



# TWELP DMR Vocoder

is an alternative to AMBE+2 DMR / dPMR vocoder, provides highest speech quality, when a voice is more natural, clear and is free of any synthesizing sounds, operating perfectly as in noiseless channel as well as in very noisy channels.

Can be used in DMR (ETSI TS 102 361) and dPMR (ETSI TS 102 658) radios as alternative vocoder (instead AMBE+2 vocoder) or as additional vocoder to provide in newest radios main superior mode, providing more high-quality voice communication, keeping simultaneously interoperability with old radios (AMBE+2 based ones).

A "joint source-channel coding" solution on TWELP 2450 bps vocoder base and FEC 1150 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 Mobile Radio (DMR), digital Private Mobile Radio (dPMR) 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:

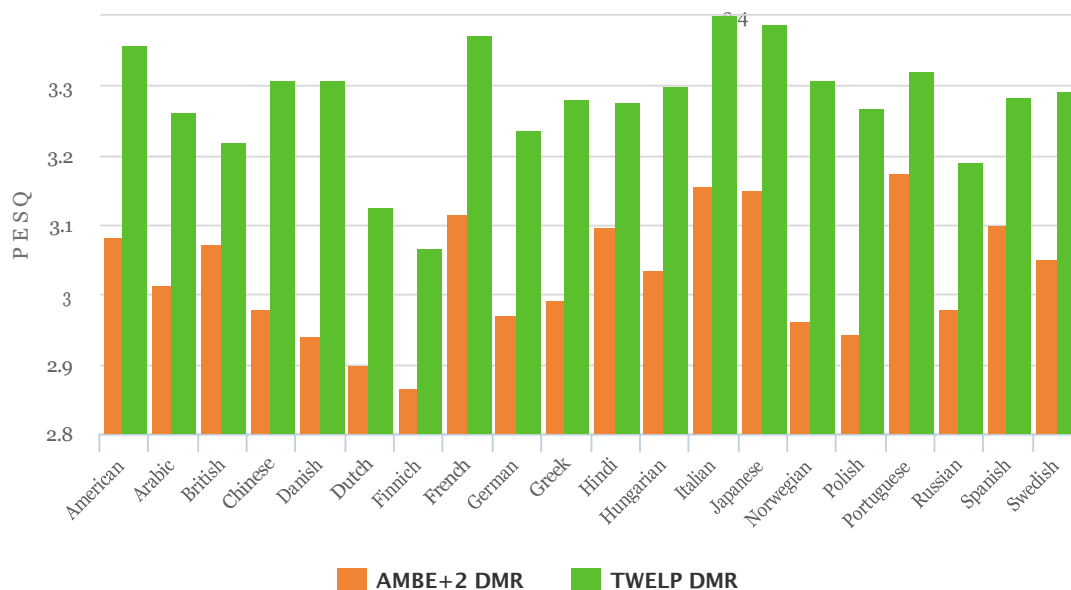
- an advance reliable method of pitch estimation
- a pitch-synchronous analysis
- an advance tri-wave model of excitation
- newest quantization schemes
- a pitch-synchronous synthesis

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 is the comparison with AMBE+2 DMR vocoder in a noiseless channel. TWELP DMR vocoder and AMBE+2 DMR vocoder (DVSI's AMBE-3000 chip, Rate#33, was used) were tested, using ITU-T P.50 speech base for 20 different languages. ITU-T P.862 utility was used for an estimation of the speech quality in PESQ terms:

# Speech Quality Comparison

TWELP DMR vs AMBE+2 DMR



A diagram demonstrates superiority TWELP DMR over AMBE+2 DMR in speech quality in a clear channel. Exact numbers are shown in the table below.

Language	AMBE+2 DMR	TWELP DMR
American	3.085	3.361
Arabic	3.014	3.264
British	3.072	3.220
Chinese	2.979	3.309
Danish	2.941	3.308
Dutch	2.900	3.126
Finnish	2.867	3.068
French	3.117	3.373
German	2.971	3.237
Greek	2.992	3.283
Hindi	3.097	3.276
Hungarian	3.037	3.302
Italian	3.155	3.427
Japanese	3.151	3.389
Norwegian	2.964	3.310
Polish	2.944	3.269
Portuguese	3.175	3.321
Russian	2.980	3.192
Spanish	3.099	3.286
Swedish	3.053	3.293
<b>Average</b>	<b>3.030</b>	<b>3.281</b>

**Superiority of the TWELP DMR vocoder is on average 0.251 PESQ !**

**Speech Samples (WAV-files).** A few independent experts listened TWELP DMR vocoder in comparison with AMBE+2 DMR vocoder (DVSI's AMBE-3000 chip, Rate#33), using method of preferences. Majority of experts preferred TWELP to AMBE+2, having noted a much more natural human-sounding voice in the TWELP vocoder.

You can listen to the short samples of the source speech as well as the speech processed by both vocoders for any of 20 languages on our website or you can download a full set of P.50 samples as zip-files for all languages simultaneously in Downloads section below.

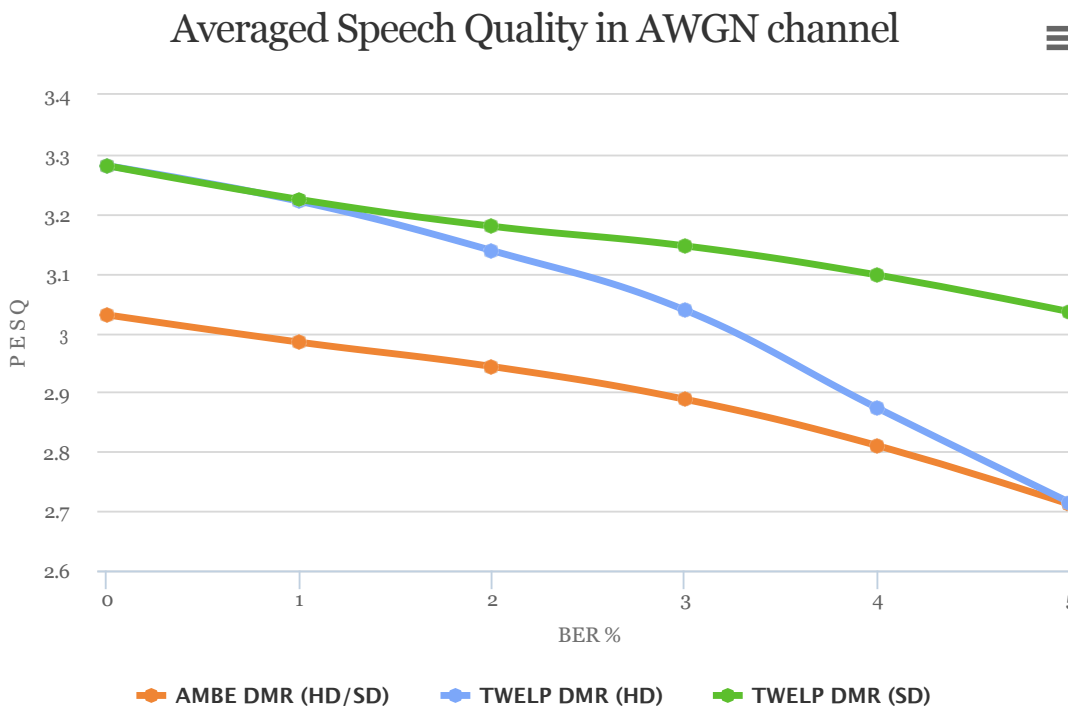
**Superiority In Quality Of The Non-speech Signals.** In contrast to other LBR vocoders (MELPe, AMBE+2, etc.), TWELP vocoders provide a high quality of non-speech signals, including police, ambulance, fire sirens, etc. This feature in conjunction with a high-quality natural human-sounding of the voice 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.

**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.

**High Robustness To The Channel Errors.** The diagram and the table below show a dependence of the averaged speech quality for AWGN-noisy channel on different BER in comparison with the other vocoders.

We recommend using the TWELP DMR vocoder in "Soft Decisions" mode from a modem. You can see the difference between "Hard Decisions" (HD) and "Soft Decisions" (SD) modes on the diagram below.



<b>BER %</b>	<b>AMBE DMR (HD/SD)</b>	<b>TWELP DMR (HD)</b>	<b>TWELP DMR (SD)</b>
<b>0</b>	3.030	3.281	3.281
<b>1</b>	2.984	3.221	3.224
<b>2</b>	2.943	3.138	3.179
<b>3</b>	2.888	3.038	3.146
<b>4</b>	2.810	2.873	3.097
<b>5</b>	2.711	2.714	3.035

You can play and listen to the short samples of the source speech as well as the speech processed by a standard DMR (AMBE+) 3600 bps (vocoder+FEC) and TWELP DMR vocoders (both in SD mode) in AWGN channel with BER = 5% for any of 20 languages on our website.

**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

<b>Bit Rate (bps)</b>	<b>Algorithm</b>	<b>Frame size (ms)</b>	<b>Algorithmic delay (including frame size) (ms)</b>	<b>Sampling rate (kHz)</b>	<b>Signal format</b>	<b>Bit stream format</b>
3600	TWELP	20	40	8	Linear 16-bit PCM	72

### 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 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	Channel	Heap	Stack
Encoder	56.5	47	56	4.8	8.8	2.0
NCSE	6.8					
AGC	0.6					
Decoder	25.9					
Encoder + Decoder	82.4					
Total	89.8					

### Resources for TI's C64 DSP platform

Module	MIPS* peak	Memory (KBytes)				
		Program	Data			
			Constants	Channel	Heap	Stack
Encoder	21.0	89	56	4.8	8.8	2.0
NCSE	2.6					
AGC	0.1					
Decoder	7.6					
Encoder + Decoder	28.6					
Total	31.3					

### Resources (estimated) for TI's C55 DSP platform

Module	MIPS* peak	Memory (KBytes)				
		Program	Data			
			Constants	Channel	Heap	Stack
Encoder	36.0	29	56	4.8	8.8	2.0
NCSE	6.2					
AGC	0.2					
Decoder	19.0					
Encoder + Decoder	55.0					
Total	61.4					

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

**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 improving 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 radio-modems 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 \(zip\)](#)
- [TWELP DMR 2450 bps speech samples \(zip\)](#)
- PC-evaluation package (zip) — at request
- User's Guide document (pdf) — at request