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STEERING SYSTEMS ASSEMBLY AUTOMATIC MACHINE CONTROL SYSTEM

ŘÍDICÍ SYSTÉM MONTÁŽNÍ STANICE AUTOMOBILOVÝCH ŘÍZENÍ

Abstrakt:
V příspěvku jsou popsány problémy technologie montáže daného případu, kterým jsou různé typy automobilových systémů řízení. Jsou popsány softwarové i hardwarové prostředky řešení. V obou případech se řešení opírá o špičkové technologie firmy SIEMENS, a to jak na úrovni řízení celého procesu, tak na úrovni vlastní montážní stanice automobilových řízení.

Abstract:
This article describes implementation of industrial assembly automatic machine control in the automotive industry. Industrial control system and the user's application were realized for the production line of automobile steering systems. The machine is responsible for the correct assembly and constriction of steering ending stubs. The article explains bases of the used assembly technology, hardware and software of the realized control system. The assembly machine functionality is controlled the industrial micro-controller SIMATIC S7-200 and special two frequency servo converters SIMOVERT MASTERDRIVE MC (Motion Control) series. Frequency converters are specially designed for industrial servo drive applications. The data transfer between the micro-controller and servo converters are realized via the RS 232 serial interface that uses USS (Universal Siemens Serial Interface) standard transmit serial protocol. User's parameters current values, diagnostic functions, error and warnings messages of the assembly machine are changed and displayed on the operator panel COROS OP3. The operator panel communicates the micro-controller via standard serial MPI (Multi-Point Interface) transmit protocol.

Keywords:
assembly steering system technology, industrial control system, text oriented operator panel, motion control, frequency servo converter, industrial communications

1 Introduction

Automatic assembly machine is one of special assembly stations in the automobile steering car systems production line. The assembly line realizes assembly process various types of automobile steering systems. The assembly machine is responsible for the correct assembly, position and constriction of steering systems ending stub axles. The correct position and fixation of steering stub axles is very important for perfect steering car system functionality. The production line technology is controlled by the main control system SIMATIC S7-400 series. The assembly processes on the station are controlled separately by its own industrial control system. There is a permanent cooperation between the local station control system and main control system of the assembly line.

2 Development tools of the control system application

2.1 STEP 7-Micro/WIN software

STEP 7-Micro/WIN is the software application specially used for S7-200 PLC (Programmable Logic Controller) series programming applications. The programming environment provides a user's friendly to develop, editing and monitor the functions and logic needed to control the industrial appli-

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cations. The software includes a set of tools required for development user industrial applications in STL (Statement List) or LAD (Ladder Logic) programming languages. The simple program structure of the STEP 7-Micro/Win development environment makes user's applications programming easy.

2.2 ProTool/Lite software

ProTool/Lite development environment is especially suited for configuring a various tapes of the text oriented SIMATIC HMI (Human-Machine Interface) operator panels. The environment provides a visualization and operator interface front-end to regular hardware of the logic controller. It can be easy integrated into STEP 7 software as part of SIEMENS TIA (Totally Integrated Automation). The ProTool/Lite development environment is a powerful and user's friendly application reduces downtime and increases programming productivity for machine level industrial control applications. The application software is running on MS Windows 98 or MS Windows NT/2000 platforms.

3 Hardware of the control system

3.1 Control system SIMATIC S7-200

SIMATIC S7-200 series is a line of micro-programmable logic controllers that can control a variety of automation applications. Compact design, flexible configuration and powerful instruction set combine to make the micro-controller a perfect solution for controlling a wide variety of industrial applications. The SIMATIC S7-200 CPU (Central Processor Unit) monitors inputs and changes outputs as controlled by the user's program, which can include Boolean logic, counting, timing, complex math operations, and communications with other intelligent devices. The micro-controller S7-200 series combines a microprocessor, an integrated power supply, input/output circuits and special modules in a compact housing to create a powerful micro industrial control system. These expansion modules enable additional functionality to the S7-200 CPU.

The micro-controller supports more different types of serial communication networks. There are two serial communication ports on the CPU. Each of serial ports can operate in PPI (Point-Point Interface), MPI (Multi-Point Interface) or in the Freeport mode. PPI interface is a master-slave protocol only. MPI interface allows both master-master and master-slave communications. Freeport mode allows control the communication port by the application program. The micro-controller S7-200 series can support the Ethernet communication based on TCP/IP transfer protocol through use of an Ethernet or Internet expansion module too.

3.2 Frequency servo converter SIMOVERT MASTERDRIVES MC

SIMOVERT MASTERDRIVES MC (Motion Control) frequency servo converter is specially designed for industrial servo drive applications and offers a modular software featuring. The frequency converter includes freely inter-connectable function blocks and integrated technological functions. Technological functions for positioning and synchronization, logical and mathematical blocks are available on the frequency converter and can be used freely too. The frequency servo converter concept is characterized a very high-level dynamic response, positioning and angular synchronism between drives. It is compatible regarding communication, technology, operator control and visualization. The frequency converter can communicate with other devices via the serial communication line either the PROFIBUS-DP or USS standard protocols. The SIMOVERT MASTERDRIVES MC is primarily vector controlled frequency converter for optimum energy supply. It is possible to use it for many control applications in a lot of industrial sectors.

3.3 Operator panel COROS HMI OP3

Text oriented operator panel COROS HMI (Human-Machine Interface) OP3 type allows operating states and current process values of a connected SIMATIC S7 control system to be visualized. Input parameters values can be changed on the operator panel and written into the connected control system. There also can by functions relating to machine diagnostics executed on the operator panel. The operator panel OP3 series is suitable for fitting into switching cabinets and control desks and for

use as a hand-held device. The configuration of the operator panel is created on a configuration computer using the ProTool/Lite configuration tool. The panel configuration consists of different components, including setting the current control system and the type of connection, general settings for the operator panel current type and objects, such as screens variables, information and error messages. The prepared configuration can by transferred into the operator panel memory. The operator panel can be connected to SIMATIC S7-200 automation system via PPI (Point-to-Point Interface) network configuration. The operator panel can be use in all small-scale applications in which operator control and monitoring of the technological process does not require the graphical display. They are in use in an extensive range of industrial applications.

4 Technological assembly process

The steering stub axles mounting station is part of the production steering car systems line. The production line is full automated and realizes all of operations useful for steering car system assembly. The one of operations is steering car stabs axles preparation. The control system and application made for the automatic assembly station are responsible for correct position, constriction and fixation of ending steering stub axles. The technological process is realized in a few steps and is started by the tender of the station. The automatic machine tender fixed steering stub axles on track bars threads and after that insert them into special barring preparations. Each of steering stub axles is automatically screwed in to desired position on track bars and tender tighten supporting female screw. The female screw constriction is executed for accurately defined moment value by the torque spanner. There is realized turning of steering stub axels by the operator defined positions as next step in the technological assembly process. When the both of steering stubs axels turning is finished the machine tender take out them from the special barring preparations. The next steering system technological process can begin on the automation station.

5 Mounting machine control application structure

The automatic assembly machine functionality is controlled by the industrial control system situated on the station. The station control system hardware of the automatic machine includes microcontroller SIMATIC S7-200 series, operator panel COROS OP3 type and two SIMOVERT MASTERDRIVES MC series frequency servo converters. The industrial control system architecture block diagram shows Figure 1.

The operations of the automatic assembly production line are controlled by SIMATIC S7-400 series. The local station control system of the machine has to do operations synchronously with other operations of the production line. Mounting pallets carry steering car systems preparations and move the preparations between several stations on the assembly line. All of production process steps are time-synchronized. Some of the stations are controlled separately by their own control systems. The working activity of next stations is operated by the main control system only. The machine programmable logic controller communicates with the main production line control system via digital input/output signals. There are signals, e.g. the pallet on the position, diagnostic signals, disabling signals etc. in the control systems interconnection. The control systems cooperation and failure-free signals exchange are important for the correct automatic assembly line functionality.

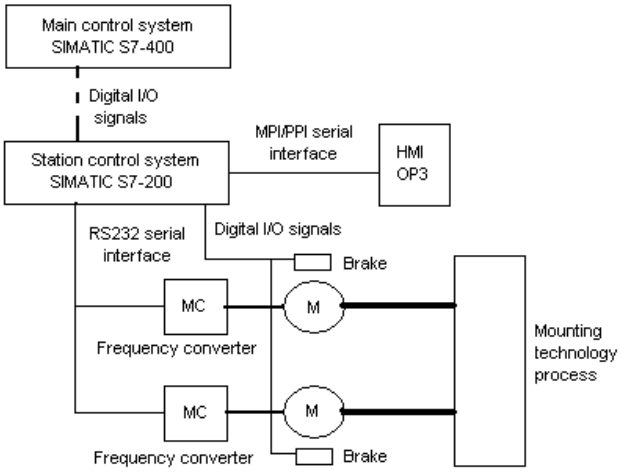

Figure 1: The mounting machine control system block diagram.

The operator panel and the micro-controller communicate by terms of the MPI/PPI standard serial interface. There are created suitable user's data areas depending on objects contained in the configuration, the data to be exchanged and an interface area to handle data synchronization in the micro-controller. The MPI/PPI network configuration uses the S7-200 logic controller unit as master. There is communication based on serial line RS 422/485 with USS (Universal Serial Transfer Protocol) between programmable logic controller and both of motion control frequency converters. The serial communication port of the micro-controller works in Freeport mode. Freeport mode can implement user-defined communications protocols to communicate with many types of intelligent devices. Freeport mode supports both ASCII and binary protocols. There is stored soft procedure to realize the USS communication protocol in the micro-controller program memory. The stored procedure uses software interrupts of the serial port and standard micro-controller functions for both data transfer and data receive. The current used transfer rate is 9600 bits/s. There is sufficient transfer rate for the small transferred data capacity on the serial port. The serial data communication is dependable in the disturbing industry environment.

The operator panel makes possible to entering tender parameters values of the assembly machine. To prevent unauthorized operation input fields on the operator panel are password level assigned in confirmation process. There is the possibility of controlling access by means of passwords and password levels for calling certain functions and inputs on the panel. When a machine tender enters to the operator panel with a password pertaining to a certain level, he is authorized to execute functions at that password level and at lower levels. The permission to execute functions of password level 9 is the sole responsibility of the super-user, who has access to all operator panel functions and parameters. The system administrator's password was set at system configuration. The super-user with password level 9 is authorized to call the password management functions only.

The automatic assembly machine can run in the manual, setting or full automatic control mode. The station uses for start of separate technological process steps the two-handled operating system in the automatic control mode. The two-handed machine operating is the instrumental to machine tender hands injury protection. The both control knobs have to be press down at the some time in terms of time interval 500ms. The output signal is generated during simultaneously pressed buttons. If ones of the button is released the output signal expire. The output signal can be regenerated after the second button release and subsequently two knobs press down repeated at the some time only. The two-handed operating functionality corresponds with the conditions of the EN 574 norm specification.

There are used asynchronous motors as electric drive units of barring preparations on the assembly station. Each of used servo frequency converters realizes speed and position regulations of the machine electric drives. The position regulators feedback is realized from the resolver and electronic linear sensor. The signal from the linear sensor is feedback signal for the steering stub axles screwing and relsolver controls their turning. The selection of the current feedback signal is chosen by the micro-controller. Output signals from sensors are connected into analog inputs on servo frequency converters. The position regulator parameters are optimized by automatic function in the frequency converter. The optimization is done with reference to the current connected asynchronous motors.

Control structures of frequency servo converters are realized of free functional control blocks and soft connectors. Values stored in the connectors are normalized values with a few exceptions, e.g. connectors for control words. The value range of these connectors covers a percentage value range from -200 % to +199,99 %. The value in connector of 100 % corresponds to the number 4000 0000H for double-word connectors. The diagram of value stored in a soft connector shows Figure 2. All of set point values have to be therefore recalculated. This way recalculated values respond to requested positions for the position regulators in the frequency servo converters structures.

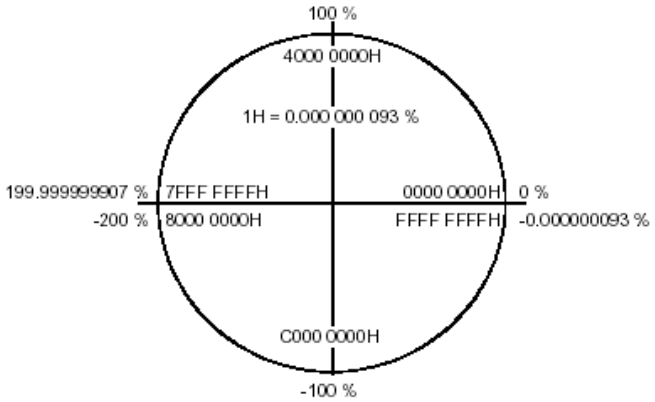

Figure 2: The soft connector with the double-word length diagram.

Current values of requested position and speed variables included in soft connectors are recalculated by the user's control application in accordance to the following formula:

$$V_{res} = V_{req} \times K_{norm} \times K_{sensor}$$

The current value in K_{sensor} constant depends on the used type of sensor and K_{norm} constant value is calculated using:

$$K_{norm} = \frac{(4000000)H}{100}$$

There is ample equipment of diagnostic system on the automatic assembly station. The diagnostic uses standard diagnostic functions of the micro-controller used. There is diagnosed the correct functionality, let as say failure-free state of the micro-controller CPU and extended modules of the control system. There is checked the current state of hydraulic, pneumatic and oil lubrication systems on the machine too. All of system error and warning messages are showed on the display of the operator panel. There is switched on the red alarm light in time of error occurrence on the station. The machine activity is stopped at once. The assembly station can by reinitialized by the machine tender after the current error state removed only.

7 Conclusion

The article illustrates how to create the control system for the automatic assembly machine. The controlled automatic station is a part of the car steering systems production line in automotive industry. This practical application shows advantages using of the modern control technology in the concrete industrial control application. The SIMOVERT MASTERDRIVES MC frequency converter is modern elements of the industrial control system specially designed for industrial servo drive applications. The micro-controller S7-200 series is a compact logic controller that can control a variety of automation industrial applications. The choice of the hardware, software and communication protocols was implemented in the appropriate manner conformable with application requirements. This way designed control system is optimal for this type of the industrial application.

Opponent: Prof. Ing. Milan Vrožina, CSc.

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