

# WELSH'S SYNTHESIZER COOKBOOK

## Vol 2: Harmonic Catalog



FRED WELSH





**Welsh's Synthesizer  
Cookbook  
Vol 2: Harmonic Catalog  
By Fred Welsh**

## **Welsh's Synthesizer Cookbook, Vol. 2: Harmonic Catalog**

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# USAGE

This book is intended primarily as a resource for synthesizer players who have either read Welsh's Synthesizer Cookbook Vol. 1 (black and yellow cover) or for those who have prior experience using harmonic analyzers to program sounds. Unlike the first volume this book does not explain how to program each sound. It does however have an advantage in that unlike the patches in the first book which are very specific the player is here free to use whatever means they choose to achieve the end result. For the most part only the harmonic content of each sound is presented. There is no information about how each sound's amplitude or tonal quality changes over time. It is left totally up to the reader to program these aspects of the sound as they see fit.

Some basic advice can however be given:

1. The low frequency harmonics of most instruments will be the first to come up in amplitude during the attack of the sound and the last to die out as the sound decays. For this reason it is usually best to sculpt the sound with a low-pass filter and its envelope before using the amplitude envelope to apply any finishing touches.

2. The harmonic structure of most instruments can sometimes be replicated simply by mixing together a couple of different waveforms and possibly changing the pitch of one to create a more elaborate harmonic structure. Much of the time this isn't enough. Truly sophisticated harmonic structure can be created with an analog or subtractive synth by employing oscillator syncing, and variable pulse width. Other less common options also include frequency modulation (FM), ring modulation, and amplitude modulation.

Each graph shows amplitude along the vertical axis and frequency along the horizontal axis. Amplitude is labeled along the left-hand edge of each graph going from 0 down to -100 dB. Frequency is labeled along the top of each graph, is displayed in Hz with a range that is different for each graph but does not exceed 20,000 Hz. The pitch of each sound is given in the title by values such as C4, B3, E2,



etc. corresponding to keys on a keyboard. This is useful to know when trying to compare a synth's output to the graphs in the book.

There are some graphs which have “Dynamic” in the title. This indicates that the amplitudes of the harmonics are unstable and go up and down in amplitude independent of each other. This is true to some extent for all sound sources but most of the time it is minor and contributes little to the sound. In the case of those graphs with “Dynamic” designated in the title the non-static nature of the harmonics is an important part of the sounds character. This is particularly true of plucked and hammered strings.

There are a number of ways in which this can be replicated on an analog or subtractive synthesizer. It can be achieved typically through pulse-width modulation as well as oscillator syncing with the slave's pitch modulated by an envelope or LFO. It can also be achieved through Frequency Modulation by setting the FM source frequency, so that the partials remain at harmonic intervals, and then modulating the depth or amount (not pitch!) of the FM source again using either an envelope or LFO. Each of these methods produces slightly different results but all will cause the harmonics to have undulating amplitudes. There is no real guidance as to how much you'll want to apply. Simply apply the amount that sounds good!

All instruments were graphed at approximately the middle of their range of pitch with the exception of pianos and guitars which have graphs for a multitude of different pitches. There are two reasons for this. The first is the importance of these instruments to current western music and secondly the fact that these instruments have harmonics which change dramatically across their range of pitch. All instruments have a different timbre, or tonal quality, across their range but this is particularly true for piano and guitar.

Watch for missing or diminished harmonics. Some sound sources either lack some harmonics or have harmonics that are very low in amplitude. Examples are the Alto Flute (pg 43) and Electric Piano (pg 53). The Alto Flute has a 1<sup>st</sup> harmonic that is nearly 40 dB lower than its 2<sup>nd</sup> harmonic. The Electric Piano has odd-numbered harmonics, such as the 1<sup>st</sup>, 3<sup>rd</sup>, and 5<sup>th</sup>, which are about 30 dB lower than their even-numbered neighbors. At quick glance the Electric Piano appears to have the 1<sup>st</sup> harmonic at C5, however upon closer examination we see that this is in fact the 2<sup>nd</sup> harmonic and the 1<sup>st</sup> harmonic

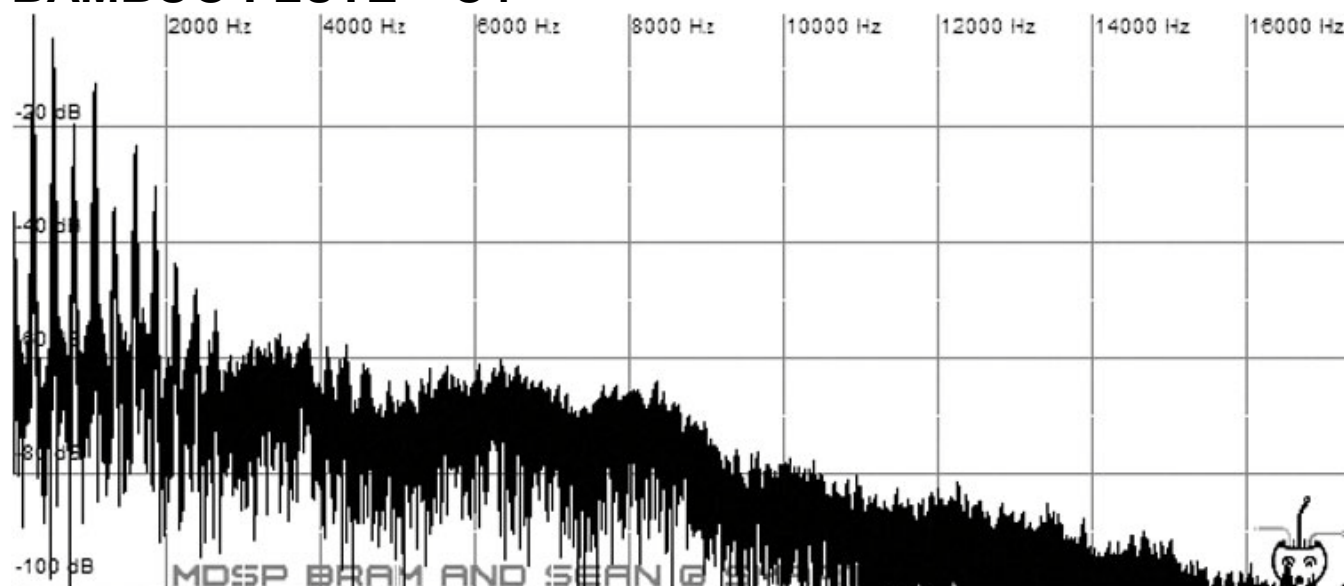
actually sits an octave lower at C4. Also watch for “False” harmonics at the very edge of the left-hand side of the graphs. Using the Alto Flute again as an example note that on the far, left-hand edge of the graph there is a short spike just below the -40 dB line. This is an artifact of the processing routine and not an actual harmonic. These are present in many of the graphs so keep this in mind.

When replicating the graphs with a synthesizer remember that the lowest-pitched harmonics at the left of each graph are the most important. The low-pitched harmonics are the responsible for creating the character of the sound while the higher-pitched harmonics are responsible for the brightness. The higher harmonics are important collectively as without them all the sounds would be dull, but on an individual basis it is not all that critical to get each one exactly right.

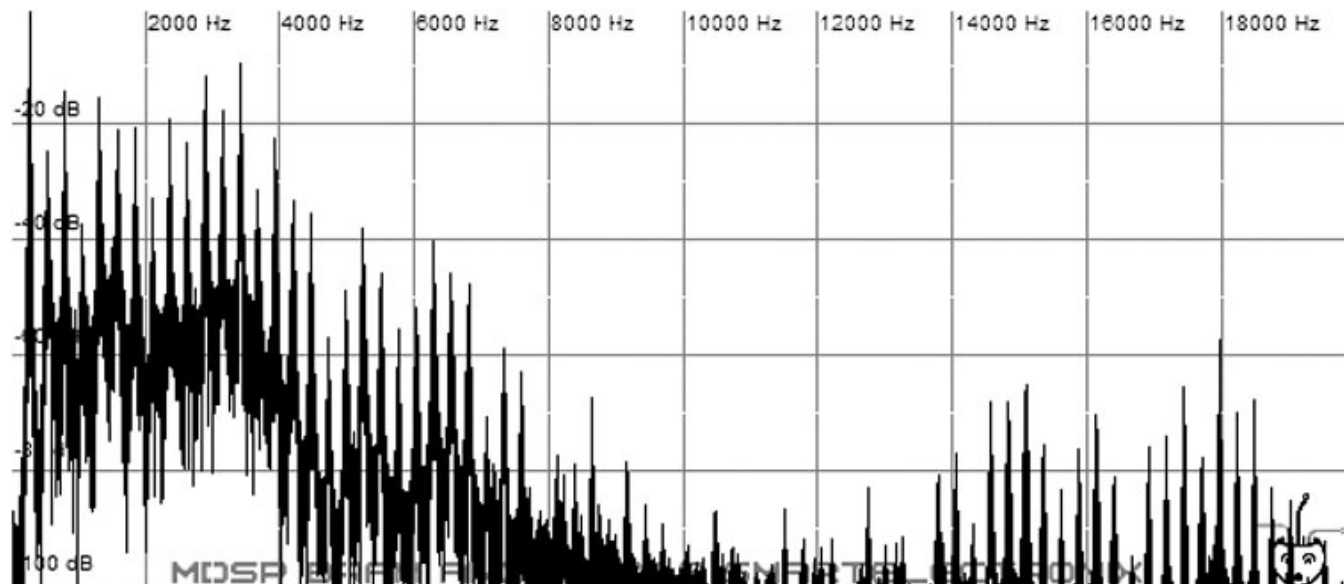


# WOODWINDS

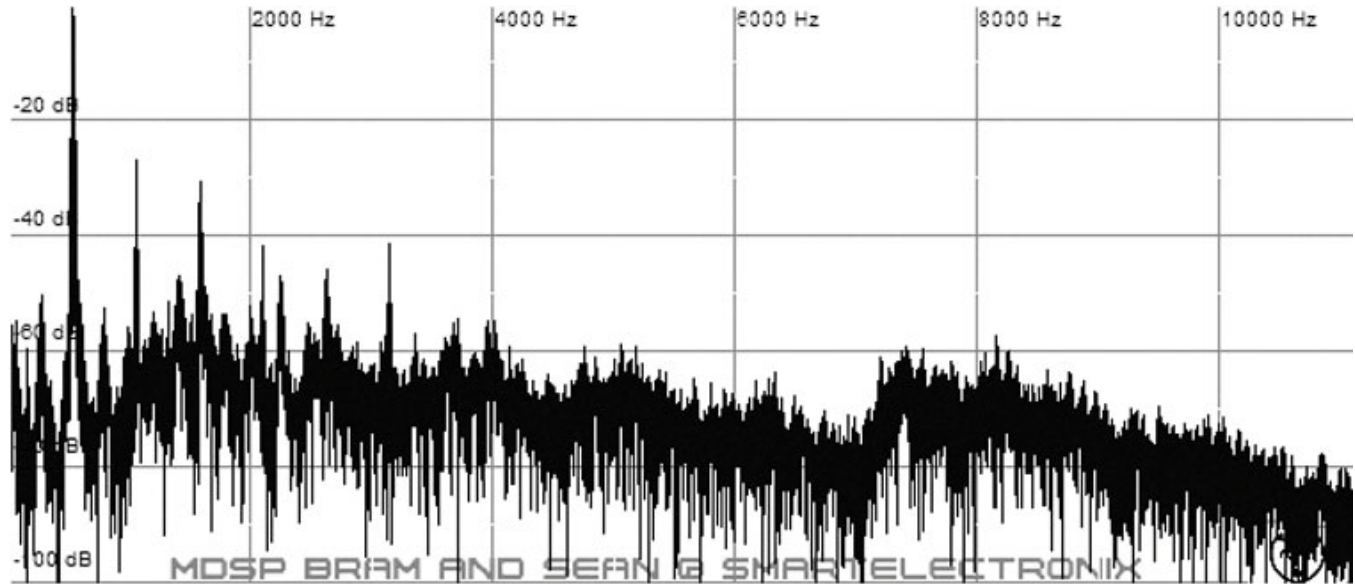
## BAMBOO FLUTE – C4



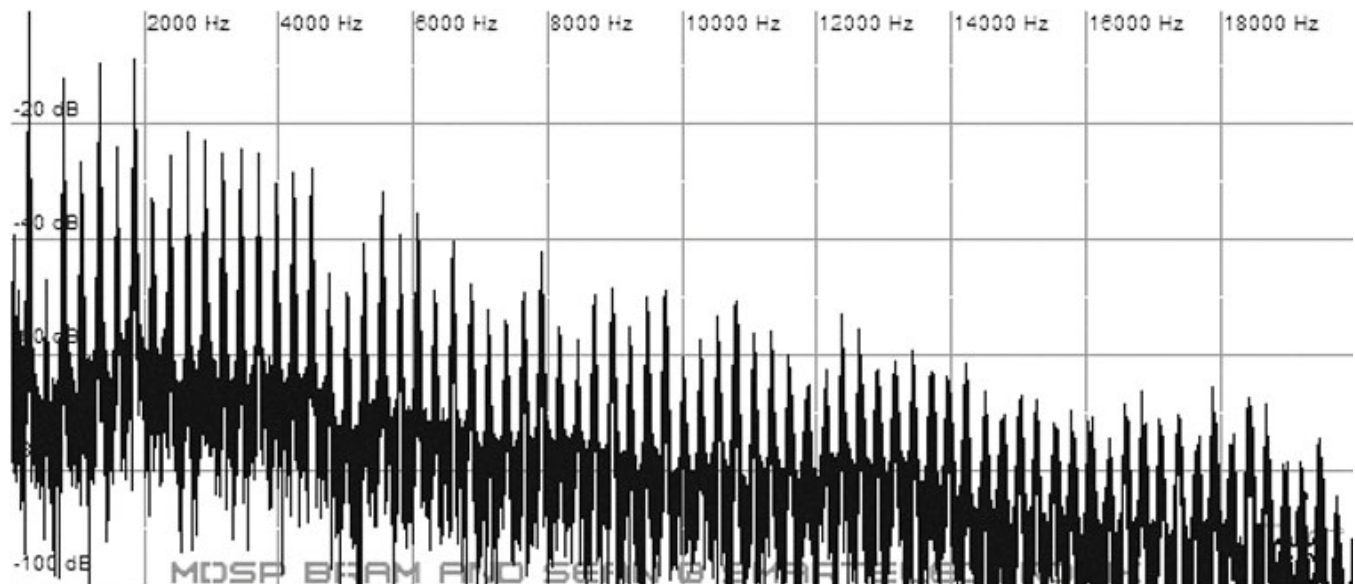
## BANGDI CHINESE FLUTE – C4



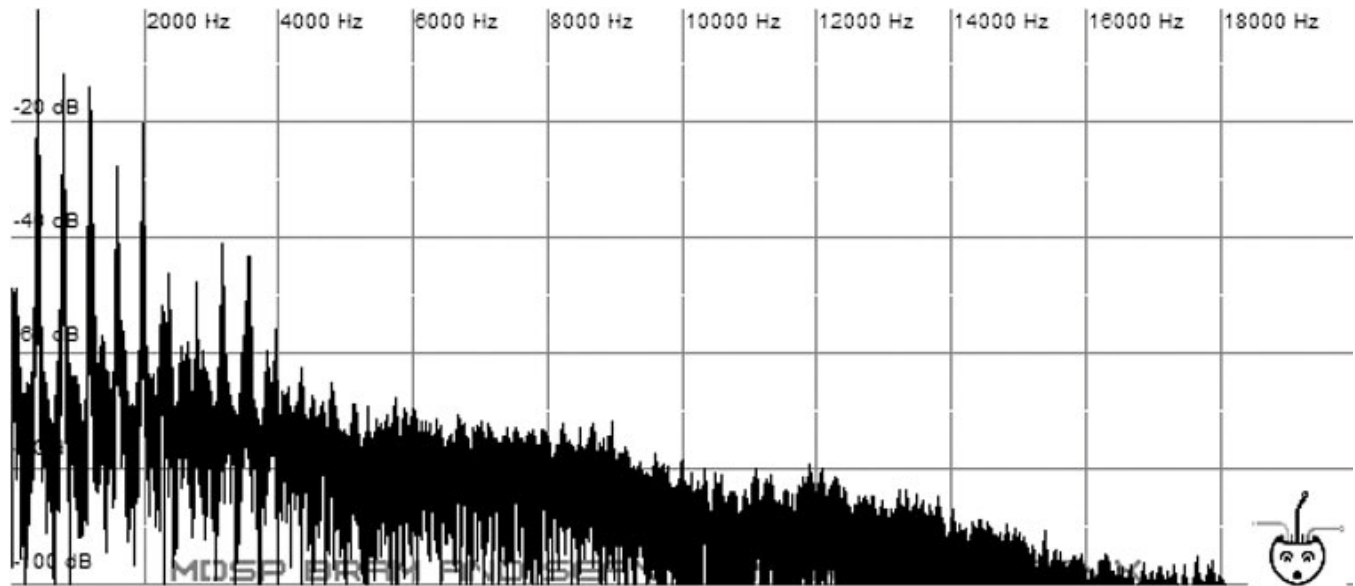
## BANSURI FLUTE – C4



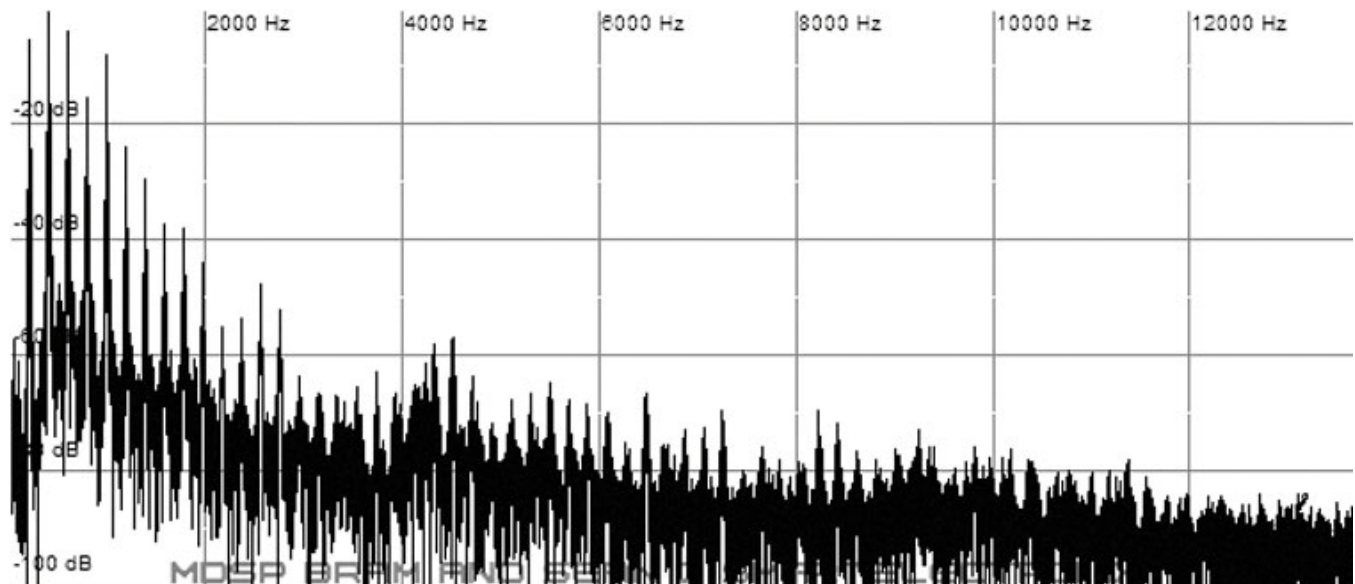
## BASS CLARINET – C4



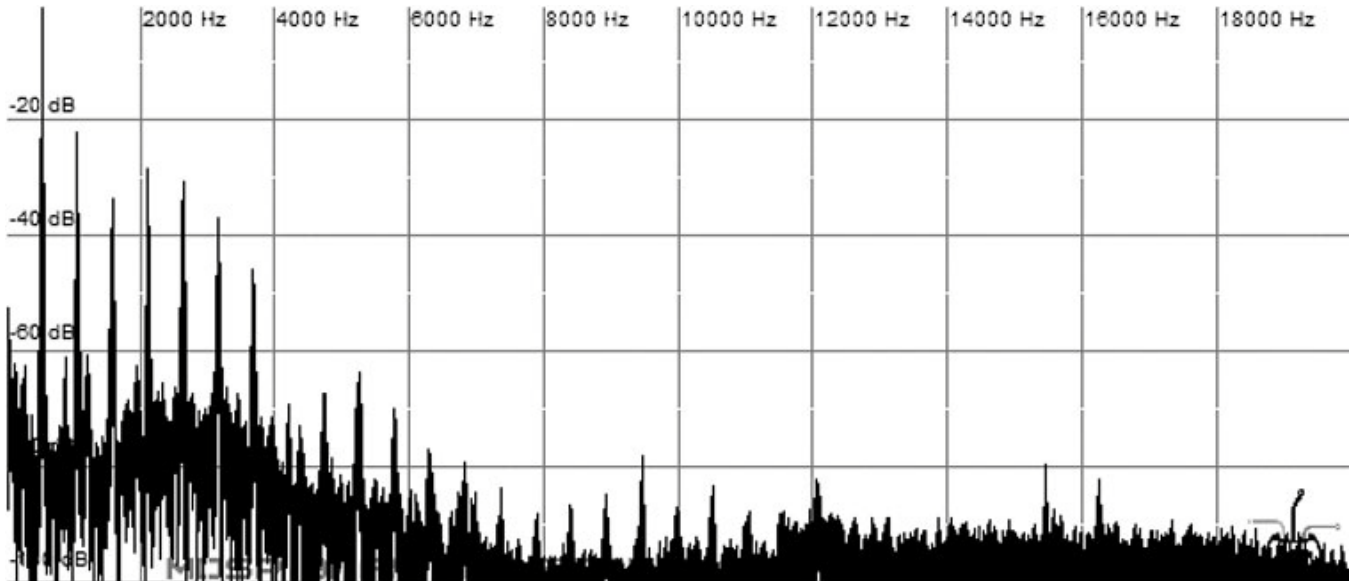
## BASS RECORDER – G4



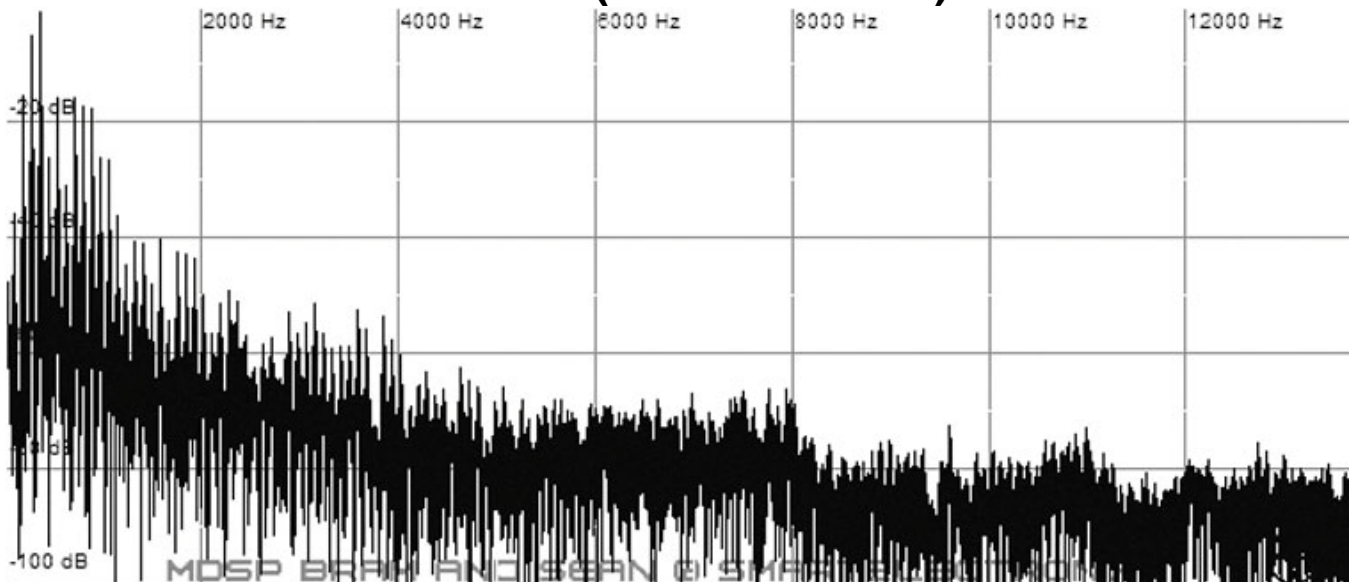
## BASSOON – G3



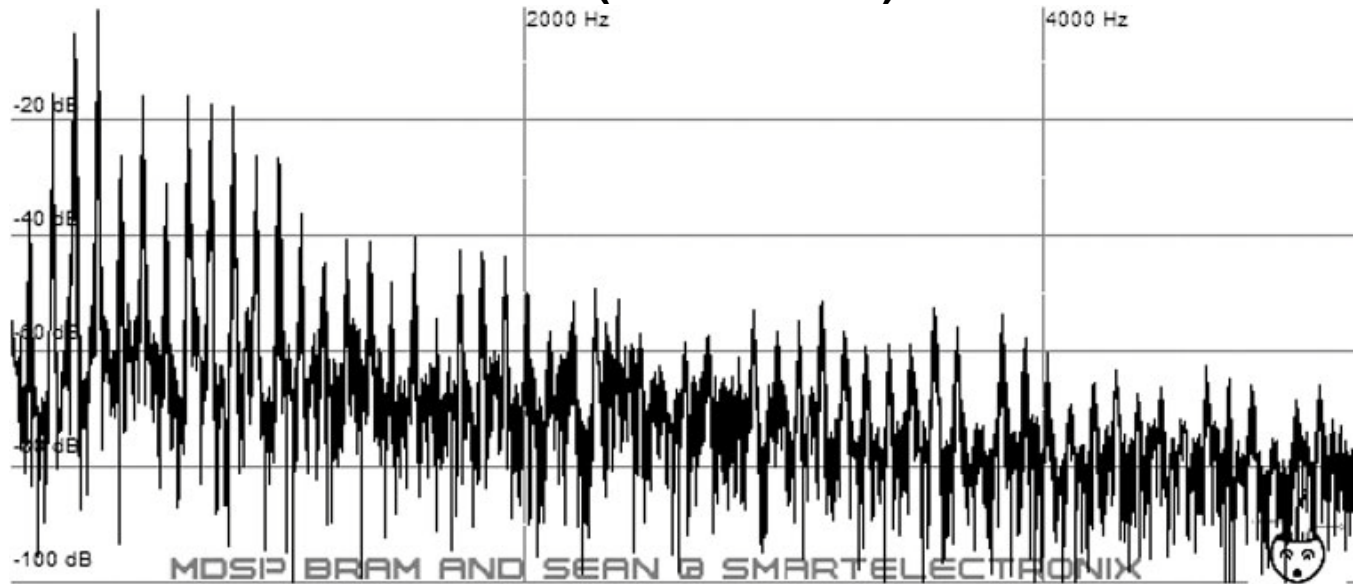
## CLARINET – C5



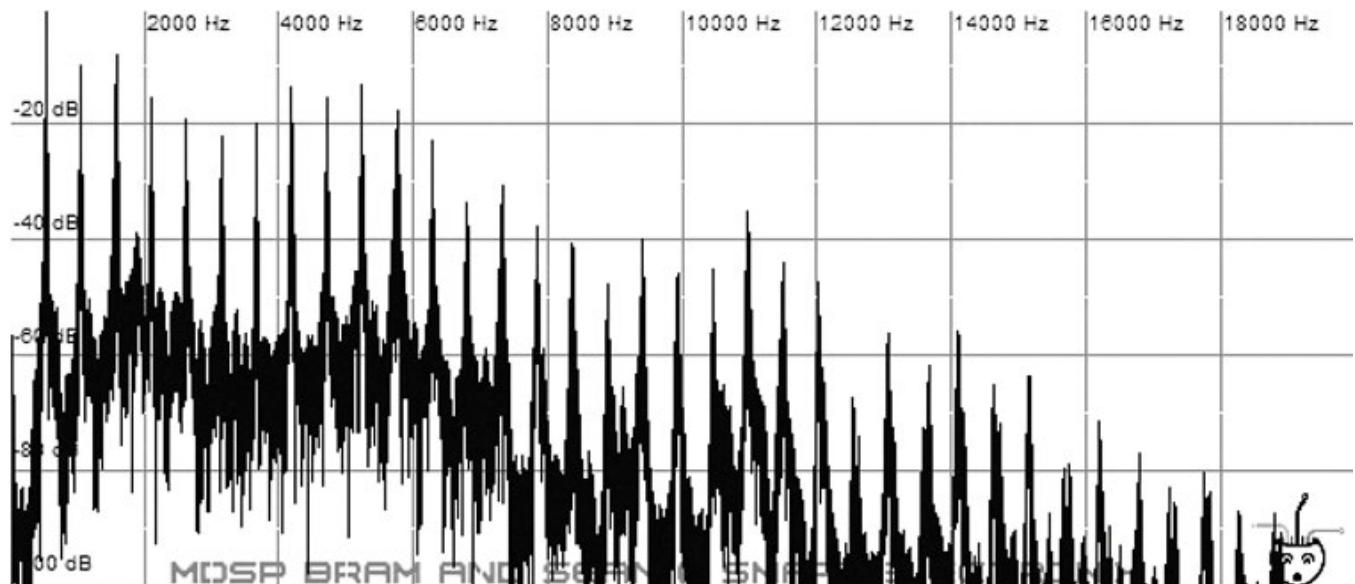
## CONTRA-BASSOON – F2 (ZOOMED OUT)



## CONTRA BASSOON – F2 (ZOOMED IN)

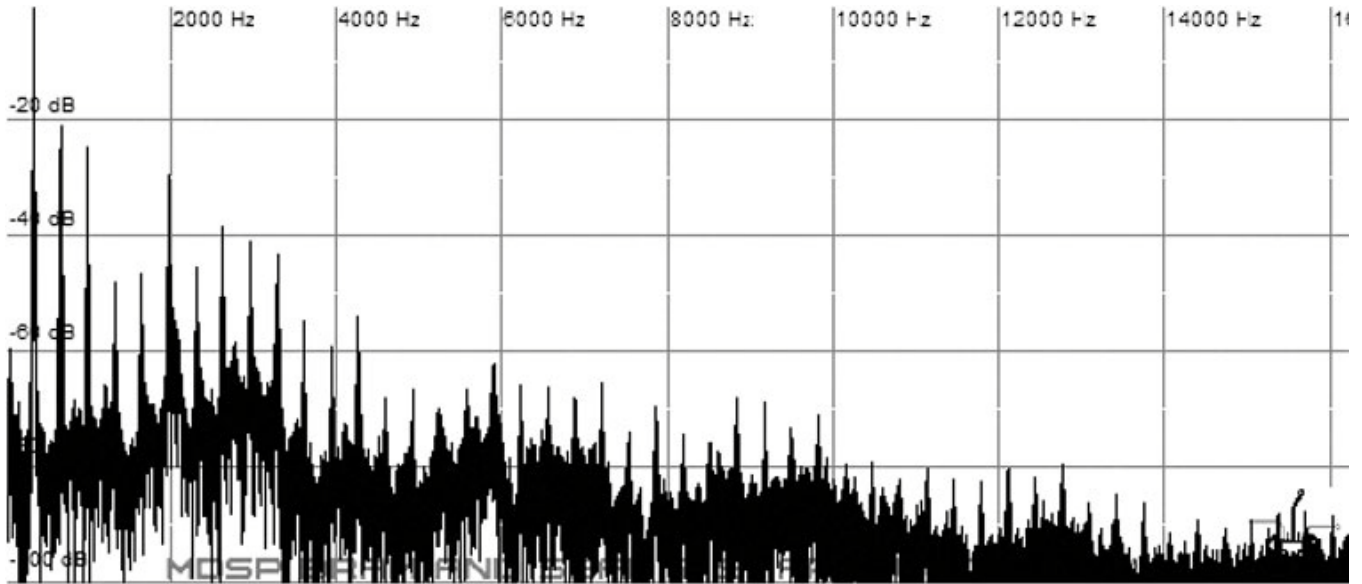


## DIZI CHINESE FLUTE – C5

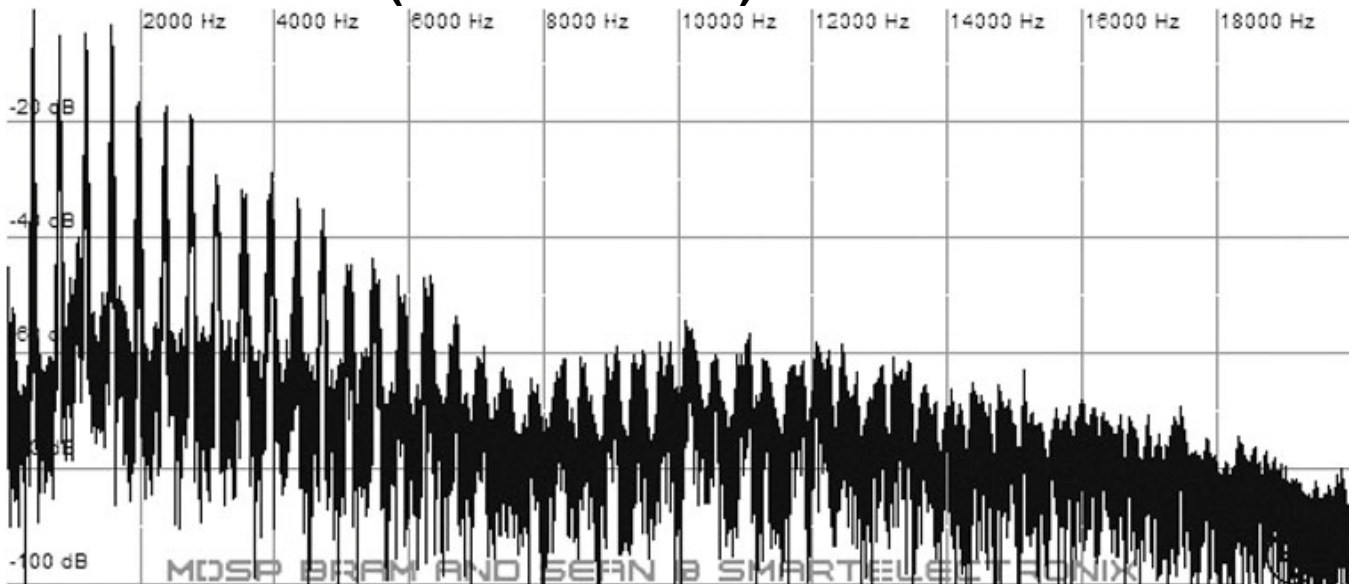




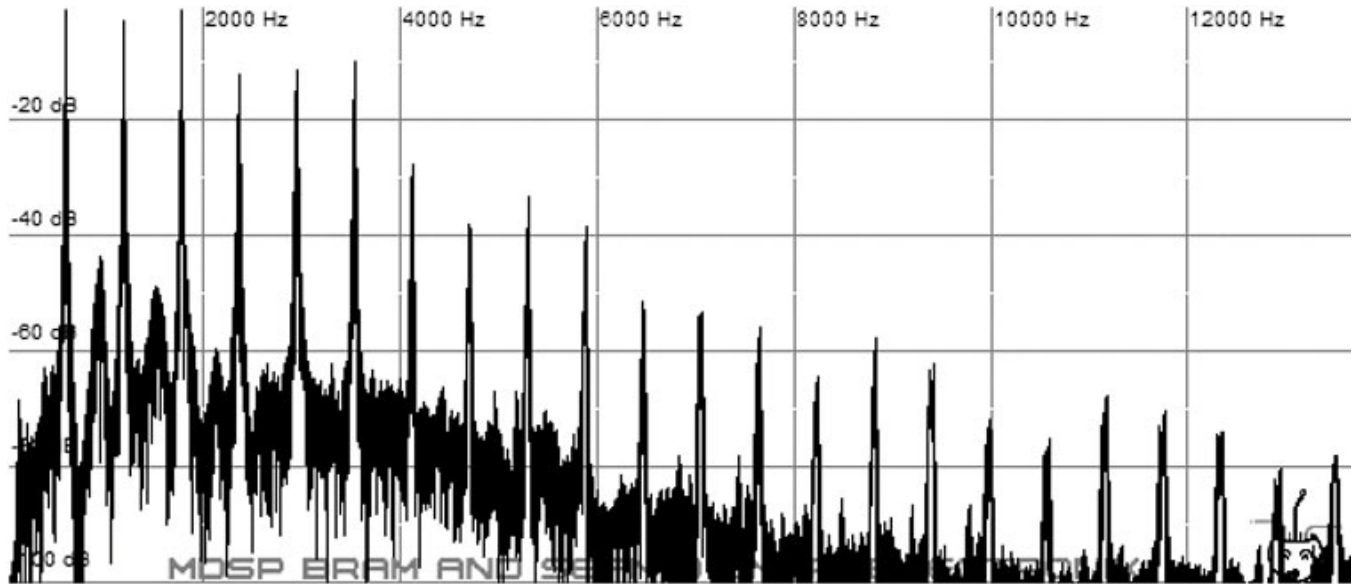
## DUDUK – E4



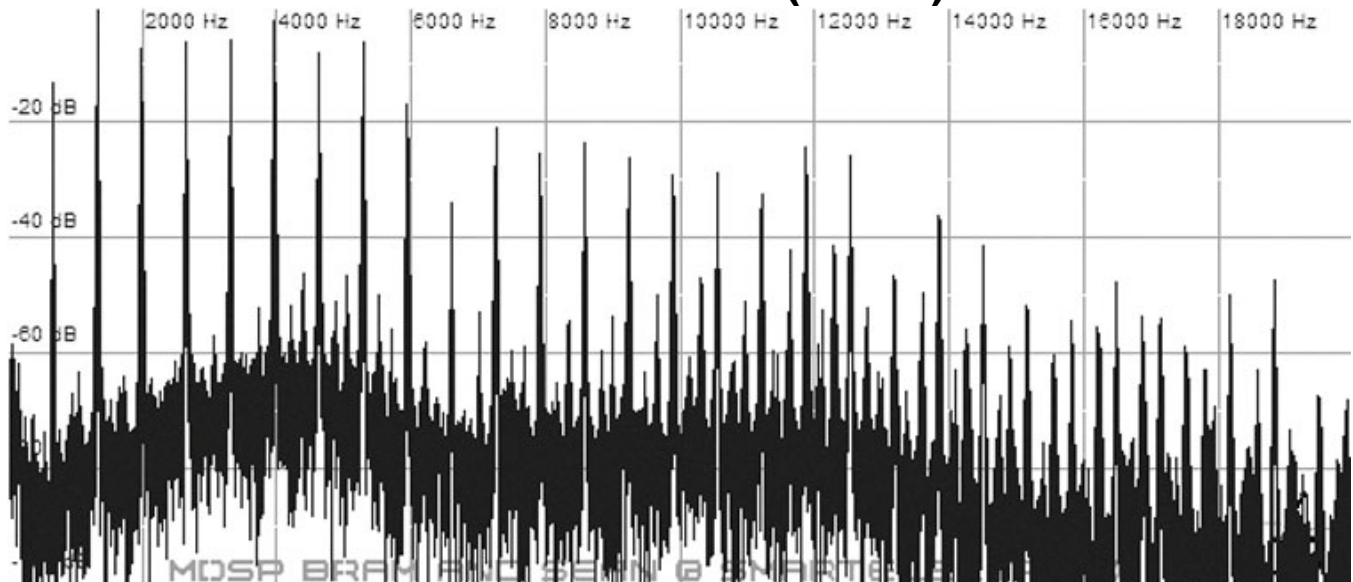
## ENGLISH HORN (COR ANGLAIS) – G4



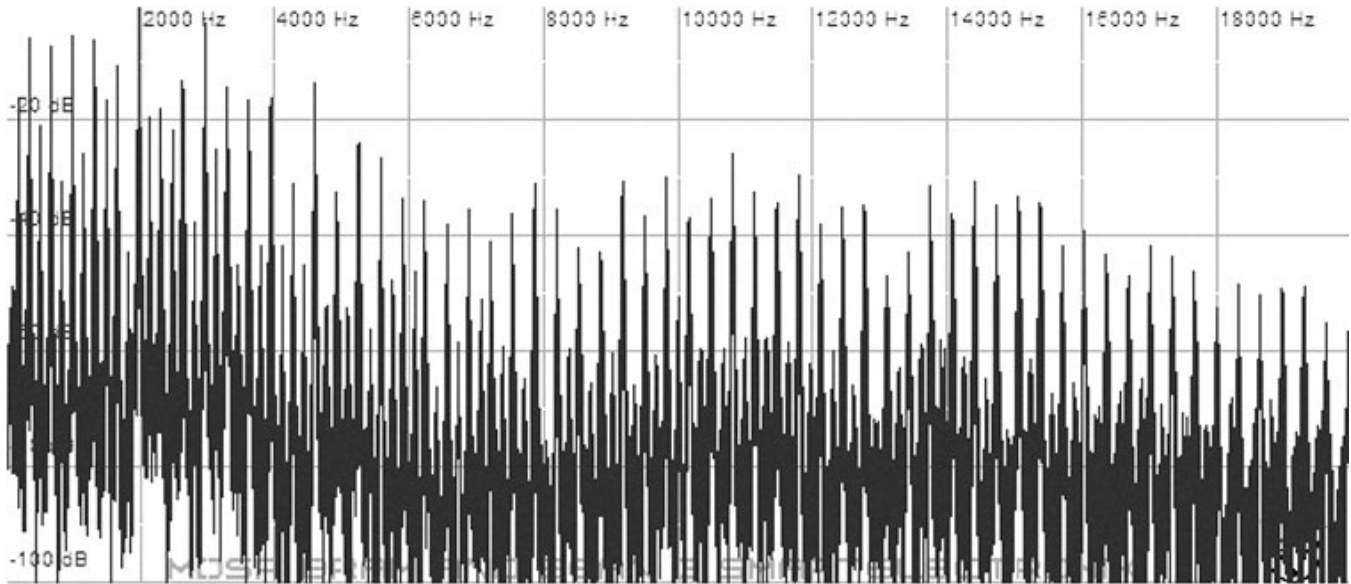
## FRENCH OBOE – D5



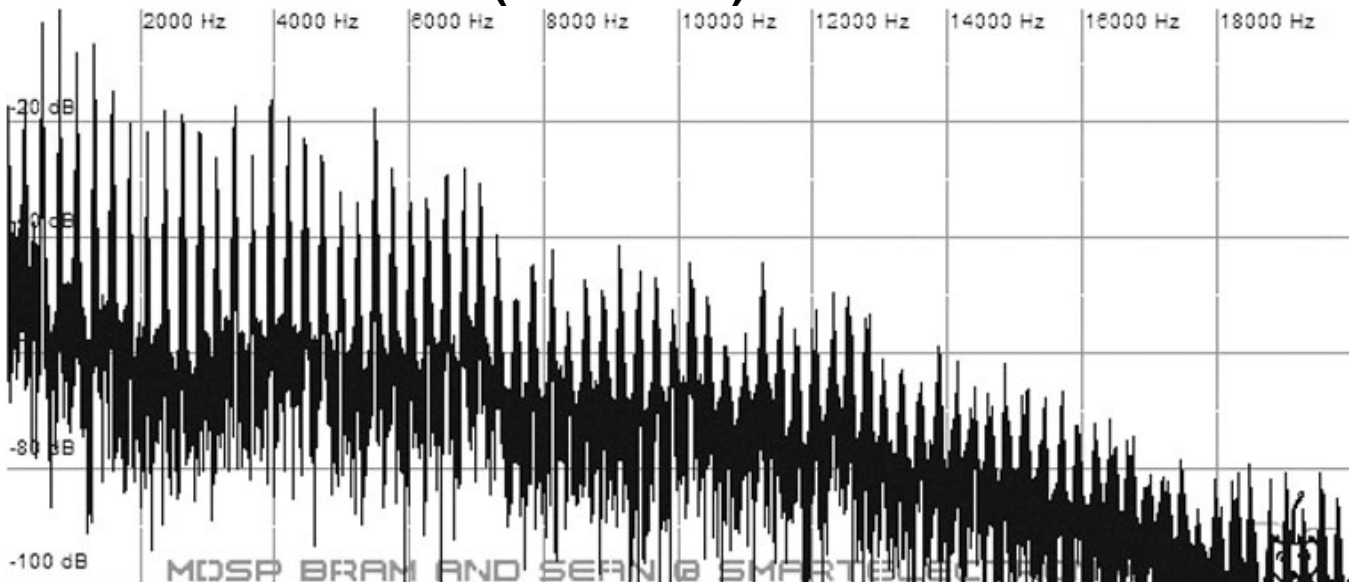
## HIGHLAND BAGPIPES CHANTER (LEAD) – E5



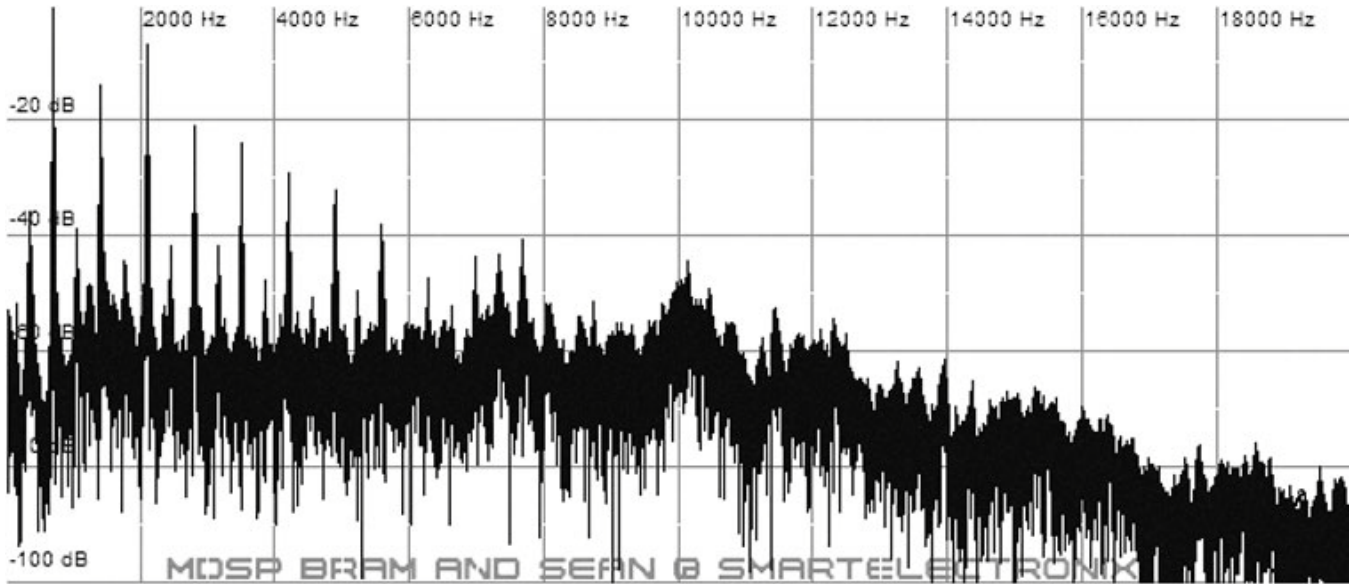
## HIGHLAND BAGPIPES DRONE – E3



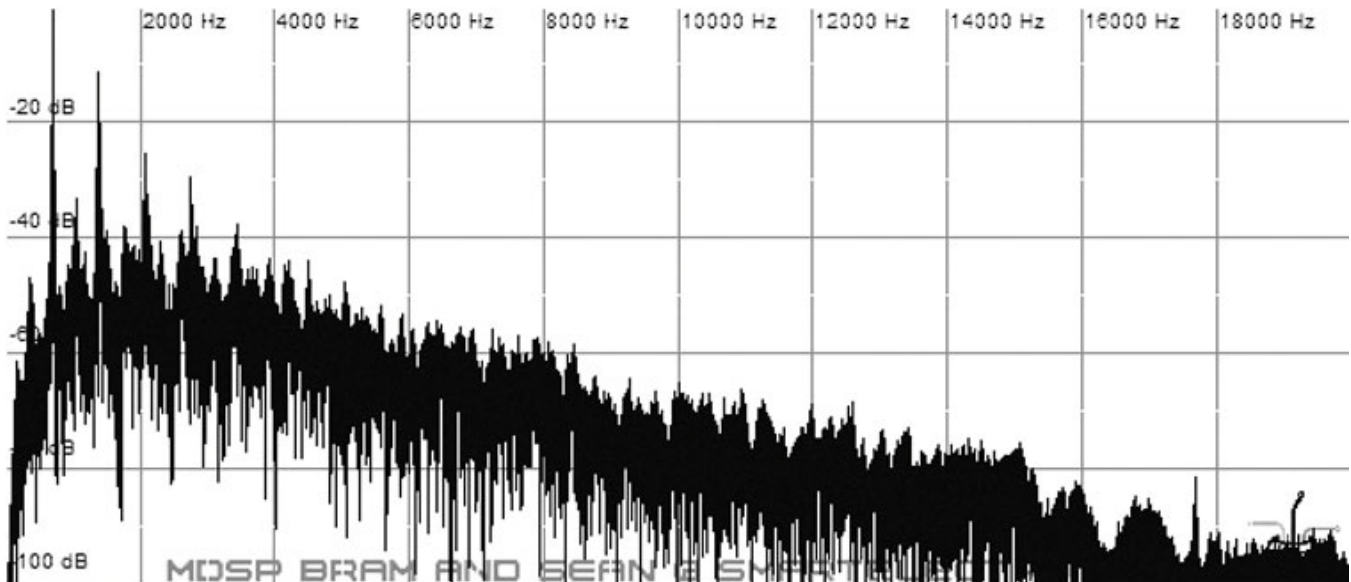
## HURDY GURDY – C4 (DYNAMIC)



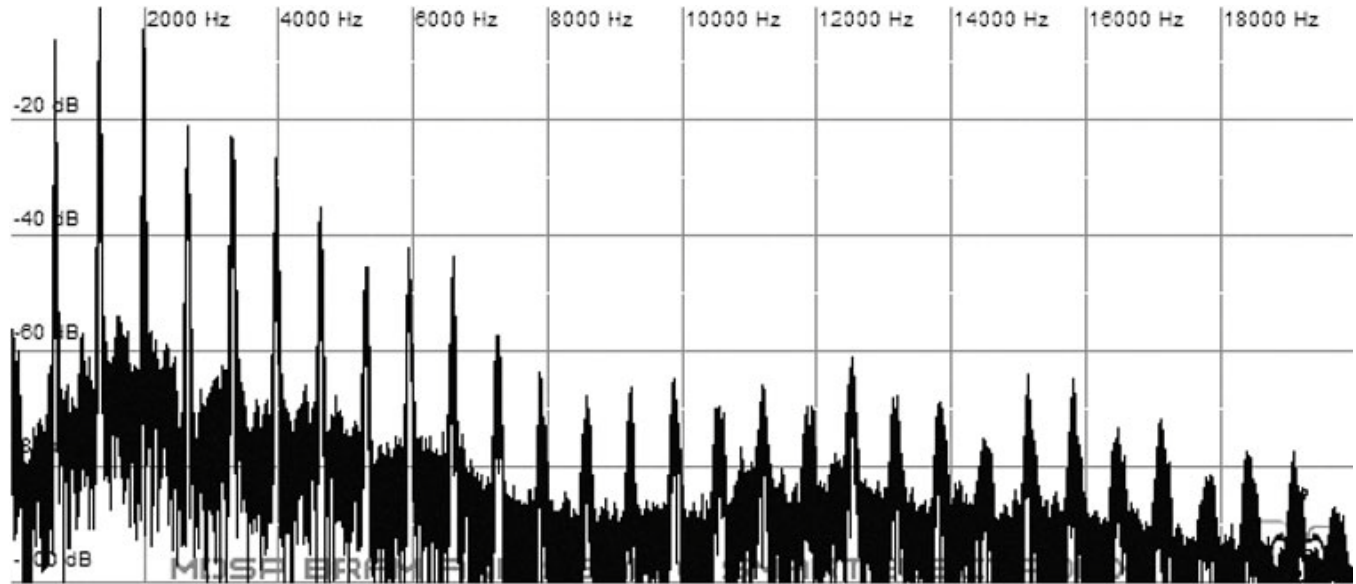
## IRISH FLUTE – F4



## KAVAL FLUTE – F4



## OBOE – E5



## OCARINA – C6

