

LavryBlue Microphone Preamplifier measurements (8-22-2005)

General comments:

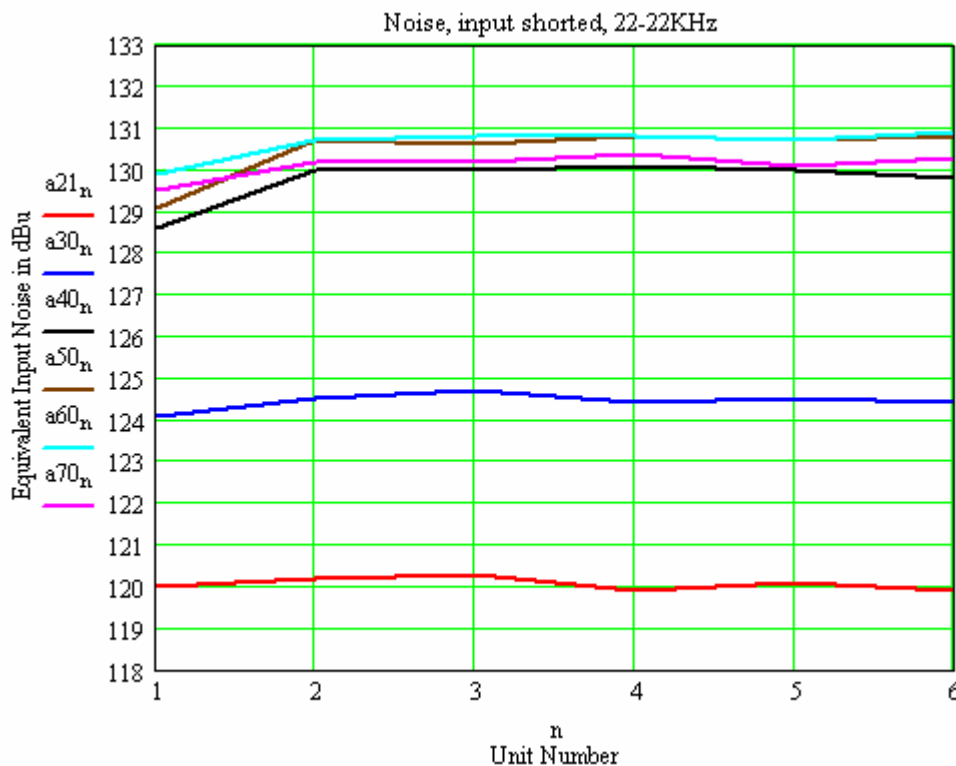
The LavryBlue micpre has been revised to better accommodate ribbon mics, and the noise floor has been reduced, the maximum gain is increased to 70dB (from 65dB).

I built 6 units of the revised version (12 channels), and picked 3 units randomly (6 channels). Below are measurements test results.

While very excited to show the measured results, I hope my presentation will help the sophisticated user understand some of the issues behind the specifications of micpre's in general. With such understanding, one can realize the goal of the LavryBlue mic pre to offer better performance than the costly state of the art mics pre's at a fraction of the cost!

1. Shorted Input noise measurements

First I checked the noise floor with the input shorted. That test shows the self-generating noise of the micpre, with no microphone attached. The measurement bandwidth setting was set to 22Hz-22KHz, no weighting.



A21 (red) is the noise floor at low gain (21dB). All 6 channels are at around -120dBu.

A30 (blue), the noise floor at gain (30dB) is between 124 and -125dBu.

A40, a50, a60 and a70 (gains of 40-70dB) are around -130dBu.

The measurement is called "Input referred noise" because it refers the noise to the input of the mic preamp. The noise one encounters at the output of the micpre is, of course,

amplified by the gain. For example, at 40dB gain setting, 130dBu input referred noise yields $-130\text{dBu} + 40\text{dB} = -90\text{dBu}$ of noise signal. Given 24dBu maximum signal output level, the dynamic range achievable is $90 + 24 = 114\text{dB}$. Repeating it for the various gain settings we get the real dynamic range of the micpre:

Gain = 21dB, dynamic range = $120 - 21 + 24 = 123\text{dB}$

Gain = 30dB, dynamic range = $124 - 30 + 24 = 114\text{dB}$

Gain = 40dB, dynamic range = $129 - 40 + 24 = 113\text{dB}$

Gain = 50dB, dynamic range = $130 - 50 + 24 = 104\text{dB}$

Gain = 60dB, dynamic range = $131 - 60 + 24 = 95\text{dB}$

Gain = 70dB, dynamic range = $131 - 70 + 24 = 85\text{dB}$

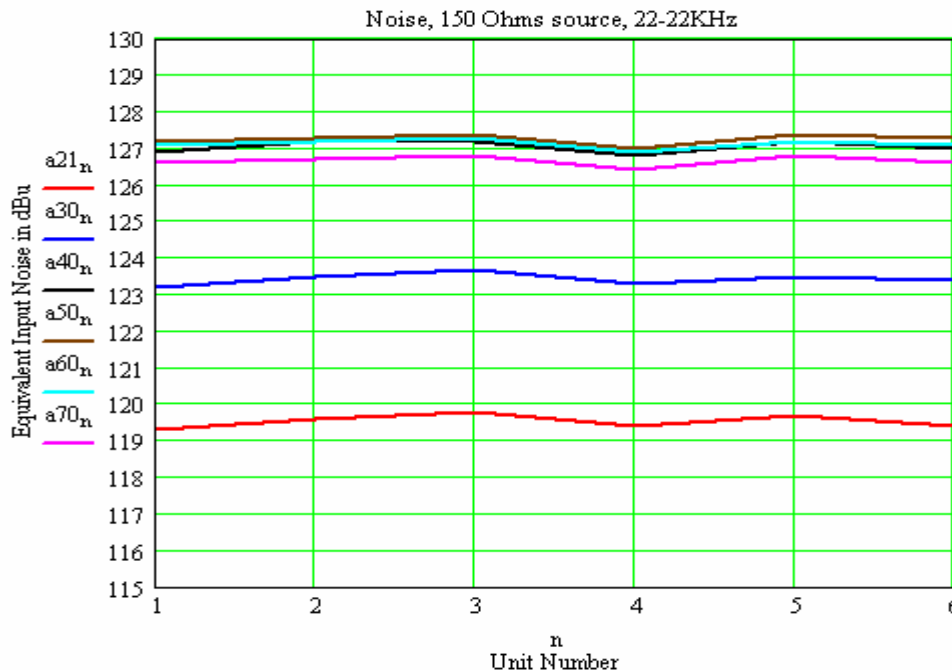
Note that using a micpre at high gain settings adds noise into the signal. Even the state of the art in low noise micpre becomes the bottleneck of dynamic range at high gains. The noise specifications of a micpre become even more important when using “weak” microphones, such as a ribbon mic. A dynamic mic yields more signal, requiring less gain. As a rule, a condenser mic yields the strongest signals, thus the best dynamic range.

2. Noise with 150 Ohms source:

While shorted input measurements have much value in comparing micpre ultimate noise performance, a “real world” application requires a microphone. Sounds picked by a real mic will disturb the measurement, therefore industry standard practice is to use a “dummy mic”, which is a simple resistor, representing a mic impedance. The resistor generates noise in 2 ways:

1. Self generation of noise (as in all resistors)
2. By interaction with the mic input current noise

The resistor values of various microphone cover a wide range of values. The value 150Ohm is very common for measurements of micpre specification.



The plot shows how replacing the input short by a 150 Ohm resistor reduces the dynamic range of the system.

A21 (red) is the noise floor at low gain (21dB). All 6 channels are at around -119.5dBu.

A30 (blue), the noise floor at gain (30dB) is between 123 and -124dBu.

A40, a50, a60 and a70 (gains of 40-70dB) are around -127dBu.

The plots show "Input referred noise". "Input referred IS the standard way to specify a micpre, but the user is advised to translate it to "real dynamic range" (accounting for gain setting). We do not listen to the micpre input, we listen to the output.

Gain = 21dB, dynamic range = $119.5 - 21 + 24 = 122.5$ dB

Gain = 30dB, dynamic range = $123.5 - 30 + 24 = 117.5$ dB

Gain = 40dB, dynamic range = $127 - 40 + 24 = 111$ dB

Gain = 50dB, dynamic range = $127 - 50 + 24 = 101$ dB

Gain = 60dB, dynamic range = $127 - 60 + 24 = 91$ dB

Gain = 70dB, dynamic range = $127 - 70 + 24 = 81$ dB

The loss in dynamic range due to the 150Ohm dummy can be seen by comparing the data to the shorted input case:

At Gain = 21dB the mic reduces the dynamic range by about .5dB

At Gain = 30dB the mic reduces the dynamic range by about 3.5dB

At Gain = 40dB the mic reduces the dynamic range by about 3.5dB

At Gain = 50dB the mic reduces the dynamic range by about 3.0dB

At Gain = 60dB the mic reduces the dynamic range by about 4.0dB

At Gain = 70dB the mic reduces the dynamic range by about 4.0dB

For all practical purposes, one can say that a dummy mic represented by 150Ohm resistor reduces the dynamic range of a state of the art mic pre by about 3-4dB. Of course a noisier micpre will show much less difference between an input shorted and a dummy mic measurements.

An important note: While 150-Ohms value has become a standard value for testing micpres, the real world values vary over a wide range. Thus a shorted input measurement is of great value, especially for lower impedance mics.

3. Total Harmonic Distortions Plus Noise (THD+N):

All testing of THD+N is done using a bandwidth of 10Hz to 30KHz

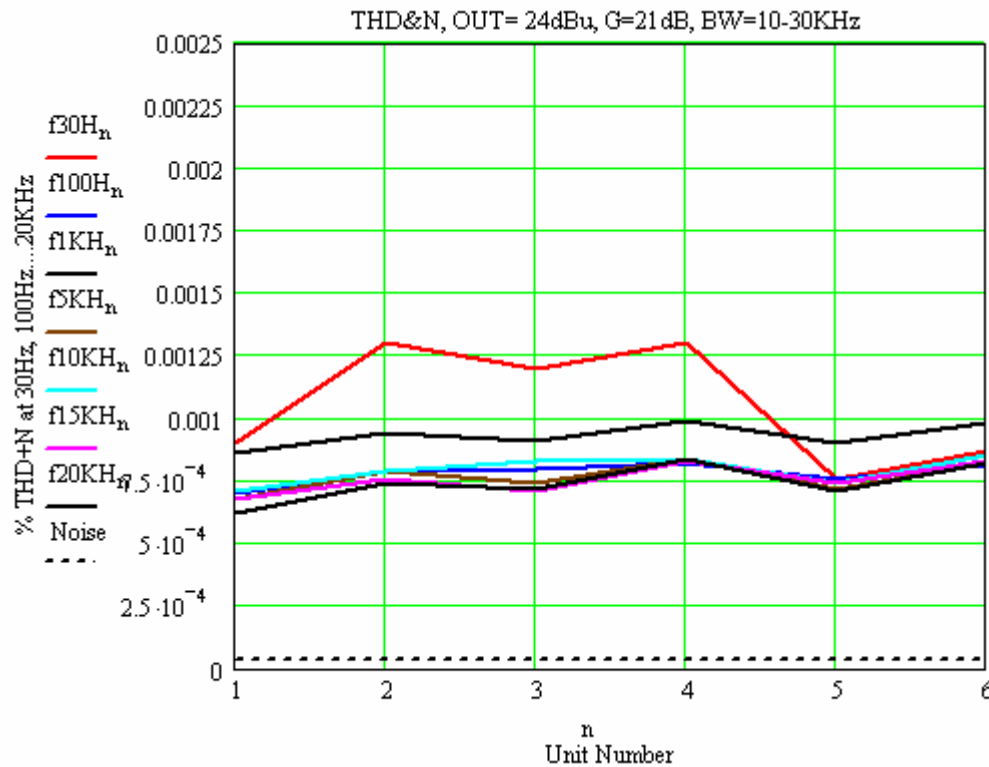
The measurement of the 6 channels is grouped by gain settings:

The gains are 21dB, 40dB, 60dB and 70dB.

Each plot (showing 6 channels) shows the values of THD+N at the following frequencies: 30Hz, 100Hz, 1KHz, 5KHz, 10KHz, 15KHz and 20KHz.

Each plot shows the THD+N results in percent, while the mic pre is driven to its specified full scale signal of 24dBu.

THD+N at 21dB gain, 24dBu output:

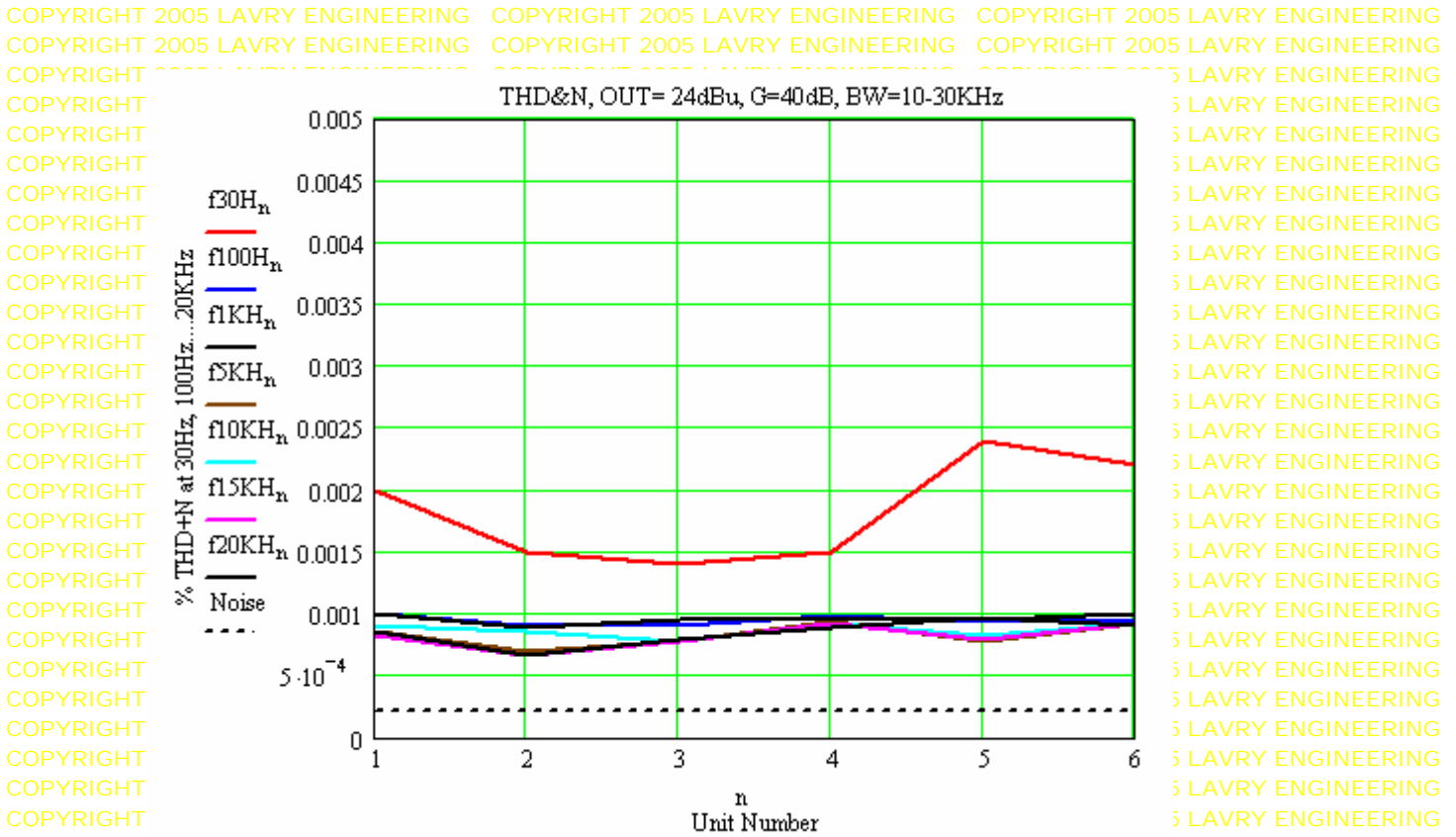


The distortion at 30Hz is the highest, but still very low at .00125%. At 100Hz the distortion goes under .001%, approaching .0006% for 1KHz and above. Note that the noise (dotted black line) is much below the distortions at Gain = 21dB.

THD+N at 40dB gain, 24dBu output:

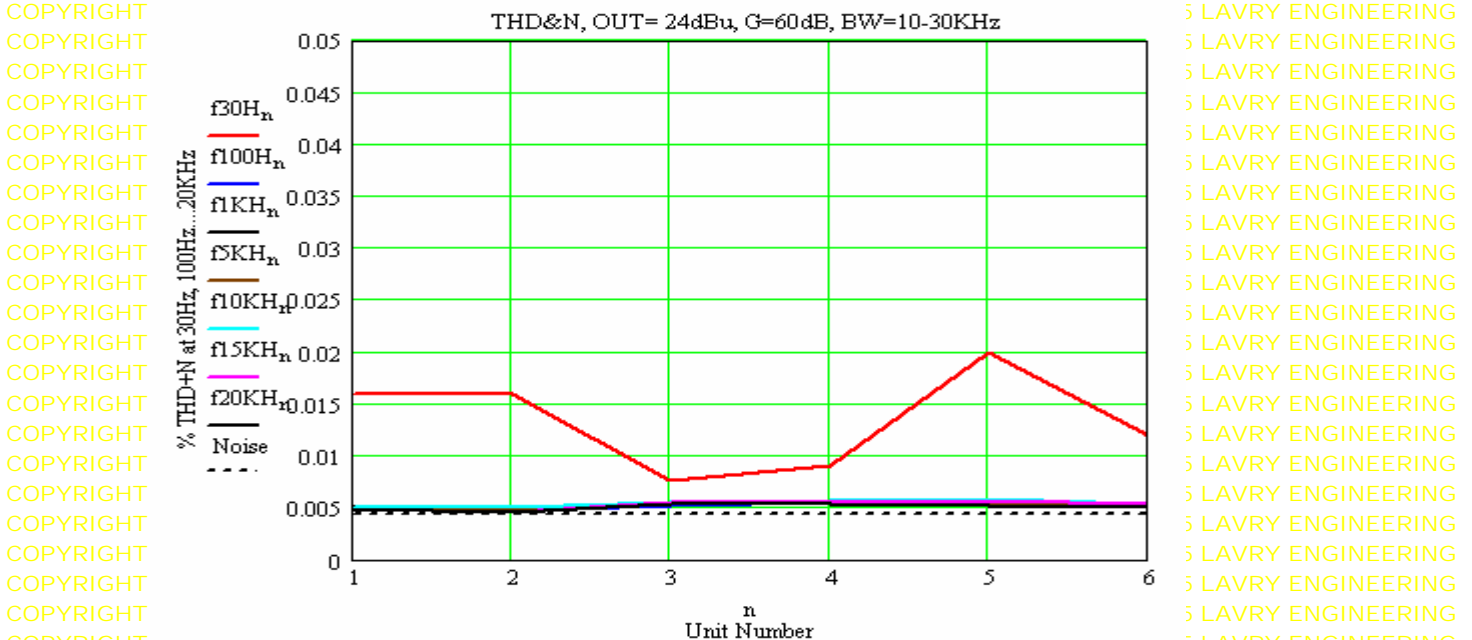
At 40dB gain, the 30Hz low frequency distortion is up to .0025%, and at all other frequencies (100Hz to 20KHz) we get below .001% performance. While the 30Hz operation is below most mic capabilities, it is an important figure when comparing to transformer based designs. The “working range” THD+N of 100Hz-20KHz is less than .001%!

Note that at 40dB gain, the distortions are the overriding factor in the THD+N figure. The noise (dotted black line) is still below the distortions at Gain = 40



THD+N at 60dB gain, 24dBu output:

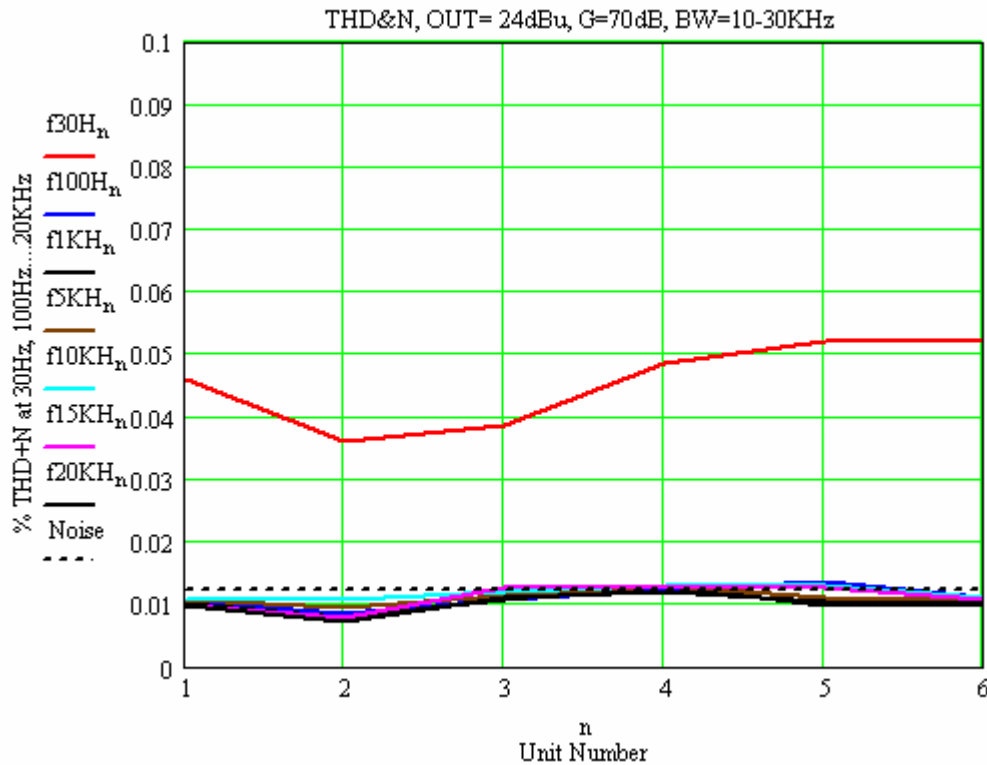
At 60dB gain, the 30Hz low frequency distortion is up to .01%-.02%, and at all other frequencies (100Hz to 20KHz) we get below .005% performance. Note that at 60dB gain, the distortions are no longer the overriding factor in the THD+N figure. The noise (dotted black line) is now the main limiting factor of the THD+N figure.



THD+N at 70dB gain, 24dBu output:

At 70dB gain, the 30Hz low frequency distortion is up to .05% and at all other frequencies (100Hz to 20KHz) we get around .01% performance.

Note that at 70dB gain, the distortions are no longer the overriding factor in the THD+N figure. The noise (dotted black line) is now the main limiting factor of the THD+N figure.

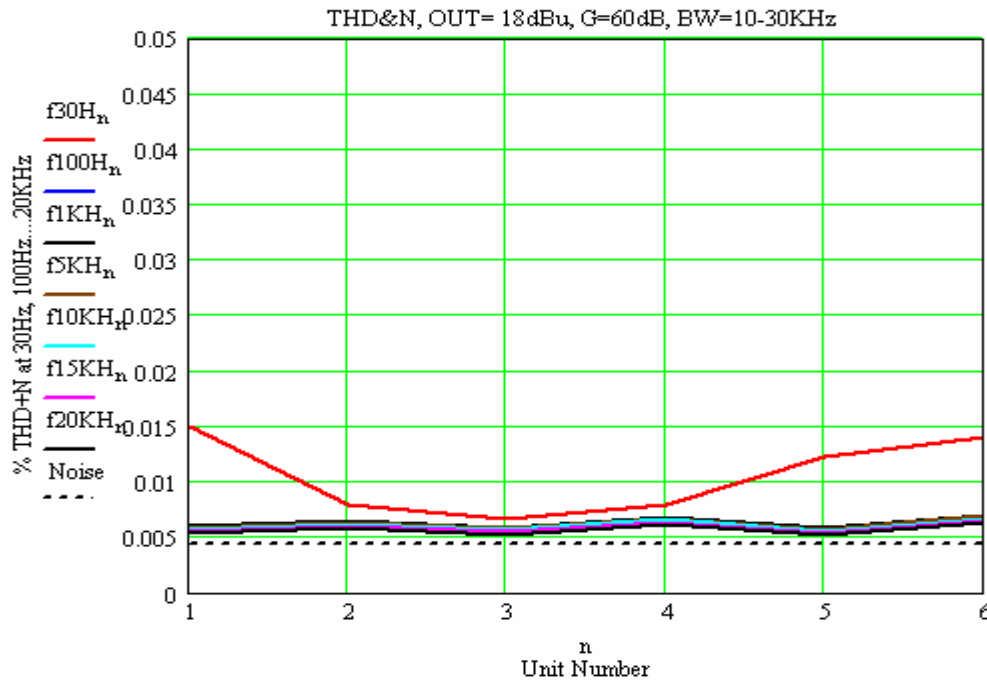


Clearly, driving the micpre to its full scale output shows the behavior under maximum stress conditions. Such peak signal is only encountered "once in a while". The following plots are a repeat of the THD+N measurements at 6dB below full scale output (at 18dBu output level):

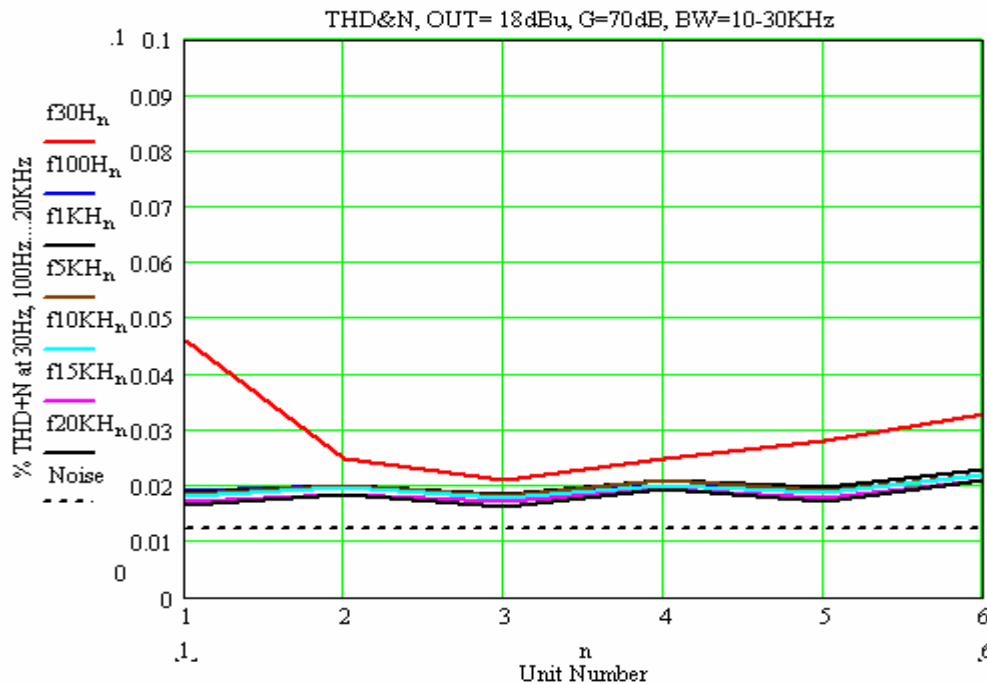
THD+N at 21dB gain, 18dBu output:

Note that the even the 30Hz THD+N is better than .001%. In fact, the THD+N for all frequencies between 30Hz to 20KHz are around .0006-.0007%!

Note that the even the 30Hz THD+N is at or below .015%. The THD+N for all other (100Hz to 20KHz) is still around .006-.007%! At 60dB gain, the noise accounts for much of the THD+N figure



THD+N at 70dB gain, 18dBu output:



The 30Hz THD+N is at or below .02%-.05%. The THD+N for all other frequencies (100Hz to 20KHz) is around .02%. Still a great performer for 70dB gain, but clearly,

pushing the gain further would impact the distortions, therefore I set the maximum gain limit to 70dB.

The input impedance question

One of the first subjects studied by an analog EE is the fact that ideal power transfer occurs when source impedance is the conjugate of the load impedance. To simplify — if possible, we want the source and load resistance to be equal. Unfortunately, microphones are incapable of delivering a low distortion signal into a load as low as the mic impedance. That fact forces the micre input impedance to be higher, and over the years, a “rule of thumb” emerged, calling for a micpre input to be at least 5-10 times higher than the mic impedance.

There are other issues involved in figuring the ideal micpre input characteristics. One such issue is “noise pickup susceptibility”. While most of the environmental noise susceptibility is dealt with by careful use of balanced and shielded cables, a lower input resistance provides lower noise susceptibility in real world use. Such fact is often overlooked in laboratory measurements.

Also, microphones are complex, and their reaction to various loads is not well documented in terms of reaction to a “sudden step”. The signal characteristics (ringing, and settling) is rarely specified.

Adding to the confusion is the fact that ribbon, dynamic and condenser technologies are all vastly different, requiring some “average” compromise for the input impedance.

After long discussions with my microphone lover friends, I decided to avoid a compromise all together, and optimize the design by mic type. There is a 3 position switch setting for ribbon mics, dynamic mics and for condensers. The condenser position activates a 48V phantom supply. I provide one double regulated extremely low noise phantom supply per channel to insure channel separation.

To be continued.