

**SIR C R REDDY COLLEGE OF ENGINEERING,
ELURU**

Department of Electronics & Communications
Engineering



Authors:

D.V.V.S.R.Bhadra Raju

V. Vijay Bhaskar

E-mail: draju_86@yahoo.co.in

vijay_vvbek19@yahoo.com

Cell: 9440468330

**Department of Electronics & Communications Engg.,
SIR CRR COLLEGE OF ENGGNEERING,
ELURU.**

SMART VOLUME TUNER FOR CELLULAR PHONES

Abstract:

This paper proposes the use of a smart volume tuner (SVT) for 2G, 2.5G, 3G cellular phones based on fuzzy logic for improving voice quality in the presence of background noise. The smart volume tuner (SVT) makes use of the noise level and class information generated by a system for fuzzy pattern classification of background noise. By intelligently adjusting the volume level, the quality of service (QoS) is improved for both stationary and nonstationary background noise in mobile environments. The SVT is personalized by using the audiogram to design the fuzzy rule base. A cellular phone which uses a smart volume tuner is generally referred to as a smart cellular phone (SCP).

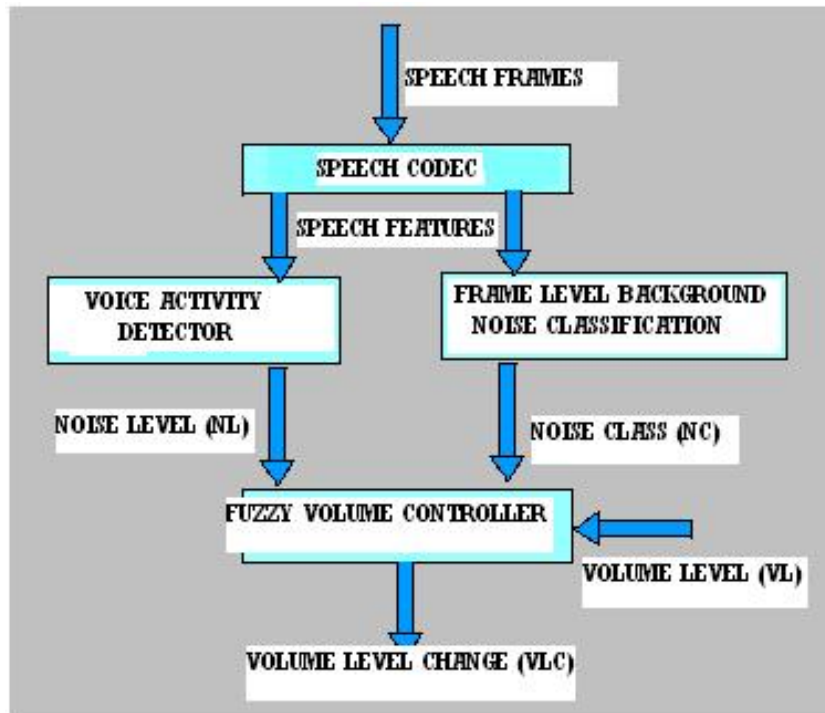
Introduction:

When having a conversation on a mobile phone, if the background noise level is high, we usually ask the speaker on the other end to speak up, or we may increase the volume. Also, during high background noise levels, users tend to bring their mobiles very close to their ears. Quality of service (QoS) is improved by providing a smart volume tuner in a cellular phone that intelligently changes the volume level based on the background noise levels and classes.

Background noise levels can be high while in buses, trains, planes, markets, sporting venues and, other public places. So background noise classification information is very useful and can be used to dynamically adapt acoustic volume levels to suit a particular type of noise. To improve the understandability of sounds in different noise environments, volume levels can be adjusted automatically. Car, bus, train noises fall into low frequency noise category. The spectrum of some classes of noise remain constant in time (stationary noise), whereas others vary suddenly (nonstationary noise).

Hearing loss in individuals can be gradual, and quality of hearing can vary from person to person. Hearing loss can also result in difficulty for individuals in understanding speech in the presence of background noise. Hence, the SVT needs to be personalized based on an individual's hearing requirements. For a person with hearing loss, the SVT rule base is designed based on audiogram.

BLOCK DIAGRAM



The smart cellular phone (SCP) adjusts the volume according to the background noise level and noise class by a fuzzy system.

The inputs to the fuzzy volume controller are

1. The noise level derived from the voice activity detector (VAD) present within the speech codec
2. The noise class obtained from a fuzzy system for background noise classification
3. The current volume level

The speech frames which arrive at the speech codec will be converted into speech features. These speech features will be given as input to the voice activity detector. The voice activity detector (VAD) computes the noise levels during noise-only periods. An adaptive noise suppressor filter is used to filter the input signal frame. The coefficients of this filter are computed during noise-only periods determined by special measures taken to identify noise only frames. These include signal stationarity and periodicity measures.

We will have linguistic terms defined for background noise levels, volume levels, and volume level changes.

NOISE LEVELS:

A fuzzy set for noise level (NL) is

1. Very Low (VL)
2. Medium Low (ML)
3. Low (L)
4. Zero (Z)
5. High (H)
6. Medium High (MH)
7. Very High (VH)

NOISE CLASSES:

The background noise classes are obtained by fuzzy system. The fuzzy noise classifier (FNC) classifies the background noise into seven types at two levels of mobility.

STATIONARY	NONSTATIONARY
Car Bus Train	Street Construction Factory Babble

The smart volume tuner makes use of the class information. The fuzzy rules are turned to improve the Quality of Service (QoS) based on the fuzzy noise classifier (FNC) output. The volume change to be applied is based on the noise class (e.g., the volume increase may not be the same for car and factory noise).

Rate of volume control change is also an important parameter; too fast a change can interfere with intelligibility itself. Hence, a comfortable volume change control rate is to be adapted based on mobile phone user service.

VOLUME LEVEL CHANGES:

The fuzzy volume controller for mobile phones adjusts the volume according to the background noise level and noise class by a fuzzy system. This change in the volume level is designated by volume level change (VLC). By intelligently adjusting the volume level, the quality of service (QoS) is improved for both stationary and nonstationary background noise in mobile environments. A fuzzy rule base is used in building the fuzzy controller.

The fuzzy set values for volume level change (VLC) consist of the following linguistic terms:

1. Large Negative (LN)
2. Medium Negative (MN)
3. Small Negative (SN)
4. Zero (ZE)
5. Small Positive (SP)
6. Medium Positive (MP)
7. Large Positive (LP)

The volume level of a speech channel refers to the average amplitude at which it generates speech. Volume levels are expressed with numerical values from '0' (silence) to maximum value on a linear scale.

The fuzzy set values for volume level (VL) are

1. Very Low (VL)
2. Low (L)
3. Normal (N)
4. High (H)
5. Very High (VH).

The fuzzy rule base contains **IF/THEN** rules such as

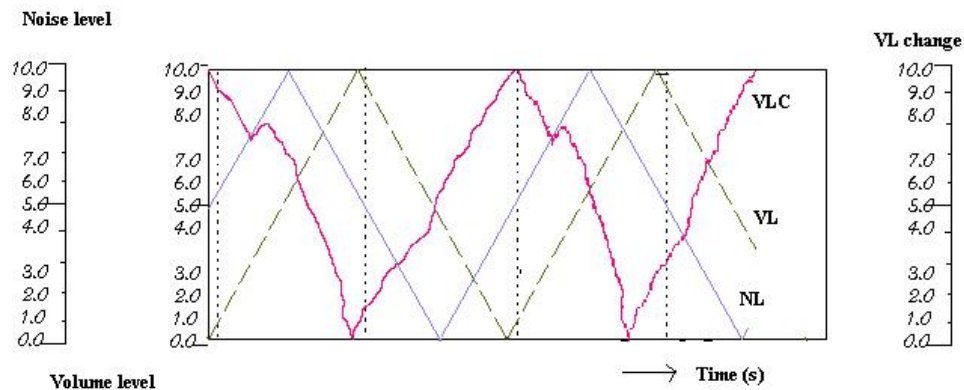
- If **NL** is low and **VL** is high and **NC** is train, then **VLC** is **MN**.
- If **NL** is high and **VL** is low and **NC** is car, then **VLC** is **LP**.
- If **NL** is very high and **VL** is very low and **NC** is babble, then **VLC** is **LP**.
- If **NL** is very high and **VL** is low and **NC** is factory, then **VLC** is **MP**.
- If **NL** is high and **VL** is zero and **NC** is bus damp, then **VLC** is **SP**.
- If **NL** is low and **VL** is high and **NC** is babble, then **VLC** is **ZE**.
- If **NL** is very high and **VL** is high and **NC** is car, then **VLC** is **MP**.

The volume level changes (VLCs) generated by Fuzzy Volume Controller corresponding to different noise levels (NLs) and volume levels (VLs) are shown below in matrix form.

		Noise level				
		n-big	n-small	zero	p-small	p-big
Volume level	n-big	p-small	p-small	p-big	p-big	p-big
	n-small	p-small	p-small	p-small	p-small	p-big
	zero	zero	zero	zero	p-small	p-small
	p-small	n-small	n-small	n-small	zero	p-small
	p-big	n-big	n-big	n-big	n-small	zero

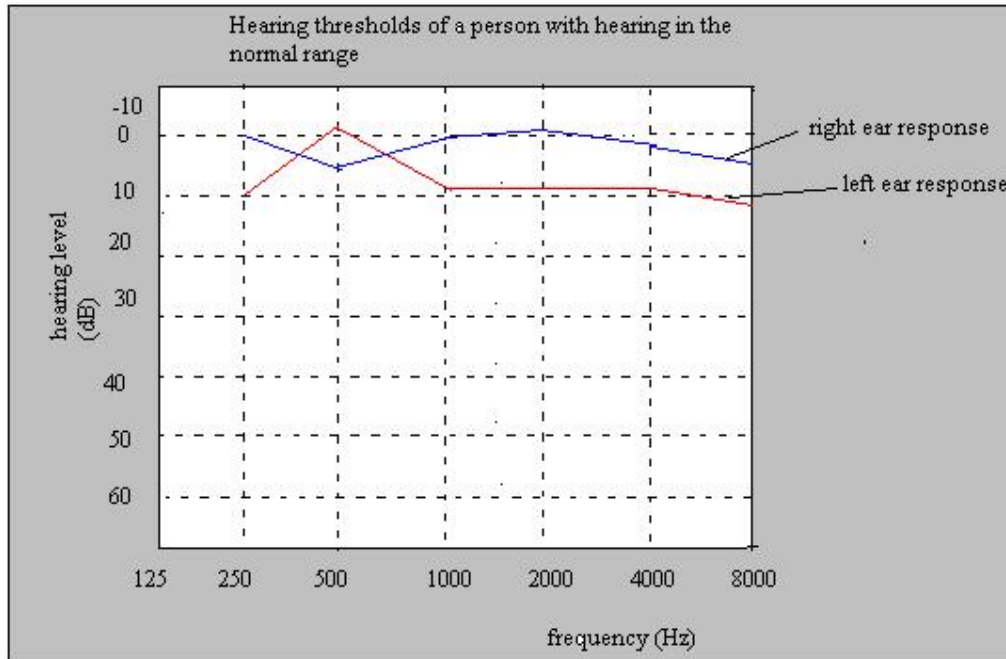
Zero (ZE) noise level indicates the noise level during which volume level settings were made by the user to suit his comforts. The fuzzy rule base may contain 30 to 40 rules. The rule base may be tuned using evolutionary techniques. During the period of conversation, the surroundings noise level may vary, so the SVT adjusts the volume, QoS is improved as volume control is transparent.

The graphical representation of volume level changes (VLCs) corresponding to different noise levels (NLs) and volume levels (VLs) is shown below.



PERSONALISED SVT:

Hearing impairments can vary from person to person. Speech intelligibility and quality of hearing can vary, and are also dependent on background noise. Since SVT is based on fuzzy logic, it can be personalized by tuning the fuzzy rule base to the requirements of the individual. Hearing loss is measured through an audiogram. An audiogram of a person shows the amount of hearing loss in each of the frequency bands, as shown in the below figure. A person with hearing loss will perceive different frequencies at different levels.



An audiogram

The pitch frequency varies from person to person and thus can be perceived differently by a person with hearing loss. The pitch frequency varies over a wide range (50-500 Hz). Also, it may vary slightly for an individual. Recently, some very successful techniques have been proposed for pitch extraction. The pitch frequency is extracted from the speech signal using autocorrelation. This is input to the SVT for fuzzification. The fuzzy rule base of the SVT is tuned based on the audiogram of the person who wants to use the mobile phone.

Fuzzy rules from the pitch based on an audiogram:

- If pitch is LOW and hearing loss is MODERATE, then volume level is HIGH.
- If pitch is MEDIUM and hearing loss is MILD, then volume level is ZERO.
- If pitch is HIGH and hearing loss is SEVERE, then volume level is VERY HIGH.

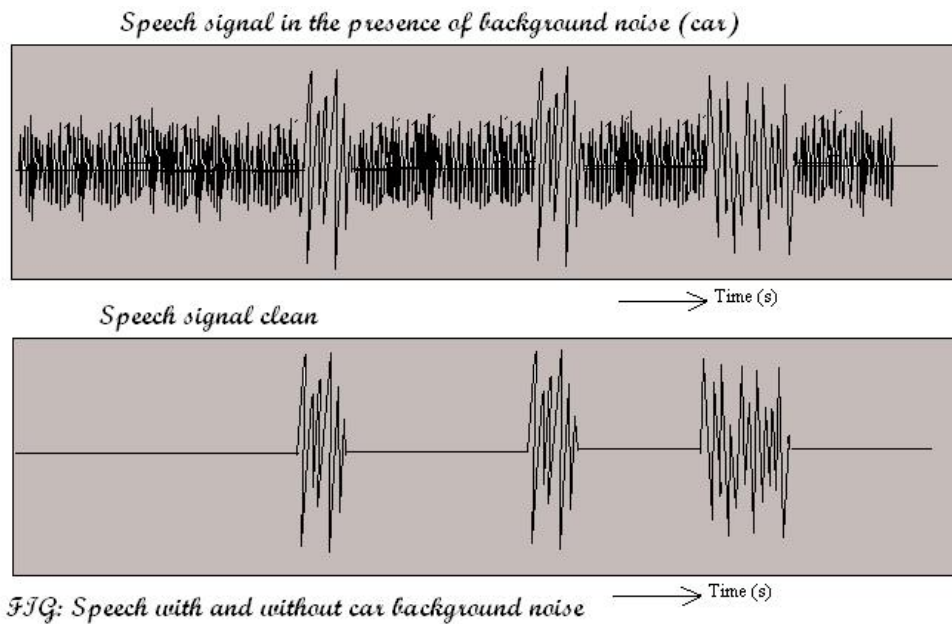
The SVT can be extended further by using the format frequencies as inputs along with the pitch frequencies.

Quality of speech:

For QoS improvement measurement while using the SCP, mean opinion score (MOS) and degradation mean opinion score (DMOS) are the most preferred subjective techniques to be used. MOS and DMOS are 5 level grading scales to measure how the speech signal qualities are perceived.

Scales used in MOS and DMOS are

- Bad, Very annoying
- Poor, Very annoying
- Fair, Slightly annoying
- Good, Audible, not annoying
- Excellent, Imperceptible



For objective speech quality measurements, the International Telecommunication Union-Telecommunication Standardization Sector (ITU-T) has introduced perceptual speech quality measurement (PSQM). Tools such as Opera are available for automated testing of speech quality. Another important technique to find the suitability of the SCP is to perform the field test (i.e., test it in a real environment).

CONCLUSIONS:

In this paper we have proposed the use of SVT in cellular phones.

Such a SCP will have the following benefits:

- Improved QoS for stationary and nonstationary noise in mobile environments, as the SVT uses the information on background noise level and class to adjust the volume level. The initial subjective listening tests indicate 20-40 percent improvement in speech quality for cellular phones with SVT.
- Some classes of noise such as car noise fall into low frequency noise. They do not affect the intelligibility of speech compared to noise classes such as factory noise. Hence, the SVT has to depend on noise classes for effective volume adjustments.
- The SVT is easily embedded in mobile handsets as it has very low memory and computational requirements. The computations are carried out by the microcontroller within the base band chip.
- The SVT can be personalized based on the audiogram for a hearing impaired person.
- The fuzzy controller can be extended with a neuro-fuzzy or genetic-fuzzy system that learns new rules to improve and optimize its performance.