ZEN Active Control System
A wideband 3 Channels X-LMS

A powerful, easy-to-use, compact and low cost controller
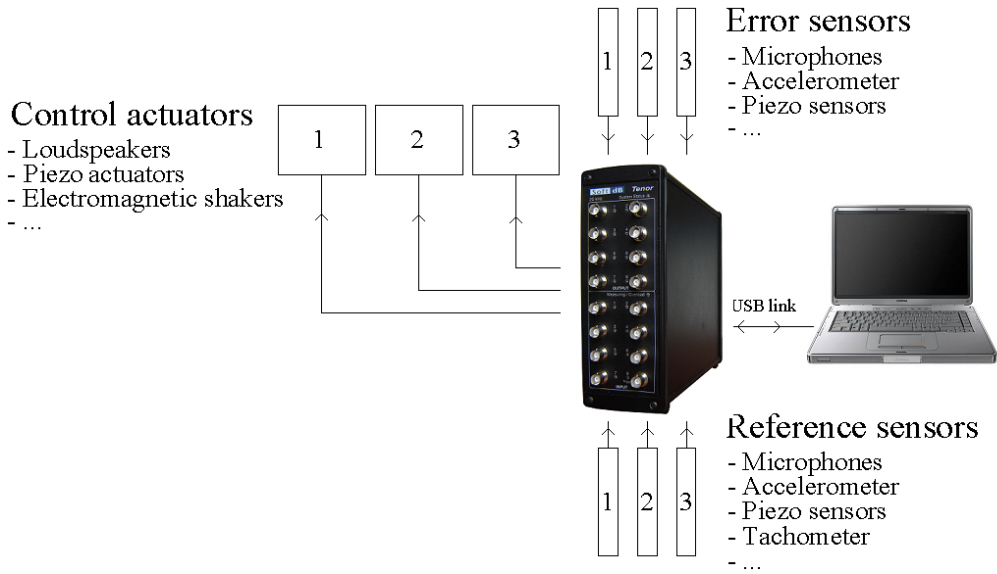

Figure 1   Schematic of the 3-Channel ZEN Active Control System

Main Features

➢ 6 inputs (3 reference signals, 3 error signals) and 3 outputs for the control signals

➢ Real-time X-LMS feed-forward with filtered references and a LMS optimization

➢ Wideband control up to 36 kHz on 3 channels simultaneously

➢ Interaction between each channels take into account (coupled mode) or not (non-coupled mode)

➢ Up to 30 dB of noise reduction (wideband applications) and up to 60 dB of noise reduction (narrow-band applications)[1]

➢ A friendly PC user interface which allows to adjust the algorithm parameters and to analyze the control results

Applications Fields

The ZEN Active Control System is ideal for acoustic and vibration application.

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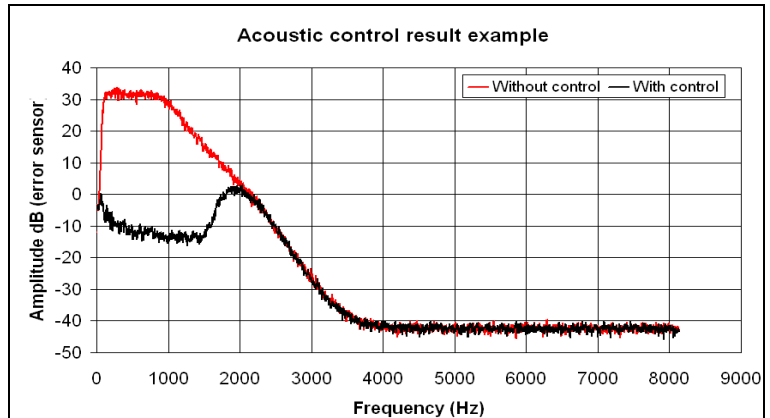
[1] In most real applications, the attenuation is limited by other parameters than the controller (precision or/and dynamic range of the sensors, power and/or linearity of the actuators).

Easy-to-use Controller

The ZEN Active Control System unit can be controlled via a friendly PC user interface. The High-Speed USB-2 connection allows to set the parameters of the controller, but also to see in real time the different signals and filters of the system.
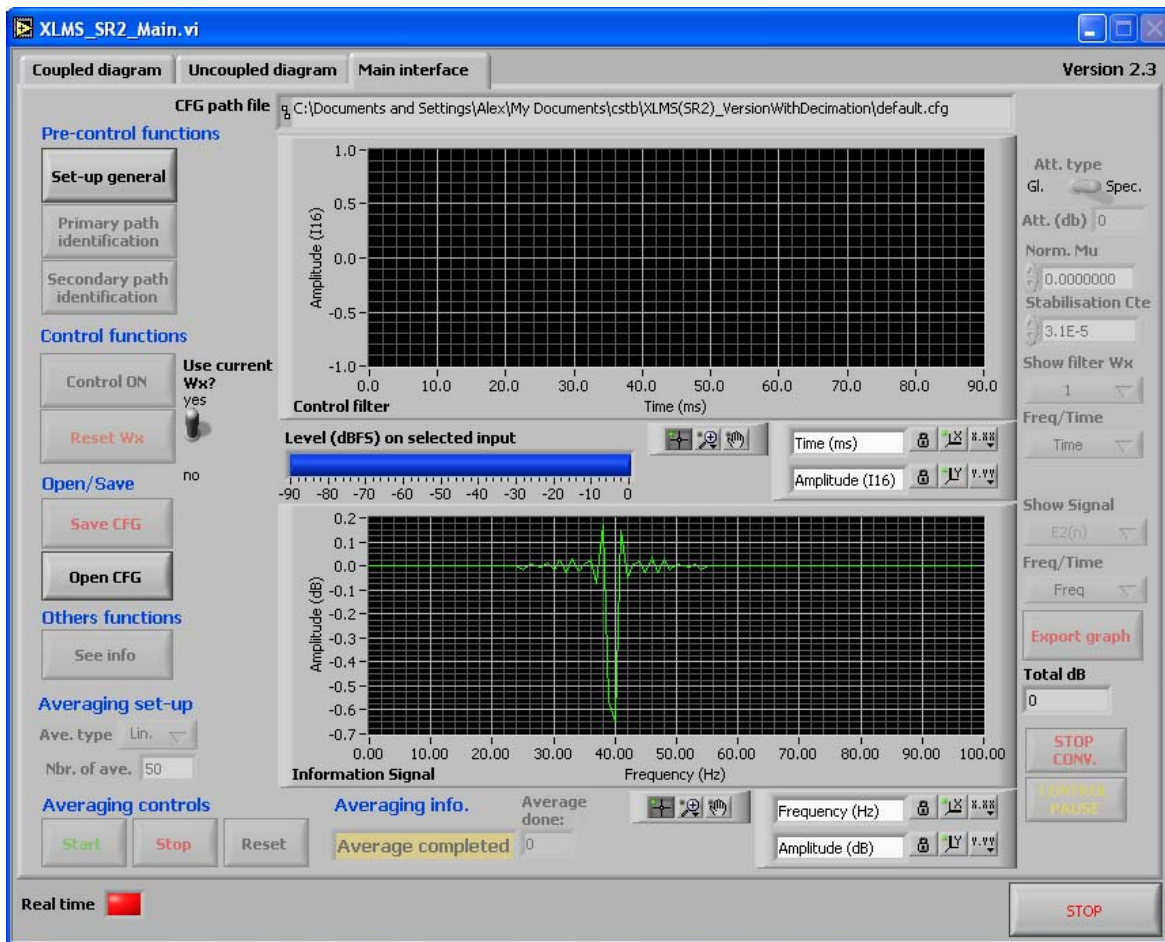
A Powerful Compact Controller

The ZEN Active Control System provides enough power to allow a precise wideband control[2]. For example, with a sampling frequency of 15.6 kHz, the controller can optimize in real time:

➢ 992 coefficients for the non-coupled mode

➢ 290 coefficients for a coupled mode case (assuming 400 coefficients for primary and secondary control paths)

Cost Effective

Based on the powerful but cost effective SR-MK2™ DSP board, the ZEN Active Control System is suitable for research laboratory requirements, but it is also ideal for industrial and commercial applications. Specific version of the ZEN Active Control System can also be provided as an OEM product.

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[2] The number of coefficients of the control filter determines the accuracy of an active wideband controller. More coefficients allows a better definition of the control filter and precision to reduce the signal over the entire frequency band. The maximum number of coefficients for the control filters depends on many factors: the optimization frequency, the number of channels and the number of coefficients for the control filters.

Details of the Control Algorithm Running on the DSP

➢ The X-LMS optimization is done in real time for a selectable sampling frequency up to 78.125 kHz.
➢ In coupled mode, the secondary control cross-paths are taken into account during the LMS optimization.
➢ In non-coupled mode, the control system acts like three separate mono-channel controllers.
➢ The *Reference signal Rx(n)* can be filtered by an adjustable high-pass to remove the DC component of the signal.
➢ The *Error signals Ex(n)* can be filtered by an adjustable high-pass to remove the DC component of the signal.
➢ Adjustable pass-band or low-pass filter on the reference and *Error Signals* to force the control on a specific spectral zone.
➢ Normalized adaptation step size *Mu*
➢ White noise (W.N.) generator can be added to the reference signals for greater control stability.
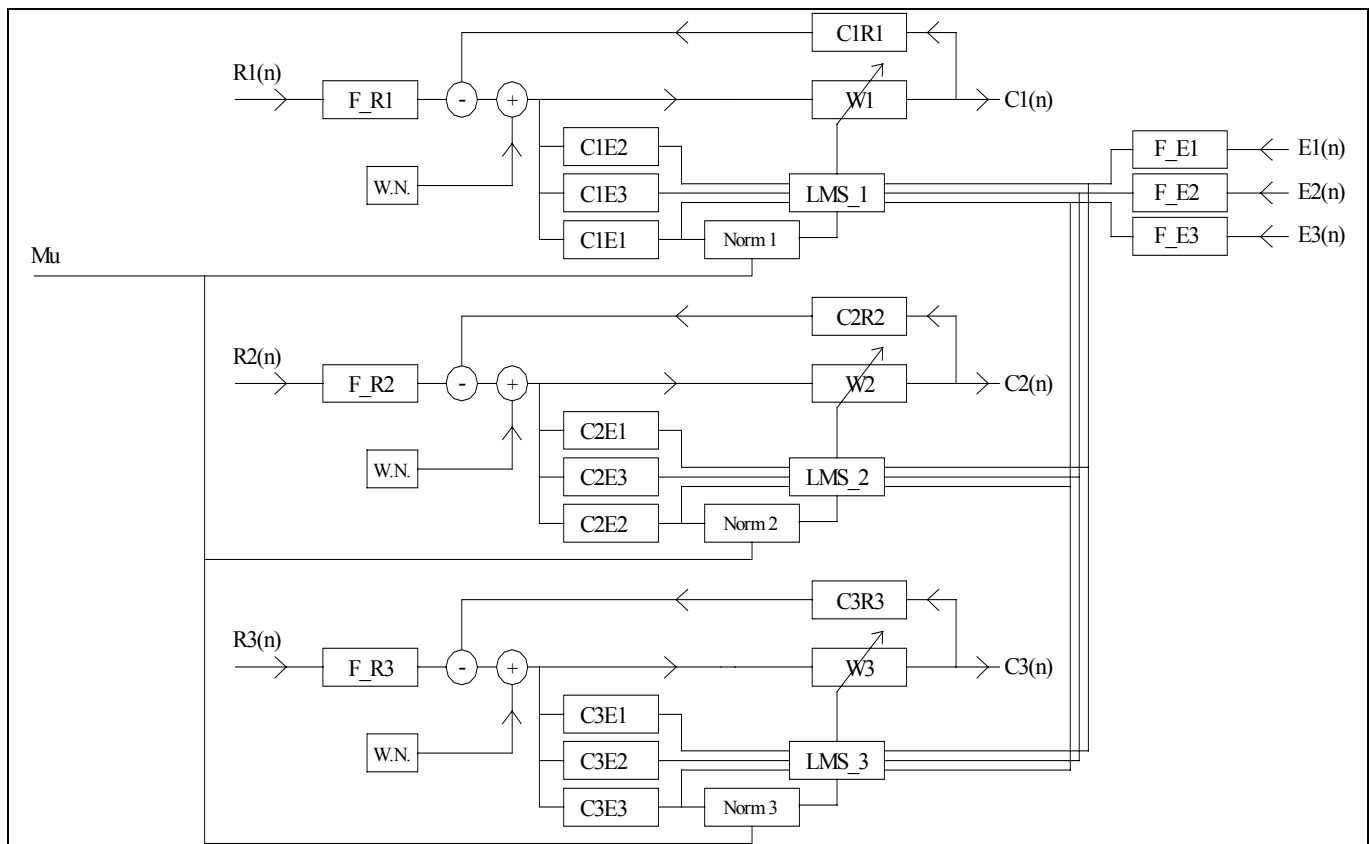

Figure 2   Schematic for coupled version of the control algorithm

Note:

Wx	Control filter *x*
CxEy	Filter of the secondary control path between the control output *x* and the error sensor *y*
CxRx	Filter of the primary control path between the control output *x* and the reference sensor *y*
Norm x	Function for the normalization of the adaptation step. The normalization is done with the energy of the filtered reference.
LMS_x	Optimization function (LMS) for the control filter x.

Technical Specifications

Hardware:

- 3 inputs for the reference signals with an adjustable gain (0 dB to 54 dB)
- 3 inputs for the error signals with an adjustable gain (0 dB to 54 dB)
- Software selectable Electret microphone input or direct input
- Direct input dynamic ±20V
- Microphone input dynamic ±2V
- 3 outputs for control signal (dynamic ±2V)
- Very low group delay: 0.4 ms
- USB 2.0 link
- Metal box, 28 x 21 x 8 cm

PC interface specifications:

- User friendly PC interface for setting the controller and analysing the control results
- Automatic control paths identification module
- Easy-to-use module for designing the pass-band filter applied on inputs
- Scope and frequency analyzer allowing the spectral analysis of any signal of the control system
- Real-time control filters observer
- Real-time estimation of the noise reduction on each channel
- Useful export functions for reports and further analysis
- Built-in analysis module

X-LMS algorithm

- Adjustable frequency span up to 39 kHz (with real-time optimization)
- Selectable coupled or non-coupled mode
- Primary control path compensation
- White noise generator for stabilization of the control filter coefficients
- Real-time normalization of the adaptation step for the LMS algorithms
- Pass-band filter on all inputs to force the control on a specific spectral zone
- Real wideband controller : for instance, at 15.6 kHz, the controller can optimize up to 290 coefficients (coupled mode) and 992 (non-coupled mode)