ISA SERIES
OPERATING MANUAL

Rev 6/95

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.

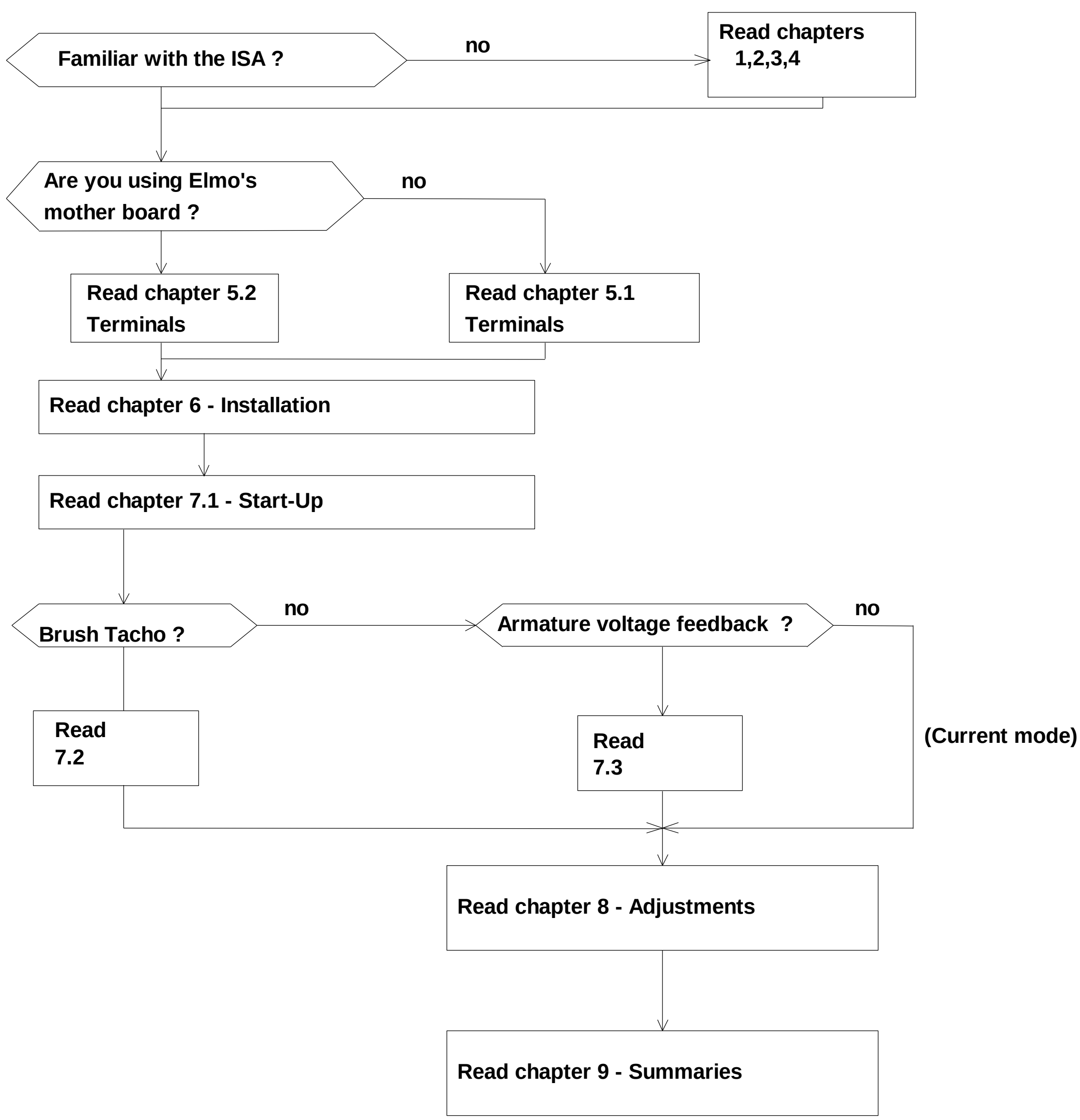
Damage claims, including consequential damages, which exceed the warranty obligation will be rejected in all cases.

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 ISA amplifier is designed for multi-axes OEM applications. It enables the user to adjust the amplifier for various types of motors and to adjust it for 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 ISA, you should read chapters 1-4 which will familiarize you with the product.



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1. Description

The ISA is a two PWM amplifiers' package assembled on an extended, rack version, Eurocard for brush type servo motors. Each one of the two amplifiers has a rated output of up to 750W.

Standard features

* Internal DC to DC converter allows for operation from a single supply.
* Zero deadband.
* Excellent linearity.
* 2 single ended inputs.
* 1 Differential input.
* Motor current monitor.
* Inhibit/fault indication (open collector)
* Remote control functions: Inhibit and CW/CCW disable.
* Adjustable compensation.
* Adjustable continuous and peak current limits.
* Dynamic contouring of continuous and peak current limits.
* Input balance (offset) adjustment.
* Operation in two velocity modes (Tacho or armature voltage feedback) or current mode.
* LEDs diagnostics.
* Two 32 poles DIN 41612 connectors for rack mounting.

Protective functions:

The following protections cause an inhibit which is either self-restart or latched (for manual reset) selectable by the user:

* Under / over voltage.
* Short circuit: between outputs or each output to ground.
* Low inductance.
* RMS current limit.
* Loss of tacho feedback.
* Over temperature.
* Wrong supply connection.

2. Type Designation

ISA - 10 / 100 - 4

ISA amplifier

Rated current

Maximum rated voltage

PWM switching frequency

20KHz when not specified

4=40KHz, 6=60KHz

3. Technical specifications

Type	DC Supply * Min-Max	Current limits Cont./Peak	Size Rack	Weight
ISA-15/55	10-55	15/30	3U/8T	0.6
ISA-10/100	20-94	10/20	3U/8T	0.6
ISA-5/200	40-195	5/10	3U/8T	0.6

* DC output voltage is 90% of DC input voltage.
* 20KHz, 40KHz or 60KHz switching frequency.
* 2KHz current loop response (minimum)
* Outputs voltages of ±13V/50mA each, for external use.
* Efficiency at rated current - 97%.
* Drift: 10↘V/▪C (referred to input)
* Operating temperature: 0-50▪C.
* Storage temperature: -10 - +70▪C.

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

4. Operation of the servo control

4.1 Inputs

The ISA has 3 inputs: 2 single ended inputs (no.1 at terminal 1 and no.2 at terminal 5) and one differential input at terminals 3,4.

The current gain of inputs 1 and 2 (current mode) is given by:

$$G_c = \frac{8 \times I_c \times K_i}{15 + R_i} \quad (A/V)$$

Ic - amplifier rated continuous current.

Ri - input resistor in Kohm.

R1 for input 1

R2 for input 2

Ki - position of wiper of trimming potentiometer

Ki=0.33 when trimmer is fully CW.

Ki=1 when trimmer is fully CW.

The current gain of the differential input for R3=R4 (current mode) is given by:

$$G_{cd} = \frac{5.33 \times I_c}{R_3} \quad (A/V)$$

R3 in Kohm

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

$$G_v = \frac{400 \times I_c \times K_i}{(15+R_i) \times R_6} \quad (A/V)$$

Ri,R6 in Kohm

The current gain of the differential input in velocity mode is given by:

$$Gvd = \frac{266 \times Ic}{R3 \times R6} \quad (A/V)$$

R3,R6 in Kohm

The maximum input voltage at terminals 1 or 5 is calculated by:

$$Vin_{max} = 10 + 0.6Ri \quad (Volts)$$

Ri in Kohm

The maximum input voltage at terminals 3,4 is calculated by:

$$Vd_{max} = 10 + R3 \quad (Volts),$$

R3=R4 in Kohm

4.2 Velocity mode

In this mode op amp U1/A 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:

$$Rf = \frac{10^{10}}{R6}$$

Resistor R6 is mounted in solderless 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 C1, R5 and COMP trimmer. Maximum AC gain is obtained with COMP trimmer set fully CW. Setting COMP trimmer fully CCW removes AC gain and no lag in response occurs. R5 and C1 are mounted in solderless terminals and can be easily replaced in cases when COMP trimmer range is not enough to get optimum response.

The output of the error amplifier is:

$$Vo = (V_1 G_{V1} + V_2 G_{V2}) \times \left[\frac{1 + SxC1xR5}{1 + SxC1xR5(1 + RfxKi/R5)} \right]$$

V_1, V_2, - Input signals

G_{V1}, G_{V2} - Gain of inputs.

Ki = Position factor of the wiper of COMP trimmer.

Full CW = 0.1

Full CCW = 1

The feedback element must be connected for negative feedback.
The polarity of the ISA servo amplifiers is such that a positive input signal results in a negative voltage at terminal M1 with respect to terminal M2.

4.2.1 Velocity control using armature voltage feedback

By inserting R8 to its solderless terminals, the armature voltage is fed into the error amplifier to be used as a velocity feedback. This feature is useful for all cases when low regulation ratio and low speed accuracy are acceptable.

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, R6 and C1 have to be removed from the circuit.

4.4 Current loop

Current loop control is obtained by op amp U1/B (Current amplifier) and R7, C2 which form a lag-lead network for current loop. The standard amp is equipped with R7 (100Kohm) and C2 (0.01æF) to get optimum current response for an average motor in this power range. These components are mounted in solderless terminals.

4.5 Current limits

The servo 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. In addition the peak current limit is time dependent as explained in 4.5.1.

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 1.6 second. 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 ISA-15/55 amplifier at constant speed and constant current of 5A. What is the maximum possible duration of a 20A peak ?

$$T_p = 2.2 \ln \frac{20 - 5}{20 - 15} = 2.42 \text{ seconds}$$

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 looses which become significantly high as speed increases and this leads to reduction of the continuous current limit. The ISA 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.

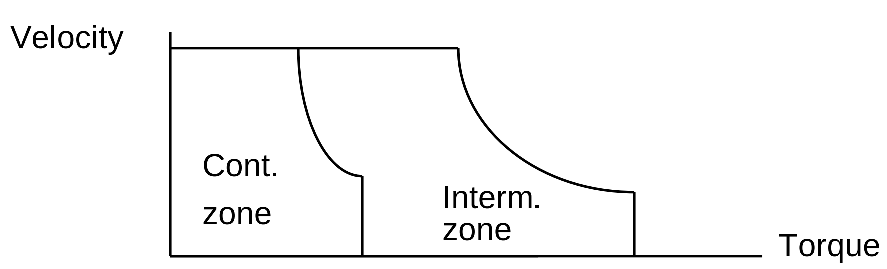


Fig. 4.2:

Typical operating envelope of a brush servo motor

4.6 Protective functions

All the protective functions activate internal inhibit. There are two modes of resetting the amplifier after the cause of the inhibit disappears: Self Restart and Latch.

- Self restart: The amplifier is inhibited only for the period that the inhibit cause is present.
- Latch: All failures latch the inhibit and only a reset signal will clear the latch.

4.6.1 Short circuit protection

This protection is realized by sensing current in the DC line. Every current peak above a certain value will inhibit the amplifier for a period of approx. 30mS (if in restart mode).

The amplifier is protected against shorts between outputs and either output to ground.

4.6.2 Under/over voltage protection

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

4.6.3 Temperature protection

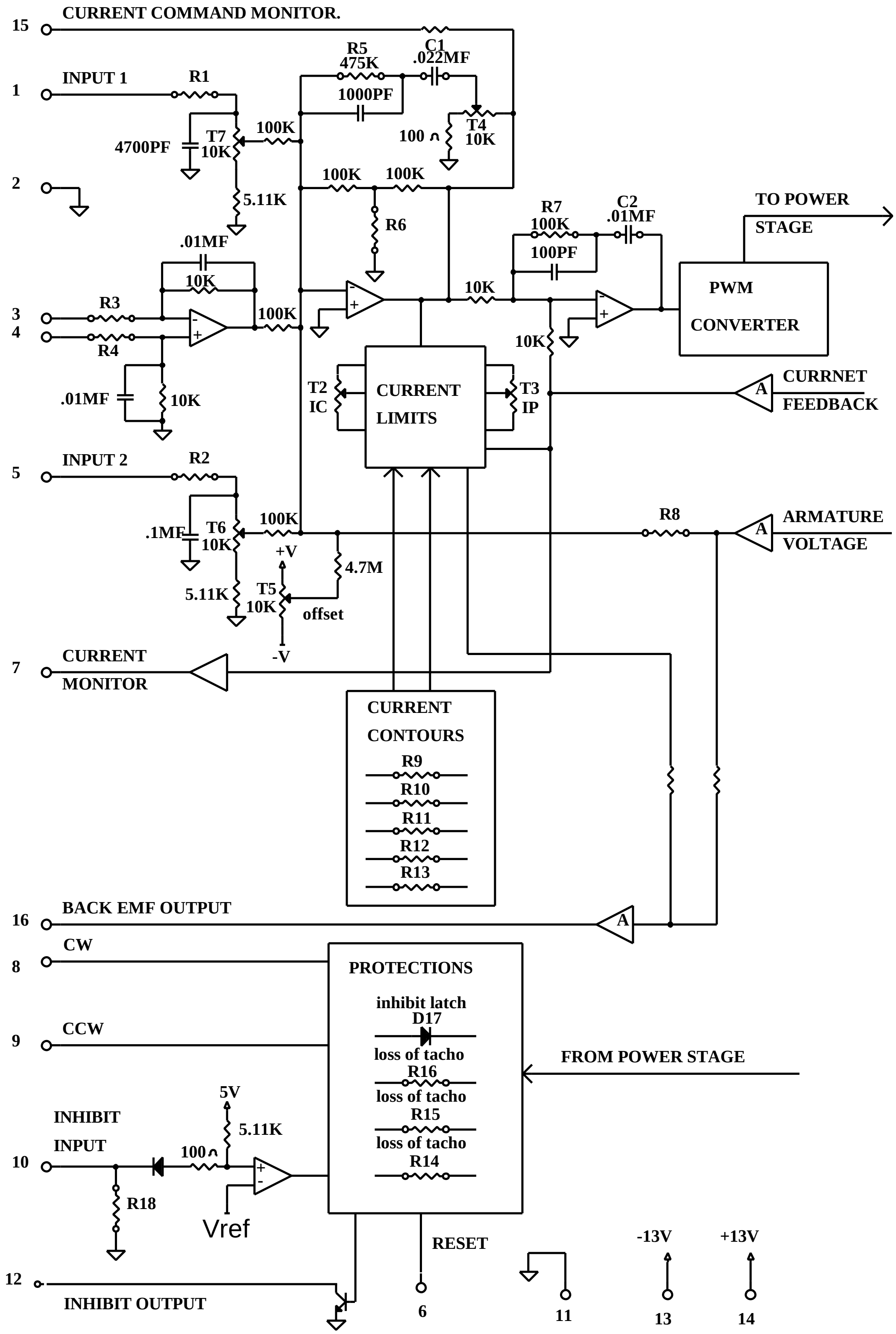
Temperature sensor is mounted on the heatsink. If, for any reason, the temperature exceeds 85▪C the amplifier will be inhibited. The amplifier will restart when the temperature drops below 80▪C.

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.

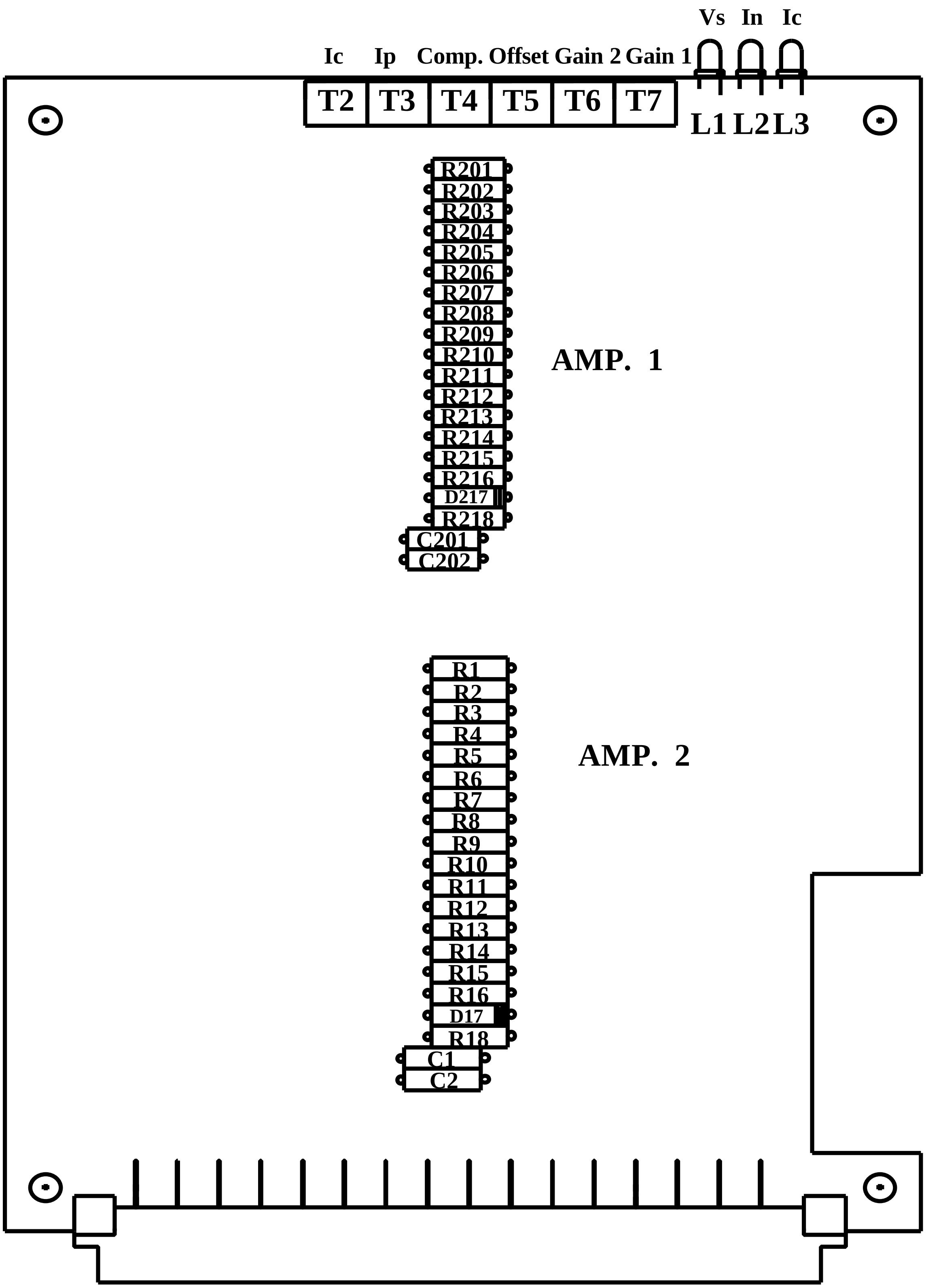
4.6.5 Loss of velocity feedback signal

If the amplifier loses the velocity feedback signal it will inhibit itself. In the "Self Restart" mode it will restart after a delay of 6-8 seconds.



All terminals numbers refer to the mother board

NOTE: ALL COMPONENTS DENOTED BY —o ARE MOUNTED IN SOLDERLESS PINS.


Vs In Ic
Ic Ip Comp. Offset Gain 2 Gain 1
T2 T3 T4 T5 T6 T7
L1 L2 L3
R201
R202
R203
R204
R205
R206
R207
R208
R209
R210
R211
R212
R213
R214
R215
R216
D217
R218
C201
C202
AMP. 1
R1
R2
R3
R4
R5
R6
R7
R8
R9
R10
R11
R12
R13
R14
R15
R16
D17
R18
C1
C2
AMP. 2

5. Terminal Description

5.1 Amplifier's connector pinout

Power stage

Din conn.	Function	Remark
(26,28,30,32 a&c)	Power input positive,(+Vs)	
(14,16 a&c)	Armature output-amplifier no. 1	This output will be negative when a positive signal is fed to one of the inputs.
(10,12 a&c)	Armature output-amplifier no. 1	This output will be positive when a positive signal is fed to one of the inputs.
(22,24 a&c)	Armature output-amplifier no. 2	This output will be negative when a positive signal is fed to one of the inputs.
(18,20 a&c)	Armature output-amplifier no. 2	This output will be positive when a positive signal is fed to one of the inputs.
(2,4,6,8 a&c)	Power input common.	

Control stage

Din conn. Amp 1/Amp 2		Function	Remark
18c	2c	Input 1	For more details see 4.1.
18a	2a	Circuit common	
20c	4c	Negative differential input	For more details see 4.1.
20a	4a	Positive differential input	For more details see 4.1.
22c	6c	Input 2	For more details see 4.1.

Control stage - cont.

Din conn. Amp 1/Amp 2		Function	Remark
22a	6a	Reset for latch mode	low level input voltage* enables the amplifier (see 7.1.5).
24c	8c	Current feedback monitor	Scale is = $\frac{Ic}{3.75}$ (A/V)
24a	8a	CW disable *	Low level signal disable.
26c	10c	CCW disable *	Low level signal disable.
26a	10a	Inhibit input *	Two modes - see chapter 7.1.1.
28c	12c	Circuit common	
28a	12a	Inhibit output indication	Whenever the Amplifier is inhibited, whether by an internal or external cause, this open collector output goes low state (max. sink current 10 mA, max. voltage 40V).
30c	14c	-13V	20mA external load.**
30a	14a	+13V	20mA external load.**
32c		Current command monitor - amplifier 1	Scale is = $\frac{Ic}{3.75}$ (A/V)
32a		Back EMF output - amplifier 1	See Apendix B.

---

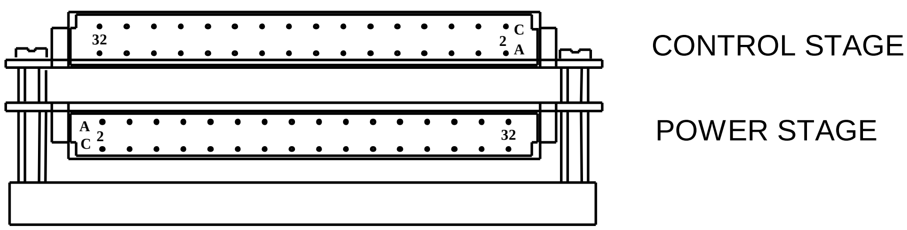
* $-1V < V_{il} < 1V$; $2V < V_{ih} < 30V$
Source sink capability - 2mA.

** The ⇧13V of each amplifier are independent supplies and should not be connected in parallel.

Control stage - cont.

Din conn. Amp 1/Amp 2		Function	Remark
	16c	Current command monitor - amplifier 2	Scale is = $\frac{Ic}{3.75}$ (A/V)
	16a	Back EMF output - amplifier 2	See Appendix B.

Remark: In the following paragraphs, the terminals will be related to the mother board terminals (M) and to the two pins in the DIN connector (one for each amplifier) as in the the following example:
M-10,R1-26a,R2-10a.



ISA DIN CONNECTORS

5.2 Mother board terminals

Power stage

M. board terminals	Function	Remark
Vs	Power input positive,(+Vs)	For both amplifiers
M1/1	Armature output-amplifier no. 1	This output will be negative when a positive signal is fed to one of the inputs.
M2/1	Armature output-amplifier no. 1	This output will be positive when a positive signal is fed to one of the inputs.
M1/2	Armature output-amplifier no. 2	This output will be negative when a positive signal is fed to one of the inputs.
M2/2	Armature output-amplifier no. 2	This output will be positive when a positive signal is fed to one of the inputs.
G	Power input common.	For both amplifiers

Control stage

M. board terminals	Function	Remark
1	Input 1	For more details see 4.1.
2	Circuit common	
3	Negative differential input	For more details see 4.1.
4	Positive differential input	For more details see 4.1.
5	Input 2	For more details see 4.1.

Control stage - cont.

M. board terminals	Function	Remark
6	Reset for latch mode	low level input voltage* enables the amplifier (see 7.1.5).
7	Current feedback monitor	Scale is = $\frac{Ic}{3.75}$ (A/V)
8	CW disable *	Low level signal disable
9	CCW disable *	Low level signal disable
10	Inhibit input *	Two modes - see chapter 7.1.1
11	Circuit common	
12	Inhibit output indication	Whenever the Amplifier is inhibited, whether by an internal or external cause, this open collector output goes low state (max. sink current 10 mA, max. voltage 40V).
13	-13V	20mA external load.**
14	+13V	20mA external load.**
15/1	Current command monitor - amplifier 1	Scale is = $\frac{Ic}{3.75}$ (A/V)
16/1	Back EMF output - amplifier 1	See Appendix B
15/2	Current command monitor - amplifier 2	Scale is = $\frac{Ic}{3.75}$ (A/V)

---

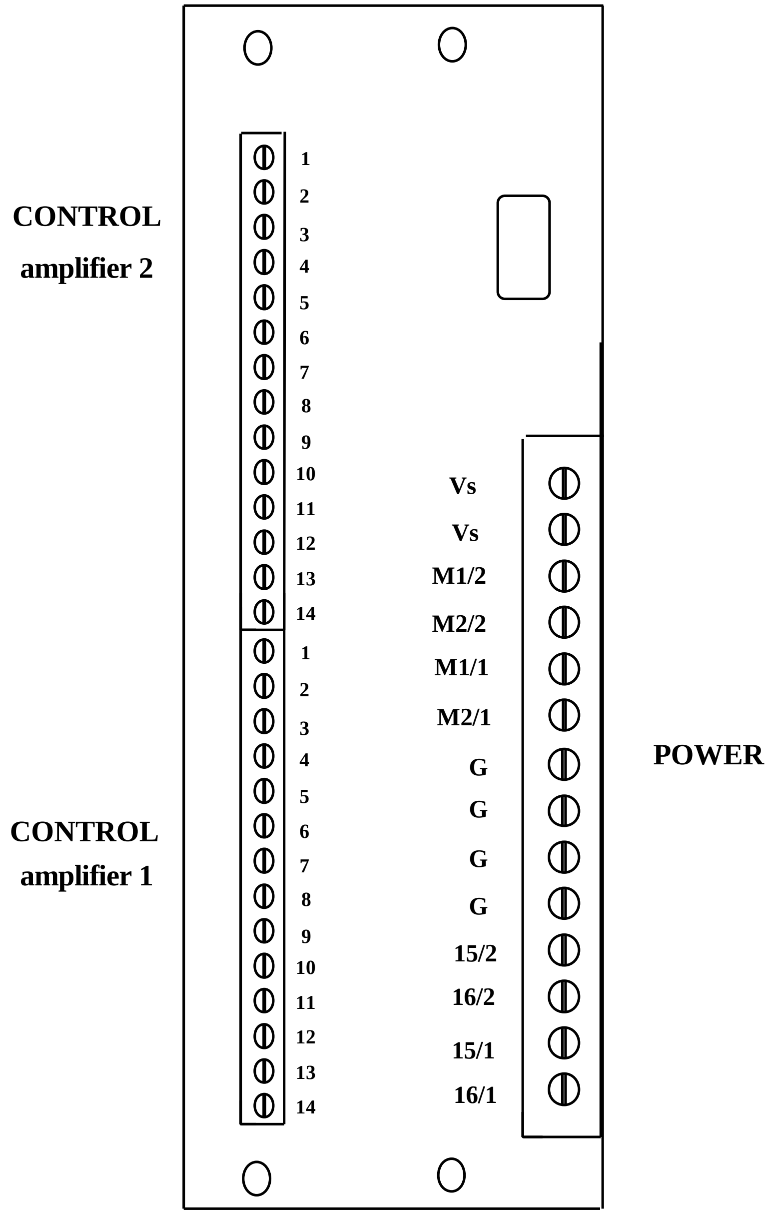
* -1V < Vil < 1V ; 2V < Vih < 30V
Source sink capability - 2mA.

** The ñ13V of each amplifier are independent supplies and should not be connected in parallel.

Control stage - cont.

M. board terminals	Function	Remark
16/2	Back EMF output - amplifier 2	See Appendix B

Remark: In the following paragraphs, the terminals will be related to the mother board terminals (M) and to the two pins in the DIN connector (one for each amplifier) as in the the following example:
M-10,R1-26a,R2-10a.


CONTROL
amplifier 2
1
2
3
4
5
6
7
8
9
10
11
12
13
14
CONTROL
amplifier 1
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Vs
Vs
M1/2
M2/2
M1/1
M2/1
G
G
G
G
15/2
16/2
15/1
16/1
POWER

MBA - ISA/N

6. Installation procedures

6.1 Mounting

The ISA amplifiers dissipate their heat by natural convection. Fan cooling is not required.

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 50% limit (10-20% of rated current is recommended). The armature current ripple (Ir) can be calculated by using the following equation:

$$Ir = \frac{0.5 \times Vs}{f \times L} \quad (A)$$

L - load inductance in mH.

Vs - Voltage of the DC supply in Volts.

f - Switching frequency in KHz.

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

$$Lch = L - Larm$$

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:

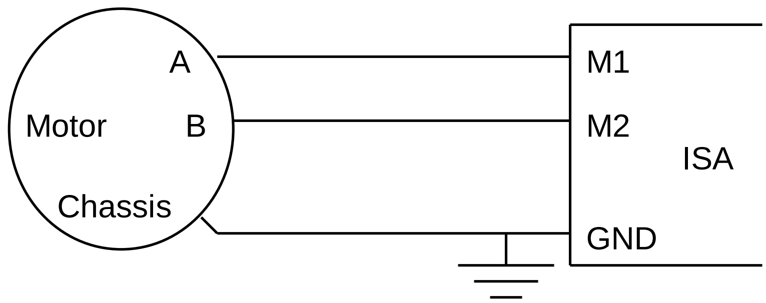
$$1.2V_{dcmin} < Vdc < 0.9V_{dcmax}$$

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

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

6.5 Wiring diagrams

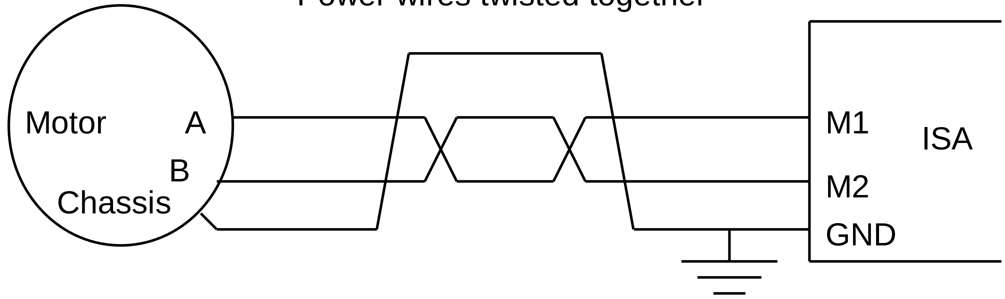
MOTOR WIRING



Minimum acceptance

==

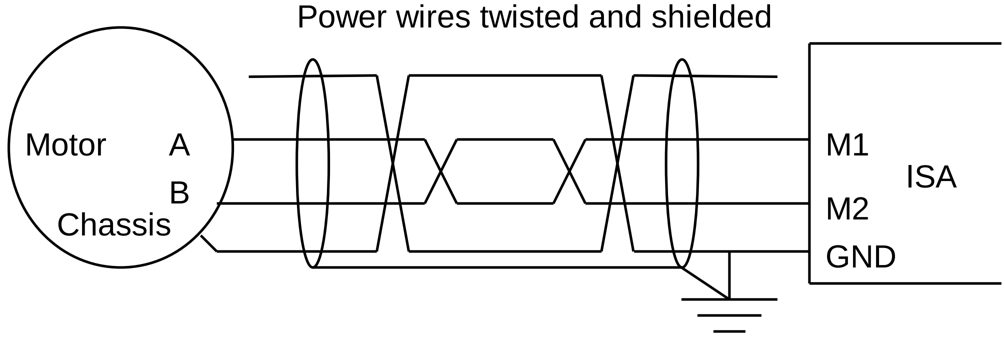
Power wires twisted together



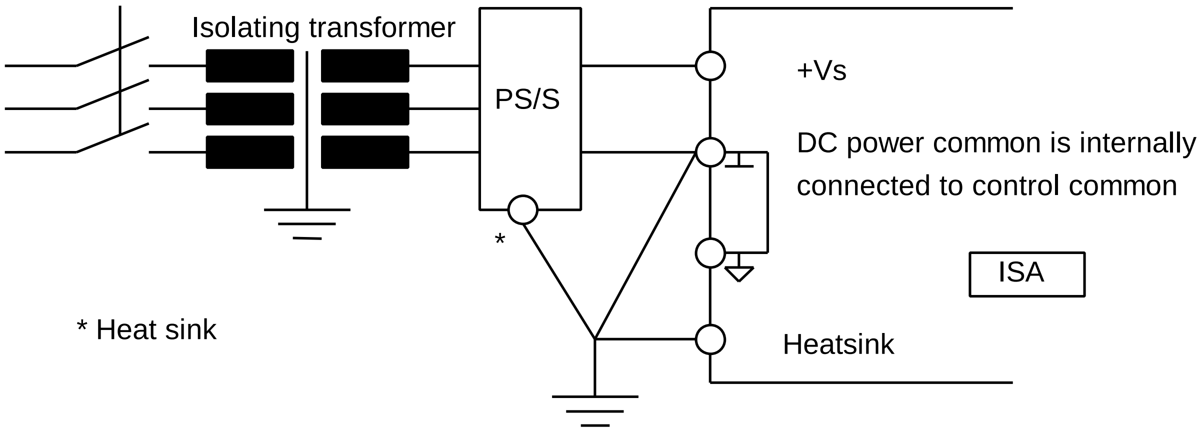
Acceptable for most applications

==

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

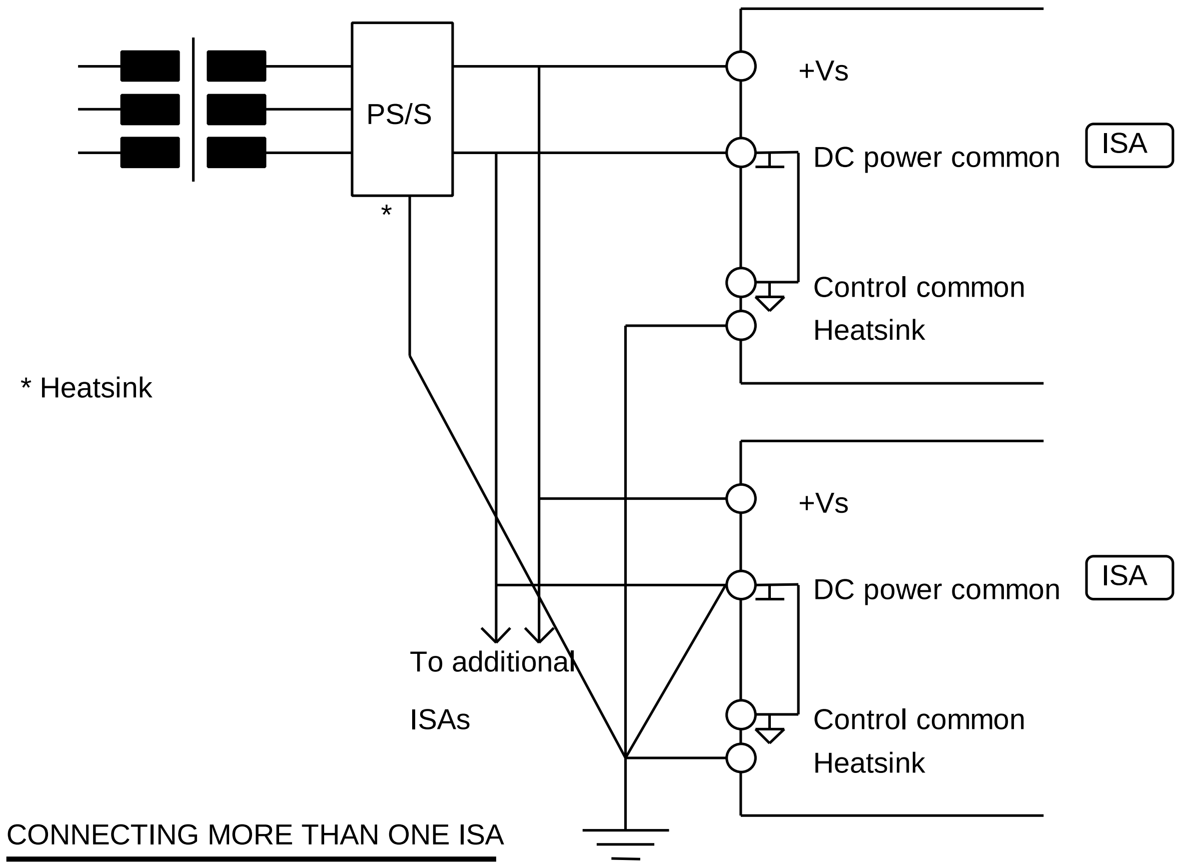
Amplifier's heat sink (by grounding the rack)

Do not ground:

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

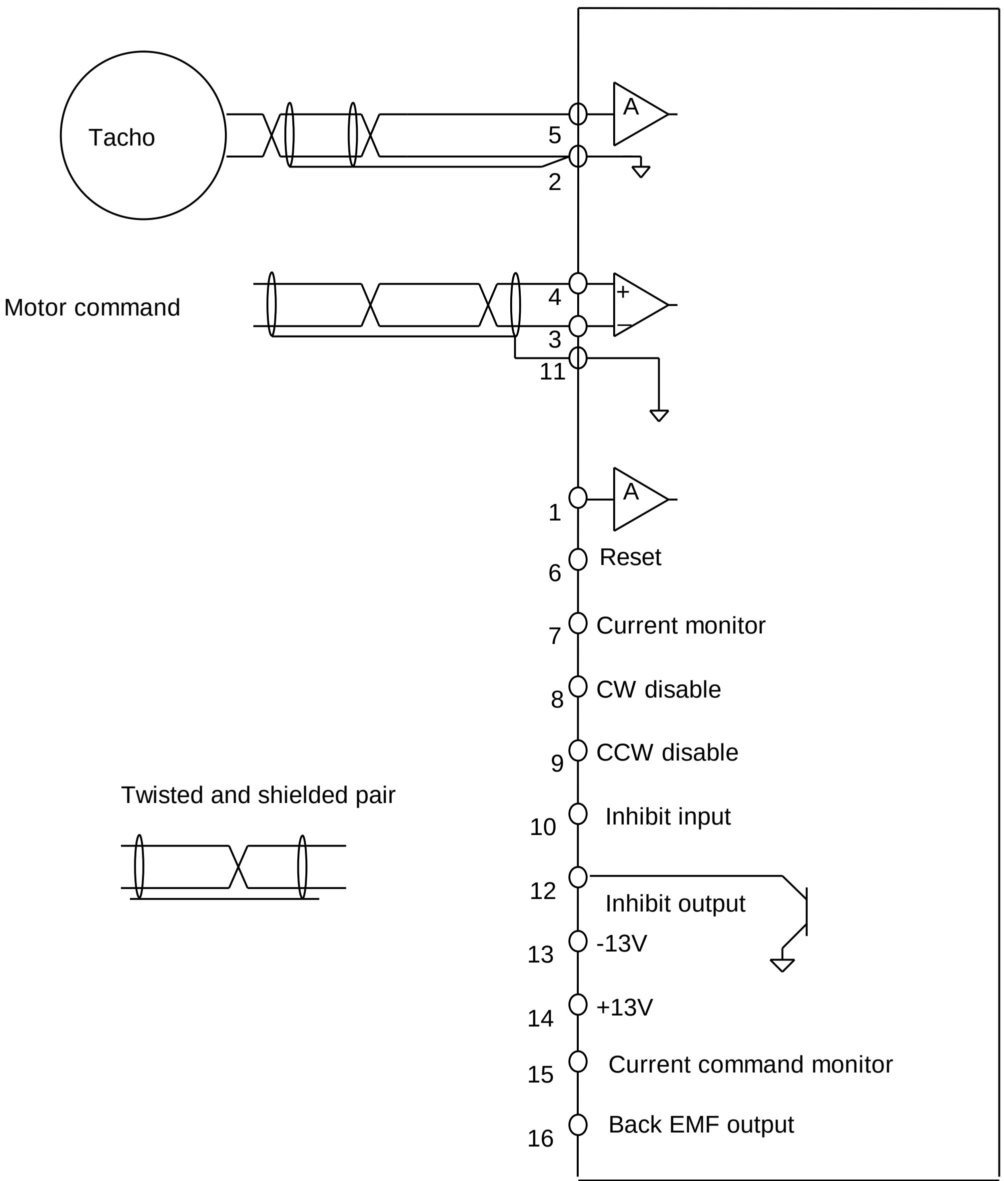
Caution:

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



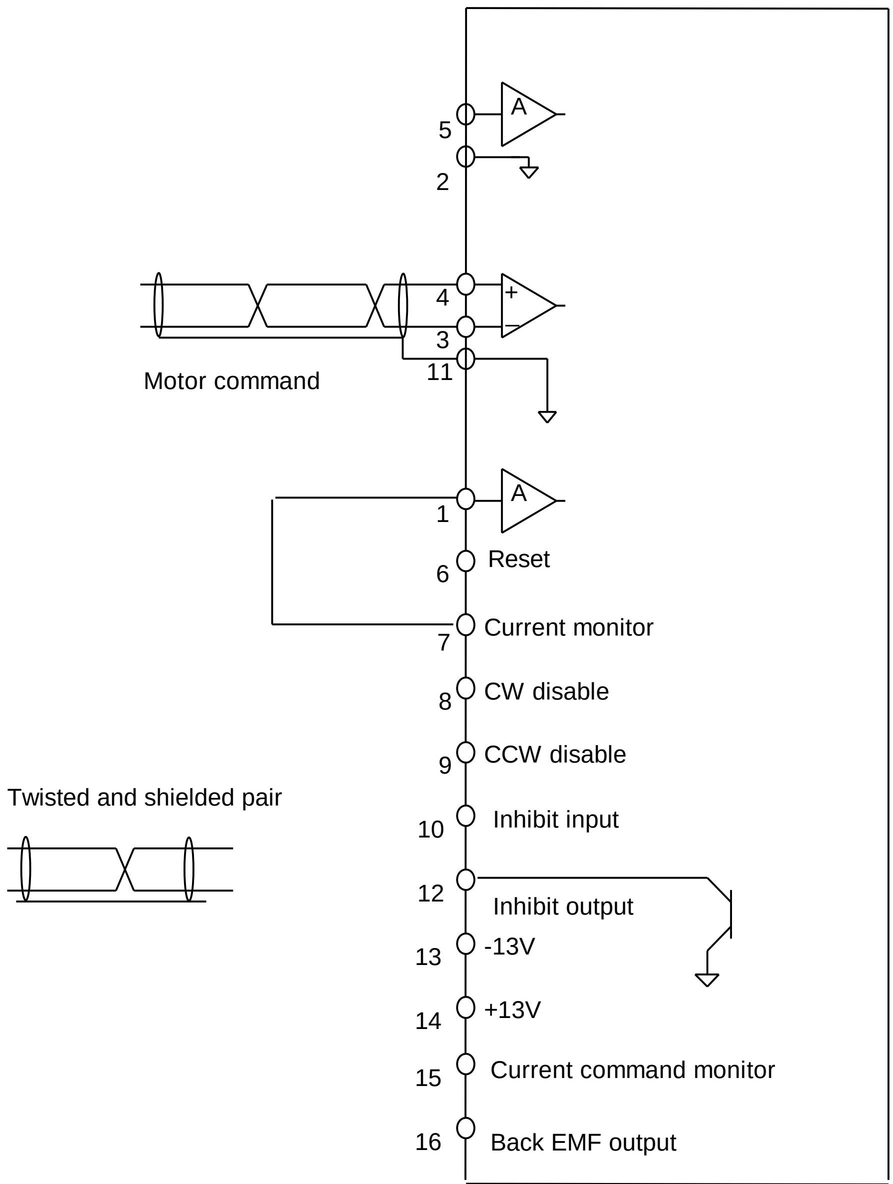
CONNECTING MORE THAN ONE ISA

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



ISA CONTROL CONNECTIONS

TACHOGENERATOR FEEDBACK



ISA 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.**
- **In the following paragraphs all the referred components have the same numbers for each "half" of the ISA card.**

7.1 Common procedures for all amplifiers types

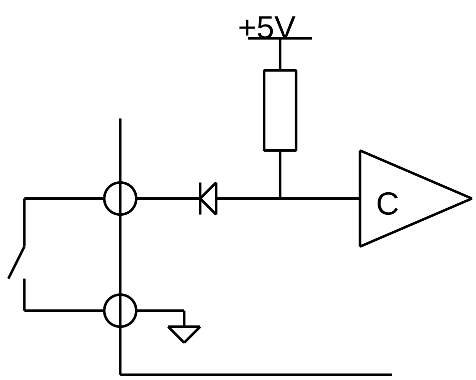
7.1.1 Inhibit logic

Select the desired Inhibit logic you need:

a) Disable by Low

Inhibit function will be activated by connecting its input to a low level signal. If no signal is applied to this input the amplifier will be enabled upon power on.

For this logic, R18 should not be installed.



ISA DISABLED BY ACTIVE LOW OR CLOSED CONTACT

$-1V \leq Vil < 1V$

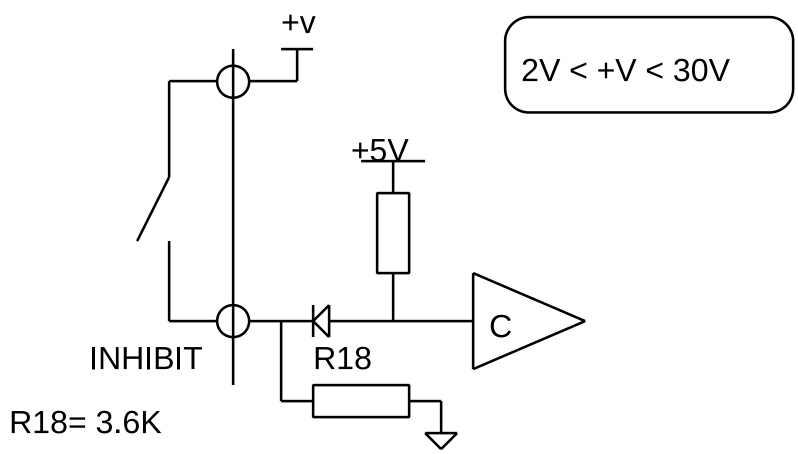
$2V \leq Vih < 30V$

b) Enable by High

Inhibit function will be de-activated by connecting its input to a high level signal. If no signal is applied to this input the amplifier will be disabled upon power on.

For this logic insert 3.6Kohm ($\pm$10%) resistors for R18. The power of this resistor is calculated according to:

$Pmin=V^2/1500$ (Watt)



ISA 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 PI amplifier.

Make sure that: R6 (30ohm), R5 (475Kohm) and C1 (0.022 µF), in solderless 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 R6 (in solderless terminals).

- Remove C1 (in solderless 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 ISA has 2 single ended inputs and a differential input.

The standard procedure recommends to use the differential input for the reference signal.

Following are the input maximum voltage and impedance with the standard values of input resistors:

INPUT - RESISTOR	STANDARD VALUE	MAX. VOLTAGE	Current Gain(A/V) (in current mode)	INPUT IMPEDANCE
Input 1 - R1	2.49Kohm	11V	0.46xIc	17.5 Kohm
Input 2 - R2	15Kohm	19V	0.27xIc	30Kohm
Differential - R3,4	20Kohm	30V	0.27xIc	30 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 installing R14, R15, and R16 as follows:

$$R14 = \frac{2430}{Vam} \quad (Kohm)$$

$$R15 = \frac{100 \times Vam}{Ip \times Rm} \quad (Kohm)$$

$$R16 \le 10 \ ohm$$

Vam - Armature voltage at maximum application speed.

Ip - Amplifiers' rated peak current limit.

Rm - Total ohmic resistance of motor.

R9 should be calculated and inserted according to the tacho voltage at maximum application velocity (Vtm):

For Vtm > 7.5V:

insert R9 = 301Kohm.

For Vtm < 7.5V:

$$R9 = \frac{2250}{Vtm} \quad (Kohm)$$

7.1.5 Latch mode of the protective functions

Self Restart (D17 removed): The amplifier is inhibited only for the period that the inhibit cause is present.

Latch (D17 inserted) Failures 4.6.1-5 latch the Inhibit and the diagnostic LED. For restart (after clearing the failure source), reset has to be performed by connecting the reset input to the circuit common.

7.1.6 Activating the dynamic contouring of the current limits

If you do not use this feature make sure that R11 and R13 are not installed on the board.

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

7.2 Velocity control using tachogenerator feedback

When using tacho feedback, it is recommended to use the single ended input no.2 for the tacho signal and to use the differential input for the reference signal in order to reduce common mode noises.

R2,R3 and R4 are calculated and inserted for two tacho voltage ranges:

For Vtm > 7.5V

R3 = R4 = 1.33xVdm (Kohm)
Vdm - maximum reference voltage at the differential input.

R2 = 2xVtm - 15 (kohm)
Vtm - Voltage generated by the tacho at maximum velocity.

For Vtm < 7.5V

R3 = R4 = 10xVdm/Vtm (Kohm)
Vdm - maximum reference voltage at the differential input.
Vtm - Voltage generated by the tacho at maximum velocity.

R2 = 470 Ohm

7.3 Velocity control using armature voltage feedback

The reference signal should be connected to the differential input and R3,R4 should be calculated and inserted according to:

R3 = R4 = 1.33xVdm (Kohm)
Vdm - maximum reference voltage at the differential input.

The armature voltage feedback will enter the error amplifier by inserting R8, calculated as follows:

R8 = 0.82xVam (Kohm)

Vam - armature voltage at maximum application speed

IxR compensation

In order to improve the speed stability in various load conditions, an IxR compensation is required. This is achieved by:

- Connect the Current Feedback Monitor (terminal M-7,R1-24c,R2-8c) to input 1 (terminal M-1,R1-18c,R2-2c).
- Rotate T7 to max. CCW position (minimum IxR compensation).
- Insert R1 as follows:

$$R1 = \frac{3 \times Vam}{Rm \times Ip} \quad \text{(Kohm)}$$

Vam - Armature voltage at maximum application speed.

Ip - Amplifiers' rated peak current limit.

Rm - Total ohmic resistance of motor.

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.

8.2 Current limits adjustment

The amplifiers' current limits can be adjusted without the need for loading. disconnect motor leads and connect a voltmeter between the Current command monitor (terminal M-15,R1-32c,R2-16c) and the circuit common. Apply maximum input voltage to one of the inputs to cause an error at the error amplifier (input gain trimmer should be fully CW). In order to adjust the continuous limit - turn T3 (Ip) fully CCW to disable Ip, then use T2 (Ic) to adjust the continuous limit by monitoring the meter readout. Full CW rotation of T2 will result in rated current limit. After adjusting the continuous limit, turn T3 up to the desired peak level.

The current monitor range is up to 7.5V and its scale depends on the amplifier rated continuous current (Ic) and is given by:

Current monitor scale (A/V) :	$\frac{Ic}{3.75}$

8.3 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.

It is also possible to increase/decrease the command gain (change the fix resistors of the differential amplifier) in order to 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.

8.4 Adjustment of the IxR compensation

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

After following all the instructions in 7.3, you may improve the speed stability in various load conditions by performing the following procedure:

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

b. Apply nominal load.

c. Increase IxR compensation (CW rotation of gain 1 - trimmer T7) until motor's 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 C1 and R5 is recommended. The final values depend on the type of motor and mechanical load, so optimum results will be achieved by the empirical method.

8.5 Response adjustment - Velocity loop

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, ñ2.0V waveform is often employed)
- Apply power to the amplifier, and while monitoring the tachometer signal, gradually adjust the COMP trimmer from the CCW toward the CW position. Optimum response (critically-damped) should be achieved at some position before reaching full CW on T4. Fig 8.1 illustrates the types of waveforms observed for various setting of T4.

In some applications, especially those where the load inertia is much smaller or larger than normally encountered, the standard compensation components values of 0.022↘F for C1 and 470Kohm for R5 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 C1 and R5 must be chosen. The following procedure can be used to select these values:

- Short circuit C1 with a short jumper wire.
- Replace R5 with a decade resistance box. Initially set the box resistance at 20Kohm.
- Set T4, the COMP trimmer to approximately midrange.
- Input a 0.5Hz, ñ2V bi-directional square wave velocity command signal to the amplifier.
- Apply power, and while monitoring the tachometer signal, gradual increase the value of the box resistance until optimum response a depicted in Fig 8.1 is achieved.
- Substitute the closest standard value discrete resistor for R6 and remove the decade resistance box.
- Remove the shorting jumper across C1, and again check the response using the squarewave test signal. If near optimum result 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 0.022 μF; or, if the response is overdamped substitute a smaller value than 0.022 μF. Repetition of this procedure should yield an optimum choice for C1.

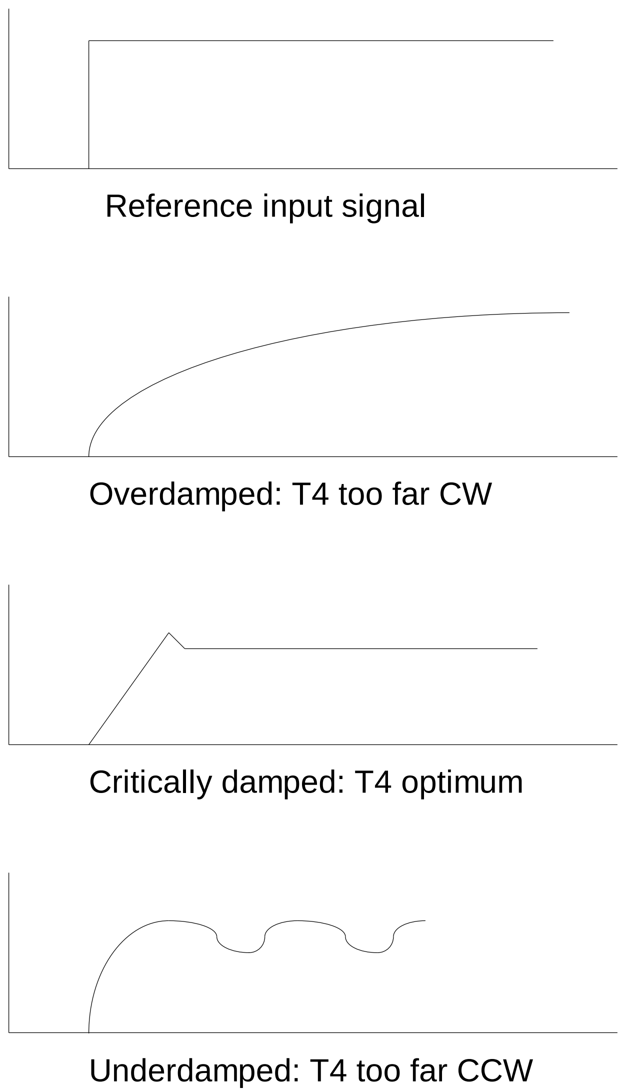


Fig. 8.1

Typical velocity response waveforms

9. Tables and summaries

9.1 Adjusting trimmers

Six trimmers are installed on the ISA board with the following functions:

T7 (Gain 1) - CW rotation increases input 1 gain.

T6 (Gain 2) - CW rotation increases input 2 gain.

T5 (Balance) - see 8.1.

T4 (compensation) - See 8.5.

T3 (Ip) - CW rotation increases peak current limit (see 8.2).

T2 (Ic) - CW rotation increases continuous current limit (see 8.2)

9.2 LED diagnostics

Three LEDs for each amplifier are installed on the ISA with the following designations: Ic, In, Vs. Under normal operation only Vs should illuminate (Vs indicates the existence of supply voltages).

The following table represents the faults indications of the LEDs:

	1	2
Ic		X
In	X	
Vs	X	X

X - Illuminated LED

1. One or more of: external inhibit, under/over voltage, short circuit, excess temperature, loss of tacho or insufficient load inductance.
2. Continuous current limit.

Appendix A - Response adjustment - 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 0.01↘F for C2 and 100Kohm for R7 may not yield with the optimum response. The current loop should be optimized as follows:

- Turn the amplifier to a current amplifier by removing C1 and R6.
- 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.

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

- Short circuit C2 with a short jumper wire.
- Replace R7 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 depicted in Fig A-1 is achieved.
- Substitute the closest standard value discrete resistor for R7 and remove the decade resistance box.
- Remove the shorting jumper across C2, 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↘F; or, if the response is overdamped, substitute smaller value than 0.01↘F. Repetition of this procedure should yield an optimum choice for C2.

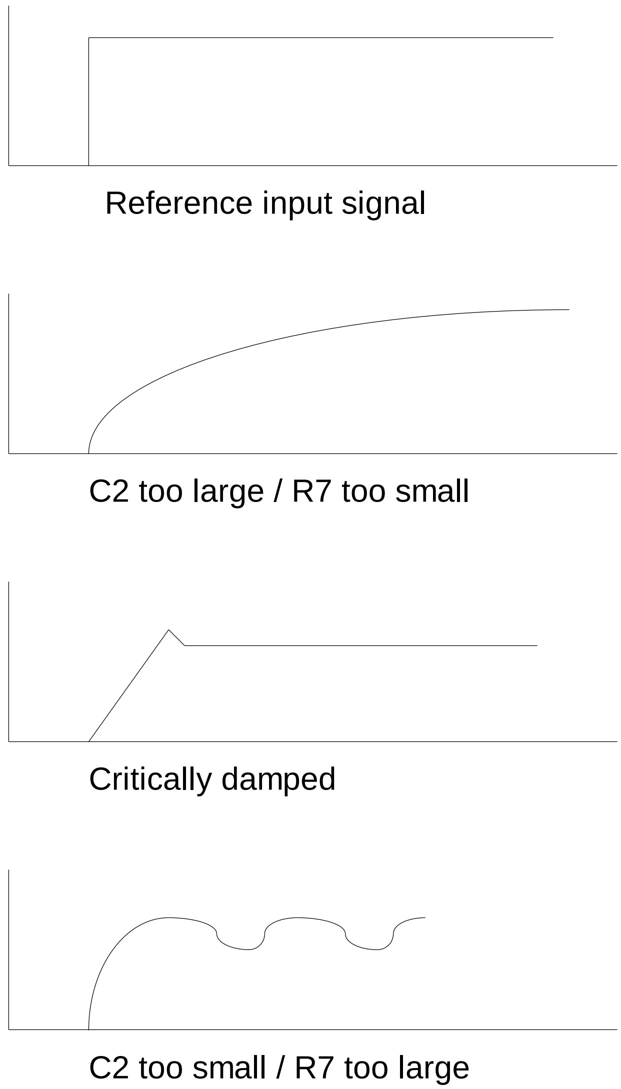


Fig. A-1

Typical current response waveforms

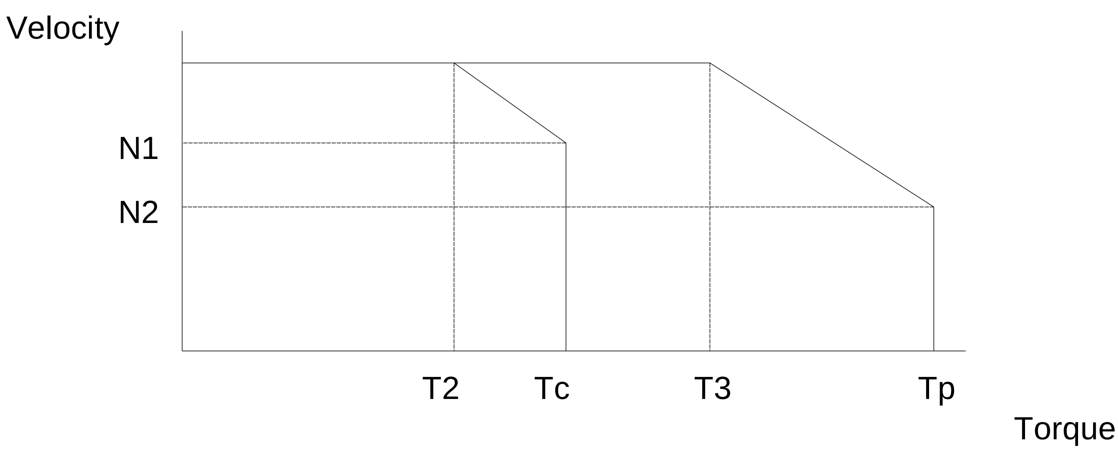
Appendix B - Current limits contour adjustment

The amplifier can be configured to have either continuous current limit or peak current limit or both which depend on motor velocity feedback. This function is enabled by calculating and inserting R11, R13.

The continuous current limit is speed dependent when R11 is inserted.

The peak current limit is speed dependent when R13 is inserted.

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



Tc - Max continuous torque up to velocity N1

T2 - Continuous torque at max velocity (Nmax).

Tp - Max peak torque up to velocity N2.

T3 - Peak torque at maximum velocity.

Fig. B-1: Current limits contour

The user should derive the relations r1=N1/Nmax, r2=T2/Tc, s1=N2/Nmax and s2=T3/Tp from the motor data sheet.

R11 and R10 (for continuous limit) and/or R13/R12 (for peak limit) should be installed according to the following relations:

Continuous current limit contouring:

$$R11 = 18.3 \frac{1 - r1}{1 - r2} \quad (\text{Kohm})$$

$$R10 = 36.6 \frac{R11}{R11 + 20r1} \quad (\text{Kohm})$$

Peak current limit contouring:

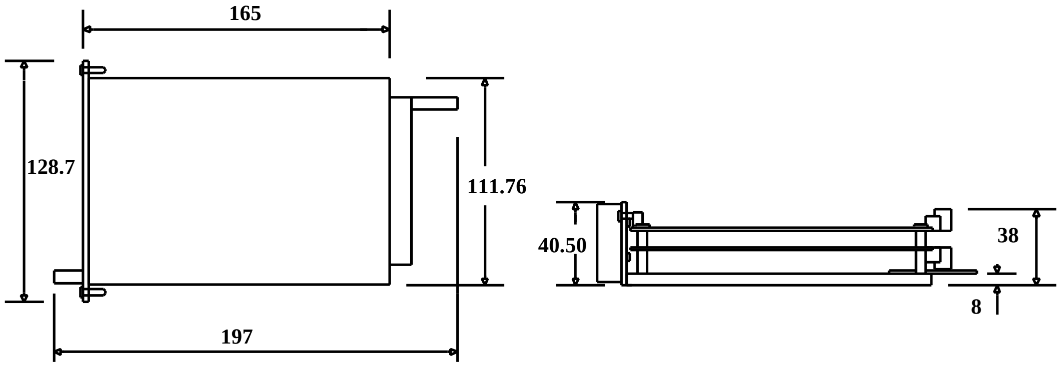
$$R13 = 18.3 \frac{1 - s1}{1 - s2} \quad (\text{Kohm})$$

$$R12 = 36.6 \frac{R13}{R13 + 20s1} \quad (\text{Kohm})$$

Dynamic contouring with armature voltage feedback

- IxR compensation must be activated as in 7.3
- Connect the Back EMF (terminal M-16,R1-32a,R2-16a) to input 2 (terminal M-5,R1-22c,R2-6c).
- Remove R31.
- Insert R2 = 470 Ohm
- Insert R9 = 301 Kohm
- Calculate and insert R14 as in 7.1.4.

DIMENSIONAL DRAWINGS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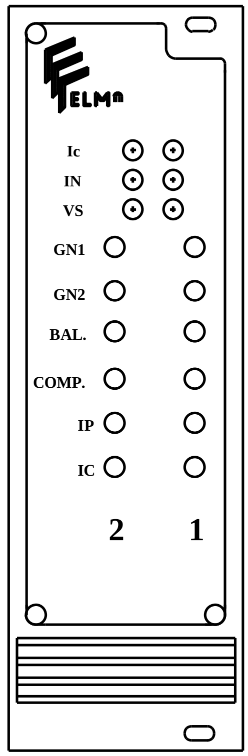

FRONT PANEL FOR ISA

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