VoIS

The Ultimate Vocoder

Will this become

your most exciting

electronics do–it–yourself

project ever?

A Feature–Packed
# 18-Channel Analog Stereo Vocoder
in a Compact 3U Rack

- Stereo vocoder
- Filter bank
- Microphone input
- Built–in excitation

- Cross–patching
- CV control
- Silence bridging
- Slew and freeze

Operating Principle

Vocoders are known for creating characteristic sounds, such as robotic voices, and for their use in a variety of musical productions. To accomplish the effect, a modulator signal, such as the human voice, is used to articulate a carrier signal.

In this vocoder, the voice and carrier inputs are split up into 18 frequency bands using bandpass filters. For each band, the envelope of the filtered voice is extracted and impressed upon the carrier signal in the same frequency band to create a synthesized signal. The sum of all the synthesized signals creates the distinctive vocoder sound.

A unique feature of this vocoder is the synthesis of a stereophonic vocoder output from the stereophonic carrier input as each individual frequency band is assigned to one of the audio channels.
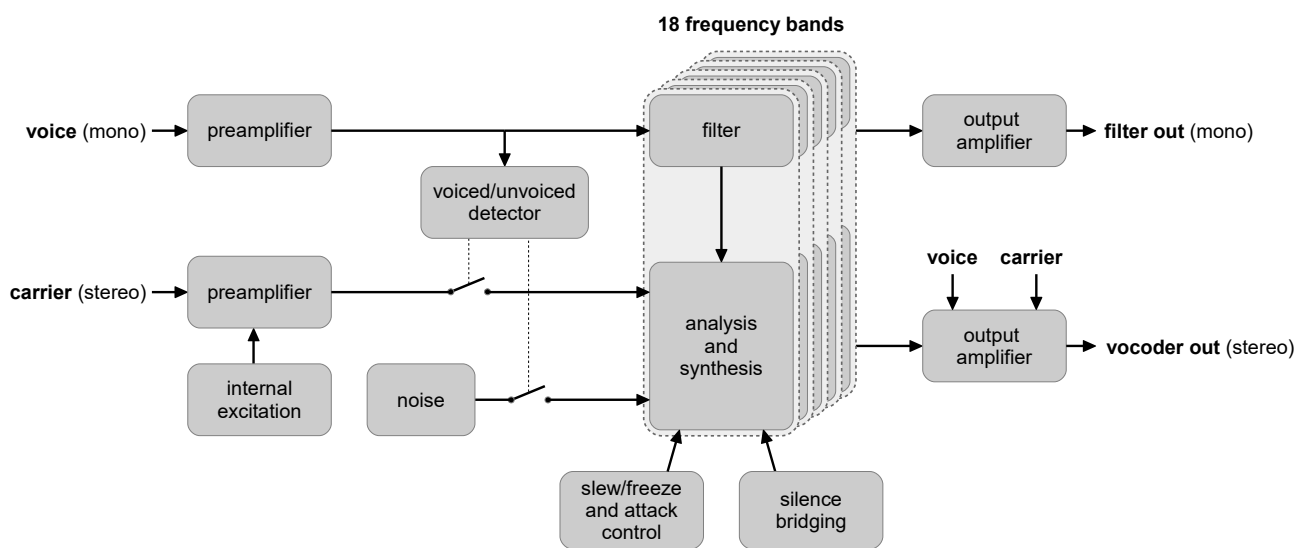
Vocoder block diagram

Internal excitation can be used instead of, or to supplement, the carrier input signal.

A so–called voiced/unvoiced detector distinguishes voiced sounds (such as 'a', 'e', 'i', 'o', or 'u') from unvoiced sounds (such as 's', 'f', 't', or 'k'). As unvoiced sounds typically have a wider frequency spectrum than the carrier signal, intelligibility is improved by replacing the carrier signal with noise during the presence of unvoiced sounds.

Silence bridging fills periods of silence with the filtered carrier signal. Using the filtered signal ensures that the carrier frequency characteristics, dialed–in via the individual channel controls, remain the same during silence and articulation.

The slew rates of the voice envelope impressed upon the carrier signal can either be slowed down (sustained), causing slurring effects, or even be stopped, effectively freezing the given part of articulation. In the latter case, the vocoder acts like a pitch–adjustable formant filter. The attack detector dynamically adjusts the slew rate depending on the rising or falling volume of the voice.

Apart from the vocoder functionality, this system also includes a filter bank where a separate monophonic filter output is composed of the voice signal filtered by the 18 bandpasses.

VoIS Features at a Glance

Voice and carrier input

- Voice signal (monophonic) and carrier signal (stereophonic) preamplifiers
- Line–in and microphone inputs via 6.35 mm (¼-inch) input jacks
- Input level control
- LED VU meters for each channel

Voiced/unvoiced detector

- Signal handling switch: carrier only, voiced/unvoiced detection, noise only
- Voiced/unvoiced LED indicators
- Noise type switch (pink or white noise)

Internal excitation

- Stereo sawtooth or square wave oscillators with coarse and fine frequency control
- External 1V/oct. CV control via 3.5 mm jack
- Noise generators

Slew/freeze handling

- Voice input freeze with LED indicator
- Voice slewing
- Attack detector
- CV slew control, 3.5 mm jack
- Freeze foot switch, 6.35 mm (¼-inch) jack

18 analysis/synthesis channels

- Channel volume control
- Filter volume control
- Cross-patching
- Voice peak level indicator
- Stereo channel selection (internal jumpers)
- CV control

Vocoder and filter output

- Separate outputs for vocoder and filter signals, 6.35 mm (¼-inch) output jacks
- Silence bridging
- Voice and carrier input monitoring/mix

VoIS Feature Comparison

Main feature comparison of the VoIS against other commercial or do–it–yourself analog vocoders:

	VoIS	VSM 201	Haible	L–1	EMS 3000	EMS 2000	ETI	Elektor	Okita	MFOS
Number of channels:	18	20	20	24	16	16	14	10	10	12
Filter quality factor:	8-pole	6-pole	8-pole	4-pole	4-pole	4-pole	4-pole	4-pole	4-pole	2-pole
Channel level control:	●	●	●	(●)	●		●	●		
Filter bank:	●	●	●							
Stereo output:	●									
Cross–patching:	●	●	●	(●)				●		
Slew/Freeze:	●		●		●	●	●			
Silence Bridging:	●	●	●		●	●				

The entry (●) means, this is available as an option.

VoIS Features in Detail

The vocoder contains a single–channel (monophonic) voice signal preamplifier and a two–channel (stereophonic) excitation signal preamplifier.
Both come with LED VU meters for best input level control (0 dB equivalent to 1 Volt input signal amplitude). The preamplifiers have 6.35 mm (¼-inch) jacks for line input and microphone input, the latter providing gain of 200 for the use with popular dynamic microphones.

For many vocoding purposes, simple sawtooth or noise signals are sufficient as carrier input.
Two convenient, independent sawtooth and noise generators are built into the vocoder. Both signals are mixed internally with the external carrier signal.
Individual controls adjust the volumes of the oscillators and noise generators. The oscillator frequencies can be accurately adjusted via the coarse and fine fequency controls. Additionally, they can be controlled via external voltages at 1 Volt per octave.

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VoIS Features in Detail

At the heart of the vocoder are 18 independent analysis and synthesis bandpass channels, spanning a frequency range from 120 Hz to 7 kHz.
Each channel has volume controls for synthesis and a separate filter output. All frequencies can be cross–patched or controlled via external control voltages (0...5 V) on 3.5 mm jacks. LEDs indicate voice peak input. For stereo effect, each frequency is assigned either to the left or right stereo channel via internal jumpers.


A voiced/unvoiced (V/UV) detector is indispensible for good intelligibility.
The V/UV detector can be switched between regular voiced/unvoiced detection or excitation either by the carrier or the noise signal only.
Another switch selects between pink or white noise as a source for the unvoiced sounds.
Two LEDs indicate the presence of either voiced or unvoiced sounds. If there is no voice input signal, the LEDs will not illuminate.
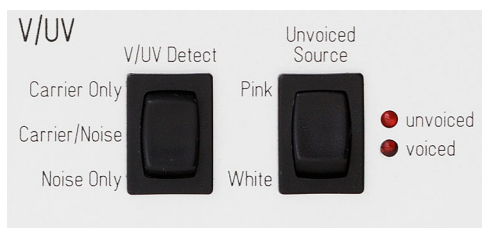
For effects purposes, the voice envelope can be slewed, leading to slurring effects, or even frozen, permanently holding the given articulation.
The slew rate is manually adjustable or via an external control voltage (1...10 V). The articulation can either be frozen via a momentary switch or via a foot switch connected to the 6.35 mm (¼-inch) jack.
The attack detector dynamically controls the slewing and freezing, depending on the voice signal level. A rising voice stops the freezing or slewing, whereas a falling voice leads back into slewing or freezing, depending on the potentiometer setting.
LEDs indicate freeze status and attack detection.

VoIS Features in Detail

The vocoder has two separate outputs, one for the stereo vocoder signal and one for the monophonic filter signal.
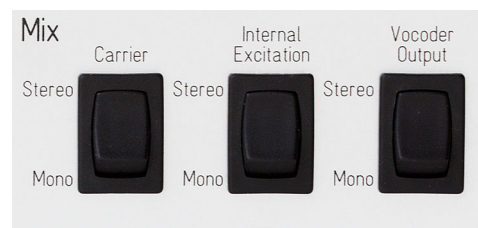The voice and carrier signals can also be mixed into the vocoder signal for monitoring or effects purposes.
Silence bridging passes the filtered carrier signal through to the vocoder output during periods of silence of the voice signal. The level of detected silence is adjustable. An LED indicates periods of silence.

At three different points in the signal chain, the character of the vocoder output can be altered by mixing the stereo channels into one.
- **Carrier:** Mixing of the stereo input channels into mono.
- **Internal Excitation:** In stereo operation, the two signal generators excite each carrier channel independently. Switched to mono, both generator signals are mixed together and fed into the individual carrier channels. The carrier channels still remain separated for external sources unless also switched to mono.
- **Vocoder Output:** Mixing of the vocoder output channels into mono.

Technical Specifications

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Architecture:	18-channel analog stereo vocoder and filter system
Rack size:	3U (19" rack, depth 235 mm)
Inputs:	Voice: 6.35 mm (¼-inch) stereo input jack, mixed down to mono, mono VU meter • Line–in: 1 V_{pp} at 0 dB, input resistance 47 kΩ • Mic–in: ~5 mV_{pp} at 0 dB, input resistance 47 kΩ Carrier: 6.35 mm (¼-inch) stereo input jack, stereo VU meter • Line–in: 1 V_{pp} at 0 dB, input resistance 47 kΩ • Mic–in: ~5 mV_{pp} at 0 dB, input resistance 47 kΩ • Selectable modes: "stereo" (channels separated) and "mono" (channels mixed)
Internal excitation:	Two independent internal sawtooth and noise generators for mix into carrier input • Sawtooth generator[1] with coarse and fine frequency as well as volume controls • Pink noise[2] generators with volume controls • 3.5 mm jacks for 1 V/oct. frequency control • Selectable modes: "stereo" (channels separated) and "mono" (channels mixed)
V/UV detector:	Voiced/unvoiced detector with automatic gain control (AGC) to adapt noise to carrier levels • Selectable detection modes: "carrier only", "carrier/noise", and "noise only" • Selectable noise sources: "pink noise" and "white noise" • LEDs for detected signal type ("voiced" or "unvoiced"), both off during silence
Analysis/ synthesis channels:	18 channels[3] with individual amplitude controls for vocoder and filter output • Frequencies: approximately 120, 150, 190, 240, 310, 390, 500, 640, 810, 1000, 1300, 1700, 2100, 2700, 3400, 4300, 5500, and 7000 Hz. • Filter type: 8–pole bandpass filters for all channels • 3.5 mm jacks for manual cross–patching (CV–out to CV–in) • CV–in controllable via external control voltages (0...5 V) • LED peak indicators, fully illuminated at roughly 0 dB
Outputs:	Vocoder: 6.35 mm (¼-inch) stereo output jack • 3.5 V_{pp} at 0 dB, output impedance load dependent (min. 600 Ω) • Mixer controls for voice and carrier • Selectable modes: "stereo" and "mono" output Filter: 6.35 mm (¼-inch) stereo output jack, mixed down to mono • 3.5 V_{pp} at 0 dB, output impedance load dependent (min. 600 Ω)
Slew/freeze:	• Manual slew rate (sustain) control, variable between "slow" (freeze) and "fast" • Momentary "freeze" switch • "Freeze" foot switch • 3.5 mm jack for external CV control of slew rate (0...10 V) • LED indicator for "freeze" • Attack detector for dynamic slew rate control with LED indicator
Silence bridging:	• Manual volume level control (squelch) • LED indicator for "silence"

[1] Configurable as square waves via internal jumpers
[2] Configurable as white noise via internal jumpers
[3] Each bandpass is assigned either to the left or right audio channel of the vocoder output via internal jumpers

Filter Design

The filters of each channel, both for the analysis and the synthesis sections, are based on the 8–pole multi–feedback bandpass filter as shown below. For accuracy and temperature stability, resistors with a tolerance of 1% from the E48 series and SMD capacitors with C0G/NP0 dielectric are used in the vocoder:
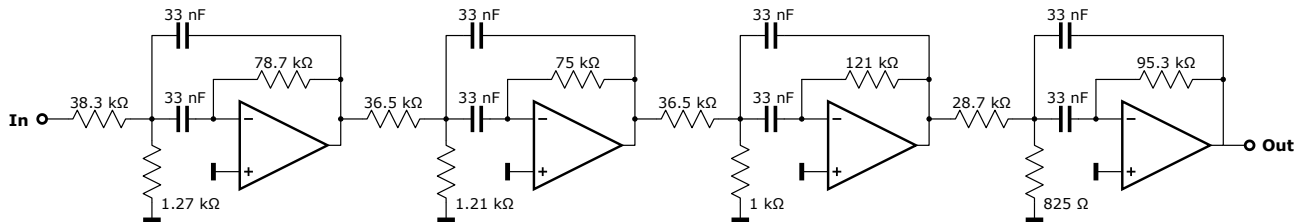
8–pole bandpass filter for the 500 Hz channel

Spice simulation results with the given channel filter topology show the excellent quality of channel separation accomplished with this design:

Channel bandpasses