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Copley Controls Corp.

Accelus™
PANEL MOUNT

DIGITAL SERVOAMPLIFIER for BRUSHLESS or BRUSH MOTORS

- ***±10V Analog Torque, or Velocity Input from Motion Controllers***
- ***Drive Brushless or Brush Motors***
- ***Digital Position Inputs for Stepper-motor Signals Pulse-Direction, CW/CCW or Master Encoder***
- ***CME 2™ Software Eliminates Wire and Try Brushless Motor Commissioning***

NEW!

MODEL	Ic	Ip	VDC
ASP-055-18	6	18	55
ASP-090-09	3	9	90
ASP-090-18	6	18	90
ASP-090-36	12	36	90
ASP-180-09	3	9	180
ASP-180-18	6	18	180

- ***CME 2™* Software**
  - **Automates motor, encoder, & Hall phasing**
  - **Powerful Oscilloscope & Signal Generator display**
  - **RS-232 Communications for Complete Amplifier Setup**
  - **Amplifier configurations saved in non-volatile Flash memory**
- **100% Digital Control of**
  - **Current loop**
  - **Velocity loop**
  - **Position loop**
- **Motor Protections:**
  - **I^2T Current-limiting**
  - **OverTemp sensor input**
  - **Brake control output**
- **Position Modes:**
  - **Stepper signal inputs CW/CCW, Pulse/Dir**
  - **Electronic Gearing from Master Quad A/B Encoder**
- **Torque & Velocity Modes:**
  - **+/-10V Analog**
  - **PWM/DIR Digital, 2-wire**
  - **PWM Digital, 50%**
- **Mounts on same footprint as Copley 5xx1 models**
- **CE Compliance:**

89/336/EEC	**Electromagnetic**
EN 55011	**Compatibility**
EN 50082-1	
98/37/EC	**Safety of Machinery**
EN 60204-1	
UL 508C	

DESCRIPTION

The *Accelus*™ servoamplifier is a 100% digital servoamplifier in a panel-mount package with a family of power options to 12A continuous and 36A peak. This new series offers sinusoidal commutation of brushless motors in torque, velocity, or position modes and fast, easy set up with *CME 2™* software.

CME 2™ software communicates with *Accelus*™ through an RS-232 link for complete amplifier setup. Auto-phasing and autotuning algorithms in *CME 2™* slash set up times for fast system commissioning and eliminate “re-wire and try” so common in brushless motor installations. *CME 2™* automates current loop tuning, as well as motor, Hall, and encoder phasing. A powerful oscilloscope and signal generator display amplifier performance for fine tuning thereafter. Amplifier control parameters are saved in non-volatile flash memory. OEM’s can inventory one part, and configure amplifiers on-site to each axis in a machine.

Advanced field-oriented-control ensures the highest motor torque over a wide speed range, minimizing motor heating and maximizing efficiency. Digital control algorithms transform stator currents into direct and quadrature components. The torque-producing quadrature current is controlled by the current loop, and the direct component is driven to zero eliminating losses from current that doesn’t produce torque. Space-vector modulation produces higher speeds than sine-pwm modulation from the same power supply.

Accelus™ works with motion controllers that close position-loops using incremental encoder feedback and process the position error in a PID filter to produce an amplifier command for torque, force, or velocity. Only one ±10V analog, or a one or two-wire digital PWM/DIR control signal is required. All commutation is done in the amplifier.

In position-mode, *Accelus*™ accepts two-wire digital step-motor control signals (CW/CCW, or Count/Direction), or operates as a slave from a master encoder. The ratio between input position pulses and motor position is programmable.

Velocity control is derived from motor encoder signals. Velocity mode is useful not only for speed-setpoint applications, but enables operation with PLC’s or controllers that output position-error signals with no PID filtering.

All amplifier circuits are DC coupled and operate from unregulated transformer-isolated DC power supplies, or regulated switching power supplies.

The panel-mount package is compatible with the mounting footprint of Copley’s 5xx1 series trapezoidal brushless amplifiers, offering an easy upgrade to sinusoidal commutation with digital control.

GENERAL SPECIFICATIONS

Test conditions: Load = 3-phase Wye connected load, 2 mH line-line. Ambient temperature = 25 °C. +HV = HV_{max}

MODEL	ASP-055-18	ASP-090-09	ASP-090-18	ASP-090-36	ASP-180-09	ASP-180-18	
OUTPUT POWER							
Peak Current	18 (12.7)	9 (6.4)	18 (12.7)	36 (25.5)	9 (6.4)	18 (12.7)	Adc (Arms)
Peak time	1	1	1	1	1	1	s
Continuous current	6 (4.2)	3 (2.1)	6 (4.2)	12 (8.5)	3 (2.1)	6 (4.2)	Adc (Arms) per phase
Peak Output Power	0.92	0.79	1.55	2.95	1.59	3.15	kW
Continuous Output Power	0.32	0.27	0.53	1.0	0.53	1.06	kW
INPUT POWER							
HV_{min} to HV_{max}	+20 to +55	+20 to +90	+20 to +90	+20 to +90	+20 to +180	+20 to +180	Vdc, Transformer-isolated
Peak current	20	10	20	40	10	20	Adc (1 sec) peak
Continuous current	6.7	3.3	6.7	13.3	3.3	6.7	Adc continuous

PWM OUTPUTS

Type	3-phase MOSFET inverter, 20 kHz center-weighted PWM, space-vector modulation
PWM ripple frequency	40 kHz

COMMUTATION & CONTROL

Current loop	20 kHz (50 µs period) update rate
Velocity & position loop	4 kHz (250 µs period) update rate
Commutation	Sinusoidal, field-oriented control of DC brushless motor
Phase Initialization	Amplifier initializes in trapezoidal commutation until a Hall transition occurs, then switches to sinusoidal commutation with phase-correction at each Hall signal transition

BANDWIDTH

Current loop, small signal	3 kHz typical, bandwidth will vary with tuning & load inductance
HV Compensation	Changes in HV do not affect bandwidth

REFERENCE INPUTS (NOTE 1)

Analog torque/velocity	±10Vdc, 12 bit resolution	Differential (J3-2,14)
Input impedance	66 kΩ	Between Ref(+), Ref(-)
Digital position reference	Pulse/Direction, CW/CCW	Stepper commands (2 MHz maximum rate)
	Quad A/B Encoder	20 Mcount/sec (after quadrature), 5 Mline/sec
Digital torque & velocity reference	PWM , Polarity	PWM = 0~100%, Polarity = 1/0
	PWM	PWM = 50% +/-50%, no polarity signal required
	PWM frequency range	1 kHz minimum, 100 kHz maximum
	PWM minimum pulse width	220 ns

DIGITAL INPUTS (NOTE 1)

All inputs	74HC14 Schmitt trigger operating from 5.0 Vdc with RC filter on input
Logic levels	Vin-LO < +1.35 Vdc, Vin-HI > +3.65 Vdc, Input voltage range 0 to +24 Vdc
Pull-up, pull-down control	[IN2,3,4] have group selectable connection of 10 kΩ input pull-up/down resistor to +5 Vdc or ground
Enable [IN2]	Dedicated input with 330us RC filter for amplifier enable, active level programmable
GP [IN1,2,3,4]	General Purpose inputs with 330us RC filter and active level select, [IN1,3,4] have programmable functions
HS [IN5,6]	High-Speed Inputs inputs with 100ns RC filter, active level select, and programmable functions

SERIAL DATA INPUT

RS-232	RxD, TxD, Gnd in 6-position, 4-contact RJ-11 type modular connector, and on J3-24, 25, & 13 Full-duplex, serial communication port for amplifier setup and control, 9600 to 115200 baud Data protocol: binary

MOTOR CONNECTIONS

Phase U, V, W	Amplifier outputs to 3-phase Wye or delta connected brushless motors with floating neutral
Hall U, V, W	Digital Hall signals
Encoder A, /A, B, /B, (X,/X)	Quadrature encoder signals, single-ended or differential (X or Index signal not required) 5 MHz maximum line frequency (20 Mcount/s) when driven from active differential outputs
[IN1] Motemp	See Digital Inputs (above) for details (Note 1)

STATUS INDICATORS

Amp Status	Bicolor LED. Amplifier status indicated by color, and blinking or non-blinking condition

DIGITAL OUTPUTS (NOTE 1)

Type	Current-sinking MOSFET open-drain output with 1kΩ pullup to +5 V through diode, 1 Adc sink max, +30 Vdc max.
[OUT1,2]	Programmable External flyback diode required with inductive loads

PROTECTIONS

HV Overvoltage	+HV > HV_{max}	Amplifier outputs turn off until +HV < HV_{max} (See Input Power for HV_{max})
HV Undervoltage	+HV < 20 Vdc	Amplifier outputs turn off until +HV > 20 Vdc
Amplifier over temperature	PC Board > 70 °C.	
Short circuits	Output to output, output to ground, internal PWM bridge faults	
I^2T Current limiting	Programmable: continuous current, peak current, peak time	
Motor over temperature	Digital inputs programmed for overtemp function will disable amplifier	

MECHANICAL & ENVIRONMENTAL

Size	6.58 in (167,1 mm) X 3.89 in (98,81 mm) X 1.17 in (29,72 mm)
Weight	0.94 lb (0.43 kg) for amplifier without heatsink
Ambient temperature	0 to +45 °C operating, -40 to +85 °C storage
Humidity	0% to 95%, non-condensing
Contaminants	Pollution degree 2
Environment	IEC68-2: 1990
Cooling	Heat sink and/or forced air cooling may be required for continuous power output (see pg. 8 & 9)

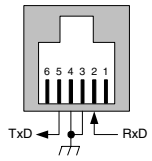
Notes

1.Digital input & output functions are programmable. Default functions are shown here.

COMMUNICATION

Accelus™ is configured via a three-wire, full-duplex RS-232 port that operates from 9600 to 115,200 Baud. *CME 2™* provides a graphic user interface (GUI) to set up all of *Accelus™* features via a computer serial port. Connections to the *Accelus™* RS-232 port P1 are via an RJ-11 style connector, and through the signal connector J3 (J3-24 & 25). RxD, TxD, and Gnd signals comprise the signals supported. The *Accelus™* Serial Cable Kit contains a modular cable, and an adapter that connects to a 9-pin, Sub-D serial port connector (COM1, COM2, etc.) on PC's and compatibles.

RS-232 Port



STATUS LED

A single bi-color LED gives the state of the amplifier by changing color, and either blinking or remaining solid. The possible color and blink combinations are:

- ***Green/Solid***: Amplifier OK and enabled. Will run in response to reference input.
- ***Green/Slow-Blinking***: Amplifier OK but not-enabled. Will run when enabled.
- ***Green/Fast-Blinking***: Positive or Negative limit switch active. Amplifier will only move in direction not inhibited by limit switch.
- ***Red/Solid***: Temporary fault condition. Amplifier will resume operation when fault is removed.
- ***Red/Blinking***: Latching fault. Operation will not resume until amp is Reset

Fault conditions: Short-circuits from output to output, output to ground, and internal shorts or over current conditions, amplifier or motor over-temperature, over or under-voltage, encoder power loss, motor phasing error (current position > 60° electrical from Hall angle), or position-mode following error. Faults are programmable as latching or non-latching.

DIGITAL INPUTS

There are six digital inputs [IN1-6] five of which are programmable functions. Inputs [IN1,5, & 6] have 10 kΩ pull-up resistors that connect to +5 Vdc to work with grounded switches, NPN open-collector, CMOS, or TTL outputs.

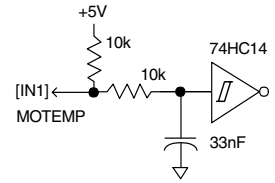
[IN2] always functions as the Enable input, and controls the ON/OFF state of the amplifier outputs. [IN2] can function simply as the amp-enable or as the amp-enable with reset. With the reset options selected, the amplifier will reset when [IN2] goes from the active to the inactive level. The default selection is active-LO with no reset. This setting is the fail-safe condition. In order to make the amplifier operate, the enable input must be connected and must be grounded to operate the amplifier. If a wire were to break, or the controller malfunction, the input would not be grounded and the amplifier would not operate. If the input is set to Active-HI, it is not in a fail-safe mode, and will be enabled with no connection to the [IN2] input. This setting is therefore not recommended for general operation.

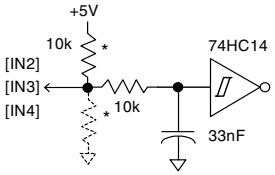
The other digital enable inputs, [IN1], [IN3-6] have alternate functions that are settable via CME 2™:

- Positive Limit Switch
- Negative Limit Switch
- Amplifier Reset
- Motor temp sensor

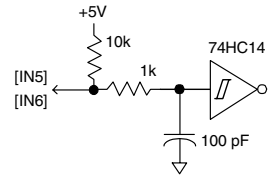
In addition to the alternate functions, the active level for each input is individually programmable.

Amplifier reset takes place on transitions of the input and is programmable to 1/0 or 0/1. The motor temp sensor function will disable the amplifier if a switch in the motor opens or closes when the motor overheats. The motor temperature switch or sensor should be grounded. The active-level setting is then set depending on the type of switch: normally open, or normally closed.





* Input resistors are programmable to pull-up to +5 Vdc or pull-down to signal ground as a group

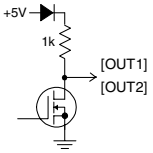


DIGITAL OUTPUTS

Digital outputs are open-drain MOSFETs with 1 kΩ pull-up resistors to +5 Vdc. These can sink up to 1 Adc from external loads operating from power supplies to +30 Vdc. When driving inductive loads such as a motor brake, an external fly-back diode is required. A diode in the output is for driving PLC inputs that are opto-isolated and connected to +24 Vdc. The diode prevents conduction from +24 Vdc through the 1 kΩ resistor to +5 Vdc in the amplifier. This could turn the input on, giving a false indication of the amplifier output state.

These outputs are level-selectable like the inputs, and each output is programmable for various functions.

Digital outputs

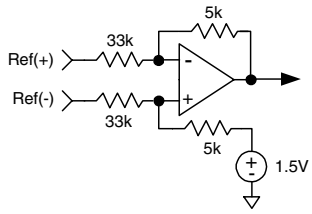


REFERENCE INPUTS

The Reference inputs command the amplifier to produce an output. *Accelus™* has analog and digital reference inputs. Only one can be active at a time.

ANALOG REFERENCE INPUT

The analog ±10 Vdc signal is an industry standard for torque or velocity control. The analog reference input is a differential amplifier which is to be connected to the motion controller ground and DAC output. Using a differential amplifier is important because there may be potential differences between the amplifier and controller grounds. The differential amplifier construction rejects these differences and measures the controller output relative to ground at the controller. Note that the voltage *between* Ref(+) and Ref(-) inputs must be zero to produce a "zero" amplifier command. Grounding Ref(-), and allowing Ref(+) to be open will produce a large command, as will grounding Ref(+) and letting Ref(-) be open. *When wiring the controller DAC output to the reference inputs, be sure to use both reference inputs, and connect Ref(-) to ground at the controller, and not at the amplifier.*



IMPORTANT!

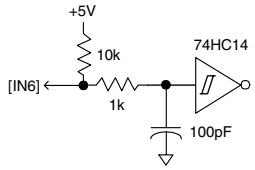
ALWAYS CONNECT BOTH ANALOG REF INPUTS. THERE MUST BE ZERO VOLTS BETWEEN REF(+) & REF(-) FOR ZERO OUTPUT FROM THE AMPLIFIER!

DIGITAL REFERENCE INPUTS

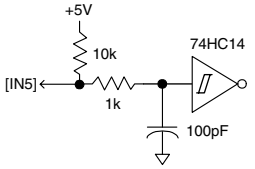
There are two logic inputs [IN5] and [IN6] for digital reference signals that are programmable for controlling torque, velocity, or position. If not used as reference inputs, they are programmble as logic inputs. When used as reference inputs these should be driven by active-output devices (i.e. CMOS, TTL). The input resistors define the default polarities when inputs are open, or for use with open-collector devices as digital logic inputs.

DIGITAL REFERENCE INPUTS (CONT'D)

PWM Torque/velocity input
or CW/Pulse/Encoder-A position input



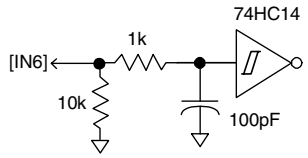
Torque/Velocity polarity
or CCW/Direction/Encoder-B position input



IMPORTANT!

AMPLIFIERS WITH SERIAL NUMBERS EQUAL TO OR LESS THAN THE NUMBERS SHOWN HERE HAVE THE INPUT CONFIGURATION SHOWN BELOW FOR [IN6]
ASP-090-09, ASP-180-09: s/n 5102xxxx
ASP-055-18, ASP-090-18, ASP-180-18: 3102xxxx
ASP-090-36: 3502xxxx

NOTE: THE LAST FOUR DIGITS ARE NOT SIGNIFICANT

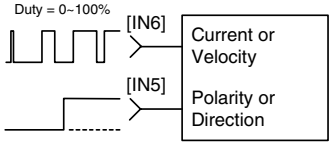


DIGITAL REFERENCE INPUTS

For torque or velocity control, the inputs may be configured in two formats:

1. PWM (0~100%) & Polarity
2. PWM (50%)

In the first case, the PWM signal can vary from 0% to 100%, and the Polarity signal is a DC level that controls the direction of the motor. The PWM duty-cycle controls the amplifier output current, or motor velocity. In current mode, 100% corresponds to the maximum output current. In velocity mode, it commands the maximum velocity that is configured.

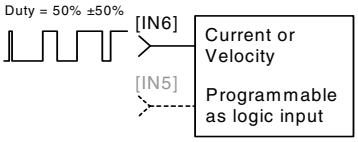


Another type of PWM input is the "50%" type. There is only one PWM signal that connects to [IN6]. The other digital input [IN5] is not used in this mode. A 50% duty-cycle corresponds to a zero-current command in torque mode, or a zero-speed output in velocity mode.

Duty-cycles of 0%, and 100% would result in negative full-scale, or positive full-scale outputs. So, the duty-cycle controls not only the magnitude, but also the polarity of the amplifier outputs.

The scale-factor for amplifier-output vs. PWM inputs is settable via *CME 2™* software in both cases.

50% PWM signals for
torque/velocity reference

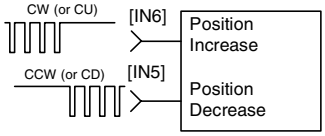


When operating *Accelus*™ in position mode, the digital reference inputs accept step-motor pulses it two formats, or quadrature-encoder signals. In either case, the ratio between input pulses, and motor encoder counts is programmable.

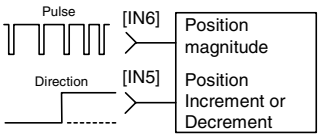
The first format of stepper-command signals is the CW/CCW (clockwise/counter-clockwise) format, which could also be called CU/CD (count-up/count-down). Pulses at [IN6] will increase the position-command to the amplifier, and pulses at [IN5] will decrease it. The other stepper-command format is the Pulse & Direction one where pulses at [IN6] will increment or decrement the position-command depending on the DC level at the Direction input, [IN5].

The active-edge is programmable for 0-1 or 1-0 transitions when in Pulse/Dir or CW/CCW input modes.

Digital reference inputs configured as CW/CCW inputs in position mode with 0-1 active-edges:

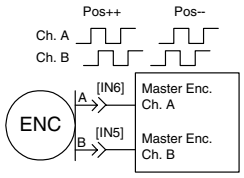


Digital reference inputs configured as Pulse-Direction inputs in position mode with 0-1 active-edges:



Digital reference inputs can also connect to a quadrature encoder that outputs two pulse trains corresponding to angle of rotation, or linear travel. The pulse trains are phase-shifted 90° which gives them the name "quadrature", and each time one changes, the amplifier can interpret the change as an incremental position command. The amplifier decodes the A and B channel signals to determine if it is an increase, or decrease in position. If the encoder is mounted on a motor that is controlled by another amplifier and controller, it is referred to as "master-slave" operation. The master in this case is the motor controlled externally, and the *Accelus™* is the slave, following the position of the master in a ratio that is configurable via *CME 2™.*

Master encoder signals as
position reference inputs

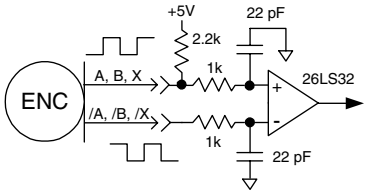


MOTOR CONNECTIONS

Motor connections are of three types: phase, Halls, and encoder. The phase connections carry the amplifier output currents that drive the motor to produce motion. The Hall signals are three digital signals that give absolute position feedback within an electrical commutation cycle. The encoder signals give incremental position feedback and are used for velocity and position modes, as well as sinusoidal commutation.

MOTOR ENCODER

The input circuit for the motor encoder signals is a differential line-receiver with R-C filtering on the inputs. The circuit is shown below. Encoders with differential outputs are preferred because they are less susceptible to noise that can be picked on single-ended outputs. For best results, encoder cabling should use twisted pair cable with one pair for each of the encoder outputs: A & /A, B & /B, and X & /X. Shielded twisted-pair is best for noise rejection. If single-ended encoders are used they should connect to J2-6,7,8. Encoders that require 200 mA or less can operate from amplifier +5 Vdc on J2-11. If more current is required then +5 Vdc from the user system can connect to J3-22 and will be available on J2-10. The encoder input circuit is shown below.



MOTOR HALL SIGNALS

Hall signals are single-ended signals that provide absolute feedback within one electrical cycle of the motor. There are three of them (U, V, & W) and they may be sourced by magnetic sensors in the motor, or by encoders that have Hall tracks. They typically operate at much lower frequencies