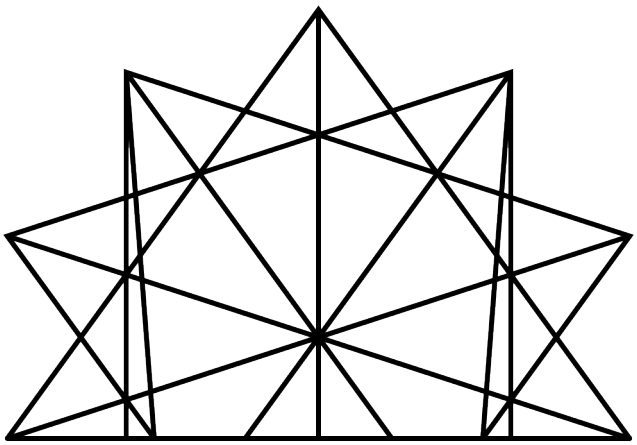
Introducing the Polychords & Microtonal Steel Guitar Fretboards



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INTRODUCING THE POLYCHORDS

The two polychords are large steel guitars which were inspired by the ancient chinese instrument called the ch'in or 'philosopher's lute.' I wanted an instrument with a long scale length, yet short enough to be playable as a steel guitar (using a sliding bar or 'steel.') Polychord 1 has two banks of strings; in other words, it is 'double-necked.' Polychord 2 has a single bank of strings. These two instruments are meant to be together, and to compliment each other. Polychord 1 has a 'chordal' tuning; it is a 'rhythm guitar' in its orientation. Polychord 2 has a 'scalar' tuning; it is a 'lead' guitar. This is refected in the tuning of each instrument.

In Polychord 1, there are two chord banks. One chord bank is tuned to C-E-G-A-B, a Ptolemaic (or double-strand) Pentad. This allows the chord types M6, m7, M7, and mb6, as well as a suspended triad. The other chord bank is tuned G-A-B-D-F, in order to get the tritone-containing chords Dom7 and m6. In this way, the two principal classes of chord-forms are represented. In a normal steel guitar, different chord-forms are achieved by using foot-pedals. But in the micro-tonal context, these foot-pedals are not possible because there are different sizes of semi-tones. This restricts the chord-forms to the tuning on the strings. Hence I have used two chord banks to increase the variety.

Polychord 2 is tuned in a 'harp-like' fashion to an extended diationic scale, called the Ptolemaic Ogdoad: pitches C-D-E-F-F#-G-A-B. This is more suitable for 'lead' type riffs in music.

These instruments have multi-coloured interchangeable fret-boards, whose rationale is explained by the accompanying short article on microtonal steel guitar fretboards. When one fretboard is replaced by another, the strings are then slightly shifted to suit the temperament. My own musical interest was mostly in 53-E.T. and 31-E.T., which mimick JI and meantone respectively. I have mostly kept the strings in pure JI. However, it is also possible to use a fret-board in 12-E.T. if desired.

One can use these instruments for teaching purposes, to display the fundamentals of acoustics. As is, they demonstrate the HARMONICAL PROPORTION, which is the use of string harmonics to relate the intervals of the strings to each other. The mechanics of the Harmonical Proportion are explained in the accompanying article: SIMPLIFIED JI TUNING PROCEDURES FOR STRINGS.

In addition, these instruments can be used for demonstrating the ARITHMETICAL PROPORTION. To do this, simply put a movable bridge under a string. One can use any piece of metal whose height is about the same as the end-bridges for this purpose. Then we have converted the instrument into a monochord. A traditional monochord-style fretboard is provided for Polychord 1. In order to guide the novice monochord user, the paper A

the crucial part in making our fretboard, so we try to be as accurate as we can. Hence, I must get a little technical here. Don't worry though, you won't need a Ph.D. to follow this, it's just a little arithmetic. We must use a series of numbers called a **fret table.** Every tuning system has its own fret table, and you can generate these numbers yourself. For equal tempered scales this can be done using a log table and a pocket calculator. Alternatively, you can acquire the information from a number of sources. I am one of those sources. Just write me for the info if you are stuck. The fret table is just a series of ratios which are peculiar to **that** particular tuning system -- ratios which define the size of the interval steps.

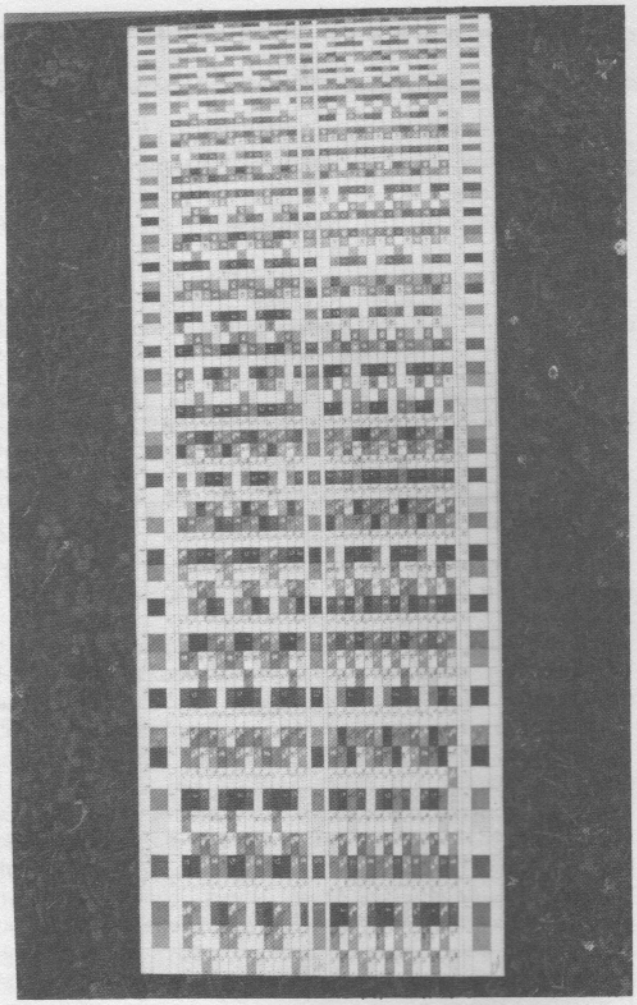
Briefly, here is a the procedure for generating the fret table for 31-E.T. We must calculate the thirty-first root of two, which can be done with the aid of a logarithm table. To save you the trouble, the answer is approximately 1.02266643. This number is used to find the position of the first fret. Now take this number and successively multiply it by itself (a calculator helps!) to find the "magic numbers" for the other frets. [For more on the reasoning behind all this, see "Scales and their Mathematical Factors" in EMI Vol I #5.]

I am reluctant to write out the complete fret table for 31-E.T. in this article, since I do not wish to take up so much space with a long list of numbers. However, I will give the first few so that you see how they are used. For 31-E.T., the first five numbers (out of 31 altogether) of the fret table are:

0--1.00
1--1.02266643
2--1.04573415
3--1.06937970
4--1.09355991

These numbers will give us the proper fret position for **any** string length. The rule is this: Divide the string length by the appropriate fret table number to get the distance from the bridge to the given fret. For example, say that our string length is 100cm. Then the first fret is 100/1.02266643 = 97.783597cm from the bridge, which is 100 - 97.783597 = 2.21641cm from the "nut" (the other bridge). In actually measuring it, we would round off the number to 2.22cm, and draw the fretline parallel to the nut. As a second example, suppose our string is 24 inches long. Then the third fret is 24/1.0693797 = 22.442917 inches from the bridge, or 24 - 22.442917 = 1.557083 inches from the nut. Obviously, it is easier to work in the metric system here, rather than the British system.

In a like manner, we must measure the position for each fret and draw it on the fretboard. All this is rather tedious, but when it's done, the rest of our job is easy and fun. On my fretboard, I have calibrated the frets for two octaves and a fifth, which makes a grand total of seventy calculations. But the second octave is easy. Just divide the first octave position by two. It is fairly easy to make the accuracy good to about a millimeter.



SIEMEN TERPSTRA'S FINGERBOARD OVERLY FOR POLYCHORD 1 -- but it's a shame we can't show it in color, for it really is a lovely sight.

We now have a fretboard covered with a lot of parallel lines which get closer together in a logarithmic sequence as we move up toward the bridge. The next step is to convert this board into a bunch of rectangular patches by filling in the lines parallel to the string lengths. Measure the distances between your strings as they cross the nut and bridge, then connect the lines so that each string has a patch under it for each fret position. Now the fretboard looks like some weird, alien chessboard!

We are almost ready to apply the color code and tint the patches -- an essential step in making the fretboard practical. But first, we must decide how we are going to tune the strings. This decision depends upon our musical purposes. Polychord 1 has two banks of strings, so that I can have alternative patterns. The first bank I have tuned (from low to high pitch) A-C-E-G-A-B-C-E-G-A-B-C-E-G. This tuning gives me a major triad, major six chord, major seven chord, minor triad, minor seven chord, minor flat-six chord, a couple of nine chords, and a suspended triad. The second bank of strings is tuned (from low to high pitch) A-B-D-F-G-A-B-D-F-G-A-B-D-F. This tuning gives me a dominant seven nine chord, and a minor sixth eleven chord. Of course, you do not need to copy this tuning. Perhaps the tuning you want is C-E-G-C-E-G-C, if your steel guitar has only seven

strings. The steel guitar being such an open-ended instrument, it seems that each player prefers a different tuning set-up. That's great, but remember that whenever we use a different tuning pattern, we must build a separate fretboard for that pattern. So it is good to have this decision made beforehand.

We are now ready to number the fret patches. The 31 tones per octave of this tuning system are numbered from 0 to 30, starting with C as 0 (by convention). For example, the pitch A has number code 23. Therefore, if one of our strings is tuned to A, then the patch under the first fret will be number 24, and so on. Alternatively, we can write the actual pitch name on the patch instead of the number, or both for that matter. The reason we do this is because I am using a sort of "paint by number" approach to coloring fretboards. The number and/or pitch name also help us find our way when we play.

With this numbering done, we can apply the color code to the fretboard. Before laying our the table though, I shall briefly explain the rationale behind the color code, which is not arbitrary. I wanted a color scheme which would highlight about half of the notes -- those notes in closest harmonic relationship to our arbitrarily chosen reference tuning pitch (C). With this arrangement, the most important frets would be emphasized in the same way that the fifth and seventh frets of a standard guitar are emphasized by an inlay.

The natural solution to this problem is to apply the rainbow sequence (red, orange, etc.) to the set of modal relationships arising from the harmonic series and its reciprocal. Thus the musical fifth and fourth are red, the major third and minor sixth are orange, the minor third and major sixth are yellow, the whole tone and minor seventh are blue, and the tritones are purple. This overall system may be applied to many different tuning systems. In the case of 31-E.T., a further refinement is necessary. For example, there are two sizes of major thirds, a "just" form and a "septimal" form. Therefore I use two shades of orange. The scheme is symmetrical about the generator tone C. This tone should also have a color, which should be white or "shining." Consequently, I use a mylar strip for C, an effect which enhances the beauty of the fretboard. Here is the color code for 31-E.T.:

FRET NUMBER		PITCH NAME		COLOR
0=31		C		Mylar (shining)
2	29	C#	Cb	Light Blue
3	28	Db	B	Deep Blue
5	26	D	Bb	Green
7	24	D#	Bbb	Light Yellow
8	23	Eb	A	Deep Yellow
10	21	E	Ab	Deep Orange
11	20	Fb	G#	Light Orange
13	18	F	G	Red
15		F#		Light Purple
16			Gb	Deep Purple

The other frets are left uncolored, to good effect. The result is a patchwork quilt which enables the player to find the right fret with far greater ease than the old monochrome approach. However, keep this limitation of the color code in mind. Different microtonal tuning systems require different variations on this general approach. I have given you the best scheme for 31-E.T., but the best color code for, say, 19-E.T. is a bit different. To elaborate these differences and the reasons for them is beyond the scope of this short article. You could write me for details on the system of your choice. I even have a color scheme for my 12-E.T. fretboard which is a distinct improvement over the old approach. Besides making playing easier, it also looks attractive!

I filled in the colors using felt-tip pens, but you could use acrylics or various other media. It is also handy to have an extra fret patch alongside the strings on both sides as a general guide. This patch gives the general fret number so that we can use a tablature system in notating the music -- a notation system peculiarly suited to steel guitars.

A word about tuning. When using this 31-E.T. fretboard it is advisable (though not strictly necessary!) to set the temperament accordingly. However, I have found that I can tune my strings justly and still use this fretboard if I use vibrato or other means to mast the inaccuracy. Also, since the 31 system is sonically indistinguishable from one-quarter comma meantone tuning, we can apply a meantone tuning regime to the strings. This is not the appropriate place to describe how to tune meantone, but this tuning is much easier to implement accurately by ear (with the use of appropriate harmonics) than is 12-E.T. I have developed a program for my computer which lets me use the terminal as an "electronic tuning fork," so that I can set the temperament for whatever system I care to investigate. Another approach, which is not as accurate, but inherent in the instrument, is to use the fret itself as the tuning guide, much like an ordinary guitar. It's low-tech and simple. Don't try to use those electronic tuners, though. They are all stuck on 12-E.T. When will the music industry finally come up with an electronic tuner which is inter-system? Any company trying to develop such a tuner should consult me for design considerations!

Polychord 1 does not have foot pedals. The reasons are various. Since I am interested in microtonal systems, I would need foot pedals which could produce different sizes of semitones. I concluded that such engineering is not worth the effort. Moreover, in my experience I have found that foot pedals are not all too accurate. The player can adjust for the inaccuracy by shifting the bar, but this procedure lowers the overall tuning accuracy. However, if your present steel guitar does have pedals, you can still apply a microtonal fretboard to the instrument.

The steel guitar has long been "ghetto-ized" in its association with country music. My musical bias has been more in the direction of Asian or intercultural approaches. Clearly, the instrument is amenable to a host of different sonic directions. I hope that this article encourages the use of the instrument for the exploration of new harmonic resources.