

AN ELECTRONIC SWITCHING SYSTEM

The present invention relates to an electronic switching system arranged to control the transfer of telephone signals between a PCM bus and selected ones of a plurality of subscriber lines.

PCM electronic switching systems are known, and generally include a telemetering signal source providing a telemetering signal for application to the receive input of subscriber line interface circuits to enable the call charge to be computed. In this respect, the call charge is computed by reversing the voltage polarity between a tip and a ring of the subscriber line, but this can generate an unwanted clicking sound. A sine wave having a frequency of 12KHz or 16KHz can be used without reversing the voltage in order to remove the clicking sound. However, a telemetering signal (sine wave) having a frequency of the order of 12KHz or 16KHz is mixed with a voice band signal and the mixed signal is coupled to the transmission path. As a result, the transmitted signal is modulated and distorted because the coupled signal is too large to process. In addition, the coupled signal must be removed at the transmitting party.

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Thus in currently conventional integrated PCM-CODEC circuits, the signal whose frequency is applied on the voice frequency band is coupled from a receiving path. It cannot therefore be eliminated by the PCM-CODEC circuit and thus additional circuit elements, such as a telemetering signal eliminator, are needed around the transmission path of the integrated PCM-CODEC circuit. If telemetering signal eliminating means are not provided the voltage level of the telemetering signal becomes more than the voltage

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level of a tone signal, and thus a modulated and distorted tone signal occurs in the integrated PCM-CODEC signal. This makes it essential for the PCM system to employ a telemetering signal eliminator. However, the requirement
5 for the additional circuit element complicates peripheral arrangements of the PCM system. Increasing the number of subscribers on a unit board becomes difficult to arrange as does wiring of the board because of the complication.

10 It is an object of the invention to reduce the disadvantages described above.

According to the present invention there is provided an electronic switching system arranged to control the
15 transfer of telephone signals between a PCM bus and selected ones of a plurality of subscriber lines, wherein each subscriber line comprises subscriber line interface circuits coupled to a pulse code modulated (PCM) coder and decoder circuit, each said PCM coder and decoder circuit
20 being coupled to said PCM bus, and said switching system comprising a resistive network connecting each said PCM coder and decoder circuit to the respective subscriber line interface circuits, and a telemetering signal source for enabling the metering of calls, wherein each said PCM coder
25 and decoder circuit comprises analog terminals coupled to said subscriber line interface circuits and digital terminals for coupling to said PCM bus, one of said digital terminals being a transmitting terminal and being coupled to a coder, and another of said digital terminals being a
30 receiving terminal and being coupled to a decoder, and wherein each said PCM coder and decoder circuit further comprises telemetering signal eliminating means including a telemetering signal filter and arranged to remove
35 telemetering signals from the signals coupled to the transmitting terminal by way of said coder.

In an embodiment, said telemetering signal eliminating means employs a switched capacitor filter for analog signals and a sigma-delta modulator for the digital signals.

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Preferably, the frequency of signals removed by said telemetering signal filter is selectable by an external pin or by an information signal.

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In an embodiment, each said telemetering signal eliminating means further comprises a band pass filter coupled to said coder, and wherein the sampling rate of said telemetering signal filter is greater than that of said band pass filter.

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In an embodiment, one of said analog terminals of each said PCM coder and decoder circuit is an input terminal and is coupled to an input buffer, and wherein said telemetering signal eliminating means further comprises a transmitted gain controller coupled to said buffer by way of a signal selector, and wherein the telemetering signal filter is coupled to the transmitted gain controller.

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For example, the telemetering signal filter may be connected to the transmitted gain controller by way of an anti-aliasing filter, and the coder is connected to the telemetering signal filter by way of a band pass filter.

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Alternatively, the transmitted gain controller may be connected between the telemetering signal filter and a band pass filter.

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Alternatively, a digital filter/transmitted gain controller may be coupled between the telemetering signal filter and the coder.

5 Embodiments of the present invention will hereinafter be described, by way of example, with reference to the accompanying drawings, in which:

10 Figure 1 shows a block diagram of PCM subscriber lines, each employing a conventional integrated PCM-CODEC circuit, of an electronic switching system;

Figure 2 shows a detailed block diagram of the conventional integrated PCM-CODEC circuit of Figure 1;

15 Figure 3 shows a diagram of an equivalent circuit for the PCM-CODEC circuit of Figure 2 illustrating the 2/4-wire transforming mechanism in an interface acting as a subscribed line matching means;

Figure 4 shows an embodiment of PCM signal processing in an electronic switching system of the present invention;

20 Figure 5 is a detailed block diagram of an integrated PCM-CODEC circuit employed in the switching system of Figure 4; and

25 Figures 6A to 6C show modifications to features of an integrated PCM-CODEC circuit of a switching system of the present invention.

30 Figure 1 illustrates a substantially conventional PCM electronic switching system which comprises a plurality of subscriber lines IC1-ICn. Each subscriber line IC1-ICn includes subscribe line interface circuits (SLIC) 1, a telemetering signal eliminator 2, a telemetering signal mixer 3, an impedance conformer 4 and an integrated PCM-

CODEC circuit 5. Each subscriber line IC1-ICn is connected to a telemetering signal source 8 and to a common bus 7 called a PCM highway. A signal which is a mix of a telemetering signal using a signal MSYNC from the
5 telemetering signal source 8 is applied to the receive input of SLIC 1 when a call charge is counted up. The integrated PCM-CODEC circuit 5, as is shown in Figure 2, comprises a selector 11, a mixer 12, a transmitted gain controller 13, an anti-aliasing filter (AAF) 14, a band
10 pass filter (BPF) 15, and a coder 16 coupled to a transmitting terminal P0. A receive terminal P1 is coupled to a decoder 17, which is connected to a low pass filter (LPF) 18, a received gain controller 19, a power operational amplifier 20, a hybrid-balanced filter 21 and
15 gain controller 22.

In the PCM system illustrated in Figures 1 and 2, the call charge is counted up by reversing the voltage of a battery between a tip T1 and ring R1. In this case, an
20 unwanted clicking sound is generated. At this time, a sine wave of a frequency of 12KHz or 16KHz can be used without voltage reverse in order to remove the clicking sound. The telemetering signal (sine wave) of the frequency of 12KHz or 16KHz is mixed with a voice band signal, and this mixed
25 signal is transmitted to tip T1 and ring R1. However, the mixed signal is coupled to the transmission path, and as a result, the transmitter signal is modulated and distorted because the coupled signal is too large to process. Furthermore, the coupled signal must be removed at the
30 transmitting party.

The problem is illustrated in Figure 3 which shows that the current i_1 through the coil L1 is generated by a signal from the receiving terminal Rx, the terminal A0 of
35 the integrated PCM-CODEC circuit 5, by means of the operation of the hybrid 2/4 converter. Thus, a secondary

induced current i_2 appears on the coil L2 coupled to a subscriber line, and causes a further induced current i_3 to occur on the coil L3 coupled to the transmitting terminal Tx. As a result, an unwanted telemetering signal is applied to the transmitting terminal A1. This means that, in the conventional integrated PCM-CODEC circuit 5, the signal which is output from the terminal A0 whose frequency is within the voice frequency band is only compensated as a signal having a different polarity from that of the induced current i_3 which is coupled to the transmitting terminal Tx by the hybrid balanced filter 21 and the gain controller 22.

However, the integrated PCM-CODEC circuit 5 cannot eliminate a telemetering signal which is coupled from a receiving path, and an additional circuit element, such as the telemetering signal eliminator 2, is required around the integrated PCM-CODEC circuit 5 of transmission path. In the operation of the conventional PCM system having the eliminator 2 and the mixer 3, the PCM-CODEC circuit 5 converts all input signals, even those containing noise, to a PCM signal (namely a digital signal) in a tone frequency band. The coupled mixed signal (echo signal) from the receiving terminal Rx is evaluated to a value of the current i_3 at the applying terminal Tx through the hybrid balanced filter 21 and then mixed with a signal of the gain controller 22 in the mixer 12. This results in a reduction of the weight of the unwanted mixed signal with telemetering signal from the terminal Rx to Tx and makes the applied gain controller adjust the variation of the gain made through the telemetering signal eliminator 2 and impedance conformer 4 show in Figure 1. A sampling operation results in the replication of the spectrum of the tone signal, and (unless Nyquist's criterion is satisfied) introduces aliasing distortion which is removed by the anti-aliasing filter 14. After removing around sampling

frequency, the tone frequency is sampled and converted to the PCM signal (or the digital signal) through the coder 16 and then the PCM signal is transferred to the PCM highway of the common bus 17.

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If a telemetering signal eliminating means is not provided in the PCM system, the voltage level of a signal of a telemetering signal source 8, in general, becomes more than several volts because in a public telephone network the telemetering signal has a great distortion rate due to the well known characteristic of the subscriber line. As a result, the telemetering signal induced on the applying terminal Tx has a voltage level which is several hundred millivolts greater than that of a tone signal.

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15 Accordingly, a modulated and distorted tone signal occurs in the integrated PCM-CODEC circuit 5. Because of this, it is essential for the PCM system to employ the telemetering signal eliminator 2.

20 However, the additional requirement of circuit element, such as the telemetering signal eliminator 2, around the integrated PCM-CODEC circuit 5 complicates the peripheral arrangements of the PCM system. The added complication arising from an increase in the number of subscribers on a unit board for a subscriber, makes it difficult to arrange the wiring of the PCM board, and this may cause a degradation in the quality of such boards.

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30 Figure 4 shows an example of a switching system of the invention, comprising a filter to be used for removing telemetering signals at the transmitting party, due to its operation with an analog signal. The switching system comprises a plurality of subscriber lines IC1'-ICn' each comprising subscribe line interface circuits (SLIC)1' interfacing a telephone line with a switching system and an
35 integrated PCM-CODEC circuit 3'. A common bus 4' called a

PCM highway is provided for transferring telephone signals into or from a subscriber according to the time division rule for the timing of telephone line use, and a telemetering signal source 5' is coupled to the PCM-CODEC circuit 3'. A central processing unit (CPU) 6' is provided to enable or disable the telephone call asked by the n'th subscriber.

As shown in Figure 5, the PCM-CODEC circuit 3' comprises a buffer 11' for enabling a high input impedance, a signal selector 12' using an analog loopback for checking trouble from the receive to transmit PCM highway, and a transmitted gain controller 13' for compensating a gain generated from where a circuit is constructed in accordance with the protocol conformed to the subscriber line and compensating gain loss between the SLIC and CODEC. The transmitted gain controller 13' is connected to an anti-aliasing filter 14' for preventing a replication of the spectrum next followed in sequential steps from being affected by noise, a telemetering signal filter 15' for echo cancellation around the sampling frequency band of the telemetering signal, a BPF 16' for filtering only a signal whose frequencies are located in the voice frequency band from 300Hz to 3.3KHz with integral $\sin x/x$ correction, and a coder for converting an analog signal to a PCM output signal. The PCM-CODEC circuit also comprises a decoder 18' for converting a PCM input signal to an analog signal, a LPF 19' for filtering only a signal whose frequency is located in the tone frequency band from 0Hz to 3.3KHz with integral $\sin x/x$ correction, a received gain controller 20' for compensating a gain generated from where a circuit is constructed in accordance with the protocol conformed to the SLIC and CODEC, a smoothing filter 21' for attenuating step pulse components of a high frequency signal generated from where the LPF is operated with a switched capacitor therein, an operational amplifier 22' for amplifying a

signal enough to drive the subscriber line, and a telemetering gate 23 for switching the supply of the telemetering source signal.

5 Referring to the integrated PCM-CODEC circuit shown in Figure 5, a calling tone signal induces the current i_2 upon the subscriber line, as shown in Figure 3, and causes the current i_3 to be generated at the transmitting terminal Tx. A signal taken along with the induced current i_3 is applied
10 to the terminal AI in the PCM-CODEC circuit 3'. The signal applied to the terminal AI includes a tone signal from the sides of a tip T and a ring R, power noise from a power source of the system, white noise generated prior to the signal's arrival at the terminal AI, and an induced
15 component (a tone frequency band and telemetering signal) at the receiving terminal Rx which appears through the path of i_1 , i_2 and i_3 . The PCM-CODEC circuit 3' converts only the necessary signal, from amongst all the signals, whose frequency is located in the tone band to a PCM signal, that
20 is, a digital signal. A signal applied to the PCM-CODEC circuit 3' is coupled to the transmitted gain controller 13' through the buffer 11' and the signal selector 12'. The transmitted gain controller 13' compensates the gain of the input signal to conform it to the protocol of the
25 subscriber line and compensates gain loss between the SLIC and the CODEC. The conformed signal then passes, in turn, through the anti-aliasing filter 14', the telemetering signal filter 15' and the BPF 16' to remove the out of voice frequency band. In the filtering process, the anti-
30 aliasing filter 14' eliminates the aliasing effect which occurred. The BPF 16', by means of a sampling circuit, removes the appearance of the aliasing between a voice signal frequency and around sampling frequency band, whilst the telemetering signal filter 15' eliminates an echo in a
35 telemetering signal.

Therefore, the resultant signal output from the BPF 16' has a frequency in the range 300Hz to 3.3KHz in the voice frequency band and is converted to the PCM signal (or the digital signal) and then transferred to the other subscriber by way of the common bus 4' of the PCM highway. On the other hand, the PCM signal input at the receiving terminal Rx is converted to an analog signal by the decoder 18' and applied to the LPF 19'. The LPF 19' only outputs a signal with a frequency in the range 0Hz to 3.3KHz in the voice band, and the signal output is applied to the received gain controller 20'. The received gain controller 20' compensates previously the gain of the output signal from the LPF 19' as much as the decremented amount itself after consideration of the characteristics of the impedance conformer 2. Such gain controlled signal contains step pulse components of high frequency obtained at the LPF 19' which consists of a switched capacitor. So, after the step pulse components in the signal have been damped by means of the smoothing filter 21', the resultant signal without the step pulses is amplified directly by the operational amplifier 22' to activate the subscriber line and then transferred to the subscriber line through the impedance conformer 2' and SLIC 1'. The telemetering gate 23' enables a signal for the telemetering process and a voice band-signal for application to a line subscriber to be transferred, just by means of a resistor, as a mixed signal. Connection or disconnection of the telemetering source 5' is by the control of the MSYNC from the telemetering source, at a given time, thus minimising the topology of the architecture of the incoming line of the telephone network.

Figures 6A, 6B and 6C show modified embodiments of an integrated PCM-CODEC circuit of the invention. In the embodiments of Figures 6A and 6B, although the circuit arrangement between the signal selector 12' and the coder

17' in the PCM-CODEC circuit 3' is changed as compared to that of Figure 5, all of the circuit elements operate substantially the same as in the circuit of Figure 5 and act to eliminate coupled telemetering signals. In the
5 circuit shown in Figure 6C a single digital filter/transmitted gain controller 30' performs the roles accomplished in the integrated PCM-CODEC circuit 3' of Figure 5 by the transmitted gain controller 13', the anti-aliasing filter 14' and the BPF 16' and thus produces the
10 same effect. In conventional processing methods with an analog and a digital signal, for the BPF 16' and the coder 17' have been employed a switched capacitor filter (SCF) for the analog signal and a sigma-deltamodulator (SDM) for the digital signal. But the invention can utilise two
15 methods in order to reduce the white noise to the level of 1/2 or 4/1 times thereof. One method is that a sampling clock is arranged to activate the telemetering filter 15' and the BPF 16'; the other method is that the operating frequency of the telemetering filter 15' is two or four
20 times thereof.

As described above, the present invention can remove telemetering signals so that they do not distort the voice band frequency of the transmitting party, by providing at
25 least a filter in the integrated PCM-CODEC circuit without adding circuit elements which is constructed around the integrated PCM-CODEC circuit.

Furthermore, the invention reduces the noise which is
30 generated with the modulation and distorted signal caused by a telemetering signal, whereby the counterpart's voice can be heard more clearly than before and more lines are available on a unit board for a subscriber.

35 It will be appreciated that modifications and variations may be made to the embodiments of the invention

as described within the scope of the appended claims.

CLAIMS

1. An electronic switching system arranged to control the transfer of telephone signals between a PCM bus and
5 selected ones of a plurality of subscriber lines, wherein each subscriber line comprises subscriber line interface circuits coupled to a pulse code modulated (PCM) coder and decoder circuit, each said PCM coder and decoder circuit being coupled to said PCM bus, and said switching system
10 comprising a resistive network connecting each said PCM coder and decoder circuit to the respective subscriber line interface circuits, and a telemetering signal source for enabling the metering of calls, wherein each said PCM coder and decoder circuit comprises analog terminals coupled to
15 said subscriber line interface circuits and digital terminals for coupling to said PCM bus, one of said digital terminals being a transmitting terminal and being coupled to a coder, and another of said digital terminals being a receiving terminal and being coupled to a decoder, and
20 wherein each said PCM coder and decoder circuit further comprises telemetering signal eliminating means including a telemetering signal filter and arranged to remove telemetering signals from the signals coupled to the transmitting terminal by way of said coder.
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2. An electronic switching system as claimed in Claim 1, wherein said telemetering signal eliminating means employs a switched capacitor filter for analog signals and a sigma-delta modulator for the digital signals.
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3. An electronic switching system as claimed in Claim 1 or 2, wherein the frequency of signals removed by said telemetering signal filter is selectable by an external pin or by an information signal.
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4. An electronic switching system as claimed in any



preceding claim, wherein each said telemetering signal eliminating means further comprises a band pass filter coupled to said coder, and wherein the sampling rate of said telemetering signal filter is greater than that of said band pass filter.

5. An electronic switching system as claimed in any preceding claim, wherein one of said analog terminals of each said PCM coder and decoder circuit is an input terminal and is coupled to an input buffer, and wherein said telemetering signal eliminating means further comprises a transmitted gain controller coupled to said buffer by way of a signal selector, and wherein the telemetering signal filter is coupled to the transmitted gain controller.

6. An electronic switching system as claimed in Claim 5, wherein the telemetering signal filter is connected to the transmitted gain controller by way of an anti-aliasing filter, and the coder is connected to the telemetering signal filter by way of a band pass filter.

7. An electronic switching system as claimed in Claim 5, wherein the transmitted gain controller is connected between the telemetering signal filter and a band pass filter.

8. An electronic switching system as claimed in Claim 5, wherein a digital filter/transmitted gain controller is coupled between the telemetering signal filter and the coder.

9. An electronic switching system as claimed in any preceding claim, further comprising a telemetering gate for each said PCM coder and decoder circuit for enabling the connection of a telephone signal and a telemetering signal



from analog terminals of said circuit to subscriber lines, each said telemetering gate being controllable by control signals.

- 5 10. An electronic switching system as claimed in any preceding claim, wherein the telemetering signal is a sine-wave signal.
- 10 11. An electronic switching system substantially as hereinbefore described with reference to Figures 4 to 6 of the accompanying drawings.

