 000		Check for 10 V p-p, 500 Hz undistorted signal

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Stimulus and Impedance Modes

Controls	Inputs / Observations	Adjust / Check
MODE: STIM **GAIN: X500**	Connect a 1 MΩ resistor (± 5%) across **PROBE+** and **PROBE-** Connect **PROBE-** to **GND** Apply 10 µA pulse to **STIMULUS** from an isolated current source Observe voltage at **OUTPUT**	Check for 500 mV steps in sync with the input pulses
MODE: REC, Ω TEST ON **CAPACITY COMP.:** adjust	Disconnect 10 µA pulse to **STIMULUS**	Check for 1 V p-p, 100 Hz square wave

Noise and Output Level

Controls	Inputs / Observations	Adjust / Check
MODE: REC **LOW CUT-OFF: 10 HZ** **HIGH CUT-OFF: 10 KHZ** **GAIN: X1000**	Connect **PROBE+** and **PROBE-** to **PROBE GND. Non-head stage** switch diff-mono-gnd to GND Observe voltage at **OUTPUT**	Check for 0.0V±25 mV p-p or less

High Pass Filter

Controls	Inputs / Observations	Adjust / Check
HIGH PASS: see note	Apply 1 mV p-p sine wave to **PROBE+** and **PROBE-** Observe voltage at **OUTPUT**	Check for voltage as indicated in note

Note: Repeat this test for each **HIGH PASS** setting. Each time, select an input signal frequency below the **HIGH PASS** setting to begin, then increase it to at least ten times above the **HIGH PASS** setting. When the input signal frequency is between the **HIGH PASS** setting and the **LOW PASS** setting the signal at **OUTPUT** should be 1 V. In contrast, when the signal frequency is decreased below the **HIGH PASS** setting, the signal at **OUTPUT** will approach 0 V. As the input signal frequency is increased above the **LOW PASS** setting, the signal at **OUTPUT** will also approach 0 V.

Low Pass Filter

Controls	Inputs / Observations	Adjust / Check
HIGH PASS: 10 HZ **LOW PASS:** see note	Apply 1 mV p-p sine wave to **PROBE+** and **PROBE-** Observe voltage at **OUTPUT**	Check for voltage as indicated in note

Note: Repeat this test for each **LOW PASS** setting. Each time, select an input signal frequency above the **LOW PASS** setting to begin, then decrease it to at least ten times below the **LOW PASS** setting. When the input signal frequency is between the **HIGH PASS** setting and the **LOW PASS** setting the signal at **OUTPUT** should be 1 V. In contrast, when the signal frequency is increased above the **LOW PASS** setting, the signal at **OUTPUT** will approach 0 V. As the input signal frequency is decreased below the **HIGH PASS** setting, the signal at **OUTPUT** will also approach 0 V.

Notch Filter

Controls	Inputs / Observations	Adjust / Check
HIGH PASS: 1 HZ **LOW PASS: 1 KHZ** **NOTCH:** see note	Apply 1 mV p-p sine wave to **PROBE+** and **PROBE-** Observe voltage at **OUTPUT**	Check for voltage as indicated in note

Note: Repeat this test for each **NOTCH** setting. Each time, begin with the input signal at 10 Hz and then increase it to 100 Hz. With **NOTCH: OUT**, the signal at **OUTPUT** should remain 1 V. With **NOTCH: IN**, the signal at **OUTPUT** should be substantially reduced around 60 Hz (or 50 Hz if your instrument has been factory preset for a 50 Hz environment) and less so above and below this frequency.

DC Offset

Controls	Inputs / Observations	Adjust / Check
HIGH PASS: DC **INPUT SWITCH: GND** **GAIN: X50**	Ground **PROBE+** and **PROBE-** with input switch or wire. Observe voltage at **OUTPUT**	Turn **COARSE** knob its full range. Check for at least a 10 V swing. Turn **FINE** knob its full range. Check for at least a 1 V swing.

Note: The Coarse setting has a 250 mV range at the inputs which translates into a 12.5 V range at the output at x50. Since the amplifier only has a 10 V output range you might not see all 12.5 V at the output. The fine position is ten times as sensitive than the coarse position 25 mV at the input).

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Theory of Operation

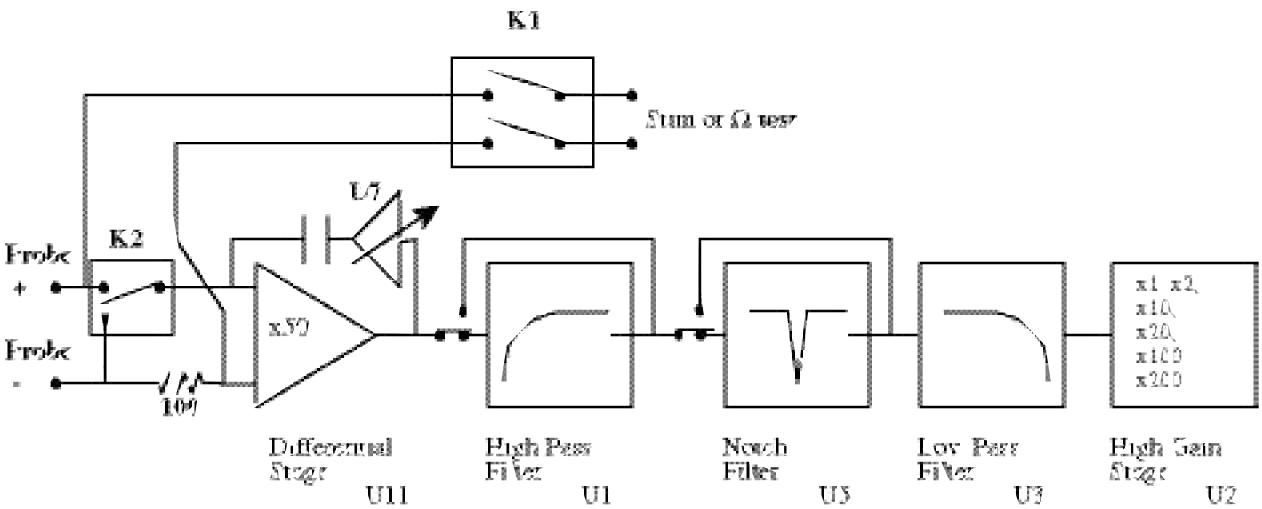
Overview

The Model 3000 is a high gain differential AC/DC amplifier. The first stage in the amplifier (with either the head stage option or non head stage version) consists of a high input impedance differentially coupled x50 amplifier. The signal from this amplifier is coupled through positive feedback with a capacitor to form capacity compensation. The capacity compensated signal is offset adjustable through a precision variable voltage reference.

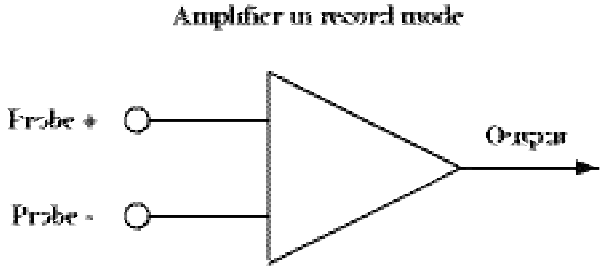
The signal from the initial stage then passes through High pass (if activated), Notch (if activated), and Low pass filters. Finally the signal passes through a gain stage of up to 200 times. The gain stage is monitored for saturation.

Operational Modes

Block Diagram



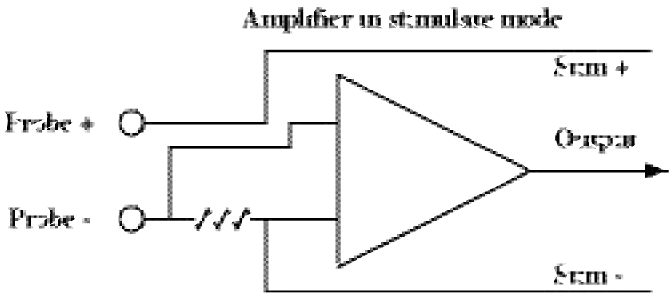
Record Mode



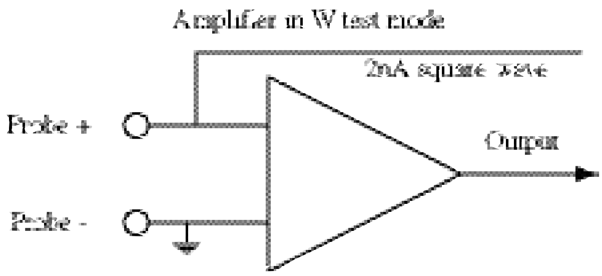
In Record Mode, the inputs of the differential amplifier U11 are switched by relay K2 (in the off position), connecting them differentially across the two electrodes in order to amplify with a x50 gain the neural activity appearing at the electrode-tissue interface. In this mode relay K1 is off so that the Stimulus leads do not feed noise into the circuit. A capacity compensation circuit provides positive feed back through U7 to minimize the effect of electrode and cable capacitance on recording and impedance measuring modes. The differential output signal of U11 passes through the High Pass Filter U1, the Notch Filter U5 if activated, and the Low Pass filter U3, in that order. Finally the signal passes through the High Gain amplifier (U2), offering x1, x2, x10, x20, x100, or x200 additional gain.

Stimulus Mode

In Stimulus Mode, the differential inputs of the Probe amplifier U11 are switched by K2 (in the on position) so that they are across a 100 Ω resistor that is in series with **PROBE-**, the indifferent electrode lead. At the same time, relay K1 to connect the stimulus source at the **STIMULUS INPUT** connector to the electrode leads. A stimulus current from an isolated source passes through the **PROBE+** lead to the active electrode, returning through the **PROBE-** lead and the 100 Ω resistor. The current creates a voltage across the 100 Ω resistor which is amplified by the differential amplifier U11 and passes through the rest of the recording circuit with including the adjustable gain amplifier U2.



Impedance Mode



When in record Mode and the Impedance switch is set to **ON**, the differential amplifier U11 is switched across the two electrode leads by K2 (in the off position). At the same time, relay K1 is on such that the internal current source is connected to the electrode leads. The current source generates a 2 nA, 100 Hz square wave that passes through the electrodes, and the voltage that develops is a measure of the electrode impedance. The output of is fed through the recording circuitry including the adjustable gain stage U2.

The current source consists of several parts. A stable timer (U8) produces a 2.5 V p-p square wave at 100 Hz that is attenuated by a 5K potentiometer. The attenuated square wave is applied to an active current source (U10), which converts the square wave voltage to a square wave current of 2 nA p-p at 100 Hz. The calibrated current source is connected to switch SW8, which switches the current to the electrode leads.

Component Modules

Differential Amplifier

The Differential Amplifier (U11) make the transformation from a differential signal to a single-ended signal. R41 is used to DC balance this stage.

DC Offset

The DC Offset control (U6) is set using potentiometers R2 and R1. The stable DC offset is feed into the reference terminal of the differential amplifier U11.

High Pass Filter

The High Pass Filter (U1) is a second-order Butterworth high-pass filters with selectable cutoff points, and a by pass setting.

Notch Filter

The Notch Filter (U5) is tuned to the line frequency. The circuit consists of a twin-T network in a feedback loop with an operational amplifier.

Low Pass Filter

The Low Pass Filter (U3) is a second-order Butterworth low-pass filters with selectable cutoff points.

Specifications

Record Mode

Gain settings available	(x50, x100, x500, x1000, x5000, or x10 000) ± 5%
Noise	2.0 µV rms (10Hz to 10kHz) 0.3 µV rms (0.1 Hz to 10 Hz)
Current Noise	0.1 fA/√Hz (1 kHz)
Offset Voltage	adjustable to zero
Input Offset Adjust Range	± 250 mV
Capacity Compensation	-4 pF to +50 pF
Maximum input Voltage	10V/Gain ± 250 mV input offset adjust

Zero Stability

Stability versus temperature	50 µV/ºC
Stability versus time	1 mV/12 hours

Stimulus Mode

Output current ratio	5V/mA, 10V/mA, 50mV/µA, 0.1V/µA, 0.2V/µA, 1V/µA,
Maximum output current reading	± 10 V or ± 2 mA
Maximum stimulus current	10 mA
Maximum stimulus voltage	
+ Diff	± 100V
- Diff	± 15V

Impedance Input

Output impedance ratio (2nA source)	0.1Vp-p/MΩ, 0.2Vp-p/MΩ, 1Vp-p/MΩ, 2Vp-p/MΩ, 10Vp-p/MΩ, 20Vp-p/MΩ
Maximum output impedance reading	40 MΩ

General Electrical

Input impedance	$>10^{15}$ MΩ || 0.2 pF differential $>10^{15}$ MΩ || 7 pF common-mode
Input bias current	100 fA, maximum, 1 fA typical
Output Impedance	100 Ω
Common mode rejection	90 dB
Notch Filter	Better than -50 dB at 60 Hz; Better than -45 dB at 50 Hz
Output dynamic range	± 10 V, minimum
High Pass filter settings	DC, 0.1, 1, 10, 100, 300 Hz ± 15%
High Pass filter gain	-40 dB / decade
Low Pass filter settings	0.1, 0.3, 1, 3, 10, 20 kHz ±15%
Low Pass filter gain	-40 dB / decade

Power

REMOTE AC Power source 100-240 VAC, 50 or 60 Hz
DC voltage into the amplifier for use inside of faraday cage

Physical Dimensions

Width	8.5 inches (21.6 cm)
Height	4 inches (10.2 cm)
Depth	3.5 inches (8.9 cm)
Weight	5 pounds

131 Business Park Loop, P.O. Box 850 Carlsborg, WA 98324
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E-mail: sales@a-msystems.com * Website: http://www.a-msystems.com

Warranty and Service

LIMITED WARRANTY

What does this warranty cover?

A-M Systems, LLC (hereinafter, “A-M Systems”) warrants to the Purchaser that the Instrument, including cables, Headstage Probes and any other accessories shipped with the Instrument,(hereafter the “hardware”) is free from defects in workmanship or material under normal use and service for the period of three (3) years. This warranty commences on the date of delivery of the hardware to the Purchaser.

What are the obligations of A-M Systems under this warranty?

During the warranty period, A-M Systems agrees to repair or replace, at its sole option, without charge to the Purchaser, any defective component part of the hardware. To obtain warranty service, the Purchaser must return the hardware to A-M Systems or an authorized A-M Systems distributor in an adequate shipping container. Any postage, shipping and insurance charges incurred in shipping the hardware to A-M Systems must be prepaid by the Purchaser and all risk for the hardware shall remain with purchaser until such time as A-M Systems takes receipt of the hardware. Upon receipt, A-M Systems will promptly repair or replace the defective unit, and then return the hardware (or its replacement) to the Purchaser, postage, shipping, and insurance prepaid. A-M Systems may use reconditioned or like new parts or units at its sole option, when repairing any hardware. Repaired products shall carry the same amount of outstanding warranty as from original purchase, or ninety (90) days which ever is greater. Any claim under the warranty must include a dated proof of purchase of the hardware covered by this warranty. In any event, A-M Systems liability for defective hardware is limited to repairing or replacing the hardware.

What is not covered by this warranty?

This warranty is contingent upon proper use and maintenance of the hardware by the Purchaser and does not cover batteries. Neglect, misuse whether intentional or otherwise, tampering with or altering the hardware, damage caused by accident, damage caused by unusual physical, electrical, chemical, or electromechanical stress, damage caused by failure of electrical power, or damage caused during transportation are not covered by this warranty.

What are the limits of liability for A-M Systems under this warranty?

A-M Systems shall not be liable for loss of data, lost profits or savings, or any special, incidental, consequential, indirect or other similar damages, whether arising from breach of contract, negligence, or other legal action, even if the company or its agent has been advised of the possibility of such damages, or for any claim brought against you by another party. THIS EQUIPMENT IS NOT INTENDED FOR CLINICAL MEASUREMENTS USING HUMAN SUBJECTS. A-M SYSTEMS DOES NOT ASSUME RESPONSIBILITY FOR INJURY OR DAMAGE DUE TO MISUSE OF THIS EQUIPMENT. Jurisdictions vary with regard to the enforceability of provisions excluding or limiting liability for incidental or consequential damages. Check the provision of your local jurisdiction to find out whether the above exclusion applies to you.

This warranty allocates risks of product failure between the Purchaser and A-M Systems. A-M Systems hardware pricing reflects this allocation of risk and the limitations of liability contained in this warranty. The agents, employees, distributors, and dealers of A-M Systems are not authorized to make modifications to this warranty, or additional warranties binding on the company. Accordingly, additional statements such as dealer advertising or presentations, whether oral or written, do not constitute warranties by A-M Systems and should not be relied upon. This warranty gives you specific legal rights. You may also have other rights which vary from one jurisdiction to another.

THE WARRANTY AND REMEDY PROVIDED ABOVE IS IN LIEU OF ALL OTHER WARRANTIES AND REMEDIES, WHETHER EXPRESS OR IMPLIED. A-M SYSTEMS DISCLAIMS THE WARRANTIES OF MERCHANTIBILITY AND FITNESS FOR A PARTICULAR USE, WITHOUT LIMITATION.

A-M Systems **3000 Manual** **DRW-5027901 rev 3**
Approved:

Revision History

Rev	**Date**	**Description**
2	6/30/06	Initial Document Control release
3	4/28/10	DCR201200 Warranty and Company info