

Application Specifics

AEROFLEX COLORADO SPRINGS MIXED-SIGNAL ASIC SOLUTIONS

IN-VEHICLE HEALTH MONITORING

PROBLEMS IN HEALTH MONITORING OF AIRCRAFT AND AUTOMOTIVE

- **Wiring** weight and complexity.
- **Low reliability.**
- **Limited performance** Data rate.
- **Noise susceptibility.**
- **System cost** Design, material, support.
- **Long design cycle time.**
- **Wireless node cost** Supporting circuitry for wireless protocol.
- **Size** Difficult to miniaturize each node.
- **Wireless asynchronous data acquisition.**

SOLUTION = AEROFLEX'S NEW NIC/NDI NETWORK ASICS WITH INTELLIBUS™ PROTOCOL

- **Single cable** Daisy-chained twisted-pair wiring between nodes.
- **High data rates** Up to 30Mbps.
- **Low cost** Low device count at each node.
- **Isochronous data acquisition** Network-wide simultaneous sampling.

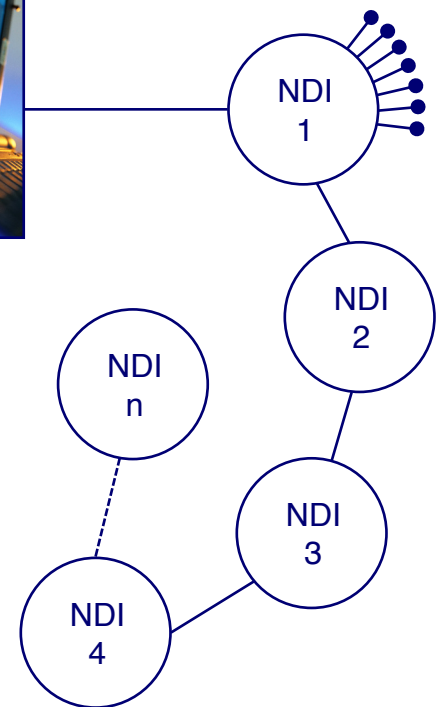
800-645-8862

See Aeroflex's AX7000-NIC and our
AX30NDI data sheets at
www.aeroflex.com/mixedsignal



Network
Interface
Controller
(inside PC)

Example: 8 actuators
or position sensors



What is the IntelliBus™ Protocol?

IntelliBus is a Boeing-developed serial databus communication standard designed to network sensors, actuators, and subsystems while providing the simplicity necessary for miniature smart sensors, the low latency needed for flight controls, the time determinism required for data analysis, and the distance for industrial control. IntelliBus permits the integration of signal conditioning, analog-to-digital conversion, and digital interfacing into a low-cost package that can be installed in any sensor, actuator, interface module, or system. Aeroflex Colorado Springs (Aeroflex) licensed the IntelliBus standard to market products in 2004.

IntelliBus has a low overhead that enables maximum data transmittal, accommodates both sensors and actuators for monitoring and control, and incorporates fault avoidance features. Additionally, IntelliBus accommodates a high sensor count per bus (over 500), allows synchronization between multiple busses, simultaneous sampling capability, and isochronous transmission with low jitter (+/- 500ps). IntelliBus is time deterministic and enables high data rates per bus (30, 15, and 7.5 Mbps) while maintaining a low cost-per-node.

Aeroflex has developed a Network System product family consisting of a Network Interface Controller (NIC) and a Network Device Interface (NDI) to address a variety of communication and control network requirements in the Factory Floor Automation and In-Vehicle Health Monitoring fields. Features include:

- ❑ A standard set of functions and services that locate, configure, and operate a wide range of transducer devices
- ❑ A mechanism to acquire and distribute data:
 - Synchronously
 - At multiple sample rates
 - Simultaneously with minimal acquisition jitter
- ❑ Minimal network latency without strict constraints on communication at the peripheral device
- ❑ Support of device (node) memory containing node information and automatic peripheral configuration (at boot)
- ❑ Multi-cast connectivity to a large number of peripheral devices
- ❑ A mechanism for any node to filter and trap network data
- ❑ Low-overhead time-deterministic device-to-device data transfers
- ❑ Data buffering to minimize network latency
- ❑ Low-cost, EMC compliant physical layer: easy-maintenance twisted-pair copper
- ❑ Capable of 30 Mbps data rate
- ❑ Scalable hardware, firmware and software

A. Physical and Data Link layers (OSI layers 1-2)

Per the product features listed above, twisted pair copper wiring is utilized with M-LVDS (Multipoint-Low-Voltage Differential Signaling) data transceivers for high-speed (30 Mbps) signaling, or RS-485 transceivers for lower speed applications. Off-the-

shelf transceivers are used. Due to proprietary bit sampling schemes in the receiver, no clock recovery or re-syncing is necessary in the physical layer (layer 1), only signal level translation and output tri-stating is required.

The typical Aeroflex NIC/NDI network system consists of one bus controller and multiple nodes. Half duplex data transmission occurs, where only the bus controller or the addressed node is actively transmitting data. More than one node may be receiving the data. (Full-duplex communication is possible on a single controller-to-node system. The Data Link layer (layer 2) support is provided by two hardware functions: the Network Interface Controller (NIC) and the Network Device Interface (NDI).

The AX7000 Network Interface Controller (NIC)

The NIC function is the master bus controller for the Aeroflex NIC/NDI network. Connecting directly to a physical layer transceiver, the NIC controls the scheduling of data communications on the network by issuing commands to the NDI devices on the network. Typically a PCI card in a host PC, the NIC uses a set of IntelliBus protocol NIC opcodes which allow host modification access to the NIC scheduler, as well as direct access to network data.

The AX30 Network Device Interface (NDI)

The NDI function is the miniaturized interface chip connecting peripheral devices onto the Aeroflex NIC/NDI serial network. The IntelliBus protocol allows each NDI device to support up to 16 peripherals (or channels). These peripherals can range from simple sensors or indicators to complex audio/visual components. With 30 Mbps of throughput on the physical bus, many NDI chips can be supported on a single Aeroflex NIC/NDI network, with the maximum addressable range of up to 509 channels per bus.

B. Presentation layer (OSI layer 6)

Included in the NDI is support for serial data communications with peripherals via SPI, ISC, I2S and UART ports. The number of ports (channels) available within a specific NDI determine the pin count and size of the device; thus, a range of NDI device package sizes supports a variety of peripheral area constraints. Input and output FIFO buffering is provided within the NDI to support the difference in data rates between the peripherals and the high-speed Aeroflex NIC/NDI traffic rate.

C. Application layer (OSI layer 7)

Included in the NDI is flexible support for a large variety of signal processing and signal conditioning devices, such as:

- ❑ Analog to Digital Converters
- ❑ Digital to Analog Converters
- ❑ Microcontrollers
- ❑ Digital I/O (switches, indicator drive)
- ❑ Inter-node communication

AX7000-NIC Network Interface Controller (NIC)

Preliminary Datasheet- May 2005

www.aeroflex.com/mixedsignal



FEATURES

- Supports IntelliBus™ Protocol v3.0
- Dual IntelliBus Network Ports
- Full and Half Duplex Support
- IntelliBus RS-485 Physical Layer
- Synchronous Data Rates up to 15.0 Mbps
- Asynchronous Data Rates of 7.5, and 15.0 Mbps
- 256K Word Schedule Memory
- 256 Word Dynamic Schedule Register Space
- 1K Word Deep Receiver FIFOs
- External IntelliBus Power Source

APPLICATIONS

- Sensor Integration
- Factory Floor Automation
- In-Vehicle Healthy Monitoring
- Process Control Systems

BENEFITS

Network Interface Controller (AX7000-NIC)

- Capable of running network schedule
- Provides gateway to other higher networks
- Supports up to 510 logical addresses of sensors, actuals, and IICs per bus
- Host processor can directly talk or control IntelliBus schedule via NIC
- Runs membership services functions
- Provides synchronous trigger time-base
- Contains network traffic FIFO buffer
- Multiple form factors available (PCI user specified)

GENERAL DESCRIPTION

The AX7000-NIC Network Interface Controller (NIC) is a third generation controller design specifically to be used as a controller in a PC based IntelliBus development system. The card plugs directly into a 66Mhz, 32-bit 3.3V PCI V2.2 compliant slot in a Pentium PC compatible computer. The card supports two semi-independent IntelliBus serial channels, which operate in asynchronous mode supporting the IntelliBus Isochronous (IS) communications tier at data rates up to 15Mbps. The IntelliBus network channels are implemented using the IntelliBus RS-485 physical layer and can be configured in a Half or Full Duplex arrangement. The card contains a 1K word deep FIFO for each of the two network receiver channels. This allows real time data collection using a standard PC operating system. All control and data retrieval operations are handled by software through registers implemented in the PCI interface. The card supports a custom microcode instruction set that is used to control the execution of a schedule. The microcode is loaded, by software, into onboard schedule memory. The card contains status lights for a real time indication of the state of the network. The NIC controls all I/O from an Interface Card.

The AX7000-NIC is manufactured at Aeroflex Colorado Springs' 104,000-square foot ISO-9001 certified facility. Aeroflex Colorado Springs has been producing high-reliability integrated circuits and circuit card assemblies for the aerospace industry since 1980.

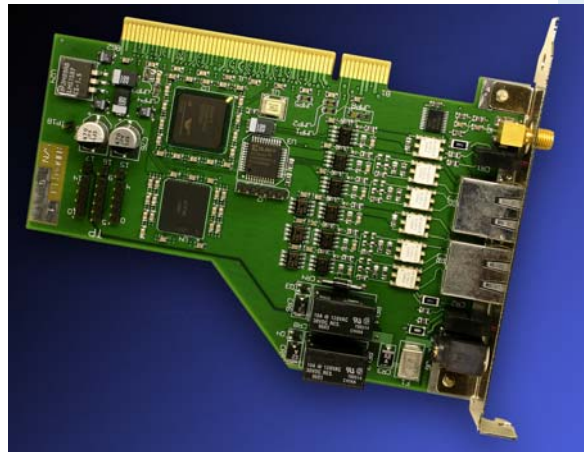


Figure 1. AX7000-NIC Network Interface Controller

ABSOLUTE MAXIMUM RATINGS¹

PARAMETER	LIMITS
PCI Bus Voltage 3.3V	-0.5 V to 4.0 V
PCI Bus Voltage 5.0V	-0.5 V to 7.0 V
External Bus Power Input	15 V
External Clock Input	-0.5 V to +7 V
Operating Temperature	0°C to +70°C
Storage Temperature	-30°C to +90°C

Notes:

1. Stresses greater than those listed under absolute maximum specifications may cause permanent damage to the device. This is a stress rating only, and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Prolonged exposure to absolute maximum rating conditions may affect reliability.

RECOMMENDED OPERATING CONDITIONS

PARAMETER	LIMITS
PCI Bus Voltage 3.3V	3.0V to 3.6V
PCI Bus Voltage 5.0V	4.7V to 5.3V
PCI Bus Current 3.3V	A
PCI Bus Current 5.0V	A
Power Dissipation	W
Operating Temperature	0°C to +70°C

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Toll Free: 800-645-8862
Fax: 719-594-8468

INTERNATIONAL

Tel: 805-778-9229
Fax: 805-778-1980

NORTHEAST

Tel: 603-888-3975
Fax: 603-888-4585

SE AND MID-ATLANTIC

Tel: 321-951-4164
Fax: 321-951-4254

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AX30NDI-09/05/02 Network Interface Device (NDI)

with IntelliBus™ Protocol

Preliminary Datasheet - May 2005

www.aeroflex.com/MixedSignal



FEATURES

- ❑ Network Device Interface (NDI) designed specifically for:
 - Factory Floor Automation applications
 - In-Vehicle Health Monitoring applications
- ❑ Compliant to IntelliBus Standards for Generation 3 Protocol
- ❑ Full IntelliBus data rates of 7.5, 15 or 30 Mbps (pin-selectable)
- ❑ Variety of package sizes: 9, 5 and 2 channel variants
- ❑ Network connection through a simple MLVDS or RS-485 external transceiver
- ❑ EDS and device bootup memory supported via 8K words of external serial flash
- ❑ Configurable internal PLL generates multiple and isochronous peripheral clocks (48 KHz to 24.576 MHz)

- ❑ Variety of serial connections to peripherals: SPI, I2S, I2C and UART
- ❑ 16-word output FIFO per channel (to peripheral)
- ❑ Dual 16-word input FIFOs per channel (from peripheral)
- ❑ Single-supply 3.3V device with 5V tolerant I/O
- ❑ Commercial and Industrial temperature ranges

INTRODUCTION

The AX30NDI devices are Network Device Interfaces compliant to the Generation 3 IntelliBus protocol. These devices allow efficient connection of a variety of peripheral devices onto a multi-point IntelliBus network. Peripheral devices can include A/D and D/A converters for data acquisition, audio and video DACs for multimedia and digital I/O for basic control and sense applications.

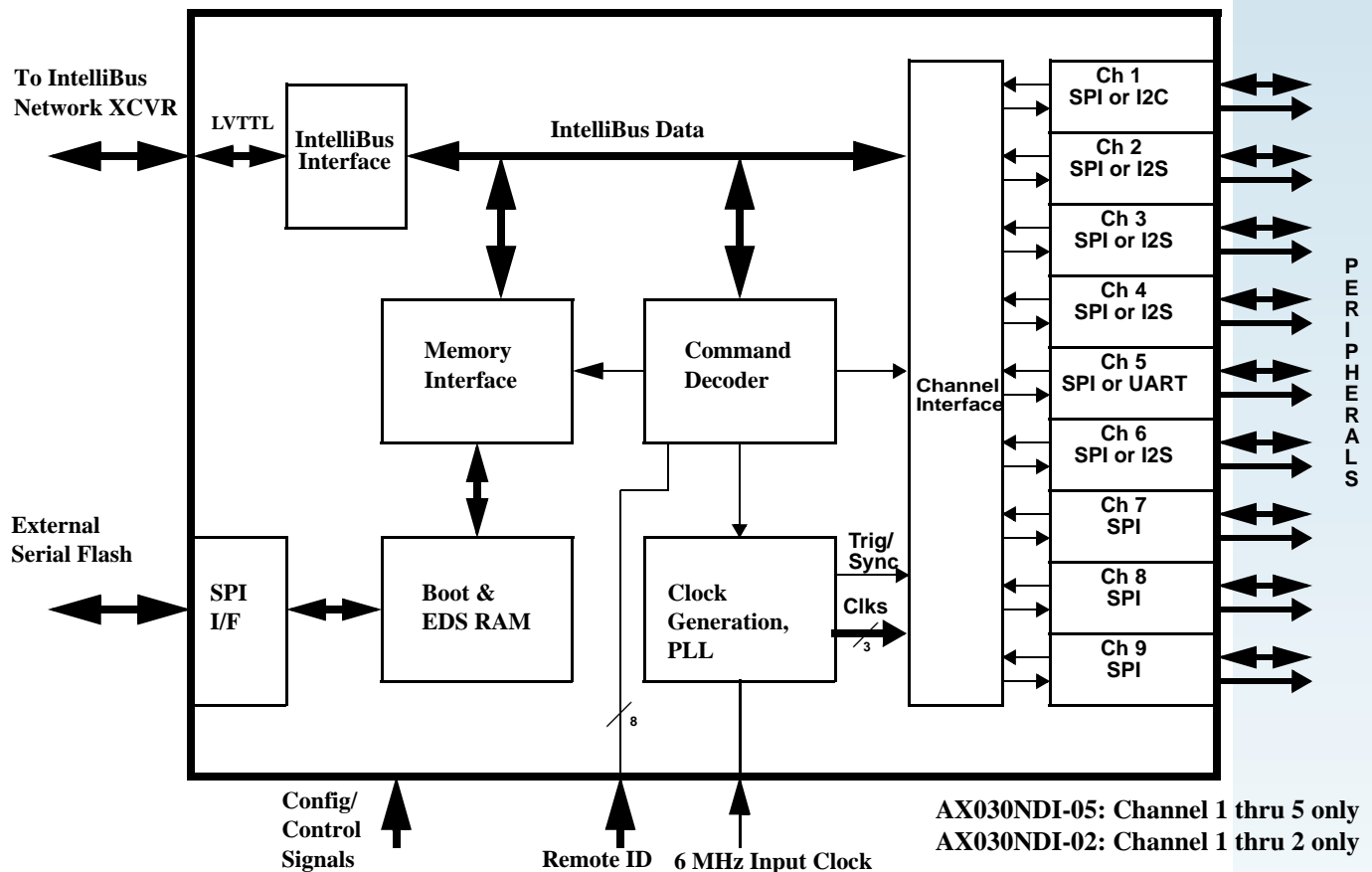


Figure 1. AX30NDI-09 Block Diagram

IntelliBus Interface

Data rates of 7.5Mbps, 15Mbps and 30Mbps are user-selectable via bit-rate select control inputs to the AX30NDI. A simple MLVDS or RS-485 external transceiver is required for the PHY layer. The internal Command Decoder interprets network IntelliBus commands from the Network Interface Controller, and performs the appropriate data transfer or peripheral control.

External Serial Flash Interface

The AX30NDI device contains a bootup algorithm to support a unique ID and unique self-configuration per port. This bootup data is stored in external flash, and downloaded at power-up into internal RAM via a serial interface. Electronic Data Sheet information is also stored in the external flash and is available for access by the IntelliBus Network Interface Controller after the bootup procedure downloads data to RAM. The flash interface is implemented as a standard SPI interface.

Peripheral Interface (Ports)

The number of available ports per NDI device type is defined in Table 1. The three family members of the AX30NDI differ only in the number of ports, thus affecting package size. Each port supports an SPI protocol. As shown in the AX30NDI-09 Block Diagram, alternate serial protocols are supported: I2C, I2S and UART. These alternate modes are user selected via pin tie-offs. Each port contains three FIFOs for buffering the data flow. A 16-word Output FIFO stores network data before transferring to the peripheral when the proper (optionally isochronous) IntelliBus command is decoded.

A 16-word Input Buffer and a second 16-word Input FIFO are provided to allow isochronous data collection at peripheral data rates, with previous-frame data output to the IntelliBus network at IntelliBus data rates. Isochronous time-deterministic data transfers to and from each port are supported by the Trigger and Sync signals, decoded from IntelliBus network commands. The PLL internal to the AX30NDI provides peripheral clocking which is locked to the Trigger signal. Three user-defined frequencies are available for use at all channels, ranging from 48 KHz to 24.576 MHz.

Remote ID Inputs

The AX30NDI contains support for ID inputs which can be read by the IntelliBus Network Interface Controller to determine the physical location of each NDI located on a bus. These signals are discrete inputs tied externally to Vdd or Ground.

Table 1. AX03NDI Packaging

Part #	Channel	Package Type	Pkg Dimensions I x w(mm)
AX30NDI-02-Q72	2	72-pin QFN	10 x 10
AX30NDI-02-B72	2	72-pin FBGA	7 x 7
AX30NDI-05-L120	5	120-pin LQFP	14 x 14
AX30NDI-05-B121	5	121-pin FBGA	8 x 8
AX30NDI-09-B169	9	169-pin FBGA	11 x 11

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Fax: 719-594-8468

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Tel: 805-778-9229
Fax: 805-778-1980

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AX30NDI-09/05/02 PHY Network Interface Device (NDI)

with IntelliBus™ Protocol and Internal PHY

Preliminary Datasheet - May 2005

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FEATURES

- ❑ Network Device Interface (NDI) designed specifically for:
 - Factory Floor Automation applications
 - In-Vehicle Health Monitoring applications
- ❑ Compliant to IntelliBus Standards for Generation 3 Protocol
- ❑ Full IntelliBus data rates of 7.5, 15 or 30 Mbps (pin-selectable)
- ❑ Variety of package sizes: 9, 5 and 2 channel variants
- ❑ Internal PHY (MLVDS transceiver) for direct IntelliBus connection
- ❑ EDS and device bootup memory supported via 8K words of external serial flash
- ❑ Configurable internal PLL generates multiple and isochronous peripheral clocks (48 KHz to 24.576 MHz)

- ❑ Variety of serial connections to peripherals: SPI, I2S, I2C and UART
- ❑ 16-word output FIFO per channel (to peripheral)
- ❑ Dual 16-word input FIFOs per channel (from peripheral)
- ❑ Single-supply 3.3V device with 5V tolerant I/O
- ❑ Commercial and Industrial temperature ranges

INTRODUCTION

The AX30NDIxxPHY devices are Network Device Interfaces compliant to the Generation 3 IntelliBus protocol. These devices allow efficient connection of a variety of peripheral devices onto a multi-point IntelliBus network. Peripheral devices can include A/D and D/A converters for data acquisition, audio and video DACs for multimedia and digital I/O for basic control and sense applications.

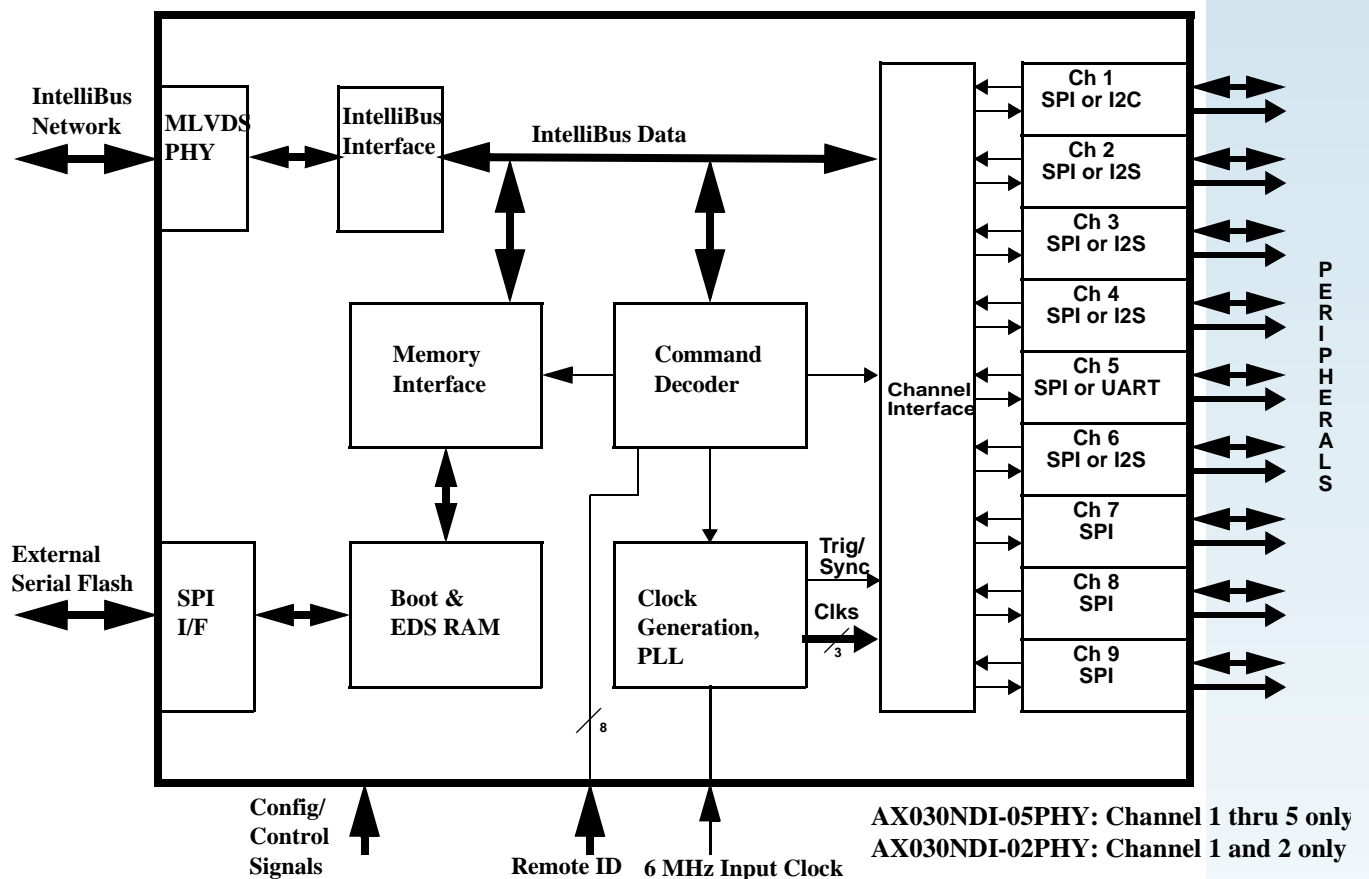


Figure 1. AX30NDI-09PHY Block Diagram

IntelliBus Interface

Data rates of 7.5Mbps, 15Mbps and 30Mbps are user-selectable via bit-rate select control inputs to the AX30NDIxxPHY. An internal transceiver provides the PHY layer signaling. The internal Command Decoder interprets network IntelliBus commands from the Network Interface Controller, and performs the appropriate data transfer or peripheral control.

External Serial Flash Interface

The AX30NDIxxPHY device contains a bootup algorithm to support a unique ID and unique self-configuration per port. This bootup data is stored in external flash, and downloaded at power-up into internal RAM via a serial interface. Electronic Data Sheet information is also stored in the external flash and is available for access by the IntelliBus Network Interface Controller after the bootup procedure downloads data to RAM. The flash interface is implemented as a standard SPI interface.

Peripheral Interface (Ports)

The number of available ports per NDI device type is defined in Table 1. The three family members of the AX30NDIxxPHY differ only in the number of ports, thus affecting package size. Each port supports an SPI protocol. As shown in the AX30NDI-09PHY Block Diagram, alternate serial protocols are supported: I2C, I2S and UART. These alternate modes are user selected via pin tie-offs. Each port contains three FIFOs for buffering the data flow. A 16-word Output FIFO stores network data before transferring to the peripheral when the proper (optionally isochronous) IntelliBus command is decoded.

A 16-word Input Buffer and a second 16-word Input FIFO are provided to allow isochronous data collection at peripheral data rates, with previous-frame data output to the IntelliBus network at IntelliBus data rates. Isochronous time-deterministic data transfers to and from each port are supported by the Trigger and Sync signals, decoded from IntelliBus network commands. The PLL internal to the AX30NDIxxPHY provides peripheral clocking which is locked to the Trigger signal. Three user-defined frequencies are available for use at all channels, ranging from 48 KHz to 24.576 MHz.

Remote ID Inputs

The AX30NDIxxPHY contains support for ID inputs which can be read by the IntelliBus Network Interface Controller to determine the physical location of each NDI located on a bus. These signals are discrete inputs tied externally to Vdd or Ground.

Table 1. AX03NDI Packaging

Part #	Channel	Package Type	Pkg Dim. I x w (mm)
AX30NDI-02PHY-Q72	2	72-pin QFN	10 x 10
AX30NDI-02PHY-B72	2	72-pin FBGA	7 x 7
AX30NDI-05PHY-L120	5	120-pin LQFP	14 x 14
AX30NDI-05PHY-B121	5	121-pin FBGA	8 x 8
AX30NDI-09PHY-B169	9	169-pin FBGA	11 x 11

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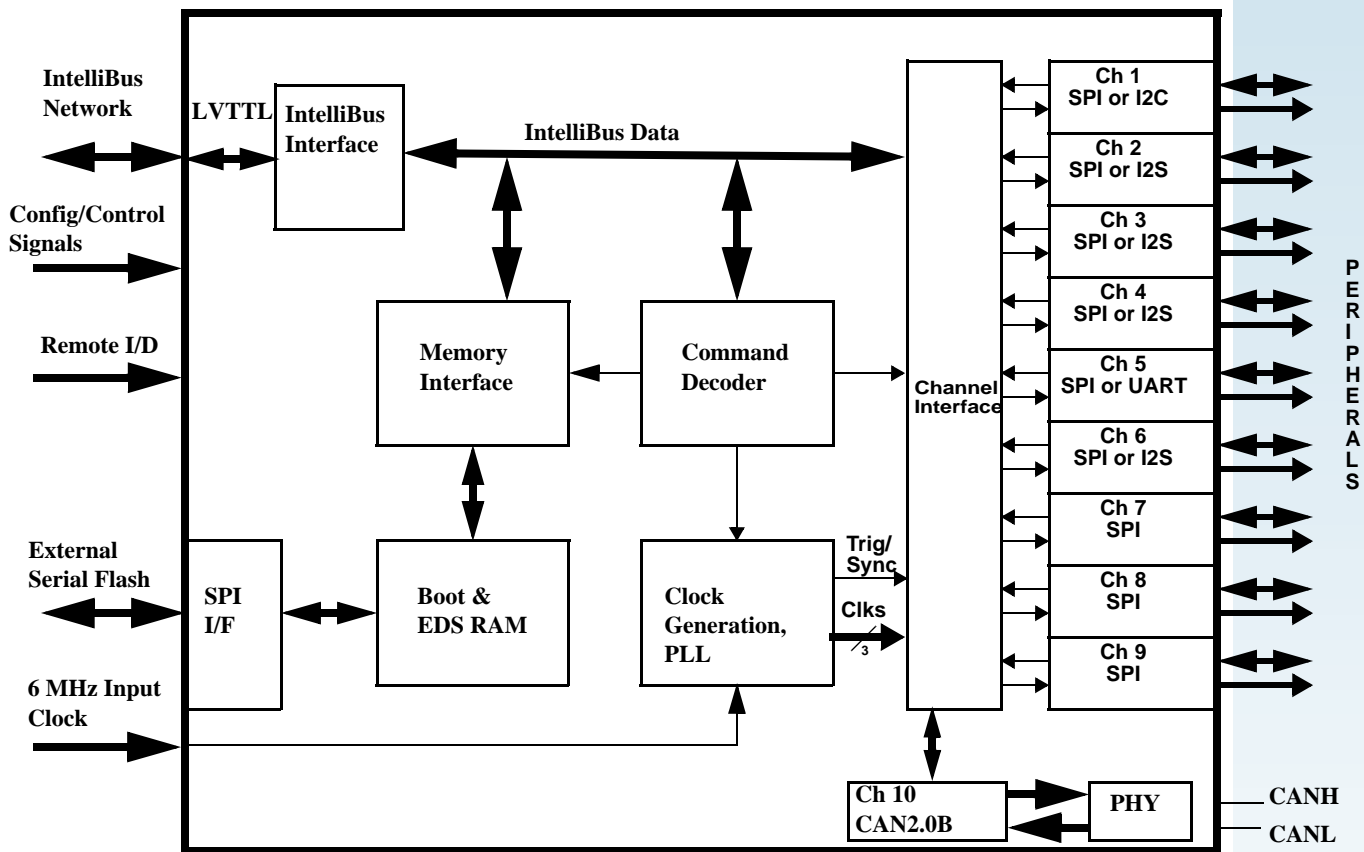
FEATURES

- ❑ Network Device Interface (NDI) designed specifically for:
 - Factory Floor Automation applications
 - In-Vehicle Health Monitoring applications
- ❑ Compliant to IntelliBus Standards for Generation 3 Protocol
- ❑ Full IntelliBus data rates of 7.5, 15 or 30 Mbps (pin-selectable)
- ❑ Integrated CAN2.0B controller and PHY interface provides IntelliBus-to-CAN network bridge
- ❑ IntelliBus network connection through a simple MLVDS or RS-485 external transceiver
- ❑ EDS and device bootup memory supported via 8K words of external serial flash
- ❑ Configurable internal PLL generates multiple and isochronous peripheral clocks (48 KHz to 24.576 MHz)

- ❑ Variety of serial connections to peripherals: SPI, I2S, I2C and UART
- ❑ 16-word output FIFO per channel (to peripheral)
- ❑ Dual 16-word input FIFOs per channel (from peripheral)
- ❑ Single-supply 3.3V device with 5V tolerant I/O
- ❑ Variety of package sizes: 10, 6 and 3channel variants
- ❑ Commercial and Industrial temperature ranges

INTRODUCTION

The AX30NDIxxCAN devices are Network Device Interfaces compliant to the Generation 3 IntelliBus protocol. These devices allow efficient connection of a variety of peripheral devices, including CAN, onto a multi-point IntelliBus network. Peripheral devices can include A/D and D/A converters for data acquisition, audio and video DACs for multimedia and digital I/O for basic control and sense applications plus CAN data.



AX30NDI-06CAN: Channel 1 thru 5 and 10 only

AX30NDX-03CAN: Channel 1, 2 and 10 only

Figure 1. AX30NDI-10CAN Block Diagram

IntelliBus Interface

Data rates of 7.5Mbps, 15Mbps and 30Mbps are user-selectable via bit-rate select control inputs to the AX30NDIxxCAN. A simple MLVDS or RS-485 external transceiver is required for the PHY layer. The internal Command Decoder interprets network IntelliBus commands from the Network Interface Controller, and performs the appropriate data transfer or peripheral control.

External Serial Flash Interface

The AX30NDIxxCAN device contains a bootup algorithm to support a unique ID and unique self-configuration per port. This bootup data is stored in external flash, and downloaded at power-up into internal RAM via a serial interface. Electronic Data Sheet information is also stored in the external flash and is available for access by the IntelliBus Network Interface Controller after the bootup procedure downloads data to RAM. The flash interface is implemented as a standard SPI interface.

Peripheral Interface (Ports)

The number of available ports per NDI device type is defined in Table 1. The three family members of the AX30NDIxxCAN differ only in the number of ports, thus affecting package size. Each port supports an SPI protocol. As shown in the AX30NDI-010CAN Block Diagram, alternate serial protocols are supported: I2C, I2S and UART. These alternate modes are user selected via pin tie-offs. Each port contains three FIFOs for buffering the data flow. A 16-word Output FIFO stores network data before transferring to the peripheral when the proper (optionally isochronous) IntelliBus command is decoded.

A 16-word Input Buffer and a second 16-word Input FIFO are provided to allow isochronous data collection at peripheral data rates, with previous-frame data output to the IntelliBus network at IntelliBus data rates. Isochronous time-deterministic data transfers to and from each port are supported by the Trigger and Sync signals, decoded from IntelliBus network commands. The PLL internal to the AX30NDI provides peripheral clocking which is locked to the Trigger signal. Three user-defined frequencies are available for use at all channels, ranging from 48 KHz to 24.576 MHz.

Remote ID Inputs

The AX30NDIxxCAN contains support for ID inputs which can be read by the IntelliBus Network Interface Controller to determine the physical location of each NDI located on a bus. These signals are discrete inputs tied externally to Vdd or Ground.

CAN Bus Interface

The AX30NDIxxCAN contains a CAN controller and PHY module implementing a bridge between the IntelliBus network and a CAN 2.0B network.

Table 1. AX03NDI Packaging

Part #	Channel	Package Type	Pkg. Dim. I x w (mm)
AX30NDI-03CAN-Q72	3	72-pin QFN	10 x 10
AX30NDI-03CAN-B72	3	72-pin FBGA	7 x 7
AX30NDI-06CAN-L120	6	120-pin LQFP	14 x 14
AX30NDI-06CAN-B121	6	121-pin FBGA	8 x 8

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Fax: 719-594-8468

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