Title: A TRANSMISSION SYSTEM

Abstract:

A transmission system, including a transmitter for transmitting data on a radio channel, and a modulator for receiving the data in a data stream and modulating the data for transmission by the transmitter, characterised by including a component for including n additional data channels in the data stream, where n is an integer. The component includes a controllable module for receiving and selectively outputting the additional channels, and a multiplexer for receiving the data stream and including the channels output by the module in said data stream for output to said modulator. The data stream is a 34 Mbit/s data stream, which can support E1, E2 and E3 data rates.
For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.
A TRANSMISSION SYSTEM

The present invention relates to a transmission system, and in particular to a transmission system for digital radio which is able to optimally utilise a digital radio channel, such as a microwave link.

Today’s digital radio network is already congested. To cope with the projected market demand, systems have to improve utilisation of a channel's capacity together with band efficiency and sensitivity. Spectrally efficient high-speed microwave radio systems have been developed to emit data rates ranging e.g. from 2 Mbit/s to 45 Mbit/s or their combinations i.e. 2×2 Mbit/s, 4×2 Mbit/s and so on. Some include additional n×64 kbit/s service channels, where n=1, 2, ..., 8, but these channels are used on top of the main data or only the main data is used. These systems have the disadvantage that utilisation of a channel's capacity cannot be optimal every time because some customers need main data and not necessarily and exactly all the n additional service channels at one time. Also the n additional channels increase the baseband of a system and reduce its sensitivity. Depending on the particular number of additional channels there is less sensitivity and a wider baseband. Moreover, the n additional channels should be available for different purposes, not only as service channels.

The present invention relates to a transmission system, including a transmitter for transmitting data on a radio channel, a modulator for receiving said data in a data stream and modulating the data for transmission by said transmitter, characterised by including means for including n additional data channels in said data stream, where n is an integer.

Advantageously, n may be varied between 1 and 8. The data stream may be a 34 Mbit/s data stream, which can support E1, E2 and E3 data rates as defined by ITU. The additional channels may be 64 kbit/s channels which can carry voice or service data.
Preferably the means includes a controllable module for receiving and selectively outputting the additional channels, and a multiplexer for receiving the data stream and including the channels output by the module in said data stream for output to said modulator.

Preferably the radio channel is a 500 MHz to 26 GHz channel.

Advantageously, the above transmission system can add $8 \times 64$ kbit/s data channels to the 34 Mbit/s stream and still occupy a bandwidth less than 14 MHz on the radio channel with a bit error rate (BER) of greater than $-82 \times 10^{-6}$.

A preferred embodiment of the present invention is hereinafter described, by way of example only, with reference to the accompanying drawings, wherein:

Figure 1 is a block diagram of a preferred embodiment of a transmission system;

Figure 2 is a block diagram of a controllable module of the transmission system;

and

Figure 3 is a block diagram of a multiplexer of the transmission system.

An optimal utilisation of digital radio channel's capacity is achieved using a controllable module (8) with 8 input channels of 64 kbit/s each and a multiplexer (9) which synchronously multiplexes up to 8 extra data channels, 64 kbit/s each, and a main data stream, which supports e.g. E1, E2 and E3 data rates as defined by ITU-R or their combinations. The controllable module with 8 channels of 64 kbit/s each is connected to the multiplexer before the processing of data in a 70/140 MHz modulator (7) and it provides in turn the optimal spectra and sensitivity of the system. Simultaneous DSP processing of n additional channels keeps robustness of the channels and the main data effectively the same. The controllable module increases the flexibility of the system and depending on its configuration i.e. if it is used with or without a forward error correction technique and depending on a value of a roll-off factor $\alpha$, which can vary, a particular number n of additional channels can be chosen optimally every time. A particular number of additional channels, from 1 up to 8, of the controllable module can be controlled from a
control n input (11), which is a three line bus, using e.g. DIP switches. One of the 8×64 kbit/s channels can be used for service purposes. A digital synthesiser (22) is used in the controllable module (8) to synchronise a particular number n of the additional channels and the main data.

Referring to Figure 1, the optimal utilisation of a channel's capacity can be applied to and used with a digital microwave link established with a modulator (7) and transmitter. The transmitter includes a synthesised phase-lock source (1), which must not include significant phase noise such that system performance is degraded (measured in terms of bit error rate and spectrum usage). The synthesised phase-lock source (1) is connected to a multiplier/amplifier (2) and together with an IF amplifier (3) feeds an upconverter (4), which generates, in turn, a particular UHF RF signal depending on the UHF band plan. An output of the upconverter (4) is connected to a power amplifier (5) to amplify the UHF RF signal according to the system requirements. A channel filter (6), which is connected to the power amplifier (5), reduces spurious emissions according to the system requirements. A 70/140 MHz modulator (7) is a flexible DSP based modulator for high data rate transmission which processes the transmitted data depending on the choice of modulation and coding schemes and feeds the IF amplifier (3). An example of a suitable modulator is described in A. Guidi et al., "Development of a spectrally efficient, high speed modem for microwave terrestrial satellite communications", What's New in Radio Communications, June/July 1997. To achieve optimal spectra and sensitivity performance of the system the controllable module (8) and the multiplexer (9) are used to multiplex synchronously of up to 8 extra data channels, 64 kbit/s each, and the main data stream (10), which supports e.g. E1, E2 and E3 data rates or their combinations, before the processing of data in the 70/140 MHz modulator (7). To achieve an optimal utilisation of spectra and sensitivity of the system and depending on system configuration a particular number of additional channels, from one up to eight, can be controlled from a control n input (11). The controllable module (8) is connected to the multiplexer (9) before the processing of data in the 70/140 MHz modulator (7).
Figure 2 illustrates use of the controllable module (8) to add 8 additional voice channels for a 2 Mbit/s system. The controllable module includes eight PCM codecs e.g. TP3057-X (National Semiconductor) from (12) through (19), which encode signals from 200 Hz up to 3400 Hz into PCM code 64 kbit/s each. These eight digital channels, 64 kbit/s each, are connected to a 8 to n multiplexer (20), where n=1, ..., 8. Depending on position of DIP switches 4-2-1 (21), which are connected to the multiplexer (20), from one up to eight 64 kbit/s channels occurs at the output of the multiplexer (20). The 4-2-1 line bus is connected to a digital synthesiser (22) as well, to control a clock frequency in the range from 2112 kHz up to 2560 kHz. Reference clock 2048 kHz for the digital synthesiser (22) is a synchronous clock to clock the main data of 2048 Mbit/s and is connected to the digital synthesiser (22) from the multiplexer (9). A 1...8 bus from the multiplexer (20) is connected to the multiplexer (9).

Figure 3 shows the multiplexer (9). A main data stream (10) e.g. 2048 Mbit/s in HDB3 G.703 form, which supports E1 data rate, is connected to a line interface (23) e.g. CS61575 of Crystal Semiconductor Corporation. Synchronous data 2.048 Mbit/s in NRZ form and a clock 2048 kHz from out of the line interface (23) is connected to a serial 32 bit register (33). The clock 2048 kHz feeds a synchronous logic (32), a synchronous counter (35), which divides the clock signal 2048 kHz by 32, and feeds the controllable module (8) as well. Each 32 bit frame output from the serial 32 bit register (33) and 1 byte frame output from a parallel 8 bit register (36) are stored into a parallel-to-serial register (37). Parallel data of this parallel-to-serial register (37) is stored by a write impulse from the synchronous logic (34), which provides it every time when the serial 32 bit register (33) and the parallel 8 bit register (36) are full and the parallel-to-serial register (37) is empty. Data of the parallel-to-serial register (37) is shifted by a clock 2112 ... 2060 kHz from the digital synthesiser (22), this clock 2112 ... 2560 kHz is connected to the synchronous logic (34) as well. Data from the multiplexer (20) is connected to the parallel 8 bit register (36). Parallel data from the parallel-to-serial register (37) is connected to a multiplexer (38). Length of output data from 33 bits up to 40 of the multiplexer (38) is controlled by the 4-2-1 line bus depending on the number n.
An example of the performance which can be achieved with the above transmission system on a digital radio channel of 1.5 to 10.5 GHz is provided by the data in the table below.

### Table 1

<table>
<thead>
<tr>
<th>Data Rate (Mbit/s)</th>
<th>Modulation</th>
<th>Band (MHz)</th>
<th>Sensitivity (dBm) BER = 10⁻⁶</th>
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<tr>
<td>2.048</td>
<td>QPSK</td>
<td>1.43</td>
<td>-106.0</td>
</tr>
<tr>
<td>2.048+4×0.064</td>
<td>QPSK</td>
<td>1.61</td>
<td>-105.2</td>
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<td>2.048+FEC*</td>
<td>QPSK</td>
<td>1.64</td>
<td>-98.3</td>
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<td>8.448+FEC</td>
<td>16-QAM</td>
<td>3.38</td>
<td>-88.3</td>
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<td>34.368+FEC</td>
<td>16-QAM</td>
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<td>34.368+8×0.064+FEC</td>
<td>16-QAM</td>
<td>13.95</td>
<td>-82.13</td>
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</tbody>
</table>

*FEC - Forward Error Correction, using 7/8 Reed-Solomon code

Many modifications will be apparent to those skilled in the art without departing from the scope of the present invention as herein described with reference to the accompanying drawings.
CLAIMS:

1. A transmission system, including:
   a transmitter for transmitting data on a radio channel; and
   a modulator for receiving said data in a data stream and modulating the data for
   transmission by said transmitter; and
   characterised by including means for including n additional data channels in said
   data stream, where n is an integer.

2. A transmission system as claimed in claim 1, wherein said means includes a
   controllable module for receiving and selectively outputting the additional channels, and a
   multiplexer for receiving the data stream and including the channels output by the module
   in said data stream for output to said modulator.

3. A transmission system as claimed in claim 2, wherein n is varied between 1 and 8.

4. A transmission system as claimed in claim 2, wherein the data stream is a 34 Mbit/s
   data stream, which can support E1, E2 and E3 data rates.

5. A transmission system as claimed in claim 4, wherein the additional channels are
   64 kbit/s channels.

6. A transmission system as claimed in claim 5, wherein the radio channel is a 500
   MHz to 26 GHz channel.

7. A transmission system as claimed in claim 5, wherein the radio channel is a
   microwave link.
Figure 3
### INTERNATIONAL SEARCH REPORT

**International application No.**

**PCT/AU00/01520**

### A. CLASSIFICATION OF SUBJECT MATTER

**Int. Cl. 7:**

- H04J 9/00; H04B 7/00,10/00; H04L 12/00; H04Q 7/20

According to International Patent Classification (IPC) or to both national classification and IPC

### B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

- H04J /IC, H04B /IC, H04L /IC

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

- WPAT, INSPEC, IBM
- Additional data channel, data stream, transmission, link/channel capacity, modulator

### C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<tbody>
<tr>
<td>X</td>
<td>US 5,963,873 A (SUZUKI) 05 October 1999 Fig 1, column 3 lines 23-34</td>
<td>1,4</td>
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<tr>
<td></td>
<td>US 5,903,573 A (WOLF) 11 May 1999 Abstract, figs. 1,3 and claims 4, 10</td>
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<tr>
<td>X</td>
<td>US 5,903,567 A (ALGER-MEUNIER) 11 May 1999 Column 2 line 21 to column 3 line 30</td>
<td>1,3,5</td>
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</table>

[ ] Further documents are listed in the continuation of Box C [ ] See patent family annex

* Special categories of cited documents:
  - "A" document defining the general state of the art which is not considered to be of particular relevance
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  - "P" document published prior to the international filing date but later than the priority date claimed

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**Date of the actual completion of the international search**

23 January 2001

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Form PCT/ISA/210 (second sheet) (July 1998)
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<tr>
<td>X</td>
<td>JP 07212341 A (SHARP CORP) 11 August 1995 Abstract</td>
<td>1,2</td>
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<tr>
<td>X</td>
<td>US 4,870,408 (ZDUNEK et al.) 26 September 1989 Fig. 1 and column 2 lines 29-44</td>
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<tr>
<td>X</td>
<td>US 4,837,858 (ABLAY et al.) 06 June 1989 Fig. 1 and column 5 lines 61-68</td>
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<td>US 4,397,030 (BECKER et al.) 02 August 1983 Abstract and column 2 line 15-24</td>
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This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

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<td>US 5,963,573</td>
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