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# User's Manual

For

# ACS306

## Digital AC Servo Drive

Revision 1.0

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Attention: Please read this manual carefully before using the drive!



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# 1. Introduction, Features and Applications

## Introduction

Leadshine's fully digital AC servo drive ACS306 is developed with 32-bit DSP based on advanced control algorithm. Since its input commands are PUL/DIR signals, the users can upgrade stepping drives to the ACS306 without changing control systems. The ACS306 can offer high precision, high speed and high reliability performance, and widely used in inkjet printers, engraving machines, and etc. A built-in controller can be used for testing and tuning. PC based and handheld configuration & tuning tools can meet different tuning environments or requirements. The ACS306 can drive both DC brushless and AC servo motors. But it is more suitable for the DC brushless servo motors. Compare to ACS606, the ACS306 has smaller size and additional alarm (fault) signal output to indicate error.

## Features

- | Input: 20 - 30VDC,
- | Peak Current: 15A , Continuous Current: 6 A (Max), 10 - 200 W
- | FOC-SVPWM technologies
- | PC based and handheld configuration tools
- | Electronic gear rate from 1/255 to 255
- | Self-test function with trapezoidal velocity profile
- | Support PUL/DIR and CW/CCW control signals
- | Opto-isolated, support single-ended and differential inputs
- | Following error lock range adjustable
- | Over-voltage, over-current, encoder failure protections
- | 10 latest failures self-record function
- | Small size, surface-mount technology

## Applications

Suitable for large and medium automation machines and equipments, such as inkjet printers, engraving machines, electronic manufacturing equipments, special NC machines, pick and place devices, packing devices, and so on. Particularly adapt to the applications require high speed, high precision, and low motor noise.

## 2. Specifications and Operating Environment

### Electrical Specifications ( $T_j = 25^\circ\text{C}/77^\circ\text{F}$ )

Parameters	ACS306			
	Min.	Typical	Max.	Unit
Peak output current	0	-	15	A
Continue output current	0	-	6	A
Supply voltage	+20	-	30	VDC
Logic signal current	7	10	16	mA
Pulse input frequency	0	-	200	kHz
Isolation resistance	500			MΩ
Current provided to encoder	-	-	100	mA

### Performance Specifications (with BLM Series Motors)

- | Position following error : +/-1 count
- | Velocity accuracy: +/-2rpm
- | Maximum acceleration speed (No Load) : 80 rpm/ms<sup>2</sup>
- | Maximum speed : 3000 rpm
- | Allowable low speed reaches 1 rpm
- | Positioning accuracy : +/-1 count
- | Suitable for 20 - 30 VDC AC/DC servo motors

## Mechanical Specifications (unit: mm[inch])

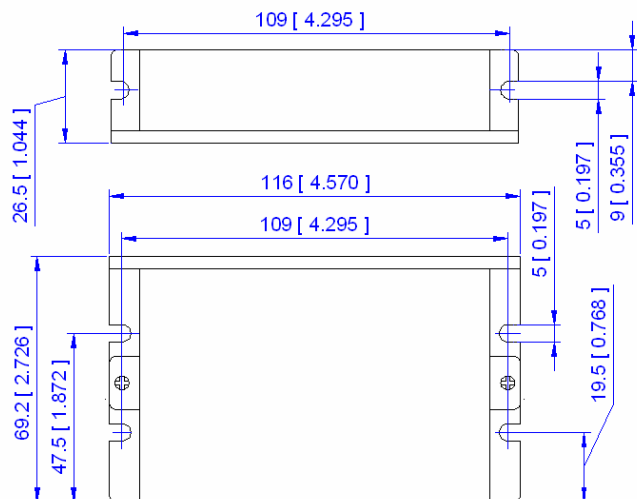


Figure 2-1: Mechanical specifications

### Elimination of Heat

- I Drive's reliable working temperature should be  $<70^{\circ}\text{C}$  [ $158^{\circ}\text{F}$ ], and motor working temperature should be  $<80^{\circ}\text{C}$  [ $176^{\circ}\text{F}$ ].
- I It is recommended to mount the drive vertically to maximize heat sink area.

### Operating Environment and Parameters

Cooling	Natural cooling or Forced cooling	
Operating Environment	Environment	Avoid dust, oil fog and corrosive gases
	Ambient Temperature	$0^{\circ}\text{C} - 50^{\circ}\text{C}$ ( $32^{\circ}\text{F} - 122^{\circ}\text{F}$ )
	Humidity	40% RH - 90% RH
	Vibration	$5.9\text{m/s}^2$ Max
Storage Temperature	$-20^{\circ}\text{C} - 65^{\circ}\text{C}$ ( $-4^{\circ}\text{F} - 149^{\circ}\text{F}$ )	
Weight	Approx. 180g (6.4z)	

## 3. Connections

### Connector Configuration

#### General Information

Feedback Signal Connector			
Pin	Signal	Description	I/O
1	EA+	Encoder channel A+ input	I
2	EB+	Encoder channel B+ input	I
3	EGD	Signal ground	GND
4	HW	Hall sensor W input	I
5	HU	Hall sensor U input	I
6	FG	Ground terminal for shielded	GND
7	EZ+	Reserve	I
8	EZ-	Reserve	I
9	HV	Hall sensor V input	I
10	NC	Not Connected	-
11	EA-	Encoder channel A- input	I
12	EB-	Encoder channel B- input	I
13	VCC	+5V @ 100 mA max.	O
14	NC	Not Connected	-
15	NC	Not Connected	-
Control Signal Connector			
Pin	Signal	Description	I/O
1	PUL+	Pulse signal input +	I
2	PUL-	Pulse signal input -	I
3	DIR+	Direction signal input +	I
4	DIR-	Direction signal input -	I
5	ENA+	Enable signal input +	I
6	ENA-	Enable signal input -	I
7	ALM+	Alarm(fault) signal +	O
8	ALM-	Alarm(fault) signal +	O

RS232 Communication Connector			
Pin	Signal	Description	I/O
1	NC	Not connected	-
2	+5V	+5V power only for STU.	O
3	TxD	RS232 transmit.	O
4	GND	Ground.	GND
5	RxD	RS232 receive.	I
6	NC	Not connected	-

High Voltage Connector			
Pin	Signal	Description	I/O
1	U	Motor phase U	O
2	V	Motor phase V	O
3	W	Motor phase W	O
4	+Vdc	DC power Input (20-30VDC)	I
5	GND	Power Ground.	GND

**More about I/O Signals**

Signal	Description
PUL+/PUL-	Pulse input signal. In single pulse (pulse/direction) mode, this input represents pulse signal, each rising or falling edge active (software configurable); 4-5V when PUL-HIGH, 0-0.5V when PUL-LOW. In double pulse mode (pulse/pulse) , this input represents clockwise (CW) pulse, active at both high level and low level . For reliable response, pulse width should be longer than 0.85μs. Series connect resistors for current-limiting when +12V or +24V used. The same as DIR and ENA signals.
DIR+/DIR-	Directions input signal. In single-pulse mode, this signal has low/high voltage levels, representing two directions of motor rotation; in double-pulse mode (software configurable), this signal is counter-clock (CCW) pulse, active at both high level and low level. For reliable motion response, DIR signal should be ahead of PUL signal by 5μs at least. 4-5V when DIR-HIGH, 0-0.5V when DIR-LOW.
ENA+/ENA-	Enable input signal. This signal used for enabling/disabling the drive. High level for enabling the drive and low level for disabling the drive. Usually left <b>UNCONNECTED</b> (ENABLED).

**More about I/O Signals (Continue')**

Signal	Description
ALM+/ALM-	Alarm (Fault) signal output. OC output, high impedance when the working status is normal and low impedance when over-voltage, over-current, phase error, encoder error, limit error, position following error happens.

**Control Signal Connections**

The ACS306 has 3 differential logic inputs to accept Enable, Pulse and Direction control signals and 1 OC (open collector) output for alarm (fault) output. These inputs are isolated to minimize or eliminate electrical noises coupled onto the control signals. Recommend use twisted wires and shielding cable for control signals to increase noise immunity in interference environments. Keep these wires far away from the power lines. In figure 3-2, input circuit for these control signals and connections to a typical motion controller is illustrated. Figure 3-3 illustrates connections to the controller with common-anode outputs.

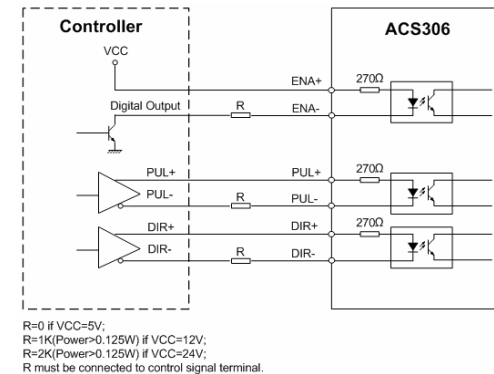


Figure 3-1: Connections to controller with differential outputs

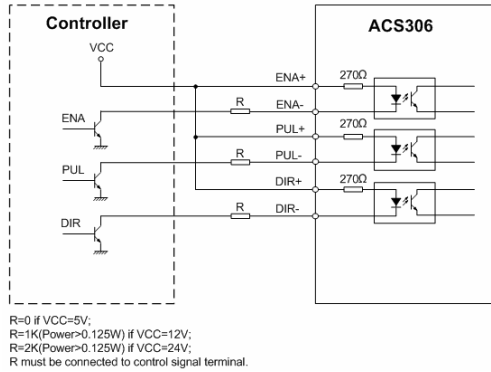


Figure 3-2: Connections to controller with common-anode outputs

### Alarm Signal Connections

The ACS306 has 1 OC (open collector) output for alarm (fault) output. In figure 2, input circuit for these control signals and connections to a typical motion controller is illustrated. Figure 3-3 illustrates connections to the controller with alarm signal outputs.

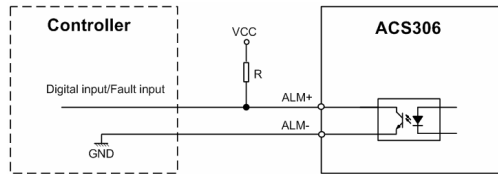


Figure 3-3: Connections to controller with alarm signal outputs

### Encoder and Hall Sensor Connections

The ACS306 can accept both incremental encoder and hall effect sensor inputs for motor shaft position feedbacks. Note that twisted-pair shielded cabling provides the best immunity in electrically noisy environments.

The ACS306 has the +5V power to supply the encoder & hall sensor. If the encoder

and hall sensor drains less than 100mA, the ACS306 can supply them directly, and connect it as Figure 3-4. If the encoder drains more than 50mA, use an external DC supply and connect it as Figure 3-5.

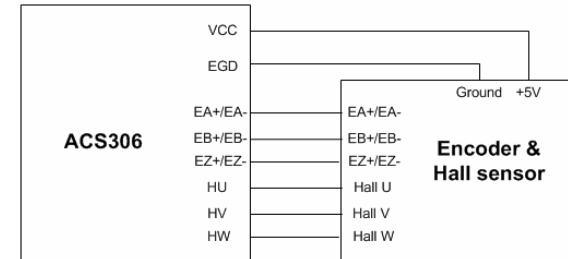


Figure 3-4: The ACS306 supplies the encoder directly

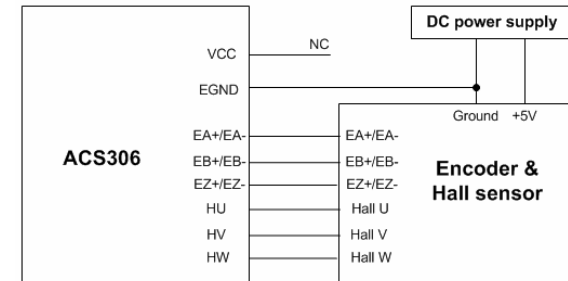


Figure 3-5: Using external DC power supply to supply the encoder

### RS232 Interface Connection

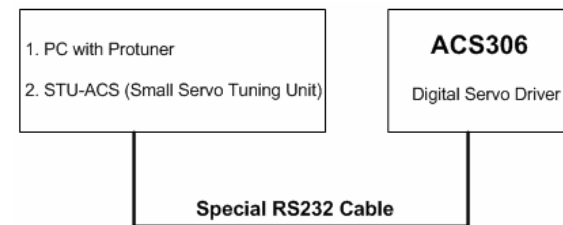
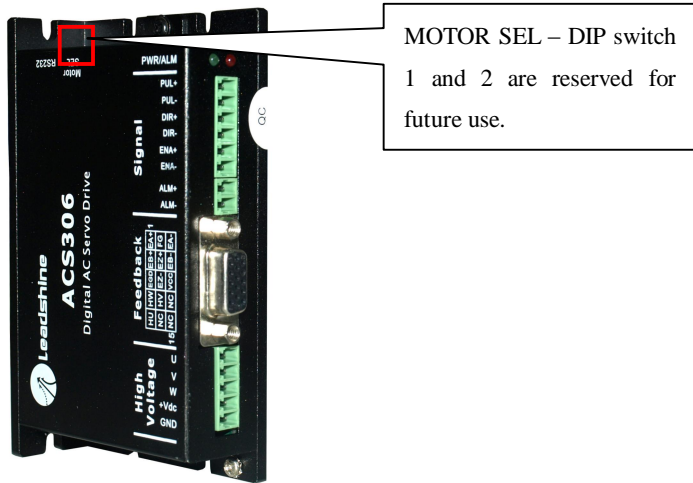


Figure 3-6: RS232 interface connection

### DIP Switch

There is a 2 bit DIP switch built inside the ACS306 as follows. It is reserved and now has no use.



### Typical Connections

A typical connection of the ACS306 is shown as Figure 3-7. Please consult “Control Signal Connections” and “Encoder and Hall Sensor Connections” for more information about controller and encoder connections.

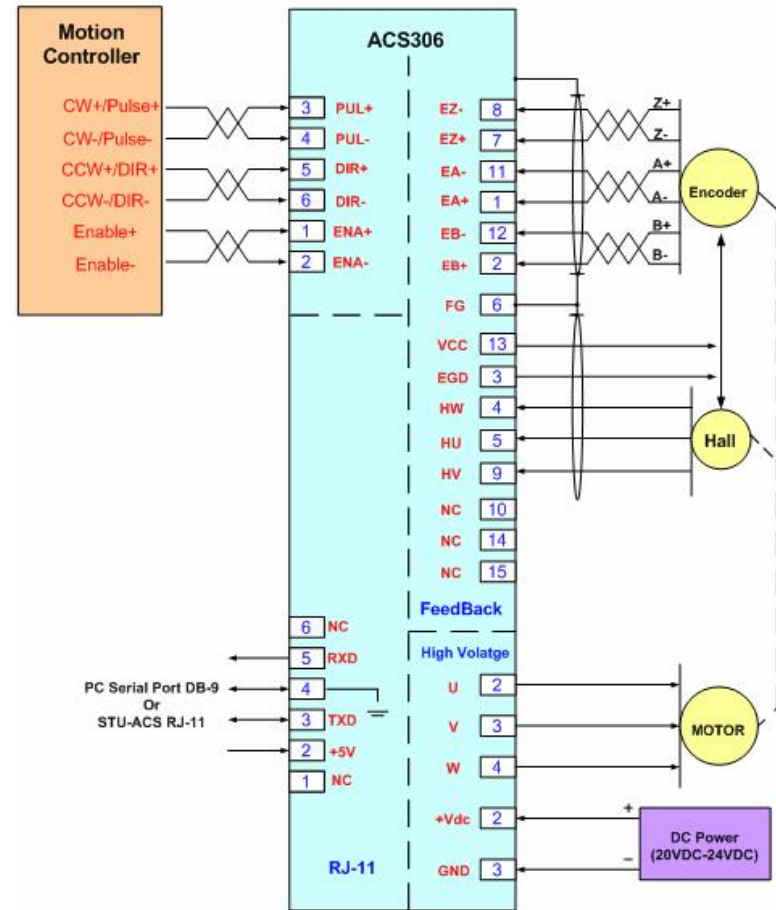


Figure 3-7: Typical connection of the ACS306

## 4. Servo Setup

Before you start the servo, you should follow the below steps.

## Install Encoder and Hall sensor

Encoder and Hall sensor provide information of the motor shaft position and rotor magnetic field orientation. The output signals from the Hall sensor have absolute phase information which is used at motor startup. If your motor has no encoder and hall sensor, you must mount an encoder and hall sensor properly on the motor before you start. Please assemble the selected module according to its factory manual.

Leadshine offers BLM series DC brushless servo motors for matching the ACS306. Please note that the ACS306 requires specific sequence of the back-EMF and hall sensor state phasing as figure 4-1. For the motor which is from other manufacturer or mounted by yourself, you may have to try all the six combination of the HU, HV, HW and/or the U, V, W wire. Contact [tech@leadshine.com](mailto:tech@leadshine.com) for further information installations to non-Leadshine servo motor.

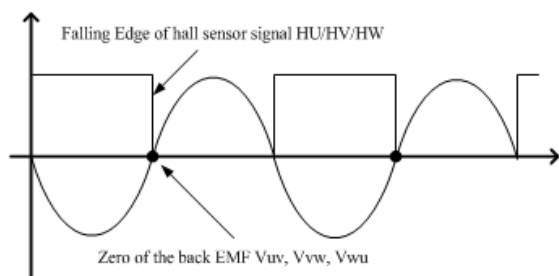


Figure 4-1: Back EMF and hall sensor sequence requirement of the ACS306

Please use shielded cables to increase noise immunity in interference environments. Keep these wires far away from the power lines.

## Prepare Power Supply

### Regulated or Unregulated Power Supply

Both regulated and unregulated power supplies can be used to supply the Drive. However, unregulated power supplies are preferred due to their ability to withstand

current surge. If regulated power supplies (such as most switching supplies.) are indeed used, it is important to have large current output rating to avoid problems like current clamp, for example using 4A supply for 3A motor-drive operation. On the other hand, if unregulated supply is used, one may use a power supply of lower current rating than that of motor (typically 50% ~70% of motor current). The reason is that the Drive draws current from the power supply capacitor of the unregulated supply only during the ON duration of the PWM cycle, but not during the OFF duration. Therefore, the average current withdrawn from power supply is considerably less than motor current. For example, two 3A motors can be well supplied by one power supply of 4A rating.

## Selecting Supply Voltage

The ACS306 can actually operate within +20 ~ +30VDC, including power input fluctuation and back EMF voltage generated by motor coils during motor shaft deceleration. The rated voltage of the motor is an important parameter when selecting supply voltage. Generally speaking, do not use a power supply voltage more than 5 volts of the rated voltage of the motor. Higher voltage may cause bigger motor vibration at lower speed, and it may also cause over-voltage protection or even drive damage.

## Prepare Controller

Prepare a controller with pulse and direction signals. However, the ACS306 has a built-in motion controller for self-test and Servo Tuning. The built-in motion controller can generate pulse signal with trapezoidal velocity profile.

## System Connections and Noise Prevention

After finishing the above steps, you can connect your servo system. Before you start, make sure that the power is off. Connect your system according to previous connection diagrams, and pay attention to the following tips when wiring.



## Wire Gauge

The smaller wire diameter (lower gauge), the higher impedance. Higher impedance wire will broadcast more noise than lower impedance wire. Therefore, when selecting the wire gauge, it is preferable to select lower gauge (i.e. larger diameter) wire. This recommendation becomes more critical as the cable length increases. Use the following table to select the appropriate wire size to use in your application.

Current (A)	Minimum wire size (AWG)
10	#20
15	#18
20	#16

## Cable Routing

All content sensitive signal wires should be routed as far away from motor power wires and Drive power wires as possible. Motor power and Drive power wires are major sources of noise and can easily corrupt a nearby signal. This issue becomes increasingly important with longer motor power and Drive power wires lengths.

## Twisted Wires

Twisted wires effectively increase noise immunity. The successive twists eliminate noise transients along the length of the cable. Both signal cables and power cables should be of the twisted and shielded type. Differential signal wires should be twisted as a pair. The combination of twisted pair wires and a differential signal significantly adds to noise immunity. Power wires should be twisted as a group along with the ground (or chassis) wire, if available.

## Cable Shielding

All signal wires should be bundled and shielded separately from Drive power and motor power wires. Power wires should also be bundled and shielded. When grounding a shield, the rule-of-thumb is to do so at the 'source' of power while

leaving the other shield end open. For example, in the case of motor power wires, this would be the drive side. Ideally, twisted pairs should be individually shielded and isolated from the outer shield, which encompasses all wires within the cable. However, since this type of stringent shielding practice is often not required, typical cables do not provide isolation between inner and outer shields.

## System Grounding

Good grounding practices help reduce the majority of noise present in a system. All common grounds within an isolated system should be tied to PE (protective earth) through a 'SINGLE' low resistance point. Avoiding repetitive links to PE creating ground loops, which is a frequent source of noise. Central point grounding should also be applied to cable shielding; shields should be open on one end and grounded on the other. Close attention should also be given to chassis wires. For example, motors are typically supplied with a chassis wire. If this chassis wire is connected to PE, but the motor chassis itself is attached to the machine frame, which is also connected to PE, a ground loop will be created. Wires used for grounding should be of a heavy gauge and as short as possible. Unused wiring should also be grounded when safe to do so since wires left floating can act as large antennas, which contribute to EMI.

## Power Supply Connection

**NEVER** connect power and ground in the wrong direction, because it will damage the ACS306 drive. The distance between the DC power supply of the drive and the drive itself should be as short as possible since the cable between the two is a source of noise. When the power supply lines are longer than 50 cm, a 1000 $\mu$ F/100V electrolytic capacitor should be connected between the terminal "GND" and the terminal "+VDC". This capacitor stabilizes the voltage supplied to the drive as well as filters noise on the power supply line. Please note that the polarity can not be reversed.

It is recommended to have multiple drives to share one power supply to reduce cost if

the supply has enough capacity. To avoid cross interference, **DO NOT** daisy-chain the power supply input pins of the drives. Instead, please connect them to power supply separately.

## 5. Tuning the Servo

### Testing the Servo

You may wish to secure the motor so it can't jump off the bench. Turn on the power supply, the green (Power) LED will light. The ACS306 has default parameters stored in the drive. If the system has no hardware and wirings problem, the motor should be locked and the drive should be ready.

If the motor jumps slightly and the red LED immediately turns on (flickers), then either the motor or the encoder is wired in reversal. Open the tuning software ProTuner and check drive status by clicking **Err\_check**. If it's **Phase Error**, then exchange motor wires or encoder inputs and try again. If it's **Encoder Error**, please check encoder and its wirings, and then try again. If it still doesn't work after you followed all of the previous steps, please contact us at [tech@leadshine.com](mailto:tech@leadshine.com).

If the red LED is off and the motor is normal, then you can start to tune the servo with selected tool. PC based tuning software **ProTuner** and handheld small servo tuning unit **STU** are available for the ACS306.

### Tuning the Servo

A servo system is error-driven. The "Gain" of the system determines how hard the servo tries to reduce the error. A high-gain system can produce large correcting torques when the error is very small. A high gain is required if the output is required to follow the input faithfully with minimal error.

A servo motor and its load both have inertia, which the servo amplifier must accelerate and decelerate while attempting to follow a change at the input. The

presence of the inertia will tend to result in over-correction, with the system oscillating beyond either side of its target. It's called **UNDER DAMPED** status. See Figure 11. This oscillation must be damped, but too much damping will cause the response to be sluggish, namely cause the system to get into an **OVER DAMPED** state. When we tune a servo, we are trying to achieve the fastest response with little or no overshoot, namely get a **CRITICALLY DAMPED** response.

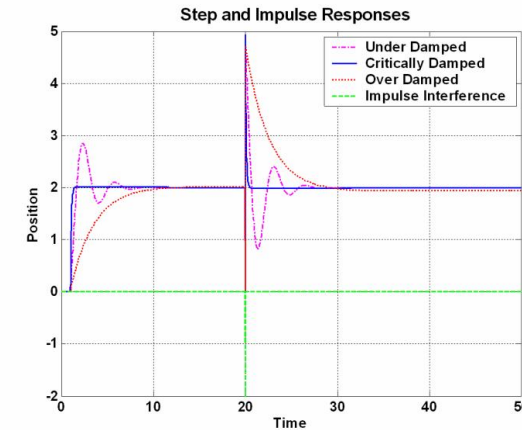


Figure 5-1: Step and impulse responses

As mentioned in previous contents, the ACS306 is a digital servo drive and its input command is PUL/DIR signal. In other words, step response just exists in each step command signal. For each step command signal is a very small movement, so **OVER SHOOT** and **SETTLING TIME** between each step are very small, causing you hardly can see a step response such as Figure 11, even if the **SET POINT** is a very large quantity and the acceleration is very high.

However, if you try to evaluate performances of the digital servo by investigating its position tracking-error or position following error, you may find it's much easier than investigating its step response. The easiest way to get a tracking-error or position following error response is to induce an impulse load on the motor. See

figure 5-1 at “time 20”.

Leadshine offers a Windows based setup software **ProTuner** to its customers for evaluating servo performances. Small servo tuning unit **STU** (optional) is available too, and it’s for field tuning without PC.

Tuning servo systems formed by the ACS306 can be summarized as the following rules:

1. If servo system is UNSTABLE, then the first thing of tuning is to stabilize the system. You can increase **Derivative Gain** of **Position Loop** (Kd) or decrease **Proportional Gain** of Position Loop (Kp) or **Integral Gain** of Position Loop (Ki).
2. If servo system is UNDER DAMPED, then increase Kd or decrease Kp or Ki.
3. If servo system is CRITICALLY DAMPED, then stop tuning and download the parameter settings to the Drive’s EEPROM.
4. If servo system is OVER DAMPED, then decrease Kd or increase Kp or Ki.

### Sequence Chart of Control Signals

In order to avoid some fault operations and deviations, PUL, DIR and EN should abide by some rules, shown as figure 5-2.

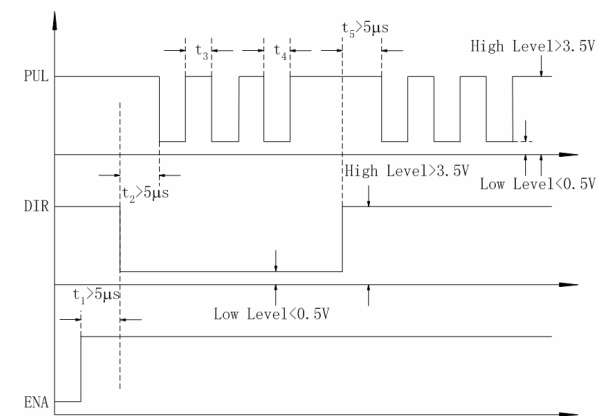


Figure 5-2: Sequence chart of control signals

### Notes:

- a)  $t_1$ : EN must be ahead of DIR by at least 5  $\mu$ s. Usually, ENA is NC (not connected). See **Connections** section for more information.
- b)  $t_2$ : DIR must be ahead of PUL active edge by at least 5  $\mu$ s to ensure correct direction.
- c)  $t_3$ : Pulse width not less than 2.5  $\mu$ s;
- d)  $t_4$ : Low level width not less than 2.5  $\mu$ s.

### Protection Functions

To improve reliability, the drive incorporates some built-in protection functions. The ACS306 uses one RED LED to indicate what protection has been activated. The periodic time of RED is 5 s (seconds), and how many times the RED turns on indicates what protection has been activated. Because only one protection can be displayed by RED LED, so the drive will decide what error to display according to their priorities. See the following **Protection Indications** table for displaying priorities.

### Over-current Protection

Protection will be activated when continuous current exceeds 20A, and RED LED

will turn on once within each periodic time (5 s).

### Over-voltage Protection

When power supply voltage exceeds  $40 \pm 1$  VDC, protection will be activated and RED LED will turn on twice within each periodic time (5 s).

### Encoder or Hall Error Protection

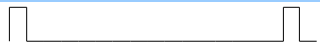



No encoder feedback signals or wrong encoder/hall sensor feedback signals will activate this protection. RED LED will turn on five times within each periodic time (5 s).

### Position Following Error Protection

When position following error reaches Position Following Error Limit parameter setting in the drive, this protection will be activated. RED LED will turn on seven times within each periodic time (5 s). Note that wrong motor connection will cause this protection too. Please check your motor connection if this protection is activated at the startup.

**Attention:** Since there is no protection against power leads (+, -) reversal, it is critical to make sure that power supply leads correctly connected to drive. Otherwise, the drive will be damaged instantly.

### Protection Indications

Priority	Time(s) of ON	Sequence wave of RED LED	Description
1 <sup>st</sup>	1		Over-current protection
2 <sup>nd</sup>	2		Over-voltage protection
3 <sup>th</sup>	5		Encoder or Hall error protection
4 <sup>th</sup>	7		Position following error protection

### Maximum Pulse Input Frequency

Maximum Pulse Input Frequency is the highest frequency at which the drive can

interpret encoder feedback. To convert this frequency to RPM, use the following formula:

$$RPM(\max) = \frac{(\text{Max Pulse Input Frequency}) \times 60}{\text{EncoderLines} \times 4}$$

### Motor Speed Calculation

The motor speed can be calculated as the following formula:

$$\text{Speed}(RPM) = \frac{(\text{Pulse Input Frequency}) \times 60}{\text{EncoderLines} \times 4}$$

## APPENDIX

### TWELVE MONTH LIMITED WARRANTY

Leadshine Technology Co., Ltd. warrants its products against defects in materials and workmanship for a period of 12 months from shipping date. During the warranty period, Leadshine will either, at its option, repair or replace products which proved to be defective.

### EXCLUSIONS

The above warranty shall not apply to defects resulting from: improper or inadequate handling by customer; improper or inadequate customer wiring; unauthorized modification or misuse; or operation beyond the electrical specifications of the product and/or operation beyond environmental specifications for the product.

### OBTAINING WARRANTY SERVICE

To obtain warranty service, a returned material authorization number (RMA) must be obtained from customer service at e-mail: [tech@leadshine.com](mailto:tech@leadshine.com) before returning product for service. Customer shall prepay shipping charges for products returned to Leadshine for warranty service, and Leadshine shall pay for return of products to customer.

### WARRANTY LIMITATIONS

Leadshine makes no other warranty, either expressed or implied, with respect to the product. Leadshine specifically disclaims the implied warranties of merchantability and fitness for a particular purpose. Some jurisdictions do not allow limitations on how long and implied warranty lasts, so the above limitation or exclusion may not apply to you. However, any implied warranty of merchantability or fitness is limited to the 12-month duration of this written warranty.

## SHIPPING FAILED PRODUCT

If your product should fail during the warranty period, e-mail customer service at [tech@leadshine.com](mailto:tech@leadshine.com) to obtain a returned material authorization number (RMA) before returning product for service. Please include a written description of the problem along with contact name and address. Send failed product to distributor in your area or: Leadshine Technology Co., Ltd. Floor 3, Block 2, Tianan Industrial Park, Nanshan Dist, Shenzhen, China. Also enclose information regarding the circumstances prior to product failure.

## CONTACT US

### China Headquarters

**Address:** 3/F, Block 2, Nanyou Tianan Industrial Park, Nanshan District Shenzhen, China

**Web:** <http://www.leadshine.com>

### Sales Hot Line:

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