TWELP 2400 bps Vocoder

Provides high speech quality - close to GSM AMR 4.75 kbps that operates on twice higher bit rate.

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 GSM AMR vocoders in noiseless channel. TWELP 2400 bps vocoder, MELPe 2400 bps vocoder and GSM AMR 4.75 kbps 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 2400 bps vs MELPe 2400 bps and GSM AMR 4750 bps
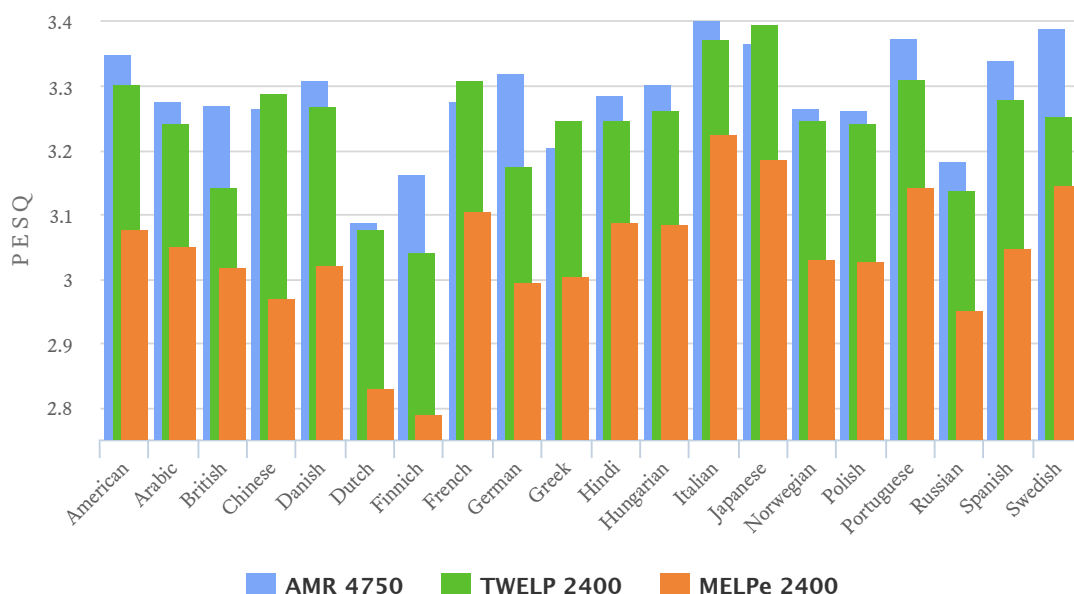
A diagram demonstrates a huge superiority of the TWELP 2400 bps over MELPe 2400 bps and a closeness (and even superiority for a few languages) to GSM AMR 4750 bps vocoder of the speech quality in clear channel. Exact numbers are presented in the table below.

Language	AMR 4750	TWELP 2400	MELPe 2400
American	3.351	3.304	3.077
Arabic	3.277	3.243	3.053
British	3.272	3.146	3.019
Chinese	3.267	3.290	2.970
Danish	3.311	3.270	3.022
Dutch	3.089	3.077	2.830
Finnich	3.166	3.043	2.791
French	3.277	3.310	3.106
German	3.321	3.178	2.998
Greek	3.206	3.248	3.004
Hindi	3.286	3.248	3.089
Hungarian	3.305	3.264	3.086
Italian	3.462	3.374	3.226
Japanese	3.369	3.398	3.188
Norwegian	3.267	3.249	3.032
Polish	3.263	3.243	3.029
Portuguese	3.377	3.312	3.146
Russian	3.186	3.140	2.952
Spanish	3.343	3.281	3.048
Swedish	3.391	3.256	3.147
Average	**3.289**	**3.244**	**3.041**

Superiority of the TWELP 2400 bps vocoder over MELP 2400 bps is on average 0.203 PESQ and just -0.045 PESQ in comparison with AMR 4750 bps

 Speech Samples (WAV-files). A few independent experts listened TWELP 2400 bps vocoder in comparison with MELPe 2400 bps vocoder and GSM AMR 4750 bps vocoder, using method of preferences. All experts preferred TWELP to the MELPe, having noted much more natural human-sounding of voice in the TWELP vocoder. A majority of experts haven't given preferences to GSM AMR or TWELP, but a majority of the remained prefered TWELP, having noted more clear sounding of speech in 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	AMR 4750 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.

We recommend to use the TWELP 2400 vocoder in good channels, where BER is not more than 0.15%.

In case you use the channels, where a majority of calls are at BER > 0.15%, we recommend to use TWELP 2400 bps Robust vocoder with "Soft Decisions" output from a modem. You can compare the robustness of the vocoders on the diagramm below.
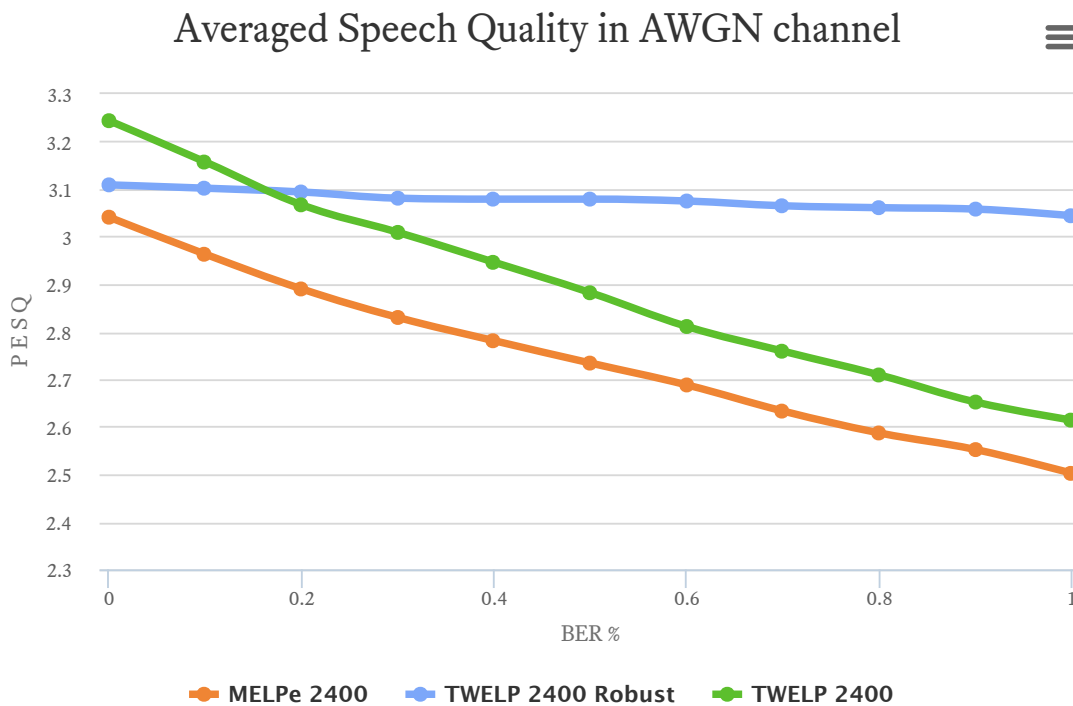
BER %	MELPe 2400	TWELP 2400 Robust	TWELP 2400
0.00	3.041	3.109	3.244
0.10	2.963	3.102	3.157
0.20	2.890	3.094	3.067
0.30	2.830	3.081	3.009
0.40	2.781	3.079	2.946
0.50	2.734	3.079	2.882
0.60	2.688	3.075	2.811
0.70	2.633	3.065	2.759
0.80	2.587	3.061	2.709
0.90	2.552	3.058	2.652
1.00	2.502	3.044	2.614

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	46.6	52	39	4.5	3.7	2.1
NCSE	5.8					
AGC	0.4					
Voice Decoder	13.5					
Voice Encoder + Voice Decoder	60.1					
Total	66.3					

Resources for TI′s C64+ DSP platform

Module	MIPS* peak	Memory (KBytes)				
		Program	Data			
			Constants	Channel	Heap	Stack
Voice Encoder	18.4	63	40	4.5	3.7	2.1
NCSE	2.7					
AGC	0.1					
Voice Decoder	4.3					
Voice Encoder + Voice Decoder	22.7					
Total	25.5					

Resources (estimated) for TI's C55 DSP platform

Module	MIPS* peak	Memory (KBytes)				
		Program	Data			
			Constants	Channel	Heap	Stack
Voice Encoder	33.0	21	39	4.5	3.7	2.1
NCSE	7.0					
AGC	0.2					
Voice Decoder	10.0					
Voice Encoder + Voice Decoder	43.0					
Total	50.2					

* 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)
- GSM AMR 4750 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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