FM Synthesis IV, a specific FM characteristic

The following two c : m ratios generate the same sideband frequencies:

```
c : m = 1 : 2  en c : m = 1 : 4
```

We now compare the two spectra. Assume the number of sidebands at six.

```
c : m = 1 : 2

| c ± nm |
upper side bands:  3,  5,  7,  9, 11,  13
lower side bands:  1, -3,  5, -7,  9, -11


c : m = 1 : 4

| c ± nm |
upper side bands:  5,  9, 13,  17, 21,  25
lower side bands:  3, -7, 11, -15, 19, -23
```

Notice that both `c : m ratios` generate only odd harmonics. The same spectrum as a square wave in conventional subtractive synthesis.

It is striking that in the example `c : m = 1 : 2` the same frequencies occur in both sidebands. Also striking is that all lower even side band frequencies are in opposite phase regarding to the same upper side band frequencies. The amplitudes of the lower side band frequencies are subtracted from the amplitudes in the upper side bands.

What happens when the modulator frequencies in both examples are not exactly `2` and `4`, but slightly, minimal increased?

For instance, `2.01` and `4.01`

```
c : m = 1 : 2.01

| c ± nm |
upper side bands: 3.01,  5.02, 7.03,  9.04, 11.05
lower side bands: 1.01, -3.02, 5.03, -7.04, -9.05

c : m = 1 : 4.01

| c ± nm |
upper side bands: 5.01,  9.02, 13.03,  17.04, 21.05
lower side bands: 3.01, -7.02, 11.03, -15.04, 19.05
```

While in the example of `c : m = 1 : 2` exactly equal frequencies occured in the upper and lower side bands. In the example of `c : m = 1 : 2.01`, the frequencies in the upper and lower side

bands are no longer exactly equal. For example, instead of 3 and -3 they become 3.01 and -3.02.
This results in beatings, a cyclic swelling and softening, determined by the difference in frequency of 3.02 – 3.01.

Fine adjustments for this slightly inharmonicity may be done by the 'detune parameter' in discrete steps from: 1 to 7 (DX7/TX7DX7II/TX802/DX200), 1 to 15 (SY77/99/TG77) and 1 to 3 (FB01/DX100/TX81Z/DX11/V50).

Note that these beatings always arise between an upper side band frequency and an a higher number lower side band frequency. In the same way there occur beatings for all the other side band frequencies, however each beating with a different speed. From a perception point of view the audible sensations resemble phasing, chorus and Leslie like effects, depending of the beating speed.

If we look at the frequencies which result from a c : m ratio 1 : 4, we don't notice beatings at all. Instead the spectrum shows a slightly inharmonicity: all partial frequencies are slightly stretched.