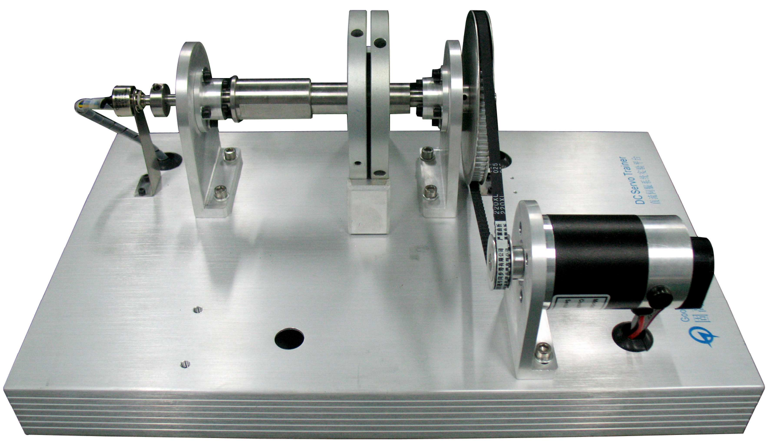
Laboratory Manual for DC Servo System Control Platform

GSMT Series

V1.01



2012.06

www.googoltech.com.cn

© 2012 Googol Technology. All rights reserved

Copyrights Statement

All rights are reserved by Googol Technology Ltd.

The Googol Technology Ltd. shall reserve all rights and relevant intellectual property rights. *Laboratory Manual for GSMT DC Servo System Control Platform*

Under the *Copyrights Law*, no one shall copy, produce, and process this document or its affiliated documents directly or indirectly without the written consent from Googol Technology Ltd.

Statement

The Googol Technology Ltd. shall reserve the rights to alter the products and its characteristics without notice.

The Googol Technology Ltd. shall be free from the responsibility of any direct or indirect harm or damage arising from improper use of this document.

Trademark

Windows and Microsoft are the registered trademarks of Microsoft.

IPM and IPM Motion Studio are the trademarks of Technosoft.

MATLAB is the trademark of MathWorks.

LabVIEW is the trademark of National Instruments (NI).

Contact Us

Googol Technology (HK) Limited
Room 1008-09, F10, C-BONS International Centre, 108 Wai Yip Street, Kwun Tong, Kowloon, HongKong
Tel.: (852) 2358 1033, (852) 2719 8310
Fax: (852) 2719 8399
http://www.googoltech.com

Googol Technology (SZ) Limited
F2, West Wing, IER Building High-tech Industrial Park, Nanshan District, Shenzhen, PRC
Tel: (86) 755 2697 0817; (86) 755 2697 0835
Fax: (86) 755 2697 0846
http://www.googoltech.com.cn

Foreword

In general, the motion control system applied in the industrial production line requires strong disturbance resistance of the system after reaching the target speed or position so as to keep its motion status. When the control system works, we shall, in consideration of the moment of inertia and load torque of the system, adjust the parameters of drive's current controller, speed controller and position controller through special software; and regulate the speed controller and position controller parameters of motion controller to have the system reach the stable, accurate, fast and strong performance index.

GSTM2012 experiment platform is the DC servo motor control system of intelligent servo drive-based single motor, with the experiment content covering adjustment of single motor's PID current controller, PID speed controller and PID position controller, as well as the parameter adjustment of PID current controller, PID speed controller and PID position controller after alternation of moment of inertia on single motor.

GSTM2013 experiment platform is the DC servo motor control system of intelligent servo drive-based double motor, with the experiment content covering adjustment of single motor's PID current controller, PID speed controller and PID position controller, the parameter adjustment of PID current controller, PID speed controller and PID position controller after alternation of moment of inertia on single motor, as well as the influence of disturbing torque on speed controller and the influence of damping torque on position controller.

GSTM2014 experiment platform is the DC servo motor control system of double motor based on high-performance motion controller GT400 and the intelligent servo drive, and the experiment content covers adjustment of single motor's PID current controller, PID speed controller and PID position controller, the parameter adjustment of PID current controller, PID speed controller and PID position controller after alternation of moment of inertia on single motor, as well as the influence of disturbing torque on speed controller and the influence of damping torque on position controller.

The high-performance motion controller GT400 in the GSTM2014 enables the real control experiment under MATLAB/Simulink, and the content covers system modeling and stability analysis, time-domain analysis of second-order system, root locus analysis of third-order system, frequency-response analysis, PID calibration, root locus correction, frequency domain method correction and state feedback, eight experiments in total, and the details are specified in Chapter V.

With this experiment platform, the user may understand the basic principles of PID's influence on system performance index, master the method to adjust the PID current controller, speed controller and position controller parameters of the DC servo drive; and comprehend the influence of damping torque and disturbing torque on position controller and speed controller performance, so as to develop the practical skills of the motion control.

We shall, through GSTM2014, get familiar with, and understand the classical analysis and calibration time-domain method, frequency-domain method and root locus method in automatic control theory to control system, and master the method to build systematical mathematical model based on experimental data and the state feedback method for modern control theory.

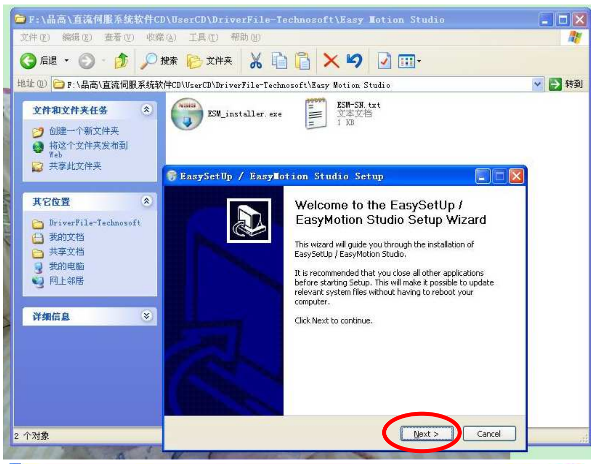
Table of Contents

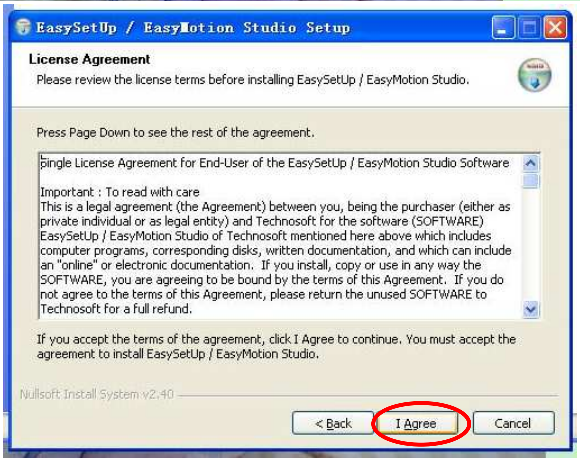
Chapter I Use of Easy Motion Studio

Note: this Chapter is applicable to GSMT2012, GSMT2013 and GSMT2014

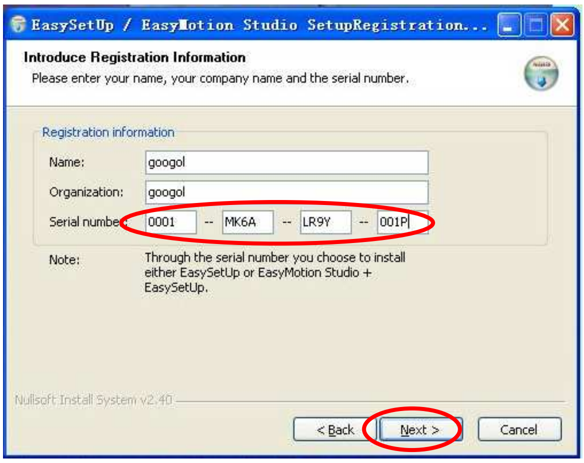
I. Installation of Easy Motion Studio

1. Put the CD into the drive, and open folder following the route root: \\DriverFile-Technosoft\Easy Motion Studio, then double click on ESM_installer.exe to install the software.





2. Open file ESM-SN.txt, enter the serial number in the page below, and press the button "NEXT", then finish the installation procedures following the install Wizard.



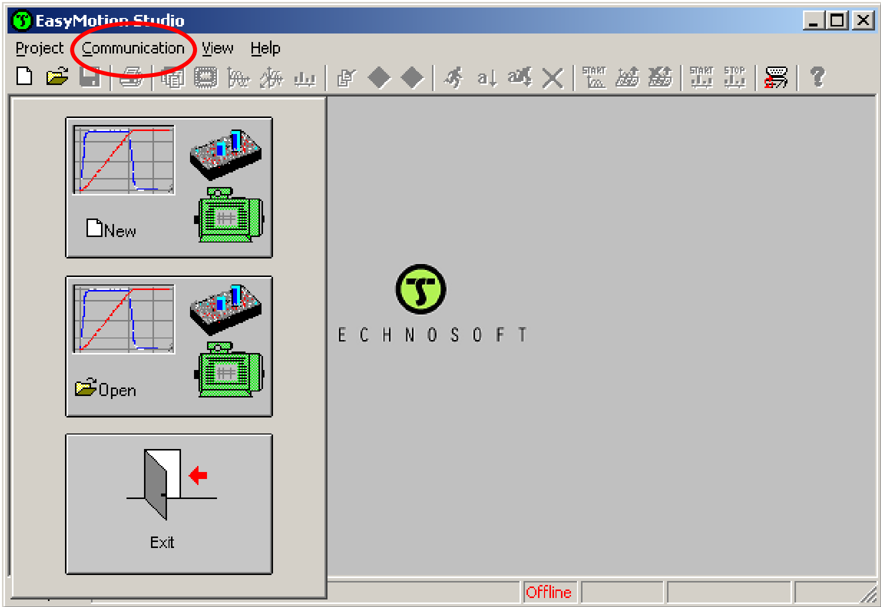
3. The installation procedures may take several minutes, please be patient.

II. Start Easy Motion Studio, and read the drive parameters from the serial port

1. Start Easy Motion Studio

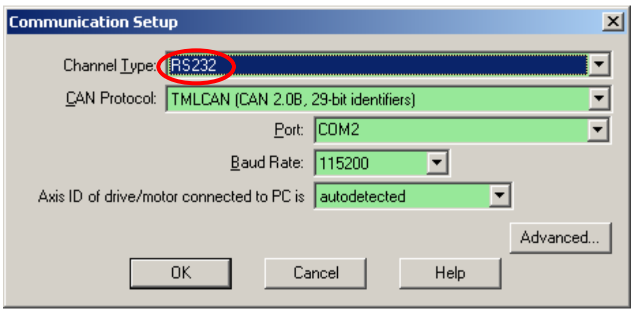
a) Click on the icon of Easy Motion Studio to open the control software as shown below:

b) Click on the menu “Communication”—“Setup” to set serial port information.



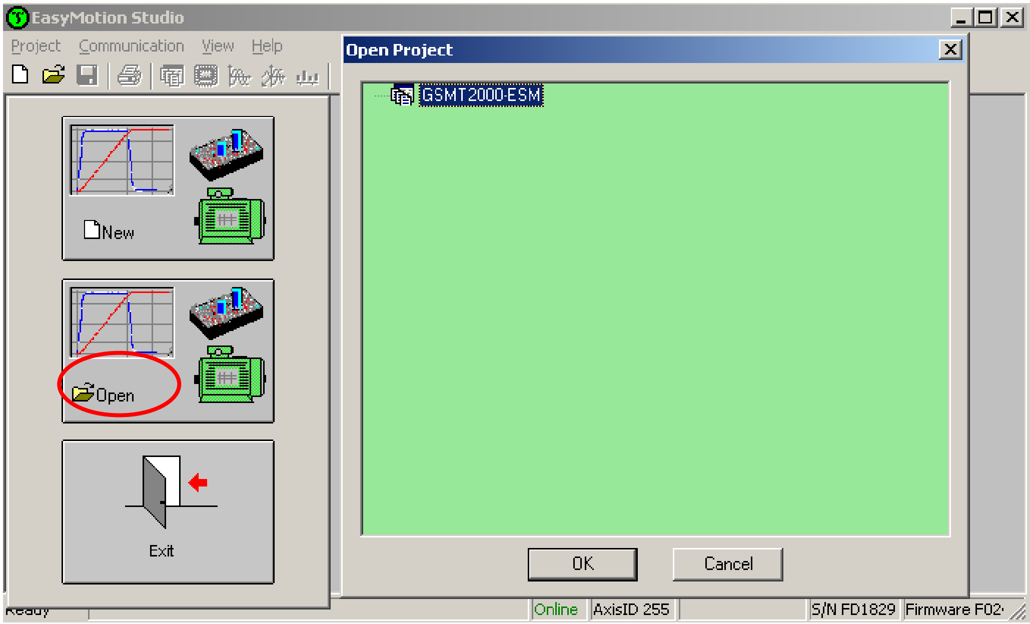
c) Select “RS232” as the channel type, and choose “Com1” for port under axis 1 motor and “Com2” for port under axis 2 motor; the Baud Rate shall be “115200” with the others default. Then click on "OK" when all settings are finished.

Note: Electric cabinet shall be powered on upon the settings of communication information of serial port, otherwise, it will beep on error as shown below:

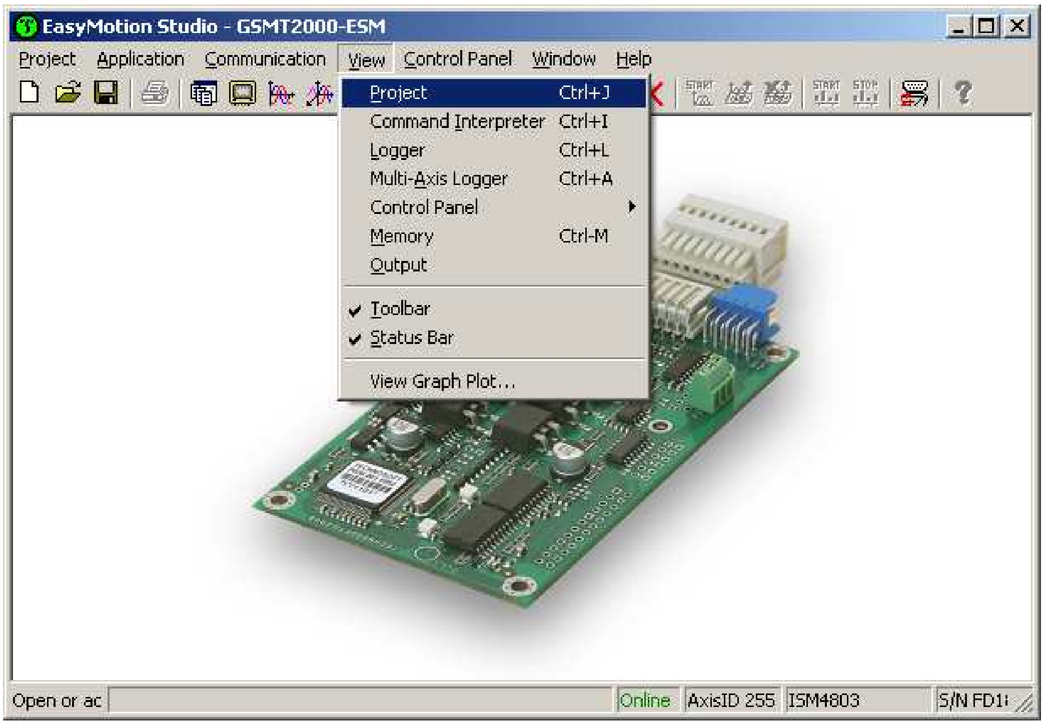


2. Parameters settings

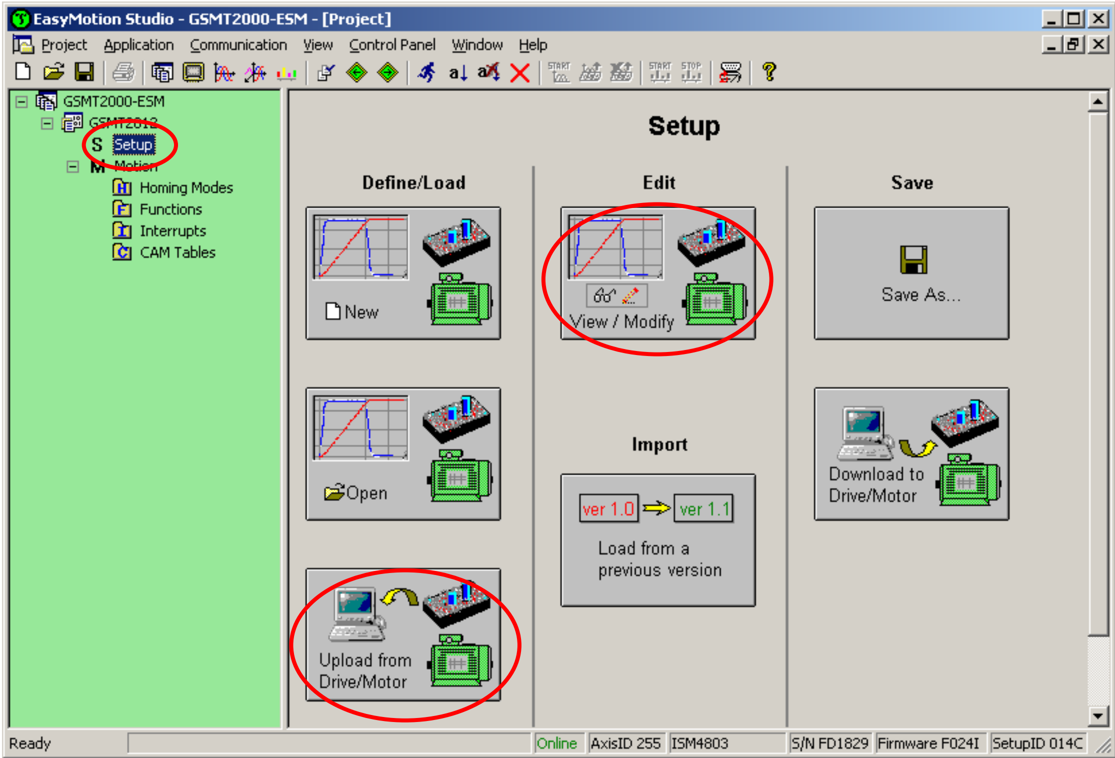
a) Enter into the catalogue Control Software\GSMT2000-ESM, and copy the control engineering file GSMT2000-ESM to the folder “Projects” under the catalogue of Easy Motion Studio, then click on "Open" icon in the software, check the “GSMT2000-ESM”, and click on the button "OK".



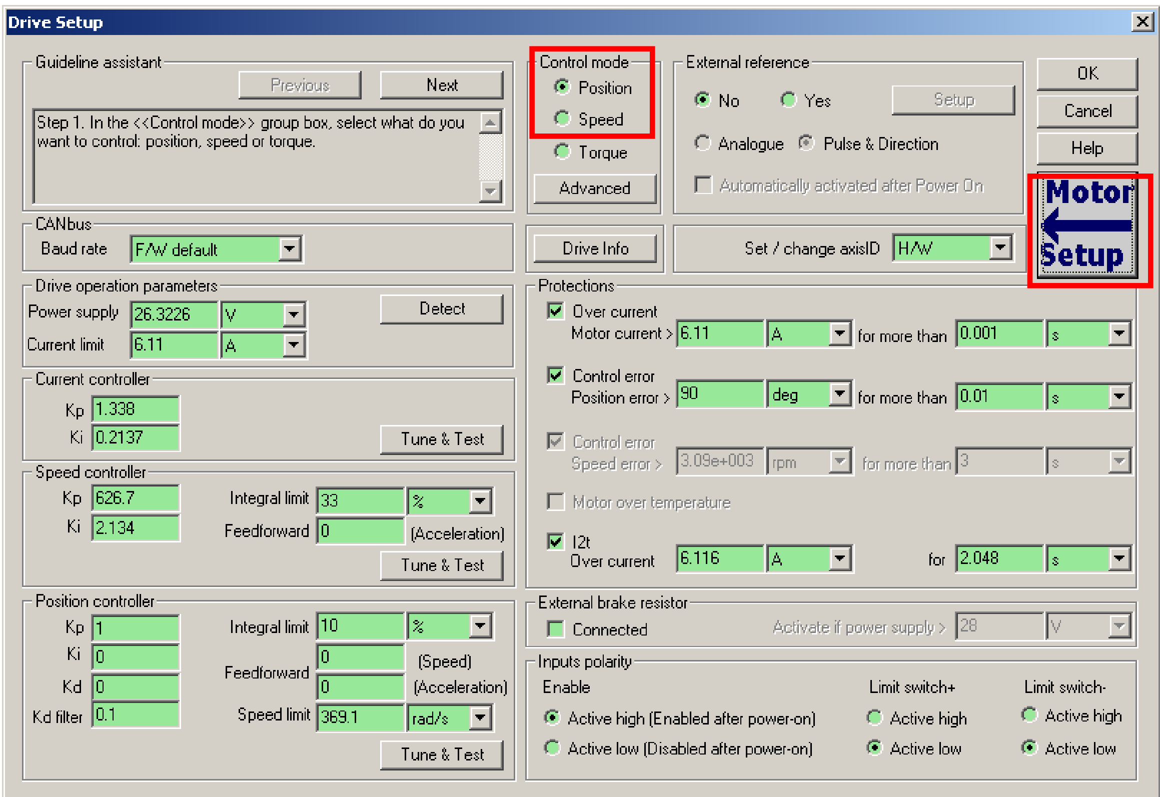
b) Click on menu "View"——“Project”



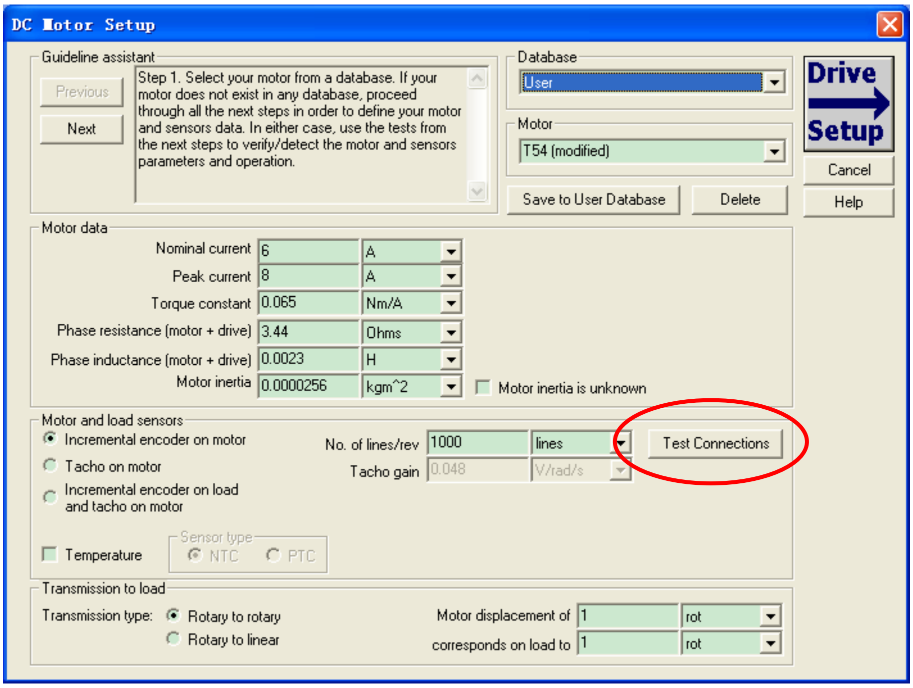
c) Click on the “S Setup” on the left column, and “Upload from Drive/Motor” on the right side, when the software shall read the motor and drive information, then choose the block of "Edit".



d) In the "Drive Setup” page, select radio button of Position or Speed in the section of "Control Mode", then press the large button of "Motor Setup".

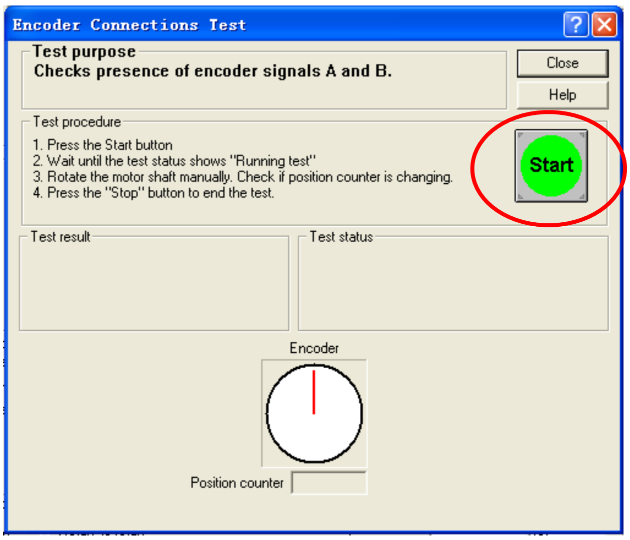


e) In the “Motor Setup”window , click on the button “Test Connections”, then the following page will pop up.

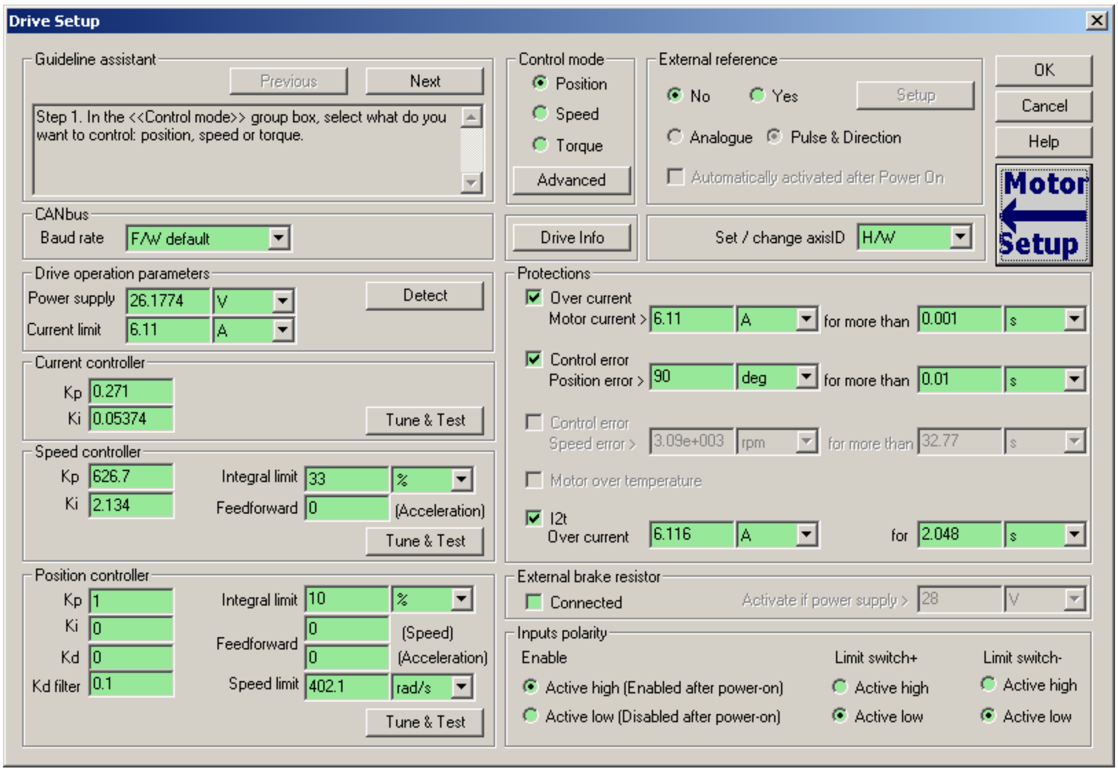


Note: Motor data shall be the specific parameters of the motor used, where the motor manual may be referred to. The other parts and functions setting of the Easy Motion Studio may refer to the help documents of Easy Motion Studio.

f) Click on striking button Start. The operator shall stand on the side closing two motors and turn the big belt pulley with hand towards the direction to the motor when the red pointer of the Encoder turns clockwise and the position counter increases; on the contrary, if the big belt pulley is turned towards the other direction, the red pointer will turn counterclockwise, and the position counter decreases.

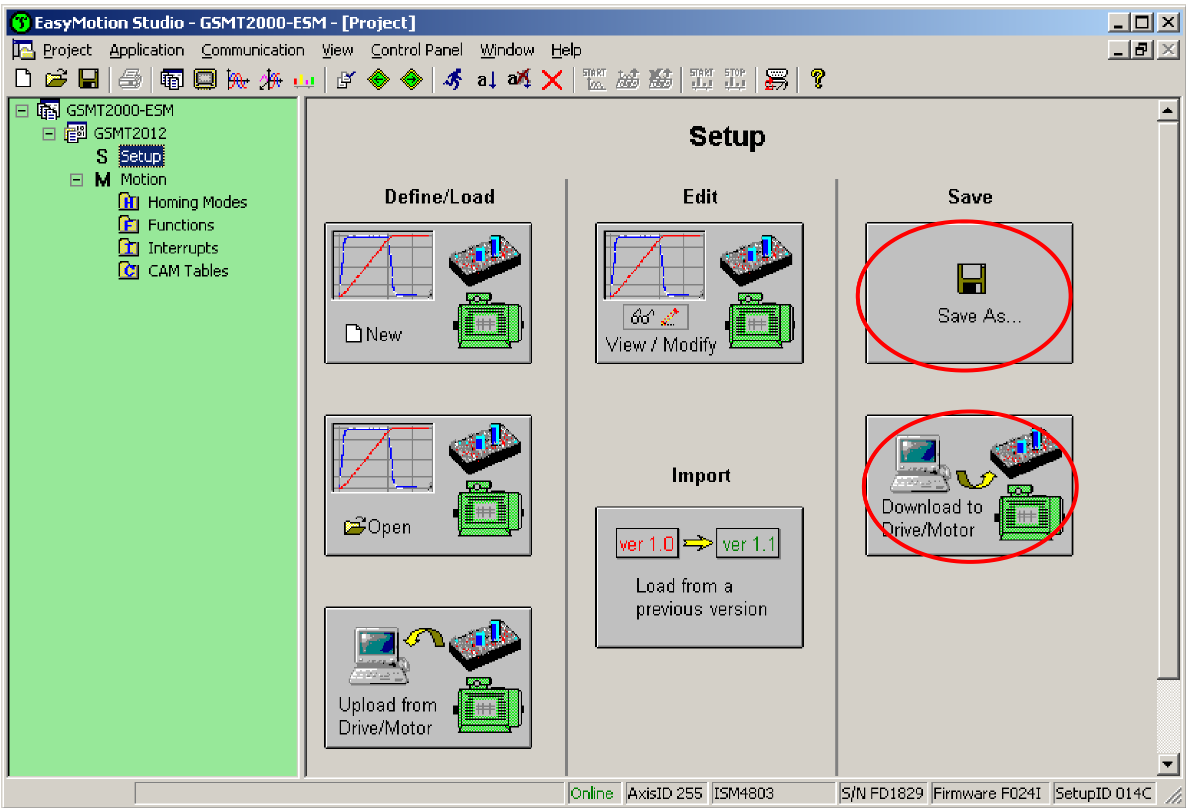


g) After the test is finished, click on the button of "Stop", then close the window, and back to the page of "Driver Setup".



Under such page, all parameters of the drive are adjustable, where the Control Mode includes "Torque" for torque control, "Speed" for speed control and "Position" for position control. The radio button of "Position" shall be selected here.

h) After the parameter is modified, click on button "OK" to back to the page below. Then click on section “Download to Driver Motor” on the right column to download the modified parameters to the drive or click on "Save as" button on the top right to save current settings.



Chapter II Single Motor's PID Parameters Adjustment

Note: this Chapter applies to GSMT2012, GSMT2013 and GSMT2014；

I. Experiment Purpose

1. Use the mechanism method to build the mathematic model for the DC servo motor;
   Master the method to tune the current controller, speed controller and position controller's PID parameters of the DC servo drive；

II. Experiment Requirements

1. Use the mechanism method to build the mathematic model for torque, revolving speed and position of the DC servo motor;
2. Tune the current controller, speed controller and position controller's PID parameters of the DC servo drive based on the expected performance index

III. Experiment Device

1. DC servo system control platform
2. PC, Easy Motion Studio software

IV. Experiment Principles

System modeling may be divided into two categories: mechanism modeling and experiment modeling. Mechanism modeling means to establish the internal input-output relations of a system via mathematical means on the basis of physics and chemistry knowledge, as well as the understanding of the motion characteristics. While experiment modeling refers to the input-output relations of a system via mathematical means, which is built after the researchers enter a series of input signal determined in advance on the object to stimulate such and the observable output is measured through the sensor. This process covers the design and selection of input signal, accurate measurement of output signal, and the study of mathematical algorithm etc.

1. The mathematical model for DC servo motor's revolving speed transient process built with mechanism method

When the armature voltage of the DC motor is changed, the differential equation of the DC motor dynamic process is

$$\tau_m \tau_e \frac{d^2 n(t)}{dt^2} + \tau_m \frac{dn(t)}{dt} + n(t) = K_c U_a - k_f T_c \tag{2.1}$$

Where, the τ_e is electromagnetic time constant, τ_m is mechanical time constant, K_c is revolving speed constant, k_f is mechanical property slope, U_a is armature voltage, $n(t)$ is motor revolving speed, and T_c is load torque. If the motor is assumed to be under ideal idle load $T_c = 0$, the transfer function shall be:

$$\frac{n(s)}{U(s)} = \frac{K_c}{\tau_m \tau_e s^2 + \tau_m s + 1} \tag{2.2}$$

In general, as regards the DC servo motor $\tau_e << \tau_m$, and (2) may approximate to

$$\frac{n(s)}{U(s)} = \frac{K_c}{\tau_m s + 1} \tag{2.3}$$

2. The mathematical model for DC servo motor's position transient process:

As position is the integral of speed, and each turn of the motor corresponds to 2π radian, it echoes to the Equation (2.3), and the transfer function of position is

$$\frac{\theta(s)}{U(s)} = \frac{K_c}{\tau_m \tau_e s^2 + \tau_m s + 1} \times \frac{2\pi}{s} \tag{2.4}$$

Corresponding to Equation (2.2), the position transfer function is

$$\frac{\theta(s)}{U(s)} = \frac{K_c}{\tau_m s + 1} \times \frac{2\pi}{s} \tag{2.5}$$

3. Mathematical model of torque:

The electromagnetic torque of the DC motor is

$$T_{em} = K_T \phi I_a \tag{2.6}$$

Where, T_{em} means the electromagnetic torque generated by the motor, it is in the unit of N*m; K_T is torque coefficient, which is determined by the motor structure, ϕ is the motor flux in the unit of Wb, and I_a is the armature current of the motor in the unit of A;

4. Manual adjustment of current controller PI parameters

There are various *PID* control algorithms with each one targeting different category. Three cases are presented in Fig. 2.1, Fig. 2.2 and Fig. 2.3 as below.

In simulated control system, the *PID* control is the most commonly used one. The principle block diagram of the simulated control system is shown in Fig. 2.1. The system is composed of simulated *PID* controller and the controlled object.