International Telecommunication Union

ITU-T Study Group 12

The Evolution of Telephonometric Testing Methodologies: The Use of Complex Signals

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HEAD acoustics

SG12 Workshop Dakar Oct. 2001

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Types of Test Signals - based on ITU-T P.501

- Non speech-like signals:
  - Deterministic Signals
  - Random Signals
  - Combined random and deterministic signals
- Speech-like signals:
  - Composite signals in time and/or frequency
  - Speech-like modulated signals
  - Complex composed signals
    - simulated speech generator
    - artificial voice/speech signals

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Deterministic Signals

- Sine wave
- Modulated sine wave
- Fourier Spectrum
  - frequency and amplitude modulation

$$s(t) = [A + \mu_{am} \cdot \cos(2\pi t \cdot f_{am})] \cdot \cos(2\pi t \cdot f_0 + \mu_{fm} \cdot \sin(2\pi t \cdot f_{fm}))$$

  - linear sweep

$$s(t) = A(f_0 + st) \cdot e^{j(\pi t(f_0 + st) + \varphi_0)}$$

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Deterministic Signals

- Application:
  - Traditional sine wave measurements for linear time-invariant systems, e.g. frequency responses, Loudness Ratings...
  - Measurements in bad SNR conditions

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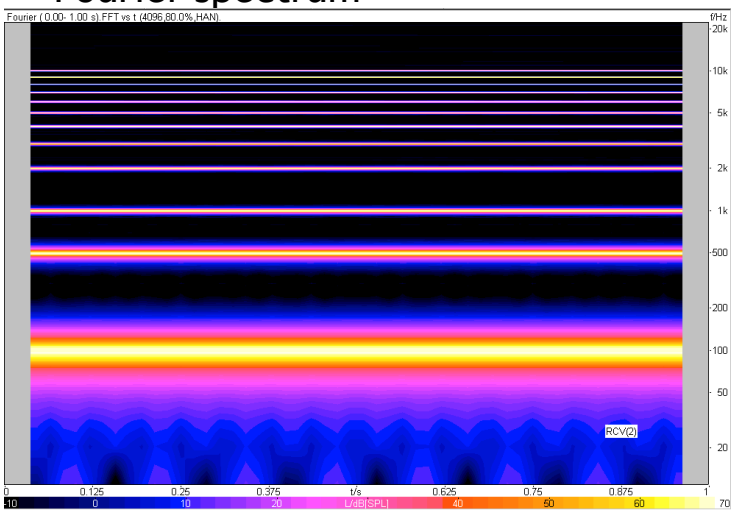
Power Density

Fourier spectrum



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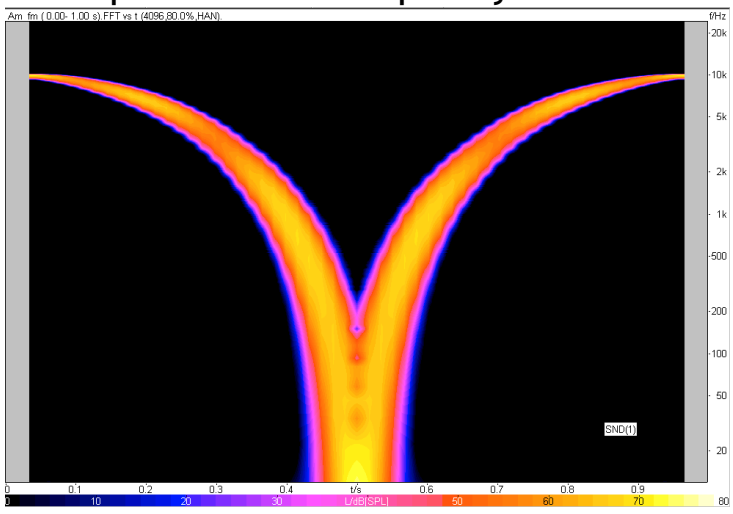
Power Density

Amplitude and Frequency



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Random Signals

- Description:
  - Random Noise
    - pink noise
    - white noise

    Typically defined by:
    - bandwidth
    - power density spectrum/level
    - crest factor
    - probability density function
    - (modulating signal)

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Random Signals

- Application:
  - Traditional measurements for linear time-invariant systems, e.g. frequency responses, Loudness Ratings...
  - Measurements of long term values, e.g. levels

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Speech-like Signals

- Classification:
  - Composite Source Signals
  - Speech-like modulated noise
  - Composed signals in frequency
  - Simulated speech generator
  - Artificial voice according to ITU-T Recommendation P.50
  - Artificial conversation speech according to ITU-T Recommendation P.59
  - Speech model process controlled by discrete Markov chains (MSMP)

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Speech-like Signals

- Application:
  - Measurement of non-linear and/or time-variant systems
  - Measurement of long term values
  - Measurement of short term values (e.g. switching)
  - Speech quality evaluation

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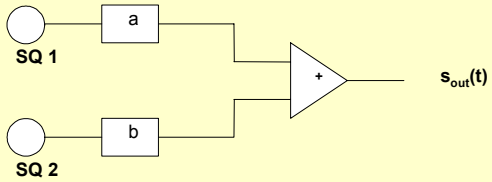
Composed Signals in Frequency

Principle of construction:



SQ1: Activation signal
e.g. speech or artificial voice
SQ2: Measurement signal with low level, typically sine wave
a,b: level adjustment

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Composed Signals in Frequency

- Application:
  - Long term measurements of speech-activated systems
  - Measurements of long term values
  - Measurements during operation of systems

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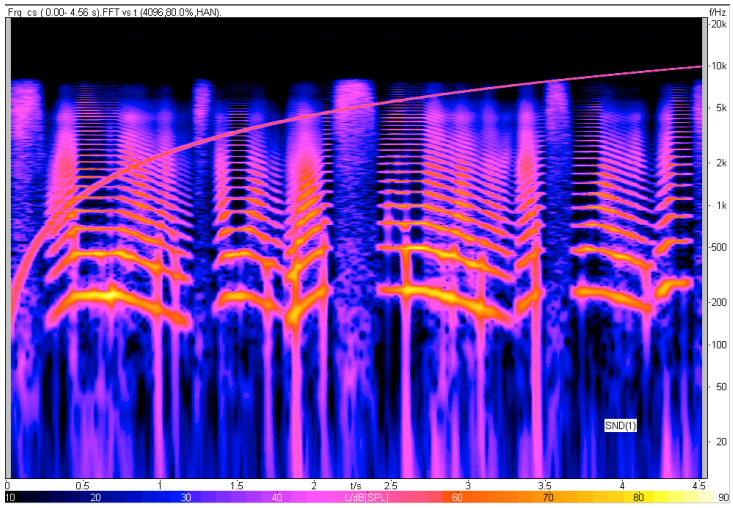
Composed Signals in Frequency

(probe tone)



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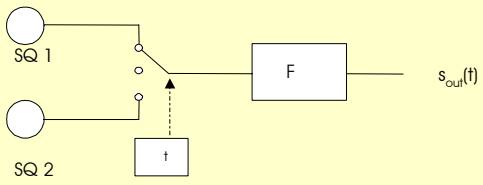
Composite Source Signal

Principle of generation:



SQ1: Signal source "voiced sound"
SQ2: Signal source "measurement signal"
e.g. pseudo random noise
t: time-dependent switch
F: Shaping filter

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Composite Source Signal

- Application:
  - Long term measurements of speech-activated systems and non-linear systems
  - Measurements of long term values
  - Measurements of short term parameters
  - Measurements of switching times
  - Double talk measurements

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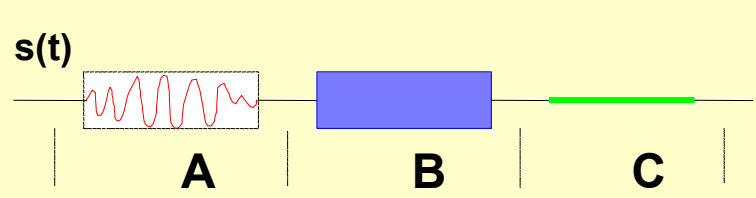
Composite Source Signal

Principle of construction



A - voiced Sound
B - test signal (e.g. pseudo random noise
C - pause

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Composite Source Signal

- A: Voiced sound of artificial speech (~50 ms)
  - activating possible speech detectors put the system in a reproducible, defined state for measurement
- B: e.g. Pseudo noise sequence (~200 ms)
  - measurement signal which can be adapted to the analysis requirements (e.g. pseudo random noise, narrow band noise, ...)
- C: Pause (~50 - 400 ms)
  - simulation of typical speech modulation, measurement of system noise under activated conditions

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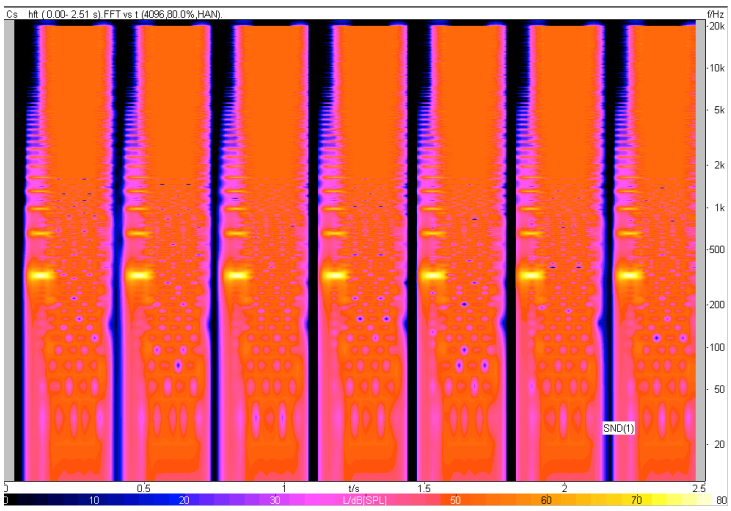
Composite Source Signal



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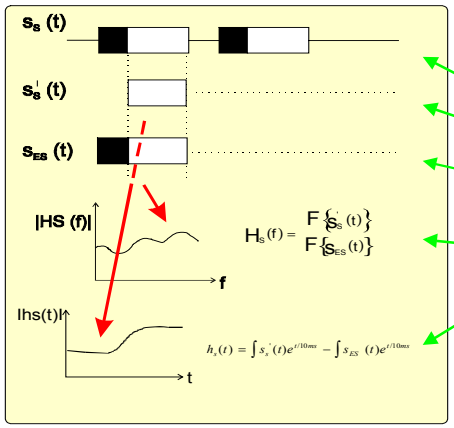
Composite Source Signal

- Example for evaluations with CSS



- Measured signal
- Cutoff of the measured signal
- Measurement signal (excitation signal)
- Frequency response
  :
- Switching characteristics

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Voice-like Composed Signals in Frequency

- Application:
  - Double talk measurements
  - Attenuation during double talk
  - Echo during double talk

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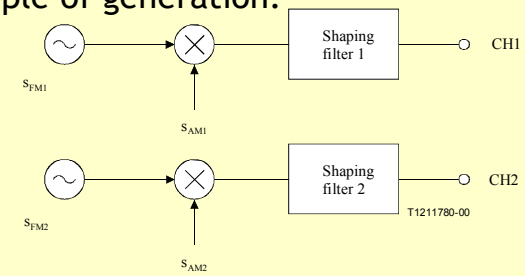
Voice-like Composed Signals in Frequency

Principle of generation:



$$s_{FM1,2}(t) = \sum A_{FM1,2} * \cos(2\pi t\, n * F_{01,2}); \qquad n = 1,2,....$$

$$s_{AM1,2}(t) = \sum A_{AM1,2} * \cos(2\pi t\, F_{AM1,2});$$

	f_{AM}	f_{FM}	F_0	shaping filter
Channel 1 (CH 1)	f_{AM1} = 3 Hz	f_{FM1} = 5 Hz	F_{01} = 270 Hz	LP, 5 dB/oct.
Channel 2 (CH 2)	f_{AM2} = 3 Hz	f_{FM2} = 5 Hz	F_{02} = 290 Hz	LP, 5 dB/oct.

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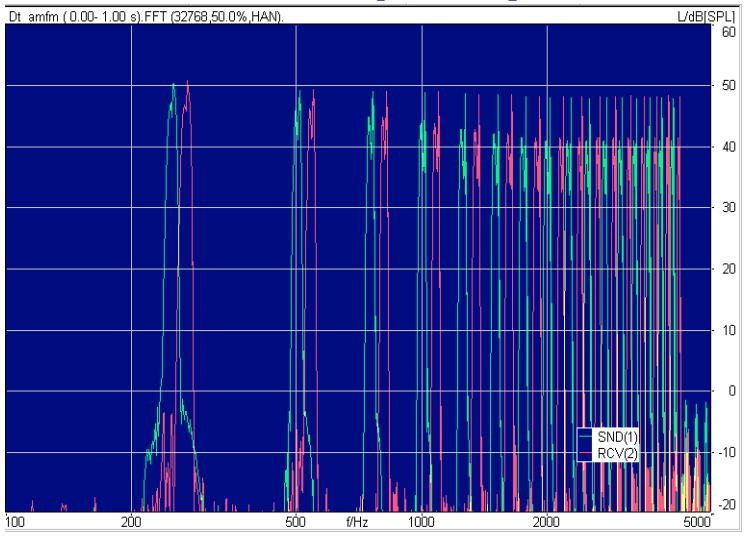
Voice-like Composed Signals in Frequency



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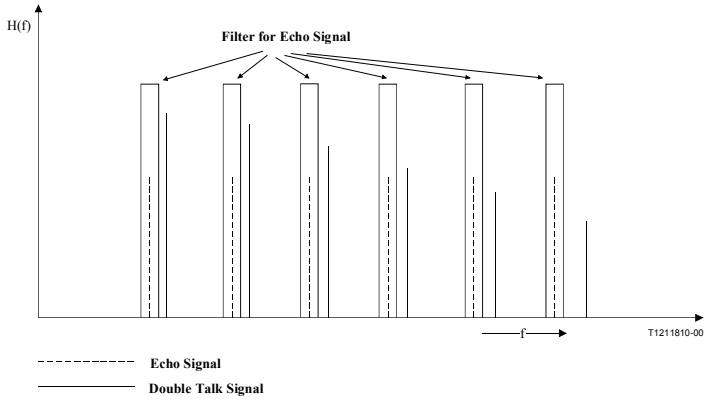
Voice-like Composed Signals in Frequency

- Typical analysis: extraction of echo components



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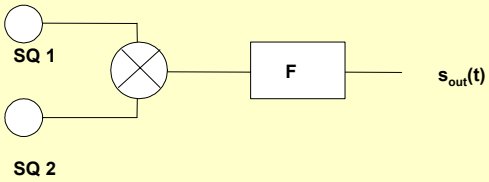
Simulated Speech Generator

Principle of generation:



SQ1: main signal source (Gaussian)
81024 k pn segmants, 80 ms each random phase
SQ2: modulating signal source (Gamma),
m= 0.545, syllabic characteristics represented by a low pass at 4 Hz
F: shaping filter

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Simulated Speech Generator

- Application:
  - Long term measurements of speech-activated, linear and non-linear systems
  - Measurements of long term values
  - Measurements of coding systems

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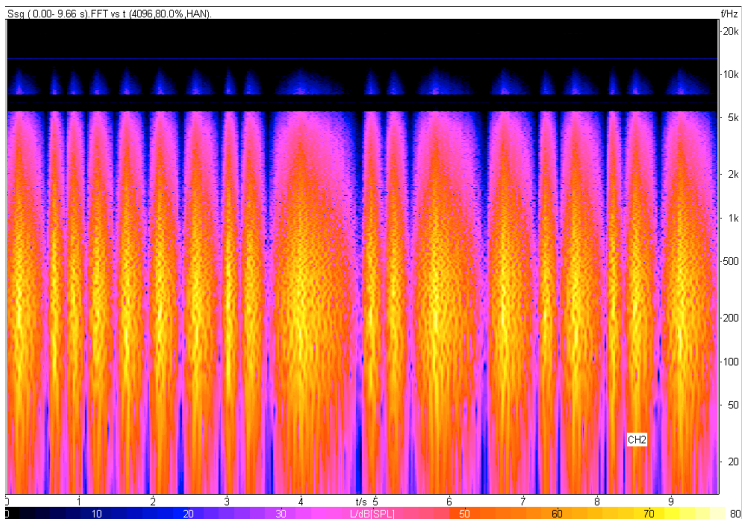
Simulated Speech Generator



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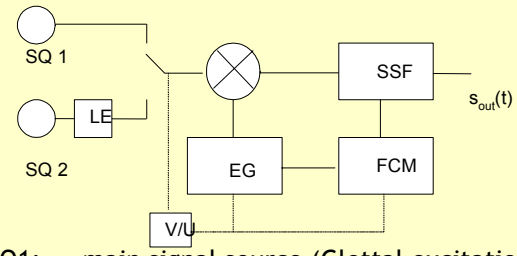
Artificial Voice ITU-T P.50

Principle of generation:



SQ1: main signal source (Glottal excitation)
SQ2: random noise
LE: low emphasis
V/U: voiced/unvoiced switching
EG: envelope generator
SSF: speech shaping filter
FCM: filter coefficients memory

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Artificial Voice ITU-T P.50

- Application:
  - Long term measurements of speech-activated, linear and non-linear systems
  - Measurements of long term values
  - Measurements of coding systems

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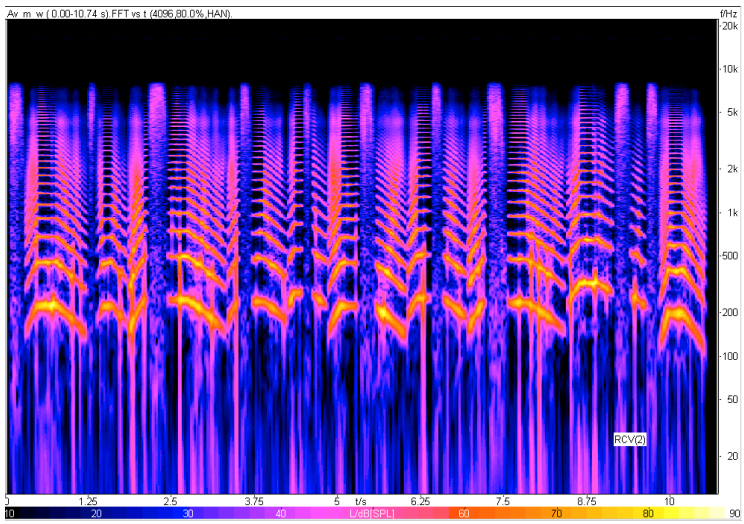
Artificial Voice ITU-T P.50



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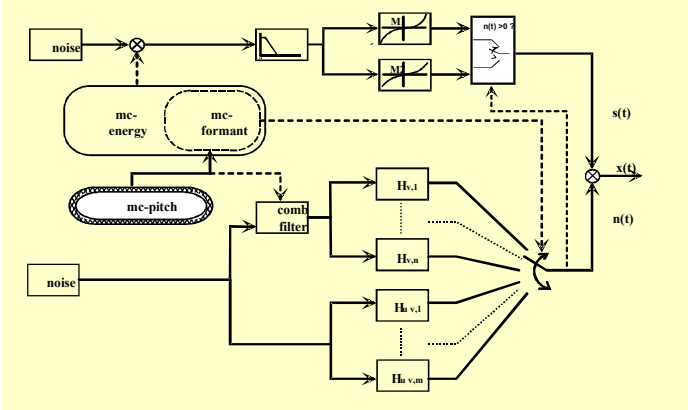
MSMP Signal
(Markov Speech Model Process)

Principle of generation:



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MSMP Signal

- Application:
  - Long term measurements of speech-activated, linear and non-linear systems
  - Measurements of long term values
  - Measurements of coding systems
  - Simulation of language-dependent and language-independent samples

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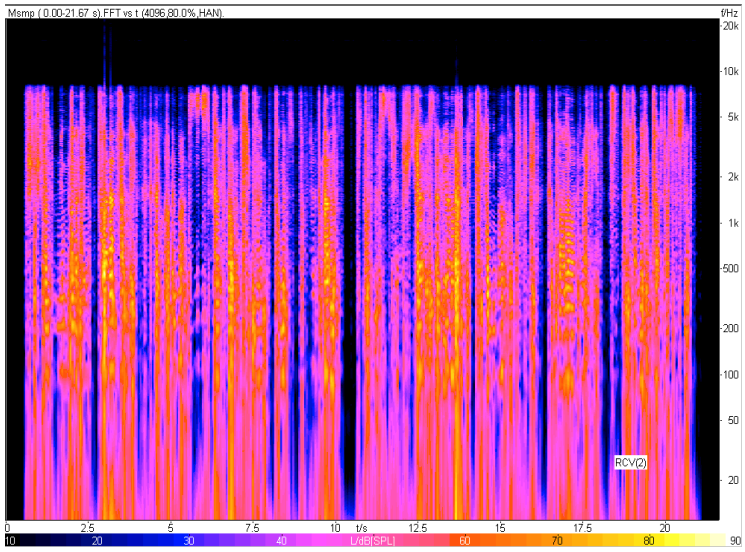
MSMP Signal



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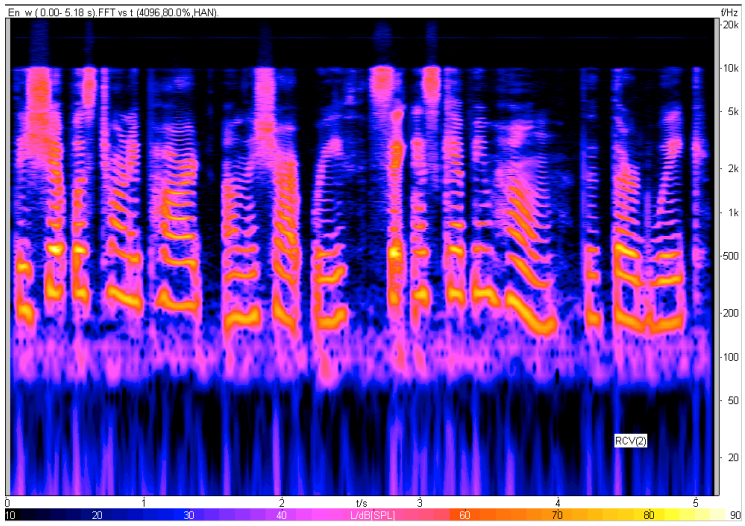
English Test Sentence



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Summary

- A big variety of test signals is available, ranging from simple test signals like sine waves to complex, speech like signals
- Special signal combinations can be used to simulate various conditions in a conversation
- A variety of analysis procedures are available to analyze different parameters of speech quality
- The relevant Recommendations:
  P.50, P.501, P.502, P.59