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Title: Smart Distributed System Accumulation Conveyor Control

Introduction

Honeywell has been a long-term participant in the industrial control marketplace. Participation in this market has kept Honeywell in constant communication with customers concerning issues and needs in the marketplace. Over the past five to seven years, several key trends have driven requirements for change in control system architectures. One of these trends is increased levels of automation and decreased levels of available human resources. A second trend is decreasing product and technology life-cycles which have made fixed automation systems cost prohibitive. These trends have driven automation users to require systems that can be modified, adapted, or upgraded as required to sustain a long-term competitive position. Control systems must advance to provide information to assist users in the maintenance of complex automation systems.

These market trends provided the force to encourage Honeywell to develop the Smart Distributed System. The Smart Distributed System is a device level network which is designed as a control platform for use in a wide variety of industrial machine control applications. Honeywell has now expanded the scope of the Smart Distributed System to include Personal Computer (PC) hardware and software to execute real-time control and provide Operator Interface software. The PC Control platform provides a mechanism that is well suited to take full advantage of information available from the networked Input/Output (I/O) system.

Application Example

On several occasions, Honeywell PC Control has been deployed to satisfy the growing needs of automation users. One example of this is found in the control of accumulation conveyors in the package distribution market. In this application, a large user of material handling equipment was attempting to enhance an existing conveyor system. Some issues the customer was attempting to address were: a reduction in the audible noise level on the conveyor; creation of a modular conveyor for increased flexibility and design consistency; improved operator health and safety; simplified maintenance; and reduced energy consumption.

These goals were accomplished through the development of an intelligent accumulation conveyor. An accumulation conveyor is a live roller conveyor designed to protect material on the conveyor from damage. Material is protected by removing the roller drive force as the conveyor becomes filled with material. A traditional accumulation conveyor utilizes a single-drive chain combined with a pneumatic/mechanical displacement mechanism to perform the accumulation function. This architecture is mechanically rigid. The continuous drive chain and pneumatic lines limit the systems flexibility and modularity. This conveyor typically uses a mechanical switch to detect the presence of material on the conveyor. This approach makes the operation of the system dependent on the size and weight of the packages on the conveyor. Lightweight packages do not properly trigger the switches, which results in material damage or spillage. The final limitation of conventional conveyor systems results from the root operation of the conveyor. Conventional accumulation conveyors drive all rollers continuously, except when the conveyor is filled and accumulated. This results in the continuous drone of spinning roller bearings and drive chain friction. It also results in continuous energy consumption.

Intelligent accumulation conveyors using Honeywell's Smart Distributed System control modules, photoelectric sensors, and motorized rollers were developed to address these issues. The Honeywell solution utilizes photoelectric sensors to detect the presence of material on the conveyor. These sensors relieve problems associated with detecting packages of various size and weight. The system also uses motorized rollers to provide the drive force to the rollers. These rollers are low voltage and low torque. This feature provides improved safety to operators, while maintaining adequate torque to transport material. The base of this architecture is a control module designed to optimize the accumulation function. The overriding philosophy of the Honeywell implementation is to activate conveyor rollers only when material is available and ready for transport. This means that rollers are only rotating when material is being transported through a particular conveyor segment. This results in significant reductions in audible noise levels of the conveyor system, decreased energy consumption, and increased roller life.

Honeywell's intelligent accumulation conveyor solution is designed to simplify maintenance. Any segment of the conveyor can be repaired through the replacement of one of three components: a photoelectric sensor, roller, or control module. The electrical complexity of this system is increased as compared to conventional accumulation conveyor through significant increases in the number of sensors and motors. The Honeywell solution utilizes the Smart Distributed System network to link the conveyor control modules. The networked solution is critical to the successful deployment and maintenance of this system. The Smart Distributed System implementation provides significant insight into the operational health of this complex electrical control system. Some examples of this insight include conveyor jam, motor failure, and control module failure. This information allows the user to quickly isolate and repair most problems occurring in the material handling system. The physical characteristics of the Smart Distributed System network creates a platform for the construction of conveyor modules which may be built and tested prior to installation and easily reconfigured after installation.

Details of specific benefits and features of this architecture are outlined in the following sections.

Smart Distributed System Network Overview
The Smart Distributed System is a device-level network which is based on the Controller Area Network (CAN) architecture. Honeywell has used this commercially available architecture and has developed a hardware and software specification to make CAN suitable for use in industrial control applications.

The Smart Distributed System specifications are public information. This means that all implementations of the Smart Distributed System protocol must be published and available to any interested parties. To date, the Smart Distributed System specifications have been distributed to over 350 organizations interested in developing Smart Distributed System compatible devices.

This means choice at all levels of the control system to a user of the Smart Distributed System. This encourages competition which ensures product availability and competitive pricing. Just as in today's control environment, individual component packaging and performance may vary between manufacturers, but all manufacturers will begin from the same base.

There are many advantages a user recognizes by selecting a device level network based on the Smart Distributed System. The following benefits are achieved through CAN:

- Proven Technology
- Robust Architecture
- Industry Accepted
- Broad Supplier Base
- Economy of Scale

The following benefits are achieved through the Smart Distributed System:

- High Speed Data Transmission
- Data Transmission Integrity
- Diagnostic Information Access
- Field Proven Network
- Scaleable To Support Future
- Products

Powered Roller Control Solution

Architecture Overview
Figure 1 illustrates the powered roller conveyor control solution using the Smart Distributed System network and PC based control.
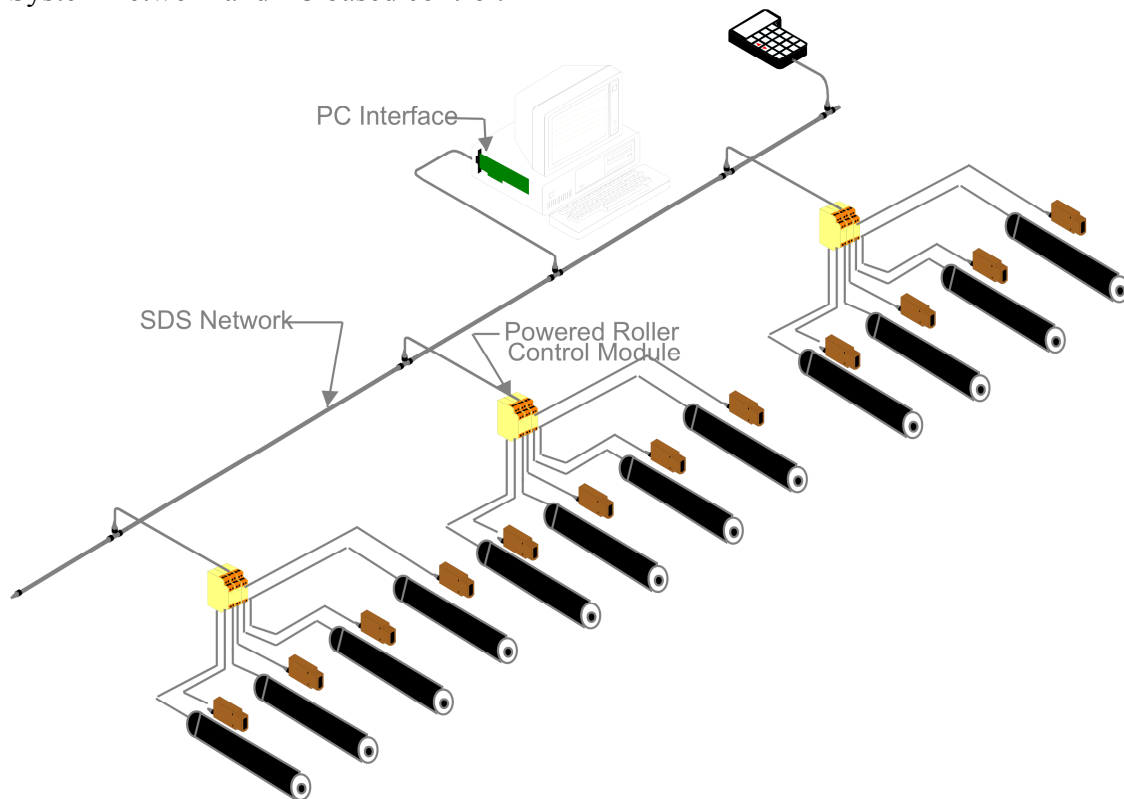

Figure 1

In **Figure 1**, you can see that the primary components which are connected directly to the network are a Personal Computer interface and the powered roller control modules. The

powered roller control module has the capacity to control up to four powered roller zones, including motors and photoelectric sensors. The module provides local motor control, motor drive circuitry, network access, and a physical base which supports all peripheral device connections. Honeywell's proposed solution provides the main control system access to conveyor control functions and system status. The following sections outline the benefits and features along with a detailed description of the proposed architecture.

Functional Description - Powered Roller Control Module
The proposed architecture, which is illustrated in **Figure 1**, is designed to provide the maximum functionality with a minimum amount of control software development. This is accomplished by embedding much of the actual motor control into the powered roller control module. The control logic required to control this system simply manages control signals between motor control modules. The control functions between zones on a module are handled by the roller control module itself. Even though the roller control module manages individual zone communications, the control system has access to the individual zone status and control. This becomes critical in divert and merge locations which require the forcing of accumulation and jog functions or tray counting.

The following is a list of the functions available to the user which can be designed into the control system's Operator Interface screens and communicated over the Smart Distributed System network:

Control Functions:
• Selectable Package Gap Mode
• Direction Control
• Force Accumulation
• Force Jog

Conveyor Status:
• Zone Available
• Zone Full
• Zone Accumulated
• Tray Count
• Number Of Active Zones In A Module

Fault Indication:
• Motor Fault (Short\Open)
• Photoelectric Sensor Gain Fault
• Loss of Motor Power Supply
• Missing Roller Control Module
• Control Module Communication Faults
• Individual Zone Jam

The primary objective of this architecture maximizes the overall efficiency of the user's facility through the implementation of powered roller conveyor technology. The proposed architecture is designed to provide access to detailed conveyor status information allowing operators in a remote control room to optimize package flow. The system is also designed to provide a control room

operator with detailed system fault data which will decrease the conveyor system's meantime to repair and improve overall maintenance utilization.

The degree of implementation of these features is a function of the control logic and Operator Interface software developed for each installation. All data listed above is available at the host computer to assist in maintenance of the package handling system.   The functions listed allow users to fully exercise the capabilities of the powered roller technology from a central control room, i.e. direction control, singulation\train mode, forced accumulate, and jog. Many of these features are not practical when using conventional conveyor technology. **Figure 2** illustrates a possible maintenance screen for 10 conveyor zones which could be incorporated into the Operator Interface software.
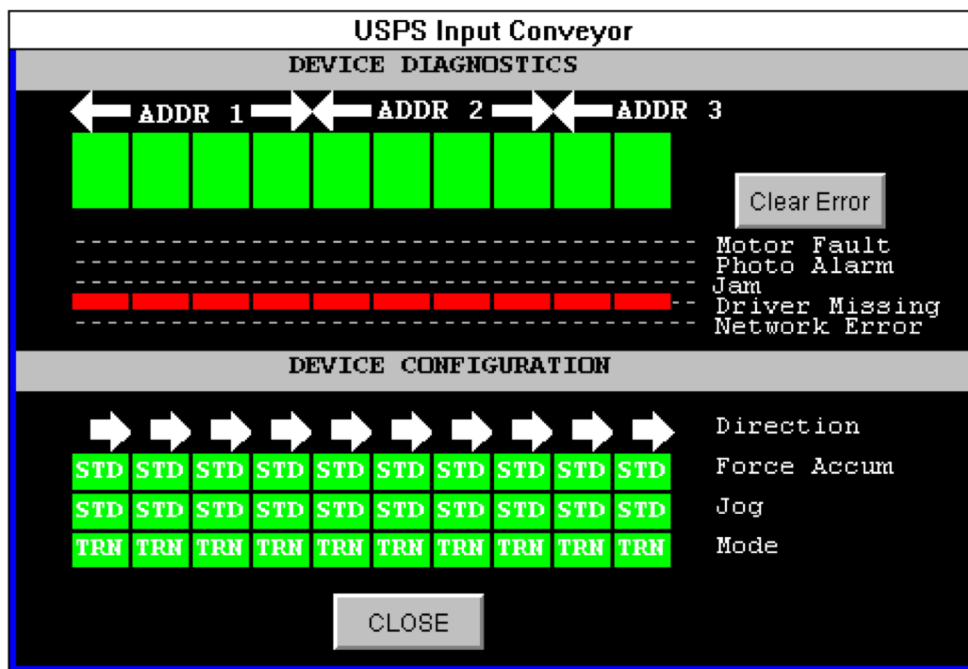

Figure 2

PC Control Architecture
The recommended host controller for the system is an industrially hardened PC executing Honeywell PC Control software. The Honeywell PC Control software provides a deterministic logic solve software package which is tightly linked to a Windows^{TM}-based Operator Interface software package. Honeywell provides hardware with installed software, eliminating configuration and compatibility issues often associated with PC based control solutions.

PC Hardware
The recommended PC is a rack mountable industrial PC with a 486\100 Mhz processor. The PC will include at least one Smart Distributed System PC Interface Card and an Ethernet card. The System Interface Card supports two independent Smart Distributed System networks. Each network supports up to 256 powered roller zones. The Ethernet card is included to support the linking of several individual PC's to a single PC in the control room (see **Figure 3**). A control room operator will have access to view all local Operator Interface screens and perform conveyor

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control directly from the PC in the control room. One potential control function includes the ability to clear jammed packages through direct access to individual conveyor zones. It is also possible to purge sections of the conveyor from the control room. Implementation of these features is dependent on the facility and the specific control software developed for each site. The proposed hardware and software will support the described level of functionality.

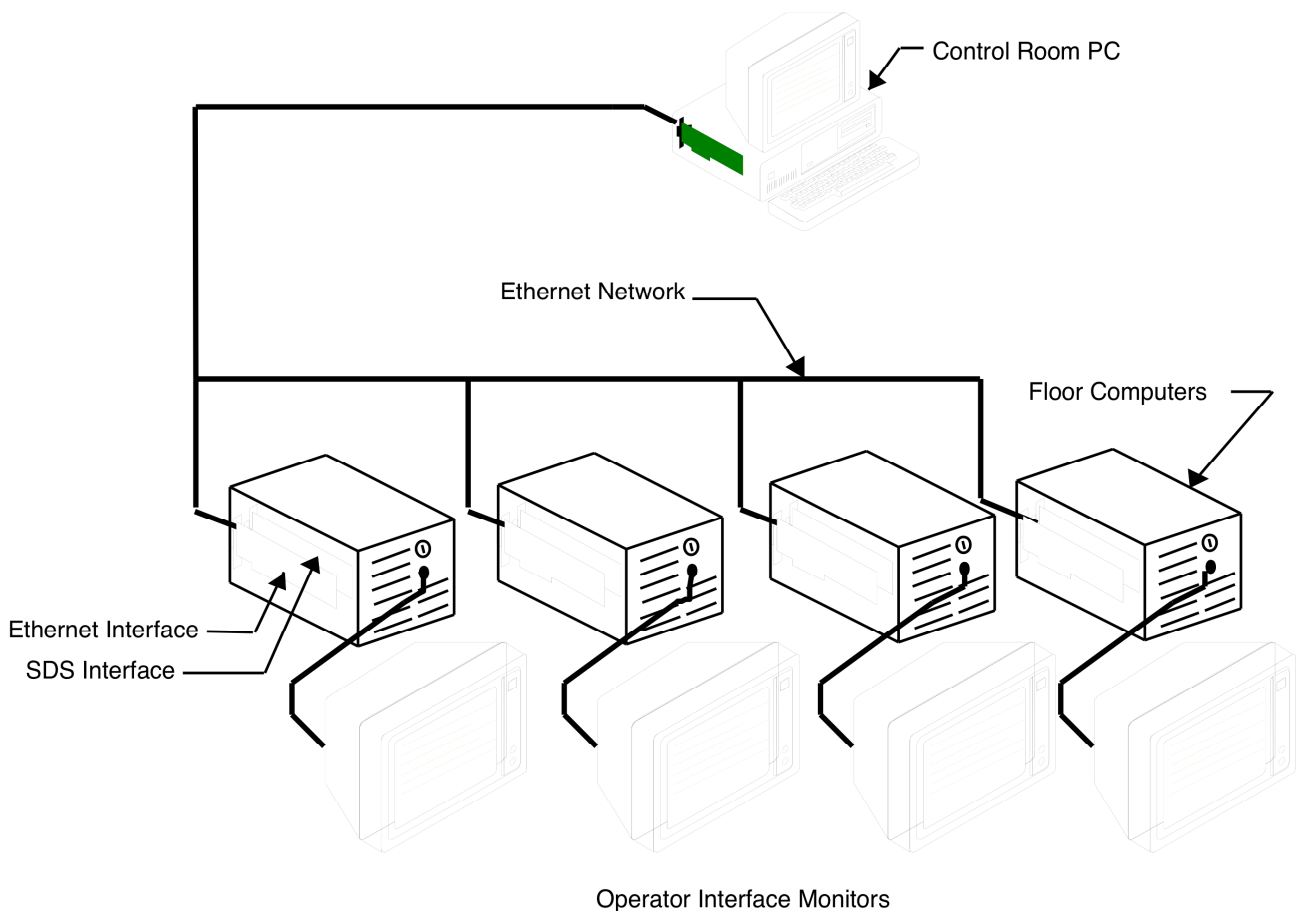TMWindows is a trademark of Microsoft Corporation.

Figure 3

PC Software

The Honeywell PC Control software supplied on the personal computer is basically two separate software packages simultaneously operating on the same hardware. The first piece of software functions similarly to software inside a Programmable Logic Controller (PLC) Central Processing Unit (CPU) module. This is the control engine for the system. The second piece of software is the Operator Interface package. The control engine is a real-time, deterministic software package

which executes control logic and manipulates the I/O devices accordingly. The control engine also controls the time available for the Operator Interface software.

The actual control logic is developed in a Windows™-based flowchart environment. There is no ladder logic programming. The flow charting environment provides user friendly development tools with inherent self-documenting features. This environment supports rapid code development and associated documentation. Configuration and diagnostic tools included in the package provide efficient development and deployment of Honeywell's PC based control systems.

The second piece of software provides the Operator Interface. This software package is based on an industry standard package and is tightly linked to the control engine. The link between these packages provides a unique combination allowing users to execute real-time control and high resolution operator interface on the same piece of hardware. The Operator Interface software supports the development of custom graphics which reflect the status of the system I/O. Conveyor status can be reflected in the Operator Interface screens representing conveyor availability or fault conditions. **Figure 4** provides a sample Operator Interface screen. The I/O may also be manipulated from the Operator Interface screens. In this scenario, buttons actuated on the Operator Interface screen are passed to the control engine, which changes the condition of the field devices. Remotely clearing a jam by jogging the conveyor or changing the direction are examples of this functionality. The Device Configuration segments in **Figure 2** are buttons which can be actuated through a touch screen or mouse to change the operation of individual powered roller conveyor sections. Pop-up windows and multiple pages of Operator Interface screens can be displayed on a single monitor.
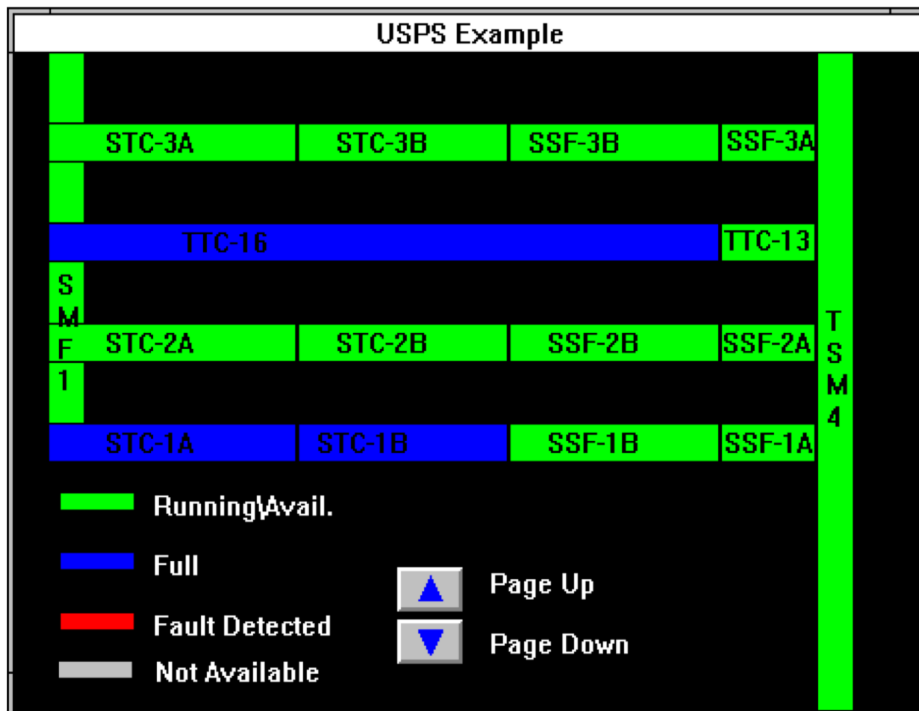

Figure 4

The linking of multiple computers as illustrated in **Figure 3** is accomplished through the Operator Interface package. Serial network drivers are included which support Ethernet connections. The same screen may be viewed at multiple locations. Operator input may also originate at multiple locations.

Summary

Intelligent accumulation conveyors present a unique challenge to control system designers. This conveyor technology incorporates large numbers of input and output devices which are highly distributed throughout the conveyor system. The physical distribution and quantity of I/O devices creates an excellent environment for the implementation of a field bus network, such as the Smart Distributed System. The high speed response and data handling capabilities of this CAN-based network make it an ideal choice to provide the expanded diagnostics and functionality required to efficiently deploy an intelligent accumulation conveyor. The combination of networked I/O and a PC-based control platform provides the user with a control system capable of exploiting the advantages of the intelligent conveyor and the control system. The end result is improved efficiency of the user's facility with an improved environment for the operators on the floor.