



## Resonance Labs: Digital vs. Analog Volume Control

**Question:** Is the volume control in the Resonance Invicta is performed in the digital domain, or in the analog domain.

**Answer:** The volume control is digital. This will disappoint many in the audio field because they are aware that the perceived signal to noise of any element of the music is proportional to the peak amplitude: that's what signal to noise means - the ratio of the noise to the signal. An analog volume control brings down the peak signal and the noise at the same time, so preserving the signal to noise to lower volume levels. So why don't we do that?

The reason is that most of the noise we deal with is actually the quantization noise of the signal itself, not the noise of the Invicta. For example, if we play a CD through a good DAC that performs at the 104db S/N level we get these results:

	16 bits (CD)	
	Analog	Digital
0	96.0	96.0
-5	96.0	96.0
-10	96.0	94.0
-15	96.0	89.0
-20	96.0	84.0
-25	96.0	79.0
-30	96.0	74.0
-35	96.0	69.0
-40	96.0	64.0
-45	91.0	59.0
-50	86.0	54.0
-55	81.0	49.0
-60	76.0	44.0

We can see that the analog volume control is showing better performance than the digital as soon as we reach -10dB. At -40dB the digital control is very much worse than the analog - by 32dB. This is why knowledgeable audiophiles will ask "how is the volume control implemented?" Let's look at the Invicta performance with its digital volume control: it is significantly different due to its higher S/N ratio. Here is the table for the Invicta with its -132dB S/N



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0	96.0	96.0
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-10	96.0	96.0
-15	96.0	96.0
-20	96.0	96.0
-25	96.0	96.0
-30	96.0	96.0
-35	96.0	96.0
-40	96.0	92.0
-45	91.0	87.0
-50	86.0	82.0
-55	81.0	77.0
-60	76.0	72.0

The performance is the same up to -40db and thereafter it differs by at most 4db.

There is no doubt that the analog volume control is better: but the difficulty of preserving the very low noise and distortion through the analog control was judged to be not worthwhile since the first difference of any kind occurs at -40dB and that difference is small.

Now the interested reader may be moved to ask: "but what about 24 bit data?" Here are the corresponding tables with realistic assumptions. The salient question to bear in mind is: "what noise is injected after the analog volume control?" In this table I have used a number of -136db because this is about what we measure when the DAC is removed from the output path and only the output amplifier and XLR driver are included. In this case the table is:

24 bits		
	Analog	Digital
0	132	132
-5	131	127
-10	126	122
-15	121	117
-20	116	112
-25	111	107
-30	106	102
-35	101	97
-40	96	92
-45	91	87
-50	86	82
-55	81	77
-60	76	72



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The analog volume control cannot maintain 132dB of performance since the output noise after the control is limited to -136dB relative to full scale, but again, it does exceed that of the digital control by a small amount 4db. [Note that this table assumes that that noise in the encoded 24bits is perfect: any real source will have about 120dB of S/N due to the ADC used at the studio]

The bottom line is: there is no doubt that ideally an analog volume control should be used. We choose not to, because in the Invicta case the benefits are not so profound as one may guess, and the difficulty of maintaining reliability, noise and distortion performance was judged to be greater than the benefit.