DMM Technology Corp.

How to Use DmmDrv.exe to Tune Up and Test Move Dyn servo

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Scope

This document describes how to use DmmDrv to set up the position/speed/torque command input mode and the drive control mode like position servo or speed servo. Additionally, it will explain how to use DmmDrv to adjust the servo gain and benchmark the servo movement to confirm if the dynamic performance meet the customer's requirement.

Contents

1.0 Install DmmDrv.exe

1.1 PC Requirement

Win98/XP/2000/Vista
CPU Speed > 250 MHz
RAM > 64MB
Available Hard Disk > 250MB

1.2 Install DmmDrv.exe

Step 1: Run the DMM CD

Step 2: Inside the DMM CD, copy the entire folder named “*PCtool_ForDyn*” onto your hard drive into the directory of your choice (There is no need to run any installation process).

Step 3: The installation is now complete. The DMM driver program can now be launched by simply double clicking the “*DMMDRV.EXE*” icon inside the “*PCtool_ForDyn*” folder.

1.3 Launching DmmDrv.exe

By double clicking the “*DMMDRV.EXE*” icon, the DmmDrv will be launched as shown:

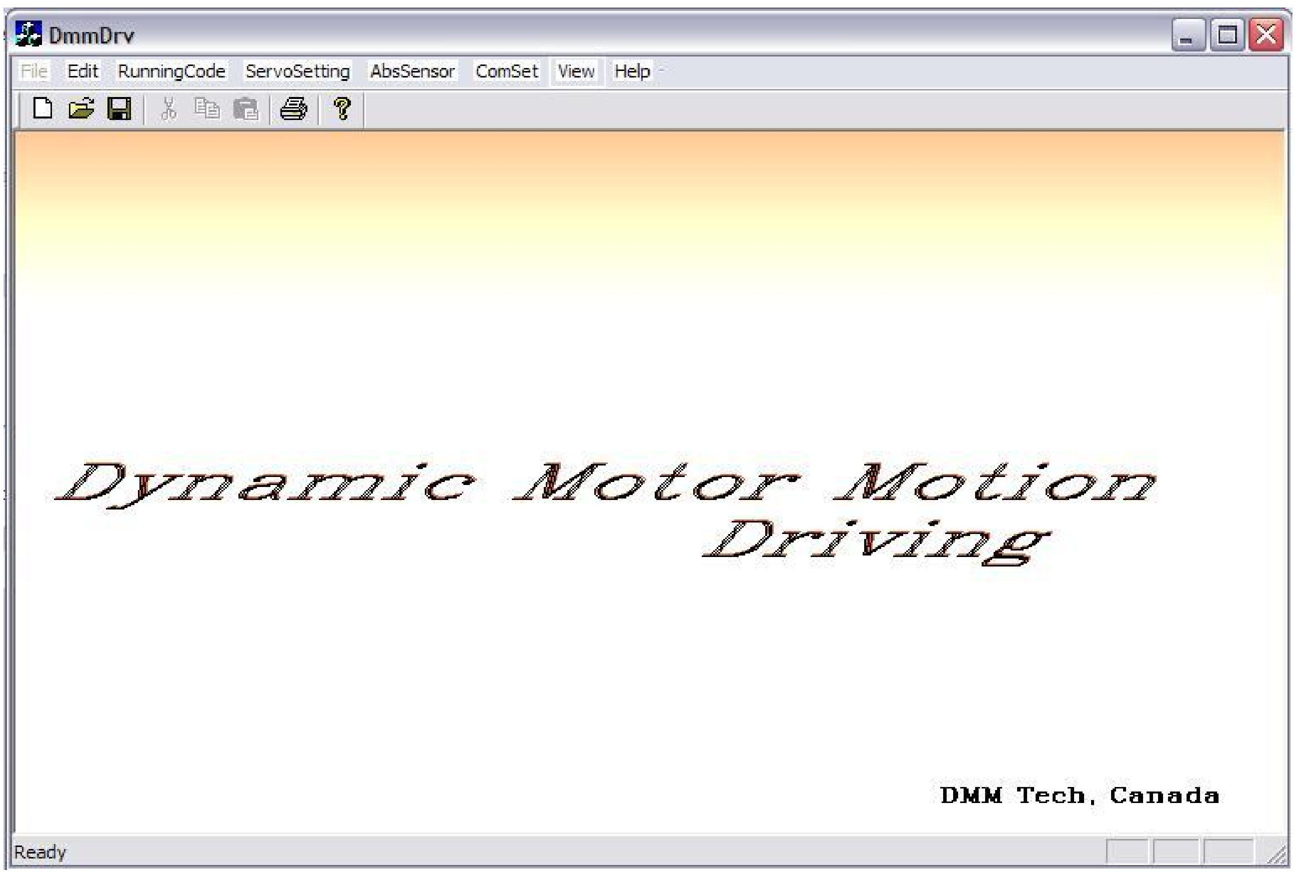

Figure 1.0

1.4 Toolbars

From Figure 1.0 the various toolbars at the top of the screen are explained below:

ComSet : Use this option to select the communication port from COM1~COM8 for both physical RS232 port (COM1, COM2) and USB virtual COM port (COM3~COM8).
For more communication details please reference Dyn2-Spec.pdf located inside the "Spec_DynServo" folder of your DMM CD.

AbsSensor: After power on, the 14bits absolute magnetic encoder is automatically in a RS232 communication mode, the AbsSensor option is used to read / save the encoder position.
*Note that this option will not work if no RS232/UBS connection exists from the PC to the encoder.

ServoSetting: From this tab, select *Dyn2-Driver*, the servo setting dialog box will now be presented. The servo MainGain, Speed gain, and integral gain all can be set here.

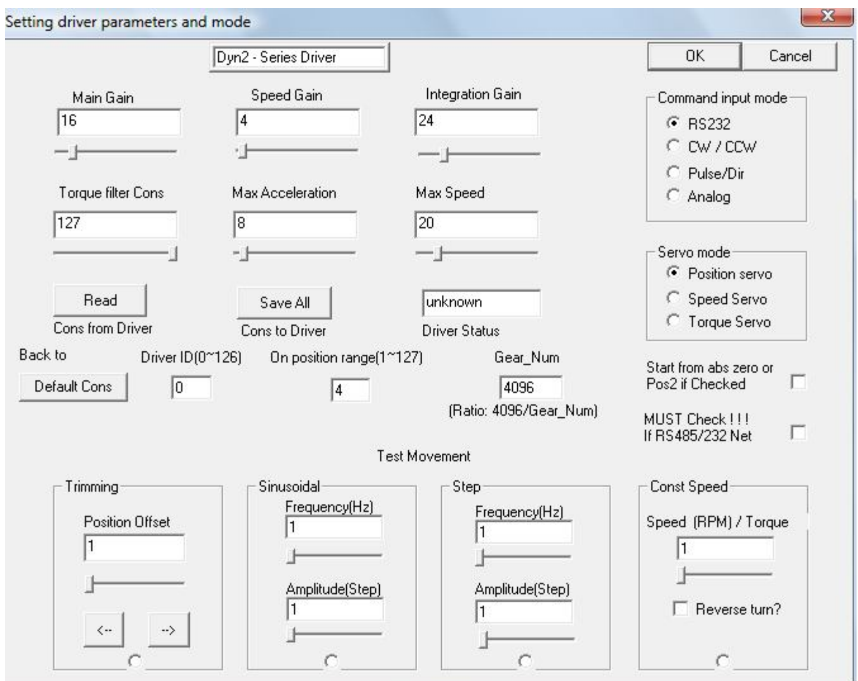

Figure 1.1

Edit: Dyn servos have the point to point S-curve function, and uses 2 or 3 motors to make linear/ circular interpolation functions built into the drive. These functions can be used in the RS232 command input mode.
The edited programs are saved as Program1.txt ~ Program5.txt
The edit tab is used to edit those instructions, as well as G codes to let a single, or multiple motors move together. The DMM program allows 5 program configurations.

2.0 Servo connection for a single drive

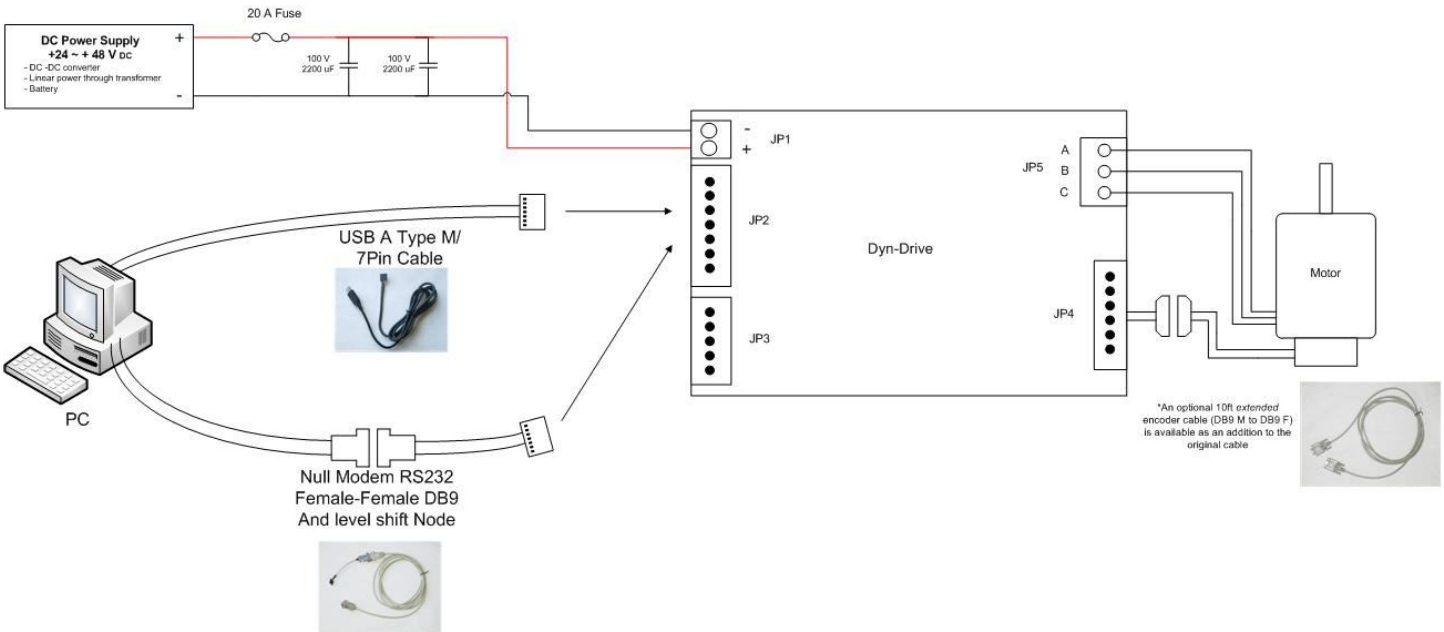

Figure 2.0

There are two ways to make a serial connection between PC and the Dyn drive. One is Through a RS232 cable if the user's PC has a physical RS232 communication port. And the other is to use a USB cable if the user's PC does not have a physical DB9 Male RS232 port.

3.0 Get connected through RS232

DMM's RS232 cables exist in two forms. One is the Null Modem cable: DB9 Female to DB9 Female. Another is a DB9 Male to molex C-Grid 7pin Female, used to link with the Dyn drive's JP2 socket connector. After the cables, motor, power source, and drive are connected as Figure 2.0 shows, the user is ready to turn on the power source.

Launch the DmmDrv.exe. Select the ComSet option from Figure 1.0 and select Com Port to indicate which RS232 port the user's computer is communicating through (COM1 or COM2).

4.0 Get connected through USB cable

The DMM USB to Drive cable is approximately 2m long. The end is a USB "A" Plug for the user's PC USB port, and the other end is a molex C-Grid 7pin Female, used to link to the Dyn drive's JP2 connector. Inside the cable, a FTDI USB-RS232 chip is built in.

In order for the Dyn driver to communicate with the PC's USB port, a custom driver must be separately installed.

Installing the USB driver

Step 1: Plug the USB side of the USB-Dyn cable into PC, and plug the molex C-Grid 7pin Female side into the Dyn drive's JP2 port.

Step 2: On the DMM CD, Double Click the "*CDM20416.exe*" (from FTDI) icon inside the "*Spec_DynServo*" folder and proceed until the driver has finished installation.

Step 3: Go to Control Panel->Administrative tools->Computer Management->Device Manager (Note: this path is for window XP, win2000. Windows Vista is similar, and final object is the Device Manager path). As shown in the picture below.

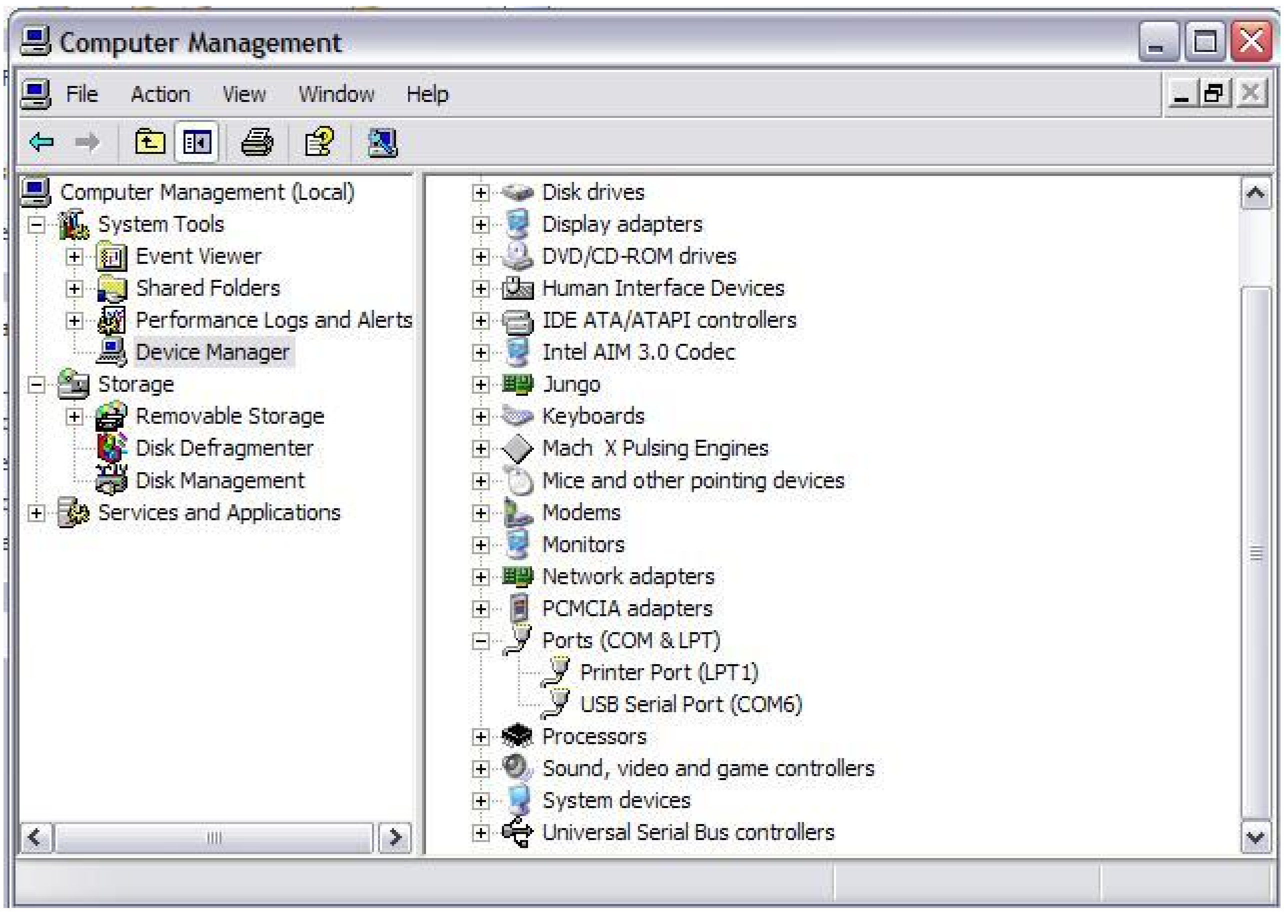

Figure 4.0

Step 4: In the Device Manager menu, select *Ports(COM&LPT)*. The USB Serial Port(COM#) etc will appeared, where # indicates any single number. Remember this port number. (Note: In figure 4.0, the port number is COM6, however this number may be different on the user's computer)

Step 5: In the DmmDrv 's (Figure 1.0) ComSet setting, select the port from step 4.

Step 6: Turn on the power to the Dyn drive. USB connection is now ready.

5.0 Set up a servo and test move

5.1 Initial set-up

Once the drive, motor and PC are connected through a RS232 or USB cable, and powered on, the set-up is ready for servo tuning and some test motions.

For first time power on, we suppose that there is no or a small inertia load on the motor shaft, thus, the servo should be well stabled for the default position servo control.

From Figure 1.0, select ServoSetting and click on Dyn2-Driver, the *setting driver parameters and mode* dialog box (Figure 5.0 below) will now be selected.

Recommended first step: Click on the "*Read*" button to read all of the servo control parameters out from the drive. The "*Read*" button is located on the center-left position of the dialog box. The "*Driver Status*" display, located in the center of dialog box will then show "Servo OnPos", indicating that the servo is working, as well as the communication between the PC and Dyn drive.

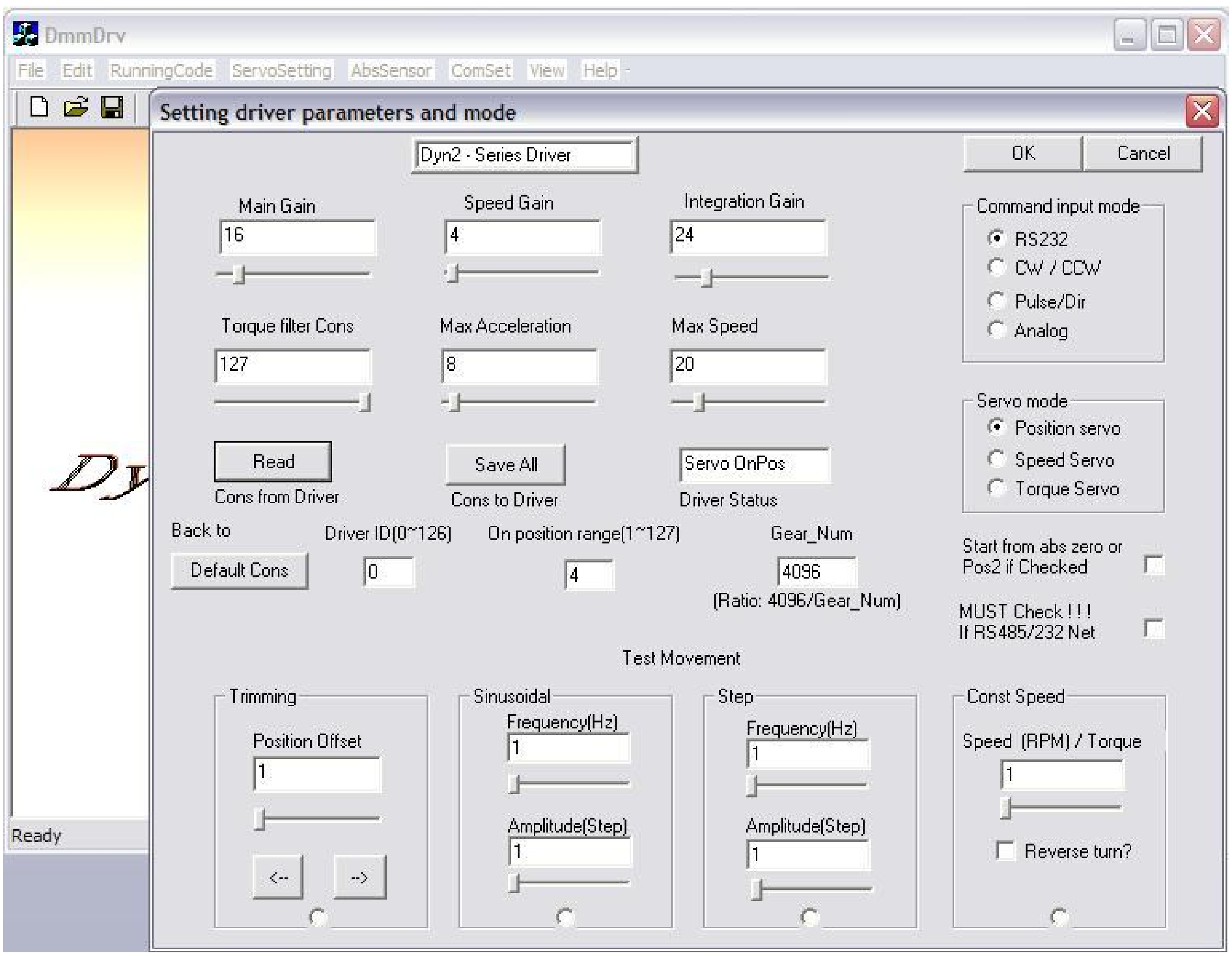

Figure 5.0

5.2 Setting Driver Parameters and Mode Menu (Figure 5.0)

Main Gain: Position servo control main gain. Ranges from 1 to 127, and default is 16. This parameter should be increased accordingly as the inertia (mass) load on the motor shaft increases. The maximum load inertia is 10 times motor shaft inertia.

Speed Gain: Speed feed back gain for position control. Normally 4~20 (default is 4).
Note: For speed servo control, the total servo loop gain is: **Main Gain x Speed Gain**.

Integration Gain: The gain to keep the position or speed servo loop at zero position error for the steady state. Normally 5~50 (default is 24).

Torque Filter Cons: A low pass filter for the torque command sent to the torque servo loop.
a / (S + a), where **a = 26 x Torque Filter Constant**.
i.e. a = 2600 if Torque Filter Constant = 100.
Normally set Torque Filter Constant = 127.

Gear_Num: Electronic gear number. Ranges from 500~16384, and default value is 4096.
GearRatio = 4096/Gear_Num. The real motor shaft will turn **(360/16384)x4096/Gear_num = 90(deg)/Gear_Num** for position command 1 count.

Max Acceleration: Maximum acceleration for the point to point S-curve motion.
Ranges from 1 ~127 (Default is 8).
Real maximum motor acceleration(rpm/s) = Max Acceleration x 635.78 x GearRatio

Max Speed: Maximum speed for the point to point S-curve motion.
Ranges from 1~127 (Default is 20).
Real maximum motor speed(rpm) = Max Speed x 12.21 x GearRatio

Driver ID: If more than 1 Dyn drives are connected through the RS232 or RS422 network, every axis servo must have a unique ID starting from 0. 0 for X axis, 1 for Y axis, 2 for Z axis.
The X, Y, and Z axis are able to make coordinated linear, or circular motions. See section 7.0 for multiple drive connection networks.

On Position Range:

If the value of *On Position Range* is between 1~126: The difference between the position command set and the real motor position is less than the *On Position Range* value, the output from Pin5 of JP3 will be low, otherwise it will be high. This option is only applicable to CW/CCW, or Pulse/Direction input mode.

If the value of *On Position Range* is 127, the output Pin5 of JP3 will represent the motor alarm (fault) signal, i.e. if the motor servo is normal, the Pin5 will be low, otherwise if the driver's alarm is triggered it will be high. Please reference the Dyn driver's specification sheet to see how the alarm is triggered.

RS485/RS232 check box: If the PC is not connected to a network of drivers, leave this unchecked.
See section 7.0 for multiple drive connection networks.

Start from abs zero or Pos2 check box: Because the Dyn servo uses the absolute encoder as feedback, there are two ways for the position servo to start with. If the box is not checked, the servo will be started from the current, now position like normal incremental encoder servos. If the box is checked, either the position servo will start from absolute zero of the encoder or from the user designated position in the encoder as POS2.

Command input mode: There are four types of input mode, RS232, CW/CCW, Step(Pulse)/direction, and Analog.

Servo mode: There are three servo modes: Position servo, Speed servo and Torque servo.

Default Cons: This button resets all the settings to default values.

Save All: After the user is finished with the settings modification, click the "*Save All*" button to save all of settings to the drive's EEPROM.

Test Movement:
Select from the four radio button in the bottom of the dialog boxes, then move the slide inputs to let motor move accordingly.

6.0 Set up a Servo for the MACH3

To set up the DmmDrv program, and Dyn drives for integration with Mach3, modifications must be made to the *Setting driver parameters and mode* menu.

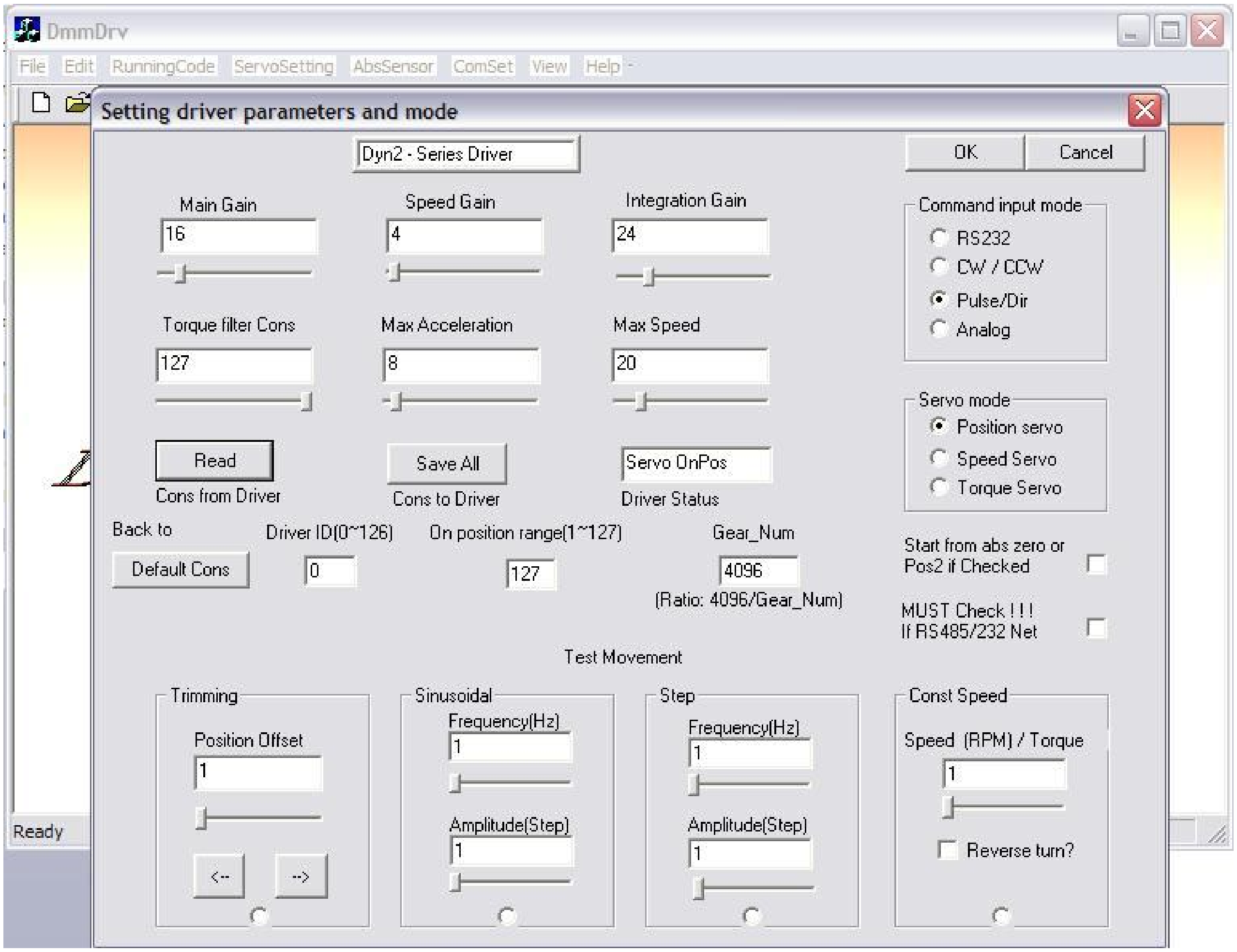

Figure 6.0

Step 1: From Figure 1.0, select *ServoSetting* and click on *Dyn2-Driver*, the "*Setting driver parameters and mode"* dialog box (Figure 1.1) will now be selected.
Step 2: Under *Command input mode* select the *Pulse/Dir option* (Figure 6.0) to correspond with the Step/Direction inputs used by Mach3.
Step 3: Under *Servo mode,* select *Position servo* (Figure 6.0.)
Step 4: Under the *On Position Range* parameter, change this value to 127 (Figure 6.0), so that the output Pin5 of the drive's JP3 represents the drive fault Signal.

The *Gear_Num* parameter can be adjusted to determine how much the motor shaft should turn given one step pulse input from Mach3. **90(deg)/Gear_Num** will be turned for one step pulse input.
Note: From Figure 6.0, the 4096/Gear_Num represents the gear ratio:

[4096counts / Gear_Num] x [360degree / 16384counts per revolution] = 90degrees/Gear_Num

According to every axis's inertia load, set the MainGain, Speed Gain and integration Gain. See section 5.2 for adjustment details.

After the user is satisfied with the settings, click on the "*Save All*" button to save all the settings to the Dyn drive's EEPROM .

7.0 Servo Connection for multiple drives in a network

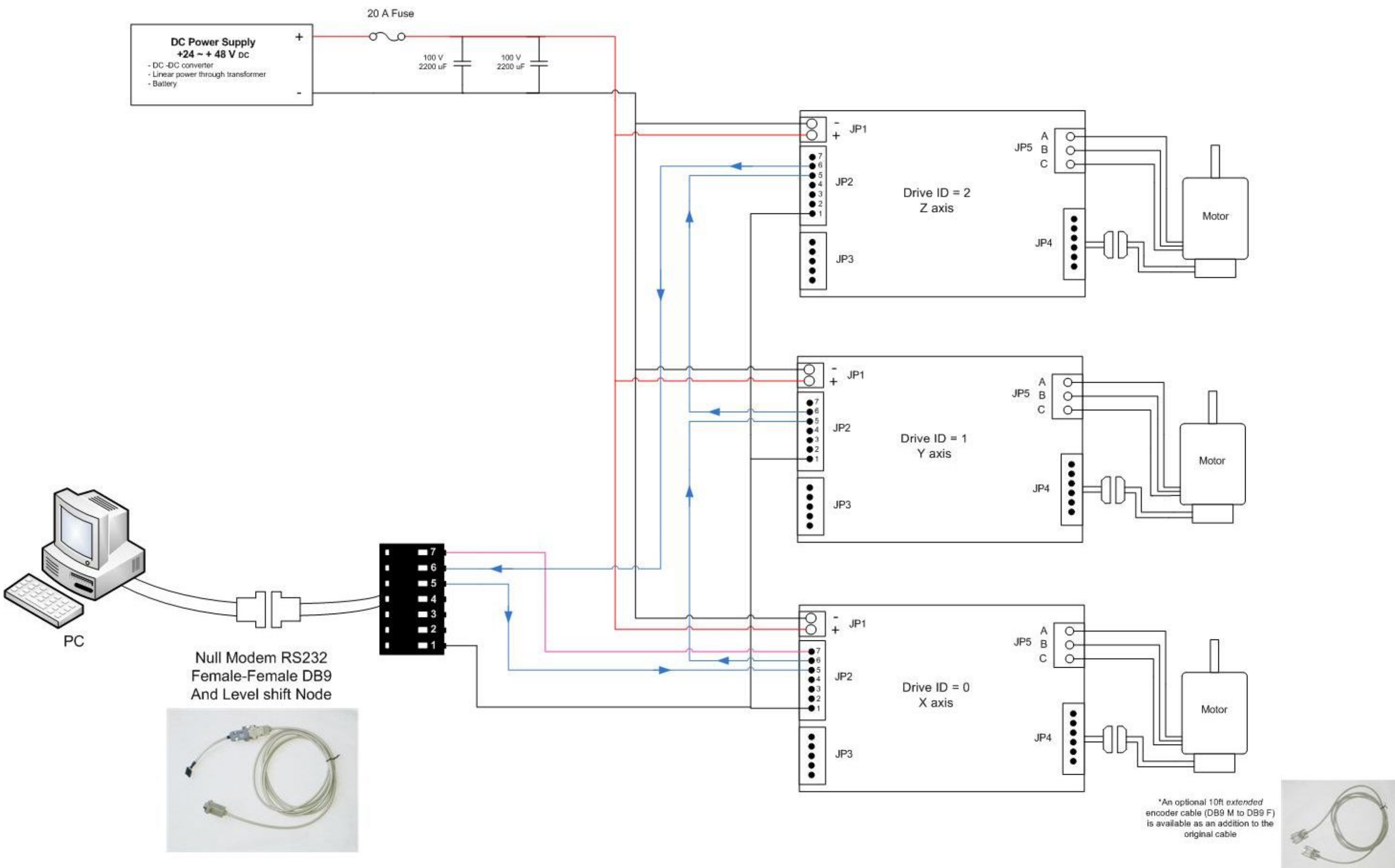

Figure 7.0

When setting the drive ID, only one drive should be connected to the PC (Figure 2.0), with the *RS485/RS232 Net* option UNCHECKED. Once the first drive's ID is set, click the *Save All* button to save the setting. Then disconnect the current drive, and proceed with the second, third etc (remember to leave the *RS485/RS232 Net* option unchecked when setting the ID).
Once all the drives ID's have been set, and saved, link all the drives as in Figure 7.0, and CHECK the *RS485/RS232 Net* option.

After all the drive's have been assigned a unique ID number from 0,1,2,3….., They can be linked together to form a network. The first three axes with ID = 0,1,2 can make coordinated motions after receiving a packet command from the user's PC.

8.0 Editing the motion control programs

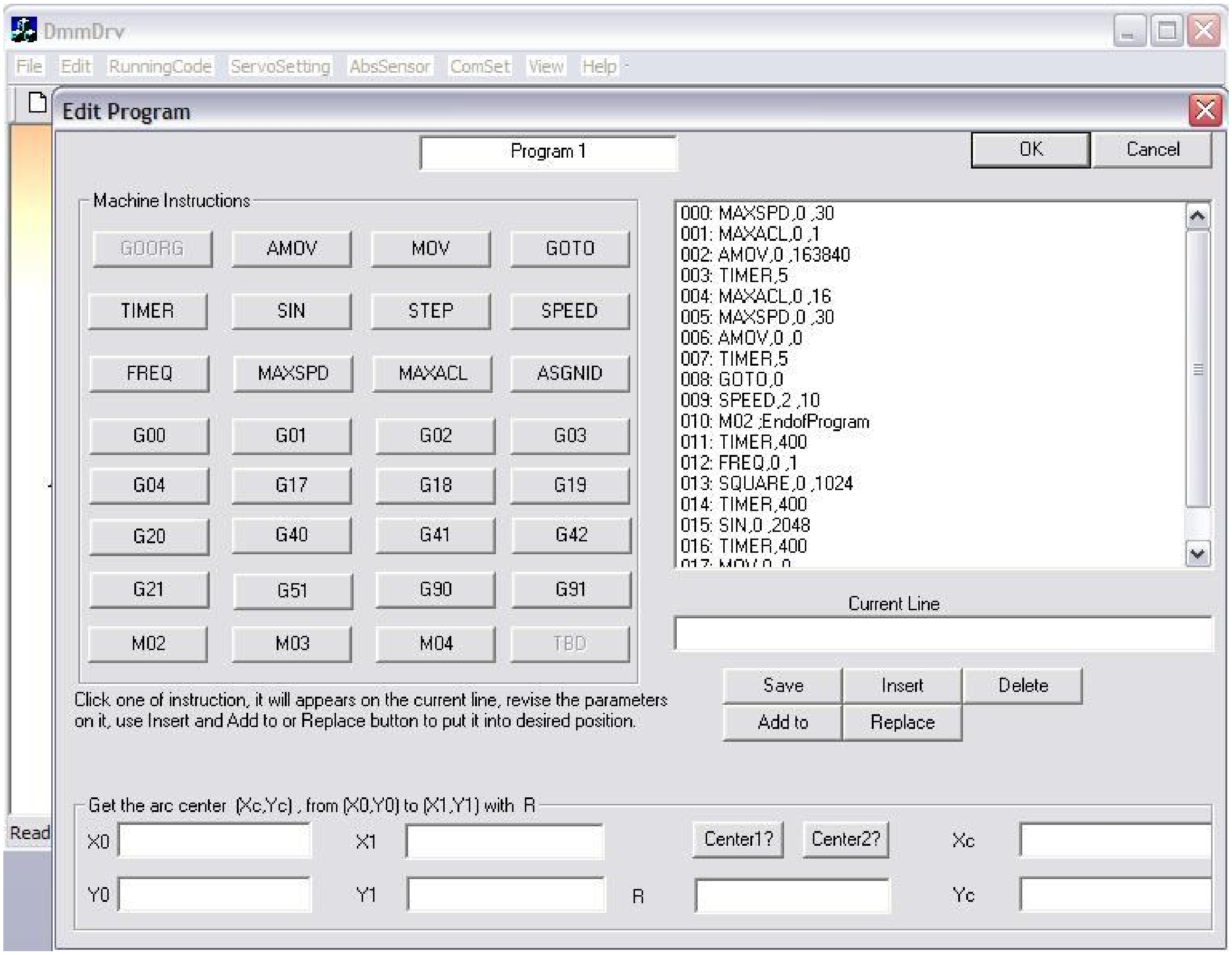

Figure 8.0

Several motion programs can be edited in order to let every axis's motor move together.
Select "Edit" from Figure 1.0 and click on Program1~5.
The edit dialog box will be opened (Figure 8.0).

"*Save*" button is used to save current program.
"*Insert*" button is used to insert the current line into the program.
"*Delete*" button is used to delete a sentence from the program
"*Add to*" will put current line onto the bottom of the program
"*Replace*" will use the current line to replace the focused line.

By clicking on one of the buttons in the *Machine Instructions* menu, the selected instruction will be selected to the *Current Line* field for editing.

When using Machine Instruction edit *G02* or *G03* circular interpolation, the circle calculation located on the bottom provides a very convenient way to get the circle, or arc centers using its input start and end points as well as the radius.

Please reference G_CodeGuide.pdf for more details.

9.0 Running the motion control programs

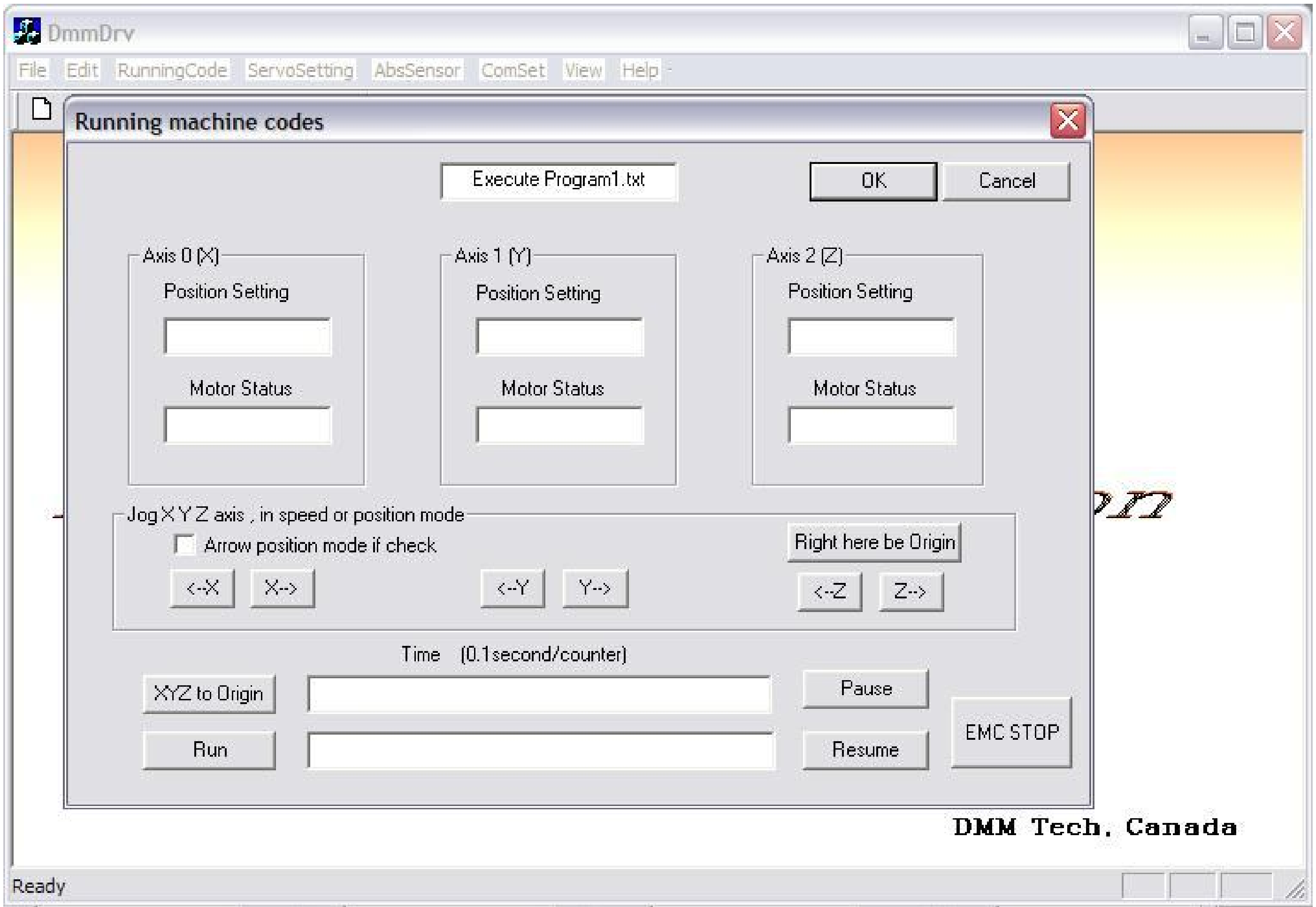

Figure 9.0

After the user has finished editing the motion control programs (section 8.0), select *RunningCode* from Figure 1.0 and click on the edited program (Program1~5). The running dialog box will now appear.

10.0 Inertia load evaluation and detailed servo gain settings

Please refer to the following references, and examples to accurately determine the servo gain values. A common belt ball-screw system driven by the Dyn servo is used as an example. For automation machinery purposes (no ball-screw) please refer to subsection 10.1 of this section for gain calculations.

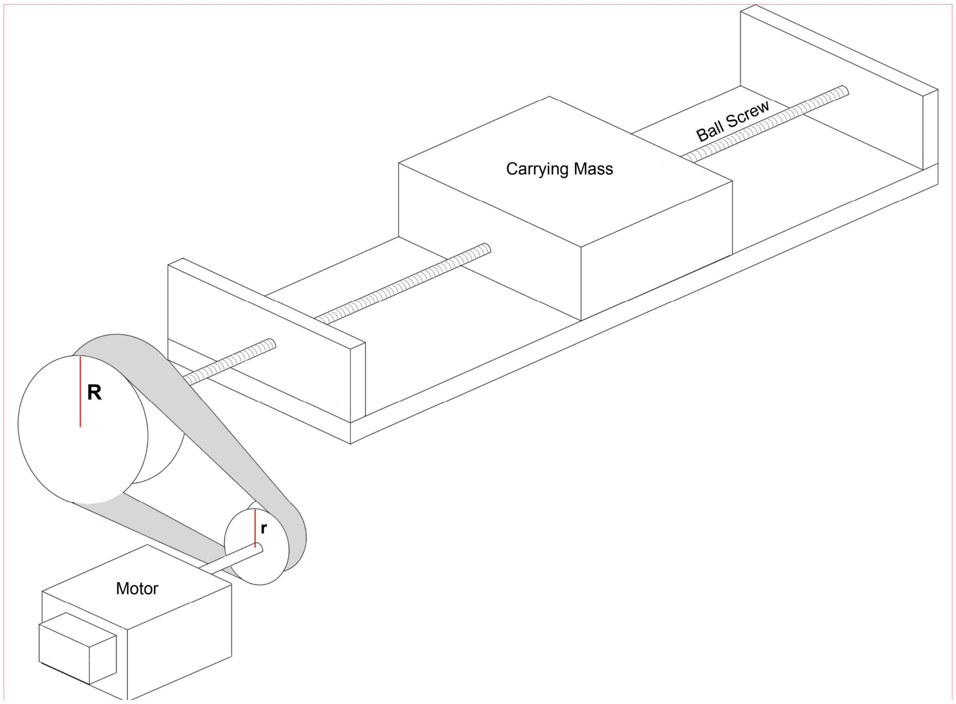

Figure 10.1

As figure 10.1 shows, the servo motor is first connected to a belt reducer which drives a ball-screw carrying a load mass.

Variables:

Motor shaft belt wheel radius:	r	(m)
Ball screw belt wheel radius:	R	(m)
Belt reducer Ratio (≥1):	$n = R / r$	
Carrying load mass:	M	(kg)
Ball screw mass:	M_b	(kg)
Ball screw belt wheel mass:	M_R	(kg)
Motor shaft belt wheel mass:	M_r	(kg)
Ball screw pitch:	p	(m)
Ball screw radius:	R_b	(m)
Ball screw belt wheel (R) moment inertia:	$J_R = M_R*R^2/2$	(kg m^2)
Motor shaft belt wheel (r) moment inertia:	$J_r = M_r*r^2/2$	(kg m^2)
Ball screw moment of inertia:	$J_b = (M_b * R_b^2) / 2$	(kg m^2)
Carrying mass moment of inertia:	$J_c = M * (p / 2\pi)^2$	(kg m^2)
Motor rotor moment of inertia:	J_o	(kg m^2)
Inertia Ratio:	$N_J = J_T / J_o$	

The total equivalent load moment of inertia (excluding intrinsic motor rotor inertia) is:

$$J_T = J_r + (J_R + J_b + J_c) / n^2$$

If a belt reduction is not used (i.e $n = 1$, $J_R = J_r = 0$) then J_T will be:

$$J_T = J_b + J_c$$

10.1 Inertia Ratio

The inertia ratio $N_J = J_T/Jo$ has a value of 0 if there is no load on the motor shaft. DMM's Dyn servo tolerates inertia ratio values of up to 10. Thus it is recommended that $N_J < 10$. Please reference the following chart for the Jo ratings of DMM's motors.

Motor	Motor rotor moment of inertia Jo (kg m^2)
250W (57DML2530L8LK)	0.438x10^-4
220W (86DHT03)	0.65x10^-4
60W (4403E060 - R1)	6.05x10^-6

For automation machineries where a ball screw is absent, simply let J_T equal to the load moment of inertia that the motor will be driving.

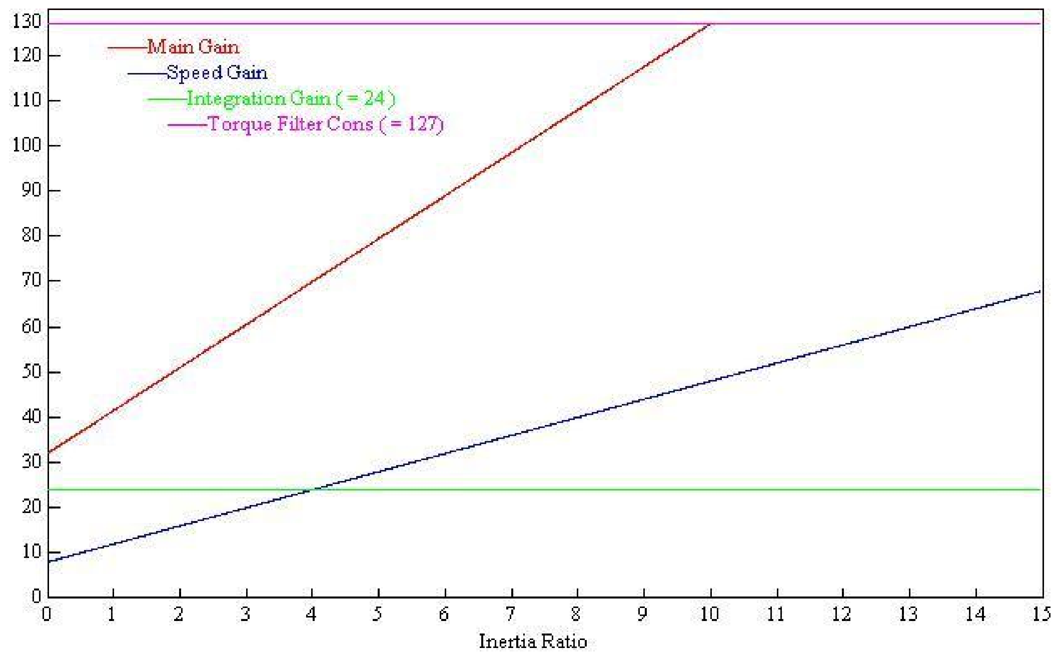

Figure 10.2

Figure 10.2, shows the recommended gain charts for different values of inertia ratios. The integration gain, and the torque filter constant should remain at 24, and 127 respectively.
In general there is a fairly large, stable margin for the users to adjust the gain levels around the recommended value in order to best suit their needs.

10.2 Calculation Example

If the 86DHT03, 220W servo motor (rated speed 3000rpm, max. torque 2.1Nm) is used with M=200kg, Mb=11kg, p=0.01m, Rb=0.015m, M_R = 0.4kg, R = 0.05m, Mr = 0.04kg, r = 0.0167m, and n = 3. *The ball screw is assumed to be 2m in length.

Using the above given calculations, we have:

$$Jc = 200 * (0.01 / 2\pi)^2 = 5\times10^{-4} \quad \text{kg m}^2$$
$$Jb = (11 * 0.015^2) / 2 = 12.4\times10^{-4} \quad \text{kg m}^2$$

$J_R = 0.4*0.05^2 /2 = 5x10^{-4}$ kg m^2
$J_r = 0.04*r^2/2 = 0.056x10^{-4}$ kg m^2
$J_o = 0.65x10^{-4}$ kg m^2

The total equivalent load moment of inertia excluding intrinsic motor rotor inertia is:

$$J_T = 0.056x10^{-4} + (5x10^{-4} + 12.4x10^{-4} + 5x10^{-4})/9 = 2.544 \times 10^{-4} \quad \text{kg m}^2$$

The Inertia Ratio is: $N_J = 2.544 / 0.65 = 3.9$

By referencing the curves from figure 10.2 above, we have:

MainGain = 65
SpeedGain = 24
Integration Gain = 24
Torque Filter Cons = 127

Maximum Travel Speed: 3000rpm*p/n = 10 (meters/min) = 393.7 (inches/min)
Maximum Torque On the ball screw: 2.1(Nm)*n = 6.3 Nm
Maximum Force on carrying Mass: 2.1(Nm)*2* π*n / p = 3958(N) = 403.9(kg)