

CSA96

CURRENT SWITCHING AMPLIFIER

Version: 1.0.8
Date: 18/12/2017



CAUTION: READ BEFORE USE

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



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,
- is trained in the soldering process and wiring of connectors,
- is familiar with the EMC and safety requirements.

To comply with the safety and EMC regulation, the user must install and configure the product correctly. Qualified person, who is familiar with the EMC and safety requirements, must install the product and is responsible for ensuring that the end product complies with the relevant laws in the country, where it is going to be used. Special care should be taken regarding electrical safety since the product is capable of providing high voltages.

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1 . DESCRIPTION

The CSA96 consists in a powerful and compact current switching amplifier designed to drive magnetic actuators. It includes a power supply and as options, the possibility to connect an external power supply, increasing output voltage and power capability, and a control board dedicated to advanced control of actuators (position control, velocity control, etc.).

The external dimensions of the CSA96 are the following:

CSA96
Width : 140 mm
Length : 210 mm
Height : 59 mm

In case of optional controller, the height is 71mm.

The bottom plate is also a thermal interface used to dissipate the heat of the converter. The packaging also features side openings for air circulation in order to enhance the heat dissipation.

2 . MAIN FEATURES

The CSA96 is available in two versions, the first one features a powerful internal AC/DC converter which allows to connect directly the amplifier on mains. The second permits to use a DC input voltage source.

CSA96	Included Power Supply	External Power Supply
Option	IS	ES
Voltage	96V	200V
Current	20A	20A
Apparent Power	1920VA	4000VA
Active Power	<660W	4kW max
Efficiency typ. (amplifier)	98%	98%
Efficiency typ. (supply)	93.5%	-
Switching frequency	50kHz	50kHz

The CSA96-IS is characterized by an integrated power supply 110/230Vac to 96V – 660W.

- **Fully isolated from ground. (4.2kV between primary and secondary)**
- **Active Power Factor Correction (meets EN 61000-3-2).**
- **High apparent and active power output.**
- **Compact size.**

3. INTENDED USE

The CSA96 is intended to be used in electrical cabinets.

4 . ELECTRICAL SAFETY INFORMATION

The following safety symbols are used in this manual.



Warning

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



Danger

This symbol alerts you about an electrical hazard.

Failure to follow these instructions will result in death or serious injury.

In order to achieve a safe operation of the CSA96 driver, some safety information must be given. This information is intended to protect the user and the product, and allows safe operating of the product.

The product includes two earth connections, one is intended to connect the driver to the earth, and the other is to connect the actuator to the earth.



Warning

Since the package is fully metallic, you need to connect the driver to the earth for the user to be safe.

Only qualified personnel can install and use the CSA96. Only Cedrat Technologies can open or repair the CSA96.



Danger

Do not open the product during or after use, lethal voltages may be present even after the product has been turned off.

Do not short the DC voltage bus or the braking resistor terminals.

Do not touch unshielded components or terminals with voltage present.

Avoid all contact with the product when powered on. If the user needs to operate on the product, follow the following guideline :

- Turn off the product and disconnect the power source.
- Wait 1 min to allow the DC bus to discharge.
- Measure the voltage on the DC bus with a properly rated voltmeter to verify that the voltage is below 42Vdc.



Danger

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.



Danger

Before powering on, ensure that enable input is turned off to help prevent an accidental startup.

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. DISCLAIMER

All product, product specifications and data are subject to change without notice to improve reliability, function or design or otherwise.

Cedrat Technologies makes no warranty, representation or guarantee regarding the suitability of the products for any particular purpose or the continuing production of any product.

Except as expressly indicated in writing, Cedrat Technologies products are not designed for use in medical, life-saving, or life-sustaining applications or for any other application in which the failure of the Cedrat Technologies product could result in personal injury or death.

7. INTERFACES

7.1. FRONT SIDE



Figure 1. Front side of the CSA96 with optional controller

Reference	Designation
1st module	Current Switching Amplifier - CSA96
Power ON	LED (green) – This diode lights when the product is connected to a power source.
Output ON	LED (green) – This diode lights when the product is enabled.
Power Error	LED (red) – This diode lights when the product is in fault state.
COM1	Connector SUBD9-M – This port is reserved.
Control Port	Connector SUBD9-F – Control Port.
2nd module	Controller Board (TBD)
Analog I/O	TBD
CAN/Profibus	
Ctrl Error	LED (red) – This diode lights when the controller board is in fault state.
Ethernet	
USB	USB port.
Digital I/O	TBD

Table 1. Electrical interface assignments.

7.2. CONTROL PORT

The User Port permits to control the amplifier with a differential analog signal ($\pm 10V$), to monitor the output current and to enable the amplifier.

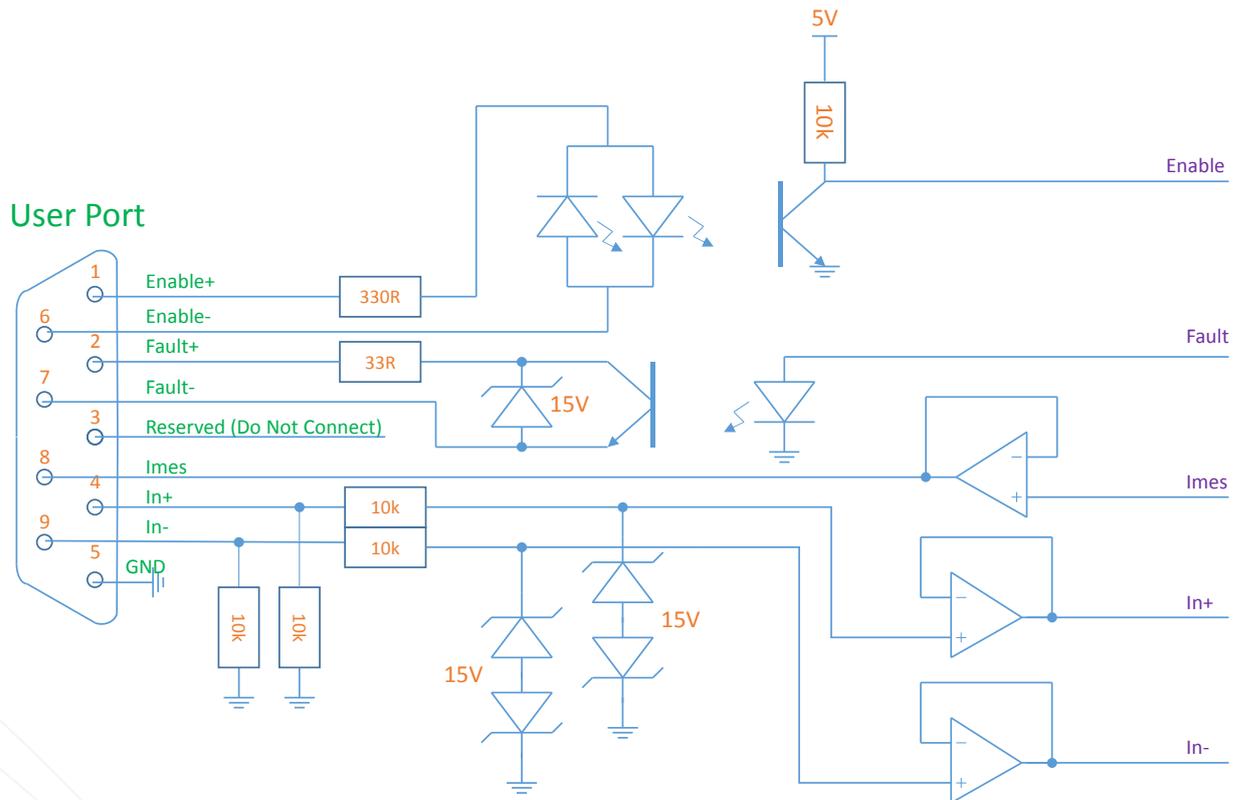


Figure 2. Internal schematic of the Control Port.

Pin	Signal	I/O	Isolation	Type	Function
1	Enable+	Input	Yes	Digital	Positive (Anode) of the enable optocoupler.
6	Enable-	Input	Yes	Digital	Negative (Cathode) of the enable optocoupler.
2	Fault+	Output	Yes	Digital	Collector of the fault optocoupler.
7	Fault-	Output	Yes	Digital	Emitter of the fault optocoupler.
3	GND		No		
8	I _{meas}	Output	No	Analog	Output current sensing (offset = 2.5V, sensitivity : 56mV/A)
4	In+	Input	No	Analog	Positive order input. (±10V)
9	In-	Input	No	Analog	Negative order input. (±10V)
5	GND		No		

Table 2. Control port pin assignments.

Note: Isolated signals can withstand 200Vrms from ground. Non-isolated signals are referenced to GND.

The order is differential to increase immunity against common mode noise.

$$Order = In_+ - In_-$$

7.3. COMMUNICATION PORT

In order to drive different actuators, the PI parameters of the internal current control may need tuning. This can be done on a PC using the TTL serial communication link and a FTDI TTL to USB converter (part number: TTL-232R-5V-WE) through the Com. 1 port.

RX, TX and CTS can be used to communicate with the amplifier in order to tune the PI controller parameters.

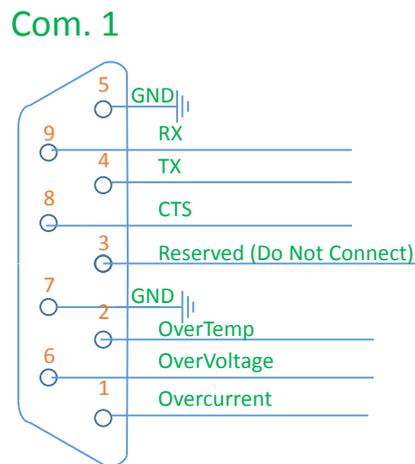


Figure 3. Internal schematic of the Com. 1 Port

Pin	Signal	I/O	Isolation	Type	Function
5	GND				
9	RX	Input	No	Digital	Receive signal - Serial communication
4	TX	Output	No	Digital	Transmit signal - Serial communication
8	CTS	Output	No	Digital	Clear To Send - Serial communication
3	Reserved				Do not connect
7	GND				
2	OT	Output	No	Digital	OverTemp fault
6	OV	Output	No	Digital	OverVoltage/UnderVoltage fault
1	OC	Output	No	Digital	OverCurrent fault

All digital inputs/outputs are TTL 5V signals.

7.3.1. Command list

The list of available digital commands for the CSA96 is in the following table:

Character	Description	Parameter range	Example
'A'	This command prints the current parameters.	0-255 Value is a 'don't care'	'A1E'
'P'	Sets the proportional term P of the PI controller	0-235	'P150E' Sets the proportional gain to 150.
'I'	Sets the integral term I of the PI controller	8310-96700	'I13300E' Sets the integral gain to 13300.

P and I command are made to be intelligible and proportional gains to usual Kp and Ki gain. Internally, those values are 8bits values, some differences may appears between entered values and effective values.

The internal current loop is presented in the Figure 4.

When a parameter of the CSA96 is modified, the new parameter value is automatically saved in a non-volatile memory. The parameters of the CSA96 are automatically recalled on startup, so that the user does not have to reconfigure the board on every power-up.

Since those commands write the memory, their execution time is longer.

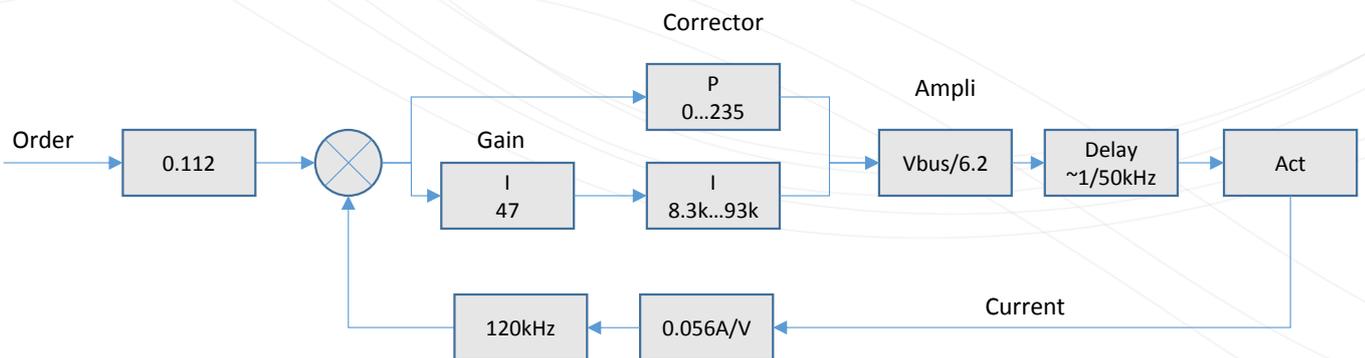


Figure 4. Internal current loop diagram.

7.4 . OPTOCOUPLERS

The series resistance of the enable optocoupler (Figure 2) has been set to allow enabling the amplifier with a digital voltage of 5V without adding any component. In this case, the current needed is 12mA. A digital command with a higher voltage is possible but needs the use of a higher series resistance which has to be

implemented externally. The optocoupler is AC-input and contains actually two light emitting diodes connected inversely parallel and are optically coupled to a phototransistor (Figure 5). These diodes can also be directly driven by current. The recommended current value is 10mA. The internal resistance is 330R as shown on Figure 2.

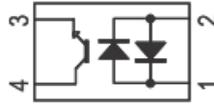


Figure 5. Internal diagram of the ACPL-214 optocoupler with its two diodes.

The breakdown voltage of the transistor side is 80V (collector-emitter), the emitter-collector breakdown voltage is 7V.

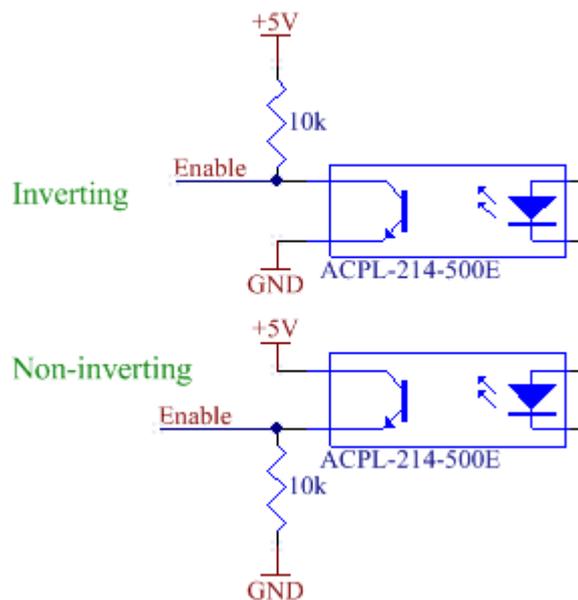


Figure 6. Inverting and non-inverting proposed connection at the user side.

7.5. TOP SIDE – POWER SUPPLY TERMINAL



Figure 7. 16XXX Side panel.

P	E	N	Vb-	Vb+	B+	B-
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Table 3. Pin out of the power supply connector. (16XXX version)

P	Line AC input (110/230Vac)
E	Earth
N	Neutral AC input (110/230Vac)
V-	Negative voltage bus
V+	Positive voltage bus
B-	Braking potential
B+	Braking potential (internally tied to V+)

Table 4. Full description of the power supply connector.

A recommended mating connector is the BLF 5.08HC/07/180F (Weidmueller):



Figure 8. BLF 5.08HC/03/180F



Danger

This connector supports potential lethal voltage. Never connect/disconnect one of these pins while the power source is on.

7.6. BOTTOM SIDE – ACTUATOR TERMINALS



Figure 9. Top left hand corner of the bottom side of the CSA96.

E	+	-
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Table 5. Pin out of the actuator (output) connector.

Connect the magnetic actuator on this terminal. Do not connect any capacitance or capacitive actuator on this terminal.

A recommended mating connector is the BLF 5.08HC/03/180F (Weidmueller).



Danger

This connector supports potential lethal voltage. Never connect/disconnect one of these pins while the power source is on.

7.7. WIRING

7.7.1. CSA96 Internal Supply version

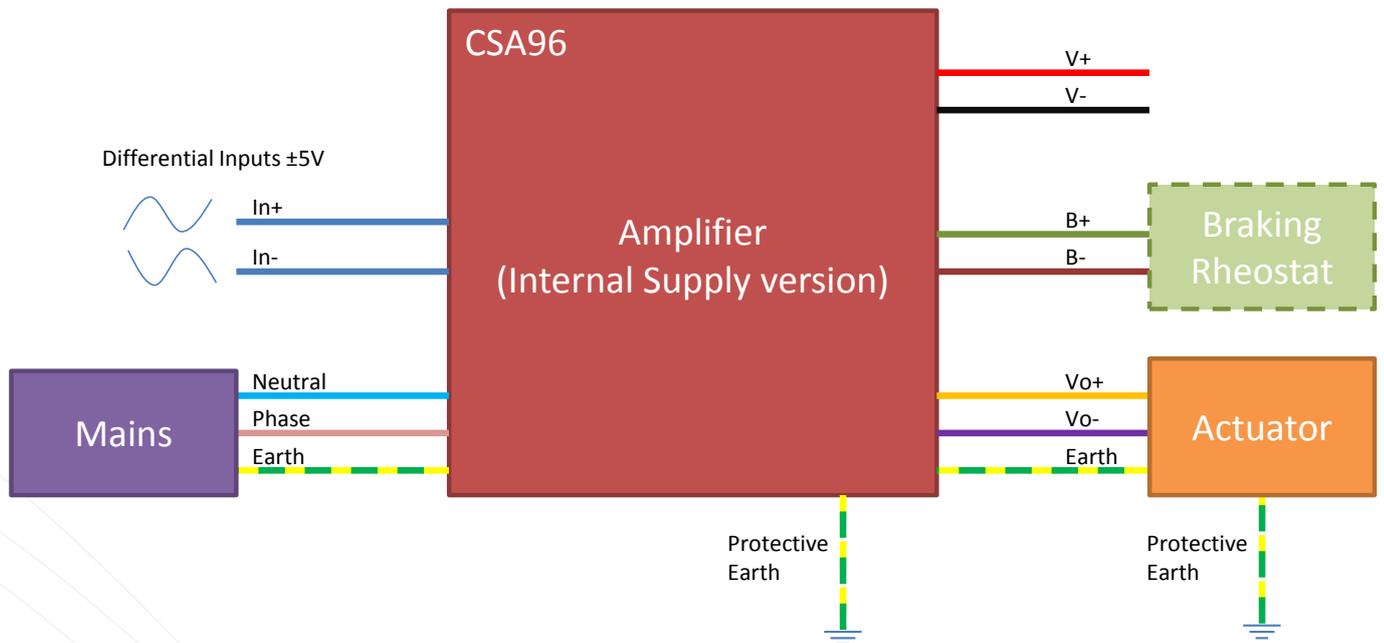


Figure 10. Wiring of the internal power supply version of the CSA96



Warning

A circuit breaker must be added to connect/disconnect the driver from main voltage.

7.7.2.CSA96 External Supply version

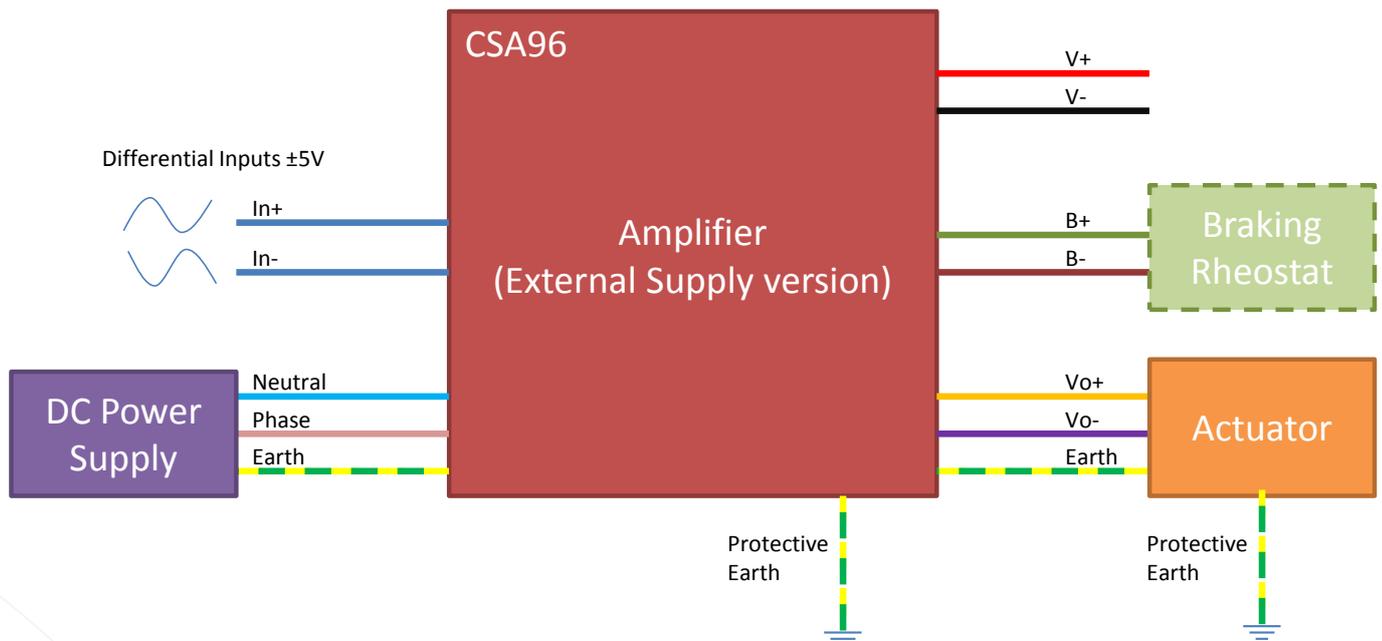


Figure 11. Wiring of the external power supply version of the CSA96

The DC power supply shall be connected to Phase and Neutral to supply the internal, auxiliary power supply of the product. It must include current limitation in order to limit the inrush current in the internal capacitors. There is no polarity since a full wave rectifier is used inside. The minimum DC voltage is 40Vdc and the maximum is 190Vdc.

The recommended wire gauge for the power cable is 14AWG with a nominal section of 2.1mm².



Warning

It is strictly forbidden to connect the electrical output channels of several CSA96 in parallel.



Danger

This product contains components with lethal voltage, it is strictly forbidden for the user to remove the boards from the case and to disconnect the load when electrically powered.

7.7.3.EMC considerations

It is highly recommended to use shielded cable to connect the actuator to the CSA96 and for the Control Port connection. Keep all wires and cables as short as possible.

8. THEORY OF OPERATION

8.1. PRINCIPLE

The switching electronic CSA96 is dedicated to supply and control magnetic actuators. The CSA96 includes a power supply with a maximal power given in the technical data sheet.

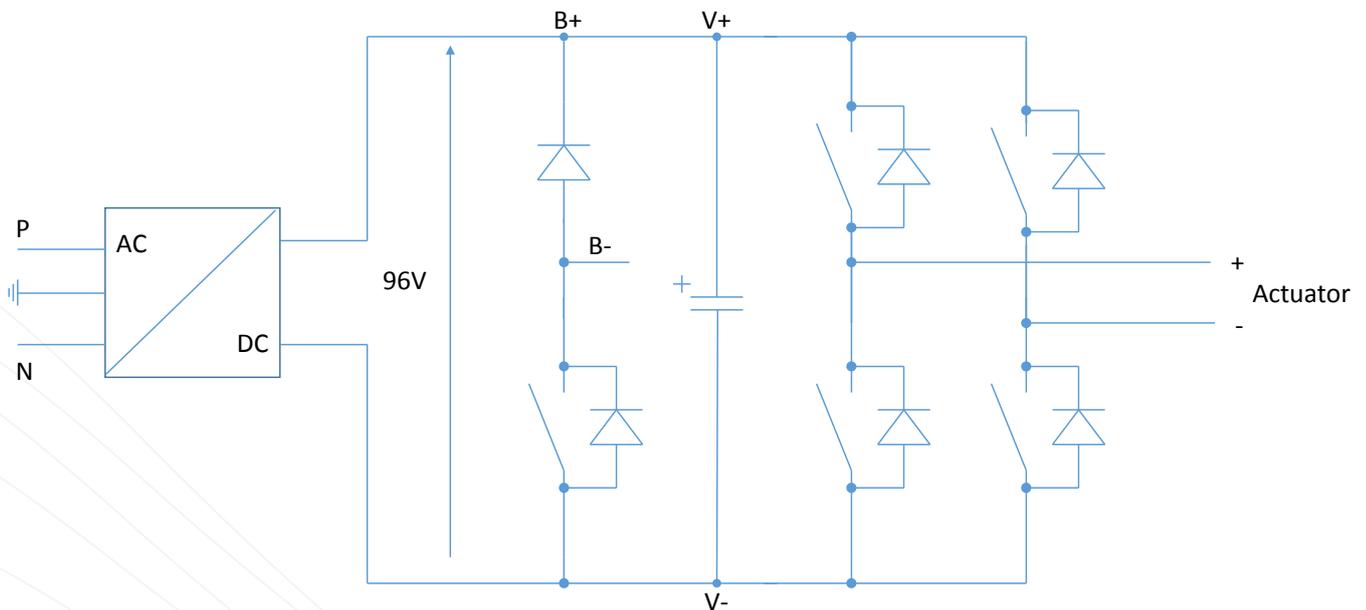


Figure 12 – Output stage principle.

The switching amplifier is built around full bridge PWM technology for high efficiency. The switching frequency of the transistors is 25 kHz. The effective switching frequency on the actuator is 50 kHz.



Warning

The output connections are floating.

The amplifier is only intended to drive magnetic actuators. Connecting capacitive actuators (such as piezo-actuators) on the outputs of the CSA96 will lead to the destruction of the amplifier.

8.2. EFFICIENCY AND COOLING

For the internal supply version, the maximum power losses of the amplifier and the internal power supply are 40W (amplifier) and 65W (power supply). With the thermal resistance of the base plate of 0.375K/W, it leads

to a temperature rise of 33 °C. Much of the time, the ambient temperature is low enough to not use a heat sink and a fan permitting a substantial cost reduction.

For the external supply version, the power losses of the amplifier can reach 80W due to the increase of the input voltage to 200Vdc.

The amplifier and the internal power supply are protected against over temperature for a heatsink temperature of 80 °C.

A recommended heat sink is the SK 42 (Fischer Elektronik) with 150 mm x 200mm dimensions. It can be cut to fit the dimensions of the product. Contact Cedrat Technologies for more information.

Worst case power losses with 20A continuous output current and 660W real power:

CSA96-IS	Typical Efficiency	Max Power Losses
Amplifier	98%	40W
Power supply	91%	65W

Those power losses are a worst case because the power losses in the power supply depends on the power needed by the actuator and the amplifier.

8.3. LIMITATIONS AND PROTECTIONS

8.3.1. Current limitation

An onboard current limitation is implemented to stay below the maximum output current. The default limitation is tuned to 20A.

8.3.2. Energy recovery

The switching amplifier is well suited to drive reactive load. In this case, the switching amplifier doesn't consume the reactive power but only the active power of the actuator plus the losses in the power switching functions.

Example:

A CSA96 providing 20A at 200Vpp with a sinus waveform (1kVA) to an ideal inductor consumes less than 40W due only to the power components losses of the amplifier. If the inductor is non-ideal, the amplifier will also deliver the active power (Joules losses and iron losses). This active power cannot be higher than the maximum power of the power supply (600W).

8.3.3. Rheostatic braking

The amplifier includes energy recovery capability which is useful to recover the energy stored in electrical element such as inductance of magnetic actuators and the mechanical energy.

Most of the time the rheostatic braking system is not necessary because linear actuators have a limited stored energy. However, if the energy to recover is high and no braking system is present, damage on the amplifier may happen.

The next equations are a rough estimation of the energy recovered by the amplifier (frictions are neglected).

They consider kinetic and magnetic energy:

$$E_k = \Delta x F = W$$

$$E_l = \frac{1}{2} L I^2$$

Where Δx is half of the full course, F is the maximum force. If this energy is less than 3.5J, there no need for a rheostat.

Example:

For a MICA200, $\Delta x = 2\text{mm}$ and $F = 200\text{N}$.

$$E_k = 2\text{mm} \times 200\text{N} = 0.4\text{J}$$

$$E_l = \frac{1}{2} \times 6\text{mH} \times 20\text{A}^2 = 1.2\text{J}$$

Thus, there no need for a rheostat with a MICA200.

When the computed energy is higher than 3.5J, the power of the rheostat needed is:

$$P = (E_k + E_l - 3.5\text{J})f$$

The resistance value will be:

$$R = \frac{V_{bus}^2}{P}$$

$V_{bus} = 96\text{V}$ for the internal supply or 200V if an external supply is chosen.

The resistance can't be lower than 10Ω .

It is up to the user to add margin on the ratings of the rheostat.

The driver is intrinsically bidirectional but not the internal power supply. Generally, the power supply is not bidirectional and cannot return energy to the AC source. With large energy to recover, the need to use a rheostat to dissipate this energy may be necessary.



Warning

If no braking resistor is connected and if the energy to recover is higher than the internal energy recovery capability of the amplifier, the product may be destroyed.

8.3.4. Buffer capacitor extension

As the preceding equations showed, the stored energy needed may be very close to the energy stored in the amplifier. In this case, it may be smarter to add a buffer capacitor extension rather than a rheostat as it would be smaller and more efficient. Ask Cedrat Technologies if the calculated energy needed is larger than 3.5J.

8.3.5. Minimum output inductance value

For normal operation, the inductance of the actuator is sufficient to provide low di/dt output for EMI and for proper operation (notably during overload). In this case, no additional output inductor is needed (assuming an actuator inductance $>100\mu\text{H}$). However, during a short condition, the current can reach a very high level faster than the protection system. The overcurrent detection takes about $4\mu\text{s}$ to trigger. An inductor should be added in order to further protect the system.

A conservative value for the inductances to be placed at the outputs of the amplifier is $2 \times 50\mu\text{H}$.

The inductances should be placed in series with the actuator at both outputs.

8.3.6. Protections

The CSA96 includes built-in protection against these fault conditions:

- Output over current.
- Short circuits of transistors.
- Power supply fault.
- Over temperature.
- Under/Overvoltage.



Warning

The maximum operating ambient temperature is 0°C to 40°C (32°F to 104°F).

9. MAIN VOLTAGE CONNEXIONS

The switching amplifier can be connected to the 110VAC or 230VAC main voltage without any modifications.

9.1. CIRCUIT BREAKER

The product does not contain any switch as part of the equipment. Consequently:

- a) A switch or circuit-breaker must be included in the installation;
- b) It must be suitably located and easily reached;
- c) It must be marked as the disconnecting device for the equipment.

The circuit breaker ratings are given below.

CSA96-IS (110Vac)	CSA96-IS (230Vac)
250V 10A type	250V 5A type

10. OPERATING INSTRUCTION FOR THE AMPLIFIER

10.1. GENERAL INSTRUCTIONS

The switching amplifier allows applying to the actuator a signal comparable to the order's one, with a gain of 2A/V.

The order must be applied with a fully differential source to avoid risks of interference and coupling.

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

1. Connect the load on the switching amplifier outputs: Vo+ and Vo-.
2. Connect the braking system on B+ and B-.
3. Connect the DB9M shielded cable on the Control Port.
4. Connect the AC source.
5. Turn on the amplifier.

TROUBLESHOOTING

Problems: Actuator doesn't move.

Possible Causes	Action
Error in wiring.	Check output connections. Verify that the Power On and Output ON LEDs light green. Verify that the Power Error LED does not light.

Problems: "Power On" LED lights green but "Output On" LED doesn't light.

Possible Causes	Action
Enable signal is not driven.	Enable signal shall be driven. (5V or 10mA)

Problems: Power On doesn't light.

Possible Causes	Action
The amplifier is not powered.	Check input connections.

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 CSA96 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 : TROUBLESHOOTING 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 authorize 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 summarize 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 summarize 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.