Performance

In this chapter, we will look at the performance of some key parameters and, where applicable, compare them with an original UMC202HD and an Audio Precision Portable One Plus. These key parameters include:

- THD, harmonics

- EIN

- CMRR and RF sensitivity

- Frequency response

- DVM error

THD and harmonics

As you can read in the chapter about the UMC202HD modifications, the THD of this audio interface can be improved considerably. Not only at high input levels, but even at input levels of -6 dBFs or lower, the THD can be made an order of magnitude lower. In particular, the third harmonic will drop considerably. I have summarised the results of the THD improvements in the table below. These were measured via a loopback connection from the generator output of the analyzer (aka line output) to one of the analyzer inputs (aka line input). The input selector was set to 200 mV, which yields a -3 dBFs level at the 200 mV input signal. You can find all REW measurement plots in this document for your reference.

Input Level	UMC202HD			Audio Analyzer			Mackie ProFX12		
	THD	H2	H3	THD	H2	H3	THD	H2	H3
0 dBFs	1.39%	0.62%	1.04%	0.0016%	0.00072%	0.00090%	Not measured	Not measured	Not measured
	-37.13 dB	-44.15 dB	-39.65 dB	-95.91 dB	-102.85 dB	-100.91 dB	Not measured	Not measured	Not measured
-3 dBFs	0.0061%	0.00065%	0.0060%	0.00048%	0.00015%	0.00034%	0.00061%	0.00029%	0.00029%
	-84.29 dB	-103.74 dB	-84.43 dB	-106.37 dB	-116.47 dB	-109.37 dB	-104.3 dB	-110.8 dB	-110.8 dB
-6 dBFs	0.0022%	0.00010%	0.0021%	0.00033%	0.000082%	0.00013%	Not measured	Not measured	Not measured
	-93.15 dB	-120 dB	-93.55 dB	-109.62 dB	-121.72 dB	-117.72 dB	Not measured	Not measured	Not measured

Harmonic Distortions of the UMC202HD, Audio Analyzer, and Mackie ProFX12 at various input levels

From the table, it is quite obvious that the UMC202HD has by far the highest HD, and the Mackie is a good runner-up. The UMC202HD harmonic distortion levels at -3 dBs would not be audible, so for an audio interface, this could be acceptable. But we are talking here about its use as a measuring instrument. And then you just want the lowest distortion levels.

Equivalent Input Noise

Another important property of an audio analyzer is the preamp self-noise contribution to the measured signal, which, of course, should be as low as possible. The noise contribution of a preamp is generally called the equivalent input noise, abbreviated EIN. You can read more about the EIN here. By measuring the EIN of the UMC202HD and of the Audio Analyzer, we can verify whether all the modifications made sense and whether the design meets the requirement of equal or lower noise than the UMC202HD noise level.

I measured the EIN of the microphone input at 2 mV sensitivity and the line input at 200 mV sensitivity. EIN is usually expressed in dBu or dBV. Personally, I prefer dBV, but I will use dBu here as it seems to be more common. To measure EIN, I first calibrated the level in the REW RTA window using a signal from the REW generator output and the built-in True RMS DVM of my analyzer. After calibration, I stopped the REW generator and removed the loopback XLR cable. I then inserted an XLR plug in the input with the desired reference impedance between pins 2 and 3 (0R or 150R).

I followed the same procedure for the UMC202HD, but as it does not have calibrated gain settings, I first had to adjust the input gain pot until I obtained the same dBFs readings for the Analyzer and the UMC202HD. I then calibrated the REW RTA level. The results are in the table below. Both the unweighted dBu and A-weighted dBu values are listed. As you can see, the audio analyzer performs about 2 to 3 dBu (A) better compared to the UMC202HD.

As a reference, I also connected a mic preamp of my Mackie ProFX12 (V1) to the audio analyzer line input and level adjusted the gain on the ProFX12 until I obtained the same level as on the 2 mV mic input of the analyzer. From the measurement data, we can read that the Mackie preamp and the Audio Analyzer preamp are on par in terms of noise level.

Input	UMC202HD		Audio Analyzer		Mackie ProFX12	
	dBu	dBu(A)	dBu	dBu(A)	dBu	dBu(A)
Mic input, 2 mV, Zi = 0R	-127.7	-130.3	-131.1	-133.7	-131.1	-133.8
Mic input, 2 mV, Zi = 150R	-125.8	-128.4	-127.6	-130.2	-127.9	-130.5
Line Input, 200 mV, Zi = 0R	NA	NA	-102	-104.6	NA	NA

EIN of the mic inputs of the UMC202HD, Audio Analyzer, and Mackie ProFX12 (through the Audio Analyzer 200mV Line Input).

CMRR and RF sensitivity

A property that is not always taken notice of when comparing preamps is the CMRR (Common Mode Rejection Ratio). In many cases, it is not even published for Audio Interfaces, perhaps because this is too difficult or unknown a concept for the average consumer. Mains hum generated in ground loops is the most well-known example of such common mode signals, but also RF signals from strong radio transmitters (nearby cell phones!) can enter the preamp/Analyzer as a common mode signal and wreak havoc on your delicate measuring signal. I have measured the CMRR over the entire audio band (see the download file with REW measurements) and summarised them below. For the CMRR measurements, I used the method described here.

With an RF Signal Injector that can inject 500 – 1200 MHz RF signals into an XLR cable, I also checked the sensitivity of frequencies from cell phones. With this RF jammer, I was able to get AM demodulation in some microphones at levels that, judged by the ear, were quite similar to what you would get from a cell phone held close to the microphone cable. For my Analyzer, I found RF immunity less important compared to the 50Hz CMRR, because RF interference would only come in bursts from my cell phone. This interference source can be eliminated quite easily by turning the phone off, but this is not the case for 50Hz/60Hz power line hum.

In the first of the two tables below, I listed the measured CMRR levels at 50 Hz and 20 kHz. The second table lists the worst-case AM demodulation levels in the 500 MHz to 1.2 GHz range as measured with the RF injector circuit. Please note: the AM detection levels listed can only be compared with each other because no standardized measuring method with calibrated measuring equipment has been used. CMRR figures are quite good indeed and exceed the 80 dB requirement of the R&S UPL Audio Analyzer. And if you go by the standards of cable manufacturer Belden, the audio band CMRR values would be in the range of Excellent to World Class. The Mackie would score Average to Good.

Input	CMRR @ 50 Hz	CMRR @ 20 kHz
Analyzer Mic input, 2 mV sensitivity	99 dB	93 dB
Analyzer Line Input, 200 mV sensitivity	95 dB	80 dB
Mackie via Line Input, 2mV sensitivity	60	72
UMC202HD Mic Input, 2 mV sensitivity	72	100

CMRR values, as measured by injecting a 1V RMS common-mode signal into the inputs.

Input	Max 217 Hz level
Analyzer Mic input, 2 mV sensitivity	-58 dBFs
Analyzer Line Input, 200 mV sensitivity	-97 dBFs
Mackie via Line Input, 2mV sensitivity	-73 dBFs
UMC202HD Mic Input, 2 mV sensitivity	-80 dBFs

RF sensitivity comparison

Although the Analyzer Mic Input sensitivity for RF signals seems quite poor compared to the other signal inputs, it is still usable. But I have to admit that the input filter circuits are less effective than I had expected. Perhaps I should have added a CM inductor in the microphone signal line, directly on the XLR input, instead of the beads and filter caps on the PCBA. The RF signal injector box has this in the output to the mixer, and it works very effectively.

Frequency Response

Frequency Response measurements were done by looping back the Line Out to the Mic and Line Inputs. I set the output impedance to 50 Ohm, the Line Input to 200 mV sensitivity and the Mic Input to Variable with max gain and 3 kOhm input impedance. I did not measure the UMC202HD FR, but I did measure the Mackie ProFX12 preamp, of which I wired the Insert output to the Line Input of the Audio Analyzer. The preamp gain was set to ~100 to match the sensitivity of the 2mV Mic input of the Audio Analyzer. The gains had to be made more or less equal as the bandwidth is a function of the gain with many Mic Preamp circuits. I was unable to set the gain of the Mackie

to *exactly* 100 because, in the 30-60 dB gain range, it is practically impossible to adjust the gain pot with better than +/- 2 dB accuracy.

As described in the Line Output circuit description, the loopback Frequency Response depends slightly on the setting of the output level potmeters. So I took measurements at 200mV output level through the Mic input and Line Input at 200 mV sensitivity and another measurement at 2V output level through the Mic input at 5V sensitivity. The 200 mV signal is flat within +/-0.1 dB between 20 Hz and 2 kHz and rises +0.3 dB at 20 kHz. Again, at 2 V, it is flat within +/-0.1dB between 20 Hz and 2 kHz but now drops 0.2 dB at 20 kHz. On the plots, the deviations seem quite significant, but it is good enough for me. It does not meet my wish for +/- 0.1 dB flatness, but it is within the +/- 0.5 dB range, which I set as a requirement.

DVM accuracy

The True RMS Digital Volt Meter was calibrated using a 6 1/2 digit calibrated Digital Multi Meter, so this should guarantee accurate measurements. At least, that was what I expected… But I measured the accuracy again about 6 months later, and I was somewhat disappointed. With most settings of the Input Selectors, the accuracy was spot-on or at least within 1%, but with some settings, the deviation was much too high. See the table below. I have yet to figure out the root cause, but I'm afraid I will have to re-calibrate the DVM. Maybe I made some typos when entering the values from the DMM. All measurements were done with a 1 kHz sine wave, by the way.

Microphone Input	DVM module	DMM value	Error
2mV through Left Ch.	2.035	2.019	0.8%
2mV through Right Ch.	2.028	2.019	0.4%
20mV Left	20.34	20.18	0.8%
20mV Right	20.34	20.18	0.8%
200mV Left	201.6	198.54	1.5%
200mV Right	201.66	198.54	1.6%
5V Left	5.041	5.04	0.0%
5V Right	5.042	5.04	0.0%
Analyzer Inputs	DVM module	DMM value	Error
200mV Left	202.26	202.11	0.1%
200mV Right	202.36	202.13	0.1%
2V Left	2.0431	2.0445	-0.1%
2V Right	2.0413	2.0445	-0.2%
20V Left	20.883	20.894	-0.1%
20V Right	20.893	20.895	0.0%
200V Left	21.13	20.896	1.1%
200V Right	19.913	20.896	-4.7%
Generator Outputs	DVM module	DMM value	Error
1V Left	1010.1	1011.8	-0.2%
1V Right	1004.2	1003.9	0.0%
10V Left	10.12	10.119	0.0%
10V Right	10.01	10.04	-0.3%

True RMS DVM accuracy on all channels and settings.

I also checked the accuracy as a function of frequency for the Left Line Input channel at 2V sensitivity and a 1V RMS sine wave input. I measured at 20 Hz, 200 Hz, 2 kHz and 20 kHz. At 20 Hz, the deviation was -1.2%, at 200 Hz and 2 kHz -0.1% and at 20 kHz it was rising sharply to +12%.

More…

Of course, there are many more features you can specify, but I'll leave it at this for now.