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CAU10 - MINIATURE LINEAR AMPLIFIER FOR PIEZOELECTRIC ACTUATORS

PRODUCT AND WARRANTY INFORMATION

Version: 3.3.3

Date: 27/02/2017

I. CAUTION: READ BEFORE OPENING

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

This driver board is dedicated to multilayers 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.

II. GENERAL DESCRIPTION

II.1. INTRODUCTION

The miniature drive electronic CA-u10 is dedicated to the supply of piezoelectric actuators based on multi-layers piezoelectric ceramics such as APA or PPA from CEDRAT TECHNOLOGIES, or benders. The CA-u10 consists in a drive electronic with a maximal power given in the attached technical data sheet, including (Figure 1):

- A DC/DC converter, based on a capacitive multiplier,
- Two linear amplifiers dedicated to capacitive load allowing excitation of piezoelectric actuators between 5 and 150 V,
- A SPI link, able to read a digital command. The miniature CA-u10 driver amplifier can also operate in push-pull mode to drive XY stages or DTT mechanisms from CEDRAT TECHNOLOGIES.

II.2. SYNOPTIC

The miniature drive electronics CA-u10 is a double-channel linear amplifier for piezoelectric actuators.

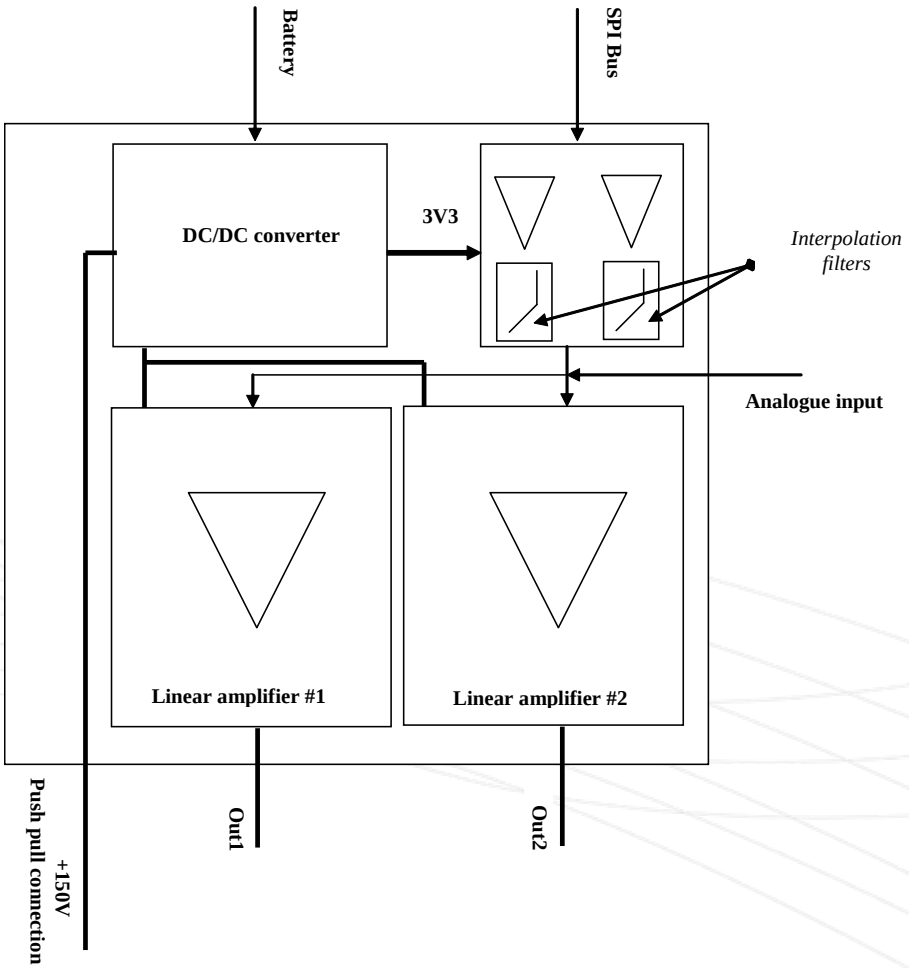


Figure 1: Synoptic of the CAu10 driver

WARNING: It is strictly forbidden to connect the 2 electrical output channels in parallel.

II.3. ELECTRONIC BOARD

The following scheme is the top view of the electronic board with the electrical interface and mechanical drawing.

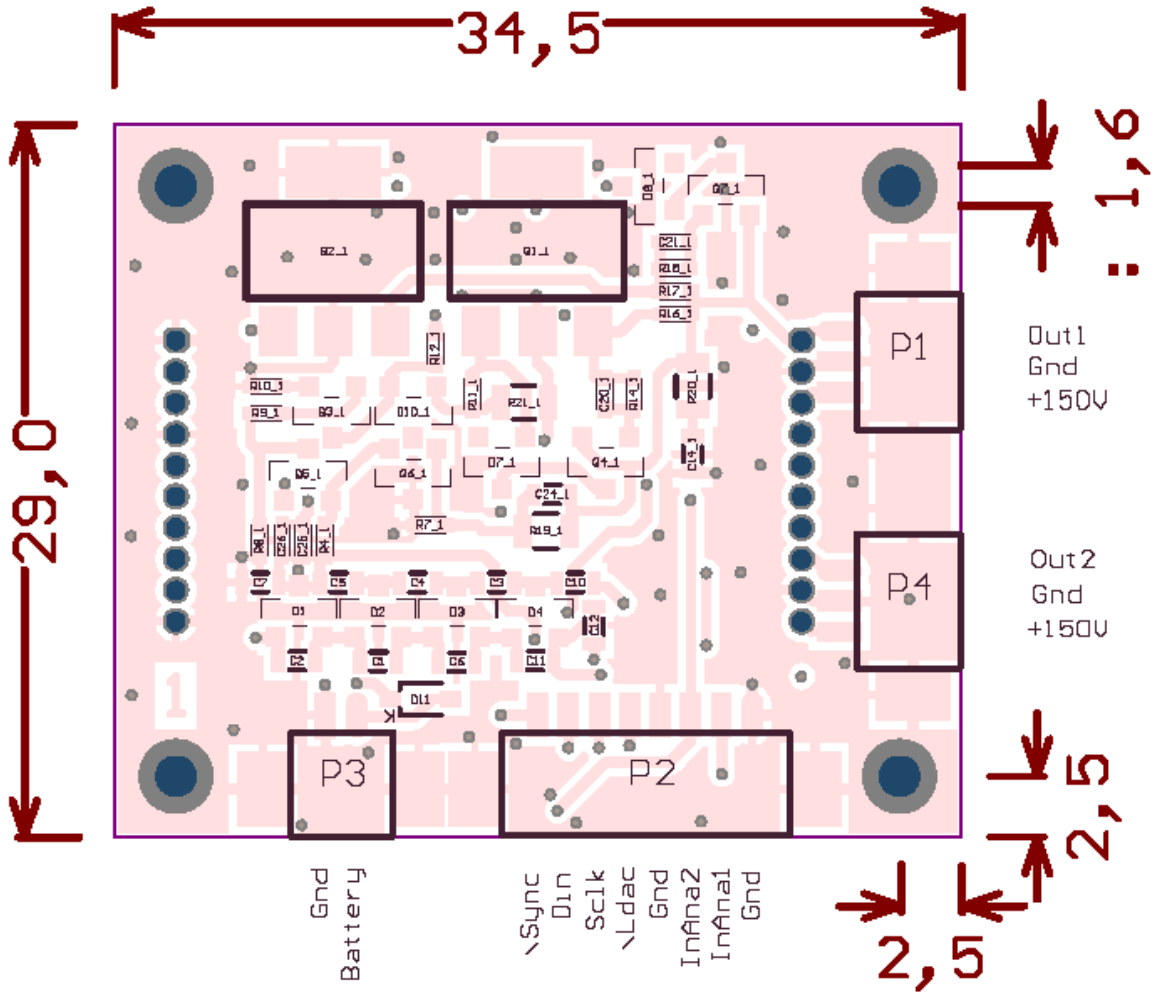


Figure 2: Top view of the CAu10 drive electronic

The CA-u10 board has 4 mounted SMD connectors to plug with the provided cables and 2 single-in-line THT footprints as an alternate connection.

II.4. SMD CONNECTION

Reference	Designation
1st connector	**P1 - Piezoelectric load channel 1**
Out 1	Channel 1 output voltage
GND	Piezo ground
+150V	DC 150 V (for push pull operational mode)
2nd connector	**P4 - Piezoelectric load channel 2**
Out 2	Channel 2 output voltage
GND	Piezo ground
+150V	DC 150 V (for push pull operational mode)
3rd connector	**P2 – digital order via SPI link – analog order**
\Sync	SPI command. Provide synchronisation line for SPI protocol
Din	Data Line to command the digital to analogue converter: 16 bits word
Sclk	SPI command. Clock signal for SPI protocol
\Ldac	SPI command. Provide synchronisation signal for the 2 channels to convert synchronously the 12 bits words in analogue signals
InAna1	Analogue order – channel 1 (comprised between 0 and 3.3 V)
InAna2	Analogue order – channel 2 (comprised between 0 and 3.3 V)
Gnd	Ground
4th connector	**P3 – DC Supply**
Battery	Battery supply (comprised between 3.3 – 12 V)
GND	Ground

The table below contains the P/N of the Molex Picoblade SMD connectors and plugs.

Designator	SMD connector P/N	PLUG + WIRE P/N
P3	53261-0271	51021-0200 + 06-66-0015
P1, P4	53261-0371	51021-0300 + 06-66-0015
P2	53261-0871	51021-0800 + 06-66-0015

WARNING: A special care in the use of the connectors should be taken in plugging and unplugging them: you have to pull onto the connector and not the cable.

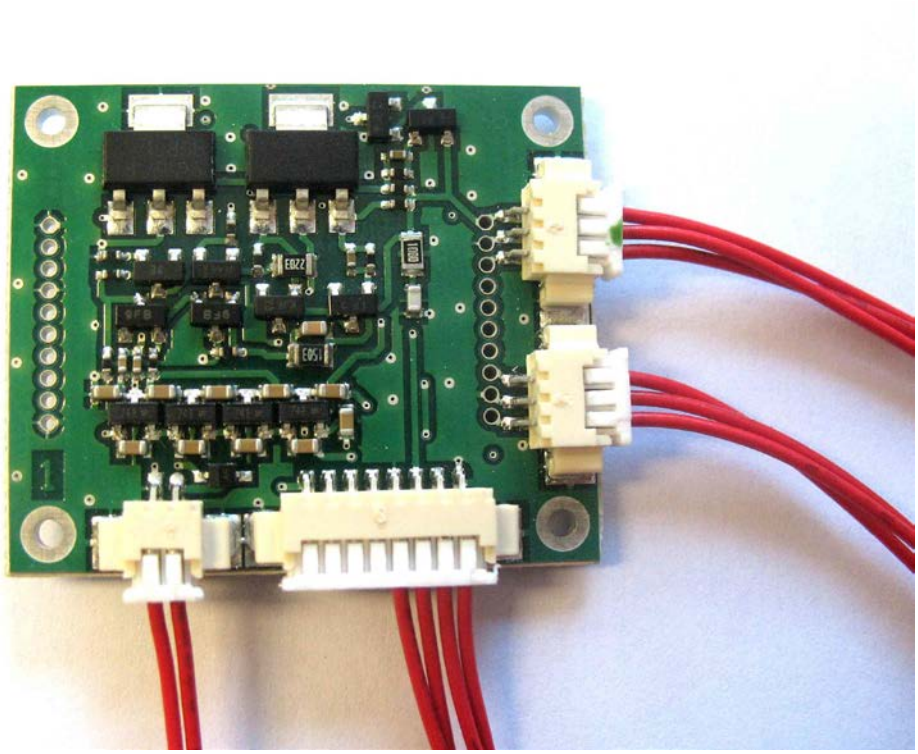


Figure 3 : CAu10 connected with the Molex cables

II.5. ALTERNATE CONNECTION

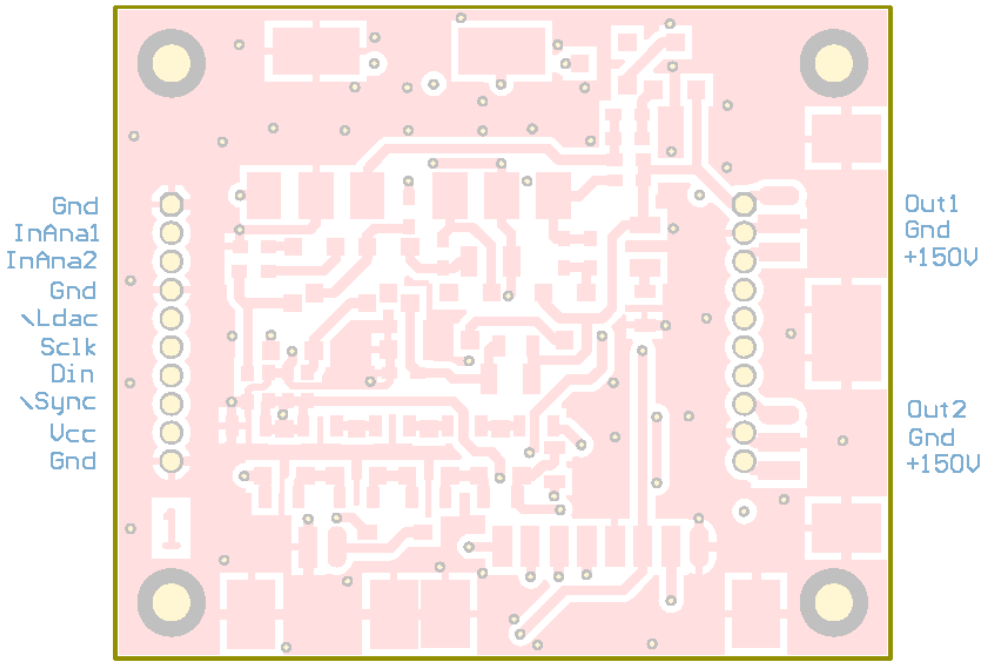


Figure 4: THT connectors pinout

The 2 SIL footprints each have ten 0.7mm holes with a 1.27mm pitch.

The pinout is on the scheme above.

II.6. MAIN CONNECTIONS

Connect the CAµ10 driver.

1. Battery & its return line : The internal DC-DC converter provide power to the voltage amplifier and SPI driver
2. SPI bus: \SYNC, DIN and SCLK are the main signals. However, if synchronisation between the channels is required, connect \LDAC to synchronise the output DAC with \LDAC signal. Or analogue signals.
3. OUT1, OUT2, optional +150V and their return line GND

II.7. ANALOGUE CONNECTIONS

In the case where the order is an analogue signal, it's possible to send directly this signal (if its range is in the range of the input driver- See datasheet) on the input of the high power amplifier. The following instruction must be apply to avoid damage: the input voltage must be lower than 3.3V.

II.8. PROTOCOL FOR SPI TRANSFER

The protocol to control the Digital to Analogue converter is based on the SPI protocol. A same circuit provides the 2 output analogue signals from only one serial data transfer.

Parameter	Limit at T_{MIN}, T_{MAX} (A, B Version)	Unit	Conditions/Comments
t_1	33	ns min	SCLK Cycle Time
t_2	13	ns min	SCLK High Time
t_3	13	ns min	SCLK Low Time
t_4	0	ns min	$\overline{SYNC}$ to SCLK Active Edge Setup Time
t_5	5	ns min	Data Setup Time
t_6	4.5	ns min	Data Hold Time
t_7	0	ns min	SCLK Falling Edge to $\overline{SYNC}$ Rising Edge
t_8	100	ns min	Minimum $\overline{SYNC}$ High Time
t_9	20	ns min	$\overline{LDAC}$ Pulse Width
t_{10}	20	ns min	SCLK Falling Edge to $\overline{LDAC}$ Rising Edge

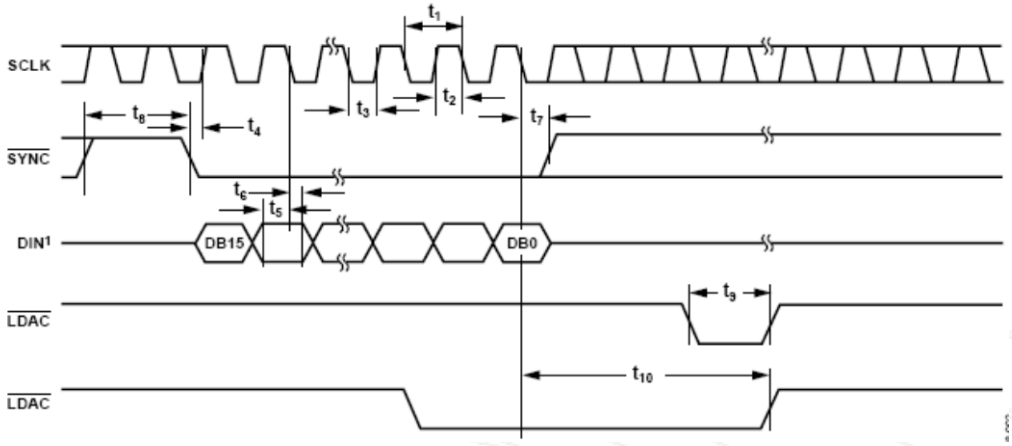


Figure 5: SPI timing diagram

Mnemonic	Description
\LDAC	Active Low control Input. This pin transfers the contents of the input registers to their respective DAC registers. Pulsing \LDAC low allows either or both DAC registers to be updated if the input register have new data. This allows simultaneous updating of booth DAC outputs.
\SYNC	Active low control input. This is the frame synchronisation signal for the input data. When \SYNC goes low, it powers on the SCLK and DIN buffer and enables the input shifts registers. Data is transferred in on the falling edge of the following 16 clocks. If \SYNC is taken high before the 16th falling edge, the rising edge of \SYNC acts as an interrupt and the write sequence is ignored by the device.
SCLK	Serial Clock input. Data is clocked into the input shift register on the falling edge of the serial clock input. Data can be transferred at rates up to 30MHz. The SCLK input buffer is powered down after each write cycle
DIN	Serial Data In. The device has a 16-bit input shift register. Data is clocked into the register on the falling edge of the serial clock input. The DIN input buffer is powered down after each cycle.

Figure 5.1: Pin function description

The input shift register is 16 bits wide. Data is loaded, MSB first, into the device as a 16-bit word under the control of a serial clock input, SCLK. The timing diagram for this operation is shown in Figure 4.

The 16-bit word consists of four control bits followed by 12 bits of DAC data, depending on the device type.

Bit 15 determines whether the data is for DAC A or DAC B.

Bit 14 determines if the reference input is buffered or unbuffered.

Bit 13 and Bit 12 control the operating mode of the DAC.

Bit	Name	Function	Power-On Default
15	$\overline{A}$/B	0: Data Written to DAC A 1: Data Written to DAC B	N/A
14	BUF	0: Reference Is Unbuffered 1: Reference Is Buffered	0
13	PD1	Mode Bit	0
12	PD0	Mode Bit	0

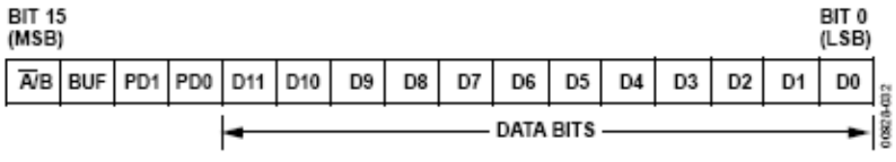


Figure 6: Input shift register content

The internal 3V3 power supply fixes the reference voltage of the converter.

II.9. INTERPOLATION FILTERS

As the piezomechanism is characterised by a strong resonant frequency, the generated step from the DA converter output can destroyed the mechanism. A 1st order low pass filter with a cut-off frequency of 1.5 kHz is present to minimise this effect if the resonant frequency is below the resonant frequency of the mechanism.

III. OPERATING INSTRUCTION FOR THE MINIATURE CA-U10 DRIVE ELECTRONIC

III.1. GENERAL INSTRUCTIONS

The linear amplifier allows applying to the actuator a signal comparable to the order's one, with a gain of 45.

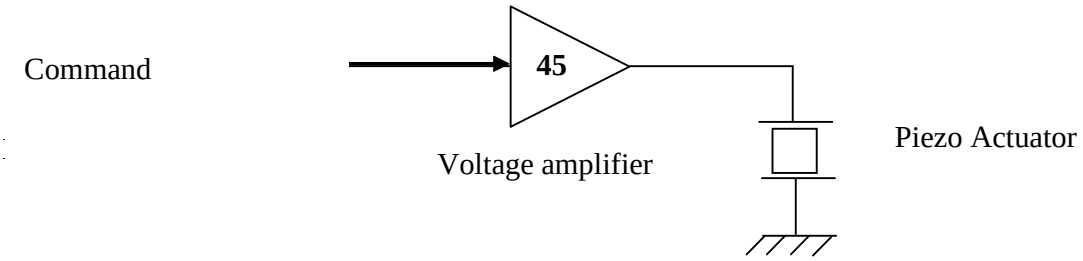


Figure 7: Principle of linear voltage amplifier

III.2. VOLTAGE CONTROL AND CURRENT LIMITATION

If the order signal is below 0 V or above 3.3 V, a protective diode and the power amplifier saturation will clamp the signal so that the voltage applied to the actuator stays roughly between 5 V and 150 V.

There is some limitation to the constant gain of the amplifier. Indeed, when the variation speed of the input signal (order) increases, the current limitation of the amplifier limits the slew rate of the output voltage. This current limitation is set to 5 mA for the sourcing current and around 10 mA for the sinking current.

III.3. USING THE PUSH-PULL MODE

For some piezoelectric devices such as the piezoelectric tilts or XY stages, it is necessary to supply two actuators simultaneously. A zero positioning is achieved with an electrical centring. Such a configuration could easily be achieved by using one amplifier, according to the figure shown below.

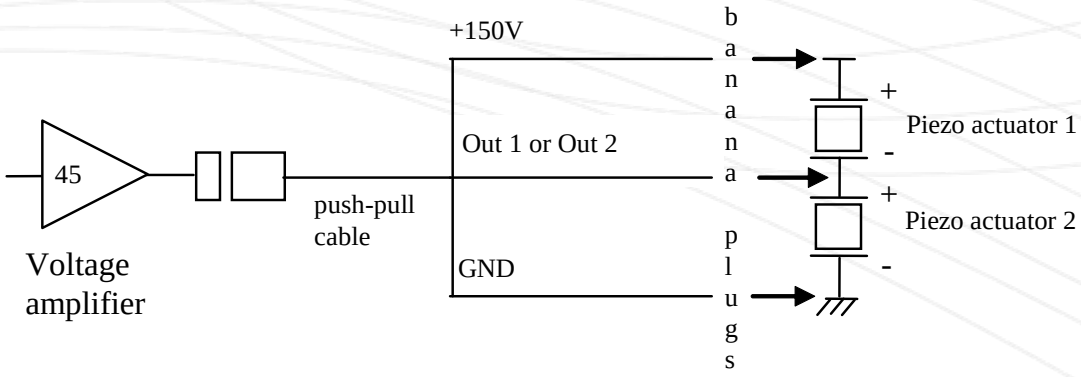


Figure 8: Principle of power supply for an actuator centred electrically

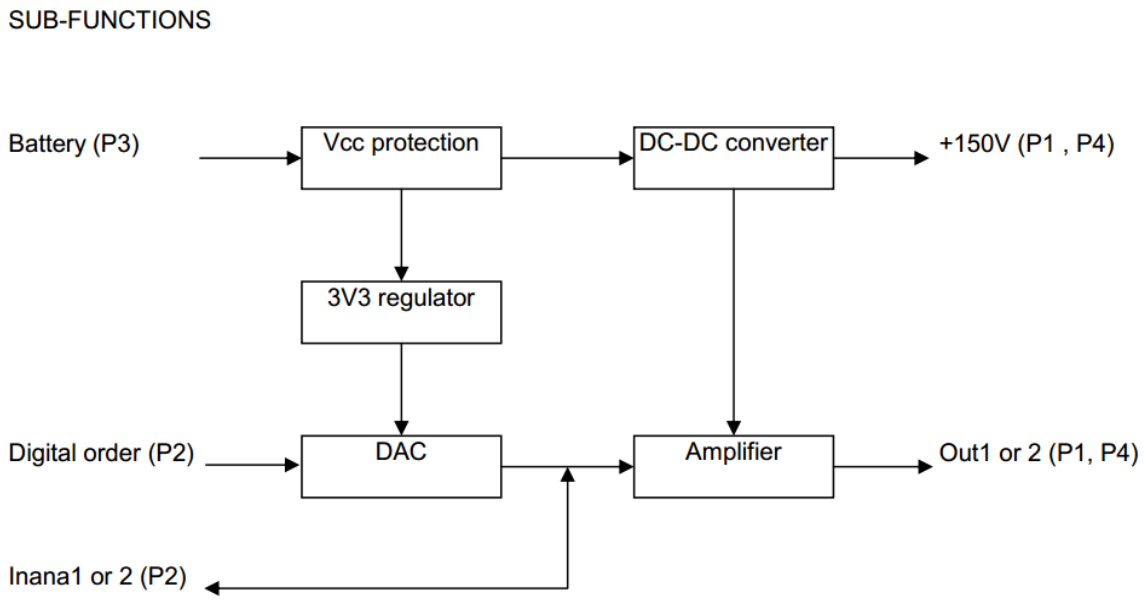
To use this mode, you need an optional cable (Molex 3 way to 4 banana plug).

Note: the electrical charge seen by the power amplifier is twice the capacitance of a single actuator, so the bandwidth is halved compared to a single actuator.

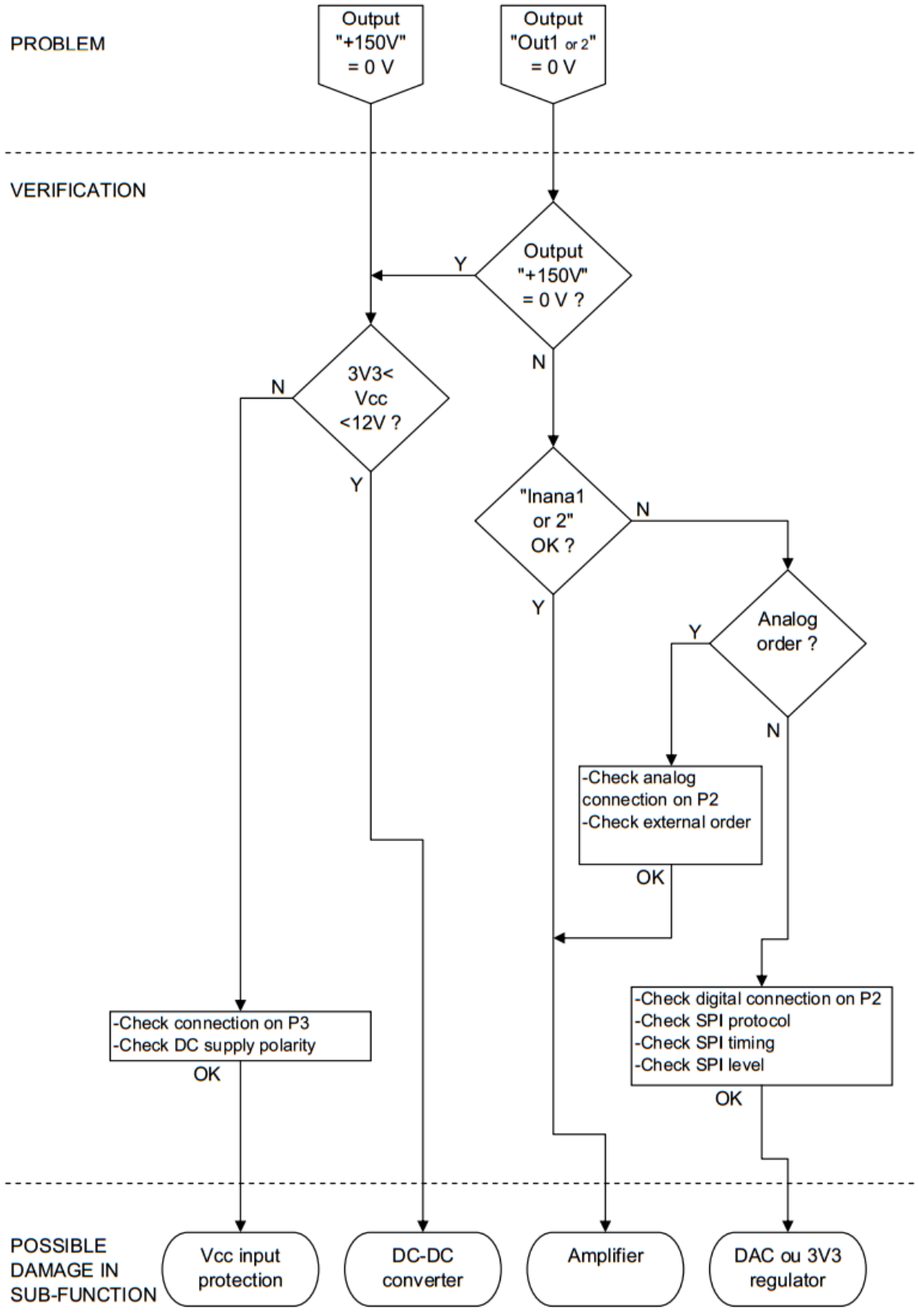
WARNING: In that mode where one of the actuator is constantly under direct voltage, it is recommended to limit in time the supply of the actuator.

IV. TROUBLE SHOOTING

The following chart shows the Cau-10 board subfunctions.



The customer is not entitled to modify the electronic board. For any matter or breakdown suspicion, we suggest the customer to contact the local vendor.


PROBLEM
Output "+150V" = 0 V
Output "Out1 or 2" = 0 V
VERIFICATION
Output "+150V" = 0 V ?
Y
N
3V3< Vcc <12V ?
N
Y
"Inana1 or 2" OK ?
N
Y
Analog order ?
Y
N
-Check analog connection on P2
-Check external order
OK
-Check digital connection on P2
-Check SPI protocol
-Check SPI timing
-Check SPI level
OK
-Check connection on P3
-Check DC supply polarity
OK
POSSIBLE DAMAGE IN SUB-FUNCTION
Vcc input protection
DC-DC converter
Amplifier
DAC ou 3V3 regulator

The customer is not entitled to modify the power supply or the linear amplifier. The only manipulations allowed to him are described in the set here above.

For any other matter or breakdown suspicion, we suggest the customer to contact the local vendor.

V. 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 CA-u10 by any unauthorised persons will invalidate this warranty.

VI. 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.

VII. 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.

VIII. ANNEXES

VIII.1. CA-U10 TECHNICAL DATASHEET

Properties CA-u10	Standard technical conditions	Unit	Nominal values	Min. val.	Max. val.
Function		-	Standalone voltage amplifier for piezo actuators		
Max. number of channels		-	2 + push-pull		
Protection		-	Overcurrent Overvoltage		
Main voltage		V	5 - 12		
Max Main Current	Main voltage = 12VDC	mA	200,0	180,0	220,0
Main frequency		Hz	-	-	-
Output voltage		V	5 / 150	-	-
Min Output voltage		V	5	4,90	5,10
Max Output voltage		V	150	147,0	153,0
Amplifier Gain		V/V	45,00	43,7	46,4
Peak Current limitation		mA	5,00	4,00	6,00
Peak output power	Sine output	VA	1,00	0,26	0,40
Output load capacitance		µF	40,00	-	44,00
Control input voltage		V	0 ... 3.3	-	-
Min input voltage		V	0,00	0,00	-
Max input voltage		V	3,30	3,300	3,47
Signal / Noise ratio		dB	70,00	63	77
Loaded output bandwidth	With 1.55µF calibrated load	Hz	6,04	-	-
Unloaded output bandwidth		Hz	1000,00	800	1100
Accuracy-Linearity	With 1.55µF load	%	0,10		0,20
DC offset setting		-	-	-	-
Min DC offset		V	-	-	-
Max DC offset		V	-	-	-
PZT connector		-	2 x Molex picoblade series 3pins Right angle male pitch 1.25 mm	-	-
External Sensor connector		-	-	-	-
Main voltage connector		-	Molex picoblade series 2pins Right angle male pitch 1.25 mm	-	-
External Control connector		-	Molex picoblade series 5pins Right angle male pitch 1.25 mm	-	-
Input impedance		k □	10,00	-	-
Weight		kg	0,01	-	-
Dimensions		W, L, H mm x mm x mm	PCB board 29x34.5x7	-	-
Cooling		-	Natural convection	-	-
Min-Max ambient Temperature		-	0...40	-	-
Option		-	PCB mounting with 1.27 pitch for right pins connectors		

VIII.2. EFFECT OF THE CURRENT LIMITATION

With a linear amplifier the applied voltage to the actuator is directly proportional to the input signal. The gain of the power amplifier CA-u10 is set to 45.

So, to obtain the whole stroke of a given actuator, one should input a signal varying from 0V to 3.3V. The applied voltage on the actuator will then vary from 0 to 150V.

There is some limitation to the constant gain of the amplifier. Indeed, when the variation speed of the input signal (order) increases, the current limitation of the amplifier limits the slew rate of the output voltage. The current provided to a piezo ceramic is depending on its capacitance and on the variation speed of the applied voltage.

The current for a capacitive load is given by the following expression:

$$I_{piezo} = C_{piezo} \times \frac{dv}{dt}$$

The max frequency for a triangle signal is given by:

$$f_{triangle\ \max} = \frac{I_{\lim}}{2 \times \Delta V \times C_{piezo}}$$

For a given current limitation, the shortest load time is given by:

$$t_{load} = \frac{\Delta V \times C_{piezo}}{I_{\lim}}$$

If we consider a sine signal, then the maximal frequency is given by:

$$f_{\sin \max} = \frac{2 \times I_{\lim}}{\Delta V \times C_{piezo} \times 2\pi}$$

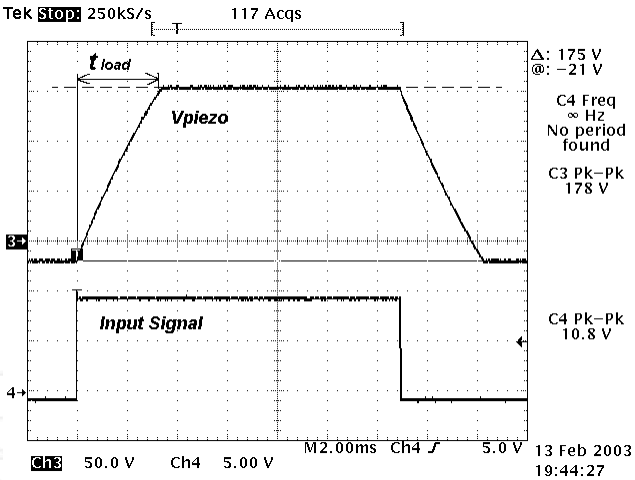


Figure 9 : The current limitation limits the voltage slew rate of the piezo

RATINGS OF THE CA-U10 BOARD ON PIEZO ACTUATOR SERIES

Considering a scale variation of [illegible] the current limitation of the CA-u10 the following table summarises the load time and bandwidth values for different piezo actuator series:

Electronic serie		CA-u10	CA45	LA75A	LA75B	LA75C
Current limitation	A	0,005	0,036	0,09	0,36	2,4
Actuator serie	**Capacitance µF**	**Load time @ 120 V (ms)**				
APA - µXS	*0,052*	*1,248*	*0,173*	*0,069*	*0,017*	*0,003*
APA - XXS	*0,150*	*3,600*	*0,500*	*0,200*	*0,050*	*0,008*
*MLA_2*5*10 - APA - XS*	*0,25*	*6,00*	*0,83*	*0,33*	*0,08*	*0,01*
*MLA_5*5*20 - APA - S, SM*	*1,55*	*37,20*	*5,17*	*2,07*	*0,52*	*0,08*
APA - M	*3,15*	*75,60*	*10,50*	*4,20*	*1,05*	*0,16*
APA - MML	*10,00*	*240,00*	*33,33*	*13,33*	*3,33*	*0,50*
APA - ML	*20,00*	*480,00*	*66,67*	*26,67*	*6,67*	*1,00*
APA - L	*40,00*	*960,00*	*133,33*	*53,33*	*13,33*	*2,00*
APA - XL	*110,00*	*2640,00*	*366,67*	*146,67*	*36,67*	*5,50*
*MLA_5*5*10 - PPA10M*	*0,70*	*16,80*	*2,33*	*0,93*	*0,23*	*0,04*
PPA20M	*1,40*	*33,60*	*4,67*	*1,87*	*0,47*	*0,07*
PPA40M	*2,70*	*64,80*	*9,00*	*3,60*	*0,90*	*0,14*
PPA40L	*13,30*	*319,20*	*44,33*	*17,73*	*4,43*	*0,67*
PPA60L	*20,00*	*480,00*	*66,67*	*26,67*	*6,67*	*1,00*
PPA80L	*26,60*	*638,40*	*88,67*	*35,47*	*8,87*	*1,33*
PPA40XL	*24,00*	*576,00*	*80,00*	*32,00*	*8,00*	*1,20*
PPA80XL	*48,00*	*1152,00*	*160,00*	*64,00*	*16,00*	*2,40*
PPA120XL	*72,00*	*1728,00*	*240,00*	*96,00*	*24,00*	*3,60*

Electronic serie		CA-u10	CA45	LA75A	LA75B	LA75C
Current limitation	A	0,005	0,036	0,09	0,36	2,4
Actuator serie	**Capacitance µF**	**Bandwidth (sinus) @ -3 dB (Hz)**				
APA - µXS	*0,052*	255,06	1836,40	4591	18364	122427
APA - XXS	*0,150*	88,42	636,62	1592	6366	42441
*MLA_2*5*10 - APA - XS*	*0,25*	*53,05*	*382,0*	*955*	*3820*	*25465*
*MLA_5*5*20 - APA - S, SM*	*1,55*	*8,56*	*61,6*	*154*	*616*	*4107*
APA - M	*3,15*	*4,21*	*30,3*	*76*	*303*	*2021*
APA - MML	*10,00*	*1,33*	*9,5*	*24*	*95*	*637*
APA - ML	*20,00*	*0,66*	*4,8*	*11,9*	*48*	*318*
APA - L	*40,00*	*0,33*	*2,4*	*6,0*	*24*	*159*
APA - XL	*110,00*	*0,12*	*0,9*	*2,2*	*9*	*58*
*MLA_5*5*10 - PPA10M*	*0,70*	*18,95*	*136,4*	*341*	*1364*	*9095*
PPA20M	*1,40*	*9,47*	*68,2*	*171*	*682*	*4547*
PPA40M	*2,70*	*4,91*	*35,4*	*88*	*354*	*2358*
PPA40L	*13,30*	*1,00*	*7,2*	*17,9*	*72*	*479*
PPA60L	*20,00*	*0,66*	*4,8*	*11,9*	*48*	*318*
PPA80L	*26,60*	*0,50*	*3,6*	*9,0*	*36*	*239*
PPA40XL	*24,00*	*0,55*	*4,0*	*9,9*	*40*	*265*
PPA80XL	*48,00*	*0,28*	*2,0*	*5,0*	*20*	*133*
PPA120XL	*72,00*	*0,18*	*1,3*	*3,3*	*13*	*88*

VIII.3. UNDERSTANDING THE FACTORY VERIFICATION SHEET

CEDRAT TECHNOLOGIES
Innovation in Mechatronics

Linear Amplifier
Factory Verification

µ10-11100 /MM/YY) Stamp and signature

CH 1 12

Test performed by
AP

Procedure : AQ7707-1 1.1

Representative load

Electrical Load: 2.3 µF

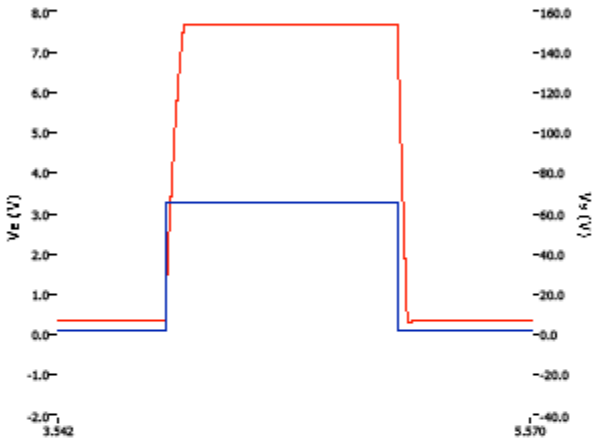
Input frequency: 0.5 Hz

Rise time (10 - 90%): 60.00 ms
Acceptance limits (ms): 20 ≤ Tr ≤ 80

Fall time (90 - 10%): 34.00 ms
Acceptance limits (ms): 20 ≤ Tf ≤ 80

Verification tests

Output voltage to Square input voltage



Representative load

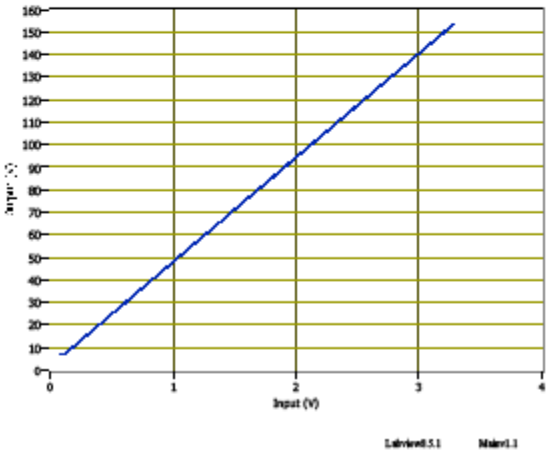
Electrical Load: 2.3 µF

Input frequency: 0.5 Hz

Gain (Vs/Ve): 46.2

Verification tests

Linearity Output voltage vs. Input voltage



VIII.4. 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 3,

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 authorisation from CEDRAT TECHNOLOGIES before sending back the hardware.