



ANDROMEDA TEMPERAMENT DESIGNER

For three centuries, musicians argued passionately about how to split an octave up into twelve notes. It wasn't that nobody had heard of today's compromise solution, *Equal Temperament*, but it was rejected on the grounds that Equal Temperament couldn't express the subtle nuances of musical intervals which the composers of the day were exploiting.

A lot of solutions, or *temperaments* were proposed, some of which remain popular to this day among musicians who play historical music: particularly music from the Renaissance and Baroque periods. A new generation of musicians are now exploring microtonal temperaments, which deal with the same compromises. By the way, the issues which caused different temperaments to be explored, also exist in musical scales other than our western diatonic scale.

Temperament Designer lets you easily design your own temperaments.

What's a temperament?

Music is based on sounds at different pitches, or frequencies. We usually make music with a relatively small set of pitches, each of which is called a note.

A temperament is a way of deciding just what the pitch will be for each note.

A bit of theory

We call the difference between two pitches an interval. Mathematically, the interval between two pitches is the ratio of their frequencies. Some combinations of pitches sound better together than others.

For example, let's take two pitches: the A above middle C, and the A just below middle C. The top A has a frequency of 440 Hz, and the lower A has a frequency of 220 Hz. The ratio between these two pitches is 440/220, which is mathematically equivalent to a ratio of 2/1. This interval is called an octave, and is found in almost all musical systems. Our ears are remarkably sensitive to this interval. If we listen to an interval which is even slightly different from an octave, it sounds unnatural and out of tune to us.

Pure Intervals

In general, intervals where the frequencies are the ratio of two small numbers, sound better to our ears than intervals which aren't. Some of the important intervals in Western music are:

- $1/2$ = an octave
- $2/3$ = a fifth
- $3/4$ = a fourth
- $4/5$ = a major third
- $5/6$ = a minor third
- $3/5$ = a major sixth

We call these pure intervals. Not only are these intervals the ratio of two small numbers, they are natural harmonics. This means that in most instruments, when you play a note, the natural harmonics of the note are also present in the sound to some degree (the exact degree to which each harmonic is present is part of what gives an instrument its own unique sound).

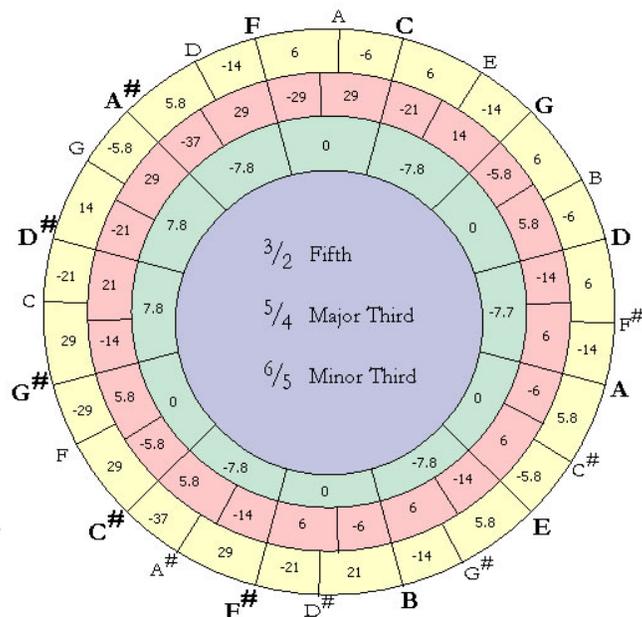
Incompatible Intervals

Ideally, we would like to define a reasonably small group of pitches which would let all of these intervals be used freely. Unfortunately, this goal is unattainable. We can demonstrate this by playing a circle of fifths. Start with any note, and play the note which is exactly a major fifth above it. Keep going, doubling back an octave when you have to, until you get back to your starting note. After playing 12 major fifths, you will have played every note exactly once, and also defined every interval that exists in a diatonic scale.

But ... If you followed the instructions, and played every major fifth as a pure interval, you would have ended up being about a quarter of a semitone away from your starting pitch —an interval called a *Pythagorean Comma*.

Here's a look at Temperament Designer.
 You see three circles:

- **Fifths**
 The inner circle shows how much each of the major fifths are stretched or compressed. The numbers are in commas. Positive numbers mean that the interval has been stretched out: negative numbers mean that the fifth has been shrunk. If you add up all the numbers in the circle, you always get -1.
- **Major thirds / Minor thirds**
 You can think of a major fifth as being a major third, followed by a minor third (or the other way around).
 The outer two circles circle show the major and minor thirds inside each of the major fifths. Again, the numbers are the number of commas the intervals are away from being pure.



It's a lot of information in a very compact form!

Once you're worked out a temperament, you can try it out, and see how it sounds to your ears.

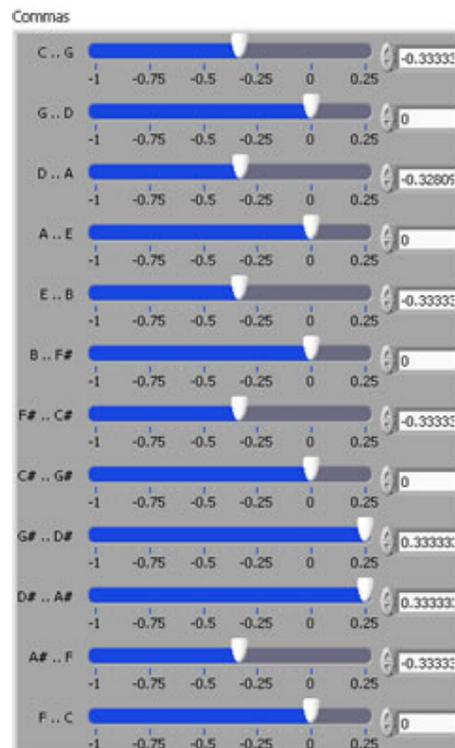
Traditionally, temperaments have been described by the amount that each of the major fifths have been expanded or shrunk.

We make it easy for you, by giving you sliders for each major fifth. The sliders automatically adjust to keep the overall adjustment (or comma) correct. You decide which note to start from, and *Temperament Designer* does the rest.

The unit you are looking at is the comma. You can specify either the Pythagorean, or the Syntonic comma (which is useful for temperaments which emphasize major thirds).

The example we've been looking at is a historical temperament called Werckmeister IV. This is a temperament that give you almost pure major fifths and major thirds in key signatures with up to three sharps, or two flats. In many cases, music which these key signatures will sound startlingly clearer than if it is played using Equal Temperament.

In key signatures with more accidentals, there will be more and more dissonant intervals. Historically, composers would often use these dissonances for effect.



National Instruments and Andromeda

Temperament Designer was developed with National Instruments technology.

We've been using LabVIEW since 1988, when LabVIEW 2.0 was still in beta testing. Since then, we've used LabVIEW to develop applications for data acquisition and data visualization in fields ranging from:

- Magnetic bearing control
- Electronic Flow Measurement validation
- Performance testing
- Torsional vibration analysis
- Commodity trading & risk analysis
- Airborne LIDAR and camera control

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