

TRANSMITTER AND METHOD FOR SUBSTANTIALLY REDUCING DEAD ZONES IN AN INDUCTIVE CONTACTLESS MOBILE PAYMENT SYSTEM

RELATED APPLICATIONS

5 This application claims the benefit of U.S. Patent Application No. 14/627,958, filed on February 20, 2015, which claims the benefit of U.S. Provisional Patent Application No. 62/103,237, filed on January 14, 2015, the contents of which are incorporated by reference herein in their entirety.

10 BACKGROUND

Transmission of magnetic stripe data has been done primarily by swiping a magnetic stripe card against a magnetic stripe reader (MSR) to enable payment, identification (ID), and access control functions. Mobile wallet applications on smartphones and tablets have had difficulty interacting with existing merchant point of sale (POS) devices or other devices with
15 MSRs. Contactless reader enabled POS terminals (typically using, for example, an ISO-14443 standard) are not ubiquitous to accept contactless or near field communications (NFC) payments. It would be expensive and would take time to replace the millions of merchant POS devices (or door locks) that only accept magnetic stripe cards, just to interact with NFC phones or other transmission means like barcodes.

20 In recent years devices, systems, and methods have been developed that included a magnetic stripe capture, storage and transmission device for use in conjunction with a mobile wallet application to capture, store and transmit magnetic stripe card data to merchants' conventional point of sale (POS) terminals and other devices with magnetic stripe readers (MSRs) or checkout systems, in physical and virtual environments. These systems provide a
25 convenient payment experience for consumers, a secure transaction for merchants, and in some cases additional data to be transmitted to a MSR for the purpose of loyalty, identification (ID), or access control.

One system developed by LoopPay Inc of Burlington, MA for securely capturing, storing and transmitting magnetic stripe payment card data includes a mobile communication
30 device and mobile application, and a magnetic stripe transporter dongle. The magnetic stripe transporter dongle includes a microprocessor, magnetic field transmitter which includes a driver and an inductor that can generate varying magnetic fields, a battery, a charging circuit, a magnetic stripe reader (MSR), a memory means or secure element, an audio jack interface, and a communication interface (for example, a USB interface, a 30pin
35 or 9pin Apple interface, a Bluetooth interface, etc.) working in conjunction with a

consumer mobile device and wallet application for capturing magnetic stripe card data, storing the data securely, and transmitting such data to merchants' point of sale (POS) or checkout systems, in the physical and virtual environments.

[0005] The Magnetic Secure Transmission (MST) technique magnetically couples simulated
5 magnetic stripe data into a POS magnetic stripe reader (MSR) **101** from a distance of 30 to 40 mm. An alternating polarity magnetic field **102** is generated by driving alternating polarity current through a suitably designed inductor. The MSR head, which contains an inductor, picks up the magnetic pulses and converts them to voltage pulses, which in turn are decoded by the reader circuit and terminal logic. This is schematically shown in **FIG. 1**.

10 However, in real life, inductors, including NFC inductors, do not have isotropic fields. Flat inductors, for example, tend to have doughnut shaped fields. Other inductors generate different field shapes.

The overlapping field patterns of the MST transmitter inductor and the reader head inductor result in one or more nulls: narrow areas where no signal transfer takes place.
15 Depending on the inductor topology, these nulls can be either on the center-line of the reader head, or along the edges off to the sides. Nulls affect the reliability of card data transmissions. While users quickly learn in which position their LoopPay device works best, some inconvenience and the need for two or three tries results at times. When MST is integrated into a smart-phone, which is larger than a LoopPay device, precise placement is
20 less likely and therefore first-time MST transmission success rate suffers.

SUMMARY OF INVENTION

In an aspect, a transmitter to generate a signal to be read by a reader is described. The transmitter includes a driver circuit; and at least two inductors connected to the driver circuit.
25 The driver circuit controls the current flow through the inductor and the current flow results in a signal such that the signal strength is above the detection limit of the reader for each of the inductors which may have at least one null region. Additionally, the inductors are positioned such that the null regions of the inductors do not overlap.

In some embodiments, the inductors are positioned to produce regions where the
30 signal strength is greater than the detection limit of the reader to result in good data read.

In some embodiments, the transmitter has only two inductors.

In some embodiments, the transmitter has at least one inductor that is an L-mode inductor and in other embodiments, the transmitter has at least one inductor that is an X-mode inductor.

In some embodiments, the L-mode inductor further comprises a conductive material. The conductive material may be selected from a group consisting of a metal wire, a printed circuit board, and stamped sheet metal shapes. The conductive material maybe plated or coated with a material selected from a group consisting of enamel, acrylic or plastic. In yet
5 other embodiments, the conductive material is shaped in the form selected from the group consisting of irregular, circle, polygon, rectangle, square, and triangle.

In some embodiments, the X-mode inductor further comprises a core, which may be made of ferrite. In some other embodiments, the core has a cross-sectional shape selected from the group consisting of irregular, circle, polygon, rectangle, square, and triangle.

10 In some embodiments, at least one inductor is an L-mode inductor and at least one inductor is an X-mode inductor. In other embodiments, all the inductors are L-mode inductors or, all the inductors are X-mode inductors.

In some embodiments, at least one inductor does not have its null region, where the signal strength is below the detection limit of the reader, positioned above the reader.

15 In some embodiments, the regions of the inductors where the signal strength is greater than the detection limit of the reader are contiguous and increase the total area where the signal strength is greater than reader detection limit. In some embodiments, the driver circuit flows the current through multiple inductors at the same time. In other embodiments, the driver circuit flows the current through multiple inductors at the separate times.

20 In another aspect, a method of driving a transmitter is described that includes a driver circuit and at least two inductors connected to the driver circuit with each inductor having at least one null region with a signal strength below the detection limit of a signal reader, wherein the driver circuit controls the current flow through the inductor that results in a signal, said method includes the steps of:

25 (a) positioning the at least two inductors in the transmitter so that the null regions of the inductors do not overlap; and

(b) flowing current through the at least two inductors to generate a composite signal.

In some embodiments, the method of driving the transmitter includes, flowing current
30 through only one inductor at a given time. In some other embodiments, the composite signal has a null region wherein the signal strength is below the detection limit of the reader. In some embodiments, the composite signal has a signal strength skewed towards one side of the reader. In some embodiments, the null region of the composite signal is located at a unique location with no overlap with the null regions of the individual inductors of the transmitter.

In some embodiments, the method of driving the transmitter includes the step of flowing current through the at least two inductors. The flowing of the current further includes alternating between flowing current through a plurality of the inductors at a given time and flowing current through only one inductor at a given time. In some embodiments, the step of
5 flowing current through the at least two inductors includes having the current flow in the same direction through all the inductors. In some other embodiments, the step of flowing current through the at least two inductors includes having at least one inductor having the current flow in the opposite direction as compared with all the other inductors.

In an aspect the transmitter includes a single inductor connected to a driver circuit. The
10 driver circuit controls the current flowing through the inductor resulting in a transmission and the driver circuit passes the current through the inductor multiple times while the inductor is moved relative to a card reader head passing through a number of positions. At at least one of the number of positions the inductor passes through, the inductor produces a transmission signal that is greater than the card reader threshold for a good data read.

15 In an aspect, the method includes passing current multiple times, controlled by a driver circuit, through a transmitter including a single inductor to produce a signal for transmission while the inductor is moved relative to a card reader head passing through a number of positions. At at least one of the number of positions the inductor passes through, the inductor produces a transmission signal that is greater than the card reader threshold for a good data
20 read.

BRIEF DESCRIPTION OF DRAWINGS

The following Figures are provided for the purpose of illustration only and are not intended to be limiting.

25 **FIG. 1** shows a schematic of Magnetic Secure Transmission (MST) system utilized in the present invention.

FIG. 2 shows a schematic of the transmitter according to the present invention.

FIG. 3 shows a schematic of the voltages induced by a flat, horizontal inductor into a typical POS terminal's card reader-head from different relative positions along the card reader
30 swipe slot.

FIG. 4 shows the mutual magnetic coupling between the MST transmitter inductor shown in **FIG. 2** and the magnetic stripe reader head inductor to transfer simulated track data to the POS terminal **403** where the coupling is very low or zero **401** and the reader threshold below which transmissions fail.

FIG. 5A and **5B** shows two examples of an L-mode inductor used in the transmitter of **FIG. 2** where the copper wire is used as the conductive material and is wound in a rectangular shape.

FIG. 6A and **6B** shows two examples of an X-mode inductor used in the transmitter of **FIG. 2** where copper wire is used as the conductive material and the core has a circular cross-section and a rectangular cross-section, respectively.

FIG. 7A shows an embodiment of the present invention with the transmitter shown in **FIG. 2** including three inductors where one inductor is an L-mode inductor and the other two inductors are X-mode inductors.

FIG. 7B shows an embodiment of the present invention with the transmitter shown in **FIG. 2** including two inductors where both the inductors are L-mode inductors.

FIG. 7C shows an embodiment of the present invention the transmitter shown in **FIG. 2** including with two inductors where both the inductors are X-mode inductors.

FIG. 8 shows a schematic of an eccentric inductor utilized in the transmitter shown in **FIG. 2** where the centers of the Inductors are separated by 1 to 2 cm.

FIG. 9 shows the schematic of the two induced signal levels **901** and **902** of the two inductors A and B whose centers are offset.

FIG. 10 shows three signal patterns possible with two inductors used in the transmitter of **FIG. 2** when used individually, or in combination.

FIG. 11 shows an H bride drive that can be used to drive the current flow through the inductors.

FIG. 12A shows an example of positive phasing with the current flowing in the transmitter of **FIG. 2** in the same direction for both inductor A and B.

FIG. 12B shows an example of negative phasing with the current flowing in the transmitter of **FIG. 2** in the opposite direction for both inductors A and B.

FIG. 13 shows the composite field shapes of inductors A and B used in the transmitter of **FIG. 2** with positive phasing and negative phasing.

DETAILED DESCRIPTION

A transmitter **200** to generate a signal to be read by a reader is described. The transmitter **200** includes a driver circuit; and at least two inductors, **201** and **202**, connected to the driver circuit **203** and **204**, respectively. The driver circuit controls the current flow through the inductors and the current flows result in a magnetic fields. The magnetic fields include areas where the signal strength is below the detection limit of the reader for each of

the inductors, **201** and **202**, which forms at least one null region. Additionally, the inductors, **201** and **202**, are positioned such that the null regions of the inductors do not overlap.

FIG. 2 shows a schematic of the transmitter **200** according to the present invention. Inductor A **201** and Inductor B **202** are driven by driver circuits A **203** and **204**, respectively.

5 The voltages induced by a flat, horizontal inductor **301** into a typical POS terminal's card reader-head **302** from different relative positions along the card reader swipe slot, is shown in **FIG. 3**. Signal transfer **303** on either side of the head **302** is strong but it diminishes closer to the center of the head **302** and becomes zero right over the head's center. A null region **304** forms in the area where the induced signal is below the reader threshold
10 **305**. The null regions can be 5 to 20 mm wide. When the user holds the MST device in the null region transmissions often fail, requiring a second or third attempt to get a good read.

The width of the null depends on the size of the inductor, the intensity of the inductor current and the sensitivity of the POS card reader. The null can be made narrower by driving more current through the inductor but it cannot be completely eliminated, although with proper
15 inductor design it can be made small enough to have less impact on use.

MST uses mutual magnetic coupling between the MST transmitter inductor **301** and the magnetic stripe reader head inductor **302** to transfer simulated track data to the POS terminal. Coupling between inductors is influenced by their physical properties and relative positions. There are certain relative positions of the inductors where the coupling is very low or zero. These
20 locations, called nulls, effect reliability and cause users to try transmissions a number of times. Similar problems also plague applications using NFC chips. The method of the present invention is capable of working with NFC transmitters to successfully eliminate NFC inductor null regions.

FIG. 4 shows the null region **401** from an analog test, where the same inductor is continuously feed with a square wave and is moved along the card reader slot (x axis) while
25 the signal level **402** picked up by the reader head **403** is displayed on the Y axis. At the left extreme the inductor is too far from the head to produce a detectable signal. As the inductor is moved towards the reader head (center) the signal first increases and peaks at about 2 cm from the head. As the inductor keeps moving and gets closer to the head, the signal drops below the reader threshold **404** to form the first effective area **405**. While continuing to
30 move forward towards the right, the signal level **402** drops further and becomes zero at the center of the head **403**. The signal level **402** starts increasing again as the inductor is moved away from the head **403** (to the right). A second effective area **406** is subsequently generated where the signal level **402** is above the reader threshold **404**. Between the two effective areas is a null. Each effective area is about 4 cm wide.

The inductor of the transmitter is an L-mode inductor, and the L-mode inductor may include a conductive material. The conductive material is selected from a group consisting of a metal wire, a printed circuit board, and stamped sheet metal shapes. The conductive material may also be plated. In some other embodiments, the conductive material is coated
 5 with a material selected from a group consisting of enamel, acrylic or plastic. In yet other embodiments, the conductive material is shaped in the form selected from the group consisting of irregular, circle, polygon, rectangle, square, and triangle. **FIG. 5A** and **5B** shows two examples of an L-mode inductor where the copper wire is used as the conductive material and is wound in a rectangular shape.

10 In some embodiments of the transmitter, at least one inductor is an X-mode inductor. The X-mode inductor may include a core, which may be made of ferrite. In some embodiments, the core has a cross-sectional shape selected from the group consisting of irregular, circle, polygon, rectangle, square, and triangle. **FIG. 6A** and **6B** shows two examples of an X-mode inductor where the copper wire is used as an the conductive material and the core has a circular
 15 cross-section and a rectangular cross-section, respectively.

In some embodiments, at least one inductor is an L-mode inductor and at least one inductor is an X-mode inductor. **FIG. 7A** shows an embodiment with three inductors, where one inductor is an L-mode inductor and the other inductors are X-mode inductors. When the transmitter has only two inductors, one inductor may be an L-mode inductor and the other
 20 inductor may be an X-mode inductor. In other embodiments, all the inductors are L-mode inductors. **FIG. 7B** shows an embodiment with two inductors where both the inductors are L-mode inductors. All of the inductors may also be X-mode inductors. **FIG. 7C** shows an embodiment with two inductors where both the inductors are X-mode inductors.

In an embodiment, the transmitter includes two eccentric inductors A and B that are
 25 driven separately or together. **FIG. 8** shows a schematic of an eccentric inductor where the centers of the Inductor A **801** and B **802** are separated by 1 to 2 cm. **FIG. 9** shows the schematic of the two induced signal levels **901** and **902** corresponding to the two inductors A **801** and B **802** whose centers are offset upon interaction with the reader head **903**. The offset centers of the inductors result in the nulls, where the signal levels **901** and **902** drop below the reader threshold
 30 **904**, for the respective inductors **801** and **802** to be offset.

The inductors with non-overlapping nulls can be used in two ways:

- 1) Individually, where the inductors are used at different times to transmit the same card data; if one inductor is in a null region and is not read by the reader, at least one other inductor, whose null is offset, will be read.

2) Combined, where the inductors are fed properly phased currents to create a composite field and a pattern where the fields of the inductors re-enforce each other in a desired direction and cancel in the other direction.

FIG. 10 shows three of the signal patterns possible with two inductors when used individually and in combination. The individual and combined shapes of signals from inductors A and B, respectively, offset by approximately 1 cm, are shown by lines A **1001** and B **1002**. The curve A+B **1003** shows the signal from inductor A+B combination, with proper phasing. It can be seen that the field generated by the combination of signal A+B is significantly stronger field on one side. This is normally configured to be towards the POS reader **1004**. The reader threshold **1005** is also shown in the **FIG. 10**.

FIG. 11 shows an H bridge drive A and B **1101** and **1102** that can be used to drive the current flow through the inductors A **1103** and B **1104**. One skilled in the art would understand that other drivers to control the current flow in the circuitry may be used alternatively.

In some embodiments, the step of flowing current through the at least two inductors includes having the current flow in the same direction through all the inductors. This is called positive phasing. In some other embodiments, the step of flowing current through the at least two inductors includes having at least one inductor having the current flow in the opposite direction as compared with all the other inductors. This is called negative phasing.

FIG. 12A shows an example of positive phasing with the current flowing in the same direction for both inductor A **1201** and B **1202**.

FIG. 12B shows an example of negative phasing with the current flowing in the opposite direction for both inductors A **1201** and B **1202**.

FIG. 13 shows the composite field shapes of inductors A **1201** and B **1202** with positive phasing **1301** and negative phasing **1302**. **FIG. 13** shows that the positive phasing produces a stronger magnetic field, while negative phasing produces a wider field. The null **1303** in the positive phasing mode is located at a different place than the null of either inductor A or B. It is noteworthy that while positive phasing will always have a null, negative phasing can make the null **1304** less deep, as shown in **FIG. 13**. In fact the null can be eliminated by adjusting the inductor current using a series resistor. However, the trade-off while eliminating the null in negative phasing is a weaker signal in the rest of the pattern.

The transmitter of the present invention uses at least two inductors with multiple transmissions that eliminate the effects of inductor nulls. The two inductors can be used either separately or at the same time. When used at the same time, the inductors are phased to create a composite magnetic field, which further increases diversity by moving the nulls and by

increasing the effective area.

In an aspect the transmitter includes a single inductor connected to a driver circuit. The driver circuit controls the current flowing through the inductor resulting in a transmission and the driver circuit passes the current through the inductor multiple times while the inductor is moved
5 relative to a card reader head passing through a number of positions. In at least one of the number of positions the inductor passes through, the inductor produces a transmission signal that is greater than the card reader threshold for a good data read.

In an aspect, the method includes passing current multiple times, controlled by a driver circuit, through a transmitter including a single inductor to produce a signal for transmission
10 while the inductor is moved relative to a card reader head passing through a number of positions. In at least one of the number of positions the inductor passes through, the inductor produces a transmission signal that is greater than the card reader threshold for a good data read.

Those skilled in the art would readily appreciate that all parameters and
15 configurations described herein are meant to be exemplary and that actual parameters and configurations will depend upon the specific application for which the systems and methods of the present invention are used. Those skilled in the art will recognize, or be able to ascertain using no more than routine experimentation, many equivalents to the specific embodiments of the invention described herein. It is, therefore, to be understood that the
20 foregoing embodiments are presented by way of example only and that the invention may be practiced otherwise than as specifically described. The present invention is directed to each individual feature, system, or method described herein. In addition, any combination of two or more such features, systems or methods, if such features, systems or methods are not mutually inconsistent, is included within the scope of the present invention.

25

What is claimed:

1. A transmitter to generate a signal to be read by a reader, comprising:
a driver circuit; and
at least two inductors connected to the driver circuit;
- 5 wherein the driver circuit controls the current flow through the inductor that results in a signal;
wherein each inductor has at least one null region, wherein the signal strength is below the detection limit of the reader; and
wherein the inductors are positioned such that the null regions of the inductors do not
10 overlap.
2. The transmitter of claim 1, wherein the inductors are positioned to produce regions where the signal strength is greater than the detection limit of the reader to result in good data read.
3. The transmitter of claim 1, wherein there are only two inductors.
- 15 4. The transmitter of claim 1, wherein at least one inductor is an L-mode inductor.
5. The transmitter of claim 1, wherein at least one inductor is an X-mode inductor.
6. The transmitter of claim 1, wherein the inductor further comprises a conductive material.
7. The transmitter of claim 6, wherein the conductive material is selected from a group
20 consisting of a metal wire, a printed circuit board, and stamped sheet metal shapes.
8. The transmitter of claim 6, wherein the conductive material is plated.
9. The transmitter of claim 6, wherein the conductive material is coated with a material selected from a group consisting of enamel, acrylic or plastic.
10. The transmitter of claim 6, wherein the conductive material is shaped in the form selected
25 from the group consisting of irregular, circle, polygon, rectangle, square, and triangle.
11. The transmitter of claim 4, wherein the inductor further comprises a core.
12. The transmitter of claim 11, wherein the core is made of ferrite.
13. The transmitter of claim 11, wherein the core has a cross-sectional shape selected from the group consisting of irregular, circle, polygon, rectangle, square, and triangle.
- 30 14. The transmitter of claim 1, wherein at least one inductor is an L-mode inductor and at least one inductor is an X-mode inductor.
15. The transmitter of claim 1, wherein both the inductors are an L-mode inductor.
16. The transmitter of claim 1, wherein both the inductors are an X-mode inductor.
17. The transmitter of claim 1, wherein at least one inductor does not have its null region,

wherein the signal strength is below the detection limit of the reader, positioned above the reader.

18. The transmitter of claim 1, wherein the driver circuit flows the current through multiple inductors at the same time.

19. The transmitter of claim 1, wherein the driver circuit flows the current through multiple
5 inductors at the separate times.

20. A transmitter to generate a signal to be read by a reader, comprising:
a driver circuit; and
an inductor connected to the driver circuit;
wherein the driver circuit controls the current flow through the inductor that
10 results in a signal transmission; and

wherein the driver circuit passes the current through the inductor multiple times while the inductor is moved relative to the reader head passing through a number of positions; and

wherein at least one of the number of positions the inductor passes through
15 the inductor produces a transmission signal that is greater than the reader threshold for a good data read.

21. A method of driving the transmitter of claim 1, comprising flowing current through only one inductor at a given time.

22. A method of driving a transmitter that includes a driver circuit and at least two
20 inductors connected to the driver circuit with each inductor having at least one null region with a signal strength below the detection limit of a signal reader, wherein the driver circuit controls the current flow through the inductor that results in a signal, said method comprising the steps of:

positioning the at least two inductors in the transmitter so that the null regions of the
25 inductors do not overlap; and
flowing current through the at least two inductors to generate a composite signal.

23. The method of claim 22, wherein the composite signal has a null region wherein the signal strength is below the detection limit of the reader.

24. The method of claim 22, wherein the composite signal has a signal strength skewed
30 towards one side of the reader.

25. The method of claim 22, wherein the null region of the composite signal is located at a unique location with no overlap with the null regions of the individual inductors of the transmitter.

26. A method of driving the transmitter of claim 22, wherein the step of flowing current

through the at least two inductors comprises alternating between flowing current through the at least two inductors at a given time and flowing current through only one inductor at a given time.

27. A method of driving transmitter of claim 22, wherein the step of flowing current through
5 the at least two inductors comprises having the current flow in the same direction through all of the inductors.

28. A method of driving transmitter of claim 22, wherein the step of flowing current through the at least two inductors comprises having at least one inductor having the current flow in the opposite direction as compared with all of the other inductors.

10 29. A method to generate a signal to be read by a reader by a transmitter including a driver circuit and an inductor connected to the driver circuit, said method comprising the steps of:

flowing a current through the inductor multiple times to produce repeated signals for transmission;

moving the inductor relative to the reader head passing through a number of
15 positions while the current is being passed through the inductor;

wherein at least one of the number of positions the inductor passes through, the inductor produces a transmission signal that is greater than the reader threshold for a good data read.