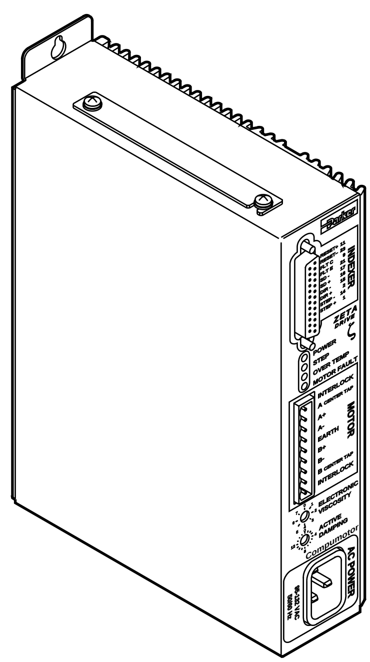
Compumotor

ZETA Drive

Installation Guide



Compumotor Division
Parker Hannifin Corporation
p/n 88-014027-01 A

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IMPORTANT

User Information

To ensure that the equipment described in this user guide, as well as all the equipment connected to and used with it, operates satisfactorily and safely, all applicable local and national codes that apply to installing and operating the equipment must be followed. Since codes can vary geographically and can change with time, it is the user's responsibility to identify and comply with the applicable standards and codes. **WARNING:** ***Failure to comply with applicable codes and standards can result in damage to equipment and/or serious injury to personnel.***

Personnel who are to install and operate the equipment should study this user guide and all referenced documentation prior to installation and/or operation of the equipment.

In no event will the provider of the equipment be liable for any incidental, consequential, or special damages of any kind or nature whatsoever, including but not limited to lost profits arising from or in any way connected with the use of this user guide or the equipment.

Technical Assistance

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CHAPTER ONE

Introduction

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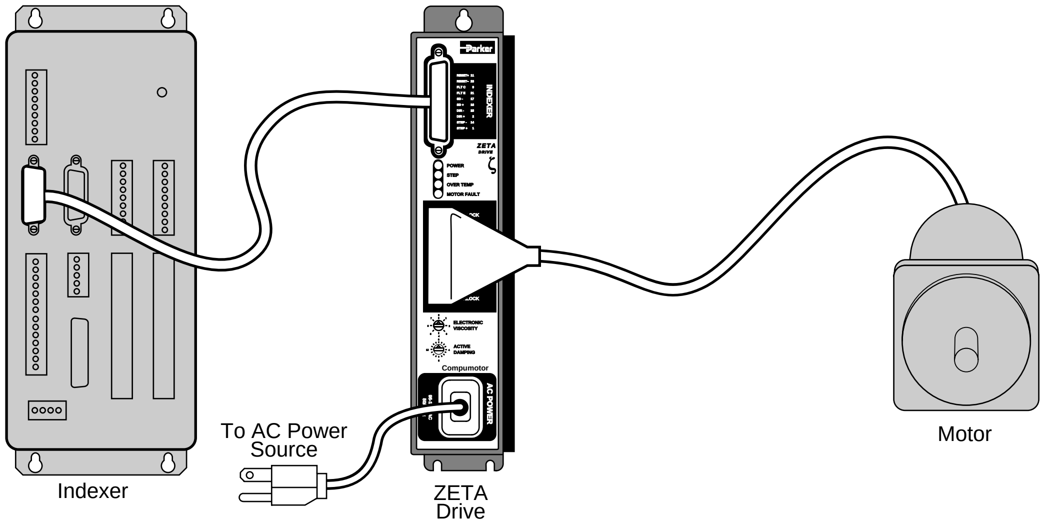
- ZETA Drive Description
- Anti-Resonance
- Active Damping
- Electronic Viscosity

ZETA DRIVE – DESCRIPTION

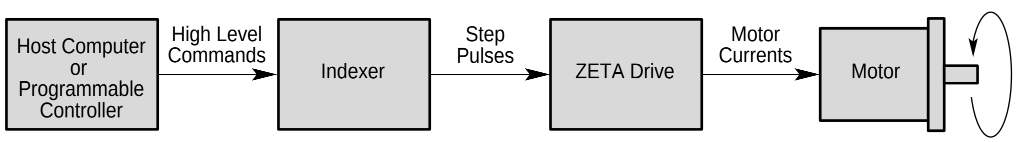
The ZETA Drive is a microstepping drive that runs two-phase step motors. It operates directly from 120VAC power; no separate DC power supply or transformer is required.

A typical system is shown below.



System Components

The indexer sends step and direction signals to the drive. For each step pulse it receives, the drive will commutate the motor to increment rotor position. This is shown in the next drawing.



Block Diagram of ZETA System

The host computer or programmable controller may or may not be necessary, depending upon the indexer's capabilities.

The motor can be wired in series or parallel; the amount of current the drive sends to the motor is set by DIP switches.

DIP SWITCHES

DIP switches are located on top of the ZETA drive, behind a removable metal cover. During the installation procedure, the user sets these DIP switches to scale the drive for motor current, resolution, waveform, and other functions.

Input & Output

All communications with the indexer take place through the ZETA Drive's 25-pin D-connector. Available inputs and outputs are:

- ❑ Step Input
- ❑ Direction Input
- ❑ Shutdown Input
- ❑ Fault Output
- ❑ Reset Input
- ❑ Clockwise/Counterclockwise Input

Potentiometers

Three potentiometers are located on top of the ZETA Drive, next to the DIP switches. The potentiometers are used to adjust the drive's electrical characteristics to match the motor's individual characteristics.

Damping Technologies in the ZETA Drive

All step motors are subject to resonance, and to ringing after quick transient moves. The ZETA Drive has three unique circuits that can damp resonance and ringing.

Anti-Resonance

This is a general purpose damping circuit that works automatically. No configuration is necessary. Anti-resonance provides aggressive and effective damping.

Active Damping

This is an extremely powerful damping circuit. The user sets four DIP switches and one rotary switch on the drive, to optimize active damping for a specific motor and load.

Anti-resonance and active damping work at speeds greater than three revolutions per second.

Electronic Viscosity (EV)

This circuit provides damping at speeds from rest up to three revolutions per second. The user sets one rotary switch on the drive, to optimize EV for a particular application. EV can reduce settling time at the end of a move, which can lead to increased machine throughput.

The ZETA Name – ζ

In the equation that describes the transfer function of a step motor, the Greek symbol ζ (zeta) is used to represent the damping ratio. Because our drive has such sophisticated and unique damping capabilities, we decided to name it the *ZETA Drive*.

ZETA MOTORS

ZETA Series motors are available from Compumotor for use with the ZETA Drive. These motors are designed to match the drive's high performance capabilities.

COMPUMOTOR FAMILY OF PRODUCTS

The ZETA Drive is completely compatible with Compumotor's broad range of microstepper indexers (single-axis and multi-axis) and motion control products.

CHAPTER TWO

Installation

IN THIS CHAPTER

- ❏ Product Ship Kit List
- ❏ Quick Test
- ❏ Motor Selection and Wiring
- ❏ Drive Configuration – DIP Switches, I/O, Potentiometers
- ❏ Mounting the Drive and Motor; Attaching the Load
- ❏ Testing the Installation
- ❏ Active Damping and Electronic Viscosity – Configuration

WHAT YOU SHOULD HAVE *(SHIP KIT)*

If you ordered a ZETA *Drive Only* (no motor), you should have:

Part	Part Number
ZETA Drive	ZETA4
Power Cable – 6.6 feet (2.0 M) in length	44-014768-01
Motor Connector – 9 pin	43-008755-01
ZETA Drive Installation Guide	88-014027-01

If you ordered a ZETA *System* (drive and motor), you should receive all of the above, plus one of the following ZETA Motors:

Part	Part Number	
ZETA Motor	ZETA57-51	ZETA83-62
	ZETA57-83	ZETA83-93
	ZETA57-102	ZETA83-135

The motor has a permanently attached cable, 10 feet (3 m) long. The motor connector is wired to the cable at the factory.

PRECAUTIONS

To prevent injuries to personnel and damage to equipment, observe the following guidelines:

- Never probe the drive. Hazardous voltages are present within the drive.
- Never open the drive. Opening the drive will void the warranty.
- Never increase the current setting to a value greater than that specified for the motor you are using. Excessive current may cause motor overheating and failure.

INSTALLATION OVERVIEW

Topics in this chapter are arranged to lead you through the installation process in a step–by–step manner. Complete each step before proceeding to the next.

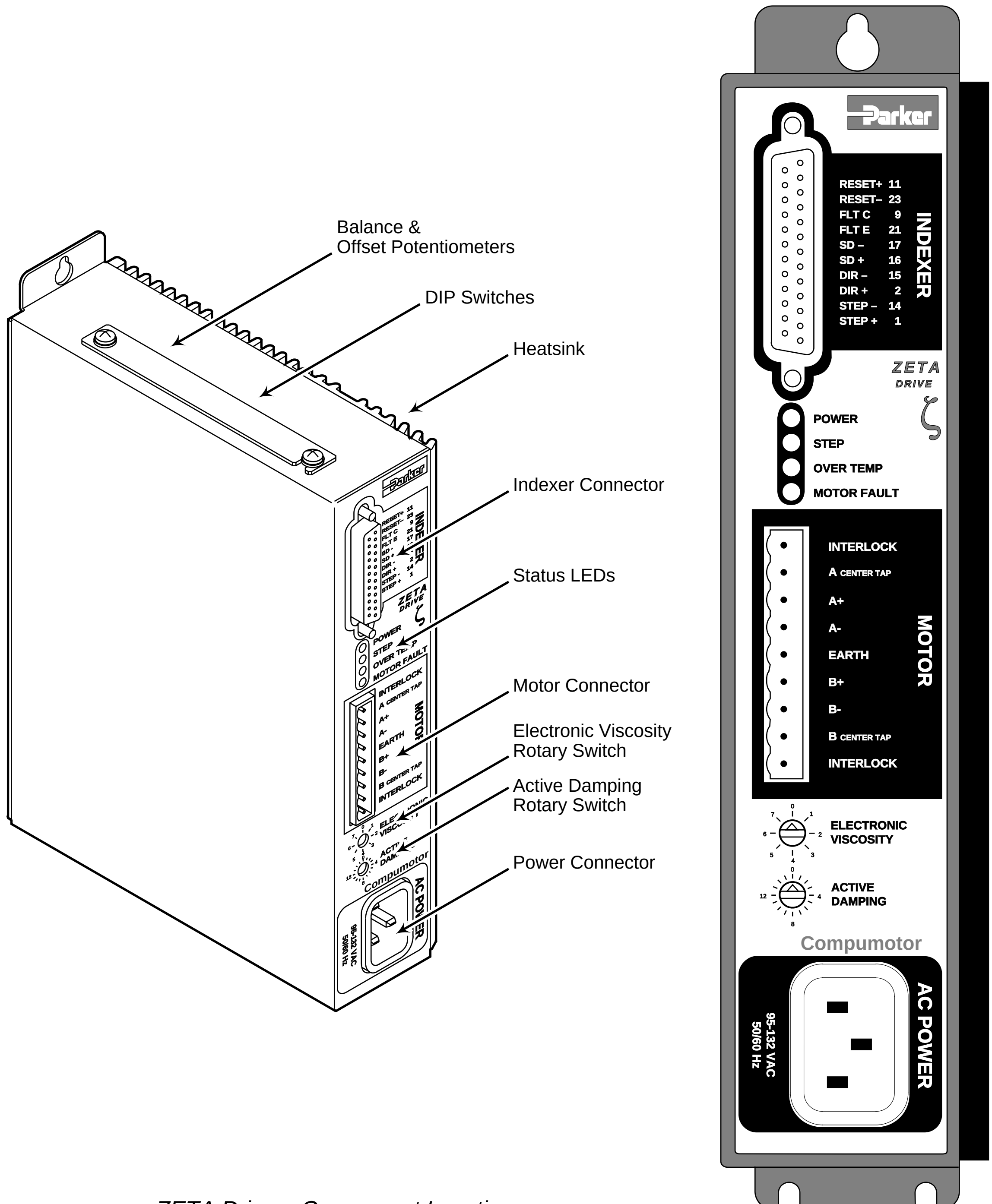
The order of topics in the installation procedure is:

- Quick Test
- Motor selection, specifications, and speed/torque curves
- Motor wiring—series vs. parallel
- DIP switch configuration
- Indexer connections and 25 pin D-connector input/output schematic
- Drive/Motor matching procedure
- Drive mounting
- Motor mounting
- Connecting the load
- Connecting AC power
- Testing the installation
- Resonance, ringing, and damping – discussion and theory
- Active Damping and Anti-Resonance configuration
- Electronic Viscosity configuration

INSTALLATION PROCEDURE

In the following installation procedure, we assume you are using a ZETA Motor with your ZETA drive. If you are using a non-Compumotor motor, consult the *Appendix* at the end of this user guide for information you may need during the following installation steps.

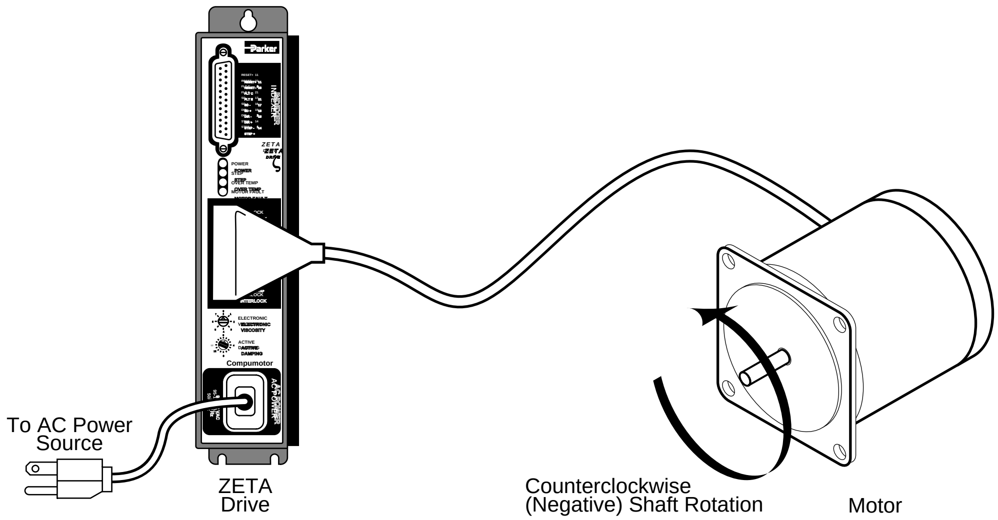
The next drawing shows locations and names of the various connectors, switches, etc., that you will encounter during the installation procedure.



ZETA Drive – Component Locations

QUICK TEST

Follow this procedure to have your ZETA drive perform its *automatic test* function. Once you set DIP switches, connect the motor, and connect AC power, the automatic test will begin—the motor shaft will turn in the counterclockwise direction until you remove power. This will verify that the drive, motor, and motor cable work properly as a system.

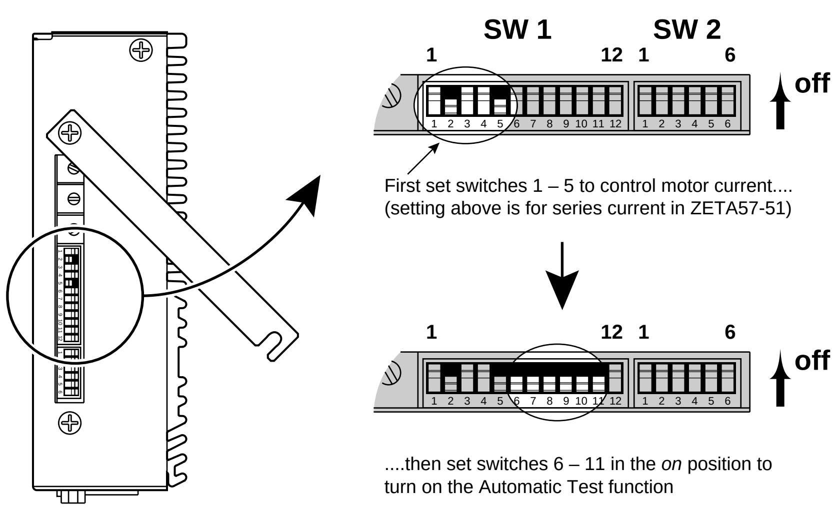


Quick Test Setup

This is a *bench top* procedure—as the drawing shows, you can perform it before you connect an indexer, mount the drive, or mount the motor. Full installation instructions follow this section.

① SET DIP SWITCHES FOR **Series** Motor Current

A 12-position and a 6-position DIP switch are located on top of the ZETA drive, behind a cover. Move the cover to access the switches. Before you change them, make note of the DIP switch settings. You will restore the switches to their original settings at the end of this procedure.



DIP Switch Location

Set DIP switches SW1-#1 — SW1-#5 for *series* current for your ZETA motor, according to the following table. ZETA motors ship from the factory with their connectors wired for series current.

Motor Size	Current	SW1-#1	SW1-#2	SW1-#3	SW1-#4	SW1-#5
ZETA57-51	1.26A	off	on	off	off	on
ZETA57-83	1.51 A	off	on	off	on	on
ZETA57-102	1.76 A	off	on	on	off	on
ZETA83-62	2.26 A	on	off	off	off	on
ZETA83-93	2.88 A	on	off	on	on	off
ZETA83-135	3.50 A	on	on	off	on	on

Using a Non-Compumotor Motor?: see the ***Appendix*** at the end of this user guide

Later in this chapter, we will give information about parallel motor current. If you configure your system for parallel operation, and then wish to repeat this automatic test, you may do so—the test will work with the drive configured for either series or parallel current.

② Set DIP Switches for the **Automatic Test** Function

Set DIP switches SW1-#6 through SW1-#11 to the *on* position. This switch combination selects the automatic test function.

③ Connect the Motor

Plug your ZETA motor cable's 9-pin connector into the drive's **MOTOR** connector. For safety, always observe the following two warnings:

WARNING

POWER MUST BE OFF when you connect or disconnect the motor connector. Lethal voltages are present on the screw terminals!

WARNING

You must ground the motor case. Large potentials can develop at the motor case that can create a lethal shock hazard if the motor case is not grounded.

The case of a ZETA motor will automatically be grounded when you plug the cable's 9-pin connector into the ZETA drive.

④ Connect AC Power

The ZETA drive does not have an ON/OFF switch. When you connect power, the automatic test will begin—the drive will turn on and the motor will start turning. Therefore, before you apply power to the ZETA drive:

- ❏ Properly secure the motor.
- ❏ Do not attach a load to the motor shaft.

To apply power, plug one end of the power cable into the drive. Plug the other end into a grounded 120VAC power source.

⑤ Observe the Automatic Test

Your ZETA Drive should now be running in the automatic test mode.

- ❏ The motor shaft should rotate at approximately one revolution per second (1 rps) in the counterclockwise (negative) direction, until you remove power.
- ❏ LED Operation – observe the LEDs on the front panel:

  POWER LED should illuminate

  STEP LED should alternately flash red and green

  OVER TEMP LED and **MOTOR FAULT** LED should not illuminate

⑥ Stop the Automatic Test

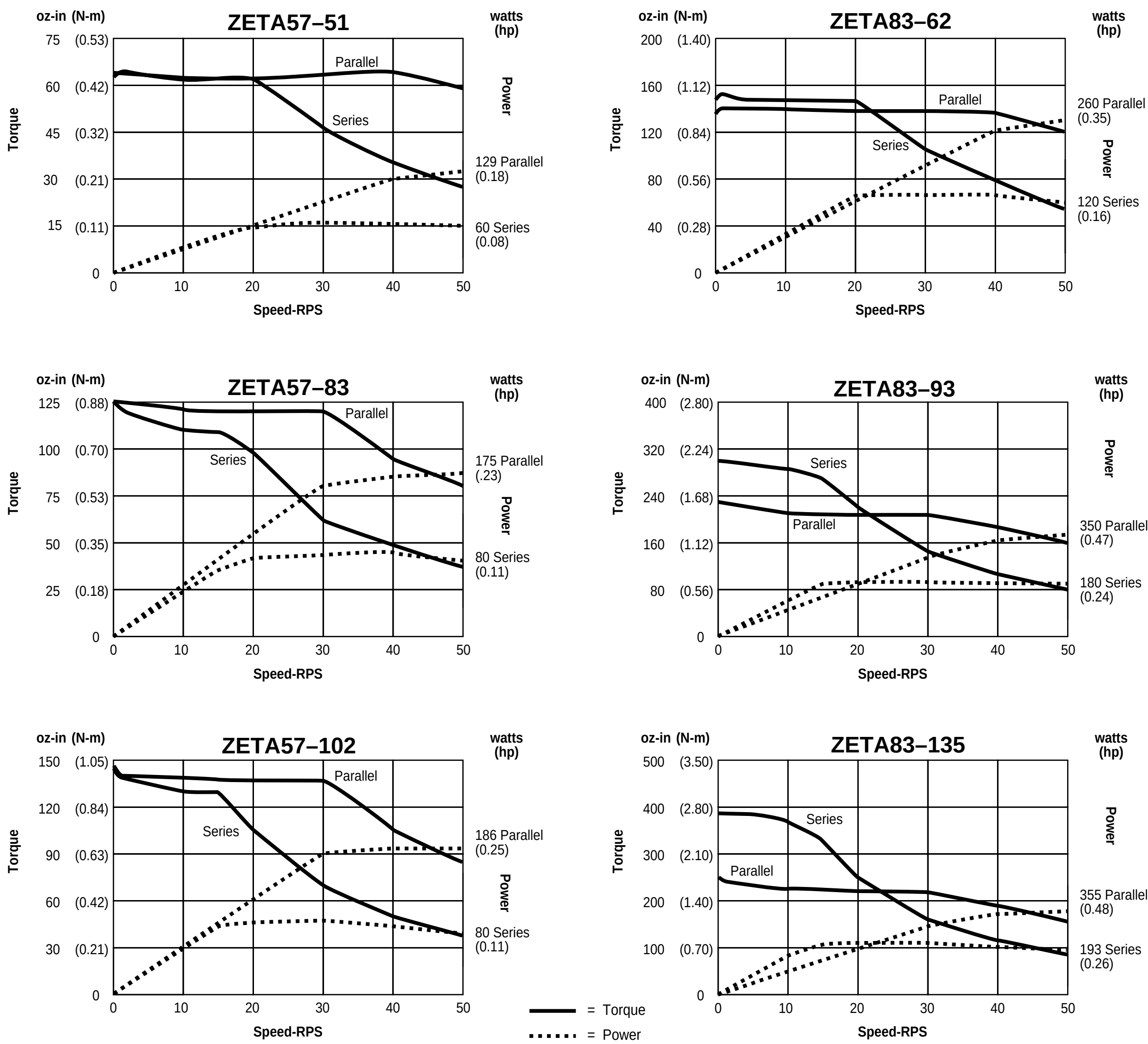
Disconnect power to stop the motor. Set DIP switches 6 – 11 to *off*, or to their original settings. Return other DIP switches to their original settings.

The procedures in the rest of this chapter will lead you through the steps required to permanently install your ZETA Drive and motor.

1 – SELECT A MOTOR

We recommend that you use a ZETA motor with your ZETA drive. Because the ZETA motor's materials, design, and construction are matched to the drive's high performance capabilities, the ZETA motor will operate more efficiently than other motors. Furthermore, the drive's special features—anti-resonance, active damping, and electronic viscosity—were optimized to work best with ZETA motors. These features will be most effective if you use a ZETA motor.

There are six ZETA motors. Speed/Torque curves, specifications, and motor dimensions for ZETA motors are shown below.



ZETA Motors – Speed/Torque Curves

Motor Specifications

		Size 23			Size 34		
		ZETA57-51	ZETA57-83	ZETA57-102	ZETA83-62	ZETA83-93	ZETA83-135
Static torque							
oz-in		65	100	125	160	300	400
(N-m)		(0.46)	(0.71)	(0.89)	(1.14)	(2.14)	(2.80)
Rotor inertia							
$oz\text{-}in^2$		0.546	1.1	1.69	3.47	6.76	10.47
($kg\text{-}m^2 \times 10^{-6}$)		(9.998)	(20.1)	(30.9)	(63.4)	(124)	(191)
Inductance							
Series	mH (small signal*)	17.37	18.5	17	10	10.5	9.2
	mH (large signal**)	26.3	26.86	24.6	14.44	15.54	13.89
Parallel	mH (small signal*)	4.34	4.62	4.25	2.5	2.62	2.3
	mH (large signal**)	6.57	6.71	6.15	3.61	3.88	3.47
Bearings							
Thrust load	lb	25	25	25	50	50	50
	(kg)	(11.3)	(11.3)	(11.3)	(22.6)	(22.6)	(22.6)
Radial load	lb	15	15	15	25	25	25
	(kg)	(6.8)	(6.8)	(6.8)	(11.3)	(11.3)	(11.3)
End play	in	0.005	0.005	0.005	0.005	0.005	0.005
Reversing load Equal to 1 lb	(cm)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
Radial play	in	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008
Per 0.5 lb load	(cm)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Weight (net)							
Motor+Cable	lb	1.6	2.4	3.2	3.8	5.1	8.3
+Connector	(kg)	(0.7)	(1.1)	(1.5)	(1.7)	(2.3)	(3.8)
Motor Cable							
Wire size	AWG	24	24	24	22	22	22
	(mm^2)	(0.25)	(0.25)	(0.25)	(0.34)	(0.34)	(0.34)
All motors:	Cable length = 10 feet (3 m); attached connector is prewired for series current;						

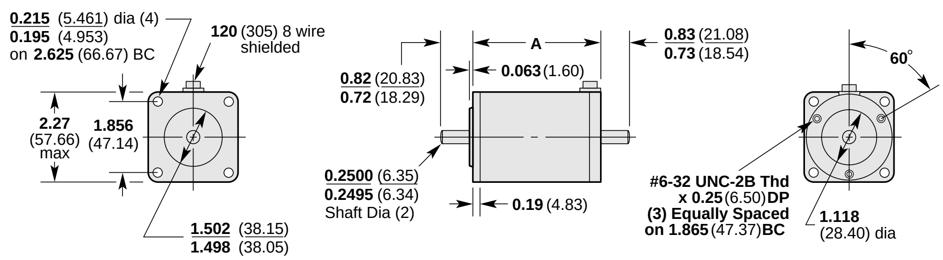
*Small Signal Inductance is found by using an inductance bridge or meter.

**Large Signal Inductance is found by measuring actual generator AC flux linkage and generator short circuit current under dynamic conditions.

Motor Dimensions

Size 23 frame

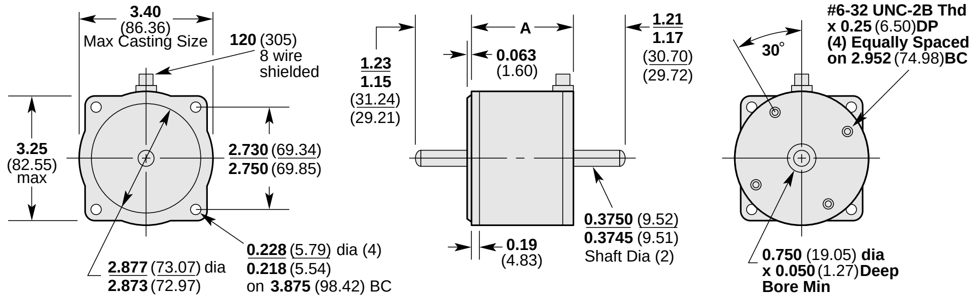
Model	A
ZETA57-51	2.0 (50.23)
ZETA57-83	3.1 (75.23)
ZETA57-102	4.0 (101.6)



ZETA Motors – Frame Size 23 Dimensions

Size 34 frame

Model	A
ZETA83-62	2.5 (62.0)
ZETA83-93	3.7 (93.98)
ZETA83-135	5.2 (129.0)



ZETA Motors – Frame Size 34 Dimensions

2 – CHOOSE SERIES OR PARALLEL MOTOR WIRING

The ZETA motor's windings—phase A and phase B—are *bifilar* windings made from double-stranded copper wire. Each phase has two half-windings, which can be wired together in series or parallel.

These two alternatives—series and parallel—produce different speed/torque characteristics, affect the motor's current rating, and alter the motor's operating temperature. They are explained below.

INTERLOCK TERMINALS

The interlock terminals on the motor connector comprise a safety feature that protects the motor connector. The drive checks for continuity between the interlock terminals. A jumper on the connector provides this continuity; the jumper must be in place, or the drive will not operate. If the connector is removed when the drive is running, continuity between the interlock terminals is broken. The drive considers this a fault: it illuminates the **MOTOR FAULT** LED, and turns off power to the motor.

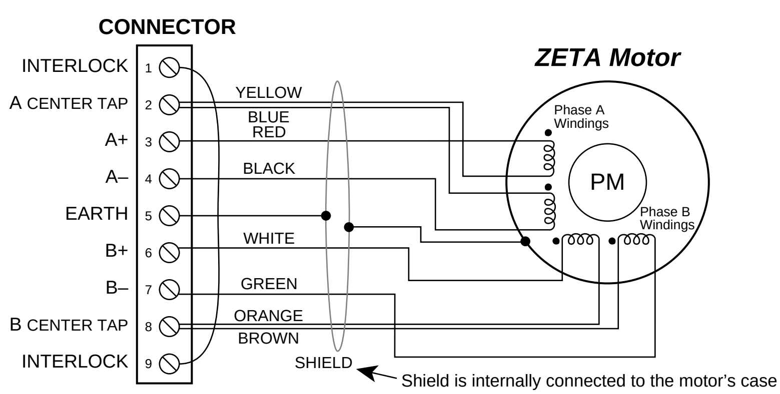
Do not extend the interlock jumper wire beyond the connector. The interlock circuit is designed to work with a *very short* jumper. Longer wires may change the electrical characteristics of the circuit, making it more susceptible to noise. Therefore, do not use a long jumper.

GROUND THE MOTOR CASE

The motor case must be grounded, for safety purposes. You can connect the ZETA motor case to the AC power ground simply by plugging in the motor cable. At the factory, one end of the cable shield is permanently wired to the motor case; the other end connects to **EARTH** on the drive's motor connector. Inside the drive, **EARTH** connects directly to the ground pin on the AC power connector. Thus, plugging in the motor cable will connect the ZETA motor case to the AC power ground.

SERIES WIRING

The ZETA motor comes with a permanently attached motor cable. It's connector is prewired for *series* motor current, as shown in the next drawing. For series operation, use the motor as it comes from the factory.



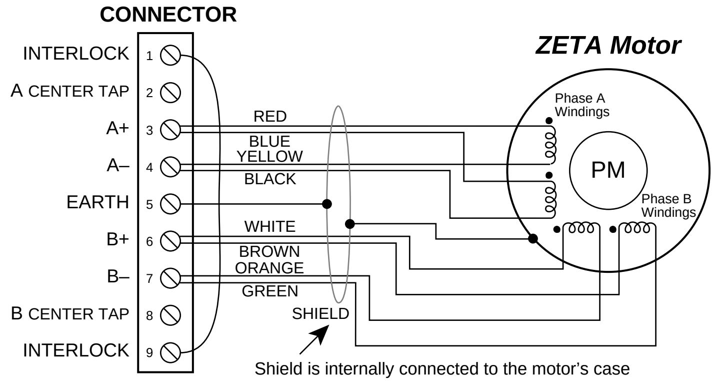
*Motor Connector – Wired for **SERIES** Motor Current*

The center tap pins are not connected to electronics inside the drive. They serve only as convenient terminals where you can connect together wires from two half-windings.

The operating temperature of a motor connected in series will be lower than that of a motor connected in parallel. Therefore, you should operate your motor in series, if your application permits. Typically, series connections work well in high torque/low speed applications.

Parallel Wiring

For parallel motor current, you must rewire the connector. Pull back the rubber boot that covers the connector, and attach wires from the motor cable according to the following diagram.



*Motor Connector – Wired for **PARALLEL** Motor Current*

At higher speeds, a motor connected in parallel will produce more torque than the same motor connected in series. However, the operating temperature of the motor in parallel will be much higher.

If you operate your motor in parallel, you must measure motor temperature under actual operating conditions. If the motor exceeds its maximum case temperature, reduce the duty cycle, or use automatic standby to reduce current at rest, or use forced air cooling to limit motor heating. ZETA motors have maximum case temperatures of 100°C (212°F).

CAUTION

High current in parallel connected motors may cause motor overheating. You may need to reduce the duty cycle to 50% to decrease motor temperature, or use automatic standby.

Series versus Parallel – Summary

To help you decide between series or parallel motor connections, the following list summarizes the points discussed above.

① Examine the speed/torque curves for your motor.
② Use series connection, if possible. (The motor will run cooler.)
③ Use parallel connection, if you need more torque than series connection provides. (Typically, at higher speeds.)
④ Parallel connection will cause the motor to run hotter, so measure motor temperature under operating conditions.
⑤ If necessary, reduce duty cycle or use forced air cooling to keep motor temperature within acceptable limits.

Precautions

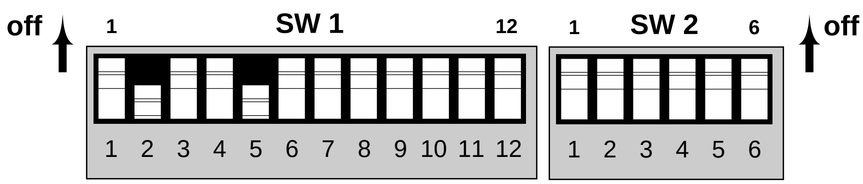
Follow these precautions when you wire the motor connector.

① Turn off power to the drive before connecting or disconnecting the motor connector.
② Verify that no wire whiskers short out motor connections.
③ Do not apply power to the drive when the motor is not connected.
④ Never extend the interlock jumper beyond the motor connector.
⑤ Never connect anything other than the motor to the motor terminals.
⑥ After wiring the motor connector, perform the Automatic Test, to verify that the connector is wired correctly.

3 – SET DIP SWITCHES

Configure the ZETA drive's DIP switches for your motor and application. The drive's 18 DIP switches are located behind the movable metal cover on top of the drive. Switch 1 (SW1) is a 12-position switch; Switch 2 (SW2) is a 6-position switch. The table below summarizes switch settings.

ZETA DIP SWITCH SETTINGS



CURRENT (amps)

S = series
P = parallel

Motor	Amps	1	2	3	4	5
	0.14	off	off	off	off	off
	0.26	off	off	off	off	on
	0.39	off	off	off	on	off
	0.51	off	off	off	on	on
	0.64	off	off	on	off	off
	0.76	off	off	on	off	on
	0.89	off	off	on	on	off
	1.01	off	off	on	on	on
	1.14	off	on	off	off	off
ZETA57-51**S**	1.26	off	on	off	off	on
	1.38	off	on	off	on	off
ZETA57-83**S**	1.51	off	on	off	on	on
	1.63	off	on	on	off	off
ZETA57-102**S**	1.76	off	on	on	off	on
	1.88	off	on	on	on	off
	2.01	off	on	on	on	on
	2.14	on	off	off	off	off
ZETA83-62**S**	2.26	on	off	off	off	on
ZETA57-51**P**	2.38	on	off	off	on	off
	2.51	on	off	off	on	on
	2.63	on	off	on	off	off
	2.76	on	off	on	off	on
ZETA83-93**S**	2.88	on	off	on	on	off
	3.01	on	off	on	on	on
ZETA57-83**P**	3.13	on	on	off	off	off
	3.26	on	on	off	off	on
ZETA57-102**P**	3.38	on	on	off	on	off
	3.50	on	on	off	on	on
ZETA83-135**S**	3.63	on	on	on	off	off
	3.75	on	on	on	off	on
	3.88	on	on	on	on	off
ZETA83-xx**P**[1]	4.00	on	on	on	on	on

RESOLUTION[2]
(steps per revolution)

	Steps	6	7	8	9
	50,800 steps	off	off	off	on
	50,000 steps	off	off	on	off
	36,000 steps	off	off	on	on
	25,600 steps	off	on	off	off
	25,400 steps	off	on	off	on
Default Setting	**25,000 steps**	**off**	**off**	**off**	**off**
	21,600 steps	off	on	on	off
	20,000 steps	off	on	on	on
	18,000 steps	on	off	off	off
	12,800 steps	on	off	off	on
	10,000 steps	on	off	on	off
	5,000 steps	on	off	on	on
	2,000 steps	on	on	off	off
	1,000 steps	on	on	off	on
	400 steps	on	on	on	off
	200 steps	on	on	on	on

WAVEFORM[2]

	Waveform	10	11
Default Setting	**-4% 3rd harmonic**	**off**	**off**
	-10% 3rd harmonic	off	on
	-6% 3rd harmonic	on	off
	Pure sine	on	on

AUTOMATIC TEST[2]

6	7	8	9	10	11
on	on	on	on	on	on

S&D/CW&CCW[2]

Mode	12
Step & Direction Indexer	off
Clockwise & Counterclockwise Indexer	on

STATIC TORQUE[3]

5	6	Torque Range N-m	Torque Range oz-in	ZETA Motor:
off	off	0.26 – 0.72	36 – 100	57-51, 57-83
off	on	0.73 – 1.41	101 – 200	57-102, 83-62
on	off	1.42 – 2.33	201 – 330	83-93, 83-135**P**
on	on	2.34 – 3.48	331 – 492	83-135**S**

INDUCTANCE[3]

3	4	Inductance Range (mH)	ZETA Motor:
off	off	20.08 & greater	57-51**S**, 57-83**S**, 57-102**S**
off	on	10.31 – 20.07	83-62**S**, 83-93**S**, 83-135**S**
on	off	5.03 – 10.30	57-51**P**, 57-83**P**, 57-102**P**
on	on	less than 5.02	83-62**P**, 83-93**P**, 83-135**P**

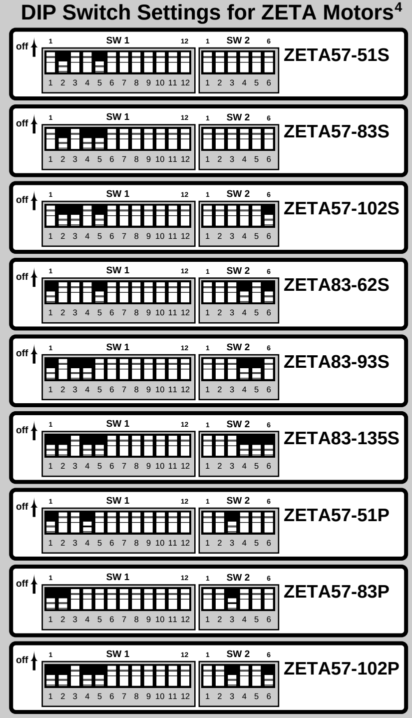
ANTI-RESONANCE DISABLE

2	
off	Anti-res. Enabled
on	Anti-res. Disabled

AUTOMATIC STANDBY

1	
off	Full Current
on	50% Current Standby

DIP Switch Settings for ZETA Motors[4]



1. ZETA83-xxP can be ZETA83-62P, ZETA83-93P, or ZETA83-135P
2. The drive reads these switches only upon power up. It reads all other switches continuously.
3. These switches are read only by active damping circuit; they are ignored if active damping is off.
4. At 25,000 steps/rev, -4%, S&D, anti-res. enabled, auto standby off. 83 motors in parallel not shown.

Motor Part Number Suffix: **S** = Series Configuration **P** = Parallel Configuration

Default Settings

If you ordered a ZETA *drive only*, the factory default position is *off* for all switches. If you ordered a ZETA *system* (drive and motor), the DIP switches were set at the factory for your particular motor, wired in series.

Motor Current

Set DIP switches SW1-#1 — SW1-#5 for motor current. Verify that your connector wiring and motor current rating match the series or parallel current you set with these five switches.

Drive Resolution

Set DIP switches SW1-#6 — SW1-#9 for drive resolution. There are sixteen settings, which range from 200 to 50,800 steps per revolution. The default setting is 25,000 steps per revolution.

Be sure to set your indexer to the same resolution as your ZETA drive. If the indexer resolution and drive resolution do not match, commanded accelerations and velocities will not be properly scaled.

Waveform

Set SW1-#10 and SW1-#11 to select a current waveform. There are four choices: one is a pure sine wave; the other three reduce the current waveform's 3rd harmonic by 4%, 6%, or 10%. In most applications, the default setting (*both switches off = -4% 3rd harmonic*) provides the best performance. For further information about selecting a waveform, see the section *Match the Drive to the Motor* later in this chapter.

NOTE: If you choose 200 steps/rev for resolution, select any waveform *except* pure sine. SW1-#6 — SW1-#11, when all *on*, do not select 200 steps/rev and pure sine—they select the automatic test (see below).

Automatic Test

DIP switches SW1-#6 — SW1-#11 have a double function. As mentioned earlier in *Quick Test*, they select the Automatic Test function when they are all *on*. For any other setting, they select resolution and waveform.

Step & Direction/CW & CCW

SW1-#12 should be *off* if you use a step & direction indexer. All Compumotor indexers are step and direction indexers.

If you use a clockwise/counterclockwise (CW & CCW) indexer, turn this switch *on*.

Automatic Standby

The *automatic standby* function allows the motor to cool when it is not moving. Automatic standby reduces motor current by 50% if the drive does not receive a step pulse for one second. Full current is restored upon the first step pulse that the drive receives. Be aware that reduced current results in reduced holding torque.

SW2-#1 should be *off* if you do not use automatic standby. Turn this switch *on* to use automatic standby. If you use position maintenance, we recommend that you do not use automatic standby.

Anti-Resonance Disable

SW2-#2 should be *off* for the anti-resonance circuit to be enabled. Normally, you will want anti-resonance enabled; therefore, this switch should be off. If you must disable anti-resonance, turn SW2-#2 *on*.

NOTE: If active damping is enabled via the rotary switch on the front of the drive, anti-resonance is automatically disabled, regardless of the setting of SW2-#2. See *Damping in the ZETA Drive* later in this chapter for an explanation.

Inductance

The active damping circuit reads SW2-#3 and SW2-#4 to determine motor inductance. Set these switches according to your motor's *large-signal* inductance. The table shows the large-signal inductance range that corresponds to each of the four settings.

Small-signal inductance is the value read on an ordinary inductance bridge or meter. Large signal inductance is found by measuring the actual generator AC flux linkage and generator short circuit current under dynamic conditions.

If you only have the small-signal inductance value available, use the formula below to approximate large-signal inductance:

$$\textit{small signal inductance} * 1.5 \approx \textit{large signal inductance}$$

NOTE: If active damping is off, switches SW2-#3 and SW2-#4 are ignored by the drive, and are inactive.

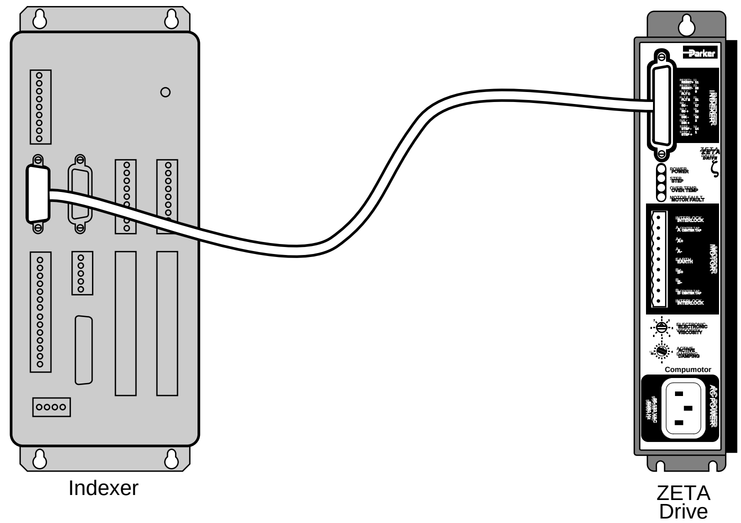
Static Torque

The active damping circuit reads SW2-#5 and SW2-#6 to determine the motor's static torque. Set these switches according to your motor; the table shows the range of static torque that corresponds to each of the four settings.

NOTE: If active damping is off, switches SW2-#5 and SW2-#6 are ignored by the drive, and are inactive.

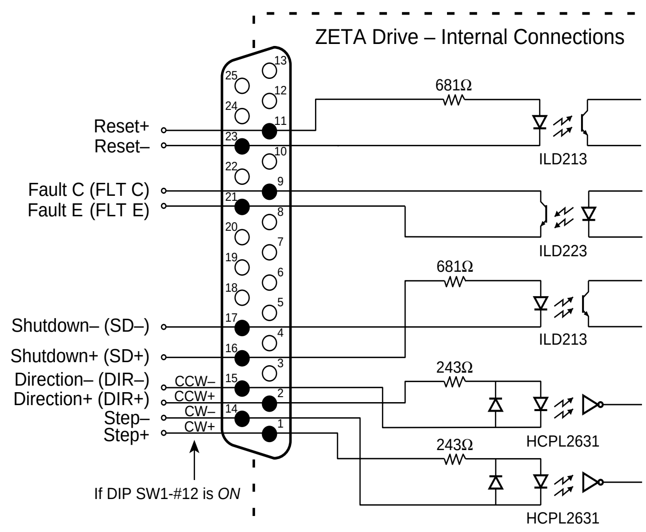
4 – Connect an Indexer – Inputs & Outputs

Connect your indexer cable to the ZETA drive's **INDEXER** connector, a 25 pin D-connector on the front of the drive. The cable that comes with Compumotor indexers is prewired for compatibility with the ZETA drive—you can plug the cable directly into the ZETA drive's indexer connector.



Connecting a Compumotor Indexer

If you make your own cable, or use a non-Compumotor indexer, consult the drawing below when you wire your cable and connector.



25 Pin D-Connector

Descriptions of each function on the 25 pin D-connector follow.

Step Input

For every step pulse it receives on its step input, the drive will commutate the motor to increment rotor position. To send a step pulse to the drive, apply a positive voltage to **STEP+** with respect to **STEP–**. The drive registers the pulse on the rising edge.

The input is optically isolated. It may also be differentially driven.

Step input specifications are:

Input Current:	6.5 mA	minimum	
	15 mA	maximum	
Input Voltage:	3.5V	minimum	(min. required for *on* or *high* signal)
	5.2V	maximum*	
Step Pulse:	200 nanosecond minimum pulse width		
	200 nanosecond minimum off time		
	2 MHz	maximum pulse rate	
Optically Isolated:	Yes		

*As a custom product, Compumotor can modify drive for higher input voltage

DIRECTION INPUT (DIR+ & DIR-)

While a positive voltage is applied to **DIR+** with respect to **DIR–**, the drive will commutate the motor in the clockwise (positive) direction as it receives step pulses on its step input.

While zero voltage (or a negative voltage) is applied to **DIR+** with respect to **DIR–**, the drive will commutate the motor in the counterclockwise (negative) direction as it receives step pulses.

The input is optically isolated. It may also be differentially driven.

Direction input specifications are:

Input Current:	6.5 mA	minimum	
	15 mA	maximum	
Input Voltage:	3.5V	minimum	(min. required for *on* or *high* signal)
	5.2V	maximum*	
Optically Isolated:	Yes		
Direction Change:	Direction input may change polarity coincident with first step pulse.		

*As a custom product, Compumotor can modify drive for higher input voltage

CLOCKWISE AND COUNTERCLOCKWISE (CW & CCW)

You can convert the ZETA drive's step and direction inputs into clockwise and counterclockwise inputs, for use with a CW/CCW indexer. To do so, set DIP Switch 1 – #12 to the *ON* position. The following changes result:

Pin #	SW1–#12 *OFF*	SW1–#12 *ON*	
1	Step+	Clockwise+	(CW+)
14	Step–	Clockwise–	(CW–)
2	Direction+	Counterclockwise+	(CCW+)
15	Direction–	Counterclockwise–	(CCW–)

Input specifications are the same as those listed above under *Step Input* and *Direction Input*. Each positive voltage pulse applied to **CW+** with respect to **CW–** causes the drive to commutate the motor and increment rotor position in the *clockwise* direction. Each positive voltage pulse applied to **CCW+** with respect to **CCW–** causes the drive to commutate the motor and increment rotor position in the *negative* direction.

SHUTDOWN INPUT (SD+ & SD-)

You can use the shutdown input to *shutdown*, or disable, the ZETA drive. To activate shutdown, apply a positive voltage to **SD+** with respect to **SD–** when the motor is not moving. During shutdown, the drive turns off current to the motor. The current stays off as long as the voltage is maintained on the shutdown input.

When you remove the voltage on the input, shutdown ends. The drive restores current to the motor, in the same phase relationship that existed before shutdown was invoked.

The shutdown input may also be differentially driven. Specifications are:

Input Current:	2.5 mA	minimum	
	30 mA	maximum	
Input Voltage:	3.5V	minimum	(min. required for *on* or *high* signal)
	13V	maximum	
	5V	maximum reverse voltage	
Active Level:	While voltage is applied, current to motor is shut down. When voltage is removed, normal operations resume.		
Time:	250 nanosecond minimum width		
Optically Isolated:	Yes		

FAULT OUTPUT (FLT C & FLT E)

The ZETA drive can signal, through its fault output, that it has detected a fault. Internally, the terminals **FLT C** and **FLT E** connect to the open collector and open emitter, respectively, of an optically isolated transistor. The transistor acts like a switch: it conducts when the drive is functioning normally; it does not conduct when any of the following conditions exist.

- ❏ No power is applied to the drive
- ❏ AC line voltage is too low (less than 95VAC)
- ❏ Drive temperature is higher than 55°C (131°F)
- ❏ Drive detects a short circuit in motor or motor cable
- ❏ Motor is not connected
- ❏ Continuity between interlock terminals is broken
- ❏ Shutdown input is active

Fault output specifications are:

V_{CE}:	30VDC
V_{CESAT}:	1 VDC
Collector Current:	40 mA minimum
Dissipation:	40 mW maximum
Optically Isolated:	Yes

RESET INPUT

The reset input provides a means for you to reset the ZETA drive, without actually cycling power. To activate the reset input, apply a positive voltage to **RESET+** with respect to **RESET–** when the motor is not moving. The reset will not be complete until 0.7 seconds after the voltage is removed. A reset has the same effect on the drive as cycling power:

- ❏ DIP switch settings are loaded into the drive for configuration.
- ❏ Existing faults are cleared.
- ❏ Current to the motor is turned off while voltage is applied to the reset input.
- ❏ After voltage is removed from the reset input, the drive's soft start procedure will ramp current up to the startup state. The motor will move to the nearest pole position.
- ❏ After voltage is removed from the reset input, there will be a 0.7 second delay before reset is complete, and normal operations can continue.

Reset input specifications are:

Input Current:	2.5 mA	minimum	
	30 mA	maximum	
Input Voltage:	3.5V	minimum	(min. required for *on* or *high* signal)
	13V	maximum	
	5V	maximum reverse voltage	
Reset Voltage Pulse:	250 nanosecond minimum pulse width		
Active Level:	While voltage is applied, reset occurs. When voltage is removed, normal operations resume.		
Reset Delay:	0.7 second delay until reset is complete, after voltage is removed from input.		
Optically Isolated:	Yes		

5 – MATCH THE DRIVE TO THE MOTOR

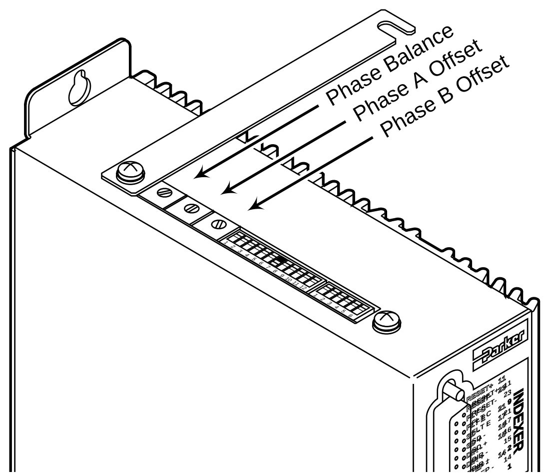
Due to slight manufacturing variations, each motor has its own particular characteristics. In the procedure below, you will adjust three potentiometers (*pots*), to match your ZETA drive to your specific motor. You will also select the best current waveform to use with your motor.

If you purchased a ZETA *system* (drive and motor together), your drive and motor were matched to each other at the factory, with the motor configured for series current. If you operate the motor with parallel current, you should perform the matching procedure below.

Even if you operate the motor with series current, we recommend that you perform the matching procedure, because your operating conditions—temperature, line voltage, etc.—may not be the same as factory conditions.

If you purchased a ZETA *drive only*, no matching was done at the factory. You should perform the following procedure.

The ZETA drive's pots are located behind the removable metal cover on top of the drive.



Potentiometer (Pot) Locations

The single turn potentiometers control the following functions:

- ❏ Phase B Offset: Controls the DC offset of Phase B motor current
- ❏ Phase A Offset: Controls the DC offset of Phase A motor current
- ❏ Phase Balance: Adjusts the magnitude of Phase B with respect to Phase A

The procedure below is a *bench top* procedure—the drive, motor, and indexer should be temporarily connected together, but not yet permanently mounted. Apply AC power when necessary to perform the steps below.

Properly secure the motor. This procedure will be easier to perform if you do not attach the load to the motor shaft. The load is not required, because the characteristics you are matching are those only of the drive/motor combination.

Matching Procedure

① Apply power to the drive, and allow it to reach a stable operating temperature. This will take at least two minutes, and may take up to 30 minutes. For optimum results, perform the matching procedure at the same ambient temperature at which your application will operate.

② For each of the adjustments that follow, consult the table below to find the speed at which to run the motor. These are speeds that cause *resonance* in the unloaded motor. When the motor is running at a resonant speed, you will notice increased noise and vibration. To make resonance the most noticeable, you may need to vary the speed around the value given below for your motor. You can find the resonant speed by touching the motor lightly with your fingertips as you vary the speed. When you feel the strongest vibrations, the motor is running at resonant speed.

Motor	Offset Adjust (rps)	Balance Adjust (rps)	Waveform Adjust (rps)
ZETA57-51	4.72	2.36	1.18
ZETA57-83	4.66	2.33	1.17
ZETA57-102	4.12	2.06	1.03
ZETA83-62	2.96	1.48	0.74
ZETA83-93	2.96	1.48	0.74
ZETA83-135	2.89	1.45	0.73

③ Run your motor at the resonant speed listed in the *Offset Adjust* column. Vary the speed slightly until you find the resonance point.

④ Adjust the Phase A Offset and Phase B Offset pots for minimum motor vibration and smoothest operation. Alternate between Phase A and Phase B to find the minimum vibration point.

⑤ Run your motor at the resonant speed listed in the *Balance Adjust* column. Vary the speed slightly until you find the resonance point.

⑥ Adjust the Phase Balance pot until you find the setting that provides minimum motor vibration and smoothest operation.

⑦ Repeat steps 3 – 6.

⑧ Run the motor at the resonant speed listed in the *Waveform Adjust* column. Vary the speed slightly until you find the resonance point.

⑨ Choose the current waveform that provides minimum motor vibrations and smoothest operation at the speed you selected in step 8. To find the best waveform, compare motor performance as you select different waveforms using DIP switches SW1-#10 and SW1-#11.

Waveform	SW1-#10	SW1-#11	
-4% 3rd harmonic	off	off	Default from factory
-10% 3rd harmonic	off	on	
-6% 3rd harmonic	on	off	
Pure sine	on	on	Do not use with 200 step/rev resolution

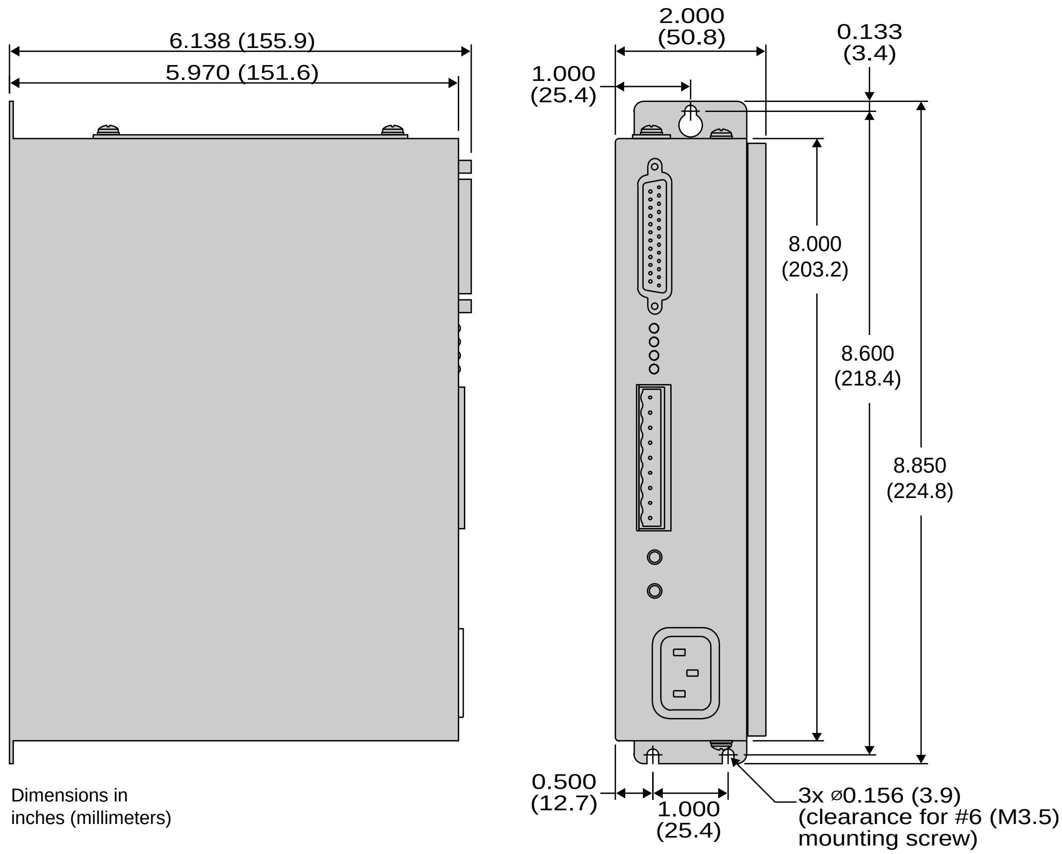
The drive reads these DIP switches only upon power up or reset. Therefore, you must cycle power or reset the drive each time you change the DIP switch settings.

⑩ Disconnect AC power to turn off the drive. Replace the cover over the pots and DIP switches. This completes the matching procedure.

Proceed to the next section to mount the drive and motor.

6 – Mount the Drive

Dimensions of the ZETA drive are shown below.



ZETA Drive Dimensions

Environmental Considerations

Temperature Specifications

Maximum Ambient Temperature:	50°C	(122°F)
Minimum Ambient Temperature:	0°C	(32°F)
Overtemperature Shutdown Fault:	55°C	(131°F)

The ZETA drive has an internal temperature sensor, located near the heatsink. If the sensor reaches 55°C (131°F), it will trigger an overtemperature fault, and the drive will shut down.

Fan Cooling

Operating the ZETA drive in high ambient temperatures may require fan cooling to keep the drive from shutting down due to an overtemperature fault.

Humidity

Keep the relative humidity below 95%, non-condensing.

Liquids

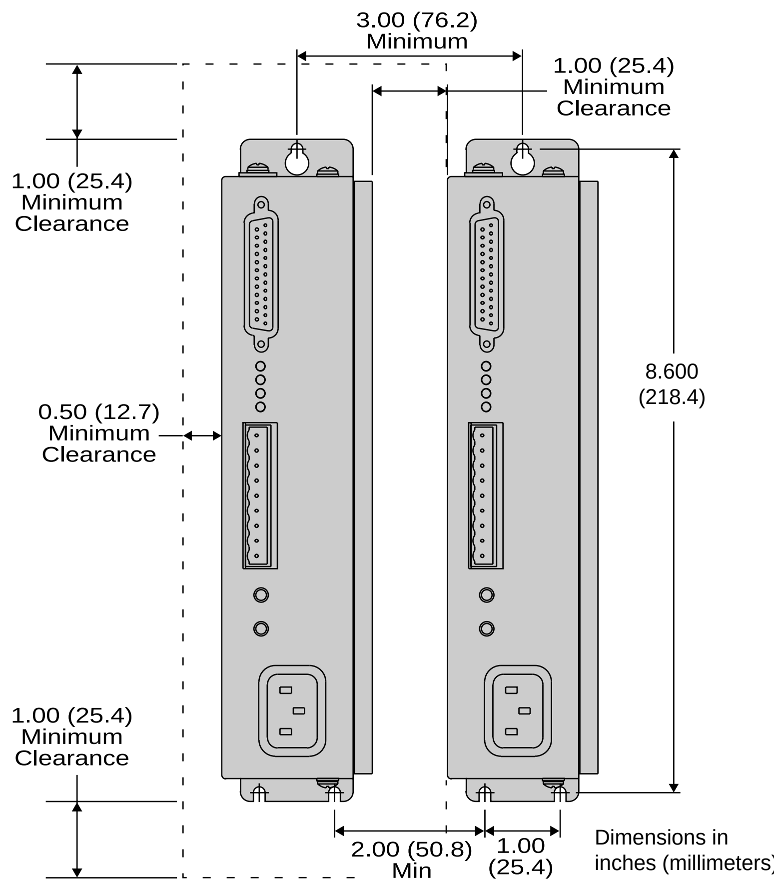
Do not allow liquids or fluids to come into contact with the ZETA drive or its cables.

AIRBORNE CONTAMINANTS

Particulate contaminants, especially electrically conductive material such as metal shavings or grinding dust, can damage the ZETA drive and motor. Do not allow contaminants to come into contact with the drive or motor.

PANEL LAYOUT

Follow these minimum spacing and clearance requirements when you mount multiple ZETA drives.



Panel Layout Dimensions

7 – MOUNT THE MOTOR

Use flange bolts to mount rotary step motors. The *pilot*, or centering flange on the motor's front face, should fit snugly in the pilot hole.

Do not use a foot-mount or cradle configuration, because the motor's torque is not evenly distributed around the motor case. When a foot mount is used, for example, any radial load on the motor shaft is multiplied by a much longer lever arm.

ZETA motors can produce very high torques and accelerations. If the mounting is inadequate, this combination of high torque/high acceleration can shear shafts and mounting hardware. Because of shock and vibration that high accelerations can produce, you may need heavier hardware than for static loads of the same magnitude.

Under certain move profiles, the motor can produce low-frequency vibrations in the mounting structure that can cause fatigue in structural members. A mechanical engineer should check the machine design to ensure that the mounting structure is adequate.

WARNING
Improper motor mounting can jeopardize personal safety, and compromise system performance.

For ZETA motor dimensions, see *Select a Motor* earlier in this chapter.

MOTOR TEMPERATURE & COOLING

The motor's face flange is used not only for mounting; it is also a *heatsink*. Mount the face flange to a large thermal mass, such as a thick steel or aluminum plate, which should be unpainted, clean, and flat. Heat will be conducted from inside the motor, through the face flange, and dissipated in the thermal mass. This is the best way to cool the motor. You can also use a fan to blow air across the motor for increased cooling, if conduction through the flange does not provide enough cooling.

MOTOR MODIFICATIONS

Modifying or machining the motor shaft will void the motor warranty. Contact a Compumotor Applications Engineer (800-358-9070) about shaft modifications as a custom product.

EXTENDING MOTOR CABLES

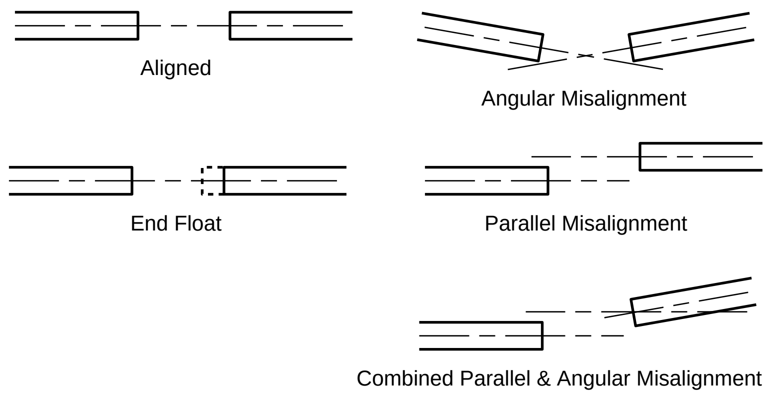
If you need to extend ZETA motor cables beyond the standard 10 feet (3 m), consult the table below for recommended wire sizes. Cables longer than 50 feet (15 m) may degrade system performance. Do not extend cables beyond 200 feet (61 m).

	Max. Current	Less than 100 ft. (30 m)		100 – 200 ft. (30 – 60 m)	
Motor Type	**(amps)**	**Size: AWG**	**mm²**	**AWG**	**mm²**
ZETA57-51**S**	1.26	22	0.34	20	0.50
ZETA57-51**P**	2.38	22	0.34	20	0.50
ZETA57-83**S**	1.51	22	0.34	20	0.50
ZETA57-83**P**	3.13	22	0.34	20	0.50
ZETA57-102**S**	1.76	22	0.34	20	0.50
ZETA57-102**P**	3.50	20	0.50	18	0.75
ZETA83-62**S**	2.26	22	0.34	20	0.50
ZETA83-62**P**	4.00	20	0.50	18	0.75
ZETA83-93**S**	2.88	22	0.34	20	0.50
ZETA83-93**P**	4.00	20	0.50	18	0.75
ZETA83-135**S**	3.50	20	0.50	18	0.75
ZETA83-135**P**	4.00	20	0.50	18	0.75

S: Series Configuration **P**: Parallel Configuration Rated current in wire sizes shown may result in a maximum temperature rise of 10°C (18°F) above ambient.

8 – Connect the Motor to the Load – Couplers

Align the motor shaft and load as accurately as possible. In most applications, some misalignment is unavoidable, due to tolerance buildups in components. However, excessive misalignment may degrade your system's performance. The three misalignment conditions, which can exist in any combination, are illustrated and described below.



Misalignment Condition

- ❏ Angular Misalignment: The center lines of two shafts intersect at an angle other than zero degrees.
- ❏ Parallel Misalignment: The offset of two mating shaft center lines, although the center lines remain parallel to each other.
- ❏ End Float: A change in the relative distance between the ends of two shafts.

The type of misalignment in your system will affect your choice of coupler.

Single-Flex Coupling

Use a single-flex coupling when you have angular misalignment only. Because a single-flex coupling is like a hinge, one and only one of the shafts must be free to move in the radial direction without constraint. ***Do not use a double-flex coupling in this situation***: it will allow too much freedom and the shaft will rotate eccentrically, which will cause large vibrations and catastrophic failure. ***Do not use a single-flex coupling with a parallel misalignment***: this will bend the shafts, causing excessive bearing loads and premature failure.

Double-Flex Coupling

Use a double-flex coupling whenever two shafts are joined with parallel misalignment, or a combination of angular and parallel misalignment (the most common situation).

Single-flex and double-flex couplings may or may not accept end play, depending on their design.

Rigid Coupling

Rigid couplings are generally not recommended, because they cannot compensate for *any* misalignment. They should be used only if the motor or load is on some form of floating mounts that allow for alignment compensation. Rigid couplings can also be used when the load is supported entirely by the motor's bearings. A small mirror connected to a motor shaft is an example of such an application.

Coupling Manufacturers

HUCO	ROCOM CORP.	HELI-CAL
70 Mitchell Blvd, Suite 201	5957 Engineer Drive	P.O. Box1460
San Rafael, CA 94903	Huntington Beach, CA 92649	Santa Maria, CA 93456
(415) 492-0278	(714) 891-9922	(805) 928-3851

9 – CONNECT AC POWER

At this point in your installation procedure, you should have mounted your drive and motor, coupled the motor to the load, and connected the indexer and motor cables to the drive.

The ZETA drive does not have an *on/off* switch. When you plug the power cord into the drive, the system will turn on. Therefore, before you apply power to the ZETA Drive, verify the following:

- ❏ Motor should be properly secured
- ❏ Motor cable should be connected to drive
- ❏ Drive should be properly mounted
- ❏ Indexer cable should be connected to drive
- ❏ Indexer cable should not be in close physical proximity to motor cable
- ❏ Active Damping rotary switch should be set to zero
- ❏ Electronic Viscosity rotary switch should be set to zero.

APPLY POWER

Apply power to the ZETA drive by plugging one end of the molded power cord into the drive's AC Power connector. The cord is 6.6 feet (2 m) long. Plug the other end of the power cord into an AC power source that meets the following specifications:

Specifications – AC Power Input

Input Power:	120VAC nominal 95VAC minimum 132VAC maximum 50 – 60 Hz
Inrush Current:	25 amps maximum
Fuses:	No user serviceable fuses
Grounding:	You must provide a proper AC power ground
Transformer:	Not required for 120VAC operation; to size step-down transformer, use Volt-Amp rating *(see below)*

WARNING

The motor case and drive are grounded through the AC power connector ground pin. You must provide a proper AC power ground for safety purposes.

PEAK POWER RATINGS

The amount of power the ZETA drive requires from your AC power source depends upon the motor you use, whether you wire the motor in series or parallel, and upon your specific application. The next table shows *peak* power requirements. Power required for your application may be less.

Motor Type	Current (Amps)	Cabinet Loss (W)	Peak Motor Loss (W)	Peak Shaft Power (W)	Peak Total Power (W)	Volt-Amp Rating (VA)
ZETA57-51**S**	1.26	11.9	25	60	97	145
ZETA57-51**P**	2.38	16.1	50	129	195	293
ZETA57-83**S**	1.51	12.7	27	80	120	180
ZETA57-83**P**	3.13	19.6	54	175	249	373
ZETA57-102**S**	1.76	13.6	30	80	124	185
ZETA57-102**P**	3.50	21.7	60	186	268	402
ZETA83-62**S**	2.26	15.5	50	120	186	278
ZETA83-62**P**	4.00	24.8	88	260	373	560
ZETA83-93**S**	2.88	18.4	52	180	250	376
ZETA83-93**P**	4.00	24.8	72	350	447	671
ZETA83-135**S**	3.50	21.7	57	193	272	408
ZETA83-135**P**	4.00	24.8	65	355	445	667

S: Series Configuration P: Parallel Configuration

10 – Test the Installation

System installation should be complete at this point. Perform the test procedure below to verify that your system is functioning properly. (Procedures to configure the drive's damping features follow this test.)

In the test procedure, you will command single revolution moves in the clockwise and counterclockwise direction. If your mechanics do not permit such moves, choose a move that allows you to easily verify correct system response.

Test Procedure

① Apply 120VAC power. The green LED labeled **POWER** should illuminate.

② Command a slow move of one revolution in the clockwise direction. Verify that the motor turns as commanded. The bicolor LED labeled **STEP** should be illuminated green while the move is in progress.

③ Command a slow move of one revolution in the counterclockwise direction. Verify that the motor turns as commanded. The bicolor LED labeled **STEP** should be illuminated green while the move is in progress.

④ Test the shutdown input. With the motor stopped, activate the input. The motor will have no torque when shutdown is activated. You should be able to turn the motor manually (if your mechanics permit).

Successful completion of this procedure will verify that your indexer and motor are correctly connected to the ZETA drive, and that the drive is functioning properly. Proceed to the following sections to configure the ZETA drive's damping features.

If the test was unsuccessful, observe the LEDs on the front panel of the ZETA drive while you try the test procedure—they may indicate the cause of the problem. (*Chapter 3 Troubleshooting* has a complete description of LED functions.) Review earlier sections of this user guide, verify that you have completed each step, and try the test procedure again.

If the test is still unsuccessful, proceed to *Chapter 3 Troubleshooting* for problem identification and solution procedures.

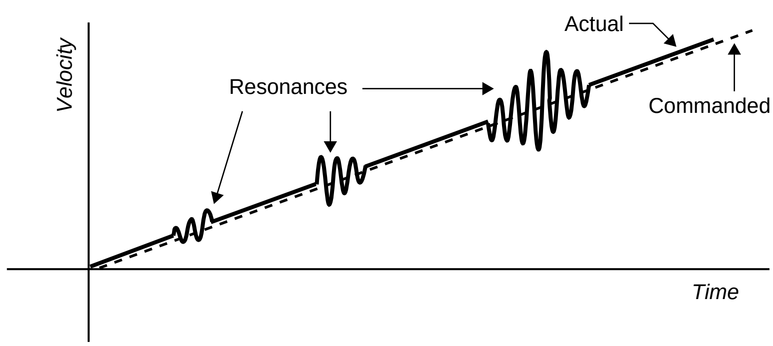
11 – Resonance, Ringing and Damping – Discussion and Theory

In this section we will discuss resonance and ringing in step motors. This information will help you configure the ZETA drive's damping features—anti-resonance, active damping, and electronic viscosity.

All step motors have natural resonant frequencies, due to the nature of their mechanical construction. Internally, the rotor acts very similarly to a mass suspended on a spring—it can oscillate about its commanded position. Externally, the machine, mounting structure, and drive electronics can also be resonant, and interact with the motor. During a move, two types of problems can arise from these causes: resonance and ringing transients.

Resonance (Steady State Response)

Resonance is a *steady state* phenomenon—it occurs when the motor's natural resonant frequencies are excited at particular velocities. It is not caused by transient commands that we give the motor. If you slowly increase your motor's speed from zero to 20 rps, for example, you may notice "rough" spots at certain speeds. The roughness is resonance; it is depicted in the next drawing.



Resonance

Instead of moving at the commanded velocity, the motor is oscillating between speeds faster and slower than commanded. This causes *error in rotor position*.

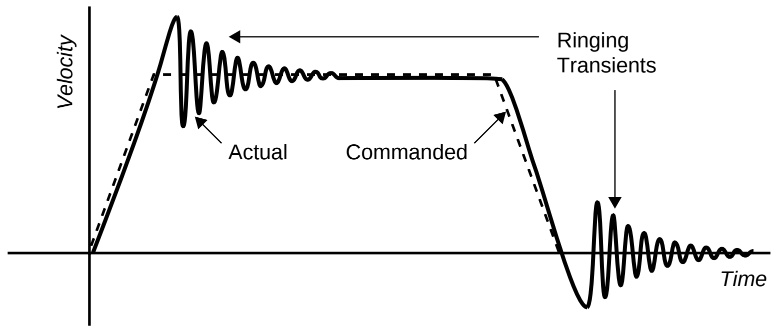
Resonance points can differ in intensity. The drawing shows a typical case—as motor speed increases, resonances of varying levels occur. Usually, the motor can accelerate through the resonance point, and run smoothly at a higher speed. However, if the resonance is extreme, the rotor can be so far out of position that it causes the motor to stall.

Resonance is affected by the load. Some loads are resonant, and can make motor resonance worse. Other loads can damp motor resonance. To solve resonance problems, system designers will sometimes attach a damping load, such as an inertial damper, to the back of the motor. However, such a load has the unwanted effect of decreasing overall performance, and increasing system cost.

The ZETA drive has internal electronics that can damp resonance, and *increase* system performance. No external devices are necessary.

Ringing (Transient Response)

Inside a step motor, the rotor behaves like a mass on a spring, as mentioned above. When commanded to quickly accelerate to a given velocity, the rotor will “ring” about that velocity, oscillating back and forth. As shown in the next drawing, the ringing *decays*—grows smaller over time—and the rotor eventually settles at the commanded velocity.



Ringing Transients

Notice that ringing can be caused both by accelerating (or decelerating) to a commanded velocity, and decelerating to a stop. In all of these cases, ringing causes *error in rotor position*.

Ringing is a *transient* phenomenon (unlike resonance, which occurs during steady state operations). It is a response to a sudden change that we impose on the system, such as “Accelerate to Velocity” or “Stop.”

Several problems are associated with ringing. It can cause audible noise; the motor must have a margin of extra torque to overcome the ringing; and longer settling times can decrease throughput.

To eliminate these problems, system designers use damping to force the ringing to decay quickly. Inertial dampers have been used as components in passive damping methods. Accelerometers, encoders, and tachometers have been used as components in active damping methods. These devices can have the unwanted effect of limiting performance, adding complexity, and increasing cost.

The ZETA drive has internal electronics that can damp ringing transients, and cause them to decay quickly. No external devices are necessary.

12 – Damping in the ZETA Drive

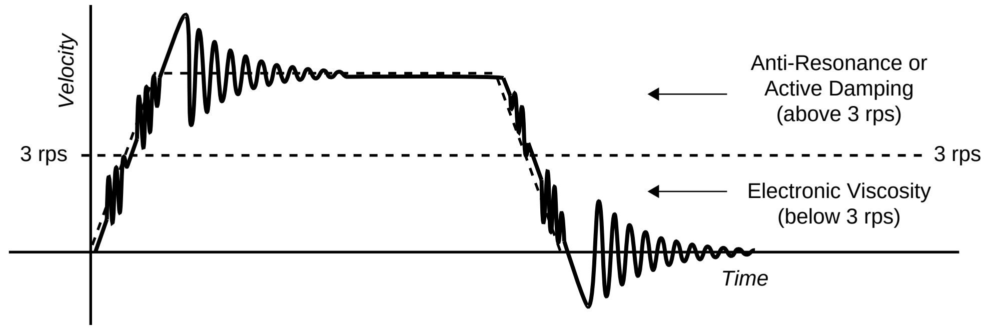
The ZETA drive has three different circuits that can damp resonance and ringing.

Anti-Resonance – General-purpose damping circuit. The drive ships from the factory with anti-resonance enabled. No configuration is necessary. Anti-resonance provides aggressive and effective damping.

Active Damping – Extremely powerful damping circuit. The drive ships from the factory with active damping disabled. You must set four DIP switches and a rotary switch to enable active damping, and optimize it for a specific motor size and load.

Electronic Viscosity – Provides damping at lower speeds. The drive ships with electronic viscosity disabled. You must set a rotary switch to enable electronic viscosity, and optimize it for the specific application.

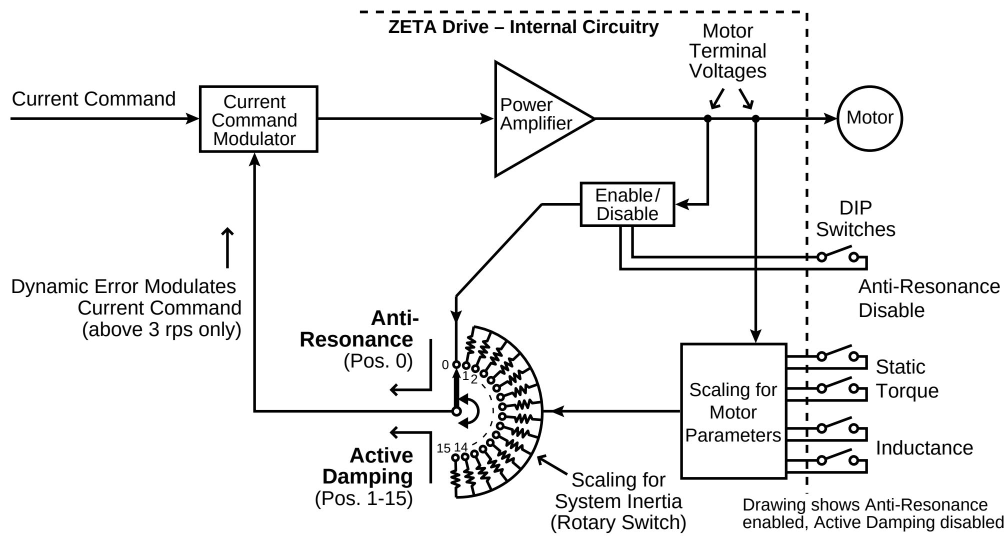
The first two damping circuits—anti-resonance and active damping—work at speeds greater than three revolutions per second (rps). Electronic viscosity works at speeds from rest up to three rps. The drive will automatically switch between the damping circuits, based upon the motor’s speed. The next drawing shows the effective range of each circuit.



Resonances, Ringing Transients, and Effective Range of Damping Circuits

Above 3 rps, the drive automatically enables anti-resonance or active damping—but not both at the same time. They are mutually exclusive.

If the rotary switch for active damping is set to the zero position, the drive enables anti-resonance. If the rotary switch is set to any position other than zero, the drive enables active damping. This relationship is shown in the next drawing. Notice that anti-resonance can also be disabled with a DIP switch.



Anti-Resonance and Active Damping – Block Diagram

Differences between anti-resonance and active damping are described next; refer to the block diagram above.

Anti-Resonance

Anti-resonance monitors the drive's motor terminals, and looks at power exchange between the drive and motor. From this, it extracts information about error in rotor position caused by resonance or ringing. It modifies the internal motor current command to correct for the error.

Anti-resonance is a general-purpose circuit. It corrects rotor position error, without knowledge about the system—whether the motor is large or small, or the system inertia is high or low. You cannot modify the circuit's gains, or customize it for a particular application—but, anti-resonance is easy to use. When enabled via the DIP switch, it works automatically.

Active Damping

Active damping monitors the motor terminals and, like anti-resonance, uses the same current command modulator to modify motor current.

Active damping uses a different method to extract information about rotor position error, however. The circuit's gains are adjustable—you can configure it for your particular system. DIP switches scale the circuit for motor inductance and static torque. A 16-position rotary switch scales the circuit for system inertia.

The active damping circuit uses this information for two purposes:

① It determines error in rotor position *very* accurately.

② It adjusts the gains of its feedback loop, based upon how much inertia the system has, and how much torque the motor can produce.

If the rotor rings or vibrates, the active damping circuit will detect the corresponding error in rotor position. It will then modify the motor current command to damp the ringing.

DIP switches on top of the drive set the amount of motor current during normal operations; this current is constant. To damp ringing, the active damping circuit can cause the drive to produce up to twice as much current as is set by the DIP switches. The extra current is only applied while damping oscillations, and lasts a very brief time.

Electronic Viscosity (EV)

The ZETA drive uses closed loop current control to develop and maintain precise currents in the motor phases. When EV is off, the current loops have a bandwidth of approximately 1000 Hz. Because this bandwidth is well beyond the knee of step motor speed-torque curves, the current loop dynamics do not limit the response of the motor.

EV monitors motor velocity, and turns on below 3 rps. It "detunes" the current loop compensation values and brings the bandwidth down to 150 Hz. With this lower bandwidth, the drive electronics become "sluggish." Ordinarily, when the rotor oscillates, it generates current in the motor's coils; but with EV's lower bandwidth, the drive's electronics impede the flow of current caused by oscillations.

The effect on the motor is as if there were a viscous drag on the rotor. At the end of a move, oscillations are damped, and the rotor quickly comes to rest. After accelerating or decelerating to velocities below 3 rps, the rotor quickly settles at the commanded velocity. EV significantly reduces low speed velocity ripple during moves below 3 rps.

EV is a "passive" circuit. It imposes viscosity on the system, but has no feedback loop to monitor the effect of the viscosity. EV keeps the amount of viscosity the same, regardless of the response of the system.

You can adjust the amount of viscosity by setting the rotary switch. This allows you to tailor the circuit for different motor sizes and system inertias, and adapt it to your application.

What's Next?

We recommend that you complete the next sections, and configure active damping and electronic viscosity. Even if you believe resonance and ringing will not cause problems in your system, you may find that the ZETA drive's damping circuits provide increased smoothness, reduced audible noise, and better performance.

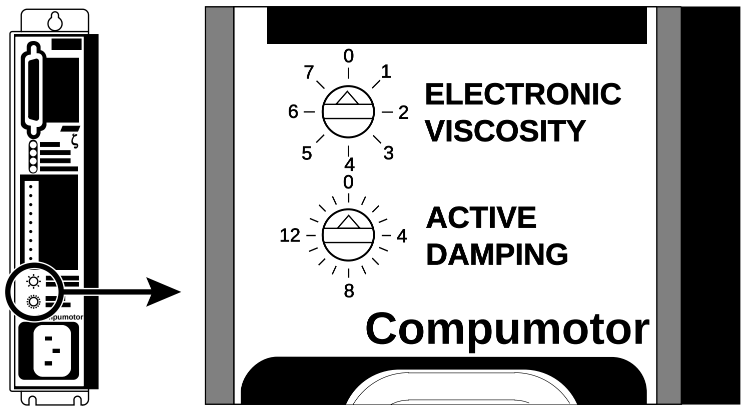
If you choose not to use active damping and electronic viscosity, at least use anti-resonance. Verify that anti-resonance is enabled (DIP SW2-#2 off), and that the rotary switches on the front of the drive, for active damping and electronic viscosity, are set to zero.

13 – SET ROTARY SWITCHES TO ZERO

The ZETA drive has two rotary switches located on its front panel:

8–Position Switch: for Electronic Viscosity
16–Position Switch: for Active Damping

The next drawing shows both switches set to zero. The slot in the switch is horizontal. Notice that the small triangle on the switch points to zero.



Rotary Switch Location (Switches Shown Set at Zero)

Set each switch to zero, as shown in the drawing. A setting of zero disables electronic viscosity and active damping. In the steps below, you will determine new switch settings to activate these two functions.

14 – CONFIGURE ACTIVE DAMPING

① VERIFY CORRECT DRIVE/MOTOR MATCHING
See *Match the Drive to the Motor* earlier in this chapter. To be fully effective, the active damping circuit requires proper matching. If you are replacing a component (new drive or motor in an existing application), you must rematch your system.

② VERIFY CORRECT DIP SWITCH SETTINGS:

Anti-Resonance	SW2-#2	switch in *OFF* position
Inductance	SW2-#3&4	set for your motor
Static Torque	SW2-#5&6	set for your motor

③ VERIFY THAT THE ACTIVE DAMPING ROTARY SWITCH IS AT ZERO

④ CALCULATE THE MAXIMUM ROTARY SWITCH SETTING
To do this, first calculate your system inertia. Be sure to include the motor's rotor inertia. Then consult the table of inertia ranges below. Find the switch setting that corresponds to your system inertia.

Switch Position #	**Total Inertia kg-cm^2**	**Total Inertia kg-m^{2}x 10^{-6}**	**Total Inertia oz-in^2**
15	0.088 – 0.205	8.8 – 20.5	0.481 – 1.121
14	0.205 – 0.572	20.5 – 57.2	1.121 – 3.144
13	0.572 – 1.069	57.2 – 106.9	3.127 – 5.845
12	1.069 – 1.754	106.9 – 175.4	5.845 – 9.590
11	1.754 – 2.727	175.4 – 272.7	9.590 – 14.910
10	2.727 – 3.715	272.7 – 371.5	14.910 – 20.312
9	3.715 – 5.020	371.5 – 502.0	20.312 – 27.447
8	5.020 – 6.275	502.0 – 627.5	27.447 – 34.308
7	6.275 – 8.045	627.5 – 804.5	34.308 – 43.986
6	8.045 – 9.595	804.5 – 959.5	43.986 – 52.460
5	9.595 – 11.76	959.5 – 1176	52.460 – 64.297
4	11.76 – 14.25	1176 – 1425	64.297 – 77.884
3	14.25 – 15.90	1425 – 1590	77.884 – 86.905
2	15.90 – 17.77	1590 – 1777	86.905 – 97.129
1	17.77 – 20.57	1777 – 2057	97.129 – 112.465
0	Active Damping Disabled		

Active Damping Rotary Switch Settings & Corresponding Inertia Ranges

This is your *maximum* switch setting. If you are on the boundary between two switch settings, pick the lower of the two numbers. In the rest of this procedure, ***never set the switch higher than this maximum setting***.

⑤ MAKE A MOVE WITH ACTIVE DAMPING TURNED OFF
(Rotary switch should be in the zero position.) This is your baseline move. Notice the sound, amount of motor vibration, etc. This move shows how your system operates with anti-resonance enabled, and active damping disabled. Each time you adjust this switch, you will compare results with this baseline move.

The move should be representative of your application, with similar velocity and acceleration. The speed must be faster than 3 rps, in order for the drive to activate anti-resonance or active damping.

⑥ TURN ON ACTIVE DAMPING
To do this, turn the active damping rotary switch to position 1. This turns on active damping at its lowest setting, and disables anti-resonance.

You can change the rotary switch setting “on the fly.” You do not have to cycle power each time you change the switch setting. During a repetitive move, you can change the switch setting while the move is in progress. This allows you to immediately compare two different switch settings.

⑦ MAKE A MOVE WITH ACTIVE DAMPING TURNED ON
Compare the sound and vibration to the baseline move.

⑧ INCREASE THE SWITCH SETTING
Turn the rotary switch to position 2 (unless position 1 is your calculated maximum). Make the move again. Compare the sound and vibration to the levels obtained at the lower setting.

⑨ FIND THE IDEAL SWITCH SETTING
Continue to increase the switch setting by single increments. Each time you increase the setting, compare the results with the lower setting. Increase the setting until you obtain optimum results for your move. This will be the setting that yields the lowest audible noise and smoothest motor operation.

Never exceed your maximum switch setting. For many applications, you will not need to go as high as the maximum setting. If you do not see perceptible improvement from one switch setting to the next, use the lower switch setting.

Higher switch settings result in higher dynamic motor current during transients, which can cause increased motor heating. Higher current also increases motor torque, resulting in sharper accelerations that can jerk or stress the mechanics in your system. If you ramp up through each intermediate switch position, you can evaluate the effects on your mechanics as you gradually increase damping.

15 – CONFIGURE ELECTRONIC VISCOSITY (EV)

If you configured active damping in the previous step, you can leave the active damping rotary switch set at the value you chose. You do not need to set active damping at zero while you configure EV.

① VERIFY THAT THE EV ROTARY SWITCH IS SET AT ZERO
EV is *off* when the switch is in the zero position.

② MAKE A MOVE WITH EV TURNED OFF
Notice the sound, amount of motor vibration, perceptible ringing, etc. This is your baseline move. It shows how your system operates with EV off. Each time you adjust this switch, you will compare results with this baseline move.

Remember, EV only works below 3 rps. Select a move that is representative of your application, with similar velocity and acceleration.

③ TURN ON EV
Turn the rotary switch to position 1. This turns on EV.

You can change the switch setting "on the fly," while the move is in progress. You do not need to cycle power each time you change the switch setting. For repetitive moves, you can change the switch setting while the move is in progress. This allows you to immediately evaluate the results, and compare two different settings.

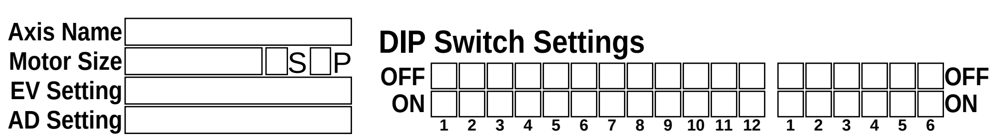
④ MAKE A MOVE WITH EV TURNED ON
Compare results to the baseline move.

⑤ INCREASE THE SWITCH SETTING
To do this, turn the switch to the next higher position. Make the move. Notice the results, and compare them to earlier settings.

⑥ FIND THE IDEAL SWITCH SETTING
Repeat step 5 until you find the setting that gives the best performance. You can try all seven switch settings. Incorrect switch settings will not cause damage.

16 – RECORD YOUR SYSTEM'S CONFIGURATION INFORMATION

This completes the installation procedure. You may wish to record your configuration information in the chart below.



Configuration Information

This chart is repeated, along with other facts, on the information label located on the side of the ZETA drive. This is a *magnetic* label. You can leave it on the drive; or, you can remove it and place it in a convenient location near the drive (on an equipment cabinet door, for example).

Use a marker or pen to write configuration information in the spaces at the bottom of the label. If you have multiple drives, you can remove the labels and stack them on top of each other, with the bottom edge of each visible. This shows information about all axes at a glance.

CHAPTER THREE

Troubleshooting

IN THIS CHAPTER

- Troubleshooting Basics
- Diagnostic LEDs
- Protective Circuits
- Automatic Test
- Anti-Resonance Disable
- Product Return Procedure

TROUBLESHOOTING BASICS

When your system does not function properly (or as you expect it to operate), the first thing that you must do is identify and isolate the problem. When you have accomplished this, you can effectively begin to resolve the problem.

The first step is to isolate each system component and ensure that each component functions properly when it is run independently. You may have to dismantle your system and put it back together piece by piece to detect the problem. If you have additional units available, you may want to exchange them with existing components in your system to help identify the source of the problem.

Determine if the problem is mechanical, electrical, or software-related. Can you repeat or re-create the problem? Random events may appear to be related, but they are not necessarily contributing factors to your problem.

You may be experiencing more than one problem. You must isolate and solve one problem at a time. Log (document) all testing and problem isolation procedures. You may need to review and consult these notes later. This will also prevent you from duplicating your testing efforts.

Once you have isolated a problem, take the necessary steps to resolve it. Refer to the problem solutions contained in this chapter. If the problem persists, contact your local technical support resource.

DIAGNOSTIC LEDS

The ZETA drive has four LEDs on its front panel. The following summary of LED functions may help you isolate problems.

LED Name	Color	Function
POWER	Green	Illuminates when AC power is applied Off if AC power is under voltage (<95VAC)
STEP	Green Red/Green	Illuminates with each applied step pulse Alternates red & green during Auto Test
OVER TEMP	Red	Indicates drive has exceeded temperature limit
MOTOR FAULT	Red	Indicates short circuit in motor or cabling Indicates open interlock

PROTECTIVE CIRCUITS

The ZETA drive has several protective circuits, some of which can indicate fault conditions by illuminating one of the above LEDs.

OVERTEMPERATURE PROTECTION

To protect against damage from high temperatures, the ZETA drive has an internal temperature sensor. If the sensor reaches 55°C (131°F) it will trigger an overtemperature fault. The red **OVER TEMP** LED will illuminate, and the drive will shut down. This is a latched fault. To restart the drive, first allow it to cool, then cycle power or toggle the reset input.

Short Circuit Protection

The ZETA drive has short circuit protection. When the drive detects a short circuit in the motor or motor cabling, it illuminates the **MOTOR FAULT** LED, and stops producing motor current. This is a latched condition. To restart the drive, first fix the short in the motor or cable, then cycle power.

Regeneration

The ZETA Drive has an internal regeneration resistor. If the motor *regenerates*—produces excess energy during deceleration—the drive will automatically dissipate the excess energy in its regeneration resistor. If the motor regenerates an excess amount of energy on a continuous basis, the drive's internal temperature may rise and trigger an overtemperature fault (see above).

Automatic Test

Often in diagnosing a problem, it is helpful to rule out possible causes. If you disconnect the load and indexer from the drive, four components remain—the drive, motor, motor cable, and power cable.

You can then configure the drive to run the automatic test function. See instructions near the beginning of *Chapter 2 Installation*. If the motor turns as expected—counterclockwise at approximately one rps—then the drive, motor, and cables are probably not the cause of the problem. The cause may lie with the indexer, limit switches, mechanics, etc.

Anti-Resonance Disable

If your mechanical system is highly resonant at precisely the *wrong* frequency, anti-resonance might interpret the mechanical vibrations as rotor position error. You would notice greater torque ripple, increased audible noise, and possibly even stalling. To solve these problems, try disabling anti-resonance (SW2-#2 on), and see if the problems improve.

You can also turn on and use active damping. The drive automatically disables anti-resonance when active damping is turned on.

Technical Support

If you cannot solve your system problems using this documentation, contact your local Automation Technology Center (ATC) or distributor for assistance. If you need to talk to our in-house application engineers, contact Parker Compumotor's Applications Department at (800) 358-9070, from 6:00 AM to 5:00 PM Pacific time.

PRODUCT RETURN PROCEDURE

If you must return your ZETA drive for repairs, use the following steps:

① Get the serial number and the model number of the defective unit, and a purchase order number to cover repair costs in the event the unit is determined to be out of warranty.

② Before you return the unit, have someone from your organization with a technical understanding of the ZETA drive and its application include answers to the following questions:

- ❏ What is the extent of the failure/reason for return?
- ❏ How long did the unit operate?
- ❏ Did any other items fail at the same time?
- ❏ What was happening when the unit failed (e.g., installing the unit, cycling power, starting other equipment, etc.)?
- ❏ How was the unit configured (in detail)?
- ❏ What, if any, cables were modified and how?
- ❏ With what equipment is the unit interfaced?
- ❏ What was the application?
- ❏ What was the system environment (temperature, enclosure, spacing, unit orientation, contaminants, etc.)?
- ❏ What upgrades, if any, are required (hardware, cables, user guide)?

③ In the USA, call your Automation Technology Center (ATC) for a Return Material Authorization (RMA) number. Returned products cannot be accepted without an RMA number. If you cannot obtain an RMA number from your ATC, call Parker Compumotor's Customer Service Department at (800) 722-2282.

Ship the unit to: Parker Hannifin Corporation
Compumotor Division
5500 Business Park Drive, Suite D
Rohnert Park, CA 94928
Attn: RMA # xxxxxxx

④ In the UK, call Parker Digiplan for a GRA (Goods Returned Authorization) number. Returned products cannot be accepted without a GRA number. The phone number for Parker Digiplan Repair Department is 0202-690911. The phone number for Parker Digiplan Service/Applications Department is 0202-699000.

Ship the unit to: Parker Digiplan Ltd.,
21, Balena Close,
Poole, Dorset,
England. BH17 7DX

⑤ Elsewhere: Contact the distributor who supplied the equipment.

ZETA APPENDIX

Using Non-Compumotor Motors

IN THIS APPENDIX

- Wiring Configurations: 4-, 6- and 8-lead motors
- Terminal Connections: 4-, 6- and 8-lead motors
- Setting Motor Current: Series or Parallel
  Unipolar or Bipolar

USING NON-COMPUMOTOR MOTORS

We recommend that you use Compumotor ZETA Series motors with the ZETA drive. If you use a non-Compumotor motor, it must meet the following requirements:

- A minimum inductance of 2 mH, series or parallel, is required. (Compumotor recommends a minimum inductance of 5 mH.)
- A minimum of 500VDC high-pot insulation rating from phase-to-phase and phase-to-ground.
- The motor must be designed for use with a bipolar drive (no common center tap).
- The motor must not have riveted rotors or stators.
- Do not use solid rotor motors.
- Test all motors carefully. Verify that the motor temperature in your application is within the system limitations. *The motor manufacturer's maximum allowable motor case temperature must not be exceeded.* You should test the motor over a 2-to-3 hour period. Motors tend to have a long thermal time constant, but can still overheat, which results in motor damage.

CAUTION

Consult your motor vendor to verify that your motor meets the above specifications. Consult your Automation Technology Center (ATC) if you have questions regarding the use of a non-Compumotor motor with Compumotor equipment.

WIRING CONFIGURATIONS

Refer to the manufacturer's motor specification document to determine the motor's wiring configuration. You can also determine the wiring configuration with an ohmmeter using the procedures below (*4-Lead Motor, 6-Lead Motor, 8-Lead Motor*). Once you determine the correct motor wiring configuration, use the terminal connection diagram, shown at the end of this section, that applies to your configuration.

4-LEAD MOTOR

1. Label one motor lead **A+**.
2. Connect one lead of an ohmmeter to the **A+** lead and touch the other lead of the ohmmeter to the three remaining motor leads until you find the lead that creates continuity. Label this lead **A–**.
3. Label the two remaining leads **B+** and **B–**. *Verify that there is continuity between the* **B+** *and* **B–** *leads.*
4. Proceed to the *Terminal Connections* section below.

6-LEAD MOTOR

1. Determine, with an ohmmeter, which three of the six motor leads are common (one phase).
2. Label each one of these three motor leads **A**.
3. Using the ohmmeter, verify that the remaining three leads are common.
4. Label the remaining three leads **B**.
5. Set the ohmmeter range to the 100 ohm scale (approximately).
6. Connect the ohmmeter's negative lead to one of the motor leads labeled **A**. Alternately measure the resistance to the two remaining motor leads also labeled **A**. The resistance measurements will reflect one of the following two scenarios.

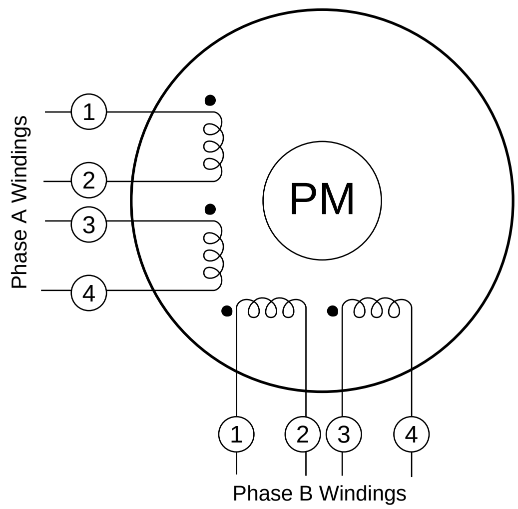
   Scenario #1 — The resistance measurements to the two remaining motor leads are virtually identical. Label the two remaining motor leads **A+** and **A–**. Label the motor lead connected to the negative lead of the ohmmeter **A CENTER TAP** (this is the center tap lead for Phase A of the motor).

Scenario #2 — The resistance measurement to the second of the three motor leads measures 50% of the resistance measurement to the third of the three motor leads. Label the second motor lead **A CENTER TAP** (this is the center tap lead for Phase A of the motor). Label the third motor lead **A–**. Label the motor lead connected to the ohmmeter **A+.**

7. Repeat the procedure as outlined in step 6 for the three leads labeled **B** (**B CENTER TAP** is the center tap lead for Phase B of the motor).
8. Proceed to the *Terminal Connections* section below.

8-Lead Motor

Because of the complexity involved in phasing an 8-lead motor, you must refer to the manufacturer's motor specification document. Using the manufacturer's specifications, label the motor leads as shown in the next drawing.



8-Lead Motor – Labeling the Leads

You can configure the 8-lead motor in series or parallel.

Series Configuration Use the following procedure for series configurations.

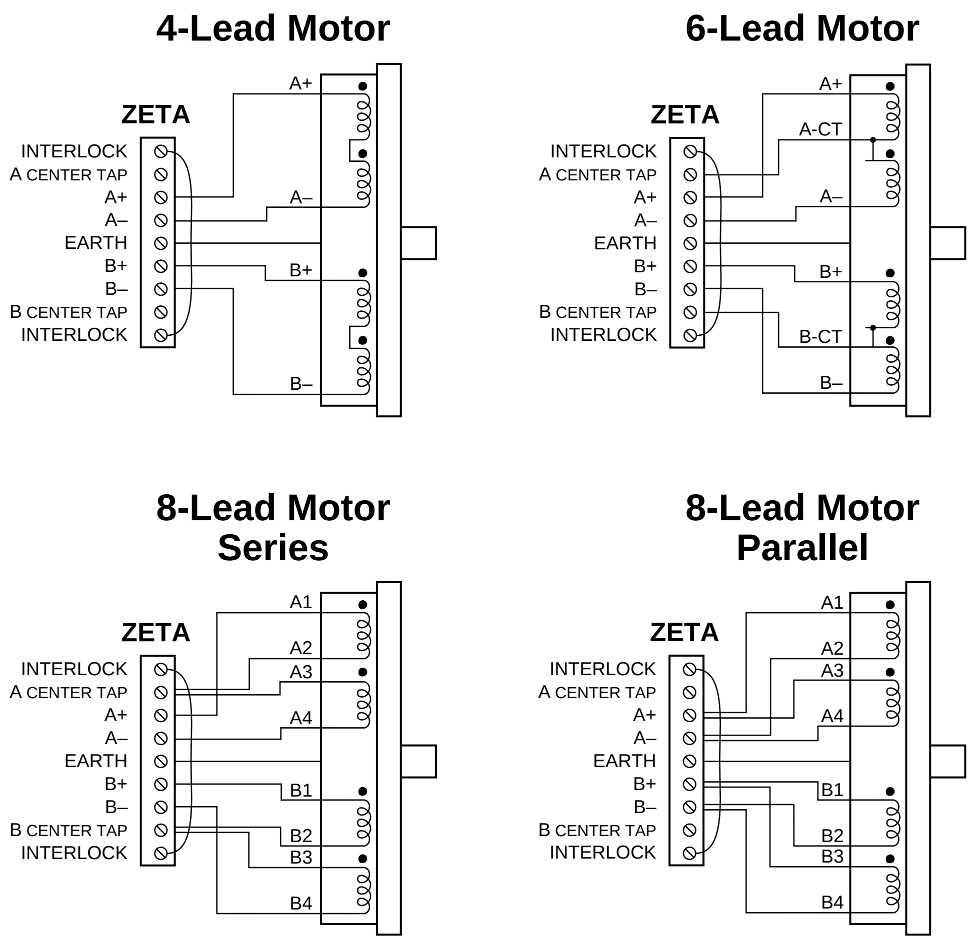
1. Connect A2 & A3 together and relabel this common point **A CENTER TAP.**
2. Connect B2 & B3 together and relabel this common point **B CENTER TAP.**
3. Relabel the A1 lead **A+**.
4. Relabel the A4 lead **A–**.
5. Relabel the B1 lead **B+**.
6. Relabel the B4 lead **B–**.
7. Proceed to the *Terminal Connections* section below.

Parallel Configuration Use the following procedure for parallel configurations.

1. Connect motor leads A1 & A3 together and relabel this common point **A+**.
2. Connect motor leads A2 & A4 together and relabel this common point **A–**.
3. Connect motor leads B1 & B3 together and relabel this common point **B**+.
4. Connect motor leads B2 & B4 together and relabel this common point **B**–.
5. Proceed to the *Terminal Connections* section below.

TERMINAL CONNECTIONS

After you determine the motor's wiring configuration, connect the motor leads to the ZETA drive's 9-pin **MOTOR** connector according to the following figure.



Non-Compumotor Motor Connections

DIRECTION OF MOTOR ROTATION

The procedures above do not determine the direction of motor shaft rotation. To find out which direction the shaft turns, you must power up your system and command motion. If the shaft turns in the opposite direction than you desire, exchange the motor leads connected to **A+** and **A–** to reverse the direction of rotation.

WARNING

Motor shaft rotation may be opposite than you expect. Do not connect a load to the shaft until you first determine the direction of shaft rotation.

The *Automatic Test*, described near the beginning of *Chapter 2 Installation*, provides a simple method of determining motor shaft rotation. The test causes the shaft to rotate in the counterclockwise (negative) direction, if the motor wires are properly connected. No indexer is required to perform the automatic test.

SETTING MOTOR CURRENT – NON-COMPUMOTOR MOTORS

To set motor current for a non-Compumotor motor, refer to the formulas below that correspond to your motor (4-lead, 6-lead, 8-lead) and use the current settings shown in the DIP switch table (in *Chapter 2 Installation*) to set the motor's current.

WARNING
Do not connect or disconnect the motor with the power on. Doing so will damage the contacts of the motor connector and may cause personal injury.

4-LEAD MOTORS

If you use a 4-lead motor, the manufacturer's current specification will translate directly to the values shown for current in the DIP switch table.

6-LEAD MOTORS

Manufacturers generally use either a bipolar rating or a unipolar rating for motor current in 6-lead motors.

Bipolar Rating: If the manufacturer specifies the motor current as a bipolar rating, you can use the DIP switch table's current settings directly to set motor current—no conversion is required.

Unipolar Rating: If the manufacturer specifies the motor current as a unipolar rating:

- Use the following formula to convert the unipolar current rating to the correct bipolar rating:

  Unipolar Current ∗ 0.707 = Bipolar Current

- Use the converted value and the DIP switch table's current settings to set the motor current.

8-LEAD MOTORS

Manufacturers generally use either a bipolar rating or a unipolar rating for motor current in 8-lead motors.

Bipolar Rating: If the manufacturer specifies the motor current as a bipolar series rating:

- If you wire the motor in **series**, use the DIP switch table's current settings directly.
- If you wire the motor in **parallel**, you must double the manufacturer's rating and then use the DIP switch table's current settings to set the motor current.

Unipolar Rating: If the manufacturer specifies the motor current as a unipolar rating:

- Use the following formula to convert the unipolar current rating to the correct bipolar rating:

  Unipolar Current ∗ 0.707 = Bipolar Current

- If you wire the motor in **series**, use the converted value and the DIP switch table's current settings to set the motor current.
- If you wire the motor in **parallel**, you must **double** the converted value and use the DIP switch table's current settings to set the motor current.

If you have questions about setting motor current, call Compumotor's Applications Engineering Department at (800) 358-9070.

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ZETA Drive
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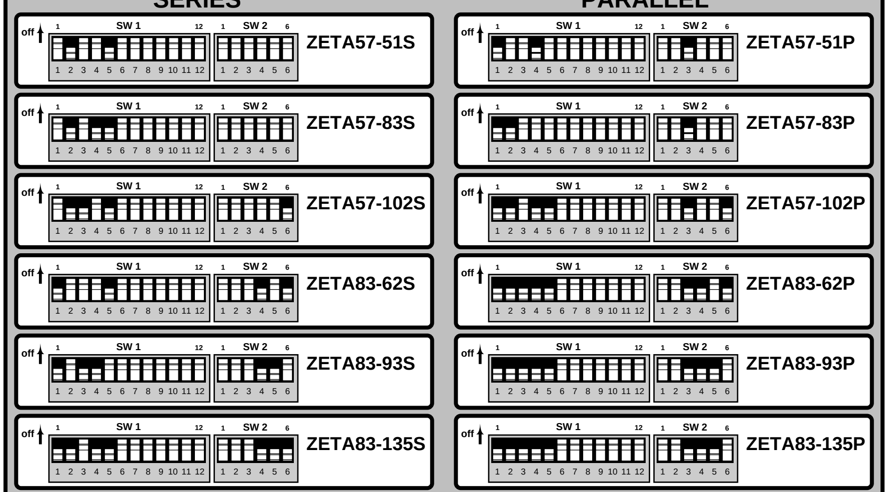
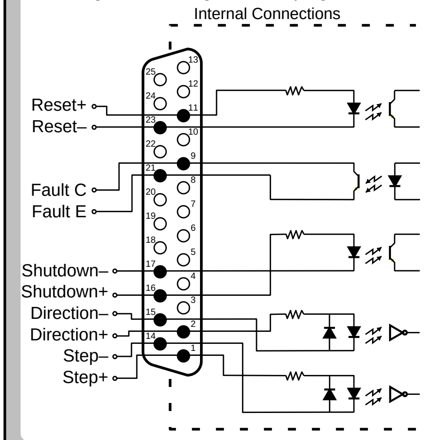
DIP Switch Settings for ZETA Motors* (for complete DIP Switch Table *see page 14*)



*Configured for 25,000 steps/rev, -4% 3rd harmonic, S&D indexer, anti-res. enabled, auto standby off

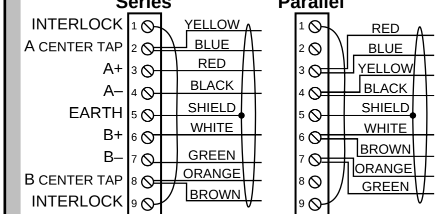
Inputs & Outputs *see page 17*



Status LEDs *see page 36*

POWER	Green when power is on
STEP	Green when drive receives step Flashes Red/Green in auto test
OVER TEMP	Red indicates over temp fault
MOTOR FAULT	Red when drive detects short circuit in motor or motor cable; Red if interlock is open

Motor Wiring – ZETA Motor Color Code
see page 12



Damping in the ZETA Drive *see page 29*

Anti-Resonance *pg 30*	Operates at speeds > 3 rps Enabled if DIP SW2-#2 is off
Electronic Viscosity *pg 31*	Operates from zero to 3 rps. Disabled if rotary sw set at 0
Active Damping *pg 30*	Operates at speeds > 3 rps Disabled if rotary sw set at 0 Maximum setting based on total inertia–see table below

Active Damping Configuration – Inertia Table

Switch Position #	Total Inertia kg-m2 x 10-6	Total Inertia oz-in2
15	8.8 – 20.5	0.481 – 1.121
14	20.5 – 57.2	1.121 – 3.144
13	57.2 – 106.9	3.127 – 5.845
12	106.9 – 175.4	5.845 – 9.590
11	175.4 – 272.7	9.590 – 14.910
10	272.7 – 371.5	14.910 – 20.312
9	371.5 – 502.0	20.312 – 27.447
8	502.0 – 627.5	27.447 – 34.308
7	627.5 – 804.5	34.308 – 43.986
6	804.5 – 959.5	43.986 – 52.460
5	959.5 – 1176	52.460 – 64.297
4	1176 – 1425	64.297 – 77.884
3	1425 – 1590	77.884 – 86.905
2	1590 – 1777	86.905 – 97.129
1	1777 – 2057	97.129 – 112.465
0	Active Damping Disabled