THE NEW CRANE MOTION CONTROL CONCEPT WITH INTEGRATED DRIVE CONTROLLER FOR ENGINEERED CRANE APPLICATION

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Abstract – **Requirements of modern container terminals result in demand for sophisticated crane control and automation systems capable of handling loads fast and reliable connection to the particular information systems. This system continuously provide up-dated information about containers moves and crane status. The total function is built up of a number of distinct building blocks installed from the beginning or added on after. Many of the building blocks are tightly connected to each other to achieve the right functionality and performance. For steel mill cranes and another heavy duty material handling systems special attention is paid to the systems robustness, reliability and availability. Generally, the crane motion control system supports positioning, brake control, and another application function. In order to achieve a number of different possibilities to solve engineered problems, the multidrive concept is applied. Mentioned concept includes: powerful process controller with advanced multitasking, capable of handling several real time critical control loops simultaneously, high speed communication links between different clients, accurate measurement and fast transmission of drive positions and speeds and centralized interface for diagnostics of the complete system. This paper presents the important features of steel mill crane motion concept with Integrated Drive Controller (IDC) system. IDC system, based on operational flexibility through standardized hardware and software modules, offers a solution for many engineered crane application problems.**

I. INTRODUCTION

The Integrated Crane Control concept is designed for handling of the complete control and automation of a container crane. The total functions is built up of a number of distinct building blocks which can be installed from the beginning or added on after the delivery of the crane. Many of the building blocks are tightly connected to each other and requires as system designed and built with the total functionality to achieve the right performance. Already the basic drive and control package has to be designed to handle the real time and communication requirements of the automation functions. In order to fulfill mentioned requirements Integrated Drive Controller (IDC) is designed. It is a speed control system for cranes and another heavy duty material handling systems. IDC is intended for slip-ring motors and fully supports positioning, brake control, rotor step switching and another application functions. The control system also includes protective functions that are necessary for crane motor drives application. Of the drive systems suitable for this size (20-1000kW) in this electrical and environmental situation the stator voltage controlled systems and slip-ring motors since long has been and still is the most suitable solution. The energy balance for a crane drive is normally not considered as important as the previous mentioned objectives. The installation cost and hence the suitability are however depending of the management of the losses on the crane. For the crane drive that most of its time is run in full speed up or full speed down the losses except motors and cables are about 4% of the motor power. The figure is similar to the described stator voltage controlled system for slip-ring motors and a regenerative frequency inverter drive system or a regenerative DC-drive system. The stator voltage controlled system has however the important advantage that the mayor part of the losses occurs in an external resistor, not inside the electrical equipment.

II. MULTIDRIVE CONCEPT

The Multidrive concept gives users of drive systems with a number of different possibilities to solve their engineering problems.

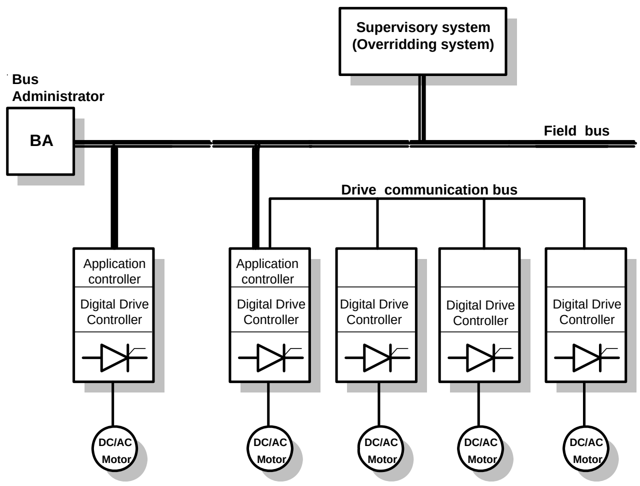

Fig 1. Multidrive system

A new concept for engineered drive applications includes: built-in distributed application control, open communication and advanced PC based tools for application programming, commissioning, trouble shooting and drive monitoring (Fig 1.)

The Application Controller (APC), common for both DC and AC drives, is basically a single board controller with all the software and hardware facilities needed to handle the application specific functions.

The Digital Drive Controller (DDC) software is fixed but various functions and operating modes can be selected via parameters. The DDC is controlled by either a torque or a speed reference provided by the APC. In distributed multicontroller systems, several application controllers are

interconnected by fast communication link where each drive can be used as a node. Common control functions are distributed to separate nodes by the use of digital communication. As well, APC's can communicate with external systems with communication boards.
Communication to the Supervisory System is achieved by Bus Administrator with standard field bus protocol. Supervisory System for the crane application (Fig.2) connects all cranes via TCP/IP communication network and optical hubs connected to the Crane Information Management Server (CIMS_NT). The maintenance functionality on the crane is concentrated in the Crane Monitoring and Maintenance System (CMMS).

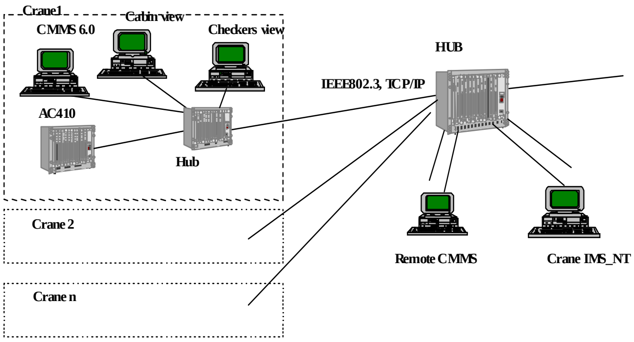

Fig 2. Crane supervisory system.

III. INTEGRATED DRIVE CONTROLLER

Basically, integrated drive controller (IDC) performs stator and rotor control functions. Because the available motor torque of induction motor is proportional for each speed to the square of the stator voltage, the speed control is obtained by varying the stator voltage so that the desired speed is obtained for a given load. Rotor control gives to the motor the right characteristics optimizing the external rotor resistance. The new drive minimizes the stator current and sensitivity to line voltage fluctuations considering the required torque. When lowering with a slightly higher speed then the motors synchronous, the motor will regenerate the energy back to the line in the most robust manner. Then the lowering speed is approaching the synchronous, the rotor resistor is minimized and the direction of torque changes electronically.

III.A. IDC configuration

The drive system, both control system as well as power electronics, is made adaptable to meet all requirements of today's and future crane drives in steel production (Fig.3). The power electronics is made in a modular form which supports the integration into the cranes structure. The space requirement is low, and the temperature withstandability is high. The control module is generating the firing pulses to the thyristors module by means of a conventional wire, which limits the distance between these units to a few meters. All control system connections are made by optical fiber. The interfaces can be installed to optimize installation cost and reduce the interference.

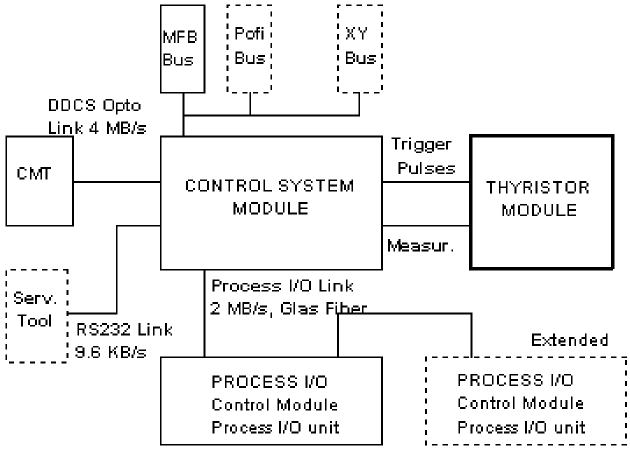

Fig.3. Structure of integrated drive controller (IDC)

III.B. Control system module design

The control system module is built up around the Motorola MC68332 microcontroller unit, (Fig. 4). The CPU core of the microcontroller is based on the MC68010, MC68020 and is binary and source code compatible with the Motorola MC68000-family. The control board comprises a number of connectors interfacing other boards or devices. The MC68332 is a 32-bit integrated microcontroller with powerful peripheral

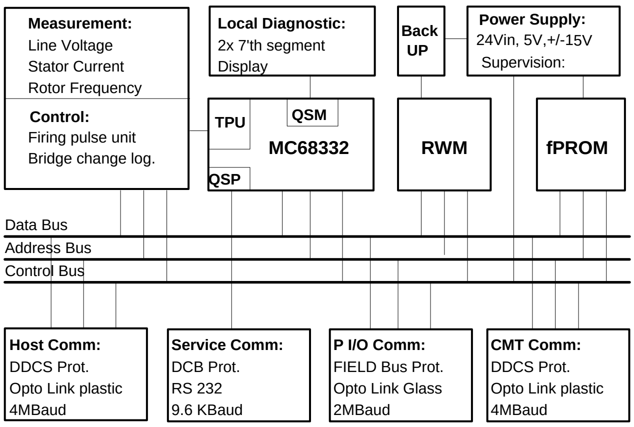

Fig.4. Control system module block diagram

subsystems [2]. MCU is based on the MC68020, the CPU instruction processing module utilize the extensive software based for the Motorola MC68k family. It includes an external interface and various functions that reduce the need for external glue logic (2 chip select lines, system protection, test, and clock submodule). The CPU module configuration registers allows the user to configure and monitor the system according to the system requirements. The system is set up by the local operating system software after a power on reset. Following monitoring functions are supported:

- Halt Monitor, responds to an assertion on HALT_N on the internal bus. HALT_N is asserted if a double bus fault is generated.
- Spurious Interrupt Monitor. If no interrupt arbitration occurs during an interrupt acknowledged cycle the BERR_N signal is asserted internally, and bus error exception is started.
- Internal Bus Monitor takes care of the response time for all internal bus accesses.
- Software watchdog, asserts reset if the software fails to service the software watchdog for a designated period of time.
- Periodic Interrupt Timer, generates periodic interrupts. The timer is used for generating time scheduler interrupts, and the period time is set by the application software.
- Reset Handling. The reset exception handling routines for the different types of reset are determined by programmer

The process I/O and Master/follower communication interface is a high speed data link based on the SDLC standard protocol [1]. The PC based Service Tool can communicate with any IDC connected to the bus. The PC is connected to the RS232 interface (9.6 kBit/s) of one IDC and communication to the other IDC's on the same bus is easily accomplished. The messages are relayed back and forth through that one IDC [3].

III.C. Process I/O control module design

The control module for different type of process I/O units is built up around the Motorola MC68302 microcontroller unit [4]. The CPU core of the microcontroller is based on the MC68000. The control module (Fig.5.) comprises a number of connectors interfacing other boards or devices: Control board, another process I/O modules and service terminal.
The MC68302 is a 32-bit Integrated microcontroller with powerful peripheral subsystems. MCU is based on the MC68000, the CPU instruction processing module utilize the extensive software based for the Motorola MC68K family. The device is especially suitable to applications in the communications industry for a wide variety of DCSs. The MC68302 contains an extensive support that simplifies the job of both the hardware and software designer. It integrates the MC68K core with the most common peripherals used in the well known MC68K base system. The independent direct memory access controller relieves the hardware design of the extra board logic. The interrupt controller can be used in a dedicated mode to generate interrupt acknowledge signals without external logic. The chip select signals and wait state logic are also totally integrated. The module configuration registers allows the user to configure and monitor the system according to the system requirements. The main Communication Processor (CP) is a RISC processor that services the three Serial Communication Channels (SCC). Serial Direct Memory Access channels are associated with three full-duplex SCCs. Each channel is permanently assigned to service the receive or transmit operation of one of the SCCs and is always available, regardless of the SCC protocol chosen. A watchdog timer is used to protect against system failures by providing a means to escape from unexpected input conditions, external events or programming errors. The system is set up by the local operating system software after a power on reset.

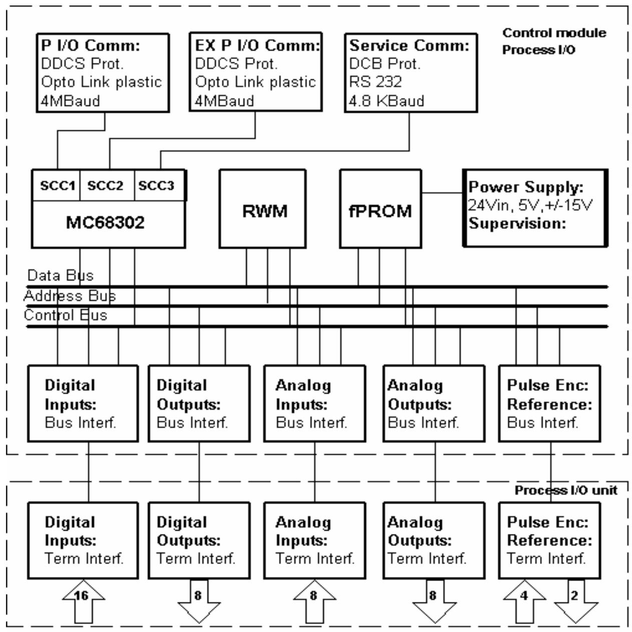

Fig.5. Process I/O control module block diagram

III.D. IDC software support

The IDC is on line programmable and various functions and operating modes can be selected by fixed number of parameters. The motor control programs are located in the control system module, which is controlled by either a torque or a speed reference provided locally (stand-alone drive system) or by the overriding system. Commissioning and Maintenance Tool (CMT) is PC based program for IDCs. The CMT offers the following functions:

- Monitoring of reference and actual values
- Setting, changing, saving, uploading, downloading and restoring of parameters
- Controlling and displaying data loggers

The Process I/O basic software support and different communication drivers are located in the control module.

IV. CONCLUSION

Presented Integrated Drive Controller (IDC) is suitable for cranes applications where system robustness, reliability and availability are basic requirements. It supports positioning, brake control, rotor step switching and another application functions. IDC performs stator and rotor control functions. Stator control is related to the torque control. Rotor control, by optimizing the external rotor resistance, gives the motor the right characteristics. As a particular sub-system, IDC can be linked in a superior overriding level for industrial automation and information interchange.

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