C H A P T E R ④

Control Mode & Adjustment

The information in this chapter will enable you to:

- ❑ Effectively use the operating modes and adjust the system to meet your application's needs
- ❑ Recognize and understand important considerations that must be addressed before you implement your application
- ❑ Understand the system's capabilities

Position Control Mode Adjustment

In the Position Control mode, motor positioning control is performed according to the command position sent from the higher-level controller. Two control methods are available in the Position Control mode: the I-PD type control system is selected with the CN1 connector IACT/PACT signal set to H, and the P type control system, with the same signal set to L. Usually, the I-PD type control system is selected in the Positioning mode.

I-PD Type Position Control

This method uses position integral feedback and is suitable for applications that require highy accurate positioning. A stable control characteristic is achieved even under load variation. In this mode, adjustments of **fc switch**, **LIM∫ switch** and **DC Gain** variable resistor are necessary.

fc Switch

The fc switch, which controls the *characteristic frequency*, is a 16-position rotary switch. The switch's values represent frequencies of 1-16Hz. The fc value can be set remotely with pins 1-8 on the CN1 connector (**FNØ - FN3**). When using the rotary switch,, **FNØ - FN3** must all be set to **H** (no connection). The value is a logical **AND** between the rotary switch and **FNØ - FN3**, ***Chapter*** ③ ***Installation*** (*Compliance Control Gain Setting* section), discusses the relationship between the switch and the inputs.

LIM Switch

This switch prevents the wind-up phenomenon by limiting the output of the digital integrator during software servo computation. The larger the switch number, the larger the limit value. The smaller the limited value, the smaller the wind-up and the shorter the setting time. However, if the limited value becomes too small, the motor output torque is limited. Therefore, it is better to make the switch value large within the no wind-up range. Wind-up is not always evident in Test mode, so final adjustment is performed during normal operation.

DC Gain Variable Resistor

The **DC Gain** variable resistor set the overall velocity loop gain. The **DC Gain** variable resistor is a single turn pot that carries a non-dimensional value of 0.5 to 5. **DC Gain** should be set as high as possible without the system vibrating, since this will result in the most responsive system. As a rule of thumb, the **DC Gain** needs to increase as the inertia is increased.

The combination of driver **CN1** connector signals **GAIN H** to **L** and the **DC Gain** variable resistor results in an adjustment range of from **0.5** to **110** times. When large inertias are present, it will be necessary to use the scale factors (**Gain H** to**L**) to access adequate **DC GAIN**. When there is an inertial change, adjust the gain so that it becomes optimum at the maximum load.

P Type Position Control

Positioning accuracy is not high because proportional control is used for positioning feedback. This position control can be set for P and I types. Refer to *Control mode, Jumper settings*.

With the P type position control (P-P type), a torque output which is proportional to the positioning error is obtained, and compliance control is possible. In this control mode, only fc switch and DC gain control are adjusted.

With the I type position control, a high tact positioning can be achieved. In this control mode, the amount of velocity feed-forward is adjusted with a jumper in addition to DC switch, DC gain control, and AC gain control.

Position Control System Adjustment Procedure

The position control system can be adjusted in the test mode. Turning ON the test switch at the front of the driver generates a 2.4Hz square-wave position command signal inside the driver to output the motor position to the POSN signal terminals. At this time, ensure that the motor exhibits reciprocal action at very small rotating angles.

The adjustment procedure for I-PD type position control in the test mode is as follows:

Step ① **Connect an oscilloscope to the POSN signal terminals**

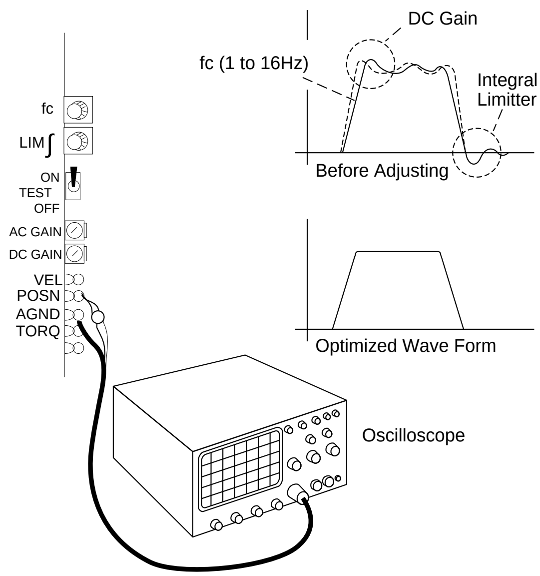
Step ② **Set the CN1 connector SERVO signal to L. Set the TEST switch to OFF.**

Step ③ **Set the TEST switch on the front of the driver to ON.**

Step ④ **Adjust the fc switch. Its variable range is from 1 to 16Hz and it should be set to about 10Hz scale graduation: 9) under normal load conditions. Set the I.LIM switch to a large value within the range where there is no hunting. Select the I.LIM switch GAIN H to L signal so they match the load condition. Fine adjustment is done using the DC gain adjustments so the POSN signal becomes a square wave.**

Step ⑤ **Set the TEST switch on the front of the driver to OFF.**

Step ⑥ **Set the CN1 connector SERVO signal to H.**



The adjustment procedure for P-I type position control in the Test mode is as follows

Step ① **Connect an oscilloscope to the POSN signal terminals**

Step ② **Set the CN1 connector SERVO signal to L. Set the TEST switch to OFF.**

Step ③ **Set the TEST switch on the front of the driver to ON.**

Step ④ **Adjust the fc switch. Its variable range is from 1 to 16Hz and it should be set around the center position under normal load conditions.**

Set the AC gain control to a large value within the range in which there is no hunting.

Fine adjustment is done using the DC gain control.

Perform the above adjustments so the POSN signal becomes a square wave.

Step ⑤ **Set the TEST switch on the front of the driver to OFF.**

Step ⑥ **Set the CN1 connector SERVO signal to H.**

Procedure for Adjustment without Measuring Instruments

The preceding section demonstrates the procedure for performing adjustments while monitoring the waveform; this section demonstrates an adjustment procedure that does not use any measuring instruments. These adjustment methods are valid only in the case of the Position Control mode (P-ID type, factory default setting).

① Calculate or otherwise verify the load inertia. In order to make use of this adjustment method, the load inertia must be known accurately. At this time, calculate the load multiple (K) by dividing the load inertia (J_L: kg•m^2 units) by the motor (Dynaserv) rotor inertia (J_M).

② Set the TEST switch on the front panel to ON.

③ Take the computed load multiple and refer to the following tables. For example, suppose the K is [15] for a DR1200A; the 5 range applies for this case.

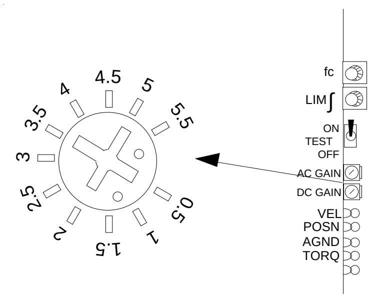
④ The value in DC gain (column 1) is 25, set the control to 25.

When the value for either A or B series is within range 1 or 2 (DC gain is 5 or less), change the DC gain switching signal to H before carrying out the setting.

⑤ Similarly, take the Column 1 values for fc and LIM∫ in the same row, and set their respective controls to those values.

⑥ When the above settings have been completed, set the TEST switch to [OFF] to complete the adjustments.

Note: The GAIN value for signal selection shown below is multiplied by the DC GAIN level value to obtain the total gain.



Setting The Dynaserv Controls

Approximate tuning parameters per inertia ratio (Load to rotor; K)

DR-A Series

		K			Set-Up Value	
Range	DR5500A	DR5400A	DR5300A	DC Gain	fc	LIM¶
1	No load	No Load	No Load	3	E	6
2	—0.4	—0.3	—0.1	4	D	6
3	0.4 —1.7	0.3—1.5	0.1—1.2	8	C	4
4	1.7—4	1.5—3.6	1.2—3.1	13	B	3
5	4—8.6	3.6—7.8	3.1—6.8	25	A	3
6	8.6—22	7.8—20	6.8—18	50	9	1
7	22—31	20—29	18—25	65	8	2
8	31—45	29—41	25—36	80	7	1
9	45—88	41—82	36—55	100	5	2
10	88—136	82—125	55—110	110	2	4

Range	DR1400A	DR1300A	DR1200A	DR1150A	DR1100A	DC Gain	fc	LIM¶
1	-1.2	-0.9	-0.5	-1.4	-0.1	3	E	5
2	1.2-2.3	0.9-1.9	0.5-1.3	0.4-1.2	0.1-0.6	4	D	3
3	2.3-5.6	1.9-4.8	1.3-3.6	1.2-3.3	0.6-2.3	8	C	2
4	5.6-11	4.8-9.7	3.6-7.5	3.3-6.9	2.3-5.1	13	B	2
5	11-22	9.7-19	7.5-15	6.9-14	5.1-11	25	A	2
6	22-55	19-49	15-38	14-36	11-27	50	9	2
7	55-77	49-68	38-54	36-50	27-38	65	8	2
8	77-110	68-97	54-77	50-72	38-55	80	7	2
9	110-166	97-146	77-116	72-108	55-82	100	5	3
10	166-331	146-292	116-232	108-215	82-165	110	2	6

Range	DR1050A	DC Gain	fc	LIM¶
1				
2				
3	-0.2	8	C	3
4	0.2-1.2	13	B	3
5	1.2-3.3	25	A	3
6	3.3-9.4	50	9	2
7	9.7-13	85	8	2
8	13-20	80	7	2
9	20-30	100	5	3
10	30-60	110	2	5

DR-E Series

Range	DR1250E	DR1220E	DR1180E	DR1130E	DC Gain	fc	LIM¶
1	-1.4	-1.3	-1	-0.8	3	E	4
2	1.4-2.6	1.3-2.4	1-2	0.9-1.7	4	D	3
3	2.6-6.2	2.4-5.9	2-5	1.7-4.4	8	C	3
4	6.2-12	5.9-12	5-10	4.4-8.8	13	B	3
5	12-24	12-23	10-20	8.8-18	25	A	2
6	24-60	23-57	20-50	18-44	50	9	1
7	60-85	57-80	50-70	44-62	65	8	1
8	85-121	80-115	70-99	62-89	80	7	1
9	121-181	115-172	99-149	89-134	100	5	1
10	181-362	172-344	149-298	134-267	110	2	5

Range	DR1100E	DR1070E	DC Gain	fc	LIM¶
1					
2	-0.3		4	D	5
3	0.3-1.5	-1	8	C	5
4	1.5-3.6	1-2.6	13	B	4
5	3.6-7.8	2.6-5.9	25	A	3
6	7.8-20	5.9-16	50	9	3
7	20-29	16-22	65	8	3
8	29-41	22-32	80	7	2
9	41-62	32-49	100	5	2
10	62-125	49-98	110	2	5

DR-B Series

Range	DR5070B	DR5050B	DR5030B	DC Gain	fc	LIM¶
1						
2	No Load	No Load	No Load	4	D	6
3	—0.7	—0.5	—0.4	8	C	4
4	0.7—2.0	0.5—1.7	0.4—1.5	13	B	3
5	2.0—4.8	1.7—4.0	1.5—3.8	25	A	3
6	4.8—13	4.0—11	3.8—11	50	9	1
7	13—19	11—16	11—15	65	8	2
8	19—27	16—23	15—22	80	7	1
9	27—41	23—36	22—34	100	5	2
10	42—82	36—72	34—68	110	2	4

Range	DR1060B	DR1045B	DR1030B	DR1015B	DR1008B	DC Gain	fc	LIM¶
1	-1.1	-1	-0.1			3	E	6
2	1.1-2.2	1-2	0.4-1.2	-0.2		4	D	6
3	2.2-5.3	2-5	1.2-3.3	0.2-1.5	-0	8	C	4
4	5.3-11	5-10	3.3-7	1.5-3.5	1-2.8	13	B	3
5	11-21	10-20	7-14	3.5-7.7	2.8-6.1	25	A	3
6	21-53	20-50	14-36	7.7-20	6.1-16	50	9	1
7	53-74	50-70	36-50	20-28	16-23	65	8	2
8	74-105	70-100	50-72	28-41	23-33	80	7	1
9	105-158	100-150	72-108	41-61	33-50	100	5	2
10	158-315	150-300	108-217	61-123	50-102	100	2	45

DM-A Series

Range	DM1200A	DM1150A	DM1100A	DM1050A	DC Gain	fc	LIM¶
1	—1.1	—0.9	—0.5	No Load	3	E	6
2	1.1—2.2	1.9—1.8	0.5—1.2	—0.4	4	D	6
3	2.2—5.4	1.8—4.6	1.2—3.5	0.4—1.8	8	C	4
4	5.4—11	4.6—9.3	3.5—7.2	1.8—4.1	13	B	3
5	11—21	9.3—19	7.2—15	4.1—8.7	25	A	3
6	21—53	19—47	15—37	8.7—23	50	9	1
7	53—75	47—66	37—52	12—32	65	8	2
8	75—107	66—94	52—75	32—46	80	7	1
9	107—180	94—141	75—112	46—69	100	5	2
10	180—320	141—282	112—224	69—138	110	2	4

DM-B Series

Range	DM1075B	DM1060B	DM1045B	DM1030B	DM1015B	DC Gain	fc	LIM¶
1	-2.1	-1.9	-1.6	-1.2	-0.4	3	E	6
2	2.1-3.7	1.9-3.4	1.6-3.0	1.2-2.4	0.4-101	4	D	6
3	3.7-8.3	3.3-7.7	3.0-6.9	2.4-5.7	1.1-3.2	8	C	4
4	8.3-16	7.7-15	6.9-14	5.7-11	3.2-67	13	B	3
5	16-32	15-30	14-27	11-22	6.7-14	25	A	3
6	32-78	30-73	27-67	22-56	14-35	50	9	1
7	78-109	73-103	67-93	56-78	35-49	65	8	2
8	109-156	103-146	93-133	78-112	49-70	80	7	1
9	156-233	146-219	133-199	112-168	70-105	100	5	2
10	233-466	219-438	199-398	168-336	105-209	110	2	4

Velocity Control Mode Adjustment

In the Velocity Control mode, the motor rotating angle is controlled so it corresponds to the velocity command voltage (±10V) from the higher-level controller. The two control methods can be selected in the Velocity Control mode (PI type and P type).

The following table shows the relationship between velocity command voltage and motor velocity.

Model	Velocity/Input Voltage (rps/V)
DR1008A to 1060B, DR1070E, DR1100E	2/10
DR1050A	1.5/10
DR1130E to 1250E, DR1100A to 1400A	1/10
DR5030B to 5070B	1/1

PI Type Velocity Control

The use of integral/proportional action in velocity control achieves smooth, disturbance-resistant control. This is the same control mode used in the conventional DC/AC servo motor control. In this control mode, only the two DC GAIN and AC GAIN adjustment controls are adjusted.

a. DC GAIN

The combination of the driver CN1 connector GAIN multiplier signals results in an adjustment range of from 0.5 to 120 times

b. AC GAIN

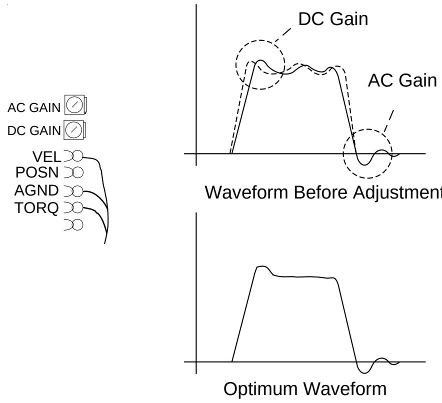
Velocity loop band damping is adjusted.

P Type Velocity Control

Since velocity control is effective only in proportional action, response is fast but is strongly influenced by disturbances in the controlled motor. In this Control mode, only the DC GAIN variable resistor at the front of the driver is adjusted. While in this velocity mode, the test switch becomes invalid.

Adjustment of Velocity Control System

Adjustment of velocity control system can be carried out in the Test mode. By turning the test switch on the front panel to ON, apply a 2.5Hz square waveform signal to the speed input in the driver, and the motor starts back and forth movements, repeatedly, at a small rotating angle. Under this condition observe the VEL Signal at the front panel on an oscilloscope, and adjust DC GAIN and AC GAIN so that VEL Signal becomes an optimum waveform as shown in the figure below.



Torque Control Mode Adjustment

In the torque control mode, current flows through the motor corresponding to the current command voltage (±8V) from the higher-level controller. Motor output torque depends on the current. Therefore, torque is 0 at 0V of command voltage, and the maximum torque is produced at 8.5V.

When using the torque control mode, carefully plan and design the velocity & position control loops and a proper interlocking system, will assure the final control system meets the exact specifications of the application.