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Power transmission through a single conductive element

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Alijani et al.

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(45) **Date of Patent: Dec. 15, 2020**

(54) **POWER TRANSMISSION THROUGH A SINGLE CONDUCTIVE ELEMENT**

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(51) **Int. Cl.**

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H03K 3/282	(2006.01)
G01R 19/165	(2006.01)
G01R 19/02	(2006.01)
G06K 19/077	(2006.01)

(52) **U.S. Cl.**

CPC ***H03K 3/2825*** (2013.01); ***G01R 19/02*** (2013.01); ***G01R 19/1658*** (2013.01); ***G06K 19/07771*** (2013.01); ***H02J 3/00*** (2013.01)

(58) **Field of Classification Search**

CPC H03K 3/282; H03K 3/2821; H03K 3/2823; H03K 3/2825; H03K 3/2826; H03K 3/2828; H03K 3/354; H02J 3/00; H02J 13/0006; H02J 2203/00

USPC ..... 331/113 R

See application file for complete search history.

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Primary Examiner — Levi Gannon

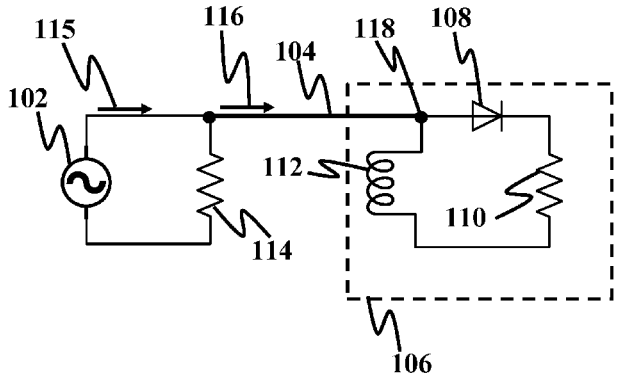
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(57) **ABSTRACT**

A circuit for power transmission through a single conductive element. The circuit includes an oscillator, a single conductive element, and a load. The oscillator is configured to generate a periodic voltage. The single conductive element is connected in series with the oscillator. The load is connected in series with the single conductive element. The load includes a first diode, a first resistor, and a first inductor. The first diode is connected in series with the single conductive element. The first resistor is connected in series with the first diode. The first inductor is connected between the first diode and the single conductive element. The first inductor is connected in series with the first resistor.

14 Claims, 7 Drawing Sheets

100



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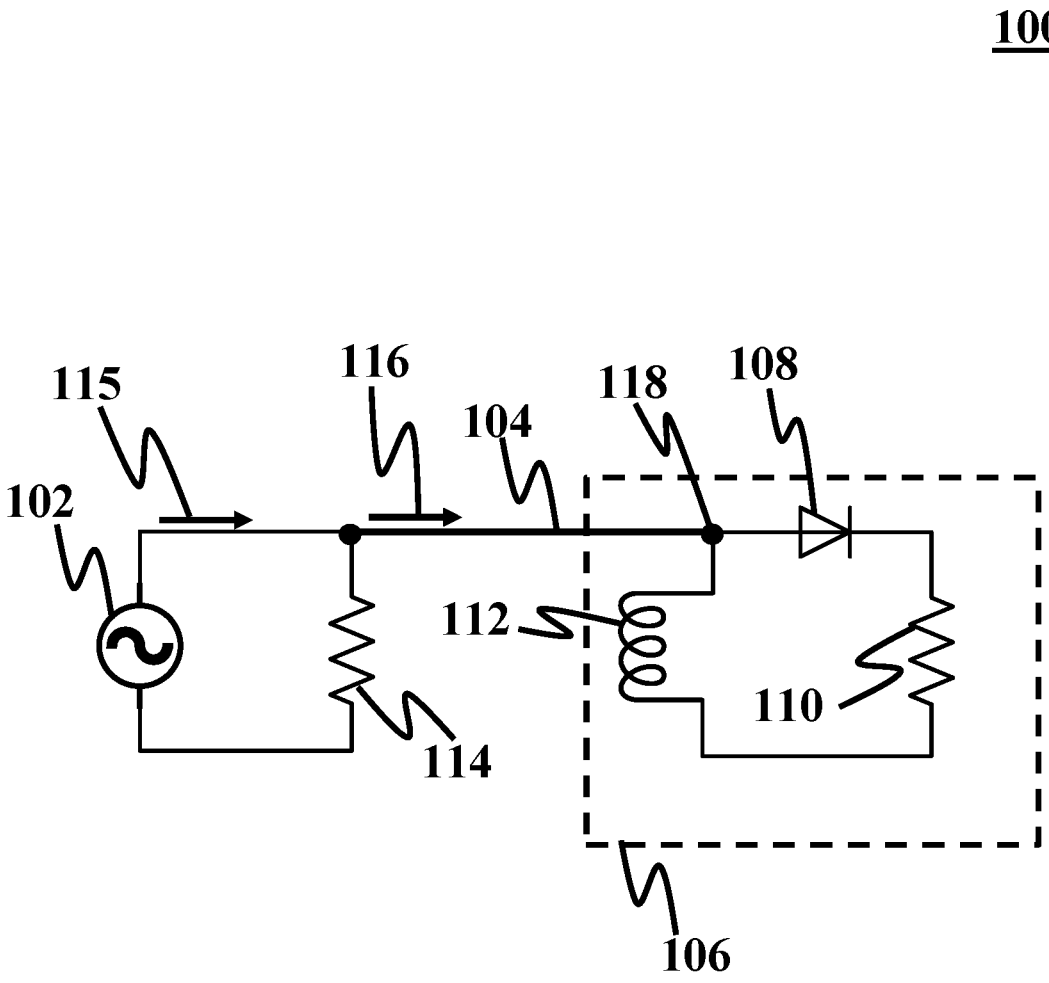


FIG. 1A

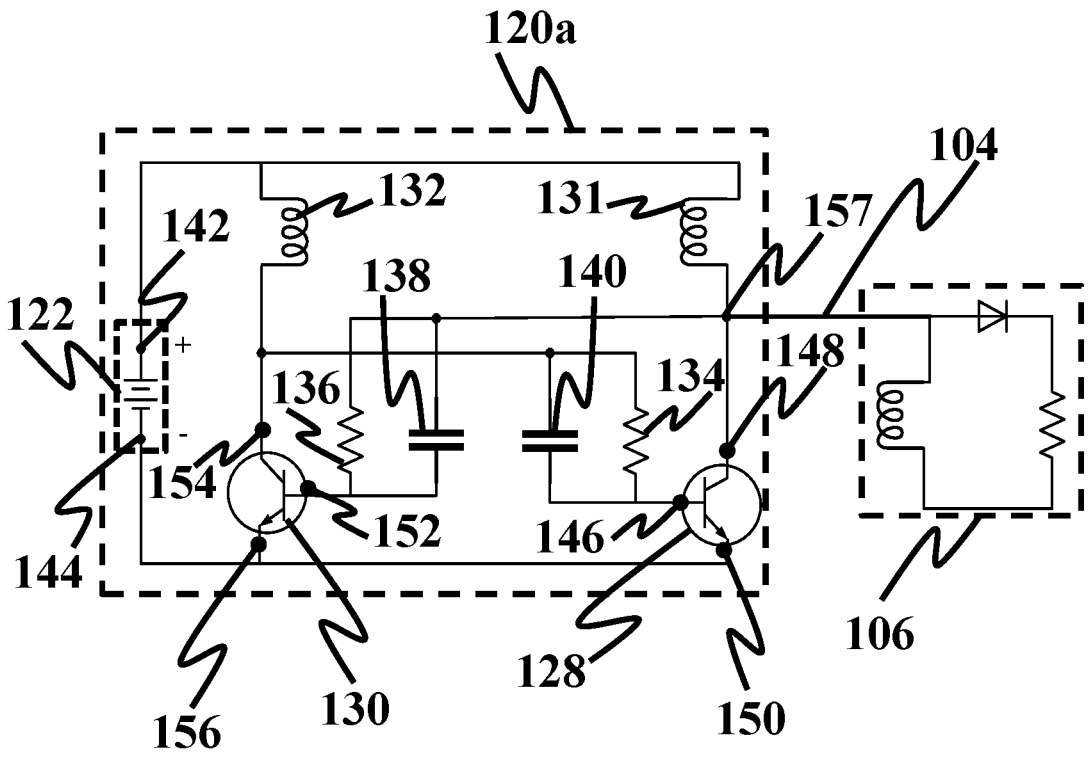

120a
104
132
131
142
157
138
140
122
+
148
136
134
-
154
152
146
144
106
128
156
130
150

FIG. 1B

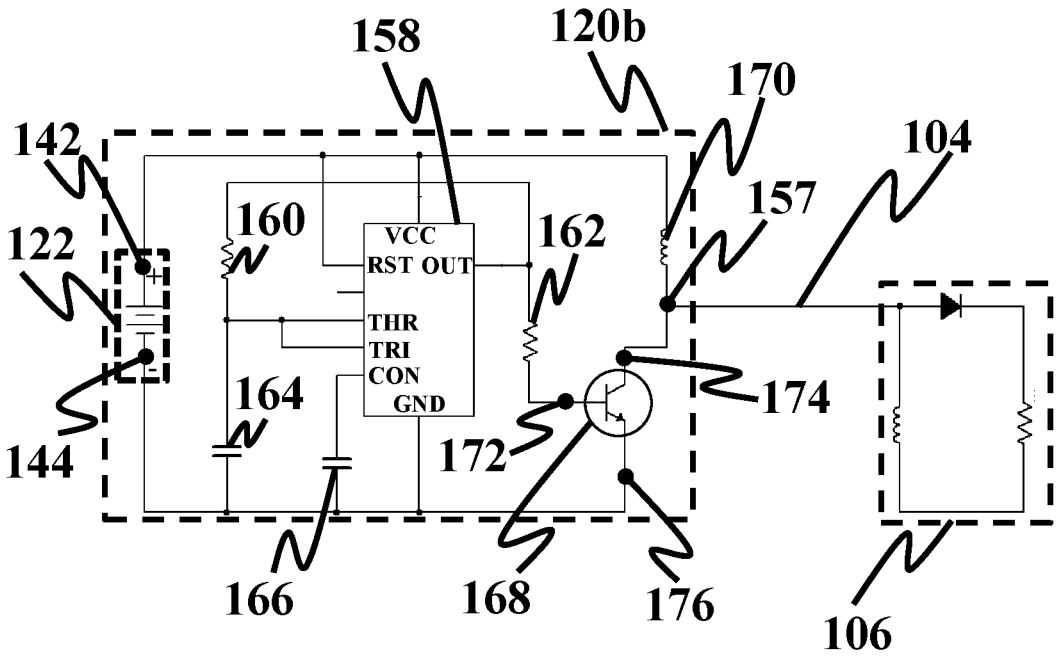

158
120b
170
142
104
157
160
162
122
VCC
RST OUT
THR
TRI
CON
GND
164
174
144
172
166
168
176
106

FIG. 1C

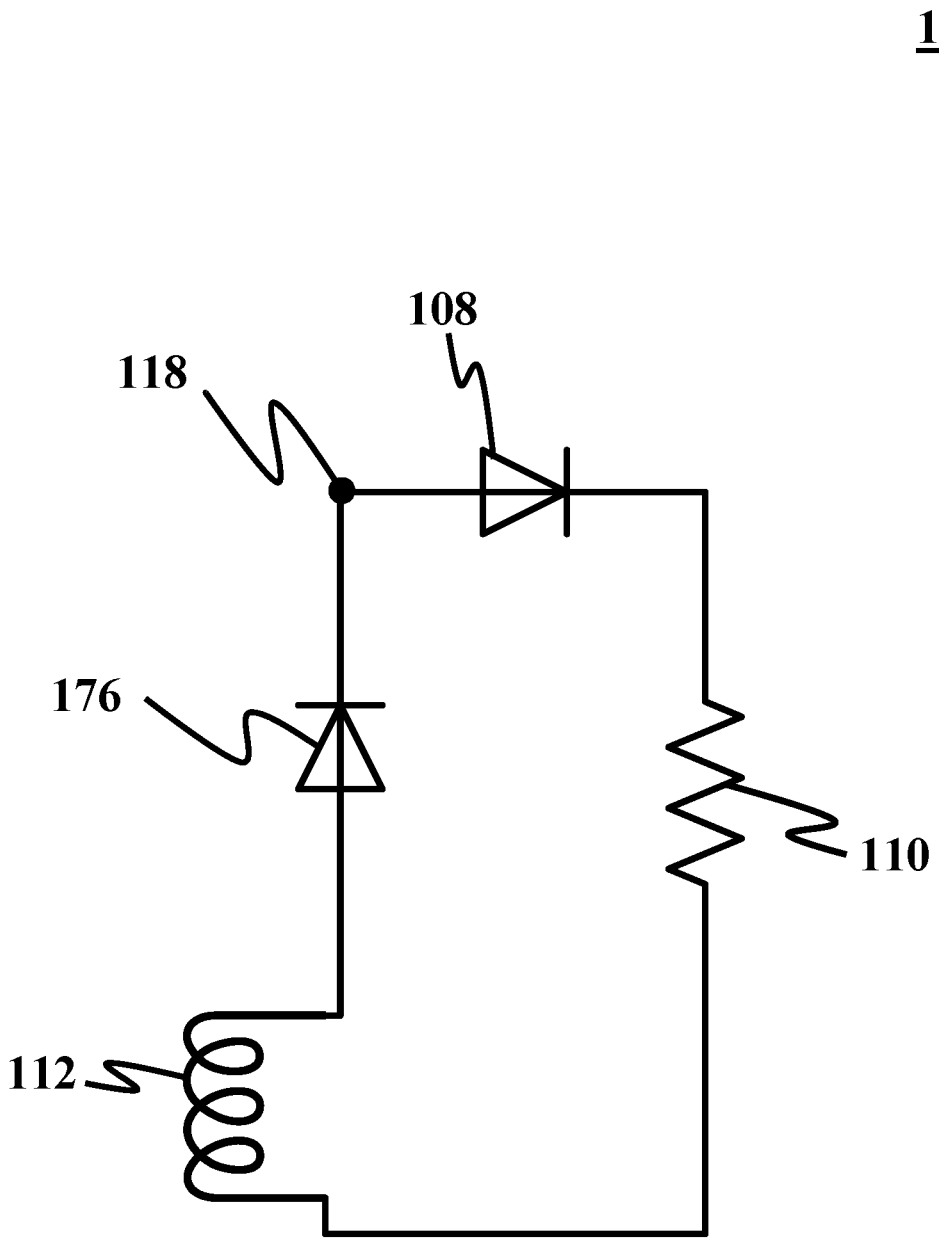


FIG. 1D

200

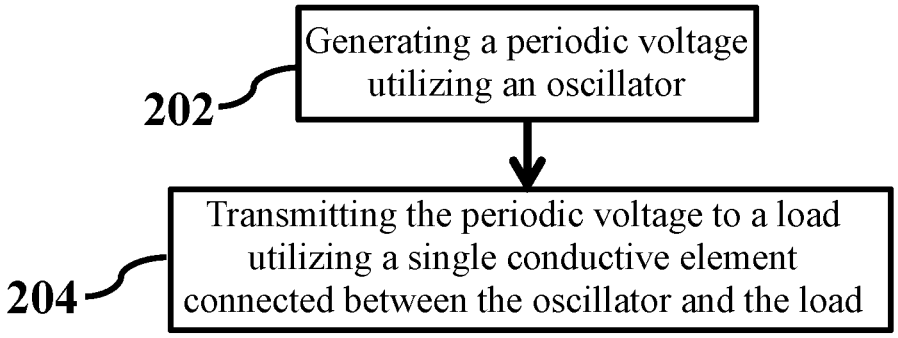

Generating a periodic voltage utilizing an oscillator
202
Transmitting the periodic voltage to a load utilizing a single conductive element connected between the oscillator and the load
204

FIG. 2

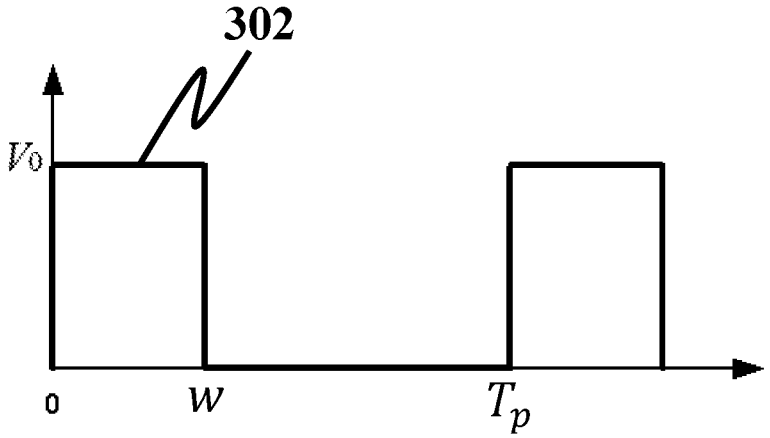


FIG. 3

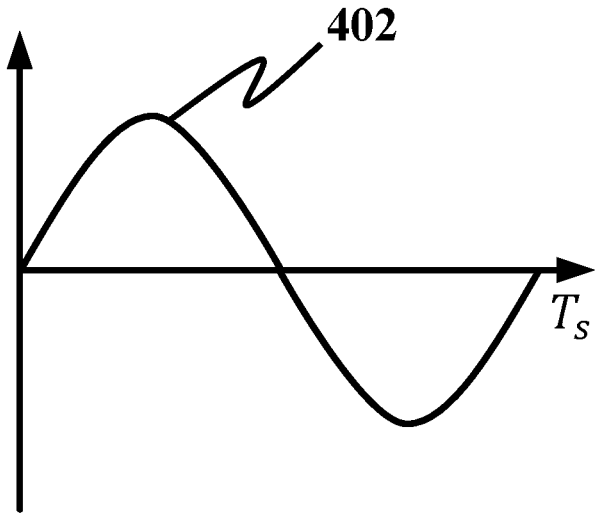


FIG. 4

POWER TRANSMISSION THROUGH A SINGLE CONDUCTIVE ELEMENT

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the benefit of priority from U.S. Provisional Patent Application Ser. No. 62/760,067, filed on Nov. 13, 2018, and entitled "GRAUND-INDEPENDENT SINGLE-WIRE TRANSMISSION LINE," which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

The present disclosure generally relates to power systems, and particularly, to power transmission systems.

BACKGROUND

Transmission lines are used for carrying electrical signals from one point to another. Conventional transmission lines, such as twisted pairs and coaxial cables, may include two conductive elements, such as wires, for transmission of electrical signals in forward and backward directions. Using two wires, however, may lead to high implementation costs and exposure to risks such as fire due to connection of wires. Transmission lines with a single wire may be capable of carrying electrical signals. However, such transmission lines may depend on a connection to ground as a voltage reference, which may limit applications with portability requirements. There is, therefore, a need for a ground-independent circuit for power transmission through a single conductive element.

SUMMARY

This summary is intended to provide an overview of the subject matter of the present disclosure, and is not intended to identify essential elements or key elements of the subject matter, nor is it intended to be used to determine the scope of the claimed implementations. The proper scope of the present disclosure may be ascertained from the claims set forth below in view of the detailed description below and the drawings.

In one general aspect, the present disclosure describes an exemplary circuit for power transmission through a single conductive element. In an exemplary embedment, the circuit may include an oscillator, a single conductive element, and a load. In an exemplary embodiment, the oscillator may be configured to generate a periodic voltage. In an exemplary embodiment, the single conductive element may be connected in series with the oscillator. In an exemplary embodiment, the load may be connected in series with the single conductive element. In an exemplary embodiment, the load may include a first diode, a first resistor, and a first inductor. In an exemplary embodiment, the first diode may be connected in series with the single conductive element. In an exemplary embodiment, the first resistor may be connected in series with the first diode. In an exemplary embodiment, the first inductor may be connected between the first diode and the single conductive element. In an exemplary embodiment, the first inductor may be connected in series with the first resistor.

In an exemplary embodiment, the periodic voltage may include one of a sinusoidal wave and a rectangular wave. In an exemplary embodiment, a pulse width w of the rectangular pulse wave may satisfy a condition defined by $w<5L_1/R_1$, where L_1 is an induction of the first inductor and R_1 is a resistance of the first resistor.

In an exemplary embodiment, the oscillator may include an astable multivibrator. In an exemplary embodiment, the astable multivibrator may include a DC voltage supply, a first transistor, a second transistor, a second inductor, a third inductor, a second resistor, a third resistor, a first capacitor, and a second capacitor. In an exemplary embodiment, the DC voltage supply may include a positive pole and a negative pole. In an exemplary embodiment, the first transistor may include a first base, a first collector, and a first emitter. In an exemplary embodiment, the first collector may be connected to the single conductive element. In an exemplary embodiment, the first emitter may be connected to the negative pole. In an exemplary embodiment, the second transistor may include a second base, a second collector, and a second emitter. In an exemplary embodiment, the second emitter may be connected to the negative pole. In an exemplary embodiment, the second inductor may be connected between the first collector and the positive pole. In an exemplary embodiment, the third inductor may be connected between the second collector and the positive pole. In an exemplary embodiment, the second resistor may be connected between the first base and the second collector. In an exemplary embodiment, the third resistor may be connected between the second base and the first collector. In an exemplary embodiment, the first capacitor may be connected in parallel with the second resistor. In an exemplary embodiment, the second capacitor may be connected in parallel with the third resistor.

In an exemplary embodiment, the load may further include a second diode. In an exemplary embodiment, the second diode may be connected between the first inductor and the single conductive element. In an exemplary embodiment, the circuit may further include a fourth resistor. In an exemplary embodiment, the fourth resistor may be connected in parallel with the oscillator.

Other exemplary systems, methods, features and advantages of the implementations will be, or will become, apparent to one of ordinary skill in the art upon examination of the following figures and detailed description. It is intended that all such additional systems, methods, features and advantages be included within this description and this summary, be within the scope of the implementations, and be protected by the claims herein.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawing figures depict one or more implementations in accord with the present teachings, by way of example only, not by way of limitation. In the figures, like reference numerals refer to the same or similar elements.

FIG. **1**A shows a schematic of a simplified circuit for power transmission through a single conductive element, consistent with one or more exemplary embodiments of the present disclosure.

FIG. **1**B shows a schematic of an astable multivibrator, consistent with one or more exemplary embodiments of the present disclosure.

FIG. **1**C shows a schematic of an astable multivibrator utilizing a 555 Timer integrated circuit, consistent with one or more exemplary embodiments of the present disclosure.

FIG. **1**D shows a schematic of a load, consistent with one or more exemplary embodiments of the present disclosure.

FIG. **2** shows a flowchart of a method for power transmission through a single conductive element, consistent with one or more exemplary embodiments of the present disclosure.

FIG. **3** shows a schematic of a rectangular pulse wave, consistent with one or more exemplary embodiments of the present disclosure.

FIG. **4** shows a schematic of a sinusoidal wave, consistent with one or more exemplary embodiments of the present disclosure.

DETAILED DESCRIPTION

In the following detailed description, numerous specific details are set forth by way of examples in order to provide a thorough understanding of the relevant teachings. However, it should be apparent that the present teachings may be practiced without such details. In other instances, well known methods, procedures, components, and/or circuitry have been described at a relatively high-level, without detail, in order to avoid unnecessarily obscuring aspects of the present teachings.

The following detailed description is presented to enable a person skilled in the art to make and use the methods and devices disclosed in exemplary embodiments of the present disclosure. For purposes of explanation, specific nomenclature is set forth to provide a thorough understanding of the present disclosure. However, it will be apparent to one skilled in the art that these specific details are not required to practice the disclosed exemplary embodiments. Descriptions of specific exemplary embodiments are provided only as representative examples. Various modifications to the exemplary implementations will be readily apparent to one skilled in the art, and the general principles defined herein may be applied to other implementations and applications without departing from the scope of the present disclosure. The present disclosure is not intended to be limited to the implementations shown but is to be accorded the widest possible scope consistent with the principles and features disclosed herein.

Herein is disclosed an exemplary circuit and method for power transmission through a single conductive element. An exemplary circuit may include an oscillator, a single conductive element, and a load, that may be connected in series. An exemplary oscillator may apply a voltage with a sinusoidal or a rectangular pulse shape to the single conductive element. As a result, an exemplary inductor embedded in the load may gradually become charged and a current may pass through the single conductive element. After a transient time, an exemplary inductor may be fully charged. Therefore, the current passing through the single conductive element may vanish. However, by reversing an output voltage of the oscillator, the inductor may start discharging, and consequently, a current in a reverse direction, i.e., from the load toward the oscillator, may pass through the single conductive element. As a result, by applying an alternative voltage to the single conductive element, an electric current may continuously pass through the single conductive element, leading to a continuous power transmission to the load.

FIG. **1**A shows a schematic of a circuit for power transmission through a single conductive element, consistent with one or more exemplary embodiments of the present disclosure. An exemplary circuit **100** may include an oscillator **102**, a single conductive element **104**, and a load **106**. In an exemplary embodiment, oscillator **102** may be configured to generate a periodic voltage. In an exemplary embodiment, single conductive element **104** may be connected in series with oscillator **102**. In an exemplary embodiment, load **106** may be connected in series with single conductive element **104**. In an exemplary embodiment, load **106** may include a diode **108**, a resistor **110**, and an inductor **112**. In an exemplary embodiment, diode **108** may be connected in series with single conductive element **104**. In an exemplary embodiment, resistor **110** may be connected in series with diode **108**. In an exemplary embodiment, inductor **112** may be connected between diode **108** and single conductive element **104**. In an exemplary embodiment, inductor **112** may be connected in series with resistor **110**. In an exemplary embodiment, circuit **100** may further include a resistor **114** connected in parallel with oscillator **102**.

FIG. **2** shows a flowchart of a method for power transmission through a single conductive element, consistent with one or more exemplary embodiments of the present disclosure. In an exemplary embodiment, different steps of a method **200** may be implemented utilizing a circuit analogous to circuit **100**. In an exemplary embodiment, method **200** may include generating a periodic voltage utilizing an oscillator (step **202**) and transmitting the periodic voltage to a load utilizing a single conductive element connected between the oscillator and the load (step **204**). In an exemplary embodiment, the oscillator may be analogous to oscillator **102**. In an exemplary embodiment, the load may be analogous to load **106**. In an exemplary embodiment, the single conductive element may be analogous to single conductive element **104**. In an exemplary embodiment, generating the periodic voltage in step **202** may include coupling resistor **114** in parallel with oscillator **102**.

In an exemplary embodiment, a source current **115** may be generated by oscillator **102**. In an exemplary embodiment, a large resistance may be chosen for resistor **114** to prevent electric charges to flow toward resistor **114**. Therefore, source current **115** may approximately equal a transmission line current **116**, which may pass through single conductive element **104**. In an exemplary embodiment, inductor **112** may be discharged before applying a voltage by oscillator **102**. Therefore, inductor **112** may act as an open circuit at a beginning of a transient time, which may prevent transmission line current **116** to flow from a load point **118** toward resistor **110** through inductor **112**. On the other hand, diode **108** may pass transmission line current **116** in only one direction, i.e., from load point **118** toward resistor **110** through diode **108**. As a result, transmission line current **116** may pass through resistor **110** and may gradually charge inductor **112**. This process may continue until inductor **112** becomes fully charged. In an exemplary embodiment, inductor **112** may act as a short circuit, and consequently, resistor **110** may be short-circuited. As a result, transmission line current **116** may not pass resistor **110** and therefore, no power may be transmitted to resistor **110**. In an exemplary embodiment, an applied voltage by oscillator **102** may become less than a voltage of inductor **112**. As a result, a voltage of load point **118** may be larger than an applied voltage by oscillator **102**. Therefore, transmission line current **116** may be transmitted in a reverse direction, i.e., from load point **118** toward oscillator **102**. This process may continue until inductor **112** may become discharged, and consequently, no transmission line current **116** may be transmitted through single conductive element **104**. In an exemplary embodiment, changing a voltage level by oscillator **102** may lead to a different value of transmission line current **116**. Therefore, applying a periodic voltage by oscillator **102** with appropriate rise and fall timing may

result in a continuous transmission line current **116** through single conductive element **104**.

For further detail with respect to step **202**, in an exemplary embodiment, generating the periodic voltage may include generating one of a sinusoidal wave and a rectangular wave. FIG. **3** shows a schematic of a rectangular pulse wave, consistent with one or more exemplary embodiments of the present disclosure. In an exemplary embodiment, the rectangular pulse wave may be similar to rectangular pulse wave **302**. In an exemplary embodiment, a pulse width w of the rectangular pulse wave may satisfy a condition defined by $w<5L_1/R_1$, where L_1 is an induction of inductor **112** and R_1 is a resistance of resistor **110**. In an exemplary embodiment, rectangular pulse wave **302** may further include a period T_p. Referring to FIGS. **1**A and **3**, in an exemplary embodiment, oscillator **102** may apply a constant voltage in a time duration w. In an exemplary embodiment, inductor **112** may be discharged before applying the constant voltage. Therefore, transmission line current **116** may pass through single conductive element **104** and charge inductor **112**. In an exemplary embodiment, a charging rate of inductor **112** may depend on resistance R_1 of resistor **110** and induction L_1 of inductor **112**. The charging rate of inductor **112** may have an inverse relationship with a time constant L_1/R_1. In an exemplary embodiment, inductor **112** may be almost fully charged after five time constants. Therefore, a voltage of first inductor may become nearly zero. As a result, resistor **110** may be short circuited, and consequently, no current may pass through resistor **110**. In an exemplary embodiment, pulse width w of rectangular pulse wave **302** may be set lower than $5L_1/R_1$ to keep an electric current pass through resistor **110**. In an exemplary embodiment, a constant voltage may be removed after a time duration w. In this case, inductor **112** may be discharged by dissipating a stored energy of inductor **112** by resistor **110**. A discharging rate of inductor **112** may have an inverse relationship with the time constant L_1/R_1. In an exemplary embodiment, inductor **112** may be almost fully discharged after five time constants. Therefore, in an exemplary embodiment, a pulse-off time of rectangular pulse wave **302**, which equals T_p–w, may be sufficiently large to fully discharge inductor **112**.

FIG. **4** shows a schematic of a sinusoidal wave, consistent with one or more exemplary embodiments of the present disclosure. In an exemplary embodiment, the sinusoidal wave may have a shape similar to sinusoidal wave **402**. In an exemplary embodiment, oscillator **102** may be configured to generate a periodic voltage including sinusoidal wave **402**. In an exemplary embodiment, the periodic voltage may be applied to load point **118**. In an exemplary embodiment, inductor **112** may be discharged before applying sinusoidal wave **402**. In an exemplary embodiment, when the periodic voltage is increasing, inductor **112** may be charged due to a positive voltage applied to inductor **112**. Therefore, transmission line current **116** may pass through single conductive element **104** to charge inductor **112**. In an exemplary embodiment, when a period T_s is large, inductor **112** may be fully charged, and consequently, resistor **110** may act as a short circuit. Consequently, no current may pass through single conductive element **104** and transmission line current **116** may vanish. On the other hand, in an exemplary embodiment, when an amplitude of sinusoidal wave **402** decreases, a voltage of inductor **112** may be larger than an amplitude of sinusoidal wave **402**. Therefore, inductor **112** may be discharged and transmission line current **116** may pass through single conductive element **104** in a reverse direction. Therefore, by choosing an appropriate period T_s, a continuous transmission line current **116** may pass through single conductive element **104**.

FIG. **1**B shows a schematic of an astable multivibrator, consistent with one or more exemplary embodiments of the present disclosure. In an exemplary embodiment, oscillator **102** may include an astable multivibrator **120***a*. In an exemplary embodiment, astable multivibrator **120***a* may include a DC voltage supply **122**, a transistor **128**, a transistor **130**, an inductor **131**, an inductor **132**, a resistor **134**, a resistor **136**, a capacitor **138**, and a capacitor **140**. In an exemplary embodiment, DC voltage supply **122** may include a positive pole **142** and a negative pole **144**. In an exemplary embodiment, transistor **128** may include a base **146**, a collector **148**, and an emitter **150**. In an exemplary embodiment, collector **148** may be connected to single conductive element **104**. In an exemplary embodiment, emitter **150** may be connected to negative pole **144**. In an exemplary embodiment, transistor **130** may include a base **152**, a collector **154**, and an emitter **156**. In an exemplary embodiment, emitter **156** may be connected to negative pole **144**. In an exemplary embodiment, inductor **131** may be connected between collector **148** and positive pole **142**. In an exemplary embodiment, inductor **132** may be connected between collector **154** and positive pole **142**. In an exemplary embodiment, resistor **134** may be connected between base **146** and collector **154**. In an exemplary embodiment, resistor **136** may be connected between base **152** and collector **148**. In an exemplary embodiment, capacitor **138** may be connected in parallel with resistor **136**. In an exemplary embodiment, capacitor **140** may be connected in parallel with resistor **134**. In an exemplary embodiment, an output node **157** may be referred to a node at which an output voltage of oscillator **102** may be obtained. In an exemplary embodiment, output node **157** may be connected to collector **148**. In an exemplary embodiment, output node **157** may also be connected to single conductive element **104**. For further detail with respect to step **202**, generating the periodic voltage utilizing the oscillator may include generating the period voltage utilizing an astable multivibrator. In an exemplary embodiment, the astable multivibrator may be analogous to astable multivibrator **120***a*.

Referring to FIGS. **1**B and **3**, in an exemplary embodiment, astable multivibrator **120***a* may provide rectangular pulse wave **302**. In an exemplary embodiment, rectangular pulse wave **302** may be provided at output node **157**. In an exemplary embodiment, resistor **134** may include a resistance R_2. In an exemplary embodiment, capacitor **140** may include a capacitance C_1. In an exemplary embodiment, pulse width w may be determined by a time constant of parallel resistor **134** and capacitor **140**, which may equal R_2C_1. In an exemplary embodiment, pulse width w may approximately equal 0.69 R_2C_1. In an exemplary embodiment, resistor **136** may include a resistance R_3. In an exemplary embodiment, capacitor **138** may include a capacitance C_2. In an exemplary embodiment, pulse-off time may be determined by a time constant of parallel resistor **136** and capacitor **138**, which may equal R_3 C_2. In an exemplary embodiment, pulse width w may approximately equal 0.69 R_3C_2. In an exemplary embodiment, period T_p may approximately equal $0.69(R_2C_1+R_3C_2)$. In an exemplary embodiment, inductor **31** may include an inductance L_2. In an exemplary embodiment, inductor **132** may include an inductance L_3. In an exemplary embodiment, inductance L_2 and inductance L_3 may be chosen very large, forcing electric charges to flow through single conductive element **104**.

FIG. **1**C shows a schematic of an astable multivibrator utilizing a 555 Timer integrated circuit (IC), consistent with

one or more exemplary embodiments of the present disclosure. In an exemplary embodiment, astable multivibrator **120***b* may be implemented utilizing a 555 Timer IC. In an exemplary embodiment, astable multivibrator **120***b* may include DC voltage supply **122**, output node **157**, a 555 Timer IC **158**, a resistor **160**, a resistor **162**, a capacitor **164**, a capacitor **166**, a transistor **168**, and an inductor **170**. In an exemplary embodiment, 555 Timer IC **158** may include a power supply pin VCC, a reset pin RST, a threshold pin THR, a trigger pin TRI, a control voltage pin CON, a ground pin GND, and an output pin OUT. In an exemplary embodiment, transistor **168** may include a base **172**, a collector **174**, and an emitter **176**. In an exemplary embodiment, reset pin RST may be connected to power supply pin VCC. In an exemplary embodiment, trigger pin TRI may be connected to threshold pin THR. In an exemplary embodiment, positive pole **142** may be connected to power supply pin VCC. In an exemplary embodiment, negative pole **144** may be connected to ground pin GND. In an exemplary embodiment, resistor **160** may be connected between threshold pin THR and output pin OUT. In an exemplary embodiment, resistor **162** may be connected between output pin OUT and base **172**. In an exemplary embodiment, capacitor **164** may be connected between threshold pin THR and ground pin GND. In an exemplary embodiment, capacitor **166** may be connected between control voltage pin CON and ground pin GND. In an exemplary embodiment, inductor **170** may be connected between collector **174** and power supply pin VCC. In an exemplary embodiment, collector **174** may be connected to output node **157**. In an exemplary embodiment, emitter **176** may be connected to ground pin GND. In an exemplary embodiment, astable multivibrator **120***b* may provide rectangular pulse wave **302** at output node **157**.

FIG. **1**D shows a schematic of a load, consistent with one or more exemplary embodiments of the present disclosure. In an exemplary embodiment, load **106** may further include a diode **119**. In an exemplary embodiment, diode **178** may be connected between inductor **112** and the single conductive element **104**. When inductor **112** is charged, inductor **112** may become conductive. As a result, transmission line current **116** may flow from load point **118** to resistor **110** through inductor **112**. In this case, inserting diode **178** may avoid transmission line current **116** to flow from load point **118** to resistor **110** through inductor **112**.

For further detail with respect to step **204**, in an exemplary embodiment, transmitting the periodic voltage to the load may include transmitting the periodic voltage to a diode analogous to diode **178**.

Example 1

In this example, a circuit including an oscillator, a single conductive element connected in series with the single conductive element, and a load connected in series with the single conductive element is demonstrated. An exemplary circuit includes an oscillator (analogous to oscillator **102**), a single conductive element (analogous to single conductive element **104**), and a load (analogous to load **106**). The oscillator is configured to generate a rectangular pulse wave (analogous to rectangular pulse wave **302**). The oscillator includes an astable multivibrator (analogous to astable multivibrator **120***a*). Transistor **128** and transistor **130** are of type 2N2222. Table 1 shows a set of elements of the circuit and their associated values. With this setting, a pulse width w of the rectangular pulse wave is about $0.69\times10^{3}\times10^{-7}\approx0.07$ ms. Due to the symmetry of the astable multivibrator, a duty cycle of the rectangular pulse wave, i.e.,

$$\frac{w}{T_p},$$

is about 0.5. Moreover, a time constant of the load is about

$$\frac{10^{-3}}{10}=0.1\text{ ms},$$

which satisfies the condition

$$w\le 5\frac{L_1}{R_1}.$$

Therefore, a current continuously passes through the LED. Therefore, the LED stays turned on until a DC voltage supply (analogous to DC voltage supply **122**) is switched on.

TABLE 1

A set of elements of the circuit and their associated values

Element	Approximate Value
DC voltage supply 122	12 V
resistor 110	10 Ω
inductor 112	1 mH
inductor 131	1 mH
inductor 132	1 mH
resistor 134	1 kΩ
resistor 136	1 kΩ
capacitor 138	100 nF
capacitor 140	100 nF

Example 2

In this example, a circuit including an oscillator, a single conductive element connected in series with the single conductive element, and a load connected in series with the single conductive element is demonstrated. An exemplary circuit includes an oscillator (analogous to oscillator **102**), a single conductive element (analogous to single conductive element **104**), and a load (analogous to load **106**). The oscillator is configured to generate a rectangular pulse wave (analogous to rectangular pulse wave **302**) with a period of about 0.14 ms. The duty cycle of the rectangular pulse wave, i.e.,

$$\frac{w}{T_p},$$

is about 0.5. The oscillator includes an astable multivibrator (analogous to astable multivibrator **120***b*) utilizing a 555 Timer IC (analogous to 555 Timer IC **158**). The utilized 555 Timer IC is of type NE **555**. A transistor (analogous to transistor **168**) of the astable multivibrator is of type TIP **122**. A diode (analogous to diode **108**) of the load is of type 1N4148. A resistor (analogous to resistor **110**) of the load is implemented utilizing a light-emitting diode (LED). Table 2 shows a set of elements of the circuit and their associated values. With this setting, a time constant of the load is about

$$\frac{10^{-3}}{10} = 0.1 \text{ ms},$$

which satisfies the condition

$$w \leq 5\frac{L_1}{R_1}.$$

Therefore, a current continuously passes through the LED and it stays turned on until a DC voltage supply (analogous to DC voltage supply **122**) is switched on.

TABLE 2

A set of elements of the circuit and their associated values

Element	Approximate Value
DC voltage supply 122	12 V
inductor 112	1 mH
resistor 160	1 kΩ
resistor 162	470 Ω
capacitor 164	100 nF
capacitor 166	100 nF
Inductor 170	100 μH
resistor 110	10 Ω

While the foregoing has described what may be considered to be the best mode and/or other examples, it is understood that various modifications may be made therein and that the subject matter disclosed herein may be implemented in various forms and examples, and that the teachings may be applied in numerous applications, only some of which have been described herein. It is intended by the following claims to claim any and all applications, modifications and variations that fall within the true scope of the present teachings.

Unless otherwise stated, all measurements, values, ratings, positions, magnitudes, sizes, and other specifications that are set forth in this specification, including in the claims that follow, are approximate, not exact. They are intended to have a reasonable range that is consistent with the functions to which they relate and with what is customary in the art to which they pertain.

The scope of protection is limited solely by the claims that now follow. That scope is intended and should be interpreted to be as broad as is consistent with the ordinary meaning of the language that is used in the claims when interpreted in light of this specification and the prosecution history that follows and to encompass all structural and functional equivalents. Notwithstanding, none of the claims are intended to embrace subject matter that fails to satisfy the requirement of Sections 101, 102, or 103 of the Patent Act, nor should they be interpreted in such a way. Any unintended embracement of such subject matter is hereby disclaimed.

Except as stated immediately above, nothing that has been stated or illustrated is intended or should be interpreted to cause a dedication of any component, step, feature, object, benefit, advantage, or equivalent to the public, regardless of whether it is or is not recited in the claims.

It will be understood that the terms and expressions used herein have the ordinary meaning as is accorded to such terms and expressions with respect to their corresponding respective areas of inquiry and study except where specific meanings have otherwise been set forth herein. Relational terms such as first and second and the like may be used solely to distinguish one entity or action from another without necessarily requiring or implying any actual such relationship or order between such entities or actions. The terms "comprises," "comprising," or any other variation thereof, are intended to cover a non-exclusive inclusion, such that a process, method, article, or apparatus that comprises a list of elements does not include only those elements but may include other elements not expressly listed or inherent to such process, method, article, or apparatus. An element proceeded by "a" or "an" does not, without further constraints, preclude the existence of additional identical elements in the process, method, article, or apparatus that comprises the element.

The Abstract of the Disclosure is provided to allow the reader to quickly ascertain the nature of the technical disclosure. It is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims. In addition, in the foregoing Detailed Description, it can be seen that various features are grouped together in various implementations. This is for purposes of streamlining the disclosure, and is not to be interpreted as reflecting an intention that the claimed implementations require more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive subject matter lies in less than all features of a single disclosed implementation. Thus, the following claims are hereby incorporated into the Detailed Description, with each claim standing on its own as a separately claimed subject matter.

While various implementations have been described, the description is intended to be exemplary, rather than limiting and it will be apparent to those of ordinary skill in the art that many more implementations and implementations are possible that are within the scope of the implementations. Although many possible combinations of features are shown in the accompanying figures and discussed in this detailed description, many other combinations of the disclosed features are possible. Any feature of any implementation may be used in combination with or substituted for any other feature or element in any other implementation unless specifically restricted. Therefore, it will be understood that any of the features shown and/or discussed in the present disclosure may be implemented together in any suitable combination. Accordingly, the implementations are not to be restricted except in light of the attached claims and their equivalents. Also, various modifications and changes may be made within the scope of the attached claims.

What is claimed is:

1. A circuit for power transmission through a single conductive element, the circuit comprising:

an astable multivibrator configured to generate a periodic voltage, the periodic voltage comprising a rectangular wave;

a single conductive element connected in series with the astable multivibrator;

a load connected in series with the single conductive element, the load comprising:

a first diode connected in series with the single conductive element;

a first resistor connected in series with the first diode;

a first inductor connected between the first diode and the single conductive element, the first inductor connected in series with the first resistor;

a second diode connected between the first inductor and the single conductive element; and

a second resistor connected in parallel with the astable multivibrator;

wherein a pulse width w of the rectangular wave satisfies a condition defined by the following:

$$w<5L_1/R_1,$$

where:

L_1 is an induction of the first inductor; and

R_1 is a resistance of the first resistor.

2. A circuit for power transmission through a single conductive element, the circuit comprising:

an oscillator configured to generate a periodic voltage;

a single conductive element connected in series with the oscillator, the single conductive element configured to receive a transmission line current from the oscillator;

a load connected in series with the single conductive element, the load comprising:

a first diode connected in series with the single conductive element;

a first resistor connected in series with the first diode; and

a first inductor connected between the first diode and the single conductive element, the first inductor connected in series with the first resistor.

3. The circuit of claim **2**, wherein the periodic voltage comprises one of a sinusoidal wave and a rectangular wave.

4. The circuit of claim **3**, wherein a pulse width w of the rectangular wave satisfies a condition defined by the following:

$$w<5L_1/R_1,$$

where:

L_1 is an induction of the first inductor; and

R_1 is a resistance of the first resistor.

5. The circuit of claim **2**, wherein the oscillator comprises an astable multivibrator, comprising:

a DC voltage supply comprising a positive pole and a negative pole;

a first transistor comprising:

a first base;

a first collector connected to the single conductive element; and

a first emitter connected to the negative pole;

a second transistor comprising:

a second base;

a second collector; and

a second emitter connected to the negative pole;

a second inductor connected between the first collector and the positive pole;

a third inductor connected between the second collector and the positive pole;

a second resistor connected between the first base and the second collector;

a third resistor connected between the second base and the first collector;

a first capacitor connected in parallel with the second resistor; and

a second capacitor connected in parallel with the third resistor.

6. The circuit of claim **2**, wherein the load further comprises a second diode connected between the first inductor and the single conductive element.

7. The circuit of claim **2**, further comprising a fourth resistor connected in parallel with the oscillator.

8. The circuit of claim **2**, wherein the transmission line current is configured to flow through the single conductive element to a load point and from the load point to the first resistor and the first inductor through the first diode.

9. A method for power transmission through a single conductive element, the method comprising:

generating a transmission line current by generating a periodic voltage utilizing an oscillator; and

transmitting the periodic voltage to a load by passing the transmission line current to the load through a single conductive element connected between the oscillator and the load, passing the transmission line current to the load comprising:

passing the transmission line current to a first diode connected in series with the single conductive element;

passing the transmission line current through the first diode to a first resistor connected in series with the first diode; and

passing the transmission line current through the first diode to a first inductor connected between the first diode and the single conductive element, the first inductor connected in series with the first resistor.

10. The method of claim **9**, wherein generating the periodic voltage comprises generating one of a sinusoidal wave and a rectangular wave.

11. The method of claim **10**, wherein a pulse width w of the rectangular wave satisfies a condition defined by the following:

$$w<5L_1/R_1,$$

where:

L_1 is an induction of the first inductor; and

R_1 is a resistant of the first resistor.

12. The method of claim **9**, wherein generating the periodic voltage utilizing the oscillator comprises generating the periodic voltage utilizing an astable multivibrator, the astable multivibrator comprising:

a DC voltage supply comprising a positive pole and a negative pole;

a first transistor comprising:

a first base;

a first collector connected to the single conductive element; and

a first emitter connected to the negative pole;

a second transistor comprising:

a second base;

a second collector; and

a second emitter connected to the negative pole;

a second inductor connected between the first collector and the positive pole;

a third inductor connected between the second collector and the positive pole;

a second resistor connected between the first base and the second collector;

a third resistor connected between the second base and the first collector;

a first capacitor connected in parallel with the second resistor; and

a second capacitor connected in parallel with the third resistor.

13. The method of claim **9**, wherein transmitting the periodic voltage to the load comprises transmitting the periodic voltage to a second diode connected between the first inductor and the single conductive element.

14. The method of claim **9**, wherein generating the periodic voltage comprises coupling a fourth resistor in parallel with the oscillator.

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