User's Manual

For

DCS810

Digital DC Servo Driver

Revision 1.0

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

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1. Introduction, Features and Applications

Introduction

The DCS810 is a digital DC servo driver developed with DSP and high efficient MOSFET technologies. In position control, it's easy for the end users to change stepping drivers to the DCS810 without changing control systems, because its input command is PUL/DIR signal, which is compatible with that of stepping drivers. In low power motion control applications, performances of DC servo systems using the DCS810 are better than those of digital AC servo systems in velocity, precision, noise, stability, or at least as good as those of digital AC servo systems. However, the cost of the DCS810 stays at the price line of stepping driver, namely far lower than those of AC servo drivers.

Compared to the DB810-50V, the DCS810 can accept differential control signals and differential encoder feedback signals, offering better anti-interference performances. Meanwhile the DCS810 has higher Max Pulse Input Frequency, hence can drive a faster motor or choose a higher accuracy encoder for a given motor. What's more, broader input voltage range makes the DCS810 can drive broader range of servo motors. Compared to the DB810A, parameter visible tuning tools make the DCS810 much easier to tune.

The DCS810 is very easy to tune and all parameters are visible. Parameter visible tuning tools, including Pro Tuner (Windows based setup software) and STU (Small servo tuning unit) can meet different tuning environments or requirements.

Features

❙ 18-80VDC, 0-20A, 20-400W.
❙ Based on DSP control technology and high smooth servo control algorithm.
❙ Parameter visible tuning tools, including Pro Tuner, EZ Tuner and STU.

❙ Feedback resolution ×4 encoder line count.
❙ Position Following error lock range adjustable
❙ Position error can be eliminated to 1 count, and Velocity error can be eliminated to the Desired Velocity* ±0.3%
❙ Electronic gear ratio from 1/255 to 255
❙ Built-in motion controller for self-test with trapezoidal velocity profile
❙ Support PUL/DIR and CW/CCW control signals
❙ Opto-isolated inputs, support single-ended and differential signals
❙ 10 latest errors self-record function
❙ Over-current, over-voltage, under-voltage, phase error, encoder error, position following error protections
❙ Small size, surface-mount technology

Applications

Suitable for a wide range of equipments and instruments such as mini type engraving machines, jet-ink machines, etc. It performs better in equipments desired for low noise, high velocity, high precision and high reliability.

2. Specifications and Operating Environment
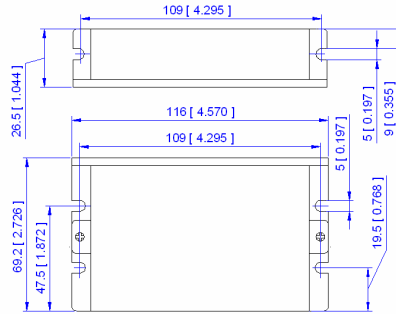
Mechanical Specifications (**unit: mm[inch]**)

Figure 1: Mechanical specifications

Elimination of Heat

l Driver's reliable working temperature should be <70℃(158℉), and motor working temperature should be <80℃(176℉);

l It is recommended to mount the driver vertically to maximize heat sink area.

Electrical Specifications (T$_j$ = 25℃/77℉)

Parameters	DCS810			
	Min.	Typical	Max.	Unit
Peak output current	0	-	20	A
Supply voltage	+18	-	+80	VDC
Logic signal current	7	10	15	mA
Pulse input frequency	0	-	500	KHz
Isolation resistance	500			MΩ
Current provided to encoder			50	mA

Operating Environment and Parameters

Cooling	Natural cooling or forced cooling	
Operating Environment	Environment	Avoid dust, oil fog and corrosive gases
	Ambient Temperature	0℃－50℃ (32℉－122℉)
	Humidity	40%RH－90%RH
	Vibration	5.9 m/s^2 Max
Storage Temperature	-20℃ － 65℃ (-4℉ － 149℉)	
Weight	Approx. 210 grams (7.41 oz)	

3. Connections

Connector Configuration

General information

Control Signal Connector			
Pin	Signal	Description	I/O
1	PUL+	Pulse control signal (+). See more information about PUL in "More about PUL/DIR/EN Signals" section.	I
2	PUL-	Pulse control signal (-).	I
3	DIR+	Direction control signal (+). See more information about DIR in "More about PUL/DIR/EN Signals" section.	I
4	DIR-	Direction control signal (-).	I
5	EN+	Enable control signal (+).	I
6	EN-	Enable control signal (-).	I
Encoder Signal Connector			
Pin	Signal	Description	I/O
1	EB+	Encoder channel B (+) input.	I
2	EB-	Encoder channel B (-) input.	I
3	EA+	Encoder channel A (+) input.	I
4	EA-	Encoder channel A (-) input.	I
5	E +5V	Positive pole of the auxiliary power supply (50 mA (Max)).	O
6	EGND	Ground of the auxiliary power supply.	GND

Power Connector			
Pin	Signal	Description	I/O
1	Motor+	Motor positive connection.	O
2	Motor-	Motor negative connection.	O
3	+VDC	+18 TO 80VDC power input.	I
4	GND	Power ground.	GND
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.	-

More about PUL/DIR/EN Signals

Pin Function	Details
PUL+ PUL-	Pulse signal: In single pulse (pulse/direction) mode, this input represents pulse signal; 4-5V when PUL-HIGH, 0-0.5V when PUL-LOW. In double pulse mode (pulse/pulse) , this input represents clockwise (CW) pulse，effective at LOW level (the fixed level). For reliable response, pulse width should be longer than 1.0μs. Series connect resistors for current-limiting when using +12V or +24V control signals.
DIR+ DIR-	DIR signal: In single-pulse mode, this signal has low/high voltage levels, representing two directions of motor rotation(set by inside R33 and R37); in double-pulse mode, this signal is counter-clock (CCW) pulse，effective at LOW level (the fixed 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. Please note that motion direction is also related to motor-driver wiring and encoder feedback A/B phase signals. Exchanging the connections of two wires of the motor to the driver and A/B phase signals of encoder will reverse motion direction.
EN+ EN-	Enable signal: This signal is used for enabling/disabling the driver. High level (NPN control signal, PNP and Differential control signals are on the contrary, namely Low level for enabling.) for enabling the driver and low level for disabling the driver. Usually left **UNCONNECTED (ENABLED)**. Series connect resistors for current-limiting when using +12V or +24V control signals.

PUL/DIR and CW/CCW Mode Settings

There are four resistors (R31/R32/R33/R37) inside the DCS810 specifically for setting PUL/DIR and CW/CCW modes, as shown in figure 2. Default setting is (b), namely PUL/DIR mode, DIR LOW for positive direction and DIR HIGH for negative direction.
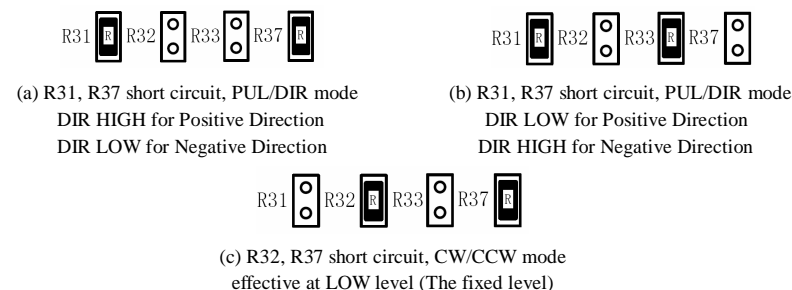

(a) R31, R37 short circuit, PUL/DIR mode
DIR HIGH for Positive Direction
DIR LOW for Negative Direction

(b) R31, R37 short circuit, PUL/DIR mode
DIR LOW for Positive Direction
DIR HIGH for Negative Direction

(c) R32, R37 short circuit, CW/CCW mode
effective at LOW level (The fixed level)

Figure 2: PUL/DIR and CW/CCW settings

Control Signal Connections

The DCS810 can accept differential and single-ended inputs (including open-collector and PNP output). The DCS810 has 2 optically isolated logic inputs to accept line driver control signals. These inputs are isolated to minimize or eliminate electrical noises coupled onto the control signals. Recommend use line driver control signals to increase noise immunity in interference environments. In the following figures, connections to open-collector and differential control signals are illustrated.
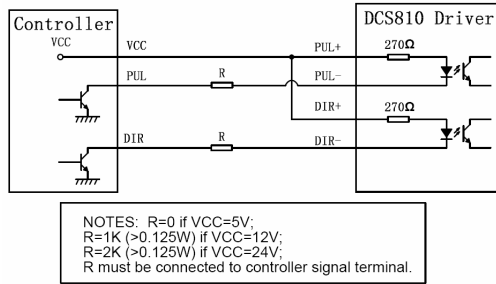
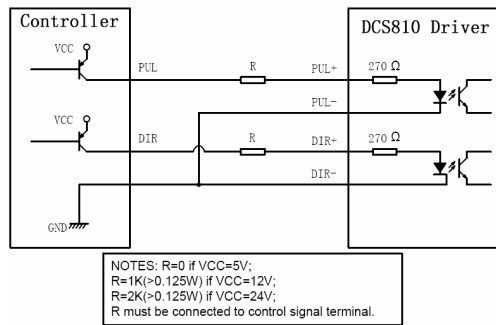Figure 3: Connections to open-collector control signal (common-anode)

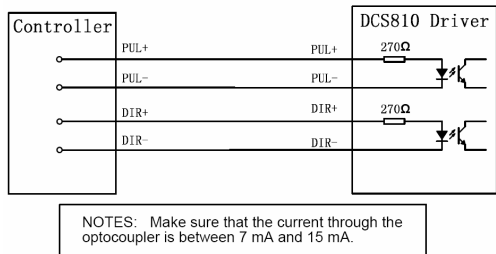Figure 4: Connections to PNP signal (common-cathode)

Figure 5: Connections to differential control signal

Encoder Connections

The DCS810 can accept encoder input from either differential or single-ended encoders. Differential encoders are preferred due to their excellent noise immunity. The connections for a single-ended encoder are identical to a differential encoder except that no connections should be made to channel A- and channel B-. (The A- and B- lines are pulled up internally to +2.5V). Note that twisted-pair shielded cabling provides the best immunity in electrically noisy environments.

If the encoder drains less than 50mA, the DCS810 can supply the encoder directly, and connect it as Figure 6 or Figure 7. If the encoder drains more than 50mA, use an external DC supply and connect it as Figure 8 or Figure 9.
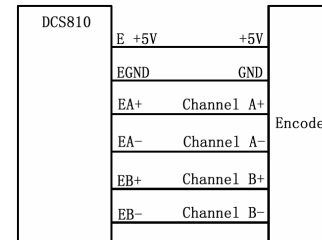

Figure 6: The DCS810 supplies the differential encoder directly
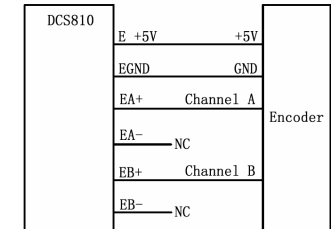

Figure 7: The DCS810 supplies the single-ended encoder directly
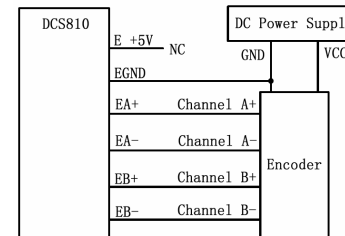

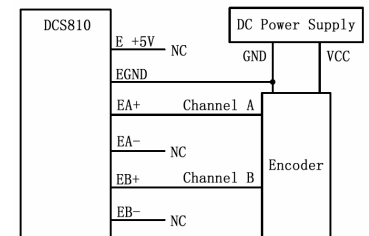Figure 8: Using external DC power supply to supply the differential encoder

Figure 9: Using external DC power supply to supply the single-ended encoder

RS232 Interface Connection
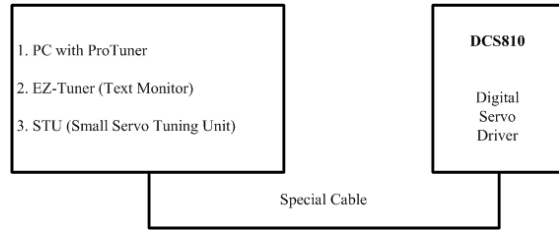
Figure 10: RS232 interface connection

Typical Connections

Two typical connections of the DCS810 are shown as Figure 11 and Figure 12. Please consult "Control Signal Connections" and "Encoder Connections" for more information about controller and encoder connections.
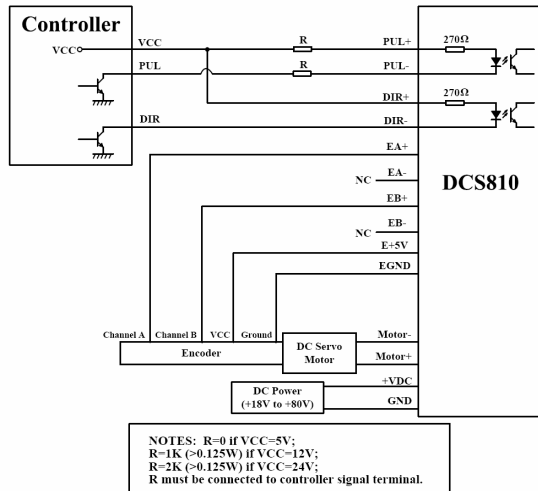
Figure 11: Typical connection (Open-collector control signal and single-ended encoder.)
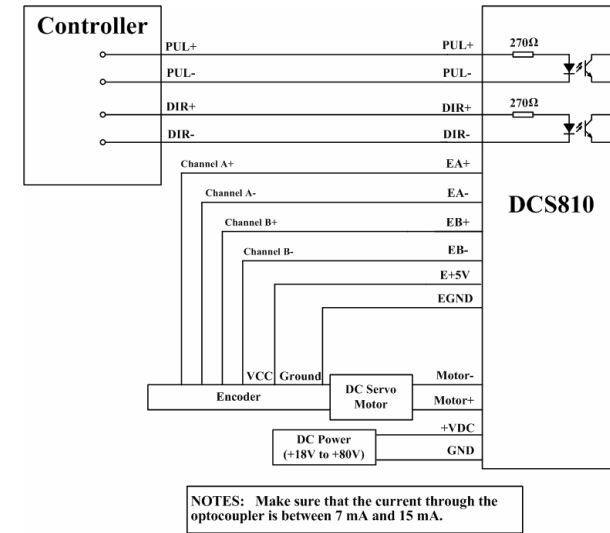
Figure 12: Typical connection (Differential control signal and differential encoder.)

4. Servo Setup

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

Install Encoder

If your motor has no encoder, you must have an encoder (more than 200 lines) properly mounted on the motor before you start. And please assemble the encoder according to its factory manual. **Here, we recommend use differential encoder again.** If you do have to use a single-ended encoder, please use shielded cables and separate encoder signal cable from interference sources, such as motor wires and power wires at least 5 cm.

Prepare Power Supply

Regulated or Unregulated Power Supply

Both regulated and unregulated power supplies can be used to supply the driver. 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-driver 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 driver 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 DCS810 can actually operate within +18V to +80VDC, 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 driver damage.

Prepare Controller

Prepare a controller with pulse and direction signals. However, the DCS810 has a built-in motion controller for self-test and Servo Tuning. The built-in motion controller can generate control 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 connection diagrams before, 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 driver power wires as possible. Motor power and driver power wires are major sources of noise and can easily corrupt a nearby signal. This issue becomes increasingly important with longer motor power and driver power wires lengths.

Twisted Wires

Twisted wires effectively increasing 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 driver 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 are 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 DCS810 driver. 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 1000μF/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 drivers 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 drivers. 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 DCS810 has default parameters stored in the driver. If the system has no hardware and wirings problem, the motor should be locked and the driver 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 driver status by clicking **Err_check**. If it's **Phase Error**, then reversal motor wires or exchange 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.

If the red LED is off and the motor is normal, then you can start to tune the servo with selected tool. **ProTuner**, **EZ-Tuner** and **STU** are available for the DCS810.

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 13. 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.
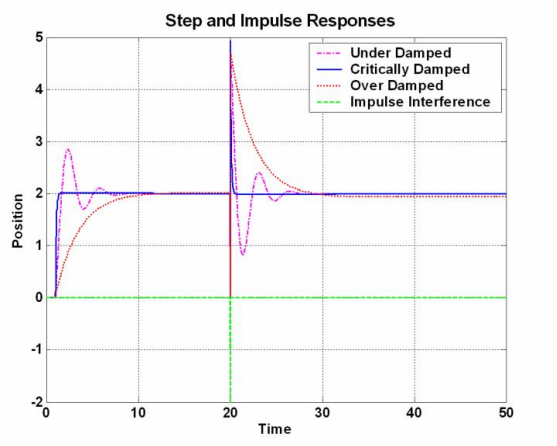

Figure 13: Step and impulse responses

As mentioned in previous contents, the DCS810 is a digital servo driver 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 13, 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 13 at "time 20".

Leadshine offer a Windows based setup software **ProTuner** and a special text monitor **EZ-Tuner** (optional) to its customers for evaluating servo performances. Small servo tuning unit **STU** (optional) is available too, and it's for field tuning without PC or power supply for the **EZ-Tuner**.

Tuning servo systems formed by DCS810 drivers 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 driver's EEPROM.
4. If servo system is OVER DAMPED, then decrease Kd or increase Kp or Ki.

Please see user's manuals of those tuning tools for more detail about Servo Tuning.

6. Using Tips

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 the following figure:
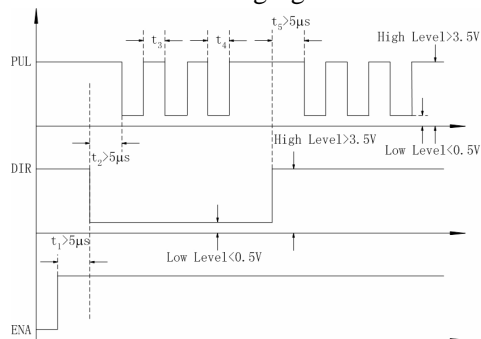

Figure14: Sequence chart of control signals

Notes:

a) t_1: EN must be ahead of DIR by at least 5μs. Usually, EN+ and EN- are NC (not connected). See **Connections** section for more information.

b) t_2: DIR must be ahead of PUL effective edge by at least 5μs to ensure correct direction.

c) t_3: Pulse width not less than 1.0s;

d) t_4: Low level width not less than 1.0s.

Protection Functions

To improve reliability, the driver incorporates some built-in protection functions. The DCS810 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 driver 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 85 ± 1.5 VDC, protection will be activated and RED LED will turn on twice within each periodic time (5 s).

Under-voltage Protection

When power supply voltage is lower than 16.5 ± 1.5 VDC, protection will be activated and RED LED will turn on three times within each periodic time (5 s).

Phase Error Protection

Motor power lines wrong & not connected and encoder feedback signals A/B phases wrong connected will activate this protection. RED LED will turn on four times within each periodic time (5 s).

Encoder Error Protection

No encoder feedback signals or wrong encoder 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 driver, this protection will be activated. RED LED will turn on seven times within each periodic time (5 s).

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

Protection Indications

Priority	Time(s) of ON	Sequence wave of RED LED	Description
1st	1		Over-current protection
2nd	2		Over-voltage protection
3rd	3		Under-voltage protection
4th	4		Phase error protection
5th	5		Encoder error protection
6th	7		Position following error protection

Changing Default Motor Direction

The DCS810 will turn the motor in the CW direction when the direction input is "high" (logical "1"). If instead CCW is preferred, then:

1) Reverse the "motor +" and "motor -" leads.
2) Reverse the encoder "Channel A" and "Channel B" leads.

Maximum Pulse Input Frequency

Maximum Pulse Input Frequency is the highest frequency at which the driver can interpret encoder feedback. To convert this frequency to RPM, use the following formula:

$$RPM\,(\max) = \frac{(Max\ \ Pulse\ \ Input\ \ Frequence) \times 60}{(Encoder\ \ Line\ \ Count) \times 4}$$

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 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 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

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