Required Instrumentation

FY20Q1 Update report: WEPG 1.3.4.403 -- Aeroacoustic Assessment of Wind Plant Control

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1 Description of project

The primary goal of the Aeroacoustic Assessment project is to characterize the acoustic emissions of the GE 1.5 SLE MW wind turbine owned by the US Department of Energy (DOE 1.5) to determine the nature and degree of changes of acoustic emissions produced when operating a utility scale wind turbine according to modern wind plant control strategies. Testing will include multiple point-measurements located to sample the acoustic emissions including points required and suggested in the International Electrotechnical Commission (IEC) standard, Wind turbines part 11: Acoustic Noise Measurement Techniques, IEC 61400-11, Edition 3.1, 2018-06, hereafter referred to simply as the Standards. This test plan documents the measurement techniques, test equipment, and analysis procedures for the following quantities at integer wind speeds from 6 to 10 m/s as recommended by the Standards:

- apparent sound pressure level,
- one-third octave band levels,
- optionally, tonality, impulsivity and amplitude modulation (listed as optional as the standards regarding these aspects of wind turbine noise are still in development, details provided below).

Measurement data is intended to be of sufficient quality to determine the change in aeroacoustic emissions from a utility scale turbine under yawed operation and validate aeroacoustics models underlying the Standards and incorporated in a module to interface with NREL's Multiphysics modeling platform, OpenFAST.

2 Measurement locations

During the period of time favorable for wind and acoustic measurements, the wind direction is mostly from the WNW. Figures 1 and 2 show the arrangement of microphones and data acquisition systems (DAS) favorable for sampling the overall sound output of the DOE 1.5. Standard frequency range (SFR) microphones specified to comply with the wind turbine noise measurement standards (20 Hz - 11.2 kHz) will be deployed at the black points. SFR mics will be placed to evenly sample the overall sound pressure level directivity field. Spacing between proximal locations are shown with black lines and annotations. The average sound pressure level difference between neighboring points is expected to be at least 3 dB,

enough to ensure a detectable difference in sound pressure level and quantify the changes induced in the directivity from wind plant control.

Low-frequency (LFR) microphones have also been specified to quantify the noise emissions of the DOE 1.5 in the sub-audible frequency range. Low-frequency noise measurements require specialized equipment, including microphones specifically designed to sample pressure field fluctuations, preamplifiers, and powered signal conditioning units that ensure a flat frequency response below 1 Hz. Due to the requirement of additional power supply to the LFR microphone setups, they will be located near each DAS, indicated as red dots in Figure 1.

To ensure that the acoustic data collected during the project may be accurately analyzed in both the time domain and frequency domain, extra care must be taken with regards to data acquisition. Each microphone will communicate with a DAS over coaxial (BNC) connection. Significant signal degradation is expected for BNC cable runs of length 200 m. Signal degradation is mitigated in the current instrumentation plan by limiting BNC cable lengths to a maximum of 50 m (red dashed lines in Figure 1). Communication from each DAS location to a central data storage server will occur over fiber-optic cables, which can transmit over much longer distances (easily up to 1 km) without signal degradation.

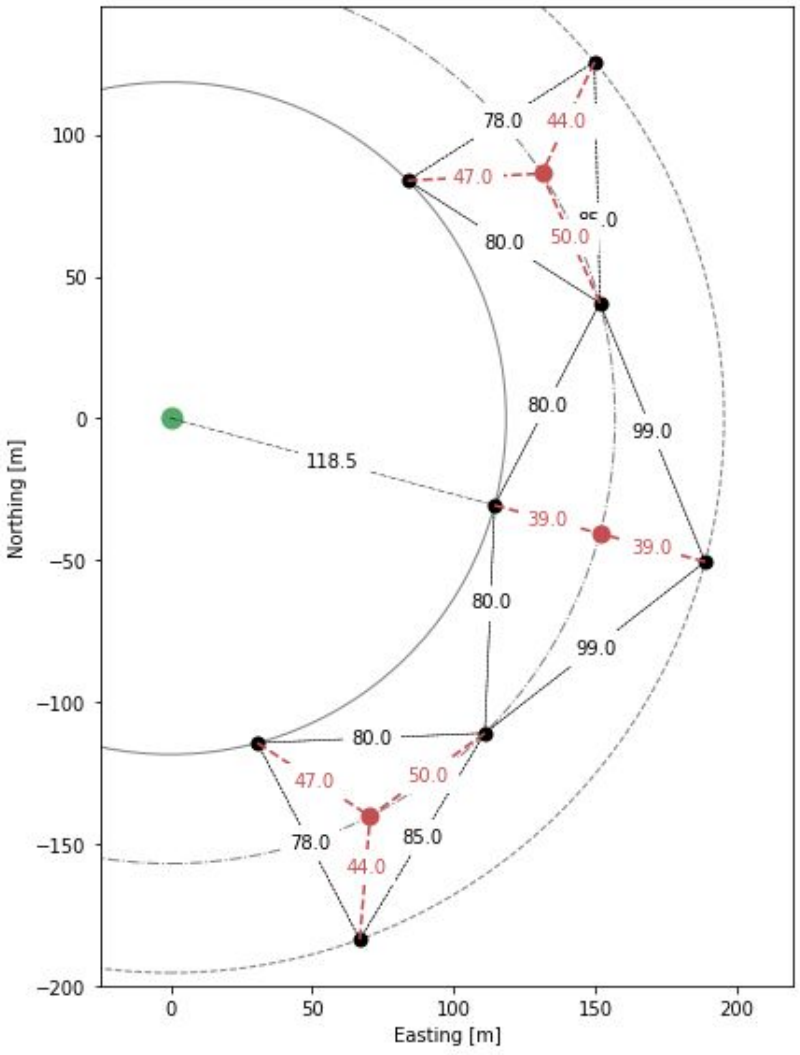


Figure 1: Schematic of measurement (black) and DAS (red) locations and spacing (m).

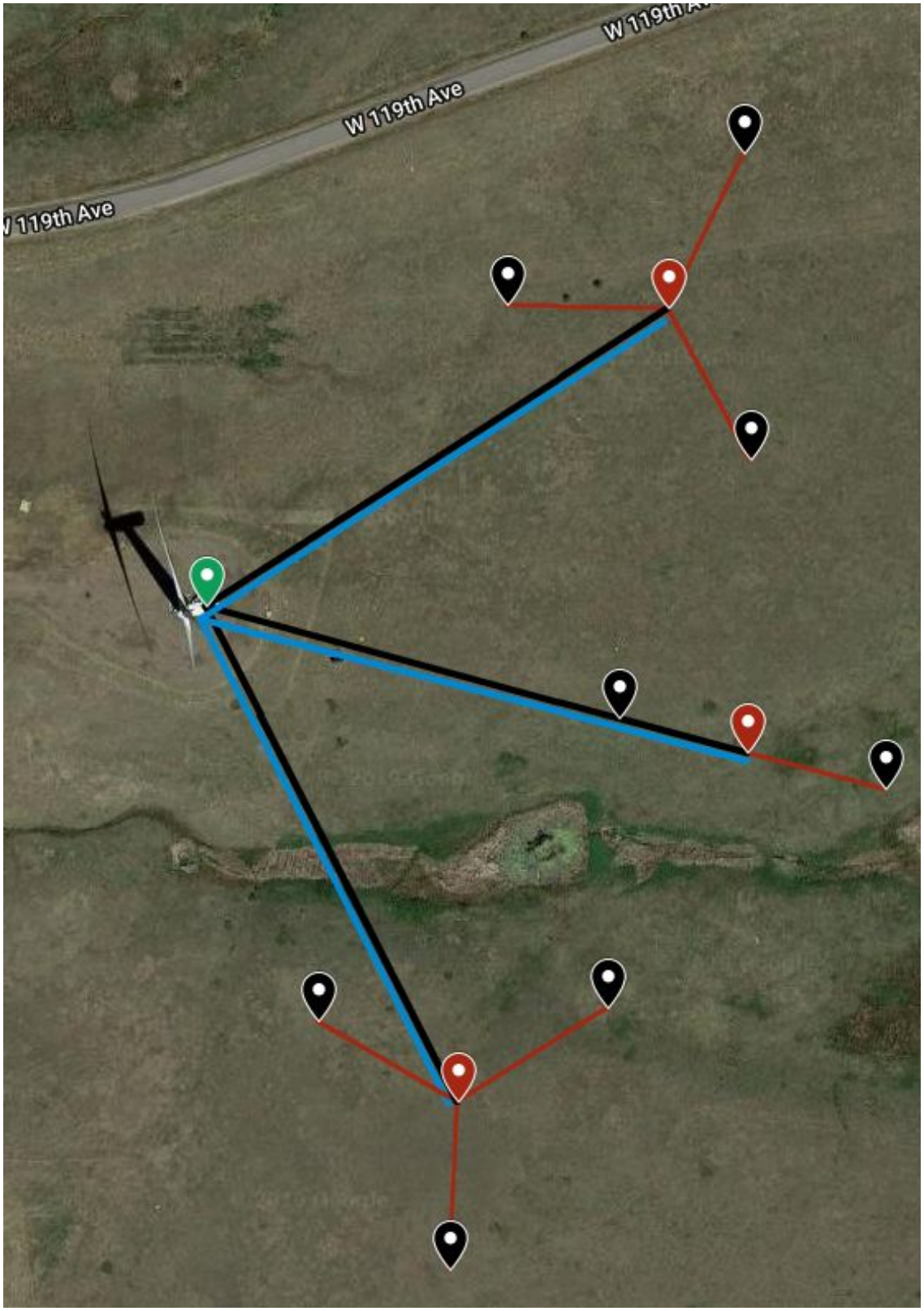


Figure 2: Map of measurement (black points) and DAS subsystem (red points) locations at NREL Flatirons. Power, fiber-optic, and BN cabling are shown in black, blue and red lines, respectively.

3 Summary of measurements

The test will continue until, at a minimum, all requirements listed in Table 1 are fulfilled for each target yaw misalignment. To fulfill the test requirements, each data period must correspond to a mean wind direction within +/-15° of the prevailing wind direction of 285°. Testing will continue until requirements are met according to the IEC Standard and NREL engineers agree that sufficient data will be deemed valid through all quality control procedures.

Table 1: Summary of observations specified in IEC 61400-11.

Measurement Type	Requirements
Overall measurements	At least 30 one-minute averages.
For A-weighted sound pressure level: (for turbine and background measurements)	At least 3 minutes of data with wind speeds ±0.5 m/s of the integer values of 6, 7, 8, 9, and 10 m/s
For octave or third octave band measurements: (for turbine and background measurements)	At least 3 minutes of data with wind speeds ±0.5 m/s of the integer values of 6, 7, 8, 9, and 10 m/s
Narrow band measurements: (for turbine and background measurements)	At least 2 minutes of data with wind speeds ±0.5 m/s of the integer values of 6, 7, 8, 9, and 10 m/s

Additional considerations for data collection, storage and quality control:

- The complete measurement chain shall be calibrated at least at one frequency before and after the measurements, or if the microphones are dis- and reconnected during the measurements.
- All acoustical signals shall be recorded and stored for later inspection.
- Periods with intruding intermittent background noise shall be omitted.
- Background noise (with the wind turbine stopped) will be measured for baseline noise comparison. Every effort shall be made to ensure that the background sound measurements are representative of the noise that occurred during the wind turbine noise emission measurements.
- The measurements shall cover as broad a range of wind speeds as practically possible. To obtain a sufficient range of wind speeds it may be necessary to take the measurements in several measurement series.
- At least 180 measurements shall be made overall for both total noise and background noise covering corresponding wind speed ranges.
- At least 10 measurements shall be made in each wind speed bin for both total noise and background noise.

- Consecutive measurements periods of 10-minutes or longer will be used as often as possible to satisfy the requirements for amplitude modulation quantification described below.

To quantify the incremental changes in wind turbine acoustic emissions induced by operating under the wake steering wind plant control strategy, measurements will be repeated for the prescribed yaw offsets listed in Table 2. The yaw offset controller will cycle between each yaw offset, holding each value for 30 minutes and repeating the schedule every 2.5 hours. The specific order of yaw offsets is intended to reduce the magnitude of the most extreme change in yaw orientation. The first 5 minutes after a new yaw offset is selected will be discarded to account for yaw positioning transients.

Table 2. Yaw Offset Schedule

Yaw Offset	0˚	25˚	18˚	10˚	-18˚
Duration	30 min	30 min	30 min	30 min	30 min

Additional Acoustic Phenomena of Interest

Impulsivity

Impulsivity is defined as the sudden onset of a sound. Noise with prominent impulses is considered to be more annoying than continuous types of noise (without impulses or tones) with the same equivalent sound pressure level, according to the NORDTEST Method Standard (NT ACOU 112). Noise impulse is defined as the combination of onset rate (dB/s) and level difference (Δ dB) for periods when gradient exceeds 10 dB/s.

Hardware requirements

- IEC Class 1 equipment
- Electric background noise 10 dB lower than acoustic background noise

Data processing requirements

- A-weighted SPL
- Time weighting “F” or “Fast” (125 ms time constant)
- 10-25 ms sample period

Amplitude Modulation

Amplitude modulation (AM) is defined as periodic fluctuations in the level of audible noise from a wind turbine (or wind turbines), where the frequency of the fluctuations is related to the blade passing frequency of the turbine rotor(s). AM quantified through peak-to-peak amplitude of fundamental modulation frequency and harmonics over a 10 s period. If energy in the fundamental frequency is more

than 4 times the masking level, AM is deemed significant. AM exists if > 50% of 10 s periods in a 10-minute block meet the above requirement.

Standard: Institute of Acoustics Noise Working Group (Wind Turbine Noise) Amplitude Modulation Working Group Final Report: A method for rating amplitude modulation in wind turbine noise (2016)

Hardware requirements

Measurement should be made according to IOA's Good Practice Guide to the Assessment and Rating of Wind Turbine Noise (IOA NWG, 2013). AM quantification methods are intended to be applied from residential distances, typically greater than 500 m from a utility-scale wind turbine. The current work will make measurements considerably closer to the DOE 1.5 than this guideline, due to limitations in data acquisition feasibility. However, the measurements taken here are expected to be of significant value in terms of validation of numerical models included in the OpenFAST Aeroacoustics Module.

Additional hardware requirements:

- Lower limit of instrument linearity range shall be no higher than 25 dB(A)
- No specific requirements for wind conditions tested under, but as broad as possible for the site and typical of complaint periods if any

Data processing requirements

- A-weighted 1/3 octave band SPL
- 100 ms sample period, 10 consecutive minutes
- 3 filter bands considered: 50-200, 100-400, 200-800 Hz

Low-Frequency and Infrasound

Broadly speaking, low-frequency noise (LFN) describes any acoustic emission at the lower range of or below what is commonly considered the audible frequency range (20-20000 Hz). Low-frequency noise has been associated with wind turbine operation, especially with downwind machines, as far back as the 1980's. For the purposes of wind turbine noise testing, the following frequency ranges are defined:

- Low frequency noise (LFN): 1/3 octave bands centered at 20 – 200 Hz
- Infrasound noise: 1/3 octave bands centered < 20 Hz
- ILFN: Infrasound + LFN (0.5 – 200 Hz)

Hardware requirements

Procedures and instrumentation requirements for low-frequency noise testing for wind energy are specified in Standard: ANSI/ASA S12.9-2016/Part 7: Quantities and Procedures for Description and Measurement of Environmental Sound, Part 7: Measurement of Low-frequency Noise and Infrasound Outdoors and in the Presence of Wind and Indoors in Occupied Spaces. From those requirements, two grades of measurements are specified: *survey grade*, for general or routine-purpose situations, and *precision grade*, for situations requiring the best available precision. Given that the measurements taken in the Aeroacoustic assessment project are intended for scientific research, and will be shared through

journal publications and technical reports, the precision grade standards are to be met for all low-frequency noise recording instrumentation. Requirements are as follows:

- LFN
    - +/- 0.5dB frequency response in 1/3 octave bands from 0.4 – 200 Hz
    - The microphone shall include a 300 mm solid foam (20 ppi) windscreen recommended by the manufacturer or better
    - The microphone shall be at a height of 1.5 m
- ILFN
    - +/- 0.5dB frequency response in 1/3 octave bands from 0.1 – 200 Hz
    - 1 m diameter ground plane (like IEC 61400-11) with 90 mm hemispherical wind screen + 450 mm diameter turbulence/secondary wind screen

Low-frequency microphones noted in Table 1 have been selected to meet the requirements for LFN and ILFN measurements.

Data processing requirements

- Calculate background wind noise for each wind speed bin
- Frequency weighting not specified (C, G, or no weighting are more appropriate)

4 Equipment selection

To meet the requirements for observing wind turbine noise emissions outlined above, specialized equipment has been selected, detailed below.

Microphones

Microphone requirements are specified under the IEC 61400-11 Standard for wind turbine noise (IEC 61400-11) as well as for sound level metering (IEC 61672) and measurement microphones (IEC 61094-4). Standards indicate that microphones must meet the Class 1 requirements for reliable measurement systems and traceable calibration. All the requirements for acoustic instrumentation under the standard are found in Section 6.1: Acoustic Instruments. Relevant excerpts are reproduced below from IEC 61400-11 Edition 3.1 2018-06 (Final Version). The Standards indicate that,

6.1.2 Equipment for the determination of the equivalent continuous A-weighted sound pressure level

"The diameter of the microphone diaphragm shall be no greater than 13mm." (paragraph 6.1.2). The equipment shall meet the requirements relevant to this document of an IEC 61672 class 1 sound level meter.

6.1.3 Equipment for the determination of A-weighted 1/3-octave band spectra

The filters shall meet the requirements relevant to this document of IEC 61260 for class 1 filters.

6.1.4 Equipment for the determination of narrow band spectra

The equipment shall fulfil the relevant requirements for IEC 61672 series class 1 instrumentation in the 20 Hz to 11 200 Hz frequency range.

6.1.6 Acoustical calibrator

The calibrator shall fulfil the requirements of IEC 60942:2003 class 1, and shall be used within its specified environmental conditions.

6.1.7 Data recording/playback systems

A data recording/playback system is a required part of the measurement instrumentation. If used for analysis (other than re-listening), the entire chain of measurement instruments shall fulfil the relevant requirements of IEC 61672 series, for class 1 instrumentation.

Table 1: Acoustic recording instrumentation

Quantity	Component	Description	Cost per unit	Component subtotal
Standard frequency range IEPE microphones				
9	4966-H-041	microphone/preamp combo for measurements down to 6.3 Hz	$1,701.00	$15,309.00
Low-frequency microphones				
4	4964	Microphone for measurements down to 0.1 Hz	$2,409.00	$9,636.00
4	2669-C	Preamp	$900.00	$3,600.00
4	1708	Signal Conditioner	$1,839.00	$7,356.00
4	AO-0414-D-100	Cable, Microphone, circular-1B 7-pin (M) to circular-1B 7-pin (F), 10m (33.3ft), max.+90°C (194°F)	$568.00	$2,272.00
Ancillary gear				
1	4231 Electrodynamic calibrator	Microphone acoustic calibrator	$1,475.00	$1,475.00
				$39,648.00

Standard frequency mics (IEPE)

The requirements for IEC 61400-11 noise measurements are satisfied by the Brüel and Kjæl (B&K) 4966-H-041, which combines a Type 4966 prepolarized, free-field microphone and a Type 1706 microphone preamplifier. Specifically, the 4966-H-041 delivers flat frequency response within the required range of 20 Hz - 11.2 kHz. Additionally, the 4966-H-041 complies with the 'Class 1' specifications in IEC Standard 61672, has an appropriate dynamic range and operating temperature range for all conditions at the NREL Flatirons Campus. Finally, the 4966-H-041 is an integrated electronic piezo-electric (IEPE) microphone, which allows microphones to be powered through BNC cables used for signal transmission.

Low-frequency mics

Specialized microphones are required to take pressure-field measurements as specified in the Standards for LFN and ILFN (ANSI/ASA S12.9-2016). Low frequency noise measurements require additional care in terms of both the acoustic recordings and signal conditioning. To make LFN measurements, the B&K Type 4964 microphone with a nominally flat frequency range below 1 Hz has been selected. These microphones have a similar dynamic range and operating temperature range as the IEPE mics above. However, measuring the low-frequency content of the acoustic emissions requires that the Type 4964 microphones be connected to a Type 2669 preamplifier and a Type 1708 signal conditioner. Because each signal conditioner requires an additional supply of external power (i.e. not powered over the communication line like IEPE microphones), LFN measurements will be made in proximity to the DAS subsystems.

Data Acquisition Systems (DAS)

Quantity	Component	Description	Cost	Subtotal
3	785622-01	cRIO-9042, 1.6 GHz Quad-Core, 70T FPGA, RT, 4-Slot, XT	$4,814.00	$14,442.00
4	779680-01	NI-9234 C Series Sound and Vibration Input Module, 4-Ch, 51.2 kS/s, IEPE and AC/DC	$2,062.00	$8,248.00
4	781632-01	NI 9467, GPS Time Synchronization Module for C Series	$735.00	$2,940.00
3	SRV-CR6075397	STANDARD SERVICE PROGRAM FOR COMPACTRIO SYSTEMS	$608.88	$1,826.64
4	779593-01	NI-9239 C Series Voltage Input Module	$1,241.00	$4,964.00
				$32,420.64

The distribution of measurement points over a large area behind the DOE 1.5 requires a similarly distributed data acquisition system. Reconciling this requirement against the need to keep cable runs short enough to minimize signal degradation points to the assembly of three DAS subsystems. Each DAS is constructed on a National Instruments (NI) CompactRIO (cRIO) chassis that combines a real-time controller with a platform for adding signal input/output modules. The chassis selected for the Aeroacoustics project (cRIO-9042) has sufficient processing power and a modular design to ensure that they will meet the needs for the measurements outlined above and be useable for other measurement campaigns in coming years. Each DAS subsystem will consist of a cRIO outfitted with three NI C-series modules:

- **NI-9234** Sound and Vibration module with 4 BNC input terminals. This module is more than capable of powering the IEPE microphone/preamp combos and processing the acoustic data for the specified frequency range.
- **NI-9239** Analog voltage input module. This module will interface with the B&K signal conditioning unit for each low frequency measurement station. A separate module will be used to ensure that each type of observation can be configured independently.
- **NI-9467** GPS Time Synchronization Module. All data need to be time-stamped locally to ensure that data can be accurately compared for subsequent time-domain analysis.

An example DAS subsystem and measurement devices are shown in a line diagram in Figure 3.

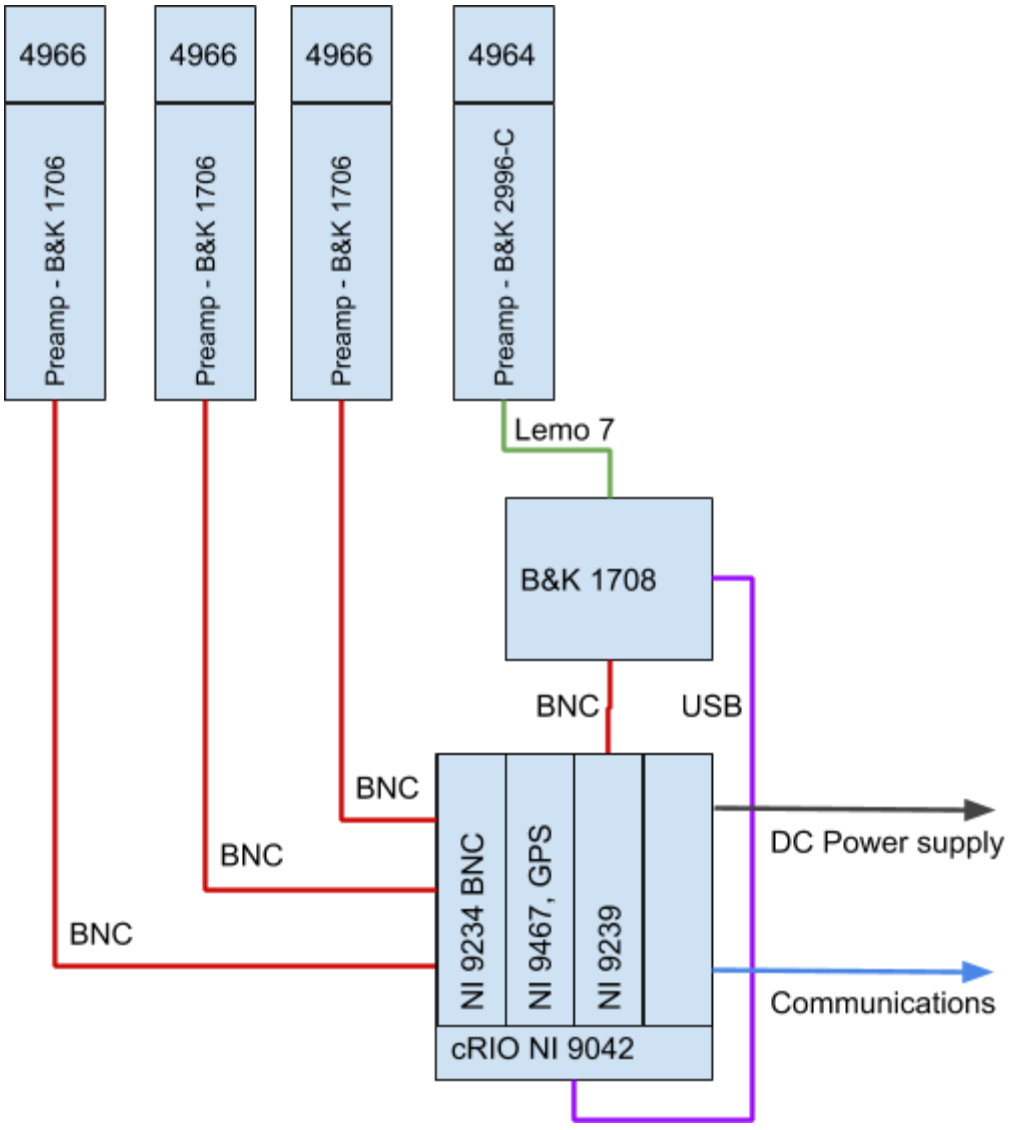


Figure 3: Line diagram of DAS subsystems

Additional memory - Local storage of each DAS will be augmented with an additional memory. Depending on space/power/temperature limitations within environmental enclosures for the cRIO and

signal conditioning modules, either a 32 GB industrial SD card or a USBc external SSD will be added to record raw acoustic data.
Communications - Information collected at each DAS will be communicated to a central data storage system through the base of the DOE 1.5 via fiber-optic cables.
Power - Power to each DAS subsystem will be routed from the base of the DOE 1.5, supplied with a minimum of 14 gauge cable, with an approximate voltage drop of 11% over the run of 150 m. DC power will be run to each DAS subsystem taking into account that the cRIO can be powered between 9 V and 30 V, and that the signal conditioner requires 0.5 A at 5 V.

Calibration

As recommended in the IEC Standards, calibration of the noise measurement system should be undertaken regularly before measurement and while deployed in the field. For calibration before, during and after acoustic measurements, an additional B&K 4231 Sound calibrator will be acquired (one already exists at NREL). Two calibrators will reduce downtime for the measurement system as both calibrators can be used in parallel.

6 Procurement

Two procurement requests (PR) have been submitted to begin the instrumentation acquisition process through NREL. Delivery of acoustic instrumentation (from B&K) and data acquisition hardware (from NI) is expected by January 15, 2020.

<u>B&K</u>
PR #127606
Brüel & Kjær North America, Inc.
Quote Number: QUO-402738-L5S2S6-1
Quote total: $39,706.50

<u>NI</u>
PR #127620
National Instruments
Quote Number: 1757700
Quote Total: $30,350.00
Note: NI procurement to be submitted 12/27/19

Appendix A: Instrument Documentation

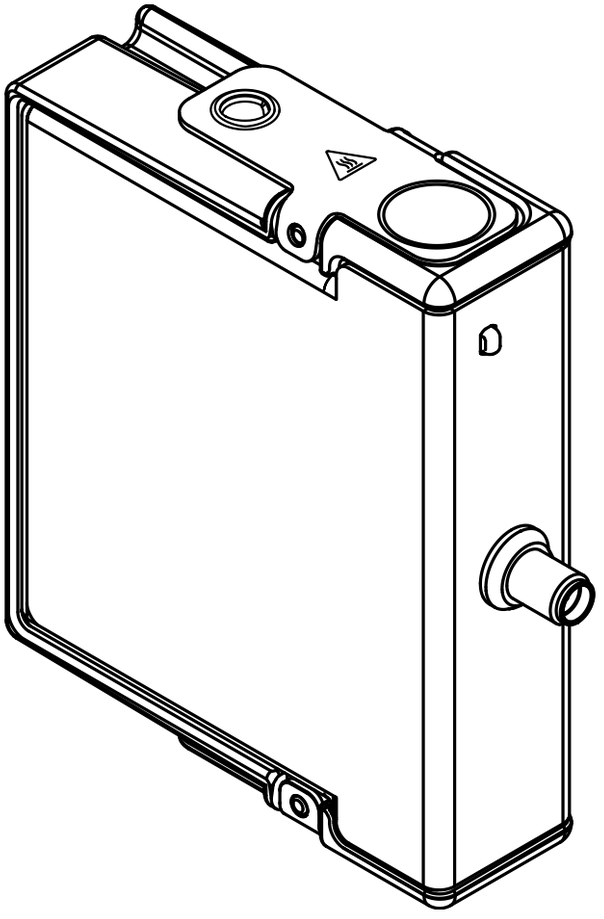
Attached documentation:

Instrument	**Filename**
NI 9467 - GPS module	373230c.pdf
NI 9234 - BNC module	374238a_02.pdf
NI 9239 - Analog input module	375939b_02.pdf
NI cRIO 9042 - Data acquisition frame	377159f_02.pdf
B&K Sound Calibrator type 4231	bp1311.pdf
B&K - Microphone preamplifier - Type 2669	bp1422.pdf
B&K - Microphone preamplifier - Type 1706	bp2225.pdf
B&K - Low-frequency mic - Type 4964	bp2478.pdf
B&K - Standard range mic - Type 4966	bp2559.pdf
B&K - Signal conditioner - Type 1708	bp2536.pdf

GETTING STARTED GUIDE

NI 9467

C Series GPS Synchronization Module



NATIONAL INSTRUMENTS™

This document explains how to connect to the NI 9467.

Note Before you begin, complete the software and hardware installation procedures in your chassis documentation.

Note The guidelines in this document are specific to the NI 9467. The other components in the system might not meet the same safety ratings. Refer to the documentation for each component in the system to determine the safety and EMC ratings for the entire system.

Safety Guidelines

Operate the NI 9467 only as described in this document.

Caution Do not operate the NI 9467 in a manner not specified in this document. Product misuse can result in a hazard. You can compromise the safety protection built into the product if the product is damaged in any way. If the product is damaged, return it to NI for repair.

Safety Guidelines for Hazardous Locations

The NI 9467 is suitable for use in Class I, Division 2, Groups A, B, C, D, T4 hazardous locations; Class I, Zone 2, AEx nA IIC T4 and Ex nA IIC T4 hazardous locations; and nonhazardous locations only. Follow these guidelines if you are installing the NI 9467 in a potentially explosive environment. Not following these guidelines may result in serious injury or death.

Caution Do not disconnect I/O-side wires or connectors unless power has been switched off or the area is known to be nonhazardous.

Caution Do not remove modules unless power has been switched off or the area is known to be nonhazardous.

Caution Substitution of components may impair suitability for Class I, Division 2.

Caution For Division 2 and Zone 2 applications, install the system in an enclosure rated to at least IP54 as defined by IEC/EN 60079-15.

Caution For Division 2 and Zone 2 applications, install a protection device between the external power supply and the Vsup pin. The device must prevent the Vsup-to-COM voltage from exceeding 50 V if there is a transient overvoltage condition.

Special Conditions for Hazardous Locations Use in Europe and Internationally

The NI 9467 has been evaluated as Ex nA IIC T4 Gc equipment under DEMKO Certificate No. 07 ATEX 0626664X and is IECEx UL 14.0089X certified. Each NI 9467 is marked Ex II 3G and is suitable for use in Zone 2 hazardous locations, in ambient temperatures of -40 °C ≤ Ta ≤ 70 °C. If you are using the NI 9467 in Gas Group IIC hazardous locations, you must use the device in an NI chassis that has been evaluated as Ex nC IIC T4, Ex IIC T4, Ex nA IIC T4, or Ex nL IIC T4 equipment.

Caution You must make sure that transient disturbances do not exceed 140% of the rated voltage.

Caution The system shall only be used in an area of not more than Pollution Degree 2, as defined in IEC 60664-1.

Caution The system shall be mounted in an ATEX/IECEx-certified enclosure with a minimum ingress protection rating of at least IP54 as defined in IEC/EN 60079-15.

Caution The enclosure must have a door or cover accessible only by the use of a tool.

Electromagnetic Compatibility Guidelines

This product was tested and complies with the regulatory requirements and limits for electromagnetic compatibility (EMC) stated in the product specifications. These requirements and limits provide reasonable protection against harmful interference when the product is operated in the intended operational electromagnetic environment.

This product is intended for use in industrial locations. However, harmful interference may occur in some installations, when the product is connected to a peripheral device or test object, or if the product is used in residential or commercial areas. To minimize interference with radio and television reception and prevent unacceptable performance degradation, install and use this product in strict accordance with the instructions in the product documentation.

Furthermore, any changes or modifications to the product not expressly approved by National Instruments could void your authority to operate it under your local regulatory rules.

Caution To ensure the specified EMC performance, operate this product only with shielded cables and accessories.

Special Conditions for Marine Applications

Some products are Lloyd's Register (LR) Type Approved for marine (shipboard) applications. To verify Lloyd's Register certification for a product, visit *ni.com/certification* and search for the LR certificate, or look for the Lloyd's Register mark on the product.

Caution In order to meet the EMC requirements for marine applications, install the product in a shielded enclosure with shielded and/or filtered power and input/output ports. In addition, take precautions when designing, selecting, and installing measurement probes and cables to ensure that the desired EMC performance is attained.

NI 9467 Overview

The NI 9467 is a stationary GPS timing module for C Series platforms. It provides accurate timing and geographic location information to the C Series host, which enables synchronization of C Series systems.

Start-Up Behavior

At start-up, the NI 9467 automatically begins determining its location through a process known as self-survey. During the self-survey, the module computes a location fix every second and averages the locations at the end to obtain a more accurate location. After the self-survey, the NI 9467 no longer computes new location fixes; it uses its known location and satellite signals to generate accurate timing signals.

Like all GPS receivers, the NI 9467 requires GPS satellite ephemeris and almanac data to compute accurate time and location. The ephemeris is detailed orbital information about each satellite (where each satellite is expected to be at a given time). The almanac data describes the general health of each satellite

(for example, the receiver must not use signals from satellites marked as unhealthy) and contains coarse orbit information. The GPS satellites broadcast the ephemeris and almanac data every 30 seconds. Therefore, it usually takes approximately 30 seconds for it to receive the ephemeris and almanac data and start computing location and timing fixes.

Status LED

The NI 9467 has a front panel LED to indicate status. The following table describes the meaning of each LED pattern.

Conditions	LED State
Normal operation	Solid green
Performing survey	Blinking green
Not enough or no satellites	Blinking yellow
Antenna error (no antenna or over-current)	Solid yellow
Unconfigured	Off

Note Although the module may not detect the presence of very low-power GPS antennas, it can still function correctly. Note that the LED and software may report antenna error under these conditions, and if the current consumed is close to the detection threshold the LED may flicker. Refer to the *Specifications* section for more details.

Connecting the NI 9467

The NI 9467 has one SMA female connector on its front panel for a GPS active antenna. The connector provides a DC voltage to power the antenna and also serves as input for the GPS RF signal.

Installing the Antenna

Caution National Instruments recommends using a lightning arrester in line with the GPS antenna installation to protect the NI 9467 and the C Series system from possible damage and operators from injury in the event of lightning.

The embedded GPS receiver in the NI 9467 requires signals from several satellites to compute accurate timing and location. The more satellites available to the receiver, the more accurately it can determine time and location. Therefore, the antenna location should be such that it receives signals from the greatest number of satellites possible. As the number of satellites visible to the antenna decreases, the synchronization performance may also decrease. Choose the antenna location so that the antenna has a clear view of the sky. There is no strict definition for a clear view of the sky, but a suitable guideline is that the GPS antenna should have a straight line of sight to the sky in all directions (360°) down to an imaginary line making a 30° angle with the ground. Locations far from trees and tall buildings that could block or reflect GPS satellite signals are best.

Maximum Cable Length

Maximum cable length depends on the GPS antenna gain and the cable's loss per unit of distance. National Instruments recommends a GPS signal strength of between -135 dBm and -120 dBm at the NI 9467 SMA input. GPS signal strength on the Earth's surface is typically -130 dBm. Targeting a signal strength

of -125 dBm at the SMA input, you can compute the maximum cable length as:

Max_cable_loss = -130 dBm + antenna_gain - (-125 dBm)

Max_cable_length = Max_cable_loss / (loss_per_unit_of_distance)

For example, if you use an active antenna with gain of 28 dB and RG-58 cable, which has a rated loss at 1.5 GHz of about 0.8 dB/m (24.5 dB/100 ft), the maximum cable length you could use is:

Max_cable_loss = -130 dBm + 28 dB - (-125 dBm) = 23 dB

Max_cable_length = 23 dB / (0.8 dB/m) ≈ 29 m

Sleep Mode

This module supports a low-power sleep mode. Support for sleep mode at the system level depends on the chassis the module is plugged into. Refer to the chassis manual for information about support for sleep mode. If the chassis supports sleep mode, refer to the software help for information about enabling sleep mode. Visit *ni.com/info* and enter `cseriesdoc` for information about C Series documentation.

Typically, when a system is in sleep mode, you cannot communicate with the modules. In sleep mode, the system consumes minimal power and may dissipate less heat than it does in normal mode. Refer to the *Specifications* section for more information about power consumption and thermal dissipation.

Notice that when the NI 9467 is in sleep mode, the GPS receiver is not powered and stops tracking satellites. When the module exits sleep mode and power to the GPS receiver is restored, the module goes through the normal power-up process, which includes the ephemeris/almanac data acquisition and self-survey process. Therefore, it can take approximately 30 seconds before usable timing and location signaling can be generated. Refer to *Start-Up Behavior* for more information.

NI 9467 Specifications

The following specifications are typical for the range -40 °C to 70 °C unless otherwise noted.

General Characteristics

Signal type	L1 frequency; GPS C/A code
Datum	WGS-84
RF GPS signal frequency	1575.42 MHz
Recommended signal strength at SMA[1]	-135 dBm to -120 dBm
Max RF power at input	3 dBm
Input impedance	50 Ω, nominal
MTBF	2,234,702 h at 25 °C; Bellcore Issue 2, Method 1, Case 3, Limited Part Stress Method
PPS accuracy[2]	±100 ns, > 99% typical

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1 Higher signal strength might saturate the receiver and degrade performance.

2 For the best timing accuracy performance, ensure that the GPS antenna has a clear view of the sky. Refer to the *Antenna Installation* section for more details.

GPS Antenna Connector Characteristics

GPS antenna connector type	SMA female
DC voltage output for active antenna	+5 V ± 10%
Max. current output	30 mA
Minimum current for antenna presence detection	6 mA typical, 9.5 mA max
Over-voltage protection	± 30 VDC

Power Requirements

Power consumption from chassis	
Active mode	150 mA max
Sleep mode	1 mA
Thermal dissipation (at 70 °C)	
Active mode	550 mW max
Sleep mode	5 mW

Physical Characteristics

To clean the module, wipe it with a dry towel.

Weight	141 g (4.5 oz)

Environmental

Refer to the manual for the chassis you are using for more information about meeting these specifications.

Operating temperature (IEC 60068-2-1, IEC 60068-2-2)	-40 °C to 70 °C
Storage temperature (IEC 60068-2-1, IEC 60068-2-2)	-40 °C to 85 °C
Ingress protection	IP40
Operating humidity (IEC 60068-2-78)	10% RH to 90% RH, noncondensing
Storage humidity (IEC 60068-2-78)	5% RH to 95% RH, noncondensing

Pollution Degree	2
Maximum altitude	5,000 m

Indoor use only.

Shock and Vibration

To meet these specifications, you must panel mount the system.

Operating vibration	
Random (IEC 60068-2-64)	5 g_{rms}, 10 Hz to 500 Hz
Sinusoidal (IEC 60068-2-6)	5 g, 10 Hz to 500 Hz
Operating shock (IEC 60068-2-27)	30 g, 11 ms half sine; 50 g, 3 ms half sine; 18 shocks at 6 orientations

Safety and Hazardous Locations Standards

Note The NI 9467 module does not provide electrical isolation.

This product is designed to meet the requirements of the following electrical equipment safety standards for measurement, control, and laboratory use:

- IEC 61010-1, EN 61010-1
- UL 61010-1, CSA 61010-1
- EN 60079-0:2012, EN 60079-15:2010
- IEC 60079-0: Ed 6, IEC 60079-15; Ed 4
- UL 60079-0; Ed 5, UL 60079-15; Ed 3
- CSA 60079-0:2011, CSA 60079-15:2012

Note For UL and other safety certifications, refer to the product label or the *Online Product Certification* section.

Hazardous Locations

U.S. (UL)	Class I, Division 2, Groups A, B, C, D, T4; Class I, Zone 2, AEx nA IIC T4
Canada (C-UL)	Class I, Division 2, Groups A, B, C, D, T4; Class I, Zone 2, Ex nA IIC T4
Europe (DEMKO)	Ex nA IIC T4 Gc

Electromagnetic Compatibility

This product meets the requirements of the following EMC standards for electrical equipment for measurement, control, and laboratory use:

- EN 61326-1 (IEC 61326-1): Class A emissions; Industrial immunity
- EN 55011 (CISPR 11): Group 1, Class A emissions
- AS/NZS CISPR 11: Group 1, Class A emissions
- FCC 47 CFR Part 15B: Class A emissions
- ICES-001: Class A emissions

Note In the United States (per FCC 47 CFR), Class A equipment is intended for use in commercial, light-industrial, and heavy-industrial locations. In Europe, Canada, Australia and New Zealand (per CISPR 11) Class A equipment is intended for use only in heavy-industrial locations.

Note Group 1 equipment (per CISPR 11) is any industrial, scientific, or medical equipment that does not intentionally generate radio frequency energy for the treatment of material or inspection/analysis purposes.

Note For EMC declarations and certifications, and additional information, refer to the *Online Product Certification* section.

CE Compliance CE

This product meets the essential requirements of applicable European Directives, as follows:

- 2014/35/EU; Low-Voltage Directive (safety)
- 2014/30/EU; Electromagnetic Compatibility Directive (EMC)
- 94/9/EC; Potentially Explosive Atmospheres (ATEX)

Online Product Certification

Refer to the product Declaration of Conformity (DoC) for additional regulatory compliance information. To obtain product certifications and the DoC for this product, visit *ni.com/certification*, search by model number or product line, and click the appropriate link in the Certification column.

Environmental Management

NI is committed to designing and manufacturing products in an environmentally responsible manner. NI recognizes that eliminating certain hazardous substances from our products is beneficial to the environment and to NI customers.

For additional environmental information, refer to the *Minimize Our Environmental Impact* web page at *ni.com/environment*. This page contains the environmental regulations and directives with which NI complies, as well as other environmental information not included in this document.

Waste Electrical and Electronic Equipment (WEEE)

EU Customers At the end of the product life cycle, all NI products must be disposed of according to local laws and regulations. For more information about how to recycle NI products in your region, visit *ni.com/environment/weee*.

电子信息产品污染控制管理办法（中国 RoHS）

中国客户 National Instruments 符合中国电子信息产品中限制使用某些有害物质指令(RoHS)。关于 National Instruments 中国 RoHS 合规性信息，请登录 ni.com/environment/rohs_china。(For information about China RoHS compliance, go to ni.com/environment/rohs_china.)

Worldwide Support and Services

The NI website is your complete resource for technical support. At *ni.com/support*, you have access to everything from troubleshooting and application development self-help resources to email and phone assistance from NI Application Engineers.

Visit *ni.com/services* for NI Factory Installation Services, repairs, extended warranty, and other services.

Visit *ni.com/register* to register your NI product. Product registration facilitates technical support and ensures that you receive important information updates from NI.

A Declaration of Conformity (DoC) is our claim of compliance with the Council of the European Communities using the manufacturer's declaration of conformity. This system affords the user protection for electromagnetic compatibility (EMC) and product safety. You can obtain the DoC for your product by visiting *ni.com/certification*. If your product supports calibration, you can obtain the calibration certificate for your product at *ni.com/calibration*.

NI corporate headquarters is located at
11500 North Mopac Expressway, Austin, Texas, 78759-3504. NI also has offices located around the world. For telephone support in the United States, create your service request at *ni.com/support* or dial 1 866 ASK MYNI (275 6964). For telephone support outside the United States, visit the *Worldwide Offices* section of *ni.com/niglobal* to access the branch office websites, which provide up-to-date contact information, support phone numbers, email addresses, and current events.

373230C-01 Mar16

DATASHEET

NI 9234

4 AI, ±5 V, 24 Bit, 51.2 kS/s/ch Simultaneous, AC/DC Coupling, IEPE AC Coupling

- Software-selectable AC/DC coupling (AC coupled at 0.5 Hz)
- Software-selectable IEPE signal conditioning with AC coupling (2 mA)
- -40 °C to 70 °C operating, 5 g vibration, 50 g shock
- 24-bit resolution
- Anti-aliasing filters
- 102 dB dynamic range
- Smart TEDS sensor compatibility

The NI 9234 is a four-channel dynamic signal acquisition module for making high-accuracy measurements from IEPE sensors. The NI 9234 delivers 102 dB of dynamic range and incorporates Integrated Electronics Piezoelectric (IEPE) signal conditioning at 2 mA constant current for accelerometers and microphones. The four input channels simultaneously acquire at rates up to 51.2 kS/s. In addition, the module includes built-in anti-aliasing filters that automatically adjust to your sampling rate. Compatible with a single-module USB carrier and NI CompactDAQ and CompactRIO hardware, the NI 9234 is ideal for a wide variety of mobile or portable applications such as industrial machine condition monitoring and in-vehicle noise, vibration, and harshness testing.

Kit Contents	• NI 9234 • NI 9234 Getting Started Guide
Recommended Accessories	• BNC Cable (x4) (779697-02)

C SERIES ANALOG MODULE COMPARISON							
Product Name	Signal Ranges	Channels	Sample Rate	Input Configurations	Noise at Maximum Sample Rate	Connectivity	Isolation Continuous
NI 9218	±5 V	2	51.2 kS/s/ch	IEPE with AC Coupling	50 μVrms	9-Position DSUB, LEMO	60 VDC Ch-Ch
NI 9230	±30 V	3	12.8 kS/s/ch	IEPE with AC Coupling, AC Coupling, DC Coupling	106 μVrms	Screw Terminal	60 VDC Ch-Earth
NI 9232	±30 V	3	102.4 kS/s/ch	IEPE with AC Coupling, AC Coupling, DC Coupling	251 μVrms	Screw Terminal	60 VDC Ch-Earth
NI 9234	±5 V	4	51.2 kS/s/ch	IEPE with AC Coupling, AC Coupling, DC Coupling	50 μVrms	BNC	None
NI 9251	±4.24 Vpk	2	102.4 kS/s/ch	AC Coupling, DC Coupling	8.8 μVrms	mini XLR	None

NI C Series Overview

NI provides more than 100 C Series modules for measurement, control, and communication applications. C Series modules can connect to any sensor or bus and allow for high-accuracy measurements that meet the demands of advanced data acquisition and control applications.

- Measurement-specific signal conditioning that connects to an array of sensors and signals
- Isolation options such as bank-to-bank, channel-to-channel, and channel-to-earth ground
- -40 °C to 70 °C temperature range to meet a variety of application and environmental needs
- Hot-swappable

The majority of C Series modules are supported in both CompactRIO and CompactDAQ platforms and you can move modules from one platform to the other with no modification.

CompactRIO

CompactRIO combines an open-embedded architecture with small size, extreme ruggedness, and C Series modules in a platform powered by the NI LabVIEW reconfigurable I/O (RIO) architecture. Each system contains an FPGA for custom timing, triggering, and processing with a wide array of available modular I/O to meet any embedded application requirement.

CompactDAQ

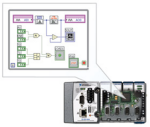
CompactDAQ is a portable, rugged data acquisition platform that integrates connectivity, data acquisition, and signal conditioning into modular I/O for directly interfacing to any sensor or signal. Using CompactDAQ with LabVIEW, you can easily customize how you acquire, analyze, visualize, and manage your measurement data.

Software

LabVIEW Professional Development System for Windows

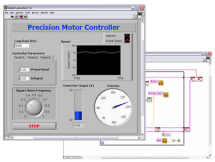
- Use advanced software tools for large project development
- Generate code automatically using DAQ Assistant and Instrument I/O Assistant
- Use advanced measurement analysis and digital signal processing
- Take advantage of open connectivity with DLLs, ActiveX, and .NET objects
- Build DLLs, executables, and MSI installers

NI LabVIEW FPGA Module



- Design FPGA applications for NI RIO hardware
- Program with the same graphical environment used for desktop and real-time applications
- Execute control algorithms with loop rates up to 300 MHz
- Implement custom timing and triggering logic, digital protocols, and DSP algorithms
- Incorporate existing HDL code and third-party IP including Xilinx IP generator functions
- Purchase as part of the LabVIEW Embedded Control and Monitoring Suite

NI LabVIEW Real-Time Module

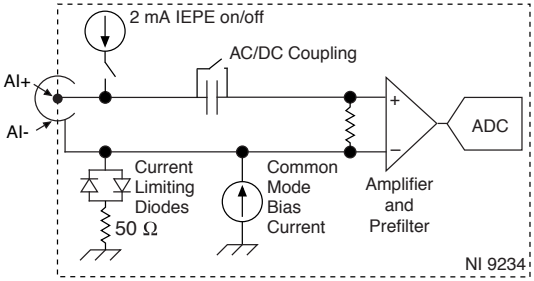


- Design deterministic real-time applications with LabVIEW graphical programming
- Download to dedicated NI or third-party hardware for reliable execution and a wide selection of I/O
- Take advantage of built-in PID control, signal processing, and analysis functions
- Automatically take advantage of multicore CPUs or set processor affinity manually
- Take advantage of real-time OS, development and debugging support, and board support
- Purchase individually or as part of a LabVIEW suite

Circuitry

The input signal on each channel is buffered, conditioned, and then sampled by a 24-bit Delta-Sigma ADC.

Figure 1. NI 9234 Input Circuitry for One Channel



The NI 9234 analog input channels are referenced to chassis ground through a 50 Ω resistor. To minimize ground noise, make sure the chassis ground is connected to earth ground. Each channel is protected from overvoltages.

AC/DC Coupling

You can configure each channel in software for AC or DC coupling. For channels set to AC coupling, you can turn the IEPE excitation current on or off. Refer to your software help for more information about configuring AC/DC coupling and enabling excitation current.

NI 9234 TEDS

The NI 9234 also has TEDS circuitry. For more information about TEDS, visit *ni.com/info* and enter the Info Code `rdteds`.

Filtering

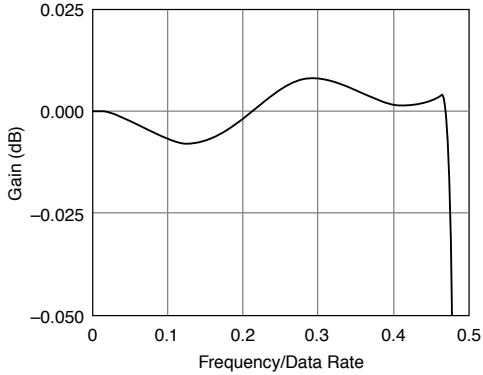
The NI 9234 uses a combination of analog and digital filtering to provide an accurate representation of in-band signals and reject out-of-band signals. The filters discriminate between signals based on the frequency range, or bandwidth, of the signal. The three important bandwidths to consider are the passband, the stopband, and the anti-imaging bandwidth.

The NI 9234 represents signals within the passband, as quantified primarily by passband ripple and phase nonlinearity. All signals that appear in the alias-free bandwidth are either unaliased signals or signals that have been filtered by at least the amount of the stopband rejection.

Passband

The signals within the passband have frequency-dependent gain or attenuation. The small amount of variation in gain with respect to frequency is called the passband flatness. The digital filters of the NI 9234 adjust the frequency range of the passband to match the data rate. Therefore, the amount of gain or attenuation at a given frequency depends on the data rate.

Figure 2. Typical Passband Response for the NI 9234



Stopband

The filter significantly attenuates all signals above the stopband frequency. The primary goal of the filter is to prevent aliasing. Therefore, the stopband frequency scales precisely with the data rate. The stopband rejection is the minimum amount of attenuation applied by the filter to all signals with frequencies within the stopband.

Alias-Free Bandwidth

Any signals that appear in the alias-free bandwidth are not aliased artifacts of signals at a higher frequency. The alias-free bandwidth is defined by the ability of the filter to reject frequencies above the stopband frequency. The alias-free bandwidth is equal to the data rate minus the stopband frequency.

Data Rates

The frequency of a master timebase (f_M) controls the data rate (f_s) of the NI 9234. The NI 9234 includes an internal master timebase with a frequency of 13.1072 MHz, but the module also can accept an external master timebase or export its own master timebase. To synchronize the data rate of an NI 9234 with other modules that use master timebases to control sampling, all of the modules must share a single master timebase source.

The following equation provides the available data rates of the NI 9234:

$$f_s = \frac{f_M \div 256}{n}$$

where n is any integer from 1 to 31.

However, the data rate must remain within the appropriate data rate range. When using the internal master timebase of 13.1072 MHz, the result is data rates of 51.2 kS/s, 25.6 kS/s, 17.067 kS/s, and so on down to 1.652 kS/s, depending on the value of n. When using an external timebase with a frequency other than 13.1072 MHz, the NI 9234 has a different set of data rates.

Note The NI 9151 R Series Expansion chassis does not support sharing timebases between modules.

NI 9234 Specifications

The following specifications are typical for the range -40 °C to 70 °C unless otherwise noted.

Caution To ensure the specified EMC performance, operate this product only with shielded cables and accessories.

Caution Do not operate the NI 9234 in a manner not specified in this document. Product misuse can result in a hazard. You can compromise the safety protection built into the product if the product is damaged in any way. If the product is damaged, return it to NI for repair.

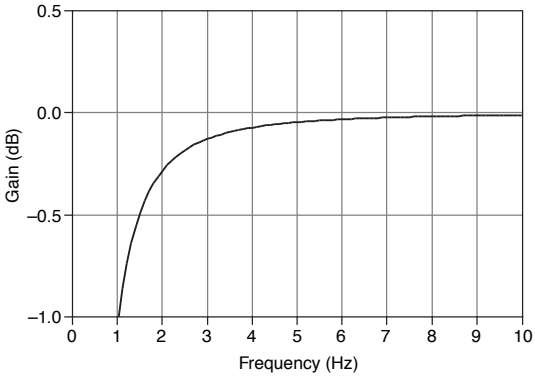
Input Characteristics

Number of channels	4 analog input channels
ADC resolution	24 bits
Type of ADC	Delta-Sigma (with analog prefiltering)
Sampling mode	Simultaneous
Type of TEDS supported	IEEE 1451.4 TEDS Class I

Internal master timebase (f_M)	
Frequency	13.1072 MHz
Accuracy	±50 ppm maximum
Data rate range (f_S)	
Using internal master timebase	
Minimum	1.652 kS/s
Maximum	51.2 kS/s
Using external master timebase	
Minimum	0.391 kS/s
Maximum	52.734 kS/s
Data rates [1] (f_S)	($f_M \div 256$)/n, n = 1, 2, ..., 31
Input coupling	AC/DC (software-selectable)
AC cutoff frequency	
-3 dB	0.5 Hz
-0.1 dB	4.6 Hz maximum

[1] The data rate must remain within the appropriate data range. Refer to the *Data Rates* for more information.

Figure 3. AC Cutoff Frequency Response



Input range	±5 V
AC voltage full-scale range	
Minimum	±5 Vpk
Typical	±5.1 Vpk
Maximum	±5.2 Vpk
Common-mode voltage range (AI- to earth ground)	±2 V maximum
IEPE excitation current (software-selectable on/off)	
Minimum	2.0 mA
Typical	2.1 mA
Power-on glitch	90 µA for 10 µs
IEPE compliance voltage	19 V maximum

If you are using an IEPE sensor, use the following equation to make sure your configuration meets the IEPE compliance voltage range.

$(V_{\text{common-mode}} + V_{\text{bias}} \pm V_{\text{full-scale}})$ must be 0 to 19

Where

$V_{\text{common-mode}}$ is the common-mode voltage applied to the NI 9234

V_{bias} is the bias voltage of the IEPE sensor

$V_{full\text{-}scale}$ is the full-scale voltage of the IEPE sensor

Overvoltage protection (with respect to chassis ground)	
For a signal source connected to AI+ and AI-	±30 V
For a low-impedance source connected to AI+ and AI-	-6 V to 30 V
Input delay	(40 + 5/512)/f_s + 2.6 µs

Table 1. Accuracy

Measurement Conditions		Percent of Reading (Gain Error)	Percent of Range[2] (Offset Error)
Calibrated	Maximum (-40 °C to 70 °C)	0.34%, ±0.03 dB	±0.14%, 7.1 mV
	Typical (25 °C ±5 °C)	0.05%, ±0.005 dB	±0.006%, 0.3 mV
Uncalibrated[3]	Maximum (-40 °C to 70 °C)	1.9%, ±0.16 dB	±0.27%, 13.9 mV
	Typical (25 °C ±5 °C)	0.48%, ±0.04 dB	±0.04%, 2.3 mV

Gain drift	
Typical	0.14 mdB/°C (16 ppm/°C)
Maximum	0.45 mdB/°C (52 ppm/°C)
Offset drift	
Typical	19.2 µV/°C
Maximum	118 µV/°C
Channel-to-channel matching	
Phase (f_{in} in kHz)	(f_{in} * 0.045° + 0.04 maximum)
Gain	
Typical	0.01 dB
Maximum	0.04 dB
Passband	
Frequency	0.45 * f_s
Flatness (f_s = 51.2 kS/s)	40 mdB (pk-to-pk maximum)

[2] Range = 5.1 Vpk

[3] Uncalibrated accuracy refers to the accuracy achieved when acquiring in raw or unscaled modes where the calibration constants stored in the module are not applied to the data.

Phase nonlinearity (f_s = 51.2 kS/s)	±0.45° maximum
Stopband	
Frequency	0.55 * f_s
Rejection	100 dB
Alias-free bandwidth	0.45 * f_s
Oversample rate	64 * f_s
Crosstalk (1 kHz)	-110 dB
CMRR ($f_{in} \leq$ 1 kHz)	
Minimum	40 dB
Typical	47 dB
SFDR (f_{in} = 1 kHz, -60 dBFS)	120 dB

Table 2. Idle Channel Noise and Noise Density

Idle Channel	51.2 kS/s	25.6 kS/s	2.048 kS/s
Noise	97 dBFS	99 dBFS	103 dBFS
	50 µVrms	40 µVrms	25 µVrms
Noise density	310 nV/√Hz	350 nV/√Hz	780 nV/√Hz

Input impedance	
Differential	305 kΩ
AI- (shield) to chassis ground	50 Ω

Table 3. Total Harmonic Distortion (THD)

Input Amplitude	1 kHz	8 kHz
-1 dBFS	-95 dB	-87 dB
-20 dBFS	-95 dB	-80 dB

Intermodulation distortion (-1 dBFS)	
DIN 250 Hz/8 kHz 4:1 amplitude ratio	-80 dB
CCIF 11 kHz/12 kHz 1:1 amplitude ratio	-93 dB
MTBF	390,362 hours at 25 °C; Bellcore Issue 2, Method 1, Case 3, Limited Part Stress Method

Power Requirements

Power consumption from chassis	
Active mode	900 mW maximum
Sleep mode	25 µW maximum
Thermal dissipation (at 70 °C)	
Active mode	930 mW maximum
Sleep mode	25 µW maximum

Physical Characteristics

If you need to clean the module, wipe it with a dry towel.

Weight	173 g (6.1 oz)

Safety Voltages

Connect only voltages that are within the following limits:

Channel-to-earth ground	±30 V maximum, Measurement Category I
Isolation	
Channel-to-channel	None
Channel-to-earth ground	None

Measurement Category I is for measurements performed on circuits not directly connected to the electrical distribution system referred to as *MAINS* voltage. MAINS is a hazardous live electrical supply system that powers equipment. This category is for measurements of voltages from specially protected secondary circuits. Such voltage measurements include signal levels, special equipment, limited-energy parts of equipment, circuits powered by regulated low-voltage sources, and electronics.

Caution Do not connect the NI 9234 to signals or use for measurements within Measurement Categories II, III, or IV.

Hazardous Locations

U.S. (UL)	Class I, Division 2, Groups A, B, C, D, T4; Class I, Zone 2, AEx nA IIC T4
Canada (C-UL)	Class I, Division 2, Groups A, B, C, D, T4; Class I, Zone 2, Ex nA IIC T4
Europe (ATEX) and International (IECEx)	Ex nA IIC T4 Gc

Safety and Hazardous Locations Standards

This product is designed to meet the requirements of the following electrical equipment safety standards for measurement, control, and laboratory use:

- IEC 61010-1, EN 61010-1
- UL 61010-1, CSA 61010-1
- EN 60079-0:2012, EN 60079-15:2010
- IEC 60079-0: Ed 6, IEC 60079-15; Ed 4
- UL 60079-0; Ed 5, UL 60079-15; Ed 3
- CSA 60079-0:2011, CSA 60079-15:2012

Note For UL and other safety certifications, refer to the product label or the *Online Product Certification* section.

Electromagnetic Compatibility

This product meets the requirements of the following EMC standards for sensitive electrical equipment for measurement, control, and laboratory use:

- EN 61326 (IEC 61326): Class A emissions; Basic immunity
- EN 55011 (CISPR 11): Group 1, Class A emissions
- AS/NZS CISPR 11: Group 1, Class A emissions
- FCC 47 CFR Part 15B: Class A emissions
- ICES-001: Class A emissions

Note For the standards applied to assess the EMC of this product, refer to the *Online Product Certification* section.

Note For EMC compliance, operate this device with shielded cabling.

CE Compliance CE

This product meets the essential requirements of applicable European Directives, as follows:

- 2014/35/EU; Low-Voltage Directive (safety)
- 2014/30/EU; Electromagnetic Compatibility Directive (EMC)
- 94/9/EC; Potentially Explosive Atmospheres (ATEX)

Online Product Certification

Refer to the product Declaration of Conformity (DoC) for additional regulatory compliance information. To obtain product certifications and the DoC for this product, visit *ni.com/certification*, search by model number or product line, and click the appropriate link in the Certification column.

Shock and Vibration

To meet these specifications, you must panel mount the system.

Operating vibration	
Random (IEC 60068-2-64)	5 g_{rms}, 10 Hz to 500 Hz
Sinusoidal (IEC 60068-2-6)	5 g, 10 Hz to 500 Hz
Operating shock (IEC 60068-2-27)	30 g, 11 ms half sine; 50 g, 3 ms half sine; 18 shocks at 6 orientations

Environmental

Refer to the manual for the chassis you are using for more information about meeting these specifications.

Operating temperature (IEC 60068-2-1, IEC 60068-2-2)	-40 °C to 70 °C
Storage temperature (IEC 60068-2-1, IEC 60068-2-2)	-40 °C to 85 °C
Ingress protection	IP40
Operating humidity (IEC 60068-2-78)	10% RH to 90% RH, noncondensing
Storage humidity (IEC 60068-2-78)	5% RH to 95% RH, noncondensing
Pollution Degree	2
Maximum altitude	5,000 m

Indoor use only.

Environmental Management

NI is committed to designing and manufacturing products in an environmentally responsible manner. NI recognizes that eliminating certain hazardous substances from our products is beneficial to the environment and to NI customers.

For additional environmental information, refer to the *Minimize Our Environmental Impact* web page at *ni.com/environment*. This page contains the environmental regulations and directives with which NI complies, as well as other environmental information not included in this document.

Waste Electrical and Electronic Equipment (WEEE)

EU Customers At the end of the product life cycle, all NI products must be disposed of according to local laws and regulations. For more information about how to recycle NI products in your region, visit *ni.com/environment/weee*.

电子信息产品污染控制管理办法（中国 RoHS）

中国客户 National Instruments 符合中国电子信息产品中限制使用某些有害物质指令(RoHS)。关于 National Instruments 中国 RoHS 合规性信息，请登录 ni.com/environment/rohs_china。(For information about China RoHS compliance, go to ni.com/environment/rohs_china.)

Calibration

You can obtain the calibration certificate and information about calibration services for the NI 9234 at *ni.com/calibration*.

Calibration interval	1 year

374238A-02 Oct15

DATASHEET

NI 9239

4 AI, ±10 V, 24 Bit, 50 kS/s/ch Simultaneous

- BNC or screw-terminal connectivity
- Anti-alias filters
- 250 Vrms, CAT II, channel-to-channel isolation (screw terminal); 60 VDC, CAT I, channel-to-channel isolation (BNC)

The NI 9239 is an analog input module for use in NI CompactDAQ or CompactRIO systems. Each channel provides a ±10 V measurement range at a 24-bit resolution. The NI 9239 outputs 50 kS/s of data at the maximum sampling rate. Designed for both speed and accuracy, the NI 9239 is an effective general-purpose analog module because of its resolution, sample rate, and input range.

Kit Contents	• NI 9239 • NI 9239 Getting Started Guide
Accessories	• NI 9971 Backshell Connector Kit (Screw Terminal) • EMI Suppression Ferrite (BNC)

NATIONAL INSTRUMENTS

C SERIES DIFFERENTIAL INPUT MODULE COMPARISON						
Product Name	Signal Levels	Channels	Sample Rate	Simultaneous	Resolution	Connectivity
NI 9215	±10 V	4	100 kS/s/ch	Yes	16-Bit	Screw-Terminal, Spring-Terminal, BNC
NI 9220	±10 V	16	100 kS/s/ch	Yes	16-Bit	Spring-Terminal, DSUB
NI 9222	±10 V	4	500 kS/s/ch	Yes	16-Bit	Screw-Terminal, BNC
NI 9223	±10 V	4	1 MS/s/ch	Yes	16-Bit	Screw-Terminal, BNC
NI 9229	±60 V	4	50 kS/s/ch	Yes	24-Bit	Screw-Terminal, BNC
NI 9239	±10 V	4	50 kS/s/ch	Yes	24-Bit	Screw-Terminal, BNC

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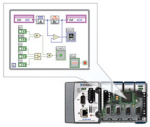
CompactDAQ is a portable, rugged data acquisition platform that integrates connectivity, data acquisition, and signal conditioning into modular I/O for directly interfacing to any sensor or signal. Using CompactDAQ with LabVIEW, you can easily customize how you acquire, analyze, visualize, and manage your measurement data.

Software

LabVIEW Professional Development System for Windows

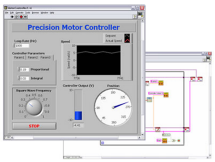
- Use advanced software tools for large project development
- Generate code automatically using DAQ Assistant and Instrument I/O Assistant
- Use advanced measurement analysis and digital signal processing
- Take advantage of open connectivity with DLLs, ActiveX, and .NET objects
- Build DLLs, executables, and MSI installers

NI LabVIEW FPGA Module



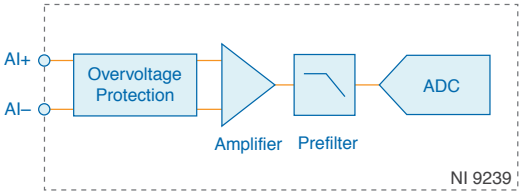
- Design FPGA applications for NI RIO hardware
- Program with the same graphical environment used for desktop and real-time applications
- Execute control algorithms with loop rates up to 300 MHz
- Implement custom timing and triggering logic, digital protocols, and DSP algorithms
- Incorporate existing HDL code and third-party IP including Xilinx IP generator functions
- Purchase as part of the LabVIEW Embedded Control and Monitoring Suite

NI LabVIEW Real-Time Module



- Design deterministic real-time applications with LabVIEW graphical programming
- Download to dedicated NI or third-party hardware for reliable execution and a wide selection of I/O
- Take advantage of built-in PID control, signal processing, and analysis functions
- Automatically take advantage of multicore CPUs or set processor affinity manually
- Take advantage of real-time OS, development and debugging support, and board support
- Purchase individually or as part of a LabVIEW suite

NI 9239 Input Circuitry



- Input signals on each channel are conditioned, buffered, and then sampled by an ADC.
- Each AI channel provides an independent signal path and ADC, enabling you to sample all channels simultaneously.

Filtering

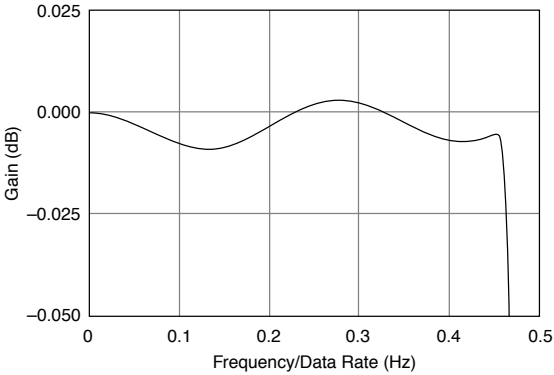
The NI 9239 uses a combination of analog and digital filtering to provide an accurate representation of in-band signals and reject out-of-band signals. The filters discriminate between signals based on the frequency range, or bandwidth, of the signal. The three important bandwidths to consider are the passband, the stopband, and the anti-imaging bandwidth.

The NI 9239 represents signals within the passband, as quantified primarily by passband ripple and phase nonlinearity. All signals that appear in the alias-free bandwidth are either unaliased signals or signals that have been filtered by at least the amount of the stopband rejection.

Passband

The signals within the passband have frequency-dependent gain or attenuation. The small amount of variation in gain with respect to frequency is called the passband flatness. The digital filters of the NI 9239 adjust the frequency range of the passband to match the data rate. Therefore, the amount of gain or attenuation at a given frequency depends on the data rate.

Figure 1. Typical Passband Response for the NI 9239



Stopband

The filter significantly attenuates all signals above the stopband frequency. The primary goal of the filter is to prevent aliasing. Therefore, the stopband frequency scales precisely with the data rate. The stopband rejection is the minimum amount of attenuation applied by the filter to all signals with frequencies within the stopband.

Alias-Free Bandwidth

Any signals that appear in the alias-free bandwidth are not aliased artifacts of signals at a higher frequency. The alias-free bandwidth is defined by the ability of the filter to reject frequencies above the stopband frequency. The alias-free bandwidth is equal to the data rate minus the stopband frequency.

Data Rates

The frequency of a master timebase (f_M) controls the data rate (f_s) of the NI 9239. The NI 9239 includes an internal master timebase with a frequency of 12.8 MHz, but the module also can accept an external master timebase or export its own master timebase. To synchronize the data rate of an NI 9239 with other modules that use master timebases to control sampling, all of the modules must share a single master timebase source.

The following equation provides the available data rates of the NI 9239:

$$f_s = \frac{f_M \div 256}{n}$$

where n is any integer from 1 to 31.

However, the data rate must remain within the appropriate data rate range. When using the internal master timebase of 12.8 MHz, the result is data rates of 50 kS/s, 25 kS/s, 16.667 kS/s,

and so on down to 1.613 kS/s, depending on the value of *n*. When using an external timebase with a frequency other than 12.8 MHz, the NI 9239 has a different set of data rates.

Note The NI 9151 R Series Expansion chassis does not support sharing timebases between modules.

NI 9239 Specifications

The following specifications are typical for the range -40 °C to 70 °C unless otherwise noted. All voltages are relative to the AI- signal on each channel unless otherwise noted.

Caution Do not operate the NI 9239 in a manner not specified in this document. Product misuse can result in a hazard. You can compromise the safety protection built into the product if the product is damaged in any way. If the product is damaged, return it to NI for repair.

Input Characteristics

Number of channels	4 analog input channels
ADC resolution	24 bits
Type of ADC	Delta-Sigma (with analog prefiltering)
Sampling mode	Simultaneous
Internal master timebase (f_M)	
Frequency	12.8 MHz
Accuracy	±100 ppm maximum
Data rate range (f_s) using internal master timebase	
Minimum	1.613 kS/s
Maximum	50 kS/s
Data rate range (f_s) using external master timebase	
Minimum	390.625 S/s
Maximum	51.2 kS/s

Figure 2. Data Rates[1] (f_s)

$$\frac{f_M \div 256}{n}, n = 1, 2, \ldots, 31$$

Input voltage ranges (AI+ to AI-)	
Nominal	±10 V
Typical	±10.52 V
Minimum	±10.3 V
Overvoltage protection	±100 V
Input coupling	DC
Input impedance (AI+ to AI-)	1 MΩ

Table 1. NI 9239 Accuracy

Measurement Conditions		Percent of Reading (Gain Error)	Percent of Range[2] (Offset Error)
Calibrated	Typical (25 °C, ±5 °C)	±0.03%	±0.008%
	Maximum (-40 °C to 70 °C)	±0.13%	±0.06%
Uncalibrated[3]	Typical (25 °C, ±5 °C)	±0.3%	±0.11%
	Maximum (-40 °C to 70 °C)	±1.4%	±0.70%

Input noise	70 µVrms
Stability	
Gain drift	±5 ppm/°C
Offset drift	±26 µV/°C
Post-calibration gain match (channel-to-channel, 20 kHz)	0.22 dB maximum
Phase mismatch	
Channel-to-channel	0.075°/kHz maximum
Module-to-module	(0.075°/kHz · f_{in}) + (360° · f_{in}/f_M)
Phase nonlinearity (f_s = 50 kS/s)	0.11° maximum

[1] The data rate must remain within the appropriate data rate range.
[2] Range equals 10.52 V
[3] Uncalibrated accuracy refers to the accuracy achieved when acquiring in raw or unscaled modes where the calibration constants stored in the module are not applied to the data.

Figure 3. Input delay

$$40\frac{5}{512}/f_s + 3.3\ \mu s$$

Passband	
Frequency	0.453 · f_s
Flatness (f_s = 50 kS/s)	±100 mdB maximum
Stopband	
Frequency	0.547 · f_s
Rejection	100 dB
Alias-free bandwidth	0.453 · f_s
-3 dB prefilter bandwidth (f_s = 50 kS/s)	24.56 kHz
Crosstalk (1 kHz)	-130 dB
CMRR (f_{in} = 60 Hz)	126 dB
SFDR (1 kHz, -60 dBFS)	128 dBFS
Total Harmonic Distortion (THD)	
1 kHz, -1 dBFS	-99 dB
1 kHz, -20 dBFS	-105 dB
MTBF	
NI 9239 with screw terminal	662,484 hours at 25 °C; Bellcore Issue 6, Method 1, Case 3, Limited Part Stress Method
NI 9239 with BNC	864,132 hours at 25 °C; Bellcore Issue 6, Method 1, Case 3, Limited Part Stress Method

Power Requirements

Power consumption from chassis	
Active mode	
NI 9239 with screw terminal	740 mW maximum
NI 9239 with BNC	800 mW maximum
Sleep mode	25 µW maximum
Thermal dissipation	
Active mode	
NI 9239 with screw terminal	760 mW maximum
NI 9239 with BNC	820 mW maximum
Sleep mode	16 mW maximum

Physical Characteristics

If you need to clean the module, wipe it with a dry towel.

Tip For two-dimensional drawings and three-dimensional models of the C Series module and connectors, visit *ni.com/dimensions* and search by module number.

Screw-terminal wiring	
Gauge	0.05 mm^2 to 1.5 mm^2 (30 AWG to 14 AWG) copper conductor wire
Wire strip length	6 mm (0.24 in.) of insulation stripped from the end
Temperature rating	90 °C minimum
Torque for screw terminals	0.22 N · m to 0.25 N · m (1.95 lb · in. to 2.21 lb · in.)
Wires per screw terminal	One wire per screw terminal; two wires per screw terminal using a 2-wire ferrule
Ferrules	0.25 mm^2 to 1.5 mm^2
Connector securement	
Securement type	Screw flanges provided
Torque for screw flanges	0.2 N · m (1.80 lb · in.)
Weight	
NI 9239 with screw terminal	147 g (5.2 oz.)
NI 9239 with BNC	169 g (6.0 oz.)

NI 9239 with Screw Terminal Safety Voltages

Connect only voltages that are within the following limits:

Isolation	
Channel-to-channel	
Continuous	250 Vrms, Measurement Category II
Withstand	1,390 V, verified by a 5 s dielectric withstand test
Channel-to-earth ground	
Continuous	250 Vrms, Measurement Category II
Withstand	2,300 V, verified by a 5 s dielectric withstand test

Division 2 and Zone 2 hazardous locations applications[4]	60 VDC, Measurement Category I

Measurement Category I is for measurements performed on circuits not directly connected to the electrical distribution system referred to as *MAINS* voltage. MAINS is a hazardous live electrical supply system that powers equipment. This category is for measurements of voltages from specially protected secondary circuits. Such voltage measurements include signal levels, special equipment, limited-energy parts of equipment, circuits powered by regulated low-voltage sources, and electronics.

Note Measurement Categories CAT I and CAT O are equivalent. These test and measurement circuits are not intended for direct connection to the MAINS building installations of Measurement Categories CAT II, CAT III, or CAT IV.

Caution If using in Division 2 or Zone 2 hazardous locations applications, do not connect the NI 9239 with screw terminal to signals or use for measurements within Measurement Categories II, III, or IV.

Measurement Category II is for measurements performed on circuits directly connected to the electrical distribution system. This category refers to local-level electrical distribution, such as that provided by a standard wall outlet, for example, 115 V for U.S. or 230 V for Europe.

Caution Do not connect the NI 9239 with screw terminal to signals or use for measurements within Measurement Categories III or IV.

NI 9239 with BNC Safety Voltages

Connect only voltages that are within the following limits:

Isolation	
Channel-to-channel	
Continuous	60 VDC, Measurement Category I
Withstand	1,000 V, verified by a 5 s dielectric withstand test
Channel-to-earth ground	
Continuous	60 VDC, Measurement Category I
Withstand	1,000 V, verified by a 5 s dielectric withstand test

Measurement Category I is for measurements performed on circuits not directly connected to the electrical distribution system referred to as *MAINS* voltage. MAINS is a hazardous live electrical supply system that powers equipment. This category is for measurements of voltages from specially protected secondary circuits. Such voltage measurements include signal levels,

[4] Channel-to-channel and channel-to-earth ground

special equipment, limited-energy parts of equipment, circuits powered by regulated low-voltage sources, and electronics.

Note Measurement Categories CAT I and CAT O are equivalent. These test and measurement circuits are not intended for direct connection to the MAINS building installations of Measurement Categories CAT II, CAT III, or CAT IV.

Caution Do not connect the NI 9239 with BNC to signals or use for measurements within Measurement Categories II, III, or IV.

Hazardous Locations

U.S. (UL)	Class I, Division 2, Groups A, B, C, D, T4; Class I, Zone 2, AEx nA IIC T4
Canada (C-UL)	Class I, Division 2, Groups A, B, C, D, T4; Class I, Zone 2, Ex nA IIC T4
Europe (ATEX) and International (IECEx)	Ex nA IIC T4 Gc

Safety and Hazardous Locations Standards

This product is designed to meet the requirements of the following electrical equipment safety standards for measurement, control, and laboratory use:

- IEC 61010-1, EN 61010-1
- UL 61010-1, CSA 61010-1
- EN 60079-0:2012, EN 60079-15:2010
- IEC 60079-0: Ed 6, IEC 60079-15; Ed 4
- UL 60079-0; Ed 5, UL 60079-15; Ed 3
- CSA 60079-0:2011, CSA 60079-15:2012

Note For UL and other safety certifications, refer to the product label or the *Online Product Certification* section.

Electromagnetic Compatibility

This product meets the requirements of the following EMC standards for electrical equipment for measurement, control, and laboratory use:

- EN 61326-1 (IEC 61326-1): Class A emissions; Industrial immunity
- EN 55011 (CISPR 11): Group 1, Class A emissions
- AS/NZS CISPR 11: Group 1, Class A emissions
- FCC 47 CFR Part 15B: Class A emissions
- ICES-001: Class A emissions

Note In the United States (per FCC 47 CFR), Class A equipment is intended for use in commercial, light-industrial, and heavy-industrial locations. In Europe,

Canada, Australia and New Zealand (per CISPR 11) Class A equipment is intended for use only in heavy-industrial locations.

Note Group 1 equipment (per CISPR 11) is any industrial, scientific, or medical equipment that does not intentionally generate radio frequency energy for the treatment of material or inspection/analysis purposes.

Note For EMC declarations and certifications, and additional information, refer to the *Online Product Certification* section.

CE Compliance CE

This product meets the essential requirements of applicable European Directives, as follows:

- 2014/35/EU; Low-Voltage Directive (safety)
- 2014/30/EU; Electromagnetic Compatibility Directive (EMC)
- 94/9/EC; Potentially Explosive Atmospheres (ATEX)

Online Product Certification

Refer to the product Declaration of Conformity (DoC) for additional regulatory compliance information. To obtain product certifications and the DoC for this product, visit *ni.com/certification*, search by model number or product line, and click the appropriate link in the Certification column.

Shock and Vibration

To meet these specifications, you must panel mount the system.

Operating vibration	
Random (IEC 60068-2-64)	5 g_{rms}, 10 Hz to 500 Hz
Sinusoidal (IEC 60068-2-6)	5 g, 10 Hz to 500 Hz
Operating shock (IEC 60068-2-27)	30 g, 11 ms half sine; 50 g, 3 ms half sine; 18 shocks at 6 orientations

Environmental

Refer to the manual for the chassis you are using for more information about meeting these specifications.

Operating temperature (IEC 60068-2-1, IEC 60068-2-2)	-40 °C to 70 °C
Storage temperature (IEC 60068-2-1, IEC 60068-2-2)	-40 °C to 85 °C
Ingress protection	IP40
Operating humidity (IEC 60068-2-78)	10% RH to 90% RH, noncondensing

Storage humidity (IEC 60068-2-78)	5% RH to 95% RH, noncondensing
Pollution Degree	2
Maximum altitude	2,000 m

Indoor use only.

Environmental Management

NI is committed to designing and manufacturing products in an environmentally responsible manner. NI recognizes that eliminating certain hazardous substances from our products is beneficial to the environment and to NI customers.

For additional environmental information, refer to the *Minimize Our Environmental Impact* web page at *ni.com/environment*. This page contains the environmental regulations and directives with which NI complies, as well as other environmental information not included in this document.

Waste Electrical and Electronic Equipment (WEEE)

EU Customers At the end of the product life cycle, all NI products must be disposed of according to local laws and regulations. For more information about how to recycle NI products in your region, visit *ni.com/environment/weee*.

电子信息产品污染控制管理办法（中国 RoHS）

中国客户 National Instruments 符合中国电子信息产品中限制使用某些有害物质指令(RoHS)。关于 National Instruments 中国 RoHS 合规性信息，请登录 `ni.com/environment/rohs_china`。(For information about China RoHS compliance, go to `ni.com/environment/rohs_china`.)

Calibration

You can obtain the calibration certificate and information about calibration services for the NI 9239 at *ni.com/calibration*.

Calibration interval	1 year

375939B-02 Apr16

SPECIFICATIONS

cRIO-9042

1.60 GHz Quad-Core CPU, 4 GB DRAM, 4 GB Storage, Kintex-7 70T FPGA, Extended Temperature, 4-Slot CompactRIO Controller

Definitions

Warranted specifications describe the performance of a model under stated operating conditions and are covered by the model warranty.

Characteristics describe values that are relevant to the use of the model under stated operating conditions but are not covered by the model warranty.

- *Typical* specifications describe the performance met by a majority of models.
- *Nominal* specifications describe an attribute that is based on design, conformance testing, or supplemental testing.

Specifications are *Typical* unless otherwise noted.

Conditions

Specifications are valid for -40 °C to 70 °C unless otherwise noted.

Processor

CPU	Intel Atom E3940
Number of cores	4
CPU frequency	1.6 GHz (base), 1.8 GHz (burst)
On-die L2 cache	2 MB

Software

Note For minimum software support information, visit *ni.com/info* and enter the Info Code `swsupport`.

Supported operating system	NI Linux Real-Time (64-bit)
Supported C Series module programming modes	Real-Time (NI-DAQmx) Real-Time Scan (I/O Variables) LabVIEW FPGA
Application software	
LabVIEW[1]	LabVIEW 2017 or later, LabVIEW Real-Time Module 2017 or later, LabVIEW FPGA Module 2017 or later,
C/C++ Development Tools for NI Linux Real-Time[2]	Eclipse Edition 2014 or later
Driver software	NI CompactRIO Device Drivers December 2017 or later

Network/Ethernet Port

Number of ports	2
Network interface	10Base-T, 100Base-TX, and 1000Base-T Ethernet
Compatibility	IEEE 802.3
Communication rates	10 Mb/s, 100 Mb/s, 1000 Mb/s auto-negotiated
Maximum cabling distance	100 m/segment

[1] LabVIEW FPGA Module is not required when using Real-Time Scan (I/O Variables) mode or Real-Time (NI-DAQmx) mode. To program the user-accessible FPGA on the cRIO-9042, the LabVIEW FPGA Module is required.

[2] C/C++ Development Tools for NI Linux Real-Time is an optional interface for C/C++ programming of the cRIO-9042 processor. Visit *ni.com/info* and enter Info Code `RIOCdev` for more information about the C/C++ Development Tools for NI Linux Real-Time.

Network Timing and Synchronization

Protocol	IEEE 802.1AS-2011 IEEE 1588-2008 (default end-to-end profile)
Supported ethernet ports	Port 0, port 1
Network synchronization accuracy[3]	<1 µs

Note The cRIO-9042 employs time-aware transmission support. For more information about time-aware transmission support, visit *ni.com/info* and enter Info Code `timeaware`.

RS-232 Serial Port

Maximum baud rate	115,200 b/s
Data bits	5, 6, 7, 8
Stop bits	1, 2
Parity	Odd, even, mark, space
Flow control	RTS/CTS, XON/XOFF, DTR/DSR
RI wake maximum low level	0.8 V
RI wake minimum high level	2.4 V
RI overvoltage tolerance	±24 V

RS-485 Serial Port

Maximum baud rate	230,400 b/s
Data bits	5, 6, 7, 8
Stop bits	1, 2
Parity	Odd, even, mark, space
Flow control	XON/XOFF

[3] Network synchronization is system-dependent. For information about network synchronization accuracy, visit *ni.com/info* and enter Info Code `criosync`.

Wire mode	4-wire, 2-wire, 2-wire auto
Isolation voltage	60 V DC continuous, port to earth ground

Note The RS-485 serial port ground and shield are functionally isolated from chassis ground to prevent ground loops, but do not meet IEC 61010-1 for safety isolation.

Cable requirement	Unshielded, 30 m maximum length (limited by EMC/surge)

Note RS-485 is capable of 1.2 km (4,000 ft) length without surge limitation.

USB Ports

Port 1:	
Type	USB Type-A, host port
USB interface	USB 2.0, Hi-Speed
Maximum data rate	480 Mb/s
Maximum current	900 mA
Port 2:	
Type	USB Type-C, host port
USB interface	USB 3.1 Gen1, SuperSpeed
Maximum data rate	5 Gb/s
Maximum current	900 mA
Alternate modes	DisplayPort
Port 3:	
Type	USB Type-C, dual role port (device or host)
USB interface	USB 3.1 Gen1, SuperSpeed
Maximum data rate	5 Gb/s
Maximum current	900 mA

DisplayPort over USB Type-C

Maximum resolution	3840 × 2160 at 60 Hz
Supported standard	DisplayPort 1.2
Supported USB ports	Port 2:

SD Card Slot

SD card support	SD and SDHC standards
Supported interface speeds	UHS-I SDR50 and DDR50

Notice Full and high speed SD cards are prohibited for use with the cRIO-9042.

Memory

Nonvolatile memory (SSD)	4 GB
Nonvolatile memory (SSD) type	Planar SLC NAND

Note Visit *ni.com/info* and enter the Info Code `ssdbp` for information about the life span of the nonvolatile memory and about best practices for using nonvolatile memory.

Volatile memory (DRAM)	
Density	4 GB
Type	DDR3L
Maximum theoretical data rate	12.8 GB/s

Reconfigurable FPGA

FPGA type	Xilinx Kintex-7 7K70T
Number of flip-flops	82,000
Number of 6-input LUTs	41,000
Number of DSP slices (18 × 25 multipliers)	240
Available block RAM	4,860 kbits
Number of DMA channels	16
Number of logical interrupts	32

Internal Real-Time Clock

Accuracy	200 ppm; 40 ppm at 25 °C

Controller PFI 0

Maximum input or output frequency	1 MHz
Cable length	3 m (10 ft)
Cable impedance	50 Ω
PFI 0 connector	SMB
Power-on state	High impedance
I/O standard compatibility	5 V TTL
I/O voltage protection	±30 V
Maximum operating conditions	
I_{OL} output low current	8 mA maximum
I_{OH} output high current	-8 mA maximum

Table 1. DC Input Characteristics

Voltage	Minimum	Maximum
Positive going threshold	1.43 V	2.28 V
Negative going threshold	0.86 V	1.53 V
Hysteresis	0.48 V	0.87 V

Table 2. DC Output Characteristics

Voltage	Conditions	Minimum	Maximum
High	—	—	5.25 V
	Sourcing 100 µA	4.65 V	—
	Sourcing 2 mA	3.60 V	—
	Sourcing 3.5 mA	3.44 V	—
Low	Sinking 100 µA	—	0.10 V
	Sinking 2 mA	—	0.64 V
	Sinking 3.5 mA	—	0.80 V

Real-Time Streaming Performance

Data throughput is dependent on the application, system, and performance of the removable storage media. For information about optimizing data throughput on the cRIO-9042 visit *ni.com/info* and enter Info Code `optdata`.

Data throughput from system memory to target	
SD card	40 MB/s
USB Type-C	100 MB/s

Real-Time (NI-DAQmx) Mode

The following specifications are applicable for modules and slots programmed in Real-Time (NI-DAQmx) mode. For more information about using modules in LabVIEW FPGA mode or Real-Time Scan (I/O Variables) mode, visit *ni.com/info* and enter Info Code `swsupport`.

Analog Input

Input FIFO size	253 samples per slot
Maximum sample rate[4]	Determined by the C Series module or modules
Timing accuracy[5]	50 ppm of sample rate
Timing resolution	12.5 ns
Number of channels supported	Determined by the C Series module or modules
Number of hardware-timed tasks	8

Analog Output

Hardware-timed tasks	
Number of hardware-timed tasks	8
Number of channels supported	
Onboard regeneration	16
Non-regeneration	Determined by the C Series module or modules
Non-hardware-timed tasks	
Number of non-hardware-timed tasks	Determined by the C Series module or modules
Number of channels supported	Determined by the C Series module or modules

[4] Performance dependent on type of installed C Series module and number of channels in the task.
[5] Does not include group delay. For more information, refer to the documentation for each C Series module.

Maximum update rate	1.6 MS/s

Note Streaming applications are limited by system-dependent factors and the capability of C Series modules.

Timing accuracy	50 ppm of sample rate
Timing resolution	12.5 ns
Waveform onboard regeneration FIFO	8,191 samples shared among channels used
Waveform streaming FIFO	253 samples per slot

Digital Waveform

Waveform acquisition (DI) FIFO	
Parallel modules	255 samples per slot
Serial modules	127 samples per slot
Waveform onboard regeneration (DO) FIFO	
Parallel modules	2,047 samples shared among slots used
Waveform streaming (DO) FIFO	
Parallel modules	255 samples per slot
Serial modules	127 samples per slot
Sample clock frequency	
Digital input	0 MHz to 10 MHz
Digital output	
ot0:6 timing engine	0 MHz to 3.5 MHz
ot7 timing engine	0 MHz to 10 MHz

Note Streaming applications are limited by system-dependent factors and the capability of C Series modules.

Timing accuracy	50 ppm
Number of digital input hardware-timed tasks	8
Number of digital output hardware-timed tasks	8

General-Purpose Counters/Timers

Number of counters/timers	4
Resolution	32 bits

Counter measurements	Edge counting, pulse, semi-period, period, two-edge separation, pulse width
Position measurements	X1, X2, X4 quadrature encoding with Channel Z reloading; two-pulse encoding
Output applications	Pulse, pulse train with dynamic updates, frequency division, equivalent time sampling
Internal base clocks	80 MHz, 20 MHz, 13.1072 MHz, 12.8 MHz, 10 MHz, 100 kHz
External base clock frequency	0 MHz to 20 MHz
Base clock accuracy	50 ppm
Output frequency	0 MHz to 20 MHz
Inputs	Gate, Source, HW_Arm, Aux, A, B, Z, Up_Down
Routing options for inputs	Any module PFI, controller PFI, analog trigger, many internal signals
FIFO	Dedicated 127-sample FIFO

Frequency Generator

Number of channels	1
Base clocks	20 MHz, 10 MHz, 100 kHz
Divisors	1 to 16 (integers)
Base clock accuracy	50 ppm
Output	Any controller PFI or module PFI terminal

Module PFI

Functionality	Static digital input, static digital output, timing input, and timing output
Timing output sources[6]	Many analog input, analog output, counter, digital input, and digital output timing signals
Timing input frequency	0 MHz to 20 MHz
Timing output frequency	0 MHz to 20 MHz

[6] Actual available signals are dependent on type of installed C Series module.

Digital Triggers

Source	Any controller PFI or module PFI terminal
Polarity	Software-selectable for most signals
Analog input function	Start Trigger, Reference Trigger, Pause Trigger, Sample Clock, Sample Clock Timebase
Analog output function	Start Trigger, Pause Trigger, Sample Clock, Sample Clock Timebase
Counter/timer function	Gate, Source, HW_Arm, Aux, A, B, Z, Up_Down

Module I/O States

At power-on	Module-dependent. Refer to the documentation for each C Series module.

Time-Based Triggers and Timestamps

Note Time-based triggers and timestamps are only supported in NI-DAQmx 18.1 or later.

Number of time-based triggers	5
Number of timestamps	6
Analog input	
Time-based triggers	Start Trigger, Sync Pulse
Timestamps	Start Trigger, Reference Trigger, First Sample
Analog output	
Time-based triggers	Start Trigger, Sync Pulse
Timestamps	Start Trigger, First Sample
Digital input	
Time-based triggers	Start Trigger
Timestamps	Start Trigger, Reference Trigger, First Sample
Digital output	
Time-based triggers	Start Trigger
Timestamps	Start Trigger, First Sample

Counter/timer input	
Time-based triggers	Arm Start Trigger
Timestamps	Arm Start Trigger
Counter/timer output	
Time-based triggers	Start Trigger, Arm Start Trigger
Timestamps	Start Trigger, Arm Start Trigger

CMOS Battery

Typical battery life with power applied to power connector	10 years
Typical battery life when stored at temperatures up to 25 °C	7.8 years
Typical battery life when stored at temperatures up to 85 °C	5.4 years

Power Requirements

Note Some C Series modules have additional power requirements. For more information about C Series module power requirements, refer to the C Series module(s) documentation.

Note Sleep mode for C Series modules is not supported in Real-Time (DAQmx) Mode.

Voltage input range (measured at the cRIO-9042 power connector)	
V1	9 V to 30 V
V2	9 V to 30 V
Maximum power consumption	60 W

Note The C terminal of the power connector is functionally isolated from chassis ground to prevent ground loops, but does not meet IEC 61010-1 for safety isolation

Note The maximum power consumption specification is based on a fully populated system running a high-stress application at elevated ambient temperature and with all C Series modules and USB devices consuming the maximum allowed power.

Typical standby power consumption	3.4 W at 24 V DC input
Recommended power supply	100 W, 24 V DC

Typical leakage current from secondary power input (V2) while system is powered from primary power input (V1)	
At 9 V	0.4 mA
At 30 V	1.93 mA

Notice Do not connect V2 to a DC Mains supply or to any supply that requires a connecting cable longer than 3 m (10 ft). A DC Mains supply is a local DC electricity supply network in the infrastructure of a site or building. V1 may be connected to DC Mains.

Notice Include a switch or circuit breaker in the installation to disconnect the system from DC Mains. The switch or circuit breaker must be suitably rated, accessible, and marked as the disconnecting device for the system.

EMC ratings for inputs as described in IEC 61000	
V1	Short lines, long lines, and DC distributed networks
V2	Short lines only
Power input connector	4-position, 3.5 mm pitch, pluggable screw terminal with screw locks, Sauro CTF04BV8-AN000A

Physical Characteristics

Weight (unloaded)	1,800 g (3 lbs, 15 oz)
Dimensions (unloaded)	219.5 mm × 88.1 mm × 121.2 mm (8.64 in. × 3.47 in. × 4.77 in.)
Power connector wiring	
Gauge	0.5 mm ^{2} to 2.1 mm^2 (20 AWG to 14 AWG) copper conductor wire
Wire strip length	6 mm (0.24 in.) of insulation stripped from the end
Temperature rating	85 °C
Torque for screw terminals	0.20 N · m to 0.25 N · m (1.8 lb · in. to 2.2 lb · in.)
Wires per screw terminal	One wire per screw terminal

Connector securement	
Securement type	Screw flanges provided
Torque for screw flanges	0.20 N · m to 0.25 N · m (1.8 lb · in. to 2.2 lb · in.)
Insulation rating	300 V, maximum

Safety Voltages

Connect only voltages that are below these limits.

V1 terminal to C terminal	30 V, maximum
V2 terminal to C terminal	30 V, maximum
Chassis ground to C terminal	30 V, maximum

Environmental

Temperature (Tested in accordance with IEC 60068-2-1 and IEC 60068-2-2)	
Operating	-40 °C to 70 °C
Storage	-40 °C to 85 °C
Ingress protection	IP20
Operating humidity (Tested in accordance with IEC 60068-2-30)	10% RH to 90% RH, noncondensing
Storage humidity (Tested in accordance with IEC 60068-2-30)	5% RH to 95% RH, noncondensing
Pollution Degree	2
Maximum altitude	5,000 m

Indoor use only.

Hazardous Locations

U.S. (UL)	Class I, Division 2, Groups A, B, C, D, T4; Class I, Zone 2, AEx nA IIC T4 Gc
Canada (C-UL)	Class I, Division 2, Groups A, B, C, D, T4; Ex nA IIC T4 Gc
Europe (ATEX) and International (IECEx)	Ex nA IIC T4 Gc

Shock and Vibration

To meet these specifications, you must mount the cRIO-9042 system directly on a flat, rigid surface as described in the user manual, affix ferrules to the ends of the terminal wires, and use retention accessories for the USB 2.0 host port (NI USB Extender Cable, 152166-xx), USB type-C ports (NI Locking USB Cables, 143556-xx; NI USB Extender Cable, 143555-xx; NI USB Display Adapters, 143557-xx or 143558-xx). All cabling should be strain-relieved near input connectors. Take care to not directionally bias cable connectors within input connectors when applying strain relief.

Operating vibration	
Random (IEC 60068-2-64)	5 g_{rms}, 10 Hz to 500 Hz
Sinusoidal (IEC 60068-2-6)	5 g, 10 Hz to 500 Hz
Operating shock (IEC 60068-2-27)	30 g, 11 ms half sine; 50 g, 3 ms half sine; 18 shocks at 6 orientations

Safety Compliance and Hazardous Locations Standards

This product is designed to meet the requirements of the following electrical equipment safety standards for measurement, control, and laboratory use:

- IEC 61010-1, EN 61010-1
- UL 61010-1, CSA C22.2 No. 61010-1
- EN 60079-0:2012, EN 60079-15:2010
- IEC 60079-0: Ed 6, IEC 60079-15; Ed 4
- UL 60079-0; Ed 6, UL 60079-15; Ed 4
- CSA C22.2 No. 60079-0, CSA C22.2 No. 60079-15

Note For UL and other safety certifications, refer to the product label or the *Product Certifications and Declarations* section.

Electromagnetic Compatibility

This product meets the requirements of the following EMC standards for electrical equipment for measurement, control, and laboratory use:

- EN 61326-1 (IEC 61326-1): Class A emissions; Industrial immunity
- EN 55011 (CISPR 11): Group 1, Class A emissions
- AS/NZS CISPR 11: Group 1, Class A emissions

- FCC 47 CFR Part 15B: Class A emissions
- ICES-001: Class A emissions

Note In the United States (per FCC 47 CFR), Class A equipment is intended for use in commercial, light-industrial, and heavy-industrial locations. In Europe, Canada, Australia and New Zealand (per CISPR 11) Class A equipment is intended for use only in heavy-industrial locations.

Note Group 1 equipment (per CISPR 11) is any industrial, scientific, or medical equipment that does not intentionally generate radio frequency energy for the treatment of material or inspection/analysis purposes.

Notice For EMC declarations and certifications, and additional information, refer to the *Product Certifications and Declarations* section.

CE Compliance CE

This product meets the essential requirements of applicable European Directives, as follows:

- 2014/35/EU; Low-Voltage Directive (safety)
- 2014/30/EU; Electromagnetic Compatibility Directive (EMC)
- 2014/34/EU; Potentially Explosive Atmospheres (ATEX)
- 2011/65/EU; Restriction of Hazardous Substances (RoHS)

Product Certifications and Declarations

Refer to the product Declaration of Conformity (DoC) for additional regulatory compliance information. To obtain product certifications and the DoC for NI products, visit *ni.com/certification*, search by model number or product line, and click the appropriate link in the Certification column.

Environmental Management

NI is committed to designing and manufacturing products in an environmentally responsible manner. NI recognizes that eliminating certain hazardous substances from our products is beneficial to the environment and to NI customers.

For additional environmental information, refer to the *Minimize Our Environmental Impact* web page at *ni.com/environment*. This page contains the environmental regulations and directives with which NI complies, as well as other environmental information not included in this document.

Waste Electrical and Electronic Equipment (WEEE)

EU Customers At the end of the product life cycle, all NI products must be disposed of according to local laws and regulations. For more information about how to recycle NI products in your region, visit *ni.com/environment/weee*.

Battery Replacement and Disposal

Battery Directive This device contains a long-life coin cell battery. If you need to replace it, use the Return Material Authorization (RMA) process or contact an authorized National Instruments service representative. For more information about compliance with the EU Battery Directive 2006/66/EC about Batteries and Accumulators and Waste Batteries and Accumulators, visit *ni.com/environment/batterydirective*.

电子信息产品污染控制管理办法（中国 RoHS）

中国客户 National Instruments 符合中国电子信息产品中限制使用某些有害物质指令(RoHS)。关于 National Instruments 中国 RoHS 合规性信息，请登录 `ni.com/environment/rohs_china`。(For information about China RoHS compliance, go to `ni.com/environment/rohs_china`.)

Worldwide Support and Services

The NI website is your complete resource for technical support. At *ni.com/support*, you have access to everything from troubleshooting and application development self-help resources to email and phone assistance from NI Application Engineers.

Visit *ni.com/services* for information about the services NI offers.

Visit *ni.com/register* to register your NI product. Product registration facilitates technical support and ensures that you receive important information updates from NI.

NI corporate headquarters is located at 11500 North Mopac Expressway, Austin, Texas, 78759-3504. NI also has offices located around the world. For support in the United States, create your service request at *ni.com/support* or dial 1 866 ASK MYNI (275 6964). For support outside the United States, visit the *Worldwide Offices* section of *ni.com/niglobal* to access the branch office websites, which provide up-to-date contact information.

377159F-02 October 26, 2018

PRODUCT DATA

Signal Conditioner Type 1708

Single-channel, battery powered for classical and CCLD input

Type 1708 provides signal conditioning, amplification and gain control for Brüel & Kjær classical microphones as well as CCLD transducers. It is designed for easy use, both in the field and in the lab, featuring a built-in rechargeable battery optimized for in situ measurements.*

Uses and Features

Uses

- Condition signals by applying gains and filters
- Provide reliable power to:
  - Classical microphone assemblies, prepolarized or polarized
  - CCLD transducers

Features

- ±60 V supply covers the maximum dynamic range of all classical microphones and preamplifiers
- 8 mA supply for compatibility with all CCLD transducers
- Charge injection calibration (CIC) via an external generator
- Built-in Li-Ion battery, provides up to 9 h of operating time for classical microphones (up to 15 h for CCLD)
- 5 V DC adaptor for powering/charging via mains
- Power cable with USB connector for powering/charging via computer
- Wide range of gains (×0.1, ×1, ×10 and ×100) to amplify analogue signal before external digital conversion, improving noise floor
- Linear, 22.4 Hz to 22.4 kHz, and A-weighting (type 0) filters for removing unwanted frequencies
- Easy-to-use switches for changing settings quickly
- LED displays for quick verification of status

Description

Type 1708 is a single-channel signal conditioner for classical microphone/preamplifier combinations as well as CCLD transducers.

Located on the front panel are the power switch, setting selectors (power supply, filter, and gain) and the LED status displays (battery, overload). The input connectors (LEMO for classical microphones, BNC for CCLD and/or direct), a BNC output connector, an SMB connector for CIC, and a coaxial connector for powering/charging the battery are located on the back panel.

Fig. 1
Left: *Front panel*
Right: *Back panel*

* CCLD: Constant current line drive, also known as DeltaTron® (IEPE compatible)

Brüel & Kjær

Transducer Power Supply

For powering both classical and CCLD transducers, there are two power supply options: polarization voltage (P_{vol}) or CCLD. Polarization voltage can be set to either 0 or 200 V, and CCLD provides an 8 mA constant current.

CCLD power has many manufacturer specific names such as DeltaTron®, ICP® (Integrated Circuit Piezoelectric), IEPE (Integrate Electronics Piezoelectric) and ISOTRON®. Type 1708 is compatible with transducers using any of the above trade names.

Gain and Filtering

Type 1708 includes analogue gain and filtering. Adding a gain before converting the signal from analogue to digital can improve the system's noise floor. Likewise, selecting a filter can remove unwanted frequencies before conversion.

Type 1708 Gain Settings:
×0.1 (–20 dB), ×1 (0 dB), ×10 (+20 dB), ×100 (+40 dB)

Type 1708 Filters:
Linear, 22.4 Hz to 22.4 kHz, A-weighting (type 0)

Fig. 2
Mains power adaptor ZG-0473 includes plug adaptor set and attached power cable AO-1429 with coaxial to USB connectors

Type 1708 Powering Options

Type 1708 features a DC coaxial (EIAJ-02) connector for powering/charging the built-in battery using either the provided mains power adaptor or a computer's USB port.

The rechargeable battery has at least 500 cycles, each lasting for about 9 hours of operation (depending on the settings), which is more convenient than replacing non-rechargeable batteries and reduces the cost of ownership.

Family of Brüel & Kjær Signal Conditioners

Table 1 *Feature comparison of Brüel & Kjær signal conditioners*

	1708	1704-A	2690-A	2829	5935-L
Mains (AC) Power	✓	✓	✓	✓	✓
USB Power	✓	✓			
Battery Power	✓	✓	Optional		✓
Number of Channels per Unit	1	1 or 2	1 to 4	4	2
Manual Control	✓	✓	✓		✓
Computer Control			✓		
Read Transducer Electronic Data Sheet (TEDS)			✓	Via external connector	
Uni (Fine) Gain Adjustment			✓		✓
Multiplexer Output			✓	✓	✓
Maximum Frequency (kHz, at filters –5% point)	>350	55	100	–	100
Maximum Gain (dB)	40	40	80	–	50
Minimum Gain (dB)	–20	0	–20	0	0
A-weighting (type 0)	✓	✓	✓		✓
Single and Double Integration Filters			✓	✓	✓
Constant Current Supply (mA)	✓	✓	✓	✓	✓

Compliance with Standards

Type 1708 is designed for use in systems with cable length <30 m.

	The CE marking is the manufacturer's declaration that the product meets the requirements of the applicable EU directives RCM mark indicates compliance with applicable ACMA technical standards – that is, for telecommunications, radio communications, EMC and EME China RoHS mark indicates compliance with administrative measures on the control of pollution caused by electronic information products according to the Ministry of Information Industries of the People's Republic of China WEEE mark indicates compliance with the EU WEEE Directive
Safety	EN/IEC 61010–1: Safety requirements for electrical equipment for measurement, control and laboratory use ANSI/UL 61010–1: Safety requirements for electrical equipment for measurement, control and laboratory use
EMC Emission	EN/IEC 61000–6–3: Generic emission standard for residential, commercial and light industrial environments EN/IEC 61000–6–4: Generic emission standard for industrial environments CISPR 22: Radio disturbance characteristics of information technology equipment. Class B Limits FCC Rules, Part 15: Complies with the limits for a Class B digital device This ISM device complies with Canadian ICES–001 (standard for interference-causing equipment)
EMC Immunity	EN/IEC 61000–6–1: Generic standards – Immunity for residential, commercial and light industrial environments EN/IEC 61000–6–2: Generic standards – Immunity for industrial environments EN/IEC 61326: Electrical equipment for measurement, control and laboratory use – EMC requirements **Note:** Effect of radiated RF, 80–1000 MHz 80% AM 1 kHz 10 V/m: <300 µV **Note:** The above is only guaranteed using accessories listed in this Product Data sheet
Temperature	IEC 60068–2–1 & IEC 60068–2–2: Environmental Testing. Cold and Dry Heat Operating Temperature: –20 to +50 °C (–4 to 122 °F) Storage Temperature: –25 to +70 °C (–13 to +158 °F)
Humidity	IEC 60068–2–78: Damp Heat: 93% RH (non-condensing at 40 °C (104 °F))
Mechanical	Non-operating: IEC 60068–2–6: Vibration: 0.3 mm, 20 m/s^2, 10 – 500 Hz IEC 60068–2–27: Shock: 1000 m/s^2 IEC 60068–2–29: Bump: 1000 bumps at 250 m/s^2
Enclosure	IEC 60529: Protection provided by enclosures: IP 20

Specifications – Type 1708

CONNECTORS
Input:
- Classical: LEMO
- CCLD: BNC

Output: BNC
External generator: SMB
Battery power supply: Coaxial EIAJ-02

BATTERY
Number of battery charging cycles (down to 80%): 500
Time to charge (in off mode), mains (AC) or USB: 5 hours

PHYSICAL
Dimensions: 110 × 140 × 36 mm (4.33 × 5.51 × 1.42 in)
Weight: 320 g (11.29 oz)

Temperature range:
- Operating: –20 to +50 °C (–4 to +122 °F)
- Charging: 10 to 40 °C (50 to 104 °F)

FILTERING AND GAIN
Filters:
- Linear
- 22.4 Hz to 22.4 kHz
- A-weighting

Gain:
- ×0.1 (–20 dB)
- ×1 (0 dB)
- ×10 (+20 dB)
- ×100 (+40 dB)

		Unit	Gain			
			×0.1 (–20 dB)	**×1 (0 dB)**	**×10 (+20 dB)**	**×100 (+40 dB)**
Amplifier Gain	**at 1 kHz**	dB	–20 ± 0.05	0 ± 0.05	20 ± 0.05	40 ± 0.05
Gain Tolerance	**10 Hz 100 kHz**	dB	±0.2	±0.1	±0.1	±0.2
Excitation Voltage	**Classical**	V	±60	±15	±15	±15
	CCLD	V		25	25	25
Excitation Current	**CCLD**	mA	8 ± 2			
Maximum Input Voltage (peak)		V	±58	±10	±0.1	±0.010
Input Protection*		V	From ±58	–14.5 to +25	–14.5 to +25	–14.5 to +25
Maximum Non-destructive Input		V	±100	±100	±100	±100
Maximum Output Voltage (peak)		V	6	10	10	10
Overload Level		V	±55	±11	±1.1	±0.11
Output Impedance		Ω	50	50	50	50

		Unit	Gain			
			×0.1 (–20 dB)	×1 (0 dB)	×10 (+20 dB)	×100 (+40 dB)
Cable Fault Voltage Levels	**CCLD overload levels**		%, CCLD current disconnected	Input voltage below +2.5 V: cable short-circuited Input voltage above +21 V: open circuit		
Total Harmonic Distortion	**at 1 kHz 1 V_{rmsout}**	dB	>70, Typ.: 80	>80, Typ.: 90	>80, Typ.: 90	>80, Typ.: 90
Output DC Offset		mV	Max.: 3.5, Typ.: 1	Max.: 3.5, Typ.: 1	Max.: 3.5, Typ.: 1	Max.: 3.5, Typ.: 1
Charge Injection Calibration (CIC)†			Yes	Yes	Yes	Yes
Frequency Range (—3 dB, max. slew rate 10 V/µs)	**Lower Limit**	Hz	<1, Typ.: 0.7	<1, Typ.: 0.7	<1, Typ.: 0.7	<1, Typ.: 0.7
	Upper Limit	kHz	>450	>450	>450	>350
Spectral Output Noise, Linear	**1 Hz**	$\mu V/\sqrt{Hz}$	<0.2, Typ.: 0.07	<0.2, Typ.: 0.06	<1.5, Typ.: 0.3	<10, Typ.: 3
	10 Hz		<0.2, Typ.: 0.05	<0.1, Typ.: 0.02	<0.5, Typ.: 0.1	<5, Typ.: 1
	100 Hz		<0.07, Typ.: 0.04	<0.05, Typ.: 0.01	<0.15, Typ.: 0.07	<1.5, Typ.: 0.7
	1 kHz		<0.07, Typ.: 0.035	<0.02, Typ.: 0.01	<0.15, Typ.: 0.07	<1.5, Typ.: 0.7
	10 kHz		<0.02, Typ.: 0.013	<0.02, Typ.: 0.01	<0.15, Typ.: 0.07	<1.5, Typ.: 0.7
	100 kHz		<0.02, Typ.: 0.013	<0.02, Typ.: 0.01	<0.15, Typ.: 0.07	<1.5, Typ.: 0.7
	150 kHz‡		<0.02, Typ.: 0.013	<0.02, Typ.: 0.01	<0.15, Typ.: 0.07	<1.5, Typ.: 0.7
Broadband Electrical Output Noise, Linear	**1 Hz to 10 kHz**	μV_{rms}	<4, Typ.: 2.5	<3, Typ.: 1.2	<8, Typ.: 6.7	<70, Typ.: 63
	1 Hz to 100 kHz		<6, Typ.: 4	<5, Typ.: 3.5	<25, Typ.: 22	<250, Typ.: 200
	1 Hz to 150 kHz‡		<7.5, Typ.: 5	<6.5, Typ.: 4.5	<32, Typ.: 28	<320, Typ.: 250
Broadband Output Noise	**Acoustic Bandpass, Linear**	μV_{rms}	<4, Typ.: 2.6	<3, Typ.: 1.6	<12, Typ.: 10	<100, Typ.: 94
	Acoustic Bandpass, Internal		<8, Typ.: 6.5	<8, Typ.: 6	<15, Typ.: 12	<110, Typ.: 95
	A-weighting, Post-processing		<4, Typ.: 2.4	<3, Typ.: 1.4	<10, Typ.: 7.6	<80, Typ.: 73
	A-weighting, Internal		<10, Typ.: 7	<10, Typ.: 7	<12, Typ.: 10	<80, Typ.: 74
Phase Difference, Device to device (typ. values), Linear weighting (without filters)	**100 kHz**		±5°	±5°	±10°	±15°
	1 Hz		±2°	±2°	±2.5°	±2.5°
Max. Amplitude Difference, Device to device, Linear weighting (without filters)	**100 kHz**	dB	±0.4	±0.1	±0.2	±0.5
	1 Hz		±0.15	±0.1	±0.15	±0.11
Battery Life (Typical)	**CCLD mode**	h	15	15	15	15
	With Preamplifier Type 2669 (±15 V supply)			9.5	9.5	9.5
	With Preamplifier Type 2669 (±60 V supply)		4			
	After low-battery level	min	30	45	45	45

* If the signal input level exceeds the measuring range significantly, the input will go into protection mode for 0.5 s. Overload will be detected, input impedance will be increased and the signal attenuated. Input signal is cut when it exceeds ±60 V.

† It is possible to calibrate the input of preamplifier using charge injection by connecting an external generator via the SMB connector. During CIC, the CIC switch and the overload diode must be set to 'On'. When not in use, CIC switch must be 'Off'.

‡ Power supply switching frequency: between 170 and 180 kHz

Ordering Information

Type 1708 Signal Conditioner

ACCESSORIES

ZG-0473 Power supply wall adaptor, 5 V
AO-1429 Power cable, DC

CALIBRATION SERVICES

1708-CVI Initial Accredited Calibration, Type 1708 with microphone
1708-CVF Accredited Calibration, Type 1708 with microphone

2018-08
BP 2559 – 12

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Brüel & Kjær

PRODUCT DATA

Sound Calibrator Type 4231

Sound Calibrator Type 4231 is a handy, portable sound source for calibration of sound level meters and other sound measurement equipment. The calibrator is very robust and stable, and conforms to EN/IEC 60942 (2003) Class LS and Class 1, and ANSI S1.40–2006.

050231

Uses and Features

Uses

- Calibration of sound level meters and other sound measurement equipment

Features

- Conforms to EN/IEC 60942 (2003) Class LS and Class 1, and ANSI S1.40–2006
- Robust, pocket-sized design with highly stable level and frequency
- Calibration accuracy ±0.2 dB
- 94 dB SPL or 114 dB SPL for calibration in noisy environments
- Extremely small influence of static pressure and temperature
- Sound pressure independent of microphone equivalent volume
- 1 kHz calibration frequency for correct calibration level independent of weighting network
- Fits Brüel & Kjær 1″ microphones (1/2″, 1/4″ and 1/8″ microphones with adaptor)
- Switches off automatically when removed from the microphone

Sound Calibrator Type 4231

Sound Calibrator Type 4231 is a pocket-sized, battery operated sound source for quick and direct calibration of sound level meters and other sound measuring systems. It fits Brüel & Kjær 1″ microphones and using the removable adaptor, 1/2″ microphones. With optional adaptors, it can be used for 1/4″ and 1/8″ microphones as well.

The calibration frequency is 1000 Hz (the reference frequency for the standardized international weighting networks), so the same calibration value is obtained for all weighting networks (A, B, C, D and Linear). The calibration pressure of 94 ±0.2 dB re 20 μPa is equal to 1 Pa or 1 N/m^2. The +20 dB level step gives 114 dB SPL, which is convenient for calibration in noisy environments, or for checking linearity.

The design of Type 4231 is based on a feed-back arrangement to ensure a highly stable sound pressure level and ease of use. The feed-back loop uses a condenser microphone (see Fig. 1), which is specially developed for this purpose.

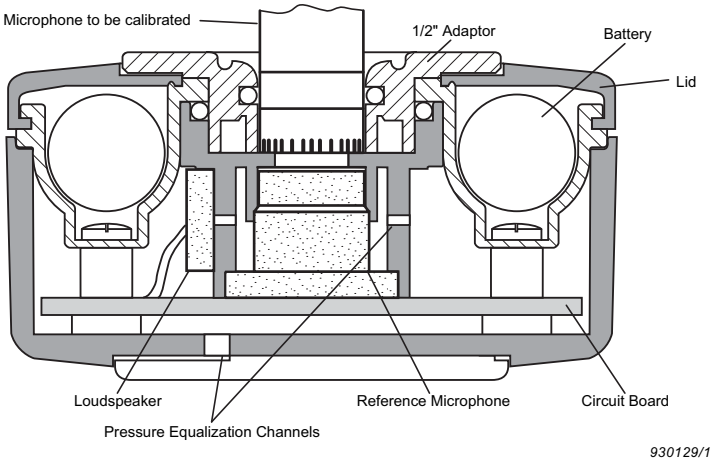

Fig. 1
Cross-sectional view of Sound Calibrator Type 4231. The feed-back loop is based on a high-quality condenser microphone to ensure a very stable sound pressure level

This microphone is optimized to have extremely high stability and independence of variations in static pressure and temperature around the 1 kHz calibration frequency. The result of this is a user-friendly calibrator where exact fitting of the microphone is not critical and the effects of changes in temperature and static pressure are negligible.

Fig. 2
Type 4231 fitted to Hand-held Analyzer Type 2250. The calibrator's centre of gravity is positioned very close to the microphone, giving a stable set-up

The calibrator gives a continuous sound pressure level when fitted on a microphone (see Fig. 2) and activated.

The sensitivity of the sound measuring equipment can then be adjusted until it indicates the correct sound pressure level.

The calibrator is automatically switched off when removed from the microphone.

A leather protection case, which does not need to be removed to use the calibrator, is supplied.

Compliance with Standards

	The CE marking is the manufacturer's declaration that the product meets the requirements of the applicable EU directives RCM mark indicates compliance with applicable ACMA technical standards – that is, for telecommunications, radio communications, EMC and EME China RoHS mark indicates compliance with administrative measures on the control of pollution caused by electronic information products according to the Ministry of Information Industries of the People's Republic of China WEEE mark indicates compliance with the EU WEEE Directive
Safety	EN/IEC 61010–1: Safety requirements for electrical equipment for measurement, control and laboratory use. ANSI/UL 61010–1: Safety requirements for electrical equipment for measurement, control and laboratory use.
EMC Emission	EN/IEC 61000–6–3: Generic emission standard for residential, commercial and light industrial environments. EN/IEC 61000–6–4: Generic emission standard for industrial environments. CISPR 22: Radio disturbance characteristics of information technology equipment. Class B Limits. FCC Rules, Part 15: Complies with the limits for a Class B digital device. EN/IEC 60942: Instrumentation Standard – Electroacoustics – Sound Calibrators.
EMC Immunity	EN/IEC 61000–6–1: Generic standards – Immunity for residential, commercial and light industrial environments. EN/IEC 61000–6–2: Generic standards – Immunity for industrial environments. EN/IEC 61326: Electrical equipment for measurement, control and laboratory use – EMC requirements. EN/IEC 60942: Instrumentation Standard – Electroacoustics – Sound Calibrators. **Note:** The above is only guaranteed using accessories listed in this Product Data sheet.
Temperature	IEC 60068–2–1 & IEC 60068–2–2: Environmental Testing. Cold and Dry Heat. Operating Temperature: –10 to +50°C (14 to 122°F) Storage Temperature: –25 to +70°C (–13 to +158°F)
Humidity	IEC 60068–2–78: Damp Heat: 90% RH (non-condensing at 40°C (104°F)).
Mechanical	Non-operating: IEC 60068–2–6: Vibration: 0.3 mm (10 to 58 Hz), 20 m/s^2 (58–500 Hz) IEC 60068–2–27: Shock: 1000 m/s^2 IEC 60068–2–29: Bump: 3000 bumps at 400 m/s^2
Enclosure	IEC 60529: Protection provided by enclosures: IP 50 with leather protection case.

Specifications – Sound Calibrator Type 4231

STANDARDS SATISFIED
EN/IEC 60942 (2003), Class LS and Class 1, Sound Calibrators
ANSI S1.40 – 2006, Specification for Acoustic Calibrators Class LS and Class 1

SOUND PRESSURE LEVELS
94.0 dB ±0.2 dB (Principal SPL) or
114.0 dB ±0.2 dB re 20 µPa at reference conditions

FREQUENCY
1 kHz ±0.1%

SPECIFIED MICROPHONE
Size according to IEC 61094-4:
- 1″ without adaptor
- 1/2″ with adaptor UC 0210 (supplied)
- 1/4″ with adaptor DP 0775 (optional)
- 1/8″ with adaptor DP 0774 (optional)

EQUIVALENT FREE-FIELD LEVEL
(0° incidence, re Nominal Sound Pressure Level)
–0.15 dB for 1/2″ Brüel & Kjær microphones. See the Type 4231 User Manual for other microphones

EQUIVALENT RANDOM INCIDENCE LEVEL
(re Nominal Sound Pressure Level)
+0.0 dB for 1″, 1/2″, 1/4″ and 1/8″ Brüel & Kjær microphones

NOMINAL EFFECTIVE COUPLER VOLUME
> 200 cm^3 at reference conditions

DISTORTION
< 1%

LEVEL STABILITY
Short-term: Better than 0.02 dB (as specified in IEC 60942)
One Year: Better than 0.05 dB (σ = 96%)
Stabilization Time: < 5 s

REFERENCE CONDITIONS
Temperature: 23°C ±3°C (73° ±5°F)
Pressure: 101 ±4 kPa
Humidity: 50%, –10% +15% RH
Effective Load Volume: 0.25 cm^3

ENVIRONMENTAL CONDITIONS
Pressure: 65 to 108 kPa
Humidity: 10 to 90% RH (non-condensing)
Effective Load Volume: 0 to 1.5 cm^3

INFLUENCE OF ENVIRONMENTAL CONDITIONS (Typical)
Temperature Coefficient: ±0.0015 dB/°C
Pressure Coefficient: $+8 \times 10^{-4}$ dB/kPa
Humidity Coefficient: 0.001 dB/% RH

POWER SUPPLY
Batteries: 2 × 1.5 V IEC Type LR6 (“AA” size)
Lifetime: Typically 200 hours continuous operation with alkaline batteries at 23°C (73°F)
Battery Check: When Type 4231 stops working continuously, and only operates when the On/Off button is held in, the batteries should be replaced

DIMENSIONS AND WEIGHT
(Without case)
Height: 40 mm (1.5″)
Width: 72 mm (2.8″)
Depth: 72 mm (2.8″)
Weight: 150 g (0.33 lb), including batteries

Note: All values are typical at 25°C (77°F), unless measurement uncertainty or tolerance field is specified. All uncertainty values are specified at 2σ (that is, expanded uncertainty using a coverage factor of 2)

Ordering Information

Type 4231 Sound Calibrator
includes the following accessories:
- KE-0317: Leather Case
- 2 × QB-0013: Alkaline Battery Type LR6
- UC-0210: Adaptor for 1/2″ microphones

Optional Accessories

DP-0775	Adaptor for 1/4″ microphones
DP-0774	Adaptor for 1/8″ microphones
DP-0887	Adaptor for Head and Torso Simulator Type 4128

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Brüel & Kjær

Product Data

Falcon™ Range

Falcon™ Range 1/2″ Microphone Preamplifier — Type 2669

USES:

- ❍ Sound measurements with Brüel & Kjær 1/2″ (1″, 1/4″ and 1/8″ with adaptor) and compatible microphones
- ❍ General-purpose preamplifier and high-impedance input probe for Brüel & Kjær measuring instruments

FEATURES:

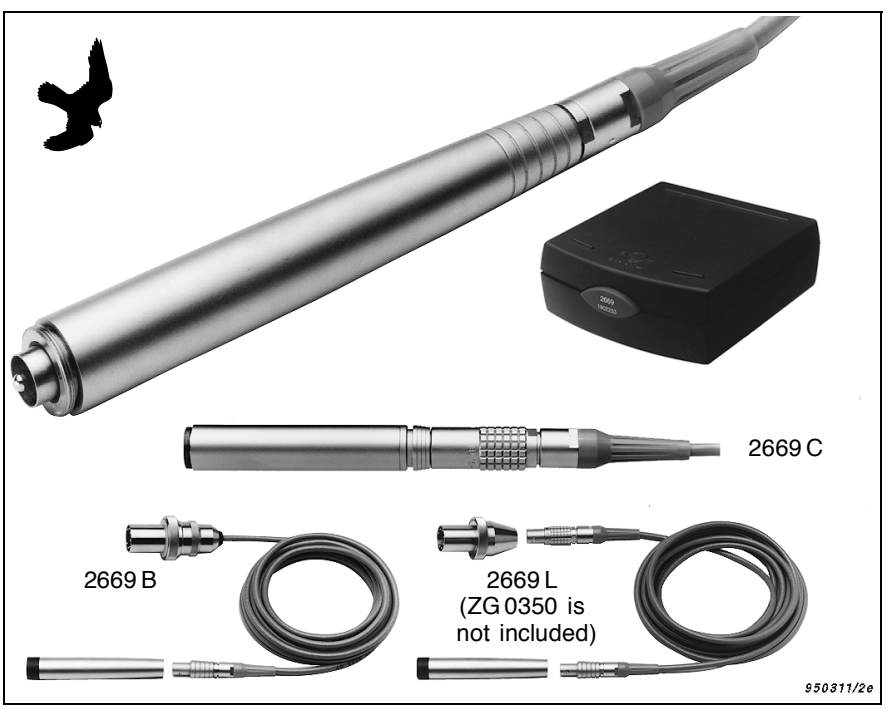
- ❍ Full electromagnetic compatibility (EMC)
- ❍ Detachable, thin cable for easy installation
- ❍ Compact LEMO connector at preamplifier
- ❍ Patented charge-injection calibration technique for on-site calibration of the whole measuring channel including the microphone
- ❍ Wide dynamic range
- ❍ Very low inherent noise, high input impedance
- ❍ Low output impedance and high output current allows use with long extension cables
- ❍ Wide working temperature range
- ❍ Falcon™ Range product with a three-year guarantee

1/2″ Microphone Preamplifier Type 2669 is a Falcon™ Range product for making precision acoustic measurements with Brüel & Kjær's wide range of condenser microphones. You can connect 1/2″ microphones directly and 1″, 1/4″ and 1/8″ types using adaptors.

The preamplifier, cable and its connectors all fulfil EMC requirements.

You can verify the condition of the microphone, preamplifier and cable on-site using its patented charge-injection calibration technique.

The preamplifier's low output impedance allows the use of long extension cables without problems.



Description

This 1/2″ Falcon™ Range microphone preamplifier operates over a wide range of temperature, humidity and other environmental conditions. It is available in three versions: the cylindrical Type 2669 C and the conical Types 2669 L and 2669 B. Apart from the shape of the housing, the only difference is the connectors. The conical form is optimized with respect to acoustical properties, whereas the cylindrical form will fit existing specialized holders.

The preamplifier has a very high input impedance presenting virtually no load to the microphone. The high output voltage together with an extremely low inherent noise level gives a wide dynamic range.

The low output impedance and high output current capability means that you can use long cables between the preamplifier and your measuring instrument without loss of signal quality. Furthermore, this Falcon™ Range microphone preamplifier comes with an extended guarantee period of three years. It is supplied in an elegant and strong plastic box made from recyclable materials.

EMC Certification

The preamplifier complies with EMC (electromagnetic compatibility) requirements specified in EN 50082 – 1 (residential, commercial and light industry) as well as in EN 50082 – 2 (industrial environment). These are generic European standards for electrical noise immunity, to ensure that instruments do not interfere with each other. To get the full benefit of this certification, the preamplifier must be connected to an instrument which also complies with EMC requirements.

Charge-injection Calibration

This is a patented technique for verifying the entire measurement set-up

including the microphone, preamplifier and connecting cable (see box below).

Microphones and Sockets

You can fit $^1/_2$″ microphones directly and 1″, $^1/_4$″ and $^1/_8$″ microphones using adaptors DB 0375, UA 0035 and UA 0036 respectively.

Preamplifier Type 2669 L is delivered with a cable which fits the LEMO preamplifier input socket on new Brüel & Kjær instruments (as well as instruments from Hewlett-Packard and Nortronic). Adaptor ZG 0350 is available for converting it to traditional 7-pin Brüel & Kjær preamplifier sockets. Alternatively, Type 2669 B is available for direct use with traditional Brüel & Kjær instruments. This cable has the same diameter and flexibility, but is equipped with a traditional Brüel & Kjær plug. Both types are fitted with a LEMO 0B connector at the preamplifier.

In contrast the cylindrical Type 2669 C is fitted with a LEMO 1B connector, which means that it can be connected directly to LEMO to LEMO extension cables. Type 2669 C is supplied without a cable.

Power Supply
You can use a dual (plus/minus) or single power supply for the preamplifier. When using a balanced power supply, the offset voltage at the output — and at the preamplifier guard ring — will be almost zero. This protects you against harmless, but unpleasant, electrical shocks if you accidentally mount or remove the microphone with power on, and gives a faster stabilisation time for a measurement set-up.

Detachable Cable (2669L and B)
The 4 mm thick connecting cable is made of silicone and is very flexible. It has a wide working temperature range (–60°C to 150°C). It has a small high-quality connector at the preamplifier end for easy detachment during installation.

Accessories
In addition to the previously mentioned adaptors for 1″, $^1/_4$″ and $^1/_8$″ microphones, other useful accessories are available. The Coaxial Input Adaptor JJ 2617 is used for measuring electrical signals by connecting the preamplifier directly to cables with microplugs (Cables AO 0038, AO 0122). The Flexible Extension Rod UA 0196 gives directional flexibility to the microphone and increases the distance between the microphone and the preamplifier. This allows continuous exposure of the microphone to high temperatures (up to 150°C, 302°F) while avoiding electrical noise otherwise generated by the preamplifier at high temperatures. For short periods the UA 0196 tolerates temperatures up to 300°C (572°F). Microphone Holder UA 1317 is used for mounting the preamplifier on a tripod without compromising the acoustical properties of the preamplifier. It can hold all Brüel & Kjær $^1/_2$″ preamplifiers. Adaptor DP 0901 is supplied with the preamplifier for use with holders that require a cylindrically shaped preamplifier.

Characteristics

The small and large signal frequency response of the preamplifier depend on the capacitance of the microphone connected to its input and the capacitive load (for example, extension cables) connected to the output.

Small Signal Frequency Response
The curves in Fig. 1 show the low-frequency response of the preamplifi-

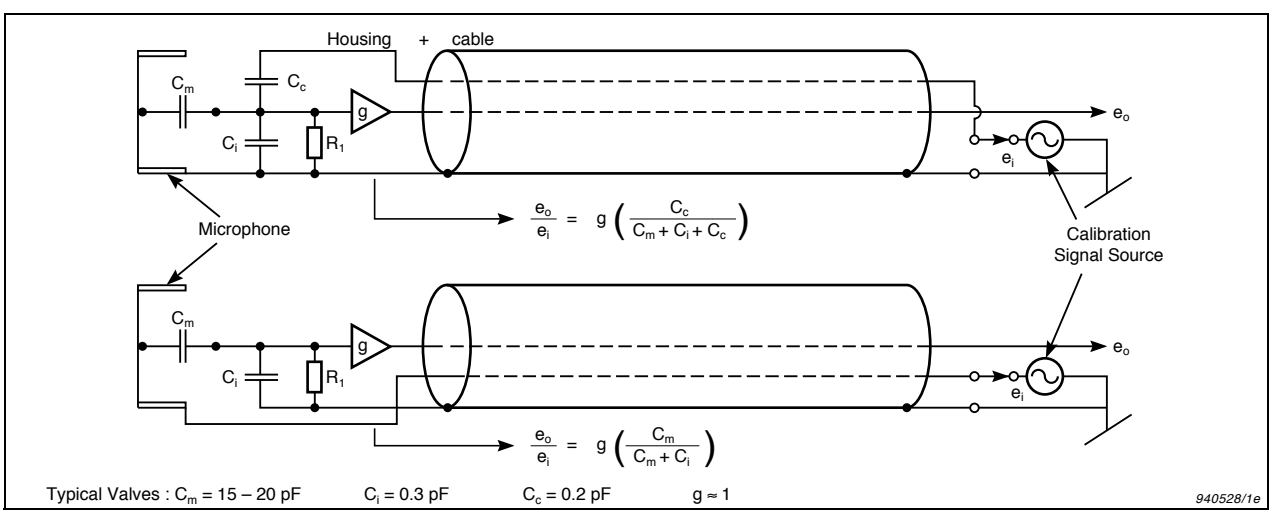
Brüel & Kjær's Patented Charge-injection Calibration Technique
The Charge-injection Calibration (CIC) technique is a method for remotely verifying the condition of the entire measurement set-up **including the microphone**. This is a great improvement over the traditional insert-voltage calibration method which virtually ignores the state of the microphone. The CIC technique is very sensitive to any change in the microphone's capacitance which is a reliable indicator of the microphone's condition.

The technique works by introducing a small but accurately defined capacitance C_c (typically 0.2 pF) with a very high leakage resistance (greater than 50000 GΩ) into the circuit of the preamplifier, see below (upper diagram). C_i and R_i represent the preamplifier's high input impedance and g its gain (≈ 1).

For a given calibration signal e_i, the output e_o of this arrangement will change measurably, even for small changes in the microphone's capacitance C_m. The CIC technique is about 100 times more sensitive than the insert-voltage calibration arrangement shown in the lower diagram.

In the extreme case where there is significant leakage between the microphone's diaphragm and its backplate (C_m becomes very large), the signal output will change by tens of decibels compared with only tenths of a decibel using the insert-voltage method.

Another important CIC feature is that, unlike the insert-voltage technique, it is far less sensitive to external electrical fields.



er for various microphone capacitances. These capacitances (47 pF, 15 pF and 6.2 pF) are typical for 1″, 1/2″ and 1/4″ microphones respectively. Note that they do not show or take into account the lower cut-off frequencies of the microphones. The effects of various capacitive output loads (cable length) on the high-frequency response are also shown. The curves in Fig. 1 apply for signal levels within the large signal limits in Table 2.

Large Signal Frequency Response

The capacitive load of extension cables on the output of the preamplifier influences its frequency response and available output voltage. If the specified maximum output current of the preamplifier is exceeded, the signal will be distorted. The curves in Fig. 2 show the upper distortion limits (3%) as a function of preamplifier output voltage, frequency and capacitive loading (cable length). The curves are shown for total supply voltages of 120 V DC and 28 V DC (±60 V DC and ±14 V DC dual supply voltages respectively).

Noise

Fig. 3 shows typical noise frequency spectra when loading the preamplifier with 6.4 pF and 15 pF microphone capacities. The low noise of the preamplifier ensures that the noise floor for a microphone/preamplifier assembly is determined mainly by the associated microphone over most of the frequency range. The preamplifier can work at temperatures up to 150°C, but reduced specifications for noise and output capability will apply.

More information on preamplifiers and other Falcon™ Range products are given in the Microphone Handbook BA 5105.

Extension Cables

Extension Cable	AO 0414/15 /16	AO 0027	AO 0028/29
Connectors	LEMO	Brüel & Kjær	
Length	3/10/30 m	3 m	10/30 m
Diameter	4 mm	6 mm	9 mm
Capacitance	290/960 /2900 pF	300 pF	570/ 1700 pF

Table 1 Extension cables

All the extension cables with LEMO connectors (see Table 1) are fully EMC certified. The preamplifier can be used with traditional cables with Brüel & Kjær connectors, but EMC compatibility is not guaranteed. The cables in Table 1 have a working temperature range from −20 to +80°C. They are very robust, have low capacitance and extremely good shielding so that several of them can be connected in series without loss of signal quality.

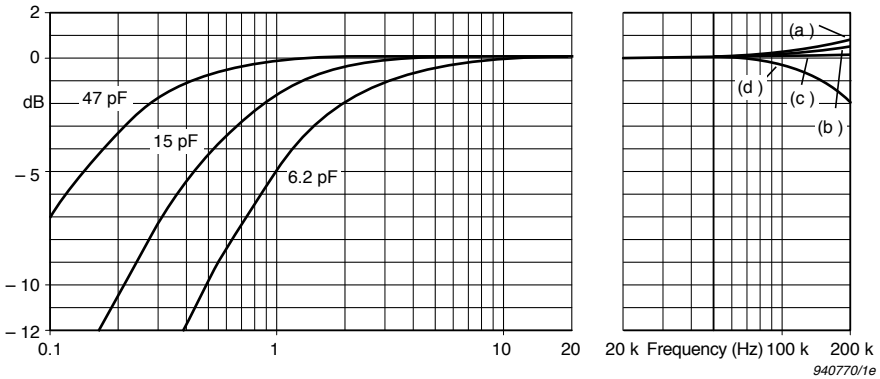


Fig. 1 Small signal frequency response of the preamplifier at low frequencies for various microphone capacitances and at high frequencies for various capacitive loads which are (a) 10 nF (b) 3 nF (c) with the 3 m cable supplied (d) 30 nF

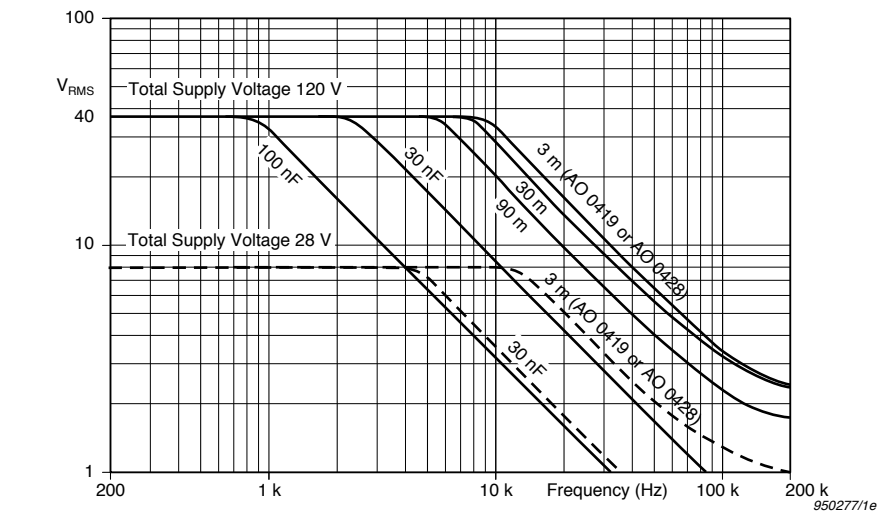


Fig. 2 Upper distortion limit (3%) as a function of preamplifier output voltage and frequency for various capacitive loads. The full-drawn curves are valid for a preamplifier powered with 120 V DC (±60 V DC) and the dotted curves are for 28 V DC (±14 V DC)

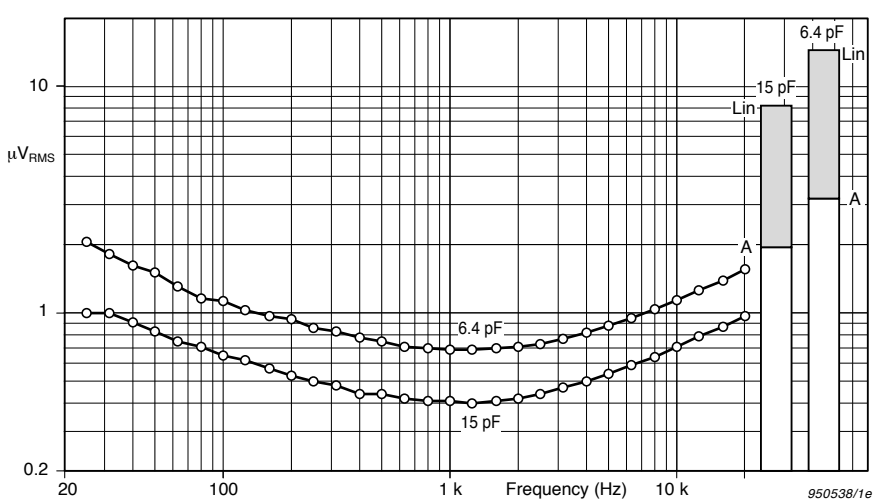
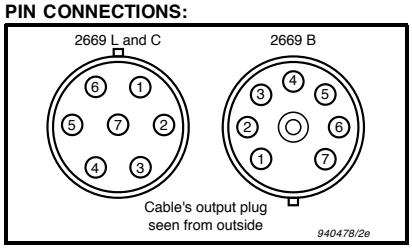


Fig. 3 Typical noise frequency spectra in µV measured with 6.4 pF and 15 pF microphone capacities. The spectra are measured in 1/3-octave bands with levels at centre frequencies indicated by circles. The bar graphs represent broad-band (22.4 Hz to 300 kHz) and A-weighted noise levels for both microphone capacities

Specifications 2669

FREQUENCY RESPONSE (re 1 kHz):
3 Hz to 200 kHz, ±0.5 dB. See Fig. 1
ATTENUATION: 0.35 dB (max.)
PHASE LINEARITY:
≤±3° from 20 Hz to 100 kHz
PHASE MATCHING: 0.3° at 50 Hz
INPUT IMPEDANCE: 15 GΩ ‖ 0.45 pF
OUTPUT IMPEDANCE: 25 Ω (max.)
CONNECTOR TYPE:
LEMO type FGJ.OB.307 at preamp. (2669 L & B)
LEMO type FGG.1B.307 (2669 L), or Brüel & Kjær JP 0715 (2669 B) to measuring device
LEMO type FWG.1B.307 at preamp. (2669 C)

PIN CONNECTIONS:



Pin	LEMO (L & C)	Brüel & Kjær (B)
1	Calibration input	Ground
2	Signal ground	Pol. voltage
3	Pol. voltage	Calibration input
4	Signal output	Signal output
5	Not connected	Power supply positive
6	Power supply positive	Not connected
7	Power supply negative/ground	Not connected
Casing	Connected to instrument chassis	

MAX. OUTPUT CURRENT: 20 mA (peak)
Note: The max. output current can be limited by the power supply
CURRENT CONSUMPTION:
3 mA plus output current

MAX. OUTPUT VOLTAGE:
Maximum output voltage V_{p-p} is equal to total supply voltage minus 10 V
OUTPUT SLEW RATE: 2 V/μs
DISTORTION (THD):
Less than –80 dB at 25 V out, 1 kHz
NOISE:
≤8.2 μV Lin. 20 Hz – 300 kHz
≤10.0 μV Lin. 20 Hz – 300 kHz (max.)
≤1.9 μV A weighted
≤2.2 μV A weighted (max.)
POWER SUPPLY, DUAL: ±14 V to ±60 V
POWER SUPPLY, SINGLE: 28 V to 120 V
OUTPUT DC OFFSET:
≈1 V for a dual supply, or
≈1/2 the voltage of a single supply

CALIBRATION INPUT:
Charge insert capacity: 0.2 pF
Max. 10 V RMS, input impedance: 1 nF
DIMENSIONS:
Diameter: 12.7 mm (0.5″)
Length: 110 mm (4.3″), (2669 L and B)
120 mm (4.7″), (2669 C)
Weight: 40 g (1.41 oz) (preamplifier only)

Note: All values are typical at 25°C (77°F), unless measurement uncertainty is specified. All uncertainty values are specified at 2σ (i.e. expanded uncertainty using a coverage factor of 2). The above are valid for 15 pF mic. capacitance and a 3 metre cable unless otherwise specified.

COMPLIANCE WITH STANDARDS:

CE	CE-mark indicates compliance with: EMC Directive and Low Voltage Directive.
Safety	EN 61010–1 and IEC 1010–1: Safety requirements for electrical equipment for measurement, control and laboratory use.
EMC Immunity	EN 50082–1: Generic immunity standard. Part 1: Residential, commercial and light industry. EN 50082–2: Generic immunity standard. Part 2: Industrial environment. **Note:** The above is guaranteed only with extension cables AO 0414, AO 0415 and AO 0416.
Temperature	IEC 68–2–1 & IEC 68–2–2: Environmental Testing. Cold and Dry Heat. Operating Temperature: –20 to +60°C (–4 to +140°F), (150°C (302°F) with increase in noise) Storage Temperature: –25 to +70°C (–13 to +158°F)
Humidity	IEC 68–2–3: 95% RH (non-condensing at 40°C (104°F))
Enclosure	IEC 529: IP 20
Mechanical	Non-operating: IEC 68–2–6: Vibration: 0.3 mm, 20 m/s^2, 10–500 Hz IEC 68–2–27: Shock: 1000 m/s^2 IEC 68–2–29: Bump: 4000 bumps at 400 m/s^2
Reliability	MI-HDBK 217F, GB (Part-Stress): MTBF >40000 hours (max. 2.5% errors/1000 h)

Charge Injection Calibration Technique patented according to US Patent No. 5,400,297. The patent includes the measurement method and its implementation.

Ordering Information

Type 2669 L 1/2″ Microphone Preamplifier (LEMO connector)
Includes the following accessories:
DP 0901: 1/2″ Cylindrical Adaptor
AO 0419: Microphone Cable 3 m (9.8 ft.)
or as a special order:
EL 4006-AC 0219-x: Microphone Cable length x m (specified by customer)

Type 2669 B 1/2″ Microphone Preamplifier (Brüel & Kjær connector)
Includes the following accessories:
DP 0901: 1/2″ Cylindrical Adaptor
AO 0428: Microphone Cable 3 m (9.8 ft.)
or as a special order:
EL 4005-AC 0219-x: Microphone Cable length x m (specified by customer)

Type 2669 C 1/2″ Microphone Preamplifier (no cable included)

Optional Accessories

ZG 0350: LEMO to 7-pin Brüel & Kjær adaptor
JJ 2617: Input Adaptor (51 pF). Is screwed directly onto a preamplifier for connection to microplug cables
UA 0196: Flexible Extension Rod
DB 0375: 1/2″ to 1″ Adaptor
UA 0035: 1/2″ to 1/4″ Adaptor
UA 0036: 1/2″ to 1/8″ Adaptor
UA 1317: 1/2″ Microphone Holder
BA 5105: Microphone Handbook
WB 0850: Insert Junction Adaptor for Type 2669 B/2669 L with Adaptor ZG 0350. For Charge-injection Calibration

Extension Cables
LEMO to LEMO:
AO 0414: 3 m (9.8 ft.)
AO 0415: 10 m (32.8 ft.)
AO 0416: 30 m (98.4 ft.)
EL 4004-AC 0079-x: Length x m (specified by customer)
AR 0014: Flat Cable, 0.5 m (1.64 ft)

Brüel & Kjær reserves the right to change specifications and accessories without notice

Brüel & Kjær

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TEDS Microphones

A TEDS (Transducer Electronic Data Sheet) microphone is a cartridge and a preamplifier assembled and sealed in a clean environment. The assembly has one type and serial number. Individual TEDS microphone information is programmed in a data chip inside the preamplifier. TEDS microphones are available with CCLD as well as classical preamplifiers. TEDS is standardized in compliance with IEEE 1454.4.

Uses and Features

Uses
- General sound measurements
- Measurement of dynamic pressure fluctuations

Features
- Plug-and-play
- Frequency: 1 Hz to 180 kHz
- Dynamic Range: 6.5 dB to 192 dB

Brüel & Kjær's TEDS Microphones

TEDS Microphone Benefits

The most important benefit of a TEDS microphone is that the actual identity and loaded sensitivity of the cartridge are programmed in the TEDS and thereby readily available for documentation and application purposes. For many Brüel & Kjær TEDS microphones, the individual frequency response is stored on a mini-CD under the S/N ratio of the microphone. During the manufacturing process the unit is sealed in a clean environment, thus eliminating contamination that could later result in reduced performance.

TEDS Templates

All Brüel & Kjær TEDS microphones, except Types 4957, 4958 and 4959, use a template that complies with IEEE P1454.4 V 0.9. A mapping that complies with IEEE 1454.4 V 1.0 is available free of charge for new TEDS microphones.

Data Transmission

Generally, there are two ways that data from the TEDS chip can be transmitted to the analyzer. The simpler way, class 2, uses a separate wire to transmit the data. For classical, LEMO type TEDS preamplifiers, pin 5 is often used for TEDS data transmission. In single-wire systems, like that used with CCLD, the same conductor is used both for signal and data transmission. This is made possible by using an electronic switch to control the mode of the wire (TEDS data or signal mode).

Selecting the Right TEDS Microphone

Brüel & Kjær offers a wide range of TEDS microphones, most of which are based on combined cartridges and preamplifiers that are available as individual units. The first selection criterion is often determined by the front-end input type: classical or CCLD. The second criterion can be the type of sound field for which the microphone is optimized.

Customer-specific TEDS Microphones

Customer-specific solutions can be made, so if you do not see what you are looking for please ask your local Brüel & Kjær sales office for a quote on a customized solution.

Common Specifications

The following pages contain short-form data for the TEDS microphones offered by Brüel & Kjær. For detailed specifications, please see the individual Product Data. Unless otherwise stated all specifications in this Product Data are valid under the following conditions:

CCLD Input Types	24 V compliance voltage
Classical Input Types	120 V_{DC} supply
Dynamic Range Low Limit	Noise floor dB A
Dynamic Range High Limit	3% distortion limit in dB SPL RMS rounded to nearest integer The undistorted peak level will normally be 3 dB higher
Cartridge Sensitivity	Nominal
TEDS Microphone Sensitivity	Stated as the nominal cartridge sensitivity except for small cartridges where the loaded sensitivity differs considerably from the open-circuit sensitivity

Most microphones come with an individual data CD and a calibration chart that includes the typical frequency response. Any microphones that do not include a CD and/or frequency response graph are noted below under each table.

Temperature Range

The read/write temperature range of the TEDS chip is guaranteed by the chip manufacturer up to 85 °C (185 °F) only, but the TEDS chip will survive the full specified temperature range of the TEDS microphone/ preamplifier without any damage.

Standard preamplifier Types 2669, 2670, 2671 and 2699 go to 80 °C (176 °F). High-temperature preamplifier Type 1706 goes to 125 °C (257 °F). Remember also to use cables with the correct temperature range.

Cable Length

TEDS will normally work with cables up to 100 m (328 ft).

Sound Field

In the sections that follow, the microphone specifications are organized by the type of sound field that the microphones are designed to measure.

Free-field microphones are designed to have a flat frequency response in a free field. At higher frequencies, reflections and diffractions cause a pressure increase in front of the diaphragm. If not corrected for, this would result in an increased output voltage from the microphone. Free-field optimization means that the frequency response of the microphone has been designed in such a way that a flat free-field frequency response at 0° angle of incidence is achieved.

Free-field microphones are commonly used for sound measurement in an anechoic chamber or far away from reflecting buildings, etc. Another application area for free-field microphones is general electroacoustic purposes, like loudspeaker and microphone measurements.

Table 1 *Free-field TEDS microphones with Type 4188 ½″ cartridge*

Input	Microphone	Preamplifier	mV/Pa	dB re 1 V/Pa	±2 dB Frequency Range (Hz)	Dynamic Range (dB)
Classical	Type 4188-C/L-001	Type 2669-C/L	31.6	−30	8 to 12.5 k	15.8 to 146
CCLD	Type 4188-A-021	Type 2671	31.6	−30	20 to 12.5 k	19 to 138

Type 4188 is suited for free-field measurements where an extra-robust prepolarized microphone with medium sensitivity is required
Type 4188 TEDS microphones do not come with a data CD nor with typical frequency response on the calibration chart

Table 2 *Free-field TEDS microphones with Type 4189 ½″ cartridge*

Input	Microphone	Preamplifier	mV/Pa	dB re 1 V/Pa	±2 dB Frequency Range (Hz)	Dynamic Range (dB)
Classical	Type 4189-B/C/L-001	Type 2669-B/C/L	50	−26	6.3 to 20 k	15.2 to 146
CCLD	Type 4189-A-021	Type 2671	50	−26	20 to 20 k	16.5 to 134
CCLD	Type 4189-A-031	Type 2699	50	−26	A-weighted*	18 to 131
CCLD	Type 4189-W-003	Type 2671-W-001	50	−26	6.3 to 20 k	16.5 to 134
CCLD	Type 4189-H-041	Type 1706	50	−26	6.3 to 20 k	16.5 to 134

Type 4189 is suited for free-field measurements where a high-sensitivity prepolarized microphone with full 20 kHz bandwidth is preferred
*For more information on A-weighting, see Type 2699 Product Data BP2009

Table 3 *Free-field TEDS microphones with Type 4190 ½″ cartridge*

Input	Microphone	Preamplifier	mV/Pa	dB re 1 V/Pa	±2 dB Frequency Range (Hz)	Dynamic Range (dB)
Classical	Type 4190-B/C/L-001	Type 2669-B/C/L	50	−26	3.15 to 20 k	15 to 148

Type 4190 is designed for free-field measurements where a high-sensitivity externally polarized microphone with full 20 kHz bandwidth is preferred

Table 4 *Free-field TEDS microphones with Type 4191 ½″ cartridge*

Input	Microphone	Preamplifier	mV/Pa	dB re 1 V/Pa	±2 dB Frequency Range (Hz)	Dynamic Range (dB)
Classical	Type 4191-B/C/L-001	Type 2669-B/C/L	12.5	−38	3.15 to 40 k	21.4 to 162

Type 4191 is designed for free-field measurements where a wideband externally polarized microphone is required

Table 5 *Free-field TEDS microphones with Type 4939 ¼″ cartridge*

Input	Microphone	Preamplifier	mV/Pa	dB re 1 V/Pa	±2 dB Frequency Range (Hz)	Dynamic Range (dB)
Classical	Type 4939-A-011	Type 2670	4	−48	4 to 100 k	35 to 164
Classical	Type 4939-C/L-002	Type 2669-C/L with UA-0035	3.5	−49	4 to 100 k	35 to 164

Type 4939 is designed for free-field measurements where a high-frequency, high-level externally polarized microphone is required

Table 6 *Free-field TEDS microphones with Type 4954 ¼″ cartridge*

Input	Microphone	Preamplifier	mV/Pa	dB re 1 V/Pa	±2 dB Frequency Range (Hz)	Dynamic Range (dB)
Classical	Type 4954-A-011	Type 2670	2.8	−51	3 to 80 k	34 to 164
CCLD	Type 4954-A	Integral with SMB	2.8	−51	16 to 80 k	40 to 159
CCLD	Type 4954-B	Integral with 10−32 UNF	2.8	−51	16 to 80 k	40 to 159

Type 4954 is designed for free-field measurements where a high-frequency, high-level prepolarized microphone is required

Table 7 *Free-field TEDS microphones with Type 4966 ½″ cartridge*

Input	Microphone	Preamplifier	mV/Pa	dB re 1 V/Pa	±2 dB Frequency Range (Hz)	Dynamic Range (dB)
CCLD	Type 4966-H-041	Type 1706	50	−26	6.3 to 20 k	16.5 to 134

Type 4966 is suited for free-field measurements where a high-sensitivity prepolarized microphone with full 20 kHz bandwidth is preferred

Pressure-field TEDS Microphones

Pressure-field microphones are optimized to have a flat frequency response in a pressure field. They are used for measurements in small, closed couplers or close to hard, reflective surfaces.

Table 8 *Pressure-field TEDS microphones with Type 4192 ½″ cartridge*

Input	Microphone	Preamplifier	mV/Pa	dB re 1 V/Pa	±2 dB Frequency Range (Hz)	Dynamic Range (dB)
Classical	Type 4192-B/C/L-001	Type 2669-B/C/L	12.5	−38	3.15 to 20 k	20.7 to 162

Type 4192 is designed for pressure-field measurements where a high-sensitivity externally polarized microphone with full 20 kHz bandwidth is preferred

Table 9 *Prepolarized pressure-field TEDS microphones with Type 4956 ½″ cartridge*

Input	Microphone	Preamplifier	mV/Pa	dB re 1 V/Pa	±2 dB Frequency Range (Hz)	Dynamic Range (dB)
CCLD	Type 4956-W-001	Type 2671-W-001	12.5	−38	3.5 to 20 k	26.5 to 135

Type 4956 is designed for pressure-field measurements where a high-frequency, high-level externally polarized microphone is required

Table 10 *Pressure-field TEDS microphones with Type 4938 ¼″ cartridge*

Input	Microphone	Preamplifier	mV/Pa	dB re 1 V/Pa	±2 dB Frequency Range (Hz)	Dynamic Range (dB)
Classical	Type 4938-A-011	Type 2670	1.4	−57	4 to 70 k	42 to 172
Classical	Type 4938-B/C/L-002	Type 2669-B/C/L with UA-0035	1.4	−57	4 to 70 k	42 to 172

Type 4938 is designed for pressure-field measurements where a high-frequency, high-level externally polarized microphone is required

Table 11 *Pressure-field TEDS microphones with Type 4944 ¼″ cartridge*

Input	Microphone	Preamplifier	mV/Pa	dB re 1 V/Pa	±2 dB Frequency Range (Hz)	Dynamic Range (dB)
Classical	Type 4944-A	Integral with SMB	0.9	−61	16 to 70 k	48 to 169
Classical	Type 4944-B	Integral with 10−32 UNF	0.9	−61	16 to 70 k	48 to 169

Type 4944 is designed for pressure-field measurements where a high-frequency, high-level prepolarized microphone is required

Table 12 *Pressure-field TEDS microphones with Type 4138 1/8″ cartridge*

Input	Microphone	Preamplifier	mV/Pa	dB re 1 V/Pa	±2 dB Frequency Range (Hz)	Dynamic Range (dB)
Classical	Type 4138-A-015	Type 2670 with UA-0160	0.56	−65	6.5 to 140 k	52.2 to 168
Classical	Type 4138-B/C/L-006	Type 2669-B/C/L with UA-0036	0.8	−62	6.5 to 140 k	52.2 to 168

Type 4138 is designed for pressure-field measurements where an absolute maximal frequency range is required. This microphone is externally polarized
Type 4138 TEDS microphones do not come with a data CD nor with typical frequency response on the calibration chart

Diffuse-field TEDS Microphones

Diffuse-field microphones, also called random-incidence microphones, are designed to have a flat response to signals arriving simultaneously from all directions – that is, a random or diffuse field. They should be used in all situations where the sound field is diffuse, and where several sources contribute to the sound pressure at the measurement position. Applications include indoor measurements where the sound is reflected by walls, ceilings and objects in the room, including in reverberation chambers, and in-cabin measurements.

Table 13 *Diffuse-field TEDS microphones with Type 4942 ½″ cartridge*

Input	Microphone	Preamplifier	mV/Pa	dB re 1 V/Pa	±2 dB Frequency Range (Hz)	Dynamic Range (dB)
Classical	Type 4942-B/C/L-001	Type 2669-B/C/L	50	−26	6.3 to 16 k	15.2 to 146
CCLD	Type 4942-A-021	Type 2671	50	−26	20 to 16 k	18 to 134
CCLD	Type 4942-A-031	Type 2699	50	−26	A-weighted	18 to 131
CCLD	Type 4942-H-041	Type 1706	50	−26	6.3 to 20 k	18 to 134

Type 4942 is designed for diffuse-field measurements where a high-sensitivity prepolarized microphone with wide bandwidth is preferred

Table 14 *Diffuse-field TEDS microphones with Type 4943 ½″ cartridge*

Input	Microphone	Preamplifier	mV/Pa	dB re 1 V/Pa	±2 dB Frequency Range (Hz)	Dynamic Range (dB)
Classical	Type 4943-B/C/L-001	Type 2669-B/C/L	50	−26	3.15 to 10 k	15.9 to 148

Type 4943 is designed for diffuse-field measurements where a high-sensitivity externally polarized microphone is preferred

Special TEDS Microphones

A number of special TEDS microphones are available:

- Infrasound Microphone Type 4193
- High-intensity Pressure-field Microphones Type 4941
- Aerospace Surface Microphone Type 4948
- Automotive Surface Microphone Type 4949
- Low-noise Free-field Microphone Type 4955
- Low-noise Free-field Microphone Type 4955-A, for hand-held analyzers such as Type 2250/2270
- 10 kHz Array Microphone Type 4957
- 20 kHz Array Microphone Type 4958
- Short 20 kHz Array Microphone Type 4959
- Multi-field Microphone Type 4961

Table 15 *Special TEDS Microphones*

Input	Microphone	Preamplifier	mV/Pa	dB re 1 V/Pa	±2 dB Frequency Range (Hz)	Dynamic Range (dB)
Classical	Type 4193-B/C/L-004	Type 2669-B/C/L with UC-0211	2	−54	0.1 to 20 k	29 to 148
Classical	Type 4941-A-011	Type 2670	0.08	−82	4 to 20 k	73.5 to 184
Classical	Type 4941-C-002	Type 2669-C with UA-0035	0.08	−82	4 to 20 k	75.8 to 184
Classical	Type 4955	Integral	1100	0.8	10 to 16 k	6.5 to 110
Classical	Type 4955-A	Integral	1100	0.8	10 to 16 k	6.5 to 110
CCLD	Type 4948	Integral	1.4	−57	5 to 20 k*	55 to 160
CCLD	Type 4949	Integral	11.2	−39	5 to 20 k*	30 to 140
CCLD	Type 4957	Integral	11.2	−39	50 to 10 k	32 to 134
CCLD	Type 4958	Integral	11.2	−39	10 to 20 k	28 to 140
CCLD	Type 4959	Integral	11.2	−39	50 to 20 k	32 to 134
CCLD	Type 4961	Integral	60	−24.5	12 to 20 k	20 to 130

* ±3 dB pressure response limits
Types 4941, 4957, 4958 and 4959 microphones do not come with an individual data CD nor with typical frequency response on the calibration chart

Ordering Information

If you do not see what you are looking for, please ask your local Brüel & Kjær sales office for a quote on a customized solution.

Order No.	Mini CD Incl.	Description
Type 4101-A	No	Binaural Microphone
Type 4138-A-015	No	Pressure-field 1/8″ Mic. Type 4138, Preamp. Type 2670, Adaptor UA-0160
Type 4138-B-006*	No	Pressure-field 1/8″ Mic. Type 4138, Preamp. Type 2669-B, Adaptor UA-0036
Type 4138-C-006	No	Pressure-field 1/8″ Mic. Type 4138, Preamp. Type 2669-C, Adaptor UA-0036
Type 4138-L-006	No	Pressure-field 1/8″ Mic. Type 4138, Preamp. Type 2669-L, Adaptor UA-0036
Type 4188-C-001	No	Prepolarized Free-field 1/2″ Mic. Type 4188, Preamp. Type 2669-C
Type 4188-L-001	No	Prepolarized Free-field 1/2″ Mic. Type 4188, Preamp. Type 2669-L
Type 4188-A-021	No	Prepolarized Free-field 1/2″ Mic. Type 4188, Preamp. Type 2671
Type 4189-B-001*	Yes	Prepolarized Free-field 1/2″ Mic. Type 4189, Preamp. Type 2669-B
Type 4189-C-001	Yes	Prepolarized Free-field 1/2″ Mic. Type 4189, Preamp. Type 2669-C
Type 4189-L-001*	Yes	Prepolarized Free-field 1/2″ Mic. Type 4189, Preamp. Type 2669-L
Type 4189-A-021	Yes	Prepolarized Free-field 1/2″ Mic. Type 4189, Preamp. Type 2671
Type 4189-A-031	Yes	Prepolarized Free-field 1/2″ Mic. Type 4189, Preamp. Type 2699
Type 4189-H-041	Yes	Prepolarized Free-field 1/2″ Mic. Type 4189, Preamp. Type 1706
Type 4189-W-003	Yes	Prepolarized Free-field 1/2″ Mic. Type 4189, Preamp. Type 2671-W-001
Type 4190-B-001*	Yes	Free-field 1/2″ Mic. Type 4190, Preamp. Type 2669-B
Type 4190-C-001	Yes	Free-field 1/2″ Mic. Type 4190, Preamp. Type 2669-C
Type 4190-L-001	Yes	Free-field 1/2″ Mic. Type 4190, Preamp. Type 2669-L
Type 4190-L-002	Yes	Free-field 1/2″ Mic. Type 4190, Preamp. Type 2669-L, Adaptor UA-1260
Type 4191-B-001*	Yes	Free-field 1/2″ Mic. Type 4191, Preamp. Type 2669-B
Type 4191-C-001	Yes	Free-field 1/2″ Mic. Type 4191, Preamp. Type 2669-C
Type 4191-L-001	Yes	Free-field 1/2″ Mic. Type 4191, Preamp. Type 2669-L
Type 4192-B-001*	Yes	Pressure-field 1/2″ Mic. Type 4192, Preamp. Type 2669-B
Type 4192-C-001	Yes	Pressure-field 1/2″ Mic. Type 4192, Preamp. Type 2669-C
Type 4192-L-001	Yes	Pressure-field 1/2″ Mic. Type 4192, Preamp. Type 2669-L
Type 4193-B-004*	Yes	Pressure-field 1/2″ Mic. Type 4193, Preamp. Type 2669-B, Adaptor UC-0211
Type 4193-C-004	Yes	Pressure-field 1/2″ Mic. Type 4193, Preamp. Type 2669-C, Adaptor UC-0211
Type 4193-L-004	Yes	Pressure-field 1/2″ Mic. Type 4193, Preamp. Type 2669-L, Adaptor UC-0211
Type 4938-A-011	Yes	Pressure-field 1/4″ Mic. Type 4938, Preamp. Type 2670
Type 4938-C-002	Yes	Pressure-field 1/4″ Mic. Type 4938, Preamp. Type 2669-C, Adaptor UA-0035
Type 4938-L-002	Yes	Pressure-field 1/4″ Mic. Type 4938, Preamp. Type 2669-L, Adaptor UA-0035
Type 4939-A-011	Yes	Free-field 1/4″ Mic. Type 4939, Preamp. Type 2670
Type 4939-C-002	Yes	Free-field 1/4″ Mic. Type 4939, Preamp. Type 2669-C, Adaptor UA-0035
Type 4939-L-002	Yes	Free-field 1/4″ Mic. Type 4939, Preamp. Type 2669-L, Adaptor UA-0035
Type 4941-A-011	No	High-level Pressure-field 1/4″ Mic. Type 4941, Preamp. Type 2670
Type 4941-C-002	No	High-level Pressure-field 1/4″ Mic. Type 4941, Preamp. Type 2669-C, Adaptor UA-0035
Type 4942-B-001*	Yes	Prepolarized Diffuse-field 1/2″ Mic. Type 4942, Preamp. Type 2669-B
Type 4942-C-001	Yes	Prepolarized Diffuse-field 1/2″ Mic. Type 4942, Preamp. Type 2669-C
Type 4942-L-001	Yes	Prepolarized Diffuse-field 1/2″ Mic. Type 4942, Preamp. Type 2669-L
Type 4942-A-021	Yes	Prepolarized Diffuse-field 1/2″ Mic. Type 4942, Preamp. Type 2671
Type 4942-A-031	Yes	Prepolarized Diffuse-field 1/2″ Mic. Type 4942, Preamp. Type 2699
Type 4942-H-041	Yes	Prepolarized Diffuse-field 1/2″ Mic. Type 4942, Preamp. 1706

Order No.	Mini CD Incl.	Description
Type 4943-B-001*	Yes	Diffuse-field 1/2″ Mic. Type 4943, Preamp. Type 2669-B
Type 4943-C-001	Yes	Diffuse-field 1/2″ Mic. Type 4943, Preamp. Type 2669-C
Type 4943-L-001	Yes	Diffuse-field 1/2″ Mic. Type 4943, Preamp. Type 2669-L
Type 4944-A	No	Pressure-field 1/4″ Mic. Type 4944 with SMB socket
Type 4944-B	No	Pressure-field 1/4″ Mic. Type 4944 with 10–32 UNF socket
Type 4948	No	Aerospace Surface Microphone
Type 4949	No	Automotive Surface Microphone
Type 4954-A	No	Free-field 1/4″ Mic. Type 4954 with SMB socket
Type 4954-B	No	Free-field 1/4″ Mic. Type 4954 with 10–32 UNF socket
Type 4954-A-011	Yes	1/4″ Prepolarized Free-field Mic. Type 4954, Preamp. Type 2670
Type 4955	Yes	1/2″ Low-noise Free-field Microphone
Type 4955-A	Yes	1/2″ Low-noise Free-field Microphone for hand-held analyzers such as Type 2250/2270
Type 4956-W-001	Yes	Prepolarized Pressure-field 1/2″ Mic. Type 4956 with Preamp. Type 2671-W-001
Type 4957†	No	10 kHz Array Microphone
Type 4958‡	No	20 kHz Precision Array Microphone
Type 4959	No	Short 20 kHz Array Microphone
Type 4966-H-041	Yes	Prepolarized Free-field 1/2″ Mic. Type 4966 with Preamp. Type 1706
Other TEDS Related Equipment		
BZ-5294	–	TEDS Editor Kit
ZZ-0245	–	In-line TEDS Adaptor for CCLD Transducer without TEDS
Type 2467-A	–	1 mV/pC Charge to CCLD Converter with TEDS
Type 2647-B	–	10 mV/pC Charge to CCLD Converter with TEDS
Type 2647-C	–	0.1 mV/pC Charge to CCLD Converter with TEDS

* These types are delivered with a LEMO to Brüel & Kjær cable AO-0428. This cable does **NOT** support TEDS
† TEDS to IEEE 1454.4, V1.0, UDID No. 127–0–0–0U
‡ TEDS to IEEE 1454.4, V1.0, UDID No. 127–0–0–1 U with complex transfer function

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Brüel & Kjær

PRODUCT DATA

½″ Prepolarized Infrasound Microphone Type 4964

Type 4964 is designed for high-precision, acoustic measurements where an infrasound microphone with high sensitivity is required. Being prepolarized, Type 4964 can be used with both CCLD and classical preamplifiers.

130187

Uses
- General noise measurements
- Wind turbine measurements
- Sonic boom measurements

Features
- Sensitivity: 50 mV/Pa
- Frequency: 0.02 Hz – 20 kHz (±3 dB)
- Dynamic Range: 14.6 – 146 dB
- Temperature: –30 to +150°C (–22 to +302°F)
- Polarization: Pre-polarized

Use of Free-field Microphones
Free-field means that the frequency response at 0 degrees incidence is flat. Free-field microphones are commonly used, for example, for recording sound measurements in anechoic chambers and far away from reflecting buildings. Another area for free-field microphones is for general electroacoustic measurement purposes like loudspeaker and microphone measurements.

At infrasound and frequencies below a few kHz, the pressure and free-field response are the same. At higher frequencies, reflections and diffractions cause pressure to increase in front of a microphone's diaphragm. Type 4964 has been optimized for free-field, and designed for use with the protection grid in place.

Type 4964 is also suited for use in class 1 sound level meters and for all high-precision acoustic measurements where a robust and stable free-field microphone with an upper frequency of 20 kHz is required.

Manufacturing and Stability
A press-fitted, stainless-steel diaphragm ensures superior long-term stability and mechanical robustness – Type 4964 will withstand the 1 m drop test of IEC 60068–2–32.

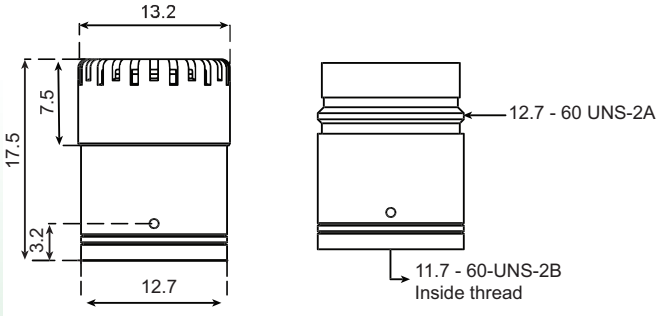
All Brüel & Kjær measuring microphones are assembled in a clean room. This ensures that the microphones maintain their inherent low noise floor and high stability, even when used in environments with a combination of high humidity and high temperature.

Polarization Voltage
Being prepolarized, Type 4964 is especially well-suited for battery operated equipment and operation in environments with high humidity.

Individual Calibration Data
Each Type 4964 comes with an individual calibration chart including information about the open-circuit sensitivity, the frequency response in a free field as well as the electrostatic actuator response.

An enclosed mini-CD contains the individual calibration data at 1/12-octave frequencies plus a wealth of technical information, such as the influence of different accessories, response in different sound fields and much more. Using the CD data and the REq-X feature of PULSE™, a real-time correction for different measurement situations, can increase measurement accuracy.

Fig. 1 *Physical specifications of Type 4964*



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Brüel & Kjær

Specifications – Prepolarized Infrasound Microphone Type 4964 (valid for serial number 2495 387)

Specification	Value
IEC 61094–4 Type Designation	WS2F
Polarization Voltage (external)	0 V (prepolarized)
Open-circuit Sensitivity (250 Hz)*	50 mV/Pa, –26 dB ±1.5 dB re 1 V/Pa)
0° Incidence Free-field Response*	0.04 Hz to 8 kHz: ±1 dB 0.03 Hz to 20 kHz: ±2 dB
Lower Limiting Frequency (–3 dB)*	0.01 to 0.05 Hz
Pressure Equalization Vent	Rear vented
Diaphragm Resonsance Frequency	14 kHz (90° phase shift)
Cartridge Capacitance (Polarized)*	14 pF at 250 Hz
Equivalent Air Volume	46 mm^3 (250 Hz)
Pistonphone Correction	0.00 dB (with Type 4228 and DP-0776)
Cartridge Thermal Noise	14.6 dB(A), 15.3 dB(Lin)
Upper Limit of Dynamic Range†	3% Distortion: >148 dB SPL Max. SPL: 158 dB (peak)
Environmental	
Operating Temperature Range	–30 to +150°C (–22 to +302°F)
Storage Temperature (in Microphone Box)	–30 to +70°C (–22 to +158°F) With mini-CD: +5 to +150°C (+41 to 122°F)
Temperature Coefficient (250 Hz)	–0.006 dB/K (–10 to +50°C/+14 to 122°F)
Pressure Coefficient	–0.01 dB/kPa
Operating Humidity Range	0 to 100% RH (without condensation)
Influence of Humidity	<0.1 dB in the absence of condensation
Vibration Sensitivity (<1000 Hz)	62.5 dB, ≈ SPL for 1 m/s^2 axial vibration
Magnetic Field Sensitivity	6 dB SPL for 80 A/m, 50 Hz field
Estimated Long-term Stability	>1 dB/1000 years in dry air at 20°C (68°F) >2 hours/ dB in dry air at 150°C (302°F) >40 years/ dB in air at 20°C (68°F), 90% RH >1 dB/year in air at 50°C (122°F), 90% RH
Physical	
Thread for Preamplifier Mounting	11.7 mm–60 UNS
Diameter with Grid	13.2 mm (0.52″)
Diameter without Grid	12.7 mm (0.50″)
Height with Grid	17.6 mm (0.69″)
Height without Grid	16.3 mm (0.64″)

* Individually calibrated
† 137 dB (peak) with CCLD preamplifier and 24 V supply and 140 (peak) with ±15 V supply

Ordering Information

Type 4964 ½″ Prepolarized Infrasound Microphone Type 4964
Includes the following accessories:
- BC-0224: Calibration Chart‡
- BC-5002: Microphone Mini-CD‡

Optional Accessories	
Type 1706	½″ CCLD High Temperature Preamplifier
Type 2669	½″ Microphone Preamplifier
2671-W-001	½″ CCLD Preamplifier (version with LLF <1.2 Hz)
Type 2699	½″ CCLD Preamplifier, A-weighted
Type 4231	Sound Calibrator
Type 4228	Pistonphone
Type 4226	Multifunction Acoustic Calibrator
DP-0776	Calibration Adapter for ½″ Microphones
UA-0033	Electrostatic Actuator
UA-1260	½″ Angle Adaptor (approx. 80°)
UA-0386	Nose Cone for ½″ Microphone
UA-0237	Windscreen for ½″ microphone, 90 mm diameter
UA-0459	Windscreen for ½″ Microphone, 65 mm diameter
Calibration Services	
4964-CAI	Accredited Initial Calibration
4964-CAF	Accredited Calibration
4964-CFF	Factory Standard Calibration

CE
Compliance with EMC Directive and Low Voltage Directive of the EU
Compliance with the EMC requirements of Australia and New Zealand

‡ State microphone serial number if re-ordering calibration data

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Local representatives and service organisations worldwide

Brüel & Kjær

PRODUCT DATA

½″ Prepolarized Free-field Microphone Type 4966

Type 4966 is designed for high-precision, free-field measurements where a microphone with high sensitivity is required. Being prepolarized, Type 4966 can be used with both CCLD‡ and classical Brüel & Kjær preamplifiers.

160180

Uses

- Precision sound-measurements
- General purpose sound-measurements
- Electroacoustic measurements

Features

- Sensitivity: 50 mV/Pa
- Frequency: 5 Hz to 20 kHz
- Dynamic Range: 14.6 to 144 dB
- Temperature: −30 to +150 °C (−22 to +302 °F)

Description

Type 4966 is a robust and stable free-field microphone cartridge designed for high-precision acoustic measurements. It is developed and refined for measurements where a high sensitivity microphone with a full 20 kHz bandwidth is preferred and is optimized for use with the protection grid in place. Type 4966 is prepolarized, so it is well suited for use in battery-operated equipment and environments with high humidity.

Because this microphone is optimized for free-field environments, it has a flat free-field response at 0° incidence. This makes Type 4966 ideal for use in anechoic chambers or far away from reflective surfaces, such as buildings, and for general electroacoustic measurement purposes, such as loudspeaker and microphone measurements.

Manufacturing and Stability

The press-fitted, stainless-steel diaphragm of Type 4966 ensures superior long-term stability and mechanical robustness, withstanding the 1 m drop test according to IEC 60068−2−32.

All Brüel & Kjær measuring microphones are assembled in a clean room. This ensures that the microphones maintain their low noise floor and high stability even in environments with a combination of high humidity and high temperature.

TEDS Microphone

Type 4966-H-041 is a transducer electric data sheet (TEDS) combination of Type 4966 and High-temperature CCLD Microphone Preamplifier Type 1706. The TEDS template is based on IEEE P1451.4 and programmed with the loaded sensitivity of the actual cartridge. This combination can be used for measurements up to 125 °C (257 °F) making it suitable for use in a broad range of applications. Brüel & Kjær offers a selection of cables, including cables for use at higher temperatures.

TEDS microphones are considered one unit because the cartridge is sealed to the preamplifier in production.

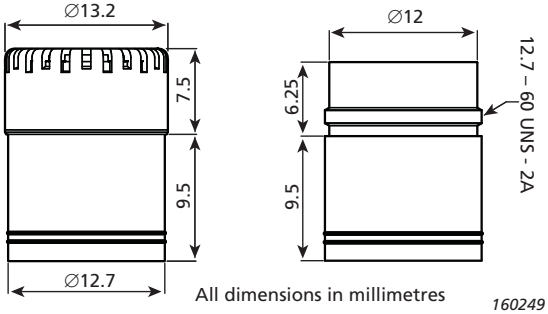
Individual Calibration Data

All calibration data for Brüel & Kjær transducers is now available electronically. Find calibration charts and correction factors at bksv.com/calibrationdata and select Search Calibrations.

Calibration charts include information about the open-circuit sensitivity, the frequency response in a free field and the electrostatic actuator response.

Correction factors contain individual calibration data at 1/12-octave frequencies and technical information, such as the influence of different accessories and the microphone's response in different sound fields. For example, use data and the REq-X feature of PULSE™ for a real-time correction under different measurement situations to increase measurement accuracy.

Fig. 1 *Dimensions of Type 4966*



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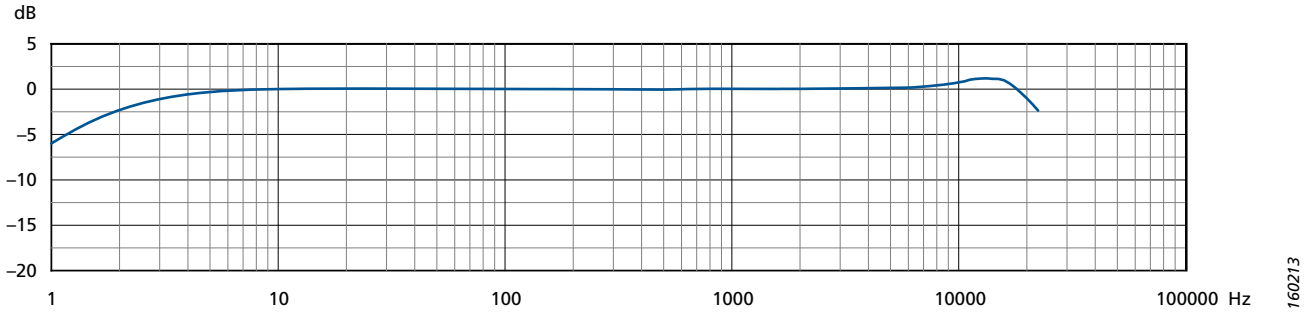
‡ CCLD: Constant current line drive, also known as DeltaTron® (IEPE compatible)

Brüel & Kjær

Fig. 2 *Typical free-field response of the microphone cartridge with protection grid. The low-frequency response is valid when the vent is exposed to the sound field*



Specifications – ½″ Free-field Microphone Type 4966

Type No.	4966
General	
IEC 61094–4 Type Designation	WS2F
Polarization Voltage	0 V (prepolarized)
Open-circuit Sensitivity (250 Hz)*	50 mV/Pa, –26 ± 1.5 dB re 1 V/Pa
0° Incidence Free-field Response*	10 Hz to 8 kHz: ±1 dB 5 Hz to 20 kHz: ±2 dB
Lower Limiting Frequency (LLF)(–3 dB)*	1 to 3 Hz
Pressure Equalization Vent	Rear vented
Cartridge Capacitance*	14 pF at 250 Hz
Pistonphone Correction (Type 4228 with DP-0776)	0.00 dB
Cartridge Thermal Noise	14.9 dB(A), 15.4 dB(Lin)
Upper Limit of Dynamic Range (3% Distortion)	>144 dB SPL†
Max. Sound Pressure Level	158 dB (peak)
Environmental	
Operating Temperature Range	–30 to +150 °C (–22 to +302 °F)
Storage Temperature In Microphone Box	–30 to +70 °C (–22 to +158 °F)
With Mini-CD	5 to 50 °C (41 to 122 °F)
Temperature Coefficient (250 Hz)	+0.003 dB/K (–10 to +50 °C, 14 to 122 °F)
Pressure Coefficient	–0.012 dB/kPa
Operating Humidity Range	0 to 100% RH (without condensation)
Influence of Humidity	<0.1 dB in the absence of condensation
Vibration Sensitivity (<1000 Hz)	62.5 dB equivalent SPL for 1 m/s^2 axial vibration
Magnetic Field Sensitivity	6 dB SPL for 80 A/m, 50 Hz field
Estimated Long-term Stability	<1 dB/1000 years in dry air at 20 °C (68 °F)
	<1 dB/2 hours in dry air at 150 °C (302 °F)
	<1 dB/40 years in 90% RH at 20 °C (68 °F)
	<1 dB/1 year in 90% RH at 50 °C (122 °F)

* Individually calibrated

† 137 dB (peak) with DeltaTron preamplifier and 24 V supply and 140 dB (peak) with ±15 V supply

All values are typical at 23 °C (73.4 °F), 101.3 kPa and 50% RH unless otherwise specified

Ordering Information

Type 4966 ½″ Prepolarized Free-field Microphone‡

TEDS COMBINATION

Type 4966-H-041 Type 4966 with Type 1706‡

OPTIONAL ACCESSORIES

Type 2669 ½″ Microphone Preamplifier

Type 1706 ½″ CCLD Microphone Preamplifier (LLF: <3 Hz)

Type 2671-W-001 ½″ CCLD Microphone Preamplifier (LLF: <1.2 Hz)

Type 2699 ½″ CCLD Microphone Preamplifier, A-weighted

Type 4231 Sound Calibrator

Type 4228 Pistonphone

Type 4226 Multifunction Acoustic Calibrator

DP-0776 Calibration Adaptor for ½″ Microphones

UA-0033 Electrostatic Actuator

UA-1260 ½″ Angle Adaptor (approx. 80°)

UA-0386 Nose Cone, ½″ microphone

UA-0237 Windscreen, ½″ microphone, ∅ 90 mm

UA-0459 Windscreen, ½″ microphone, ∅ 65 mm

CALIBRATION SERVICES

4966-CAI Accredited Initial Calibration

4966-CAF Accredited Calibration

4966-CFF Factory Standard Calibration

COMPLIANCE WITH STANDARDS

‡ Calibration data can be found at bksv.com

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