

**"PCM MONITOR"****Technical Field**

The present invention relates to a method and apparatus for acquiring and analysing PCM data in a communications system.

**Background Art**

In a complex communications environment involving thousands of telephone circuits, it is essential that on-going monitoring and quality analysis be performed. This is particularly the case in the field of pulse code modulation, or PCM. In PCM, a signal is encoded as a stream of digits, which are transmitted as digital pulses. Individual voice circuits are multiplexed to form a PCM stream. However, there are as yet few instruments available for monitoring traffic contained in PCM streams. Such instruments as are available are predominantly hardware based and inflexible in the range of functions which they can perform.

One class of devices merely samples PCM channels sequentially to provide estimates of voice and data traffic. Other devices require introduction of test signals, thereby utilising system capacity, and do not examine real life telephony signals.

There is accordingly a need for a flexible PCM monitoring system which can perform a wide variety of monitoring and analytical functions, and is capable of being reconfigured to meet future needs in this area.

**Disclosure of Invention**

One aspect of the present invention relates to a method of analyzing PCM communications, comprising:

- (a) extracting a PCM sample of PCM data of predetermined duration from a selected circuit;
- (b) processing said sample to produce a non-compressed corresponding data sample;
- (c) storing said data sample in memory;

(d) performing a processing operation on said stored data sample; and

(e) producing a signal indicative of at least one parameter associated with said PCM sample.

In another aspect, the invention provides a method of analyzing PCM communications, comprising:

(i) extracting a first PCM sample of PCM data of predetermined duration from a selected circuit;

(ii) processing said sample to produce a non-compressed corresponding data sample;

(iii) storing said data sample in memory;

(iv) performing a processing operation on said stored data sample;

(v) determining whether the selected circuit is carrying voice traffic;

(vi) if the circuit is carrying voice traffic, extracting a second sample of PCM data of predetermined duration from said selected circuit;

(vii) processing said second sample to produce a non-compressed corresponding second data sample;

(viii) storing said second data sample in memory;

(ix) performing a processing operation on said stored second data sample; and

(x) producing a signal indicative of the presence or absence of echo on said circuit.

According to a further aspect, the present invention comprises apparatus for analyzing PCM communications, comprising in combination:

(a) interfacing means for connecting to at least one PCM stream and allowing selection of any circuit within said PCM stream;

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(b) sampling means for extracting a PCM sample of predetermined duration from said circuit;

(c) processing means for producing a non-compressed data sample corresponding to said PCM sample;

5 (d) memory means for storing said data sample; and

(e) further processing means for performing a data processing operation on said data sample and producing a signal indicative of at least one parameter associated with said PCM sample.

#### **Brief Description of Drawings**

10 Further advantages will be apparent from the following description of an illustrative embodiment with reference to the drawings, in which:

Figure 1 is a block schematic diagram of the overall arrangement of the invention; and

15 Figures 2 to 7 illustrate visual displays of samples of circuit waveforms in various circumstances.

#### **Detailed Description**

The quality monitor according to the present invention is preferably hosted by a PC, such as an IBM compatible PC (AT type). It should be appreciated that the exact processor used to implement the invention is by no means a limitation on the scope of the  
20 present invention.

The embodiment of the present invention which will be described in detail can monitor 8 PCM streams (both transmit and receive paths) with up to 248 PCM circuits. It can detect, measure, and report on echo and other transmission impairments such as excessive signal levels, PCM coding errors, and codec level saturation. It can also help in  
25 the investigation of more obscure defects such as incomplete echo cancellation due to distortion of the echo signal. The inventive device will also provide reports on traffic classifications such as Voice, Data and Other (idle AIS etc).

The present invention allows for non-intrusive measurement of live telephone traffic so as to provide objective measurements of call quality. Importantly, the  
30 inventive device operates such that the measurements are indicative of call quality as experienced by users of the communications network.

The effective acquisition of data and analysis of the data without perturbing the communications network are important aspects of the invention.

35 Referring to Figure 1, sample data is acquired from PCM streams 30 via a 4-

wire interface 19 to acquisition module 17. This requires the steps of:

- (i) selecting the PCM stream containing the circuit to be analysed;
- (ii) selecting the circuit within the selected PCM stream to be analysed;
- (iii) sampling PCM data for a predetermined time period (for instance 1.0 to 5.0 seconds) from the selected circuit and storing it in the PC memory 14; and
- (iv) converting the stored data from PCM format to a non-compressed format (sample data) suitable for analysis by the quality monitor.

The interface with the PCM stream is preferably via high impedance probes, so as to minimize the intrusiveness of the operation.

During step (iii), all the samples occurring over the sample period, in both directions of the connection, are stored in memory

Step (iv) is preferably performed by means of a look-up table. In CCITT G.711 standard PCM, each compressed format 8-bit value has a non-compressed 12-bit equivalent. The conversion may be performed by referring to the memory location referenced by the compressed format and extracting the corresponding non-compressed 12-bit value.

The sample data may be dealt within a variety of ways as required. An important advantage of the present invention is that the data once extracted for each sample period is stored and may be reviewed or processed at leisure. The exact reasons for sampling or monitoring need not be apparent when the sample is monitored - any desired analysis may be performed as and when required. Moreover, analyses may be performed which are difficult or impossible in real time, for example, echo estimation, noise measurements, peak and average signal levels, PCM coding

saturation and PCM coding errors. This analysis is carried out by the DSPU 15. It may directly stored for later review, using memory 18 or external memory devices 22, or displayed on the VDU screen 21 after processing by display module 13.

One of the first operations which is generally performed during either sampling or monitoring is to determine the type of signal being dealt with i.e. whether we have speech or data or no activity. This is done by quantifying the way the activity level is changing in the captured sample. Data type activity tends to be very constant in its activity pattern while speech activity tends to be variable.

The actual values in a sample are also examined. If all samples in a sample period had only one value (i.e. a constant signal) then we conclude that the circuit was either STATIC/DLE or AIS. Which is the case depends on the value itself. Also the range of values in a sample is examined. The analysis of the values in a given range yields such.....

information as the presence of level saturation and/or the presence of coding errors.

If a display of the captured sample is required then the video controller of the PC is switched into "bit-mode" and the captured sample is "bit-mapped" onto the screen, as is well understood by those skilled in the art.

Passive echo analysis may be carried out to determine echo delay and magnitude. Delays of at least 1050 ms may be identified and quantified using the illustrated embodiment of the invention. This is performed by cross-correlation to locate signals and images, and the time delay and reflection coefficient can then be readily determined. This technique can therefore passively monitor both near and far end echo. Further, when this data and the known circuit and the time data are compared with TCDP data relating to call destination and routing, the source of echo can be located and rectified. This is a very powerful tool for locating and eliminating problems in local and remote networks.

The algorithm that detects and quantifies echo is a two stage process. The first process consists of a cross-correlation (done in the frequency domain) to detect and "roughly" quantify an echo. The second process consists either of cross-correlation in time or an adaptive-filter type process (least-mean-squares), both evaluated over the delay reported by the first process. The purpose of the second process is to precisely quantify the echo.

Further, as the monitor is adapted to be left on a poll, monitor and store basis connected to a set of PCM streams, the data may be accumulated for later attention to abnormalities.

Similarly, the monitor can monitor noise on a long term basis and highlight unsuspected or unlocated problems. Trials of the system have located problems associated with

peak clipping, coding errors, and harmonic distortion whose existence was previously not suspected. The present invention is capable of discovering and locating errors which would either go undetected with existing apparatus or whose discovery would be extremely time consuming and labour intensive. It will be appreciated that in the monitor mode of operation, samples are generally held for so long as necessary to extract the required data and then deleted.

A further advantage of the present invention is that it enables display of the PCM streams, not merely statistics. This has proved experimentally to be of great assistance in locating and recognising problems and is not provided in existing systems.

Figure 2 illustrates a typical normal speech transmission with no echo evident.

Figure 3, however, shows a display where the presence of far-end echo is apparent. The RX signal is a delayed and attenuated replica of the transmitted signal. The RX signal is amplified to make the trace more legible. As the horizontal axis represents about 5 seconds, the echo is delayed by about 1 second. Figure 4 illustrates a trace exhibiting near-end echo - the near end of the transmitting link is transmitting echo back to the far end of the transmission link. The delay is, as a consequence, much shorter.

CCITT, Rec. G.711 states that PCM can handle signal levels which, when quantised, correspond to the 12-bit number  $\pm 4032$ . When analogue signals above this level are input into a PCM coder it 'clips off' the levels above the saturation threshold. When the PCM signal is converted back to analogue form in the receiving end, it will look as if its peaks have been clipped off. Figure 5 illustrates a signal exhibiting level saturation on the receive path. The invention may be used to detect codec saturation and excessive levels, and report the maximum and average levels for both the transmit and receive lines.

Level measurements are vital in the quality-monitoring process because saturation may cause perceptible harmonic and intermodulation distortion to conversations. Moreover, excessive levels may cause problems to data equipment and are likely to jeopardise the correct functioning of echo cancellers, resulting in excessive echo.

Coding errors occur when an analogue signal is within amplitude range of the PCM scheme, but is not coded correctly from analogue form at the transmitting end. When this occurs customers are likely to hear 'hollow', distorted speech, and data traffic may be corrupted. Figure 6 illustrates the display associated with such errors. Because the inventive monitor detects and displays coding errors, corrective action can be initiated early.

Figure 7 illustrates the display associated with data traffic on both transmit and receive paths. Preferably, the monitor is arranged such that an initial sampling for about 1 second occurs, after which the sample is processed to determine whether the circuit is carrying voice or non voice traffic. If the sample is non voice, no further sample is required. If, however, the sample is a voice signal a further about 4 second sample is required to allow for echo detection.

It will be understood that overall control of the monitor is preferably undertaken by control software 12, via an operator interface 11 and suitable input means such as a keyboard 20.

The monitor according to the present invention may be remotely accessed and

data down loaded via any suitable link, for instance serial or telephone lines. This in turn allows for a set of monitors to be controlled from a single central location. It is also noted that the inventive device may also be used to monitor 4-wire analogue connections.

It will be apparent to those skilled in the art that variations and additions are possible within the scope of the invention described without departing from the general inventive concept.

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**CLAIMS**

1. A method of analysing PCM communications, comprising:
  - 5 (a) extracting a PCM sample of PCM data of predetermined duration from a selected circuit;
  - (b) processing said sample to produce a non-compressed corresponding data sample;
  - (c) storing said data sample in memory;
  - 10 (d) performing a processing operation on said stored data sample; and
  - (e) producing a signal indicative of at least one parameter associated with said PCM sample.
2. The method of Claim 1, wherein steps (d) and (e) are performed a plurality of  
15 times in respect of different parameters.
3. The method of Claim 1 or Claim 2, further comprising:
  - (f) displaying a visual indication of said parameter.
- 20 4. The method of Claim 1, further comprising:
  - (g) displaying a visual representation of said data sample.
5. The method of Claim 1, further comprising the step of selecting a desired PCM  
stream from a plurality of streams and selecting a PCM circuit from a PCM stream  
25 comprising a plurality of such circuits.
6. The method of Claim 1, wherein the signals indicative of parameters are stored  
in a further memory means and the method is repeated for a plurality of circuits so as  
to produce a set of data stored in said memory representative of selected system  
30 statistics.
7. A method of analysing PCM communications, comprising:
  - (i) extracting a first PCM sample of PCM data of predetermined duration  
from a selected circuit;
  - 35 (ii) processing said sample to produce a non-compressed corresponding data



sample;

(iii) storing said data sample in memory;

(iv) performing a processing operation on said stored data sample;

(v) determining whether the selected circuit is carrying voice traffic;

5 (vi) if the circuit is carrying voice traffic, extracting a second sample of PCM data of predetermined duration from said selected circuit;

(vii) processing said second sample to produce a non-compressed corresponding second data sample;

(viii) storing said second data sample in memory;

10 (ix) performing a processing operation on said stored second data sample;

and

(x) producing a signal indicative of the presence or absence of echo on said circuit.

15 8. Apparatus for analysing PCM communications, comprising in combination:

interfacing means for non-intrusively connecting to at least one PCM stream and allowing selection of any circuit within said PCM stream;

sampling means for extracting a PCM sample of predetermined duration from said circuit;

20 processing means for producing a non-compressed data sample corresponding to said PCM sample and memory means for storing said data sample; and

further processing means for performing a data processing operation on said data sample and producing a signal indicative of at least one parameter associated with said PCM sample.

9. A method of analysing PCM communications substantially as hereinbefore described with reference to the accompanying drawings.

10. Apparatus for analysing PCM communications substantially as hereinbefore described with reference to the accompanying drawings.

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