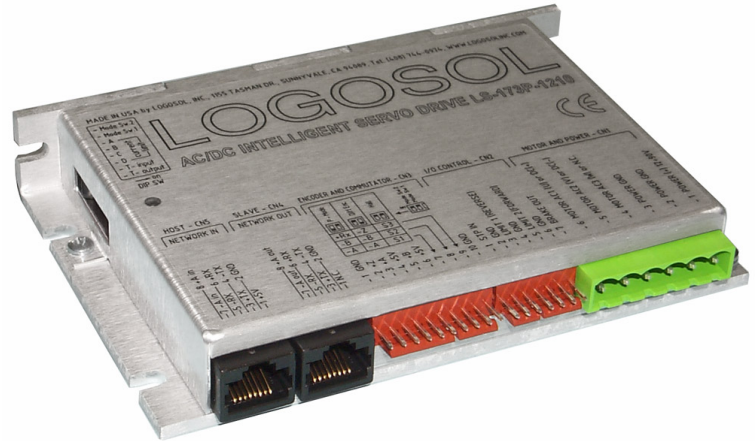


Logosol AC/DC Intelligent Servo Drive LS-173E

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Features

- ❑ **Motors supported:**
 - Panasonic A and S series motors
 - Brushless 60/120° commutated
 - Brush-commutated (DC)
 - Motors with index coded commutation
- ❑ **Output current**
 - 12A peak, 8A continuous
 - 20A peak, 12A continuous
- ❑ **12 to 90V single power supply**
- ❑ **32-bit position, velocity, acceleration, 16-bit PID filter gain values**
- ❑ **Comprehensive motor output short-circuit protection:**
 - Output to output
 - Output to ground
 - Output to power
- ❑ **Adjustable motor current limit**
- ❑ **Over/under voltage shutdown**
- ❑ **Overheating protection**
- ❑ **Hardware stop input**
- ❑ **Forward and reverse over travel inputs**
- ❑ **Communication speed 19.2 - 115.2 KBps**
- ❑ **Servo rate 2 kHz**
- ❑ **PWM frequency 20 kHz**
- ❑ **Command rate up to 1000/sec**
- ❑ **Encoder transition rate up to 5MHz.**
- ❑ **Small footprint (5" x 3.3" x 0.85")**



Description

LS-173E is a single-axis motion controller with integrated servo amplifier designed for applications using Panasonic A and S series motors, standard brushless or brush-commutated motors, and motors with index coded commutation, up to 1 HP. Trapezoidal brushless motor commutation is performed. Up to 31 intelligent servo drives can be controlled over a multi-drop full duplex RS-485 network in a distributed motion control environment. Standard RJ-45 connectors and commercially available cables are used for daisy chaining of the modules.

LS-173E is equipped with various safety features such as short circuit protection for the motor and amplifier, over travel limit switch inputs, hardware stop input, over and under voltage shutdown. The maximum motor output current can be limited by setting of dipswitches or by software.

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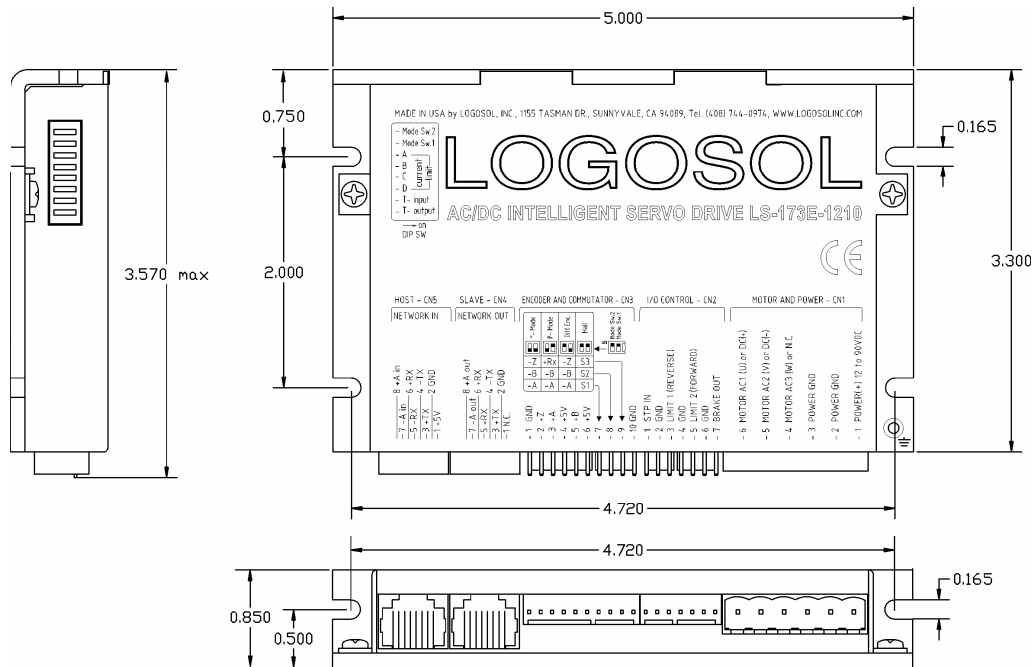
TECHNICAL SPECIFICATIONS rated at 25°C ambient, POWER (+)=60VDC, Load=250μH motor

POWER SUPPLY VOLTAGE	12 to 90 V DC, 100V Absolute Maximum
MAX MOTOR OUTPUT CURRENT LS-173E-1210, LS-173E4-1210 LS-173E-2010 LS-173E4-2010	Peak/Continuous 8A/12A 12A/20A
MAX MOTOR OUTPUT VOLTAGE	$V_{out} = 0.96(\text{POWER (+)}) - 0.17(I_{out})$
MIN LOAD INDUCTANCE	200μH
PWM SWITCHING FREQUENCY LS-173E-1210, LS-173E-2010 LS-173E4-1210, LS-173E4-2010	19,512 KHz 39,024 KHz
SERVO RATE	0.512 msec
SERIAL BAUD RATE	19.2 – 115.2 Kbps (faster communication rates are possible at lower servo rates)
OPEN COLLECTOR BRAKE OUTPUT Max voltage applied to output Max current load	48V 0.3A
INPUTS Encoder & Commutation Digital Inputs	TTL with 2K2 pull-up to 5V LOmin=-0.5V, HImax=48V
ENCODER	Quadrature with index
COMMUTATION	Hall sensors 60/120°
LEDS ORANGE GREEN or RED with two intensity levels	Power 'ok' (ORANGE and GREEN leds are ON when the Power Servo 'on' is 'OK' and the device is not initialized) Power 'ok' – low intensity / Servo 'on' – high intensity
PROTECTION Short circuit Overheating shut off	Motor output to motor output Motor output to POWER GND Motor output to POWER (+) Activated at 80 °C
FIRE-SAFETY	Internal fuse
POWER DISSIPATION (max)	30W
THERMAL REQUIREMENTS Storage temperature range Operating temperature range	-30 to +85 °C 0 to 45 °C
MECHANICAL Size Weight	L=5.00", H=3.30", D=0.85" 0.55lb. (250gr.)
MATING CONNECTORS Power & Motor Inputs & Outputs Encoder & Commutator Communication	Magnum EM2565-06-VL or Phoenix MSTB 2.5/6-ST-5.08 Molex 22-01-3077 housing with 08-50-0114 pins (7 pcs.) Molex 22-01-3107 housing with 08-50-0114 pins (10 pcs.) 8 pin RJ-45

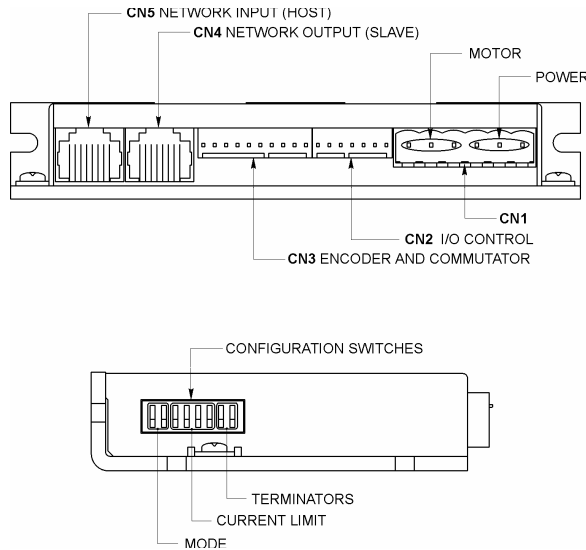
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DIMENSIONAL DRAWING



SERVO DRIVE LAYOUT



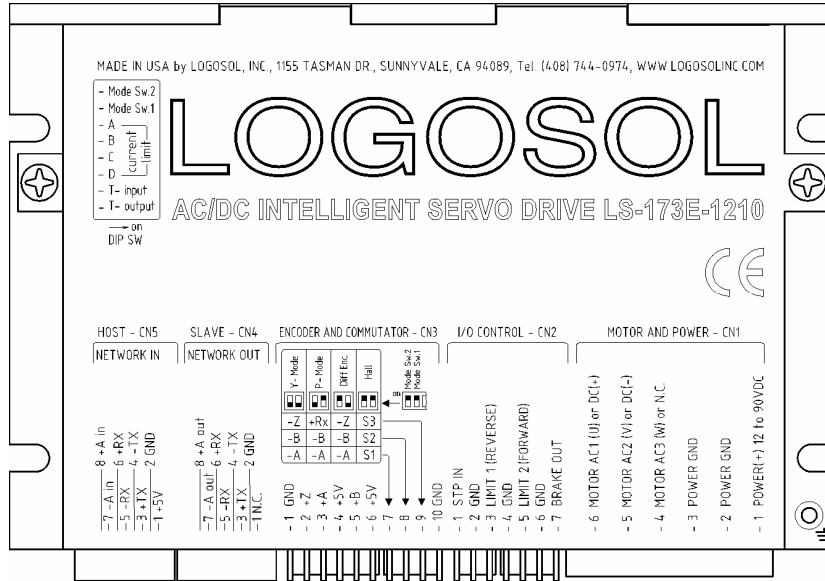
ORDERING GUIDE

PART NUMBER	MODEL	DESCRIPTION
912173026	LS-173E-1210	Intelligent Servo Drive 12A/8A /100V 20KHz PWM
912173027	LS-173E-2010	Intelligent Servo Drive 20A/12A /100V 20KHz PWM
912173028	LS-173E4-1210	Intelligent Servo Drive 12A/8A /100V 40KHz PWM
912173029	LS-173E4-2010	Intelligent Servo Drive 10A/12A /100V 40KHz PWM
230601004	LS-173-CN	Mating connector kit
230601017	PAN-AS-CN	Mating connector kit for Panasonic A and S series motors

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CONNECTORS AND PINOUT



DIP SW – DIP SWITCH

SW	SIGNAL	DESCRIPTION	FACTORY SETTING
1	T-out	Transmit line terminator	OFF
2	T-in	Receive line terminator	OFF
3	CL-D	Current limit switch	OFF
4	CL-C	Current limit switch	ON
5	CL-B	Current limit switch	ON
6	CL-A	Current limit switch	ON
7	Mode SW1	SW1=ON, SW2=ON – Brush or brushless motor with single ended (non differential) encoder SW1=OFF, SW2=ON – Brush motor with differential encoder	
8	Mode SW2	SW1=ON, SW2=OFF – Panasonic A or S series motor (P-mode) SW1=OFF, SW2=OFF – Motor with index coded commutation	

CN1 – POWER AND MOTOR CONNECTOR

PIN	SIGNAL	DESCRIPTION
1	POWER (+) 12 to 90V	12 to 90V power supply, positive terminal
2	POWER GND*	Power supply ground
3	POWER GND*	Power supply ground
4	MOTOR AC3 (W) or NC	Output to motor Phase #3 terminal for brushless motors or motors with index coded commutation Phase W for Panasonic A and S series motors Not connected for brush motors
5	MOTOR AC2 (V) or DC (-)	Output to motor Phase #2 terminal for brushless motors or motors with index coded commutation Phase V for Panasonic A and S series motors Negative terminal for brush motors
6	MOTOR AC1 (U) or DC (+)	Output to motor Phase #1 terminal for brushless motors or motors with index coded commutation Phase U for Panasonic A and S series motors Positive terminal for brush motors

* POWER GND and GND are electrically connected. Drive Case is isolated from Drive circuitry and can be grounded externally.

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CN2 – I/O CONTROL

PIN	SIGNAL	DESCRIPTION
1	STP IN	Stop input (disable servo amplifier)
2	GND*	Signal ground
3	LIMIT 1 (REVERSE)	Over travel input
4	GND*	Signal ground
5	LIMIT 2 (FORWARD)	Over travel input.
6	GND*	Signal ground
7	BRAKE OUT	Brake output. Open collector output 48V/0.3A.

CN3 – ENCODER AND COMMUTATOR

PIN	SIGNAL	DESCRIPTION
1	GND*	Encoder ground
2	Z	Encoder index
3	A	Encoder phase A
4	+5V**	Encoder power supply
5	B	Encoder phase B
6	+5V**	Commutator power supply
7	S1	Hall sensor input #1 for brushless motors
	-A	Encoder phase –A for DC brush motors with differential encoder or motors with index coded commutation
	-A	Encoder phase –A for Panasonic A and S series motors
8	S2	Hall sensor input #2 for brushless motors
	-B	Encoder phase –B for DC brush motors with differential encoder or motors with index coded commutation
	-B	Encoder phase –B for Panasonic A and S series motors
9	S3	Hall sensor input #3 for brushless motors
	-Z	Encoder phase –Z for DC brush motors with differential encoder or motors with index coded commutation
	+RX	Hall data for Panasonic A and S series motors
10	GND*	Commutator ground

CN4 – NETWORK OUT (SLAVE)

PIN	SIGNAL	DESCRIPTION
1	N.C.	Not connected
2	GND*	Interface ground
3	+TX	(+) Transmit data
4	-TX	(-) Transmit data
5	-RX	(-) Receive data
6	+RX	(+) Receive data
7	-A out	(-) Address output
8	+A out	(+) Address output

CN5 – NETWORK IN (HOST)

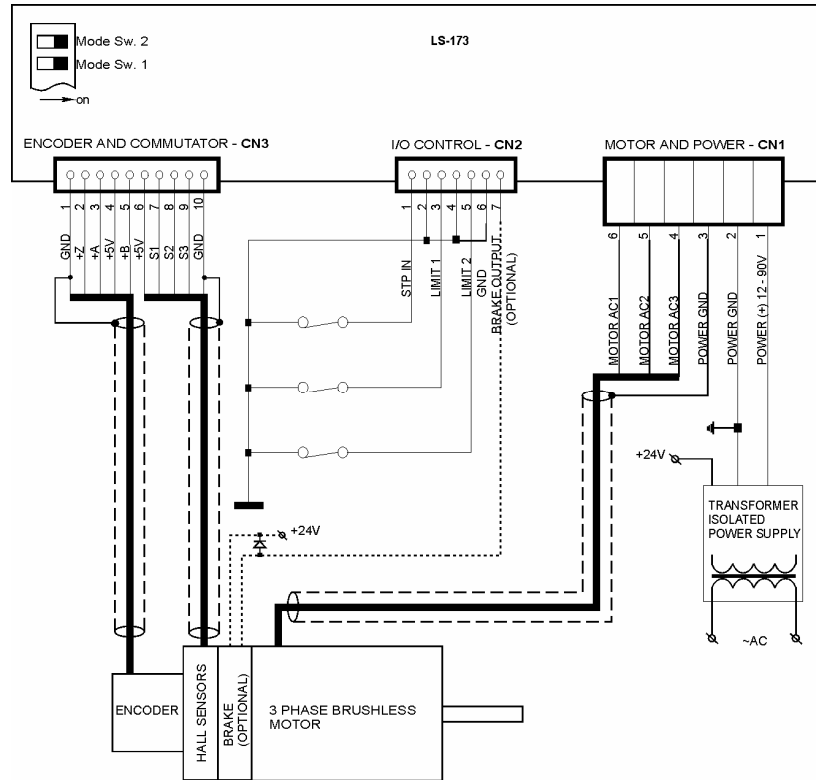
PIN	SIGNAL	DESCRIPTION
1	+5V**	RS-232 adapter power supply
2	GND*	Interface ground
3	+TX	(+) Transmit data
4	-TX	(-) Transmit data
5	-RX	(-) Receive data
6	+RX	(+) Receive data
7	-A in	(-) Address input
8	+A in	(+) Address input

** 200mA Max current for all three outputs combined.

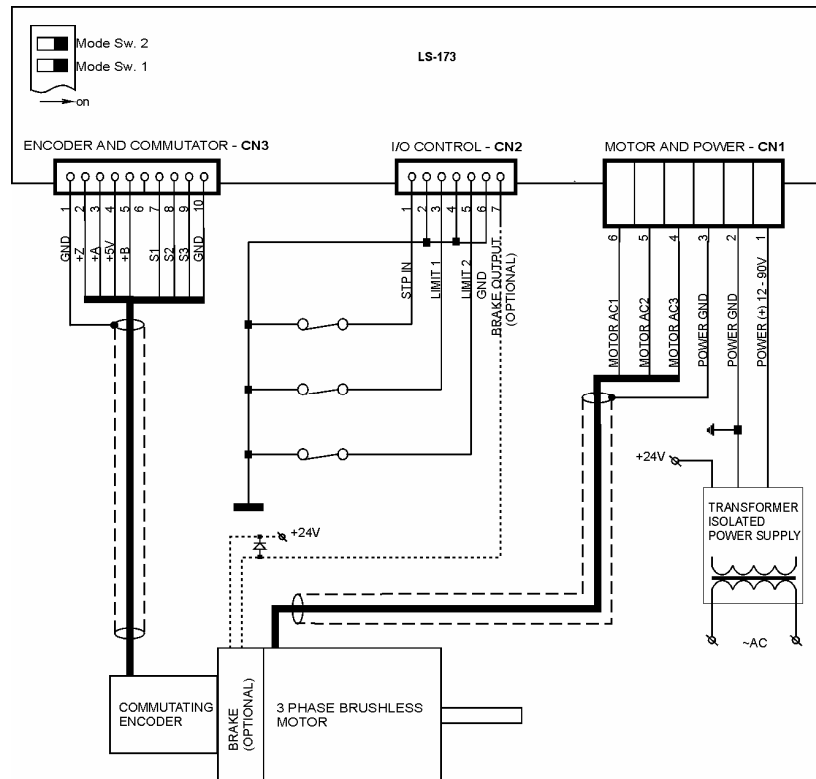
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SAMPLE APPLICATION using Brushless motor



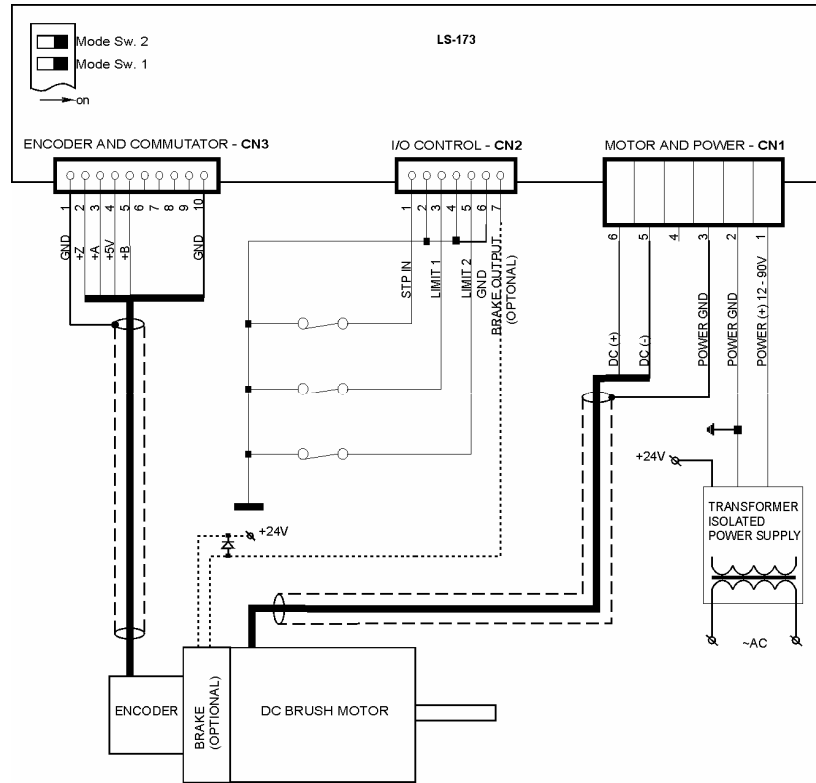
SAMPLE APPLICATION using Brushless motor with commutating encoder



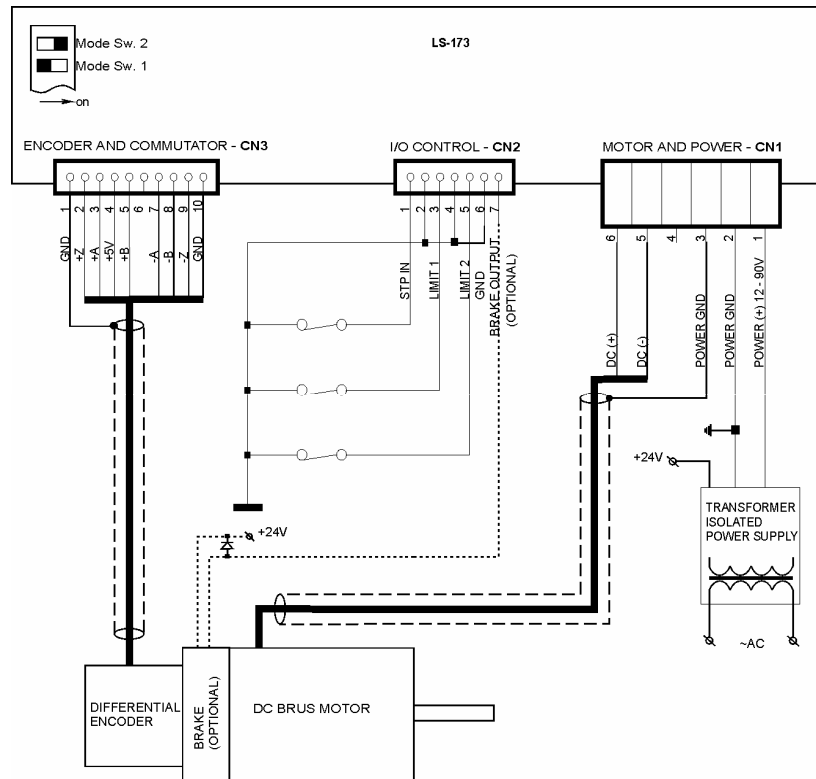
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SAMPLE APPLICATION using DC (brush) motor with single ended encoder



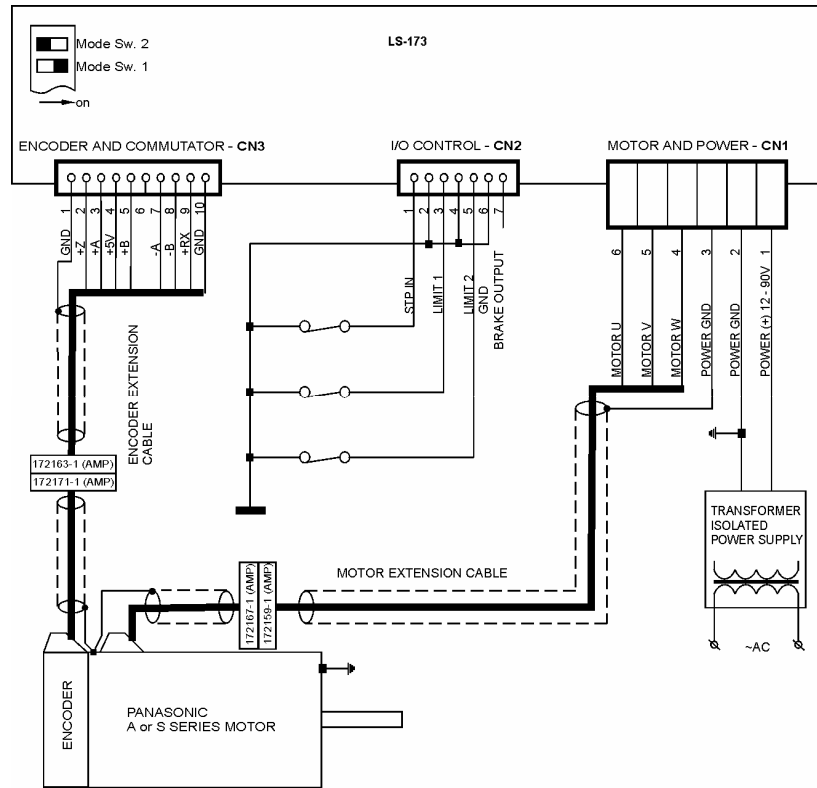
SAMPLE APPLICATION using DC (brush) motor with differential encoder



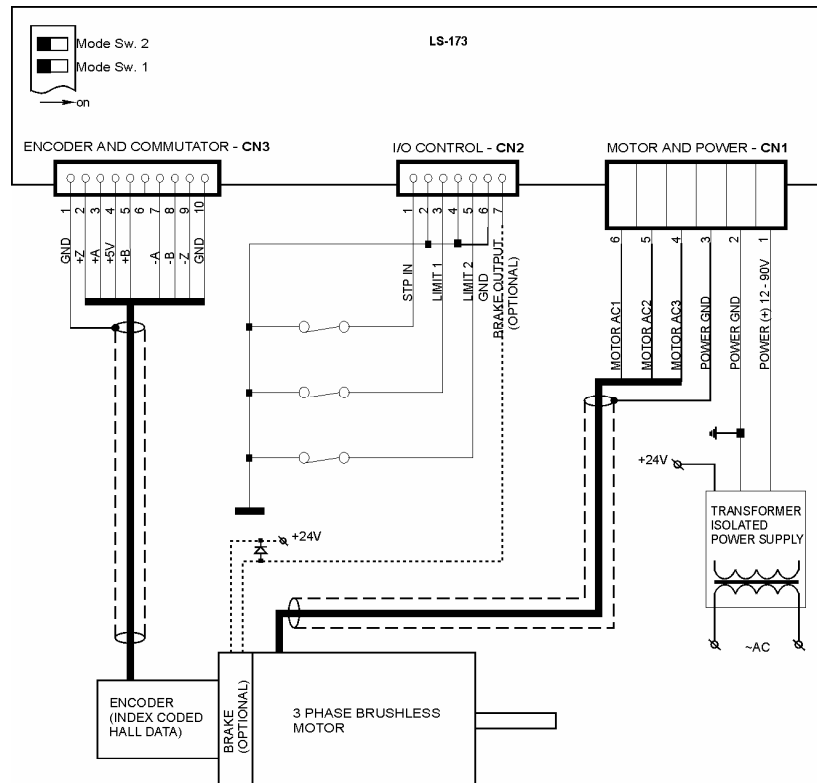
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SAMPLE APPLICATION using Panasonic A and S series motor



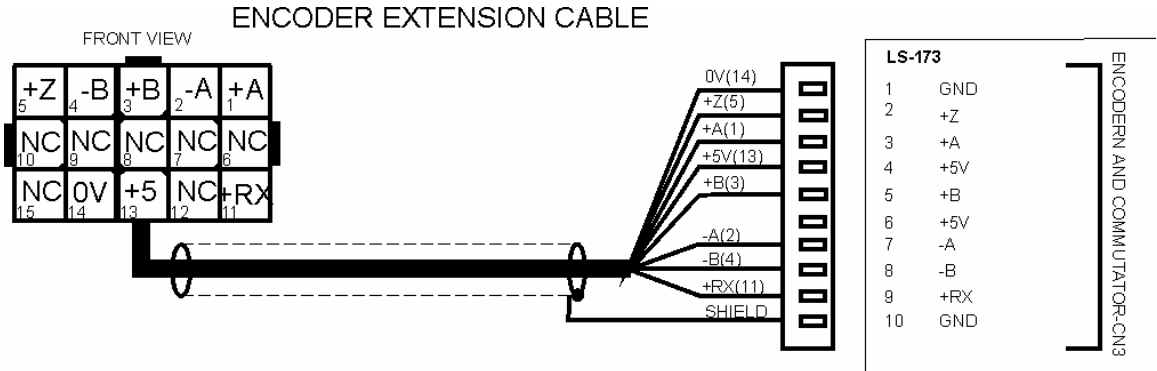
SAMPLE APPLICATION using motor with index coded commutation



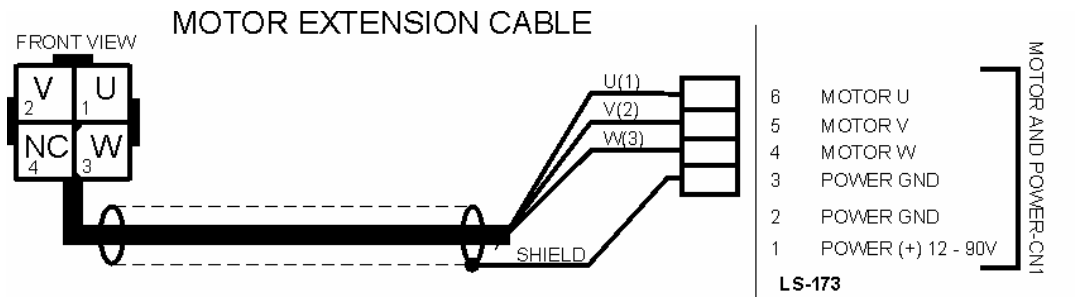
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EXTENSION CABLES for Panasonic A and S series motors



ENCODER MATING CONNECTOR (AMP CAP 172163-1) + 8 pins 170365-1			LS-173/4P ENCODER AND COMMUTATOR CONNECTOR (MOLEX 22-01-3107) + 9 pins 08-50-0114	
PIN#	SIGNAL NAME	PIN#	SIGNAL NAME	
1	+ A channel output	3	+A	
2	- A channel output	7	-A	
3	+ B channel output	5	+B	
4	- B channel output	8	-B	
5	+ Z channel output	2	+Z	
6	N.C.			
7	N.C.			
8	N.C.			
9	N.C.			
10	N.C.			
11	+RX	9	RX+	
12	N.C.			
13	+5V	4	+5V	
14	0V	1	GND	
15	N.C.	10	GND (SHIELD)	

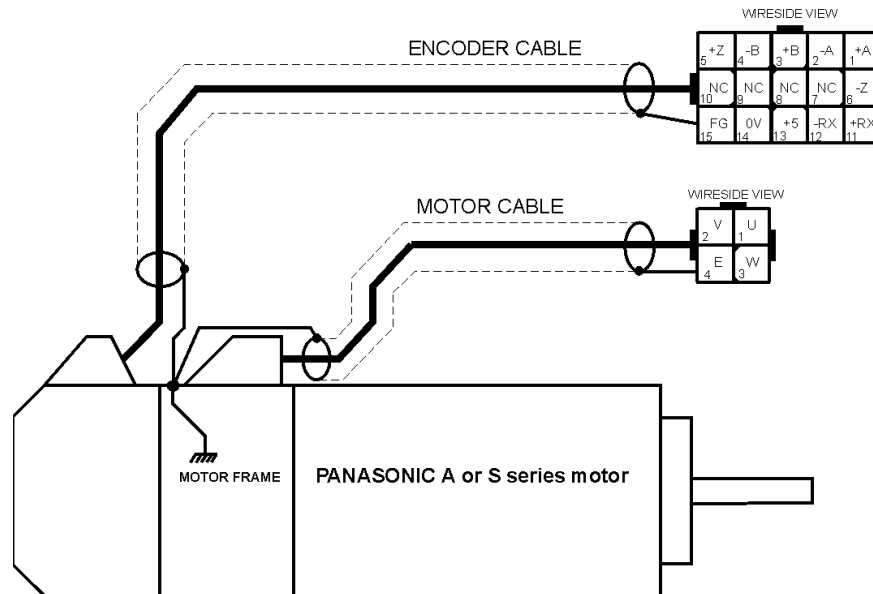


MOTOR MATING CONNECTOR (AMP CAP 172159-1) + 3 pin 170366-1		LS-173/4P MOTOR CONNECTOR (PHOENIX CONTACT MSTB2.5/6-ST-5.08)	
PIN#	SIGNAL NAME	PIN#	SIGNAL NAME
1	U phase	6	MOTOR U
2	V phase	5	MOTOR V
3	W phase	4	MOTOR W
4	N.C.	3	POWER GND

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PANASONIC A AND S SERIES MOTORS WIRING DIAGRAM



ENCODER CONNECTOR		
PIN#	SIGNAL NAME	WIRE COLOR
1	+ A channel output	Red
2	- A channel output	Pink
3	+ B channel output	Green
4	- B channel output	Blue
5	+ Z channel output	Yellow
6	- Z channel output	Orange
7	NC	NA
8	NC	NA
9	NC	NA
10	NC	NA
11	+RX	Light blue
12	-RX	Purple
13	+5V	White
14	0V	Black
15	FG = motor frame	Black

MOTOR CONNECTOR		
PIN#	SIGNAL NAME	WIRE COLOR
1	U phase	Red
2	V phase	White
3	W phase	Black
4	E = motor frame	Green/yellow

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LOGOSOL LS-173E QUICK START GUIDE

Hardware Setup

1. Connect power supply (12 to 90 V DC) to LS-173E.
2. Connect your motor, encoder, Hall sensors and any other I/O you may have.
3. Connect RS-232 adapter and RJ-45 network cable between LS-173E and your host computer.

Software Installation

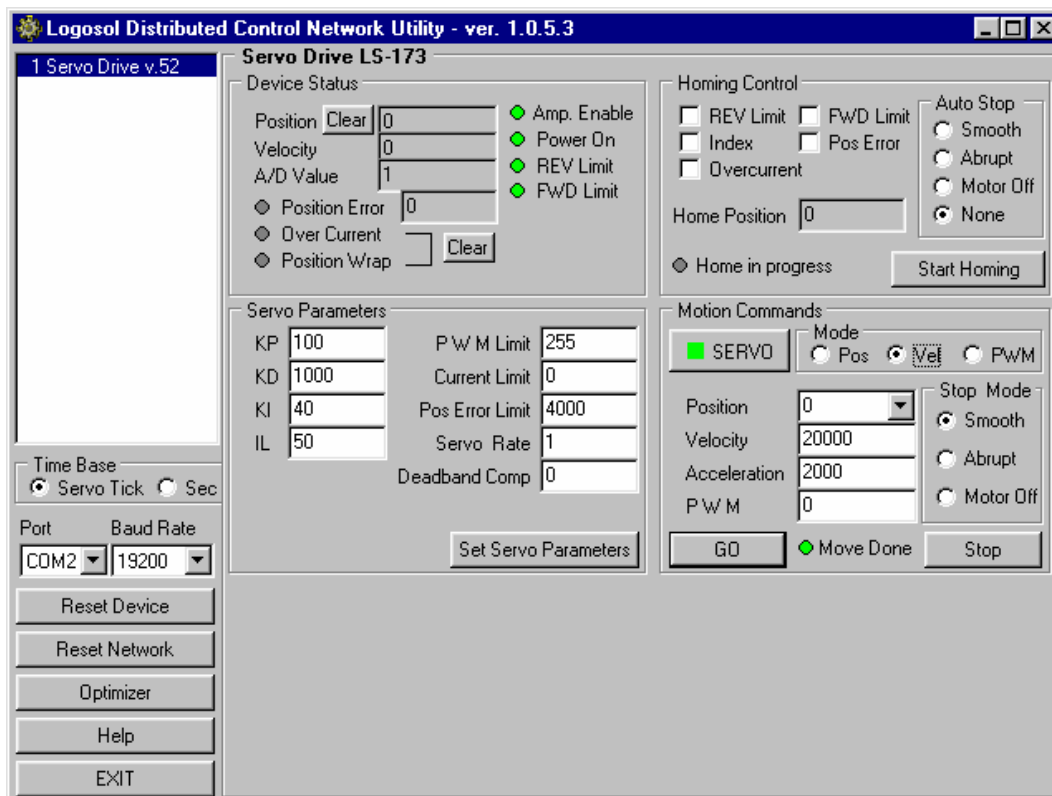
1. Installation and using Logosol Distributed Control Network Utility

A. Installation

1. Insert the Logosol Distributed Control Network Utility installation disk into the floppy drive.
2. Select Run from the Windows 95/98/NT/XP Start menu.
3. Type a:\dcnsetup and then click OK (a: represents the drive letter).
4. The installation wizard will guide you through the setup process.

B. Initial Connection to the Host

1. Turn on the power supply.
2. Run the Logosol Distributed Control Network Utility.
3. Choose the proper COM port
4. Click "SERVO" button.
5. Click "GO" button. The motor should rotate slowly in positive direction. Click "Stop" to interrupt the motion. More information about using LDCN utility is available in LDCN Help.



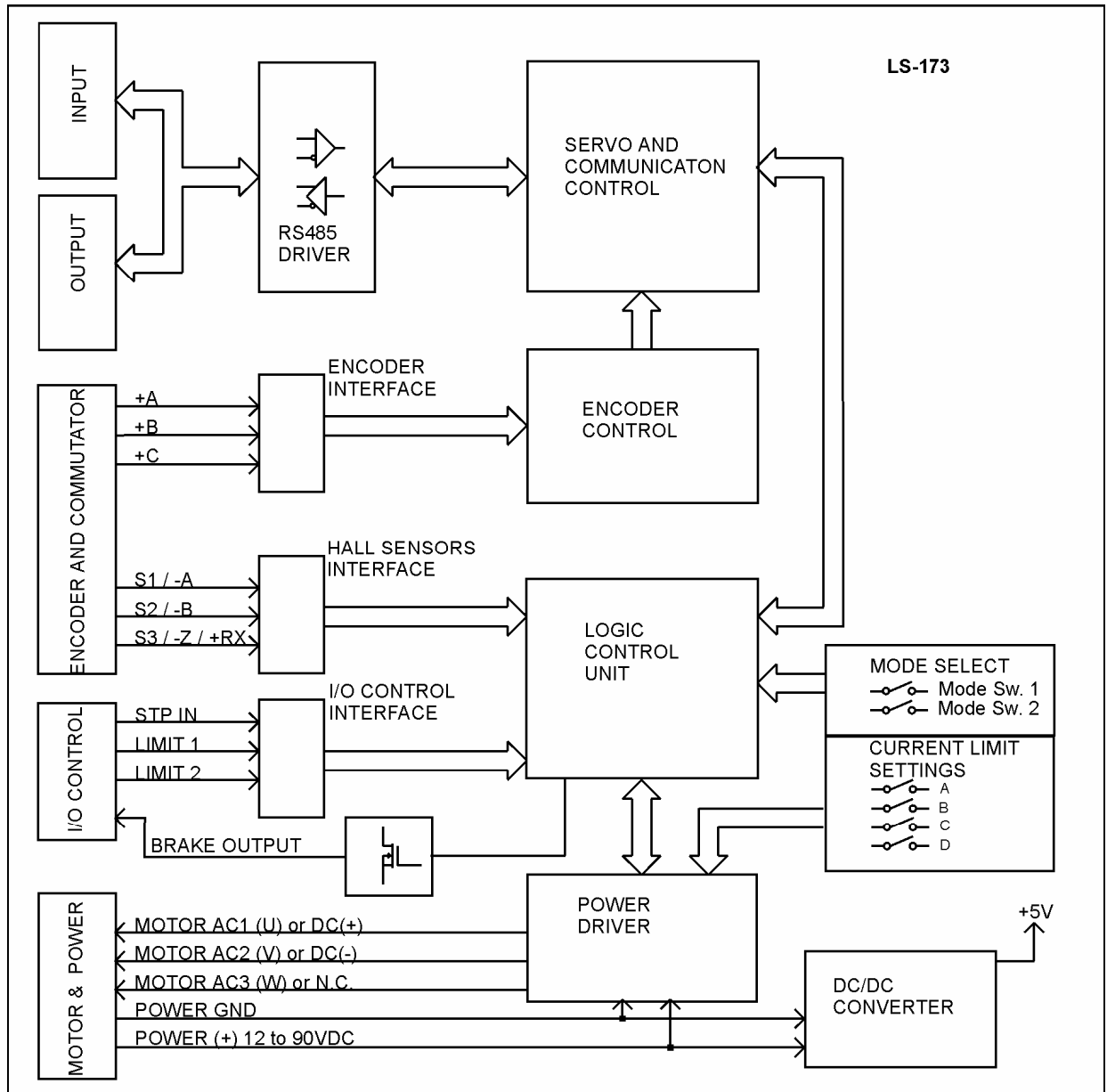
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LS-173E ARCHITECTURE

Overview

The LS-173E Intelligent Servo Drive is a highly integrated servo control module including a motion controller, servo amplifier, serial communication interface, optical encoder interface, limit switch inputs, and protection circuit (short circuit, under and overvoltage, overcurrent and software controlled current limit). The Servo Drive is designed so that up to 31 controllers can be daisy-chained and connected directly to a single standard serial port (RS-232 adapter may be necessary).



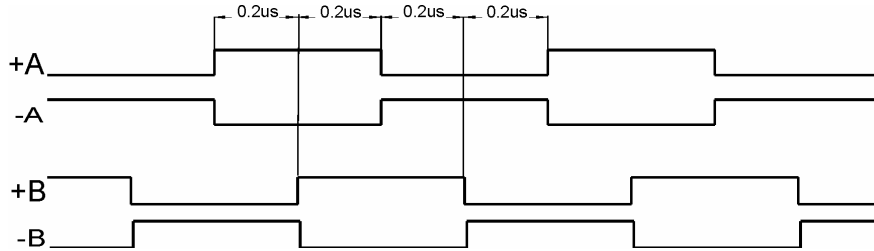
Functional Diagram

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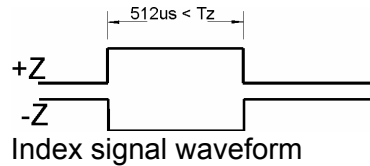
Encoder Input

The encoder interface accepts two square wave inputs, A, B (+A, -A, +B, -B for differential encoders) from an incremental encoder. Ideally, these square waves are 50% duty cycle and exactly +/-90 degrees out of phase. In any case, the time between encoder state transitions should be not less than 0.2 μ sec. With ideally formed encoder pulses, this would correspond to a 2500-line encoder (10000 counts/rev) rotating at 30,000 RPM.



Encoder signal waveforms (CW direction)

Some incremental encoders are equipped with Index output Z (+Z and -Z for differential encoders). In order to make possible to capture Home position on Index the velocity during homing procedure have to guarantee index pulse longer then 512 μ S. The maximum theoretical homing velocity is one encoder count per servo tick (refer to "Set Homing Mode" command in "Command description" section in this document).



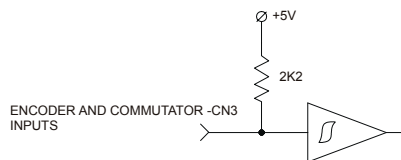
Index signal waveform

Multifunctional Inputs

To set the functions of pins 7, 8, 9 of ENCODER AND COMMUTATOR connector use the table* :

MODE SW 1	MODE SW-2	ENCODER AND COMMUTATOR – CN3			MOTOR TYPE
		PIN 7	PIN 8	PIN 9	
ON	ON	Hall input S1	Hall input S2	Hall input S3	Brushless or brush motor with single ended encoder
OFF	ON	Encoder phase -A	Encoder phase -B	Encoder phase -Z	Brush motor with differential encoder
ON	OFF	Encoder phase -A	Encoder phase -B	Commutation data +RX	Panasonic A or S series motor
OFF	OFF	Encoder phase -A	Encoder phase -B	Encoder phase -Z	Brushless motor with index coded commutation

All ENCODER AND COMMUTATOR (CN3) inputs are equipped with pull-up resistors 2K2 to +5V.



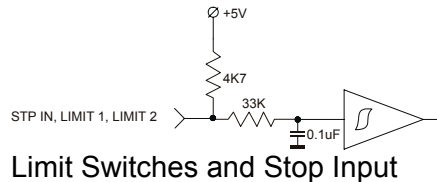
* Refer also to Sample Applications in this document.

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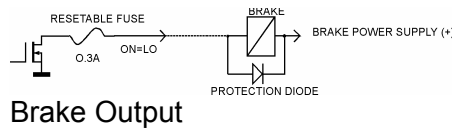
Digital Inputs

There are 3 digital inputs - STP IN, LIMIT 1 (REVERSE) and LIMIT 2 (FORWARD). STP IN may be used only as "STOP" input. Limit inputs may be used as "HOME" switches, limit switches or as general-purpose inputs. (Refer to *I/O Control* and *Set Homing Mode* commands in the *Command Description* section in this document) All are with pull-up resistors 4K7 to +5V.



Brake Output

Brake is released (brake output is "on") when Power_on (bit3 of Status byte) and Pic_ae (bit0 of Stop command data byte) are set to 1.



Brake will be engaged (Brake output is "off") if:

- STP IN is open;
- Overvoltage;
- Overcurrent;
- Motor short;
- Overheat;
- Position error exceeds the position error limit.

Note: For additional information refer to Status bits and LED, Status byte and Auxiliary status byte and Stop command description, sections of this document. If Power Driver is OK, brake will be released after Pic_ae 0 to 1 transition.

Dip Switches

Dip switches are used for overcurrent limit setting, mode select and terminator control.

Two of the switches, T-in and T-out, are used for connecting terminators to receive and transmit lines.

The overcurrent limit can be set using A, B, C, and D switches (refer to *Overcurrent DIP Switch Settings...* of *Safety Features* section in this document).

LS-173E can be configured for different motor types using Mode Sw.1 and Mode Sw. 2. To select the appropriate setting, refer to *Sample applications* and *Encoder and Commutator inputs* sections in this document.

Serial Command Interface

Serial communication with the LS-173E drives adheres to a full-duplex (4 wire) 8 bit asynchronous protocol with one start bit, followed by 8 data bits (lsb first), followed by a single stop bit. The communication protocol of the LS-173E also supports a full-duplex multi-drop RS-485 interface that allows multiple LS-173E intelligent servo drives to be controlled over a single RS-485 port. In this case, the host sends commands over its RS-485 transmit line and receives all status data back over the shared RS-485 receive line.

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The command protocol is a strict master/slave protocol in which the host master sends a command packet over the command line to a specific LS-173E slave. The data are stored in the buffer of the LS-173E until the end of the current servo cycle (0.512 msec max.) and then the command is executed. The servo drive then sends back a status packet. Typically, the host does not send another command until a status packet has been received to insure that it does not overwrite any previous command data still in use.

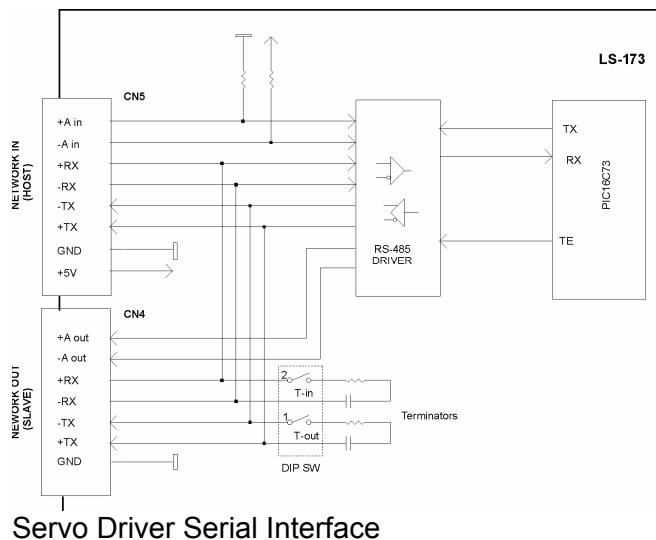
Each command packet consists of following:

- Header byte (0xAA)*
- Address byte - individual or group (0x00 - 0xFF)*
- Command byte*
- 0 - 15 data bytes*
- Checksum byte*

The command byte is divided into upper and lower nibbles: the lower nibble is the command value; the upper nibble is the number of additional data bytes, which will follow the command byte. The checksum byte is 8 bit sum of the address byte, the command byte and the data bytes. The number of data bytes depends on the particular command chosen. After a command is issued, the corresponding controller will send back a status packet consisting of:

- Status byte*
- 0-16 optional bytes of status data*
- Checksum byte*

The status byte contains basic status information about the LS-173E, including a checksum error flag for the command just received. The optional data bytes may include data such as the position, velocity, etc. and are programmable by the host. The checksum byte is the 8 bit sum of the status byte and the additional optional status data bytes. All 16-bit and 32-bit data is send with the least significant byte first.



Addressing

Rather than having to hard-wire or switch-select the address of each LS-173E servo drive, the host dynamically sets the address of each LS-173E with the aid of the daisy-chained "A in" and "A out" lines. This allows additional LS-173E controllers to be added to an RS-485 network with no hardware changes. On power-up, "A in" of the first LS-173E is pulled low, its communication is enabled and the default address is 0x00. When the *Set Address* command is issued to give

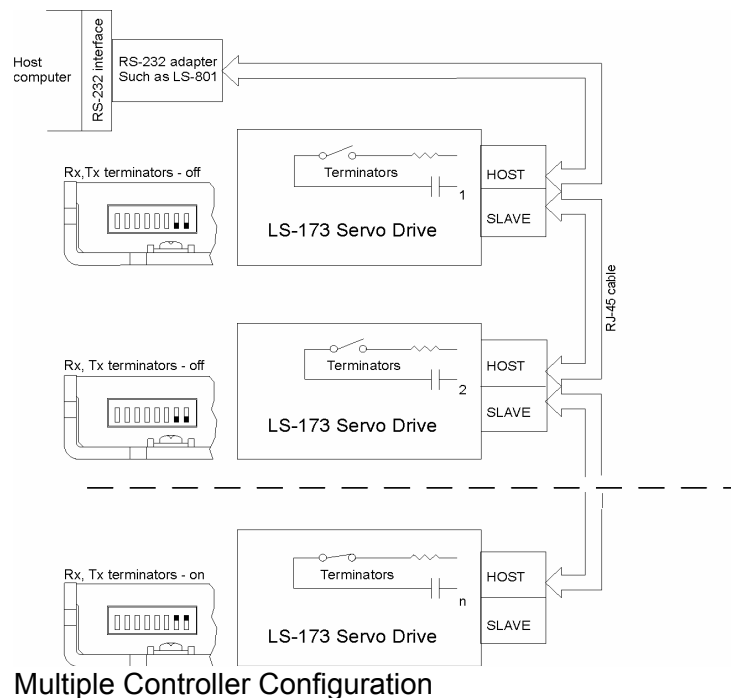
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this LS-173E new unique address, it will lower its “A out” pin. Connecting “A out” pin to the “A in” pin of the next servo drive in the network will enable its communication at default address of 0x00. Repeating this process allows a variable number of controllers present to be given unique addresses. See *Initializing procedure and programming examples for LS-173E* later in this document.

Group Addresses

In addition to the individual address, each controller has a secondary group address. Several LS-173E controllers may share a common group address. This address is useful for sending commands, which must be performed simultaneously by a number of drivers (e.g. *Start motion, Set Baud Rate*, etc.). When a LS-173E receives a command sent to its group address, it will execute the command but not send back a status packet. This prevents data collisions on the shared response line. When programming group addresses, however, the host can specify that one member of the group is the “group leader”. The group leader will send back a status packet just like it would for a command sent to its individual address. The group address is programmed at the same time as the unique individual address using the *Set Address* command.



Communication Rate

The default baud rate after power-up is 19.2 Kbps. Baud rates up to 115.2 Kbps may be used at maximum servo rate. After communication has been established with all servo drives on a single network, the baud rate may be changed to a higher value with the *Set Baud Rate* command.

Servo Control

LS-173E uses a “proportional-integral-derivative”, or PID filter. The PWM signal is a square wave with 51.2µsec (LS-173E) or 25.6µsec (LS-173E4) period and varying duty cycle. A PWM value of 1023 corresponds to 100% and a value of 0 corresponds to 0%. Usually, PWM value greater than 1000 is not recommended. The position, velocity and acceleration are programmed as 32-bit quantities in units of encoder counts for servo ticks. For example, a velocity of one revolution per second of a motor with a 500 line encoder (2000 counts/rev) at a tick time of 0.512 msec. would correspond to a velocity of 1.0240 counts/tick. Velocities and accelerations use the lower 16 bits as a fractional component so the actual programmed velocity would be 1.024×2^{16} or

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67,109. An acceleration of 4 rev/sec/sec (which would bring us up to the desired speed in ¼ sec) would be 0.0021 counts/tick/tick; with the lower 16 bits the fractional component, this would be programmed as 0.0021×2^{16} or 137. Position is programmed as a straight 32-bit quantity with no fractional component. Note that if the servo rate divisor is modified, the time dependent velocity and acceleration parameters will also have to be modified.

PWM Mode Operation

If the position servo is disabled, the motor is operated in a raw PWM output mode and no trapezoidal or velocity profiling is performed. In this mode, a user specified PWM value is outputted directly to the amplifier. A PWM value of 255 corresponds to 100% and a value of 0 corresponds to 0%. Command position is continually updated to match the actual position of the motor and there will be no abrupt jump in the motor's position when position or velocity modes are entered. Also while the position servo is disabled, the command velocity is continually updated to match the actual velocity of motor. Thus, when velocity mode is entered, there will be no discontinuity in the motor's velocity. (Trapezoidal profile motions, however, will still force the motor to begin at zero velocity).

Connecting Brushless or Brush Type Motor

LS-173E is capable of driving brushless commutated (AC) and brush (DC) type motors. No jumpers or other setting are required. If there are no Hall sensors connected to "ENCODER AND COMMUTATOR", LS-173E drives the motor as brush (DC) type. The positive motor lead should be connected to "MOTOR AC1 (U) or DC+" terminal and negative to "MOTOR AC2 (V) or DC-" terminal of "MOTOR AND POWER" connector. If Hall sensors are detected, LS-173E performs commutation according to their state.

Often, connecting the brushless motor phases is difficult because of the different terms and signal names, which different manufactures are using. Here is a simple procedure that may be used.

Connect the motor commutation sensors to LS-173E "ENCODER AND COMMUTATOR" connector according to the next table with most common manufacture signal names.

LS-173E Encoder & Sensor Connector signal	Motor manufacture signal name			
S1	R	U	A	S1
S2	S	V	B	S2
S3	T	W	C	S3

Connect the commutator power leads to GND and +5V. Connect the encoder and its power lines to the same connector. Connect the three motor leads to "MOTOR AC1 (U) or DC+", "MOTOR AC2 (V) or DC-", "MOTOR AC3 (W) or NC" of LS-173E "MOTOR AND POWER" connector using the same order as for the commutation sensors. Power on LS-173E. Initialize the controller. Rotate motor shaft CW (ClockWise) by hand and check if the motor position is increasing. If motor position is not changing or it is decreasing, check encoder connection. Set the Drive in PWM mode. Start the motor with PWM for example 5 (this value might be enough or not depending on motor used) Set PWM to -5. If the phasing is correct the motor shaft should rotate CW (CCW) smoothly without any jerks. Otherwise try different motor leads connection. There are only six combinations and it is recommended to try all of them. Usually only one works fine. If you find more than one, try to run the motor at higher speed. Set the Drive in velocity mode and start the motor in CW direction. If the motor runs away, directions of motor and encoder are opposite. To change the motor direction exchange S1 with S3 and AC1 with AC2. To change the encoder direction exchange A and B phase wires.

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STATUS and SAFETY features

To protect both the user device and the controller, LS-173E is equipped with various safety features.

STP IN – Stop Input

For normal operation STP IN signal must be LOW (closed). If it is HIGH (open) it will disable the Power Driver and set status byte bit 3 (Power_on) to zero.

Undervoltage/Overvoltage Protection

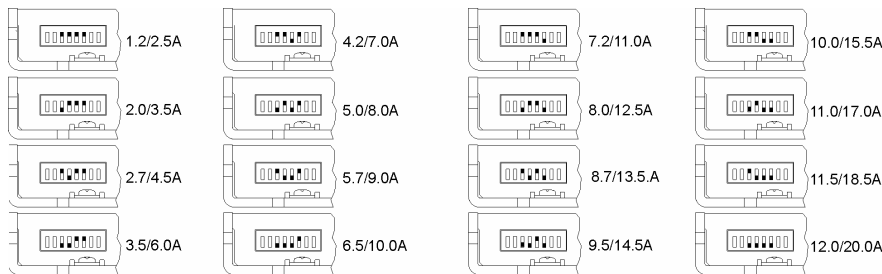
LS-173E is protected against power supply under/overvoltage. In case the power supply is below 12V hardware reset is generated. More than 91V will disable the Power Driver and set status byte bit 3 (Power_on) to zero.

Overcurrent Protection

A protection circuit monitors the output current of the motor and limit to a value set by dipswitch. If the motor is overloaded for less than 100 ms, the output current is limited to the selected level. Power Driver will be disabled if the motor is overloaded for more than 100 ms. To set CL (current limit) use the table:

Overcurrent DIP Switch Settings for:

LS-173E-1210, LS-173E4-1210 / LS-173E-2010, LS-173E4-2010



Motor current monitoring

Motor current can be monitored using *Read Status* command (refer to Command Description section of this document). A/D value is proportional to the motor current according to the following table:

A/D values as function of motor current

	A/D Value				
	25	50	100	150	200
LS-173E-1210 LS-173E4-1210	1.0A	2.0A	4.0A	6.0A	8.0A
LS-173E-2010 LS-173E4-2010	1.7A	3.4A	6.7A	10.0A	13.5A

A/D value and CL (*Current Limit* parameter of *Set Gain* command) may be used for current limit control. CL is compared each servo tick with A/D value (proportional to the motor current).

The actual PWM output value is:

$$PWM = PWM_{calc} - PWM_{adj}$$

Where: PWM is output value; PWM_{calc} is motion command calculated value; PWM_{adj} (0 < PWM_{adj} ≤ PWM_{calc}) is internal parameter. If CL < A/D PWM_{adj} is incremented by 1 each servo tick. If CL > A/D PWM_{adj} is decremented by 1 to 0. Bit 2 (Current_Limit) of status byte will be set. CL is in the range of 0 ÷ 255 and only odd values must be used.

If A/D > CL for more than 200ms the Power Driver will be disabled (refer to Status Bits and LED section of this document).

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System Status

Stop Motor command - refer to *Stop motor* command (page 24):

Bit 0 – Pic_ae.

Auxiliary Status byte diagnostic bits - refer to *Read status* command (page 22) and *Status byte and Auxiliary status byte definitions* (page 27):

Bit 0 – Index;

Bit 2 – Servo_on.

Status byte diagnostic bits - refer to *Read status* command (page 22) and *Status byte and Auxiliary status byte definitions* (page 27):

Bit 3 – Power_on;

Bit 4 – Pos_error;

Bit 5 – Limit 1 (Reverse);

Bit 6 – Limit 2 (Forward).

Diagnostic bits

Status Bit 6 Limit 2	Status Bit 5 Limit 1	Status Bit 4 Pos_error	Status Bit 3 Power_on	Auxiliary Bit 2 Servo_on	Auxiliary Bit 0 Index	Stop Cmd Bit 0 Pic_ae	CONDITION	LS-173E with Orange and Green LEDs	LS-173E with RED LED	BRAKE OUT
1	1	X	1	0	1	0	Servo OFF, Power Driver OFF	Orange	Low intensity	Off
For limit	Rev limit	0*	1	1	Encoder	1	Servo ON, Power Driver ON	Green	High intensity	On
				0			Servo OFF, Power Driver ON			
0	X	X	1	0	1	0	Overheat	Orange	Low intensity	Off
X	0	X	1	0	1	0	STOP input activated			
X	X	1	0	0	1	0	Overvoltage			
1	0	1	0	0	1	1	STOP input activated (latched)*			
0	1	1	0	0	1	1	Motor short/Overvoltage*			
1	1	1	0	0	1	1	Overheat*			
0	0	1	0	0	1	1	Overcurrent*			
1	0	1	0	0	0	1	Encoder error* - differential encoder modes			
X	X	1	1	0	X	1	Position error*			

*To restore the normal operation:

- Set to 0 Pic_ae (*Stop motor* command, page 24);
- Send *Clear sticky bits* command (page 26);
- If there is no more fault condition Power_on (*Status Byte* Bit 3, page 27) will be set to 1;
- To turn servo ON set Pic_ae to 1 (*Stop motor* command, page 24).

Power-up and Reset Conditions

On Power-up or reset, the following state is established:

Motor position is reset to zero;

Velocity and acceleration values are set to zero;

All gain parameters and limit values are set to zero;

The servo rate divisor is set to 1 (0.512msec servo rate);

The PWM value is set to zero;

The controller is placed in PWM mode;

The default status data is the status byte only;

The individual address is set to 0x00 and the group address to 0xFF (group leader not set);

Communications are disabled pending a low value of "A in";

The baud rate is set to 19.2 KBPS;

In the status byte, the move_done and pos_error flags will be set and the current_limit and home_in_progress flags will be clear;

In the auxiliary status byte, the pos_wrap, servo_on, accel_done, slew_done and servo_overrun flags will be cleared.

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COMMAND SPECIFICATION

List of Commands

Command	CMD Code	# Data bytes	Description	While Moving?
Reset position	0x0	0	Sets position counter to zero.	No
Set address	0x1	2	Sets the individual and group addresses	Yes
Define status	0x2	1	Defines which data should be sent in every status packet	Yes
Read status	0x3	1	Causes particular status data to be returned just once	Yes
Load trajectory	0x4	1-14	Loads motion trajectory parameters	Maybe*
Start motion	0x5	0	Executes the previously loaded trajectory	Maybe**
Set gain	0x6	14	Sets the PID gains and operating limits	Yes
Stop motor	0x7	1	Stops the motor in one of three manners	Yes
I/O control	0x8	1	Sets the direction and values of the LIMIT pins	Yes
Set home mode	0x9	1	Sets conditions for capturing the home position	Yes
Set baud rate	0xA	1	Sets the baud rate (group command only)	Yes
Clear bits	0xB	0	Clears the sticky status bits	Yes
Save as home	0xC	0	Saves the current position in the home position register	Yes
Nop	0xD	0	Simply causes the defined status data to be returned	Yes
Nop	0xE	0	Simply causes the defined status data to be returned	Yes
Hard reset	0xF	0	Resets the controller to its power-up state.	Yes

*Only allowed while moving if the "start motion now" bit of the trajectory control word is not set or if the "profile mode" bit is set for velocity mode.

**Only allowed while moving if the previously loaded trajectory has the "profile mode" bit set for velocity mode.

Command Description

Reset Position

Command value: 0x0
Number of data bytes: 0
Command byte: 0x00

Description:

Resets the 32-bit encoder counter to 0. Also resets the internal command position to 0 to prevent the motor from jumping abruptly if the position servo is enabled. Do not issue this command while executing a trapezoidal profile motion.

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Set Address

Command value: 0x1

Number of data bytes: 2

Command byte: 0x21

Data bytes:

1. Individual address: 0x01-0x7F (initial address 0x00)
2. Group Address: 0x80-0xFF (initial value 0xFF)

Description:

Sets the individual address and group address. Group addresses are always interpreted as being between 0x80 and 0xFF. If a Drive is to be a group leader, clear bit 7 of the desired group address in the second data byte. The module will automatically set bit 7 internally after flagging the Drive as a group leader. (If bit 7 of the second data byte is set, the module will default to being a group member.) The first time this command is issued after power-up or reset, it will also enable communications for the next Drive in the network chain by lowering the it's "A out" signal.

Define Status

Command value: 0x2

Number of data bytes: 1

Command byte: 0x12

Data bytes:

1. Status items: (default: 0x00)

- | | | |
|-----|----|---|
| Bit | 0: | send position (4 bytes) |
| | 1: | send A/D value (1 byte) |
| | 2: | send actual velocity (2 bytes - no fractional component) |
| | 3: | send auxiliary status byte (1 byte) |
| | 4: | send home position (4 bytes) |
| | 5: | send device ID and version number (2 bytes)
(First byte - motor controller device ID = 0,
Second byte - version number =50 to 59 (decimal)) |
| | 6: | send current position error (2 bytes) |
| | 7: | don't care |

Description:

Defines what additional data will be sent in the status packet along with the status byte. Setting bits in the command's data byte will cause the corresponding additional data bytes to be sent after the status byte. The status data will always be sent in the order listed. For example if bits 0 and 3 are set, the status packet will consist of the status byte followed by four bytes of position data, followed by the aux. status byte, followed by the checksum. The status packet returned in response to this command will include the additional data bytes specified. On power-up or reset, the default status packet will include only the status byte and the checksum byte.

Note: The actual velocity is a positive number when moving in reverse direction and a negative number when moving in forward direction.

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Read Status

Command value: 0x3

Number of data bytes: 1

Command byte: 0x13

Data bytes:

1. Status items:

- | | | |
|-----|----|--|
| Bit | 0: | send position (4 bytes) |
| | 1: | send A/D value (1 byte) |
| | 2: | send actual velocity (2 bytes - no fractional component) |
| | 3: | send auxiliary status byte (1 byte) |
| | 4: | send home position (4 bytes) |
| | 5: | send device ID, version number (2 bytes)
First byte - motor controller device ID = 0,
Second byte - version number = 50 to 59 (decimal)) |
| | 6: | send current position error (2 bytes) |
| | 7: | don't care |

Description:

This is a non-permanent version of the *Define Status* command. The status packet returned in response to this command will incorporate the data bytes specified, but subsequent status packets will include only the data bytes previously specified with the *Define Status* command.

Note: The actual velocity is a positive number when moving in reverse direction and a negative number when moving in forward direction.

Load Trajectory

Command value: 0x4

Number of data bytes: $n = 1-14$

Command byte: 0xn4

Data bytes:

1. Control byte:

- | | | |
|-----|----|--|
| Bit | 0: | load position data ($n = n + 4$ bytes) |
| | 1: | load velocity data ($n = n + 4$ bytes) |
| | 2: | load acceleration data ($n = n + 4$ bytes) |
| | 3: | load PWM value ($n = n + 1$ bytes) |
| | 4: | servo mode - 0 = PWM mode, 1 = position servo |
| | 5: | profile mode - 0 = trapezoidal profile, 1 = velocity profile |
| | 6: | velocity/PWM direction - 0 = FWD, 1 = REV |
| | 7: | start motion now |

Description:

All motion parameters are set with this command. Setting one of the first four bits in the control byte will require additional data bytes to be sent (as indicated) in the order listed. The position data (range +/- 0x7FFFFFFF) is only used as the goal position in trapezoidal profile mode. The velocity data (range 0x00000000 to 0x7FFFFFFF) is used as the goal velocity in velocity profile mode or as the maximum velocity in trapezoidal profile mode. Velocity is given in encoder counts per servo tick, multiplied by 65536. The acceleration data (range 0x00000000 to 0x7FFFFFFF) is used in both trapezoidal and velocity profile mode. Acceleration is given in encoder counts per servo tick per servo tick, multiplied by 65536. The PWM value (range 0x00 - 0xFF), used only when the position servo is not operating, sends a raw PWM value directly to the amplifier. The PWM value is reset to 0 internally on any condition, which automatically disables the position servo.

Bit 4 of the control byte specifies whether the position servo should be used or if the PWM mode should be entered. Bit 5 specifies whether a trapezoidal profile motion should be initiated or if the velocity profiler is used. Trapezoidal profile motions should only be initialized when the

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motor velocity is 0. (Bit 0 of the status byte indicates when a trapezoidal profile motion has been completed, or in velocity mode, when the command velocity has been reached.) Bit 6 indicates the velocity or PWM direction and is ignored in trapezoidal profile mode. If bit 7 is set, the command will be executed immediately. If bit 7 is clear, the command data will be buffered and it will be executed when the *Start Motion* command is issued. For example to load only new position data and acceleration data but not to start the motion yet, the command byte would be 0x94, the control byte would be 0x15, followed by 4 bytes of position data (least significant byte first), followed by 4 bytes of acceleration data.

If in the middle of a trapezoidal position move, a new *Load Trajectory* command is issued with new position data downloaded, new position data will be used as a relative offset to modify the goal position. For example, if in the middle of a move to position 50,000, a new *Load Trajectory* command with new position data of 10,000 is loaded, the motor will stop at final position of 60,000. The relative offset can be either positive or negative. The new *Load Trajectory* command must be issued while the motor is running at a constant velocity – issuing the command while accelerating or decelerating will cause a position error to occur. If more than one *Load Trajectory* is issued before the end of move, the goal position will be modified by the sum of relative offsets.

* While the position may range from -0x7FFFFFFF to +0x7FFFFFFF, the goal position should not differ from the current position by more than 0x7FFFFFFF.

Start Motion

Command value: 0x5
Number of data bytes: 0
Command byte: 0x05

Description:

Causes the trajectory information loaded with the most recent Load Trajectory command to execute. This is useful for loading several Drives with trajectory information and then starting them simultaneously with a group command.

Set Gain

Command value: 0x6
Number of data bytes: 14
Command byte: 0xE6
Data bytes:
1,2. Position gain KP (0 - 0x7FFF)
3,4. Velocity gain KD (0 - 0x7FFF)
5,6. Integral gain KI (0 - 0x7FFF)
7,8. Integration limit IL (0 - 0x7FFF)
9. Output limit OL (0 - 0xFF) (typically recommended 0xFA)
10. Current limit CL (0 - 0xFF) (only odd values)
11,12. Position error limit EL (0 - 0x3FFF)
13. Servo rate divisor SR (1 - 0xFF)
14. Amplifier deadband compensation (0 - 0xFF) (typical value is between 0x03 and 0x05)

Description:

Sets all parameters and limits governing the behavior of the position servo. KP, KD, KI and IL are PID filter parameters. OL limits the maximal PWM output value to $0 < \text{PWM} \leq \text{OL}$ in position servo modes. In PWM mode OL is ignored. CL is used for motor current limitation (refer to *Motor current monitoring* in *Safety Features* for detailed information). Setting CL=0 effectively disables current limiting. The position error limit (EL) will cause the position servo to be disabled should the position error grow beyond the limit. The servo rate divisor sets the servo tick time to be a multiple of 0.512 msec (1.953 KHz). For example SR=3 gives a servo rate of 651 Hz. The servo

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tick rate is also used as the profiling timebase, although command processing and current limiting are always performed at the maximum tick rate. Sometimes it is necessary to compensate the deadband region around zero PWM output exhibited by some amplifier/motor combinations. The deadband compensation value will be added to the magnitude of the PWM output to force the amplifier into its active region.

Stop Motor

Command value: 0x7
Number of data bytes: 1 or 5
Command byte: 0x17 or 0x57

Data bytes:

1. Stop control byte

Bit 0: Pic_ae (Power Driver enable)
1: Turn motor off
2: Stop abruptly
3: Stop smoothly
4: Stop here
5-7: Clear all to 0

2-5. Stopping position (only required if bit 4 above is set)

Description:

Stops the motor in the specified manner. If bit 0 of the Stop Control Byte is set, Power Driver will be enabled. If bit 0 is cleared Power Driver will be disabled, regardless of the state of the other bits. Pic_ae also controls the meaning of bit 3 (Power_on), bit 5 (Limit 1 (Reverse)), and bit 6 (Limit 2 (Forward)) of status byte (refer to *Status Bits* section of *Safety Features* in this document). If bit 1 is set, the position servo will be disabled, the PWM output value will be set to 0, and bits 2, 3 and 4 are ignored. If bit 2 is set, the current command velocity and the goal velocity will be set to 0, the position servo will be enabled, and velocity mode will be entered. If the velocity servo was previously disabled, the motor will simply start servoing to its current position. If the motor was previously moving in one of the profiling modes, it will stop moving abruptly and servo to its current position. This stopping mode should only be used as an emergency stop where the motor position needs to be maintained. Setting bit 3 enters a more graceful stop mode - this sets the goal velocity to 0 and enters velocity mode, causing the motor to decelerate to a stop at the current acceleration rate. If bit 4 is set, the motor will move to the specified stopping position abruptly with no profiling. This mode can be used to cause the motor to track a continuous string of command positions. Note that if the stopping position is too far from the current position, a position error will be generated. Only one of the bits 1, 2, 3 or 4 should be set at the same time. The *Stop Motor* command must be issued initially to set Pic_ae before other motion commands are issued.

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I/O Control

Command value: 0x8

Number of data bytes: 1

Command byte: 0x18

Data bytes:

1. I/O control byte

- | | | |
|-----|------|---|
| Bit | 0: | Output value of Limit 1 (not used) |
| | 1: | Output value of Limit 2 (not used) |
| | 2: | Direction of Limit 1 (Reverse) (must be set to 1 = input) |
| | 3: | Direction of Limit 2 (Forward) (must be set to 1 = input) |
| | 4-7: | Don't care |

Description:

After power-up Limit 1 (Reverse) and Limit 2 (Forward) inputs.

Set Homing Mode

Command value: 0x9

Number of data bytes: 1

Command byte: 0x19

Data bytes:

1. Homing control byte

- | | | |
|-----|----|--|
| Bit | 0: | Capture home position on change of Limit 1 (Reverse) |
| | 1: | Capture home position on change of Limit 2 (Forward) |
| | 2: | Turn motor off on home |
| | 3: | Capture home on change of Index |
| | 4: | Stop abruptly on home |
| | 5: | Stop smoothly on home |
| | 6: | Capture home position when an excess position error occurs |
| | 7: | Capture home position when current limiting occurs |

Description:

Causes the Drive to monitor the specified conditions and capture the home position when any of the flagged conditions occur. The home_in_progress bit in the status byte is set when this command is issued and it is then lowered when the home position has been found. Setting one (and only one) of bits 2, 4 or 5 will cause the motor to stop automatically in the specified manner once the home condition has been triggered. This feature can also be used as a safety shutoff.

Note: For homing with Index signal, use low velocities, which ensure the time of the Index pulse is at least one servo tick (0.512 msec). The maximum theoretical homing velocity is 65536 (one encoder count per servo tick). Depending of motor vibrations, the homing velocity should be less than 65536. A recommended homing velocity is 16384 (0.25 encoder counts per servo tick).

Set Baud Rate

Command value: 0xA

Number of data bytes: 1

Command byte: 0x1A

Data bytes:

1. Baud rate divisor,	BRD	9600	BRD = 0x81
-----------------------	-----	------	------------

115200	BRD = 0x0A
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Description:

Sets the communication baud rate. All drives on the network must have their baud rates changed at the same time; therefore this command should only be issued to a group including all of the controllers on the network. A status packet returned from this command would be at the new baud rate, so typically (unless the host's baud rate can be accurately synchronized) there should be no group leader when this command is issued.

Clear Sticky Bits

Command value: 0xB
Number of data bytes: 0
Command byte: 0x0B

Description:

The overcurrent and position error bits in the status byte and the position wrap and servo timer overrun bits in the auxiliary status byte will stay set unless cleared explicitly with this command.

Save Current Position as Home

Command value: 0xC
Number of data bytes: 0
Command byte: 0x0C

Description:

Causes the current position to be saved as the home position. This command is typically issued to a group of controllers to cause their current positions to be stored synchronously. The stored positions can then be read individually by reading the home position

No Operation

Command value: 0xD or 0xE
Number of data bytes: 0
Command byte: 0x0D or 0x0E

Description:

Does nothing except cause a status packet with the currently defined status data to be returned.

Hard Reset

Command value: 0xF
Number of data bytes: 0
Command byte: 0x0F

Description:

Resets the control module to its power-up state. No status will be returned. Typically, this command is issued to all the modules on the network, although if the baud rate is set at the default, it is possible to reset and re-initialize the addresses of a contiguous sub-chain of modules.

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STATUS BYTE AND AUXILIARY STATUS BYTE DEFINITIONS

Status Byte

<u>Bit</u>	<u>Name</u>	<u>Definition</u>
0	Move_done	Clear when in the middle of a trapezoidal profile move or in velocity mode, when accelerating from one velocity to the next. This bit is set otherwise, including while the position servo is disabled
1	Cksum_error	Set if there was a checksum error in the just received command packet
2	Current_limit	Set if current limiting has exceeded (refer to <i>Motor Current Monitoring</i> section in this document). Must be cleared by user with <i>Clear Sticky Bits</i> command
3	Power_on/diag. bit	Refer to <i>Status Bits and LED</i> section in this document
4	Pos_error	Set if the position error has exceeded the position error limit. It is also set whenever the position servo is disabled. Must be cleared by user with <i>Clear Sticky Bits</i> command
5	Limit 1 (Reverse) / diag. bit	Reverse Limit or diagnostic bit (refer to <i>Status Bits and LED</i> section in this document).
6	Limit 2 (Forward) / diag. bit	Forward Limit or diagnostic bit (refer to <i>Status Bits and LED</i> section in this document).
7	Home_in_progress	Set while searching for a home position. Reset to zero once the home position has been captured

Auxiliary Status Byte

<u>Bit</u>	<u>Name</u>	<u>Definition</u>
0	Index/diag. bit	Compliment of the value of the index input or diagnostic bit (refer to <i>Status Bits and LED</i> section in this document).
1	Pos_wrap	Set if the 32-bit position counter wraps around. Must be cleared with the <i>Clear Sticky Bits</i> command
2	Servo_on	Set if the position servo is enabled, clear otherwise
3	Accel_done	Set when the initial acceleration phase of a trapezoidal profile move is completed. Cleared when the next move is started
4	Slew_done	Set when the slew portion of a trapezoidal profile move is complete. Cleared when the next move is started
5	Servo_overrun	At the highest baud rate and servo rate, certain combinations of calculations may cause the servo, profiling, and command processing to take longer than 0.512 msec, in which case, this bit will be set. This is typically not serious, only periodically introducing a small fraction of a millisecond delay to the servo tick time. Cleared with the <i>Clear Sticky Bits</i> command

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INITIALIZING PROCEDURE AND PROGRAMMING EXAMPLES FOR SERVO DRIVES

To ensure a proper operation of all Servo drives connected to the network, the following initializing steps should be executed:

1. Reset all modules with *Hard Reset* command.
2. Set the addresses for all connected drives.
3. Set the individual gains (KP, KD, KI, IL, OL, CL, EL, SR and DB). Minimal requirements are: KP <> 0, EL <> 0 and SR <> 0.
4. Use *Load trajectory* command to set the target position, velocity acceleration with start motion now in trapezoidal mode. Minimal requirements are acceleration <> 0 and target position = 0. This command does not start any motion. It is necessary to initialize internal registers of the module.
5. Close the servo loop by using *Stop Motor* command (Pic_ae=1 and Stop abruptly=1).

Understanding the Serial Communication with Servo drives

The Serial Communication with Servo drives is strictly master-slave and matches repeatedly two elements:

- Sending a command to the specified drive's address;
- Receiving answer to the sent command – Status Byte(s).

Note: During the communication all bytes are sent with LSB first.

Commands

There are 16 commands managing Servo drives (refer to Command Description). Each command as shown in the following two tables includes header, address, command, data bytes and one checksum byte. Checksum does not include header byte.

Structure of Read Status command

Byte 1	Byte 2	Byte 3		Byte 4	Byte 5
Header	Address (Individual or Group)	Command Code		Data Byte	CheckSum = Byte 2 + Byte 3 + Data Byte
		High 4 bits No. of data bytes	Low 4 bits command code		
AA	01	1	3	01	15

Examples

Cmd. Bytes	Byte 1	Byte 2	Byte 3	Byte 4 – N	Byte N+1
Command	Header	Address	Cmd. Code	Data Byte(s)	Checksum
Reset position	AA	01	0 0		01
Define status	AA	05	1 2	05	1C
Set address	AA	01	2 1	07 FF	21
Load trajectory	AA	01	5 4	91 00 28 00 00	0E
Set gain	AA	01	E 6	64 00 00 04 00 00 00 00 FF 00 00 08 01 00	57

Status Data

The structure of the returned status information depends on *Define Status* or *Read Status* commands (refer to Command Description). By default only the Status byte and Checksum are returned to the host.

Examples

Byte 1	Optional Bytes 0-16	CheckSum
Status Byte	Additional Status Bytes as position, velocity, home position, A/D auxiliary byte, version and position error.	CheckSum = Byte 1+ Optional Bytes
09	no additional status bytes requested	09
09	00 28 00 00 – four additional status bytes	31

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Addressing

Each drive in the daisy-chained network has two addresses:

- Individual - for individual control of each drive. Its range is from 01h to 7Fh.
- Group - for simultaneous control of all group members by sending a single command to their group address. It is in the range of 80h to FFh.

Both these addresses have to be set during the initialization process.

The group may have Group leader responsible to send status data. Its address is:

Group leader address = Group address - 80h.

If there is no group leader - no status data will be send after a group command.

Set Baud Rate command must be sent only as a group command with no group leader, otherwise communication problems may occur.

Set Address command format

Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
Header	Preset Address	Command code	Individual Address	Group Address	Checksum
AA	00	21	01	FF	21

Setting the Addresses

After power-up and *Hard Reset* command all drives have their address set to 00h and only the first drive (starting from the host) has its communication enabled. Consecutive *Set Address* commands are sent to address 00h until all drives are addressed. This procedure can be executed once after *Hard Reset*. The table below shows the steps to address 3-drives network.

Example of sequential addressing for three Servo drives

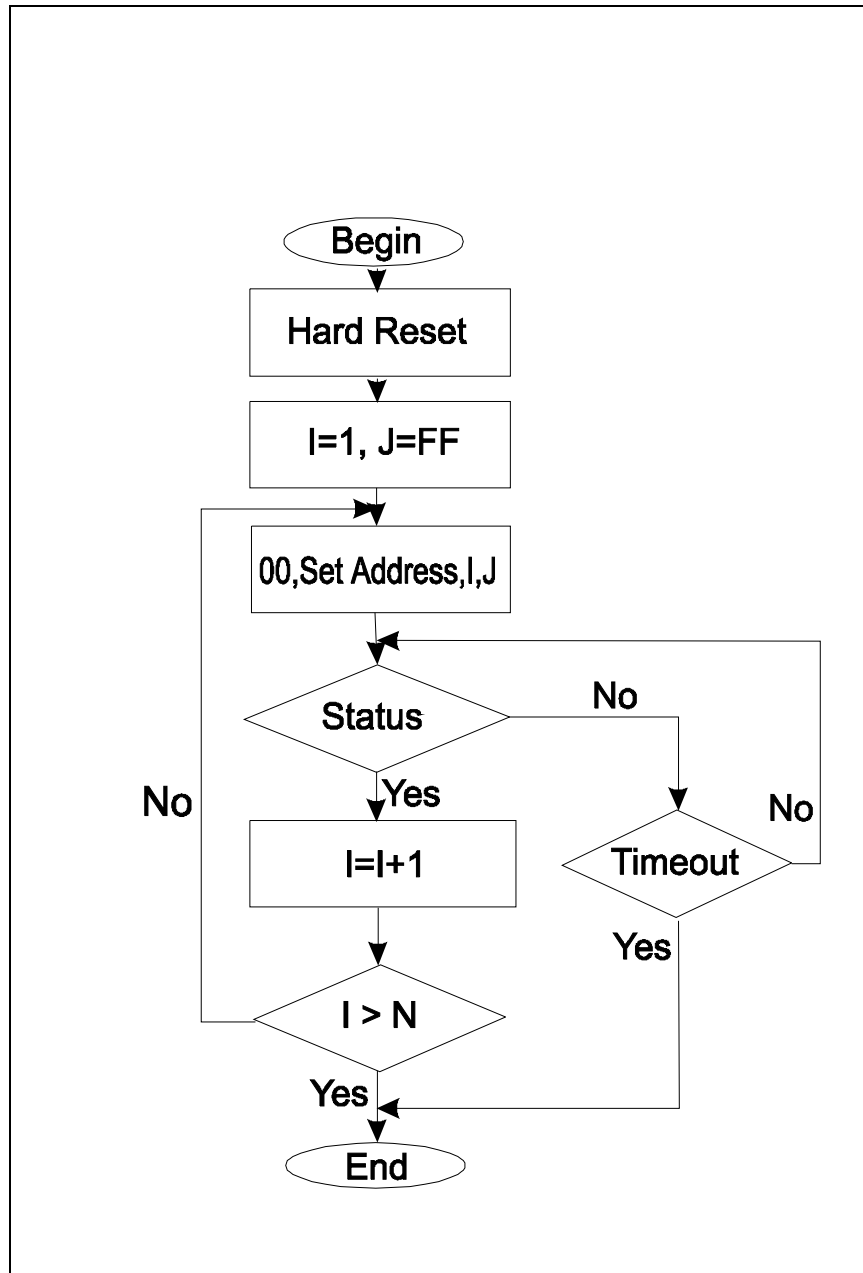
Step	Command	Set address Hexadecimal Code	Drive 1		Drive 2		Drive 3	
			Individual address	Group address	Individual address	Group address	Individual address	Group address
0	Power-up							
1	Hard Reset	AA FF 0F 0E	address=00 communication <i>enabled</i>		address=00 communication <i>disabled</i>		address=00 communication <i>disabled</i>	
2	Set Address Drive1 = 01	AA 00 21 01 FF 21	01	FF	address=00 communication <i>enabled</i>		address=00 communication <i>disabled</i>	
3	Set Address Drive2 = 02	AA 00 21 02 FF 22	01	FF	02	FF	address=00 communication <i>enabled</i>	
4	Set Address Drive3 = 03	AA 00 21 03 FF 23	01	FF	02	FF	03	FF

Note: Before start addressing *Hard Reset* command must be issued.

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The flowchart shows the addressing procedure of N drives network. There is no group leader and the group address is FF.



I - Individual Address; *J* - Group Address = FF;
Status - Status Data sent to the Host; *Timeout* - Greater than one servo circle.

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Examples of Managing Two Servo-Drives

- # 1 – Resets all modules with group command.
- # 2 and # 3 - Set the addresses of drives 1 and 2.
- # 4 and # 6 - Set PID parameters of drives 1 and 2.
- # 6 and # 7 - Starts motion in trapezoidal mode with target position=0, velocity=0, acceleration=1 and PWM=0.
- # 8 and # 9 - Close servo loops of drives 1 and 2. Initialization is complete at this point.
- # 10 and # 10 - Load trajectories (positions, velocities and accelerations) for drives 1 and 2.
- # 12 and # 13 - Load and execute new trajectory for drive 1.
- # 14 and # 15 - Read additional status bytes from drives 1 and 2.
- # 16, # 17 and #18 - Load new trajectories for drives 1 and 2 and execute them with one command sent to the drives' group address.

Examples

#	Hexadecimal code of command	Comments
1	AA FF 0F 0E	<i>Hard Reset</i>
2	AA 00 21 01 FF 21	<i>Set Address 01h</i> for drive 1. Group address=FFh.
3	AA 00 21 02 FF 22	<i>Set Address 02h</i> for drive 2. Group address=FFh.
4	AA 01 E6 64 00 00 04 00 00 00 00 FF 00 00 08 01 00 57	<i>Set Gains</i> of drive 1 – defines PID parameters: KP=64h, KI=400h, KI=00h, IL=00h, OL=FFh, CL=00h, EL=800h, SR=01h, DC=00h.
5	AA 02 E6 64 00 00 04 00 00 00 00 FF 00 00 08 01 00 58	<i>Set Gains</i> of drive 2 – defines PID parameters: KP=64h, KI=400h, KI=00h, IL=00h, OL=FFh, CL=00h, EL=800h, SR=01h, DC=00h.
6	AA 01 E4 9F 00 00 00 00 00 00 00 00 01 00 00 00 00 85	<i>Load trajectory</i> for drive 1 – target position=0, velocity=0, acceleration=1, PWM=0 and start motion now
7	AA 02 E4 9F 00 00 00 00 00 00 00 00 01 00 00 00 00 86	<i>Load trajectory</i> for drive 2 – target position=0, velocity=0, acceleration=1, PWM=0 and start motion now
8	AA 01 17 05 1D	<i>Stop Motor</i> - closes servo loop of drive 1 with <i>Power Driver enable</i> and <i>Stop Abruptly</i> in Command byte.
9	AA 02 17 05 1E	<i>Stop Motor</i> - closes servo loop of drive 2 with <i>Power Driver enable</i> and <i>Stop Abruptly</i> in Command byte.
10	AA 01 E4 9F 00 00 00 00 00 00 80 01 00 64 00 00 00 00 69	<i>Load Trajectory</i> of drive 1 with Pos=0000h, Vel=18000h, Acc=6400h, PWM=00h, servo mode=1.
11	AA 02 E4 9F 00 00 00 00 00 00 80 01 00 64 00 00 00 00 6A	<i>Load Trajectory</i> of drive 2 with Pos=0000h, Vel=18000h, Acc=6400h, PWM=00h, servo mode=1.
12	AA 01 54 11 00 28 00 00 8E	<i>Load Trajectory</i> of drive 1 with new position=2800h.
13	AA 01 05 06	<i>Start Motion</i> - executes previously loaded trajectory.
14	AA 01 13 05 19	<i>Read Status</i> from drive 1 (plus position and velocity).
15	AA 02 13 05 1A	<i>Read Status</i> from drive 2 (plus position and velocity).
16	AA 01 54 11 20 4E 00 00 D4	<i>Load Trajectory</i> of drive 1 with new position=4E20h.
17	AA 02 54 11 E0 B1 FF FF F6	<i>Load Trajectory</i> of drive 2 with new position=FFFFB1E0h (-4E20h).
18	AA FF 05 04	<i>Start Motion</i> – executes previously loaded trajectories. The command is sent to the drives' group address FFh.

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Procedure Initialize

AA FF 0F 0E	Hard reset
AA 00 21 01 FF 21	Set address
AA 00 21 02 FF 22	Search for more modules until no response received
AA 01 13 20 34	Read Device ID and Version number
AA 01 13 FF 13	Read all status data
AA 01 E6 64 00 00 04 00 00 00 00 FF 00 00 08 01 00 57	Set Gain parameters
AA 01 E4 9F 00 00 00 00 00 00 00 00 01 00 00 00 00 85	Set Trajectory parameters
AA 01 17 05 1D	Close servo loop

Procedure FindHomePosition

AA 01 E6 C8 00 20 03 46 00 28 00 FF 00 40 1F 01 00 9F	Set gain parameters: KP=200, KD=800, KI=70, IL=40, Output limit=255, current limit =0, Position error limit=8000, Servo rate divisor=1 amplifier deadband compensation=0
AA 01 17 09 21	Close the servo loop (Stop smoothly and amplifier enable)
AA 01 94 37 25 06 01 00 58 01 00 00 51	Load trajectory: Velocity mode, Forward direction, Velocity=1 round per second (67109 programmed velocity for 500 line encoder), Acceleration = 10 round per second ² (344 programmed acceleration for 500 line encoder)
AA 01 19 12 2C	Set home mode - capture home position on change of Forward Limit and stop abruptly
AA 01 05 06	Start motion
wait while home_in_progress bit=1	Home position is found on change of Forward Limit
AA 01 19 18 32	Set home mode - capture home position on change of Index and stop abruptly
AA 01 94 77 25 06 01 00 58 01 00 00 91	Load trajectory: Velocity mode, Reverse direction
AA 01 05 06	Start motion
wait while home_in_progress bit=1	Home position is found on change of Index

Calculation of programmed velocity and acceleration for servo rate divisor = 1:

Vel = (encoder counts per revolution) x (number of revolutions per second) x 33.554432

Acc = (encoder counts per revolution) x (number of revolutions per second²) x 0.017179869184

For this example:

Vel = 2000 x 1 x 33.554432 = 67109 = 00010625h

Acc = 2000 x 10 x 0.017179869184 = 344 = 00000158h