

Description

Method and receiving unit for synchronizing a packet-oriented received tone signal with a generated tone signal

In communication networks, and especially in Voice over IP communication networks, compression methods—according to ITU standard G.729, for example—are used for transmitting speech and tones or tone signals, wherein the compression concepts used are best suited for speech transmission. When transmitting multi-frequency tones—known in the industry as DTMF dial tones—or fax/modem signaling tones, under certain circumstances the compression process can cause undesired changes in certain features of the digitized tones. In order to avoid such problems and facilitate tone recognition in the counterpart device, a standardized method according to RFC 2833 can be used to transmit fax/modem signaling tones, wherein this method is configured for transmitting tone signals that are used for signaling that creates a communication connection between Voice over IP terminals.

For example, when transmitting a fax/modem tone signal at 2100 Hz according to RFC 2833, the sending side recognizes and suppresses an incoming fax/modem tone signal or a digitized or analog tone signal. At the same time, a piece of tone information is generated in place of the recognized fax/modem tone signal and, in the case of a Voice over IP transmission, is inserted into special RTP (Real Time Protocol) data packets which are then sent over the Internet or over networks with Internet protocol. The tone information according to RFC 2833 contains data about the tone type, level, and duration of the fax/modem tone signal. On the receiving side, after the transmitted tone information is measured using a tone generator, the fax/modem tone signal is reproduced and inserted into the decoded signal from the RTP data packets.

Because a time span of typically 20-30 ms is required for recognition of the transmitted fax/modem tone signals, it is not possible to suppress the portions or bit patterns of a fax/modem tone signal transmitted up to that point and transmit them further without an additional undesired delay. On the receiving side, when converting between the fax/modem tone signal produced in the tone generator and reinserted and the unsuppressed bit pattern of the fax/modem tone signal, there can be signal processes that a downstream tone detector may misinterpret as a phase reversal or phase shift or as amplitude modulation. These misinterpretations can occur especially in scenarios where a fax/modem tone signal is transmitted through multiple networks with Internet protocol or there are multiple transfers of the fax/modem tone signal according to RFC 2833. Misinterpretations often lead to significant problems or to complete failure when transmitting a fax/modem tone signal using data packets or RTP data packets.

The underlying concept of the invention is therefore to improve transmission of audio information, especially tone signals according to RFC standard 2833. The solution is contained in the features of claim 1.

The defining aspect of the invented method consists of the features wherein:

- a) the tone signal is inserted into data packets on the sending side,
- b) the tone signal is also transmitted in special data packets by the sending side, using a piece of tone-signal-specific tone information,
- c) a tone generator on the receiving side generates a tone signal according to the transmitted tone information,
- d) the phase difference between the transmitted and generated tone signals is ascertained before the generated tone is inserted into the data packets and is compared with a predefined phase difference,

- e) if the ascertained phase difference exceeds the predefined phase difference, the tone generator is used to shift the phase of the generated tone by a predefined phase value, and
- f) steps d) and e) are repeated until the ascertained phase difference lies under the predefined phase difference, at which point the generated tone signal is inserted into the data packets in place of the transmitted tone signal.

An important advantage of the invention lies in the fact that a phase detector does not have to be constantly active for synchronizing the phase of the tone signal produced in the tone generator, because synchronization is necessary only when a tone signal or piece of tone information is received and insertion of the tone signal is imminent.

According to one embodiment of the invention:

- g) the last two transferred bit patterns of the transmitted tone signal that are produced before the preset time when the generated tone signal is inserted into the data packets are stored,
- h) a first phase difference between the last stored bit pattern and the currently produced bit pattern of the generated tone signal is ascertained,
- i) a second phase difference between the previous stored bit pattern and the currently produced previous bit pattern of the generated tone signal is ascertained,
- j) the ascertained first and second phase differences are compared with a predefined phase difference,
- k) if the ascertained first and second phase differences exceed the predefined phase difference, the tone generator is used to shift the phase of the generated tone by a predefined phase value, and
- l) steps g) through k) are repeated until the first or second ascertained phase difference is less than the predefined phase difference.

An advantage of this embodiment of the invention lies in the fact that only two bit patterns or scanning patterns—also known as “samples” in the industry—can be stored at a time, which permits short processing times for the synchronization process.

Further advantageous examples of the invented method and an embodiment of an analysis unit according to the invention are described in additional claims.

The invention and further examples of it are explained below with reference to two drawings, which contain:

Figure 1 a block schematic diagram of a communication arrangement in which the invented method is used, and

Figure 2 a second block schematic diagram of an arrangement for using the invented method in a receiving unit according to Figure 1.

Figure 1 shows a sending and a receiving unit SE and EE on which communication connections can be established over the Internet IN. The sending and receiving units SE, EE can consist of gateways, for example, which can be used to transmit speech information and signaling information over the Internet IN through a communication connection, which in the execution example is a Voice over IP connection.

For the execution example it is assumed that the data packets dp consist of Voice over IP data packets dp that are transmitted by the sending unit SE over the Internet IN—which alternatively can be a local network with Internet protocol—to the receiving unit EE. For the execution example it is further assumed that the data packets dp are transmitted according to the RTP (Real Time Protocol). The RTP is defined in RFC standard 1889 or 3550 and is a protocol for

continuous transmission of real-time data such as audiovisual or multimedia data over IP-based networks.

In addition to the user information transmitted in the data packets dp —such as speech information in Voice over IP data packets—introduced tone signals ts , such as DTMF tone signals or fax/modem tone signals, should also be transmitted to the sending unit SE . The currently existing compression processes are best suited for compression of speech signals in particular. When compressing tone signals ts , not all tone features are transmitted unchanged. To avoid this disadvantage and to facilitate recognition of tones in the receiving unit, a process according to RFC standard 2833 should be used. The following explains the invented method as used to transmit a fax/modem tone signal, wherein a modem tone signal is represented by the example of a 2100 Hz tone signal, which is used to switch off the echo canceller that is provided for speech transmission, in order to create a transmission channel in data transmission mode.

According to the standard, the sending side examines the signals that are to be transmitted to see if there are tone signals, i.e., a fax/modem tone signal mod , and if one is recognized, transmission of the fax/modem tone signal mod is suppressed. This means that no data packet dp with a recognized fax/modem tone signal is sent out. When the fax/modem signal is recognized, its characteristics such as frequency, level, and tone type are also recognized and are placed into a piece of tone information ti . Instead of the recognized fax/modem signal, a separate data packet dp' containing the tone information ti is transmitted. According to standard RFC 2833, after the tone information ti is received, the sending side uses a tone generator TG (see Figure 2) to recreate the fax/modem signal mod according to the tone information ti —frequency, level, tone type—and inserts it into the data stream in data packets dp using an insertion/reading unit ELE (see Figure 2).

In the procedure according to the standard, time is needed to recognize a tone signal ts or a fax/modem signal mod —usually 20-30 ms. During this time, the sending side inserts the fax/modem signal mod into data packets dp , before suppression of the fax/modem signal takes effect. The tone information ti is also transmitted in a separate data packet dp . On the receiving side then, when the signal produced by the tone generator TG is inserted, there can be a phase shift or phase reversal of the fax/modem signal mod that is not suppressed at the right time. This phase shift can lead to significant problems in downstream tone detectors. The invented method is especially well suited to preventing these problems.

According to the invention, a tone signal ts or fax/modem signal mod is no longer suppressed after it is recognized by the sending side, but rather is retransmitted, as designated in Figure 1 by an arrow marked $dp(mod)$. In addition, according to standard RFC 2833, the parameters of the recognized fax/modem signal mod , such as its tone type, level, and frequency, are taken from it, placed into a piece of tone information ti , and inserted into a separate data packet dp , designated in Figure 1 by an arrow marked $dp'(mod)$.

Figure 2 shows a possible arrangement for executing the invented method in the receiving unit EE . With an insertion/reading unit ELE , to which data packets dp are transmitted by the sending unit SE , the tone information ti from the separate data packet dp' is read and sent on to the tone generator TG , in which the fax/modem signal mod' is then produced. The fax/modem signal mod' is created using individual bit patterns s —also known in the industry as samples—and these bit patterns s , instead of the transmitted fax/modem signal mod , are inserted into the bit pattern stream of the data packets dp at a predefined point in time t_e .

Because the bit pattern s produced by the tone generator TG must be inserted with little or no phase shift, the phase relationship of the bit pattern s is ascertained for the fax/modem signal mod sent before time t_e . To do this, a first and second bit pattern s_1, s_2 transmitted before time t_x are read by the insertion/reading unit ELE and stored in a memory SP. From the memory SP, the two bit patterns s_1, s_2 are read by a phase detector PD, and their phase relationships are compared with two bit patterns s_1', s_2' that were produced by the tone generator TG and are to be inserted into the data packets dp at time t_x . In the phase detector PD, the phase differences $\Delta\phi$ of the first bit patterns s_1, s_1' and the second bit patterns s_2, s_2' are ascertained and then compared with a predefined phase difference ϕ_v . The predefined phase difference ϕ_v is the maximum phase difference that can exist between the transmitted fax/modem signal mod and the fax/modem signal mod' produced in the tone generator TG, or that can be tolerated in order to prevent problems with downstream tone detectors.

For this execution example it is assumed that the phase difference $\Delta\phi$ is greater than the predefined phase difference ϕ_v and therefore, in order to prevent too high of a phase shift, the two bit patterns s_1', s_2' produced by the tone generator TG, as well as subsequent bit patterns, cannot be inserted into the data packets dp at time t_x .

According to the invention, the phase of the bit patterns s' produced by the tone generator TG or of the fax/modem signal mod' is changed or shifted to a predefined phase ϕ . The predefined phase ϕ is selected such that a gradual change of the bit pattern s' produced by the tone generator TG to the predefined phase ϕ will achieve a result below the predefined phase difference $\Delta\phi$ without causing another phase reversal.

Next a later insertion time t_e is set, and the next two bit patterns s transmitted before the insertion time t_e are read by the insertion/reading unit ELE and stored in the memory SP (not shown in the figure). The two bit patterns s' produced by the tone generator TG before a later insertion time t_e are used for the phase comparison with the stored bit patterns s . If the phase difference ascertained is beyond the predefined phase difference $\Delta\phi$, the steps in the method described above for changing each bit pattern s' produced by the tone generator TG to the predefined phase ϕ are repeated until the phase difference $\Delta\phi$ is smaller than the predefined phase difference ϕ_v ; these repeated processes are not shown in the figure.

When the phase detector determines that the phase difference $\Delta\phi$ is smaller than the predefined phase difference ϕ_v , then at insertion time t_e , instead of the bit patterns s_1, s_2 for the transmitted fax/modem signal mod, the bit patterns s_1', s_2' and additional bit patterns s' for the fax/modem signal mod' produced in the tone generator TG are inserted in the data packets dp using the insertion/reading unit ELE. For clarity, the figure shows only the variation in which the phase difference $\Delta\phi$ is smaller than the predefined phase difference ϕ_v after just one comparison, so the bit patterns $s_1', s_2', \text{etc.}$ produced in the tone generator TG can be inserted immediately at insertion time t_e into the data packets dp .

If there are no additional steps according to an Internet protocol, then the bit patterns $s_1, s_2, \text{etc.}$ or the fax/modem signal mod' can be transmitted to other protocols or converted to an analog fax/modem signal mod'.

The invented method is not limited to the execution example, but can be used in all sending and receiving units through which tone signals are sent according to RFC standard 2833 or similar processes.

Patent claims

1. Method for synchronizing a tone signal (ts (mod)) transmitted in data packets (dp),
 - a) in which the tone signal (ts) is inserted into the transmitted data packets (dp),
 - b) in which the tone signal (ts) is transmitted by means of a piece of tone-signal(ts)-specific information (ti) in special data packets (dp'),
 - c) in which a tone generator (TG) generates the tone signal (ts') according to the transmitted tone information (ti),
 - d) in which the phase difference ($\Delta\phi$ between the transmitted tone signal (ts) and the generated tone signal (ts')) is ascertained before insertion of the generated tone signal (ts') into the data packets (dp) begins and is compared to a predefined phase difference (ϕ_v),
 - e) in which, if the ascertained phase difference ($\Delta\phi$) exceeds the predefined phase difference (ϕ_v), the phase of the generated tone signal (ts') is changed by the tone generator (TG) to a predefined phase (ϕ),
 - f) in which steps d) and e) are repeated until the ascertained phase difference ($\Delta\phi$) lies under the predefined phase difference (ϕ_v), at which point the generated tone signal (ts) is inserted into the data packets (dp) in place of the transmitted tone signal (ts).

2. Method as in claim 1, distinguished in that
 - g) the last two transmitted bit patterns (s1, s2) of the transmitted tone signal (ts) that were produced before the predefined insertion time (t_e) of the generated tone signal (ts') into the data packets (dp) are stored,
 - h) a first phase difference ($\Delta\phi$) is ascertained between the last stored bit pattern (s2) and the last bit pattern (s2') for the generated tone signal (ts') produced before the insertion time (t_e),

- i) a second phase difference ($\Delta\phi$) is ascertained between the previously stored bit pattern (s1) and the previous bit pattern (s1) for the generated tone produced before the insertion time (t_e),
 - j) the ascertained first and second phase differences ($\Delta\phi$) are compared with a predefined phase difference (ϕ_v),
 - k) if the ascertained first and second phase differences exceed the predefined phase difference (ϕ_v), the tone generator (TG) is used to shift the phase of the generated tone signal (ts') by a predefined phase value (ϕ),
 - l) steps g) through k) are repeated until the first or second ascertained phase difference lies below the predefined phase difference ($\Delta\phi$).
3. Method as in claim 2, distinguished in that comparison of the second ascertained phase difference ($\Delta\phi$) with the predefined phase difference (ϕ_v) is given priority.
4. Method as in any of the preceding claims, distinguished in that the tone information (ti) is produced and transmitted according to RFC standard 2833.
5. Method as in any of the preceding claims, distinguished in that the data packets (dp) are produced and transmitted with the RTP protocol according to RFC standard 3511.
6. Method as in any of the preceding claims, distinguished in that the tone signal (ts, ts') consists of a fax/modem signal (mod).

7. Receiving equipment for synchronizing a tone signal (ts (mod)) transmitted in data packets (dp),
 - a) with a receiving unit (EE) for receiving a tone signal (ts) inserted in data packets (dp), and
 - b) for receiving a piece of tone-signal(ts)-specific tone information (ti) transmitted in special data packets (dp'),
 - c) with a tone generator (TG) for generating the tone signal (ts') produced according to the transmitted tone information (ti),
 - d) with a phase detector (PD) for ascertaining the phase difference ($\Delta\phi$ between the transmitted tone signal (ts) and the generated tone signal (ts')) before insertion of the generated tone signal (ts') into the data packets (dp) begins, and for comparison with a predefined phase difference (ϕ_v),
 - e) the tone generator (TG) is configured such that, if the ascertained phase difference ($\Delta\phi$) exceeds the predefined phase difference (ϕ_v), the phase (ϕ) of the generated tone signal (ts') is shifted by a predefined phase (ϕ_v),
 - f) the receiving equipment is configured such that steps d) and e) are repeated until the ascertained phase difference ($\Delta\phi$) lies under the predefined phase difference (ϕ_v) and the generated tone signal (ts) is inserted in the data packets (dp) in place of the transmitted tone signal (ts).

8. Receiving equipment as in claim 8, equipped with
 - g) an insertion/reading unit (ELE) and a memory (SP) for storing the last two transmitted bit patterns (s_1 , s_2) of the transmitted tone signal (ts) that were produced before the preset insertion time (t_e) for inserting the generated tone signal (ts') in the data packets (dp),
 - h) with a phase detector (PD)

for ascertaining a first phase difference ($\Delta\phi$) between the last stored bit pattern (s2) and the last bit pattern (s2') produced from the generated tone signal (ts') before the insertion time (t_e), and

- i) for ascertaining a second phase difference ($\Delta\phi$) between the previous stored bit pattern (s1) and the previous bit pattern (s1) produced before the insertion time (t_e), and
- j) for comparing the ascertained first and second phase differences ($\Delta\phi$) with a predefined phase difference (ϕ_v),
- k) the tone generator (TG) is configured such that, if the ascertained first and second phase differences exceed the predefined phase difference (ϕ_v), the phase of the generated tone signal (ts') is shifted by a predefined phase value (ϕ), and
- l) the insertion/reading unit (ELE), the memory (SP), the phase detector (PD), and the tone generator (TG) are configured such that steps g) through k) are repeated until the ascertained first or second phase difference lies under the predefined phase difference ($\Delta\phi$).

9. Receiving equipment as in claim 8 or 9, distinguished in that a piece of tone information (ti) generated according to RFC standard 2833 can be received.