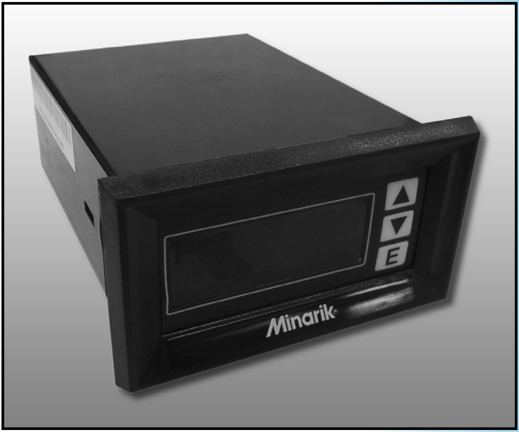
Minarik Automation & Control

DLC600

User's Manual



DIGI-LOK

Programmable Digital Control

Printed in the United States of America.

Safety Warnings

- This symbol ⚠ denotes an important safety tip or warning. **Please read these instructions carefully** before performing any of the procedures contained in this manual.

- **DO NOT INSTALL, REMOVE, OR REWIRE THIS EQUIPMENT WITH POWER APPLIED.** Have a qualified electrical technician install, adjust and service this equipment. Follow the National Electrical Code and all other applicable electrical and safety codes, including the provisions of the Occupational Safety and Health Act (OSHA), when installing equipment.

- Reduce the chance of an electrical fire, shock, or explosion by proper grounding, over-current protection, thermal protection, and enclosure. Follow sound maintenance procedures.

⚠ **The DLC600 is not isolated from earth ground**. Circuit potentials are at 115 VAC or 230 VAC above earth ground. Avoid direct contact with the printed circuit board or with circuit elements to prevent the risk of serious injury or fatality. Use a non-metallic screwdriver for adjusting the calibration trimpots.

Contents

Illustrations

Introduction

Minarik's DLC600 control is a dual-voltage digital control used with a drive, motor and feedback device to regulate and display motor speed. The user may enter and display the motor speed in RPM or other units, such as feet per minute or inches per second. The DLC600 offers the advantage of repeatable speed settings and speed stability.

Basic operation principles

The DLC600 generates a frequency and compares this to the frequency coming from the feedback transducer attached to the motor shaft. The DLC600 then generates an analog voltage to the speed control to correct for any difference between the DLC600 reference frequency and the motor feedback frequency.

The DLC600 also counts the motor transducer pulses for a fixed period of time (called *gate time*) and displays this value on the front panel, usually in the form of motor revolutions per minute.

The DLC600-generated frequency is derived from an internal 50 Hz reference. The generated frequency is equal to the 50 Hz internal reference multiplied by the set speed. The product of the internal reference and set speed is then divided by the speed scale factor (SSF), which is entered by the user via the front panel pushbuttons. Refer to page 31 for more information on setting the speed scale factor.

DLC600 benefits

The DLC600 includes these benefits:

- **Excellent speed regulation:** 0.05% speed regulation of set speed for tight control, with a speed range of 30:1 with 1800 RPM motor.
- **Pushbutton programming:** Quick and easy programming using three front panel pushbuttons.
- **4-digit LED display:** 0.5 inch (13 mm) wide digits are easily readable.
- **Programmable decimal point:** Great for specific application readouts.
- **Selectable feedback devices:** Accepts magnetic pickup, hall effect, inductive proximity sensor or encoder input.
- **+5 VDC or +12 VDC (10 mA max) power supply for feedback devices:** Additional power supply is unnecessary.
- **Removable screw-terminal block:** Easy terminal block connections.
- **Frequency output terminals:** Each DLC600 provides a frequency output which can be used to control a second DLC600.

Specifications

AC Line Voltage	115 VAC or 230 VAC, ±10%, 50/60 Hz, single phase
AC Line Power	5.5 watts nominally
Acceptable Feedback Sources	5 VDC or 12 VDC NPN-type encoder 5 VDC or 12 VDC NPN-type proximity switch Hall effect sensor Magnetic pickup
Feedback Frequency Range **External Reference Frequency†**	10 – 3000 Hz
External Input Frequency Range††	0 Hz - 500 KHz
Maximum Analog Output Voltage	+10 VDC
Standard gate time	1 second
Power Supply Voltage for Feedback Devices (10 mA max)	+5 VDC or +12 VDC
Speed Regulation	0.05% of set speed
Feedback Frequency Range	0 - 3000 Hz
Ambient Operating Temperature Range	10°C–40°C
Weight	approximately 1 lb

† +5 VDC CMOS logic level signal or open-collector NPN transistor; applied to IN and C terminals.

†† Signal applied to Fin and C terminals. The product of the DLC leader frequency and speed setting may not exceed 500 KHz.

Dimensions

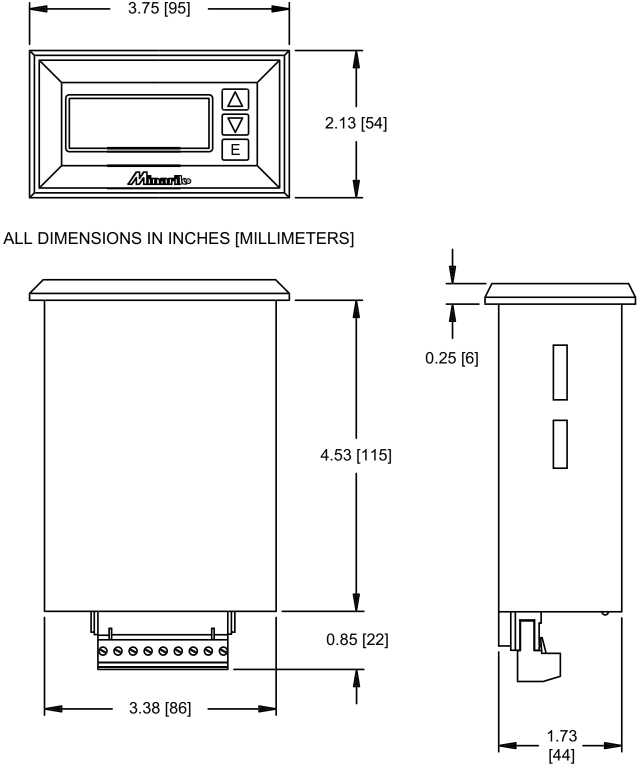


Figure 1. DLC600 Dimensions

Installation

Warning

Variable speed DC drives manufactured by other companies may require hookup procedures that differ from those given in this manual. Contact your local Minarik branch or distributor for assistance. A schematic diagram and the manufacturer's instruction for interfacing the drive with an external speed-setting signal may be required before the correct wiring scheme can be determined.

Mounting

Protect the control from dirt, moisture, and accidental contact. Provide sufficient room for access to the terminal block and calibration trimpots.

Mount the control away from other heat sources. Operate the drive within the specified ambient operating temperature range.

Prevent loose connections by avoiding excessive vibration of the control.

Wiring

Warning

Do not install, remove, or rewire this equipment with power applied. Failure to heed this warning may result in fire, explosion, or serious injury.

This drive is not isolated from earth ground. Circuit potentials are at 115 or 230 VAC above ground. To prevent the risk of injury or fatality, avoid direct contact with the printed circuit board or with circuit elements.

Do not disconnect any of the motor leads from the drive unless power is removed or the drive is disabled. Opening any one motor lead may destroy the drive.

Shielding guidelines

As a general rule, Minarik recommends shielding of all conductors.

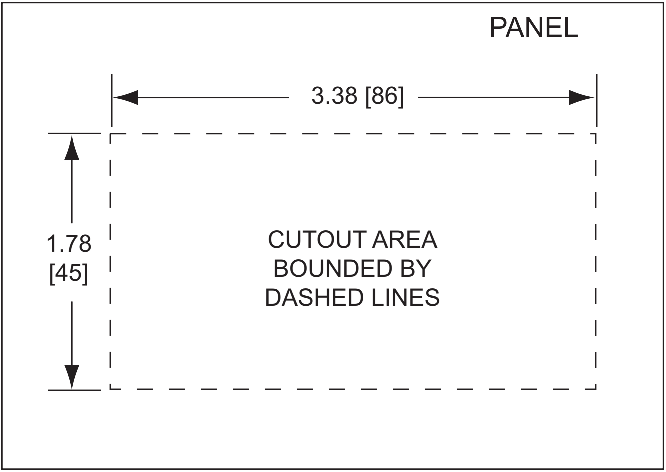
If it is not practical to shield power conductors, Minarik recommends shielding all logic-level leads. If shielding is not practical, the user should twist all logic leads with themselves to minimize induced noise.

It may be necessary to earth ground the shielded cable. If noise is produced by devices other than the controller, ground the shield at the drive end. If noise is generated by a device on the controller, ground the shield at the end away from the controller. Do not ground both ends of the shield.

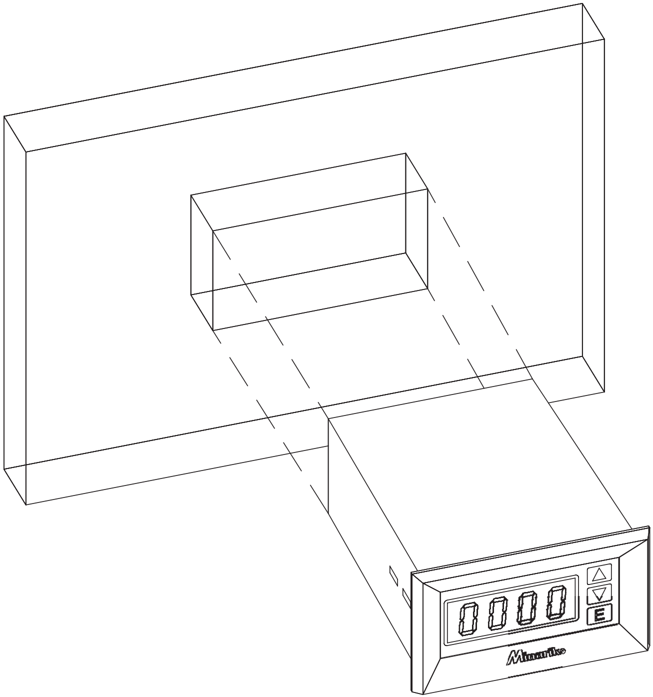
If the controller continues to pick up noise after grounding the shield, it may be necessary to add AC line filtering devices, or to mount the controller in a less noisy environment.

Panel installation

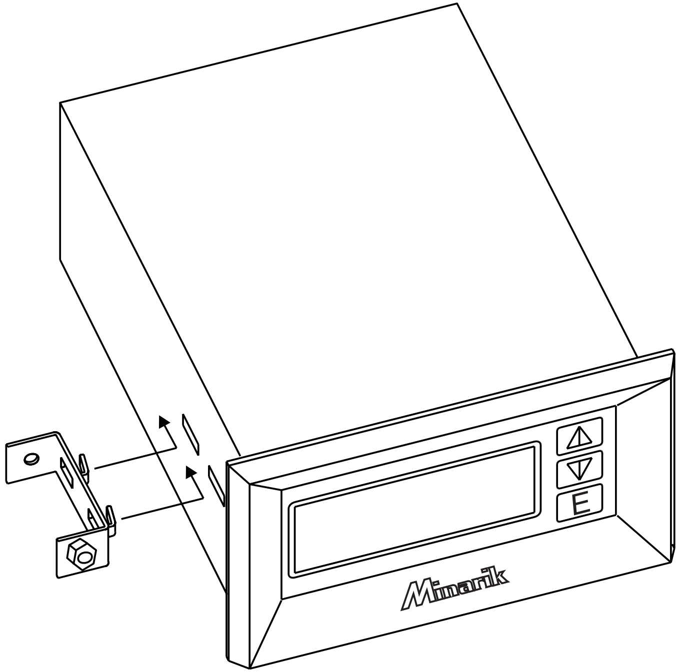
Step 1. Cut a rectangular hole in the panel 1.78 inches (45 mm) high, and 3.38 inches (86 mm) wide.



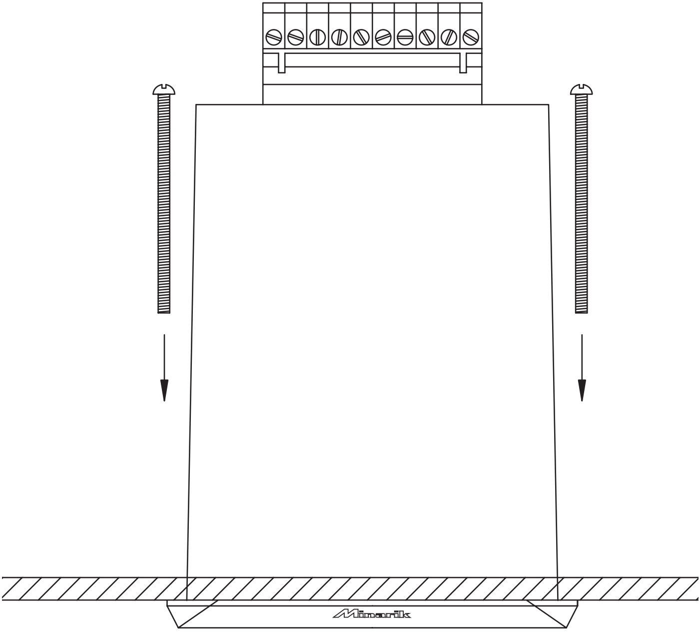
Step 2. Slide the DLC600 into the panel opening.



Step 3. Insert the two mounting brackets into each side of the DLC600 case.



Step 4. Secure the DLC600 to the panel using the bracket screws.



Feedback device selection

Acceptable feedback frequency at any set speed in an application must lie within the 0 Hz -3000 Hz range. Feedback frequency is directly proportional to the number of feedback pulses per revolution (PPR) and to the speed of the shaft (RPM) that the feedback transducer monitors.

The feedback range relates to the motor speed as follows:

$$PPR_{minimum} = \frac{600}{RPM_{minimum}}$$

$$PPR_{maximum} = \frac{120,000}{RPM_{maximum}}$$

For example, consider an application in which the feedback source is monitoring a driven shaft, and not the motor armature shaft. This shaft is running at speeds as low as 1 RPM.

$$PPR_{minimum} = \frac{600}{RPM_{minimum}}$$

$$PPR_{minimum} = \frac{600}{1} = 600$$

The selected feedback device must produce at least 600 PPR.

Now consider an application that requires monitoring and controlling a driven shaft at speeds as high as 4000 RPM.

$$PPR_{maximum} = \frac{120{,}000}{RPM_{maximum}}$$

$$PPR_{maximum} = \frac{120{,}000}{4000} = 30$$

The selected feedback device must produce 30 or fewer pulses per revolution.

The DLC600 can control armature shaft speeds within a 30:1 range. Under no circumstances can the DLC600 be expected to control motor speeds beyond this speed range.

Rear panel selector and DIP switches

Access the switches from the rear of the DLC600 case. Using a screwdriver, loosen the two screws that attach the nameplate to the case. The switches are visible when the nameplate is removed.

Line voltage switch

The slide switch on the left rear of the DLC600 (Figure 2) is the line voltage switch. Set this switch to the left position for 115 VAC input, or to the right for 230 VAC input.

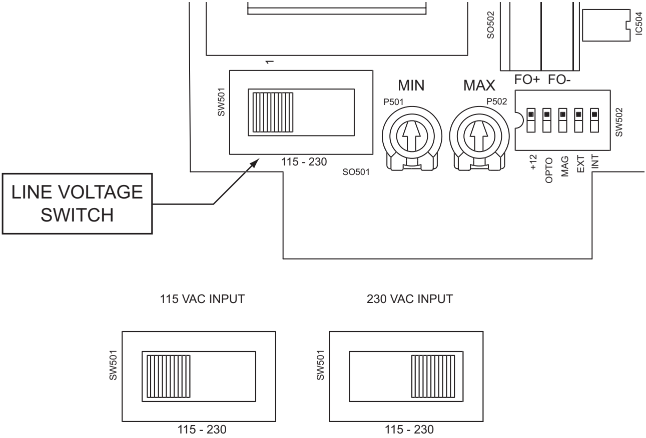


Figure 2. Line Voltage Select Switch

DIP switch settings

The dip switches on the right rear of the DLC600 (Figure 3) are the **supply voltage and feedback switches**.

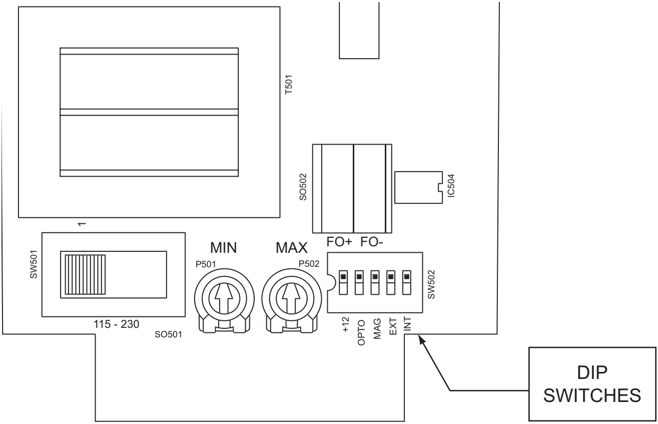


Figure 3. DIP Switch Location

Encoder power supply voltage (DIP switch 1)

DIP switch 1 selects the supply voltage for an external encoder (Figure 4). Set to OFF for +5 VDC, or ON for +12 VDC. The power supply voltage has a maximum current of 10 mA.

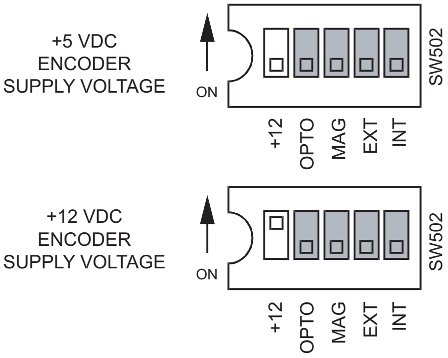


Figure 4. Encoder Power Supply Voltage Select DIP Switch

Feedback device selection (DIP switches 2 and 3)

DIP switches 2 and 3 are for feedback device selection (Figure 5). If an optical pickup, hall sensor, proximity switch, or open-collector transducer is used, set DIP switch 2 to ON and 3 to OFF. If a magnetic pickup is used, set DIP switch 2 to OFF and 3 to ON.

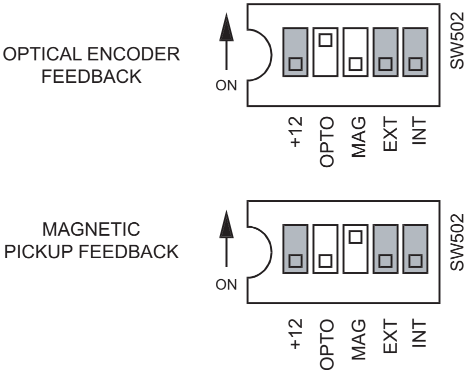


Figure 5. Feedback Device DIP Switch Settings

Reference signal selection (DIP switches 4 and 5)

DIP switches 4 and 5 are for reference signal selection (Figure 6). If an external reference signal is used, set DIP switch 4 to ON and 5 to OFF. If an internal reference signal is used (normal operation), set DIP switch 4 to OFF and 5 to ON.

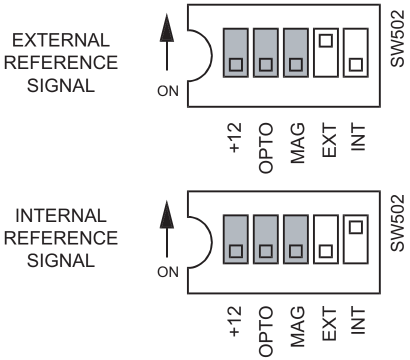


Figure 6. Reference Signal Selection DIP Switch Settings

Connections

Warning

Connections to Minarik regenerative and XP-AC series drives differ from connections to non-regenerative drives. Improper connection to regenerative or XP-AC series drives may result in damage to the DLC600 or drive.

Variable speed DC drives manufactured by other companies may require hookup procedures that differ from those given in this manual. Contact your local Minarik branch or distributor for assistance. A schematic diagram and the manufacturer's instruction for interfacing the drive with an external speed-setting signal may be required before the correct wiring scheme can be determined.

Terminal descriptions

Line voltage terminals (G, L1, L2)

Connect the line voltage to these terminals. The DLC600 is ON when power is applied to these terminals. Always provide a positive disconnect to shut down the DLC600 in case of an emergency.

Output terminals (S1, S2) (non-regenerative drives)

When connecting the DLC600 to non-regenerative drives, connect S1 to the drive's common (S1) terminal and S2 to the drive's signal input (S2) terminal. Make no connection to the drive's S3 terminal. Refer to Figure 7 (page 21).

NOTE: Refer to Figure 8 (page 22) for information on connecting regenerative drives and Figure 9 (page 23) for information on connecting XP-AC series drives to the DLC600.

Feedback terminals (+, IN, C)

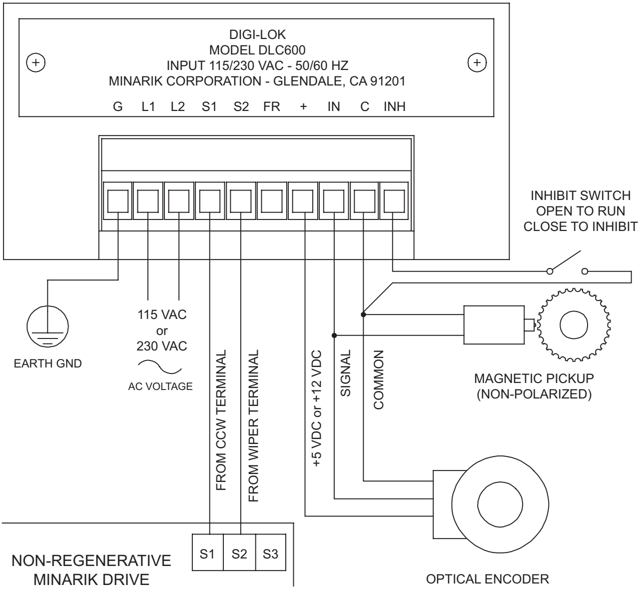
If a magnetic pickup is used, connect the pickup leads to terminals IN and C as shown in Figure 7. If an optical encoder is used, connect its positive input voltage lead to +, the signal lead to IN, and the signal common lead to C. The voltage at the + lead is determined by setting DIP switch 1.

NOTE: Only one feedback source may be used at any time.

Inhibit terminal (INH)

Short INH to common (C) to inhibit the DLC600. The DLC600 output will drop to the MIN trimpot setting. Remove the short to resume operation. An alternative is to connect a single-pole, single throw switch as shown in Figure 7. Close the switch to inhibit; open the switch to resume operation.

Connections to non-regenerative Minarik drives



Note: Only one feedback device (magnetic pickup or optical encoder) may be used at a time. Refer to Figure 8 for connections to Minarik regenerative drives, and Figure 9 for connections to Minarik XP-AC series drives. Contact your Minarik sales representative for assistance.

Figure 7. Non-Regenerative Minarik Drive Connections

Output terminal connections to regenerative drives

Warning

Failure to connect the DLC600 properly can damage the DLC600, drive, or motor.

Minarik regenerative drives provide a +10 VDC reference voltage when measured from drive terminal S1 to drive terminal S0, and a –10 VDC reference voltage when measured from drive terminal S3 to drive terminal S0.

For this reason, connect DLC600 terminal S1 to drive teminal S0, and DLC600 terminal S2 to drive terminal S2 (Figure 8). Set the MIN SPD trimpot on the regenerative drive to full CCW. Make no connection to drive terminals S1 and S3.

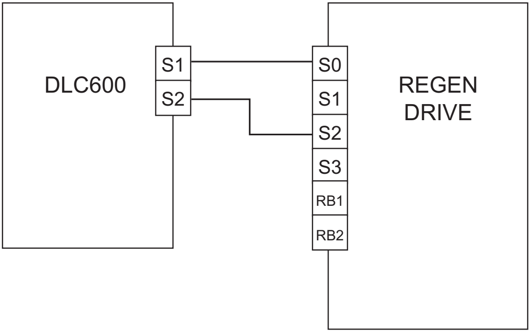


Figure 8. DLC600 connections to regenerative drives

Output terminal connections to XP-AC series drives

Warning

Failure to connect the DLC600 properly can damage the DLC600, drive, or motor.

Most Minarik drives provide a positive reference voltage when measured from terminal S1 (+) to terminal S2 (–), usually in a range of 0 – 10 VDC. XP-AC drives also provide a positive reference voltage; however; terminal S1 is positive and terminal S2 is negative or common.

For this reason, connect DLC600 terminal S1 to XP-AC drive terminal S2. Connect DLC600 terminal S2 to XP-AC drive terminal S1. Make no connection to S3. Refer to Figure 9.

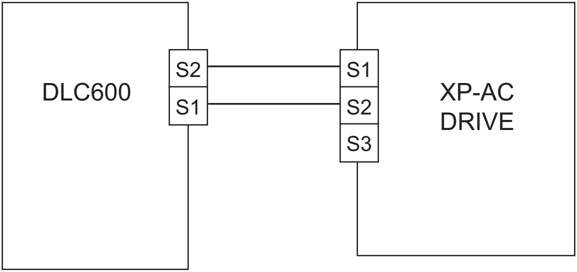


Figure 9. DLC600 connections to XP-AC drives

Inhibit operation

Short INH to common (C) to inhibit the DLC600. The DLC600 output will drop to the MIN trimpot setting. Remove the short to resume operation. An alternative is to connect a single-pole, single throw switch as shown in Figure 7 (page 21). Close the switch to inhibit; open the switch to resume operation.

Frequency output terminals

The DLC600 can be used as a signal source to control another DLC600 via SO502 terminals FO+ and FO-. SO502 is a two-terminal, cage-clamp terminal block on the printed circuit board. The frequency output available from these terminals is equal to 50% of the commanded speed.

Refer to page 52 for instructions on connecting two DLC600s in a leader-follower configuration. The leader DLC600 may drive only one DLC600 as a follower.

Calibration

> **Warning**
>
> Dangerous voltages exist on the drive and DLC600 when they are powered. When possible, disconnect the voltage input from the DLC600 before adjusting the trimpots. If the trimpots must be adjusted with power applied, use insulated tools and the appropriate personal protection equipment. BE ALERT. High voltages can cause serious or fatal injury.

All adjustments increase with CW rotation, and decrease with CCW rotation. Use a non-metallic screwdriver for calibration. Each trimpot is identified on the printed circuit board.

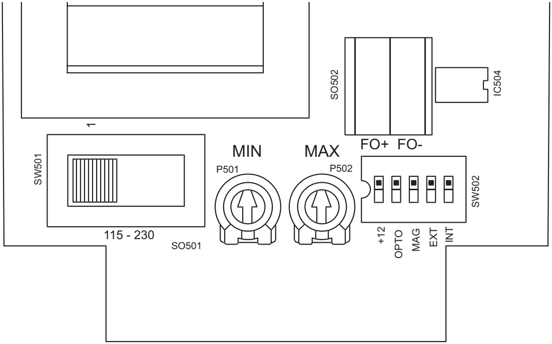


Figure 10. Calibration Trimpot Layout

Drive calibration

Calibrate the drive for use with the DLC600. The purpose is to optimize the response on the drive to the DLC600 signal and to minimize any tendency by the drive to independently attempt to regulate motor speed. The following are the drive’s trimpot settings:

Minimum speed: CCW (motor stopped)
Maximum speed: CW (maximum voltage setting)
Acceleration: CCW (fastest acceleration)
Deceleration: CCW (fastest deceleration)
IR COMP: CCW (minimum regulation)
Current Limit: 150% of motor current rating

DLC600 calibration procedure

> ⚠ **Warning**
>
> Dangerous voltages exist on the drive when it is powered. When possible, disconnect the voltage input from the drive before adjusting the trimpots. If the trimpots must be adjusted with power applied, use insulated tools and the appropriate personal protection equipment. BE ALERT. High voltages can cause serious or fatal injury.

DLC600 MIN OUT and MAX OUT trimpots are factory calibrated for Minarik MM20000-series drives. Recalibration may be necessary if a drive other than the MM20000 series is used.

DLC600 MIN and MAX trimpot adjustment

1. Set the MIN and MAX trimpots full CCW.

2. Set the motor speed to zero using the following steps:

   A. Press ENTER once. The most significant digit (the leftmost numeral) will blink.

   B. Use the UP and DOWN pushbutton to set this digit to zero.

   C. Press ENTER once. The second digit from the left will blink.

   D. Use the UP and DOWN pushbutton to set this digit to zero.

   E. Press ENTER once. The second digit from the right will blink.

   F. Use the UP and DOWN pushbutton to set this digit to zero.

   G. Press ENTER once. The least significant digit (the rightmost numeral) will blink.

   H. Use the UP and DOWN pushbutton to set this digit to zero.

   I. Press ENTER once to return to the operating mode.

3. Adjust the MIN trimpot CW until the motor shaft starts to rotate. Slowly adjust the MIN trimpot CCW until the motor just stops.

4. Set the DLC600 speed to 200% of maximum desired motor speed as outlined in step 2 above.

5. Adjust the MAX trimpot until the motor is running at 120% of desired motor speed.

6. Check that the MIN trimpot does not need to be readjusted after completing this procedure by repeating steps 2 and 3 as necessary.

Programming

Program parameters

Five parameters must be known before programming the DLC600. These parameters are speed scaling factor, load response, display scaling factor, gate time and decimal point location. All parameters except gate time must be programmed into the DLC600.

Speed scaling factor

The speed scaling factor (SSF) correlates the digital speed set at the DLC600 with the speed (in RPM) desired at the feedback shaft. The SSF equation is

$$\text{SSF} = \frac{(\text{speed entry})(3000)}{(\text{shaft RPM})(\text{PPR})}$$

where,

speed entry	=	speed programmed at the DLC600. This speed entry may be numerically different than the actual shaft RPM (for example, feet per minute, gallons per minute, inches per second, etc.)
shaft RPM	=	the speed (in RPM) of the shaft where the encoder is mounted.
PPR	=	the pulses per revolution generated by the encoder.

The SSF range is 3 through 9999, and the factory setting is 50.

Load response number

The load response number determines how fast the DLC600 responds to load changes. The higher the load response number, the faster the DLC600 will respond.

The load response number range is 0 through 99. The factory setting is 25.

Display scaling factor

The display scaling factor (DSF) correlates the speed displayed by the DLC600 with the speed at the feedback shaft. The DSF equation is:

$$\text{DSF} = \frac{(\text{speed display})(3000)}{(\text{shaft RPM})(\text{PPR})}$$

where,

speed display	=	speed displayed at the DLC600. This speed entry may be numerically different than the actual shaft RPM (for example, feet per minute, gallons per minute, inches per second, etc.)
shaft RPM	=	the speed (in RPM) of the shaft where the encoder is mounted.
PPR	=	the pulses per revolution generated by the encoder.

The DSF range is 3 through 9999, and the factory setting is 50.

Gate time

The display scaling factor determines the gate time (the time between successive display updates). The recommended gate time range is 0.5 – 3 sec. The gate time equation is shown below:

$$\text{gate time} = \frac{DSF}{50}$$

Decimal point location number

The decimal point location number fixes the decimal point within the DLC600 display. The DLC600 may be set for no decimal point, or for a decimal point in the tenths, hundredths, or thousandths position. The factory setting is for no decimal point.

DLC600 program parameters worksheet

1. Find the equation variables.

PPR = ____________

speed entry = ____________
Use any typical setpoint value used in your application. Units of measure are irrelevant for the speed entry, so you do not need to use the decimal point. For example, use 1254 if the speed entry is actually 1.254 meters per second or 12.54 liters per minute.

speed display = ____________
Enter the number you would like to see when the speed entry is entered as the setpoint. Just like the speed entry, do not use the decimal point.

shaft speed in RPM = ____________

2. Calculate the program parameters.

$$\textbf{SSF} = \frac{\text{(speed entry)(3000)}}{\text{(shaft RPM)(PPR)}} = \underline{\hspace{3cm}}$$

$$\textbf{DSF} = \frac{\text{(speed display)(3000)}}{\text{(shaft RPM)(PPR)}} = \underline{\hspace{3cm}}$$

$$\textbf{gate time} = \frac{\text{DSF}}{50} = \underline{\hspace{3cm}}$$

Note: Round off numbers to the nearest integer.

Entering the programming mode

Warning

Disconnect power to the drive and DLC600 prior to entering programming mode.

1. Press and hold the ENTER pushbutton (labeled **E**) while applying AC power to the DLC600 *only*. Do not apply power to the drive.

2. Release the ENTER pushbutton after AC power is applied.

You have entered the programming mode when the decimal point appears on the display in the lower right-hand corner. If no decimal points appear or if any number is flashing, remove AC power, then repeat steps 1 and 2.

Viewing the programming screens

The programming screens are identified by the position of the decimal point displayed: one decimal indicates speed scaling factor mode, two decimals indicates load response number mode, three decimals indicates display scaling factor mode, and four decimal points indicates decimal point location mode.

After entering the programming mode, press ENTER to scroll through the programming screens.

The DLC600 factory settings are:

Speed scaling factor = 50	Display: **0 0 5 0.**
Load response = 25	Display: **0 0 2.5**
Display scaling factor = 50	Display: **0 0.5 0**
Decimal point location: none	Display: **0.0 0 0**

Entering calculated program parameters

1. Press ENTER until the decimal point is displayed in the lower right corner (e.g., **1 2 3 4.**)

2. Press the up and down pushbuttons you reach the calculated speed scaling factor.

3. Press ENTER until the decimal point is displayed between the far right digit and the second digit from the right (e.g., **1 2 3.4**)

4. Press the up and down pushbuttons until you reach the desired load response number.

5. Press ENTER until the decimal point is displayed between the second and third digits from the right (e.g., **1 2.3 4**)

6. Press the up and down pushbuttons until you reach the calculated display scale factor.

7. Press ENTER until the decimal point is displayed between the first and second digits from the left (e.g., **1.2 3 4**)

8. Press the up and down pushbutton until the desired decimal location is displayed:

   0.000 = no decimal (i.e. **1 2 3 4**)
   0.001 = tenths (i.e. **1 2 3.4**)
   0.002 = hundredths (i.e. **1 2.3 4**)
   0.003 = thousandths (i.e. **1.2 3 4**)

Save the program settings and exit the programming mode

1. Press and hold the ENTER pushbutton.

2. Press the UP pushbutton to exit the program mode.

Repeat steps 1 and 2 if you are still in the programming mode. If a numeral is flashing, press ENTER repeatedly until all digits stop flashing.

Set the speed

1. Press ENTER once. The most significant digit will blink.
2. Use the up and down pushbuttons to set the desired value for this digit.
3. Press ENTER once. The second digit from the left will blink.
4. Use the up and down pushbuttons to set the desired value for this digit.
5. Press ENTER once. The third digit from the right will blink.
6. Use the up and down pushbuttons to set the desired value for this digit.
7. Press ENTER once. The least significant digit will blink.
8. Use the up and down pushbuttons to set the desired value for this digit.
9. Press ENTER once to return to the operating mode.
10. Remove power to the DLC600.

11. Reconnect the drive and apply power to the DLC600 and drive simultaneously.

12. The motor will accelerate to the set speed.

13. To change the set speed, repeat steps 1 through 9.

Programming Examples

Example 1

An application uses a 30 tooth magnetic pickup mounted on a motor shaft. The application requires that the motor speed and the display to be equal to the speed entry. Calculate the program parameters.

Solution:

PPR = 30

Speed entry = 100 (arbitrarily chosen)

Speed display = 100 (same as speed entry)

Shaft RPM = 100 (same as speed entry)

$$\textbf{SSF} = \frac{\text{(speed entry)(3000)}}{\text{(shaft RPM)(PPR)}} = \frac{(100)(3000)}{(100)(30)} = 100$$

$$\textbf{DSF} = \frac{\text{(speed display)(3000)}}{\text{(shaft RPM)(PPR)}} = \frac{(100)(3000)}{(100)(30)} = 100$$

$$\textbf{gate time} = \frac{\text{DSF}}{50} = \frac{100}{50} = 2 \text{ seconds}$$

Example 2

An application uses a 60 tooth magnetic pickup mounted on a motor shaft. The application requires that the motor speed and the display to be equal to the speed entry. Calculate the program parameters.

Solution:

PPR = 60

Speed entry = 100 (arbitrarily chosen)

Speed display = 100 (same as speed entry)

Shaft RPM = 100 (same as speed entry)

Using the equations for the program parameters:

$$\textbf{SSF} = \frac{\text{(speed entry)(3000)}}{\text{(shaft RPM)(PPR)}} = \frac{(100)(3000)}{(100)(60)} = 50$$

$$\textbf{DSF} = \frac{\text{(speed display)(3000)}}{\text{(shaft RPM)(PPR)}} = \frac{(100)(3000)}{(100)(60)} = 50$$

$$\textbf{gate time} = \frac{\text{DSF}}{50} = \frac{50}{50} = 1 \text{ second}$$

The PPR in this example is larger than the PPR in Example 1. Increasing the PPR *decreases* the speed scaling factor, display scaling factor, and the gate time.

Example 3

An application uses a 30 tooth magnetic pickup mounted on a motor shaft that is part of an exercise treadmill. The pulley is driving a belt that has a radius of 4 inches. The application requires the user to enter the speed in miles per hour, and the display to read in miles per hour. Calculate the program parameters.

Solution:

PPR = 30

Speed entry = 10 (for 10 miles per hour; arbitrarily chosen)

Speed display = 10 (display is the same as the speed entry)

Calculate the corresponding shaft speed (shaft RPM) by converting 10 miles per hour to RPM.

$$10 \frac{\text{mi}}{\text{hr}} = \frac{10\text{ mi}}{1\text{ hr}} \times \frac{5280\text{ ft}}{1\text{ mi}} \times \frac{12\text{ in}}{1\text{ ft}} \times \frac{1\text{ hr}}{60\text{ min}} \times \frac{1\text{ rev}}{2\pi(4)\text{ in}}$$

$$= 420.17 \frac{\text{rev}}{\text{min}} = 420.17\text{ RPM}$$

Note: $2\pi(4)$ = circumference of the pulley in inches.

$$\textbf{SSF} = \frac{(\text{speed entry})(3000)}{(\text{shaft RPM})(\text{PPR})} = \frac{(10)(3000)}{(420.17)(30)} = 2.379$$

Note: We must program in whole numbers. So, SSF = 2.

$$\textbf{DSF} = \frac{(\text{speed display})(3000)}{(\text{shaft RPM})(\text{PPR})} = \frac{(10)(3000)}{(420.17)(30)} = 2.379 \cong 2$$

$$\textbf{gate time} = \frac{DSF}{50} = \frac{2}{50} = 0.04 \text{ second}$$

The gate time is too small. You may introduce a decimal point on the display. The user could enter 100 which would appear as 10.0 miles per hour on the display. The speed entry and speed display numbers in the formula now become 100. Recalculating the parameters:

$$\textbf{SSF} = \frac{\text{(speed entry)(3000)}}{\text{(shaft RPM)(PPR)}} = \frac{(100)(3000)}{(420.17)(30)} = 23.79$$

Note: You must program in whole numbers. So, SSF = 24.

$$\textbf{DSF} = \frac{\text{(speed display)(3000)}}{\text{(shaft RPM)(PPR)}} = \frac{(100)(3000)}{(420.17)(30)} = 23.79 \cong 24$$

$$\textbf{gate time} = \frac{DSF}{50} = \frac{24}{50} = 0.48 \cong 0.5 \text{ sec.}$$

Adding a decimal point widens the input range (the range of settings from 0 to maximum), increases the gate time, and decreases the rounding error to the nearest digit in the first calculation of the SSF and DSF. The DLC600 has a gate time range of 0.5 – 3 seconds.

Example 4

An application uses a 30 tooth magnetic pickup mounted on the high speed shaft of a gear motor. The gear ratio is 40:1 and the high speed RPM is 1800. The user will enter the speed of the low speed shaft. The speed of the low speed shaft will show on the display. Calculate the program parameters.

Solution:

PPR = 30

Speed entry = 10 (for 10 RPM; arbitrarily chosen)

Speed display = 10 (same as speed entry)

Since the gear ratio is 40:1, the high speed shaft RPM is 400 RPM.

Using the equations for the program parameters:

$$\textbf{SSF} = \frac{\text{(speed entry)(3000)}}{\text{(shaft RPM)(PPR)}} = \frac{(10)(3000)}{(400)(30)} = 2.5$$

$$\textbf{DSF} = \frac{\text{(speed display)(3000)}}{\text{(shaft RPM)(PPR)}} = \frac{(10)(3000)}{(400)(30)} = 2.5$$

$$\textbf{gate time} = \frac{\text{DSF}}{50} = \frac{2.5}{50} = 0.05 \text{ seconds}$$

The gate time is not within the DLC600 range of 0.5 – 3 seconds.. There is also a significant error (20%) in rounding 2.5 to 3. Introduce a decimal point and recalculate the program parameters. Since the user will enter 10.0 for 10 RPM, the speed entry is now 100. The speed display is also 100.

Recalculating the program parameters:

$$\textbf{SSF} = \frac{\text{(speed entry)(3000)}}{\text{(shaft RPM)(PPR)}} = \frac{(100)(3000)}{(400)(30)} = 25$$

$$\textbf{DSF} = \frac{\text{(speed display)(3000)}}{\text{(shaft RPM)(PPR)}} = \frac{(100)(3000)}{(400)(30)} = 25$$

$$\textbf{gate time} = \frac{\text{DSF}}{50} = \frac{25}{50} = 0.5 \text{ seconds}$$

This is much more acceptable. Note that there is no error due to rounding here because the SSF and DSF came out to be whole numbers.

Leader-follower applications

The DLC600 can be used to follow an external frequency for leader-follower applications. The external frequency must be a 5 VDC CMOS logic-level signal or open-collector NPN transistor. The external frequency must be within the range of 10 – 3000 Hz for correct operation.

The product of the external frequency and the set speed on the DLC600 must not exceed 500 kHz. This will limit the speed set value to 5000 or less (500,000/10 = 50,000; however, the DLC600 only uses 4 digits. Thus, the maximum is 5000).

The display can be set to read the speed ratio, actual speed in RPM or a process value (such as feet per second or gallons per minute). Values of 100 and 1000 have the advantage of being easily read as a ratio or percentage of the leader.

To select external reference, set DIP switch 4 of SW502 to ON and DIP switch 5 to OFF. Refer to Figure 6 (page 18).

Connect a leader encoder to the DLC600's Fin, + and C terminals as shown in Figure 11 (page 49). Ensure that the encoder is mounted to the shaft of the leader motor.

Leader-Follower example using leader encoder

In this example, a DLC600 controls a follower motor at 100% of the leader motor's speed; that is, the follower and leader operate at the same speed in RPM. An external reference frequency to the DLC600 is generated by an encoder attached to the leader motor shaft. The DLC600 will follow this frequency input.

Assume that the following conditions exist:

- The leader motor's maximum speed is 1800 RPM.
- The encoder attached to the leader motor shaft has a resolution of 60 lines.
- The gear monitored by the magnetic pickup has 30 teeth.

NOTE: For this example, if the set speed is 100, the motor will follow at 100% of the leader motor speed. If the set speed is 50, the motor will follow at 50% of the leader motor speed. The DLC600 will display the follower speed in RPM.

First, calculate the leader frequency (FR) using the following formula:

$$FR = \frac{RPM}{60} \times PPR$$

where
RPM is the maximum speed of the leader motor in revolutions per minute
PPR is the number of encoder lines per revolution

Thus,

$$FR = \frac{RPM}{60} \text{ X } PPR$$

$$FR = \frac{1800}{60} \text{ X } 60 = 1800$$

The leader frequency is 1800 Hz.

Next, calculate the motor feedback frequency (FM) using the following formula:

$$FM = \frac{RPM}{60} \text{ X } PPR$$

where
RPM is the maximum follower magnetic pickup speed in revolutions per minute.
PPR is the number of magnetic pickup pulses per revolution.

Thus,

$$FM = \frac{RPM}{60} \text{ X } PPR$$

$$FM = \frac{1800}{60} \text{ X } 30 = 900$$

The motor feedback frequency is 900 Hz.

Having derived the value of FR and FM for the SSF formula, you can now calculate the speed scale factor.

Calculate the scale speed factor (SSF)

Program the speed scale factor (SSF) per the following formula:

$$SSF = \frac{FR \text{ X (set speed)}}{FM}$$

where,

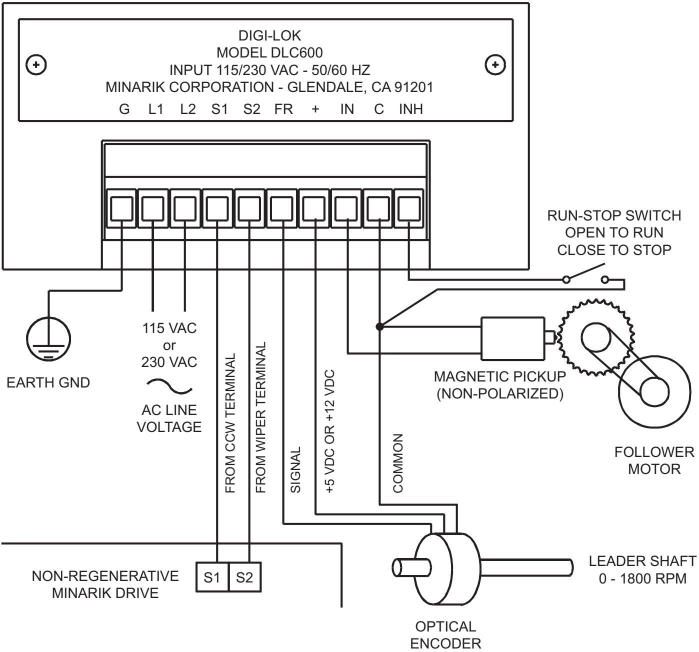
FR	=	leader frequency (Hz)
FM	=	follower feedback frequency (Hz).
Set speed	=	desired leader/follower speed ratio, expressed as a percentage. Since you want the leader and follower to operate at the same speed in this example, the set speed value is 100.

Thus,

$$SSF = \frac{FR \text{ X (set speed)}}{FM}$$

$$SSF = \frac{1800 \text{ X } 100}{900} = 200$$

The speed scale factor is 200.



REFER TO THE INSTALLATION SECTION FOR INFORMATION ON CONNECTING TO XP-AC SERIES OR REGENERATIVE MINARIK DRIVES.

Figure 11. Leader/Follower Application Using Leader Encoder

Leader-follower application using two DLC600s

> **NOTE:** The DLC600 may drive only one follower using this method.
>
> **NOTE:** The product of the external frequency and the set speed on the follower DLC600 must not exceed 500 kHz.

The DLC600 can be used as a signal source to control another DLC600 via SO502 terminals FO+ and FO-. SO502 is a two-terminal, cage-clamp terminal block on the PCB.

A worksheet has been provided on page 56 to help you calculate the required parameters.

Set the follower DLC600 for external reference

The follower DLC600 must be set for an external reference signal. Set DIP switch 4 of SW502 to ON and DIP switch 5 to OFF. Refer to Figure 6 (page 18).

Leader-follower connections

Use 28 - 14 AWG wire to connect the leader and follower DLC600s. Connect SO502 terminal FO- on the leader DLC600 to the C terminal on the follower DLC600. Connect SO502 terminal FO+ on the leader DLC600 to the FR IN terminal on the follower DLC600. Refer to Figure 12 (page 52) for a connection diagram.

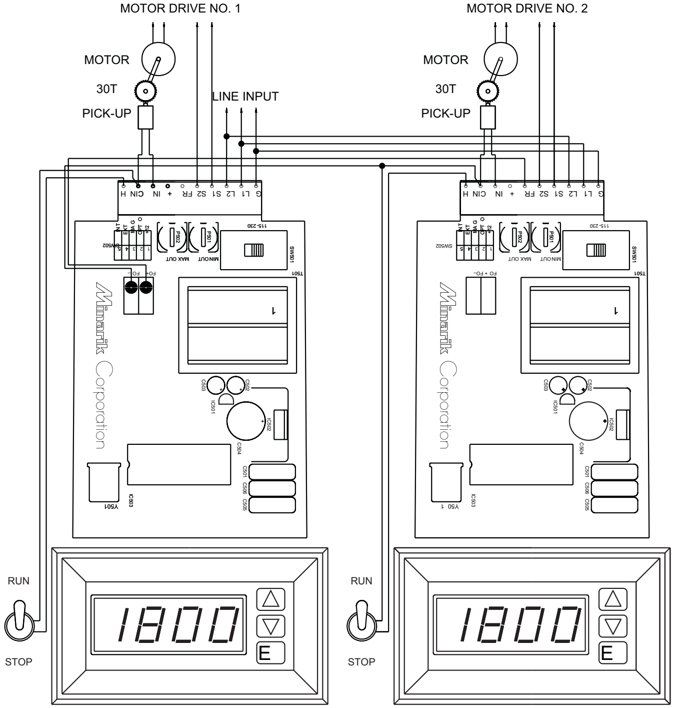
If the leads are longer than 12 inches (30 cm), Minarik recommends that you use shielded leads. If shielding is not practical, you should twist all logic leads with themselves to minimize induced noise.

Programming the leader

Program the leader DLC600 to reflect the following conditions. Refer to page 30 for instructions on programming the DLC600.

1. Set the speed scale factor to 100. Although the speed scale factor may be set to any value, the frequency output via FO+ and FO- is always the equivalent of 50% of set speed. Thus, setting the speed scale factor to 100 makes it easier to monitor the signal sent to the follower DLC600.

2. Set the display scale factor to 100. Like the speed scale factor, the display scale factor may be set to any value; however, a setting of 100 makes it easier to monitor the system.



LEADER
(RPM)

1800 SET SPEED = 1800 RPM
SSF = 100
DSF = 100

FOLLOWER NO. 1
SET IN PERCENT/DISPLAY IN RPM

100 SET SPEED = 1800 RPM
SSF = 50
DSF = 100

Figure 12. Leader-Follower Connection Diagram Using Two DLC600s

Programming the follower

Program the follower DLC600 as follows.

1. Calculate the follower reference frequency (Fr) using the following formula:

$$\textbf{Fr} = \frac{25 \text{ X SET SPEED}}{\text{SSF}}$$

where,

SET SPEED = leader motor speed in RPM, and

SSF = speed scale factor of the leader DLC600

In this example, assume the set speed is 1800 RPM. The leader SSF in this example is 100.

Thus,

$$\textbf{Fr} = \frac{25 \text{ X SET SPEED}}{\text{SSF}}$$

$$\textbf{Fr} = \frac{25 \text{ X } 1800}{100} = 450$$

The reference frequency is 450 Hz.

2. Next, calculate the follower motor feedback frequency (Fm) using the following formula:

$$\textbf{Fm} = \frac{\text{RPM}}{60} \text{ X PPR}$$

where,
RPM = follower motor speed in RPM, and

PPR = follower transducer pulses per revolution

As noted earlier, assume the motor speed is 1800 RPM. The follower transducer PPR in this example is 30.

Thus,

$$\textbf{Fm} = \frac{RPM}{60} \times PPR$$

$$\textbf{Fm} = \frac{1800}{60} \times 30 = 900$$

The follower motor feedback frequency is 900 Hz.

3. Calculate the speed scale factor using the following formula.

$$\textbf{SSF} = \frac{Fr \times SET\ SPEED}{Fm}$$

where,

Fr = reference frequency input at Fin & COM terminals of follower.
Set speed = follower speed as a percentage of leader speed
Fm = frequency of motor feedback pulses

Using the earlier calculations in this example, Fr = 450 Hz, set speed = 100% and Fm = 900 Hz. Calculate the speed scale factor as follows:

$$\textbf{SSF} = \frac{\text{FOUT X SET SPEED}}{\text{Fm}}$$

$$\textbf{SSF} = \frac{450 \text{ X } 100}{900} = 50$$

The speed scale factor is 50. Enter this value on the follower DLC600 speed scale factor programming screen.

4. Minarik recommends you set the follower display scale factor to 100. Although you can set the DSF to whatever value you desire, setting it to 100 removes the need to correlate the DSF value with system speed.

5. Enter the follower speed setting as a percentage of the leader DLC600 speed. For example, if you want the follower to run at the same speed as the leader, the speed setting would be 100. You would enter 50 to run the follower at 50% of the leader, 33 to run at 33%, etc. Refer to page 37 for instructions on entering the set speed.

DLC600 leader-follower worksheet

1. Find the equation variables.

Leader speed scale factor = ____________

Leader frequency output (Fr) = ____________

Do not use the decimal point.

Leader set speed = ____________

Do not use the decimal point. For example, use 1254 if the speed entry is actually 1.254 meters per second or 12.54 liters per minute.

Follower feedback PPR = ____________

Follower motor feedback frequency (Fm) = ____________

Follower speed scale factor = ____________

2. Calculate the program parameters for the follower DLC600.

$$\textbf{Fr} = \frac{\text{25 X SET SPEED}}{\text{LEADER SSF}}$$

$$\textbf{Fm} = \frac{\text{RPM}}{60} \text{ X PPR}$$

$$\textbf{SSF} = \frac{\text{Fr X FOLLOWER SET SPEED}}{\text{Fm}}$$

Note: Round off numbers to the nearest integer.

Troubleshooting

> **Warning**
>
> Dangerous voltages exist on the drive and DLC600 when they are powered. When possible, disconnect the voltage input from the DLC600 before troubleshooting. BE ALERT. High voltages can cause serious or fatal injury.

Check the following steps before proceeding:

1. The AC line voltage must be connected to the proper terminals.
2. Check that the voltage switches and jumpers are set correctly.
3. The motor must be rated for the drive's rated armature voltage and current.
4. Check that all terminal block connections are correct.

For additional assistance, contact your local Minarik distributor, or the factory direct:
1-800-MINARIK (646-2745) or Fax: 1-800-394-6334

The motor will not run

1. The connections from the DLC600 to the drive, and from the drive to the motor, may not be wired correctly. Check the connections from the DLC600 to the drive, and from the drive to the motor.

2. The drive may be defective. Disconnect the DLC600 from the drive. Connect a speed adjust potentiometer to the drive, and check if the motor runs properly.

3. The motor may be defective. Test the system with another motor.

The motor will not lock into speed

1. The load response number may be too low (if the oscillation is gradual) or too high (if the oscillation is very rapid).

2. The drive may be incorrectly calibrated. Check that the acceleration, deceleration, and IR COMP trimpot settings are at their minimum settings.

3. If a magnetic pickup is used, extensive runout may cause an interruption in the feedback pulse train. Check that the pickup's sensing tip is directly over the center of the gear teeth. The gap between the sensing tip and the gear tip should be no greater than 0.010 inch.

4. Electrical noise may cause the DLC600 to attempt corrections that are not justified. Check the continuity and shielding of the pickup leads.

5. Rapid shifts in load may be pulling the motor out of its set speed. Consider using a regenerative drive with the DLC600.

The motor is running at a fixed difference below set speed

1. There may be a 60 Hz signal riding on the pickup leads. Check that the pickup leads are run in their own conduit and that all connections are secure. For long paths, these leads must be shielded, and properly grounded at the DLC600 end.

The motor runs at top speeds regardless of the set speed

1. There may be an electromechanical defect in the pickup or sensor, or a break in the pickup or sensor leads. Check that the pickup or sensor is working properly, and that there are no breaks in the pickup or sensor leads.

2. The pickup may not be properly aligned over the gear, causing inaccurate feedback information. Check the alignment of the pickup over the gear.

3. Verify that the drive's common terminal is connected to the DLC600's S1 terminal.

4. The control may be defective. Replace the DLC600 with a speed adjust potentiometer and check whether the motor runs properly.

Notes

Notes

Unconditional Warranty

A. Warranty

Minarik Corporation (referred to as "the Corporation") warrants that its products will be free from defects in workmanship and material for twelve (12) months or 3,000 hours, whichever comes first, from date of manufacture thereof. Within this warranty period, the Corporation will repair or replace, at its sole discretion, such products that are returned to Minarik Corporation, 901 East Thompson Avenue, Glendale, CA 91201-2011 USA.

This warranty applies only to standard catalog products, and does not apply to specials. Any returns for special controls will be evaluated on a case-by-case basis. The Corporation is not responsible for removal, installation, or any other incidental expenses incurred in shipping the product to and from the repair point.

B. Disclaimer

The provisions of Paragraph A are the Corporation's sole obligation and exclude all other warranties of merchantability for use, express or implied. The Corporation further disclaims any responsibility whatsoever to the customer or to any other person for injury to the person or damage or loss of property of value caused by any product that has been subject to misuse, negligence, or accident, or misapplied or modified by unauthorized persons or improperly installed.

C. Limitations of Liability

In the event of any claim for breach of any of the Corporation's obligations, whether express or implied, and particularly of any other claim or breech of warranty contained in Paragraph A, or of any other warranties, express or implied, or claim of liability that might, despite Paragraph B, be decided against the Corporation by lawful authority, the Corporation shall under no circumstances be liable for any consequential damages, losses, or expense arising in connection with the use of, or inability to use, the Corporation's product for any purpose whatsoever.

An adjustment made under warranty does not void the warranty, nor does it imply an extension of the original 12-month warranty period. Products serviced and/or parts replaced on a no-charge basis during the warranty period carry the unexpired portion of the original warranty only.

If for any reason any of the foregoing provisions shall be ineffective, the Corporation's liability for damages arising out of its manufacture or sale of equipment, or use thereof, whether such liability is based on warranty, contract, negligence, strict liability in tort, or otherwise, shall not in any event exceed the full purchase price of such equipment.

Any action against the Corporation based upon any liability or obligation arising hereunder or under any law applicable to the sale of equipment or the use thereof, must be commenced within one year after the cause of such action arises.

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