What is a PGV™ ?

The PGV, or Parametric Guitar Vocoder extends the possibilities of a guitar vocoder. A conventional vocoder filters the guitar signal based on the voice spectrum. The PGV instead first analyses the guitar signal by measuring the pitch and amplitude of each string, then uses them as the parameters for synthesizing corresponding notes that each have the spectrum of the vocal input of the microphone. When the parameters are known, they can also be modified in the synthesis part for creating different special effects.

Because only the guitar string amplitudes and pitch frequencies are used, a singing guitar player can use PGV to produce a very natural sounding multi-voice output of his/her vocal performance. This is because there is no distortion from the guitar spectral characteristics like in a normal vocoder.

The analysis-synthesis -principle allows many freedoms for the synth: when all six string frequencies are defined, they can be transposed and modulated freely, e.g. to generate vibrato, FM or PM modulation. The vocal microphone spectrum (timbre) can be modified independently of the note frequencies, i.e. to make "baby" or "giant" voices. These special effects can be controlled using an expression pedal input and/or separate knobs on the PGV. The box has a footswitch for selecting the effect that you control with the pedal: either noise, vibrato/pitch bend, or modulation. Additional controls include a knob for spectrum shift, a switch for octave down transpose, and a spectrum hold switch for freezing a momentary vocal spectrum of a vowel.

For testing and other purposes, you might want to hear just the guitar signal without vocals, so we added sine wave generators for each of the string notes. You can control the volumes of the signals with the “Pilot Gain” potentiometer. The special effects can be applied to the sine wave too, thus creating more spectrally rich sounds. Therefore the PGV can also be used as a conventional guitar synth.

The PGV also features a non-parametric vocoder mode, or a conventional vocoder. It can be activated by using the footswitch to toggle to the “direct vocoder” mode. In a conventional vocoder the guitar - or any other input signal – is simply modulated using a synthesis filter bank that follows the vocal spectrum. Since the guitar string parameters are not measured in this mode, there are less modification possibilities. However, because the vocal spectrum is still measured, the “spectrum shift” knob can be used in this mode, and the momentary spectrum can also be frozen.

Limitations

Many other guitar synthesizers also do string spectral analysis, but the great advantage of the PGV is that it is used with a standard guitar pickup with the mono ¼” plug cable, while others typically require installation of a separate string pickup, and use a clumsy multiwire cable. However, analysis of the six different signals from the composite guitar signal is a complicated task, therefore some inherent limitations follow:

- The notes where the fundamental falls to the same frequency as the harmonic of a lower note will not be detected separately. In practice this only applies to two intervals, the octave and the octave + fourth. However, the contribution of the higher note can still be heard from the amplitude increase of the lower note.

- There is a limitation on how close frequencies can be detected separately. The PGV can discriminate notes down to one semitone difference, however, the amplitude differences also matter. A high amplitude note will obscure a close lower amplitude note. An exact specification is difficult to give, because several harmonics of each note are used in the analysis, but roughly for one semitone pitch difference, less than 6dB amplitude difference is required for successful discrimination; for larger pitch differences, considerably larger amplitude differences are tolerated. In order to prevent erroneous switching to higher harmonics when very close notes interfere, an interval of one octave +/- one semitone above any note is also blocked.

- The PGV continuously follows the pitch of a string when using slide or vibrato, however there is a limit to the note tracking speed. As an example, if in vibrato the pitch is rapidly varied between two notes, eventually the note breaks into two notes at the extreme ends of the vibrato instead of following the single original note. Luckily the PGV effects include the vibrato and pitch bend options that have no such speed limits, so such vibrato can be simulated with the effect controls..

- Very low amplitude fundamental notes may cause skipping to higher harmonics. This is very dependent on the guitar pickup characteristics and its location. We have found that typically a humbucking neck pickup is

most reliable. Select the pickup that you get the most reliable results with and adjust the "threshold" knob accordingly. Of course, the “direct” vocoder mode does not have these limitations, since it does not use pitch analysis, but there are less parameter modification options.

Latency

An analysis-synthesis system has inherent latency. There are two different factors, the latency from each of the guitar string signals to the analysed pitch and amplitude, and the latency from the vocal mic to the corresponding vocoder signal. The string analysis latency varies with string pitch, because a certain number of signal cycles is needed for the analysis. In Figure 1. the latencies are shown for notes at three successive octaves. The latency can be shortened by keeping the “threshold” setting as low as possible. If the octave down transpose switch is applied, the latency is decreased to the value of the actual string played. The latency does not allow very fast guitar playing; however, the guitar playing style in the vocoder applications is closer to a vocalist who supports him/herself with the guitar accompaniment, rather than fast lead guitar. Therefore the crucial latency is from the vocal microphone to the corresponding vocoder signal output. In the PGV this is effectively reduced to almost half from the conventional vocoder setup that uses both an analysis filterbank and a synthesis filterbank.The PGV instead uses Fourier synthesis, thus avoiding the filter delays at the synthesis part. Therefore the vocoder latency for the vocal sound is below 10ms which is barely recognisable. Figure 2. shows the delay between the input microphone signal and the corresponding output of the vocoder when the guitar string amplitude remains constant.
In the “direct” vocoder mode there is no pitch analysis latency, therefore it has shorter guitar latency, but it has about double total filter latency, because it uses filters also in the synthesis part.

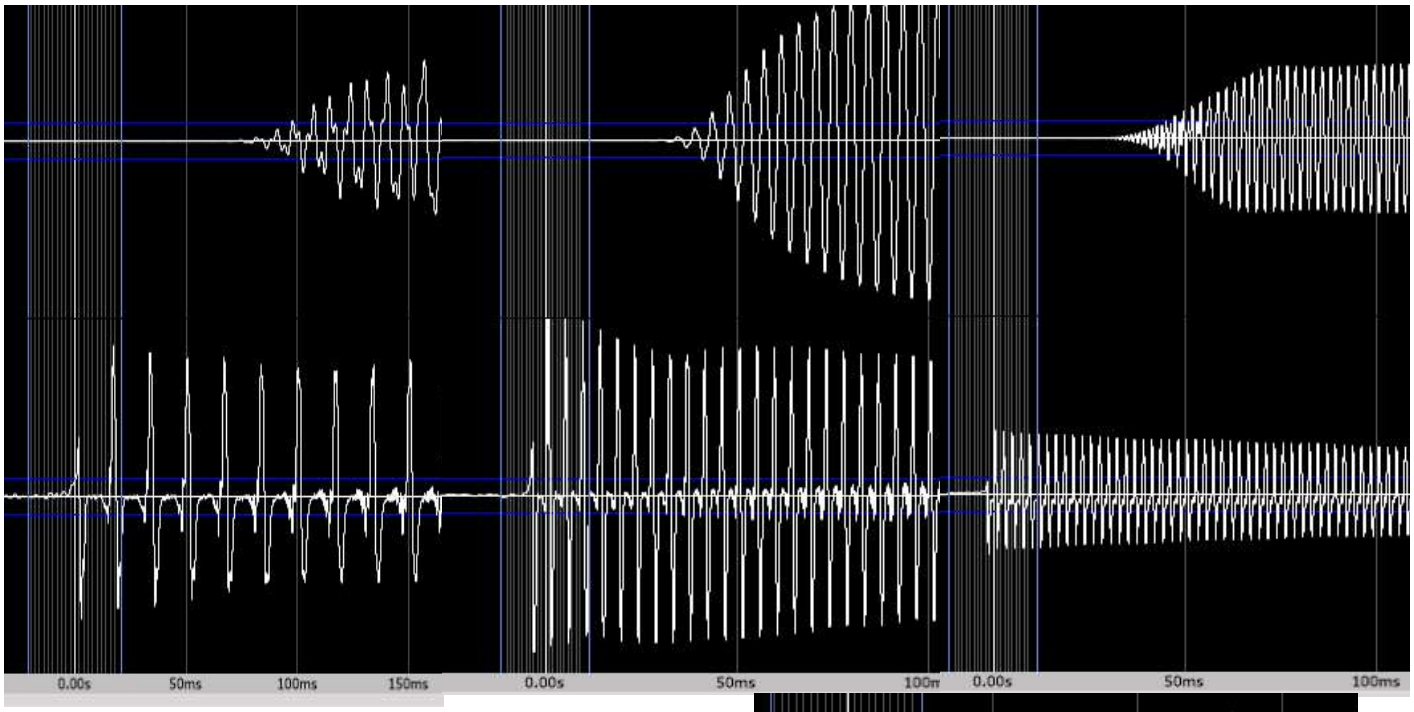

Figure 1. Guitar string frequency analysis latency for A2 (left), A3 (middle) and A4 (right). The original guitar signal is at the bottom trace, and synthesis output at the top trace.

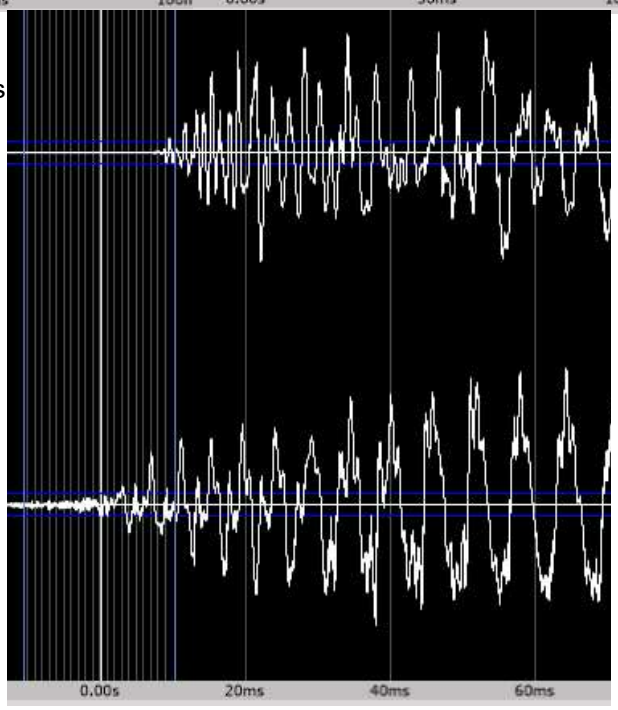

Figure 2. The vocal microphone latency from the input microphone (lower trace) signal to the vocoder signal (upper trace).