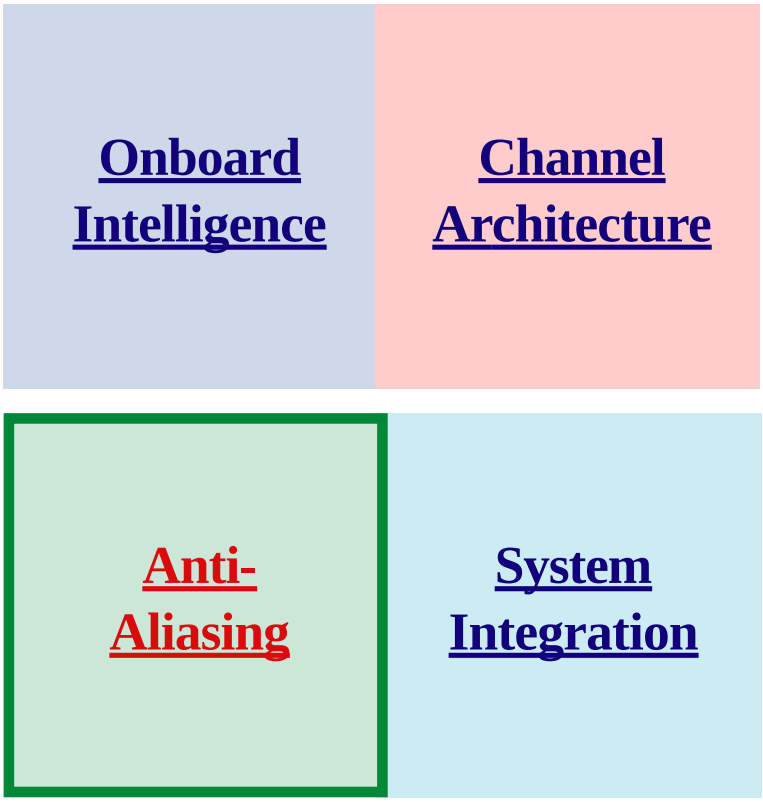
Anti-Aliasing



ANTI-ALIASING and SIGNAL CONDITIONING

from

MICROSTAR LABORATORIES™

Anti-Aliasing

defending your data against aliasing

Any system that digitizes analog inputs – unless it first filters out high frequencies – implicitly presumes that the analog inputs contain no frequencies above the Nyquist frequency. Any such frequencies will corrupt the digitized results by appearing among them as lower frequency aliasing.

Introducing This Catalog

This catalog section guides you through the anti-aliasing solutions that Microstar Laboratories offers. It does so in enough detail for you to determine how to include anti-aliasing components in the system you configure using the two earlier catalog sections: Onboard Intelligence and Channel Architecture. It includes photographs of all Eurocards and other hardware to do with anti-aliasing, and it gives enough information on part numbers to identify the user manuals to access for more information. If you do not yet have all our user manuals, please ask us for them. You can do this right now by phone or on the Web. If you do not have our current price list, please ask us for that as well.

During your visit to our Web site, you can request the DAPtools Basic CD. This contains all our user manuals for all our software and hardware products in Windows Help format as well as in PDF format. When you want more detail on a product than you can find in this catalog, please refer to the relevant user manual on this CD. Or call us.

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Microstar Laboratories warrants all hardware products for one year. After that, the company will repair products at minimal cost if vendors still supply any parts needed. In practice, Microstar Laboratories buys discontinued parts for inventory to prolong the useful life of older products. Please ask for a copy of the Microstar Laboratories Limited Warranty for details of the one-year warranty.

Digitizing a signal destroys all evidence of any frequencies higher than half the sampling rate. Samples of these higher frequencies map exactly into their lower frequency aliases. You cannot detect any one of the higher frequencies in your sampled data. But you do detect each alias. And this corrupts your results.

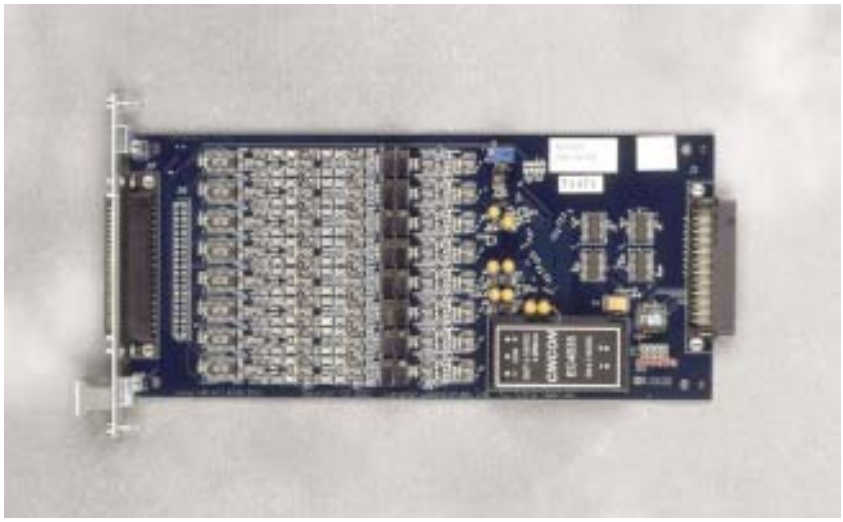
A suitable analog filter, placed between a sensor and any analog-to-digital converter, effectively takes out unwanted higher frequencies. Microstar Laboratories offers two off-the-shelf implementations. The one to choose depends on the application.

MSXB 048

The simpler implementation, using MSXB 048 Filtered Analog Input Expansion Boards in place of MSXB 037 Analog Input Expansion Boards, works with any a-Series DAP. Each of the sixteen input channels on an MSXB 048 board has its own analog filter built in. Nine models of the board offer nine different cutoff options, ranging from 100Hz through 50kHz. See inside back cover.

iDSC 1816

For more advanced filter applications, and those that require higher and variable cutoff frequencies, choose the iDSC 1816: a specialized DAP with onboard analog filters. The iDSC 1816 combines brick-wall anti-aliasing filters on each of 8 simultaneous channels with 16-bit data acquisition all on one board at a throughput of 1.2M samples per second: 153.6k samples per second on each of the 8 channels. It comes with DSCview software and with support for other Windows and Linux programs.



Onboard analog filters – similar to the analog filters on the iDSC 1816 – block unwanted high frequencies on each channel of the MSXB 048, shown here.

iDSC 1816: 1.2 million filtered samples per second

- **An iDSC 1816 board optically isolates its analog section from the PC.**
- **An iDSC 1816 board supports applications that require simultaneous sampling on up to 8 simultaneous inputs.**
- **An iDSC 1816 board can work with others as a single synchronized system.**

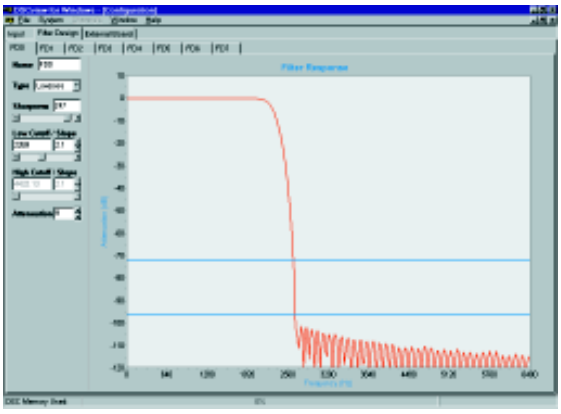
Anti-Aliasing

- 16-bit data acquisition
- 8 simultaneous inputs
- Multiple sampling rates
- Industry-standard software

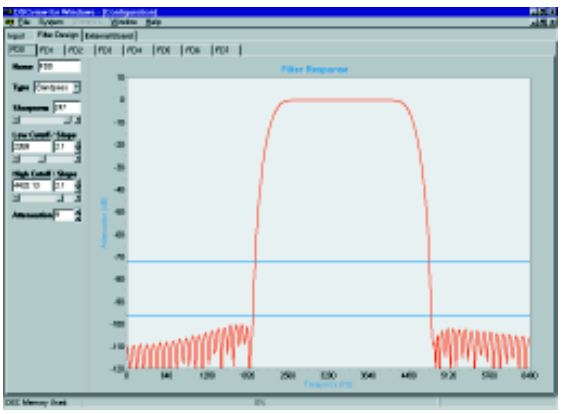
ONBOARD FILTERS

- Linear phase response
- Guaranteed anti-aliasing
- User-specified filters
- Channel-by-channel cutoffs

1.2M SAMPLES PER SECOND



Onscreen sliders let you customize the filter on each channel. DSCview displays the characteristic curve in real time: like this one of a typical lowpass filter.



A typical bandpass filter as displayed in DSCview

The iDSC 1816 comes with DSCview included – see screen images on the left. It also includes software tools that let you access these and other DSCview functions from your choice of user interface: from DASY*Lab*, LabVIEW, or Agilent VEE; or from one you build yourself in any Windows application or language that supports DLL calls.

With DSCview software on your PC, you can customize the filter characteristics channel by channel and transmit them to one or more iDSC 1816 boards. Download DSCview from our Web site and check out the multiple-board feature along with the filter-design interface.

Microstar Laboratories provides other software[1] that integrates with your choice of user interface to allow you to supervise multiple iDSC boards from elsewhere on a network. In particular, you can control high-speed disk logging of filtered data – on a separate configuration optimized for the purpose – free from network delays and at a rate unaffected by random events on your own PC.

[1] DAPcell Software – a Windows service

iDSC 1816 Specifications

Anti-Aliasing Filter Board for the PCI bus

96 dB per Quarter-Octave *16-bit resolution*

High-Speed Input

The iDSC 1816 provides continuous, gap-free input, and allows a different cutoff frequency on each channel.

Software-Selectable Acquisition Front End

Menu choices configure which physical inputs to sample. The iDSC 1816 provides up to 8 simultaneous inputs each with its own separate software-selected filter.

INPUT	
Analog inputs	8
Ranges (volts)	±5, ±10
Samples (x1000) per second per ADC	153.6
A/D Converters	8
A/D Resolution (bits)	16
A/D Converter type	Sigma-delta
Gain	1
Timer inputs	
TTL	2
DSP	
Onboard DSP chips	2 @ 100 MHz
MICROPROCESSOR	
486 Processor	DX4
Clock speed (MHz)	96
Onboard operating system	32-bit
RAM (Mbytes)	16
PC INTERFACE	
Interface type	PCI
Samples (x 1000) transferred/second*	1229
Five boards synchronized*	6144
Samples (x 1000) logged/second*	1229
Five boards synchronized*	6144

** Continuous maximum disk logging and data transfer rates vary with PC platform.*

Data Acquisition, Spectral Analysis, and Aliasing

Data acquisition digitizes an analog signal by sampling it at discrete times, several times in each cycle, to produce a stream of numbers. Spectral analysis does the math on these numbers, mostly using the fast Fourier transform, that breaks out the frequency components of the signal. And **aliasing** — high-frequency results folded into otherwise accurate data — **corrupts the results.**

The iDSC 1816 board takes out all aliasing from data acquisition. Guaranteed. Using the latest **analog** and **digital** components and proprietary algorithms, it implements onboard brick-wall filters. And that **makes spectral analysis reliable.**

The filters in the iDSC 1816 have variable cutoff frequencies — up to 61.44 kHz — and linear phase response. Each channel can have a different filter. And the board **requires no programming.**

Synchronizing Several Boards

Onboard circuitry and special synchronization connectors can support several Microstar Laboratories boards, in any combination of iDSC and DAP models, running in the same PC. A software-selectable master iDSC provides a sampling clock to software-selectable slave iDSC boards. A master DAP provides a sampling or an update clock to software-selectable slave DAPs.

The iDSC sampling clock signal, when applied to the external clock input of the master DAP, synchronizes both groups of boards. Each DAP then may sample up to 153.6k samples per second. Microstar Laboratories also provides for synchronization of boards installed in different PCs. Call for details.

Sampling Rate

Onboard analog filters pass signals to eight Sigma-Delta A/D converters that each run at 9.83M samples per second. This high rate allows digital filtering and decimation to eliminate any aliases below the stopband of the analog filters, and the hardware design delivers simultaneous streams of filtered data at 153.6k samples per second on each channel. Two additional TTL inputs provide clock/timer signals the application can access. The iDSC 1816 synchronizes the data streams with any signals on these channels. Configurable symmetric FIR filters implemented on two DSP chips allow any of these sampling rates:

			153600		
102400			76800		
51200			38400		
25600			19200		15360
12800		10240	9600		7680
6400		5120	4800		3840
3200	3072	2560	2400	2048	1920
1600	1536	1280	1200	1024	960
800	768	640	600	512	480
400	384	320	300	256	240
200	192	160	150	128	120
100	96	80	75	64	60
50	48	40		32	30
25	24	20		16	15
	12	10		8	

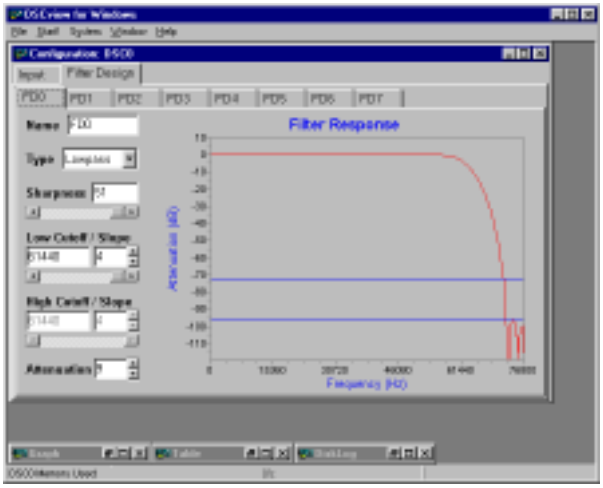
Cutoff Frequency

Valid cutoff frequencies fall in the range 2% to 80% of Nyquist; in other words: 100 to 2.5 samples per cycle. So cutoff frequencies range from 61.44 kHz on down. Above 50% of Nyquist, resulting filters roll off at better than 96 dB per quarter-octave.

DSCview

Windows
Linux

During the design process, the right mouse button provides additional funtions: crosshair track (numeric readout); Y-display (scale options); default response (for a given sample rate); copy design (to clipboard); paste design (from clipboard).



Filter Design Screen

DSCview, a complete Windows or Linux application,allows immediate and easy access to the iDSC 1816. DSCview requires no programming, and provides a graphical interface to

- design and configure filters
- save and load workspaces
- select system options
- perform signal conditioning
- configure multiple iDSC boards
- output data in graphs and tables
- disk log data to a text or binary file
- server disk log data to a binary file

Microstar Laboratories includes appropriate software functions from DSCview to support other interfaces: DASY*Lab*, Agilent VEE, LabVIEW, LabWindows/CVI, and MATLAB. We also include the same user functionality for Visual Basic, Visual C++, and other Windows programming environments through DSCIO.DLL.

DSCIO.DLL provides a link between these programming environments and the iDSC board. It lets users easily program custom interfaces in any environment they choose. If you prefer, use the Delphi and C++ Builder development environments through a native DSC Component, and program your own user interfaces. All user interfaces share a common look and feel for designing and configuring filters.

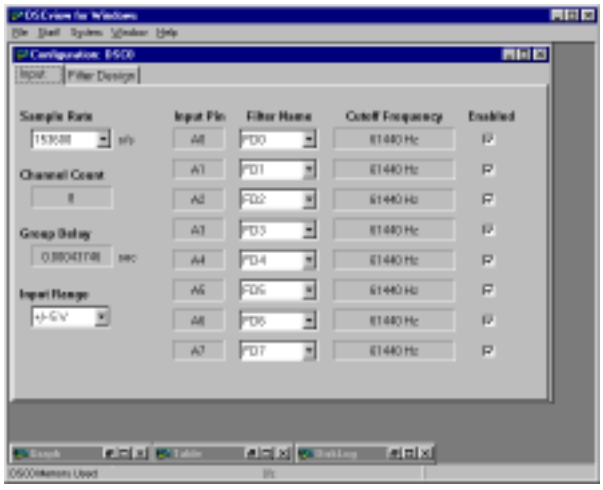
iDSC Filters

Selecting the Filter Design tab in the DSCview Configuration Window activates the Filter Design Screen. This screen provides for up to eight unique filter designs: one for each channel, if required. Selecting one of eight tabs in the Filter Design Screen puts the specifications for that filter on top, and allows choices for

- filter ID
- filter type
- sharpness
- low cutoff frequency
- low cutoff slope
- high cutoff frequency
- high cutoff slope
- attenuation

Selecting the Input tab in the DSCview Configuration Window activates the Input Screen. This screen allows choices for

- sample rate
- input range
- filter ID (for each channel)
- enable/disable (each channel)



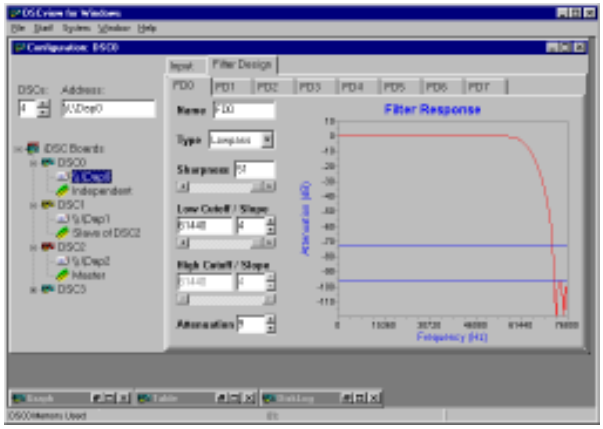
Displayed properties include transition band cutoff frequencies for each channel, and group delay.

Input Screen

Multiple Boards

From the DSCview menu, System|Board Setup Display|Group Interface activates multiple board support and provides choices for

- DSCs – the number of iDSC boards in the system
- address – the unique address of a board
- mode – independent, slave, or master



Group Interface Screen

The right mouse button provides additional funtions: external board enable (for signal conditioning, see below); external board calibrate (if enabled); raw data select (cut out filter); remote master; server disk log; copy configuration (to clipboard); paste configuration (from clipboard).

Signal Conditioning

The External Board tab (see Group Interfacer Screen caption) activates signal conditioning. This allows choices for

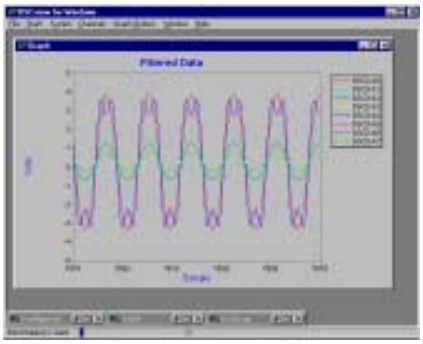
- input type – DC coupling, AC coupling, or Excitation
- input range – ±10 mV, ±20 mV, ±50 mV, ±100 mV, ±200 mV, ±500 mV, ±1 V, ±2 V, ±5 V, or ±10 V
- input offset – range depends on input range
- output excitation – 0 V, 1 V, 2 V, 5 V, or 10 V

External Board Screen

Displayed properties include the input offset range for each channel: ±0.5 V, ±1.0 V, ±2.5 V, or ±5.0 V (supported range dependent on input range).

Output Data Screens

There are four types of output data screens: graph, table, disk log, and server disk log. The user may have any number of graph, table and disk log screens. However, there is only one server disk log screen and it emerges automatically if server disk logging is enabled.



Graph Screen

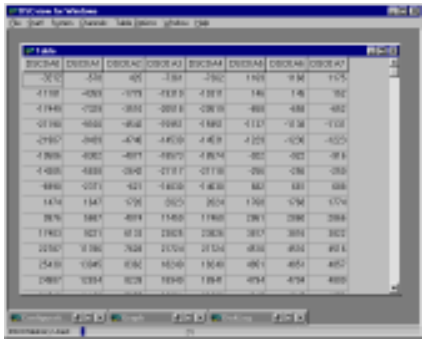
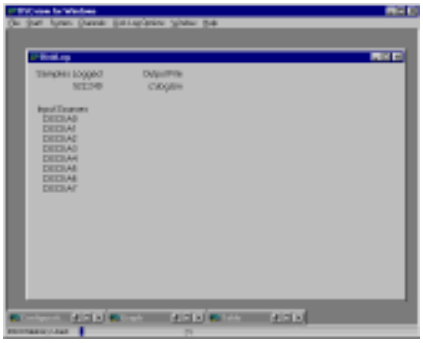
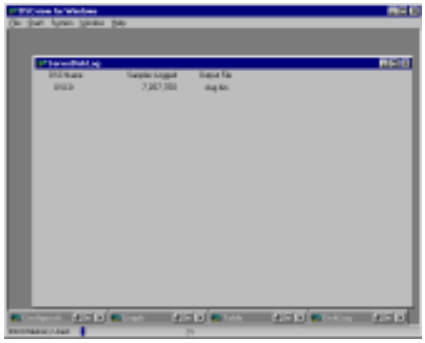


Table Screen

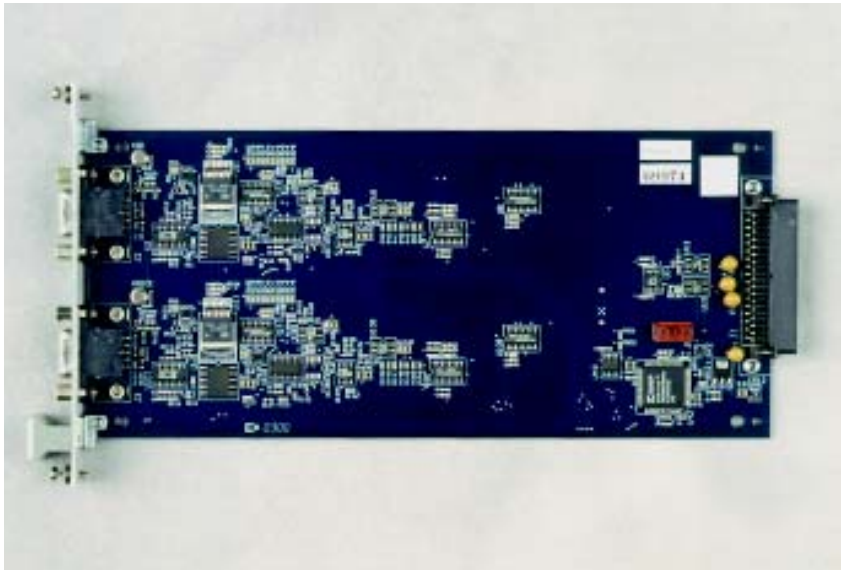


Disk Log Screen



Server Disk Log Screen

The MSSC-8 Sensor Signal-Conditioning Module for the iDSC 1816



Key Component: 2-channel MSXB 044 board with 15-pin DB connectors shown at left

Microstar Laboratories has developed an 8-channel sensor signal-conditioning module, the MSSC-8, that complements the 8-channel iDSC 1816 board to provide a continuous path in a single package: starting with raw measurements at the sensor and ending with conditioned anti-aliased data logged to disk on a PC.

An MSCBL 048 cable connects the MSSC-8 sensor signal-conditioning module to an 8-channel iDSC 1816 data acquisition board that has built-in anti-aliasing filters. This combination scales up in two dimensions. First, a PC may contain four iDSC 1816 boards – each connected to an MSSC-8 – for a total of 32 channels of conditioned anti-aliased data acquired at the maximum rate of 153.6k samples per second per channel.[1] Second, DAPcell network software, with at-the-server disk logging, supports multiple instances of these 32-channel modules controlled from a single DAPcell client. See box on far right.

The MSSC-8 brings with it the potential for hundreds of channels of simultaneously-sampled, conditioned, anti-aliased data logged to disk at up to 153.6k samples per second per channel.

Each 8-channel MSSC-8 module contains four 2-channel MSXB 044 boards. The MSXB 044 board provides direct connection to sensors, and offers many signal-conditioning services in a single convenient package. These include

- current sensor excitation: 4 mA at up to 28 Volts
- voltage sensor excitation: 1, 2, 5, and 10 Volts at up to 70 mA
- quarter-, half-, and full-bridge resistor networks
- 120 and 350 ohm resistors as standard options
- any value resistor networks, sensor by sensor
- 10 full-scale options: 10 mV, 20 mV, 50 mV, 100 mV, 200 mV, 500 mV, and 1, 2, 5, and 10 Volts
- programmable gain with auto-calibration
- programmable AC/DC coupling for ICP sensors

Order Signal Conditioning by Channel Count
SCS-08
SCS-16
SCS-24
SCS-32
Each package consists of an enclosure and 1, 2, 3, or 4 MSSC-8 modules, for a total of 8, 16, 24, or 32 channels.

Order Integrated Systems by Channel Count
FSCS-32
FSCS-64
FSCS-128
FSCS-256
Each system consists of 1, 2, 4, or 8 synchronized SCS-32 packages, each with a PC and four iDSC 1816 boards.

[1] A single PC may contain more than four iDSC 1816 boards, but, with more than five, then may not log to disk at the full data acquisition rate. Four MSSC-8 modules exactly fit in a single full-size industrial enclosure. See opposite page.

Sensor Signal Conditioning for the iDSC 1816: the MSSC-

Overview of System Components

Each MSXB 044 board conditions signals for two input channels. Four boards and an MSXB 046 interface board plug into an MSXB 047 backplane in a 5-slot 3U card cage provided by Microstar Laboratories. **These components make up the hardware for a single 8-channel MSSC-8 signal-conditioning module.** An MSCBL 048 cable runs from the MSXB 046 interface board to an 8-channel iDSC 1816 board occupying a PCI slot in a PC.

The MSCBL 048 cable carries signals to the PC. Another cable, not shown, carries power from it. The MSXB 046 converts 12-volt power from the PC to six voltage levels required for signal conditioning: ±5 volts, +12 volts, ±15 volts, and +30 volts. The MSXB 047 backplane distributes power at these different levels to the MSXB 044 boards plugged into the backplane, and it carries conditioned signals back from them on their way through the MSXB 046 interface board and the MSCBL 048 on to the iDSC 1816 in the PC.

A single PC can support up to fourteen iDSC 1816 boards. At these high channel counts, signal-conditioning power requirements likely will exceed 12-volt power normally available from the PC. In any case where this may happen, Microstar Laboratories can make special arrangements to boost the power provided by the PC.

Commercially available off-the-shelf PCs and associated disk controllers and drives have enough electrical power and enough computing power to form a balanced total system with four iDSC 1816 boards and four MSSC-8 sensor signal-conditioning modules. A total system like this can continuously log to disk all 32 channels of conditioned anti-aliased data at the full data acquisition rate of 153.6k samples per second – an overall rate of just under 5 million samples per second.

An MSXB 045 board in each of two or more networked PCs, that each contain one or more iDSC 1816 boards, allows the whole networked system to work as a single synchronized system with possibly hundreds of conditioned channels.

Connector

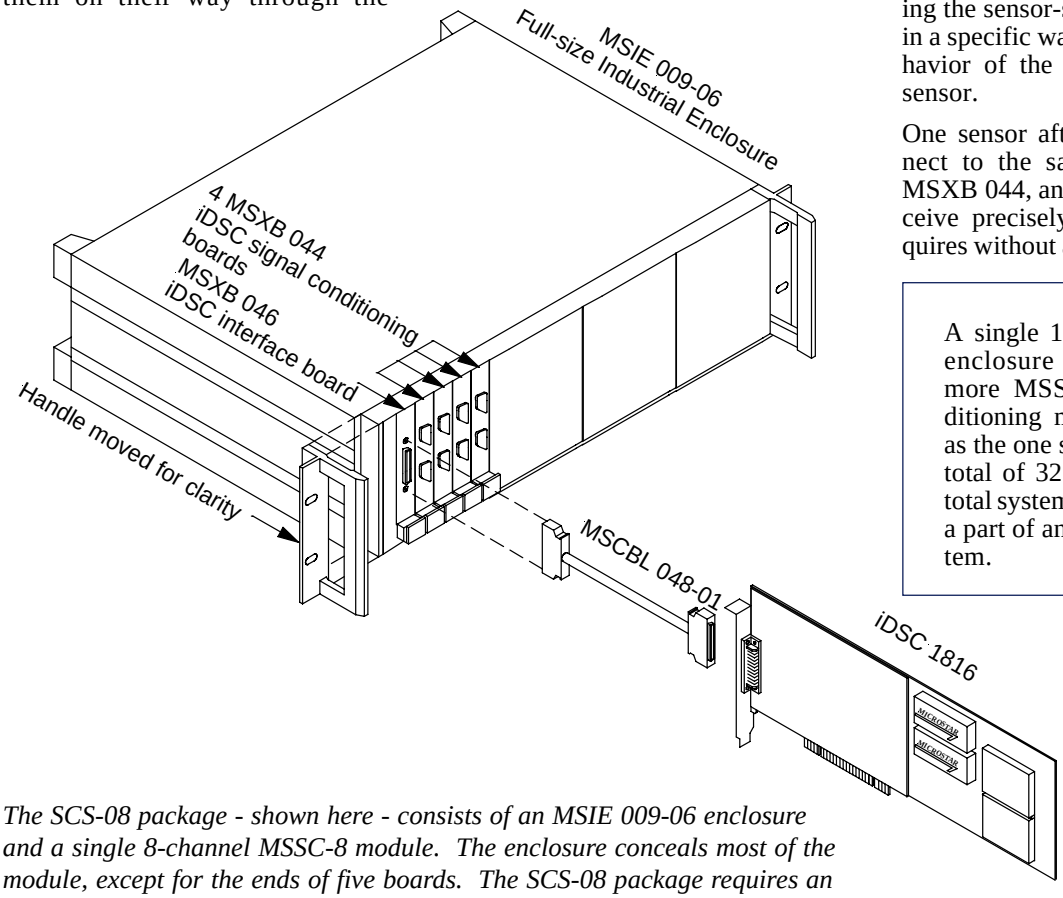
The MSXB 044 board employs the widely available 15-pin sub-D (VGA) connector for each of its two channels. How the user wires the sensor to this connector determines the signal-conditioning services provided by the MSXB 044 board.

One pair of wires carries the signal, one pair the excitation voltage or current, and a third pair the feedback of the excitation voltage at the sensor.

Other pins determine the choice of quarter-, half-, or full-bridge resistor network, and allow the installation, within the connector, of specific resistors for customized networks for different sensors. So wiring the sensor-side of the connector in a specific way customizes the behavior of the MSXB 044 for that sensor.

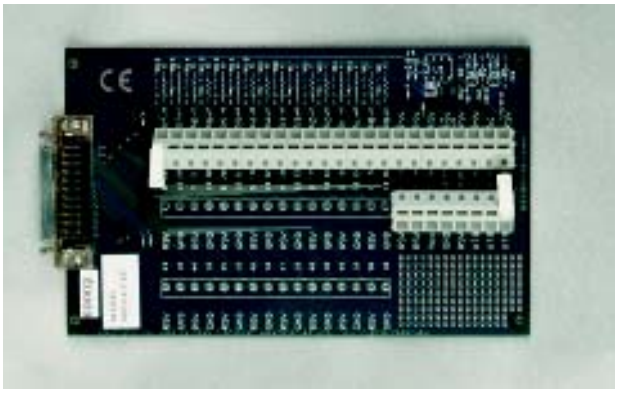
One sensor after another can connect to the same channel of the MSXB 044, and each sensor can receive precisely the services it requires without any further attention.

A single 19-inch industrial enclosure can hold three more MSSC-8 signal-conditioning modules, as well as the one shown here, for a total of 32 channels – as a total system on its own, or as a part of an even larger system.



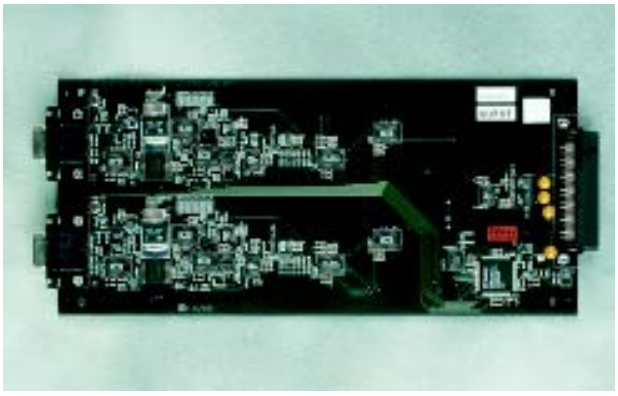
The SCS-08 package - shown here - consists of an MSIE 009-06 enclosure and a single 8-channel MSSC-8 module. The enclosure conceals most of the module, except for the ends of five boards. The SCS-08 package requires an MSCBL 048-01 cable to send conditioned signals to an iDSC 1816 anti-aliasing data acquisition board in a PC. It also requires another cable, not shown here, to carry power from the PC.

MSXB 042
MSXB 043
MSXB 044
MSXB 045
MSXB 048



MSXB 042 Analog Termination

MSXB 043 BNC Termination



MSXB 044 Expansion

MSXB 042
Analog Termination

The MSXB 042 Analog Termination Board allows quick and secure connection of discrete wires to the iDSC 1816 board.

MSXB 042 includes locations to install voltage divider resistors and 0-20mA termination resistors, as well as a Cold Junction Compensation (CJC) circuit for thermo-couple applications.

This model requires cable MSCBL 048-01.

- **Model MSXB 042-01** **Wago terminals, D connector**

MSXB 043
BNC Termination

BNC Termination Boards for the iDSC 1816.

- **Model MSXB 043-01** **enclosure panel**

MSXB 044
Expansion

The MSXB 044 Expansion Board works with the iDSC 1816 to add signal conditioning to the data acquisition and anti-aliasing capabilities. Four MSXB 044 boards are included in each MSSC-8 module. Purchase the MSXB 044 as part of a complete SCS system: an enclosure and 1, 2, 3, or 4 MSSC-8 modules, for a total of 8, 16, 24, or 32 channels. See pages 6 and 7.

The MSXB 044 board itself provides direct connection to sensors, and offers many signal-conditioning services in a single convenient package.

- **Model MSXB 044-01** **system component**

MSXB 045
LVDS

The MSXB 045 LVDS Board works with multiple iDSC 1816 boards to provide synchronization for many channels of data. An MSXB 045 board in each of two or more networked PCs, that each contain one or more iDSC 1816 boards, allows the whole networked system to work as a single synchronized system with possibly hundreds of conditioned channels.

MSXB 045 requires cable MSCBL 083-01 and one of either MSCBL 084-01 or MSCBL 085-01.

- **Model MSXB 045-01** **transmitter/ internal receiver**
- **Model MSXB 045-10** **external receiver only**

MSXB 045 LVDS

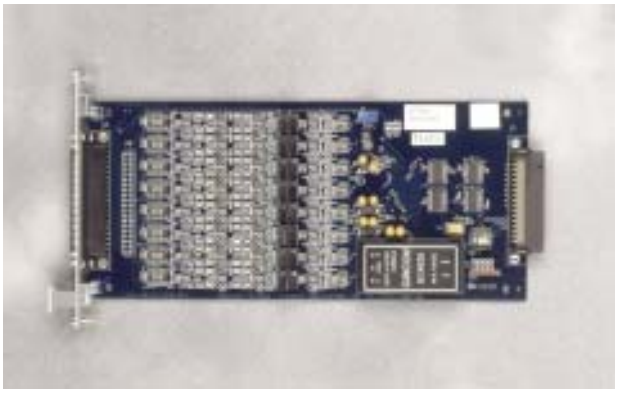
MSXB 048
Filtered Analog Input Expansion

The MSXB 048 Filtered Analog Input Expansion Board has a four-pole low-pass Butterworth filter on each of its 16 single-ended channels. For DAP applications that require analog filters to take out all above-Nyquist frequencies before signal conversion, it simply replaces the MSXB 037 Analog Input Expansion board. Signal inputs normally connect to the MSXB 048 through a panel-mount DB-37 connector.

The Microstar Laboratories Channel Architecture allows sixteen MSXB 048 boards to connect to a single DAP board for up to 256 channels of filtered input. The MSXB 048 typically draws 8 Watts of +5V power. The channel architecture includes three ways to supply power to the 68-line analog backplane in the MSIE industrial enclosure: from the PC, from an external source, or from a factory-installed power supply built into the industrial enclosure.

Low channel-count applications that draw power from the PC, and that do not require the expansion potential offered by the Microstar Laboratories Channel Architecture, may instead use an MSXB 048 board packaged in a Single-Board Enclosure (SBE). Low channel-count applications that do not require the EMI shielding offered by the Microstar Laboratories Channel Architecture hardware – but that do require anti-aliasing measures – can use stand-alone versions of the MSXB 048. Signal inputs for these versions connect to a board-mount shrouded header.

As well as sampling input signals, the MSXB 048 can sample an onboard +5V reference and the onboard signal ground. This allows software offset calibration and verification of proper operation without changing the input cabling.



MSXB 048 Filtered Analog Input Expansion

- **Model MSXB 048-03-100** **100Hz Filtered Analog Input Expansion, DB37 I/O**
- **Model MSXB 048-03-1K** **1kHz Filtered Analog Input Expansion, DB37 I/O**
- **Model MSXB 048-03-10K** **10kHz Filtered Analog Input Expansion, DB37 I/O**

- **Model MSXB 048-03-250** **250Hz Filtered Analog Input Expansion, DB37 I/O**
- **Model MSXB 048-03-2.5K** **2.5kHz Filtered Analog Input Expansion, DB37 I/O**
- **Model MSXB 048-03-25K** **25kHz Filtered Analog Input Expansion, DB37 I/O**

- **Model MSXB 048-03-500** **500Hz Filtered Analog Input Expansion, DB37 I/O**
- **Model MSXB 048-03-5K** **5kHz Filtered Analog Input Expansion, DB37 I/O**
- **Model MSXB 048-03-50K** **50kHz Filtered Analog Input Expansion, DB37 I/O**

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