BALL & BEAM CONTROL SYSTEM

Overview

GBB series Ball & Beam control system are specially designed for courses in automatic control principle, modern control engineering, and electrical motor control. It is able to control the position of a stainless steel ball on the track by adjusting the rotating angle of a beam. The system consists of two parts, namely the Ball & Beam body and the control system.

The Ball & Beam body consists of a v-grooved steel bar and a free rolling ball. The linear sensor measures the position of the ball on the track by measuring the output voltage from the stainless steel bar. A DC motor is connects to a gear reducer, which controls the angle of beam, accordingly realize the position control of the ball. Experiments such as system modeling, design of feedback controller, P, PD and PID control system design, design controllers using root locus methods, and frequency response methods etc. can be achieved with this experiment platform.

GBB2004

Experiment Content and Directions

With the experiment platform, students will learn the method of control system analysis and design as they are new in this area. "Experiment course based on the control system analysis and design of ball and beam" describes how to select control algorithm for better performance index after the electrical and mechanical part of the control system is completely confirmed. Method of control system analysis and design is introduced gradually according to the learning characteristic of the students.

Comprehensive Experiment	PID adjustment
Designed Experiment	Root locus adjustment
	Frequency domain adjustment
	Status feedback control
Verifying Experiment	System modeling and stability analysis

GBB1004

Composition Structure of Control System

There are two different control for the two ball and beam systems. For real time control under Matlab, GBB2004 model is recommended.

Non-real time control by intelligent drive (up to Matlab ver. R2010b) or Analog Control Box

PC   RS232   Intelligent Drive   GBB1004

Analog Control Box   GBB1004
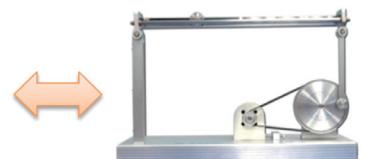
Ball & BEAM

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Real time control by using dedicated motion controller − for Matlab ver. R2012b or above

Motion Controller

PC

Intelligent Drive
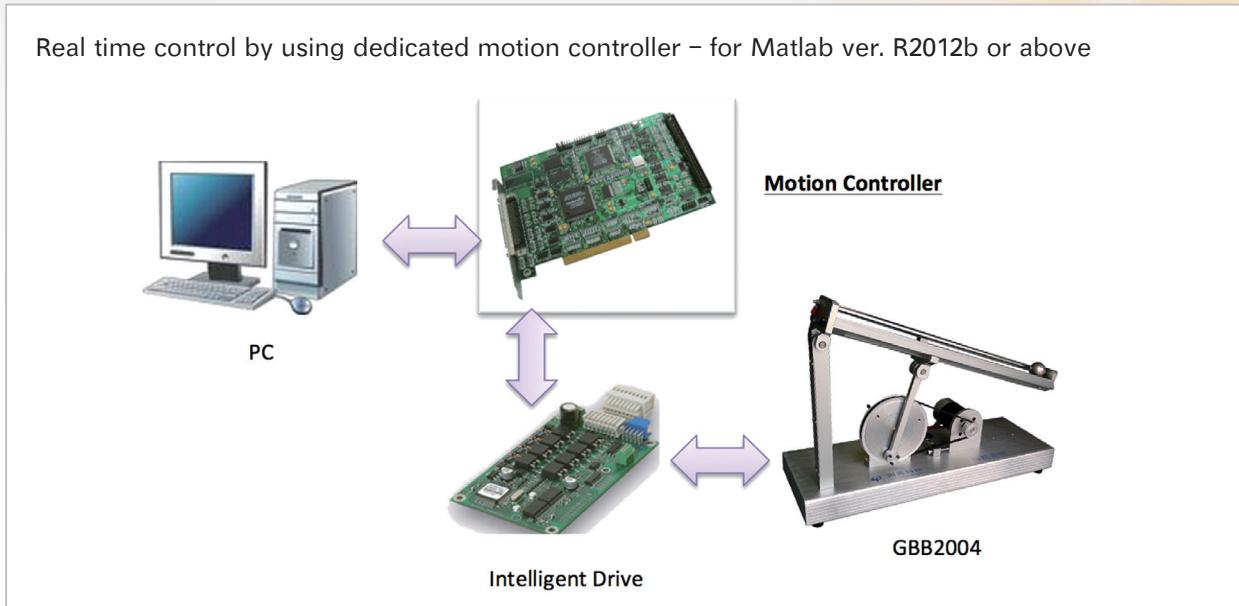
GBB2004

Model	GBB1004	GBB2004
Mechanical structure	System input rang is small and slower response	System input range increased and quicker response
Control method	IPM Motion Studio	GTS-400 motion control card
Real-time control	No	YES
System input range	Smaller	Larger
Experiment quality	simple mathematical model	many non-linear factors are considered
	big variation between step response simulation curve and actual curve;	simulation and actual curves are very close
	overall performance is poor	overall performance is good

Matlab Control Interface

Take frequency domain step response as an example:
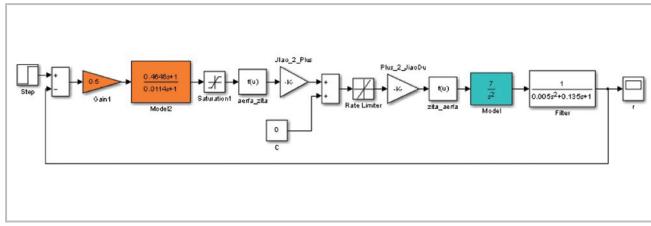
Frequency domain step response simulation curve:
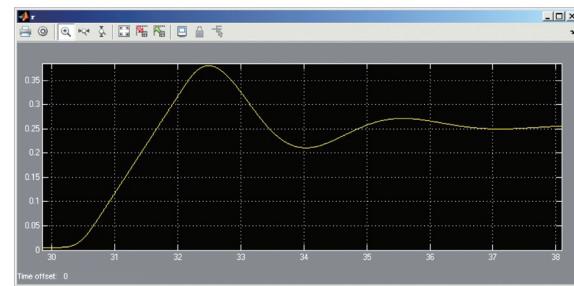
Frequency domain step response real time control curve:
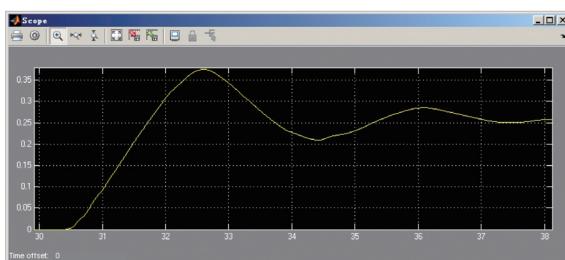
Frequency domain step response real time control interface:
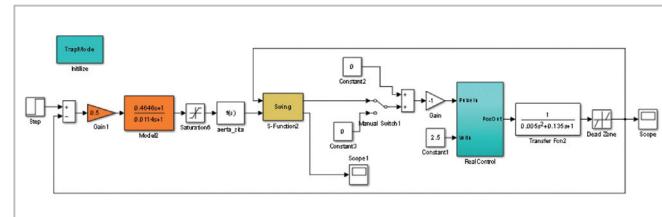
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	Controller parameters	Performance Index
Compensation Simulation	$0.5 \times \dfrac{1+0.4646s}{1+0.0114s}$	δ =33% t_s=6s, Steady-state error 2%
Compensation Result	$0.5 \times \dfrac{1+0.4646s}{1+0.0114s}$	δ =39% t_s=8.1s, Steady-state error 8.2%

Technical Specifications

Moving range	400mm	Ball diameter	30mm
Control precision	< 5mm	Motor	DC servo 70W
Synchronous belt reduction ratio	4	Power supply	AC220V 50HZ 1A (AC110V optional)
Weight	< 10Kg	Dimension	530 x 200 x 332 mm

Ordering Guide

Model no.	Product name	Standard package
GBB2004	Ball & beam system (new)	Ball & beam system main body (new)
		GTS-400 motion control card
		Electric control module
		Easy Motion Studio software development platform
		Googol Simulink general software experiment platform
GBB1004	Ball & beam system	Ball & beam system main body
		Electric control module
		IPM Motion Studio software development platform
		Googol Simulink general software experiment platform
GAES1001	Analog control system	For both systems (Optional)

Ball & BEAM

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