Virtual Instrumentation Performs dBrnC Noise Measurements

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The Challenge: Performing dBrnC noise measurements on several power supply test stations.
The Solution: Synthesizing the filter digitally using the LabVIEW Advanced Analysis Toolkit, SCXI™ signal conditioning, and data acquisition.

Introduction

Power Conversion Products (PCP), a leading manufacturer of high-power switchmode rectifiers for the telecommunications industry, hired Alliance Technologies Group (ATG), a National Instruments Alliance Program member, to develop an automated test system for its Twinpack Plus 2.5 kW rectifiers. The test system needed to measure the performance of the rectifier including voltage regulation, efficiency, power factor, and dBrnC noise over various line and load conditions.

System Components

After reviewing PCP's test requirements, we found that the most cost-effective solution for measuring the voltage regulation, efficiency, and power factor involved the use of SCXI™-1120, coupled with data acquisition. For the complex dBrnC measurement, purchasing an expensive audio analyzer with excess functionality was unnecessary.

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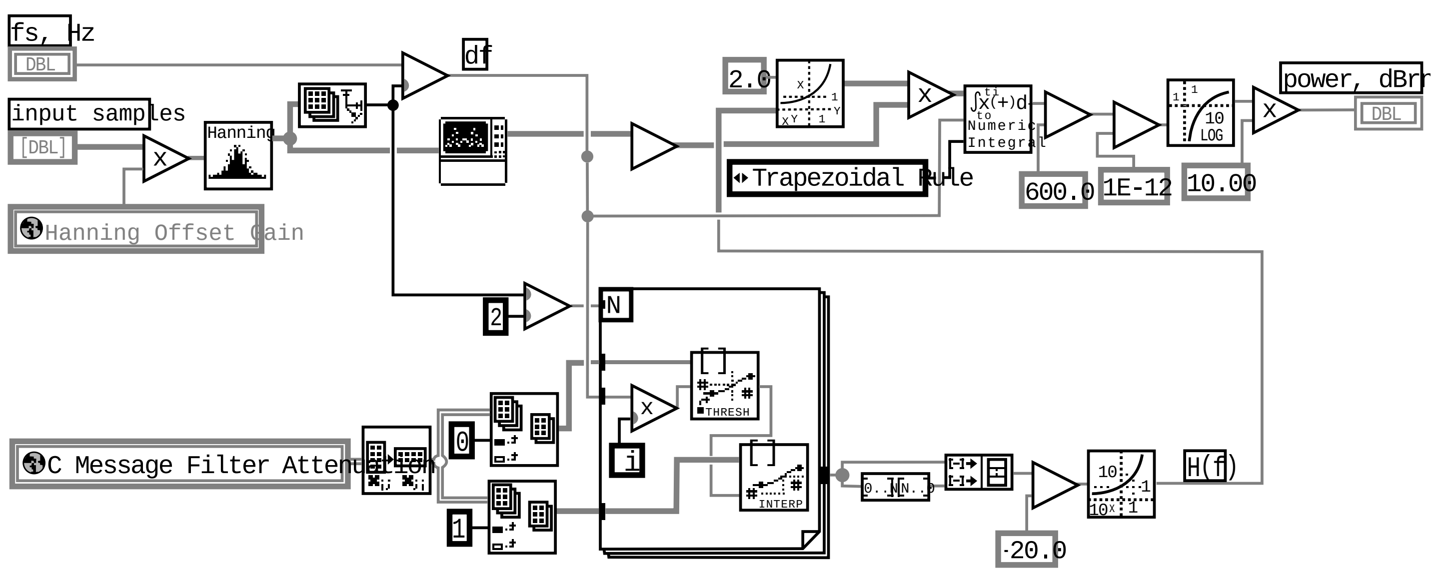
Because the human ear is not equally sensitive to all voice frequencies and because telephone handsets do not have a flat electrical-to-acoustical frequency response, not all frequency components of noise are equally objectionable. In the 1960s, Bell Labs devised a noise-weighting filter to correlate measurements with a listener's subjective assessment. This frequency response, called a C-message-weighted filter, has a 0 dB reference at 1 kHz with components above and below this frequency attenuated to match the response of the ear and telephone handsets.

One common specification found in telephony applications is dBrnC – the amount of noise measured through this C-message-weighted filter relative to a reference noise level of 1 picoWatt. A simple approach to performing the dBrnC measurement is to purchase a commercially available audio analyzer. This audio analyzer performs the dBrnC measurement but also includes functions unnecessary for PCP's application. Because PCP only required one function from this instrument, that measurement had a high price tag.

Having unused channels and jumper-selectable gains, the SCXI-1120 and MIO DAQ board provided a method for obtaining an amplified, isolated, digital representation of the signal. Using the LabVIEW Advanced Analysis Toolkit, we synthesized the C-message-weighted filter digitally and incorporated the dBrnC measurement with virtual instrumentation.

Measurement Process

Simulations showed the most efficient and accurate method of implementing the filter involved first computing the power spectral density of the input signal. Integrating the output over all frequencies then derives the output power.



LabVIEW code implementing dBrnC measurements.

Using a sampling rate of 40 kHz, a total of 8,192 input samples were windowed with a Hanning window. This reduces the spectral leakage that occurs when computing the power spectral density found in using a straight boxcar window. The input samples are gain-corrected because the Hanning filter attenuates the input samples by a factor of 1.64. The Hanning-filtered samples are then taken through the auto power spectrum VI.

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The C-message filter is frequency interpolated to match the frequency bin size of the input power spectral density. The result is then squared and multiplied by the input power spectral density and integrated. This result is then referenced to 600 ohms and to the reference noise of 1 picoWatt.

PCP's maximum and minimum noise levels were 30 and 0 dBrnC respectively. As a rule of thumb, we kept the quantization noise floor from the converters at least 10 dB below the smallest signal. This results in a required dynamic range of at least 40 dB. Given a 12-bit MIO board in the system, this gave a dynamic range of 72 dB, easily meeting the requirement.

With a 0 dBrnC signal across a telephony-standard impedance of 600 Ω, the minimum voltage would be at 24 Vrms, a low-level signal. Maintaining the maximum ± 5.0 V rails over the SCXI interface and using the 12-bit MIO board, we computed that the quantization noise would be 10 dB below the lowest level signal with gains ranging from 116 to 1479. By using a gain value in the SCXI-1120 near the minimum, there would be plenty of headroom available for any high-level signals outside the C-message-weighted filters bandwidth but prior to the digital filter.

Because the signal measured has an appreciable DC component, it was necessary to add a blocking capacitor with a low leakage current. A large leakage current can cause an excessive DC bias that takes away from the headroom in the converter. We used the 10 kHz filters on the SCXI-1120 for antialiasing and to help attenuate the frequency components above 10 kHz. With this network, an SCXI-1120 gain of 200, and the 12-bit MIO board, we found the noise floor of the measurement system to be at –12 dBrnC.

Results

The advanced analysis capabilities of LabVIEW gave us the ability to implement the single dBrnC measurement in a system that already contained DAQ products. The resulting product increased performance and reduced costs.

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LabVIEW Evaluation Package

The LabVIEW Evaluation Package includes a free, fully-functional LabVIEW Evaluation CD with which users can do tutorials, run sample programs, and learn to build virtual instrumentation applications for a variety of telecom applications. LabVIEW graphical programming software is available for Windows NT/95/3.1, Macintosh, Sun, HP-UX, and Concurrent PowerMAX.

Order the evaluation package by calling (800) 258-7022 or downloading the program online at ni.com/labview/lv_dl.htm

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