

Harmonic Series Guitars - Instructions by Dante Rosati

Hi Dante,

I decided that I am going to do an about face with the 18 edo acoustic I made and imitate one of your harmonic series guitars using the wire and glue method. I was wondering if you might have any words of wisdom to pass along from your experience in making and playing / composing on those guitars. I have not decided which layout to try yet.

Thank you for your time,

Chris

[Dante Rosati](#)

Hi Chris- if you like Annulets and Wings, that's the harmonic series guitar. the nice thing about that setup is you see how the series is laid out across the 3 or 4 octaves. the drawback is there are very few notes in the first octave, basically the bottom three strings only have 4 5 6 7. the midrange say starting from the fourth string to the second has 8-15 and above that you have 16-31 and even the beginnings of the next octave. so theirs a lot of variety but the smaller intervals are all in the higher range. the limitation is not a lot of different bass notes. also this guitar has the strings tuned c g c g c g which is good for certain patterns and not so good for others.

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11:43am

[Dante Rosati](#)

The guitar I've been playing for the last year or so just has 8-15 throughout the range. (the only video of this guitar so far is "no snow") it's also tuned to 2 3 4 5 6 7 which is a very nice open tuning but of course always has the 7 in there. i did a student's guitar to a 12 note JI setup and we tuned the strings to a more standard open E tuning 2 3 4 5 6 8 which works very nice and is somewhat more neutral without the 7 in there. This scale, having only 8 notes, is somewhat limited but i wanted this on purpose to really explore this octave. i have a few pieces i hope to post eventually that show that this limited scale still has a lot of potential even with so few notes.

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Dante Rosati

The next guitar I would do would move up to the 16-31 octave, repeating in each octave and tuned to either 2 3 4 5 6 7 or 2 3 4 5 6 8. this would have a 16 note scale that has plenty of notes for anything you could want. if you just want to make one harmonic series guitar this would probably be the most versatile one, although the basic harmonic series guitar heard in annulets and wings is elegant in its own way because it has the actual series laid out right there under your fingers.

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Dante Rosati

Other possibilities include tunings and scales that don't necessarily start at the octave. the scale from 12-23 is interesting and if you had the strings tuned in some way that went with it, would probably work. Andrew Heathwaite has something about this somewhere on the xenowiki.

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Dante Rosati

I'm copying below something I've been writing on and off (mostly off) with tips about the conversion process. It's not finished at all but you might find it useful:

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[Dante Rosati](#)

Now that I have converted (re-fretted) and played several microtonal guitars over a number of years, I have learned a lot by trial and error about the process.

Step 1

Select a guitar and remove the frets.

I have only re-fretted classical (nylon string) acoustic guitars, so my remarks will only apply to them directly. If you are converting another type of guitar, some of the advice may still be applicable.

Different guitars have frets that are harder or easier to remove, and worn down frets on a well played guitar will be harder to remove than frets on a new guitar. A pair of needle nose pliers may be all you need, although if you cannot get a grip on the fret to begin pulling it out, you may need a screwdriver or small chisel to get the end of the fret pried up a little to get a grip on it with the pliers. Usually there will be a certain amount of flaking and chipping of the fingerboard wood as the fret comes out, but since the grooves will be filled with wood putty, these can be filled as well, so not to worry.

Using a small spatula, fill the grooves and any splinter-pits with wood putty and leave it to dry. You can usually tell how dry it is by the color change: when it is wet it is dark colored and as it dries it gets lighter.

You can use sandpaper to smooth the fingerboard, but a sanding block is much better. You can get ones that are like sponges covered with the sanding surfaces: these work fine.

If there are still any depressions on the fingerboard, apply a bit more wood putty and, after it is dry, sand. Repeat until you are satisfied with the flatness of the fingerboard.

I always at this point apply a couple of coats of white paint, and I have always just used left over house paint from under the sink. One reason for this is to cover up the ugly patches from the putty, and if you decide to mark any frets on the guitar with color, they will show up better on top of the white paint.

The next step is to put the strings on, and here is where some decisions have to be made about what open tuning is going to be used. Depending on your open tuning, you may be able to use a standard set of guitar strings, or you may need to substitute strings or have more than one string of the same gauge. Also consider if using low, normal, or high tension strings will be appropriate for the pitches you want to tune to.

For example, both the 21-tone Just Intonation guitar as well as the Harmonic Series guitar are tuned to a simple open-fifths tuning (C-G-C-G-C-G). Using a standard set of strings, the 6th string will be tuned a major third low, the 5th a whole step low, the 4th a whole step low, the 3rd as is, the 2nd a half step high and the 1st a minor third high. None of these is really any problem except the 1st string which will be under a lot of tension tuned up a third. This string can break so it is best to use a normal or low tension string for this course, whereas the lower strings are all tuned low, so perhaps high tension strings are better to keep them from being too loose. In general, strings sound better at their designated pitch or tuned up a bit. When tuned below their normal pitch they can start sounding tubby and unclear. This is just an example of how to consider which strings to use.

Before frets can be placed, the strings must be settled down in terms of stretching. If you put new strings on the guitar, it will be at least several days before you will want to attempt to set frets. When placing frets, the open string must be precisely tuned before each and every fret is set. If the open string is slightly out of tune, then even if the fret is accurately placed (to produce its desired pitch), when the string is correctly tuned later, the fret will then be out of tune. So, keeping the open string stably in tune while setting the frets is of the utmost importance. Of course, I am talking about setting frets either by ear, matching to a reference pitch, or tuning each fret placement using a frequency counter. If you are going to try and place frets by measurement, this will not be an issue.

I have never tried to place frets by measurement for the simple reason that I am sure that it would not work to the kind of accuracy desirable in just intonation. There are many reasons for this, and they all would collectively contribute to inaccuracies. First, if you are measuring from the nut, where exactly is the beginning of the vibrating string? Right at the edge of the nut? Or is the string still at least partially dampened at this edge? The same goes for the bridge, and uncertainties of the exact point at which the string ends there.

In addition to this, each of the six strings has differing thicknesses and rigidity, which causes them to vibrate differently. Electric guitars have individually adjustable bridges for each string, and it is precisely because of the different tensions, thicknesses and rigidities of the strings. That is, for the 12th (octave) fret to go all the way across the neck, that is, for each string to have its vibrational midpoint in the same place, they need to be slightly different scale lengths. Perhaps you have seen a classical guitar bridge with a slightly offset segment for the third string, this is because of the same situation.

So, all the guitars that have one bridge for all the strings, and one fret across the neck for all the strings are, quite simply, out of tune. This may not be such a problem in 12-tone equal temperament, where everything is already a bit out of tune (compared to JI), but the tolerances in JI, especially the low integer ratios, is much smaller and any mistuning is very noticeable. For all these reasons, separately and collectively, I choose to place frets by ear or by frequency counter, thus ensuring exactly what pitch will be heard on each string at each fret position.

It is for this reason that one must decide on both fretted and open tunings before setting up the guitar. If you place your frets with the whole guitar tuned to C (for example), that is, with C as your 1/1, and then later decide that you don't like the sound that low and would rather have D as your 1/1, then none of your frets will be true anymore. Changing the pitch from C to D will change the tension of the strings enough to change its vibrational characteristics, and the frets will be off. So, best to decide what your 1/1 is going to be, decide the open tuning, tune the guitar up and let the strings settle into that tuning for a few days.

Since you have an enforced wait at this point, why not play some fretless guitar for a few days until it is time to place the frets? Even though fretless nylon is not acoustically very effective, and can sound like rubber bands, you can still hear enough to have some fun.

Dante Rosati

So now it is a few days later, the guitar strings stay basically in tune, have decided what tuning you want your frets to be, so it is time to begin placing frets. You can either use software to generate a reference pitch and move the fret until it matches the reference pitch, or use a frequency counter and move the fret until it is within the desired accuracy based on your computations of what the frequencies should be. The latter is more accurate, but with some care the ear-method can be quite accurate too.

Fret wire: You may have to experiment with different wire gages, depending on the action of the guitar. If the action is low, thicker wire may produce buzzing, and so thinner wire may work better. A coil of wire from the hardware store costs little, and the same needle nose pliers that you used to pull the frets out can now be used to cut pieces of wire approximately 1/4 to 3/8 inch long. I just cut a whole bunch by eye, put them all in a saucer, and then fish around as i go for one that seems the right length. It is actually handy to have slightly different length pieces, for the locations (like the 2/1 point, assuming you have one in your scale) where the frets are nearly in line, shorter lengths are better and longer pieces can be used where a fret will not have any neighbors on adjacent strings.

The frets for the outer (1st and 6th) strings should be placed so that there is not much sticking out. You will cut your hand if there are sharp edges sticking out from the edge of the fingerboard, and I eventually got a Dremel to grind the burrs down. You can also just get a Dremel grinding wheel or tip and put it in the chuck of a drill, although a drill is usually heavier and harder to maneuver. You can also use a metal file but it has a tendency to dislodge the glued frets if used too roughly.

I first used Scala to generate the pitches for fret placement, so I will describe this method, even though I have since switched to using a frequency counter which gives greater accuracy.

First, tune the open string to the correct pitch using Scala to generate the pitch. As I said, this must be checked and re-checked before placing each fret, otherwise all your efforts of placing the fret accurately will be wasted. Place the fret under the string, press behind it, and pluck the string, aurally comparing the result with the tone being generated by Scala (Scala can be set so mouse-over triggers the midi and sustain can be on as long as the mouse is over the key). Of course, other software that is capable of generating tones at any desired frequency can be used as well. Rather than use a sine wave sound, a triangle wave or a midi patch of an oboe or clarinet can make it easier to hear the pitch.). Adjust the fret position until the note you hear when you pluck the string matches the reference pitch. Firmly pressing the string will keep the fret in place while you reach with your other hand for the Krazy-glue tube and place a small dot of glue along the inner and outer edge of the fret both above and below the string. Try to keep the glue off the string as this will cause a mess and a string with Krazyglue all over it will not vibrate truly any more.

Recently I have begun using the frequency counter in the iphone/ipad app "Guitar Toolkit". It gives .1cps readings which are accurate enough for this purpose. In the lowest octave of the guitar, which ranges in frequency from, .1cps translates in 1cent, and by the time you reach the top range of the guitar, .1cps translates into less than 1/2 cent. Now, this method is not without its challenges either, but it is more accurate. What is immediately noticeable is that the frequency from the moment the string is plucked is dynamic. Generally it is .1 or .2 cps higher at the attack, then settles down after a second or two. This raises interesting questions about, for example, the tuning of a rapidly executed scale, which would be slightly sharper than the same notes played in a sustained passage. This is evidence of my contention that tuning on acoustic instruments is an art as well as a science, and that an instrument like an acoustic nylon string guitar is a living breathing wooden organism more than it is a machine. I do not see this as a drawback, on the contrary, it is precisely what allows acoustic music to escape the cold, canned sound of much electronic music that can perhaps be said to suffer from too much accuracy! It is the same reason why midi playback software started incorporating "human feel" algorithms that basically add a small random error to the timing in an attempt to sound more like a person playing and less like a computer. Pure computer music a la Csound has its own aesthetic, but midi that tries to sound like acoustic instruments is always a wanna-be and sounds like it. In any case, the seeming paradox of trying to tune an acoustic instrument to surgical precision all the while it is breathing and changing is exactly the right paradox to produce humanist art.

Since the guitar is lying flat to place the frets, the iPhone can be placed on the soundboard or the iPad near the guitar. If it is placed on the soundboard, it should be moved around during the measurement of different ranges, as different areas of the soundboard vibrate to different frequencies.

I generally place all the frets along each string one at a time, but other approaches are possible. For example, if your tuning is derived from the harmonic series, you could place frets on higher strings by matching them to harmonics played on lower strings. Just be sure that both strings are absolutely in tune before you do this. The 2/1 or "12th" fret, i.e., the octave (if there is one in your setup) can be placed by comparison with the harmonic at the "12th" fret, in addition to, or instead of, the other methods. Also, if your open tuning has more than one string tuned to the same pitch in octaves, you can fret one to match the frets already placed on the other.

Once you have all the frets placed, it's time to start checking and rechecking, playing octaves to see if they are in tune, and making any fine adjustments. If you haven't put too much glue around the fret it is easy to pop one off with the needle nose pliers, and either move it or use a fresh one. One difficulty is after to pop a fret off, there will be a small groove where the fret was formed by the dried glue. These small ridges can make it hard to move the fret to a position a millimeter or less from where it was initially placed. In this case, use the Dremel grinder to get rid of the glue off the fingerboard before you try to reposition the fret. Another thing to check for at this point is buzzing caused by an unevenness of your fingerboard sanding job. Again using the Dremel with grinding point you can grind down the fret surface a bit until the buzzing disappears. If that does not seem to be working, take the fret off altogether and grind the area on the fingerboard down a bit, since this is easier, then reapply a fresh fret.

As I said, the instrument is a living breathing organism, your ears and tuning awareness are (hopefully) changing and developing, so it is a good idea to go over the tuning from time to time and see if there are any notes that could use adjustment. I find that while playing around on the guitar any slightly "off" notes become noticeable very soon, in which case don't hesitate to adjust them. Rather than thinking of the tuning pegs as the only way to tune the guitar, think of the fret adjustment as part of the process too. Of course, you should be able to get your frets in tune so that they no longer need adjustment, but this may take longer than you think.

All the guitars I have fretted so far have color coding on the fingerboard, as I find this aids greatly in the orientation process and remembering sequences, and it looks nice too. There are many different approaches to color coding, depending on your tuning setup. On my 21-tone JI guitar, I colored the frets by prime limit: red for 2 and 3, green for 5 and blue for 7.

On the Harmonic Series guitar, I started the same way but added more colors for the additional prime limit intervals. On the Prime Guitar, since every note was a different prime limit ratio, I used a three color alternating scheme just to help me find locations.

Believe me, when you have upwards of double the number of frets per octave and they are in different places on each string, it becomes very difficult to find your way without the colors.

On the Prime Guitar I did write the number of the harmonic in the middle of each fret with an indelible marker. This also looks cool and helps if you want to jot down ideas in tablature.

On the Diatonic Harmonic guitar I was more interested in which notes come from which octave of the harmonic series, so the coloring was based on this, and in addition I wrote the numbers 8-15 on the frets.

On a 5-limit 12-tone JI guitar I converted for a student, we decided on a six color coding based on the odd limit of the ratios, so that notes with the same odd limit had the same color. So you can see there are many possible approaches, and course not having any colors at all is also possible, in which case paint the fingerboard black before you fret it.

There are some drawbacks here such as the dirt and grease from your fingers eventually darken the colors, especially if you use yellow, but it is easy to repaint the frets when you change the strings. An actual luthier could probably make a guitar with a light colored wood for the fingerboard which could then be stained and varnished with the different colors and would be more permanent.

[Chris Vaisvil](#)

wow! thanks for all of the information - one really important piece of information that I didn't have a clue about is the fact that you need to have the strings tuned to the fretting. I need to study this more. Thank you so very much for the time it took to enter this in!!