

SA75

SWITCHING AMPLIFIER FOR PIEZOELECTRIC  
ACTUATORS

Version : 1.2.3  
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### CAUTION: READ BEFORE OPENING

For safety purposes these instructions must be read before use of this product.

**This power amplifier is dedicated to piezoelectric actuators.**

Only qualified personnel should work on or around this equipment and only after becoming thoroughly familiar with all warnings, safety notices, and procedures contained herein.

**The successful and safe operation of this equipment is dependent on proper handling, installation and operation.**

A "qualified person" is one who is familiar with the installation, construction and operation of the equipment and the hazards involved. In addition, he/she has the following qualifications :  
is trained and authorized to energize, de-energize, clean, and ground equipment in accordance with established practices, is trained in the proper care and use of protective equipment in accordance with established safety practices.

## Table of contents

1.	DESCRIPTION .....	5
1.1.	FRONT AND REAR PANEL .....	5
2.	MAIN FEATURES .....	7
3.	APPLICATIONS .....	7
4.	ELECTRICAL SAFETY INFORMATION .....	8
5.	INFORMATION ON DISPOSAL FOR USERS OF WASTE ELECTRICAL & ELECTRONIC EQUIPMENT (PRIVATE HOUSEHOLDS) .....	10
6.	GENERAL DESCRIPTION .....	11
6.1.	VOLTAGE CONTROL LOOP .....	12
6.2.	BANDWIDTH .....	12
6.2.1.	Power bandwidth .....	12
6.2.2.	Small signal bandwidth .....	13
6.3.	ENERGY RECOVERY .....	14
7.	MAIN VOLTAGE CONNEXIONS .....	15
8.	OPERATING INSTRUCTIONS FOR THE SWITCHING POWER SUPPLY, AC/DC CONVERTER (SC75) .....	15
9.	OPERATING INSTRUCTIONS FOR THE AMPLIFIER (SA75) .....	16
9.1.	GENERAL INSTRUCTIONS .....	16
9.2.	LIMITATIONS AND PROTECTIONS .....	18

9.2.1. Voltage limitation . . . . .	18
9.2.2. Current limitation . . . . .	18
9.2.3. Slew rate limitation . . . . .	18
9.2.4. Output voltage protection . . . . .	18
9.2.5. Output current protection . . . . .	19
9.2.6. Temperature protection . . . . .	19
9.2.7. Reset protection . . . . .	19
<b>10. OPEN/CLOSED LOOP . . . . .</b>	<b>20</b>
<b>TROUBLE SHOOTING . . . . .</b>	<b>21</b>
<b>WARRANTY CONDITIONS AND EXCEPTIONS . . . . .</b>	<b>24</b>
<b>INSPECTION UPON RECEIPT . . . . .</b>	<b>25</b>
<b>AFTER-SALES SERVICE . . . . .</b>	<b>26</b>
<b>APPENDIX 1 : CONNECTIONS . . . . .</b>	<b>27</b>
<b>APPENDIX 2 : TROUBLE SHOOTING FORM . . . . .</b>	<b>28</b>

## 1. DESCRIPTION

The SA75 consists in a powerful switching amplifier designed to piezoelectric actuators. The package follows the next dimensions:

RACK 84F-4U
Width : 470 mm
Length : 310 mm
Height : 200 mm

This electronic is a modular one; which means that a RACK84F, for instance, may receive two power supply units (SC75) and up to 4 amplification channels (SA75X\_Y- X represents A, B, D version and Y represents 1 or 2 channels), as well as sensors conditioning units:

- Strain gauges sensors conditioner (SG75 unit),
- Eddy current sensors conditioner (ECS75 unit).

And servo controllers:

- UC45 on the SA75 board,
- UC65 on specific position.

Nota: "X" refers to the "A", "B" or "D" version of the driving electronics.

### 1.1. FRONT AND REAR PANEL

The rear panel includes the main power connection, the ON/OFF switch and the fuses. The front panel includes the connections with actuators, orders, the switches to close the loop (SERVO) and the led indications regarding faults (Cf. Figure 1). The rack can include other boards described in separate documentations.

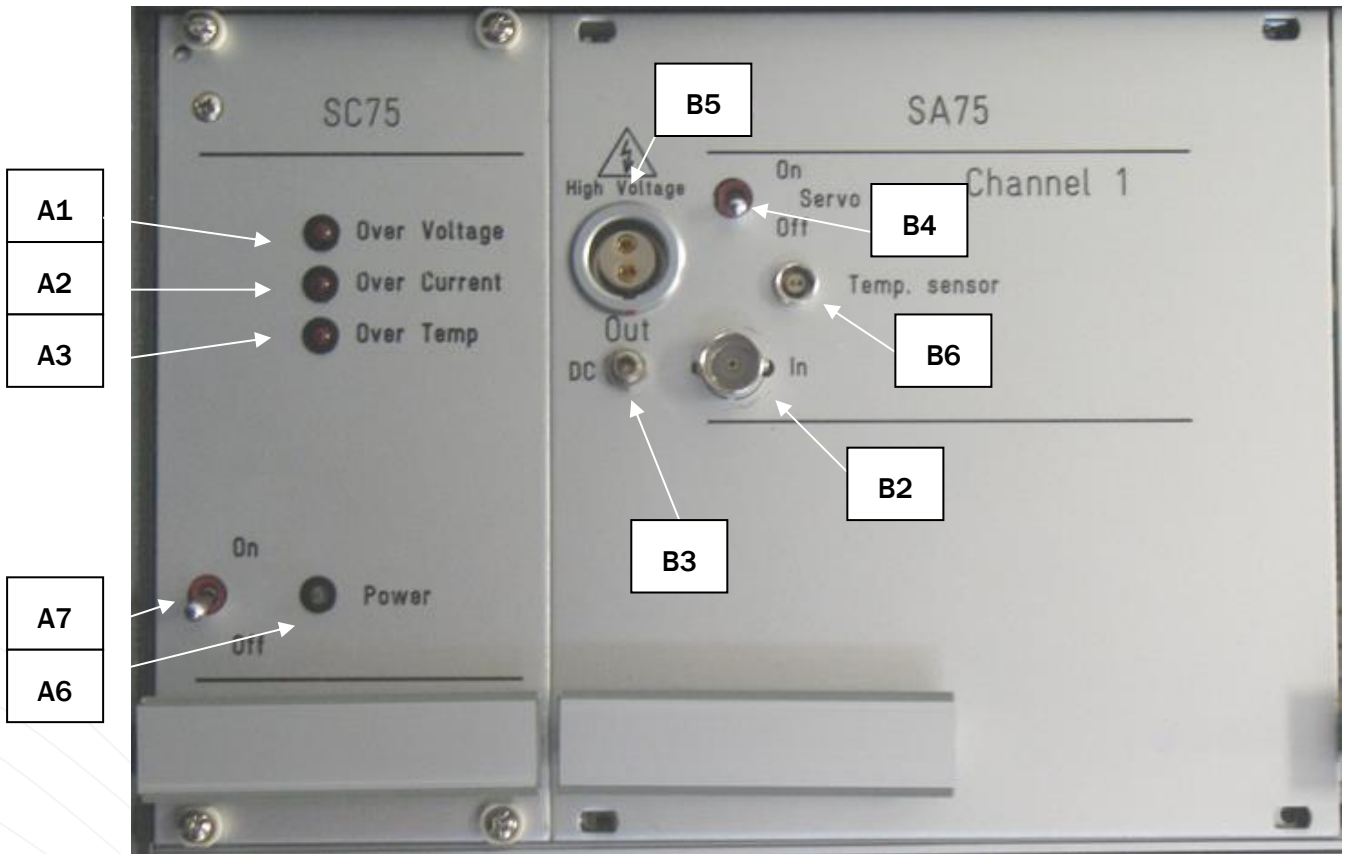


Figure 1 - Front panel of the SA75 power supply

Each item is described in the next table.

Reference	Designation
<b>1<sup>st</sup> module</b>	<b>Main power supply unit - SC75</b>
A1	Over Voltage – This diode lights when the amplifier detects an overvoltage on the actuator.
A2	Over Current – This diode lights when the amplifier detects an overcurrent.
A3	Over Temp – This diode lights when the actuator or the amplifier reaches the maximum temp
A6	Led power supply presence (green) - Led protect (red)
A7	Power On Switch
<b>2<sup>nd</sup> module</b>	<b>Switching amplifier - SA75X</b>
B2	Order BNC connector – channel 1
B3	DC offset order potentiometer (10 turn screw)- channel 1
B4	Closed loop selector (SERVO ON / OFF) – channel 1
B5	LEMO connector for piezo actuator – channel 1
B6	LEMO connector for over temperature protection of piezo actuator – channel 1

**Note:** If overvoltage, overtemp or overcurrent appear on the SC75 board side, the A6 lights red but no flag appears on A1, A2, and A3.

## 2. MAIN FEATURES

SA75	Value
Output Voltage	150V -20V
Output Current	20A
Max. Apparent Power <sup>(1)</sup>	1252VA
Active Power <sup>(2)</sup>	175W
Efficiency typ.	94%
Switching frequency	200kHz

(1) For sine waves only.

(2) Active power for the actuator and the amplifier losses.

The product includes a power supply, namely SC75, compatible with 110/230Vac main lines and capable of an output voltage of 175V and an output power of 175W.

- Power Factor Correction.
- High apparent and active power output.
- Compact.
- High efficiency.
- Energy recovering.
- Fast rise and fall times.
- Large power bandwidth.
- Fully isolated from ground.

## 3. APPLICATIONS

- Large piezoelectric actuators driving (capacitance >5 $\mu$ F).

## 4 . ELECTRICAL SAFETY INFORMATION

The following safety symbols are used in this manual.



Danger

For your own safety and for your system security, be sure to carefully respect that information.

In order to achieve safe operation of the SA75 amplifier, some safety information must be given. This information is intended to protect the user and the product and allows safe operating of the product.



Danger

- This product contains components with lethal voltage, it is strictly forbidden for the user to remove the boards from the rack. It is also strictly forbidden to disconnect the load when electrically powered.
- The actuator may store lethal energy for an indefinite time, do not touch the actuator or its connections. The user can discharge the actuator thanks to the amplifier with a null order.





Warning

This symbol is intended to alert you about an important element concerning the product.



Warning

- Do not open the product during or after use, lethal voltages may be present even after the product has been turned off.
- This device produces hazardous potentials and should be used by suitably qualified personnel. Do not operate the device when there are exposed conductors. Parts of the circuit may store charge so precautions must also be taken when the device is not powered.
- A special care in the use of the LEMO connections should be taken in plugging and unplugging them: you have to pull onto the connector and not the cable.
- It is strictly forbidden to connect the electrical output channels of several SA75x in parallel.
- The switching amplifier must be connected to a piezo load before switch on the A7 switch (Power on). Otherwise the power amplifier may be unstable.

A qualified person is a person entitled to perform near electric endanger.

## 5. INFORMATION ON DISPOSAL FOR USERS OF WASTE ELECTRICAL & ELECTRONIC EQUIPMENT (PRIVATE HOUSEHOLDS)



This symbol on the product(s) and / or accompanying documents means that used electrical and electronic products should not be mixed with general household waste. For proper treatment, recovery and recycling, please take this product(s) to designated collection points where it will be accepted free of charge.

Alternatively, in some countries you may be able to return your products to your local retailer upon purchase of an equivalent new product.

Disposing of this product correctly will help save valuable resources and prevent any potential negative effects on human health and the environment, which could otherwise arise from inappropriate waste handling.

Please contact your local authority for further details of your nearest designated collection point.

Penalties may be applicable for incorrect disposal of this waste, in accordance with your national legislation.

### **For business users in the European Union:**

If you wish to discard electrical and electronic equipment, please contact your dealer or supplier for further information.

### **Information on Disposal in other Countries outside the European Union**

This symbol is only valid in the European Union. If you wish to discard this product please contact your local authorities or dealer and ask for the correct method of disposal.

## 6. GENERAL DESCRIPTION

The switching electronic SA75 is dedicated to the supply and control of piezoelectric actuators based on multi-layers piezoelectric ceramics such as APA or PPA from [Cedrat Technologies](#). The SA75 consists in an amplifier with a maximal power given in the attached technical datasheet.

- A switching power supply (SC75) providing a continuous voltage from the main power (1<sup>st</sup> module),
- A switching power amplifier (SA75) dedicated to capacitive load allowing excitation of piezoelectric actuators between -20 and 150 V (2<sup>nd</sup> module),
- A strain gauge conditioner (SG75) allowing to measure the displacement of piezoelectric actuators equipped with gauges (optional module),
- A servo controller (UC45) allowing to close the loop and to insure a feedback control on the actuator (optional module)

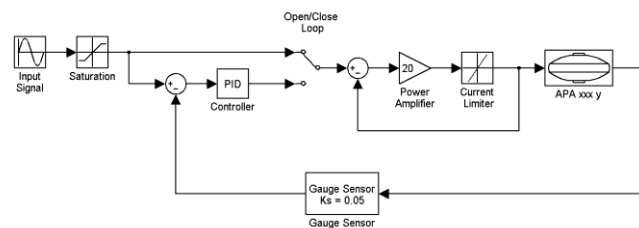


Figure 2 - Synoptic of the electronic control of a piezo actuator

A switching amplifier is built around PWM technology and a dedicated output filter including inductors and capacitors. As the piezo load is capacitive, the output PWM is filtered and a continuous output signal is supplied to the piezo load (see below).

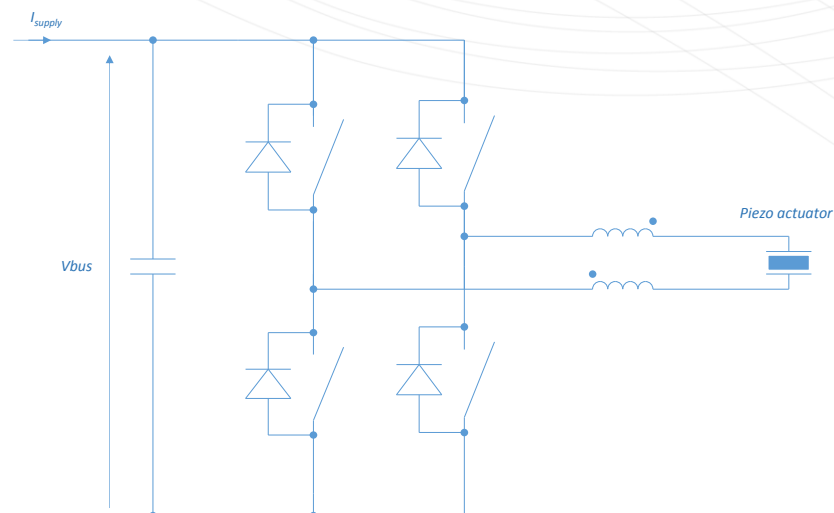


Figure 3 - Synoptic of a switching piezoelectric amplifier

**Warning**

- The output piezo connections are floating. If the operator wants to measure the output voltage on the load, a differential probe able to withstand more than 250V must be used. If the operator doesn't use a differential probe, damage on the switching amplifier may arise.
- The amplifier is only intended to perform on piezo actuator or on capacitive loads.
- The switching amplifier must be connected to a piezo load before switch on the A7 switch (Power on). Otherwise the power amplifier may be instable.

## 6.1. VOLTAGE CONTROL LOOP

A specific controller is implemented to control the output voltage on the piezoelectric actuators. The controller is tuned with the output load to provide the best performances in regards of the control (speed and accuracy). For this reason, your switching amplifier is tuned with factory settings and the operator cannot change the load without a lack of performance.

- If the amplifier is tuned for one actuator with a capacitance  $C$ , using an actuator with a capacitance smaller than  $C$  may conduct to instability which may lead the amplifier to enter in protection mode.
- If the user put a higher capacitance, there is no stability issue, but the performance (rise time, bandwidth) could be better with an optimized tuning.

## 6.2. BANDWIDTH

The amplifier is characterized with two specific bandwidths.

- The power bandwidth
- The signal bandwidth

### 6.2.1. Power bandwidth

The first one is due to the possibility to the SA75 to provide the necessary current to charge and discharge the piezo load: This is the current or power capability. Following the next formula:

$$I = C \frac{dV}{dt}$$

Equation 1. Electrodynamics fundamental equation.

The max current depends on your switching power amplifier current range:

- 5A (SA75A)
- 10A (SA75B)
- 20A (SA75D)

If the commanded signal is high frequency and when the max output current is reached, the output voltage is limited such as a slew rate (see

Figure 4).

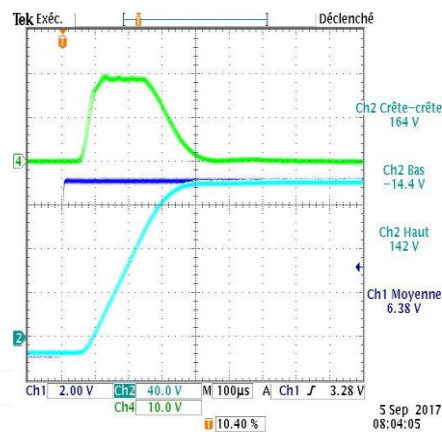


Figure 4. Current (CH4, green), Order (CH1, dark blue) and output voltage on a 30µF capacitance actuator with SA75D. These curves show typical output current and voltage for a step response.

For relatively small capacitance values, the rise time is also affected by the current slew rate of the amplifier.

### 6.2.2.Small signal bandwidth

The second one is the possibility to drive a piezo when the power bandwidth is not reached (small signal).

Note: This parameter is directly linked to the controller performance. The controller must be tuned in accordance with the capacitance of the piezo actuator to obtain the best performance.

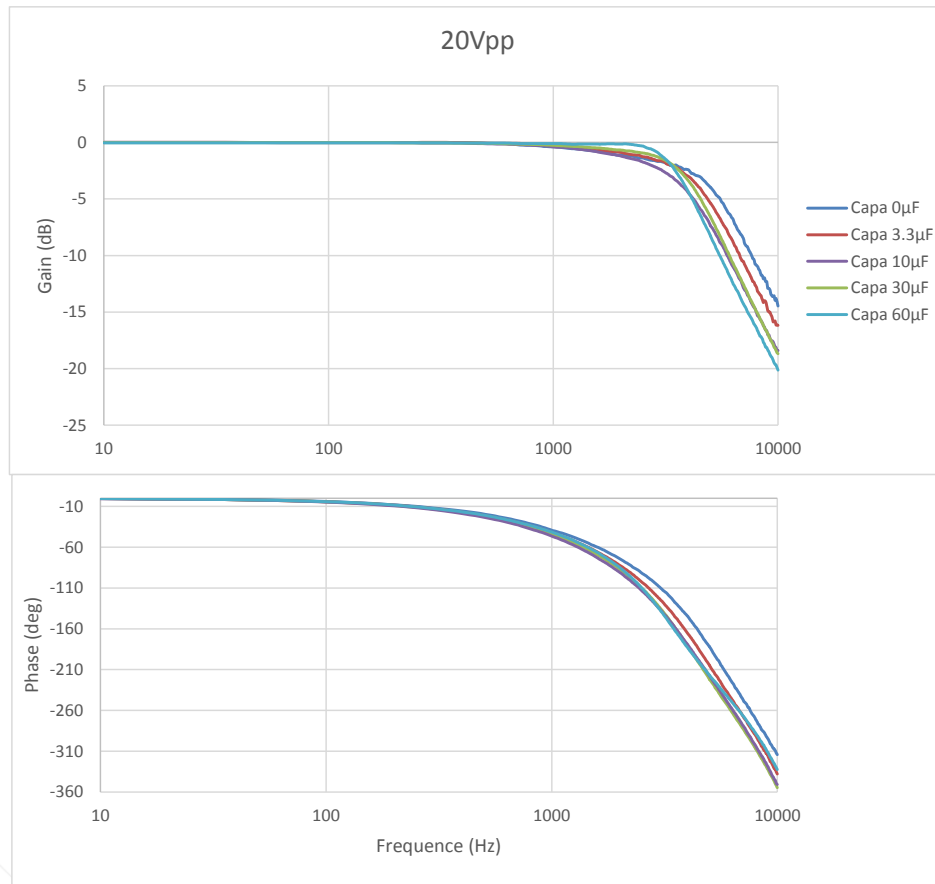


Figure 5. Small signal bandwidth (20Vpp) for different capacitance.

### 6.3. ENERGY RECOVERY

The switching amplifier is well suited to drive reactive load. With the specific topology used, the energy stored in the capacitive load can be transferred into the internal buffer capacitors. Hence, the switching amplifier doesn't consume the reactive power, but only the active power of the piezoelectric actuators and the losses in the power switching functions.

Ex: A switching power amplifier providing sine signal with 10A at 170p-p to the load (625VA) consumes less than 12.5W (from piezo dielectric losses) plus 30W due to the power components losses.

## 7. MAIN VOLTAGE CONNEXIONS

The switching amplifier is able to be connected on the 110VAC or 230VAC main voltage without any modifications but a fuse adaptation:

### 1 SA75 & SC75 :

SC75 (110Vac)	SC75 (230Vac)
fuse 1: 250V 4A T type	fuse 1: 250V 2A T type
fuse 2: 250V 4A T type	fuse 2: 250V 2A T type

### 2 SA75 & SC75 :

SC75 (110Vac)	SC75 (230Vac)
fuse 1: 250V 8A T type	fuse 1: 250V 4A T type
fuse 2: 250V 8A T type	fuse 2: 250V 4A T type

**Note:** The fuses are reachable in the main voltage plug on the rear face.

## 8. OPERATING INSTRUCTIONS FOR THE SWITCHING POWER SUPPLY, AC/DC CONVERTER (SC75)

This module produces from the mains, the regulated DC voltage to the amplifier functioning needs:

**+175Vdc regulated voltage with up to 175W maximum output power.**

The switch A7 is used to power on and off the power supply and the amplifier. There is a delay of less than two seconds between the activation of the switch and the effective start up of the SC75/SA75.

It is possible to shut down the amplifier by using the switch A7. This switch is the easiest way to disable the piezoelectric actuator as soon as required. However, few seconds are necessary to come to a completely discharged actuator.

This module is protected against over temperature, over voltage and over current conditions.



Warning

It is recommended to keep free space all around the electronic rack while driving in order to make the ventilation easier and to obtain the nominal performance of the driving electronics.

Note: Do use the tilt feet for the SA75 rack versions.



Danger

Do not unplug the boards when the rack is powered on. This may cause large electrical damage and creates risk for the operator.

## 9. OPERATING INSTRUCTIONS FOR THE AMPLIFIER (SA75)

### 9.1. GENERAL INSTRUCTIONS

The switching amplifier allows applying to the actuator a signal comparable to the order's one, with a gain of 20.

The order may be applied in two different and complementary manners:

- Static offset (potentiometer): B3 screw,
- Dynamic order: B2 connector.

These two signals are added and their sum should fall between  $-1V$  and  $7.5V$ .

To connect the actuator to the voltage amplifier, the standard cable available is a coaxial LEMO connector in one end and 2 banana 4mm plugs in second end (see Annex 1).

A thermal protection of the piezo is implemented when B6 is connected with the temperature sensor embedded on the piezo actuator. When the surface temperature reaches  $80^{\circ}C$ , the output of the SA75 is switched OFF and only an OFF-ON sequence on A7 switch could rearm the protection to re-initialise the latch.

The operator should follow the next sequence to assure a proper use of the switching amplifier.



1. Connect the piezo load on the switching amplifier output. If the load is not connected, the voltage output could be unstable. For piezoelectric actuators with metallic shell, the operator could connect the shell to the earth.
2. Switch on the main selector on the rear panel. The A2, A3, A4 blinks red during few milliseconds and the A6 led should light green. If not, don't follow the sequence and call your vendor.
3. Verify that B4 is in correct position: Servo Off if the piezo is not coupled with position control loop or Servo On if the piezo is coupled with position control loop. If servo is in On position with no position control loop, a DC signal will be apply on the command corresponding to 5V output.
4. The operator should switch on the A7 switch to power on the switching amplifier with no order through B2 BNC (zero command). With this operation, the Bus voltage is applied on the H Bridge and the amplifier switches.
5. Apply through B2 BNC connector the order. We suggest before sending the final command to valid the voltage output by applying small signals. This suggestion limits some risks on the piezo actuator with a bad order.
6. To switch off the output voltage of the switching amplifier, the operator may only suppress it command (or applying 0V)
7. If maintenance on the piezo actuator or its harness is necessary, the operator should switch off the A7 switch to avoid electrical risk.

Nota: A specific sequence is applied on the switching amplifier when the operator switches on the A7 switch. Accordingly, when the SC75 is powered on, the SA75 waits few hundred milliseconds to be operational and able to send the command on the amplifier (See Figure 6). This sequence is necessary to well start the switching amplifier. If the sequence doesn't work well, the A6 led will light red. In this case, the operator re-initialises the process by switching off the A7 switch followed by switching on.

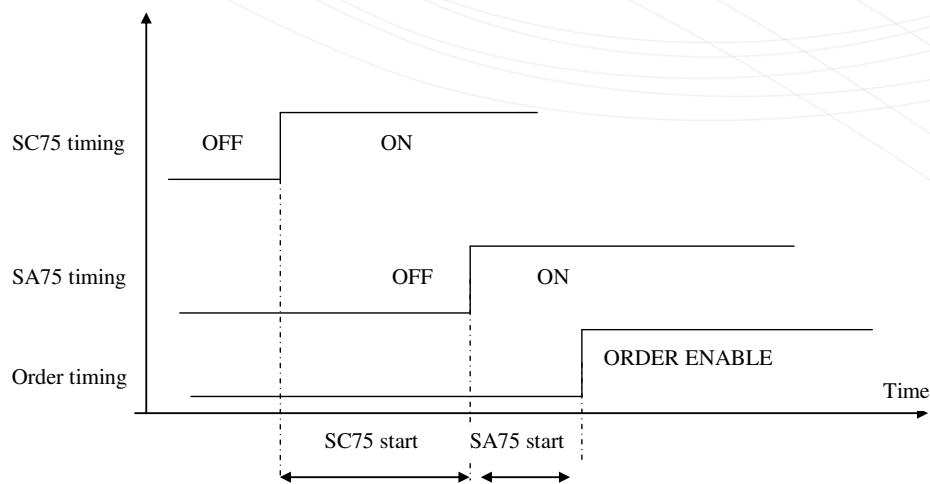


Figure 6 – Automatic Timing during ON switching



Warning

When the switching amplifier is commanded to supply the piezo with large current, the operator should valid that the small rise and fall time don't excite the mechanical resonant frequency of the piezo mechanism. If no protection is taken into account, damages on the MLA can occur with electric and mechanical damages on each part.



Warning

If the operator wants to increase the length of the harness, the wire section should be above  $1.5\text{mm}^2$  to be compatible with the large current flow.

## 9.2. SATURATION AND PROTECTIONS

### 9.2.1. Voltage saturation

An onboard input voltage limitation is implemented to not reach the voltage limits of the piezoelectric actuator. If the order signal is below  $-1\text{V}$  or above  $7.5\text{V}$ , the power amplifier saturation will clamp the signal so that the voltage applied to the actuator stays roughly between  $-20\text{V}$  and  $150\text{V}$ .

**Note:** This saturation doesn't limit the output voltage, if ringing appears due to an electric or mechanic resonance. However, the Output voltage protection does.

### 9.2.2. Current saturation

The maximum output current is limited to respectively  $5\text{A}$ ,  $10\text{A}$  or  $20\text{A}$  depending on the version of the SA75 (resp. A, B and D).

### 9.2.3. Slew rate

The latter limitation will affect the voltage slew rate according to the Equation 1.

### 9.2.4. Output voltage protection

The output voltage is protected to  $+170\text{V}$  and  $-30\text{V}$ . If the output voltage reaches those values, the amplifier shuts down and the OverVoltage Led on the SC75 lights.

#### 9.2.5. Output current protection

The output current is protected to  $\pm 25A$ . If the output current reaches those values, the amplifier shuts down and the OverCurrent Led on the SC75 lights.

The amplifier is protected against load short circuit and transistor short circuit.

#### 9.2.6. Temperature protection

The temperatures of the actuator and of the amplifier are protected. If the amplifier's temperature or the actuator's temperature reaches  $80^{\circ}C$ , the amplifier shuts down and the OverTemp Led on the SC75 lights.

#### 9.2.7. Reset protection

For each fault, the power supply and the amplifier are shut down and only an OFF-ON sequence on A7 switch can reset the latch.

## 10 . OPEN/CLOSED LOOP

**By default, the open/closed loop selector should be set on the mode open loop (SERVO OFF): in that mode, the amplifier applies a voltage gain of 20 to the input.**

**A displacement sensor, its conditioner and a servo controller will be necessary to use the closed loop (SERVO ON); otherwise the order will be set to zero.**

## TROUBLE SHOOTING

**Problem: The plugged piezo actuator does not move while the rear connection and the A7 is switched on.**

Action	Possible Causes
<p><b>Check the led A6 :</b></p> <p><b>a) If A6 is off</b></p> <ul style="list-style-type: none"> <li>- Check the main cable and the fuses at the rear panel</li> </ul> <p><b>b) If A6 is red</b></p> <ul style="list-style-type: none"> <li>- Check the connection lines to the piezo actuator / disconnect every LEMO cable. Test the electronics with the unplugged and plugged piezo actuator, as follows</li> <li>- switch A7 off</li> </ul> <p><b>If A6 is green</b></p> <ul style="list-style-type: none"> <li>- switch A7 on</li> </ul> <p>if the electronics works,</p> <p>if the electronics doesn't work,</p> <p><b>If A6 is red</b></p> <ul style="list-style-type: none"> <li>- Wait for 10 minutes and switch A7 on</li> </ul> <p>if the electronics works,</p>	<ul style="list-style-type: none"> <li>- misconnection with main cable or burnt fuses</li> <li>- The electronics is in protection</li> <li>- May be a short circuit through the cable connection or through the piezo actuator occurred</li> <li>- an external parasitic noise might have disturbed it</li> <li>- a breakdown is certain</li> <li>- The electronics was in thermal protection and needed to cool itself down</li> </ul>

if the electronics doesn't work,	a breakdown is certain
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**Problem: incoherent response from the actuator in open loop**

Action	Possible Causes
Check the output signal (B5)  If the DC offset is wrong, turn (B3) to settle it*	The DC offset may be wrong

**Problem: incoherent response from the actuator in closed loop**

Action	Possible Causes
Go back in mode SERVO OFF (B4) and check the sensor's response (C2)**	The strain gauges offset (C3) may be wrong

\* 10 turns potentiometers are used: do not hesitate to rotate the potentiometers and keep attention to the 'clac' noise arising at the end of the trimmer range.

\*\* Adjusting the Strain Gauge offset

- Apply a command of 0V (by a 50 Ohms BNC connector on B2 for instance),
- Check that the voltage output on B5 is nearly zero,
- Adjust the potentiometer B3 to get the output B5 near zero,
- Measure the output of the Strain Gauge conditioner C2,
- Adjust the potentiometer C3, so that the output C2 is 0.38 V

**One has :**

$$V_{sg} = (\text{SetPointLA} + 1) / \text{MaxAmplitudeLA} * \text{MaxAmplitudeSG} - 0,5$$

**With :**

$$\text{MaxAmplitudeLA} = 8.5$$

$$\text{MaxAmplitudeSG} = 7.5$$

The customer is not entitled to modify the power supply or the switching amplifier. The only manipulations allowed to him are described in the set here above, including the replacement of (the) external fuse(s.). For any other matter or breakdown suspicion, we suggest the customer to contact your local vendor.

## WARRANTY CONDITIONS AND EXCEPTIONS

The equipment is warranted for one year, including parts and labour, and only under standard technical conditions as outlined above and expressly mentioned in the technical data sheet. Repairs will be carried out at CEDRAT TECHNOLOGIES or through your vendor. Shipping, handling and insurance costs to return a part for repair must be paid by the customer.

Interventions or attempts to service or repair the SA75 by any unauthorized persons will invalidate this warranty.



## INSPECTION UPON RECEIPT

**This product has been inspected and shown to operate correctly at the time of shipment, as verified by the Factory Verification Form that accompanies the power supply**

**Immediately upon receipt of the product, it should be inspected carefully for any signs of damage that may have occurred during shipment. If any damage is found, a claim should be filed with the carrier.**

**The package should also be inspected for completeness according to the enclosed packing list. If an order is incorrect or incomplete, contact your distributor.**

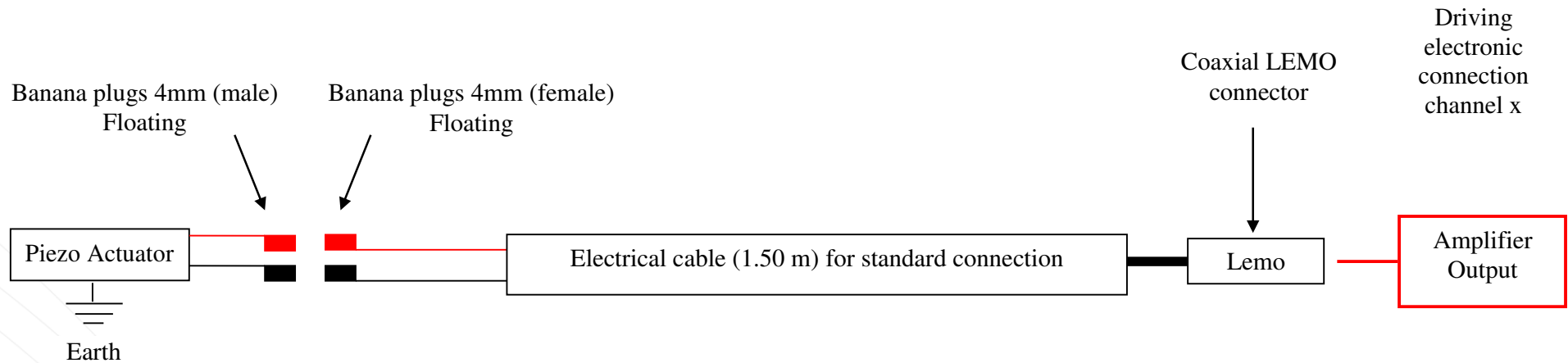
**CEDRAT TECHNOLOGIES recommends the customer to keep the original package for any further carriage of the electronic product.**

## AFTER-SALES SERVICE

If a device requires service, please contact **CEDRAT TECHNOLOGIES** or your local vendor. Please include the device model and serial number in all correspondence with **CEDRAT TECHNOLOGIES** or your vendor.

## APPENDIX 1 : CONNECTIONS

### Scheme of the cable connection for standard electrical configuration



**Note: the piezo connections are floating. Only mechanical shell could be connected to earth.**

## APPENDIX 2 : TROUBLE SHOOTING FORM

In case of trouble or breakdown with the electronic device, this form must be completed by the customer in order to:

- Allow Cedrat Technologies to authorise the product return back to the factory,
- Help Cedrat Technologies in repairing it.

**Product:** Please give mention here the references and delivery date,

**History:** Please summarise here every action which has been performed with the device since the delivery,

**Problem description:** Please describe here the problems faced with the electronics and which are not described in the paragraph 7,

**Notations:** Please define here the short term used for external devices plugged in the electronics in order to make the writing of “problem identification” easier,

**Problem identification:** Please summarise and describe here, using the “notations”, the operation that could lead to problem identification,

**Action:** Please mention and update here every action undertaken by yourself, by Cedrat Technologies or by your local vendor,

Please note that you need to get the authorization from CEDRAT TECHNOLOGIES before sending back the hardware.