TWELP 1600 bps Robust Vocoder

Provides high speech quality as in noiseless channel as well as in noisy channel.

A "joint source-channel coding" solution on TWELP 1200 bps vocoder base and FEC 400 bps as UEP-RCPC (Unequal Error Protection Rate Compatible Punctured Convolution) code provides reliable protection of the bits strictly in accordance with their sensitivity to errors.

For Digital HF Radio, Digital Mobile Radio (DMR) and other markets.

TWELP Technology Features. The vocoder is based on newest technology of 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 by:

- advance reliable method of pitch estimation
- pitch-synchronous analysis
- advance tri-wave model of excitation
- newest quantization schemes
- 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. on the same bit rate in range from 300 bps up to 9600 bps and more. 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 is the comparison with MELPe 1200 bps vocoder in noiseless channel. TWELP 1600 bps Robust vocoder and MELPe 1200 bps vocoder were tested, using ITU-T P.50 speech base for 20 different languages. ITU-T P.862 utility was used for estimation of the speech quality in PESQ terms:

Speech Quality Comparison
TWELP 1600 bps Robust vs MELPe 1200 bps
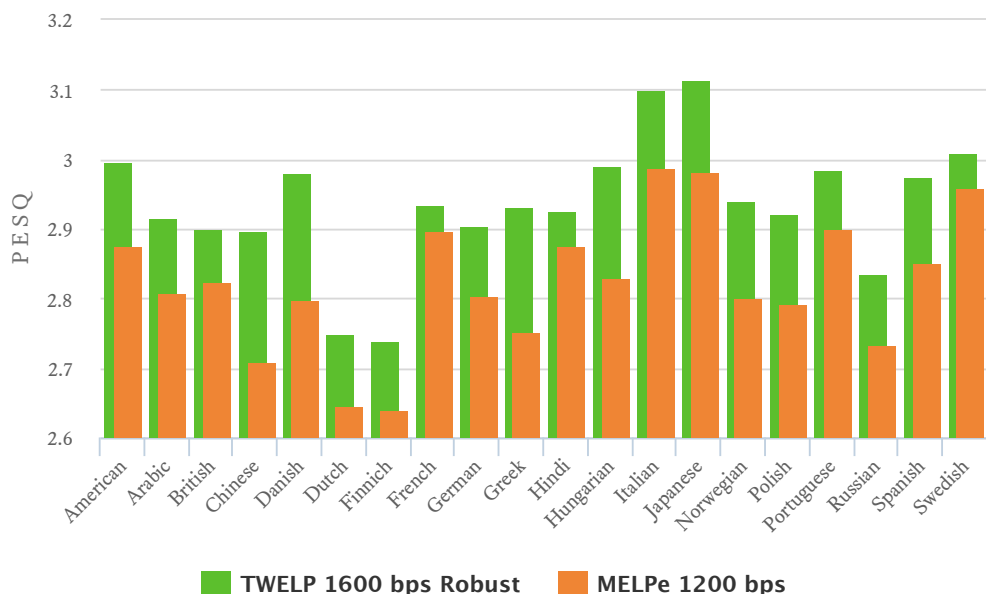
A diagram demonstrates superiority TWELP 1600 Robust over MELPe 1200 in speech quality in clear channel. Exact numbers are shown in the table below.

Language	TWELP 1600 bps Robust	MELPe 1200 bps
American	2.997	2.876
Arabic	2.917	2.809
British	2.9	2.826
Chinese	2.898	2.71
Danish	2.98	2.797
Dutch	2.751	2.646
Finnich	2.74	2.641
French	2.934	2.897
German	2.906	2.803
Greek	2.933	2.753
Hindi	2.927	2.875
Hungarian	2.991	2.831
Italian	3.102	2.989
Japanese	3.113	2.983
Norwegian	2.941	2.8
Polish	2.922	2.792
Portuguese	2.986	2.9
Russian	2.837	2.735
Spanish	2.976	2.851
Swedish	3.009	2.958
Average	**2.938**	**2.8236**

# Superiority of the TWELP 1600 bps Robust vocoder is on average 0.1144 PESQ

Speech Samples (WAV-files). A few independent experts listened TWELP 1600 bps Robust vocoder in comparison with MELPe 1200 bps vocoder, using method of preferences. Majority of experts preferred TWELP to MELPe, having noted much more natural human-sounding of voice in the TWELP vocoder. You can play and listen short samples of the source speech as well as the speech processed by both vocoders for any of 20 languages, using links in the table below.

Also, you can download full set of the P.50 samples as zip-files for all languages simultaneously, using the links in the "Downloads" para in a bottom of the page.

| Language	Source speech	MELPe 1200 bps	TWELP 1600 bps Robust
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 high quality of non-speech signals, including police, ambulance, fire sirens, etc. This feature in conjunction with high quality natural human-sounding of voice makes TWELP vocoders well suitable for replacement of analog radio by digital radio and also for other applications where high quality transmitting of non-speech signals is relevant along with high quality transmitting of speech signals.

Source type	Source signal	MELPe 1200 bps	TWELP 1600 bps Robust

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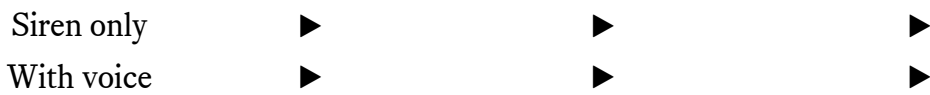
High Robustness To Acoustic Noise. In contrast to other LBR vocoders, TWELP vocoders are well robust to acoustic noise thanks to robust reliable method of pitch estimation and other features of TWELP technology.

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

NCSE Mode	Source signal	MELPe 1200 bps	TWELP 1600 bps Robust
Disabled	▶	▶	▶
Enabled	▶	▶	▶
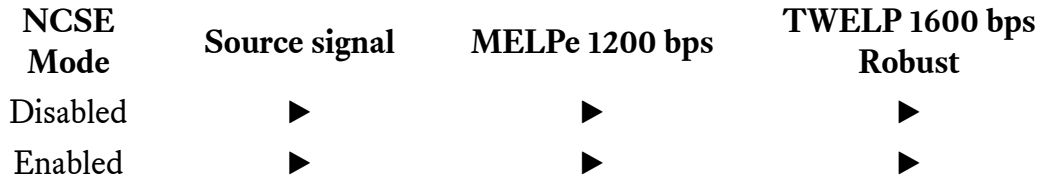
High Robustness To The Channel Errors. The diagram and table below show a dependence of the averaged speech quality for AWGN-noisy channel for different BER in comparison with other vocoders.

We recommend to use the TWELP 1600 vocoder in good channels, where BER is not more than 0.1%.

In case you use the channels, where a majority of calls are at BER > 0.1%, we recommend to use TWELP 1600 bps Robust vocoder with "Soft Decisions" output from a modem. You can compare the robustness of the vocoders on the diagramm below.

Averaged Speech Quality in AWGN channel

TWELP 1600 Robust HD   TWELP 1600 Robust SD   TWELP 1600
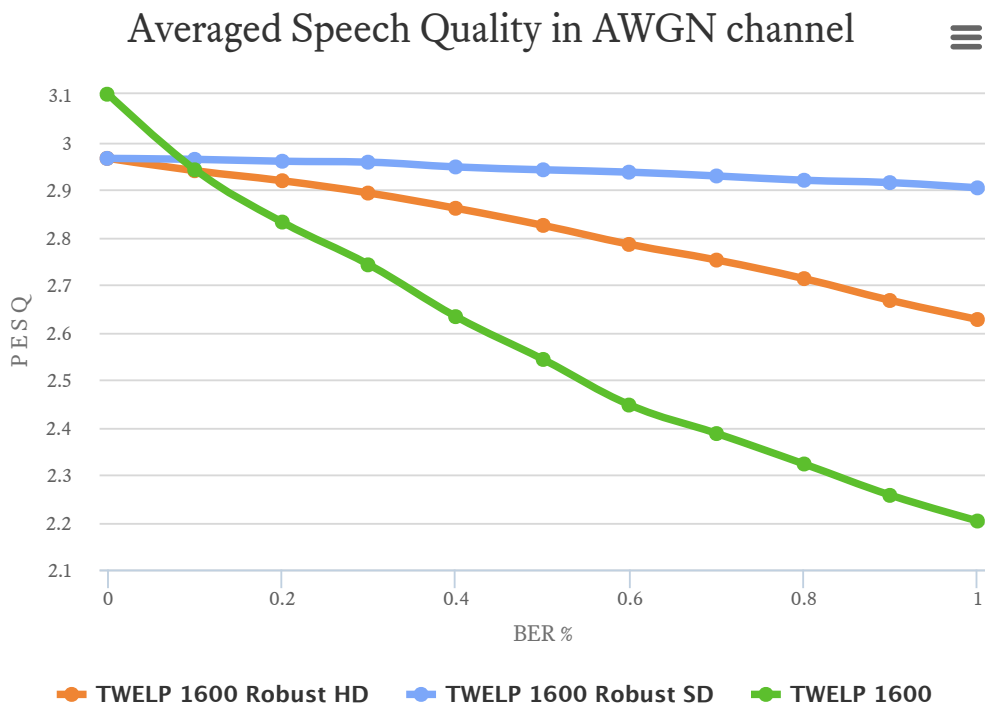
BER %	TWELP 1600 Robust HD	TWELP 1600 Robust SD	TWELP 1600
0.00	2.965	2.965	3.100
0.10	2.939	2.963	2.941
0.20	2.918	2.959	2.831
0.30	2.892	2.957	2.741
0.40	2.860	2.947	2.632
0.50	2.824	2.941	2.542
0.60	2.784	2.936	2.446
0.70	2.751	2.928	2.386
0.80	2.712	2.919	2.322
0.90	2.666	2.914	2.256
1.00	2.626	2.903	2.202

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 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
1600	TWELP	40	60	8	Linear 16-bit PCM	64

Additional functionalities

Name	Functionality	Technical characteristics	
		Name	**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 international standards	
Tone Generator	Single/Dual tones generation	Special generator, kept continuity of 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	Channel	Heap	Stack	
Voice Encoder	81.3	35	172	4.6	12.9	1.0	
NCSE	6.4						
AGC	0.3						
Voice Decoder	23.1						
Voice Encoder + Voice Decoder	104.4						
Total	111.1						

Resources for TI′s C64 DSP platform

Module	MIPS* peak	Memory (KBytes)					
		Program	Data				
			Constants	Channel	Heap	Stack	
Voice Encoder	30.1	68	171	4.6	12.9	1.0	
NCSE	2.8						
AGC	0.3						
Voice Decoder	6.8						
Voice Encoder + Voice Decoder	36.9						
Total	40.0						

Resources (estimated) for TI's C55 DSP platform

Module	MIPS* peak	Memory (KBytes)				
		Program	Data			
			Constants	Channel	Heap	Stack
Voice Encoder	48	21	171	4.6	12.9	1.0
NCSE	6.7					
AGC	0.3					
Voice Decoder	17.0					
Voice Encoder + Voice Decoder	65.0					
Total	72.0					

* DSPINI continues optimization of the TWELP algorithm and code in order to minimize computational complexity of the vocoder.

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

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

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

Licensing Terms. To use the vocoder, 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 with us for details.

Prospects. DSPINI is impoving and developing continuously a set of new vocoders with 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 1200 bps speech samples (zip)](#)
- [TWELP 1200 bps speech samples (zip)](#)
- PC-evaluation package (zip) — on request
- User′s Guide document (pdf) — on request

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