User Manual

CL86

Closed Loop Stepper Drive

Revision 3.1

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Notice

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Record of Revisions

Revision	Date	Description of Release
1.0	*September, 2017*	*Initial Release*
3.1	*October, 2018*	*Firmware and PC software update to version 3.1*

Table of Contents

1. Introduction

Leadshine CL86 is a closed loop stepper drive designed to solve the loss of step problem in open loop stepper control systems, thus increase system reliability at minimal cost increase. It implements advanced control algorithm of Leadshine based on its tens of years' experience in stepper and servo controls. The CL86
is highly reliable and affordable and performs excellent in many industrial applications such as CNC, medical, electronics, packaging...

The CL86 can power 2-phase NEMA 34 stepper motors with incremental encoders. Compared with traditional open loop stepper systems, a CL86 adopted closed loop step system can eliminate potential loss of step, make real-time position error correction, and do not need torque reservation (100% torque implementation). Also it can power the driven stepper motor with reduced heating, lower noise, low vibration…

1.1 Features

- No loss of step

- No torque reservation

- No hunting or overshooting

- No tuning for easy setup

- A configurable digital output for the option of In Position, or Brake Control

- Low noise and vibration, smooth motion

- Enhance performance at low speed application(<60RPM)

- CS-D808: 30-80VDC & CS-D1008: 30-100VDC supply voltage, max 8A output current

- Max 200 KHz input frequency

- 15 micro step settings of 800-51,200 via DIP switches, or 200-51,200 via software (increase by 200)

- Protections for over voltage, over current and position following error

1.2 Applications

When a CL86 closed loop stepper drive is implemented with a compatible stepper motor with encoder, the closed stepper system can be adopted in many small to median speed applications such as CNC routers, CNC mills, CNC laser cutters, CNC plasma, lab automation instruments, plotters, medical equipment, electronic equipment, small packaging machines, etc.

2. Specifications

2.1 Electrical Specifications

Parameters		Min	Typical	Max	Unit
Output Current		4	-	8.0(Peak)	A
Operating Voltage	CL86	30	48, 60	80	VDC
	CL86	30	48, 60, 70	100	VDC
		18	-	80	VAC
Logic signal current		7	10	20	mA
Pulse input frequency		0	-	200	kHz
Minimal pulse width		2.5	-	-	μS
Minimal direction setup		5.0	-	-	μS
Isolation resistance		500			MΩ

2.2 Environment

Cooling		Natural Cooling or Forced Cooling
Operating Environment	Environment	Avoid dust, oil fog and corrosive gases
	Ambient Temperature	0°C － 65°C (32°F - 149°F)
	Humidity	40%RH－90%RH
	Operating Temperature	0°C － 50°C (32°F - 122°F)
	Vibration	10-50Hz / 0.15mm
Storage Temperature		-20°C － 65°C (-4°F - 149°F)
Weight		Approx. 600 g (21.1 oz)

2.3 Mechanical Specifications

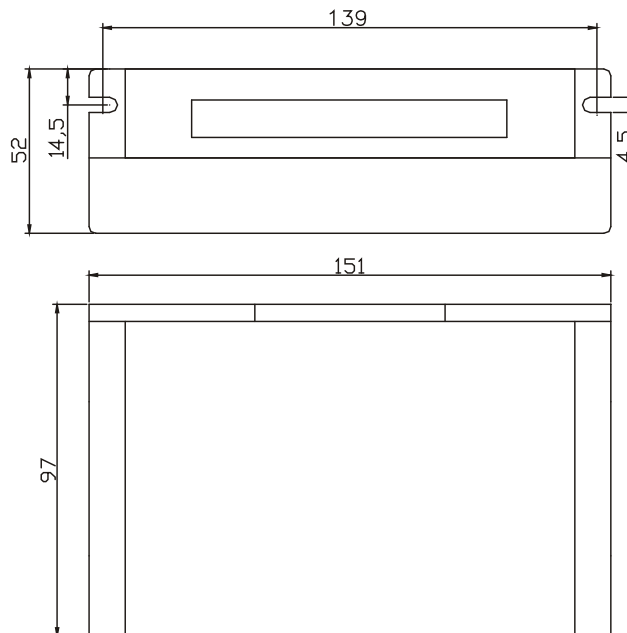(unit: mm [1inch=25.4mm])

Figure 1: Mechanical specifications

2.4 Heat Dissipation

● CL86 reliable working temperature should be no more than 60 ℃ (140°F)

● It is recommended to mount the drive vertically to maximize heat dissipation. Mount a cooling fan nearby if necessary.

● If multiple CL86 drives are installed, it is suggested to keep a minimal 30mm (12 inches) between two of them.

3. Connections and LED Indication

A CL86 closed loop stepper drive has 5 connection blocks from P1 to P5 (see figure 2).
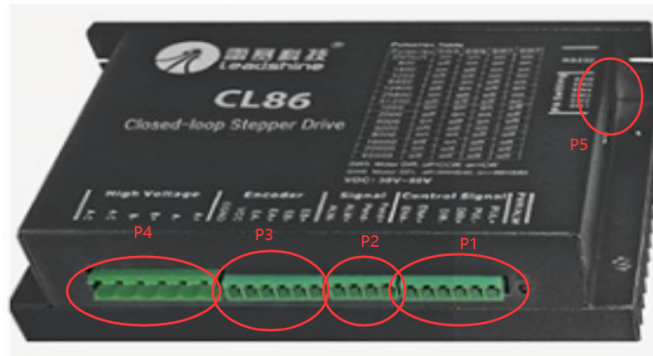

Figure 2: CL86

3.1 Connector P1 & P2– Control Input and Output Connections

3.1.1 Pin Assignments of P1 & P2

The P1 & P2 connector in Figure 2 contains connections for control signals and a configurable digital output.

a) Pinout Definitions

There are 3 control signals for pulse, direction, and enable. See the following table for details.

Pin Name	I/O	Details
PUL+	I	Pulse signal: (**1**). In single pulse (pulse & direction) control mode, this input represents pulse signal. A pulse signal is active at the rising or falling voltage edge (set by PC software). **(2).** In
PUL-	I	double-pulse (CW/CCW) control mode (set by PC software), this signal input represents clockwise (CW) pulse, and is active at both high voltage level and low voltage level. **(3).** 4.5-24V for voltage HIGH, 0-0.5V for voltage LOW (same for DIR and ENA signals). **(4).** Pulse width should be set to 2.5μs or longer.
DIR+	I	Direction signal: (**1**). In single pulse (step & direction) control mode, this signal's low and high voltage levels represent the two directions of motor rotation (e.g. clockwise and

DIR-	**I**	counterclockwise). **(2).** In double-pulse (CW & CCW) control mode, this signal represents counterclockwise (CCW) rotation. It is active at both voltage high level and low level. **(3).** Minimal DIR signal setup time should be at least 5μs. **(4).** Rotation direction is related to your motor/drive wiring. You can reverse the default rotation direction by toggling the SW5 DIP switch.
ENA+	**I**	Enable signal: This signal is used for enabling/disabling the drive. High voltage level of 4.5-24V (NPN control signal) for enabling the drive and low voltage level of 0-0.5VDC for disabling the drive. PNP and Differential control signals are on the contrary, namely Low level for enabling. By default this signal is left **UNCONNECTED & ENABLED**.
ENA-	**I**	
Pend+	**O**	Configurable Digital Output Signal: A configurable OC output signal. It takes a sinking or sourcing 20mA current at 5-24V. It can to be configured as one of the 2 types, *IN POSITION* (default), or *BRAKE CONTROL* through Leadshine ProTuner CS-D software.
Pend-	**O**	
ALM+	**O**	Fault Signal: An OC output signal which is active when one of the following error protection is activated: over-voltage, over-current, and position following error. This port can sink or source 20mA current at 5-24V. The resistance between ALM+ and ALM- is low impedance in normal operation, and will change to high when the drive goes into error protection. The voltage active level of this fault output signal can be configured by configuration software.
ALM-	**O**	

Notes: (1) Shielding control signal wires is suggested; (2) to avoid/reduce interference, don't tie control signal cables and power wires together.

b) *In Position, or Brake control Output Configuration*

The digital output on the P2 connector, marked as Pend+ & Pend-, is software configurable (read Leadshine ProTuner CS-D software manual). It can be configured as one of the available 2 options - "In Position", and "Brake Control". Read Leadshine ProTuner CS-D closed loop software manual for how to configure this output.

- *In Position*

  Use Leadshine ProTuner for CS-D software to configure this output as an IN POSITION output. In this case, an output signal can be sent out when the targeted position is in the "Target" range (see *parameter Distance to Send "In position" Output Signal* in software manual) to external devices such as relays, motion controllers, PLCs, IO boards, etc.

- *Brake Control*

  Use Leadshine ProTuner for CS-D software to configure this output as a BRAKE CONTROL output. In this case, this signal can be used for automatic brake control while system power failure. It is recommended to connect a fly-wheel diode in parallel to a 24VDC relay and brake coil connection. Refer to the following figure for brake connection
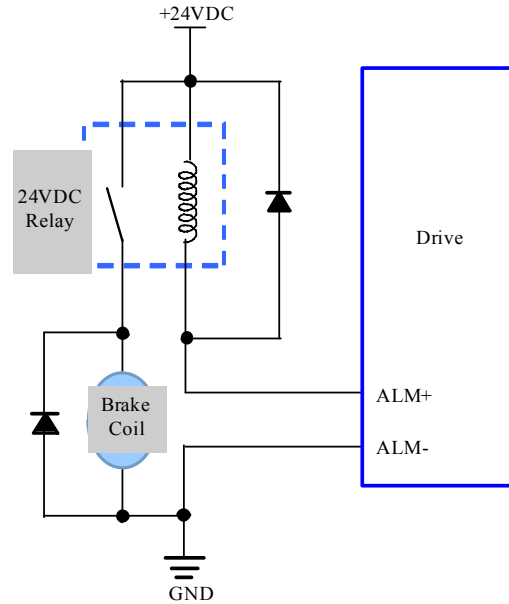
Figure 3: Brake Output Connection

3.1.2 Typical Control and Fault Output Connections

The CL86 can accept differential and single-ended control signal inputs (open-collector and PNP output). A CL86 has 3 optically isolated control inputs, PUL, DIR, and ENA. Refer to the following two figures for connections of open-collector and PNP signals.
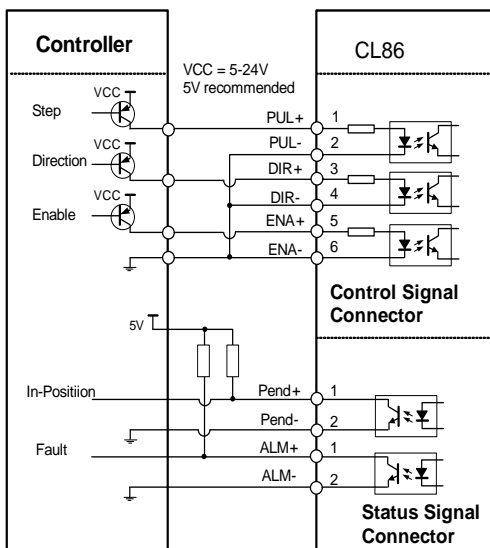

Figure 4: Connections to PNP signal
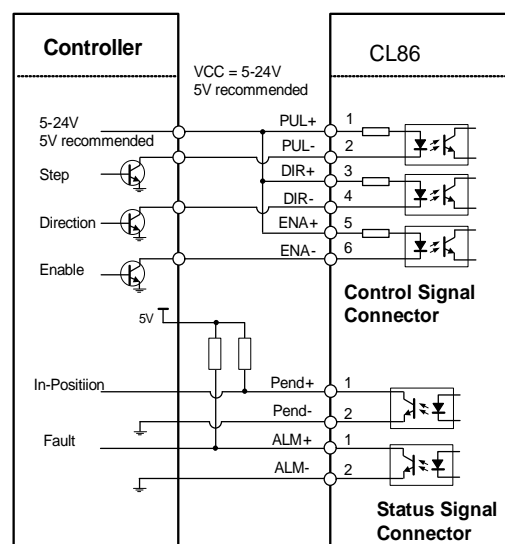
(common-cathode)

Figure 5: Connections to open-collector signal

(common-anode)

3.2 Connector P3 - Encoder Connection

The P3 connector in Figure 2 is for encoder signal connection. Refer to the following table for details.

Drive Pin Name	Description
EB+	Encoder B+ input connection
EB-	Encoder B- input connection
EA+	Encoder A+ input connection
EA-	Encoder A- input connection
VCC	encoder +5V voltage output connection
EGND	Power ground connection

3.3 Connector P4 - Motor and Power Supply Connection

The P4 connector in Figure 2 is for motor connection. Refer to the following table for details.

- CL86

Pin Name	Details
A+	Stepper motor A+ connection. Connect motor A+ wire to this pin
A-	Stepper motor A- connection. Connect motor A- wire to this pin
B+	Stepper motor B+ connection. Connect motor B+ wire to this pin
B-	Stepper motor B- connection. Connect motor B- wire to this pin
+Vdc	Power supply positive connection. 18-80VDC power supply voltage
GND	Power supply ground connection.

- CL86

Pin Name	Details
A+	Stepper motor A+ connection. Connect motor A+ wire to this pin

| A-	Stepper motor A- connection. Connect motor A- wire to this pin
B-	Stepper motor B+ connection. Connect motor B+ wire to this pin
B-	Stepper motor B- connection. Connect motor B- wire to this pin
AC	Power supply connection. 30-100VDC or 20-70VAC power supply voltage
AC	

Notes: see Appendix B for compatible Leadshine power supplies

3.4 Connector P5 – RS232 Connection

The P5 connector in Figure 2 is a RS232 communication port for PC connection. Refer to the following pin definitions.

RS232 Communication Port – RJ11

Pin	Name	I/O	Description
1	NC	-	Not connected.
2	+5V	O	+5V power output.
3	TxD	O	RS232 transmit.
4	GND	GND	Ground.
5	RxD	I	RS232 receive.
6	NC	-	Not connected.
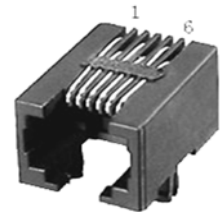
Notes: RS232 connection of CS-D808 / CS-D1008 is for tuning purpose only, not for RS232 command controls.

3.5 LED Light Indication

There are two LED lights for CL86, one red and one green. The GREEN one is the power indicator which will be always on generally. The RED one is a protection indicator. It is off always when a CL86 operates normally, but will flash 1, 2 or 7 times in a 5-second period when error protection is enabled. Different number of flashes indicates different protection type (read Section 9).

4. Motor Selection

The CL86 is designed to power 2-phase (or 4-phase 0.9 degree) NEMA 34 stepper motors under 10000-line incremental encoders (recommend 1000-line). Leadshine offers many high performance stepper motors compatible with the CL86 which you can find in the Appendix A of this document. The CL86 can also power similar stepper motors with incremental encoders from third-party suppliers.

5. Power Supply Selection

The CL86 can power medium size closed loop stepper motors (frame size NEMA 34) from Leadshine (see Appendix A) or other motor manufacturers. To get good system performance, it is important to select proper supply voltage and output current. Generally speaking, supply voltage determines the high speed performance of the motor, while output current determines the output torque of the driven motor (particularly at lower speed). Higher supply voltage will allow higher motor speed to be achieved, at the price of more noise and heating. If the motion speed requirement is low, it's better to use lower supply voltage to decrease noise, heating and improve reliability.

Notes: See Appendix B at the end of this document for Leadshine CL86 compatible switching power supplies specially designed for stepper & servo controls.

5.1 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 and fast response for current change. If you prefer to a regulated power supply, it is suggested to choose such a power supply specially designed for stepper/servo controls such as Leadshine RPS series (http://www.leadshine.com/producttypes.aspx?producttype=regulated-switching). Or, in the case when only normal switching power supplies are available, it is important to use "OVERSIZE" high current output rating power supplies (for example, using a 4A power supply for 3A stepper motor) to avoid problems such as current clamp. 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.

5.2 Power Supply Sharing

Multiple CL86 drives can share one power supply to save space and reduce cost, if that power supply has enough power capacity. To avoid cross interference, connect each stepper drive directly to the shared power supply separately. To avoid cross interference, DO NOT daisy-chain connect the power supply input pins of the Drivers. Instead connect them to power supply separately.

5.3 Selecting Supply Voltage

The CL86 is designed to operate within 30-80VDC voltage input. When selecting a power supply, besides voltage from the power supply power line voltage fluctuation and back EMF voltage generated during motor deceleration needs also to be taken into account. Ideally it is suggested to use a power supply with the output of **30-72VDC**, leaving room for power line voltage fluctuation and back-EMF.

Higher supply voltage can increase motor torque at higher speeds, thus helpful for avoiding losing steps. However, higher voltage may cause bigger motor vibration at lower speed, and it may also cause over-voltage protection or even drive damage. Therefore, it is suggested to choose only sufficiently high supply voltage for intended applications.

6. DIP Switch Configurations

The CL86 has a built-in 8-bit DIP switch to set microstep resolution, motor direction, auto tuning switch and so on.
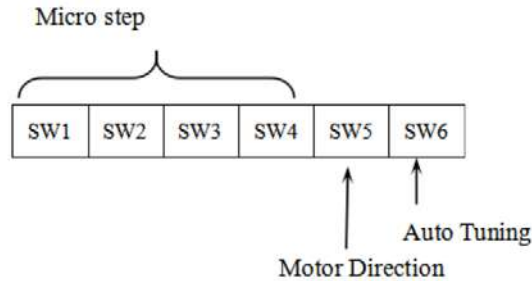
Figure 6: DIP switch Setting

6.1 Microstep Resolution (SW1-SW4)

Microstep resolution is set by SW1, 2, 3, 4 of the DIP switches as shown in the following table:

Steps/Revolution	SW1	SW2	SW3	SW4
Software Configured (Defaulted to 1600)	on	on	on	on
800	off	on	on	on
1600	on	off	on	on
3200	off	off	on	on
6400	on	on	off	on
12800	off	on	off	on
25600	on	off	off	on
51200	off	off	off	on
1000	on	on	on	off
2000	off	on	on	off
4000	on	off	on	off

5000	off	off	on	off
8000	on	on	off	off
10000	off	on	off	off
20000	on	off	off	off
40000	off	off	off	off

6.2 Other DIP Switch Settings (SW5-SW6)

	Function	**On**	**Off**
SW5	Default Direction	CW (clockwise)	CCW (counterclockwise)
SW6	Auto Tuning	No	Yes

7. Typical Connection

A complete closed loop stepper system should include a stepper motor with encoder, CL86 drive, power supply and controller (pulse generator). A typical connection is illustrated in figure 6.
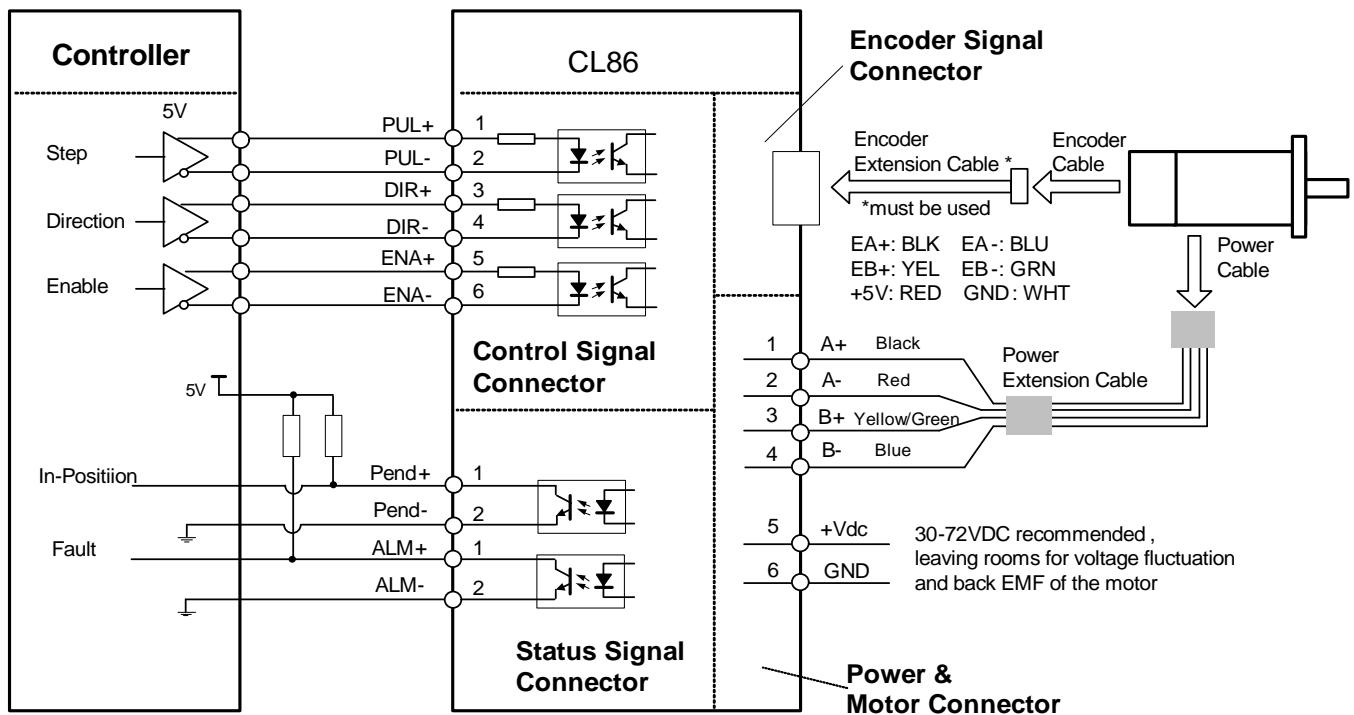

Figure 7: Typical connection

8. Sequence Chart of Control Signals

In order to avoid some fault operations and deviations, PUL, DIR and ENA should abide by some rules, shown as following diagram:
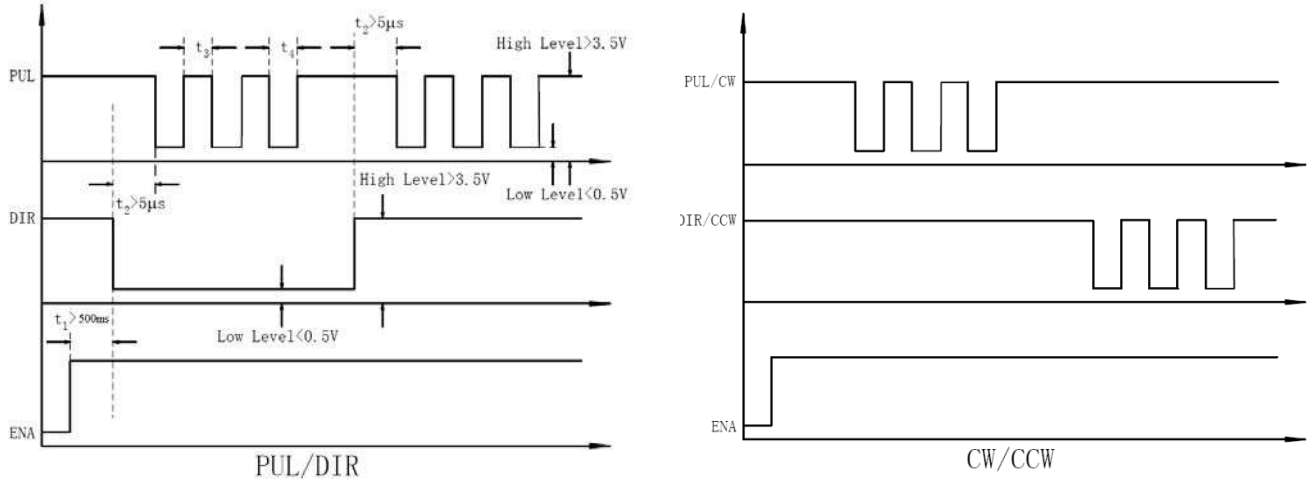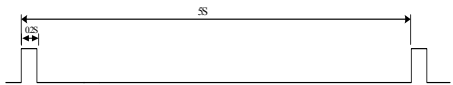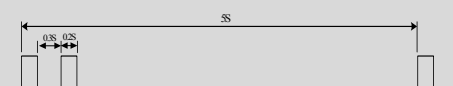

Figure 8: Sequence chart of control signals

Remark:

a) t1: ENA must be ahead of DIR by at least 500ms. Usually, ENA+ and ENA- are NC (not connected). See "Connector P1 Configurations" for more information.

b) t2: DIR must be ahead of PUL effective edge by 5us to ensure correct direction;

c) t3: Pulse width not less than 2.5 us;

d) t4: Low level width not less than 2.5us.

9. Protection Functions

To improve reliability, the drive incorporates some built-in protections features.

Priority	Time(s) of Blink	Sequence wave of red LED	Description
1st	1		Over-current protection activated when peak current exceeds the limit.
2nd	2		Over-voltage protection activated when drive working voltage is greater than 113VDC for CS-D808 (160 VDC for CS-D1008)

3nd	7		Position following error

When above protections are active, the motor shaft will be free or the red LED blinks. Reset the drive by repowering it to make it function properly after removing above problems.
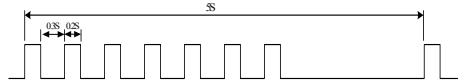
10. Software Configuration

The CL86 is designed for simple setup and implementation. For most applications no software configuration or tuning is needed especially when driving Leadshine stepper motors with encoders (see Appendix A). If you want to do fine tuning or custom configurations such as micro-step, current percentage change…, you can use Leadshine's free ProTuner software to make the changes. Download ProTuner at http://www.leadshine.com/UploadFile/Down/ProTuner_CS_Ds.V1.0.zip or http://www.leadshineusa.com/UploadFile/Down/ProTuner_CS_Ds.V1.0.zip. Download the software manual at http://www.leadshine.com/UploadFile/Down/CS-Dsm_V1.0.pdf or http://www.leadshineusa.com/UploadFile/Down/CS-Dsm_V1.0.pdf.

11. Accessories

If you plan to use the ProTuner software, contact your supplier or Leadshine to purchase the RS232 cable with part number CABLE-PC for connecting the CL86 to a computer with Windows 7 /8 /10 installed. In the case of using USB to RS232 conversion, contact your supplier or Leadshine for such a cable with part number USB2.0-232 which has been verified working fine.

CABLE-PC

(RS232 tuning cable)

USB2.0-232

(USB to RS232 Conversion Cable)

12. Troubleshooting

In the event that your drive doesn't operate properly, the first step is to identify whether the problem is electrical or mechanical in nature. The next step is to isolate the system component that is causing the problem. As part of this process you may have to disconnect the individual components that make up your system and verify that they operate independently. It is important to document each step in the troubleshooting process. You may need this documentation to refer back to at a later date, and these details will greatly assist our Technical Support staff in determining the problem

should you need assistance.

Many of the problems that affect motion control systems can be traced to electrical noise, controller software errors, or mistake in wiring.

Symptoms	Possible Problems	Solutions
Motor is not rotating	No power	Connect power supply correctly
	Microstep resolution setting is wrong	Setting appropriate microstep
	Fault condition exists	Check wiring and restart power
	The drive is disabled	Drive restore factory setting, and keep ENA+, ENA- input signals unconnected.
Wrong motor rotation direction	The Direction signal level is reverse	Toggling the SW5 DIP switch
The drive in fault	Red light flashes once in a 5-second period	The motor coil may short circuit or exiting the wrong wiring
	Red light flashes twice in a 5-second period	The power supply exceeds Max. operation voltage
	Red light flashes 7-times in a 5-second period	If using Leadshine's motor, refer to motor wiring in datasheet;If using 3rd motor, need to swap the wiring of motor phase A+ and phase A-
	Red light is always on after power on	The drive is burned
Erratic motor motion	Control signal is too weak	Ensure the current of control signal is within 7-16mA
	Control signal is interfered	Don't tie the control signal cable with power cable together
	Wrong motor connection	Refer to user manual of drive and motor datasheet
	Something wrong with motor coil	Check the motor is normal
Motor stalls during acceleration	Current setting is too small	Choose another power supply with lager power or increase the

		output current of drive
	Motor is undersized for the application	Choose another motor with higher torque
	Acceleration is set too high	Reduce the acceleration
	Power supply voltage too low	Choose another power supply with large voltage output
Excessive motor & drive heating	Inadequate heat sinking / cooling	Refer to chapter 2.4
	Motor peak current setting is too high	Reduce the current value refer to motor datasheet
Motor vibration when power on	Speed loop Kp is too high	Reduce the speed loop Kp value

13. Warranty

Twelve Month Warranty

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

Exclusions

The above warranty does not extend to any product damaged by reasons of improper or inadequate handlings by customer, improper or inadequate customer wirings, 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, please contact your seller to obtain a returned material authorization number (RMA) before returning product for service.

Shipping Failed Products

If your product fail during the warranty period, please contact your seller for how and where to ship the failed product for warranty or repair services first, you can also e-mail customer service at info@cloudray.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.

Appendix A. Leadshine CL86 Compatible Stepper Motors

The following Leadshine stepper motors with 1000-line encoders have been tested working with the CL86 closed loop stepper drive.

Model	Frame Size (NEMA)	Torque (N.m / Oz-In)	Series	Length (mm / inch)	Notes
CS-M23435		3.5 / 495		95 / 2.20	-
CS-M23435-S		3.5 / 495		95 / 2.48	0.50-inch (12.7-mm) shaft
CS-M23445		4.5 / 637		109 / 2.76	-
CS-M23445-S		4.5 / 637		109 / 3.27	0.50-inch (12.7-mm) shaft
CS-M23445B		4.5 / 637		135 / 2.44	24VDC brake integrated
CS-M23445WP		4.5 / 637		115 / 2.08	IP65 rated
CS-M23480		8.0 / 1132		127 / 3.03	-
CS-M23480-S		8.0 / 1132		127 / 3.82	0.50-inch (12.7-mm) shaft
CS-M23480B	34	8.0 / 1132	CS-M	173 / 3.82	24VDC brake integrated
CS-M23480WP		8.0 / 1132		133 / 2.94	IP65 rated
CS-M23485		8.5 / 1202		147 / 4.13	-
CS-M23485-S		8.5 / 1202		147 / 4.13	0.50-inch (12.7-mm) shaft
CS-M23485B		8.5 / 1202		173 / 3.46	24VDC brake integrated
CS-M23485WP		8.5 / 1202		154 / 3.08	IP65 rated
CS-M234120		12.0 / 1698		158 / 4.29	-
CS-M234120B		12.0 / 1698		184 / 4.29	24VDC brake integrated
CS-M234120WP		12.0 / 1698		164 / 3.82	IP65 rated

Note: all above stepper motors are mounted with 1000-line incremental encoders

Appendix B.   Leadshine CL86 Compatible Power Supplies

It is highly suggested to use the following Leadshine power supplies to power CL86 to get optimized performance. Those power supply are specially designed for stepper and servo controls.

Model	Output Voltage (VDC)	Series Model	Continuous Current (A)	Max Current (A)	Input Voltage (VAC)
RPS488V20	48		8.3	24.9	85-132 / 176-264
RPS4810V20	48		10.5	31.5	85-132 / 176-264
RPS488	48	RPS	7.3	8.5	85-132 / 176-264
RPS4810	48		10.4	12.5	85-132 / 176-264
RPS608	60		8.5	10.5	85-132 / 176-264
SPS407	42		7.0	9.0	180-240
SPS407-L	42		4.7	9.0	90-130
SPS487	48	SPS	7.0	9.0	180-240
SPS487-L	48		3.0	9.0	90-130
SPS705	68		5.0	7.0	180-240
SPS705-L	68		3.0	7.0	90-130

Appendix C.   Powering a Third Party Motor with CL86

It is highly recommended to choose a Leadshine closed stepper motor along with the CL86closed loop stepper drive, for getting the best system performance and easy setup. See Appendix A for frequently purchased Leadshine closed loop stepper motors.

For an OEM project if you can't find one on Appendix A meeting your requirements there, contact Leadshine sales directly by emailing info@cloudray.com . Leadshine carry's many other custom models and there may be one there which can satisfy your application need already.

In the case of powering a third party closed loop stepper motor, pay special attention as described below.

- Your stepper motor must be a 2-phase stepper motor
- Your stepper motor must be mounted with a quadrature rotary encoder with the resolution of 500-5,000 line (2,000- 20,000 CPR).
- When the CL86 is first-time powered on after your stepper motor is connected, check the following possible causes if a position following error (see Section 9 above) happens.
    o Confirm both encoder and power cables are connected properly and tightly secured.
    o Power off the drive then swap the A+ and A- motor connections to the CL86 drive.
       The reason is the definitions of your Motor A+ and A- are different from those marked on CL86 motor connection pins (P4 of Figure 2).

   If protection error is still seen after the above steps, contact your drive supplier or Leadshine technical support.