

Reduced-Cable Smart Motors Using DC Power Line Communication

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Abstract

A novel servomotor design that is powered and controlled through only one wire is presented in this paper. A traditional servomotor needs both a power cable and a control cable connecting the motor to a control amplifier. Cables are bulky, heavy, and expensive and, more importantly, difficult to install and maintain in many applications. Particularly for multi-axis applications, like robots and machine tools, cable harnesses become thick and long, and are difficult to run through a stack of many axes, being a major burden and bottleneck in electromechanical drives. The objective of this research is to eliminate such bulky cables by integrating and consolidating power cables and signal cables into a single wire, and transmitting control signals through the signal wire. Signals are coded by using a CDMA protocol and are superimposed on the single wire that supplies a DC voltage to each motor. In this paper first the principle of reduced-cable smart motors is described, followed by the architecture of signal transmission system using direct sequence spread spectrum. A prototype system is designed, and the signal transmission line is simulated to verify the principle.

1. Introduction

Robots, machine tools and other mechatronic systems have many axes of servomotors to control. Traditionally, as shown in Figure 1, we need numerous power cables to supply the necessary power for those servomotors and signal wires for transmitting sensor signals. Cables and wires have become a bottleneck in electromechanical devices. Especially as the degree of freedom of a machine increases they are difficult to install through a stack of many axes. Mover, Cables are bulky, heavy, expensive and difficult to assemble and maintain in high degree-of-freedom applications. The goal of this paper is to eliminate such bulky cables by integrating and consolidating power cables and signal cables into a single

wire. We will achieve this goal by combining a smart motor architecture with multi access data communication technology.

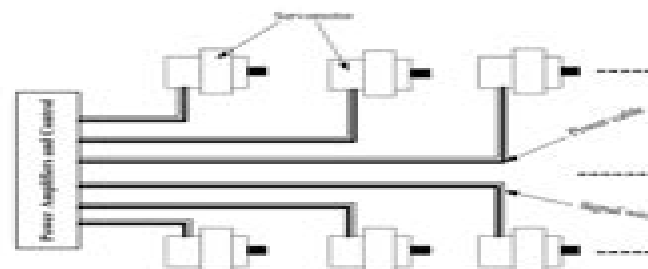


Figure 1 Need of numerous cables for a high d.o.f. electromechanical drive system.

A smart motor, also called an integrated motor, is a servomotor having a drive amplifier and a feedback controller housed inside the motor chassis. It is the type of self-contained motor packaged together with its control units, encoders and sensors, etc. Combining the motor and control allows both parts of the package to be tailored to match the performance of the other. Time saving in setting up and adjusting control system units of the motor is the benefit of this combined drive when it is replaced. Nevertheless, the most important reason to result in the motor-to-controller matching is the benefits we acquire in case of implementation and reduced electromagnetic interference (EMI) by eliminating the long lead length between motor and power amplifier, and then noise can be suppressed. Bigler proposed the prototype design of a smart motor [5], and most of smart motors presently produced have internal structures similar to his design. The most important feature in his design is that all electrical signals between the motor and controller are transmitted via pins, eliminating wiring harnesses of the

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Reduced Cable Smart Motors Using Dc Power Line Communication:

Proceedings 2003 IEEE/RSJ International Conference on Intelligent Robots and Systems ,2003 Power Line Communications Lutz Lampe,Andrea M. Tonello,Theo G. Swart,2016-04-27 This second edition of Power Line Communications will show some adjustments in content including new material on PLC for home and industry PLC for multimedia PLC for smart grid and PLC for vehicles Additional chapters include coverage of Channel Characterization Electromagnetic Compatibility Coupling and Digital Transmission Techniques This book will provide the reader with a wide coverage of the major developments within the field With contributions from some of the most active researchers on PLC the book brings together a wealth of international experts on specific PLC topics *Conducted Electromagnetic Interference (EMI) in Smart Grids* Robert Smolenski,2012-03-23 As power systems develop to incorporate renewable energy sources the delivery systems may be disrupted by the changes involved The grid s technology and management must be developed to form Smart Grids between consumers suppliers and producers Conducted Electromagnetic Interference EMI in Smart Grids considers the specific side effects related to electromagnetic interference EMI generated by the application of these Smart Grids Conducted Electromagnetic Interference EMI in Smart Grids presents specific EMI conducted phenomena as well as effective methods to filter and handle them once identified After introduction to Smart Grids the following sections cover dedicated methods for EMI reduction and potential avenues for future development including chapters dedicated to potential system services descriptions of the EMI spectra shaping methods methods of interference voltage compensation and theoretical analysis of experimental results By focusing on these key aspects Conducted Electromagnetic Interference EMI in Smart Grids provides a concise and comprehensive coverage of an extensive subject matter It constitutes a key resource for any industry practitioners researchers or system designers with interest in Smart Grids particularly their electromagnetic compatibility in the conducted EMI frequency range Control and Mechatronics Bodgan Wilamowski,J. David Irwin,2018-10-08 The Industrial Electronics Handbook Second Edition combines traditional and newer more specialized knowledge that will help industrial electronics engineers develop practical solutions for the design and implementation of high power applications Embracing the broad technological scope of the field this collection explores fundamental areas including analog and digital circuits electronics electromagnetic machines signal processing and industrial control and communications systems It also facilitates the use of intelligent systems such as neural networks fuzzy systems and evolutionary methods in terms of a hierarchical structure that makes factory control and supervision more efficient by addressing the needs of all production components Enhancing its value this fully updated collection presents research and global trends as published in the IEEE Transactions on Industrial Electronics Journal one of the largest and most respected publications in the field Control and Mechatronics presents concepts of control theory in a way that makes them easily understandable and practically useful for engineers or students working with control system applications Focusing more on

practical applications than on mathematics this book avoids typical theorems and proofs and instead uses plain language and useful examples to Concentrate on control system analysis and design comparing various techniques Cover estimation observation and identification of the objects to be controlled to ensure accurate system models before production Explore the various aspects of robotics and mechatronics Other volumes in the set Fundamentals of Industrial Electronics Power Electronics and Motor Drives Industrial Communication Systems Intelligent Systems **1997 IEEE 12th Applied Power Electronics Conference** ,1997 These proceedings provide comprehensive coverage of the fundamental technology used in the control and conversion of electric power The papers cover the entire electric power industry from supply basis to magnetic design from manufacturability to regulation **Smart Grids** David Bakken,2017-12-19 The utilization of sensors communications and computer technologies to create greater efficiency in the generation transmission distribution and consumption of electricity will enable better management of the electric power system As the use of smart grid technologies grows utilities will be able to automate meter reading and billing and consumers will be more aware of their energy usage and the associated costs The results will require utilities and their suppliers to develop new business models strategies and processes With an emphasis on reducing costs and improving return on investment ROI for utilities Smart Grids Clouds Communications Open Source and Automation explores the design and implementation of smart grid technologies considering the benefits to consumers as well as businesses Focusing on industrial applications the text Provides a state of the art account of the smart grid Explains how smart grid technologies are currently being used Includes detailed examples and test cases for real life implementation Discusses trade offs associated with the utilization of smart grid technologies Describes smart grid simulation software and offers insight into the future of the smart grid The electric power grid is in the early stages of a sea of change Nobody knows which business models will survive but companies heeding the lessons found in Smart Grids Clouds Communications Open Source and Automation might just increase their chances for success Energy Management Systems Giridhar Kini,2011-08-01 This book comprises of 13 chapters and is written by experts from industries and academics from countries such as USA Canada Germany India Australia Spain Italy Japan Slovenia Malaysia Mexico etc This book covers many important aspects of energy management forecasting optimization methods and their applications in selected industrial residential generation system This book also captures important aspects of smart grid and photovoltaic system Some of the key features of books are as follows Energy management methodology in industrial plant with a case study Online energy system optimization modelling Energy optimization case study Energy demand analysis and forecast Energy management in intelligent buildings PV array energy yield case study of Slovenia Optimal design of cooling water systems Supercapacitor design methodology for transportation Locomotive tractive energy resources management Smart grid and dynamic power management **NASA Tech Briefs** ,2003 *High Technology* ,1986 Electrical Motor Controls for Integrated Systems Gary Rockis,Glen A. Mazur,2005 Electrical Motor Controls for Integrated Systems continues the long

tradition of technical content presented in a user friendly format A comprehensive overview of the control industry is augmented with practical applications used in the field With new large detailed illustrations contemporary photographs and informative factoids the premier motor control text remains the first choice of electrical training programs *Switchgear Design, Operation, and Maintenance Using Industry Standards* Gyan Ranjan Biswal, Bhaveshkumar R. Bhalja, 2025-04-18 *Switchgear Design Operation and Maintenance using Industry Standards* Protective Mechanisms Sensing Technology and Communication Standards is a practical handbook from both industry experts and academics covering the latest developments in switchgear This book breaks down cutting edge practical techniques according to the hierarchy of switchgear operations with an emphasis on critical technologies for automation in the energy transition Following a helpful refresher on switchgear fundamentals Part I examines essential safety considerations from fault identification and resolution to DC type circuit breakers and other protective mechanisms Part II sets out operating principles and testing procedures for reliable smart substations including communication protocols validation and cyber security Finally Part III considers essential operational maintenance such as circuit breaker maintenance and the critical function of high voltage DC switchgear for the energy transition An up to date helping hand for the transfer from university programs to industry *Switchgear Design Operation and Maintenance using Industry Standards* will allow professionals to design operate and maintain the smart automated substations the energy transition needs Tailors itself to industry standards and the practical hierarchy of switchgear operations for maximum application Includes clear chapter objectives and case studies to support learning Covers the latest switchgear developments for automated substations to support the energy transition

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