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How a Network Switch Affects Audio Playback – An Extreme Deep Dive!

by JAAP

Introduction

Contents

In recent weeks or months your author has locked himself up in a measuring room with many switches and loud measuring equipment. This to investigate the influence of network switches on audio clocks. Will it be possible to find 'evidence'?

As an enthusiast you are always looking for improvements in the audio chain. The biggest steps can be made with acoustics, a suitable loudspeaker and a good loudspeaker / amplifier match. A decent source and appropriate cabling also belong to a properly balanced system. After that we enter troubled waters, because what about energy supply? Power is power, right? Or what about speaker decoupling? And pucks under equipment?

Some things are very difficult to explain. We do hear something, but we don't really know where it comes from. Think cables. Anyone who performs simple measurements on cables will not be able to explain why one cable sounds great and the other does not. Highly accurate measuring equipment is needed to gain some insight. But even those only tell a small part of the story. The regular reader of Alpha Audio knows that we have spent a long time testing speaker cables. Just to name an example. If we then look at power conditioning, the same applies in fact: we hear differences, but it is very difficult to explain or measure. We are still working on it to make a solid set-up.

If we then look at network audio and then specifically at switches, no serious research has actually been done at all. Some tests with fiberglass, as we also did a few years ago, but no real measurements or elaborated theories. Anyway, we couldn't find it. That prompted your author to dive deeper and start measuring. You have already read the first story. In part part we will go further and look at the clock jitter in a streamer. How is it affected if we use several switches?

DO NOT look at the data!

“You don't know what you're talking about. Learn how a protocol works!” “Another audiophool who has no idea how TCP/IP works. If he were to delve into it, he wouldn't be wasting his time like that!” “Data is data. A one is a one and a zero is a zero. What nonsense. It's all in the mind. What idiots” A few quotes from dear viewers and readers when we talk about switches in an audio network.

We would prefer to stand on a high roof with a large PA system and shout: there is NO difference in data transmission between switches. Data just arrives. Bits and bytes do not become more 'corrupt' with a cheap switch. The very robust protocols also ensure that. Think of TCP with built-in error correction. If those protocols didn't exist, the internet wouldn't work. It's that simple. In addition, a streamer always buffers part of the data stream to prevent problems. That's not the problem at all.

huh? What are you saying! So there is no difference in switches?

Yes… but on a completely different side… Noise. Yes… here we go again. Power supply noise and other noise generated by high-frequency switching. There we measure huge differences. There are very 'silent' switches and extremely noisy models. And that's where we continued to investigate. So forget about data… it's not there.

The measurement setup




For this study, a number of members have been added to the measurement family. First of all, the Wavecrest SIA 3000. This is a Signal Integrity Analyzer that can literally measure jitter down to femtoseconds. The internal resolution is 200fs (femtoseconds) and the internal reference clock has less than 1ps jitter. Our calibrations on the machine itself confirm this (it had to calibrate itself again after the trip from South Korea). This is really impressive for a machine from 2002. And also for a machine that would come out now. It is not for nothing that these machines were practically unaffordable at the time. It really is extremely accurate – and sensitive! – device with which we can measure clock jitter ultra-precisely. And phase noise, low-frequency modulations, etc. Unfortunately, we don't have all the licenses for it, but enough for what we do. And extra licenses… are a bit pricey… understatement.

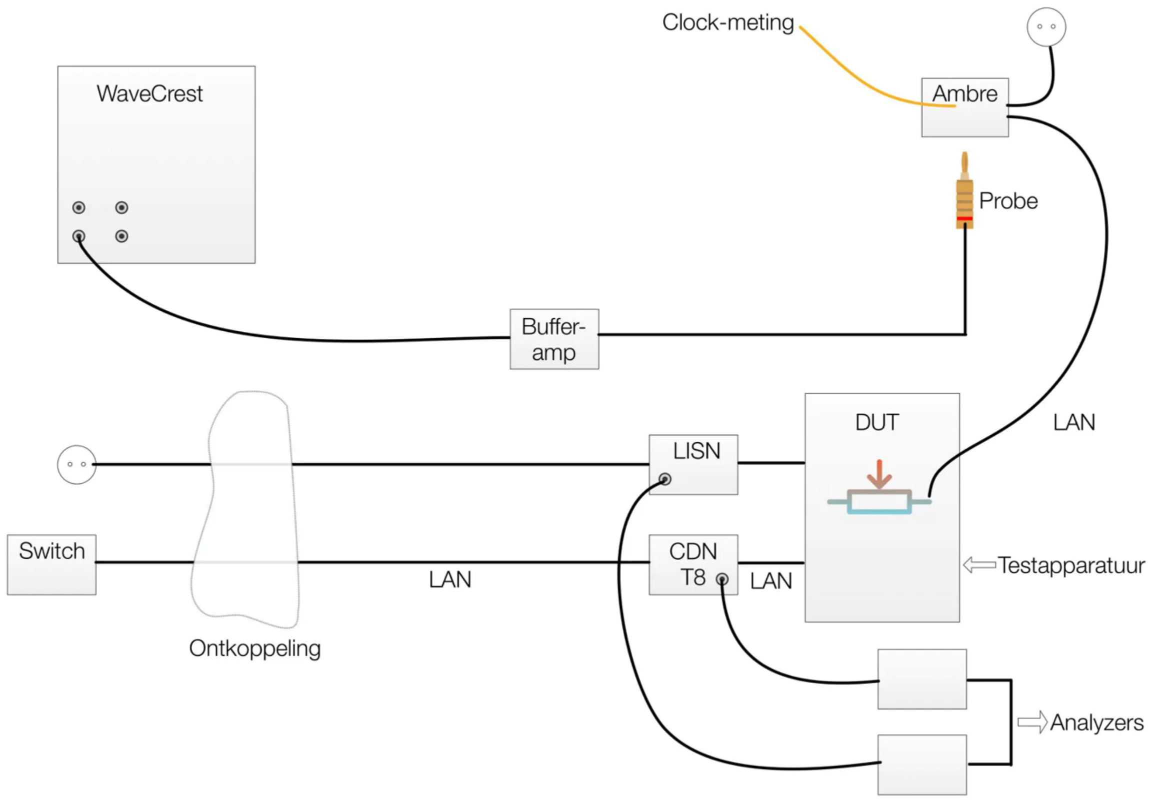
We also purchased a new Rohde & Schwarz probe. This is to realize a decent bandwidth for the measurements; the R&S probe has a bandwidth of dc to 300MHz. Enough for this project.

And finally we bought an impedance buffer amp to convert from 1M Ohm to 50 Ohm to connect with the correct impedance to the Wavecrest. It has an input impedance of 50 ohms. We have chosen a model from Matthews Engineering because of the price / quality (dc - 400 MHz and very quiet) and the fact that it works on both batteries and USB power. In the end we powered it via an adapter from USB to the lab power supply.

The set-up for the measurements was relatively simple. It had to be, because every change in set-up results in slightly different outcomes. Incidentally, a clock also works with temperature and other external factors. So a measurement on day one may be slightly different than on day two. Very annoying, because it means that we really have to measure everything in succession in order to be able to compare things. However, the absolute differences between the switches remain the same. If that wasn't the case, we would have really gone crazy these past few weeks.

We have taken a Metrum Acoustics Ambre as a base. This is a nice midrange streamer with two neat, tightly powered vcxo clocks from Tentlabs. We were able to get to the clock fairly easily, so that we could properly put the measuring probe on it. We then connected the switch to our LISN (Line Impedance Stabilizer Network) to both decouple and measure the power supply noise. The switch is also connected to the CDN T8 for the same reason: the network is disconnected and we can measure noise from the CDN. We also measure – one after the other – the power adapter and the network cable through an RF current probe to measure common mode. We measure noise from the network at both high and low frequency (low frequency goes through the Prism dScope).

Below an overview. Thanks to our news tiger Ronald for transferring the indefinable scribble into a readable picture. The analysers (Prism and Spectrum Analyzer) for the LISN and CDN are not mutually connected. That line is a bit unfortunate.



The test candidate

Now we recently did a big test of switches. We listened blindly and your author performed the first series of measurements, which mainly consisted of measurements of all kinds of noise. This laid the foundation for this in-depth study. Because, as it soon turned out: the poorly measuring switches did not sound pleasant either. That should be explainable, right?

We have selected a number of candidates for this test for further analysis. Including the Netgear 108E, Dlink 108, Dlink 1210, Pura Ammonite V2 and Elite and of course fiber. We also switched power supplies to determine the influence of a different power supply. We deliberately do not say 'better' nutrition here.

Important!

It is important to realize that we had to measure over several days. One set of measurements on a switch takes about 45 minutes to get it right. Since we made several combinations, we performed the final measurements over three days to collect enough data for this article and some conclusions.

As said before, everything affects the measurements. We don't have a completely shielded lab, so there are slight variations between day one and day two. However, we also carried out control measurements in each series, so that we know what these deviations are. We have included that in the conclusions.

We have included everything from one series in the table in the measurement chapter, so that you do have a concrete overview with comparable results.

How do you read the measurements?

Jitter is complex matter. There are various types of jitter. And each form has a different 'origin'. It is explained very nicely here. Hans Beekhuyzen also has an excellent explanation of jitter and its effects on his Youtube channel.

We can break down jitter – or Total Jitter in jargon – into Deterministic or “Bound” Jitter (DJ) and Unbound Jitter (RMS). Deterministic jitter (also called peak / peak) is again broken down into other forms. Think of Periodic (PJ) and data dependent (DDJ) jitter, where data dependent is split into Duty Cycle Distortion and Intersymbol Interference.

What did we see?

Below we go through all the measurements we have made. It's a lot of data, so we can imagine that you're cross-eyed after going through all the images. In any case, your author can hardly see a measurement report anymore. Under each switch we put a summary in plain language. So if you just want to know what we found, just read the text.

Note: the noise measurement on the LAN side – measurements with RF Probe LAN in the name – are measured on an active cable. This is to make realistic measurements. The spikes between 4 and 10 MHz are therefore data that you see running. This is right!
Let's ask the question first:

Does a switch affect the clock in a streamer or dac?

Yes: 100%. We have now proven that, we hope.

Then the question:

Is the influence of a switch on the measurements – and display – large?

That is more difficult to answer. Because in terms of total jitter, it's not too bad if we're honest. Certain areas are more affected, but that may require more research.

However: in terms of phase noise, we find 10 dBc/Hz quite significant. In addition, the audible influence is also quite significant between a router supplied free of charge compared to a decent Netgear or Dlink. And the step to a 'real' audio switch is also considerable, we can say. We don't dare to say what the situation is between the various 'audiograde' switches. That could be another test.

To briefly summarize this long story about the influence of network switches on clock jitter: our measurements have shown that the phase noise in particular decreases with a decent switch that does not transmit much (common mode) low-frequency noise to the streamer. In our measurements we see a direct relationship between low-frequency noise from the network port and phase noise on the clock.

Is that audible? Yes: we conclude that it is audible. As far as we are concerned, the listening tests show that switches with a lot of noise from the port sound less good. And now that we have been able to establish the relationship between this noise (especially low-frequency noise) and phase noise on a clock in a streamer, we think that has also been proven, to be honest.

More elements

Incidentally, we have now only measured the influence of a network switch on the clock in a streamer. (And that was enough for this story). Know, however, that we actually measured the influence of an external noise source on an audio circuit. Looking at it 'dry', we see the influence of an external noise source on the streamer's power supply which in turn affects the clock circuit.

So you should be able to extend these results to other areas in that device. This noise also affects other, crucial areas. Think of an output stage of the dac. So it always makes sense to use quieter components. In this case, however, we wanted to demonstrate that network switches also influence your audio installation. And that has NOTHING to do with data integrity!