

INDUSTRIAL CONTROLS CONSULTING

A Division of Bull's Eye Marketing, Inc.

— PRESENTS —

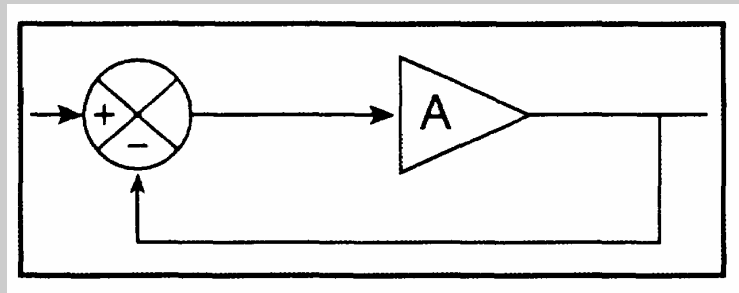
WORKING WITH SERVOS

IN-HOUSE

“We don’t use servos because we don’t understand them!”

“No one in our company has servo training or experience!”

“We don’t see the advantage of converting to servos!”



Are these the type of comments that you are hearing? Do you wonder what you can do to improve the situation? Is your company getting involved in servos and motion control? Do key engineers and senior technicians know how to size motors and drives?

Two professional engineers in Wisconsin have developed a seminar to appeal to engineering managers who want to train their technical staff on servos and motion control. The two-day seminar is entitled *Working with Servos*.

Day one of the seminar provides enough theory and exercises to predict how a servo will respond to sine waves and step inputs. You will understand what PID, feedforward, and S curves are and why they are used. It also shows a method of predicting the actual path that two axes of servos will follow at the corner.

Day two investigates the many interface concerns when applying a servo. Discussed are backlash, windup, coulomb friction, static friction, resolution, duty cycle, stiffness, inertia, and thrust. Methods for calculating and compensating them are described. Also discussed are manual and computer sizing of drives and motors. Detailed seminar outline is given inside.

CALL 920-929-6544!

WORKING WITH SERVOS AND MOTORS

— BRING A CALCULATOR! —

DAY ONE: Servo Basics and Performance Prediction

“Servo Basics and Performance Prediction” is intended to review the basics of servos and to apply those basics in predicting how a servo will respond under different conditions. It is best suited for engineers who want an intuitive grasp of the workings of servos, an understanding of the terminology involved and the ability to determine how well the servo can be expected to perform in real applications. Day one will cover the following subjects and questions.

8:00 a.m. to 8:30 a.m.

Registration, Continental Breakfast*

8:30 a.m. to 12 noon

Morning Session

- ⌚ A vision of motion control.
- ⌚ The basic gain equations.
- ⌚ Feedback
- ⌚ Type 0,1 and 2 servos.
- ⌚ Bode diagrams made easy.
- ⌚ How a Bode diagram is useful in predicting servo response.
- ⌚ Characteristics of a motor.
- ⌚ Relating gain to the real world.
- ⌚ Response to sinusoidal inputs.
- ⌚ Servo response to step inputs.

12 noon to 1:00 p.m.

Lunch (our treat!!)*

1:00 p.m to 4:30 p.m.

Afternoon Session

- ⌚ Investigating what happens at corners?
- ⌚ Importance of gain setting.
- ⌚ What is the advantage of feedforward and what is it?
- ⌚ What is a type 2 system?
- ⌚ PID in a servo.
- ⌚ Stability criteria in a servo.
- ⌚ Load effects on stability.
- ⌚ S curves and their application.

4:30 p.m. to ?

Questions and answers One-on-one discussion

DAY TWO: Servo Considerations and Drive Sizing

“Servo Considerations and Drive Sizing” covers the electrical and mechanical characteristics that are important when marrying drives and motors to mechanical devices. It is best suited for engineers who apply controls to machines and must contend with the typical problems encountered. It will help to recognize problems and understand what must be done to solve them. Day two content is as follows:

8:00 a.m. to 8:30 a.m.

Registration, Continental Breakfast*

8:30 a.m. to 12 noon

Morning Session

- | | |
|-------------------------------|--------------------------------|
| ⌚ DEFINITIONS | ⌚ COMPENSATING TECHNIQUES |
| ⌚ DRIVE MOTOR CHARACTERISTICS | ⌚ DRIVE SPEED & ACCELERATION |
| ⌚ DRIVE CLASSIFICATIONS | ⌚ Critical Speed |
| ⌚ Evolution | ⌚ S-Curves |
| ⌚ Classes-Overall/Electric/AC | ⌚ DRIVE THRUST/TORQUE |
| ⌚ DRIVE MOTOR EQUATIONS | ⌚ DRIVE INERTIA CONSIDERATIONS |
| ⌚ AMPLIFIERS/TYPES | ⌚ Calculations · Problems |
| | ⌚ DRIVE RATIOS |

12 noon to 1:00 p.m.

Lunch (our treat!!)*

1:00 p.m to 4:30 p.m.

Afternoon Session

- | | |
|---------------------|-----------------------|
| ⌚ DRIVE PERFORMANCE | ⌚ DRIVE DUTY CYCLE |
| ⌚ DRIVE STIFFNESS | ⌚ DRIVE FRICTION |
| ⌚ Equations | ⌚ DRIVE SIZING |
| ⌚ DRIVE RESOLUTION | ⌚ Introduction |
| ⌚ Equations | ⌚ Manual Drive Sizing |
| | ⌚ Problem |
| | ⌚ CAE example |

4:30 p.m. to ?

Questions and answers One-on-one discussion

NOTES: 1. There will be a short break in the morning and one in the afternoon with soda and coffee. Lunch will also be served.* 2. A seminar manual will be available for each attendee. 3. Hand-held calculators are required since problems are used to reinforce the concepts.

*Food and beverages for in-house seminars are at the discretion of the company.

JOIN THE MANY WHO HAVE BENEFITTED IN THE PAST

IN-HOUSE:

Allen-Bradley*
R.A. Jones
Martin Marietta
Proctor & Gamble*
Compumotor
Johnson & Johnson
Corning, Inc.*
Motor Science
GE-FANUC*
Bartell Machinery
Cincinnati Milacron
Motion Engineering*
Kollmorgen
Parker Daedel
Giddings & Lewis, Inc.
Motion Solutions
John Deere
ABB - Flexible Automation
Industrial Indexing
R.H. Strasbaugh
Yaskawa Electric
Paper Converting Machinery
Heidelberg Web Systems
Hopman
John Deere*
Tawas Tool Co.
Xycom*
Mitsubishi Electric
* 2 or more times
CITY-SITES: (partial list)
Wisconsin Tissue
Cutting Tools, Inc.
Kewaunee Engineering Corp.
L & S Electric
Tree Machine Co.
Appleton Papers
Lucas Aerospace
Presto Products
J.M. Grimstad
Universal Instrument Corp.
Automation Specialists
Stanley Engineered Components
Uni Distribution
Shanklin Corp.
Roll Systems, Inc.

Target Electronic Supply, Inc.
Allen-Bradley
Pacific Scientific
Eagle Electric Supply
CMI Dearborn
Crocker Limited
Federal Mogul
New Products Corp.
Vickers, Inc.
TRW
Gentex Corp.
General Motors - Romulus
Franchino Mold
Fitzpatrick Electric
The Don Blackburn Co.
Eaton Corp.
H & H Tube and Manuf.
Alliance
Du Pont
Robamatix, Inc.
Detroit Edison
NC Servo Technology
Ford Motor Co.
International Paper
Automation, Inc.
Electrolines
Software Algorithms, Inc.
Fife Electric
Siemens
McBroom Electric Co.
Mosier Fluid Power
Copeland
Promation, Inc.
Indiana Glass Co.
Cincinnati Milacron
Marion Merrell Dow
Dorsey Alexander, Inc.
Thompson Consumer Electric
Stevens Graphics
Nelcor
AM Graphics
PMI Food Equipment Group
Phase Metrics
Poly Cast Technology
Pro-Power Associates
Proven Designs
PS Group, Inc.

Zero-Max
Zippo Manufacturing
Combibloc
R.A. Jones & Co.
Emerson Power Transmission Corp.
Machine Drive Co.
Multi-Line Technologies
ITT Automotive
KOM Lamb, Inc.
Magna Products Corp.
Ormec
Ross Equipment Corp.
Theta Technology
Aromat Corp.
Trupower Engineering
Johnson & Johnson
Ortho-McNeil Pharmaceutical
Devro, Inc.
Nabisco
ILC Data Device Corp.
HD Systems, Inc.
Sumitomo Machine Co.
Picut Manufacturing
EAP, Inc.
Melcor Corp.
Lenze Power Transmission
Berg Electronics
Mateer-Burt
J.L. Souser
HPI
August Design, Inc.
Pittman Div.
NAWCADWAR
Graybill Machines
EG&G Pressure Science
U.S. Army
Dentsply International, Inc.
Eastalco
Ward Machinery
McKee Foods Corp.
Rexroth - Indramat
SAIC
Schneider Canada, Inc.
SDK & Associates, Ltd.
Solatron
Prince Machine

Kollmorgen
Kliklok Corp.
Micro Mo Electronics
Duracell USA
Parker-Hannifin Corp.
Debardeleben & Assoc., Inc.
American Cast Iron Pipe Co.
Avery Dennison - K&M Div.
Hilco, Inc.
Phifer Wire Products, Inc.
Cooper Power Systems
Intram Automation
Southern Power
Shippers Paper Products Co.
Cookville Electric Motor Co.
Bama Pie Limited
Kwikset Corp.
Trinity Forge
Harmonic Drive Technologies
CRC Evans
L&H Supply Co., Inc.
Control Automation
Warner Electric
Nyma, Inc.
Orlando Baking Co.
USG Interiors
Lincoln Electric Co.
Hurco Manufacturing
Comptrol, Inc.
Detroit Diesel Corp.
Process Automation, Inc.
Hausse Automation
E & E Engineering
Sauder Woodworking
ABTCO
Kimberly Clark
Mobil Chemical
Controlink
St. George Crystal, Ltd.
Stone Ind.
Synrad - Emerald Laser, Ltd.
Tamarack Scientific
Tibor Machine Products
Toddco General, Inc.
SVG Lithography
Wire Mold Corp.
Cummins-Allison Corp.

Camco
Koepeke & Assoc.
Masonite Corp.
Guardian Electric Co.
John Sterling Corp.
Hill Engineering
Indramat
Cincinnati, Inc.
Flodyne Hydrane
Wm. J. Murphy Co.
Omron, Inc.
Mark Andy, Inc.
Hunter Engineering
Dickey-John Co.
Sunnen Products Co.
M&W Packaging
Richard Greene Co.
Brady University
Missouri Valley Electric
Republic Paperboard Co.
Kornfeld-Thorpe Electric
Sealright Engineering Services
LDR Products Textron
Bridgestone/Firestone
Evergreen Packaging Equip.
Townsend Engineering
Ramco Electric Co.
3M
Custom Servo Motors
Eesco United
Fluoroware
Brenton Engineering
Aetrium
Contrex/Fenner
Seagate
Scanner Technologies
Sci Med
Tol-O-Matic, Inc.
Utilisec, Inc.
White Sands Missile Ranch
Whitey Company
Youngstown State University
Omni Rel
Gerber Garment Tech.
Adept Technology
Allied Signal
AMK - Drives & Controls, Inc.

Argonne National Lab
Belstone Electronics Corp.
Blackburn Motion Products
BWI Kartridgpak
Calex Corp.
Cello-Foil Products, Inc.
Cinti Gilbert Machine Tool Co.
Distributed Motion, Inc.
Eagle Equipment Corp.
EG&G Pressure Science
Electrolines
Exonic Systems
Food & Drug Administration
Fox Valley Technical College
Gardner Disc Grinders
GE Fanuc
Grab Systems
Guardian Electric
Guidant
Hammond Machines
HESCO
Hitech Control Systems, Inc.
Homersmith, Inc.
Hostvedt-Pavoni, Inc.
Kelbrun Engineering Co.
Kirkwood Commutator Co.
Krugger Tool
Maida Development Co.
Maryland Wire Belts, Inc.
Michelin
Mideastern, Inc.
Moraine Park Technical College
Motion Control Corp.
Motorola Manufacturing
NASA Goddard Space Ctr.
Newcor
Norton
Oven-Fresh/April Hill
Pandjiris, Inc.
Personal Products Corp.
T. Sendzimir
Pitney Bowes

WORKING WITH SERVOS AND MOTORS



THOMAS B. BULLOCK

Tom is president of the Industrial Controls Consulting (ICC) division of Bull's Eye Marketing, Inc., a company that provides technical education, strategic planning, market research and sales and marketing planning in the industrial machine control field. Mr. Bullock spent thirty-one years in industry before forming ICC in 1990. He began his career

designing servos and numerical controls, subsequently moving into engineering management, sales and marketing management, and general management. Tom obtained a degree in engineering from the University of Wisconsin in 1959. He also has a Master's degree in engineering from the University of Pennsylvania and has 27 credits in business as a graduate student at the University of Wisconsin-Oshkosh. He is a registered professional engineer and holds five patents.

Tom is a past Chairman of the NC Committee of the AMT (formerly the National Machine Tool Builders Association). He has served as National Director, Area Vice President, and National Treasurer of the NMA (the National Management Association). He served as the Steering Committee Chairman and Past President for the Industrial Computing Society. He is a free lance writer who has had dozens of articles published in the last three years. He is a member of, and has been involved in, numerous national and community organizations and activities.



GEORGE W. YUNKIN

George is a staff consultant with ICC. In 1950, George received a B.S. degree in electrical engineering from Michigan State University and in 1957, an M.S. degree in electrical engineering from the University of Wisconsin. Prior to joining ICC in 1992, George had over forty years industrial experience with Westinghouse

Electric Corp. and Giddings and Lewis, Inc., where his duties included servo drive control systems development, design of hydraulic drives, and teaching of numerical control and feedback control theory. He has been awarded two patents, has authored numerous technical papers and articles, and is a Registered Professional Engineer. His book, "Industrial Servo Control Systems Fundamentals and Applications", 2nd Edition, was published in 2002.

George has served as President of the Institute of Electrical and Electronic Engineers (IEEE) Industry Applications Society (IAS) in 1974, Chairman of Industrial Control, Industrial Drives and Machine Tools Industry Committee, along with numerous other assignments. He was awarded the 1984 IEEE Standards Medallion and the IEEE Medallion Medal. In 1988 he was awarded the IEEE IAS Distinguished Service Award, and in 1991 was elected to the IEEE grade of FELLOW. The IEEE Third Millennium Medal was awarded to him in October 2000 for his outstanding contributions to IEEE and machine automation.

GENERAL INFORMATION ON IN-HOUSE SEMINAR

ON-SITE SCHOOL/SEMINAR FEES:

The two-day seminar is \$2,700. Travel and incidental expenses and course materials are extra. Course material cost per student is \$100 for the two-day seminar.

REFUNDS AND CANCELLATIONS:

Administrative fees for cancellation are as follows:

- Over 2 week notice - no charge
- Less than 2 weeks - \$150
- Less than 1 week - \$300

LOCATION:

Contracting organizations for in-house seminar should provide a classroom large enough to accommodate the attendees comfortably. Also needed will be a blackboard or whiteboard, screen, and overhead projector.

Canceling organization will be responsible to ICC for additional expenses including non-refundable airline tickets and other non-recoverable charges. In the event ICC must cancel due to unknown circumstances, ICC will not be held accountable for charges incurred by the contracting organization.

COMPARISON OF COSTS

This comparison shows the cost for conducting a seminar in-house compared to attending at one of ICC's city sites both locally and where travel is required. The value of a person's travel time would be an additional consideration favoring in-house seminars. A single seminar registration at a city site is \$695, two or more city site registrations from an organization is \$595 per person.

Cost per student for a 2 day seminar

Total cost to organizations for a 2 day seminar

# OF PEOPLE	IN-HOUSE	CITY SITE WITH-OUT TRAVEL & HOTEL	CITY SITE WITH TRAVEL & HOTEL
3	\$1,233	\$595	\$995
4	\$950	\$595	\$995
5	\$780	\$595	\$995
6	\$667	\$595	\$995
8	\$525	\$595	\$995
10	\$440	\$595	\$995
12	\$383	\$595	\$995
14	\$343	\$595	\$995
16	\$313	\$595	\$995
18	\$289	\$595	\$995
20	\$270	\$595	\$995
30	\$213	\$595	\$995
40	\$185	\$595	\$995

# OF PEOPLE	IN-HOUSE	CITY SITE WITH-OUT TRAVEL & HOTEL	CITY SITE WITH TRAVEL & HOTEL
3	\$3,700	\$1,785	\$2,985
4	\$3,800	\$2,380	\$3,980
5	\$3,900	\$2,975	\$4,975
6	\$4,000	\$3,570	\$5,970
8	\$4,200	\$4,760	\$7,960
10	\$4,400	\$5,950	\$9,950
12	\$4,600	\$7,140	\$11,940
14	\$4,800	\$8,330	\$13,930
16	\$5,000	\$9,520	\$15,920
18	\$5,200	\$10,710	\$17,910
20	\$5,400	\$11,900	\$19,900
30	\$6,400	\$17,850	\$29,850
40	\$7,400	\$23,800	\$39,800

NOTE: All expense costs are estimates only. Student travel assumes \$200 for two days of hotel and meals and \$200 in travel. Also, in-house seminar fees are \$2,700 for 2 days plus \$700 total expenses. Seminar materials for in-house training are \$100 per student.