Subject: Turntable Cartridge Measurements
Posted by Wayne Parham on Fri, 21 Dec 2018 21:52:54 GMT
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In the "Stylus Inspection" thread, we got sidetracked onto the related topic of cartridge evaluation. So that prompted me to start a new thread, specifically about the ways to measure cartridges.

I found an article in the attached "Bruel & Kjaer Technical Review" journal from 1976. Pages 25-34 discuss using an accelerometer to provide a signal for testing turntable cartridges.
Bruel & Kjaer Technical Review, 1976, No. 2
I understand that some people use a test record instead of an accelerometer to vibrate the stylus. That would be good too and probably more accessible for most people.

I've tended to trust cartridge manufacturers to provide products that perform well, having flat frequency response and low distortion. They are sort of a "trusted reference" for me. But it occurred to me that this is quite an assumption.

Even if the cartridge provides flat response with the stylus provided when it is connected to the right load impedance on the input of a phono stage with the perfect RIAA curve - How much am I deviating from that years later when I switch to an aftermarket replacement stylus? And how much of an impact does the load resistance and capacitance matter? The RIAA curve in the phono stage isn't a cartridge issue, but it definitely matters too, and its filter function may depend upon and interact with the cartridge source impedance. So these are the things I'd love to see actually measured.

Subject: Re: Turntable Cartridge Measurements
Posted by Wayne Parham on Thu, 10 Jan 2019 18:10:16 GMT
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On Bruce Heran's advice, I have purchased and received the "Analogue Productions Ultimate Test LP." I haven't even opened it yet, because I'm going to finish my stylus microscope evaluation first. But I am getting prepared.

I already have an oscilloscope, distortion analyzer, signal generator, frequency counter and a bunch of other test equipment like tube testers and what not. As an electrical engineer, I've aquired all kinds of test goodies, and used them for many years. I also have several acoustic test systems, like LMS and WTPro. So I'm good on test equipment.

But it does occur to me that none of this stuff can be synchronized. It's all stand-alone equipment. So while I can see the waveform and its amplitude, and can also see the frequency of a sine, I cannot log them together. The way systems like LMS and WTPro do it is they generate their test signal and then listen to it. So they can know what they sent to compare it with what they get back.

In this case, the test signal will come from a record. I'll simply be watching it with a scope and frequency counter. I'd have to record the amplitudes and frequencies manually. Maybe the sweep goes slow enough that's not difficult, I don't know. Maybe I should just open up the album and follow its directions. :lol:

But I do anticipate that it might be useful to have a system that can log frequency and amplitude simultaneously. So I'm thinking about trying out a PC-based oscilloscope. I've never done that 'cause I have the "real thing." Never needed or thought I wanted a PC 'scope. But now, I'm thinking it might be useful for this, so I can log frequency and amplitude, and perhaps export that to something to make a frequency response chart.

Towards that aim, I'm looking at software called Daqarta. I'll let you know as I make progress.

I'm also thinking about the RIAA curve in the phono stage. I'll be measuring a system, not just the cartridge. Significant aspects of the signal path include the cartridge stylus (mass/spring), its motors (coil/magnet), the cartridge load impedance (L/C/R) and the RIAA filter function within the phono stage. So these measurements won't totally isolate the cartridge.

Subject: Re: Turntable Cartridge Measurements
Posted by Wayne Parham on Mon, 08 Jul 2019 23:14:13 GMT
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I spent a few hours this weekend and made some measurements of my turntable, cartridge and phono stage using Analog Productions test record and the Daqarta PC measurement system.

This measurement set is just an examination, and not an adjustment or setup series of measurements. Perhaps later I'll swap cartridges and make setup adjustments, taking measurements along the way.

The turntable under test is a Rega P2. The cartridge is an older purple Elys I. And the phono stage is a Pro-Ject Tube Box II.

The test record provides a series of tones for evaluation. Most are fixed single-frequency, but there is a low-frequency sweep and a high-frequency sweep for measuring amplitude response. And there is a two-tone signal for testing intermodulation distortion.

Subject: Re: Turntable Cartridge Measurements
Posted by Wayne Parham on Mon, 08 Jul 2019 23:21:09 GMT
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Single-frequency sine signals are useful for measuring speed accuracy and for measuring

channel separation. Cartridge azimuth has an effect on channel separation: If the stylus is perfectly perpendicular to the groove, then a signal on the left channel groove will be present only on the left channel and not on the right, and vice versa.

1kHz sine

Using a 1kHz sine in both channels, we can see amplitude and phase matching:

1kHz on both channels

The amplitude and phase are well-matched between channels. Looks like there's a slight zero-offset difference between left and right channels.

1kHz on the left channel only

1kHz on the right channel only

The signal is present only on the channel intended, so azimuth is set pretty well.

File Attachments

1) Both_1kHz.png, downloaded 925 times
2) Left_1kHz.png, downloaded 931 times
3) Right_1kHz.png, downloaded 923 times

Subject: Re: Turntable Cartridge Measurements
Posted by Wayne Parham on Tue, 09 Jul 2019 00:40:08 GMT
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The sweeps (which are actually stepped sines) are of equal amplitude so if the reactive load on the cartridge and the RIAA equalization is accurate, then the output of at all frequencies will be equal amplitude.

I switched from oscilloscope view to spectrum view for this test. That made it easier to see the signal and its amplitude: As frequency rises, the position of the signal simply moves to the right on the graph.

There are a couple things I would have liked to have done differently. One is the horizontal (frequency) scale, which is linear and goes clear out to 24kHz. That's fine when doing high-frequency sweeps, but it would have been better for me to have switched to a view that limited the range to 1kHz, placing that at the far right of the chart for low-frequency sweeps. I'm not familiar with Daqarta yet, so I don't know how to do that or if it's even possible.

The other thing I would have liked to have done was to sample the screen captures more often, so I could capture all the signals. I had a screen capture program set to grab the Daqarta window every half-second, so it missed some of the signals. I still got a good representation of the behavior of the system though. Maybe next time I'll study the program more so I can capture all the frames, perhaps as an animated GIF.

Stepped sines from 1kHz to 10Hz:

Amplitude response looks pretty good and flat between 10Hz and 1kHz.

File Attachments

1) Sweep_00729.png, downloaded 902 times
2) Sweep_00590.png, downloaded 901 times
3) Sweep_00373.png, downloaded 895 times
4) Sweep_00318.png, downloaded 884 times
5) Sweep_00264.png, downloaded 862 times
6) Sweep_00250.png, downloaded 884 times
7) Sweep_00197.png, downloaded 885 times
8) Sweep_00137.png, downloaded 867 times
9) Sweep_00130.png, downloaded 874 times
10) Sweep_00095.png, downloaded 889 times
11) Sweep_00080.png, downloaded 887 times
12) Sweep_00067.png, downloaded 857 times
13) Sweep_00054.png, downloaded 863 times
14) Sweep_00040.png, downloaded 860 times
15) Sweep_00020.png, downloaded 852 times

Subject: Re: Turntable Cartridge Measurements
Posted by Wayne Parham on Tue, 09 Jul 2019 01:35:20 GMT
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Stepped sines from 1kHz to 20kHz:

Amplitude is consistent with all these samples so the frequency response of this cartridge and phono stage is nice and flat.

File Attachments

1) Sweep_01007.png, downloaded 849 times
2) Sweep_01187.png, downloaded 836 times
3) Sweep_01903.png, downloaded 848 times
4) Sweep_02550.png, downloaded 770 times
5) Sweep_04057.png, downloaded 831 times
6) Sweep_06467.png, downloaded 820 times
7) Sweep_07810.png, downloaded 826 times
8) Sweep_12473.png, downloaded 831 times
9) Sweep_14121.png, downloaded 810 times

Subject: Re: Turntable Cartridge Measurements
Posted by Wayne Parham on Tue, 09 Jul 2019 02:01:15 GMT
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Intermodulation distortion (IMD) from 60Hz and 4kHz sines

The intermodulation test signal is a 60Hz sine and a 4kHz sine. Clipping in the phono stage (or measurement system) will increase IMD, as will the incorrect vertical tracking angle.

This measurement doesn't look good but it's hard to know how much of that is the measurement system and how much is the device under test. For one thing, I need to be able to change the horizontal scale so that I can see the area around 4kHz very closely. I would expect to see 3940Hz and 4060Hz components from intemodulation, but I can't see that well because of the horizontal resolution. What I can see pretty clearly are 2nd and 3rd harmonics at 8kHz and 12kHz, which tells me something else is going on. Probably clipping in the measurement amplifier or possibly the phono stage.

File Attachments

1) IMD_60Hz_and_4kHz.png, downloaded 816 times

Subject: Re: Turntable Cartridge Measurements
Posted by Wayne Parham on Tue, 09 Jul 2019 02:22:38 GMT
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Observations:

There is evidence of harmonics in some of these measurements. I'm confident that the amplitude of the fundamental is still accurate because I initially measured in oscilloscope view and saw that the fundamental wasn't clipped. So if that information is all that is needed, then the presence of these harmonics isn't important. But sometimes - like distortion measurements - harmonics are an indication of some sort of nonlinearity, and that makes me less confident in the IMD measurements.

What I don't yet know is whether the harmonics were caused by a sampling artifact or by something like clipping in the phono stage or in the measurement amplifier. I am most suspicious of the measurement amplifier and ADC, because the phono stage was not operated beyond its limits. It was used as it normally would be. The measurement amplifier/DAC used was a Behringer UMC202HD, and it has variable gain controls. I could have simply set those too high.

The frequency counter seems off in some measurements. When Daqarta is in spectrum view mode, the horizontal scale is linear with lines every 2kHz. So it is easy to read what frequency is presented from the horizontal position. In some cases, the position indicates a frequency that is different from what the counter reads. An example is the stepped sine sweep where the frequency counter reads 14121.248. The position indicates the frequency of that measurement was closer to 18kHz.

The frequency counter errors could have been a result from the harmonics. When there is more than one sine wave present, a frequency counter cannot really know what to count. So the multiple frequencies from harmonics may throw off the counter. Or it may have been that there was too much noise, or the frequency counter may just not be all that accurate. It did seem to work well when presented with a clear single sine though.

Subject: Re: Turntable Cartridge Measurements
Posted by gofar99 on Thu, 11 Jul 2019 02:38:07 GMT
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Hi Wayne, Quite interesting. I suspect the problems arise because of the UC202. I have one plus a few others and found the one that gives the best results is a SIIG HD7.1Box. An older unit, but native 24/96 resolution. I feed it to a Velleman PCSGU250 PC scope. Also an older dual trace unit. It can provide many of the measurements at the same time you were having trouble with. Together with the test LP and using a Simaudio Moon phono preamp which is not my most favorite to listen to, but is extremely accurate and quiet (they say over -100 db in MM) I get what I feel are accurate and consistent measurements. My findings have been that cartridges are not as accurate as many folks think....at least none the average person can afford. I use ones as lowly as an AT F7 to as high as a Dynavector Karat 23MR-RS with a middle ground of a Grado Sonata

II. Channel balance in amplitude is often quite good. Things like separation of channels and cross talk are almost always not symmetrical. One channel will tend to bleed onto the other in a unsymmetrical manner (L-R one values R-L slightly different) Even the high end ones are prone to this. As price goes up (usually) the performance gets better up to a point. A parameter you didn't address is tracking. As long as a cartridge is nicely nestled in the groove all is well. The moment the amplitude of the modulation exceeds some value performance goes down the tube.

All this is good stuff...but in a perverse manner it doesn't tell you how a particular turntable, arm and cartridge will sound. I have a number that measure rather closely, and sound quite different. A lowish end AT and a higher one measure nearly identically, but sound worlds apart. I guess this is what makes our hobby fun to pursue. BTW, the screen captures are quite good.

So much for my babbling....

Subject: Re: Turntable Cartridge Measurements
Posted by Wayne Parham on Thu, 11 Jul 2019 13:38:40 GMT
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I agree with you about the Behringer amp/ADC/DAC. It has a variety of settings I can adjust - both analog and digital - so I think I can probably dial it in a little better. I was able to get a lot of useful information from it straight out of the box though.

What isn't maybe immediately obvious from the charts I attached in this thread is that the UHF artifacts I saw usually happened when I presented HF sines. To be more specific, sines above 1kHz were more likely to create these artifacts than lower frequencies, and signals above 10kHz almost always did. It didn't seem to be related to amplitude either, which would seem to reduce the likelihood that the problem was from clipping somewhere in the signal chain. It really appeared to be an aliasing artifact or an anomaly from a non-linear anti-aliasing filter. Could be a little of both.

But that's just seat-of-the-pants conjecture on my part. I'll need some more time with this Behringer unit and its device driver to form a conclusion.
