

SYSTEM SUMMARY

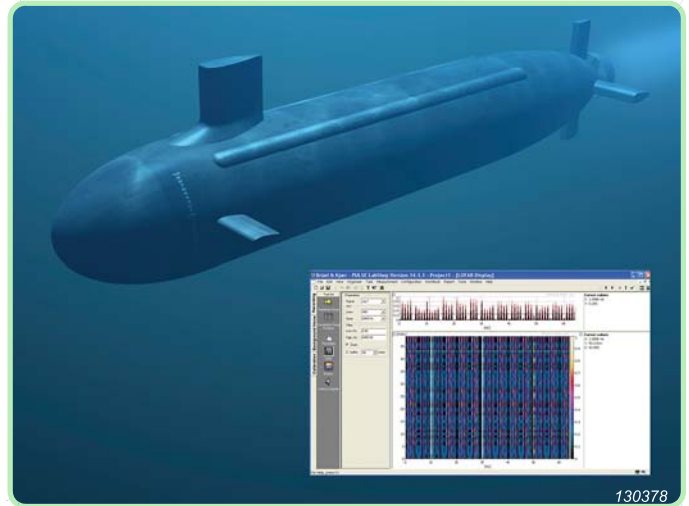
Self-noise Monitoring System

The Brüel & Kjær Self-noise Monitoring System (SNMS) is a permanently-installed, integrated solution for vibration and noise monitoring of submarines and other vessels where management of the acoustic signature is vital.

Acoustic detection and identification techniques continuously become more advanced and sophisticated. As they evolve, so must acoustic stealth strategies. To maintain acoustic discretion, all noise sources of a vessel must be considered, including personnel, on-board equipment and cavitation, as well as the radiated noise signature of the vessel as a whole.

Brüel & Kjær has extensive experience with underwater acoustics and testing solutions that can be used in application-specific tasks, from investigating, analysing and identifying noise sources to validating advanced designs.

Based on Brüel & Kjær's Commercial-off-the-Shelf (COTS) PULSE™ platform, the SNMS integrates LAN-XI data acquisition hardware and PULSE software applications to provide a fully integrated solution for monitoring and analysing noise sources.



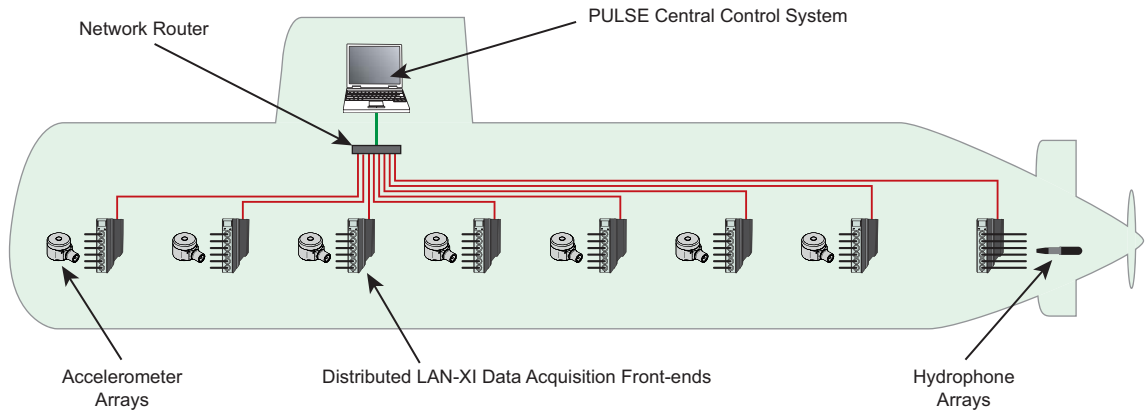
System Overview

The SNMS performs monitoring and analysis of structure-borne and cavitation noise generated in the submarine or surface vessel, from a series of sensor arrays fitted at selected positions throughout the vessel. The purpose is to assist ship staff to maintain a low-noise signature. The SNMS' main functions are as follows:

- Measuring the vibration of the hull, and the hydrodynamic noise
- Monitoring, recording, analysing and listening to the various noise sources within the vessel for the purposes of carrying out noise surveillance and cavitation monitoring
- Continuously and automatically monitoring to ensure that limits for both broadband (third-octave) and narrow-band noise are not exceeded
- Recording and storing the measured spectra for subsequent recall for examination or comparison with other similar records
- Provide facilities whereby an operator may setup and control the SNMS functions, and display the results of the various measurements, analyses and recordings
- Provide a network interface to command and control systems for exchange of data/alarm information, and for remote access to the self-noise monitoring system

The system comprises permanently installed transducers (hull mounted accelerometers and external hydrophones), transducer power supply, data acquisition, data analysis, storage and display and data interface, see Fig. 1.

Fig. 1
SNMS System architecture – the main system components are the LAN-XI front-ends, which can be located at different positions throughout the vessel



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Sensors

Brüel & Kjær has a wide range of OEM sensors for diverse naval applications. Ranging from high-sensitivity hydrophones to radiation-hardened, EMI-immune and water-proof accelerometers designed for extreme long-term operating conditions, (see Fig. 2).

Fig. 2
A variety of noise and vibration sensors are available



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Strategically mounted accelerometers and hydrophones provide input to the measuring/monitoring system.

Hydrophones are used for cavitation sensing and waterborne noise monitoring, and accelerometers for hull vibration monitoring.

CVLD Sensor Technology

In the high electro-magnetic environments often found around the heavy machinery in ships, it can be a challenge to prevent noise-pickup from corrupting the low level vibro-acoustic signals measured.

Constant Voltage Line Drive (CVLD) sensor technology can be used to advantage to reduce noise pick-up. The CVLD sensor produces the signal as a modulated current rather than a voltage, and is thus not sensitive to EMI induced voltage signals – even in long sensor cables.

Data Acquisition

Fig. 3
LAN-XI data
acquisition hardware



The main system component of the SNMS is the LAN-XI data acquisition hardware, which is a versatile system of modular units that can be combined in frames, set up as distributed or used as a stand-alone data acquisition system.

Typically, the LAN-XI modules are distributed around the vessel at suitable locations close to the sensors to ensure maximum flexibility and short runs of expensive analogue signal cabling.

The modules are robust, extremely compact units well suited for mounting in the often hot and confined spaces of a submarine. The LAN-XI modules provide all data acquisition, powering and conditioning functionality:

- Acquiring accelerometer and hydrophone signals
- Providing power for array accelerometers and hydrophones
- Conditioning, filtering and amplifying signals
- Performing analog to digital conversion on signals, with suitable anti-alias filtering
- Transmitting signals to the central control station via the LAN

High Dynamic Range

The LAN-XI data acquisition units provide a very high dynamic input range. From the quietest of whispers to the loudest of bangs, Brüel & Kjær's 160 dB DYN-X input technology ensures that the input ranging of the units is always optimal – avoiding high-level overloads at the same time as utilising the extreme low noise floor.

Wide Frequency Range

The family of LAN-XI hardware comprises a number of module types, optimised for different applications. Modules are available that can measure up to 25.6, 51.2, 102.4 and 204.8 kHz (with a corresponding sampling frequency of 65.5, 132, 264 and 528 kHz, respectively).

Local Area Network (LAN)

Interfacing between the data acquisition hardware and acquisition workstation is via standard TCP/IP technology. This offers the flexibility of using standard copper/fibre transmission, providing high-speed, redundant networks.

Powering the Modules via POE

Power over Ethernet (POE) means the power needed for each input module is carried by the LAN cables rather than by separate power cables. This minimises the number of cables required, resulting in lower cost, faster setup, easier maintenance, and greater installation flexibility.

Synchronising the Modules via PTP

IEEE standardised LAN network protocol is used to synchronize the different modules in the system with sub-microsecond accuracy. This can be used with any LAN-XI module, either as stand-alone, in a frame, or in a distributed system. All modules distributed throughout the vessel can be synchronized using the same LAN cabling as the signal and module power.

Central Control Station

At the central control station operators have immediate access to all sensor channels in the system, and it is from this location the analysis and data management takes place. The workstation runs a full suite of PULSE application software, comprising many functions and displays, such as third-octave, narrowband FFT, waterfall, Demon and Lofar analysis, and many more.

The complete operation of the SNMS is controlled by a dedicated application. A customer user interface would typically provide:

- System setup
- Automated and user initiated scans
- Ability to listen to any signal
- Warning/Alarms indication
- Detailed signal analysis and troubleshooting

The workstation is optimised to manage the large data throughput and real-time analysis requirements required by the application.

Audio Monitoring

An audio monitor function provides operators with the ability to listen to any signal from any sensor. This is especially useful for monitoring of cavitation.

System Enhancements

Portable Machinery Vibration Surveys

Fig. 4
Hand-held Analyzer
Type 2250-H



Portable vibration meters are available for manual machinery vibration surveys and troubleshooting to examine and monitor parts, assemblies and sub-assemblies for increased vibration. Brüel & Kjær's Hand-held Analyzer Type 2250-H would be ideal for this task, see Fig. 4.

High vibration levels can be analysed 'on the spot' using detailed vibration analysis tools, and pass/fail tolerance level bands can be configured.

Carry-on Systems

For applications such as acoustic sea trials, noise surveys and ranging, the requirements for the measuring/analysis system may be of more of a short-term nature, rather than permanent installation. Here, between 300 and 400 channel systems (or more) are used as 'carry-on' systems to perform specific time-limited tasks. Data acquisition modules are often located in portable racks for ease of use, rather than being distributed around the vessel. The full range of PULSE analysis tools is available for any and all challenging measurement and analysis tasks.

SNMS Based on COTS Equipment

The SNMS is based on Commercial-Off-The-Shelf (COTS) equipment with an architecture exploiting commercial processing development. This facilitates regular upkeep of both software and hardware, with minimal impact on submarine scheduling, whilst simplifying maintenance practices, system support and training.

The use of COTS equipment reduces total cost of ownership versus earlier bespoke systems, fully addressing twenty-first century demands for technological innovation, adaptability and obsolescence.

