DSP Innovations

TWELP 2400 bps Vocoder

Provides very high speech quality - much better than MELPe 2400 bps vocoder and AMBE+2 2450 bps vocoder.

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

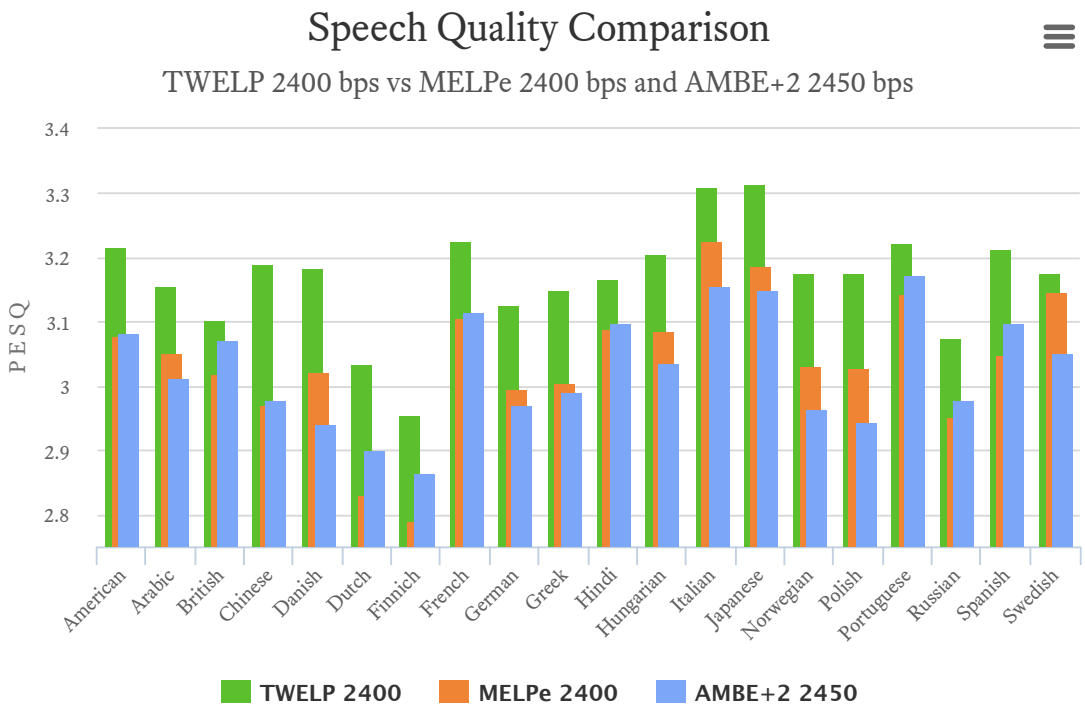
TWELP Technology Features. The vocoder is based on newest technology of speech coding called "Tri-Wave Excited Linear Prediction" (TWELP) that was developed by experts of DSPINI.

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 and AMBE+2 vocoders in noiseless channel. TWELP 2400 bps vocoder, MELPe 2400 bps vocoder and AMBE+2 2450 bps vocoder (DVSI's AMBE-3000 chip, rate 33) 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:



A diagram demonstrates superiority of the TWELP 2400 bps over MELPe 2400 bps and AMBE+2 2450 bps in speech quality in clear channel. Exact numbers are presented in the table below.

Language	**TWELP 2400**	**MELPe 2400**	**AMBE+2 2450**
American	3.217	3.077	3.085
Arabic	3.156	3.053	3.014
British	3.104	3.019	3.072
Chinese	3.190	2.970	2.979
Danish	3.185	3.022	2.941
Dutch	3.035	2.830	2.900
Finnich	2.956	2.791	2.867
French	3.225	3.106	3.117
German	3.127	2.998	2.971
Greek	3.149	3.004	2.992
Hindi	3.169	3.089	3.097
Hungarian	3.205	3.086	3.037
Italian	3.310	3.226	3.155
Japanese	3.316	3.188	3.151
Norwegian	3.176	3.032	2.964
Polish	3.176	3.029	2.944
Portuguese	3.224	3.146	3.175
Russian	3.076	2.952	2.980
Spanish	3.214	3.048	3.099
Swedish	3.178	3.147	3.053
Average	**3.1693**	**3.0407**	**3.0297**

Superiority of the TWELP 2400 bps vocoder is on average 0.13 and 0.14 PESQ appropriately

Speech Samples (WAV-files). A few independent experts listened TWELP 2400 bps vocoder in comparison with MELPe 2400 bps vocoder and AMBE+2 2450 bps vocoder, using method of preferences. Majority of experts preferred TWELP to MELPe and to AMBE+2, 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 these 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	AMBE+2 2450 bps	MELPe 2400 bps	TWELP 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 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 2400 bps	TWELP 2400 bps

Siren only	▶	▶	▶
With voice	▶	▶	▶

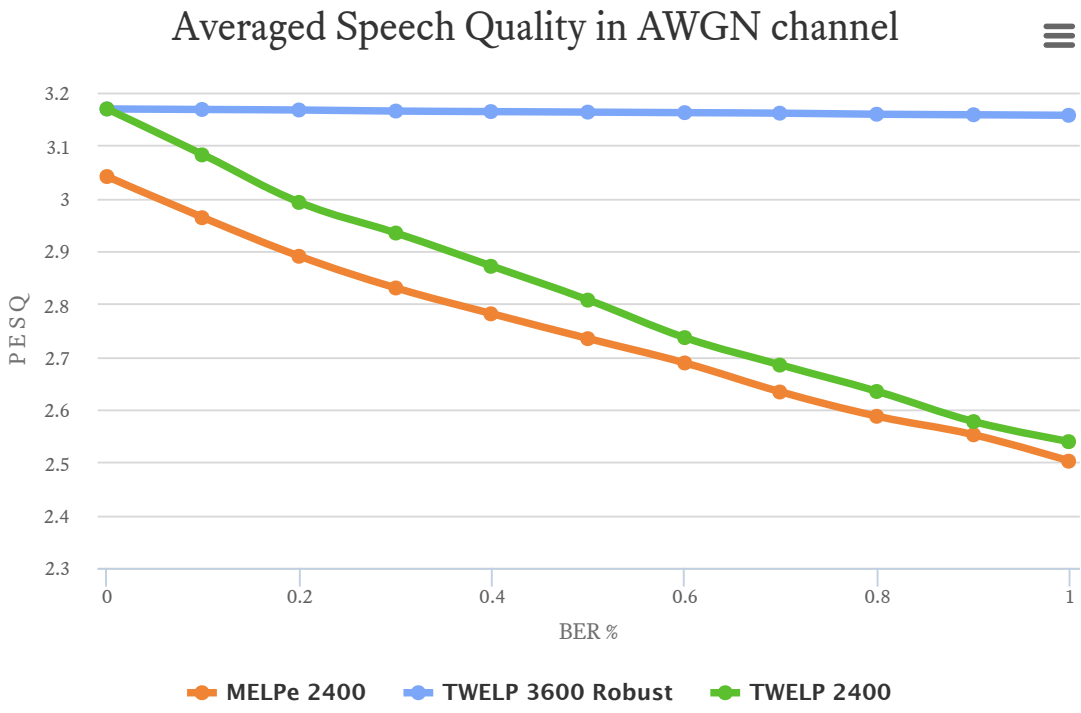
High Robustness To Acoustic Noise. In contrast to other LBR vocoders, TWELP vocoders are well robust to acoustic noise thanks to robust reliable method of pitch estimation and other features of TWELP technology.

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

NCSE Mode	Source signal	MELPe 2400 bps	TWELP 2400 bps
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.

Special "robust" versions of the TWELP vocoders include FEC that are integrated with vocoder on base of "joint source-channel coding" approach that provides high speech quality simultaneously in noisy channel as well as in noiseless channel. FEC can operate with "soft decisions" as well as with "hard decisions" from a modem. "Soft decisions" mode provides much better robustness in comparison with the "hard decisions" mode.



BER %	MELPe 2400	TWELP 3600 Robust	TWELP 2400

0.00	3.041	3.169	3.169
0.10	2.963	3.168	3.082
0.20	2.890	3.167	2.992
0.30	2.830	3.165	2.934
0.40	2.781	3.164	2.871
0.50	2.734	3.163	2.807
0.60	2.688	3.162	2.736
0.70	2.633	3.161	2.684
0.80	2.587	3.159	2.634
0.90	2.552	3.158	2.577
1.00	2.502	3.157	2.539

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**
2400	TWELP	20	40	8	Linear 16-bit PCM	48

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	49.3	33	37	4.5	4.8	2.1
NCSE	6.7					
AGC	0.2					
Voice Decoder	14.4					
Voice Encoder + Voice Decoder	63.7					
Total	70.6					

Resources for TI's C64 DSP platform

Module	**MIPS* peak**	**Memory** (KBytes)				
		Program	**Data**			
			Constants	**Channel**	**Heap**	**Stack**
Voice Encoder	17.6	63	37	4.5	4.8	2.1
NCSE	2.9					
AGC	0.1					
Voice Decoder	4.1					
Voice Encoder + Voice Decoder	21.7					
Total	24.7					

Resources (estimated) for TI's C55 DSP platform

Module	MIPS* peak	**Memory** (KBytes)				
		Program	**Data**			
			Constants	**Channel**	**Heap**	**Stack**
Voice Encoder	30.0	21	37	4.5	4.8	2.1
NCSE	7.0					
AGC	0.2					
Voice Decoder	10.0					
Voice Encoder + Voice Decoder	40.0					
Total	47.2					

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

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)
- AMBE+2 2450 bps speech samples (zip)
- MELPe 2400 bps speech samples (zip)
- TWELP 2400 bps speech samples (zip)
- PC-evaluation package (zip) — on request
- User's Guide document (pdf) — on request

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