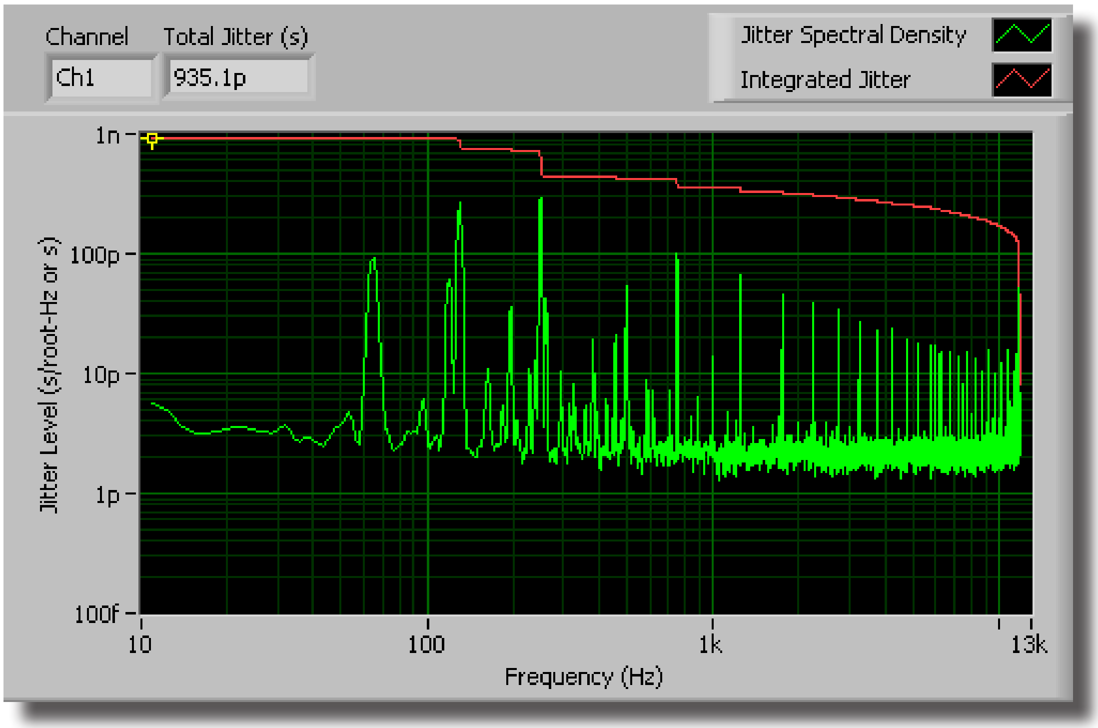
- 2700 Series
- APx585 family
- APx525 family
- APx515

Measuring Jitter with J-Test

By Adam Liberman



Introduction

Jitter is any undesirable fluctuation in timing from an expected clock rate. When a digital audio signal with jitter enters a D/A (Digital to Analog) converter, any jitter the converter is unable to correct will manifest itself as defects in the reconstructed analog audio waveform. Therefore, under certain conditions, it is possible to measure the effect of jitter in the physical digital transport stream by analyzing the analog audio signal at the converter output.

J-Test

The late Julian Dunn developed a special digital test signal for this purpose called J-test, which stimulates worse-case jitter over an AES3 digital audio connection. AES3 includes balanced and unbalanced pro formats, as well as the coaxial and optical SPDIF consumer variants.

The J-test signal has two components. The first is an undithered sine wave at 1/4 the digital sample rate (12 kHz for a 48 kHz sample rate), with an amplitude of one half of full scale. The second component is an undithered low-frequency square wave with an amplitude of 1 LSB (least significant bit). The frequency is not critical, but for a sample frequency of 48 kHz, a rate of 250 Hz is normally used, as that makes the signal synchronous with the AES3 channel status block of 192 samples. At only 1 LSB, the 250 Hz signal is extremely small and only apparent when jitter is present.

J-Test and AES3 / SPDIF

AES3 formats do not have a separate clock line, so therefore the receiver has to reconstruct the clock from the edge transitions of the audio data. This is significant, because any variation in the arrival of each transition can affect the recovered clock rate. Due to resistive-capacitive effects which limit the rise-time of the signal, the waveform at any instant is a function of what's currently being put on the line by the transmitter, and any history from what was sent previously. This is known as intersymbol interference (see figure 1).

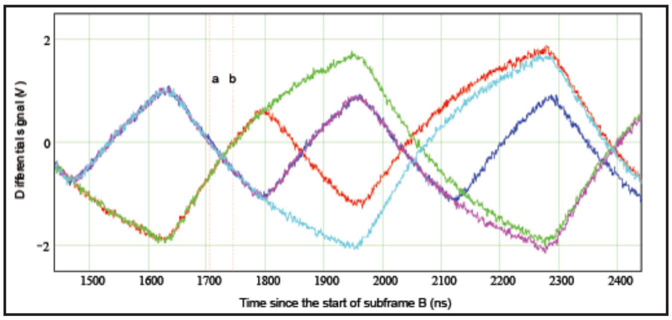


Figure 1: Intersymbol interference.

In the J-test signal, almost all the bits change at the same time, from all 0's to all 1's and back again, at a rate of 250 Hz. The waveform edges in the all-0s bits are slightly displaced from the those of the all-1s bits, due to the intersymbol interference. This low-frequency coherent alternation in the bit values produces strong jitter spectral components at 250 Hz and at odd multiples of that frequency, as well as sidebands around the high frequency tone. These artifacts can clearly be seen and measured using FFT analysis. In the examples made with the APx utility below, D/A converter #2 (figures 3 & 5) shows far more jitter (935.1ps) than D/A converter #1 (51.0 ps, figures 2 & 4))

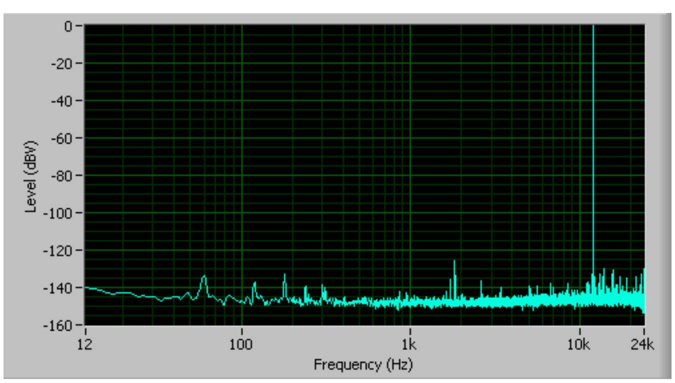


Figure 2: J-Test FFT result for D/A convertor #1.

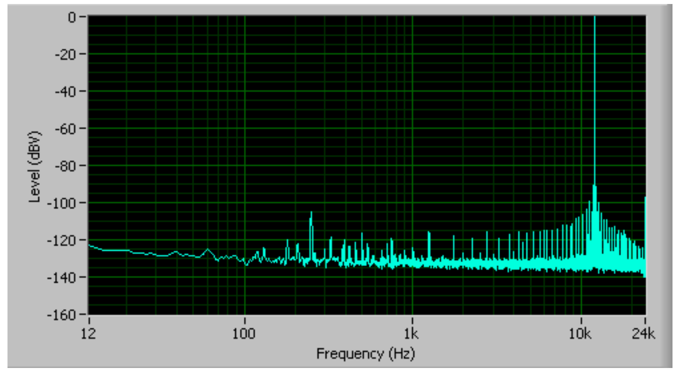


Figure 3: J-Test FFT result for D/A convertor #2.

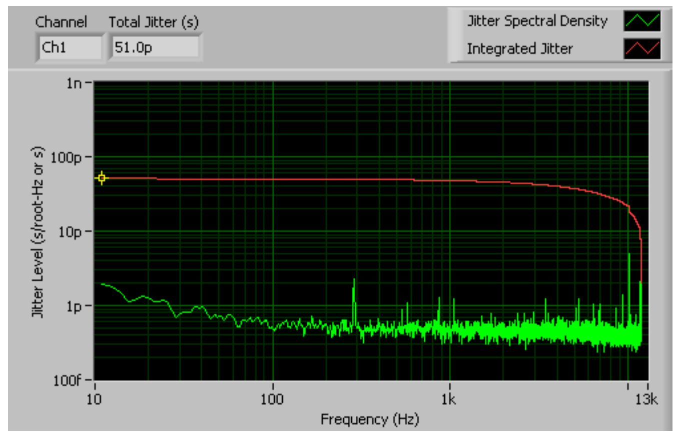


Figure 4: J-Test spectra result for D/A convertor #1.

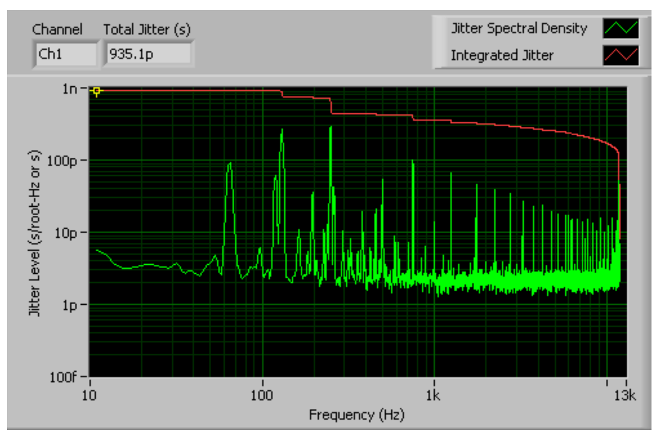


Figure 5: J-Test spectra result for D/A convertor #2.

HDMI, Disc Players

J-test does not induce jitter over HDMI. Like AES3, HDMI does not have an audio clock line and the clock must therefore be reconstructed. But audio over HDMI is sent in packets between the video frames, and not as a continuous synchronous stream. HDMI uses the video clock to reconstruct the audio clock. Although there is possibility for jitter in HDMI, the content of the test signal has no effect on its frequency or magnitude. Because we can't stimulate jitter at a particular frequency, unless there is a specific coherent interference source causing it, any jitter that is present may very likely be random and will just cause an increase in the noise floor with no visible spikes in the FFT.

The same situation occurs in a disc player. A disc player pickup transmits data internally over I2S, which contains a separate audio clock line, and not over AES3. Therefore, the J-test signal can not induce jitter into the signal.

APx J-Test Measurement Utility

The APx J-Test Measurement Utility lets you measure jitter on an APx analyzer using the J-test signal. It displays graphs showing the FFT spectrum, the jitter spectral density, and the integrated jitter, in addition to a total jitter value (figure 6). Tools are included for manipulating the graphs, and exporting graphic images and data.

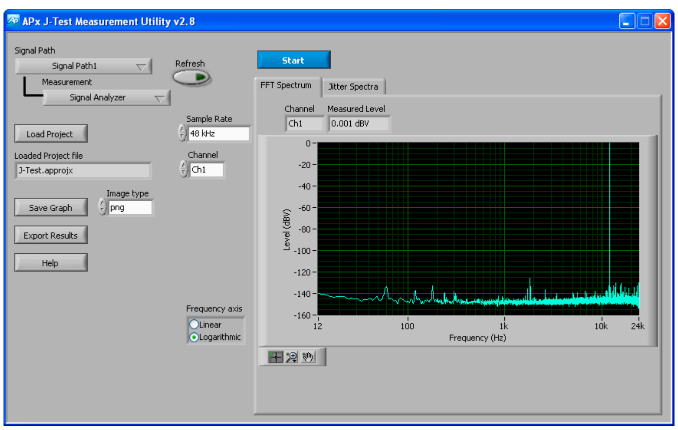


Figure 6: APx J-Test Measurement Utility, FFT Spectrum.

If APx500 is not running when you start the utility, it will load. A prompt will ask if you want to open the default project file that comes with the utility. We suggest that you start out using it, as it is already preconfigured with the correct settings. Change the input and output configuration in the project's signal path setup if necessary. The utility also has controls that allow you to load your own project and specify the signal path and measurement name.

Set the desired Output Sample Rate (44.1, 48, 96, or 192 kHz) and then click Start to begin the acquisition. The FFT will average 16 times to reduce noise, and results will be displayed when it completes. You may then switch between the FFT Spectrum and Jitter Spectra graphs and utilize the toolbox located below for setting cursors, zooming, and moving. The Channel Selector control lets you choose to display either the left or right channel.

AP2700 J-Test

The AP2700 software has a J-Test signal built into the Digital Generator (waveform Special: J-Test) and does not utilize a separate utility. An AP2700 macro (d-a jtest jitter.apb) that properly configures a test and produces the graphed results is included with the book *Measurement Techniques for Digital Audio* by Julian Dunn, which may be downloaded from ap.com.

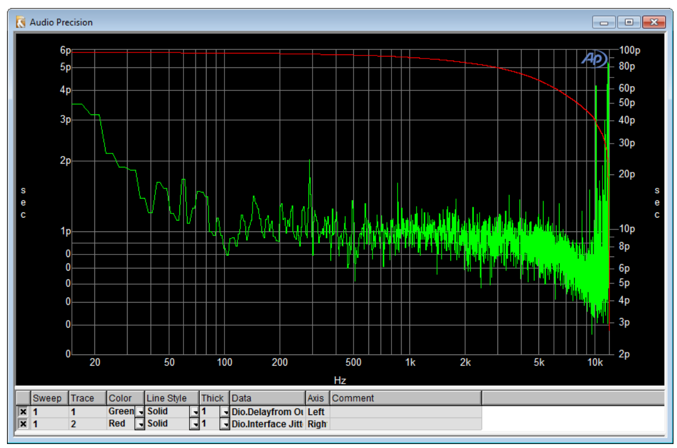


Figure 7: AP2700 J-Test spectra.

Related Downloads:

APx J-Test Measurement Utility:
http://ap.com/display/file/587

Measurement Techniques for Digital Audio (book)
By Julian Dunn. Includes extensive discussion on jitter as well as the J-Test macros and other macros and tests for the AP2700.
http://ap.com/display/file/17

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5750 SW Arctic Drive, Beaverton, Oregon 97005 | 503-627-0832
www.ap.com