Next-Generation Automatic Volume Control for Mobile Phones

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Summary

• Problem
  Noise interferes with speech intelligibility
  - In cars, crowds, outdoors

• Solution
  SmartAVC™ maintains constant intelligibility

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**SmartAVC™ Unique Features**

- Weights noise in frequency domain
  - Calculates PSIL for intelligibility
- Filters noise in time domain ~ 1/4 sec
- Smoothes fluctuations – graceful volume control
- Finds minimum-volume preference
• **SmartAVC™** is set of algorithms
  – software or hardware on chips or DSPs
    -- US Pat. 7,760,893 – July 2010
    -- US Pat. 7,908,134 – March 2011
    -- Int’l. patents pending

• **SmartAVC™** available as Android demo app

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Conventional AVC

- Automatic volume controls in:
  - Mobile phones – Nokia Voice Clarity, LG Voice Clarity, Motorola CrystalTalk®,…
  - Bluetooth headsets – Jabra, BlackBerry,…
  - Car radios (speed-dependent) – Alpine,…
  - TVs (for commercials)

- Work poorly or not at all – all ‘Default Off’

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AVC Smartness Scale

Constant Intelligibility – SmartAVC™ patents, 2010 and 2011

Speech-Interference Noise Level

Perceived Noise

Total Noise

Constant $S/N_A$ – Nokia patent, 1999

Constant $S/N$ – AMD patent, 1997

Manual $S$

 Constant $S$ – Loud Signal

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SmartAVC™ Advantages

Conventional AVC

Preserves S/N

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**SmartAVC™ Advantages**

**Conventional AVC**
- Preserves S/N

**SmartAVC™**
- Preserves Intelligibility

SmartAVC™ Advantages

• Only SmartAVC™:
  • Controls volume without sacrificing quality
  • ‘Knows’ which noises interfere with intelligibility
  • Adjusts only for persistent speech interference
  • Smoothes volume fluctuations
  • Eliminates noise spikes/static bursts

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SmartAVC™ Functional Diagram

- **CORRELATE VOICE**
- **WEIGHT FREQUENCIES**
- **REDUCE TRANSIENTS**
- **PREFERRED SIGNAL/SIL**

**VOICE + BACKGROUND NOISE** → **BACKGROUND NOISE** → **SPEECH-INTERFERENCE NOISE (SIL)** → **VOLUME CONTROL SIGNAL** → **MANUAL CONTROL**

**SmartAVC™ FOR CELL PHONES**

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SmartAVC™ Component Diagram

Cell Phone Receiver
- Receiver
- Audio Amplifier
- Speaker

AVC
- Noise Microphone
- A/D
- DSP
- A/D
- Constraints

Cell Phone Transmitter
- Voice Microphone
- Amplifier
- Transmitter

Noise Microphone
- A/D
- Phase Correl.
- Amplit. Correl.
- Signal Subtract
- FFT

Voice Microphone
- A/D
- Constraints
- Solver
- SIL
- Bandpass Filters

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SmartAVC™ Optimizes Throughput

- **SmartAVC™ response time** ~ ¼ sec
  - Ignores transients
  - Loss ~ one syllable
  - Annoyance minimal
- **SmartAVC™ time step** < 0.1(¼ sec) ~ 1/40 sec
  - Well-behaved integration
- **SmartAVC™ sample rate** > 128(40 Hz)

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**SmartAVC™ Optimized for PSIL**

- PSIL is average noise level in Octaves 1 – 3
- FFT optimized for calculating PSIL*

**Octaves**

<table>
<thead>
<tr>
<th>Frequency (kHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>0.5</td>
</tr>
<tr>
<td>1</td>
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<tr>
<td>1.5</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>2.5</td>
</tr>
<tr>
<td>3</td>
</tr>
</tbody>
</table>

*PSIL: Psychoacoustic Subjective Index of Loudness*
SmartAVC™ Solver Algorithm

• SmartAVC™ solver algorithm ignores transient noise

Normalized Equation

\[
a''(t) + b\omega_0 a'(t) + \omega_0^2 a(t) = \omega_0^2 [S(t) + R(t)]
\]
\[
A''(t) + b\omega_0 A'(t) + \omega_0^2 [A(t) - S(t)] = 0
\]
\[
A_{i+1}' = A_i' + (N/s) A_i''
\]

if \(|A_i - S_i| \geq r_0\), then \(A_{i+1} = A_i + (N/s) A_i'\),

otherwise \(A_{i+1} = A_i\)

\[
A_i''' = \omega_0^2 S_{i+1} - b\omega_0 A_{i+1}' - \omega_0^2 A_{i+1}
\]

if \(A_{i+1} \leq A_{\min}\), then \(A_{i+1} = A_{\min}\)
**SmartAVC™** Ignores Transient Noise

Graph showing the comparison between noise and SmartAVC™. The graph plots SPL (dB) against Time (sec). The graph demonstrates how SmartAVC™ reduces noise compared to normal noise levels.

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**SmartAVC™ Key Points**

- Hearing clearly **anywhere** is key advantage
- Smoothly maintains constant intelligibility
- Easily implemented on handsets
  - Minimal processing, no hardware changes
- Highly leveraged way to enhance user experience

SmartAVC™ Demo App

Welcome to the SmartAVC Demo.
Please select your desired initial volume and PSIL offset and scaling.

Use SmartAVC7

File
smartavc.mp3

Volume
Offset
Scaling

Start Demo

SmartAVC™ Demo
Starmark, Inc.

Description
This application is a live, interactive demonstration of SmartAVC™, the World’s Smartest Automatic Volume Control (SM) for your phone and other audio devices that you use wherever it gets noisy.

It’s easy and fun to use this app. Shout, whistle, sing, clap, and make any other ‘background noises’ into your phone, and listen to how SmartAVC™ compensates by smoothly and gracefully adjusting the volume of the recorded voice to maintain its intelligibility. SmartAVC™ is truly an auditory luxury!

Simple directions for using this app are given at the end of this description.

Users who viewed this also viewed
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Install

Visit Developer’s Website

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