Servo Amplifier PMA 90 / 180

Printed Motor Works

Rev. 2, 14/04/2009

Features

- **Motors supported:**
  - **Brushless DC 60°/120° commutated**
  - **Brushed DC**
  - **Printed Armature DC**
- **18 to 180VDC single power supply**
- **Up to 20A peak / 12A continuous current**
- **Selectable modes of operation:**
  - **Current (Torque)**
  - **Encoder Velocity**
  - **Analogue position**
  - **Tacho Velocity**
  - **Hall Velocity**
- **Individually adjustable continuous and peak current limits**
- **Comprehensive short-circuit protection:**
  - **Output to output**
  - **Output to ground**
  - **Output to power**
- **Over/under voltage shutdown**
- **Internal fast blowing fuse for maximum safety**
- **No integrator windup during power-up or if the amplifier is disabled**
- **Four quadrant regenerative operation**
- **Small footprint, low cost, easy to use**

Description:

The PMA 90/180 servo amplifier is designed for applications using brushed DC motors, low inductance printed armature motors or brushless DC motors up to 750W.

It provides a full set of features for motor control including amplifier enable and direction enable inputs for connection to limit switches, and all necessary protections for the motor and amplifier. The PMA 90/180 can be used in conjunction with digital servo controllers or as a stand-alone drive.

Input gain, loop gain and offset can be adjusted. The offset potentiometer can also be used as an on-board full range reference signal.

A configurable component carrier and mode switches are used to select the operation mode and to customise the amplifier for specific motor parameters. Individually adjustable peak and continuous current limits allow high acceleration without sacrificing protection against continuous overloads. Peak current time can be adjusted from 50 ms to 3 sec.

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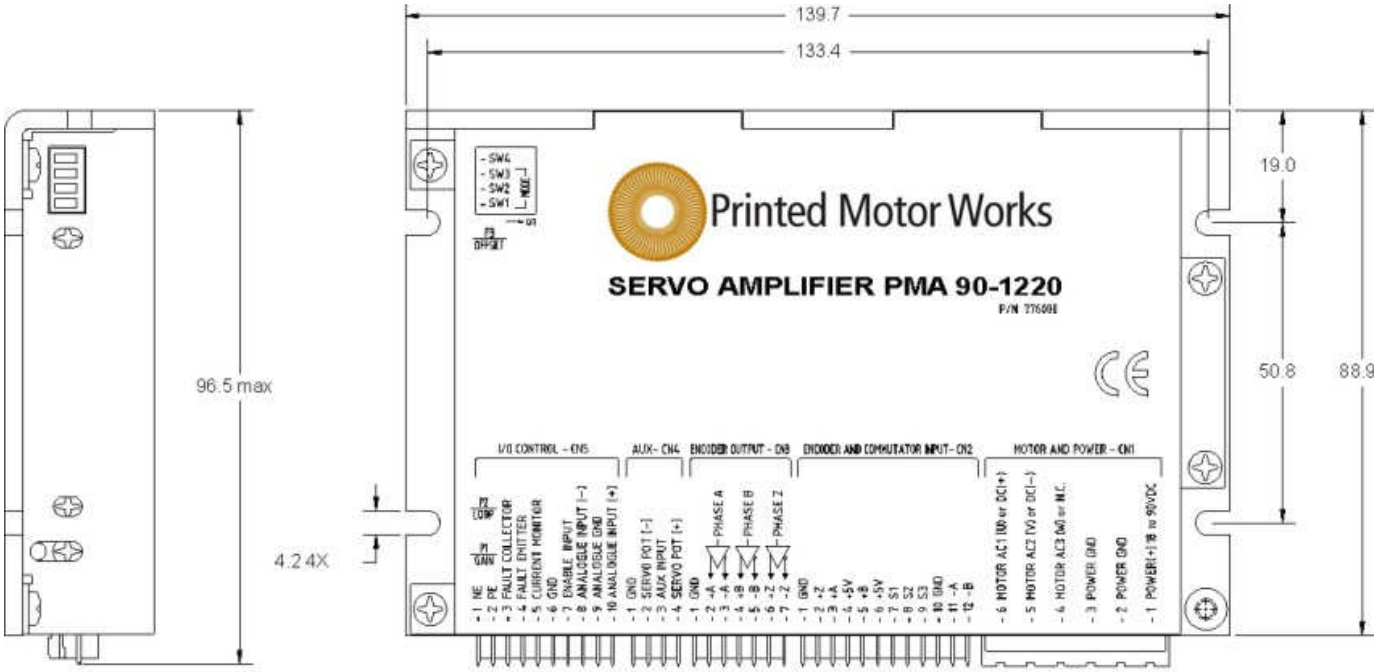
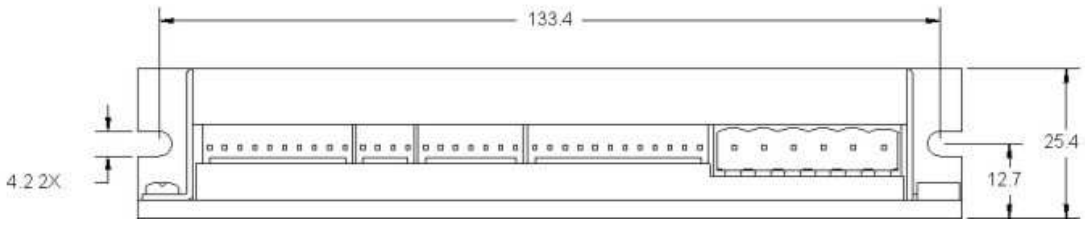
TECHNICAL SPECIFICATIONS rated at 25°C ambient, POWER (+)=60VDC, Load=250µH motor

DC POWER SUPPLY VOLTAGE		
PMA 180-0406 PMA 90-0812 PMA 90-1220		18 to 180VDC (200VDC Abs. Max) 18 to 90VDC (100VDC Abs. Max) 18 to 90VDC (100VDC Abs. Max)
OUTPUT CURRENT		
PMA 90-0406 continuous / peak PMA 90-0812 continuous / peak PMA 90-1220 continuous / peak		4A / 6A 8A / 12A 12A / 20A
OPERATING MODES		Current (torque) - as delivered Encoder Velocity Analogue Position Tacho Velocity Hall Velocity
COOLING		
Convection cooling Forced air cooling or heatsink maintaining 60ºC max		Output continuous current less than: ± 2A - PMA 180-0406 ± 4A - PMA 90-0812 ± 6A - PMA 90-1220 Current higher than listed above
OUTPUT VOLTAGE		Vout= 0.96(HV) – 0.21(Iout)
MINIMUM LOAD INDUCTANCE Note: for use with printed armature motors it is recommended that an external inductance of at least 100µH (total) is added in series with the motor leads		200µH
SMALL SIGNAL BANDWIDTH Note: actual bandwidth will depend on power supply voltage, load inductance, and configurable components		2.5KHz with 250µH load
PWM SWITCHING FREQUENCY		40KHz
ANALOGUE INPUT CHARACTERISTICS		Differential, ±10V (±20V max), 50K to GND
GAINS – Current mode PMA 180-0406 PMA 90-0812 PMA 90-1220		 0.5 A/V as delivered. Adjustable 0 to 5 A/V 1 A/V as delivered. Adjustable 0 to 10 A/V 1.6 A/V as delivered. Adjustable 0 to 16 A/V
POTENTIOMETERS		
INPUT GAIN LOOP GAIN OFFSET		Attenuates ANALOGUE INPUT from x 1 to zero Increases A/V gain in current mode Controls bandwidth in velocity mode ORR = 10M – adjusts the imbalance in the input signal or in the servo amplifier ORR = 220K – can be used as on board reference signal driving servo amplifier output up to ±100%
COMMUTATION		60/120º hall mode
ENCODER AND COMMUTATOR INPUTS		HI: ≥ 1.5V, LO: ≤ 0.9V (–0.5VDC to + 5.5VDC Abs. Max) Hysteresis TYP. = 0.6V, Pull up to +5V = 3K3
AUX INPUT		±3V to ±50VDC (±60V Abs.Max)
LOGIC INPUTS	SW4=ON pull down resistors – 3K3 (accepts external voltage)	SW4=OFF pull up resistors – 3K3 (amplifier supplies 5V)
ENABLE INPUT PE NE	HI: 3.5V ≤ V ≤ 30V, LO: 0V ≤ V ≤ 1.2V HI enables amplifier, LOW (OPEN) inhibits HI enables positive d.o. rotation, LOW (OPEN) inhibits HI enables negative d.o. rotation, LOW (OPEN) inhibits	HI: 3.5V ≤V ≤ 5V, LO: 0V ≤ V ≤ 1.2V LO enables amplifier, HI (OPEN) inhibits LO enables positive d.o. rotation, HI (OPEN) inhibits LO enables negative d.o. rotation, HI (OPEN) inhibits
POWER UP DELAY		<1.5 sec
FAULT OUTPUT		
Optocoupler Umax=35V Imax=20mA		ON – when operates normally OFF- when amplifier is disabled, motor output is shorted, temperature sensor is activated, or power supply is out of range
INDICATOR (LED)		GREEN when operating normally RED when amplifier is disabled, output is shorted, temperature sensor is activated, or power supply is out of range
CURRENT MONITOR		
10K, 10nF RC filter PMA 180-0406 PMA 90-0812 PMA 90-1220		 ± 3.6V at ±6A (0.6V/A) ± 3.6V at ±12A (0.3V/A) ± 3.6V at ±20A (0.18V/A)
PROTECTION		
Output short (output to output, output to ground, output to POWER (+)) Power supply voltage too low (undervoltage) Power supply voltage too high (overvoltage) Overtemperature		Shutdown when output is shorted with self resume Shutdown at POWER (+) < 18VDC with self resume Shutdown (with self resume) at: POWER (+) > 91VDC for PMA 90-812, PMA 90-1220 POWER (+) > 180VDC for PMA 90-46 Shutdown at 75 °C internal temperature with self resume
FIRE SAFETY – internal fuse		10A Quick blow
POWER DISSIPATION		
Minimum power consumption at 0A output, 18VDC power supply Power dissipation at 5A output, 60VDC power supply Power dissipation at 10A output, 60VDC power supply		2W 16W 32W
THERMAL REQUIREMENTS		
Storage temperature range Operating temperature range		–30 to +85 °C 0 to 45 °C
MECHANICAL		
Size Weight		5.5 x 3.5 x 1 in. (140 x 89 x 25.4 mm) 0.65 lb. (0.3 kg)

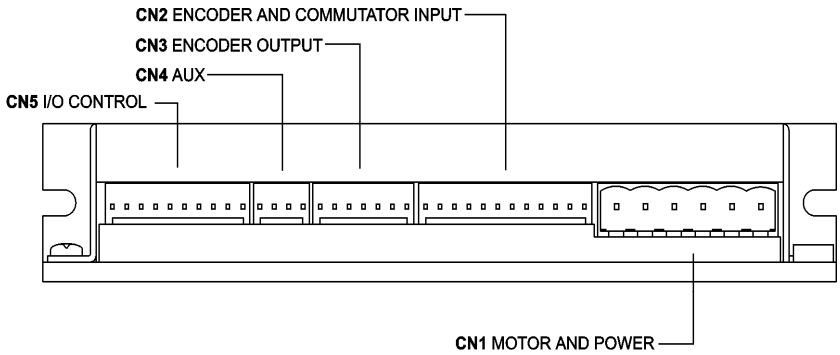
MATING CONNECTORS	RECOMMENDED CONNECTOR TYPE
MOTOR AND POWER	Magnum EM2565-06-VL or Phoenix: MSTB 2.5/6-ST-5.08
ENCODER AND COMUTATOR INPUT	Molex: 22-01-3127 housing with 08-50-0114 pins (12pcs)
ENCODER OUTPUT	Molex: 22-01-3077 housing with 08-50-0114 pins (7pcs)
AUX	Molex: 22-01-3047 housing with 08-50-0114 pins (4pcs)
I/O CONTROL	Molex: 22-01-3107 housing with 08-50-0114 pins (10pcs)

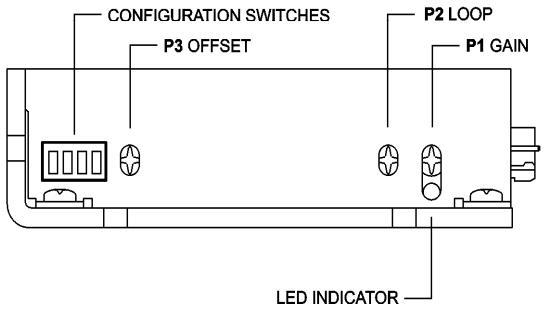
OUTLINE DIMENSIONS in millimetres





AMPLIFIER LAYOUT

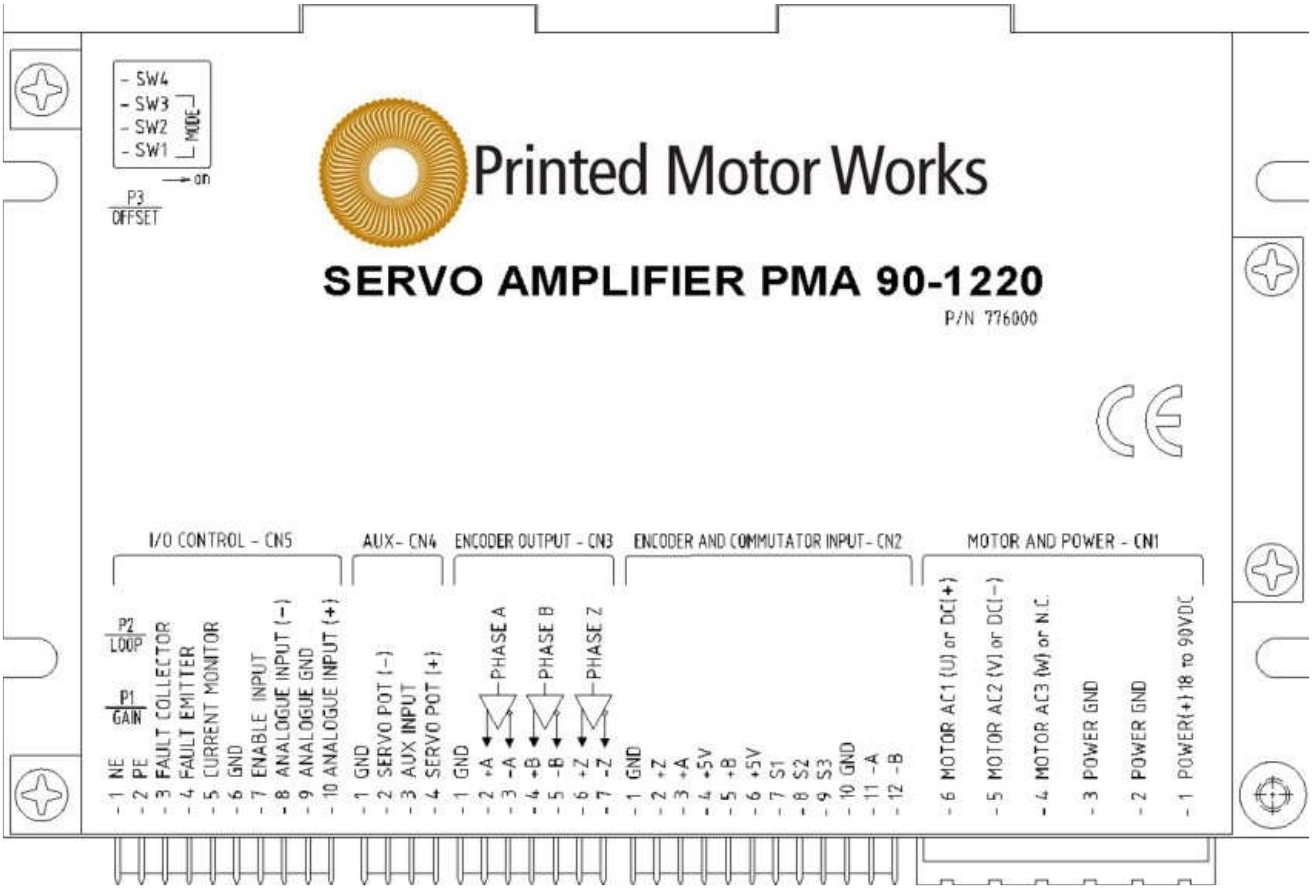




ORDERING GUIDE

PART NUMBER	MODEL	DESCRIPTION
776005	PMA 180-0406	AC/DC Servo Amplifier 6A/180V
776006	PMA 90-0812	AC/DC Servo Amplifier 12A/90V
776000	PMA 90-1220	AC/DC Servo Amplifier 20A/90V
776004	PMA 90 CN	Mating connector kit

CONNECTORS AND PINOUTS



CN1 – MOTOR AND POWER

PIN	SIGNAL	DESCRIPTION
1	POWER +18 to +90VDC	DC Power Supply Input PMA 90-0812, PMA 90-1220 - 18 to 90VDC PMA 180-0406 - 18 to 180VDC
2 and 3	POWER GND*	Power Supply Return and Amplifier GROUND
4	MOTOR AC3 (W) or NC	Amplifier Output to Motor phase 3 for brushless motors Not connected for brushed motors
5	MOTOR AC2 (V) or DC(-)	Amplifier Output to Motor phase 2 for brushless motors Amplifier Output to Motor (-) terminal for brushed motors
6	MOTOR AC1 (U) or DC(+)	Amplifier Output to Motor phase 1 for brushless motors Amplifier Output to Motor (+) terminal for brushed motors

CN2 – ENCODER AND COMMUTATOR INPUT

PIN	SIGNAL	DESCRIPTION
1	GND*	Encoder ground
2	+Z	Encoder Index positive terminal
3	+A	Encoder phase A positive terminal
4	+5V	Encoder power supply
5	+B	Encoder phase B positive terminal
6	+5V	Commutator power supply
7	S1	Hall sensor input 1 for brushless motors, NC for brushed motors
8	S2	Hall sensor input 2 for brushless motors, NC for brushed motors
9	S3	Hall sensor input 3 for brushless motors, NC for brushed motors
10	GND*	Commutator ground
11	-A	Encoder phase A negative terminal
12	-B	Encoder phase B negative terminal

*Note: POWER GND, GND and ANALOGUE GND are electrically connected. Amplifier case is isolated from the amplifier circuitry and can be grounded externally.

CN3 – ENCODER OUTPUT

PIN	SIGNAL	DESCRIPTION
1	GND*	Signal ground
2	+A	Phase A output positive terminal
3	-A	Phase A output negative terminal
4	+B	Phase B output positive terminal
5	-B	Phase B output negative terminal
6	+Z	Index output positive terminal
7	-Z	Index output negative terminal

CN4 – AUX

PIN	SIGNAL	DESCRIPTION
1	GND*	Signal ground
2	SERVO POT (-)	-5V Reference voltage output with 1K5 resistor in series
3	AUX INPUT	Tachometer input Potentiometer input in analogue position mode
4	SERVO POT (+)	+5V Reference voltage output with 1K5 resistor in series

CN5 – I/O CONTROL

PIN	**SIGNAL**	**DESCRIPTION**	
1	NE	SW4=ON	SW4=OFF
		HI (3.5V ≤ V ≤ 30V) if the direction is enabled LO (0V ≤ V ≤ 1.2V or OPEN) if the direction is disabled	LO (0V ≤ V ≤ 1.2V) if the direction is enabled HI (3.5V ≤ V ≤ 30V or OPEN) if the direction is disabled
2	PE	SW4=ON	SW4=OFF
		HI (3.5V ≤ V ≤ 30V) if the direction is enabled LO (0V ≤ V ≤ 1.2V or OPEN) if the direction is disabled	LO (0V ≤ V ≤ 1.2V) if the direction is enabled HI (3.5V ≤ V ≤ 30V or OPEN) if the direction is disabled
3	FAULT COLLECTOR	Optocoupler Fault = OFF (open)	
4	FAULT EMITTER		
5	CURRENT MONITOR	Current monitor output PMA 180-0406 - ± 0.6 V/A PMA 90-0812 - ± 0.3 V/A PMA 90-1220 - ± 0.18 V/A	
6	GND*	Signal ground	
7	ENABLE INPUT	SW4=ON	SW4=OFF
		Amplifier enable input HI (3.5V ≤ V ≤ 30V) enables the amplifier LO (0V ≤ V ≤ 1.2V or OPEN) disables the amplifier	Amplifier enable input LO (0V ≤ V ≤ 1.2V) enables the amplifier HI (3.5V ≤ V ≤ 30V or OPEN) disables the amplifier
8	ANALOGUE INPUT (–)	Negative analogue input ±10V	
9	ANALOGUE GND*	Analogue ground	
10	ANALOGUE INPUT (+)	Positive analogue input ±10V	

*Note: POWER GND, GND and ANALOGUE GND are electrically connected. Amplifier case is isolated from the amplifier circuitry and can be grounded externally.

MODE SELECT DIP SWITCHES

SW1	**SW2**	**SW3**	**Encoder**	**MODE SELECT TABLE**
OFF	ON	ON	X	Brushed or Brushless motors - any mode other than Hall and Encoder Velocity
SYNC*	OFF	ON	X	Brushless motors - Hall Velocity mode NOTE: SYNC should be ON or OFF depending on motor winding / hall sensor phasing.
ON	ON	OFF	2500	Brushed or Brushless motors - Encoder Velocity mode
ON	ON	OFF	2000/2048	
ON	ON	OFF	1500/1536	
OFF	ON	OFF	1000/1024	
OFF	ON	OFF	750/768	
ON	OFF	OFF	500/512	
OFF	OFF	OFF	250/258	
OFF	OFF	OFF	100/128	

*NOTE: SYNC should be ON or OFF depending on motor winding / hall sensor phasing.

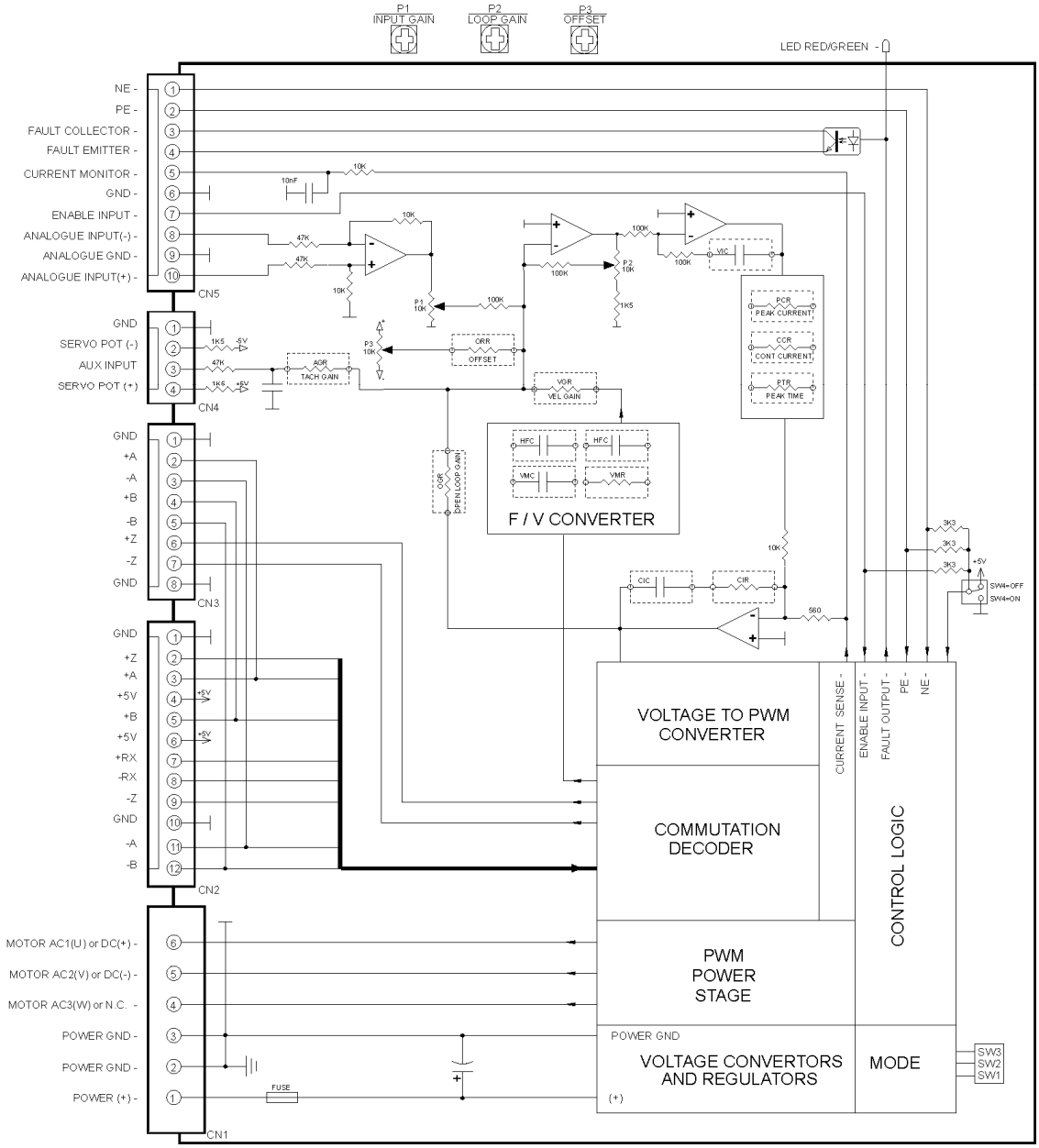
ENABLE, PE and NE polarity DIP SW4

SW4	ENABLE, PE and NE
ON	Active **HIGH** (for sensors with sourcing output)
OFF	Active LOW (for sensors with open collector output)

POTENTIOMETER FUNCTIONS

POT.	FUNCTION	DESCRIPTION
P1	INPUT GAIN	Adjusts the ratio between the analogue input signal and servo amplifier output
P2	LOOP GAIN	Adjusts voltage to current transfer ratio in current mode Adjusts loop gain and bandwidth in velocity, open loop and analogue position modes
P3	OFFSET	ORR = 10M – compensates the input signal imbalance and servo amplifier offset (low range) ORR = 220K –on board reference signal source driving amplifier output up to ±100%

FUNCTIONAL DIAGRAM



MODE SELECT TABLES

Set the mode switches according to the table:

MOTOR TYPE – MODE	Encoder	SW1	SW2	SW3
Brushed or Brushless motors - any mode other than Hall and Encoder Velocity	**X**	OFF	ON	ON
Brushless motors - Hall Velocity mode	**X**	SYNC*	OFF	ON
Brushed or Brushless motors - Encoder Velocity mode	**2500**	ON	ON	OFF
	2000/2048	ON	ON	OFF
	1500/1536	ON	ON	OFF
	1000/1024	OFF	ON	OFF
	750/768	OFF	ON	OFF
	500/512	ON	OFF	OFF
	250/258	OFF	OFF	OFF
	100/128	OFF	OFF	OFF

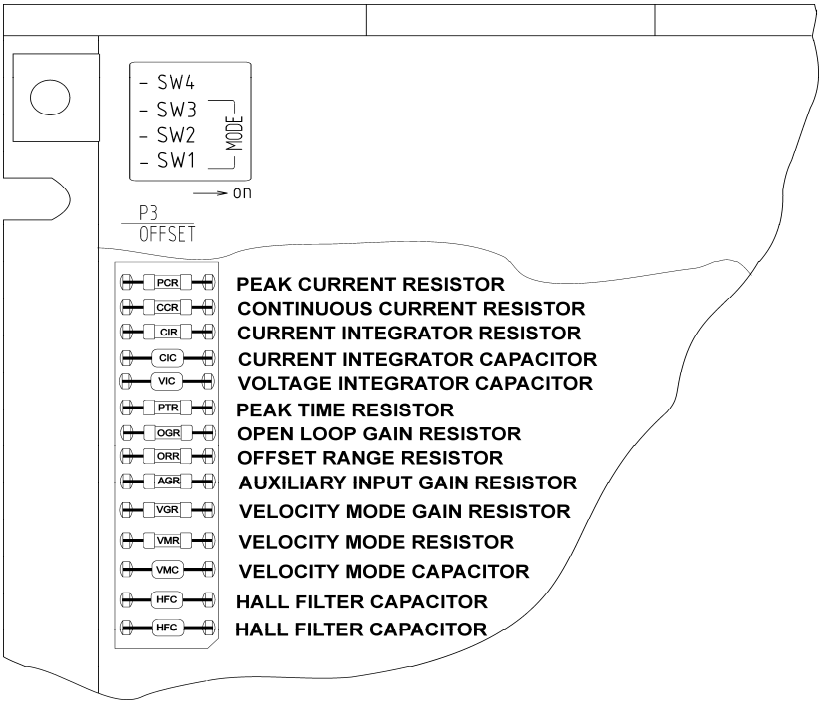
*NOTE: SYNC should be ON or OFF depending on motor winding / hall sensor phasing.

Select enable inputs active level:

SW4	ENABLE, PE and NE
ON	Active **HIGH** (for sensors with sourcing output)
OFF	Active **LOW** (for sensors with open collector output)

Install the appropriate components on **Configurable Component Carrier** according to the table:

MODE	PCR	CCR	CIR	CIC	VIC	PTR	OGR	ORR	AGR	VGR	VMR	VMC	HFC
Torque	R	R	R	C	SHORT	R	OPEN	R	OPEN	OPEN	100K	OPEN	OPEN
Encoder velocity	R	R	R	C	C	R	OPEN	R	OPEN	R	100K	1nF	OPEN
Hall velocity	R	R	R	C	C	R	OPEN	R	OPEN	R	R	10nF	2x 10nF
Open loop	R	R	R	C	C	R	R	R	OPEN	OPEN	100K	OPEN	OPEN
Tacho velocity	R	R	R	C	C	R	OPEN	R	R	OPEN	100K	OPEN	OPEN
Analogue position	R	R	R	C	C	R	Typically 1M	R	Typically 47K	OPEN	100K	OPEN	OPEN



CONFIGURABLE COMPONENTS SETTING

PCR is the adjusting resistor for peak current limit (*factory standard setting - **PCR**=SHORT*).
CCR is the adjusting resistor for continuous current limit (*factory standard setting - **CCR**=SHORT*).

The table below shows component values for the most used continuous and peak current combinations.

I peak (A) PMA 90/180 0406 / 0812 / 1220	**I cont (A)** PMA 90/180 0406 / 0812 / 1220	**PCR**	**CCR**
6 / 12 / 20	4 / 8 / 13	SHORT	SHORT
6 / 12 / 20	3 / 6 / 10	SHORT	10K
5 / 10 / 17	3 / 6 / 10	5K6	5K6
5 / 10 / 17	2.5 / 5/ 8	5K6	16K
4 / 8 / 13	2 / 4 / 7	15K	24K
3.5 / 7 / 12	1.8 / 3.5 / 6	20K	30K

I peak (A) PMA 90/180 0406 / 0812 / 1220	**I cont (A)** PMA 90/180 0406 / 0812 / 1220	**PCR**	**CCR**
3 / 6 / 10	1.7 / 3 / 5	27K	36K
2.5 / 5 / 8.3	1.2 / 2.5 / 4.2	36K	47K
2 / 4 / 7	1 / 2 / 3.3	56K	75K
1.7 / 3 / 5	0.7 / 1.5 / 2.5	82K	110K
1 / 2 / 3.3	0.5 / 1 / 1.7	130K	150K
0.5 / 1 / 1.7	0.2 / 0.5 / 0.8	220K	330K

CIR is the current integrator resistor (*factory standard setting - **CIR**=22K*).
CIC is the current integrator capacitor (*factory standard setting - **CIC**=100nF*).

The values of these components are related to the amplifier bandwidth and have to be configured depending on the motor inductance and power supply voltage.

Optimisation procedure

Set the amplifier in current mode by putting jumper wire instead of **VIC**. Set **P1** and **P2** fully CCW. Connect the motor and power supply to the amplifier. Apply a square wave signal ±1V at 20 to 50Hz to amplifier **ANALOGUE INPUT**. Use an oscilloscope to measure the signal at current monitor (**CN5**-pin4). Enable the amplifier **AMP ENABLE**=LOW. Rotate **P1** CW to set ±150mV square wave signal at the oscilloscope screen. Using **CIR** selected from the table below, select lowest value of **CIC** that does best result in overshoot or degradation of the pulse response.

The table below shows some approximate values of the current integrator resistor and capacitor depending on motor inductance.

LOAD INDUCTANCE	**CIC**	**CIR**
0.2 to 0.6mH	47nF	10K
0.7 to 1.9mH	100nF	10K
2.0 to 6.0mH	100nF	22K
7.0 to 20mH	220nF	22K

Note: Values in the table are for 24VDC power supply voltage. For higher voltages **CIR** should be decreased and **CIC** increased.

VIC is the voltage integrator capacitor (*factory standard setting - **VIC**=SHORT*).

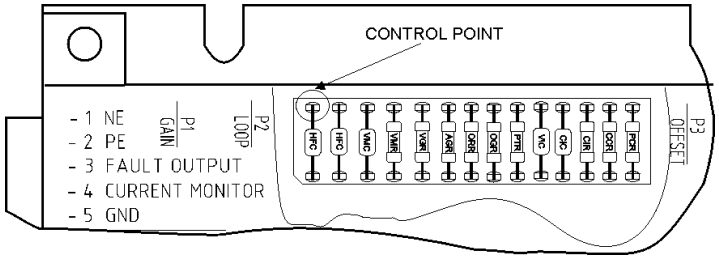
For current mode the wire jumper or 0 Ohm resistor should be left in place. Changing of the wire jumper with a capacitor is necessary for all velocity, open loop and analogue position modes. Proceed with **CIR** and **CIC** optimisation before **VIC** optimisation.

Optimisation procedure for **TACHO VELOCITY** mode

Set the amplifier in velocity mode putting **VIC** = 220nF. Set **P1** fully CCW. Connect motor and tachometer. Power and enable the amplifier. Rotate the motor shaft manually. If the tachometer polarity is wrong, the motor will ”Run away”. If this happens, reverse tachometer wires **(+)** and **(-)**. With correct tachometer polarity, the motor will resist the manual rotation of its shaft. Apply square wave signal ± 1V at 5 to 20 Hz to amplifier **ANALOGUE INPUT**. Move the oscilloscope probe to **AUX INPUT** pin. Rotate **P1** CW to set ± 1V square wave signal at the oscilloscope screen. Find the best response (lowest rise time with minimum overshoots) by changing **VIC** and adjusting **P2 LOOP GAIN**.

Optimisation procedure for **ENCODER VELOCITY** mode

Set the amplifier in velocity mode putting **VIC** = 220nF. Set **P1** fully CCW. Connect motor and encoder. Power and enable the amplifier. Rotate motors shaft slightly. If the encoder polarity is wrong the motor will "Run away". If this happens, swap encoder wires **+A/+B** and **-A/-B**. With correct encoder polarity, the motor will resist the manual rotation of its shaft. Apply square wave signal ± 1V at 5 to 20 Hz* to amplifier **ANALOGUE INPUT**. Move the oscilloscope probe to the control point shown on the picture below:



Rotate **P1** CW to set ±250mV square wave signal at the oscilloscope screen. Find the best response (lowest rise time with minimum overshoots) by changing **VIC** and adjusting **P2 LOOP GAIN**.

Note: ***** For max speed 5000 rpm. For max speed 2500 rpm apply ±2V at 5 to 20Hz.

PTR is adjusting resistor for the **PEAK TIME** (*factory standard setting - **PTR**=OPEN*). The table below shows some basic settings.

PEAK TIME	PTR
3 sec	OPEN
2 sec	510K
1.5 sec	330K
1 sec	150K

PEAK TIME	PTR
0.5 sec	68K
0.25 sec	33K
0.1 sec	15K
0.05 sec	SHORT

OGR is open loop gain resistor (*factory standard setting - **OGR**=OPEN*).

OGR converts the amplifier into a Voltage to PWM converter (**OPEN LOOP** mode).

To setup the **OGR** value use the table:

INPUT VOLTAGE	OGR	PWM
±10V	68K	100%
±5V	130K	100%

ORR is the offset range resistor (*factory standard setting - **ORR**=10M*).

Its value changes the range of regulation with the **OFFSET** potentiometer. For 100% regulation set the **ORR** = 220K. To reduce the regulation range, increase the resistor. Factory setting **ORR** = 10M gives enough range for input imbalance adjustment. Any values greater then 220K can be used.

AGR is an adjustment resistor affecting the amplifier in **TACHO VELOCITY** and **ANALOGUE POSITION** modes (*factory standard setting - **AGR**=OPEN*).

The resistor value changes amplifier auxiliary input sensitivity between ZERO (**AGR=OPEN**) and MAX (**AGR=47K***). Choose the value of **AGR** depending on your application, between 47K and 2M2 (corresponding to ±2V and ±50V input sensitivity).

*Note: Do not use resistor with lower value than 47K.

VGR is the **ENCODER VELOCITY** and **HALL VELOCITY** mode gain resistor (*factory standard setting - **VGR**=OPEN*).

To select the **VGR** value use the following table:

MODE	ENCODER	SW1	SW2	SW3	VGR / max RPM		
					5Krpm	2.5Krpm	1.5Krpm
Hall Velocity	**X**	SYNC*	OFF	ON	150K	75K	47K
Encoder Velocity	**2500**	ON	ON	OFF	150K	75K	47K
	2000/2048	ON	ON	OFF	120K	60K	36K
	1500/1536	ON	ON	OFF	91K	47K	27K
	1000/1024	OFF	ON	OFF	150K	75K	47K
	750/768	OFF	ON	OFF	110K	56K	33K
	500/512	ON	OFF	OFF	150K	75K	47K
	250/256	OFF	OFF	OFF	150K	75K	47K
	100/128	OFF	OFF	OFF	56K	27K	16K

*NOTE: SYNC should be ON or OFF depending on motor winding / hall sensor phasing.

VMR is **VELOCITY** mode resistor (*factory standard setting - **VMR**=100K*).

To set the **VMR** use the following table:

MODE	COMMUTATIONS PER REVOLUTION	VMR
Hall Velocity	**1**	91K
	2	47K
	4	24K
	8	11K
Encoder Velocity	**X**	100K
All other modes	**X**	100K

VMC is **VELOCITY** mode capacitor (*factory standard setting - **VMC**=OPEN*).

To set the **VMC** use the following table:

MODE	VMC
Hall Velocity	10nF
Encoder Velocity	1nF
All other modes	OPEN

HFC are **two 10nF** capacitors used only in **HALL VELOCITY** mode (*factory standard setting - **HFC**=OPEN*).

MODE	HFC
Hall Velocity	2x10nF
Encoder Velocity	OPEN
All other modes	OPEN