[0018] The electromechanical actuator may be any suitable component that is able to produce feasible vibration located within the product so that the optimal effect can be introduced. Vibration control signal is fed into this component, and a vibration is felt on the fingers, facial skin, wrist, cheek or other suitable locations.

[0019] The so-called FO-parameter (phonetic term, fundamental frequency) of the speech may be used for coding (signal modification), which helps one to interpret the incoming speech in a noisy environment. This makes it is possible to take into account the intonation and phonetic weight of the speech, which is an important property in some languages, such as Chinese, Vietnamese, etc., in which the tone and height of the voice is very important.

[0020] An acoustical transducer made to fit inside the user's ear could incorporate the vibrotactile feature or functionality, for example, such a transducer could easily be applied via the phone itself or another small device, such as audio transducer or accessory device.

Implementation in a Network

[0021] The audio-to-vibrotactile conversion processing may, in some cases, require so much processing power that it may be more feasible to implement this functionality in the telecommunications network. If a network-based solution is used, this feature will work with older phones as well and more processing power can be used. Also, a separately-priced network service can be provided to a specific customer. In this case, a phone subscriber will make a personal agreement with a network operator to use this kind of service, which is then utilized as associated with the specific telephone number in question. Network service can also utilize personalized hearing parameters adjusting the speech processing. These personal parameter(s) can be either selected by trial-error based, present values or personalized values given by a customer's physician.

BRIEF DESCRIPTION OF THE DRAWING

[0022] The drawing includes the following Figures:

[0023] **FIG. 1** is a diagram of one embodiment of a mobile phone in a telecommunications network that is the subject matter of the present invention.

[0024] **FIG. 2** is a diagram of a vibrotactile module shown in **FIG. 1** that is the subject matter of the present invention.

[0025] **FIG. 3** is a diagram of a hardware-based signal processor that is part of an audio-to-vibrotactile converter shown in **FIG. 2**.

[0026] **FIG. 4** is a diagram of a frequency domain filtering or equalization module that forms part of the hardware-based signal processor shown in **FIG. 3**.

[0027] **FIG. 5** is a diagram of a linear/non-linear amplification module that forms part of the hardware-based signal processor shown in **FIG. 3**.

[0028] **FIG. 6** is a diagram of a speech mixing module that forms part of the hardware-based signal processor shown in **FIG. 3**.

[0029] **FIG. 7** is a diagram of a software-based signal processor that forms part of an audio-to-vibrotactile converter shown in **FIG. 2**.

[0030] **FIG. 8** is a diagram of a speech encoding algorithm module that forms part of the software-based signal processor shown in **FIG. 7**.

[0031] **FIG. 9** is a diagram of an electro-mechanical actuator that forms part of a vibrotactile actuator shown in **FIG. 2**.

[0032] **FIG. 10** is a diagram of an acoustic actuator that forms part of a vibrotactile actuator shown in **FIG. 2**.

[0033] **FIG. 11** is a diagram of another embodiment of a mobile phone in a telecommunications network that is the subject matter of the present invention.

[0034] **FIG. 12** is a diagram of a personalized hearing parameters module of an audio-to-vibrotactile converter shown in **FIG. 11**.

DETAILED DESCRIPTION OF INVENTION

FIG. 1: Mobile Phone

[0035] **FIG. 1** shows a mobile phone generally indicated as **10** for use in connection with a telecommunication network generally indicated as **12**. The scope of the invention is also intended to cover other user equipment and mobile electronic devices, such as a portable computer.

[0036] The mobile phone **10** includes a signal processor **12** connected to a radio access network module **14** having an antenna **16**, a display module **18**, an audio module **20**, a microphone **22**, a read only memory **24** (ROM or EPROM), a keyboard module **26** and a random access memory **28** (RAM), which are all known in the art. The operation of the signal processor **12** in relation to the aforementioned elements is also known in the art. Moreover, the scope of the invention is not intended to be limited to any particular kind or type of these elements. For example, the scope of the invention is intended to include the radio access network module **14** being an antenna module **14**, a radio frequency (RF) module, a radio modem or the like.

[0037] The signal processor **12** is also connected to an audio-modulated vibrotactile module **30**. The whole thrust of the invention relates to the operation of the audio-modulated vibrotactile module **30** with respect to the voice modulation of incoming speech into a vibrotactile sensation that can be sensed by the user of the mobile phone **10**.

[0038] In operation, the audio-modulated vibrotactile module **30** responds to a telecommunications signal containing information about incoming speech from a called/calling party **11**, and provides an audio-modulated vibrotactile module force containing information about the incoming speech from the called/calling party **11** to vibrate a user's fingers, facial skin, wrist, cheek or other suitable location.

[0039] As discussed below, the audio-to-vibrotactile conversion may be performed in the mobile phone **10** as shown in **FIG. 1** or in the telecommunications network as shown and described below in relation to **FIG. 11**.

FIG. 2: Audio-Modulated Vibrotactile Module

[0040] **FIG. 2** shows in detail the audio-modulated vibrotactile module **30** having an audio-to-vibrotactile converter **40** and a vibrotactile actuator **42**.