

US Patent & Trademark Office

Patent Public Search | Text View

United States Patent Application Publication

20250266831

Kind Code

A1

Publication Date

August 21, 2025

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ISOLATION DEVICE HAVING INDUCTIVE AND CAPACITIVE ISOLATION CIRCUIT

Abstract

An isolation circuit arrangement may include an isolation barrier and may be configured to receive one or more input signals on a low voltage side and deliver one or more output signals on a high voltage side. The isolation barrier may include a first capacitor, arranged along a first input line, a second capacitor arranged along a second input line, electrically parallel to the first capacitor, and a first inductor having a first end that is coupled to a first electrode of the first capacitor and having a second end that is coupled to a first electrode of the second capacitor. The isolation barrier may further include a center tap, connected to the first inductor, and a second inductor that is inductively coupled to the first inductor and is arranged with a first output end and a second output end on a high voltage side of the isolation circuit arrangement.

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Appl. No.: 18/442322

Filed: February 15, 2024

Publication Classification

Int. Cl.: H03K17/691 (20060101); H03K17/567 (20060101)

U.S. Cl.:

CPC H03K17/691 (20130101); H03K17/567 (20130101)

Background/Summary

BACKGROUND

Field

[0001] Embodiments relate to the field of circuit protection devices, including, isolated gate drivers and digital isolators.

Discussion of Related Art

[0002] An insulated gate bipolar transistor (IGBT) or power metal oxide semiconductor field effect transistor (MOSFET) each represent a voltage-controlled device that is used as a switching element in power supply circuits and motor drives, amongst other systems. The gate is the electrically insulated control terminal for each device. The other terminals of a MOSFET are source and drain, and for an IGBT the other terminals are called collector and emitter. To operate a MOSFET/IGBT, a voltage is applied to the gate that is relative to the source/emitter of the device. Dedicated drivers are used to apply voltage and provide drive current to the gate of the power device.

[0003] For operating an IGBT/power MOSFET as a switch, a voltage sufficiently larger than the gate threshold voltage should be applied between the gate and source/emitter terminals. A gate driver may be supplied to convert a low-power input from a microcontroller into a high-current drive input for the gate of a high-power transistor such as an IGBT or power MOSFET.

[0004] For a system using gate drivers, galvanic isolation may be necessary for functional purposes and it might also be a safety requirement. In particular, galvanic isolation may be a requirement between the high power side and low voltage control circuit if there is any human involvement on the control side. The isolation also protects low voltage electronics from any damage due to faults on the high power side. In one example, an isolated gate driver circuit may employ capacitive structures to supply galvanic isolation from a controller side (Low voltage) to high power switch side (high voltage).

[0005] A parameter of interest for operation of an isolated gate driver for high frequency operation is the common-mode transient immunity (CMTI). CMTI may refer to the maximum tolerable rate of rise or fall of the common mode voltage applied between two isolated circuits. The unit is normally represented as kV/us or V/ns. A relatively higher CMTI means that the two isolated circuits, both transmitter side and receiver side, function relatively better without error when striking the isolation barrier with very high rise slew rate, or high fall slew rate.

[0006] Recently wide band gap (WBG) semiconductors have attracted increasing attention for use as power transistors, including SiC, GaN, and other known WBG materials. These materials enable faster switching speed in comparison to silicon, for example. In particular, fast switching on the order of 3 ns or less is possible in the context of an isolated gate driver circuit. This fast switching generates disturbances through the isolation barrier, thus compromising gate driver operation. In particular, to switch from 0 to 1000 V in 3 ns, a CMTI of at least 300 kV/ms may be called for, which capability may not be readily provided in present day gate driver circuits. Moreover, for higher voltage switching, even higher CMTI may be required.

[0007] In view of the above, the present disclosure is provided.

Brief Summary

[0008] In one embodiment, an isolation circuit arrangement is provided. As such, the isolation circuit arrangement may include an isolation barrier and may be configured to receive one or more input signals on a low voltage side and deliver one or more output signals on a high voltage side. The isolation barrier may include a first capacitor, arranged along a first input line, and a second capacitor arranged along a second input line, in electrically parallel fashion to the first capacitor. The isolation barrier may also include a first inductor having a first end that is coupled to a first electrode of the first capacitor and having a second end that is coupled to a first electrode of the

second capacitor. The isolation barrier may further include a center tap, connected to the first inductor, and a second inductor that is inductively coupled to the first inductor and is arranged with a first output end and a second output end on a high voltage side of the isolation circuit arrangement.

[0009] In another embodiment, a gate driver arrangement is provided. The gate driver arrangement may include a signal source to generate one or more control signals, and an isolation barrier, to receive the one or more control signals, the isolation barrier comprising an isolation circuit. The isolation circuit may include a first capacitor, arranged along a first input line, and a second capacitor arranged along a second input line, in electrically parallel fashion to the first capacitor. The isolation circuit may also include a first inductor having a first end that is coupled to the first capacitor and having a second end that is coupled to the second capacitor. The isolation circuit may further include a center tap, connected to the first inductor, and a second inductor that is inductively coupled to the first inductor and is arranged with a first output end and a second output end on a high voltage side of the gate driver arrangement.

[0010] In a further embodiment, a gate driver arrangement is provided, including a signal source to generate one or more control signals, and an isolation barrier, to receive the one or more control signals. The isolation barrier may have an isolation circuit, where the isolation circuit includes a first capacitor, arranged along a first input line, and a second capacitor arranged along a second input line, in electrically parallel fashion to the first capacitor. The isolation barrier may also include a first inductor having a first end that is coupled to the first capacitor and having a second end that is coupled to the second capacitor. The isolation barrier may further include a grounded center tap, connected to the first inductor, and a second inductor that is inductively coupled to the first inductor and is arranged with a first output end and a second output end on a high voltage side of the gate driver arrangement. The gate driver arrangement may also include a demodulator, coupled to the second inductor, and a gate driver, coupled to demodulator, and arranged to output a drive signal to a gate of a power switch.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] FIG. 1A illustrates a gate driver arrangement according to embodiments of the disclosure;

[0012] FIG. 1B illustrates another gate driver arrangement according to embodiments of the disclosure;

[0013] FIG. 2A shows one instance of operation of the arrangement of FIG. 1;

[0014] FIG. 2B illustrates details of a common-mode voltage pulse;

[0015] FIG. 3 shows a top view of an isolation chip, according to some embodiments of the disclosure;

[0016] FIG. 4 depicts another gate driver arrangement, according to further embodiments of the disclosure;

[0017] FIG. 5A depicts an isolation circuit arrangement, according to further embodiments of the disclosure;

[0018] FIG. 5B shows an image of an embodiment of the connection between isolation circuits of FIG. 5A;

[0019] FIG. 6 depicts an isolation circuit arrangement, according to additional embodiments of the disclosure;

[0020] FIG. 7 depicts an isolation circuit arrangement, according to additional embodiments of the disclosure;

[0021] FIG. 8 depicts an isolation circuit arrangement, according to additional embodiments of the disclosure; and

[0022] FIG. **9** illustrates an isolation circuit arrangement according to further embodiments of the disclosure.

DESCRIPTION OF EMBODIMENTS

[0023] The present embodiments will now be described more fully hereinafter with reference to the accompanying drawings, in which exemplary embodiments are shown. The embodiments are not to be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey their scope to those skilled in the art. In the drawings, like numbers refer to like elements throughout.

[0024] In the following description and/or claims, the terms “on,” “overlying,” “disposed on” and “over” may be used in the following description and claims. “On,” “overlying,” “disposed on” and “over” may be used to indicate that two or more elements are in direct physical contact with one another. Also, the term “on,” “overlying,” “disposed on,” and “over”, may mean that two or more elements are not in direct contact with one another. For example, “over” may mean that one element is above another element while not contacting one another and may have another element or elements in between the two elements. Furthermore, the term “and/or” may mean “and”, it may mean “or”, it may mean “exclusive-or”, it may mean “one”, it may mean “some, but not all”, it may mean “neither”, and/or it may mean “both”, although the scope of claimed subject matter is not limited in this respect.

[0025] In various embodiments, systems, devices, and techniques are provided for isolated gate driver circuits. According to some embodiments, as described hereinbelow, circuitry is disclosed to provide illustration of functional equivalents for implementing an isolated gate driver circuit, where the details of actual components, and circuit arrangements for implementing the gate drive signal may vary, as will be understood by those of ordinary skill in the art.

[0026] Turning to FIG. **1A** there is shown an isolation circuit arrangement **10** according to some embodiments of the disclosure. The isolation circuit arrangement **10** implements an isolation function for providing galvanic isolation between a signal source located on a low voltage (LV) side of the isolation circuit arrangement **10**. The signal source **102** may be a microcontroller to output a control signal that is used to control the gate of a power switch located on the HV side of the isolation circuit arrangement **10**, for example.

[0027] As further shown in FIG. **1A**, the isolation circuit arrangement **10** includes an isolation circuit **104**. This circuit may function as an isolation barrier to provide galvanic isolation between the signal source **102** and other circuitry operating at low voltage, and circuitry operating at the high voltage (HV) side of the isolation circuit arrangement **10**.

[0028] The isolation circuit **104** includes a novel arrangement of capacitive and inductive elements that provide a galvanic isolation between the low voltage (LV) side and HV side in the isolation circuit arrangement **10**. As depicted in FIG. **1A**, the isolation circuit **104** may include a first capacitor **112**, arranged along a first input line **122**, and a second capacitor **114** arranged along a second input line **124**. The second capacitor **114** is arranged in electrically parallel fashion to the first capacitor **112**. In various embodiments, the first capacitor **112** and second capacitor **114** may be arranged to have the same capacitance.

[0029] The isolation circuit **104** may further include an inductive circuit that is arranged, for example, like a coreless transformer with a first and second inductor. As shown in FIG. **1A**, a first inductor **116** is provided having a first end that is coupled to the first capacitor **112** and having a second end that is coupled to the second capacitor **114**. A second inductor **118** is provided that is inductively coupled to the first inductor **116** and is arranged to couple to component such as a demodulator **128**.

[0030] In various non-limiting embodiments, the isolation circuit **104** may be arranged in a semiconductor chip that may be a standalone chip that is separate from the signal source **102**, while in other embodiments the isolation circuit **104** may be integrated on the same chip as the signal source **102**. Likewise, in some embodiments the isolation circuit may be provided on a chip that is

separate from a component on the HV side, such as a demodulator **128**, while in other embodiments, the isolation circuit **104** may be integrated on a same chip as other components on the HV side, such as a demodulator **128**.

[0031] Turning to FIG. **1B** there is shown an isolation circuit arrangement **100** according to some embodiments of the disclosure. The isolation circuit arrangement **100** implements an isolated gate driver function for controlling operation of power switching circuitry **106**. The power switching circuitry may be implemented using known power transistors, such as IGBTs or power MOSFETs. In any case, the isolation circuit arrangement is structured so as to provide a control signal to a gate of the power transistor of power switching circuitry **106**. In some examples, voltage across the main terminals of a high side switch of the power switching circuitry **106** may be up to 1 kV or greater. The isolation circuit arrangement **100** may include a drive signal source, shown as signal source **102**, such as a microcontroller to output a gate driver signal that is used to control the gate of the power switching circuitry **106**. This signal source **102** may operate on a low voltage side of the isolation circuit arrangement **100**. As such, the signal source **102** may output a series of drive pulses that cause to power switching circuitry **106** to output a series of voltage pulses that have an amplitude corresponding to the maximum voltage crossing the power switching circuitry **106**, as explained in more detail with respect to FIGS. **2A** and **2B** to follow.

[0032] As further shown in FIG. **1B**, the isolation circuit arrangement **100** includes an isolation circuit **104**. This circuit is arranged to provide galvanic isolation between the signal source **102** and other circuitry operating at low voltage, and the power switching circuitry **106**, operating at the high voltage (HV) side of the isolation circuit arrangement **100**.

[0033] The isolation circuit **104** includes a novel arrangement of capacitive and inductive elements that provide a galvanic isolation between the low voltage (LV) side and HV side in the isolation circuit arrangement **100**. As depicted in FIG. **1B**, the isolation circuit **104** may include a first capacitor **112**, arranged along a first input line **122**, and a second capacitor **114** arranged along a second input line **124**. The second capacitor **114** is arranged in electrically parallel fashion to the first capacitor **112**. In various embodiments, the first capacitor **112** and second capacitor **114** may be arranged to have the same capacitance.

[0034] The isolation circuit **104** may further include an inductive circuit that is arranged, for example, like a coreless transformer with a first and second inductor. As shown in FIG. **1B**, a first inductor **116** is provided having a first end that is coupled to the first capacitor **112** and having a second end that is coupled to the second capacitor **114**. A second inductor **118** is provided that is inductively coupled to the first inductor **116** and is arranged with a first output end that is to electrically couple to a demodulator **128**. An output of the demodulator **128** connects to gate driver for a gate terminal **130** of a power switch **132**. The second end of the second inductor **118** may be coupled to a low voltage side of the power switch **132**, via demodulator **128**, as shown.

[0035] In various non-limiting embodiments, the isolation circuit **104** may be arranged in a semiconductor chip that may be a standalone chip that is separate from the signal source **102** and the power switch **132**. For example, the isolation circuit **104** may be formed in a semiconductor chip based in a silicon substrate in some embodiments. On the other hand, the power switch **132** may be embodied in another semiconductor substrate, such as a GaN substrate, a SiC substrate, or a silicon substrate, according to different embodiments. In the example shown, the isolation circuit arrangement **100** may include a demodulator **128** and gate driver circuit **126**, both components being arranged on the high voltage (HV) side.

[0036] FIG. **2A** shows one instance of operation of the arrangement of FIG. **1B**. In order to control operation of the power switch **132**, the signal source **102** may be arranged to output a control signal **140** that is ultimately used to switch the gate terminal **130** of the power switch **132** from an ON state to an OFF state, and to thus drive a current/voltage pulse through the power switch **132**. As an example, the signal source **102** may be arranged to generate the control signal **140** as a pulse width modulated pulse train. After passing through the isolation circuit **104**, and demodulator **128**, a

resulting gate signal **142** may be generated by the gate driver circuit **126** to control opening and closing of the gate terminal **130**.

[0037] To explain the advantages of the isolation circuit **104**, it is noted that in known isolated gate driver circuits, based on capacitive isolation, for example, the gate driver may be referenced to the switching node **144** of the power switch **132**. In such conventional circuits, as the power switch transitions between ON state and OFF state, a voltage signal **146**, also shown as V_{cm} , will develop, as shown in FIG. 2B. Depending upon the magnitude of voltage and the switching speed the slope of the voltage signal, or the value of dV/dt may be on the order of 100 kV/ms, 300 kV/ms, 500 kV/ms or 1000 kV/ms, or greater. This common mode transient voltage may propagate through the isolation barrier in known isolation circuits, compromising gate driver operation. In contrast, while the isolation circuit **104** also provides galvanic isolation via the first capacitor **112** and the second capacitor **114**, as in known gate drivers, the isolation circuit **104** provides immunity to common mode transients. This result is particularly due to the arrangement of the first inductor **116** and the second inductor **118**, in a transformer configuration, with a center tap **120** provided for current discharge.

[0038] In principle, the configuration of the isolation circuit **104** may provide a protection equivalent to a relatively higher value of CMTI, such as greater than CMTI of at least 100 kV/ms, at least 200 kV/ms or greater than 300 kV/ms. Thus, if the power switching circuitry **106** is embodied in a HBG chip, such as GaN or SiC, even if the HBG chip operates at switching speeds of ~ 1 ns, the circuitry of the isolation circuit arrangement **100**, including that circuitry on the low voltage side, will be protected from common mode transients that may otherwise cross the isolation barrier, thus ensuring operation without such noise. In particular, the provision of ground connection for the center tap **120** provides a path to redirect current caused in CMT events directly to ground, so that circuitries such as the demodulator **128** do not experience in the CMT. Note that in optional embodiments the center tap need not be grounded, in which case CMT immunity may not be as pronounced as in the case of a grounded center tap. In some variants of the embodiment of FIG. 2B, the first inductor **116**, the second inductor **118**, and center tap **120** may be arranged in a symmetrical transformer configuration so as to avoid the generation of any common mode signals due to transformer asymmetry.

[0039] FIG. 3 shows a top view of an isolation chip **148**, according to some embodiments of the disclosure. In this example, the isolation circuit **104** may be embedded in the isolation chip **148**, which chip may be formed in any suitable semiconductor substrate, such as silicon. In this embodiment, the first capacitor **112** and second capacitor **114** of the isolation circuit **104** are arranged as a parallel plate structure where a pair of electrodes (only the top electrode is visible) are arranged in planar fashion along a main plane of the semiconductor chip. Note that the first capacitor **112** and the second capacitor **114** are arranged symmetrically within the isolation chip **148**, and have a somewhat rectangular shape. However, according to various embodiments of the disclosure the first capacitor **112** and second capacitor **114** may have any suitable shape and arrangement.

[0040] In this embodiment, the first inductor **116** and second inductor **118** of the isolation circuit **104** are also arranged in a planar structure along the main plane of the isolation chip **148**. The first inductor **116** may be disposed in an interleaved fashion with the second inductor **118**, according to some embodiments. Note that exact shape of the first inductor **116** and second inductor **118** may vary according to different embodiments.

[0041] FIG. 4 depicts another isolation circuit arrangement, according to further embodiments of the disclosure. In this example, the isolation circuit arrangement **150** may include components similar to the embodiment of FIG. 1, where like components are labeled the same. In this example an isolation circuit function is provided by two parts, including a first isolation circuit that is represented by isolation circuit **104**, described previously, and a second isolation circuit, represented by the isolation circuit **154**. As illustrated, the isolation circuit **104** and the isolation

circuit **154** are arranged in electrical series with one another. With reference to the components of isolation circuit **104**, described previously, each of these circuits may include a first capacitor and a second capacitor arranged in electrically parallel fashion to the first capacitor, as well as a first inductor and a second inductor, where the first inductor has a first end that is coupled to the first capacitor and a second end that is coupled to the second capacitor. The first inductor is also provided with a center tap as shown.

[0042] Note that in this configuration, the first capacitor of the isolation circuit **104** is electrically conductively connected to the first capacitor of the second isolation circuit, meaning the isolation circuit **154**, and the second capacitor of the isolation circuit **104** is electrically conductively connected to the second capacitor of the second isolation circuit. According to various embodiments of the disclosure, the isolation circuit **104** may be arranged in a first semiconductor chip, while the isolation circuit **154** is arranged in a second semiconductor chip.

[0043] In operation of the isolation circuit arrangement **150**, each transformer part directs one polarity of the CMT current: one center tap is used for positive slope CMTI event the other center tap is used for the negative slope CMTI event. The splitting of the capacitor part allows implementing the isolation circuit arrangement **150** in two different chips. Note also that the ground domain in the isolation circuit **104** is different from the ground domain of the isolation circuit **154**, as indicated.

[0044] FIG. 5A depicts an isolation circuit arrangement **200**, according to further embodiments of the disclosure. The isolation circuit arrangement **200** in this embodiment and in embodiments disclosed in FIGS. 6-8 may be used, for example, as gate driver arrangement for controlling switches on a high voltage side of an isolation barrier, where the switches are gated semiconductor devices, such as MOSFETs or IGBTs. The isolation circuit arrangement **200** may be implemented in a package that includes two semiconductor chips, according to some embodiments. In operation, the isolation circuit arrangement **200** may be used to couple a signal source that operates on a low voltage (LV) side to a component on a high voltage side (HV), such as a switch, described previously. As such, the isolation circuit arrangement **200** may provide galvanic isolation between the LV side and HV side, and may further provide enhanced CMTI, as described previously. In the example shown, the isolation circuit arrangement **200** includes a first chip **202** and a second chip **204**, which components may be arranged in a common package, as noted. In this embodiment, an isolation barrier **210** is distributed between the first chip **202** and the second chip **204**. In one example, the first chip **202** may include transmitter circuitry **206**, while the second chip **204** includes a demodulator **128** and gate driver circuit **126**. In the example shown, the first chip **202** may include the isolation circuit **154**, while the second chip **204** includes the isolation circuit **104**, as described previously. Note that the isolation circuit **154** may be arranged on a periphery of the first chip **202**, while the isolation circuit **104** is arranged on a periphery of the second chip **204**. The isolation circuit **154** may be connected to the isolation circuit **104** using any suitable conductive connector, such as bond wires (BW), which wires may extend from electrodes of each of the capacitors of the isolation barrier **210**. An image of an embodiment of the connection between isolation circuit **154** and isolation circuit **104** is shown in FIG. 5B. Thus, the capacitor C1 of isolation circuit **104** is connected through a bond wire to the capacitor C3 of isolation circuit **154**, while the capacitor C2 of isolation circuit **104** is connected through a bond wire to the capacitor C4 of isolation circuit **154**. Together, the isolation circuit **104**, isolation circuit **154** and bondwires BW form the isolation barrier **210**, which arrangement provides galvanic isolation as well as enhanced CMTI. Note also that the ground domain in the isolation circuit **104** is different from the ground domain of the isolation circuit **154**, as indicated.

[0045] FIG. 6 depicts an isolation circuit arrangement **250**, according to additional embodiments of the disclosure. The isolation circuit arrangement **250** may be implemented in a package that includes two semiconductor chips, according to some embodiments. In operation, the isolation circuit arrangement **250** may be used to couple a signal source that operates on a low voltage (LV)

side to a component on a high voltage side (HV), such as a switch, described previously. As such, the isolation circuit arrangement **250** may provide galvanic isolation between the LV side and HV side, and may further provide enhanced CMTI, as described previously. In the example shown, the isolation circuit arrangement **250** includes a first chip **202** and a second chip **262**, which components may be arranged in a common package, as noted. In this embodiment, an isolation barrier **260** is distributed between the first chip **202** and the second chip **262**. In one example, the first chip **202** may include transmitter circuitry **206**, while the second chip **262** includes the demodulator **128** and gate driver circuit **126**. In the example shown, the first chip **202** may include the isolation circuit **154**, while the second chip **262** includes an isolation circuit **264**. Note that the isolation circuit **154** may be arranged on a periphery of the first chip **202**, while the isolation circuit **264** is arranged on a periphery of the second chip **262**. The isolation circuit **154** may be connected to the isolation circuit **264** using any suitable conductive connector, such as bond wires (BW), which wires may extend from electrodes of each of the capacitors of the isolation barrier **260**, generally as described above with respect to FIG. 5A and FIG. 5B. In this case, the capacitor electrode is connected through bondwire to the inductor electrode. Together, the isolation circuit **104**, isolation circuit **264** and bondwires BW form the isolation barrier **260**, which arrangement provides galvanic isolation as well as enhanced CMTI. In this embodiment, the isolation circuit **264** includes a first inductor L1 and a second inductor L2, but does not include a set of capacitors. Thus, the galvanic isolation of the isolation barrier **260** is provided by the capacitors C3 and capacitor C4 in the isolation circuit **154**. Note also that the ground domain in the isolation circuit **154** is different from the ground domain of the isolation circuit **264**, as indicated.

[0046] FIG. 7 depicts an isolation circuit arrangement **280**, according to additional embodiments of the disclosure. The isolation circuit arrangement **280** may be implemented in a package that includes two semiconductor chips, according to some embodiments. In operation, the isolation circuit arrangement **280** may be used to couple a signal source that operates on a low voltage (LV) side to a component on a high voltage side (HV), such as a switch, described previously. As such, the isolation circuit arrangement **280** may provide galvanic isolation between the LV side and HV side, and may further provide enhanced CMTI, as described previously. In the example shown, the isolation circuit arrangement **280** includes a first chip **292** and a second chip **204**, which components may be arranged in a common package, as noted. In this embodiment, an isolation barrier **290** is distributed between the first chip **292** and the second chip **204**. In one example, the first chip **292** may include transmitter circuitry **206**, while the second chip **204** includes the demodulator **128** and gate driver circuit **126**. In the example shown, the first chip **292** may include an isolation circuit **294**, while the second chip **204** includes an isolation circuit **104**, described previously. Note that the isolation circuit **294** may be arranged on a periphery of the first chip **292**, while the isolation circuit **104** is arranged on a periphery of the second chip **204**. The isolation circuit **294** may be connected to the isolation circuit **104** using any suitable conductive connector, such as bond wires (BW), which wires may extend from electrodes of each of the capacitors of the isolation barrier **290**, generally as described above with respect to FIG. 5A and FIG. 5B. In this case, the capacitor electrode is connected through bondwire to the inductor electrode. Together, the isolation circuit **104**, isolation circuit **294** and bondwires BW form the isolation barrier **290**, which arrangement provides galvanic isolation as well as enhanced CMTI. In this embodiment, the isolation circuit **294** includes a first inductor L1 and a second inductor L2, but does not include a set of capacitors. Thus, the galvanic isolation of the isolation barrier **290** is provided by the capacitors C1 and capacitor C2 in the isolation circuit **104**. Note also that the ground domain in the isolation circuit **104** is different from the ground domain of the isolation circuit **294**, as indicated.

[0047] FIG. 8 depicts an isolation circuit arrangement **300**, according to additional embodiments of the disclosure. The isolation circuit arrangement **300** may be implemented in a package that includes a single semiconductor chip, shown as chip **302**, according to some embodiments. In operation, the isolation circuit arrangement **300** may be used to couple a signal source that operates

on a low voltage (LV) side to a component on a high voltage side (HV), such as a switch, described previously. As such, the isolation circuit arrangement **300** may provide galvanic isolation between the LV side and HV side, and may further provide enhanced CMTI, as described previously. In the example shown, the isolation circuit arrangement **300** includes a chip **302**, which component may be arranged in a package that couples components on the HV side to components on the LV side. In one example, the chip **302** may include transmitter circuitry **206**, the demodulator **128** and gate driver circuit **126**. In the example shown, the chip **302** may include an isolation barrier **310**. The isolation barrier **310** provides galvanic isolation as well as enhanced CMTI. In this embodiment, the isolation barrier **310** includes a first inductor **L1** and a second inductor **L2**, arranged on an HV side, and a third inductor **L3** and fourth inductor **L4**, arranged on the LV side. A single set of capacitors is provided in the isolation circuit, shown as capacitor **C1** and capacitor **C2**, providing the galvanic isolation of the isolation barrier **310**. Note that for implementation in a single semiconductor chip, an insulation means is called for within the semiconductor substrate, such as a silicon-on-insulator (SOI) architecture. Note also that the ground domain differs between the two different center taps, **CT1** and **CT2**, as shown.

[0048] FIG. **9** illustrates an isolation circuit arrangement **400** according to further embodiments of the disclosure. The isolation circuit arrangement **400** may be implemented as a digital isolator for such applications as isolating communication interfaces. In this embodiment, an isolation barrier, such as any of the isolation barriers of the aforementioned embodiments, may be arranged between a transmitter **402** on the LV side and a demodulator **404** on the HV side.

[0049] While the present embodiments have been disclosed with reference to certain embodiments, numerous modifications, alterations and changes to the described embodiments are possible while not departing from the sphere and scope of the present disclosure, as defined in the appended claims. Accordingly, the present embodiments are not to be limited to the described embodiments, and may have the full scope defined by the language of the following claims, and equivalents thereof.

Claims

1. An isolation circuit arrangement, configured to receive one or more input signals on a low voltage side and deliver one or more output signals on a high voltage side, the isolation circuit arrangement comprising an isolation barrier, comprising: a first capacitor, arranged along a first input line; a second capacitor arranged along a second input line, in electrically parallel fashion to the first capacitor; a first inductor having a first end that is coupled to a first electrode of the first capacitor and having a second end that is coupled to a first electrode of the second capacitor; a center tap, connected to the first inductor; and a second inductor that is inductively coupled to the first inductor and is arranged with a first output end and a second output end on a high voltage side of the isolation circuit arrangement.
2. The isolation circuit arrangement of claim 1, wherein the isolation barrier is arranged in a single semiconductor chip.
3. The isolation circuit arrangement of claim 2, the isolation circuit further comprising: a third inductor having a first end that is coupled to the first capacitor and having a second end that is coupled to the second capacitor; a center tap, connected to the third inductor; and a fourth inductor that is inductively coupled to the third inductor and is arranged with a first input end and a second input end on a low voltage side of the isolation circuit arrangement.
4. The isolation circuit arrangement of claim 1, wherein the first capacitor, second capacitor, first inductor and second inductor are arranged in a first isolation circuit, wherein a second isolation circuit is disposed in the isolation circuit arrangement, the second isolation circuit comprising: a third capacitor, connected to the first capacitor; a fourth capacitor connected to the second capacitor; a third inductor having a first end that is coupled to the third capacitor and having a

second end that is coupled to the fourth capacitor; and a fourth inductor that is inductively coupled to the third inductor and is arranged with a first input end and a second input end on a low voltage side of the isolation circuit arrangement.

5. The isolation circuit arrangement of claim 4, wherein the first isolation circuit and the second isolation circuit together form an isolation barrier, wherein the first isolation circuit is disposed in a first semiconductor chip, the second isolation circuit is disposed in a second semiconductor chip, and wherein the first isolation circuit is connected to the second isolation circuit via a pair of conductive connectors.

6. The isolation circuit of claim 5, the first semiconductor chip further comprising a transmitter, and the second semiconductor chip further comprising a demodulator and a gate driver.

7. The isolation circuit arrangement of claim 1, further comprising an inductor circuit, comprising: a third inductor having a first end that is coupled to a second electrode of the first capacitor and having a second end that is coupled to a second end of the second capacitor a center tap, connected to the third inductor; and a fourth inductor that is inductively coupled to the third inductor and is arranged with a first input end and a second input end on a low voltage side of the isolation circuit arrangement.

8. The isolation circuit arrangement of claim 7, wherein the inductor circuit and the first capacitor and second capacitor are disposed in a first semiconductor chip, and wherein the first inductor and second inductor are disposed in a second semiconductor chip.

9. The isolation circuit arrangement of claim 7, wherein the first capacitor, second capacitor, first inductor and second inductor are arranged in a first isolation circuit, wherein the first isolation circuit is arranged in a first chip, and wherein the inductor circuit is arranged in a second semiconductor chip.

10. The isolation circuit arrangement of claim 7, wherein the first capacitor, second capacitor, first inductor, second inductor and the inductor circuit are arranged together in one semiconductor chip., wherein the one semiconductor chip is a silicon-on-insulator chip.

11. A gate driver arrangement: a signal source to generate one or more control signals; an isolation barrier, to receive the one or more control signals, the isolation barrier comprising an isolation circuit, wherein the isolation circuit comprises: a first capacitor, arranged along a first input line; a second capacitor arranged along a second input line, in electrically parallel fashion to the first capacitor; a first inductor having a first end that is coupled to the first capacitor and having a second end that is coupled to the second capacitor; a center tap, connected to the first inductor; and a second inductor that is inductively coupled to the first inductor and is arranged with a first output end and a second output end on a high voltage side of the gate driver arrangement.

12. The gate driver arrangement of claim 11, further comprising: a demodulator, arranged on the high voltage side; and a gate driver, coupled to the demodulator, and arranged to output a gate drive signal to a high side switch.

13. The gate driver arrangement of claim 11, the isolation barrier further comprising: a third inductor having a first end that is coupled to the first capacitor and having a second end that is coupled to the second capacitor; a center tap, connected to the third inductor; and a fourth inductor that is inductively coupled to the third inductor and is arranged with a first input end and a second input end on a low voltage side of the gate driver arrangement.

14. The gate driver arrangement of claim 13, wherein the third inductor, fourth inductor, the first capacitor and second capacitor are disposed in a first semiconductor chip, and wherein the first inductor and second inductor are disposed in a second semiconductor chip.

15. The gate driver arrangement of claim 13, wherein the first capacitor, second capacitor, first inductor and second inductor are arranged in a first isolation circuit, wherein the first isolation circuit is arranged in a first chip, and wherein the third inductor and the fourth inductor are arranged in a second semiconductor chip.

16. The gate driver arrangement of claim 13, wherein the isolation barrier is arranged in a single

semiconductor chip.

17. The gate driver arrangement of claim 11, wherein the first capacitor, second capacitor, first inductor and second inductor are arranged in a first isolation circuit, wherein a second isolation circuit is disposed in the isolation barrier, the second isolation circuit comprising: a third capacitor, connected to the first capacitor; a fourth capacitor connected to the second capacitor; a third inductor having a first end that is coupled to the third capacitor and having a second end that is coupled to the fourth capacitor; and a fourth inductor that is inductively coupled to the third inductor and is arranged with a first input end and a second input end on a low voltage side of the gate driver arrangement.

18. The gate driver arrangement of claim 17, wherein the first isolation circuit is disposed in a first semiconductor chip, the second isolation circuit is disposed in a second semiconductor chip, and wherein the first isolation circuit is connected to the second isolation circuit via a pair of bond wires.

19. The gate driver arrangement of claim 18, the first semiconductor chip further comprising a transmitter, and the second semiconductor chip further comprising a demodulator and a gate driver.

20. A gate driver arrangement, comprising: a signal source to generate one or more control signals; an isolation barrier, to receive the one or more control signals, the isolation barrier comprising an isolation circuit, wherein the isolation circuit comprises: a first capacitor, arranged along a first input line; a second capacitor arranged along a second input line, in electrically parallel fashion to the first capacitor; a first inductor having a first end that is coupled to the first capacitor and having a second end that is coupled to the second capacitor; a grounded center tap, connected to the first inductor; and a second inductor that is inductively coupled to the first inductor and is arranged with a first output end and a second output end on a high voltage side of the gate driver arrangement; a demodulator, coupled to the second inductor; and a gate driver, coupled to demodulator, and arranged to output a drive signal to a gate of a power switch.
