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TWELP 1200/2400 bps Scalable Vocoder

Provides the highest quality of digital voice communication and loseless interoperability between networks with different bandwidth, providing two-layer encoding at 1200 bps (basic layer) + 1200 bps (extension layer) = 2400 bps bit rate total.

It's ideal for Digital Voice in HF radio at 1200 and 2400 bps, as well as in VHF/UHF radio, supporting both 2400 bps and 1200 bps bit rates. This ensures the highest voice quality in each network and maintains lossless interoperability between them. Transcoding is not needed, which saves significant computational resources in gateways and also means no degradation in speech quality, even when users interoperate at different bit rates.

TWELP vocoder enables cutting the bitrate in half compared to current standard solutions while maintaining high speech quality in conditions with a lower SNR (3-7 dB lower). It also enables doubling the number of channels in VHF/UHF radio without compromising voice communication quality.

For Digital Voice in HF, VHF/UHF Radio, Digital Mobile Radio (DMR) and other markets.

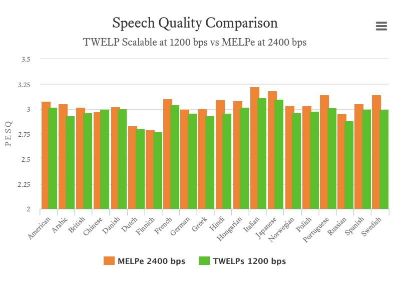
TWELP Technology Features.
The vocoder is based on the newest technology of a speech coding called "Tri-Wave Excited Linear Prediction" (TWELP) that was developed by experts of DSPINI.

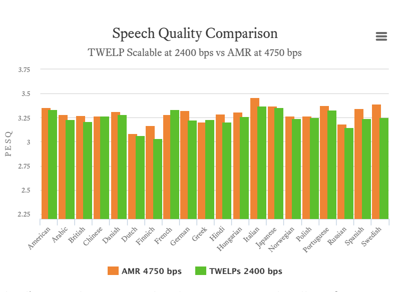
TWELP technology is a new class of vocoders that differs from any other LPC-based vocoders in:

- an advance reliable method of pitch estimation
- a pitch-synchronous analysis
- an advance tri-wave model of excitation
- newest quantization schemes
- a pitch-synchronous synthesis

Thanks to these unique features, TWELP technology provides much better speech quality in comparison with any well-known technologies, including AMBE+2, MELPe, ACELP, etc. at the same bit rate in range from 300 bps up to 9600 bps and beyond. Moreover, in contrast to other LBR vocoders (like MELPe, etc.) TWELP provides much better quality for non-speech signals like sirens, background music, etc.

Superiority In Speech Quality.
Here's the comparative analysis between the TWELP 1200/2400 scalable vocoder and standard MELPe and AMR vocoders, which operate at twice the higher bit rates.
TWELP at 1200 bps bit rate is compared with MELPe at 2400 bps, and TWELP at 2400 bps is compared with standard AMR at 4750 bps.
The ITU-T P.50 speech database for 20 different languages was utilized, and the ITU-T P.862 utility was employed to estimate speech quality in PESQ terms.





The diagrams demonstrate that the TWELP vocoder allows for a two-fold reduction in bit rate compared to standard vocoders while maintaining speech quality at the same high level (subjectively even better—listen to it below).
Exact numbers are shown in the tables below.

Language	MELPe 2400 bps	TWELPs 1200 bps
American	3.077	3.015
Arabic	3.053	2.933
British	3.019	2.963
Chinese	2.970	3.000
Danish	3.022	3.003
Dutch	2.830	2.801
Finnich	2.791	2.769
French	3.106	3.043
German	2.998	2.958
Greek	3.004	2.933
Hindi	3.089	2.956
Hungarian	3.086	3.018
Italian	3.226	3.111
Japanese	3.188	3.098
Norwegian	3.032	2.965
Polish	3.029	2.975
Portuguese	3.146	3.009
Russian	2.952	2.883
Spanish	3.048	3.000
Swedish	3.147	2.992
Average	**3.041**	**2.971**
The difference in quality is on average just 0.07 PESQ		

Language	AMR 4750 bps	TWELPs 2400 bps
American	3.357	3.334
Arabic	3.277	3.228
British	3.272	3.212
Chinese	3.267	3.264
Danish	3.311	3.279
Dutch	3.089	3.065
Finnich	3.166	3.032
French	3.277	3.336
German	3.321	3.226
Greek	3.206	3.229
Hindi	3.286	3.205
Hungarian	3.305	3.258
Italian	3.462	3.367
Japanese	3.369	3.355
Norwegian	3.267	3.238
Polish	3.263	3.250
Portuguese	3.377	3.325
Russian	3.186	3.150
Spanish	3.343	3.237
Swedish	3.391	3.251
Average	**3.289**	**3.242**
The difference in quality is on average just 0.047 PESQ		

Speech Samples (WAV-files).
Several independent experts listened to the TWELP 1200/2400 scalable vocoder in comparison with MELPe and AMR vocoders that operated at twice the higher bit rates, using a method of preferences.
Despite the objective estimations of speech quality in PESQ terms being approximately the same, the majority of experts preferred TWELP over the standard vocoders especially for low bit rate, noting a much more natural human-sounding voice in the TWELP vocoder.
You can listen to short samples of the source speech as well as the speech processed by each pair of vocoders for any of the 20 languages in the table below.
Additionally, you can download a full set of P.50 samples as zip-files for all languages simultaneously in the Downloads section below.

Language	Source speech	MELPe 2400 bps	TWELPs 1200 bps
American	▶	▶	▶
Arabic	▶	▶	▶
British	▶	▶	▶
Chinese	▶	▶	▶
Danish	▶	▶	▶
Dutch	▶	▶	▶
Finnich	▶	▶	▶
French	▶	▶	▶
German	▶	▶	▶
Greek	▶	▶	▶
Hindi	▶	▶	▶
Hungarian	▶	▶	▶
Italian	▶	▶	▶
Japanese	▶	▶	▶
Norwegian	▶	▶	▶
Polish	▶	▶	▶
Portuguese	▶	▶	▶
Russian	▶	▶	▶
Spanish	▶	▶	▶
Swedish	▶	▶	▶

Language	Source speech	AMR 4750 bps	TWELPs 2400 bps
American	▶	▶	▶
Arabic	▶	▶	▶
British	▶	▶	▶
Chinese	▶	▶	▶
Danish	▶	▶	▶
Dutch	▶	▶	▶
Finnich	▶	▶	▶
French	▶	▶	▶
German	▶	▶	▶
Greek	▶	▶	▶
Hindi	▶	▶	▶
Hungarian	▶	▶	▶
Italian	▶	▶	▶
Japanese	▶	▶	▶
Norwegian	▶	▶	▶
Polish	▶	▶	▶
Portuguese	▶	▶	▶
Russian	▶	▶	▶
Spanish	▶	▶	▶
Swedish	▶	▶	▶

Superiority In Quality Of The Non-speech Signals.
In contrast to other LBR vocoders (MELPe, AMBE+2, etc.), TWELP vocoders provide a high quality of non-speech signals, including police, ambulance, fire sirens, etc. This feature in conjunction with a high quality natural human-sounding of the voice makes TWELP vocoders well suitable for replacement of analog radio with a digital radio and also for other applications where a high quality transmission of non-speech signals is relevant along with a high quality transmission of speech signals.

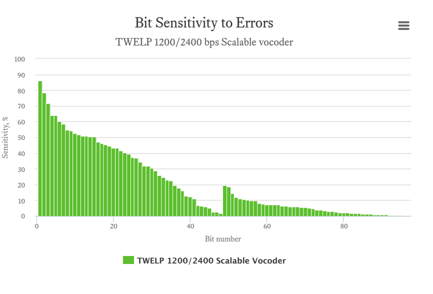
Source type	Source signal	MELPe 2400	TWELPs 2400
Siren only	▶	▶	▶
With voice	▶	▶	▶

High Robustness To Acoustic Noise.
In contrast to other LBR vocoders, TWELP vocoders are well robust to acoustic noise thanks to robust reliable method of pitch estimation and other features of TWELP technology.

Moreover, vocoder includes in-built Noise Cancellation—Speech Enhancement (NCSE) functionality that improves a speech quality in a noisy acoustic environment.

NCSE Mode	Source signal	MELPe 2400	TWELPs 2400
Disabled	▶	▶	▶
Enabled	▶	▶	▶

High Robustness To The Channel Errors.
The diagram below illustrates the sensitivity of bits at the output of the vocoder to communication channel errors.
Essentially, the diagram shows by what percentage speech quality is reduced when a specific bit is distorted. The first bits in order cause catastrophic distortions, while the latter bits have significantly less impact on quality.



The first half (48 bits) represents the basic layer, while the second half (48 bits) represents the extension layer of the scalable vocoder.

We strongly recommend using FEC (Forward Error Correction) with unequal protection of the bits in strong accordance with their sensitivity to errors and utilizing 'Soft Decisions' decoding. This will provide the highest robustness of the vocoder against errors in the channel.

Additional Functionalities.
The following additional functionalities are developed by DSPINI and integrated into TWELP vocoders:

- Automatic Gain Control (AGC),
- Noise Cancellation for Speech Enhancement (NCSE)
- Voice Activity Detector (VAD),
- Tone Detection/Generation (Single tones and Dual tones). The tones are transmitted by the vocoder facilities.

Each functionality has unique features, performance and characteristics, providing a significant superiority over any well-known implementations on the market.

Technical Characteristics And Resource Requirements:

Technical characteristics

Bit Rate (bps)	Algorithm	Frame size (ms)	Algorithmic delay (including frame size) (ms)	Sampling rate (kHz)	Signal format	Bit stream format
1200/2400	TWELP	40	60	8	Linear 16-bit PCM	48/96

Additional functionalities

Name	Functionality	Technical characteristics: Name	Technical characteristics: Value
AGC	Automatic Gain Control	Control range:	0 ... +20 dB
NCSE	Noise Canceller - Speech Enhancer	SNR increasing	> 6 dB
		Speech quality improvement	> 0.1 PESQ
Tone Detector	Single/Dual tones detection	In accordance with the international standards	
Tone Generator	Single/Dual tones generation	Special generator, kept continuity of a signal (phase and amplitude of signal of previous frame)	
VAD	Voice Activity Detection	Reliable detection speech in background noise	
CNG	Comfort Noise Generation	Type of noise	"white"
		Level	- 60 dB

Resources for ARM Cortex-M4 platform

Module	MIPS* peak	Memory (KBytes): Program	Data: Constants	Data: Channel	Data: Heap	Data: Stack
Encoder	145	52	968	5.0	4.0	1.0
NCSE	6					
AGC	0.6					
Decoder	19					
Encoder + Decoder	164					
Total	171					

Resources for TI's C64 DSP platform

Module	MIPS* peak	Memory (KBytes): Program	Data: Constants	Data: Channel	Data: Heap	Data: Stack
Encoder	52	98	968	5.0	4.0	1.0
NCSE	2.7					
AGC	0.3					
Decoder	5.5					
Encoder + Decoder	57.5					
Total	60.5					

Resources (estimated) for TI's C55 DSP platform

Module	MIPS* peak	Memory (KBytes): Program	Data: Constants	Data: Channel	Data: Heap	Data: Stack
Encoder	88	32	968	5.0	4.0	1.0
NCSE	7					
AGC	0.4					
Decoder	13					
Encoder + Decoder	101					
Total	109					

* DSPINI continues optimization of the TWELP algorithm and the code in order to minimize a computational complexity of the vocoder.
For use cases, where consumption resources are critical, we can reduce MIPS as well as memory, but with minor decreasing of speech quality.

Vulnerability / Security.
DSPINI guarantees an ABSOLUTE cleanliness of the software from any undocumented features, undeclared capabilities, etc. All our customers can be assured that any our software/code doesn't contain any secret functions or features hidden from the user. We are ready to provide the source codes of our software products for an appropriate certification if needed.

Guarantee And Support.
DSPINI guarantees a quality and accordance of all technical characteristics of the product to the requirement of the current specifications. Testing and the other method of quality control are used for a guarantee support.

Any Platforms.
DSPINI can port this vocoder software onto any other DSP, RISC or general-purposes platform in a short time: 1-2 months.

Licensing Terms.
To use the vocoder software, a customer should obtain a license from DSPINI only.

Customization.
The vocoder can be customized under any specific requirements - other bit rate, frame size, any other robustness to channel errors, etc. Please contact us for the details.

Prospects.
DSPINI is impoving and developing continuously a set of new vocoders with the range from 300 bps up to 9600 bps, based on TWELP technology.

Related Software.
This vocoder may be effectively used in a bundle with other DSPINI's products:

- Linear and acoustic echo cancellers,
- Multichannel noise cancellers (including two-microphone adaptive array),
- Wired or radiomodems for any types of channels and bitrates,
- Other products.

Downloads:

- Datasheet (pdf)
- ITU-T P.50 source speech samples (zip)
- MELPe 2400 bps speech samples (zip)
- TWELP-1200/2400 1200 bps speech samples (zip)
- AMR 4750 bps speech samples (zip)
- TWELP-1200/2400 2400 bps speech samples (zip)
- PC-evaluation package (zip) — at request
- User's Guide document (pdf) — at request

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