INFRANOR

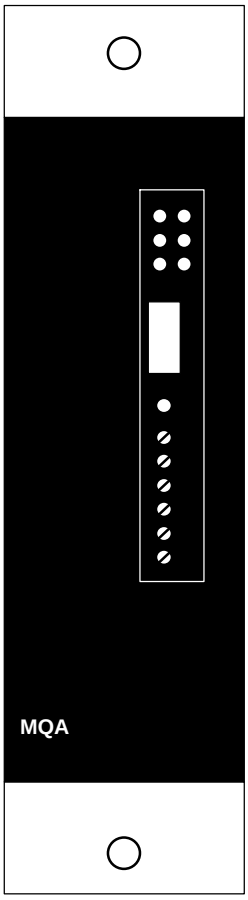
OPERATING MANUAL

SERIES MQA

BRUSHLESS SERVO CONTROLLERS

(Trapezoidal Type)

Version 1.0



This is a general manual describing a series of single axis DC trapezoidal Servo amplifiers having output capability suitable for driving DC brushless Servo motors. This manual may be used in conjunction with appropriate and referenced drawings pertaining to the various specific models. Maintenance procedures should be attempted only by highly skilled technicians using proper test equipment. Read your warranty provision carefully before attempting to adjust or service the unit.

RECEIVING AND HANDLING

Upon delivery of the equipment, inspect the shipping containers and contents for indications of damages incurred in transit. If any of the items specified in the bill of lading are damaged, or the quantity is incorrect, do not accept them until the freight or express agent makes an appropriate notation on your freight bill or express receipt.

Claims for loss or damage in shipment must not be deducted from your invoice, nor should payment be withheld pending adjustment of any such claims.

Store the equipment in a clean, dry area. It is advisable to leave the equipment in its shipping container until ready for use. Each amplifier is checked carefully before shipment. However, upon receipt, the user should make sure that the amplifier received corresponds to or is properly rated in terms of rated voltage and current for the type of motor which is to be driven. The descriptive label affixed to the amplifier specifies electrical ratings.

OPERATING MANUAL
INFRANOR
SERIES MQA
PWM BRUSHLESS SERVO CONTROLLERS
(January 1999)

1.0.0 GENERAL

1.1.0 Introduction

The MQA servo modules are extremely compact PWM servo amplifiers that provide 4 quadrant speed control of any trapezoidal servo motors with Hall-effect feedback. The MQA Series amplifiers are designed for regulation of brushless DC motors. The MQA power supply transforms ac voltage into dc voltage. From dc voltage the amplifier produces the current for the motor. Hall sensors produce necessary information concerning rotor position. Output current is PWM controlled and due to high chopper frequency a large bandwidth and dynamics are obtained.

Relations for the operation of the motor:

- Torque is proportional to output current
- Speed is proportional to frequency of output current
- Direction of rotation corresponds to sense of rotation of the output current

1.2.0 General description of the MQA Series

The MQA Series amplifier modules for DC brushless motors consist of:

- one power stage card
- one logic card to be adapted to any DC brushless motor having Hall sensor devices
- one single or three phase power supply
- one shunt regulator circuit with an internal resistor

Each MQA module has its own DC/DC converter to provide appropriate logic voltage to the module without the need for an additional input voltage. The rated input voltage is 90 or 175VAC rms between phases, which provides a DC Bus voltage of 125 or 240 VDC.

The MQA module requires an isolation transformer. A rectifier and a shunt regulator are also included in the MQA module. The braking resistor is mounted internally to the unit.

2.0.0 SPECIFICATIONS

2.1.0 MQA specifications

Model	I_{max} (A)	I_{eff} (A)	*Input voltage*	*Output voltage*	*Heatsink*
MQA 1204	8	4	45-90VAC	120VDC	No
MQA 1208	16	8	45-90VAC	120VDC	No
MQA 1210	20	10	45-90VAC	120VDC	No
MQA 2404	8	4	45-175VAC	240VDC	No
MQA 2408	16	8	45-175VAC	240VDC	No
MQA 2410	20	10	45-175VAC	240VDC	Yes

Powerstage

Model	**MQA 12 xx**	**MQA 24 xx**
Input voltage *****	45-**90** VAC	45-**175** VAC
Output voltage	120 VDC	240 VDC
Overvoltage	159 VDC	320 VDC
Sunt regulator on	152 VDC	307 VDC
Shunt regulator off	147 VDC	297 VDC

PWM chopper frequency	16 KHz
Protection	Over current Over voltage Short-circuit Over temperature

***** Isolation transformer required

Speed regulator

Input voltage	Differential ± 10 V DC , 20 KΩ impedance
Tacho reference signal	3 ph AC Tach or DC Tach , Encoder or Tach (option)
Compensation network	PI (PID)
P-Gain correction	Potentiometer adjustment
I-Gain correction	Component
Speed control range	1: 10000 with linear tach 30- 3000 (6000) rpm ± 0,1 % 1-30 rpm ± 0,3 % < 1 rpm ± 5 %

Current regulator

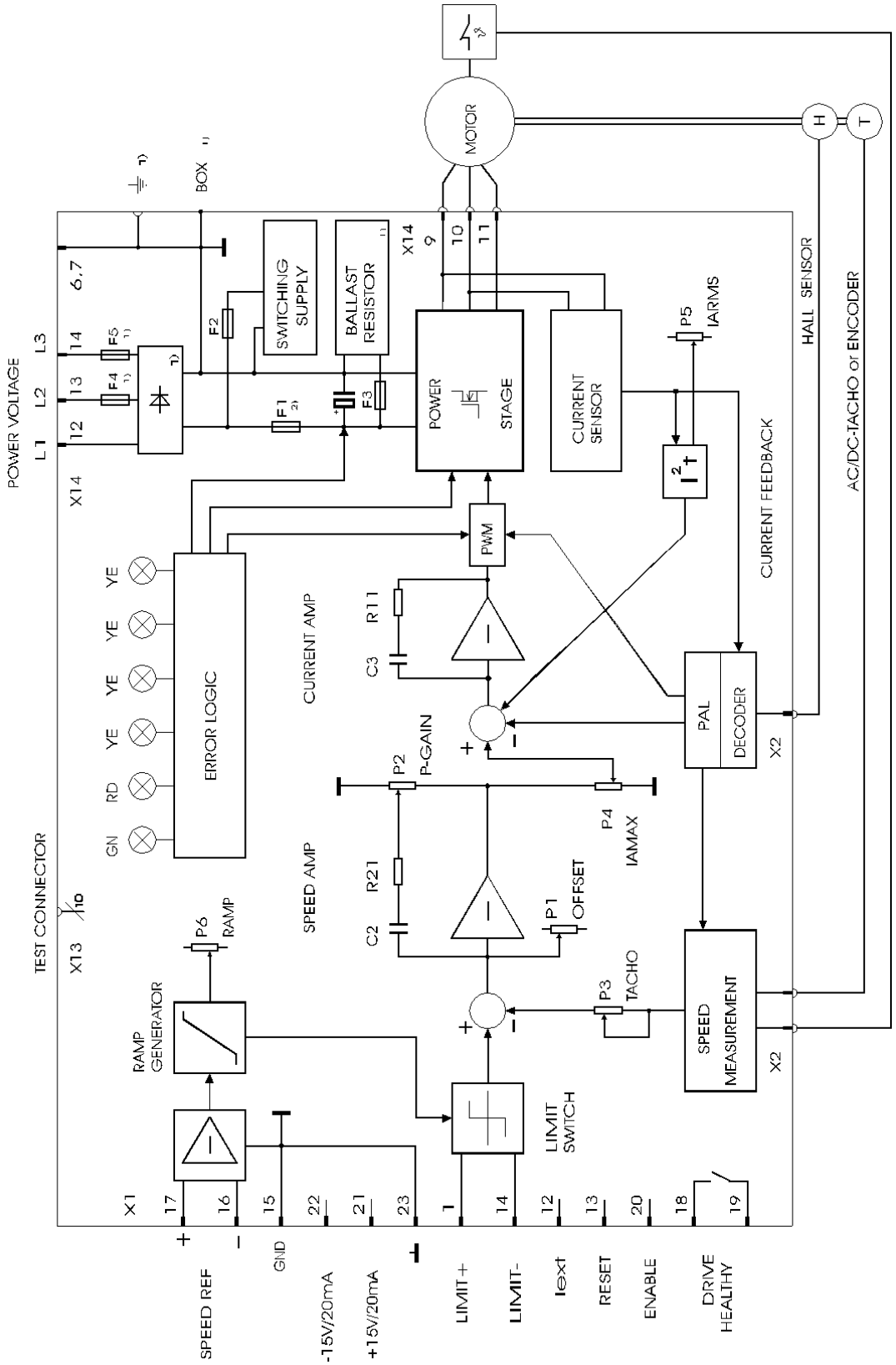
Compensation network	PI
Current limit 1	I_{max} adjustment with potentiometer
Current limit 2	I_{eff} adjustment wiith potentiometer
Current monitor	± 10 V = ± I_{max} @ ± 10 %
Band width	1 KHz
Amplifier ready signal	Dry relay contact 100 V , 20 mA

General specifications

Operating temperature	0....45 °C
Storage temperature	-10 to + 60 °C
Cooling	Air convection or fan (see table)
Humidity	65 % relative humidity max.

3.0.0 PRINCIPAL OF OPERATION

3.1.0 Block diagram

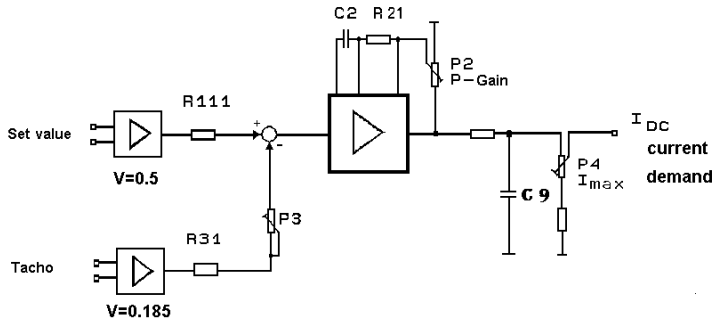


3.2.0 Speed controller

In order to achieve best performance for the system motor/amplifier, optimization of speed circuit is necessary. The following components are used:

- P2 /R21: P- Gain
- C2: I - Gain
- P3/R31: tachometer signal

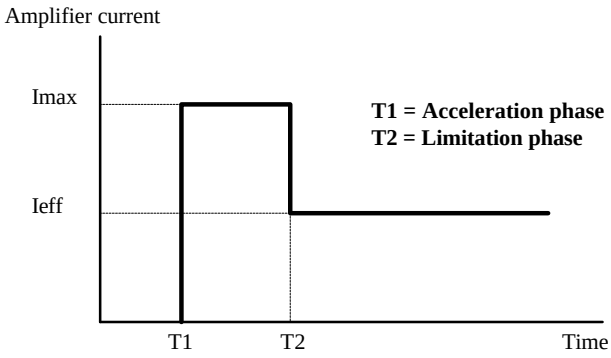
Components can be adjusted at the factory.



3.3.0 Armature Current Measurement

Armature current is measured by means of a shunt placed in series with the armature circuit. The voltage produced can be measured at the "I-Monitor" test point. 10 Volts output corresponds to the maximum current of the amplifier.

Eff - Function I_{Arms}



The Ieff value of the armature current is constantly simulated with the aid of an electronic qudrant network. Irrespective of the cycle or the shape of current wave form, a potentiometer ensures that the Ieff value is not exceeded by lowering the maximum current threshold. This functional response is indicated by a yellow LED.

3.4.0 External current limitation

With this function, the armature current I_{Amax} can be set by an external voltage to the value desired (if open input = no limitation). The relation of current limit is: 8...100 % Imax for a control voltage from 0...9V (referenced to GND).

3.5.0 Ramp generator

The speed command integrator provides acceleration and deceleration of the motor without negative effects on control precision or stiffness. Every speed command voltage (positive or negative) will be converted in a ramp function. Time constant can be altered with P6 within the following limits (see section 6.2.2). Asymmetrical conditions of positive or negative ramp will be achieved by using R169 (positive ramp) and/or R170 (negative ramp) as shown in section 6.2.2.

3.6.0 Encoder option (velocity feedback)

From the signals of the encoder the “encoder tach” circuitry generates a DC tach signal. In order to reach an optimal tach signal , the “encoder tach” has to be adjusted to the following parameters (see section 6.6.0):

- Encoder resolution
- Maximum speed
- Polarity

Tach voltage polarity can be reversed with jumper BR3 and BR4 if motor runs away. Exceeding the speed range selected with BR 5- 7 leads to saturation, therefore it is important to adapt the encoder resolution vs.the motor maximum speed.

3.7.0 Limit Switch Inputs

Connecting 24 VDC to the terminals for negative and positive limit switch will enable the corresponding motor direction. Two yellow LED will indicate the limit switch status. Negative or positive command logic can be selected according to section 6.4.0.

3.8.0 Isolation power transformer

An isolation transformer is necessary to power the MQA Series. If a three phase isolation transformer is to be used, do not connect the neutral to earth ground. This would result in a power stage failure.

4.0.0 INPUTS / OUTPUTS

4.1.0 X1 Input - Output command connector (Sub-D 25 points male)

Pin	Function	I / O	REMARKS
1	Limit switch +	I	Positive or negative logic (see section 6.4.0)
	(Tach monitor)	O	Optional output 0 to ± 10V
2	NC		
3	NC		
4	Marker Z/	O	Differential output of the encoder marker pulse
5	Marker Z	O	Differential output of the encoder marker pulse
6	Channel A/	O	Differential output of the encoder channel A
7	Channel A	O	Differential output of the encoder cahnnel A
8	Channel B/	O	Differential output of the encoder channel B
9	Channel B	O	Differential output of the encoder cahnnel B
10	I-Gain on/off	I	I-Gain on or off, I-gain on if open
11	0 Volts		
12	Current limitation I limit	I	External current limitation 0 to 10 V for 100 % to 0 % of Imax
13	Reset	I	Amplifier reset (contact between 13 and 11)
14	Limit switch +	I	Positive or negative logic (see sction 6.4.0)
	(Current monitor)	O	Optional output 0 to ± 10V
15	0 Volt speed input command CV	I	
16	Input command CV +	I	± 10 V speed input command for max. speed
17	Input command CV -	I	or current ± 10 V input command for Imax if amplifier is set in current mode
18	Amplifier ready	O	Relay contact: closed if amplifier OK, open if fault.
19	Amplifier ready	O	Umax = 100 V or Imax = 10 mA
20	ENABLE	I	Positive or negative logic (see section 6.4.0)
21	+ 15 V	O	10 mA maximum output current
22	- 15 V	O	10 mA maximum output current
23	0 Volts		
24	0 Volts		
25	0 Volts		

For use of negative/positive command logic, see section 6.4.0

4.1.0 X2 Motor sensor signal connector (Sub-D 25 points female)

Pin	Function	I / O	REMARKS
1	Marker Z	I	Differential input of the encoder marker pulse
2	Channel A	I	Differential input of the encoder channel A
3	Channel B	I	Differential input of the encoder channel B
4	0 Volts		
5	+5 Volts [1]	O	Max 50mA output
6	Limit switch +	I	Positive or negative logic (see section 6.4.0)
	(Tach monitor)	O	Optional output 0 to ± 10V
7	Limit switch +	I	Positive or negative logic (see section 6.4.0)
	(Current monitor)	O	Optional output 0 to ± 10V
8	Hall sensor 1	I	+15 Volts (+5 Volts) input sensor
9	+ 15 V	O	5 mA maximum output current
10	+ 15 V	O	5 mA maximum output current
11	DC Tachometer negative (AC Tachometer center point)	I	Max 60 Volts DC input
12	AC Tachometer phase 2	I	Max ± 15 Volts
13	AC Tachometer phase 3	I	Max ± 15 Volts

14	Marker Z/	I	Differential input of the encoder marker pulse
15	Channel A /	I	Differential input of the encoder channel A
16	Channel B	I	Differential input of the encoder channel B
17	0 Volts		
18	+5 Volts [1]	O	Max 50mA output
19	Hall sensor 3	I	+15 Volts (+5 Volts) input sensor
20	Hall sensor 2	I	+15 Volts (+5 Volts) input sensor
21	- 15 V	O	10 mA maximum output current
22	Motor temperature sensor	I	NTC or PTC input sensor (see csection 6.3.0)
23	DC Tachometer positive	I	Max 60 Volts DC input
24	0 Volts		
25	AC Tachometer phase 3	I	Max ± 15 Volts

[1] Maximum 150mA if using encoder tachometer option

4.3.0 **X13 Test connector** (10 pin front panel)

PIN	FUNCTION	REMARKS
1	Enable	
2	-15 Volts	Maximum 10mA
3	Input command monitor	0 to ± 9 V for ± max. speed or max current (torque mode) (±10%)
4	0 Volts	
5	Current monitor IDC	0 to ± 9 V for maximum amplifier current output (±10%)
6	Current monitor Imeasure	0 to ± 9 V for maximum amplifier current output (±10%)
7	0 Volts	
8	Speed monitor GT	0 to ± 9V for maximum mtor speed (±10%)
9	+ 15 Volts	Maximum 10mA
10	Ampliifer error	+ 15 Volts when an error occur in the amplifer

4.4.0 **X14 Motor and Supply connector** (14 pins Weidmuller type)

Pin	Function	I / O	REMARKS
1	NC		
2	- 15 V	O	10 mA maximum output current
3	+ 15 V	O	10 mA maximum output current
4	Limit switch +	I	Positive or negative logic (see section 6.4.0)
	(Tach monitor)	O	Optional output 0 to ± 10V
5	Limit switch +	I	Positive or negative logic (see section 6.4.0)
	(Current monitor)	O	Optional output 0 to ± 10V
6	0 Volts		0 Volts power
7	0 Volts		0 Volts temperature sensor
8	Motor temperature sensor	I	NTC or PTC input sensor (see section 6.3.0)
9	Motor phase 1	O	Motor output three phases (phase U)
10	Motor phase 2	O	Motor output three phases (phase V)
11	Motor phase 3	O	Motor output three phases (phase W)
12	Input power voltage phase 1	I	Input AC seconday transformer (90 or 175VAC)
13	Input power voltage phase 2	I	Input AC seconday transformer (90 or 175VAC)
14	Input power voltage phase 3	I	Input AC seconday transformer (90 or 175VAC)

5.0.0 WIRING RECOMMENDATIONS (IEC 801 AND EN 55011)

5.1.0 GND wiring and grounding

The reference potential is the **earth (ground).** Motors and sensors are grounded via their housing. If a reference of potential exist, like a main chassis or a cabinet, with a low impedance between the different elements, it should be used to connect ALL reference to it and also connect this reference to the earth (ground).

Long reference potential connections are suitable ONLY if these connections have a very low impedance (< 0.1Ω).
Cables with low potential must NEVER run in the proximity of power lines.
Each conductor cable (carrying a potential) must be shielded. Several wires in the same sleeve must be twisted and shielded.

According to the IEC 801 standard, the connectors must be metallic or metal plated and must have a 360° shield connection (see chapter 8.6.0).

5.2.0 Motor, sensors and encoder cables

Cable ends should have a metallic collar allowing a 360° shielded connection.
Motor cables (four wires) must be shielded to avoid common mode effects (Mavilor p/n 410-0051, 410-0052, Belden p/n 9367).
The recommended encoder cable is a three pair twisted with an individual shield on each pair (Mavilor p/n 410-0053, Belden p/n 9728, Oflex p/n 34252). Hall sensors cable should be shielded as well.

5.3.0 Input command cable

Analog input command signal (CV) requires a twisted and shielded pair cable. The shield must have a "360°" connection via metallic collars at both ends. If the shield is connected by means of a pig tail, it must be connected at one end to a 0 Volt pin of X1 on the amplifier side with a connection as short as possible.

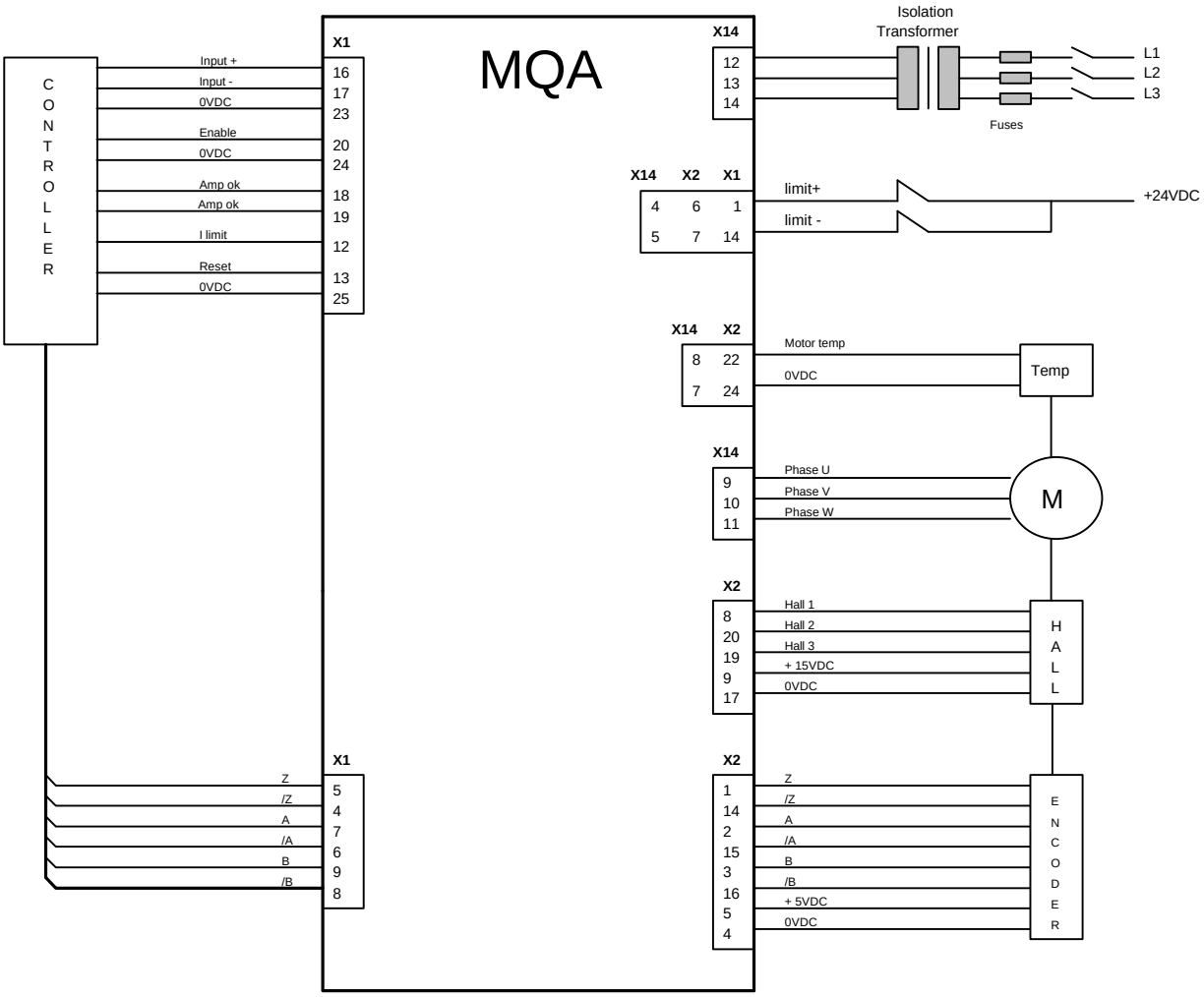
Input command (CV) wiring must be made according to the polarity between the controller and the amplifier (CV on "diff high" of the controller). Logic 0 Volt is directly connected to the amplifier housing. The connection continuity is ensured by the fastening screws on the front panels. The amplifier 0 Volt and the controller 0 Volt MUST be connected by means of a wire. The shield MUST NEVER be used as a conductor of the 0 Volt potential.

CAUTION: The command cables (input command, Hall sensors, encoder) as well as the power cables MUST only be connected and/or disconnected with the amplifier TURNED OFF.

Note: Never plug in or unplug any connectors on the amplifier when power is applied. A time of discharge of 3 minutes must be considered

6.0.0 COMMISSIONING

6.1.0 MQA Module connection



The adjustment of hall sensors and tachometer is made at the factory. Setting of the amplifier for another motor is possible (contact factory) . Hall sensor with 60ø and 120ø and brushless hall sensors as well as DC tachometer can be used.

6.2.0 Offset adjustment

If an input of exactly 0 V is applied to the command input then the motor shaft should be at stand still. Any creep can be eliminated with P1.

All other adjustments are only necessary if the amplifier has not been adjusted at the factory.

The front potentiometers should be adjusted as follows:

- P1 Offset (10 turns CW)
- P2 P-Gin (10 turns CW)
- P3 Tach voltage (10 turns CW)
- P4 Max. current (10 turns CW)
- P5 Ieff Current (10 turns CW)

6.3.0 Speed adjustment

As a general rule, amplifiers driving servo motors are designed such that the continuously rated speed of the motor corresponds to an input command to the amplifier of 10 V.

Apply a 10 volt signal to the command input and measure the motor speed.
the tach potentiometer P3 can now be adjusted until the correct maximum speed is reached. If unable to obtain the speed over range of P3, then consult factory for modifications (test point X13 Pin 8).

6.4.0 Maximum current adjustment I_{Amax}

The amplifier is capable of supplying twice its rated current for 5 seconds. Peak current will be adjusted by P4. On test point X13 Pin 6 (I_{Amax} -Monitor) armature current value
($\pm$ 9V = $\pm$ I_{Amax}) is available.

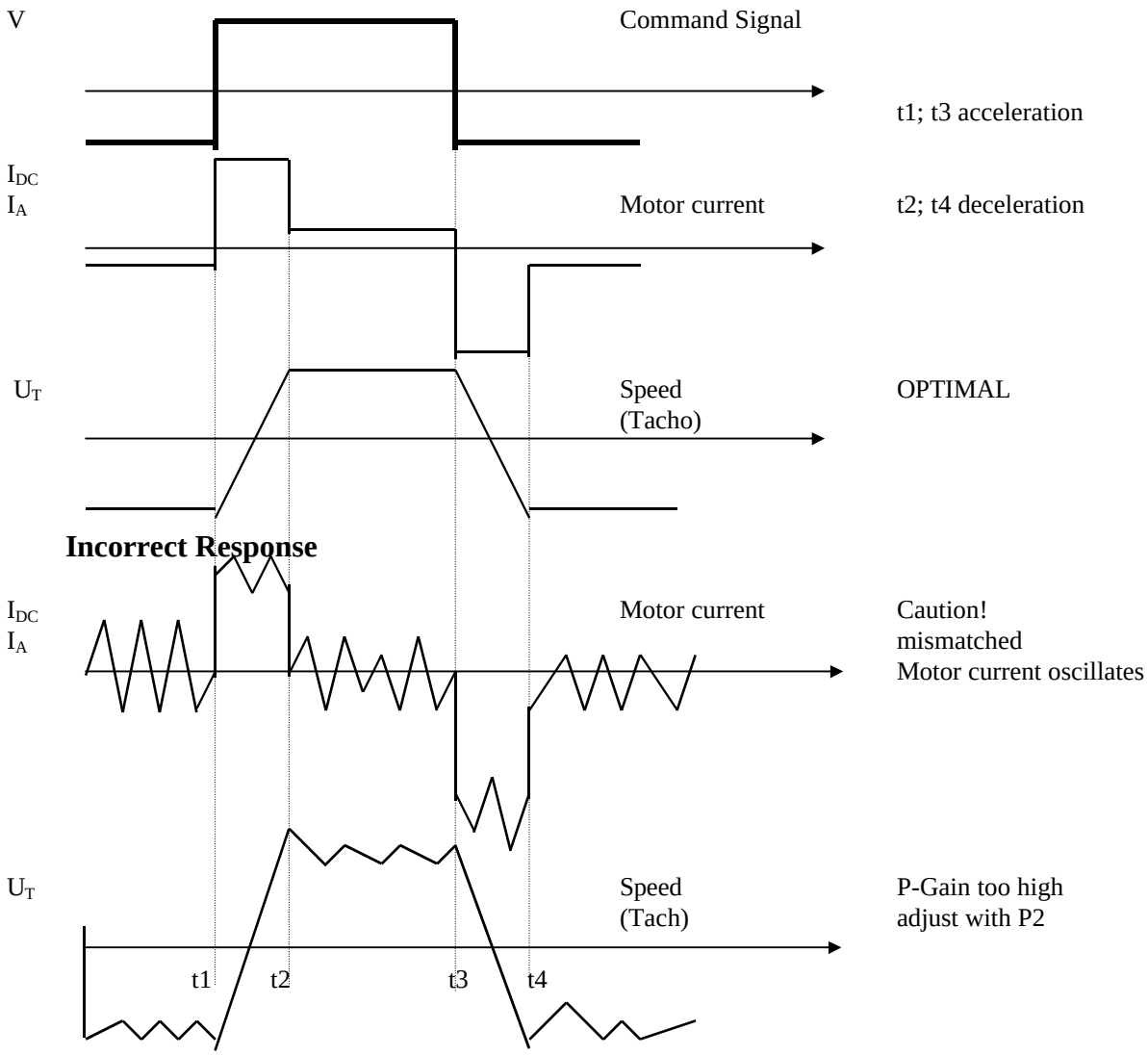
6.5.0 Effective current adjustment I_{eff}

Follow the procedure given above for adjustment of I_{Amax} . The I_{eff} potentiometer P5 can be adjusted and its value read from the current monitor after about 5 seconds. The I_{eff} circuits are operating when the I_{eff} yellow LED lid.

6.6.0 Proportional Gain

Amplifiers are equipped with a standard setting and can be adapted by P2. R21 and C2 on the personality card will nedd to be adjusted if the P2 setting is not possible (outside the range).

Response when correctly adjusted



Incorrect Response

7.0.0 ADJUSTABLE COMPONENTS

7.1.0 X10 MQA Personality card (14 pins DIL on board)

PIN	Function	Component	PIN	Function	Component
1/14	I-Gain Speed loop	C 2	**2/13**	P Gain Speed loop	R 21
3/12	Tacho adjustment	R 31	**4/11**	Low pass filter	C 21
5/10	I-Gain current loop	C 3	**6/9**	P-Gain current loop	R 4
7/8	Check	R 193			

7.2.0 Limit switch and Ramp generator

Component	Ramp	Limit switch pos. + 24 V	Limit switch neg. 0 V	Ramp and Limit + 24 V	Ramp and Limit - 0 V	without all
BR 12 (R 184)	X	---	---	---	---	X
BR 7 (R 187)	X	---	---	X	X	---
BR 6 (R 186)	---	X	X	---	---	X
N 7	---	X	X	X	X	---
BR 14 (R 188)	---	---	X	---	X	---
BR 9 (R 189)	X	X	---	X	---	X
BR 15 (R 179)	---	---	X	---	x	---

R62 (R63)	Ramp time in seconds per Volt P6 in left	Ramp time in seconds per Volt P6 in right
-	0.020	0.73
3,9 M Ω	0.013	0.58
1,5M Ω	0.010	0.44
1M Ω	0.008	0.37
270k Ω	0.004	0.16

Note: Table is valid for C61= 470nF ; Standard C61 not mounted, Ramp not active

7.3.0 Motor -Temperature-Sensor Type PTC or NTC

Component	PTC	NTC
R141	0Ω	------
R142	-----	0Ω
R143	1 kΩ	10 KΩ
R144	10 K Ω	1 KΩ

7.4.0 Enable positive/negative logic

Component	Active low (0 V)	Active high (+ 15...24 V)
R16 (0 R)	X	---
R158 (0 R)	---	X

7.5.0 AC-DC or Encoder Speed control

Component	AC brushless	DC- Linear	Encoder Tacho
BR 3	---	X	---
R 86	150 Ω	---	---
C 42	10 nF	---	---
BR22	---	---	X

7.6.0 Encoder Option (Velocity feedback)

Solder jumper			Encoder resolution - pulse per revolution						max.
Br. 5	Br. 6	Br. 7	**250**	**500**	**512**	**1000**	**1024**	**2048**	Speed
close	Open	open	38.400	19.200	18.750	9.600	9.375	4.688	
open	Open	close	19.200	9.600	9.375	4.800	4.688	2.344	rpm
open	Close	open	9.600	4.800	4.688	2.400	2.344	1.172	

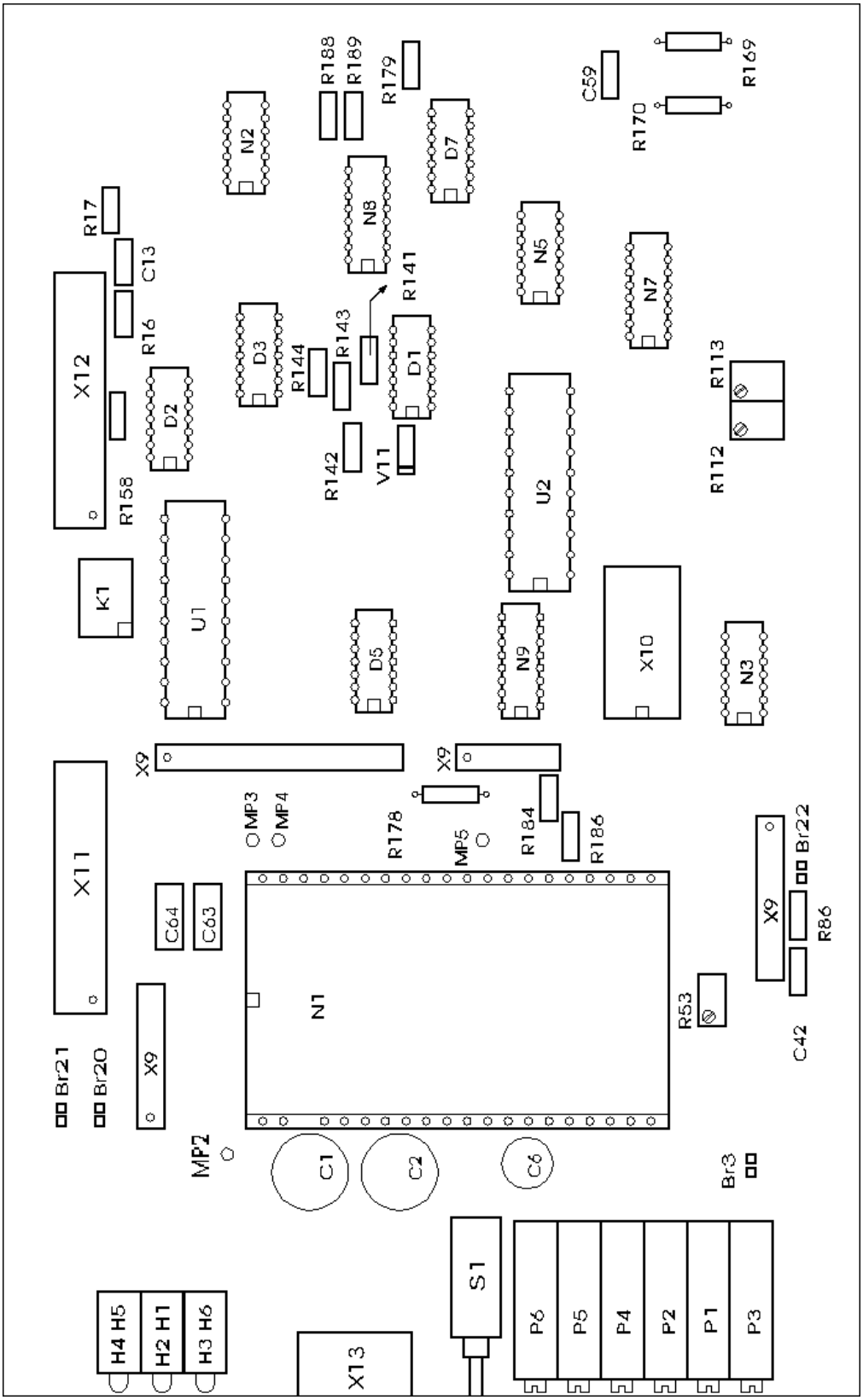
BR3 closed, tach vltage = positive ; BR4 closed, tach voltage = negative

8.0.0 FAULT FINDING

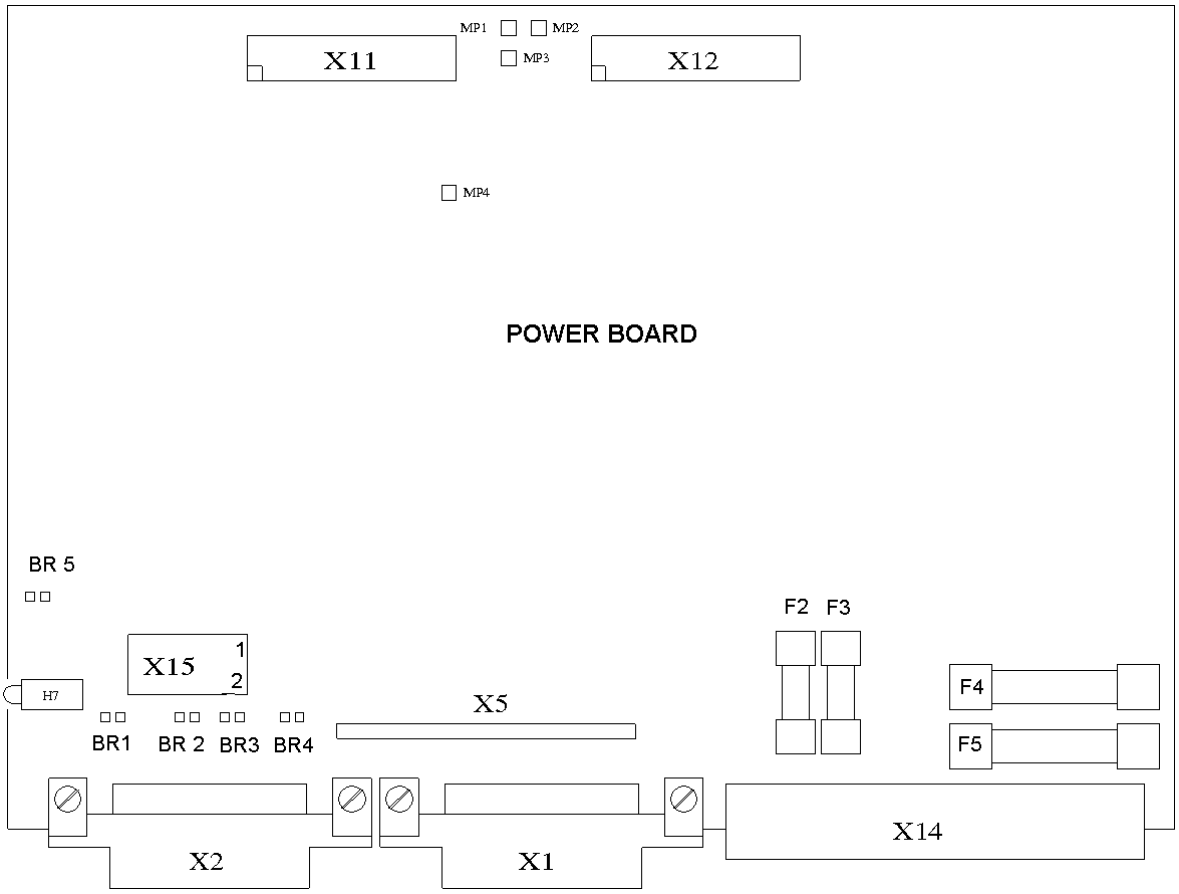
Symptom	Cause	Remedy
Motor will not run and no current flows in the motor	No supply voltage	Check that all fuses are good and all supply voltages are present
The motor will not start although the current is present	The motor is blocked (mechanically)	Release the brake and make a no load-test
	Shorted motor circuit	Check the wiring of the motor
The motor runs unevenly	P-gain too high I-gain too small	Turn P2 ccw Increase C 2
	Wiring problem	Check the wiring
Red LED lights immediately after power on	Hall sensor fault	Check the wiring
	Motor temp. sensor fault	Check the wiring
Red LED is on after a long running time	Output stage overheat motor overheat	Let the motor or amplifier cool down, check the duty cycle
Red LED lights when the motor is decelerating	Over voltage caused by high system inertia	Check the braking system
Red LED lights immediately after power on	Over voltage cause by too high bus voltage	Check the secondary transformer voltage, if necessary change the transformer

9.0.0 DIMENSIONS AND DRAWINGS

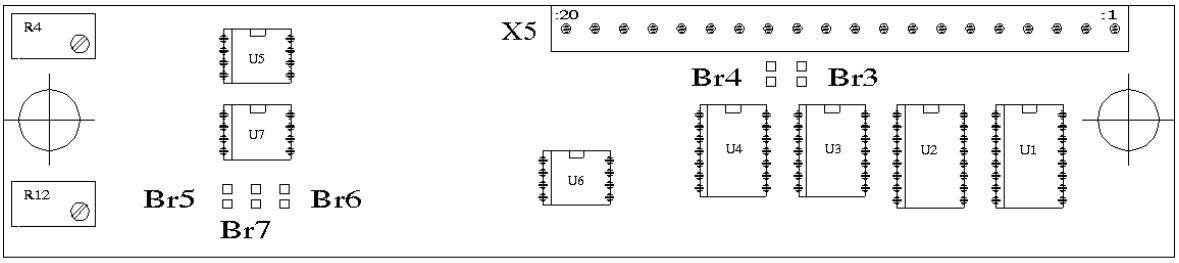
9.1.0 Logic card components location



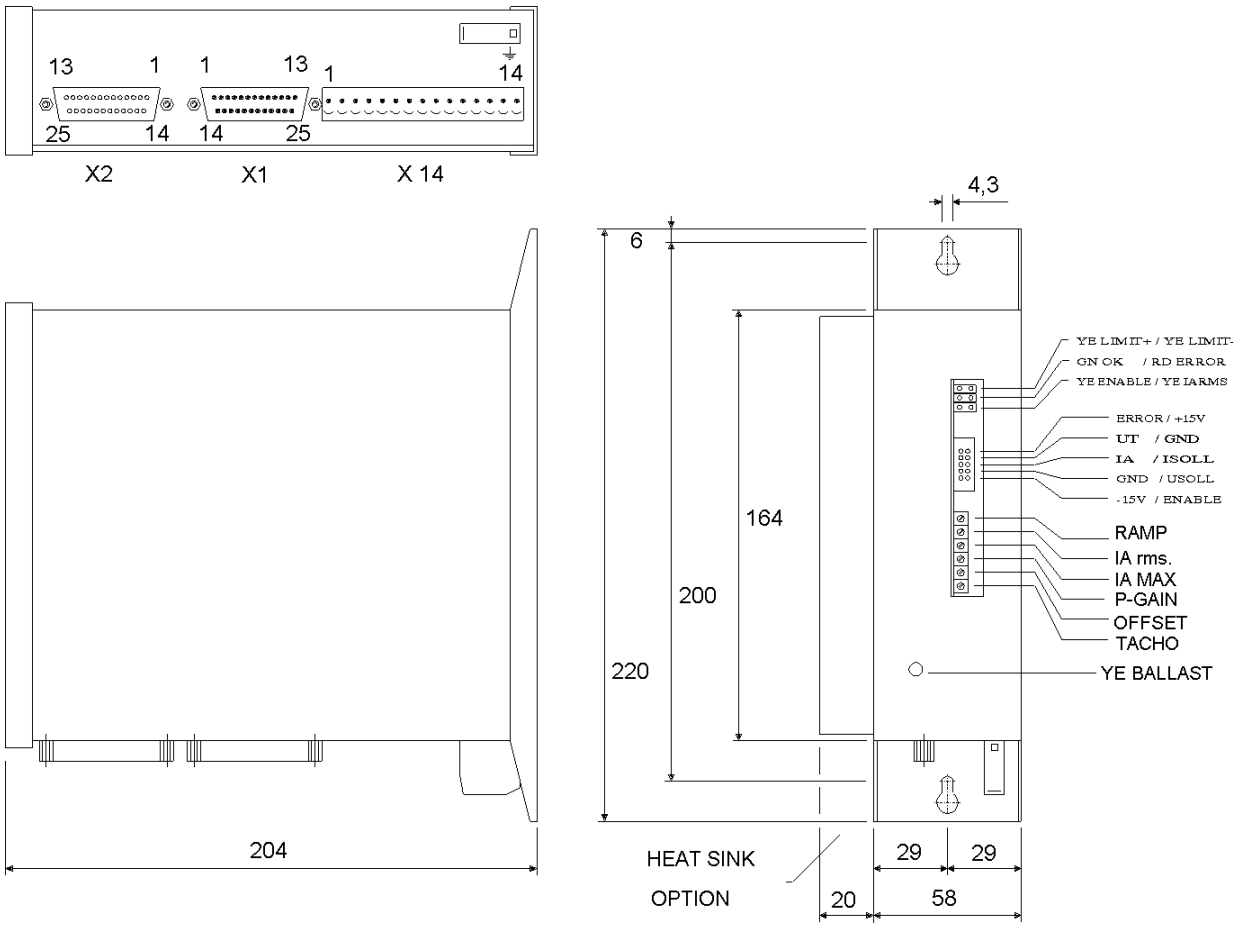
9.2.0 Fuse location



9.3.0 Encoder tachometer card components location



9.4.0 MQA Dimensions



Dimensions are in mm

This page has been left blan intentionnaly