dance with the IRT specifications but can be changed by the manufacturer on request.)

Limiter The XMAD board includes a limiter to prevent clipping. Clicking the [Lim On] button will enable the limiter. (This is indicated by the red button.) The additional “Lim” meter displays the decrease in level. It operates in reverse to the gain meter.

Note: The parameter settings are fixed (threshold: –0.06 dBFS; attack time: 0 samples; hold time: 10 ms; release time: 0.5 s; ratio: limit); they can be changed by the manufacturer only.

Generator Clicking the [On] button in the “Generator” pane will route the generator bus to the input of the XMAD/XMIC board. To adjust it to standard microphone levels, the generator signal is decreased by 50 dB. For example, when setting a generator level of +6 dBu, a voltage of –44 dBu (6 dBu – 50 dBu) will be present at the microphone input.

When enabled, the [On] button will be red. Clicking the [FCT] button will open the “Generator” window with the generator settings.

[LINK] Button Clicking the [LINK] button will link the limiter key inputs of two neighboring channels and their operation. In this case, the settings of the current channel will be copied to its stereo partner. Settings can then be made to any of the two channels. Phase inversion is not within the scope of channel linking. The green [LINK] button indicates the enabled channel link. Clicking the button again will cancel the channel link.

For more information, refer to the “Boards” reference section that also has the technical specifications.

Excursus: The TrueMatch Technology

Outstanding audio quality thanks to unprecedented converter technology

Compared to conventional A/D converters, the patented TrueMatch technology provides for enhanced dynamics. Today, converters with 64 or 128 times oversampling are almost exclusively used in modern studios. They feature an excellent linearity that depends merely on the accuracy of the utilized down-sampling filters and is therefore considered as practically perfect.

However, linearity curves in A/D-converter specifications still show errors that increase as levels reduce. These errors are essentially caused by the following factors:

Noise A positive difference indicates that the digitized value corresponds to an input voltage higher than the actually applied voltage. The quantization noise is added to the input voltage.

Insufficient bit resolution Both positive and negative variations from linear results indicate truncation errors – the digitized value does not represent the input signal adequately. Such errors are also referred to as “quantization noise”.

Consequently, today’s conversion technology is perfectly suitable for digitizing high-level audio signals. Conventional converters achieve the hypothetically best digitization accuracy just below the clipping threshold. Today, THD&N values of better than –100 dBFS (i.e. <0.001%) are almost standard.

Low-level Signals

Significantly worse results are achieved, however, with low-level signals. For example, when a signal level is 60 dB below the clipping threshold, conventional converters will accomplish THD&N values no better than 0.1...0.5% (i.e. –60...45 dB@60 dBFS), meaning that such signals are digitized with a maximum of 8...10 utilized bits!

Hence, it is not only the high levels that need to be considered. (No engineer will complain about a harmonic distortion of 1% at full-scale level as this is already produced by speakers.) Low-level signals, too, must be as low-distortion and low-noise as possible.

Dynamic Enhancement

As our acoustic environment has a large dynamic range and loud signals must never exceed the clipping threshold (a sufficient headroom must be considered), audio technology has always called for improved dynamics, or, in terms of the digital age, for more “bits”.

Consequently, methods using better and better resolutions have been developed but have always been based on theoretical dynamic values: 16-bit A/D converters feature a THD&N of –96 dBFS, 20-bit converters of –120 dBFS, and 24-bit converters even of –144 dBFS (approximate values). However, analog technology (or, to be more precise, the fact that harmonic distortion increases with rising levels due to – analog – input stages) has never been seriously taken into account.

Converters in Real Life

The figure below shows the interdependence between THD&N and level. The theoretical value of a 24-bit converter at full-scale level (0 dBFS) is approximately –144 dBFS. A signal with a very low level of less than 144 dBFS cannot be processed by such a converter anymore as the quantization noise predominates (see the broken line).

The right part of the illustration shows the additional distortion produced by the real converter as the level increases.

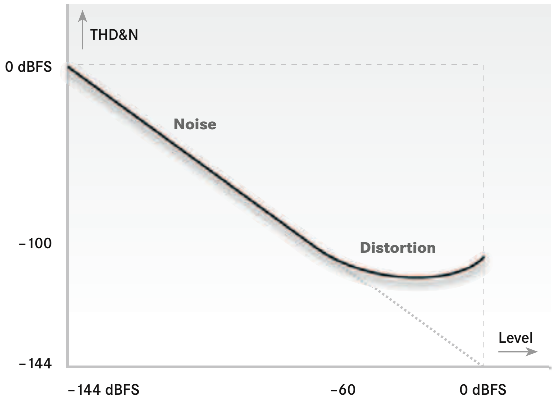


Fig.: Interdependence of THD&N and level with conventional converters

The Idea Behind TrueMatch

The factors described made us develop the TrueMatch technology. The objective was to achieve excellent THD&N values at high *and* low levels.

The idea is to run a standard 24-bit converter in its optimum operating range by deploying a variable preamp function; the converter must, however, never clip. TrueMatch achieves this by using multiple preamplifiers for various amplification ranges, each featuring its own A/D converter.

When a signal is applied, a processor selects the most appropriate of the available converters on the basis of the signal level.

This so-called “gain-ranging” technique is well known; however, it has one shortcoming: All gain factors of the individual preamps and the errors of all converters must be known in order to compensate them. And it is particularly the intermediate ranges between any two converters that may present difficulties.

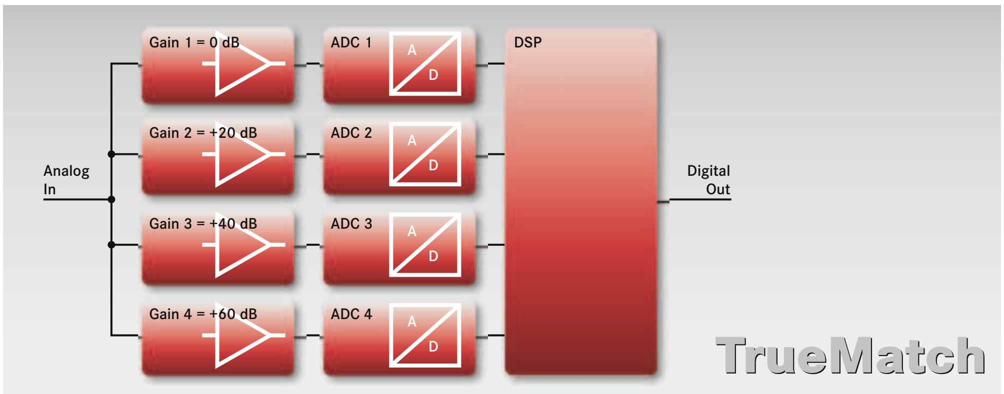


Fig.: Principle of the TrueMatch converter

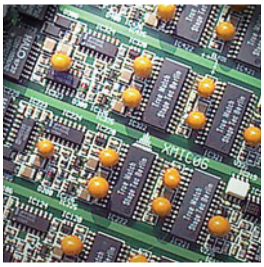
TrueMatch Logic

Stage Tec has invested many years of hard work into the development of a method that does not only convert audio signals but also permanently monitors all amplifiers and A/D converters involved; all relevant values are constantly being measured with extreme accuracy. Gain and offset errors, even phase shifts, and pulse-dependent distortion between the individual signal paths are detected and immediately corrected. The corrections are much more exact than the employed A/D converters, meaning that correction errors are far below the converters' noise floor and cannot be verified by measuring.

For instance, phase shifts between the individual paths can now be corrected to a value better than 0.01° at 20 kHz!

Consequently, the corrections do neutralize not only component tolerances and aging inside the used amplifiers but also eliminate exemplary dispersion of the individual converters and parameter shifting caused by temperature changes. Thus, it is possible to use an A/D converter for digitizing a signal that is being output by another converter - and even the noise floor of the other converter can be determined! The converters are truly matched!

The Implementation of the TrueMatch Converter



The preamp gain is distributed in a way that exactly one A/D converter is operated in its optimum range just below the clipping threshold. Thus, for achieving optimum THD&N values over the entire dynamic range, the processor "just" has to find and select the A/D converter(s) with the most accurate conversion result and to perform all necessary corrections. Therefore, it is practically possible to make converters with a resolution of more than 24 bits and a dynamic range of better than 144 dB. The 32-bit microphone A/D converter manufactured by Stage Tec accomplishes a utilizable dynamic range of more than 150 dB!

The Analog Side

Extreme demands like never before are put on the analog components, too. The amplifiers must be able to process voltage ranges of more than eight decades! They must work both extremely low-noise and low-THD. Analog and digital signals from converters currently not in use must not falsify the utilizable signal by crosstalk.

Despite of the enormous overhead needed, for example, by a fourfold-stacked 28-bit A/D converter, the Stage Tec converter requires only marginally more supply voltage than conventional, monolithically structured A/D converters.

TrueMatch has been patented in most countries and has also been licensed to other manufacturers. Stage Tec uses the system in all high-quality converters, for example, for the XAD and XMAD/XMIC boards.

Correction values

More than 45 correction parameters (some fixed, some variable) are determined individually for each converter stage inside Stage Tec's 28-bit converters. All these parameters are then considered during the conversion process. They include:

Permanent gain-quotient verification	$gain_2/gain_1$
	$gain_3/gain_2$
	$gain_4/gain_3$
Permanent offset-voltage variation verification	$U_{offset2}-U_{offset1}$
	$U_{offset3}-U_{offset2}$
	$U_{offset4}-U_{offset3}$
Permanent phase-shift verification	$phase_2-phase_1$
	$phase_3-phase_2$
	$phase_4-phase_3$
Total-gain calibration (performed once)	V_{signal}
	$V_{generator}$

Table: TrueMatch correction values