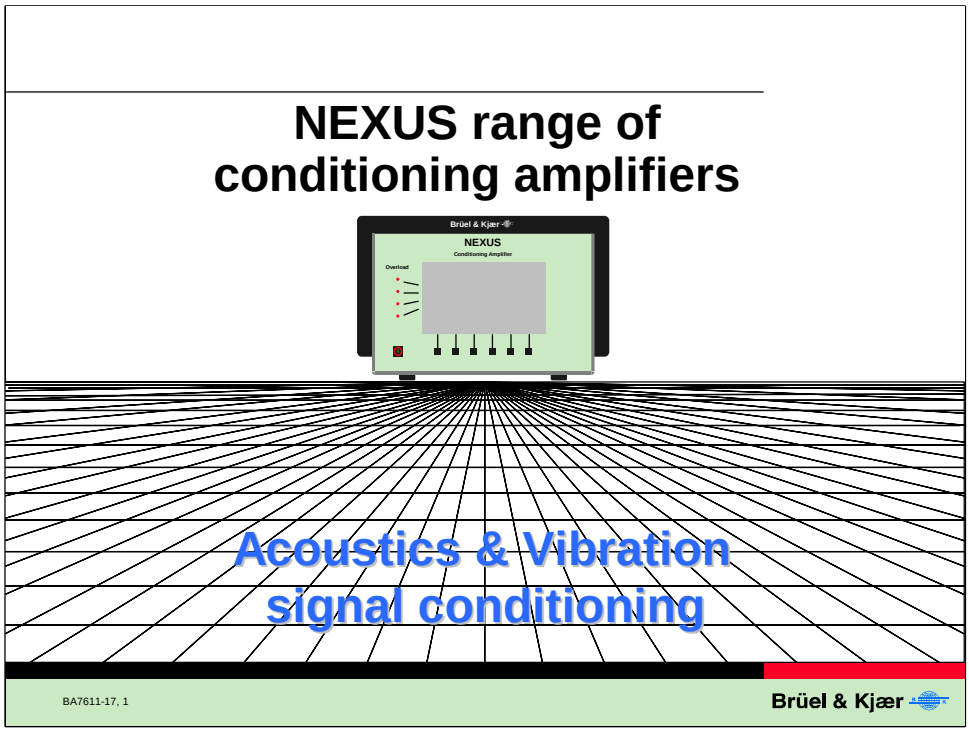


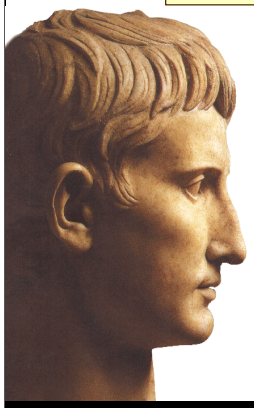
Abstract

This presentation gives an overview of the NEXUS range of signal conditioning amplifiers for acoustic and vibration transducers. The concept of configurability is explained together with the most important advances in signal conditioning such as intelligent overload detection, Charge Injection Calibration and Mounted Resonance Technique.

LECTURE NOTE

What is NEXUS?

- **NEXUS** is Latin for the link, bond, connexion
- **NEXUS** is the link between sound & vibration transducers and data gathering system



- **NEXUS** is a range of configurable instruments
- **NEXUS** is for
  - » charge accelerometers
  - » DeltaTron accelerometers
  - » microphones
  - » hydrophones
  - » force transducers
  - » impulse hammers
  - » intensity probes
  - » trigger devices
  - » direct voltage inputs
  - » etc.

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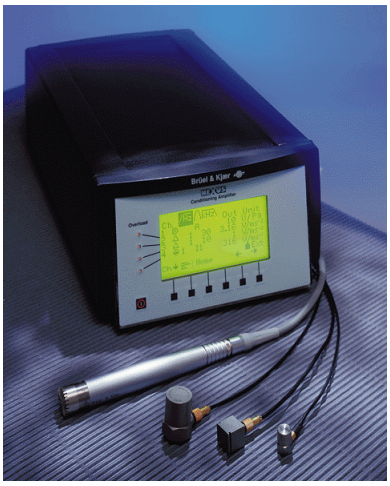
Brüel & Kjær

NEXUS is a range of signal conditioning amplifiers for practically all Brüel & Kjær transducers. The name NEXUS (from the Latin meaning link, bond, connexion) was chosen to indicate that NEXUS connects the transducers to the measurement system which could be a Brüel & Kjær or other system.

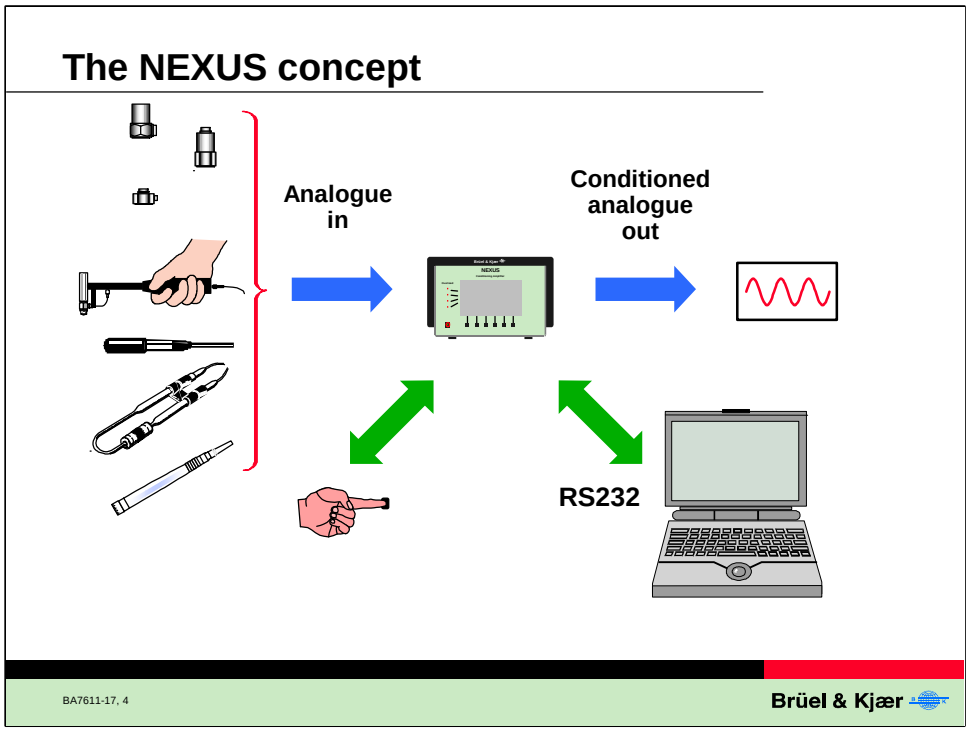
DeltaTron ® is the equivalent of ICP ® .

ICP is a Registered trademark of PCB.

Agenda



- Introduction to NEXUS range of conditioning amplifiers
- What are the features & benefits of NEXUS?
- Summary



NEXUS supports practically all types of transducer input including:

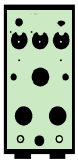
- Charge and DeltaTron ® accelerometers
- Condenser microphones
- Hydrophones
- Force transducers
- Intensity probes
- Direct voltage input

NEXUS offers: 1 to 4 channels in one box plus manual or computer control.

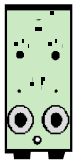
NEXUS provides a conditioned analogue output (AC).

Leading supplier of conditioning amplifiers

- Brüel & Kjær is and has been a leading supplier of quality products, signal conditioning amplifiers and power supplies, for many years



Conditioning Amplifier Type 2635



Two-channel Micro-phone Power Supply Type 5935

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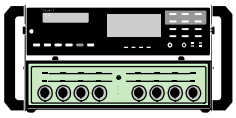
Brüel & Kjær

Brüel & Kjær conditioning amplifiers are known for:

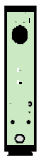
• Wide acceptance in industry. De facto industrial standards
• High quality
• High specifications

Different conditioning amplifiers

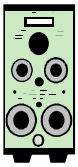
- Many different signal conditioning amplifiers have been designed over the years



DAT recorder with Eight/Four-channel Acoustic Front-end Types 5966/5968 or Eight-channel DeltaTron™ Supply Type 5963



Charge Amplifier Type 2651



Two-channel Micro-phone Power Supply Type 2804

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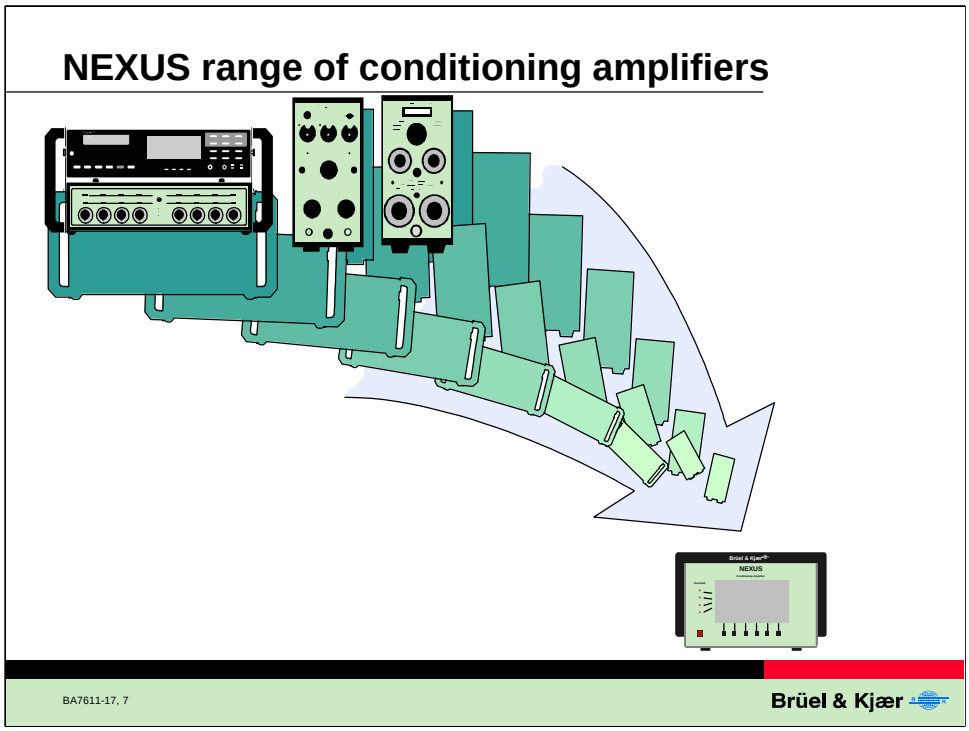
Brüel & Kjær

NEXUS directly replaces Brüel & Kjær DAT amplifiers and signal conditioning amplifiers, as follows:

Earlier Brüel & Kjær Signal Conditioning Amplifiers	The NEXUS range
2635	2692-A-0I1
5935	2690-A-0I2
5963	2x2693-A-0S4
5974	2x2692-A-0S4
5966	2x2690-A-0S4
5968	2690-A-0S4

NEXUS also replaces other models, although not all specifications are fulfilled.



NEXUS offers facilities for a whole range of measurement tasks in just one box.

The NEXUS range of conditioning amplifiers

Microphone	2690 A 0S2	2-Ch. Microphone
	2690 A 0S4	4-Ch. Microphone
	2690 A 0F2	2-Ch. Microphone with Filters
	2690 A 0F4	4-Ch. Microphone with Filters
Intensity	2691 A 0S2	2-Ch. Intensity
Charge	2692 A 0S1	1-Ch. Charge
	2692 A 0S4	4-Ch. Charge
	2692 A 0I1	1-Ch. Charge with Single and Double Integration
	2692 A 0I4	4-Ch. Charge with Single and Double Integration
DeltaTron	2693 A 0S4	4-Ch. DeltaTron
	2693 A 0F4	4-Ch. DeltaTron with Filters
	2693 A 0I4	4-Ch. DeltaTron with Single and Double Integration

Your own configuration of inputs (1 to 4 ch.) and optional filters

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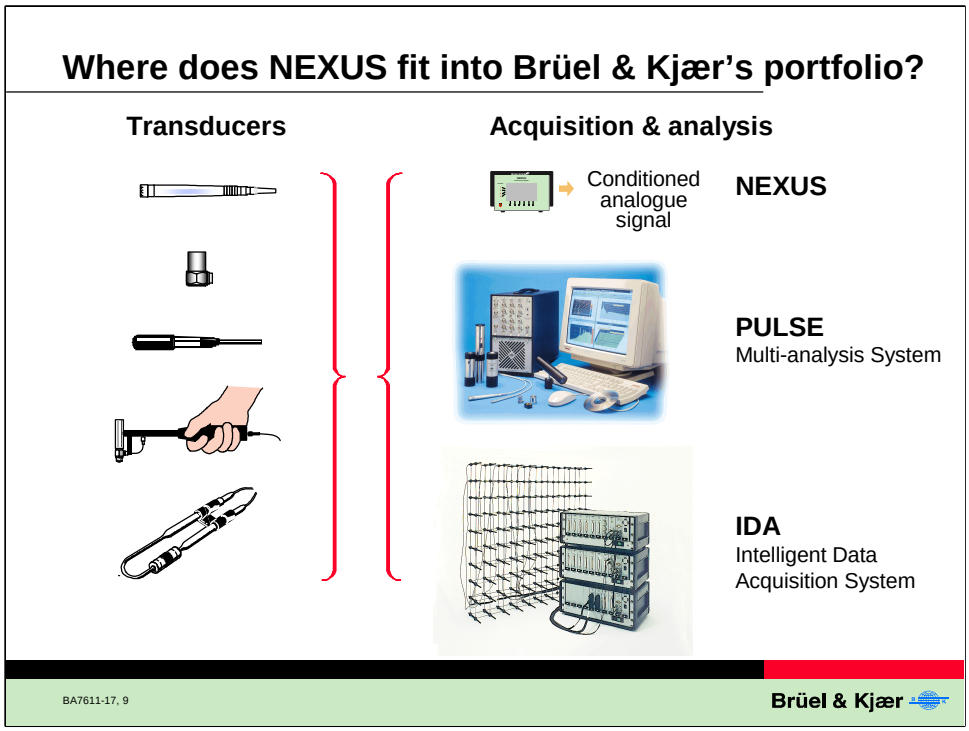
Brüel & Kjær

There are 12 standard NEXUS models to choose from. We can also configure NEXUS to suit your needs, specifically you can specify the number of channels (1-4), the type of input (microphone, charge, DeltaTron, intensity)l and the type of option - such as the special weighting and integration filters that are available.

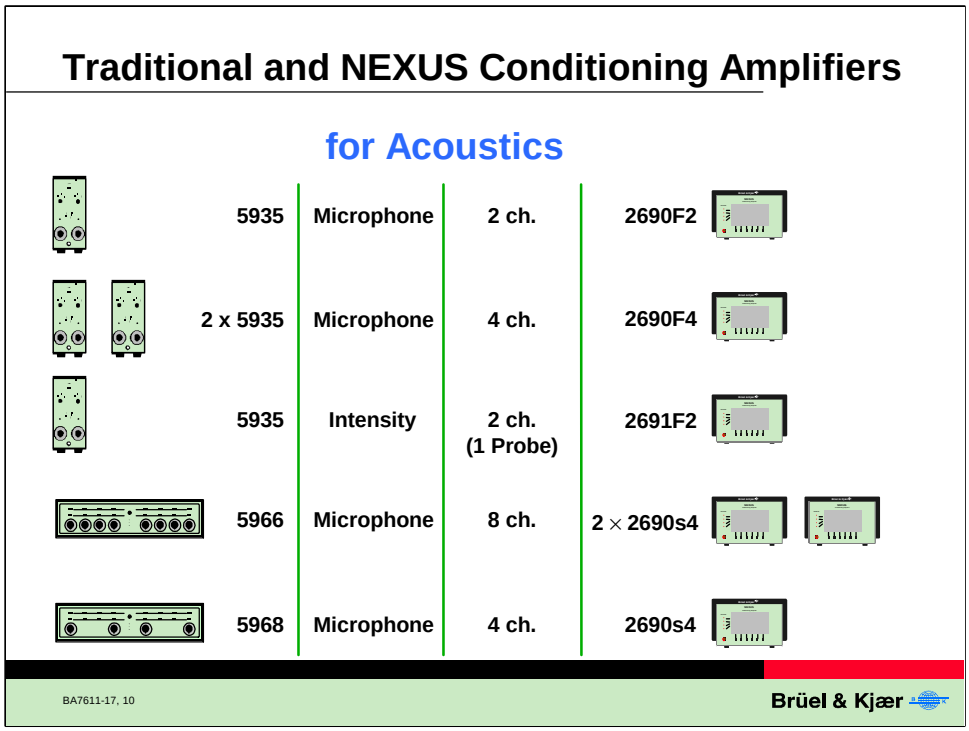


NEXUS is a component of data acquisition systems, including those of other vendors.

NEXUS is a general conditioning amplifier. It is used mainly for applications where up to 32 channels are required, although up to 99 channels can be provided.

In comparison to IDA and PULSE:

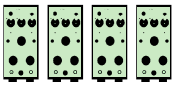
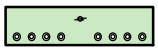
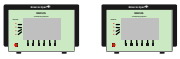
PULSE provides a maximum of 32 channels, while IDA offers up to 3000 channels.



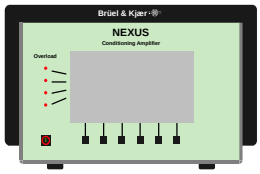
The perceived value of the NEXUS instruments is very high when compared to the traditional conditioning amplifiers. NEXUS offers greater functionality and better specifications and a very attractive price.

Traditional and NEXUS Conditioning Amplifiers

for Vibration

	2635	Charge	1 ch.	2692 I1 
	4 x 2635	Charge	4 ch.	2692 I4 
	5974	Charge	8 ch.	2 x 2692 S4 
	5963	DeltaTron™	8 ch.	2 x 2693 S4 

Key benefits of NEXUS



- Configurability
- 100% remote controllable
- Excellent Specifications
- Weight and size
- Support for
  - Charge accelerometers
  - DeltaTron™
  - Microphones
  - Intensity probes
  - Voltage input
- Overload capabilities
- Charge Injection Calibration
- Single ended/floating
- Mounted Resonance test
- Easy to use Human Interface
- Battery or External power
- Full CE approval

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Brüel & Kjær

Configurability: NEXUS can be configured to your needs

Computer Controlled: It can be ‘Daisy Chained’ using the RS 232 interface

Excellent Specifications: Give flexibility and performance. e.g. high dynamic range and low noise.

Weight and size: It can fit into a 19” rack or be used in the field

Supports Transducers: Handles both acoustic and vibration transducers

Overload Capabilities: For example, transducer current overload detection

Charge Injection Calibration: For remote verification of the entire measurement setup

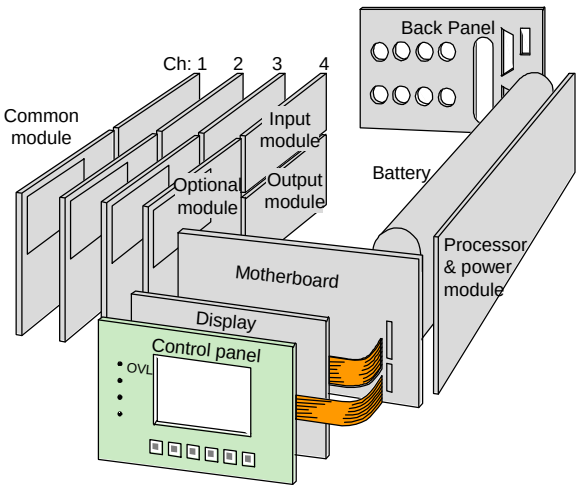
Mounted Resonance Test: For a remote check of accelerometer mounting

Easy to Use: For example, the clear graphical display

Battery or External Power: Internal battery (with built-in LED to give charge condition) or DC power input

Full CE approval

Configurability



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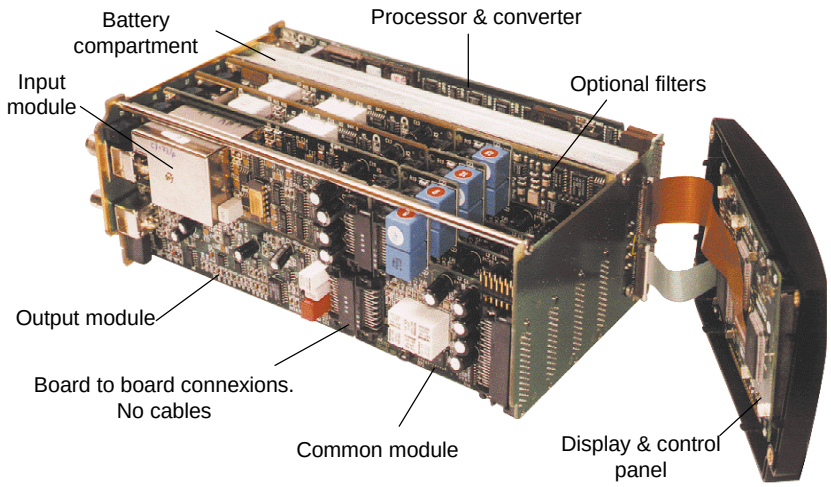
Brüel & Kjær

NEXUS is configured with up to 4 channels. Each channel contains 3 modules plus one more that is optional, for example, for special weighting filters that might be required.

NEXUS standard options	**NEXUS Order number**
Upper Limiting Frequency 140 kHz	WH 3219
Whole Body Vibration X, Y and Z Direction Filters	WH 3206
900 Hz to 1100 Hz Band Pass Filter	WH 3278
Constant Power On	WH 3282
Single and Double Integration Filter	ZE 0788
A, B, C and D Weighting Filters	ZE 0794

Individual filters available on request

Inside NEXUS



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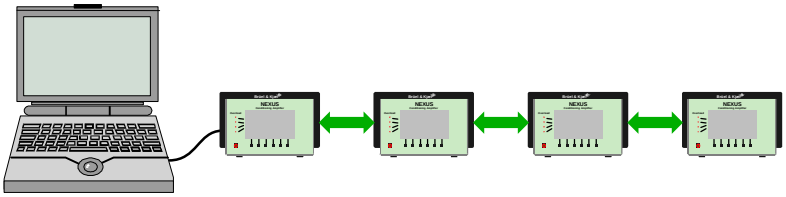
Brüel & Kjær

NEXUS is solidly built with board to board connectors. There are no cables which might be shaken loose or damaged. The entire instrument is encased in an extruded 3mm thick aluminium casing for protection against electromagnetic radiation and also against physical knocks.

Remote Control



Computer interface

- Remote Control using PC
- RS 232 daisy chain

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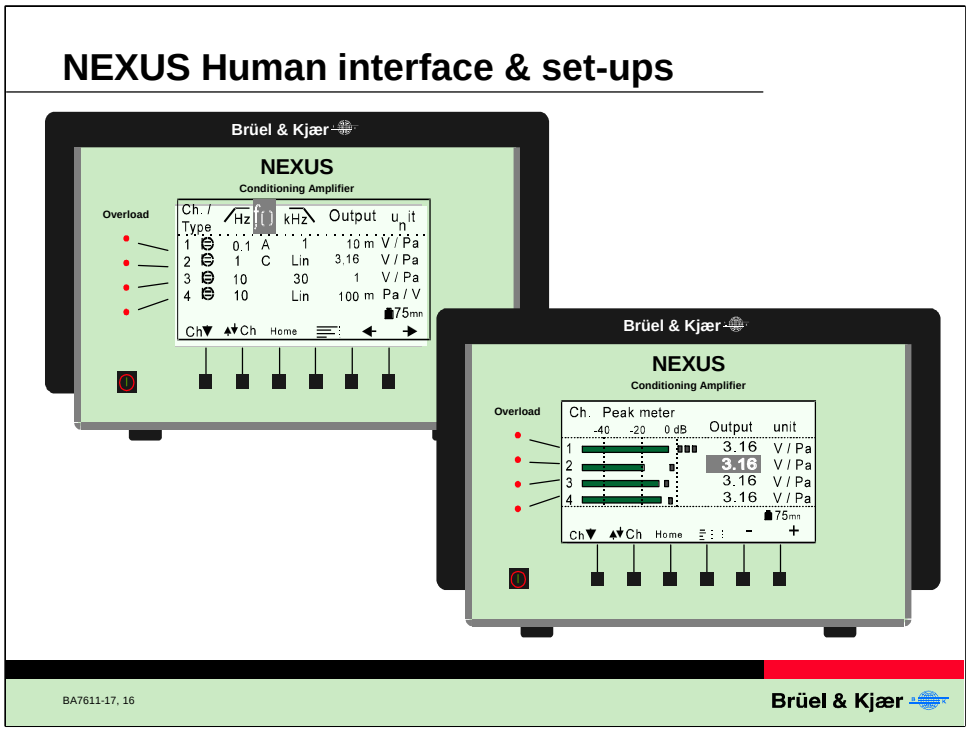
It can sometimes be advantageous to use a palm top computer as a remote control unit to control NEXUS especially if the NEXUS unit is not readily accessible or if more than one NEXUS is being used at once. The NEXUS units are designed to be stacked on top of one another. For more permanent installations, accessories are available to hold 3 NEXUS units in a 19” rack or up to 9 units in a portable 19” rack.

When NEXUS is under remote control, the 6 icons above the soft keys are replaced with the text “REMOTE”.



Human interface:

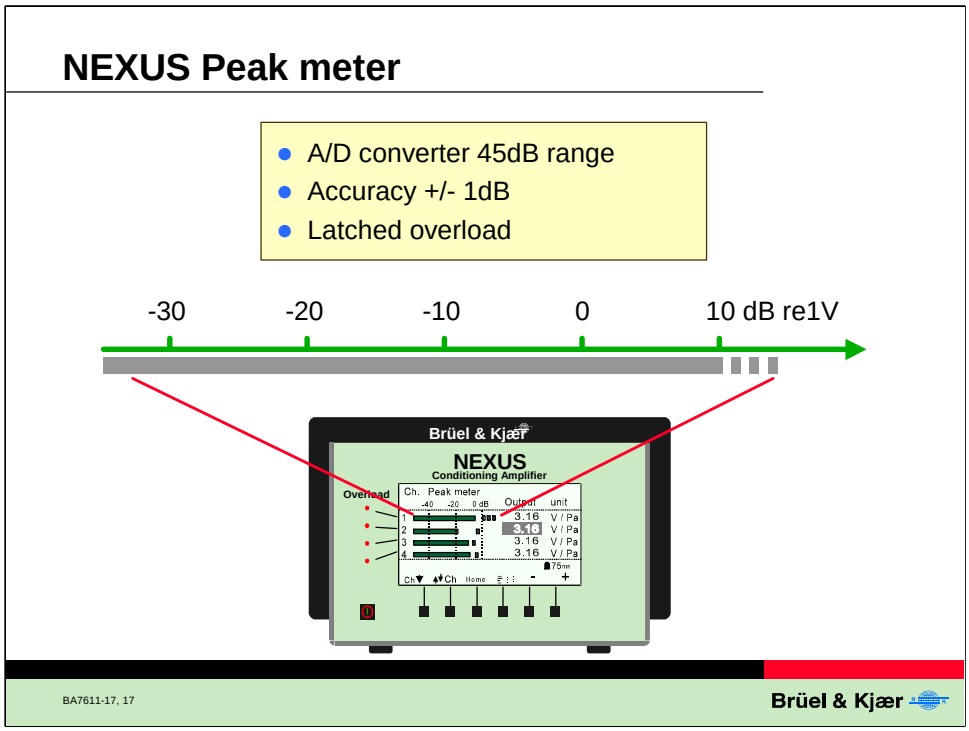
- Clear graphical display
- Robust soft keys with locking facility - sealed for long term use
- Keys can withstand being pressed at least 1 million times
- Easy to use interface (Peak meter is for setup purposes)

Setup:

Setups are quick and easy. As an example, to setup a calculated output:

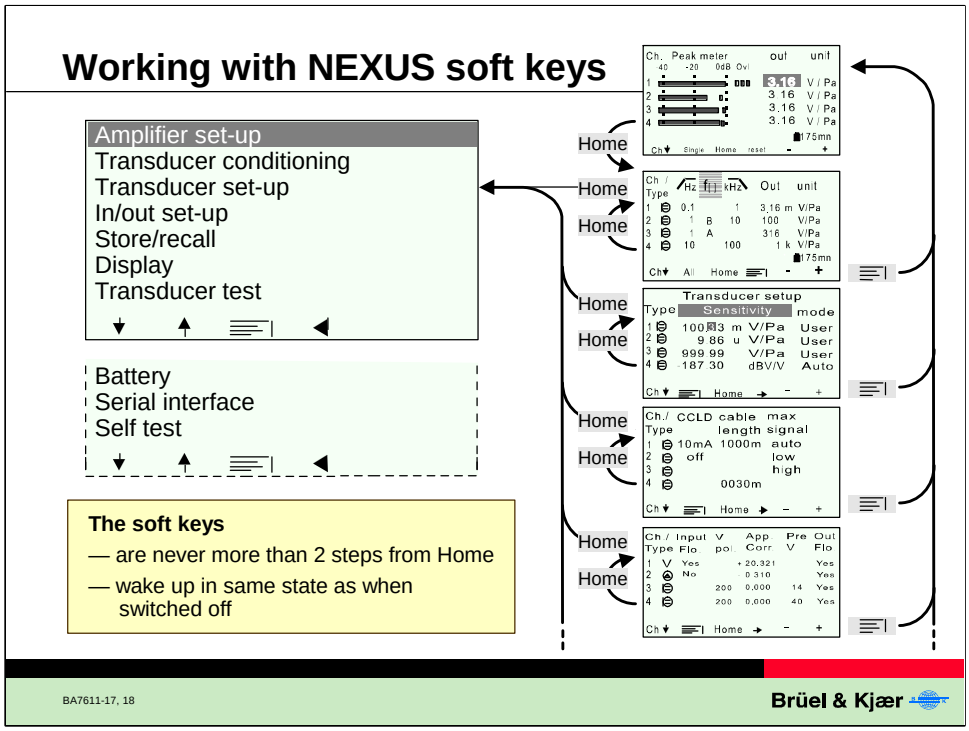
1. Key in the sensitivity of the transducer
2. Set the output, for example 1 Volt per unit
3. NEXUS sets the corresponding gain

This gives a fixed output for data acquisition irrespective of the transducer used.



Peak meter

The Peak meter allows the instantaneous peak values for all channels and the maximum peak values (peak hold) since they were reset. Overload indications are also shown in this set-up.



It is quick and easy to work with NEXUS menus. And because you are never more than two levels from the Setup menu you never lose sight of where you are. Ninety five percent of the time, the NEXUS unit will be used in the Amplifier set-up or the Peak-meter menu.

NEXUS rear view

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Brüel & Kjær

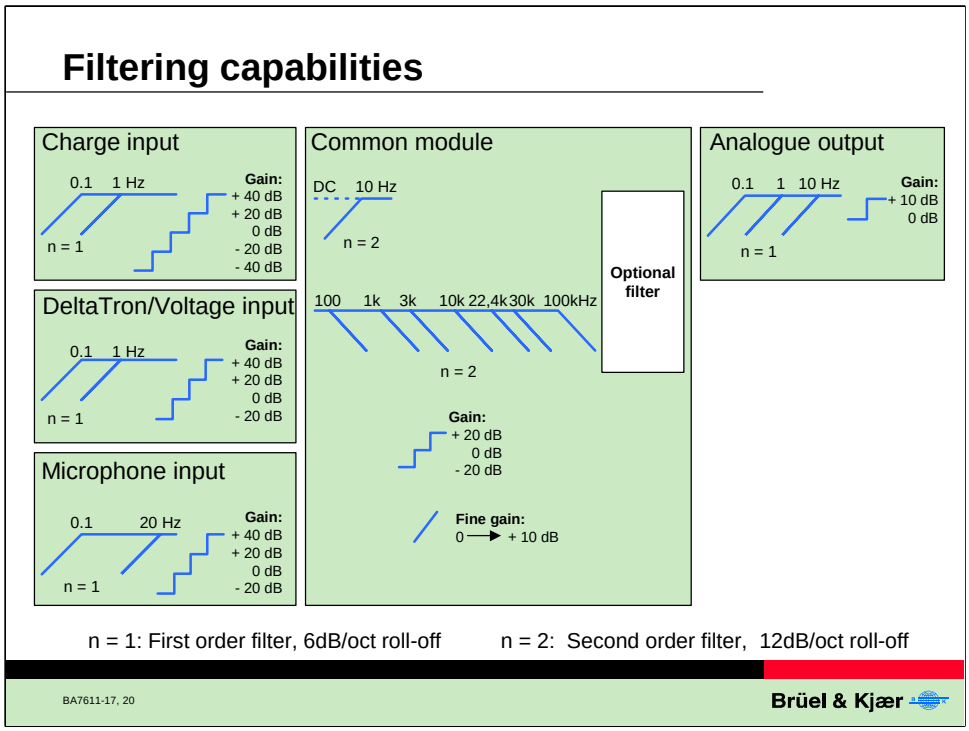
The power supply is 10-33V DC with a lockable socket.

The input and output RS232 sockets allows NEXUS units to be ‘Daisy Chained’.

It is easy to exchange batteries from the rear of the unit

Plugs and Connectors:

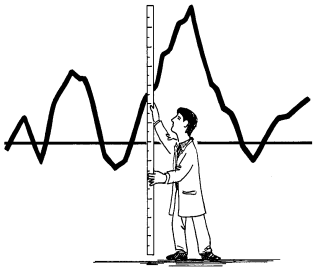
- Standard earth plug
- TNC Charge (adaptor to 10-32 UNF included)
- 7 pin LEMO microphone
- BNT DeltaTron® **(adaptor to 10-32 UNF included)**



Gain is distributed on all three modules to optimise signal to noise ratio. NEXUS sets the gain automatically.

Various filters can be added if the standard ones are not sufficient, for example, Band-pass filters. Additional filters are supplied on the optional module e.g. type 0 IEC, A, B, C, D weightings.

Transducer test and Self test



Transducer test (analogue)

- Charge Injection Calibration for microphone input
- Mounted Resonance technique for charge input 
- Reference oscillator for charge channels

Self test (digital)

- Communication between processor boards, display and control panel

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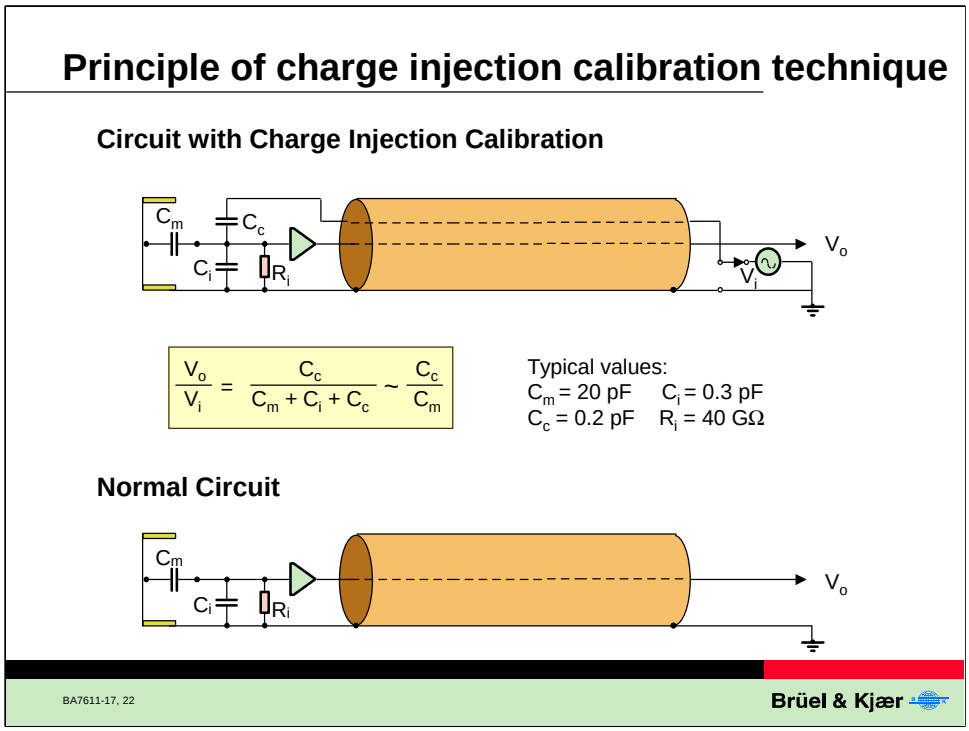
By using the NEXUS transducer tests, such as Charge Injection Calibration and Mounted Resonance technique, the user can ensure that the transducers are correctly connected and functioning correctly. These two analogue tests are patented.

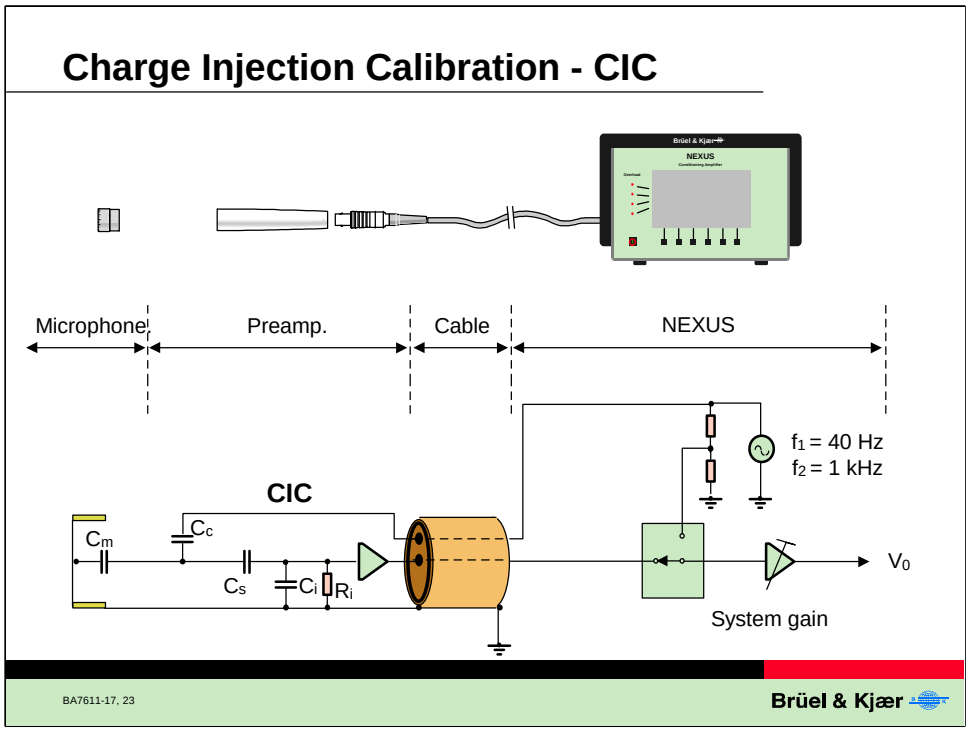
The self-test facility is used to test the digital circuitry of NEXUS.



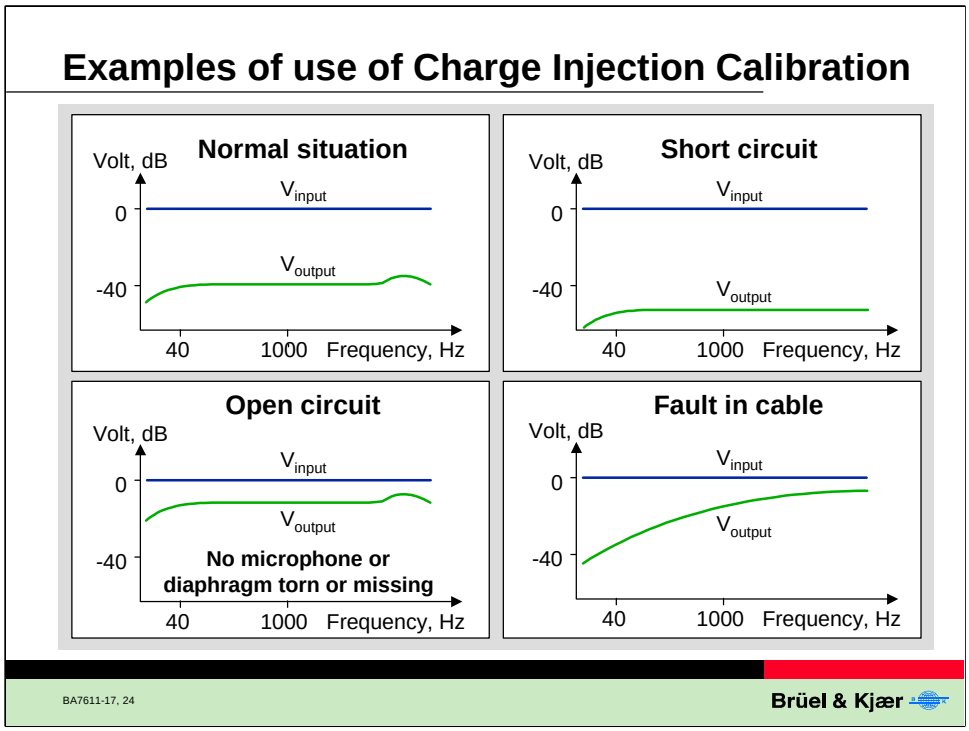
Charge Injection Calibration

Charge Injection Calibration (CIC) provides a convenient verification of the entire measurement set-up, including the microphone, preamplifier and connecting cable.

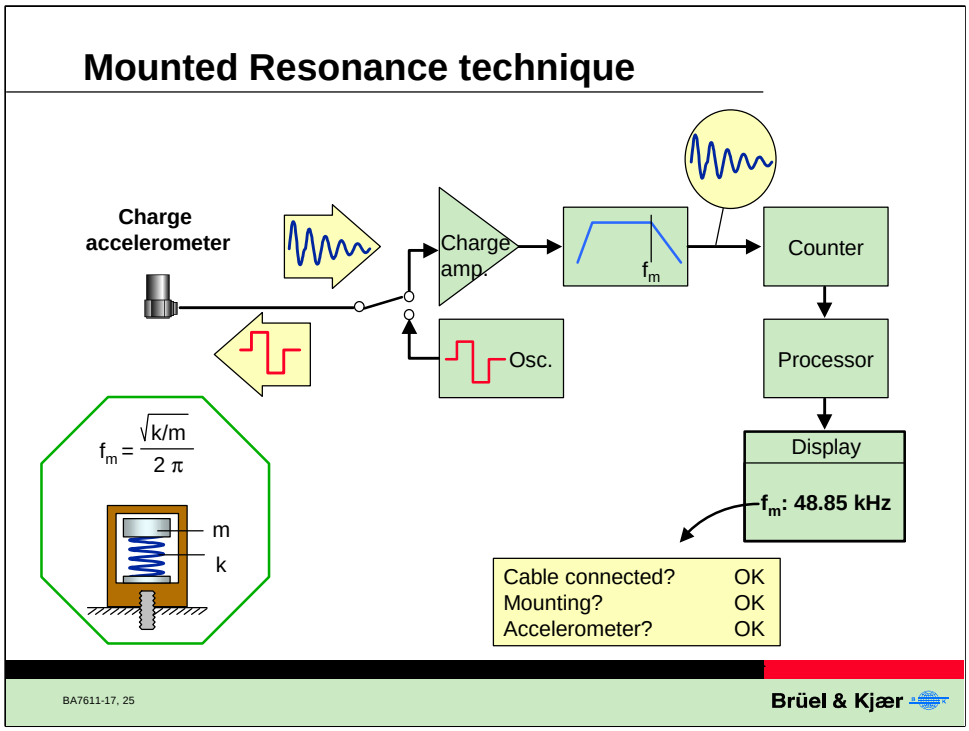
CIC is a patented technique based on a relative measurement of the capacitance of the microphone cartridge. A very small and stable capacitance is introduced into the front end of the preamplifier. This, together with the microphone capacitance, makes a capacitive attenuator. This capacitance is then fed with a calibration signal. The ratio between the calibration signal and the output signal provides a measure of the attenuation, and is, therefore, an extremely good indicator of the condition of the complete measurement system.



In NEXUS, Charge Injection Calibration is implemented using a sine tone generator which provides two frequencies, 40Hz and 1kHz.This is sufficient to detect changes down to fractions of a dB in the frequency response of the microphone, preamplifier, cable system. Full details of use of the Charge Injection Calibration technique can be found in the Microphone Handbook (order number BA 5105).



The examples here are illustrated with a wide band signal. The user is interested, not in the actual level but in relative changes in level. Ideally, the user can perform Charge Injection Calibration on his system and build up a library of results for the normal system and for a faulty system. When a fault occurs, the user will have a good indication of its location. Generally speaking, acoustical calibration is much more involved than Charge Injection Calibration. Unfortunately, Charge Injection Calibration cannot replace acoustical calibration. However, the number of times that the user need make an acoustical calibration can be reduced thus saving time and money.



The Mounted Resonance technique is used to check:

1. That a cable is connected to an accelerometer
2. Whether the accelerometer is mounted or hanging loose
3. That the mounting is good

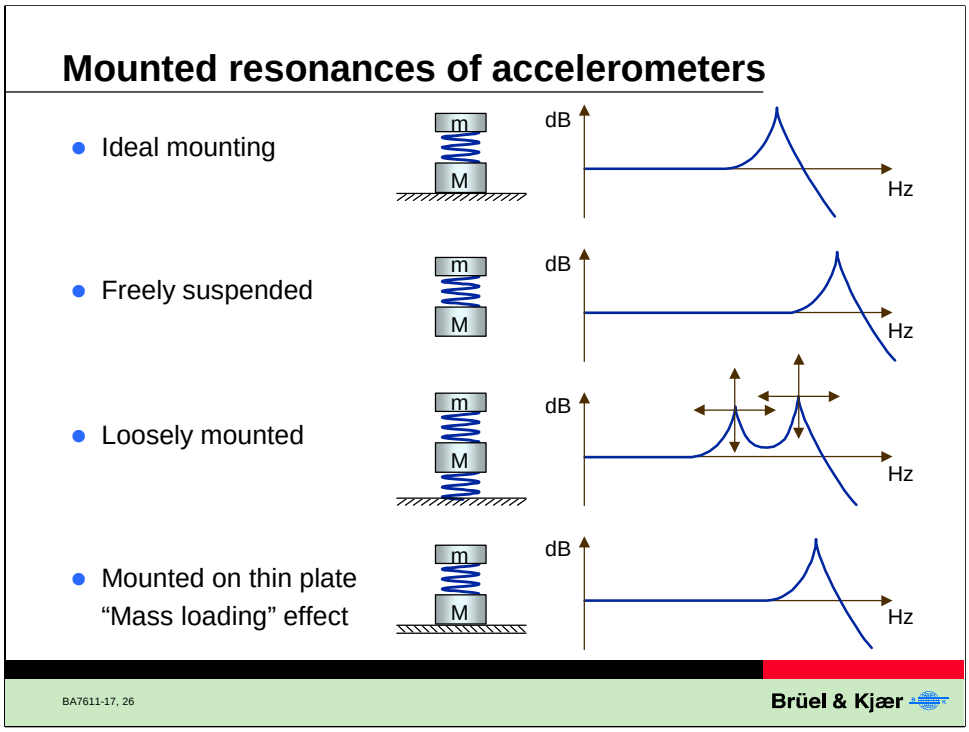
DeltaTron® accelerometers have built-in electronics and therefore the Mounted Resonance technique does not apply to this type of accelerometer.

In simple terms, the Mounted Resonance technique works as follows:

1. The accelerometer is excited
2. The response obtained is filtered
3. The frequency is counted

This frequency equals the mounted resonance frequency which can then be compared with the Calibration charge.

See *Technical Review No.1 1996* for a full description of the technique.



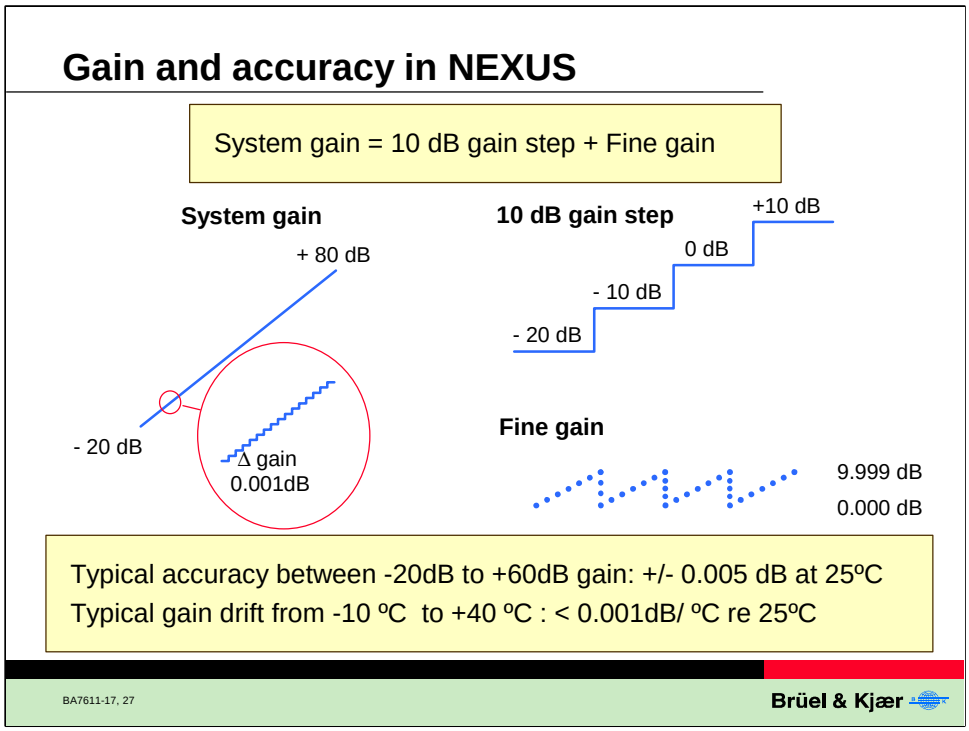
Mounted resoance works well with charge accelerometers with mounted resonance frequencies under 30kHz e.g.Type 4383 (28kHz). MRT usually works well up to 45kHz e.g. Type 4371 (42kHz). Above 45kHz MRT cannot be expected to work.

With low sensitivity ceramics (used in high temperature accelerometerssuch as Type 5874), MRT does not usually work.

With charge transducers with high damping of the resonance (e.g. hydrophones), MRT does not work.

For an application in a production environment see "Testing of knock sensors" in Technical Review nr.1 1997.

For some theoretical background see "Accelerometer mounted resonance test" Technical Review nr.1 1996 Application Note "Mounted Resonance measurements using Type 2525" BO 0413-11



Digital Gain Control provides a relative calibration of each 10 dB gain step. Each step is adjusted with the fine gain to achieve high accuracy. This is done at the factory and can be performed at Brüel & Kjær Service Centres equipped with an ATAC System (Automatic Test & Calibration System).

Particular advantages of Digital Gain Control are:

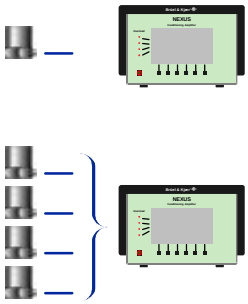
- It does not involve any analogue components (that could drift)

- It does not involve mechanical components and is therefore very stable and accurate over time.

1 ch and 4 ch. Vibration Charge Amplifier

Features

- Single and double integration optional
- Several filters
- Transducer sensitivity conditioning
- Overload detection
- Mounted resonance technique
- Floating input and floating output independent on all channels



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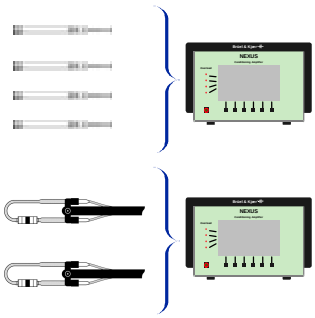
Brüel & Kjær

The standard charge amplifiers in the NEXUS range are a single channel and a four channel unit with and without integration. These are expected to replace the Charge Amplifier Type 2635 as the industrial standard charge amplifier and become the new benchmark instrument.

2 ch and 4 ch Microphone Conditioning Amplifier

Features

- Microphone polarisation voltage
- Preamplifier power supply
- Several filters e.g. A-weighting filter
- Transducer sensitivity conditioning
- Overload detection
- Charge injection calibration (CIC)
- Floating input and output
- Phase matching for intensity
- B, C, D weighting filter optional



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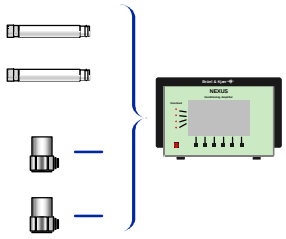
Brüel & Kjær

The standard NEXUS units for acoustics are a two channel and a four channel NEXUS unit for microphones (with and without A,B, C & D filters) and a two channel (single probe) for sound intensity.

4 ch. DeltaTron™ Conditioning Amplifier

Features

- Constant current supply, 4 mA, 10 mA
- Tacho probe supply
- Several filters
- Transducer sensitivity conditioning
- Overload detection
- Floating input and output
- Direct voltage input
- Single and double integration optional



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Brüel & Kjær

The DeltaTron modules can be used with DeltaTron accelerometers and DeltaTron microphones preamplifiers. The standard units are supplied without filters, with integration and with filters. The constant current supply of 4mA is usually used when battery life time is a consideration. The 10mA supply can be an advantage when long cables are used.

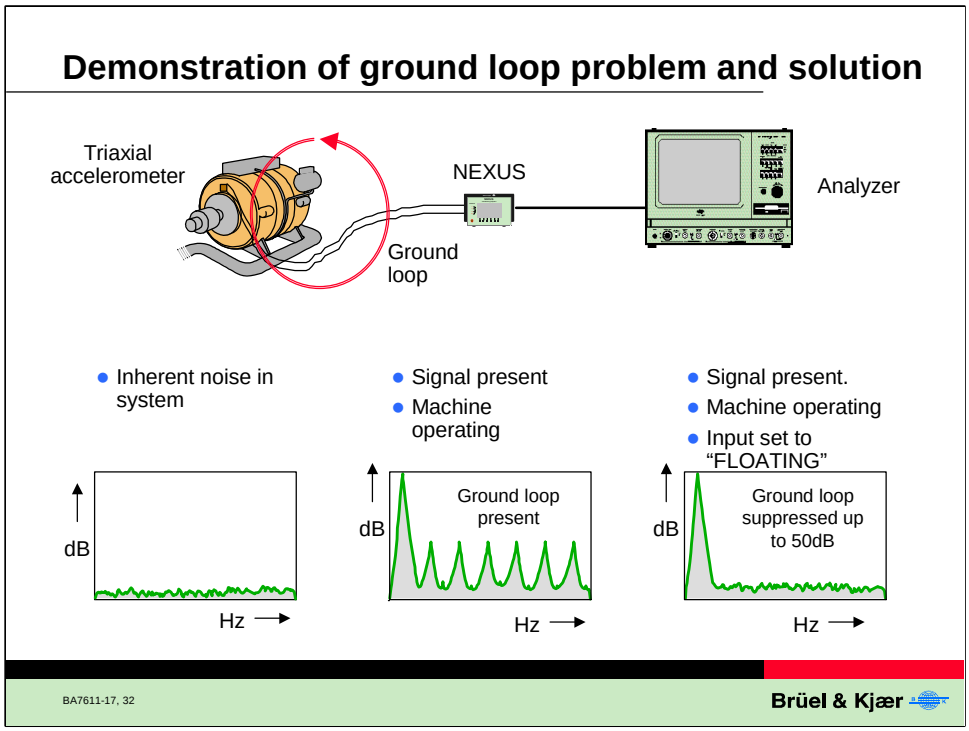
On all DeltaTron input modules, a plus eight volt DC supply is available via a BNT (Bayonnet Node Triaxial) socket. This can be used, for example, to supply a tacho probe.

Dynamic range, grounding considerations

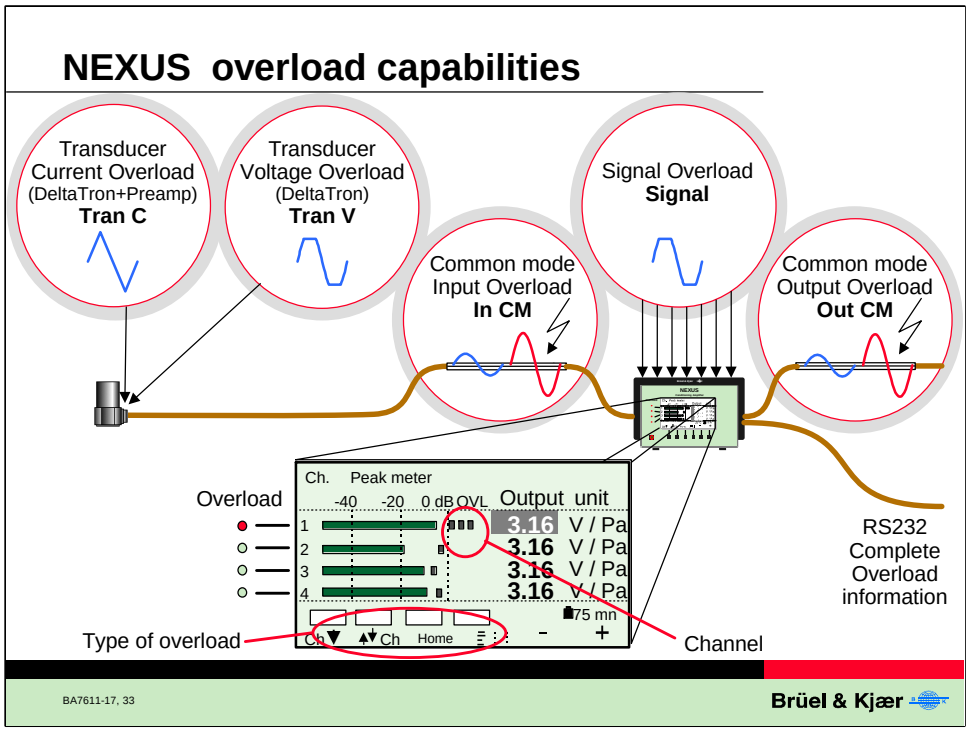
- Typically 120 dB (10 Hz - 5 kHz)
- Improved S/N ratio
- Improved grounding capabilities independent for all channels
  - floating input
  - floating output
- Improved resistance to EMC
- Floating input gives better rejection of ground loop problems of up to 50 dB

Floating input involves a ground loop current that is converted into a common mode voltage signal on the input.

In multi-accelerometer systems, floating input gives up to 50dB better rejection of ground loop registration relative to single-ended input.



Ground loops are suppressed by up to 50 dB.



Transducer Current Overload is for use with DeltaTron transducers and Preamplifiers.

Transducer Voltage Overload is for use with DeltaTron transducers.

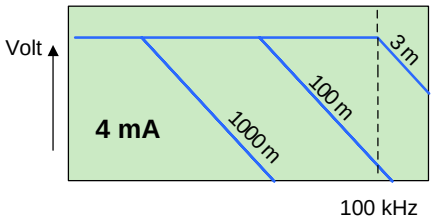
Note: Charge module has no transducer overload due to the extremely large dynamic range of the charge accelerometers. However signal overloads in the NEXUS unit itself can be detected.

Transducer current overload

for DeltaTron® inputs and preamplifier inputs

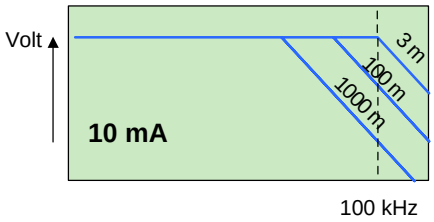
Causes:

- Levels too high at high frequencies
- Cables too long



Possible solutions:

- Decrease signal
- Shorten cable
- Increase supply current 4 mA to 10 mA (DeltaTron)
- Change transducer to less sensitive type



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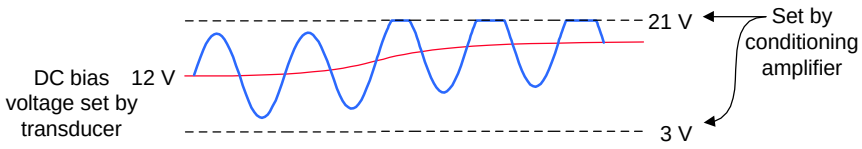
Transducer current overload is usually not a problem which one needs to worry about. However, when one uses long cables and measures signals with a high frequency content, then one approaches the limit for the voltage which the transducer can deliver without distorting the signal. With 1000 metres of cable it is possible to reach the limit for a “current overload” (i.e. the transducer distorts the signal) at 1 V. A signal of 1 V would not be detected by a normal signal overload, therefore a special “transducer current overload” has been introduced into NEXUS which continuously calculates whether the transducer can handle the incoming signals. The transducer overload is measured and calculated as a function of the transducer type (i.e. microphone preamplifier, DeltaTron), cable length and supply current. The use of transducer current overload reduces the possibility of erroneous measurements.

Transducer voltage overload for DeltaTron® input



Causes

- Extremes in temperature < 3V, > 21V
- Missing transducer > 21 V
- Short circuit < 3V
- Broken cable (open circuit) >21 V

Possible solutions

- Decrease signal level
- Check transducer
- Choose transducer with lower sensitivity

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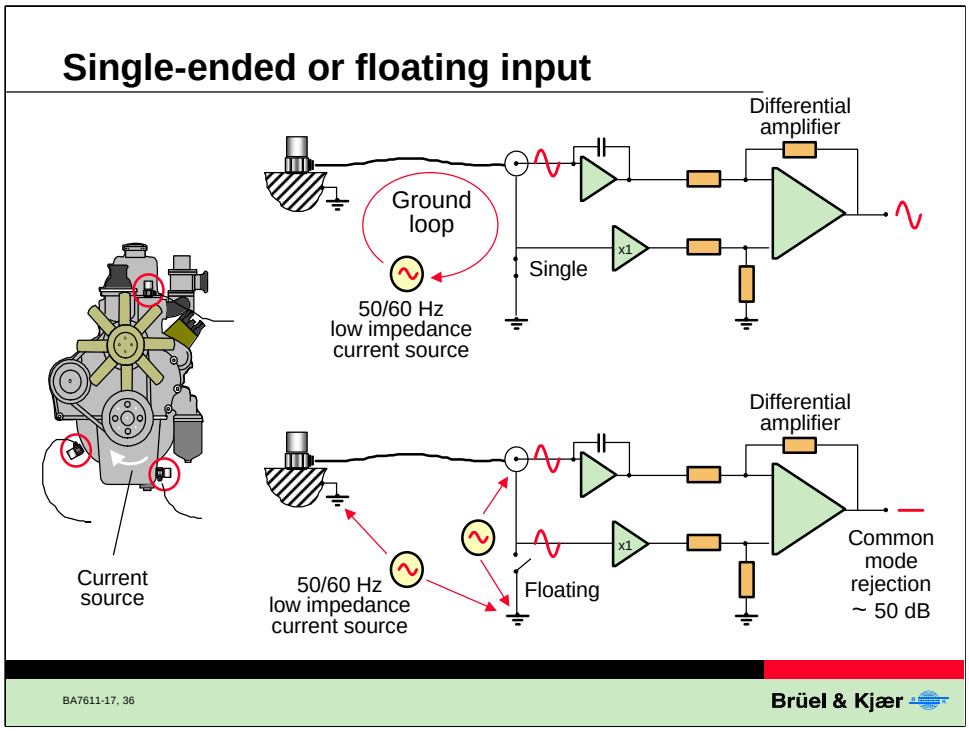
Transducer voltage overload can be considered as a window comparator which indicates an overload if a DeltaTron transducer strays out of its normal working region. The overload will also be activated if the cable to the transducer is short-circuited or broken.

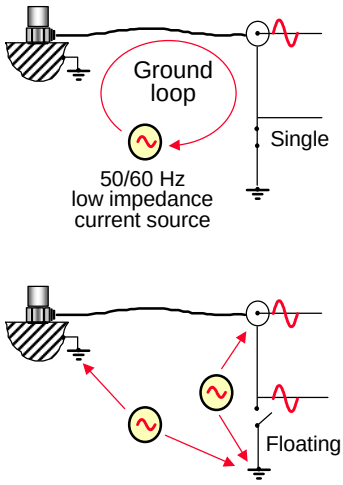


In machines, there is always the possibility that the machinery housing is not at earth potential. Consequently, the accelerometer housing and the cable screen will not be at earth potential either and a voltage drop will exist along the cable.

Electromagnetic interference also causes a similar voltage drop along the cable. The solution to these problems is to employ the “floating input” together with only one grounding cable from the machinery housing to the NEXUS unit.

NEXUS can cope with earth potential differences of up to +/- 5 V. If these levels are exceeded then a “common mode overload” is indicated.

Common mode overload



Causes

- Extraneous magnetic fields
- Potential difference at transducer contact points

Possible solution

- Set “floating” on “input”/”output”
- Remove EM source
- Remove signal cable from EM source
- Reduce voltage difference between transducer and NEXUS (e.g. earth both transducer and NEXUS)

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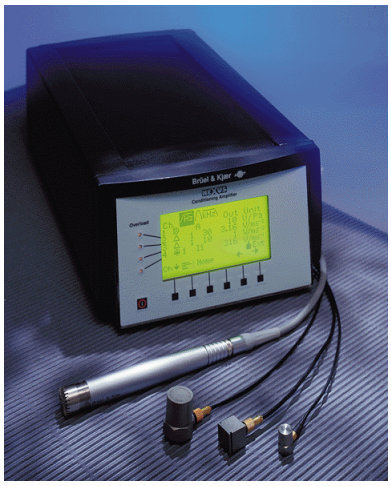
NEXUS is able to handle earth potential differences of up to +/- 5V. If this level is exceeded, a Common Mode Overload will be indicated.

Support of IEEE P1451.4 transducers



NEXUS version 2.0 and greater

supports single node

IEEE P1451.4 transducers

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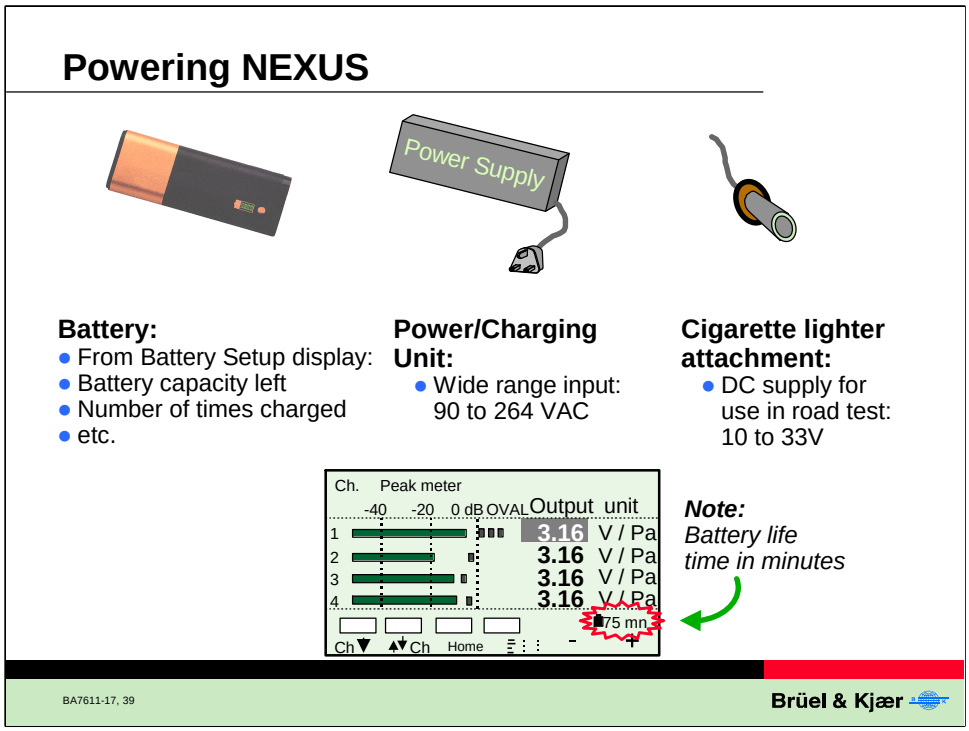
IEEE P1451.4

The IEEE P1451 Working Group has been working on a uniform approach for connecting sensors and actuators to communication networks, control systems and measurement systems. IEEE P1451.4 proposes a mixed-mode smart transducer communication protocol based on existing analogue connections. It also specifies Transducer Electronic Data Sheet (TEDS) formats for interfacing analogue transducers with additional, smart features to legacy systems. The proposed interface is designed to be compatible with other IEEE P1451 network capable transducer interfaces.



There are several different ways of powering NEXUS:

1. Rechargeable battery. A separate battery charger is available as an accessory.

2. Power supply which can also charge the battery simultaneously,

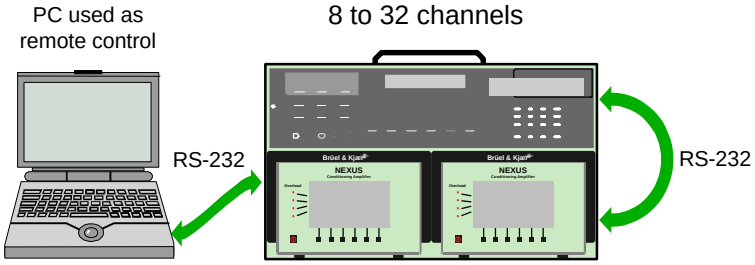
3. Cigarette lighter attachment.

4. Mains power supply for rack mounted NEXUS units up to 32 channels.

Remote Control

— On-road measurements

- NEXUS can be used with DAT recorders



Remote set-up of all parameters including main DAT parameters

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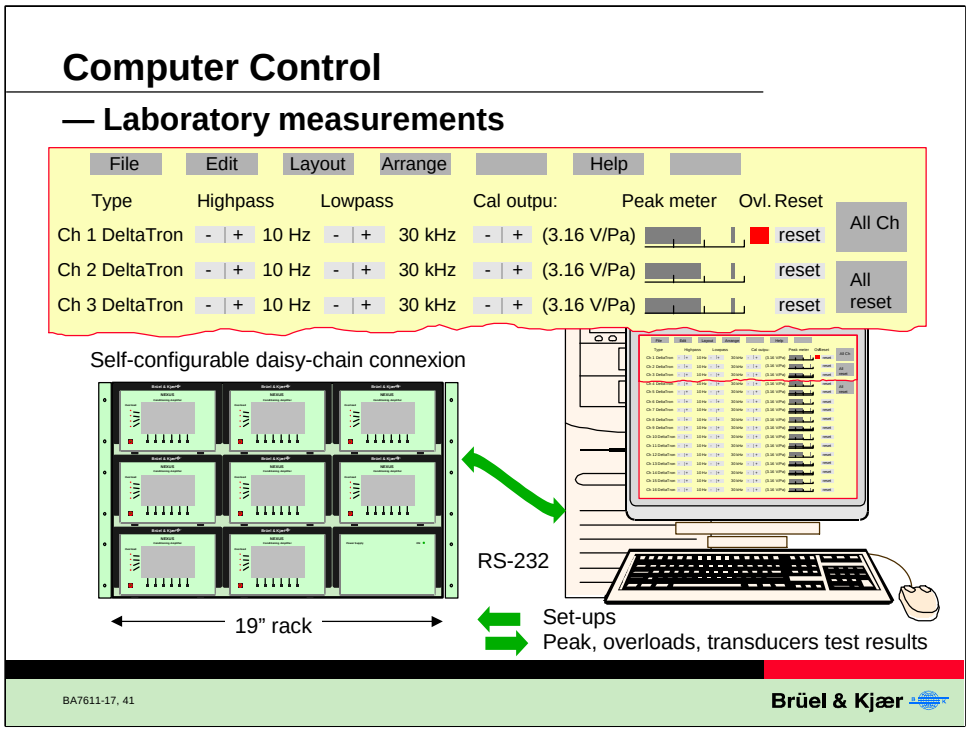
For on road measurements, for example, recordings using a DAT recorder, a remote control unit in the form of a palm top computer is a great advantage. It means that the driver of the vehicle can also control the measurement; both the DAT recorder and the NEXUS units.

A portable rack for use on the backseat of the vehicle is available as an accessory.

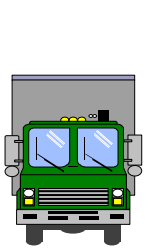


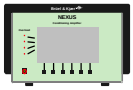
A windows based PC software program enables the user to down load set ups to several NEXUS units quickly and efficiently.

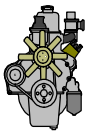
Partnering with the automotive industry

- **NEXUS** was specified in co-operation with
  - FORD, USA
  - BMW, Germany

- **NEXUS** can be configured to other industries







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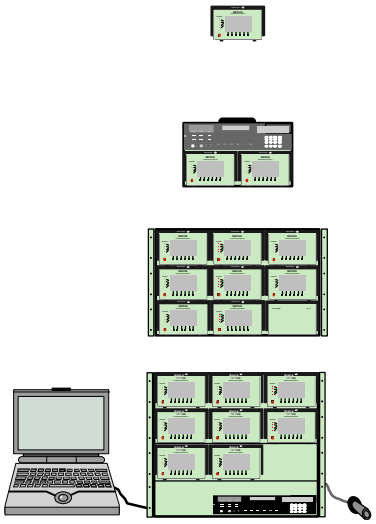
Close co-operation with leading automotive manufacturers during the development phase of NEXUS means that the specifications are dedicated for the automotive industry. However the modular design of NEXUS means that NEXUS can be configured for other industries if required.

Application solutions



- Stand alone
- 8 ch DAT
- 19” rack mounted 16 to 32 ch. for test rigs with either PC control or remote control and mains power supply
- 19” portable rack 16 to 32 ch. with cigarette lighter attachment for on-road test

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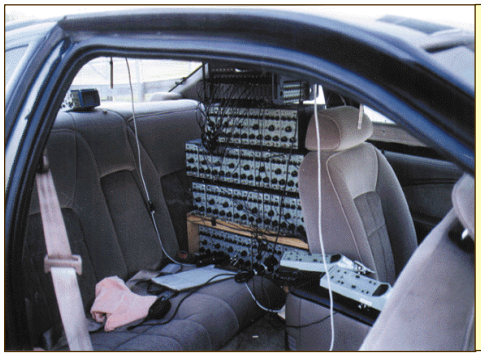
NEXUS is a general instrument with many applications. Four possible solutions are shown here.

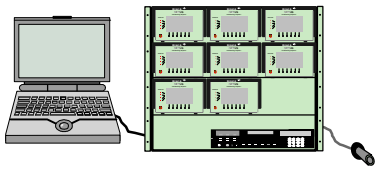
As a security measure, the NEXUS soft keys on the front panel can be locked to prevent interference. Pressing the three left hand keys simultaneously, locks the soft keys. To remove the lock, a special key combination is required.

On board applications in automotive industry



The users require

- Portable units
- Rack mounted units
- Multichannel measurements



Solution: NEXUS

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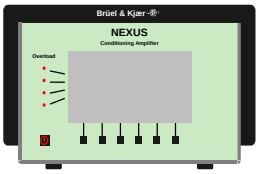
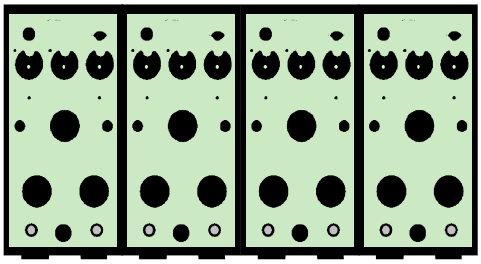
Brüel & Kjær

Many automotive customers use the Charge Amplifier Type 2635 taped together on the back seat of a vehicle for on road applications. NEXUS can provide a more compact solution without the necessity of an extra person in the vehicle to operate the equipment.

Weight and size



Conditioning Amplifier
NEXUS
4 channels
3.0 kg including batteries



Conditioning Amplifier
2635
4 channels
4 × 1.45 kg = **5.8** kg including batteries

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Brüel & Kjær

Not only on performance and price but also on weight and size, NEXUS offers the user considerable benefits.

Accessories

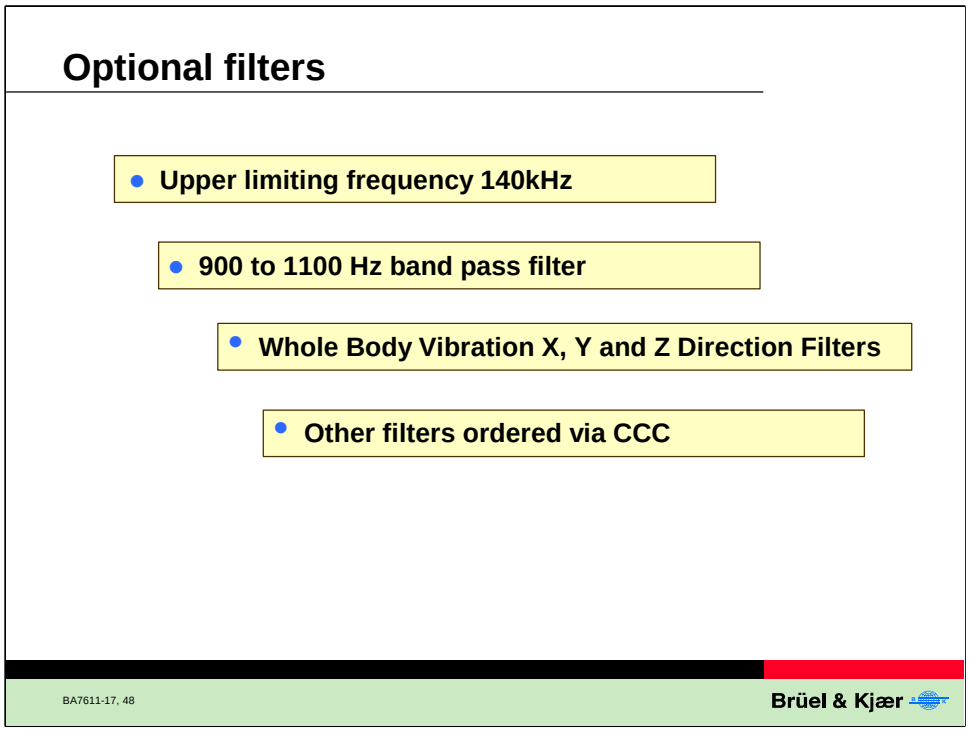
- KQ 0158 19” rack adaptor
- UA1409 Frame for SONY DAT series 200. Holds up to 4 NEXUS
- UA 1482 Frame for SONY SIR 1000. Holds 1 or 2 NEXUS units
- ZE 0794 A, B, C, D filters
- ZE 0788 Single & double integration
- KK 0049 19” combination frame. Holds up to 3 NEXUS units.
- WB 1436 32 ch. power supply for 19” rack
- ZG 0405 Stand alone battery/charging unit
- QB 0048Battery
- Type 7749 Remote control software (to be released)

Note: ZG 0400 Wall plug included in NEXUS

A full list of accessories and accessory part numbers can be found in the Product Data sheet.

Ordering, upgrading, service

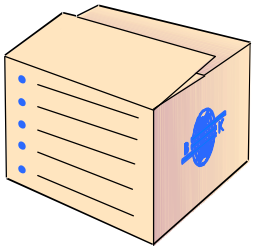
- Ordering via Ordering Form BA 0287
- Upgrade of hardware at service centres
- Upgrade of software via RS232
- Service
- Traceable calibration



The design of NEXUS (i.e. modularity which board to board connexions) means that it is ideal as a platform on which future developments can be based.

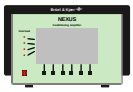
Summary

- One product range for vibration & acoustics
- Modular concept – Easy upgrade
- Easy to use Human Interface
- Support for
  - Charge accelerometers
  - DeltaTron™ transducers
  - Microphones (Falcon™ Range)
  - Intensity probes
  - Voltage input
- Full CE approval
- Computer controlled
- Battery or external power
- Direct indication of Peak and Peak Hold



What conditioning amplifier gives you..

- Configurability
- 100% remote control
- Excellent Specifications
- Weight and size
- Single ended / floating
- Support for
  - Charge accelerometers
  - DeltaTron™
  - Microphones
  - Intensity probes
  - Voltage input
- Overload capabilities
- Charge Injection Calibration
- Mounted Resonance test
- Easy to use Human Interface
- Battery or External power
- Full CE approval



....NEXUS does!