ESA SERIES
OPERATING MANUAL

Rev 9/98

ELMO-WARRANTY PERFORMANCE

The warranty performance covers only ELMO's products and only the elimination of problems that are due to manufacturing defects resulting in impaired function, deficient workmanship or defective material. Specifically excluded from warranty is the elimination of problems which are caused by abuse, damage, neglect, overloading, wrong operation, unauthorized manipulations etc.

The following maximum warranty period applies:

12 months from the time of operational startup but not later than 18 months from shipment by the manufacturing plant.

Units repaired under warranty have to be treated as an entity. A breakdown of the repair procedure (for instance of the repair of a unit into repair of cards) is not permissible.

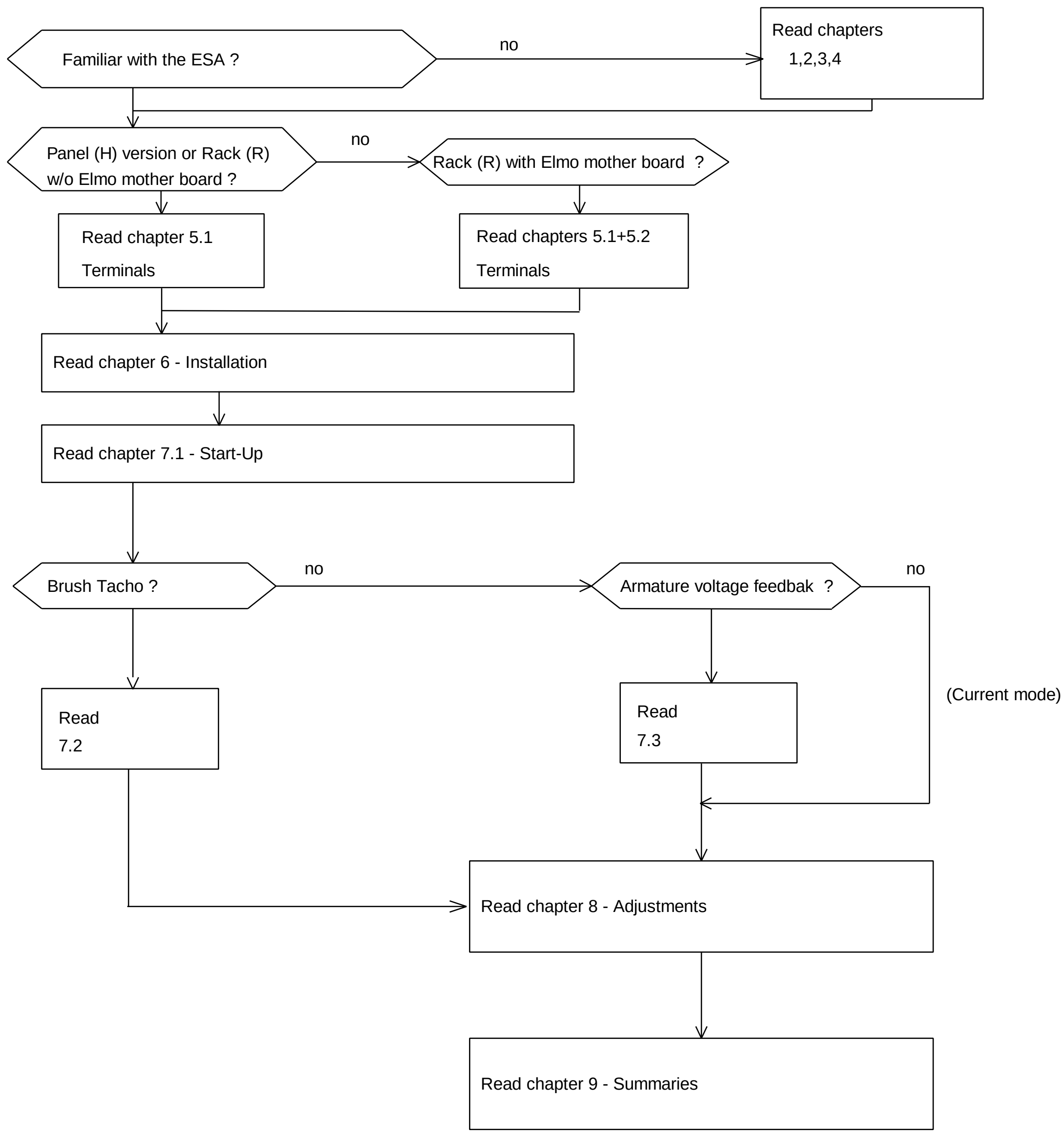
Damage claims, including consequential damages, which exceed the warranty obligation will be rejected in all cases.

If any term or condition in this warranty performance shall be at variance or inconsistent with any provision or condition (whether special or general) contained or referred to in the Terms and Conditions of Sales set out at the back of Elmo's Standard Acknowledge Form, than the later shall prevail and be effective.

How to use this manual - Flow Chart

The ESA amplifier represents a flexible design approach which enables applying various options and allows several modes of operation.

Use the following flow chart in order to determine the chapters that you should read. If you are a new user of the ESA, you should read chapters 1-4 which will familiarize you with the product.



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1. Description

The ESA is a unique PWM servo amplifier designed for DC servo motors. It utilizes power MOSFETs which contribute to its high efficiency and compact design.

The ESA is constructed from two PCBs mounted on a heat sink plate. The lower board contains the power switching transistors which drive the motor, terminals for the power stage, the switch mode power supply and the protection logic. The upper PCB contains the control logic, terminals for the control stage, adjusting trimmers and indication LED's.

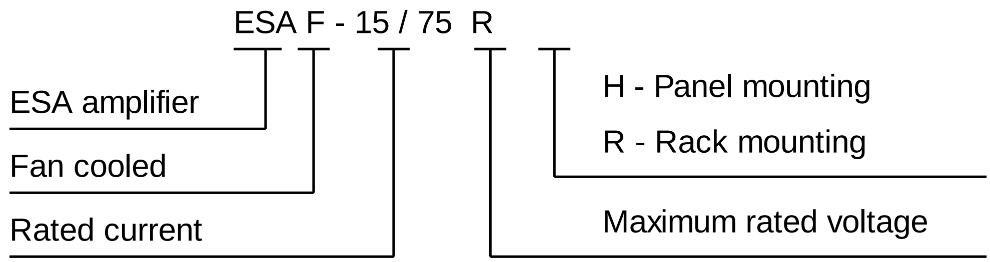
The ESA is manufactured in two mounting versions:

- Panel mounting version.
- Standard rack modules with DIN 41612 connectors.

Standard features

* Internal SMPS allows for operation from a single supply.
* Zero deadband.
* Excellent linearity.
* 3 single ended inputs: gain adjustment.
* One free differential input.
* Motor current monitor.
* Inhibit/fault indication (logic level).
* Remote control functions: Inhibit, CW and CCW disable.
* Adjustable compensation.
* Adjustable Continuous and peak current limits.
* Dynamic contouring of continuous and peak current limits.
* Input balance (offset).
* LED diagnostics.
* Operation in two velocity modes (Tacho or armature voltage feedback) or current mode. The amplifiers are fully protected against the following faults:
* Under/over voltage.
* Shorts between: outputs, output to ground, output to supply.
* Insufficient load inductance.
* RMS current limit.
* Excess temperature.
* Loss of tacho signal.

2. Type Designation



3. Technical Specifications

Type	DC Supply Min-Max*	Current limits Cont/Peak	Size Panel	Size Rack	Weight (Kg)
ESA-10/75	20-75	10/25	ES1	3U/12T	0.7
ESA-15/75	20-75	15/37	ES2	3U/19T	1.4
ESA-10/160	40-160	10/25	ES2	3U/19T	1.4
ESA-16/160	40-160	16/40	ES3	6U/19T	3.0
ESA-16/200	60-200	16/40	ES3	6U/19T	3.0
ESAF-20/75	20-75	20/40	ES1	3U/12T	0.7
ESAF-8/160	40-160	8/16	ES1	3U/12T	0.7
ESAF-12/160	40-160	12/24	ES1	3U/12T	0.7
ESAF-20/160	40-160	20/40	ES4	6U/12T	1.3
ESAF-30/160**	40-160	30/60	ES5	6U/19T	3.5
ESAF-25/200**	60-200	25/50	ES5	6U/19T	3.5

* DC output voltage is 90% of DC input voltage.
* 20KHz switching frequency.
* 2KHz current loop response.
* Outputs voltages of ±7.5V for external use (20mA each)
* Efficiency at rated current - 95%.
* Drift: 10μV/°C (referred to input)
* Operating temperature: 0-50°C.
* Storage temperature: -10 - +70°C.

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* These are the absolute minimum-maximum DC supply voltages under any condition.

** Only these types include integral fan.

4. Operation of the servo control

4.1 Inputs

The ESA has 3 single ended inputs (no.1 at terminal 5, no.2 at terminal 6 and no.3 at terminal 7). Each input is buffered by a voltage follower having high input impedance to isolate the input from the rest of the circuit. Care must be taken not to apply input voltage above the maximum input voltage as this will cause the input op amp to operate beyond its limits ($\pm$5V) and in extreme cases may even damage the op amp.

In addition, there is a free differential input at terminals 11,12 which is not internally connected to the error amplifier.

The current gain of each single ended input (current mode) is given by:

$$Gc = \frac{18 \times Ic \times Ki}{12.7 + Ri} \quad (Amp/Volt);$$

Ri in Kohm

Ic - Amplifiers rated continuous current limit.

Ri - Input resistor in Kohm

R130 for input 1

R96 for input 2

R95 for Input 3

Ki - Position of wiper of trimming potentiometer (T6, T7, T8).

Ki = 0.2 when trimmer is fully CCW

Ki = 1.0 when trimmer is fully CW

The current gain of the single ended inputs in velocity mode is given by (place the appropriate Gc for each input):

$$Gv = \frac{10 \times Gc}{R51} \quad (Amp/Volt) \quad ;R51 \text{ in KOHM}$$

The current gain of the differential input (current mode or velocity mode) is:

$$G_{cd} = \frac{R131}{R134} \times G_{ci} \; ;$$

R131=R133; R132=R134

Gci - Gain of the input to which the differential amplifier's output is connected.

The impedance of each single ended input is given by:

$$R_{in} = 12.7 + R_i \quad (\text{Kohms}) \; ; \; R_i \text{ in Kohm}$$

The maximum input voltage at terminals 4,5 or 6 is calculated by:

$$V_{in} = 5 + 0.4 \times R_i \quad (\text{Volt}) \; ; \; R_i \text{ in Kohm}$$

The maximum input voltage at the differential amplifier inputs (terminals 11,12) is calculated by:

$$V_{id} < \frac{5 \times R134}{R131} \quad (\text{Volt})$$

R131=R133; R132=R134

4.2 Velocity mode

In this mode op amp U4/4 is employed as a high gain error amplifier. The amplifier sums velocity command and the tachogenerator feedback signal, and provides the necessary servo compensation and gain adjustments, resulting in stable, optimum servo operation.

This op amp is configured with two feedback paths:

One, in the form of a resistive T network, controls the DC gain of this amplifier. The equivalent value of a T network is given by:

$$R_f = \frac{R43 \times R44}{R51}$$

Resistor R51 is mounted in soldering terminals so it can be changed easily whenever the DC gain of the error amplifier is to be changed.

The AC gain is controlled by C19, R14 and T4. Maximum AC gain is obtained with T4 set fully CW. Setting T4 fully CCW removes AC gain and no lag in response occurs.

R14 and C19 are mounted in soldering terminals and can be easily replaced in cases when T4 range is not enough to get optimum response.

The output of the error amplifier is:

$$Vo=(V1Gv1+V2Gv2+V3Gv3)\times\left[\frac{1 + S\times C19\times R14}{1 + S\times C19\times R14(1+Rf\times K4/R14)}\right]$$

V1,V2,V3 - Input signals

Gv1,Gv2,Gv3 - Gain of inputs.

K4 = Position factor of the wiper of T4.

Full CW = 1

Full CCW = 0.01

The feedback element must be connected for negative feedback.

The polarity of the ESA servo amplifiers is such that a positive input signal results in a positive voltage at terminal 1 with respect to terminal 4 for 3U size types and in a negative voltage at terminal 1 with respect to terminal 4 for 6U size types.

A filtering capacitor, C7, is placed in parallel to R14 to minimize noise carried on the input signals. This is specially beneficial when employing motors where a significant degree of electromagnetic coupling is present between armature and tachogenerator. Values in the range of 1000pF - 6800pF are recommended.

4.2.1 Velocity control using armature voltage feedback.

Armature voltage may be used as velocity feedback in all cases when low regulation ratio and speed accuracy are acceptable. In this case, the armature voltage is first scaled down by the free differential amplifier. The output of the differential amplifier is fed to input 3.

4.3 Current mode

In order to operate the servo amplifier as a current amplifier, the velocity loop should be disabled. This is done by converting the error amplifier into a low gain DC amplifier which has a flat response beyond the desired current bandwidth. In this mode, R51 and R14 have to be removed from the circuit.

4.4 Current loop

Current loop control is obtained by op amp U4/1 (Current amplifier) and R50, C20 which form a lag-lead network for current loop.

The standard amp is equipped with R50 (100Kohm) and C20 (0.01 µF) to get optimum current

response for an average motor in this power range. These components are mounted in soldering terminals.

4.5 Current limits

The amplifier can operate in the following voltage-current plane:

-Ip	**-Ic**	**+V** **Ic**	**Ip**
Intermittent zone	**Continuous zone**	**-V**	

Ic - Continuous current Ip - Peak current

Fig. 4.1: Voltage-Current plane

Each amplifier is factory calibrated to have this shape of voltage-current operating area with rated values of continuous and peak current limits.

4.5.1 Time dependent peak current limit

The peak current is so designed that its duration is a function of the peak amplitude and the motor actual operating current before the peak demand. The maximum peak current is available for 2 seconds. The duration of Ip is given by:

$$T_p = 2.2 \ln \frac{I_p - I_{op}}{I_p - I_c}$$

Ic - Amplifier continuous current rating.

Ip - Peak demanded (not amplifier Ip)

Iop - Actual operating current before the peak demand.

Example:

A motor is driven by an ESAF-12/160 amplifier at constant speed and constant current of 5A. What is the maximum possible duration of a 20A peak ?

$$T_p = 2.2 \ln \frac{20 - 5}{20 - 12} = 1.38 \text{ seconds}$$

4.5.2 Dynamic contouring of continuous and peak current limits

Most of the servo motors have reduced continuous current limits at high speeds (Fig. 4.2). This phenomenon is due to commutation limits and iron loses which become significantly high as speed increases and this leads to reduction of the continuous current limit.

The ESA amplifiers have the features which enable the user to define the current limit envelope as closely as possible to the motor operating envelope defined by the motor manufacturer.

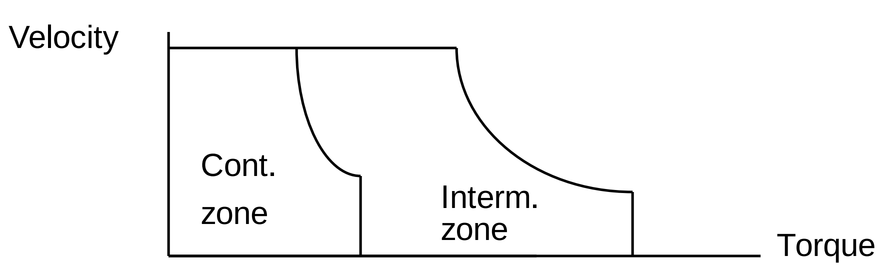


Fig. 4.2:

Typical operating envelope of a brush servo motor

4.6 Protective functions

All the protective functions activate internal inhibit. If the cause of the inhibit disappears, the amplifier will restart automatically.

4.6.1 Short circuit protection

Every current peak above a certain value inhibits the amplifier for a period of approx. 30mS.

If a short circuit condition still exists, the cycle will repeat endlessly.

The amplifier is protected against shorts between outputs, either output to ground or to positive supply line.

4.6.2 Under/over voltage protection

Whenever the DC bus voltage is under or over the limits indicated in the technical specifications, the amplifier will be inhibited.

4.6.3 Temperature protection

Temperature sensor is mounted on the heatsink. If the temperature exceeds 85 °C the amplifier will be inhibited. The amplifier will restart when the temperature drops below 80 degrees.

In types ESAF-30/160 and ESAF-25/200, a 24VDC brushless fan is installed and it is fed by an internal power supply.

4.6.4 Insufficient load inductance

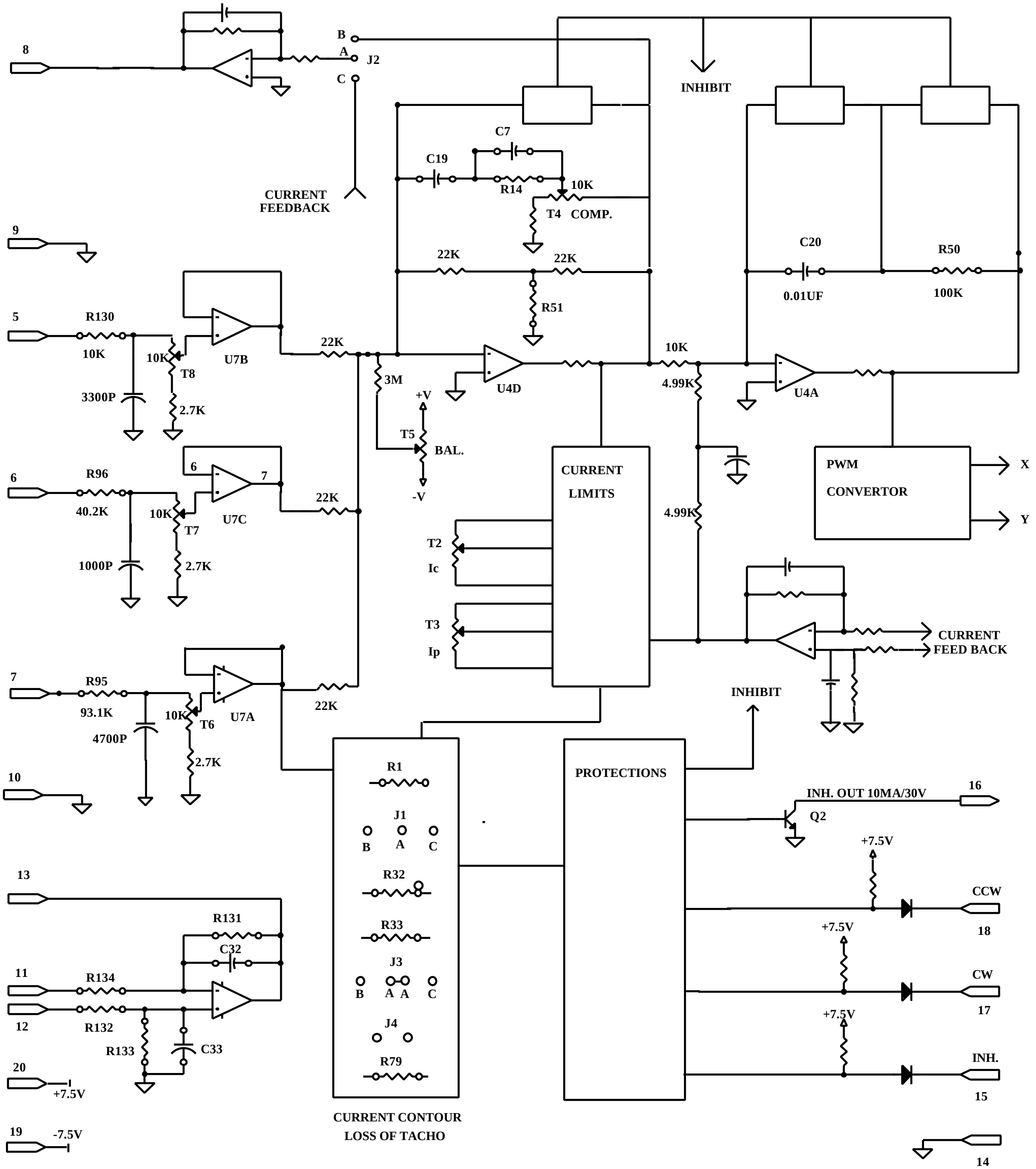
Whenever the load inductance is too small, the current spikes will be very high. In such cases the amplifier will be disabled.

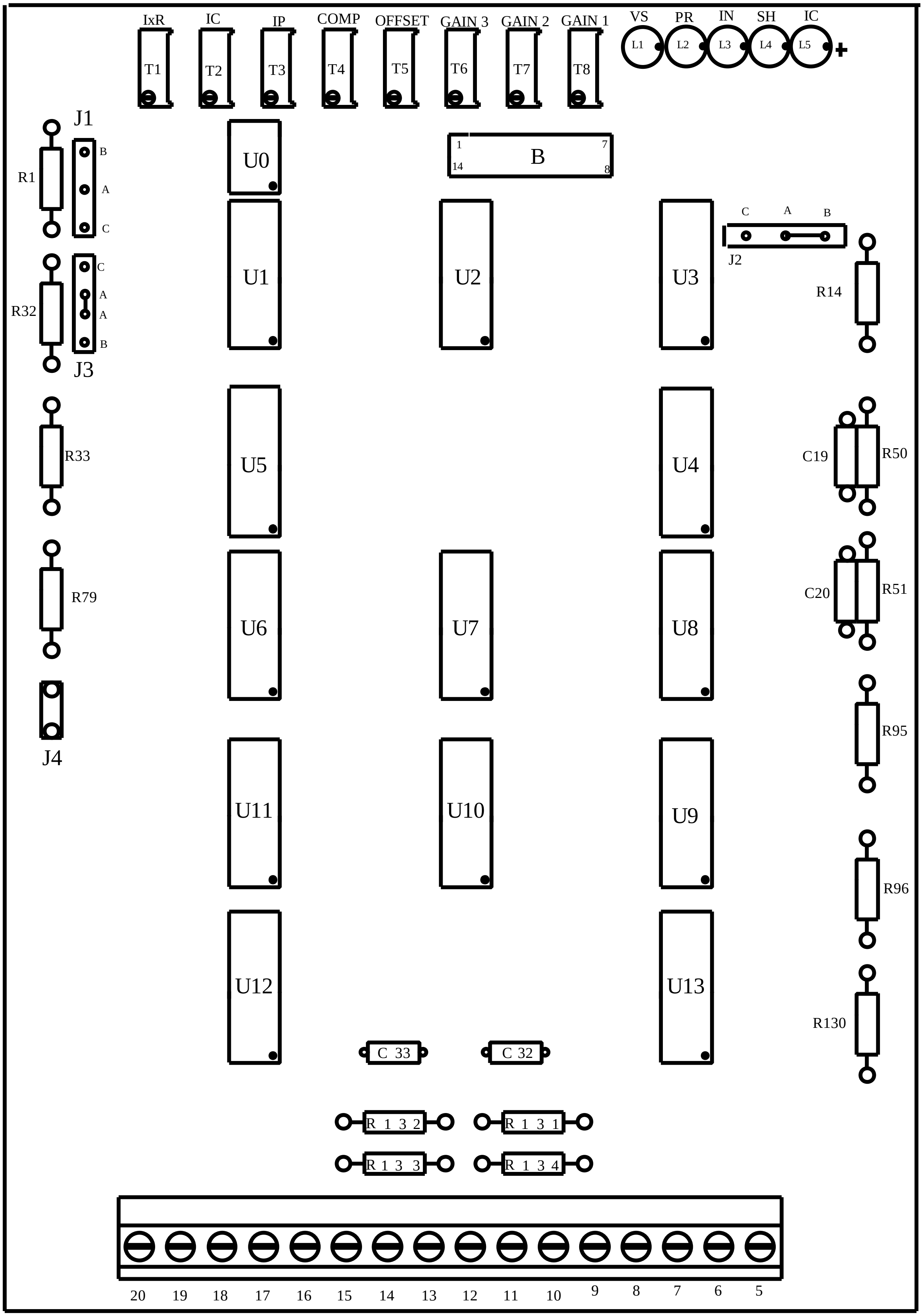
4.6.5 Loss of tacho signal

This protection operates by inhibiting the amplifier for 6-8 seconds whenever it does not sense a tacho signal at input 3, and then automatically restarting it. This cycle will continue endlessly but the motor speed will not run away (small movements will be noticed).

4.6.6 Internal power supply failure

In any case that the sum of the internal power supplies is below 13V or its difference higher than 1V, the amplifier will be inhibited.


8
B
A
J2
C
CURRENT
FEEDBACK
INHIBIT
C7
C19
R14
10K
T4 COMP.
C20
R50
9
22K
22K
R51
0.01UF
100K
5
R130
10K
10K
T8
U7B
22K
3M
+V
U4D
10K
4.99K
U4A
3300P
2.7K
T5
BAL.
6
R96
6
7
40.2K
10K
T7
U7C
22K
-V
CURRENT
LIMITS
PWM
CONVERTOR
X
Y
4.99K
1000P
2.7K
T2
Ic
T3
Ip
CURRENT
FEED BACK
7
R95
93.1K
10K
T6
U7A
4700P
2.7K
22K
INHIBIT
10
R1
PROTECTIONS
INH. OUT 10MA/30V
16
J1
B
A
C
Q2
13
R32
+7.5V
CCW
18
R131
R33
+7.5V
C32
J3
11
R134
B
A A
C
CW
12
R132
17
R133
C33
J4
+7.5V
20
R79
INH.
+7.5V
15
CURRENT CONTOUR
LOSS OF TACHO
19
-7.5V
14


IxR
IC
IP
COMP
OFFSET
GAIN 3
GAIN 2
GAIN 1
VS
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SH
IC
T1
T2
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T5
T6
T7
T8
L1
L2
L3
L4
L5
J1
R1
B
A
C
U0
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7
14
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U1
U2
U3
C
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B
J2
R14
R32
C
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J3
R33
U5
U4
C19
R50
R79
U6
U7
U8
C20
R51
J4
U11
U10
U9
R95
R96
U12
U13
R130
C 33
C 32
R 1 3 2
R 1 3 1
R 1 3 3
R 1 3 4
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6
5

5. Terminal Description

5.1 Terminals for Horizontal and Rack mounting versions

Power stage of 3U size ESA

H	R	Function	Remark
1	18,20*	Armature output	This output will be positive when a positive signal is fed to one of the inputs.
2	22,24*	Power input common	
3	26,28*	Power input positive (+Vs)	
4	30,32*	Armature output	This output will be negative when a positive signal is fed to one of the inputs.

Power stage of 6U size ESA

H	R	Function	Remark
1	4,6,8*	Armature output	This output will be Negative when a positive signal is fed to one of the inputs.
2	12,14, 16*	Power input common	
3	20,22, 24*	Power input positive	
4	28,30, 32*	Armature output	This output will be positive when a positive signal is fed to one of the inputs.

* All the DIN connector pins must be shorted.

Control stage

H	R	Function	Remark
5	10a	Input 1	For more details see 4.1.
6	10c	Input 2	For more details see 4.1.
7	12a	Input 3	For more details see 4.1.
8	12c	Motor current monitor	Current monitor scale: 8-12A types: 0.2V/A 15-20A types: 0.125V/A 25-30A types 0.08V/A
9,10,14	16a,c	Circuit common	
11	14c	Negative input of differential amplifier	For more details see Appendix C.
12	2a	Positive input of differential amplifier	For more details see Appendix C.
13	2c	Output of differential amplifier	For more details see Appendix C.
15	4a	Inhibit input	This terminal provides a means of disabling the amplifier (both logic and power stages) by applying low level input voltage. *
16	4c	Inhibit indication output	Whenever the amplifier is inhibited, whether by an internal or external cause, this open collector output goes low state (Max sink current 10mA).

* -7V < Vil< +1V
Source sink current capability - 2mA min.

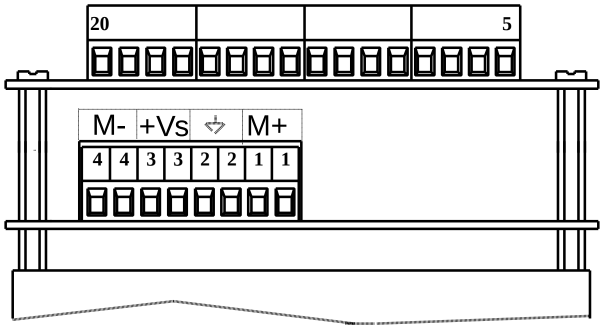
Control stage - cont.

H	R	Function	Remark
17	6a	CW disable	Low level input voltage * will disable half of the power bridge and rotation in one direction.
18	6c	CCW disable	Low level input voltage * will disable half of the power bridge and rotation in one direction.
19	8a	-7.5V	20mA external load.
20	8c	+7.5V	20mA external load.

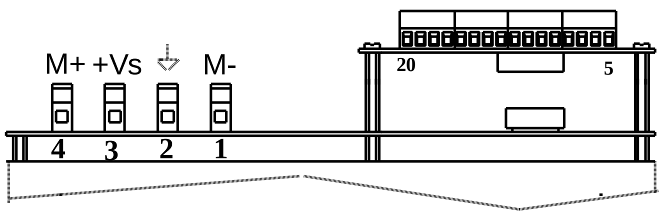
When using ESAF-30/160R or ESAF-25/200R, a 24VDC supply for brushless fan is available at the following pins:

	30ac	+24VDC	300mA supply for fan only
	32ac	Fan common	Fan common, internally connected to the circuit common.

Remark: In the following paragraphs the terminals will be related to all the mounting types as in the following example:
H-18,R-6c.



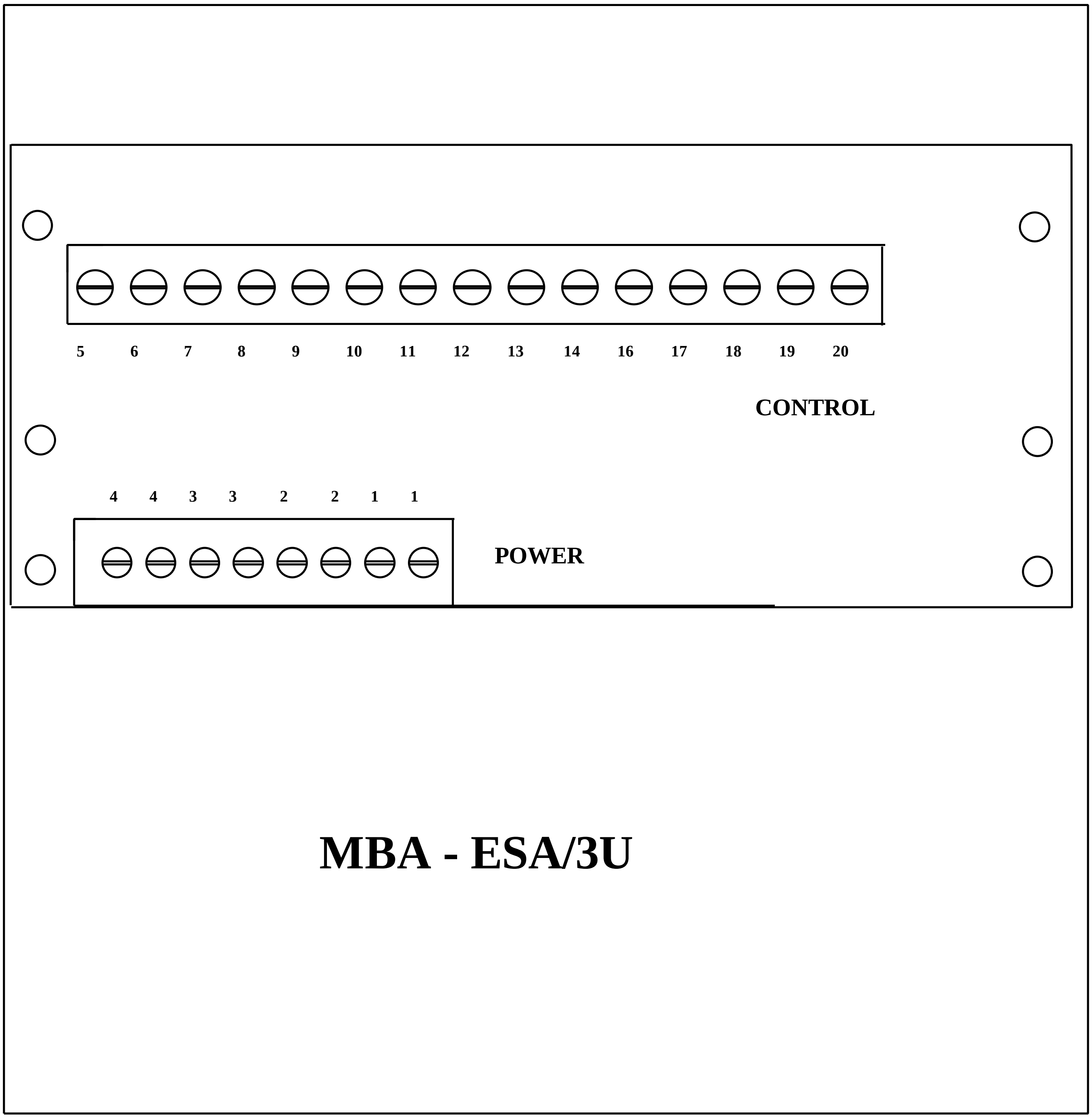
ESA (3U SIZE) - TERMINALS

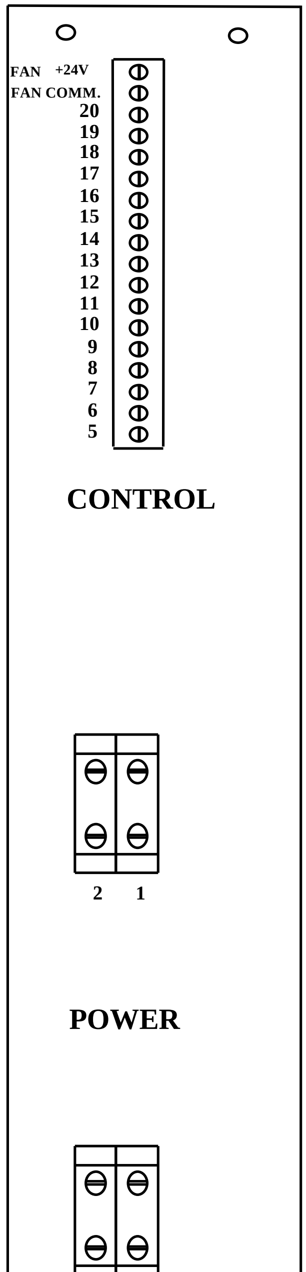


ESA (6U SIZE) - TERMINALS

5.2 Mother boards terminals

The MBA-ESA/3U and MBA-ESA/6U are designed for 19" rack systems. They have screw type terminals for both power and signals with identical designations as in the panel versions.




FAN +24V
FAN COMM.
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
CONTROL
2 1
POWER
3 4

MBA - ESA/6U

6. Installation procedures

6.1 Mounting

The ESA series dissipates its heat by natural convection except ESAF types which are fan cooled. For optimum dissipation the amplifiers should be mounted with the fins vertical.

6.2 Wiring

Proper wiring, grounding and shielding techniques are important in obtaining proper servo operation and performance. Incorrect wiring, grounding or shielding can cause erratic servo performance or even a complete lack of operation.

a) Keep motor wires as far as possible from the signal level wiring (feedback signals, control signals, etc.).
b) If additional inductors (chokes) are required, keep the wires between the amplifier and the chokes as short as possible.
c) Minimize lead lengths as much as is practical.
d) Use twisted and shielded wires for connecting all signals (command and feedback). Avoid running these wires in close proximity to power leads or other sources of EMI noise.
e) Use a 4 wires twisted and shielded cable for the motor connection.
f) Shield must be connected at one end only to avoid ground loops.
g) All grounded components should be tied together at a single point (star connection). This point should then be tied with a single conductor to an earth ground point.
h) After wiring is completed, carefully inspect all conditions to ensure tightness, good solder joints etc.

6.3 Load inductance

The total load inductance must be sufficient to keep the current ripple within the limits (10% of rated current is recommended). The armature current ripple (Ir) can be calculated by using the following equation:

$$I_r = \frac{2.5 \times 10^{-2} \times V_s}{L}$$

L - load inductance in mH.

Vs - Voltage of the DC supply in Volts.

If motor inductance does not exceed this value, a choke should be added (on the motor branch) summing together the required inductance

$$L_{ch} = L - L_{arm}$$

Lch - Choke inductance

Larm - Armature inductance

6.4 DC power supply

DC power supply can be at any voltage in the range defined within the technical specifications (chapter 3). However, if the power source to the power supply is the AC line (through a transformer), safety margins have to be considered to avoid activating the under/over voltage protection due to line variations and/or voltage drop under load.

The nominal DC bus voltage should be in the following range:

$$1.2V_{dcmin} < V_{dc} < 0.9V_{dcmax}$$

V_{dcmin} - Minimum DC bus in the table of chapter 3

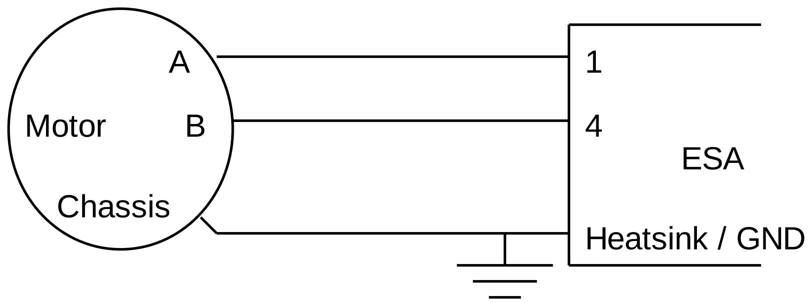
V_{dcmax} - Maximum DC bus in the table of chapter 3

The transformer power should be calculated to have the capability to deliver power to the amplifier (including peak power), without significant voltage drops.

While driving high inertia loads, the power supply must be equipped with a shunt regulator, otherwise, the amplifier will be disabled whenever the capacitors are charged above the maximum voltage.

6.5 Wiring diagrams

MOTOR WIRING



Minimum acceptance

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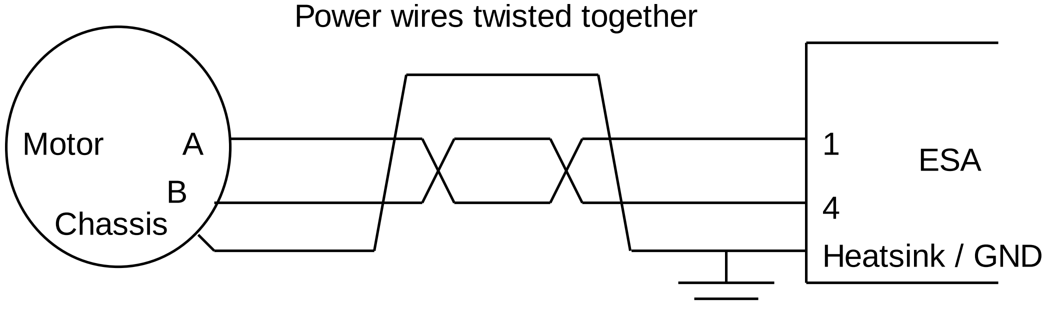
Power wires twisted together



Acceptable for most applications

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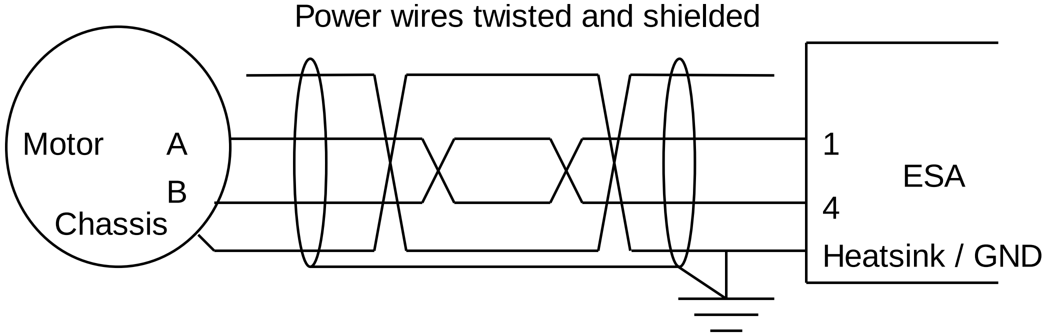
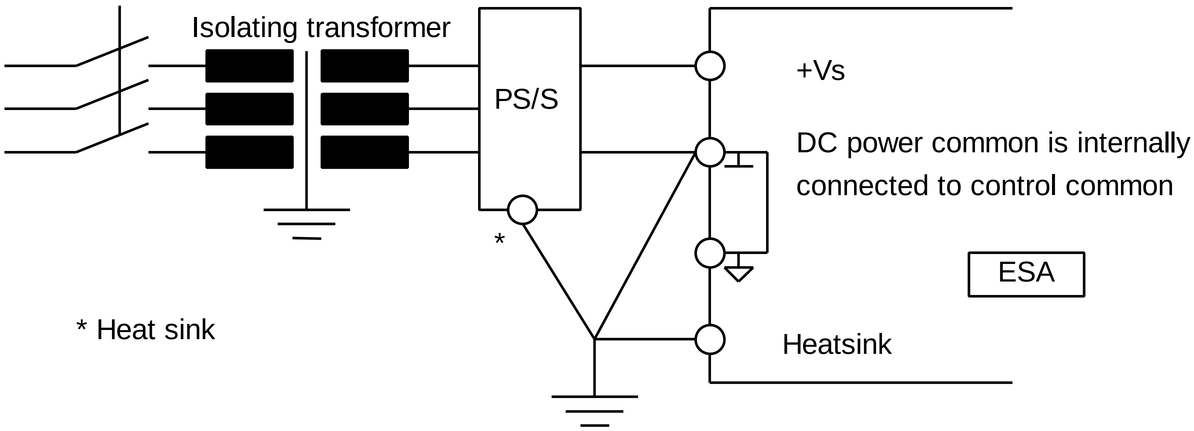
Power wires twisted and shielded



Optimum wiring, minimum RFI



Guide lines for connecting a non isolated amplifier with an isolating power transformer

Ground:

DC power common

Motor chassis

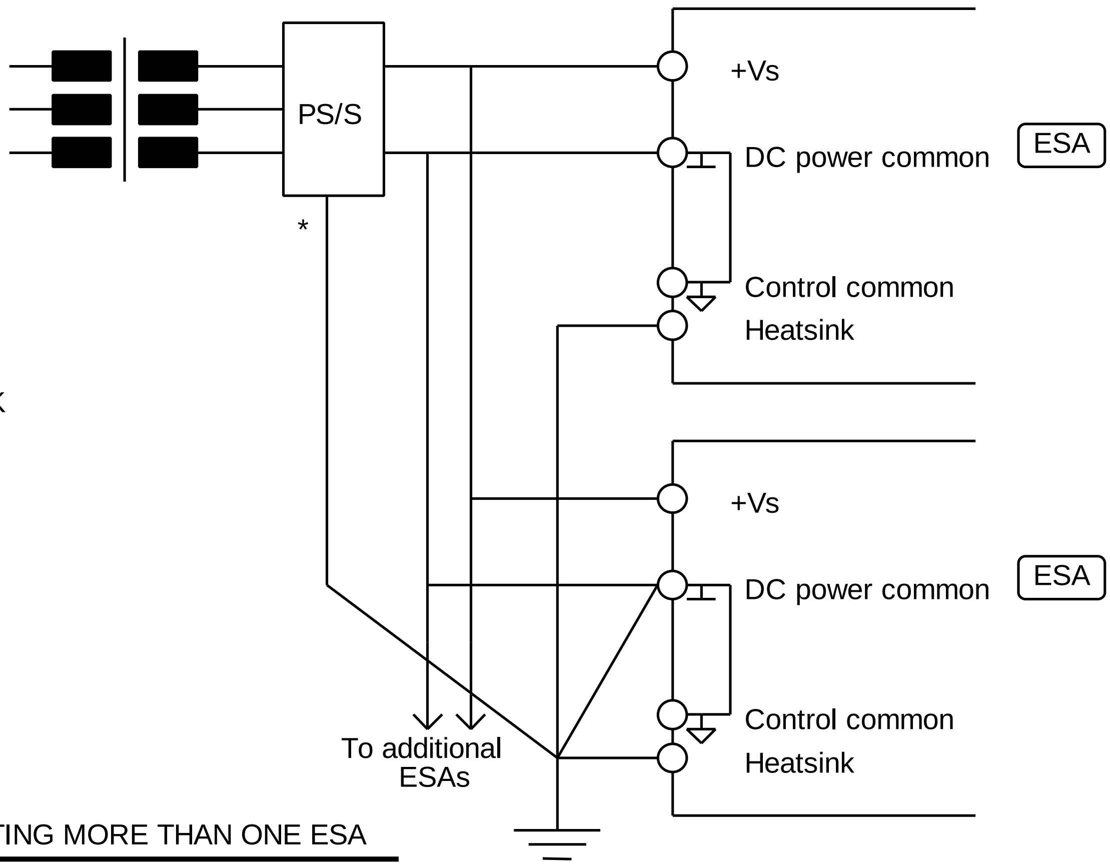
Amplifier's heat sink

Do not ground:

Control common - It is internally connected to the power common. Grounding the control common will create a ground loop.

Caution:

- If source of motor command is grounded, use amplifier's differential input. Otherwise, ground loop is created.

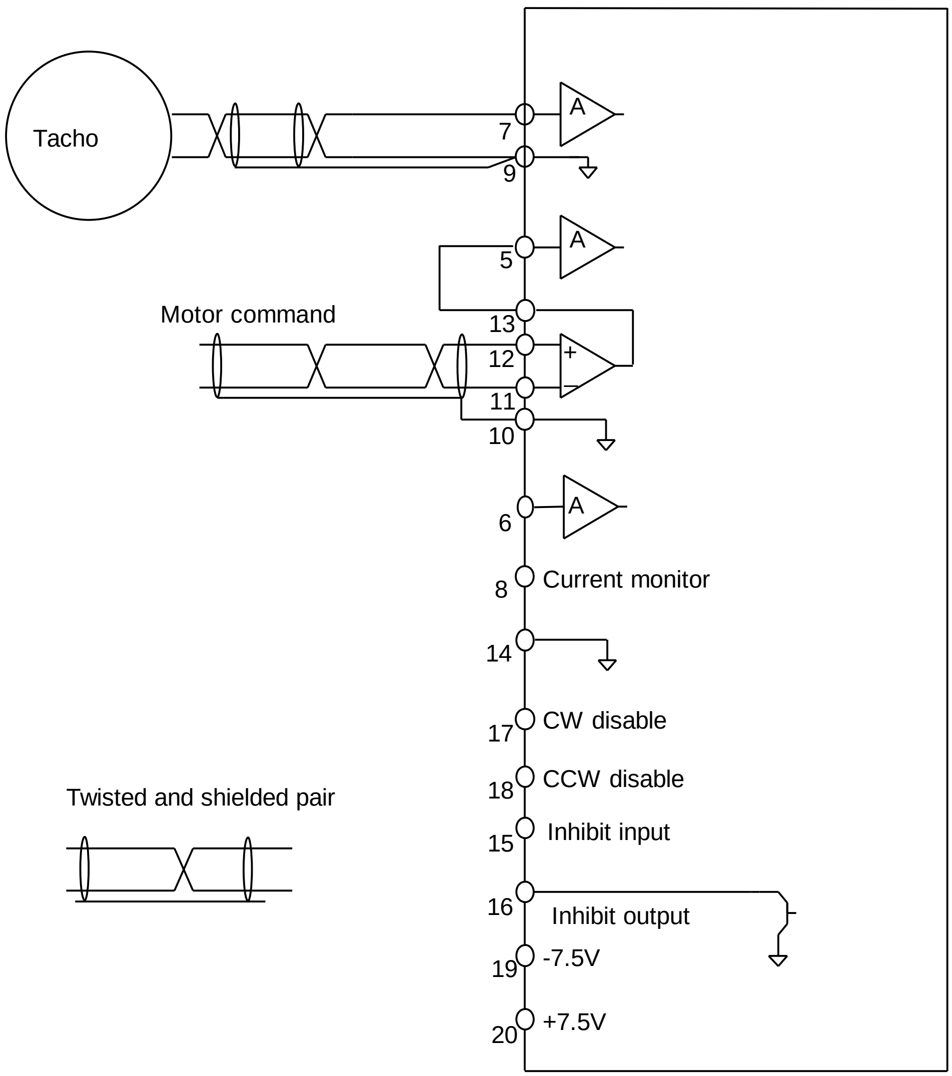


*

HEATSINK

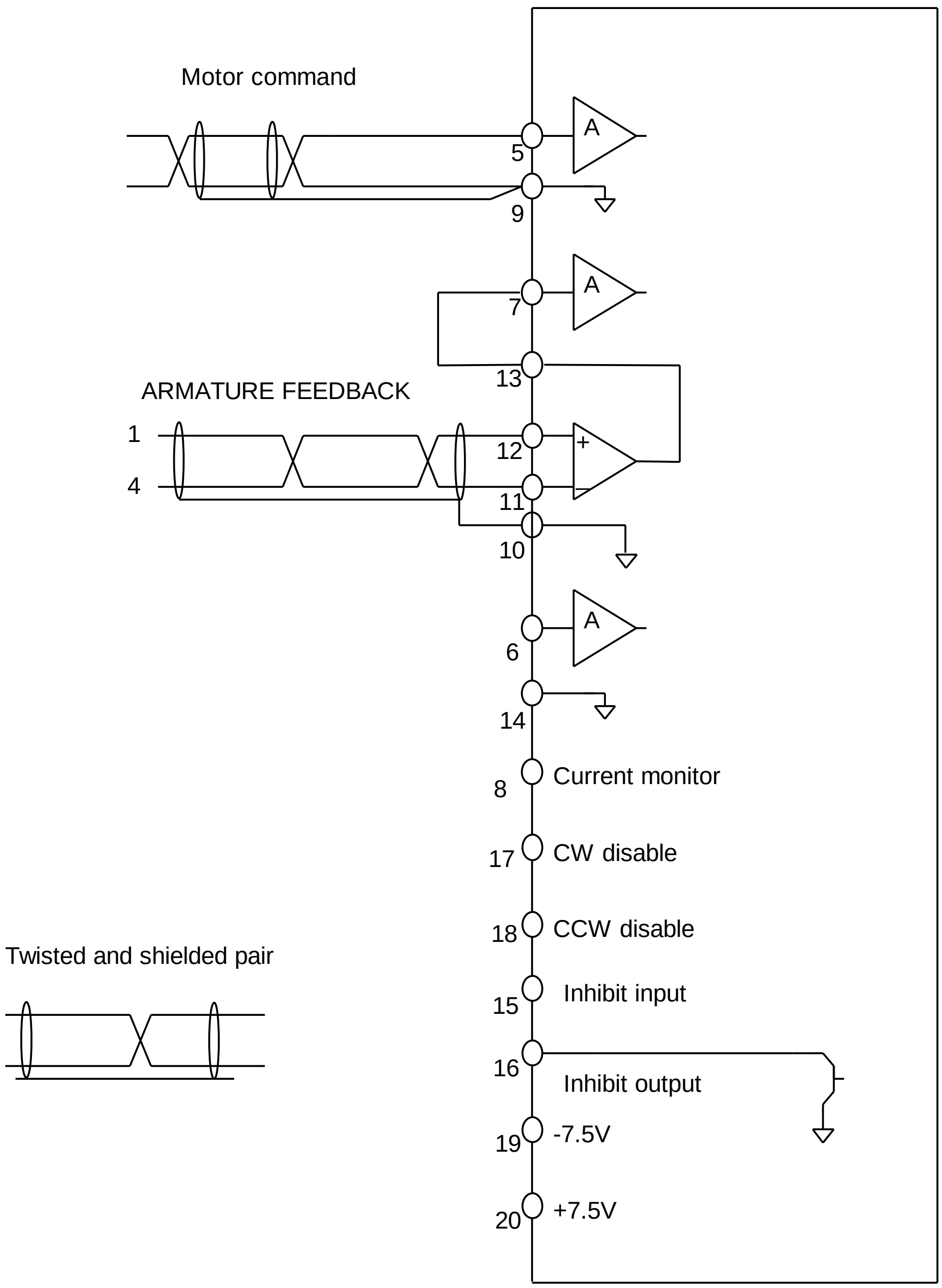
CONNECTING MORE THAN ONE ESA

All rules about supply connections described in the previous page are also valid for multi-ESA connection.



ESA CONTROL CONNECTIONS

TACHOGENERATOR FEEDBACK



ESA CONTROL CONNECTIONS

ARMATURE VOLTAGE FEEDBACK

7. Start - Up Procedures

All the operations of this chapter do not require power on the unit. The steps of paragraph 7.1 must be performed before proceeding to the appropriate feedback sensor section.

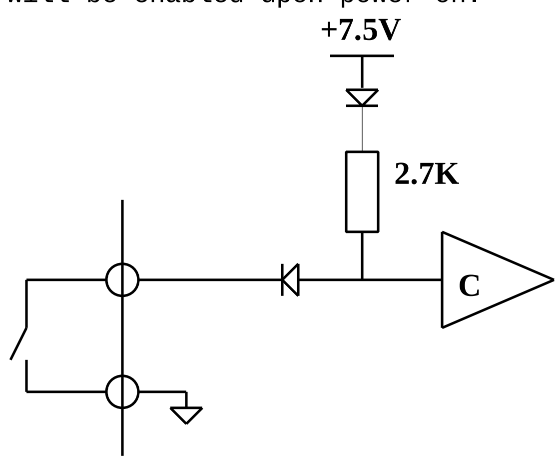
7.1 Common procedures for all amplifiers types

7.1.1 Inhibit logic

Select the desired Inhibit logic you need:

a) Disable by Low

Inhibit function will be activated by connecting its input (terminal H-15,R-4a) to a low level signal. If no signal is applied to this input the amplifier will be enabled upon power on.



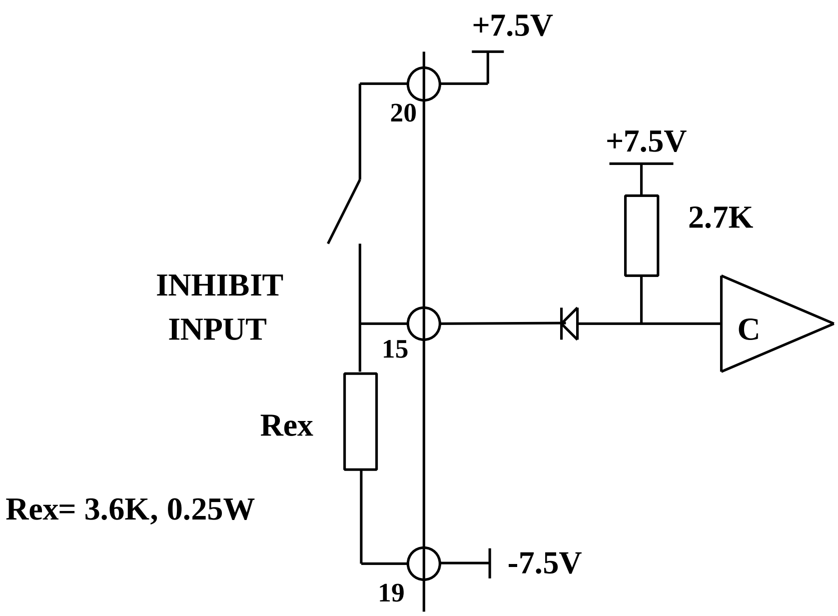
ESA DISABLED BY ACTIVE LOW OR CLOSED CONTACT

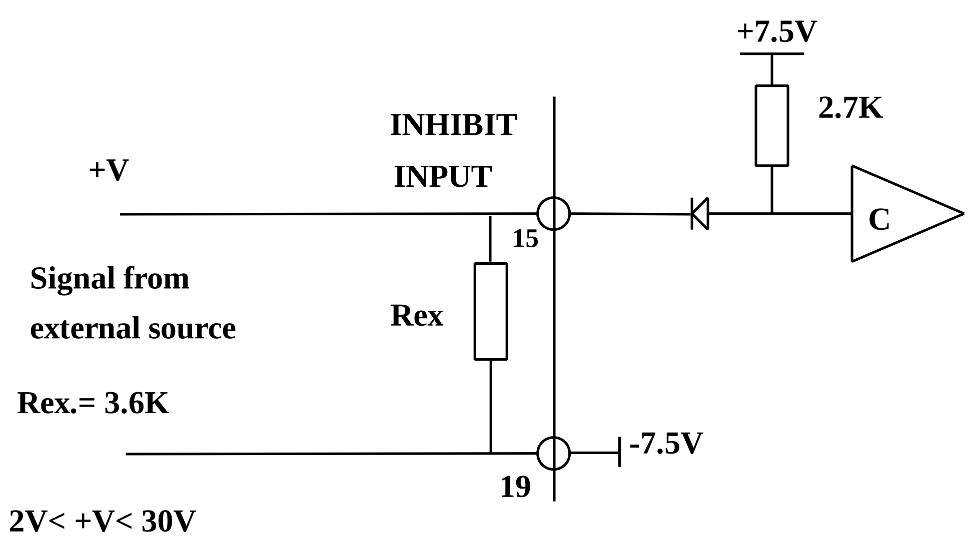
b) Enable by High

Inhibit function will be de-activated by connecting its input (terminal H-15.R-4a) to a high level signal and adding an external resistor (Rex) as in the following examples. If no signal is applied to this input the amplifier will be disabled upon power on.

The minimum power of Rex is given by:

$$P = \frac{(V+7.5)^2}{2000} \quad \text{(Watt)}$$





ESA ENABLED BY ACTIVE HIGH OR CLOSED CONTACT

7.1.2 Velocity mode

To operate in velocity mode the velocity loop should be enabled by converting the error amplifier to a high gain PID amplifier. **Make sure that R51 (16.5ohm), R14 (130Kohm) C19 (0.047 mF) and C7 (4700pF), in soldering terminals, are installed on the board.**

7.1.3 Current mode

a) Converting the amplifier into current mode

To operate in current mode the velocity loop should be disabled by converting the error amplifier to a low gain proportional amplifier.

- Remove R51 (in soldering terminals).

- Remove C19 (in soldering terminals).

In addition, you must make sure that the velocity feedback signal is not entering the error amplifier. If a tachogenerator is used, make sure that it is not connected to the amplifier.

b) Selecting the reference signal gain

The ESA has 3 single ended inputs (terminals 5,6,7) and a free differential amplifier with its inputs at terminals H-11,R-14c, H-12,R-2a and its output at terminal H-13,R-2c.

The standard procedure recommends to use the differential input for the reference signal and to connect the output to input 1 - terminal H-5,R-10a.

Following are the input parameters with the standard values of input resistors:

INPUT - RESISTOR	STANDARD VALUE	MAX. VOLTAGE	Current Gain(A/V) (in current mode)	INPUT IMPEDANCE
Terminal 5 - R130	10Kohm	9V	0.79xIc	22.7 Kohm
Terminal 6 - R96	40.2Kohm	21V	0.34xIc	52.9 Kohm
Terminal 7 - R95	93.1Kohm	42V	0.17xIc	97.3 Kohm

See chapter 4.1 for calculation of other values

7.1.4 Activating the loss of tacho protection (velocity mode only)

Activating the loss of tacho protection is done by inserting J4 (Short jumper) and R79, calculated as follows:

$$R79 = \frac{35xVs}{IcxRa} \text{ Kohm ; Ra in Ohm}$$

Vs - Voltage of power DC bus

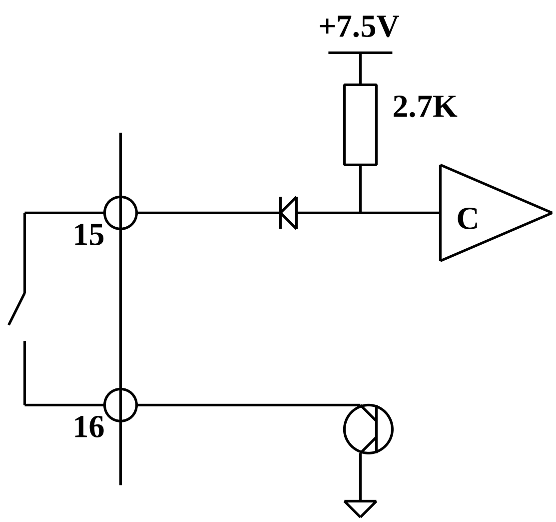
Ic - Amplifiers' rated continuous current limit

Ra - Total ohmic resistance in armature circuit

7.1.5 Latch mode of the protective functions

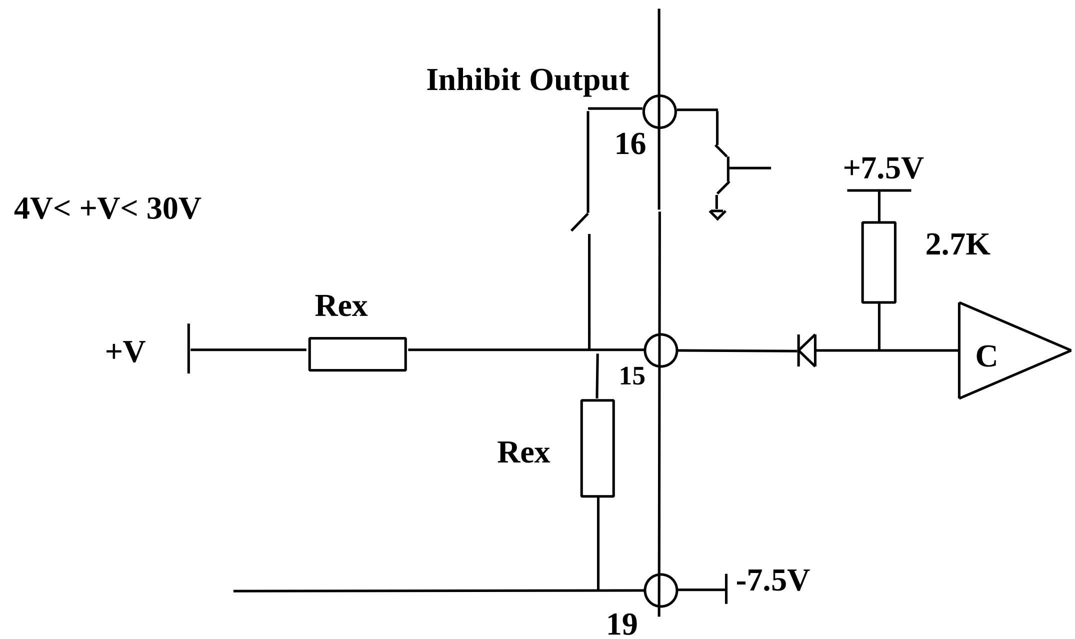
In order to cause a latch condition at each time that an inhibit occurs, connect the inhibit output (terminal H-16,R-4c) to the inhibit input (terminal H-15,R-4a) as per the following drawings. Resetting the latch is done by momentarily opening this connection.

a) Connection for Inhibit logic: Disable by Low



ESA - LATCH MODE WITH INHIBIT LOGIC: DISABLE BY LOW

b) Connection for Inhibit logic: Enable by High



LATCH MODE WITH INHIBIT LOGIC: ENABLE BY HIGH

7.1.6 Activating the dynamic contouring of the current limits

If you do not use this feature make sure that J3(A-B) and J3(A-C) are not installed on the board.

If you want to activate this function refer to appendix B.

7.2 Velocity control using tachogenerator feedback

Adjusting the reference voltage (motor command), which is connected to the differential input, is done by inserting:

R131= R133= 10K.

R132= R134= 2.5Vdm (Kohm),

Vdm- maximum reference voltage at the differential input.

The tacho voltage is adjusted by calculating R95 for two tachogenerator voltages ranges:

For Vtm > 4V

$$R95 = 3.2(Vtm - 4);\ Kohm$$

Vtm - Voltage generated by tachogenerator at maximum application velocity.

For Vtm < 4V

$$R95 = 1\ Kohm$$

$$R1 = \frac{10Vtm}{4-Vtm};\ Kohm$$

Vtm - Voltage generated by tachogenerator at maximum application velocity.

7.3 Velocity control using armature voltage feedback

Armature voltage may be used as velocity feedback in all cases when low regulation ratio and speed accuracy are acceptable. Using the differential amplifier to adjust its value, this voltage can be obtained at terminal H-13,R-2c. Attention must be paid not to saturate the amplifier by observing the following restrictions:

C32 = C33 = 0.1-0.47μF, ceramic capacitor.

$$\frac{R133}{R132} < \frac{5}{Vs}$$

$$R132 = R134 \geq 10Vs;\ Kohm$$

Vs is the DC voltage of the power supply.

The velocity loop is closed by connecting the following terminals:

Terminal H-1,R-18,20 in the power stage to terminal H-11,R-14c in the control board.

Terminal H-4,R-30,32 in the power stage to terminal H-12,R-2a in the control board.

8. Amplifier adjustment and diagnostics

Important remarks:

A. If all the previous steps were accomplished you may now turn on the power and continue with the following adjustments. You may omit the step for current mode or velocity mode according to your application.

B.

In some applications, especially those where the motor electrical parameters (total inductance and resistance in the armature circuit) are much smaller or larger than normally encountered, the current loop response should be optimized before proceeding with the following steps - See Appendix A.

8.1 Balance adjustment

If the motor is rotating with the command signal at zero voltage, a balance adjustment will be necessary. Turn the balance trimmer (T5) as required until the motor stops. As a rule, have the command signal connected and set to zero when balancing the amplifier. This way, any offset in the command signal will be canceled.

If the balance trimmer has insufficient range, a lower value of resistance can be substituted for R10 to obtain a wider adjustment range.

8.2 Current limit adjustment

The amplifier current limits can be adjusted without the need for loading if the current monitor jumper - J2 is in the current command position (standard factory setting):

A-B short

A-C open

Disconnect motor leads and remove J4 (if installed). Connect a voltmeter between terminal H-8,R-12c and the circuit common, and apply maximum input voltage to one of the inputs to cause an error at the error amplifier (input gain trimmer should be fully CW). Its maximum voltage limits the maximum current delivered to the motor.

In order to adjust the continuous limit, the peak limit should be lower than the continuous limit - turn T3 (Ip) CCW. At the point when peak limit=continuous limit, the meter readout will stop decreasing. Turn 4-6 turns more. Then, using T2 (Ic), adjust the continuous limit by monitoring the meter readout (see following table for current monitor scaling).

After adjusting the continuous limit, readjust T3 up to the desired peak level.

Continuous current rating	Current monitor scale
5-12A	0.2 V/A
15-20A	0.125 V/A
25-30A	0.08 V/A

8.3 Current gain adjustment (current mode)

a) Disconnect motors leads.

b) Apply voltage to the desired input and read the current monitor output at terminal H-8,R-12c. Adjust the input gain trimmer until the desired gain is achieved. The current gain (A/V) is given by:

$$Gc = \frac{\text{Current monitor voltage}}{\text{Vin x Current monitor scale}}$$

8.4 Adjusting the motor speed (velocity mode only)

Adjusting the speed is done by adjusting the input gain trimmer of the tacho feedback:

- Increasing/decreasing the feedback gain will decrease/increase the speed.
- Increasing/decreasing the command gain will increase/decrease the speed.

Best performance is achieved when the feedback gain is as close as possible to its maximum value. Therefore, the final adjustment should yield with Ki of the tacho input trimmer over 0.8.

8.5 Adjustment of the IxR compensation

> If you do not use this feature, skip this chapter.

IxR trimmer will be installed only if the amplifier was ordered for this option. Adjustment of IxR compensation should be done as follows:

a. Run motor at 2/3 of nominal speed.

b. Apply nominal load.

c. Increase IxR compensation (CW rotation of IxR trimmer) until motors speed reaches the no load speed.

d. Notice that a high compensation may result in unstable operation of the amplifier.

Reducing the DC and AC gains of the error amplifier by increasing C19 and R51 is recommended. The final values depend on the type of motor and mechanical load, so optimum results will be achieved by the empirical method.

8.6 Response adjustment (velocity mode only)

In most applications optimum response is achieved by adjusting the compensation (COMP) trimmer. Adjustment procedure is as follows:

- Provide the amplifier with a low frequency, bi-directional square wave velocity command (A 0.5Hz, ±2.0V waveform is often employed).
- Apply power to the amplifier, and while monitoring the tacho signal, gradually adjust the COMP trimmer from the CW toward the CCW position. Optimum response (critically-damped) should be achieved at some position before reaching full CCW on T4. Fig 8.1 illustrates some waveforms observed for various T4 settings.

In some applications, especially those where the load inertia is much smaller or larger than normally encountered, the standard compensation components values of 0.047µF for C19 and 120Kohm for R14 may not allow an optimum setting of the COMP trimmer T4. In fact, the velocity loop may be unstable for any setting of T4.

In these cases different values for C19 and R14 must be chosen. The following procedure can be used to select these values:

- Short circuit C19 with a short jumper wire.
- Replace R14 with a decade resistance box. Initially set the box resistance at 20Kohm.
- Set T4, the COMP trimmer to approximately midrange.
- Input a 0.5Hz, 2V bi-directional square wave velocity command signal to the amplifier.
- Apply power, and while monitoring the tachometer signal, gradually increase the value of the box resistance until optimum response as depicted in Fig 8.1 is achieved.
- Substitute the closest standard value discrete resistor for R14 and remove the decade resistance box.
- Remove the shorting jumper across C19, and again check the response using the squarewave test signal. If near optimum results are obtained, trim the response using the COMP trimmer T4 for the optimum.
- If the previous step does not yield satisfactory results, if unacceptable overshooting has been noted, substitute a larger value than 0.047 µF; or, if the response is overdamped substitute a smaller value than 0.047µF. Repetition of this procedure should yield an optimum choice for C19.
- Finally, select a new value of C7 so that the time constant of R14xC7 remains approx. as it was with the standard value of R14

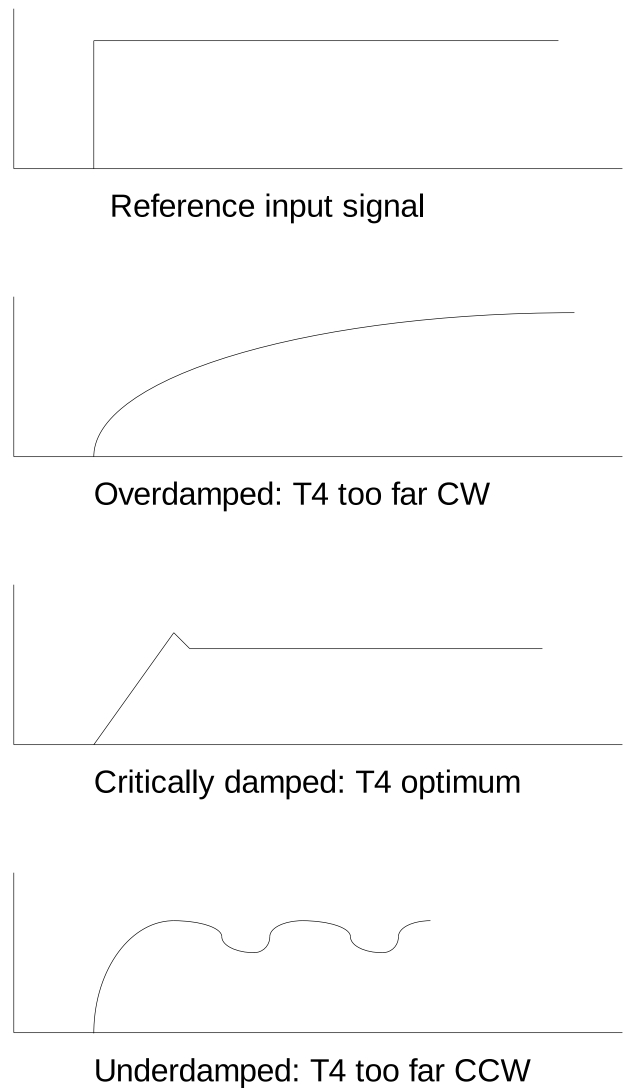


Fig. 8.1

Typical velocity response waveforms

9. Tables and summaries

9.1 Adjusting trimmers

Eight trimmers are installed on the upper board of the amplifier with the following functions:

T8 (Gain 1)	CW rotation increases input 1 gain
T7 (Gain 2)	CW rotation increases input 2 gain
T6 (Gain 3)	CW rotation increases input 3 gain
T5 (Balance)	See 8.1.
T4 (compen.)	See 8.6.
T3 (Ip)	CW rotation increases peak current limit.
T2 (Ic)	CW rotation increases continuous current limit (see 8.2).
T1 (IxR)	IxR compensation (see 8.5)

9.2 LED diagnostics

Five LEDs are installed on the upper board of the amplifier with the following designations: Ic, Sh, In, Pr, Vs. Under normal operation only Vs should illuminate (Vs indicates the existence of supply voltages). The following table represents all the combinations possibilities of the LEDs:

LED	1	2	3	4	5	6	7
Ic				X	X		
Sh			X			X	
In	X	X	X		X	X	X
Pr		X				X	
Vs	X	X	X	X	X	X	

X - Illuminated LED

1. External inhibit.
2. Under / over voltage protection.
3. Short protection.
4. Continuous current limit.
5. Insufficient load inductance or loss of tacho feedback.
6. Excess temperature.
7. Internal supplies are loaded (either internally or externally).

Appendix A - Response adjustment of the current loop

In most applications it is not necessary to adjust the current loop to achieve the optimum response. When there are extreme electrical parameters in the armature circuit (inductance and resistance) the standard components values of 0.01μF for C20 and 100Kohm for R50 may not yield with the optimum response. The current loop should be optimized as follows:

- Turn the amplifier to a current amplifier by removing R51 and R14.
- Provide the amplifier with a bi-directional square wave current command (100-200Hz, ±2.0V waveform is often employed).
- Apply power to the amplifier, and monitor the load current either by a current probe or by the current monitor. For this application J2 should be arranged as follows:

  A-C Short

  A-B Open

If the current response is not critically damped, use the following procedure:

- Short circuit C20 with a short jumper wire.
- Replace R50 with a decade resistance box. Initially set the box resistance at 10Kohm.
- Apply the square wave test signal to the amplifier input.
- Apply power, and while monitoring the load current, gradually increase the value of the box resistance until optimum response as depicted in Fig A-1 is achieved.
- Substitute the closest standard value discrete resistor for R50 and remove the decade resistance box.
- Remove the shorting jumper across C20, and again check the response using the square wave test signal.
- If the previous step does not yield satisfactory results, if unacceptable overshooting has been noted, substitute a larger value than 0.01 μF; or, if the response is overdamped, substitute a smaller value than 0.01 μF. Repetition of this procedure should yield an optimum choice for C20.

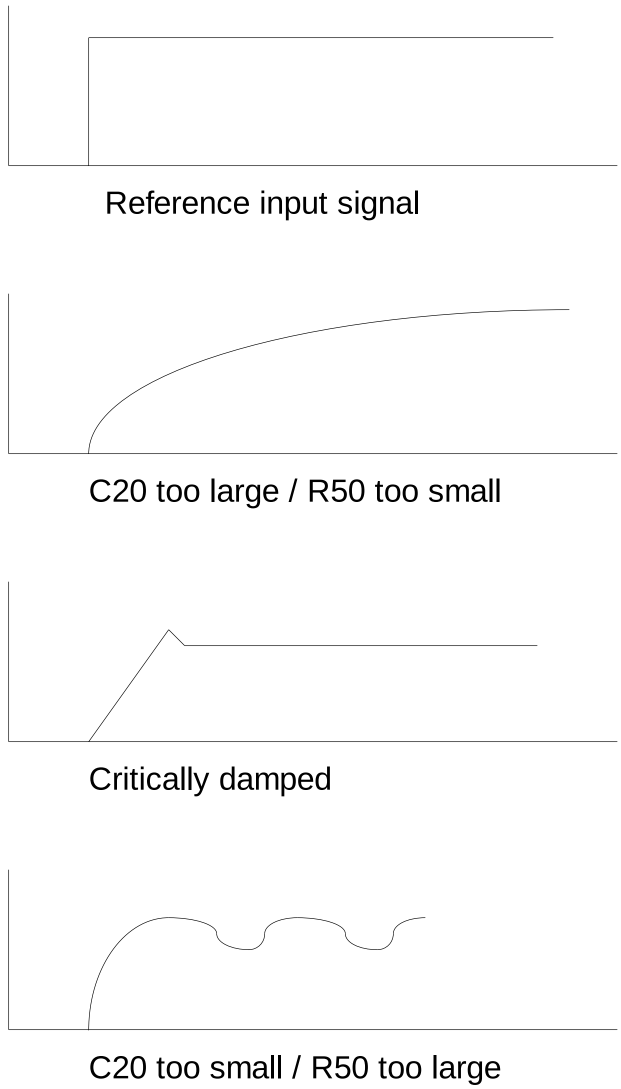


Fig. A-1

Typical current response waveforms

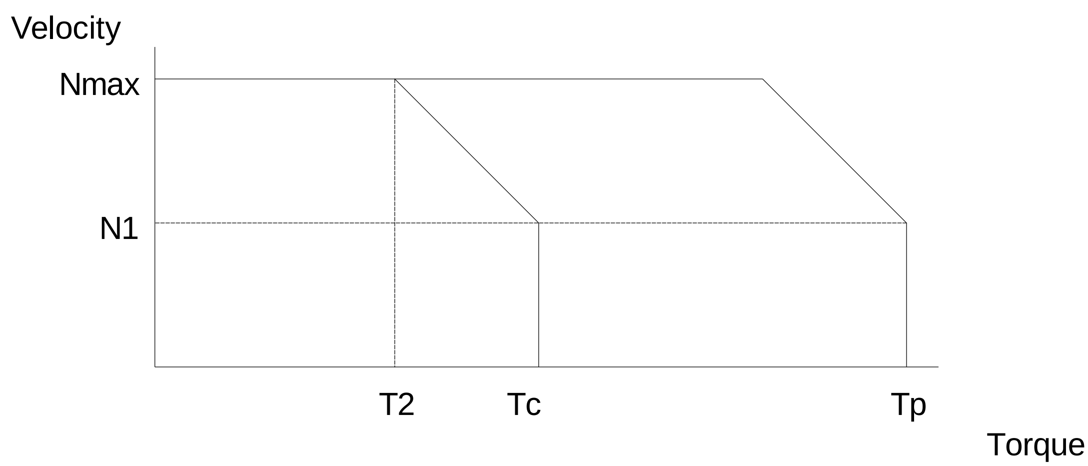
Appendix B - Current limits contour adjustment

The amplifier can be configured to have either continuous current limit or peak current limit or both which depend on motor velocity. For this purpose (when using tacho feedback) J1 has to be arranged as follows:

A - B   Open

A - C   Short

The general shape of the operating envelope is given in fig. B-1



Tc - Max. continuous torque up to velocity N1

T2 - torque at max. velocity Nmax.

Fig. B-1

Current limits contour

The user should derive the relations r1=N1/Nmax and r2=T2/Tc from the motor data sheet. R32 and R33 should be installed with values according to the following relations:

$$R32 = 33 \times \frac{1 - r1}{1 - r2} \quad \text{(Kohm)}$$

$$R33 = 62 \times \frac{R32}{R32 + 33 \times r1} \quad \text{(Kohm)}$$

The continuous current limit is velocity dependent (without peak current contouring) if J3 is arranged as follows:

A-B = Short
A-C = Open

The peak current limit is velocity dependent (without continuous current contouring) if J3 is arranged as follows:

A-B = Open
A-C = Short

In order to get velocity dependent continuous and peak current limits, J3 has to be arranged as follows:

A-B = Short
A-C = Short

Notice:
When operating in current mode or armature voltage feedback the contour will be activated by arranging J1 as follows:

A-B = Short
A-C = Open
R79 should also be inserted (For calculation of R79 see 7.1.4)

Appendix C - Differential amplifier connection

The differential amplifier is provided for your optional use. It can be used for buffering, inverting or elimination of common mode signals.

The differential amplifier inputs are available at terminals H-11,R-14c, ,H-12,R-12a. Terminal H-11,R-14c is the inverting input, terminal H-12,R-2a is the non-inverting input. The output is at terminal H-13,R-12c, and is to be connected to an available input terminal. The differential amplifier is not internally connected to the summing junction.

The differential amplifier may be used as a buffer or as an eliminator of common mode signals. For a non-inverting buffer amplifier, connect the positive signal lead to terminal H-12,R-2a, and the negative signal lead to terminal H-11,R-14c, and connect terminal H-11,R-14c to the circuit common. For an inverting buffer amplifier, connect the positive signal lead to terminal H-11,R-14c, the negative signal lead to terminal H-12,R-2a, and connect terminal H-12,R-2a to the circuit common.

The output of the differential amplifier is given by:

$$V_o = \frac{V_{12} \times R133}{R133 + R132} \times \left(1 + \frac{R131}{R134} \right) - \frac{V_{11} \times R131}{R134}$$

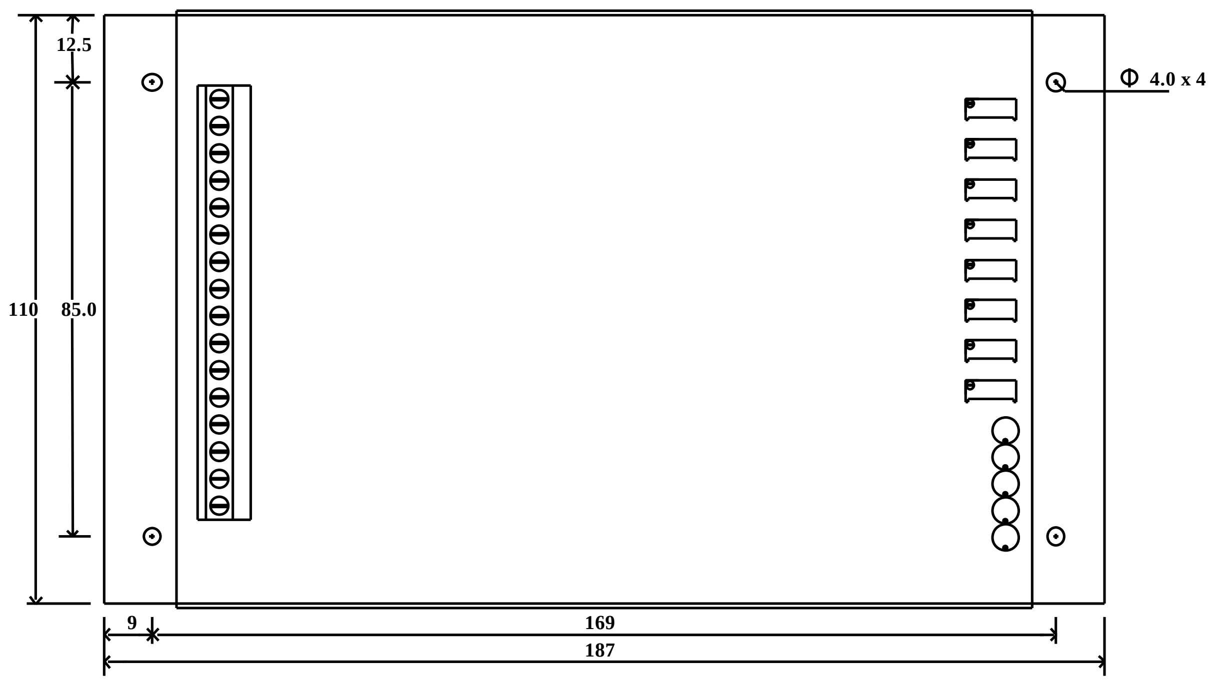
V_{12} - Input voltage of terminal H-12,R-2a.

V_{11} - Input voltage of terminal H-11,R-14c.

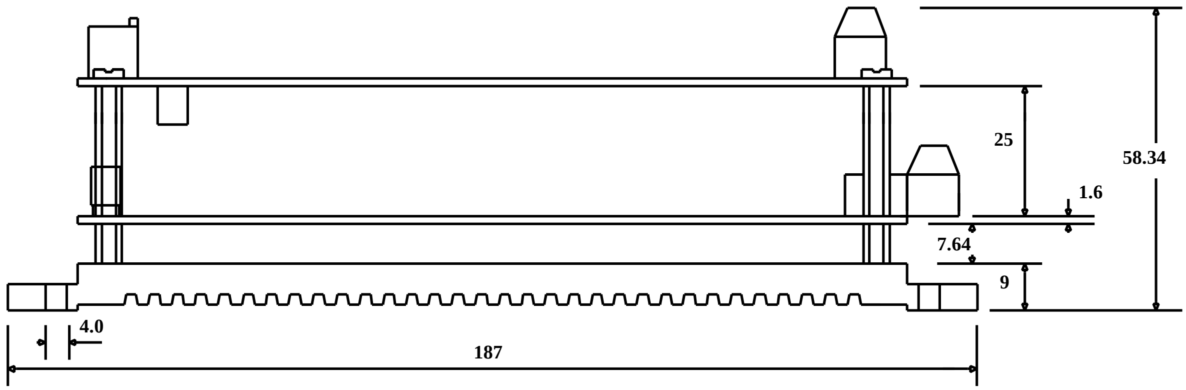
$$V_{12max} \le \frac{6 \times (R133 + R132)}{R133}; \quad V_{11max} \le \frac{6 \times R131}{R134}$$

See schematic in chapter 4.

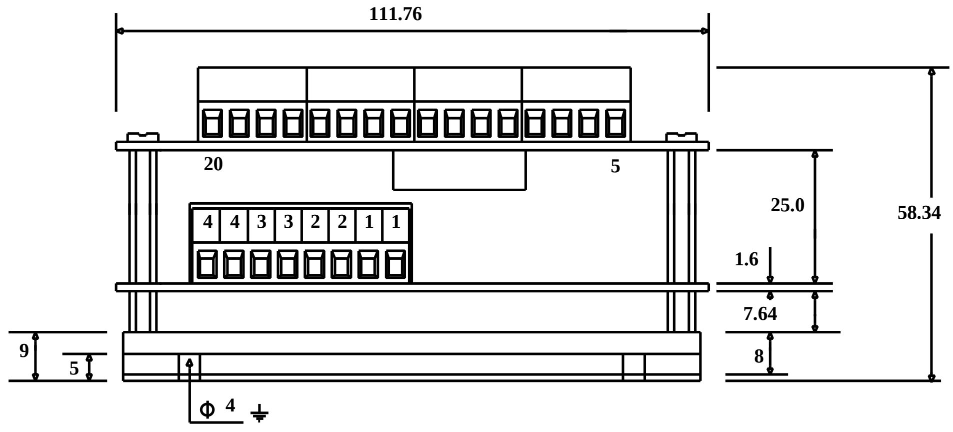
DIMENSIONAL DRAWINGS



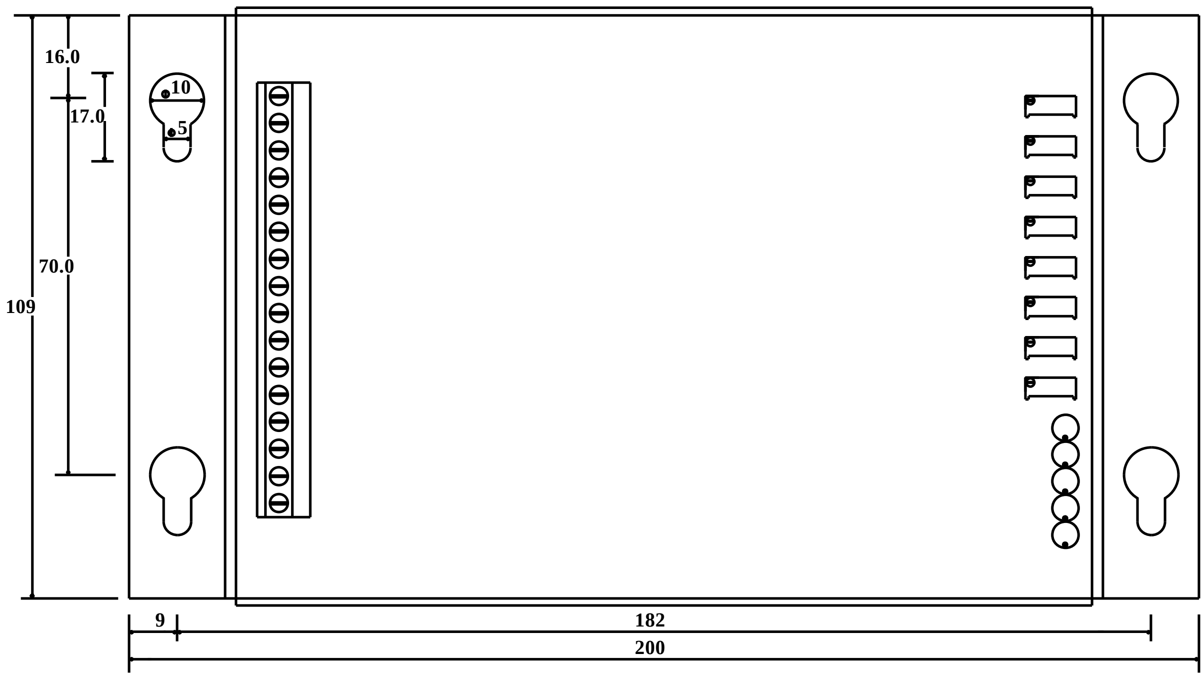
ES1 - TOP VIEW



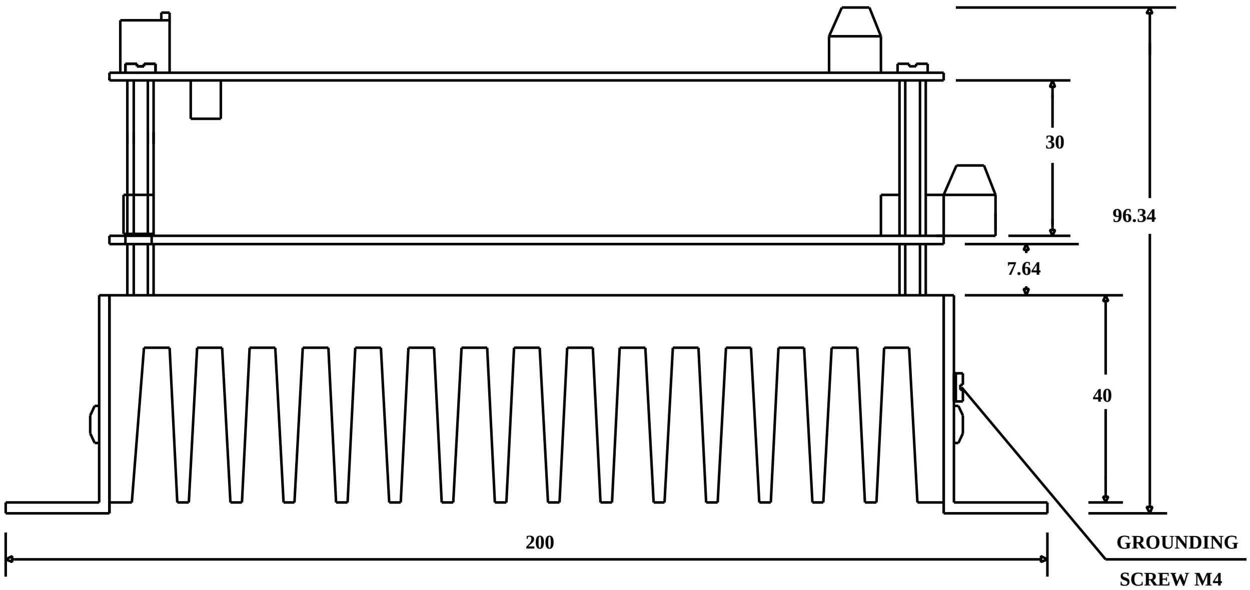
ES1 - SIDE VIEW



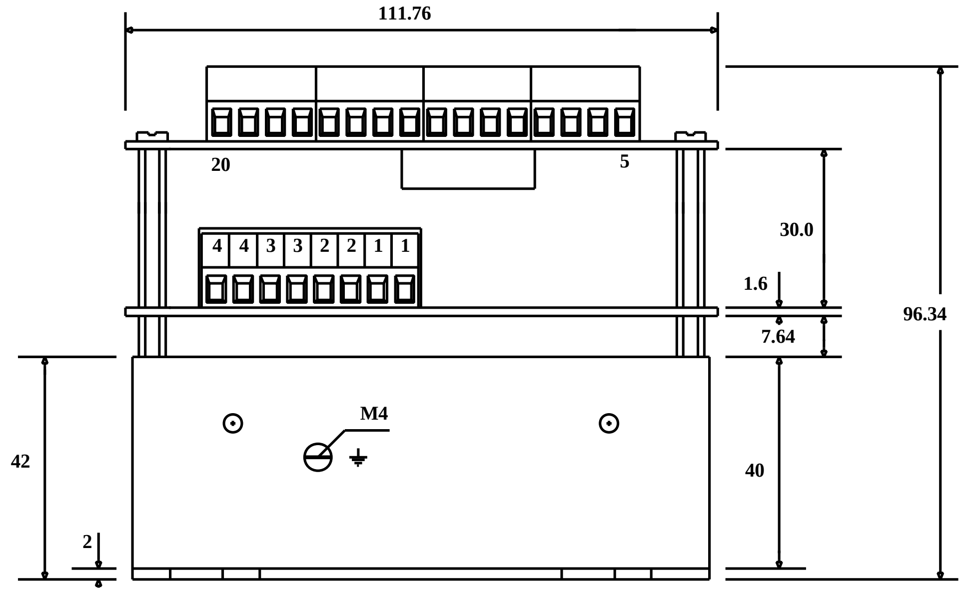
ES1 - SIDE VIEW



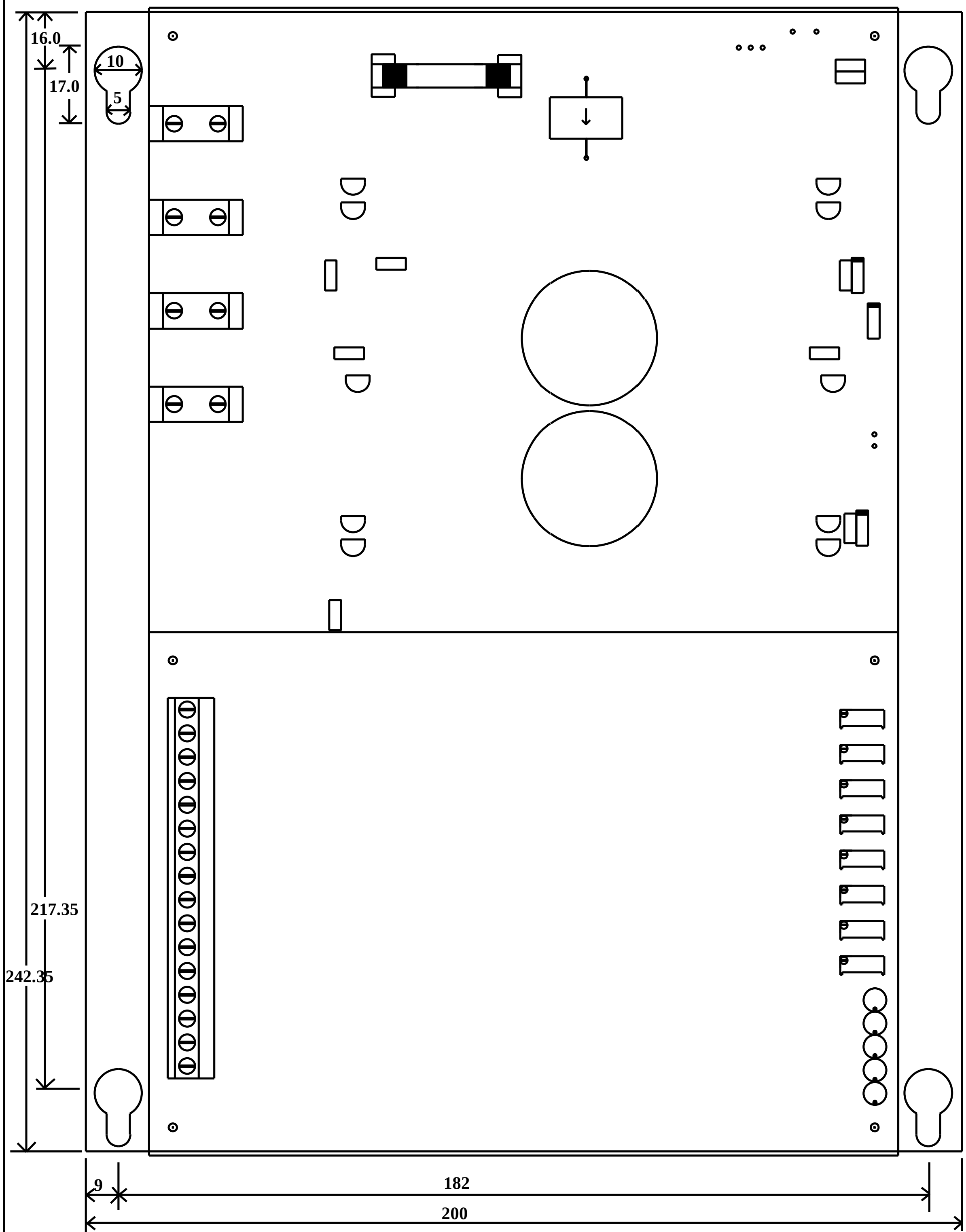
ES2 - TOP VIEW



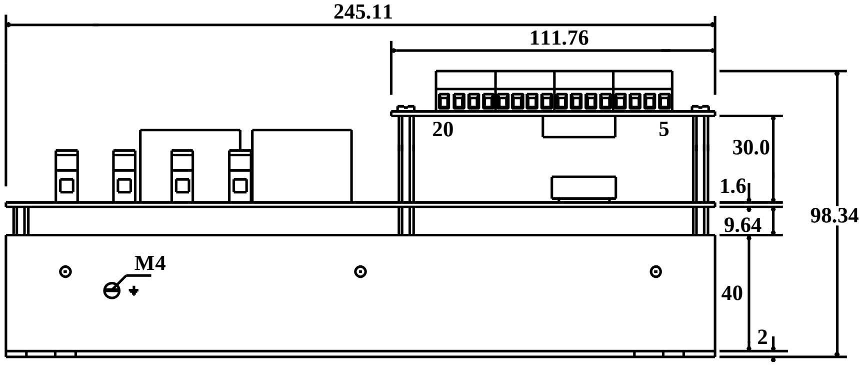
ES2 - SIDE VIEW



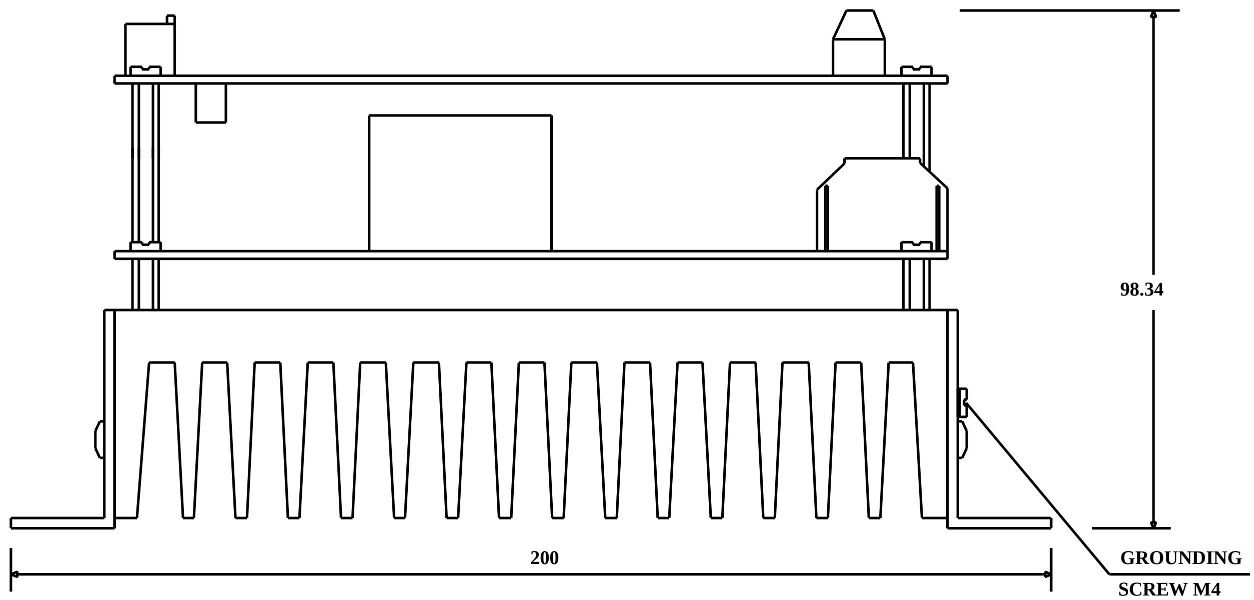
ES2 - SIDE VIEW



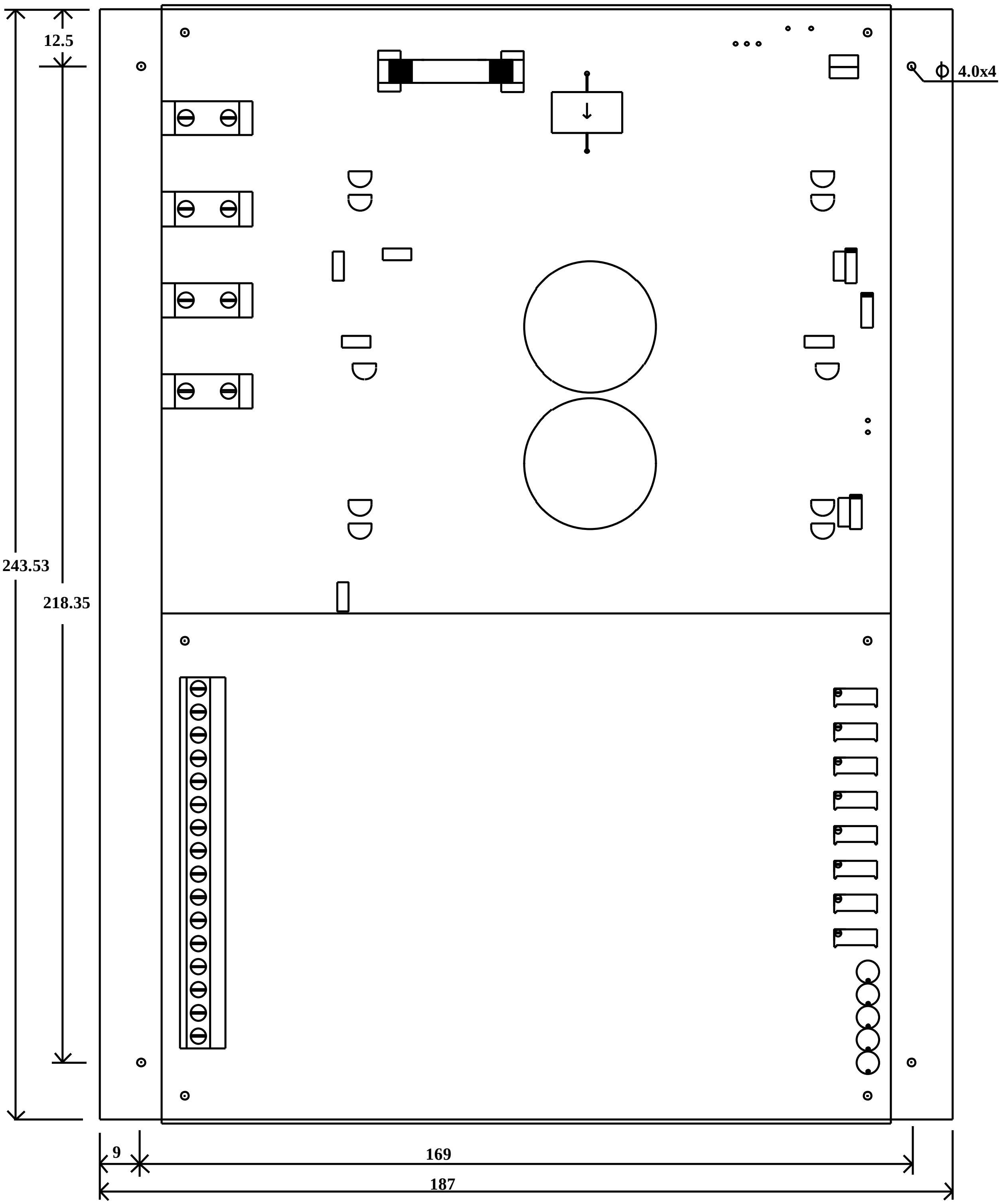
ES3 - TOP VIEW



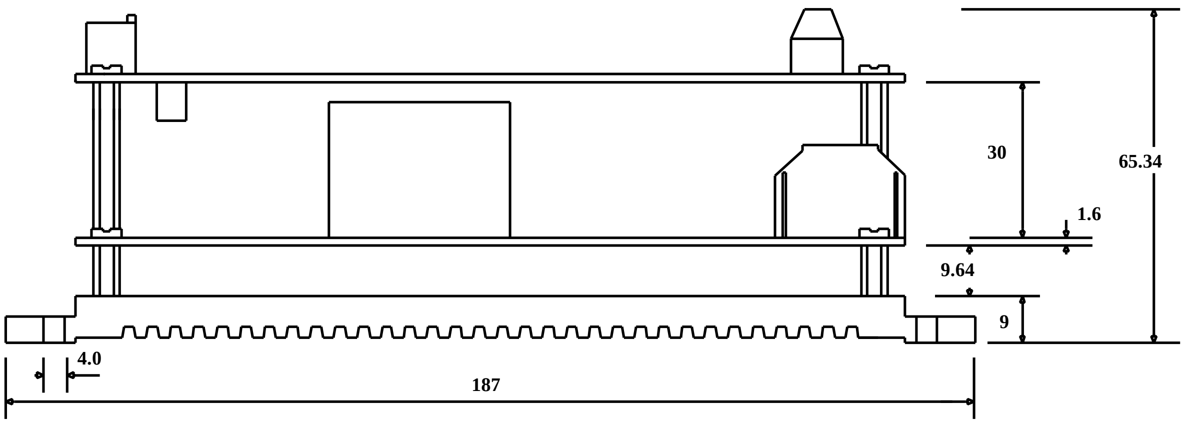
ES3 - SIDE VIEW



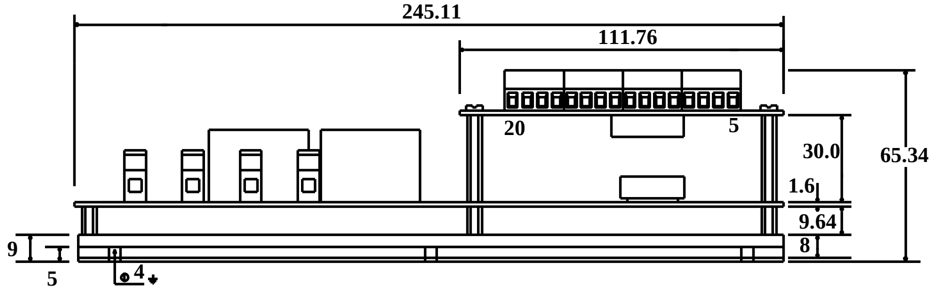
ES3 - SIDE VIEW



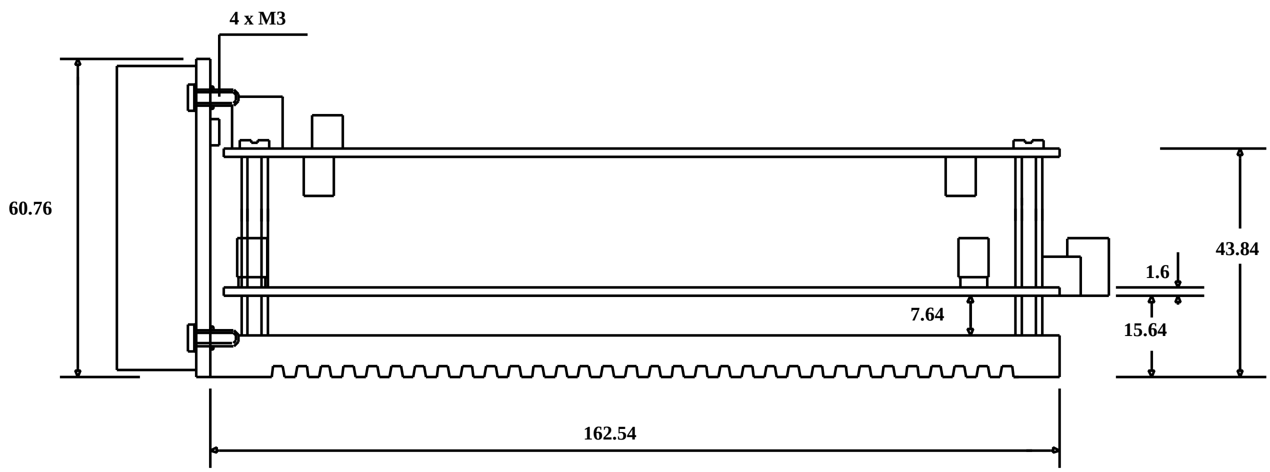
ES4 - TOP VIEW



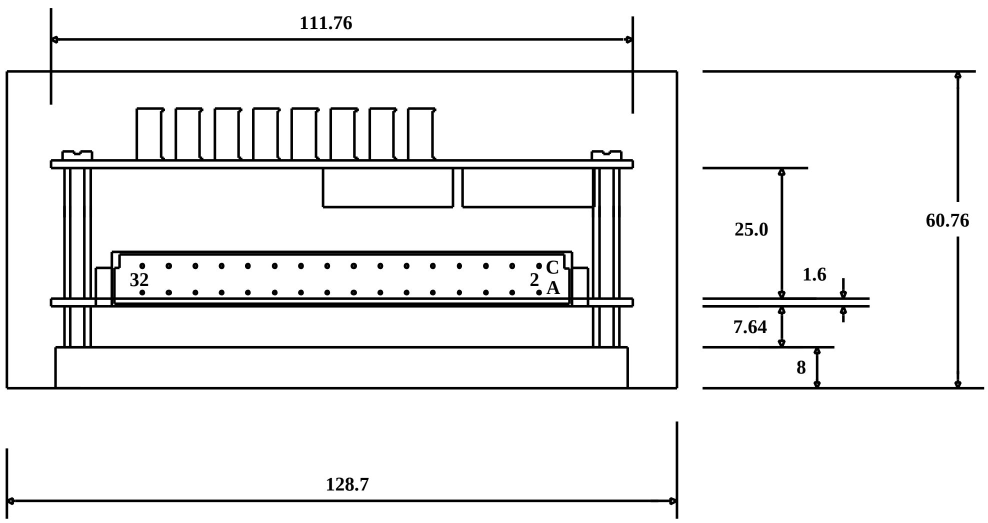
ES4 - SIDE VIEW



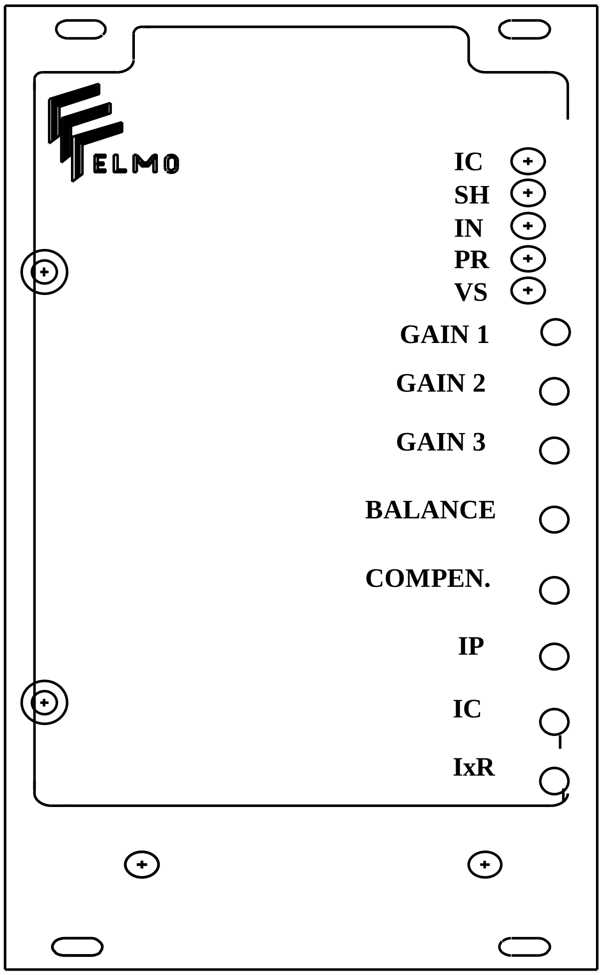
ES4 - SIDE VIEW



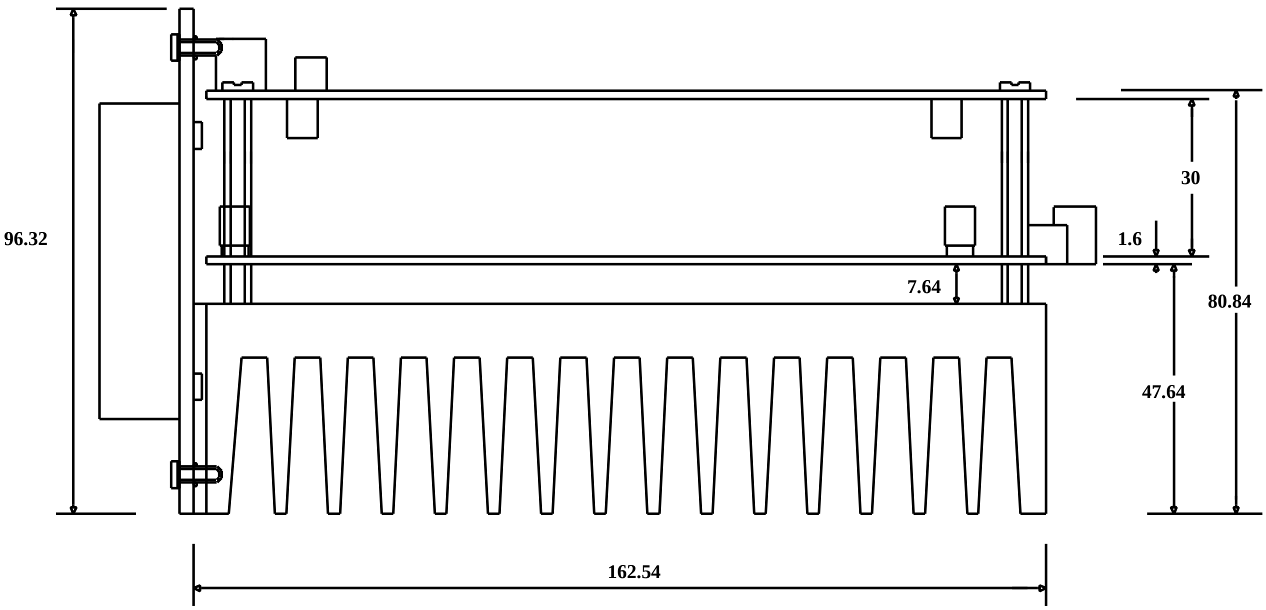
ESA RACK MOUNTING (3U/12T) - SIDE VIEW 1



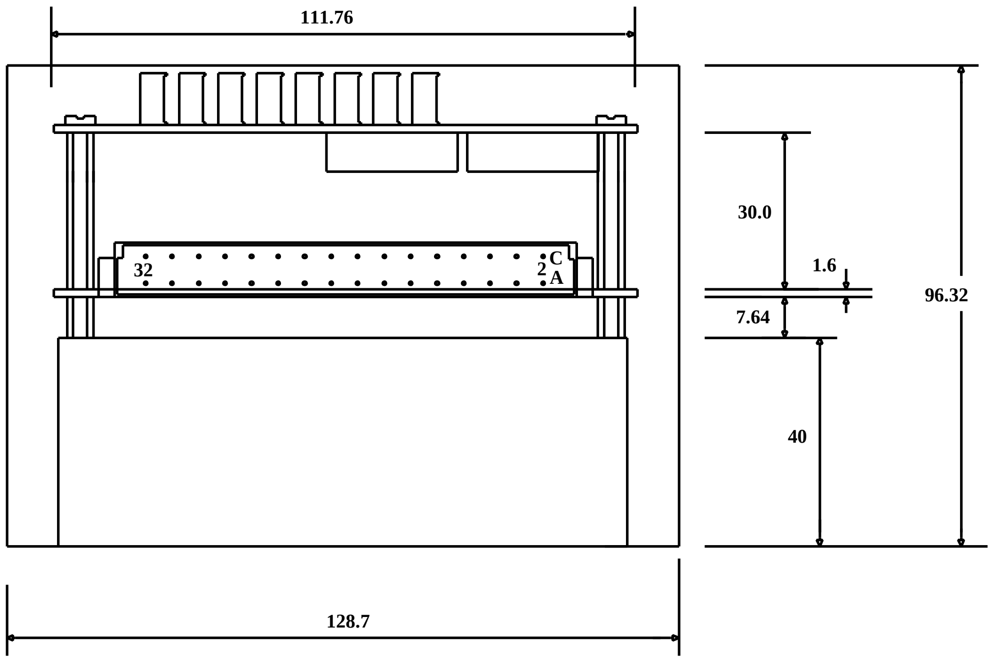
ESA RACK MOUNTING (3U/12T) - SIDE VIEW 2



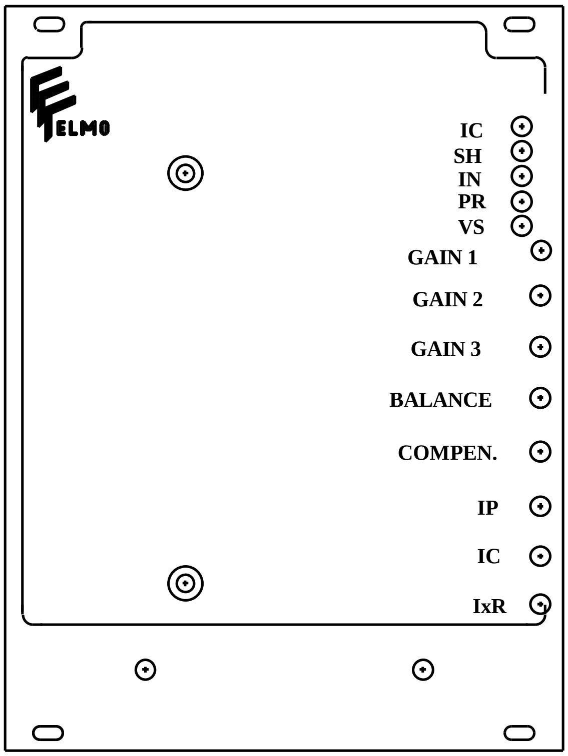
FRONT PANEL FOR ESA 3U/12T.



ESA RACK MOUNTING (3U/19T) - SIDE VIEW 1

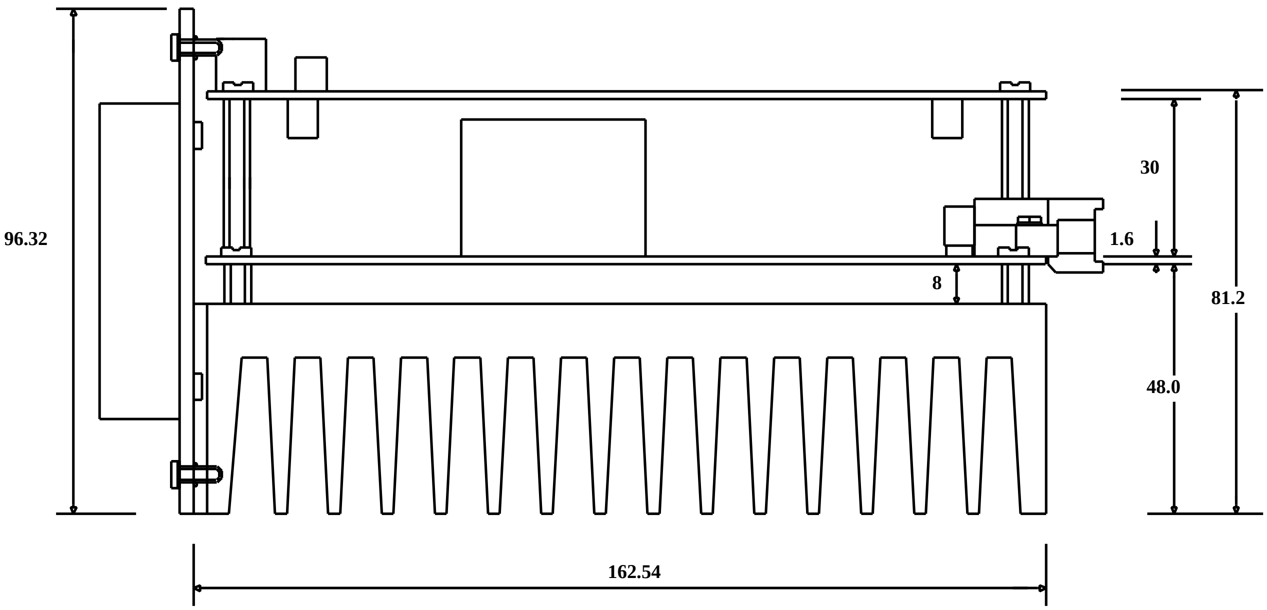


ESA RACK MOUNTING (3U/19T) - SIDE VIEW 2

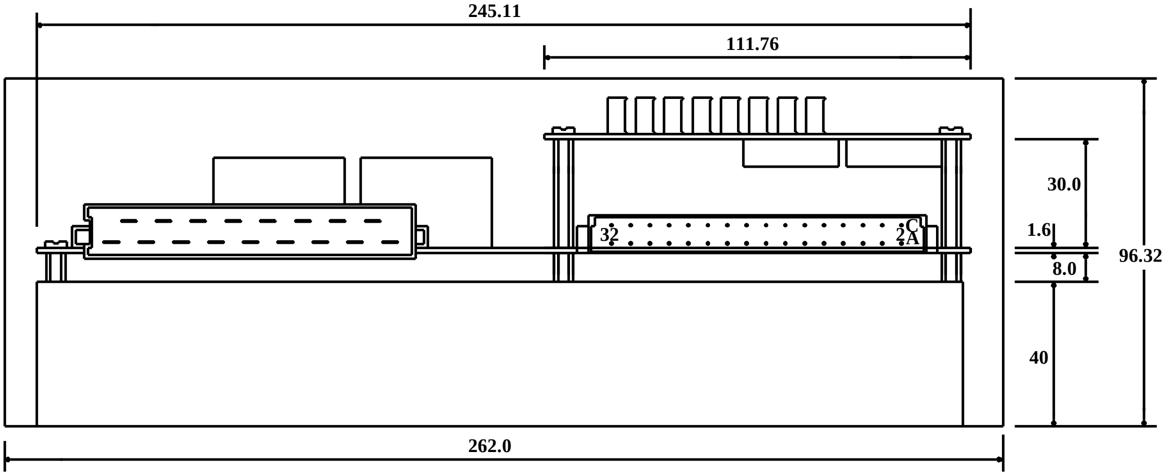


NOTE:

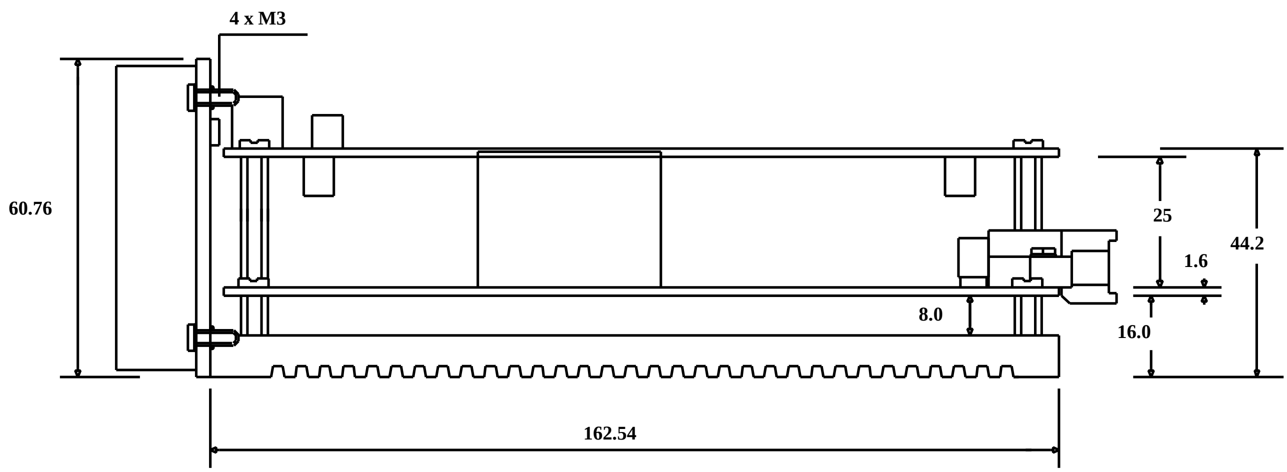
BELONGS TO ESA, 3U/19T.



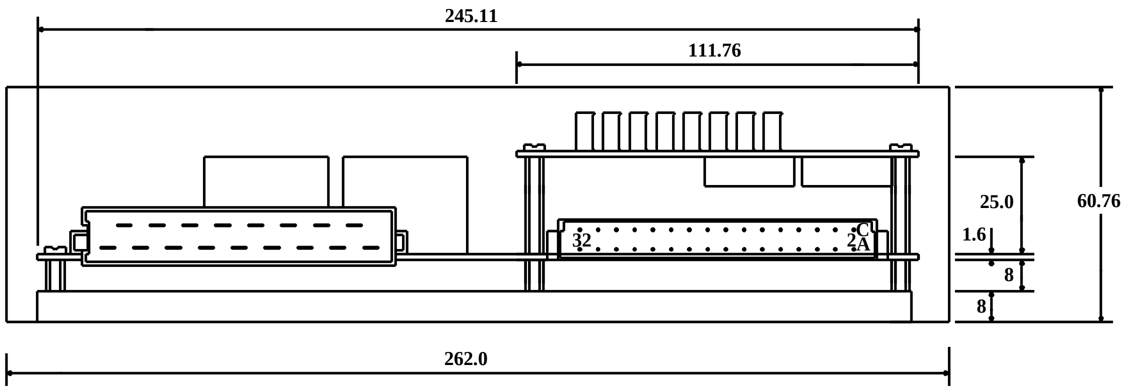
ESA RACK MOUNTING (6U/19T) - SIDE VIEW 1



ESA RACK MOUNTING (6U/19T) - SIDE VIEW 2



ESA RACK MOUNTING (6U/12T) - SIDE VIEW 1



ESA RACK MOUNTING (6U/12T) - SIDE VIEW 2

List of ELMO Service Centers

ISRAEL

Elmo Motion Control LTD
34 Segula ST.
Petah-Tikva 49103
Tel: (03)934-5059
Fax: (03)934-5126

EUROPE

Elmo Motion Control
7 Stanserstrasse
CH-6362 Stansstad
Switzerland
Tel: (041)610775
Fax: (041)610778

U.S.A

Elmo Motion Control INC.
1200 Woodruff Road,
Suite C-22,
Greenville, SC 29607
Tel: (803) 288-9316
Fax: (803) 288-9318

==

AUSTRIA

Kwapil
POB 64
A-1091 Wien
Tel: (0222) 342597
Fax: (0222) 311203

BENELUX

Eltromat B.V.
Looierij 26
4760 AB Zevenbergen
The Netherlands
Tel: (01680) 25925
Telefax: (01680) 28485

FINLAND

OY Scandrive
Elsankuja 2 K
SF-02231 Espoo
Tel: 358-0-8035044
Fax: 358-0-8035055

FRANCE

A 2 V SA
11-12 Rue Eugene HENAFF,
78190 Trappes,
Tel: (1) 30620101
Fax: (1) 30626204

GERMANY

IME GmbH
Brugger str. 8
78628 Rottweil
Tel: 0741/22091
Fax: 0741/22060

ITALY

Servotecnica SRL
Viale Lombardia 20
20095 Cusano Milanino (MI)
Tel: (02) 6131341
Fax: (02) 6132397

SPAIN

Anitronic, S/A
Apartado 129
Avda. Eulogio Estarta, s/n - 3.planta
20870 Elgoibar (Guipuzcoa)
Tel: 943-740550-4
Fax: 943-743489

SWEDEN

Aratron AB
P.O.B 20087,
Kratsbodavagen 50,
S-16120 Bromma
Tel: 8-981875
Fax: 8-984281

UNITED KINGDOM

INMOCO Limited
4 Brunel Close
Drayton Fields
Daventry NN11 5LE
Tel: 0327/300320
Fax: 0327/300319