

# SA-500

## SERVO CONTROLLER / LINEAR AMPLIFIER FOR PIEZOELECTRIC (CAPACITIVE) LOADS



## USER MANUAL

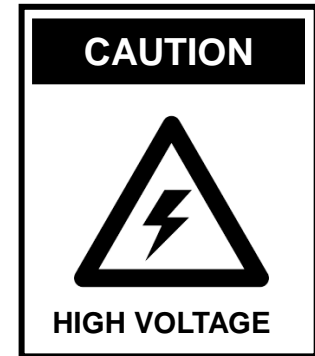
## **SA-500 LINEAR PIEZOELECTRIC AMPLIFIER**

*This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.*

Please review the following points for both personal and equipment safety while operating the linear piezoelectric amplifier.

### **HIGH ENERGY/VOLTAGE WARNINGS**

Exercise caution when using amplifiers. High energy level can be stored at the output voltage terminals on all amplifiers in normal operations. In addition, potentially lethal voltages exist in the power circuit and the output screw terminals. Filter capacitors store potentially dangerous energy for some time after power is removed.



### **AC SOURCE GROUNDING WARNING**

Ensure that the amplifier's power supply is connected to a grounded AC outlet with the recommended AC input connector configured for the available line voltage.

### **OPERATING AND SERVICES PRECAUTIONS**

Operate the amplifier in an environment free of flammable gases or fumes. Do not use substitute parts or make any unauthorized modifications to the amplifier to ensure that its safety features are not degraded. Contact DSM for service and repair assistance.

## SA-500 SPECIFICATIONS

- Output Voltage: -30/+150V or -30/+200V
- Input Voltage Signal (gain = 20): -1.50V to +7.50V (for -30/+150V unit)  
-1.50V to +10.0V (for -30/+200V unit)
- Maximum Continuous Current: 500mA, > 5msec
- Maximum Peak Current: 1000mA, < 5msec
- Dimensions: 100mm x 240mm x 330mm (4" x 9.5" x 13")
- Operating Voltage: 100 ~ 240VAC, 50 ~ 60Hz
- Amplifier bandwidth: > 3kHz (-3dB, large signal)
- Electrical Noise on Output: ~4mVrms
- Short circuit, over-current, and over-temperature protection
- Output Connector: SMA
- Input Connector: BNC (24-bit analog input)
- Auxiliary Connector (OPTIONAL): BNC (for example, to monitor a feedback signal)
- Analog / Digital Feedback Connector: Typically 9-pin D-sub
- Communications: Serial (RS-232) via 9-pin D-sub
- Altitude < 2000M

NOTE: The output voltage is configured at the factory and is not re-configurable in the field.


### *Optional Features (as required or specified):*

- Second 24-bit analog input channel
- Two channels each of digital I/O for enabling TTL lines

### *Software Communication and Control*

The SA-500 is shipped with a dll that can be used in National Instruments LabVIEW, Visual Basic, and Visual C to communicate with the amplifier. Please refer to the supplementary documentation "Serial Com DLL".

## WARNING!

 This device is marked with the international caution symbol. It is important to read the Recommended Operation section of this manual before using this device as it contains important information related to product safety.

### *General Precautions*

- ◆ All insulation of leads connected to output terminals should have at least a 300V rating.
- ◆ Do not use clip leads in the connections used in arrangements employing the SA-500 linear amplifier. They are very dangerous for high-voltage work.
- ◆ Do not place objects on top of or close beside the amplifier during operation. Adequate airflow around the unit is encouraged to allow heat to dissipate.
- ◆ Do not place SA-500 amplifier in such a way it is difficult to get to the power plug.
- ◆ Ensure that the amplifier's power supply is connected to a grounded AC outlet with the recommended AC input connector configured for the available line voltage.

### *Acceptable Load Types*

- ◆ This amplifier is designed to drive capacitive loads only. Do not use this amplifier to drive resistive loads. The amplifier will only work properly when a capacitive load is connected to the output.
- ◆ Never connect an inductive or a resistive load to the unit. This would cause a short-lived high-current pulse at the output and would damage the amplifier unit.

### *Short Circuit Damage*

- ◆ Although the SA-500 is protected against a short-circuit on the output, it is recommended that a short circuit condition be avoided.
- ◆ Never connect an "earth ground" lead (e.g., an oscilloscope ground lead) to the center pin of the SMA output terminal. This causes a short-lived high-current pulse and subsequent damage to the unit.
- ◆ If the user desires to observe or audit the output signal of the amplifier using a voltage meter or an oscilloscope, the user must ensure that the meter or oscilloscope has an input impedance of at least 1 MOhm. A smaller input impedance could damage the amplifier.

## RECOMMENDED OPERATION

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### *Intended Use*

DSM's SA-500 linear amplifier is intended to drive piezoelectric (capacitive) loads of the following types:

1. Low voltage piezoelectric materials rated for a maximum operating range of  $-30$  to  $+150V$  (piezo devices which have two lead wires: output voltage and ground)
2. Low voltage piezoelectric materials rated for a maximum operating range of  $-30$  to  $+200V$  (piezo devices which have two lead wires: output voltage and ground)

The SA-500 applies a gain of 20 to analog input signals and generates an output voltage suitable for driving or actuating piezoelectric materials of the types described previously.



Figure 1. Front Panel View

### *Instructions for Use*

#### Start-Up / Shut-Down Procedure

The SA-500 amplifier can be powered-up and powered-down with or without being connected to an input signal. However, DSM recommends that the amplifier be connected to a load (capacitive, such as a piezoelectric device of the appropriate rating) during start-up and while the amplifier is running; operating without a load can be damaging to the amplifier's circuitry.

During start-up and shut-down, the output of the amplifier passes through some fast voltage transients that quickly settle to zero volts (assuming there is no voltage on the input). These fast voltage transients can cause the load (piezo actuator or stage) to move, and there can be an audible noise that results from this fast motion. This is not damaging to the piezo element.

#### Operation

Prior to completing the electrical connections outlined below, ensure that the work place is free of conductive objects that could pose electrical hazards to the user should the objects make contact with the high voltage output connector of the SA-500 amplifier. Connect line power to the SA-500 through the receptacle on the back panel.

*Connect the load to the SA-500 via the OUTPUT SMA connector*

The SA-500 will have been configured at the factory for an output voltage range corresponding to the specifications of the customer's load (either  $-30$  to  $+150\text{V}$  or  $-30$  to  $+200\text{V}$  for standard configurations).

A load (i.e., a piezoelectric actuator) is connected to the amplifier via the OUTPUT SMA connector on the amplifier's front panel. The output voltage can then be adjusted via SET VOLTAGE functions of the interface dial (described in detail in a subsequent section) or by enabling servo control.



**CAUTION:** When the SA-500 is powered, the OUTPUT SMA connector of the amplifier can carry voltages ranging up to  $200\text{V}$ , depending upon the amplifier's configuration. The SA-500 amplifier should not be left running for an extended time without having the output line connected to an appropriate capacitive load, such as a piezo actuator.

*Connect the host PC's serial communication port (RS-232) to the SA-500's 9-pin SERIAL IN connector*

A 9-pin D-sub connector labeled "SERIAL IN" has been included on the back of the amplifier. It is used to connect the amplifier to another device, such as a PC, using RS-232 serial communication. This connector is configured to be used with a "straight-through" cable. *If a null-modem type cable is used, the amplifier will not communicate properly.* More details about interfacing with the SA-500 can be found in the supplementary document titled "Serial Com DLL".

*Using the serial connection or through the front display's user interface, adjust the target position and PID control gain settings as needed to achieve the desired output from the piezoelectric load*

The SA-500 circuitry incorporates a microcontroller that enables a simple user interface. User input is accomplished through the interface dial on the front panel using a combination of turning the dial and pressing the dial in to select or to confirm a command. Alternatively, the commands required for controlling the SA-500 can be accessed through RS-232 serial communication as described in the supplementary document titled "Serial Com DLL".

Refer to the Menu Trees on pages 9-11 for menus and options associated with the user interface.

*Connect the Position Sensor for Displacement Feedback*

Position feedback (e.g., from a capacitive probe, LVDT, or encoder) is provided to the SA-500 via a 9 pin D-sub connector on the back of the unit, which is labeled accordingly as "FEEDBACK". The SA-500 can not correctly execute closed-loop control without a properly connected and configured feedback signal. If applicable, please refer to the supplementary documentation provided by DSM for the particular details regarding the use of the feedback sensor chosen for your system.

Depending upon the configuration, the SA-500 can be supplied with a BNC connector in the AUX location on the front panel of the enclosure. This connector can carry the analog feedback

signal from the displacement sensor for auditing and data acquisition purposes if desired. It is not necessary to be connected to this AUX analog channel.

#### *Connect the Input Voltage Signal for Voltage Signal Mode*

If the SA-500 has been configured to support this mode, it is possible to use a voltage signal to transmit the position target to the amplifier. The input line (accessed through the enclosure's front panel INPUT BNC connector) is normally configured for -10 Volt to +10 Volt operation. See the next section for more information.

### **NOTES REGARDING INTERCHANGEABLE HARDWARE**

The SA-500 amplifier uses a digital PID control algorithm that adjusts the output voltage based on the feedback signal supplied to the amplifier. In some cases, the PID settings were "tuned" for a specific actuator. Each amplifier was tested with a feedback and a piezo-electric positioning stage as a matched set; in some cases, it may be necessary to maintain matched sets.

### **MODES OF OPERATION**

The position target to which the SA-500 seeks to move the actuator can be communicated to the amplifier in multiple ways. Depending on how the amplifier has been configured, there may be multiple modes of operation that can be used to set the position target. These modes are described below.

#### *Single Point Mode*

This mode is normally the default condition for the amplifier. In this mode, the position target can be communicated to the SA-500 either through the front panel interface (see Position Status Menu on page 7) or via serial communication, as described in the document "Serial Com DLL". Upon receipt of a new position target, the amplifier seeks to move the actuator to the new target as quickly as possible, based on the current PID settings.

#### *Voltage Signal Mode*

If the SA-500 has been configured to support this mode, it is possible to use a voltage signal to transmit the position target to the amplifier. The input line (accessed through the enclosure's front panel INPUT BNC connector) is normally configured for -10 Volt to +10 Volt operation. Voltage outside of this range should not be input on this line; excessive voltage can damage amplifier hardware. The amplifier can be set to this mode using either serial communication or by selecting VOLTAGE SIGNAL under the CONFIG AMP menu. This mode of operation is useful for having arbitrary motion profiles such as sine waves, step moves, or contoured moves communicated to the amplifier by a function generator or computer.

#### *Ramp Move Mode*

Some amplifiers have included an algorithm to execute internally generated ramp moves. In this mode, a fixed ramp rate and position target are communicated to the amplifier via serial communication, along with a trigger signal to begin the move. This mode is generally selected

using serial communication. Details about this feature can be found in the document “Serial Com DLL”.

### *SA Mode*

This amplifier is not configurable for an open loop voltage follower (VF) mode. The SA-500 can only be used in a closed loop system.

### **SERVO ENABLE/DISABLE**

On startup, closed-loop control is disabled. Thus, even if a position target is input, the amplifier will not move the actuator to this target. The amplifier will begin closed-loop control after the ENABLE SERVO command is executed, either using the SERVO STATUS menu or serial communication. Note that if the amplifier is in single point mode, it will adopt the current position as its new position target when ENABLE SERVO is executed. This prevents a large jump in position when servo control is enabled.

### **NOTES REGARDING USER INTERFACE**

Although the PID settings for each amplifier are normally tested with the associated actuator and saved prior to shipment, the end user may be able to improve system response by changing the PID settings using the SERVO PARAMETERS menu. Although any changes will be immediately updated in the closed-loop controller, all changes *will be lost* after turning off the amplifier unless they are saved using the SAVE SETTINGS menu. Servo control is disabled when the settings are saved, but it can be reestablished using the SERVO STATUS menu.

Two voltage “rails” provide power to the amplifier. These rail voltages are approximately  $-30\text{ V}$  and  $+150\text{ V}$  unless otherwise noted on the amplifier's serial number label on the back panel of the amplifier. They represent the two extremes of motion that an actuator powered by the SA-500 can achieve. By choosing the positive or negative rail under the SET VOLTAGE menu, the actuator is automatically moved to its fully extended or retracted position. Note that servo control is automatically disabled by this selection, as the amplifier is setting a voltage without regard to position. While generally not used during normal operation, this menu is useful for testing the range of motion of an actuator and checking that the feedback device is functioning properly.

### **CIRCUITRY PROTECTION**

The SA-500 circuitry incorporates over-current, over-temperature, and short-circuit protection.

When the protection circuitry is enabled as a result of a short circuit condition, the amplifier will disconnect the output temporarily and will attempt to restart. During restart, the amplifier will recheck the conditions and will go into protection mode again if conditions are not yet favorable. This protection thus protects both the amplifier and the load.



The SA-500 is equipped with temperature sensors that will protect the circuitry if the internal temperature of the unit exceeds the safe operating condition. The over-temperature condition triggers at approximately 70C. Although the signal from the input BNC will continue to be fed into the amplifier and the amplifier will remain connected to the load, the output signal will be restricted to a small voltage oscillation (20-30 mV) around earth ground until the sensor indicates that the unit has reached approximately 50C. There is no indication in the user interface display to communicate the over-temperature condition to the operator.

However, if the equipment is used in a manner not specified by DSM, the protection provided by the equipment may be impaired.

### **RECOMMENDED ENVIRONMENTAL CONDITIONS FOR OPERATION**

The SA-500 is designed to operate in non-hazardous environments. Any deviation from the specified environment must be approved by DSM and may result in the voiding of any warranty. Any deviation not approved by DSM will be grounds for voiding of any warranty.

- Environmental Temperature: 0-50C
- Percent Relative Humidity: 0-80% non condensing
- Operating Supply Voltage: 100 ~ 240VAC, 50 ~ 60Hz
- Altitude < 2000M

### **CLEANING**

Prior to any cleaning, unplug the electrical power to the SA-500. Dust can be readily removed by wiping or by blowing with compressed dry air. Wiping the unit with a damp cloth is acceptable, but care must be taken not to leave any residual liquid at the electrical connections.



**CAUTION:** As with any electrical device, do not spill or immerse the SA-500 amplifier in liquids in order to avoid electrical shock.

### **REPLACEMENT PARTS**

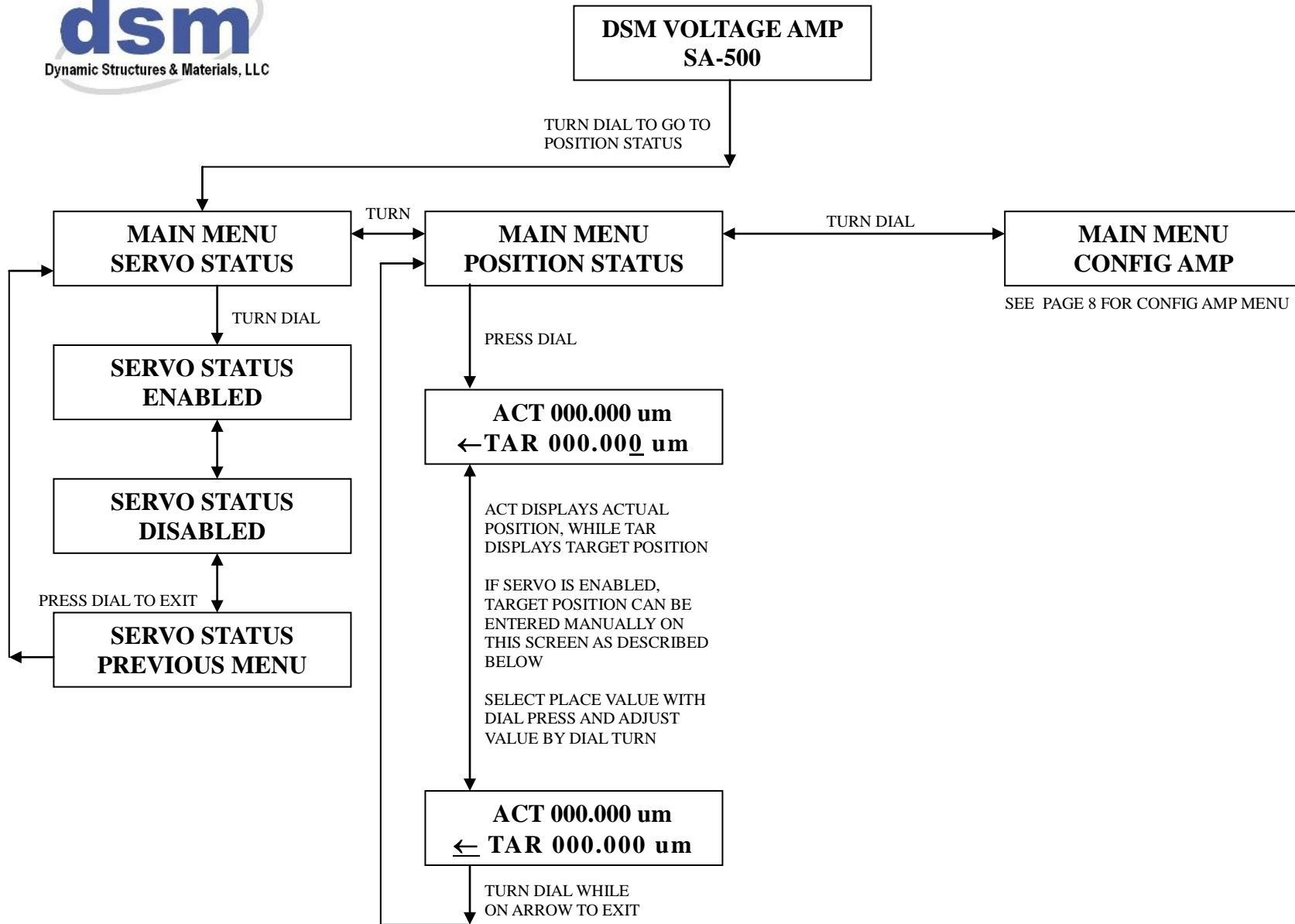
#### Power Cord

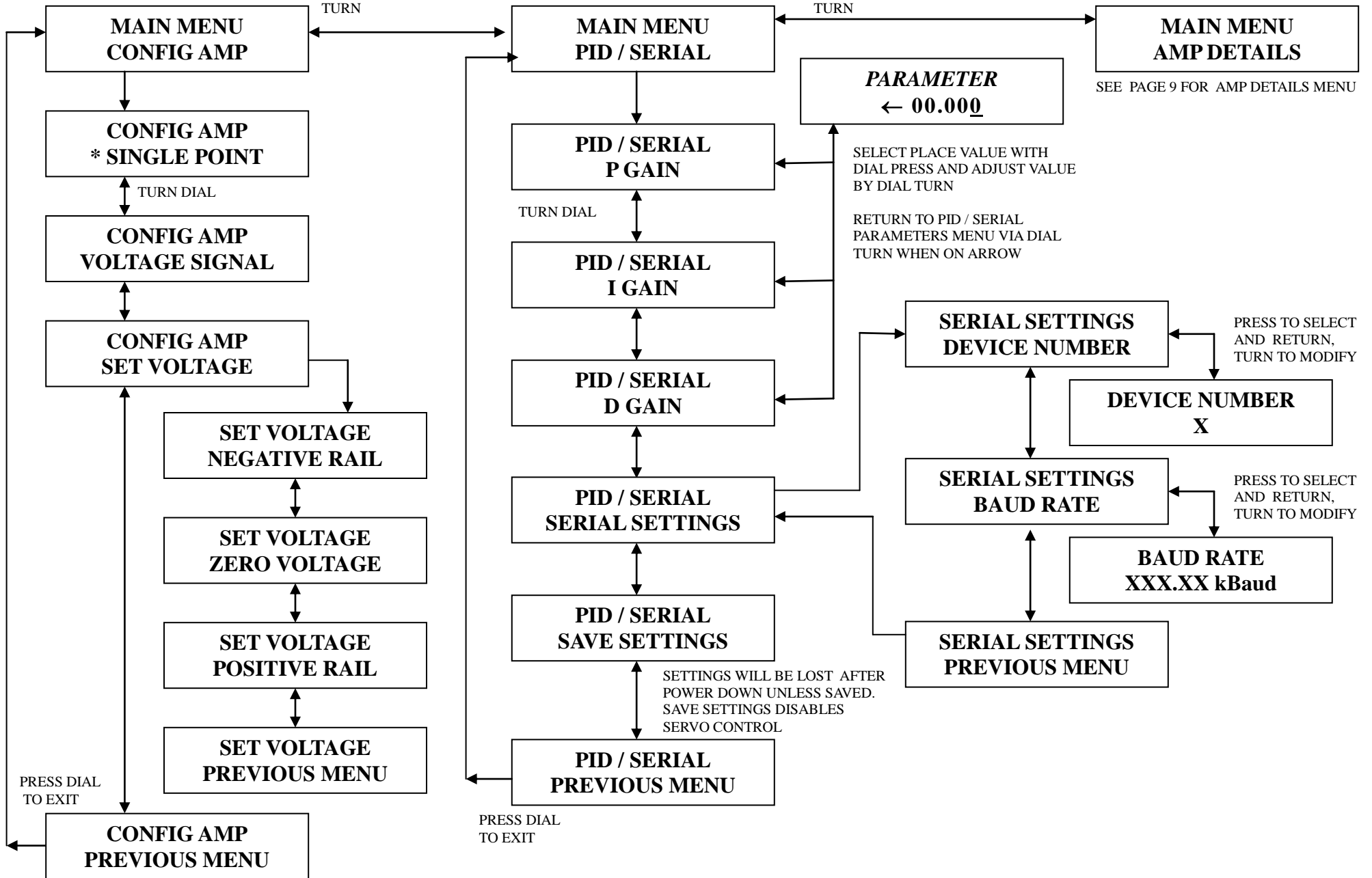
Power cord should not be replaced with one lower than 18AWG, 3 Conductors, IEC320-C13

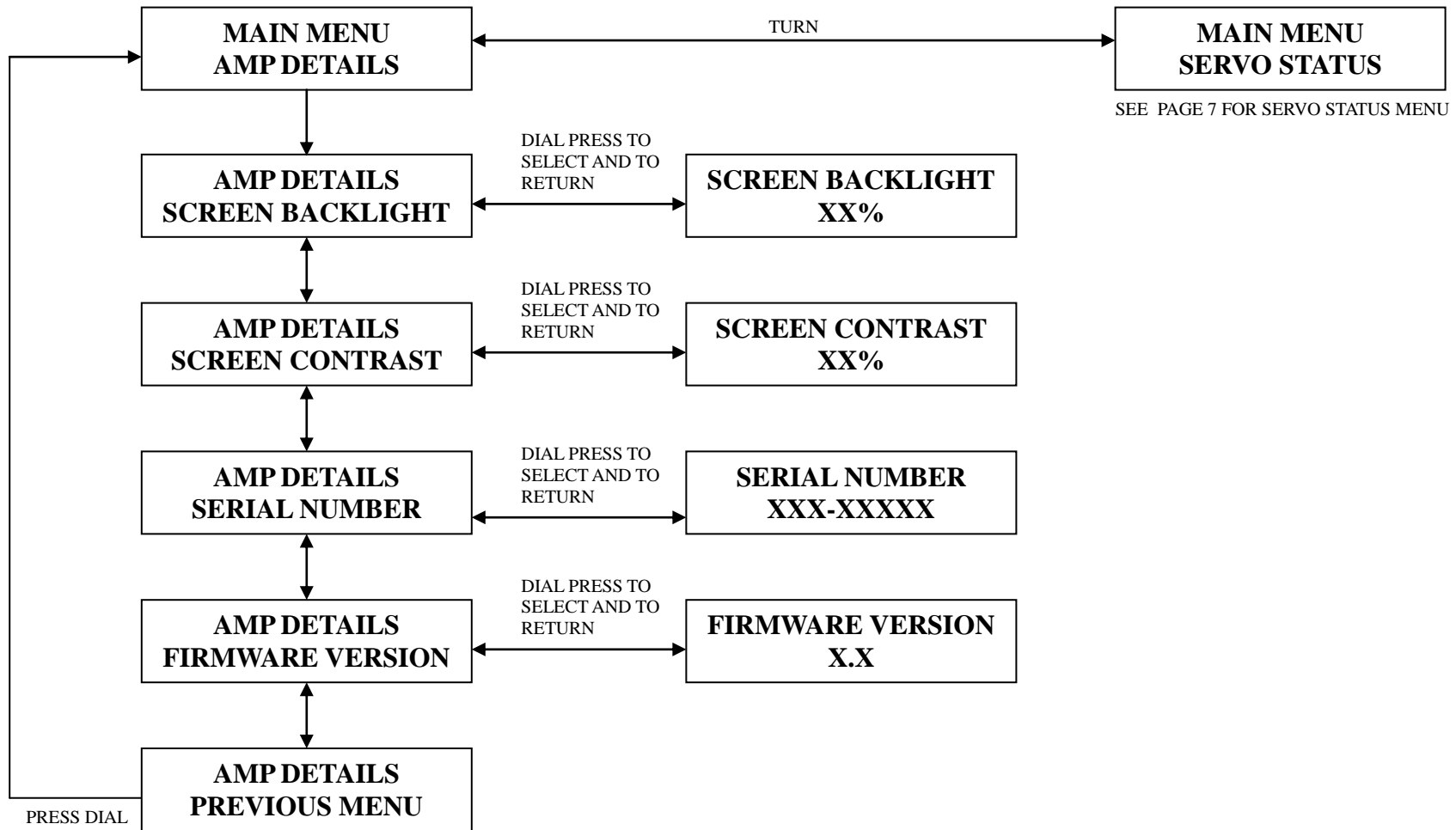
#### Fuse

Recommended part – Manufacturer # 0034.1522

Description- Fuse Glass 4A , 250VAC 5x20MM







## **Warranty Information**

The DSM Warranty Period is a period of 60 days beginning on the date that DSM ships the new, customer-purchased equipment or software. DSM warrants that its new equipment will be free from defects in materials and workmanship during the DSM Warranty Period.

DSM warrants that its software shall be fit for the particular uses described in DSM product literature and user's manuals available at the time of initial equipment shipment, and shall operate properly during the DSM Warranty Period.

In the event that DSM receives written notice of a claim under this Warranty within the DSM Warranty Period, DSM will repair or replace equipment or software, at its option, at no charge. These services shall be performed at DSM's factory or its designated repair facility.

Freight charges to return equipment or software to DSM are the customer's responsibility. DSM will pay freight charges to return the equipment to the customer.

### *Warranty Shipments Outside of North America:*

Warranty-repaired product is generally re-imported into the customer's country without duty, however the customer can most efficiently complete the administration of this duty exemption. Return freight to convey repaired or replaced parts or equipment from DSM to customer shall be "E.X.W." as such term is described by Incoterms 2000, with such expenses charged to customer's freight account for direct payment by customer to their freight service provider. All brokerage, freight, shipping, forwarding and handling charges, duties, customs and taxes applicable to warranty-repaired product shipments, if any, will be paid directly by the customer. DSM agrees to promptly reimburse customer for its actual freight cost incurred, *excluding* brokerage and handling charges, duties, customs and taxes, for warranty shipment from DSM to customer, using the same class of freight service selected to initially return the warranty claim equipment to DSM.

Reinstallation and recalibration of DSM equipment and software into a customer-specific application are not covered by this Warranty.

Equipment or software repaired or replaced under this Warranty are covered under the remaining DSM Warranty Period, if any, associated with the original new equipment or software.

### Exclusions

This Warranty does not cover:

1. Damage related to modification of DSM equipment or software after initial shipment by DSM.
2. Consequential or incidental damages such as property damage and incidental expenses.
3. Conditions caused by external factors such as abuse, misuse, inadequate power supply, or acts of God.

Owing to the wide range of experimental uses attempted by our customers, DSM does not warrant that its products are fit for a particular use.

Opening of devices, machines, or electronics enclosures by anyone other than DSM voids this Warranty.