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(54) SYSTEM AND ELECTRONIC DEVICE FOR PROVIDING A SPREAD SPECTRUM SIGNAL

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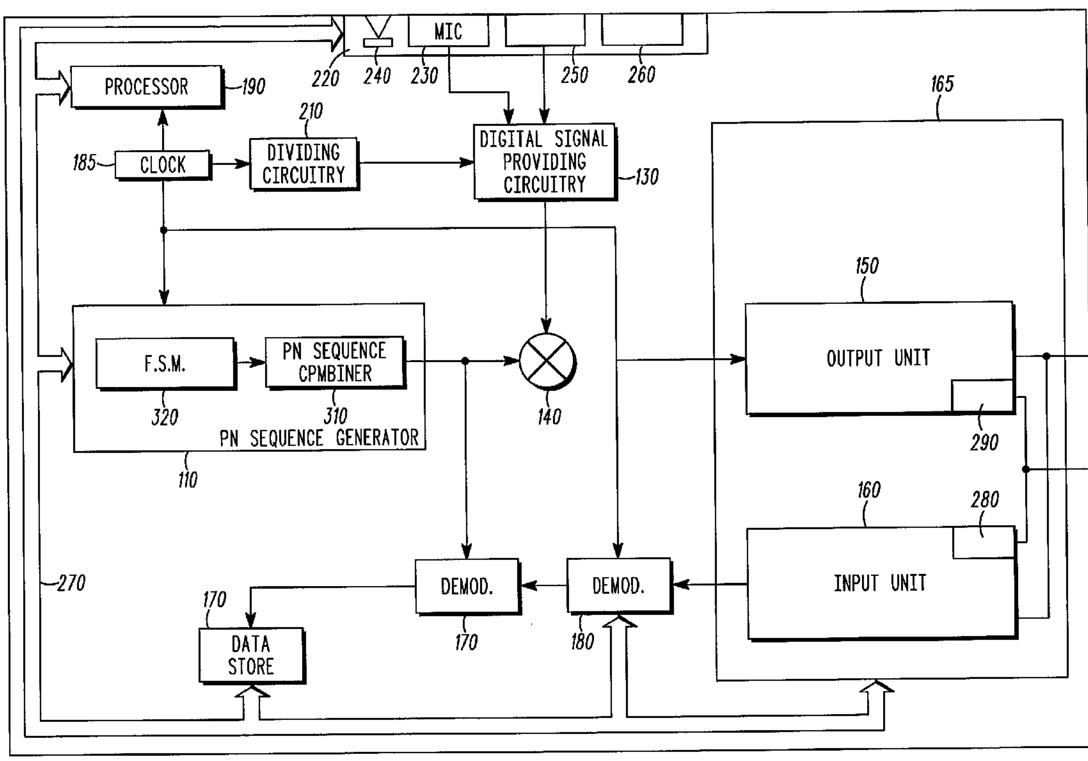
(57) **ABSTRACT**

A system and electronic device (**100**) for providing a spread spectrum signal. The device (**100**) has a modulator (**140**), digital signal providing circuitry (**130**) coupled to the modulator (**140**), a modulation pseudo noise sequence generator (**110**) having a sequence output coupled to the modulator (**140**) and an output unit (**150**) coupled to the modulator (**140**). In use, the digital signal providing circuitry (**130**) provides data bits each of which is modulated, by the modulator (**140**), with a pseudo noise sequence supplied from modulation pseudo noise sequence generator (**110**) to thereby provide the spread spectrum signal that is transmitted by the output unit (**150**). There is also a demodulator (**170**) and input unit (**160**) for demodulating received spread spectrum signals.



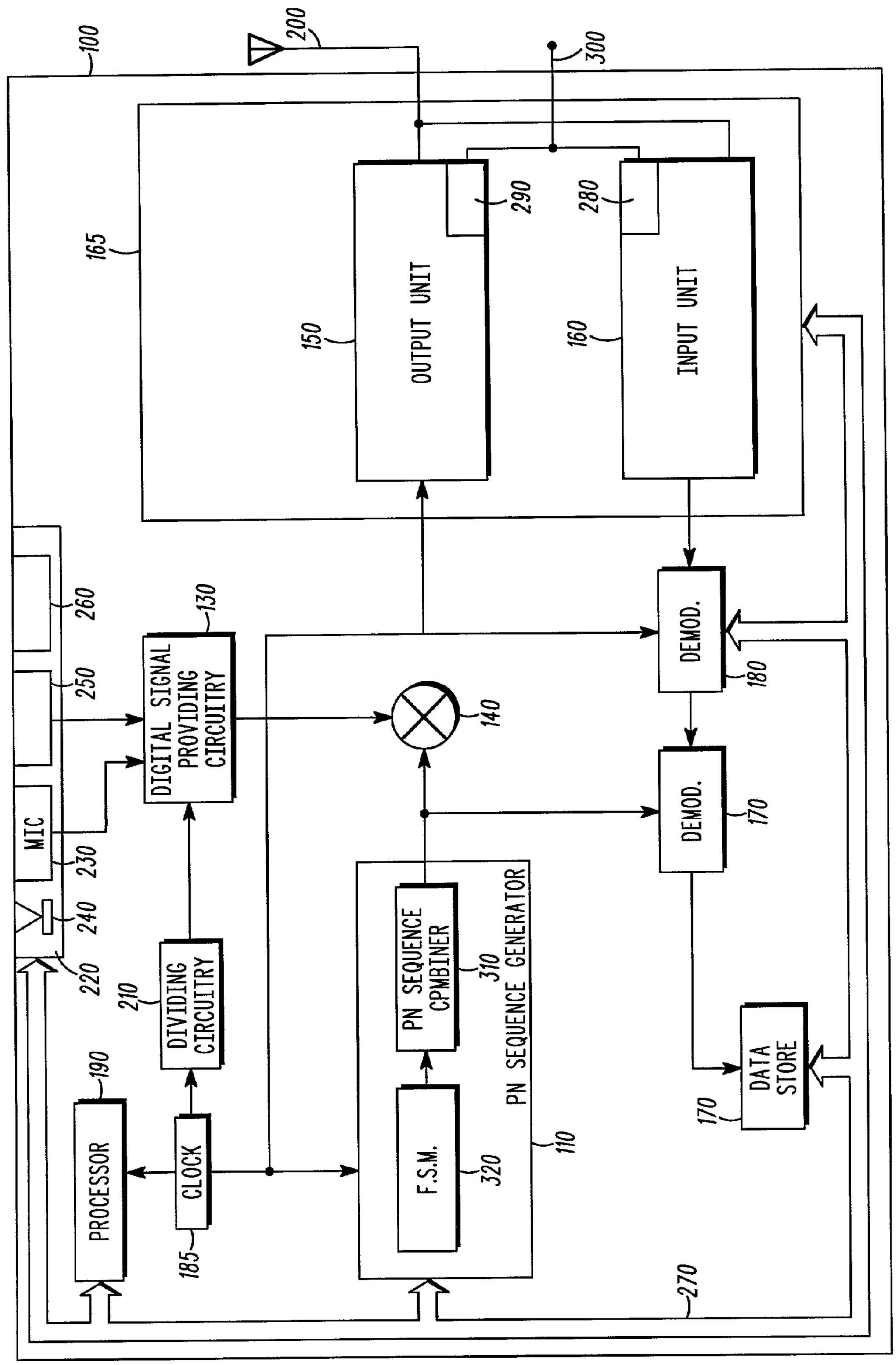

100
200
300
165
290
280
150
OUTPUT UNIT
160
INPUT UNIT
260
250
130
DIGITAL SIGNAL PROVIDING CIRCUITRY
MIC
230
240
220
140
DEMOD.
180
DEMOD.
170
210
DIVIDING CIRCUITRY
PN SEQUENCE CPMBINER
310
PN SEQUENCE GENERATOR
190
PROCESSOR
CLOCK
185
F.S.M.
320
110
DATA STORE
170
270

FIG. 1

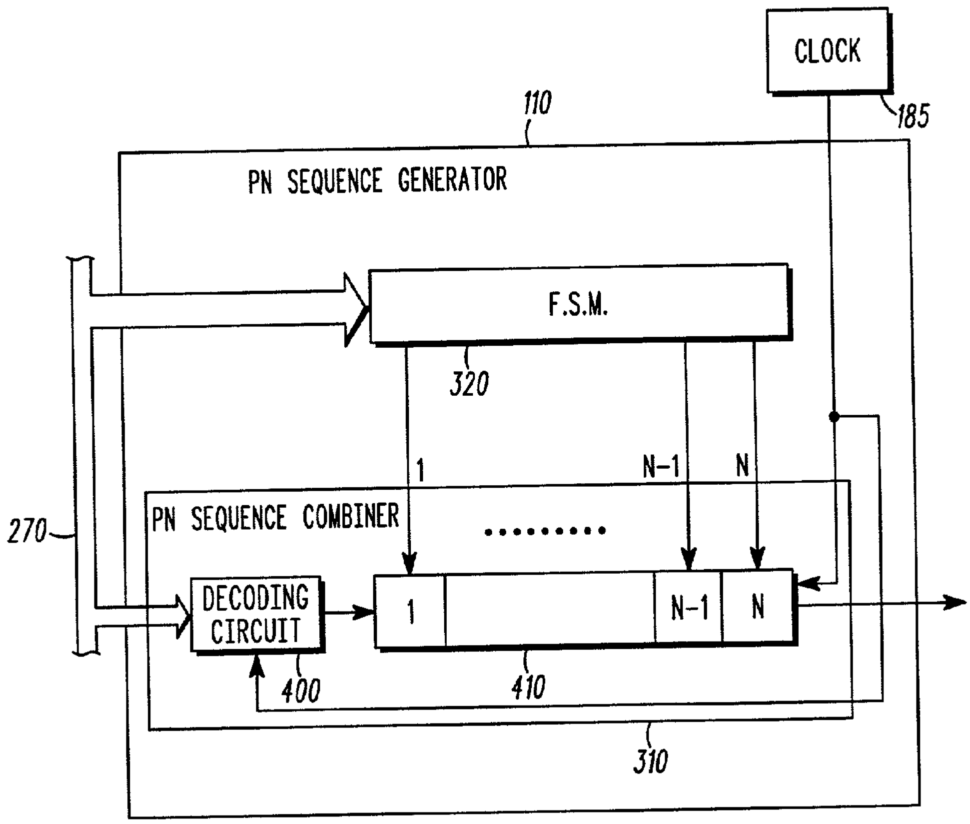

CLOCK
185
110
PN SEQUENCE GENERATOR
F.S.M.
320
1
N-1
N
PN SEQUENCE COMBINER
270
DECODING CIRCUIT
1
N-1
N
400
410
310

FIG. 2

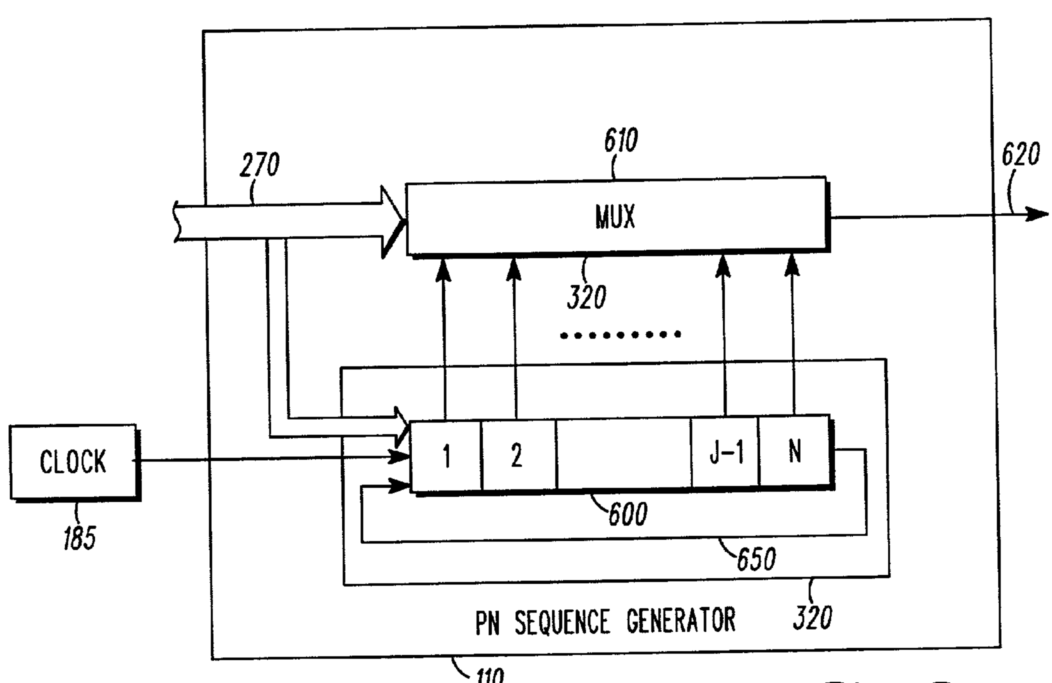

610
270
620
MUX
320
CLOCK
1
2
J-1
N
185
600
650
PN SEQUENCE GENERATOR
320
110

FIG. 3

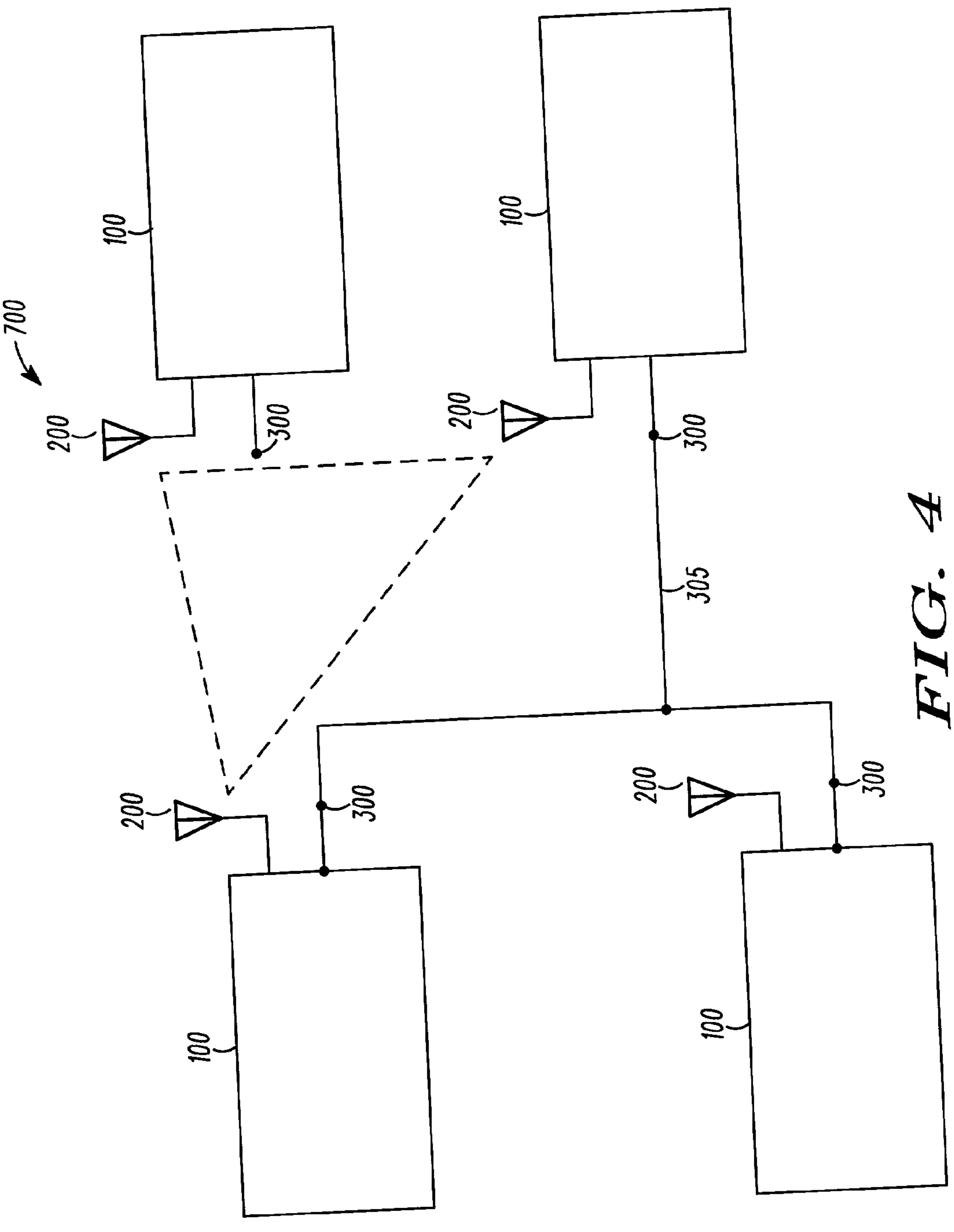


FIG. 4

SYSTEM AND ELECTRONIC DEVICE FOR PROVIDING A SPREAD SPECTRUM SIGNAL

FIELD OF THE INVENTION

[0001] This invention relates to a Direct Sequence Spread Spectrum (DSSS) system and an electronic device for providing a DSSS signal. The invention is particularly useful for, but not necessarily limited to, systems and devices with radio frequency communication links.

BACKGROUND OF THE INVENTION

[0002] Spread Spectrum (SS) technologies have been used for anti-jamming and security communications systems as well as commercial cellular and other wireless communications networks. Recently, an unconventional form of SS technology, namely ultra-wideband (UWB) technology, has attracted a great deal of attention because of its unique advantages over other conventional SS systems. One of the most important characteristics of the UWB signals is that their bandwidths could be orders of magnitude more than that of the conventional SS systems. Due to their ultra-wide bandwidth, UWB signals demonstrate unique properties such as high time-resolution and deep materials penetration. UWE technology may enable the realisation of exceptionally high performance, low cost wireless communications systems with improved capacity. These UWB systems include wireless cable replacement devices, ultra-high speed Local Area Networks (LANs), and ultra-low power wireless links for Personal Area Networks (PANs).

[0003] A major concern of UWB systems is that they could potentially interfere with existing communications systems because the emission bandwidth of UWB devices generally exceeds one gigahertz and may be greater than ten gigahertz. Furthermore, when generated by conventional direct sequence (DS) modulation or pulse position modulation, UWB signals contain a number of spectral peaks and/or spectral lines which could be harmful to, or at least interfere with, other communications systems.

SUMMARY OF THE INVENTION

[0004] According to one aspect of the invention there is provided an electronic device for providing a spread spectrum signal, the device comprising: a modulator having a modulator output; digital signal providing circuitry having a signal output coupled to a signal input of the modulator; a modulation pseudo noise sequence generator having a sequence output coupled to a sequence input of said modulator; and an output unit coupled to the modulator output, wherein, in use, the digital signal providing circuitry provides data bits each of which is modulated, by the modulator, with a pseudo noise sequence supplied from the modulation pseudo noise sequence generator to thereby provide the spread spectrum signal that is transmitted by said output unit.

[0005] Suitably, the output unit may include a radio transmitter.

[0006] The output unit may include a modem. Preferably, the output unit may provide for connection and transmission of said spread spectrum signal to a wired communication link.

[0007] Suitably, said pseudo noise sequence generator may include a finite state machine. The modulation pseudo noise sequence generator may suitably includes a sequence combiner coupled to said finite state machine, wherein, in use, pseudo noise data bits associated with cyclical states of said finite state machine are sequentially combined into a sequence by said sequence generator to provide said pseudo noise sequence. Preferably, modulation of the data bits may be synchronized with the pseudo noise sequence.

[0008] The electronic device may be a radio communication device such as a two-way radio communication device and the digital signal providing circuitry may be coupled to a microphone. Typically, the signal providing circuitry preferably includes a digital data store.

[0009] Preferably, the electronic device may include: a demodulator having a demodulator output; a demodulation pseudo noise sequence generator having a output coupled to an input of the demodulator; and an input unit with an output coupled to the demodulator wherein, in use, a spread spectrum signal received by said input unit is demodulated, by the modulator, with a pseudo noise sequence supplied from the demodulation pseudo noise sequence generator to thereby provide a digital signal.

[0010] Suitably, state transitions of the receiving finite state machine may be synchronized with the spread spectrum signal.

[0011] According to another aspect of the invention there is provided a spread spectrum signal communication system comprising: a communication link; and a plurality of electronic devices in communication with each other by the communication link, the electronic devices comprising: a modulator having a modulator output; digital signal providing circuitry having a signal output coupled to a signal input of the modulator; a modulation pseudo noise sequence generator having a sequence output coupled to a sequence input of the modulator; and an output unit coupled to said modulator output, wherein, in use, the digital signal providing circuitry provides data bits each of which is modulated, by said modulator, with a pseudo noise sequence supplied from the modulation pseudo noise sequence generator to thereby provide a spread spectrum signal that is transmitted by said output unit.

[0012] The electronic device of the spread spectrum signal communication system may suitably include any or all of the above elements or functions.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] In order that the invention may be readily understood and put into practical effect, reference will now be made to preferred embodiments as illustrated with reference to the accompanying drawings in which:

[0014] **FIG. 1** is a schematic block diagram of an electronic device for generating a DSSS signal in accordance with the invention;

[0015] **FIG. 2** is a first preferred embodiment of schematic block diagram of a pseudo noise sequence generator comprising part of the electronic device of **FIG. 1**;

[0016] **FIG. 3** is a second preferred embodiment of schematic block diagram of a pseudo noise sequence generator comprising part of the electronic device of **FIG. 1**; and

[0017] **FIG. 4** is a schematic block diagram of a spread spectrum signal communication system.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

[0018] Referring to **FIG. 1** there is illustrated a schematic block diagram of an electronic device **100** for providing a DSSS signal. The electronic device **100** is typically a single or two way radio communication device, it may also form part of a computer or other processing unit coupled to a network by a wired communication link or radio link. The electronic device **100** includes a combined common modulation pseudo noise sequence generator and a demodulation pseudo noise sequence generator hereafter referred to as pseudo noise sequence generator **110**. The electronic device **100** also has a modulator **140** with a modulator output and a digital signal providing circuitry **130** coupled to a signal input of modulator **140**. The pseudo noise sequence generator **110** has a sequence output coupled to an input of the modulator **140**. There is also an output unit **150** coupled to the output of the modulator **140**.

[0019] The electronic device **100** also includes a demodulator **170** with a demodulator output and an input unit **160** indirectly coupled to the demodulator **170** by a buffer **180**. It will be apparent to a person skilled in the art that buffer **180** may form part of input unit **160**. The pseudo noise sequence generator **110** has a sequence output coupled to an input of the demodulator **170** and an output of the demodulator **170** is coupled to digital data store **175**. In order to provide synchronization of signals and pseudo noise sequences to modulator **140** and demodulator **170**, the electronic device **100** includes a clock **185** with outputs coupled to a processor **190** (with associated memory not shown), pseudo sequence generator **110** and buffer **180**. The clock is also indirectly coupled through dividing circuitry **210** to a digital signal providing circuitry **130**. The output unit **150** includes a radio transmitter coupled to an antenna **200**. The input unit **160** includes a radio receiver coupled to antenna **200**.

[0020] There is also a user interface **220** having, in one embodiment, a microphone **230**, a speaker **240**, an input command or data device **250** (typically in the form of a keypad or interactive display screen) and an optional display screen **260**. The microphone **230** and command device **250** are coupled to the digital providing circuitry **130** and a bus **270** couples processor **190** to the user interface, the pseudo noise sequence generator **110**, data store **175**, buffer **180** and a communication port **165** comprising the output unit **150** and input unit **160**. The output unit **150** has a radio transmitter for transmitting spread spectrum signals by radio waves at common antenna **200**. Input unit **160** has a radio receiver coupled to common antenna **200**. There is also a transmitter modem **290** forming part of output unit **150** and a receiver modem **280** forming part of input unit **160**. Alternatively, output unit **150** and input unit **160** may be compatible for direct network connection (by a wired communication link or otherwise), and provide an Ethernet port at a port node **300** of the communication port **165**.

[0021] The pseudo noise sequence generator **110** includes a pseudo noise sequence combiner **310** coupled to a finite state machine **320**. An output from the sequence combiner **310** is coupled to the sequence input of the modulator **140** and an input of the demodulator **170**.

[0022] Referring to **FIG. 2** there is illustrated a first preferred embodiment of schematic block diagram of the pseudo noise sequence generator **110** that includes the finite state machine **320** and pseudo noise sequence combiner **310**. As will be apparent to a person skilled in the art, the finite state machine **320** can be implemented by a non-liner feedback shift register configuration or by pseudo random numbers stored in memory (typically a Read Only Memory). The pseudo noise sequence combiner **310** includes a decoding circuit **400** coupled to the bus **270**, with a decoding circuit output providing a control signal to an N bit shift register **410**. The finite state machine **320** has an N bit output bus each bit being coupled to a corresponding bit of the shift register **410**. The clock **185** is also coupled to the shift register **410** and decoding circuit **400**.

[0023] The Finite State Machine **320** has M states and each state is represented by a unique sequence of N random bits, where M and N can be any positive integer. For each time interval T, corresponding to a clock cycle at an output of the dividing circuitry **210**, one data bit from the digital providing circuitry **130** is provided to modulator **140**. Further, for each time interval T, the generated N random bit values by the Finite State Machine **320** are concurrently loaded into respective bits of the shift register **410**, the loading being controlled by the decoding circuit **400** which counts the number of clock cycles from the clock **185**. Once N random bit values are loaded into to shift register **410**, they are shifted out to the modulator **140** during the time interval T. The pseudo noise sequence combiner **110** sequentially combines all N random bit values from all M states to provide output pseudo noise sequence whose period is M*T. Referring to both **FIGS. 1 and 2**, for each time interval T, the Modulator **140** receives one bit from the digital signal providing circuitry **130** and a sequence of N random bits from the pseudo noise sequence generator **110**. Within each time interval T, the output waveform from the Modulator **140** varies with the value of the bit from the digital signal providing circuitry **130** and the bit sequence of N random bits from the pseudo noise sequence generator **110**. The Modulator **140** modulates the pseudo noise sequence generated by the pseudo noise sequence generator **110** with the output of the digital signal providing circuitry **130** by digital signal modulation, resulting in a DSSS signal which is provided to the output unit **150**.

[0024] The digital providing circuitry **130** is basically a buffer that receives data from the user interface **220**. The electronic device **100** may also receive a spread spectrum signal at the input unit **160**. This received spread spectrum signal is stored in the buffer **180** and demodulated by demodulator **170**, wherein for each time interval T the demodulator **170** receives N bits from the buffer **180** and a sequence of N random bits from the pseudo noise sequence generator **110**. The demodulated output from demodulator **170** is then stored in the data store **175** and if desired contents from this data store **175** can be sent to the user interface **220**.

[0025] Referring to **FIG. 3** there is illustrated a second preferred embodiment of schematic block diagram of the pseudo noise sequence generator **110**. In this embodiment, the finite state machine **320** is a J (J>=N) bit shift register **600**. Adjacent N arbitrarily assigned random bits of the shift register **600** provide a pseudo noise sequence for modulating one bit from the digital providing circuitry **130**. Each adjacent N bits that provide a pseudo noise sequence can be conceptually regarded as one of M (M<=J) states of a Finite

State Machine. An output from each bit of the shift register **600** is coupled to a multiplexer **610**. The multiplexer **610** has a serial output **620** and is coupled to receive instructions from bus **270**. The output from the Jth bit is also fed back, by a feedback loop **650**, to the first bit of the shift register **600**. The pseudo noise sequence generator **110** can provide an extended pseudo noise sequence of, for example, M*N bits. The pseudo noise generator **110** is initialised with a seed value that is effected after a command signal is provided by bus **270** to shift register **600**. The pseudo noise generator **110** operates by firstly receiving a multiplexer control signal from bus **270** which enables serial output **620** and selects one of the J bits of shift register **600** to be coupled to output **620**. A clock signal from clock **185** provides a shifting of data in the J bits and an enable signal to the multiplexer **610** so that the serial output **620** is only enabled during steady state conditions. In operation, after N clock cycles there will have been N bits provided at serial output **620**. To provide an extended pseudo noise sequence, M of the J bits in the shift register **600** can be selected to be transparent to serial output **620** by providing multiplexer control signals to multiplexer **610**. After M*N clock cycles, both multiplexer **610** and shift register **600** are reset and an extended pseudo noise sequence of period M*N can be provided at serial output **620**.

[**0026**] In **FIG. 4**. there is illustrated a schematic block diagram of a spread spectrum signal communication system **700** comprising a plurality of electronic devices **100** communicating with each other either by port nodes **300** coupled by wired communication links **305** or by antennas **200** using radio waves. As will be apparent to a person skilled in the art, received spread spectrum signals may be asynchronous and therefore synchronization techniques are used to demodulate the spread spectrum signal. One of the synchronization techniques is to correlate the received signal with the local pseudo noise sequence and find the maximum output of the correlation. Thus the received signal is synchronized at the epoch when the maximum correlation is reached.

[**0027**] The present invention operates such that the digital signal providing circuitry **130** typically receives data from the user interface. The digital signal providing circuitry **130** then provides data bits each of which is modulated, by modulator **140**, with a pseudo noise sequence supplied from said modulation pseudo noise sequence generator **110** to thereby provide a spread spectrum signal that is transmitted by the output unit **150**. Synchronization of modulation of data bits from the digital signal providing circuitry **130** with a pseudo noise sequence is provided by the clock **185** and dividing circuitry **210**. Similarly, a spread spectrum signal received by the input unit **160** is temporarily stored in the buffer **180** and then demodulated, by the modulator **170**, with the pseudo noise sequence supplied from the demodulation pseudo noise sequence generator **110** to thereby provide a digital signal.

[**0028**] At the system level, the electronic devices **100** communicate using the spread spectrum signal transmitted using the wired communication links **305** or by radio waves linked by the antennas **200**. The invention may therefore alleviate at least one of the communication problems associated with spectral peaks or spectral lines.

[**0029**] Advantageously, by using extended pseudo noise sequence to modulate each bit of the digital signal provided from the digital signal providing circuitry, spectral properties are improved substantially. In this regard, by using an extended pseudo noise sequence, a normalized maximum power spectral density value can be shown to be 1+1/N if the original pseudo noise sequence is an m-sequence of period N. Further, the power spectral density has an envelope that is nearly flat and is basically nearly white in spectrum which can cause less interference to other communications.

[**0030**] Although the invention has been described with reference to preferred embodiments it is to be understood that the invention is not restricted to the particular embodiments described herein.

We claim:

1. An electronic device for providing a spread spectrum signal, said device comprising:

a modulator having a modulator output;

digital signal providing circuitry having a signal output coupled to a signal input of said modulator;

a modulation pseudo noise sequence generator having a sequence output coupled to a sequence input of said modulator; and

an output unit coupled to said modulator output, wherein, in use, said digital signal providing circuitry provides data bits each of which is modulated, by said modulator, with a pseudo noise sequence supplied from said modulation pseudo noise sequence generator to thereby provide the spread spectrum signal that is transmitted by said output unit.

2. An electronic device as claimed in claim 1, wherein said output unit includes a radio transmitter.

3. An electronic device as claimed in claim 1, wherein said output unit includes a modem.

4. An electronic device as claimed in claim 1, wherein said output unit provides for connection and transmission of said spread spectrum signal to a wired communication link.

5. An electronic device as claimed in claim 1, wherein said pseudo noise sequence generator includes a finite state machine.

6. An electronic device as claimed in claim 5, wherein said modulation pseudo noise sequence generator includes a sequence combiner coupled to said finite state machine, wherein, in use, pseudo noise data bits associated with cyclical states of said finite state machine are sequentially combined into a sequence by said sequence generator to provide said pseudo noise sequence.

7. An electronic device as claimed in claim 1, wherein modulation of said data bits with a pseudo noise sequence are synchronized.

8. An electronic device as claimed in claim 1, wherein said electronic device is a radio communication device.

9. An electronic device as claimed in claim 3, wherein said electronic device is a two-way radio communication device.

10. An electronic device as claimed in claim 1, wherein said digital signal providing circuitry is coupled to a microphone.

11. An electronic device as claimed in claim 1, wherein said signal providing circuitry includes a digital data store.

12. An electronic device as claimed in claim 1, wherein said electronic device includes:

a demodulator having a demodulator output;

a demodulation pseudo noise sequence generator having a output coupled to an input of said demodulator; and

an input unit with an output coupled to said demodulator wherein, in use, a spread spectrum signal received by said input unit is demodulated, by said demodulator, with a pseudo noise sequence supplied from said demodulation pseudo noise sequence generator to thereby provide a digital signal.

13. An electronic device as claimed in claim 1, wherein state transitions of said receiving finite state machine are synchronized with said spread spectrum signal.

14. A spread spectrum signal communication system, said system comprising:

a communication link; and

a plurality of electronic devices in communication with each other by said communication link, said electronic devices comprising:

a modulator having a modulator output;

digital signal providing circuitry having a signal output coupled to a signal input of said modulator;

a modulation pseudo noise sequence generator having a sequence output coupled to a sequence input of said modulator; and

an output unit coupled to said modulator output, wherein, in use, said digital signal providing circuitry provides data bits each of which is modulated, by said modulator, with a pseudo noise sequence supplied from said modulation pseudo noise sequence generator to thereby provide a spread spectrum signal that is transmitted by said output unit.

15. A spread spectrum signal communication system as claimed in claim 14, wherein said output unit includes a radio transmitter.

16. A spread spectrum signal communication system as claimed in claim 14, wherein said output unit includes a modem.

17. A spread spectrum signal communication system as claimed in claim 14, wherein said output unit provides for connection and transmission of said spread spectrum signal to a wired communication link.

18. A spread spectrum signal communication system as claimed in claim 14, wherein said modulation pseudo noise sequence generator includes a finite state machine.

19. A spread spectrum signal communication system as claimed in claim 18, wherein said modulation pseudo noise sequence generator includes a sequence combiner coupled to said finite state machine, and wherein, in use, pseudo noise data bits associated with cyclical states of said finite state machine are sequentially combined into a sequence by said sequence generator to provide said pseudo noise sequence.

20. A spread spectrum signal communication system as claimed in claim 14, wherein modulation of said data bits with a pseudo noise sequence are synchronized.

21. A spread spectrum signal communication system as claimed in claim 14, wherein said electronic device is a radio communication device.

22. A spread spectrum signal communication system as claimed in claim 14, wherein said electronic device is a two-way radio communication device.

23. A spread spectrum signal communication system as claimed in claim 14, wherein said digital signal providing circuitry is coupled to a microphone.

24. A spread spectrum signal communication system as claimed in claim 14, wherein said signal providing circuitry includes a digital data store.

25. A spread spectrum signal communication system as claimed in claim 14, wherein said electronic device includes:

a demodulator having a demodulator output;

a demodulation pseudo noise sequence generator having a output coupled to an input of said demodulator; and

an input unit with an output coupled to said demodulator wherein, in use, a spread spectrum signal received by said input unit is demodulated, by said demodulator, with a pseudo noise sequence supplied from said demodulation pseudo noise sequence generator to thereby provide a digital signal.

26. A spread spectrum signal communication system as claimed in claim 14, wherein state transitions of said receiving finite state machine are synchronized with said spread spectrum signal.

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