symphony™

Harmony Distributed Control Unit
Overview

Features and Benefits

- **Integrated controller:** Consolidates area management and control and network communications into one user-replaceable unit, reducing implementation costs.
- **Downloadable firmware:** Downloaded via the network to take advantage of future system enhancements, thereby reducing life cycle costs.
- **Compatible with existing configurations:** Execution environment is compatible with existing Controlware II™ control strategy configurations for DCI System Six®.
- **True on-line configuration:** Allows Controlware II modules to be added, deleted, or modified without interrupting the process.
- **Redundancy:** Provides exceptionally high availability and fault tolerance when configured as a redundant pair to provide automatic database update and bumpless transfer in the event of switchover. One-to-one redundancy is available for:
  - Control processors.
  - Power supplies.
  - I/O boards.
  - Control network connection.
- **On-line maintenance:** Provides the capability for "hot" board removal and replacement without affecting HDCU operations.
- **Powerful yet easy-to-use control language:** Connect-the-dots soft-wiring of Controlware II modules for direct control of regulatory, sequential, and batch processes with user-selectable scan rates as fast as 100 milliseconds.

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The Harmony Distributed Control Unit (Harmony DCU or HDCU) is a DCI System Six compatible microprocessor-based area management and control node for the Symphony Enterprise Management and Control System. The HDCU interfaces directly to the process, performing all functions necessary to monitor and control the process on a stand-alone basis. The controller communicates with other system nodes over control network (Cnet). It collects process inputs, performs control algorithms, and outputs control signals to process level devices. The controller also imports and exports process data from and to other system nodes, and accepts operator control commands through network connected workstations.

The controller communicates with frame mounted HDCU I/O boards to meet the input and output requirements of virtually any process. Each controller can handle thousands of analog and digital I/O points with functions such as multi-loop, analog, sequential, batch, and advanced controls. It has advanced data acquisition features to support trending, variable alarming, alarm inhibiting, and event history.

ABB

Designed for applications requiring sequence control combined with regulatory control, the HDCU incorporates Controlware II, a language designed for process control, which supports a full range of analog control functions, parameter setup, and interlocking functions for both continuous and batch processes. On-board, user-addressable Controlware II modules enhance processing power and support even the most complex process management and control strategies. Controlware II supports a standard library of control algorithms from simple boolean logic functions (i.e., AND and NOT) to complex process loop control and calculations (i.e., fifth order polynomials), with no advanced programming knowledge required to apply these capabilities. Programming and control language support includes Controlware™ command language (CCL), ChemFlex™ sequence modules (MSEQ), and custom control modules (CCM).

Description

The HDCU consists of four major assemblies (Fig. 1):

- DCU control processor (DCP II).
- Intelligent input / output boards (IOBs).
- Card frame.
- Power supply.

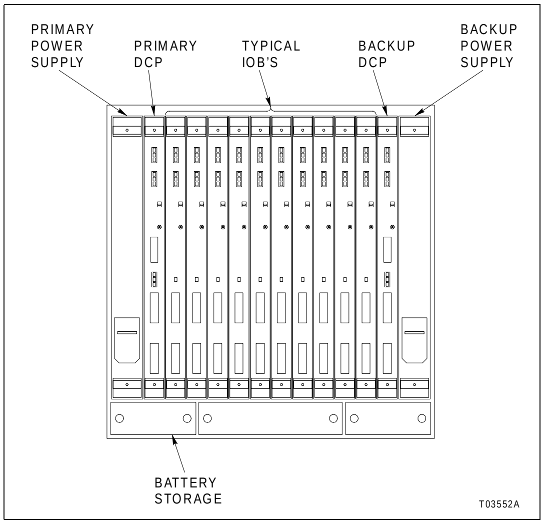

Figure 1. Single Harmony DCU Card Frame

Redundancy Features

The HDCU has been designed with redundancy as an integral concept, providing the control system user with the highest level of control integrity. Each element of the HDCU (with the exception of the card frame) is optionally available with one-to-one redundancy, allowing the implementation of redundancy on a partial or complete basis.

- Each HDCU control processor provides a dual channel interface to the redundant control network.

- Two HDCU control processors (DCP IIs) can be implemented in the first card frame of an HDCU, providing one-to-one redundancy, with automatic switchover to the backup unit. Configuration changes to the on-line DCP II are mirrored to the backup unit, providing hot stand-by operation.

- Any of the six available I/O boards (IOBs) can be paired in adjacent card slots for one-to-one redundancy, with automatic switchover to the stand-by IOB.
- The HDCU control processor and card frame back plane use two process I/O buses. Each bus addresses alternate process I/O card slots to support I/O board redundancy.
- Two HDCU power supplies can be implemented in each HDCU card frame. Operating in current-sharing mode, one supply will take full load operation if the other power supply becomes unavailable.
- Independent power feeds are provided for each power supply, allowing the user to implement redundant power sources, if desired.

HDCU Control Processor (DCP II)

The HDCU control processor (DCP II) is responsible for the execution of Controlware II and manages the activity of the HDCU resident I/O circuit cards. The DCP II is a modular plug-in assembly that mounts into the HDCU frame within designated card slots. It incorporates a 32-bit microprocessor running at 50 megahertz. The resident operating system is a multitasking, interrupt driven, real-time operating system. The memory system consisting of ROM and battery backed DRAM has built-in automatic error detection and correction features that further bolster system reliability and availability. Eight or 16-megabyte memory cards are supplied on daughter board assemblies to support DRAM configurations of eight, 16, or 32 megabytes.

The CPU board also supports redundant Ethernet™ TCP/IP network communications for Cnet and a serial port for local diagnostics and programming. A dual channel Ethernet communications controller is integrated onto the main processor board of the DCP II at a clock speed of 25 megahertz. This interfaces the DCP II to the IEEE 802.3 Ethernet control network. Both firmware and configurations are downloadable via Cnet minimizing overall life-cycle support costs.

HDCU Input/Output Boards (IOBs)

Intelligent I/O Boards (IOBs) are microprocessor based circuit boards designed for use within the HDCU card frame. Intelligent I/O boards accommodate different types of I/O signal mixes. Each HDCU card frame has between 10 and 12 IOB slots available depending on the quantity of HDCU control processors installed. Any of the IOBs may operate in any of the designated intelligent I/O board slots. I/O boards plug-connect to remote mounted interface terminal boards (ITBs) via cable sets for field wiring terminations. Figure 2 shows a typical HDCU IOB connection to ITBs. The HDCU supports six intelligent I/O board types as follows:

- 40PB3201 for the A-Loop.
- 40PB3202 for the D-Loop.
- 40PB3203 for the P-Loop.
- 40PB3204 for the CIO.
- 40PB3205 for the DIO.
- 40PB3206 for the analog-input.

A-Loop Board Capabilities

The A-Loop IOB provides four - four to 20 milliamp analog current outputs, eight - zero to five volt analog inputs, 16 discrete inputs and eight discrete outputs. Additionally, the board provides a feedback capability with four analog inputs to monitor the four analog outputs, and eight discrete inputs to monitor the eight discrete outputs.

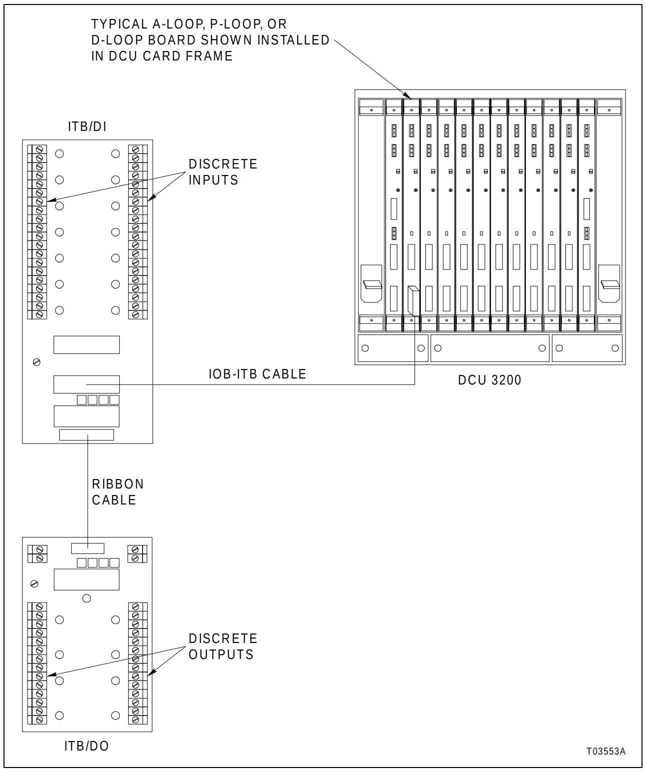

Figure 2. Typical IOB Connection to ITB

D-Loop Board Capabilities

The D-Loop IOB provides 32 discrete inputs and 16 discrete outputs. Additionally, the board provides a feedback capability with 16 status inputs to monitor the 16 discrete outputs.

P-Loop Board Capabilities

The P-Loop IOB provides four - four to 20 milliamp analog current outputs, eight frequency inputs, 16 discrete inputs and eight discrete outputs. Additionally, the board provides a feedback capability with four analog inputs to monitor the four analog outputs, and eight discrete inputs to monitor the eight discrete outputs.

A-Input Board Capabilities

The A-Input IOB provides 24 analog inputs of zero to five volts.

CIO Board Capabilities

The communications input/output (CIO) board provides serial communication capabilities for interfacing with external communication devices such as PLCs and Micro-DCI as well as devices supporting Modbus protocol such as weigh scales, motor drives, smart valves, and compressors. The CIO board provides two RS-232-C/RS485 programmable serial ports (with modem control lines), two RS-232-C programmable serial ports (three-wire type), one ANSI/IEEE 802.3 Ethernet port, and one RS-232-C serial diagnostic console port. The CIO board supports software drivers for Allen-Bradley™ PLCs, Micro DCI data link, and Modbus protocol and provides a platform for custom application software development by certified integrators for drivers to other external devices.

DIO Board Capabilities

The distributed input/output (DIO) board is a dedicated implementation of the more general purpose CIO board. The DIO board provides serial communication capabilities for interfacing with one type of device, DIO modules. The DIO board provides a single frequency shift key (FSK) encoded half duplex serial communications port for the distributed I/O TransNet™ communications network. The DIO board acts as a master node on the TransNet communications network for interfacing with distributed I/O modules. Up to 120 distributed I/O modules are accessible by a single DIO board.

IOB Signal Design Features

Analog Inputs. Each analog input (for those IOBs with analog inputs) zero to five volt signal is converted to a 12 bit value (plus sign) by a multiplexed analog-to-digital converter (ADC) per IOB. The digital value generated by the ADC is read by the Controlware II ANI module for monitoring and control. Each analog input is isolated using high input impedance common mode separating differential amplifiers.

Pulse/Frequency Inputs. Each pulse/frequency input (for those IOBs with pulse/frequency inputs) zero to 32 kilohertz signal is accumulated by a dedicated counter per channel into a 24 bit totalized value. The IOB also computes and stores the per second pulse rate. The totalized value and pulse rate are read by the Controlware II ANI module for monitoring and control. Each pulse/frequency input is isolated using high input impedance common mode separating differential amplifiers.

Analog Outputs. Each analog output (for those IOBs with analog outputs) employs digital to analog output circuitry to convert a 12 bit value computed by the Controlware II ANO module to a four to 20 milliamp signal for controlled device positioning. The outputs are calibrated for zero to 20.8 milliamp current output. This provides a +/- five percent over range capability for standard four to 20 milliamp (3.8 to 20.8) operation. Controlware II can also adjust the output to achieve an extended 0 to 20 milliamp output range. Each analog output is isolated from each other. Data is isolated via optical coupling. Power is galvanically isolated via DC-to-DC converters. Each current output is internally monitored by an on-board analog-to-digital converter.

Discrete Outputs. Each discrete output (for those IOBs with discrete outputs) employs an optically isolated bipolar power FET and is rated for 200 milliamp rms operation at +/- 50 VDC or 35 VACrms. The discrete outputs are ideally suited to applications such as buffer relay drivers, indicator drivers, digital interfaces, etc. A ¼-amp fuse protects each output line from accidental overloads. Filters and voltage clamp circuitry protect the FET switches from transient line conditions, including those caused by cable inductance at the rated load current. The status of each discrete output is indicated by LEDs located on the field wiring ITBs.

Discrete Inputs. Each discrete input (for those IOBs with discrete inputs) is isolated by optical couplers and dual dc-to-dc converters. They are organized into groups of eight inputs with a common group return with the groups alternately pulse powered. The status of each discrete input is indicated by LEDs located on the field wiring ITBs.

HDCU Card Frame

The HDCU card frame is a circuit board card cage suitable for 19-inch rack mounting within a process control cabinet or for wall mounting. It is designed to house intelligent I/O boards, HDCU control processors (DCP II) and HDCU power supplies. Each card frame can hold from 10 to 12 I/O boards depending on options selected, in addition to the DCP II and power supply, with a maximum of two card frames per HDCU. I/O circuit boards may be grouped in any combination since individual board slots are not electrically characterized with the exception of the DCP II and power supply slots. The characterization of each I/O card position is done by means of Controlware II configuration.

- Uses a universal process I/O board structure and is easily expandable.
- Process I/O card removal and maintenance do not require HDCU power shutdown.
- Front access to circuit cards and I/O cable connections.
- Mounting options for 19-inch rack enclosure or wall mounting.

HDCU Card Frame Power Supply

Each card frame requires a minimum of one power supply to power the DCP II and all I/O cards mounted within each frame. In a redundant configuration two power supplies can be mounted within each card frame for a maximum of four power supplies per HDCU.

The power supplies are available in two price/performance selections. The standard HDCU power supply, referred to as DCUPS-EG, is available for use with either 115 or 230 VAC operation. The second, enhanced functionality version is a micro-processor based unit referred to a DCUPS-uP which is available for use in 24 VDC, 115 VAC, or 230 VAC operation.

- Mounts within dedicated card slot position in the card frame.

- Single power supply can accommodate any combination of I/O cards and HDCU control processors in a single or redundant configuration within a single card frame.

- Available in a single or redundant configuration within a card frame with ability to mix DCUPS-uP and DCUPS-EG power supplies within the same HDCU card frame.

- Four hours of battery backup for HDCU control processor DRAM memory provided by internal sealed lead-acid battery that can be extended by 40 hours with an external battery connection.

DCUPS-µP Capabilities

The DCUPS-µP includes a microprocessor based power supply controller which allows for the remote online monitoring and adjustment of the power supply output voltages, output current, cooling fan speed, and monitoring of operational parameters such as temperature and battery status from the operator console.

DCUPS-µP design features include:

- An on-board intelligent power supply controller for monitoring voltage, current, battery status, temperature and controlling cooling fan speed.

- Communicates with HDCU control processor; provides alarm and maintenance messages.

DCUPS-EG Capabilities

As a comparison to the DCUPS-µP, the DCUPS-EG provides a reduced capability to monitor and control the power supply operation from an operator console. The DCUPS-EG's communication capability is limited to a go/no-go status to the DCP II which identifies the operational readiness state of the DCUPS-EG. The DCUPS-EG monitors the operational readiness of the following parameters: output voltages, operating temperature, lead acid battery, battery charger and fan speed control.

DCUPS-EG design features include:

- Operational readiness indication at the operator console for output voltages, temperature, battery, charger, and fan speed.
- On-board test points to measure power supply voltage at source and load.
- On-board potentiometer to adjust +5 volt output.
- Input voltage selector switch for either 115 VAC or 230 VAC operation.

Software

The basic HDCU unit is supplied complete with all Controlware II functions regardless of the hardware I/O capacity. As a result, systems started with a minimum I/O complement can be expanded later without changing the existing software configuration. An HDCU's Controlware II configuration can be modified at any time without shutting down the process. Thus a new control strategy can be implemented inexpensively in a fraction of the time required for a hardwired system.

Controlware II consists of various types of software modules that perform unique process control functions which can be configured to work together as an operational system. The software modules use a function index code (FIX) to modify a module's behavior. As an example, by changing the FIX of a CAL module, the module can change from performing multiplication to performing addition.

Field Wiring Connections

Interface Termination Boards (ITBs)

In order to minimize installation time and costs, a series of field wiring interface terminal boards (ITBs) are available for use with the HDCU. Field wiring terminates directly on the ITBs to facilitate installation. All ITB assemblies (with the exception of the ITB/PS-24 and ITB/DOE) cable directly to HDCU intelligent I/O boards (IOBs) using the same 28 conductor cable design. These cables are available in lengths of four feet, eight feet, and in five-foot increments from 10 to 50 feet and in 10-foot increments from 50 to 100 feet. Two cable connectors are provided on each of these ITBs for cabling to redundant IOBs. Several ITB versions are available to accommodate different types of I/O signals.

ITBs can be mounted in the same cabinet as, or in adjacent cabinets to, the HDCU, or they can be mounted remotely up to 30 meters (100 feet) from the HDCU. Each ITB has a common board width of 76.2 millimeters (three inches) which allows the ITB to snap in and out of commercially available plastic track or DIN rail mounting.

Analog I/O

The ITB/AX, ITB/AXNI, ITB/AM and ITB/AM7B are interface terminal boards that support both analog input and output signals. All of these ITBs pass four to 20 milliamp output signals from an A-Loop IOB directly to field devices. The ITB/AX and ITB/AXNI can also pass four to 20 milliamp output signals from a P-Loop IOB directly to field devices. The ITB/AX and ITB/AXNI receive four to 20 milliamp or one to five VDC analog input signals from field transmitters and pass them directly to the A-Loop IOB. Additionally, the ITB/AX and ITB/AXNI can receive pulse/frequency input signals (up to 32 kilohertz) from field transmitters and pass them directly to the P-Loop IOB. The ITB/AXNI is suitable for Nonincendive, Class 1, Division 2 field device connection. The ITB/AX is used for nonhazardous field device connection.

The ITB/AM and ITB/AM7B provide signal conditioning for analog inputs by converting the field input (i.e., thermocouple, RTD) to a one to five VDC signal for the A-Loop IOB. The ITB/AM supports conditioning modules that require an external five VDC power supply and the ITB/AM7B supports conditioning modules that use external 24 VDC power. Both are suitable for Nonincendive, Class 1, Division 2 field device connection.

Analog Inputs

The ITB/AX-12, ITB/AXNI-12, and ITB/AM7B-12 are interface terminal boards that support only analog inputs and connect to the A-Input IOB. The ITB/AX-12 and ITB/AXNI-12 receive four to 20 milliamp or one to five VDC analog input signals from field transmitters and pass them directly to the A-Input IOB. The ITB/AXNI-12 is suitable for Nonincendive, Class 1, Division 2 field device connection. The ITB/AX-12 is used for nonhazardous field device connection.

The ITB/AM7B-12 provides signal conditioning for analog inputs by converting the field input (i.e., thermocouple, RTD) to a one to five VDC signal for the A-Input IOB. The ITB/AM7B-12 supports the same conditioning modules used with the ITB/AM7B. Like the ITB/AM7B, the ITB/AM7B-12 requires external 24 VDC power, and is suitable for Nonincendive, Class 1, Division 2 field device connection.

Discrete Inputs

The ITB/DI and ITB/DIM are discrete input type interface terminal boards. These boards receive discrete inputs from field devices and pass them to an IOB. The ITB/DI passes the signal directly to the IOB, whereas the ITB/DIM provides signal conditioning for discrete inputs by optically isolating the field input power from the DC signal used by the IOB. Each of these boards can connect to a discrete output ITB via a 10 conductor flat cable. Discrete output signals are passed from an IOB through a discrete input ITB to a discrete output ITB via the 10 conductor flat cable. Figure 2 is a typical ITB/DI to ITB/DO connection. The ITB/DI is suitable for Nonincendive, Class 1, Division 2 field device connection. The ITB/DIM is used for nonhazardous field device connection.

The ITB/DIX is used in place of an ITB/DI or ITB/DIM when an IOB requires discrete outputs, with no need for discrete inputs. The ITB/DIX acts solely as a connector to an ITB/DO, ITB/DONI, ITB/DOM, or ITB/DOR. The ITB/DIX does not support any discrete input channels.

Discrete Outputs

The ITB/DO, ITB/DONI, ITB/DOM, and ITB/DOR are discrete output type interface terminal boards. An IOB passes the discrete output signals through either an ITB/DI, ITB/DIM or an ITB/DIX to these discrete output ITBs via a 10 conductor flat cable. The IOB discrete output signals are passed directly to the field devices by the ITB/DO or ITB/DONI, whereas the ITB/DOM and ITB/DOR process the IOB discrete output signals using conditioning modules that isolate the field device power from the DC signal used by the IOB. The ITB/DOM uses optical isolation, and the ITB/DOR uses a Form C relay with dry contacts. The ITB/DONI is suitable for Nonincendive, Class 1, Division 2 field device connection. The ITB/DO, ITB/DOM, and ITB/DOR are used for nonhazardous field device connection.

Discrete Output Extenders

The ITB/DOE is an interface terminal board that allows a discrete output ITB to be mounted remotely (up to 100 feet) from a discrete input ITB. ITB/DOEs are used in pairs with one ITB/DOE connected to an ITB / DI, ITB / DIX, or ITB / DIM via a 10 conductor flat cable, and the other ITB / DOE connected to the ITB / DO, ITB / DONI, ITB / DOM, or ITB / DOR via a 10 conductor flat cable. The two ITB / DOEs are connected together via the same type of 28 conductor cable used for IOB to ITB connection.

Foreign Device I/O

The ITB / CIO is a serial communications interface terminal board. ITB / CIOs provide four serial communication port connections. Two of the serial ports are dedicated for RS-232-C operation, and the other two are configurable for either RS-232-C or RS485 operation. An ITB / CIO connects back to a communications input / output (CIO) board or a distributed input / output (DIO) board via the same type of 28 conductor cable used for all other IOB to ITB connections. The ITB / CIO is used for linking communications with PLCs, weigh scales, and ABB Micro-DCI loop controllers, as well as with distributed input / output modules.

Power Supply

The ITB / PS-24 is a power supply type ITB used to supply +24 volt power for two-wire transmitters (ITB / AX, ITB / AXNI, ITB / AX-12, and ITB / AXNI-12), discrete signal conditioning modules (ITB / DIM and ITB / DOM), discrete output relay coils (ITB / DOR), low power discrete output 24 VDC devices (ITB / DO and ITB / DONI), and analog input 7B conditioning modules (ITB / AM7B and ITB / AM7B-12). ITB power supplies may be implemented in separate or redundant, load sharing configurations. Table 1 summarizes the supported connectivity between ITBs and IOBs.

Table 1. Supported ITB to IOB Connections

ITBs	I/O Boards[1]											
	A-Loop		P-Loop		D-Loop		A-Input		CIO		DIO	
	L	U	L	U	L	U	L	U	L	U	L	U
AX		√		√								
AXNI		√		√								
AM		√										
AM7B		√										
AX-12							√	√				
AXNI-12							√	√				
AM7B-12							√	√				
DI	√		√		√	√						
DIM	√		√		√	√						
DIX	√		√		√	√						
CIO									√		√	
DO	Connects to any DO connector on the ITB/DI, ITB/DIM, ITB/DIX or ITB/DOE											
DONI												
DOM												
DOR												
DOE	Connects to any DO connector on the ITB/DI, ITB/DIM or ITB/DIX. Connects to any DO connector on the ITB/DO, ITB/DONI, ITB/DOM or ITB/DOR.											
PS24												

NOTE:
1. Each IOB has 2 connector ports where L = lower and U = upper

Operation

The HDCU (composed of a single or redundant CPU, power supplies, and IOBs mounted in one or two HDCU card frames) represents one area management and control node in the Symphony system. The controller receives process input and sends output signals via a variety of HDCU I/O boards. Additionally, data can be exchanged with other nodes via Cnet.

An extensive library of ready-to-use Controlware II process control functions and powerful structured languages (supporting user-defined generation of custom functions) gives the tools needed to design complex control strategies to fit any continuous, sequential, or batch control application. Each Harmony DCU is scaleable from small to large Controlware II module capacity. Both the control algorithms and the user-defined configurations are maintained upon loss of power. ROM is used for booting the processor on power-up, and battery backed DRAM is used for storage of Controlware II configurations. Future enhancements can be downloaded via Cnet without having to perform physical modifications to each controller such as replacing ROMs or swapping modules, thus reducing life cycle cost of ownership.

The high-speed redundancy communication link between a pair of controllers provides the means for automatic one-for-one backup ensuring high system availability. If the primary controller should fail, the secondary is waiting in standby mode with the same control strategy and current process data, and immediately assumes control. Diagnostic routines are constantly checking the integrity of the hardware and firmware. The memory subsystem in the HDCU is designed with automatic error detection and correction circuitry, making it extremely fault tolerant and secure for control applications.

Control Network

The controller is a node on Cnet. The HDCU uses Cnet for such things as to:

- Communicate field input values and states for process monitoring and control.
- Communicate configuration parameters that determine the operation of functions such as alarming, trending, and logging, on a human system interface.
- Process field input data acquisition.
- Receive control instructions from a human system interface to adjust process field outputs.
- Provide feedback to plant personnel of actual output changes.

Cnet is a 10 megabit per second IEEE 802.3 Ethernet highway using TCP/IP protocol with CSMA/CD. It supports up to 32 Harmony DCU controller node connections and up to 32 legacy PCU2000 node connections. Data is transferred in messages that contain system data, control, and configuration information. Alarm or state changes are reported on an exception basis. The controller generates messages upon request and an exception report periodically to update data, after a process point reaches a defined alarm limit or changes state. Event triggered or polled peer-to-peer communication for transferring point data between controller nodes is done over Cnet using standard Controlware II peer-to-peer (PTP) software modules.

Figure 3 shows the HDCU in a system architecture and a legacy DCI-5000 controller with both residing as nodes on Cnet. Figure 4 shows a dual frame HDCU with interfaces to local I/O, distributed I/O and serial communication I/O.

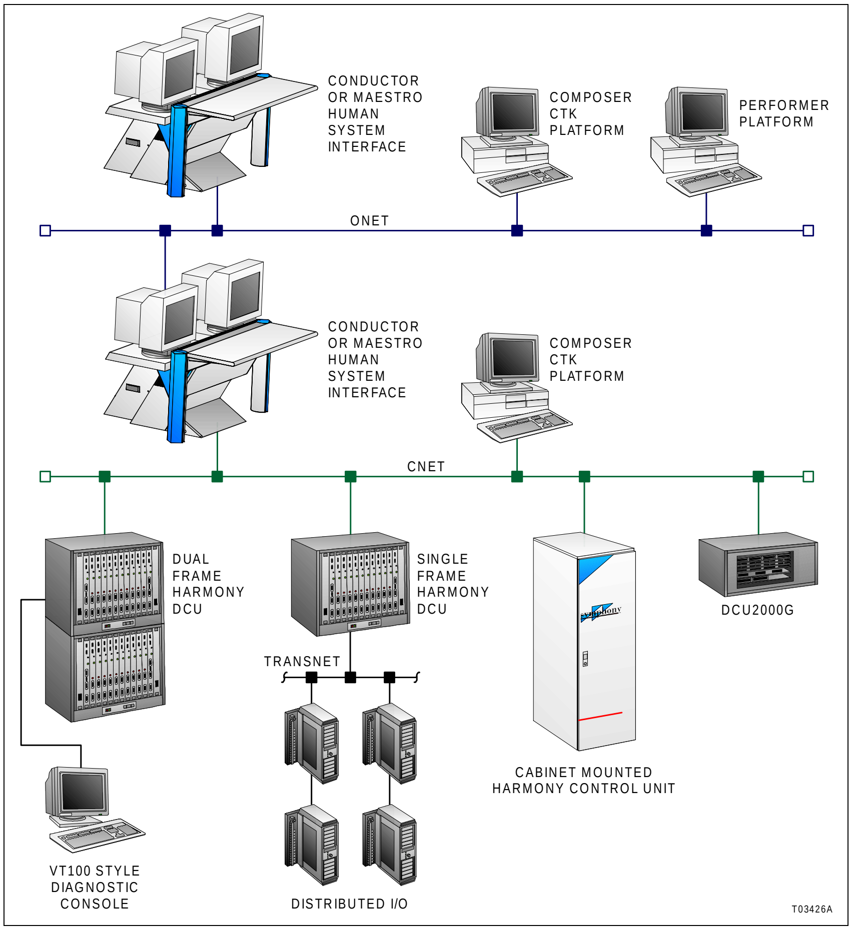

Figure 3. Harmony Communications Architecture

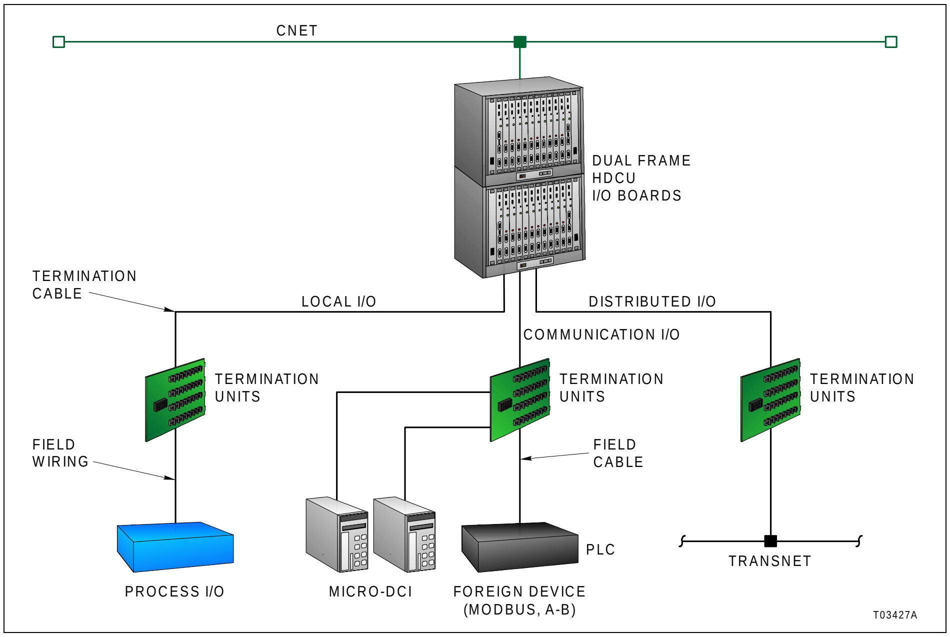

Figure 4. Harmony DCU I/O

Compatibility

The HDCU is fully compatible with existing DCU3200 controllers. The HDCU can be used in established DCU3200 installations using Ethernet communication networks. Controlware II configurations in existing DCU3200 controllers can be downloaded to the HDCU without modification. The HDCU can run Controlware II software for Symphony or DCI System Six software releases.

Configuration Tools

The HDCU can be configured and tuned using any Symphony configuration tool that supports editing Controlware II. This includes, for example:

- Composer™/CTK (3.0 and later).
- Conductor NT (2.3 and later).
- Conductor UX (3.0 and later).

The Composer/CTK tool is the recommended method for creating and managing controller configurations.

Software Licenses

The HDCU uses software licensing to manage its major available features. A software key is necessary for proper operation of specific functions. The following functions are under license management control:

- Number of Controlware II modules (750, and more than 750).
- CIO interfaces.

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