

MR2002-CE Civil Engineering System

The ultimate vibration measurement system from SYSCOM Instruments.

Modular design, rugged packaging and Swiss quality provide reliable performance in civil engineering environments.

The efficient, reliable and easy-to-use MR2002CE RED BOX provides data you always can rely on.

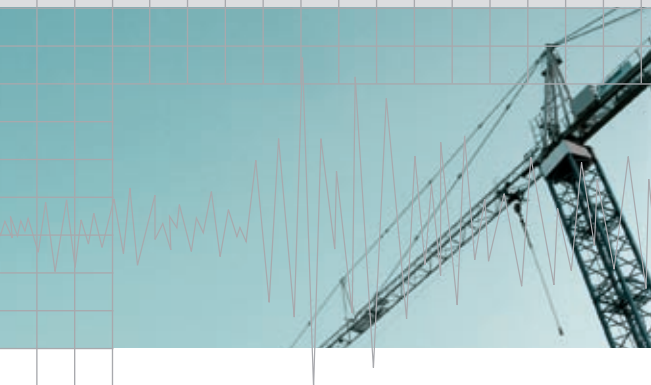
Optional features include:

- RED ALERT Remote Alerting/Remote Control
- RED SAFE Up to 1 GByte Mass Storage
- Networks of up to 8 RED BOXes (up to 24 axis)
- DEEP RED Dynamic Range of 150dB
- Seamless Integration Into existing WAN / WLAN networks



Product Overview

MR2002-CE Civil Engineering System



Sensors

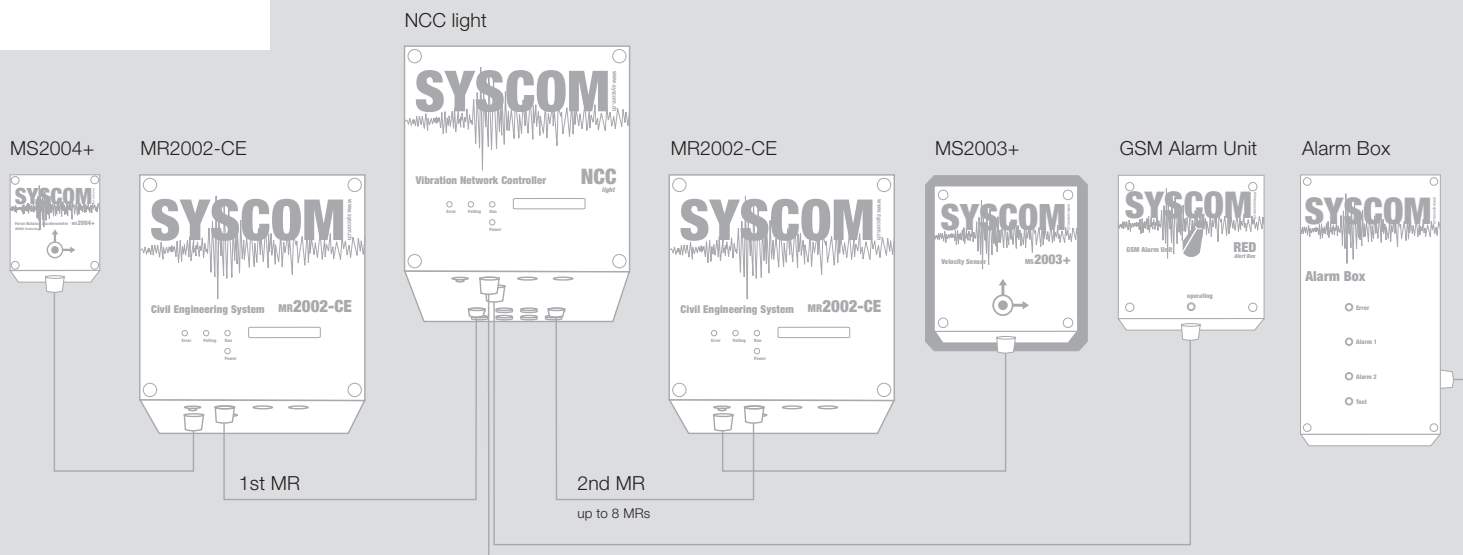
MS2003+ Velocity Sensor

Principle	Active, electronically compensated geophone
Direction	Vertical or Horizontal (Uni-axial), 3 orthogonal directions (tri-axial)
Measuring range	0.0035 to 115 mm/s (option: 0.00007 to 2.3 mm/s) 0.0001378 in/s to 4.528 in/s (option: 0.0000028 in/s to 0.09 in/s)
Frequency range	1 to 315 Hz
Casing	Alu (122 x 120 x 91 mm); approx. 1500 g

MS2004+ Triaxial Accelerometer

Principle	Micro mechanical (MEMS), force balance accelerometer (FBA)
Direction	3 orthogonal directions
Measuring range	0.069 mg to 1 g
Frequency range	0 to 150 Hz
Casing	Aluminium (80 x 75 x 57 mm); approx. 400g

Wiring Diagram



Features

The RED BOX MR2002-CE from SYSCOM is a compact, modular vibration recorder, designed for diverse civil engineering applications. It includes an MR2002CE recording unit and an external triaxial velocity or acceleration sensor, housed in rugged, splash proof, aluminum housings along with sensor mounting plates, cables and PC software. The RED BOX is very easy to install and operate for cost-effective and versatile vibration monitoring.

Dual Recording Mode

For long-term vibration monitoring, dual triggered and background mode recording is an important feature. Triggered recording creates event time histories in waveform files when vibration exceeds a user-specified threshold level. At the same time, the background mode records the peak of the vibration for each user-selectable time window in a peak file. The main frequency calculated by a continuous FFT (optional) may also be stored in the peak files.

Communication Options

Freestanding RED BOXES may be integrated in a wireless network using 802.11 b/g WLAN or GSM/GPRS/EDGE technology. Alarm messages are then sent to an e-mail server. Peak data are continuously sent to the server. Recorded waveform data may be downloaded automatically or selectively whenever required by the user. If transmission capacity and cost considerations are favorable the server may be used to poll stations continuously to retrieve waveform data.

PC Software

Syscom's WINCOM provides easy access to the settings of the RED BOX and to the data stored in the RED BOX. Direct communication via RS-232 or USB and remote access via modem, GSM (in dial-up mode) or GPRS or LAN/WAN (over TCP/IP using static or dynamic IP address - DYNDNS). The VIEW 2002 software provides comprehensive analysis and professional presentation of MR2002-CE RED BOX data. The software license includes analysis in time and frequency domain, statistical data analysis as well as specific analysis according to different national codes such as European (e.g. DIN 4150/2 and Dutch SBR) and US standards.

Interconnection

Syscom's NCC interconnects up to 8 RED BOXES in a star topology network for the simultaneous monitoring of vibrations at different sites. Each station works as an autonomous unit while the NCC provides time synchronization and network management functions including common triggering (all stations start recording if the vibration exceeds the threshold at one site), programmable voting logic to avoid false alarms, and single-point network control for setup and data retrieval on site or from a remote location.

The Master/Slave option interconnects up to 4 RED BOXES in a daisy-chain network. It provides the same features as the NCC, except for the sophisticated trigger and alarm voting logic. Common trigger is initiated by the MASTER only.

Self-Test

The RED BOX provides a continuous self-test function. It assures you at any time that the system is fully operational. A programmable and fully comprehensive system self-test includes memory and battery status as well as a calibration pulse to the sensor. The RED ALERT option allows the RED BOX to send you a daily message to let you know the system is working properly, or to alert you in case of a Warning or Error condition.

Alerting

The ALARM BOX option provides relay contact and supply power for a local alarm (siren, flashing light), and the RED ALERT option provides a remote alarm via a cellular or internet link. Stations, or networks, with the RED ALERT remote alarm option send their alarm messages as text message (SMS), fax messages or e-mail to user-designated people responsible for the project. Subsequently, the data (waveform and peak files) can be selectively uploaded and analyzed without a visit to the project site.

Data Integrity

The recordings in the MR are well protected from being tampered with (it is not possible to delete single files). The RED BOX is equipped with 2 MBytes SRAM as primary storage device where all the data are stored. The RED SAFE option enhances the recording capabilities of the RED BOX and provides a storage capacity of 1/2 hour of waveform recording per MByte - from 16 up to 1000 hours storage on compact flash (CF) memory cards from 32 MBytes to 1 GByte. The most interesting data may be selectively retrieved from the CF card as the card is directly readable on a PC. The contents of the CF card is compressed and protected. The RED BOX handles the writing to the CF card as a separate task that copies the files after complete recording in the primary memory, featuring read after write verification.

Case Studies

Construction Sites

Construction site monitoring to determine the effects of vibration on structures and humans requires rugged and 100% reliable measuring equipment that is easy to install and operate. Immediate corrective action is needed if a pre-defined vibration alarm level is exceeded.

Ready availability of the recorded data is a must. National regulations (e.g. the German DIN 45669-3) ask for a fully comprehensive system operability check after installation.

A single RED BOX with RED ALERT is enough to monitor a simple construction site. For more demanding measurements several free-standing RED BOXes at different sites may be needed. In this case the installation of a wireless network might be more economical (instead of equipping every RED BOX with a RED ALERT. If a local alarm (siren or flashlight) is required, an ALARM BOX should be added. The recording of the peak files give evidence that the system was operational 24 hours a day, 365 days a year.

The RED SAFE option may be useful to reduce site visits to a minimum. The most interesting data may be retrieved after an alarm.

Railway Lines

Vibration measurement along railway lines generally generates a lot of data (e.g. waveform recording of all trains during a 24 hour period) near the tracks and in structures. Three up to 9 measuring points with simultaneous recording, normally vertical measurements only are needed. The data are analyzed in frequency domain by 1/3-octave spectral values. By comparing the spectra of different measuring point the transfer spectra can be calculated. These data are used for modeling and prediction of the propagation of vibration and structure-borne noise (re-radiated rumbling audible sound).

For a simple measurement (1 axis near the tracks, 1 axis at the foundation and 1 axis in the uppermost floor of the structure) a RED BOX with 3 uniaxial sensors is the appropriate choice. For more demanding measurements (2 axis near the tracks, to determine the speed of the train) and simultaneous measurement in more than one structure or at intermediate points, up to 3 RED BOXes, in Master-/Slave interconnection (using wired 4-20 mA interconnection or wireless) is the best choice. The main advantage of such a system, compared to traditional multi-channel systems is its immunity against electromagnetic interference, as the analogue signals from the sensors are not

Assessment of Dynamic Behavior

Determination of the dynamic behavior of structures, e.g. bridges is often used in the context of seismic qualification or to monitor the state-of-health of a structure over time to study effects of ageing or deterioration due to overstraining. The key parameters to be obtained are Eigenfrequency and damping ratio. As for all dynamic measurements, the structure has to be excited, either by ambient noise or by forced vibration (impulsive or harmonic excitation). Of course the use ambient noise is the most convenient method, as no additional machinery is needed, on the other hand this method requires equipment with a very high dynamic range.

Tests on a bridge showed that ambient vibration is sufficient to determine vertical and transverse Eigenfrequencies. The measurement required that traffic be stopped briefly. After decay of all traffic induced vibrations, ten measurements of 20 seconds duration were recorded.

For a simple measurement a single RED BOX, with DEEP RED and RED SAFE option is an ideal choice. Due to the very broad frequency response (1 Hz up to 315 Hz) also large structures with a low Eigenfrequency can be measured. The high dynamic range of up to 150 dB

The full set of data is redundantly stored on the CF card. Data analysis starts with the peak file data to provide an overview. The Peak vs. Frequency plot can then be made. Waveform data of relevant time history series may be analyzed in-depth.



transmitted over a long distance. As the RED BOX located near the track is the master, only vibration caused by the trains are captured and not those with their source within the structure. The RED SAFE option is mandatory to provide sufficient recording capacity.

Data analysis with VEIW2002 is very simple using the methods for statistical analysis of the data. With a mouse click, averaged amplitude or octave band spectra may be computed, or transfer spectra between measuring points calculated. For documentation purposes also the waveform data and their temporal distribution during the measuring period can be visualized, easily.



make sure that the very low amplitudes are captured with a good resolution.

VIEW2002 calculates the average spectra of all measurements (frequency enhancement method) to determine the Eigenfrequencies.



VIEW 2002 Data Analysis Software

Time Domain

Time domain analysis includes the representation of recorded signals as time histories, the calculation of the derived signals such as displacement, velocity and acceleration and the calculation of the vector sum. Filtering of the signals can be made with Butterworth or FFT-Filters. The recorded signals are displayed as triplets (three orthogonal directions). They can be enlarged and displayed for all channels. With Zoom and Point functions the significant parts can be displayed and labeled.

Damping

The damping function calculates Eigenfrequency and damping for a decaying vibration. VIEW 2002 calculates the damping ratio in terms of percent of critical damping (assuming a single degree of freedom system) for the signal section determined by the user. The graphical representation allows a straightforward control of the computed result.

Frequency Domain

Frequency analysis in terms of amplitude or power spectra are readily produced with VIEW 2002. The user interface includes procedures like "zero stuffing" and "windowing" easy to understand. Zoom and point functions allow quick and easy display and labeling of interesting data.

1/3rd Octave Band And Response Spectrum

The representation of the frequency analysis in terms of a 1/3rd octave band spectrum is primarily used in connection with train induced vibrations. Numerous analysis programs for train vibration prediction use these spectra. VIEW 2002 includes two types of 1/3rd octave band spectra: the average 1/3rd octave band spectrum and the maximum octave band spectrum.

Response spectra are calculated with various damping ratios.

File Group Analysis

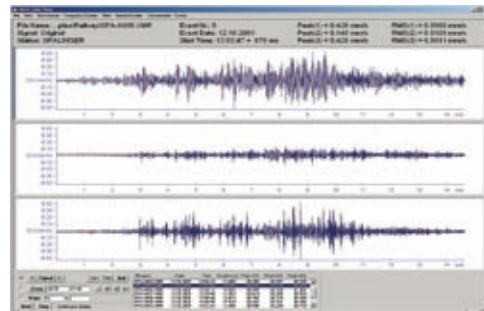
File Group Analysis is a very powerful tool to analyze large amount of data. With this tool, a series of files can be processed and statistically analysed according to the selected method, including: peak values and vector sum; RMS values with threshold values; and, Peak vs. main frequency. Customized analysis methods can be created in the menu « Process Data», where various analysis procedures like Filters, Integration, Differentiation, Frequency analysis etc. can be combined.

Peak VS -Frequency-Diagram

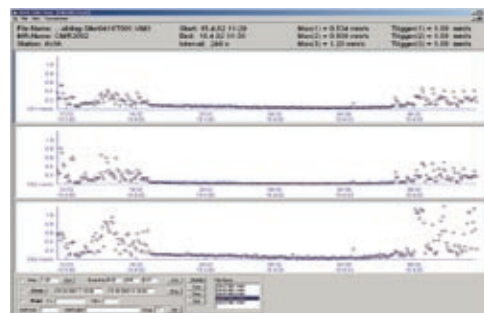
The Peak vs Frequency Diagram with national code limits is fully implemented. Presently the SN 640 312a and DIN 4150/3 are available. Others can be entered by the user.

3-D-Representation

Vibration recordings are not always easy to understand and interpret. With complex vibration time histories a 3-D-representation is often quite helpful. The 3-D-Diagram in VIEW 2002 can be rotated in all directions allowing an optimal display of the vibration process.



VIEW 2002 Data Analysis Software, Waveform File



VIEW 2002 Data Analysis Software, Peak File