A short-range communication system includes an antenna, a transmitter, and a receiver. The antenna is an electrical conductor formed as a planar coil with rings thereof being uniformly spaced. The transmitter is spaced apart from the plane of the coil by a gap. An amplitude-modulated and asynchronous signal indicative of a data stream of known peak amplitude is transmitted into the gap. The receiver detects the coil's resonance and decodes same to recover the data stream.

17 Claims, 2 Drawing Sheets
SHORT-RANGE COMMUNICATION SYSTEM

ORIGIN OF THE INVENTION

The invention described herein was made by employees of the United States Government and may be manufactured and used by or for the Government of the United States for governmental purposes without the payment of any royalties thereon or therefore.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to wireless communication systems. More specifically, the invention is short-range communication for simultaneous gap sensing and wireless data transfer.

2. Description of the Related Art

Small gap sensing is utilized in a variety of robotic applications. Ideally, a gap is sensed by some type of non-contact apparatus using optical sensing, acoustic sensing, magnetic field sensing, etc. These devices and/or systems are single-function devices/system generally only capable of determining proximity between a “transmitter” and a “receiver” that are spaced-apart from one another. While such single-function devices/systems work, multi-function devices/systems are preferred for cost effectiveness and improved overall system operation.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a multi-function, short range communication system for sensing a gap and transmitting information across the gap.

Other objects and advantages of the present invention will become more obvious hereinafter in the specification and drawings.

In accordance with the present invention, a short-range communication system includes an antenna defined by an electromagnetic wave 120 across a gap region 20 defined between transmitter 12 and antenna 14. In general, the waveform that defines wave 120 is indicative of data that is to be communicated to receiver 16. An example of such a waveform is referenced by numeral 122. The length of gap region 20 is referenced by “L” in FIG. 1. While the particular length L is not a limitation of the present invention, typical values for L are preferred for cost effectiveness and improved overall system operation.

BRIEF DESCRIPTION OF THE DRAWING(S)

FIG. 1 is a top-level block diagram of a short-range communication system in accordance with the present invention.

FIG. 2 is a diagram of a mobile transmitter in accordance with an embodiment of the present invention.

FIG. 3 is a plan view of a coil antenna in accordance with an embodiment of the present invention.

FIG. 4 is a schematic view of a multi-function, short-range communication system in accordance with an embodiment of the present invention.
various other ways (e.g., made on a silicon die for MEMS applications) without departing from the scope of the present invention.

Regardless of the particular construction of conductor 140/substrate 142, conductor 140 is arranged to define uniformly-spaced rings with portions of the rings being parallel to one another and to a planar axis 144 of the coiled arrangement of conductor 140. In terms of gap sensing, this antenna embodiment will be sensitive to gap changes anywhere along axis 144. Accordingly, this type of antenna design is well-suited for applications that permit or provide for relative movement between the system's transmitter and antenna along axis 144.

A more detailed example of a multi-function, short-range communication system in accordance with the present invention is shown in FIG. 4 and is referenced by numeral 50.

Similar to system 10, communication system 50 includes a transmitter 52, an antenna 54, and a receiver 56. Transmitter 52 has an alternating current (AC) excitation waveform source 520 that generates a carrier frequency signal. The particular frequency of the generated signal is not a limitation of the present invention. The carrier signal generated by source 520 is passed through a switch 522 before being applied to a transmission antenna 524 (e.g., a non-shielded, coil inductor). Switch 522 can be an on/off type switch that passes/inhibits the signal from source 520 based on an on/off control signal applied thereto at 522A. In the present invention, control signal 522A is a serial digital data stream (e.g., data stream 526) indicative of data that is to be communicated across gap region 20. Data stream 526 can originate within transmitter 52 or can be supplied thereto from an external source (not shown) without departing from the scope of the present invention. Switch 522 uses the carrier signal from source 20 and data stream 526 to output an amplitude modulated asynchronous signal indicated by numeral 528. Signal 528 has known peak amplitude "A" that is provided to receiver 56 or known "a priori" by receiver 56. Signal 528 is applied to antenna 524 where an electromagnetic wave indicative thereof is transmitted into gap region 20.

Antenna 54 is disposed on the other side of gap region 20 and can be configured as described above. For example, antenna 54 could be constructed as shown in FIG. 3 in which case transmitter 52 and/or antenna 54 can be coupled to a device(s) that causes relative movement therebetween on either side of gap region 20.

Receiver 56 is coupled to antenna 54 in order to detect the resonance thereof caused by the electromagnetic wave output of antenna 524. As mentioned above, receiver 56 decodes the detected resonance to sense changes in gap region 20 and reconstruct data stream 526 being communicated to receiver 56. While these functions can be achieved by a variety of electronics methods, a simple approach is illustrated by way of example. The basic goal of the decoding function is to remove the carrier frequency from the resonance signal generated by antenna 524. In the illustrated embodiment, this is achieved by the combination of a squaring circuit 560, a demodulating circuit 562, and a filter 564 (e.g., a low pass filter when the carrier frequency is high relative to the frequency of data stream 526).

Squaring circuit 560 and demodulating circuit 562 each receive the detected resonance signal 566 from antenna 54. Resonance signal 566 will be of the form of signal 528 but with reduced peak amplitude "B" where B is less than A and is in proportion to the length L of gap region 20. Squaring circuit 560 generates a squared version of resonance signal 566 that is supplied to demodulating circuit 562. The resulting output of demodulating circuit 562 is applied to filter 564 where the carrier frequency (associated with the carrier signal generated by source 520) is removed. The output of filter 564 is a demodulated data stream 568 that resembles data stream 526 except that the peak amplitude of data stream 568 is affected by gap region 20. Accordingly, a processor 570 (or other monitoring circuit) can be used to monitor the peak amplitude of data stream 568 and compare same to the peak amplitude A of signal 528 (e.g., known "a priori" or provided to processor 570). Changes in the peak amplitude of data stream 568 are indicative of changes in length L of gap region 20. Thus, processor 570 completes the gap sensing function of communication system 50.

The final signal reconstruction step is performed by a signal conditioning circuit 572 that restores the amplitude of data stream 568 to acceptable transistor-transistor logic (TTL) levels. For example, signal conditioning circuit 572 could increase the peak amplitude of data stream 568 to that of data stream 526. In such a case, the resulting output of circuit 572 (i.e., data stream 574) is identical to data stream 526 to complete the data communication function of communication system 50.

The advantages of the present invention are numerous. Gap sensing and data communication are performed simultaneously by the same system in a non-contact fashion. The antenna used to receive an airborne data transmission can be readily designed for relative movement with respect to the system's transmitter. Thus, the present invention will be particularly useful in a variety of robotic systems where small gaps must be sensed and/or maintained between two devices, and where data needs to be communicated between the two devices when such gaps exist.

Although the invention has been described relative to a specific embodiment thereof, there are numerous variations and modifications that will be readily apparent to those skilled in the art in light of the above teachings. For example, the system's transmitter could also be configured to receive transmissions in which case the communication system could provide bi-directional communication. In addition, the present invention is not limited to single-transmitter/single-receiver system described herein. For example, a master/slave (or half-duplex) system could also be constructed based on the principles described herein without departing from the scope of the present invention. It is therefore to be understood that, within the scope of the appended claims, the invention may be practiced other than as specifically described.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A short-range communication system, comprising:
   an antenna defined by an electrical conductor arranged in a plane, said conductor forming a coil with rings thereof being uniformly spaced;
   a transmitter spaced apart from said plane of said coil by a gap, said transmitter transmitting an electromagnetic wave towards said coil, said wave being an amplitude-modulated and asynchronous signal indicative of a data stream of known peak amplitude wherein said coil is excited to resonance in correspondence with said amplitude-modulated and asynchronous signal; and
   a receiver coupled to said coil for detecting said resonance and an actual peak amplitude associated therewith wherein said actual peak amplitude is indicative of the magnitude of said gap, said receiver further decoding said resonance to recover said data stream.

2. A short-range communication system as in claim 1, further comprising a non-conductive planar substrate, said conductor being mounted on said substrate.

3. A short-range communication system as in claim 2, wherein said conductor is printed on said substrate.
4. A short-range communication system as in claim 1, wherein said transmitter comprises:
a signal source for generating an alternating current (AC) signal; and
means, coupled to said signal source and adapted to be
coupled to a digital source generating said data stream,
for using said AC signal and said data stream to transmit
said wave into said gap.
5. A short-range communication system as in claim 4,
wherein said means includes a switch for permitting said AC
signal to be transmitted into said gap only when said data
stream defines a digital “1”.
6. A short-range communication system as in claim 1,
wherein said receiver comprises:
a demodulator electrically coupled across said coil for
generating a digital signal from said resonance, said
digital signal defined by said actual peak amplitude; and
a signal conditioner coupled to said demodulator for
increasing said actual peak amplitude of said digital
signal.
7. A short-range communication system as in claim 1,
further comprising means coupled to at least one of said
antenna and said transmit for causing relative movement
therebetween.
8. A short-range communication system, comprising:
an antenna defined by an electrical conductor having a first
end and a second end, said conductor formed in a plane
as a coil with portions of said coil being uniformly
spaced and parallel along an axis of said plane;
a transmitter spaced apart from said plane of said coil by a
gap, said transmitter transmitting an electromagnetic
wave towards said coil, said wave being an amplitude-
modulated and asynchronous signal; and
a transmitter spaced apart from said plane plane of said coil by a
gap, said transmitter transmitting an electromagnetic
wave towards said coil, said wave being an amplitude-
modulated and asynchronous signal, said transmit-
er further being adapted for movement in a direction
aligned with said axis; and
a receiver coupled to said first end and said second end of
said coil for detecting said resonance and an actual peak
amplitude associated therewith wherein said actual peak
amplitude is indicative of the magnitude of said gap, said
receiver further decoding said resonance to recover said
data stream.
9. A short-range communication system as in claim 8,
further comprising a non-conductive planar substrate, said
conductors being mounted on said substrate.
10. A short-range communication system as in claim 9,
wherein said conductor is printed on said substrate.
11. A short-range communication system as in claim 8,
wherein said transmitter comprises:
a signal source for generating an alternating current (AC)
signal; and
an on/off switch coupled to said signal source and adapted
to have its on/off operation controlled by a digital source
generating said data stream wherein said AC signal is
converted to said wave for transmission into said gap.
12. A short-range communication system as in claim 8,
wherein said receiver comprises:
a demodulator electrically coupled across said coil for
generating a digital signal from said resonance, said
digital signal defined by said actual peak amplitude; and
a signal conditioner coupled to said demodulator for
increasing said actual peak amplitude to said known
peak amplitude of said data stream.
13. A short-range communication system, comprising:
an antenna defined by an electrical conductor having a first
end and a second end, said conductor formed in a plane
as a coil with portions of said coil being uniformly
spaced and parallel along an axis of said plane;
a transmitter spaced apart from said plane of said coil by a
gap, said transmitter transmitting an electromagnetic
wave towards said coil, said wave being an amplitude-
modulated and asynchronous signal indicative of a data
stream of known peak amplitude wherein said coil is
excited to resonance in correspondence with said ampli-
tude-modulated and asynchronous signal;
means coupled to said transmitter for moving said trans-
mittor in a direction aligned with said axis; and
a receiver coupled to said first end and said second end of
said coil for detecting said resonance and an actual peak
amplitude is indicative of the magnitude of said gap, said
receiver further decoding said resonance to recover said
data stream.
14. A short-range communication system as in claim 13,
further comprising a non-conductive planar substrate, said
conductors being mounted on said substrate.
15. A short-range communication system as in claim 14,
wherein said conductor is printed on said substrate.
16. A short-range communication system as in claim 13,
wherein said transmitter comprises:
a signal source for generating an alternating current (AC)
signal; and
an on/off switch coupled to said signal source and adapted
to have its on/off operation controlled by a digital source
generating said data stream wherein said AC signal is
converted to said wave for transmission into said gap.
17. A short-range communication system as in claim 13,
wherein said receiver comprises:
a demodulator electrically coupled across said coil for
generating a digital signal from said resonance, said
digital signal peak amplitude; and
a signal conditioner coupled to said demodulator for
increasing said actual peak amplitude to said known
peak amplitude of said data stream.

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