CHAPTER TWO

# Installation

## IN THIS CHAPTER

- Product Ship Kit List
- Motor Selection and Wiring
- Quick Test
- 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 ZETA4-240 Drive, you should have:

| Part | Part Number |
|---|---|
| ZETA4-240 Drive | ZETA4-240 |
| 240VAC Power Connector | 43-011905-01 |
| Motor Connector – 7 pin, with jumper installed | 71-016155-01 |
| Boot for Motor Connector | 58-016135-01 |
| ZETA4-240 Drive User Guide | 88-015027-01 |

You may have ordered one of the following options:

| Part | Part Number | |
|---|---|---|
| R Series Motor | RS31C-*nnnnn* | RS42C-*nnnnn* |
| | RS32C-*nnnnn* | RE42C-*nnnnn* |
| | RS33C-*nnnnn* | RS43C-*nnnnn* |
| Cable Kit for LVD/EMC Installation | C10 | |
| EMC Kit for LVD/EMC Installation | ZETA EMC SHIPKIT | |

## 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.

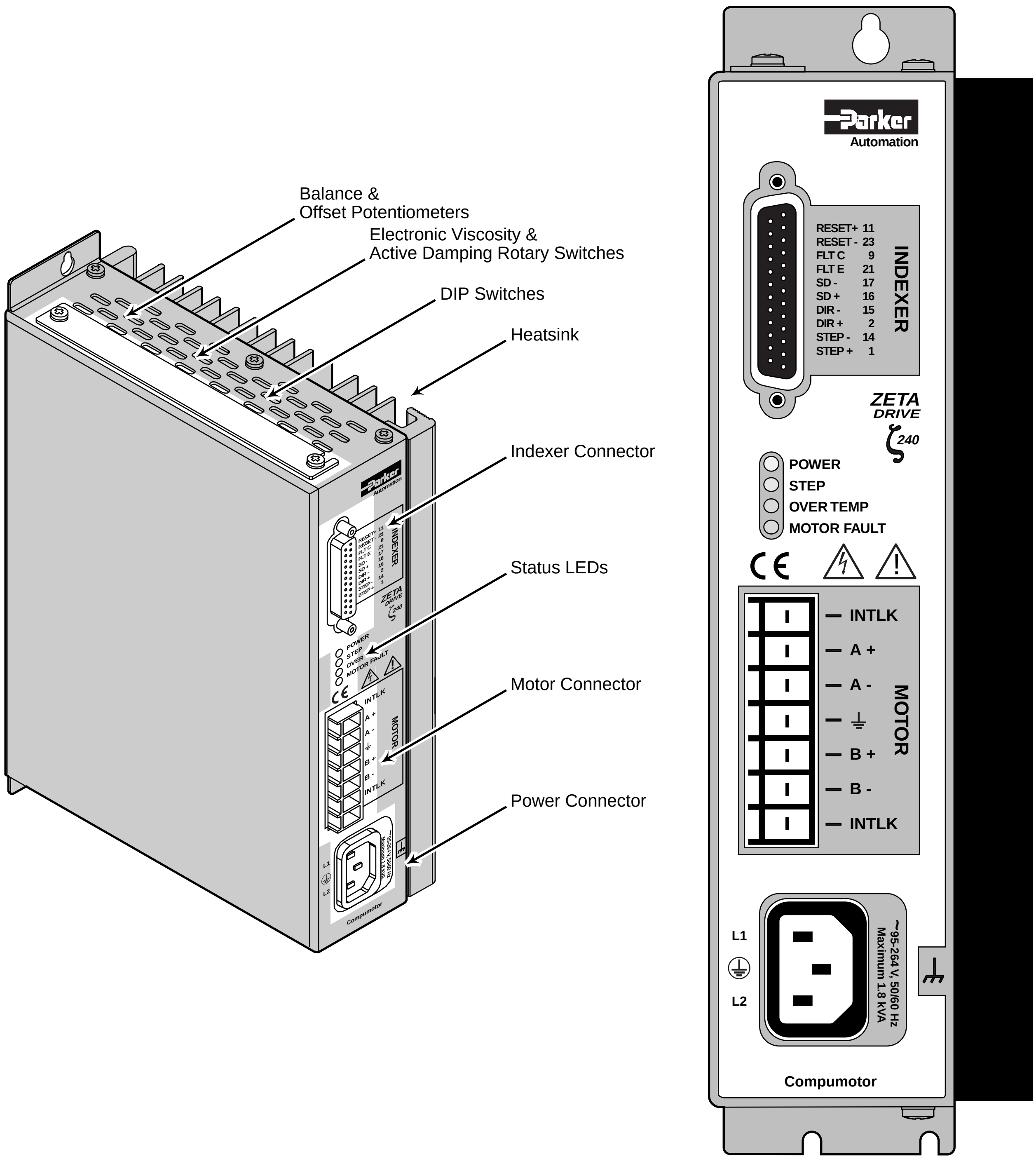
The order of topics in the installation procedure is:

- Motor selection—specifications, speed/torque curves, and dimensions
- Motor wiring—series vs. parallel
- Quick Test
- 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 Compumotor R Series motor and operating your ZETA4-240 Drive at 240VAC. If you do not use an R motor, consult *Appendix A, Using Non-Compumotor Motors*. For LVD/EMC, consult *Appendix B, LVD and EMC Installation Guide*. For 120VAC information, consult *Appendix C, 120VAC Operations*.

The next drawing shows locations and names of the various components that you will encounter during the installation procedure.




*Component Locations*

## PRE-INSTALLATION

This section explains steps to take before you permanently install your system—selecting a motor, wiring it for series or parallel motor current, and performing a quick test.

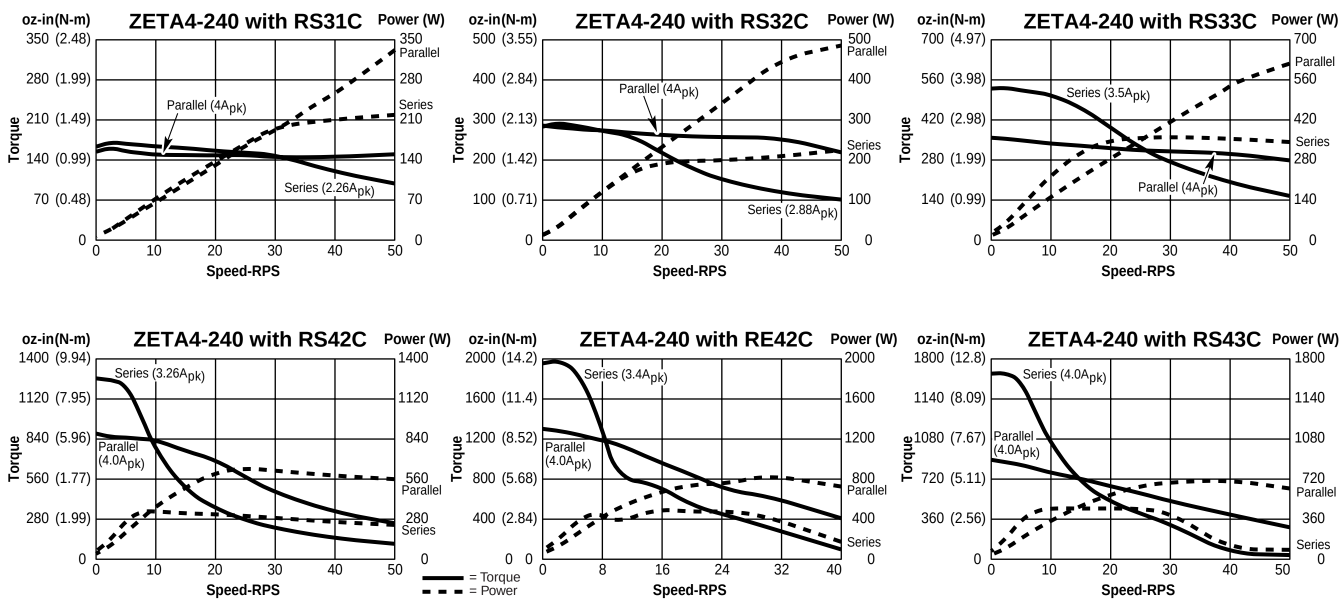
We assume you will operate your ZETA4-240 Drive at 240VAC. For 120VAC information, follow instructions in this chapter, and also consult *Appendix C, 120VAC Operations* for additional instructions, and information about Compumotor O and R Motors with 120V windings.

## 1 – SELECT A MOTOR

We recommend that you use a Compumotor R Motor (with 240V "C" windings) with your ZETA4-240 Drive. Because the R Motor's materials, design, and construction are matched to the drive's high performance capabilities, it 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 R Motors. These features will be most effective if you use an R Motor.

Speed/Torque curves, specifications, and motor dimensions for R Motors are shown below. (See Appendix C for similar information about O and R motors with 120V "B" windings.)

### SPEED/TORQUE CURVES




Note 1: Parallel connected motors are limited to 50% duty cycle when operated above 5 rps. For greater than 50% duty cycle above 5 rps, you must connect the motor in series. Fan cooling the motor will increase duty cycles above 5 rps.

Note 2: Viscous damper is not required to achieve speed torque curves.

Note 3: ±10% torque variance due to motor tolerance .

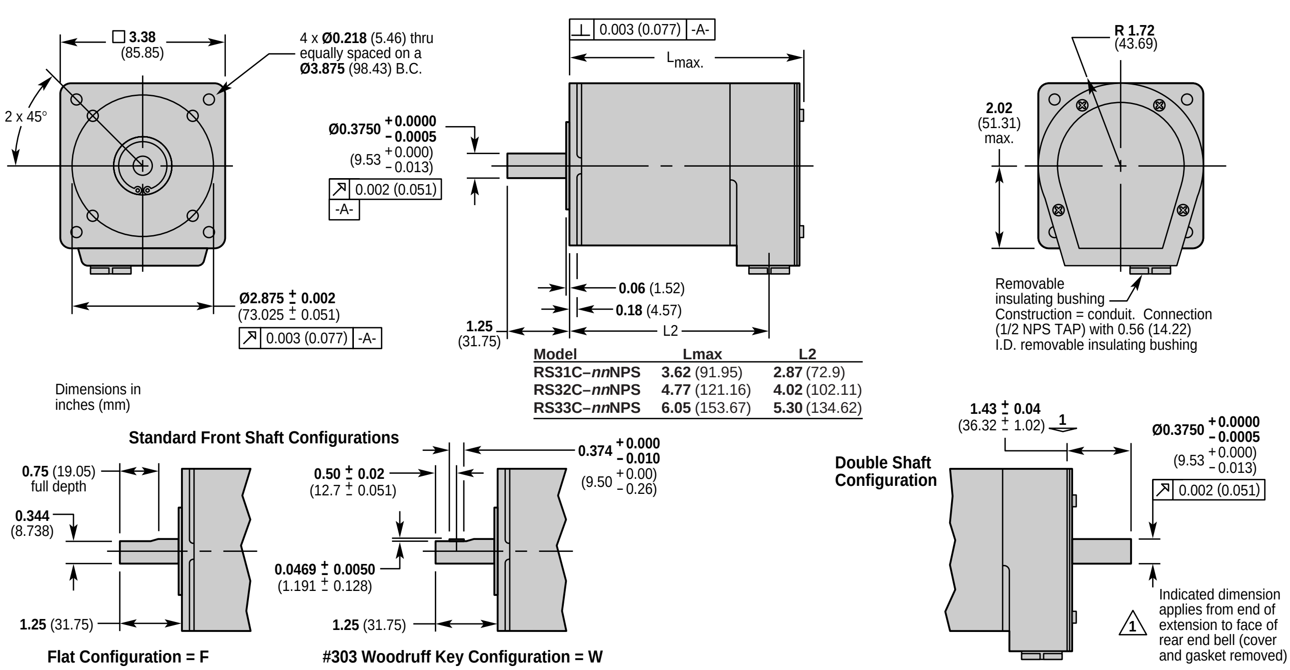
*Speed/Torque Curves for R Motors with ZETA4-240 Drive*

## R Series Motor Specifications

| | Size 34 | | | Size 42 | | |
|---|---|---|---|---|---|---|
| | RS31C | RS32C | RS33C | RS42C | RE42C | RS43C |
| **Static torque** | | | | | | |
| oz-in | 171 | 292 | 532 | 1,266 | 1,959 | 1,671 |
| (N-m) | (1.21) | (2.06) | (3.76) | (8.94) | (13.8) | (11.8) |
| **Rotor inertia** | | | | | | |
| oz-in$^2$ | 3.226 | 6.561 | 9.623 | 61.73 | 61.73 | 92.62 |
| (kg-cm$^2$) | (.59) | (1.2 ) | (1.8) | (11.29) | (11.29) | (16.94) |
| **Drive Current Apk (Arms)** | | | | | | |
| Series | 2.26 (1.6) | 2.88 (2.0) | 3.5 (2.5) | 3.26 (2.3) | 3.4 (2.4) | 4.0 (2.8) |
| Parallel | 4.0 (2.8) | 4.0 (2.8) | 4.0 (2.8) | 4.0 (2.8) | 4.0 (2.8) | 4.0 (2.8) |
| **Phase Inductance (mH)** | | | | | | |
| Series | 17.4 | 26.2 | 23.3 | 65.4 | 55.6 | 42.9 |
| Parallel | 4.3 | 6.5 | 5.8 | 16.4 | 13.9 | 10.7 |
| **Detent Torque** | | | | | | |
| oz-in | 8.8 | 18.0 | 27.0 | 50.0 | 81.0 | 71.0 |
| (kg-cm$^2$) | 0.062 | 0.130 | 0.190 | (0.350) | (0.570) | (0.500) |
| **Bearings – Thrust load** | | | | | | |
| lb | 180 | 180 | 180 | 400 | 400 | 400 |
| (kg) | (81.6) | (81.6) | (81.6) | (182) | (182) | (182) |
| **Bearings – Radial load** | | | | | | |
| lb | 35 | 35 | 35 | 140 | 140 | 140 |
| (kg) | (15.9) | (15.9) | (15.9) | (63.6) | (63.6) | (63.6) |
| **Bearings – End play** *(Reversing load Equal to 1 lb)* | | | | | | |
| in | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| (mm) | (0.025) | (0.025) | (0.025) | (0.025) | (0.025) | (0.025) |
| **Bearings – Radial play** *(Per 0.5 lb load )* | | | | | | |
| in | 0.0008 | 0.0008 | 0.0008 | 0.0008 | 0.0008 | 0.0008 |
| (mm) | (0.02) | (0.02) | (0.02) | (0.02) | (0.02) | (0.02) |
| **Motor Weight** | | | | | | |
| lb | 3.2 | 5.3 | 7.6 | 18.2 | 18.2 | 25.7 |
| (kg) | (1.45) | (2.41) | (3.45) | (8.26) | (8.26) | (11.66) |
| **Certifications** | | | | | | |
| UL recognized | yes | yes | yes | yes | yes | yes |
| CE (LVD) | yes | yes | yes | yes | yes | yes |
| CE (EMC & LVD) | * | * | * | * | * | * |

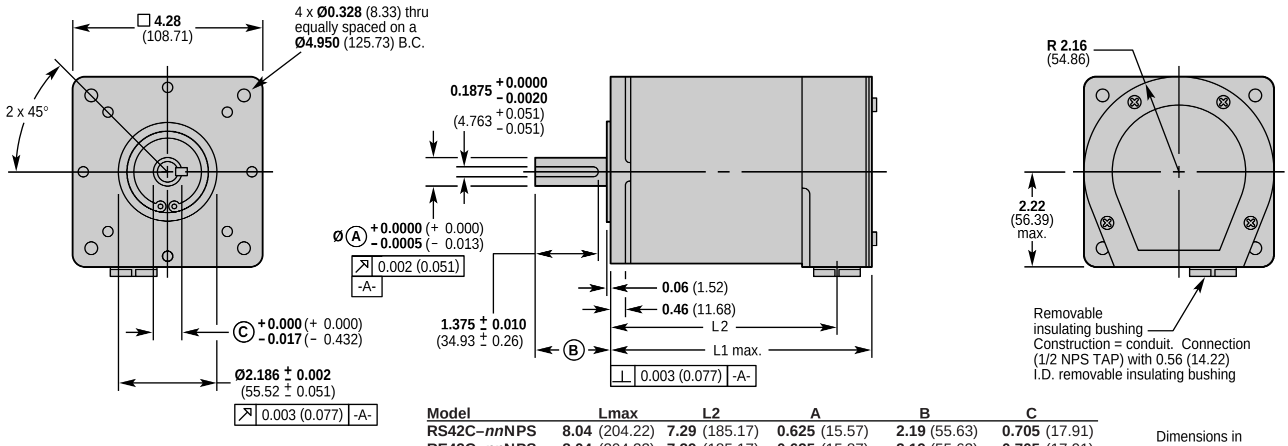
*EMC is achievable with C10 Cable Kit and EMC Kit

## Motor Dimensions



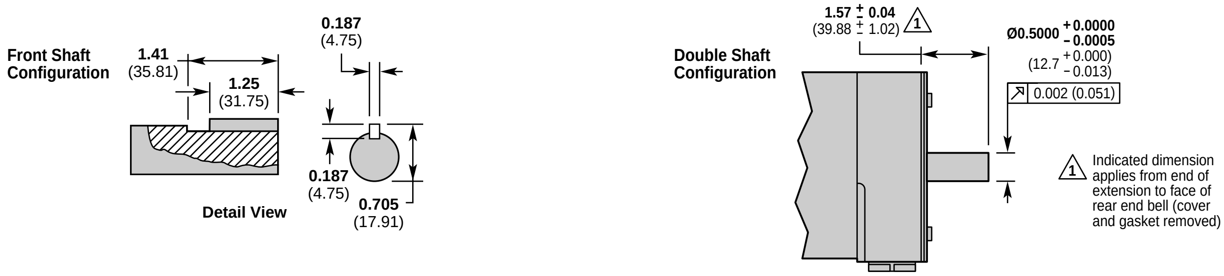

| Model | Lmax | L2 |
|---|---|---|
| RS31C–*nn*NPS | **3.62** (91.95) | **2.87** (72.9) |
| RS32C–*nn*NPS | **4.77** (121.16) | **4.02** (102.11) |
| RS33C–*nn*NPS | **6.05** (153.67) | **5.30** (134.62) |

*R Motors – Frame Size 34 Dimensions*




| Model | Lmax | L2 | A | B | C |
|---|---|---|---|---|---|
| RS42C–*nn*NPS | **8.04** (204.22) | **7.29** (185.17) | **0.625** (15.57) | **2.19** (55.63) | **0.705** (17.91) |
| RE42C–*nn*NPS | **8.04** (204.22) | **7.29** (185.17) | **0.625** (15.87) | **2.19** (55.63) | **0.705** (17.91) |
| RS43C–*nn*NPS | **10.56** (268.23) | **9.81** (249.18) | **0.75** (19.05) | **2.19** (55.63) | **0.83** (21.09) |

Dimensions in inches (mm)




*R Motors – Frame Size 42 Dimensions*

## 2 – Choose Series or Parallel Motor Wiring

The R 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.

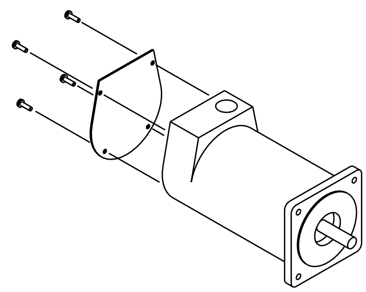
Do not extend the interlock jumper wire beyond the connector. The interlock circuit is designed to work with a *very short* jumper. Longer wires may change the electrical characteristics of the circuit, making it more susceptible to noise. Therefore, do not use a long jumper.

## Ground the Motor Case

You must ground the motor case, for safety purposes. Connect a green/yellow wire from the motor's protective earth terminal to the drive's ground terminal on its motor connector. Inside the drive, this ground terminal connects directly to the ground pin on the AC power connector. (The C10 Cable Kit has a motor cable that contains a green/yellow wire.)

## Wiring the R Motor

The R Motor is sold with no cable attached. A cable kit is available from Compumotor (part number C10) that includes a motor cable and mounting hardware. To connect a motor cable, remove the end bell cover plate from the end of the motor, as shown below.



*Removing Cover Plate*

Make connections according to the following diagrams, which show typical series and parallel connections.

Cut individual wires to length, to avoid excess wire inside the end bell.

## Precautions

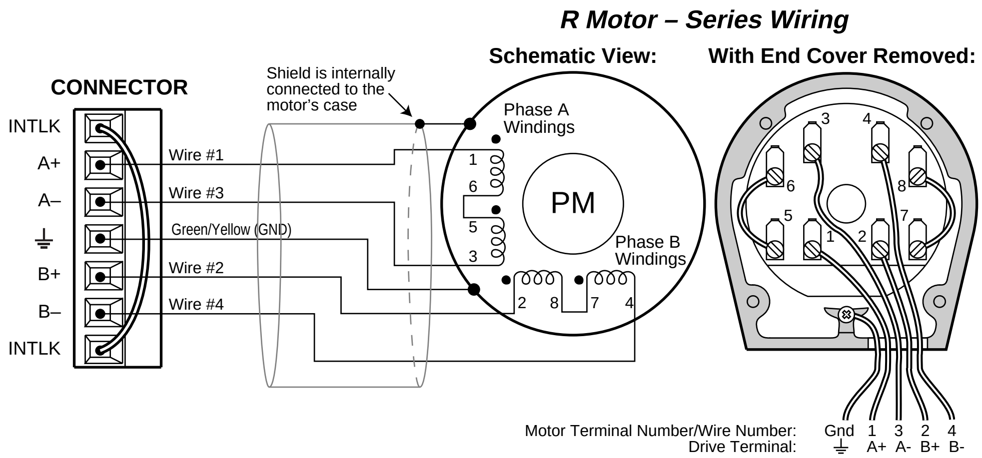
Follow these precautions when you wire the motor and connector.

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. When finished, perform the Automatic Test to verify proper connections.

## Series Wiring

For series operation, make connections according to the next diagram.

Notice that you must use jumper wires to connect terminal #7 to #8, and to connect terminal #5 to #6. Use 18 AWG (0.75 mm) or larger diameter wire for the jumpers, with ring terminals attached to each end.

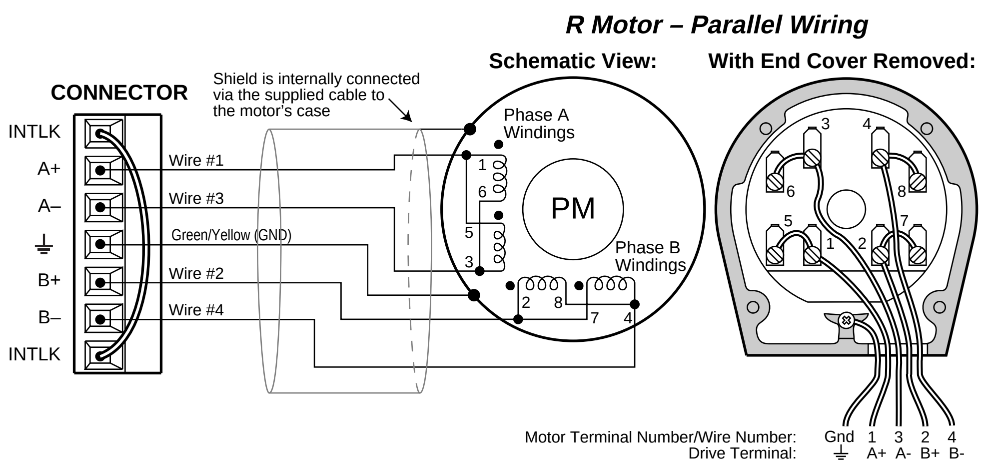



*Motor Connector – Wired for **SERIES** Motor Current*

The operating temperature of a motor connected in series will typically 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 operation, make connections according to the next diagram.




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

Use jumper wires to connect terminal #2 to #7, #4 to #8, #1 to #5, and #3 to #6. Use 18 AWG (0.75 mm) or larger diameter wire, with ring terminals.

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.

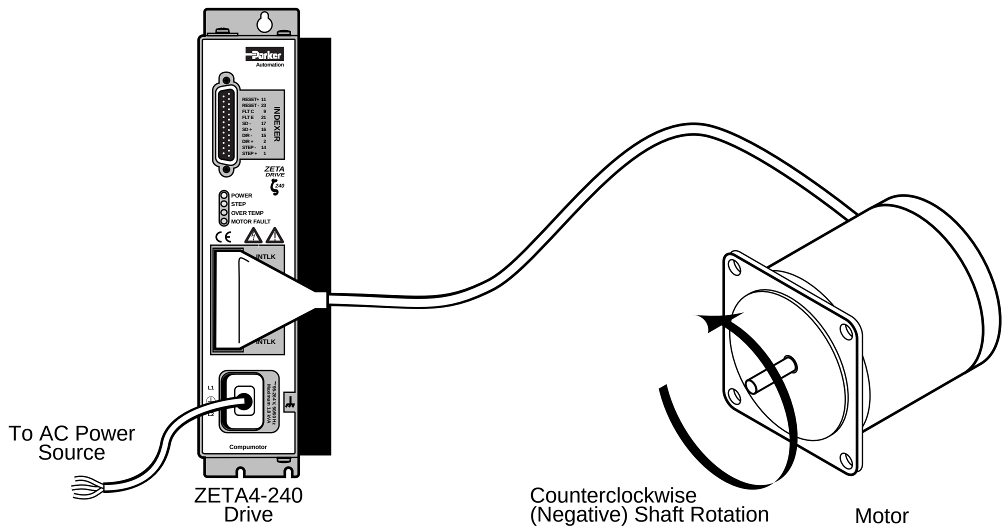
If you operate your motor in parallel, you must measure motor temperature under actual operating conditions. R Motors have maximum allowable temperatures of 100°C (212°F).

***CAUTION***

High current in parallel connected motors may cause motor overheating. If the motor exceeds its maximum case temperature, reduce the duty cycle to 50%, or use automatic standby, or use forced air cooling to decrease motor temperature.

## 3 – QUICK TEST

Follow this procedure to have your ZETA4-240 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.

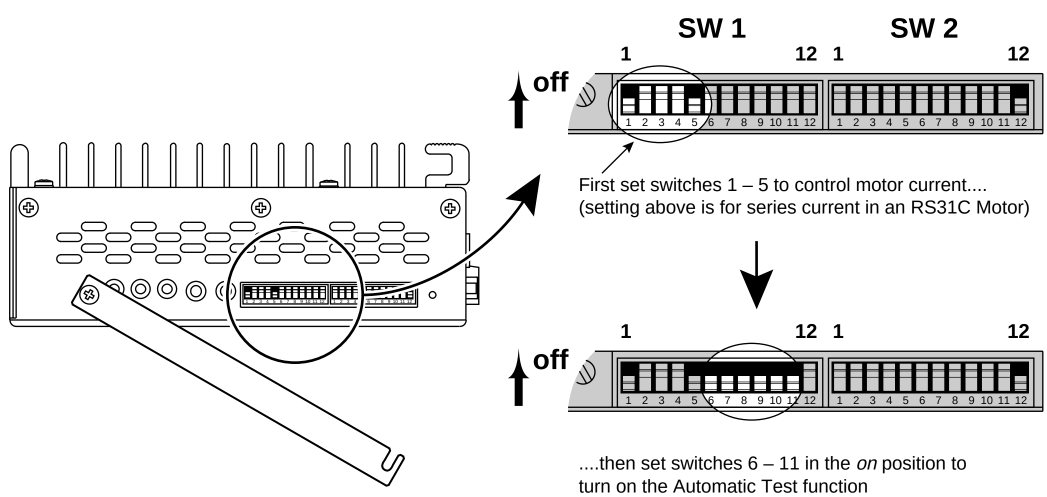



*Quick Test Setup*

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

Two 12-position DIP switches are located on top of the ZETA4-240 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*

Use the following table to set DIP switches SW1-#1 — SW1-#5 for *series* current for your R Motor.

| Motor Size | Current | SW1-#1 | SW1-#2 | SW1-#3 | SW1-#4 | SW1-#5 |
|---|---|---|---|---|---|---|
| RS31C | 2.26A (pk) | on | off | off | off | on |
| RS32C | 2.88A (pk) | on | off | on | on | off |
| RS33C | 3.50A (pk) | on | on | off | on | on |
| RS42C | 3.26A (pk) | on | on | off | off | on |
| RE42C | 3.38A (pk) | on | on | off | on | off |
| RS43C | 4.00A (pk) | on | on | on | on | on |

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

## 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 R Motor cable's 7-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 an R Motor will automatically be grounded when you plug the cable's 7-pin connector into the ZETA4-240 Drive.

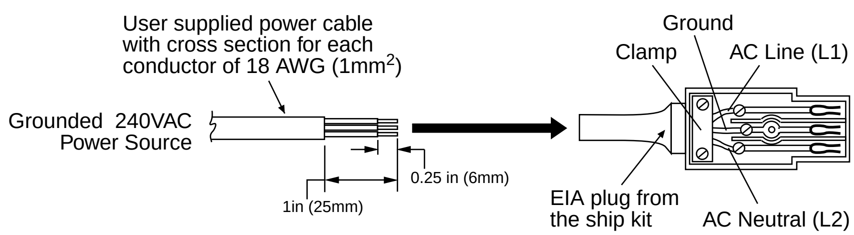
## 4. Connect AC Power

The ZETA4-240 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 ZETA4-240 Drive:

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

Wire your power cable to the 240VAC plug that you received with the drive. See the following diagram and instructions.

(For 120VAC information, consult *Appendix C, 120VAC Operations*).




*AC Input Connector Wiring*

1. Remove the cover on the EIA plug.
2. Build your power cable as shown. **DO NOT USE A 120VAC CABLE**.
3. Slide the power cable into the plug.
4. Connect the conductor wires.
5. Lock the conductor wires under the clamp.
6. Reassemble the plug.

Plug the connector into the drive, and energize your grounded 240VAC power source.

### 5. Observe the Automatic Test

Your ZETA4-240 Drive should now be running in 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.
- LEDs on the front panel should operate as follows:

| | |
|---|---|
| **POWER** | LED should illuminate |
| **STEP** | LED should alternately flash red and green |
| **OVER TEMP** | LED should not illuminate |
| **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.

# Installation

The procedures in the rest of this chapter will lead you through the steps required to permanently install your ZETA4-240 Drive and motor.

## 1 – Set DIP Switches

Configure the ZETA4-240 Drive's DIP switches for your motor and application. The drive's 24 DIP switches are located behind the movable metal cover on top of the drive. Switch 1 (SW1) and Switch 2 (SW2) are each 12-position DIP switches. The next table summarizes switch settings. At the end of this section, we show settings for individual ZETA motors. (If you use an O or R motor at 120VAC, see *Appendix C* for DIP switch settings.)

### Default Settings

The factory default position is *off* for all switches.

### Motor Current

Set DIP switches SW1-#1 — SW1-#5 for motor current. Verify that your motor wiring, connector wiring, and motor current rating match the series or parallel current that 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 ZETA4-240 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 others 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, do not select pure sine for a waveform. 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 top of the drive, anti-resonance is automatically disabled, regardless of the setting of SW2-#2. See *Damping in the ZETA4-240 Drive* later in this chapter for an explanation.

### ANTI-RESONANCE PHASE

This switch allows a broad range of motors to benefit from the anti-resonance damping technique. SW2-#3 should be *off* if your mechanical system's resonant frequency is 200 Hz or less. SW2-#3 should be *on* if your mechanical system's resonant frequency is greater than 200 Hz, if your motor drives an extremely low inertia load, or if your system has an extremely high torque to inertia ratio.

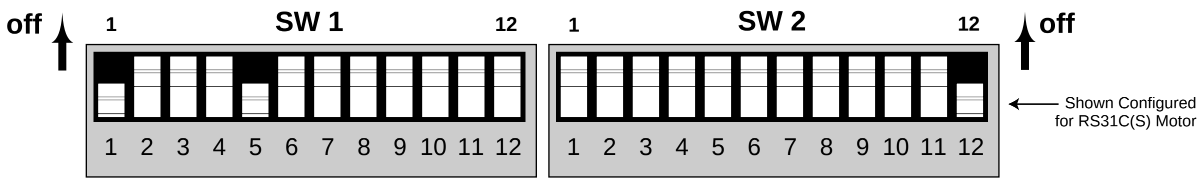
### ANTI-RESONANCE GAIN

Large rotor motors, or motors driving large inertial loads, may require a reduction in anti-resonance gain. This will be evident if the load becomes too responsive and settles in an overly abrupt manner for your application. SW2-#4 should be *off* if system's inertia is 20 kg-cm$^2$ or less. SW2-#4 should be *on* if system's inertia is greater than 20 kg-cm$^2$

### CURRENT LOOP GAIN

SW2-#5 should be *off* for normal current-loop gain. You can reduce the responsiveness of the current control loop by setting SW2-#5 to the *on* position. This may be necessary when connecting a motor with an extremely low inductance value, on the order of 2 mH. If you hear a high

# ZETA4-240 DIP SWITCH SETTINGS




## SW 1

### Current (amps pk)

| R Series Motor[4] | Current (amps pk) | 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 |
| | 1.26 | off | on | off | off | on |
| | 1.38 | off | on | off | on | off |
| | 1.51 | off | on | off | on | on |
| | 1.63 | off | on | on | off | off |
| (S) = Series | 1.76 | off | on | on | off | on |
| (P) = Parallel | 1.88 | off | on | on | on | off |
| | 2.01 | off | on | on | on | on |
| | 2.14 | on | off | off | off | off |
| RS31C(S) | 2.26 | on | off | off | off | on |
| | 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 |
| RS32C(S) | 2.88 | on | off | on | on | off |
| | 3.01 | on | off | on | on | on |
| | 3.13 | on | on | off | off | off |
| RS42C(S) | 3.26 | on | on | off | off | on |
| RE42C(S) | 3.38 | on | on | off | on | off |
| RS33C(S) | 3.50 | on | on | off | on | on |
| | 3.63 | on | on | on | off | off |
| | 3.75 | on | on | on | off | on |
| RS43C(S) | 3.88 | on | on | on | on | off |
| RxxxC(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]

| | 12 |
|---|---|
| Step & Direction Indexer | **off** |
| Clockwise & Counterclockwise Indexer | on |

## SW 2

### Static Torque[3, 4]

| 9 | 10 | 11 | 12 | Torque Range N-m | Torque Range oz-in | Motor |
|---|---|---|---|---|---|---|
| **off** | **off** | **off** | **off** | 0.26 – 0.72 | 36–100 | |
| off | off | off | on | 0.73 – 1.41 | 101–200 | RS31C |
| off | off | on | off | 1.42 – 2.33 | 201–330 | RS32C |
| off | off | on | on | 2.34 – 3.47 | 331–492 | RS33C(P) |
| off | on | off | off | 1.48 – 2.12 | 210–300 | |
| off | on | off | on | 2.13 – 3.60 | 301–510 | RS33C(S) |
| off | on | on | off | 3.61 – 7.06 | 511–1000 | |
| off | on | on | on | 7.07 – 14.83 | 1001–2100 | RS42C(S) RE42C(S) RS43C(S) |
| on | off | off | off | 3.18 – 4.94 | 450–700 | |
| on | off | off | on | 4.95 – 7.77 | 700–1100 | RS42C(P) RE42C(P) RS43C(P) |
| on | off | on | off | 7.78 – 16.24 | 1101–2300 | |
| on | off | on | on | 16.25 – 35.31 | 2301–5000 | |
| on | on | off | off | 5.65 – 8.12 | 800–1150 | |
| on | on | off | on | 8.13 – 14.12 | 1151–2000 | |
| on | on | on | off | 14.13 – 28.95 | 2001–4100 | |
| on | on | on | on | 28.96 – 60.02 | 4101–8500 | |

### Inductance[3, 4]

| 7 | 8 | Inductance Range (mH) | Motor: |
|---|---|---|---|
| **off** | **off** | 20.08 & greater | RS31C(S), RS32C(S), RS33C(S) RS42C, RE42C(S), 4S43C(S) |
| off | on | 10.31 – 20.07 | RS43C(P) |
| on | off | 5.03 – 10.30 | RS31C(P), RS32C(P), RS33C(P), RE42C(P) |
| on | on | less than 5.02 | |

### System Inertia

| 6 | |
|---|---|
| **off** | Less than 20kg-cm$^2$ |
| on | Greater than 20kg-cm$^2$ |

### Current-Loop Gain

| 5 | |
|---|---|
| **off** | Standard |
| on | Reduced |

### Anti-Resonance Gain

| 4 | |
|---|---|
| **off** | Standard (system inertia < 20kg-cm$^2$) |
| on | Reduced (system inertia > 20kg-cm$^2$) |

### Anti-Resonance Phase

| 3 | |
|---|---|
| **off** | Resonant Freq. < 200 Hz |
| on | Resonant Freq. > 200 Hz |

### Anti-Resonance Disable

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

### Automatic Standby

| 1 | |
|---|---|
| **off** | Full Current |
| on | 50% Current Standby |

**NOTES:**

1. RxxxC(P) can be RS31C(P), RS32C(P), RS33C(P), RS42C(P), RE42C(P), RS43C(P).
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. Motor Part Number Suffix: (S) = Series Configuration (P) = Parallel Configuration

pitched (10 kHz) oscillation from the motor, you can decrease or eliminate the oscillation by reducing loop gain. Excessive loop gain may cause motor faults at high loads; reduce loop gain to eliminate this problem.

## System Inertia

This switch selects the low or high inertia range, which pre-scales the 16-position rotary switch used by the active damping circuit. (This is explained later in this chapter, in *12 – Configure Active Damping*.)

## Inductance

The active damping circuit reads SW2-#7 and SW2-#8 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.

Large signal inductance is found by measuring the actual generator AC flux linkage and generator short circuit current under dynamic conditions. Small-signal inductance is the value read on an ordinary inductance bridge or meter. 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-#7 and SW2-#8 are ignored by the drive, and are inactive.

## Static Torque

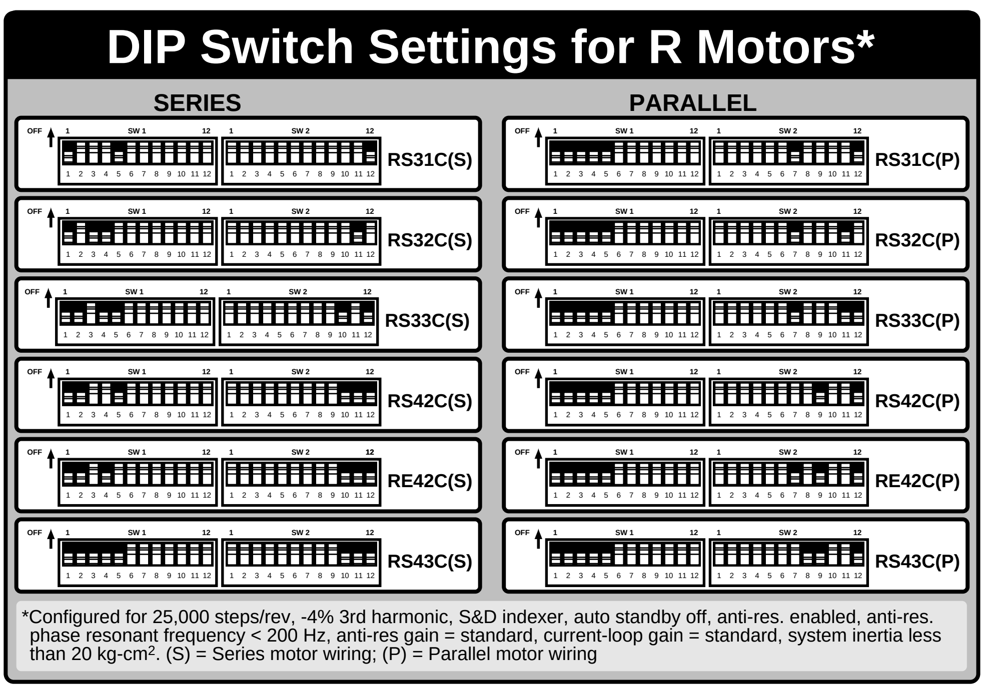
The active damping circuit reads SW2-#9 — SW2-#12 to determine the motor's static torque. Set these switches according to your motor; the table shows the range of static torque that corresponds to each of the four settings. NOTE: If active damping is *off*, switches SW2-#9 — SW2-#12 are ignored by the drive, and are inactive.

## Replace Cover

Replace and secure the cover after you set the DIP switches.

## DIP Switch Settings for Compumotor R Motors

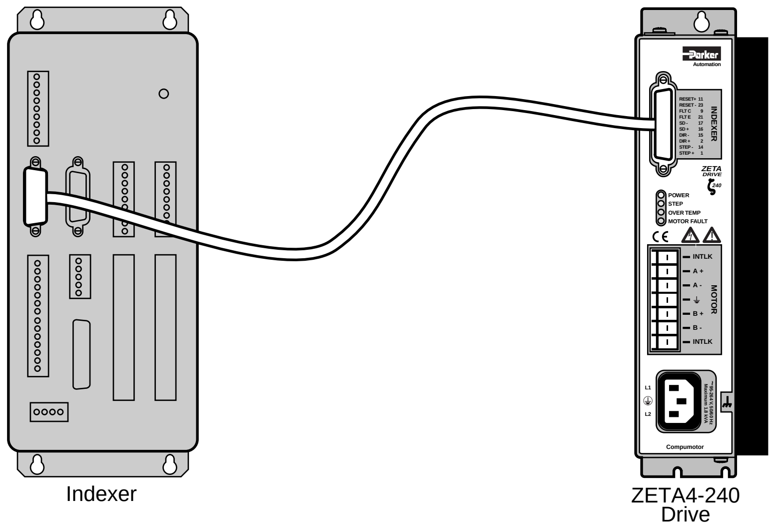
The next illustration summarizes switch settings for Compumotor R Motors.




*DIP Switch settings for Compumotor R Motors*

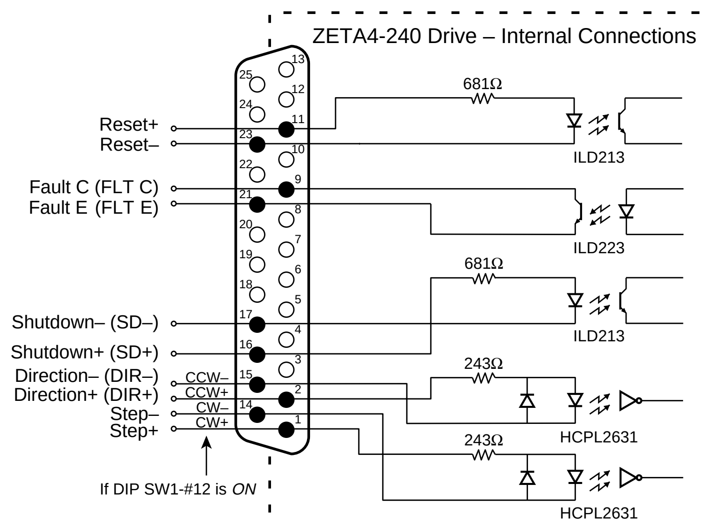
## 2 – Connect an Indexer – Inputs & Outputs

Connect your indexer cable to the ZETA4-240 Drive's **INDEXER** connector, a 25 pin D-connector on the front of the drive. The cable that comes with Compumotor indexers is pre-wired for compatibility with the ZETA4-240 Drive—you can plug the cable directly into the ZETA4-240 Drive's indexer connector. (See *Appendix B, LVD and EMC Installation Guide* for additional instructions regarding EMC, and Compumotor's optional EMC compliant cable.)




*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 ZETA4-240 Drive's step and direction inputs to clockwise and counterclockwise inputs, for use with a CW/CCW indexer. To do so, set DIP SW1–#12 to the *on* position. These 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 ZETA4-240 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 ZETA4-240 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: | 80 mA minimum |
| Dissipation: | 80 mW maximum |
| Optically Isolated: | Yes |

## RESET INPUT

The reset input provides a means for you to reset the ZETA4-240 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 start-up 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.

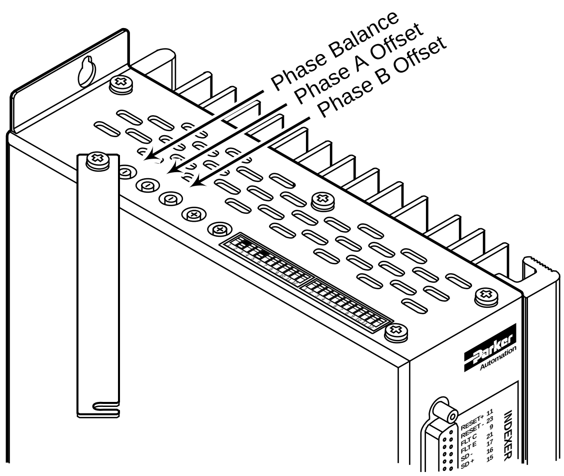
Reset input specifications are:

| | | | |
|---|---|---|---|
| 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 | | |

## 3 – 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, to match your ZETA4-240 Drive to your specific motor. You will also select the best current waveform to use with your motor.

The ZETA4-240 Drive's potentiometers are located behind the removable metal cover on top of the drive.




*Potentiometer 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**
   Allow the drive 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. **Consult Table for Operating Speeds**
   For each of the adjustments that follow, consult the next table 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) |
|---|---|---|---|
| RS31C (S) | 2.93 | 1.47 | 0.73 |
| RS31C (P) | 2.78 | 1.39 | 0.70 |
| RS32C (S) | 3.08 | 1.54 | 0.77 |
| RS32C (P) | 2.76 | 1.38 | 0.69 |
| RS33C (S) | 3.07 | 1.53 | 0.77 |
| RS33C (P) | 2.49 | 1.24 | 0.62 |
| RS42C (S) | 1.78 | 0.89 | 0.45 |
| RS42C (P) | 1.55 | 0.77 | 0.39 |
| RE42C (S) | 2.99 | 1.50 | 0.75 |
| RE42C (P) | 2.04 | 1.02 | 0.51 |
| RS43C (S) | 1.80 | 0.90 | 0.45 |
| RS43C (P) | 1.40 | 0.70 | 0.35 |

(For O and R Motors at 120VAC, see *Appendix C, 120VAC Operation*.)

3. **Run Motor at *Offset Adjust* Resonant Speed**
   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 Phase A Offset and Phase B Offset**
   Adjust the offset potentiometers for minimum motor vibration and smoothest operation. Alternate between Phase A and Phase B to find the minimum vibration point.

5. **Run Motor at *Balance Adjust* Resonant Speed**
   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 Phase Balance**
   Adjust the Phase Balance potentiometer until you find the setting that provides minimum motor vibration and smoothest operation.

7. **Repeat steps 3 – 6**

8. **Run Motor at *Waveform Adjust* Resonant Speed**
   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 Waveform for Smoothest Operation**
   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 |

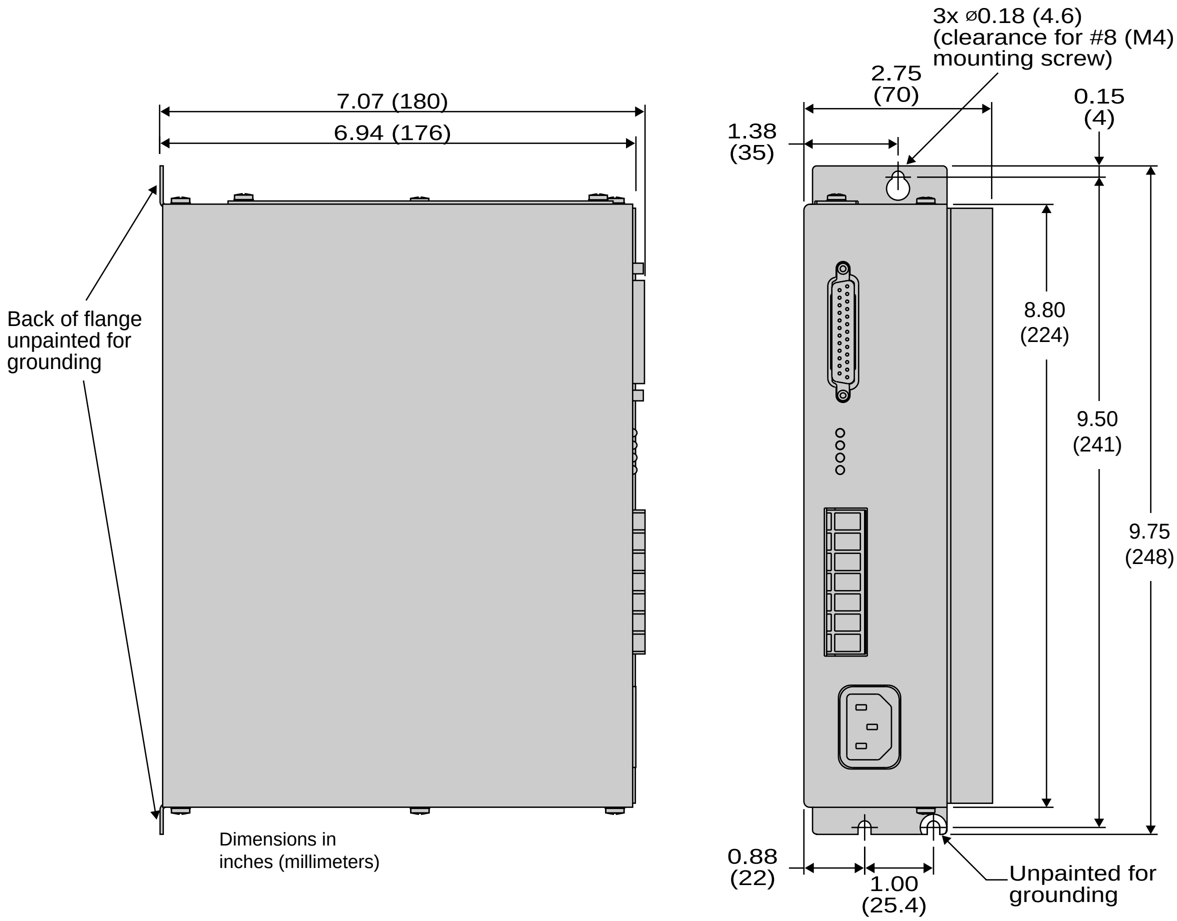
   The drive reads these DIP switches only upon power up or reset. Therefore, you must cycle power or reset the drive each time you change the DIP switch settings.

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

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

## 4 – Mount the Drive

Dimensions of the ZETA4-240 Drive are shown below.




*ZETA4-240 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 ZETA4-240 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 ZETA4-240 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

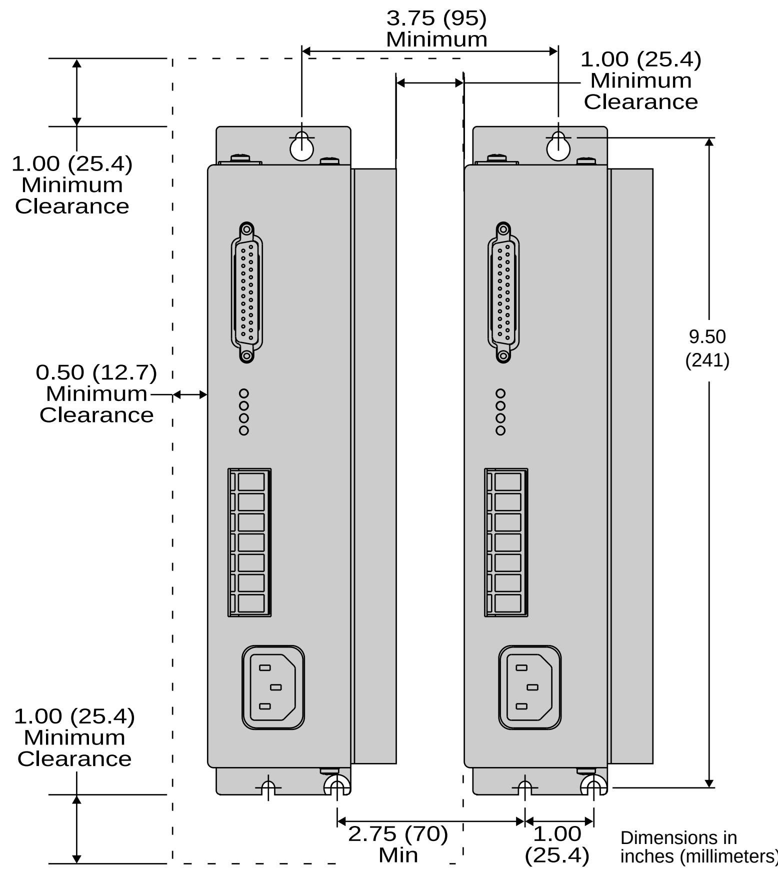
Do not allow liquids or fluids to come into contact with the ZETA4-240 Drive or its cables.

### AIRBORNE CONTAMINANTS

Particulate contaminants, especially electrically conductive material such as metal shavings or grinding dust, can damage the ZETA4-240 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 ZETA4-240 Drives.




*Panel Layout Dimensions*

## 5 – 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.

Motors used with the ZETA4-240 Drive can produce very high torque and acceleration. 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 safety of personnel, and compromise system performance.

For Compumotor R Series 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 R 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). LVD and EMC installations require special cables, which are not included in the table below; see *Appendix B, LVD and EMC Installation Guide* for additional instructions for LVD/EMC cables.

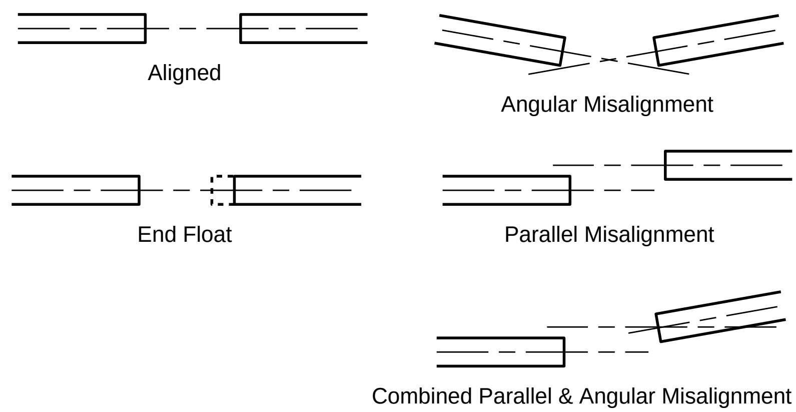
| | Max. Current | Less than 100 ft. (30 m) | | 100 – 200 ft. (30 – 60 m) | |
|---|---|---|---|---|---|
| **Motor Type** | **(amps)** | **Size: AWG** | **$mm^2$** | **AWG** | **$mm^2$** |
| RS31C (S) | 2.26 | 20 | 0.50 | 18 | 0.75 |
| RS31C (P) | 4.00 | 18 | 0.75 | 16 | 1.50 |
| RS32C (S) | 2.88 | 20 | 0.50 | 18 | 0.75 |
| RS32C (P) | 4.00 | 18 | 0.75 | 16 | 1.50 |
| RS33C (S) | 3.50 | 18 | 0.75 | 16 | 1.50 |
| RS33C (P) | 4.00 | 18 | 0.75 | 16 | 1.50 |
| RS42C (S) | 3.26 | 20 | 0.50 | 18 | 0.75 |
| RS42C (P) | 4.00 | 18 | 0.75 | 16 | 1.50 |
| RE42C (S) | 3.38 | 20 | 0.50 | 18 | 0.75 |
| RE42C (P) | 4.00 | 18 | 0.75 | 16 | 1.50 |
| RS43C (S) | 4.00 | 18 | 0.75 | 16 | 1.50 |
| RS43C (P) | 4.00 | 18 | 0.75 | 16 | 1.50 |

(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.

## 6 – 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. Three misalignment conditions, which can exist in any combination, are illustrated and described below.




*Misalignment Conditions*

- 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 |

## 7 – 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 ZETA4-240 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 ZETA4-240 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

The ZETA4-240 Drive is shipped with a mating connector for its AC power input. Wire your power cable to this mating connector. (Wiring instructions and a diagram were given earlier in this chapter, under *Connect AC Power* in the *Quick Test* section.) To apply power, plug the connector into the drive's AC power input. Your AC power source should meet the following specifications:

**Specifications – AC Power Input**

| | |
|---|---|
| Input Power: | 240VAC nominal<br>95VAC minimum<br>264VAC maximum<br>50 – 60 Hz |
| Inrush Current: | 25 amps maximum |
| Fuses: | No user serviceable fuses |
| Grounding: | You must provide a proper AC power ground |
| Transformer: | To size stepdown 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 ZETA4-240 Drive requires from your AC power source depends upon the motor you use, whether it is wired in series or parallel, and upon your specific application. The next table shows *peak* power requirements at 240VAC. Power required for your application may be less. (For 120VAC information, see *Appendix C, 120VAC Operations*.)

| Motor Type | Current (Amps) | Cabinet Loss (W) | Peak Motor Loss (W) | Peak Shaft Power (W) | Peak Total Power (W) | Volt-Amp Rating (VA) |
|---|---|---|---|---|---|---|
| RS31C (S) | 2.26 | 46.0 | 131 | 204 | 381 | 611 |
| RS31C (P) | 4.00 | 62.1 | 417 | 393 | 872 | 1337 |
| RS32C (S) | 2.88 | 29.3 | 157 | 230 | 416 | 649 |
| RS32C (P) | 4.00 | 87.7 | 331 | 455 | 873 | 1312 |
| RS33C (S) | 3.50 | 34.2 | 162 | 336 | 532 | 822 |
| RS33C (P) | 4.00 | 76.3 | 342 | 528 | 947 | 1401 |
| RS42C (S) | 3.26 | 39.2 | 94 | 327 | 461 | 758 |
| RS42C (P) | 4.00 | 61.8 | 215 | 537 | 814 | 1258 |
| RE42C (S) | 3.38 | 38.4 | 89 | 461 | 588 | 962 |
| RE42C (P) | 4.00 | 55.1 | 229 | 629 | 913 | 1384 |
| RS43C (S) | 4.00 | 51.9 | 159 | 487 | 697 | 1016 |
| RS43C (P) | 4.00 | 73.7 | 325 | 630 | 1028 | 1526 |

(S) = Series Configuration (P) = Parallel Configuration

## 8 – 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 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 rev 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 shutdown 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 ZETA4-240 Drive, and that the drive is functioning properly. Proceed to the following sections to configure the ZETA4-240 Drive's damping features.

If the test was unsuccessful, observe the LEDs on the front panel of the ZETA4-240 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.

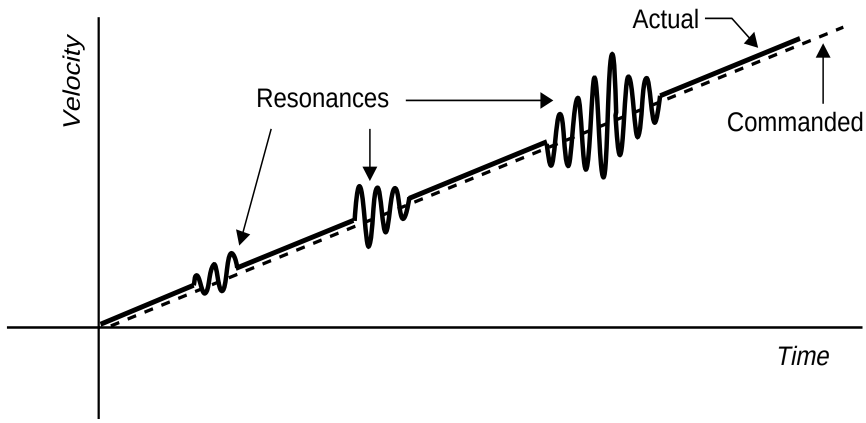
## 9 – RESONANCE, RINGING AND DAMPING – DISCUSSION AND THEORY

In this section we will discuss resonance and ringing in step motors. This information will help you configure the ZETA4-240 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*.

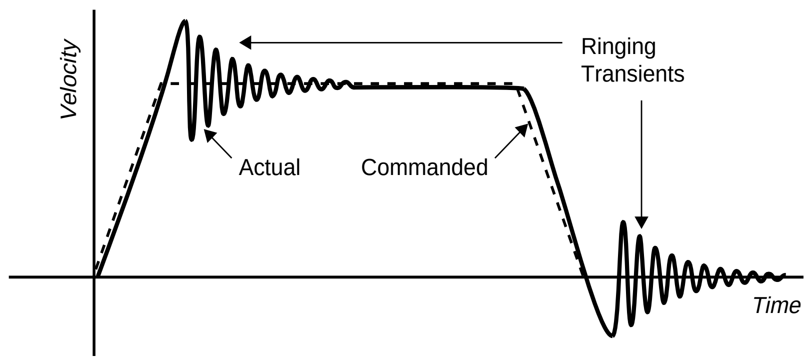
Resonance points can differ in intensity. The drawing shows a typical case—as motor speed increases, resonances of varying levels occur. Usually, the motor can accelerate through the resonance point, and run smoothly at a higher speed. However, if the resonance is extreme, the rotor can be so far out 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 ZETA4-240 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 ZETA4-240 Drive has internal electronics that damp ringing transients, causing them to decay quickly. No external devices are necessary.

## 10 – Damping in the ZETA4-240 Drive

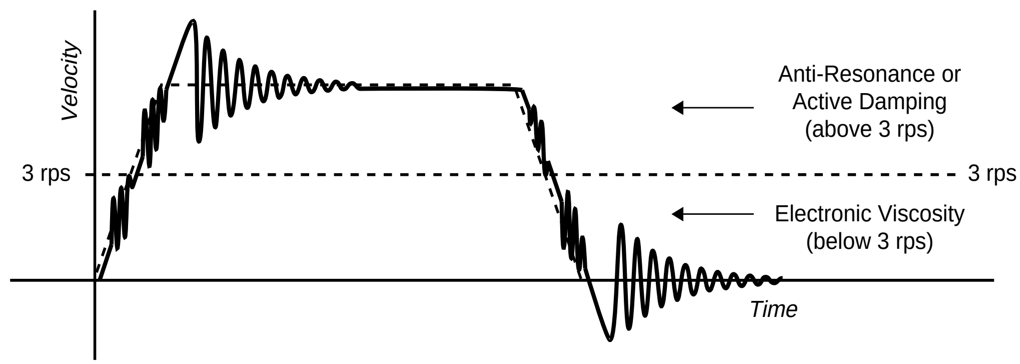
The ZETA4-240 Drive has three different circuits that can damp resonance and ringing.

**Anti-Resonance** – General-purpose damping circuit. The drive ships from the factory with anti-resonance enabled. You can optimize its performance by setting two DIP switches. 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 seven DIP switches (SW2-#6 – SW2-#12) 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.

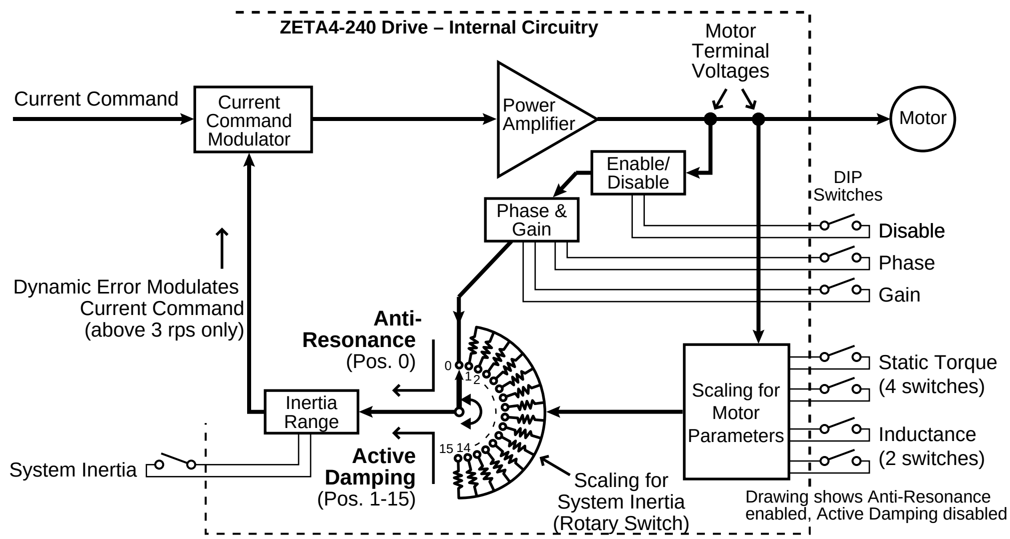
The first two damping circuits—anti-resonance and active damping—work at speeds greater than three revolutions per second (rps). Electronic viscosity works at speeds from rest up to three rps. The drive will automatically switch between the damping circuits, based upon the motor's speed. The next drawing 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 can optimize the circuit by setting two DIP switches. One selects a range for the circuit's phase; the other selects a range for the circuit's gain.

## 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, static torque and inertia range. 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 the circuit damps oscillations, and lasts a very brief time.

## Electronic Viscosity (EV)

The ZETA4-240 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 ZETA4-240 Drive's damping circuits provide increased smoothness, reduced audible noise, and better performance.

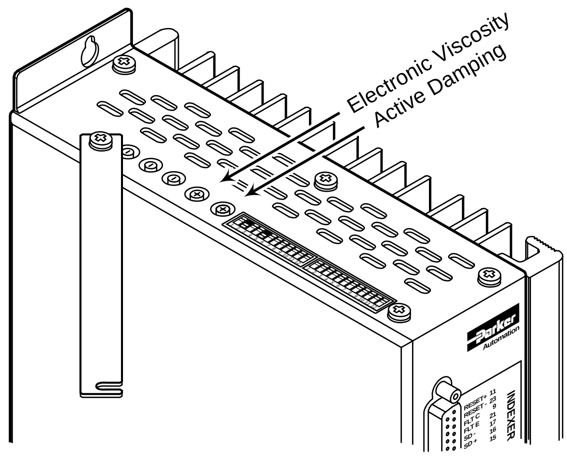
If you choose not to use active damping and electronic viscosity, at least use anti-resonance. Verify that anti-resonance is enabled (DIP SW2-#2 off), and that the rotary switches on the front of the drive, for active damping and electronic viscosity, are set to zero.

## 11 – Set Rotary Switches To Zero

The ZETA4-240 Drive has two rotary switches located behind the movable cover plate on top of the drive:

| | |
|---|---|
| 10–Position Switch: | for Electronic Viscosity (positions 0 – 7 are active) |
| 16–Position Switch: | for Active Damping |

Set each switch to zero. 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.




*Rotary Switch Location*

## 12 – Configure Active Damping

Follow these steps to configure the active damping circuit.

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 re-match your system.

2. **Verify Correct DIP Switch Settings**

| | | |
|---|---|---|
| Anti-Resonance | SW2-#2 | switch in *OFF* position |
| Inductance | SW2-#7 – #8 | set for your motor |
| Static Torque | SW2-#9 – #12 | 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.

**DIP SW2–#6 in *OFF* Position (Low Inertia Range)**

| Switch Position | Total Inertia (kg-cm²) | Total Inertia (kg-m²x 10⁻⁶) | Total Inertia (oz-in²) |
|---|---|---|---|
| 15 | 0.088 – 0.205 | 8.8 – 20.5 | 0.481 – 1.121 |
| 14 | 0.205 – 0.572 | 20.5 – 57.2 | 1.121 – 3.127 |
| 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 – 11.760 | 959.5 – 1176.0 | 52.460 – 64.297 |
| 4 | 11.760 – 14.245 | 1176.0 – 1424.5 | 64.297 – 77.884 |
| 3 | 14.245 – 15.895 | 1424.5 – 1589.5 | 77.884 – 86.905 |
| 2 | 15.895 – 17.765 | 1589.5 – 1776.5 | 86.905 – 97.130 |
| 1 | 17.765 – 20.570 | 1776.5 – 2057.0 | 97.130 – 112.466 |
| 0 | Active Damping Disabled | | |

**DIP SW2–#6 in *ON* Position (High Inertia Range)**

| Switch Position | Total Inertia (kg-cm²) | Total Inertia (kg-m²x 10⁻⁶) | Total Inertia (oz-in²) |
|---|---|---|---|
| 15 | 13 – 31 | 1324 – 3084 | 75 – 169 |
| 14 | 31 – 86 | 3084 – 8606 | 169 – 471 |
| 13 | 86 – 161 | 8606 – 16084 | 471 – 879 |
| 12 | 161 – 264 | 16084 – 26390 | 879 – 1443 |
| 11 | 264 – 410 | 26390 – 41029 | 1443 – 2243 |
| 10 | 410 – 559 | 41029 – 55894 | 2243 – 3056 |
| 9 | 559 – 755 | 55894 – 75528 | 3056 – 4129 |
| 8 | 755 – 944 | 75528 – 94411 | 4129 – 5162 |
| 7 | 944 – 1210 | 94411 – 121041 | 5162 – 6618 |
| 6 | 1210 – 1444 | 121041 – 144362 | 6618 – 7893 |
| 5 | 1444 – 1769 | 144362 – 176935 | 7893 – 9674 |
| 4 | 1769 – 2143 | 176935 – 214323 | 9674 – 11718 |
| 3 | 2143 – 2391 | 214323 – 239148 | 11718 – 13075 |
| 2 | 2391 – 2673 | 239148 – 267283 | 13075 – 14614 |
| 1 | 2673 – 3095 | 267283 – 309486 | 14614 – 16921 |
| 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**
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.

## 13 – 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**
   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.

## 14 – Record Your System's Configuration Information

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

Axis Name
Motor Size ☐S ☐P
EV Setting
AD Setting

**DIP Switch Settings**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OFF | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | OFF |
| ON | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ON |

*Configuration Information*

This chart is repeated, along with other facts, on the information label located on the side of the ZETA4-240 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.