

## Application Design

The information in this chapter will enable you to:

- ❑ Become familiar with the front panel interface
- ❑ Customize the system to meet your requirements (operating modes and tuning)
- ❑ Understand the use of encoder output signals

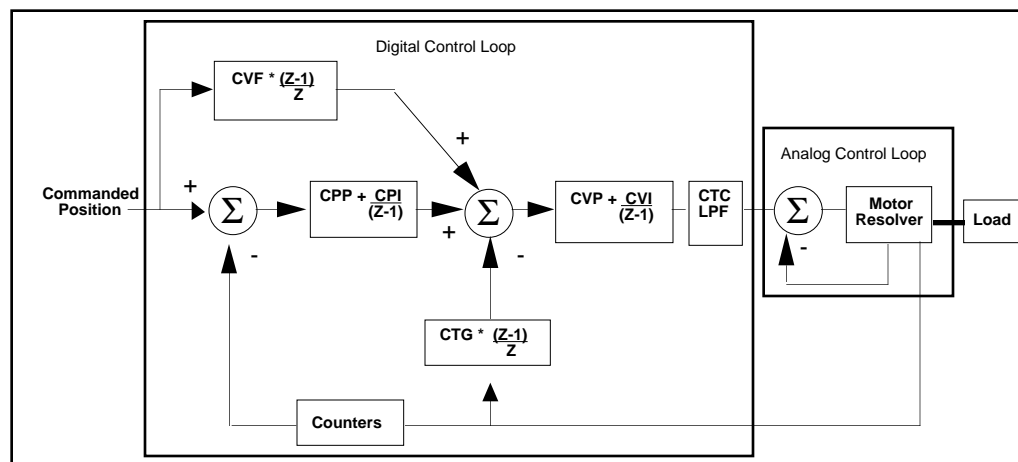
### Basic Servo Tuning Theory

The Z Series Drive employs two basic control loops.

- ❑ Digital Control Loop
- ❑ Analog Control Loop

The *digital control loop* uses information from the resolver and user inputs to determine what the commanded motor currents should be.

The *analog control loop* takes current commands from the digital control loop and pulse width modulates the bus voltage to achieve these currents in the motor.



Digital and Analog Control Loops

The digital control loop has 15 parameters that you can adjust to obtain optimal shaft performance. You cannot adjust the analog control loop. It is configured to run all sixteen Z Series motors (605, 606, 610, 620, 630, 640, 805, 806, 810, 820, 830, 840, 910, 920, 930, and 940) at optimum performance without modification. To ensure that the system operates properly, you must select the correct motor size with the Configure Motor (CMTR) command (refer to Chapter 4 Software Reference).

Tuning parameters can vary significantly in each operating mode (Position mode, Velocity mode, or Torque mode). To simplify the task of tuning, default tuning parameters are stored for each motor size in each mode. If the default parameters do not provide adequate performance, you can manually tune the drive with the front panel interface or the RS-232C interface. All tuning parameters are accessible via the RS-232C interface; however, only some are accessible via the front panel.

Command	RS-232C	Front Panel	Tuning Commands
CPD	Yes	Yes	Configure Position Derivative
CPDM	Yes	No	Configure Position Derivative Maximum
CPI	Yes	Yes	Configure Position Integral
CPIM	Yes	No	Configure Position Integral Maximum
CPP	Yes	Yes	Configure Position Proportional
CPPM	Yes	No	Configure Position Proportional Maximum
CTC	Yes	No	Configure Time Constant
CTG	Yes	Yes	Configure Tach Gain
CTGM	Yes	No	Configure Tach Gain Maximum
CVF	Yes	No	Configure Velocity Feed-Forward
CVFM	Yes	No	Configure Velocity Feed-Forward Maximum
CVI	Yes	No	Configure Velocity Integral
CVIM	Yes	No	Configure Velocity Integral Maximum
CVP	Yes	Yes	Configure Velocity Proportional
CVPM	Yes	No	Configure Velocity Proportional Maximum

#### Tuning Parameter Commands

## Tuning Procedure

If you are using the Z Drive for the first time, Compumotor recommends that you use the RS-232C interface. This interface provides access to all of the tuning parameters and gives you real-time access to some of the control variables. Two basic commands—DDI (Display Drive Information) and DSP (Display Servo Picture)—are designed to help you tune the drive. The DDI command lists all the tuning parameters as well as motor's resolution, drive configuration, etc. You can use this command to verify the drive's current operating mode. A sample DDI command response is shown below.

	PP	PI	PD	VP	VI	VF	TG
* PERCENT	50	05	00	10	00	60	60
* MAXIMUM	10000	00400	32000	10000	00000	32000	32000

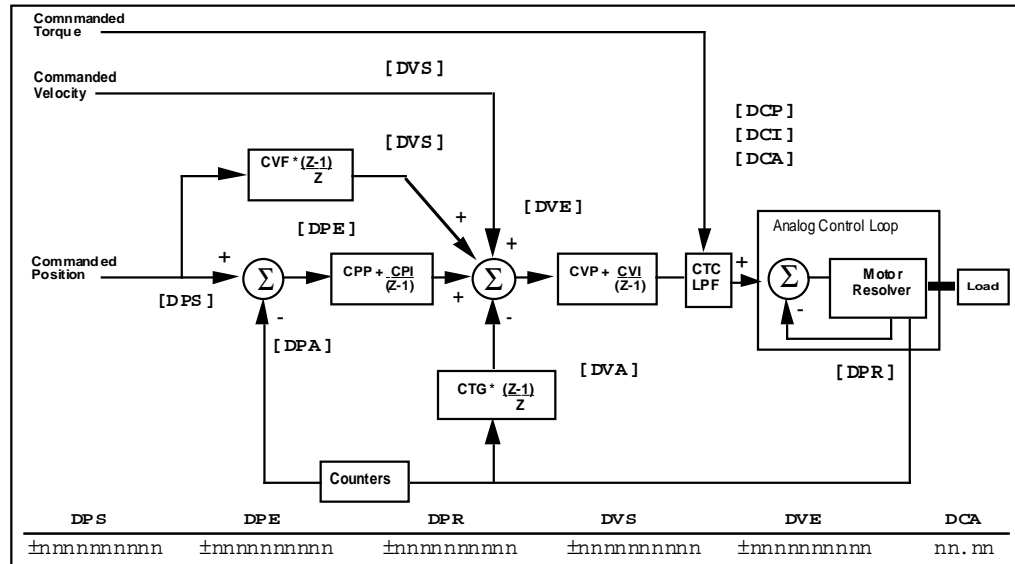
\*TIME\_CONSTANT=00005 (\*100 MICROSECONDS)  
 \*AVE\_CURRENT\_LIMIT=20.00\_AMPS  
 \*PEAK\_CURRENT\_LIMIT=40.00\_AMPS  
 \*MOTOR\_RESOLUTION=05090  
 \*RESOLVER\_RESOLUTION=AUTO  
 \*MOTOR\_TYPE=Z620

All the gain commands have a maximum limit. This is done to provide a wide dynamic range. For example, the gain term PP (Position Proportional) can vary from 0-99% using the CPP command. The maximum CPPM value can vary from 0 - 32,767. The equation below illustrates the number that is actually used in the control loop assuming that CPP = 50 and CPPM = 10000.

$$\begin{aligned}
 \text{Position Proportional gain} &= (\text{CPP}/100) * \text{CPPM} \\
 &= 50\% * 10000 \\
 &= 5000
 \end{aligned}$$

The DSP command gives you near real-time servo parameters. Use this command to get an approximate real-time preview of what the control loop is doing and how changing the parameters will affect the system. The software commands in brackets [ ] are the actual data in the loop. These variables are continuously updated. These commands are defined below.

**Helpful Hint:**  
A DSP command and the different parameters that you can display while the drive is operating.



Display Servo Picture Command (DSP) Response

The following display commands will help you tune the Z Drive.

DCA: Display Current Average

This command displays the Z Drive's average current.

DCP: Display Current Peak

This command displays the Z Drive's peak current.

DPS: Display Position Setpoint

This command displays the actual number of steps received from an indexer or pulse generator. This display is inactive in velocity and torque mode operation.

DPA: Display Position Actual

This command displays the motor shaft's actual position.

DPE: Display Position Error

This command displays the difference between the commanded and actual position in user-defined resolution.

DPR: Display Position Resolver

This command displays the position of the resolver. It rolls over numerically every mechanical revolution.

DVS: Display Velocity Setpoint

This command displays the desired velocity. In Position mode, this would correspond to the rate of change in steps.

DVA: Display Velocity Actual

This command displays the actual motor shaft velocity in rpm.

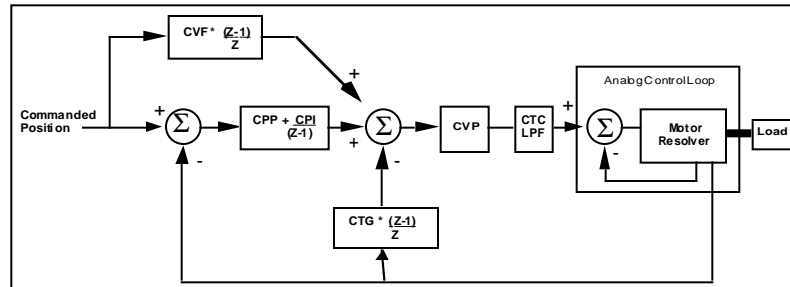
DVE: Display Velocity Error

This command displays the difference in the commanded velocity and the actual velocity in rpm.

# Servo Tuning

The Z Drive's microprocessor-based indexer internally generates position setpoint commands while the Z Drive's DSP closes the position loop.

**Helpful Hint:**  
This figure illustrates the active part of the control loop.



Z Drive Tuning

The following table contains the Z Drive's tuning commands.

Command	Tuning Commands
CPD	Configure Position Derivative
CPDM	Configure Position Derivative Maximum
CPI	Configure Position Integral
CPIM	Configure Position Integral Maximum
CPP	Configure Position Proportional
CPPM	Configure Position Proportional Maximum
CTC	Configure Time Constant
CTG	Configure Tach Gain
CTGM	Configure Tach Gain Maximum
CVF	Configure Velocity Feed-Forward
CVFM	Configure Velocity Feed-Forward Maximum
CVP	Configure Velocity Proportional
CVPM	Configure Velocity Proportional Maximum

Tuning Commands

CPP: Configure Position loop Proportional Gain

This command directly reflects the *stiffness* of the system. Generally, you want this gain as high as possible without causing the system to oscillate.

CPI: Configure Position Loop Integral Gain

This command directly influences the final position accuracy. In the default mode, it is turned on, but only slightly. It is error-limited to prevent integral windup.

CPD: Configure Position Loop Derivative Gain

This command sets both the digital tach gain and the velocity feed-forward gain to the same value. It has the effect of *damping* the system response. This gain is increased if the motor oscillates at zero commanded position.

CVP: Configure Velocity Loop Proportional Gain

This command directly reflects the *stiffness* of the system similar to the CPP command. Generally, you want this gain as high as possible without causing the system to oscillate. The only difference with this command relative to CPP is that it takes into account the velocity tach gain.

CVF: Configure Velocity Feed-forward Gain

This term reduces the position loop following error only when the shaft is turning. It does not affect the system's dynamics.

CTG: Configure Tach Gain

This term allows additional damping. If you increase this term, the system will become sluggish, but you will be able to stabilize large inertias.

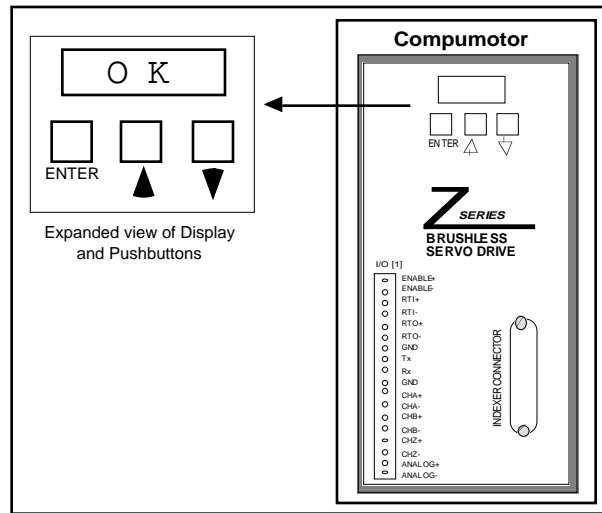
CTC: Configure Torque Time Constant

This command filters the output response of the digital controller. The motor is *commutated* every 100  $\mu$ s and the servo loop is updated every 500  $\mu$ s. In between each servo update, the commutation can use an average torque commanded value. The default is to 500  $\mu$ s (CTC5). This effectively low-pass filters the torque command signal with a -3dB frequency of 2000 Hz. You can change this value to decrease the low-pass filter frequency. This will lower the drive's bandwidth.

# Alphanumeric Display and Pushbuttons

The Z Drive has a four-character, dot-matrix, alphanumeric display. All error messages are scrolled across the display when a fault occurs.

**Helpful Hint:**  
You can modify many drive parameters with the three pushbuttons.



Z Drive Display and Pushbuttons

## Fault Messages

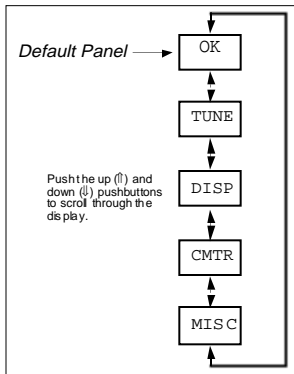
When a fault occurs, the corresponding fault message will appear. A fault code followed by a description of the fault scroll across the display.

Example: **ERROR #04 > OVER\_VOLTAGE**

Fault messages are displayed continually until the fault is removed and the drive is turned on again. Refer to *Chapter 8 Maintenance & Troubleshooting* for a complete list of error messages and troubleshooting methods.

## Pushbutton Operation

You can use the Z Drive's pushbuttons to modify drive parameters and to display several drive variables. The figure (left column) is an overview of the Main menu panels and sub-panels. Although only one panel is shown on the display at a time, the Z Drive's display operates in a menu-driven format.



Main Menu Panel (Overview)

The default value for the drive's Configure Pushbuttons (CPB) command is CPB1. This fully enables the front panel. CPB0 provides you with access to all front panel displays. CPB0, however, will not let you activate any of the menus.

OK is the default message. It indicates that you are in the main menu. Use the up and down pushbuttons to view the menu items in the following order:

- **OK** Default user message, the home panel
- **TUNE** Tune Menu
- **DISP** Display Menu
- **CMTR** Configure Motor Menu
- **MISC** Miscellaneous Menu

To choose a menu, press the up and down pushbuttons to display the menu you want. Press **ENTER** to access the sub-panel menu. Each menu is discussed in detail below.

O K	T U N E	D I S P	C M T R	M I S C
Home Panel	P P n n	D V E L	6 0 5	S A V E
	P I n n	D E R R	6 0 6	R F S
	P D n n	D C A	6 1 0	B R m m
	T G n n		6 2 0	A D p p
	V P n n		6 3 0	FOLL/NTFL
	V I n n		6 3 5	SEQU
	V F n n		6 4 0	REV#
			8 0 5	JOG
			8 0 6	
			8 1 0	
		8 2 0		
		8 3 0		
		8 4 0		
		9 1 0		
		9 2 0		
		9 3 0		
		9 4 0		
		F M C A		

Main Menu Panel for a Z Series System (Overview)

Pressing the **UP** and **DOWN** pushbuttons at the same time will return the display to the *Home* panel, regardless of the sub-menu that you are currently using. If you do not press any pushbuttons for several seconds, the display will also return to the home panel.

If an error message is scrolling when the front panel is accessed, the scrolling will be interrupted. When no pushbutton is pressed for several seconds, the scrolling message will return.

If you hold a pushbutton, the selected feature will repeat automatically. If you hold a pushbutton for several seconds, the selected feature will repeat automatically at an accelerated pace. To reset the drive, press the **UP**, **DOWN**, and **ENTER** pushbuttons together (works like the Reset [Z] command).

## TUNE Menu


Select the **TUNE** menu to adjust the system gains for optimum performance. **The drive is factory-configured for typical user loads. Hence, many applications do not require tuning.** The following gains are available.

- PPnn** Position Proportional Gain
- PInn** Position Integral Gain
- PDnn** Position Derivative Gain
- TGnn** Tachometer Gain
- VPnn** Velocity Proportional Gain
- VI nn** Velocity Integral Gain
- VFnn** Velocity Feed-forward Gain

The variable **nn** represents a percentage ranging from **00** to **99**. Use the **UP** and **DOWN** pushbuttons to locate the desired gain parameter on the display panel. To change the gain value, press and hold the **ENTER** pushbutton while using the **UP** or **DOWN** pushbuttons to increase or decrease the gain. When the desired value is reached, release the **UP** or **DOWN** pushbutton and the **ENTER** pushbutton. After you modify the gain, you can now change another gain or press the **UP** and **DOWN** pushbuttons together to return to the main menu. To change the maximum gain values, you must use a terminal and communicate via *RS-232C*.

## DISP Menu

Select the **DISP** menu to display drive parameters on the front panel. To review the respective numerical values, press the **ENTER** pushbutton. The following parameters are may be displayed:

 **Helpful Hint:**  
To return to the Main menu, press **UP** and **DOWN** simultaneously.

- DVEL** Display Actual Shaft Velocity in rpm
- DERR** Display Position error in steps (-999 to +999)
- DCA** Display Average Current X 100 (0234=2.34 amps)

## CMTR Menu

Select the **CMTR** menu to configure the motor type (**CMTR** command). The following choices are available:

- |                              |                              |  |
|------------------------------|------------------------------|--|
| <input type="checkbox"/> 605 | <input type="checkbox"/> 805 | <input type="checkbox"/> 910                                       |
| <input type="checkbox"/> 606 | <input type="checkbox"/> 806 | <input type="checkbox"/> 920                                       |
| <input type="checkbox"/> 610 | <input type="checkbox"/> 810 | <input type="checkbox"/> 930                                       |
| <input type="checkbox"/> 620 | <input type="checkbox"/> 820 | <input type="checkbox"/> 940                                       |
| <input type="checkbox"/> 630 | <input type="checkbox"/> 830 | <input type="checkbox"/> <b>FMCA: Find Motor Commutation Angle</b> |
| <input type="checkbox"/> 635 | <input type="checkbox"/> 840 |  |
| <input type="checkbox"/> 640 |                              |  |

To select a motor size, locating the desired motor size with the up and down pushbuttons and press the **ENTER** pushbutton. The preset motor size is designated by an asterisk. Changing motor sizes also changes some of the tuning parameters. The drive has been configured at the factory for the motor type that you ordered. *If you change motor sizes, be sure to enter the proper **CMTR** value.*

### **WARNING**

Disconnect the load prior to re-commutating the motor. System damage and/or personal injury can occur during re-commutation if the load is attached.

This command recalculates the mechanical offset between the rotor poles and the stator poles. The offset is factory-set to zero, but you can recalibrate the offset if you select the **FMCA** panel and press the **ENTER** pushbutton to select the **FMCA** command. This command locates the rotor magnets relative to the stator windings and allows you to properly commutate the motor. *All of Compumotor's resolvers are pre-aligned to the rotors at the factory, so this procedure is not usually necessary.*

## MISC Menu

Selecting the **MISC** menu allows you to perform a variety of functions. The following section explains the submenu choices and their functions.

- SAVE** Saves the servo tuning parameters to battery-backed RAM. To use, press the **ENTER** pushbutton. **\*SV\*** will be displayed when this function is executed.
- RFS** This option returns all servo parameters to factory settings. To use this command, press the **ENTER** pushbutton. **FSET** will be displayed after the command is executed.
- BRnn** This option allows you to change the baud rate (**nn** = 03, 06, 12, 24, 48, and 96—these values represent baud rates 300, 600, 1200, 2400, 4800, and 9600 respectively). To change the baud rate, press the **ENTER** and **UP** or **DOWN** pushbuttons simultaneously (as appropriate).
- ADpp** This option allows you to change the device address (**pp** represents a device address from 01 to 99). To change the device address, press the **ENTER** and **UP** or **DOWN** pushbuttons simultaneously (as appropriate).
- REV#** When you press the **ENTER** pushbutton, this menu displays the current microprocessor and DSP software revision levels (respectively).

## Tuning in Different Modes of Operation

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The Z Drive has three modes of operation.

- Position Mode
- Velocity Mode
- Torque Mode

Each mode of operation has a unique tuning procedure.

## Position Mode

Position mode (CZM1) is the default operating mode of the Z Drive. The Z Drive interprets incoming Step/Direction pulses as position commands. A constant step rate represents constant velocity, and an increasing (decreasing) step rate represents acceleration (deceleration).

 **Helpful Hint:**  
Position Mode Tuning  
Procedure

Use the following steps to tune the Z Drive in Position mode.

- Step ①** Set motor resolution to the proper number of steps/rev you desire (refer to **CMR** command in *Chapter 6 Software Reference*). The default is 5000 steps/rev.
- Step ②** Check to make sure the **CMTR** command reports back the actual motor you are using. If it is wrong, change it with the **CMTR** command (refer to *Chapter 6 Software Reference*).
- Step ③** Attach the load and make your desired move with the default settings. Pay careful attention to the response time, end-of-position overshoot, following error, etc.
- Step ④** Vary parameters to improve your performance if needed. Some common performance problems and suggested tuning procedures on how to improve performance are listed below.

**Shaft Seems Spongy**

*Solution Procedure:*

- ① Increase **CPP**
- ② Increase **CVP**
- ③ Decrease **CTG**
- ④ Increase **CPI**

**Shaft Oscillates**

*Solution Procedure:*

- ① Increase **CTG**
- ② Decrease **CVP**
- ③ Decrease **CPP**
- ④ Decrease **CPI**

**Shaft Overshoots at End of Move**

*Solution Procedure:*

- ① Decrease **CPI**
- ② Increase **CTG**

**Shaft Has Too Much Following Error During Move**


*Solution Procedure:*

- ① Increase **CVF**
- ② Decrease **CTG**
- ③ Increase allowable **CPE**

- Step ⑤** When performance is acceptable, you can save your gain parameters with a **Save (SV)** command over RS-232C or with the front panel display (press the **ENTER** pushbutton in the **SAVE** display).

## Torque Mode

You can control motor torque directly by running the Z Drive in Torque mode (CZM2). The analog voltage input is located on the I/O[1] connector. When the terminals are shorted, the Analog+/Analog- input represents no commanded torque. A positive voltage at Analog+ with respect to Analog- represents torque in the CW direction. A negative voltage represents torque in the CCW direction.

 **Helpful Hint:**  
If you run the Z Drive in Torque mode, consider the following Torque mode characteristics.

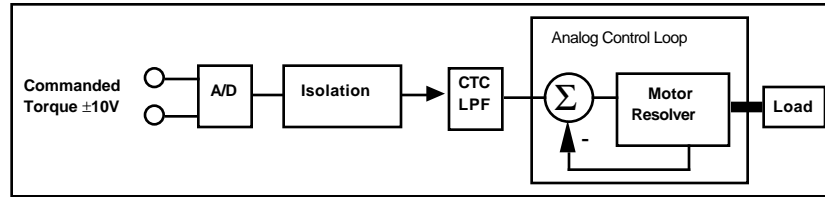
- All position and velocity control parameters are set to zero when Torque mode is activated.
- The default setting for analog voltage is 10V it equals the maximum rated continuous current. This parameter can be adjusted to a larger value.  
For example, a Z610 motor has a continuous rated current of 20A. The default value for the Analog Voltage Range (**ANV**) command is 10V = 20A for the Z610 motor. You can enter **ANV40** to change the value to 10V = 40A. However, if you request 40A for more than 3.3 seconds, the drive will shutdown due to excessive average current.

- ❑ The torque angle is set to 90° for CW torque and -90° for CCW torque. There is some automatic phase advancing done to maintain maximum shaft torque as a function of shaft speed.
- ❑ If the motor creeps at zero commanded torque, use the Analog Voltage Zero (ANZ) command to recalibrate the zero commanded torque.

Torque mode operation uses even a smaller part of the servo controller.

*There is virtually no tuning in Torque mode.* Only the CTC command, which adds additional filtering, can be used.

**Helpful Hint:**  
Active control loop



Torque Mode Tuning

There are three additional commands that facilitate Torque mode.

- ❑ The Analog Voltage Range (ANV) command
- ❑ The Analog Zero (ANZ) command
- ❑ The Analog Deadband (ANDB) command

ANV: Analog Voltage Range

This command sets the relationship between the analog voltage and the commanded torque. The default ANV setting is such that +10V is equivalent to the maximum continuous CW torque and -10V is equivalent to the maximum continuous CCW torque. This scaling factor can be changed such that +10V equates to the maximum peak CW torque, however, be aware that you can only command peak torque for 4.0 seconds before the drive faults.

ANZ: Analog Zero

You can use ANZ command to subtract any offset voltage that may be causing the motor to creep at zero commanded torque (0V). This command can also be used to operate the drive from 0V - 10V. You can set the the input voltage to 5V, issue the ANZ command, and 5V - 10V will correspond to CW torque and 0 - 5V as CCW torque (-10V to 0V will also be interpreted as CCW torque).

ANDB: Analog Deadband

The ANDB command sets the deadband window around zero commanded torque. If the motor oscillates, significant noise may be coupled on the analog input lines. Follow recommended noise immunity practices (proper grounding, twisted pair of control wires, etc.). If the motor still creeps, you can set the deadband window in units of tens of mV. An ANDB.1 command will require a signal of at least 100mV to be interpreted as a torque command. Normally, this deadband window is centered around 0V; however, in the case above where ANZ positioned the zero torque command at 5V, ANDB will center around 5V.

## Velocity Mode

You can control motor velocity by running the Z Drive in Velocity mode (CZM3). In Velocity mode, the drive accepts a ±10V analog signal that represents commanded motor velocity. The analog voltage input is located on the I/O[1] connector. When the terminals are shorted, the Analog+/Analog- input represents no commanded velocity. A positive voltage at Analog+ with respect to Analog- represents velocity in the CW direction. A negative voltage represents velocity in the CCW direction.

In Velocity mode, you command an analog voltage between ±10V representing velocity. This signal is digitized and compared to the actual velocity of the shaft. The resolution of the signal is ±1.7 rpm. There are three additional commands that facilitate the use of Velocity mode.

- ❑ The Analog Voltage Range (ANV) command
- ❑ The Analog Zero (ANZ) command
- ❑ The Analog Deadband (ANDB) command

ANV: Analog Voltage Range

ANV sets the relationship between the analog voltage and the commanded velocity. The default setting of this command is such that +10V is equivalent to the maximum continuous CW velocity and -10V is equivalent to the maximum continuous CCW velocity. This scaling factor can be changed such that +10V equates to values greater than the maximum continuous velocity.

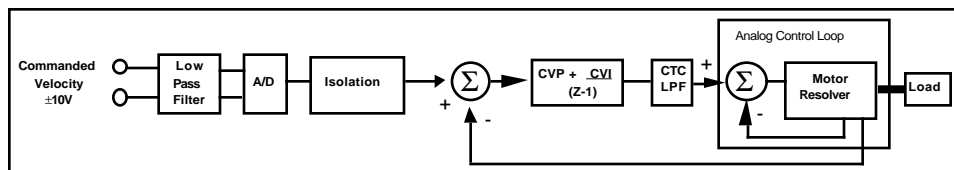
ANZ: Analog Zero

ANZ subtracts any offset voltage that may be causing the motor to creep at zero commanded velocity (0V). This command can also be used to operate the drive from 0 - 10V. You can set the the input voltage to 5V, issue the ANZ command, and 5V - 10V will correspond to CW velocity and 0 - 5V as CCW velocity (-10V to 0V will also be interpreted as CCW velocity).

ANDB: Analog Deadband

ANDB sets the deadband window around zero commanded velocity. If the motor oscillates, significant noise may be coupled on the analog input lines. Follow recommended noise immunity practices (proper grounding, twisted pair of control wires, etc.). If the motor still creeps, you can set the deadband window in units of 10's of mV. An ANDB.1 command will require a signal of at least 100 mV to be interpreted as a velocity command. Normally, this deadband window is centered around 0V; however, in the case above where ANZ positioned the zero velocity command at 5V, ANDB will center around 5V.

**Helpful Hint:**  
Velocity mode uses a smaller part of the servo controller.



Velocity Mode Tuning

The following gains affect shaft performance in Velocity mode:

CVP: Configure Velocity Loop Proportional Gain

This command directly reflects the *stiffness* of the system. Generally, you want this gain as high as possible without causing the system to oscillate.

CVI: Configure Velocity Loop Integral Gain

This command will tend to zero out any velocity error. It will also increase the shaft stiffness.

CTG: Configure Tach Gain

This term is automatically set to 1 in the controller.

CTC: Configure Torque Time Constant

CTC filters the output response of the digital controller. The motor current is *commutated* every 100 μs and the velocity servo loop is updated every 500 μs. In between each servo update, the current commands use an average torque value. The default is set to 500 μs (CTC5). This effectively low-pass filters the torque command signal with a -3dB frequency of 2000 Hz. You can change this value so that the low-pass filter frequency can be made lower. This will lower the drive's bandwidth. **This command is most applicable when used with Velocity and Torque modes.**

**Helpful Hint:**  
Velocity Mode Tuning Procedure

Use the following steps to tune the Z Drive in Velocity mode.

Step ①

Set motor resolution to proper number of steps/rev. The default is 5,000 steps/rev.

Step ②

Check to make sure the CMTR command reports back the actual motor you are using. If it is wrong, change it with the CMTR command (Refer to Chapter ⑥ Software Reference).

Step ③

Attach load and make your desired move with the default settings. Pay attention to the response time, velocity overshoot, following error etc.

Step ④

Issue a DSP command and repeat your move.

- Step ⑤ Connect an oscilloscope to the Analog Monitor output. Be sure that the SSR command is set to 0 so that the motor velocity will be sent to the motor Analog Monitor terminals.
- Step ⑥ Vary parameters to improve performance if needed. Sample performance problems and suggested tuning procedures to resolve them are listed below.
- |  |  |
|--|--|
| <b>System Seems Too Spongy</b>             | <p><i>Solution Procedure:</i></p> <ol style="list-style-type: none"> <li>① Increase CVP</li> <li>② Increase CVI</li> </ol> <p>Shaft Oscillates</p> |
| <b>Shaft Oscillates</b>                    | <p><i>Solution Procedure:</i></p> <ol style="list-style-type: none"> <li>① Decrease CVP</li> <li>② Decrease CVI</li> <li>③ Increase CTC</li> </ol> |
| <b>Motor Creeps with Zero Voltage (0V)</b> | <p><i>Solution Procedure:</i></p> <ol style="list-style-type: none"> <li>① Issue an ANZ command</li> <li>② Increase ANDB</li> </ol>                |
| <b>Slow-Speed Performance Rough</b>        | <p><i>Solution Procedure:</i></p> <ol style="list-style-type: none"> <li>① Decrease ANV</li> <li>② Increase CVP</li> </ol>                         |
- Step ⑦ When performance is acceptable, you can save your gain parameters with a Save (SV) command or with the front panel display (press the ENTER pushbutton in the SAVE display).

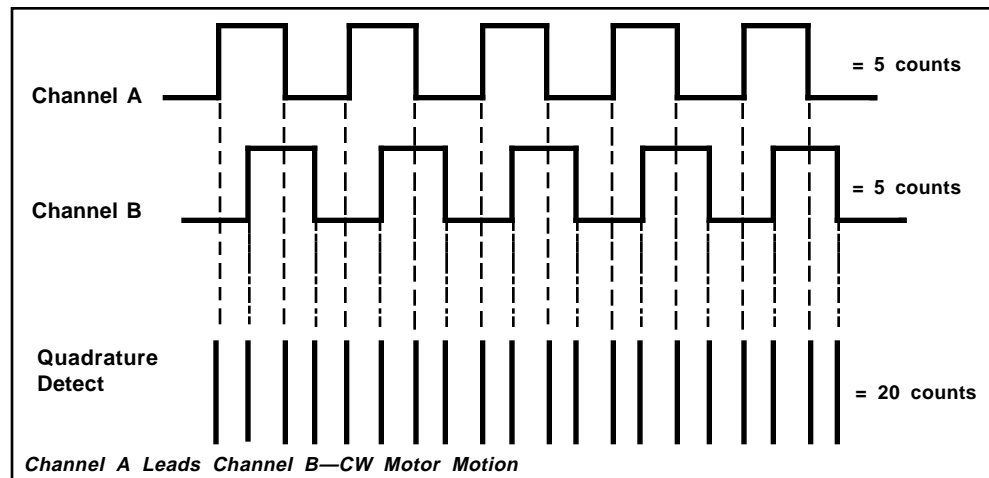
## Pseudo-Quadrature Outputs

The Z Drive's pseudo-quadrature outputs are located on screw terminal I/O[1]. These quadrature outputs are called **pseudo** because they are hardware-derived from resolver information and not from an actual encoder. The resolution is 1024 counts per revolution—pre-quadrature or 4096 counts per revolution—post-quadrature. Three signals constitute the pseudo-quadrature outputs:

- Channel A (CHA)
- Channel B (CHB)
- Channel Z (CHZ)

Channels A and B produce two square waves that are 90 electrical degrees apart. The position of the motor shaft can be determined by counting pulses. Direction can be determined by comparing the phase shift of Channel A relative to Channel B (e.g., if Channel A leads Channel B, the motor shaft is moving CW).

**Helpful Hint:** Many Compumotor indexers and controllers have a quadrature detect circuit that can enhance motor resolution. By monitoring the rising and falling edges of CHA and CHB, each pulse is equivalent to four counts. In this way, the 1024 counts are translated into 4096 counts.



Quadrature Detection

The Z Channel, or marker, provides a reference pulse once per revolution. The Z marker will appear at the same time as the **DPR** (Display Position Resolver) command shows the resolver information changing from 00000 to 65535 or vice versa.

The quadrature outputs are true differential or complementary outputs. The use of complementary outputs increases the system's noise immunity. When Channel A+ (CHA+) goes high, Channel A- (CHA-) goes low, and vice versa.

With all servo drives, the motor shaft position may be changing  $\pm 1$  or more resolver counts, even when the shaft appears still. If the drive is servoing around the roll-over point of the resolver data, the Z pulse will appear each time the data goes from 00000 to 65535 or from 65535 to 00000.

*The pseudo-quadrature outputs are derived from the resolver's digital information. Using automatic resolver resolution switching (refer to the **Configure Resolver Resolution (CRR)** command in Chapter 6 **Software Reference**) will cause errors in the quadrature outputs when the resolver's resolution is changed.*

*If you will be accelerating through any resolver switching points, use a fixed resolver resolution (e.g., **CRR12**) to get correct quadrature outputs.*